MAT 101	LINEAR ALGEBRA AND CALCULUS	CATEGORY	L	T	P	CREDIT	Year of Introduction
		BSC	3	1	0	4	2019

Preamble: This course introduces students to some basic mathematical ideas and tools which are at the core of any engineering course. A brief course in Linear Algebra familiarises students with some basic techniques in matrix theory which are essential for analysing linear systems. The calculus of functions of one or more variables taught in this course are useful in modelling and analysing physical phenomena involving continuous change of variables or parameters and have applications across all branches of engineering.

Prerequisite: A basic course in one-variable calculus and matrix theory.

Course Outcomes: After the completion of the course the student will be able to

CO 1	solve systems of linear equations, diagonalize matrices and characterise quadratic forms
CO 2	compute the partial and total derivatives and maxima and minima of multivariable functions
CO 3	compute multiple integrals and apply them to find areas and volumes of geometrical shapes, mass and centre of gravity of plane laminas
CO 4	perform various tests to determine whether a given series is convergent, absolutely convergent or conditionally convergent
CO 5	determine the Taylor and Fourier series expansion of functions and learn their applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	2	1			1	2		2
CO 2	3	3	3	3	2	1			1	2		2
CO 3	3	3	3	3	2	1			1	2		2
CO 4	3	2	3	2	1	1			1	2		2
CO 5	3	3	3	3	2	1			1	2		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 2 (Marks)	
Remember	10	10	20
Understand	20	20	40
Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks
Assignments: Assignment should include specific problems highlighting the applications of the methods introduced in this course in science and engineering.

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Solve systems of linear equations, diagonalize matrices and characterise quadratic forms

1. A is a real matrix of order $3 \times 3$and $X = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$. What can you say about the solution of $AX = 0$if rank of A is 1? 2 ?3?

2. Given$A = \begin{bmatrix} 3 & 0 & 2 \\ 0 & 2 & 0 \\ -2 & 0 & 0 \end{bmatrix}$, find an orthogonal matrix Pthat diagonalizes A.

3. Find out what type of conic section the following quadratic form represents

$$17x^2 - 30x_1x_2 + 17x_2^2 = 128$$

4. The matrix $A = \begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$has an eigen value5 with corresponding Eigen vector$X = \begin{bmatrix} 1 \\ 2 \\ -1 \end{bmatrix}$. Find A^5X

Course Outcome 2 (CO2): compute the partial and total derivatives and maxima and minima of multivariable functions

1. Find the slope of the surface $z = x^2y + 5y^3$in the x-direction at the point (1,-2)

2. Given the function $w = xy + z$, use chain rule to find the instantaneous rate of change of $w$at each point along the curve $x = cost, y = sint, z = t$

3. Determine the dimension of rectangular box open at the top , having a volume 32 cubic ft and requiring the least amount of material for it's construction.

Course Outcome 3(CO3): compute multiple integrals and apply them to find areas and volumes of geometrical shapes, mass and centre of gravity of plane laminas.

1. Evaluate $\iint_D (x + 2y)\, DA$where D is the region bounded by the parabolas $y = 2x^2$and $y = 1 + x^2$

2. Explain how you would find the volume under the surface $z = f(x, y)$and over a specific region Din the xyplane using (i) double integral (ii) triple integral?

3. Find the mass and centre of gravity of a triangular lamina with vertices (0,0), (2,1), (0,3) if the density function is $f(x, y) = x + y$

4. Use spherical coordinates to evaluate $\iiint_B (x^2 + y^2 + z^2)^3\, dV$where B is the unit ball defined by $B = \{(x, y, z): x^2 + y^2 + z^2 \leq 1\}$

Course Outcome 4 (CO4): perform various tests to determine whether a given series is convergent, absolutely convergent or conditionally convergent.

1. What is the difference between a sequence and a series and when do you say that they are convergent? Divergent?

2. Determine whether the series $\sum_{n=1}^{n=\infty} \frac{5}{2n^2+4n+3}$converges or diverges.

3. Is the series $\sum_{n=1}^{n=\infty} \frac{(-1)^{n-1}}{n}$convergent? Absolutely convergent? Conditionally convergent?

Course Outcome 5 (CO5): determine the Taylor and Fourier series expansion of functions and learn their applications.

1. Assuming the possibility of expansion find the Maclaurin series expansion of

   $f(x) = (1 + x)^k$for$|x| < 1$where $k$is any real number. What happens if $k$is a positive

   integer?

2. Use Maclaurin series of $ln(1 + x), -1 < x \leq 1$to find an approximate value of$ln2$.

3. Find the Fourier series of the function$f(x) = x^2, -2 \leq x < 2, f(x + 4) = f(x)$. Hence using Parseval's identity prove that $1 + \frac{1}{2^4} + \frac{1}{3^4} + \ \ldots \ = \frac{\pi^4}{90}$

4. Expand the function $f(x) = x\ (0 < x < 1/2)$ into a (i) Fourier sine series (ii) Fourier cosine series.

Model Question paper

QP CODE: PAGES:3

Reg No:_______________

Name :_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

***Course Code:* MAT 101**

Max. Marks: 100 **Duration: 3 Hours**

LINEAR ALGEBRA AND CALCULUs

(2019-Scheme)

(Common to all branches)

PART A

(Answer **all** questions, **each** question carries 3 marks)

1. Determine the rank of the matrix $A = \begin{bmatrix} 1 & 2 & -1 \\ -2 & -4 & 2 \\ 3 & 6 & -3 \end{bmatrix}$.
2. Write down the eigen values of $= \begin{bmatrix} 2 & 0 \\ 0 & -1 \end{bmatrix}$. What are the eigen values of $P^{-1}AP$ where $P = \begin{bmatrix} -4 & 2 \\ 3 & -1 \end{bmatrix}$?
3. Find $f_x(1,3)$ and $f_y(1,3)$ for the function $f(x,y) = 2x^3y^2 + 2y + 4x$.
4. Show that the function $u(x,t) = \sin(x - ct)$ is a solution of the equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$.
5. Use double integral to find the area of the region enclosed between the parabolas $y = \frac{1}{2}x^2$ and the line $y = 2x$.
6. Use polar coordinates to evaluate the area of the region bounded by $x^2 + y^2 = 4$, the line $y = x$ and the y axis in the first quadrant
7. Test the convergence of the series $\sum_{k=1}^{\infty} \frac{k}{k+1}$.
8. Test the convergence of the alternating series $\sum_{k=1}^{\infty} (-1)^{k+1} \frac{1}{k}$ using Leibnitz test.
9. Find the Taylor series expansion of $sin\pi x$ about $x = \frac{1}{2}$.
10. Find the values to which the Fourier series of

    $f(x) = x$ for $-\pi < x < \pi$, with $f(x + 2\pi) = f(x)$ converges (10x3=30)

PART B

(Answer **one full** question from each module, each question carries **14** marks)

Module -I

11. (a) Solve the following system of equations

$$y + z - 2w = 0$$
$$2x - 3y - 3z + 6w = 2$$
$$4x + y + z - 2w = 4$$

(b) Find the eigen values and eigen vectors of the matrix $\begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$

12. (a) Diagonalize the matrix $\begin{bmatrix} -1 & 2 & -2 \\ 2 & 4 & 1 \\ 2 & 1 & 4 \end{bmatrix}$

(b) What kind of conic section the quadratic form$3x_1^2 + 22x_1x_2 + 3x_2^2 = 0$ represents? Transform it to principal axes.

Module - II

13. (a) Find the local linear approximation to $f(x, y) = \sqrt{x^2 + y^2}$ at the point $(3, 4)$.Use it to approximate $f(3.04,3.98)$

(b) Let $w = \sqrt{x^2 + y^2 + z^2}$, $x = cos\theta, y = sin\theta, z = tan\theta$. Use chain rule to find $\frac{dw}{d\theta}$when $\theta = \frac{\pi}{4}$.

14. (a) Let $z = f(x, y)$ where $x = rcos\theta, y = rsin\theta$, prove that $\left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2 = \left(\frac{\partial z}{\partial r}\right)^2 + \frac{1}{r^2}\left(\frac{\partial z}{\partial \theta}\right)^2$.

(b) Locate all relative maxima, relative minima and saddle points $f(x, y) = xy + \frac{a^3}{x} + \frac{b^3}{y} (a \neq 0, b \neq 0)$.

Module - III

15. (a) Evaluate$\iint_D (2x^2y + 9y^3)\, dxdy$ where D is the region bounded by $y = \frac{2}{3}x$ and $y = 2\sqrt{x}$

(b) Evaluate $\int_0^4 \int_{\sqrt{y}}^2 e^{x^3}\, dxdy$ changing the order of integration.

16. (a) Find the volume of the solid bounded by the cylinder $x^2 + y^2 = 4$ and the planes $y + z = 4$ and $z = 0$..

(b) Evaluate $\iiint \sqrt{1 - x^2 - y^2 - z^2}\, dxdydz$, taken throughout the volume of the sphere $x^2 + y^2 + z^2 = 1$, by transforming to spherical polar coordinates

Module - IV

17. (a) Test the convergence of the series

(i) $\sum_{k=1}^{\infty} \frac{k^k}{k!}$ (ii) $\sum_{k=2}^{\infty} \left(\frac{4k-5}{2k+1}\right)^k$

(b) Determine the convergence or divergence of the series $\sum_{k=1}^{\infty} (-1)^k \frac{(2k-1)!}{3^k}$

18. (a) Check whether the series $\sum_{k=1}^{\infty} (-1)^{k+1} \frac{(2k)!}{(3k-2)!}$is absolutely convergent, conditionally convergent or divergent.

(b) Test the convergence of the series $1+\frac{1.2}{1.3}+\frac{1.2.3}{1.3.5}+\frac{1.2.3.4}{1.3.5.7}+\cdots$

Module - V

19. (a) Obtain the Fourier series of for $f(x) = e^{-x}$, in the interval $0 < x < 2\pi$.with $f(x+2\pi) = f(x)$. Hence deduce the value of $\sum_{n=2}^{\infty}\frac{(-1)^n}{1+n^2}$.

(b) Find the half range sine series of $f(x) = \begin{cases} \frac{2kL}{x} & if\ 0 < x < \frac{L}{2} \\ \frac{2k(L-x)}{L} & if\ \frac{L}{2} < x < L \end{cases}$

20. (a)Expand $(1+x)^{-2}$.as a Taylor series about $x = 0$and state the region of convergence of the series.

(b) Find the Fourier series for $f(x) = x^2$ in the interval $-\pi < x < \pi$

with $f(x+2\pi) = f(x)$.Hence show that $\frac{1}{1^4}+\frac{1}{2^4}+\frac{1}{3^4}+\cdots = \frac{\pi^4}{90}$. (14X5=70)

Syllabus

Module 1 (Linear algebra)

(Text 2: Relevant topics from sections 7.3, 7.4, 7.5, 8.1,8.3,8.4)

Systems of linear equations, Solution by Gauss elimination, row echelon form and rank of a matrix, fundamental theorem for linear systems (homogeneous and non-homogeneous, without proof), Eigen values and eigen vectors. Diagonaliztion of matrices, orthogonal transformation, quadratic forms and their canonical forms.

Module 2 (multivariable calculus-Differentiation)

(Text 1: Relevant topics from sections 13.3, 13.4, 13.5, 13.8)

Concept of limit and continuity of functions of two variables, partial derivatives, Differentials, Local Linear approximations, chain rule, total derivative, Relative maxima and minima, Absolute maxima and minima on closed and bounded set.

Module 3(multivariable calculus-Integration)

(Text 1: Relevant topics from sections 14.1, 14.2, 14.3, 14.5, 14.6, 14.8)

Double integrals (Cartesian), reversing the order of integration, Change of coordinates (Cartesian to polar), finding areas and volume using double integrals, mass and centre of gravity of inhomogeneous laminas using double integral. Triple integrals, volume calculated as triple integral, triple integral in cylindrical and spherical coordinates (computations involving spheres, cylinders).

Module 4 (sequences and series)

(Text 1: Relevant topics from sections 9.1, 9.3, 9.4, 9.5, 9.6)

Convergence of sequences and series, convergence of geometric series and p-series(without proof), test of convergence (comparison, ratio and root tests without proof); Alternating series and Leibnitz test, absolute and conditional convergence.

Module 5 (Series representation of functions)

(Text 1: Relevant topics from sections 9.8, 9.9. Text 2: Relevant topics from sections 11.1, 11.2, 11.6)

Taylor series (without proof, assuming the possibility of power series expansion in appropriate domains), Binomial series and series representation of exponential, trigonometric, logarithmic functions (without proofs of convergence); Fourier series, Euler formulas, Convergence of Fourier series (without proof), half range sine and cosine series, Parseval's theorem (without proof).

Text Books

1. H. Anton, I. Biven,S.Davis, "Calculus", Wiley, 10th edition, 2015.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdition, John Wiley & Sons, 2016.

Reference Books

1. J. Stewart, Essential Calculus, Cengage, 2nd edition, 2017
2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9 th Edition, Pearson, Reprint, 2002.
3. Peter V. O'Neil, Advanced Engineering Mathematics , Cengage, 7th Edition, 2012
4. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
5. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36 Edition, 2010.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Linear Algebra (10 hours)**	
1.1	Systems of linear equations, Solution by Gauss elimination	1
1.2	Row echelon form, finding rank from row echelon form, fundamental theorem for linear systems	3
1.3	Eigen values and eigen vectors	2
1.4	Diagonaliztion of matrices, orthogonal transformation, quadratic forms	4

	and their canonical forms.	
2	**Multivariable calculus-Differentiation (8 hours)**	
2.1	Concept of limit and continuity of functions of two variables, partial derivatives	2
2.2	Differentials, Local Linear approximations	2
2.3	Chain rule, total derivative	2
2.4	Maxima and minima	2
3	**Multivariable calculus-Integration (10 hours)**	
3.1	Double integrals (Cartesian)-evaluation	2
3.2	Change of order of integration in double integrals, change of coordinates (Cartesian to polar),	2
3.3	Finding areas and volumes, mass and centre of gravity of plane laminas	3
3.4	Triple integrals	3
4	**Sequences and series (8 hours)**	
4.1	Convergence of sequences and series, geometric and p-series	2
4.2	Test of convergence(comparison, ratio and root)	4
4.3	Alternating series and Leibnitz test, absolute and conditional convergence	2
5	**Series representation of functions (9 hours)**	
5.1	Taylor series, Binomial series and series representation of exponential, trigonometric, logarithmic functions;	3
5.2	Fourier series, Euler formulas, Convergence of Fourier series(Dirichlet's conditions)	3
5.3	Half range sine and cosine series, Parseval's theorem.	3

MAT 102	VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS	CATEGORY	L	T	P	CREDIT	Year of Introduction
		BSC	3	1	0	4	2019

Preamble: This course introduces the concepts and applications of differentiation and integration of vector valued functions, differential equations, Laplace and Fourier Transforms. The objective of this course is to familiarize the prospective engineers with some advanced concepts and methods in Mathematics which include the Calculus of vector valued functions, ordinary differential equations and basic transforms such as Laplace and Fourier Transforms which are invaluable for any engineer's mathematical tool box. The topics treated in this course have applications in all branches of engineering.

Prerequisite: Calculus of single and multi variable functions.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Compute the derivatives and line integrals of vector functions and learn their applications
CO 2	Evaluate surface and volume integrals and learn their inter-relations and applications.
CO 3	Solve homogeneous and non-homogeneous linear differential equation with constant coefficients
CO 4	Compute Laplace transform and apply them to solve ODEs arising in engineering
CO 5	Determine the Fourier transforms of functions and apply them to solve problems arising in engineering

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	2	1			1	2		2
CO 2	3	3	3	3	2	1			1	2		2
CO 3	3	3	3	3	2	1			1	2		2
CO 4	3	3	3	3	2	1			1	2		2
CO 5	3	3	3	3	2	1			1	2		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks	Test 2 (Marks)	
Remember	10	10	20
Understand	20	20	40
Apply	20	20	40
Analyse			
Evaluate			

Create			

Mark distribution

Total Marks	**CIE** (Marks)	**ESE** (Marks)	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks
Assignments: Assignment should include specific problems highlighting the applications of the methods introduced in this course in science and engineering.

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Compute the derivatives and line integrals of vector functions and learn their applications

1. How would you calculate the speed, velocity and acceleration at any instant of a particle moving in space whose position vector at time $t$is $\boldsymbol{r}(t)$?

2. Find the work done by the force field $F = (e^x - y^3)\boldsymbol{i} + (\cos y + x^3)$on a particle that travels once around the unit circle centred at origin having radius 1.

3. When do you say that a vector field is conservative? What are the implications if a vector field is conservative?

Course Outcome 2 (CO2): Evaluate surface and volume integrals and learn their inter-relations and applications

1. Write any one application each of line integral, double integral and surface integral.

2. Use the divergence theorem to find the outward flux of the vector field $F(x, y , z) = z\boldsymbol{k}$across the

$$x^2 + y^2 + z^2 = a^2$$

3. State Greens theorem. Use Green's theorem to express the area of a plane region bounded by a curve as a line integral.

Course Outcome 3 (CO3): Solve homogeneous and non-homogeneous linear differential equation with constant coefficients

1. If $y_1(x)$ and $y_2(x)$ are solutions of $y'' + py' + qy = 0$, where p, q are constants, show that

   $y_1(x) + y_2(x)$ is also a solution.

2. Solve the differential equation $y'' + y = 0.001x^2$ using method of undetermined coefficient.

3. Solve the differential equation of $y''' - 3y'' + 3y' - y = e^x - x - 1$.

Course Outcome 4 (CO4): Compute Laplace transform and apply them to solve ODEs arising in engineering

1. What is the inverse Laplace Transformof $(s) = \frac{3s-137}{s^2+2s+4}$?

2. Find Laplace Transform of Unit step function.

3. Solve the differential equation of $y'' + 9y = \delta\left(t - \frac{\pi}{2}\right)$? Given $y(0) = 2,\ y'(0) = 0$

Course Outcome 5(CO5): Determine the Fourier transforms of functions and apply them to solve problems arising in engineering

1. Find the Fourier integral representation of function defined by $f(x) = e^{-x}$ for $x > 0$ and $f(x) = 0$ for $x < 0$.

2. What are the conditions for the existence of Fourier Transform of a function $f(x)$?

3. Find the Fourier transform of $f(x) = 1$ for $|x| < 1$ and $f(x) = 0$ otherwise.

Model Question paper

QP CODE: PAGES:3

Reg No:_______________

Name :_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: MAT 102

Max. Marks: 100 **Duration: 3 Hours**

VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS

(2019-Scheme)

(Common to all branches)

PART A

(Answer all questions. Each question carries 3 marks)

1. Is the vector $\boldsymbol{r}$ **where** $\boldsymbol{r} = x\boldsymbol{i} + y\boldsymbol{j} + z\boldsymbol{k}$ conservative. Justify your answer.
2. State Greens theorem including all the required hypotheses
3. What is the outward flux of $\boldsymbol{F}(\boldsymbol{x}, \boldsymbol{y}, \boldsymbol{z}) = x\boldsymbol{i} + y\boldsymbol{j} + z\boldsymbol{k}$ across any unit cube**.**
4. What is the relationship between Green's theorem and Stokes theorem?
5. Solve $y'' + 4y' + 2.5y = 0$
6. Does the function $y = C_1 \cos x + C_2\, sinx$form a solution of$y'' + y = 0$?. Is it the general solution? Justify your answer.
7. Find the Laplace transform of $e^{-t} \sinh 4t$
8. Find the Laplace inverse transform of $\frac{1}{s\,(s^2+\omega^2)}$.
9. Given the Fourier transform $\frac{1}{\sqrt{2}} e^{-\frac{\omega^2}{4}}$ of $f(x) = e^{-x^2}$, find the Fourier transform of xe^{-x^2}
10. State the convolution theorem for Fourier transform

PART B

(Answer one full question from each module. Each full question carries 14 marks)

MODULE 1

11a) Prove that the force field $\boldsymbol{F} = e^y\boldsymbol{i} + xe^y\boldsymbol{j}$is conservative in the entire xy-plane

b**)** Use Greens theorem to find the area enclosed by the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$

12 a) Find the divergence of the vector field$\boldsymbol{F} = \frac{c}{(\boldsymbol{x^2+y^2+z^2})^{3/2}}(x\boldsymbol{i} + y\boldsymbol{j} + z\boldsymbol{k})$

b) Find the work done by the force field$\boldsymbol{F}(x, y, z) = xy\boldsymbol{i} + yz\boldsymbol{j} + xz\boldsymbol{k}$along C where

C is the curve$\boldsymbol{r}(t) = t\boldsymbol{i} + t^2\boldsymbol{j} + t^3\boldsymbol{k}$

MODULE II

13 a) Use divergence theorem to find the outward flux of the vector field

$\boldsymbol{F} = 2x\boldsymbol{i} + 3y\boldsymbol{j} + z^3\boldsymbol{k}$acrossthe unit cube bounded by or $x = 0$, $y = 0$,$z = 0$,$x = 1$,$y = 1$,$z = 1$

b) Find the circulation of $\boldsymbol{F} = (x - z)\boldsymbol{i} + (y - x)\boldsymbol{j} + (\boldsymbol{z} - \boldsymbol{xy})\boldsymbol{k}$ using Stokes theorem around the triangle with vertices $A(1,0,0)$, $B(0,2,0)$and $C(0,0,1)$

14 a**)** Use divergence theorem to find the volume of the cylindrical solid bounded by $x^2 + 4x + y^2 = 7$, $z = -1$, $z = 4$, given the vector field $\boldsymbol{F} = \boldsymbol{x}i + \boldsymbol{y}j + \boldsymbol{z}k$ across surfaceof the cylinder

b) Use Stokes theorem to evaluate$\int_C \boldsymbol{F}.\boldsymbol{dr}$where$\boldsymbol{F} = x^2\boldsymbol{i} + 3x\boldsymbol{j} - y^3\boldsymbol{k}$where Cis the circle $x^2 + y^2 = 1$ in the xy- plane with counterclockwise orientation looking down the positive z-axis

MODULE III

15 a) Solve $y'' + 4y' + 4y = x^2 + e^{-x}\cos x$

b) Solve $y''' - 3y'' + 3y' - y = e^x - x - 1$

16 a) Solve $\boldsymbol{y}''' + \boldsymbol{3}y'' + 3y' + y = 30e^{-x}$ given $y(0) = 3, y'(0) = -3$, $y''(0) = -47$

b) Using method of variation of parameters, solve $y'' + y = sec\, x$

MODULE IV

17 a) Find the inverse Laplace transform of $F(s) = \frac{2(e^{-s} - e^{-3s})}{s^2 - 4}$

b) Solve the differential equation $y'' + 16y = 4\delta(t - 3\pi)$; $y(0) = 2, y'(0) = 0$ using Laplace transform

18 a) Solve $y'' + 3y' + 2y = f(t)$ where $f(t) = 1$ for $0 < t < 1$ and $f(t) = 1$ for $t > 1$ using Laplace transform

b) Apply convolution theorem to find the Laplace inverse transform of $\frac{1}{s^2(s^2+\omega^2)}$

MODULE V

19 a) Find the Fourier cosine integral representation for $f(x) = e^{-kx}$ for $x > 0$ and $k > 0$ and hence evaluate $\int_0^\infty \frac{\cos wx}{k^2 + w^2}$ the function

b) Does the Fourier sine transform $f(x) = x^{-1}\sin x$ for $0 < x < \infty$ exist? Justify your answer

20 a) Find the Fourier transform of $f(x) = |x|$ for $|x| < 1$ and $f(x) = 0$ otherwise

b) Find the Fourier cosine transform of $f(x) = e^{-ax}$ for a> 0

Syllabus

Module 1 (Calculus of vector functions)

(Text 1: Relevant topics from sections 12.1, 12.2, 12.6, 13.6, 15.1, 15.2, 15.3)

Vector valued function of single variable, derivative of vector function and geometrical interpretation, motion along a curve-velocity, speed and acceleration. Concept of scalar and vector fields , Gradient and its properties, directional derivative , divergence and curl, Line integrals of vector fields, work as line integral, Conservative vector fields , independence of path and potential function(results without proof).

Module 2 (Vector integral theorems)

(Text 1: Relevant topics from sections 15.4, 15.5, 15.6, 15.7, 15.8)

Green's theorem (for simply connected domains, without proof) and applications to evaluating line integrals and finding areas. Surface integrals over surfaces of the form z = g(x, y), y = g(x, z) or x = g(y, z) , Flux integrals over surfaces of the form z = g(x, y), y = g(x, z) or x = g(y, z), divergence theorem (without proof) and its applications to finding flux integrals, Stokes' theorem (without proof) and its applications to finding line integrals of vector fields and work done.

Module- 3 (Ordinary differential equations)

(Text 2: Relevant topics from sections 2.1, 2.2, 2.5, 2.6, 2.7, 2.10, 3.1, 3.2, 3.3)

Homogenous linear differential equation of second order, superposition principle,general solution, homogenous linear ODEs with constant coefficients-general solution. Solution of Euler-Cauchy equations (second order only).Existence and uniqueness (without proof). Non homogenous linear ODEs-general solution, solution by the method of undetermined coefficients (for the right hand side of the form x^n,e^{kx},$sinax$,$cosax$,$e^{kx}sinax e^{kx}cosax$and their linear combinations), methods of variation of parameters. Solution of higher order equations-homogeneous and non-homogeneous with constant coefficient using method of undetermined coefficient.

Module- 4 (Laplace transforms)

(Text 2: Relevant topics from sections 6.1,6.2,6.3,6.4,6.5)

Laplace Transform and its inverse ,Existence theorem (without proof) , linearity,Laplace transform of basic functions, first shifting theorem, Laplace transform of derivatives and integrals, solution of differential equations using Laplace transform, Unit step function, Second shifting theorems. Dirac delta function and its Laplace transform, Solution of ordinary differential equation involving unit step function and Dirac delta functions. Convolution theorem(without proof)and its application to finding inverse Laplace transform of products of functions.

Module-5 (Fourier Tranforms)

(Text 2: Relevant topics from sections 11.7,11.8, 11.9)

Fourier integral representation, Fourier sine and cosine integrals. Fourier sine and cosine transforms, inverse sine and cosine transform. Fourier transform and inverse Fourier transform, basic properties. The Fourier transform of derivatives. Convolution theorem (without proof)

Text Books

1. H. Anton, I. Biven S.Davis, "Calculus", Wiley, 10th edition, 2015.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley, 10th edition, 2015.

Reference Books

1. J. Stewart, Essential Calculus, Cengage, 2nd edition, 2017
2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9 th Edition, Pearson,Reprint, 2002.
3. Peter O Neil, Advanced Engineering Mathematics, 7th Edition, Thomson, 2007.
4. Louis C Barret, C Ray Wylie, "Advanced Engineering Mathematics", Tata McGraw Hill, 6th edition, 2003.
5. VeerarajanT."Engineering Mathematics for first year", Tata McGraw - Hill, 2008.
6. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th edition , 2010.
7. Srimanta Pal, Subodh C. Bhunia, "Engineering Mathematics", Oxford University Press, 2015.
8. Ronald N. Bracewell, "The Fourier Transform and its Applications", McGraw – Hill International Editions, 2000.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Calculus of vector functions (9 hours)**	
1.1	Vector valued function of a scalar variable - derivative of vector valued function of scalar variable t-geometrical meaning	2
1.2	Motion along a curve-speed , velocity, acceleration	1
1.3	Gradient and its properties, directional derivative , divergent and curl	3
1.4	Line integrals with respect to arc length, line integrals of vector fields. Work done as line integral	2
1.5	Conservative vector field, independence of path, potential function	1

2	**Vector integral theorems(9 hours)**	
2.1	Green's theorem and it's applications	2
2.2	Surface integrals , flux integral and their evaluation	3
2.3	Divergence theorem and applications	2
2.4	Stokes theorem and applications	2
3	**Ordinary Differential Equations (9 hours)**	
3.1	Homogenous linear equation of second order, Superposition principle, general solution	1
3.2	Homogenous linear ODEs of second order with constant coefficients	2
3.3	Second order Euler-Cauchy equation	1
3.4	Non homogenous linear differential equations of second order with constant coefficient-solution by undetermined coefficients, variation of parameters.	3
3.5	Higher order equations with constant coefficients	2
4	**Laplace Transform (10 hours)**	
4.1	Laplace Transform , inverse Transform, Linearity, First shifting theorem, transform of basic functions	2
4.2	Transform of derivatives and integrals	1
4.3	Solution of Differential equations, Initial value problems by Laplace transform method.	2
4.4	Unit step function --- Second shifting theorem	2
4.5	Dirac Delta function and solution of ODE involving Dirac delta function	2
4.6	Convolution and related problems.	1
5	**Fourier Transform (8 hours)**	
5.1	Fourier integral representation	1
5.2	Fourier Cosine and Sine integrals and transforms	2
5.3	Complex Fourier integral representation, Fourier transform and its inverse transforms, basic properties	3
5.4	Fourier transform of derivatives, Convolution theorem	2

EST 130	BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		ESC	4	0	0	4	2019

Preamble:

This course aims to (1) equip the students with an understanding of the fundamental principles of electrical engineering(2) provide an overview of evolution of electronics, and introduce the working principle and examples of fundamental electronic devices and circuits (3) provide an overview of evolution of communication systems, and introduce the basic concepts in radio communication.

Prerequisite: Physics and Mathematics (Pre-university level)

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply fundamental concepts and circuit laws to solve simple DC electric circuits
CO 2	Develop and solve models of magnetic circuits
CO 3	Apply the fundamental laws of electrical engineering to solve simple ac circuits in steady state
CO 4	Describe working of a voltage amplifier
CO 5	Outline the principle of an electronic instrumentation system
CO 6	Explain the principle of radio and cellular communication

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1	-	-	-	-	-	-	-	-	-	2
CO 2	3	1	-	-	-	-	-	-	-	-	-	2
CO 3	3	1	-	-	-	-	-	-	-	-	-	2
CO 4	2	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	-	-	-	-	-	-	2
CO 6	2	-	-	-	-	-	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	Basic Electrical Engineering			Basic Electronics Engineering		
	Continuous Assessment Tests		End Semester Examination (Marks)	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 2 (Marks)		Test 1 (Marks)	Test 2 (Marks)	
Remember	0	0	10	10	10	20
Understand	12.5	12.5	20	15	15	30
Apply	12.5	12.5	20			
Analyse						
Evaluate						
Create						

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part I – Basic Electrical Engineering and Part II – Basic Electronics Engineering. Part I and PART II carries 50 marks each. For the end semester examination, part I contain 2 parts - Part A and Part B. Part A contain 5 questions carrying 4 marks each (not exceeding 2 questions from each module). Part B contains 2 questions from each module out of which one to be answered. Each question carries 10 mark and can have maximum 2 sub-divisions. The pattern for end semester examination for part II is same as that of part I. **However, student should answer both part I and part 2 in separate answer booklets.**

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Solve problems based on current division rule.

2. Solve problems with Mesh/node analysis.

3. Solve problems on Wye-Delta Transformation.

Course Outcome 2 (CO2):

1. Problems on series magnetic circuits

2. Problems on parallel magnetic circuits

3. Problems on composite magnetic ciruits

4. **Course Outcome 3 (CO3):**

1. problems on self inductance, mutual inductance and coefficient of coupling

2. problems on rms and average values of periodic waveforms

3. problems on series ac circuits

4. Compare star and Delta connected 3 phase AC systems.

Course Outcome 4 (CO4): Describe working of a voltage amplifier

1.What is the need of voltage divider biasing in an RC coupled amplifier?

2. Define operating point in the context of a BJT amplifier.

3. Why is it required to have a voltage amplifier in a public address system?

Course Outcome 5 (CO5): Outline the principle of an electronic instrumentation system

1. Draw the block diagram of an electronic instrumentation system.

2. What is a transducer?

3. Explain the working principle of operation of digital multimeter.

Course Outcome 6 (CO6): Explain the principle of radio and cellular communication

1. What is the working principle of an antenna when used in a radio transmitter?

2. What is the need of two separate sections RF section and IF section in a super heterodyne receiver?

3. What is meant by a cell in a cellular communication?

Model Question Paper

QP CODE: Pages: 3

Reg No.:________________

Name:__________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EST 130

Course Name: BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING

Max. Marks: 100 Duration: 3 hours

Answer both part I and part 2 in separate answer booklets

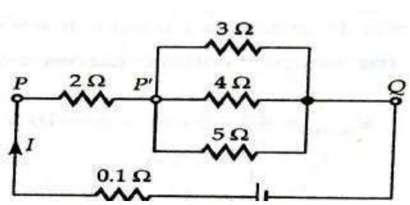
PART I

BASIC ELECTRICAL ENGINEERING

PART A

Answer all questions; each question carries 4 marks.

1. Calculate the current through the 4Ω resistor in the circuit shown, applying current division rule:



2. Calculate the RMS and average values of a purely sinusoidal current having peak value 15A.

3. An alternating voltage of (80+j60)V is applied to an RX circuit and the current flowing through the circuit is (-4+j10)A. Calculate the impedance of the circuit in rectangular and polar forms. Also determine if X is inductive or capacitive.

4. Derive the relation between line and phase values of voltage in a three phase star connected system.

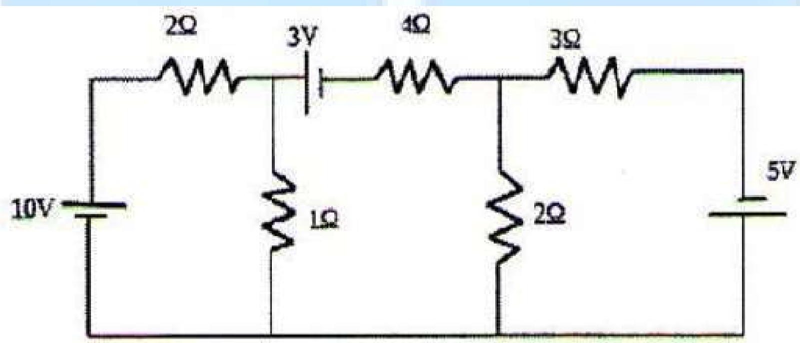
5. Compare electric and magnetic circuits. *(5x4=20)*

PART B

Answer one question from each module; each question carries 10 marks.

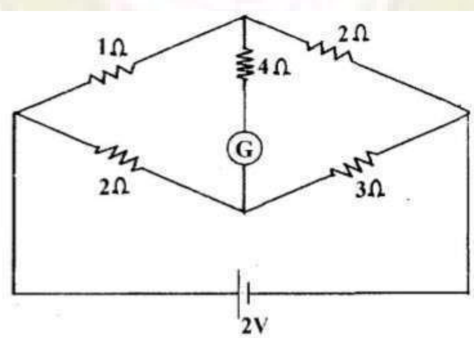
Module 1

6. . Calculate the node voltages in the circuit shown, applying node analysis:



7. (a) State and explain Kirchhoff's laws. (4 marks)

(b) Calculate the current through the galvanometer (G) in the circuit shown:



(6 marks)

Module 2

8. (a) State and explain Faraday's laws of electromagnetic induction with examples. (4 marks)

(b) Differentiate between statically and dynamically induced emf. A conductor of length 0.5m moves in a uniform magnetic field of flux density 1.1T at a velocity of 30m/s. Calculate the emf induced in the conductor if the direction of motion of the conductor is inclined at 60^0 to the direction of field. (6 marks)

9. (a) Derive the amplitude factor and form factor of a purely sinusoidal waveform. (5 marks)

(b) A current wave is made up of two components-a 5A dc component and a 50Hz ac component, which is a sinusoidal wave with a peak value of 5A. Sketch the resultant waveform and determine its RMS and average values. (5 marks)

Module 3

10. Draw the power triangle and define active, reactive and apparent powers in ac circuits. Two coils A and B are connected in series across a 240V, 50Hz supply. The resistance of A is 5Ω and the inductance of B is 0.015H. If the input from the supply is 3kW and 2kVAR, find the inductance of A and the resistance of B. Also calculate the voltage across each coil.

11. A balanced three phase load consists of three coils each having resistance of 4Ω and inductance 0.02H. It is connected to a 415V, 50Hz, 3-phase ac supply. Determine the phase voltage, phase current, power factor and active power when the loads are connected in (i) star (ii) delta.

(3x10=30)

PART II

BASIC ELECTRONICS ENGINEERING

PART A

Answer all questions; each question carries 4 marks.

1. Give the specifications of a resistor. The colour bands marked on a resistor are Blue, Grey, Yellow and Gold. What are the minimum and maximum resistance values expected from that resistance?
2. What is meant by avalanche breakdown?
3. Explain the working of a full-wave bridge rectifier.
4. Discuss the role of coupling and bypass capacitors in a single stage RC coupled amplifier.
5. Differentiate AM and FM communication systems.

(5x4=20)

PART B

Answer one question from each module; each question carries 10 marks.

Module 4

6. a) Explain with diagram the principle of operation of an NPN transistor. (5)

   b) Sketch and explain the typical input-output characteristics of a BJT when connected in common emitter configuration. (5)

OR

7. a) Explain the formation of a potential barrier in a P-N junction diode. (5)

   b) What do you understand by Avalanche breakdown? Draw and explain the V-I characteristics of a P-N junction and Zener diode. (5)

Module 5

8. a) With a neat circuit diagram, explain the working of an RC coupled amplifier. (6)

   b) Draw the frequency response characteristics of an RC coupled amplifier and state the reasons for the reduction of gain at lower and higher frequencies. (4)

OR

9. a) With the help of block diagram, explain how an electronic instrumentation system. (6)

   b) Explain the principle of an antenna. (4)

Module 6

10. a) With the help of a block diagram, explain the working of Super hetrodyne receiver. (6)

    b) Explain the importance of antenna in a communication system. (4)

OR

11. a) With neat sketches explain a cellular communication system. (5)

    b) Explain GSM communication with the help of a block diagram. (5)

(3x10=30)

SYLLABUS

MODULE 1: Elementary Concepts of Electric Circuits

Elementary concepts of DC electric circuits: Basic Terminology including voltage, current, power, resistance, emf; Resistances in series and parallel; Current and Voltage Division Rules; Capacitors & Inductors: V-I relations and energy stored. Ohms Law and Kirchhoff's laws-Problems; Star-delta conversion (resistive networks only-derivation not required)-problems.

Analysis of DC electric circuits: Mesh current method - Matrix representation - Solution of network equations. Node voltage methods-matrix representation-solution of network equations by matrix methods. Numerical problems.

MODULE 2: Elementary Concepts of Magnetic circuits, Electromagnetic Induction and AC fundamentals

Magnetic Circuits: Basic Terminology: MMF, field strength, flux density, reluctance - comparison between electric and magnetic circuits- Series and parallel magnetic circuits with composite materials, numerical problems.

Electromagnetic Induction: Faraday's laws, problems, Lenz's law- statically induced and dynamically induced emfs - Self-inductance and mutual inductance, coefficient of coupling

Alternating Current fundamentals: Generation of alternating voltages-Representation of sinusoidal waveforms: frequency, period, Average, RMS values and form factor of waveforms-Numerical Problems.

MODULE 3: AC Circuits

AC Circuits: Phasor representation of sinusoidal quantities. Trignometric, Rectangular, Polar and complex forms. Analysis of simple AC circuits: Purely resistive, inductive & capacitive circuits; Inductive and capacitive reactance, concept of impedance. Average Power Power factor. Analysis of RL, RC and RLC series circuits-active, reactive and apparent power. Simple numerical problems.

Three phase AC systems: Generation of three phase voltages; advantages of three phase systems, star and delta connections (balanced only), relation between line and phase voltages, line and phase currents- Numerical problems

MODULE 4

Introduction to Semiconductor devices: Evolution of electronics – Vacuum tubes to nano electronics. Resistors, Capacitors and Inductors (constructional features not required): types, specifications. Standard values, color coding. PN Junction diode: Principle of operation, V-I characteristics, principle of avalanche breakdown. Bipolar Junction Transistors: PNP and NPN structures, Principle of operation, relation between current gains in CE, CB and CC, input and output characteristics of common emitter configuration.

MODULE 5

Basic electronic circuits and instrumentation: Rectifiers and power supplies: Block diagram description of a dc power supply, Working of a full wave bridge rectifier, capacitor filter (no analysis), working of simple zener voltage regulator. Amplifiers: Block diagram of Public Address system, Circuit diagram and working of common emitter (RC coupled) amplifier with its frequency response, Concept of voltage divider biasing. Electronic Instrumentation: Block diagram of an electronic instrumentation system.

MODULE 6

Introduction to Communication Systems: Evolution of communication systems – Telegraphy to 5G. Radio communication: principle of AM & FM, frequency bands used for various communication systems, block diagram of super heterodyne receiver, Principle of antenna – radiation from accelerated charge. Mobile communication: basic principles of cellular communications, principle and block diagram of GSM.

Text Books

1. D P Kothari and I J Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
2. D C Kulshreshtha, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
3. ChinmoySaha, Arindham Halder and Debarati Ganguly, Basic Electronics - Principles and Applications, Cambridge University Press, 2018.
4. M.S.Sukhija and T.K.Nagsarkar, Basic Electrical and Electronics Engineering, Oxford University Press, 2012.
5. Wayne Tomasi and Neil Storey, A Textbook On Basic Communication and Information Engineering, Pearson, 2010.

Reference Books

1. Del Toro V, "Electrical Engineering Fundamentals", Pearson Education.
2. T. K. Nagsarkar, M. S. Sukhija, "Basic Electrical Engineering", Oxford Higher Education.
3. Hayt W H, Kemmerly J E, and Durbin S M, "Engineering Circuit Analysis", Tata McGraw-Hill
4. Hughes, "Electrical and Electronic Technology", Pearson Education.
5. V. N. Mittle and Arvind Mittal, "Basic Electrical Engineering," Second Edition, McGraw Hill.
6. Parker and Smith, "Problems in Electrical Engineering", CBS Publishers and Distributors.
7. S. B. Lal Seksena and Kaustuv Dasgupta, "Fundamentals of Electrical Engineering", Cambridge University Press.
8. Anant Agarwal, Jeffrey Lang, Foundations of Analog and Digital Electronic Circuits, Morgan Kaufmann Publishers, 2005.
9. Bernard Grob, Ba sic Electronics, McGraw Hill.
10. A. Bruce Carlson, Paul B. Crilly, Communication Systems: An Introduction to Signals and Noise in Electrical Communication, Tata McGraw Hill, 5^{th} Edition.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
1	***Elementary Concepts of Electric Circuits***	
1.1	**Elementary concepts of DC electric circuits:** Basic Terminology including voltage, current, power, resistance, emf; Resistances in series and parallel; Current and Voltage Division Rules; Capacitors & Inductors: V-I relations and energy stored. Ohms Law and Kirchhoff's laws-Problems; Star-delta conversion (resistive networks only-derivation not required)-problems.	1 2 1
1.2	**Analysis of DC electric circuits:** Mesh current method - Matrix representation - Solution of network equations. Node voltage methods-matrix representation-solution of network equations by matrix methods. Numerical problems.	1 1 2
2	**Elementary Concepts of Magnetic circuits, Electromagnetic Induction and AC fundamentals**	
2.1	**Magnetic Circuits:** Basic Terminology: MMF, field strength, flux density, reluctance - comparison between electric and magnetic circuits- Series and parallel magnetic circuits with composite materials, numerical problems.	1 2
2.2	**Electromagnetic Induction:** Faraday's laws, problems, Lenz's law-statically induced and dynamically induced emfs - Self-inductance and mutual inductance, coefficient of coupling	1 2
2.3	**Alternating Current fundamentals:** Generation of alternating voltages-Representation of sinusoidal waveforms: frequency, period, Average, RMS values and form factor of waveforms-Numerical Problems.	2
3	**AC Circuits**	

3.1	**AC Circuits:** Phasor representation of sinusoidal quantities. Trigonometric, Rectangular, Polar and complex forms. Analysis of simple AC circuits: Purely resistive, inductive & capacitive circuits; Inductive and capacitive reactance, concept of impedance. Average Power, Power factor. Analysis of RL, RC and RLC series circuits-active, reactive and apparent power. Simple numerical problems.	1 2 1 2
3.2	**Three phase AC systems:** Generation of three phase voltages; advantages of three phase systems, star and delta connections (balanced only), relation between line and phase voltages, line and phase currents- Numerical problems.	2
4	**Introduction to Semiconductor devices**	
4.1	Evolution of electronics – Vacuum tubes to nano electronics (In evolutional perspective only)	1
4.2	Resistors, Capacitors and Inductors: types, specifications. Standard values, color coding (No constructional features)	2
4.3	**PN Junction diode**: Principle of operation, V-I characteristics, principle of avalanche breakdown	2
4.4	**Bipolar Junction Transistors:** PNP and NPN structures, Principle of operation, relation between current gains in CE, CB and CC, input and output characteristics of common emitter configuration	3
5	**Basic electronic circuits and instrumentation**	
5.1	**Rectifiers and power supplies:** Block diagram description of a dc power supply, Working of a full wave bridge rectifier, capacitor filter (no analysis), working of simple zener voltage regulator	3
5.2	**Amplifiers:** Block diagram of Public Address system, Circuit diagram and working of common emitter (RC coupled) amplifier with its frequency response, Concept of voltage divider biasing	4
5.3	**Electronic Instrumentation:** Block diagram of an electronic instrumentation system	2
6	**Introduction to Communication Systems**	
6.1	Evolution of communication systems – Telegraphy to 5G	1

6.2	**Radio communication:** principle of AM & FM, frequency bands used for various communication systems, block diagram of super heterodyne receiver, Principle of antenna – radiation from accelerated charge	4
6.3	**Mobile communication:** basic principles of cellular communications, principle and block diagram of GSM.	2

Suggested Simulation Assignments for Basic Electronics Engineering

1. Plot V-I characteristics of Si and Ge diodes on a simulator
2. Plot Input and Output characteristics of BJT on a simulator
3. Implementation of half wave and full wave rectifiers
4. Simulation of RC coupled amplifier with the design supplied
5. Generation of AM signal

Note: The simulations can be done on open tools such as QUCS, KiCad, GNURadio or similar software to augment the understanding.

CYT 100	ENGINEERING CHEMISTRY	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		BSC	3	1	0	4	2019

Preamble: To enable the students to acquire knowledge in the concepts of chemistry for engineering applications and to familiarize the students with different application oriented topics like spectroscopy, electrochemistry, instrumental methods etc. Also familiarize the students with topics like mechanism of corrosion, corrosion prevention methods, SEM, stereochemistry, polymers, desalination etc., which enable them to develop abilities and skills that are relevant to the study and practice of chemistry.

Prerequisite: Concepts of chemistry introduced at the plus two levels in schools

Course outcomes: After the completion of the course the students will be able to

CO 1	Apply the basic concepts of electrochemistry and corrosion to explore its possible applications in various engineering fields.
CO 2	Understand various spectroscopic techniques like UV-Visible, IR, NMR and its applications.
CO 3	Apply the knowledge of analytical method for characterizing a chemical mixture or a compound. Understand the basic concept of SEM for surface characterisation of nanomaterials.
CO 4	Learn about the basics of stereochemistry and its application. Apply the knowledge of conducting polymers and advanced polymers in engineering.
CO 5	Study various types of water treatment methods to develop skills for treating wastewater.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	1	2	1									
CO 2	1	1		1	2							
CO 3	1	1		1	2							
CO 4	2	1										
CO 5	1			1			3					

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	**2**	
Remember	15	15	30
Understand	25	25	50
Apply	10	10	20
Analyse			
Evaluate			
Create			

End Semester Examination Pattern: There will be two parts- **Part A** and **Part B. Part A** contains **10** questions (**2** questions from each module), having **3** marks for each question. Students should answer **all** questions. **Part B** contains **2** questions from each module, of which student should answer any one. Each question can have maximum **2** subdivisions and carries **14** marks.

Course Level Assessment Questions

Course Outcome 1 (CO 1):

1. What is calomel electrode? Give the reduction reaction (3 Marks)

2. List three important advantages of potentiometric titration (3 Marks)

3. (a) Explain how electroless plating copper and nickel are carried out (10 Marks)

(b) Calculate the emf of the following cell at 30°C, Z n / Zn^{2+} (0.1M) // Ag^+ (0.01M) // Ag.

Given E^0 Zn^{2+}/Zn = -0.76 V, E^0 Ag^+/Ag = 0.8 V. (4 Marks)

Course Outcome 2 (CO 2)

1. State Beer Lambert's law (3 Marks)

2. List the important applications of IR spectroscopy (3 Marks)

3. (a) What is Chemical shift? What are factors affecting Chemical shift? How ^1H NMR spectrum of CH_3COCH_2Cl interpreted using the concept of chemical shift. (10 Marks)

(b) Calculate the force constant of HF molecule, if it shows IR absorption at 4138 cm^{-1}. Given that atomic masses of hydrogen and fluorine are 1u and 19u respectively. (4 Marks)

Course Outcome 3 (CO 3):

1. Distinguish between TGA and DTA (3 Marks)

2. Give two differences between GSC and GLC (3 Marks)

3. (a) Explain the principle, instrumentation and procedure of HPLC (10 Marks)

(b) Interpret TGA of $CaC_2O_4 . H_2O$ (4 Marks)

Course Outcome 4 (CO 4):

1. Explain the geometrical isomerism in double bonds (3 Marks)

2. What are the rules of assigning R-S notation? (3 Marks)

3. (a) What are conducting polymers? How it is classified? Give the preparation of polyaniline (10 Marks)

(b) Draw the stereoisomers possible for CH_3-$(CHOH)_2$-COOH (4 Marks)

Course Outcome 5 (CO 5):

1. What is degree of hardness? (3 Marks)

2. Define BOD and COD (3 Marks)

3. (a) Explain the EDTA estimation of hardness (10 Marks)

(b) Standard hard water contains 20 g of CaCO3 per liter,50 mL of this required 30mL of EDTA solution, 50mL of sample water required 20mL of EDTA solution. 50mL sample water after boiling required 14 mL EDTA solution. Calculate the temporary hardness of the given sample of water, in terms of ppm. (4 Marks)

MODEL QUESTION PAPER

Total Pages:

Reg No.:________________ Name:____________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER B.TECH DEGREE EXAMINATION

Course Code: CYT100,

Course Name: ENGINEERING CHEMISTRY

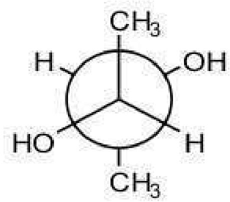
Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks Marks

1	What is potentiometric titration? How the end point is determined graphically?	(3)
2	What is Galvanic series? How is it different from electrochemical series?	(3)
3	Which of the following molecules can give IR absorption? Give reason? (a) O_2 (b) H_2O (c) N_2 (d) HCl	(3)
4	Which of the following molecules show UV-Visible absorption? Give reason. (a) Ethane (b) Butadiene (c) Benzene	(3)

5		What are the visualization techniques used in TLC?	(3)
6		Write the three important applications of nanomaterials.	(3)
7		Draw the Fischer projection formula and find R-S notation of	(3)



8		Write the structure of a) Polypyrroleb) Kevlar.	(3
9		What is break point chlorination?	(3)
10		What is reverse osmosis?	(3)

PART B

Answer any one full question from each module, each question carries 14 marks

Module 1

11 a) Give the construction of Li-ion cell. Give the reactions that take place at the electrodes during charging and discharging. What happens to anodic material when the cell is 100% charged. (10)

b) Calculate the standard electrode potential of Cu, if its electrode potential at 25 °C is 0.296 V and the concentration of Cu^{2+} is 0.015 M. (4)

OR

12 a) Explain the mechanism of electrochemical corrosion of iron in oxygen rich and oxygen deficient acidic and basic environments. (10)

b) Given below are reduction potentials of some species (4)

$MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$; $E^0 = +1.51$ V

$Cl_2 + 2e \rightarrow 2Cl^-$; $E^0 = +1.36$ V

$S_2O_8^{2-} + 2e \rightarrow 2SO_4^{2-}$; $E^0 = +1.98$ V

Use the above data to examine whether the acids, dil. HCl and dil. H_2SO_4 , can be used to provide acid medium in redox titrations involving $KMnO_4$.

Module 2

13 a) What is spin-spin splitting? Draw the NMR spectrum of (i) CH_3 CH_2CH_2 Br (ii) $CH_3CH(Br)CH_3$ Explain how NMR spectrum can be used to identify the two isomers. (10)

b) A dye solution of concentration 0.08M shows absorbance of 0.012 at 600 nm; while a test solution of same dye shows absorbance of 0.084 under same conditions. Find the concentration of the test solution. (4)

OR

14 a) Explain the basic principle of UV-Visible spectroscopy. What are the possible electronic transitions? Explain with examples. (10)

b) Sketch the vibrational modes of CO_2 and H_2O. Which of them are IR active? (4)

Module 3

15	a)	Explain the principle, instrumentation and procedure involved in gas chromatography.	(10)
	b)	Explain the DTA of $CaC_2O_4.H_2O$ with a neat sketch.	(4)
		OR	
16	a)	Explain the various chemical methods used for the synthesis of nanomaterial	(10)
	b)	How TGA is used to analyse the thermal stability of polymers?	(4)

Module 4

17	a)	What are conformers? Draw the*cis* and *trans*isomers of 1, 3-dimethylcylohexane. Which conformer (chair form) is more stable in each case?	(10)
	b)	What is ABS? Give properties and applications.	(4)
		OR	
18	a)	Explain the various structural isomers with suitable example.	(10)
	b)	What is OLED? Draw a labelled diagram.	(4)

Module 5

19	a)	What are ion exchange resins? Explain ion exchange process for removal of hardness of water? How exhausted resins are regenerated?	(10)
	b)	50 mL sewage water is diluted to 2000 mL with dilution water; the initial dissolved oxygen was 7.7 ppm. The dissolved oxygen level after 5 days of incubation was 2.4 ppm. Find the BOD of the sewage.	(4)
		OR	
20	a)	What are the different steps in sewage treatment? Give the flow diagram. Explain the working of trickling filter.	(10)
	b)	Calculate the temporary and permanent hardness of a water sample which contains $[Ca^{2+}]$ = 160 mg/L, $[Mg^{2+}]$ = 192 mg/L and $[HCO_3^-]$ = 122 mg/L.	(4)

Syllabus

Module 1

Electrochemistry and Corrosion

Introduction - Differences between electrolytic and electrochemical cells - Daniel cell - redox reactions - cell representation. Different types of electrodes (brief) - Reference electrodes - SHE - Calomel electrode - Glass Electrode - Construction and Working. Single electrode potential - definition - Helmholtz electrical double layer -Determination of E^0 using calomel electrode.Determination of pH using glass electrode.Electrochemical series and its applications. Free energy and EMF - Nernst Equation - Derivation - single electrode and cell (Numericals) -Application - Variation of emf with temperature. Potentiometric titration - Introduction -Redox titration only.Lithiumion cell - construction and working.Conductivity- Measurement of conductivity of a solution (Numericals).

Corrosion-Electrochemicalcorrosion – mechanism. Galvanic series- cathodic protection - electroless plating –Copper and Nickel plating.

Module 2

Spectroscopic Techniques and Applications

Introduction- Types of spectrum - electromagnetic spectrum - molecular energy levels - Beer Lambert's law (Numericals). UV-Visible Spectroscopy – Principle - Types of electronic transitions - Energy level diagram of ethane, butadiene, benzene and hexatriene. Instrumentation of UV-Visible spectrometer and applications.IR-Spectroscopy – Principle - Number of vibrational modes - Vibrational energy states of a diatomic molecule and -Determination of force constant of diatomic molecule (Numericals) –Applications. ^{1}H NMR spectroscopy – Principle - Relation between field strength and frequency - chemical shift - spin-spin splitting (spectral problems) - coupling constant (definition) - applications of NMR- including MRI (brief).

Module 3

Instrumental Methods and Nanomaterials

Thermal analysis –TGA- Principle, instrumentation (block diagram) and applications – TGA of $CaC_2O_4.H_2O$ and polymers. DTA-Principle, instrumentation (block diagram) and applications - DTA of $CaC_2O_4.H_2O$. Chromatographic methods - Basic principles and applications of column and TLC-Retention factor. GC and HPLC-Principle, instrumentation (block diagram) - retention time and applications.

Nanomaterials - Definition - Classification - Chemical methods of preparation - Hydrolysis and Reduction - Applications of nanomaterials - Surface characterisation -SEM – Principle and instrumentation (block diagram).

Module 4

Stereochemistry and Polymer Chemistry

Isomerism-Structural, chain, position, functional, tautomerism and matamerism - Definition with examples - Representation of 3D structures-Newman, Sawhorse, Wedge and Fischer projection of substituted methane and ethane. Stereoisomerism - Geometrical isomerism in double bonds and cycloalkanes (cis-trans and E-Z notations). R-S Notation – Rules and examples - Optical isomerism, Chirality, Enantiomers and Diastereoisomers-Definition with examples.Conformational analysis of ethane, butane, cyclohexane, mono and di methyl substituted cyclohexane.

Copolymers - Definition - Types - Random, Alternating, Block and Graft copolymers - ABS - preparation, properties and applications.Kevlar-preparation, properties and applications.Conducting polymers - Doping -Polyaniline and Polypyrrole - preparation properties and applications. OLED - Principle, construction and advantages.

Module 5

Water Chemistry and Sewage Water Treatment

Water characteristics - Hardness - Types of hardness- Temporary and Permanent - Disadvantages of hard water -Units of hardness- ppm and mg/L -Degree of hardness (Numericals) - Estimation of hardness-EDTA method (Numericals). Water softening methods-Ion exchange process-Principle, procedure and advantages. Reverse osmosis – principle, process and advantages. Municipal water treatment (brief) - Disinfection methods - chlorination, ozone andUV irradiation.

Dissolved oxygen (DO) -Estimation (only brief procedure-Winkler's method), BOD and COD-definition, estimation (only brief procedure) and significance (Numericals). Sewage water treatment - Primary, Secondary and Tertiary - Flow diagram -Trickling filter and UASB process.

Text Books

1. B. L. Tembe, Kamaluddin, M. S. Krishnan, "Engineering Chemistry (NPTEL Web-book)", 2018.

2. P. W. Atkins, "Physical Chemistry", Oxford University Press, 10^{th} edn., 2014.

Reference Books

1. C. N. Banwell, "Fundamentals of Molecular Spectroscopy", McGraw-Hill, 4^{th}edn., 1995.
2. Donald L. Pavia, "Introduction to Spectroscopy", Cengage Learning India Pvt. Ltd., 2015.
3. B. R. Puri, L. R. Sharma, M. S. Pathania, "Principles of Physical Chemistry", Vishal Publishing Co., 47^{th} Edition, 2017.
4. H. H. Willard, L. L. Merritt, "Instrumental Methods of Analysis", CBS Publishers, 7^{th} Edition, 2005.
5. Ernest L. Eliel, Samuel H. Wilen, "Stereo-chemistry of Organic Compounds", WILEY, 2008.
6. Raymond B. Seymour, Charles E. Carraher, "Polymer Chemistry: An Introduction", Marcel Dekker Inc; 4th Revised Edition, 1996.
7. MuhammedArif, Annette Fernandez, Kavitha P. Nair "Engineering Chemistry", Owl Books, 2019.
8. Ahad J., "Engineering Chemistry", Jai Publication, 2019.
9. Roy K. Varghese, "Engineering Chemistry", Crownplus Publishers, 2019.
10. Soney C. George,RinoLaly Jose, "Text Book of Engineering Chemistry", S. Chand & Company Pvt Ltd, 2019.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (hrs)
1	**Electrochemistry and Corrosion**	9
1.1	Introduction - Differences between electrolytic and electrochemical cells- Daniel cell - redox reactions - cell representation. Different types of electrodes (brief) - Reference electrodes- SHE - Calomel electrode - Glass Electrode - Construction and Working.	2
1.2	Single electrode potential – definition - Helmholtz electrical double layer - Determination of E^0 using calomel electrode. Determination of pH using glass electrode. Electrochemical series and its applications. Free energy and EMF - Nernst Equation – Derivation - single electrode and cell (Numericals) -Application -Variation of emf with temperature.	3
1.3	Potentiometric titration - Introduction -Redox titration only. Lithiumion cell - construction and working. Conductivity- Measurement of conductivity of a solution (Numericals).	2
1.4	Corrosion-Electrochemicalcorrosion – mechanism. Galvanic series- cathodic protection - electroless plating –Copper and Nickel plating.	2
2	**Spectroscopic Techniques and Applications**	9
2.1	Introduction- Types of spectrum - electromagnetic spectrum - molecular energy levels - Beer Lambert's law (Numericals).	2
2.2	UV-Visible Spectroscopy – Principle - Types of electronic transitions - Energy level diagram of ethane, butadiene, benzene and hexatriene. Instrumentation of UV-Visible spectrometer and applications.	2
2.3	IR-Spectroscopy – Principle - Number of vibrational modes -Vibrational energy states of a diatomic molecule and -Determination of force constant of diatomic molecule (Numericals) –Applications.	2
2.4	^1H NMR spectroscopy – Principle - Relation between field strength and frequency - chemical shift - spin-spin splitting (spectral problems) - coupling constant (definition) - applications of NMR- including MRI (brief).	3
3	**Instrumental Methods and Nanomaterials**	9
3.1	Thermal analysis –TGA- Principle, instrumentation (block diagram) and applications – TGA of $CaC_2O_4.H_2O$ and polymers. DTA-Principle, instrumentation (block diagram) and applications - DTA of $CaC_2O_4.H_2O$.	2

3.2	Chromatographic methods - Basic principles and applications of column and TLC-Retention factor.	**2**
3.3	GC and HPLC-Principle, instrumentation (block diagram) - retention time and applications.	**2**
3.4	Nanomaterials - Definition - Classification - Chemical methods of preparation - Hydrolysis and Reduction - Applications of nanomaterials - Surface characterisation -SEM – Principle and instrumentation (block diagram).	**3**
4	**Stereochemistry and Polymer Chemistry**	**9**
4.1	Isomerism-Structural, chain, position, functional, tautomerism and matamerism - Definition with examples - Representation of 3D structures-Newman, Sawhorse, Wedge and Fischer projection of substituted methane and ethane. Stereoisomerism - Geometrical isomerism in double bonds and cycloalkanes (cis-trans and E-Z notations).	**2**
4.2	R-S Notation – Rules and examples - Optical isomerism, Chirality, Enantiomers and Diastereoisomers-Definition with examples.	**1**
4.3	Conformational analysis of ethane, butane, cyclohexane, mono and di methyl substituted cyclohexane.	**2**
4.4	Copolymers - Definition - Types - Random, Alternating, Block and Graft copolymers - ABS - preparation, properties and applications. Kevlar-preparation, properties and applications. Conducting polymers - Doping -Polyaniline and Polypyrrole - preparation properties and applications. OLED - Principle, construction and advantages.	**4**
5	**Water Chemistry and Sewage Water Treatment**	**9**
5.1	Water characteristics - Hardness - Types of hardness- Temporary and Permanent - Disadvantages of hard water -Units of hardness- ppm and mg/L -Degree of hardness (Numericals) - Estimation of hardness-EDTA method (Numericals). Water softening methods-Ion exchange process-Principle, procedure and advantages. Reverse osmosis – principle, process and advantages.	**3**
5.2	Municipal water treatment (brief) - Disinfection methods - chlorination, ozone andUV irradiation.	**2**
5.3	Dissolved oxygen (DO) -Estimation (only brief procedure-Winkler's method), BOD and COD-definition, estimation (only brief procedure) and significance (Numericals).	**2**
5.4	Sewage water treatment - Primary, Secondary and Tertiary - Flow diagram - Trickling filter and UASB process.	**2**

EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		ESC	4	0	0	4	2019

Preamble:

Objective of this course is to provide an insight and inculcate the essentials of Civil Engineering discipline to the students of all branches of Engineering and to provide the students an illustration of the significance of the Civil Engineering Profession in satisfying the societal needs.

To introduce the students to the basic principles of mechanical engineering

Prerequisite: NIL

Course Outcomes: After completion of the course, the student will be able to

CO 1	Recall the role of civil engineer in society and to relate the various disciplines of Civil Engineering.
CO 2	Explain different types of buildings, building components, building materials and building construction
CO 3	Describe the importance, objectives and principles of surveying.
CO 4	Summarise the basic infrastructure services MEP, HVAC, elevators, escalators and ramps
CO 5	Discuss the Materials, energy systems, water management and environment for green buildings.
CO 6	Analyse thermodynamic cycles and calculate its efficiency
CO 7	Illustrate the working and features of IC Engines
CO 8	Explain the basic principles of Refrigeration and Air Conditioning
CO 9	Describe the working of hydraulic machines
CO 10	Explain the working of power transmission elements
CO 11	Describe the basic manufacturing, metal joining and machining processes

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	-	-	-	-	3	2	2	-	-	-	-
CO2	3	2	-	1	3	-	-	3	-	-	-	-
CO3	3	2	-	-	3	-	-	-	2	-	-	-

CO4	3	2	-	-	3	-	-	-	2	-	-	-
CO5	3	2	-	-	3	2	3	-	2	-	-	-
CO6	3	2										
CO7	3	1										
CO8	3	1										
CO9	3	2										
CO10	3	1										
CO11	3											

Assessment Pattern

	Basic Civil Engineering			**Basic Mechanical Engineering**		
Bloom's Category	**Continuous Assessment**		**End Semester Examination (marks)**	**Continuous Assessment**		**End Semester Examination (marks)**
	Test 1 marks	**Test 2 marks**		**Test 1 marks**	**Test 2 marks**	
Remember	5	5	10	7.5	7.5	15
Understand	20	20	40	12.5	12.5	25
Apply				5	5	10
Analyse						
Evaluate						
Create						

Mark distribution

Total Marks	CIE (Marks)	ESE (Marks)	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern:

There will be two parts; Part I – Basic Civil Engineering and Part II – Basic Mechanical Engineering. Part I and PART II carries 50 marks each. For the end semester examination, part I contain 2 parts -

Part A and Part B. Part A contain 5 questions carrying 4 marks each (not exceeding 2 questions from each module). Part B contains 2 questions from each module out of which one to be answered. Each question carries 10 mark and can have maximum 2 sub-divisions. The pattern for end semester examination for part II is same as that of part I. **However, student should answer both part I and part 2 in separate answer booklets.**

Course Level Assessment Questions:

Course Outcome CO1: *To recall the role of civil engineer in society and to relate the various disciplines of Civil Engineering.*

1.Explain relevance of Civil engineering in the overall infrastructural development of the country.
Course outcome 2 (CO2) (One question from each module and not more than two)

Explain different types of buildings, building components, building materials and building construction

1. Discuss the difference between plinth area and carpet area.

Course outcome 3 (CO3) (One question from each module and not more than two)

Describe the importance, objectives and principles of surveying.

1. Explain the importance of surveying in Civil Engineering

Course outcome 4 (CO4) (One question from each module and not more than two)

Summarise the basic infrastructure services MEP, HVAC, elevators, escalators and ramps

1. Explain the civil engineering aspects of elevators, escalators and ramps in buildings

Course outcome 5 (CO5) (One question from each module and not more than two)

Discuss the Materials, energy systems, water management and environment for green buildings.

1. Discuss the relevance of Green building in society

Section II *Answer any 1 full question from each module. Each full question carries 10 marks*

Course Outcome 1 (CO1) (Two full question from each module and each question can have maximum 2 sub-divisions)

To recall the role of civil engineer in society and to relate the various disciplines of Civil Engineering

CO Questions

1. a List out the types of building as per occupancy. Explain any two, each in about five sentences.
b. Discuss the components of a building with a neat figure.

2. a. What are the major disciplines of civil engineering and explain their role in the infrastructural framework.

b. Explain the role of NBC, KBR & CRZ norms in building rules and regulations prevailing in our country.

Course Outcome 2 (CO2) & Course Outcome 3 (CO3) (Two full question from each module and each question can have maximum 2 sub-divisions)

Explain different types of buildings, building components, building materials and building construction & Describe the importance, objectives and principles of surveying.

CO Questions

1. **a.** What are the different kinds of cement available and what is their use.
   b. List the properties of good building bricks. Explain any five.
2. a. List and explain any five modern construction materials used for construction.
   b. Explain the objectives and principles of surveying

Course outcome 4 (CO4) & Course outcome 5 (CO5) (Two full question from each module and each question can have maximum 2 sub-divisions)

Summarise the basic infrastructure services MEP, HVAC, elevators, escalators and ramps & Discuss the Materials, energy systems, water management and environment for green buildings.

CO Questions

1. **a**. Draw the elevation and plan of one brick thick wall with English bond
   b. Explain the energy systems and water management in Green buildings

2. **a.** Draw neat sketch of the following foundations: (i) Isolated stepped footing; (ii) Cantilever footing; and (iii) Continuous footing.

   b. Discuss the civil engineering aspect of MEP and HVAC in a commercial building

Course Outcome 6 (CO6):

1. In an air standard Otto cycle the compression ratio is 7 and compression begins at 35°C, 0.1 MPa. The maximum temperature of the cycle is 1100°C. Find
   i) Heat supplied per kg of air,
   ii) Work done per kg of air,
   iii) Cycle efficiency
   Take Cp = 1.005 kJ/kgK and Cv=0.718 kJ/kgK
2. A Carnot cycle works with adiabatic compression ratio of 5 and isothermal expansion ratio of 2. The volume of air at the beginning of isothermal expansion is 0.3 m^3. If the maximum temperature and pressure is limited to 550K and 21 bar, determine the minimum temperature in the cycle and efficiency of the cycle.
3. In an ideal diesel cycle, the temperature at the beginning and end of compression is 65°C and 620°C respectively. The temperature at the beginning and end of the expansion is 1850°C and 850 °C. Determine the ideal efficiency of the cycle.

4. Explain the concepts of CRDI and MPFI in IC Engines.

Course Outcome 7 (CO7)

1. With the help of a neat sketch explain the working of a 4 stroke SI engine
2. Compare the working of 2 stroke and 4 stroke IC engines
3. Explain the classification of IC Engines.

Course Outcome 8(CO8):

1. Explain the working of vapour compression refrigeration system.
2. With the help of suitable sketch explain the working of a split air conditioner.
3. Define: COP, specific humidity, relative humidity and dew point temperature.

Course Outcome 9 (CO9):

1. Explain the working of a single stage centrifugal pump with sketches.
2. With the help of a neat sketch, explain the working of a reciprocating pump.
3. A turbine is to operate under a head of 25 m at 200 rpm. The discharge is 9 m^3/s. If the overall efficiency of the turbine is 90%. Determine the power developed by the turbine.

Course Outcome 10 (CO10):

1. Explain the working of belt drive and gear drive with the help of neat sketches
2. Explain a single plate clutch.
3. Sketch different types of gear trains and explain.

Course Outcome 11 (CO11):

1. Describe the operations which can be performed using drilling machine.
2. Explain the functions of runners and risers used in casting.
3. With a neat sketch, explain the working and parts of a lathe.

Model Question Paper

QP CODE: **EST120** page:3

Reg No:___________________

Name:______________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EST 120

Course Name: BASICS OF CIVIL AND MECHANICAL ENGINEERING

Max. Marks: 100 Duration: 3 hours

Answer both part I and part 2 in separate answer booklets

PART I: BASIC CIVIL ENGINEERING

PART A

(Answer all questions. Each question carries 4 marks)

1. Explain relevance of Civil engineering in the overall infrastructural development of the country.
2. Discuss the difference between plinth area and carpet area.
3. Explain different types of steel with their properties.
4. What are the different kinds of cement available and what is their use?
5. Define bearing capacity of soil.

(5 x 4 = 20)

Part B

Answer one full question from each module.

MODULE I

6a. List out the types of building as per occupancy. Explain any two, each in about five sentences. (5)
 b. Discuss the components of a building with a neat figure. (5)

OR

7a. What are the major disciplines of civil engineering and explain their role in the infrastructural framework. (5)
 b. Explain the role of NBC, KBR & CRZ norms in building rules and regulations prevailing in our country. (5)

MODULE II

8a. What are the different kinds of cement available and what is their use. (5)
 b. List the properties of good building bricks. Explain any five. (5)

OR

9a. List and explain any five modern construction materials used for construction. (5)
 b. Explain the objectives and principles of surveying (5)

MODULE III

10a. Draw the elevation and plan of one brick thick wall with English bond (5)
 b. Explain the energy systems and water management in Green buildings (5)

OR

11a. Draw neat sketch of the following foundations: (i) Isolated stepped footing;
(ii) Cantilever footing; and (iii) Continuous footing. (5)
 b. Discuss the civil engineering aspect of MEP and HVAC in a commercial building (5)

[10 x 3 = 30]

PART II: BASIC MECHANICAL ENGINEERING

PART A

Answer all questions. Each question carries 4 marks

1. Sketch the P-v and T-s diagram of a Carnot cycle and List the processes.
2. Illustrate the working of an epicyclic gear train.
3. Explain cooling and dehumidification processes.
4. Differentiate between soldering and brazing.
5. Explain the principle of Additive manufacturing.

4 x 5 = 20 marks

Part B

Answer one full question from each module.

MODULE I

6. In an air standard Otto cycle the compression ratio is 7 and compression begins at 35^{o}C, 0.1MPa. The maximum temperature of the cycle is 1100^{o}C. Find

   i) Heat supplied per kg of air,
   ii) Work done per kg of air,
   iii)Cycle efficiency

   Take C_p = 1.005 kJ/kgK and C_v=0.718 kJ/kgK — 10 marks

OR

7. a) Explain the working of a 4 stroke SI engine with neat sketches. — 7 marks
   b) Explain the fuel system of a petrol engine. — 3 marks

MODULE II

8. a) Explain the working of a vapour compression system with help of a block diagram. — 7 marks
   b) Define: Specific humidity, relative humidity and dew point temperature. — 3 marks

OR

9. With the help of a neat sketch, explain the working of a centrifugal pump. — 10 marks

MODULE III

10. Explain the two high, three high, four high and cluster rolling mills with neat sketches. — 10 marks

OR

11. a) Describe the arc welding process with a neat sketch. — 6 marks
    b) Differentiate between up-milling and down-milling operations. — 4 marks

SYLLABUS

Module 1

General Introduction to Civil Engineering: Relevance of Civil Engineering in the overall infrastructural development of the country. Responsibility of an engineer in ensuring the safety of built environment. Brief introduction to major disciplines of Civil Engineering like Transportation Engineering, Structural Engineering, Geo-technical Engineering, Water Resources Engineering and Environmental Engineering.

Introduction to buildings: Types of buildings, selection of site for buildings, components of a residential building and their functions.

Building rules and regulations: Relevance of NBC, KBR & CRZ norms (brief discussion only).

Building area: Plinth area, built up area, floor area, carpet area and floor area ratio for a building as per KBR.

Module 2

Surveying: Importance, objectives and principles.

Construction materials, Conventional construction materials**:** types, properties and uses of building materials: bricks, stones, cement, sand and timber

Cement concrete: Constituent materials, properties and types.

Steel: Steel sections and steel reinforcements, types and uses.

Modern construction materials:- Architectural glass, ceramics, Plastics, composite materials, thermal and acoustic insulating materials, decorative panels, waterproofing materials. Modern uses of gypsum, pre-fabricated building components (brief discussion only).

Module 3

Building Construction: Foundations: Bearing capacity of soil (definition only), functions of foundations, types – shallow and deep (brief discussion only). Load bearing and framed structures (concept only).

Brick masonry: - Header and stretcher bond, English bond & Flemish bond random rubble masonry.

Roofs and floors: - Functions, types; flooring materials (brief discussion only).

Basic infrastructure services: MEP, HVAC, elevators, escalators and ramps (Civil Engineering aspects only), fire safety for buildings.

Green buildings:- Materials, energy systems, water management and environment for green buildings. (brief discussion only).

Module 4

Analysis of thermodynamic cycles: Carnot, Otto, Diesel cycles, Derivation of efficiency of these cycles, Problems to calculate heat added, heat rejected, net work and efficiency. IC Engines: CI, SI, 2-Stroke, 4-Stroke engines. Listing the parts of different types of IC Engines. Efficiencies of IC Engines(Definitions only), Air, Fuel, cooling and lubricating systems in SI and CI Engines, CRDI, MPFI. Concept of hybrid engines.

Module 5

Refrigeration: Unit of refrigeration, reversed Carnot cycle,COP, vapour compression cycle (only description and no problems); Definitions of dry, wet & dew point temperatures, specific humidity and relative humidity, Cooling and dehumidification, Layout of unit and central air conditioners.

Description about working with sketches of: Reciprocating pump, Centrifugal pump, Pelton turbine, Francis turbine and Kaplan turbine. Overall efficiency, Problems on calculation of input and output power of pumps and turbines (No velocity triangles)

Description about working with sketches of: Belt and Chain drives, Gear and Gear trains, Single plate clutches.

Module 6

Manufacturing Process: Basic description of the manufacturing processes – Sand Casting, Forging, Rolling, Extrusion and their applications.

Metal Joining Processes: List types of welding, Description with sketches of Arc Welding, Soldering and Brazing and their applications

Basic Machining operations: Turning, Drilling, Milling and Grinding.

Description about working with block diagram of: Lathe, Drilling machine, Milling machine, CNC Machine. Principle of CAD/CAM, Rapid and Additive manufacturing.

Text Books:

1. Rangwala, S. C., Essentials of Civil Engineering, Charotar Publishing House
2. Mckay, W.B. and Mckay, J. K., Building Construction, Volumes 1 to 4, Pearson India Education Services

References Books:

1. Chen W.F and Liew J Y R (Eds), The Civil Engineering Handbook. II Edition CRC Press (Taylor and Francis)
2. Chudley, R and Greeno R, Building construction handbook, Addison Wesley, Longman group, England
3. Chudley, R, Construction Technology, Vol. I to IV, Longman group, England Course Plan
4. Kandya A A, Elements of Civil Engineering, Charotar Publishing house
5. Mamlouk, M. S., and Zaniewski, J. P., Materials for Civil and Construction Engineering, Pearson Publishers
6. Rangwala S.C and Dalal K B Building Construction Charotar Publishing house
7. Clifford, M., Simmons, K. and Shipway, P., An Introduction to Mechanical Engineering Part I - CRC Press
8. Roy and Choudhary, Elements of Mechanical Engineering, Media Promoters &Publishers Pvt. Ltd., Mumbai.
9. Sawhney, G. S., Fundamentals of Mechanical Engineering, PHI
10. G Shanmugam, M S Palanichamy, Basic Civil and Mechanical Engineering, McGraw Hill Education; First edition, 2018
11. Benjamin,J.,Basic Mechanical Engineering,Pentex Books,9th Edition,2018
12. Balachandran, P.Basic Mechanical Engineering,Owl Books

Course Contents and Lecture Schedule:

No	Topic	Course outcomes addressed	No. of Lectures
1	**Module I**		**Total: 7**
1.1	*General Introduction to Civil Engineering*: Relevance of Civil Engineering in the overall infrastructural development of the country. Responsibility of an engineer in ensuring the safety of built environment.	CO1	1
1.2	Brief introduction to major disciplines of Civil Engineering like Transportation Engineering, Structural Engineering, Geo-technical Engineering, Water Resources Engineering and Environmental Engineering.	CO1	2
1.3	*Introduction to buildings:* Types of buildings, selection of site for buildings, components of a residential building and their functions.	CO2	2
1.4	*Building rules and regulations:* Relevance of NBC, KBR & CRZ norms (brief discussion only)	CO2	1
1.5	*Building area:* Plinth area, built up area, floor area, carpet area and floor area ratio for a building as per KBR.	CO2	1
2	**Module 2**		**Total: 7**
2.1	*Surveying:* Importance, objectives and principles.	CO3	1
2.2	Bricks: - Classification, properties of good bricks, and tests on bricks	CO2	1
2.3	Stones: - *Qualities* of good stones, types of stones and their uses. Cement: - Good qualities of cement, types of cement and their uses.	CO2	1
2.4	Sand: - Classification, qualities of good sand and sieve analysis (basics only). Timber: - Characteristics, properties and uses.	CO2	1
2.5	Cement concrete: - Constituent materials, properties and types, Steel: - Steel sections and steel reinforcements, types and uses.	CO2	1

2.6	Modern construction materials: - Architectural glass, ceramics, plastics, composite materials, thermal and acoustic insulating materials, decorative panels, waterproofing materials, modern uses of gypsum, pre-fabricated building components (brief discussion only)	CO2	2
3	**Module 3**		**Total: 7**
3.1	Foundations: - Bearing capacity of soil (definition only), functions of foundations, types – shallow and deep (brief discussion only). Brick masonry: - Header and stretcher bond, English bond & Flemish bond– elevation and plan (one & one and a half brick wall only). Random rubble masonry.	CO2	2
3.2	Roofs: Functions, types; roofing materials (brief discussion only) Floors: Functions, types; flooring materials (brief discussion only)	CO2	2
3.3	*Basic infrastructure services:* MEP, HVAC, Elevators, escalators and ramps (Civil Engineering aspects only) fire safety for buildings	CO4	2
3.4	*Green buildings:*- Materials, energy systems, water management and environment for green buildings. (brief discussion only)	CO5	1
4	**MODULE 4**		
4.1	Analysis of thermodynamic cycles: Carnot, Otto, and Diesel cycle- Derivation of efficiency of these cycles, Problems to calculate heat added, heat rejected, net work and efficiency	4	
4.2	IC Engines: CI, SI, 2-Stroke, 4-Stroke engines. Listing the parts of different types of IC Engines, efficiencies of IC Engines(Description only)	2	
4.3	Air, Fuel, cooling and lubricating systems in SI and CI Engines, CRDI, MPFI. Concept of hybrid engines	2	
5	**MODULE 5**		
5.1	Refrigeration: Unit of refrigeration, reversed Carnot cycle, COP, vapour compression cycle (only description and no problems)	1	
5.2	Definitions of dry, wet & dew point temperatures, specific humidity and relative humidity, Cooling and dehumidification, Layout of unit and central air conditioners.	1	

5.3	Description about working with sketches : Reciprocating pump, Centrifugal pump, Pelton turbine, Francis turbine and Kaplan turbine. Overall efficiency, Problems on calculation of input and output power of pumps and turbines (No velocity triangles)	4
5.4	Description about working with sketches of: Belt and Chain drives, Gear and Gear trains, Single plate clutches	3
6	**MODULE 6**	
6.1	Manufacturing Process: Basic description of the manufacturing processes – Sand Casting, Forging, Rolling, Extrusion and their applications.	2
6.2	Metal Joining Processes :List types of welding, Description with sketches of Arc Welding, Soldering and Brazing, and their applications	1
6.3	Basic Machining operations: Turning, Drilling, Milling and Grinding Description about working with block diagrams of: Lathe, Drilling machine, Milling machine, CNC Machine	3
6.4	Principle of CAD/CAM, Rapid and Additive manufacturing	1

EST 100	ENGINEERING MECHANICS	CATEGORY	L	T	P	CREDIT	Year of Introduction
		ESC	2	1	0	3	2019

Preamble: Goal of this course is to expose the students to the fundamental concepts of mechanics and enhance their problem-solving skills. It introduces students to the influence of applied force system and the geometrical properties of the rigid bodies while stationary or in motion. After this course students will be able to recognize similar problems in real-world situations and respond accordingly.

Prerequisite: Nil

Course Outcomes: After completion of the course the student will be able to:

CO 1	Recall principles and theorems related to rigid body mechanics
CO 2	Identify and describe the components of system of forces acting on the rigid body
CO 3	Apply the conditions of equilibrium to various practical problems involving different force system.
CO 4	Choose appropriate theorems, principles or formulae to solve problems of mechanics.
CO 5	Solve problems involving rigid bodies, applying the properties of distributed areas and masses

Mapping of course outcomes with program outcomes (Minimum requirement)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	2	-	-	-	-	-	-	-	-	-	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-
CO 3	3	3	-	-	-	-	-	-	-	-	-	-
CO 4	3	3	-	-	-	-	-	-	-	-	-	-
CO 5	3	3	-	-	-	-	-	-	-	-	-	-

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 2 (Marks)	
Remember	10	10	15
Understand	10	10	15
Apply	30	30	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

<u>End Semester Examination Pattern:</u> There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

<u>Course Level Assessment Questions:</u>

Part A

Course Outcome 1 (CO1): (One question from each module to meet the course objective 1: *To recall principles and theorems related to rigid body mechanics***)**

1. Explain D'Alembert's principle

2. Distinguish static and dynamic friction

3. State and explain perpendicular axis theorem

Course Outcome 2 (CO2) (One question from each module to meet the course objective 2: *To identify and describe the components of system of forces acting on the rigid body***)**

1. A simply supported beam AB of span 5 m is carrying point loads 5 kN, 3 kN and 2 kN at 1m, 3m and 4m respectively from support A. Calculate the support reaction at B.

2. A gymnast holding onto a bar, is suspended motionless in mid-air. The bar is supported by two ropes that attach to the ceiling. Diagram the forces acting on the combination of gymnast and bar

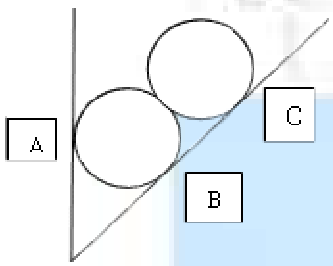
3. While you are riding your bike, you turn a corner following a circular arc. Illustrate the forces that act on your bike to keep you along the circular path ?

Part B

All the questions under this section shall assess the learning levels corresponding to the course outcomes listed below.

CO 3	To apply the conditions of equilibrium to various practical problems involving different force system.
CO 4	To choose appropriate theorems, principles or formulae to solve problems of mechanics.
CO 5	To solve problems involving rigid bodies, applying the properties of distributed areas and masses

1. Two rollers each of weight 100 N are supported by an inclined plane and a vertical wall. Find the reaction at the points of contact A, B, C. Assume all the surfaces to be smooth.

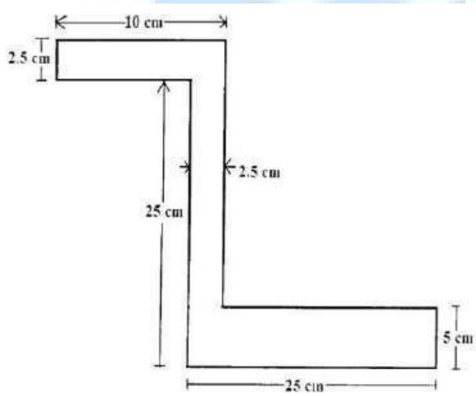


Course outcome identifier	**Description of course outcome**	**Learning level assessed**	**Marks allocated**
CO 3	To apply the conditions of equilibrium to various practical problems involving different force system.	Applying – (Sketch the free body diagram that represent equilibrium state of the body)	4
CO 4	To choose appropriate theorems, principles or formulae to solve problems of mechanics.	Applying (Choose the equations and formulae required for calculation)	4
CO 5	To solve problems involving rigid bodies, applying the properties of distributed areas and masses	Applying (Solve the problem based on the descriptions given in CO3 and CO4)	6
Total			14

2. A cylindrical disc, 50 cm diameter and cm thickness, is in contact with a horizontal conveyor belts running at uniform speeds of 5 m/s. Assuming there is no slip at points of contact determine (i) angular velocity of disc (ii) Angular acceleration of disc if velocity of conveyor changes to 8 m/s. Also compute the moment acting about the axis of the disc in both cases.

Course outcome identifier	Description of course outcome	Learning level assessed	Marks allocated
CO 3	To apply the conditions of equilibrium to various practical problems involving different force system.	Applying – (Sketch the free body diagram that represent state of the body)	4
CO 4	To choose appropriate theorems, principles or formulae to solve problems of mechanics.	Applying (Choose the equations and formulae required for calculation)	4
CO 5	To solve problems involving rigid bodies, applying the properties of distributed areas and masses	Applying (Solve the problem based on the descriptions given in CO3 and CO4)	6
Total			14

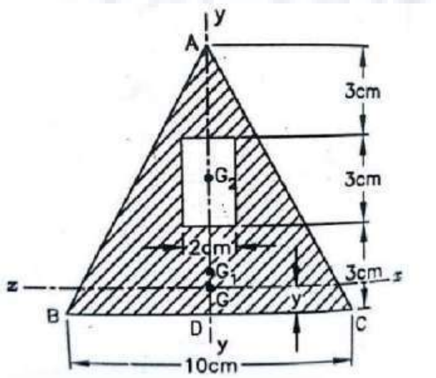
3. Determine the centroid of the given section



Course outcome identifier	Description of course outcome	Learning level assessed	Marks allocated
CO 3	To apply the conditions of equilibrium to various practical problems involving different force system.	Applying – (Illustrate the computation of centroid for the given geometrical shape)	4
CO 4	To choose appropriate theorems, principles or formulae to solve problems of mechanics.	Applying (Choose the equations and formulae required for calculation)	4
CO 5	To solve problems involving rigid bodies, applying the properties of distributed	Applying (Solve the problem based on the descriptions	6

	areas and masses	given in CO3 and CO4)	
Total			14

4. A rectangular hole is made in a triangular section as shown. Find moment of inertia about the section x-x passing through the CG of the section and parallel to BC.



Course outcome identifier	Description of course outcome	Learning level assessed	Marks allocated
CO 3	To apply the conditions of equilibrium to various practical problems involving different force system.	Applying – (Illustrate the computation of moment of inertia for the given geometrical shape)	4
CO 4	To choose appropriate theorems, principles or formulae to solve problems of mechanics.	Applying (Choose the equations and formulae required for calculation)	4
CO 5	To solve problems involving rigid bodies, applying the properties of distributed areas and masses	Applying (Solve the problem based on the descriptions given in CO3 and CO4)	6
Total			14

Model Question Paper

QP CODE:

Reg No.:_______________

Name:___________________________ ___

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EST 100

ENGINEERING MECHANICS

Max. Marks: 100 Duration: 3 hours

Part A

(Answer all questions; each question carries 3 marks)

1. Explain D'Alembert's principle

2. Distinguish static and dynamic frictioni.

3. State and explain perpendicular axis theorem.

4. A simply supported beam AB of span 5 m is carrying point loads 5 kN, 3 kN and 2 kN at 1m, 3m and 4m respectively from support A. Calculate the support reaction at B.

5. A gymnast holding onto a bar, is suspended motionless in mid-air. The bar is supported by two ropes that attach to the ceiling. Diagram the forces acting on the combination of gymnast and bar

6. While you are riding your bike, you turn a corner following a circular arc. Illustrate the forces that act on your bike to keep you along the circular path ?

7. Compare damped and undamped free vibrations.

8. State the equation of motion of a rotating rigid body, rotating about its fixed axis.

9. Illustrate the significance of instantaneous centre in the analysis of rigid body undergoing rotational motion.

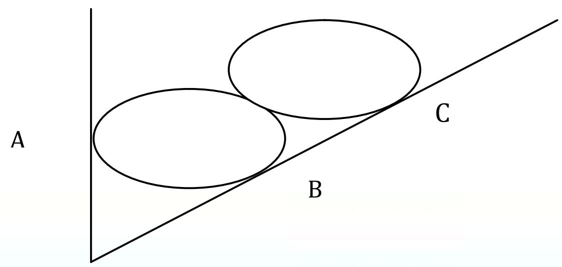
10. Highlight the principles of mechanics applied in the evaluation of elastic collusion of rigid bodies.

PART B

(Answer **one full** question from each module, each question carries **14** marks)

Module -I

11. Two identical rollers each of weight 100 N are supported by an inclined plane, making an angle of 30^{o} with the vertical, and a vertical wall. Find the reaction at the points of contact A, B, C. Assume all the surfaces to be smooth. (14 marks)

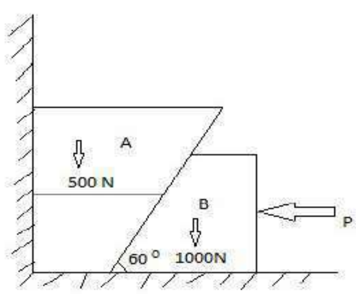


12. A string tied to a wall is made to pass over a pulley placed 2m away from it. A weight P is attached to the string such that the string stretches by 2m from the support on the wall to the location of attachment of weight. Determine the force P required to maintain 200 kg body in position for $\theta = 30^o$, The diameter of pulley B is negligible. (14 marks)

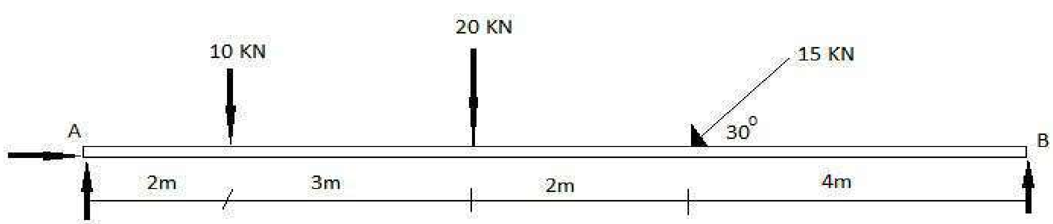
Module – 2

13. Two blocks A & B are resting against a wall and the floor as shown in figure below. Find the value of horizontal force P applied to the lower block that will hold the system in equilibrium. Coefficient of friction are : 0.25 at the floor, 0.3 at the wall and 0.2 between the blocks.

(14 marks)

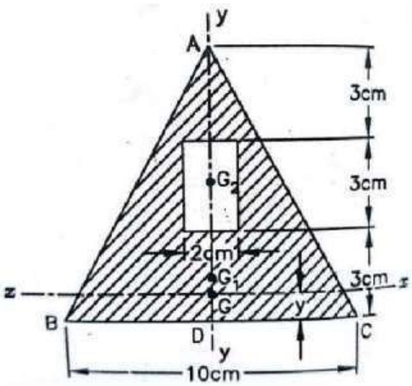


14. A beam is hinged at A and roller supported at B. It is acted upon by loads as shown below.
Find the reactions at A & B. (14 marks)

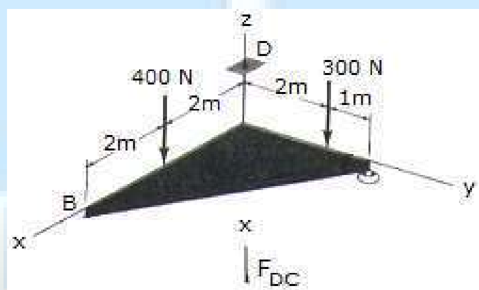


Module – 3

15. A rectangular hole is made in a triangular section as shown. Find moment of inertia about the section x-x passing through the CG of the section and parallel to BC. (14 marks)



16. Support A has ball and socket connection. Roller support at B prevents motion in the —z direction. Corner *C* is tied to *D* by a rope. The triangle is weightless. Determine the unknown force components acting at *A*, *B*, and *C*. (14 marks)



Module - 4

17. A cricket ball is thrown by a fielder from a height of 2m at an angle of 30^0 to the horizontal with an initial velocity of 20 m/s , hits the wickets at a height of 0.5 m from the ground. How far was the fielder from the wicket? (14 marks)

18. An engine of weight 500 kN pull a train weighing 1500 kN up an incline of 1 in 100. The train starts from rest and moves with constant acceleration against a resistance of 5 N/kN. It attains a maximum speed of 36 kmph in 1 km distance. Determine the tension in the coupling between train and engine and the traction force developed by the engine. (14marks)

Module – 5

19. A cylindrical disc, 50 cm diameter and 10 cm thickness having mass of 10 kg, is in contact with a horizontal conveyor belt running at uniform speeds of 5 m/s. Assuming there is no slip at points of contact determine (i) angular velocity of disc (ii) Angular acceleration of disc if velocity of conveyor changes to 8 m/s in 10 seconds. Also compute the moment acting about the axis of the disc in both cases. (14 marks)

20. A wheel rotating about fixed axis at 20 rpm is uniformly accelerated for 70 seconds during which time it makes 50 revolutions. Find the (i) angular velocity at the end of this interval and (ii) time required for the velocity to reach 100 revolutions per minute. (14 marks)

SYLLABUS

Module 1

Introduction to Engineering Mechanics-statics-basic principles of statics-Parallelogram law, equilibrium law, principles of superposition and transmissibility, law of action and reaction(review) free body diagrams.

Concurrent coplanar forces-composition and resolution of forces-resultant and equilibrium equations – methods of projections – methods of moments – Varignon’s Theorem of moments.

Module 2

Friction – sliding friction - Coulomb’s laws of friction – analysis of single bodies –wedges, ladder-analysis of connected bodies .

Parallel coplanar forces – couple - resultant of parallel forces – centre of parallel forces – equilibrium of parallel forces – Simple beam subject to concentrated vertical loads. General coplanar force system - resultant and equilibrium equations.

Module 3

Centroid of composite areas- – moment of inertia-parallel axis and perpendicular axis theorems. Polar moment of inertia,radius of gyration,mass moment of inertia-ring,cylinder and disc.

Theorem of Pappus Guldinus(demonstration only)

Forces in space - vectorial representation of forces, moments and couples –resultant and equilibrium equations – concurrent forces in space (simple problems only)

Module 4

Dynamics – rectilinear translation - equations of kinematics(review)

kinetics – equation of motion – D’Alembert’s principle. – motion on horizontal and inclined surfaces, motion of connected bodies. Impulse momentum equation and work energy equation (concepts only).

Curvilinear translation - equations of kinematics –projectile motion(review), kinetics – equation of motion. Moment of momentum and work energy equation (concepts only).

Module 5

Rotation – kinematics of rotation- equation of motion for a rigid body rotating about a fixed axis – rotation under a constant moment.

Plane motion of rigid body – instantaneous centre of rotation (concept only).

Simple harmonic motion – free vibration –degree of freedom- undamped free vibration of spring mass system-effect of damping(concept only)

Text Books

1. Timoshenko and Young, Engineering Mechanics, McGraw Hill Publishers
2. Shames, I. H., Engineering Mechanics - Statics and Dynamics, Prentice Hall of India.
3. R. C. Hibbeler and Ashok Gupta, Engineering Mechanics, Vol. I statics, Vol II Dynamics, Pearson Education.

References

1. Merriam J. L and Kraige L. G., Engineering Mechanics - Vols. 1 and 2, John Wiley.

2. Tayal A K, Engineering Mechanics – Statics and Dynamics, Umesh Publications

3. Bhavikkatti, S.S., Engineering Mechanics, New Age International Publishers

4. F.P.Beer abd E.R.Johnston (2011), Vector Mechanics for Engineers, Vol.I-Statics, Vol.II-Dynamics, 9th Ed, Tata McGraw Hill

5. Rajasekaran S and Sankarasubramanian G, Engineering Mechanics - Statics and Dynamics, Vikas Publishing House Pvt Ltd.

Course Contents and Lecture Schedule:

Module	Topic	Course outcomes addressed	No. of Hours
1	**Module 1**		**Total: 7**
1.1	Introduction to engineering mechanics – introduction on statics and dynamics - Basic principles of statics – Parellogram law, equilibrium law – Superposition and transmissibility, law of action and reaction (review the topics)	CO1 and CO2	1
1.2	Free body diagrams. Degree of freedom-types of supports and nature of reactions - exercises for free body diagram preparation – composition and resolution of forces, resultant and equilibrium equations (review the topics) - numerical exercises for illustration.	CO1 and CO2	1
1.3	Concurrent coplanar forces - analysis of concurrent forces -methods of projections – illustrative numerical exercise – teacher assisted problem solving.	CO1 and CO2	1
1.4	Analysis of concurrent forces -methods of moment-Varignon's Theorem of Moments - illustrative numerical exercise– teacher assisted problem solving.	CO1 and CO2	1
1.5	Analysis of concurrent force systems – extended problem solving - Session I.	CO3,CO4 and CO5	1
1.6	Analysis of concurrent force systems – extended problem solving - Session II – learning review quiz.	CO3,CO4 and CO5	1
1.7	Analysis of concurrent force systems – extended problem solving - Session III.	CO3,CO4 and CO5	1
2	**Module 2**		**Total: 7**
2.1	Friction – sliding friction - Coulomb's laws of friction – analysis of single bodies –illustrative examples on wedges and ladder-teacher	CO1 and CO2	1

	assisted problem solving tutorials using problems from wedges and ladder.		
2.2	Problems on friction - analysis of connected bodies. illustrative numerical exercise– teacher assisted problem solving.	CO3, CO4 and CO5	1
2.3	Problems on friction-extended problem solving	CO3,C04 and CO5	1
2.4	Parallel coplanar forces – couple - resultant of parallel forces – centre of parallel forces – equilibrium of parallel forces – Simple beam subject to concentrated vertical loads.	CO1 and CO2	1
2.5	General coplanar force system - resultant and equilibrium equations - illustrative examples- teacher assisted problem solving.	CO1 and CO2	1
2.6	General coplanar force system-resultant and equilibrium equations - illustrative examples	CO3, CO4 and CO5	1
2.7	General coplanar force system - Extended problem solving - Quiz to evaluate learning level.	CO3, CO4 and CO5	1
3	**Module 3**		**Total: 7**
3.1	Centroid of simple and regular geometrical shapes – centroid of figures in combination - composite areas- examples for illustration – problems for practice to be done by self.	CO1 and CO2	1
3.2	Moment of inertia- parallel axis theorem –examples for illustration - problems for practice to be done by self.	CO1 and CO2	1
3.3	Moment of inertia - perpendicular axis theorem - example for illustration to be given as hand out and discussion on the solved example.	CO1 and CO2	1
3.4	Solutions to practice problems – problems related to centroid and moment of inertia - problems for practice to be done by self.	CO3, CO4 and CO5	1
3.5	Polar moment of inertia, Radius of gyration. Mass moment of inertia of ring, cylinder and uniform disc. Theorem of Pappus Guldinus - Demonstration	CO1 and CO2	1
3.6	Introduction to forces in space – vectorial representation of forces, moments and couples – simple problems to illustrate vector representations of forces, moments and couples to be done in class.	CO1,and CO2	1
3.7	Solution to practice problems - resultant and equilibrium equations for concurrent forces in space – concurrent forces in space - 2 simple problems to illustrate the application of resultant and equilibrium equations for concurrent forces in space.	CO3,CO4 and CO5	1
4	**Module 4**		**Total: 7**

4.1	Introduction to dynamics – review of rectilinear translation - equations of kinematics – problems to review the concepts – additional problems involving extended application as exercises .	CO1 and CO2	1
4.2	Solutions to exercises with necessary explanation given as hand out – introduction to kinetics – equation of motion – D'Alembert's principle – illustration of the concepts using one numerical exercise from motion on horizontal and inclined surfaces.	CO1 and CO2	1
4.3	Motion of connected bodies - example for illustration to be given as hand out and discussion on the solved example – problems for practice to be done by self.	CO3, CO4 and CO5	1
4.4	Motion of connected bodies-extended problem solving.	CO3, CO4 & CO5	1
4.5	Curvilinear translation - Review of kinematics –projectile motion – simple problems to review the concepts – introduction to kinetics – equation of motion – illustration of the concepts using numerical exercises.	CO3, CO4 & CO5	1
4.6	Extended problem solving – rectilinear and curvilinear translation.	CO3, CO4 & CO5	1
4.7	Concepts on Impulse momentum equation and work energy equation (rectilinear translation – discussions to bring out difference between elastic and inelastic collusions). Concepts on Moment of momentum and work energy equation (curvilinear translation).	CO1 and CO2	1
5	**Module 5**		**Total: 7**
5.1	Rotation – kinematics of rotation- equation of motion for a rigid body rotating about a fixed axis – simple problems for illustration.	CO1 and CO2	1
5.2	Rotation under a constant moment – teacher assisted problem solving.	CO3,CO4 and CO5	1
5.3	Rotation under a constant moment - extended problem solving.	CO3, CO4 and CO5	1
5.4	Plane motion of rigid body- instantaneous centre of rotation (concept only).	CO1 and CO2	1
5.5	Introduction to harmonic oscillation –free vibrations - simple harmonic motion – differential equation and solution. Degree of freedom – examples of single degree of freedom (SDOF) systems – Idealisation of mechanical systems as spring-mass systems (concept only).	CO1 and CO2	1

5.6	SDOF spring mass system –equation of motion – undamped free vibration response - concept of natural frequency. Free vibration response due to initial conditions. Simple problems on determination of natural frequency and free vibration response to test the understanding level.	CO1 and CO2	1
5.7	Free vibration analysis of SDOF spring-mass systems – Problem solving Effect of damping on free vibration response (concept only).	CO1and CO2	1

EST 110	ENGINEERING GRAPHICS	CATEGORY	L	T	P	CREDIT	Year of Introduction
		ESC	2	0	2	3	2019

Preamble: To enable the student to effectively perform technical communication through graphical representation as per global standards.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Draw the projection of points and lines located in different quadrants
CO 2	Prepare multiview orthographic projections of objects by visualizing them in different positions
CO 3	Draw sectional views and develop surfaces of a given object
CO 4	Prepare pictorial drawings using the principles of isometric and perspective projections to visualize objects in three dimensions.
CO 5	Convert 3D views to orthographic views
CO 6	Obtain multiview projections and solid models of objects using CAD tools

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3											
CO 2	3											
CO 3	3	1										
CO 4	3									1		
CO 5	3									2		
CO 6	3				3					3		

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (100 Marks)**
	Test 1 (15 Marks)	**Test 2 (15 Marks)**	
Remember			
Understand	5		20
Apply	10	10	80
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE (Marks)	ESE (Marks)	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

CIA for section A carries 25 marks (15 marks for 1 test and Class work 10 marks)

CIA for section B carries 15 marks (10 marks for 1 test and Class work 5 marks)

End Semester Examination Pattern:

ESE will be of 3 hour duration on A4 size answer booklet and will be for 100 marks. The question paper shall contain two questions from each module of Section A only. Student has to answer any one question from each module. Each question carries 20 marks.

Course Level Assessment Questions

(Questions may be framed based on the outline given under each course outcome)

Course Outcome 1 (CO1):

1. Locate points in different quadrants as per given conditions.
2. Problems on lines inclined to both planes .
3. Find True length, Inclinations and Traces of lines.

Course Outcome 2 (CO2)

1. Draw orthographic views of solids and combination solids
2. Draw views of solids inclined to any one reference plane.
3. Draw views of solids inclined to both reference planes.

Course Outcome 3 (CO3):

1. Draw views of solids sectioned by a cutting plane
2. Find location and inclination of cutting plane given true shape of the section
3. Draw development of lateral surface of solids and also its sectioned views

Course Outcome 4 (CO4):

1. Draw Isometric views/projections of soilds
2. Draw Isometric views/projections of combination of soilds
3. Draw Perspective views of Soilds

Course Outcome 5 (CO5):

1. Draw Orthographic views of solids from given three dimensional view

Course Outcome 6 (CO6):

1. Draw the given figure including dimensions using 2D software
2. Create 3D model using modelling software from the given orthographic views or 3D figure or from real 3D objects

Model Question paper

QP CODE: PAGES:3

Reg No:_______________

Name :_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EST 110

ENGINEERING GRAPHICS

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

Instructions: Retain necessary Construction lines
Show necessary dimensions
Answer any ONE question from each module
Each question carries 20 marks

MODULE I

1. The end point A of a line is 20mm above HP and 10mm in front of VP. The other end of the line is 50mm above HP and 15mm behind VP. The distance between the end projectors is 70mm. Draw the projections of the line. Find the true length and true inclinations of the line with the principal planes. Also locate the traces of the line.
2. One end of a line is 20mm from both the principal planes of projection. The other end of the line is 50mm above HP and 40mm in front of VP. The true length of the line is 70mm. Draw the projections of the line. Find its apparent inclinations, elevation length and plan length. Also locate its traces.

MODULE II

3. A pentagonal pyramid of base side 25mm and height 40mm, is resting on the ground on one of its triangular faces. The base edge of that face is inclined 30° to VP. Draw the projections of the solid.

4. A hexagonal prism has side 25mm and height 50mm has a corner of its base on the ground and the long edge containing that corner inclined at 30^o to HP and 45^o to VP. Draw the projections of the solid.

MODULE III

5. A triangular prism of base side 40mm and height 70mm is resting with its base on the ground and having an edge of the base perpendicular to VP. Section the solid such that the true shape of the section is a trapezium of parallel sides 30mm and 10mm. Draw the projections showing the true shape. Find the inclination of the cutting plane with the ground plane.

6. Draw the development of a pentagonal pyramid of base side 30mm and height 50mm. A string is wound from a corner of the base round the pyramid and back to the same point through the shortest distance. Show the position of the string in the elevation and plan.

MODULE IV

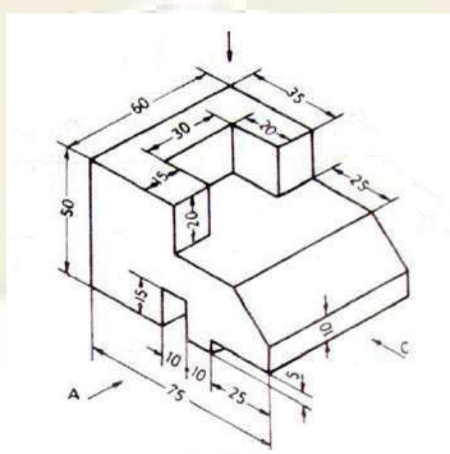
7. The frustum of a cone has base diameter 50mm and top diameter 40mm has a height of 60mm. It is paced centrally on top of a rectangular slab of size 80x60mm and of thickness 20mm. Draw the isometric view of the combination.

8. A hexagonal prism has base side 35mm and height 60mm. A sphere of diameter 40mm is placed centrally on top of it. Draw the isometric projection of the combination.

MODULE V

9. Draw the perspective view of a pentagonal prism, 20mm side and 45mm long lying on one of its rectangular faces on the ground and having its axis perpendicular to picture plane. One of its pentagonal faces touches the picture plane and the station point is 50mm in front of PP, 25mm above the ground plane and lies in a central plane, which is 70mm to the left of the center of the prism.

10. Draw three orthographic views with dimensions of the object shown in figure below.



(20X5=100)

Time : 3 hours **EST110 ENGINEERING GRAPHICS** **Max. Marks: 100**

SCHEME OF VALUATION

1. Locating the points and drawing the projections of the line – 4 marks
   Finding true length by any one method – 6 marks
   Finding true inclination with VP – 2 marks
   Finding true inclination with HP – 2 marks
   Locating horizontal trace – 2 marks
   Locating vertical trace – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

2. Locating the points and drawing true length of the line – 4 marks
   Finding projections by any method – 6 marks
   Finding length of elevation and plan – 2 marks
   Finding apparent inclinations – 2 marks
   Locating horizontal trace – 2 marks
   Locating vertical trace – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

3. Drawing initial position plan and elevation – 4 marks
   First inclination views – 4 marks
   Second inclination views -8 marks
   Marking invisible edges – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

   (Any one method or combination of methods for solving can be used.
   If initial position is wrong then maximum 50% marks may be allotted for the answer)

4. Drawing initial position plan and elevation – 4 marks
   First inclination views – 4 marks
   Second inclination views -8 marks
   Marking invisible edges – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

   (Any one method or combination of methods for solving can be used
   If initial position is wrong then maximum 50% marks may be allotted for the answer)

5. Drawing initial position plan and elevation – 4 marks
   Locating section plane as per given condition – 5 marks
   Drawing true shape -5 marks
   Finding inclination of cutting plane – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

6. Drawing initial position plan and elevation – 4 marks
   Development of the pyramid – 6 marks

Locating string in development -2 marks
Locating string in elevation – 3 marks
Locating string in plan – 3 marks
Dimensioning and neatness – 2 marks

Total = 20 marks

7. Drawing initial positions – 4 marks
   Isometric View of Slab -6 marks
   Isometric View of Frustum – 10 marks
   Dimensioning and neatness – 2 marks

Total = 20 marks

(Initial position is optional, hence redistribute if needed.
Reduce 4 marks if Isometric scale is taken)

8. Drawing initial positions – 4 marks
   Isometric scale – 4 marks
   Isometric projection of prism -5 marks
   Isometric projection of sphere – 5 marks
   Dimensioning and neatness – 2 marks

Total = 20 marks

(Initial position is optional, hence redistribute if needed.

9. Drawing the planes and locating the station point – 4 marks
   Locating elevation points – 2 marks
   Locating plan points – 2 marks
   Drawing the perspective view – 10 marks
   Dimensioning and neatness – 2 marks

Total = 20 marks

10. Drawing the elevation – 8marks
    Drawing the plan – 4 marks
    Drawing the side view – 4 marks
    Marking invisible edges – 2 marks
    Dimensioning and neatness – 2 marks

Total = 20 marks

SYLLABUS

General Instructions:

- First angle projection to be followed
- Section A practice problems to be performed on A4 size sheets
- Section B classes to be conducted on CAD lab

SECTION A

Module 1

Introduction : Relevance of technical drawing in engineering field. Types of lines, Dimensioning, BIS code of practice for technical drawing.

Orthographic projection of Points and Lines: Projection of points in different quadrants, Projection of straight lines inclined to one plane and inclined to both planes. Trace of line. Inclination of lines with reference planes True length of line inclined to both the reference planes.

Module 2

Orthographic projection of Solids: Projection of Simple solids such as Triangular, Rectangle, Square, Pentagonal and Hexagonal Prisms, Pyramids, Cone and Cylinder. Projection of solids in simple position including profile view. Projection of solids with axis inclined to one of the reference planes and with axis inclined to both reference planes.

Module 3

Sections of Solids: Sections of Prisms, Pyramids, Cone, Cylinder with axis in vertical position and cut by different section planes. True shape of the sections. Also locating the section plane when the true shape of the section is given.

Development of Surfaces: Development of surfaces of the above solids and solids cut by different section planes. Also finding the shortest distance between two points on the surface.

Module 4

Isometric Projection: Isometric View and Projections of Prisms, Pyramids, Cone , Cylinder, Frustum of Pyramid, Frustum of Cone, Sphere, Hemisphere and their combinations.

Module 5

Perspective Projection: Perspective projection of Prisms and Pyramids with axis perpendicular to the ground plane, axis perpendicular to picture plane.

Conversion of Pictorial Views: Conversion of pictorial views into orthographic views.

SECTION B

(To be conducted in CAD Lab)

Introduction to Computer Aided Drawing: Role of CAD in design and development of new products, Advantages of CAD. Creating two dimensional drawing with dimensions using suitable software. (Minimum 2 exercises mandatory)

Introduction to Solid Modelling: Creating 3D models of various components using suitable modelling software. (Minimum 2 exercises mandatory)

Text Books

1. Bhatt, N.D., Engineering Drawing, Charotar Publishing House Pvt. Ltd.
2. John, K.C. Engineering Graphics, Prentice Hall India Publishers.

Reference Books

1. Anilkumar, K.N., Engineering Graphics, Adhyuth narayan Publishers
2. Agrawal, B. And Agrawal, C.M., Engineering Darwing, Tata McGraw Hill Publishers.
3. Benjamin, J., Engineering Graphics, Pentex Publishers- 3rd Edition, 2017
4. Duff, J.M. and Ross, W.A., Engineering Design and Visualisation, Cengage Learning.
5. Kulkarni, D.M., Rastogi, A.P. and Sarkar, A.K., Engineering Graphics with AutoCAD, PHI.
6. Luzaddff, W.J. and Duff, J.M., Fundamentals of Engineering Drawing, PHI.
7. Varghese, P.I., Engineering Graphics, V I P Publishers
8. Venugopal, K., Engineering Drawing and Graphics, New Age International Publishers.

Course Contents and Lecture Schedule

No	**SECTION A**	No. of Hours
1	**MODULE I**	
1.1	Introduction to graphics, types of lines, Dimensioning	1
1.2	Concept of principle planes of projection, different quadrants, locating points on different quadrants	2
1.3	Projection of lines, inclined to one plane. Lines inclined to both planes, trapezoid method of solving problems on lines.	2
1.4	Problems on lines using trapezoid method	2
1.5	Line rotation method of solving, problems on line rotation method	2
2	**MODULE II**	
2.1	Introduction of different solids, Simple position plan and elevation of solids	2
2.2	Problems on views of solids inclined to one plane	2
2.3	Problems on views of solids inclined to both planes	2
2.4	Practice problems on solids inclined to both planes	2

3	**MODULE III**	
3.1	Introduction to section planes. AIP and AVP. Principle of locating cutting points and finding true shape	2
3.2	Problems on sections of different solids	2
3.3	Problems when the true shape is given	2
3.4	Principle of development of solids, sectioned solids	2
4	**MODULE IV**	
4.1	Principle of Isometric View and Projection, Isometric Scale. Problems on simple solids	2
4.2	Isometric problems on Frustum of solids, Sphere and Hemisphere	2
4.3	Problems on combination of different solids	2
5	**MODULE V**	
5.1	Introduction to perspective projection, different planes, station point etc. Perspective problems on pyramids	2
5.2	Perspective problems on prisms	2
5.3	Practice on conversion of pictorial views into orthographic views	2
	SECTION B *(To be conducted in CAD lab)*	
1	Introduction to CAD and software. Familiarising features of 2D software. Practice on making 2D drawings	2
2	Practice session on 2D drafting	2
3	Introduction to solid modelling and software	2
4	Practice session on 3D modelling	2

EST 102	PROGRAMING IN C	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		ESC	2	1	2	4	2019

Preamble: The syllabus is prepared with the view of preparing the Engineering Graduates capable of writing readable C programs to solve computational problems that they may have to solve in their professional life. The course content is decided to cover the essential programming fundamentals which can be taught within the given slots in the curriculum. This course has got 2 Hours per week for practicing programming in C. A list showing 24 mandatory programming problems are given at the end. The instructor is supposed to give homework/assignments to write the listed programs in the rough record as and when the required theory part is covered in the class. The students are expected to come prepared with the required program written in the rough record for the lab classes.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyze a computational problem and develop an algorithm/flowchart to find its solution
CO 2	Develop readable* C programs with branching and looping statements, which uses Arithmetic, Logical, Relational or Bitwise operators.
CO 3	Write readable C programs with arrays, structure or union for storing the data to be processed
CO 4	Divide a given computational problem into a number of modules and develop a readable multi-function C program by using recursion if required, to find the solution to the computational problem
CO 5	Write readable C programs which use pointers for array processing and parameter passing
CO 6	Develop readable C programs with files for reading input and storing output

readable* - readability of a program means the following:

1. Logic used is easy to follow
2. Standards to be followed for indentation and formatting
3. Meaningful names are given to variables
4. Concise comments are provided wherever needed

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔	✔		✔				✔	✔	✔
CO2	✔	✔	✔	✔	✔					✔		✔
CO3	✔	✔	✔	✔	✔					✔		✔
CO4	✔	✔	✔	✔	✔					✔	✔	✔
CO5	✔	✔			✔					✔		✔
CO6	✔	✔			✔					✔		✔

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination Marks**
	Test 1 (Marks)	**Test 2 (Marks)**	
Remember	15	10	25
Understand	10	15	25
Apply	20	20	40
Analyse	5	5	10
Evaluate			
Create			

Mark distribution

Total Marks	**CIE Marks**	**ESE Marks**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test 1 (for theory, for 2 hrs)	: 20 marks
Continuous Assessment Test 2 (for lab, internal examination, for 2 hrs)	: 20 marks

Internal Examination Pattern: There will be two parts; Part A and Part B. Part A contains 5 questions with 2 questions from each module (2.5 modules x 2 = 5), having 3 marks for each question. Students should answer all questions. Part B also contains 5 questions with 2 questions from each module (2.5 modules x 2 = 5), of which a student should answer any one. The questions should not have sub-divisions and each one carries 7 marks.

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Sample Course Level Assessment Questions

Course Outcome 1 (CO1): Write an algorithm to check whether largest of 3 natural numbers is prime or not. Also, draw a flowchart for solving the same problem.

Course Outcome 2 (CO2): Write an easy to read C program to process a set of n natural numbers and to find the largest even number and smallest odd number from the given set of numbers. The program should not use division and modulus operators.

Course Outcome 3(CO3): Write an easy to read C program to process the marks obtained by n students of a class and prepare their rank list based on the sum of the marks obtained. There are 3 subjects for which examinations are conducted and the third subject is an elective where a student is allowed to take any one of the two courses offered.

Course Outcome 4 (CO4): Write an easy to read C program to find the value of a mathematical function f which is defined as follows. f(n) = n! / (sum of factors of n), if n is not prime and f(n) = n! / (sum of digits of n), if n is prime.

Course Outcome 5 (CO5): Write an easy to read C program to sort a set of n integers and to find the number of unique numbers and the number of repeated numbers in the given set of numbers. Use a function which takes an integer array of n elements, sorts the array using the Bubble Sorting Technique and returns the number of unique numbers and the number of repeated numbers in the given array.

Course Outcome 6 (CO6): Write an easy to read C program to process a text file and to print the Palindrome words into an output file.

Model Question paper

QP CODE: PAGES:3

Reg No:_______________

Name :_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

***Course Code:* EST 102**

Course Name: Programming in C (Common to all programs)

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Write short note on processor and memory in a computer.
2. What are the differences between compiled and interpreted languages? Give example for each.
3. Write a C program to read a Natural Number through keyboard and to display the reverse of the given number. For example, if "3214567" is given as input, the output to be shown is "7654123".
4. Is it advisable to use *goto* statements in a C program? Justify your answer.
5. Explain the different ways in which you can *declare & initialize* a single dimensional array.
6. Write a C program to read a sentence through keyboard and to display the count of white spaces in the given sentence.
7. What are the advantages of using functions in a program?
8. With a simple example program, explain *scope* and *life time* of variables in C.
9. Write a function in C which takes the address of a single dimensional array (containing a finite sequence of numbers) and the number of numbers stored in the array as arguments and stores the numbers in the same array in reverse order. Use pointers to access the elements of the array.
10. With an example, explain the different modes of opening a file. (10x3=30)

Part B

Answer any one Question from each module. Each question carries 14 Marks

11. (a) Draw a flow chart to find the position of an element in a given sequence, using linear searching technique. With an example explain how the flowchart finds the position of a given element. **(10)**

    (b) Write a pseudo code representing the flowchart for linear searching. **(4)**

OR

12. (a) With the help of a flow chart, explain the bubble sort operation. Illustrate with an example. **(10)**
    (b) Write an algorithm representing the flowchart for bubble sort. **(4)**

13. (a) Write a C program to read an English Alphabet through keyboard and display whether the given Alphabet is in upper case or lower case. **(6)**
    (b) Explain how one can use the builtin function in C, *scanf*to read values of different data types. Also explain using examples how one can use the builtin function in C, *printf*for text formatting. **(8)**

OR

14. (a) With suitable examples, explain various operators in C. (10)
    (b) Explain how characters are stored and processed in C. **(4)**

15. (a) Write a function in C which takes a 2-Dimensional array storing a matrix of numbers and the order of the matrix (number of rows and columns) as arguments and displays the sum of the elements stored in each row. **(6)**
    (b) Write a C program to check whether a given matrix is a diagonal matrix. **(8)**

OR

16. (a) Without using any builtin string processing function like *strlen*, *strcat* etc., write a program to concatenate two strings. **(8)**
    (b) Write a C program to perform bubble sort. **(6)**

17. (a) Write a function namely *myFact* in C to find the factorial of a given number. Also, write another function in C namely*nCr* which accepts two positive integer parameters *n* and *r* and returns the value of the mathematical function*C(n,r)*(n! / (r! x (n - r)!)). The function *nCr* is expected to make use of the factorial function *myFact.* *(10)*
    (b) What is recursion? Give an example. **(4)**

OR

18. (a) With a suitable example, explain the differences between a structure and a union in C. **(6)**
    (b) Declare a structure namely *Student* to store the details (*roll number, name, mark_for_C*) of a student. Then, write a program in C to find the average mark obtained by the students in a class for the subject *Programming in C* (using the field *mark_for_C*). Use array of structures to store the required data **(8)**

19. (a) With a suitable example, explain the concept of pass by reference. **(6)**
    (b) With a suitable example, explain how pointers can help in changing the content of a single dimensionally array passed as an argument to a function in C. **(8)**

OR

20. (a) Differentiate between sequential files and random access files? **(4)**

(b) Using the prototypes explain the functionality provided by the following functions. (10)

rewind()

i. *fseek()*

ii. *ftell()*

iii. *fread()*

iv. *fwrite()* ***(14X5=70)***

SYLLABUS

Programming in C (Common to all disciplines)

Module 1

Basics of Computer Hardware and Software

Basics of Computer Architecture: processor, Memory, Input& Output devices

Application Software & System software: Compilers, interpreters, High level and low level languages

Introduction to structured approach to programming, Flow chart Algorithms, Pseudo code (*bubble sort, linear search - algorithms and pseudocode*)

Module 2

Program Basics

Basic structure of C program: Character set, Tokens, Identifiers in C, Variables and Data Types , Constants, Console IO Operations, printf and scanf

Operators and Expressions: Expressions and Arithmetic Operators, Relational and Logical Operators, Conditional operator, size of operator, Assignment operators and Bitwise Operators. Operators Precedence

Control Flow Statements: If Statement, Switch Statement, Unconditional Branching using goto statement, While Loop, Do While Loop, For Loop, Break and Continue statements.(Simple programs covering control flow)

Module 3

Arrays and strings

Arrays Declaration and Initialization, 1-Dimensional Array, 2-Dimensional Array

String processing: In built String handling functions (strlen, strcpy, strcat and strcmp, puts, gets) Linear search program, bubble sort program, simple programs covering arrays and strings

Module 4

Working with functions

Introduction to modular programming, writing functions, formal parameters, actual parameters Pass by Value, Recursion, Arrays as Function Parameters structure, union, Storage Classes, Scope and life time of variables, *simple programs using functions*

Module 5

Pointers and Files

Basics of Pointer: declaring pointers, accessing data though pointers, NULL pointer,array access using pointers, pass by reference effect

File Operations: open, close, read, write, append

Sequential access and random access to files: In built file handlingfunctions (*rewind() ,fseek(), ftell(), feof(), fread(), fwrite()*), *simple programs covering pointers and files.*

Text Books

1. Schaum Series, Gottfried B.S.,Tata McGraw Hill,Programming with C
2. E. Balagurusamy, Mcgraw Hill,Programming in ANSI C
3. Asok N Kamthane, Pearson,Programming in C
4. Anita Goel, Pearson, Computer Fundamentals

Reference Books

1. Anita Goel and Ajay Mittal, Pearson, Computer fundamentals and Programming in C
2. Brian W. Kernighan and Dennis M. Ritchie, Pearson, C Programming Language
3. Rajaraman V, PHI, Computer Basics and Programming in C
4. Yashavant P, Kanetkar, BPB Publications, Let us C

Course Contents and Lecture Schedule

	Module 1: Basics of Computer Hardware and Software	**(7 hours)**
1.1	**Basics of Computer Architecture:** Processor, Memory, Input& Output devices	**2 hours**
1.2	**Application Software & System software:** Compilers, interpreters, High level and low level languages	**2 hours**
1.3	Introduction to structured approach to programming, Flow chart	**1 hours**
1.4	Algorithms, Pseudo code (*bubble sort, linear search - algorithms and pseudocode*)	**2 hours**
Module 2: Program Basics		**(8 hours)**
2.1	**Basic structure of C program:** Character set, Tokens, Identifiers in C, Variables and Data Types , Constants, Console IO Operations, printf and scanf	**2 hours**
2.2	**Operators and Expressions:** Expressions and Arithmetic Operators, Relational and Logical Operators, Conditional operator, sizeof operator, Assignment operators and Bitwise Operators. Operators Precedence	**2 hours**

2.3	**Control Flow Statements:** If Statement, Switch Statement, Unconditional Branching using goto statement, While Loop, Do While Loop, For Loop, Break and Continue statements.*(Simple programs covering control flow)*	**4 hours**
Module 3: Arrays and strings:		**(6 hours)**
3.1	Arrays Declaration and Initialization, 1-Dimensional Array, 2-Dimensional Array	**2 hours**
3.2	**String processing:** In built String handling functions(*strlen, strcpy, strcat and strcmp, puts, gets*)	**2 hours**
3.3	Linear search program, bubble sort program, *simple programs covering arrays and strings*	**3 hours**
Module 4: Working with functions		**(7 hours)**
4.1	Introduction to modular programming, writing functions, formal parameters, actual parameters	**2 hours**
4.2	Pass by Value, Recursion, Arrays as Function Parameters	**2 hours**
4.3	structure, union, Storage Classes,Scope and life time of variables, *simple programs using functions*	**3 hours**
Module 5: Pointers and Files		**(7 hours)**
5.1	**Basics of Pointer**: declaring pointers, accessing data though pointers, NULL pointer,array access using pointers, pass by reference effect	**3 hours**
5.2	**File Operations**: open, close, read, write, append	1 **hours**
5.3	**Sequential access and random access to files:** In built file handlingfunctions (*rewind() ,fseek(), ftell(), feof(), fread(), fwrite()*)**,** *simple programs covering pointers and files.*	**2 hours**

C PROGRAMMING LAB (Practical part of EST 102, Programming in C)

Assessment Method: The Academic Assessment for the Programming lab should be done internally by the College. The assessment shall be made on 50 marks and the mark is divided as follows: Practical Records/Outputs - 20 marks (internal by the College), Regular Lab Viva - 5 marks (internal by the College), Final Practical Exam – 25 marks (internal by the College).

The mark obtained out of 50 will be converted into equivalent proportion out of 20 for CIE computation.

LIST OF LAB EXPERIMENTS

1. Familiarization of Hardware Components of a Computer

2. Familiarization of Linux environment – How to do Programming in C with Linux

3. Familiarization of console I/O and operators in C

i) Display "Hello World"

ii) Read two numbers, add them and display theirsum

iii) Read the radius of a circle, calculate its area and display it

iv)Evaluate the arithmetic expression ((a -b / c * d + e) * (f +g)) and display its solution.Read the values of the variables from the user through console.

4. Read 3 integer values and find the largest amoung them.

5. Read a Natural Number and check whether the number is prime or not

6. Read a Natural Number and check whether the number is Armstrong or not

7. Read n integers, store them in an array and find their sum and average

8. Read n integers, store them in an array and search for an element in the array using an algorithm for Linear Search

9. Read n integers, store them in an array and sort the elements in the array using Bubble Sort algorithm

10**.** Read a string (word), store it in an array and check whether it is a palindrome word or not.

11. Read two strings (each one ending with a $ symbol), store them in arrays and concatenate them without using library functions.

12. Read a string (ending with a $ symbol), store it in an array and count the number of vowels, consonants and spaces in it.

13. Read two input each representing the distances between two points in the Euclidean space, store these in structure variables and add the two distance values.

14. Using structure, read and print data of n employees (*Name, Employee Id and Salary*)

15. Declare a union containing 5 string variables (*Name, House Name, City Name, State and Pin code*) each with a length of C_SIZE (user defined constant). Then, read and display the address of a person using a variable of the union.

16. Find the factorial of a given Natural Number n usingrecursive and non recursive functions

17. Read a string (word), store it in an array and obtain its reverse by using a user defined function.

18. Write a menu driven program for performing matrix addition, multiplication and finding the transpose. Use functions to (i) read a matrix, (ii) find the sum of two matrices, (iii) find the product of two matrices, (i) find the transpose of a matrix and (v) display a matrix.

19. Do the following using pointers

i) add two numbers

ii) swap two numbers using a user defined function

20. Input and Print the elements of an array using pointers

21. Compute sum of the elements stored in an array using pointers and user defined function.

22. Create a file and perform the following

iii) Write data to the file

iv) Read the data in a given file & display the file content on console

v) append new data and display on console

23. Open a text input file and count number of characters, words and lines in it; and store the results in an output file.

HUN 101	LIFE SKILLS	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		MNC	2	0	2	---	**2019**

Preamble: Life skills are those competencies that provide the means for an individual to be resourceful and positive while taking on life's vicissitudes. Development of one's personality by being aware of the self, connecting with others, reflecting on the abstract and the concrete, leading and generating change, and staying rooted in time-tested values and principles is being aimed at. This course is designed to enhance the employability and maximize the potential of the students by introducing them to the principles that underly personal and professional success, and help them acquire the skills needed to apply these principles in their lives and careers.

Prerequisite: None

Course Outcomes: After the completion of the course the student will be able to

CO 1	Define and Identify different life skills required in personal and professional life
CO 2	Develop an awareness of the self and apply well-defined techniques to cope with emotions and stress.
CO 3	Explain the basic mechanics of effective communication and demonstrate these through presentations.
CO 4	Take part in group discussions
CO 5	Use appropriate thinking and problem solving techniques to solve new problems
CO 6	Understand the basics of teamwork and leadership

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1						2		1	2	2	1	3
CO 2									3			2
CO 3						1			1	3		
CO 4										3		1
CO 5		3	2	1								
CO 6						1			3			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	50	50	2 hours

Continuous Internal Evaluation
Total Marks: 50

Attendance	: 10 marks
Regular assessment	: 15 marks
Series test (one test only, should include first three modules)	: 25 marks

Regular assessment

- Group Discussion (Marks: 9)

  Create groups of about 6 students each and engage them on a GD on a suitable topic for about 20 minutes. Parameters to be used for evaluation are as follows:

  - Communication Skills : 3 marks
  - Subject Clarity : 2 marks
  - Group Dynamics : 2 marks
  - Behaviours & Mannerisms : 2 marks

- Presentation Skills (Marks: 6)

  Identify a suitable topic and ask the students to prepare a presentation (preferably a power point presentation) for about 10 minutes. Parameters to be used for evaluation are as follows:

  - Communication Skills : 2 marks
  - Platform Skills : 2 marks
  - Subject Clarity/Knowledge : 2 marks

End Semester Examination
Total Marks: 50 **Time: 2 hrs.**

Part A: Short answer question (25 marks)
There will be one question from each MODULE (five questions in total, five marks each). Each question should be written in about maximum of 400 words. Parameters to be used for evaluation are as follows:
(i) Content Clarity/Subject Knowledge
(ii) Presentation style
(iii) Organization of content

Part B: Case Study (25 marks)
The students will be given a case study with questions at the end. The students have to analyze the case and answer the question at the end. Parameters to be used for evaluation are as follows:
(i) Analyze the case situation
(ii) Key players/characters of the case
(iii) Identification of the problem (both major & minor if exists)
(iv) Bring out alternatives
(v) Analyze each alternative against the problem
(vi) Choose the best alternative
(vii) Implement as solution
(viii) Conclusion

(ix) Answer the question at the end of the case

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. List 'life skills' as identified by WHO
2. What do you mean by effective communication?
3. What are the essential life skills required by a professional?

Course Outcome 2 (CO2)

1. Identify an effective means to deal with workplace stress.
2. How can a student apply journaling to stress management?
3. What is the PATH method? Describe a situation where this method can be used effectively.

Course Outcome 3(CO3):

1. Identify the communication network structure that can be observed in the given situations. Describe them.

   (a) A group discussion on development.

   (b) An address from the Principal regarding punctuality.

   (c) A reporter interviewing a movie star.

   (d) Discussing the answers of a test with a group of friends.
2. Elucidate the importance of non-verbal communication in making a presentation
3. Differentiate between kinesics, proxemics, and chronemics with examples.

Course Outcome 4 (CO4):

1. How can a participant conclude a group discussion effectively?
2. 'Listening skills are essential for effectively participating in a group discussion.' Do you agree? Substantiate your answer.

Course Outcome 5 (CO5):

1. Illustrate the creative thinking process with the help of a suitable example
2. Translate the following problem from verbal to graphic form and find the solution : *In a quiz, Ananth has 50 points more than Bimal, Chinmay has 60 points less than Ananth, and Dharini is 20 points ahead of Chinmay. What is the difference in points between Bimal and Dharini?*

3. List at least five ways in which the problem "How to increase profit?" can be redefined

Course Outcome 6 (CO6):

1. A group of engineers decided to brainstorm a design issue on a new product. Since no one wanted to disagree with the senior members, new ideas were not flowing freely. What group dynamics technique would you suggest to avoid this 'groupthink'? Explain the procedure.
2. “A group focuses on individual contribution, while a team must focus on synergy.” Explain.
3. Identify the type of group formed / constituted in each of the given situations

    a) A Police Inspector with subordinates reporting to him

    b) An enquiry committee constituted to investigate a specific incident

    c) The Accounts Department of a company

    d) A group of book lovers who meet to talk about reading

Syllabus

Module 1

Overview of Life Skills: Meaning and significance of life skills, Life skills identified by WHO: Self-awareness, Empathy, Critical thinking, Creative thinking, Decision making, problem solving, Effective communication, interpersonal relationship, coping with stress, coping with emotion.

Life skills for professionals: positive thinking, right attitude, attention to detail, having the big picture, learning skills, research skills, perseverance, setting goals and achieving them, helping others, leadership, motivation, self-motivation, and motivating others, personality development, IQ, EQ, and SQ

Module 2

Self-awareness: definition, need for self-awareness; Coping With Stress and Emotions, Human Values, tools and techniques of SA: questionnaires, journaling, reflective questions, meditation, mindfulness, psychometric tests, feedback.

Stress Management: Stress, reasons and effects, identifying stress, stress diaries, the four A's of stress management, techniques, Approaches: action-oriented, emotion-oriented, acceptance-oriented, resilience, Gratitude Training,

Coping with emotions: Identifying and managing emotions, harmful ways of dealing with emotions, PATH method and relaxation techniques.

Morals, Values and Ethics: Integrity, Civic Virtue, Respect for Others, Living Peacefully. Caring, Sharing, Honesty, Courage, Valuing Time, Time management, Co operation, Commitment, Empathy, Self-Confidence, Character, Spirituality, Avoiding Procrastination, Sense of Engineering Ethics.

Module 3

21st century skills: Creativity, Critical Thinking, Collaboration, Problem Solving, Decision Making, Need for Creativity in the 21st century, Imagination, Intuition, Experience, Sources of Creativity, Lateral Thinking, Myths of creativity, Critical thinking Vs Creative thinking, Functions of Left Brain & Right brain, Convergent & Divergent Thinking, Critical reading & Multiple Intelligence.

Steps in problem solving: Problem Solving Techniques, Six Thinking Hats, Mind Mapping, Forced Connections. Analytical Thinking, Numeric, symbolic, and graphic reasoning. Scientific temperament and Logical thinking.

Module 4

Group and Team Dynamics: Introduction to Groups: Composition, formation, Cycle, thinking, Clarifying expectations, Problem Solving, Consensus, Dynamics techniques, Group vs Team, Team Dynamics, Virtual Teams. Managing team performance and managing conflicts, Intrapreneurship.

Module 5

Leadership: Leadership framework, entrepreneurial and moral leadership, vision, cultural dimensions. Growing as a leader, turnaround leadership, managing diverse stakeholders, crisis management. Types of Leadership, Traits, Styles, VUCA Leadership, Levels of Leadership, Transactional vs Transformational Leaders, Leadership Grid, Effective Leaders.

Lab Activities

Verbal

Effective communication and Presentation skills.
Different kinds of communication; Flow of communication; Communication networks, Types of barriers; Miscommunication
Introduction to presentations and group discussions.
Learning styles: visual, aural, verbal, kinaesthetic, logical, social, solitary; Previewing, KWL table, active listening, REAP method
Note-taking skills: outlining, non-linear note-taking methods, Cornell notes, three column note taking.
Memory techniques: mnemonics, association, flashcards, keywords, outlines, spider diagrams and mind maps, spaced repetition.
Time management: auditing, identifying time wasters, managing distractions, calendars and checklists; Prioritizing - Goal setting, SMART goals; Productivity tools and apps, Pomodoro technique.

Non Verbal:

Non-verbal Communication and Body Language: Forms of non-verbal communication; Interpreting body-language cues; Kinesics; Proxemics; Chronemics; Effective use of body language, Communication in a multi cultural environment.

Reference Books

1. Shiv Khera, You Can Win, Macmillan Books, New York, 2003.
2. Barun K. Mitra, “Personality Development & Soft Skills”, Oxford Publishers, Third impression, 2017.
3. ICT Academy of Kerala, "Life Skills for Engineers", McGraw Hill Education (India) Private Ltd., 2016.
4. Caruso, D. R. and Salovey P, “The Emotionally Intelligent Manager: How to Develop and Use the Four Key Emotional Skills of Leadership”, John Wiley & Sons, 2004.
5. Kalyana, “Soft Skill for Managers”; First Edition; Wiley Publishing Ltd, 2015.
6. Larry James, “The First Book of Life Skills”; First Edition, Embassy Books, 2016.
7. Shalini Verma, “Development of Life Skills and Professional Practice”; First Edition; Sultan Chand (G/L) & Company, 2014.
8. Daniel Goleman, "Emotional Intelligence"; Bantam, 2006.
9. Remesh S., Vishnu R.G., "Life Skills for Engineers", Ridhima Publications, First Edition, 2016.
10. Butterfield Jeff, “Soft Skills for Everyone”, Cengage Learning India Pvt Ltd; 1 edition, 2011.
11. Training in Interpersonal Skills: Tips for Managing People at Work, Pearson Education, India; 6 edition, 2015.
12. The Ace of Soft Skills: Attitude, Communication and Etiquette for Success, Pearson Education; 1 edition, 2013.

HUN 102	PROFESSIONAL COMMUNICATION	CATEGORY	L	T	P	CREDIT
		MNC	2	0	2	--

Preamble: Clear, precise, and effective communication has become a *sine qua non* in today's information-driven world given its interdependencies and seamless connectivity. Any aspiring professional cannot but master the key elements of such communication. The objective of this course is to equip students with the necessary skills to listen, read, write, and speak so as to comprehend and successfully convey any idea, technical or otherwise, as well as give them the necessary polish to become persuasive communicators.

Prerequisite: None

Course Outcomes: After the completion of the course the student will be able to

CO 1	Develop vocabulary and language skills relevant to engineering as a profession
CO 2	Analyze, interpret and effectively summarize a variety of textual content
CO 3	Create effective technical presentations
CO 4	Discuss a given technical/non-technical topic in a group setting and arrive at generalizations/consensus
CO 5	Identify drawbacks in listening patterns and apply listening techniques for specific needs
CO 6	Create professional and technical documents that are clear and adhering to all the necessary conventions

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1										3		2
CO 2										1		3
CO 3						1			1	3		
CO 4										3		1
CO 5		1							2	3		
CO 6	1					1			1	3		

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	50	50	2 hours

Continuous Internal Evaluation

Total Marks: 50

Attendance	: 10 marks
Regular assessment	: 25 marks
Series test (one test only, should include verbal aptitude for placement and higher studies, this test will be conducted for 50 marks and reduced to 15)	: 15 marks

Regular assessment

Project report presentation and Technical presentation through PPT	: 7.5 marks
Listening Test	: 5 marks
Group discussion/mock job interview	: 7.5 marks
Resume submission	: 5 marks

End Semester Examination

Total Marks: 50, Time: 2 hrs.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. List down the ways in which gestures affect verbal communication.
2. Match the words and meanings

Ambiguous	promotion
Bona fide	referring to whole
Holistic	not clear
Exaltation	genuine

3. Expand the following Compound Nouns - a. Water supply. b. Object recognition. c. Steam turbine

Course Outcome 2 (CO2)

1. Read the passage below and prepare notes:

Mathematics, rightly viewed, possesses not only truth, but supreme beauty—a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show. The true spirit of delight, the exaltation, the sense of being more than man, which is the touchstone of the highest excellence, is to be found in mathematics as surely as in poetry. What is best in mathematics deserves not merely to be learnt as a task, but to be assimilated as a part of daily thought, and brought again and again before the mind with ever-renewed encouragement. Real life is, to most men, a long second-best, a perpetual compromise between the ideal and the possible; but the world of pure reason knows no compromise, no practical limitations, no barrier to the creative activity embodying in splendid edifices the passionate aspiration after the perfect from which all great work springs. Remote from human passions, remote even from the pitiful facts of nature, the generations have gradually created an ordered cosmos, where pure thought can dwell as in its natural home, and where one, at least, of our nobler impulses can escape from the dreary exile of the actual world.

So little, however, have mathematicians aimed at beauty, that hardly anything in their work has had this conscious purpose. Much, owing to irrepressible instincts, which were better than avowed *beliefs, has been moulded by an unconscious taste; but much also has been spoilt by false notions of what was fitting. The characteristic excellence of mathematics is only to be found where the reasoning is rigidly logical: the rules of logic are to mathematics what those of structure are to architecture. In the most beautiful work, a chain of argument is presented in which every link is important on its own account, in which there is an air of ease and lucidity throughout, and the premises achieve more than would have been thought possible, by means which appear natural and inevitable. Literature embodies what is general in particular circumstances whose universal significance shines through their individual dress; but mathematics endeavours to present whatever is most general in its purity, without any irrelevant trappings.*

How should the teaching of mathematics be conducted so as to communicate to the learner as much as possible of this high ideal? Here experience must, in a great measure, be our guide; but some maxims may result from our consideration of the ultimate purpose to be achieved.

- From "On the teaching of mathematics" – Bertrand Russell

2. Enumerate the advantages and disadvantages of speed reading. Discuss how it can impact comprehension.

Course Outcome 3(CO3):

1. What are the key elements of a successful presentation?
2. Elucidate the importance of non-verbal communication in making a presentation
3. List out the key components in a technical presentation.

Course Outcome 4 (CO4):

1. Discuss: 'In today's world, being a good listener is more important than being a good Speaker.'
2. Listen to a video/live group discussion on a particular topic, and prepare a brief summary of the proceedings.
3. List the do's and don'ts in a group discussion.

Course Outcome 5 (CO5):

1. Watch a movie clip and write the subtitles for the dialogue.
2. What do you mean by barriers to effective listening? List ways to overcome each of these.
3. What are the different types of interviews? How are listening skills particularly important in Skype/telephonic interviews?

Course Outcome 6 (CO6):

1. Explain the basic structure of a technical report.
2. You have been offered an internship in a much sought-after aerospace company and are very excited about it. However, the dates clash with your series tests. Write a letter to the Manager – University Relations of the company asking them if they can change the dates to coincide with your vacation.
3. You work in a well-reputed aerospace company as Manager – University Relations. You are in charge of offering internships. A student has sent you a letter requesting you to change the dates allotted to him since he has series exams at that time. But there are no vacancies available during the period he has requested for. Compose an e-mail informing him of this and suggest that he try to arrange the matter with his college.

Syllabus

Module 1

Use of language in communication: Significance of technical communication Vocabulary Development: technical vocabulary, vocabulary used in formal letters/emails and reports, sequence words, misspelled words, compound words, finding suitable synonyms, paraphrasing, verbal analogies. Language Development: subject-verb agreement, personal passive voice, numerical adjectives, embedded sentences, clauses, conditionals, reported speech, active/passive voice.

Technology-based communication: Effective email messages, slide presentations, editing skills using software. Modern day research and study skills: search engines, repositories, forums such as Git Hub, Stack Exchange, OSS communities (MOOC, SWAYAM, NPTEL), and Quora; Plagiarism

Module 2

Reading, Comprehension, and Summarizing: Reading styles, speed, valuation, critical reading, reading and comprehending shorter and longer technical articles from journals, newspapers, identifying the various transitions in a text, SQ3R method, PQRST method, speed reading. Comprehension: techniques, understanding textbooks, marking and underlining, Note-taking: recognizing non-verbal cues.

Module 3

Oral Presentation: Voice modulation, tone, describing a process, Presentation Skills: Oral presentation and public speaking skills, business presentations, Preparation: organizing the material, self-Introduction, introducing the topic, answering questions, individual presentation practice, presenting visuals effectively.

Debate and Group Discussions: introduction to Group Discussion (GD), differences between GD and debate; participating GD, understanding GD, brainstorming the topic, questioning and clarifying, GD strategies, activities to improve GD skills

Module 4

Listening and Interview Skills Listening: Active and Passive listening, listening: for general content, to fill up information, intensive listening, for specific information, to answer, and to understand. Developing effective listening skills, barriers to effective listening, listening to longer technical talks, listening to classroom lectures, talks on engineering /technology, listening to documentaries and making notes, TED talks.

Interview Skills: types of interviews, successful interviews, interview etiquette, dress code, body language, telephone/online (skype) interviews, one-to-one interview & panel interview, FAQs related to job interviews

Module 5

Formal writing: Technical Writing: differences between technical and literary style. Letter Writing (formal, informal and semi formal), Job applications, Minute preparation, CV preparation (differences between Bio-Data, CV and Resume), and Reports. Elements of style, Common Errors in Writing: describing a process, use of sequence words, Statements of Purpose, Instructions, Checklists.

Analytical and issue-based Essays and Report Writing: basics of report writing; Referencing Style (IEEE Format), structure of a report; types of reports, references, bibliography.

Lab Activities

Written: Letter writing, CV writing, Attending a meeting and Minute Preparation, Vocabulary Building
Spoken: Phonetics, MMFS (Multimedia Feedback System), Mirroring, Elevator Pitch, telephone etiquette, qualities of a good presentation with emphasis on body language and use of visual aids.
Listening: Exercises based on audio materials like radio and podcasts. Listening to Song. practice and exercises.
Reading: Speed Reading, Reading with the help of Audio Visual Aids, Reading Comprehension Skills
Mock interview and Debate/Group Discussion: concepts, types, Do's and don'ts- intensive practice

Reference Books

1. English for Engineers and Technologists (Combined edition, Vol. 1 and 2), Orient Blackswan 2010.
2. Meenakshi Raman and Sangeetha Sharma,"Technical Communication: Principles and Practice", 2nd Edition, Oxford University Press, 2011
3. Stephen E. Lucas, "The Art of Public Speaking", 10th Edition; McGraw Hill Education, 2012.
4. Ashraf Rizvi, "Effective Technical Communication", 2nd Edition, McGraw Hill Education, 2017.
5. William Strunk Jr. & E.B. White, "The Elements of Style", 4th Edition, Pearson, 1999.
6. David F. Beer and David McMurrey, Guide to writing as an Engineer, John Willey. New York, 2004.
7. Goodheart-Willcox, "Professional Communication", First Edition , 2017.
8. Training in Interpersonal Skills: Tips for Managing People at Work, Pearson Education, India, 6 edition, 2015.
9. The Ace of Soft Skills: Attitude, Communication and Etiquette for Success, Pearson Education; 1 edition, 2013.
10. Anand Ganguly, "Success in Interview", RPH, 5th Edition, 2016.
11. Raman Sharma, "Technical Communications", Oxford Publication, London, 2004.

CYL 120	ENGINEERING CHEMISTRY LAB	CATEGORY	L	T	P	CREDIT
		BSC	0	0	2	1

Preamble: To impart scientific approach and to familiarize with the experiments in chemistry relevant for research projects in higher semesters

Prerequisite: Experiments in chemistry introduced at the plus two levels in schools

Course outcomes: After the completion of the course the students will be able to

CO 1	Understand and practice different techniques of quantitative chemical analysis to generate experimental skills and apply these skills to various analyses
CO 2	Develop skills relevant to synthesize organic polymers and acquire the practical skill to use TLC for the identification of drugs
CO 3	Develop the ability to understand and explain the use of modern spectroscopic techniques for analysing and interpreting the IR spectra and NMR spectra of some organic compounds
CO 4	Acquire the ability to understand, explain and use instrumental techniques for chemical analysis
CO 5	Learn to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments
CO 6	Function as a member of a team, communicate effectively and engage in further learning. Also understand how chemistry addresses social, economical and environmental problems and why it is an integral part of curriculum

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3				2							3
CO 2	3				3							3
CO 3	3				3							3
CO 4	3				3							3
CO 5	3				1							3
CO 6	3				1							3

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration(Internal)
100	100	-	1 hour

Continuous Internal Evaluation Pattern:

Attendance	: 20 marks
Class work/ Assessment /Viva-voce	: 50 marks
End semester examination (Internally by college)	: 30 marks

End Semester Examination Pattern: Written Objective Examination of one hour

SYLLABUS

LIST OF EXPERIMENTS (MINIMUM 8 MANDATORY)

1. Estimation of total hardness of water-EDTA method
2. Potentiometric titration
3. Determination of cell constant and conductance of solutions.
4. Calibration of pH meter and determination of pH of a solution
5. Estimation of chloride in water
6. Identification of drugs using TLC
7. Determination of wavelength of absorption maximum and colorimetric estimation of Fe^{3+} in solution
8. Determination of molar absorptivity of a compound ($KMnO_4$ or any water soluble food colorant)
9. Synthesis of polymers (a) Urea-formaldehyde resin (b) Phenol-formaldehyde resin
10. Estimation of iron in iron ore
11. Estimation of copper in brass
12. Estimation of dissolved oxygen by Winkler's method
13. (a) Analysis of IR spectra (minimum 3 spectra) (b) Analysis of ^1H NMR spectra (minimum 3 spectra)
14. Flame photometric estimation of Na^+ to find out the salinity in sand
15. Determination of acid value of a vegetable oil
16. Determination of saponification of a vegetable oil

Reference Books

1. G. Svehla, B. Sivasankar, "Vogel's Qualitative Inorganic Analysis", Pearson, 2012.
2. R. K. Mohapatra, "Engineering Chemistry with Laboratory Experiments", PHI Learning, 2017.
3. Muhammed Arif, "Engineering Chemistry Lab Manual", Owl publishers, 2019.
4. Ahad J., "Engineering Chemistry Lab manual", Jai Publications, 2019.
5. Roy K Varghese, "Engineering Chemistry Laboratory Manual", Crownplus Publishers, 2019.
6. Soney C George, Rino Laly Jose, "Lab Manual of Engineering Chemistry", S. Chand & Company Pvt Ltd, New Delhi, 2019.

ESL 120	CIVIL & MECHANICAL WORKSHOP	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
			0	0	2	1	2019

Preamble: The course is designed to train the students to identify and manage the tools, materials and methods required to execute an engineering project. Students will be introduced to a team working environment where they develop the necessary skills for planning, preparing and executing an engineering project.

To enable the student to familiarize various tools, measuring devices, practices and different methods of manufacturing processes employed in industry for fabricating components.

Prerequisite: None

Course Outcomes: After the completion of the course the student will be able to:

Course Outcome	Course Outcome Description
CO 1	Name different devices and tools used for civil engineering measurements
CO 2	Explain the use of various tools and devices for various field measurements
CO 3	Demonstrate the steps involved in basic civil engineering activities like plot measurement, setting out operation, evaluating the natural profile of land, plumbing and undertaking simple construction work.
CO 4	Choose materials and methods required for basic civil engineering activities like field measurements, masonry work and plumbing.
CO 5	Compare different techniques and devices used in civil engineering measurements
CO 6	Identify Basic Mechanical workshop operations in accordance with the material and objects
CO 7	Apply appropriate Tools and Instruments with respect to the mechanical workshop trades
CO 8	Apply appropriate safety measures with respect to the mechanical workshop trades

Mapping of course outcomes with program outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	-	-	-	1	1	-	-	2	2	-	-
CO 2	1	-	-	-	1	1	-	-	2	2	-	-
CO 3	1	-	-	-	1	1	-	2	2	2	1	-
CO 4	1	-	-	-	1	1	-	2	2	2	1	1
CO 5	1	-	-	-	1	1	-	-	2	2		1
CO 6	2											

CO 7	2											
CO 8	2											

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	70	30	1 hour

Assessment Procedure: Total marks allotted for the course is 100 marks. CIE shall be conducted for 70 marks and ESE for 30 marks. CIE should be done for the work done by the student and also viva voce based on the work done on each practical session. ESE shall be evaluated by written examination of one hour duration conducted internally by the institute.

Continuous Internal Evaluation Pattern:

Attendance : 20 marks
Class work/ Assessment /Viva-voce : 50 marks
End semester examination (Internally by college) : 30 marks

End Semester Examination Pattern: Written Objective Examination of one hour

SYLLABUS

PART 1

CIVIL WORKSHOP

Exercise 1. Calculate the area of a built-up space and a small parcel of land- Use standard measuring tape and digital distance measuring devices

Exercise 2. (a) Use screw gauge and vernier calliper to measure the diameter of a steel rod and thickness of a flat bar

(b) Transfer the level from one point to another using a water level

(c) Set out a one room building with a given plan and measuring tape

Exercise 3. Find the level difference between any two points using dumpy level

Exercise 4. (a) Construct a $1\frac{1}{2}$ thick brick wall of 50 cm height and 60 cm length using English bond. Use spirit level to assess the tilt of walls.

(b) Estimate the number of different types of building blocks to construct this wall.

Exercise 5. (a) Introduce the students to plumbing tools, different types of pipes, type of connections, traps, valves ,fixtures and sanitary fittings.

(b) Install a small rainwater harvesting installation in the campus

Reference Books:

1. Khanna P.N, "Indian Practical Civil Engineering Handbook", Engineers Publishers.
2. Bhavikatti. S, "Surveying and Levelling (Volume 1)", I.K. International Publishing House
3. Arora S.P and Bindra S.P, " Building Construction", Dhanpat Rai Publications
4. S. C. Rangwala, "Engineering Materials," Charotar Publishing House.

PART II

MECHANICAL WORKSHOP

LIST OF EXERCISES

(Minimum EIGHT units mandatory and FIVE models from Units 2 to 8 mandatory)

UNIT 1:- General : Introduction to workshop practice, Safety precautions, Shop floor ethics, Basic First Aid knowledge.

Study of mechanical tools, components and their applications: (a) Tools: screw drivers, spanners, Allen keys, cutting pliers etc and accessories (b) bearings, seals, O-rings, circlips, keys etc.

UNIT 2:- Carpentry : Understanding of carpentry tools

Minimum any one model

1. T –Lap joint 2. Cross lap joint 3. Dovetail joint 4. Mortise joints

UNIT 3:- Foundry : Understanding of foundry tools

Minimum any one model

1.Bench Molding 2. Floor Molding 3. Core making 4. Pattern making

UNIT 4: - Sheet Metal : Understanding of sheet metal working tools

Minimum any one model

1. Cylindrical shape
2. Conical shape
3. Prismatic shaped job from sheet metal

UNIT 5: - Fitting : Understanding of tools used for fitting

Minimum any one model

1. Square Joint
2. V- Joint
3. Male and female fitting

UNIT 6: - Plumbing : Understanding of plumbing tools, pipe joints

Any one exercise on joining of pipes making use of minimum three types of pipe joints

UNIT 7: - Smithy: Understanding of tools used for smithy.

Demonstrating the forge-ability of different materials (MS, Al, alloy steel and cast steels) in cold and hot states.

Observing the qualitative difference in the hardness of these materials

Minimum any one exercise on smithy

1. Square prism
2. Hexagonal headed bolt
3. Hexagonal prism
4. Octagonal prism

UNIT 8: -Welding: Understanding of welding equipments

Minimum any one welding practice

Making Joints using electric arc welding. bead formation in horizontal, vertical and over head positions

UNIT 9: - Assembly: Demonstration only

Dissembling and assembling of

1. Cylinder and piston assembly
2. Tail stock assembly
3. Bicycle
4. Pump or any other machine

UNIT 10: - Machines: Demonstration and applications of the following machines

Shaping and slotting machine; Milling machine; Grinding Machine; Lathe; Drilling Machine.

UNIT 11: - Modern manufacturing methods: Power tools, CNC machine tools, 3D printing, Glass cutting.

Course Contents and Lecture Schedule:

No	Topic	No of Sessions
1	**INTRODUCTION**	
1.1	Workshop practice, shop floor precautions, ethics and First Aid knowledge. Studies of mechanical tools, components and their applications: (a) Tools: screw drivers, spanners, Allen keys, cutting pliers etc and accessories (b) bearings, seals, O-rings, circlips, keys etc	1
2	**CARPENTRY**	
2.1	Understanding of carpentry tools and making minimum one model	2

3	**FOUNDRY**	
3.1	Understanding of foundry tools and making minimum one model	2
4	**SHEET METAL**	
4.1	Understanding of sheet metal working tools and making minimum one model	2
5	**FITTING**	
5.1	Understanding of fitting tools and making minimum one model	2
6	**PLUMBING**	
6.1	Understanding of pipe joints and plumbing tools and making minimum one model	2
7	**SMITHY**	
7.1	Understanding of smithy tools and making minimum one model	2
8	**WELDING**	
8.1	Understanding of welding equipments and making minimum one model	2
9	**ASSEMBLY**	
9.1	Demonstration of assembly and dissembling of multiple parts components	1
10	**MACHINES**	
10.1	Demonstration of various machines	1
11	**MODERN MANUFACTURING METHODS**	
11.1	Demonstrations of: power tools, CNC Machine tools, 3D printing, Glass cutting	1

PHL 120	ENGINEERING PHYSICS LAB	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		BSC	0	0	2	1	2019

Preamble: The aim of this course is to make the students gain practical knowledge to co-relate with the theoretical studies and to develop practical applications of engineering materials and use the principle in the right way to implement the modern technology.

Prerequisite: Higher secondary level Physics

Course Outcomes: After the completion of the course the student will be able to

CO 1	Develop analytical/experimental skills and impart prerequisite hands on experience for engineering laboratories
CO 2	Understand the need for precise measurement practices for data recording
CO 3	Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical calculations
CO 4	Analyze the techniques and skills associated with modern scientific tools such as lasers and fiber optics
CO 5	Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3				3			1	2			1
CO 2	3				3			1	2			1
CO 3	3				3			1	2			1
CO 4	3				3			1	2			1
CO 5	3				3			1	2			1

Mark distribution

Total Marks	**CIE Marks**	**ESE Marks**	**ESE Duration(Internal)**
100	100	-	1 hour

Continuous Internal Evaluation Pattern:

Attendance	: 20 marks
Class work/ Assessment /Viva-voce	: 50 marks
End semester examination (Internally by college)	: 30 marks

End Semester Examination Pattern: Written Objective Examination of one hour

SYLLABUS

LIST OF EXPERIMENTS

(Minimum 8 experiments should be completed)

1. CRO-Measurement of frequency and amplitude of wave forms
2. Measurement of strain using strain gauge and wheatstone bridge
3. LCR Circuit – Forced and damped harmonic oscillations
4. Melde's string apparatus- Measurement of frequency in the transverse and longitudinal mode
5. Wave length measurement of a monochromatic source of light using Newton's Rings method.
6. Determination of diameter of a thin wire or thickness of a thin strip of paper using air wedge method.
7. To measure the wavelength using a millimeter scale as a grating.
8. Measurement of wavelength of a source of light using grating.
9. Determination of dispersive power and resolving power of a plane transmission grating
10. Determination of the particle size of lycopodium powder
11. Determination of the wavelength of He-Ne laser or any standard laser using diffraction grating
12. Calculate the numerical aperture and study the losses that occur in optical fiber cable.
13. I-V characteristics of solar cell.
14. LED Characteristics.
15. Ultrasonic Diffractometer- Wavelength and velocity measurement of ultrasonic waves in a liquid
16. Deflection magnetometer-Moment of a magnet- Tan A position.

Reference books

1. S.L.Gupta and Dr.V.Kumar, "Practical physics with viva voice", Pragati PrakashanPublishers, Revised Edition, 2009
2. M.N.Avadhanulu, A.A.Dani and Pokely P.M, "Experiments in Engineering Physics", S.Chand&Co,2008
3. S. K. Gupta, "Engineering physics practicals", Krishna Prakashan Pvt. Ltd., 2014
4. P. R. Sasikumar "Practical Physics", PHI Ltd., 2011.

ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		ESC	0	0	2	1	2019

Preamble: Electrical Workshop is intended to impart skills to plan and carry out simple electrical wiring. It is essential for the practicing engineers to identify the basic practices and safety measures in electrical wiring.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Demonstrate safety measures against electric shocks.
CO 2	Identify the tools used for electrical wiring, electrical accessories, wires, cables, batteries and standard symbols
CO 3	Develop the connection diagram, identify the suitable accessories and materials necessary for wiring simple lighting circuits for domestic buildings
CO 4	Identify and test various electronic components
CO 5	Draw circuit schematics with EDA tools
CO 6	Assemble and test electronic circuits on boards
CO 7	Work in a team with good interpersonal skills

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	-	-	-	-	-	3	-	-	-	-	-	1
CO 2	2	-	-	-	-	-	-	-	-	1	-	-
CO 3	2	-	-	1	-	1	-	1	2	2	-	2
CO 4	3	-	-	-	-	-	-	-	-	-	-	2
CO 5	3	-	-	-	2	-	-	-	-	-	-	2
CO 6	3	-	-	-	2	-	-	-	-	-	-	1
CO 7	-	-	-	-	-	-	-	-	3	2	-	2

Mark distribution

Total Marks	CIE	ESE	ESE Duration(Internal)
100	100	-	1 hour

Continuous Internal Evaluation Pattern:

Attendance	: 20 marks
Class work/ Assessment /Viva-voce	: 50 marks
End semester examination (Internally by college)	: 30 marks

End Semester Examination Pattern: Written Objective Examination of one hour

Syllabus

PART 1

ELECTRICAL

List of Exercises / Experiments

1. a) Demonstrate the precautionary steps adopted in case of Electrical shocks.

   b)Identify different types of cables, wires, switches, fuses, fuse carriers, MCB, ELCB and MCCB with ratings.
2. Wiring of simple light circuit for controlling light/ fan point (PVC conduit wiring)
3. Wiring of light/fan circuit using Two way switches . (Staircase wiring)
4. Wiring of Fluorescent lamps and light sockets (6A) with a power circuit for controlling power device. (16A socket)
5. Wiring of power distribution arrangement using single phase MCB distribution board with ELCB, main switch and Energy meter.
6. a)Identify different types of batteries with their specifications.

   b)Demonstrate the Pipe and Plate Earthing Schemes using Charts/Site Visit.

PART II

ELECTRONICS

List of Exercises / Experiments (Minimum of 7 mandatory)

1. Familiarization/Identification of electronic components with specification (Functionality, type, size, colour coding, package, symbol, cost etc. [Active, Passive, Electrical, Electronic, Electro-mechanical, Wires, Cables, Connectors, Fuses, Switches, Relays, Crystals, Displays, Fasteners, Heat sink etc.)

2. Drawing of electronic circuit diagrams using BIS/IEEE symbols and introduction to EDA tools (such as Dia or XCircuit), Interpret data sheets of discrete components and IC's, Estimation and costing.

3. Familiarization/Application of testing instruments and commonly used tools. [Multimeter, Function generator, Power supply, DSO etc.] [Soldering iron, De-soldering pump, Pliers, Cutters, Wire strippers, Screw drivers, Tweezers, Crimping tool, Hot air soldering and de- soldering station etc.]

4. Testing of electronic components [Resistor, Capacitor, Diode, Transistor and JFET using multimeter.]

5. Inter-connection methods and soldering practice. [Bread board, Wrapping, Crimping, Soldering - types - selection of materials and safety precautions, soldering practice in connectors and general purpose PCB, Crimping.]

6. Printed circuit boards (PCB) [Types, Single sided, Double sided, PTH, Processing methods, Design and fabrication of a single sided PCB for a simple circuit with manual etching (Ferric chloride) and drilling.]
7. Assembling of electronic circuits using SMT (Surface Mount Technology) stations.
8. Assembling of electronic circuit/system on general purpose PCB, test and show the functioning (**Any Two circuits).**

   1. Fixed voltage power supply with transformer, rectifier diode, capacitor filter, zener/IC regulator.
   2. Square wave generation using IC 555 timer in IC base.
   3. Sine wave generation using IC 741 OP-AMP in IC base.
   4. RC coupled amplifier with transistor BC107.

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CODE MCN201	SUSTAINABLE ENGINEERING	CATEGORY	L	T	P	CREDIT
			2	0	0	NIL

Preamble: Objective of this course is to inculcate in students an awareness of environmental issues and the global initiatives towards attaining sustainability. The student should realize the potential of technology in bringing in sustainable practices.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the relevance and the concept of sustainability and the global initiatives in this direction
CO 2	Explain the different types of environmental pollution problems and their sustainable solutions
CO 3	Discuss the environmental regulations and standards
CO 4	Outline the concepts related to conventional and non-conventional energy
CO 5	Demonstrate the broad perspective of sustainable practices by utilizing engineering knowledge and principles

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1						2	3					2
CO 2						2	3					2
CO 3						2	3					2
CO 4						2	3					2
CO 5						2	3					2

Assessment Pattern

Mark distribution

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	20	40
Understand	20	20	40
Apply	10	10	20
Analyse			
Evaluate			
Create			

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Level Assessment Questions

Course Outcome 1 (CO1): Understand the relevance and the concept of sustainability and the global initiatives in this direction

1. Explain with an example a technology that has contributed positively to sustainable development.
2. Write a note on Millennium Development Goals.

Course Outcome 2 (CO2) Explain the different types of environmental pollution problems and their sustainable solutions

1. Explain the 3R concept in solid waste management?
2. Write a note on any one environmental pollution problem and suggest a sustainable solution.
3. In the absence of green house effect the surface temperature of earth would not have been suitable for survival of life on earth. Comment on this statement.

Course Outcome 3(CO3) Discuss the environmental regulations and standards

1. Illustrate Life Cycle Analysis with an example of your choice.
2. "Nature is the most successful designer and the most brilliant engineer that has ever evolved". Discuss.

Course Outcome 4 (CO4): Outline the concepts related to conventional and non-conventional energy

1. Suggest a sustainable system to generate hot water in a residential building in tropical climate.
2. Enumerate the impacts of biomass energy on the environment.

Course Outcome 5 (CO5): Demonstrate the broad perspective of sustainable practices by utilizing engineering knowledge and principles

1. Suggest suitable measures to make the conveyance facilities used by your institution sustainable.

Model Question paper

Part A

(Answer all questions. Each question carries 3 marks each)

1. Define sustainable development.
2. Write a short note on Millennium Development Goals.
3. Describe carbon credit
4. Give an account of climate change and its effect on environment.
5. Describe biomimicry? Give two examples.
6. Explain the basic concept of Life Cycle Assessment.
7. Name three renewable energy sources.

8. Mention some of the disadvantages of wind energy.

9. Enlist some of the features of sustainable habitat.

10. Explain green engineering.

Part B

(Answer one question from each module. Each question carries 14 marks)

11. Discuss the evolution of the concept of sustainability. Comment on its relevance in the modern world.

OR

12. Explain Clean Development Mechanism.

13. Explain the common sources of water pollution and its harmful effects.

OR

14. Give an account of solid waste management in cities.

15. Explain the different steps involved in the conduct of Environmental Impact Assessment.

OR

16. Suggest some methods to create public awareness on environmental issues.

17. Comment on the statement, “Almost all energy that man uses comes from the Sun”.

OR

18. Write notes on:

    a. Land degradation due to water logging.

    b. Over exploitation of water.

19. Discuss the elements related to sustainable urbanisation.

OR

20. Discuss any three methods by which you can increase energy efficiency in buildings.

Syllabus

Sustainability- need and concept, technology and sustainable development-Natural resources and their pollution, Carbon credits, Zero waste concept. Life Cycle Analysis, Environmental Impact Assessment studies, Sustainable habitat, Green buildings, green materials, Energy, Conventional and renewable sources, Sustainable urbanization, Industrial Ecology.

Module 1

Sustainability: Introduction, concept, evolution of the concept; Social, environmental and economic sustainability concepts; Sustainable development, Nexus between Technology and Sustainable development; Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs), Clean Development Mechanism (CDM).

Module 2

Environmental Pollution: Air Pollution and its effects, Water pollution and its sources, Zero waste concept and 3 R concepts in solid waste management; Greenhouse effect, Global warming, Climate change, Ozone layer depletion, Carbon credits, carbon trading and carbon foot print, legal provisions for environmental protection.

Module 3

Environmental management standards: ISO 14001:2015 frame work and benefits, Scope and goal of Life Cycle Analysis (LCA), Circular economy, Bio-mimicking, Environment Impact Assessment (EIA), Industrial ecology and industrial symbiosis.

Module 4

Resources and its utilisation: Basic concepts of Conventional and non-conventional energy, General idea about solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans and Geothermal energy.

Module 5

Sustainability practices: Basic concept of sustainable habitat, Methods for increasing energy efficiency in buildings, Green Engineering, Sustainable Urbanisation, Sustainable cities, Sustainable transport.

Reference Books

1. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
2. Bradley. A.S; Adebayo,A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning
3. Environment Impact Assessment Guidelines, Notification of Government of India, 2006
4. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998
5. ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating System
6. Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.
7. Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Language Book Society (ELBS).
8. Purohit, S. S., Green Technology - An approach for sustainable environment, Agrobios Publication

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Sustainability	
1.1	Introduction, concept, evolution of the concept	1
1.2	Social, environmental and economic sustainability concepts	1
1.3	Sustainable development, Nexus between Technology and Susta development	1
1.4	Millennium Development Goals (MDGs) and Sustainable Development G (SDGs)	1
1.5	Clean Development Mechanism (CDM)	1
2	Environmental Pollution	
2.1	Air Pollution and its effects	1
2.2	Water pollution and its sources	1
2.3	Zero waste concept and 3 R concepts in solid waste management	1
2.4	Greenhouse effect, Global warming, Climate change, Ozone layer depletio	1
2.5	Carbon credits, carbon trading and carbon foot print.	1
2.6	Legal provisions for environmental protection.	1
3	Environmental management standard	
3.1	Environmental management standards	1
3.2	ISO 14001:2015 frame work and benefits	1
3.3	Scope and Goal of Life Cycle Analysis (LCA)	1
3.4	Circular economy, Bio-mimicking	1
3.5	Environment Impact Assessment (EIA)	1
3.6	Industrial Ecology, Industrial Symbiosis	1
4	Resources and its utilisation	
4.1	Basic concepts of Conventional and non-conventional energy	1
4.2	General idea about solar energy, Fuel cells	1
4.3	Wind energy, Small hydro plants, bio-fuels	1
4.4	Energy derived from oceans and Geothermal energy	1
5	Sustainability Practices	
5.1	Basic concept of sustainable habitat	1
5.2	Methods for increasing energy efficiency of buildings	1
5.3	Green Engineering	1
5.4	Sustainable Urbanisation, Sustainable cities, Sustainable transport	1

HUMANITIES

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
			2	0	0	2
EST 200	DESIGN AND ENGINEERING					

Preamble:

The purpose of this course is to

i) introduce the undergraduate engineering students the fundamental principles of design engineering,

ii) make them understand the steps involved in the design process and

iii) familiarize them with the basic tools used and approaches in design.

Students are expected to apply design thinking in learning as well as while practicing engineering, which is very important and relevant for today. Case studies from various practical situations will help the students realize that design is not only concerned about the function but also many other factors like customer requirements, economics, reliability, etc. along with a variety of life cycle issues.

The course will help students to consider aesthetics, ergonomics and sustainability factors in designs and also to practice professional ethics while designing.

Prerequisite

Nil.The course will be generic to all engineering disciplines and will not require specialized preparation or prerequisites in any of the individual engineering disciplines.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Explain the different concepts and principles involved in design engineering.
CO 2	Apply design thinking while learning and practicing engineering.
CO 3	Develop innovative, reliable, sustainable and economically viable designs incorporating knowledge in engineering.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	1					1			1		
CO 2		2				1		1				2
CO 3			2			1	1		2	2		1

Assessment Pattern

Continuous Internal Evaluation (CIE) Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination (ESE) Pattern: There will be two parts; Part A and Part B.

Part A	: 30 marks
part B	: 70 marks

Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.
Part B contains 2 case study questions from each module of which student should answer any one. Each question carry 14 marks and can have maximum 2 sub questions.

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	5	5	10
Understand	10	10	20
Apply	35	35	70
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1): Appreciate the different concepts and principles involved in design engineering.

1. State how engineering design is different from other kinds of design

2. List the different stages in a design process

3. Describe design thinking.

4. State the function of prototyping and proofing in engineering design

5. Write notes on the following concepts in connection with design engineering 1) Modular Design, 2) Life Cycle Design , 3) Value Engineering, 4) Concurrent Engineering, and 5) Reverse Engineering

6. State design rights.

Course Outcome 2 (CO2) Apply design thinking while learning and practicing engineering.

1. Construct the iterative process for design thinking in developing simple products like a pen, umbrella, bag, etc.

2. Show with an example how divergent-convergent thinking helps in generating alternative designs and then how to narrow down to the best design.

3. Describe how a problem-based learning helps in creating better design engineering solutions.

4. Discuss as an engineer, how ethics play a decisive role in your designs

Course Outcome 3(CO3): Develop innovative, reliable, sustainable and economically viable designs incorporating different segments of knowledge in engineering.

1. Illustrate the development of any simple product by passing through the different stages of design process

2. Show the graphical design communication with the help of detailed 2D or 3D drawings for any simple product.

3. Describe how to develop new designs for simple products through bio-mimicry.

Model Question paper

Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD/FOURTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code: EST 200

Course Name: DESIGN AND ENGINEERING

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each question carries 3 marks

Use only hand sketches

(1) Write about the basic design process

(2) Describe how to finalize the design objectives.

(3) State the role of divergent-convergent questioning in design thinking.

(4) Discuss how to perform design thinking in a team managing the conflicts.

(5) Show how engineering sketches and drawings convey designs.

(6) Explain the role of mathematics and physics in design engineering process

(7) Distinguish between project-based learning and problem-based learning in design engineering.

(8) Describe how concepts like value engineering , concurrent engineering and reverse engineering influence engineering designs?

(9) Show how designs are varied based on the aspects of production methods, life span, reliability and environment?

(10) Explain how economics influence the engineering designs?

(10x3 marks =30 marks)

Part B

Answer any ONE question from each module. Each question carry 14 marks

Module 1

(11) Show the designing of a wrist watch going through the various stages of the design process. Use hand sketches to illustrate the processes

or

(12) Find the customer requirements for designing a new car showroom. Show how the design objectives were finalized considering the design constraints?

Module 2

(13) Illustrate the design thinking approach for designing a bag for college students within a limited budget. Describe each stage of the process and the iterative procedure involved. Use hand sketches to support your arguments

or

(14) Construct a number of possible designs and then refine them to narrow down to the best design for a drug trolley used in hospitals. Show how the divergent-convergent thinking helps in the process. Provide your rationale for each step by using hand sketches only.

Module 3

(15) Graphically communicate the design of a thermo flask used to keep hot coffee. Draw the detailed 2D drawings of the same with design detailing, material selection, scale drawings, dimensions, tolerances, etc. Use only hand sketches.

or

(16) Describe the role of mathematical modelling in design engineering. Show how mathematics and physics play a role in designing a lifting mechanism to raise 100 kg of weight to a floor at a height of 10 meters in a construction site.

Module 4

(17) Show the development of a nature inspired design for a solar powered bus waiting shed beside a highway. Relate between natural and man-made designs. Use hand sketches to support your arguments

or

(18) Show the design of a simple sofa and then depict how the design changes when considering 1) aesthetics and 2) ergonomics into consideration. Give hand sketches and explanations to justify the changes in designs.

Module 5

(19) Examine the changes in the design of a foot wear with constraints of 1) production methods, 2) life span requirement, 3) reliability issues and 4) environmental factors. Use hand sketches and give proper rationalization for the changes in design.

(20) Describe the how to estimate the cost of a particular design using ANY of the following i) a website, ii) the layout of a plant, iii) the elevation of a building, iv) an electrical or electronic system or device and v) a car.
Show how economics will influence the engineering designs. Use hand sketches to support your arguments

(5x14 marks =70 marks)

Syllabus

Module 1

Design Process- Introduction to Design and Engineering Design, Defining a Design Process-Detailing Customer Requirements, Setting Design Objectives, Identifying Constraints, Establishing Functions, Generating Design Alternatives and Choosing a Design.

Module 2

Design Thinking Approach-Introduction to Design Thinking, Iterative Design Thinking Process Stages: Empathize, Define, Ideate, Prototype and Test. Design Thinking as Divergent-Convergent Questioning. Design Thinking in a Team Environment.

Module 3

Design Communication (Languages of Engineering Design)-Communicating Designs Graphically, Communicating Designs Orally and in Writing. Mathematical Modeling In Design, Prototyping and Proofing the Design.

Module 4

Design Engineering Concepts-Project-based Learning and Problem-based Learning in Design. Modular Design and Life Cycle Design Approaches. Application of Bio-mimicry, Aesthetics and Ergonomics in Design. Value Engineering, Concurrent Engineering, and Reverse Engineering in Design.

Module 5

Expediency, Economics and Environment in Design Engineering-Design for Production, Use, and Sustainability. Engineering Economics in Design. Design Rights Ethics in Design

Text Books

1) YousefHaik, SangarappillaiSivaloganathan, Tamer M. Shahin, Engineering Design Process, Cengage Learning 2003, Third Edition, ISBN-10: 9781305253285,

2) Voland, G., Engineering by Design, Pearson India 2014, Second Edition, ISBN 9332535051

Reference Books

1.Philip Kosky, Robert Balmer, William Keat, George Wise, Exploring Engineering, Fourth Edition: An Introduction to Engineering and Design, Academic Press 2015, 4th Edition, ISBN: 9780128012420.

2. Clive L. Dym, Engineering Design: A Project-Based Introduction, John Wiley & Sons, New York 2009, Fourth Edition, ISBN: 978-1-118-32458-5

3. Nigel Cross, Design Thinking: Understanding How Designers Think and Work, Berg Publishers 2011, First Edition, ISBN: 978-1847886361

4. Pahl, G., Beitz, W., Feldhusen, J., Grote, K.-H., Engineering Design: A Systematic Approach, Springer 2007, Third Edition, ISBN 978-1-84628-319-2

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Module 1: Design Process	
1.1	Introduction to Design and Engineering Design. What does it mean to design something? How Is engineering design different from other kinds of design? Where and when do engineers design? What are the basic vocabulary in engineering design? How to learn and do engineering design.	1
1.2	Defining a Design Process: Detailing Customer Requirements. How to do engineering design? Illustrate the process with an example. How to identify the customer requirements of design?	1
1.3	Defining a Design Process: Setting Design Objectives, Identifying Constraints, Establishing Functions. How to finalize the design objectives? How to identify the design constraints? How to express the functions a design in engineering terms?	1
1.4	Defining a Design Process: Generating Design Alternatives and Choosing a Design. How to generate or create feasible design alternatives? How to identify the "best possible design"?	1
1.5	Case Studies: Stages of Design Process. Conduct exercises for designing simple products going through the different stages of design process.	1
2	Module 2: Design Thinking Approach	
2.1	Introduction to Design Thinking How does the design thinking approach help engineers in creating innovative and efficient designs?	1
2.2	Iterative Design Thinking Process Stages: Empathize, Define, Ideate, Prototype and Test How can the engineers arrive at better designs utilizing the iterative design thinking process (in which knowledge acquired in the later stages can be applied back to the earlier stages)?	1
2.3	Design Thinking as Divergent-Convergent Questioning. Describe how to create a number of possible designs and then how to refine and narrow down to the 'best design'.	1
2.4	Design Thinking in a Team Environment. How to perform design thinking as a team managing the conflicts ?	1
2.5	Case Studies: Design Thinking Approach. Conduct exercises using the design thinking approach for	1

	designing any simple products within a limited time and budget	
3	Module 3: Design Communication (Languages of Engineering Design)	
3.1	Communicating Designs Graphically How do engineering sketches and drawings convey designs	1
3.2	Communicating Designs Orally and in Writing How can a design be communicated through oral presentation or technical reports efficiently?	1
	First Series Examination	
3.3	Mathematical Modelling in Design How do mathematics and physics become a part of the design process?	1
3.4	Prototyping and Proofing the Design How to predict whether the design will function well or not?	1
3.5	Case Studies: Communicating Designs Graphically. Conduct exercises for design communication through detailed 2D or 3D drawings of simple products with design detailing, material selection, scale drawings, dimensions, tolerances, etc.	1
4	Module 4: Design Engineering Concepts	
4.1	Project-based Learning and Problem-based Learning in Design. How engineering students can learn design engineering through projects? How students can take up problems to learn design engineering?	1
4.2	Modular Design and Life Cycle Design Approaches. What is modular approach in design engineering? How it helps? How the life cycle design approach influences design decisions?	1
4.3	Application of Bio-mimicry, Aesthetics and Ergonomics in Design. How do aesthetics and ergonomics change engineering designs? How do the intelligence in nature inspire engineering designs? What are the common examples of bio-mimicry in engineering?	1
4.4	Value Engineering, Concurrent Engineering, and Reverse Engineering in Design. How do concepts like value engineering , concurrent engineering and reverse engineering influence engineering designs?	1
4.5	Case Studies: Bio-mimicry based Designs. Conduct exercises to develop new designs for simple	1

	products using biomimicry and train students to bring out new nature inspired designs.	
5	<u>Module 5: Expediency, Economics and Environment in Design Engineering</u>	
5.1	Design for Production, Use, and Sustainability. How designs are finalized based on the aspects of production methods, life span, reliability and environment?	1
5.2	Engineering Economics in Design. How to estimate the cost of a particular design and how will economics influence the engineering designs?	1
5.3	DesignRights What are design rights and how can an engineer put it into practice?	1
5.4	Ethics in Design. How do ethics play a decisive role in engineering design?	1
5.5	Case Studies: Design for Production, Use, and Sustainability. Conduct exercises using simple products to show how designs change with constraints of production methods, life span requirement, reliability issues and environmental factors.	1
	SecondSeries Examination	

Code.	Course Name	L	T	P	Hrs	Credit
HUT 200	Professional Ethics	2	0	0	2	2

Preamble:To enable students to create awareness on ethics and human values.

Prerequisite: Nil

Course Outcomes After the completion of the course the student will be able to

CO 1	Understand the core values that shape the ethical behaviour of a professional.
CO 2	Adopt a good character and follow an ethical life.
CO 3	Explain therole and responsibility in technological development by keeping personal and legal ethics.
CO 4	Solve moral and ethical problems through exploration and assessment by esta experiments.
CO 5	Apply the knowledge of human values and social values to contemporary ethical valu global issues.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO 1								2			2	
CO 2								2			2	
CO 3								3			2	
CO 4								3			2	
CO 5								3			2	

Assessment Pattern

Bloom's category	Continuous Assessment Tests		End Semester Exam
	1	2	
Remember	15	15	30
Understood	20	20	40
Apply	15	15	30

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Tests (2 Nos) : 25 marks
Assignments/Quiz : 15 marks

End Semester Examination Pattern:There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. PartB contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):
1. Define integrity and point out ethical values.
2. Describe the qualities required to live a peaceful life.
3. Explain the role of engineers in modern society.

Course Outcome 2 (CO2)
1. Derive the codes of ethics.
2. Differentiate consensus and controversy.
3. Discuss in detail about character and confidence.

Course Outcome 3(CO3):
1. Explain the role of professional's ethics in technological development.
2. Distinguish between self interest and conflicts of interest.
3. Review on industrial standards and legal ethics.

Course Outcome 4 (CO4):
1. Illustrate the role of engineers as experimenters.
2. Interpret the terms safety and risk.
3. Show how the occupational crimes are resolved by keeping the rights of employees.

Course Outcome 5 (CO5):
1. Exemplify the engineers as managers.
2. Investigate the causes and effects of acid rain with a case study.
3. Explorate the need of environmental ethics in technological development.

HUMANITIES

Model Question paper

QP CODE: Reg No:_______________

PAGES:3 Name :_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD/FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: HUT 200

Course Name: PROFESSIONAL ETHICS

Max. Marks: 100 Duration: 3 Hours

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Define empathy and honesty.
2. Briefly explain about morals, values and ethics.
3. Interpret the two forms of self-respect.
4. List out the models of professional roles.
5. Indicate the advantages of using standards.
6. Point out the conditions required to define a valid consent?
7. Identify the conflicts of interests with an example?
8. Recall confidentiality.
9. Conclude the features of biometric ethic.
10. Name any three professional societies and their role relevant to engineers.

(10x3 = 30 marks)

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. a) Classify the relationship between ethical values and law?

b) Compare between caring and sharing. (10+4 = 14 marks)

Or

12. a) Exemplify a comprehensive review about integrity and respect for others.

b) Discuss about coperation and commitment. (8+6 = 14 marks)

MODULE II

13.a)Explain the three main levels of moral developments, deviced by Kohlberg.

b)Differentiate moral codes and optimal codes. (10+4 = 14 marks)

Or

14. a)Extrapolate the duty ethics and right ethics.

b)Discuss in detail the three types of inquiries in engineering ethics. (8+6 = 14 marks)

MODULE III

15.a) Summarize the following features of morally responsible engineers.

(i) Moral autonomy (ii) Accountability

b)Explain the rights of employees (8+6 = 14 marks)

Or

16. a)Explain the reasons for Chernobyl mishap ?

b)Describe the methods to improve collegiality and loyalty. (8+6 = 14 marks)

MODULE IV

17.a)Execute collegiality with respect to commitment, respect and connectedness.

b)Identify conflicts of interests with an example. (8+6 = 14 marks)

Or

18. a)Explain in detail about professional rights and employee rights.

b)Exemplify engineers as managers.

MODULE V

19.a)Evaluate the technology transfer and appropriate technology.

b) Explain about computer and internet ethics. (8+6 = 14 marks)

Or

20. a)Investigate the causes and effects of acid rain with a case study.

b) Conclude the features of ecocentric and biocentric ethics. (8+6 = 14 marks)

Syllabus

Module 1 – Human Values.

Morals, values and Ethics – Integrity – Academic integrity – Work Ethics – Service Learning – Civic Virtue – Respect for others – Living peacefully – Caring and Sharing – Honestly – courage – Cooperation commitment – Empathy – Self Confidence – Social Expectations.

Module 2 - Engineering Ethics & Professionalism.

Senses of Engineering Ethics – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Profession and Professionalism – Models of professional roles – Theories about right action – Self interest – Customs and Religion – Uses of Ethical Theories.

Module 3 – Engineering as social Experimentation.

Engineering as Experimentation – Engineers as responsible Experimenters – Codes of Ethics – Plagiarism – A balanced outlook on law – Challenges case study – Bhopal gas tragedy.

Module 4 – Responsibilities and Rights.

Collegiality and loyalty – Managing conflict – Respect for authority – Collective bargaining – Confidentiality – Role of confidentiality in moral integrity – Conflicts of interest – Occupational crime – Professional rights – Employee right – IPR Discrimination.

Module 5 – Global Ethical Issues.

Multinational Corporations – Environmental Ethics – Business Ethics – Computer Ethics – Role in Technological Development – Engineers as Managers – Consulting Engineers – Engineers as Expert witnesses and advisors – Moral leadership.

Text Book

1. M Govindarajan, S Natarajan and V S Senthil Kumar, Engineering Ethics, PHI Learning Private Ltd,New Delhi,2012.
2. R S Naagarazan, A text book on professional ethics and human values, New age internationa (P) limited ,New Delhi,2006.

Reference Books

1. Mike W Martin and Roland Schinzinger, Ethics in Engineering, 4th edition, Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi,2014.
2. Charles D Fleddermann, Engineering Ethics, Pearson Education/ Prentice Hall of India, New Jersey,2004.
3. Charles E Harris, Michael S Protchard and Michael J Rabins, Engineering Ethics- Concepts and cases, Wadsworth Thompson Learning, United states,2005.
4. http://www.slideword.org/slidestag.aspx/human-values-and-Professional-ethics

Course Contents and Lecture Schedule

SL.No	Topic	No. of Lectures 25
1	Module 1 – Human Values.	
1.1	Morals, values and Ethics, Integrity, Academic Integrity, Work Ethics	1
1.2	Service Learning, Civic Virtue, Respect for others, Living peacefully	1
1.3	Caring and Sharing, Honesty, Courage, Co-operation commitment	2
1.4	Empathy, Self Confidence, Social Expectations	1
2	Module 2- Engineering Ethics & Professionalism.	
2.1	Senses of Engineering Ethics, Variety of moral issues, Types of inqu	1
2.2	Moral dilemmas, Moral Autonomy, Kohlberg's theory	1
2.3	Gilligan's theory, Consensus and Controversy, Profession & Professionalism, Models of professional roles, Theories about right action	2
2.4	Self interest, Customs and Religion, Uses of Ethical Theories	1
3	Module 3- Engineering as social Experimentation.	
3.1	Engineering as Experimentation, Engineers as responsible Experimen	1
3.2	Codes of Ethics, Plagiarism, A balanced outlook on law	2
3.3	Challenger case study, Bhopal gas tragedy	2
4	Module 4- Responsibilities and Rights.	
4.1	Collegiality and loyalty, Managing conflict, Respect for authority	1
4.2	Collective bargaining, Confidentiality, Role of confidentiality in moral integrity, Conflicts of interest	2
4.3	Occupational crime, Professional rights, Employee right, IPR Discrimination	2
5	Module 5- Global Ethical Issues.	
5.1	Multinational Corporations, Environmental Ethics, Business Ethics, Computer Ethics	2
5.2	Role in Technological Development, Moral leadership	1
5.3	Engineers as Managers, Consulting Engineers, Engineers as Expert witnesses and advisors	2

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HUMANITIES

CODE	COURSE NAME	CATEGOR	L	T	P	CREDIT
MCN202	CONSTITUTION OF INDIA		2	0	0	NIL

Preamble:

The study of their own country constitution and studying the importance environment as well as understanding their own human rights help the students to concentrate on their day to day discipline. It also gives the knowledge and strength to face the society and people.

Prerequisite Nil

Course Outcomes After the completion of the course the student will be able to

CO 1	Explain the background of the present constitution of India and features.
CO 2	Utilize the fundamental rights and duties.
CO 3	Understand the working of the union executive, parliament and judiciary.
CO 4	Understand the working of the state executive, legislature and judiciary.
CO 5	Utilize the special provisions and statutory institutions.
CO 6	Show national and patriotic spirit as responsible citizens of the country

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1						2	2	2		2		
CO 2						3	3	3		3		
CO 3						3	2	3		3		
CO 4						3	2	3		3		
CO 5						3	2	3		3		
CO 6						3	3	3		2		

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	20	40
Understand	20	20	40
Apply	10	10	20
Analyse			

Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1 Discuss the historical background of the Indian constitution.

2 Explain the salient features of the Indian constitution.

3 Discuss the importance of preamble in the implementation of constitution.

Course Outcome 2 (CO2)

1 What are fundamental rights ? Examine each of them.

2 Examine the scope of freedom of speech and expression underlying the constitution.

3 The thumb impression of an accused is taken by the police against his will. He contends that this is a violation of his rights under Art 20(3) of the constitution. Decide

Course Outcome 3(CO3):

1 Explain the powers of the President to suspend the fundamental rights during emergency.

2 Explain the salient features of appeal by special leave.

3. List the constitutional powers of President.

Course Outcome 4 (CO4):

1 Discuss the constitutional powers of Governor.

2 Examine the writ jurisdiction of High court.

3 Discuss the qualification and disqualification of membership of state legislature.

Course Outcome 5 (CO5):

1 Discuss the duties and powers of comptroller and auditor general.

2 Discuss the proclamation of emergency.

3 A state levies tax on motor vehicles used in the state, for the purpose of maintaining roads in the state. X challenges the levy of the tax on the ground that it violates the freedom of interstate commerce guaranteed under Art 301. Decide.

Course Outcome 6 (CO6):

1 Explain the advantages of citizenship.

2 List the important principles contained in the directive principles of state policy.

3 Discuss the various aspects contained in the preamble of the constitution

Model Question paper

PART A

(Answer all questions. Each question carries 3 marks)

1 Define and explain the term constitution.

2 Explain the need and importance of Preamble.

3 What is directive principle of state policy?

4 Define the State.

5 List the functions of Attorney general of India.

6 Explain the review power of Supreme court.

7 List the qualifications of Governor.

8 Explain the term and removal of Judges in High court.

9 Explain the powers of public service commission.

10 List three types of emergency under Indian constitution.

(10X3=30marks)

PART B

(Answer on question from each module. Each question carries 14 marks)

Module 1

11 Discuss the various methods of acquiring Indian citizenship.

12 Examine the salient features of the Indian constitution.

Module 2

13 A high court passes a judgement against X. X desires to file a writ petition in the supreme court under Art32, on the ground that the judgement violates his fundamental rights. Advise him whether he can do so.

14 What is meant by directive principles of State policy? List the directives.

Module 3

15 Describe the procedure of election and removal of the President of India.

16 Supreme court may in its discretion grant special leave to appeal. Examine the situation.

Module 4

17 Discuss the powers of Governor.

18 X filed a writ petition under Art226 which was dismissed. Subsequently, he filed a writ petition under Art32 of the constitution, seeking the same remedy. The Government argued that the writ petition should be dismissed, on the ground of res judicata. Decide.

Module 5

19 Examine the scope of the financial relations between the union and the states

20 Discuss the effects of proclamation of emergency.

(14X5=70marks)

Syllabus

Module 1 Definition, historical background, features, preamble, territory, citizenship.

Module 2 State, fundamental rights, directive principles, duties.

Module 3 The machinery of the union government.

Module 4 Government machinery in the states

Module 5 The federal system, Statutory Institutions, miscellaneous provisions

Text Books

1 D D Basu, Introduction to the constitution of India, Lexis Nexis, New Delhi, 24e, 2019

2 PM Bhakshi, The constitution of India, Universal Law, 14e, 2017

Reference Books

1 Ministry of law and justice, The constitution of India, Govt of India, New Delhi, 2019.

2 JN Pandey, The constitutional law of India, Central Law agency, Allahabad, 51e, 2019

3 MV Pylee, India's Constitution, S Chand and company, New Delhi, 16e, 2016

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Module 1	
1.1	Definition of constitution, historical background, salient features of the constitution.	1
1.2	Preamble of the constitution, union and its territory	1
1.3	Meaning of citizenship, types, termination of citizenship	2
2	Module 2	
2.1	Definition of state, fundamental rights, general nature, classification, right to equality, right to freedom, right against exploitation	2

2.2	Right to freedom of religion, cultural and educational rights, right to constitutional remedies. Protection in respect of conviction for offences.	2
2.3	Directive principles of state policy, classification of directives, fundamental duties.	2
3	Module 3	
3.1	The Union executive, the President, the vice President, the council of ministers, the Prime minister, Attorney-General, functions.	2
3.2	The parliament, composition, Rajya sabha, Lok sabha, qualification and disqualification of membership, functions of parliament	2
3.3	Union judiciary, the supreme court, jurisdiction, appeal by special leave.	1
4	Module 4	
4.1	The State executive, the Governor, the council of ministers, the Chief minister, advocate general, union Territories	2
4.2	The State Legislature, composition, qualification and disqualification of membership, functions.	2
4.3	The state judiciary, the high court, jurisdiction, writs jurisdiction	1
5	Module 5	
5.1	Relations between the Union and the States, legislative relation, administrative relation, financial Relations, Inter State council, finance commission.	1
5.2	Emergency provision, freedom of trade commerce and inter course, comptroller and auditor general of India, public Services, public service commission, administrative Tribunals	2
5.3	Official language, elections, special provisions relating to certain classes, amendment of the Constitution.	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
			2	0	0	2
EST 200	DESIGN AND ENGINEERING					

Preamble:

The purpose of this course is to

i) introduce the undergraduate engineering students the fundamental principles of design engineering,

ii) make them understand the steps involved in the design process and

iii) familiarize them with the basic tools used and approaches in design.

Students are expected to apply design thinking in learning as well as while practicing engineering, which is very important and relevant for today. Case studies from various practical situations will help the students realize that design is not only concerned about the function but also many other factors like customer requirements, economics, reliability, etc. along with a variety of life cycle issues.

The course will help students to consider aesthetics, ergonomics and sustainability factors in designs and also to practice professional ethics while designing.

Prerequisite

Nil. The course will be generic to all engineering disciplines and will not require specialized preparation or prerequisites in any of the individual engineering disciplines.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Explain the different concepts and principles involved in design engineering.
CO 2	Apply design thinking while learning and practicing engineering.
CO 3	Develop innovative, reliable, sustainable and economically viable designs incorporating knowledge in engineering.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	1					1			1		
CO 2		2				1		1				2
CO 3			2			1	1		2	2		1

Assessment Pattern

Continuous Internal Evaluation (CIE) Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination (ESE) Pattern: There will be two parts; Part A and Part B.

Part A	: 30 marks
part B	: 70 marks

Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.
Part B contains 2 case study questions from each module of which student should answer any one. Each question carry 14 marks and can have maximum 2 sub questions.

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	5	5	10
Understand	10	10	20
Apply	35	35	70
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1): Appreciate the different concepts and principles involved in design engineering.

1. State how engineering design is different from other kinds of design

2. List the different stages in a design process

3. Describe design thinking.

4. State the function of prototyping and proofing in engineering design

5. Write notes on the following concepts in connection with design engineering 1) Modular Design, 2) Life Cycle Design , 3) Value Engineering, 4) Concurrent Engineering, and 5) Reverse Engineering

6. State design rights.

Course Outcome 2 (CO2) Apply design thinking while learning and practicing engineering.

1. Construct the iterative process for design thinking in developing simple products like a pen, umbrella, bag, etc.

2. Show with an example how divergent-convergent thinking helps in generating alternative designs and then how to narrow down to the best design.

3. Describe how a problem-based learning helps in creating better design engineering solutions.

4. Discuss as an engineer, how ethics play a decisive role in your designs

Course Outcome 3(CO3): Develop innovative, reliable, sustainable and economically viable designs incorporating different segments of knowledge in engineering.

1. Illustrate the development of any simple product by passing through the different stages of design process

2. Show the graphical design communication with the help of detailed 2D or 3D drawings for any simple product.

3. Describe how to develop new designs for simple products through bio-mimicry.

Model Question paper

Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD/FOURTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code: EST 200

Course Name: DESIGN AND ENGINEERING

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each question carries 3 marks

Use only hand sketches

(1) Write about the basic design process

(2) Describe how to finalize the design objectives.

(3) State the role of divergent-convergent questioning in design thinking.

(4) Discuss how to perform design thinking in a team managing the conflicts.

(5) Show how engineering sketches and drawings convey designs.

(6) Explain the role of mathematics and physics in design engineering process

(7) Distinguish between project-based learning and problem-based learning in design engineering.

(8) Describe how concepts like value engineering , concurrent engineering and reverse engineering influence engineering designs?

(9) Show how designs are varied based on the aspects of production methods, life span, reliability and environment?

(10) Explain how economics influence the engineering designs?

(10x3 marks =30 marks)

Part B

Answer any ONE question from each module. Each question carry 14 marks

Module 1

(11) Show the designing of a wrist watch going through the various stages of the design process. Use hand sketches to illustrate the processes

or

(12) Find the customer requirements for designing a new car showroom. Show how the design objectives were finalized considering the design constraints?

Module 2

(13) Illustrate the design thinking approach for designing a bag for college students within a limited budget. Describe each stage of the process and the iterative procedure involved. Use hand sketches to support your arguments

or

(14) Construct a number of possible designs and then refine them to narrow down to the best design for a drug trolley used in hospitals. Show how the divergent-convergent thinking helps in the process. Provide your rationale for each step by using hand sketches only.

Module 3

(15) Graphically communicate the design of a thermo flask used to keep hot coffee. Draw the detailed 2D drawings of the same with design detailing, material selection, scale drawings, dimensions, tolerances, etc. Use only hand sketches.

or

(16) Describe the role of mathematical modelling in design engineering. Show how mathematics and physics play a role in designing a lifting mechanism to raise 100 kg of weight to a floor at a height of 10 meters in a construction site.

Module 4

(17) Show the development of a nature inspired design for a solar powered bus waiting shed beside a highway. Relate between natural and man-made designs. Use hand sketches to support your arguments

or

(18) Show the design of a simple sofa and then depict how the design changes when considering 1) aesthetics and 2) ergonomics into consideration. Give hand sketches and explanations to justify the changes in designs.

Module 5

(19) Examine the changes in the design of a foot wear with constraints of 1) production methods, 2) life span requirement, 3) reliability issues and 4) environmental factors. Use hand sketches and give proper rationalization for the changes in design.

or

(20) Describe the how to estimate the cost of a particular design using ANY of the following i) a website, ii) the layout of a plant, iii) the elevation of a building, iv) an electrical or electronic system or device and v) a car.
Show how economics will influence the engineering designs. Use hand sketches to support your arguments

(5x14 marks =70 marks)

Syllabus

Module 1

Design Process- Introduction to Design and Engineering Design, Defining a Design Process- Detailing Customer Requirements, Setting Design Objectives, Identifying Constraints, Establishing Functions, Generating Design Alternatives and Choosing a Design.

Module 2

Design Thinking Approach- Introduction to Design Thinking, Iterative Design Thinking Process Stages: Empathize, Define, Ideate, Prototype and Test. Design Thinking as Divergent-Convergent Questioning. Design Thinking in a Team Environment.

Module 3

Design Communication (Languages of Engineering Design)- Communicating Designs Graphically, Communicating Designs Orally and in Writing. Mathematical Modeling In Design, Prototyping and Proofing the Design.

Module 4

Design Engineering Concepts- Project-based Learning and Problem-based Learning in Design. Modular Design and Life Cycle Design Approaches. Application of Bio-mimicry, Aesthetics and Ergonomics in Design. Value Engineering, Concurrent Engineering, and Reverse Engineering in Design.

Module 5

Expediency, Economics and Environment in Design Engineering- Design for Production, Use, and Sustainability. Engineering Economics in Design. Design Rights Ethics in Design

Text Books

1) YousefHaik, SangarappillaiSivaloganathan, Tamer M. Shahin, Engineering Design Process, Cengage Learning 2003, Third Edition, ISBN-10: 9781305253285,

2) Voland, G., Engineering by Design, Pearson India 2014, Second Edition, ISBN 9332535051

Reference Books

1. Philip Kosky, Robert Balmer, William Keat, George Wise, Exploring Engineering, Fourth Edition: An Introduction to Engineering and Design, Academic Press 2015, 4th Edition, ISBN: 9780128012420.

2. Clive L. Dym, Engineering Design: A Project-Based Introduction, John Wiley & Sons, New York 2009, Fourth Edition, ISBN: 978-1-118-32458-5

3. Nigel Cross, Design Thinking: Understanding How Designers Think and Work, Berg Publishers 2011, First Edition, ISBN: 978-1847886361

4. Pahl, G., Beitz, W., Feldhusen, J., Grote, K.-H., Engineering Design: A Systematic Approach, Springer 2007, Third Edition, ISBN 978-1-84628-319-2

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Module 1: Design Process	
1.1	Introduction to Design and Engineering Design. What does it mean to design something? How Is engineering design different from other kinds of design? Where and when do engineers design? What are the basic vocabulary in engineering design? How to learn and do engineering design.	1
1.2	Defining a Design Process: Detailing Customer Requirements. How to do engineering design? Illustrate the process with an example. How to identify the customer requirements of design?	1
1.3	Defining a Design Process: Setting Design Objectives, Identifying Constraints, Establishing Functions. How to finalize the design objectives? How to identify the design constraints? How to express the functions a design in engineering terms?	1
1.4	Defining a Design Process: Generating Design Alternatives and Choosing a Design. How to generate or create feasible design alternatives? How to identify the "best possible design"?	1
1.5	Case Studies: Stages of Design Process. Conduct exercises for designing simple products going through the different stages of design process.	1
2	Module 2: Design Thinking Approach	
2.1	Introduction to Design Thinking How does the design thinking approach help engineers in creating innovative and efficient designs?	1
2.2	Iterative Design Thinking Process Stages: Empathize, Define, Ideate, Prototype and Test How can the engineers arrive at better designs utilizing the iterative design thinking process (in which knowledge acquired in the later stages can be applied back to the earlier stages)?	1
2.3	Design Thinking as Divergent-Convergent Questioning. Describe how to create a number of possible designs and then how to refine and narrow down to the 'best design'.	1
2.4	Design Thinking in a Team Environment. How to perform design thinking as a team managing the conflicts ?	1
2.5	Case Studies: Design Thinking Approach. Conduct exercises using the design thinking approach for	1

	designing any simple products within a limited time and budget	
3	Module 3: Design Communication (Languages of Engineering Design)	
3.1	Communicating Designs Graphically. How do engineering sketches and drawings convey designs	1
3.2	Communicating Designs Orally and in Writing How can a design be communicated through oral presentation or technical reports efficiently?	1
	First Series Examination	
3.3	Mathematical Modelling in Design. How do mathematics and physics become a part of the design process?	1
3.4	Prototyping and Proofing the Design. How to predict whether the design will function well or not?	1
3.5	Case Studies: Communicating Designs Graphically. Conduct exercises for design communication through detailed 2D or 3D drawings of simple products with design detailing, material selection, scale drawings, dimensions, tolerances, etc.	1
4	Module 4: Design Engineering Concepts	
4.1	Project-based Learning and Problem-based Learning in Design. How engineering students can learn design engineering through projects? How students can take up problems to learn design engineering?	1
4.2	Modular Design and Life Cycle Design Approaches. What is modular approach in design engineering? How it helps? How the life cycle design approach influences design decisions?	1
4.3	Application of Bio-mimicry, Aesthetics and Ergonomics in Design. How do aesthetics and ergonomics change engineering designs? How do the intelligence in nature inspire engineering designs? What are the common examples of bio-mimicry in engineering?	1
4.4	Value Engineering, Concurrent Engineering, and Reverse Engineering in Design. How do concepts like value engineering , concurrent engineering and reverse engineering influence engineering designs?	1
4.5	Case Studies: Bio-mimicry based Designs. Conduct exercises to develop new designs for simple	1

	products using bio-mimicry and train students to bring out new nature inspired designs.	
5	<u>Module 5: Expediency, Economics and Environment in Design Engineering</u>	
5.1	Design for Production, Use, and Sustainability. How designs are finalized based on the aspects of production methods, life span, reliability and environment?	1
5.2	Engineering Economics in Design. How to estimate the cost of a particular design and how will economics influence the engineering designs?	1
5.3	DesignRights. What are design rights and how can an engineer put it into practice?	1
5.4	Ethics in Design. How do ethics play a decisive role in engineering design?	1
5.5	Case Studies: Design for Production, Use, and Sustainability. Conduct exercises using simple products to show how designs change with constraints of production methods, life span requirement, reliability issues and environmental factors.	1
	SecondSeries Examination	

Code.	Course Name	L	T	P	Hrs	Credit
HUT 200	Professional Ethics	2	0	0	2	2

Preamble:To enable students to create awareness on ethics and human values.

Prerequisite: Nil

Course Outcomes After the completion of the course the student will be able to

CO 1	Understand the core values that shape the ethical behaviour of a professional.
CO 2	Adopt a good character and follow an ethical life.
CO 3	Explain therole and responsibility in technological development by keeping personal and legal ethics.
CO 4	Solve moral and ethical problems through exploration and assessment by esta experiments.
CO 5	Apply the knowledge of human values and social values to contemporary ethical valu global issues.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO 1								2			2	
CO 2								2			2	
CO 3								3			2	
CO 4								3			2	
CO 5								3			2	

Assessment Pattern

Bloom's category	Continuous Assessment Tests		End Semester Exam
	1	2	
Remember	15	15	30
Understood	20	20	40
Apply	15	15	30

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Tests (2 Nos) : 25 marks
Assignments/Quiz : 15 marks

End Semester Examination Pattern:There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. PartB contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):
1. Define integrity and point out ethical values.
2. Describe the qualities required to live a peaceful life.
3. Explain the role of engineers in modern society.

Course Outcome 2 (CO2)
1. Derive the codes of ethics.
2. Differentiate consensus and controversy.
3. Discuss in detail about character and confidence.

Course Outcome 3(CO3):
1. Explain the role of professional's ethics in technological development.
2. Distinguish between self interest and conflicts of interest.
3. Review on industrial standards and legal ethics.

Course Outcome 4 (CO4):
1. Illustrate the role of engineers as experimenters.
2. Interpret the terms safety and risk.
3. Show how the occupational crimes are resolved by keeping the rights of employees.

Course Outcome 5 (CO5):
1. Exemplify the engineers as managers.
2. Investigate the causes and effects of acid rain with a case study.
3. Explorate the need of environmental ethics in technological development.

Model Question paper

QP CODE: Reg No:______________

PAGES:3 Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD/FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: HUT 200

Course Name: PROFESSIONAL ETHICS

Max. Marks: 100 Duration: 3 Hours

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Define empathy and honesty.
2. Briefly explain about morals, values and ethics.
3. Interpret the two forms of self-respect.
4. List out the models of professional roles.
5. Indicate the advantages of using standards.
6. Point out the conditions required to define a valid consent?
7. Identify the conflicts of interests with an example?
8. Recall confidentiality.
9. Conclude the features of biometric ethic.
10. Name any three professional societies and their role relevant to engineers.

(10x3 = 30 marks)

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. a) Classify the relationship between ethical values and law?

b) Compare between caring and sharing. (10+4 = 14 marks)

Or

12. a) Exemplify a comprehensive review about integrity and respect for others.

b) Discuss about coperation and commitment. (8+6 = 14 marks)

MODULE II

13.a)Explain the three main levels of moral developments, deviced by Kohlberg.

b)Differentiate moral codes and optimal codes. (10+4 = 14 marks)

Or

14. a)Extrapolate the duty ethics and right ethics.

b)Discuss in detail the three types of inquiries in engineering ethics. (8+6 = 14 marks)

MODULE III

15.a) Summarize the following features of morally responsible engineers.

(i) Moral autonomy (ii) Accountability

b)Explain the rights of employees (8+6 = 14 marks)

Or

16. a)Explain the reasons for Chernobyl mishap ?

b)Describe the methods to improve collegiality and loyalty. (8+6 = 14 marks)

MODULE IV

17.a)Execute collegiality with respect to commitment, respect and connectedness.

b)Identify conflicts of interests with an example. (8+6 = 14 marks)

Or

18. a)Explain in detail about professional rights and employee rights.

b)Exemplify engineers as managers.

MODULE V

19.a)Evaluate the technology transfer and appropriate technology.

b) Explain about computer and internet ethics. (8+6 = 14 marks)

Or

20. a)Investigate the causes and effects of acid rain with a case study.

b) Conclude the features of ecocentric and biocentric ethics. (8+6 = 14 marks)

Syllabus

Module 1 – Human Values.

Morals, values and Ethics – Integrity – Academic integrity – Work Ethics – Service Learning – Civic Virtue – Respect for others – Living peacefully – Caring and Sharing – Honestly – courage – Cooperation commitment – Empathy – Self Confidence – Social Expectations.

Module 2 - Engineering Ethics & Professionalism.

Senses of Engineering Ethics – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Profession and Professionalism – Models of professional roles – Theories about right action – Self interest – Customs and Religion – Uses of Ethical Theories.

Module 3 – Engineering as social Experimentation.

Engineering as Experimentation – Engineers as responsible Experimenters – Codes of Ethics – Plagiarism – A balanced outlook on law – Challenges case study – Bhopal gas tragedy.

Module 4 – Responsibilities and Rights.

Collegiality and loyalty – Managing conflict – Respect for authority – Collective bargaining – Confidentiality – Role of confidentiality in moral integrity – Conflicts of interest – Occupational crime – Professional rights – Employee right – IPR Discrimination.

Module 5 – Global Ethical Issues.

Multinational Corporations – Environmental Ethics – Business Ethics – Computer Ethics – Role in Technological Development – Engineers as Managers – Consulting Engineers – Engineers as Expert witnesses and advisors – Moral leadership.

Text Book

1. M Govindarajan, S Natarajan and V S Senthil Kumar, Engineering Ethics, PHI Learning Private Ltd,New Delhi,2012.

2. R S Naagarazan, A text book on professional ethics and human values, New age international (P) limited ,New Delhi,2006.

Reference Books

1. Mike W Martin and Roland Schinzinger, Ethics in Engineering,4th edition, Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi,2014.
2. Charles D Fleddermann, Engineering Ethics, Pearson Education/ Prentice Hall of India, New Jersey,2004.
3. Charles E Harris, Michael S Protchard and Michael J Rabins, Engineering Ethics- Concepts and cases, Wadsworth Thompson Learning, United states,2005.
4. http://www.slideword.org/slidestag.aspx/human-values-and-Professional-ethics

Course Contents and Lecture Schedule

SL.No	Topic	No. of Lectures 25
1	Module 1 – Human Values.	
1.1	Morals, values and Ethics, Integrity, Academic Integrity, Work Ethics	1
1.2	Service Learning, Civic Virtue, Respect for others, Living peacefully	1
1.3	Caring and Sharing, Honesty, Courage, Co-operation commitment	2
1.4	Empathy, Self Confidence, Social Expectations	1
2	Module 2- Engineering Ethics & Professionalism.	
2.1	Senses of Engineering Ethics, Variety of moral issues, Types of inqu	1
2.2	Moral dilemmas, Moral Autonomy, Kohlberg's theory	1
2.3	Gilligan's theory, Consensus and Controversy, Profession & Professionalism, Models of professional roles, Theories about right action	2
2.4	Self interest, Customs and Religion, Uses of Ethical Theories	1
3	Module 3- Engineering as social Experimentation.	
3.1	Engineering as Experimentation, Engineers as responsible Experimen	1
3.2	Codes of Ethics, Plagiarism, A balanced outlook on law	2
3.3	Challenger case study, Bhopal gas tragedy	2
4	Module 4- Responsibilities and Rights.	
4.1	Collegiality and loyalty, Managing conflict, Respect for authority	1
4.2	Collective bargaining, Confidentiality, Role of confidentiality in moral integrity, Conflicts of interest	2
4.3	Occupational crime, Professional rights, Employee right, IPR Discrimination	2
5	Module 5- Global Ethical Issues.	
5.1	Multinational Corporations, Environmental Ethics, Business Ethics, Computer Ethics	2
5.2	Role in Technological Development, Moral leadership	1
5.3	Engineers as Managers, Consulting Engineers, Engineers as Expert witnesses and advisors	2

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Simulation Assignments (ECT203)

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mod-5, mod-2 and mod-10 operation.

Develop a mod-40 (mod-8 and mod-5) counter by cascading two such subcircuits.

Simulate and observe the timing diagram and truth table.

Synchronous Counters

Design and develop a 4-bit synchronous counter using J-K ip- ops.

Perform digital simulation and observe the timing diagram and truth table.

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Model Question Paper

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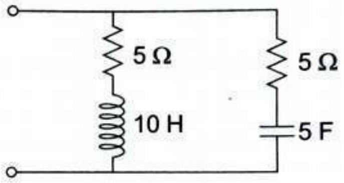
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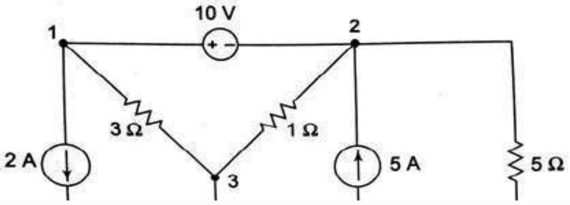

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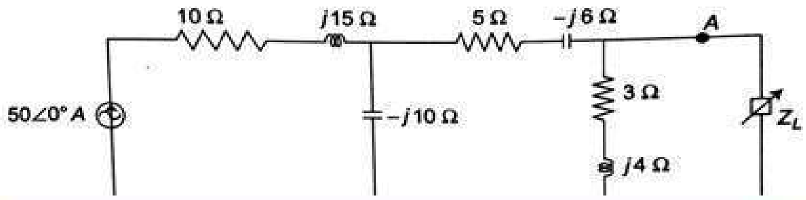

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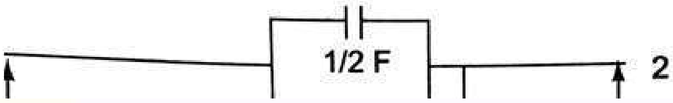

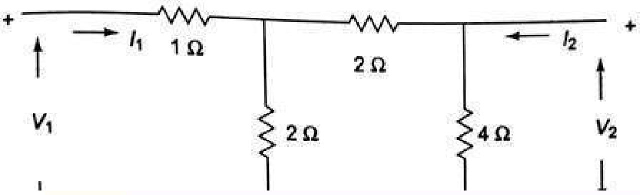
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CO7	3	3	2	2	3	0	0	0	3	1	0	1

Assessment Pattern

Course Level Assessment Questions

2. Write and execute a function to solve for the current transient through an RL network (with $\frac{r}{L} = 1$) that is driven by the signal $5e^{t}$ U(t)

etc. using built in modules.

3. Vectorized computing without loops for fast scienti c applications.

Experiment 3. Realization of Arrays and Matrices

$$f(t) = 4t + 3$$

and plot it for the vector t = [5; 5] with increment 0.01

6. Use general integration tool to compute

3 5 7

7. Use this to compute for the rst 10, 20, 50 and 100 terms.

Experiment 9: Coin Toss and the Level Crossing Problem

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FRPELQDWLRQDO RU VHTXHQWLDO ORJLF ,QVWHDG RI WZR DVVLJ
WKH FRXUVH SURMHFW DORQJ ZLWK VHULHV WHVWV HDFK FDUU\
SURMHFW D EULHI UHSRUW VKDOO EH VXEPLWWHG E\ WKH VWXGH
UHSRUW KDV WR EH VXEPLWWHG IRU DFDGHPLF DXGLWLQJ $ IHZ V

6DPSOH FRXUVH SURMHFWV

%&' 6XEWUDFWRU
x 0DNH ELW SDUDOOHO DGGHU FLUFXLW LQYHULORJ
x 0DNH D RQH GLJLW %&' VXEWUDFWHU LQ 9HULORJ V\QWKHVL]
x 7HVW WKH FLUFXLW ZLWK %&' LQSXWV

'LJLWDO 7KHUPRPHWHU
x 'HYHORS D FLUFXLW ZLWK D WHPSHUDWXUH VHQVRU DQG GLV
WHPSHUDWXUH
x 6ROGHU WKH FLUFXLW RQ 3&% DQG WHVWLW

(OHFWURQLF 'LVSOD\
x 7KLV GLVSOD\ VKRXOG UHFHLYH WKH LQSXW IURP DQ DOSKDQ
/&' GLVSOD\
x 7KH GHFRGHU DQG GLJLWDO FLUFXLWU\ LV WR GHYHORSHG LQ
)3*$

(OHFWURQLF 5RXOHWWH :KHHO
x /('V DUH SODFHG LQ D FLUFOH DQG QXPEHUHG WKDW UHVHP
x $ ELW VKLIW UHJLVWHU JHQHUDWHV D UDQGRP ELW SDWWH
x :KHQ D SXVK EXWWRQ LV SUHVVHG WKH VLQJOH OLJKWV RQH
x 'HYHORS WKH VKLIW UHJLVWHU UDQGRP SDWWHUQ JHQHUDWR
DQG WHVW WKH FLUFXLW

7KUHH %LW &DUU\ /RRN $KHDG $GGHU
x 'HVLJQ WKH FLUFXLW RI D WKUHH ELW FDUU\ ORRN DKHDGDGG
x 'HYHORS WKH YHULORJ FRGH IRU LW DQG LPSOHPHQW DQG WH
SHUIRUPDQFH ZLWK D SDUDOOHODGGHU

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ 7KHUH ZLOO EH WZR SDUWV 3DUW $ DQG 3D
TXHVWLRQV ZLWK TXHVWLRQV IURP HDFK PRGXOH KDYLQJ PD
DQVZHU DOO TXHVWLRQV 3DUW % FRQWDLQV TXHVWLRQV IURP
DQ\ RQH (DFK TXHVWLRQ FDQ KDYH PD[LPXP VXE GLYLVLRQV D
YHULORJ PRGHOOLQJ VKRXOG QRW KDYH D FUHGLW PRUH WKDQ

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

&RXUVH 2XWFRPH &2 1XPEHU 6\VWHPV DQG &RGHV

&RQVLGHU WKH VLJQHG ELQDU\ QXPEHUV $ DQG %
FRPSOHPHQW IRUP)LQG WKH YDOXH RI WKH IROORZLQJ P
$ ± %
3HUIRUP WKH IROORZLQJ &)) $ RSHUDWLRQV L ' &(
&RQYHUW GHFLPDO WR ERWK %&' DQG $6&,, FRGHV)
EH DSSHQGHG DW WKH OHIW

&RXUVH 2XWFRPH &2 %RROHDQ 3RVWXODWHV DQG FRPE

'HVLJQ D PDJQLWXGH FRPSDUDWRU WR FRPSDUH WZR $ DQG % ELW
6LPSOLI\ XVLQJ . PDS) D E F G P
([SODLQ WKH RSHUDWLRQ RI D [PXOWLSOH[HU DQG LPSOR
PXOWLSOH[HU) $ % & ' P

&RXUVH 2XWFRPH &2 /RJLF IDPLOLHV DQG LWV FKDUDFW

'HILQH WKH WHUPV QRLVH PDUJLQ SURSDJDWLRQ GHOD\ I
IDPLOLHV &RPSDUH 77/ DQG &026 ORJLF IDPLOLHV VKRZLQ
PHQWLRQHGWHUPV
'UDZ WKH FLUFXLW DQG H[SODLQ WKH RSHUDWLRQ RI D 77
&RPSDUH 77/ &026 ORJLF IDPLOLHV LQ WHUPV RI IDQ LQ

&RXUVH 2XWFRPH &2 6HTXHQWLDO /RJLF &LUFXLWV

5HDOL]H D 7 IOLS IORS XVLQJ 1$1' JDWHV DQG H[SODLQ W
H[FLWDWLRQ WDEOH DQG FKDUDFWHULVWLFHTXDWLRQ
([SODLQ D 02' DV\QFKURQRXV FRXQWHU XVLQJ -.)OLS)O
'UDZ WKH ORJLF GLDJUDP RI ELW 3,32 VKLIW UHJLVWHU Z
H[SODLQ LWVZRUNLQJ

6\OODEXV

0RGXOH 1XPEHU 6\VWHPV DQG &RGHV
%LQDU\ DQG KH[DGHFLPDO QXPEHU V\VWHPV 0HWKRGV R
KH[DGHFLPDO DULWKPHWLF 5HSUHVHQWDWLRQ RI VLJQHG
QXPEHUV %LQDU\ FRGHG GHFLPDO FRGHV *UD\ FRGHV ([F
$6&,,

0RGXOH %RROHDQ 3RVWXODWHV DQG)XQGDPHQWDO *DWH
%RROHDQ SRVWXODWHV DQG ODZV ± /RJLF)XQFWLRQV DQG
RI 'XDOLW\ 0LQLPL]DWLRQ RI VLPSOH %RROHDQ H[SUHVVLR
6XPV 326 .DUQDXJK PDS 0LQLPL]DWLRQ

0RGXOH &RPELQDWRULDO DQG $ULWKPHWLF &LUFXLWV
&RPELQDWRULDO /RJLF 6\VWHPV &RPSDUDWRUV 0XOWLS
'HFRGHU +DOI DQG)XOO $GGHUV 6XEWUDFWRUV 6HULDO D

0RGXOH 6HTXHQWLDO /RJLF &LUFXLWV
%XLOGLQJ EORFNV OLNH 6 5 -. DQG 0DVWHU 6ODYH -.)) (
DQG FKDUDFWHULVWLF HTXDWLRQ ,PSOHPHQWDWLRQ ZLWK
FRXQWHUV 6KLIW UHJLVWHUV 6,32 6,62 3,62 3,32 5LQ
$V\QFKURQRXV DQG 6\QFKURQRXV FRXQWHU 0RG 1 FRXQWHU

0RGXOH /RJLF IDPLOLHV DQG LWV FKDUDFWHULVWLFV

&RPSDULVRQ RI ORJLF IDPLOLHV 77/ (&/ &026 FRQFHSWV
IDQ RXW SURSDJDWLRQ GHOD\ WUDQVLWLRQ WLPH SRZHU
77/ LQYHUWHU FLUFXLW GHVFULSWLRQ DQG RSHUDWLRQ
RSHUDWLRQ
7H[W %RRNV

0DQR 0 0 &LOHWWL 0 ' ³'LJLWDO 'HVLJQ´ 3HDUVRQ ,QGLD

' 9 +DOO ³'LJLWDO &LUFXLWV DQG 6\VWHPV´ 7DWD 0F*U

6 %URZQ = 9UDQHVLF ³)XQGDPHQWDOV RI 'LJLWDO /RJ
0F*UDZ+LOO

6DPLU 3DOQLNDU³9HULORJ +'/ $ *XLGH WR 'LJLWDO 'HVL
3UHVV

5 3 -DLQ ³0RGHUQ GLJLWDO (OHFWURQLFV´ 7DWD 0F*U

5HIHUHQFH %RRNV

: + *RWKPDQQ ³'LJLWDO (OHFWURQLFV ± $Q LQWURGXFW
QG (GLWLRQ
:DNHUO\ -) ³'LJLWDO 'HVLJQ 3ULQFLSOHV DQG 3UDFWL

$ $QDQWKDNXPDU ´)XQGDPHQWDOV RI 'LJLWDO &LUFXLV

)OHWFKHU :LOOLDP , $Q (QJLQHHULQJ $SSURDFK WR 'L
(GLWLRQ 3UHQWLFH +DOO ,QGLD

&RXUVH &RQWHQWV DQG /HFWXUH 6FKHGXOH

1	7R	1R RI /H
í	1XPEHU 6\VWHPV DQG &RGHV	
	%LQDU\ RFWDO DQG KH[DGHFLPDO QXPEHU V\VWHPV 0 FRQYHUVLRQV	
	%LQDU\ RFWDO DQG K	
	5HSUHVHQWDWLRQ RI VLJQHG QXPEH	
	%LQDU\GHFLPDO FRGHV *UD\	
	%RROHDQ 3RVWXODWHV	
	%RROHDQ SRVWXODWHV DQG ODZV ± /RJLF)XQFWLRQV 7KHRUHPV 3ULQFLSOH RI 'XDOLW\	
	0LQLPL]DWLRQ RI %RROHDQ H[SUHVVLRQV 6XP RI 3URG 6XPV 326	
	.DUQDXJK PDS	
	&RPELQDWRULDO DQG $ULWKPHWLF &LUFXLWV	
	&RPELQDWRULDO &RPSDUDWRUV 0XOWLS	
	(QFRGHU 'HFRGHU +DOI DQG)XOO $GGHUV 6XEWUDFW $GGHUV %&' $GGHU	
	6HTXHQWLDO /	
	%XLOGLQJ E 5 -. DQG 6ODYH -.)) (GJH	
	&RQYHUVLRQ RI)OLSIORSV ([FLWDW	
	5LSSO6\QFKURQRXV FRXQ 6,32 6,62 3,6	
	5LQJ FRXQWHU DQG -RKQVRQV FRXQWHU	
	$V\QFKURQRXV DQG 6\QFKURQRXV FRXQWHU 0RG 1 FRX	
	/RJLF IDPLOLHV DQG LWV FKDUDFWHULVWLFV	

	&RPSDULVRQ RI 77/ (&&026 FRQFHSWV QRLVH PDUJLQV IDQ RXW SURSDJDWLRQ GHOD\ WUDQV FRQVXPSWLRQ DQG SRZHU GHOD\ SURGXFW	
	77/ LQY FLUFXLW GHVFUL	
	&026 LQY FLUFXLW GHVFUL	

6LPXODWLRQ $VVLJQPHQWV $(7

7KH IROORZLQJ VLPXODWLRQV FDQ EH GRQH LQ 48&6 .L&D

%&' $GGHU

‡5HDOL]HDRQHELWSDUDOOHUDGGHU VLPXODWHDQGWHVVW

‡&DVFDGHIRXUVXFKDGGHUVWRIRUPDIRXUELWSDUDOOHOD

‡6LPXODWH LW DQG PDNH LW LQWR D VXEFLUFXLW

‡'HYHORS D RQH GLJLW %&' DGGHU EDVHG RQ WKH VX
WHVWLW

%&' 6XEWUDFWRU

‡8VH WKH DERYH ELW DGGHU VXEFLUFXLW LPSOHP
%&'VXEWUDFWRU

‡7HVW LW ZLWK WZR %&'LQSXWV

/RJLF ,PSOHPHQWDWLRQ ZLWK0XOWLSOH[HU

‡'HYHORSDQ PXOWLSOH[HUXVLQJJDWHV VLPXODWH WH

‡ ‡8
VHW
KLVVXEFLUFXLWWRLPSOHPHQWWKH HORJLFIXQFWLRQ

0RGLI\WKHWUXWKWDEOHSURSHUO\ DQG LPSOHPHQWWK
P

XVLQJ RQH PXOWLSOH[HU

%&' WR 6HYHQ 6HJPHQW 'HFRGHU

‡'HYHORS D %&' WR VHYHQ VHJPHQW GHFRGHU XVLQJ
DVXEFLUFXLW

‡VLPXODWH WKLV DQG WHVWLW

5LSSOH &RXQWHUV

‡8QGHUVWDQG WKH LQWHUQDO FLUFXLW RI ,& DQG

: 0DNH LW LQWR D VXEFLUFXLW DQG VLPXODWH LW 2
WLPLQJ GLDJUDPV IRU PRG PRG DQG PRG RSHUD

6\QFKURQRXV &RXQWHUV

‡'HVLJQ DQG GHYHORS D ELW V\QFKURQRXV FRXQWHU

‡3HUIRUPGLJLWDOVLPXODWLRQDQGREVHUYHWKHWLPLQJ

0RGHO 4XHVWLRQ 3DSHU

$ 3 - $EGXO .DODP 7HFKQRORJLFDO 8QLYHUVLW\
7KLUG 6HPHVWHU % 7HFK 'HJUHH

([DPLQDWLRQ %UDQFK (OHFWURQLFV DQG &RPPXQLFDWLRQ

&RXUVH $(7 'LJLWDO &LUFXLW 'HVLJQ

7LPH +UV 0D[0DUNV

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—œ Ž›11 ••1 žŽœ•'˜—œ1

&RQY WR ELQDU\ DQG .
&RPSDUH ELWZLVH DQG OF .
3UFWKDW1$1'DQG125DUH(.
&RQYWKH H[SUHVVLF& $&' .
WRPLQ
,QWHUSUH\3ULQFLSOH .
([SODLQ WKH ZRUN .
:KDW LV UDFH DUF .
&RQYD 7 IORS W IO .
'HILQH LQ DQ RXW RI OR. .
'HILQH QRLVH KRFD\R.FDOFX .

3$57 %
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0RGXOH ,

$	6XEWUDFW IURP XVLQJ ¶V FRPSOHP.HQW DULWKPH		
%			.
	25		
$	([SODLQ WKH IORDWLQJ DQG IL[HG SRLQW UHSUHVHQWDWL EHUV		
%	,OOXVWUDWH WKH PHWKRG IRU FRQYHUVLRQ.RI *UD\ WR %L FRGH ZLWK		

0RGXOH ,,

$	6LPSOLI\ XVLQJ .0DS		.
%	'HYHOFLUFXLW WR LPSOHPHQ		.
	25		
$	,PSOHPHQW WKH XQLYHUVDO JDWHV XVLQJ EDVLF JDWHV		.
%	5HGXFH WKH IROORZLQJ %RROHDQ IXQFWLRQ XVLQJ . 0DS VLPSOLILHG IXQFWLRQ XVLQJ WKH ORJLF JDWHV		

0RGXOH ,,,

$	'HVLJQ D ELW PDJQLWXGH FRPSDUDWRU FLUFXLW		.
%	'HYHORS D IXOO DGGHU FLUFXLW DQG H[SODLQ		
	25		
$	([SODLQ WKH RSHUDWLRQ RI D PXOWLSOH[HU XVLQJ QH		
%	,PSOHPHQW WKH ORJLF IXQFWLRQ XVLQJ DQG PXOWLSOH[HUV		.

0RGXOH ,9

	'HVLJQ 02' DV\QFKURQRXV FRXQWHU XVLQJ . 7 IOLS IORS		
	25		
$	([SODLQ WKH RSHUDWLRQ RI 0DVWHU 6ODYH . - . IOLSIORS		
%	'HULYH WKH HTXDWLRQ IRU 4		.

0RGXOH 9

$	([SODLQ LQ GHWDLO DERXW 77/ ZLWK RSHQ FROOHFWRU RX		
%	'UDZ DQ (&/ EDVLF JDWH DQG H[SODLQ		.
	25		
$	'HPRQVWUDWH WKH &026 ORJLF FLUFXLW FRQILJXUDWLRQ GH		.
%	&RPSDUH WKH FKDUDFWHULVWLFV RI		.

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}µŒ• Kµš }u Wî tKŠ• Œ šZ •]Pv •š ‰• ÁZ] Z v µ• š}]u‰Œ}À Œ •}oµš]}v }((o š]}v šÇ‰ À}ošu š Œ• v uu š Œ•M

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dŒ v• µ Œ•U ‰Œ]v]‰o • v ‰‰o] š]}v• }(•] šŒ v• µ Œ•W šZ Œu} }µ‰o •U ZdU >ZU]•‰o u vš šŒ v• µ Œ•U •šŒ]v P µP •U šŒ v• µ Œ•U ,oo ((š šŒ v• µ Œ•X

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Œ] P •W]včŒ} µ š]}vU •}µŒ • v š š}Œ• (}Œ Œ] P •X ' v
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<]u Z &}Áo Œ U o šŒ}v] /v•šŒµu vš •]Pv U KÆ(}Œ Œ ‰Œ]vš
< o•] ,^ U o šŒ}v] /v•šŒµu vš š]}v v D •µŒ u vš•U D 'Œ Á Z]
$. 6ZDKQ\ $ &RXUVH LQ (OHFWURQLF 0HDVXUHPHQWV DQG ,QVWUXPH
&R

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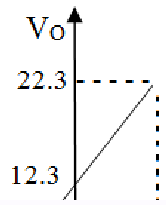
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Simulation Assignments (ECT202)

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Model Question Paper

15(A) De ne sampling theorem. Determine the Nyquist rate and (6) K_2

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Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	30	30	70
Apply	10	10	10
Analyse			
Evaluate			
Create			

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): [illegible] of CROs and DSOs?

Course Outcome 2 (CO2): [illegible] resolution [illegible] meters?

Course Outcome 3 (CO3): List and explain various applications of bridges.

Course Outcome 4 (CO4): Design [illegible] 1000K [illegible] 500 [illegible] temperature.

Course Outcome 5 (CO5): What are the functions of spectrum [illegible] limitations [illegible] spectrum analyzer.

Syllabus

Module 1

Principles of measurement [illegible] accuracy, precision, sensitivity, resolution [illegible] Errors in measurement, statistical analysis.

Module 2

Indicating instruments [illegible]

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'HWHUPLQDWLRQ RI FKDUDFWHULVWLFV RI WKHUPRFRXSOH

'HWHUPLQDWLRQ RI FKDUDFWHULVWLFV RI WKHUPLVWRU

'HWHUPLQDWLRQ RI SUHVVXUH XVLQJ VWUDLQ JDXJH SLH]RHOH

'HWHUPLQDWLRQ RI VRXQG SUHVVXUH OHYHO XVLQJ VRXQG OH

&DOLEUDWLRQ RI SUHVVXUH JDXJH XVLQJ GHDG ZHLJKW WHVWH

0HDVXUHPHQW RI VSHHG XVLQJ SKRWRHOHFWULF SLFNXS

0HDVXUHPHQW RI VSHHG XVLQJ VWURERVFRSH

'HWHUPLQDWLRQ RI FKDUDFWHULVWLFV RI KDOO HIIHFW WUDQV

0HDVXUHPHQW RI GLVSODFHPHQW XVLQJ LQGXFWLYH WUDQVGX

'HWHUPLQDWLRQ RI FKDUDFWHULVWLFV RI FDSDFLWLYH GLVSO

3UHVVXUH PHDVXUHPHQW XVLQJ 8 WXEH PDQRPHWHU

6WXG\ RI ORDGLQJ HIIHFW LQ SRWHQWLRPHWHU

0HDVXUHPHQW RI IUHTXHQF\ DQG

3DUW % $W OHDVW H[SHULPHQWV DUH PDQGDW

([SHULPHQWV VKDOO EH GRQH XVLQJ S\WKRQ /DEYLHZ $XG

0HDVXUHPHQW RI WHPSHUDWXUH

0HDVXUHPHQW RI OHYHO LQ ZDWHU WDQN

0HDVXUHPHQW RI SUHVVXUH

:LQG YHORFLW\ PHDVXUHPHQW

0HDVXUHPHQW RI KXPLGLW\

6LPXODWLRQ RI :KHDWVWRQH EULGJH XVLQJ /DEYLHZ

6LPXODWLRQ RI $QGHUVRQ¶V EULGJH XVLQJ /DEYLHZ

6LPXODWLRQ RI 0D[ZHOO¶V LQGXFWDQFH EULGJH DQG 0D[Z XVLQJ /DEYLHZ

0DQXDO KDV WR EH SUHSDUHG E\ WKH FROOHJH

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		9$&				

3UHDPEOH 7KLV FRXUVH DLPV WR JLYH DQ LQWURGXFWLRQ WR

3UHUHTXLVLWH ,QWURGXFWLRQ WR 6LJQDOV DQG 6\VWHPV

&RXUVH 2XWFRPHV $IWHU WKH FRPSOHWLRQ RI WKH FRXUVH WKH VW

&2	([SODLQ KRZ GLJLWDO VLJQDOV DUH REWDLQHG IURP FRQWL
&2	$SSO\ )RXULHU WUDQVIRUP
&2	,PSOHPHQW (
&2	([SODLQ WKH SUDFWLFDO OLPLWDWLRQV LQ '63 LPSOHPHQW
&2	([SODLQ WKH VWUXFW

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV

	32	32	32	32	32	32	32	32	32	32	32	32
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$VVHVVPHQW 3DWWHUQ

%ORRP¶V	&RQWLQXRXV $V		(QG 6HPHVWHU
5HPHP			
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$SS			
$QD			
(YDO			
&UH			

0DUN GLVWULEXWLRQ

7RWDO	&,	(6(	(6('XUD
			KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV PDUNV
$VVLJQPHQW 4XL] &RXUVH SURMHFW

(QG 6HPHVWHU ([DPLQ 7KHUH ZLOO EH WZR SDUWV 3DUW $ DQG
TXHVWLRQV ZLWK TXHVWLRQV IURP HDFK PRGXOH KDYLQJ PD
DOO TXHVWLRQV 3DUW % FRQWDLQV TXHVWLRQV IURP HDFK I
(DFK TXHVWLRQ FDQ KDYH PD[LPXP VXE GLYLVLRQV DQG FDUU\

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

&RXUVH 2XWFRPH &2 'LVFUHWH 6LJQDOV DQG 6DPSOLQ

'HILQH D GLJLWDO VLJQDO *LYH WKH IUHTXHQF\ UDQJH R
WKHRUHP DQG VKRZ JUDSKLFDOO\ KRZ VDPSOHV DUH JHQHU

:KDW VKRXOG EH WKH PLQLPXP IUHTXHQF\ WR VDPSOH
JUDSKLFDOO\ KRZ WKH FRQWLQXRXV WLPH VLJQDO LV UHFR

&RXUVH 2XWFRPH &2 $SSOLFDWLRQ RI)RXULHU 7UDQVI

*LYH WKH H[SUHVVLRQ IRU ')7 RI DQ 1 SRLQW VHTXHQFH
LPSXOVH VHTXHQFH

'HULYH WKH UDGGL[GHFLPDWLRQ LQ WLPH DOJRULWKP

&RXUVH 2XWFRPH &2 ,PSOHPHQWDWLRQ RI 'LJLWDO)LO

*LYH WKH GLIIHUHQFH HTXDWLRQ RI DQ ,,5 ILOWHU *LYH

'HVLJQ DQ ,,5 %XWWHUZRUWK ILOWHU IRU SDVVEDQG IUHT
7KH VWRS EDQG DQG SDVVV EDQG DWWHQXDWLRQV DUH

&RXUVH 2XWFRPH &2 3UDFWLFDO /LPLWDWLRQV RI 'LJL

$ ([SODLQ WKH OLPLW F\FOH RVFLOODWLRQV LQ ,,5 ILOW

% ([SODLQ WKH HIIHFWV RI FRHIILFLHQW TXDQWL]DWLRQ

$ ([SODLQ WKH HIIHFWV RI URXQG RI QRLVH LQ GLJLWDO
% ([SODLQ WKH IL[HG DQG IORDWLQJ SRLQW DULWKPHWL

&RXUVH 2XWFRPH &2 6WUXFWXUH RI 'LJLWDO 6LJQDO 3

$ ([SODLQ WKH IXQFWLRQ RI WKH 0$& XQLW LQ D '63

% ([SODLQ WKH GLIIHUHQFHV EHWZHHQ +DUYDUG DQG 9RQ

'UDZ WKH LQWHUQDO VWUXFWXUH RI D IORDWLQJ SRLQW

6\OODEXV

0RGXOH 6LJQDO 3URFHVVLQJ)XQGDPHQWDOV
'LVFUHWH WLPH DQG GLJLWDO VLJQDOV %DVLF HOHPHQWV RI GL
UDWH)UHTXHQF\ DOLDVLQJ GXH WR VDPSOLQJ 1HHG IRU DQWL
± 3URSHUWLHV &RPSXWDWLRQ RI VSHFWUXP

0RGXOH 'LVFUHWH)RXULHU 7UDQVIRUP ± 3URSHUWLHV DQG $S
'LVFUHWH)RXULHU WUDQVIRUP ')7 DV D OLQHDU WUDQVIRUPDW
ORQJ GDWD VHTXHQFHV))7 5DGL[',7 DQG ',) DOJRULWKPV &R
DSSOLFDWLRQ

0RGXOH 'LJLWDO)LOWHUV
'LJLWDO),5)LOWHU 7UDQVIHU IXQFWLRQ 'LIIHUHQFH HTXDW
ZLQGRZLQJ 'LUHFW IRUP DQG FDVFDGH UHDOL]DWLRQ RI),5 D
IXQFWLRQ 'LIIHUHQFH HTXDWLRQ 'HVLJQ RI DQDORJ %XWWHU
$QDORJ IUHTXHQF\ WUDQVIRUPDWLRQV ,PSXOVH LQYDULDQ
SURWRW\SH WR GLJLWDO WUDQVIRUPDWLRQV

0RGXOH)LQLWH ZRUG OHQJWK HIIHFWV LQ GLJLWDO ILOWHUV
)L[HG SRLQW DULWKPHWLF)ORDWLQJ SRLQW DULWKPHWLF 7UX
2YHUIORZ HUURU 3URGXFW URXQG RII HUURU 6FDOLQJ /LPLW

*HQHUDO DQG VSHFLDO SXUSRVH KDUGZDUH IRU '63 &RPSXWHU
0$& VSHFLDO LQVWUXFWLRQ UHSOLFDWLRQ RQ FKLS FDFKH *H
IDPLO\ ,PSOHPHQWDWLRQ RI GLJLWDO ILOWHULQJ RQ GVS SUR

7H[W %RRNV
3URDNLV - * 0DQRODNLV ' * ³'LJLWDO 6LJQDO 3URFHVVLQJ
H 3UHQWLFH +DOO RI ,QGLD
,IHDFKRU (& -HUYLV % : ³'LJLWDO 6LJQDO 3URFHVVLQJ 6
(GXFDWLRQ $VLD
&KHQ & 7 ³'LJLWDO 6LJQDO 3URFHVVLQJ 6SHFWUDO &RPSXW

5HIHUHQFH %RRNV
0LWUD 6 . ³'LJLWDO 6LJQDO 3URFHVVLQJ $ &RPSXWHU %DVH
0RQVRQ + +D\HV 6FKDXPV RXWOLQH 'LJLWDO 6LJQDO3URFHVVL

&RXUVH &RQWHQWV DQG /HFWXUH 6FKHGXOH

1R	7RSLF	1R RI /HFWXUHV
	6LJQDO 3URFHVVL	
	2YHUYLHZ RI VLJQDOV)UHTXH	
	&RQYHUVLRQ RI DQDORJ VLJQDOV WR GLJLWDO VLJQD UHFRQVWUXFWLRQ $'& DQG '$& VSHFWUD DQG DQWLD	
	'7)7 SURSHUWL	
	')7	
	')7 IURP '7)7 ')7 DV D OLQHDU WUDQVIRUPDWLRQ : PD 3URSHUWLHV RI ')7 &RPSXWDWLRQDO FKDOOHQJHV	

	))7 IRU FRPSWDWLRQDO DGYDQWDJH 5DGL[',7 DQG LQ SODFH FRPSXWDWLRQ %LW UHYHUVDO SHUPXWDWL	
	)LOWHULQJ RI	
	'LJLWDO	
	0RGHO RI),5 DQG ,,5 ILOWHUV 'LUHFW IRUP , DQG ,, I VLPSOH),5 GHVLJQ	
	,,5 ILOWHU GHVLJQ RI %XWWHUZRUWK ILOWHU 'LUHF UHDOL]DWLRQ	
	$QDORJ WR GLJLWDO WUDQVIRUPDWLRQ LPSXOVH LQY WUDQVIRUPDWLRQ	
	)LQLWH OHQJWK	
	1XPEHU UHSUHVHQWDWLRQ 7UXQFDWLRQ 5RXQGLQJ HUURU LQ $'& 2YHUIORZ HUURU SURGXFW URXQG RI /LPLW F\FOH RVFLOODWLRQ	
	7UXQFDWLRQ 5RXQGLQJ 4XDQWL]DWLRQ HUURU LQ $' HUURU SURGXFW URXQG RII HUURU 6FDOLQJ /LPLW	
	'63 $UFKL'	
	9RQ 1HXPDQQ DQG +DUYDUG DUFKLWHFWXUH &RPSDU	
	'DWD SDWKV RI IL[HG DQG IORDWLQJ SRLQW '63 SURFH RI YDULRXV EORFNV $UFKLWHFWXUH RI D W\SLFDO '63	
	,PSOHPHQWDWLRQ RI	

6LPXODWLRQ $VVLJQPHQWV $(7

7KH IROORZLQJ VLPXODWLRQ DVVLJQPHQWV FDQ EH

6&,/$% 2&7$9(

*HQHUDWH WKH IROORZLQJ GLVFUHWHVLJQDOV

‡ ,PSXOVHVLJQDO

‡ 3XOVH VLJQDODQG

‡ 7ULDQJXODUVLJQDO

:ULWHDIXQFWLRQWRFRPSXWHWKH')7RIDGLVFUHWH QRQDIHZ VLJQDOV DQG SORW WKHLU PDJQLWXGH

: &RPSXWHWKHOLQHDUFRQYROX[W‹RQEHWZHH @ZLWK @ 2EVHUYH WKH VWHS SORW RI ERW WKHFRQYROXWLRQ

‡ 1RZOHW @D[Q>G @ &RPSXWHWKHFRQYROXWLR QG[

:)OLS WKH[EVLJQDO WKDW LW EHFRPHV &RQYROYH LW

ZLWKK&RPSDUH WKH UHVXOW ZLWK WKH SUHYLRXV

5HSHDW WKH DERYH KW>ZR VWHS@VDQGWK
K > @

‡ *LYH \RXULQIHUHQFH

‡ &RPSXWH WKH ')71 PDWUL[IRUDQG

‡ 3ORW WKH ILUVW URZV LQ HDFK FDVH DQG D
EDVLVIXQFWLRQV

3ORW WKH UHDO SDUW RI WKHVH PDWULFHV DV L
SHULRGLFLWLHV DQG KDOI SHULRGLFLWLHV LQ W

‡ 1RUPDOL]HHDFK PDWUL[1 &RPSXWH WKH HLJHQYDOX
QRUPDOL]HG
PDWUL[DQG REVHUYH WKDW DOO ^HLJHQYDOXH
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‡ 5HDOL]H D FRQWLQXRXV WLPH /7, V\VWHP ZLWK V

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+ V V V

2QH PD\ XVH FLV\VLQ VLQ PDWODE RU LQ 3\WKRQ

‡ 0DNH LW LQWR D GLVFUHWH V\VWHP DQG GL

‡ 2EVHUYH WKH VWHS UHVSRQVH LQ ERWK FDVHV D

‡ 'RZQORDG D YLEUDWLRQ VLJQDO LQ

‡ /RDGWKLVVLJQDOLQWRDQDUUD\ LQ 2FWDYH3\W
KRQ

‡ XQGHUVWDQG WKH VDPSOLQJ UDWH RI WKLVVL

‡ 3ORW DQG REVHUYH WKH YLEUDWLRQ VLJQDOZ

‡ &RPSXWH WKH DEVROXWH VTXDUHG YDOXH RI W
YLEUDWLRQVLJQDO

‡ 3ORWLWDQGREVHUYHWKHVSHFWUDOFRPSRQHQWV

0XOWLSO\ SURPLQHQW GLVFUHWH IUHTXHQFLHV L
REVHUYH DQG DSSUHFLDWH WKH PD[RU IUHTXHQF

0RGHO 4XHVWLRQ 3DSHU

$ 3 - $EGXO .DODP 7HFKQRORJLFDO
8QLYHUVLW\

)RXUWK 6HPHVWHU % 7HFK 'HJUHH

([DPLQDWLRQ %UDQFK (OHFWURQL

DQG &RPPXQLFDWLRQ

&RXUVH $(7 ,QWURGXFWLRQ WR 'LJLWDO 6
3URFHVVLQJ

7LPH +UV 0D[0DUNV

3$57 $
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'HILQH IUHTXHQF\ RI D GLVFUHWH VLJQDO DQG
.
6WDWH 1\TXLVW VDPSOLQJ WKHRUHP IRU ORZ
VLJQDOV DQG WKH IRUPXOD IRU VLJQDO UHFR
([SODLQ ZK\ ')7 RSHUDWLRQ LV DOLQHDU WU
([SODLQ KRZ))7 UHGXFHV WKH FRPSXWDWLR
.
:ULWH WKH H[SUHVVVLRQ IRU WKH +DPPLQJ Z
.
*LYH WKH H[SUHVVLRQ IRU ELOLQHDU WUDQ
DQG H[SODLQ WKH WHUP IUHTXHQF\ ZDUSLQ
([SODLQ WKH TXDQWL]DWLRQ HUURULQ$'&V .
([SODLQWKH VDQG V .
FRPSOHPHQWUHSUHVHQWDWLRQRIQXPEHUVL
SURFHVVRU .
&RPSDUH IORDWLQJ SRLQW DQG IL[HG SRLQW
LQ D '63 SURFHVVRU
([SODLQ IXQFWLRQ RIDEDUUHOVKLIWHULQD'63

3$57 %

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0RGXO

$ ([SODLQ KRZ DQDORJ VLJQDOV DUH FRQYHUWH
VLJQ

% :KDW DOO GLJLWDO IUHTXHQFN+] .
V
QDO LV VDPN+]DQ N+]LPSXOVH

25

$ *LYH WKH H[SUHVVLRQ IRU '7)7 &RPSXWH WK .
W
VLJ [Q > î î

% ([SO KR VDPS DIIH W VSHF RW .
VLJ DQ WKH QHHG RI DQ

XVLQJ UDGL[',)DOJRULWKP

0RGXOH ,,

$ *LYH WKH UDGL[GHFLPDWLRQ LQ WLPH DOJRU
))7 FRPSX

% +RZ LV LQ SODFH FRPSXWDWLRQ .

25

$)LQG WKH ')7 RI WKH VHTXHQFH .

% +RZ LV ELW UHYHUVH DG .

0RGXOH ,,,

% &RQYHUW WKH V V .
DQDORJILOWHU

+ V

LQWR GLJLWDO ILOWHU XVLQJ LPSXOVH LQY

25

$,PSOHPHQW WKH)>,5 ILOWHU@ KXQ@ .
ZLWK PLQL PXP PXOWLSOLHUV LQ GLUHFWIRU

% 'HVLJQ DQ ,,5 %XWWHUZRUWK ILOWHU IR .
IUHTXHQF\N+]DQG VWRSEDQG IUHTXHQF\
N+] 7KH VWRS EDQGDQG SDVVV EDQG
DWWHQXDWLRQV DUH UHVSHFWLYHO\

0RGXOH ,9

$ ([SODLQ VF\FOH RVFLOODWLRQ .

% 'HULYH WKH TXDQWL]DWLRQ QRLVH SRZHU .
$'&

25

$)LQG WKH RXWSXW QRLVH YDULDQFH RI D I .
V\VWHP ZLWK WUDQVIHUIXQFWLRQ

+]

îÂ]

WKDW LV GULYHQ E\ D]HUR PHDQ ZKLWH *D
QRLVH RI YDUL DQFH

% ([SODLQ WKH IL[HG DQG IORDWLQJ SRLQW .
XVHG LQ '63 SURFHVVRUV

0RGXOH 9

'UDZ DQG H[SODLQ WKH IXQFWLRQDO EORFN
IORDWLQJ SRLQW '63SURFHVVRU

25

$ &RPS 9R1HXPDQQDUFKLWHFWXUH .
WXUH

% ([SODLQ WKH VLJQLILFDQFH DQG .
D '63 SURFHVVRU

$(7	,QWURGXFWLRQ WR $QDORJ &LUFXLWV	&$7(*25< 9$&	/	7	3	&5(',76

3UHDPEOH 7KLV FRXUVH DLPV WR GHYHORS WKH VNLOO RI WKH

3UHUHTXLVLWH (67 %DVLFV RI (OHFWULFDO DQG (OHFWURQLFV (

&RXUVH 2XWFRPHV $IWHU WKH FRPSOHWLRQ RI WKH FRXUVH WKH V

&2	$QDO\]H VLPSOH FLUFXLWV XVLQJ GLRGHV UHVLVWR
&2	%XLOG DPSOLILHU DQG RVFLOODWRU FLUFXLWV
&2	'HYHORS 3RZHU VXSSOLHV '$ DQG $' FRQYHUWRUV
&2	'HYHORS DQG DQDO\]H FLUFXLWV XVLQJ RSHUDWLRQD 3//

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV

	32	32	32	32	32	32	32	32	32	32	32	32
&2												
&2												
&2												
&2												

$VVHVVPHQW 3DWWHUQ

%ORRP¶V		&RQWLQXRXV 7H'		(QG 6HPHVWHU
5HPHP	.			
8QGHU	.			
$SS	.			
$QD	.			
(YDO				
&UH				

0DUN GLVWULEXWLRQ

7RWDO 0DUNV	&,(	(6(	(6('XUDWLRQ
			KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV PDUNV
$VVLJQPHQW 4XL] &RXUVHSURMHFW PDUNV

(QG 6HPHVWHU ([DPLQ 7KHUH ZLOO EH WZR SDUWV 3DUW $
3DUW $ FRQWDLQ TXHVWLRQV ZLWK TXHVWLRQV IURP
HDFK TXHVWLRQ 6WXGHQWV VKRXOG DQVZHU DOO TXHVWL
HDFK PRGXOH RI ZKLFK VWXGHQW VKRXOG DQVZHU DQ\
PD[LPXP VXE GLYLVLRQV DQG FDUU\ PDUNV

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

&RXUVH 2XWFRPH &2 5HDOL]H VLPSOH FLUFXLWV XVLQ
FDSDFLWRUV

)RU WKH JLYHQ VSHFLILFDWLRQ GHVLJQ D GLIIHUHQWL

)RU WKH JLYHQ LQSXW ZDYHIRUP DQG FLUFXLW GUDZ
ZDYHIRUP DQG WUDQVIHU FKDUDFWHULVWLFV

([SODLQWKHZRUNLQJRI5&GLIIHUHQWLDWRUDQGLQWHJU
WSXW ZDYHIRUP IRU GLIIHUHQW WLPH SHULRGV

&RXUVH 2XWFRPH &2 'HVLJQ DPSOLILHU DQG RVFLOODW

)RU WKH JLYHQ WUDQVLVWRU ELDVLQJ FLUFXLW GHWH
FXUUHQWV DQG YROWDJHV

([SODLQ WKH FRQVWUXFWLRQ SULQFLSOH RI RSHUDW

'HVLJQ D 5& FRXSOHG DPSOLILHU IRU D JLYHQ JDLQ

'HVLJQ D +DUWOH\ RVFLOODWRU WR JHQHUDWH D JLYH

&RXUVH 2XWFRPH &2 'HVLJQ 3RZHU VXSSOLHV ' $ DQG $ '
YDULRXV DSSOLFDWLRQV

'HVLJQ D VHULHV YROWDJH UHJXODWRU

)RU WKH UHJXODWRU FLUFXLW ILQG WKH RXWSXW YRO

,QD ELW'$& IRUDJLYHQUHIHUHQFHYROWDJH ILQGWKHD
O LQSXW

&RXUVH 2XWFRPH &2 'HVLJQ FLUFXLWV XVLQJ RSHUDW
YDULRXV DSSOLFDWLRQV

)RU WKH JLYHQ GLIIHUHQFH DPSOLILHU ILQG WKH RX

'HULYH WKH H[SUHVVLRQ IRU IUHTXHQF\ RI RVFLOODW
RVFLOODWRU XVLQJ RS DPS

5HDOL]H D VXPPLQJ DPSOLILHU WR REWDLQ D JLYHQ R

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0RGXOH

:DYH VKDSLQJ &LUFXLWV 6LQXVRLGDO DQG QRQ VLQXVRLGDO ZDYH VKDSH
GLIIHUHQWLDWLQJ DQG LQWHJUDWLQJ FLUFXLWV &OLSSLQJ
&ODPSLQJ FLUFXLWV 3RVLWLYH QHJDWLYH DQG ELDVHG FOD
7UDQVLVWRU ELDVLQJ ,QWURGXFWLRQ RSHUDWLQJ SRLQW FRQFHSW RI
QRW UHTXLUHG IL[HG ELDV VHOI ELDV YROWDJH GLYLGHU E

0RGXOH

026)(7 6WUXFWXUH (QKDQFHPHQW DQG 'HSOHWLRQ W\SHV SU
$PSOLILHUV &ODVVLILFDWLRQ RI DPSOLILHUV 5& FRXSOHG DPSOL
DQG IUHTXHQF\ UHVSRQVH 0XOWLVWDJH DPSOLILHUV HIIHFW
)HHGEDFN LQ DPSOLILHUV QHJDWLYH IHHGEDFN RQ DPSOLILHUV
026)(7 $PSOLILHU &LUFXLW GLDJUDP GHVLJQ DQG ZRUNLQJ RI FRPP

0RGXOH

2VFLOODWRUV &ODVVLILFDWLRQ FULWHULRQ IRU RVFLOODWLRQ :LH
RVFLOODWRU GHVLJQ HTXDWLRQV DQG ZRUNLQJ RI WKH FLUF
5HJXODWHG SRZHU VXSSOLHV 6LPSOH]HQHU YROWDJH UHJXODWRU
SLQ UHJXODWRUV ;; DQG ;; '& WR '& FRQYHUVLRQ &LUFX
6036

0RGXOH

2SHUDWLRQDO DPSOLILHUV &KDUDFWHULVWLFV RI RS DPSV JDLQ EDQGZLG
YROWDJH RIIVHW FXUUHQW FRPSDULVRQ RI LGHDO DQG SUD
VFDOH FKDQJHU VLJQ FKDQJHU DGGHU VXPPLQJ DPSOLILH
&RPSDUDWRU ,QVWUXPHQWDWLRQ DPSOLILHU

0RGXOH

,QWHJUDWHG &LUFXLWV $' DQG '$ FRQYHUWRUV ± LPSRUWDQW VSHFLILFD
5 5 ODGGHU W\SH ' $ FRQYHUWRUV)ODVK DQG VLJPD GHOWD

7H[W %RRNV

5REHUW %R\OHVWDG DQG / 1DVKHOVN\ (OHFWURQLF 'HYL

6DOLYDKDQDQ 6 DQG 9 6 . %KDDVNDUDQ /LQHDU ,QWH
+LOO

5HIHUHQFH %RRNV

'DYLG $ %HOO (OHFWURQLF 'HYLFHV DQG &LUFXLWV 2[IR

1HDPHQ '   (OHFWURQLF &LUFXLWV $QDO\VLV DQG 'HVLJQ

0LOOPDQ - DQG & +DONLDV ,QWHJUDWHG (OHFWURQLFV

2S $PSV DQG /LQHDU ,QWHJUDWHG &LUFXLWV 5DPDNDQW

. *RSDNXPDU 'HVLJQ DQG $QDO\VLV RI (OHFWURQLF &LUF

&RXUVH &RQWHQWV DQG /HFWXUH 6FKHGXOH

1R	7RSLF	1R RI /HFW
	:DYH VKDSLQ	
	6LQXVRLG VLQXVRLGDO	
	3ULQFLSOH DQG ZRUNLQJ LQWHJUDW	
	&OLSSLQ 3RVLWLYH QHJDWL	
	&ODPSLQJ 3RVLWLYH QHJDWLY	
	7UDQVLVW	
	,QWURGXFWLRQ RSHUDWL	
	7KHUPDO IL[HG ELDV VHOI ELD	
	)LHOG HIIHFW	
	026)(6WUXFWXUH (QKDQFHPHQW DQ RSHUDWLRQ DQG FKDUDFWHULVWLFV	
	$PSOL	
	&ODVVLILFDWLRQ RI DPSOLILHUV 5& FRXSOHG DPSOLIL ZRUNLQJ YROWDJH JDLQ DQG	
	0XOWLVWDJ HIIHFW RI FDVFDGLQJ	
	)HHGEDFN LQ (IIHFW RI QHJDWLYH I	
	026)(7 $PS &LUFXLW GLDJUDP GFRPP VRXUFH 026)(7 DPSOLILHU	
	2VFLO	
	&ODVVLILFDWLRQ F	
	:LHQ EULGJH RVFLOODWRU	
	5HJXODWHG SR	
	VLPSOH]HQHU YROWDJH UHJXODWRU VHULHV YROWDJH UHJXODWLRQ	
	SLQ UH ;; DQG	
	'& WR '& FRQYHUVLRQ &LUFXLW EOR	
	2SHUDWLRQDO	
	'LIIHUHQWL	
	FKDUDFWH DPSV JDLQ EDQG &055 R YROWDJH RIIVHW FXUUHQW FRPSDULVRQ RI LGHDO DQ DPS ,&	
	DSSOLFDWLRQV RI RS DPSV VFDOH FKDQJHU VLJQ FKD DPSOLILHU VXEWUDFWRU LQWHJUDWRU GLIIHUHQWLDW	

	&RPSDUDWRU 6FKPLWW WULJJHU /LQHDU VZHHS JHQHUDWR	

	,QWHJUDWHG FLUFXLWV	
	' $ DQG $ ' FRQYHUWRUV ± LPSRUWDQW VSHFLILFDWLRQV 6D	
	5 5 ODGGHU W\SH ' $ FRQYHUWRUV	
	)ODVK DQG VXFFHVVLYH DSSUR[LPDWLRQ W\SH $ ' FRQYHUWH	
	&LUFXLW GLDJUDP DQG ZRUNLQJ RI 7LPHU ,& DVWDEOH DQ PXOWLYLEUDWRUV XVLQJ %DVLF RI 3//	

$VVLJQPHQW

$WOHDVW RQH DVVLJQPHQW VKRXOG EH VLPXODWLRQ RI WUDQ VLPXODWLRQ VRIWZDUH

0RGHO 4XHVWLRQ SDSHU

$3- $%'8/ .$/$0 7(&+12/2*,&$/ 81,9(56,7<

7+,5' 6(0(67(5 % 7(&+ '(*5(((;$0,1$7,21 0RGHO 4XHVWLRQ 3DSHU

&RXUVH &RGH $(7

3URJUDP $SSOLHG (OHFWURQLFV DQG ,QVWUXPHQWD

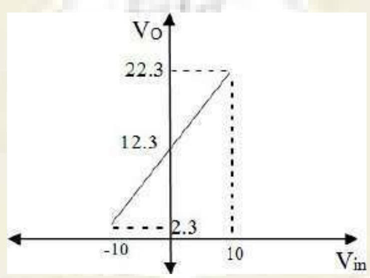
&RXUVH 1DPH ,QWURGXFWLRQ WR $QDORJ &LUFXLWV

0D[0DUNV 'XUDWLRQ +RXUV

3$57 $

$QVZHU $// 4XHVWLRQV (DFK &DUULHV PDUN

'HVLJQ D FODPSHU FLUFXLW WR JHW WKH IROORZLQJ WUDQV DVVXPLQJ YROWDJH GURS DFURVV WKH GLRGH V 9



*LYH WKH LPSRUWDQFH RI ELDVLQJ LQ WUDQVLVWRUV" 0HQ RI RSHUDWLQJ SRLQW

:KDW LV OLQH UHJXODWLRQ DQG ORDG UHJXODWLRQ LQ WKH UHJXODWRU" ([SODLQ ZLWK HTXDWLRQ IRU SHUFHQWDJH RI U

&RPSDUH WKH IHDWXUHV RI)(7 ZLWK %-7 .

:KDW LV WKH HIIHFW RI FDVFDGLQJ LQ JDLQ DQG EDQGZLGWK

'LVFXVV DERXW VLPSOH]H(.

5HDOL]H D FLUFXLW WR REWDLQ 9R 9 9 9 XVLQJ RSHUD
DPSOLILHU 8VH PLQLPXP YDOXH RI UHVLVWDQFH DV .

'HVLJQ D PRQRVWDEOH PXOWLYLEUDWRU XVLQJ ,& WLPHU
SHULRG RI PV

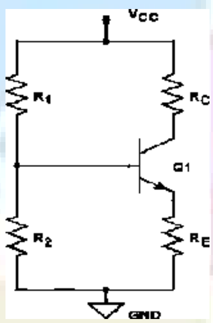
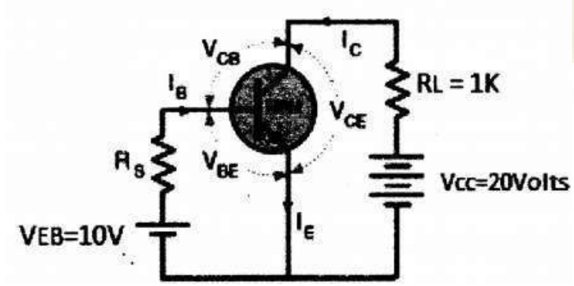
'HVFULEH WKH ZRUNLQJ RI D)ODVK.W\SH $ ' &RQYHUW
H[DP

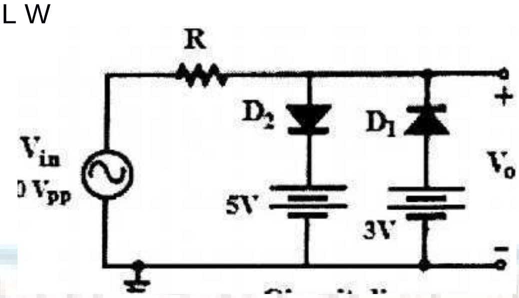
'HILQH 6OHZ UDWH &055 .RIIVHW YROWDJH D
FXUUHQW

3$57 ± %

$QVZHU RQH TXHVWLRQ IURP HDFK PRGXOH HDFK TXHV

0RGXOH ± ,

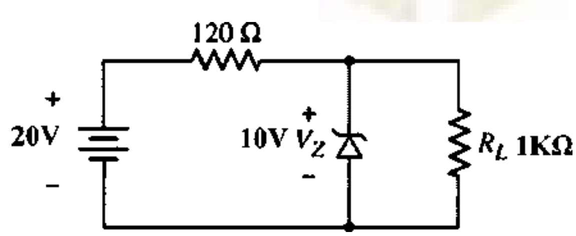
	D 'HVLJQ D GLIIHUHQWLDWRU FLUFXLW IRU D VTXDUH ZDYH VLJQD IUHTXHQF\ .+]	&2			
	E &RQVLGHU D VHOI ELDVLQJ FLUFXLW VKRZQ LQ ILJXUH EHORZ Z 5F .Ÿ ZKLFK LV RSHUDWHG DW 9 4,F PS ILQG 5 5 DQG 5H $VVXPH 9%(9 	&2			
	25				
	D ([SODLQ WKH ZRUNLQJ RI DQ 5& GLIIHU LQSXW ZLWK SHULRG 7 6NHWFK WKH RXWSXW ZDYHIRUP IRU 5& DQG 5& 7	&2			
	E :LWK UHIHUHQFH WR WKH IROORZLQJ FLUFXLW GUDZ WKH ORD SRLQW RI D 6LOLFRQ WUDQVLVWRU RSHUDWLQJ LQ &(PRGH EDV GDWD V .Ÿ5 /5 .Ÿ QHJOHFW , $ %2 	&2			

F	'UDZ WKH RXWSXW ZDYHIRUP DQG WUDQVIHU FKDUDFWHULVWL FLUFXLW 	&2	.	

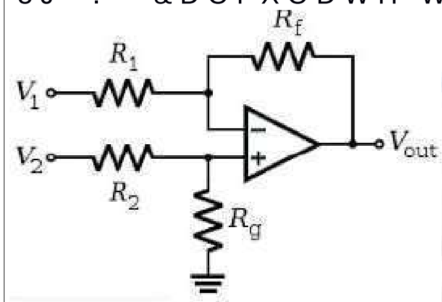
0RGXOH ± ,,

D	:LWK QHDW VNHWFKHV H[SODLQ WKH FRQVWUXFWLRQ SUL FKDUDFWHULVWLFV RI DQ 1 FKDQQHO HQKDQFHPHQW 026)(	&2	.	
I	'UDZ WKH FLUFXLW RI DQ 5& FRXSOHG DPSOLILHU DQG H[SODLQ HOHPHQW	&2	.	
	25			
I	'UDZ WKH FLUFXLW RI D FRPPRQ VRXU WKH H[SUHVVLRQV IRU YROWDJH JDLQ DQG LQSXW UHVLVW	&2	.	
E	6NHWFK WKH IUHTXHQF\ UHVSRQVH RI UHDVRQV IRU JDLQ UHGXFWLRQ LQ ERWK HQGV	&2	.	

0RGXOH ± ,,,

I	'HVLJQ D +DUWOH\ RVFLOODWRU \	&2	.	
E	'UDZ WKH FLUFXLW RI D VHULHV YROWDJH UHJXODWRU ([S WKH LQSXW YROWDJH DV ZHOO DV ORDG FXUUHQW YDULHV GHOLYHU 9 P$ PD[LPXP ORDG FXUUHQW	&2	.	
	25			
I	:LWK QHDW GLDJUDP H[SODLQ WKH Z EULGJH RVFLOODWRU XVLQJ %-7	&2	.	
E	'HULYH WKH H[SUHVVLRQ IRU WKH IUHTXHQF\ RI RVFLOODW RVFLOODWRU XVLQJ %-7	&2	.	
F	)RU WKH FLUFXLW VKRZQ EHORZ ILQG WKH RXWSXW YROWD FXUUHQW WKURXJK WKH]HQHU GLRGH 	&2	.	

0RGXOH ± ,9

l	:LWK FLUFXLW UHOHYDQW HTXDWLRQ D 6FKPLW WULJJHU XVLQJ RS DPS		&2	.
E	7KH GLIIHUHQFH DPSOLILHU VKRZQ LQ WKH ILJXUH KDYH 5 5 . 5J . &DOFXODWH WKH RXWSXW YROWDJH 		&2	.
	25			
D	:LWK FLUFXLWV DQG HTXDWLRQV VKRZ WKDW DQ RS DPS F GLIIHUHQWLDWRU DGGHU DQG VXEWUDFWRU		&2	.
l	:KDW GR \RX PHDQ E\ GI:LWK QHDW H[SODLQ WKH ZRUNLQJ RI DQ RSHQ ORRS 23 $03 GLIIHUHQ		&2	.

0RGXOH ± 9

D	([SODLQ WKH ZRUNLQJ RI 5 5 ODGGHU W\SH '$& ,Q D EL UHIHUHQFH YROWDJH LV JLYHQ DV 9)LQG DQDORJ RXWSXW RI		&2	.
E	:LWK QHDW GLDJUDP H[SODLQ WKH ZRUNLQJ RI ,& WLPHU		&2	.
	25			
D	$ ELW 5 5 ODGGHU W\SH '$& KDYLQJ 5 N DQG 95 9 LWV UHVROXWLRQ DQG RXWSXW YROWDJH IRU DQ LQSXW		&2	.
E	'HVLJQ DQ DVWDEOH PXOWLYLEUDWRU XVLQJ ,& WLPHU .+] DQG D GXW\ F\FOH RI $VVXPH F))		&2	.
l	'UDZ WKH FLUFXLW GLDJUDP RI D \ H[SODLQ WKH QHFHVVLW\ RI WKLV FLUFXLW LQ $ WR ' FRQ		&2	.

6LPXODWLRQ $VVLJQPHQWV $(7

7KH IROORZLQJ VLPXODWLRQV FDQ EH GRQH LQ 48&6 .L&DG R

'HVLJQ DQG VLPXODWH 5& FRXSOHG DPSOLILHU   2EVHUYH WKH
$& IUHTXHQF\ UHVSRQVH DQG XQGHUVWDQG WKH YDULDWLRQ
WKH HIIHFW RI QHJDWLYH IHHGEDFN E\ FKDQJLQJ WKH FDSDFLW
'HVLJQ DQG VLPXODWH :LHQ EULGJH RVFLOODWRU IRU D IUHTXH
ODWLRQ DQG REVHUYH WKH RXWSXW ZDYHIRUP
UHQW ,2   P$ ZLWK DQG ZLWKRXW VKRUW FLUFXLW SURWHF
UHJXODWLRQV
'HVLJQ DQG LPSOHPHQW GLIIHUHQWLDO DPSOLILHU DQG PHDVX
WHULVWLFV
'HVLJQ DQG VLPXODWH QRQ LQYHUWLQJ DPSOLILHU IRU JDLQ
VLJQDOV 5XQ WKH DF VLPXODWLRQ DQG REVHUYH WKH IUHTXH
'HVLJQ DQG VLPXODWH D   ELW IODVK W\SH $'& 2EVHUYH WKH
FKDUDFWHULVWLFV
'HVLJQ DQG VLPXODWH 5 í 5 '$& FLUFXLW
'HVLJQ DQG LPSOHPHQW 6FKPLWW WULJJHU FLUFXLW IRU XSSHU
WULJJHULQJ SRLQW RI í 9 XVLQJ RS DPSV

K dîôò	KhZ^ E /EdZK h d/KE dK /E h^dZ/ > /E^dZhD Ed d/KE	d 'KZ s	: ï	(	\ ì	Z ð

WŒu o dW Z •Çoo µ•]• ‰Œ ‰ Œ Á]šZ À] Á }(P]À]vP šZ •šµ •] o u vš• }( ]v µ•šŒ] o]v•šŒµu vš š]}v •Ç•š uX µ š} šZ Œ ‰Œ • vš š]À •Ç•š u• v À] • Œ]• µ••]v šZ •Çoo µ

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D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

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}µŒ• Kµš }u í](KEí•W š v Æ‰o š]v]v}v ‰(š o DFFXUDF\ SUHFLVLRQ VHQVLWLYLW\ UHVROXWLRQ

}µŒ• Kµš }u îtZ~ šKî•ŒW šZ •]Pv •š ‰• ÁZ] Z v µ• š}]u‰Œ v Œ •}oµš]}v }(À o š] v]vP ‰ š Œ•M

}µŒ• Kµš }u ïv~ Kï•ŒW> ‰ o• ‰ Œ Z]v]‰o ŒµšÀ}vŒ]v‰ ‰ o] }v}v d X•

}µŒ• Kµš }u ðK~ð•ZW šŒšZ]v µ•šŒ] o }‰ ‰ o] š]}v• U Æ‰o]v

}µŒ• Kµš }u ñ}Á Kñ•W Œ šµŒ (( ]v•š Œµu vš š]}v• Æ ‰š• Œ• šZ u šZ} • u‰ (Œ}µ ‰ Œ}‰ Œ]v•šŒµu vš š]}v •Ç•š u•X

^Ço oµ•

D}µo í

3ULQFLSOHV RI PHDVXUHPHQWV DFFXUDF UHVROXWLRQ /RDGLQJ HIIHFW FKDUDFWHULVWLFV VDIHW\ PH &RPPHUFLDO VWDQGDUGV

D}µo î

/v] š]vP]v•šŒµu vš• t‰Œ]v]‰o • v }‰ Œ š]}vXr]Œ}v U Çv u} u š Œ U]v µš]}v šÇ‰ u š Œ•X 'Œ v ^Z] o]vP }(u •µŒ]vP •Ç•š u•X šZ} Œ Ç }•]oo}• }‰ •U Z } Œ }Œ Œ U yrz Wo}šš ŒU >]•‰o Ç•X

D} µo ï

dŒ v• µ Œ•U ‰Œ]v]‰o • v ‰‰o] š]}v• }(•] šŒ v• µ Œ•
šZ Œu} }µ‰o •U Zd U > ZU]•‰o u vš šŒ v• µ 6PDUW WUDQVPLW
UDQJH VSHFLILFDWLRQV DQG VWDQGDUGV ,QWHUIDFLQJ RI VHQV

D} µo ð

&DOLEUDWLRQ DQG WHVWLQJ VWDQGDUGV IRU LQVWUXPHQWV
SHUIRUPDQFH WHVWV ± LPSHGDQFH UHVROXWLRQ QRLVH WKUH

Œ] P •W]všŒ} µ š]}vU •}µŒ • v š š}Œ• (}Œ Œ] P •X ' v Œ
XdÇ‰ • }(Œ] P • ttZ š•š}v U < oÀ]vU ŒŒÇ &}•š Œ •o] Á]Œ Œ
Œ] P X

D} µo ñ

2SHUDWLQJ FRQVROH DQG FRQWURO URRP SDQHO GHVLJQ
HTXLSPHQW +HDW GLVVLSDWLRQ IRUFHG DLU FLUFXODWLR
VKLHOGLQJ 3URWHFWLRQ DJDLQVW HOHFWURVWDWLF GLVFK
UDWH DQDO\VLV

d Æš }}l•

íX À] oo U o šŒ}v] /v•šŒµu vš š]}v v D •µŒ u vš• U ï
îX XW šŒ v]• U ^ v•}Œ• v dŒ v• µ Œ•U îµìì ïŒ•U W,/ î
ïX '}o]vP t v t]]• & o šŒ] o D •µŒ u vš• v D •µŒ]vP
íõõï

ðX%HOD * /LSWRQ 3URFHVV &RQWURO LQVWUXPHQW HQJLQHHU

ñX' 3DWUDQDELV 6HQVRUV DQG WUDQVGXFHUV 3+,

Z (Œ v }}l•

íX <]u Z &}Áo Œ U o šŒ}v] /v•šŒµu vš •]Pv U KÆ(}Œ Œ ‰Œ]vš
îX < o•] ,^ U o šŒ}v] /v•šŒµu vš š]}v v D •µŒ u vš•U D 'Œ Á Z
ïX < ^Á ZvÇ U }µŒ•]v o šŒ}v] D •µŒ u vš• v /v•šŒµu vš š]}

ðX'}o]vP t v t]]• & o šŒ] o D •µŒ u vš• v D •µŒ]vP •Ç•š

ñX o PµŒµ•Á uÇ U Z o]]o]šÇ vP]v Œ]vP U D 'Œ Á ,]oo

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î	/v] š]vP]v•šŒµu vš•	í
îX	(o š]}vu š	ï
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0RGHO 4XHVWLRQ SDSHU

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í¿	tZ š Œ šZ À Œ]}µ• ‰ ••]À v š]À Z ÁZÇ Z š Œ u}À o]• }(Œ]š] o]u‰}Œš v M	í¿	K	<
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îì	•tZ š]• u vš Ç šZ š Œu Z[Œ o]]o]šÇ (š}Œ• ÁZ] Z ((š Œ o]]o]šÇM ÁZ š Œ šZ ‰}••] o • vZ v u vš• ÁZ] Z v]v Œ •]Œ o]š]o]šÇX]• µ••	í¿	K	<

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$(7	,167580(17$7,21 6<67(0 '(6,*1	9$&				

3UHDPEOH 7KH V\OODEXV LV SUHSDUHG ZLWK D YLHZ RI JLYLQJ W
EDVLF FRQFHSWV RI GHVLJQ RI GHVLJQ RI LQVWUXPHQWV DQ
DQG TXDOLW\ FRQWURO

3UHUHTXLVLWH 1LO

&RXUVH 2XWFRPHV $IWHU WKH FRPSOHWLRQ RI WKH FRXUVH WKH VWXGHQ

&2	'HVFULSWLRQ	.QRZOHGJH /HYHO
&2	,GHQWLI\ GLIIHUHQW VWDQGDUGV HPSOR\HG LQ WKH PDQXID DQG LQVWUXPHQWV	
&2	8WLOL]H WKH VHOHFWLRQ FULWHULD HPSOR\HG LQ WKH VHO DQG LQVWUXPHQWV LQ LQVWUXPHQWDWLRQ	
&2	6XPPDUL]H WKH FDOLEUDWLRQ HPSOR\HG IRU WUDQVGX LQVWUXPHQWV	
&2	$SSO\ WKH SULQFLSOHV JRYHUQLQJ LQVWDOODWLRQ RI FRQW RSHUDWLRQ	
&2	([SODLQ WKH FRQFHSWV RI YDULRXV FRQWURO VFKHPHV XV V\VWHPV DQG WKH SULQFLSOHV RI UHOLDELOLW\ IDLOXUH D FRQWURO	

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV

	32	32	32	32	32	32	32	32	32	32	32	32
&2												
&2												
&2												
&2												
&2												

$VVHVVPHQW 3DWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW 7HVWV		(QG 6HPHVWHU ([DPLQDWLRQ
5HPHP			
8QGHUVWDQG			
$SS			
$QDO\VH			
(YDOXDWH			
&UHDWH			

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ 7KHUH ZLOO EH WZR SDUWV ‰ Œš•V W Œš v W Œš X
‹µ •š]}v• Á]šZ î ‹µ •š]}v• (Œ}u Z u}µo U Z À]vP ï u Œl• (}Œ Z ‹µ
v•Á Œ oo ‹µ •š]}v•X W Œš }vš]v• î ‹µ •š]}v• (Œ}u Z u}µo }(ÁZ
vÇ }v X Z ‹µ •š]}v v Z À u Æ]uµu î •µ r]À]•]}v• v ŒŒÇ íð u Œ

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

&RXUVH 2XWFRPH 2 :KDW DUH WKH HQYLURQPHQWDO UHTXLUHPHQWV DQG LQWHUQDWLRQDO VWDQGD
IRU LQVWUXPHQWV

&RXUVH 2XWFRPH 2 :KDW DUH WKH IXQFWLRQDO DQG SUDFWLFDO GLIIH
V\VWHPV XVHG WR PHDVXUH [WKLV WKHUPRPHWHU SUHVVXUH IORZ WXUH

&RXUVH 2XWFRPH 2 :KDW DUH WKH VWDQGDUG SURFHGXUHV IRU FDOLEUDWLRQ IRU LQVWUXPHQ

&RXUVH 2XWFRPH 2 ZKDW DUH WKH PDMRU IDFWRUV WDNHQ LQWR FRQVLGHUDW
FRQWURO SDQHOV

&RXUVH 2XWFRPH 2 ZKDW DUH WKH HOHFWURPDJQHWLF LQWHUIHUHQFH VRXUFHV
PHDVXUHPHQW V\VWHP DQG HOHFWURPDJQHWLF LQWHUIHUHQFH LQ)DUDGD\ FDJH 5

6\OODEXV

0RGXOH

&RQFHSWV RI LQVWUXPHQW GHVLJQ VSHFLILFDWLRQ UHTXLUHPHQWV
0LOLWDU\ ,QGXVWULDO DQG &RPPHUFLDO VWDQGDUGV %,6
VWDQGDUGV ',1 VWDQGDUGV ,QVWUXPHQWV V\PEROV DQG VLJQ

0RGXOH

3HUIRUPDQFH FKDUDFWHULVWLFV DQG VHOHFWLRQ FULWHULD
FULWHULD IRU IORZ SUHVVXUH DQG WHPSHUDWXUH PHDVXUHPHQW GHYLFHV VSH
VWDQGDUGV ,QWHUIDFLQJ RI VHQVRUV DQG HQG GHYLFHV 'LVSO

0RGXOH

&DOLEUDWLRQ DQG WHVWLQJ &DOLEUDWLRQ DQG WHVWLQJ VWDQGDUGV IRU
GLVSOD\ GHYLFHV 0HDVXUHPHQW DQG SHUIRUPDQFH WHVWV ±
DQG OLIH WHVWV 0HDVXUHPHQWV RI YROWDJH FXUUHQW
LQVWUXPHQWDWLRQ DPSOLILHU LVRODWLRQ DPSOLILHU DFWLYH
FLUFXLWV

0RGXOH

&RQWURO SDQHO GHVLJQ 2SHUDWRU FRQVROH DQG FRQWURO URRP SDQHO
HQYLURQPHQW IRU HOHFWURQLF HTXLSPHQW +HDW GLVVLSDW
FRQVLGHUDWLRQV *URXQGLQJ DQG VKLHOGLQJ 3URWHFWL
(OHFWURPDJQHWLF LQWHUIHUHQFH DQG FRPSDWLELOLW\ 'HVLJ
VL]HV GHVLJQ UXOHV GLJLWDO DQDORJ VLQJOH DQG PXOWLOD
SDFNDJHV DQG WRROV

0RGXOH

3ULQFLSOHV DQG GHVLJQ RI 3URSRUWLRQDO ,QWHJUDO 'HULYDWLYH FRQWUROOHUV DQG WKHLU FKDUDFWHULVWLFV 5HO
FRQWURO &RQWURO YDOYHV ±DSSOLFDWLRQV GHVLJQ DQG FRQV

5HOLDELOLW\ SULQFLSOHV 0775 07%))DLOXUH UDWH DQDO\VLV 3
&RQWURO FKDUWV 64& 740 3ULQFLSOHV ,62 VHULHV
FHUWLILFDWLRQ 4XDOLW\ DXGLW

7H[W %RRNV

%HOD * /LSWRQ 3URFHVV &RQWURO LQVWUXPHQW HQJLQHHUV
' 3DWUDQDELV 6HQVRUV DQG 7UDQVGXFHUV 3+,
*ROGLQJ (: DQG :LGGLV) & (OHFWULFDO 0HDVXUHPHQWV DQG
FR
5 6 +DQGSLFN 3ULQWHG &LUFXLW %RDUGV 0F*UDZ +LOO 3URIHVVLRQDO
(%DODJXUXVZDP\ 5HOLDELOLW\ HQJLQHHULQJ 0F *UD
'DOH %HVWHUILHOG HW DO 7RWDO 4XDOLW\ 0DQDJHPHQW 3H

5HIHUHQFH ERRNV

:DUHQ ER[OHLWQHU (OHFWURVWDWLF 'LVFKDUJH DQG (OHFWU

.LP 5)RZOHU (OHFWURQLF ,QVWUXPHQW 'HVLJQ 2[IRUG UH
.DOVL +6 (OHFWURQLF ,QVWUXPHQWDWLRQ DQG 0HDVXUHPHQW
$. 6ZDKQ\ $ &RXUVH LQ (OHFWURQLF 0HDVXUHPHQWV DQG ,QVWUXPH

&RXUVH &RQWHQWV DQG /HFWXUH 6FKHGXOH

1R	7RSLF	1R RI /HFWXUHV
	&RQFHSWV RI LQVWUXPHQW GHVLJQ	
	IXQFWLRQDO UHTXLUHPHQWV DQG VSHFLILFDWLRQV	

	6WDQGDUGV ±PLOLWDU\ LQGXVWULDO DQG FRPPHUFLDO VWD		
	%,6 VWDQGDUGV $16, VWDQGDUGV 1(0$ VWDQGDUGV ',1 ,QVWUXPHQWV V\PEROV DQG VLJQDOV		
	3HUIRUPDQFH FKDUDFWHULVWLFV DQG VHOHFWLRQ FULWHULD		
	3HUIRUPDQFH FKDUDFWHULVWLFV DQG VHOHFWLRQ FULWHULD OHYHO WUDQVGXFHUV		
	6PDUW WUDQVPLWWHUV		
	GLVSOD\ GHYLFHV DQG SORWWLQJ GHYLFHV		
	&DOLEUDWLRQ DQG WHVWLQJ VWDQGDUGV		
	&DOLEUDWLRQ DQG WHVWLQJ VWDQGDUGV IRU LQVWUXPHQWV GHYLFHV		
	0HDVXUHPHQW DQG SHUIRUPDQFH WHVWV		
	'HVLJQ RI LQVWUXPHQWDWLRQ DPSOLILHU LVRODWLRQ DPSO		
	&RQWURO SDQHO GHVLJQ		
	2SHUDWLQJ FRQVROH DQG FRQWURO URRP SDQHO GHVLJQ		
	&RQWURO RI URRP HQYLURQPHQW IRU HOHFWURQLF HTXLSPH		
	+HDW GLVVLSDWLRQ IRUFHG DLU FLUFXODWLRQ DQG KXPLG *URXQGLQJ DQG VKLHOGLQJ 3URWHFWLRQ DJDLQVW HOHFW (OHFWURPDJQHWLF LQWHUIHUHQFH DQG FRPSDWLELOLW\		
	'HVLJQ JXLGHOLQHV IRU 3&% V OD\RXW VFKHPHV 3&% VL]H GLJLWDO DQDORJ VLQJOH DQG PXOWLOD\HU 3&% V DXWR &$' SDFNDJHV DQG WRROV		
	3ULQFLSOHV DQG GHVLJQ RI FRQWUROOHUV		
	3URSRUWLRQDO FRQWUROOHUV 3URSRUWLRQDO ,QWHJUDO FKDUDFWHULVWLFV		
	3URSRUWLRQDO ,QWHJUDO 'HULYDWLYH FRQWUROOHUV DQG V		

	0LFURSURFHVVRU EDVHG FRQWURO	
	&RQWURO YDOYHV ±DSSOLFDWLRQV GHVLJQ DQG FRQWURO	
	SULQFLSOHV RI 0775 07%)	
	)DLOXUH UDWH DQDO\VLV 3URGXFW TXDOLW\ YDULDQFH	
	&RQWURO FKDUWV 64& 740 3ULQFLSOHV	
	4XDOLW\ VWDQGDUGV SURFHGXUH &HUWLILFDWLRQ 4XD	

W: h> < > D d ,EK>K'/ > hE/s Z^/dz

DK > Yh ^d/KE W W Z

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d/D W ï,Z D Z<^Wíìì

3$57 $

~ v•Á Œ >> Yµ •š]}v•X Z ŒŒ] • ï u Œl••

í	tZ š]• šZ]((Œ v šÁ v šZ š Œu• Z[}uu Œ] o •š v Œ [[X	K	<
î	tZ š Œ šZ •] (µv š]}v o •]Œ o Z Ç	K	<
ïX	tZ š]• u vš Ç šZ š Œu Z[•u Œ	Kî	<î
ðX	• Œ] Z}Á v}]• PŒ • ‰ Œ(}Ç	Kî	<î
ñX	>]•š šZ (}Œ •]vÀ}oÀ]v v o šŒ} Çv u] K]v•šŒµu vš X	Kï	<î
òX	]• µ•• šZ v (}Œ v]•]	Kî	<î
óX	]• µ•• šZ v (}Œ o šŒ}u Pv š]]]v•šŒµu vš š]}v •Ç•š u•X	Kï	<î
ôX	tZ š •š ‰• v š l v š} Œ µ šZ µ]]o]v•šŒµu vš•X Æ‰o]vX	Kð	<î
õ	Æ‰o]v šZ •]Œ o Z Œ š (	K	<
íìX	tZ š Œ šZ u i}Œ vÀ]Œ}vu vš o (š}Œ• Á Z] < PŒ • šZ o](}(v]v•šŒµu vš š]}v •Ç•š uU Œ] (oÇ Æ‰o]v	Kñ	<î

WZdr

v•Á Œ vÇ }v ‹µ •š]}v (Œ}u Z u} µo

D} µo /

í í	]((Œ vš] š šÁ v šZ š Œu• Z[(µv Z[•‰](] š]}v•[[X tšZ •µ]š o Æ u‰o U Æ‰o]v šZ • šÁ} (}Œ u Z]v M	íð	Kí	<î
	K			
íîX	tZ š]• u vš Ç šZ š Œu• Z[µŒ Œ (Œ v š}u •µŒ]vP]v•šŒµu vš•X tZ š Œ šZ (š}Œ• ÁZ] Z o] šZ Z[µŒ Ç Z[v Z[‰Œ]•]}v[[}(u •µŒ]vP]v•šŒµu vš•M	íì	Kî	<î
•	tZ š Œ šZ u i}Œ š P}Œ] • }(u •µŒ]v •µ]š o Æ u‰o •X	ð	Kî	<î

D} µo //

íïX	t]šZ •µ]š o] PŒ u• v oÇÌ šZ (µv š]} • u •µŒ u vš •Ç•š uM v oÇÌ Z}Á šZ Œ •}oµš]}v v µŒ Ç }(šZ •Ç•š u v]u‰Œ}À X	íð	Kî	<ï
	KZ			
íðX	t]šZ •µ]š o] PŒ u• Æ‰o]v šZ Á}Œl]•‰o Ç •Ç•š uX	íì	Kð	<î
	>]•š u Œ]š• v u Œ]š• }(	¿	K	<

D} µo ///

í í	>]•š šŒ vÁZ] Z v µ• š} u •µŒ o}Á À oµ • }(À}oš P • v µŒŒ vš•X • Œ] šZ]Œ ‰Œ]v]‰o •X tZ šŒ v• µ Œ Á]oo •µ]š o š} u •µŒ šZ À}oš P Æ]•š]vP]v v šŒ v•u]••]}v o]v X :µ•š](Ç Ç}µŒ • o š]}v X	í¿	K	<
	K			
íòX	tZ š]• šZ]((Œ vš šÇ‰ • }(v}]• • v •Ç•š u•X Z}Á v šZ ((š• }(v}]• Z À u]š]P š M Æ‰o]v]v š	íì	Kï	<î
•	tZ š]• šZ]u‰}Œš v }(v]v•šŒµu vš	ð	Kï	<î

	•]Œ o Z Œ			

D} µo /s

íó	Æ‰o]v Z}Á š u‰ Œ šµŒ U Zµu]]šÇ v (µv š]}v]vP }(u •µŒ u vš •Ç•š u•X ÁZ š šZ À Œ] š]}v• µ š} šZ}• (š}Œ•M	íð v	Kï }v	<î š} }À Œ }u
	KZ			
í¿	tZ š Œ šZ À Œ]}µ• ‰ š Œ u}À o • Z u ÁZÇ Z š Œ u}À o]• }(Œ]š] o]u‰}Œš v	í¿	K	<

D} µo s

íõ	tZ š]• u vš Ç šZ š Œu Z[Œ o]]o]šÇ[(š}Œ• ÁZ] Z ((š Œ o]]o]šÇM ÁZ š Œ šZ ‰}••] o vZ v u vš• ÁZ] Z v]v Œ • Œ o]]o]šÇX]• µ••]v š]oX	íì	Kñ	<î •]P
•	tZ š Œ šZ Œ o š]À u Œ]š• }(WU W/ Æ‰o]vX	ð	Kñ	<î
	K			
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WŒu o dW Z •Çoo µ•]• ‰Œ ‰ Œ Á]šZ À] Á }(P]À]vP šZ •šµ •] o u vš• }(v o šŒ}v] •Ç•š u •]Pv µ•]vP s Œ]o}P Z Œ Á š} šZ À •šv •• }(šZ (] o U }voÇ •] •]Pv š Zv]‹µ • Œ]• µ

WŒ Œ ‹µ]•]š W ‰š }(o}P]]Œ µ]š •]Pv

}µŒ• Kµš}u • (š Œ šZ }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo

K	• Œ] s Œ]o}P Z Œ Á Œ • Œ
K	Æ‰> vPµ P }v•šŒµ š• v
K	•]Pv]P]š
K	s Œ](Ç Z À]}µŒ o u} o•
K	•]Pv Z P]•š Œ dŒ v•(Œ > À o]Œ
K	^ÇvšZ •]Ì Zd

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

	WK	WK	WK	WK	WK	WK	WK	WK	WK	W íì	W íí	W íî
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K	ï											í
K	ï		î		í							í
K	ï		î		í							í
K	ï		î		í							í
K	ï		î		í							í

•• ••u vš W šš Œv

o}}u[• š	}vš]vµ}µ• •• ••u		v ^ u •š Œ Æ
	í	î	
Z u u	íì	íì	îì
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D Œl]•šŒ] µš]}v

d}š o D	/	^	^ µŒ
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}vš]vµ}µ• /vš Œv o À oµ š]}v W ššŒvW

šš v v W íì u Œl•
}vš]vµ}µ• •• ••u vš d •š ~î vµu Œ•• W îñ u Œl•
••]Pvu všlYµ]Ìl }µŒ• ‰Œ}iWšíñ u Œl•

v ^ u •š Œ Æ u]v š]}v dZ WŒššÁŒ}ovW šÁ} ‰ Œš•V W Œš v W Œš
‹µ •š]}v• Á]šZ î ‹µ •š]}v• (Œ}u Z u} µo U Z À]vP ï u Œl• (}Œ Z
v•Á Œ oo ‹µ •š]}v•X W Œš }vš]v• î ‹µ •š]}v• (Œ}u Z u} µo }(Á
}v X Z ‹µ •š]}v v Z À u Æ]uµu î •µ r]À]•]}v• v ŒŒÇ íð u Œl•X

}µŒ• > À o •• ••u vš Yµ •š]}v•

}µŒ• Kµš }u í ~Kí•W

íX Æ‰o]v Á]šZ Æ u‰o •W •]•‰o Ç š •l• • ^šŒ} š •l• • D}v]
îX h•]vP Æ u‰o U Æ‰o]v }µš }v µŒŒ vš v •š š u vš Á]šZ •Ç
ïX tZ š]• (µv š]}v o À Œ](] š]}vM

}µŒ• Kµš }u î ~Kî•

íX (]v < ÇÁ}Œ • v / vš](] Œ•X
îX Æ‰o]v Á]šZ Æ u‰o •X • tZ]š •‰ • •šŒ vPšZ• • K‰ Œ š]
ïX o ••](Ç v Æ‰o]v •šŒ vPšZ• v }vš vš]}v Œ •}oµš]}v

}µŒ• Kµš }u ï~Kï•W

íX •]Pv u} µo v š •š v Z (}Œ Z o(r ŒX
îX tZ š]• ŒŒ Ç }(/v•š v • }(‰Œ]u]š]À •M
ïX tŒ]š s Œ]o}P } (}Œ í š} ð uµoš]‰o Æ Œ u} µo Ç µ•]vP î š

}µŒ• Kµš }u ð ~Kð•W

ðX tŒ]š s Œ]o}P } µ•]vP • •š š u vš (}Œ vÇ }v Æ u‰o X
ñX •]Pv }µvš Œ u} µo v š •š v Z š}]ooµ•šŒ š šZ µ• }(t
òX tŒ]š s Œ]o}P u} µo (}Œ ‰}•]š]À P šŒ]PP Œ (o]‰ (o}‰X

}µŒ• Kµš }u ñ ~Kñ•W

óX •]Pv s Œ]o}P u} µo µ•]vP ‰ šZ o Ç
ôX Æ‰o]v šZ }‰ Œ š]}v }(WDK^ •Á]š ZX
õX •]Pv s Œ]o}P u} µo }(ðr]š µ• •Á]š Z Œ š šZ š (o}Á o

}µŒ• Kµš }u ò ~ Kò•W

íìXtŒ]š š •š v Z (}Œ u}}Œ š š}Œ š} }všŒ}o šZ o ÇX
ííX •]Pv s Œ]o}P u} µo (}Œ DK^ (o]‰r(o}‰X
íîXtŒ]š •Çvš Æ (}Œ ÁZ]o o}}‰ v ÁŒ]š s Œ]o}P } (}Œ vr]š

D} o Yµ •š]}v ‰ ‰ Œ

YW K W W ' ^Wï

Z PE}W

E u W

W: h>< > Dd ,EK>K'/ >hE/s Z^/dz&/Z^d^ D ^d Z Xd , 'Z y
KEU DKEd, ~z Z

}µŒ• } dWîõð

}µŒ• E u W ^Ç•š u •]Pv h•]vP s Œ]o}P

D ÆXD ŒI•Wíìì µŒ š]}vW ï,}µŒ•

W Zd

v•Á Œ oo Yµ •š]}v•X Z ‹µ •š]}v ŒŒ] • ï D ŒI•

íX (]v o}P] o À o• Œ o À vš š} À Œ]o}P , >
îX o ••](Ç šZ š šÇ‰ • v Æ‰o]vX
ïX Æ‰o]v EKZ P š ‰Œ]u]š]À Á]šZ Æ u‰o X
ðX,}Á]• o Ç u} o]v š (o}Á o À oX
ñXtŒ]š s Œ]o}P } µ•]vP](r o• •š š u vš (}Œ vÇ }v Æ u‰o
òX • Œ] ••]Pvu vš š} s XŠ}Œ K‰ Œ š}Œ•
óXtŒ]š }µš •Á]š Z ‰Œ]u]š]À •
ôX • Œ]]v•š vš] š]}v Á]šZ –^šŒ vPšZ•– v – o Ç•–
õX • Œ] ‰]š]À D} o
íìXtZ š]• • ‹µ vš] o •ÇvšZ •]• }( ]P]š o •Ç•š u
~íìÆïAïì•

W Œš

v•Á Œ vÇ }v Yµ •š]}v (Œ}u Z u} µo X Z ‹µ •š]}v ŒŒ

íõX ~ • Æ‰o]v šZ ^ ‹µ vš] o D} or& l D} oX ~ò•
~ •tZ š]• &µv š]}v o Z P]•š ŒX Æ‰o]v]v š]oX ~ô•

KZ

îìX ~ • Æ‰o]v šZ ^š š]X D Z]v }]vP
~ • tZ š Œ šZ À Œ]}µ• • ‹µ vš] o u u}ŒÇ •š}Œ P ~ô•u} o• Æ‰

^Ço o µ•

D}µo í

/všŒ}µ š]}v š} ss ŒEŒ]o}P]P, >W >U > À o• }(•]Pv • Œ]‰š]}vU }v µŒ
^ÇvšZ •]•U &µv š]}v s Œ](] š]}vU ^Ç•š u d •l•U WŒ}PŒ uu]vP > vPµ
v ^ÇvšZ •]• d}}o•

> vPµ P }v•šŒµ š• v /v šŒ À µš]}v šW < ÇÁ}Œ •U / vš](] Œ•U tZ]š ^‰
}uu vš•U Eµu Œ•U ^šŒ]vP•U >}P] s oµ •U ^šŒ vPšZ•U š dÇ‰ •U
K‰ Œ š}Œ•X

D}µo î

' š > À o D}o]vPW/vš Œ}µ š]}vU E ' š WŒ]u]š]À U D}µo ^šŒµ šµŒ U
/ooµ•šŒ š]À Æ u‰o •U dŒ]•š š ' š •U ŒŒ Ç }(/v•š v • }(WŒ]u]š
WŒ]u]š]À •U o ÇU ^šŒ vPšZ• v }v•šŒµ š]}v Z •}oµš]}vU E š dÇ‰

D} oo]vP š š (o}Á >À o W/vš Œ}µ š]}vU }vš]vµ}µ• ••]Pvu vš ^šŒµ šµŒ U
••]Pvu vš•U ••]Pvu vš š} s š}Œ K‰ Œ š}Œ•X

D}µo ï

Z À]}µŒ o D} o]vPW /vš Œ}µ š]}vU K‰ Œ š]}v• v ••]Pvu vš•U &µv š]}v o
}v•šŒµ šU ••]Pvu vš• Á]šZ o Ç•U –t]š– }v•šŒµ šU Dµoš]‰o oÁ
> À oU o} l]vP v E}vr o} l]vP ••]Pvu vš•U dZ – • – ^š š u všU ^]u
}v•šŒµ š•U – ••]Pvr r ••]Pv– }v•šŒµ š•U –Z ‰ š– }v•šŒµ šU (}Œ
>}}‰–U &}Œ À Œ >}}‰X

D}µo ð

^Á]š Z > À o D} o]vPW E}vr •]•š}Œ ^Á]š Z •U DK^ ^Á]š Z •U]]Œ š]}v
Á]šZ ^Á]š Z WŒ]u]š]À •U /v•š vš] š]}v Á]šZ –^šŒ vPšZ•– v – o Ç•–
Z À]}µŒ o u} o• }( ]P]š o]Œ µ]š•r Æ u‰o •

D} µo ñ

^ ‹µ vš] o]Œ µ]šW ^ Œ ‰š] }v D} o• r & l D} oU ‰]š]À D} o
•] D u}ŒÇ }u‰}v vš•U &µv š]}v o Z P]•š ŒU ^š š] D Z]v }]vPU

d Æš }}l•

íXdXZX W u v Z vU o dŒ]‰µŒ ^µv Œ]U •]Pv dZŒ}µPZ s Œ
îX•]v o] v E À]U s Œo]}P]P]š o ^Ç•š u •]PvUdD,U îv]š]}v

Z (Œ v }}l•

íX &µv u vš o• }( ]P]š o >}P] Á]šZ s Œ]o}P •]Pv r ^š ‰Z v Œ}ÁvU
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îX À v]P]š o >}P] •]Pv µ•]vP s Œ]o}PU ^š š D Z]v • ˜ ^ÇvšZ
vP P > Œv]vPU îìíîX
ïX s Œ]o}P , > r ^ u]Œ W ov]šl ŒU îv]š]}vU W Œ•}v µ š]}vU îìì
ðX À v]P]š o •]Pv Á]šZ s Œ]o}P , > r D] Z o X]o šš]U W,/Uîì

}µŒ• }vš vš• v > šµŒ ^ Z µo

E}	d}‰]	E}X }(> šµŒ •
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íX	/všŒ} µ š]}v š} s Œ • , >U > À o• • Œ]‰š]}vU }v µŒŒ v ÇU ^]uµo š]}v v s Œ](] š]}vU ^Ç•š u d •l•U WŒ}PŒ uu]vP ^]uµo š]}v v ^ÇvšZ •]• d}}o•	í ^ÇvšZ •]•U &µv š]}v > vPµ P /vš Œ(U D
íX	> vPµ P }v•šŒµ š• v /všŒ} µ š]}vU / v š](] Œ•U tZ]š ^‰ U Z Œ š Œ•U }uu vš•U Eµu Œ•U ^šŒ] >}P] s oµ •U ^šŒ vPšZ•U š dÇ‰ •U ^ o Œ• v s š}Œ•U W Œ K‰ Œ š}Œ•X	
î	' d > s > DK >>/E'UDK >>/E' d	
îX	' š > À o D} /všŒ} µ š]}vUWŒ]u]š]À ^šŒµ šµŒ U KšZ Œ ' š WŒ]u]š]À •U /ooµ•šŒ š]À Æ u‰o •U d ŒŒ Ç }(/v•š v • }(WŒ]u]š]À •U •]Pv }(&o]‰r&o}‰• Á]šZ ' š WŒ]u]š]À •U o ÇU ^šŒ vPšZ• v }v•šŒµ š]}v Z •}oµš]}vU E š •]Pv }(•]]Œ µ]šX	í

î X	D} o o] v P š š / v š Œ } µ š] } v U } v š] v µ ^ š Œ µ š µ Œ U o Ç • v } v š] v µ } µ • • •] P v u v š • U • •] P v u v š š } s š K ‰ Œ š } Œ • X	¿
ï	, s / K h Z > D K > > / E '	(
ï X	/ v š Œ } µ š] } v U K ‰ Œ š] } v • v • •] P v u v š • U ï & µ v š] } v o] (µ Œ š] } – / v] š] o – } v • š Œ µ š U • •] P v u v š • Á] š Z o Ç •	
ï X	– t] š – } v • š Œ µ š U D µ o š] ‰ o o Á Ç • o } l U î •] P v • š Z À] } µ Œ o	
ï X	o } l] v P v E } v r o } l] v P • •] P v u v š • U d Z – ¿ • – ^ š š u v š U ^] u µ o š] } v & o } Á U – / (– v –] (r o • – } v • š Œ µ š • U – • •] P v r r • •] P v } v • š Œ µ š • U – Z ‰ š – } v • š Œ µ š U (} Œ o } } ‰ U – d Z] • o – } v • š > } } ‰ – U & } Œ	
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ñ X	& l D } o U ‰] š] À D }	ï
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3UHDPEOH 7KH V\OODEXV LV SUHSDUHG ZLWK D YLHZ RI JLYLQJ W DOJHEUD DQG WR VROYH OLQHDU H

3UHUHTXLVLWH 1,/

&RXUVH 2XWFRPH $IWHU WKH FRPSOHWLRQ RI WKH FRXUVH WKH VWX

&2	7R GHYHORS WKH VNLOOV LQ DEVWUDFW DOJHEUD
&2	7R GHYHORS WKH VNLOOV WR VROYH OLQHDU HTXDWLRQ
&2	7R GHYHORS WKH VNLOOV WR IRUPXODWH OLQHDU WUDQ
&2	7R XQGHUVWDQG DQG DSSO\ WKH FRQFHSW RI LQQHU SU
&2	7R DSSO\ DQG DQDO\VH (LJHQ YHFWRU GHFRPSRVLWLRQ DQDO\VH 6LQJXODU 9DOXH 'HFRPSRVLWLRQ RI PDWULFHV

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV

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$VVHVVPHQW 3DWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW 7HVWV		(QG 6HPHVWHU ([DPLQDWLRQ
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&UHDWH			

0DUN GLVWULEXWLRQ

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&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV

&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV PDUNV

$VVLJQPHQW 4XL] &RXUVHSURMHFW PDUNV

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ 7KHUH ZLOO EH WZR SDUWV 3DUW $ DQ
TXHVWLRQV ZLWK TXHVWLRQV IURP HDFK PRGXOH KDYLQ
DQVZHU DOO TXHVWLRQV 3DUW % FRQWDLQV TXHVWLRQV
DQ\ RQH (DFK TXHVWLRQ FDQ KDYH PD[LPXP VXE GLYLVLRQ

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

&RXUVH 2XWFRPH &2 $EVWUDFW DOJHEUD

'HILQH WKH DOJHEUDLF VWUXFWXUH JURXS *LYH DQ H[DPSOH

'HILQH WKH IROORZLQJ WHUPV ZLWK UHVSHFW WR D YHFWRU V
L /LQHDU LQGHSHQGHQFH LL %DVLV LLL 'LPHQVLRQ

&RXUVH 2XWFRPH &2 6ROXWLRQ WR OLQHDU V\VWHP

)LQG WKH LQYHUVH RI % ZLWKRXW ILQGLQJ WKH GHWHUPLQDQ

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6ROYH DQG ILQG WKH VROXWLRQV WR WKH V\VWHP RI HTXDWL

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t T5 E u T6 F u T7 E T8 L u
u T5 E u T6 F v T7 F t T8 L s

&RXUVH 2XWFRPH &2 /LQHDU WUDQVIRUPDWLRQ

&KDQJH WKH EDVLV IURP WKH IROORZLQJ YHFWRUV

)LQG D EDVLV IRU URZ VSDFH DQG QXOO VSDFH RI WKH IROORZ
Fu x Fs s y
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&RXUVH 2XWFRPH &2 ,QQHU SURGXFW

'HILQH LQQHU SURGXFW VSDFH

,V EH D YHFWRU VSDFH RI SRO\QRPLDOV ZLWK LQQHU SURGXFW
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$OJHEUDLF 6WUXFWXUHV *URXS 5LQJ)LHOG 9HFWRU 6SDFHV
VSDQQHG E\ VHW RI YHFWRUV /LQHDU GHSHQGHQFH DQG /LQH
GLPHQVLRQDO YHFWRU VSDFHV

0RGXOH

6ROXWLRQV WR /LQHDU 6\VWHP RI (TXDWLRQV 6LPSOH V\VWHP
*DXVVLDQ HOLPLQDWLRQ 1XOO 6SDFH DQG 5DQJH 5DQN DQG Q
*HQHUDO 6ROXWLRQ RI D OLQHDU V\VWHP (OHPHQWDU\ 5RZ D
H[LVWHQFH DQG XQLTXHQHVV RI VROXWLRQV SURMHFWLRQ OH

0RGXOH

/LQHDU 7UDQVIRUPDWLRQV IRXU IXQGDPHQWDO VXEVSDFHV RI
UDQN QXOOLW\ WKHRUHP 0DWUL[UHSUHVHQWDWLRQ RI OLQHD

0RGXOH

,QQHU SURGXFW ,QQHU SURGXFW 6SDFHV &DXFK\ ± 6FKZDU] LQ
RUWKRQRUPDOL]DWLRQ 2UWKRQRUPDO EDVLV ([SDQVLRQ LQ W
'HFRPSRVLWLRQ RI D YHFWRU ZLWK UHVSHFW WR D VXEVSDFH
7KHRUHP

0RGXOH

(LJHQYDOXH ± (LJHQYHFWRU SDLUV FKDUDFWHULVWLF HTXDWLR
DQG JHRPHWULF PXOWLSOLFLW\ 'LDJRQDOL]DWLRQ FULWHU
'HFRPSRVLWLRQ RI WKH PDWUL[LQ WHUPV RI SURMHFWLRQV 5H
RI (LJHQ YDOXHV (LJHQ YHFWRUV 8QLWDU\ 2UWKRJRQDO GL
6\PPHWULF 0DWULFHV 6SHFWUDO 7KHRUHP 3RVLWLYH DQG 1HJ

*HQHUDO 0DWULFHV 5DQN 1XOOLW\ 5DQJH DQG 1XOO 6SDFH
9DOXH 'HFRPSRVLWLRQ

7H[W ERRNV

*) 6LPPRQV 7RSRORJ\ DQG 0RGHUQ $QDO\VLV 0F*UDZ +LO

)UD]LHU 0LFKDHO : $Q ,QWURGXFWLRQ WR :DYHOHWV WKUR

5HIHUHQFH %RRNV

+RIIPDQ .HQQHWK DQG .XQ]H 5D\ /LQHDU $OJHEUD 3UHQWLFH

5HLFKDUG %URQVRQ $FDGHPLF 3UHVV

&RXUVH &RQWHQWV DQG /HFWXUH 6FKHGXOH

1R	7RSLF	1R RI /HFWXUHV
	9HFWRU 6SDFHV 6XEVSDFHV	
	/LQHDU &RPELQDWLRQV 6XEVS	
	/LQHDU GHSHQGHQFH DQG /LQHDU LQGHSHQGHQFH	
	6SDQQLQJ VHW DQG EDVLV)LQLWH	
	6ROXWLRQV WR /LQHDU 6\VWHP RI (TXDWLRQV 6LPSOH V\V +RPRJHQHRXV DQG 1RQ KRPRJHQHRXV V\VWHPV *DXVVLDQ HOLPLQDWLRQ	
	1XOO 6SDFH DQG 5DQJH 5DQN DQG QXOOLW\ &RQVLVWHQF WHUPV RI UDQN	
	*HQHUDO 6ROXWLRQ RI D OLQHDU V\VWHP (OHPHQWDU\ 5RZ RSHUDWLRQV 5RZ 5HGXFHG)RUP H[LVWHQFH DQG XQLTXHQ VROXWLRQV	
	3URMHFWLRQ OHDVW VTXDUH VROXWLRQ SVHXGR LQYHUVL	
	/LQHDU 7UDQVIRUPDWLRQV IRXU IXQGDPHQWDO VXEVSDFHV WUDQVIRUPDWLRQ	
	LQYHUVH WUDQVIRUPDWLRQ UDQN QXOOLW\ WKHRUHP	
	0DWUL[UHSUHVHQWDWLRQ RI OLQHDU WUDQVIRUPDWLRQ	
	&KDQJH RI %D	
	,QQHU SURGXFW ,QQHU SURGXFW 6SDFHV &DXFK\ ± 6FKZDU	
	1RUP 2UWKRJRQDOLW\ *UDP ± 6FKPLGW RUWKRQRUPDOL]D 2UWKRQRUPDO EDVLV ([SDQVLRQ LQ WHUPV RI RUWKRQRUP 2UWKRJRQDO FRPSOHPHQW	
	'HFRPSRVLWLRQ RI D YHFWRU ZLWK UHVSHFW WR D VXEVSD RUWKRJRQDO FRPSOHPHQW ± 3\WKDJRUDV 7KHRUHP	
	(LJHQYDOXH ± (LJHQYHFWRU SDLUV FKDUDFWHULVWLF HTX PXOWLSOLFLW\ (LJHQYHFWRUV (LJHQVSDFHV DQG JHRPHW 'LDJRQDOL]DWLRQ FULWHULRQ 7KH GLDJRQDOL]LQJ PDWUL[	
	3URMHFWLRQV 'HFRPSRVLWLRQ RI WKH PDWUL[LQ WHUPV	

	5HDO 6\PPHWULF DQG +HUPLWLDQ PDWULFHV 3URSHUWLH YDOXHV (LJHQ YHFWRUV 8QLWDU\ 2UWKRJRQDO GLDJDQDO &RPSOHV +HUPLWLDQ 5HDO 6\PPHWULF 0DWULFHV	
	6SHFWUDO 7KHRUHP 3RVLWLYH DQG 1HJDWLYH 'HILQLWH D 'HILQLWH PDWULFHV	
	*HQHUDO 0DWULFHV 5DQN 1XOOLW\ 5DQJH DQG 1XOO 6SD DQG 7	
	6LQJXODU 9DOXHV 6LQJXODU 9DOXH 'HFRPSRVLWLRQ	

0RGHO 4XHVWLRQ 3DSHU

$ 3 - $EGXO .DODP 7HFKQRORJLFDO 8QLYHUVLW\

)RXUWK 6HPHVWHU % 7HFK 'HJUHH ([DPLQDWLRQ

%UDQFK (OHFWURQLFV DQG &RPPXQLFDWLRQ

&RXUVH $(7 /LQHDU $OJHEUD

7LPH +UV 0D[0DUNV

3$57 $

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	‹µ •š]}v•		
W1	(]v •]• v]u v•]}v (}Œ	YÀ š}Œ •%	W1
X1	/(v}š • À š}Œ •‰ (šZ À Œ (] o •Z}Á šZ Ç ÇR L FÙR ()Œ (ÙR²8	Y1	X1
Y1	(]v]vÀ Œ• }(o]v Œ šŒ v•(}Œu š]}v	Y1	W1

Z1	^šš v ‰Œ}À vÇ }v ‰Œ}‰ ŒšÇ }(‰Œ}i š]}v u šŒ]Æ	Y1	X1
[1	tZ š]• vµoo •‰ }(o]v Œ šŒ v•(}Œu š]}vM ']À v Æ u‰o	Y1	W1
\1	/(W A ÁZ Œ]•] P}v o u šŒ]Æ •Z}Á šZ š }oµuv• }(W Œ]P vÀ š}Œ• }(u šŒ]Æ 1	Y1	X1
]1	,I ‹•I &DQ \RX)LQG D FRPPRQ YHFWRU LQ DQG MXVWLI\ \RXU DQVZHU	Y1	Y1
^1	:KDW LV DQ (LJHQ YHFWRU RI D OLQHDU WUDQVIRUPDWLRQ" :KDW LV PHDQW E\ JHRPHWULF PXOWLSOLFLW\ RI DQ (LJHQ YDOXH"	Y1	W1
_1	,I GHQRWH D ILQLWH GLPHQVLRQDO YHFWRU VSDFH RYHU WKH ILHOG RI ZLWK LQYHUWLEOH SRO\QRPLDO H[SUHVVLRQ LQ RYHU	Y1	X1
WV1	(]v µv]š ŒÇ šŒ v•(}Œu š]}vM ']À v Æ u‰o	Y1	W1

3$57 %

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íí	D ‹l EH D YHFWRU VSDFH DQG SURYH WKH WULDQJXODU LQHTXDOL ‹(‹ E‹ F ‹	ò	< í
	E)LQG WKH EDVLV DQG GLPHQVLRQ IRU WKH Rs L tiá Rt Lwiá Ru Lsie	íì	< î
	K		
íî	(]v šZ (}oo}Á]vP š Œu• Á]šZ (L /LQHDU LQGHSHQGHQFH LL %DVLV LLL 'LPHQVLRQ	ò	< í
	Z l ÁZ šZ Œ šZ (}oo}Á]vP À š}Œ• (}Œu •] Fs L (ti Ft L (vi Fu L (si	ô	< î
	D} µo î		
íï	)LQG WKH LQYHUVH RI % ZLWKRXW ILQGLQJ WKH GHWHUPLQD	ò	< î
	6ROYH DQG ILQG WKH RI HTX $\neg_5$ E $\neg_6$ F t $\neg_7$ E \ $\neg_8$ L v; t $\neg_5$ E u $\neg_6$ F u $\neg_7$ E $\neg_8$ L u; u $\neg_5$ E u $\neg_6$ F v $\neg_7$ F t $\neg_8$ L s	ô	< î
	25		
íð	tZ š]• šZ o •š •‹µ Œ •}oµš]}v ~> M^} šZ ‹µ š]}v	íð	< í
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	K Z		
í ò	ÁZ š • vµoo •‰ }(o]v Œ šŒ v•(}Œu š]}vM šZ vµoo •‰ #‰ }(ri	ô	< î
	^Z}Á šZ š vµoo •‰]• šZ }ŒšZ}P}v o }u‰o uðvš }(<Œ}Á •‰ šŒ v•(}Œu š]}v u šŒ]Æ		
	D} µo ð		
í ó	(]v]vv Œ ‰Œ} µ(š •‰ Á Z Œ /v}š v]vv Œ ‰Œ} µ š •‰ šZ v ‰Œ}À šZ ^ ZÁ Œš[•]v ‹µ o]šÇ		
	,I EH D YHFWRU VSDFH RI SRO\QRPLDO ZLWK LQQHU SURGXF ì E:l;C:l;@ L l; L ι l F v C:l; L l[6])LQG E LF L L ; ; (		
í ô	^Z}Á šZ š •]u]o Œ]šÇ šŒ v•(}Œu š]}v }• • v}š Z vP šZ <î]P v À šŒ v•(}Œu š]}v u šŒ]Æ		
	tZ š]• •]u]o Œ]šÇ šŒ v•(}Œu š]}v M X]v šŒ }‰ Œ š}Œ Ç (&]v šZ u šŒ]Æ Œ‰Œ •]Àš š]}v }(•] L ·(s (t L ·:s t; :t v;		
	D} µo ñ		
í õ	^š š v ‰Œ}À vÇ }v ‰Œ}‰ ŒšÇ }(‰Œ}i š]}v u šŒ]ÆM		
	&]v šZ ‰Œ}i š]}v }(šZ }oµuv •‰ }(# L] > L j	í ì	< ï
î ì	] P}v o]Ì šZ u šŒ]Æ # L (‰}•]•] o	ó	< ï
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WŒ u oZW }µŒ• ‰Œ}À] • lv}Áo P }(•šŒ •• •U •šŒ]v• v (}Œu š]}v• À Œ]}µ• o} •X /š Z o‰•]v •• ••]vP šZ •šŒ •• • v (}Œu š]}v• šZŒ}µPZ u šÁ]•š]vP Œ• }Œ }u]v š]}v• }(}šZX o•}]š Z o‰• š} µv Œ•š v šZ •] ‰Œ

WŒ Œ ‹µ]•]š W vP]v Œ]vP D Z v] •

}µŒ• Kµš }u • W šZ }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo o š}

K í	Æ‰o]v šZ (µv u vš o }v ‰š• }((}Œu o •}o] •]v šZ ‰ Œ•‰ š]À
K	•]Pv À Œ]}µ• l]v • }(Æ] o o} u u Œ• µv Œ
K ï	o µo š šZ o} •]v u•U (}Œ • v u}u vš• ••}] š Á]šZ]((Œ vš •
K ð	/ooµ•šŒ š šZ šZ }ŒÇU ‰Œ]v]‰o • ••}] š š} v]vP }(u v šÁ]•š ‰Œ]v]‰o • }( ]r Æ] o •š š }(•šŒ •• •]v À Œ]}µ• ‰Œ} o u• šZŒ}µPZ
K ñ	Æ‰o]v ‰Œ}‰ Œš] • ••}] š Á]šZ]Œ Œ (š u š Œ] o•X

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

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K î	ï	ï	î	í	í					
K ï	ï	ï	î	í	í					
K ð	ï	ï	î	í	í					
K ñ	ï									

•• ••u vš W šš Œv

o}}u[• š P}ŒÇ	}vš]vµ}µ• •• ••u vš d •š•		v ^ u •š Œ Æ u]v š]}v
	í	î	
Z u u Œ	íì	íì	îì
hv Œ•š v	íì	íì	îì
‰	ïì	ïì	ò
v oÇ•			
À oµ š			
Œ š			

D Œl]•šŒ] µš]}v

d}š o D Œl•	/	^	^ µŒ š]}v
íñì	ñì	íìì	ï Z}µŒ•

}vš]vµ}µ• /vš Œv o À oµ š]}v W šš ŒvW

šš v v W íì u Œl•
}vš]vµ}µ• •• ••u vš d •š ~î vµu Œ•• W îñ u Œl•
••]Pvu všlYµ]Ìl }µŒ• ‰Œ}i š W íñ u Œl•

v ^ u •š Œ Æ u]v š]}v ÁŒ]šš v Á]šZ }v W Œš•V W Œš v W Œš X
Á]šZ î ‹µ •š]}v• (Œ}u Z u} µo U Z À]vP ï u Œl• (}Œ Z ‹µ •š]
W Œš }vš]v• î ‹µ •š]}v• ((Œ}u Z Z] •šµ vš •Z}µo v•Á Œ vÇ }
Z À u Æ]uµu }(íì •µ]À]•]}v• v Œ

}µŒ• > À o •• ••u v

}µŒ• Kµš }u í ~ Kí•

íX Æ‰o]v o]v Œ •Z Œ •šŒ]

îX tZ š Œ   o •š] }v

ïX Œ •• Œ }(o vPšZ îXîñ u Á]šZ •‹µ Œ Œ}•• • š]}v }(
š v•]o (}Œ }(íñìì lE A ííì 'W bvA ìXïðX š Œu]v šZ]v Œ •

}µŒ• Kµš }u î ~ Kî•

íX Æ‰o]v •š •š] oÇ]v š Œu]

îX tŒ]š ‰Œ]v]‰o }

ïX Œ]À šZ Æ‰Œ ••]}v (}Œ Z vP]v rÁ]PZšX

}µŒ• Kµš }u ï ~ Kï•

íX tŒ]š]((Œ vš šÇ‰

îX Æ‰o]v W}]vš }(

ïX š Œu]v šZ •Z vŒ v]vP u}D š šZ u] ‰}]vš •]u‰o •Z}Áv]v
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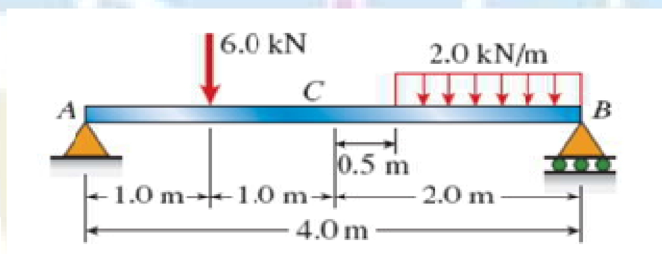

}µŒ• Kµš }u ð ~ Kð•

íX tŒ]š šZ ••µu‰š]}v• }(šZ

îX Œ Á šZ D}ZŒ[•]Œ

ïX Œ]À šZ Œ o š]}v o •Z Œ •š

}µŒ• Kµš }u ñ ~ Kñ•

íX Æ‰o]v]((Œ }u‰ }X

îX tŒ]š šZ Z Œ š Œ• }

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D} o Yµ •š]}v W ‰ Œ

YW K W   Z P E}Wrrrrrrrrrr

W: h> < > D d ,EK>K'/ > hE/s ^d Z Xd , 'Z   y D

DKEd, ˜ z Z

}µŒ• } W Kd îìí

D , E/ ^ D d Z/ >^ E /Z Z &d D d Z/

D ÆXD Œl•Wíìì   µŒ š]}vW

W Zd

v•Á Œ oo Yµ •š]}v•X   Z ‹µ •

íX (]v (š}Œ }(Œl]vP •šŒ •• v oo}Á o   X

îX Æ‰o]v Z}u}P v}µ• ˜]•}šŒ}‰] ‰Œ

ïXtZ š]• šZ ‰Œ}   µŒ š} (]v]v }u‰}•]š

ðX Æ‰o]v •š š] ooÇ]v š Œu]v š

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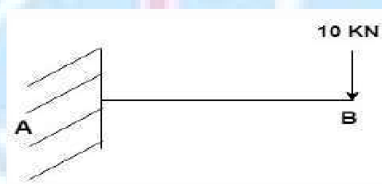
òXtZ š Á]oo   šZ À Œ] š]}v]v D (}Œ š



óXtŒ]š šZ ••µu‰š]}v• }(šZ }(

ôX Œ Á šZ D}ZŒ[•]Œ o (}Œ ‰µ(

õXtŒ]š šZ o ••]([š]}v }(

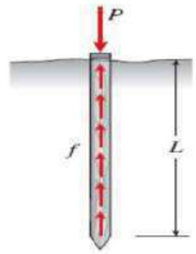
íìXtŒ]š šZ ‰ŒZ]PZ š u‰ Œ šµ

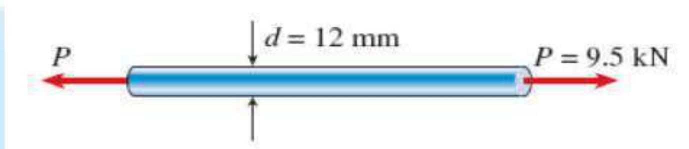
W Zd

v•Á Œ vÇ }v (µoo ‹µ •š]}v (Œ}u   Z u} µ D Œl•

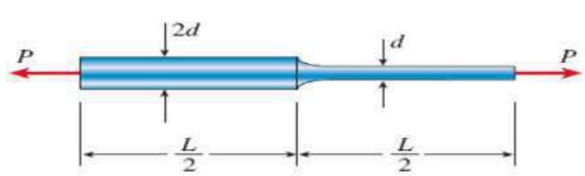
D} µo í

ííX~ •   Á}} ‰]o U Œ]À v]vš} šZWvš]Œ oÇ Ç (Œ]
•] • ~•   (]PµŒ •X dZ ‰ Œ µv]š o vPšZ }(‰]o
µv](}ŒuoÇ]•šŒ] µš   }À Œ šZ •µŒ(}(>U Œ}••r
• š]}v o UŒ v u} µoµ• }(X
  ]X Œ]À   (}Œuµo (}Œ }(šZ ‰]o]v šUŒu•X }(
    ~ð•
  ]]X Œ Á   ] PŒ u •Z}Á]vP Z}Á•šŒ •• À ZŒ]}µPZ
    o vPšZ }(~ð•


P
f
L

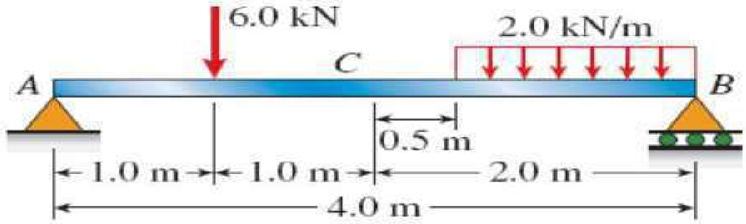

d = 12 mm
P
P = 9.5 kN


45°
A
B

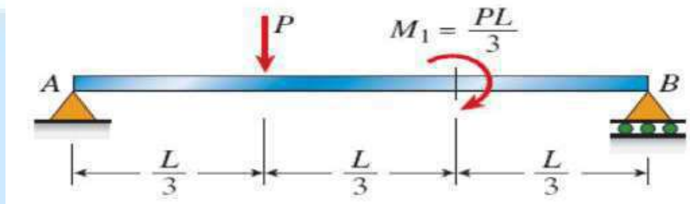

2d
d
P
P
L/2
L/2

D} µo ï

íñX š Œu]v šZ •¿s v v]vP u}D vš šZ u] %}[]vš • u •Z}Áv]v šZ (]PµŒ X



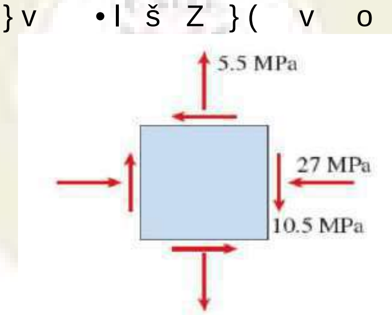
íòX • dZ •]u‰o •Z}Áv]v šZ (]PµŒ]• •µ i š šW v o} lÁ]• D AWl šZ š]vP š šZ šZ]Œ ‰}]r(}Œ v v]vP}u vš] PŒ u• (}Œ šZ]• uX ~íì•



~ • Œ]À šZ Œ o š]}v•Z]‰ šÁ v •Z Œ (~ð•

D} µo ð

íóX v o u vš ‰o vv (Œ}u šZ (µ• o P }(v]Œ‰ }u‰Œ ••]À •šŒ •• • }(u]v šZ Z}Œ]Ì}vš o]Œ •šŒ •• • }(u Pv]šµ ñXñ DW]v šZ À Œš] o •šŒ •• • }(u Pv]šµ íìXñ DW š]v šZ]Œ š]} š]vP }v v o u vš }Œ] vš }(ïñ£ (Œ}u šZ Z}Œ šZ • •šŒ ••• • }v • l š Z }(v o u v ~íð•



íôX •š o Œ }Œ µo Œ Œ}•• • š> îX ñ u]• •µ i š š v•]o (}Œ î ð lv v]vP u}u vš X ñ lE u ~• /X • µ‰}v v o o}Á o •šŒ ••] š Œu]v Œ ‹µ]Œ }(šZ ŒV]•Œ]P Z}Œ š }(šZ //X Z ‰ •š] v/ oµ]vP šZ Á] ~íð•

D} µo ñ

íõX • Æ‰o]v šZ ‰‰o] š]}v }(š]š v]µu v š]š v]µu oo}Ç•]

~ • • Œ] šZ Z]PZ š u‰ Œ šµŒ u š Œ] o Z Œ š Œ]Ì š]}v

îìXtZ š Œ }u‰}•]š u š Œ] o•M Æ‰o]v]((Œ vš šÇ‰ • }(}

v š •l š Z •X

^Çoo µ•

D} µo í

^šŒ •• t E}Œu oU •Z Œ v v]vP •šŒ •• •U ^šŒ •• • }v]v o]v ‰o v U (
•Z Œ •šŒ]v•U W}]••}v[• Œ š]}X ^šŒ •• t •šŒ]v] PŒ u• (}Œ u]o •š o]v š
•}(š Œµ ŒU Œ]ššo u š Œ] o v }‰‰ Œ]v }u‰Œ ••]}vX ,}}l[• o Á (}Œ o
µv Œ Æ] o v •Z Œ (}Œu š]}vU µol u} µoµ•U] Æ] o v šŒ] Æ] o (}Œu
u š Œ] o }v•š vš ~ Œ]À š]}v••U (]v]š]}v }(•šŒ •• v •šŒ]v š ‰}]vš ~]v
š v•}Œ• v]š• }u‰}v vš• }voÇ•U & š}Œ }(• (šÇU u ŒP]v }(• (šÇU •]Pv (

D} µo î

(}Œu š]}v]v Æ] ooÇ o} Œ• ~ Œ•]v • Œ] •U ‰ Œ oo oU]vš Œu] š
o} • v]u v•]}v••U ‰Œ]v]‰o }(•µ‰ Œ‰}•]š]}vU •š š] ooÇ]v š Œu]v š
Æ] ooÇ o} Œ• ~]v oµ]vP }u‰}µv v }u‰}•]š Œ••U (}Œu š]}v }(
µv Œ]š• • o(rÁ]PZšX ^šŒ]v v ŒPÇU Œ •]o] v v š}µPZv •• t (}Œ ‰µŒ
Œ µv Œ • o(rÁ]PZšX

D} µo ï

dÇ‰ • }(>} •U šÇ‰ • }(^µ‰‰}ŒšU šÇ‰ • }(u•U v]vP }µ‰o v šÁ]
š Œu]v š]}v }(•µ‰‰}Œš Œ š]}vU ^Z Œ (}Œ v v]vP u}u vš•U Z o š]}v
(}Œ r v]vP u}u vš•~ Œ]À š]}v (}Œ oo šZ • •• v]vP u}u vš v •Z Œ (
~ vš]o À Œ v •]u‰oÇ •µ‰‰}Œš • •µ i š š} }v všŒ š o} U µv](}ŒuoÇ
À ŒÇ]vP o} •U }µ‰o • v šZ Œ }u]v š]}v•U W}]vš }(}všŒ (o ÆµŒ U ‰}
v]vP ‰}]vš v u Æ]uµu •Z Œ (}Œ X

D} µo ð

&o ÆµŒ o •šŒ •• • t dZ }ŒÇ }(•]u‰o v]vPU ••µu‰š]}v•U Œ]À š]}v }(‹
š Œu]v š]}v }(v]vP •šŒ •• • ~Œ š vPµo ŒU •‹µ Œ U š Œ] vPµo ŒU •}o]]
}voÇ•X d}Œ•]}v r Œ]À š]}v }(‹µ š]}v }(š}Œ•]}vU ••µu‰š]}v•U ‰‰o] š]}v
v Z}oo}Á]Œ µo Œ •Z (šU š}Œ•]}v o Œ]P]]šÇU }u‰}µv •šŒ •• • r }u]v
vš Œ] o}]vP µv Œ š v•]}vl }u‰Œ ••]}v r }u]v v]vP v šÁ]•š]vP o} •
‰Œ]v]‰ o ‰o v • v •šŒ •• • ~Á]šZ}µš Œ]À š]}v••U ‹µ š]}v• }(šŒ v•(}Œu
•šŒ •• •

D} µo ñ

' v Œ o Œ ‹µ]Œ u vš• }(u š Œ] o• (}Œ Œ}•‰ ‰‰o] š]}v•U ^šŒµ šµŒ o D
]Œ Œ (š u š o• v oo}Ç•U oµu]v]µu v oµu]v]µu oo}Ç•U d]š v]µu v d]š v
}‰‰ Œ oo}Ç•U D Pv •]µu v D Pv •]µu oo}Ç•U }u‰}•]š u š Œ] o• t /všŒ}
D šŒ]Æ u š Œ] oX ^µ‰ Œ oo}Ç• t Z]PZ š u‰ Œ šµŒ u š Œ] o Z Œ š Œ]Ì š]

d Æš }}l•

íX : u • ' Œ ~ ŒŒÇ '}} v}U ^D ZvZ}]u•}}v(r D P] vŒ[Œ}o]ššP]µvU îììôX

îX d]šš Œš}vX'X ^]Œ Œ (š D š Œ] o• v WŒ} •• •—U ñšZ]š]}vU W]šu v Wµ

Z (Œ v }}l•

íX Z šš vU ^šŒ vPšZ }(D š Œ] o•U î D 'Œ Á ,]oo µ š]}v /v] U îììí

îX ZX X ,] o ŒU D Z v] • }(D š Œ] o•U W Œ•}v µ š]}vU îììô

ïX &}Œ u v XU À v }u‰}•]š •U À}š l /v(}Œu š]}v Z •}µŒ •U îìíò

}µŒ• }vš vš• v > šµŒ ^ Z µo

E}	d}‰]	E}X }(> šµŒ •
í	D} µo í	d}š oW ô
íXí	^šŒ •• t E}Œu oU •Z Œ v v]vP •šŒ •• •U ^šŒ í •• • }v]v o]v ‰ (]v]š]}v• }(o]v Œ v}Œu o v •Z Œ •šŒ]v•U W}]••}v[• Œ š]} r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	
íXî	•šŒ •• t •šŒ]v] PŒ u• (}Œ u]o •š o]v š v•]}vU î oµu]v]µu oo}ÇU Z •}(š Œµ ŒU Œ]ššo u š Œ] o v }‰‰ Œ]v }u‰Œ ••]}v	
íXï	,}}l [• o Á (}Œ o]v ŒoÇ o •š]]•}šŒ}‰] u š Œ] o µv Œ Æ] o v (}Œu š]}vU µol u} µoµ•U] Æ] o v šŒ] Æ] o (}Œu š]}v• r]ooµ•š vµu Œ] o Æ Œ]•	
íXð	,}}l [• o Á (}Œ o]v ŒoÇ o •š]]•}šŒ}‰] u š Œ] o µv Œ Æ] o v (}Œu š]}vU µol u} µoµ•U] Æ] o v šŒ] Æ] o (}Œu š]}v• r Æš v ‰Œ} o u •}oÀ]vP	
íXñ	Z o š]}v•Z]‰ šÁ v u š Œ] o }v•š vš ~ Œ]À š]}v••Ú (]v]š]}v }(•šŒ • •šŒ]v š ‰}]vš ~]všŒ} µ š]}v š} •šŒ •• v •šŒ]v š v•}Œ• v]š• }u }voÇ•U & š}Œ }(• (šÇU u ŒP]v }(• (šÇ r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	
íXò	•]Pv (}Œ Æ] o o} • v]Œ š •Z Œ r]ooµ•šŒ š]Àî vµu Œ] o Æ Œ]•	
î	D} µo î	d}š oW õ
îXí	(}Œu š]}v]v Æ] ooÇ o} Œ• ~ Œ•]v • Œ] •U ‰ Œ oo oU]vš Œu o} •U }vš]vµ}µ•oÇ À ŒÇ]vP o} • v]u v•]}v••U r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	
îXî	(}Œu š]}v]v Æ] ooÇ o} Œ• ~ Œ•]v • Œ] •U ‰ Œ oo oU]vš Œu o} •U }vš]vµ}µ•oÇ À ŒÇ]vP o} • v]u v•]}v••U r Æš v ‰Œ} o u •}oÀ]vP	
îXï	‰Œ]v]‰o }(•µ‰ Œ‰}•]š]}vU •š š] ooÇ]v š Œu]v š •šŒµ šµŒ r vµu Œ] o Æ Œ]•	
îXð	šZ Œu o ((š•]v Æ] ooÇ o} Œ• ~]v oµ]vP }u‰}µv v }u‰}•] Œ•• r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	
îXñ	šZ Œu o ((š•]v Æ] ooÇ o} Œ• ~]v oµ]vP }u‰}µv v }u‰}•] Œ•• r Æš v ‰Œ} o u •}oÀ]vP	
îXò	(}Œu š]}v }(‰Œ]•u š v }v] o Œ µv Œ]š• •o(rÁ]PZš r]ooµ•š vµu Œ] o Æ Œ]•	
îXó	^šŒ]v v ŒPÇU Œ •]o] v v š}µPZv •• t (}Œ ‰µŒí Æ] o o}]vPU ‰ }v] o Œ µv Œ • o(rÁ]PZš r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	
ï	D} µo ï	d}š oW íì
ïXí	dÇ‰ • }(>} •U šÇ‰ • }(^µ‰‰}ŒšU dÇ‰ • }(µ•Uí v]vP }µ‰o v }µ‰o ~ }v ‰š KvoÇ•U š Œu]v š]}v }(•µ‰‰}Œš Œ š]}vX	
ïXî	^Z Œ (}Œ v v]vP u}u vš•U Z o š]}v•Z]‰• šÁ í v o} •r•Z Œ (}Œ v]vP u}u vš• ~ Œ]À š]}v (}Œ oo šZ •X	
ïXï	v]vP u}u vš v •Z Œ (}Œ] PŒ u• }(u• ~ vîš]o À Œ v •]u‰oÇ •µ‰‰}Œš • r }v všŒ š o} r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	
ïXð	v]vP u}u vš v •Z Œ (}Œ] PŒ u• }(u• ~ vîš]o À Œ v •]u‰oÇ •µ‰‰}Œš • r µv](}ŒuoÇ]•šŒ] µš o} •U µv](}ŒuoÇ À ŒÇ]vP o} • r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	
ïXñ	v]vP u}u vš v •Z Œ (}Œ] PŒ u• }(u• ~ vîš]o À Œ v •]u‰oÇ •µ‰‰}Œš • r µv](}ŒuoÇ]•šŒ] µš o} •U µv](}ŒuoÇ À ŒÇ]vP o} • r ‰Œ} o u •}oÀ]vP	
ïXò	v]vP u}u vš v •Z Œ (}Œ] PŒ u• }(u• ~ vîš]o À Œ v •]u‰oÇ •µ‰‰}Œš • r }µ‰o • v šZ Œ }u]v š]}v• r]ooµ•šŒ š]À vµu Œ] o Æ	

ïXó	v]vP u}u vš v •Z Œ (}Œ] PŒ u• }(u• ~ vš]o À Œ v •]u‰oÇ •µ‰‰}Œš • r }µ‰o • v šZ Œ }u]v š]}v• r Æš v ‰Œ} o u •}oÀ]vP	ís]o À Œ v •]u‰oÇ Æš v ‰Œ} o u •}oÀ]vP
ïXô	W}]vš }(}všŒ (o ÆµŒ U ‰}]vš v u Pv]šµ u Æ]uµu •Z Œ (}Œ X	}(u Æ]uµu v]vP ‰}]vš í
ð	D} µo ð	d}š oW íì
ðXí	&o ÆµŒ o •šŒ •• • t dZ }ŒÇ }(•]u‰o v]vPU ‹µ š]}v }(v]vPU v µšŒ o Æ]•	í •µu‰š]}v•U Œ]À š
ðXî	š Œu]v š]}v }(v]vP •šŒ ••• ~Œ š vPµo ŒU ‰]Œ µo Œ v Z}oo}Á]Œ µo Œ • š]}v• }voÇ• r]ooµ•šŒ š]À vµu Œ] o	•‹µ Œ U šŒ] vPµo Œ ‰}]vš vµu Œ] o
ðXï	d}Œ•]}v r Œ]À š]}v }(‹µ š]}v }(š}Œ•]}vU ••µu‰š]}v•	í
ðXð	‰‰o] š]}v }(š}Œ•]}v o ‹µ š]}v š} •}o] v Z}oo}Á]Œ µo Œ •Z (šU šŒ]P]šÇ r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	í š
ðXñ	}u‰}µv •šŒ •• • r }u]v Æ] oU (o ÆµŒ o v •Z Œ o} • t vš o}]vP µv Œ š v•]}vl }u‰Œ ••]}v r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	vš
ðXò	}u]v v]vP v šÁ]•š]vP o} •	í
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CODE	COURSE NAME	CATEGOR	L	T	P	CREDIT
MET203	MECHANICS OF FLUIDS	PCC	3	1	-	4

Preamble:

This course provides an introduction to the properties and behaviour of fluids. It enables to apply the concepts in engineering, pipe networks. It introduces the concepts of boundary layers, dimensional analysis and model testing

Prerequisite: NIL

Course Outcomes

After completion of the course the student will be able to

CO1	Define Properties of Fluids and Solve hydrostatic problems
CO2	Explain fluid kinematics and Classify fluid flows
CO3	Interpret Euler and Navier-Stokes equations and Solve problems using Bernoulli's equation
CO4	Evaluate energy loses in pipes and sketch energy gradient lines
CO5	Explain the concept of boundary layer and its applications
CO6	Use dimensional Analysis for model studies

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										
CO2	3	2	1									
CO3	3	2	1									
CO4	3	3	2									
CO5	3	2	1									
CO6	3	2	1									

Assessment Pattern

Blooms Category	CA			ESA
	Assignment	Test- 1	Test- 2	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

Mark distribution & Duration of Examination :

Total Marks	CA	ESE	ESE Duration
150	50	100	3 Hours

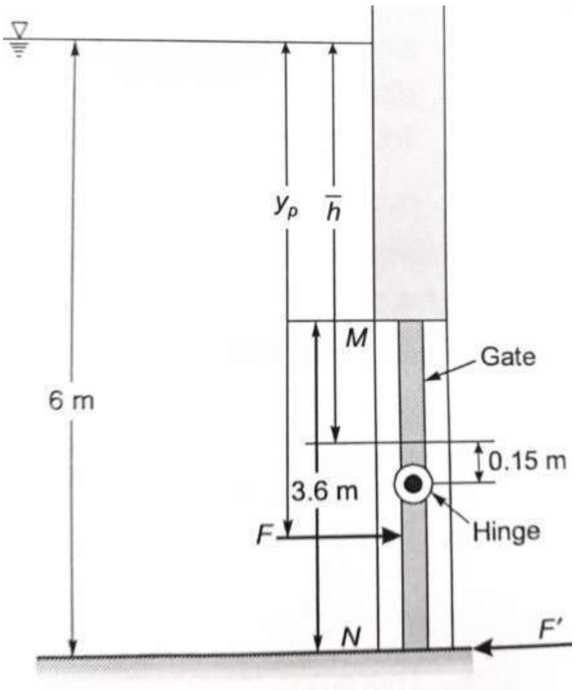
End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1

1. A 3.6 1.5 m wide rectangular gate MN is vertical and is hinged at point 0.15 m below the center of gravity of the gate. The total depth of water is 6 m. What horizontal force must be applied at the bottom of the gate to keep the gate closed.



2. A stationary liquid is strati ed so that its density is $_0(1 + h)$ at a depth h below the free surface. At a depth h in this liquid, what is the pressure in excess of $_0gh$?

3. If the velocity pro le of a uid is parabolic with free stream velocity 120 cm/s occurring at 20 cm from the plate, calculate the velocity gradients and shear stress at a distance of 0, 10, 20 cm from the plate. Take the viscosity of uid as 8.5 poise.

Course Outcome 2

1. Di erentiate between the Eulerian and Lagrangian method of representing uid motion.

2. A velocity eld is given by $u = 3y^2$, $v = 2x$ and $w = 0$ in arbitrary units. Is this ow steady or unsteady? Is it two or three dimensional? At (x,y,z)=(2,1,0), compute

   (a) velocity

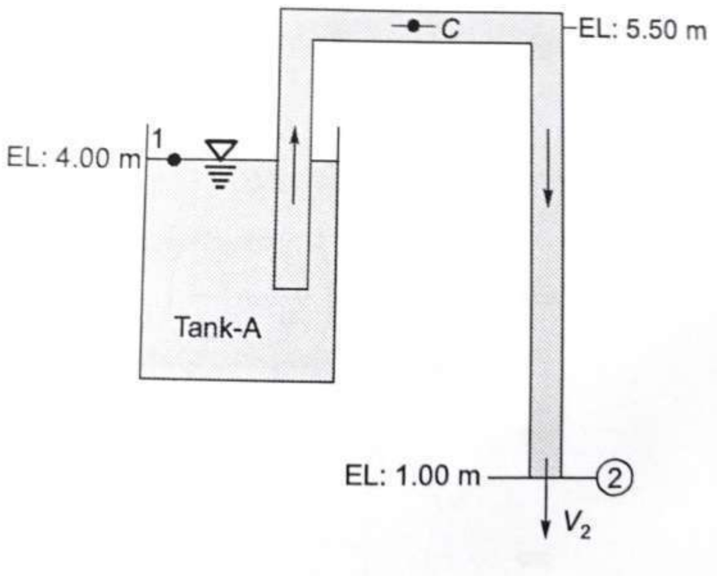
   (b) local acceleration

   (c) convective acceleration

3. A stream function in two dimensional ow is $= 2xy$. Show that the ow is irrotational and determine the corresponding velocity potential.

Course Outcome 3

1. A siphon consisting of a pipe of 15 cm diameter is used to empty kerosene oil (relative density=0.8) from tank A. The siphon discharges to the atmosphere at an elevation of 1.00 m. The oil surface in the tank is at an elevation of 4.00 m. The center line of the siphon pipe at its highest point C is at an elevation of 5.50 m. Estimate,



   (a) Discharge in the pipe
   (b) Pressure at point C.

   The losses in the pipe can be assumed to be 0.5 m up to the summit and 1.2 m from summit to the outlet.

2. Derive the Euler's equation of motion along a streamline and from that derive the Bernouli's equation.

3. What is water hammer? Explain di erent cases of water hammer. Derive the expression for pressure rise in any one of the case.

Course Outcome 4

1. Two reservoir with a di erence in water surface elevation of 10 m are connected by a pipeline AB and BC joined in series. Pipe AB is 10 cm in diameter, 20 m long and has a value of friction factor f = 0:02. Pipe BC is 16 cm diameter, 25 m long and has a friction factor f=0.018. The junctions with reservoirs and between pipes are abrupt.
   (a) Sketch Total energy line and Hydraulic gradient line
   (b) Calculate the discharge.

2. Oil of viscosity 0.1 Pas and speci c gravity 0.9 ows through a horizontal pipe of 25 mm diameter. If the pressure drop per meter length of the pipe is 12 KPa, determine
   (a) Discharge through the pipe
   (b) Shear stress at the pipe wall
   (c) Reynolds number of the ow

(d) Power required in Watts if the length of the pipe is 50m

3. In a hydraulic power plant, a reinforced concrete pipe of diameter D is used to transmit water from the reservoir to the turbine. If H is the total head supply at the entrance of the pipe and h_f is the loss of head in the pipe, then derive the condition for maximum power supply through the pipe.

Course Outcome 5

1. Write a short note on boundary layer separation and discuss any two methods to control the same.

2. Find the displacement thickness, momentum thickness and energy thickness for velocity distribution in boundary layer given by

$$\frac{u}{U_1} = 2 \; \underline{y} \qquad \underline{y}^{\;2}$$

3. A thin plate is moving in still atmospheric air at a velocity of 4m=s. The length of the plate is 0.5 m and width 0.4 m. Calculate the

   (a) thickness of the boundary layer at the end of the plate and

   (b) drag force on one side of the plate.

   Take density of air as 1.25 $kg{=}m^3$ and kinematic viscosity 0.15 stokes.

Course Outcome 6

1. State and explain Buckingham's pi theorem.

2. An underwater device is 1.5m long and is to move at 3.5 m/s speed. A geometrically similar model 30 cm long is tested in a variable pressure wind tunnel at a speed of 35 m/s. Calculate the pressure of air in the model if the model experience a drag force of 40 N, calculate the prototype drag force. [Assume density of water = 998 $kg{=}m^3$, density of air at standard atmospheric pressure = 1.17 $kg{=}m^3$, dynamic viscosity of air at local atmospheric pressure = $1{:}95 \; 10^5$ Pas and dynamic viscosity of water = $1 \; 10^3$ Pas]

3. Explain the importance of dimensionless numbers and discuss any two similarity laws. Where are these model laws used?

SYLLABUS

Module 1: Introduction: Fluids and continuum, Physical properties of fluids, density, specific weight, vapour pressure, Newton's law of viscosity. Ideal and real fluids, Newtonian and Non-Newtonian fluids. Fluid Statics - Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies, fluid masses subjected to uniform accelerations, measurement of pressure.

Module 2: Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow, 1-D, 2-D and 3-D flow, steady, unsteady, uniform, non-uniform, laminar, turbulent, rotational, irrotational flows, stream lines, path lines, streak lines, stream tubes, velocity and acceleration in fluid, circulation and vorticity, stream function and potential function, Laplace equation, equipotential lines, flow nets, uses and limitations.

Module 3: Control volume analysis of mass, momentum and energy, Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation), Navier-Stokes equations (without proof) in cartesian co-ordinates. Dynamics of Fluid flow: Bernoulli's equation, Energies in flowing fluid, head, pressure, dynamic, static and total head, Venturi and Orifice meters, Notches and Weirs (description only for notches and weirs). Hydraulic coefficients, Velocity measurement Pitot tube and Pitot-static tube.

Module 4: Pipe Flow: Viscous flow: Reynolds experiment to classify laminar and turbulent flows, significance of Reynolds number, critical Reynolds number, shear stress and velocity distribution in a pipe, law of fluid friction, head loss due to friction, Hagen Poiseuille equation. Turbulent flow: Darcy-Weisbach equation, Chezy's equation Moody's chart, Major and minor energy losses, hydraulic gradient and total energy line, flow through long pipes, pipes in series, pipes in parallel, equivalent pipe, siphon, transmission of power through pipes, efficiency of transmission, Water hammer, Cavitation.

Module 5: Boundary Layer : Growth of boundary layer over a flat plate and definition of boundary layer thickness, displacement thickness, momentum thickness and energy thickness, laminar and turbulent boundary layers, laminar sub layer, velocity profile, Von-Karman momentum integral equations for the boundary layers, calculation of drag, separation of boundary and methods of control. Dimensional Analysis: Dimensional analysis, Buckingham's theorem, important non dimensional numbers and their significance, geometric, Kinematic and dynamic similarity, model studies. Froude, Reynolds, Weber, Cauchy and Mach laws- Applications and limitations of model testing, simple problems only

Text Books

John. M. Cimbala and Yunus A. Cengel, Fluid Mechanics: Fundamentals and Applications (4th edition, SIE), 2019

Robert W. Fox, Alan T. McDonald, Philip J. Pritchard and John W. Mitchell, Fluid Mechanics, Wiley India, 2018

Reference Books

White, F. M., Fluid Mechanics, McGraw Hill Education India Private Limited, 8th Edition, 2017

Rathakrishnan, E. Fluid Mechanics: An Introduction, Prentice Hall India, 3rd Edition 2012

COURSE PLAN

Module	Topics	Hours Allotted
I	Introduction: Fluids and continuum, Physical properties of fluids, density, specific weight, vapour pressure, Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids. Fluid Statics - Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies, fluid masses subjected to uniform accelerations, measurement of pressure.	7-2-0
II	Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow, 1-D, 2-D and 3-D flow, steady, unsteady, uniform, non-uniform, laminar, turbulent, rotational, irrotational flows, stream lines, path lines, streak lines, stream tubes, velocity and acceleration in fluid, circulation and vorticity, stream function and potential function, Laplace equation, equipotential lines, flow nets, uses and limitations.	6-2-0
III	Control volume analysis of mass, momentum and energy, Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation), Navier-Stokes equations (without proof) in cartesian co-ordinates Dynamics of Fluid flow: Bernoulli's equation, Energies in flowing fluid, head, pressure, dynamic, static and total head, Venturi and Orifice meters, Notches and Weirs (description only for notches and weirs). Hydraulic coefficients, Velocity measurements: Pitot tube and Pitot-static tube.	6-2-0
IV	Pipe Flow: Viscous flow: Reynolds experiment to classify laminar and turbulent flows, significance of Reynolds number, critical Reynolds number, shear stress and velocity distribution in a pipe, law of fluid friction, head	9-3-0

	loss due to friction, Hagen Poiseuille equation. Turbulent flow: Darcy Weisbach equation, Chezy's equation Moody's chart, Major and minor energy losses, hydraulic gradient and total energy line, flow through long pipes, pipes in series, pipes in parallel, equivalent pipe, siphon, transmission of power through pipes, efficiency of transmission, Water hammer, Cavitation.	
V	Boundary Layer : Growth of boundary layer over a flat plate and definition of boundary layer thickness, displacement thickness, momentum thickness and energy thickness, laminar and turbulent boundary layers, laminar sub layer, velocity profile, Von-Karman momentum integral equations for the boundary layers, calculation of drag, separation of boundary and methods of control. Dimensional Analysis: Dimensional analysis, Buckingham's theorem, important non dimensional numbers and their significance, geometric, Kinematic and dynamic similarity, model studies. Froude, Reynolds, Weber, Cauchy and Mach laws- Applications and limitations of model testing, simple problems only	8-2-0

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

IV SEMESTER B.TECH DEGREE EXAMINATION

MET203: MECHANICS OF FLUIDS

Mechanical Engineering

Maximum: 100 Marks Duration: 3 hours

PART A

Answer all questions, each question carries 3 marks

1. The speci c gravity of a liquid is 3.0. What are its speci c weight, speci c mass and speci c volume.
2. State Pascal's law and give some examples where this principle is used.
3. Explain Streamlines, Streaklines and Pathlines.
4. What do you understand by the terms: (i) Total acceleration, (ii) Convective acceleration, and (iii) Local acceleration.
5. Name the di erent forces present in a uid ow. For the Euler's equation of motion, which forces are taken into consideration.
6. Di erentiate between pitot tube and pitot static tube.
7. De ne and explain the terms (i) Hydraulic gradiant line and (ii) Total energy line.
8. Show that the coe cient of friction for viscous ow through a circular pipe is given by

$$f = \frac{16}{Re}$$

where Re is the Reynolds number.

9. What do you mean by repeating variables? How repeating variables are selected for dimensional analysis.
10. How will you determine whether a boundary layer ow is attached ow, detached ow or on the verge of separation.

(10 3=30 Marks)

PART B

Answer one full question from each module

MODULE-I

11. (a) Through a very narrow gap of height h, a thin plate of large extend is pulled at a velocity V. On one side of the plate is oil of viscosity $_1$ and on the other side oil of viscosity $_2$. Calculate the position of the plate so that

    i. the shear force on the two sides of the plate is equal.

    ii. the pull required to drag the plate is minimum.

    Assume linear velocity distribution in transverse direction. (7 Marks)

    (b) A metallic cube of 30 cm side and weight 500 N is lowered into a tank containing two uid layers of water and mercury. Top edge of the cube is at water surface. Determine the position of the block at water mercury interface when it has reached equilibrium. (7 Marks)

12. (a) A rectangular tank 1.5 m wide, 3 m long and 1.8 m deep contains water to a depth of 1.2 m. Find the horizontal acceleration which may be imparted to the tank in the direction of length so that

    i. there is just no spilling from the tank

    ii. front bottom corner of the tank is just exposed.

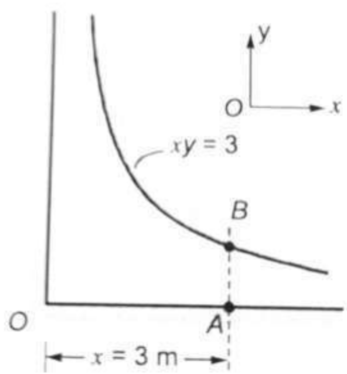
    (7 Marks)

    (b) A spherical water drop of 1 mm diameter splits up in air into 64 smaller drops of equal size. Find the work required in splitting up the drop. The surface tension coe cient of water in air = 0.073 N=m (7 Marks)

MODULE-II

13. (a) In a uid ow eld, velocity vector is given by $v = (0{:}5 + 8x)i + (0{:}5 \quad 0{:}8y)j$. Find the equation of streamline for the given velocity eld. (7 Marks)

    (b) The stream function = $4xy$ in which is in cm^2=s and x and y are in meters describe the incompressible ow between the boundary shown below:



Calculate

i. Velocity at B

ii. Convective acceleration at B

iii. Flow per unit width across AB

(7 Marks)

14. (a) Consider the velocity eld given by $u = x^2$ and $v = 2xy$. Find the circulation around the area bounded by $A(1;1); B(2;1); C(2;2); D(1;2)$. (7 Marks)

(b) Verify whether the following are valid potential functions.

i. $= 2x + 5y$

ii. $= 4x^2 \quad 5y^2$

(7 Marks)

MODULE-III

15. (a) A submarine moves horizontally in sea and has its axis 15 m below the surface of the water. A pitot tube properly placed just in front of the submarine and along its axis is connected to two limbs of a U tube containing mercury. The di erence of level is found to be 170 mm. Find the speed of the submarine knowing that the speci c gravity of mercury is 13.6 and that of sea water is 1.026 with respect to water. (7 Marks)

(b) A pitot tube is inserted in a pipe of 30 cm diameter. The static pressure of the tube is 10 cm of mercury vacuum. The stagnation pressure at the centre of the pipe recorded by the pitot tube is $1.0 N{=}cm^2$. Calculate the rate of ow of water through the pipe, if the mean velocity of ow is 0.85 times central velocity. Assume coe cient of tube as 0.98. (7 Marks)

16. (a) A smooth pipe of uniform diameter 25 cm, a pressure of 50 KPa was observed at section 1 which has an elevation of 10 m. At another section 2, at an elevation of 12 m, the pressure was 20 KPa and the velocity was 1.25 m/s. Determine the direction of ow and the head loss between the two sections. The uid in the pipe is water. (8 Marks)

(b) Petrol of speci c gravity 0.8 is following through a pipe of 30 cm diameter. The pipe is inclined at 30 to horizontal. The venturi has a throat diameter of 10 cm. U tube manometer reads 6.25 cm Hg. Calculate the discharge through the pipe. Assume $C_d = 0{:}98$. (6 Marks)

MODULE-IV

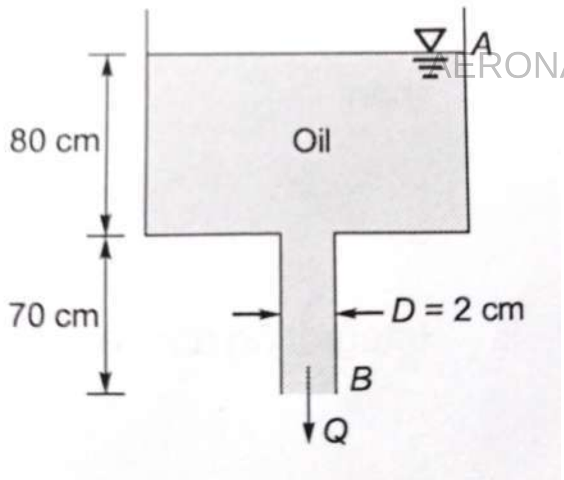
17. (a) Assuming viscous ow through a circular pipe derive the expression for,

i. Velocity distribution

ii. Shear stress distribution

Also plot the velocity and shear stress distribution. (7 Marks)

(b) A large tank shown in the gure has a vertical pipe 70 cm long and 2 cm in diameter. The tank contain oil of density $920 Kg{=}m^3$ and viscosity 1.5 poise. Find the discharge through the tube when the height of oil level of the tank is 0.80 m above the pipe inlet.



(7 Marks)

18. (a) A compound piping system consist of 1800 m of 50 cm, 1200 m of 40 cm and 600 m of 30 com diameter pipes o same material connected in series.
   i. What is the equivalent length of a 40 cm pipe of same material?
   ii. What is the equivalent diameter of a pipe 3600 m long?
   iii. If three pipes are in parallel what is equivalent length of 50 cm pipe?

(10 Marks)

(b) A pipe line of 2100 m is used for transmitting 103 KW. The pressure at the inlet of the pipe is $392.4 N=cm^2$. If the e ciency of transmission is 80%, nd the diameter of the pipe. Take $f = 0{:}005$. (4 Marks)

MODULE-V

19. (a) The velocity pro le u of a boundary layer ow over a at plate is given by

$$\frac{u}{U_1} = \frac{3}{2}\frac{y}{\ } \quad \frac{1}{2}\frac{y}{\ }^{3}$$

If the boundary thickness is given as

$$= \sqrt{\frac{280\,x}{13U_1}}$$

develop the expression for local drag coe cient C_{fx} over the distance $x = L$ from the leading edge of the plate. (7 Marks)

(b) A model test is to be conducted in a water tunnel using a 1:20 model of a submarine which is used to travel at a speed of 12 km=h deep under the sea. The water temperature in the tunnel is so maintained that its kinematic viscosity is half as that of the sea water. At what speed the model test is to be conducted. (7 Marks)

20. (a) With a neat sketch explain the di erent regions of the boundary layer along a long thin at plate. (7 Marks)

(b) Using Buckingham's pi theorem show that the velocity through a circular ori ce is given by

$$\sqrt{2gH} \quad \frac{D}{H}; \frac{\ }{VH}$$

where H is the head causing ow, D is the diameter of the ori ce, is the coe cient of viscosity, is the mass density and g is the acceleration due to gravity. (7 Marks)

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6WDWH WKH XVHV RI VWULQJHUV DQG ORQJHURQV

'HILQH WKH ZRUNLQJ SULQFLSOH RI *\URVFRSH

'LIIHUHQWLDWH EHWZHHQ 7$6 ($6 DQG ,$6

'HSLFW WKH FXUYH ZKLFK JLYHV WKH HIIHFW RI DOWLWXGH R

'LIIHUHQWLDWH EHWZHHQ 'LKHGUDO DQG DQKHGUDO

([SODLQ WKH UROH RI VLGHVOLS LQ ORQJLWXGLQDO VWDELOL

:KDW DUH WKH FKDUDFWHULVWLF PRGHV RI VWLFN IL[HG ORQ

í ì X ([SODLQ VQDNLQJ PRGH

3$57 %

$QVZHU RQH IXOO TXHVWLRQ IURP HDFK PRGXOH HDFK TX

0RGXOH

L 'HULYH DQ H[SUHVVLRQ RI YDULDWLRQ RI SUHVVXUH LQ WL Œ u Œ l•

LL :LWK QHDW VNHWFK EULHIO\ H[SODLQ DERXW DHU

DHURIRLO"

D} µo rî

íîX~]•LIIHUHQWLDWH EHWZHHQ PRQRFRTXH DQG VHPL PRQRFRTXH

LL :LWK WKH DLG RI QHDW VNHWFK H[SODLQ WKH ZRUNLQJ R

L ([SODLQ $XWRSLORW 6\VWHP ZLWK QHDW GLDJUDP PDUN

LL %ULHIO\ H[SODLQ DQ\ NLQGV RI IOLJKW YHKLFOHV ZLWK

D} µo rï

L)LQG RXW WKH WRWDO GUDJ RI DQ DLUSODQH IO\LQJ OH
WRWDO GUDJ FRHIILFLHQW LV $VVXPLQJ WKDW WKH ZLQJ DU
DQG ZHLJKW RI WKH DLUSODQH LV NJ PDUNV

LL ([SODLQ DQ\ IRXU PHWKRGV RI GUDJ UHGXFWLRQ LQ DLUS

L 'HULYH DQG H[SODLQ SRZHU DYDLODEOH DQG SRZHU UHTX

LL $Q DLUFUDIW ZHLJKLQJ .1 KDV D ZLQJ DUHD RI LIF
& &&DOFXODWH WKH PLQLPXP WKUXVW UHTXLUHG IRU
WKH FRUUHVSRQGLQJ WUXH DLUVSHHG DW VHD OHYHO DW .

D} µo rð

L 'HULYH WKH %UHJXHW¶V 5DQJH HTXDWLRQ

LL $Q DLUSODQH ZHLJKLQJ 1 KDV D ZLQJ SODQIRUP
WKH IRUP & &'XULQJ FUXLVH DW DQ DOWLWXGH RI NP LWV
LW LV IRUFHG WR GHFHQW GRZQ LQ D SRZHUOHVV JOLGH &D
PD[LPXP UDQJH RYHU WKH JURXQG

~]'HULYH WDNH RII SHUIRUPDQFH HTXDWLRQV ZLWK QHDW VNH

LL ([SODLQ 6WDWLF ORQJLWXGLQDO VWDELOLW\

D} µo rñ

$ ZLQJ ERG\ PRGHO LV WHVWHG LQ D VXEVRQLF ZLQG WXQQH
. DQG &FJ DUH DQG UHVSHFWLYHO\ 7KH WDLO ORFDWL
YROXPH UDWLR LV 7KHQ GHWHUPLQH WKH WDLO OLIW FXUYH VORSH
. DQG G FDQ EH DOWHUHG 7KH WDLO FDOFXODWH WKH QHXWUDO SRL
ORFDWLRQ DQG DOVR VWDWLF PDUJLQ

D ([SODLQ WKH IROORZLQJ 3KHQRPHQRQ

L 'XWFK 5ROO

LL 6SLUDO LQVWDELOLW\

LLL 6SLQ PDUNV

:ULWH EULHI VKRUW QRWHV RQ

6WDELOLW\ GHULYDWLYHV LQ ORQJLWXGLQDO G\QDP

LL 6WDELOLW\ TXDUWLF

Syllabus

Module 1

Module 2

Module 3

Module 4

Module 5

Text Books

- Perkins C D and Hage R E “Airplane Performance stab

  Son Inc NY

- -RKQ ' $QGHUVRQ -U ´$LUFUDIW 3HUIRUPDQFH DQG 'HVLJQ´
- 1HOVRQ 5 & ³)OLJKW 6WDELOLW\ DQG $XWRPDWLF &RQWURO

Z (Œ v }}l•

- (WNLQ % ³'\QDPLFV RI)OLJKW 6WDELOLW\ DQG &RQWURO´ (
- %DELVWHU $: ³$LUFUDIW '\QDPLF 6WDELOLW\ DQG 5HVSRQV
- 'RPPDVFK ' 2 6KHUE\ 6 6 DQG &RQQROO\ 7) ³$HURSODQ (GLWLRQ ,VDDF 3LWPDQ /RQGRQ
- 0F &RUQLFN % : ³$HURG\QDPLFV $HURQDXWLFV DQG)OLJKW

}µŒ• }vš vš• v > šµŒ ^ Z µo

E}	d}‰]	E}X }(> šµŒ •
í		D} µo ôí
íXí	WZÇ•] o ‰Œ}‰ Œš] • v •šŒµ šµŒ }(‰Œ ••µŒ v oš]šµ Œ o š]}v•Z]‰•	î
íXî	•] }v ‰š•W o](š ~ •] Œ]U Œ}(}] vµu ŒU u v} µÀŒ •X	í
íXï	o ••](] š]}v }(E Œ}(}]o•U •‰ š Œ ‰Œ ••µŒ v Œ} Çv u] všŒ r Œ}(}]o Z Œ š Œ]•š] •r o](µŒÀ •	î
íXð	WŒ]u ŒÇ v ^ }v ŒÇ (µv š] ^Z ‰ v]u v•]}v }(Œ} (}]oX	í
íXñ	•‰ š Œ š]} }(D v Œ} Çv u] Z}Œ v À] •X	í
î		D} µo î
îXí	' v Œ o šÇ (µ• o }v•šŒµ š]}vU dŒµ••U u}v} }‹µ	í
îXî	dÇ‰] o Á]vP •šŒµ šµŒ	í
îXï	]((Œ vš šÇ‰ • }((o]PZš À Z] o •U o ••](] š]}v•	î
îXð	t]vP v > v]vP P Œ }v(]PµŒ š]}v•	î
îXñ	•]]v•šŒµu vš~ oš]u š ŒUd Z}u š ŒU'(/v] š}ŒUW]š}šr^š š] ^Ç•Çš uUD Z D š Œ•	î
îXò	šÇ‰] o •Ç•š u• (}Œ ~]P]š o (oÇ Ç Á]Œ ‰]o}š •Ç•š u•	î
ï		D} µo ï
ïXí	D •µŒ u vš }(•‰ ~ D Z vµu Œ dŒµ U]Œ •‰ U ^šŒ uo]v v oµ((}] •	î
ïXî	s Œ]dÇ‰ • }(Œ P]v]Œ‰o D šZ} • }(	î

	Œ µ š]}v }(	
ïXï	^šŒ]PZš v o À o (o]PZšU šZŒµ•š Œ ‹µ]Œ	vî À]o o
ïXð	W}Á Œ Œ ‹µ]Œ v À]o o U ((š }(oš]šµ î}v šZŒµ•š v ‰}Á	
ð	D} µo ð	
ðXí	}v]š]}v• (}Œ u]v]uµu Œ P v u]v]uµu ‰}Á Œ Œ ‹µ]Œ	
ðXî	'o]]vP v o]u]vP (o]PZšU	î
ðXï	d l }((v o v]vP ‰ dµŒv]vP ‰ Œ(}Œu v À Œš] o šµŒv	î
ðXð	Wµoo µ‰ v ‰µoo }Ávl	í
ðXñ	srv] PŒ u	í
ðXò	PŒ • }((Œ }u }(•Ç•š uU •š š] \ o}vP]šµ]v o •š]o]šÇ	î
ñ	D} µo ñ	íì
ñXí	}všŒ] µš]}v }( ]v]À] µ o }u‰}v vš•	î
ñXî	v µšŒ o ‰}]všU •š š] u ŒP]vU ,]vP ((š]À v ••X]Œ Œ (š ‹µ š]}v• }(u}š]}vU •š]o]šÇ Œ]À š] •š]o]šÇ ‹µ Œš] U WZµP}] u}š]}v	ï
ñXï	]Z Œ o }všŒ] µš]}v }(À Œ]}µ• }u‰}v]o Œ}v }všŒ}o ‰}Á ŒU •šŒ]‰ šZ }ŒÇ	î
ñXð	]o Œ}v Œ À Œ• oU Á šZ Œ } l •š]o] Œ ‹µ]Œ u vš•U }Œ• o (]vU µš Z Œ}ooU •‰]Œ o v]Œ š]}v o]À µš}Œ}š š]}v v •‰]v~ • Œ]‰š]À •	ï

K> îìí	&>h/ D , E/ ^ >	d 'KZ	:	(	\	Z /
		W		ì	ì	ï

î

WŒ u o}W ~(šZ]• }µŒ•]• š} ‰Œ}À] ‰Œ š] o lv}Áo P]v À Œ](] (o}Á v š}]u‰ Œš lv}Áo P]v u •µŒ]vP ‰Œ ••µŒ U]• Z ŒP v À •šµ všs v •]oÇ ‰‰oÇ šZ]• lv}Áo P]v šZ]Œ Œ o o](X

WŒ Œ ‹µ]•]š W E/>

}µŒ• Kµš }u • W (š Œ šZ }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo o

K	o] Œ š (o}Á u •µŒ]vP À] • •µ Z • s vš
K	š Œu]v ZÇ Œ µo]
K	š Œu]v o}••
K	\o}š À o}]šÇ ‰Œ}(]o • (}
Kí	š Œu]v šZ •š]o]šÇ
K¿	š Œu]v šZ (}Œ • š]vP µ š}]u‰ P (}Œ •µ u ŒP } Ç

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

	WK	WK	WK	WK	WK	WK	WK	WK	WK	W íì	W íí	W íî
K	ï	î	î	î					î			
K	ï	î	î	î					î			
K	ï	î	î	î					î			
K	ï	î	î	î					î			
Kí	ï	î	î	î					î			
K¿	ï	î	î	î					î			

•• ••u vš W šš Œv

D Œl]•šŒ] µš]}v

d}š o D Œl•	/	^	^
íñì	óñ	óñ	îXñ Z}µŒ•

µŒ š]}v

}vš]vµ}µ• /vš Œv o À oµ š]}v W šš ŒvW

šš v v W íñ u Œl•
}vš]vµ}µ• •• ••u vš W ïì u Œl•
/vš Œv o d •š ~/uu] š oÇ (}Œ šZ • }v • Œ] • š •š• W ïì u Œl•

v ^ u •š Œ Æ u]v š]}v W ~}šo}Á]vP Pµ] o]v • •Z}µo (}oo}Á Œ P Œ u Œl•
~ • WŒ o]u]v ŒÇ Á}Œl W

~ • /u‰o u vš]vP šZ Á}Œll }v µ š]vP šZ Æ‰ Œ]u vš
~ • W Œ(}Œu v U Œ •µoš v]v(Œ v ~µ• P }(‹µ]‰u vš• v šŒ}µ o
~ • s]À À} W îì u
~ • Z }Œ W ñ D Œ

' v Œ o]v•šŒµ š]}v•W WŒ š] o Æ u]v š]}v š} }v µ š]uu] š oÇ
}À Œ]vP vš]Œ •Çoo µ• P]À v o}ÁX À oµ š]}v]• • Œ]}µ• ‰Œ} ••
šZ ‹µ o Œ •‰}v•]]o]šÇ }(}šZ šZ]vš Œv o v Æš Œv o Æ u]v Œ
À oµ š ‰ Œ Ç •Z}µo v}š Æ îìX ^šµ vš• •Z oo oo}Á (}Œ
}voÇ }v •µ u]šš]vP šZ µoÇ Œš](] Œ }Œ X dZ Æš Œv o Æ u]v Œ

}µŒ• > À o •• ••u vš Yµ •š]}v•

}µŒ• Kµš }u í~ KŒ•š (o}Á u •µŒ]vP À] • •µ Z • s všµŒ]u š ŒU
v}š Z •

íX š Œu]v }(} ((]] vš }( ]• Z ŒP v o] Œ š]}v }(Œ š vPµo Œ

îX š Œu]v }(} ((]] vš }( ]• Z ŒP v o] Œ š]}v }(srE}š Z

ïX š Œu]v }(} ((]] vš }( ]• Z ŒP v o] Œ š]}v }(KŒ](] u š Œ

ðX š Œu]v }(} ((]] vš }( ]• Z ŒP v o] Œ š]}v }(s všµŒ]u š Œ

}µŒ• Kµš }u î~ KŒ•š îW ZÇ Œ µo] } ((]] vš•

íX š Œu]v }(ZÇ Œ µo] } ((]] vš• }(}Œ](] •X

}µŒ• Kµš }u ï~ KŒ•š W o}•• •]v ‰]‰ •

íX š Œu]v Z ÌÇ[• }v•š vš v Œ Ç[• } ((]] vš }v ‰]‰ (Œ] š]}v

îX š Œu]v }(u]v}Œ o}•• •]v À Œ]}µ• ‰]‰ (]šš]vP•

}µŒ• Kµš }u ð~ KŒ•š ðW o}š À o}]šÇ ‰Œ}(]o • (}Œ vÇ P]À v (oµ] (o}Á

íXWo}š šZ À o}]šÇ ‰Œ}(]o µ•]vP W]š}šr•š š] šµ

}µŒ• Kµš }u ñ~ KŒ•š ñW šZ •š]o]šÇ }((o} š]vP } ÇX

íX š Œu]v }(u š všŒ] Z]PZš }((o} š]vP } Ç

}µŒ• Kµš }u ò~ KŒ•š òW šZ (}Œ • š]vP µ š}]u‰ š }(i š• }v •µŒ(
(}Œ }v •µ u ŒP } Ç

íX/u‰ š }(i š }v (o š •µŒ(

îX/u‰ š }(i š }v µŒÀ •µŒ(

ïXD •µŒ u vš }(Œ P }v]Œ µo Œ Ço]v Œ]v Z]PZ Z Çv}o • vµu

>/^d K& yW Z/D Ed^

íX š Œu]v š]}v }(} ((]] vš }( ]• Z ŒP v o] Œ š]}v }(Œ š vPµ

îX š Œu]v š]}v }(} ((]] vš }( ]• Z ŒP v o] Œ š]}v }(srE}š Z

ïX š Œu]v š]}v }(} ((]] vš }( ]• Z ŒP v o] Œ š]}v }(KŒ](] u

ðX š Œu]v š]}v }(} ((]] vš }( ]• Z ŒP v o] Œ š]}v }(s všµŒ]u

ñX š Œu]v š]}v }(Z ÌÇ[• }v•š vš v Œ Ç[• } ((]] vš }v ‰]‰ (Œ]

òX š Œu]v š]}v }(ZÇ Œ µo] } ((]] vš• }(}Œ](] •X

óX š Œu]v š]}v }(u š vš Œ] Z]PZš }((o} š]vP } ÇX

ôX š Œu]v š]}v }(u]v}Œ o}•• •]v À Œ]}µ• ‰]‰ (]šš]vP•

õX o] Œ š]}v }(‰Œ ••µŒ P µP

íìX š Œu]v š]}v }(À o}]šÇ ‰Œ}(]o µ•]vP W]š}šr•š š] šµ

ííXD •µŒ u vš }(&oµ] s]• }•]šÇ

íîXD •µŒ u vš }(Œ P }v]Œ µo Œ Ço]v Œ]v Z]PZ Z Çv}o • vµu

íïXZ Çv}o • Æ‰ Œ]u vš

íðXs Œ](] š]}v }(Œv}µoo][• šZ }Œ u v Œ Á ,'> v d >

íñXu‰ š }(i š }v (o š •µŒ(

íòXu‰ š }(i š }v µŒÀ •µŒ(

E}š W u]v]uµu }(íì Æ‰ Œ]u vš• Œ u v š}ŒÇX

K îìì	D d Z/ > d ^d/	d 'KZ	:	(	\	Z /
		W	ì	ì	ï	î

WŒ u o'}Wo Y(šZ]• }µŒ•]• š} Æ‰}•ZšŒ šš(Œ]ìvš•vš}ÀšZoµ š šZ
u š Œ] o• µ•]vP •šŒµXš](À Œ šZZv]‹µ}µŒ• •šµ vš• Á]oo o š} Œ }P
‰Œ} o u•]v Œ orÁ}Œo •]šµ š]}v• v Œ •‰}v }Œ]vPoÇX

WŒ Œ ‹µ]•]š WŒ]vP D Z v] •

}µŒ• Kµš }u(š• WŒ šZ }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo o

K	}v µ š š v•] v }u‰Œ ••š} Z Œ š Œ]ì š šZ u
K	š Œu]v Z Œ v ••
K	}v µ (o š]}' v v]vP
K	}v µ š (o ÆµŒ o v š}Œ•]}v š •š š}

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

	Wk	Wk	Wk	Wk	Wk	Wk	Wk	Wk	Wk	W íì	W íí	W íî
K	ï	í	î						î			î
K	ï	í	î						î			î
K	ï	í	î						î			î
K	ï	í	î						î			î

•• ••u vš W šš Œv

D Œl]•šŒ] µš]}v

d}š o D Œl•	/	^	^ µŒ š]}v
íñì	óñ	óñ	îXñ Z}µŒ•

}vš]vµ}µ• /vš Œv o À oµ š]}v W šš ŒvW

šš v v W íñ u Œl•
}vš]vµ}µ• •• ••u vš W ïì u Œl•
/vš Œv o d •š ~/uu] š oÇ (}Œ šZ • }v • Œ] • š •š• W ïì u Œl•

v ^ u •š Œ Æ u]v š]}v W(}šo}Á]vP Pµ] o]v • •Z}µo (}oo}Á Œ P Œ
u Œl•
~ • WŒ o]u]v ŒÇ Á}Œl W
~ • /u‰o u vš]vP šZ Á}Œll }v µ š]vP šZ Æ‰ Œ]u vš
~ • W Œ(}Œu v U Œ •µoš v]v(Œ v ~µ• P }(‹µ]‰u vš• v šŒ}µ o
~ • s]À À} W îì u
~ • Z }Œ W ñ D Œ

' v Œ o]v•šŒµ š]}v•W WŒ š] o Æ u]v š]}v š} }v µ š]uu] š oÇ
}À Œ]vP vš]Œ •Çoo µ• P]À v o}ÁX À oµ š]}v]• • Œ]}µ• ‰Œ} ••
šZ ‹µ o Œ •‰}v•]]o]šÇ }(}šZ šZ]vš Œv o v Æš Œv o Æ u]v Œ

>/^d K& yW Z/D Ed^

íX d v•]}v š •š }v u]o •š ol š}Œr•š ol Z]PZ •šŒ vPšZ •š o v •š]Œ
D Z]v

îX d v•]}v š •š }v u]o •š ol š}Œr•š ol Z]PZ •šŒ vPšZ •š o v •š]Œ
d v•}u š Œ

ïX }u‰Œ ••]}v š •š }v •‰Œ]vP

ðX d}Œ•]}v ‰ v µoµu ~u]o •š oU oµu]v]µu v Œ •• Á]Œ ••

ñX , Œ v •• š •š ~ Œ]v ooU s] l Œ• v Z} lÁ oo•

òX /u‰ š š •š ~/Ì} v Z Œ‰Ç•

óX d}Œ•]}v š •š }v u]o •š o Œ} •X

ôX ^Z Œ š •š }v u]o •š o Œ} •

õX & š]Pµ š •š t ^šµ Ç }(š •š]vP u Z]v X

íìX v]vP š •š }v Á}} v u•X

ííX ^šŒµš š •š ~ }oµuv µ lo]vP Æ‰ Œ]u vš•

íîX s Œ](] š]}v }(o ŒI D ÆÁ oo[• o Á }(Œ]‰Œ} o (o š]}v v š
u} µoµ• }(•š oX

íïX WZ}š} o •š] u šZ} • (}Œ •šŒ •• u •µŒ u vš•X

íðX :}u]vÇ Z Œ v]o]šÇ š •š

íñX D •µŒ u vš µ•]vP •šŒ]v P µP •

íòX š Œu]v š]}v }(u}u vš }( ]v Œš] }(Œ}š š]vP }] •

íóX (o š]}v d •š }v •š o v š]u Œ u

E}š W u]v]uµu }(íì Æ‰ Œ]u vš• Œ u v š}ŒÇX

Z (Œ v }}l•

íX '] š ŒX D Z v] o D š ooµŒPÇU D 'Œ Á ,]ooUîìíï

îX ooÇ : tU Z]o Ç t WU Æ‰ Œ]u vš o ^šŒ •• v oÇ•]• U D 'Œ Á ,]o

ïX o À Z iU : Ç lµu Œ dU dZ À •]uµšZµ DXU WŒ š] o E}v •šŒµ š]
]•šŒ] µš}Œ•Uîìíñ

ðX d]u}•Z vl} v ' Œ U D Z v] • }(D š Œ] o•U ^ Wµ o]•Z Œ•U E Á o

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0 , 1 2 5

Kd î ô í	&hE D Ed >^ K& ZKE hd/ ^	d 'K Z s	: ï	(í	\ ì	Z ð

W Œ u o W

dZ]• }µŒ• ‰Œ}À] • v }À ŒÀ] Á v]všŒ} µ š]}v š} šZ (µv u vš o• } o o}}v• š} •‰ (o]PZš

W Œ Œ ‹µ]•]š W E/>

}µŒ• Kµš }u š• W šZ }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo o

K	Æ‰o]v (µ Œ}v µš] • v
K	• Œ •]Œ(}]o Z Œ š
K	W Œ] ‰ Œ(}Œu‰Œ}‰
K	Æ‰]((Œ vš šÇ‰ • }(‰‰o]
K	‰‰oÇ šZ u}š]}v }(}] •

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

	W K	W K	W K	W K	W K	W K	W K	W K	W K	W í ì	W í í	W í î
K	ï											
K	ï	í										
K	ï	í										
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•• ••u vš W šš Œv

o}}u[• š	}vš]vµ}µ• •• ••u		v ^ u •š Œ Æ
	í	î	
Z u u	í ì	í ì	ï ì
hv Œ•	î ì	î ì	ï ì
‰	î ì	î ì	¿ ì
v o			
À o			
Œ			

D Œl]•šŒ] µš]}v

d}š o D	/	^	^ µŒ
í ñ	ñ	í ì ì	ï Z}µ

}vš]vµ}µ• /vš Œv o À oµ š]}v W šš ŒvW

šš v v W íì u Œl•
}vš]vµ}µ• •• ••u vš d •š ~î vµu Œ•• W îñ u Œl•
••]Pvu všlYµ]Ìl }µŒ• ‰Œ}i š W íñ u Œl•

v ^ u •š Œ Æ u]v š]}v Á]oo W šÁ} ‰ Œš•V W Œš v W Œš X
‹µ •š]}v• Á]šZ î ‹µ •š]}v• (Œ}u Z u} µo U Z À]vP ï u Œl• (}Œ Z ‹µ
v•Á Œ oo ‹µ •š]}v•X W Œš }vš]v• î ‹µ •š]}v• (Œ}u Z u} µo }(ÁZ
vÇ }v X Z ‹µ •š]}v v Z À u Æ]uµu î •µ r]À]•]}v• v ŒŒÇ íð u Œ

}µŒ• > À o •• ••u vš Yµ •š]}v•

}µŒ• Kµš }u í ~ Kí•W

íX]•š]vPµ]•Z šZ o](š P v Œ š šÁ v v]Œ Œ (š v oo}}vX

îX &]v šZ ‰Œ ••µŒ v š u‰ Œ šµŒ š v oš]šµ }(íñ <u (Œ}u •

ïX Æ‰o]v šZ À Œ]}µ• }u‰}v vš µ• š} }všŒ}o šZ]Œ Œ (šMX

}µŒ• Kµš }u î ~ Kî•

íX Æ‰o]v ÁZÇ šZ vµu Œ• µ• (}Œ v}u v o šµŒ }(Œ}(}]o•M

îX]•š]vPµ]•Z šÁ v všŒ }(‰Œ ••µŒ v Œ} Çv u] • všŒ X

ïX Æ‰o]v Á]šZ •l š Z •]((Œ vš šÇ‰ • }(o v]vP P Œ• µ•]v]Œ

}µŒ• Kµš }u ï~ Kï•W

íX tZ š Œ šZ o ••](] š]}v• }(‰Œ}‰ oo Œ•M tZ š Œ šZ (}Œ • š]

îX ,}Á šZ šZŒµ•š]• P v Œ š]v Z o] }‰š ŒM Æ‰o]v šZ ÁZÇ šZ

ïX ,}Á šZ u v} µÀŒ]vP ‰}••] o]v Z o] }‰š ŒM tZÇ šZ š]o Œ}š}Œ

}µŒ• Kµš }u ð ~ Kð•W

íX Æ‰o]v šZ]((Œ vš šÇ‰ • }(Œ} l š µ• X ,}Á šZ šZŒµ•š P v Œ š

îX tZÇ šZ]Œ Œ šZ ‰Œ}‰µo•]}v •Ç•š u]• v}š ‰š]v Œ} l š ‰Œ}

ïX]•š]vPµ]•Z šÁ v •}o] o]‹µ] v ZÇ Œ] Œ} l š•M

}µŒ• Kµš }u ñ ~ Kñ•W

íX Æ‰o]v šZ •]Æ }Œ]š o u vš• Á]šZ •l š ZX

îX ^š š v ‰Œ}À < ‰o Œ[• o Á•M

ïX Œ]À v Æ‰Œ ••]}v (}Œ • ‰ À o}]šÇ v }Œ]š o À o}]šÇX

D} o Yµ •š]}v ‰ ‰ Œ D} o Yµ •š]}v ‰ ‰ Œ

YW K W

W: h> < > D d ,EK>K'/ > hE/s Z^/dz d,/Z ^ D ^d Z Xd , 'Z y

DKEd, ˜ z Z

}µŒ• } W Kdîôí

&hE D Ed >^ K& ZKE hd/ ^

D ÆXD ŒI•Wíìì

W Zd

v•Á Œ oo Yµ •š]}v•X Z ‹µ •š]}v ŒŒ] • ï D ŒI•

íX Œ Á v Æ‰o]vµŒÀ (}Œ u Œ Œ}(}]oX

îXtZ] Z ‰Œ]u ŒÇ }všŒ}o •µŒ(• µ• š} }všŒ}o šZ ‰]š Z]v
o•} Æ‰o]v Œ] (oÇ šZ }‰ Œ š]}v }(šZ š }všŒ}o •µŒ(•

ïXtZ š]• D Z vµu ŒM ,}Á]Œ Œ (š š P}Œ]Ì • }v D Z v}

ðX } šZ (}oo}Á]vP E]Œ(}]o•]• îðíî]]• ììíñ

ñX Æ‰o]v šZ ‰µŒ‰}• }(š]o Œ}š}Œ o]v Z o] }‰š ŒX

òXtZ š Œ šZ (}Œ • š]vP }v ‰Œ}‰ oo Œ }(v Œ}‰o v M

óX/ooµ•šŒ š ‰Œ ••µŒ r(Œ} I š vP]v X

ôXE u vÇ šZŒ (µ o• µ•]v]‰Œ}‰ oo vš Œ} I š vP]v X

õXtZ š Œ < ‰o Œ[• šZŒ o Á•M

íìX}Á & •š /• • ‰ À o}]šÇ]v u‰Z š • o À oM

W Zd

v•Á Œ vÇ }v (µoo ‹µ •š]}v (Œ}u Z u} µo X Z ‹µ •š]}v Œ

D} µo í

ííX Æ‰o]v šZ Œ o š]}v•Z]‰• }(š u‰ Œ šµŒ U ‰Œ ••µŒ Á]š
•I š ZX

íîX ~ • :µ•š](Ç ÁZÇ u} Œv]Œ‰o v • Œ u}v}‰o v •X
~ • ^I š Z šZ u i}Œ }u‰}v vš• }(v]Œ Œ (š v Æ‰o]v šZ

D} µo î

íïX ~• Œ]À šZ Œ o š]}v•Z]‰ šÁ v Á]vP o}]vP v Œµ]• •
~• Æ‰o]v Z}Á • v šŒ l ÁZ o]•š v v o µo š
P Œ µ•]vP •µ]š o] PŒ uX
~• ,}Á u v Œ} Çv u] všŒ o µo š (}Œ š ‰ Œ Á]v

íðX WŒ}À šZ š šZ o](šrš}r Œ P Œ š]}]• u •µŒ }(šZ Œ
]Œ‰o v X

D} µo ï

íñX ~• tŒ]š •Z}Œš v}š • }v Z o] }‰š Œ Z}À Œ]vP v µš}Œ}š š]
~• • Œ] šZ À Œ]}µ• šÇ‰ • }(‰Œ}‰ oo Œ• µ•]v]Œ Œ

íòX ~• Æ‰o]v šZ À Œ]}µ• }u‰}v vš• v šZ]Œ (µv š]}v• }(Z
~• tŒ]š •Z}Œš v}š • }v Œ}š}Œ o Œ} Çv u] •X

D} µo ð

íóX ~• Œ]À šZ ‹µ š]}v }(u}š]}v Œ o š • šZ µŒv}µš À o}]šÇ
]u‰µo• X
~• >]•š v • Œ] šZ]((Œ vš š P}Œ] • }(o]‹µ] ‰Œ}‰

íôX ~• t]šZ šZ Z o‰ }(v š •l š ZU Æ‰o]v šZ À Œ]}µ• µŒ
‰Œ}‰ oo vš•X
~• tŒ]š šZ À vš P • }(ZÇ Œ] ‰Œ}‰ oo vš Œ} l š• }u‰
‰Œ}‰ oo vš• Œ} l š•X

D} µo ñ

íõX ~• Œ]À šZ ‹µ š]}v }(u}š]}v]v v]v Œš] o (Œ u v Z
PŒ À]š š]}v o ‰ Œ u š ŒM

îìX ~• Œ]À v Æ‰Œ ••]}v (}Œ • ‰ À o}]šÇ v }Œ]š o À o}

^Çoo µ•

D} µoUí

,]•š}ŒÇ }(&o]PZš• r oo}}v (o]PZš UKŒv]šZ}‰š Œ•U ŒoÇ]
À o}‰u vš•]v Œ} Çv u] •U WZÇ•] o ‰Œ}‰ Œš] • v •šŒµ
š u‰ Œ šµŒ U ‰Œ ••µŒ v oš]šµ Œ o š]}v•Z]‰•X o ••]
}u‰}v vš• }(v]Œ Œ (šX •] }v ‰š•ŒW}(}o}(•šUD ŒZ Pv µu u}ŒUvš
u v} µÀŒ •X

D} µo î

Œ} Çv u] (}Œ • }v]Œ Œ (šU o ••](] š]}v }(E Œ}(}]o•U
všŒ }(‰Œ ••µŒ v Œ} Çv u] všŒ U t]vP v > v]vP P

/všŒ} µ š]}v š}]Œ Œ (š •šŒµ šµŒ • v u š Œ] o•W P v Œ
u}v} }‹µ U • u]u}v} }‹µ v P } •] •šŒµ šµŒ •V šÇ‰] o Á]vP v
u š oo] v v}vru š oo] u š Œ] o• (}Œ]Œ Œ (š ‰‰o] š]}vX

D} µo ï

WŒ}‰ oo Œ r K‰ Œ š]vP WŒ]v]‰o U W Œš• }(‰Œ}‰ oo ŒU W
‰Œ}‰ oo ŒU WŒ}‰ oo Œ šZ }Œ] •X •] , o] }‰š Œ }u‰}v
, o] }‰š Œ Œ} Çv u] •U ,}À Œ]vP v µš}Œ}š š]}vU

D} µo ð

dÇ‰ • }(Œ} l š•X &µv u vš o ‰Œ]v]‰o •X WŒ]v]‰o • }(}‰
o ••](] š]}v }(Œ} l š•X •] ‰Œ]v]‰o • }(•}o] U o]‹µ] U v
(µv š]}v• v ‰‰o] š]}v• }(Œ} l š ‰Œ}‰µo•]}vU /}v ‰Œ}‰µo•]}vU
•]oX

D} µo ñ

KŒ]š o D Z v] •r ^}o Œ •Ç•š uU W}•]š]}v }v ŒšZ •µŒ(U dZ
o v ŒU KŒ]š o o u vš•XU < ‰o Œ[• o Á•U dÇ‰ • }(}Œ]š•U
E Áš}v• o Á }(PŒ À]š š]}v•U Z (Œ v (Œ u X ‹µ š]}v• }(u}š]}v

d Æš }}l•

íX :}Zv v Œ•}vU &µv u vš o• }(Œ} Çv u] •U D Œ 'Œ Á ,]oo

îX X>X ,}µPZš}v WXtX Œ‰ vš Œ ^š À v ,X }oo] }šš v] o dX
vP]v Œ]vP •šµ vš• Œ} Çv u] •U]šZ ,]v u vvV ó š]}vU îìíò

Z (Œ v }}I•

íX < Œu} U X XU D Z v] • }(&o]PZš ^šZU W Œ•}v /v] U íí

îX : t }Œv o]•• U , & Z ^ Z}Ç ŒU v < & t II ŒU Z} I š WŒ}

Çv u] WU •Ušu v Wµ o]•Z]vP U íõóõ

}µŒ• }vš všƒ v > šµŒ ^ Z µo

E}	d}‰]	E}X }(> šµŒ •
í	D} µo í	
íXí	,]•š}ŒÇ }(&o]PZš• r oo}}v (o]PZš]‰o v • v u}v}‰o v • À o}‰u vš•]v Œ} Çv u] •	UKŒv]šZ}‰š Œ•U
íXî	WZÇ•] o ‰Œ}‰ Œš] • v •šŒµ šµŒ š u‰ Œ šµŒ U ‰Œ ••µŒ v oš]šµ	}(šZ šu}•‰Z Œ U Œ o š]}v•Z]‰•X
íXï	o ••](] š]}v }( ]Œ Œ (šU }v ‰š•W o](šU ŒP U]o} uv Z vµu ŒU u v} µÀŒ •X	•]u‰}vðvš• }(v]Œ Œ (šX
î	D} µo î	
îXí	Œ} Çv u] (}Œ • }v]Œ Œ (šU •‰ š Œ š]}U Á]vP o}]vPU všŒ U t]vP v > v]vP P Œ }v(]PµŒ	o ••](] š]}v }(E Œ}(‰Œ ••µŒ v Œ} š]}v•X
îXî	/všŒ} µ š]}v š}]Œ Œ (š •šŒµ šµŒ • }v•šŒµ š]}vV u}v} }‹µ U • u]u}v} }‹µ •šŒµ šµŒ •V	vï u š Œ] o•W P v Œ v P } •]
îXï	šÇ‰] o Á]vP v (µ• o P •šŒµ šµŒ V u š oo] v v}vru š oo] u š Œ] o• (}Œ	ï]Œ Œ (š ‰‰o] š]}v
ï	D} µo ï	
ïXí	WŒ}‰ oo Œ r K‰ Œ š]vP WŒ]v]‰o š]vP }v ‰Œ}‰ oo Œ	U WŒ}‰ oo Œ o ••](
ïXî	WŒ}‰ oo Œ šZ }Œ] •	ï
ïXï	•] , o] }‰š Œ Œ} Çv u] •U ,}À Œ]vP v µš}Œ}š š]}v , o] }‰š Œ }u‰}v vš• v šZ]Œ (µv š]}v•X	ï
ð	D} µo ð	
ðXí	dÇ‰ • }(Œ} I š•X &µv u vš o ‰Œ]v }(Œ} I š	ï]‰o •X WŒ]v]‰o • }
ðXî	dÇ‰ • v o ••](] š]}v }(Œ} I š•X o]‹µ] U v ZÇ Œ] Œ} I š• v šZ]Œ (µv š]}v• v	ï] ‰Œ]v]‰o • }(•} ‰‰o] š]}v
ðXï	o šŒ] Œ} I š ‰Œ}‰µo•]}vU /}v ‰Œ}‰µo•]}vU Eµ o Œ •]oX	
ñ	D} µo ñ	

ñXí	KŒ]š o D Z v] •r ^}o Œ •Ç•š uU W o •š] o •‰Z Œ U d]u v o v ŒU o Á•	}ï]š]}v }v ŒšZ •µŒ(KŒ]š o o u vš•XU <
ñXî	dÇ‰ • }(}Œ]š•U • ‰ À o}]šÇU }Œ PŒ À]š š]}v•U Z (Œ v (Œ u	Œï]š o À o}]šÇU E Áš
ñXï	‹µ š]}v• }(u}š]}v]v v]v Œš] o (Œ	uï	

6 (0 (6 7 (5

Kdîìî	d, ZDK zE D/ ^	d 'KZ	:	(	\	Z /
		W		ï	í	ì

ð

WŒ u'ÇŽ W}(šZ]• }µŒ•]• š} Æ‰}•µŠš]š}šµ]Àvš• v š}Çš Z• }(u Z]v v ‰Œ} •• • (}Œ šŒ v•(}Œu š]}v }(v ŒP Ç• š}(ÁšZ v Œ }µŒ lÇvu]Z• š}µo o š} ‹µ vš](Ç šZŒ}µPZ u •µŒ u vš }(Œ o š ‰Œ}‰ Œš] •U š}]vš Œ Ÿ]}v}(š Œ šZ]• }µŒ• •šµ vš• Á]oo o š} Œ }Pv]Ì •]u]o Œ •]šµ š]}v• v Œ •‰}v }Œ]vPoÇX

WŒ Œ ‹µ]•]š W E]o

}µŒ• KµšŸ}u•W š Z }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo o

K	À oµ š šZ À Œ]}µ• šZ Œu} Çv u] Œ
K	v oÇ• v •}oÀ šZ ‰Œ} o u• ((o}Á ‰
K	v oÇ• šZ]Œ •
K	o o Œ š }v]š]}v }(Á}(
K	v oÇ• šZ ‰Œ‰µŒ •µ

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

	Wk	Wk	Wk	Wk	Wk	Wk	Wk	Wk	Wk	W íì	W íí	W íî
K	ï	ï	í									
K	ï	ï	í									
Kï	ï	ï	í									
K	ï	ï	í									
K	ï	ï	í									

•• ••u vš W šš Œv

o}}u[• š	}vš]vµ}µ• •• ••u		v ^ u •š Œ Æ
	í	î	
Z u u	íì	íì	íì
hv Œ•	îì	îì	îì
‰	îì	îì	ó
v o			
À oµ			
Œ			

D Œl]•šŒ] µš]}v

d}š o D	/	^	^ µŒ
íñì	ñì	íìì	ï Z}µŒ•

}vš]vµ}µ• /vš Œv o À oµ š]}v W šš ŒvW

šš v v W íì u Œl•
}vš]vµ}µ• •• ••u vš d •š ~î vµu Œ•• W îñ u Œl•
••]Pvu všlYµ]Ìl }µŒ• ‰Œ}i š W íñ u Œl•

v ^ u •š Œ Æ u]v š]}v W dZ Œ Á]oo W šÁ} ‰ Œš•V W Œš X
‹µ •š]}v• Á]šZ î ‹µ •š]}v• (Œ}u Z u} µo U Z À]vP ï u Œl• (}Œ Z ‹µ
v•Á Œ oo ‹µ •š]}v•X W Œš }vš]v• î ‹µ •š]}v• (Œ}u Z u} µo }(ÁZ
vÇ }v X Z ‹µ •š]}v v Z À u Æ]uµu î •µ r]À]•]}v• v ŒŒÇ íð u Œ

}µŒ• > À o •• ••u vš Yµ •š]}v•

}µŒ• Kµš }u í ~ Kí•W À oµ š šZ À Œ]}µ• šZ Œu} Çv u] Œ o š]}v

íX >]•š }µš šZ D ÆÁ oo[• ‹µ š]}v

îX Æ‰o]v šZ µ• • }(všŒ}‰Ç]v Œ •

ïX Œ]À šZ o µ•]µ• t o ‰ ÇŒ}v ‹µ š]}v

}µŒ• Kµš }u î Kî• W oÇ v oÇ• šZ ‰Œ} o u v •}oÀ šZ ‰Œ} o u
v v}vr(o}Á ‰Œ} ••

íXHULYH DQ H[SUHVVLRQ IRU VWHDG\ IORZ HQHUJ\ HTXDWLRQ

îX$ PULJLG WDQN LQLWLDOO\ FRQWDLQV ... FRQQHFWHG WR D
.3D DQG 7KH YDOYH LV RSHQHG DQG DLU LV DOORZHG WR HQ
WDQN UHDFKHV WKH OLQH SUHVVXUH DW ZKLFK WKH YDOYH LV
LQGLFDWHV WKDW DLU WHPSHUDWXUH ...
WDQN E WKH DPRXQW RI KHDW WUDQVIHU

ïX Œ]À

$$dQ = \left[\frac{\gamma-n}{\gamma-1}\right] x\ polytropic\ work$$

$$C_n - C_v\left[\frac{\gamma-n}{1-n}\right]$$

}µŒ• Kµš }u ï Kï• W šZ]Œ •š v Œ Ç o

íX}u‰ Œ Kšš}U] • o v µ o Ç o

îX }u‰ Œ Œ Çš}v v Z vl]v Ç o •

ïX v vP]v Á}Œl• }v v] o µ o Ç o U šZ ‰Œ ••µŒ v š u‰ Œ š
Œ v ì X dZ }u‰Œ ••]}v Œ š]} }(šZ Ç o]• íí v u Æ]uµu ‰Œ ••µ
dZ Z š •µ‰‰o] š }v•š vš ‰Œ ••µŒ }vš]vµ • (}Œ ñ9 }(šZ •šŒ}l
]Œ v Ç o ((]] v ÇM

}µŒ• Kµš }u ð Kð• W š }v]š]}v }(Á}Œl]vP u]µu íXÆ‰o]v ^ ZLW(K(WšKH KHOS RI D GLDJUDP

îX6KRZ WKDW WKH ILUVW ODZ RI WKHUPRG\QDPLFV OHDGV WR WKH
WKHUPRG\QDPLF V\VWHP´

ïXHILQH VSHFLILF KHDW 'HULYH D UHODWLRQ EHWZHHQ VSHFLILF

}µŒ• Kµš }u ñ ~ Kñ•W v oÇ• šZ ‰Œ}‰ Œš] • }(‰µŒ •µ •š v

íX]• µ•• šZ Wrd] PŒ u (}Œ ‰µŒ •µ •š v

îX ‰Œ ••µŒ }}l Œ }vš]v• íXñ <P }(• šµŒ š •š u š ñ ŒX &]v
Œ i š •} • š} Œ µ šZ ‹µ o]šÇ š} òì9 ŒÇX š Œu]v šZ ‰Œ •
•š u š šZ v Á •š š

ïX šZ Œu o ‰}Á Œ ‰o vš }‰ Œ š]vP }v v] o Z vl]v Ç o Z • u •
]šX t š Œ]• (š} šZ }]o Œ š ñì Œ v o À • šZ }v v• Œ • • šµ
u •• (o}Á Œ š }(}}o]vP Á š Œ šZŒ}µPZ šZ }v v• Œ]• ñìì <Pl•X d
}v v• Œ } š ïì o À • Xš ðò µo š šZ š u‰ Œ šµŒ š ÁZ] Z •š u vš Œ
šZ šZ Œu o ((]] v Ç }(šZ ‰}Á Œ ‰o vš v šZ ‰}Á Œ }µš‰µš }(šZ

D} o Yµ •š]}v W ‰ Œ

YW K W

E u Wzzzzzzzzzzzzzzzzz

W: h> < > D d ,EK>K'/ > hE/s Z^/dz &/Z^d ^ D ^d Z Xd , 'Z y
DKEd,˜ z Z

d, ZDK zE D/ ^

}µŒ• } W Kd îìî

D ÆX D Œl•W íìì

W Œš

~ v•Á Œ oo ‹µ •š]}v•V Z ‹µ •š]}v ŒŒ] • ï u Œl••

íXt]šZ šZ Z o‰ }(v š] PŒ u Æ‰o]v ^ l ((š

îX6KRZ WKDW WKH ILUVW ODZ RI WKHUPRG\QDPLFV OHDGV WR W
SURSHUW\ RI D WKHUPRG\QDPLF V\VWHP´

ïX^š š šZ < oÀ]vrWo vI •š š u vš }(šZ • }v o Á }(šZ Œu} Ç

ðX^š š šZ Œv}š šZ }Œ u

ñX vµu Œ'}šµÇ r ^š} }o šZ }Œ u

òX Æ‰o]v šZ µ• • }(všŒ}‰Ç]v Œ •

óX>]•š }µš šZ D ÆÁ oo[• ‹µ š]}v

ôX }u‰ Œ Kšš}U]• o v µ o Ç o

õX,}Á } • Œ Çš}v Ç o }u‰ Œ Á]šZ Z vI]v Ç o

íìX]• µ•• šZ Wrd] PŒ u (}Œ ‰µŒ •µ •š v

W Zd

~ v•Á Œ }v (µoo ‹µ •š]}v (Œ}u Z u} µo U Z ‹µ •š]}v ŒŒ] •

D} µo rí

Œ]À $dQ = \left[\frac{\gamma - n}{\gamma - 1}\right] x\ polytropic\ work$

$C_n = C_v\left[\frac{\gamma - n}{1 - n}\right]$

íîX~]$ IOXLG DW D SUHVVXUH RI EDU DQG FRQWDLQHG LQ D F\OL
EHKLQG D SLVWRQ H[SDQGV UHYHUVLEO\ WR D SUHVVXUH RI
& LV D FRQVWDQW &DOFXODWH WKH ZRUN GRQH E\ WKH IOXL

LL 'HILQH VSHFLILF KHDW 'HULYH D UHODWLRQ EHWZHHQ V

D} µo

íïX~]$ ULJLG WDQN LQLWLDOO\ FRQWDLQV DLU DW FRQQHFWHG
VXSSO\ OLQH DW & 7KH YDOYH LV RSHQHG DQG DLU LV DOOR
XQWLO WKH SUHVVXUH LQ WKH WDQN UHDFKHV WKH OLQH
WKHUPRPHWHU LV SODFHG LQ WKH WDQN LQGLFDWHV WKDW
'HWHUPLQH D WKH PDVV RI DLU WKDW KDV HQWHUHG WKH W

PDUNV

LL 'HULYH DQ H[SUHVVLRQ IRU VWHDG\ IORZ HQHUJ\ HTXDWL

íðX Œ À Œ•] o Z š vP]v }‰ Œ š • šÁ v šÁ} Œ • ŒÀ}]Œ• š š u
ðî X dZ vP]v Œ]À • Œ À Œ•] o Œ (Œ]P Œ š}Œ ÁZ] Z }‰ Œ
š u‰ Œ šµŒ • v}(ðîX dZ Z š šŒ v•(Œ š} šZ Z š vP]v]• îììì<i
Á}Œl }µš‰µš }(šZ }u]v vP]v Œ (Œ]P Œ š}Œ ‰o vš]• ïòì <:

~ •À oµ š šZ Z š šŒ v•(Œ š} šZ Œ (Œ]P Œ vš v šZ v š Z
š ðìX

~ •Z }v•] Œ ~ • P]À v šZ š šZ ((]] v Ç }(šZ Z š vP]v v
Œ (Œ]P Œ š}Œ Œ Z ðì9 }(šZ]Œ u Æ]uµu ‰}••] o À oµ •

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íñX]• vµu Œ š o µ•]µ• /v ‹µ o]šÇ PDUNV

~]]• Œ]P] Ço]v Œ }v( ]v]šv Œ }PX ì ñ šu í Œ v îõì<]• Z š Œ À
µvš]o šZ š u‰ Œ šµŒ }u • ïòì <X š Œu]v šZ Z š •µ‰‰o]
••µu v]šŒ}P v š} ‰ Œ(A šXÐ • v v Z ìõò Xõï :l<P<

íòX]• ^Z}Á šZ š šZ Á}Œl }v Ç o}• •Ç•š u Ç]vš Œ š]vP }voÇ
Œ À Œ•] o ‰Œ} ••]• oÁ Ç• u}Œ šZ v šZ š }v Ç]š]v v]ŒŒ
• u v •š š •X

LL &DOFXODWH WKH GHFUHDVH LQ DYHUDJH WKH HQHUJ\ ZKHQ
RI ZDWHU DW WKH SUHVVXUH EHLQJ WDNHQ DV FRQVWDQW
VXUURXQGLQJV LV .- .J.

D} µo rð

íóX]• Œ]À šZ &]Œ•š v • }v d ^ ‹µ š]}v PDUNV

~]]• Œ]À šZ o µ•]µ• t o ‰ ÇŒ}v ‹µ š]}v

íôXv vP]v Á}Œl• }v v] o µ o Ç o U šZ ‰Œ ••µŒ v š u‰ Œ
Ç o í Œ X dZ }u‰Œ ••]}v Œ š]} }(šZ Ç o]• íí v u Æ]u
o]u]š ðõXî ŒX dZ Z š •µ‰‰o] š }v•š vš ‰Œ ••µŒ }vš]vµ
šZ Á}Œl }v ‰ Œ <P }( ]Œ v Ç o ((]] v ÇM

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íõX ‰Œ ••µŒ }}l Œ }vš]v• íXñ <P }(• šµŒ š •š u š ñ ŒX &]v
uµ•š Œ i š •} • š} Œ µ šZ ‹µ o]šÇ š} òì9 ŒÇX š Œu
š u‰ Œ šµŒ }(šZ •š u š šZ v Á •š š

îìX šZ Œu o ‰}Á Œ ‰o vš }‰ Œ š]vP }v v] o Z vl]v Ç o Z •
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š ìXí ŒX dZ u •• (o}Á Œ š }(}}o]vP Á š Œ šZŒ}µPZ šZ }
}}o]vP Á š Œ vš Œ• šZ Á š Œ •š ïð µo š šZ š u‰ Œ šµŒ
ÁZ] Z •š u vš Œ• šZ šµŒ]v U šZ šZ Œu o ((]] v Ç }(šZ ‰}
}µš‰µš }(šZ šµŒ]v X

^Çoo µ•

D} µo í

•] }v ‰š• r D Œ}• }‰] v D] Œ}• }‰] À] Á‰}]vš•U }v ‰š }(}vš
^Ç•š u v }všŒ}o s}oµu U ^µŒŒ}µv]vPU }µv Œ] •U dÇ‰ • }(^Ç•š u
‰Œ}‰ Œš] •U WŒ} ••U Ç o U dZ Œu} Çv u] ‹µ]o] Œ]µuU Yµ •] t •š
(µv š]}vX • Œ}šZ > Á }(dZ Œu} Çv u] •U v ŒPÇ r t}Œl r W À Á}Œl
šŒ v•(ŒU Z š v Z š ‰]šÇX :}µo [• Æ‰ Œ]u vš r &]Œ•š o Á }(dZ
š} E}v (o}Á WŒ} ••r všZ o‰Çr•‰](] Z š•r WDDí

D} µo î

&]Œ•š o Á ‰‰o] š} &o}Á WŒ} ••U D •• v v ŒPÇ o v]v •]µ
‰‰o] š]}v• }(^& r: š vP]v }u‰}v vš•U dŒ v•] vš (o}Á t &]oo]v
~WŒ} o u••U >]u]š š]}v• }(šZ &]Œ•š > ÁX ^ }v > Á }(dZ Œu} Çv u]
vP]v U , š ‰µu‰ t W Œ(}Œu v (š}Œ•U < oÀ]vrWo v l v o µ•]µ•
šÁ} •š š u vš•U Z À Œ•]]o]šÇU /ŒŒ À Œ•]]o]šÇU /ŒŒ À Œ•] o WŒ} ••U µ• • }(/ŒŒ
o ÁU WDDîU Œv}š[• šZ }Œ u v]š• }Œ}oo Œ] •U •}oµš dZ Œu} Çv

D} µo ï

o µ•]µ• /v ‹µ o]šÇU všŒ}‰Çr µ• • }(všŒ}‰Ç Z vP U všŒ}‰Ç Z
‰Œ} •• •U ‰Œ]v]‰o }( ]v Œ • }(všŒ}‰Ç v]š• ‰‰o] š]}v•U
o}• •Ç•š uU všŒ}‰Ç v]•}Œ ŒU Z À Œ•] o] š] ‰Œ} ••r]
v ŒPÇU À]o]o]šÇ v /ŒŒ À Œ•]]o]šÇr h• (µo Á}ŒlU •š š U À
]ŒŒ À Œ•]]o]šÇ]v }‰ v v o}• •Ç•š u• r '}µÇr^š} }o šZ }Œ uU dZ

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' v Œ o dZ Œu} Çv u] Z o š]}v• t }u]v &]Œ•š v ^ }v o Á ‹µ š]}
'] [• (µv š]}v• r D ÆÁ oo[• Z o š]}v•U d • ‹µ š]}v•X dZ o ‰ ÇŒ}v ‹µ
v ŒPÇU všZ o‰Ç v všŒ}‰ÇU •‰](] Z š•U dZŒ}ššo]vP ‰Œ}
]vÀ Œ•]}v µŒÀ X]Œ •š v Œ Ç o •r Kšš} Ç o U] • oU µ o v Œ
((]] v Çr u v ((š]À ‰Œ ••µŒ

D} µo ñ

WµŒ ^µ •š v •U WZ • dŒ v•(}Œu š]}v•U dŒ]‰o ‰}]všU ‰Œ}‰ Œš]
v ‰rd] PŒ u }(‰µŒ •µ •š v U ‰rÀrd •µŒ(U ^ šµŒ š]}v ‰Œ ••µ
] PŒ u•U Zr•] PŒ u• }Œ D}oo] Œ Z Œš•U ŒÇv •• &Œ š]}vU •š u š
•š u š o •X ^š v Œ Z vl]v Ç o U Z Z š v Z P v Œ š]}v Ç o U ,
•š uU }v•µu‰š]}v Ud}vv }(Œ (Œ]P Œ š]}v

d Æš }}l•

íX E PXWX<XU ^ vP]v Œ]vP dZ Œu} Çv u] •_U d š D 'Œ Ár,]ooU E
îX zµvµ• X vP o v D] Z o X }o •U ^dZ Œu} Çv u] •W v vP]v
D 'Œ Ár,]oo óšZ]š]}v îìíìX

Z (Œ v }}l•

íX Œ}Œ XWU ^ dZ Œu} Çv u] •_U d š D 'Œ Ár,]ooU E Á oZ]U î
îX zs Z }U^ vP]v Œ]vP dZ Œu} Çv u] • šZŒ}µPZ Æ u‰o •_U hv]À
ïX ,}ou vX:XWXU ^dZ Œu} Çv u] •_U ïŒ]š]}vU D 'Œ Ár,]ooU îìì
ðXD Œ o U W}šZ ŒU Œ]P tU ^}u Œš}vU ^dZ Œu} Çv u] • (}Œ v
^ Œ] •Ud š D 'Œ Ár,]ooU E Á oZ]U îììðX
ñXZ šZ lŒ]•Zv v XU ^&µv u vš o• }(vP]v Œ]vP dZ Œu} Çv u] •_
îììñX

}µŒ• }vš vš• v > šµŒ ^ Z µo

E}	d}‰]	E}X }(> šµŒ •
í		D} µo ôí
íXí	•] }v D Œ}• }‰] v D] Œ}• }‰] À] }vš]vµµuU dZ Œu} Çv u] ^Ç•š u v }všŒ}o s}oµu U ^µŒŒ}µv]v }µv Œ] •U dÇ‰ • }(^Ç•š u•U hv]À Œ• U dZ Œu} Çv u] ‰Œ}‰ WŒ} ••U Ç o U dZ Œu} Çv u] ‹µ]o] Œ]µuU Yµ •] t •š š] WŒ ^š š U W}]vš v W šZ (µv š]}v	í
íXî	• Œ}šZ > Á }(dZ Œu} Ç t}Œ W Á}Œl v šÇ‰ • }(Á}Œl šŒ v•(ŒU Z š v Z š ‰]šÇ	î
íXï	:}µo [• Æ &]Œ•š o Á }(dZ všZ •‰ Z š•r WDDí	í
íXð	&]Œ•š o Á ‰‰o] š} E}v (o}Á WŒ} ••	ï
î		D} µo î
îXí	&]Œ•š o Á ‰‰o] š} &o}Á W o v]v •š Ç (o}Á ‰Œ} ••XX	í
îXî	‰‰o] š]}v• }(^& r: š vP]v }u‰}v vš•U	î
îXï	dŒ vš (t&]oo]v u‰šÇWŒ} ••X~WŒ} o u• šZ &]Œ•š > ÁX	î
îXð	^ }v > Á }(dZ Œu} Çv u] •U dZ Œu o Z ‰µu‰ t W Œ(}Œu v (š}Œ•U < oÀ]vrWo v l v o µ•]µ• ^š š u	î

	‹µ]À o v }(šÁ} •š š u vš•	
îXñ	Z À Œ• U/À Œ•] o WŒ} ••U µ• • }(/ŒŒ • }v o ÁU WDDî	î
îXò	Œv}š[• šZ }Œ u v]š• }Œ}oo Œ] •U d u‰ Œ šµŒ • o X	í
ï	D} µo ï	
ïXí	o µ•]µ• /v ‹µ o]š µ• • }(všŒ}‰Ç Z Z vP •]v À Œ]}µ• šZ Œu} Çv u] ‰Œ} •• •U ‰Œ]v]‰o }( ]v Œ všŒ}‰Ç v]š• ‰‰o] š]}v•U	î
ïXî	všŒ}‰Ç P v Œ š]}v]v Ç•š uU všŒ}‰Ç Z À Œ•] o] š] ‰Œ} ••r]• všŒ}‰] ‰Œ} ••	î
ïXï	À]o o v ŒPÇU À]o]o] h• (µo Á}Œ •š š U À]o]o]šÇ (µv š]}v	î
ïXð	À]o]o]šÇ v]ŒŒ À Œ•]]o]šÇ]v '}µ(^š} }o šZ }Œ u U dZ]Œ o Á }(šZ Œu} Çv u] •	î
ð	D} µo ð	
ðXí	' v Œ o dZ Œu} Çv u¦t }u]v &]Œ•š v ‘ ‹µ š]}v• t , ouZ}ošÌ v '] [• (µv š]}v• r D ÆÁ oo[• Z o š]}v•	î
ðXî	d • ‹µ š]}v•X dZ o ‰ ÇŒ}v ‹µ š]}v	î
ðXï	‹µ š]}v• (}Œ]vš Œv o v ŒPÇU všZ o‰Ç v všŒ}‰Ç	
ðXð	•‰](] Z š•U dZŒ}ššo]vP ‰Œ} ••U :}µ µŒÀ X	í
ðXñ	]Œ •š v Œ Kšš} Ç o U] • oU µ o] •š v Œ ((]] v Çru v ((š]À ‰Œ ••µŒ	ï
ñ	D} µo ñ	íì
ñXí	WµŒ ^µ •š v •U WZ • dŒ v•(}Œu š]}v•U Z vP }(‰Z • U drÀU ‰rÀ v ‰rd] PŒ u }(‰µŒ •µ •š v U •µŒ(	î
ñXî	^ šµŒ š]}v ‰Œ ••µŒ v Z v •] PŒ •] PŒ u• }Œ D}oo] Œ Z Œš•U ŒÇv •• &Œ š]}vU •š u š o •X V o µo š]}v• µ•]vP •š u š o •X	ï
ñXï	^š v Œ Z vl]v Ç o	î
ñXð	Z Z š v Z š]}'Ç o U , š Œ š U · }v•µu‰ Ud}vv }(Œ (Œ]P Œ š]}v	ï

$27	$(52'<1$0,&6 ,	&$7(*25< /	7	3	&5(',7	
		3&				

3UHDPEOH 7KH FRXUVH LV PHDQW WR JLYH WKH OHDUQHUV DQ LQ

3UHUHTXLVLWH HFKDQLFV RI)OXLGV

&RXUVH 2XWFRPHV $IWHU WKH FRPSOHWLRQ RI WKH FRXUVH WKH VW

&2	([SODLQ DQG XVH EDVLF WKHRUHPV LQ IOXLG PHFKDQLF
&2	6NHWFK WKH VWUHDP OLQH DQG HTXLSRWHQWLDO OLQH HOHPHQWDU\ IORZ FRPELQDWLRQV
&2	7UDQVIRUP WKH IORZ SDVW D ERG\ RI GHILQLWH VKDSH ERGLHV E\ XVLQJ FRPSOH[YDULDEOHV
&2	$SSO\ DLUIRLO WKHRU\ WR SUHGLFW DLU IRLO SHUIRUPD
&2	$SSO\ WKH FRQFHSWV RI SURSHOOHU WKHRU\

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV

	32	32	32	32	32	32	32	32	32	332	3232	32
&2												
&2												
&2												
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$VVHVVPHQW 3DWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW 7HVWV		(QG 6HPHVW
5HPHP			
8QGHUVWDQG			
$SS			
$QDO\VH			
(YDOXDWH			
&UHDWH			

0DUN GLVWULEXWLRQ

7RWDO 0DUNV	&,(	(6(	(6('XUDWLRQ
			KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV

&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV PDUNV

$VVLJQPHQW 4XL] &RXUVH SURMHFW PDUNV

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ 7KHUH ZLOO EH WZR SDUWV 3DUW $ D
FRQWDLQ TXHVWLRQV ZLWK TXHVWLRQV IURP HDFK PRG
6WXGHQWV VKRXOG DQVZHU DOO TXHVWLRQV 3DUW % FRQW
VWXGHQW VKRXOG DQVZHU DQ\ RQH (DFK TXHVWLRQ FDQ K
PDUNV

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

&RXUVH 2XWFRPH &2

'HULYH (XOHU HTXDWLRQ IRU D WKUHH GLPHQVLRQDO)ORZ

([SODLQ %DURWURSLF IORZ .HOYLQ¶V WKHRUHP VWUHDPO

([SODLQ *UHHQ¶V OHPPD &LUFXODWLRQ DQG 9RUWLFLW\

&RXUVH 2XWFRPH &2

'HULYH PDWKHPDWLFDO H[SUHVVLRQ IRU VWUHDP IXQFWL
OLQH

7UDFH VWUHDP OLQHV DQG HTXLSRWHQWLDO OLQHV RI
VRXUFH DQG D VLQN HTXDO VWUHQJWK LQ D IUHH VWUHDP

3URYH WKDW WKH VWUHDP IXQFWLRQ DQG HTXLSRWHQWLD

&RXUVH 2XWFRPH &2

)LQG WKH FRPSOH[YHORFLW\ RI D OLQH VRXUFH"

7UDQVIRUP D FLUFXODU F\OLQGHU LQ WR D IODW SODWH

:ULWH QRWHV RQ 0RGLILHG -RXNRZVNL¶V WUDQVIRUPDWL

&RXUVH 2XWFRPH &2

'HPRQVWUDWH %LRW DQG 6DYHUW ODZ ERXQG YRUWH[DQ

'HULYH DQ H[SUHVVLRQ IRU &O &G DFFRUGLQJ WR WKLQ D

$Q DLUSODQH KDYLQJ DQ HOOLSWLFDO ZLQJ DOO XS ZHLJK
DUHD IO\LQJ DW DQ DOWLWXGH RI ZKHUH WKH GHQVLW\ UDW
OLIW GUDJ UDWLR LV HVWLPDWH WKH SDUDVLWH GUDJ FR

&RXUVH 2XWFRPH &2

'HULYH DQ H[SUHVVLRQ IRU WKUXVW SURGXFHG E\ D SURS
WKHRU\

$Q DLUVFUHZ LV UHTXLUHG WR SURGXFH D WKUXVW RI
OHYHO ,I WKH GLDPHWHU LV P HVWLPDWH WKH PLQLPXP
EDVLV RI)URXGH¶V WKHRU\

([SODLQ WKH FKDUDFWHULVWLFV RI WXUEXOHQW IORZ

0RGHO 4XHVWLRQ SDSHU

0RGHO 4XHVWLRQ SDSHU

43 &2'(

$3- $%'8/ .$/$0 7(&+12/2*,&$/ 81,9(56,7< 7+,5' 6(0(67(5 % 7(&+ '(*5(((;$0,1$7,21

0217+ <($5

&RXUVH &RGH $27

$(52'<1$0,&6 ,

0D[0DUNV

3$57 $

$QVZHU DOO 4XHVWLRQV (DFK TXHV

&DOFXODWH WKH SUHVVXUH DW WKH VWDJQDWLRQ SRLQ
WKH VWDQGDUG VHD OHYHO FRQGLWLRQ ZLWK D YHORFL

'HULYH DQ HTXDWLRQ IRU VWUHDP OLQH LQ D ' IORZ IL

6NHWFK WKH VWUHDP OLQHV DQG HTXLSRWHQWLDO OL
XQLIRUP IORZ ILHOG"

6NHWFK WKH VWUHDP OLQH RYHU D VPRRWK F\OLQGHU D

([SODLQ & 5 HTXDWLRQ DQG ZKDW LV LWV VLJQLILFDQFH

3URYH WKDW WKH WKLFNQHVV UDWLR $\frac{t}{3} \cong 1.8\left(\frac{a}{b}-1\right)$ RI D -RNRZVNL DHU

:KDW LV HOOLSWLFDO ZLQJ" +RZ D UHFWDQJXODU SODQ
GLVWULEXWLRQ"

$ IODW SODWH LV NHSW DW DQ DQJOH RI DWWDFN . NHS
WKH YDOXH RI &/"

:ULWH WKH DVVXPSWLRQV RI)URXGH¶V PRPHQWXP WKHR

([SODLQ EULHIO\ 3RZHU FRHIILFLHQW"

3$57 %

$QVZHU DQ\ RQH IXOO TXHVWLRQ IURP HDFK PRGXOH (DFK

0RGXOH

D 'HULYH DQ H[SUHVVLRQ IRU YRUWLFLW\ LQ D ' IORZ IL

E 7KH YHORFLW\ FRPSRQHQW LQ D ' IORZ ILHOG $\frac{y^3}{x}+2x-x^2y$ DQG $2xy^2+2y-\frac{x^3}{3}$ DUH 6KRZ

WKDW WKHVH IXQFWLRQV UHSUHVHQW D SRVVLEOH FDVH RI DQ LU

D 6WDWH DQG SURYH .HOYLQV WKHRUHP"

E'HULYH DQ H[SUHVVLRQ IRU YRUDFLW\ LQ D ' IORZ ILHOG

0RGXOH

D 3URYH WKDW WKH VWUHDP OLQHV DQG WKH HTXLSRWHQWLDO

E $ VWUHDP IXQFWLRQ Ü [\ FDOFXODWH WKH YHORFLW

DQG GLUHFWLRQ RI WKH UHVXOWDQW YHORFLW\"

7KH SRWHQWLDO IXQFWLRQ $\frac{-xy^3}{3}-x^2+\frac{x^3y}{3}+y^2$)LQG WKH YHORFLW\ FRPSRQHQWV LQ

GLUHFWLRQ" $OVR ILQG LWV UHSUHVHQWDWLRQ"6KRZ WKDW RI IO

0RGXOH

7UDQVIRUP D ULJKW FLUFXODU F\OLQGHU LQ WR D IODW S

D 'HULYH DQ H[SUHVVLRQ IRU WKH IRUFHV DQG PRPHQW

ILHOG DFFRUGLQJ WR %ODVLXV WKHRUHP

E $ IODW SODWH RI P FKRUG SODFHG DW DQ DQJOH RI DV

)LQG WKH FRHIILFLHQW RI OLIW DQG UHDFWLRQ DW VHD OHY

0RGXOH

&RQVLGHU 1$&$ DHURIRLO 7KH PHDQ FDPEHU OLQH

$$\frac{Z}{C}=2.6595\left[\left(\frac{x}{c}\right)^3-0.6075\left(\frac{x}{c}\right)^2+0.1147\left(\frac{x}{c}\right)\right] \quad \text{for } 0\le\frac{x}{c}\le 0.2025$$

$$\frac{z}{c}=0.02208\left(1-\frac{x}{c}\right) \quad \text{for } 0.2025\le\frac{x}{c}\le 1$$

D 'HULYH DQ H[SUHVVLRQ IRU LQGXFHG GUDJ LQ D ILQLWH

E 'HULYH DQ H[SUHVVLRQ IRU D LQGXFHG GUDJ IRU DQ H

0RGXOH

D 'HULYH DQ H[SUHVVLRQ IRU HIILFLHQF\ RI D SURSHOOHU

$Q DLUVFUHZ RI P GLDPHWHU KDV WKH IROORZLQJ FKD

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· 4				
2				

&DOFXODWH WKH IRUZDUG VSHHG DW ZKLFK LW DEVRUEV N: D WKUXVW XQGHU WKHVH FRQGLWLRQV &RPSDUH WKH HIILFLHQF\ I GLVF RI WKH VDPH DUHD JLYLQJ WKH VDPH WKUXVW XQGHU WKH

6\OODEXV

0RGXOH

(XOHU HTXDWLRQ ,QFRPSUHVVLEOH %HUQRXOOL¶V HTXDW 9RUWLFLW\ 6WRNH¶V WKHRUHP %DURWURSLF IORZ .HOYLQ¶

0RGXOH

6WUHDP IXQFWLRQ 3RWHQWLDO IXQFWLRQ (TXLSRWHQWLD FRPELQDWLRQV ,GHDO)ORZ RYHU D FLUFXODU F\OLQGHU .XWWD FRQGLWLRQ .XWWD -XNRZVNL¶V WKHRUHP 6WDUWL URXJK F\OLQGHUV

0RGXOH

&DXFK\ 5LHPDQQ UHODWLRQV &RPSOH[SRWHQWLDO 0HWK .XWWD -XNRZVNL WUDQVIRUPDWLRQ DQG LWV DSSOLFDWLRQ

0RGXOH

7KLQ DLUIRLO WKHRU\ DQG LWV DSSOLFDWLRQV 9RUWH[ILO DQG 7UDLOLQJ YRUWH[+RUVH VKRH YRUWH[/LIWLQJ OLQH

0RGXOH

3URSHOOHU WKHRULHV ,GHDO 0RPHQWXP DQG %ODGH HO SHUIRUPDQFH RI SURSHOOHUV XVLQJ SURSHOOHU FKDUWV %

7H[W %RRNV

-RKQ ' $QGHUVRQ)XQGDPHQWDOV RI $HURG\QDPLFV WK (GLWLRQ 0F*U

(/ +RXJKWRQ 3 : &DUSHQWHU 6WHYHQ + &ROOLFRWW $HURG\QDPLFV IRU (QJLQHHULQJ VWXGHQWV

5HIHUHQFH %RRNV

$ & .HUPRGH 0HFKDQLFV RI)OLJKW 3HDUVRQ ,QGLD

- %HUWLQ $HURG\QDPLFV IRU (QJLQHHUV 3HDUVRQ (GXFD

)UDQN 0 :KLWH)OXLG 0HFKDQLFV wk HGLWLRQ 0F*UDZ +LOO

-RVHSK .DW] DQG $OOHQ 3ORWNLQ /RZ 6SHHG $HURG\QDP
0HWKRG 0F*UDZ +LOO

&RXUVH &RQWHQWV DQG /HFWXUH 6FKHGXOH

1R	0RGXOH	1R RI /HFWXUHV
	0RGXOH	
	(XOHU HTXDWLRQ ,QFRPSUHVVLEOH %HUQRXOOL¶V HTX	
	*UHHQ¶V OHPPD &LUFXODWLRQ DQG 9RUWLFLW\ 6WRN	
	%DURWURSLF IORZ .HOYLQ¶V WKHRUHP 6WUHDPOLQH	
	0RGXOH	
	6WUHDP IXQFWLRQ 3RWHQWLDO IXQFWLRQ (TXLSRWHQ IORZV DQG WKHLU FRPELQDWLRQV	
	,GHDO)ORZ RYHU D FLUFXODU F\OLQGHU '¶$OHPEHUW 0DJQXV HIIHFW	
	.XWWD FRQGLWLRQ .XWWD -XNRZVNL¶V WKHRUHP 6WD IORZ RYHU VPRRWK DQG URXJK F\OLQGHUV	
	0RGXOH	
	&DXFK\ 5LHPDQQ UHODWLRQV &RPSOH[SRWHQWLDO	
	0HWKRGRORJ\ RI FRQIRUPDO WUDQVIRUPDWLRQ .XWWD WUDQVIRUPDWLRQ DQG LWV DSSOLFDWLRQV	
	%ODVLXV HTXDWLRQ	
	0RGXOH	
	7KLQ DLUIRLO WKHRU\ DQG LWV DSSOLFDWLRQV	
	9RUWH[ILODPHQW %LRW DQG 6DYDUW ODZ %RXQG YR YRUWH[+RUVH VKRH YRUWH[	
	/LIWLQJ OLQH WKHRU\ DQG LWV OLPLWDWLRQV	
	0RGXOH	
	3URSHOOHU WKHRULHV ,GHDO 0RPHQWXP DQG %ODGH H	
	1XPHULFDO SUREOHPV RQ WKH SHUIRUPDQFH RI SURSH SURSHOOHU FKDUWV	
	%DVLFV RI WXUEXOHQW IORZ	

Kd îìò	/Z Z &d ^dZh dhZ ^ /	d 'K Z z>		d	W	Z	/d z Œ }(/všŒ} µ
		W		ïí	ì	ð	îìíõ

WŒ u dZW‰Œ]u ŒÇ P} o }(šZ]• •µ i š]• š} P]À •šµ vš• v µv Œ o u vš• v •• ŒÇ š} v oÇ•]Œ Œ (š •šŒµ šµŒ •X •] • Œ u‰Z •]ì /š]•]vš v šZ š šZ •šµ vš• •Z}Áv Z}Á š} Æš v v ‰‰oÇ šZ •šŒµ šµŒ o ‰Œ} o u• ~ u•U }oµuv•U š X•X dZ]•]v oµ • Œ or]u v•]}v o v šZŒ r]u v•]}v o • •X

WŒ Œ ‹µ]•]š W E]o

}µŒ• Kµš }u(š•WŒ šZ }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo o

K	•]Pv }(‰Œ]•u š] }u‰}v vš• µ•]v
K	^}oÀ (o š]}vµv Œ À Œ]}µ• o}]vP }v]ŀ] o u
K	h• v ŒPÇ ‰Œ]v]‰o • š} •}oÀ (}Œ v
K	v oÇ• •š š] ooÇ]v š C
K	v oÇ• •] •šŒµ šµŒ o }u‰}v vš• v •Ç•š u•

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

	WK	WK	WK	WK	WK	WK	WK	WK	WK	W íì	W íí	W íî
K	ï	ï	î	í	í							
K	ï	ï	î	í	í							
K	ï	ï	î	í	í							
K	ï	ï	î	í	í							
K	ï	ï	î	í	í							

•• ••u vš W šš Œv

o}}u[• P}	}vš]vµ}µ• •• ••u		v ^ u •š Œ Æ
	í	î	
Z u u	íì	íì	íí
hv Œ•	íì	íì	íí
‰ ?	ïì	ïì	ó
v o(			
À oµ			
Œ			

D Œl]•šŒ] µš]}v

d}š o D Œl•	/	^ ^
íñì	ñì	íìì ï Z}µŒ•

µŒ š]}v

}vš]vµ}µ• /vš Œv o À oµ š]}v W šš ŒvW

šš v v W íì u Œl•
}vš]vµ}µ• •• ••u vš d •š ~î vµu Œ•• W îñ u Œl•
••]Pvu vš lYµ]ìl }µŒ• ‰Œ}i š W íñ u Œl•

v ^ u •š Œ Æ u]v š]}v Z W Œ šš Á]šZ oW šÁ} ‰ Œš•V W Œš v W Œš X
‹µ •š]}v• Á]šZ î ‹µ •š]}v• (Œ}u Z u} µo U Z À]vP ï u Œl• (}Œ Z ‹µ
v•Á Œ oo ‹µ •š]}v•X W Œš }vš]v• î ‹µ •š]}v• (Œ}u Z u} µo }(ÁZ
vÇ }v X Z ‹µ •š]}v v Z À u Æ]uµu î •µ r]À]•]}v• v ŒŒÇ íð u Œ

}µŒ• > À o •• ••u vš Yµ •š]}v•

}µŒ• Kµš }u í ~ Kí•W

íX Æ‰o]v } š Z Œ o •Z Œ •šŒ •• šZ }ŒÇX

îX •š o u Z]v ‰ Œš]• •š š] ooÇ o} v Z • Ç] o •šŒ vPšZ }(ï
•šŒ •• •š š • (]v šZ (š}Œ }(• (šÇ µ•]vP Z }(šZ šZŒ •š š] ( ]

•Æ A óì DW ÆÇ A ïì DW

ïX Œ]À u Æ]uµu]•š}Œš]}v v ŒPÇ šZ }ŒÇX

}µŒ• Kµš }u î ~ Kî•W

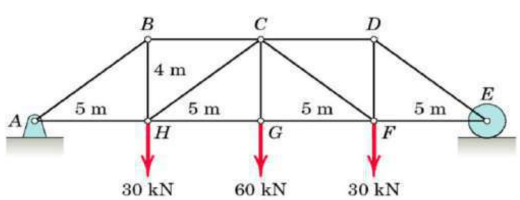
íX Œ]À]((Œ vš] o ‹µ š]}v }(šZ (o š]}v µŒÀ }(WŒ]•u š] Œ}š š]}vX

îX Œ]À šZ •Z Œ (}Œuµo }(u•X

ïX Æ‰o]v • }v u}u vš Œ šZ }Œ uX

}µŒ• Kµš }u ï ~ Kï•W

íX š Œu]v šZ (}Œ]v Z u u Œ }(šZ o} šŒµ•• Ç D šZ} }(•



î X Œ] À • š Œ] v v Œ P Ç } (v] v P (Œ } u (o š] } v (} Œ u µ o X

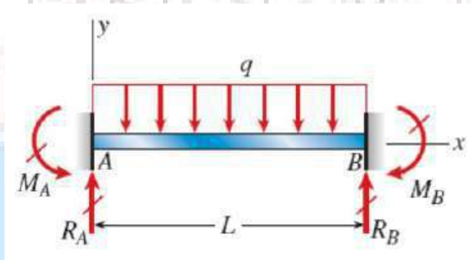
ï X Æ ‰ o] v ï š Œ µ • • • X

} µ Œ • K µ š } u ð ~ K ð • W

í X Æ ‰ o] v] ((Œ v š š Ç ‰ • } (• š š] o o Ç] v š Œ u] v š u • X

î X Æ ‰ o] v o ‰ Ç Œ } v ï u } u v š ‹ µ š] } v

ï X &] v • o } ‰ v (o š] } v } (u P] À v o } Á X



} µ Œ • K µ š } u ñ ~ K ñ • W

í X t Z] Z Œ } • • r • š] } v o • Z ‰] • š Z } ‰ š] u µ u • Z ‰ (} Œ ‰ Œ] • u š] } o

î X Œ Á µ o Œ [• µ Œ À X

ï X] ((Œ v š] š o • š] v] v o • š] } o µ u v Z À] } µ Œ X

D} o Yµ •š]}v ‰ ‰ Œ

YW K W

W: h> < > D d ,EK>K'/ > hE/s Z^/dz d,/Z ^ D ^d Z Xd , 'Z y

DKEd, ˜ z Z

}µŒ• } W Kd îìò

/Z Z &d ^dZh dhZ ^ /

D ÆXD Œl•Wíìì

W Zd

v•Á Œ oo Yµ •š]}v•X Z ‹µ •š]}v ŒŒ] • ï D Œl•

íXtZ š]• šZ •š •µ]š o šZ }ŒÇ š} •]Pv µ š]o u š Œ] oM

îXtZ š Œ šZ]•š]v š]À •š P • }(Œ ‰ ( ]oµŒ M

ïXtZ š Œ šZ o]u]š š]}v• }v šZ µ• }(•Z Œ (}Œuµo M

ðX Æ‰o]v (]Œ•š u}u vš Œ šZ }Œ uX

ñX Æ‰o]v •š]Po] v}• šZ }Œ uX

òX Œ]À šZ]((Œ vš] o ‹µ š]}v }(šZ (o š]}v µŒÀ }(š u‰ Œ šµŒ Z vP X

óXtŒ]š]((Œ vš šÇ‰ • }(•š š] ooÇ]v š Œu]v š u•X

ôXtZ š Œ ‹µ š]}v• }(}u‰ š]]o]šÇM tZÇ]•]š µ• M

õX Œ Á µo Œ[• µŒÀ (}Œ ‰]vv t ‰]vv }oµuvX

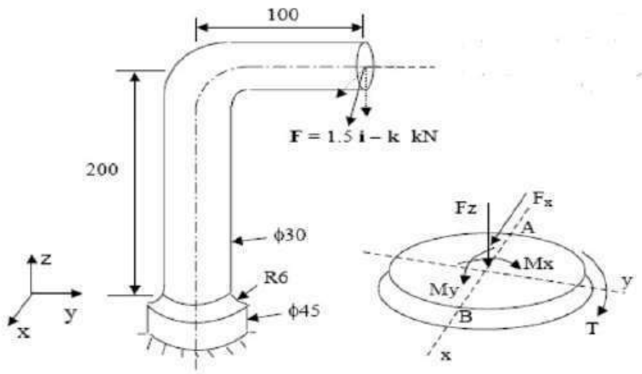
íìX Æ‰o]v •Z vo Ç šZ }ŒÇ }( ]v o •š] µ lo]vPX

W Zd

v•Á Œ vÇ }v (µoo ‹µ •š]}v (Œ}u Z u} µo X Z ‹µ •š]}v

D} µo í

ííX$ FDVW LURQ VWUXFWXUH LV ORDGHG DV VKRZQ LQ WKH VWUHQJWK RI 03D DQG \LHOG VWUHQJWK RI 03D VWUXFWXUH XVLQJ EHVW EULWWOH IDLOXUH WKHRU\



íîX Ço]v Œ] o •Z (š u }(•š o }(Ç] o •šŒ vPšZ óìì DW]
}v•]•š]vP }(v]vP u}u vš íì<Eru v š}Œ•]}v o u}u všïì <
šZ] u š Œ }(šZ •Z (š µ•]vP

/X D Æ]uµu •Z Œ •šŒ •• šZ }ŒÇ

//X D Æ]uµu •šŒ]v vŒPÇ šZ }ŒÇ

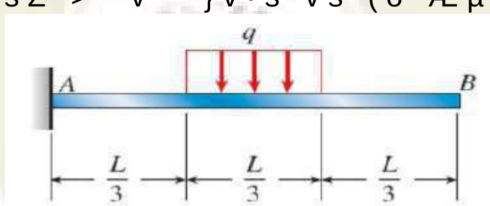
••µu]vP (š}Œ }(• (šÇ }(îX d l A îíì 'W v W}

D} µo î

íïX • Œ]À šZ]((Œ vš] o ‹µ š]}v }((o š]}v µŒÀ }(
Œ}š š]}vX

~ • Æ‰o]v šZ }vš]vµ]šÇ }v]š]}v• }(•]u‰o •µ‰‰}Œš u

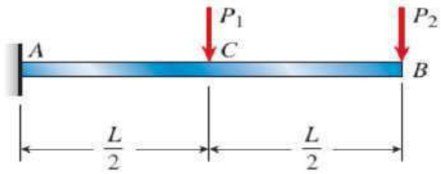
íðX • vš]o À Œ u •µ‰‰}Œš• µv](}Œu o} }( ]vš v•]š
šZ •‰ vX š Œu]v šZ (o š]}v v vPo }(Œ}š š]}v š v
u Z • o vPšZ > v }v•š vš (o Æµ Œ o Œ]P]]šÇ /X•



~ • Œ]À šZ Æ‰Œ ••]}v (}Œ •Z Œ •šŒ •• •]v Œ š vP
]•šŒ] µš]}vX

D} µo ï

íñX vš]o À Œ •µ‰‰}Œš• šÁ} }v Wš Œ W U o}•Z}Áv]v šZ
(]PµŒ X

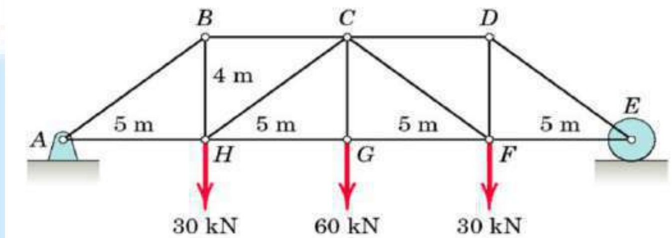


/X À oµ š šZ •šŒ]v v ŒPÇ }(šZ u (Œ}u šZ v]
šZ uX

//X À oµ š šZ •šŒ]v v ŒPÇ }(šZ u (Œ}u šZ ‹µ
(o š]}v µŒÀ X

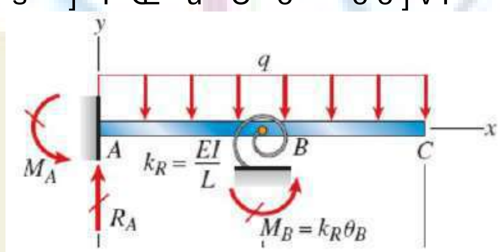
///X&Œ}u šZ •šŒ]v v ŒPÇU š Œu]v šZ (o š]}v µv

íòX š Œu]v šZ (}Œ]v Z u u Œ }(šZ o} šŒµ•• Ç D šZ

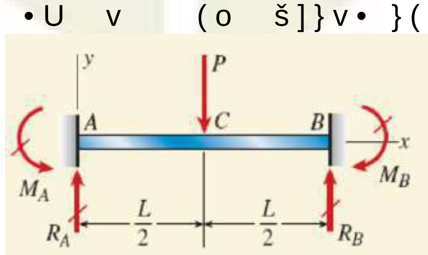


D} µo ð

íóX ‰Œ}‰‰ vš]o À Œ>]• u}}(o ÇPšZ µv](}ŒuoÇ]•šŒ] µš o}
Á]šZ]všŒ‹X • ‰]šZÇ u]• •µ‰‰}Œš o] v šŒ oÇ o •š] Œ}š š]}v o •‰
Á]šZ •š]((v ••]v ‰Œ}À] • ŒD•]µš]vP Œ}š š]}v X h• šZ
u šZ} }(•µ‰ Œ‰}•]š]}v š} •}oÀ (}Œ oo Œ š]}v•X o•} Œ
v]vPru}u vš] PŒ u•U o oo]vP ÇA/>Œ]š] o }Œ]v š •X~íð



íôXZ (]Æ r v •Z}Áv]v &]PX íìrõ •µ‰‰}ŒšW š šZ v všŒ š o}
u] ‰}]všX v oÇ• šZ]• u Ç •}oÀ]vP šZ (}µŒšZr}Œ Œ]((
(o š]}v µŒÀ ~šZ o} ‹µ š]}v•X š Œu]v šZ Œ š]}v•U
u}u vš•U •o}‰ •U v (o š]}v• }(šZ uX



D} µo ñ

íõX Œ]À]((Œ vš] o ‹µ š]}v }(}oµuv µ lo]vP }oµuv• Á]šZ %
(}Œ Œ]š] o o} X

îìX • Æ%o]v vÇ šÁ}]v o •š] µ lo]vP šZ }Œ] •X

- • Æ%o]v µo Œ[• µŒÀ X
- • ^ µ lo]vP]• •š]o]šÇ %Œ} o u_X }uu všX

^Ço o µ•

D} µo í

dZ }Œ] • }(( ]oµŒ • t /v %o v v •}oµš u Æ]uµu •Z Œ •šŒ •• •U
šZ }ŒÇU D Æ]uµu •Z Œ •šŒ •• šZ }ŒÇU D Æ]uµu %Œ]v]%o •šŒ]v š
u Æ]uµu]•š}Œš]}v v ŒPÇ šZ }ŒÇU •]Pv }(%Œ]•u š] }u%}v vš•
K š Z Œ o ^Z Œ •šŒ •• šZ }ŒÇX •]Pv P]v•š]u% š o}]vP ~/v oµ
}u%}v vš• }voÇ•U (š]Pµ U Œ % v •šŒ •• Œ o Æ š]}v ~E} vµu Œ] o

D} µo î

^Z Œ •šŒ •• •]v u• t Œ]À š]}v }(•Z Œ (}Œuµo U o]u]š š]}vU Á
]ooµ•šŒ š]À %Œ} o u• ~Œ š vPµo Œ v]Œ µo Œ Œ}•• • š]}v• }voÇ
‹µ š]}v }(šZ (o š]}v µŒÀ ~WŒ]•u š] u• Á]šZ •u oo vPo • }(
}v]š]}v v }vš]vµ]šÇ }v]š]}v•U }µ o]vš PŒ š]}v u šZ} • ~ Œ]À š]
v •]u%o •µ%%}Œš u• Á]šZ %}]vš o} }voÇ•U WŒ]v]%o }(•µ%
šZ }Œ uU • }v u}u vš Œ šZ }Œ uX

D} µo ï

^šŒ]v v ŒPÇ }(v]vP t Œ]À š]}vU]((Œ vš o}]vP }v]š]}v•X
Œ]À š]}vU Œ•]v • Œ] •U Œ•]v % Œ oo oX •š]Po] v}• šZ }Œ u t
µ• Ç v}vrµv](}Œu š u% Œ šµŒ Z vP X Wo v šŒµ•• v oÇ•]• t u
• š]}v•X ïr šŒµ•• •X

D} µo ð

^š š] ooÇ /v š Œu]v š u• t dÇ% • }(•š š] ooÇ]v š Œu]v š u•U
‹µ š]}v }(šZ (o š]}v µŒÀ U u šZ} }(•µ% Œ%}•]š]}vU o % ÇŒ
š u% Œ šµŒ ((š•X

D} µo ñ

}oµuv• t µ lo]vP v •š]o]šÇU Œ]š] o o} X }oµuv• Á]šZ ‰]vv }oµuv µ lo]vPU •}oµš]}v }(šZ]((Œ vš] o ‹µ š]}vU µo Œ o} U Œ] }(o ŒP (o š]}v•U]u‰ Œ(š]}v• v]v o •š] Z À]}µŒU }‰š]uµu Á]šZ }šZ Œ •µ‰‰}Œš]vP }v]š]}v• ~(]Æ r(Œ ˜ (]Æ r(]Æ }voÇ• t (}Œ }oµuv v • vš µŒÀ X o •š] v]v o •š] }oµuv Z À]}µŒX t D} µoµ• šZ }ŒÇU Œ µ u} µoµ• šZ }ŒÇ v •Z vo Ç šZ }ŒÇ

d Æš }}l•

íX : u • ' Œ ˜ ŒŒÇ '}} v}U ^D Z

îX dX,X'X D]Œ• }ŒU(š ^šŒµ šµŒ • (}Œ_U P À] Œ]vP Œ}•‰ vš•vP]v Œ]vPU &}µŒšZ]š]}vU îìíóX

Z (Œ v }}l•

íX µšo ŒU :X hv Œ•š v]vP]Œ Œ (š ^šŒµ šµŒ •U &}µŒšZ]š]}vX

îX &o oU :X X WŒ š] o ^šŒ •• v oÇ•]• (}Œ •]Pv vP]v Œ•X > l]

ïX v /všŒ} µ š]}v š} Œ}•‰ ^šŒµ šµŒ o v oÇ•]•U ,]•o ŒU t]o ÇU

ðX dZ }ŒÇ }(o •š] ^š]o]šÇU d]u}•Z vl} ~ v ' Œ •U D 'Œ Ár,]ooU íõ

}µŒ• }vš vš• v > šµŒ ^ Z µo

E}	d}‰]	E}X }(> šµŒ •
í	D} µo í	d}š oW õ
íXí	dZ }Œ] • }(t/v ‰ov •}oµš u Æ]uµu •Z D Æ]uµu ‰Œ]v]‰o •šŒ •• šZ }ŒÇU D Æ]uµu •Z Œ •šŒ •• šZ]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	î
íXî	D Æ]uµu ‰Œ]v]‰o •šŒ]v šZ }ŒÇU d}š]•š}Œš]}v v ŒPÇ šZ }ŒÇ r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	î
íXï	•]Pv }(‰Œ]•u š] }u‰}v vš• µv]ooµ•š vµu Œ] o Æ Œ]•	í
íXð	•]Pv }(‰Œ]•u š] }u‰}v vš• µv Æš v ‰Œ} o u •}oÀ]vP	í
	K š Z Œ o ^Z Œ]ooµ•šŒ š]À Œ	í
íXñ	•]Pv P]v•š o}]vP ~/v oµ]]ooµ•š vµu Œ] o Æ Œ]•	í
íXò	(š]Pµ U Œ ‰ v •šŒvµ Œ	í
î	D} µo î	d}š oW íì
îXí	^Z Œ •šŒ •• • t Œ]À š]}v }(•Z Œ (}Œ	í

	Á Œ‰]vP µ š}	
îXî	]ooµ•šŒ š]À ‰Œ} o u• ~ Œ š vPµo Œ	í
îXï	(o š]}v }(t]((Œ vš] o ‹µ š]}v }(šZ ~WŒ]•u š] u• Á]šZ •u oo vPo • }(Œ}š š]}v }voÇ•U }µv }v]š]}v v }vš]vµ]šÇ }v]š]}v•	í
îXð	}µ o]vš PŒ š]}v u šZ} • ~ Œ]À š]}v• •]u‰o •µ‰‰}Œš u• Á]šZ ‰}]vš o} }voÇ•U	í
îXñ	WŒ]v]‰o }(·]ooµ•šŒ š]À vµu	í
îXò	WŒ]v]‰o }(· Æš ‰Œ} o u	í
îXó	(]Œ•š u}u vš Œ]ooµ•šŒ š]À vµu	í
îXô	(]Œ•š u}u vš Œ Æš v ‰Œ} c	í
îXõ	• }v u}u vš Œ]ooµ•šŒ š]À vµu	í
îXíì	• }v u}u vš Œ Æš ‰Œ} o u	í
ï	D} µo ï	d}š oW õ
ïXí	^šŒ]v v ŒPÇt Œ]À š]}vU]((Œ vš	í
ïXî	^šŒ]v v ŒPÇ t Œ]À š]}vU]((Œ vš]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	í
ïXï	^šŒ]v v ŒIvIt Œ]À š]}vU Œ•]v • Œ	í
ïXð	•š]PošZ }Œt ‰‰o]	î
ïXñ	(o š]}v }(u µ µv](}Œu š u‰ Œ	í
ïXò	Wo v šŒµ•t u šZ} }(i}]vš•U u šZ	î
ïXó	ï šŒµ	í
ð	D} µo ð	d}š oW íì
ðXí	^š š] ooÇ /v š Œut dÇ‰ • }(•š š] ooÇ u•	í
ðXî	v oÇ•]• Ç šZ]((Œ vš] o ‹µ š]}]ooµ•š vµu Œ] o Æ Œ]•	í
ðXï	v oÇ•]• Ç šZ]((Œ vš] o ·}v µ Æš v ‰Œ} o u •}oÀ]vP	î
ðXð	u šZ} }(•µ‰]ooµ•šŒ š]À vµu	î
ðXñ	o ‰ ÇŒ}v ï u}u v]ooµ•šŒ š]À vµu	í
ðXò	o ‰ ÇŒ}v ï u}u v Æš v ‰Œ} c	î
ðXó	š u‰ Œ šµš	í
ñ	D} µo ñ	d}š oW õ
ñXí	}oµut µ lo]vP v •š]o]š	í
ñXî	}oµuv• Á]šZ ‰ t]((Œ vš] o ‹µ š]}v }(•}oµš]}v }(šZ]((Œ vš] o ‹µ š]}vU µo Œ o} U Œ]š] o •šŒ ••	í
ñXï	µo Œ[• µŒÀ U ((š• }(o ŒP Z À]}µŒU }‰š]uµu •Z ‰ }(}oµuv•X	í

ñ X ð	} o µ u v • Á] š Z } š Z Œ • µ ‰ ‰ } Œ (Œ ˜ ( ] Æ . t ((š] À o v P š Z X	î
ñ X ñ	^ v š (} Œ u µ o (} Œ } o µ u v v • v š µ Œ À X	í
ñ X ò	o • š] v] v o • š] } o µ u v Z À] } µ Œ	í
ñ X ó	/ v o • š] t d v P t D } µ o µ • š Z } Œ Ç U Œ µ v • Z v o Ç š Z } Œ Ç X	î

K>îìî	ZK zE D/ ^ E &>/',d D ,	E/d^ 'K Z	:	(	\	Z /
		W		ì	ì	ï î

WŒ u o}W }(šZ]• }µŒ•]• š} ‰Œ}À] ‰Œ š] o lv}Áo P]v (µv u
P }u šŒ] o ‰Œ}‰ Œš] • v š} À]•µ o]Ì šZ (o}Á v ‰Œ ••µŒ]•šŒ]

WŒ Œ ‹µ]•]š W D •]Z W] • }(&o]PZš v]Œ Œ (š •] •

}µŒ• Kµš }u • (š Œ šZ }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo o

K	š Œu]v šZ Œ} Çv u] (}Œ • v u}u vš• Æ‰ Œ}] •
K	s]•µ o]Ì o}Á v ‰Œ ••µŒ]•šŒ] µš]}v
K	À oµ š Ào š Œ o v o}vP]šµ]v o •š]o]
K	u}v•šŒ š •š] v]š• Œ

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

	Wk	Wk	Wk	Wk	Wk	Wk	Wk	Wk	Wk	W íì	W íí	W íî
K	ï	î	î	î					î			î
K	ï	î	î	î					î			î
K	ï	í	í	î					í			î
K	ï	í	í	î					í			î

•• ••u vš W šš Œv

D Œl]•šŒ] µš]}v

d}š o D Œl•	/	^	^ µŒ š]}v
íñì	óñ	óñ	îXñ Z}µŒ•

}vš]vµ}µ• /vš Œv o À oµ š]}v W šš ŒvW

šš v v W íñ u Œl•
}vš]vµ}µ• •• ••u vš W ïì u Œl•
/vš Œv o d •š ~/uu] š oÇ (}Œ šZ • }v • Œ] • š •š• W ïì u Œl•

v ^ u •š Œ Æ u]v š]}v W šš Œv dZ (}oo}Á]vP Pµ] o]v • •Z}µo (}oo}Á Œ P Œ
u Œl•
~ • WŒ o]u]v ŒÇ Á}Œl W
~ • /u‰o u vš]vP šZ Á}Œll }v µ š]vP šZ Æ‰ Œ]u vš
~ • W Œ(}Œu v U Œ •µoš v]v(Œ v ~µ• P }(‹µ]‰u vš• v šŒ}µ o
~ • s]À À} W îì u
~ • Z }Œ W ñ D Œ

>/^d K& yW Z/D Ed^

íX o] Œ š]}v }(•µ •}v] t]v šµvv oX

îX š Œu]v š]}v }(>](šU Œ PU ^] (}Œ }(^Çuu šŒ] o Œ}(}]o

ïX š Œu]v š]}v }(>](šU Œ PU ^] (}Œ }(u Œ Œ}(}]o

ðX š Œu]v š]}v }(D}u vš• š]vP }v ^Çuu šŒ] Œ}(}]oX

ñX WŒ ••µŒ]•šŒ] µš]}v }À Œ •u}}šZ v Œ}µPZ]Œ µo Œ Ço]v Œ

òX WŒ ••µŒ]•šŒ] µš]}v }À Œ •Çuu šŒ] v u Œ Œ}(}]o

óX &o}Á À]•µ o]Ì š]}v •šµ] •]v Œ}(}]oX

ôX &o}Á À]•µ o]Ì š]}v •šµ] •]v Ço]v ŒU &o š Wo š •X

õX &o}Á À]•µ o]Ì š]}v •šµ] •]v À Œ]}µ• u} o• ~]Œ Œ (šU Œ• š X•

íìX &o}Á À]•µ o]Ì š]}v µ•]vP , o r•Z Á ‰‰ Œ šµ•X

ííX š Œu]v š]}v }(šZ ((š }(•‰ }v šš]šµ (}Œ o À o (o]PZš ˜ •š

íîX D •µŒ u vš }(šZ o](š µŒÀ (}Œ šZ Á]vP µ‰ š} ˜ Ç}v •š ooX

íïX š Œu]v š]}v }(v µšŒ o •š]o]šÇ ˜ ‰o}š šŒ]u µŒÀ •X

íðX u}v•šŒ š]}v }(‰ZµP}] u}š]}v]v š Œu• }(oš]šµ X

íñX u}v•šŒ š]}v }(•Z}Œš ‰ Œ]} }•]oo š]}v µ š} •µ v]•šµŒ v

íòX š Œu]v š]}v }(D Z E}X }(•µ‰ Œ•}v] Á À • µ•]vP t]v dµvv oX

íóX ^šµ Ç }((o}Á À]•µ o]Ì š]}v Ç ^ ,>/ Z E D šZ} X

E}š W u]v]uµu }(íì Æ‰ Œ]u vš• Œ u v š}ŒÇ

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		3&				

3UHDPEOH 7R LQWURGXFH WKH FRQFHSW RI GHVLJQ DQG GUDIWLQJ
YDULRXV VRIWZDUH SDFNDJHV $IWHU WKH FRPSOHWLRQ RI WKLV
GUDIW EDVLF PHFKDQLFDO DQG DHUR FRPSRQHQWV

3UHUHTXLVLWH (QJLQHHULQJ *UDSKLFV

&RXUVH 2XWFRPH $IWHU WKH FRPSOHWLRQ RI WKH FRXUVH WKH VWXGHQ

&2	6XPPDULVH ' ' PRGHOOLQJ VRIWZDUH
&2	'UDZ VLPSOH MRLQWV LQ PRGHOOLQJ VRIWZDUH
&2	&UHDWH PRGHOV RI GLIIHUHQW FRQWURO FRPSRQHQWV
&2	'UDZ ' PRGHOV RI FULWLFDO DLUFUDIW FRPSRQHQWV
&2	6NHWFK VXUIDFH PRGHO RI FULWLFDO VKDSH FRPSRQHQ

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV

	32	32	32	32	32	32	32	32	32	32	32	32
&2												
&2												
&2												
&2												
&2												

$VVHVVPHQW 3DWWHUQ

0DUN GLVWULEXWLRQ

7RWDO 0DUNV	&,(	(6(	(6('XUDWLRQ
			KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW PDUNV
,QWHUQDO 7HVW ,PPHGLDWHO\ EHIRUH WKH VHFRQG VHULHV WHV

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ 7KH IROORZLQJ JXLGHOLQHV VKRXOG EH IRO
RI PDUNV
D 3UHOLPLQDU\ ZRUN

E ,PSOHPHQWLQJ WKH ZRUN &RQGXFWLQJ WKH H[SHULPHQW
F 3HUIRUPDQFH UHVXOW DQG LQIHUHQFH XVDJH RI HTXLSPHQW
G 9LYD YRFH P
H 5HFRUG 0DU

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

&2 6XPPDULVH ' ' PRGHOOLQJ VRIWZDUH

'UDZ WKH IURQW YLHZ RI DQ DLUFUDIW E\ XVLQJ ILUVW DQ

&2 'UDZ VLPSOH MRLQWV LQ PRGHOOLQJ VRIWZDUH

D 'HVLJQ DQG GUDIW ULYHWHG MRLQW E\ XVLQJ ODS MRL

E ([SODLQ LQ GHWDLO DERXW WHUPLQRORJLHV XVHG LQ

D 'HVLJQ DQG GUDIW ULYHWHG MRLQW E\ XVLQJ EXWW M

E :KHWKHU EXWW MRLQW RU ODS MRLQW LV PRUH HIILFL

D 'HVLJQ DQG GUDIW ZHOGHG MRLQW E\ XVLQJ EXWW MRL

E ([SODLQ LQ GHWDLO DERXW YDULRXV FODVVHV RI ZHOG

&2 &UHDWH PRGHOV RI GLIIHUHQW FRQWURO FRPSRQHQWV

D 'UDZ DQG 'HVLJQ D EHOO FUDQN

E ([SODLQ LQ GHWDLO DERXW VWUXFWXUDO FRPSRQHQW

&2 'UDZ ' PRGHOV RI FULWLFDO DLUFUDIW FRPSRQHQWV

'UDZ DQG GHVLJQ RI WXUELQH EODGH ZLWK JHRPHWULF X
ZLWK D VXLWDEOH WZLVW DQJOH

&2 6NHWFK VXUIDFH PRGHO RI FULWLFDO VKDSH FRPSRQH

D 'UDZ DQG GHVLJQ RI WDSHUHG VZHSW ZLQJ ZLWK JHRP
1$&$ DHURIRLO DW URRW DQG 1$&$ DHURIRLO DW WL
UDWLR

E :ULWH GRZQ DQ\ GLIIHUHQFHV EHWZHHQ PRQRFRTXH DQ

'UDZ WKH OD\RXW RI VHPL PRQRFRTXH IXVHODJH VWUXF
EXONKHDG VWULQJHUV DQG VSDUV

/,67 2) (;3(5,0(176

,QWURGXFWLRQ WR $HURQDXWLFDO &$' ' VNHWFKHU

'HVLJQ DQG GUDIWLQJ RI ULYHWHG MRLQWV

'HVLJQ DQG GUDIWLQJ RI ZHOGHG MRLQWV

'HVLJQ DQG GUDIWLQJ RI YLHZ GLDJUDP RI DQ DLUFUDIW

'HVLJQ DQG GUDIWLQJ RI FRQWURO FRPSRQHQWV EHOO F

'HVLJQ DQG GUDIWLQJ RI FRQWURO FRPSRQHQWV JHDU

'HVLJQ DQG GUDIWLQJ RI FRQWURO FRPSRQHQWV FDP

'HVLJQ DQG GUDIWLQJ RI FRQWURO FRPSRQHQWV SXVK SX

'HVLJQ DQG GUDIWLQJ RI FRQQHFWLQJ URG

/D\RXW RI DLUFUDIW ODQGLQJ JHDU

'HVLJQ RI WXUELQH EODGHV ZLWK WZLVW

'HVLJQ RI VHFWLRQ RI IXVHODJH %XONKHDG VWULQJHUV I

'HVLJQ RI WDSHUHG ZLQJ ZLWK JHRPHWULF DQG DHURG\QD

'HVLJQ RI WDSHUHG VZHSW ZLQJ ZLWK JHRPHWULF DQG DH

DHURIRLOV

1RWH $ PLQLPXP RI   H[SHULPHQWV DUH PDQGDWRU\

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WŒ u o W

dZ P} o }(šZ }µŒ•]• š} P]À •šµ vš• •] µv Œ•š v]vP }(u Z v] •

WŒ Œ ‹µ]•]š W

E/>

}µŒ• Kµš }u • WŒ šZ }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo o

K	Æ‰ •] }(}v• ŒÀ š]À ‹µ š]}v• v
K	‰‰oÇ]Œ(}]o šZ }ŒÇ š} ‰Œ] š](
K	o µv Œ•š v ‰ Œ(}Œu
K	‰‰oÇ šZ u v} µÀŒ]vP }(Z Œ š (
K	‰‰oÇ šZ }v ‰š•

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

	WK	WK	WK	WK	WK	WK	WK	WK	WK	W íì	W íí	W íî
K	ï	î										
K	ï	î	í									
K	ï	î	î									
K	ï	î	í									
K	ï	î										

•• ••u vš W šš Œv

o}}u[• š	}vš]vµ}µ• •• ••u		v ^ u •š Œ Æ
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v o			
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D Œl]•šŒ] µš]}v

d}š o D	Œl•	/	^ ^
íñì	ñì	íìì	ï Z}µŒ•

µŒ š]}v

îX WŒ}À šZ š šZ ‰Œ ••µŒ]((Œ v Œ}•• šZ }µv ŒÇ o Ç Œ]• v

ïX • Œ] šZ Z Œ š Œ]•š] • }(šµŒ µo vš (o}ÁX

D} o Yµ •š]}v ‰ ‰ Œ

YW K W

DKEd, ˜ z Z

}µŒ• } W Kdîôî

&hE D Ed >^ K& ZK zE D/ ^

D ÆXD ŒI•Wíìì

W Zd

v•Á Œ oo Yµ •š]}v•X Z ‹µ •š]}v ŒŒ] • ï D ŒI•

íX Œ]À ‹µ š]}v (}Œ •šŒ uo]v]v ïr (o}Á (] o X

îX^I š Z šZ •šŒ uo]v v ‹µ]‰}š vš] o o]v • }(•}µŒ v •]

ïXtZ š Œ šZ ••µu‰š]}v• u (}Œ šZ]v Œ}(}]o šZ }ŒÇM

ðX Æ‰o]v šZ o](š]vP o]v šZ }ŒÇ v]š• o]u]š š]}v•M

ñX Æ‰o]v ÁZ š]•]v] š]Œ•‰ v šŒµ]Œ•‰ M

òX^I š Z v ÁŒ]š šZ }v]š]}v (}Œ •š Ç o À o (o]PZšM

óXtZ š Œ šZ (}Œ • š]vP }v šµŒv]vP (o]PZšM /v] š]š Á

ôX Œ] (oÇ Æ‰o]v šZ u}š]}v }(v]Œ Œ (š }µš šZŒ Æ]• Á

õXtZ š Œ šZ ••µu‰š]}v• (}Œ ‰Œ}‰ oo Œ šZ }ŒÇM

íìX^I š Z šZ }µv ŒÇ o Ç Œ v]v] š]u‰}Œš vš ‰Œ}(]o •M

W Zd

v•Á Œ vÇ }v (µoo ‹µ •š]}v (Œ}u Z u} µo X Z ‹µ •š]}v Œ

D} µo í

ííX • Œ]À µo Œ[• ‹µ š]}v v Z v µ Œv}µoo][• ‹µ š]}v

~ •X •}µŒ v •]vI }(‹µ o •šŒ vPšZ]• ou}•š o}• š} Z

Œ]À v Æ‰Œ ••]}v (}Œ šZ •š Pv š]}v •šŒ u o]v~ó} (}Œ šZ }u

íîX WŒ}À šZ š šZ •šŒ u o]v • v ‹µ]‰}š vš] o o]v • Œ oÁ Ç
• ^l š Z šZ •šŒ uo]v • }À Œ •‰]vv]vP Ço]v Œ µv Œ]((Œ
~ð•

D} µo î

íïX Œ]À v Æ‰Œ ••]}v (}Œ šZ } ((] vš }(o](š (}Œ v Œ}(
šZ }ŒÇ

íðX v]Œ‰o v Z À]vP v oo]‰š] o Á]vP oo µ‰ Á]PZš]• ñìì
Á]vP Œ î (ïìÇ]vP š v oš]šµ ÁZ Œ šZ v•]šÇ Œ š]} }(ìXò š
o](šl Œ P Œ š]}]• íì •š]u š ‰ Œ •]š Œ P }(([vš }(šZ]Œ‰o

D} µo ï

íñX Œ]À v Æ‰Œ ••]}v (}Œ À o}]šÇ }ŒŒ •‰}v]vP š} u]v]u
(o]PZšM tZ š]• šZ }v]š]}v (}Œ u]v]uµu Œ PM ^l š Z šZ l s
]((Œ vš Œ P• v]u‰}Œš vš ‰}]vš•

íòX • v]Œ Œ (š Z • Á]vP î o v]v• }(Œ îPìì%}o Œ ‹µ š]}v]•
ìXíò=ìXìñîX o µo š]š• u Æ]uµu o](š š} Œ P Œ š]}U šZ u]v]uµ
}ŒŒ •‰}v]vP š} •‰ }(íììul•M

D} µo ð

íó~ • Œ]À v Æ‰Œ ••]}v (}Œ šZ À o}]šÇ šµŒvU u]v]uµu Œ]
(}Œ •š Ç šµŒv]vP (o]PZš
~ •tZ š Œ šZ o]u]š š]}v• }v šµŒv

íôX &}Œ v]Œ Œ (š P]À v Á]vP o}]vP îìlPl•‹ uU šZ îU Œ P ‰}o Ç
(]v šZ (•š •š vPo }(Po] U šZ Œ š }(•]vl (}Œ Po] ‰ šZ
Œ š }(•]vl (}Œ Po] ‰ šZ vPo }(íì P š v oš]šµ }(òììu

D} µo ñ

íõ Œ]À v Æ‰Œ ••]}v (}Œ šZ (([v Ç }(‰Œ}‰ oo Œ }Œ
šZ }ŒÇ sv

îìX • Æ‰o]v Á]šZ •µ]š o •l š Z • }µv ŒÇ o Ç Œ šZ] lv ••M

~ •]• µ•• šZ Z Œ š Œ]•š] • }(šµŒ µo vš (o}Á •

}µŒ• }vš vš• v > šµŒ ^ Z µo

E}	d}‰]	E}X }(> šµŒ •
í	D} µo í	
íXí	µo Œ ‹µ š]}v U/v }u‰Œ ••] o Œv}µ o o][• ‹µ š]}v]Œ µo v s}Œš] •U ^šŒ uo]v U	ï
íXî	^šŒ u (µv š]}vU /ŒŒ}š š]}v o (o}ÁU W}š vš] o (µv š]}vU ‹µ]‰}š vš] o o]v U o u vš ŒÇ (o}Á• v šZ]Œ }u]v š]}v•~Z vl]v Z o(} ÇU v Z vl]v (µoo } Ç•	ð
íXï	/ o &o}Á }À Œ]Œ µo Œ Ço]v ŒU [o u Œš[• ‰ Œ }Á ((šUX	î
î	D} µo î	
îXí	dZ]v]Œ(}]o šZ }ŒÇ v]š• ‰‰o] š]}v•	î
îXî	s}Œš Æ (]o u vš]}š v ^ À Œš o Á U }µv À}Œš Æ v d À}Œš ÆU ,}Œ• •Z} À}Œš ÆU	ï
îXï	>](š]vP o]v šZ }ŒÇ v]š• o]u]š š]}v•	ïX
ï	D} µo ï	
ïXí	D •µŒ u vš }(•‰ ˜ D Z vµu ŒU dŒ µ U /v] š v ‹µ]À o vš]Œ •‰ U ^šŒ uo]v v oµ((}] •U s Œ]}µ• d }(Œ P]v]Œ‰o v •U Œ P ‰}o Œ µŒÀ U D šZ} • }(Œ P }( ]Œ‰o v •X	ð
ïXî	Œ} (}]o Z Œ š Œ]•š] • v •Çu }o•X	ï
ïXï	^šŒ]PZš v o À o (o]PZšU dZŒµ•š Œ ‹µ]Œ v À]o o U Œ ‹µ]Œ v À]o o U ((š }(oš]šµ }v šZŒµ•š v ‰}Á Œ ‹µ]Œ U D v]š• ((š•X D v Œ} Çv u] Z Œ X }v]š]}v• (}Œ u]v]uµu Œ P v u]v]uµu ‰}Á Œ Œ ‹µ]Œ	ð
ð	D} µo ð	
ðXí	'o]]vP v o]u]vP (o]PZšU Z vP v î v µŒ v X	î
ðXî	d I r}((v o v]vP ‰ Œ(}Œu v U dµŒv]vP ‰ Œ(}Œu v U ,}Œ]Ì}vš o v À Œš] o šµŒv	ï
ðXï	D}š]}v }µš šZŒ Æ] • •µ Z • ‰]š Z ŒZ}oo Ç Á v]š• }v}Œ] µš]}v }(À Œ]}µ• }u‰}v vš•U]o Œ}v }vš Œ}o ‰}Á Œ	ï
ñ	D} µo ñ	
ñXí	}µv ŒÇ oÇ Œ v }µv ŒÇ oÇ Œ šZ] lv ••U]•‰o u vš šZ] lv ••U D}u všµu šZ] lv ••U v ŒPÇ šZ] lv ••U ^Z ‰ ‰ Œ u š ŒU	ð
ñXî	}µv ŒÇ oÇ Œ ‹µ š]}v• (}Œ •š Ç šÁ}]u v•]}v o]v }u‰Œ ••] o (o}ÁU WŒ}‰ oo Œ šZ }ŒÇX	ð
ñXï	•] • }(šµŒ µo vš (o}ÁX	í

K	KhZ^ E D	d 'KZ	:	(	\	Z /
Kd î ô ð	WW>/ d, ZDK zE D/	^ s	ï	í	ì	ð

WŒ u o} W }(šZ]• }µŒ•]• š} Æ‰}•‹µšZš]•šš]Àvš•vš}ÇšZ• }(u Z]v v ‰Œ} •• • (}Œ šŒ v•(}Œu š]}v }(v ŒX‰ ÇÁ• š(ÁšZ Œ]µŒ lÇvu]Z• šÁ}µo o š} ‹µ vš](Ç šZŒ}µPZ u •µŒ u vš }(Œ o š ‰Œ}‰ Œš] •U š} šZ • v o•} À o}‰ •]]Œ Ç o X (š Œ šZ]• }µŒ• •šµ vš• Á]oo ‰Œ} o u•]v Œ orÁ}Œo •]šµ š]}v• v Œ •‰}v }Œ]vPoÇX

}µŒ• Kµš }u • (š Œ šZ }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo o š

K	À oµ š šZ À Œ]}µ• šZ Œu} Çv u] Œ
K	v oÇ• v •}oÀ šZ ‰Œ} o u• ((o}Á ‰
K	v oÇ• šZ]Œ • ‹
K	/oo µ•šŒ š }v]š]}v }(
K	v oÇ• šZ ‰Œ}‰ Œš]

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

	WK	WK	WK	WK	WK	WK	WK	WK	WK	W íì	W íí	W íî
K	ï	ï										
K	ï	ï	î									
K	ï	ï										
K	ï	ï	î									
K	ï	ï	î									

•• ••u vš W šš Œv

o}}u[• š	}vš]vµ}µ• •• ••u		v ^ u •š Œ Æ
	í	î	
Z u u	íì	íì	íì
hv Œ•	îì	îì	îì
‰	îì	îì	ó
v o			
À oµ			
Œ			

D Œl]•šŒ] µš]}v

d}š o D Œl•	/	^	^ µŒ š]}v
íñì	ñì	íìì	ï Z}µŒ•

}vš]vµ}µ• /vš Œv o À oµ š]}v W šš ŒvW

šš v v W íì u Œl•
}vš]vµ}µ• •• ••u vš d •š ~î vµu Œ•• W îñ u Œl•
••]Pvu všlYµ]Ìl }µŒ• ‰Œ}i š W íñ u Œl•

v ^ u •š Œ Æ u]v š]}v W dZ WŒ šš ÁŒ]š v W šÁ} ‰ Œš•V W Œš v W Œš X
‹µ •š]}v• Á]šZ î ‹µ •š]}v• (Œ}u Z u} µo U Z À]vP ï u Œl• (}Œ Z ‹µ
v•Á Œ oo ‹µ •š]}v•X W Œš }vš]v• î ‹µ •š]}v• (Œ}u Z u} µo }(ÁZ
vÇ }v X Z ‹µ •š]}v v Z À u Æ]uµu î •µ r]À]•]}v• v ŒŒÇ íð u Œ

}µŒ• > À o •• ••u vš Yµ •š]}v•

}µŒ• > À o •• ••u vš Yµ •š]}v•

}µŒ• Kµš }u í ~ Kí•W À oµ š šZ À Œ]}µ• šZ Œu} Çv u] Œ o š]}v

íX >]•š }µš šZ D ÆÁ oo[• ‹µ š]}v

îX Æ‰o]v šZ µ• • }(všŒ}‰Ç]v Œ •

ïX Œ]À šZ o µ•]µ• t o ‰ ÇŒ}v ‹µ š]}v

}µŒ• Kµš }u î Œ]š Œ]} v oÇ• šZ ‰Œ} o u v •}oÀ šZ ‰Œ} o u•
v v}vr(o}Á ‰Œ} ••

íXHULYH DQ H[SUHVVLRQ IRU VWHDG\ IORZ HQHUJ\ HTXDWLRQ

îX$ PULJLG WDQN LQLWLDOO\ FRQWDLQV DLU DW FRQVWDQW WHPSHUDWXUH WR D
.3D DQG 7KH YDOYH LV RSHQHG DQG DLU LV DOORZHG WR HQ
WDQN UHDFKHV WKH OLQH SUHVVXUH DW ZKLFK WKH YDOYH LV FO
LQGLFDWHV WKDW DLU WHPSHUDWXUH LQ WKH WDQN LV WKDW RI WKH
WDQN E WKH DPRXQW RI KHDW WUDQVIHU

ïX Œ]À

$$dQ = \left[\frac{\gamma-n}{\gamma-1}\right] x \; polytropic \; work$$

$$C_n = C_v\left[\frac{\gamma - n}{1-n}\right]$$

}µŒ• Kµš }u ï ~ Kï•W šZ]Œ •š v Œ Ç o

íX }u‰ Œ Kšš}U] • o v µ o Ç o

îX }u‰ Œ Œ Çš}v v Z vl]v Ç o •

ïX šZ Œu o ‰}Á Œ ‰o vš }‰ Œ š]vP }v v] o Z vl]v Ç o Z • u
šZŒ}µPZ]šX t š Œ]• (š} šZ }]o Œ š ñì Œ v o À • šZ }v v• Œ
ŒX dZ u•• (o}Á Œ š }(}}o]vP Á š Œ šZŒ}µPZ šZ }v v• Œ]• ñìì

vš Œ• šZ }v }v• Œ oš ïÀ • Xš ðò µo š šZ š u‰ Œ šµŒ š ÁZ] Z •š u
šZ šµŒ]v U šZ šZ Œu o ((]] v Ç }(šZ ‰}Á Œ ‰o vš v šZ ‰}Á Œ

}µŒ• Kµš }u ðoo•µKšŒWš }v]š]}v }(Á}Œl]vP u]µu

íXÆ‰o]v ^ l ((š Á]šZ šZ Z o‰ }(v š] PŒ u

î6KRZ WKDW WKH ILUVW ODZ RI WKHUPRG\QDPLFV OHDGV WR WKH
WKHUPRG\QDPLF V\VWHP´

ïXHILQH VSHFLILF KHDW 'HULYH D UHODWLRQ EHWZHHQ VSHFLILF

}µŒ• Kµš }u ñ ~ Kñ•W v oÇ• šZ ‰Œ}‰ Œš] • }(‰µŒ •µ •š v

íX]• µ•• šZ Wrd] PŒ u (}Œ ‰µŒ •µ •š v

îX ‰Œ ••µŒ }}l Œ }vš]v• íXñ <P }(• šµŒ š •š u š ñ ŒX &]v
Œ i š •} • š} Œ µ šZ ‹µ o]šÇ š} òì9 ŒÇX š Œu]v šZ ‰Œ ••
•š u š šZ v Á •š š

ïX šZ Œu o ‰}Á Œ ‰o vš }‰ Œ š]vP }v v] o Z vl]v Ç o Z • u •
]šX t š Œ]• (š} šZ }]o Œ š ñì Œ v o À • šZ }v v• Œ • • šµŒ
u •• (o}Á Œ š }(}}o]vP Á š Œ šZŒ}µPZ šZ }v v• Œ]• ñìì <Pl•X dZ
}v v• Œ š vïì o À • Xš ðò µo š šZ š u‰ Œ šµŒ š ÁZ] Z •š u vš Œ
šZ šZ Œu o ((]] v Ç }(šZ ‰}Á Œ ‰o vš v šZ ‰}Á Œ }µš‰µš }(šZ

D} o Yµ •š]}v W ‰ Œ

YW K W

E u Wzzzzzzzzzzzzzzzzz

W: h> < > D d ,EK>K'/ > hE/s Z^/dz &/Z^d ^ D ^d Z Xd , 'Z y
DKEd,˜z Z

WW>/ d, ZDK zE D/ ^

}µŒ• } W Kd îôð

D ÆX D Œl•W íìì

W Œš

~ v•Á Œ oo ‹µ •š]}v•V Z ‹µ •š]}v ŒŒ] • ï u Œl••

íX Æ‰o]v :}µo • Æ‰ Œ]u vš Á]šZ šZ Z o‰ }(v š] PŒ uX

š u‰ Œ šµŒ •v}(rðïK dZ Z š šŒ v•(Œ š} šZ Z š vP]v]• îììì<i
Á}Œl }µš‰µš }(šZ }u]v vP]v Œ (Œ]P Œ š}Œ ‰o vš]• ïòì <:

~ •À oµ š šZ Z š šŒ v•(Œ š} šZ Œ (Œ]P Œ vš v šZ v š Z š
ðï X

~ •Z }v•] Œ ~ • P]À v šZ š šZ ((]] v Ç }(šZ Z š vP]v v
Œ (Œ]P Œ š}Œ Œ Z ðì9 }(šZ]Œ u Æ]uµu ‰}••] o À oµ •

D} µo rï

íñX]• Œ]À šZ &]Œ•š v • }v d ^ ‹µ š]}v PDUNV

~]]• Œ]À šZ o µ•]µ• t o ‰ ÇŒ}v ‹µ š]}v

íòX~]• ^Z}Á šZ š šZ Á}Œl }v Ç o}• •Ç•š u Ç]vš Œ š]vP }voÇ
Œ À Œ•] o ‰Œ} ••]• oÁ Ç• u}Œ šZ v šZ š }v Ç]š]v v]ŒŒ
• u v •š š •X

LL &DOFXODWH WKH GHFUHDVH LQ DYDLODEOH HQHUJ\ ZKHQ
RI ZDWHU DW WKH SUHVVXUH EHLQJ WDNHQ DV FRQVWDQW
VXUURXQGLQJV EHLQJ & S .- .J.

D} µo rð

íóX š u]v]š] ooÇ š ìX] D}o U î ì }v•š vš À}oµu X~ • š ÁZ š š u‰
šZ •š u }u • šµŒ š À ‰}µŒM ~ • tZ š šZ •š š Z ‹µ o]šÇ š ôì
šŒ v•(ŒŒ ‰ Œ <P }(•š u]v ôì D}o]vP (Œ}u îñì

íôX šZ Œu o ‰}Á Œ ‰o vš }‰ Œ š]vP }v v] o Z vl]v Ç o Z •
šZŒ}µPZ]šX tš Œ]• (š} šZ }]o Œ š ñì Œ v o À • šZ }v
š ìXí ŒX dZ u •• (o}Á Œ š }(}}o]vP Á š Œ šZŒ}µPZ šZ }v
}}o]vP Á š Œ vš Œ• šZ }v v•Œ Œ š ïðò µo š šZ š u‰ Œ šµŒ
ÁZ] Z •š u vš Œ• šZ šµŒ]v U šZ šZ Œu o ((]] v Ç }(šZ ‰}
}µš‰µš }(šZ šµŒ]v X

D} µo rñ

íõX šµŒ }i š]Œ Œ (š (o] • Á]šZ À o}]šÇ }(ïìì ul• š v oš]šµ
v rðïX dZ }u‰Œ ••}Œ Z • ‰Œ ••µŒ Œ š]} }(íìU v šZ š u‰
šZ šµŒ]v]v oXš]• ííìì <X šZ }u‰Œ ••}Œ š Œ š }(ñì <P]•X
š u‰ Œ šµŒ v ‰Œ ••µŒ }(šZ P • • š šZ šµŒ]v Æ]šU ~
v}ÌÌo Æ]š v ~ • šZ ‰Œ}‰µo•]À ((]] v Ç }(šZ Ç o X

îìX t]šZ šZ Z o‰ }(v š] PŒ u Æ‰o]v šZ o ••](] š]}v }(i š vP]

^Çoo µ•

D} µo í

•] }v ‰š• r }v ‰š }(}vš]vµµuU u Œ}• }‰] ‰‰Œ} ZU šZ Œu}
}‰ v v]•}o š X WŒ}‰ ŒšÇU •š š U ‰ šZ v ‰Œ} ••U ‹µ •]r•š š] ‰
•‰](] Z š ‰]š] •U • Œ}šZ > Á }(dZ Œu} Çv u] •r v ŒPÇ r t}
Æ‰ Œ]u všr &]Œ•š o Á }(dZ Œu} Çv u] • r &]Œ•š o Á ‰‰o] š} E}v
Z š•r WDDíX&]Œ•š o Á ‰‰o] š} &o}Á WŒ} ••U D •• v v ŒPÇ
‰Œ} ••X ‰‰o] š]}v• }(^& U dŒ v•] vš (o}Á t&]oo]vP v u‰šÇ]vP
}(šZ &]Œ•š > ÁX

D} µo î

^ }v o Á }(šZ Œu} Çv u] • t < oÀ]v Wo v l v o µ•]µ• •š š u vš•X
/ŒŒ À Œ•]]o]šÇU dZ Œu o Œ • ŒÀ}]ŒU Œv}š šZ }Œ uX Œv}š Ç o
KWU dZ Œu} Çv u] š u‰ Œ šµŒ • o t o µ•]µ•]v ‹µ o]šÇU }v ‰š
(}Œ À Œ]}µ• ‰Œ} •• •X všŒ}‰Ç ‰Œ]v]‰o r D]Æ]vP }((oµ] •X

D} µo ï

À]o]o]šÇ v /ŒŒ À Œ•]]o]šÇr h• (µo Á}ŒlU •š š U À]o]
]ŒŒ À Œ•]]o]šÇ]v }‰ v o}• •Ç•š u• r '}µÇr^š} }o šZ }Œ u U dZ
' v Œ o dZ Œu} Çv u] Z o š]}v• t }u]v &]Œ•š v ^ }v o Á ‹µ š]}
'] [• (µv š]}v• r D ÆÁ oo[• Z o š]}v•U d • ‹µ š]}v•X dZ o ‰ ÇŒ}v ‹µ

D} µo ð

WµŒ ^µ •š v •U WZ • dŒ v•(}Œu š]}v•U dŒ]‰o ‰}]všU ‰Œ}‰ Œš]
v ‰rd] PŒ u }(‰µŒ •µ •š v U ‰rÀrd •µŒ(U ^ šµŒ š]}v ‰Œ ••µ
] PŒ u•U Zr•] PŒ u• }Œ D}oo] Œ Z Œš•U ŒÇv •• &Œ š]}vU •š u š
•š u š o •X ^š v Œ Z vl]v Ç o U Z Z š v Z P v Œ š]}v Ç o U ,
•š uU }v•µu‰š]}v Ud}vv }(Œ (Œ]P Œ š]}v

D} µo ñ

]Œ •š v Œ Ç o •rKšš}U] • oU µ oU Œ] ••}vU šl]v•}vU ^š]Œo]vP
((]] v Ç t u v ((š]À ‰Œ ••µŒ X o ••](] š]}v }(i š vP]v •U šZŒµ

d Æš }}l•

íXE PXWX<XU ^ vP]v Œ]vP dZ Œu} Çv u] •_U d š D 'Œ Ár,]ooU E

îXzµvµ• X vP o v D] Z o X }o •U ^dZ Œu} Çv u] •W v vP]v

D 'Œ Ár,]oo ^] v l vP]v Œ]vPlD šZV óšZ]š]}v îìíìX

Z (Œ v }}l•

íX Œ}Œ XWU ^ dZ Œu} Çv u] •_U d š D 'Œ Ár,]ooU E Á oZ]U î

îXzs Z }U^ vP]v Œ]vP dZ Œu} Çv u] • šZŒ}µPZ Æ u‰o •_U hv]À

ïX,}ou vX:XWXU ^dZ Œu} Çv u] •_U ïŒ]š]}vU D 'Œ Ár,]ooU îììó

ðXD Œ o U W}šZ ŒU Œ]P tU ^}u Œš}vU ^dZ Œu} Çv u] • (}Œ vP

^ Œ] •Ud š D 'Œ Ár,]ooU E Á oZ]U îììðX

ñXZ šZ lŒ]•Zv v XU ^&µv u vš o• }(vP]v Œ]vP dZ Œu} Çv u] •_

îììñX

}µŒ• }vš vš• v > šµŒ ^ Z µo

E}	d}‰]	E}X }(> šµŒ •
í		D} µío í
íXí	•] }v }v ‰š }(}vš]vµµuU u Œ šZ Œu} Çv u] •Çš u• t o}• U }‰ v v]•}o š X WŒ}‰ ŒšÇU •š ‰ šZ v ‰Œ} ••U ‹µ •]r•š š] ‰Œ} ••U]vš Œv o v ŒPÇU všZ •‰](] Z š ‰]š] •	î
íXî	• Œ}šZ > Á }(dZ (v Œ t}Œ W À Á	í
íXï	:}µo [• Æ‰ &]Œ•š o Á }(dZ &]Œ•š o Á E}v (o}Á WŒ} ••r všZ o‰Çr•‰](] Z š•r WDDíX	ï
íXð	&]Œ•š o Á ‰‰o] š} &o}Á WŒ} ••U D •š Ç (o}Á ‰Œ} ••X ‰‰o] š]}v• }(^&	ï
íXñ	dŒ v•] vt&]oo]vP v u‰šÇ]vP WŒ} ••X šZ &]Œ•š > ÁX	î
î		D} µo î
îXí	^ }v o Á }(šZ Œıt< oÀ]v Wo v l •š š u vš•X WDDî UZ À Œ•]]o]šÇ v /ŒŒ À Œ•]]o]šÇU dZ Œu o	î
îXî	Œv}š šZ }Œ uX Œv}š Ç o U Z À Œ K\	î
îXï	dZ Œu} Çv u] š u‰ t o µ•]µ•]v ‹µ o]š(všŒ}‰ÇU	î
îXð	všŒ}‰Ç Z vP (}Œ À všŒ}‰Ç ' D]Æ]v (oµ] •	ï
ï		Dð µo ï
ïXí	À]o Ç v /ŒŒ h• (µo Á}ŒlU •š š	í

	(µv š]	
ïXî	À]o]o]šÇ v]ŒŒ À Œ•]]o]šÇ]v '}µ ^š} }o šZ }Œ u U dZ]Œ o Á }(šZ Œu} Çv u] •X	î
ïXï	' v Œ o dZ Œu} Çv ut }u]v &]Œ•š}v o ‹µ š]}v• t , ouZ}ošÌ v '] [• (µv š]}v• r D ÆÁ oo[• Z o š]}v•	î
ïXð	d • ‹µ š]}v•X dZ o ‰ ÇŒ}v ‹µ š]}v	î
ð		íì D} µo ð
ðXí	WµŒ ^µ •š v •U WZ • dŒ v•(}Œ‰ Œš] • Z vP }(‰Z • U drÀU ‰rÀ v ‰rd] PŒ u }(‰µŒ •µ •š v U •µŒ(	î
ðXî	^ šµŒ š]}v ‰Œ ••µŒ vZ v •] PŒ •] PŒ u• }Œ D}oo] Œ ZŒš•U ŒÇv •• &Œ š]}vU •š u š o •X V o µo š]}v• µ•]vP •š u š o •X	ï
ðXï	^š v Œ Z vl]v Ç o	î
ðXð	Z Z š v Z P v Œ š]}v Ç o U , š Œ š U Ud}vv }(Œ (Œ]P Œ š]}v	ï
ñ		ô D} µo ñ
ñXí	]Œ •š v ‡ Kšš}U	î
ñXî	µ oU Œ] ••}vU šl	î
ñXï	Œ Çš}v]Œ •š v Œ tu v ((š]À	î
ñXð	o ••]([š]}v }(tšZŒµ•š	î

Kd î ô ò	D , E/ ^ K& D d Z/ ^dZh dhZ ^	d 'K ž >^ E s	: ï	(í	\ ì	Z / z Œ }(/vš Œ ð îìíõ

WŒ u o ZW }µŒ• ‰Œ}À] • lv}Áo P }(•šŒ •• •U •šŒ]v• v (}Œu š]}v• À Œ]}µ• o} •X /š Z o‰•]v •• ••]vP šZ •šŒ ••• v (}Œu š]}v• šZŒ}µPZ u šÁ]•š]vP Œ• }Œ }u]v š]}v• }(}šZX o•} Z o‰• š} •]Pv ‰Œ]•u š] }u‰}v v

WŒ Œ ‹µ]•]š W E]o

}µŒ• Kµš }u W }µŒ• Kµš }u W šZ }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo o š}

K í	Æ‰o]v šZ (µv u vš o }v ‰š• }((}Œu o •}o] •]v šZ ‰ Œ•‰ š]À
K î	•]Pv À Œ]}µ• l]v • }(Æ] o o} u u Œ• µv Œ]((Œ vš }µv ŒÇ }v
K ï	o µo š šZ o} •]v u•U (}Œ • v u}u vš• ••}] š Á]šZ]((Œ vš •
K ð	/oo µ•šŒ š šZ šZ }ŒÇU ‰Œ]v]‰o • ••}] š } v]vP }(u v šÁ]•š ‰Œ]v]‰o • }( ]r Æ] o •š š }(•šŒ •• •]v À Œ]}µ• ‰Œ} o u• šZŒ}µPZ
K ñ	•]Pv }(‰Œ]•u š] }u‰}v vš• µ•]vP •µ]š o ( ]oµŒ šZ }ŒÇX

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

	WK í	WK î	WK ï	WK ð	WK ñ	WK ò	WK ó	WK ô	WK õ	WK
K í	ï									
K î	ï	ï	î							
K ï	ï	ï	î							
K ð	ï	ï	î							
K	ï									

•• ••u vš W šš Œv

o}}u[• š P}ŒÇ	}vš]vµ}µ• •• ••u vš d •š•		v ^ u •š Œ Æ u]v š]}v
	í	î	
Z u u	íí	íí	ïì
hv Œ•š v	íñ	íñ	ïì
‰‰oÇ	îì	îì	ðì
v oÇ•			
À oµ š			
Œ š			

D Œl]•šŒ] µš]}v

d}š o D Œl•	/	^	^ µŒ š]}v
íñì	ñì	íìì	ï Z}µŒ•

}vš]vµ}µ• /vš Œv o À oµ š]}v W šš ŒvW

šš v v W íì u Œl•
}vš]vµ}µ• •• ••u vš d •š ~î vµ Œ•• W îñ u Œl•
••]Pvu vš lYµ]Ì l }µŒ• ‰Œ}i š W íñ u Œl•

v ^ u •š Œ Æ u]v š]}v ‰ ŒšW š Á} ‰ Œš•V W Œš v W
Á]šZ î ‹µ •š]}v• (Œ}u Z u} µo U Z À]vP ï u Œl• (}Œ Z ‹µ •š]
W Œš }vš]v• î ‹µ •š]}v• (Œ}u Z u} µo }(vÇ }v X Z ‹µ
Z À u Æ]uµu]À]•]}v• v ŒŒ

}µŒ• > À o •• ••u

}µŒ• Kµš }u í ~ Kí•

íX Æ‰o]v o]v Œ •Z Œ •šŒ

îX tZ š Œ o •š] }v

ïX Œ •• Œ }(u ÁPšZ •‹µ Œ Œ}•• • š]}v }(õì uu }v
š v•]o (}Œ }(íñìì lE A ííì 'W bvA ìXïðX š Œu]v šZ]v Œ •

}µŒ• Kµš }u î ~ Kî•

íXÆ‰o]v •š š] ooÇ]vµŒ

îX tŒ]š ‰Œ]v]‰o }

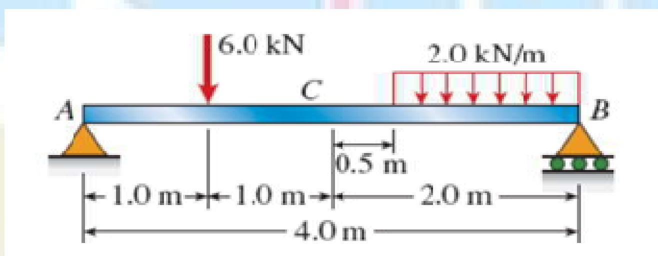
ïX Œ]À šZ Æ‰Œ ••]}v (}Œ Z vP]v rÁ]PZšX

}µŒ• Kµš }u ï ~ Kï•

íX tŒ]š]((Œ vš šÇ‰

îX Æ‰o]v W}]vš }( ]

ïX š Œu]v šZ •Z vŒ v]vP u}D š šZ u] ‰}]vš •]u‰ •Z}Áv]v
šZ (]PµŒ X



}µŒ• Kµš }u ð ~ Kð•

íX tŒ]š šZ ••µu‰š]}v• }(šZ

îX Œ Á šZ D}ZŒ[•]Œ

ïX Œ]À šZ š}Œ•]}v o •Z

}µŒ• Kµš }u ñ ~ Kñ•

íX Æ‰o]v } š Z Œ o •

îX•š o u Z]v ‰ Œš]• •š š] ooÇ o} v Z • Ç] o •šŒ vP
(]v šZ (š}Œ }(• (šÇ µ•]vP Z }(šZ

•Æ A óì DW•ÆÇ A ïì DW

ïX Œ]À u Æ]uµu]•š}Œš]}

D} o Yµ •š]}v ‰ ‰ Œ

YW K W rrrrrrrrrrrr

W: h> < > D K> K,d E/ > hE/s Z^/dz ^d Z Xd , 'Z y D

DKEd, ~ z Z

}µŒ• } W Kdîôò

D , E/ ^ K& D d E ^dZh dhZ ^

D ÆXD ŒI•Wíìì µŒ š]}vW

W Zd

v•Á Œ oo Yµ •š]}v•X Z ‹µ •

íX (]v (š}Œ }(• (šÇU Á}ŒI]vP •š

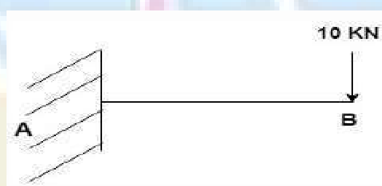
îX Æ‰o]v Z}u}P v}µ• ~]•}šŒ}‰] ‰o

ïXtZ š]• šZ ‰Œ} µŒ š•šŒ •• •]v }u% ŒM

ðX Æ‰o]v •š š] ooÇ]v š Œu]v š

ñX Æ‰o]v]((Œ vš

òXtZ š Á]oo šZ À Œ] š]}v]v D (}Œ š



óXtŒ]š šZ ••µu‰š]}v• }(šZ }(

ôX Œ Á šZ D}ŒŒ'o (}Œ ‰µŒ •Z (

õXtZ š]• šZ •š •µ]š š} •]Pv µ š]o u š Æ‰o]v

íìXtZ š Œ šZ]•š]v š]À •š P

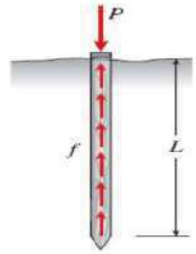
W Zd

v•Á Œ vÇ }v (µoo ‹µ •š]}v (Œ}u Z u} µ D ŒI•

D} µo í

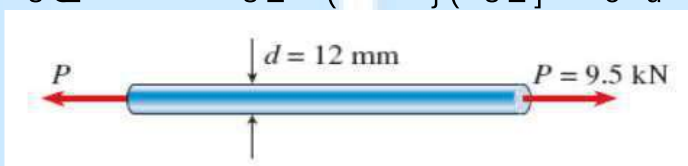
ííX~ • Á}} ‰]o U Œ]À v]vš} šZ Wvš]Œ oÇ Ç (Œ]
•] • ~• (]PµŒ •X dZ ‰ Œ µv]š o vPšZ }(‰]o
µv](}ŒuoÇ]•šŒ] µš }À Œ šZ •µŒ(}(>U Œ}••r
• š]}v o UŒ v u} µoµ• }(X

]X Œ]À (}Œuµo (}Œ }(šZ ‰]o]vUšŒuv•X}(
~ð•
]]X Œ Á] PŒ u •Z}Á]vP Z}Á šZ À Œ•šZ•Œ}µPZ
o vPšZ }(šZ ‰]o X



~ • Œ]À šZ Œ o š]}v•Z]‰ šÁ v o •š] }v•š v

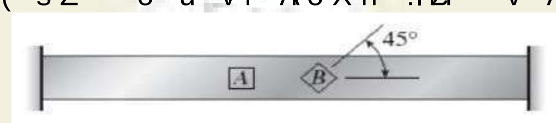
íîX~ • •š o Œ Á A íî uu]• •µ i š š} VA õX }
]X tZ š]• šZ u Æ]uµu v}Œu o
]]X tZ š]• šZ u Æ]uµu
]]]X Œ Á •šŒ •• o u vš }Œ] vš š ðñ£ š} šZ
•šŒ •• • šZ (• }(šZ]• o u vš ~ò•



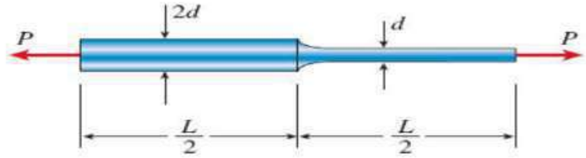
~ • Œ Á •šŒ ••]v] PŒ u (}Œ µ š]o v Œ]ššo
~ • Æ‰o]v]v µŒ }(u š Œ] o•X

D} µo î

íïX~ • }‰‰ Œ Œ Á]šZ Œ š vPµo Œ Œ}•• • š]
•µ‰‰}Œš• ~• (]PµŒ •X ^µ • ‹µ všoÇU šZ š u
š Œu]v šZ •šŒ •• • }v o v U v •Z}Á šZ •
}v•I š Z • }(šZ o u vr Áó Xñ ºZ îìí v Áîì 'W X•



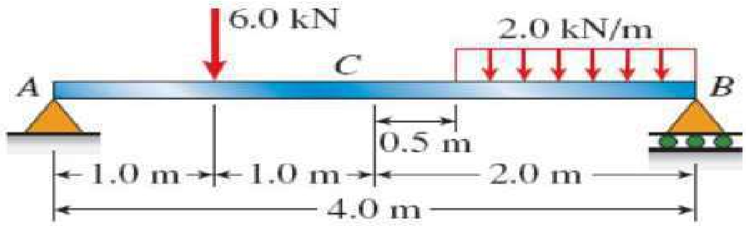
~ • Œ]À šZ Æ‰Œ ••]}v (}Œ (}Œu š]}rÁ]PZš ~ñ•
íðX~ • Œ }( ]Œ µo Œ Œ}•• • š]}v Z v]• •Z}Áv
]v šZ (]PµŒ X dZ o vPšZ }(>îì v šZ u} µ
o •š]]šÇ }(šZ X
]X K š]v (}Œuµo (}Œ šh}(šZ Œ µ šWX
]]X o µo š šZ •šŒ]v 'W A îó lEU š>ZA òìì uuU
] u š Œ ðì uuU v šZ u š Œ A íìñ 'W X



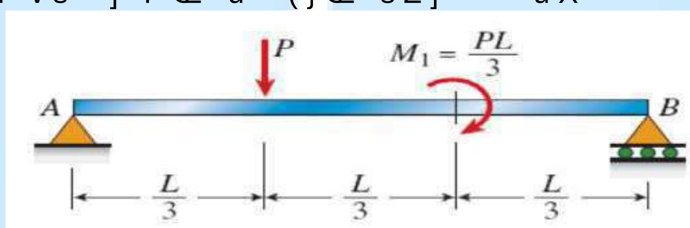
~ • Æ‰o]v š}µPZv •• }(‰Œr]•‰o u vš µŒ

D} µo ï

íñX š Œu]v šZ •¿s v v]vP u}D všššZ u] %}[]všZ •]
u •Z}Áv]v šZ (]PµŒ X



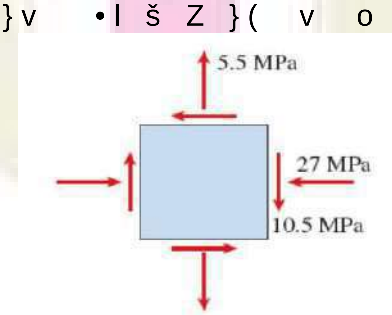
íòX • dZ •]u‰(•Z}Áv]v šZ (]PµŒ]• •µ i š šW
v o} lÁ]• D AWl¤ š]vP š šZ šZ]Œ ‰}]r(}Œ v
v]vuP}ru vš] PŒ u• (}Œ šZ]• uX ~íì•



~ • Œ]À šZ Œ o š]}v•Z]‰ šÁ v •Z Œ (}Œ

D} µo ð

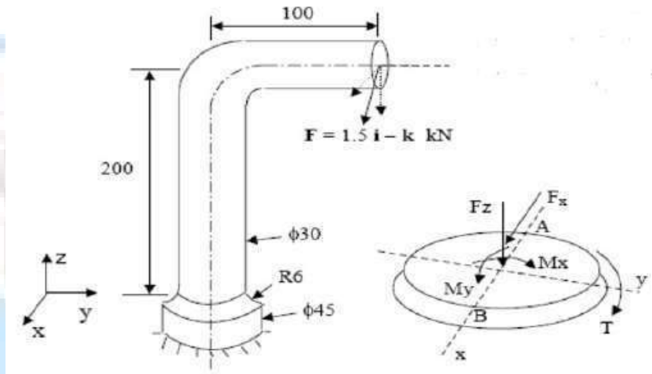
íóX v o u vš‰o vv •(Œ}u šZ (µ• o P }(v]Œ‰
}u‰Œ ••]À •šŒ •• • }(u]v šZ Z}Œ]Ì}vš o]Œ
•šŒ •• • }(u Pv]šµ ñXñ DW]v šZ À Œš] o
•šŒ •• • }(u Pv]šµ íìXñ DW š]v šZ]Œ š]}
š]vP }v v o u vš }Œ] vš }(ïñ£ (Œ}u šZ Z}Œ
šZ • •šŒ •• • }v •l š Z }(v o u vš }Œ] vš š



íôX •š o Œ }(•}o]]Œ µo Œ > îXñ u]• •µ i š
š v•]o (]AŒîð lE v]vP u}uDAšïXñ lE u ~•
/X • µ‰}v v oo}Á o •šŒ ••]v š v•]}v
Œ ‹µ]Œ }(šZ ŒV]•Œ P Œ šZ Á
//X Z ‰ š ~/•]v oµ]vP šZ Á]PZš }(~íð•

D} µo ñ

íõX $FDVW LURQ VWUXFWXUH LV ORDGHG DV VKRZ
VWUHQJWK RI 03D DQG \LHOG VWUHQJWK
VWUXFWXUH XVLQJ EHVV\



îìX Ço]v •Œ](šo u }(•š o }(Ç] o •šŒ vPšZ óìì D
}v•]•š]vP }(v]vP ru v š}Œ•]}v o uuX š Œ<Er
šZ] u š Œ }(šZ

/X D Æ]uµu •Z Œ •š

//X D Æ]uµu •šŒ]v v

••µu]vP (š}Œ }(• (šÇ }(îX d l A îíì 'W

^Çoo µ•

D} µo í

^šŒ •}Œu oU •Z Œ v Œ]vP •šŒ •• •U ^šŒ •• • }v]v
v •Z Œ •šŒ]v•U W}]•t •šŒ]v] PŒ u• (}Œ u]o •š o]v
Z Œ v •}(š Œµ ŒU Œ]šš]v }u‰Œ ••]}vX ,}}l [• o Á
]•}šŒ}‰] u š Œ] o µv Œ Æ] o v •Z Œ (}Œu š]}vU
(}Œu š]}v•X Z o š]}v•Z]‰ šÁ v u š Œ] o }v•š vš ~ Œ]
š ‰}]vš µ~š]}v• }(•šŒ •• v •šŒ]v š v•}Œ• v]š• }u
u ŒP]v }(• (šÇU •]Pv (}Œ Æ

D} µo î

(}Œu š]}v]v Æ] ooÇ o} Œ• ~ Œ•]v • Œ] •U ‰ Œ
À ŒÇ]o} • v]u v•]}v•U ‰Œ]v]‰o }(•µ‰ Œ‰}•]š]}vU
((š•]v Æ] ooÇ o} Œ• ~]v oµ]vP }u‰}µv v }u
v }v] o Œ µvÁ ŒP]šZ•X ^š Œ]v v š}µPZ (}Œ• ‰µŒ Æ
‰Œ]•u š] v }v] orÁ]PZšX

D} µo ï

dÇ‰ • }(>} •U šÇ‰ • }(^µ‰‰}ŒšU dÇ‰ • }(u•U v]vP }µ‰o
KvoÇ•U š Œu]v š]}v }(•µ‰‰}Œš Œ š]}vU ^Z Œ (}Œ v v]vP u}
o} •r•Z Œ (}Œ r v]vP u}u vš•~ Œ]À š]}v (}Œ oo šZ • •• v]vP
] PŒ u• }(u• ~ vš]o À Œ v •]u‰oÇ •µ‰‰}Œš • •µ i š š} }v
]•šŒ] µš o} •U µv](}ŒuoÇ À ŒÇ]vP o} •U }µ‰o • v šZ Œ }u]v
‰}]vš v u Pv]šµ }(u Æ]uµu v]vP ‰}]vš v u Æ]uµu •Z Œ (}Œ X

D} µo ð

&o ÆµŒ o •šŒ •• • t dZ }ŒÇ }(•]u‰o v]vPU ••µu‰š]}v•U Œ]À
v µšŒ o Æ]•U š Œu]v š]}v }(v]vP •šŒ •• • ~Œ š vPµo ŒU •‹µ Œ
Z}oo}Á]Œ µo Œ • š]}v• }voÇ•X d}Œ•]}v r Œ]À š]}v }(‹µ š]}v }(š}
}(š}Œ•]}v o ‹µ š]}v š} •}o] v Z}oo}Á]Œ µo Œ •Z (šU š}Œ•]}v o
}u]v Æ] oU (o ÆµŒ o v •Z Œ o} • t všŒ] o}]vP µv Œ š v•
v]vP v šÁ]•š]vP o} •X Wo v •š š }(•šŒ •• r ‰Œ]v]‰ o ‰o v • v
‹µ š]}v• }(šŒ v•(}Œu š]}vU D}ZŒ[•]Œ o (}Œ]r Æ] o •šŒ •• •

D} µo ñ

dZ }Œ] • }(( ]oµŒ • t /v ‰o v v •}oµš u Æ]uµu •Z Œ •šŒ •• •U
šZ }ŒÇU D Æ]uµu •Z Œ •šŒ •• šZ }ŒÇU D Æ]uµu ‰Œ]v]‰o •šŒ]v š
u Æ]uµu]•š}Œš]}v v ŒPÇ šZ }ŒÇU •]Pv }(‰Œ]•u š] }u‰}v vš•
K š Z Œ o ^Z Œ •šŒ •• šZ }ŒÇX •]Pv P]v•š]u‰ š o}]vP ~/v oµ
}u‰}v vš• }voÇ•U (š]Pµ U Œ ‰ v •šŒ •• Œ o Æ š]}v ~E} vµu Œ] o

d Æš }}l•

íX : u • ' Œ ~ ŒŒÇ '}} v}U ^D Z v]u •}(D PŒ ^š]‰ v šŒ]vP U îììôX

îX d]šš Œš}vX'X ^]Œ Œ (š D š Œ] o• v WŒ} •• •—U s]š]}vU W]šu

Z (Œ v }}l•

íX Z šš vU ^šŒ vPšZ }(D š Œ] o•U î D 'Œ Á ,]oo µ š]}v /v] U îììí

îX ZX X ,] o ŒU D Z v] • }(D š Œ] o•U W Œ•}v µ š]}vU îììô

ïX ^X:}• U ^µ Z] D ŒÇ <µŒ] vU D Z v] • }(^}o] •U W vš P}vU îìíñ

ðX Àv }u‰}•]š • t]v Ç &}Œ u v

}µŒ• }vš vš• v > šµŒ ^ Z µo

E}	d}‰]	E}X }(> šµŒ •
í	D} µo í	d}š oW ô
íXí	^šŒ •• t E}Œu oU •Z Œ v Œ]vP •šŒ •• •U ^šŒ •• • }v]v o]v (]v]š]}v• }(o]v Œ v}Œu o v •Z Œ •šŒ]v•U W}]••}v[• Œ š]} r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	
íXî	•šŒt •šŒ]v] PŒ u• (}Œ u]o •š o]v š v v •}(š Œµ ŒU Œ]ššo u š Œ] o v }‰‰ Œ]v }u‰Œ ••]}v	î
íXï	,}}l[• o Á (}Œ o]v ŒoÇ o •š]]•}šŒ}‰] •Z (}Œu š]}vU µol u}µoµ•U] Æ] o v (}Œu š]}v•]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	í šŒ] Æ] o

íXð	,}}l [• o Á (}Œ o]v ŒoÇ o •š]]•}šŒ}‰] (}Œu š]}vU µol u} µoµ•U] Æ] o v šŒ ‰Œ} o u •}oÀ]vP	uš Œ] o µv Œ Æ] o (}Œu š]}v• r Æ
íXñ	Z o š]}v•Z]‰ šÁ v u š Œ] o }v•š vš ~ •šŒ •• v •šŒ]v š ‰}]vš ~]všŒ} µ š]}v š} •šŒ •• v •šŒ]v v]š• }u‰}v vš• }voÇ•U & š}Œ }(• (šÇU u ŒP]v }(• (šÇ r]oo vµu Œ] o Æ Œ]•	í
íXò	•]Pv (}Œ Æ] o o} • v]Œ š •Z Œ r]ooµ•šŒ š]À vµu Œ] o	
î	D} µo î	d}š oW õ
îXí	(}Œu š]}v]v Æ] ooÇ o} Œ• ~ Œ•]v • Œ]î•U ‰ Œ oo oU]v Æ] o o} •U }vš]vµ}µ•oÇ À ŒÇ]vP o} • v]u v•]}v••U r]ooµ• vµu Œ] o Æ Œ]•	
îXî	(}Œu š]}v]v Æ] ooÇ o} Œ• ~ Œ•]v • Œ]í•U ‰ Œ oo oU]v Æ] o o} •U }vš]vµ}µ•oÇ À ŒÇ]vP o} • v]u v•]}v••U r Æš ‰Œ} o u •}oÀ]vP	
îXï	‰Œ]v]‰o }(•µ‰ Œ‰}•]š]}vU •š š] ooÇ]ví š Œu]v š •šŒµ]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	
îXð	šZ Œu o ((š•]v Æ] ooÇ o} Œ• ~]v oµ]vP }u‰}µv }u‰}•]š Œ•• r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	
îXñ	šZ Œu o ((š•]v Æ] ooÇ o} Œ• ~]v oµ]vP }u‰}µv }u‰}•]š Œ•• r Æš v ‰Œ} o u •}oÀ]vP	
îXò	(}Œu š]}v }(‰Œ]•u š] v }v] o Œ µv Œ]š• • o(rÁ]PZš]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	
îXó	^šŒ]v v ŒPÇU Œ •]o] v v š}µPZv •• t (}íŒ ‰µŒ Æ] o o ‰Œ]•u š] v }v] o Œ µv Œ • o(rÁ]PZš r]ooµ•šŒ š]À vµ Æ Œ]•	
ï	D} µo ï	d}š oW íì
ïXí	dÇ‰ • }(>} •U šÇ‰ • }(^µ‰‰}ŒšU dÇ‰ šÁ]•š]vP }µ‰o ~ }v ‰š KvoÇ•U š Œu]v š]}v }(•µ‰‰}Œš Œ š	í
ïXî	^Z Œ (}Œ v v]‚Z o š]}v•Z]‰• ‚ •Z (}Œ r v]vP u}u vš• ~ Œ]À š]}v (}Œ oo šZ • ••X	í
ïXï	v]vP u}u vš v •Z Œ (}Œ] PŒ u• }(u•í ~ vš]o À Œ v •]u‰oÇ •µ‰‰}Œš • r }v všŒ š o} r]ooµ•šŒ š]À vµu Œ] o	
ïXð	v]vP u}u vš v •Z Œ (}Œ] PŒ u• }(u•î ~ vš]o À Œ v •]u‰oÇ •µ‰‰}Œš • r µv](}ŒuoÇ]•šŒ] µš o} •U µv](}ŒuoÇ À r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	
ïXñ	v]vP u}u vš v •Z Œ (}Œ] PŒ u• }(u•í ~ vš]o À Œ v •]u‰oÇ •µ‰‰}Œš • r µv](}ŒuoÇ]•šŒ] µš o} •U µv](}ŒuoÇ À r Æš v ‰Œ} o u •}oÀ]vP	
ïXò	v]vP u}u vš v •Z Œ (}Œ] PŒ u• } •]u‰oÇ •µ‰‰}Œš • r }µ‰o • v šZ Œ }u]v š]}v• r]ooµ•š vµu Œ] o Æ Œ]•	î
ïXó	v]vP u}u vš v •Z Œ (}Œ] PŒ u• }(u•í ~ vš]o À Œ v •]u‰oÇ •µ‰‰}Œš • r }µ‰o • v šZ Œ }u]v š]}v• r Æš v ‰Œ} o u •}oÀ]vP	
ïXô	W}]vš }(}všŒ (o ÆµŒ U ‰}]vš v u Pv]šµ }(íu Æ]uµu v]vP ‰ v u Æ]uµu •Z Œ (}Œ X	

ð	D} µo ð	d}š oW íì
ðXí	&o Æ µ Œ ot dZ }ŒÇ }(•]u‰o v]vPU •• }(‹µ š]}v }(v]vPU v µšŒ o Æ]•	í
ðXî	š Œu]v š]}v }(v]vP •šŒ •• • ~Œ š vP]Œ µo Œ v Z}oo}Á]Œ µo Œ • š]}v• }voÇ• r]ooµ•šŒ š]À v Æ Œ]•	í
ðXï	d}Œ•]}v r Œ]À š]}v }(‹µ š]}v }(š}Œ•]}vU ••µu‰š]}v•	í
ðXð	‰‰o] š]}v }(š}Œ•]}v o ‹µ š]}v š} •}o] v Z}oo}Á]Œ µo Œ š}Œ•]}v o Œ]P]]šÇ r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	í
ðXñ	}u‰}µv •šŒ •• • r }u]v Æ] oU (o ÆµŒ o v •Z Œ o} • všŒ] o}]vP µv Œ š v•]}vl }u‰Œ ••]}v r]ooµ•šŒ š]À vµu Æ Œ]•	í
ðXò	}u]v v]vP v šÁ	í
ðXó	}u‰}µv •šŒ •• • r }u]v Æ] oU (o ÆµŒ o v •Z Œ o} • všŒ] o}]vP µv Œ š v•]}vl }u‰Œ ••]}vX }u]v v]vP v šÁ]•š]vP o} • r Æš v ‰Œ} o u •}oÀ]vP	í
ðXô	Wo v •š š }(•šŒ •• r ‰Œ]v]‰ o ‰o v • v •šŒ •• • ~Á]š Œ]À š]}v••U ‹µ š]}v• }(šŒ v•(}Œu š]}v r]ooµ•šŒ š]À vµu Æ Œ]•	í
ðXõ	D}ZŒ[•]Œ o (}Œ]r Æ] o •šŒ •• • r r]ooµ•šŒ š]À vµu Œ] o	î
ñ	D} µo ñ	d}š oW õ
ñXí	dZ }Œ] • }(( ]oµŒ • t /v ‰o v v •}oµš u Æ]uµu •Z Œ •šŒ •• D Æ]uµu ‰Œ]v]‰o •šŒ •• šZ }ŒÇU D Æ]uµu •Z Œ •šŒ •• šZ }ŒÇ]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	î
ñXî	D Æ]uµu ‰Œ]v]‰o •šŒ]v šZ }ŒÇU d}š o •šŒ]v v ŒPÇ šZ }ŒÇ]•š}Œš]}v v ŒPÇ šZ }ŒÇ r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	î
ñXï	•]Pv }(‰Œ]•u š] }u‰}v vš• µv Œ }u]v •šŒ •• • r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	í
ñXð	•]Pv }(‰Œ]•u š] }u‰}v vš• µv Œ }u]v •šŒ •• • r Æš v ‰Œ} o u •}oÀ]vP	í
ñXñ	K š Z Œ o ^Z Œ •šŒ •• šZ }ŒÇ r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	í
ñXò	•]Pv P]v•š]u‰ š o}]vP ~/v oµ]vP Œ]À š]}v• r]ooµ•šŒ š]À vµu Œ] o Æ Œ]•	í
ñXó	(š]Pµ U Œ ‰ v •šŒ •• Œ o Æ š]}v ~E} vµu Œ] o•	í

6 (0 (6 7 (5

+ 2 1 2 8 5 6

Kd îõî	s E &>h/ D , E/ ^	d 'Kz	:	(	\	Z /
		s	ï	í	ì	ð

WŒ u o W

dZ]• }µŒ•]• •µŒÀ Ç }(‰Œ]v]‰ o }v ‰š• v u šZ} • }((oµ] Çv }v• ŒÀ š]}v ‹µ š]}v•U Æ š •}oµš]}v• }(E À] Œr^š}l • ‹µ š]}v•U /v•š]všŒ} µ š]}v š} šµŒ µo v v šµŒ µo v u} oo]vP

WŒ Œ ‹µ]•]š W

D d îìïr D Z v] • }(&oµ] •

}µŒ• Kµš }u(š•WŒ šZ }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo o

K	‰‰oÇ }v ‹µ š]}v• }((oµ]
K	hš]o]Ì Œ}Æ]u š •}oµš]}v• ^š}l • ‹µ
K	Æ‰o]v]v•š]o]šÇ u Z
K	}u‰µš ((}µv ŒÇ
K	Æ‰o]v šµ v šµŒ u} (

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

	W K	W K	W K	W K	W K	W K	W K	W K	W K	W íì	W íí	W íî
K	ï											
K	ï	î	í	í								
K	ï	î	í									
K	ï	î	í									
K	ï	í										

•• ••u vš W šš Œv

o}}u[• š	}vš]vµ}µ• •• ••u		v ^ u •š Œ]v š
	í	î	
Z u u	íì	íì	íì
hv Œ•	îì	îì	îì
‰ ç	îì	îì	ó
v o(			
À oµ			
Œ			

D Œl]•šŒ] µš]}v

d}š o D	Œl•	/	^	^ µŒ š]}v
íñì	ñì	íìì	ï Z}µŒ•	

}vš]vµ}µ• /vš Œv o À oµ š]}v W šš ŒvW

šš v v W íì u Œl•
}vš]vµ}µ• •• ••u vš d •š ~î vµu Œ•• W îñ u Œl•
••]Pvu všlYµ]Ìl }µŒ• ‰Œ}i š W íñ u Œl•

v ^ u •š Œ Æ u]v š]}v W šš ŒvW dZ ŒšÁ]oo W šÁ} ‰ Œš•V W Œš v W Œš X
‹µ •š]}v• Á]šZ î ‹µ •š]}v• (Œ}u Z u} µo U Z À]vP ï u Œl• (}Œ Z ‹µ
v•Á Œ oo ‹µ •š]}v•X W Œš }vš]v• î ‹µ •š]}v• (Œ}u Z u} µo }(ÁZ
vÇ }v X Z ‹µ •š]}v v Z À u Æ]uµu î •µ r]À]•]}v• v ŒŒÇ íð u Œ

}µŒ• > À o •• ••u vš Yµ •š]}v•

}µŒ• Kµš }u í ~ Kí•W

í •‰Z Œ] o š vl }vš]v• ô <P }(}ÆÇP v š íî D‰ v ïñ P X &]v š
î &}Œ šZ À o}]šÇ (] o P]À v Ç šZ ‹µ š]}v s A ,ïÆU rðÇU ìƒ (]v šZ
‰o v Æ = Ç A ð šÁ v ‰}]vš• ÆAí v ÆAðX ••µu Á] šZ }(µv]š o v

}µŒ• Kµš }u î ~ Kî•

íX v oµu]v]µu v} ò u o}vP ÁZ] Z v ‰‰Œ}Æ]u š • (o š •µŒ
Á š Œ }(o ŒP o l š ò lD l ZX dZ š u‰ Œ šµŒ }(šZ Á š Œ
ÁZ šZ Œ šZ (o}Á]• o u]v Œ }Œ šµŒ µo všX

îX^š Œš]vP (Œ}u E À] Œr^š}l • ‹µ š]}v•X Œ]À šZ ‹µ š]}v• ‰‰o]
•‰Z Œ X /v ÁZ š Œ vP }(Z } • šZ]• ‰‰Œ}Æ]u š]}v Z}o M

}µŒ• Kµš }u ï~ Kï•W

íX Œ] (oÇ • Œ] ^š}l [• (]Œ•š ‰Œ} o u v ÁŒ]š }Áv šZ P}À Œv]v
v }µv ŒÇ }v]š]}v•

îX Œ]À šZ À o}]šÇ]•šŒ] µš]}v]v šZ P ‰ šÁ v šÁ} Œ}š š]vP }v
šZ]• ‹µ š]}v Œ µ •U]v šZ o]u]š }(}µš Œ Ço]v Œ }u]vP À ŒÇ o Œ
‰}š vš] o À}Œš ÆX Œ]À v Æ‰Œ ••]}v (}Œ u •• (oµÆ }(u ••]š]}v
•l š Z šZ]v ‰rÀ ‰o v

}µŒ• Kµš }u ð ~ Kð•W

íX Æ‰o]v šZ v ••]šÇ }(u} oo]vP šµŒ µo v X D vš]}v vÇ šÁ} šµŒ
Á] oÇ µ•

îX]Œ š íô P v í šu ‰Œ ••µŒ (o}Á• •š]oÇ š òì v l • ‰ •š î
‰o š X dZ •µŒ(š u‰ Œ šµŒ }(šZ ‰o š]• ðñ P X ••µu]vP Z
š}š o Œ š }(Z š o}•• (Œ}u }v •] }(šZ ‰o š X

}µŒ• Kµš }u ñ ~ Kñ•W

íX • Œ] ÁZ š]• u vš Ç > ŒP Ç ^]uµo š]}vX

îX tZ š]• u vš Ç <}ou}P}Œ}À o vPšZ • o •M • Œ] šZ v ŒP
(o}Á• • (µv š]}v }(šZ]• • o

D} o Yµ •š]}v ‰ ‰ Œ

YW K W

W: h> < > D d ,EK>K'/ > hE/s Z^/dz d,/Z ^ D ^d Z Xd , 'Z y

DKEd, ˜ z Z

}µŒ• } W Kd îõî

s E &>h/ D , E/ ^

D ÆXD Œl•Wíìì

W Zd

v•Á Œ oo Yµ •š]}v•X Z ‹µ •š]}v ŒŒ] • ï D Œl•

íXtZ š Œ }v•š]šµš]À Œ o š]}v•M ']À v Æ u‰o X

îX •‰Z Œ] o š vl }vš]v• íì <P }(}ÆÇP v š íð D‰ v ïñ P
šZ š vlX

ïX • Œ] šZ •• vš] o]((Œ v šÁ v Œ ‰]vP (o}Á• v]vÀ]

ðX v oµu]v]µu v} ñ u o}vP ÁZ] Z v ‰‰Œ}Æ]u š • (o š •µŒ(
o ŒP o l š ô lD l ZX dZ š u‰ Œ šµŒ }(šZ Á š Œ]• íì P X
]• o u]v Œ }Œ šµŒ µo všX

ñX Œ] (oÇ • Œ] ^š}l [• (]Œ•š ‰Œ} o u v ÁŒ]š }Áv šZ P}À Œv]vP
v }µv ŒÇ }v]š]}v•X

òX Æ‰o]v ÁZÇ šZ Œ]• Œ]š] o š u‰ Œ šµŒ]((Œ v]v Z Ço]PZ

óX (]v Z Ço]PZ vµu Œ v]š• ‰ZÇ•] o •]Pv](] v v]v Z š šŒ v•(Œ

ôX Æ‰o]v šZ v ••]šÇ }(u} oo]vP šµŒ µo v X D vš]}v vÇ šÁ} šµŒ
Á] oÇ µ• X

õX • Œ] šZ ‰Œ} •• }(v ŒPÇ •]vP]v šµŒ µo vš (o}Á•X

íìX • Œ] ÁZ š]• u vš Ç > ŒP Ç ^]uµo š]}vM

W Zd

v•Á Œ vÇ }v (µoo ‹µ •š]}v (Œ}u Z u} µo X Z ‹µ •š]}v

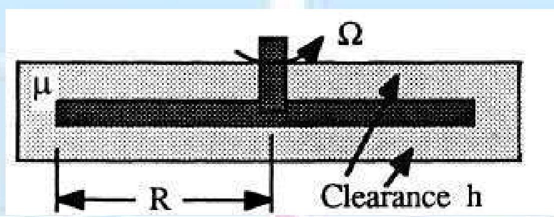
D} µo í

íX ~ • &}Œ šZ À o}]šÇ (] o P]À v Ç šZ ‹µ š]}v s A , ðÆU
Œ š Œ}••]vP šZ ‰o v Æ = Ç A ï šÁ v ‰}]vš• ÆAí v ÆAïX
]v Æ]Œ š]}vX

~íì•

~ • tZ š Œ v}vrE Áš}v] v (oµ] • M ,}Á šZ Ç Œ o ••](]
íîX /v šZ E šµŒ_o }vÀ š]}v Z š šŒ v•(Œ ‰Œ} ••U šZ u}µv
‰ v • }v šZ (oµ] v•]šÇ Œ šZ À]• }•]šÇ … U šZ šZ Œu o }v
]((Œ v Pd v šZ o vPšZ • o > v šZ } ((]] vš }(šZ Œu o
íïŒ~MŒXMd•Œ]À šZ v}vr]u v•]}v o ‰ Œ u š Œ• (}Œ šZ]• ‰Œ}
(]v o }ŒŒ o š]}v v ÁŒ]šš v • Eµ A (~ Z U 'Œ • ÁZ Œ Eµ]
Z Çv}o • vµu Œ v 'Œ]• šZ 'Œ •Z}(vµu ŒX

D} µo î



íïX]• }(Œ]µ• Z Œ}š š •]v•]]Œ µo Œ Z}o U (]oo Á]šZ
O Œ l• Á]šZ o Œ v }(Z uu • •Z}Áv]v šZ (]PµŒ }À X
µ• U • Œ}š š]vP À]• }u š Œ ÁZ Œ Ç u •µŒ]vP šZ š}Œ‹µ
o]‹µ] v š Œu]v X š Œu]v šZ À]• }•]šÇ }(šZ o]‹µ]](
ZWD v šZ u •µŒ š}Œ‹µ]• ìXñïó EruX

íðX ^š Œš]vP (Œ}u E À] Œr^š}l • ‹µ š]}v•X Œ]À šZ ‹µ š]}v•
}À Œ •‰Z Œ X /v ÁZ š Œ vP }(Z } • šZ]• ‰‰Œ}Æ]u š]}v Z}o

D} µo ï

íñX Œ]À šZ KŒŒr^}uu Œ(] o ‹µ š]}v • Œ]]vP šZ •š]o]šÇ

íòX Œ]À šZ À o}]šÇ]•šŒ] µš]}v]v šZ P ‰ šÁ v šÁ} Œ}
^Z}Á šZ š šZ]• ‹µ š]}v Œ µ •U]v šZ o]u]š }(}µš Œ Ço]v Œ
Œ}š š]vPU š} ‰}š vš] o À}Œš ÆX

D} µo /ðvWŒ} µ š]}vU &o}Á ‰ •š t P ^š Pv š]}v W}]vš }µv ŒÇ > Ç
&}Œu }(šZ }µv ŒÇ > Ç Œ ‹µ š]}v•U Æ]•Çuu šŒ] > u]v Œ :šX
šŒ v•(}Œu š]}v v D vPo Œ dŒ v•(}Œu š]}v dZ Œu o }µv ŒÇ > Ç Œ
,}Œ]Ì}vš o &o š Wo š & olv Œr^l v t P dZ Œu o }µv ŒÇ > Ç Œ /•}š
Á]šZ }v•š vš , š &oµÆ dZ /vš PŒ o D šZ} (}Œ dZ Œu o }vÀ š]}v
d u‰ Œ šµŒ Z P]}v &o š Wo š Á]šZ }v•š vš , š &oµÆ E šµŒ o
s Œš] o Wo š XE šµŒ o }vÀ š]}v }v s Œš] o Wo š Á]šZ hv](}Œu
E šµŒ o }vÀ š]}v }v v /•}šZ Œu o s Œš] o Wo š d u‰ Œ šµŒ]•š
X

D} µo /ñvWŒ} µ š]}v ^š š]•š] o ‰‰Œ} Z š} šµŒ µo vš (o}Á u} o]vP >
<}o}u}PŒ}À[• v ŒPÇ •]vP šZ }ŒÇ Z Çv}o • À Œ P šµŒ µo vš E
v (}Œ šµŒ µo v u} o]vPX }v ‰š }(Ç À]• }•]šÇ v WŒ v šo[•
• Œ}U }v v šÁ} ‹µ š]}v šµŒ µo v u} o• v Z Çv}o [• •šŒ •• u} o•X
šµŒ µo vš (o}Á•X

d Æš }}l•

~í•tZ]š U &sX•D}µ• &oµ]Œ &o}ÁU îìíó
~î•DµŒ o] Z ŒU <X v ' Ašvu]•ÁP]v Œ]vP &oµ] ‰u Z v] •
^] v /vš Œv š]}v o >š V ïŒ Z À]•]š]}v]š]}v
Z (Œ v }}l•

íX ^ Zo] Zš]vPU ,X }µv0FEUDZ-LOO (G LWLRQ HGLWLRQ

îX 'Œ oU tX WXU À v &oµ] u Z v] U îìì] WŒ ••Uí

}µŒ• }vš vš• v > šµŒ ^ Z µo

E}	d}‰]	E}X }(> šµŒ •
í	D} µo íwµv u vš o• }(&oµ] D}š]}v	
íXí	(]v]š]}v }((oµ] šZ }v ‰š }(À]• }•]šÇX E ••]šÇ (}Œ (] • Œ]‰š]}v }((oµ] (o}Á• ^ o Œ v À š}Œ (] o • s o}]šÇ o Œ š]}v }((oµ] (o}Á• dŒ v•‰}Œš dZ }Œ uU D ••U D}u všµu v v ŒPÇ }v• ŒÀ š]}v WŒ]v]‰o • (}Œ &oµ] &o}Á	
íXî	^šŒ •• • }v (oµ] o u vš Z š }((}Œu š]}v v }v•š]šµš] Œ o š]}v• E À] Œr^š}l • ‹µ š]}v•	
íXï	&]Œ•š o Á }(šZ Œu} Çv u] • v šZ v ŒPÇ ‹µ š]}v }v]š]}v•]u v•]}vo •• ‰ Œ u š Œ• E}v	E Áš}v] v (oµ] •
î	D} µo íwÀ]•] ‰‰Œ}Æ]u š]}v• v Æ š ^}oµš	
îXí	•] • }(‰ v o u šZ} • Œv}µoo]• šZ }Œ u v ‰‰o] š]}v• Æ š •}oµš]}v• }(E À] Œ ^š}l • ‹µ š]}v• (}Œ •š Ç v µv•š Ç (o}Á•X	
îXî	dÁ}r]u v•]}v o &o}Á šÁ v W Œ oo o Wo š • W}]• µ]oo &	

	Z š vPµo Œ }v µ]š]v Z}µv }v µ]š &o}Á šÁ v }v všŒ]]Œ µo Œ Ço]v Wo š v^š}l •[• &]Œ•š WŒ} o u K•]oo ^ }v WŒ} o u	}Œ vvµo µ• }µ šš Œ• /u‰µo•]À D}š]}v š]}v }(Wo š v^š}l •[•
îXï	/u‰µo•]À Wo v W}]• µ]oo v }‹µ šš }µ šš &o}Á Wo v ^š Pv š]}v >]v Æ]•Çuu šŒ] ^š Pv š]}v W}]vš &o}ÁX]À ŒP vš Z vv o• &o}Á]v > u]v Œ : šX &o}Á µ š} Z}š š]vP]•l	õ• &o}Á• /u‰µo•]À &o}Á dZŒ r]u v•]}v &o}Á]vš} }vÀ ŒP ^‰]Œ o Z vv o &o}Á µ š} Z
ï	D} µo >ïWÁ Z Çv}o • Eµu Œ &o}Á•	
ïXí	^š}l • ‰‰Œ}Æ]u š]}v ^o}Á ^š Ç &o}Á W •š µ š} ^‰Z Œ hv ŒP}]vP ^]u‰o K• v[• ‰‰Œ}Æ]u š]}v (}Œ ^o}Á s]• }µ• &o}Á X	ïÁ W •š ^}o] ^‰Z Œ , Œu}v] dŒ v•o š]}v
ïXî	Z •}oµš]}v }(šZ ^š}l •ItZ]š Z W Œ dZ }ŒÇ }(&oµ] &o}Á• KŒŒr^}uu Œ(o /v•š]o]šÇ]v s]• }µ• &oµ] v	ï}Æ • X >]v Œ ^š]o ‹µ š]}v dZ Œu o
ïXï	Z Ço]PZr v Œ }vÀ š]}v ^š]o]šÇ]Œ µo Œ Ço]v Œ• ^š	ï}(&o}Á šÁ v Z}š
ð	D} µo ðWµv ŒÇ o Ç Œ ‰‰Œ}Æ]u š]	
ðXí	/všŒ} µ š]}vU &o}Á W •š t P &o}Á dZ /vš PŒ o &}Œu }(šZ Æ]•Çuu šŒ] > u]v Œ : š X &o}Á ^ ‰ Œ š]}v	^š Pvî š]}v W}]vš }µv ŒÇ > Ç Œ ‹µ š]}v•U
ðXî	^]u]o Œ]šÇ šŒ v•(}Œu š]}v v D vPo }µv ŒÇ > Ç Œ• &}Œ }vÀ š]}v }v	ïŒ dŒ v•(}Œu š]}v dZ ,}Œ]Ì}vš o &o š Wo š
ðXï	& olv Œr^l v t P dZ Œu o }µv ŒÇ Wo š &o š Wo š Á]šZ }v•š vš dZ Œu o }vÀ š]}v &o š Wo š Á]šZ Z P]}v &o š Wo š Á]šZ v /•}šZ Œu o s Œš] o Wo š Wo š Á]šZ hv](}Œu }vÀ š]}v }v v /•}šZ Œu o s Œš] o]•šŒ] µš]}v]v v Æ]•Çuu šŒ] : š X	õ > Ç Œ /•}šZ Œu o , š &oµÆ dZ /vš PŒ o D š }v•š vš d u‰ Œ šµ , š &oµÆ E šµŒ o }vÀ š }vÀ š]}v }v s Œ E š}µ (}Œ E š d u‰ Œ šµŒ
ñ	D} µo ñWdµŒ µo vš &o}/Z]Œ D}	
ñXí	/všŒ} µ š]}v ^š š]•š] o ‰‰Œ} Z š }µŒ µo vš > vPšZ v š]u • o • v <}o}u}P}Œ}À[• šZ }ŒÇ	ïšµŒ µo vš (o}Á u} v ŒPÇ •]vP
ñXî	Z Çv}o • À Œ P šµŒ µo vš E À] Œ (}Œ šµŒ µo v u} o]vPX }v ‰š }(	ïš}l • ‹µ š]}v• šZ Ç À]• }•]šÇ v WŒ v

	u]Æ]vP o vPšZ ZÇ‰}šZ •]•	
ñXï	• Œ}U }v v šÁ} ‹µ š]}v šµŒ µo v •šŒ •• u} o•X > ŒP Ç •]uµo š]}v }(	ü} o• v Z Çv}o [• šµŒ µo vš (o}Á•X

K d î õ ð	' ^ z E D / ^	d 'K z	:	(	\	Z /
		s	ï	í	ì	ð

W Œ u o Z W • } µ Œ • ‰ Œ } À] • •] • } (} u ‰ Œ • •] o (o µ] (o } Á • v
(} Œ ‰ Œ š] o ‰ ‰ o] š] } v •

W Œ Œ ‹ µ] •] š W • } (& o µ] • U d Z Œ u } Ç v u] •

} µ Œ • K µ š } u • W š Z } u ‰ o š] } v } (š Z } µ Œ • š Z • š µ v š Á] o o

K	o µ o š Z v P • š } (o } Á • Œ } • •
K	‰ ‰ o Ç š Z •] } v ‰ š • } (µ v • š
K ï	} u ‰ µ š š Z ((š } (u • •] š] } v] v š Z (o } Á ‰ Œ u š Œ •
K	•] š ((š } (Z u] o Œ š] } v
K ñ	Æ ‰ o] v š Z ((š } (Z u] o Œ š] } v] v v } Ì Ì o (o } Á X

D ‰ ‰] v P } (} µ Œ • } µ š } u • Á] š Z ‰ Œ } P Œ u } µ š } u •

	W K	W K	W K	W K	W K	W K	W K	W K	W K	W í ì	W í í	W í î
K	ï	î			í							
K	ï	î			í							
K	ï	î										
K	ï	í										
K	ï	í										

• • • • u v š W š š Œ v

o } } u [• š	} v š] v µ } µ • • • • u		v ^ u • š Œ Æ
	í	î	
Z u u	í ì	í ì	î ì
h v Œ •	î ì	î ì	î ì
‰ ?	î ì	î ì	¿ ì
v o (			
À o µ			
Œ			

D Œ l] • š Œ] µ š] } v

d } š o D	/	^	^ µ Œ
í ñ ì	ñ ì	í ì ì	ï Z } µ Œ •

}vš]vµ}µ• /vš Œv o À oµ š]}v W šš ŒvW

šš v v W íì u Œl•
}vš]vµ}µ• •• ••u vš d •š ~î vµu Œ•• W îñ u Œl•
••]Pvu všlYµ]Ìl }µŒ• ‰Œ}i š W íñ u Œl•

v ^ u •š Œ Æ u]v š]}v Á]oo Z À šÁ} ‰ Œš•V W Œš v W Œš X
‹µ •š]}v• Á]šZ î ‹µ •š]}v• (Œ}u Z u} µo U Z À]vP ï u Œl• (}Œ Z ‹µ
v•Á Œ oo ‹µ •š]}v•X W Œš }vš]v• î ‹µ •š]}v• (Œ}u Z u} µo }(ÁZ
vÇ }v X Z ‹µ •š]}v v Z À u Æ]uµu î •µ r]À]•]}v• v ŒŒÇ íð u Œ

}µŒ• > À o •• ••u vš Yµ •š]}v•

}µŒ• Kµš }u í ~ Kí•W

íX Æ‰o]v ÁZÇ šZ •Z} l Á À]• š Z]v o v } ÇM

îX E}Œu o •Z} l Á À šŒ À oo]vP š íîñìul• u}À •]v š} •š]oo]Œ š •
(Œ}u ‰o v Á ooX }u‰ Œ šZ ‰Œ ••µŒ Œ š]} Œ}•• šZ Œ (o š •
]v] vš •Z} lX Æ‰o]v ÁZÇ šZ ‰Œ ••µŒ Œ š]}]•]((Œ všX tZ š Œ
‰ •• P }(šZ Œ (o š Á À M

ïX tZÇ šZ Œ (o š •Z} l Á À]• o •• } o]‹µ šZ v šZ]v] vš }v (}Œ š
]u P]v ŒÇ Á P vPo MX

}µŒ• Kµš }u î ~ Kî•

íX Œ]À v Æ‰Œ ••]}v (}Œ š]u š l v š}]• Z ŒP]Œ (Œ}u Z u Œ
µv•š Ç (o}Á }v]š]}v

îX r E}Ìlo]• }vv š š} Z u Œ š ZÀ}o µu ñì uZ ŒP šZŒ}µPZ š
v}Ìlo (Œ}u š}š o ‰Œ ••µŒ ïXñ Œ š} íXìí ŒX µŒ]vP šZ]•]• Z ŒP
Æ]š š} šZŒ} šX &]v šZ À o}]šÇ }(šZ •Z} l Á À](šZ o vPšZ }(šZ
••µu Œ }(šZŒ}š šo •] í ìu }v]š]}v]• í Œ š}š o š u‰ Œ šµŒ òìì< v
šÁ v šZ ‰Œ ••µŒ v š u‰ Œ šµŒ]•]•}šZ Œu oX

ïX]• µ•• šZ]À ŒP v vPo ((š]v šZ (o}Á • ‰ Œ š]}v]v r E}Ì

}µŒ• Kµš }u ï~ Kï•W

íX Æ‰o]v šZ ((š }(u ••]š]}v }v (o}Á ‰Œ}‰ Œš] •M

îX]Œ Á]šZ]v]š] o •š Pv š]}v }v]š]}v }(òìì< v íDW (o}Á• š D Z v
všŒ v š} }vš vš Œ ‰}Œ}µ• Á oo µ šX µŒ]vP ‰ •• P šZŒ}µP
]v Œ • Ç ñì9X &]v šZ Æ]š }v]š]}vM

ïX Æ‰o]v šZ ((š }(u •• Œ i š]}v }v (o}Á ‰Œ}‰ Œš] •X

}µŒ• Kµš }u ð ~ Kð•W

íX]•š]vPµ]•Z šÁ v &Œ}Ì v (o}Á• Z u] ooÇ ‹µ]o] Œ]µu (o}Á v v}v

îX Æ‰o]v Á]šZ š u‰ Œ šµŒ]•šŒ] µš]}v µŒÀ šZ ((š }(Z u] o v }u‰ Œ Á]šZ (Œ}Ì v (o}Á

ïX Æ‰o]v ÁZÇ šZ ZÇ‰ Œ•}v] } Ç v}• Œ o v]v •Z ‰ ÁZ]o šZ

}µŒ• Kµš }u ñ ~ Kñ•W

íX Æ‰o]v Z}Á šZ }u‰µš š]}v o u šZ} v]v }}‰ Œ š Z u] oo

îX Æ‰o]v Á]šZ š u‰ Œ šµŒ]•šŒ] µš]}v µŒÀ šZ ((š •}o] ‰ Œš v }u‰ Œ Á]šZ] o (o}ÁX

ïX Æ‰o]v Á]šZ š u‰ Œ šµŒ]•šŒ] µš]}v µŒÀ šZ ((š }(Z u] o v }u‰ Œ Á]šZ (Œ}Ì v (o}ÁX

D} o Yµ •š]}v ‰ ‰ Œ

YW K W

W: h> < > D d ,EK>K'/ > hE/s Z^/dz d,/Z ^ D ^d Z Xd , 'Z y

DKEd, ˜ z Z

}µŒ• } W Kdîõð

' ^ zE D/ ^

D ÆXD ŒI•Wíìì

W Zd

v•Á Œ oo Yµ •š]}v•X Z ‹µ •š]}v ŒŒ] • ï D ŒI•

íX o µo š šZ D Z E} }(v]Œ Œ (š (oÇ]vP]v •š v Œ • À o}]šÇ }(ðñìuI•X

îX^I š Z WŒ v šo• oo]‰• (Œ}u v ŒPÇ ‹µ š]}v v]v] š }Œ]vP š} D Z vµu Œ

ïX^I š Z šZ Á À ‰ šš Œv• }(šZ i š }(v µv Œ Æ‰ v v}ÌÌ

ðX Æ‰o]v ÁZÇ šZ }vš}µŒ v}ÌÌo • Œ o •• • ‰ Œ š šZ v }

ñX Æ‰o]v šZ ((š }(u ••]š]}v š} šZ (o}Á Á]šZ •µ]š o •I

òX^I š Z šZ ,µP}v]}š µŒÀ (}Œ] š] (o}Á]v Wrs ‰o v ‰}]vš•

^Çoo µ•

D} µo Wí &µv u vš o }v ‰š• }(}u‰Œ ••] o (oµ] (o}Á•U WŒ v šo[
D}À]vP v}Œu o •Z} lU Z (o š]}v }(v}Œu o •Z} l Á À (Œ}u Á oo v ‰
•Z} lU ^šŒ}vP v Á l •Z} lU Œ (o š]}v }(•Z} l Á À }Á •Z} l Á À U

D} µo îW/v•š Ç (o}Á šZŒ}µPZ •µ •}v] v •µ‰ Œ•}v] v}Ììo •U ÆZ µ•š
v}Ììo • ~] u}v •Z} l••U Z o v}Ììo •U o}•• •U ^µuu Œ(] o Œ]š Œ]}vU
v}Ììo U

D} µo ïW••]š]}v š} šZ (o}ÁU ((š }(u ••]š]}v }v (o}Á ‰Œ}‰
v}Œu o š} šZ u]v •šŒ u ‰‰o] š]}v š} •}o] ‰Œ}‰µo•]}v Œ} l š u}š}

D} µo Wð ‹µ]o] Œ]µu v}Œu o •Z} l Á À U ‹µ]o] Œ]µu oµvš } Ç (o}Á•U
‹µ]o] Œ]µu v}Œu o •Z} l Á À U v}vr ‹µ]o] Œ]µu oµvš } Ç (o}Á•U } o]‹

D} µo Wñ ‹µ]o] Œ]µu ‹µ •] }v]u v•]}v o (o}Á šZŒ}µPZ v}Ììo •U šÁ}r‰Z
‹µ •] }v]u v•]}v o (o}Á šZŒ}µPZ v}Ììo •U uµoš]r‰Z • (o}ÁX }u‰ Œ š
‹µ]o] Œ]µuU v}vr ‹µ]o] Œ]µu (o}Á šZŒ}µPZ šZ v}Ììo X

d Æš }}l•

íX }u‰Œ ••] o &oµ] Çv u] • Á]šZ ‰ Œ•}v o }u‰µšŒ ‰‰o] š]}v Ç
'LY

îX ,Ç‰ Œ•}v] v ,]PZ d u‰ Œ šµŒ ' • Çv u] • Ç :}Zv v Œ•}vU /

Z (Œ v }}l•

íX ' • Çv u] • Ç D µŒ] : •µ Œ}ÁU :} ,}((u vU t]o Ç

îX o u vš• }(' • Çv u] • Ç >] ‰u vv v Z}•Zl} U }À Œ Wµ o] š]}v•

}µŒ• }vš vš• v > šµŒ ^ Z µo

E}	d}‰]	E}X }(> šµŒ •
í	D} µo í	
íXí	}u‰Œ ••]]o]šÇU E}v]u v•]}v o W Œ u š Œ•U WŒ v šo•	
íXî	E}Œu o •Z} lU D}À]vP v}Œu o •Z} lU Zï(o š]}v }(v}Œu o •Z} Á À (Œ}u Á oo v ‰Œ ••µŒ }µv ŒÇX	
íXï	K o]‹µ •Z} lU ^šŒ}vP v Á l •Z} lU Œ (o š]}v }(•Z} l Á À }Á •Z} l Á À U	
î	D} µo î	
îXí	hv•š Ç (o}Á šZŒ}µPZ •µ •}v] v •µ‰ Œ•}v] v}Ììo •U	
îXî	ÆZ µ•š P • Á À ‰Œ}‰ P š]}v }(}À Œõ Æ‰ v U hv Œ Æ‰ v v}Ììo • ~] u}v •Z} l••U	
îXï	Z o v}Ììo •U o}•• •U •µuu Œ (] o • Œ]š Œ] U &o}Á • ‰ Œ	

	šZ v}ÌÌo U }vš}µŒ v }v] o v}ÌÌo •X	
ï	D} µo ï	
ïXí	D ••]š]}v š} šZ (o}ÁU •]u‰o u ••]š]}v }v (o}Á ‰Œ}‰ Œš] •X	ï]š]}vU ((š }(u ••
ïXî	D ••]š]}v v}Œu o š} šZ u]v •šŒ	uï
ïXï	‰‰o] š]}v š} •}o] ‰Œ}‰µo•]}v Œ}	l š u}š}ŒU }u µ•š]}v
ð	D} µo ð	
ðXí	,]PZ š u‰ Œ šµŒ ‹µ]o] Œ]µu (o}Ár Æ‰Œ ••]}v (}Œ À o}]šÇ }(•}µv]v v ‹µ]o] Œ]µu Z u] ooÇ Œ š]vP P •U /v ‰ v v }(D Z vµu ŒU	'ðÀ Œv]vP ‹µ š]}v•U ‹µ]o] Œ]µu v v}vr
ðXî	‹µ]o] Œ]µu v}Œu o •Z} l Á À U } o]‹µ •Z} l Á À	‹µ]o]ïŒ]µu oµvš } Ç (o}Á
ðXï	E}vr ‹µ]o] Œ]µu v}Œu o •Z} l Á À U (o}Á•U } o]‹µ •Z} l Á À	v}îvr ‹µ]o] Œ]µu oµvš
ñ	D} µo ñ	
ñXí	‹µ]o] Œ]µu ‹µ •] }v]u v•]}v o (o}Á ‰Z • (o}Á	šõZŒ}µPZ v}ÌÌo •U šÁ]
ñXî	E}vr ‹µ]o] Œ]µu ‹µ •] }v]u v•]}v o uµoš]r‰Z • (o}ÁX	(ö}Á šZŒ}µPZ v}ÌÌo •U
ñXï	}u‰ Œ š]À •šµ] • }v (Œ}Ì v ‹µ]o] šZŒ}µPZ šZ v}ÌÌo X	Œî]µuU v}vr ‹µ]o] Œ]µu

Kd îõò	s E D , E/ ^ K& D d Z/ >^	d 'KZz	:	(	\	Z /	z Œ }(/vš Œ
		s	ï	í	ì	ð	îìíõ

WŒ u oZ]W }µŒ• ‰Œ}À] • v]všŒ} µ š]}v š} šZ u šZ u š] o (}µv š]}v• } s š}Œ• v š v•}Œ•U ‰Œ}‰ Œš] • v •] }‰ Œ š]}v•X <]v u š] • }((}Œ šZ Œu} Çv u] •X ^šŒ ••X }v•š]šµš]À ‹µ š]}v•X o •š] U À]• }µ•U v À]• } ^]u‰o ‰Œ} o u•]v (]v]š v o]v Œ o •š]]šÇU v]v E À] Œr^š}l • (o}Á•X À]• } o •š]]šÇ

WŒ Œ ‹µ]•]š W E]o

}µŒ• Kµš } u W šZ }u‰o š]}v }(šZ }µŒ• šZ •šµ vš Á]oo o š}

K í	W Œ(}Œu À š}Œ v š v•}Œ u v]‰µo š]}v•]v Œš •] v v µŒÀ]o]v Œ
K î	• Œ] u}š]}vU (}Œu š]}v v (}Œ •]v }vš]vµµuX
K ï	Œ]À ‹µ š]}v• }(u}š]}v v }v• ŒÀ š]}v o Á• (}Œ }vš]vµµuX
K ð	‰‰oÇ }v•š]šµš]À u} o• (}Œ (oµ] • v À]• } o •š] •}o] •X
K ñ	^}oÀ •]u‰o }µv ŒÇ À oµ ‰Œ} o u• (}Œ (oµ] • v •}o] •X

D ‰‰]vP }(}µŒ• }µš }u • Á]šZ ‰Œ}PŒ u }µš }u •

	WK í	WK î	WK ï	WK ð	WK ñ	WK ò	WK ó	WK ô	WK õ	WK
K í	ï								í	
K î	ï								í	
K ï	ï	ï	î	í	í				í	
K ð	ï								í	
K ñ	ï	ï	î	í	í				í	

•• ••u vš W šš Œv

o}}u[• š P}ŒÇ	}vš]vµ}µ• •• ••u vš d •š•		v ^ u •š Œ Æ u]v š]}v
	í	î	
Z u u Œ	íì	íì	îì
hv Œ•š v	íñ	íñ	ïì
‰‰oÇ	îñ	îñ	ñì
v oÇ•			
À oµ š			
Œ š			

D Œl]•šŒ] µš]}v

d}š o D Œl•	/	^	^ µŒ š]}v
íñì	ñì	íìì	ï Z}µŒ•

}vš]vµ}µ• /vš Œv o À oµ š]}v W šš ŒvW

šš v v   W íì u Œl•
}vš]vµ}µ• •• ••u vš d •š ~î vµu Œ•• W îñ u Œl•
••]Pvu všlYµ]Ìl }µŒ• ‰Œ}i š   W íñ u Œl•

v ^ u •š Œ Æ u]v š]}vW Z WŒ šš ŒvW šÁ} ‰ Œš•V W Œš   v W Œš X W Œš
Á]šZ î ‹µ •š]}v• (Œ}u   Z u} µo U Z À]vP ï u Œl• (}Œ   Z ‹µ •š]}vX ^šµ vš•
W Œš   }vš]v• î ‹µ •š]}v• (Œ}u   Z u} µo }(ÁZ] Z •šµ vš •Z}µo v•Á Œ v
Z À u Æ]uµu î •µ r]À]•]}v• v   ŒŒÇ íð u Œl•X

}µŒ• > À o •• ••u vš Yµ •š]}v•
}µŒ• Kµš }u í ~ Kí•W

íX ^š š }(•šŒ •• š ‰}]vš]• š v•}Œ ‹µ vš]šÇX Æ‰o]v

îX Æ‰o]v ' }u šŒ]]vš Œ‰Œ š š]}v }( ]P vÀ š}Œ•

ïX •/{ ƒ L ÙZ}o • (}Œ À ŒÇ •Çuu šŒ] •š Œ •• š v•}Œ

}µŒ• Kµš }u î ~ Kî•

íX Æ‰o]v]Œ š]}v o Œ]À š]À }(š v•}ŒX

îX (]v > À]r]À]š š v•}ŒX

ïX WŒï}À÷ïQ L ï&ïQ F:ï&Q?E:ï&Q

}µŒ• Kµš }u ï ~ Kï•W

íX tŒ]š P }u šŒ]]vš Œ‰Œ š š]}v }( ]o š]}v

îX Æ‰o]v Z Çv}o •[• šŒ v•‰}Œš šZ }Œ u

ïX 7KH PRWLRQ RI FRQWLQXXP LV GHILQHG E\ WKH YHORFLW\ RL Fß T á RL Ú :KHUH J @ DÚH QRQ]HUR FRQVWDQWV 7KHQ VKRZ LVRFKRULF

}µŒ• Kµš }u ð ~ Kð•W

íX Æ‰o]v W]}oVWHUZV (WHQVRU

îX Æ‰o]v SULQFLSOH RI IUDPH LQGLIIHUHQFH

ïX dÁ} •Çuu šŒ] š v•}Œ• Œ •] š}   } Æ] o](šZ]Œ]P vÀ š}Œ• Œ
}ŒšZ}v}Œu o]P vÀ š}Œ• }uu}v•X ^Z}Á šZ š šZ v• š}Œ]P vÀ š}Œ• Œ
•šŒ]vŒ } Æ] o](v }voÇ](šZ o µ Z µ •ŒÇ v •šŒ]v š v•}Œ

}µŒ• Kµš }u ñ ~ Kñ•W

íX Æ‰o]v }u‰ š]]o]šÇ }v]š]}v v]š• P }u šŒ]]vš Œ‰Œ š š]}v•X

îX Æ‰o]v P v Œ o]• D ÆÁ oo u} o (}Œ À]• } o •š] u š Œ] o•X

ïX Œ]À •šŒ]v }u‰ š]]o]šÇ }v]š]}vX

D} o Yµ •š]}v ‰ ‰ Œ

YW K W

W: h> < > D d ,EK>K'/ > hE/s Z^/dz d,/Z ^ D ^d Z Xd , 'Z y D/E

DKEd, ˜ z Z

}µŒ• } W Kdîõò

s E D , E/ ^ K& D d Z/ >^

D ÆXD ŒI•Wíìì

W Zd

v•Á Œ oo Yµ •š]}v•X Z ‹µ •š]}v ŒŒ] • ï D ŒI•

íXtZ š]•]o š Œ o (]oš Œ]vP (}Œ š v•}Œ À oµ š M

îX }]š]À u ‰• u]š š v•}Œ ‰Œ} µ šM Æ‰o]v

ïX/•]š ‰}••] o š} (]v > À]r]À]š š v•}Œ]v î]u v•]}vM tZÇM

ðX Æ‰o]v PŒ] vš }(š v•}Œ ‹µ vš]šÇX

ñX Æ‰o]v Z Çv}o •[• šŒ v•‰}Œš šZ }Œ uX

òXtŒ]š šZ Œ o š]}v šÁ v À}Œš]]šÇ v]Œ µo š]}v š v•}Œ•

óX Æ‰o]v <]ŒVZZU}(HVV WHQVRU

ôX Æ‰o 3UJLQFLSOH RI PDWHULDO IUDPH LQGLIIHUHQFH

õX Æ‰o]v Z}Á À]• } o •š] u š Œ] o•]((Œ (Œ}u o •š] u š Œ]

íìX Æ‰o]v •Z vo Ç šZ }ŒÇ }( ]v o •š] µ lo]vPX

W Zd

v•Á Œ vÇ }v (µoo ‹µ •š]}v (Œ}u Z u} µo X Z ‹µ •š]}v

D} µo í

ííX ~ ;I: LV D VNHZ V\PPHWULF WHQVRU; WKHQ VKRZ WKDW RUWKRJRQDO WHQVRU

~ ;I• ÷ ƒ LÙKROGV IRU HYHU\ 6\PPHWULF WHQVRU DQG VNHZ V\PPHWULF WHQVRU

$ /HW ÆáœáE H RUWKRJRQDO EDVLV 7KHQ VKRZ WKDW HLJHQYHFWRUV DUH RUWKRJRQDO DQG OLQHDUO\ LQGHSHQGHQW HLJHQ YHFWRUV RI

D} µo î

íïX 3URIY:ÎHR; L ÎÏR E RÏÎ

~ •

ÏQ ÷ÏQ;€ L Ï&:ÏQ;Q F:Ï&QQ?E :Ï&Q6

~ô•

íðXHW + EH D VXUIDFH ERXQGHG EXFLRQ WR XUZD&UG/HQWRUPDO EH D YHFWRU IUHQG RQ WKH W7KHQ ORZ LQJ VWRNHV WKHRUHP

ì¼:J H;R @T{ L+ F Jê;J÷ ÏR ò ~íð•

D} µo ï

7KH PRWLRQ RI FRQWLQXXP LV GHILQHG E\ WKH YHORFLW\ RL F T á 5L Ú :KHUH @ DUH QRQ]HUR FRQVWDQWV 7KHQ

, VKRZ WKDW WKH PRWLRQ LV LVRFKRULF

,,)LQG RXW WKH FRPSRQHQWV RI

/HW - EH GHWHUPLQDQW)RU &DXFK\ *UHHQ VWUDLQ WHQVRU 7KHQ VKRZ WKDW

$$\frac{!\tilde{A}}{!\frac{1}{4}} L \frac{5}{6} , \%$$

~íð•

D} µo ð

íóXZR V\PPHWULF WHQVRUV DUH VDLG WR EH FRD[LDO LI WKH\ KDYH D VHW RI RUWKRQRUPDO HLJHQYHFWRUV FR .LUFKKRII 6WUHVV WHQVRU LQ WKH ULJKW &DXFK\ *UHHQ VWUDLQ &DXFK\ VWUHVV DQG OHIW &DXFK\ *UHHQ % VWUDLQ

~íð•

íôXHÎW DQG EH VFDODU DQG VHFRQG RUGHU WHQVRU ILHOG WUDQVSRUW WKHRUHPV

$$\frac{@}{@T_{\frac{1}{4}}} » Î @T L » \frac{&Î}{&P} E Î.p@T$$

$$\frac{×}{×ë} ï_{\{} t" ò L ï_{\{} \frac{@}{½ ç} E :Ï&œ F t :Ïœ;Í A" \qquad ~íð$$

D} µo ñ

íõX Œ]À •šŒ •• }u‰ š]]o]šÇ v •šŒ]v }u‰ š]]o]šÇ (}Œ
~íð•

îìX Æ‰o]v]((Œ vš u} o• }(À]• } o •š]
~íð•

^Çoo µ•

D} µo í

s š}Œ •‰ U µ ZÇr^ ZÁ ŒšÌ]v ‹µ o]šÇU v dŒ] vPo]v ‹µ o]šÇX }
‰Œ} µ šU <Œ}v l Œ oš U W Œuµš š]}v •Çu }oX (]v]š]}v }(š v•}ŒU
]v ÆU µuuÇ]v ÆX Æ u‰o • š} µv Œ•š v v}š š]}v•U K‰ Œ š]}v• }v
}(š}Œ š v•}ŒU /vÀ Œ] vš• }(^KdU /vÀ Œ• }(^KdX]P vÀ oµ •
]vš Œ‰Œ š š]}v }( ]P vÀ š}Œ•U Ço Çr, u]oš}v šZ }Œ uX

D} µo î

^l Ár•Çuu šŒ] U KŒšZ}P}v oU v ^Çuu šŒ] š v•}Œ•X]š]À }u‰}•
^‹µ Œ Œ}}š š v•}ŒX Xo µoµ• }(š v•}Œ•

D} µo ï

<]v u š] • r D ‰‰]vP (µv š]}vU (}Œu š]}v PŒ] všU > vPšZU Œ U
•‰ š] o • Œ]‰š]}vX Z š }((}Œu š]}vU ^‰]v š v•}Œ•U ^šŒ]v š v•}
Œµo }( ]vš PŒ š]}vU dŒ v•‰}Œš šZ }Œ u•X

D} µo ð

µ ZÇ ZÇ‰}šZ •]• v µ ZÇ šZ }Œ uU ‹µ š]}v }(u}š]}vX vPµo Œ u}u
}(u}š]}v]v u š Œ] o }}Œ]v š •U W]}o <]Œ ZZ}((•šŒ •• š v•}ŒX v
šZ Œu} Çv u] •X WŒ]v]‰o }(u š Œ] o (Œ u r]v]((Œ v X

D} µo ñ

}v•š]šµš]À ‹µ š]}v•X >]v Œ o •š]]šÇX &oµ] u Z v] •X s]• } o •š]]š

d Æš }}l•

íX v /všŒ} µ š]}v š} }vš]vµµu D Z v] • Á]šZ ‰‰o] š]}v•U Ç :X EX Z Ç
îììô ~/^ E ·õóôrìrñîírôóìðrï•X

îX :}PU X^XU &}µv š]}v• v ‰‰o] š]}v• }(u Z v] •W s}oµu /W }vš]vµµu u
Wµ o]•Z]vP Z}µ• X

Z (Œ v }}l•

íX D oÀ ŒvU >X XU /všŒ} µ š]}v š} šZ u Z v] • }(}vš]vµ}µ• u]µuU íõòõU W

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ïXî	D š Œ] o v •‰ š] o • Œ]‰š]}vX	î
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		3&&					

3UHDPEOH

0HFKDQLFV RI VROLGV LV RQH RI WKH IRXQGDWLRQ FRXUVH
FRXUVH SURYLGHV WKH IXQGDPHQWDO FRQFHSWV RI PHFKD
VWXGHQWV WR GHYHORS WKHLU DQDO\WLFDO DQG SUREOH
VWXGHQWV WR WKH YDULRXV LQWHUQDO HIIHFWV LQGXFH
GHIRUPDWLRQV GXH WR GLIIHUHQW W\SHV RI ORDGLQJ $IW
GHWHUPLQH WKH VWUHVV VWUDLQ DQG GHIRUPDWLRQ RI OR

3UHUHTXLVLWH (6 (QJLQHHULQJ 0HFKDQLFV

&RXUVH 2XWFRPH $IWHU WKH FRPSOHWLRQ RI WKH FRXUVH WKH VW

&RXUVH 2XWFRPH	'HVFULSWLRQ RI &RXUVH 2XWFRPH	3UHVFULEHG OHDUQLQJ OHYHO
&2	5HFDOO WKH IXQGDPHQWDO WHUPV DQG WKHRUHPV PHFKDQLFV RI OLQHDU HODVWLF GHIRUPDEOH ERGLH	5HPHPEHULQJ
&2	([SODLQ WKH EHKDYLRU DQG UHVSRQVH RI YDULRX HOHPHQWV XQGHU YDULRXV ORDGLQJ FRQGLWLRQV	8QGHUVWDQGLQJ
&2	$SSO\ WKH SULQFLSOHV RI VROLG PHFKDQLFV WR FD VWUHVVHV VWUDLQV VWUHVV UHVXOWDQWV DQG VWUXFWXUDO HOHPHQWV VXEMHFWHG WR D[LDO WU EHQGLQJ WZLVWLQJ PRPHQWV	$SSO\LQJ
&2	&KRRVH DSSURSULDWH SULQFLSOHV RU IRUPXOD WR FRQVWDQWV RI PDWHULDOV PDNLQJ XVH RI WKH DYDLODEOH	$SSO\LQJ
&2	3HUIRUP VWUHVV WUDQVIRUPDWLRQV LGHQWLI\ SU VWUHVVHV DQG PD[LPXP VKHDU VWUHVVHV DW D SRLQ PHPEHU	$SSO\LQJ
&2	$QDO\VH WKH JLYHQ VWUXFWXUDO PHPEHU WR FDO ORDG RU SURSRUWLRQ WKH FURVV VHFWLRQ WR FDU	$QDO\VLQJ

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV

	32	32	32	32	32	32	32	32	32	32	32	32
&2												
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$VVHVVPHQW 3DWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW 7HVWV		(QG 6HPHVWHU ([DPLQDWLR
5HPHF			
8QGHUVWDQG			
$SSO\			
$QDO\VH			
(YDOXDWH			
&UH			

0DUN GLVWULEXWLRQ

7RWDO 0DUNV	&,(	(6(	(6('XUDWLRQ
			KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV PDUNV
$VVLJQPHQW 4XL] &RXUVH SURMHFW PDUNV

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ 7KHUH ZLOO EH WZR SDUWV 3DUW $ D
FRQWDLQ TXHVWLRQV ZLWK TXHVWLRQV IURP HDFK PRG
6WXGHQWV VKRXOG DQVZHU DOO TXHVWLRQV 3DUW % FRQW
VWXGHQW VKRXOG DQVZHU DQ\ RQH (DFK TXHVWLRQ FDUUL
VXE GLYLVLRQV

&RXUVH /HYHO $VVHVVPHQW 6DPSOH 4XHVWLRQV

&2 5HFDOO WKH IXQGDPHQWDO WHUPV DQG WKHRUHPV
OLQHDU HODVWLF GHIRUPDEOH ERGLHV

:KDW LV SURSRUWLRQDOLW\ OLPLW" :KDW LV LWV VLJQ
6NHWFK WKH VWUHVV VWUDLQ FXUYH RI PLOG VWHHO D
:KDW LV 3RLVVRQ¶V UDWLR"
:KDW LV %XON PRGXOXV RI (ODVWLFLW\" :ULWH WKH U
PRGXOXV RI HODVWLFLW\ DQG <RXQJ¶V PRGXOXV RI HO
:KDW LV SXUH EHQGLQJ" *LYH DQ H[DPSOH
:KDW LV SRLQW RI FRQWUDIOH[XUH"
:KDW DUH WKH OLPLWDWLRQV RI (XOHU¶V IRUPXOD WR
VOHQGHU FROXPQV
:KDW LV VWUDLQ HQHUJ\"
:KDW LV FRPSOHPHQWDU\ VKHDU VWUHVV"
:KDW DUH SULQFLSDO VWUHVVHV DQG SULQFLSDO SODQ

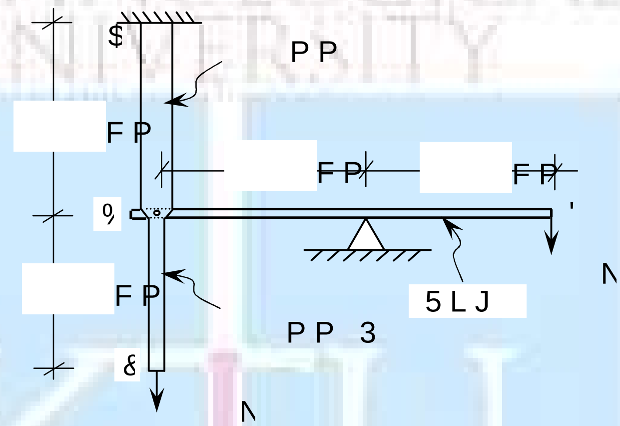
&2 ([SODLQ WKH EHKDYLRU DQG UHVSRQVH RI YDULRXV V
YDULRXV ORDGLQJ FRQGLWLRQV

([SODLQ KRZ WKH GHIRUPDWLRQ RI DQ D[LDOO\ ORDGHG
FURVV VHFWLRQ LV FDOFXODWHG"
([SODLQ WKH EHKDYLRU RI PLOG VWHHO XQGHU JUDGXD
([SODLQ WKH HIIHFW RI WHPSHUDWXUH FKDQJH RQ D F
PDWHULDOV
+RZ GR \RX FRPSXWH WKH PD[LPXP VWUHVV LQGXFHG
ORDG"
([SODLQ WKH FRQFHSW RI %0 DQG 6) LQ EHDPV ZLWK
EHDP VXEMHFWHG WR XQLIRUPO\ GLVWULEXWHG ORDG F
/LVW WKUHH LPSRUWDQW DVVXPSWLRQV XVHG LQ WKH
H[SODLQ WKHLU VLJQLILFDQFH
([SODLQ WKH EHKDYLRU RI VOHQGHU FROXPQV XQGHU D
'LVWLQJXLVK EHWZHHQ VKRUW DQG ORQJ FROXPQV ZLW
XQGHU D[LDO FRPSUHVVLRQ
([SODLQ KRZ WKH OLPLWDWLRQ RI (XOHU¶V IRUPXOD W
FROXPQV LV DGGUHVVHG LQ 5DQNLQH¶V IRUPXOD

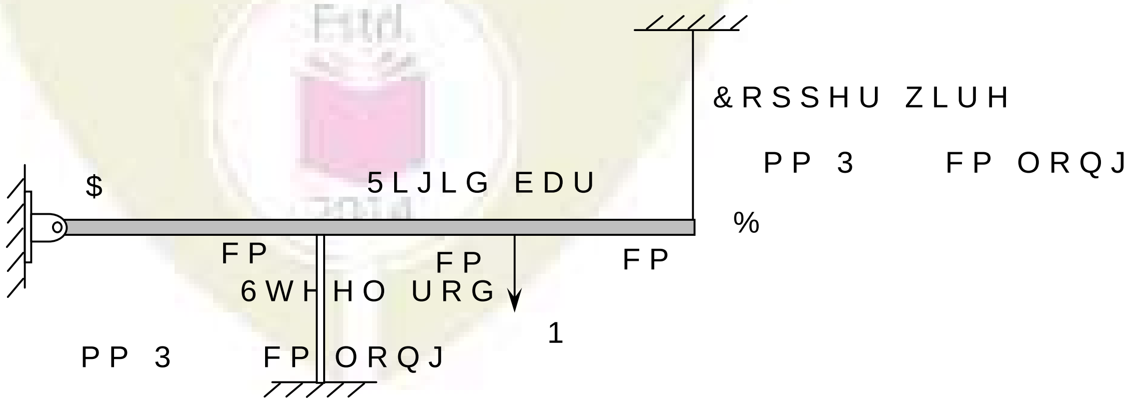
&2 $SSO\ WKH SULQFLSOHV RI VROLG PHFKDQLFV WR FD
VWUHVV UHVXOWDQWV DQG VWUDLQ HQHUJLHV LQ V
D[LDO WUDQVYHUVH ORDGV DQG EHQGLQJ WZLVWLQJ P

$ VWHHO IODW RI FURVV VHFWLRQ PP î PP FDUUL
WKH VWUHVV LQGXFHG LQ WKH FURVV VHFWLRQ ,I D
PDGH QRUPDO WR WKH IODW VXUIDFH ILQG WKH PD
VHFWLRQ

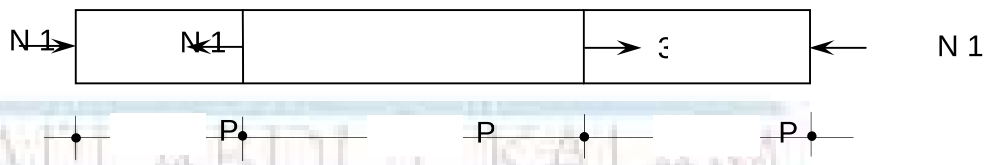
7KH EDU $%& VKRZQ LQ ILJXUH LV PD VHFWL
EDU %' LV ULJLG)LQG WKH VWUHVVHV LQ SRUWLRQ
GHIOHFWLRQ DW & 7DNH (*3D



$ ULJLG EDU$%RI OHQJWK FP KLQJHG DW RQH HQ
D FRSSHU ZLUH DV VKRZQ)LQG WKH VWUHVVHV LQG
GRZQZDUG ORDG DFWLQJ DW FP IURP WKH KLQJHG
YHUWLFDO GHIOHFWLRQ DW % DOVR 0RGXOXV RI HODV
DQG *3D UHVSHFWLYHO\ 1HJOHFW WKH ZHLJKW RI W

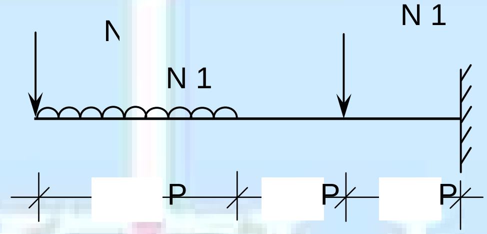


$ PP GLDPHWHU VWHHO EDU LV VXEMHFWHG WR IR
YDOXH 3 QHFHVVDU\ IRU HTXLOLEULXP DQG VWUHVVHV
FDOFXODWH WKH ILQDO OHQJWK RI WKH EDU 7DNH (

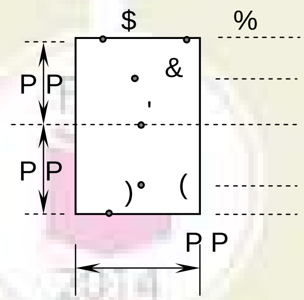


$ F\OLQGULFDO EDU ZLWK WZR VHFW GLDPH\
PP DQG PP UHVSHFWLYHO\ LV VXEMHFWHG WR DQ D
VWUHVV LV &DO1FXODWH WKH VWUDLQ HQHUJ\ VWRUHG

'UDZ WKH 6)' DQG %0' RI WKH EHDP VKRZQ



)LJXUH VKRZV WKH FURVV VHFWLRQ RI D EHDP)LQG
QDWXUH DW SRLQWV $ % & ' (DQG) LI WKH VHFWLRQ
WKH YDULDWLRQ RI VWUHVV DFURVV WKH FURVV VHFW
$OVR FDOFXODWH WKH VKHDU VWUHVV DW WKHVH SRL
N1



&2 &KRRVH DSSURSULDWH SULQFLSOHV RU IRUPXOD WR I
PDWHULDOV PDNLQJ XVH RI WKH LQIRUPDWLRQ DYDLOD

$ FRQFUHWH F\OLQGHU RI GLDPHWHU PP DQG KH
FRPSUHVVLRQ ,W ZDV IRXQG WKDW WKH GLDPHWHU ZD
KHLJKW ZDV GHFUHDVHG E\ PP XQGHU WKH DFWLR
N1 &DOFXODWH WKH PRGXOXV RI HODVWLFLW\ 3RLVV
PRGXOXV RI FRQFUHWH

$ WHQVLRQ WHVW LV FDUULHG RXW RQ D PLOG VWHHO
XQGHU D ORDG RI N1 LW UHDFKHV D PD[LPXP ORDG
7KH GLDPHWHU RI WKH EDU DW EUHDNLQJ ZDV IRXQG W
WKH EDU RYHU D JDXJH OHQJWK RI PP ZDV IRXQG WR
N1 (VWLPDWH D <RXQJ¶V PRGXOXV E \LHOG VWUHQ
DFWXDO EUHDNLQJ VWUHQJWK

&2 3HUIRUP VWUHVV WUDQVIRUPDWLRQV LGHQWLI\ SU
PD[LPXP VKHDU VWUHVV DW D SRLQW LQ D VWUXFWXUD

$ EDU RI PP GLDPHWHU FDUULHV DQ D[LDO SXOO
VKHDU VWUHVV RQ D SODQH LQFOLQHG DW ƒ ZLWK
PD[LPXP VKHDU VWUHVV LQGXFHG LQ WKH EDU DQG W
SODQH"

$W D FHUWDLQ SRLQW LQ D VWUDLQHG PDWHULDO W
WR HDFK RWKHU DUH 03D WHQVLOH DQG 03D
DFFRPSDQLHG E\ D VKHDU VWUHVV RI PDJQLWXGH 0
DQG ORFDWH WKHLU SODQHV $OVR ILQG WKH PD[LPX
RQ WKH SODQH RI PD[LPXP VKHDU VWUHVV

&2 $QDO\VH WKH JLYHQ VWUXFWXUDO PHPEHU WR FDOFX
WKH FURVV VHFWLRQ WR FDUU\ WKH ORDG VDIHO\

$ WLPEHU PP î PP LV XVHG DV D VLPSO\
P)LQG WKH PD[LPXP XQLIRUPO\ GLVWULEXWHG ORDG W
WR D FRQFHQWUDWHG ORDG RI N1 DFWLQJ DW WKH PL
VWUHVV LQ WKH EHDP LV1HJOHFW VHOI ZHLJKW RI EHDP

$ P ORQJ FDQWLOHYHU EHDP RI UHFWDQJXODU VHFWLR
N1 P RYHU WKH ZKROH VSDQ ,I WKH PD[LPXP EHQGLQJ
1 PP ILQG WKH GLPHQVLRQV RI WKH FURVV VHFWLRQ DV

$ FDVW LURQ WHVW EHDP PP VTXDUH LQ VHFWLRQ
VXSSRUWHG DW HQGV ,W IDLOV XQGHU D FHQWUDO OR
HQG ZLOO EUHDN D FDQWLOHYHU RI WKH VDPH PDWHULD
PP ORQJ"

$ VROLG FLUFXODU VKDIW WUDQVPLWV N: SRZHU DW U
VKDIW LI WKH WZLVW LQ WKH VKDIW LV QRW WR H[FHHG ƒ LQ WKH OHQJWK RI WKH VKDIW VKHDU
OLPLWHG WR 03D 7DNH * *3D

6<//$%86

0RGXOH ±

5HYLHZ RI VWDWLFV &RQFHSW RI VWUHVV DQG VWUDLQ ± W\SHV
<RXQJ¶V PRGXOXV RI HODVWLFLW\
6WUHVV VWUDLQ GLDJUDP RI PLOG VWHHO
)DFWRU RI VDIHW\ ZRUNLQJ VWUHVV
$[LDOO\ ORDGHG EDUV ZLWK XQLIRUP FURVV VHFWLRQ±VWUHVV V
'HIRUPDWLRQ RI D[LDOO\ ORDGHG EDUV ZLWK YDU\LQJ FURVV VHF
6WDWLFDOO\ LQGHWHUPLQDWH V\VWHPV QXPEHU RI XQNQRZQV U

0RGXOH ±

7HPSHUDWXUH HIIHFWV WHPSHUDWXUH VWUHVV LQ FRPSRVLWH E
6KHDU VWUHVV DQG VKHDU VWUDLQ 0RGXOXV RI ULJLGLW\ VLPSO
/DWHUDO VWUDLQ 3RLVVRQ¶V UDWLR YROXPHWULF VWUDLQ
%XON PRGXOXV RI HODVWLFLW\ UHODWLRQVKLSV EHWZHHQ HODV
6WUDLQ HQHUJ\ ± FRQFHSW 6WUDLQ HQHUJ\ GXH WR QRUPDO VWU
6WUDLQ HQHUJ\ LQ EDUV FDUU\LQJ D[LDO ORDGV
,QVWDQWDQHRXV VWUHVV LQ EDUV GXH WR JUDGXDO VXGGHQ DQ
6WUHVVHV LQ WKLQ F\OLQGHUV DQG VSKHUHV GXH WR LQWHUQDO

0RGXOH ±

%HDPV ± GLIIHUHQW W\SHV   7\SHV RI ORDGLQJ RQ EHDPV &RQFH
5HODWLRQVKLS EHWZHHQ LQWHQVLW\ RI ORDG VKHDU IRUFH DQG
6KHDU IRUFH DQG EHQGLQJ PRPHQW GLDJUDPV RI FDQWLOHYHU E
RYHUKDQJLQJ EHDPV IRU GLIIHUHQW W\SH RI ORDGV 3RLQW RI FR

0RGXOH ±

7KHRU\ RI VLPSOH EHQGLQJ DVVXPSWLRQV DQG OLPLWDWLRQV
&DOFXODWLRQ RI QRUPDO VWUHVV LQ EHDPV PRPHQW RI UHVLVWD
6KHDU VWUHVV LQ EHDPV
%HDPV RI XQLIRUP VWUHQJWK
6WUDLQ HQHUJ\ GXH WR EHQGLQJ ± FDOFXODWLRQ RI VWUDLQ HQ
'LIIHUHQWLDO HTXDWLRQ IRU FDOFXODWLQJ WKH GHIOHFWLRQ RI
6WXGHQWV DUH QRW H[SHFWHG WR VROYH GHIOHFWLRQ SUREOHP

0RGXOH ±

6WUHVVHV RQ LQFOLQHG VHFWLRQV IRU XQLD[LDO DQG ELD[LDO V
3ULQFLSDO VWUHVVHV DQG SULQFLSDO SODQHV LQ ' SUREOHPV
6WUDLQV DORQJ SULQFLSDO GLUHFWLRQV
0RKU¶V FLUFOH RI VWUHVV IRU ' SUREOHPV
6KRUW FROXPQV ± GLUHFW DQG EHQGLQJ VWUHVV .HUQ RI D VHFW
6OHQGHU FROXPQV ± (XOHU¶V EXFNOLQJ ORDG VOHQGHUQHVV UD
5DQNLQHV IRUPXOD
7RUVLRQ RI FLUFXODU DQG KROORZ FLUFXODU VKDIWV 3RZHU WU
FLUFXODU VKDIWV 6WUDLQ HQHUJ\ GXH WR WRUVLRQ

7H[W %RRNV

+ - 6KDK DQG6 % -XQQDUNDU 0HFKDQLFV RI 6WUXFW
+RXVH

5 . %DQVDO $ 7H[W ERRN RI 6WUHQJWK RI 0DWHULDOV
'HOKL

% & 3XQPLD $VKRN . -DLQ $UXQ .XPDU -DLQ 0HFKDQL
3XEOLFDWLRQV 3 /WG 1HZ 'HOKL

5HIHUHQFHV

(JRU 3 3RSRY (QJLQHHULQJ 0HFKDQLFV RI 6ROLGV 3UH
-DPHV 0 *HUH 6 3 7LPRVKHQNR 0HFKDQLFV RI 0DWHULD
'LVWULEXWRUV 1HZ 'HOKL

5 & +LEEHOHU 0HFKDQLFV RI 0DWHULDOV HGQ 3HDU

6 5DPDPUXWKDP DQG 5 1DUD\DQDQ 6WUHQJWK RI 0DWH
&R 3 /WG

5DWWDQ 6WUHQJWK RI 0DWHULDOV 0F*UDZ +LOO (GXFD

/HFWXUH 3ODQ ±0HFKDQLFV RI 6ROLGV

0RGXOH	7RSLF	&RXUVH 2XWFRPHV DGGUHVVHG	1R RI /HFWXUHV
	0RGXOH , 7RWDO OHFWXUH KRXUV		
	5HYLHZ RI VWDWLFV ± HTXLOLEULXP FRQGLWLRQV IUHH ER FHQWURLG PRPHQW RI LQHUWLD		
	&RQFHSW RI VWUHVV W\SHV RI VWUHVVHV &RQFHSW RI VW VWUDLQV 6WUHVV ± VWUDLQ UHODWLRQ +RRNH¶V ODZ <R[RI HODVWLFLW\	&2 &2 &2	
	6WUHVV VWUDLQ GLDJUDP RI PLOG VWHHO ± SURSRUWLRQDO OLPL \LHOG SRLQW XOWLPDWH VWUHVV IUDFWXUH 7UXH DQG HQ FXUYH LQ FDVH RI RWKHU PDWHULDOV)DFWRU RI VDIHW\ ZRUNLQJ VWUHVV 6WUHVV VWUDLQ GLDJUDP (ODVWLF FRQVWDQWV (ODVWLF FXUYHV	&2 &2	
	$[LDOO\ ORDGHG EDUV ZLWK XQLIRUP FURVV VHFWLRQ± FDO VWUHVV VWUDLQ DQG GHIRUPDWLRQ	&2 &2	
	'HIRUPDWLRQ RI D[LDOO\ ORDGHG EDUV ZLWK YDU\LQJ FUR 6WHSSHG EDUV EDUV ZLWK WDSHULQJ FURVV VHFWLRQ	&2	
	'HIRUPDWLRQ RI D[LDOO\ ORDGHG EDUV ZLWK YDU\LQJ D[LD HORQJDWLRQ RI EDUV XQGHU VHOI ZHLJKW HORQJDWLRQ FR XQLIRUP VWHSSHG EDUV	&2	
	6WDWLFDOO\ LQGHWHUPLQDWH V\VWHPV ± DQDO\VLV RI D[LD FRPSRVLWH EDUV ZLWK PD[LPXP WZR PDWHULDOV	&2 &2	
	$QDO\VLV RI LQGHWHUPLQDWH V\VWHPV ZLWK D[LDO ORDG PHPEHUV QXPEHU RI XQNQRZQV UHVWULFWHG WR WZR ([DPSOH $VVHVVPHQW /HYHO 4XHVWLRQ RI &2	&2 &2	

	0RGXOH ,, 7RWDO OHFWXUH KRXUV		
	7HPSHUDWXUH HIIHFWV WHPSHUDWXUH VWUHVV LQ FRPSRV	&2 &2	
	6KHDU VWUHVV DQG VKHDU VWUDLQ 0RGXOXV RI ULJLGLW\ SXQFKLQJ VKHDU	&2 &2	&2 &2
	/DWHUDO VWUDLQ 3RLVVRQ¶V UDWLR YROXPHWULF VWUDL 9ROXPHWULF VWUDLQ RI UHFWDQJXODU EDU FLUFXODU EDU 9ROXPHWULF VWUDLQ H[SUHVVHG LQ WHUPV RI VWUDLQV DO PXWXDOO\ SHUSHQGLFXODU GLUHFWLRQV	&2 &2	
	%XON PRGXOXV RI HODVWLFLW\ UHODWLRQVKLSV EHWZHHQ FRQVWDQWV	&2 &2	
	6WUDLQ HQHUJ\ ± FRQFHSW 5HVLOLHQFH PRGXOXV RI UHV SURRI UHVLOLHQFH 6WUDLQ HQHUJ\ GXH WR QRUPDO VWUHVV &DOFXODWLRQ RI V HQHUJ\ LQ EDUV FDUU\LQJ D[LDO ORDGV 6WUDLQ HQHUJ\ GXH WR VKHDU VWUHVV	&2 &2	&2
	,QVWDQWDQHRXV VWUHVV LQ EDUV GXH WR JUDGXDO VXGG ORDGV	&2 &2	&2
	6WUHVVHV LQ WKLQ F\OLQGHUV DQG VSKHUHV GXH WR LQWH	&2 &2	&2
	0RGXOH ,,, 7RWDO OHFWXUH KRXUV		
	%HDPV ± GLIIHUHQW W\SHV 7\SHV RI ORDGLQJ RQ EHDPV EHQGLQJ PRPHQW DQG VKHDU IRUFH 6KHDU IRUFH DQG EHQ PRPHQW GLDJUDPV	&2 &2	
	5HODWLRQVKLS EHWZHHQ ORDG VKHDU IRUFH DQG EHQGLQ 'HPRQVWUDWLRQ XVLQJ VLPSOH H[DPSOHV	&2	
	6KHDU IRUFH DQG EHQGLQJ PRPHQW GLDJUDPV RI FDQWLOH VXEMHFWHG WR SRLQW ORDG FRQFHQWUDWHG PRPHQWV XQ GLVWULEXWHG DQG XQLIRUPO\ YDU\LQJ ORDGV	&2	
	6KHDU IRUFH DQG EHQGLQJ PRPHQW GLDJUDPV RI VLPSO\ V EHDPV VXEMHFWHG WR SRLQW ORDG FRQFHQWUDWHG PRPHQ GLVWULEXWHG DQG XQLIRUPO\ YDU\LQJ ORDGV	&2	
	6KHDU IRUFH DQG EHQGLQJ PRPHQW GLDJUDPV RI RYHUKDQ VXEMHFWHG WR SRLQW ORDG FRQFHQWUDWHG PRPHQW DQG GLVWULEXWHG ORDGV 3RLQW RI FRQWUDIOH[XUH	&2 &2	
	0RGXOH ,9 7RWDO OHFWXUH KRXUV		
	7KHRU\ RI VLPSOH EHQGLQJ ± GHULYDWLRQ RI HTXDWLRQ D DQG OLPLWDWLRQV	&2 &2	
	9DULDWLRQ RI EHQGLQJ VWUHVV DFURVV WKH FURVV VHFWL 0D[LPXP EHQGLQJ VWUHVV VHFWLRQ PRGXOXV PRPHQW RI UHVLVWDQFH	&2 &2	
	&DOFXODWLRQ RI QRUPDO VWUHVV LQ EHDPV 3UREOHPV LQYROYLQJ EHQGLQJ VWUHVV	&2	

	6KHDU VWUHVV LQ EHDPV ± GHULYDWLRQ RI HTXDWLRQ 9DULDWLRQ RI VKHDU VWUHVV DFURVV WKH FURVV VHFWLRQ 'HULYDWLRQ UHTXLUHG IRU UHFWDQJXODU FLUFXODU DQG VHFWLRQV RQO\	&2 &2	
	&DOFXODWLRQ RI VKHDU VWUHVV SUREOHPV LQYROYLQJ VK	&2	
	&DOFXODWLRQ RI DOORZDEOH ORDGV LQ EHDPV EDVHG RQ E DQG VKHDU VWUHVV FULWHULD	&2	
	3URSRUWLRQLQJ EHDP VHFWLRQV WR FDUU\ JLYHQ ORD H[FHHGLQJ WKH DOORZDEOH EHQGLQJ VWUHVV DQG VKHDU V %HDPV RI XQLIRUP VWUHQJWK	&2	
	6WUDLQ HQHUJ\ GXH WR EHQGLQJ ± FDOFXODWLRQ RI VWUD EHDPV &DQWLOHYHU DQG VLPSO\ VXSSRUWHG EHDPV VXEMHFWHG DQG XQLIRUPO\ GLVWULEXWHG ORDG	&2 &2 &2	
	0RPHQW FXUYDWXUH UHODWLRQ %DVLF GLIIHUHQWLDO HTX FDOFXODWLQJ WKH GHIOHFWLRQ RI EHDPV 6LPSOH H[DPSOH WR FDOFXODWH GHIOHFWLRQ RI EHDPV VX FDQWLOHYHU EHDP ZLWK SRLQW ORDG DW IUHH HQG IRU GH SXUSRVH	&2	
	0RGXOH 9 7RWDO OHFWXUH KRXUV		
	6WUHVVHV RQ LQFOLQHG SODQHV IRU XQLD[LDO DQG ELD[LD (OHPHQW VXEMHFWHG WR SXUH VKHDU	&2	
	3ULQFLSDO VWUHVVHV DQG SULQFLSDO SODQHV LQ ' SUREO VKHDU VWUHVV 6WUDLQV DORQJ SULQFLSDO GLUHFWLRQV	&2 &2	&2
	0RKU¶V FLUFOH RI VWUHVV IRU ' SUREOHPV	&2	&2
	6KRUW FROXPQV ± GLUHFW DQG EHQGLQJ VWUHVV .HUQ RI D VHFWLRQ FRQFHSW RQO\	&2 &2	&2
	6OHQGHU FROXPQV ±%XFNOLQJ (XOHU¶V EXFNOLQJ ORDG I ZLWK SLQQHG HQGV (XOHUV¶ EXFNOLQJ ORDG IRU FROXPQV GLIIHUHQW HQG FRQGLWLRQV QR GHULYDWLRQ UHTXLUHG RI FROXPQV ZLWK GLIIHUHQW HQG FRQGLWLRQV	&2 &2	&2
	6OHQGHUQHVV UDWLR OLPLWDWLRQ RI (XOHU¶V IRUPXOD 5DQNLQH¶V IRUPXOD 6DIH ORDG FDOFXODWLRQ XVLQJ 5DQN IRUPXOD GHPRQVWUDWLRQ RQO\	&2 &2	&2
	7RUVLRQ RI FLUFXODU DQG KROORZ FLUFXODU VKDIWV DV GHULYDWLRQ RI WRUVLRQ HTXDWLRQ 9DULDWLRQ RI VWUHVV VHFWLRQ 3RODU PRGXOXV	&2 &2	&2
	3RZHU WUDQVPLWWHG E\ FLUFXODU VKDIWV DQG KROORZ FL 3URSRUWLRQLQJ WKH VKDIWV WR WUDQVPLW D JLYHQ SRZHU VWUHVV DQG DQJOH RI WZLVW FRQVLGHUDWLRQV 6WUDLQ HQHUJ\ GXH WR WRUVLRQ	&2	&2

02'(/ 48(67,21 3$3(5

5HJ 1R BBBBBBBBBBBBBBB 1DPH BBBBBBBBBBBBBBBBBBBBBBB

$3- $%'8/ .$/$0 7(&+12/2*,&$/ 81,9(56,7<
7+,5' 6(0(67(5 % 7(&+ '(*5(((;$0,1$7,21

&RXUVH &RGH &(7

&RXUVH 1DPH 0(&+$1,&6 2) 62/,'6

0D[0DUN 'XUDWLRQ

3$57 $

$QVZHU DOO TXHVWLRQV HDFK TXHVWLRQ FDUULH

D 'HILQH WKH WHUPV L SURSRUWLRQDOLW\ OLPLW LL

E ([SODLQ KRZ WKH GHIRUPDWLRQ RI DQ D[LDOO\ ORDGHG ED
FDOFXODWHG"

F ([SODLQ WKH HIIHFW RI WHPSHUDWXUH FKDQJH RQ D FRPSRV

G :KDW LV %XON PRGXOXV RI (ODVWLFLW\" :ULWH WKH UHODW
DQG <RXQJ¶V PRGXOXV RI HODVWLFLW\

H :KDW LV WKH UHODWLRQVKLS EHWZHHQ LQWHQVLW\ RI ORDG

I ([SODLQ WKH FRQFHSW RI %0 DQG 6) LQ EHDPV ZLWK WKH
XQLIRUPO\ GLVWULEXWHG ORDG RYHU WKH ZKROH VSDQ

J :KDW LV SXUH EHQGLQJ" *LYH DQ H[DPSOH

K /LVW WKUHH LPSRUWDQW DVVXPSWLRQV XVHG LQ WKH WKHR

L :KDW DUH SULQFLSDO VWUHVVHV DQG SULQFLSDO SODQHV"

M 'LVWLQJXLVK EHWZHHQ VKRUW DQG ORQJ FROXPQV ZLWK U
FRPSUHVVLRQ

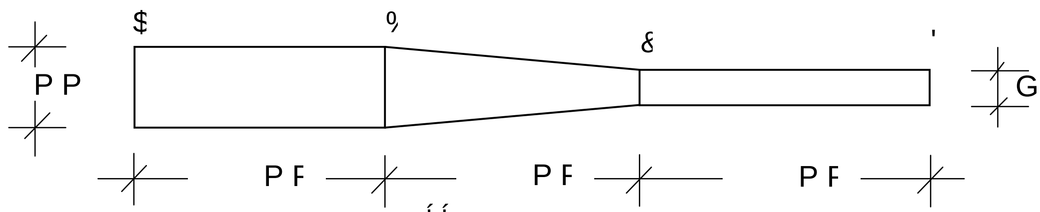
î PDUNV

3$57 %

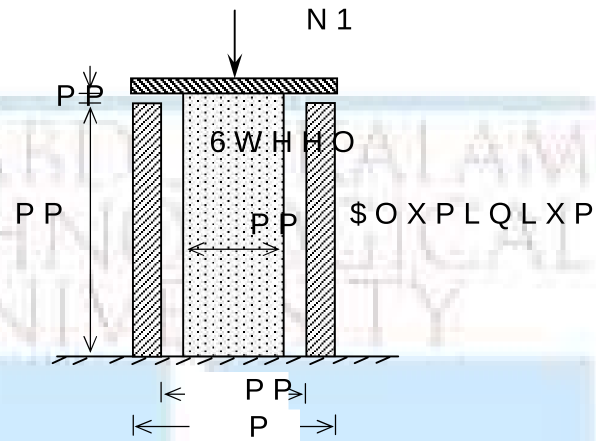
$QVZHU RQH IXOO TXHVWLRQ IURP HDFK PRGXOH HDFK I

0RGXOH ,

$ EDU RI FLUFXODU FURVV VHFWLRQ KDV WKUHH VHJPHQWV
FRQVWDQW GLDPHWHU RI PP 7KH SRUWLRQ %& KDV GLD
WR GLDPHWHU 'µ 7KH SRUWLRQ &' KDV D FRQVWDQW GLDPHWHU
HORQJDWH E\ PP XQGHU DQ D[LDO <RXQJ¶V
PRGXOXV RI HODVWLFLW\ RI WKH PDWHULDO DV *3D



$ VWHHO URG RI PP GLDPHWHU LV SODFHG LQ D KRO
GLDPHWHU PP DQG H[WHUQDO GLDPHWHU PP 7KH VW
EDU FDUULHV D FRPSUHVVLYH IRUFH RI N1 WKURXJK D
VWHHO DQG DOXPLQLXP (V *3D DQG (DO *3D



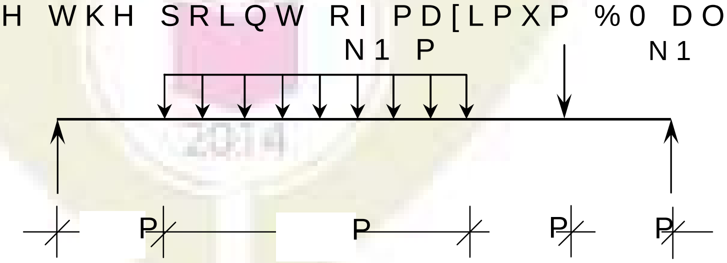
0RGXOH ,,

$ FRQFUHWH F\OLQGHU RI GLDPHWHU PP DQG KHLJK
FRPSUHVVLRQ ,W ZDV IRXQG WKDW WKH GLDPHWHU ZDV
ZDV GHFUHDVHG E\ PP XQGHU WKH DFWLRQ RI D FRP
WKH PRGXOXV RI HODVWLFLW\ 3RLVVRQ¶V UDWLR EXON

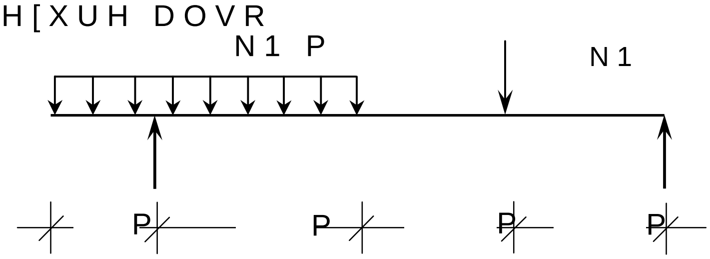
$ FRPSRXQG EDU LV PDGH RI D FHQWUDO VWHHO
FRSSHU SODWHV PP ZLGH DQG PP WKLFN DUH ULJLGO\
WKH EDU DW QRUPDO WHPSHUDWXUH LV &
VWUHVV LQ HDFK PHWDO DQG WKH FKDQJH LQ OHQJWK (F
î 1 PPDQG . î &

0RGXOH ,,,

'UDZ WKH 6)' DQG %0' RI WKH EHDP ORDGHG DV VKRZQ L
DQG ORFDWH WKH SRLQW RI PD[LPXP %0 DOVR



$Q RYHUKDQJLQJ EHDP LV ORDGHG DV VKRZQ 'UDZ 6)'
FRQWUDIOH[XUH DOVR



0RGXOH ,9

D $ VLPSO\ VXSSRUWHG EHDP RI WULDQJXODU FURVV V
PP FDUULHV D XGO RI N1 P RYHU D VSDQ RI P)
FRPSUHVVLYH VWUHVVHV LQGXFHG 'UDZ WKH YDULDWL
PDUNV

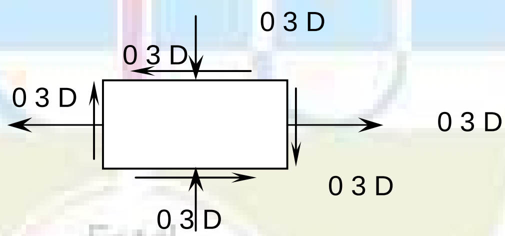
E &DOFXODWH WKH WRWDO VWUDLQ HQHUJ\ GXH WR EHQGLQJ :WDOO WRDGV IUHH HQG
D SRLQW

D $ WLPEHU EHDP PP î PP ZLGWK PP LV XVHG DV
VSDQ P)LQG WKH PD[LPXP XQLIRUPO\ GLVWULEXWHG ORD
FRQFHQWUDWHG ORDG RI N1 DFWLQJ DW WKH PLG VSDQ
VWUHVV LQ WKH EHDP DUH QRW WR H[FHHG 1 PP LQ HDFK 1HJOHFW V
RI EHDP

E :KDW LV EHDP RI XQLIRUP VWUHQJWK" *LYH DQ

0RGXOH 9

$ SRLQ VWUDLQHG ERG\ LV VXEMHFWHG WR)LQG WKH
VWUHVVHV DQG PD[LPXP VKHDU VWUHVV $OVR ORFDWH W
VKHDU VWUHVV ZLWK UHVSHFW WR WKH YHUWLFDO SODQ
WKH SULQFLSDO VWUHVV *3D DQG DOVR 7DNH



$ VROLG FLUFXODU VKDIW WUDQVPLWV N: SRZHU DW
LI WKH WZLVW LQ WKH OHQJWK RI VKDIW GRHV QRW H[FHHG DQG VKHDU
03D 7DNH *3D

&(7	)OXLG 0HFKDQLFV +\GUDXOLFV	&DWHJRU\	/	7	3	&UHGLW	<HDU RI ,QWURGXFWLRQ
		3&&					

3UHDPEOH *RDO RI WKLV FRXUVH LV WR H[SRVH WKH VWXGHQWV
K\GUDXOLFV RI SLSHV DQG RSHQ FKDQQHOV DQG WR HQKDQ
ZLOO KHOS LQ DSSO\LQJ WKHP IRU WKH GHVLJQ RI K\GUXO

3UH UHTXLVLWH (OHPHQWDU\ PDWKHPDWLFV FRQFHSWV LQ HQJLQH

&RXUVH RXWFRPH

$IWHU WKH FRXUVH WKH VWXGHQW ZLOO EH DEOH WR

&2	5HFDOO WKH UHOHYDQW SULQFLSOHV RI K\GURVWDWL
&2	,GHQWLI\ RU GHVFULEH WKH W\SH FKDUDFWHULVWLF
&2	(VWLPDWH WKH IOXLG SUHVVXUH SHUIRUP WKH VW FRQGLWLRQ
&2	&RPSXWH GLVFKDUJH WKURXJK SLSHV RU HVWLPDW K\GUDXOLF SULQFLSOHV RI FRQWLQXLW\ HQHUJ\ DQG
&2	$QDO\]H RU FRPSXWH WKH IORZ WKURXJK RSHQ FKD FKDQQHOV

&(7)OXLG 0HFKDQLFV DQG +\GUDXOLFV		32	32	32	32	32	32	32	32	32	32	32	32
	&2												
	&2												
	&2												
	&2												
	&2												

$VVHVVPHQW SDWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW 7HVWV		(QG 6HPHVWHU ([DPLQDWLRQ 0DUNV
	7HVW 0DUNV	7HVW 0DUNV	
5HPHPEHU			
8QGHUVWDQG			
$SSO\			
$QDO\]H			

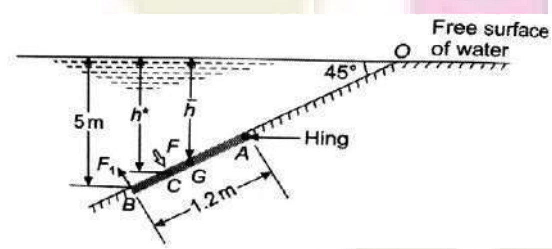
(YDOXDWH			
&UHDWH			

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV
$VVLJQPHQW 4XL] &RXUVH SURMHFW PDUNV
7RWDO PDUNV

(QG VHPHVWHU H[DPLQDWLRQ SDWWHUQ ± 7KHUH ZLOO EH WZR SDUWV 3DUW
FRQWDLQ TXHVWLRQV ZLWK TXHVWLRQV IURP HDF
TXHVWLRQ 6WXGHQWV VKRXOG DQVZHU DOO TXHVWLR
PRGXOH RI ZKLFK VWXGHQW VKRXOG DQVZHU DQ\ RQH (
GLYLVLRQV DQG FDUU\ PDUNV

4Q 1R	4XHVWLRQ	0DUNV	&RXUVH RXWFRPH &2 $VVHVVHG
	3DUW $ $QVZHU $// 4XHVWLRQV		
	([SODLQ WKH PHWKRG RI HVWLPDWLRQ RI K\GURVWD RQ FXUYHG VXUIDFHV		&2
	&RPSDUH WKH XVH RI SLH]RPHWHU DQG PDQRPHW SUHVVXUH PHDVXUHPHQW		&2
	([SODLQ WKH H[SHULPHQWDO PHWKRG RI GHWHUPL PHWDFHQWULF KHLJKW		&2
	'HILQH VWUHDPOLQH VWUHDNOLQH DQG SDWKOLQH		&2
	([SODLQ WKH XVH DQG SULQFLSOH RI 3LWRW WXEH		&2
	2EWDLQ WKH GLVFKDUJH HTXDWLRQ RI D ODUJH UH RULILFH		&2
	([SODLQ FRQYH\DQFH DQG VHFWLRQ IDFWRU IRU IORZ DQG WKHLU SUDFWLFDO DSSOLFDWLRQV		&2
	2EWDLQ WKH FRQGLWLRQ IRU PD[LPXP YHORFLW\		

	FLUFXODU FKDQQHOV		
	6WDWH WKH DVVXPSWLRQV LQYROYHG LQ WKH GH G\QDPLF HTXDWLRQ RI JUDGXDOO\ YDULHG ORZ		&2
	([SODLQ WKH FODVVLILFDWLRQ RI K\GUDXOLF MXPS)URXGH¶V 1XPEHU		&2
	3DUW % $QVZHU $1< 21( )8// TXHVWLRQ IURP HDFK PRGXOH		
	0RGXOH ,		
D	'LIIHUHQWLDWH JDXJH SUHVVXUH DWPRVSKHULF SU DEVROXWH SUHVVXUH		&2
E	$ 8 WXEH PDQRPHWHU LV XVHG WR PHDVXUH WKH SU ZDWHU LQ D SLSHOLQH ZKLFK LV LQ H[FHVV RI DWP 7KH OHIW OLPE LV FRQQHFWHG WR WKH SLSHOLQH D LV RSHQ WR DWPRVSKHUH 7KH IUHH VXUIDFH RI PHU ULJKW OLPE LV LQ OHYHO ZLWK WKH FHQWUH OLQH R WKH OHYHO GLIIHUHQFH RI PHUFXU\ LQ WKH OLPE PDQRPHWHU LV FP &RPSXWH WKH ZDWHU SUHVVXU SLSHOLQH ,I WKH SUHVVXUH RI ZDWHU LV LQFUHDVL FRPSXWH WKH PDQRPHWULF UHDGLQJ		&2
D	2EWDLQ WKH H[SUHVVLRQ IRU FHQWUH RI SUHVV ODPLQD SODFHG LQ IOXLG LQ YHUWLFDO SRVLWLR		&2
E	$Q LQFOLQHG UHFWDQJXODU VOXLFH JDWH $% P E VKRZQ LQ ILJ LV LQVWDOOHG WR FRQWURO WKH G ZDWHU 7KH HQG $ LV KLQJHG 'HWHUPLQH WKH IRUF WR JDWH DSSOLHG DW % WR RSHQ LW 		&2
	0RGXOH ,,		
D	)LQG WKH DFFHOHUDWLRQ DW DIWHU VHF IRU JLYHQ X E]\W Y [] W Z [\		&2
E	'HULYH FRQWLQXLW\ HTXDWLRQ LQ ' &DUWHVLDQ FR		&2

D	$ VROLG F\OLQGHU P LQ GLDPHWHU DQG P LQ OHQ LQ ZDWHU ZLWK LWV D[LV YHUWLFDO ,I WKH VSHFLI WKH PDWHULDO RI WKH F\OLQGHU LV ILQG WKH KHLJKW DQG FRPPHQW RQ WKH VWDELOLW\ RI WKH ER		&2
E	([SODLQ WKH VWDELOLW\ FRQGLWLRQV RI IORDWLQ VXEPHUJHG ERGLHV		&2
	0RGXOH ,,,		
	*DVROLQH VSHFLILF JUDYLW\ IORZV DW D UDWH LQ XSZDUG GLUHFWLRQ WKURXJK DQ LQFOLQHG YH ILWWHG WR D PP GLDPHWHU SLSH 7KH YHQWXUL LQFOLQHG R WR YHUWLFDO DQG LWV PP GLDPHWHU WK LV P IURP WKH HQWUDQFH DORQJ LWV OHQJWK JDXJHV LQVHUWHG DW WKH LQOHW DQG WKURDW VKR 1 PP DQG 1 PP UHVSHFWLYHO\ &RPSXWH WKH FRHIILFLHQW RI GLVFKDUJH RI WKH YHQWXUL LQVWHDG RI SUHVVXUH JDXJHV WKH HQWUDQFH DQG FRQQHFWHG WR WZR OLPEV RI D PHUFXU\ X WXEH PD GHWHUPLQH WKH PDQRPHWULF UHDGLQJ		&2
	$ SLSHOLQH RI P GLDPHWHU LV NP ORQJ 7R LQ WKH GLVFKDUJH DQRWKHU SLSH RI VDPH GLDPH LQWURGXFHG LQ SDUDOOHO WR WKH ILUVW SLSH IRU RI OHQJWK ,I DQG KHDG DW LQOHW LV PP FDOFXODWH WKH LQFUHDVH LQ GLVFKDUJH 1HJOHFW		&2
	0RGXOH ,9		
D	([SODLQ WKH FKDUDFWHULVWLFV RI YHORFLW\ GLVW RSHQ FKDQQHOV		&2
E	$ OLQHG FDQDO Q LV RI WUDSH]RLGDO VHFWLRQ VLGH YHUWLFDO DQG RWKHU ZLWK D VORSH RI + FKDQQHO LV WR EH ODLG RQ D VORSH RI FDOFXODWH WKH GLPHQVLRQV RI WKH HIILFLH WKDW UHTXLUHV PLQLPXP OLQLQJ		&2
D	2EWDLQ WKH GLVFKDUJH HTXDWLRQ RI D &LSROHWWL		&2
E	$ P ORQJ ZHLU LV GLYLGHG LQWR HTXDO ED\V YHUWLFDO SRVWV HDFK P ZLGH 8VLQJ)UDQFLV FDOFXODWH WKH GLVFKDUJH RYHU WKH ZHLU LI WKH FUHVW LV P DQG YHORFLW\ RI DSSURDFK LV P VH		&2
	0RGXOH 9		
D	6WDWH WKH FKDUDFWHULVWLFV RI 0 W\SH SURILOHV		&2

E	$ YHU\ ZLGH UHFWDQJXODU FKDQQHO FDUULHV D GLV FXPHFV SHU P ZLGWK 7KH FKDQQHO KDV D EHG VO DQG 0DQQLQJ¶V URXJKQHVV FRHIILFLHQW) WKH GLVWDQFH WR D VHFWLRQ ZKHUH ZDWHU GHSWK L VLQJOH VWHS PHWKRG		&2
D	6KRZ WKDW PLQLPXP VSHFLILF IRUFH IRU D JLYHQ G LQGLFDWH WKH FULWLFDO IORZ LQ RSHQ FKDQQHOV		&2
E	7KH HQHUJ\ ORVV DQG)URXGH QXPEHU DIWHU WKH K KRUL]RQWDO UHFWDQJXODU FKDQQHO DUH DQG D UHVSHFWLYHO\ 'HWHUPLQH WKH GHSWK EHIRUH WKH DQG WKH SRZHU ORVW SHU P ZLGWK RI WKH FKDQQHO		&2

0RGHO 4XHVWLRQ 3DSHU

5HJ 1R YYYYYYY 43 &2'(YYY

1DPH YYYYYYYYYYYYYYYY

$3- $%'8/ .$/$0 7(&+12/2*,&$/ 81,9(56,7<

7+,5' 6(0(67(5 % 7(&+ '(*5(((;$0,1$7,21 0217+ <($5

&RXUVH &RGH &(7

)OXLG 0HFKDQLFV DQG +\GUDXOLFV

0D[0DUNV 'XUDWLRQ

3DUW $

$QVZHU DOO TXHVWLRQV HDFK TXHVWLRQ FDUU

([SODLQ WKH PHWKRG RI HVWLPDWLRQ RI K\GURVWDV

&RPSDUH WKH XVH RI SLH]RPHWHU DQG PDQRPHWHU

([SODLQ WKH H[SHULPHQWDO PHWKRG RI GHWHUPLQD

'HILQH VWUHDPOLQH VWUHDNOLQH DQG SDWKOLQH

([SODLQ WKH XVH DQG SULQFLSOH RI 3LWRW WXEH

2EWDLQ WKH GLVFKDUJH HTXDWLRQ RI D ODUJH UHFWD

([SODLQ FRQYH\DQFH DQG VHFWLRQ IDFWRU IRU X
DSSOLFDWLRQV

2EWDLQ WKH FRQGLWLRQ IRU PD[LPXP YHORFLW\ WK

6WDWH WKH DVVXPSWLRQV LQYROYHG LQ WKH GHUL
YDULHG IORZ

([SODLQ WKH FODVVLILFDWLRQ RI K\GUDXOLF MXPSV

0DUNV [0DUNV

3DUW %

$QVZHU RQH IXOO TXHVWLRQ IURP HDFK PRGXOH HDFK

0RGXOH ,

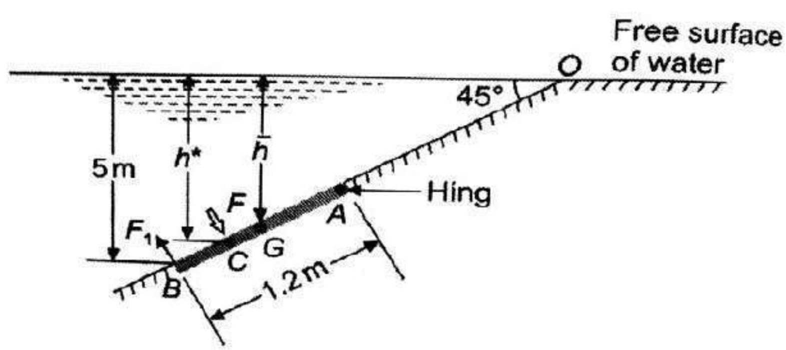
D 'LIIHUHQWLDWH JDXJH SUHVVXUH DWPRVSKHULF SUH

E $ 8 WXEH PDQRPHWHU LV XVHG WR PHDVXUH WKH H[FHVV RI DWPRVSKHULF 7KH OHIW OLPE LV FRQQHFWH DWPRVSKHUH 7KH IUHH VXUIDFH RI PHUFXU\ LQ WKH U RI WKH SLSH DQG WKH OHYHO GLIIHUHQFH RI PHUFXU\ &RPSXWH WKH ZDWHU SUHVVXUH LQ WKH SLSHOLQH ,I FRPSXWH WKH PDQRPHWULF UHDGLQJ

25

D 2EWDLQ WKH H[SUHVVLRQ IRU FHQWUH RI SUHVVXUH SRVLWLRQ

E $Q LQFOLQHG UHFWDQJXODU VOXLFH JDWH $% P WKH GLVFKDUJH RI ZDWHU 7KH HQG $ LV KLQJHG 'HW DW % WR RSHQ LW



0RGXOH ,,

D)LQG WKH DFFHOHUDWLRQ DW X \] WDIWHU [\] W VHF\ IR

0DUNV

E 'HULYH FRQWLQXLW\ HTXDWLRQ LQ ' &DUWHVLDQ FR

25

D $ VROLG F\OLQGHU P LQ GLDPHWHU DQG P LQ OH
WKH VSHFLILF JUDYLW\ RI WKH PDWHULDO RI WKH F\OL
FRPPHQW RQ WKH VWDELOLW\ RI WKH ERG\

E ([SODLQ WKH VWDELOLW\ FRQGLWLRQV RI IORDWLQ

0RGXOH ,,,

*DVROLQH VSHFLILF JUDYLW\ IORZV DW D UDWH
LQFOLQHG YHQWXULPHWHU ILWWHG WR D PP GLDPH
R WR YHUWLFDO DQG LWV PP GLDPHWHU WKURDW
OHQJWK 3UHVVXUH JDXJHV LQVHUWHG DW WKH LQOHW
DQG 1PP UHVSHFWLYHO\ &RPSXWH WKH FRHIILFLHQW
,I LQVWHDG RI SUHVVXUH JDXJHV WKH HQWUDQFH DQ
PHUFXU\ X WXEH PDQRPHWHU GHWHUPLQH WKH PDQRPH

25

$ SLSHOLQH RI P GLDPHWHU LV NP ORQJ 7R LQ
VDPH GLDPHWHU LV LQWURGXFHG LQ SDUDOOHO WR WK
I DQG KHDG DW LQOHW LV PP FDOFXODWH WKH
ORVVHV

0RGXOH ,9

D ([SODLQ WKH FKDUDFWHULVWLFV RI YHORFLW\ GLVWU

E $ OLQHG FDQDO Q LV RI WUDSH]RLGDO VHFWLR
VORSH RI + 9 ,I WKH FKDQQHO LV WR GHOLYHU P
FDOFXODWH WKH GLPHQVLRQV RI WKH HIILFLHQW VHFW

25

D 2EWDLQ WKH GLVFKDUJH HTXDWLRQ RI D &LSROHWWL

E $ P ORQJ ZHLU LV GLYLGHG LQWR HTXDO ED\V
)UDQFLV IRUPXOD FDOFXODWH WKH GLVFKDUJH RYHU W
DQG YHORFLW\ RI DSSURDFK LV P VHF

0RGXOH 9

D 6WDWH WKH FKDUDFWHULVWLFV RI 0 W\SH SURILOHV

E $ YHU\ ZLGH UHFWDQJXODU FKDQQHO FDUULHV D
FKDQQHO KDV D EHG VORSH RI DQG 0DQQLQJ¶V U
GLVWDQFH WR D VHFWLRQ ZHUH ZDWHU GHSWK LV P

25

D 6KRZ WKDW PLQLPXP VSHFLILF IRUFH IRU D JLYHQ GL
FKDQQHOV
E 7KH HQHUJ\ ORVV DQG)URXGH QXPEHU DIWHU WKH
DQG UHVSHFWLYHO\ 'HWHUPLQH WKH GHSWK E
ORVW SHU P ZLGWK RI WKH FKDQQHO

&RXUVH &RGH &(7
)OXLG 0HFKDQLFV DQG +\GUDXOLFV
6\OODEXV

0RGXOH ,

,QWURGXFWLRQ WR WKH VXEMHFW)OXLG SURSHUWLHV PD
JUDYLW\ &ODVVLILFDWLRQ RI)OXLGV SUHUHTXLVLWH QR
)OXLG VWDWLFV YDULDWLRQ RI SUHVVXUH LQ D IOXLG PH
DQG PDQRPHWHUV 8 WXEH PDQRPHWHUV)RUFHV RQ LPPH
SRVLWLRQV +\GURVWDWLF IRUFH RQ FXUYHG VXUIDFHV ±
VSLOOZD\ JDWHV

0RGXOH ,,

%XR\DQF\ DQG)ORDWDWLRQ %XR\DQW IRUFH 3ULQFLSOH
VXEPHUJHG ERGLHV PHWDFHQWUH DQG PHWDFHQWULF KHL
RI PHWDFHQWULF KHLJKW
+\GURG\QDPLFV 0HWKRGV RI GHVFULELQJ IOXLG PRWLRQ
DQG DFFHOHUDWLRQ W\SHV RI IOXLG IORZ GHVFULSWL
VWUHDNOLQH FRQWLQXLW\ HTXDWLRQ LQ RQH WZR DQG W

0RGXOH ,,,

)OXLG NLQHWLFV IRUFHV FRQVLGHUHG LQ GHVFULELQJ IOX
E\ LQWHJUDWLRQ RI (XOHU¶V HTXDWLRQ DORQJ D VWUH
$SSOLFDWLRQV RI %HUQRXOOL¶V HTXDWLRQ 9HQWXULPHW

FRHIILFLHQWV RI RULILFHV DQG WKHLU H[SHULPHQWDO GHV
ODUJH UHFWDQJXODU RULILFHV

3LSH IORZ FRPSXWDWLRQ RI PDMRU DQG PLQRU ORVVHV
HQHUJ\ OLQH SLSHV LQ VHULHV HTXLYDOHQW SLSH IORZ W

0RGXOH ,9

2SHQ FKDQQHO IORZ ± FRPSDULVRQ EHWZHHQ SLSH IORZ DQ
LQ RSHQ FKDQQHOV W\SHV RI FKDQQHOV W\SH RI IORZ
XQLIRUP IORZ FRPSXWDWLRQV &KH]\¶V HTXDWLRQ .XWW
HFRQRPLFDO VHFWLRQV ± UHFWDQJXODU WULDQJXODU DQ
GLVFKDUJH DQG PD[LPXP YHORFLW\ WKURXJK FLUFXODU FK
)ORZ PHDVXUHPHQW LQ FKDQQHOV ± QRWFKHV DQG ZHLUV
YHORFLW\ RI DSSURDFK DQG HQG FRQWUDFWLRQ GLVFKD
ZHLU WUDSH]RLGDO DQG &LSROHWWL ZHLU VXEPHUJHG ZH

0RGXOH 9

6SHFLILF HQHUJ\ VSHFLILF HQHUJ\ GLDJUDP DQG GLVFK
FRPSXWDWLRQ
*UDGXDOO\ YDULHG IORZ '\QDPLF HTXDWLRQ RI JUDGXDOO
FKDUDFWHULVWLFV RI ZDWHU VXUIDFH SURILOHV LQ UHFWD
RI ZDWHU VXUIDFH SURILOHV E\ GLUHFW VWHS PHWKRG
6SHFLILF IRUFH 5DSLGO\ YDULHG IORZ +\GUDXOLF MXPS F
VHTXHQW GHSWKV DQG HQHUJ\ ORVV IRU D K\GUDXOLF MX
XVHV DQG FKDUDFWHULVWLFV RI K\GUDXOLF MXPS

7H[W %RRNV

0RGL 3 1 DQG 6 0 6HWK +\GUDXOLFV)OXLG 0HFKDQ

6XEUDPDQ\D .   7KHRU\ DQG $SSOLFDWLRQV RI)OXLG 0H
6XEUDPDQ\D .   )ORZ LQ 2SHQ FKDQQHOV 7DWD 0F*UDZ

5HIHUHQFHV

6WUHHWHU 9 /)OXLG 0HFKDQLFV 0F *UDZ +LOO 3XEOLV
%UXFH 5 0XQVRQ 'RQDOG) <RXQJ   )XQGDPHQWDOV RI
VRQV
-DLQ $.   )OXLG 0HFKDQLFV .KDQQD 3XEOLVKHUV 'HOK
-RVHSK .DW] ,QWURGXFWRU\ )OXLG 0HFKDQLFV &DPEULG
$URUD . 5)OXLG 0HFKDQLFV +\GUDXOLFV DQG +\GUDX

1DUDVLPKDQ 6 $)LUVW &RXUVH LQ)OXLG 0HFKDQLFV

)UDQN 0 :KLWH)OXLG 0HFKDQLFV 0F *UDZ +LOO
0RKDQW\ $.)OXLG 0HFKDQLFV 3UHQWLFH +DOO 1HZ 'H
1DUD\DQD 3LOODL 1 3ULQFLSOHV RI)OXLG 0HFKDQLFV

.XPDU ' 1)OXLG 0HFKDQLFV DQG)OXLG SRZHU (QJLQHHU

&RXUVH &RGH &(7
)OXLG 0HFKDQLFV DQG +\GUDXOLFV
&RXUVH FRQWHQW DQG 6FKHGXOH RI OHFWXUHV

0RGXOH	7RSLF	&RXUVH RXWFRPH DGGUHVVHG	1R RI +RXUV
0RGXOH , +RX			
	,QWURGXFWLRQ WR WKH VXEMHFW)OXLG SURSHUWLHV ZHLJKW YLVFRVLW\ VSHFLILF JUDYLW\ &ODVVLILFDWLRQ	&2	
	)OXLG VWDWLFV IOXLG SUHVVXUH DQG YDULDWLRQ RI 3UHVVXUH KHDG	&2	
	0HDVXUHPHQW RI SUHVVXUH XVLQJ SLH]RPHWHUV DQG PDQ	&2	
	3UREOHPV RQ SUHVVXUH PHDVXUHPHQW	&2	
	7XWRULDO	&2	
	3UHVVXUH KHDG RQ LPPHUVHG SODQH YHUWLFDO DQG LQF	&2	
	3UREOHPV RQ HVWLPDWLRQ RI SUHVVXUH	&2	
	(VWLPDWLRQ RI SUHVVXUH IRUFH DFWLQJ RQ FXUYHG VXUI	&2	
	7XWRULDO	&2	
0RGXOH ,, +RXUV			
	%XR\DQF\ EXR\DQW IRUFH SULQFLSOH RI IORDWDWLR VXEPHUJHG ERGLHV	&2	
	6WDELOLW\ RI IORDWLQJ ERGLHV PHWDFHQWUH DQG P DQDO\WLFDO GHWHUPLQDWLRQ	&2	
	0HWDFHQWULF KHLJKW H[SHULPHQWDO GHWHUPLQDWLRQ	&2	
	3UREOHPV RQ EXR\DQF\ DQG IORDWDWLRQ	&2	

	.LQHPDWLFV RI IOXLGV 0HWKRGV RI GHVFULELQJ IOXLG P DQG (XOHULDQ PHWKRGV 7\SHV RI IOXLG IORZ 'HVFULS PRWLRQ VWUHDPOLQH VWUHDNOLQH DQG SDWKOLQH	&2	
	9HORFLW\ $FFHOHUDWLRQ RI IOXLG SDUWLFOH FRQY DFFHOHUDWLRQ	&2	
	3UREOHPV RQ IORZ SURSHUWLHV	&2	
	&RQVHUYDWLRQ RI PDVV (TXDWLRQ RI FRQWLQXLW\ LQ '		
	7XWRULDO	&2	
0RGXOH ,,, +RXUV			
	,QWURGXFWLRQ WR IOXLG NLQHWLFV ± IRUFHV DFWLQJ PRWLRQ DQG LQWHJUDWLRQ RI (XOHU¶V HTXDWLRQ RI VWUHDPOLQH %HUQRXOOL¶V (TXDWLRQ (QHUJ\ FRUUHFWL	&2	
	$SSOLFDWLRQV RI %HUQRXOOL¶V HTXDWLRQ 9HQWXULPHW 3UREOHPV	&2	
	3UREOHPV	&2	
	)ORZ WKURXJK RULILFHV W\SHV RI RULILFHV ([SHULPHQW +\GUDXOLF FRHIILFLHQWV	&2	
	)ORZ RYHU D VKDUS HGJHG RULILFH)ORZ WKURXJK ODU RULILFH DQG VXEPHUJHG RULILFHV	&2	
	3LSH IORZ (TXDWLRQV IRU GHWHUPLQDWLRQ RI PDMRU D ORVVHV	&2	
	+\GUDXOLF JUDGLHQW DQG WRWDO HQHUJ\ OLQH SLSHV LQ	&2	
	3UREOHPV RQ GLVFKDUJH FRPSXWDWLRQ	&2	
	7XWRULDO	&2	
0RGXOH ,9 +RXUV			
	,QWURGXFWLRQ GLIIHUHQFH EHWZHHQ SLSH IORZ DQG RS W\SHV RI FKDQQHOV DQG IORZ YHORFLW\ GLVWULEXWLRQ	&2	
	*HRPHWULF HOHPHQWV RI FKDQQHOV FRPSXWDWLRQ IRU 8QLIRUP IORZ 'HULYDWLRQ RI &KH]\¶V HTXDWLRQ	&2	
	0DQQLQJ¶V DQG .XWWHU¶V (TXDWLRQ &RQFHSW RI &RQY 6HFWLRQ IDFWRU SUREOHPV	&2	
	3UREOHPV		
	0RVW HFRQRPLFDO VHFWLRQV FRQGLWLRQV IRU UHFWDQJ WUDSH]RLGDO FKDQQHOV	&2	
	0RVW HFRQRPLFDO FLUFXODU FKDQQHOV 3UREOHPV	&2	
	)ORZ PHDVXUHPHQW LQ FKDQQHOV 7\SHV RI ZHLUV UHFWDQJXODU DQG WULDQJXODU VKDUS FUHVWHG ZHL FRQWUDFWLRQ DQG YHORFLW\ RI DSSURDFK	&2	

	)ORZ RYHU D WUDSH]RLGDO ZHLU &LSROOHWWL ZHLU E VXEPHUJHG ZHLUV	&2	
	7XWRULDO	&2	
0RGXOH 9 +RXUV			
	6SHFLILF HQHUJ\ 6SHFLILF HQHUJ\ GLDJUDP FRPSXWDW GHSWK	&2	
	3UREOHPV	&2	
	*UDGXDOO\ YDULHG IORZ &RQFHSW)RUPV RI *9) HTXDWL	&2	
	7\SHV DQG &KDUDFWHULVWLFV RI ZDWHU VXUIDFH SURIL	&2	
	3UREOHPV	&2	
	&RPSXWDWLRQ RI OHQJWK RI ZDWHU VXUIDFH SURILOH PHWKRG 3UREOHPV	&2	
	6SHFLILF IRUFH &RQMXJDWH GHSWKV +\GUDXOLF MXPS VHTXHQW GHSWK UHODWLRQ LQ UHFWDQJXODU FKDQQHOV	&2	
	&KDUDFWHULVWLFV W\SHV DQG XVHV RI K\GUDXOLF MXP	&2	
	7XWRULDO	&2	

&(7	6859(<,1* *(20$7,&6	&$7(*25<	/	7	3	&5(',7	<($5 2) ,1752'8&7,21
		3&&					

3UHDPEOH
2EMHFWLYH RI WKH FRXUVH LV WR LPSDUW DQ DZDUHQHVV DQG LQVWUXPHQWV RI VXUYH\LQJ HUURUV DVVRFLDWHG ZL WHFKQLTXHV

3UHUHTXLVLWH 1LO

&RXUVH 2XWFRPHV $IWHU WKH FRPSOHWLRQ RI WKH FRXUVH WKH V

&2	$SSO\ VXUYH\LQJ WHFKQLTXHV DQG SULQFLSOHV RI O PDSV FRPSXWDWLRQ RI DUHD YROXPH DQG VNHWFKLQ
&2	$SSO\ WKH SULQFLSOHV RI VXUYH\LQJ IRU WULDQJXOD
&2	$SSO\ GLIIHUHQW PHWKRGV RI WUDYHUVH VXUYH\LQJ I
&2	,GHQWLI\ WKH SRVVLEOH HUURUV LQ VXUYH\LQJ D PHDVXUHPHQWV
&2	$SSO\ WKH EDVLF NQRZOHGJH RI VHWWLQJ RXW RI GLI
&2	(PSOR\ VXUYH\LQJ WHFKQLTXHV XVLQJ DGYDQFHG VXU

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV

	32	32	32	32	32	32	32	32	32	32	32	32
&2												
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$VVHVVPHQW 3DWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW 7HVWV		(QG 6HPHVWHU ([DPLQDWLRQ PDUNV
	7HVW 0DUNV	7HVW	
5HPHPEHU			
8QGHUVWDQG			
$SSO\			
$QDO\VH			
(YDOXDWH			
&UHDWH			

0DUN 'LVWULEXWLRQ

7RWDO 0D	UNV &,(	0DUNV	(6(0DUNV	(6
			KRXUV	

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ
$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV PDU
$VVLJQPHQW 4XL] &RXUVH 3URMHFW PDUNV

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ
7KH TXHVWLRQ FRQVLVWV RI WZR SDUWV 3DUW $ DQG 3D
PDUNV IRU HDFK WZR TXHVWLRQV IURP HDFK PRGXOH 3D
PRGXOH RXW RI ZKLFK RQH KDV WR EH DQVZHUHG (DFK
PD[LPXP VXEGLYLVLRQV

6DPSOH &RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

&RXUVH 2XWFRPH &2 7KH IROORZLQJ SHUSHQGLFXODU RIIVHWV
IURP D VXUYH\ OLQH $% WR DQ LUUHJXODU ERXQGDU\ OLQH
DQG &DOFXODWH WKH DUHD LQ VTP HQFORVHG EHWZHH
ILUVW DQG WKH ODVW RIIVHWV E\ L 6LPSVRQV UXOH LL 7U

&RXUVH 2XWFRPH &2 :KDW LV PHDQW E\ VDWHOOLWH VWDWLRQ D
HFFHQWULF VWDWLRQ 6 PHWUHV WR WKH ZHVW RI WKH
PHDVXUHG $QJOH %6& ƒ ¶ ´ $QJOH &6$ ƒ ¶ ¶¶ 7K
RSSRVLWH VLGHV RI WKH OLQH $% &DOFXODWH WKH FRUU
P DQG P UHVSHFWLYHO\

&RXUVH 2XWFRPH &2 +RZ GR \RX EDODQFH D FORVHG WUDYHUVH
JUDSKLFDO PHWKRG RI %RZGLWFK¶V UXOH"

&RXUVH 2XWFRPH &2 +RZ LV WKH PRVW SUREDEOH YDOXH LQ G
ZHLJKWV GHWHUPLQHG"

&RXUVH 2XWFRPH &2 +RZ GR \RX VHW RXW D VLPSOH FXUYH E
WDQJHQWLDO DQJOHV &DOFXODWH WKH QHFHVVDU\ GDWD
DQ\ RWKHU GDWD LI UHTXLUHG

&RXUVH 2XWFRPH &2 :KDW DUH VSHFWUDO VLJQDWXUH FXUYHV" '
RI VRLO ZDWHU DQG YHJHWDWLRQ

6\OODEXV

0RGXOH

,QWURGXFWLRQ WR 6XUYH\LQJ 3ULQFLSOHV /LQHDU DQJXODU DQG JUDSK
6XUYH\ OLQHV UDQJLQJ %HDULQJ RI VXUYH\ OLQHV /RF
RULHQWDWLRQ E\ FRPSDVV DQG E\ EDFNVLJKWLQJ

/HYHOOLQJ 3ULQFLSOHV RI OHYHOOLQJ 'XPS\ OHYHO ERRNLQJ
GLIIHUHQWLDO UHFLSURFDO OHYHOLQJ SURILOH OHYHOO
(UURUV LQ OHYHOLQJ

&RQWRXULQJ &KDUDFWHULVWLFV PHWKRGV XVHV

0RGXOH

$UHD DQG 9ROXPH &RPSXWDWLRQ RI DUHD E\ RIIVHWV WR EDVH OL
WULDQJOHV YROXPH RI OHYHO VHFWLRQ E\ SULVPRLGDO D

0DVV GLDJUDP &RQVWUXFWLRQ &KDUDFWHULVWLFV DQG X

7KHRGROLWH 6XUYH\LQJ ,QVWUXPHQWV 0HDVXUHPHQW RI KRUL]RQWDO
VWDGLD DQG WDQJHQWLDO WDFKHRPHWU\ LQWURGXFWLRQ

7ULDQJXODWLRQ 7ULDQJXODWLRQ ILJXUHV 7ULDQJXODWLRQ VWDW
6WDWLRQV DQG UHGXFWLRQ WR FHQWUH

0RGXOH

7UDYHUVH 6XUYH\LQJ 0HWKRGV RI WUDYHUVLQJ &KHFNV LQ FORVHG
%DODQFLQJ WKH WUDYHUVH %RZGLWFK¶V UXOH 7UDQVLW
UXOH RPLWWHG PHDVXUHPHQWV D OLQH DQG DQ DQJOH R

7KHRU\ RI (UURUV 7\SHV WKHRU\ RI OHDVW VTXDUHV :HLJKWLQ
YDOXH &RPSXWDWLRQ RI LQGLUHFWO\ REVHUYHG TXDQWLW

0RGXOH

&XUYH 6XUYH\LQJ (OHPHQWV RI VLPSOH DQG FRPSRXQG FXUYHV ±
PHWKRGV RQO\ ± (OHPHQWV RI 5HYHUVH FXUYH ,QWURGX
FXUYH ± (OHPHQWV RI WUDQVLWLRQ FXUYH 9HUWLFDO FX

7RWDO 6WDWLRQ ± 3ULQFLSOHV RI ('0 SULQFLSOHV DQG ZRUNLQJ DGY

0RGXOH

*OREDO 3RVLWLR&RQLQJ6HQVWHPV DQG SULQFLSOHV VDWHOOL
VLJQDO VWUXFWXUH DSSOLFDWLRQ RI *36 *36 6XUYH\LQJ
PHWKRGV ± '*36

5HPRWH 6HQVLQJ/LWLRQ (OHFWURPDJQHWLF VSHFWUXP (QH
DQG HDUWK VXUIDFH IHDWXUHV VSHFWUDO UHIOHFWDQFH
VHQVRUV $FWLYH DQG 3DVVLYH 5HVROXWLRQ VSDWLDO
0XOWL VSHFWUDO VFDQQLQJ $ORQJ WUDFN DQG DFURVV WU

*HRJUDSKLFDO ,QIRUPDWLRQ 6\VWHP *,6 *,6 RSHUDWLRQV
PHWKRGV &RRUGLQDWH V\VWHPV *HRJUDSKLF DQG 3URMHF
DQG DWWULEXWH GDWD 5DVWHU DQG YHFWRU GDWD UHSUH

7H[W %RRNV

'U % & 3XQPLD $VKRN .XPDU -DLQ $UXQ .XPDU -DLQ
SXEOLFDWLRQV 3 /WG
&KDQJ . ³,QWURGXFWLRQ WR *HRJUDSKLF ,QIRUPDWLR
3XEOLVKLQJ &R /WG
*HRUJH -RVHSK ³)XQGDPHQWDOV RI 5HPRWH 6HQVLQJ´

5HIHUHQFHV

& 9HQNDWUDPDLDK 7H[WERRN RI 6XUYH\LQJ 8QLYHUV
-DPHV 0 $QGHUVHQ (GZDUG 0 0LNKDLO 6XUYH\LQJ 7KH
(GXFDWLRQ
3URI 7 3 .HQHWNDU 3URI 6 9 .XONDUQL 6XUYH\LQJ DQ
3UDNDVKDQ
1 1%DVDN 6XUYH\LQJ DQG /HYHOOLQJ 0F*UDZ+LOO (G
5 $JRU $ 7H[W ERRN RI 6XUYH\LQJ DQG /HYHOOLQJ .K
6 . 'XJJDO 6XUYH\LQJ 9RO , 7DWD 0F*UDZ +LOO /WG
6 . 'XJJDO 6XUYH\LQJ 9RO ,, 7DWD 0F*UDZ +LOO /WG
%XUURXJK 3 3ULQFLSOHV RI *HRJUDSKLFDO ,QIRUPDW

,OLIIH & - 'DWXPV DQG 0DS 3URMHFWLRQV IRU 5HPRWH
3XEOLVKLQJ
-DPHV 0 $QGHUVHQ (GZDUG 0 0LNKDLO 6XUYH\LQJ 7KH
HGXFDWLRQ H
.DQJ WVXQJ &KDQJ Ä,QWURGXFWLRQ WR *,6Æ 7DWD 0

/LOOHVDQG 0 DQG .LHIHU : ³5HPRWH 6HQVLQJ DQG ,PD
6RQV ,QF

&RXUVH &RQWHQW DQG OHFWXUH 6FKHGXOH

1R	7RSLF	&RXUVH 2XWFRPHV	1R RI
	0RGXOH		7RWDO
	,QWURGXFWLRQ 3ULQFLSOHV /LQHDU DQJXODU DQ JUDSKLFDO PHWKRGV 6XUYH\ VWDWLRQV 6XUYH\ %HDULQJ RI VXUYH\ OLQHV /RFDO DWWUDFWLRQ 'HF RI RULHQWDWLRQ	&2	
	/HYHO 3ULQFLSOHV RI OHYHOOLQJ %RRNLQJ UHGXFLQJ OHYHOV 0HWKRGV VLPSOH GLIIHUHQWLDO OHYHOLQJ SURILOH OHYHOOLQJ DQG FURVV VHFWL $XWR /HYHO (UURUV LQ OHYHOLQJ	&2	
	&RQWF &KDUDFWHULVWLFV PHWKRGV XVHV	&2	
	0RGXOH		7RWDO
	$UHD DQG FRPSXWDWLRQ RI DUHD E\ GLYLGLQJ DUHD LQWR QXPEHU RI WULDQJOHV VHFWLRQ E\ SULVPRLGDO DQG WUDSH]RLGDO IRUPXOD	&2	
	0DVV GL &RQVWUXFWLRQ &KDUDFWHULVWLFV DQG X	&2	
	7KHRGROLWH ,QVWUXPHQWV 0HDVXUHPHQW RI KRUL] DQG YHUWLFDO DQJOH SULQFLSOHV RI VWDGLD WDFKHRPHWU\ LQWURGXFWLRQ RQO\	&2	
	7ULDQJX 7ULDQJXODWLRQ ILJXUHV 7ULDQJXODWLRQ ,QWHU YLVLELOLW\ RI VWDWLRQV 6DWHOOLWH 6WD FHQWUH	&2	
	0RGXOH		7RWDO
	7UDYHUVH 0HWKRGV RI WUDYHUVLQJ &KHFNV LQ F WUDYHUVH 7UDYHUVH FRPSXWDWLRQV %DODQFLQJ %RZGLWFK¶V UXOH 7UDQVLW UXOH JUDSKLFDO P %RZGLWFK¶V UXOH *DOHV 7UDYHUVH WDEOH RPLW D OLQH DQG DQ DQJOH RQO\	&2	
	7KHRU\ RI ± 7\SHV WKHRU\ RI OHDVW VTXDUHV :HLJ RI REVHUYDWLRQV 0RVW SUREDEOH YDOXH &RP LQGLUHFWO\ REVHUYHG TXDQWLWLHV PHWKRG RI Q	&2	
	0RGXOH		7RWDO
	&XUYH 6XU± (OHPHQWV RI VLPSOH DQG FRPSRXQG FX ± 0HWKRGV RI VHWWLQJ RXW $QJXODU PHWKRGV RQ 5HYHUVH FXUYH ,QWURGXFWLRQ RQO\ ± 7UDQVLWLR FXUYH ± (OHPHQWV RI WUDQVLWLRQ FXUYH 9H LQWURGXFWLRQ RQO\	&2	
	7FDO 6W ± FRQFHSW RI ('0 SULQFLSOHV DQG ZRUN DGYDQWDJHV DQG DSSOLFDWLRQV	&2	
	0RGXOH		7RWDO
	*OREDO 3RVLWL &RPSRQHQWV DQG 3ULQFLSOHV 6DWHOOLWH UDQJLQJ FDOFXODWLQJ SRVLWLRQ	&2	

	DSSOLFDWLRQ RI *36 *36 6XUYH\LQJ PHWKRGV 6W VWDWLF .LQHPDWLF PHWKRGV ± '*36		
	5HPRWH 6 'HILQLWLRQ (OHFWURPDJQHWLF VSHFW (QHUJ\ LQWHUDFWLRQV ZLWK DWPRVSKHUH DQG HDU VSHFWUDO UHIOHFWDQFH RI YHJHWDWLRQ VRLO DQG RI VHQVRUV $FWLYH DQG 3DVVLYH 5HVROXWLRQ V UDGLRPHWULF DQG 7HPSRUDO UHVROXWLRQ 0XOWL $ORQJ WUDFN DQG DFURVV WUDFN VFDQQLQJ	&2	
	*HRJUDSKLFDO ,QIR FRPSRQHQWV RI *,6 RSHUDWLRQV 0DS SURMHFWLRQV PHWKRGV &RRU *HRJUDSKLF DQG 3URMHFWHG FRRUGLQDWH V\VWHP 6SDWLDO DQG DWWULEXWH GDWD 5DVWHU DQG YHFW	&2,6	*,6

$3- $%'8/ .$/$0 7(&+12/2*,&$/ 81,9(56,7<
7+,5' 6(0(67(5 % 7(&+ '(*5(((;$0,1$7,21 0217+ <($5

&RXUVH &7 &RGH

&RXUVH 6859(<,1* *(20$7,&6
0RGHO 4XHVWLRQ 3DSHU

0DUNV

3$57 $
$QVZHU DOO 4XHVWLRQV (DFK TXHVWLRQ FDU

:KDW DUH WKH JHQHUDO SULQFLSOHV RI VXUYH\LQJ"
'HILQH EDFN VLJKW IRUHVLJKW DQG LQWHUPHGLDWH
+RZ GR \RX GHWHUPLQH WKH LQWHUYLVLELOLW\ RI WU
:KDW LV WKH SULQFLSOH RI VWDGLD WDFKHRPHWU\"
+RZ ZLOO \RX GHWHUPLQH SUREDEOH HUURU RI FRPS
:KDW DUH WKH FKHFNV LQ FORVHG WUDYHUVH"
:KDW DUH WKH HOHPHQWV RI D FRPSRXQG FXUYH"
([SODLQ WKH WZR WKHRGROLWH PHWKRG RI VHWWLQJ
:KDW LV PXOWL VSHFWUDO VFDQQLQJ" 'LIIHUHQWLDW
:KDW LV PHDQW E\ VDWHOOLWH UDQJLQJ"

3$57 %
$QVZHU RQH IXOO TXHVWLRQ IURP HDFK PR

D 'HILQH FRQWRXU :KDW DUH WKH FKDUDFWHULVWL

E 7KH IROORZLQJ UHDGLQJV ZHUH WDNHQ LQ D UXQ
/LQH)% %%
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L 6WDWH WKH VWDWLRQV ZKLFK ZHUH DIIHFWHG EV
LL 'HWHUPLQH WKH FRUUHFWHG EHDULQJV
LLL &DOFXODWH WKH WUXH EHDULQJV LI WKH GHFO

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D :KDW DUH WKH GLIIHUHQW PHWKRGV RI RULHQWDW

E 7KH IROORZLQJ UHDGLQJV ZHUH WDNHQ ZLWK D GX
FRQWLQXRXVO\ VORSLQJ JURXQG DW P LQWHUYD
DQG
RI WKH ILUVW SRLQW LV 5XOH RXW D SDJH R
UHDGLQJV 'HWHUPLQH 5/V RI DOO SRLQWV XVLQJ K
WKH JUDGLHQW RI WKH OLQH MRLQLQJ WKH ILUVW D

D 7KH IROORZLQJ SHUSHQGLFXODU RIIVHWV ZHUH W
$% WR DQ LUUHJXODU ERXQGDU\ OLQH
&DOFXODWH WKH DUHD LQ VTP HQFORVHG EHV
ERXQGDU\ WKH ILUVW DQG WKH ODVW RIIVHWV E\ L

E ([SODLQ 0DVV GLDJUDP DQG LWV FKDUDFWHULVWL

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D ([SODLQ WKH PHWKRG RI REVHUYLQJ WKH KRUL]RQ
UHLWHUDWLRQ LQ WULDQJXODWLRQ VXUYH\

E :KDW LV PHDQW E\ VDWHOOLWH VWDWLRQ DQG UH
6 PHWUHV WR WKH ZHVW RI WKH PDLQ VWDWLRQ
$QJOH %6& ƒ ¶ ´ $QJOH &6$ ƒ ¶ ¶¶ 7KH VW
RSSRVLWH VLGHV RI WKH OLQH $% &DOFXODWH WKH
%& DUH P DQG P UHVSHFWLYHO\

D 7KH IROORZLQJ DUH WKH PHDQ YDOXHV REVHUYHG
$ % & DW RQH VWDWLRQ
$ ƒ ¶ ¶¶ ZLWK ZHLJKW
$ % ƒ ƒ ¶¶ ZLWK ZHLJKW
$ % & ƒ ¶ ¶¶ ZLWK ZHLJKW
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&DOFXODWH WKH PRVW SUREDEOH YDOXH RI $ % D

E 'LVWLQJXLVK EHWZHHQ D FORVHG WUDYHUVH DQG
IDVW QHHGOH PHWKRG RI WUDYHUVH VXUYH\LQJ

25

D 6WDWH WKH IXQGDPHQWDO SULQFLSOH RI PHWKRG
YDOXH LQ GLUHFW REVHUYDWLRQV RI HTXDO ZHLJKW

E 'HVFULEH WKH SURFHGXUHV IRU EDODQFLQJ D FOR

D 7ZR WDQJHQWV LQWHUVHFW DW FKDLQDJH¶ P
&DOFXODWH WKH QHFHVVDU\ GDWD IRU VHWWLQJ RX
WDQJHQWV LI LW LV LQWHQGHG WR VHW RXW WKH F
7DNH SHJ LQWHUYDO HTXDO WR P

E :KDW DUH WKH DGYDQWDJHV DQG DSSOLFDWLRQV

25

D :KDW LV WUDQVLWLRQ FXUYH" :KDW DUH LWV IXQ
WKH OHQJWK RI WUDQVLWLRQ FXUYH"

E ([SODLQ WKH SULQFLSOH EHKLQG HOHFWUR PDJQH

D :KDW DUH WKH FRPSRQHQWV RI *36" ,OOXVWUDWL
HDFK RI WKHP LQ GHWDLO

E :KDW DUH WKH DSSOLFDWLRQV RI *,6"

25

D +RZ GRHV HOHFWUR PDJQHWLF UDGLDWLRQ LQWHU

E :KDW DUH WKH YDULRXV W\SHV RI PDS SURMHFWLR

&(/	&,9,/ (1*,1((5,1* 3/$11,1* '5$)7,1* /$%	&$7(*25<	/	7	3	&5(',7	<($5 2) ,1752'8&7,21
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3UHDPEOH 7KH FRXUVH LV GHVLJQHG WRLQWURGXFH WKH IXQ
GUDZLQJDQG XQGHUVWDQG WKH SULQFLSOHV RI SODQQLQJ
GUDIWLQJ RI EXLOGLQJV PDQXDOO\ DQG XVLQJ GUDIWLQJ VR

3UHUHTXLVLWH 'Z W,/ ^

&RXUVH 2XWFRPHV DQG $VVHVVPHQW $IWHU WKH FRPSOHWLRQ RI WKH FRXU
ZLOO EH DEOH WR

&RXUVH 2XWFRPH &2	&RXUVH 2XWFRPH 'HVFULSWLRQ	&2 $VVHVVPHQW VWUDWHJ\
&2	,OOXVWUDWH DELOLW\ WR RUJDQLVH V\VWHPDWLFDOO\ DQG SURIHVVLRQDOO\	$VVHVVPHQW RI WKH RYHUDOO FOYLU RU JHQLQYDHQW RI WKH GUDZLQJ ODEHO DQG WHPSODWHV XVHG
&2	3UHSDUH EXLOGLQJ GUDZLQJV DV SHU JXLGHOLQHV	$SSOLFDWLRQ RI JXLGHOLQHV IRU VSHF IXQFWLRQDO SODQQLQJ RI EXLOGLQJ XQLW
&2	$VVHVV D FRPSOHWH EXLOGLQJ GUDZLQJ WR LQFOXGH QHFHVVDU\ LQIRUPDWLRQ	/HYHO RI LQFRUSRUDWLRQ RI *XLGHOLQHV VSHFLILHG E\ 1%& PHHWLQJ WKH UHTXLUHPHQW RI EXLOGLQJ UXOHV VSHFLILHG E\ ORFDO ERGLHV RI DGPLQLVWUDWLRQ
&2	&UHDWH D GLJLWDO IRUP RI WKH GUDIWLQJ VRIWZDUH	(YDOXDWLRQ RI WKH EXLOGLQJ SODQ XVLQJ SULQWRXWV RI SUHSDUHG EXLOGLQJ SODQ

0DSSLQJ RI FRXUVH RXWFRPHV &2V ZLWK SURJUDP RXWFRP

&2 32	32	32	32	32	32	32	32	32	32	32	32	32
&2												
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/LVW RI ([SHULPHQWV $Q\ H[SHULPHQWV RXW RI QH
PDQGDWRULO\ 0DQXDO GUDIWLQJ DQG GUDIWLQJ XVLQJ FRP
PDQGDWRU\ IRU WKH H[SHULPHQWV

'UDZ VHFWLRQDO GHWDLOV DQG HOHYDWLRQ RI SDQHOHG
'UDZ VHFWLRQDO GHWDLOV DQG HOHYDWLRQ RI JOD]HGZ
'UDZ VHFWLRQDO GHWDLOV GHWDLOLQJ RQ IL[LQJ D
ZLQGRZV
'UDZ HOHYDWLRQ VHFWLRQ DQG GHWDLOLQJ RI FRQQHF
IRU IL[LQJDW WKHVXSSRUW IRU VWHHO URRI WUXVV
'UDZ SODQ VHFWLRQ DQG HOHYDWLRQ RI GRJ OHJJHG V
'UDZ VHFWLRQDO GHWDLOV RI D ORDG EHDULQJ ZDOO R
LVRODWHG IRRWLQJ DQG SLOH IRRWLQJ ZLWK SLOH FDS
'UDZ SODQ VHFWLRQ DQG HOHYDWLRQ RI VLQJOH VWRUL
'UDZ SODQ VHFWLRQ DQG HOHYDWLRQ RI WZR VWRULHG
'UDZ SODQ VHFWLRQ DQG HOHYDWLRQ RI D FRPPXQLW\
3UHSDUH D VLWH SODQ DQG VHUYLFH SODQDV SHU ODWH
3UHSDUH GHWDLOHG GUDZLQJ RQ EXLOGLQJ VHUYLFHV
RQO\ DQG RQ VLWH ZDVWHZDWHU GLVSRVDO V\VWHPV OL
'UDZ SODQ VHFWLRQ DQG HOHYDWLRQ RI PXOWL VWRULI
'UDZ SODQ VHFWLRQ DQG HOHYDWLRQ RI D SXEOLF EXL
FHQWUH SRVW RIILFH EDQN HWF
'UDZ SODQ VHFWLRQ DQG HOHYDWLRQ RI D LQGXVWULD
DQG 3(% EDVHG ZDOOLQJ HOHPHQWV
&UHDWH ' PRGHO RI D WZR VWRULHG UHVLGHQWLDO EXL

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íX1DWLRQDO %XLOGLQJ &RGH RI ,QGLD
îX.HUDOD SDQFKD\DW EXLOGLQJ UXOHV
ïX.HUDOD 0XQLFLSDOLW\ EXLOGLQJ UXOHV
ðX'U %DODJRSDO 7 6 3UDEKX %XLOGLQJ 'UDZLQJ DQG
&DOLFXW
ñX$XWR&$' (VVHQWLDOV $XWRGHVN RIILFLDO 3UHVV -RK
òX6KDK 0 * .DOH & 0 DQG 3DWNL 6 < %XLOGLQJ 'UD
$SSURDFK WR %XLOW (QYLURQPHQW 7DWD 0F*UDZ +LO
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&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ
0DUNV IRU H[HUFLVHV XVLQJ PDQXDO GUDIWLQJLQ $ 3DSH
0DUNV IRU H[HUFLVHV XVLQJ FRPSXWHU DLGHG GUDIWLQJ

&2V	$VVHVVPHQW 6WUDWHJ\	0DUNLQJ &ULWHULD	
&2	$VVHVVPHQW RYHUDOO RUJDQLVDWLRQ RI WKH GUDZLQJ WHPSODWHV XVHG	0DUNV WR EH DZDUGHG EDVHG RQ WKH VDQLWDWLRQ RI SUHVHQWDWLRQV GLVSOD\HG LQ PDQXDO GUDZLQJ	
&2	$SSOLF[JXLGHOLQHV IRU SODQQLQJ RI HDFK XQLW	0DUNV DZDUGHG EDVHG RQ WKH GHVLJQ RI WKH SUHSDUHG SODQ RI WKH EXLOGLQJ	
&2	/HYHO RI LQ RI *XLGHOLQHV VSHFLILHG E\ 1%& PHHWLQJ WKH UHTXLUHPHQW RI UXOHV VSHFLILHG E\ ORFDO ERGLHV RI DGPLQLVWUDWLRQ	0DUNV WR EH DZDUGHG EDVHG RQ WKH FKHFNOLVWV RI DVVHVVPHQW IRU WKH SUHSDUHG SODQ RI WKH EXLOGLQJ	
&2	(YDOXDWLRQ SULQWRXWV EXLOGLQJ SODQ	0DUNV WR EH DZDUGHG EDVHG RQ WKH SULQWRXW RI WKH ILQDO SODQ RI WKH EXLOGLQJ	

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3UHDPEOH
2EMHFWLYH RI WKH FRXUVH LV WR LPSDUW SUDFWLFDO H[S
WHFKQLTXHV RI ILHOG VXUYH\LQJ 7KH FRXUVH LV GHVLJQH
DQG DGYDQFHG VXUYH\LQJ LQVWUXPHQWV

3UHUHTXLVLWH

&RXUVH 2XWFRPHV $IWHU WKH FRPSOHWLRQ RI WKH FRXUVH WKH V

&2	8VH FRQYHQWLRQDO VXUYH\LQJ WRROV VXFK DV FKDLQ GHWHUPLQDWLRQ
&2	$SSO\ OHYHOOLQJ SULQFLSOHV LQ ILHOG
&2	6ROYH WULDQJXODWLRQ SUREOHPV XVLQJ WKHRGROLW
&2	(PSOR\ WRWDO VWDWLRQ IRU ILHOG VXUYH\LQJ
&2	'HPRQVWUDWH WKH XVH RI GLVWRPDW DQG KDQGKHOG

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV

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&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

&RXUVH 2XWFRPH &2 3ORW WKH JLYHQ DUHD XVLQJ FKDLQ WDSH
DUHD

&RXUVH 2XWFRPH &2 'HWHUPLQH WKH UHGXFHG OHYHOV RI WKH
UHVSHFW WR WKH %HQFK 0DUN RI 5/

&RXUVH 2XWFRPH &2)LQG RXW WKH GLVWDQFH EHWZHHQ WZR L
%DVHOLQH PHDVXUHPHQW LV DOORZHG

&RXUVH 2XWFRPH &2 &RPSXWH WKH DUHD RI D JLYHQ SORW XVLQJ

&RXUVH 2XWFRPH &2 ([SODLQ WKH SDUWV RI D KDQGKHOG *36 ZLW

$VVHVVPHQW 3DWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW	(QG 6HPHVWHU ([DPLQDWLRQ
5HPHPEHU		
8QGHUVWDQG		
$SSO\		
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(YDOXDWH		
&UHDWH		

0DUN 'LVWULEXWLRQ

7RWDO 0DUNV	&,(0DUNV	(6(0DUNV	(6('
			KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ &,(3DWWHUQ

$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW PD
,QWHUQDO 7HVW ,PPHGLDWHO\ EHIRUH WKH VHFRQG VHULH

(QG 6HPHVWHU ([DPLQDWLRQ (6(3DWWHUQ

3UDFWLFDO H[DPLQDWLRQ VKDOO LQFOXGH SUREOHPV RQ
PDUN GLVWULEXWLRQ 7KH IROORZLQJ JXLGHOLQHV VKRXO
D 3UHOLPLQDU\ ZRUN
E ,PSOHPHQWLQJ WKH ZRUN &RQGXFWLQJ WKH H[SHULPHQ
F 3HUIRUPDQFH UHVXOW DQG LQIHUHQFH XVDJH RI HTXL
G 9LYD YRFH
H 5HFRUG 0DU

*HQHUDO LQVWUXFWLRQV
3UDFWLFDO H[DPLQDWLRQ WR EH FRQGXFWHG LPPHGLDWH
V\OODEXV JLYHQ EHORZ (YDOXDWLRQ LV D VHULRXV SURF
UHVSRQVLELOLW\ RI ERWK WKH LQWHUQDO DQG H[WHUQDO
SHU GD\ VKRXOG QRW H[FHHG 6WXGHQWV VKDOO EH DOO
VXEPLWWLQJ WKH GXO\ FHUWLILHG UHFRUG 7KH H[WHUQDO

6\OODEXV

/LVW RI ([HUFLVHV ([SHULPHQWV

,QWURGXFWLRQ WR FRQYHQWLRQDO VXUYH\LQJ V
/HYHOOLQJ VHVVLRQV
7KHRGROLWH VXUYH\LQJ VHVVLRQV
7RWDO 6WDWLRQ VXUYH\ VHVVLRQV
6WXG\ RI LQVWUXPHQWV VHVVLRQ
$XWRPDWLF OHYHO
GLJLWDO OHYHO
+DQGKHOG *36

&RXUVH &RQWHQW DQG 3UDFWLFDO 6FKHGXOH $Q\ WZHOYH

([SW 1R	/LVW RI H[HUFLVHV H[SHULPHQWV	&RXUVH 2XWFRPH	1R RI +RXUV
	,QWURGXFWLRQ WR FRQYHQWLRQDO VXUYH\LQJ D &KDLQ VXUYH\LQJ E &RPSDVV VXUYH\LQJ	&2	
	/HYHOOLQJ 6LPSOH OHYHOLQJ 'LIIHUHQWLDO OHYHOOLQJ)O\ OHYHOOLQJ &RQWRXULQJ	&2	
	7KHRGROLWH VXUYH\LQJ 'LVWDQFH EHWZHHQ DFFHVVLEOH SRLQWV KRUL]RQWD 'LVWDQFH EHWZHHQ LQDFFHVVLEOH SRLQWV KRUL]RQ /HYHO GLIIHUHQFH EHWZHHQ SRLQWV YHUWLFDO DQJO 7DQJHQWLDO WDFKHRPHWU\ YHUWLFDO DQJOH +HLJKW RI EXLOGLQJ YHUWLFDO DQJOH	&2	
	7RWDO VWDWLRQ VXUYH\ +HLJKWV DQG GLVWDQFHV $UHD FRPSXWDWLRQ &RQWRXULQJ 'RZQORDGLQJ	&2	
	6WXG\ RI LQVWUXPHQWV D $XWRPDWLF OHYHO E 'LJLWDO OHYHO F +DQGKHOG *36	&2	

5HIHUHQFH %RRNV

'U % & 3XQPLD $VKRN .XPDU -DLQ $UXQ .XPDU -DLQ
3 /WG
& 9HQNDWUDPDLDK 7H[WERRN RI 6XUYH\LQJ 8QLYHUVLW

3URI 7 3 .HQHWNDU 3URI 6 9 .XONDUQL 6XUYH\LQJ DQG
3UDNDVKDQ
5 $JRU $ 7H[W ERRN RI 6XUYH\LQJ DQG /HYHOOLQJ .KD
6 . 'XJJDO 6XUYH\LQJ 9RO , 7DWD 0F*UDZ +LOO /WG 5H
6 . 'XJJDO 6XUYH\LQJ 9RO ,, 7DWD 0F*UDZ +LOO /WG

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3UHDPEOH

7KLV FRXUVH SURYLGHV WKH HVVHQWLDO DVSHFWV RI EXLO
EXLOGLQJV PDWHULDOV RI FRQVWUXFWLRQ DQG VWUXFWXU
(QJLQHHULQJ

3UH UHTXLVLWH 1LO

&RXUVH 2XWFRPHV $IWHU WKH FRPSOHWLRQ RI WKH FRXUVH WKH VWX

&RXUVH 2XWFRPH	'HVFULSWLRQ RI &RXUVH 2XWFRPH	3UHVFULEHG OHDUQLQJ OHYHO
&2	([SODLQ WKH SURSHUWLHV DQG WHVWLQJ PHWKRG PDWHULDOV XVHG IRU EXLOGLQJ FRQVWUXFWLRQ	8QGHUVWDQGLQJ
&2	([SODLQ WKH FRQVWUXFWLRQ GHWDLOV RI GLIIHUHQ EXLOGLQJV	8QGHUVWDQGLQJ
&2	([SODLQ FRQVWUXFWLRQ SUDFWLFHV VXFK DV SUHI HIIHFWLYH DQG VXVWDLQDEOH WHFKQRORJLHV	8QGHUVWDQGLQJ
&2	([SODLQ WKH GHWDLOV DQG EHKDYLRU RI VWUXFWX VWUXFWXUDO HOHPHQWV XVHG LQ EXLOGLQJV	8QGHUVWDQGLQJ

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV 0L

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0DUN GLVWULEXWLRQ

7RWDO 0DUNV	&,(	(6(	(6('XUDWLRQ
			KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV PDUNV
$VVLJQPHQW 4XL] &RXUVH SURMHFW PDUNV

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ 7KHUH ZLOO EH WZR SDUWV 3DUW $ D
FRQWDLQ TXHVWLRQV ZLWK TXHVWLRQV IURP HDFK PRGX
6WXGHQWV VKRXOG DQVZHU DOO TXHVWLRQV 3DUW % FRQWD
VWXGHQW VKRXOG DQVZHU DQ\ RQH (DFK TXHVWLRQ FDUUL
VXE GLYLVLRQV

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

&2 ([SODLQ WKH SURSHUWLHV DQG WHVWLQJ PHWKRGV
EXLOGLQJ FRQVWUXFWLRQ

:KDW LV EOHQGHG FHPHQW" :KDW DUH LWV DGYDQWDJHV
([SODLQ DQ\ RQH WHVW SHUIRUPHG RQ FRDUVH DJJUHJD
'LVFXVV WKH UROH RI DGPL[WXUHV LQ FRQFUHWH
([SODLQ DQ\ RQH WHVW SHUIRUPHG LQ IUHVK FRQFUHWH
([SODLQ DQ\ RQH WHVW SHUIRUPHG RQ KDUGHQHG FRQFU

&2 ([SODLQ WKH FRQVWUXFWLRQ GHWDLOV RI GLIIHUHQW FR

:KDW LV D OLQWHO" :K\ LV LW UHTXLUHG"
([SODLQ WKH GLIIHUHQW W\SHV RI VKDOORZ IRXQGDWLR
([SODLQ WKH GLIIHUHQW W\SHV RI GHHS IRXQGDWLRQV
([SODLQ WKH SURFHGXUH DGRSWHG IRU OD\LQJ PDUEOH

&2 ([SODLQ FRQVWUXFWLRQ SUDFWLFHV VXFK DV SUHIDEULF
WHFKQRORJLHV

:KDW LV SUHIDEULFDWLRQ" :KDW DUH WKH DGYDQWDJHV
FRQVWUXFWLRQ"
([SODLQ WKH FRQVWUXFWLRQ GHWDLOV RI UDW WUDS ER
([SODLQ WKH SULQFLSOHV RI ILOOHU VODE

&2 ([SODLQ WKH GHWDLOV DQG EHKDYLRU RI VWUXFWXUDO
XVHG LQ EXLOGLQJV

:KDW DUH WKH GLIIHUHQW IRUPV RI UHLQIRUFHPHQW XVH
RI HDFK
'LVWLQJXLVK EHWZHHQ ORDG EHDULQJ ZDOO FRQVWUXFW
FRQVWUXFWLRQ
6NHWFK DQ\ WZR W\SHV RI VWHHO URRI WUXVV
6NHWFK WKH UHLQIRUFHPHQW GHWDLOV RI D VLPSO\ VXS

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0RGXOH

&HPHQW ± 7\SHV &RPSRVLWLRQ PDQXIDFWXULQJ SURFHV
SURSHUWLHV WHVWV 0RUWDU ± W\SHV SURSHUWLHV XVHV

0RGXOH

&RQFUHWH ± 3&& 5&& 3URSHUWLHV RI IUHVK FRQFUHWH
KDUGHQHG FRQFUHWH ± WHVWV IRU VWUHQJWK 1RPLQDO PL

0RGXOH

)ORRULQJ DQG URRILQJ PDWHULDOV /LQWHOV DQG DUFKHV
ZLQGRZV DQG YHQWLODWRUV)LQLVKLQJ ZRUNV 7LPEHU SU

0RGXOH

)RXQGDWLRQV ± VKDOORZ DQG GHHS &RVW HIIHFWLYH
WHFKQRORJLHV 1RQ GHVWUXFWLYH WHVWLQJ RI FRQFUHWH

0RGXOH

6WUXFWXUDO HOHPHQWV EHDPV FROXPQV DQG VODEV 3U
UHLQIRUFHPHQWV 5HLQIRUFHPHQW GHWDLOV RI VWUXFWXU
IORRU V\VWHPV

7H[W %RRNV

3XQPLD % & %XLOGLQJ &RQVWUXFWLRQ /D[PL 3XEOLFD
$URUD DQG %LQGUD %XLOGLQJ &RQVWUXFWLRQ 'KDQSD
6KHWW\ 0 6 &RQFUHWH 7HFKQRORJ\ 6 &KDQG FRPSD

5HIHUHQFHV

0DGDQ 0HKWD :DOWHU 6FDUERURXJK DQG 'LDQH $USVX
3ULQFLSOHV 0DWHULDOV DQG 6\VWHPV 3HDUVRQ
'DQLHO 6FKRGHN DQG 0DUWLQ %HFKWKROG 6WUXFWXUH
9 6DQNDUD6XEUDPDQL\DQ &RQVWUXFWLRQ 7HFKQRORJ\
6 6 %KDYLNDWWL &RQVWUXFWLRQ 7HFKQRORJ\ &KHVV
5DQJZDOD 6 & (QJLQHHULQJ 0DWHULDOV &KDURWDU 3X

3 & 9DUJKHVH %XLOGLQJ 0DWHULDOV 3+, /HDUQLQJ 3Y

0HKWD DQG 0RQWHLUR &RQFUHWH 0LFUR VWUXFWXUH
+LOO 3URIHVVLRQDO

1HYLOOH $ 0 DQG %URRNV - - &RQFUHWH 7HFKQRORJ

5 6DQWKDNXPDU &RQFUHWH 7HFKQRORJ\ 2[IRUG 3XEO

/HFWXUH 3ODQ %XLOGLQJ &RQVWUXFWLRQ DQG 6WU

0RGXOH	7RSLF	&RXUVH 2XWFRPHV DGGUHVVHG	1R RI /HFWXUHV
	0RGXOH , 7RWDO OHFWXUH KRXUV		
	&HPHQW ± 7\SHV RI FHPHQWV FKHPLFDO FRPSRVLWLR %OHQGHG FHPHQWV	&2	
	0DQXIDFWXULQJ RI FHPHQW	&2	
	3URSHUWLHV DQG WHVWV RQ FHPHQW +\GUDWLRQ RI		
	$JJUHJDWHV ± W\SHV UROH RI DJJUHJDWHV	&2	
	3URSHUWLHV RI DJJUHJDWHV DQG WHVWV *UDGLQJ UH 1DWXUDO DQG V\QWKHWLF DJJUHJDWHV	&2	
	0RUWDU ± W\SHV 6DQG ± SURSHUWLHV XVHV	&2	
	:DWHU TXDOLW\ IRU FRQVWUXFWLRQ &KHPLFDO DGPL[W\SHV DQG XVHV	&2	
	0RGXOH ,, 7RWDO OHFWXUH KRXUV		
	&RQFUHWH ± 3&& 5&& DQG 3UHVWUHVVHG FRQFUHWH GHVFULSWLRQV RQO\	&2	
	0DNLQJ RI FRQFUHWH ± EDWFKLQJ PL[LQJ WUDQVSRU SODFLQJ FRPSDFWLQJ ILQLVKLQJ DQG FXULQJ	&2	
	3URSHUWLHV RI IUHVK FRQFUHWH ± ZRUNDELOLW\ VHJ EOHHGLQJ	&2	
	)DFWRUV DIIHFWLQJ ZRUNDELOLW\ DQG VWUHQJWK ± Z ZRUNDELOLW\ GHPRQVWUDWLRQ RI VOXPS WHVW	&2	
	(IIHFWV RI DJJUHJDWHV RQ SURSHUWLHV RI FRQFUHWH	&2	
	3URSHUWLHV RI KDUGHQHG FRQFUHWH ± WHVWV IRU V FRQFUHWH LQ FRPSUHVVLRQ WHQVLRQ DQG IOH[XUH	&2	
	1RPLQDO PL[HV DQG GHVLJQ PL[HV PL[GHVLJQDWLRQ PL[HG FRQFUHWH	&2	
	0RGXOH ,,, 7RWDO OHFWXUH KRXUV		
	)ORRULQJ DQG URRILQJ PDWHULDOV	&2	
	/LQWHOV DQG DUFKHV ± W\SHV	&2	
	'RRUV :LQGRZV DQG YHQWLODWRUV ± W\SHV DQG FRQ		

	GHWDLOV		
	)LQLVKLQJ ZRUNV 3DLQW ± W\SHV	&2	
	7LPEHU ± VHDVRQLQJ	&2	
	7LPEHU SURGXFWV ± SURSHUWLHV DQG XVHV RI SO\ZR ERDUG DQG SDUWLFOH ERDUG	&2	
	)RUPZRUN &RQVWUXFWLRQ DQG H[SDQVLRQ MRLQWV	&2	
	0RGXOH ,9 7RWDO OHFWXUH KRXUV		
	7\SHV RI VKDOORZ IRXQGDWLRQV	&2	
	7\SHV RI GHHS IRXQGDWLRQV	&2	
	)RXQGDWLRQ IDLOXUH ± FDXVHV	&2	
	,QWURGXFWLRQ WR FRVW HIIHFWLYH FRQVWUXFWLRQ ILOOHU VODE DQG UDW WUDS ERQG PDVRQU\	&2	
	6XVWDLQDEOH EXLOGLQJ WHFKQRORJLHV	&2	
	1RQ GHVWUXFWLYH WHVWLQJ RI FRQFUHWH ± UHERXQG DQG XOWUDVRQLF SXOVH YHORFLW\ WHVW ZLWK GHPR	&2	
	,QWURGXFWLRQ WR SUHIDEULFDWHG FRQVWUXFWLRQ VOLS IRUP FRQVWUXFWLRQ	&2	
	0RGXOH 9 7RWDO OHFWXUH KRXUV		
	,QWURGXFWLRQ WR VWUXFWXUDO V\VWHPV ± IXQFWLR VWUXFWXUDO HOHPHQWV ± EHDPV FROXPQV DQG VODE	&2	
	3ULQFLSOHV RI UHLQIRUFHG FRQFUHWH W\SHV RI UHL ± WHQVLRQ UHLQIRUFHPHQWV FRPSUHVVLRQ UHLQIRU VWLUUXSV	&2	
	5HLQIRUFHPHQW GHWDLOV RI EHDPV FROXPQV DQG VO		
	6WUXFWXUDO V\VWHPV ± ORDG EHDULQJ ZDOOV PRPH IUDPHV	&2	
	6WUXFWXUDO V\VWHPV ± WUXVVHV FDEOHV DQG PHPE		
	(OHYDWHG FRQFUHWH IORRU V\VWHPV EHDPV VXSSRU FRQFUHWH IORRUV ± RQH ZD\ DQG WZR ZD\ VODEV IOD	&2	

02'(/ 48(67,21 3$3(5

5HJ 1R BBBBBBBBBBBBBBB 1DPH BBBBBBBBBBBBBBBBBBBBBBBBBI

$3- $%'8/ .$/$0 7(&+12/2*,&$/ 81,9(56,7<
7+,5' 6(0(67(5 % 7(&+ '(*5(((;$0,1$7,21

&RXUVH &RGH &(7

&RXUVH 1DPH %8,/',1* &216758&7,21 $1' 6758&785$/ 6<67(

0D[0DUNV 'XUDWLRQ +RXU

3$57 $

$QVZHU DOO TXHVWLRQV HDFK TXHVWLRQ FDUUL

D :KDW LV K\GUDWLRQ RI FHPHQW"

E :KDW LV PRUWDU" :KDW DUH LWV XVHV"

F :KDW DUH WKH DGYDQWDJHV RI SUHVWUHVVHG FRQFUHWH R

G 'LVWLQJXLVK EHWZHHQ QRPLQDO PL[DQG GHVLJQ PL[

H 1DPH GLIIHUHQW W\SHV RI SDLQWV DQG PHQWLRQ WKHLU XV

I /LVW GLIIHUHQW W\SHV RI WLPEHU SURGXFWV XVHG LQ

J :KDW LV D UDIW IRXQGDWLRQ"

K ([SODLQ DQ\ RQH QRQ GHVWUXFWLYH WHVW XVHG WR D

L :KDW LV D WUXVV" +RZ GRHV D WUXVV UHVLVW H[WHUQDO O

M :K\ LV UHLQIRUFHPHQW HVVHQWLDO LQ FRQFUHWH EHDPV"

î PDUNV

3$57 %

$QVZHU RQH IXOO TXHVWLRQ IURP HDFK PRGXOH HDFK I

0RGXOH ,

D :KDW LV PHDQ E\ JUDGLQJ RI DJJUHJDWHV"

E ([SODLQ WKH SURFHVV RI PDQXIDFWXULQJ FHPHQW

D ([SODLQ WKH UROH RI DGPL[WXUHV LQ FRQFUHWH

E ([SODLQ WKH YDULRXV WHVWV XVHG WR DVVHVV SURSH

0RGXOH ,,

D :KDW LV FXULQJ RI FRQFUHWH" :K\ LV LW LPSRUWDQW

E :KDW LV PHDQW E\ ZRUNDELOLW\ RI FRQFUHWH" 'LVFX ZRUNDELOLW\ RI FRQFUHWH

D 'LVWLQJXLVK EHWZHHQ VHJUHJDWLRQ DQG EOHHGLQJ

E ([SODLQ WKH YDULRXV WHVWV SHUIRUPHG RQ KDUGHQH

0RGXOH ,,,

D 6NHWFK D W\SLFDO D

E :KDW LV VHDVRQLQJ RI WLPEHU" ([SODLQ GLIIHUHQW

D :KDW LV D OLQWHO

E ([SODLQ GLIIHUHQW W\SHV RI VFDIIROGLQJV

0RGXOH ,9

D ([SODLQ ZLWK QHDW VNHWFKHV DQ\ WKUHH W\SHV RI

E 'HVFULEH WKH FDXVHV RI IRXQGDWLRQ IDLOXUH

D :KDW LV D VOLS IRUP" :KHUH DUH WKH\ XVHG"

E ([SODLQ WKH FRQVWUXFWLRQ RI ILOOHU VODEV

0RGXOH 9

D :KDW DUH WKH IXQFWLRQV RI D VWUXFWXUDO V\VWHP

E :LWK WKH KHOS RI QHDW VNHWFKHV H[SODLQ WKH GL LQ EHDPV" $OVR H[SODLQ WKH IXQFWLRQV RI HDFK

D 'LVWLQJXLVK EHWZHHQ RQH Z

E &RPS ORDG EHDULQJ ZDOO FRQVWUXFWL FRQVWUXFWLRQ

&(7	,1752'8&7,21 72 *(27(&+1,&$/ (1*,1((5,1*	&$7(*25<		/7	3	&5(',7	<HDU RI ,QWURGXFWLRQ
		9$&					

3UHDPEOH *RDO RI WKLV FRXUVH LV WR H[SRVH WKH VWXGHQWV W
DQG IRXQGDWLRQ HQJLQHHULQJ $IWHU WKLV FRXUVH VWXGH
WR UHFRJQL]H SUDFWLFDO SUREOHPV LQ UHDO ZRUOG VLWXD

3UHUHTXLVLWH 1LO

&RXUVH 2XWFRPHV $IWHU FRPSOHWLRQ RI WKH FRXUVH WKH VWXGHQW

&2	([SODLQ WKH EDVLF FRQFHSWV WKHRULHV DQG PHW DQG IRXQGDWLRQ HQJLQHHULQJ
&2	6ROYH WKH EDVLF SURSHUWLHV RI VRLO E\ DSSO\LQ
&2	'HWHUPLQH WKH HQJLQHHULQJ SURSHUWLHV RI VR UHVXOWV DQG WKH IXQGDPHQWDO FRQFHSWV
&2	(VWLPDWH WKH GHVLJQ SDUDPHWHUV RI IRRWLQJV D

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV 0LQ

	32	32	32	32	32	32	32	32	32	32	32	32
&2												
&2												
&2												
&2												

$VVHVVPHQW 3DWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW 7HVWV		(QG 6HPHVWHU ([DPLQDWLRQ 0DUNV
	7HVW 0DUNV	7HVW 0DUNV	
5HPHPEHU			
8QGHUVWDQG			
$SSO\			
$QDO\VH			
(YDOXDWH			
&UHDWH			

0DUN 'LVWULEXWLRQ

7RWDO	0DUNV	&,(0DUNV	(6(0DUNV (6('XUDWLRQ
			KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ &,(3DWWHUQ

$WWHQGDQFH 0DUNV

&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV 0DUNV

$VVLJQPHQW 4XL] &RXUVH SURMHFW 0DUNV

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ 7KHUH ZLOO EH WZR SDUWV 3DUW
FRQWDLQV TXHVWLRQV ZLWK TXHVWLRQV IURP HDFK PRGX
VKRXOG DQVZHU DOO TXHVWLRQV 3DUW % FRQWDLQV TXHV
DQVZHU DQ\ RQH (DFK TXHVWLRQ FDQ KDYH PD[LPXP VXE GL

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

4XHVWLRQV PD\ EH IUDPHG EDVHG RQ WKH RXWOLQH JLYHQ X

&RXUVH 2XWFRPH &2

7KH IXQGDPHQWDO FRQFHSWV RI EDVLF SURSHUWLHV DQG
7KH IXQGDPHQWDO FRQFHSWV RI HQJLQHHULQJ SURSHUWL
VWUHQJWK FRQVROLGDWLRQ FRPSDFWLRQ
&RQFHSWV RI 7RWDO QHXWUDO DQG HIIHFWLYH VWUHVV
%DVLF WKHRULHV RI (DUWK SUHVVXUH %HDULQJ &DSDFLW

&RXUVH 2XWFRPH &2

6ROYH WKH EDVLF SURSHUWLHV RI VRLO E\ DSSO\LQJ IXQ

&RXUVH 2XWFRPH &2

&DOFXODWH WKH HQJLQHHULQJ SURSHUWLHV RI VRLO UH
VKHDU VWUHQJWK E\ DSSO\LQJ WKH ODERUDWRU\ WHVW
&DOFXODWH WKH HQJLQHHULQJ SURSHUWLHV RI VRLO E\ D
WR WRWDO QHXWUDO DQG HIIHFWLYH VWUHVV DQG YHUW

&RXUVH 2XWFRPH &2

(VWLPDWH WKH HDUWK SUHVVXUH DFWLQJ RQ WKH UHWDL
(VWLPDWH WKH EHDULQJ FDSDFLW\ RI IRRWLQJV
(VWLPDWH WKH LPPHGLDWH DQG FRQVROLGDWLRQ VHWWO

0RGHO 4XHVWLRQ 3DSHU

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5HJ 1R BBBBBBBBBBBBBBBB 1DPH BBBBBBBBBBBB

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)2857+ 6(0(67(5 % 7(&+ '(*5(((;$0,1$7,21 0217+ <($5

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&RXUVH 1DPH ,1752'8&7,21 72 *(27(&+1,&$/ (1*,1((5,1*

0D[0DUNV 'XUDWLRQ

3DUW $

$QVZHU DOO TXHVWLRQV HDFK TXHVWLRQ FDUUL

'UDZ D WKUHH SKDVH EORFN GLDJUDP DQG GHILQH L
LLL 'HJUHH RI VDWXUDWLRQ

([SODLQ GLIIHUHQW W\SHV RI VRLO VWUXFWXUHV

'HILQH L :HOO JUDGHG LL 3RRUO\ JUDGHG DQG LLL *DS

'HILQH L /LTXLG /LPLW LL 3ODVWLF /LPLW DQG LLL 6KU

([SODLQ 0RKU &RXORPE VKHDU VWUHQJWK WKHRU\

([SODLQ GLIIHUHQW W\SHV RI HDUWK SUHVVXUHV

([SODLQ WKH VLWXDWLRQV LQ ZKLFK FRPELQHG IRRWLQJV D

/LVW WKH DVVXPSWLRQV RI 7HU]DJKL¶V WKHRU\ RI EHDULQJ

'HILQH L SUH FRQVROLGDWLRQ SUHVVXUH LL &RPSUHVVL

'LIIHUHQWLDWH EHWZHHQ &RQVROLGDWLRQ DQG &RPSDFWLR

3$57 %

$QVZHU RQH IXOO TXHVWLRQ IURP HDFK PRGXOH HDFK

0RGXOH ±

D 'HULYH WKH UHODWLRQ EHWZHHQ EXON XQLW ZHLJKW
VDWXUDWLRQ IURP WKH IXQGDPHQWDOV

E $ VDPSOH RI ZHW VLOW\ FOD\ VRLO ZHLJKV N1 7KH
RQ WKH VDPSOH 'HQVLW\:DWHU FRQWHQW Z 6SHFLI
'HWHUPLQH L 'U\ GHQVLW\ LL 9RLG 5DWLR LLL 3R
6DWXUDWHG XQLW ZHLJKW YL 6XEPHUJHG XQLW ZHLJKW

D ([SODLQ WKH SURFHGXUHV WR GHWHUPLQH WKH ILHOG G

E FP FRUH FXWWHU ZHLJKLQJ 1 ZDV XVHG WR ILQG
HPEDQNPHQW 7KH ZHLJKW RI FRUH FXWWHU ZLWK LQ VLW
WHVWV RQ WKH VDPSOH LQGLFDWHG ZDWHU FRQWHQW R
'HWHUPLQH WKH EXON XQLW ZHLJKW GU\ XQLW ZHLJKW

FDOFXODWH WKH VDWXUDWHG XQLW ZHLJKW DQG WKH FR
VDWXUDWHG GXULQJ UDLQ ZLWKRXW FKDQJH LQ YROXPH

0RGXOH ±

D ([SODLQ WKH IDFWRUV DIIHFWLQJ SHUPHDELOLW\ RI VRL
E$ VRLO VDPSOH RI KHLJKW FP DQG D FURVV VHFWLRQ
SHUPHDELOLW\ WHVW ZLWK KHDG RI FP DQG FF RI ZD
WHVW LQWHUYDO RI PLQ &RPSXWH WKH FRHIILFLHQW RI
,I WKH VDPH VDPSOH LV VXEMHFWHG WR IDOOLQJ KHDG
IURP FP WR FP LQ PLQ 'HWHUPLQH WKH FURVV VHFW
D $ FRQFHQWUDWHG ORDG RI N1 LV DSSOLHG DW JURX
L DW D GHSWK RI P EHORZ WKH ORDG LL DW D GLVWD
WKHRU\ 0DU
E $ VDQG GHSRVLW RI P WKLFN ZDV ORDGHG
:7 LV DW P EHORZ */ 'HQVLW\ RI VDQG DERYH :7 LV
'UDZ 7RWDO 1HXWUDO DQG (IIHFWLYH 6WUHVV 'LDJUDPV
0DUNV

0RGXOH ±

D /LVW WKH DGYDQWDJHV DQG GLVDGYDQWDJHV RI 'LUHFW
E $ F\OLQGULFDO VSHFLPHQ RI VRLO IDLOV ZKHQ LW LV D[LDOO\
XQFRQILQHG)DLOXUH SODQH PDNHV DQ DQJOH RI 'HWHU
SDUDPHWHUV F 0DUNV
D ([SODLQ FULWLFDO GHSWK RI DQ XQVXSSRUWHG FXW LQ
E $ UHWDLQLQJ ZDOO P KLJK ZLWK D VPRRWK YHUWLFDO
RI VRLO DERYH ZDWHU WDEOH LV N1 P DQG EHORZ ZDW
P EHORZ JURXQG OHYHO)LQG WKH WRWDO DFWLYH SUHVV
RI DSSOLFDWLRQ DERYH WKH EDVH E\ 5DQNLQH¶V WKHRU\

0RGXOH ±

([SODLQ GLIIHUHQW W\SHV RI VKDOORZ IRXQGDWLRQV DQ
HDFK W\SH RI IRRWLQJV
D ([SODLQ YDULRXV IDFWRUV WKDW DIIHFW XOWLPDWH EH
E $ VTXDUH IRRWLQJ RI P [P LV WR EH IRXQGHG DW D G
GDWD

J N1 P & N1 P I

1 1 1

'HWHUPLQH WKH QHW VDIH EHDULQJ FDSDFLW\ ZLWK D IDF
L P IURP JURXQG OHYHO LL P IURP JURXQG OH

0RGXOH ±

D :KDW LV PHDQW E\ ,PPHGLDWH 6HWWOHPHQW" +RZ WR G
E $ P VTXDUH IRRWLQJ DW D GHSWK RI P IURP JURXQG
N1 P,I D FRPSUHVVLEOH FOD\ OD\HU P WKLFN H[LVWV
GHWHUPLQH WKH VHWWOHPHQW RI WKH IRRWLQJ GXH WR
WDEOH DW D GHSWK RI P EHORZ */ DERYH DQG EHORZ

N1 P EHORZ ZDWHU WDEOH)RU FODD\ DQG *HU 1/ 7DNHZ N1 P 0DUNV

D :KDW LV PHDQW E\ $OORZDEOH VHWWOHPHQW"

E 7KH IROORZLQJ DUH UHVXOWV RI D VWDQGDUGV SURFWR

:DWHU &RQWHQW						
%XON 'HQVLW\ N1 P						

3ORW WKH ZDWHU FRQWHQW ± GU\ GHQVLW\ FXUYH DQG GHQVLW\ $OVR SORW WKH]HUR DLU YRLGV FXUYH 7DNH

6<//$%86

0RGXOH	&RQWHQWV
	,QWURGXFWLRQ WR VRLO PHFKDQLFV 6RLO W\SHV 0DM %DVLF VRLO SURSHUWLHV 9RLG UDWLR SRURVLW\ GHJU VSHFLILF JUDYLW\ XQLW ZHLJKW 5HODWLRQVKLS EHW SUREOHPV /DERUDWRU\ 'HWHUPLQDWLRQ RI :DWHU FRQWHQW E\ R S\FQRPHWHU VSHFLILF JUDYLW\ ERWWOH DQG)LHOG G)LHOG GHQVLW\ E\ &RUH &XWWHU PHWKRG 6RLO 6WUXFWXUH VLQJOH JUDLQHG KRQH\ FRPEHG IO WKHLU HIIHFWV RQ WKH EDVLF VRLO SURSHUWLHV ± 6HQV
	,QGH[SURSHUWLHV 6LHYH DQDO\VLV ± :HOO JUDGHG &RQVLVWHQF\ $WWHUEHUJ /LPLWV DQG 3ODVWLFLW\ ,Q 3HUPHDELOLW\ RI VRLOV 'DUF\¶V ODZ ± 1XPHULFDO 3UR 3ULQFLSOH RI HIIHFWLYH VWUHVV 7RWDO QHXWUDO D QXPHULFDO SUREOHPV 6WUHVV GLVWULEXWLRQ %RXVVLQHVT¶V HTXDWLRQV I $SSUR[LPDWH PHWKRGV IRU 9HUWLFDO 3UHVVXUH EHQH 0HWKRG QXPHULFDO SUREOHPV ,VREDUV 3UHVVXUH E
	6KHDU VWUHQJWK RI VRLOV 3UDFWLFDO $SSOLFDWLRQV FLUFOH PHWKRG IRU GHWHUPLQDWLRQ RI SULQFLSDO S VKHDU SDUDPHWHUV DQG SULQFLSDO VWUHVVHV >QR GH %ULHI GLVFXVVLRQ RI 'LUHFW VKHDU WHVW 8&& /DWHUDO HDUWK SUHVVXUH ± $W UHVW DFWLYH DQG SD >QR GHULYDWLRQ UHTXLUHG@ ,QIOXHQFH RI VXUFKDUJ SUHVVXUH QXPHULFDO SUREOHPV
	)RXQGDWLRQ JHQHUDO FRQVLGHUDWLRQ)XQFWLRQV R GHHS IRXQGDWLRQV 'LIIHUHQW W\SHV RI IRXQGDWLRQ &RPELQHG)RRWLQJV ± 5HFWDQJXODU DQG 7UDSH]RLG)RXQGDWLRQV 6HOHFWLRQ RI W\SH RI IRXQGDWLRQ W\SHV RI IRXQGDWLRQV %HDULQJ FDSDFLW\ RI VKDOORZ IRXQGDWLRQV ± 8OWLPD)DLOXUH PHFKDQLVP DVVXPSWLRQV DQG HTXDWLRQ RI VWULS IRRWLQJ >QR GHULYDWLRQ UHTXLUHG@ ± %HDUL IRUPXODH IRU FLUFXODU DQG VTXDUH IRRWLQJV QXPHU IDLOXUH)DFWRUV DIIHFWLQJ EHDULQJ FDSDFLW\ ± (II QXPHULFDO SUREOHPV
	6HWWOHPHQW DQDO\VLV ,QWURGXFWLRQ FDXVHV RI V WRWDO VHWWOHPHQW ±(VWLPDWLRQ RI LPPHGLDWH VHWW &RQVROLGDWLRQ 'HILQLWLRQ ± 6SULQJ DQDORJ\ IRU YHUVXV SUHVVXUH UHODWLRQVKLS &RHIILFLHQW RI FRP 3UH FRQVROLGDWLRQ 3UHVVXUH &RPSUHVVLRQ LQGH[(QRUPDOO\ FRQVROLGDWHG FOD\V 1XPHULFDO SUREOHP $OORZDEOH VHWWOHPHQW 7RWDO DQG GLIIHUHQWLDO V &RPSDFWLRQ RI VRLOV 'LIIHUHQFH EHWZHHQ FRQVRO +HDY\ &RPSDFWLRQ 7HVWV ± 20& DQG 0''

7H[W %RRNV

5DQMDQ * DQG $ 6 5 5DR %DVLF DQG $SSOLHG 6RLO 0H

$URUD . 5 *HRWHFKQLFDO (QJLQHHULQJ 6WDQGDUG 3XE

5HIHUHQFHV

'DV % 0 3ULQFLSOHV RI *HRWHFKQLFDO (QJLQHHULQJ &

9HQNDWUDPDLDK *HRWHFKQLFDO (QJJ 8QLYHUVLWLHV 3U

7HU]DJKL . DQG 5 % 3HFN 6RLO 0HFKDQLFV LQ (QJLQHH

$ 9 1DUDVLPKD 5DR DQG & 9HQNDWUDPDLDK 1XPHULFDO 3
TXHVWLRQV LQ *HRWHFKQLFDO (QJLQHHULQJ 8QLYHUVLWL

3XUXVKRWKDPDUDM 3 6RLO 0HFKDQLFV DQG)RXQGDWLRQ
3YW /WG

7D\ORU ':)XQGDPHQWDOV RI 6RLO 0HFKDQLFV $VLD 3XE

&RXUVH &RQWHQWV DQG /HFWXUH 6FKHGXOH

0RGXOH	&RQWHQWV	2XWFRPHV $GGUHVVHG	+RXUV
	0RGXOH		
	1DWXUH RI VRLO DQG IXQFWLRQDO UHODWLRQVKLSV PHFKDQLFV ± 6RLO W\SHV ± 0DMRU VRLO GHSRVLWV RI ,	&2	
	SKDVH V\VWHP ± %DVLF VRLO SURSHUWLHV 9RLG UDW VDWXUDWLRQ DLU FRQWHQW ZDWHU FRQWHQW VSHFLI	&2	
	5HODWLRQVKLSV EHWZHHQ EDVLF VRLO SURSHUWLHV	&2	
	1XPHULFDO SUREOHPV	&2	
	'HWHUPLQDWLRQ RI :DWHU FRQWHQW E\ RYHQ GU\LQJ 6 S\FQRPHWHU VSHFLILF JUDYLW\ ERWWOH	&2	
	'HWHUPLQDWLRQ RI)LHOG GHQVLW\ E\ VDQG UHSODFHP &XWWHU PHWKRG	&2	
	1XPHULFDO SUREOHPV	&2	
	6RLO 6WUXFWXUH DQG WKHLU HIIHFWV RQ WKH EDVLF VR DQG 7KL[RWURS\	&2	
	0RGXOH		
	,QGH[SURSHUWLHV 6LHYH DQDO\VLV ± :HOO JUDGHG 6 JUDGHG VRLOV	&2	
	&RQVLVWHQF\ $WWHUEHUJ /LPLWV DQG 3ODVWLFLW\ ,Q	&2	
	3ODVWLFLW\ &KDUW ±, 6 FODVVLILFDWLRQ	&2	
	3HUPHDELOLW\ RI VRLOV 'DUF\¶V ODZ ±)DFWRUV DIIHF		
	3ULQFLSOH RI HIIHFWLYH VWUHVV 7RWDO QHXWUDO 3UHVVXUH GLDJUDPV	&2	
	1XPHULFDO SUREOHPV	&2	
	6WUHVV GLVWULEXWLRQ ,QWURGXFWLRQ %RXVVLQHV SUHVVXUH GXH WR SRLQW ORDGV ± 1XPHULFDO SUREOHP	&2 &2	
	$SSUR[LPDWH PHWKRGV IRU 9HUWLFDO 3UHVVXUH EHQHI 'LVWULEXWLRQ 0HWKRG QXPHULFDO SUREOHPV	&2 &2	
	,VREDUV 3UHVVXUH EXOEV	&2	
	0RGXOH		
	6KHDU VWUHQJWK RI VRLOV 3UDFWLFDO $SSOLFDWLRQV FULWHULRQ	&2	
	0RKU FLUFOH PHWKRG IRU GHWHUPLQDWLRQ RI SULQFLS UHODWLRQVKLS EHWZHHQ VKHDU SDUDPHWHUV DQG S GHULYDWLRQ UHTXLUHG@	&2	
	1XPHULFDO 3UREOHPV	&2	
	%ULHI GLVFXVVLRQ RI 'LUHFW VKHDU WHVW	&2	8&&

	/DWHUDO HDUWK SUHVVXUH ± $W UHVW DFWLYH DQG SD		
	5DQNLQH¶V WKHRULHV >QR GHULYDWLRQ UHTXLUHG@	&2	
	,QIOXHQFH RI VXUFKDUJH DQG ZDWHU WDEOH RQ HDUWK	&2	
	1XPHULFDO SUREOHPV	&2	
	(DUWK SUHVVXUH RQ UHWDLQLQJ ZDOOV ZLWK OD\HUHG 3UREOHPV	&2 &2	
	0RGXOH		
	)RXQGDWLRQV)XQFWLRQV RI IRXQGDWLRQV 'HILQLV GHHS IRXQGDWLRQV	&2	
	'LIIHUHQW W\SHV RI IRXQGDWLRQV 6WULS)RRWLQJV &RPELQHG)RRWLQJV ± 5HFWDQJXODU 7UDSH]RLGDO DQG 3LOH)RXQGDWLRQV	&2	
	6HOHFWLRQ RI W\SH RI IRXQGDWLRQ $GYDQWDJHV DQG W\SHV RI IRXQGDWLRQV	&2	
	%HDULQJ FDSDFLW\ RI VKDOORZ IRXQGDWLRQV ± 8OWLPD EHDULQJ FDSDFLW\	&2	
	)DLOXUH PHFKDQLVP DVVXPSWLRQV DQG HTXDWLRQ RI FDSDFLW\ WKHRU\ IRU VWULS IRRWLQJ >QR GHULYDWLRQ	&2	
	%HDULQJ FDSDFLW\ IDFWRUV DQG FKDUWV 7HU]DJKL¶V DQG VTXDUH IRRWLQJV	&2	
	1XPHULFDO SUREOHPV	&2	
	(IIHFW RI ZDWHU WDEOH RQ EHDULQJ FDSDFLW\ QXPHU	&2	
	/RFDO DQG JHQHUDO VKHDU IDLOXUH)DFWRUV DIIHFWL		
	0RGXOH		
	6HWWOHPHQW DQDO\VLV ,QWURGXFWLRQ FDXVHV RI V FRQVROLGDWLRQ DQG WRWDO VHWWOHPHQW	&2	
	(VWLPDWLRQ RI LPPHGLDWH VHWWOHPHQW ± 1XPHULFDO	&2	
	&RQVROLGDWLRQ 'HILQLWLRQ ± 6SULQJ DQDORJ\ IRU VX		
	9RLG UDWLR YHUVXV SUHVVXUH UHODWLRQVKLS &RHIILF DQG YROXPH FRPSUHVVLELOLW\ ± 3UH FRQVROLGDWL &RPSUHVVLRQ LQGH[	&2	
	(VWLPDWLRQ RI PDJQLWXGH RI VHWWOHPHQW RI QRUPDO 1XPHULFDO SUREOHPV	&2	
	$OORZDEOH VHWWOHPHQW 7RWDO DQG GLIIHUHQWLDO VWDQGDUG	&2	
	&RPSDFWLRQ RI VRLOV 'LIIHUHQFH EHWZHHQ FRQV FRPSDFWLRQ	&2	
	,6 /LJKW +HDY\ &RPSDFWLRQ 7HVWV ± 202& DQG 0''	&2	
	1XPHULFDO 3UREOHPV	&2	

&2'(&(7	&RXUVH 1DPH ,1)250$7,&6)25 ,1)5$6758&785(0$1$*(0(17	&$7(*25<	/	7	3	&5(',7
		9$&				

3UHDPEOH 7KLV FRXUVH LV DLPHG DW H[SRVLQJ WKH VWXGHQWV WR V
7KLQJV ,R7 LQ &LYLO (QJLQHHULQJ ,W LQWURGXFHV VWXGHQW
LQIRUPDWLFV ,R7 DV LW LV DSSOLFDEOH WR FLYLO HQJLQHHULQ
SRVLWLRQ WR DSSUHFLDWH WKH XVH RI LQIRUPDWLFV ,R7LQ FLY
GHYHORSPHQWV LQ WKLV VHFWRU

3UHUHTXLVLWH 1LO

&RXUVH 2XWFRPHV

&RXUVH 2XWFRPH	'HVFULSWLRQ RI &RXUVH 2XWFRPH	3UHVFULEHG OHDUQLQJ OHYHO
&2	7R XQGHUVWDQG WKH IXQGDPHQWDO FRQFHSWV RI GDWD LQIRUPDWLFV LQWHUQHW RI WKLQJV	5HPHPEHULQJ 8QGHUVWDQGLQJ
&2	7R OHDUQ WKH XVH RI JHRPDWLFVLQ SODQQLQJ DQG VLWLQJ LQIUDVWUXFWXUH SURMHFWV	$SSO\LQJ $QDO\VLQJ
&2	7R DSSO\ EXLOGLQJ LQIRUPDWLFV LQ FRQVWUXFWLRQ SURMHFW PDQDJHPHQW	$SSO\LQJ $QDO\VLQJ
&2	7R OHDUQ WKH UROH RI ,R7 WHFKQRORJ\ LQ LQIUDVWUXFWXUH PDQDJHPHQW	$SSO\LQJ $QDO\VLQJ

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV 0LQLPX

	32	32	32	32	32	32	32	32	32	32	32	32
&2												
&2												
&2												
&2												

$VVHVVPHQW 3DWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW 7HVWV		(QG 6HPHVWHU ([DPLQDWLRQ
5HPHPEHU			
8QGHUVWDQG			
$SSO\			
$QDO\VH			
(YDOXDWH			
&UHDWH			

0DUN GLVWULEXWLRQ

7RWDO 0DUNV	&,(	(6(	(6('XUDWLRQ
			KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV PDUNV
$VVLJQPHQW 4XL] &RXUVH SURMHFW PDUNV

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ 7KHUH ZLOO EH WZR SDUWV 3DUW $ DQG 3D
TXHVWLRQV ZLWK TXHVWLRQV IURP HDFK PRGXOH KDYLQJ PD
DQVZHU DOO TXHVWLRQV 3DUW % FRQWDLQV TXHVWLRQV IURP
DQ\ RQH (DFK TXHVWLRQ FDUULHV PDUNV DQG FDQ KDYH PD[LP

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

4XHVWLRQV PD\ EH IUDPHG EDVHG RQ WKH RXWOLQH JLYHQ

&RXUVH 2XWFRPH &2 7R XQGHUVWDQG WKH IXQGDPHQWDO FRQFHSWV RI
LQWHUQHW RI WKLQJV

([SODLQ',.: S\UDPLG
([SODLQ WKH GDWD PLQLQJ WHFKQLTXHV
'LVFXVV GLIIHUHQW GDWD PRGHOV
'LVFXVV WKH YHFWRU GDWD DQDO\VLV WHFKQLTXHV
([SODLQ &2%LH VWDQGDUG
/LVW ,R7 SURWRFROV
:KDW DUH WKH HOHPHQWV RI %,0"

&RXUVH 2XWFRPH &2 7R OHDUQ WKH XVH RI JHRPDWLFV IRU SODQQL
LQIUDVWUXFWXUH SURMHFWV

'LVFXVV KRZ JHRPDWLFV KHOS LQ VLWH VHOHFWLRQ RI D
'LVFXVV KRZ WHUUDLQ PRGHOLQJ LV DQ LPSRUWDQW JHR
SODQQLQJ

&RXUVH 2XWFRPH &2 7R DSSO\ EXLOGLQJ LQIRUPDWLFV LQ FRQVWUX
SURMHFW PDQDJHPHQW

+RZ %,0 KHOSV LQ UHGXFLQJ WKH FRVW RI FRQVWUXFWLR
'LVFXVV WKH VWHSV LQ GHYHORSLQJ D %,0 IRU DQ LQIUD

&RXUVH 2XWFRPH &2 7R OHDUQ WKH UROH RI ,R7 WHFKQRORJ\ LQ LQ
+RZ D ZDWHU VXSSO\ V\VWHP FRXOG EHQHILW E\ ,R7 WHF
0RQLWRULQJ LQIUDVWUXFWXUH SURMHFWV FRXOG OHYHU

6\OODEXV

0RGXOH 'DWD WR ,QIRUPDWLRQ

+LVWRU\ RI LQIRUPDWLFV ',.: S\UDPLG GDWD PDQDJHPHQW
PDQDJHPHQW V\VWHPV 'DWD DQDO\VLV WHFKQLTXHV VSDWL
SDWWHUQV 'DWD PLQLQJ WHFKQLTXHV GDWD SURFHVVLQJ I

0RGXOH *HRLQIRUPDWLFV

)XQGDPHQWDO FRQFHSWV LQ *HR LQIRUPDWLFV &RPSRQHQW
DQG UDVWHU GDWD PRGHOV 0HWKRGV RI GDWD LQSXW 6SD
EXIIHULQJ RYHUOD\ 5DVWHU GDWD DQDO\VLV ORFDO RSHU
RSHUDWLRQV *,6 RXWSXW FDUWRJUDSKLF DQG QRQ FDUW

0RGXOH 3ODQQLQJ DQG 6LWH VHOHFWLRQ

6LWH VXLWDELOLW\ DQDO\VLV IRU 5HVLGHQWLDO DUHD ,QG
'LVSRVDO :DWHU WUHDWPHQW SODQW UHVHUYRLUV
/DQG XVH /DQG FRYHU PDSSLQJ *URXQG :DWHU 3RWHQWLDO
0DSSLQJ 7HUUDLQ PRGHOOLQJ
1HWZRUN $QDO\VLV :DWHU VXSSO\ OLQH 6HZHU OLQH 3RZH
QHWZRUN

0RGXOH %XLOGLQJ ,QIRUPDWLFV

%XLOGLQJ ,QIRUPDWLRQ 0RGHOOLQJ 'HILQLWLRQ (OHPHQWV RI %
VWDQGDUG SRWHQWLDO DQG DSSOLFDWLRQV RI %,0 &DVH VWXG

0RGXOH ,QWHUQHW RI 7KLQJV ,R7 LQ &LYLO ,QIUDVWUXFW

,R7 6WDQGDUGV 3URWRFROV &RQFHSW RI ,R7 LQ FLYLO HQ
SURGXFW PRQLWRULQJ DQG SURMHFW 0DQDJHPHQW
6PDUW %XLOGLQJV VHQVRUV GHYLFHV VHOHFWLRQ FULWH
0DQDJHPHQW $SSOLFDWLRQV 7UDIILF 5HJXODWLRQ :DWHU 6
(QHUJ\ XVH

7H[W %RRNV

- &DPSEHOO (VVHQWLDOV RI *HRJUDSKLF ,QIRUPDWLRQ 6\VW
5DPH](OPDVUL 6KDPNDQW% 1DYDWKH)XQGDPHQWDO R
$GGLVRQ :HVOH\
%,0 +DQGERRN $ *XLGH WR %XLOGLQJ ,QIRUPDWLRQ 0RGHOL
(QJLQHHUV &RQWUDFWRUV DQG)DFLOLW\ 0DQDJHUV 3XEOL
-XO\ /DQJXDJH (QJOLVK ,6%1

5HIHUHQFH %RRNV

5DMD 5 $,VVD DQG 6YHWODQD 2OELQD %XLOGLQJ ,QIR
DQG 3UDFWLFHV $6&(

6DPXHO *UHHQJDUG 7KH LQWHUQHW RI WKLQJV 7KH 0,7
6HULHV ,6%1
6KDVKL6KHNKDU DQG 6DQMD\ &KDZOD 6SDWLDO 'DWDED
%XLOGLQJ ,QIRUPDWLRQ 0RGHOLQJ %,0 LQ &XUUHQW DQ
:LOH\ 6RQV HGLWLRQ $XJXVW /DQJXDJH (QJ

/HFWXUH 3ODQ ± ,QIRUPDWLFV IRU ,QIUDVWUXFWXUH 0D

0RGXOH	7RSLF	&RXUVH RXWFRPH DGGUHVVHG	1R RI /HFWXUHV
	0RGXOH , 7RWDO OHFWXUH KRXUV		
	+LVWRU\ RI LQIRUPDWLFV	&2	/HFWXUH
	',.: S\UDPLG 0HWD GDWD	&2	/HFWXUH
	'DWD PDQDJHPHQW	&2	/HFWXUH
	'DWD W\SHV 0HWD GDWD	&2	/HFWXUH
	'DWDEDVH PDQDJHPHQW V\VWHPV	&2	/HFWXUH
	'DWD DQDO\VLV WHFKQLTXHV	&2	/HFWXUH
	7UHQGV 3DWWHUQV LQ GDWD DQDO\VLV	&2	/HFWXUH
	'DWD PLQLQJ WHFKQLTXHV	&2	/HFWXUH
	'DWD SURFHVVLQJ IRU LQIRUPDWLRQ	&2	/HFWXUH
	0RGXOH ,, 7RWDO OHFWXUH KRXUV		
	)XQGDPHQWDO FRQFHSWV LQ *HR LQIRUPDWLFV	&2	/HFWXUH
	&RPSRQHQWV RI *,6	&2	/HFWXUH
	6SDWLDO GDWD DQG DWWULEXWHV	&2	/HFWXUH
	'DWD PRGHOV YHFWRU UDVWHU	&2	/HFWXUH
	0HWKRGV RI GDWD LQSXW	&2	/HFWXUH
	6SDWLDO GDWD HGLWLQJ	&2	/HFWXUH
	9HFWRU GDWD DQDO\VLV	&2	/HFWXUH
	5DVWHU GDWD DQDO\VLV ORFDO QHLJKERUKRRG DQDO\V	&2	/HFWXUH
	5DVWHU GDWD DQDO\VLV]RQDO DQDO\VLV *,6 RXWSXW	&2	/HFWXUH

	0RGXOH ,,, 7RWDO OHFWXUH KRXUV		
	6LWH VXLWDELOLW\ DQDO\VLV IRU 5HVLGHQWLDO DUHD ,Q DU	&2	/HFWXUH
	6LWH VXLWDELOLW\ DQDO\VLV IRU UHFUHDWLRQDO DUHD ZDVWH GLVSRVDO	&2	/HFWXUH
	6LWH VXLWDELOLW\ DQDO\VLV IRU ZDWHU WUHDWPHQW UHVHUYRLU	&2	/HFWXUH
	/DQG XVH ODQG FRYHU PDSSLQJ	&2	/HFWXUH
	*URXQG ZDWHU SRWHQWLDO]RQDWLRQ +D]DUG]RQDWLRQ PDSSLQJ	&2	/HFWXUH
	7HUUDLQ PRGHOOLQJ	&2	/HFWXUH
	1HWZRUN DQDO\VLV IRU ZDWHU VXSSO\ VHZHU OLQHV	&2	/HFWXUH
	1HWZRUN DQDO\VLV IRU SRZHU OLQH WHOHFRPPXQLFDWL	&2	/HFWXUH
	1HWZRUN DQDO\VLV IRU URDG QHWZRUN	&2	/HFWXUH
	0RGXOH ,9 7RWDO OHFWXUH KRXUV		
	%XLOGLQJ ,QIRUPDWLRQ 0RGHOOLQJ 'HILQLWLRQ	&2	/HFWXUH
	(OHPHQWV RI %,0	&2	/HFWXUH
	6WHSV LQ %,0 GHYHORSPHQW	&2	/HFWXUH
	&2%LH VWDQGDUG	&2	/HFWXUH
	3RWHQWLDO DSSOLFDWLRQV RI %,0	&2	/HFWXUH
	&DVH VWXGLHV RI %,0	&2	/HFWXUH
	0RGXOH 9 7RWDO OHFWXUH KRXUV		
	,R7 6WDQGDUGV 3URWRFROV &RQFHSW RI ,R7 LQ FLYLO HQJLQHHULQJ	&2	/HFWXUH
	$SSOLFDWLRQ RI ,R7 LQ FRQVWUXFWLRQ SURGXFW PRQLWR SURMHFW PDQDJHPHQW	&2	/HFWXUH
	6PDUW EXLOGLQJV	&2	/HFWXUH
	6HOHFWLRQ FULWHULD RI VHQVRU GHYLFHV 'DWD LQWHJ	&2	/HFWXUH
	0DQDJHPHQW DSSOLFDWLRQV RI ,R7 7UDIILF ZDWHU VXSSO SROOXWLRQ FRQWURO +9$& HQHUJ\ XVH	&2	/HFWXUH

0RGHO 4XHVWLRQ 3DSHU

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5HJ 1R BBBBBBBBBBBBBBBB 1DPH BBBBBBBBBBBB

$3- $%'8/ .$/$0 7(&+12/2*,&$/ 81,9(56,7<

7+,5' 6(0(67(5 % 7(&+ '(*5(((;$0,1$7,21 0217+ <($5

&RXUVH &RGH
&RXUVH 1DPH ,1)250$7,&6)25 ,1)5$6758&785(0$1$*(0(17

0D[0DUNV 'XUDWLRQ

3DUW $
$QVZHU DOO TXHVWLRQV HDFK TXHVWLRQ FDUULH

([SODLQ GLIIHUHQW GDWD W\SHV

([SODLQ ',.: S\UDPLG

&RPSDUH YHFWRU UDVWHU PRGHO

:KDW DUH WKH FRPSRQHQWV RI *,6"

([SODLQ QHWZRUN DQDO\VLV

:KDW LV WKH LPSRUWDQFH RI WHUUDLQ PRGHOLQJ"

'HILQH %,0

:KDW LV &2%LH VWDQGDUG"

/LVW WKH ,R7 SURWRFROV

([SODLQ WKH FRQFHSW RI VPDUW EXLOGLQJV

3$57 %
$QVZHU RQH IXOO TXHVWLRQ IURP HDFK PRGXOH HDFK

D 'LVFXVV GDWD DQDO\VLV WHFKQLTXHV IRU VSDWLDO GD

E ([SODLQ WKH VWHSV LQ SURFHVVLQJ GDWD LQWR LQIRU

25

D %ULHIO\ GHVFULEH WKH KLVWRU\ RI LQIRUPDWLFV

E ([SODLQ YDULRXV GDWD PLQLQJ WHFKQLTXHV

D 'LVFXVV YDULRXV GDWD LQSXWWLQJ PHWKRGV IRU *,6

E([SODLQ YDULRXV YHFWRU DQDO\VLV WHFKQLTXHV

25

D ([SODLQ EXIIHULQJ DQDO\VLV :KDW LV LWV DSSOLFDW

E ([SODLQ YDULRXV UDVWHU GDWD DQDO\VLV WHFKQLTXH

D +RZ WKH VLWH VXLWDELOLW\ DQDO\VLV LV FDUULHG R

0DUNV

E ([SODLQ KRZ JHRPDWLFV LV XVHIXO IRU PDSSLQJ KD]D

25

D ([SODLQ WKH PHWKRGRORJ\ IRU URDG QHWZRUN DQDO

E ([SODLQ WKH SURFHVV RI FRQYHUWLQJ GDWD WR LQIRU

0DUNV

D :KDW DUH WKH DSSOLFDWLRQV RI %,0"

E 'LVFXVV WKH VWHSV LQ GHYHORSLQJ D %,0 IRU DQ LQI

25

D ([SODLQ WKH HOHPHQWV RI %,0

E +RZ %,0 KHOSV LQ UHGXFLQJ WKH FRVW RI FRQVWUXFW

D :KDW VHQVRUV GHYLFHV ZRXOG KHOS LQ PRQLWRULQ

0DUNV

E ,QIUDVWUXFWXUHPDQDJHPHQW FRXOG OHYHUDJH IURP

0DUNV

25

D :KDW DUH WKH VHOHFWLRQ FULWHULD IRU VHQVRUV G

0DUNV

E 'LVFXVV KRZ ,R7 WHFKQRORJLHV FRXOG KHOS LQ SROO

6 (0 (6 7 (5

&(7	(QJLQHHULQJ *HRORJ\	&DWHJRU\	/	7	3	&UHGLWV	<HDU RI ,QWURGXFWLRQ
		3&&					

3UHDPEOH *RDO RI WKLV FRXUVH LV WR LQWURGXFH WR WKH V
PDWHULDOV JURXQGZDWHU DQG WKH JHRORJLFDO FKDUDF
ZKLFK DUH UHOHYDQW WR WKH &LYLO (QJLQHHULQJ DSSOLFD

3UHUHTXLVLWHV 1LO

&RXUVH 2XWFRPHV $IWHU FRPSOHWLRQ RI WKH FRXUVH WKH VWXGHQ

&2	5HFDOO WKH IXQGDPHQWDO FRQFHSWV RI VXUIDFH SUR URFNV JURXQGZDWHU DQG JHRORJLFDO
&2	,GHQWLI\ DQG GHVFULEH WKH VXUIDFH SURFHVVHV VXE JURXQGZDWHU DQG JHRORJLFDO IDF\
&2	$SSO\ WKH EDVLF FRQFHSWV RI VXUIDFH DQG VXEVXUID JURXQGZDWHU DQG JHRORJLFDO FKDUDF
&2	$QDO\]H DQG FODVVLI\ JHRORJLFDO SUR
&2	(YDOXDWLRQ RI JHRORJLFDO IDFWR

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV 0L

	32	32	32	32	32	32	32	32	32	32	32	32
&2												
&2												
&2												
&2												
&2												

$VVHVVPHQW SDWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW 7HVWV 7HVW 0DUNV	7HVW 0DUNV	(QG 6HPHVWHU ([DPLQDWLRQ 0DUNV
5HPHPEHU	PDUNV IRU HDFK TXHVWLRQ LQ ZKLFK RQH TXHVWLRQ IURP WKLUG PRG		
8QGHUVWDQG		PDUNV IRU HDFK TXHVWLRQ LQ ZKLFK RQH TXHVWLRQ IURP WKLUG PRG	
$SSO\	4XHVWLRQ IRU PDUNV LV IURP WKLUG PRG	4XHVWLRQ IRU PDUNV LV IURP WKLUG PRG	
$QDO\VH			
(YDOXDWH			

0DUN GLVWULEXWLRQ

7RWDO	0DUNV PDUN	V(6(&,(NPDUNV	7HVW 'XUD	(6('XUDWLRQ
			KF	KR

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV

&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV PDUNV

$VVLJQPHQW 4XL] &RXUVHSURMHFW PDUNV

(QG 6HPHVWHU ([DPLQDWLRQ3DWWHUQ

7KHUH ZLOO EH WZR SDUWV 3DUW $ DQG 3DUW % 3DUW $

IURP HDFK PRGXOH KDYLQJ PDUNV IRU HDFK TXHVWLRQ 6

3DUW % FRQWDLQV TXHVWLRQV IURP HDFK PRGXOH RI ZKLF

TXHVWLRQ FDQ KDYH PD[LPXP VXE GLYLVLRQV DQG FDUU\

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

3DUW $

&RXUVH 2XWFRPH &2 2QH TXHVWLRQ IURP HDFK PRGXO

7R UHFDOO WKH IXQGDPHQWDO FRQFHSWV RI VXUIDFH SURF

JURXQGZDWHU DQG JHRORJLFDO IDFWRUV LQ FLYLO HQJLQHH

'HILQH ZHDWKHULQJ RI URFNV

&RXUVH 2XWFRPH &2 2QH TXHVWLRQ IURP HDFK PRGXOH

LGHQWLI\ DQG GHVFULEH WKH VXUIDFH SURFHVVHV VXEVXU

DQG JHRORJLFDO IDFWRUV LQ FLYLO HQJLQHHULQJ FRQVWUX

([SODLQ WKH FODVVLILFDWLRQ RI VRLO

3DUW %

$OO WKH TXHVWLRQV XQGHU WKLV VHFWLRQ VKDOO DVVHVV

FRXUVH RXWFRPHV DQG

D&ODVVLI\ ZHDWKHULQJ DQG GLVFXVV WKH HQJLQHHULQJ

PDVVHV PDUNV

E:ULWH \RXU FRPPHQWV RQ WKH UHOHYDQFH RI JHRORJ\

PDUNV

0RGHO 4XHVWLRQ 3DSHU

43 &2'(

5HJ1R____________

1DPH____________________

3- $%'8/ .$/$0 7(&+12/2*,&$/ 81,9(56,7<),567 6(0(67(5

% 7(&+ '(*5(((;$0,1$7,21 217+ <($5

&RXUVH &RGH &(7

(1*,1((5,1* *(2/2*<

0D[0DUNV 'XUDWLRQ KRXUV

3DUW $

$QVZHU DOO TXHVWLRQV HDFK TXHVWLRQ FDUU

'HILQH ZHDWKHULQJ RIURFNV

([SODLQ VRLO HURVLRQ DQG FODVVLILFDWLRQ RIVRLOV

'HVFULEH HDUWKTXDNHV DQG ZULWH QRWHV RQ VHLVPRJ

,OOXVWUDWH WKH HODVWLF UHERXQG WKHRU\ ZLWK DGL

'HILQH *K\EHQ +HU]EHUJ UHODWLRQ LQ VHD ZDWHULQWU

([SODLQ 'DUF\ V /DZ ZLWK D QHDWGLDJUDP

:ULWH GRZQ WKH SK\VLFDO SURSHUWLHV DQG FKHPLFDO

D &DOFLWH

E *\SVXP

'HVFULEH WKH GLIIHUHQW W\SHV RI LJQHRXV URFNV EDV

,OOXVWUDWH WKH PDMRU SDUWV RI WKH IROG ZLWK D Q

'LVWLQJXLVK EHWZHHQ FOLQRPHWHU FRPSDVV DQG %UX

3$57 %

$QVZHU RQH IXOO TXHVWLRQ IURP HDFK PRGXOH HDFK

0RGXOH

D'LVFXVV WKH UHOHYDQFH RI JHRORJ\ LQ FLYLO HQJLQH

E*LYH DQ DFFRXQW RQ FODVVLILFDWLRQ RI ZHDWKHULQJ

H[DPSOHV PDUNV

'HVFULEH WKH JHRORJLFDO ZRUN RI ULYHUV 'LVFXVV GL

E\ ZHDWKHULQJ DQG ULYHU DFWLRQ ZLWK VXLWDEOH GL

0RGXOH

&RPPHQW RQ WKH UHODWLRQ RI HDUWKTXDNHV ZLWK SO

GLIIHUHQW SODWHV ZLWK HDUWKTXDNH SURQH DUHD

'LVFXVV WKH YDULRXV W\SHV RI VHLVPLF ZDYHV DQG WK
VWUXFWXUH RI HDUWK PDUNV

0RGXOH

'LVFXVV WKH YHUWLFDO GLVWULEXWLRQ RI JURXQGZDWH
SURSHUWLHV RI URFNV DQG K\GURORJLFDO F\FOH ZLWK
D(OXFLGDWH DSSOLFDWLRQ RI HOHFWULFDO UHVLVWLYL
PDUNV
E*LYH D EULHI DFFRXQW RQ GLIIHUHQW JURXQG ZDWHU

0RGXOH

'LVWLQJXLVK EHWZHHQ PHWDPRUSKLF DQG VHGLPHQWDU
VWUXFWXUH ZLWK GLDJUDPV PDUNV
D(OXFLGDWH YDULRXV SK\VLFDO SURSHUWLHV RI PLQHU
E*LYH DQ DFFRXQW RQ KDUGQHVV RI PLQHUDOV ZLWK 0R

0RGXOH

D(QXPHUDWH WKH JHRORJLFDO IDFWRUV WR EH FRQVLGH
PDUNV
E'LVFXVV WKH JHRORJLFDO FRQGLWLRQV VXLWDEOH DQG
WXQQHOV PDUNV
'LVWLQJXLVK EHWZHHQ IROGV DQG IDXOWV *LYH DQ DFF
QHDW GLDJUDPV PDUNV

(1*,1((5,1* *(2/2*<

6\OODEXV

0RG)	&RQW	+RX
0RGXOH ([WHUQDO (DUWK 3URFHVVHV	5HOHYDQFH RI *HRORJ\ LQ &LYLO (QJLQHHULQJ WKH HDUWK. :HDWKHULQJ RI URFNV 7\SHV RI ZHDWKHULQJ RI 2ULJLQ RI 3URGXFWV RI ZHDWKHULQJ OLNH VDQG VRLO VRLO SURILOH 6RLO HURVLRQ DQG VRLO F (QJLQHHULQJ VLJQLILFDQFH RI ZHDWKHULQJ E *HR ULYHUV F /DQGVOLGHV W\SHV FDXVHV DQG FRQ &RDVWDO 3URFHVVHV *HRORJLFDO ZRUN E\ ZDYHV FRDVWDO SURWHFWLRQPHDVXUHV	
0RGXOH ,QWHUQDO (DUWK 3URFHVVHV	,QWHUQDO 3URFHVVHV (DUWKTXDNHV 3ODWH 7HFWRQ 2ULJLQ RI HDUWKTXDNHV 6HLVPLF ZDYHV 5DWLQJ RI HDUWKTXDNHV 6HLVPLF]RQHV RI ,QGLD %DVLF IDFWRU ,QWHULRU RI WKH HDUWK DV UHYHDOHG E ZDYHV	
0RGXOH *URXQGZDWHU	+\GURJHRORJ\ 2FFXUUHQFH RI JURXQGZDWHU DTXLIHUV FRQILQLQJ EHGV SRURVLW\ DQG YHUW JURXQGZDWHU 'DUF\ V /DZ 3HUPHDELOLW\ K\GUDX 3UREOHPV FUHDWHG E\ JURXQGZDWHU WR FLYLO H 0HWKRGV WR FRQWURO JURXQGZDWHU SUREOHPV VXUYH\ IRU JURXQGZDWHU H[SORUDWLRQ 6HDZDWH DUHD *K\EHQ +HU]EHUJ UHODWLRQ	
0RGXOH (DUWK 0DWHULDOV	0LQHUDOV 3K\VLFDO SURSHUWLHV RI PLQHUDOV SK\VL DQG FKHPLFDO FRPSRVLWLRQ RI PLQHUDOV OLNH SODJLRFODVH ELRWLWH PXVFRYLWH KRUQEOHQG FDOFLWH J\SVXP 3HWURORJ\ ,JQHRXV VHGLPHQWDU\ DQG PHWDPRUSKLF U URFNV &KHPLFDO DQG PLQHUDORJLFDO FODVVLILF 6HGLPHQWDU\ URFNV W\SHV EDVHG RQ PRGH RI VWUXFWXUHV 0HWDPRUSKLF URFNV VWUXFWXUHV RQ JUDQLWH GROHULWH EDVDOW VDQGVWRQH OLPHV DQG FKDUQRFNLWH 5RFN W\SHV RI .HUDOD 5RFNF\F	
0RGXOH 6HFRQGDU\ 6WUXFWXUHV 5RFNV	6WUXFWXUDO $WWLWXGH RI URFNV ± 'LS DQG 6W 7HUPLQRORJ\ EULHI FODVVLILFDWLRQ DQG HQJLQH IROGV IDXOWV DQG MRLQWV *HRORJLFDO SDUW RI FRQVWUXFWLRQ RI GDPV UHVHUYRLUV DQ 7RSRVKHHW 6WUXFWXUDOPDSSLQJ &OLQRPHWHU FR FRPSDVV	

7H[WERRNV

'XJJDO 6 . 3DQGH\ + . DQG 5DZDW 1 (QJLQHHULQJ * (GXFDWLRQ 1HZ'HOKL

RNKDOH .9. 3ULQFLSOHV RI (QJLQHHULQJ *HRORJ\ +\GHUDEDG

6LQJK 3 (QJLQHHULQJ DQG *HQHUDO *HRORJ\ 6. .D\
6XELQR*DQJRSDGK\D\ (QJLQHHULQJ *HRORJ\ 2[IRU

5HIHUHQFHV

'DYLG . 7RGG /DUU\ : 0D\V *URXQGZDWHU +\GURJH
/WG
*RNKDOH î1í 0DQXDO RI *HRORJLFDO 0DSV &%6 3XEOLVKH
*ULEEOH &' 5XWOH\V (OHPHQWV RI 0LQHUDORJ\ 6SU
0DUOODQG 3 %LOOLQJV 6WUXFWXUDO *HRORJ\ 3HDU

&RXUVH &RQWHQWV DQG /HFWXUH 6FKHGXOH

0RGXOH	7RSLF	1R RI KRXUV
0RGXOH	:HDWKHULQJ RI URFNV 7\SHV RI ZHDWKHULQJ 3 2ULJLQ RI 3URGXFWV RI ZHDWKHULQJ OLNH VDQG VI	
	6RLO SURILOH 6RLO HURVLRQ DQG VRLO FRQVHUY (QJLQHHULQJ VLJQLILFDQFH RI ZHDWKHULQJ	
	*HRORJLFDO SURFHVVHV E\ ULYHUV /DQGVOLGHV FRQWURO	
	&RDVWDO 3URFHVVHV *HRORJLFDO ZRUN E\ ZDYHV DQG FRDVWDO SU	
0RGXOH	(DUWKTXDNHV 3ODWH 7HFWRQLFV 2ULJLQ RI HDU ZDYHV 5DWLQJ RI HDUWKTXDNHV W\SHV RI HDUWK	
	6HLVPLF]RQHV RI ,QGLD %DVLFV RI VHLVPLF VDIH	
	,QWHULRU RI WKH HDUWK DV UHYHDOHG E\ SURSDJ ZDYHV	
0RGXOH	2FFXUUHQFH RI JURXQGZDWHU DTXLIHUV DQG W\ FRQILQLQJ EHGV SRURVLW\ DQG YHUWLFDO G JURXQ(	
	'DUF\ V /DZ 3HUPHDELOLW\ K\GU FUHDWHG E\ JURXQGZDWHU WR FLYLO HQJLQHHULQ	
	0HWKRGV WR FRQWURO JURXQGZDWHU SUREOHPV	
	(OHFWULFDO UHVLVWLYLW\ VXUYH\ IRU JURXQGZD	
	6HDZDWHU LQWUXVLRQ LQ &RDVWDO DUHD *K\EHQ	
0RGXOH	3K\VLFDO SURSHUWLHV RI PLQHUDOV SK\VLFDO FKHPLFDO FRPSRVLWLRQ RI PLQHUDOV OLNH TXD SODJLRFODVH ELRWLWH PXVFRYLWH KRUQE K\SHUVWKHQH FDOFLWH J\SVXP	

	,JQHRXV VHGLPHQWDU\ DQG PHWDPRUSKLF URFNV &KHPLFDO DQG PLQHUDORJLFDO FODVVLILFDWLR 6HGLPHQWDU\ URFNV W\SHV EDVHG RQ PRGH RI VWUXFWXUHV 0HWDPRUSKLF URFNV VWUXFWXUHV VWXG\ RI JUDQLWH GROHULWH EDVDOW VDQGVW JQHLVV PDUEOH DQG FKDUQRFNLWH 5RFN W\SHV F\FOH		
0RGXOH	$WWLWXGH RI URFNV ± 'LS DQG 6WULNH 7HUPLQRO		
	%ULHI FODVVLILFDWLRQ DQG H IDXOWV DQG MRLQWV		
	*HRORJLFDO SDUW RI VLWH LQY GDPV UHVHUYRLUV DQG WXQQHOV		
	7RSRVKHHW 6WUXFWXUDO PDSSLQJ &OLQRPHWHU %UXQWRQ FRPSDVV		

&(7	*(27(&+1,&$/ (1*,1((5,1*	&$7(*25<		/7	3	&5(',7	<HDU RI ,QWURGXFWLRQ
		3&&					

3UHDPEOH *RDO RI WKLV FRXUVH LV WR H[SRVH WKH VWXGHQWV
PHFKDQLFV DQG ODERUDWRU\ WHVWV WR GHWHUPLQH WKH
$IWHU WKLV FRXUVH VWXGHQWV ZLOO EH DEOH WR LGHQW
SUREOHPV LQ UHDO ZRUOG VLWXDWLRQV DQG UHVSRQG DFFI

3UHUHTXLVLWH 1LO

&RXUVH 2XWFRPHV $IWHU FRPSOHWLRQ RI WKH FRXUVH WKH VWXGHQ

&2	([SODLQ WKH IXQGDPHQWDO FRQFHSWV RI EDVLF D
&2	'HVFULEH WKH ODERUDWRU\ WHVWLQJ PHWKRGV IR
&2	6ROYH WKH EDVLF SURSHUWLHV RI VRLO E\ DSSO\L
&2	&DOFXODWH WKH HQJLQHHULQJ SURSHUWLHV RI VR DQG WKH IXQGDPHQWDO FRQFHSWV RI VRLO PHFKDQ
&2	$QDO\]H WKH VRLO SURSHUWLHV WR LGHQWLI\ DQG

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV 0L

	32	32	32	32	32	32	32	32	32	32	32	32
&2												
&2												
&2												
&2												
&2												

$VVHVVPHQW 3DWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW 7HVWV		(QG 6HPHVWHU ([DPLQDWLRQ 0DUNV
	7HVW 0DUNV	7HVW 0DUNV	
5HPHPEHU			
8QGHUVWDQG			
$SSO\			
$QDO\VH			
(YDOXDWH			
&UHDWH			

0DUN 'LVWULEXWLRQ

7RWDO 0DUNV	&,(0DUNV	(6(0DUNV	(6('XUDWLRQ
			KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ &,(3DWWHUQ

$WWHQGDQFH 0DUNV

&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV 0DUN

$VVLJQPHQW 4XL] &RXUVH SURMHFW 0DUNV

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ 7KHUH ZLOO EH WZR SDUWV 3DUW
FRQWDLQV TXHVWLRQV ZLWK TXHVWLRQV IURP HDFK PRG
VKRXOG DQVZHU DOO TXHVWLRQV 3DUW % FRQWDLQV TXHV
DQVZHU DQ\ RQH (DFK TXHVWLRQ FDQ KDYH PD[LPXP VXE G

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

4XHVWLRQV PD\ EH IUDPHG EDVHG RQ WKH RXWOLQH JLYHQ

&RXUVH 2XWFRPH &2

7KH IXQGDPHQWDO FRQFHSWV RI EDVLF SURSHUWLHV DQ
7KH IXQGDPHQWDO FRQFHSWV RI HQJLQHHULQJ SURSHUW
FRQVROLGDWLRQ FRPSDFWLRQ VKHDU VWUHQJWK
&RQFHSWV RI 7RWDO QHXWUDO DQG HIIHFWLYH VWUHVV
&RQFHSWV RI 6ORSH VWDELOLW\

&RXUVH 2XWFRPH &2

7KH ODERUDWRU\ WHVWLQJ PHWKRGV IRU GHWHUPLQLQJ
7KH ODERUDWRU\ WHVWLQJ PHWKRGV IRU GHWHUPLQLQJ
3HUPHDELOLW\ FRQVROLGDWLRQ FRPSDFWLRQ VKHDU

&RXUVH 2XWFRPH &2

6ROYH WKH EDVLF SURSHUWLHV RI VRLO E\ DSSO\LQJ IX

&RXUVH 2XWFRPH &2

&DOFXODWH WKH HQJLQHHULQJ SURSHUWLHV RI VRLO
FRPSDFWLRQ VKHDU VWUHQJWK E\ DSSO\LQJ WKH ODER
&DOFXODWH WKH VHWWOHPHQW RI IRRWLQJV GXH WR F
FRQVROLGDWLRQ VHWWOHPHQW
&DOFXODWH WKH HQJLQHHULQJ SURSHUWLHV RI VRLO E
UHODWHG WR WRWDO QHXWUDO DQG HIIHFWLYH VWUHV
&DOFXODWH WKH VWDELOLW\ RI VORSHV

&RXUVH 2XWFRPH &2

,GHQWLI\ DQG FODVVLI\ WKH VRLO E\ DQDO\VLQJ WKH ED

0RGHO 4XHVWLRQ 3DSHU

43 &2'(

5HJ 1R BBBBBBBBBBBBBBBB 1DPH BBBBBBBBBBB

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)2857+ 6(0(67(5 % 7(&+ '(*5(((;$0,1$7,21 0217+ <($5

&RXUVH &RGH &(7

&RXUVH 1DPH *(27(&+1,&$/ (1*,1((5,1* ,

0D[0DUNV 'XUDWLRQ

3DUW $

$QVZHU DOO TXHVWLRQV HDFK TXHVWLRQ FDUU

'UDZ D WKUHH SKDVH EORFN GLDJUDP DQG GHILQH L 9RLG
LLL 'HJUHH RI VDWXUDWLRQ

([SODLQ WKH SURFHGXUH IRU 6SHFLILF *UDYLW\ WHVW XVL

'HILQH L /LTXLG /LPLW LL 3ODVWLF /LPLW LLL 6KULQ

'LIIHUHQWLDWH EHWZHHQ &RHIILFLHQW RI 3HUPHDELOLW\

([SODLQ 7RWDO 6WUHVV 1HXWUDO 6WUHVV DQG (IIHFWLYH

/LVW WKH DVVXPSWLRQV RI %RXVVLQHVT¶V WKHRU\

'HILQH SUH FRQVROLGDWLRQ SUHVVXUH ([SODLQ WKH PH
SUHVVXUH

'LIIHUHQWLDWH EHWZHHQ &RQVROLGDWLRQ DQG &RPSDFWLR

([SODLQ 0RKU &RXORPE VKHDU VWUHQJWK WKHRU\

:KDW DUH WKH GLIIHUHQW W\SHV RI VORSH IDLOXUHV"

3$57 %

$QVZHU RQH IXOO TXHVWLRQ IURP HDFK PRGXOH HDFK

0RGXOH ±

D 'HULYH WKH UHODWLRQ EHWZHHQ EXON XQLW ZHLJKW
VDWXUDWLRQ IURP WKH IXQGDPHQWDOV

E $ VDPSOH RI ZHW VLOW\ FOD\ VRLO ZHLJKV N1 7KH
RQ WKH VDPSOH 'HQVLW\ZDWHU FRQWHQW Z 6SHFLI
'HWHUPLQH L 'U\ GHQVLW\ LL 9RLG 5DWLR LLL 3
Y 6DWXUDWHG XQLW ZHLJKW YL 6XEPHUJHG XQLW ZHL

D ([SODLQ GLIIHUHQW W\SHV RI VRLO VWUXFWXUHV

E FP FRUH FXWWHU ZHLJKLQJ 1 ZDV XVHG WR ILQ
HPEDQNPHQW 7KH ZHLJKW RI FRUH FXWWHU ZLWK LQ VL
WHVWV RQ WKH VDPSOH LQGLFDWHG ZDWHU FRQWHQW
'HWHUPLQH WKH EXON XQLW ZHLJKW GU\ XQLW ZHLJKW
FDOFXODWH WKH VDWXUDWHG XQLW ZHLJKW DQG WKH FR
VDWXUDWHG GXULQJ UDLQ ZLWKRXW FKDQJH LQ YROXPH

0RGXOH ±

D :KDW LV WKH XVH RI SDUWLFOH VL]H GLVWULEXWLRQ F
FXUYH GHILQH WKH IROORZLQJ WHUPV L ZHOO JUDGHG
JUDGHG VRLO

E 7HVWV RQ D ILQHG JUDLQHG VRLO VDPSOH LQGLFDWHG

/LTXLG /LPLW 3ODVWLF /LPLW DQG 6KULQNDJH /
,6 &RGH ,I WKH VSHFLPHQ RI WKLV VRLO VKULQNV IURP
DW WKH VKULQNDJH OLPLW FDOFXODWH WKH VSHFLILF J

D ([SODLQ WKH IDFWRUV DIIHFWLQJ SHUPHDELOLW\ RI VR
E$ VRLO VDPSOH RI KHLJKW FP DQG GLDPHWHU FP
SHUPHDELOLW\ WHVW ZLWK KHDG RI FP DQG FF RI ZD
WHVW LQWHUYDO RI PLQ &RPSXWH WKH FRHIILFLHQW R
,I WKH VDPH VDPSOH LV VXEMHFWHG WR IDOOLQJ KHDG
IURP FP WR FP LQ PLQ 'HWHUPLQH WKH FURVV VHF

0RGXOH ±

D ([SODLQ 4XLFN 6DQG &RQGLWLRQ DQG &ULWLFDO +\GUD

E $ VDQG GHSRVLW RI P WKLFN ZDV ORDGHG DW WKH
:7 LV DW P EHORZ */ 'HQVLW\ DERYH :7 DQG EHORZ N1 P
'UDZ 7RWDO 1HXWUDO DQG (IIHFWLYH 6WUHVV 'LDJUDPV
0DUNV

D $ FRQFHQWUDWHG ORDG RI N1 LV DSSOLHG DW JU
L DW D GHSWK RI P EHORZ WKH ORDG LL DW D G
%RXVVLQHVT¶V WKHRU\

E $ ZDWHU WDQN LV IRXQGHG RQ D FLUFXODU ULQJ W\SH
LWV H[WHUQDO GLDPHWHU LV P &RPSXWH WKH YHUWLF
IRXQGDWLRQ LI SUHVVXUH RQ WKH IRXQGDWLRQ LV N

0RGXOH ±

D $ P WKLFN FOD\ OD\HU ZLWK GRXEOH GUDLQDJH VHW
FP VHF &DOFXODWH WKH OLNHO\ XOWLPDWH FRQVROLGD
WDNH WR XQGHUJR RI WKLV VHWWOHPHQW

E $ P VTXDUH IRRWLQJ DW D GHSWK RI P IURP JURXQ
N1 P,I D FRPSUHVVLEOH FOD\ OD\HU P WKLFN H[LVWV
GHWHUPLQH WKH VHWWOHPHQW RI WKH IRRWLQJ GXH WR
WDEOH DW D GHSWK RI P EHORZ */ DERYH DQG EHORZ

N1 P EHORZ ZDWHU WDEOH)RU FODQ OD\HU *'/ 7DNHZ
N1 P 0DUNV

D ([SODLQ WKH ILHOG FRPSDFWLRQ PHWKRGV

E 7KH IROORZLQJ DUH UHVXOWV RI D VWDQGDUGV SURFWR

:DWHU &RQWHQW						
%XON 'HQVLW\ N1 P						

3ORW WKH ZDWHU FRQWHQW ± GU\ GHQVLW\ FXUYH DQG
GHQVLW\ $OVR SORW WKH]HUR DLU YRLGV FXUYH 7DNH

0RGXOH ±

D $ F\OLQGULFDO VSHFLPHQ RI VRLO IDLOV ZKHQ WKH D[LDO
ODWHUDOO\ XQFRQILQHG)DLOXUH SODQH PDNHV DQ DQJOH
VWUHQJWK SDUDPHWHUV F 0DUNV

E 'HWHUPLQH WKH VKHDU VWUHQJWK SDUDPHWHUV XVLQJ

6DPS	&RQILQLQJ 3UHVVXUH	'HYLDWRU 6WUHVV

0DUNV

D ([SODLQ WKH 6ZHGLVK FLUFOH PHWKRG IRU WKH DQDO\

E 'HWHUPLQH IDFWRU RI VDIHW\ RI YHUWLFDO IRXQGDWLR
J N1 P $VVXPH 7D\ORU¶V VWDELOLW\ QR 6Q

6<//$%86

0RGXOH

1DWXUH RI VRLO DQG IXQF,QWURGXFWLRQ WR VRLO PHFKDQL
VRLO GHSRVLWV RI ,QGLD SKDVH V\VWHP ± %DVLF VRLO
VDWXUDWLRQ DLU FRQWHQW ZDWHU FRQWHQW VSHFLILF JU
SURSHUWLHV 1XPHULFDO SUREOHPV

'HWHUPLQDWLRQ RI :DWHU FRQWHQW E\ RYHQ GU\LQJ 6SHF
JUDYLW\ ERWWOH 'HWHUPLQDWLRQ RI)LHOG GHQVLW\ E\ V
1XPHULFDO SUREOHPV

6RLO 6WUXFWXUH DQG WKHLU HIIHFWV RQ WKH EDVLF VRLO

0RGXOH

,QGH[SURSHUWLHV ± 6LHYH DQDO\VLV ± :HOO JUDGHG SRRUO\ JUDGHG
± +\GURPHWHU DQDO\VLV >QR GHULYDWLRQ UHTXLUHG IRU
'HQVLW\ 1XPHULFDO SUREOHPV &RQVLVWHQF\ ± $WWHUEHU
ODERUDWRU\ WHVWV IRU /LTXLG /LPLW 3ODVWLF /LPLW 6K

,6 FODVVLILFDWLRQ RI VRLO 1XPHULFDO SUREOHPV

3HUPHDELOLW\ ± 'DUF\¶V ODZ ±)DFWRUV DIIHFWLQJ SHUPHDELO
KHDG DQG IDOOLQJ KHDG SHUPHDELOLW\ WHVWV 1XPHULFD
GHSRVLWV QXPHULFDO SUREOHPV

0RGXOH

3ULQFLSOH RI HIIHFWLYH VWUHVV ± 7RWDO QHXWUDO DQG HIIHFWLYH VWUHVV
SUREOHPV 3UHVVXUH GLDJUDPV LQ VRLOV VDWXUDWHG E
&ULWLFDO K\GUDXOLF JUDGLHQW

6WUHVV GLVWULEXWLRQ ± ,QWURGXFWLRQ %RXVVLQHVT¶V HTXDWLRQV IR
DQG OLQH ORDGV ± $VVXPSWLRQV DQG /LPLWDWLRQV 1XP
XQLIRUPO\ GLVWULEXWHG ORDGV EHQHDWK VWULS FLUFXOD
1XPHULFDO SUREOHPV

$SSUR[LPDWH PHWKRGV IRU YHUWLFDO VWUHVV GLVWULEX
(TXLYDOHQW 3RLQW /RDG PHWKRG 'LVWULEXWLRQ 0HWKR
3UHVVXUH EXOEV ± 1HZPDUN¶V FKDUWV &RQVWUXFWLRQ S

0RGXOH

&RQVROLGDWLRQ ± ,QWURGXFWLRQ ± &RQFHSWV RI &RHIILFLHQW RI
FRPSUHVVLELOLW\ H ORJ S FXUYH &RPSUHVVLRQ LQGH[5
3UHVVXUH 1RUPDOO\ FRQVROLGDWHG RYHU FRQVROLGDWH
PDJQLWXGH RI VHWWOHPHQW RI QRUPDOO\ FRQVROLGDWHG

7HU]DJKL¶V WKHRU\ RI RQH GLPHQVLRQDO FRQVROLGDWLRQ
FRQVROLGDWLRQ ± 7LPH IDFWRU &RHIILFLHQW RI FRQVRO
FRQVROLGDWLRQ WHVW ± 'HWHUPLQDWLRQ RI &RHIILFLHQW R

&RPSDFWLRQ ± 'LIIHUHQFH EHWZHHQ FRQVROLGDWLRQ DQG F
&RPSDFWLRQ 7HVWV ± 20& DQG 0'' =HUR $LU YRLGV OLQH

FRPSDFWLRQ)LHOG FRPSDFWLRQ PHWKRGV 3URFWRU QHH

0RGXOH

6KHDU VWUHQJ3UDFWLFDO $SSOLFDWLRQV 0RKU &RXORPE
PHWKRG IRU GHWHUPLQDWLRQ RI SULQFLSDO SODQHV DQG V
DQG SULQFLSDO VWUHVVHV 1XPHULFDO SUREOHPV

%ULHI GLVFXVVLRQ RI /DERUDWRU\ WHVWV 7ULD[LDO FRPSU
HIIHFWLYH VWUHVV VWUHQJWK SDUDPHWHUV 8QFRQILQHG F
WHVW ± $SSOLFDELOLW\ 1XPHULFDO SUREOHPV

6WDELOLW\ RI I7RH IDLOXUH VORSH EDVH IDLOXUH VOLS IDLOXUH
DQDO\VLVDQG \FLV)ULFWLRQ FLUFOH PHWKRG 7D\ORU¶V
1XPHULFDO 3UREOHPV

7H[W %RRNV

5DQMDQ * DQG $ 6 5 5DR %DVLF DQG $SSOLHG 6RLO 0

$URUD . 5 *HRWHFKQLFDO (QJLQHHULQJ 6WDQGDUG 3X

5HIHUHQFHV

'DV % 0 3ULQFLSOHV RI *HRWHFKQLFDO (QJLQHHULQJ

9HQNDWUDPDLDK *HRWHFKQLFDO (QJJ 8QLYHUVLWLHV 3

7HU]DJKL . DQG 5 % 3HFN 6RLO 0HFKDQLFV LQ (QJLQH

$ 9 1DUDVLPKD 5DR DQG & 9HQNDWUDPDLDK 1XPHULFDO
TXHVWLRQV LQ *HRWHFKQLFDO (QJLQHHULQJ 8QLYHUVLW

3XUXVKRWKDPDUDM 3 6RLO 0HFKDQLFV DQG)RXQGDWLR
3YW /WG

7D\ORU ' :)XQGDPHQWDOV RI 6RLO 0HFKDQLFV $VLD 3

&RXUVH &RQWHQWV DQG /HFWXUH 6FKHGXOH

0RGXOH	&RQWHQWV	2XWFRPHV $GGUHVVHG	+RXUV
	0RGXOH		
	1DWXUH RI VRLO DQG IXQFW,QWURGXFWLRQ WR VRLO DQG VRLO PHFKDQLFV ± 6RLO W\SHV ± 0DMRU VRLO GHSRVLWV RI ,	&2	
	SKDVH V\VWHP ± %DVLF VRLO SURSHUWLHV 9RLG U GHJUHH RI VDWXUDWLRQ DLU FRQWHQW ZDWHU FRQWH XQLW ZHLJKW	&2	
	5HODWLRQVKLS EHWZHHQ EDVLF VRLO SURSHUWLHV	&2	
	1XPHULFDO SUREOHPV	&2	
	'HWHUPLQDWLRQ RI :DWHU FRQWHQW E\ RYHQ GU\LQJ 6 XVLQJ S\FQRPHWHU VSHFLILF JUDYLW\ ERWWOH	&2	
	'HWHUPLQDWLRQ RI)LHOG GHQVLW\ E\ VDQG UHSODFHPHQ &RUH &XWWHU PHWKRG	&2	
	1XPHULFDO SUREOHPV	&2	&2
	6RLO 6WUXFWXUH DQG WKHLU HIIHFWV RQ WKH EDVLF 6HQVLWLYLW\ DQG 7KL[RWURS\	&2	&2
	0RGXOH		
	,QGH[SURSHUWLHV DQDO\VLV ± :HOO JUDGHG SRRUO\ JU DQG JDS JUDGHG VRLOV	&2	&2
	6WRNH¶V ODZ ± +\GURPHWHU DQDO\VLV >QR GHULYDWL SHUFHQWDJH ILQHU DQG GLDPHWHU@ ± 5HODWLYH 'HQV	&2	
	1XPHULFDO SUREOHPV	&2	
	&RQVLVWHQF\ ± $WWHUEHUJ /LPLWV DQG ,QGLFHV ± 3O ODERUDWRU\ WHVWV IRU /LTXLG /LPLW 3ODVWLF /LPLW	&2	&2
	1XPHULFDO SUREOHPV	&2	
	,6 FODVVLILFDWLRQ RI VRLO 1XPHULFDO SUREOHPV	&2	&2
	3HUPHDELOLW\ RI VRLOV ±'DUF\¶V ODZ ±)DFWRUV DIIHFWLQJ SHUPHDELOLW\ ± /DERUDWRU\ WHVWV &RQVWDQW KHDG SHUPHDELOLW\ WHVWV	&2	&2
	1XPHULFDO SUREOHPV	&2	
	$YHUDJH SHUPHDELOLW\ RI VWUDWLILHG GHSRVLWV SUREOHPV	&2	&2
	0RGXOH		
	3ULQFLSOH RI HIIHFWLYH VWUHVV DQG HIIHFWLYH VWU 3UHVVXUH GLDJUDPV	&2	
	1XPHULFDO SUREOHPV	&2	
	3UHVVXUH GLDJUDPV LQ VRLOV VDWXUDWHG E\ FDSLOO VDQG FRQGLWLRQ ± &ULWLFDO K\GUDXOLF JUDGLHQW	&2	
	6WUHVV GLVWULEXWLRQ ,QWURGXFWLRQ %RXVVLQHVT¶V HTXDWLR YHUWLFDO SUHVVXUH GXH WR SRLQW ORDGV DQG OLQH DQG /LPLWDWLRQV	&2	

	1XPHULFDO SUREOHPV	&2	
	9HUWLFDO SUHVVXUH GXH WR XQLIRUPO\ GLVWULEXWHG FLUFXODU DQG UHFWDQJXODU VKDSHV >QR GHULYDWLRQ	&2	
	1XPHULFDO SUREOHPV	&2	
	$SSUR[LPDWH PHWKRGV IRU YHUWLFDO VWUHVV GLVWU SUHVVXUH EHQHDWK IRRWLQJV (TXLYDOHQW 3RLQW /R 'LVWULEXWLRQ 0HWKRG 1XPHULFDO SUREOHPV	&2	
	3UHVVXUH ,VREDUV 3UHVVXUH EXOEV ± 1HZPDUN¶ &RQVWUXFWLRQ SURFHGXUH QRW UHTXLUHG DQG WKH	&2	
	0RGXOH		
	&RQVROLGDWLRQ ± &RQFHSWV RI &RHIILFLHQW FRPSUHVVLELOLW\ DQG YROXPH FRPSUHVVLELOLW\ H &RPSUHVVLRQ LQGH[5HFRPSUHVVLRQ LQGH[DQG 3UH 3UHVVXUH	&2	
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CET206	TRANSPORTATION ENGINEERING	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		3 & &	4	0	0	4	2019

Preamble

Objective of the course is to introduce the principles and practice of Highway, Railway, Harbour and dock, Tunnel and Airport Engineering.

Prerequisite: Nil

Course Outcomes:

	Description
CO No.	At the end of the course, students will be able to:
CO 1	Apply the basic principles of Highway planning and design highway geometric elements
CO 2	Apply standard code specifications in judging the quality of highway materials; designing of flexible pavements
CO 3	Explain phenomena in road traffic by collection, analysis and interpretation of traffic data through surveys; creative design of traffic control facilities
CO 4	Understand about railway systems, tunnel, harbour and docks
CO 5	Express basics of airport engineering and design airport elements

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	3	1		1	3	1		2		1
CO 2	3	1	3	1		1	1	1		1		1
CO 3	3	2	2	1					1	2		2
CO 4	2						2	1				2
CO 5	3	3	3			3		2				

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (marks)
	Test 1 Marks	Test 2 Marks	
Remembe	7.5	7.5	30
Understan	7.5	7.5	30
Apply	5	5	20
Analyse	5	5	20
Evaluate			
Create			

Mark Distribution

Total Marks	CIE (Marks)	ESE (Marks)	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers : 25 marks
Assignment/Quiz/Course Project : 15 marks

End Semester Examination Pattern:

The question consists of two parts- Part A and Part B. Part A consists of 10 questions with 3 marks for each (two questions from each module). Part B consists of two questions from each module, out of which one has to be answered. Each question carries 14 marks and can have maximum 2 subdivisions.

Sample Course Level Assessment Questions:

1 Course Outcome 1 (CO1):While aligning a highway in a built up area, it was necessary to provide a horizontal curve of radius 300 m for a design speed 65Km/hr, length of wheel base-6m and pavement width 10.5m. Assume rate of introduction of super elevation as 1 in 100 and super elevation is provided by rotating about centre line. Design super elevation, extra widening of pavement and length of transition curve.

2 Course Outcome 2 (CO2):Design a flexible pavement for two lane single carriage way for present traffic 1200 commercial vehicles per day, period of construction= 3 yrs, annual traffic growth = 7.5%, Design CBR = 7%, Design life = 15 yrs. Use IRC method.

3 Course Outcome 3 (CO3):Traffic in a congested multilane highway lane is observed to have an average spacing of 200 ft,and an average headway of 3.8s. Estimate the rate of flow, density and speed of traffic in this lane.

4 Course Outcome 4 (CO4):
Sketch the component parts of a permanent way and mark the salient points

5 Course Outcome 5 (CO5):The total length of a runway is 1000 m. The elevation at distance 0,200 m, 400 m, 600 m, 800 m and 1000 m are 100.0 m, 99.2 m, 101.0 m, 101.8 m, 101.4 m and 101.0 m respectively. What will be the effective gradient of runway?

Syllabus

Module	Contents	Hours
1	Introduction to Transportation Engineering, Classification of roads, Typical cross sections of roads in urban and rural area, Requirements and factors controlling alignment of roads Introduction to geometric design of highways, Design controls and criteria, Design of highway cross section elements, Design of horizontal alignment - Stopping sight distance, Overtaking sight distance, super elevation, transition curve, length and shift of transition curve, extra widening. Vertical alignment (introduction only)	10
2	Introduction to highway materials, Desirable properties and testing of road aggregates, bituminous materials and sub grade soil. Introduction of flexible and rigid pavements, Factors influencing the design of flexible pavements, Design of flexible pavements by CBR method and IRC 37: 2018. Construction (bituminous pavemer	9
3	Introduction to traffic engineering, Traffic characteristics, Capacity and Level of Service, Design Speed, Traffic surveys, Types of road intersections, Traffic control devices (introduction only), Design of isolated signals by Webster's method.	7
4	Railway Engineering - Component parts of a railway track - functions, concept of Gauges, coning of wheels, cant deficiency, compensation of gradients Tunnel Engineering: Tunnel – sections, tunnel surveying - alignment, transferring centre grade into tunnel. Harbours – classification, features, requirements. Break waters - necessity and functions, classification. Docks – Functions and types - dry docks, wet docks (Introduction only)	8
5	Introduction to Airport Engineering, Components of airport, selection of site for airport. Runway orientation, basic runway length and corrections required, Taxiways and aprons.	8

Text Books

1. Khanna, S.K. and Justo C.E.G., Highway Engineering, Nem Chand & Bros., 2015
2. Kadiyali, L. R. and N.B Lal, Principles and Practices of Highway Engineering, Khanna Publishers, 2013
3. Khanna, S. K. and Arora. M. G., Airport Planning and Design, Nemchand& Bros
4. Mundrey J. S, Railway Track Engineering, Tata McGraw Hill, 2009

5. Rangawala, S.C. , Railway Engineering, Charotor Publishing House
6. Rao G. V, Principles of Transportation and Highway Engineering, Tata McGrawHill, 1996
7. Srinivasan,R., Harbour, Dock & Tunnel Engineering, Charotor Publishing House, 28e, 2016

References

1. Horonjeff R. and McKelvy, F., Planning and Design of Airports, McGraw Hill, 5e, 2010
2. IRC: 37-2018, Guidelines for the Design of Flexible Pavements, IRC 2018, New Delhi
3. O' Flaherty, C.A (Ed.)., Transport Planning and Traffic Engineering, Elsevier, 1997
4. Rangwala, S. C., Airport Engg. Charotar Publishing Co., 16e, 2016
5. Yoder, E. J and Witczak, M. W, Principles of Pavement Design, John Wiley & Sons, 1991
6. Bindra, S.P., A course in Docks and Harbour Engineering, Dhanpat Rai& Sons
7. Chandra, S. and Agarwal, M.M., Railway Engineering, Oxford University Press, New Delhi, 2008
8. Saxena, S. C and Arora, S. P, Railway Engineering, Dhanpat Rai& Sons, 7e, 2010
9. Subhash C. Saxena, Railway Engineering, Dhanpat Rai& Sons

Course Content and lecture Schedule:

No.	Topic	Course Outcome	No. of Hrs
1	Module 1		Total: 10
1.1	Introduction to Transportation Engineering Classification of roads, Typical cross sections of roads in urban and rural area, Requirements and factors controlling alignment of roads.	CO1	2
1.2	Introduction to geometric design of highways, Design controls and criteria, Design of highway cross section elements	CO1	2
1.3	Design of horizontal alignment - Stopping sight distance, Overtaking sight distance, super elevation, transition curve, length and shift of transition curve, extra widening. Vertical alignment (introduction only)	CO1	6
2	Module 2		Total: 9
2.1	Introduction to highway materials, Desirable properties and testing of road aggregates, bituminous materials and sub grade soil.	CO2	3
2.2	Introduction of flexible and rigid pavements, Factors influencing the design of flexible pavements, Design of flexible pavements by CBR method and IRC 37 : 2018	CO2	3
2.3	Construction of bituminous pavements	CO2	3
3	Module 3		Total: 7
3.1	Introduction to traffic engineering, Traffic characteristics, Capacity and Level of Service, Design Speed, Traffic surveys, Types of road intersections,	CO3	4
3.2	Traffic control devices (introduction only), Design of isolated signals by Webster's method.	CO3	3
4	Module 4		Total: 8
4.1	Railway Engineering - Component parts of a railway track - functions, concept of Gauges, coning of wheels, cant deficiency, compensation of gradients	CO4	4
4.2	Tunnel Engineering: Tunnel – sections, tunnel surveying - alignment, transferring centre grade into tunnel.	CO4	2
4.3	Harbours – classification, features, requirements. Break waters - necessity and functions, classification. Docks – Functions and types - dry docks, wet docks (Introduction only)	CO4	2
5	Module 5		Total: 8
5.1	Introduction to Airport Engineering, Components of airport, selection of site for airport.	CO5	3
5.2	Runway orientation basic runway length and corrections required, Taxiways and aprons.	CO5	5

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CET 206

Course Name: TRANSPORTATION ENGINEERING

Model Question Paper

Marks:100 Duration: 3 hrs

PART A
(Answer all questions. Each question carry three marks)

1. With a sketch, explain typical cross sectional layout of a two lane road in urban areas.
2. What is meant by reaction time? What is its role in Geometric design of highways?
3. Outline the IRC 37- 2018 recommendations for determining the thickness of Flexible pavements.
4. Differentiate flexible and rigid pavements
5. How would you draw the fundamental diagram of traffic flow
6. Explain grade separated intersections and discuss the advantages and limitations
7. Analyse the concept of cant deficiency with suitable explanations
8. Write short note on Littoral Drift
9. Enumerate the various factors which would be kept in view while selecting suitable site for an airport.
10. What are taxiways?

PART B
(Answer one full question from each module)

11. a) Enumerate the factors governing the width of carriage way. State the IRC specifications for width of carriage way for various classes of roads. (10)
b) Write a brief note on classification of highways in India. (4)

OR

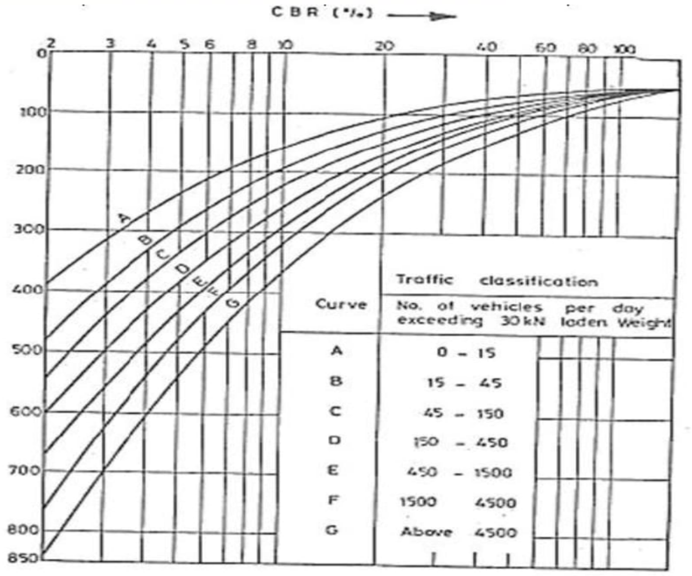
12. a) Calculate the stopping sight distance on a highway for a design speed of 100 kmph. (6)
b) What is super elevation? Explain the design steps of super elevation. (8)

13a) Explain the construction practices of the following bituminous base courses.

1) Bituminous macadam
2) Penetration macadam (6)

b) The soil subgrade sample was obtained from the project site and the CBR tests conducted at field density gave the following readings. Draw the load penetration curve and determine the CBR value and find the total thickness of the pavement by CBR method as recommended by IRC for commercial vehicles 1500 per day, with 7% growth rate. The pavement construction is to be completed in three years after last traffic count. (Use the standard design chart provided) (8)

Penetratio (mm)	Load (kg)	Penetratio (mm)	Load (kg)
0.0	0.0	3.0	60.0
0.5	6.0	4.0	70.0
1.0	17.0	5.0	77.0
1.5	30.0	7.5	89.0
2.0	42.0	10.0	100.0
2.5	55.0	12.5	115.0



OR

14 a) Explain in detail the various factors that influencing the design of flexible pavements? (10)

b) List out the desirable properties of aggregates to be used in pavement construction. Also specify various tests for judging the suitability of aggregates. (4)

15 a) What are the advantages and disadvantages of traffic signals? (8)

b) What is (i) Saturation flow, (ii) Lost time, and (iii) Phase in a signal design? (6)

OR

16 a) Define the basic terms basic capacity, possible capacity and practical capacity and analyze its importance in traffic engineering. (6)

b) Evaluate the factors affecting level of service of a multilane highway. (8)

17 a) Analyse various types of gradient used on railway track. What is grade compensation and why is it necessary? (6)

b) State the natural and meteorological phenomena a harbour engineer has to study and briefly mention the effects of these phenomena (8)

OR

18 a) Explain the functions of rails, sleepers and ballast. (8)

b) What are the classifications of tunneling? (6)

19 a) Explain in detail about the functions of taxiways and aprons. (6)

b) What are the factors to be considered in the orientation of runway? (8)

OR

20 a) What are the factors affecting selection of site for airport? (4)

b) The length of a runway under standard conditions is 1500m. The airport is to be provided at an elevation of 110m above mean sea level. The airport reference temperature is 320C. Following data refers to the proposed longitudinal section of runway. Determine the corrected length of runway. (10)

End to end of runway (m)	Grade (%)	End to end of runway (m)	Grade (%)
0 to 30(	+1	1500 to 180	+1
300 to 90(	-0.2	1800 to 210	-0.3
900 to 150	+0.5		

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YLVXDOLVDWLRQ DQG SODQQLQJ RI YDULRXV W\SHV RI EXLOG

3UHUHTXLVLWH (QJLQHHULQJ *UDSKLFV

&RXUVH 2XWFRPH $IWHU WKH FRPSOHWLRQ RI WKH FRXUVH WKH VWXGHQ

&2	7KH VWXGHQW ZLOO EH DEOH WR XQGHUVWDQG EXLOGLQJ GUDZLQJ VFDOHV DQG GLPHQVLRQLQJ
&2	7KH VWXGHQW ZLOO GHWDLO SODQ HOHYDWLRQ RI SDQHOHG GRRU JOD]HG RI URRI WUXVV
&2	7KH VWXGHQW ZLOO SODQ DQG VHFWLRQDO HOHYDWLRQ RI VWDLUFDVH
&2	8QGHUVWDQG WKH EDVLF FRQFHSWV DQG PHWKRGV RI E 6RIWZDUH
&2	7KH VWXGHQW ZLOO EH DEOH WR SUHSDUH SODQ 6HSWLF GHWDLOHG GUDZLQJ

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$WWHQGDQFH PDUNV

&RQWLQXRXV $VVHVVP PI

$VVLJQPHQW 4XL] &RXUVH 3URMHFW PDUNV

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ Á]oo Z À]v î •]Ì v•Á Œ }}lo š v Á]oo (}Œ íìì u Œl•X ~}voÇ u vµ o Œ (š]vP (}Œ ^ •X ñ • Œ]‰š] ZU }v (Œ}u Z u} µo X î Œ Á]vP ‹µ •š]}v• }(ðñ u Œl• ZU Á]šZ u} µo •X

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*HQHUDO ± 6WXG\ RI ,6 &RGHV RI SUDFWLFH RQ EXLOG GLPHQVLRQLQJ

6HFWLRQDO SODQ VHFWLRQDO HOHYDWLRQ IURQW YLH *OD]HG ZLQGRZV

0RGXOH

7\SHV RI 5RRI 5RRILQJ (OHYDWLRQ DQG MRLQW GHWDLO

7\SHV RI 6WDLUV 3ODQ DQG VHFWLRQDO HOHYDWLRQ RI

0RGXOH

%XLOGLQJ UXOHV 7ZR VWRULHG DQG PXOWL VWRUH\HG

3XEOLF EXLOGLQJV OLNH RIILFHV EDQN GLVSHQVDU\ HV

0RGXOH

%XLOGLQJ UXOHV ,QGXVWULDO EXLOGLQJ 3ODQ VHFWL

3UHSDUDWLRQ RI VLWH SODQ DQG VHUYLFH SODQ

0RGXOH

3UHSDUDWLRQ RI 6HSWLF WDQN DQG VRDN SLW GHWDLO

&RXUVH &RQWHQW DQG OHFWXUHU 6FKHGXOH

1R	&RXUVH 3ODQ	&RXUVH 2XWFRPH	1R RI +UV
	0RGXOH *HQHUDO ± 6WXG\ RI ,6 &RGHV RI SUDFWLFH RQ EXI GUDZLQJ 6FDOHV PHWKRG RI GLPHQVLRQLQJ	&2	
	6HFWLRQDO SODQ VHFWLRQDO HOHYDWLRQ IURQW MRLQW GHWDLOV RI D 3DQHOOHG GRRUV E *OD]HG ZLQGRZV	&2	
	0RGXOH 7\SHV RI 5RRIV 5RRI WUXVV LQ VWHHO VHFWLRQV	&2	
	7\SHV RI 6WDLUV 5HLQIRUFHG FRQFUHWH VWDLUFDVH	&2	
	0RGXOH %XLOGLQJ UXOHV 3ODQ VHFWLRQ DQG HOHYDWLRQ RI D7ZR VWRULHG EXLOGLQJ ~ • PXOWL VWRUH\HG EXLOGLQJ F 3XEOLF EXLOGLQJ	&2	

	0RGXOH %XLOGLQJ UXOHV DQG W\SH RI ,QGXVWULDO EXLOGL 3ODQ HOHYDWLRQ DQG VHFWLRQ RI LQGXVWULDO EX	&2	
	3UHSDUDWLRQ RI VLWH SODQ VHUYLFH SODQ	&2	
	0RGXOH 3UHSDUDWLRQ RI 6HSWLF WDQN DQG VRDN SLW GUDZLQJ	&2	

5HIHUHQFH %RRNV

1DWLRQDO %XLOGLQJ &RGH RI ,QGLD

.HUDOD 0XQLFLSDO %XLOGLQJ 5XOHV

'U %DODJRSDO 7 6 3UDEKX %XLOGLQJ 'UDZLQJ DQG 'HWDLOLQ

0RGHO 4XHVWLRQ 3DSHU

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&RXUVH &RGH &RXUVH 1DPH

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0D[0DUNV 'XUDWLRQ KRXUV

3DUW $

$QVZHU DOO TXHVWLRQV HDFK TXHVWLRQ FDUULHV

'UDZ QHDW VNHWFKHV IRU IROORZLQJ OLQHV D 6HFWL
OLQH G ([WHQVLRQ OLQH

:KDW DUH WKH PDMRU FRPSRQHQWV RI D VWHHO WUXVV

:KDW LV WKH GLIIHUHQFH EHWZHHQ ZDLVW VODE DQG IR

:KDW LV)$5 DQG)6,"

6WDWH WKH LPSRUWDQFH RI VLWH SODQ DQG RSHQLQJV

3$57 %

$QVZHU 7ZR IXOO TXHVWLRQ HDFK TXHVWLRQ FDUULHV

'UDZ WKH HOHYDWLRQ RI D SDQHOOHG GRRU
VL]H [PP

3ODQ && VWDLU FDVH GLPHQVLRQ [FP 'UDZ SODQ YLHZ
DQG VHFWLRQDO YLHZ 7DNH IORRU KHLJKW P

6LQJOH VWRUHG UHVLGHQWLDO KRXVH ZLWK WKH IROORZ
VHFWLRQ

L 9HUDQGDK LL %HG URRP QR¶V RQH ZLWK DWWDFK
ZRUN DUHD YL FRPPRQ WRLOHW

'UDZ WKH SODQ DQG VHFWLRQ RI WKH IROORZLQJ UHTXLUHPHQWV

L 'RFWRU¶V URRP LL FDXVDOLW\

LLL 'UHVVLQJ DUHD LY 3KDUPDF\

Y /DERUDWRU\ YL 6WRUH URRP

YLL 7RLOHWV YLL ZDUG EHG

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		9$&					

3UHDPEOH

2EMHFWLYH RI WKH FRXUVH LV WR LQWURGXFH WKH SU
(QJLQHHULQJ DQG 7UDQVSRUWDWLRQ 3ODQQLQJ

3UHUHTXLVLWH

&RXUVH 2XWFRPHV

	'HVFULSWLRQ
&2 1R	$W WKH HQG RI WKH FRXUVH VWXGHQWV ZLOO EH
	'LVF WKH EDVLF FKDUDFWHULVWLFV RI +LJKZD\V DQG
	$QD(WKH IHDWXUHV RI KLJKZD\ PDWHULDOV YDULRX FRQVWUXFWLRQ WHFKQLTXHV
	,QWH WKH EDVLFV RI WUDIILF FKDUDFWHULVWLFV GH VXUYH\V DQG LQWHUSUHW GDWD XQGHUVWDQG WKH
	(VWD WKH EDVLFV RI GLIIHUHQW PRGHV RI WUDQVSR FKDUDFWHULVWLFV LQFOXGLQJ UDLO ZDWHU DQG DL
	$SSU 7UDYHO 'HPDQG (VWLPDWLRQ SURFHVV DQG WKH PHDVXUHV DQG LWV DSSOLFDWLRQ WKURXJK SURPRW

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV

	32	32	32	32	32	32	32	32	32	32	32	32

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination marks
	Test (Marks)	Test (Marks)	
Remember			
Understand			
Apply			
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE D
			hours

Continuous Internal Evaluation Pattern

Attendance marks

Continuous Assessment Test numbers marks

Assignment Quiz Course Project marks

End Semester Examination Pattern

The question consists of two parts Part A and Par
marks for each one questions from each module Par
module out of which one has to be answered Each qu
maximum subdivisions

Course Level Assessment Questions

Course Outcome CO: What are the basic requirements for
Describe thefactors considered in finalising the D

Course Outcome CO: Describe the specifications of materi
bituminous concrete pavements

Course Outcome CO: Explain the effect of various vehicul
stream behaviour

Course Outcome CO: Sketch the typical layout of an airp
taxiways runways apron and terminal building for
Course Outcome CO: What are the options available in
transportation sustainable? What are the steps
in India?

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	,QWURGXFWLRQ WR 7UDQVSRUWDWLRQ (QJLQHHULQJ GHYHORSPHQW RI D VRFLHW\ &ODVVLILFDWLRQ RI URDG LQ XUEDQ DQG UXUDO DUHD ,QWURGXFWLRQ WR JHRPHWULF GHVLJQ RI KLJKZD\V KL	
	,QWURGXFWLRQ RI IOH[LEOH DQG ULJLG SDYHPHQWV ,QWURGXFWLRQ WR KLJKZD\ PDWHULDOV 'HVLUDEOH DJJUHJDWHV ELWXPLQRXV PDWHULDOV DQG VXE JUDGH &RQVWUXFWLRQ RI ELWXPLQRXV SDYHPHQWV DQG ULJLG	
	,QWURGXFWLRQ WR WUDIILF HQJLQHHULQJ 7UDIILF FKD 6HUYLFH 'HVLJQ 6SHHG 7UDIILF VLJQDOV DQG PDUNLQ 7UDIILF FRQWURO GHYLFHV LQWURGXFWLRQ RQO\	
	5DLOZD\ (QJLQHHULQJ &RPSRQHQW SDUWV RI D UDLOZ *DXJHV FRQLQJ RI ZKHHOV +DUERXUV ± FODVVLILFDWLRQ IHDWXUHV UHTXLUHPHQ IXQFWLRQV FODVVLILFDWLRQ 'RFNV ±)XQFWLRQV DQG W\SHV GU\ GRFNV ZHW GRFNV $LUSRUW (QJLQHHULQJ &RPSRQHQWV RI DLUSRUW D RULHQWDWLRQ 7D[LZD\V DSURQV DQG 7HUPLQDO %XL	
	7UDQVSRUWDWLRQ 3ODQQLQJ 1HHG IRU 7UDQVSRUWDW LQWHUDFWLRQ 7UDYHO 'HPDQG (VWLPDWLRQ ± ,QWURG 6XVWDLQDEOH XUEDQ WUDQVSRUW LVVXHV DQG FKD VXVWDLQDEOH WUDQVSRUWDWLRQ JUHHQ YHKLFOHV D IXHOV	

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.KDQQD 6 . -XVWR (* +LJKZD\ (QJLQHHULQJ 1HP &KD
.DGL\DOL / 5 7UDIILF (QJLQHHULQJ 7UDQVSRUWDWLRQ
.KDQQD 6 . DQG $URUD 0 * $LUSRUW 3ODQQLQJ DQG '
5DQJDZDOD 6 & 5DLOZD\ (QJLQHHULQJ &KDURWDU 3XE
5DR * 9 3ULQFLSOHV RI 7UDQVSRUWDWLRQ DQG +LJKZD\
6ULQLYDVDQ 5 +DUERXU 'RFN 7XQQHO (QJLQHHULQJ

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3DUWKR &KDNUDERUW\ DQG $QLPHVK 'DV 3ULQFLSOHV RI
,5& *XLGHOLQHV IRU WKH 'HVLJQ RI)OH[LEOH 3DY
,5& 7HQWDWLYH *XLGHOLQHV IRU WKH 'HVLJQ RI)O
2¶)ODKHUW\ & $ (G 7UDQVSRUW 3ODQQLQJ DQG 7UDI (OVHYLHU
& 6 3DSDFRVWDV DQG 3 ' 3UHYHGRXURV 7UDQVSRUWDWL
<RGHU (- :LWH]DN 0 : 3ULQFLSOHV RI 3DYHPHQW 'HV
6XVWDLQDEOH 8UEDQ 7UDQVSRUW 6KDQJKDL 0DQXDO ± $
LQ WKH VW &HQWXU\

&RXUVH &RQWHQW DQG OHFWXUH 6FKHGXOH			
1R	7RSLF	&RXUVH 2XWFRPH	1R RI +UV
	0RGXOH		7RWDO
	,QWURGXFWLRQ WR 7UDQVSRUWDWLRQ (QJLQHHULQ WUDQVSRUWDWLRQ LQ WKH GHYHORSPHQW RI D VRFLHW RI 7UDQVSRUWDWLRQ (QJLQHHULQJ	&2	
	&ODVVLILFDWLRQ RI URDGV 7\SLFDO FURVV VHFWLR XUEDQ DQG UXUDO DUHD	&2	
	,QWURGXFWLRQ WR JHRPHWULF GHVLJQ RI KLJKZD\V VHFWLRQ HOHPHQWV +RUL]RQWDO DOLJQPHQW DQG 9H LQWURGXFWLRQ RQO\	&2	
	0RGXOH		7RWDO
	,QWURGXFWLRQ RI IOH[LEOH DQG ULJLG SDYHPHQWV	&2	
	,QWURGXFWLRQ WR KLJKZD\ PDWHULDOV 'HVLUDEOH WHVWLQJ RI URDG DJJUHJDWHV	&2	
	&RQVWUXFWLRQ RI ELWXPLQRXV SDYHPHQW VDQG UL %DVLFV RQO\	&2	
	0RGXOH		7RWDO
	,QWURGXFWLRQ WR WUDIILF HQJLQHHULQJ 7UDIILF FK		
	&DSDFLW\ DQG /HYHO RI 6HUYLFH 'HVLJQ 6SHHG	&2	
	7UDIILF VLJQDOV DQG PDUNLQJV	&2	
	7\SHV RI URDG LQWHUVHFWLRQV 7UDIILF FRQWU LQWURGXFWLRQ RQO\	&2	
	0RGXOH		7RWDO
	5DLOZD\ (QJLQHHULQJ &RPSRQHQWV SDUWV RI D UDLO IXQFWLRQV FRQFHSW RI *DXJHV FRQLQJ RI ZKHHOV	&2	
	+DUERXUV ± FODVVLILFDWLRQ IHDWXUHV UHTXLUHPH QHFHVVLW\ DQG IXQFWLRQV FODVVLILFDWLRQ 'RFNV ±)XQFWLRQV DQG W\SHV GU\ GRFNV ZHW G ,QWURGXFWLRQ RQO\	&2	
	,QWURGXFWLRQ WR $LUSRUW (QJLQHHULQJ &RPSRQH 5XQZD\ RULHQWDWLRQ 7D[LZD\V DQG DSURQV DQG %XLOGLQJ	&2	
	0RGXOH		7RWDO
	1HHG IRU 7UDQVSRUWDWLRQ SODQQLQJ 7UDQVSRUW LQWHUDFWLRQ	&2	
	7UDYHO 'HPDQG (VWLPDWLRQ 6WHSV LQ VWDJH SODQ		
	6XVWDLQDEOH XUEDQ WUDQVSRUW ,VVXHV DQG FKDOO	&2	
	3ROLF\ RSWLRQV IRU XUEDQ WUDQVSRUW 3XVK DQG 107 SODQQLQJ 7UDQVLW RULHQWHG GHYHORSPHQW	&2	
	(PHUJLQJ FRQFHSWV LQ VXVWDLQDEOH WUDQVSRUW YHKLFOHV DQG JUHHQ URDGV JUHHQ DQG DOWHUQDWH	&2	

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$QVZHU DOO 4XHVWLRQV (DFK TXHVWLRQ FDUUL

:KDW LV WKH UROH RI URDGV LQ ,QGLDQ HFRQRP\"
([SODLQ EULHIO\ WKH FODVVLILFDWLRQ RI KLJKZD\V LQ ,QG
'LIIHUHQWLDWH IOH[LEOH DQG ULJLG SDYHPHQW
'LIIHUHQWLDWH WDFN FRDW DQG SULPH FRDW :KDW DUH
'LVWLQJXLVK EHWZHHQ WUDIILF FDSDFLW\ EDVLF FDSDF
'LVFXVV DERXW WKH UHTXLUHPHQWV RI WUDIILF FRQWUR
/LVW DQG GHILQH WKH FRPSRQHQW SDUWV RI D UDLOZD\
:KDW DUH WKH GHWULPHQWDO IRUFHV DFWLQJ RQ D EUH
/LVW WKH UROH RI WUDQVSRUWDWLRQ SODQQLQJ WR VR
:KDW DUH WKH DGYDQWDJHV RI JUHHQ IXHO"

[PDUNV

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$QVZHU RQH IXOO TXHVWLRQ IURP HDFK PRGX

D :KDW DUH WKH IDFWRUV FRQWUROOLQJ WKH DOLJQP
LQIOXHQFH HDFK RI WKHP LQ GHWDLO"

E 'LVFXVV DERXW WKH YDULRXV FURVV VHFWLRQ HO
JHRPHWULF GHVLJQ RI KLJKZD\V"

25

D 'HVLJQ WKH UDWH RI VXSHU HOHYDWLRQ IRU D KRUL
DQG VSHHG NPSK

E :KDW LV RYHUWDNLQJ VLJKW GLVWDQFH" 'HULYH W

D 'LIIHUHQWLDWH IOH[LEOH DQG ULJLG SDYHPHQWV 6

E 'LVFXVV WKH GHVLUDEOH SURSHUWLHV RI DJJUHJDWHV X

25

D 'LVFXVV DQ\ WKUHH SURSHUWLHV RI ELWXPHQ DQG WKHL
RI ELWXPLQRXV PL[HV LQ SDYHPHQWV

E :KDW DUH WKH IDFWRUV WR EH FRQVLGHUHG LQ GHVLJQ
WKHLU VLJQLILFDQFH"

D ([SODLQ WKH HIIHFW RI YDULRXV YHKLFXODU FKDUDFWHU

E'UDZ D W\SLFDO 6SHHG IORZ GLDJUDP DQG LQGLFDWH WK

25

D :KDW DUH WKH DGYDQWDJHV DQG GLVDGYDQWDJHV R

E(QXPHUDWH WKH EDVLF W\SHV RI LQWHUVHFWLRQV DQG E

D ([SODLQ ZLWK QHDW VNHWFKHV WKH FRQFHSW RI FR

E+RZ DUH KDUERXUV FODVVLILHG" ([SODLQ ZLWK VNHWFKH

25

D 'LVWLQJXLVK EHWZHHQ ZHW GRFNV DQG GU\ GRFNV" :KDW

E(QXPHUDWH WKH IDFWRUV WKDW DUH WR EH FRQVLGHUHG

D (QXPHUDWH KRZ ODQG XVH DQG WUDQVSRUWDWLRQ SODQ

E%ULHIO\ H[SODLQ WKH YDULRXV VWDJHV LQ WUDYHO GHP

25

D :KDW DUH WKH ZD\V WR RYHUFRPH WKH LVVXHV DQG FKD

E+RZ FDQ JUHHQ YHKLFOHV DQG JUHHQ URDGV FRQWULEX

&(7	&OLPDWH &KDQJH DQG +D]DUG 0LWLJDWLRQ	&DWHJRU\	/	7	3	&UHGLW	<HDU RI ,QWURGXFWLRQ
		9$&					

3UHDPEOH 7KH FRXUVH LV GHVLJQHG WR EXLOG FOLPDWH OLWH FOLPDWH FKDQJH UHODWHG LVVXHV ,W KHOSV OHDUQHUV FKDQJH DQG FOLPDWH PRGHOV HYDOXDWH WKH LPSDFWV OHDUQHUV WR WDNH DSSURSULDWH DFWLRQV WR DGRSW YD

3UH UHTXLVLWH 1LO

&RXUVH RXWFRPH

$IWHU WKH FRXUVH WKH VWXGHQW ZLOO EDOH WR

&2	([SODLQ WKH EDVLF SK\VLFDO SULQFLSOHV RI WKH JO
&2	'HVFULEH WKH ODUJH VFDOH FOLPDWLF FKDQJHV ZKLI
&2	/LVW DFWLRQV LQ NH\ VHFWRUV WR PLWLJDWH KD]DU
&2	,GHQWLI\ LQWHUQDWLRQDO LQLWLDWLYHV ZKLFK VX FKDOOHQJHV
&2	$QDO\VH WKH LPSDFW RI FOLPDWH FKDQJH RQ HFRV\V

&(7 &OLPDWH &KDQJH DQG +D]DUG 0LWLJDWLRQ		32	32	32	32	32	32	32	32	32	32	32	32	362
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$VVHVVPHQW SDWWHUQ

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&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV
$VVLJQPHQW 4XL] &RXUVH SURMHFW PDUNV
7RWDO PDUNV

(QG VHPHVWHU H[DPLQDWLRQ SDWWHUQ ± 7KHUH ZLOO EH WZR SDUWV 3DUW FRQWDLQ TXHVWLRQV ZLWK TXHVWLRQV IURP HDF TXHVWLRQ 6WXGHQWV VKRXOG DQVZHU DOO TXHVWLR(PRGXOH RI ZKLFK VWXGHQW VKRXOG DQVZHU DQ\ RQH (GLYLVLRQV DQG FDUU\ PDUNV

&RXUVH /HYHO $VVHVVPHQW

4Q 1R	4XHVWLRQ	0DUNV	&RXUVH RXWFRPH &2 $VVHVVHG
	3DUW $		
	'HILQH FOLPDWH V\VWHP		&2
	+RZ GRHV $OEHGR DIIHFW FOLPDWH RI D SODFH"		&2
	%ULHIO\ H[SODLQ (O 1LQR DQG LWV HIIHFWV		&2

	:KDW LV FDUERQ F\FOLQJ"		&2
	'HVFULEH DERXW *HQHUDO &LUFXODWLRQ 0RGHOV		&2
	&RPPHQW RQ 2FHDQ $FLGLILFDWLRQ		&2
	'LVFXVV WKH PLVVLRQ RI ,QWHUJRYHUQPHQWDO 3DQH &OLPDWH &KDQJH		&2
	:KDW LV 0RQWUHDO 3URWRFRO"		&2
	%ULHIO\ H[SODLQ &DUERQ GLR[LGH &DSWXUH DQG 6W		&2
	'LVFXVV WKH LPSRUWDQFH RI ELR HQHUJ\ FURSV		&2
	3DUW % $QVZHU $1< 21( )8// TXHVWLRQ IURP HDFK PRGXOH		
	0RGXOH ,		
D	:KDW LV WKH JHQHUDO FLUFXODWLRQ RI WKH DWPRV		&2
E	+RZ GRHV WKH JHQHUDO FLUFXODWLRQ DIIHFW WK FOLPDWH"		&2
D	:KDW LV WKH FRPSRVLWLRQ DQG VWUXFWXUH RI WKH		&2
E	([SODLQ WKH VLJQLILFDQFH RI ZDWHU LQ WKH DWPR FOLPDWH RI HDUWK		&2
	0RGXOH ,,		
D	6WDWH DQG H[SODLQ *OREDO :DUPLQJ 3RWHQWLDO		&2
E	%ULHIO\ H[SODLQ *DQGKLDQ LGHDV RQ *OREDO ZDUP		&2
D	'HVFULEH WKH LPSRUWDQFH RI *UHHQKRXVH HIIHFW R FOLPDWH V\VWHP		&2

E	'LVFXVV WKH URОH RI FDUERQ GLR[LGH LQ *UHHQKRX		&2
	0RGXOH ,,,		
	%ULHIO\ H[SODLQ WKH LPSDFW RI FOLPDWH FKDQJH R WHPSHUDWXUH DQG SUHFLSLWDWLRQ		&2
	'HVFULEH WKH GLIIHUHQW XQFHUWDLQWLHV LQKHUHQ SURMHFWLRQ RI FOLPDWH		&2
	0RGXOH ,9		
	(QXPHUDWH WKH LQWHUQDWLRQDO LQLWLDWLYHV WR FKDQJH FKDOOHQJHV DQG H[SODLQ DQ\ WZR		&2
D	2XWOLQH WKH VWUXFWXUH RI WKH ,QWHUJRYHUQPHQ &OLPDWH &KDQJH		&2
E	([SODLQ WKH FRPSUHKHQVLYH $VVHVVPHQW 5HSRUWV		&2
	0RGXOH 9		
D	([SODLQ KD]DUGV GXH WR FOLPDWH FKDQJH DQG GHV SRVVLEOH PLWLJDWLRQ PHDVXUHV WR LW		&2
D	'LVFXVV WKH FRQFHSW RI HQHUJ\ HIILFLHQF\ LQ EXLO UHVSRQVH WR FOLPDWH FKDQJH		&2
E	'LVFXVV WKH LPSDFW RI FOLPDWH FKDQJH RQ (FRV\V DGDSWDWLRQ PHDVXUHV		&2

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3DUW $

$QVZHU DOO TXHVWLRQV HDFK TXHVWLRQ FDUU

'HILQH FOLPDWH V\VWHP

+RZ GRHV $OEHGR DIIHFW FOLPDWH"

%ULHIO\ H[SODLQ (O 1LQR DQG LWV HIIHFWV

:KDW LV FDUERQ F\FOLQJ"

'HVFULEH DERXW *HQHUDO &LUFXODWLRQ 0RGHOV

&RPPHQW RQ 2FHDQ $FLGLILFDWLRQ

'LVFXVV WKH PLVVLRQ RI ,QWHUJRYHUQPHQWDO 3DQHO

:KDW LV 0RQWUHDO 3URWRFRO"

%ULHIO\ H[SODLQ &DUERQ GLR[LGH &DSWXUH DQG 6WRU

'LVFXVV WKH LPSRUWDQFH RI ELR HQHUJ\ FURSV

3DUW %

$QVZHU RQH IXOO TXHVWLRQ IURP HDFK PRGXOH HDFK

0RGXOH ,

D :KDW LV WKH JHQHUDO FLUFXODWLRQ RI WKH DWPRV

E +RZ GRHV WKH JHQHUDO FLUFXODWLRQ DIIHFW WKH

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D :KDW LV WKH FRPSRVLWLRQ DQG VWUXFWXUH RI WKH

E ([SODLQ WKH VLJQLILFDQFH RI ZDWHU LQ WKH DWPR

0RGXOH ,,

D 6WDWH DQG H[SODLQ *OREDO :DUPLQJ 3RWHQWLDO

E %ULHIO\ H[SODLQ *DQGKLDQ LGHDV RQ *OREDO ZDU

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D 'HVFULEH WKH LPSRUWDQFH RI *UHHQKRXVH HIIHFW

E 'LVFXVV WKH UROH RI FDUERQ GLR[LGH LQ *UHHQKR

0RGXOH ,,,

([SODLQ WKH LPSDFW RI FOLPDWH FKDQJH RQ VXUIDFH
0DUNV

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'HVFULEH WKH GLIIHUHQW XQFHUWDLQWLHV LQKHUHQW

0RGXOH ,9

(QXPHUDWH WKH LQWHUQDWLRQDO LQLWLDWLYHV WR D
DQ\ WZR 0DU

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D 2XWOLQH WKH VWUXFWXUH RI WKH ,QWHUJRYHUQPHQ

E ([SODLQ WKH FRPSUHKHQVLYH $VVHVVPHQW 5HSRUW

0RGXOH 9

([SODLQ KD]DUGV GXH WR FOLPDWH FKDQJH DQG GHVFU
0DUNV

25

D 'LVFXVV WKH FRQFHSW RI HQHUJ\ HIILFLHQF\ LQ EXL
0DUNV

E 'LVFXVV WKH LPSDFW RI FOLPDWH FKDQJH RQ (FRV\
0DUNV

&RXUVH &RGH &(7
&OLPDWH &KDQJH DQG +D]DUG 0LWLJDWLRQ

0RGXOH ,

,QWURGXFWLRQ WR (DUWK¶V &OLPDWH 6\VWHP
VFDOHV RI PRWLRQ ODUJH VFDOH PRWLRQ JHQHUDO FL
$WPRVSKHULF VWUXFWXUH DQG WKHUPRG\QDPLFV SUH
VWUXFWXUH ZDWHU LQ WKH DWPRVSKHUH $WPRVSKHULF

0RGXOH ,,

+XUULFDQHV DQG *OREDO 2FHDQ &LUFXODWLRQ (O 1
3DOHR LQGLFDWRUV RI FOLPDWH 7KH 1DWXUH RI 6WRU
*UHHQKRXVH HIIHFW JUHHQKRXVH JDVHV VRXUFHV RI HPL
(DUWK¶V &DUERQ 5HVHUYRLUV &DUERQ &\FOLQJ &OLPDW
(IIHFWV RI *OREDO ZDUPLQJ *DQGKLDQ LGHDV RQ JORE

0RGXOH ,,,

&OLPDWH GDWD DQG PRGHOV RI DWPRVSKHULF IOXLG PHF
WXUEXOHQFH PL[LQJ OHQJWK PRGHOV $WPRVSKHULF F
PRGHOV $QDO\VHV RI FOLPDWH GDWD &OLPDWH SURMH
FOLPDWH FKDQJH RQ 6XUIDFH WHPSHUDWXUH 3UHFLSLW
LFH H[WHQW

0RGXOH ,9

,QWHUQDWLRQDO LQLWLDWLYHV WR DGGUHVV WKH (DUWK
FOLPDWH ± V ,,6 '2(V 6WDUWXS RI WKH 8 1 ,
)UDPHZRUN &RQYHQWLRQ RQ &OLPDWH &KDQJH 7KH .
&RQYHQWLRQ (DUWK 6XPPLW 0RQWUHDO 3URWRFRO 3
(PLVVLRQV 5HVWULFWLRQV

0RGXOH 9

&OLPDWH &KDQJH $GDSWDWLRQ $GDSWDWLRQ WR FOLPDWH
WKH ILHOGV RI (FRV\VWHPV DQG ELRGLYHUVLW\ $JULFX
KXPDQ KHDOWK ZDWHU VXSSO\ VDQLWDWLRQ DQG LQIU

DQG 0LWLJDWLRQ 0HDVXUHV ([WUHPH ZHDWKHU HYHQW
KXPDQLW\ IRRG ZDWHU KHDOWK %ULHI H[SODQDWLR
&&6 %LR HQHUJ\ FURSV (QHUJ\ HIILFLHQF\ LQ EXLOGL

7H[W %RRNV

- 0DUN 0DVOLQ &OLPDWH &KDQJH $ 9HU\ 6KRUW ,QWURGXF
- -DQ & YDQ 'DP ,PSDFWV RI &OLPDWH &KDQJH DQG &O 5HJLPHV &DPEULGJH 8QLYHUVLW\ 3UHVV 8.
- 7UHQEHUWK . (&OLPDWH 6\VWHP 0RGHOLQJ &DPEULGJH 8QLYHUVLW &DPEULGJH 8 .

5HIHUHQFHV

- ,3&& VHFRQG DVVHVVPHQW UHSRUW :RUNLQJ *URXS , 5HSRUW
- ,3&& IRXUWK DVVHVVPHQW UHSRUW 7KH $5 V\QWKHVLV UHSR
- ,3&& IRXUWK DVVHVVPHQW UHSRUW :RUNLQJ *URXS , 5HSRUW
- ,3&& IRXUWK DVVHVVPHQW UHSRUW :RUNLQJ *URXS ,, 5HSRU
- ,3&& IRXUWK DVVHVVPHQW UHSRUW :RUNLQJ *URXS ,,, 5HSRU
- ,3&& ILIWK DVVHVVPHQW UHSRUW 7KH $5 V\QWKHVLV UHSRU

&RXUVH &RGH &(7
&OLPDWH &KDQJH DQG +D]DUG 0LWLJDWLRQ
&RXUVH FRQWHQW DQG 6FKHGXOH RI /HFWXUH

0RGXOH	7RSLF	&RXUVH RXWFRPH DGGUHVVHG	1R RI +RXUV
0RGXOH , +R			
	,QWURGXFWLRQ WR (DUWK¶V &OLPDWH 6\VWHP %DV	&2	
	5DGLDWLRQ $OEHGR (PLVVLYLW\	&2	
	6FDOHV RI PRWLRQ ODUJH VFDOH PRWLRQ	&2	
	*HQHUDO FLUFXODWLRQ WURSRVSKHUH VWUDWRVSK	&2	
	$WPRVSKHULF VWUXFWXUH DQG WKHUPRG\QDPLFV	&2	
	3UHVVXUH GHQVLW\ FRPSRVLWLRQ	&2	

	7HPSHUDWXUH VWUXFWXUH ZDWHU LQ WKH DWPRVS	&2	
	$WPRVSKHULF SKRWRFKHPLVWU\	&2	
	&KHPLFDO NLQHWLFV	&2	
0RGXOH ,, +RX			
	+XUULFDQHV DQG *OREDO ZDUPLQJ *OREDO 2FHDQ &	&2	
	(O 1LQR DQG LWV HIIHFWV 3DOHR LQGLFDWRUV RI	&2	
	7KH 1DWXUH RI 6WRUPV²F\FORQHV WRUQDGRHV DQG	&2	
	*UHHQKRXVH HIIHFW JUHHQKRXVH JDVHV VRXUFHV R	&2	
	7KH 5ROH RI &DUERQ 'LR[LGH 7KH (DUWK¶V &DUERQ	&2	
	&DUERQ &\FOLQJ &OLPDWH DQG :HDWKHU *OREDO ZD	&2	
	(IIHFWV RI *OREDO ZDUPLQJ	&2	
	(IIHFWV RI *OREDO ZDUPLQJ	&2	
	*DQGKLDQ LGHDV RQ JOREDO ZDUPLQJ	&2	

0RGXOH ,,,			
	&OLPDWH GDWD DQG 0RGHOV (TXDWLRQV RI DWPRVS PHFKDQLFV HQHUJ\ HTXDWLRQ WXUEXOHQFH	&2	
	0L[LQJ OHQJWK PRGHOV	&2	
	$WPRVSKHULF FKHPLFDO WUDQVSRUW	&2	
	*HQHUDO FLUFXODWLRQ PRGHOV	&2	
	$QDO\VHV RI FOLPDWH GDWD	&2	
	&OLPDWH SURMHFWLRQV DQG WKHLU XQFHUWDLQWLH	&2	
	,PSDFWV RI FOLPDWH FKDQJH RQ 6XUIDFH WHPSHUDWX	&2	
	,PSDFWV RI FOLPDWH FKDQJH RQ 2FHDQ S+ 6HD OHY LFH H[WHQW	&2	

	,PSDFWV RI FOLPDWH FKDQJH RQ 2FHDQ S+ 6HD OHY LFH H[WHQW	&2	
0RGXOH ,9 +RXUV			
	,QWHUQDWLRQDO LQLWLDWLYHV WR DGGUHVV WKH	&2	
	+LVWRU\ RI (DUWK¶V FOLPDWH ± V,6 '2(	&2	
	6WDUWXS RI WKH 8 1 ,3&& 0LVVLRQ RI WKH ,3&&	&2	
	7KH)UDPHZRUN &RQYHQWLRQ RQ &OLPDWH &KDQJH	&2	
	7KH .\RWR 3URWRFRO WR WKH)UDPHZRUN &RQYHQW	&2	
	(DUWK	&2	
	0RQWUHDO 3URWRFRO	&2	
	3ROLF\ $	&2	
	,QWHUQDWLRQDOO\ $GRSWHG (PLVVLRQV 5HVWULFW	&2	

0RGXOH 9			
	&OLPDWH &KDQJH $GDSWDWLRQ 0LWLJDWLRQ 0HDV	&2	
	$GDSWDWLRQ WR FOLPDWH FKDQ ELRGL	&2	
	$JULFXOWXUH DQG IRRG VHFXULW\ ODQG XVH IRU	&2	
	:DWHU VXSSO\ VDQLWDWLRQ DQG LQIUDVWUXFWXU	&2	
	+D]DUGV GXH WR FOLPDWH FKI ([WUHPH ZHD	&2	
	0LWLJDWLRQ PHDVXUHV LQ VHFWRUV YLWDO WR KX KHDOWK	&2	
	&DUERQ GLR[LGH FDSWXUH DQG VWRUDJH &&6	&2	
	%LR HQHUJ\ FURSV (QHUJ\ HIILFLHQF\ LQ EXLOGLQ	&2	
	(QHUJ\ HIILFLHQF\ LQ EXLOGLQJV	&2	

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	$'9$1&(' 0(&+$1,&6 2) 62/,'6	9$&				

3UHDPEOH 2EMHFWLYH RI WKLV FRXUVH LV WR H[SRVH WKH VWXGHQW RI PDWHULDOV DQG HQKDQFH WKHLU SUREOHP VROYLQJ VNLOOV VWUDLQV LQ ' DQG ' VROLG ERGLHV ,W LQWURGXFHV VWXGH IDLOXUH DQG IDLOXUH FULWHULD 6WXGHQWV ZLOO EH DEOH WR HTXDWLRQV LQ GHDOLQJ ZLWK HODVWLF VROLGV $IWHU WKLV PHFKDQLFDO EHKDYLRXU RI HODVWLF PDWHULDOV E\ GHWHUPL DSSOLFDWLRQ RI ORDG

3UHUHTXLVLWH 0HFKDQLFV RI 6ROLGV

&RXUVH 2XWFRPHV

&RXUVH 2XWFRPH	'HVFULSWLRQ RI &RXUVH 2XWFRPH	3UHVFULEHG OHDUQLQJ OHYHO
&2	7R H[SODLQ WKH PDWHULDO SURSHUWLHV RI VROLGV DQG DQG VWUDLQ GHYHORSHG LQ VROLGV GXH WR DSSOLHG O	5HPHPEHULQJ 8QGHUVWDQGLQJ $SSO\LQJ
&2	7R LOOXVWUDWH WKH GLIIHUHQW IDLOXUH WKHRULH IDLOXUH FULWHULD WR ILQG RXW WKH)DFWRU RI 6D VWUXFWXUDO IDLOXUH	$SSO\LQJ $QDO\VLQJ
&2	7R SUHGLFW WKH VWUXFWXUDO UHVSRQVH RI VWDQG RI LVRWURSLF PDWHULDOV GXH WR DSSOLHG WRUVL	$SSO\LQJ $QDO\VLQJ

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV 0LQLPX

	32	32	32	32	32	32	32	32	32	32	32	32
&2												
&2												
&2												

$VVHVVPHQW 3DWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW 7HVWV		(QG 6HPHVWHU ([DPLQDWLRQ
5HPHPEHU			
8QGHUVWDQG			
$SSO\			
$QDO\VH			
(YDOXDWH			
&UHDWH			

0DUN GLVWULEXWLRQ

7RWDO 0DUNV	&,(	(6(	(6('XUDWLRQ
			KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV PDUNV
$VVLJQPHQW 4XL] &RXUVH SURMHFW PDUNV

(QG 6HPHVWHU ([DPLQ 7KHUH ZLOO EH WZR SDUWV 3DUW $ DQG 3D
TXHVWLRQV ZLWK TXHVWLRQV IURP HDFK PRGXOH KDYLQJ PD
DQVZHU DOO TXHVWLRQV 3DUW % FRQWDLQV TXHVWLRQV IURP
DQ\ RQH (DFK TXHVWLRQ FDUULHV PDUNV DQG FDQ KDYH PD[LP

&RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

3DUW $

&RXUVH 2XWFRPH &2 7ZR TXHVWLRQV HDFK IURP PRGXOH W
REMHF 7R XQGHUVWDQG WKH PDWHULDO SURSHUWLHV RI VROLGV D
GHYHORSHG LQ VROLGV GXH WR DSSOLHG ORDGV

([SODLQ VWUHVV LQYDULDQWV
([SODLQ 6WUHVV VSDFH
([SODLQ WKH WUDQVIRUPDWLRQ RI VWUDLQ
([SODLQ WUDQVIRUPDWLRQ RI VWUHVV
/LVWWKH GLIIHUHQWLDO HTXDWLRQV RI HTXLOLEULXP IRU
6WDWH WKH DVVXPSWLRQV LQ FODVVLFDO OLQHDU HODVWL
'LIIHUHQWLDWH EHWZHHQ SULQFLSDO VWUHVV DQG SULQF
/LVW WKH VL[FRPSDWLELOLW\ HTXDWLRQV IRU D WKUHH G
'LVWLQJXLVK EHWZHHQ UHFWDQJXODU VWUDLQ URVHWWH
'LIIHUHQWLDWH EHWZHHQ VWUHVV WHQVRU DQG VWUDLQ
([SODLQ RFWDKHGUDO VWUHVVHV VWUDLQ

&RXUVH 2XWFRPH &2 7ZR TXHVWLRQV IURP PR 7R GXOH WR PHHW
XQGHUVWDQG WKH GLIIHUHQW IDLOXUH WKHRULHV DQG DSSO
RI 6DIHW\

'LVFXVV WKH IDLOXUH FULWHULD IRU GXFWLOH PDWHULDOV
'LVFXVV WKH IDLOXUH FULWHULD IRU EULWWOH PDWHULDOV
([SODLQ 3DOP UHQ UXOH
'LVFXVV WKH IDLOXUH GXH WR VWUHVV UHYHUVDO
([SODLQ 61 &XUYH
([SODLQ VWUHVV FRQFHQWUDWLRQ IDFWRU

&RXUVH 2XWFRPH &2 7ZR TXHVWLRQV IURP PRGXOH 7R PHHV
SUHGLFW WKH VWUXFWXUDO UHVSRQVH RI VWDQGDUG FURVV
DSSOLHG WRUVLRQ

'LVFXVV WKH XVH RI 6W 9HQDQWV VHPL LQYHUVH PHWKRG
([SODLQ 3UDQGWO¶V PHPEUDQH DQDORJ\

3DUW %

$OO WKH TXHVWLRQV XQGHU WKLV VHFWLRQ VKDOO DVVHVV WKH
RXWFRPHV OLVWHG EHORZ

&2	7R XQGHUVWDQG WKH PDWHULDO SURSHUWLHV RI VROLGV DQ VROLGV GXH WR DSSOLHG ORDGV
&2	7R OHDUQ WKH GLIIHUHQW IDLOXUH WKHRULHV DQG DSS)DFWRU RI 6DIHW\ DJDLQVW VWUXFWXUDO IDLOXUH
&2	7R SUHGLFW WKH VWUXFWXUDO UHVSRQVH RI VWDQGDUG GXH WR DSSOLHG WRUVLRQ

7KH VWDWH RI VWUDLQ DW D SRLQW LQ DQ LVRWURSLF PDW

rärrt r Frärrt
e r Frärrv rärirrx
Frärrt rärrrx r

'HWHUPLQH VWUHVV WHQVRU DW WKLV SRLQW 7DNH (*3

&RXUVH RXWFRPH LGHQWLILHU	'HVFULSWLRQ RI FRXUVH RXWFRPH	/HDUQLQJ OHYHO D	0DUNV DOORFDWHG
&2	7R H[SODLQ WKH PDWHULDO SURSHUWLHV RI VROLGV DQG WKH VWDWH RI VWUHVV DQG VWUDLQ GHYHORSHG LQ VROLGV GXH WR DSSOLHG ORDGV	5HPHPEHULQJ ± 5HODWLRQ EHWZHHQ /DPH¶V &RQVWDQ DQG (SRLVVRQV UDWLR ' PDWUL[IRU ,VRWURSLF 0DWHULDO	
		8QGHUVWDQGLQJ &RQVWLWXWLYH 6WUH VWUDLQ 5HODWLRQVKLS	
		$QDO\VLQJ &RPSXWDWLRQ RI VWUHVV IURP VWUDLQ ZLWK DSSOLFDWLRQ RI &RQVWLWXWLYH VWUHVV VWUDLQ UHODW	
		$SSO\LQJ)RUPDWLRQ RI 6WUHVV WHQV IURP VWUHVV FRPSRQHQWV	
7RWDO			

$ ORZ FDUERQ VWHHO VKDIW LV GHVLJQHG WR KDYH D GLDI
D[LDO ORDG 3 N1 D PRPHQW 0 1 P DQG D WRUTXH
IRU WKH VWHHO LV 03D GHWHUPLQH WKH IDFWRU RI VD
RQ WKH D 7UHVFD FULWHULRQ RI IDLOXUH E 9RQ PLVHV F
RFFXUV DW LQLWLDWLRQ RI \LHOGLQJ

&RXUVH RXWFRPH LGHQWLILHU	'HVFULSWLRQ RI FRXUVH RXWFRPH	/HDUQLQJ OHYHO DVVHVVHG	0DUNV DOORFDWHG
&2	7R H[SODLQ WKH PDWHULDO SURSHUWLHV RI VROLGV DQG WKH VWDWH RI VWUHVV DQG VWUDLQ GHYHORSHG LQ VROLGV GXH WR DSSOLHG ORDGV	$SSO\LQJ ± &RPSXWDWLRQ RI VWDWH RI VWUHVV IURP ORDGLQJ VLWXDWLRQ	
&2	7R LOOXVWUDWH WKH GLIIHUHQW IDLOXUH WKHRULHV DQG DSSO\ WKH DSW IDLOXUH FULWHULD WR ILQG WKH)DFWRU RI 6DIHW\ DJDLQVW VWUXFWXUDO IDLOXUH	5HPHPEHULQJ ±)RUPXODH IRU WKH 7UHVFD 9RQ PLVHV &ULWHULD	
		$SSO\LQJ ± &RPSXWDWLRQ RI)DFWRU RI 6DIHW\	
7RWDO			

$ VTXDUH VKDIW KDV PP VLGHV DQG KDV WKH VDPH FU
FLUFXODU DQG HTXLODWHUDO WULDQJXODU FURVV VHFWLR
N1P 'HWHUPLQH WKH PD[LPXP VKHDULQJ VWUHVV IRU HDFK

&RXUVH RXWFRPH LGHQWLILHU	'HVFULSWLRQ RI FRXUVH RXWFRPH	/HDUQLQJ OHYHO DVVHVVHG	0DUNV DOORFDWHG
&2	7R SUHGLFW WKH VWUXFWXUDO UHVSRQVH RI VWDQGDUG FURVV VHFWLRQV RI LVRWURSLF PDWHULDOV GXH WR DSSOLHG WRUVLRQ	8QGHUVWDQGLQJ ± .QRZOHGJH UHJDUGLQJ 6DLQW 9HQDQW¶V 6HPL ,QYHUVH 0HWKRG	
		$SSO\LQJ 8VH RI 6WUHVV)XQFWLRQ	
		5HPHPEHULQJ 5HODWLRQ EHWZHHQ PD[LPXP VKHDU VWUHVV ZLWK DSSOLHG 7RUVLRQ DQG WKH JHRPHWULF SDUDPHWHUV	
		$SSO\LQJ 8VH RI DSSURSULDWH (TXDWLRQ	
7RWDO			

0RGHO 4XHVWLRQ 3DSHU

&(7 $GYDQFHG 0HFKDQLFV RI 6ROLGV

4Q 1R	4XHVWLRQV	0DUNV	&RXUVH 2XWFRPH &2 $VVHVVHG
3DUW $ $QVZHU DOO TXHVWLRQV HDFK TXHVWLRQ FDU			
	([SODLQ WUDQVIRUPDWLRQ RI VWUHVV		
	'LIIHUHQWLDWH EHWZHHQ VSKHULFDO DQG 'HYLDWRULDO		
	([SODLQ VWUDLQ LQYDULDQWV		
	'LVWLQJXLVK EHWZHHQ UHFWDQJXODU VWUDLQ URVHWWH VWUDLQ URVHWWH		
	/LVW WKH VL[FRPSDWLELOLW\ HTXDWLRQV IRU D WKUHH		
	/LVW RXW WKH GLIIHUHQWLDO HTXDWLRQV RI HTXLOLEULX GLPHQVLRQDO VWUHVV VWDWH		
	'LVFXVV WKH IDLOXUH FULWHULD IRU GXFWLOH PDWHULDOV		
	([SODLQ VWUHVV FRQFHQWUDWLRQ IDFWRU		
	'LVFXVV WKH XVH RI 6W 9HQDQWV VHPL LQYHUVH PHWKRG		
	([SODLQ 3UDQGWO¶V PHPEUDQH DQDORJ\		
3DUW % $QVZHU RQH IXOO TXHVWLRQ IURP HDFK PRGXOH HD			
0RGXOH ,			
D	'HULYH WKH H[SUHVVLRQ IRU WKH VWUHVV RQ DUELWUD XQLW QRUPDO YHFWRU Q GHILQHG E\ FRRUGLQDWH V\VWHP ZLWK [\ DQG] DV UHIHUHQFH D[		UHFWDQJXODU
E	)LQG WKH H[SUHVVLRQ IRU WKH 1RUPDO VWUHVV DQG 6K D QHZ FRRUGLQDWH V\VWHP ZLWK ; < DQG = DV WKH UH D[LV LV GHILQHG E\ D[LV LV GHILQHG E\ PM Q DQG = D[LV LV GHILQHG E\		
25			
D	$ UHFWDQJXODU EDU RI PHWDO RI FURVV VHFWLRQ PP VXEMHFWHG WR DQ D[LDO WHQVLOH IRUFH RI N1 &DO QRUPDO VKHDU DQG UHVXOWDQW VWUHVVHV RQ D SODQ WKH IROORZLQJ GLUHFWLRQ FRVLQHV		
E	7KH VWDWH RI VWUHVV DW D SRLQW LV JLYHQ E\ WKH WHUPV		

	ι › ι ‹› › tį 03D'HWHUPLQH WKH SULQFLSDO VWUHVVHV DQG W u t { SULQFLSDO GLUHFWLRQV)LQG RXW WKH VWUHVV LQYDU SODQH DQG VKRZ WKDW LW UHPDLQV XQFKDQJHG		
0RGXOH ,,			
D	%\ PHDQV RI VWUDLQ URVHWWH WKH IROORZLQJ VWUD GXULQJ WKH WHVW RQ D VWUXFWXUDO PHPEHU PLFURPHWUHV PLFURPHWUHV P PLFURPHWUHV P 'HWHUPLQH WKH PDJQLWXGH DQG GLUHFWLRQV RI SULQ		
E	,I WKH GLVSODFHPHQW ILHOG LQ D ERG\ LV VSHFLILHG Y]\ DQG Z ['HWHUPLQH WKH VWUDLQ WHQVRU DW D SRLQW ZKRVH FRRUGLQDWHV DUH		
25			
	7KH VWUDLQ FRPSRQHQWV DW D SRLQW ZLWK UHVSHFW V\VWHP DUH [\ ] [\ \] [] ,I WKH FRRUGLQDWHD[HV DUH URWDWHG DERXW WKH] D WKH DQWLFORFNZLVH GLUHFWLRQ GHWHUPLQH WKH FRPSRQHQWV		
0RGXOH ,,,			
	7KH VWDWH RI VWUDLQ DW D SRLQW LV JLYHQ E\ VWUDL rrrt r Frrrt e r Frärrv rärirrx Frärrt rärrrx r 'HWHUPLQH VWUHVV WHQVRU DW WKLV SRLQW 7DNH (3RLVVRQ¶V UDWLR		
25			
D	8QGHU ZKDW FRQGLWLRQV DUH WKH IROORZLQJ H[SUH FRPSRQHQWV RI VWUDLQ DW D SRLQW FRPSDWLEOH" [D[\ E\ F[\ D[E[[\ . [[\ D[\		
E	7KH VWUHVV FRPSRQHQWV DW D SRLQW LQ D ERG\ DUH J 1 [[\] [1 [\] \ 1 [\ \] 2 [2] 2 [] [\] [\ 'HWHUPLQH ZKHWKHU WKHVH FRPSRQHQWV RI VWUHV HTXLOLEULXP HTXDWLRQV RU QRW DW WKH SRLQW GHWHUPLQH WKH VXLWDEOH ERG\ IRUFH UHTXLUHG DW WKHVH VWUHVV FRPSRQHQWV DUH XQGHU HTXLOLEULXP		

0RGXOH ,9			
	5HSXHVHQW DOO WKH \LHOG FULWHULD IRU IDLOXUH JU VWUHVV VSDFH ZLWĶKDUQĶFIRDQJXKHDPUDW[HULDO VWHHO $VVXPH WKH \LHOG SRLQW RI VWHHO DV 03 UDWLR DV 0HQWLRQ WKH HTXDWLRQ DOVR LQ WKH J		
25			
	$ FORVHG HQG WKLQ ZDOOHG F\OLQGULFDO RI D PHWDO 03D KDV DQ LQVLGH GLDPHWHU RI PP 7KH F\OL VXEMHFWHG WR DQ LQWHUQDO SUHVVXUH RI 03D DQG N1 'HWHUPLQH WKH WRUTXH WKDW FDQ EH DSSOLHG LI WKH IDFWRU RI VDIHW\ IRU GHVLJQ LV &KHFN PDWHULDO LV VDIH XQGHU 9RQ PLVHV FULWHULD		
0RGXOH 9			
	$ KROORZ WKLQ ZDOO EUDVV WXEH KDV DQ HTXLODWHUD VHFWLRQ 7KH PHDQ OHQJWK RI HDFK VLGH RI WKH WUL 7KH ZDOO WKLFNQHVV LV PP 'HWHUPLQH WKH WRUT DQJOH RI WZLVW IRU DQ DYHUDJH VKHDULQJ VWUHVV R *3D		
25			
	$ WRUVLRQ PHPEHU KDV DQ HOOLSWLFDO FURVV VHFWL PLQRU GLPHQVLRQV RI PP DQG PP UHVSHFWLYH \LHOG VWUHVV RI WKH PDWHULDO LV 03D 'HWHUPLQH WRUTXH WKDW FDQ EH DSSOLHG WR WKH WRUVLRQ PH IDFWRU RI VDIHW\ XVLQJ PD[LPXP VKHDULQJ VWUHVV IDLOXUH		

6\OODEXV

0RGXOH 6WUHVV LQ '

'HILQLWLRQ RI VWUHVV DW D SRLQW 6WUHVV 1RWDWLRQ 6W
6WUHVV RQ DQ REOLTXH SODQH 7UDQVIRUPDWLRQ RI VWUH\
2FWDKHGUDO 6WUHVV 0HDQ DQG 'HYLDWRU 6WUHVV 3ODQH
'LPHQVLRQV 'LIIHUHQWLDO (TXDWLRQV RI PRWLRQ RI D GHIR

0RGXOH 6WUDLQ LQ '

7\SHV RI 6WUDLQ 'HIRUPDWLRQ RI D GHIRUPDEOH ERG\ 6WU
6SKHULFDO DQG 'HYLDWRULDO 6WUDLQ 7HQVRU 3ULQFLSDO
6WUDLQV 0RKU &LUFOH IRU VWUDLQ (TXDWLRQV RI &RPSDWL

0RGXOH (OHPHQWV RI 7KHRU\ RI (ODVWLFLW\

6WUDLQ (QHUJ\ 'HQVLW\ &RPSOHPHQWDU\ ,QWHUQDO (QHUJ\
'HQVLW\ (ODVWLFLW\ DQG &RPSOHPHQWDU\ ,QWHUQDO (QHUJ
$QLVRWURSLF (ODVWLFLW\ ,VRWURSLF (ODVWLFLW\ 'LVSODF
HTXLOLEULXP HTXDWLRQV DQG ERXQGDU\ FRQGLWLRQV

0RGXOH)DLOXUH DQG)DLOXUH FULWHULD

0RGHV RI IDLOXUH \LHOG IDLOXUH FULWHULD 0D[LPXP 3ULQFLSD
FULWHULD 0D[LPXP 6WUDLQ &ULWHULD 0D[LPXP 6WUDLQ (QHUJ\ '
IDWLJXH 6WUHVV &RQFHQWUDWLRQ)DFWRU 3DOP 0LQHU 5XOH 6

0RGXOH 7RUVLRQ

7RUVLRQ RI D F\OLQGULFDO EDU RI FLUFXODU FURVV VHFWL
IXQFWLRQ DSSURDFK HOOLSWLFDO HTXLODWHUDO WULDQJO
3UDQGWO¶V PHPEUDQH DQDORJ\ +ROORZ WKLQ ZDOO WRUVLR

7H[W %RRNV

$ 3 %RUHVL DQG 2 0 6LGHERWWRP $GYDQFHG 0HFKDQLFV RI 0D
6RQV

5 ' &RRN DQG : & <RXQJ $GYDQFHG 0HFKDQLFV RI 0DWHULDOV
,QWO ,QF

6ULQDWK / 6 $GYDQFHG 0HFKDQLFV RI 6ROLGV 7DWD 0F*UDZ +L

5HIHUHQFH %RRNV

6 3 7LPRVFKHQNR 6WUHQJWK RI 0DWHULDOV 9RO ,, &%6 3XEOL

6KDPHV (+ 0HFKDQLFV RI 'HIRUPDEOH VROLGV 3UHQWLFH +D

7LPRVKHQNR 6 3 DQG *RRGLHU - 1 7KHRU\ RI HODVWLFLW\ 0F*U

/HFWXUH 3ODQ ± $GYDQFHG 0HFKDQLFV RI 6ROLGV

0RGXOH	7RSLF	&RXUVH RXWFRPH DGGUHVVHG	1R RI /HFWXUHV
	0RGXOH , 7RWDO OHFWXUH KRXUV		
	'HILQLWLRQ RI VWUHVV DW D SRLQW 6WUHVV 1RWDWLR 7HQVRU 0HDQ DQG 'HYLDWRU 6WUHVV	&2	/HFWXUH
	'HILQLWLRQ RI 3ODQH 1RUPDO 6WUHVV RQ DQ REOLTXH SODQH	&2	/HFWXUH
	6KHDULQJ 6WUHVV RQ DQ REOLTXH SODQH	&2	/HFWXUH
	7UDQVIRUPDWLRQ RI VWUHVV 3ULQFLSDO 6WUHVV	&2	/HFWXUH
	6WUHVV ,QYDULDQWV 2FWDKHGUDO 6WUHVV	&2	/HFWXUH
	3ODQH VWUHVV 0RKU¶V &LUFOH LQ 7ZR 'LPHQVLRQV	&2	/HFWXUH
	'LIIHUHQWLDO (TXDWLRQV RI PRWLRQ RI D GHIRUPDEOH ERG\	&2	/HFWXUH
	0RGXOH ,, 7RWDO OHFWXUH KRXUV		
	7\SHV RI 6WUDLQ 'HIRUPDWLRQ RI D GHIRUPDEOH ERG\	&2	/HFWXUH
	6WUDLQ 7HQVRU 6WUDLQ 7UDQVIRUPDWLRQ	&2	/HFWXUH
	6SKHULFDO DQG 'HYLDWRULDO 6WUDLQ 7HQVRU	&2	/HFWXUH
	3ULQFLSDO 6WUDLQV 6WUDLQ ,QYDULDQWV	&2	/HFWXUH
	2FWDKHGUDO 6WUDLQV 0RKU &LUFOH IRU VWUDLQ	&2	/HFWXUH
	(TXDWLRQV RI &RPSDWLELOLW\ IRU 6WUDLQ	&2	/HFWXUH
	6WUDLQ 5RVHWWHV	&2	/HFWXUH
	0RGXOH ,,, 7RWDO OHFWXUH KRXUV		
	6WUDLQ (QHUJ\ 'HQVLW\ &RPSOHPHQWDU\ ,QWHUQDO (QHUJ\ 'HQVLW\	&2	/HFWXUH
	(ODVWLFLW\ DQG 6WUDLQ (QHUJ\ 'HQVLW\	&2	/HFWXUH
	(ODVWLFLW\ DQG &RPSOHPHQWDU\ ,QWHUQDO (QHUJ\ 'HQVLW\	&2	/HFWXUH
	*HQHUDOL]HG +RRNH¶V /DZ	&2	/HFWXUH
	$QLVRWURSLF (ODVWLFLW\ ,VRWURSLF (ODVWLFLW\	&2	/HFWXUH
	'LVSODFHPHQWV VWUDLQV DQG FRPSDWLELOLW\	&2	/HFWXUH
	(TXLOLEULXP HTXDWLRQV DQG ERXQGDU\ FRQGLWLRQV	&2	/HFWXUH

	0RGXOH ,9 7RWDO OHFWXUH KRXUV		
	0RGHV RI IDLOXUH \LHOG IDLOXUH FULWHULD	&2	/HFWXUH
	0D[LPXP 3ULQFLSDO 6WUHVV &ULWHULD 0D[LPXP 6KHDU VWUHVV FULWHULD	&2	/HFWXUH
	0D[LPXP 6WUDLQ &ULWHULD	&2	/HFWXUH
	0D[LPXP 6WUDLQ (QHUJ\ 'HQVLW\ &ULWHULD	&2	/HFWXUH
	9RQ 0LVHV &ULWHULD	&2	/HFWXUH
	IDWLJXH 6WUHVV &RQFHQWUDWLRQ)DFWRU	&2	/HFWXUH
	3DOP 0LQHU 5XOH 61 &XUYH	&2	/HFWXUH
	0RGXOH 9 7RWDO OHFWXUH KRXUV		
	7RUVLRQ RI D F\OLQGULFDO EDU RI FLUFXODU FURVV V	&2	/HFWXUH
	6W 9HQDQW¶V VHPL LQYHUVH PHWKRG	&2	/HFWXUH
	6WUHVV IXQFWLRQ DSSURDFK HOOLSWLFDO	&2	/HFWXUH
	7RUVLRQ (TXLODWHUDO WULDQJOH FURVV VHFWLRQV	&2	/HFWXUH
	7RUVLRQ QDUURZ UHFWDQJXODU FURVV VHFWLRQV	&2	/HFWXUH
	3UDQGWO¶V PHPEUDQH DQDORJ\	&2	/HFWXUH
	+ROORZ WKLQ ZDOO WRUVLRQ PHPEHUV	&2	/HFWXUH

&(7	3$9(0(17 &216758&7,21 $1' 0$1$*(0(17	&$7(*25<	/	7	3	&5(',7	<($5 2) ,1752'8&7,21
		9$&					

3UHDPEOH

2EMHFWLYH RI WKH FRXUVH LV WR LQWURGXFH WKH SULQF
LQIUDVWUXFWXUH DVVHW PDQDJHPHQW

3UHUHTXLVLWH 1,/

&RXUVH 2XWFRPHV

	'HVFULSWLRQ
&2 1R	$W WKH HQG RI WKH FRXUVH VWXGHQWV ZLOO EH DE
&2	7R XQGHUVWDQG WKH FKDUDFWHUL]DWLRQ RI PDWHU FRQVWUXFWLRQ
&2	7R FDUU\ RXW PL[GHVLJQ RI YDULRXV ELWXPLQRXV
&2	7R VWXG\ FRQVWUXFWLRQ SUDFWLFHV RI IOH[LEOH S
&2	7R XQGHUVWDQG WKH FRQVWUXFWLRQ SUDFWLFHV D SDYHPHQW
&2	7R VWXG\ WKH IXQGDPHQWDOV RI SDYHPHQW HYDOX PDQDJHPHQW V\VWHP

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV

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$VVHVVPHQW 3DWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW		(QG 6HPHVWHU ([DPLQDWLRQ PDUNV
	7HVW 0DUNV	7HVW 0DUNV	
5HPHPEHU			
8QGHUVWDQG			
$SSO\			
$QDO\VH			
(YDOXDWH			
&UHDWH			

0DUN 'LVWULEXWLRQ

7RWDO 0DUNV	&,(0DUNV	(6(0DUNV	(6(' KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ

$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV PDUN
$VVLJQPHQW 4XL] &RXUVH 3URMHFW PDUNV

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ
7KH TXHVWLRQ FRQVLVWV RI WZR SDUWV 3DUW $ DQG 3DUW
PDUNV IRU HDFK WZR TXHVWLRQV IURP HDFK PRGXOH 3DU
PRGXOH RXW RI ZKLFK RQH KDV WR EH DQVZHUHG (DFK TX
PD[LPXP VXEGLYLVLRQV

6DPSOH &RXUVH /HYHO $VVHVVPHQW 4XHVWLRQV

&RXUVH 2XWFRPH (&2): ([SODLQ WKH GHVLUDEOH SURSHUWLHV RI
GLIIHUHQW W\SHV RI SDYHPHQW FRQVWUXFWLRQ"

&RXUVH 2XWFRPH (&2): $ ELWXPHQ PL[WXUH FRQWDLQV FRDUVH
DJJUHJDWH DVSKDOW E\ ZHLJKW 'HWHUPLQH XQLW ZHL
DLU YRLGV" &$)$ $*

&RXUVH 2XWFRPH (&2): ([SODLQ WKH PHWKRG RI SUHSDUDWLRQ RI P
IRU OD\LQJ ELWXPLQRXV PDFDGDP EDVH FRXUVH"

&RXUVH 2XWFRPH (&2): :LWK QHDW VNHWFK H[SODLQ WKH MRLQWV LQ
&RXUVH 2XWFRPH (&2): &RPSDUH SURMHFW OHYHO DQG QHWZRUN OH
V\VWHPV

6\OODEXV

0RGXOH

3DYHPHQW IXQFWLRQV DQG FKDUDFWHULVWLFV 7\SHV RI S
FRPSDULVRQ 'LIIHUHQW OD\HUV RI IOH[LEOH DQG ULJLG SD
3DYHPHQW PDWHULDOV FKDUDFWHUL]DWLRQ RI VXE JUDGH VRLO VRLO
URDG DJJUHJDWH SULQFLSOHV DQG PHWKRGV RI JUDGDWL
XVHV RI ELWXPHQ HPXOVLRQ FXWEDFN DQG PRGLILHG ELW

0RGXOH

%LWXPLQRXV SDYHPHQW SUHSDUDWLRQ OD\HU V\VWHP DQG SUHPL[
PDWHULDOV
0L[GHVLJQ SK\VLFDO DQG YROXPHWULF SURSHUWLHV RI ELWXP
GHVLJQ 6XSHU SDYH PL[GHVLJQ

0RGXOH

&RQVWUXFWLRQ RI IOH[LEOH SDYHPHQW YDULRXV OD\HUV SUHSD
VXE JUDGH JUDQXODU VXE EDVH *6%   :%0 :00 %LWXPLQR
ZHDULQJ FRXUVHV VSHFLILFDWLRQV JXLGH OLQHV HTXL
OD\HUV LQ IOH[LEOH SDYHPHQW TXDOLW\ FRQWURO IRU IO

0RGXOH

&RQVWUXFWLRQ RI FHPHQW FRQFUHWH SDYHPHQW PDWHULDO FKDUDFWHUL]DWLRQ S
DQG EDVH 7\SHV RI MRLQWV LQ 5LJLG SDYHPHQWV LWV IX
LQ MRLQWV DQG 3&& VODE FRQVWUXFWLRQ

0RGXOH

,QWURGXFWLRQ WR SDYHPHQW PDQDJHPHQW V\VWHP 306
FRPSRQHQWV JHQHUDO VWUXFWXUH GDWD FROOHFWLRQ
HYDOXDWLRQ SDYHPHQW GHWHULRUDWLRQ PRGHOV   SDYH
DQG SURMHFW OHYHO W\SHV RI SDYHPHQW PDQDJHPHQ
UHKDELOLWDWLRQ DFWLYLWLHV OLIH F\FOH FRVW DQDO\VL

7(;7 %22.6

.KDQQD 6 . -XVWR (* $ 9HHUDUDJDYDQ +LJKZD\ (Q
.KDQQD 3XEOLVKHUV

.DGL\DOL / 5 3ULQFLSOHV RI +LJKZD\ (QJLQHHULQJ

5DMLE % 0DOOLFN DQG 7DKDU(O .RUFKL 3DYHPHQW

5DR * 9 3ULQFLSOHV RI 7UDQVSRUWDWLRQ DQG +LJ

3ULWKYL 6LQJK .KDQGKDO %LWXPLQRXV 5RDG &RQV

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0DQXDO IRU FRQVWUXFWLRQ DQG VXSHUYLVLRQ RI %

6KDKLQ 0 < 3DYHPHQW 0DQDJHPHQW IRU $LUSRUWV
+DOO
,5& *XLGHOLQHV IRU WKH 'HVLJQ RI)OH[LEOH

0R57+ ,5& FRGH IRU SDYHPHQW HYDOXDWLRQ GDWD

&RXUVH &RQWHQW DQG OHFWXUH 6FKHGXOH

6O 1R	7RSLF	&RXUVH 2XWFRPH	1R RI +RXUV
	0RGXOH		7RWDO
	)XQFWLRQV DQG FKDUDFWHULVWLFV RI SDYHPHQWV SDYHPHQW DQG FRPSDULVRQ IOH[LEOH SDYHPHQW UL SDYHPHQW	&2	
	'LIIHUHQW OD\HUV DQG SURSHUWLHV RI IOH[LEOH DQ		
	FKDUDFWHUL]DWLRQ RI VXE JUDGH VRLO DQG VRLO F V\VWHP	&2	
	3URSHUWLHV RI URDG DJJUHJDWH SULQFLSOHV DQG F JUDGDWLRQ RI VRLO DJJUHJDWH PL[HV	&2	
	&KDUDFWHULVWLFV DQG XVHV RI ELWXPHQ HPXOVLRQ PRGLILHG ELWXPHQ	&2	
	0RGXOH		7RWDO
	3HQHWUDWLRQ OD\HU V\VWHP DQG SUHPL[HG DJJUHJD		
	3K\VLFDO DQG YROXPHWULF SURSHUWLHV RI ELWXPLQ 0DUVKDOO PHWKRG RI PL[GHVLJQ 6XSHUSDYH 0L[GHV	&2	
	0RGXOH		7RWDO
	)XQFWLRQV RI YDULRXV OD\HUV RI IOH[LEOH SDYHPHQ DQG FRQVWUXFWLRQ RI VXE JUDGH JUDQXODU VXE ED *6% :%0 :00 %LWXPLQRXV PDFDGDP 'LIIHUHQW W\S RI ZHDULQJ FRXUVHV VSHFLILFDWLRQV JXLGHOLQHV	&2	
	(TXLSPHQW XVHG IRU WKH FRQVWUXFWLRQ RI GLIIHUH IOH[LEOH SDYHPHQW TXDOLW\ FRQWURO IRU IOH[LEOH FRQVWUXFWLRQ	&2	
	0RGXOH		7RWDO
	&RQVWUXFWLRQ RI FHPHQW FRQFUHWH SDYHPHQW PD FKDUDFWHUL]DWLRQ SUHSDUDWLRQ RI VXEJUDGH DQG	&2	
	7\SHV RI MRLQWV LQ 5LJLG SDYHPHQWV LWV IXQFWLR SUHVHWWLQJ UHLQIRUFHPHQW LQ MRLQWV DQG 3&& VO	&2	
	0RGXOH		7RWDO
	,QWURGXFWLRQ WR SDYHPHQW PDQDJHPHQW V\VWHP 3 FRQFHSW GHILQLWLRQ REMHFWLYHV FRPSRQHQWV J GDWD FROOHFWLRQ	&2	
	3DYHPHQW HYDOXDWLRQ IXQFWLRQDO DQG VWUXFWX SDYHPHQW GHWHULRUDWLRQ PRGHOV	&2	
	3DYHPHQW PDQDJHPHQW OHYHOV QHWZRUN SURJUDP OHYHO	&2	
	7\SHV RI SDYHPHQW PDQDJHPHQW V\VWHP 7\SHV RI 0DLQWHQDQFH DQG UHKDELOLWDWLRQ DFWLYLWLHV	&2	
	OLIH F\FOH FRVW DQDO\VLV RI VWUDWHJLHV SRSXODU		

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7+,5' 6(0(67(5 % 7(&+ '(*5(((;$0,1$7,21 0217+ <($5

&RXUVH &RGH &(7

&RXUVH 1DPH 3$9(0(17 &216758&7,21 $1' 0$1$*(0(17
0RGHO 4XHVWLRQ 3DSHU

0DUNV

3$57 $
$QVZHU DOO 4XHVWLRQV (DFK TXHVWLRQ FDUUL

:KDW DUH WKH IXQFWLRQV RI SDYHPHQW"
'HILQH HPXOVLILHG DQG FXWEDFN ELWXPHQ
:KDW DUH WKH W\SHV RI ELWXPHQ PL[HV IRU SDYHPHQW
'HILQH 90$ DQG 9)%
'UDZ D W\SLFDO FURVV VHFWLRQ RI D KLJKZD\ LQ FX
SDYHPHQW OD\HUV
:KDW DUH WKH FRPPRQ W\SHV RI HTXLSPHQW IRU FRPS
VXEJUDGH"
'UDZ D QHDW GLDJUDP VKRZLQJ YDULRXV FRPSRQHQW
:KDW DUH REMHFWV RI SURYLGLQJ GRZHO EDUV LQ &&S
'LIIHUHQWLDWH EHWZHHQ IXQFWLRQDO DQG VWUXFWXU
:KDW DUH WKH REMHFWLYHV RI 3DYHPHQW 0DQDJHPHQW
[

3$57 %
$QVZHU RQH IXOO TXHVWLRQ IURP HDFK PRGX

D 'LIIHUHQWLDWH EHWZHHQ IOH[LEOH DQG ULJLG SDY

E ([SODLQ &%5 DQG WKH WHVW SURFHGXUH LQ WKH OD
REWDLQHG DQG LQWHUSUHWHG"

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D :KDW DUH WKH GHVLUDEOH SURSHUWLHV RI URDG DJ
DQG VKDSH WHVW

E ([SODLQ JUDGLQJ RI ELWXPHQ

D 'LIIHUHQWLDWH EHWZHHQ GHQVH JUDGHG DQG JDS J
HDFK

E ,Q D 0DUVKDOO WHVW ELWXPLQRXV FRQFUHWH F\O
ZLWK WKH YROXPH RI FF 7KH ZHLJKWV DQG VSHFLI
JLYHQ LQ WKH WDEOH 'HWHUPLQH 90$

7\SH	$	$	$	)O\DVK
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%LWXP

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D ([SODLQ WKH 0DUVKDOO PHWKRG RI ELWXPLQRXV PL[

E ,Q D ELWXPLQRXV FRQFUHWH PL[WKH WKHRUHWLFDO
JUDYLW\ LV VSHFLILF JUDYLW\ RI ELWXPHQ XVHG L
LQ WKH PL['HWHUPLQH 90$ 9)%

D ([SODLQ WKH FRQVWUXFWLRQ SURFHGXUH IRU EDVH
FRQVWUXFWLRQ

E /LVW YDULRXV H[FDYDWLQJ PDFKLQHU\ XVHG GXULQJ
XVHV DQG OLPLWDWLRQV RI HDFK

25

D :ULWH QRWHV RQ WKH IROORZLQJ W\SHV RI ELWXPLQ
DVSKDOW LL VOXUU\ VHDO LLL PLFUR VXUIDFLQJ

E :KDW DUH WKH TXDOLW\ FRQWURO WHVWV GXULQJ W
OD\HU" 0HQWLRQ WKH REMHFWLYHV RI HDFK

D :ULWH DQRWH RQ LPSRUWDQFH DQG FRQVWUXFWLRQ
GU\ OHDQ FRQFUHWH VXE EDVH FRXUVH LLL VHSDUDW

E $ ULJLG SDYHPHQW LV FRQVWUXFWHG ... WHPSHUDWXUH L
ZLQWHU WHPSHUDWXUH ... DW H[SDQVLRQ MRLQW LV PP
&DOFXODWH WKH VSDFLQJ RI H[SDQVLRQ MRLQW"

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D :KDW DUH WKH GLIIHUHQW PDWHULDOV UHTXLUHG IR
0HQWLRQ KRZ D FRQFUHWH PL[LV GHVLJQHG IRU REWD

E &ODVVLI\ GLIIHUHQW W\SHV RI MRLQWV LQ && SDYH

D 'LIIHUHQWLDWH EHWZHHQ GHVWUXFWLYH DQG QRQ G
SDYHPHQW

E &RPSDUH SURMHFW OHYHO DQG QHWZRUN OHYH

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D 'LVFXVV WKH VWUXFWXUH FRPSRQHQW RI D

E ([SODLQ /LIH &\FOH &RVW $QDO\VLV

&(7	*(2*5$3+,&$/ ,1)250$7,21 6<67(06	&$7(*25<		/7	3	&5(',7	<HDU RI ,QWURGXFWLRQ
		9$&					

3UHDPEOH *RDO RI WKLV FRXUVH LV WR H[SRVH WKH VWXGHQWV W
RI *HRJUDSKLFDO ,QIRUPDWLRQ 6\VWHP *,6 $IWHU VXFFHVV
DEOH WR LGHQWLI\ WKH UHTXLUHPHQWV IRU WKH GHYHORSPH

3UHUHTXLVLWH

&RXUVH 2XWFRPHV $IWHU FRPSOHWLRQ RI WKH FRXUVH WKH VWXGHQW

&RXUVH RXWFRPH LGHQ	'HVFULSWLRQ RI FRXUVH RXWFRPH	3UHVFULEHG OHDUQLQJ OHYHO
&2	7R GHILQH WHUPV EDVLF FRQFHSWV DQG RSHUDWLRQV LQ	5HPHPEHULQJ
&2	7R LGHQWLI\ YDULRXV GDWD W\SHV DQG WKHLU FKDUDFWH	8QGHUVWDQGLQJ
&2	7R LOOXVWUDWH YDULRXV DSSURDFKHV RI VSDWLDO GDWD VLJQLILFDQFH LQ GHFLVLRQ PDNLQJ	
&2	7R GHPRQVWUDWH WKH DSSOLFDWLRQ RI *,6 DQG DOOLHG DFURVV GLYHUVH ILHOGV	

0DSSLQJ RI FRXUVH RXWFRPHV ZLWK SURJUDP RXWFRPHV 0LQ

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$VVHVVPHQW 3DWWHUQ

%ORRP¶V &DWHJRU\	&RQWLQXRXV $VVHVVPHQW 7HVWV		(QG 6HPHVWHU ([DPLQDWLRQ 0DUNV
	7HVW 0DUNV	7HVW 0DUNV	
5HPHPEHU			
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&UHDWH			

0DUN 'LVWULEXWLRQ

7RWDO 0DUNV	&,(0DUNV	(6(0DUNV	(6(
			KRXUV

&RQWLQXRXV ,QWHUQDO (YDOXDWLRQ 3DWWHUQ
$WWHQGDQFH PDUNV
&RQWLQXRXV $VVHVVPHQW 7HVW QXPEHUV PDUNV
$VVLJQPHQW 4XL] &RXUVH 3URMHFW PDUNV

(QG 6HPHVWHU ([DPLQDWLRQ 3DWWHUQ

7KHUH ZLOO EH WZR SDUWV 3DUW $ DQG 3DUW %

3DUW $ FRQWDLQV TXHVWLRQV ZLWK TXHVWLRQV IURP H
PDUNV 6WXGHQWV VKRXOG DQVZHU DOO TXHVWLRQV

3DUW % FRQWDLQV TXHVWLRQV IURP HDFK PRGXOH RI ZKLFK
FDUULHV PDUNV DQG FDQ KDYH PD[LPXP VXE GLYLVLRQV

6\OODEXV

0RGXOH

%DVLF FRQFHSWV RI *,6 +LVWRU\ RI *,6 &RPSRQHQWV RI *,6 *HR
$SSOLFDWLRQ RI *,6 3RSXODU *,6 6RIWZDUHV

*HRJUDSKLF &R RUGLQDWH V\VWHP 0DS 3URMHFWLRQV &RPPRQO
V\VWHP *HRUHIHUHQFLQJ *HRPHWULF 7UDQVIRUPDWLRQV

7XWRULDO ,QWURGXFLQJ DQ\ *,6 VRIWZDUH DQG LWV WRROV

0RGXOH

'DWD VWUXFWXUH 9HFWRU 'DWD PRGHO 5DVWHU 'DWD PRGHO 7\
0HWDGDWD 9HFWRU WR 5DVWHU FRQYHUVLRQ 'LJLWL]DWLRQ

*HRGDWDEDVH PDQDJHPHQW $WWULEXWH GDWD PDQDJHPHQW &DU

7XWRULDO H[HUFLVHV *HRUHIHUHQFLQJ UDVWHU WR YHFWRU FRQY

0RGXOH

*,6 'DWD 3URFHVVLQJ ±9HFWRU GDWD $QDO\VLV %XIIHULQJ 2YHUO
LQ SRO\JRQ 'LVWDQFH PHDVXUHPHQW 3DWWHUQ DQDO\VLV 0DS PD

5DVWHU 'DWD $QDO\VLV /RFDO RSHUDWLRQV 1HLJKERXUKRRG R
RSHUDWLRQV

7XWRULDO H[HUFLVHV 'LJLWL]DWLRQ XVLQJ DYDLODEOH GDWD VRX

0RGXOH

$GYDQFHG $SSOLFDWLRQV ,QWURGXFWLRQ WR WHUUDLQ PDSSLQJ
DVSHFW :HE*,6

'DWD TXDOLW\ DQDO\VLV ± 6RXUFHV RI (UURU ± &RPSRQHQWV RI 'D

7XWRULDO H[HUFLVHV ZRUNLQJ ZLWK D VXUIDFH WHUUDLQ PRGHO

0RGXOH

5HPRWH VHQVLQJ 'HILQLWLRQ %DVLF 3ULQFLSOHV $SSOLFDWLRQ

*OREDO 3RVLWLRQLQJ 6\VWHP *36 *36 %DVLF FRQFHSWV *36
DSSOLFDWLRQV *36 $SSOLFDWLRQ RI *,6 HQYLURQPHQW

7XWRULDO H[HUFLVHV &UHDWH D VPDOO *,6 PRGXOH XVLQJ *36 RU

7H[W %RRNV

&KDQJ . ³,QWURGXFWLRQ WR *HRJUDSKLF ,QIRUPDWLRQ 6\
3XEOLVKLQJ &R /WG

*HRUJH -RVHSK ³)XQGDPHQWDOV RI 5HPRWH 6HQVLQJ´ 8QL

5REHUW /DXULQL DQG 'HUHN 7KRPSVRQ ³)XQGDPHQWDOV R
6\VWHPV´ $FDGHPLF 3UHVV

5HIHUHQFHV

%XUURXJK3 3ULQFLSOHV RI *HRJUDSKLFDO ,QIRUPDWLRQ V

,OLIIH & - 'DWXPV DQG 0DS 3URMHFWLRQV IRU 5HPRWH 6H
:KLWWOHV 3XEOLVKLQJ
.DQJ WVXQJ &KDQJ Ä,QWURGXFWLRQ WR *,6Æ 7DWD 0F*UD

/LOOHVDQG 0 DQG .LHIHU : ³5HPRWH 6HQVLQJ DQG ,PDJH ,Q
DQG 6RQV ,QF

,OLIIH & - 'DWXPV DQG 0DS 3URMHFWLRQV IRU 5HPRWH 6H
:KLWWOHV 3XEOLVKLQJ

&RXUVH &RQWHQWV DQG /HFWXUH 6FKHGXOH

1R	7RSLF	&RXUVH 2XWFRPHV	1R RI /HFWXUHV
	0RGXOH		7RW
	•] }v ‰š• U ,]•š}ŒÇ }('/^U }u ' }•‰ š] o š U ššŒ] µš š U '/^ }‰ Œ š]}v•U ‰‰o] š]}v }('/^ U W}‰µo Œ '/^ ^}(šÁ Œ •X	&2	&2
	}}Œ]v š •' }PŒ }}Œ]v š •Ç•š WŒ}i š]}v•U }uu}voÇ µ• D ‰ WŒ}i š]}v•U WŒ}i š }r }Œ]v š •Ç•š uU ' }Œ (Œ v]vPU ' }u šŒ] dŒ v•(}Œu š]}v•X	&2	&2
	dµš}Œ] or /všŒ} µ]vP '/^ •}(šÁ Œ v š}}o•X	&2	&2
	0RGXOH		7RWDO
	'DWDVWUX 9HFWRU 'DWD PRGHO 5DVWHU 'DWD PRGHO 7\SHV RI 5DVWHU GDWD 'DWD LQSXWV WR *,6 SODWIRUP 0HWDGDWD 9H FRQYHUVLRQ 'LJLWL]DWLRQ	&2 &2	&2
	'DWDEDVH PDQDJHPHQW D *HRGDWDEDVH PDQDJHPHQW $WWULEXWH GDWD PDQDJHPHQW &DUWRJUDSKV PDNLQJ HOHPHQWV	&2 &2	&2
	7XWRULDO H[HUFLVHV 'LJLWL]DWLRQ XVLQJ DYDLODEOH GDW FUHDWLQJ D 0DS 8VLQJ GLIIHUHQW PDS HOHPHQWV	&2	&2
	0RGXOH		7RWDO
	*,6 'D 3URFH ± 9HFWRU GDWD $QDO\VLV %XIIHULQJ 2YHUOD\ 3RLQW LQ 3RO\JRQ /LQH LQ SRO\JRQ 3RO\JRQ LQ SRO\JRQ 'L PHDVXUHPHQW 3DWWHUQ DQDO\VLV 0DS PDQLSXODWLRQ $QDO\VLV	&2 &2 &2	&2 &2
	5DVWHU 'DWD $QDO\VLV /RFDO RSHUDWLRQV 1HLJKERUKRRG RSHUDWLRQ =RQDO 2SHUDWLRQ RWKHU 5DVWHU GDWD RSHUDWLRQV	&2 &2	&2 &2
	7XWRULDO H[HUFLVHV 'LJLWL]DWLRQ XVLQJ DYDLODEOH GDW FUHDWLQJ D 0DS 8VLQJ GLIIHUHQW PDS HOHPHQWV	&2	&2
	0RGXOH		7RW
	$GYDQFHG $SSOLFDWLRQV &RQWULEXWLRQ WR WHUUDLQ PDSSLQJ '(0 DQG 7,1 WHUUDLQ PDSSLQJ WHFKQLTXHV 6ORSH DQG DVSHFW :HE*	&2 &2	&2 &2
	'DWD TXDOLW\ 6RXUFHV RI (UURU ± &RPSRQHQWV RI 'DWD 4XDOLW\	&2 &2	&2 &2
	7XWRULDO H[HUFLVHV ZRUNLQJ ZLWK D VXUIDFH WHUUDLQ PR		
	0RGXOH		7RWDO
	5HPRWH VHQVLQJ 2EMHFWLRQ %DVLF 3ULQFLSOHV $SSOLFDWLRQ RI UHPRWH VHQVLQJ LQ *,6	&2 &2	&2 &2
	*OREDO 3RVLWLRQLQJ *36 %DVLF 3ULQFLSOHV *36 VHJPHQWV VDWHOOLWHV UHFHLYHUV *36 DSSOLFDWLRQV $SSOLFDWLRQ RI *36 GDWD LQ *,6 HQYLURQPHQW	&2 &2 &2	&2 &2 *36
	dµš}Œ] o Æ Œ]• •W Œ š •u oo '/^ u µo]vP 'W^ }Œ Z^ š X	&2	&2

6DPSOH &RXUVH /HYHO $VVHVVPHQW 4XHV

&2	7R GHILQH WHUPV EDVLF FRQFHSWV DQG RSHUDWL
&2	7R LGHQWLI\ YDULRXV GDWD W\SHV DQG WKHLU FKD
&2	7R LOOXVWUDWH YDULRXV DSSURDFKHV RI VSDWLDO VLJQLILFDQFH LQ GHFLVLRQ PDNLQJ
&2	7R GHPRQVWUDWH WKH DSSOLFDWLRQ RI *,6 DQG D DFURVV GLYHUVH ILHOGV

&2

3UHSDUH D VKRUW DFFRXQW RQ *HRGHWLF GDWXP (OOLSVRLG

6WDWH DQ\ WZR IXQFWLRQV RI D *,6 PRGXOH

:ULWH D VKRUW QRWH RQ 'LJLWDO (OHYDWLRQ 0RGHO

&2

&RPSDUH UDVWHU GDWD VHWV DQG YHFWRU GDWD VHWV +LJK

%ULHIO\ H[SODLQ UDVWHU GDWD IRUP LQ *,6

([SODLQ DQ\ WZR DSSURDFKHV IRU VSDWLDO GDWD DFTXLVLWL

&2

3UHSDUH VKRUW GHVFULSWLRQ RQ L 3RVLWLRQDO DFFXUDF\

([SODLQ DQ\ WZR W\SHV RI HUURUV DVVRFLDWHG ZLWK VSDWLD

([SODLQ GLIIHUHQW W\SH RI LPDJH UHVROXWLRQV DQG HVWDEO

&2

%ULHIO\ LOOXVWUDWH WKH XWLOLW\ RI *,6 PRGXOH LQ WUDFNL

([SODLQ KRZ *36 LV XVHG LQ WKH PDS SUHSDUDWLRQ DQG ORF

+LJKOLJKW WKH DGYDQWDJHV RIIHUHG E\ UHPRWH VHQVLQJ RS

0RGHO 4XHVWLRQ 3DSHU

43 &2'(

5HJ 1R BBBBBBBBBBBBBBBB   1DPH BBBBBBBBBBB

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0D[0DUNV   'XUDWLRQ

3$57 $

$QVZHU DOO TXHVWLRQV

u

,OOXVWUDWH DQ\ WZR VSDWLDO GDWD FROOHFWLRQ PH

:KDW DUH WKH GLIIHUHQW FRPSRQHQWV LQ *,6"

'HILQH L 9HFWRU GDWD LL 5DVWHU GDWD

(VWDEOLVK WKH URCH RI VKDSHILOHV LQ *,6

'LVWLQJXLVK EHWZHHQ SDWWHUQ DQDO\VLV DQG QHWZR

'HPRQVWUDWH WKH VLJQLILFDQFH RI EXIIHULQJ LQ *,6

6WDWH DQ\ WZR VRXUFHV RI GDWD HUURU

'HILQH WKH WHUPV 6ORSH DQG $VSHFW

/LVW DQ\ WZR DSSOLFDWLRQV RI *,6 LQ FRPELQDWLRQ Z

,OOXVWUDWH WKH URCH RI DWRPLF FORFN LQ *36

3$57 %

L ([SODLQ GLIIHUHQW WHFKQLTXHV RI UHPRWH VHQVLQJ

LL :KDW LV WKH URCH RI JHRUHIHUHQFLQJ LQ *,6 RSHUD

RU

L LOOXVWUDWH DQ\ WKUHH DSSOLFDWLRQV RI *,6

LL &RPSDUH F\OLQGULFDO SURMHFWLRQV DQG FRQLFDO

L :KDW DUH WKH GLIIHUHQW PRGHOV DGRSWHG WR UHSU

LLL +LJKOLJKW WKH URCH RI GLJLWLVDWLRQ LQ PDS SUH

RU

L /LVW WKH VWHSV LQYROYHG LQ WKH SUHSDUDWLRQ RI

LL &RPSDUH FRQWLQXRXV UDVWHU DQG GLVFUHWH UDVW

L 3UHSDUH D VKRUW DFFRXQW RQ D 3DWWHUQ DQDO\VLV

LL ,OOXVWUDWH DQ\ WZR UDVWHU GDWD RSHUDWLRQV

RU

L ([SODLQ DQ\ WKUHH IDFWRUV WKDW LQIOXHQFHV WKH

LL :KDW DUH WKH GLIIHUHQW]RQDO RSHUDWLRQV VXJJH
GDWD "

L ([SODLQ WKH LPSRUWDQFH RI XVLQJ '(0 IRU YDULRXV

LL 3UHSDUH GLIIHUHQW VRXUFHV RI HUURU LQ D *,6 RSH

RU

L 6WDWH DQ\ WZR DSSURDFKHV WR UHGXFH WKH HUURU

LL 3UHSDUH D EULHI GHVFULSWLRQ RI *,6 GDWD VWDQGD

L 'LIIHUHQWLDWH EHWZHHQ JURXQG EDVHG UHPRWH VH

LL -XVWLI\ LQWHJUDWLRQ RI *,6 DQG *36 WHFKQRORJLH
ORJLVWLF RSHUDWLRQV

RU

L ([SODLQ GLIIHUHQW FRPSRQHQWV RI D *36 VHJPHQW

LL ,OOXVWUDWH WKH XWLOLW\ RI UHPRWH VHQVLQJ GDW

6 (0 (6 7 (5

DISCRETE MATHEMATICAL STRUCTURES

MAT 203	DISCRETE MATHEMATICAL STRUCTURES	CATEGORY	L	T	P	CREDITS
		BSC	3	1	0	4

Preamble:

The purpose of this course is to create awareness in students about the basic terminolo in advanced courses in Computer Science and develop rigorous logical thinking for different kinds of problems in Computer Science. This course helps the learner to ap theory and applications of elementary Counting Principles, Propositional Logic, Predicate Lo Lattices, Generating Functions, Recurrence Relations and Algebraic Structures eventually practical applications.

Prerequisite: A sound b ematics

Course Outcomes: Afte ill be able to

CO#	
CO1	Check the va ntified Propositional using truth ta eory on Propositiona (Cognitive Kn
CO2	Solve countin unting techniques - R Sum, Rule of nial Theorem, Pigeo Principle and e Knowledge Level: Apply)
CO3	Classify bina n application for eac of binary relation, in Computer Science (Cognitive Knowledge Level: Understand)
CO4	Illustrate an application for Partially Ordered Sets and Complete Lattice Computer Science (Cognitive Knowledge Level: Apply)
CO5	Explain Generating Functions and solve First Order and Second Order Recurrence Relations with Constant Coefficients (Cognitive Knowledge Level: Apply)
CO6	Illustrate the abstract algebraic systems - Semigroups, Monoids, G Homomorphism and Isomorphism of Monoids and Groups (Cognitive Knowledge Level: Understand)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓		✓						✓
CO4	✓	✓	✓	✓		✓						✓
CO5	✓	✓	✓	✓								✓
CO6	✓	✓	✓									✓

Abstrac	ation
PO#	Broa	d PO
PO1	Engineering Kn	Sustainability
PO2	Problem Analysi	
PO3	Design/Develop	n work
PO4	Conduct investi problems	
PO5	Modern tool usa	ent and Finance
PO6	The Engineer a	

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance 10 marks

Continuous Assessment Tests (Average of Series Tests 1 & 2) 25 marks

Continuous Assessment Assignment 15 marks

Internal Examination Pa

Each of the two interna 0 marks. First series t

be preferably conducte us and the second se

shall be preferably con e syllabus. There will

parts: Part A and Part , 2 questions each f

completed modules an ule), having 3 marks f

question adding up to er all questions from

Part B contains 7 que he completed module

question from the partly t of the 7 questions, a

should answer any 5.

End Semester Examina

There will be two parts; Part A and Part B. Part A contains questions with 2 questions fro each module, having 3 marks for each question. Students should answer all question contains 2 full questions from each module of which student should answer any one question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module Ð 1(Fundamentals of Logic)

Mathematical logic - Basic connectives and truth table, Statements, Logical Conne Tautology, Contradiction. Logical Equivalence - The Laws of Logic, The Principle of duality, Substitution Rules . The implication - The Contrapositive, The Converse, The Inverse.

Logical Implication - Rules of Inference. The use of Quantifiers - Open Statement, Quar Logically Equivalent Ð Contrapositive, Converse , Inverse, Logical equivalences and implications for quantified statement, Implications , Negation.

Module - 2 (Fundamentals of Counting Theory)

The Rule of Sum Ð Extension of Sum Rule . The Rule of Product - Extension of Product Permutations. Combinations. The Binomial Theorem (without proof). Combination Repetition. The Pigeon hole Principle. The Principle of Inclusion and Exclusion The (Without Proof) - Generalization of the Principle. Derangements.

Module - 3 (Relations and Functions)

Cartesian Product - Binary Relation. Function Ð domain , range-one to one function, Ima restriction. Properties of Relations- Reachability Relations, Reflexive Relations, Symmetric Relations, Transitive relations, Anti-symmetric Relations, Partial Order relations, Equiva Relations, Irreflexive re

Partially ordered Set Ð ... nt, Least upper bound Greatest Lower bound ... Ed) Equivalence Relations and Partitions - Equival

Lattice - Dual Lattice , ... operties of Lattice , S Lattice , Complete Latti ... stributive Lattice.

Module - 4 (Generating

Generating Function ... techniques, Expone generating function. F ... th constant coefficier homogeneous, non-hc ... ar recurrence relation constant coefficients, h

Module - 5 (Algebraic S

Algebraic system-prop ... Semi group and monoi cyclic monoid , sub semi group and sub monoid, Homomorphism and Isomorphism of S group and monoids. Group- Elementary properties, subgroup, symmetric group on three symbols ,The direct product of two groups, Group Homomorphism, Isomorphism of grou Cyclicgroup. Rightcosets - Leftcosets. LagrangeÕs Theore

Text Book

1. Discrete and Combinatorial Mathematics (An Applied Introduction), Ralph P Grimald V Ramana , 5th Edition, Pearson

Reference Books

1) Kenneth H. Rosen, Discrete Mathematics and Its Applications with Combinatoric Graph Theory, Seventh Edition, MGH, 2011
2) Trembly J.P and Manohar R, ÒDiscrete Mathematical Structures with Applicati Computer ScienceÓ, Tata Mc Graw Hill Pub. Co. Ltd., New Delhi, 2003.
3) Bernard Kolman, Robert C. Busby, Sharan Cutler Ross, ÒDiscrete Mathe StructuresÓ, Pearson Education Pvt Ltd., New Delhi, 2003
4) Kenneth H .Rosen, ÒDiscrete Mathematics and its ApplicationsÓ, 5/e, Tata Mc G Pub. Co. Ltd, New Delhi 2003
5) Richard Johnsonbaugh, ÒDiscrete MathematicsÓ, 5/e, Pearson Education Asia, N 2002.
6) Joe L Mott, Abraham Kandel, Theodore P Baker,ÒDiscrete Mathematics for Com Scientists and MathematiciansÓ, 2/e, Prentice-Hall India, 2009.

Course Outcome 1 (CC …

1. Show that R!M , … ously (without using tr table)
2. Represent the fc … ery city in Canada is c

Course Outcome 2 (C(…

1. How many possi … MASSASAUGA in wh AÕ s are togethe …
2. Find the number … hich are not divisible 6 or 8

Course Outcome 3 (CC …

1. If A = {1, 2, 3, 4} … xive and symmetric bu transitive.
2. Let Z be the set … nce Modulo 3 Ò defir = { (x,y) /x ! Z,y ! … equivalence relation.

Course Outcome 4 (CC …

1. Assume A ={ a, b, c}. Let P(A) be its power set and be the subset relation on tl power set. Draw the Hasse diagram of (P(A), ").
2. What is meant by Bounded Lattice ? Give an example.

Course Outcome 5 (CO5):

1. Solve $a_r - 3a_{r-1} - 4a_{r-2} = 3^r$ using Generating function method; Given $a_0 = 1$, $a_1 = 2$.
2. Find the generating function for the sequence $1, 3, 3^2, 3^3$ ÉÉ.

Course Outcome 6 (CO6):

1. Prove that the group { 1,-1, i, -i } is cyclic with generators i and Ði.
2. State and prove LagrangeÕs Theorem.

Model Question Paper

QP CODE:

Reg No:______________

Name :______________ PAGE:

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code:MAT 203

Cours tures

Max.Marks :100 Duration: 3 Hrs

Answer 3 Marks

1. Show the followi table: (P ^ Q) => P#Q
2. Write the negati hen I will not walkÓ
3. What is pigeon h numbers from 1 to 8 th prove that at leas
4. In how many wa be arranged ?
5. Show that the di he set Z
6. Consider the fun o f) and (f o g).
7. What is meant b
8. Provide one exa tion. Mention the degre also.
9. What is a monoid ? Explain.
10. Let (A, .) be a group. Show that $(ab)^{-1} = b^{-1}a^{-1}$

(10 x 3 = 30 Marks)

PART B

(Answer any one Question from each Module. Each question carries 14 Marks)

11.

(a) Show that S ! R is tautologically implied by (PVQ) " (P#R) " (Q#S)

(6 marks)

(b) Show that from

(ii) (!x)(F(x) " S(x)) # (y) (M(y) # W(y)).

(iii)(!y) (M(y) " ?ŠW(y)) the conclusion (x)(F(x) #?ŠS(x)) follows.

(8 marks)

OR

12.

(a) Show that (x) (P(x) ! Q(x)) " ((x)P(x) ! (!x) Q(x)) using indirect method of proof . !

(6 marks)!

(b) Discuss indirect method of proof . Show that the following premises are incorlsist

(i) If Jack misses many classes through illness, then he fails high school.

(ii) If Jack fails high school, then he is uneducated.

(iii)If Jack re d.

(iv)Jack mis a lot of books

(8 marks)

13.

(a) Explain binor ^{3}xin the expansion of $(x+y)^{12}$, (x+2y

(6 marks)

(b) How many 5 c ,3,4,5 using the digits wi repetition ?!

(i) How ma

(ii) How ma

(8 marks)

14.

(a) There are 8 and receives another return. No on How many ways are th distribute the

(6 marks)

(b) Six papers are set in an examination of which two are mathematical. Only examination will be conducted in a day. In how many different orders ,can the p be arranged so that

(i) Two mathematical papers are consecutive?

(ii) Two mathematical papers are not consecutive?

(8 marks)!

15.

(a) Let A = { 1,2,3,4,...11,12} and let R be the equivalence relation on A x A define
(a,b) R (c,d) iff a+d = b+c. Prove that R is an equivalence relation and finc
equivalence class of (2 ,5)

(8 marks)

(b) What is a chain lattice ? Explain. Also show that every chain is a distributive lattic

(6 marks)!

OR

16.

(a) Suppose f(x) = x+2 , g(x) = x-2, and h(x) = 3x for! R , where R is the set of rea
numbers. Find (g o f) , (f o g) , (f o f) and (g o g)

(8 marks)

(b) Let R and S be two relations on a set A . If R and S are symmetric, Prove that
is also symmetric.

(6 marks)!

17.

(a) Solve the rec ; Given a_0 = 0; a_1 = 41
using generat

(8 marks)

(b) Solve the rec generating function.

(6 marks)!

18.

(a) Solve a_n - 3a ons.

(8 marks)

(b) Use generati e relation $a_n = 2a_{n-1} + 2^n$;
with a_0 = 2.

(6 marks)

19.

(a) Prove that the set 'Q' of rational numbers other than 1 forms an abelian grou
respect to the operation ' * ' defined by a * b = a+b -ab.

(8 Marks)

(b) Show that the direct product of two group is a group.

(6 Marks)

OR

20.

(a) Show that the subgroup of a cyclic group is cyclic.

(8 Marks)

(b) Let (A,*) be a group. Show that (A,*) is an abelian group if and only if $a^2*b^2=(a*b)^2$ for all
ÔaÕ and ÔbÕ in A

(6 Marks)!

TEACHING PLAN

No	Contents	No of Lecture Hrs
	Module Ð 1 (Fundamentals of Logic) (9 hrs)	
1.1	Mathematical logic, Basic Connectives and Truth Table	1
1.2	Statements, Logical Connectives, Tautology, Contradiction	1
1.3	Logical Equivalence, The Laws of Logic	1
1.4	The Principle of duality, Substitution Rules	1
1.5	The implication, The Contrapositive, the Converse , the Inv	1
1.6	Logical Implic	1
1.7	The use of Q ti	1
1.8	Logically Eq Inverse	1
1.9	Logical Implic	1
	Module - 2 y) (9 hrs)	
2.1	The Pigeon-h	1
2.2	The Rule of S	1
2.3	Extension of	1
2.4	The Rule of P	1
2.5	Extension of	1
2.6	Combinations	1
2.7	The Binomia	1
2.8	The Principle of Inclusion and Exclusion Theorem (With Proof) Generalization of the Principle	1
2.9	Derangements	1
	Module - 3 (Relations and Functions) (9 hrs)	
3.1	Cartesian Product, Binary Relation, Function, Domain, Ra One to One Function Image - Restriction	1
3.2	Properties, Reachability Relations, Reflexi Relations,Symmetric Relations,Transitive relatio Antisymmetric Relations.	1

3.3	Partial Order relations	1
3.4	Equivalence Relation, Irreflexive Relations.	1
3.5	Partially ordered Set, Hasse Diagram.	1
3.6	Maximal-Minimal Element, Least Upper bound, Grea Lower Bound	1
3.7	Equivalence Relations and Partitions ,Equivalence Class	1
3.8	Lattice- Dual Lattice,sub lattice , Properties of glb and lub	1
3.9	Properties of ... att Bounded Latti	1
Module - 4 (Gen ... Relations) (9 hrs)		
4.1	Generating F	1
4.2	Exponential (	1
4.3	First Order ... nt Coefficients (	1
4.4	First Order ... nt Coefficients (	1
4.5	Homogeneou	1
4.6	Non homoger	1
4.7	Second order linear recurrence relations with constant coefficients	1
4.8	Homogeneous Solution	1
4.9	Non homogeneous Solution	1
Module - 5 (Algebraic Structures)(9 hrs)		
5.1	Algebraic System-Properties, Homomorphism a Isomorphism	1
5.2	Semi group , Monoid, Cyclic monoid	1

5.3	Sub semigroup and sub monoid	1
5.4	Homomorphism and Isomorphism of Semigroup, Monoids Groups	1
5.5	Elementary Properties, Subgroup, Symmetric group on symbols	1
5.6	The direct Product of two Groups	1
5.7	Group Homomorphism, Isomorphism, Cyclic group	1
5.8	Right coset, Left coset	1
5.9	LagrangeÕs	1

CST 201	DATA STRUCTURES	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	3	1	0	4	2019

Preamble: This course aims at moulding the learner to understand the various data struct their organization and operations. The course helps the learners to assess the applic different data structures and associated algorithms for solving real world problem which r to compare and select appropriate data structures to solve the problem efficiently. This introduces abstract concepts for data organization and manipulation using data structure stacks, queues, linkec [illegible] signing their own data s to solve practical appli [illegible] er Science.

Prerequisite: Topics co [illegible] EST 102)

CO1	Design an a [illegible] calculate the time/ complexities o [illegible] l: Apply)
CO2	Identify the s [illegible]) to represent a data required to b [illegible] onal problem and wr algorithm to f [illegible] em (Cognitive Knowledge Level: Apply)
CO3	Write an algo [illegible] al problem by selectin appropriate d [illegible] it a data item to be pr (Cognitive Kno [illegible]
CO4	Store a given [illegible] n to enable efficient ac data in the giv [illegible]
CO5	Select appropriate sorting algorithms to be used in specific circumstances (Cognitive Knowledge Level: Analyze)
CO6	Design and implement Data Structures for solving real world problems effic (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔	✔		✔						✔
CO2	✔	✔	✔	✔		✔						✔
CO3	✔	✔	✔	✔		✔						✔
CO4	✔	✔	✔	✔		✔						✔
CO5	✔	✔	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			✔
CO6	✔	✔	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			✔

Abs[illegible]			
PO#	B[illegible]	[illegible]	[illegible]Broad PO
PO1	Engineering K[illegible]	[illegible]	[illegible] and Sustainability
PO2	Problem Analy[illegible]	[illegible]	[illegible]
PO3	Design/Develo[illegible]	[illegible]	[illegible]d team work
PO4	Conduct inve[illegible] problems	[illegible]	[illegible]ion
PO5	Modern tool us[illegible]	[illegible]	[illegible]agement and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern

BloomÕs Category	Continuous Assessment Tests		End Semester Examination Marks
	Test1 (Percentage)	Test2 (Percentage)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40

Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance

Continuous Assessme

Continuous Assessme

Internal Examination F

Each of the two intern ... 50 marks

First Internal Examina ... ompleting the first half syllabus and the Sec ... ly conducted after co remaining part of the s

There will be two part ... stions (preferably, 2 q each from the compl ... ly covered module), h marks for each questi ... nts should answer all q from Part A. Part B ... ons each from the co modules and 1 question from the partly covered module), each with 7 marks. Out o questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questio each module, having 3 marks for each question. Students should answer all question contains 2 questions from each module of which a student should answer any one. Each can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module 1

Basic Concepts of Data Structures

System Life Cycle, Algorithms, Performance Analysis, Space Complexity, Time Comp
Asymptotic Notation, Complexity Calculation of Simple Algorithms

Module 2

Arrays and Searching

Polynomial representation using Arrays, Sparse matrix, Stacks, Queues-Circular Queues
Queues, Double Ende
Linear Search and Bir

Linked List and Memo

Self Referential Struc Linked List-Operatior
Linked List. Doubly L Queues using Linked
Polynomial representa
Memory allocation anc allocation schemes

Trees and Graphs

Trees, Binary Trees-T Tree Traversals, Binar
Trees- Binary Search
Graphs, Representati eadth First Search on
Applications of Graph

Module 5

Sorting and Hashing

Sorting Techniques Ð Selection Sort, Insertion Sort, Quick Sort, Merge Sort and Heap So
Hashing- Hashing Techniques, Collision Resolution, Overflow handling, Hashing funct
Mid square, Division, Folding, Digit Analysis

Text Book

1. Ellis Horowitz, Sartaj Sahni and Susan Anderson-Freed, Universities
   Fundamentals of Data Structures in C

Reference Books

1. Samanta D., Classic Data Structures, Prentice Hall India.
2. Richard F. Gilberg, Behrouz A. Forouzan, Data Structures: A Pseudocode Approa C, 2/e, Cengage Learning.
3. Aho A. V., J. E. Hopcroft and J. D. Ullman, Data Structures and Algorithms, Pe Publication.
4. Tremblay J. P. and P. G. Sorenson, Introduction to Data Structures with Applicatio McGraw Hill.
5. Peter Brass, Ad sity Press.
6. Lipschuts S., T aumÕs Series.
7. Wirth N., Algori e Hall.
8. Hugges J. K. a ogramming, PHI.
9. Martin Barrett, vare Design, John Wile

Sample Course Leve

Course Outcome1(C ion and calculate its time complexity.

Course Outcome 2(resent the polynomial $5x^4y^6+24x^3y^4-17x^2y^3+$ variate polynomials represented using li

Course Outcome 3(CO3):Create a Binary search Tree with node representing the following sequence 14, 15, 4, 18, 9, 16, 20, 17, 3, 7, 5, 2 and perform inorder, preorde and postorder traversals on the above tree and print the output.

Course Outcome 4(CO4):The size of a hash table is 7. The index of the hash table varies from 0 to 6. Consider the keys 89, 18, 49, 58, 25 in the order. Show how the key are stored in the hash table using Linear probing.

Course Outcome 5(CO5): In what circumstances does Quick Sort perform over Merge sort.

Course Outcome 6(CO6):Design a reservation system for railways that include waiting list. If the reservation is full ÒDisplay reservation fullÓ and put the passenger i in waiting list and give a waiting list number. If a passenger cancels the ticket, then th seat should be automatically allocated to the first passenger in the waiting list.

QP CODE: PAGES:3

Reg No:___________

Name:____________

APJ ABDUL KAL ... ESTER B.TECH

Max.Marks:100 Duration: 3 Hours

Ans

1. Calculate the frequency count of the statement x = x+1; in the following code seg

   for (i = 0; i< n; i++)

   for (j = 0; j< n; j*=2)

   x = x + 1;

2. What is the relevance of verification in System Life Cycle?
3. Write an algorithm to insert a new element in a particular position of an array.

4. Convert the expression ((A/(B-D+E))*(F-G)*H) to postfix form. Show each step in conversion including the stack contents

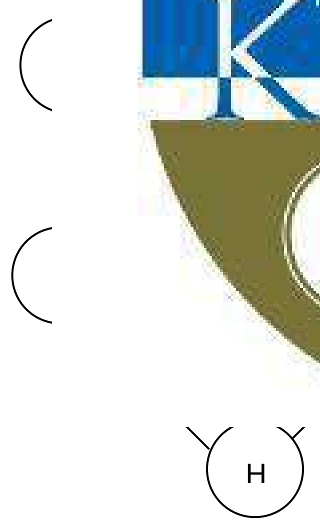
5. Write an algorithm to count the number of occurrences of a character in a linked lis node contains only one character)

6. Write an algorithm for best-fit method of memory allocation

7. Draw the binary tree whose sequential representation is given below

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	B	C		D	E					F	G	-	-	-

8. Find the Depth



9. Write an algorithm to arrange n numbers in nonincreasing order.

10. Let the size of a hash table is 10. The index of the hash table varies from 0 to 9. the keys 73, 54, 15, 48, 89, 66, 37, 18, 41, 22, 62 are mapped using modulo c Show how the keys are distributed using chaining method.

Part B

Answer any one Question from each module. Each question carries 14 Marks

11. a) Explain the System Life Cycle in detail (10)

b) How the performance of an algorithm is evaluated? (4)

OR

12. a) Write algorit [illegible] d Compare their time complexitie [illegible] (10)

b) Between O([illegible] hy? (4)

13. a) Write algorit [illegible] uble ended queue. Demonstrat [illegible] (10)

b) Compare an [illegible] eue (4

14. a) Write an alg [illegible] Priority Queue (8

b) Discuss an [illegible] refix expression (6

15. a) Write an alg [illegible] ed using linked list (1

b) How doubly linked list can be used to find palindromes ? (4)

OR

16. a) How is memory compaction (de-allocation) done in memory management ? (

b) Discuss the advantages and disadvantages of First-fit, Best-fit and Worst-fit alloc schemes (6)

17. a) List the properties of Binary Search Tree. Write an algorithm to search an eleme

from a Binary Search Tree (10)

b) Write an iterative algorithm for in-order traversal of a Binary Tree (4)

OR

18. a) Give algorithms for DFS and BFS of a graph and explain with examples (

b) How graphs can be represented in a Computer? (6

19. a) Write algorit (10

b) Illustrate the 38, 8, 0, 28, 45, -12, 8
42 (4)

20. a) With exampl for hashing

b) Apply the ha g on the data 2341,
2839, 430, 22 le (

Modul		(5 hours)
1.1	System Life	1 hour
1.2	Algorithms ,	1 hour
1.3	Space Complexity, Time Complexity	1 hour
1.4	Asymptotic Notation (Big O Notation)	1 hour
1.5	Complexity Calculation of Simple Algorithms	1hour
Module 2 :Arrays and Searching		(10 hours)
2.1	Polynomial representation using Arrays	1 hour
2.2	Sparse matrix (Lecture 1)	1 hour
2.3	Sparse matrix (Lecture 2)	1 hour

2.4	Stacks	1 hour
2.5	Queues, Circular Queues	1 hour
2.6	Priority Queues,	1 hour
2.7	Double Ended Queues,	1 hour
2.8	Conversion and Evaluation of Expressions (Lecture 1)	1 hour
2.9	Conversion and Evaluation of Expressions (Lecture 2)	1 hour
2.10	Linear Search and Binary Search	1 hour
Module 3 : Linked List and Memory Management		(12 hours)
3.1	Self Referen	1 hour
3.2	Dynamic Me	1 hour
3.3	Singly Linke	1 hour
3.4	Doubly Link	1 hour
3.5	Circular Lin	1 hour
3.6	Stacks usin	1 hour
3.7	Queues usi	1 hour
3.8	Polynomial	1 hour
3.9	Polynomial	1 hour
3.10	Memory de-	1 hour
3.11	Memory allo	1 hour
3.12	Best-fit and	1hour
Module 4 :Trees and Graphs		(8 hours)
4.1	Trees, Binary Trees	1hour
4.2	Tree Operations, Binary Tree Representation,	1hour
4.3	Tree Traversals	1hour
4.4	Binary Search Trees	1hour
4.5	Binary Search Tree Operations	1hour
4.6	Graphs, Representation of Graphs	1hour

4.7	Depth First Search and Breadth First Search on Graphs	1hour
4.8	Applications of Graphs	1hour
Module 5 : Sorting and Hashing		(10 hours)
5.1	Sorting Techniques Ð Selection Sort	1hour
5.2	Insertion Sort	1hour
5.3	Quick Sort	1hour
5.4	Merge Sort	1hour
5.5	Heap Sort	1hour
5.6	Hashing- Ha	1hour
5.7	Collision Re	1hour
5.8	Overflow ha	1hour
5.9	Hashing fun	1hour
5.10	Folding and	1hour

CST 203	Logic System Design	Category	L	T	P	Credit	Year of Introduction
		PCC	3	1	0	4	2019

Preamble: The objective of the course is to familiarize learners with the basic conce Boolean algebra and digital systems. This course covers the design of simple combinati sequential logic circuits, representation and arithmetic algorithms for Binary, BCD (I Coded Decimal) and Floating point numbers which in turn are helpful in underst organization & design of a computer system and understanding how patterns of ones a can be used to store information on computers, including multimedia data.

Prerequisite: Nil

Course Outcomes: Afte ... ill be able to

CO#	
CO1	Illustrate dec ... number systems, p conversions ... complementation, a subtraction, ... Cognitive Knowledge level: Unders
CO2	Simplify a giv ... ational circuit to imple the simplified ... ive Knowledge level: Apply)
CO3	Design comb ... tors, Decoders, Mag Comparators ... rogrammable Logic D ROM and PL
CO4	Design sequ ... Shift Registers. (Cognitive Knowledge le
CO5	Use algorithms to perform addition and subtraction on binary, BCD and floating numbers (Cognitive Knowledge level: Understand)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										✓
CO2	✓	✓	✓	✓		✓						✓
CO3	✓	✓	✓	✓		✓						✓
CO4	✓	✓	✓	✓		✓						✓
CO5	✓	✓	✓									✓

Abstr		litation
PO#	Br	road PO
PO1	Engineering Kı	nd Sustainability
PO2	ProblemAnalys	
PO3	Design/Develo	team work
PO4	Conduct inves problems	n
PO5	Modern tool us	ement and Finance
PO6	The Engineer	ing

Assessment Pattern:

BloomÕs Catego			End Semester mination Marks (%)
Remember	20	20	20
Understand	35	35	35
Apply	45	45	45
Analyse			
Evaluate			
Create			

Mark Distribution:

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:
Attendance : 10 marks
Continuous Assessment Test : 25 marks
Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:
Each of the two internal examinations has to be conducted out of 50 marks. First series [illegible] be preferably conduct [illegible] bus and the second se[illegible] shall be preferably co [illegible] he syllabus. There will [illegible] parts: Part A and Pa[illegible] [illegible]ly, 2 questions each [illegible] completed modules a[illegible] [illegible]dule), having 3 marks [illegible] question adding up t[illegible] [illegible]wer all questions from [illegible] Part B contains 7 qu[illegible] [illegible] the completed module[illegible] question from the part [illegible] [illegible]ut of the 7 questions, a[illegible] should answer any 5.

End Semester Examir[illegible]
There will be two part [illegible] [illegible]estions with 2 questio[illegible] each module, having [illegible] [illegible]d answer all question[illegible] contains 2 questions f[illegible] [illegible] answer any one. Each [illegible] can have maximum 2 [illegible]

Number systems, Ope[illegible]

Decimal, Binary, Octal and Hexadecimal Number Systems- Number Base Conve[illegible] Addition, Subtraction, Multiplication and Division of binary numbers. Representatio[illegible] negative numbers- Complements, Subtraction with complements. Addition and subtra[illegible] BCD, Octal and Hexadecimal numbers. Binary codes- Decimal codes, Error detectio[illegible] Reflected code, Character coding schemes Ð ASCII, EBCDIC.

Module II

Boolean Algebra

Postulates of Boolean Algebra. Basic theorems and Properties of Boolean Algebra. Functions - Canonical and Standard forms. Simplification of Boolean Functions- Karnaugh- Map Method (upto five variables), DonÕt care conditions, Product o[illegible]

simplification, Tabulation Method. Digital Logic Gates- Implementation of Boolean functi
using basic and universal gates.

Module III

Combinational Logic Circuits

Design Procedure & Implementation of combinational logic circuits- Binary adders subtractors, Binary Parallel adder, Carry look ahead adder, BCD adder, Code con Magnitude comparator, Decoder, Demultiplexer, Encoder, Multiplexer, Parity gene Checker.

Module IV

Sequential logic circuits:

Flip-flops- SR, JK, T and D. Triggering of flip-flops- Master slave flip- flops, Edge- trigge flip- flops. Excitation table and characteristic equation. Registers- register with parallel Counter design: Asyn rs, timing sequences ar diagrams. Synchronou counter.

Shift registers

Shift registers Ð Seri irectional Shift Register Parallel load. Ring cou d state diagrams.

Arithmetic algorithms

Algorithms for additi signed magnitude and complement represe traction of BCD num Representation of flo and subtraction of floa point numbers.

Programmable Logic
ROM. Programmable circuits using PLA.

Text Books:

1. M. Morris Mano, Digital Logic & Computer Design, 4/e, Pearson Education, 2013
2. Thomas L Floyd, Digital Fundamentals, 10/e, Pearson Education, 2009.
3. M. Morris Mano, Computer System Architecture, 3/e, Pearson Education, 2007.

Reference Books:

1. M. Morris Mano, Michael D Ciletti , Digital Design With An Introduction to the Verilog HDL, 5/e, Pearson Education, 2013.
2. Donald D Givone, Digital Principles and Design, Tata McGraw Hill, 2003

Sample Course Level Assessment Questions

Course Outcome1(CO1): Perform the following number base conversions:

a) $(250.55)_{10}$ to Hexadecimal b) $(357)_{8}$ to Decimal

Course Outcome 2(CO2): Given a Boolean function F and don't care conditions D, Karnaugh map obtain the simplified expression in (i) SOP and (ii) POS:

$$F(A,B,C,D) = A'B'D' + A'CD + A'BC$$
$$D(A,B,C,D) = A'BC'D + ACD + AB'D$$

Course Outcome 3(CO3): Design a BCD to Excess-3 Code Convertor.

Course Outcome 4(CO4): Design a 4- bit binary ripple counter.

Course Outcome 5(CO5): Demonstrate floating-point addition algorithm.

Model Question Paper

QP CODE: PAGES: 2

Reg No:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 203

Course name : LOGIC SYSTEM DESIGN

Max Marks: 100 Duration: 3 Hours

PART-A

(Ans ... marks)

1. Represent the ... mal and perform
   addition of thes...
2. Subtract $(1101)_2$ ... $)_2$ 1's complement arithmetic.
3. Find the dual a ... + B(A + B').
4. Using K-map, r...
5. Design a half s...
6. Design a comb ... al digit by 5 represent BCD. The outp ... be obtained from the lines without us...
7. Differentiate b ... unter.
8. Construct D flip- flop using NAND gates. Also give its truth table.
9. Explain how a shift register is used for serial data transfer?
10. Write short notes on ROM.

PART-B

(Answer any one full question from each module) (14X5=70

11. (a) Perform the following operations using 2Õs complement arithmetic: (8)

(i) 88_{10} + $(\$ 37)_{10}$ (ii) $(\$ 20)_{10}$ + $(\$ 12)_{10}$

(b) Perform the following base conversions: (i) $(101011.11)_2$ to octal (6)

(ii) $(3F9B)_{16}$ to binary (iii) $(121)_{10}$ to binary (iv) $(3077)_8$ to binary

OR

12. (a) Find the 12 bit 2!s complement representation of the following decimal numbers. (6)

(i) Ð 97 (ii) Ð 224 (iii) - 197.5

(b) Perform the following operations (8)

(i)(520) +(488) (ii)(520) $ (488)

13. (a) Prove that (4)

(

(b) Using K-ma products form, (10)
using the

F(w

d(w

14. (a) Simplify th method. (8)

(i) F

(ii) F

(b) Convert th (6)

(i) F

(ii) F(x, y, z) = #(0,3,6,7)

(iii) F(A, B, C, D) = #(0,1,2,3,4,6,12

15. (a) Implement Full adder circuit using NAND gate only. (4)

(b) Design a code converter for converting BCD to Excess 3 code (10)

OR

16. (a) With a neat diagram explain 4-bit carry look-ahead adder. (6)

(b) Design a Gray to binary code converter using a 4x1 MUX. Draw circuit diagram and explain. (8)

17. (a) Design a counter that count the states 0,3,5,6,0É using T flip- flops. (10)

(b) Write the characteristics equation, excitation table of JK, T and D flipfl (4)

OR

18. (a) Explain race around condition and how it can be avoided. (6)

(b) Design a synchronous Binary Up-Down Counter. (8)

19. (a) With a neat diagram explain universal shift register. (8)

(b) Explain Jo (6)

20. (a) Write algor n. (8)

(b) Implement $_2$ = BC+ AC (6)
using minir

Module 1: Number sy		(7 hours)
1.1	Number Syster l number sys Number Base	1 hour
1.2	Binary Arithme Division of Binary Numbers. (Lecture 1)	1 hour
1.3	Addition, Subtraction, Multiplication & Division of Binary Numbers. (Lectu 2)	1 hour
1.4	Representation of Negative Numbers- Complements, subtraction complements.	1 hour
1.5	BCD Arithmetic: Addition and Subtraction of BCD Numbers	1 hour
1.6	Octal and Hexadecimal Arithmetic: Addition & Subtraction of Octal ar Hexadecimal Numbers.	1 hour

1.7	Binary Codes: Decimal Codes, Error detection codes, Reflected c Character Coding Schemes-ASCII, EBCDIC	1 hour
Module 2: Boolean Algebra		(9 hours)
2.1	Introduction to Boolean Algebra: Postulates of Boolean Algebra	1 hour
2.2	Basic theorems and Properties of Boolean Algebra	1 hour
2.3	Boolean Functions: Canonical and Standard Forms	1 hour
2.4	Simplification of Boolean Functions: Karnaugh -Map Method (upto fi variables), DonÕt care conditions (Lecture 1)	1 hour
2.5	Simplification of Boolean Functions: Karnaugh -Map Method (upto fi variables), DonÕ	1 hour
2.6	Product of sum	1 hour
2.7	Tabulation met	1 hour
2.8	Digital Logic ... XOR, XNOR Implementation ... rsal gates. (L 1)	1 hour
2.9	Digital Logic ... XOR, XNOR Implementation ... rsal gates. (L 2)	1 hour
Module 3: Combinati		(9 hours)
3.1	Design Proced ... its	1 hour
3.2	Binary Adders: Implementation	1 hour
3.3	Binary Subtractors: Implementation of Half Subtractor, Full Subtractor	1 hour
3.4	Implementation of Binary Parallel Adder ,Carry look ahead Adder, BCD A (Lecture 1)	1 hour
3.5	Implementation of Binary Parallel Adder ,Carry look ahead Adder, BCD A (Lecture 2)	1 hour

3.6	Implementation of Various Combinational Circuits: Code Converters, Magnitude Comparator	1 hour
3.7	Implementation of Decoder, Demultiplexer	1 hour
3.8	Implementation of Encoder, Multiplexer	1 hour
3.9	Implementation of Parity Generator/Checker	1 hour
Module 4: Sequential logic circuits:		(9 hours)
4.1	Flip flops: SR, JK, T and D flip flops (Lecture 1)	1 hour
4.2	SR, JK, T and [illegible]	1 hour
4.3	Triggering of f[illegible] ggered flip-flo[illegible] (Lecture 1)	1 hour
4.4	Triggering of f[illegible] ggered flip-flo[illegible] (Lecture 2)	1 hour
4.5	Excitation table [illegible]	1 hour
4.6	Registers- Reg[illegible]	1 hour
4.7	Counter Design [illegible] Asynchronous [illegible] sequences an[illegible] diagrams. (Lec[illegible]	1 hour
4.8	Asynchronous [illegible] sequences an[illegible] diagrams. (Lec[illegible]	1 hour
4.9	Synchronous counters- Binary Up- down counter, BCD counter	1 hour
Module 5: Shift registers, Arithmetic algorithms & PLDÕs		(11 hours)
5.1	Shift Registers - Serial In Serial Out, Serial In Parallel Out.	1 hour
5.2	Bidirectional Shift Register with Parallel load	1 hour

5.3	Shift register counters - Ring Counter, Johnson Counter- timing seque and state diagrams	1 hour
5.4	Arithmetic Algorithms: Algorithm for addition and subtraction of binar numbers in Signed magnitude and 2Õs complement representations (Le	1 hour
5.5	Algorithm for addition and subtraction of binary numbers in Signed magn and 2Õs complement representations (Lecture 2)	1 hour
5.6	Algorithm for addition and subtraction of BCD numbers	1 hour
5.7	Representation of floating point numbers (IEEE Standard representations	1 hour
5.8	Algorithms for floating point addition and subtraction	1 hour
5.9	Programmable	1 hour
5.10	PLA, Implemen)	1 hour
5.11	PLA, Implemen)	1 hour

CST 205	OBJECT ORIENTED PROGRAMMING USING JAVA	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	3	1	0	4	2019

Preamble: The purpose of this course is to enable learners to solve problems by bre down to object level while designing software and to implement it using Java. This course Object Oriented Principles, Object Oriented Programming in Java, Inheritance, Ex handling, Event handling, multithreaded programming and working with window-l graphics. This course helps the learners to develop Desktop GUI Applications, applications, Enterpris eb based Applications.

Prerequisite: Topics c N C (EST 102)

Course Outcomes: Aft will be able to

CO1	Write Java ncepts - classes, c constructors sm (Cognitive Know Level: Apply
CO2	Utilise dataty packages & interfaces Output Strea (Cognitive Knowledge Apply)
CO3	Illustrate ho a using exception ha mechanism (
CO4	Write applica g and database conne (Cognitive K
CO5	Write Graphical User Interface based application programs by utilising handling features and Swing in Java (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓						✓		✓
CO4	✓	✓	✓	✓								✓
CO5	✓	✓	✓	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			✓

Abs…		…ation
PO#	Broa…	…ad PO
PO1	Engineering Kno…	…stainability
PO2	Problem Analysi…	
PO3	Design/Develop…	…work
PO4	Conduct investi… problems	
PO5	Modern tool usa…	… and Finance
PO6	The Engineer ar…	

Assessment Pattern

BloomÕs Category	Continuous Assessment Tests		End Semester Examination
	Test1 (Marks %)	Test2 (Marks %)	Marks (%)
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance

Continuous Assessme

Continuous Assessme

Internal Examination F

Each of the two intern ... 50 marks

First series test shall ... e first half of the syllal the second series te ... npleting remaining pai syllabus.

There will be two part ... stions (preferably, 2 qu each from the comple ... tly covered module), h marks for each questi ... nts should answer all q from Part A. Part B ... ons each from the coi modules and 1 question from the partly covered module), each with 7 marks. Out o questions in Part B, a student should answer any 5.

End Semester Examination Pattern:There will be two parts; Part A and Part B. Part A cont 10 questions with 2 questions from each module, having 3 marks for each question. S should answer all questions. Part B contains 2 questions from each module of which a should answer any one. Each question can have maximum 2 sub-divisions and carry 14 r

SYLLABUS

Object Oriented Programming Using Java

Module 1

Introduction:

Approaches to Software Design - Functional Oriented Design, Object Oriented Design Study of Automated Fire Alarm System.

Object Modeling Using Unified Modeling Language (UML) Đ Basic Object Oriented conc UML diagrams, Use case model, Class diagram, Interaction diagram, Activity diagram, chart diagram.

Introduction to Java Ja ... Environment, Develop Platforms -Standard, ... ava compiler, Bytecode applet, Java Buzzword ... bage Collection, Lexical

Core Java Fundament

Primitive Data types ... ters, Boolean. Literals, Conversion and Castin

Operators -Arithmetic ... Operators, Boolean Lo Operators, Assignmen ... Operator Precedence.

Control Statements - S ... nd Jump Statements.

Object Oriented Pro ... Declaring Objects, Obj Reference, Introductio ... thod Overloading, Usin Objects as Paramete ... Control, Static Member Variables, Inner Class ... gth Arguments.

Inheritance - Super C ... Members, Calling Order Constructors, Method Overriding, the Object class, Abstract Classes and Methods, final, usin with Inheritance.

Module 3

More features of Java:

Packages and Interfaces - Defining Package, CLASSPATH, Access Protection, Im Packages, Interfaces.

Exception Handling - Checked Exceptions, Unchecked Exceptions, try Block and catch Clause, Multiple catch Clauses, Nested try Statements, throw, throws and finally.

Input/Output - I/O Basics, Reading Console Input, Writing Console Output, PrintWriter C Object Streams and Serialization, Working with Files.

Module 4

Advanced features of Java:

Java Library - String Handling Ð String Constructors, String Length, Special String Oper Character Extraction, String Comparison, Searching Strings, Modifying Strings, using val Comparison of StringBuffer and String.

Collections framework –Collections overview, Collections Interfaces- Collection Interface, Interface.

Collections Class Ð ArrayList class. Accessing a Collection via an Iterator.

Event handling –Event Handling Mechanisms, Delegation Event Model, Event Classes, S of Events, Event Listener Interfaces, Using the Delegation Model.

Multithreaded Progra ... ain Thread, Creating T Creating Multiple Thre ... g and Stopping Threac

Graphical User Interfa

Swings fundamentals ... ller (MVC), Swing Cor Components and Cc ... g in Swings, Swing Managers, Exploring ... , JTextField.

Java DataBase Conn ... Executing Queries Ð c table, delete, insert, se

Text Books:

1. Herbert Schild ... McGraw Hill, 2011.
2. Rajib Mall, Fu ... PHI, 2014.
3. Paul Deitel, H ... ojects 11th Edition, Pearsor 2018.

Reference Books:

1. Y. Daniel Liang, Introduction to Java Programming, 7/e, Pearson, 2013.
2. Nageswararao R., Core Java: An Integrated Approach, Dreamtech Press, 2008.
3. Flanagan D., Java in A Nutshell, 5/e, O'Reilly, 2005.
4. Barclay K., J. Savage, Object Oriented Design with UML and Java, Elsevier, 2004.
5. Sierra K., Head First Java, 2/e, O'Reilly, 2005.
6. Balagurusamy E., Programming JAVA a Primer, 5/e, McGraw Hill, 2014.

Sample Course Level Assessment Questions

Course Outcome1(CO1): For the following passage develop UML diagrams and then implement it as a Java program in accordance with your UML design.

Passage: College Office collects semester fee and college bus fee for each student. clerk at the college office collects the fees from each student. The bus fee is calculate depending on the distance of the corresponding bus stop from the college. The semes fee varies depending upon the semester as well as branch of each student. Students supposed to pay the fees in full. Economically backward students are eligible for 50% discount in semester fee. The consolidated fees receipt is issued to each student by clerk, which contair semester and branch student along with c and view the details c fees remitted and d l clerk level login to th system. Clerk is abl atus of fees payment each student.

Course Outcome 2 a post fix expression containing two opera k should be implement as a separate entity

Course Outcome 3(art, run, sleep and join methods in Thread c

Course Outcome 4(arate buttons to add, delete and display s semester and branch study based on stud

Course Outcome 5(CO5):Using Swing create a JFrame with a JLabel and two JButtons. Set the texts of JButtons as ÒYesÓ and ÒNoÓ respectively. Set the JLabelÕ to the text of the button currently being pressed. Initially the JLabelÕs text is blank.

Model Question Paper

QP CODE: PAGES:3

Reg No:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 205

Cours ... g Java

Max.Marks:100 Duration: 3 Hours

A ... 3 Marks

1. Briefly explain ... Java.
2. Describe the c ... ava program.
3. Explain the co
4. What is the us
5. Explain the co
6. Explain any tw
7. Distinguish the ... comparing String type?
8. What are Colle ... nterface in Java.
9. Explain any two properties of Swing components in Java.
10. Explain JLabel component. With suitable examples explain any two of its construc

Part B

Answer any one question completely from each module

11.

(a) Describe in detail any three Object Oriented Programming principles. Illustrate suitable examples.

(9)

(b) What is Java Runtime Environment? What is the role of Java Virtual Machine in

(5)

OR

12.

(a) Compare and contrast Java standard edition and Java enterprise edition.

(5)

(b) Why is Java considered to be platform independent? What is the role of Bytec making Java platform independent?

(9)

13.

(a) Explain in

(8)

(b) Explain au ... example. What are the conditions

(6)

14.

(a) Using a su ... between private and public members in

(8)

(b) Is it possib ... hod? Give justification fo your answe

(6)

15.

(a) Explain in ... streams with suitable samples.

(6)

(b) Describe in detail about exception handling, try block and catch clause with the help of a suitable Java program.

(8)

OR

16.

(a) Explain object streams in Java. Explain the role of Serializable interface w suitable code sample.

(8)

(b) Explain throw, throws and finally constructs with the help of a Java program.

(6)

17.

(a) Describe in detail the creation of a thread using the Runnable interface ar Thread class with suitable examples.

(10)

(b) Explain List Interface. Mention any two exceptions thrown by its methods.

(4)

OR

18.

(a) Explain in detail the Delegation Event model for event handling in Java.

(7)

(b) Write a simple program by extending appropriate class to demonstrate the work threads in j

(7)

19.

(a) Write a Jav el and JButton by adding to JFrame.

(7)

(b) Explain st aBase Connectivity in programs.

(7)

20.

(a) Explain the

(7)

(b) Write a Jav add student details to i JDBC.

(7)

Teaching Plan		
Module 1 : Introduction		(8 hours)
1.1	Approaches to Software Design- Functional Oriented Design, Ol Oriented Design, Case Study of Automated Fire Alarm System.	1 hour
1.2	Object Modeling Using UML Ð Basic object oriented concepts	1 hour
1.3	Basic object oriented concepts	1 hour
1.4	UML diagrams, Use case model	1hour
1.5	Class diagra	1hour
1.6	Activity diag	1hour
1.7	Java progr ... nvironm Developmen ... ava com Bytecode	1hour
1.8	Java applet ... e, Comi Garbage Co	1hour
M		(11 hours)
2.1	Core Java ... gers, Flo Point Types,	1 hour
2.2	Literals, Typ ... ays, Str Vector class	1 hour
2.3	Operators: ... , Relati Operators, ... nt Oper Conditional (Ternary) Operator, Operator Precedence.	1 hour
2.4	Control Statements: Selection Statements, Iteration Statemen Jump Statements.	1 hour
2.5	Object Oriented Programming in JavaClass Fundamentals, Declari Objects, Object Reference, Introduction to Methods	1 hour
2.6	Constructors,this Keyword, Method Overloading, Using Objects Parameters	1 hour
2.7	Returning Objects, Recursion, Access Control, static Members	1 hour

2.8	Final Variables, Inner Classes, Command-Line Arguments, Var Length Arguments	1 hour
2.9	Inheritance : Super class, Sub class, the keywords super, protected Members,	1 hour
2.10	Calling Order of Constructors, Method Overriding, the Object clas	1 hour
2.11	Abstract Classes and Methods, Using final with Inheritance	1 hour
Module 3: More features of Java		(8 hours)
3.1	Packages and Interfaces: Defining Package, CLASSPATH, A Protection, Importing Packages	1 hour
3.2	Interfaces	1 hour
3.3	Input / Outp ... ting Con Output, Prin	1 hour
3.4	Object Strea	1 hour
3.5	Working wit	1 hour
3.6	Exception H ... xception try Block and ca	1 hour
3.7	Multiple catc	1 hour
3.8	throw, throw	1 hour
M		(10 hours)
4.1	Java Library ... tring Le Special Strir	1hour
4.2	Character ... ing Stri Modifying Strings Using valueOf( ), Comparison of String Bu and String.	1hour
4.3	Collections framework Ð Collections overview, Collections Interfa Collection Interface	1hour
4.4	List Interface, Collections Class Ð ArrayList Class	1hour
4.5	Accessing Collections via an Iterator.	1hour
4.6	Event handling: Event Handling Mechanisms, Delegation E Model	1hour
4.7	Delegation Event Model, Event Classes	1hour

4.8	Sources of Events, Event Listener Interfaces, Using the Deleg Model	1hour
4.9	Multithreaded Programming: The Java Thread Model, The M Thread, Creating Thread	1hour
4.10	Creating Multiple Threads, Synchronization, Suspending, Resu and Stopping Threads.	1hour
Module 5: Graphical User Interface and Database support of Java		(8 hours)
5.1	Swings fundamentals, Swing Key Features	1hour
5.2	MVC, Swing Controls, Components and Containers	1hour
5.3	Swing Packa	1 hour
5.4	Swing Layou	1hour
5.5	Exploring Sv JTextFie	1 hour
5.6	JDBC overv create delete, inser prerequi	1hour
5.7	Creating anc nsert, se	1 hour
5.8	Creating anc nsert, se	1 hour

CSL 201	DATA STRUCTURES LAB	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	0	0	3	2	2019

Preamble: The aim of the Course is to give hands-on experience for Learners on crea using different Data Structures. Data Structures are used to process data and arrang different formats for many applications. The most commonly performed operations o structures are traversing, searching, inserting, deleting and few special operations like and sorting.

Prerequisite: Topics covered under the course Programming in C (EST 102)

CO1	Write a time/s ... lists/trees/graphs to p necessary fu ... er requirements (Cognitive Knowledge Lev
CO2	Write a time/s ... rds based on a given the record (Cog
CO3	Examine a ... pace complexity and complexities ... pply)
CO4	Design and i ... esent given data (Cognitive Knowledge Lev
CO5	Write a time/ ... metic expression fro notation to an
CO6	Write a prog ... y Allocation and Gar Collection (Co

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓		✓		✓		✓		✓
CO2	✓	✓	✓	✓				✓		✓		✓
CO3	✓	✓	✓	✓				✓		✓		✓
CO4	✓	✓	✓	✓				✓		✓		✓
CO5	✓	✓	✓	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	✓		✓
CO6	✓	✓	✓	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	✓		✓

Abs[illegible]			
PO#	B[illegible]	[illegible]	[illegible]Broad PO
PO1	Engineering Kn[illegible]	[illegible]	[illegible] and Sustainability
PO2	Problem Analys[illegible]	[illegible]	[illegible]
PO3	Design/Develop[illegible]	[illegible]	[illegible]d team work
PO4	Conduct inve[illegible] problems	[illegible]	[illegible]ion
PO5	Modern tool us[illegible]	[illegible]	[illegible]agement and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern

BloomÕs Category	Continuous Assessment Test (Internal Exam)Percentage	End Semester Examination Percentage
Remember	20	20
Understand	20	20
Apply	60	60
Analyse		
Evaluate		
Create		

Mark Distribution

Total Marks			ESE Duration
150			3 hours

Continuous Internal E

Attendance

Continuous Evaluati

Continuous Assessment Test : 15 marks

Viva-voce : 15 marks

Internal Examination Pattern: The marks will be distributed as Algorithm 30 marks, Prog 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks which will be convertec 15 while calculating Internal Evaluation marks.

End Semester Examination Pattern:The marks will be distributed as Algorithm 30 mar Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks will be conve of 75 for End Semester Examination.

Operating System to Use in Lab : Linux

Compiler/Software to Use in Lab : gcc

Programming Language to Use in Lab : Ansi C

Fair Lab Record:

All Students attending the Data Structures Lab should have a Fair Record. The fair recor be produced in the University Lab Examination. Every experiment conducted in the lab be noted in the fair record. For every experiment in the fair record the right hand page contain Experiment Heading, Experiment Number, Date of Experiment, Aim of Exper Data Structure used and the operations performed on them, Details of Experiment ir algorithm and Result contain a print out of tl used for the experime put.

1. Implementatior arrays**
2. Implementatior EUE and Circular Queu using arrays**
3. Application pro n from one notation to another notatio
4. Implementatior
5. Implementatior linked list.pression
6. Implementatior
7. Representation of polynomials using linked list, addition and multiplication of polynomials. **
8. Implementation of binary trees using linked lists and arrays- creations, insertion, d and traversal. **
9. Implementation of binary search trees Ð creation, insertion, deletion, search
10. Any application programs using trees
11. Implementation of sorting algorithms Ð bubble, insertion, selection, quick, merge s

and heap sort.**

12. Implementation of searching algorithms Đ linear search, binary search.**

13. Representation of graphs and computing various parameters (in degree, out degre adjacency list, adjacency matrix.

14. Implementation of BFS and DFS for each graph representations.**

15. Implementation of hash table using your own mapping functions and observe collis and overflow resolving schemes.**

16. Simulation of fi

17. Simulation of a ... or using doubly linked
** mandatory.

DAT/ ... ONS

1. Write a program to ... array. Calculate the sur two polynomials a ... olynomial and the res polynomial.

2. C Write a program ... te a function to conver matrices to tuple fc ... the two matrices repre in tuple form and c ... in tuple form and displ sum in tuple form.

3. Write a program to enter two matrices in normal form . Write a function to conver matrices to tuple form and display it. Also find the transpose of the two matrices repre in tuple form and display it. Find the sum of the two matrices in tuple form and displ sum in tuple form.

4. Implement a circular queue using arrays with the operations:
   4.1. Insert an element to the queue.
   4.2. Delete an elements from the queue.
   4.3. Display the contents of the queue after each operation.

5. Implement a Queue using arrays with the operations:

5.1. Insert elements to the Queue.
5.2. Delete elements from the Queue.
5.3. Display the contents of the Queue after each operation.

6. Implement a Stack using arrays with the operations:
    6.1. Pushing elements to the Stack.
    6.2. Popping elements from the Stack
    6.3. Display the contents of the Stack after each operation.

7. Implement a Priority Queue using arrays with the operations:
    7.1. Insert elements to the Priority Queue.
    7.2. Delete elements from the Priority Queue.
    7.3. Display the co … ation.

8. Implement a Doub … ations:
    8.1. Insert elemen
    8.2. Insert elemen
    8.3. Delete eleme
    8.4. Delete eleme
    8.5. Display the qu

9. Using stack conv … sion and evaluate the expression.

10. Write a program to … ession using stacks.

11. Convert an infix ex … ng a stack

12. Write a menu drive … ations on a Linked List
    12.1. Display
    12.2. Insert at Beg
    12.3. Insert at End
    12.4. Insert at a specified Position
    12.5. Delete from Beginning
    12.6. Delete from End
    12.7. Delete from a specified Position

13. Implement a stack using linked list with the operations:
    13.1. Push elements to the queue.
    13.2. Pop elements from the queue.
    13.3. Display the queue after each operation.

14. Implement a Queue using linked list with the operations:

14.1.Insert an elements to the queue.
14.2.Delete an elements from the queue.
14.3.Display the queue after each operation.

15. Write a program to reverse the content of queue using stack

16. Write a program to read two polynomials and store them using linked list. Calculate th of the two polynomials and display the first polynomial, second polynomial and the res polynomial.

17. Write a program to read two polynomials and store them using linked list. Find the pr of two polynomials and store the result using linked list. Display the resultant polynomi

18. Write a program fc iables using linked list.

19. The details of stuc ored in a linked list. Writ functions for the
    19.1. Insert
    19.2. Delete
    19.3. Search
    19.4. Sort on the
    19.5. Display the

20. Create a Doubly L r from the string. Check given string is pal

21. Create a binary tre
    21.1. Insert a n
    21.2. Inorder tr
    21.3. Preorder t
    21.4. Postorder traversal.
    21.5. Delete a node.

22. Write a program to create a binary search tree and find the number of leaf nodes

23. Create a binary search tree with the following operations:
    23.1. Insert a new node .
    23.2. Inorder traversal.
    23.3. Preorder traversal.
    23.4. Postorder traversal.
    23.5. Delete a node.

24. Write a program to sort a set of numbers using a binary tree.

25. Represent any given graph and
    25.1. Perform a depth first search .
    25.2. Perform a breadth first search

26. Create a text file containing the name, height, weight of the students in a class. F Quick sort and Merge sort on this data and store the resultant data in two separate fil write the time taken by the two sorting methods into the respective files.

    Eg. Sony Mathew 5.5 60
    A
    F

27. Write a program tc find a particular numbe the sorted set usi

28. Implement a Hash f hash table be 10 so th index varies from

29. Implement a Hash esolution

CSL 203	OBJECT ORIENTED PROGRAMMING LAB (IN JAVA)	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	0	0	3	2	2019

Preamble: The aim of the course is to provide hands-on experience to the learners on object oriented concepts in Java Programming. This course helps the learners to enhan… pability to design and implement various Java applications for real world problems.

Prerequisite: Topics covered under the course Programming in C (EST 102)

Course Outcomes:

At the end of the cou…

CO1	Implement … ıctors, inheritance, m… overloadin… ognitive Knowledge L… Apply)
CO2	Implement … perators, control stat… built in p… ıms and Files (Cog… Knowledge…
CO3	Implement … using exception ha… (Cognitive …
CO4	Implement … ıltithreading and da… connectivit…
CO5	Implement … programs by utilizing handling fe… ːdge Level: Apply)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓			✓		✓		✓
CO2	✓	✓	✓	✓	✓			✓		✓		✓
CO3	✓	✓	✓	✓	✓			✓		✓		✓
CO4	✓	✓	✓	✓	✓			✓		✓		✓
CO5	✓	✓	✓	✓	✓			✓		✓		✓

Abstract POs deÞned by National Board of Accreditation			
PO#	Broad PO	PO#	Broad PO
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern to		agement and Finance
PO6	The Engi		rning

Assessment Pattern

BloomÕs Catego		ester Examination ercentage)
Remember		20
Understand		20
Apply		60
Analyse		
Evaluate		
Create		

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 15 marks
Continuous Evaluation in Lab	: 30 marks
Continuous Assessment Test	: 15 marks
Viva-voce	: 15 marks

Internal Examination Pattern: The marks will be distributed as Algorithm 30 marks, Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks which will be co verted out of 15 while

End Semester Exami d as Algorithm 30 marks, Program 20 m Total 100 marks will b converted out of 75 fo

Operating System to U

Compiler/Software to ose, NetBeans,

Programming Langua

Fair Lab Record:

All Students attendin (in Java) should have Record. The fair reco b Examination. Every ment conducted in th r every experiment in record the right hand page should contain Experiment Heading, Experiment Number, Experiment, Aim of Experiment, Operations Performed, Details of Experiment including rithm and Result of Experiment. The left hand page should contain a print out of the co for the experiment and sample output obtained for a set of input.

SYLLABUS

The syllabus contains six sessions (A, B, C, D, E, F). Each session consists of three Java exercises, out of which at least two questions are mandatory.

(A) Basic programs using datatypes, operators, and control statements in Java.

1) Write a Java program that checks whether a given string is a palindrome or not.
   Ex: MALAYALAM is palindrome.
2) Write a Java Program to find the frequency of a given character in a string. **
3) Write a Java pro

(B) Object Oriented P ... e of constructors, inhe method overloading & ... ction:

4) Write a Java p ... mployee' having the fo members: Nam ... lso has a method nam Salary( )' which ... asses 'Officer' and 'Ma inherits the 'Em ... asses have data memb cialization' and ... e, age, phone number, and salary to a ... ct of both of these clas print the same.
5) Write a java pr ... Shape that contains a method named ... named Rectangle, Tria Hexagon such ... ss Shape. Each one of es contains onl ... the number of sides in en geometrical ... phism). **
6) Write a Java program to demonstrate the use of garbage collector.

(C) Handling different types of files as well as input and output management methods:

7) Write a file handling program in Java with reader/writer.
8) Write a Java program that read from a file and write to file by handling all file related ex- ceptions. **
9) Write a Java program that reads a line of integers, and then displays each integer sum of all the integers (Use String Tokenizer class of java.util). **

(D) Exception handling and multi-threading applications:

10) Write a Java program that shows the usage of try, catch, throws and finally. **
11) Write a Java program that implements a multi-threaded program which has three First thread generates a random integer every 1 second. If the value is even, thread computes the square of the number and prints. If the value is odd the thir will print the value of cube of the number.
12) Write a Java program that shows thread synchronization. **

(E) Graphics Programming:

13) Write a Java program that works as a simple calculator. Arrange Buttons for dig the + - * % operations properly. Add a text field to display the result. Handle any p exceptions like
14) Write a Java pr ram lets the user selec three lights: rec elected, the light is turn and only one lig he program starts. **
15) Write a Java pr ing Java Database Con ty (JDBC).

(F) Standard Searchi ctures and algorithms from course Data Stru

16) Write a Java pr
    1) Create a
    2) Delete a
    3) Display t
17) Write a Java pr for sorting a list of na ascending orde
18) Write a Java program that implements the binary search algorithm.

** Mandatory

PRACTICE QUESTIONS

1) Write a Java program to reverse an given string.
2) Write a Java program to display the transpose of a given matrix.
3) Write a Java program to find the second smallest element in an array.
4) Write a Java program to check whether a given number is prime or not.
5) Write a Java program to calculate the area of different shapes namely circle, re and triangle using the concept of method overloading.
6) Write two Java classes Employee and Engineer. Engineer should inherit from En class. Employee class to have two methods display() and calcSalary(). Write a pro display the eng class using a single ob stantiation (i.e.,
   ! display() on return any valueNameEx of class is E
   ! calcSalary() is 10000Ó and calcSa Engineer di
7) Write a Java pr
8) Write a Java pr ıed exception.
9) Write a Java pr /ing all odd number be and 100 and se between 1 and 100.
10) Write a Java pr
11) Write a Java p file on the screen, wit number before
12) Write a Java p ters, lines and words i file.
13) Write a Java pr
14) Write a Java pr r classes (general).
15) Write a Java program that allows the user to draw lines, rectangles and ovals.
16) Write a Java Swing program to print a wave form on the output screen.
17) Write a program to accept rollno, name, CGPA of ÒnÓ students and store the database using JDBC connectivity. Display the list of students having CGPA grea 7. (Use MySQL /PostgreSQL).
18) Write a Java program to implement Heap sort algorithm using array.

6 5

CST 2 1	OBJECT ORIENTED PROGRAMMING	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		MINOR	3	1	0	4	2019

Preamble: This is the programming course for awarding B.Tech. Minor in Computer S and Engineering with specialization in Software Engineering The purpose of this course is enable learners to solve problems by breaking it down to object level while designing s and to implement it using Java. This course covers Object Oriented Principles, Object (Programming in Java, Inheritance, Exception handling, Event handling, multithr programming and wo ... course helps the lear develop Mobile applic ... Applications and Web Applications.

Prerequisite: Topics co ... C (EST 102)

Course Outcomes: Aft ... will be able to

CO1	Write Java ... ncepts - classes, c constructors ... sm (Cognitive Know Level: Apply)
CO2	Utilise dataty ... packages & interfaces Output Strea ... (Cognitive Knowledge Apply)
CO3	Illustrate ho ... a using exception ha mechanism (
CO4	Write application programs in Java using multithreading (Cognitive Knowl Level: Apply)
CO5	Write Graphical User Interface based application programs by utilising handling features and Swing in Java (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcome

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓						✓		✓
CO4	✓	✓	✓	✓								✓
CO5	✓	✓	✓									✓

Abs... ...ation			
PO#	Broa... ...ad PO		
PO1	Engineering Knc... ...stainability		
PO2	Problem Analysi...		
PO3	Design/Develop... ...vork		
PO4	Conduct investi... problems		
PO5	Modern tool usa... and Finance		
PO6	The Engineer ar...		

Assessment Pattern

BloomÕs Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test1 (Marks %)	Test2 (Marks %)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessme

Internal Examination F

Each of the two intern 50 marks

First series test shall e first half of the syllal the second series te npleting remaining pai syllabus.

There will be two part stions (preferably, 2 qu each from the comple :ly covered module), h marks for each questi nts should answer all q from Part A. Part B ons each from the coi modules and 1 quest n with 7 marks. Out o questions in Part B, a

End Semester Examination Pattern:There will be two parts; Part A and Part B. Part A cont 10 questions with 2 questions from each module, having 3 marks for each question. should answer all questions. Part B contains 2 questions from each module of which a should answer any one. Each question can have maximum 2 sub-divisions and carry 14 r

SYLLABUS

Object Oriented Programming Using Java

Module 1

Introduction:

Approaches to Software Design - Functional Oriented Design, Object Oriented Design Study of Automated Fire Alarm System.

Object Modeling Using UML Ð Basic Object Oriented concepts, UML (Unified Mode Language) diagrams, Use case model, Class diagram, Interaction diagram, Activity di State chart diagram.

Introduction to Java Ja Environment, Develop Platforms -Standard, ava compiler, Bytecode applet, Java Buzzwor age Collection, Lexical

Core Java Fundamen

Primitive Data types ters, Boolean. Literals, Conversion and Casti

Operators - Arithmeti Operators, Boolean L Operators, Assignme Operator Precedence.

Control Statements - nd Jump Statements.

Object Oriented Pro Declaring Objects, Obj Reference, Introducti thod Overloading, Usin Objects as Paramete Control, Static Member Variables, Inner Class gth Arguments.

Module 3

More features of Java:

Inheritance - Super Class, Sub Class, The Keyword super, protected Members, Calling C Constructors, Method Overriding, the Object class, Abstract Classes and Methods, Usir with Inheritance.

Packages and Interfaces - Defining Package, CLASSPATH, Access Protection, Imp Packages, Interfaces.

Exception Handling - Checked Exceptions, Unchecked Exceptions, try Block and catch Clause, Multiple catch Clauses, Nested try Statements, throw, throws and finally.

Module 4

Advanced features of Java:

Input/Output - I/O Basics, Reading Console Input, Writing Console Output, PrintWriter

Object Streams and Serialization, Reading and Writing Files.

Java Library - String Handling Đ String Constructors, String Length, Special String Oper
Character Extraction, String Comparison, Searching Strings, Modifying Strings,
valueOf(), Comparison of StringBuffer and String.

Collections framewor ... ass Đ ArrayList. Acc
Collections via an Iter

GUI Programming, Ev ... g:

Swing fundamentals ... ler (MVC), Swing Cor
Components and Con ... Button, JTextField.

Event handling Event ... odel, Event Classes, S
of Events, Event Liste

Multithreaded Progra ... ain Thread, Creating
Creating Multiple Thre ... hreads.

Text Books:

1. Herbert Schild ... McGraw Hill, 2011.
2. Rajib Mall, Fu ... PHI, 2014.
3. Paul Deitel, Harvey Deitel, Java How to Program, Early Objects 11th Edition, Pearsor 2018.

Reference Books:

1. Y. Daniel Liang, Introduction to Java Programming, 7/e, Pearson, 2013.
2. Nageswararao R., Core Java: An Integrated Approach, Dreamtech Press, 2008.
3. Flanagan D., Java in A Nutshell, 5/e, O'Reilly, 2005.
4. Barclay K., J. Savage, Object Oriented Design with UML and Java, Elsevier, 2004.
5. Sierra K., Head First Java, 2/e, O'Reilly, 2005.
6. Balagurusamy E., Programming JAVA a Primer, 5/e, McGraw Hill, 2014.

Sample Course Level Assessment Questions

Course Outcome1(CO1): For the following passage develop UML diagrams and then implement it as a Java program in accordance with your UML design.

Passage: College Office collects semester fee and college bus fee for each student. clerk at the college [illegible] he bus fee is calculate[illegible] depending on the di[illegible] ne college. The semes[illegible] fee varies dependin[illegible] ach student. Students supposed to pay the [illegible] nts are eligible for 50[illegible] discount in semeste[illegible] d to each student by [illegible] clerk, which contai[illegible] semester and branch [illegible] student along with c[illegible] and view the details [illegible] fees remitted and d[illegible] l clerk level login to th[illegible] system. Clerk is abl[illegible] atus of fees payment [illegible] each student.

Course Outcome 2 [illegible] e rank list of students based one their per[illegible] gree examination at A[illegible] Abdul Kalam Techn[illegible] ed in a file.

Course Outcome 3 [illegible] event handling and exception handling [illegible]

Course Outcome 4 (CO4):Write a program to demonstrate the start, run, sleep and join methods in Thread class..

Model Question Paper

QP CODE: PAGES:3

Reg No:_______________

Name:_________________

APJ A RSITY

THIRD SEMESTE ONTH & YEAR

Cour g Java

Max.Marks:100 Duration: 3 Hours

3 Marks

1. Briefly explain rtable.
2. Describe the c example.
3. Explain the dif
4. Explain the us e Java program
5. Explain the us
6. What are the different types of exceptions?
7. Explain file handling features available in Java.
8. Write a simple program to read and print an integer value in Java.
9. Explain the concept of main thread in multi-threading.
10. Explain any two Event classes in Java.

Part B

Answer any one question completely from each module

11.

(a) Describe in detail polymorphism, abstraction and inheritance with suitable exam (9)

(b) What is Java Virtual Machine? (5)

OR

12.

(a) Compare and contrast Functional Oriented and Object Oriented approac considering a simple bus ticket reservation system. (5)

(b) What is a class diagram? Explain with an example. (9)

13.

(a) Explain pri ent from other data type (8)

(b) Explain var (6)

14.s

(a) Using a sui iethods and constructors (8)

(b) Explain the (6)

15.

(a) Using a tak nheritance. (6)

(b) Describe in andcatch clause in Java with the help of a suitable Java program. (8)

OR

16.

(a) What is an interface in Java? Explain with a suitable example. (8)

(b) Explain throw, throws and finally constructs with the help of a Java program. (6)

17.

(a) Explain ArrayList collections framework. Also explain the use of iterator accessing collections.

(8)

(b) Bring out difference between Ò==Ó and equals() method with the help of a samp program

(6)

OR

18.

(a) Compare Byte Streams and Character Streams. Write a program to demonstr usage of the PrintWriter class.

(8)

(b) Explain any three String constructors with the help of sample code for each.

(6)

19.

(a) Explain in c ... ıandling in Java.

(7)

(b) Describe in ... ınable interface.

(7)

20.

(a) What are tl ... ad?

(4)

(b) Write a Gra ... ɔgram to implement a s calculator ... :raction, multiplication division. Us ... may be three text boxes first two fo ... four buttons for the ak operations. ... ɔw how you handle ever

(10)

Teaching Plan		
Module 1 (Introduction)		(8 hours)
1.1	Approaches to Software Design- Functional Oriented De Object-Oriented Design, Case Study of Automated Fire A System.	1 hour
1.2	Object Modeling Using UML Đ Basic object oriented concepts	1 hour
1.3	Basic object oriented concepts	1 hour
1.4	UML diagra	1hour
1.5	Class diag	1hour
1.6	Activity dia	1hour
1.7	Java prog nvironm Developme ava com Bytecode	1hour
1.8	Java apple re, Com Garbage C	1hour
M		(12 hours)
2.1	Primitive D , Charac Boolean	1 hour
2.2	Literals, Ty rays, Str Vector clas	1 hour
2.3	Operators s, Relati Operators, Boolean Logical Operators, Assignment Oper Conditional (Ternary) Operator, Operator Precedence.	1 hour
2.4	Control Statements - Selection Statements, Iteration Statemen Jump Statements.	1 hour
2.5	Object Oriented Programming in Java Class Fundamental Declaring Objects	1 hour
2.6	Object Reference, Introduction to Methods	1 hour
2.7	Constructors, this Keyword	1 hour
2.8	Method Overloading, Using Objects as Parameters	1 hour

2.9	Returning Objects, Recursion	1 hour
2.10	Access Control, static Members	1 hour
2.11	Final Variables, Inner Classes	1 hour
2.12	Command-Line Arguments, Variable Length Arguments	1 hour
	Module 3 (More features of Java)	(8 hours)
3.1	Inheritance - Super class, Sub class, the keyword super, pro Members,	1 hour
3.2	Calling Order of Constructors, Method Overriding, the Object cla	1 hour
3.3	Abstract Cl ... nce	1 hour
3.4	Packages ... PATH, A Protection,	1 hour
3.5	Interfaces	1 hour
3.6	Exception ... Exceptio try Block a	1 hour
3.7	Multiple ca	1 hour
3.8	throw, thro	1 hour
	Mo	(8 hours)
4.1	Input/Outp	1hour
4.2	Writing Co	1hour
4.3	Object Stre	1hour
4.4	Serializatio	1hour
4.5	Working with Files	1hour
4.6	Java Library - String Handling Ð String Constructors, String Le Special String Operations	1hour
4.7	Character Extraction, String Comparison, Searching Str Modifying Strings Using valueOf( ), Comparison of StringBu and String.	1hour
4.8	Collections framework Ð Collections overview, Collections Cla ArrayList. Accessing Collections via an Iterator.	1hour

Module 5 (GUI Programming, Event Handling and Multithreaded Programming)		(9 hours)
5.1	Swings fundamentals, Swing Key Features	
5.2	MVC, Swing Controls, Components and Containers	
5.3	Exploring Swing ĐJFrame, JLabel, JButton, JTextField.	
5.4	Event handling- Event Handling Mechanisms, Delegation Ev Model	1hour
5.5	Delegation Event Model, Event Classes	1hour
5.6	Sources of ... he Deleg Model	1hour
5.7	Multithreac ... el, The Thread, Cr	1hour
5.8	Creating M	1hour
5.9	Suspendin	1hour

CST 2 3	Python for Machine Learning	Category	L	T	P	Credit	Year of Introduction
		MINOR	3	1	0	4	2019

Preamble: This is a programming course for awarding B. Tech. Minor in Computer Scien Engineering with specialization in Machine Learning. The objective of the course is to prov learners an insight into Python programming, and develop programming skills to man development of software systems. It covers programming environment, important instru data representations, intermediate level features, Object Oriented Programming and processing of Python. This course lays the foundation to develop web applications, M Learning, and Artificial Intelligence-based applications and tools, Data Science and Visualization applications.

Prerequisite: Nil

Course Outcomes: Afte ... ill be able to

CO1	Write, test an ... edge level: Apply)
CO2	Illustrate use ... switch-case) and ite (while and fo ... wledge level: Apply)
CO3	Develop prog ... s, Sets and Dictiona Python (Cog
CO4	Implement O ... (Cognitive Knowledge level: Apply)
CO5	Write progra ... es by utilizing the mo Numpy, Matp ... el: Apply)

Mapping of course ou

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	!	!	!		!						!	!
CO2	!	!	!		!					!		!
CO3	!	!	!		!	!	!					!
CO4	!	!	!		!		!					!
CO5	!	!	!	!	!	!						!

Abstract POs defined by National Board of Accreditation

#PO	Broad PO	#PO	Broad PO
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of comple problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer		g

Assessment Pattern

BloomÕs Categor			End Semester xamination (Marks in percentage)
Remember			20
Understand			35
Apply			45
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test : 25 marks
Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. The first se shall be preferably conducted after completing the first half of the syllabus and the secor test shall be preferably conducted after completing the remaining part of the syllabus. Th be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions ea the completed modules and 1 question from the partly completed module), having 3 m each question adding up to 15 marks for part A. Students should answer all questions f A. Part B contains 7 questions (preferably, 3 questions each from the completed modul question from the partly completed module), each with 7 marks. Out of the 7 questions, a should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questior each module, having 3 marks for each question. Students should answer all question contains 2 questions from each module of which a student should answer any one. Each can have a maximum of 2 sub divisions and carries 14 marks.

Programming Environ

Getting Started with … he interactive shell, E Saving, and Running … software development - Case Study.

Basic coding skills - W … and Character sets, Ke Variables and Assignr … orking with numeric da conversions, Commer … Output. Formatting outp Python works. Detecti … lt in functions and moc math module.

Building Python Progr

Control statements - Selection structure (if-else, switch-case), Iteration structure(for, Testing the control statements, Lazy evaluation. Functions - Hiding redundancy and com Arguments and return values, Variable scopes and parameter passing, Named argume function, Working with recursion, Lambda functions. Strings and number systems - function, Handling numbers in various formats.

Module III

Data Representation:

Lists - Basic list Operations and functions, List of lists, Slicing, Searching and sorting lis comprehension. Work with tuples. Sets. Work with dates and times. Dictionaries - Dic functions, dictionary literals, adding and removing keys, accessing and replacing traversing dictionaries, reverse lookup. Case Study - Data Structure Selection.

Module IV

Object Oriented Programming:

Design with classes - Objects and Classes, Methods, Instance Variables, Constructor, A and Mutators. Structuring classes with Inheritance and Polymorphism. Abstract C Exceptions - Handle a single exception, handle multiple exceptions.

Module V

Data Processing:

The os and sys module iting text files, Manipul binary files. NumPy - Matrix Operations, Ra numbers. Plotting a Ticks, Labels, and Leg Working with CSV files ocessing Data.

Text Books:

1. Kenneth A Lamb ms, 2/e, Cengage Pub 2016
2. Wes McKinney, P ly Publishers, 2017

Reference Books:

1. Allen B. Downey uter Scientist, 2/e, Sch 2016
2. Michael Urban an f/Murach, 2016
3. David M.Baezly, y Professional; 4/e, 200
4. Charles Severan tion,
5. http://swcarpentry.github.io/python-novice-gapminder/

Sample Course Level Assessment Questions

Course Outcome1(CO1): What is type conversion? How is it done in Python?

Course Outcome 2(CO2): Write a Python program which takes a positive integer n as input and finds the sum of cubes all positive even numbers less than or equal to the number.

Course Outcome 3(CO3): Given is a list of of words, wordlist, and a string, name. Write a Python function which takes wordlist and name as input and returns a tuple. The first eleme

the output tuple is the number of words in the wordlist which have name as a substring in it. Th
second element of the tuple is a list showing the index at which the **name** occurs in each of t
words of the wordlist and a 0 if it doesnÕt occur.

Course Outcome 4(CO4): Write a Python program to implement the addition, subtraction
multiplication of complex numbers using classes. Use constructors to create objects. The
the program consist of real and imaginary parts of the complex numbers.

Course Outcome 5(CO5): Given a file Òauto.csvÓ of automobile data with their fields index,
company, body-style, wheel-base, length, engine-type, num-of-cylinders, horsepower, ave
mileage, and price, write python code to

1) Clean and Update the CSV file
2) Print total cars of all companies
3) Find the average mileage of all companies
4) Find the highest priced car of all companies.

Model Question Paper

QP CODE: PAGES:

Reg No:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH (MINOR) DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST2 3

Course name : PYTHON FOR MACHINE LEARNING

Max Marks: 100 Duration: 3 Hours

(Ans [illegible] narks)

1. Explain the bas [illegible] ples.
2. Write a Python [illegible] he sum of digits of the number. Promp [illegible]
3. Explain the cor [illegible] thon programming lan with a suitable [illegible]
4. Discuss format [illegible] ples.
5. Discuss the rel [illegible] detail.
6. Discuss the foll [illegible]
   i. get( ) ii. Key [illegible] vi. items( )
7. What is polymo [illegible] OOP in Python.
8. How is exception handling accomplished in Python programs?
9. Write a note on the os and os.path modules in Python. Also, discuss the walk( ) and getcwd( ) methods of the os module.
10. Describe the characteristics of the CSV format.

PART-B

(Answer any one full question from each module)

11. (a) Compare and contrast interpreted languages and compiled languag How does it affect the quality of program development and executior of the program? (6)

(b) What are the possible errors in a Python program. Write a Pytho program to print the value of $2n^2+n+5$ for n provided by the user. (8)

OR

12. (a) Describe Arithmetic operators, Assignment operators, Compa operators, Logical operators, and Bitwise operators in detail with exan (6)

(b) Explain the software development process in detail. (8)

13. (a) Write a Py … a leap year or n year is a l … le by 100 exce those divis (5)

(b) Input 4 int … find the sum negative … em. Also, finc averages ((9)

14. (a) Write a Py … terms using th series (8)

sin … degrees

(b) Write a Py … tring is a Palin or not usin (6)

15. (a) Write a Python code to create a function called list_of_frequency that take a string and prints the letters in non-increasing order of the frequer their occurrences. Use dictionaries. (5)

(b) Write a Python program to read a list of numbers and sort the list in a decreasing order without using any built in functions. Separate fur should be written to sort the list wherein the name of the list is pass the parameter. (9)

OR

16. (a) Illustrate the following Set methods with an example. (6)
i. intersection( ) ii. Union( ) iii. Issubset( ) iv. Difference( ) v. update( ) vi. discard( )

(b) Write a Python program to check the validity of a password given b (8)
user.
The Password should satisfy the following criteria:
1. Contains at least one letter between a and z
2. Contains at least one number between 0 and 9
3. Contains at least one letter between A and Z
4. Contains at least one special character from $, #, @
5. Minimum length of password: 6

17. (a) How can a class be instantiated in Python? Write a Python progr (10)
express th ... ss RECTANGL
parameter ... mber functions
find center

(b) Explain inh ... type of inherita (4)

18. (a) Write a P ... radius and t (6)
methods w ... r of a given circ

(b) Write Pyth ... and implemen (8)
__add__(... isplay the resu
overloadin

19. (a) Write a Py ... find the transp (8)
the resulta

(b) Given a fil ... index, company (6)
body-style, wheel-base, length, engine-type, num-of-cylinders, horse
average-mileage, and price, write Python codes using Pandas to
1) Clean and Update the CSV file
2) Print total cars of all companies
3) Find the average mileage of all companies
4) Find the highest priced car of all companies.

OR

20. (a) Write Python program to write the data given below to a CSV file. (5)

SN Name Country Contribution Year
1 Linus Torvalds Finland Linux Kernel 1991
2 Tim Berners-Lee England World Wide Web 1990
3 Guido van Rossum Netherlands Python 1991

(b) Given the sales information of a company as CSV file with the follo (9)
fields month_number, facecream, facewash, toothpaste, bathing shampoo, moisturizer, total_units, total_profit. Write Python code visualize the data as follows

1) Toothpaste sales data of each month and show it using a scatt
2) Face cream and face wash product sales data and show it us bar chart
3) Calculate total sale data for last year for each product and sl usi

(14X5=70)

Module 1: Programm		(10 hours)
1.1	Getting Startec ... the intera shell Editing, S	1 hour
1.2	Using editors: I	1 hour
1.3	Jupyter	1 hour
1.4	The software d	1 hour
1.5	Basic coding skills: Working with data types, Numeric data types Character sets, Keywords, Variables and Assignment state Operators, Expressions,	1 hour
1.6	Working with numeric data, Type conversions, Comments in the prog	1 hour
1.7	Input, Processing, and Output, Formatting output Ð How Python worl	1 hour
1.8	How Python works Ð Detecting and correcting syntax errors	1 hour
1.9	Using built in functions and modules: Case Ð Using math module	1 hour
1.10	Using built in functions and modules: Case Ð Using math m (Examples)	1 hour

Module 2: Building Python Programs		(8 hours)
2.1	Control statements: Selection structure (if-else, switch-case),	1 hour
2.2	Iteration structure(for, while), Testing the control statements, evaluation	1 hour
2.3	Functions: Hiding redundancy and complexity, Arguments and r values,	1 hour
2.4	Variable scopes and parameter passing	1 hour
2.5	Named arguments, Main function,	1 hour
2.6	Working with recursion, Lambda functions	1 hour
2.7	Strings and number systems: String function	1 hour
2.8	Handling numb	1 hour
Module 3: Data Repr		(9 hours)
3.1	Lists: Basic list	1 hour
3.2	Slicing, Searcl	1 hour
3.3	List comprehen	1 hour
3.4	Work with tuple	1 hour
3.5	Work with date	1 hour
3.6	Dictionaries: D	1 hour
3.7	Dictionary liter ... g & repla values	1 hour
3.8	Traversing dict	1 hour
3.9	Case Study: D	1 hour
Module 4: Object Oriented Programming		(8 hours)
4.1	Design with classes : Objects and Classes, Methods, Instance Variab	1 hour
4.2	Constructor, Accessors and Mutators	1 hour
4.3	Structuring classes with Inheritance	1 hour
4.4	Polymorphism	1 hour
4.5	Abstract Classes	1 hour
4.6	Abstract Classes	1 hour
4.7	Exceptions : Handle a single exception	1 hour

4.8	handle multiple exceptions	1 hour
Module 5: Data Processing		(10 hours)
5.1	The os and sys modules	1 hour
5.2	Introduction to file I/O: Reading and writing text files	1 hour
5.3	Manipulating binary files	1 hour
5.4	NumPy : Basics, Creating arrays, Arithmetic, Slicing	1 hour
5.5	Matrix Operations, Random numbers.	1 hour
5.6	Matplotlib : Basic plot	1 hour
5.7	Matplotlib - Ticks, Labels, and Legends	1 hour
5.8	Working with C[illegible]	1 hour
5.9	Pandas : Read[illegible]	1 hour
5.10	Pandas : Proce[illegible]	1 hour

CST 2 5	DATA COMMUNICATION	Category	L	T	P	Credit	Year of Introduction
		MINOR	3	1	0	4	2019

Preamble: This is a basic course in communication for awarding B. Tech. Minor in Comp Science and Engineering with specialization in Networing. The purpose of this course is prepare learners to understand the communication entities and the associated issue field of Computer Science. This course covers fundamental concepts of data transmission media, digital & analog transmissions, multiplexing & spread spectrum, error detecti correction and switc ... the learner to understa concepts in networki

Prerequisite: NIL

Course Outcomes: A ... t will be able to

CO1	Descr ... for Analog and D transm
CO2	Discu ... sion (Cognitive knowledge: Unde
CO3	Selec ... stics and propagation (Cog
CO4	Use a ... a given scenario (Cognitive know
CO5	Illustr ... technologies (Cognitive knowledge: Understand)
CO6	Explain error detection & correction techniques and switching techn used in data communication (Cognitive knowledge: Understand)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓								✓		✓
CO2	✓	✓								✓		✓
CO3	✓											✓
CO4	✓	✓	✓	✓								✓
CO5	✓	✓	✓	✓						✓		✓
CO6	✓	✓								✓		✓

Abstr			litation
PO#	B		oad PO
PO1	Engineering		nd Sustainability
PO2	Problem Ana		
PO3	Design/Deve		eam work
PO4	Conduct i complex pro		n
PO5	Modern tool		ement and Finance
PO6	The Enginee		ng

Assessment Pattern

BloomÕs Category	Test 1 (Marks in percentage)	Test 2 (Marks in percentage)	End Semester Examination (Marks in percentage)
Remember	30	30	30
Understand	40	40	40
Apply	30	30	30
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:
Attendance : 10 marks
Continuous Assessment Test : 25 marks
Continuous Assessment Assignment : 15 marks

Internal Examination
Each of the two inter of 50 marks. First ser
shall be preferably c he syllabus and the s
series test shall be pr ng part of the syllabus
will be two parts: Par (preferably, 2 questior
from the completed mpleted module), ha
marks for each ques Students should answ
questions from Part , 3 questions each fr
completed modules a dule), each with 7 mar
of the 7 questions, a s

End Semester Exami
There will be two part stions with 2 question
each module, having d answer all questions
contains 2 questions ould answer any one
question can have ma s.

Data Transmission Basics

Communication model - Simplex, Half duplex, Full duplex transmission. Periodic An signals - Sine wave, Amplitude, Phase, Wavelength, Time and frequency domain, Banc Analog & digital data and signals. Transmission impairments - Attenuation, Delay disto Noise. Data rate limits - Noiseless channel, Nyquist bandwidth, Noisy channel, Shar capacity formula.

Module 2

Transmission Media
Guided Transmission Media - Twisted pair, Coaxial cable, Optical fiber. Unguided me Radio waves, Terrestrial microwave, Satellite microwave, Infrared. Wireless Propaga Ground wave propagation, Sky Wave propagation, Line-of-Sight (LoS) Propagation.

Module 3

Digital Transmission and Analog Transmission

Digital data to Digital signal Ð Non-Return-to-Zero (NRZ), Return-to-Zero (RZ), Multile binary, Biphase. Analog data to Digital signal - Sampling theorem, Pulse Code Modu (PCM), Delta Modulation (DM). Digital data to Analog signal: Amplitude Shift Keyi (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK). Analog data to An signal: Amplitude Modulation (AM), Frequency Modulation (FM), Phase Modulation (PM

Module 4

Multiplexing and Spread Spectrum

Multiplexing - Frequency Division Multiplexing (FDM), Wave length Division Multiplexin (WDM), Time Division Multiplexing (TDM), Characteristics, Synchronous TDM, Statisti TDM. Spread Spectrum Techniques - Direct Sequence Spread Spectrum (DSSS), Fre Hopping Spread Spectrum (FHSS), Code Division Multiplexing, Code Division Mult Access (CDMA).

Error Detection, Corre

Digital data commu ansmission, Synchro transmission. Detecti , Parity check, Chec Cyclic Redundancy (EC), Hamming Dista Hamming Code. Ba ching, Packet Switch Message Switching.

Text Books

1. Forouzan B. A., Da Graw Hill, 2013.
2. William Stallings, D rson Education, Inc.

Reference Books

1. Schiller J., Mobile 009.
2. Curt M. White, Fur on 7/e, Cengage learni

Sample Course Level Assessment Questions

Course Outcome 1 (CO1): What is a periodic analog signal? List the main properties of a periodic analog signal.

Course Outcome 2 (CO2): What is attenuation? How can it be handled?

Course Outcome 3 (CO3): How can interference be reduced using optical fiber?

Course Outcome 4(CO4): Encode the data sequence 101011100 using Multilevel binary and Biphase schemes.

Course Outcome 5(CO5): Explain direct sequence spread spectrum with a neat diagran

Course Outcome 6(CO6): Using Cyclic Redundancy Check (CRC), given the data-word 11110000 and the divisor 10011, show the generation of the codeword at the sender the checking of the codeword at the receiver.

Model Question Paper

QP CODE: PAGES: ___

Reg No:_______________
Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER B.TECH DEGREE (MINOR) EXAMINATION, MONTH & YEAR

Course Code: CST2 5

Max Marks: 100 Duration: 3 Hours

(Ans ... arks)

1. What is bandwidt ... ignal has a bandwidth Hz and the highe ... n if the signal contai frequencies of sar
2. Assume that a TV ... vith 4.5 MHz bandwid a 35 dB Signal-to- ... el.
3. What is the purpo
4. Which wireless pr ... tion? Justify your ansv
5. Explain the workir
6. Illustrate the equi ...)1001101 using Non-R to-Zero(NRZ) - Le
7. Distinguish betwe ... Multiplexing.
8. Apply Direct Seq ... using the Barker se 10110111000. Show the encoding and decoding steps.
9. Find the minimum hamming distance for the following cases:
   a) Detection of two errors
   b) Correction of two errors
   c) Detection of 3 errors or correction of 2 errors
   d) Detection of 6 errors or correction of 2 errors
10. Find the parity bit for simple even parity check for the following.
   a) 1001010
   b) 0001100
   c) 1000000
   d) 1110111

PART-B

(Answer ANY one full question from each module. Each question carries 14 marks)

11. a) With the help of suitable figures, distinguish between time domain and frequ domain.

b) Describe the different types of transmission impairments.

(10)

OR

12. a) Calculate the b sed into 4 sine waves frequencies 50 H he spectrum, assumir components havi are multiple of two ir increasing order.

(6)

b) Distinguish bet pacity. Consider a noi channel with a ba h (i) Two signal levels (ii) Four signal lev these cases.

(8)

13. a) For a parabolic a diameter of 2 m, cal the effective a

(6)

b) List any four ad coaxial cable and fibe cable.

(8)

OR

14. a) Compare the features of terrestrial microwave and satellite microwave.

(6)

b) With the help of suitable diagrams, differentiate Multi-mode and Single-mode op fibres. How the rays are propagated in Step-index and Graded-index Multi-mode f

(8)

15. a) Distinguish between data rate and signal rate.

(4)

b) What is polar encoding? Encode the pattern 010011001110 using the two Bi schemes.

(10)

OR

16. a) Show the equivalent analog sine wave pattern of the bit string 010011010 Amplitude Shift Keying, Frequency Shift Keying and Phase Shift Keying.

(4)

b) State Sampling theorem. Explain Pulse Code Modulation with suitable figures.

(10)

17. a) Four channels xing. If each channel s 100 bytes/sec anc ne the frame size, dura a frame, frame rat

(6)

b) With the help requency Hopping Sp Spectrum.

(8)

18. a) Explain the diffe put data rate is handle Time Division Mul

(4)

b) Suppose Alice and Bob are communicating using Code Division Multiple Access. uses the code [+1 +1] and Bob uses the code [+1 -1]. Alice sends the data bit 0 ar sends the data bit 1. Show the data in the channel and how they can detect what th person has sent.

(10)

19. a) Explain parity check with examples.

(4)

b) Describe the need for a switch. What are the different phases in circuit switching?

(10)

OR

20. a) With the help of a suitable example, explain the virtual circuit approach of p
switching.

(6)

b) Find the Hamming code for the data-word 1011001. Assume odd parity.

(8)

Teaching Plan

		(8 Hours)
1.1	Introductior uplex, F duplex tran	1
1.2	Periodic A e, Pha Wavelengtl	1
1.3	Time and fr	1
1.4	Analog data	1
1.5	Digital data	1
1.6	Transmissi n, Nois	1
1.7	Data rate li	1
1.8	Noisy chan	1
		(7 Hours)
2.1	Guided Tra e	1
2.2	Optical fiber	1
2.3	Unguided media - Radio waves	1
2.4	Terrestrial microwave, Satellite microwave	1
2.5	Infrared	1
2.6	Wireless Propagation - Ground wave propagation	1
2.7	Wave propagation, Line-of-Sight (LoS) Propagation	1
Module 3: Digital Transmission and Analog Transmission		(10 Hours)
3.1	Digital data to Digital signal Ð Non-Return-to-Zero (NRZ)	1
3.2	Return-to-Zero (RZ), Multilevel binary	1

3.3	Biphase	1
3.4	Analog data to Digital signal - Sampling theorem	1
3.5	Pulse Code Modulation (PCM)	1
3.6	Delta Modulation (DM)	1
3.7	Digital data to Analog signal: Amplitude Shift Keying (ASK)	1
3.8	Frequency Shift Keying (FSK), Phase Shift Keying (PSK)	1
3.9	Analog data to Analog signal: Amplitude Modulation (AM)	1
3.10	Frequency Modulation (FM), Phase Modulation (PM)	1
Module		(9 Hours)
4.1	Multiplexing	1
4.2	Wave leng ... Divisio Multiplexing	1
4.3	Synchronou	1
4.4	Spread Spe	1
4.5	Direct Sequ	1
4.6	Frequency	1
4.7	Code Divisi	1
4.8	Code Divisi	1
4.9	CDMA	1
Module 5:		(11 Hours)
5.1	Digital data communication techniques - Asynchronous Synchronous transmission	1
5.2	Detecting and correcting errors - Types of Errors	1
5.3	Parity check, Checksum	1
5.4	Cyclic Redundancy Check (CRC)	1
5.5	CRC	1
5.6	Forward Error Correction (FEC)	1
5.7	Hamming Distance, Hamming Code	1
5.8	Hamming Code	1
5.9	Basic principles of Switching - Circuit Switching	1

5.10	Packet Switching	1
5.11	Message Switching	1

6 5

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MAT 206	GRAPH THEORY	BSC	3	1	0	4

Preamble: This course introduces fundamental concepts in Graph Theory, inc properties and characterisation of graph/trees and graph theoretic algorithms, wh widely used in Mathematical modelling and has got applications across Computer S and other branches in Engineering.

Prerequisite: The topics covered under the course Discrete Mathematical Structures (I 203)

Course Outcomes: A ... nt will be able to

CO 1	Explain vert ... lassification of graph trees & their ... derstand)	
CO 2	Demonstrat ... and Hamiltonian g (Cognitive K	
CO 3	Illustrate the ... ns for finding minimu spanning tr ... rithms for finding s paths. (Cog	
CO 4	Explain pla ... cation for planar gr (Cognitive K	
CO 5	Illustrate ho ... gnitive Knowledge Level: Apply	
CO 6	Explain the ... e an example applic for vertex co	

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	!	!	!							!		!
CO 2	!	!	!	!						!		!
CO 3	!	!	!	!						!		!
CO 4	!	!	!	!						!		!
CO 5	!	!	!							!		!
CO 6	!	!	!			!				!		!

Abstr...		...litation
PO#	B...	...road PO
PO1	Engineering ...	... and Sustainability
PO2	Problem Ana...	
PO3	Design/Deve...	...d team work
PO4	Conduct inv... problems	...on
PO5	Modern tool ...	...gement and Finance
PO6	The Enginee...	...ning

Assessment Pattern

BloomÕs Categ...	...		End Semester Examination (%)
	1	2	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessn

Continuous Assessn

Internal Examination

Each of the two inter ... 50 marks

First Internal Examir ... mpleting the first half
syllabus and the Sec ... y conducted after cor
remaining part of the

There will be two ... 5 questions (prefer
questions each from ... n the partly covered
having 3 marks for e ... rt A. Students should
all questions from P ... y, 3 questions each f
completed modules ... ule), each with 7 ma
of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern: There will be two parts; Part A and Part B. Pa
contain 10 questions with 2 questions from each module, having 3 marks for each q
Students should answer all questions. Part B contains 2 questions from each module
student should answer anyone. Each question can have maximum 2 sub-divisions ar
14 marks.

Syllabus

Module 1

Introduction to Graphs : Introduction- Basic definition Ð Application of graphs Ð finite infinite and bipartite graphs Ð Incidence and Degree Ð Isolated vertex, pendant vertex and Null graph. Paths and circuits Ð Isomorphism, sub graphs, walks, paths and circuits, connected graphs, disconnected graphs and components.

Module 2

Eulerian and Hamiltonian graphs : Euler graphs, Operations on graphs, Hamiltonian p and circuits, Travelling salesman problem. Directed graphs Ð types of digraphs, Digra binary relation, Direc

Trees and Graph Alg x, Distance and centr tree - Rooted and bi PrimÕs algorithm and algorithm, DijkstraÕs ortest path algorithm.

Connectivity and Pla nectivity, Cut set and Vertices, Fundamen heorem (proof not re Different representat metric dual.

Graph Representat resentation of grap Adjacency matrix, I rix. Coloring- Chrom number, Chromatic lor problem and Five problem. Greedy col

Text book:

1. Narsingh Deo, Graph theory, PHI,1979

Reference Books:

1. R. Diestel, Graph Theory, free online edition, 2016: diestel-graph-theory.co basic.html.
2. Douglas B. West, Introduction to Graph Theory, Prentice Hall India Ltd.,2001
3. Robin J. Wilson, Introduction to Graph Theory, Longman Group Ltd.,2010
4. J.A. Bondy and U.S.R. Murty. Graph theory with Applications

Sample Course Level Assessment Questions.

Course Outcome 1 (CO1):

1. Differentiate a walk, path and circuit in a graph.

2. Is it possible to construct a graph with 12 vertices such that two of the vertices degree 3 and the remaining vertices have degree 4? Justify

3. Prove that a simple graph with n vertices must be connected, if it has more $\frac{(n-1)(n-2)}{2}$ edges.

4. Prove the staten ...) has exactly two odd ... then there must b ...

Course Outcome 2 (...

1. Define Hamiltonia ... for each.

2. Define directed ... digraphs and asymm ... digraphs.

3. Prove that a conn ... s of G are of even degr ...

4. Prove that a grap ... path if the sum of the de ... of every pair of ve ... $d(V_j) = n - 1$

Course Outcome 3 (...

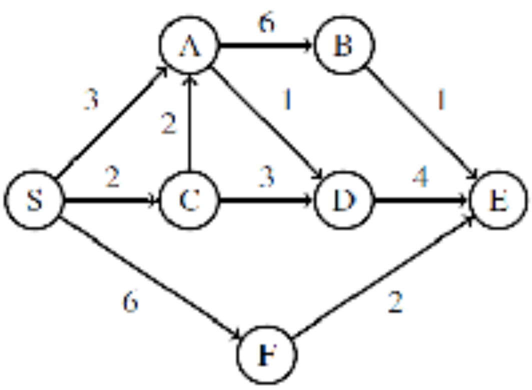
1. Discuss the cent ...

2. Define binary tree. Then prove that number of pendant vertices in a binary tree is $\frac{(n+1)}{2}$

3. Prove that a tree with n vertices has $n - 1$ edges.

4. Explain Floyd Warshall algorithm.

5. Run DijkstraÕs algorithm on the following directed graph, starting at vertex S.



Course Outcome 4 (CO4):

1. Define edge connectivity, vertex connectivity and separable graphs. Give an exar each.
2. Prove that a connected graph with n vertices and e edges has $e - n + 2$ edges.
3. Prove the statement: Every cut set in a connected graph G must also contain at branch of every spanning tree of G.
4. Draw the geome check whether G and G* are self-duals or

Course Outcome 5 (

1. Show that if A(G) ph with n vertices, then rank of A(G) is $n-$
2. Show that if B is a ices and m edges, the rank B = $m-n+1$.
3. Derive the relatic ne fundamental cycle and the fundamental cut-set matrix of a graph G
4. Characterize simple, self-dual graphs in terms of their cycle and cut-set matrices.

Course Outcome 6 (CO6):

1. Show that an n vertex graph is a tree iff its chromatic polynomial is $P_n(\lambda) = \lambda(\lambda - 1)^{n-1}$
2. Prove the statement: "A covering g of a graph is minimal if g contains no path o three or more."
3. Find the chromatic polynomial of the graph

Model Question paper

QP Code : Total Pages: 4

Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

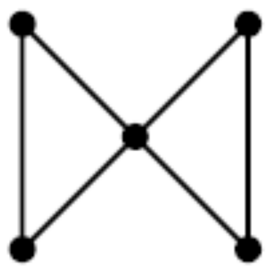
IV SEMESTER B.TECH DEGREE EXAMINATION, MONTH and YEAR

Course Code: MAT 206

Course Name: GRAPH THEORY

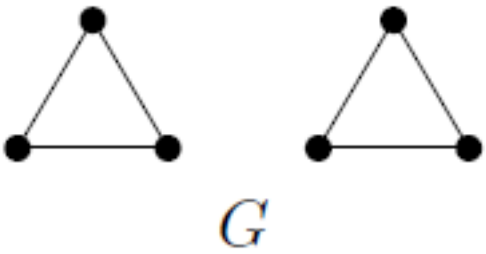
Max. Marks: 100 Duration: 3 Hours

		s.	Marks
1	Construct a … m having degr… three having … degree 10.		(3)
2	What is the … ith 35 edges, vertices are …		(3)
3	Define a E… graph which is Hamiltonian …		(3)
4	Give an exa… h without a di… Hamiltonian …		(3)
5	What is the …		(3)
6	How many s… ph		(3)



7 Show that in a simple connected planar graph G having V-vertices, E-edges, (3)
and no triangles E <= 3V - 6.

8 Let G be the following disconnected planar graph. Draw its dual G*, ar (3)
dual of the dual (G*)*.



9 Consider th ... mple connecte (3)
graph whos ... er of edges. Pr
every row o

10 A graph isc ... es (and the ec (3)
adjacent to ... iromatic numb
Show that k

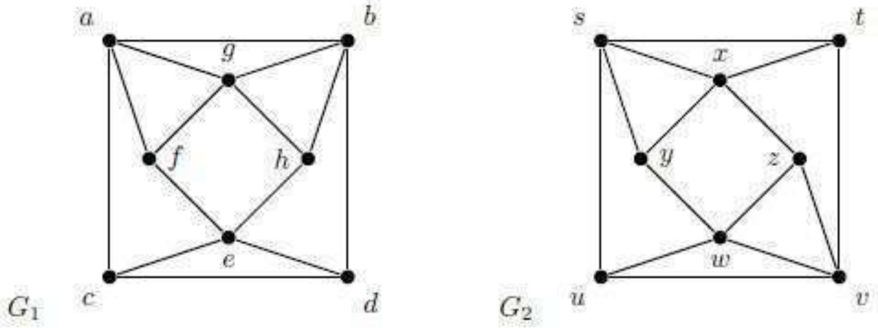
Answer an ... estion carries 14 Mar

11 a) Prove that f ... s has two verti (6)
the same de

b) Prove that i ... /2 edge disjoin (8)
Hamiltonian

OR

12 a) Determine whether the following graphs $G_1 = (V_1, E_1)$ and $G_2 = (V_2, E_2)$ are isomorphic or not. Give justification. (6)



b) Prove that ents can have (8)

most (n-k) (

13 a) Let S be a s tices are subs (8)

of S of size they are disjoin

i. Draw

ii. How or G to have a

Hami

b) Let G be a onents, both (6)

Eulerian. W eed to be added G

to obtain an

14 a) Show that an cycle has (8)

independent set of size k + 1.

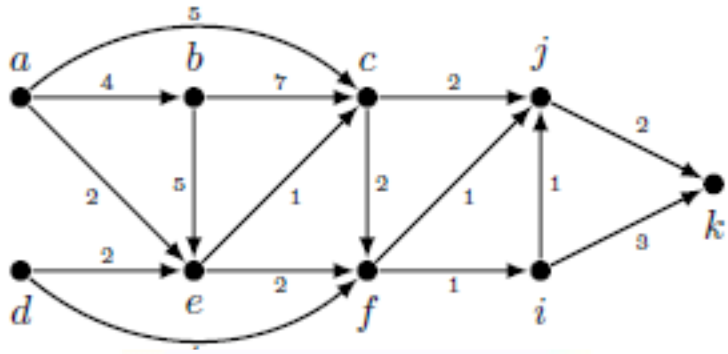
b) i. Let G be a graph that has exactly two connected components being Hamiltonian graphs. Find the minimum number of edges one needs to add to G to obtain a Hamiltonian graph. (6)

ii. For which values of n the graph Q_n (hyper-cube on n vertices) is Eulerian.

15 a) A tree T has at least one vertex of degree 4, and at least one vertex of degree 3. Prove that T has at least 5 leaves. (5)

b) Write DijkstraÕs shortest path algorithm. (9)

Consider the following weighted directed graph G.

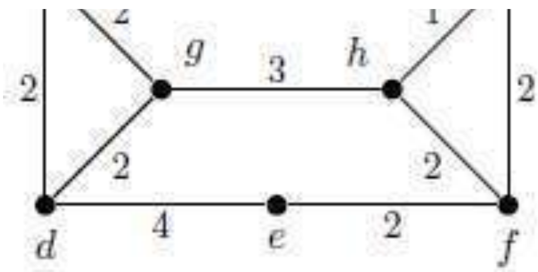


Find the sh ... ices in G using DijkstraÕs s ...

16 a) Define penc ... e number of p ... vertices in a ... (5)

b) Write PrimČ ... ee. (9)

Find a min ... ghted graph, u ... Prim's algor ...



Determine the number of minimum spanning trees for the given graph.

17	a)	i.	State and prove Euler's Theorem relating the number of faces, edg vertices for a planar graph.	(9)
		ii.	If G is a 5-regular simple graph and |V| = 10, prove that G is non-pla	
	b)		Let G be a connected graph and e an edge of G. Show that e is a cut-edge i and only if e belongs to every spanning tree.	(5)

OR

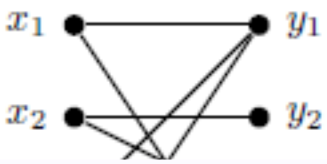
18	a)	State Kuratowski's theorem, and use it to show that the graph G below planar. Draw G on the plane without edges crossing. Your drawing s use the labelling of the vertices given.	(9)
	b)	Let G be a ... e belongs to a loop if and o	(5)
19	a)	Define the c... n vertices and e edges with a	(7)
	b)	Give the definition of the chromatic polynomial $P_G(k)$. Directly from the definition, prove that the chromatic polynomials of W_n and C_n satisfy the identity $P_{W_n}(k) = k\,P_{C_{n-1}}(k - 1)$.	(7)

OR

20	a)	Define the incidence matrix of a graph G with an example. Prove that t rank of an incidence matrix of a connected graph with n vertices is n-1.	(4)

b) i. A graph G has chromatic polynomial $P_G(k) = k^4-4k^3+5k^2-2k$. How many vertices and edges does G have? Is G bipartite? Justify you answers.

ii. Find a maximum matching in the graph below and use Hall's the to show that it is indeed maximum.



(10)

Assignments

Assignment must inc nputer Science.

Teaching Plan		
No	Topic	No. of Lectures
1	Module-I (Introduction to Graphs)	(8)
1.	Introduction- Basic definition Ð Application of graphs Ð finite infinite graphs, bipartite graphs,	1
2.	Incidence and Degree Ð Isolated vertex, pendent vertex and Null	1
3.	Paths and circuits	1
4.	Isomorphism	1
5.	Sub graphs,	1
6.	Paths and ci	1
7.	Connected g	1
8.	Disconnecte	1
2	Mc	(8)
1.	Euler graphs	1
2.	Operations c	1
3.	Hamiltonian	1
4.	Hamiltonian	1
5.	Travelling sa	1
6.	Directed gra	1
7.	Digraphs and binary relation, Directed paths	1
8.	FleuryÕs algorithm	1
3	Module-III (Trees and Graph Algorithms)	(11)
1.	Trees Ð properties	1
2.	Trees Ð properties	1
3.	Trees Ð properties, pendent vertex	1
4.	Distance and centres in a tree	1

5.	Rooted and binary tree	1
6.	Counting trees	1
7.	Spanning trees, Fundamental circuits	1
8.	PrimÕs algorithm	1
9.	KruskalÕs algorithm	1
10.	DijkstraÕs shortest path algorithm	1
11.	Floyd-Warshall shortest path algorithm	1
4	Mo	(9)
1.	Vertex Conn	1
2.	Cut set and	1
3.	Fundamenta	1
4.	Fundamenta	1
5.	Planar graph	1
6.	KuratowskiÕ	1
7.	Different rep	1
8.	Euler's theor	1
9.	Geometric d	1
5	Module- ring)	(9)
1.	Matrix representation of graphs- Adjacency matrix, Incidence Mat	1
2.	Circuit Matrix, Path Matrix	1
3.	Colouring- chromatic number,	1
4.	Chromatic polynomial	1
5.	Matching	1
6.	Covering	1
7.	Four colour problem and five colour problem	1

8.	Four colour problem and five colour problem	1
9.	Greedy colouring algorithm.	1

CST 202	Computer Organization and Architecture	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	3	1	0	4	2019

Preamble:

The course is prepared with the view of enabling the learners capable of understand fundamental architecture of a digital computer. Study of Computer Organizatior Architecture is essential to understand the hardware behind the code and its executior physical level by interacting with existing memory and I/O structure. It helps the lear to understand the fun … so that they can exte features of compute … ems occurring in con architecture

Prerequisite : Topics … sign (CST 203)

Course Outcomes: A … will be able to

CO#	
CO1	Recognize a … onents, I/O organizati pipelining sch … ge: Understand)
CO2	Explain the ty … ons used in memory s (Cognitive Kn
CO3	Demonstrate … ution of a given instr (Cognitive Knowledge Level: Apply))
CO4	Illustrate the design of Arithmetic Logic Unit and explain the usage of registers (Cognitive Knowledge Level: Apply)
CO5	Explain the implementation aspects of arithmetic algorithms in a digital com (Cognitive Knowledge Level:Apply)
CO6	Develop the control logic for a given arithmetic problem (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								✓
CO2	✓	✓	✓	✓						✓		✓
CO3	✓	✓	✓	✓						✓		✓
CO4	✓	✓	✓	✓						✓		✓
CO5	✓	✓	✓	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	✓		✓
CO6	✓	✓	✓	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			✓

Abs [illegible]			
PO#	[illegible]	[illegible]	Broad PO
PO1	Engineering Kr [illegible]	[illegible]	ent and Sustainability
PO2	Problem Analy [illegible]	[illegible]	
PO3	Design/Develo [illegible]	[illegible]	and team work
PO4	Conduct inv [illegible] problems	[illegible]	cation
PO5	Modern tool us [illegible]	[illegible]	anagement and Finan [illegible]
PO6	The Engineer a [illegible]	[illegible]	earning

Assessment Pattern

BloomÕs Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test1 (%)	Test2 (%)	
Remember	20	20	30
Understand	40	40	30
Apply	40	40	40
Analyze			

Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessme : 25 marks

Continuous Assessme : 15 marks

Internal Examination P

Each of the two intern 50 marks

First Internal Examina ompleting the first half syllabus and the Sec bly conducted after cor remaining part of the s

There will be two part stions (preferably, 2 qu each from the completed modules and 1 question from the partly covered module), h marks for each question adding up to 15 marks for part A. Students should answer all q from Part A. Part B contains 7 questions (preferably, 3 questions each from the co modules and 1 question from the partly covered module), each with 7 marks. Out o questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questio each module, having 3 marks for each question. Students should answer all question contains 2 questions from each module of which a student should answer any one. Each can have maximum 2 sub-divisions and carries 14 marks.

<u>Syllabus</u>

Module 1

Basic Structure of co ... l concepts - bus struc
Memory locations a ... ns and instruction seq
addressing modes.

Basic processing unit ... Ð execution of a co
instruction - single b

Register transfer logic ... shift micro operations.

Processor logic desi ... ogic unit - design of
arithmetic circuit - de ... ic unit - status register
design of shifter - pro

Module 3

Arithmetic algorithms: ... estoring method) of bin
numbers. Array mult
Pipelining: Basic prin ... instruction and arithn
pipelines (Design examples not required), hazard detection and resolution.

Module 4

Control Logic Design: Control organization Ð Hard_wired control-microprogram contr control of processor unit - Microprogram sequencer,micro programmed CPU organiz horizontal and vertical micro instructions.

Module 5

I/O organization: accessing of I/O devices Ð interrupts, interrupt hardware -Direct m access.

Memory system: basic concepts Ð semiconductor RAMs. memory system considerat ROMs, Content addressable memory, cache memories - mapping functions.

Text Books

1. Hamacher C., Z. Vranesic and S. Zaky, Computer Organization ,5/e, McGraw Hill, 2
2. Mano M. M., Digital Logic & Computer Design, PHI, 2004
3. KaiHwang, Faye Alye Briggs, Computer architecture and parallel processing Mc Hill, 1984

Reference Books

1. Mano M. M., D ı Education, 2013.
2. Patterson D.A. ion and Design, 5/e, Kaufmann Publ
3. William Stalling Designing for Perform Pearson, 9/e, 2
4. Chaudhuri P., (ıtice Hall, 2008.
5. Rajaraman V. ion and Architecture, F Hall, 2011

Sample Course Leve

Course Outcome1(n a memory access operation and how a

Course Outcome 2(CO2): Explain the steps taken by the system to handle a write miss condition inside the cache memory.

Course Outcome 3(CO3):Generate the sequence of control signals required for the execution of the instruction MOV [R1],R2 in a threebus organization.

Course Outcome 4(CO4):Design a 4-bit combinational logic shifter with 2 control signals H0 and H1 that perform the following operations :

H1	H0	Operation
0	0	Transfer 1's to all output line
0	1	No shift operation
1	0	Shift left
1	1	Shift right

Course Outcome 5(CO5): Explain the restoring algorithm for binary division. Also trace the algorithm t

Course Outcome 6(C l on microprogramed control to perform th in sign magnitude form

Model Question Paper

QP CODE: PAGES:2

Reg No:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code:CST 202

Cour ... cture

Max.Marks:100 Duration: 3 Hours

Ans

1. Give the signifi
2. Distinguish bet ... Also give the significar these notations
3. Compare I/O m
4. Give the import
5. Justify the signi
6. How does the a ... s in an ALU.
7. Illustrate divide overflow with an example.
8. Write notes on arithmetic pipeline.
9. Briefly explain the role of micro program sequence.
10. Differentiate between horizontal and vertical micro instructions.

Part B

Answer any one Question from each module. Each question carries 14 Marks

11.

11.(a) What is the significance of addressing modes in computer architecture.

(4)

11.(b) Write the control sequence for the instruction DIV R1,[R2] in a three bus struc
(10)

OR

12. Explain the concept of a single bus organization with help of a diagram. Write the contr
sequence for the instruction ADD [R1],[R2].

(14)

13. Explain various re

(14)

14.

14.(a) Design a 4 ignals H1 and H2 that
perform the hesis are the values of
control var OÕs to S (00), shift right
shift left (1

(5)

14.(b) Design an ogic operation with a giv
binary add

(9)

15.

15.(a) Give the log " !
(4)

15.(b) Identify the appropriate algorithm available inside the system to perform
multiplication between -14 and -9. Also trace the algorithm for the above input
(10)

OR

16.

16.(a) List and explain the different pipeline hazards and their possible solutions

(10)

16.(b) Design a combinational circuit for 3x2 multiplication.

(4)

17. Design a hardwared control unit used to perform addition/subtraction of 2 numbers represented in sign magnitude form.

(14)

OR

18. Give the structure of the micro program sequencer and its role in sequencing the instructions.

(14)

19.

19.(a) Explain the ... s can be implemented"

(10)

19.(b) Give the st

(4)

20.

20.(a) Explain the ... emory.

(9)

20.(b) Briefly exp

(5)

TEACHING PLAN		
No	Contents	No of Lecture Hrs
	Module 1 : (Basic Structure of computers) (9 hours)	
1.1	Functional units,basic operational concepts,bus structures (introduction)	1
1.2	Memory locations and addresses , memory operations	1
1.3	Instructions [illegible]	1
1.4	Addressing [illegible]	1
1.5	Fundamental [illegible] cle	1
1.6	Execution of [illegible] (Lecture	1
1.7	Execution of [illegible] (Lecture	1
1.8	Execution of [illegible] n (Lectur	1
1.9	Execution of [illegible] n (Lectur	1
	Module 2 :(R [illegible] sign (10 hours)	
2.1	Inter register [illegible]	1
2.2	Inter register [illegible]	1
2.3	Processor or[illegible]	1
2.4	Design of arithmetic circuit	1
2.5	Design of logic circuit	1
2.6	Design of arithmetic logic unit	1
2.7	Design of status register	1
2.8	Design of shifter - processor unit	1

2.9	Design of accumulator (Lecture 1)	1
2.10	Design of accumulator (Lecture 2)	1
Module 3 : (Arithmetic algorithms and Pipelining) (9 hours)		
3.1	Algorithm for multiplication of binary numbers	1
3.2	Algorithm for division (restoring method) of binary numbers	1
3.3	Array multiplier	1
3.4	BoothÕs mul	1
3.5	Pipelining: Ba	1
3.6	Classificatior	1
3.7	Classificatior	1
3.8	Instruction a ... uired)	1
3.9	Hazard dete	1
4.1	Control orgar ... re 1)	1
4.2	Control orgar ... re 2)	1
4.3	Control orgar ... re 3)	1
4.4	Design of mi ... t (Lectur	1
4.5	Design of mi ... t (Lectur	1
4.6	Design of microprogram control logicÐcontrol of processor unit (Lectur	1
4.7	Microprogram sequencer	1
4.8	Micro programmed CPU organization	1
4.9	Microinstructions Ðhorizontal and vertical micro instructions	1
Module 5 : (Basic processing units, I/O and memory) (8 hours)		
5.1	Accessing of I/O devices Ðinterrupts	1
5.2	Interrupt hardware	1

5.3	Direct memory access	1
5.4	Memory system: basic concepts Ðsemiconductor RAMs	1
5.5	Memory system considerations Ð ROMs	1
5.6	Content addressable memory	1
5.7	Cache memories -mapping functions (Lecture 1)	1
5.8	Cache memories -mapping functions (Lecture 2)	1

CST 204	Database Management Systems	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	3	1	0	4	2019

Preamble: This course provides a clear understanding of fundamental principles of Da Management Systems (DBMS) with special focus on relational databases to the learn topics covered in this course are basic concepts of DBMS, Entity Relationship (ER) Relational Database principles, Relational Algebra, Structured Query Language (SQL), P Data Organization, No ncepts. The course als glimpse of the alterna s course helps the lea manage data efficie o maintain data ass organizations and to d nologies.

Prerequisite: Topics c CST 201), Exposure to a High Level Language like C

Course Outcomes: Aft will be able to

CO1	Summarize a cteristics of database (Cognitive Kn
CO2	Model real w s, using Entity Relatio diagrams.(Co
CO3	Model and and querying data relational mo
CO4	Demonstrate abase applications (Cognitive Knowledge Level: Apply)
CO5	Discuss and compare the aspects of Concurrency Control and Recovery in D systems (Cognitive Knowledge Level: Apply)
CO6	Explain various types of NoSQL databases (Cognitive Knowledge Level: Understand)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔									✔
CO2	✔	✔	✔	✔								✔
CO3	✔	✔	✔	✔								✔
CO4	✔	✔	✔							✔		✔
CO5	✔	✔	✔							✔		✔
CO6	✔	✔	✔							✔		✔

Abs			
PO#	B		road PO
PO1	Engineering Kr		nd Sustainability
PO2	Problem Analy		
PO3	Design/Develo		team work
PO4	Conduct inve problems		n
PO5	Modern tool us		ement and Finance
PO6	The Engineer		ng

Assessment Pattern

BloomÕs Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test1 (%)	Test2 (%)	
Remember	30	30	30
Understand	40	40	40
Apply	30	30	30

Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	[illegible]	[illegible]	3 hours

Continuous Internal E

Attendance : 10 marks

Continuous Assessme : 25 marks

Continuous Assessme : 15 marks

Internal Examination F

Each of the two intern 50 marks

First Internal Examina mpleting the first half syllabus and the Sec ly conducted after cor remaining part of the s

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 qu each from the completed modules and 1 question from the partly covered module), h marks for each question adding up to 15 marks for part A. Students should answer all q from Part A. Part B contains 7 questions (preferably, 3 questions each from the co modules and 1 question from the partly covered module), each with 7 marks. Out o questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questio each module, having 3 marks for each question. Students should answer all question contains 2 questions from each module of which a student should answer any one. Each can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module 1: Introduction & Entity Relationship (ER) Model

Concept & Overview aracteristics of Databa system, Database Us ictured data. Data Mo Schema - Three S s, Database architect classification.

ER model- Basic cor elationships and cons cardinality, participatio legree 3.

Structure of Relationa izing ER diagram to re schema

Introduction to Relatio ct operations, join - Eq natural join. query exa guage (SQL), Data De Language (DDL), Ta , DROP, ALTER, INS DELETE, UPDATE.

Module 3: SQL DML (Data Manipulation Language), Physical Data Organization

SQL DML (Data Manipulation Language)SQL queries on single and multiple tables, Ne queries (correlated and non-correlated), Aggregation and grouping, Views, assertions, SQL data types.

Physical Data Organization- Review of terms: physical and logical records, blocking fa pinned and unpinned organization. Heap files, Indexing, Singe level indices, numerical ex Multi-level-indices, numerical examples, B-Trees & B+-Trees (structure only, algorithm required), Extendible Hashing, Indexing on multiple keys Ð grid files.

Module 4: Normalization

Different anomalies in designing a database, The idea of normalization, Functional depe
ArmstrongÕs Axioms (proofs not required), Closures and their computation, Equival
Functional Dependencies (FD), Minimal Cover (proofs not required). First Normal Form
Second Normal Form (2NF), Third Normal Form (3NF), Boyce Codd Normal Form (B
Lossless join and dependency preserving decomposition, Algorithms for checking Lossless Joi
(LJ) and Dependency Preserving (DP) properties.

Module 5: Transactions, Concurrency and Recovery, Recent Topics

Transaction Processing Concepts - overview of concurrency control, Transaction Mo
Significance of concu ... tates, System Log, De
Properties of transacti
Serial schedules, Co ... flict equivalence and
serializability, Recove ... g, Two-phase locking
variations. Log-based ... heck-pointing.

Introduction to NoSQ ... -value DB (examples
Redis), Document DE

Main characteristics ... Cassandra) and Gra
(examples from : Arar

Text Books

1. Elmasri R. ar ... els, Languages, Desi
   Application Pr
2. Sliberschatz A. ... System Concepts, 6/e,
   Hill, 2011.

Reference Books:

1. Adam Fowler, NoSQL for Dummies, John Wiley & Sons, 2015
2. NoSQL Data Models: Trends and Challenges (Computer Engineering: Databases
   Data), Wiley, 2018
3. Web Resource: https://www.w3resource.com/redis/
4. web Resource: https://www.w3schools.in/category/mongodb/
5. Web Resource: https://www.tutorialspoint.com/cassandra/cassandra_introduction.htm
6. Web Resource : https://www.tutorialspoint.com/arangodb/index.htm

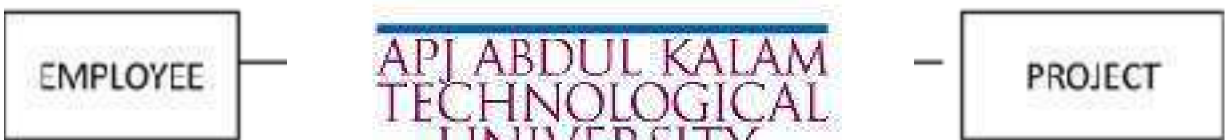
Sample Course Level Assessment Questions

Course Outcome1 (CO1):

1. List out any three salient features of database systems, which distinguish it fron system.
2. Give one example each for logical and physical data independence.

Course Outcome 2(CO2):

1. What facts about the relationships between entities EMPLOYEE and PROJE(conveyed by the following ER diagram?



1. Design an ER dia There is a set of er), name, main stadiur which city this te and each player belon team. Each play e, DoB, start year, ar number that he u here is a host team ar team.

Course Outcome 3((

1. For the SQL qu pleÕ AND C = Ôonathe table R(A, B, (equivalent relational al expressions.
2. Given the FDs the sequence of ArmstrongÕs A !(a) (b) PR ! S (c) QR ! SU
3. Consider a relation PLAYER (PLAYER-NO, PLAYER-NAME, PLAYER-POS TEAM, TEAM-COLOR, COACH-NO, COACH-NAME, TEAM-CAPTAIN). Assum that PLAYER-NO is the only key of the relation and that the following depender hold:

   TEAM!{TEAM-COLOR, COACH-NO, TEAM-CAPTAIN}
   COACH-NO!COACH-NAME.

   i. Is the relation in 2NF? If not, decompose to 2NF.
   ii. Is the relation in 3NF? If not, decompose to 3NF.

4. In the following tables foreign keys have the same name as primary keys DIRECTED-BY, which refers to the primary key ARTIST-ID. Consider only single-director movies.
MOVIES(<u>MOVIE-ID</u>, MNAME, GENRE, LENGTH, DIRECTED-BY)
ARTIST(<u>ARTIST-ID</u>, ANAME)
ACTING(<u>ARTIST-ID, MOVIE-ID</u>)
Write SQL expressions for the following queries:
   (a) Name(s) and director name(s) of movie(s) acted by ÔJennyÕ.
   (b) Names of actors who have never acted with ÔRonyÕ
   (c) Count of movies genre-wise.
   (d) Name(s) of movies with maximum length.

Course Outcome 4(

1. Consider an E … ch record is of size 80
The file is sor … , which is the primar
Assuming un-s … es and block pointer si
bytes. Comput … retrieving an employe
based on empl … evel primary index is u

Course Outcome 5(

1. Determine if th … edu cascade-less? Justi
your answer r1(…), c3, r2(Y), w2(Z), w2
c2. (Note: ri(X … te on item X; ci means
transaction Ti co
2. Two-phase lock

Course Outcome 6(

1. List out any thr … ive example of a docu
MongoDB.

Model Question paper

QPCODE

Reg No:_________________

Name:__________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 204

Course Name: Database Management Systems

Max.Marks:100 Duration: 3 Hours

Answ

1 List out any three

2 When is multi-val g?

3 For the SQL quer leÕ AND C = Ô on the table R(A, equivalent relat algebra expressio

4 Outline the conce

5 How is the purpo aving clause?

6 What is the use o

7 When do you say

8 Given the FDs P! equence of ArmstrongÕs Axi

9 What is meant by the lost update problem?

10 What is meant by check pointing?

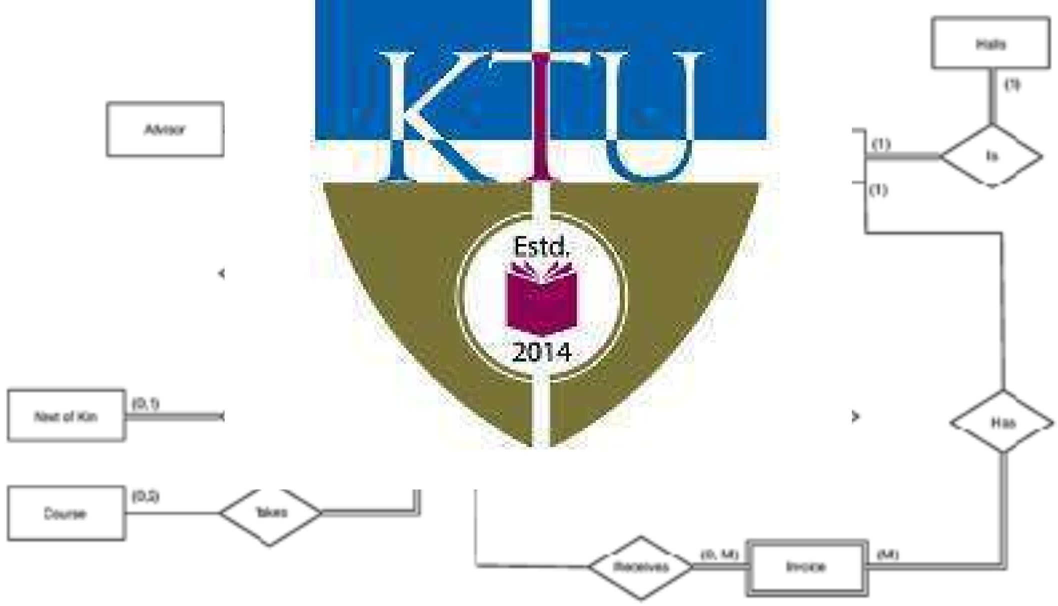
PART B

Answer any one Question from each module. Each question carries 14 Marks

11 a. Design an ER diagram for the following scenario: There is a set of teams team has an ID (unique identifier), name, main stadium, and to which cit team belongs. Each team has many players, and each player belongs team. Each player has a number (unique identifier), name, DoB, start ye shirt number that he uses. Teams play matches, in each match there is team and a guest team. The match takes place in the stadium of the ho For each match we need to keep track of the following: The date on whi game is played The final result of the match. The players participated match. For each player, how many goals he scored, whether or not h yellow card, and whether or not he took red card. During the match, one may substitute another player. We want to capture this substitution and th at which it too rees. For each we have an II perience. One r is the main re . (14)

12 a. Interpret the t

(8)



b. Distinguish between physical data independence and logical data indepe with suitable examples. (6)

13 EMPLOYEE(ENO, NAME, ADDRESS, DOB, AGE, GENDER, SALARY, DNUM, SUPERENO) (14)
DEPARTMENT(DNO, DNAME, DLOCATION, DPHONE, MGRENO)
PROJECT(PNO, PNAME, PLOCATION, PCOST, CDNO)

DNUM is a foreign key that identifies the department to which an empl belongs. MGRENO is a foreign key identifying the employee who manage department. CDNO is a foreign key identifying the department that contro project. SUPERENO is a foreign key identifying the supervisor of each emplo

Write relational algebra expressions for the following queries:-

(a) Names of [illegible] n 20000.
(b) Salaries o [illegible]
(c) Names of [illegible] name
(d) For each [illegible] ng with his depa name and [illegible] s
(e) Names of [illegible]

14 a.Write SQL DD [illegible] suitable domain types): (10)

i. Crea [illegible] CLASS, SEM, ADVI [illegible] T). Assume tha ADVI [illegible] e.

ii. Delet [illegible] loyees of the depa [illegible]

iii. Incre [illegible]

b.Illustrate foreign key constraint with a typical example. (4)

15 For the relation schema below, give an expression in SQL for each of the ((14)
that follows:

employee(employee-name, street, city)
works(employee-name, company-name, salary)
company(company-name, city)
manages(employee-name, manager-name)

a) Find the names, street address, and cities of residence for all emp
who work for the Company ÔRIL Inc.' and earn more than $10,000.
b) Find the names of all employees who live in the same cities a
companies for which they work.
c) Find the n ÔKYS Inc.Õ. A
that all pe
d) Find the r an every emplo
ÔSB Corp nost one compa
e) List out n decreasing orc
number of

16 a. Consider ere each record (9)
size 80 by 15 bytes long),
is the prin on and block si
512 bytes needed for se
records ba
i. No
ii. Sin
iii. Mul
Assume a

b. Illustrate correlated and non-correlated nested queries with real examp (5)

17 a. Illstrate3NF and BCNF with suitable real examples. (6)

b. Given a relation R(A1,A2,A3,A4,A5) with functional dependen (8)
A1!A2A4 and A4!A5, check if the decomposition R1(A1,A2,A3), R2(A1,A4), R3(A2,A4,A5) is lossless.

OR

18 a. Consider the un-normalized relation R(A, B, C, D, E, F, G) with the (7)
A!B , AC!G, AD!EF, EF!G, CDE!AB. Trace the normalization process to reach 3NF relations.

b. Illustrate Lossless Join Decomposition and Dependency Pres (7)
Decomposition with typical examples.

19 a. Discuss the four ACID properties and their importance. (7)

b. Determine if the following schedule is conflict serializable. Is the sch (7)
recoverable? Is the schedule cascade-less? Justify your answers.

r1(X), r2(Z), r1(Z), r3(X), r3(Y), w1(X), c1, w3(Y), c3, r2(Y), w2(Z
w2(Y), c2

(Note: ri(X)/wi(X) means transaction Ti issues read/write on item X
means transaction Ti commits.)

20 a. Discuss th Graph DB. (7)

b. Illustrate t ng three transa (7)
Argue tha hat 2Pl can le
deadlock.

Teaching Plan

	Course Name	Hours (48)
	Module 1: Introduction & ER Model	8
1.1	Concept & Overview of DBMS, Characteristics of DB syst Database Users.	1
1.2	Structured, semi-structured and unstructured data. Data Mode Schema	1
1.3	Three-S	1
1.4	Databas	1
1.5	ER mod … tations	1
1.6	Relation … tion, notati	1
1.7	Weak er	1
1.8	ER diag	1
	Module	7
2.1	Structur … ts	1
2.2	Synthes … ntroductio relationa	1
2.3	Relation … operation	1
2.4	Relation	1
2.5	Query e	1
2.6	Introduction to SQL, important data types	1
2.7	DDL, Table definitions and operations Ð CREATE, DROP, ALT INSERT, DELETE, UPDATE	1
	Module 3: SQL DML, Physical Data Organization	11
3.1	SQL DML, SQL queries on single and multiple tables	1
3.2	Nested queries (correlated and non-correlated)	1
3.3	Aggregation and grouping	1

	Course Name	Hours (48)
3.4	Views, assertions (with examples)	1
3.5	Triggers (with examples), SQL data types	1
3.6	Review of terms: physical and logical records, blocking fa pinned and unpinned organization. Heap files, Indexing	1
3.7	Singe level indices, numerical examples	1
3.8	Multi-level-indices, numerical examples	1
3.9	B-Trees ... required)	1
3.10	Extendil	1
3.11	Indexing	1
	Module	8
4.1	Differen ... The ide normaliz	1
4.2	Functior ... s not requi	1
4.3	Closures ... FDs, min Cover (p	1
4.4	1NF, 2N	1
4.5	3NF, BC	1
4.6	Lossless ... ition	1
4.7	Algorithr ... ency prese properties (Lecture 1)	1
4.8	Algorithms for checking Lossless Join and Dependency prese properties (Lecture 2)	1
	Module 5: Transactions, Concurrency and Recovery, Recer Topics	14
5.1	Transaction Processing Concepts: Transaction Model	1
5.2	Overview of concurrency control, Significance of concurre Control & Recovery	1
5.3	Transaction States, System Log	1

	Course Name	Hours (48)
5.4	Desirable Properties of transactions, Serial schedules	1
5.5	Concurrent and Serializable Schedules	1
5.6	Conflict equivalence and conflict serializability	1
5.7	Recoverable and cascade-less schedules	1
5.8	Locking, Two-phase locking, strict 2PL.	1
5.9	Log-based recovery	1
5.10	Deferrec [illegible] ample	1
5.11	Deferrec [illegible] dule) exa check-p [illegible]	1
5.12	Introduc [illegible]	1
5.13	Main ch [illegible] from: Re Docume [illegible] ed study expecte [illegible]	1
5.14	Main cl [illegible] amples fr Cassanc [illegible] oDB) [de study nc [illegible]	1

CST 206	OPERATING SYSTEMS	Category	L	T	P	Credit	Year of Introduction
		PCC	3	1	0	4	2019

Preamble: Study of operating system is an essential to understand the overall worl computer system, tradeoffs between performance and functionality and the division between hardware and software. This course introduces the concepts of memory man device management, process management, file management and security & pı mechanisms available in an operating system. The course helps the learner to under fundamentals about any operating system design so that they can extend the features of system to detect and solve many problems occurring in operating system and to maı computer resources appropriately.

Prerequisite: Topics cc 201) and Programming in C (EST 102)

Course Outcomes: Aft will be able to

CO1	Explain the ating Systems in com devices. (Cc
CO2	Illustrate the ocess scheduling mec employed ir Understand)
CO3	Explain prc ems and illustrate p synchroniza Semaphores and Mc (Cognitive k
CO4	Explain any voidance and recove managing d knowledge: Understan
CO5	Explain the rating Systems. (Cognitive knowledge:
CO6	Explain the security aspects and algorithms for file and storage managen Operating Systems. (Cognitive knowledge: Understand)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓							✓		✓
CO2	✓	✓	✓	✓						✓		✓
CO3	✓	✓	✓	✓						✓		✓
CO4	✓	✓	✓	✓						✓		✓
CO5	✓	✓	✓	✓						✓		✓
CO6	✓	✓	✓	✓						✓		✓

Abs		
PO#	B	road PO
PO1	Engineering Knc	d Sustainability
PO2	Problem Analysi	
PO3	Design/Develop	eam work
PO4	Conduct investig problems	
PO5	Modern tool usa	ment and Finance
PO6	The Engineer ar	g

Assessment Pattern

BloomÕs Category	Test 1 (Marks in percentage)	Test 2 (Marks in percentage)	End Semester Examination (Marks in percentage)
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:
Attendance : 10 marks
Continuous Assessment Test : 25 marks
Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series
be preferably conduct … bus and the second se
shall be preferably co … he syllabus. There will
parts: Part A and Pa … ly, 2 questions each
completed modules a … dule), having 3 marks
question adding up to … wer all questions from
Part B contains 7 qu … the completed module
question from the part … ut of the 7 questions, a
should answer any 5.

End Semester Examir
There will be two part … estions with 2 questio
each module, having … ld answer all question
contains 2 questions f … answer any one. Each
can have maximum 2

Introduction: Operating system overview Đ Operations, Functions, Service Đ Syster
Types Đ Operating System structure - Simple structure, Layered approach, Microkernel,
Đ System boot process.

Module II

Processes - Process states, Process control block, threads, scheduling, Operations on p
process creation and termination Đ Inter-process communication - shared memory
Message passing systems.

Process Scheduling Ð Basic concepts- Scheduling criteria -scheduling algorithms- Firs
First Served, Shortest Job Firs, Priority scheduling, Round robin scheduling

Module III

Process synchronization- Race conditions Ð Critical section problem Ð PetersonÕs
Synchronization hardware, Mutex Locks, Semaphores, Monitors Ð Synchronization pro
Producer Consumer, Dining Philosophers and Readers-Writers.

Deadlocks: Necessary conditions, Resource allocation graphs, Deadlock prevention, D
avoidance Ð BankerÕs algorithms, Deadlock detection, Recovery from deadlock.

Module IV

Memory Management: Concept of address spaces, Swapping, Contiguous memory allo
fixed and variable pa ... nory, Demand paging
replacement algorithm

File System:File conce ... Ð Access methods, Pro
File-system implemen ... methods.
Storage Management: ... Structure, Disk sched
Disk formatting.

Text Book

Abraham Silberschatz ... ating System Conce th
Edition, Wiley India 20

Reference Books:

1. Andrew S Tanenl ... Prentice Hall, 2015.
2. William Stallings, ÒOperating systemsÓ, 6th Edition, Pearson, Global Edition, 2015.
3. Garry Nutt, Nabendu Chaki, Sarmistha Neogy, ÒOperating SystemsÓ, 3rd Edition, Pearson Education.
4. D.M.Dhamdhere, ÒOperating SystemsÓ, 2nd Edition, Tata McGraw Hill, 2011.
5. Sibsankar Haldar, Alex A Aravind, ÒOperating SystemsÓ, Pearson Education.

Sample Course Level Assessment Questions

Course Outcome1 (CO1): What is the main advantage of the micro kernel approach to sy
design? How do user program and system program interact in a microkernel architecture?

Course Outcome 2 (CO2): Define process. With the help of a neat diagram explain diffe
states of process.

Course Outcome 3 (CO3): What do you mean by binary semaphore and counting semap
With C, explain implementation of wait () and signal().

Course Outcome 4 (CO4): Describe resource allocation graph for the following. a) with
deadlock b) with a cycle but no deadlock.

Course Outcome 5 (CO5): Consider the following page reference string 1, 2, 3, 4, 2, 1, 5,
1, 2, 3, 7, 6, 3, 2, 1, 2 ... there are 4 page frames
the following page rep ... nal

Course Outcome 6 (C ... ethods with advantages
disadvantages.

QP CODE: PAGES: ___

Reg No:___________
Name:____________

APJ A ... ITY
FOURTH SEMES ... ONTH & YEAR

Course name : OPERATING SYSTEMS

Max Marks: 100 Duration: 3 Hours

PART-A

(Answer All Questions. Each question carries 3 marks)

1. How does hardware find the Operating System kernel after system switch-on?
2. What is the purpose of system call in operating system?
3. Why is context switching considered as an overhead to the system?

4. How is inter process communication implement using shared memory?

5. Describe resource allocation graph for the following.

   a) with a deadlock   b)with a cycle but no deadlock.

6. What is critical section? What requirement should be satisfied by a solution to the c section problem?

7. Consider the reference string 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6 many page faults occur while using FCFS for the following cases.

   a) frame=2   b)frame=3

8. Differentiate between internal and external fragmentations.

9. Compare sequ storage devices.

10. Define the terr

module)

11. a) Explain the foll olithic systems
    (ii) Layered S ch. (12)

    b) Under what c g a time sharing system PC or a single

12. a) What is the ma o system design? How program and sy itecture? (8)

    b) Describe the differences between symmetric and asymmetric multiprocessing? W the advantages and disadvantages of multiprocessor systems? (6)

13. a) Define process. With the help of a neat diagram explain different states of process. (8)
    b) Explain how a new process can be created in Unix using fork system call. (6)

OR

14 a) Find the average waiting time and average turnaround time for the processes given table below using:- i) SRT scheduling algorithm ii) Priority scheduling algorithm (9)

Process	Arrival Time (ms)	CPU Burst Time (ms)	Priority
P1	0	5	3
P2	2	4	1
P3	3	1	2
P4	5	2	4

b) What is a Process Control Block? Explain the fields used in a Process Control Block. (5)

15. Consider a system with five processes P_0 through P_4 and three resources of type A, B, (
Resource type A has 10 instances, B has 5 instances and C has 7 instances. Suppos
t_0 following snapshot of the system has been taken:

Process		Available		
		A	B	C
P_0		3	3	2
P_1				
P_2				
P_3				
P_4				

i) What will be the cor … safe state? If Yes, then

the safe sequence? (

iii)What will happen if … of resource type A and

instances of resource type C? (6)

OR

16. a) State dining philosopherÕs problem and give a solution using semaphores. (7)

b) What do you mean by binary semaphore and counting semaphore? With C struct,
implementation of wait () and signal()

17. a) Consider the following page reference string 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 3, 6. Find out the number of page faults if there are 4 page frames, using the foll page replacement algorithms i) LRU ii) FIFO iii) Optimal (9)

b) Explain the steps involved in handling a page fault. (5)

OR

18. a) With a diagram, explain how paging is done with TLB. (5)

b) Memory partitions of sizes 100 kb, 500 kb, 200 kb, 300 kb, 600 kb are available would best ,worst and first fit algorithms place processes of size 212 kb, 417 kb, 1 426 kb in order. Rank the algorithms in terms of how efficiently they uses memory. (9)

19. a) Suppose that a ... 0 to 4999. the drive cu services a reque ... was at cylinder 125. the of pending requ ... 948, 1509, 1022, 1750 Starting from the ... in cylinders) that the dis moves to satisfy ... g algorithms

i) FCFS ii ... -SCAN (10)

b) What is the use ... (4)

20. a) Explain the diffe ... es and disadvantages. (8)

b) Explain the follo ... ributes (6)

		5 Hours
1.1	Introduction to	1
1.2	Operating System operations, functions, service	1
1.3	System calls, Types	1
1.4	Operating System Structure: Simple, Layered, Microkernel, Modules	1
1.5	System Boot Process	1
	Module 2 Ð Processes and Process Scheduling	9 Hours
2.1	Processes, Process states	1
2.2	Process Control Block, Threads	1

2.3	Scheduling	1
2.4	Operations on processes: process creation and termination	1
2.5	Inter-process communication: Shared memory systems, Message Pa	1
2.6	Process Scheduling Ð Basic concepts, Scheduling Criteria	1
2.7	Scheduling algorithms - Basics	1
2.8	First come First Served, Shortest Job First	1
2.9	Priority scheduling, Round Robin Scheduling	1
	Module 3 - Process synchronization and Dead locks	13 Hours
3.1	Process synchronization, Race conditions	1
3.2	Critical Section	1
3.3	Synchronizatio	1
3.4	Semaphores	1
3.5	Monitors	1
3.6	Synchronizatio	1
3.7	Synchronizatio	1
3.8	Deadlocks: Ne phs	1
3.9	Deadlock preve	1
3.10	Deadlock avoic	1
3.11	BankerÕs algo	1
3.12	Deadlock deteo	1
3.13	Deadlock recov	1
	Module 4 - Memory Management	9 Hours
4.1	Memory Management: Concept of Address spaces	1
4.2	Swapping	1
4.3	Contiguous memory allocation, fixed and variable partitions	1
4.4	Segmentation.	1
4.5	Paging (Lecture 1)	1
4.6	Paging (Lecture 2)	1
4.7	Virtual memory, Demand Paging	1

4.8	Page replacement algorithms (Lecture 1)	1
4.9	Page replacement algorithms (Lecture 2)	1
	Module 5 - File and Disk management	9 Hours
5.1	File concept, Attributes, Operations, types, structure	1
5.2	Access methods	1
5.3	Protection	1
5.4	File-System implementation	1
5.5	Directory implementation	1
5.6	Allocation methods	1
5.7	Magnetic disks [illegible]	1
5.8	Disk schedulin[illegible]	1
5.9	Disk formatting [illegible]	1

CSL 202	DIGITAL LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This course helps the learners to get familiarized with (i) Digital Logic De through the implementation of Logic Circuits using ICs of basic logic gates & flops and (ii) Hardware Description Language based Digital Design. This course hel learners to design and implement hardware systems in areas such as games, mus filters, wireless communications and graphical displays.

Prerequisite:Topics covered under the course Logic System Design (CST 203)

Course Outcomes: After the completion of the course the student will be able to

CO 1	Design and … ng Logic Gates (Cog Knowledge …
CO 2	Design ar … sing Integrated Ci (Cognitive …
CO 3	Simulate fu … s written in a Hardw Description …
CO 4	Function e … ccomplish a given t designing a … Knowledge Level: Apply)

Mapping of course o…

	PO 1	PO 2								PO10	PO11	PO12
CO 1	✔	✔	✔	✔				✔				✔
CO 2	✔	✔	✔	✔				✔				✔
CO 3	✔	✔	✔	✔	✔			✔				✔
CO 4	✔	✔	✔	✔				✔	✔			✔

Assessment Pattern

BloomÕs Category	Continuous Assessment Test (Internal Exam) (Percentage)	End Semester Examination (Percentage)
Remember	20	20
Understand	20	20
Apply	60	60
Analyse		
Evaluate		
Create		

Mark Distribution

Total Marks	ESE Duration
150	3 hours

Continuous Internal

Attendance

Continuous Evaluati

Continuous Assessn

Viva-voce : 15 marks

Internal Examination Pattern: The marks will be distributed as Design/Algorithm marks, Implementation/Program 20 marks, Output 20 marks and Viva 30 marks. To marks which will be converted out of 15 while calculating Internal Evaluation marks.

End Semester Examination Pattern:The marks will be distributed as Design/Algorithn marks, Implementation/Program 20 marks, Output 20 marks and Viva 30 marks. To marks will be converted out of 75 for End Semester Examination.

Fair Lab Record:

All Students attending the Digital Lab should have a Fair Record. The fair record sh produced in the University Lab Examination. Every experiment conducted in the lab be noted in the fair record. For every experiment in the fair record, the right hand page contain Experiment Heading, Experiment Number, Date of Experiment, and A Experiment. The left hand page should contain components used, circuit design or a of the code used for the experiment and sample output obtained.

SYLLABUS

Conduct a minimum of 8 experiments from Part A and a minimum of 4 experiments from Part B. The starred experiments in Part A are mandatory. The lab work should be conduct in groups (maximum student in the group be assessed based

- A 2 hour ses comfortable with the trainer kit/bre
- The following rd or trainer kits.
- Out of the 1 8 experiments shou completed by nts (5).

1. Realization of fur and POS forms).
2. Design and reali and full subtractor us a) basic gates (b
3. Code converters 3 and Binary to Gra converters.
4. Design and imple adder using IC7483.
5. Implementation JK Flip Flops using b gates.*
6. Asynchronous Co counter.
7. Asynchronous Counter: Realization of Mod N counters (At least one up counter a down counter to be implemented). *
8. Synchronous Counter: Realization of 4-bit up/down counter.
9. Synchronous Counter: Realization of Mod-N counters and sequence generators. one mod N counter and one sequence generator to be implemented) *
10. Realization of Shift Register (Serial input left/right shift register), Ring counter Johnson Counter using flipflops. *
11. Realization of counters using ICÕs (7490, 7492, 7493).
12. Design and implement BCD to Seven Segment Decoder.
13. Realization of Multiplexers and De-multiplexers using gates.
14. Realization of combinational circuits using MUX & DEMUX ICs (74150, 74154).
15. To design and set up a 2-bit magnitude comparator using basic gates.

PART B (Any 4 Experiments)

¥ The following experiments aim at training the students in digital circuit design Verilog. The experiments will lay a foundation for digital design with Hardw Description Languages.

¥ A 3 hour introductory session shall be spent to make the students aware fundamentals of development using Verilog

¥ Out of the 8 experiments listed below, a minimum of 4 experiments shou completed by a student

Experiment 1. Realization of Logic Gates and Familiarization of Verilog

(a) Familiarization of the basic syntax of Verilog

(b) Development of Verilog modules for basic gates and to verify truth tables.

(c) Design and simulate the HDL code to realize three and four variable Bo functions

Experiment 2: Half ad

(a) Development nodeling styles (data structural/beh

(b) Development tural modeling using adder.

Experiment 3: Design

Design and simulate

(a) 4- bit binary to

(b) 4- bit gray to b

Experiment 4: Mux a

(a) Development

(b) Development

Experiment 5: Adder

(a) Write the Veril

(b) Development of Verilog modules for a BCD adder

Experiment 6: Magnitude Comparator

Development of Verilog modules for a 4 bit magnitude comparator

Experiment 7: Flipflops and shiftregisters

(a) Development of Verilog modules for SR, JK, T and D flip flops.

(b) Development of Verilog modules for a Johnson/Ring counter

Experiment 8: Counters

(a) Development of Verilog modules for an asynchronous decade counter.

(b) Development of Verilog modules for a 3 bit synchronous up-down counter.

Practice Questions

PART A

1. Design a two bit parallel adder using gates and implement it using ICs of basic
2. A combinatorial circuit has 4 inputs and one output. The output is equal to 1 wh all inputs are 1, (b) none of the inputs are 1, (c) an odd number of inputs are e 1. Obtain the truth table and output function for this circuit and implement the sa
3. Design and implement a parallel subtractor.
4. Design and implement a digital circuit that converts Gray code to Binary.
5. Design a combinational logic circuit that will output the 1Õs compliment of a input number
6. Implement and test the logic function $f(A, B, C) = \sum m(0,1,3,6$ using an 8:1 MUX IC
7. Design a circu … on counter based on bit, M.
8. Design a 4-bi
9. Design a Cou … 7,6,4
10. Design an as
11. Design and i … flip flop ICs to gener sequence: 0

1. Develop Veril … ural modeling using subtractors.
2. Design a 4 bit
3. Develop Verilo … unter.
4. Write Verilog c
5. Develop Verilo … 3 code to binary.
6. Write the Ve … t-bench. Use all pos combinations
7. Write the har … ter with shift left and right modes of operations and test its functioning.
8. Write the hardware description in Verilog of a mod-N (N > 9) counter and test it.

CS /20	OPERATING SYSTEMS LAB	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	0	0	3	2	2019

Preamble: The course aims to offer students a hands-on experience on Operating concepts using a constructivist approach and problem-oriented learning. Operating sys the fundamental part of every computing device to run any type of software.

Prerequisite: Topics covered in the courses are Data Structures (CST 201) and Programmin in C (EST 102)

Course Outcomes:

At the end of the cour

CO1	Illustrate th Understand	Cognitive knowledge:
CO2	Implement Systems. (C	ommunication in Ope
CO3	Implement based CPU	Round Robin and P e: Apply)
CO4	Illustrate th Frequently	Recently Used and nowledge: Apply)
CO5	Implement Systems. (	lock Avoidance in Ope
CO6	Implement Systems. (C	sk Scheduling in Ope

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔					✔		✔		✔
CO2	✔	✔	✔					✔		✔		✔
CO3	✔	✔	✔	✔				✔		✔		✔
CO4	✔	✔	✔	✔				✔		✔		✔
CO5	✔	✔	✔	✔				✔		✔		✔
CO6	✔	✔	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	✔		✔

Abs [illegible]			
PO#	B [illegible]	[illegible]	Broad PO
PO1	Engineering Kno [illegible]	[illegible]	[illegible]nd Sustainability
PO2	Problem Analysi [illegible]	[illegible]	
PO3	Design/Develop [illegible]	[illegible]	[illegible] team work
PO4	Conduct investig [illegible] problems	[illegible]	[illegible]n
PO5	Modern tool usa [illegible]	[illegible]	[illegible]gement and Finance
PO6	The Engineer ar [illegible]	[illegible]	[illegible]ing

Assessment Pattern:

BloomÕs Category	Continuous Assessment Test (Internal Exam) Marks in percentage	End Semester Examination Marks in percentage
Remember	20	20
Understand	20	20
Apply	60	60
Analyse		
Evaluate		
Create		

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks

Continuous Eva

Continuous Ass

Viva Voce

Internal Examinati as Algorithm 30 mark Program 20 marks tal 100 marks which w converted out of 15

End Semester Ex ks will be distributed Algorithm 30 marks iva 30 marks. Total 75 n

Operating System t

Compiler/Software t

Progamming Langu

Fair Lab Record:

All Students attending the Operating System Lab should have a Fair Record. The fair r should be produced in the University Lab Examination. Every experiment conducted ir lab should be noted in the fair record. For every experiment in the fair record, the right page should contain Experiment Heading, Experiment Number, Date of experiment, Ai the Experiment and the operations performed on them, Details of experiment inclu algorithm and result of Experiment. The left hand page should contain a print out of the used for experiment and sample output obtained for a set of input.

SYLLABUS

OPERATING SYSTEMS LAB

* mandatory

1. Basic Linux commands
2. Shell programming

    -Command syntax

    -Write simple functions with basic tests, loops, patterns

3. System calls of Linux operating system:*

    fork, exe ... ddir

4. Write programs ... g system (open, read,
5. Implement pro ... g Shared Memory *
6. Implement Sen
7. Implementation ... obin b) SJF c) FCFS d) Priority *
8. Implementation ... partition*

    a) First Fit

9. Implement l pa ...) LFU*
10. Implement the ... *
11. Implementation
12. Simulate file al

    b) Sequent

13. Simulate disk s

    c) FCFS b)SCAN c) C-SCAN

OPERATING SYSTEMS LAB - PRACTICE QUESTIONS

1. Write a program to create a process in linux.
2. Write programs using the following system calls of Linux operating system:

    fork, exec, getpid, exit, wait, close, stat, opendir, readdir

3. Write programs using the I/O system calls of Linux operating system (open, read,

4. Given the list of processes, their CPU burst times and arrival times, display/prir Gantt chart for FCFS and SJF. For each of the scheduling policies, compute and pr average waiting time and average turnaround time

5. Write a C program to simulate following non-preemptive CPU scheduling algorithms find turnaround time and waiting time.

   a) FCFS b) SJF c) Round Robin (pre-emptive) d) Priority

6. Write a C program to simulate following contiguous memory allocation techniques

   a) Worst-fit b) Best-fit c) First-fit

7. Write a C program to simulate paging technique of memory management.

8. Write a C program to simulate Bankers algorithm for the purpose of deadlock avoid

9. Write a C progr) FCFS b) SCAN c) C-S

10. Write a C progr a) FIFO b) LRU c) LFU

11. Write a C progr using semaphores.

12. Write a prograr irectory in memory.

13. Write a prograr on.

14. Write a C progr gies.

   a)

6 5

CST 2	Programming Methodologies	Category	L	T	P	CREDIT	YEAR OF INTRODUCTION
		MINOR	3	1	0	4	2019

Preamble: This is the second course for awarding B.Tech Minor in Computer Science and Engineering with specialization in Software Engineering The course provides the learner clear understanding of the main constructs of contemporary programming languages various systems of ideas that have been used to guide the design of programming la This course covers the concepts of Names, Bindings & Scope, Statement-Level Structures, Sub Progr ing, Exception Handlin Handling, Concurrenc gic Programming. This helps the learners to e critical evaluation of and upcoming prograr r to choose the most ap language for a given proach to structure or the code and classify ures.

Prerequisite:

1. Topics cover 2)
2. Object Orien

Course Outcomes: Afte e able to

CO1	Explain the c es and compare Impe Functional a gnitive Knowledge L Understand)
CO2	Explain the characteristics of data types and variables (Cognitive Knowledge Understand)
CO3	Illustrate how control flow structures and subprograms help in developin structure of a program to solve a computational problem (Cognitive Knowledge Apply)
CO4	Explain the characteristics of Object Oriented Programming Languages (Co Knowledge Level: Understand)
CO5	Compare concurrency constructs in different programming languages (Co Knowledge Level: Understand)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓							✓		✓
CO2	✓	✓								✓		✓
CO3	✓	✓	✓	✓								✓
CO4	✓	✓								✓		✓
CO5	✓	✓	✓	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			✓

Abs[illegible]				
PO#	l[illegible]		[illegible]	[illegible]Broad PO
PO1	Engineering Kr[illegible]		[illegible]	[illegible]nd Sustainability
PO2	Problem Analys[illegible]		[illegible]	[illegible]
PO3	Design/Develo[illegible]		[illegible]	[illegible]team work
PO4	Conduct invest[illegible] problems		[illegible]	[illegible]n
PO5	Modern tool us[illegible]		[illegible]	[illegible]ement and Finance
PO6	The Engineer a[illegible]		[illegible]	[illegible]ng

Assessment Pattern

BloomÕs Category	Continuous Assessment Tests		End Semester Examination (Marks%)
	Test 1 (Marks%)	Test 2 (Marks%)	
Remember	30	30	30
Understand	50	50	50
Apply	20	20	20
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance

Continuous Assessme

Continuous Assessme

Internal Examination P

Each of the two intern ... 50 marks. First series t be preferably conduct ... bus and the second se shall be preferably co ... he syllabus. There will parts: Part A and Pa ... ly, 2 questions each f completed modules a ... dule), having 3 marks f question adding up to ... wer all questions from Part B contains 7 qu ... the completed module question from the partly completed module), each with 7 marks. Out of the 7 questions, a should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questio each module, having 3 marks for each question. Students should answer all question contains 2 questions from each module of which a student should answer any one. Each can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module 1

Introduction Ð Role of Programming Languages, Programming Domains, Language Eval Criteria, Influence on Language Design, Language Design Trade-offs, Implementation Me Names, Bindings & Scope Ð Names, Variables, Concept of Binding, Scope and Life Referencing Environments.

Module 2

Data TypesÐ Primitive Data Types, Character String Types, User-Defined Ordinal Types, Types, Record Types ype Checking, Strong T Type Equivalence. erloaded Operators, T Conversions, Relatio uit Evaluation. Assignm Assignment Statemen

Statement-Level Co s, Iterative Statemen Unconditional Branchi Design Issues of Subpr Local Referencing E Subprograms as Par Overloaded Subprogr

Support for Object Orie ng, Design Issues for Obj Oriented Languages, S ++, Implementation of C Oriented Constructs. Ex ies. Event Handling Introduction to Event Handling.

Module 5

Concurrency Ð Subprogram Level Concurrency, Semaphores, Monitors, Message P Functional Programming Languages Ð Introduction to LISP and Scheme, Compariso Functional and Imperative Languages. Logic Programming Languages Ð Basic Elem Prolog, Applications of Logic Programming.

Text Books

1. Robert W. Sebesta, Concepts of Programming Languages, 10th Edition, Pearson.
2. Scott M. L., Programming Language Pragmatics, 3rd Edn., Morgan Kaufmann Publishers

Reference Books:

1. Kenneth C. Louden, Programming Languages: Principles and Practice, 2nd Edn., Cengag Learning.
2. Tucker A. B. and R. E. Noonan, Programming Languages: Principles and Paradig Edn. ÐTMH.
3. Ravi Sethi, Programming Languages: Concepts & Constructs, 2nd Edn., Pearso Education.
4. David A. Watt, Programming Language Design Concepts, Wiley Dreamtech

Sample Course Level

Course Outcome 1 (C ... guages based on the la evaluation criteria. Pr ... e language evaluation Identify the advantag ... tional and logic progra languages.

Course Outcome 2 (C ... that are specific to cha string types are (1) wh ... racter array or a primiti (2) whether strings ha ... ver.

Course Outcome 3 (C

1. Describe three ... d logical looping state needed.
2. Describe the ways that aliases can occur with pass-by-reference parameters.
3. Identify the two fundamental design considerations for parameter-passing methods

Course Outcome 4 (CO4):

1. Describe the role of a virtual method table in implementing dynamic method bindin
2. Identify one disadvantage of inheritance.

Course Outcome 5 (CO5): Evaluate the use of semaphores and monitors for pro competition synchronization and cooperation synchronization.

Model Question paper

QP CODE: PAGES:3

Reg No:_______________ Name :_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH (MINOR) DEGREE EXAMINA TION, MONTH &

YEAR Course Code: CST2 2

Course Name: Programming Methodologies

Max.Marks:100 Duration: 3 Hours

A rks

1. Differentiate be
2. Define binding
3. What are the a s?
4. Define narrowi
5. Why for statem of older languages?
6. What are the a cal variables in subprogr
7. Explain the cor mple.
8. Is it mandatory ages? Justify your answe
9. What are the a s?
10. Explain the wo

Answer any stion carries 14 Marks

11.

(a) Explain different criteria used for evaluating languages.

(7 marks)

(b) Explain the major methods of implementing programming languages.

(7 marks)

OR

12.

(a) Explain the meanings, purposes, advantages and disadvantages of four categ scalar variables according to their storage bindings.

(7 marks)

(b) What is referencing environment of a statement? Show the referer environment at the indicated program points (1), (2), (3) & (4) for the follow program segment. Assume that the programming language used is statically sc

```
program  example;
    var  a, b : integer;
    procedure    sub1;
            var   x, y: integer;
            begin { sub1 }
            ÉÉÉ..                                    (1)
            end { sub1 }
    procedure    sub2;
            va
            É
             p




            b
            É
            e
begin {exan
            É
end {examp
```

(7 Marks)

13.

(a) Explain an data types and also in how dangli

(7 marks)

(b) Describe the lazy and eager approaches for reclaiming garbage.

(7 marks)

OR

14.

(a) What is meant byside effect and illustrate the advantages of referent transparency?

(8 marks)

(b) Explain the terms: compound assignment operator, coercion and short circuit evaluation.

(6 marks

15.

(a) Explain different categories of iteration control statements.

(8 marks)

(b) Explain techniques used for identifying correct referencing environment fo subprogram that was sent as a parameter.

(6 marks)

OR

16.

(a) Describe the implementation models of Parameter passing.

(10 Marks)

(b) Differentiate coroutines from conventional subprograms.

(4 marks)

17.

(a) What is a tions are handled in o oriented la

(7 Marks)

(b) What are t es? (7 M

18. Explain the foll

(i) Encaps
(ii) Inherita
(iii) Constru
(iv) Operat
(v) Polymo

(14 Marks)

19.

(a) Compare f ages.

(7 Marks)

(b) Explain the

(7 Marks)

OR

20.

(a) Explain the searching strategies used in Prolog. Why backward chaining is pre over forward chaining in Prolog?

(10 Marks)

(b) How does a binary semaphore differ from an ordinary semaphore?

(4 Marks)

Teaching Plan

Module 1 (Introduction)		9 Hours
1.1	Introduction : Reasons for studying Concepts of program languages, Programming Domains	1 Hour
1.2	Language Evaluation Criteria (Lecture 1)	1 Hour
1.3	Language Evaluation Criteria (Lecture 2)	1 Hour
1.4	Influence … de-off	1 Hour
1.5	Implemer	1 Hour
1.6	Names, V	1 Hour
1.7	Concept	1 Hour
1.8	Scope an	1 Hour
1.9	Referenc	1 Hour
Module 2 (D … ents)		8 Hours
2.1	Primitive	1 Hour
2.2	User-Defi	1 Hour
2.3	Record T … es	1 Hour
2.4	Implemer … Chec Strong Ty	1 Hour
2.5	Express… rithm Expressions	1 Hour
2.6	Overloaded Operators, Type Conversions	1 Hour
2.7	Relational and Boolean Expressions, Short-Circuit Evaluati	1 Hour
2.8	Assignment Statements, Mixed-mode Assignment	1 Hour
Module 3 (Statement Level Control Structures, Subprograms)		8 Hours
3.1	Selection Statements, Iterative Statements	1 Hour
3.2	Unconditional Branching	1 Hour

3.3	Guarded Commands	1 Hour
3.4	Subprograms: Design Issues of Subprograms	1 Hour
3.5	Local Referencing Environments	1 Hour
3.6	Parameter Passing Methods	1 Hour
3.7	Subprograms as Parameters, Overloaded Subprograms	1 Hour
3.8	Closures, Co-routines	1 Hour
Module 4 (Support for Object Oriented Programming, Exception Handling, Event handling)		10 Hours
4.1	Inheritanc [illegible]	1 Hour
4.2	Dynamic [illegible]	1 Hour
4.3	Design Is [illegible]	1 Hour
4.4	Support f [illegible]	1 Hour
4.5	Implemer [illegible] e 1)	1 Hour
4.6	Implemer [illegible] e 2)	1 Hour
4.7	Implemer [illegible] e 3)	1 Hour
4.8	Basic Co [illegible]	1 Hour
4.9	Exceptior [illegible]	1 Hour
4.10	Introducti [illegible]	1 Hour
Module 5 (Cor [illegible] ogic		10 Hours
5.1	Subprogr [illegible]	1 Hour
5.2	Semaphores	1 Hour
5.3	Monitors	1 Hour
5.4	Message Passing	1 Hour
5.5	Introduction to LISP and Scheme (Lecture 1)	1 Hour
5.6	Introduction to LISP and Scheme (Lecture 2)	1 Hour
5.7	Comparison of Functional and Imperative Languages	1 Hour
5.8	Basic Elements of Prolog (Lecture 1)	1 Hour

5.9	Basic Elements of Prolog (Lecture 2)	1 Hour
5.10	Applications of Logic Programming	1 Hour

CODE CST284	MATHEMATICS FOR MACHINE LEARNING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This is the foundational course for awarding B. Tech. Honours in Computer Science and Engineering with specialization in Machine Learning. The purpose of this course is to introduce mathematical foundations of basic Machine Learning concepts among learners, on which Machine Learning systems are built. This course covers Linear Algebra, Vector Calculus, Probability and Distributions, Optimization and Machine Learning problems. Concepts in this course help the learners to understand the mathematical principles in Machine Learning and aid in the creation of new Machine Learning solutions, understand & debug existing ones, and learn about the inherent assumptions & limitations of the current methodologies.

Prerequisite: A sound background in higher secondary school Mathematics.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Make use of the concepts, rules and results about linear equations, matrix a vector spaces, eigenvalues & eigenvectors and orthogonality & diagonalization to solve computational problems (Cognitive Knowledge Level: Apply)
CO 2	Perform calculus operations on functions of several variables and matrices, including partial derivatives and gradients (Cognitive Knowledge Level: Apply)
CO 3	Utilize the concepts, rules and results about probability, random variables, a & multiplicative rules, conditional probability, probability distributions and Ba theorem to find solutions of computational problems (Cognitive Knowledge L Apply)
CO 4	Train Machine Learning Models using unconstrained and constrained optimiz methods (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	¥	¥	¥	¥								¥
CO 2	¥	¥	¥									¥
CO 3	¥	¥	¥	¥								¥
CO 4	¥	¥	¥	¥		¥						¥

Abstract POs defined by National Board of Accreditation			
PO#	Broad PO	PO#	Broad PO
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20%	20%	20%
Understand	40%	40%	40%
Apply	40%	40%	40%
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Tests : 25 marks
Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module 1

LINEAR ALGEBRA: Systems of Linear Equations – Matrices, Solving Systems of Linear Equations. Vector Spaces – Vector Spaces, Linear Independence, Basis and Rank. Linear Mappings – Matrix Representation of Linear Mappings, Basis Change, Image and Kernel.

Module 2

ANALYTIC GEOMETRY, MATRIX DECOMPOSITIONS : Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Orthogonal Projections – Projection into One Dimensional Subspaces, Projection onto General Subspaces, Gram-Schmidt Orthogonalization.

Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation.

Module 3

VECTOR CALCULUS : Differentiation of Univariate Functions Partial Differentiation and Gradients, Gradients of Vector Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients. Back propagation and Automatic Differentiation – Gradients in Deep Network, Automatic Differentiation Higher Order Derivatives Linearization and Multivariate Taylor Series.

Module 4

PROBABILITY AND DISTRIBUTIONS : Construction of a Probability Space - Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem. Summary Statistics and Independence – Gaussian Distribution - Conjugacy and the Exponential Family - Change of Variables/Inverse Transform.

Module 5

OPTIMIZATIO N : Optimization Using Gradient Descent - Gradient Descent With Momentum, Stochastic Gradient Descent. Constrained Optimization and Lagrange Multipliers - Convex Optimization - Linear Programming - Quadratic Programming.

Text book:

1. Mathematics for Machine Learning by Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong published by Cambridge University Press (freely available at https:// mml - book.github.io)

Reference books:

1. Linear Algebra and Its Applications, 4th Edition by Gilbert Strang
2. Linear Algebra Done Right by Axler, Sheldon, 2015 published by Springer
3. Introduction to Applied Linear Algebra by Stephen Boyd and Lieven Vandenberghe, 2018 published by Cambridge University Press
4. Convex Optimization by Stephen Boyd and Lieven Vandenberghe, 2004 published by Cambridge University Press
5. Pattern Recognition and Machine Learning by Christopher M Bishop, 2006, published by Springer
6. Learning with Kernels – Support Vector Machines, Regularization, Optimization, and Beyond by Bernhard Scholkopf and Smola, Alexander J Smola, 2002, published by MIT Press
7. Information Theory, Inference, and Learning Algorithms by David J. C MacKay, 2003 published by Cambridge University Press
8. Machine Learning: A Probabilistic Perspective by Kevin P Murphy, 2012 published by MIT Press.
9. The Nature of Statistical Learning Theory by Vladimir N Vapnik, 2000, published by Springer

Sample Course Level Assessment Questions.
Course Outcome 1 (CO1):

1. Find the set S of all solutions in x of the following inhomogeneous linear systems Ax = b, where A and b are defined as follows:

$$A = \begin{bmatrix} 1 & -1 & 0 & 0 & 1 \\ 1 & 1 & 0 & -3 & 0 \\ 2 & -1 & 0 & 1 & -1 \\ -1 & 2 & 0 & -2 & -1 \end{bmatrix}, \quad b = \begin{bmatrix} 3 \\ 6 \\ 5 \\ -1 \end{bmatrix}$$

2. Determine the inverses of the following matrix if possible

$$A = \begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{bmatrix}$$

3. Find the characteristic equation, eigenvalues, and eigenspaces corresponding to each eigenvalue of the following matrix

$$\begin{bmatrix} 2 & 0 & 4 \\ 0 & 3 & 0 \\ 0 & 1 & 2 \end{bmatrix}$$

4. Diagonalize the following matrix, if possible

$$\begin{bmatrix} 3 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 1 & 0 & 0 & 3 \end{bmatrix}$$

5. Find the singular value decomposition (SVD) of the following matrix

$$\begin{bmatrix} 0 & 1 & 1 \\ \sqrt{2} & 2 & 0 \\ 0 & 1 & 1 \end{bmatrix}$$

Course Outcome 2 (CO2):

1. For a scalar function f(x, y, z) = $x^2 + 3y^2 + 2z^2$, find the gradient and its magnitude at the point (1, 2, -1)
2. Find the maximum and minimum values of the function $f(x,y)=4x+4y-x^2-y^2$ subject to the condition $x^2 + y^2 <= 2$.
3. Suppose you were trying to minimize $f(x, y) = x^2 + 2y + 2y^2$. Along what vector should you travel from (5,12)?
4. Find the second order Taylor series expansion for $f(x, y) = (x + y)^2$ about (0 ,0).
5. Find the critical points of $f(x, y) = x^2 - 3xy+5x-2y+6y^2+8$.
6. Compute the gradient of the Rectified Linear Unit (ReLU) function ReLU(z) = max(0 , z).
7. Let $L = ||Ax - b||_2^2$, where A is a matrix and x and b are vectors. Derive dL in terms of dx.

Course Outcome 3 (CO3):

1. Let J and T be independent events, where P(J)=0.4 and P(T)=0.7.
   i. Find 3 - @ 7
   ii. Find P(J T)
   iii. Find 3 - @ 7 •
2. Let A and B be events such that P(A)=0.45 , P(B)=0.35 and P(A B)=0.5. Find P(A B̂).
3. A random variable R has the probability distribution as shown in the following table:

r	1	2	3	4	5
P(R=r)	0.2	a	b	0.25	0.15

   i. Given that E(R)=2.85, find a and b
   ii. Find P(R>2).
4. A biased coin (with probability of obtaining a head equal to p > 0) is tossed repeatedly and independently until the first head is observed. Compute the probability that the first head appears at an even numbered toss.
5. Two players A and B are competing at a trivia quiz game involving a series of questions. On any individual question, the probabilities that A and B give the correct answer are p and q respectively, for all questions, with outcomes for different

questions being independent. The game finishes when a player wins by answering a question correctly. Compute the probability that A winsif

i. A answers the firstquestion,

ii. B answers the first question.

6. A coin for which P(heads) = p is tossed until two successive tails are obtained. Find the probability that the experiment is completed on the n^{th} toss.

Course Outcome 4(CO4):

1. Find the extrema of f(x, y) = x subject to g(x, y) = x^2 + $2y^2$ =3.
2. Maximize the function f(x, y, z) = xy + yz + xz on the unit sphere g(x, y, z) = x^2 + y^2 + z^2 =1.
3. Provide necessary and sufficient conditions under which a quadratic optimization problem be written as a linear least squaresproblem.
4. Consider the univariate function f(x) = x^3 + $6x^2$ - 3x - 5. Find its stationary points and indicate whether they are maximum, minimum, or saddle points.
5. Consider the update equation for stochastic gradient descent. Write down the update when we use a mini-batch size ofone.
6. Consider the function

$$f(x) = (x_1 - x_2)^2 + \frac{1}{1 + x_1^2 + x_2^2}.$$

i. Is f(x) a convex function? Justify youranswer.

ii. Is (1 ,-1) a local/global minimum? Justify youranswer.

7. Is the function f(x, y) = $2x^2$ + y^2 + 6xy - x + 3y - 7 convex, concave, or neither? Justify youranswer.
8. Consider the following convex optimization problem

$$\text{minimize } \frac{x^2}{2} + x + 4y^2 - 2y$$

Subject to the constraint x + y >= 4, x, y >= 1.

Derive an explicit form of the Lagrangian dual problem.

9. Solve the following LP problem with the simplexmethod.

$$max\ 5x_1 + 6x_2 + 9x_3 + 8x_4$$

subject to the constraints

$$\begin{array}{ccccccccc} x_1 & + & 2x_2 & + & 3x_3 & + & x_4 & \leq & 5 \\ x_1 & + & x_2 & + & 2x_3 & + & 3x_4 & \leq & 3 \end{array}$$

$$x_1, x_2, x_3, x_4 \geq 0$$

Model Question paper

	QP Code :		Total Pages : 5
Reg No.:_______________		Name:_________________________	

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

IV SEMESTER B.TECH (HONOURS) DEGREE EXAMINATION, MONTH and YEAR

Course Code:CST 284

Course Name:MATHEMATICS FOR FOR MACHINE LEARNING

Max. Marks: 100		Duration: 3 Hours

PART A

		Answerall questions, each carries3 marks	Marks
1		Show that with the usual operation of scalar multiplication but with add on reals given by x # y = 2(x + y) is not a vector space.	
2		Are the following sets of vectors linearly independent? Explain your answer. $x_1 = \begin{bmatrix}2\\-1\\3\end{bmatrix}, \quad x_2 = \begin{bmatrix}1\\1\\-2\end{bmatrix}, \quad x_3 = \begin{bmatrix}3\\-3\\8\end{bmatrix}$	
3		Find the angle between the vectors $T = \begin{bmatrix}1\\1\end{bmatrix}$ and $U = \begin{bmatrix}1\\2\end{bmatrix}$	
4		Find the eigen values of the following matrix in terms of k. Can you find eigen vector corresponding to each of the eigen values? $\begin{bmatrix}1 & k\\2 & 1\end{bmatrix}$	
5		Let $f(x, y, z) = xye^r$, where $r = x^2+z^2-5$. Calculate the gradient of f at the point (1, 3, -2).	
6		Compute the Taylor polynomials T_n, n =0 , ... , 5 of f(x) = sin(x) + cos(x) at $x_0 = 0$.	
7		Let X be a continuous random variable with probability density function 0 <= x <= 1 defined by $f(x) = 3x^2$. Find the pdf of $Y = X^2$.	
8		Show that if two events A and B are independent, then A and B' are independent.	
9		Explain the principle of the gradient descent algorithm	
10		Briefly explain the difference between (batch) gradient descent and stochastic gradient descent. Give an example of when you might prefer one over the other.	

PART B

Answer any one Question from each module. Each question carries 14 Marks

11	a)	i.Find all solutions to the system of linearequations $$-4x + 5z = -2$$ $$-3x - 3y + 5z = 3$$ $$-x + 2y + 2z = -1$$	(4)

		ii. Prove that all vectors orthogonal to í T @ forms a subspace W of R^3. What is dim (W) and why?	(4)
	b)	A set of n linearly independent vectors in R^n forms a basis. Does the set of vectors í í) form a basis for R^3? Explain your reasons.	(6)
		OR	
12	a)	Find all solutions in T= e T1 T2 T3 i Ð 4^3 of the equation system #T= 12 T, where #= e 6 4 3 / 6 0 9 / 0 8 0 i and $\sum_{i=1}^{3} x_i = 1$.	(7)
	b)	Consider the transformation T (x, y) = (x + y, x + 2y, 2x + 3y) Obtain ker T and use this to calculate the nullity. Also find the transformation mat for T.	(7)
13	a)	Use the Gram-Schmidt process to find an orthogonal basis for the col space of the following matrix. $\begin{bmatrix} 2 & 1 & 0 \\ 1 & -1 & 1 \\ 0 & 3 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	(7)
	b)	Find the SVD of the matrix. B 2 F1 F1 2 C	(7)
		OR	
14	a)	i. Let L be the line through the origin in R^2 that is parallel to the vector > T @. Find the standard matrix of the orthogonal projection onto L. Also find the point on L which is closest to the point (7, 1) and find the point on L which is closest to the point (-3 , 5)	(6)
		ii. Find the rank-1 approximation of $\begin{bmatrix} 3 & 2 & 2 \\ 2 & 3 & -2 \end{bmatrix}$	
	b)	i. Find an orthonormal basis of R^3 consisting of eigenvectors for the following matrix. $\begin{bmatrix} 1 & 0 & -2 \\ 0 & 5 & 0 \\ -2 & 0 & 4 \end{bmatrix}$	(8)
		ii. Find a 3×3 orthogonal matrix S and a 3×3 diagonal matrix D such that A = SDS^T	

15	a)	Askierisonamountainwithequation$z=100-0.4x^2-0.3y^2$,where z denotes height. i. The skier is located at the point with xy-coordinates (1, 1), and wants to ski downhill along the steepest possible path. In which direction (indicated by a vector (a, b) in the xy-plane) should the skier beginskiing. ii. The skier begins skiing in the direction given by the xy-vector (a, b) you found in part (i), so the skier heads in a direction in space given by the vector (a, b, c). Find the value of c.	(8)
	b)	Find the linear approximation to the function f(x,y) = 2 - sin(-x - 3y) at the point , and then use your answer to estimate I . Œ	(6)
		OR	
16	a)	Let g be the function given by $$g(x,y)=\begin{cases}\dfrac{x^2y}{x^2+y^2} & \text{if } (x,y)\neq(0,0);\\ 0 & \text{if } (x,y)=(0,0).\end{cases}$$ i. Calculate the partial derivatives of g at (0,0) ii. Show that g is not differentiable at (0,0)	(8)
	b)	Find the second order Taylor series expansion for $f(x,y) = e^{-(x2+y2)}\cos(xy)$ about (0 , 0)	(6)
17	a)	There are two bags. The first bag contains four mangos and two apples; the second bag contains four mangos and four apples. We also have a biased coin, which shows "heads" with probability 0.6 and "tails" with probability 0.4. If the coin shows "heads". we pick a fruit at random from bag 1; otherwise we pick a fruit at random from bag 2. Your friend flips the coin (you cannot see the result), picks a fruit at random from the corresponding bag, and presents you a mango. What is the probability that the mango was picked from bag 2?	(6)
	b)	Suppose that one has written a computer program that sometimes compiles and sometimes not (code does not change). You decide to model the apparent stochasticity (success vs. no success) x of the compiler using a % H U Q R X O O L G L V W U L E X W L R Q Z L W K S D U D P H W H U $p(x\mid\mu)=\mu^{x}(1-\mu)^{1-x}, \quad x\in\{0,1\}$ Choose a conjugate prior for the Bernoulli likelihood and compute the posterior distribution S $x_1, \ldots, x_N$).	(8)
		OR	
18	a)	Two dice are rolled. A = 'sum of two dice equals 3' B = 'sum of two dice equals 7' C = 'at least one of the dice shows a 1'	(6)

i. What is P(A|C)?
ii. What is P(B|C)?
iii. Are A and C independent? What about B and C?

b) Consider the following bivariate distribution p(x,y) of two discrete random variables X and Y . (8)

Y					
y_1	0.01	0.02	0.03	0.1	0.1
y_2	0.05	0.1	0.05	0.07	0.2
y_3	0.1	0.05	0.03	0.05	0.04
	x_1	x_2	x_3	x_4	x_5

X

Compute:

i. The marginal distributions p(x) and p(y).
ii. The conditional distributions $p(x|Y = y_1)$ and $p(y|X = x_3)$.

19 a) Find the extrema of $f(x,y,z) = x - y + z$ subject to $g(x,y,z) = x^2 + y^2 + z^2 = 2$. (8)

b) Let

$$P = \begin{bmatrix} 13 & 12 & -2 \\ 12 & 17 & 6 \\ -2 & 6 & 12 \end{bmatrix}, \quad q = \begin{bmatrix} -22.0 \\ -14.5 \\ 13.0 \end{bmatrix}, \quad \text{and } r = 1.$$

Show that x* = (1, 1/2, -1) is optimal for the optimization problem

$$\begin{array}{ll} \min & \frac{1}{2}x^T P x + q^T x + r \\ \text{s.t.} & -1 \le x_i \le 1, \; i = 1, 2, 3. \end{array}$$

(6)

OR

20 a) Derive the gradient descent training rule assuming that the target function is represented as $o_d = w_0 + w_1x_1 + ... + w_nx_n$. Define explicitly the cost/error function E, assuming that a set of training examples D is provided, where each training example d ∈ D is associated with the target output t_d. (8)

b) Find the maximum value of $f(x,y,z) = xyz$ given that $g(x,y,z) = x + y + z = 3$ and x,y,z>=0. (6)

***

Teaching Plan		
No	Topic	No. of Lectures (49)
	Module-I (LINEAR ALGEBRA)	8
1.1	Matrices, Solving Systems of Linear Equations	1
1.2	Vector Spaces	1
1.3	Linear Independence	1
1.4	Basis and Rank (Lecture-1)	1
1.5	Basis and Rank (Lecture-2)	1
1.6	Linear Mappings	1
1.7	Matrix Representation of Linear Mappings	1
1.8	Images and Kernel	1
	Module-II (ANALYTIC GEOMETRY, MATRIX DECOMPOSITIONS)	11
2.1	Norms, Inner Products	1
2.2	Lengths and Distances, Angles and Orthogonality	1
2.3	Orthonormal Basis, Orthogonal Complement	1
2.4	Orthogonal Projections – Projection into One Dimensional Subspaces	1
2.5	Projection onto General Subspaces.	1
2.6	Gram-Schmidt Orthogonalization	1
2.7	Determinant and Trace, Eigen values and Eigenvectors.	1
2.8	Cholesky Decomposition	1
2.9	Eigen decomposition and Diagonalization	1
2.10	Singular Value Decomposition	1
2.11	Matrix Approximation	1
	Module-III (VECTOR CALCULUS)	9
3.1	Differentiation of Univariate Functions, Partial Differentiation and Gradients	1
3.2	Gradients of Vector Valued Functions (Lecture 1)	1
3.3	Gradients of Vector Valued Functions (Lecture 2)	1

3.4	Gradients of Matrices	1
3.5	Useful Identities for Computing Gradients	1
3.6	Backpropagation and Automatic Differentiation – Gradients in deep Netwok	1
3.7	Automatic Differentiation	1
3.8	Higher Order Derivatives	1
3.9	Linearization and Multivariate Taylor Series	1
	Module-IV (PROBABILITY AND DISTRIBUTIONS)	10
4.1	Construction of a Probability Space	1
4.2	Discrete and Continuous Probabilities (Probability Density Function, Cumulative Distribution Function)	1
4.3	Sum Rule, Product Rule	1
4.4	Bayes' Theorem	1
4.5	Summary Statistics and Independence (Lecture 1)	1
4.6	Summary Statistics and Independence (Lecture 2)	1
4.7	Bernoulli, Binomial, Uniform (Discrete) Distributions	1
4.8	Uniform (Continuous), Poisson Distributions	1
4.9	Gaussian Distribution	1
4.10	Conjugacy and the Exponential Family (Beta – Bernoulli, Beta – Binomial Conjugacies)	1
	Module-V (OPTIMIZATION)	7
5.1	Optimization Using Gradient Descent.	1
5.2	Gradient Descent With Momentum, Stochastic Gradient Descent	1
5.3	Constrained Optimization and Lagrange Multipliers (Lecture 1)	1
5.4	Constrained Optimization and Lagrange Multipliers (Lecture 2)	1
5.5	Convex Optimization	1
5.6	Linear Programming	1
5.7	Quadratic Programming	1

CST 2 6	INTRODUCTION TO COMPUTER NETWORKS	Category	L	T	P	Credit	Year of Introduction
		MINOR	3	1	0	4	2019

Preamble: This is the second course for awarding B. Tech. Minor in Computer Scien[illegible] Engineering with specialization in Networking. Study of this course provides the learner[illegible] clear understanding of how computer networks from local area networks to the mass[illegible] global Internet are built and how they allow the usage of computers to share informat[illegible] communicate with o[illegible] OSI Reference model[illegible] inter-networking. This [illegible] alyze the existing netw[illegible] technologies and to c[illegible] system.

Prerequisite: Data C[illegible]

Course Outcomes: A[illegible] t will be able to

CO 1	Explai[illegible] ocols and network [illegible] models[illegible]
CO 2	Discus[illegible] link layer protocols, b[illegible] and sw[illegible]
CO 3	Illustrat[illegible] d wireless LAN proto[illegible] (IEEE [illegible] : Understand)
CO 4	Select [illegible] n control techniques [illegible] Quality of Service requirements for a network (Cognitive Knowledge : Apply)
CO 5	Illustrate the functions and protocols of network layer, transport laye[illegible] application layer in inter-networking (Cognitive Knowledge : Understand)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓								✓		✓
CO2	✓	✓	✓							✓		✓
CO3	✓	✓	✓							✓		✓
CO4	✓	✓	✓									✓
CO5	✓	✓	✓			✓				✓		✓

Abstr ... ditation		
PO#	B ...	road PO
PO1	Engineering K ...	nd Sustainability
PO2	Problem Anal ...	
PO3	Design/Devel ...	team work
PO4	Conduct inve ... problems	n
PO5	Modern tool u ...	ement and Finance
PO6	The Enginee ...	ng

Assessment Pattern

BloomÕs Category	Test 1 (Marks in percentage)	Test 2 (Marks in percentage)	End Semester Examination (Marks in percentage)
Remember	40	30	30
Understand	60	50	50
Apply		20	20
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:
Attendance : 10 marks
Continuous Assessment Test : 25 marks
Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two interr 50 marks. First series
be preferably conduc bus and the second se
shall be preferably co he syllabus. There will
parts: Part A and Pa ly, 2 questions each
completed modules a dule), having 3 marks
question adding up t wer all questions from
Part B contains 7 qu the completed module
question from the pa s. Out of the 7 quest
student should answe

End Semester Exami
There will be two par estions with 2 questio
each module, having ld answer all question
contains 2 questions hould answer any on
question can have ma .

Module 1

Introduction Ð Uses of Computer Networks, Network Hardware, Network Software, Ref Models Ð The OSI Reference Model, The TCP/IP Reference Model, Comparison of O TCP/IP Reference models.

Module 2

The Data Link Layer - Data Link layer Design Issues, Error Detection and Corre Elementary Data Link Protocols, Sliding Window Protocols, HDLC (High-Level Data Control) Protocol. The Medium Access Control (MAC) Sub layer Ð The Channel Allo Problem, Multiple Access Protocols, Ethernet, Wireless LANs - 802.11 a/b/g/n, Brid Switches.

Module 3

Network Layer Design Issues. Routing Algorithms - The Optimality Principle, Shortes routing, Flooding, Distance Vector Routing, Link State Routing, Multicast Routing, Routi Mobile Hosts. Congestion Control Algorithms, Quality of Service (QoS) - Requiren Techniques for Achieving Good QoS.

Module 4

Network Layer in Internet Đ The IP Protocol, IP Addresses, Internet Control Message I (ICMP), Address Resolution Protocol (ARP), Reverse Address Resolution Protocol (R Bootstrap Protocol (BOOTP), Dynamic Host Configuration Protocol (DHCP). Open Sh Path First (OSPF) Protocol, Border Gateway Protocol (BGP), Internet Multicasting, ICMPv6.

Transport Layer Đ Th o the Upper Layers, T Service Primitives. Th sion Control Protocol (Overview of TCP, TC ment & Release, Cor Management Modelir tion Control.

Application Layer Đ e System (DNS), Elec mail, MIME, Simple N d Wide Web Đ Archite Overview.

Text Book

Andrew S. Tanen e Hall India).

Reference Books

1. Behrouz A For , 4/e, Tata McGraw Hil
2. Larry L Peterson and Bruce S Dave, Computer Networks Đ A Systems Approach Morgan Kaufmann.
3. Fred Halsall, Computer Networking and the Internet, 5/e.
4. James F. Kurose, Keith W. Ross, Computer Networking: A Top-Down Approach, 6/
5. Keshav, An Engineering Approach to Computer Networks, Addison Wesley, 1998.
6. W. Richard Stevens. TCP/IP Illustrated volume 1, Addison-Wesley, 2005.
7. William Stallings, Computer Networking with Internet Protocols, Prentice-Hall, 200
8. Request for Comments (RFC) Pages - IETF -https://www.ietf.org/rfc.html

Sample Course Level Assessment Questions

CourseOutcome1 (CO1): Compare TCP/IP Reference model and OSI Reference model

CourseOutcome2 (CO2): Distinguish between switches and bridges.

CourseOutcome3 (CO3): Draw and explain the frame format for Ethernet.

CourseOutcome5 (CO4): Discuss remedies for count to infinity problem in routing.

CourseOutcome4 (CO5): Subnet the Class C IP Address 206.16.2.0 so that you have 3 subnets. What is the subnet mask for the maximum number of hosts? How many hosts c each subnet have?

Model Question Paper

QP CODE: PAGES: ___

Reg No:___________

Name:____________

APJ A[illegible] RSITY

FOURTH SEMES[illegible] ION, MONTH &

Course na[illegible] TWORKS

Max Marks: 100 Duration: 3 Hours

(Ans[illegible] marks)

1. Why Layered A[illegible] Define the terms protoco interface?
2. What are the different service primitives in Computer Networks?
3. Draw and explain Ethernet frame format.
4. What is the output string when the bit string 0111101111101111110 is subjected to b stuffing?
5. Discuss the count to infinity problem in routing.
6. What is flooding? Describe any two situations where flooding is advantageous.
7. What is IP (Internet Protocol) subnetting? Illustrate with example.
8. How many octets does the smallest possible IPv6 (IP version 6) datagram contain?
9. Can TCP (Transmission Control Protocol) be used directly over a network (e.g. an Ethernet) without using IP? Justify your answer
10. What is the role of SNMP (Simple Network Management Protocol)?

(10x3=30)

Part B

(Answer any one Question from each module. Each question carries 14 Marks)

Module I

11. (a) With a neat diagram, explain the OSI (Open Systems Interconnection) referen Model.

(b) Compare OSI Reference model and the TCP/IP model (6)

OR

12. (a) Consider tw... ...riented service. One of offers a relia... ...ble message stream. Ar identical? Ju...

(b) Compare ... ...litan Area Networks) a WAN (Wide...

13. (a) Discuss the ... n CSMA/CA (Carrier S Multiple Acce... (8)

(b) Briefly expl... ...nk Control). (6)

14. (a) Explain the... (

(b) Distinguish...

Module III

15. (a) Illustrate Distance Vector Routing Algorithm with an example. (8)

(b) Explain the characteristics of RIP (Routing Information Protocol). (6)

OR

16. (a) Explain an Interior Gateway protocol that uses a link state algorithm to propaga routing information. (6

(b) Explain how routing is performed in a Mobile network. (8)

Module IV

17. (a) Explain address resolution problem and RARP (Reverse Address Resolution Pr
with an example network.

(b) How IGMP (Internet Group Management Protocol) supports internet multicastin
Explain.

OR

18. (a) Subnet the class C IP address 195.1.1.0 so that you have 10 subnets with a ma
of 12 hosts in each subnet.

(b) Draw IPv6 Datagram format and explain its features. (8)

19. (a) Distinguish tocol) header formats. (8)

(b) Explain the rce record types for IPv (6)

20. (a) What is the) in E-mail? (6)

(b) With the hel WW (World Wide Web). (8)

		(8 Hours)
1.1	Introduc	1
1.2	Networ (LAN Metropolitan Area Networks (MAN), Wide Area Networ (WAN).	1
1.3	Network Hardware Ð Wireless Networks, Home Netwo Internetworks	1
1.4	Network Software ÐÐ Protocol Hierarchies.	1
1.5	Network Software ÐÐ Design issues for the layers.	1
1.6	Network Software Ð Connection Oriented and Connectio Services, Service Primitives, Relationship of Services Protocols.	1
1.7	Reference Models Ð The OSI Reference Model	1

1.8	Reference Models Ð The TCP/IP Reference Model, Compa of OSI and TCP/IP Reference models	1
Module 2		(11 Hours)
2.1	Data Link layer Design Issues.	1
2.2	Error Detection and Correction - Error Correcting Codes	1
2.3	Error Detection and Correction - Error Detecting Codes	1
2.4	Elementary Data link Protocols.	1
2.5	Sliding \	1
2.6	HDLC (I	1
2.7	The Me ... e Char Allocatic	1
2.8	Etherne ... ding, Etherne ... xponen Backoff	1
2.9	Etherne ... ernet, Etherne ... Contro	1
2.10	Wireless	1
2.11	Bridges	1
		(9 Hours)
3.1	Network Layer Design Issues.	1
3.2	Routing Algorithms - The Optimality Principle, Shortest p routing, Flooding.	1
3.3	Distance Vector Routing, Link State Routing.	1
3.4	Link State Routing.	1
3.5	Multicast Routing, Routing for Mobile Hosts	1
3.6	Distance Vector Routing, Link State Routing	1

3.7	Congestion control algorithms - General Principles Congestion Control, Congestion Prevention Polici Congestion Control in Virtual-Circuit Subnets	1
3.8	Congestion control algorithms - Congestion Control Datagram Subnets, Load Shedding, Jitter Control	1
3.9	Quality of Service Đ Requirements, Techniques for Achie Good Quality of Service.	1
Module 4		(9 Hours)
4.1	Network layer in internet, IP Protocol	1
4.2	IP Addr [illegible] ain Ro (CIDR)	1
4.3	IP Addre [illegible]	1
4.4	Internet [illegible] Resolu Protocol [illegible] ol (RAR	1
4.5	Bootstra [illegible] nfigurat Protocol	1
4.6	Open Sh [illegible]	1
4.7	Border G [illegible]	1
4.8	Internet I [illegible]	1
4.9	IPv6, Inte [illegible] CMPv6)	1
Module 5		(8 Hours)
5.1	The Transport Service Đ Services Provided to the Upper La Transport Service Primitives. The User Datagram Prot (UDP)	1
5.2	Transmission Control Protocol (TCP) Đ Overview of TCP, Segment Header, Connection Establishment & Rele Connection Management Modeling.	1
5.3	TCP Retransmission Policy, TCP Congestion Control.	1
5.4	Application Layer Đ File Transfer Protocol (FTP).	1
5.5	Domain Name System (DNS).	1

5.6	Electronic Mail.	1
5.7	Simple Network Management Protocol (SNMP)	1
5.8	World Wide Web Đ Architectural Overview	1

6 5

6

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT	Year of Introduction
CST 2 2	Number Theory	Honours	4	0	0	4	2019

Preamble: This is the foundational course for awarding B. Tech. Honours in Computer Scien

Engineering with specialization in Security in Computing. The purpose of this course is to cre awareness among learners about the important areas of number theory used in computer scie course covers Divisibility & Modular Arithmetic, Primes & Congruences, Euler's Function, Qua Residues and Arithmetic Functions, Sum of Squares and Continued fractions. Concepts in Theory help the learner to apply them eventually in practical applications in Computer organiz Security, Coding & Cryptography, Random number generation, Hash functions and Graphics.

Prerequisite: A sound [illegible] thematics

Course Outcomes: Aft [illegible] will be able to

CO1	Illustrate mod [illegible] chniques (Cognitive Knowledge Level:Underst [illegible]
CO2	Use the meth [illegible] ction to verify the correctn mathematical [illegible] ly)
CO3	Utilize theore [illegible] gruences, quadratic resid integer factori [illegible] systems (Cognitive Knowledge Level: Analyse [illegible]
CO4	Illustrate uses [illegible] an algorithm in Cryptograp Security (Cogi [illegible]
CO5	Explain applic [illegible] Science (Cognitive Knowledge Level:Understand)
CO6	Implement Number Theoretic Algorithms using a programming language (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓						✓		✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓		✓						✓
CO4	✓	✓										✓
CO5	✓	✓								✓		✓
CO6	✓	✓										✓

Ab… …reditation			
PO#			Broad PO
PO1	Engineerin…		…ment and Sustainability
PO2	Problem A…		
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of comple… problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern

BloomÕs Category	Continuous Assessment Tests		End Semester Examination Marks (Percentage)
	Test1 (Percentage)	Test2 (Percentage)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyse	[illegible]	[illegible]	
Evaluate	[illegible]	[illegible]	
Create	[illegible]	[illegible]	

Mark Distribution

Total Marks	[illegible]	ESE Duration
150	[illegible]	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the s and the Second Internal Examination shall be preferably conducted after completing remainin the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questio from the completed modules and 1 question from the partly covered module), having 3 marks question adding up to 15 marks for part A. Students should answer all questions from Part A contains 7 questions (preferably, 3 questions each from the completed modules and 1 ques the partly covered mo estions in Part B, a studen answer any 5.

End Semester Examin

There will be two part estions with 2 questions fro module, having 3 ma wer all questions. Part B c questions from each any one. Each question maximum 2 sub-divisi

Divisibility and Modula

Finite Fields Ð Groups

Divisibility - Divisibility and Division Algorithms, Well ordering Principle,BezoutÕs Identity.

Modular Arithmetic- Properties, Euclid's algorithm for the greatest common divisor, Extended E Algorithm, Least Common multiple, Solving Linear Diophantine Equations, Modular Division.

Module 2

Primes and Congruences:

Prime Numbers-Prime Numbers andprime-powerfactorization, Fermat and Mersenne prime Primality testing and factorization.

Congruences-Linear congruences, Simultaneous linear congruences, Chinese Remainder FermatÕs little theorem, Wilson's theorem.

Module 3

Congruences with a Prime-Power Modulus&Euler's Function:

Congruences with a Prime-Power Modulus-Arithmetic modulo p, Pseudoprimes and Car numbers, Solving congruences modulo prime powers.

Euler's Function-EulerÕs Totient function, Applications of EulerÕs Totient function, Tra Cryptosystem, Limitations.

The Group of units- T imitive roots, Applications primitive roots.

Module 4

Quadratic Residues &

Quadratic Residues- ıadratic residues, Legendre Jacobi Symbol, Quadı

Arithmetic Functions- Mobius function and its pro Mobius inversion form

Module 5

Sum of Squares and C

Sum of Squares- Sum of two squares, The Gaussian integers, Sum of three squares, Su squares.

Continued Fractions -Finite continued fractions, Infinite continued fractions, Pell's Equation, S of PellÕs equation by continued fractions.

Text Books

1. G.A. Jones & J.M. Jones, Elementary Number Theory, Springer UTM, 2007.

2. Joseph Silverman, A Friendly introduction to Number Theory, Pearson Ed. 2009.

Reference Books

1. William Stallings, Cryptography and Network Security Principles and Practice, Pearson Ed
2. Tom M.Apostol, ÔIntroduction to Analytic Number TheoryÕ, Narosa Publishing House Pv New Delhi, (1996).
3. Neal Koblitz, A course in Number Theory and Cryptography, 2nd Edition, Springer ,2004.

Sample Course Level Assessment Questions

Course Outcome 1 (CO1): Describe the properties of modular arithmetic and modulo operator.

Course Outcome 2 (C … the integer solution (3, ±5).

Course Outcome 3 (C … symbols and use it to determ whether 888 is a qua … 999.

Course Outcome 4 (C … solve the system of congrue "2(mod 3), x "3(mod 5 …

Course Outcome 5(C(…

Course Outcome 6 … o solve Diophantine equat efficiently. Given three … l return some x and y such that a x + b y = c.

Model Question Paper

QP CODE: PAGES: 03

RegNo : É.............................. Name :ÉÉÉ..ÉÉÉÉÉ

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER BTECH (HONOURS) DEGREE EXAMINATION, MONTH &YEAR

Course Code:CST2 2 Course

Name: Number Theory

Max.Marks:100 Duration: 3 Hours

Answer a (10x3=30)

1. State and pr
2. Find gcd d c / where a and b are integers
3. Solve the cc
4. Use Fermat ne.
5. If m is relativ
6. Explain how ital signatures.
7. Define Mobi ultiplicative.
8. State and pr
9. Show that ev ed uniquely as the sum of tv squares.
10. Find the cc l number 55/89.

Part B

Answer any one Question from each module.

Each question carries 14 Marks

11. (a) State the Euclidean algorithm and its extension with an example. (

(b) Find all the solutions of 24x + 34 y = 6. (7)

OR

12. (a) Describe the properties of modular arithmetic and modulo operator. (

(b) Explain Extended Euclidean algorithm. Using the algorithm find the multiplicative inverse of 135 mod 61 (7)

13. (a) State and prove WilsonÕs theorem . (7

(b) Explain FermatÕs factorization method and use it to factor 809009 (7

OR

14. (a) Using Chinese remainder theorem, solve the system of congruences,
x "2(mod 3), x "3(mod 5), x "2(mod 7) (7)

(b) Define Fermat primes. Show that any two distinct Fermat numbers are Relatively prime. (7)

15. (a) Disti ncryption techniques.
Also (7)

(b) Defin ichael number must
be th (7)

16. (a)Defin trivial bases for which
(

(b) Find
dulo 13
dulo 19 (8

17. (a) Dete...es modulo 17. Also determine whether 219 is a quadratic residue or non residue of the prime 383 (8)

(b) State the law of quadratic reciprocity. Determine those odd primes p for which 3 is a quadratic residue and those for which it is a non residue. (6)

OR

18. (a) State and prove properties of LegendreÕs symbol. (7

(b) State the law of reciprocity for Jacobi symbols and using it determine whether 888 is a quadratic residue or non residue of the prime 1999. (7

19. (a) Prove that the equation $y^2 = x^3 - 2$ has only the integer solution (3 , ±5). (7)

(b) Define a Gaussian integer. Factorize the Gaussian integer 440 # 55i. (7

OR

20. (a) If m, and n can be expressed as sum of four squares, then show that mn can also be expressed the sum of four squares. (7)

(b) Find all the solutions of the Diophantine equation $x^2 - 6y^2 = 1$. (7)

Teaching Plan

Module 1: Divisibility and Euclidean Algorithm		9 hours
1.1	Finite Fields	1 hour
1.2	Finite Fields	1 hour
1.3	Divisibility an ... e.	1 hour
1.4	Decimal Exp ... on Divisor, BezoutÕs Th	1 hour
1.5	Modular Arith ... Arithmetic Operations, F	1 hour
1.6	Euclid's algo ... ded EuclidÕs Algorithm.	1 hour
1.7	Solving Linea	1 hour
1.8	Least Comm	1 hour
1.9	Implementati ... dÕs Algorithm solution of Linear Diophantine Equations.	1 hour
Module 2: Primes and Congruences		9 hours
2.1	Prime Numbersand prime-powerFactorization.	1 hour
2.2	Fermat and Mersenne primes.	1 hour
2.3	Primality testing and factorization, Miller -Rabin Test for Primality.	1 hour
2.4	Pollard's Rho Method for Factorization, FermatÕs Factorization.	1 hour

2.5	Linear congruences, Simultaneous linear congruences.	1 hour
2.6	Chinese Remainder Theorem.	1 hour
2.7	Implementation of Chinese Remainder Theorem.	1 hour
2.8	Fermat's little theorem.	1 hour
2.9	Wilson's theorem.	1 hour
Module 3: Congruences with a Prime-Power Modulus &Euler's Function		9 hours
3.1	Congruences ... odulo p.	1 hour
3.2	Pseudo-prim ...	1 hour
3.3	Solving cong ...	1 hour
3.4	Definition of ... ies.	1 hour
3.5	Multiplicativit ...	1 hour
3.6	Applications ...	1 hour
3.7	Traditional C ... raphy.	1 hour
3.8	The Group o ...	1 hour
3.9	Existence of primitive roots for Primes, Applications of primitive roots.	1 hour
Module 4: Quadratic Residues and Arithmetic Functions		9 hours
4.1	Quadratic congruences, The group of Quadratic Residues.	1 hour
4.2	Legendre symbol, Jacobi Symbol.	1 hour
4.3	Quadratic reciprocity.	1 hour
4.4	Quadratic residues for prime-power moduli.	1 hour
4.5	Arithmetic Functions: Definition and examples.	1 hour

4.6	Perfect numbers, Definition and proposition.	1 hour
4.7	Mobius inversion formula., application of the Mobius inversion formula.	1 hour
4.8	Mobius function and its properties.	1 hour
4.9	The Dirichlet Product, Definition and proof.	1 hour
Module 5: Sum of Squares and Continued Fractions		9 hours
5.1	Sum of Squares, Sum of two squares	1 hour
5.2	The Gaussia [illegible]	1 hour
5.3	Sum of three [illegible]	1 hour
5.4	Sum of four [illegible]	1 hour
5.5	Continued Fr [illegible]	1 hour
5.6	Continued Fr [illegible]	1 hour
5.7	Infinite contir [illegible]	1 hour
5.8	Pell's Equati [illegible]	1 hour
5.9	Solution of P [illegible]	1 hour

CODE CST294	COMPUTATIONAL FUNDAMENTALS FOR MACHINE LEARNING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This is the foundational course for awarding B. Tech. Honours in Computer Science and Engineering with specialization in Machine Learning. The purpose of this course is to introduce mathematical foundations of basic Machine Learning concepts among learners, on which Machine Learning systems are built. This course covers Linear Algebra, Vector Calculus, Probability and Distributions, Optimization and Machine Learning problems. Concepts in this course help the learners to understand the mathematical principles in Machine Learning and aid in the creation of new Machine Learning solutions, understand & debug existing ones, and learn about the inherent assumptions & limitations of the current methodologies.

Prerequisite: A sound background in higher secondary school Mathematics.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Make use of the concepts, rules and results about linear equations, matrix a vector spaces, eigenvalues & eigenvectors and orthogonality & diagonalization to solve computational problems (Cognitive Knowledge Level: Apply)
CO 2	Perform calculus operations on functions of several variables and matrices, including partial derivatives and gradients (Cognitive Knowledge Level: Apply)
CO 3	Utilize the concepts, rules and results about probability, random variables, a & multiplicative rules, conditional probability, probability distributions and Ba theorem to find solutions of computational problems (Cognitive Knowledge L Apply)
CO 4	Train Machine Learning Models using unconstrained and constrained optimization methods (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	¥	¥	¥	¥								¥
CO 2	¥	¥	¥									¥
CO 3	¥	¥	¥	¥								¥
CO 4	¥	¥	¥	¥		¥						¥

Abstract POs defined by National Board of Accreditation			
PO#	Broad PO	PO#	Broad PO
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20%	20%	20%
Understand	40%	40%	40%
Apply	40%	40%	40%
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Tests : 25 marks
Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module 1

LINEAR ALGEBRA: Systems of Linear Equations – Matrices, Solving Systems of Linear Equations. Vector Spaces – Vector Spaces, Linear Independence, Basis and Rank. Linear Mappings – Matrix Representation of Linear Mappings, Basis Change, Image and Kernel.

Module 2

ANALYTIC GEOMETRY, MATRIX DECOMPOSITIONS : Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Orthogonal Projections – Projection into One Dimensional Subspaces, Projection onto General Subspaces, Gram-Schmidt Orthogonalization.

Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation.

Module 3

VECTOR CALCULUS : Differentiation of Univariate Functions - Partial Differentiation and Gradients, Gradients of Vector Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients. Back propagation and Automatic Differentiation – Gradients in Deep Network, Automatic Differentiation. Higher Order Derivatives - Linearization and Multivariate Taylor Series.

Module 4

Probability and Distributions : Construction of a Probability Space - Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem. Summary Statistics and Independence – Gaussian Distribution - Conjugacy and the Exponential Family - Change of Variables/Inverse Transform.

Module 5

Optimization : Optimization Using Gradient Descent - Gradient Descent With Momentum, Stochastic Gradient Descent. Constrained Optimization and Lagrange Multipliers - Convex Optimization - Linear Programming - Quadratic Programming.

Text book:

1. Mathematics for Machine Learning by Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong published by Cambridge University Press (freely available at https://mml - book.github.io)

Reference books:

1. Linear Algebra and Its Applications, 4th Edition by Gilbert Strang
2. Linear Algebra Done Right by Axler, Sheldon, 2015 published by Springer
3. Introduction to Applied Linear Algebra by Stephen Boyd and Lieven Vandenberghe, 2018 published by Cambridge University Press
4. Convex Optimization by Stephen Boyd and Lieven Vandenberghe, 2004 published by Cambridge University Press
5. Pattern Recognition and Machine Learning by Christopher M Bishop, 2006, published by Springer
6. Learning with Kernels – Support Vector Machines, Regularization, Optimization, and Beyond by Bernhard Scholkopf and Smola, Alexander J Smola, 2002, published by MIT Press
7. Information Theory, Inference, and Learning Algorithms by David J. C MacKay, 2003 published by Cambridge University Press
8. Machine Learning: A Probabilistic Perspective by Kevin P Murphy, 2012 published by MIT Press.
9. The Nature of Statistical Learning Theory by Vladimir N Vapnik, 2000, published by Springer

Sample Course Level Assessment Questions.

Course Outcome 1 (CO1):

1. Find the set S of all solutions in x of the following inhomogeneous linear system Ax = b, where A and b are defined as follows:

$$A = \begin{bmatrix} 1 & -1 & 0 & 0 & 1 \\ 1 & 1 & 0 & -3 & 0 \\ 2 & -1 & 0 & 1 & -1 \\ -1 & 2 & 0 & -2 & -1 \end{bmatrix}, \quad b = \begin{bmatrix} 3 \\ 6 \\ 5 \\ -1 \end{bmatrix}$$

2. Determine the inverses of the following matrix if possible

$$A = \begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{bmatrix}$$

3. Find the characteristic equation, eigenvalues, and eigenspaces corresponding to each eigenvalue of the following matrix

$$\begin{bmatrix} 2 & 0 & 4 \\ 0 & 3 & 0 \\ 0 & 1 & 2 \end{bmatrix}$$

4. Diagonalize the following matrix, if possible

$$\begin{bmatrix} 3 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 1 & 0 & 0 & 3 \end{bmatrix}$$

5. Find the singular value decomposition (SVD) of the following matrix

$$\begin{bmatrix} 0 & 1 & 1 \\ \sqrt{2} & 2 & 0 \\ 0 & 1 & 1 \end{bmatrix}$$

Course Outcome 2 (CO2):

1. For a scalar function $f(x, y, z) = x^2 + 3y^2 + 2z^2$, find the gradient and its magnitude at the point (1, 2, -1)
2. Find the maximum and minimum values of the function $f(x,y)=4x+4y-x^2-y^2$ subject to the condition $x^2 + y^2 <= 2$.
3. Suppose you were trying to minimize $f(x, y) = x^2 + 2y + 2y^2$. Along what vector should you travel from (5,12)?
4. Find the second order Taylor series expansion for $f(x, y) = (x + y)^2$ about (0 ,0)
5. Find the critical points of $f(x, y) = x^2 - 3xy+5x-2y+6y^2+8$.
6. Compute the gradient of the Rectified Linear Unit (ReLU) function ReLU(z) = max(0 , z)
7. Let $L = \|Ax - b\|_2^2$, where A is a matrix and x and b are vectors. Derive dL in terms of dx.

Course Outcome 3 (CO3):

1. Let J and T be independent events, where P(J)=0.4 and P(T)=0.7.
   i. Find 3 - @ 7
   ii. Find P(J T)
   iii. Find 3 - @ 7 •
2. Let A and B be events such that P(A)=0.45 , P(B)=0.35 and P(B|A)=0.5. Find P(A B).
3. A random variable R has the probability distribution as shown in the following table:

r	1	2	3	4	5
P(R=r)	0.2	a	b	0.25	0.15

   i. Given that E(R)=2.85, find a and b

ii. Find $P(R>2)$.

4. A biased coin (with probability of obtaining a head equal to $p > 0$) is tossed repeatedly and independently until the first head is observed. Compute the probability that the first head appears at an even numbered toss.
5. Two players A and B are competing at a trivia quiz game involving a series of questions. On any individual question, the probabilities that A and B give the correct answer are p and q respectively, for all questions, with outcomes for different questions being independent. The game finishes when a player wins by answering a question correctly. Compute the probability that A wins if

   i. A answers the first question,

   ii. B answers the first question.
6. A coin for which P(heads) = p is tossed until two successive tails are obtained. Find the probability that the experiment is completed on the r^{th} toss.

Course Outcome 4(CO4):

1. Find the extrema of $f(x, y) = x$ subject to $g(x, y) = x^2 + 2y^2 = 3$.
2. Maximize the function $f(x, y, z) = xy + yz + xz$ on the unit sphere $g(x, y, z) = x^2 + y^2 + z^2 = 1$.
3. Provide necessary and sufficient conditions under which a quadratic optimization problem be written as a linear least squares problem.
4. Consider the univariate function $f(x) = x^3 + 6x^2 - 3x - 5$. Find its stationary points and indicate whether they are maximum, minimum, or saddle points.
5. Consider the update equation for stochastic gradient descent. Write down the update when we use a mini-batch size of one.
6. Consider the function

$$f(x) = (x_1 - x_2)^2 + \frac{1}{1 + x_1^2 + x_2^2}.$$

   i. Is f(x) a convex function? Justify your answer.

   ii. Is (1 , -1) a local/global minimum? Justify your answer.
7. Is the function $f(x, y) = 2x^2 + y^2 + 6xy - x + 3y - 7$ convex, concave, or neither? Justify your answer.
8. Consider the following convex optimization problem

$$\text{minimize } \frac{x^2}{2} + x + 4y^2 - 2y$$

Subject to the constraint x + y >= 4, x, y >= 1.

Derive an explicit form of the Lagrangian dual problem.

9. Solve the following LP problem with the simplexmethod.

$$max\ 5x_1 + 6x_2 + 9x_3 + 8x_4$$

subject to the constraints

$$\begin{array}{ccccccccc} x_1 & + & 2x_2 & + & 3x_3 & + & x_4 & \leq & 5 \\ x_1 & + & x_2 & + & 2x_3 & + & 3x_4 & \leq & 3 \end{array}$$

$$x_1, x_2, x_3, x_4 \geq 0$$

Model Question paper

	QP Code :		Total Pages : 5
Reg No.:________________		Name:____________________________	

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY IV SEMESTER B.TECH (HONOURS) DEGREE EXAMINATION, MONTH and YEAR
Course Code:CST 294
Course Name: COMPUTATIONAL FUNDAMENTALS FOR MACHINE LEARNING

Max. Marks: 100		Duration: 3 Hours

PART A

		Answerall questions, each carries3 marks	Marks
1		Show that with the usual operation of scalar multiplication but with add on reals given by x # y = 2(x + y) is not a vector space.	
2		Are the following sets of vectors linearly independent? Explain answer. $x_1 = \begin{bmatrix} 2 \\ -1 \\ 3 \end{bmatrix}, \quad x_2 = \begin{bmatrix} 1 \\ 1 \\ -2 \end{bmatrix}, \quad x_3 = \begin{bmatrix} 3 \\ -3 \\ 8 \end{bmatrix}$	
3		Find the angle between the vectors $T = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $U = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$	
4		Find the eigen values of the following matrix in terms of k. Can you find eigen vector corresponding to each of the eigen values? $\begin{bmatrix} 1 & k \\ 2 & 1 \end{bmatrix}$	
5		Let $f(x, y, z) = xye^r$, where $r = x^2+z^2-5$. Calculate the gradient of f at the point $(1, 3, -2)$.	
6		Compute the Taylor polynomials T_n, $n = 0, \ldots, 5$ of $f(x) = \sin(x) + \cos(x)$ at $x_0 = 0$.	
7		Let X be a continuous random variable with probability density functio 0 <= x <= 1 defined by $f(x) = 3x^2$. Find the pdf of $Y = X^2$.	
8		Show that if two events A and B are independent, then A and B' are independent.	
9		Explain the principle of the gradient descent algorithm	
10		Briefly explain the difference between (batch) gradient descent stochastic gradient descent. Give an example of when you might prefer one	

		over the other.	
PART B			
Answer any one Question from each module. Each question carries 14 Marks			
11	a)	i.Find all solutions to the system of linearequations $-4x + 5z = -2$ $-3x - 3y + 5z = 3$ $-x + 2y + 2z = -1$	(4)
		ii. Prove that all vectors orthogonal to > Tí form@ a subspace W of R^3. What is dim (W)and why?	(4)
	b)	A set of nlinearly independent vectors in R^n forms a basis. Does the set of vectors í í) form a basis for R^3? Explain yourreasons.	(6)
		OR	
12	a)	Find all solutions in T= e T1 T2 T3 i Đ 4³ of the equation system #T= 12 T, where #= 6 4 3 / 6 0 9 / 0 8 0 i and Ã$^3_{i=1}$ x_i = 1.	(7)
	b)	Consider the transformation T(x, y) = (x +y, x + 2y, 2x + 3y) Obtainker T and use this to calculate the nullity. Also find the transformation matrix forT.	(7)
13	a)	Use the Gram-Schmidt process to find an orthogonal basis for the col space of the following matrix. $\begin{bmatrix} 2 & 1 & 0 \\ 1 & -1 & 1 \\ 0 & 3 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	(7)
	b)	Find the SVD of the matrix. B 2 F1 F1 2 C	(7)

		OR	
14	a)	i. Let L be the line through the origin in R^2 that is parallel to the vector > ^{T}. Find the standard matrix of the orthogonal projection onto L. Also find the point on L which is closest to the point (7, 1) and find the point on L which is closest to the point (-3 , 5)	(6)
		ii. Find the rank 1 approximation of $\begin{bmatrix} 3 & 2 & 2 \\ 2 & 3 & -2 \end{bmatrix}$	
	b)	i. Find an orthonormal basis of R^3 consisting of eigenvectors for the following matrix. $\begin{bmatrix} 1 & 0 & -2 \\ 0 & 5 & 0 \\ -2 & 0 & 4 \end{bmatrix}$	(8)
		ii. Find a 3×3 orthogonal matrix S and a 3×3 diagonal matrix D such that $A = SDS^T$	
15	a)	A skier is on a mountain with equation $z = 100 - 0.4x^2 - 0.3y^2$, where z denotes height. i. The skier is located at the point with xy-coordinates (1, 1), and wants to ski downhill along the steepest possible path. In which direction (indicated by a vector (a, b) in the xy-plane) should the skier begin skiing. ii. The skier begins skiing in the direction given by the xy-vector (a, b) you found in part (i), so the skier heads in a direction in space given by the vector (a, b, c). Find the value of c.	(8)
	b)	Find the linear approximation to the function f(x,y) = 2 - sin(-x - 3y) at the point , and then use your answer to estimate I . Œ	(6)
		OR	
16	a)	Let g be the function given by $g(x,y) = \begin{cases} \dfrac{x^2 y}{x^2 + y^2} & \text{if } (x,y) \neq (0,0); \\ 0 & \text{if } (x,y) = (0,0). \end{cases}$	(8)

		i. Calculate the partial derivatives of g at (0,0). ii. Show that g is not differentiable at (0,0)	
	b)	Find the second order Taylor series expansion for $f(x,y) = e^{-(x2+y2)}\cos(xy)$ about (0 , 0)	(6)
17	a)	There are two bags. The first bag contains four mangos and two appl second bag contains four mangos and four apples also. We have a biased coin, which shows “heads” with probability 0.6 and “tails” with probability 0.4. If the coin shows “heads”. we pick a fruitat random from ba otherwise we pick a fruit at random from bag 2. Your friend flips the coin (you cannot see the result), picks a fruit at random from the corresponding bag, and presents you a mango. What is the probability that the mango was picked from bag 2?	(6)
	b)	Suppose that one has written a computer program that sometimes cc and sometimes not (code does not change). You decide to mod apparent stochasticity (success vs. no success) x of the compiler u %HUQRXOOL GLVWULEXWLRQ ZLWK SDUDPHWHU $p(x \mid \mu) = \mu^{x}(1-\mu)^{1-x}, \quad x \in \{0,1\}$ Choose a conjugate prior for the Bernoulli likelihood and compute the posterior distribution S $_1$, ... , x_N).	(8)
		OR	
18	a)	Two dice are rolled. A = ‘sum of two dice equals 3’ B = ‘sum of two dice equals 7’ C = ‘at least one of the dice shows a 1’ i. What is P(A|C)? ii. What is P(B|C)? iii. Are A and C independent? What about B and C?	(6)
	b)	Consider the following bivariate distribution p(x,y) of two discrete rand	(8)

variables X and Y .

		x_1	x_2	x_3	x_4	x_5
Y	y_1	0.01	0.02	0.03	0.1	0.1
	y_2	0.05	0.1	0.05	0.07	0.2
	y_3	0.1	0.05	0.03	0.05	0.04
				X		

Compute:

i. The marginal distributions p(x) and p(y).

ii. The conditional distributions $p(x|Y = y_1)$ and $p(y|X = x_3)$.

19 a) Find the extrema of $f(x,y,z) = x - y + z$ subject to $g(x,y,z) = x^2 + y^2 + z^2 = 2$. (8)

b) Let

$$P = \begin{bmatrix} 13 & 12 & -2 \\ 12 & 17 & 6 \\ -2 & 6 & 12 \end{bmatrix}, \quad q = \begin{bmatrix} -22.0 \\ -14.5 \\ 13.0 \end{bmatrix}, \quad \text{and} \quad r = 1.$$

Show that x* = (1, 1/2, -1) is optimal for the optimization problem

$$\begin{array}{ll} \text{min} & \frac{1}{2}x^T P x + q^T x + r \\ \text{s.t.} & -1 \le x_i \le 1, \; i = 1, 2, 3. \end{array}$$

(6)

OR

20 a) Derive the gradient descent training rule assuming that the target function is represented as $o_d = w_0 + w_1x_1 + \dots + w_nx_n$. Define explicitly the cost/error function E, assuming that a set of training examples D is provided, where each training example d D is associated with the target output t_d. (8)

b) Find the maximum value of $f(x,y,z) = xyz$ given that $g(x,y,z) = x + y + z = 3$ and x,y,z>=0. (6)

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Teaching Plan		
No	Topic	No. of Lectures (49)
	Module-I (LINEAR ALGEBRA)	8
1.1	Matrices, Solving Systems of Linear Equations	1
1.2	Vector Spaces	1
1.3	Linear Independence	1
1.4	Basis and Rank (Lecture 1)	1
1.5	Basis and Rank (Lecture 2)	1
1.6	Linear Mappings	1
1.7	Matrix Representation of Linear Mappings	1
1.8	Images and Kernel	1
	Module-II (ANALYTIC GEOMETRY, MATRIX DECOMPOSITIONS)	11
2.1	Norms, Inner Products	1
2.2	Lengths and Distances, Angles and Orthogonality	1
2.3	Orthonormal Basis, Orthogonal Complement	1
2.4	Orthogonal Projections – Projection into One Dimensional Subspaces	1
2.5	Projection onto General Subspaces.	1
2.6	Gram-Schmidt Orthogonalization	1
2.7	Determinant and Trace, Eigen values and Eigenvectors.	1
2.8	Cholesky Decomposition	1
2.9	Eigen decomposition and Diagonalization	1
2.10	Singular Value Decomposition	1
2.11	Matrix Approximation	1

	Module-III (VECTOR CALCULUS)	9
3.1	Differentiation of Univariate Functions, Partial Differentiation and Gradients	1
3.2	Gradients of Vector Valued Functions (Lecture 1)	1
3.3	Gradients of Vector Valued Functions (Lecture 2)	1
3.4	Gradients of Matrices	1
3.5	Useful Identities for Computing Gradients	1
3.6	Backpropagation and Automatic Differentiation – Gradients in dee Netwok	1
3.7	Automatic Differentiation	1
3.8	Higher Order Derivatives	1
3.9	Linearization and Multivariate Taylor Series	1
	Module-IV (PROBABILITY AND DISTRIBUTIONS)	10
4.1	Construction of a Probability Space	1
4.2	Discrete and Continuous Probabilities (Probability Density Function, Cumulative Distribution Function)	1
4.3	Sum Rule, Product Rule	1
4.4	Bayes' Theorem	1
4.5	Summary Statistics and Independence (Lecture 1)	1
4.6	Summary Statistics and Independence (Lecture 2)	1
4.7	Bernoulli, Binomial, Uniform (Discrete) Distributions	1
4.8	Uniform (Continuous), Poisson Distributions	1
4.9	Gaussian Distribution	1
4.10	Conjugacy and the Exponential Family (Beta – Bernoulli, Beta – Binomial Conjugacies)	1
	Module-V (OPTIMIZATION)	7
5.1	Optimization Using Gradient Descent.	1
5.2	Gradient Descent With Momentum, Stochastic Gradient Descent	1
5.3	Constrained Optimization and Lagrange Multipliers (Lecture 1)	1

5.4	Constrained Optimization and Lagrange Multipliers (Lecture 2)	1
5.5	Convex Optimization	1
5.6	Linear Programming	1
5.7	Quadratic Programming	1

CST 2 6	Principles of Program Analysis and Verification	Category	L	T	P	CREDIT	YEAR OF INTRODUCTION
		HONOURS	3	1	0	4	2019

Preamble: This is the foundational course for awarding B. Tech. Honours in Computer S and Engineering with specialization in Formal Methods. Program Analysis and Progr Verification are two important areas of study, discussing Methods, Technologies and T ensure reliability and correctness of software systems. The syllabus for this course is with the view of introducing the Foundational Concepts, Methods and Tools in Program A and Program Verificati

Prerequisite: Topics c Structures (MAT 203).

Course Outcomes: Af will be able to

CO1	Explain the ains, Fixed Points, Connections, , Hoare Triples, We Preconditions ns to perform Analysis Verification of stand)
CO2	Illustrate met al Data flow Analysis given Program evel: Analyse)
CO3	Formulate a given Data flow Ana problem and itive knowledge level: Analyse)
CO4	Use KildallÕs of Programs and co the results o d Distributive Frame (Cognitive knowledge level: Apply)
CO5	Explain the concept of Loop Invariants and use them in Hoare Triple based W Precondition analysis to verify the total correctness of a code segment (Cognitive knowledge level: Apply)
CO6	Use the tool VCC to specify and verify the correctness of a C Program with res a given set of properties (Cognitive knowledge level: Analyse)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔	✔		✔				✔		✔
CO2	✔	✔	✔	✔		✔				✔		✔
CO3	✔	✔	✔	✔	✔	✔						✔
CO4	✔	✔	✔	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			✔
CO5	✔	✔	✔	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	✔		✔
CO6	✔	✔	✔	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			✔

Abstr[illegible]ditation			
PO#	[illegible]	[illegible]	[illegible]Broad PO
PO1	Engineering [illegible]	[illegible]	[illegible]t and Sustainability
PO2	Problem Ana[illegible]	[illegible]	[illegible]
PO3	Design/Deve[illegible]	[illegible]	[illegible]d team work
PO4	Conduct inv[illegible] problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern:

BloomÕs Category	Continuous Assessment Tests		End Semester Examination Marks
	Test 1 (Percentage)	Test 2 (Percentage)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyze			
Evaluate	[illegible]	[illegible]	
Create	[illegible]	[illegible]	

Mark Distribution

Total Marks	[illegible]	[illegible]	ESE Duration
150	[illegible]	[illegible]	3 hours

Continuous Internal E[illegible]

Attendance [illegible]

Continuous Assessment Tests : 25 Marks

Assignment : 15 Marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First series test shall be preferably conducted after completing the first half of the syllal the second series test shall be preferably conducted after completing the remaining pa syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 qu each from the completed modules and 1 question from the partly covered module), h marks for each question adding up to 15 marks for part A. Students should answer all q from Part A. Part B contains 7 questions (preferably, 3 questions each from the co modules and 1 question from the partly covered module), each with 7 marks. Out o questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questio each module, having 3 marks for each question. Students should answer all questions f A. Part B contains 2 questions from each module of which a student should answer any c question carries 14 ma ximum 2 sub-divisions.

Mathematical Founda Lattice, Construction Complete Lattices, Ch nt Theorem.

Introduction to Progra ng Definition Analysis, D Flow Analysis, Abstra solutions for the Data Analysis problem.

Intraprocedural DataFlow Analysis Ð Available Expressions Analysis, Reaching Definit Analysis, Very Busy Expressions Analysis, Live Variable Analysis, Derived Data Information, Monotone and Distributive Frameworks, Equation Solving - Maximal Fixed (MFP) and Meet Over all Paths (MOP) solutions.

Interprocedural Data Flow Analysis - Structural Operational Semantics, Intraprocedural v Interprocedural Analysis, Making Context Explicit, Call Strings as Context, Flow Sens versus Flow Insensitivity, Implementing Interprocedural Data-flow Analysis using the WALA.

Module 4

Abstract Interpretation - A Mundane Approach to Correctness, Approximations of Fi Points, Galois Connections, Systematic Design of Galois Connections, Induced Ope KildallÕs Algorithm for Abstract Interpretation.

Module 5

Program Verification - Why should we Specify and Verify Code, A framework for softw verification - A core programming Language, Hoare Triples, Partial and Total Corre Program Variables a ... Partial Correctness, Invariants, Verifying c ... ent C).

Text Books

1. Flemming Niel ... nciples of Program Ana Springer (1998)
2. Michael Hutch ... e - Modeling and Reas about Systems ... n.

References

1. Julian Dolby ar ... DI 2010), available onli http://wala.sour
2. Ernie & Hillebr ... fying C Programs: A Tutorial.

Sample Course Level Assessment Questions

Course Outcome1 (CO1):

1. Find a lattice to represent the data states of a given program and propose a soun interpretation framework to do a given analysis on the program.
2. When is an abstract interpretation framework said to be sound? Illustrate w example.
3. When is an abstract interpretation framework said to be precise? Illustrate w example.

Course Outcome2 (CO2):

1. Illustrate how o ion Analysis on a prog
2. Illustrate how o on Analysis on a progr
3. Illustrate how o ysis on a program.

Course Outcome3 (CO

1. Illustrate how o is using the tool WALA.

Course Outcome4 (CO

1. Illustrate the w cedural Available Expre Analysis on a p
2. Compare the r ms for Abstract Interp in Monotone ar

Course Outcome5 (CO

1. Illustrate the ons (VCs) using we precondition analysis.
2. Explain the concepts of partials and total correctness of programs.
3. Explain the necessity of obtaining loop invariants in verifying the total correctnes program.

Course Outcome6 (CO6):

1. Using the tool VCC prove that a given code segment satisfies a given property.

Model Question paper

QP CODE: PAGES:3

Reg No:______________ Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

4th SEMESTER B.TECH DEGREE (HONOURS) EXAMINATION, MONTH & YEAR

Course Code: CST2 6

Course Name: Principles of Program Analysis and Verification

Max.Marks n: 3 Hours

Ans larks

1. What is a comp lattice.
2. Show that ever
3. Write a progra of a number. Explain statements of y
4. Consider a pro plications. Draw the fl graph of the pro
5. What is Availab ation for AE analysis.
6. What is Live va LV analysis.
7. Let P be a prog $F_A, !_{AC}$) and ($B, F_B, !_{BC}$) be two abstrac aA. Let ! and ! be the abstraction and , what are the conditio required for ! ar
8. When is KildallOs algorithm for abstract interpretation guaranteed to terminate? your answer.
9. Is it possible to verify total correctness of a program using Hoare Logic? If yes, ho possible?
10. Define loop invariant. Show a simple loop with a loop invariant.

PART B

Answer any one Question from each module. Each question carries 14 Marks

11.

a. What is an infinite ascending chain in a lattice? Show an example lattice w infinite ascending chain. Is it possible for a complete lattice to contain an ir ascending chain? (7 marks)

b. State and prove Knaster-Tarski fixed point theorem. (7 marks)

OR

12.

a. Conside ... ction defined as follow when x < ... 1, otherwise $f(x) = x$. Then, sh ... nts, (ii) the set of all pr fixpoints ... (7 marks)

b. Let (D, " ... ach subset of D. Then, prove that ever ... (7 marks)

13.

a. With a s ... oach in Data Flow Anal (7 marks)

b. With a s ... he collecting semantic program ... (7 marks)

14.

a. With an ... d Approach in Data Analysis ... (7 marks)

b. Discuss ... roblem of computing th solution ... ow Analysis. (7 marks)

15.

a. Using Intraprocedural Reaching Definition Analysis, find the assignments and generated by each of the blocks in the program

$[x:=5]^1;$

$[y:=1]^2;$

while $[x>1]^3$ do

$([y:=x*y]^4; [x:=x-1]^5)$

(7 marks)

b. Analyse the following program using Intraprocedural Very Busy Expre analysis

if [a>b] 1 then
([x: =b-a] 2 ; [y: =a-b] 3)
else
([y: =b-a] 4; [x: =a-b] 5)

(7 marks)

OR

16.

a. Find Maximal Fixed Point (MFP) solution for the program
[x: =a+b] 1;
[y: =a*b] 2 ;
while [y>a+b] 3 do
([a: =a+1] 4; [x: =a+b] 5)

(7 marks)

b. With exa … sensitive and flow insen
analysis … (7 marks)

17.

a. Prove th … (L , " , !, M) is a Galois
connecti … (7 marks)

b. Prove th … ere exists M # L such
that (L , " … : M # L is completely
multiplic … L , " , !, M) is a Galois
connecti … (7 marks)

18.

a. Show th … s and : Vi! "! # i are
represer …
((! … #1

(7 marks)

b. Briefly e … etation (7 marks)

19.

a. Briefly explain the need of specification and verification of code. (7 marks)

b. Argue that Hoare Logic is sound. When Hoare Logic is complete? Let {A}P
be a Hoare triple such that Hoare Logic is complete for the program P. Ther
always possible to check the validity of the Hoare Triple? If not, what is
difficulty? (7 marks)

OR

20.

a. With suitable examples, show the difference between partial and total correc

(7 marks)

b. With a suitable example, show how a basic program segment can be v
using the tool VCC. (7 marks)

Teaching Plan

Module 1 (Mathematical Foundations)		6 Hours
1.1	Partially Ordered Set	1 Hour
1.2	Complete Lattice, Construction of Complete Lattices	1 Hour
1.3	Chains	1 Hour
1.4	Fixed Points	1 Hour
1.5	Knaster-Tarsk	1 Hour
1.6	Proof of Knas	1 Hour
Mod		5 Hours
2.1	The WHILE la	1 Hour
2.2	Data Flow An	1 Hour
2.3	Reaching Def	1 Hour
2.4	Abstract Inter	1 Hour
2.5	Algorithm to fi ... ysis probler	1 Hour
		15 Hours
3.1	Available Expressions Analysis, Reaching Definitions Analysis	1 Hour
3.2	Very Busy Expressions Analysis	1 Hour
3.3	Live Variable Analysis	1 Hour
3.4	Derived Data Flow Information	1 Hour
3.5	Monotone and Distributive Frameworks	1 Hour
3.6	Equation Solving - MFP Solution	1 Hour

3.7	Equation Solving - MOP Solution	1 Hour
3.8	Structural Operational Semantics (Lecture 1)	1 Hour
3.9	Structural Operational Semantics (Lecture 2)	1 Hour
3.10	Intraprocedural versus Interprocedural Analysis	1 Hour
3.11	Making Context Explicit	1 Hour
3.12	Call Strings as Context	1 Hour
3.13	Flow Sensitivity versus Flow Insensitivity	1 Hour
3.14	Implementing … e Tool WAL (Lecture 1)	1 Hour
3.15	Implementing … e Tool WAL (Lecture 2)	1 Hour
		8 Hours
4.1	A Mundane A…	1 Hour
4.2	Approximatio…	1 Hour
4.3	Galois Conne…	1 Hour
4.4	Systematic D…	1 Hour
4.5	Systematic D…	1 Hour
4.6	Induced Oper…	1 Hour
4.7	KildallÕs Algorithm for Abstract Interpretation (Lecture 1)	1 Hour
4.8	KildallÕs Algorithm for Abstract Interpretation (Lecture 2)	1 Hour
	Module 5 (Program Verification)	11 Hours
5.1	Why should we Specify and Verify Code	1 Hour
5.2	A framework for software verification - A core programming Language	1 Hour

5.3	Hoare Triples (Lecture 1)	1 Hour
5.4	Hoare Triples (Lecture 2)	1 Hour
5.5	Partial and Total Correctness	1 Hour
5.6	Program Variables and Logical Variables	1 Hour
5.7	Proof Calculu	1 Hour
5.8	Loop Invarian	1 Hour
5.9	Verifying C pr	1 Hour
5.10	Verifying C pr	1 Hour
5.11	Verifying C pr	1 Hour

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Simulation Assignments (ECT203)

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mod-5, mod-2 and mod-10 operation.

Develop a mod-40 (mod-8 and mod-5) counter by cascading two such subcircuits.

Simulate and observe the timing diagram and truth table.

Synchronous Counters

Design and develop a 4-bit synchronous counter using J-K ip- ops.

Perform digital simulation and observe the timing diagram and truth table.

Sequence Generator

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Model Question Paper

OR

12(A) Explain the oating and xed point representation of num- (8) K_2

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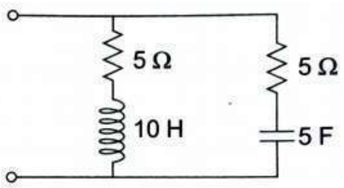
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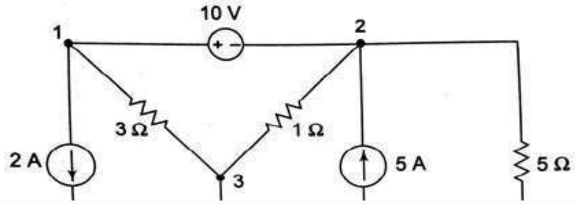

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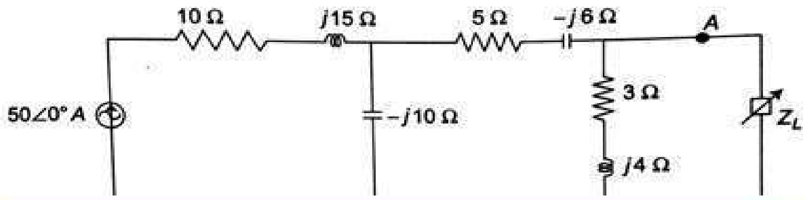

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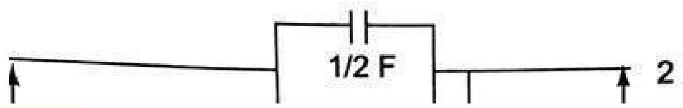

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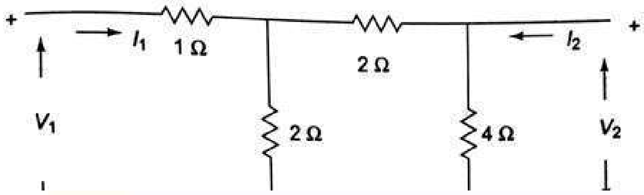
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ECL 201	SCIENTIFIC COMPUTING LABORATORY	CATEGORY	L	T	P	CREDIT

CO6	3	3	2	2	3	0	0	0	3	1	0	0
CO7	3	3	2	2	3	0	0	0	3	1	0	1

Assessment Pattern

Course Level Assessment Questions

2. Write and execute a function to solve for the current transient through an RL network (with $\frac{r}{L} = 1$) that is driven by the signal $5e^{t}$ $U(t)$

CO5-Data Analysis

etc. using built in modules.

3. Vectorized computing without loops for fast scienti c applications.

Experiment 3. Realization of Arrays and Matrices

$f(t) = 4t + 3$

and plot it for the vector t = [5; 5] with increment 0.01

6. Use general integration tool to compute

Experiment 6. Simple Data Visualization

3 5 7

7. Use this to compute for the rst 10, 20, 50 and 100 terms.

Experiment 9: Coin Toss and the Level Crossing Problem

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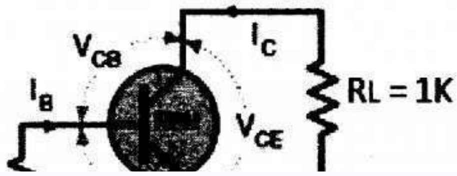

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Simulation Assignments

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Simulation Assignments

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AM R

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Assemble the kit by soldering all components and enjoy.

Generation of Discrete Signals

Generate the following discrete signals

- Impulse signal
- Pulse signal and
- Triangular signal

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Model Question Paper

17 The impulse response of a linear time invariant system is (14) K_3

Simulation Assignments

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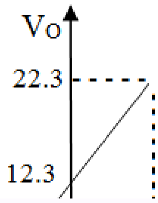

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Simulation Assignments (ECT202)

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Simulation Assignments (ECT 204)

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Model Question Paper

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ELECTRONICS AND COMMUNICATION ENGINEERING

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ECT282	Microcontrollers	CATEGORY	L	T	P	CREDIT
		Minor	3	1	0	4

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer

1. The 8051 Microcontrollers: Architecture Programming and Applications, K Uma Rao & Andhe Pallavi, Pearson, 2011.

2. ARM System - on-chip Architecture, Steve Furber, Pearson Education

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Computer Arithmetic and Processor Basics**	
1.1	Functional units of a computer, Von Neumann and Harvard computer	2
4.4	Simple Applications - Solar Tracker, 4-Digit 7-Segment LED Display, Tilt Sensor, Home Security Alarm System, Digital Thermometer, IoT applications	3
5	**ARM Based System**	

5.1	Introduction - ARM family, ARM 7 register architecture, ARM programmer's model	3
5.2	Raspberry pi 4 board – Introduction and brief description	2
5.3	Applications - Portable Bluetooth speaker, Remote-controlled car, Photo Booth, IoT weather station, Home automation centre, Portable Digital eBook Library	4

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		external memory of an 8051 microcontroller.	
	b)	How a DAC can be interfaced to 8051? Explain.	(6)
		OR	

ELECTRONICS AND COMMUNICATION ENGINEERING

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Simulation Assignments

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B3ZS

B6ZS

Decode and compare the result with the original bit pattern.

Base Band BPSK System

Cretae a random binary sequence of 5000 bit. Convert it into a bipolar NRZ code.

Create a BPSK mapper that maps bit 0 to zero phase and bit 1 to phase.

Plot the real part of the mapped signal against the imaginary part to observe the signal

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Model Question Paper

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12(A)	Explain how companding is achieved practically using di er- ent levels	(8)	K 2

12(B) Explain mid-rise and mid-tread quantizers (6) K_2

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Simulation Assignments

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Make it into a discrete system (possibly with scipy.signal.cont2discrete)

Observe the step response in both cases and compare.

6. Download a vibration signal in .wav format.

Load this signal into an array. One may use the scipy.io.wavfile module in Python.

understand the sampling rate of this signal.

Plot and observe the vibration signal waveform.

Compute the absolute squared value of the FFT of the vibration signal.

Plot it and observe the spectral components in the discrete frequency domain.

Multiply prominent discrete frequencies by the sampling rate and observe and appreciate the major frequency components in Hz.

Model Question Paper

PART B

15(B) Convert the analog lter (7) K_3

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Simulation Assignments

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Simulation of a Point Process

1. It is required to simulate a point Poisson process, say the arrival of packets in a queue.
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Model Question Paper

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Estd.
2014

PART B

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is WSS with a uniformly distributed random variable in the interval [;].

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Simulation Assignments

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Central Limit Theorem

Simulate a coin toss experiment that generates a string of length N of 0s and 1s that are uniformly distributed.

Toss the coin M times and sum up the string in every toss.

Plot the normalized histogram of the sum values for $M = 100; 1000; 5000$. Observe that it is a

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1. Generate a cosinusoid of say 100 Hz frequency and bury it in AWGN of comparable variance.

2. Write functions for periodogram and ARMA method to estimate the spectrum of the cosinusoid.

3. The student may install the Python package spectrum and repeat the estimations steps using its modules and compare the plot of spectra with those resulted by your functions.

Model Question Paper

PART B

of $Z = \sqrt{X^2 + Y^2}$

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CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET201	MECHANICS OF SOLIDS	PCC	3	1	0	4

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Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
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COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Determine the resultant traction at a point in a plane using the stress tensor.

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SYLLABUS

Module 1

Deformation behaviour of elastic solids in equilibrium under the action of a system of forces, method of sections. Stress vectors on Cartesian coordinate planes passing through a point, stress at

Text Books

1. Mechanics of materials in SI units, R .C. Hibbeler, Pearson Higher Education 2018

2. Advanced Mechanics of Solids, L. S. Srinath, McGraw Hill Education

3. Design of Machine Elements, V. B Bhandari, McGraw Hill Education

Reference Books

1. Engineering Mechanics of Solids, Popov E., PHI 2002

COURSE PLAN

No	Topic	No of lectures
1	Module 1: Stress and Strain Analysis	9 hours
	Describe the deformation behaviour of elastic solids in equilibrium under	
3.2	shaft. Simple problems to estimate the stress in solid and hollow shafts	1 hr
3.3	Numerical problems for basic design of circular shafts subjected to exter applied torques	1 hr
3.4	Shear force and bending moment diagrams for cantilever and simply	2 hrs

	supported beams subjected to point load, moment, UDL and linearly varying load	
3.5	Differential equations between load, shear force and bending moment.	1 hr
	Normal and shear stress in beam: Derivation of flexural formula, section modulus, flexural rigidity, numerical problems to evaluate bending stress	

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION

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12. a) d Z • š š } (‰ o v • š Œ • • š $_{xx}$ = 40 D]WšU $_{yy}$ = 20 MPa and $_{xy}$ = 16 MPa Using Mohr's circle determine the i) principal stresses and principal planes and ii) maximum shear stress. (7 marks)

b) Thestate of stress at a point is given below. Find the resultant stress vector acting on a plane with direction cosines n_x=0.47, n_y=0.82 and n_z=0.33 Find the normal and tangential stresses acting on this plane. (7 marks)

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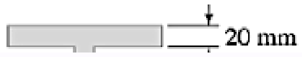
OR

16. a) A simply supported beam of span of 10 m carries a UDL of 40 kN/m. The cross section is of I shape as given below. Calculatethe maximum stress produced due to bending and plot thebending stress distribution (9marks)



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ck. The column is 5m long with one end fixed and other end hinged. Use Rankine's formula and Z v l] v [• } v • š v š • í l=ó3ð5i N/mm^2. Compare this load by crippling load given by Euler's formula. Take E = 110 GPa. (8 marks)

b) Explain the maximum normal stress theory, maximum strain energy theory and maximum shear stress theory of failure. (6 marks)

OR

20. a) The principal stresses at a point in an elastic material are 22 N/mm^2 (tensile), 110 N/mm^2

CODE	COURSE NAME	CATEGOR	L	T	P	CREDIT
MET203	MECHANICS OF FLUIDS	PCC	3	1	-	4

Preamble:

This course provides an introduction to the properties and behaviour of fluids. It enables to apply the concepts in engineering, pipe networks. It introduces the concepts of boundary layers, dimensional analysis and model testing.

Prerequisite: NIL

Course Outcomes

After completion of the course the student will be able to

CO1	Define Properties of Fluids and Solve hydrostatic problems
CO2	Explain fluid kinematics and Classify fluid flows
CO3	Interpret Euler and Navier Stokes equations and Solve problems using Bernoulli's equation
CO4	Evaluate energy loses in pipes and sketch energy gradient lines
CO5	Explain the concept of boundary layer and its applications
CO6	Use dimensional Analysis for model studies

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										
CO2	3	2	1									
CO3	3	2	1									
CO4	3	3	2									
CO5	3	2	1									
CO6	3	2	1									

Assessment Pattern

Blooms Category	CA			ESA
	Assignment	Test- 1	Test- 2	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

Mark distribution & Duration of Examination :

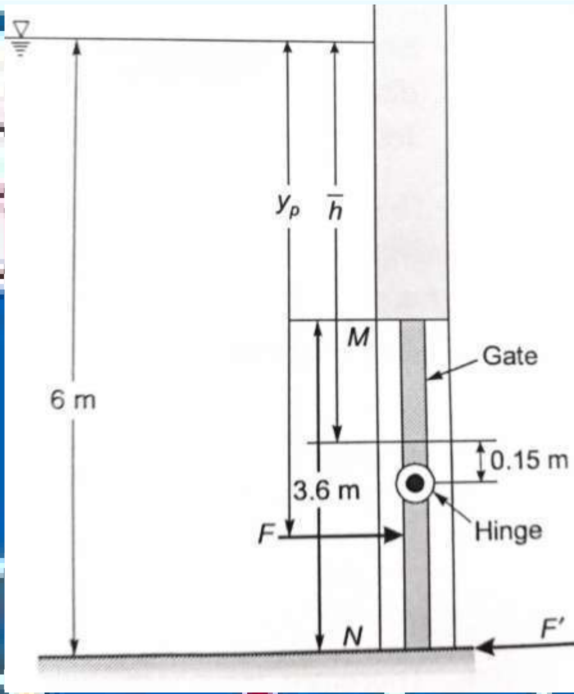
Total Marks	CA	ESE	ESE Duration
150	50	100	3 Hours

End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Outcome 1

1. A 3.6 1.5 m wide rectangular gate MN is vertical and is hinged at point 0.15 m below the center of gravity of the gate. The total depth of water is 6 m. What horizontal force must be applied at the bottom of the gate to keep the gate closed.



2. A stationary liquid is strati ed so that its density is $_0(1 + h)$ at a depth h below the free surface. At a depthh in this liquid, what is the pressure in excess of$_0$gh?

3. If the velocity pro le of a uid is parabolic with free stream velocity 120 cm/s occurring at 20 cm from the plate, calculate the velocity gradients and shear stress at a distance of 0, 10, 20 cm from the plate. Take the viscosity of uid as 8.5 poise.

Course Outcome 2

1. Di erentiate between the Eulerian and Lagrangian method of representing uid motion.

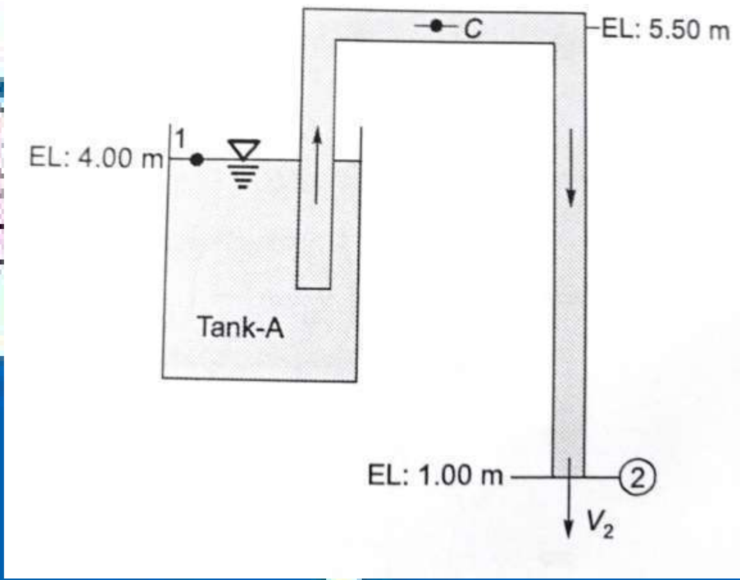
2. A velocity eld is given by $u = 3y^2$, $v = 2x$ and $w = 0$ in arbitrary units. Is this ow steady or unsteady? Is it two or three dimensional? At (x,y,z)=(2,1,0), compute

   (a) velocity
   (b) local acceleration
   (c) convective acceleration

3. A stream function in two dimensional ow is $= 2xy$. Show that the ow is irrotational and determine the corresponding velocity potential.

Course Outcome 3

1. A siphon consisting of a pipe of 15 cm diameter is used to empty kerosene oil (relative density=0.8) from tank A. The siphon discharges to the atmosphere at an elevation of 1.00 m. The oil surface in the tank is at an elevation of 4.00 m. The center line of the siphon pipe at its highest point C is at an elevation of 5.50 m. Estimate,



   (a) Discharge in the pipe
   (b) Pressure at point C.

   The losses in the pipe can be assumed to be 0.5 m up to the summit and 1.2 m from summit to the outlet.

2. Derive the Euler's equation of motion along a streamline and from that derive the Bernouli's equation.

3. What is water hammer? Explain di erent cases of water hammer. Derive the expression for pressure rise in any one of the case.

Course Outcome 4

1. Two reservoir with a di erence in water surface elevation of 10 m are connected by a pipeline AB and BC joined in series. Pipe AB is 10 cm in diameter, 20 m long and has a value of friction factor f = 0:02. Pipe BC is 16 cm diameter, 25 m long and has a friction factor f=0.018. The junctions with reservoirs and between pipes are abrupt.

   (a) Sketch Total energy line and Hydraulic gradient line
   (b) Calculate the discharge.

2. Oil of viscosity 0.1 Pas and speci c gravity 0.9 ows through a horizontal pipe of 25 mm diameter. If the pressure drop per meter length of the pipe is 12 KPa, determine

   (a) Discharge through the pipe
   (b) Shear stress at the pipe wall
   (c) Reynolds number of the ow

(d) Power required in Watts if the length of the pipe is 50m

3. In a hydraulic power plant, a reinforced concrete pipe of diameter D is used to transmit water from the reservoir to the turbine. If H is the total head supply at the entrance of the pipe and h_f is the loss of head in the pipe, then derive the condition for maximum power supply through the pipe.

Course Outcome 5

1. Write a short note on boundary layer separation and discuss any two methods to control the same.

2. Find the displacement thickness, momentum thickness and energy thickness for velocity distribution in boundary layer given by

$$\frac{u}{U_1} = 2\,\frac{y}{\;}\quad\frac{y}{\;}^{2}$$

3. A thin plate is moving in still atmospheric air at a velocity of 4m=s. The length of the plate is 0.5 m and width 0.4 m. Calculate the

   (a) thickness of the boundary layer at the end of the plate and

   (b) drag force on one side of the plate.

   Take density of air as 1.25 kg=m^3 and kinematic viscosity 0.15 stokes.

Course Outcome 6

1. State and explain Buckingham's pi theorem.

2. An underwater device is 1.5m long and is to move at 3.5 m/s speed. A geometrically similar model 30 cm long is tested in a variable pressure wind tunnel at a speed of 35 m/s. Calculate the pressure of air in the model if the model experience a drag force of 40 N, calculate the prototype drag force. [Assume density of water = 998 kg=m^3, density of air at standard atmospheric pressure = 1.17 kg=m^3, dynamic viscosity of air at local atmospheric pressure = 1:95 10^5 Pas and dynamic viscosity of water = 1 10^3 Pas]

3. Explain the importance of dimensionless numbers and discuss any two similarity laws. Where are these model laws used?

SYLLABUS

Module 1: Introduction: Fluids and continuum, Physical properties of fluids, density, specific weight, vapour pressure, Newton's law of viscosity. Ideal and real fluids, Newtonian and Non-Newtonian fluids. Fluid Statics - Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies, fluid masses subjected to uniform accelerations, measurement of pressure.

Module 2: Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow, 1-D, 2-D and 3-D flow, steady, unsteady, uniform, non-uniform, laminar, turbulent, rotational, irrotational flows, stream lines, path lines, streak lines, stream tubes, velocity and acceleration in fluid, circulation and vorticity, stream function and potential function, Laplace equation, equipotential lines, flow nets, uses and limitations.

Module 3: Control volume analysis of mass, momentum and energy, Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation), Navier-Stokes equations (without proof) in cartesian co-ordinates. Dynamics of Fluid flow: Bernoulli's equation, Energies in flowing fluid, head, pressure, dynamic, static and total head, Venturi and Orifice meters, Notches and Weirs (description only for notches and weirs). Hydraulic coefficients, Velocity measurement Pitot tube and Pitot-static tube.

Module 4: Pipe Flow: Viscous flow: Reynolds experiment to classify laminar and turbulent flows, significance of Reynolds number, critical Reynolds number, shear stress and velocity distribution in a pipe, law of fluid friction, head loss due to friction, Hagen Poiseuille equation. Turbulent flow: Darcy-Weisbach equation, Chezy's equation Moody's chart, Major and minor energy losses, hydraulic gradient and total energy line, flow through long pipes, pipes in series, pipes in parallel, equivalent pipe, siphon, transmission of power through pipes, efficiency of transmission, Water hammer, Cavitation.

Module 5: Boundary Layer : Growth of boundary layer over a flat plate and definition of boundary layer thickness, displacement thickness, momentum thickness and energy thickness, laminar and turbulent boundary layers, laminar sub layer, velocity profile, Von-Karman momentum integral equations for the boundary layers, calculation of drag, separation of boundary and methods of control. Dimensional Analysis: Dimensional analysis, Buckingham's theorem, important non dimensional numbers and their significance, geometric, Kinematic and dynamic similarity, model studies. Froude, Reynolds, Weber, Cauchy and Mach laws- Applications and limitations of model testing, simple problems only

Text Books

John. M. Cimbala and Yunus A. Cengel, Fluid Mechanics: Fundamentals and Applications (4th edition, SIE), 2019

Robert W. Fox, Alan T. McDonald, Philip J. Pritchard and John W. Mitchell Fluid Mechanics, Wiley India, 2018

Reference Books

White, F. M., Fluid Mechanics, McGraw Hill Education India Private Limited, 8th Edition,2017

Rathakrishnan, E. Fluid Mechanics: An Introduction, Prentice Hall India, 3rd Edition 2012

COURSE PLAN

Module	Topics	Hours Allotted
I	Introduction: Fluids and continuum, Physical properties of fluids, densit specific weight, vapour pressure, Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids. Fluid Statics-Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies, fluid masses subjected to uniform accelerations, measurement of pressure.	7-2-0
II	Kinematics of fluid flow-Eulerian and Lagrangian approaches, classificat of fluid flow, 1-D, 2-D and 3-D flow, steady, unsteady, uniform, non-uniform, laminar, turbulent, rotational, irrotational flows, stream lines, path lines, streak lines, stream tubes, velocity and acceleration in fluid, circulation and vorticity, stream function and potential function, Laplace equation, equipotential lines, flow nets, uses and limitations.	6-2-0
III	Control volume analysis of mass, momentum and energy, Equations of flui dynamics: Differential equations of mass, energy and momentum (Euler's equation), Navier-Stokes equations (without proof) in cartesian co-ordinates Dynamics of Fluid flow: Bernoulli's equation, Energies in flowing fluid, head, pressure, dynamic, static and total head, Venturi and Orifice meters, Notches and Weirs (description only for notches and weirs). Hydraulic coefficients, Velocity measurements: Pitot tube and Pitot-static tube.	6-2-0
IV	Pipe Flow: Viscous flow: Reynolds experiment to classify laminar and turbulent flows, significance of Reynolds number, critical Reynolds number, shear stress and velocity distribution in a pipe, law of fluid friction, heac	9-3-0

	loss due to friction, Hagen Poiseuille equation. Turbulent flow: Darcy Weisbach equation, Chezy's equation Moody's chart, Major and minor energy losses, hydraulic gradient and total energy line, flow through long pipes, pipes in series, pipes in parallel, equivalent pipe, siphon, transmission of power through pipes, efficiency of transmission, Water hammer, Cavitation.	
V	Boundary Layer : Growth of boundary layer over a flat plate and definiti of boundary layer thickness, displacement thickness, momentum thickness and energy thickness, laminar and turbulent boundary layers, laminar sub layer, velocity profile, Von Karman momentum integral equations for the boundary layers, calculation of drag, separation of boundary and methods of control. Dimensional Analysis: Dimensional analysis, Buckingham's theorem, important non dimensional numbers and their significance, geometric, Kinematic and dynamic similarity, model studies. Froude, Reynolds, Weber, Cauchy and Mach laws Applications and limitations of model testing, simple problems only	8-2-0

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

IV SEMESTER B.TECH DEGREE EXAMINATION

MET203: MECHANICS OF FLUIDS

Mechanical Engineering

Maximum: 100 Marks Duration: 3 hours

PART A

Answer all questions, each question carries 3 marks

1. The speci c gravity of a liquid is 3.0. What are its speci c weight, speci c mass and speci c volume.
2. State Pascal's law and give some examples where this principle is used.
3. Explain Streamlines, Streaklines and Pathlines.
4. What do you understand by the terms: () Total acceleration, (ii) Convective acceleration, and (iii) Local acceleration.
5. Name the di erent forces present in a uid ow. For the Euler's equation of motion, which forces are taken into consideration.
6. Di erentiate between pitot tube and pitot static tube.
7. De ne and explain the terms () Hydraulic gradiant line and (ii) Total energy line.
8. Show that the coe cient of friction for viscous ow through a circular pipe is given by

$$f = \frac{16}{Re}$$

   where Re is the Reynolds number.
9. What do you mean by repeating variables? How repeating variables are selected for dimensional analysis.
10. How will you determine whether a boundary layer ow is attached ow, detached ow or on the verge of separation.

(10 3=30 Marks)

PART B

Answer one full question from each module

MODULE-I

11. (a) Through a very narrow gap of height h, a thin plate of large extend is pulled at a velocity V. On one side of the plate is oil of viscosity μ_1 and on the other side oil of viscosity μ_2. Calculate the position of the plate so that

    i. the shear force on the two sides of the plate is equal.

    ii. the pull required to drag the plate is minimum.

    Assume linear velocity distribution in transverse direction. (7 Marks)

    (b) A metallic cube of 30 cm side and weight 500 N is lowered into a tank containing two fluid layers of water and mercury. Top edge of the cube is at water surface. Determine the position of the block at water-mercury interface when it has reached equilibrium. (7 Marks)

12. (a) A rectangular tank 1.5 m wide, 3 m long and 1.8 m deep contains water to a depth of 1.2 m. Find the horizontal acceleration which may be imparted to the tank in the direction of length so that

    i. there is just no spilling from the tank

    ii. front bottom corner of the tank is just exposed.

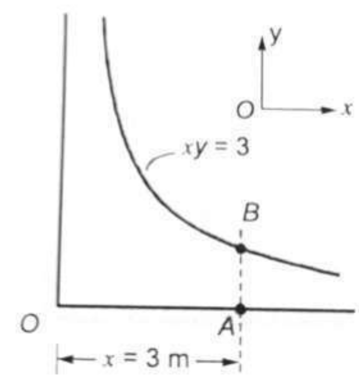
    (7 Marks)

    (b) A spherical water drop of 1 mm diameter splits up in air into 64 smaller drops of equal size. Find the work required in splitting up the drop. The surface tension coefficient of water in air = 0.073 N/m (7 Marks)

MODULE-II

13. (a) In a fluid flow field, velocity vector is given by $v = (0.5 + 8x)i + (0.5 - 0.8y)j$. Find the equation of streamline for the given velocity field. (7 Marks)

    (b) The stream function $\psi = 4xy$ in which ψ is in cm^2/s and x and y are in meters describe the incompressible flow between the boundary shown below:



Calculate

i. Velocity at B

ii. Convective acceleration at B

iii. Flow per unit width across AB

(7 Marks)

14. (a) Consider the velocity eld given by $u = x^2$ and $v = 2xy$. Find the circulation around the area bounded by $A(1;1); B(2;1); C(2;2); D(1;2)$. (7 Marks)

(b) Verify whether the following are valid potential functions.

i. $= 2x + 5y$

ii. $= 4x^2 \quad 5y^2$

(7 Marks)

MODULE-III

15. (a) A submarine moves horizontally in sea and has its axis 15 m below the surface of the water. A pitot tube properly placed just in front of the submarine and along its axis is connected to two limbs of a U tube containing mercury. The di erence of level is found to be 170 mm. Find the speed of the submarine knowing that the speci c gravity of mercury is 13.6 and that of sea water is 1.026 with respect to water. (7 Marks)

(b) A pitot tube is inserted in a pipe of 30 cm diameter. The static pressure of the tube is 10 cm of mercury vacuum. The stagnation pressure at the centre of the pipe recorded by the pitot tube is $1.0 N{=}cm^2$. Calculate the rate of ow of water through the pipe, if the mean velocity of ow is 0.85 times central velocity. Assume coe cient of tube as 0.98. (7 Marks)

16. (a) A smooth pipe of uniform diameter 25 cm, a pressure of 50 KPa was observed at section 1 which has an elevation of 10 m. At another section 2, at an elevation of 12 m, the pressure was 20 KPa and the velocity was 1.25 m/s. Determine the direction of ow and the head loss between the two sections. The uid in the pipe is water. (8 Marks)

(b) Petrol of speci c gravity 0.8 is following through a pipe of 30 cm diameter. The pipe is inclined at 30 to horizontal. The venturi has a throat diameter of 10 cm. U tube manometer reads 6.25 cm Hg. Calculate the discharge through the pipe. Assume $C_d = 0{:}98$. (6 Marks)

MODULE-IV

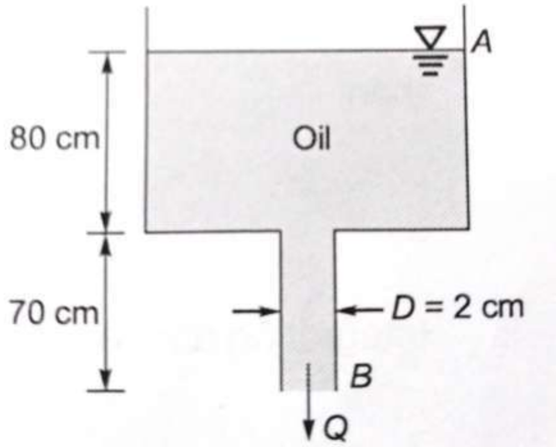
17. (a) Assuming viscous ow through a circular pipe derive the expression for,

i. Velocity distribution

ii. Shear stress distribution

Also plot the velocity and shear stress distribution. (7 Marks)

(b) A large tank shown in the gure has a vertical pipe 70 cm long and 2 cm in diameter. The tank contain oil of density $920 Kg{=}m^3$ and viscosity 1.5 poise. Find the discharge through the tube when the height of oil level of the tank is 0.80 m above the pipe inlet.



(7 Marks)

18. (a) A compound piping system consist of 1800 m of 50 cm, 1200 m of 40 cm and 600 m of 30 com diameter pipes of same material connected in series.
   i. What is the equivalent length of a 40 cm pipe of same material?
   ii. What is the equivalent diameter of a pipe 3600 m long?
   iii. If three pipes are in parallel what is equivalent length of 50 cm pipe?

(10 Marks)

(b) A pipe line of 2100 m is used for transmitting 103 KW. The pressure at the inlet of the pipe is $392.4 N/cm^2$. If the efficiency of transmission is 80%, find the diameter of the pipe. Take $f = 0.005$. (4 Marks)

MODULE-V

19. (a) The velocity profile u of a boundary layer flow over a flat plate is given by

$$\frac{u}{U_1} = \frac{3}{2}\frac{y}{\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$$

If the boundary thickness is given as

$$\delta = \sqrt{\frac{280\,\nu x}{13U_1}}$$

develop the expression for local drag coefficient C_{fx} over the distance $x = L$ from the leading edge of the plate. (7 Marks)

(b) A model test is to be conducted in a water tunnel using a 1:20 model of a submarine which is used to travel at a speed of 12 km/h deep under the sea. The water temperature in the tunnel is so maintained that its kinematic viscosity is half as that of the sea water. At what speed the model test is to be conducted. (7 Marks)

20. (a) With a neat sketch explain the different regions of the boundary layer along a long thin flat plate. (7 Marks)

(b) Using Buckingham's pi theorem show that the velocity through a circular orifice is given by

$$V = \sqrt{2gH}\,\phi\left(\frac{D}{H}, \frac{\mu}{\rho VH}\right)$$

where H is the head causing flow, D is the diameter of the orifice, μ is the coefficient of viscosity, ρ is the mass density and g is the acceleration due to gravity. (7 Marks)

MET 205	METALLURGY & MATERIAL SCIENCE	CATEGORY	L	T	P	Credits	Year of Introduction
		PCC	3	1	0	4	2019

Preamble:

Understanding of the correlation between the chemical bonds and crystal structure of metallic materials to their mechanical properties.

Recognize the importance of crystal imperfections including dislocations in plastic deformation

Learning about different phases and heat treatment methods to tailor the properties of alloys.

Examine the mechanisms of materials failure through fatigue and creep.

To determine properties of unknown materials and develop an awareness to app knowledge in material design

Prerequisite: PHT 110 Engineering Physics and CYT 100 Engineering Chemistry

Course Outcomes - At the end of the course students will be able

CO 1	Understand the basic chemical bonds, crystal structures (BCC, FCC, and HCP), a their relationship with the properties.
CO 2	Analyze the microstructure of metallic materials using phase diagrams and modi microstructure and properties using different heat treatments.
CO 3	How to quantify mechanical integrity and failure in materials
CO 4	Apply the basic principles of ferrous and non-ferrous metallurgy for selecting materia for specific applications
CO 5	Define and differentiate engineering materials on the basis of structure and pro for engineering applications

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-		-	-
CO 2	-	3		-	-	-	-	-	-	-	-	-
CO 3		-	-	2	-	-	-	-	-	-	-	-
CO 4		-	-	-	3	-	-	-	-	-	-	-
CO 5	-	-	-	-		-	-	-	-	-	-	2

ASSESSMENT PATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 11 (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyze	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments	15 marks
Continuous Assessment Test (Minimum 2 numbers)	25 marks

End semester pattern: There will be two parts; Part A and Part B. Part A contain questions with 2 questions from each module, having 3 marks for each question. Stu should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Part -A

Course Outcome 1 (CO1): Understand the basic chemical bonds, crystal structures (BCC, FCC, and HCP), and their relationship with the properties

1. What are the attributes of atomic and crystalline structures into the stress-strain curve?
2. Explain the significance of long range and short range order of atomic arrangement on mechanical strength.
3. What is the difference between an allotrope and polymorphism?
4. Draw the (112) and (111) planes in simple cubic cell.

Course Outcome2 (CO2): Analyze the microstructure of metallic materials using phase diagr and modify the microstructure and properties using different heat treatments.

1. What is the driving force for recrystallisation and grain growth of metallic crystals?
2. What is the driving force for the formation of spheroidite.
3. What is tempered martensite?
4. Why 100 % pure metals are weak strength?

Part -B

Course Outcome3 (CO3): How to quantify mechanical integrity and failure in materials

1. $ VPDOO KROH LV GULOOHG WKURXJK D VWHHO SC progress until repairs can be made. Explain in detail and derive the equation for the principle.
2. Draw and explain S-N curves for ferrous and nonferrous metals. Explain different methods improve fatigue resistance.
3. Explain different stages of creep; Give an application of creep phenomenon. What is superplasticity?

Course Outcome4 (CO4): Apply the basic principles of ferrous and non-ferrous metallurgy for selecting materials for specific applications

1. What are the classification, compositions and applications of high speed steel? Identify 18:4:1
2. Describe the composition, properties, and use of Bronze and Gun metal.
3. Explain the importance of all the non-ferrous alloys in automotive applications. Elaborate the composition, properties and typical applications of few non-ferrous alloys.

Course Outcome5 (CO5): Define and differentiate engineering materials on the basis of structure and properties for engineering applications.

1. Carbon is allowed to diffuse through a steel plate 15 mm thick. The concentrations of ca the two faces are 0.65 and 0.30 kg C/m^3 Fe, which are maintained constant. If the pre-exponential and activation energy are 6.2x10^{-7}m^2/s and 80,000 J/mol, respectively, comp the temperature at which the diffusion flux is 1.43 x 10^{-9} kg/m^2-s.
2. Explain the fundamental effects of alloying elements in steel on polymorphic transformatio temperatures, grain growth, eutectoid point, retardation of the transformation rates, form and stability of carbides.
3. Describe the kind of fracture which may occur as a result of a loose fitting key on a shaft

SYLLABUS

MODULE - 1

Earlier and present development of atomic structure - Primary bonds: - characteristics of covalen ionic and metallic bond - properties based on atomic bonding - Secondary bonds - classification, application (Brief review only).

Crystallography: - SC, BCC, FCC, HCP structures, APF - theoretical density simple problems - Miller Indices: - crystal plane and direction - Modes of plastic deformation: - Slip and twinning - Schmid's law - Crystallization: Effects of grain size, Hall - Petch theory, simple problems.

MODULE - II

Classification of crystal imperfections forest of dislocation, role of surface defects on crac initiation - Burgers vector ±Frank Read source - Correlation of dislocation density with strength and nano concept - high and low angle grain boundaries ±driving force for grain growth and applications - Polishing and etching - X ±ray diffraction, simple problems ±SEM and TEM - Diffusion in solids, I L F N ¶ V laws, mechanisms, applications of diffusion in mechanical engineering, simple problems.

MODULE - III

Phase diagrams: - need of alloying - classification of alloys - Hume Rothery`s rule equilibrium diagram of common types of binary systems: five types - Coring - lever rule and Gibb`s phase rule - Reactions Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties - Heat treatment: TTT, CCT diagram, applications - Tempering - Hardenability, Jominy end quench test, applications - Surface hardening methods

MODULE - IV

Strengthening mechanisms - cold and hot working - alloy steels: how alloying elements affecti properties of steel - nickel steels - chromium steels - high speed steels - cast irons - principal non ferrous alloys.

MODULE - V

Fatigue - creep - DBTT - super plasticity - need, properties and applications of composites, s alloy, intermetallics, maraging steel, Titanium - Ceramics: structures, applications.

Text Books

1. Callister William. D., Material Science and Engineering, John Wiley, 2014
2. Higgins R.A. - Engineering Metallurgy part I ±ELBS, 1998

Reference

1. Avner H Sidney, Introduction to Physical Metallurgy, Tata McGraw Hill, 2009
2. Anderson J.C et.al., Material Science for Engineers, Chapman and Hall, 1990
3. Clark and Varney, Physical metallurgy for Engineers, Van Nostrand, 1964
4. Dieter George E, Mechanical Metallurgy, Tata McGraw Hill, 1976
5. Raghavan V, Material Science and Engineering, Prentice Hall, 2004
6. Reed Hill E. Robert, Physical metallurgy principles, 4th edition, Cengage Learning, 2009
7. Myers Marc and Krishna Kumar Chawla, Mechanical behavior of materials, Caml University press, 2008
8. Van Vlack - Elements of Material Science - Addison Wesley, 1989
9. https://nptel.ac.in/courses/113/106/113106032

MODEL QUESTION PAPER

METALLURGY & MATERIAL SCIENCE - MET 205

Max. Marks : 100 Duration : 3 Hours

Part ±A

Answer all questions.

Answer all questions, each question carries 3 marks

1. What is a slip system? Describe the slip systems in FCC, BCC and HCP metals
2. NASA's Parker Solar Probe will be the first ever mission to "touch" the Sun. The spacecr about the size of a small car, will travel directly into the Sun's atmosphere about 4 millior from the earth surface. Postulate the coolant used in the parker solar probe with chemica bonds.
3. What is the driving force for grain growth during heat treatment
4. What are the roles of surface imperfections on crack initiation
5. Explain the difference between hardness and hardenability.
6. What is tempered martensite? Explain its structure with sketch.
7. Postulate, why cast irons are brittle?
8. How are properties of aluminum affected by the inclusion of (a) copper (b) silicon as alloying elements?
9. What is the grain size preferred for creep applications? Why. Explain thermal fatigue?
10. Explain fracture toughness and its attributes into screw jack?

PART ±B

Answer one full question from each module.

MODULE ±1

11. a. Calculate the APF of SC, BCC and FCC (7 marks).

    b. What is slip system and explain why FCC materials exhibit ductility and BCC and HCP exhibit brittle nature with details of slip system (7 marks).

OR

12. Explain the effect of: (i) Grain size; (ii) Grain size distribution and (iii) Grain orientation (i Grain shape on strength and creep resistance with neat sketches. Attributes of Hall-Petch equation and grain boundaries (14 marks).

MODULE ±2

13. a. Describe step by step procedure for metallographic specimen preparation? Name different types etchants used for specific metals and methods to determine grain size (7 marks).

b. Carbon is allowed to diffuse through a steel plate 15 mm thick. The concentrations of at the two faces are 0.65 and 0.30 kg C/m^3, which are maintained constant. If the-p exponential and activation energy are 6.2 x 10^{-7} m^2/s and 80,000 J/mol, respectively, compute the temperature at which the diffusion flux is 1.43 x 10^{-9} kg/m^2-s (7 marks).

OR

14. a. Explain the fundamental differences of SEM and TEM with neat sketches (7 marks).

b. A beam of X-rays wavelength 1.54Å is incident on a crystal at a glancing angle of ¶ Z K H Q W K H I L U V W R U G H U % U D J J ¶ V U H I angle for third order reflection (7 marks).

MODULE ±3

15. Postulate with neat sketches, why 100% pure metals are weaker? What are the primary functions of alloying? Explain the fundamental rules governing the alloying with neat sk and how is it accomplished in substitution and interstitial solid solutions (14 marks).

OR

16. Draw the isothermal transformation diagram of eutectoid steel and then sketch and lab time temperature path that will produce 100% coarse and fine pearlite (2) A time temperature path that will produce 50% martensite and 50% bainite (3) A time temperature path that will produce 100% martensite (4) A time temperature path that will produce 100% bainite (14 marks).

MODULE ±4

17. Explain the effect of, polymorphic transformation temperature, formation and stabilit carbides, grain growth, displacement of the eutectoid point, retardation of the transformatic rates, improvement of corrosion resistance on adding alloy elements to steel (14 marks).

OR

18. Give the composition, microstructure, properties and applications of (i) Gray iron and SG iron (ii) White iron and Gray iron. (iii) Malleable iron and Gray iron. (iv) Gray iron and Mot iron, (v) SG iron and Vermicullar Graphite iron (14 marks).

MODULE ±5

19. a $ V P D O O K R O H L V G U L O O H G W K U R X J K D V W H H O S progress until repairs can be made or not? Explain in detail and derive the e (7 marks).

b What is ductile to brittle transition in steel DBTT? What are the factors affecting ductil brittle transition? Narrate with neat sketch (7 marks).

OR

20. Classify ceramics with radius ratio with neat sketches. Explain with an example for each of the AX, AmXp, AmBmXp type structures in ceramics with neat sketch (14 marks).

COURSE CONTENT AND LECTURE SCHEDULES.

Module	TOPIC	No. of hours	Course outcomes
1.1	Earlier and present development of atomic structure; attributes of ionization energy and conductivity, electronegativity and correlation of atomic radius t strength; electron configurations; - Primary bonds: - characteristics b covalent, ionic and metallic bond: attributes of bond energy, cohesive density, directional and non-directional - properties based on atom bonding: - attributes of deeper energy well and shallow energy well to me temperature, coefficient of thermal expansion - attributes of modulus o elasticity in metal cutting process - Secondary bonds: - classification - hydrogen bond and anomalous behavior of ice float on water, application - specific heat, applications (Brief review only).	2	CO1
1.2	Crystallography: - Crystal, space lattice, unit cell- SC, BCC, FCC, atomic packing factor and HCP structures - short and long range order - effects of crystalline and amorphous structure on mechanical properties.	2	CO1 CO2
1.3	Coordination number and radius ratio; theoretical density; simple problems Polymorphism and allotropy.	1	
1.4	Miller Indices: - crystal plane and direction - Attributes of miller indices fo slip system, brittleness of BCC, HCP and ductility of FCC - Modes of plastic deformation: - Slip and twinning.	1	CO5
1.5	Schmid's law, equation, critical resolved shear stress, correlation of slip system with plastic deformation in metals and applications.	1	
1.6	Mechanism of crystallization: Homogeneous and heterogeneous nu formation, under cooling, dendritic growth, grain boundary irregulari Effects of grain size, grain size distribution, grain shape, grain orientatio dislocation/strength and creep resistance - Hall - Petch theory, simpl problems	2	CO2
2.1	Classification of crystal imperfections - types of point and dislocations.	1	CO2
2.2	Effect of point defects on mechanical properties - forest of dislocation, role o surface defects on crack initiation - Burgers vector	1	
2.3	Dislocation source, significance of Frank-Read source in metals deformation - Correlation of dislocation density with strength and nano con applications.	3	CO2
2.4	Significance high and low angle grain boundaries on dislocation ± driving force for grain growth and applications during heat treatment.		
2.5	Polishing and etching to determine the microstructure and grain - Fundamentals and crystal structure determination by X ± ray diffraction, simple problems ± SEM and TEM.	2	CO2 CO5
2.6	Diffusion L Q V R O L G laws, mechanisms, applications of diffusion mechanical engineering, simple problems.	1	

3.1	Phase diagrams: - Limitations of pure metals and need of alloying - classification of alloys, solid solutions, Hume Rothery`s rule - equilibrium diagram of common types of binary systems: five types	2	CO2 CO5
3.2	Coring - lever rule and Gibb`s phase rule - Reactions: - monotectic, eutectic, eutectoid, peritectic, peritectoid.	1	
3.3	Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties changes in austenite, ledeburite, ferrite, cementite, s features of martensite transformation, bainite, spheroidite etc.	3	CO2 CO5
3.4	Heat treatment: - Definition and necessity ± TTT for a eutectoid iron-carbon alloy, CCT diagram, applications - annealing, normalizing, hardenin spheroidizing.		
3.5	Tempering: - austempering, martempering and ausforming - Comparative study on ductility and strength with structure of pearlite, bainite, spher martensite, tempered martensite and ausforming.	1	CO2
3.6	Hardenability, Jominy end quench test, applications - Surface hardening methods - no change in surface composition methods - Flame, induction, lase and electron beam hardening processes - change in surface compositio methods :carburizing and Nitriding; applications.	2	CO2
4.1	Cold working: Detailed discussion on strain hardening; recovery; re-crystallization, effect of stored energy; re-crystallization temperature - hot working Bauschinger effect and attributes in metal forming.	1	
4.2	Alloy steels- Effects of alloying elements on steel: dislocation movem polymorphic transformation temperature, alpha and beta stabilizers, form and stability of carbides, grain growth, displacement of the eutectoid poi retardation of the transformation rates, improvement in corrosion resis mechanical properties	1	CO4
4.3	Nickel steels, Chromium steels etc. - change of steel properties by adding alloying elements: - Molybdenum, Nickel, Chromium, Vanadium, Tungste Cobalt, Silicon, Copper and Lead. High speed steels - Cast irons Classifications; grey, white, malleable and spheroidal graphite cast iro composition, microstructure, properties and applications. Principal Non ferrous Alloys: - Aluminum, Copper, Magnesium, Nickel, study composition, properties, applications, reference shall be made to the diagrams whenever necessary. (Topic 4.3 may be considered as a assignme	4	CO4 CO5
4.4	Fatigue - Stress cycles ± Primary and secondary stress raisers - Characteristics of fatigue failure, fatigue tests, S-N curve.	1	CO3
4.5	Factors affecting fatigue strength: stress concentration, size effect, s roughness, change in surface properties, surface residual stress - Ways to improve fatigue life ± effect of temperature on fatigue, thermal fatigue and applications in metal cutting.	2	

5.1	Fracture: ±Brittle and ductile fracture±Griffith theory of brittle fracture± Stress concentration, stress raiser±Effect of plastic deformation on crac propagation- transgranular, intergranular fracture- Effect of impact loading on ductile material and its application in forging, applications Mechanism of fatigue failure.	2	CO3
5.2	Structural features of fatigue: crack initiation, growth, propagation- Fracture toughness (definition only) applications - Ductile to brittle transition temperature (DBTT) in steels and structural changes during DBT applications.	1	
5.3	Creep - Creep curves±creep tests Structural change: deformation by slip sub-grain formation, grain boundary sliding Mechanism of creep deformatio - threshold for creep, prevention against creep Super plasticity: need an applications	2	CO3
5.4	Composites- Need of development of composites, fiber phase, matrix phase, only need and characteristics of PMC, MMC, and CMC.	2	CO3 CO5
5.5	Modern engineering materials: only fundamentals, need, properties a applications of, intermetallics, maraging steel, super alloys, Titanium- Ceramics: coordination number and radius ratios- AX, A_mX_p, $A_mB_mX_p$ type structures±applications.	3	

MEL201	COMPUTER AIDED MACHINE DRAWING	CATEGORY	L	T	P	Credits	Year of Introduction
		PCC	0	0	3	2	2019

Preamble: To introduce students to the basics and standards of engineering drawing rel machines and components.

To make students familiarize with different types of riveted and welded joints, surface roughness symbols; limits, fits and tolerances.

To convey the principles and requirements of machine and production drawings.

To introduce the preparation of drawings of assembled and disassembled view of important valves and machine components used in mechanical engineering applications.

To introduce standard CAD packages for drafting and modeling of engineering components.

Prerequisite: EST 110- Engineering Graphics

Course Outcomes- At the end of the course students will be ab

CO1	Apply the knowledge of engineering drawings and standards to prepare star dimensioned drawings of machine parts and other engineering components.
CO2	Prepare standard assembly drawings of machine components and valves using part draw and bill of materials.
CO3	Apply limits and tolerances to components and choose appropriate fits for giv assemblies
CO 4	Interpret the symbols of welded, machining and surface roughness on the comp drawings.
CO 5	Prepare part and assembly drawings and Bill of Materials of machine components ar valves using CAD software.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3									3		
CO2	3		2							3		
CO3	3	2										
CO4	3											
CO5	3				3					3		1

Assessment Pattern

Bloom's taxonomy	Continuous Assessment Tests	
	Test 1 PART A Sketching and Manual Drawing	Test 2 PART B CAD Drawing
Remember	25	20
Understand	15	15
Apply	30	20
Analyse	10	10
Evaluate	10	15
Create	10	20

Mark Distribution

Total Marks	CIE Marks	ESE marks	ESE duration
150	75	75	2.5 hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	15 marks
Regular class work/Drawing/Workshop Record/Lab Record and Class Performance	30 marks
Continuous Assessment Test (minimum two te:	30 marks

End semester examination pattern

End semester examination shall be conducted on Sketching and CAD drawing on based complete syllabus

The following general guidelines should be maintained for the award of marks

Part A Sketching – 15 marks

Part B CAD drawing – 50marks

Viva Voce – 10 marks

Conduct of University Practical Examinations

The Principals of the concerned Engineering Colleges with the help of Chairmen/Chairperson will conduct the practical examination with the approval fror University and bonafide work / laboratory record, hall ticket, identity card issued by college are mandatory for appearing practical University examinations. No practical exami should be conducted without the presence of an external examiner appointed by the Un

END SEMSTER EXAMINATION

MODEL QUESTION PAPER

MEL 201: COMPUTER AIDED MACHINE DRAWING

Duration : 2.5 hours Marks : 75

Note :

1. All dimensions in mm
2. Assume missing dimensions appropriately.
3. A4 size answer booklet shall be supplied.
4. Viva Voce shall be conducted for 10 marks.

PART A (SKETCHING)
(Answer any TWO questions) 15 marks

1. Sketch two views of a single riveted single strap butt joint. Take dimensions of the plate as 10mm. Mark the proportions in the drawing.

2. Show by means of neat sketches, any three methods employed for preventing nuts from getting loose on account of vibrations

3. Compute the limit dimensions of the shaft and the hole for a clearance fit based on shaft basis system if:

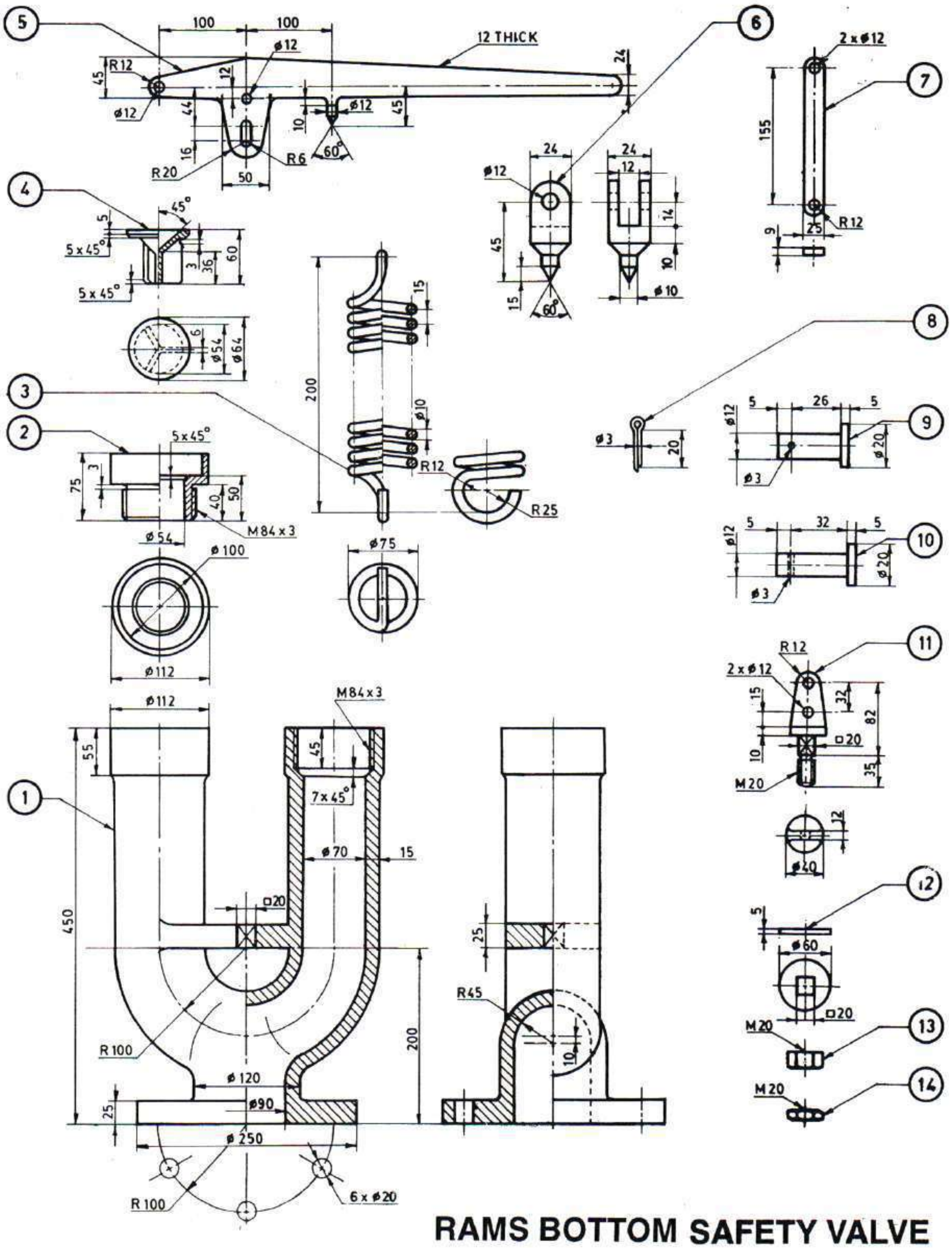
   Basic size= 30 mm
   Minimum clearance = 0.007 mm
   Tolerance on hole = 0.021 mm
   Tolerance on shaft= 0.021 mm

   Check the calculated dimensions. Represent the limit dimensions schematically.

PART B (CAD DRAWING) 50 marks

4. Draw any two assembled views of the Ramsbottom Safety Valve as per the details given in the figure using any suitable CAD software. Also prepare bill of materials and tolerance data sheet.

Item	Description	Qty	Material	Item	Description	Qty	Material
1	Body	1	C.I.	8	Split Pin	3	M.S.
2	Valve Seat	2	G.M.	9	Pin for Link	2	M.S.
3	Spring	1	Steel	10	Pin for Pivot	1	M.S.
4	Valve	2	G.M.	11	Shackle	1	M.S.
5	Lever	1	M.S.	12	Washer	1	M.S.
6	Pivot	1	M.S.	13	Nut	1	M.S.
7	Link	2	M.S.	14	Lock Nut	1	M.S.



RAMS BOTTOM SAFETY VALVE

SYLLABUS

Introduction to machine drawing, drawing standards, fits, tolerances, surface roughness, assembly and part drawings of simple assemblies and subassemblies of machine parts viz., couplings, clutches, bearings, I.C. engine components, valves, machine tools, etc; introduction to CAD etc.

Text Books:
1. N. D. Bhatt and V.M. Panchal, Machine Drawing, Charotar Publishing House.
2. P I Varghese and K C John, Machine Drawing, VIP Publishers.
Reference Books
1. Ajeet Singh, Machine Drawing Includes AutoCAD, Tata McGrawhill.
2. P S Gill, Machine Drawing, Kataria& Sons.

Course content and drawing schedules.

No:	List of Exercises	Course outcomes	No. of hours
	PART –A (Manual drawing) (Minimum 6 drawings compulsory)		
1	Temporary Joint: Principles of drawing, free hand sketching, Importance of machine Drawing. BIS Code of practice for Engineerin Drawing, lines, types of lines, dimensioning, scales drawing, sectional views, Riveted joints	CO 1	3
2	Fasteners: Sketching of conventional representation of welded joints,Bolts and Nutsor Keys ,and Foundation Bolts.	CO 1	3
3	Fits and Tolerances: Limits, Fits– Tolerances of individual dimensions – Specification of Fits – basic principles of geometric & dimensional tolerances. Surface Roughness: Preparation of production drawings and reading of part and assembly drawings, surface roughness, indication of surface roughness, etc.	CO 2	3
4	Detailed drawing of Cotter joints, Knuckle joint and Pipe joints	CO 2	3
5	Assembly drawings(2D): Stuffing box and Screw jack	CO 1 CO3 CO4	3

	PART –B (CAD drawing) (Minimum 6 drawings compulsory)		
6	Introduction to drafting software like Auto CAD, basic commands, keyboard shortcuts. Coordinate and unit setting, Drawing, Editing, Measuring, Dimensioning, Plotting Commands, Layering Concepts, Matching, . Detailing, Detailed drawings.	CO 1 CO 2 CO 3 CO5	3
7	Drawing of Shaft couplings and Oldham's coupling	CO 1 CO 2 CO 3 CO5	3
8	Assembly drawings(2D)with Bill of materials: Lathe Tailstock and Universal joint	CO 1 CO3 CO5	3
9	Assembly drawings(2D)with Bill of materials: Connecting rod and Plummer block	CO 1 CO3 CO5	3
10	Assembly drawings(2D)with Bill of materials: Rams Bottom Safety Valve Or Steam stop valve	CO 1 CO3 CO5	3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MEL203	MATERIAL ^ TESTING LAB	PCC	0	0	3	2

Preamble:

The objective of this course is to give a broad understanding of common materials related to mechanical engineering with an emphasis on the fundamental structure-property-application and its relationships. A group of 6/7 students can conduct experiment effectively. A total of six experiments for the duration of 2 hours each is proposed for this course.

Prerequisite: A course on Engineering Mechanics is require

Course Outcomes:

After the completion of the course the student will be able to

CO 1	To understand the basic concepts of analysis of circular shafts subjected to torsion.
CO 2	To understand the behaviour of engineering component subjected to cyclic loading and failure concepts
CO 3	Evaluate the strength of ductile and brittle materials subjected to compressive, Tensile shear and bending forces
CO 4	Evaluate the microstructural morphology of ductile or brittle materials and its fracture modes (ductile /brittle fracture) during tension test
CO 5	To specify suitable material for applications in the field design and manufacturing.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO 9	PO 10	PO 11	PO 12
CO 1	3				3							
CO 2	3	3	1		3				3	2	2	1
CO 3	3	3	3	1	3				3	2	3	2
CO 4	3	3	3	3	3	2	2	1	3	2	3	2
CO 5	3	3	3	1	3	2	2	1	3	2	3	2

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern

The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and troubleshooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions:

Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

A minimum of 10 experiments are to be performed.

SYLLABUS

LIST OF EXPERIMENTS

1. To conduct tension test on ductile material (mild steel/ tor-steel/ high strength steel) using Universal tension testing machine and Extensometer.
2. To conduct compression test on ductile material (mild steel/ tor steel/ high strength steel) using Universal tension testing machine and Extensometer
3. To conduct tension test on Brittle material (cast iron) using Universal tension testing machine and Extensometer.
4. To conduct shear test on mild steel rod.
5. To conduct microstructure features of mild steel/copper/ brass/aluminium using optical microscope, double disc polishing machine, emery papers and etchent.
6. To conduct fractography study of ductile or brittle material using optical microscope

7. To conduct Hardness test of a given material.(Brinell, Vickers and Rockwell)
8. To determine torsional rigidity of mild steel/copper/brass rod.
9. To determine flexural rigidity of mild steel/ copper/brass material using universal testing machine.
10. To determine fracture toughness of the given material using Universal tension testing machine.
11. To study the procedure for plotting SN curve using Fatigue testing machine
12. To conduct a Toughness test of the given material using Izod and Charpy Machine
13. To determine spring stiffness of close coiled/open coiled/series/parallel arrangements.
14. To conduct bending test on wooden beam
15. To conduct stress measurements using Photo elastic methods.
16. To conduct strain measurements using strain gauges.
17. To determine moment of inertia of rotating bodies
18. To conduct an experiment to Verify Clerk Maxwell's law of reciprocal deflection and determine young's Modulus of steel
19. To determine the surface roughness of a polished specimen using surface profilometer.

Reference Books

1. G E Dieter. Mechanical Metallurgy, McGraw Hill,2013
2. Dally J W, Railey W P, Experimental Stress analysis, McGraw Hill,1991
3. Baldev Raj, Jayakumar T, Thavasimuthu M., Practical Non destructive testing, Narosa Book Distributors,2015

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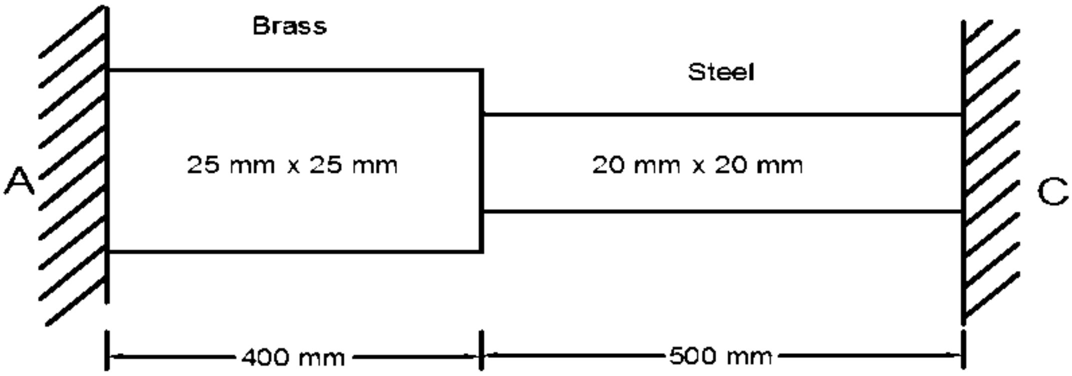

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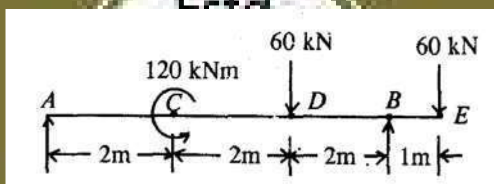

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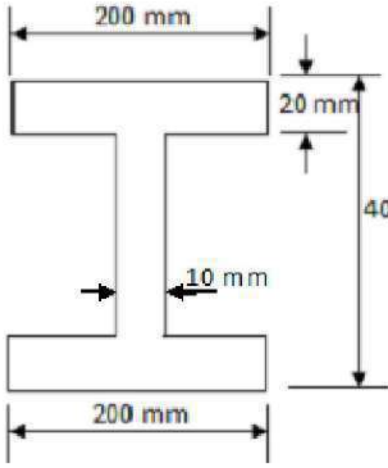

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CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET203	FLUID MECHANICS AND MACHINERY	VAC	3	1	0	4

Preamble:

This course provides an introduction to the properties and behaviour of fluids. It enables to apply the concepts in engineering. The course also gives an introduction of hydraulic pumps and turbines.

Prerequisite NIL

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Define Properties of Fluids and Solve hydrostatic problems
CO 2	Explain fluid kinematics and Classify fluid flows
CO 3	Interpret Euler's equation and Solve problems using Bernoulli's equation
CO 4	Explain the working of turbines and Select a turbine for specific application.
CO 5	Explain the characteristics of centrifugal and reciprocating pumps

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2										
CO 2	3	2	1									
CO 3	3	2	1									
CO 4	3	2	1									
CO 5	3	2	1									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

MECHANICAL ENGINEERING

Course Outcome 1

1. De ne total pressure on a surface and center of pressure on a surface. What do you understand by the term hydrostatic pressure ?

2. An isosceles triangle of base 3m and altitude 6m is immersed vertically in water with its axis of symmetry horizontal. If the head on its axis is 9m, locate the center of pressure.

3. A triangular plate of 2m base and 2.5m altitude is immersed in water at an inclination of 30 with the base parallel to and at a depth of 2m from the free surface. Find the total hydrostatic force on the side of the plate and the position of its action.

Course Outcome 2

1. De ne the following and give one practical example for each of the following:

   (a) laminar ow

   (b) Turbulent ow

   (c) Steady ow

   (d) Uniform ow

2. A two dimensional ow is described by the velocity components, $u = 5x^3$; $v = 15x^2y$. Evaluate the stream function, velocity, and acceleration at point P(1,2).

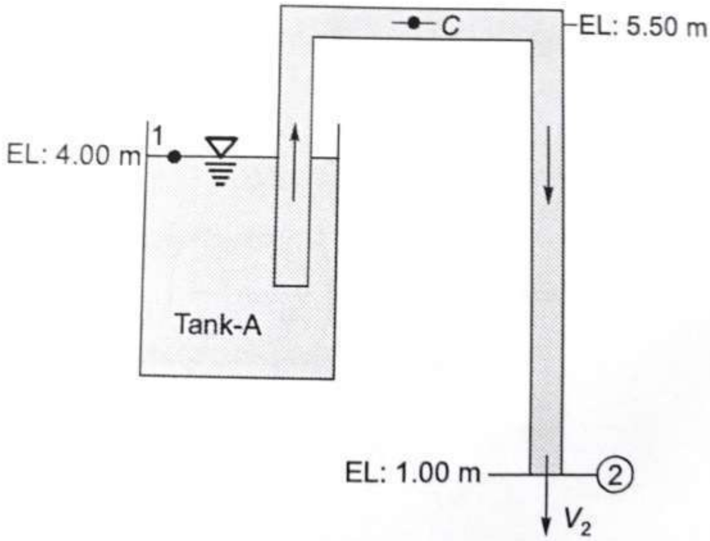
3. For the velocity components u = ay sin(xy) and v = ax sin(xy), obtain an expression for the velocity potential function.

Course Outcome 3

1. Derive the Euler's equation of motion along a streamline and from that derive the Bernouli's equation.

2. Oil of speci c gravity 0.8 ows through a 0.2 m diameter pipe under a pressure of 100 KPa. If the datum is 5 m below the center line of the pipe and the total energy with respect to the datum is 35 N m/N. Calculate the discharge.

3. A siphon consisting of a pipe of 15 cm diameter is used to empty kerosene oil (relative density=0.8) from tank A. The siphon discharges to the atmosphere at an elevation of 1.00 m. The oil surface in the tank is at an elevation of 4.00 m. The center line of the siphon pipe at its highest point C is at an elevation of 5.50 m. Estimate,



(a) Discharge in the pipe

(b) Pressure at point C.

Course Outcome 4

1. Di erentiate between impulse and reaction turbine.
2. Prove that for a single jet Pelton wheel, the speci c speed is given by the relation

$$N_s = 219:78\frac{d}{D}\sqrt{\ }_{o}$$

3. A Pelton wheel having semicircular buckets and working under a head of 120 m is running at 500 rpm. The discharge through the nozzle is 40 L/s and the diameter of the wheel is 50 cm. Find the following:

   (a) The power available at the nozzle.

   (b) Hydraulic e ciency of the wheel, if coe cient of velocity is 0.96.

Course Outcome 5

1. Distinguis between positive displacement pump and roto dynamic pump
2. Expalin the phenomenon of cavitation and methods to avoid it
3. Explain the signi cance of NPSH in the installation of a centrifugal pump

SYLLABUS

Module 1

Fundamental concepts: Properties of fluid- density, specific weight, viscosity, surface tension, capillarity, vapour pressure, bulk modulus, compressibility, velocity, rate of shear strain, Newton's law of viscosity, Newtonian and non-Newtonian fluids, real and ideal fluids, incompressible and compressible fluids.

Module 2

Fluid statics: Atmospheric pressure, gauge pressure and absolute pressure. Pascal's Law, measurement of pressure- piezo meter, manometers, pressure gauges, energies in flowing fluid, head- pressure, dynamic, static and total head, forces on planar surfaces immersed in fluids, centre of pressure, buoyancy, equilibrium of floating bodies, metacentre and metacentric height.

Fluid kinematics and dynamics: Classification of flow-1D, 2D and 3D flow, steady, unsteady, uniform, non-uniform, rotational, irrotational, laminar and turbulent flow, path line, streak line and stream line.

Module 3

Continuity equation, Euler's equation, Bernoulli's equation. Reynolds experiment, Reynold's number. Hagen-Poiseuille equation, head loss due to friction, friction, Darcy-Weisbach equation, Chezy's formula, compounding pipes, branching of pipes, siphon effect, water hammer transmission of power through pipes (simple problems) .

Flow rate measurements- venturi and orifice meters, notches and weirs (description only for notches, weirs and meters), practical applications, velocity measurements- Pitot tube and Pitot – static tube.

Module 4

Hydraulic turbines: Impact of jets on vanes- flat, curved, stationary and moving vanes- radial flow over vanes. Impulse and Reaction Turbines – Pelton Wheel constructional features- speed ratio, jet ratio & work done , losses and efficiencies, inward and outward flow reaction turbines- Francis turbine constructional features, work done and efficiencies – axial flow turbine (Kaplan) constructional features, work done and efficiencies, draft tubes, surge tanks, cavitation in turbines.

Module 5

Positive displacement pumps- reciprocating pump, indicator diagram, air vessels and their purposes, slip, negative slip and work required and efficiency, effect of acceleration and friction on indicator diagram (no derivations), multi cylinder pumps.

Rotary pumps – centrifugal pump, working principle, impeller, casings, manometric head, work, efficiency and losses, priming, specific speed, multistage pumps, selection of pumps, pump characteristics.

Text Books

1. Mahesh Kumar, Fluid Mechanics and Machines, Pearson, 1st edition, 2019.

2. Pati, S., Textbook of Fluid Mechanics and Hydraulic Machines, Tata McGraw Hill, 1st Edition, 2017.

Reference Books

1. Cimbala & Cengel, Fluid Mechanics: Fundamentals and Applications (4th edition, SIE) McGraw Hill, 2019

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
1		
1.1	Fundamental concepts: Properties of fluid- density, specific weight, viscosity, surface tension, capillarity, vapour pressure	3
1.2	Bulk modulus, compressibility, velocity, rate of shear strain, Newton law of viscosity	3
1.3	Newtonian and non-Newtonian fluids, real and ideal fluids, incompressible and compressible fluids.	3
2		
2.1	Fluid statics: Atmospheric pressure, gauge pressure and absolute pressure. Pascal's Law, measurement of pressure- piezo meter, manometers, pressure gauges, energies in flowing fluid	3
2.2	Head- pressure, dynamic, static and total head, forces on planar surfaces immersed in fluids, centre of pressure, buoyancy, equilibrium of floating bodies, metacentre and metacentric height.	3

2.3	Fluid kinematics and dynamics: Classification of flow - 1D, 2D and 3D flow, steady, unsteady, uniform, non-uniform, rotational, irrotational, laminar and turbulent flow, path line, streak line and stream line	3
3		
3.1	Continuity equation, Euler's equation, Bernoulli's equation. Reynolds experiment, Reynold's number. Hagen-Poiseuille equation	3
3.2	Head loss due to friction, friction, Darcy-Weisbach equation, Chezy's formula, compounding pipes, branching of pipes, siphon effect, water hammer transmission of power through pipes (simple problems)	3
3.3	Flow rate measurements - venturi and orifice meters, notches and weirs (description only for notches, weirs and meters), practical applications, velocity measurements - Pitot tube and Pitot static tube	3
4		
4.1	Hydraulic turbines: Impact of jets on vanes - flat, curved, stationary and moving vanes - radial flow over vanes	3
4.2	Impulse and Reaction Turbines – Pelton Wheel constructional features speed ratio, jet ratio & work done, losses and efficiencies, inward and outward flow reaction turbines - Francis turbine constructional features, work done and efficiencies	3
4.3	Axial flow turbine (Kaplan) constructional features, work done and efficiencies, draft tubes, surge tanks, cavitation in turbines	3
5		
5.1	Positive displacement pumps - reciprocating pump, indicator diagram, air vessels and their purposes	3
5.2	Slip, negative slip and work required and efficiency, effect of acceleration and friction on indicator diagram (no derivations), multi cylinder pumps	3
5.3	Rotary pumps: – centrifugal pump, working principle, impeller, casings manometric head, work, efficiency and losses, priming, specific speed, multistage pumps, selection of pumps, pump characteristics	3

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

MECHANICAL ENGINEERING

IV SEMESTER B.TECH DEGREE EXAMINATION

MET2 3: FLUID MECHANICS AND MACHINER Y

Maximum: 100 Marks

Duration: 3 hours

PART A

Answer all questions, each question carries 3 marks

1. De ne a uid. What is the di erence between ideal and real uid?
2. Explain the phenomena of capillarity, Obtain the expression for capillary rise of a liquid
3. Distinguish between gauge pressure and absolute pressure.Estimate in meters the depth below the surface of a lake at which the pressure is equal to twice atmospheric pressure.
4. De ne and distinguish between Streamline Streak line and path line
5. Water escapes from large storage tank through a small drain hole in the bottom.If the water depth is 2m, what is the exit velocity?If a similar tank contained gasoline what would be the exit velocity?
6. Oil of speci c gravity 0.8 ows through a 0.2m diameter pipe under a pressure of 100 kN/m^2. If the datum is 5m below the center line of the pipe and the total energy with respect to the datum is 35m. Calculate the discharge.
7. Di erentiate between impulse and reaction turbine
8. Explain the functions of Draft tube
9. De ne slip and percentage slip of a reciprocating pump, what are the reasons for negative slip.
10. What are the di erent classi cations of centrifugal pump?

(10 3=30 Marks)

PART B

Answer one full question from each module

MODULE-I

11. (a) Write a short note on surface tension. Derive expressions for the pressure

i. within a droplet of water

ii. inside a soap bubble

(8 marks)

(b) Define the term viscosity,on what factors does it depend and give the units in which it is expressed. (6 marks)

12. (a) A U-tube is made up of two capillaries of bores 1mm and 2.2mm respectively. The tube is held vertically with zero contact angle. It is partially filled with liquid of surface tension 0.06 N/m. If the estimated difference in the level of two menisci is 15mm, determine the mass density of the liquid. (7 marks)

(b) A volume of 3.2 m^3 of certain oil weighs 27.5kN. Calculate its

i. mass denisty

ii. weight density

iii. Specific volume

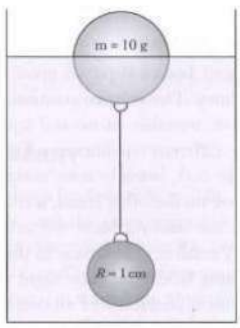
iv. Specific gravity

If the kinematic viscosity of the oil is 7 10^{3} Stokes, what would be its dynamic viscosity in centipoises. (7 marks)

MODULE-II

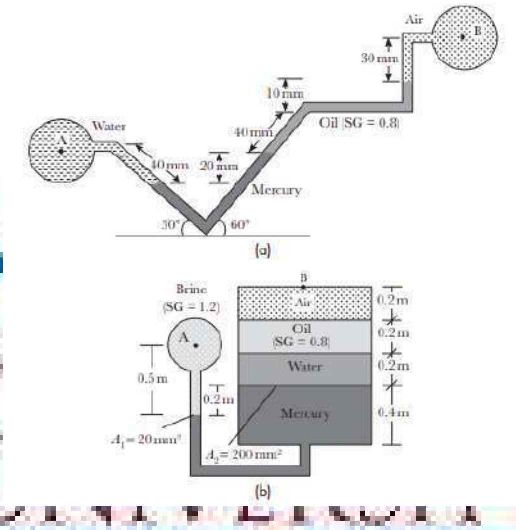
13. (a) A steel ball of radius 1 cm is hanging inside the water tank by means of a string attached to a hollow plastic ball having raadius 3 cm weighing 10g floating at the free surface, as shown in Fig. Determine the tension in the string and volume of the plastic ball submerged in water. (Take density of the steel ball to be 7850 kg/m^3 (7 marks)

Fig.1



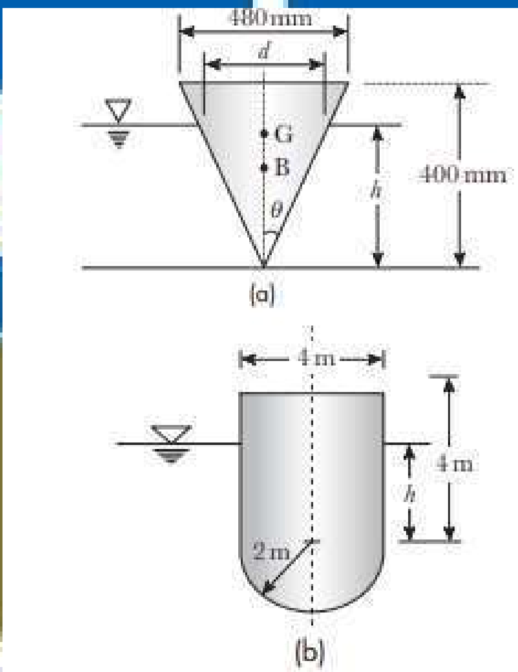
(b) If the velocity distribution for a 2D ideal flow is given by $u = \frac{x}{2+t}$; $v = \frac{y}{1+3t}$ Obtain the equation of (a) the streamlines, (b) the pathlines, and (c) the streaklines that pass through point (1, 2) at t = 0. (7 marks)

14. (a) Find out the pressure di erence between points A and B for the manometers shown in the gures



(7 marks)

(b) Check whether the oating objects having speci c gravity 0.8 shown in Fig. are stable or not.

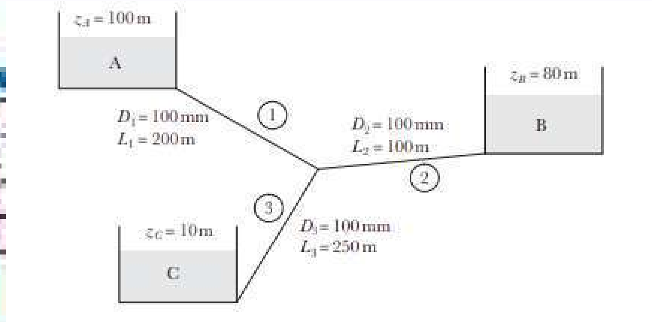


(7 marks)

MODULE-III

15. (a) The maximum velocity for the viscous ow through a 200mm diameter pipe is 3m/s. Determine the average velocity and the radial distance from the pipe axis at which it occurs. In addition, determine the velocity at 25mm from the pipe wall.(7 marks)

    (b) Determine the discharge in each branch of the pipe network shown in Fig. Assume same friction factor f = 0.03 in each pipe. (7 marks)



16. (a) Prove that for power transmission through pipes transmission power is maximum when head loss due to friction is one third of the power available at the inlet.(7 marks)

    (b) A 5km long water pipeline is used to transmit 200 kW of hydraulic power. If the pressure at the inlet is 6MPa and the pressure drop across the pipe length is 2MPa. Determine the pipe diameter and its transmission e ciency. Take the friction factor f = 0.04 (7 marks)

MODULE-IV

17. (a) A double jet Pelton wheel has a speci c speed of 16 and is required to deliver 1200 kW. The turbine is supplied through a pipeline from a reservoir whose level is 380m above the nozzles. Allowing 8% for friction loss in the pipe, calculate the following:

    i. Speed in rpm
    ii. Diameter of the jet
    iii. Mean diameter of the bucket

    Assume C_v = 0.98, speed ratio = 0.46, and overall e ciency = 85% (10 marks)

    (b) De ne the terms unit power, unit speed, ad unit discharge with reference to a hydraulic turbine. (4 marks)

18. (a) Show that the force exerted by a uid jet in its direction of ow on a semicircular vane is twice that exerted on a at plate, both plates being xed in position. (7 marks)

    (b) A Keplan turbine runner is to be designed to develop 9000 kW. The net available head is 5.5m. Assume a speed ratio 2, ow ratio 0.65, and total e ciency 85%. The diameter of the boss is 1/3 the diameter of the runner. Find : (7 marks)

    i. Diameter of the runner.
    ii. Speed of the runner.
    iii. Speci c speed of the turbine.

MODULE-V

19. (a) Draw the performance curves of a centrifugal pump. Also discuss the e ect of blade outlet angles (7 marks)

(b) A centrifugal pump discharges 0.2 m^3/s of water at a head of 25 m when running at a speed of 1400 rpm.The manometric e ciency is 80%. If the impeller has an outer diameter of 30 cm and width of 5 cm, determine the vane angle at the outlet. (7 marks)

20. (a) A single acting reciprocating pump of 200 mm bore and 300 mm stroke runs at 30 rpm. The suction head is 4 m and the delivery head is 15 m. Considering acceleration determine the pressure in the cylinder at the beginning and end of suction and delivery strokes. Take the value of atmospheric pressure as 10.3 m of water head. The length of suction pipe is 8 m and that of delivery pipe is 20 m. The pipe diameters are 120 mm each (7 marks)

(b) The construction details of a centrifugal pump is as follows; Impeller diameter= 50 cm Impeller width=2.5 cm Speed= 1200 rpm Suction head= 6 m Delivery head= 40 m Outlet blade angle= 30. Manometric e ciency : 80% Overall e rciency :75%. Determine the power required to drive the pump. Also calculate the pressures at the suction and delivery side of the pump. assume the frictional drop in suction is 2 m and in the delivery 8m and inlet swirl as zero (7 marks)

MET 2 5	MATERIAL SCIENCE AND TECHNOLOGY (MINOR)	CATEGORY	L	T	P	Credits	Year of Introduction
		VAC	4	0	0	4	2019

Preamble:

Understanding the correlation between the chemical bonds and crystal structure of metallic materials.
Recognize the importance of crystal imperfections including dislocations in plastic deformation
Understanding the mechanisms of materials failure through fatigue and creep.
Understanding the fundamental characteristics of conductors and resistors.
Understanding the fundamental characteristics of semi and super conductors.

Prerequisite: PHT 110 Engineering Physics and CYT 100 Engineering Chemistry

Course Outcomes - At the end of the course students will be able

CO 1	Understand the basic chemical bonds, crystal structures and their relationship with the properties.
CO 2	How to quantify failure of materials
CO 3	Given a hypothetical or real problem with electronic materials device or process, explain the cause of the problem and propose solutions.
CO 4	Understand how materials interact at the nanoscale
CO 5	Define and differentiate engineering materials on the basis of structure and prope for engineering applications.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-		-	-
CO 2	-	3		-	-	-	-	-	-	-	-	-
CO 3		-	-	2	-		-	-	-	-	-	-
CO 4		-	-	-	3	-	-	-	-	-	-	-
CO 5	-	-	-	-		-	-	-	-	-	-	2

ASSESSMENTPATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test I (Marks)	Test II (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyze	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments	15 marks
Continuous Assessment Test (Minimum 2 numbers)	25 marks

End semester pattern:- There will be two parts; Part A and Part B. Part A contain questions with 2 questions from each module, having 3 marks for each que Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Understand the basic chemical bonds, crystal structures and their relationship with the properties.

1. Why ionic and covalent bonded materials are poor conductors? Draw electronic configurations
2. Correlate the strength of an element with atomic number.
3. What kind of bonding you expect in the following materials: NaCl, Cadmium Telluride an Bronze.
4. Explain how grain size influences the strength of a metal

Course Outcome 2 (CO2): How to quantify failure of materials

1. Explain the factors affecting the fatigue strength?
2. Explain the effects of crystalline and non-crystalline structure on strength of a metal.
3. What are the roles of surface defects on crack propagation?
4. $ VPDOO KROH LV GULOOHG WKURXJK D VWHHO SOD progress until repairs can be made or not? Explain in detail and derive the equation
5. Explain the effect of impact loading on ductile materials

Course Outcome 3 (CO3): Given a hypothetical or real problem with an electronic materials de or process, explain the cause of the problem and propose solutions.

1. Explain why nichrome and not copper is used as a heating element.
2. Why does the conductivity of a semiconductor change with impurity content? Compare t with the behavior of metallic conductors.
3. Explain why lead and zinc with an even number of electrons in the outer shell and a full valence band are conductors.
4. When ice melts into water, the dielectric constant increases, in contrast to the decrease observed during the melting of HCl. Explain why this is so

Course Outcome 4 (CO4): Understand how materials interact at the nanoscale

1. What is the concept of nano? Correlate the significance of dislocation density to single crystal silicon ICs used in electronic industry.
2. Explain touch screens
3. Explain flexible electronic circuits

Course Outcome 5 (CO5): Define and differentiate engineering materials on the basis of stru and properties for engineering applications

1. Explain the slip systems of BCC, FCC and HCP. Why BCC and HCP exhibit brittle nature ar FCC ductile nature?
2. Explain in detail the different strengthening mechanisms of metallic crystals
3. Explain why Aluminum used in long distance transmission lines cannot be strengthened solid solution.
4. Explain the attributes of surface breakdown of an insulator

SYLLABUS

MODULE - 1

Earlier and present development of atomic structure primary bonds - secondary bonds - earlier and present development of atomic structure primary bonds - secondary bonds classification of engineering materials levels of structure crystallography - structure - property relationships in materials - classification of engineering materials

MODULE - II

Miller indices: - modes of plastic deformation - structure determination by X-ray diffraction - Classification of crystal imperfections - Diffusion L'Q V R O L G laws - I L F N { I V dislocation density - mechanism of crystallization homogeneous and heterogeneous nuclei formation Hall - Petch theory.

MODULE - III

Phase diagrams: Limitations of pure metals and need of alloying - classification of alloys, solid solutions, Hume Rothery`s rule - strengthening mechanisms - Fatigue - Stress cycles - fatigue tests, - S-N curve - Ductile to brittle transition temperature (DBTT) in steels - Creep Creep curves - creep tests - Super plasticity - introduction to super alloys.

MODULE - IV

Composites: fiber and composite phase polymer matrix composites - metal matrix composites - ceramic matrix composites dielectric materials - conductors - resistor materials

MODULE - V

Superconducting phenomenon - semi conductors - fabrication of integrated circuits - semiconductor devices.

Text Books

1. Callister William. D., Material Science and Engineering, John Wiley, 2014
2. Raghavan V, Material Science and Engineering, Prentice Hall, 2004

Reference

1. Avner H Sidney, Introduction to Physical Metallurgy, Tata McGraw Hill, 2009
2. Anderson J.C. et.al., Material Science for Engineers, Chapman and Hall, 1990
3. Dieter George E, Mechanical Metallurgy, Tata McGraw Hill, 1976

MODEL QUESTION PAPER

MATERIAL SCIENCE & TECHNOLOGY - MET 2 5

Max. Marks : 100 Duration : 3 Hours

Part –A

Answer all questions.

Answer all questions, each question carries 3 marks

1. NASA's Parker Solar Probe will be the first ever mission to "touch" the Sun. The spacecraft, a the size of a small car, will travel directly into the Sun's atmosphere about 4 million miles fr earth surface. Postulate the coolant used in the parker solar probe with the merits.
2. Distinguish between crystal and non crystalline materials.
3. What is the driving force for diffusion?
4. What are the roles of surface imperfections on crack initiation?
5. What is the grain size preferred for creep applications? Why
6. Explain the attributes of DBTT
7. Make a list of at least four different sports implements that are made of or contain composites
8. What is the distinction between matrix and dispersed phases in a composite material?
9. Specify three elements that you would add to pure silicon to make it an extrinsic semiconductor of the n-type, and (ii) the p-type.
10. Explain why nichrome and not copper is used as a heating element

PART -B

Answer one full question from each module.

Module -1

11. Calculate the APF of SC, BCC and FCC (14 marks).

OR

12. Distinguish between characteristics of ionic, covalent ad metallic bonds (14 marks).

Module -2

13. Explain the effect of: (i) Grain size; (ii) Grain size distribution and (iii) Grain orientation (iv) Gra shape on strength and creep resistance with neat sketches. Attributes of Hall Petch equation and grain boundaries (14 marks).

OR

14. Distinguish between homogeneous and heterogeneous nuclei formation (14 marks).

Module -3

15. Postulate with neat sketches, why 100 % pure metals are weaker? What are the primary functions o alloying? Explain the fundamental rules governing the alloying with neat sketches and ho accomplished in substitution and interstitial solid solutions? (14 marks).

OR

16. Explain fatigue test and attributes of S-N curve (14 marks).

Module -4

17. For a polymer-matrix fiber-reinforced composite, (a) list three functions of the matrix phase; (b) Compare the desired mechanical characteristics of matrix and fiber phases; and (c) cite two reasons why there must be a strong bond between fiber and matrix at their interface (14 marks).

OR

18. The dielectric constant of polyethylene is independent of temperature, while that of polyvinylch is not. Explain this difference in behavior on the basis of their monomer structures (14 marks).

Module -5

19. (a) Derive the kinetic energy of free electrons as a function of their wavenumber (7 marks).
   (b) The resistivity of silver at room temperature is 1.6×10^{-8} ohm m. Calculate the collision Time for electron scattering (7 marks).

OR

20. (a). Explain why lead and zinc with an even number of electrons in the outer shell and valence band are conductors (7 marks).
   (b). Calculate the fraction of holes present at 300 K in silicon doped with indium. The acceptor level is 0.16 eV above the top of the valence band (7 marks).

Course content and lecture schedules.

Module	TOPIC	No. of hours	Course outcomes
1.1	Earlier and present development of atomic structure; correlation of atomic radius to strength; electron configurations; Primary bonds - characteristics of covalent, ionic and metallic bond-properties from bonding.	2	CO1
1.2	Secondary bonds - classification hydrogen bond and anomalo behavior of ice float on water, application- specific heat, applications.	2	
1.3	Classification of engineering materials levels of structure crystallography: crystal, space lattice, unit cell- APF of BCC, FCC, HCP structures.	2	
1.4	short and long range order non crystalline - structure-property relationships in materials.	1	
2.1	Miller indices: - crystal plane and direction - attributes of miller indices for slip system, brittleness of BCC, HCP and ductility of FCC - modes of plastic deformation: - slip and twinning - structure determination by X-ray diffraction.	3	CO1 CO2
2.2	Classification of crystal imperfections: types of point and dislocations - Diffusion L Q V R O L G V I L F N ¶ V O D Z V - dislocation density and attributes of nano structures.	3	

2.3	Mechanism of crystallization: Homogeneous and heterogeneous nu formation, under cooling, dendritic growth, grain boundary irregularity	1	CO1 CO2
2.4	Effects of grain size, grain size distribution, grain shape, grain orient on dislocation/strength and creep resistance - Hall - Petch theory.	2	
3.1	Phase diagrams: Limitations of pure metals and need of alloying classification of alloys, solid solutions, Hume Rothery's rule strengthening mechanisms.	3	
3.2	Fatigue - Stress cycles – Primary and secondary stress raiser Characteristics of fatigue failure, fatigue tests, S-N curve attributes.	2	CO2 CO5
3.3	Factors affecting fatigue strength: stress concentration, size effect, s roughness, change in surface properties, surface residual stress. Ways to improve fatigue life.	2	
3.4	Ductile to brittle transition temperature (DBTT) in steels - Creep, Creep curves – creep tests. Super plasticity - introduction to nickel based sup alloys, characteristics and applications.	2	CO1 CO2
4.1	Composites - fiber and composite phase - polymer matrix composites - metal matrix composites ceramic matrix composites	2	
4.2	Dielectric materials: polarization, temperature and frequency effe electric breakdown, ferroelectric materials	3	CO1 CO2
4.3	Conductors- the resistivity range, free electron theory	2	
4.4	Conduction by free electrons, conductor and resistor materials.	2	
5.1	Superconducting phenomenon, Type I and Type II superconductors potential applications	3	CO3
5.2	Semi conductors: energy gap in solids, intrinsic and extrinsic semiconductors, semiconductor materials.	2	
5.3	Fabrication of integrated circuits - production of metallurgical grad silicon, semiconductor grade silicon, single crystal growth, w manufacture, oxidation, photolithography, doping.	3	CO4
5.4	Ion implantation, epitaxial growth, metallization.	1	
5.5	Some semiconductor devices: junction diodes, lasers and transist photondetectors.	2	CO4

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CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET202	ENGINEERING THERMODYNAMICS	PCC	3	1	-	4

Preamble :

Thermodynamics is the study of energy. . Without energy life cannot exist. Activities from breathing to the launching of rockets involves energy transactions and are subject to thermodynamicanalysis Engineering devices like engines, turbines, refrigeration and air conditioning systems, propulsion systems etc., work on energy transformations and must be analysed using principles of thermodynamics. So, a thorough knowledge of thermodynamic concepts is essential for a mechanical engineer. This course offers an introduction to the basic concepts and laws of thermodynamics

Prerequisite :NIL

Course Outcomes :

After completion of the course the student will be able to

CO1	Understand basic concepts and laws of thermodynamics
CO2	Conduct first lawanalysis of open and closed systems
CO3	Determine entropy andavailabilitychanges associated with different processes
CO4	Understand the application and limitations of different equations of state
CO5	Determine change in properties of pure substancesduring phase change processes
CO6	Evaluate properties of ideal gas mixtures

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										2
CO2	2	2	1	1								1
CO3	3	3	2	2								1
CO4	2	2	2	2								1
CO5	3	3	2	1								1
CO6	3	3	2	2								1

Assessment Pattern

Blooms Category	CA			ESA
	Assignment	Test- 1	Test- 2	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

Mark distribution & Duration of Examination :

Total Marks	CA	ESE	ESE Duration
150	50	100	3 Hours

End semester pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1

1. Discuss the limitations of first law of thermodynamics.
2. Second law of thermodynamics is often called a directional law . Why?
3. Explain Joule-Kelvin effect. What is the significance of the inversion curve ?

Course Outcome 2

1. A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas-tight, frictionless piston – cylinder device. The air is now compressed to a final pressure of 600 kPa . During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process.

2. Carbon dioxide enters an adiabatic nozzle steadily at 1 MPa and 500°C with a mass flow rate of 600 kg/hr and leaves at 100 kPa and 450 m/s. The inlet area of the nozzle is 40 cm^2. Determine (a) the inlet velocity and (b) the exit temperature.

3. A vertical piston –cylinder device initially contains 0.25 m^3 of air at 600 kPa and 300°C. A valve connected to the cylinder is now opened and air is allowed to escape until three-quarters of the mass leave the cylinder at which point the volume is 0.05 m^3. Determine the final temperature in the cylinder and the boundary work during this process.

Course Outcome 3

1.An adiabatic vessel contains l2P }(Á š Œ š îñ – X By paddle-wheel work transfer, the
š u‰ Œ šµŒ }(Á š Œ]•]v Œ • š} ïì X /(šZ •‰](] Z š }(Á
4.186 kJ/kg.K, find the entropy change of the universe.

2. Two kilograms of water at 80°C is mixed adiabatically with 3 kg of water at 30°C in a constant pressure process at 1 atm. Find the increase in entropy of the total mass of water due to the mixing process.

3. ŒP}v v š Œ• v]v•µo š šµŒ]v }‰ Œ š]vP µv Œ •š Ç •š š exhausts at 350 kPa. The mass flow rate is 0.5 kg/s and the turbine develops power at the rate of 120 kW. Determine (a)the temperature of the argon at the turbine exit, (b) the irreversibility of the turbine and (c) the second law efficiency. Neglect KE and PE effects. Take T_0 A îì v p_0= 1 bar

Course Outcome 4

1. What are the limitations of ideal gas equation and how does Van der Waals equation overcome these limitations ?

2. Discuss law of corresponding states and its role in the construction of compressibility chart.

3. A rigid tank contains 2 kmol of N_2 and 6 kmol of CH_4 gases at 200 K and 12 MPa. Estimate the volume of the tank, using (a) ideal gas equation of state (b) the compressibility chart and Amagat's law

Course Outcome 5

íX ^š u]• šZŒ}šš o (Œ}u ï DW v òìì š} îXñ DW X š Œu]v šZ the end of the throttling process.

2. Determine the change in specific volume, specific enthalpy and quality of steam as saturated steam at 15 bar expands isentropically to 1 bar. Use steam tables

3. Estimate the enthalpy of vapourization of steam at 500 kPa, using the Clapeyron equation and compare it with the tabulated value

Course Outcome 6

1. A gaseous mixture contains , by volume, 21% nitrogen, 50% hydrogen and 29 % carbon dioxide. Calculate the molecular weight of the mixture, the characteristic gas constant of the mixture and the value of the reversible adiabatic expansion index X š íì c_p values of nitrogen, hydrogen and carbon dioxide are 1.039, 14.235 and 0.828 kJ/kg.K respectively.

2. A mixture of 2 kmol of CO_2 v ï ku}o }( ]Œ]• }vš]v]v š vl š íõõ lW v air to be a mixture of 79% N_2 and 21% O_2 by volume , calculate (a) the individual mass of CO_2, N_2 and O_2, (b) the percentage content of carbon by mass in the mixture and (c) the molar mass , characteristic gas constant and the specific volume of the mixture

3. A gas mixture in an engine cylinder has 12% CO_2, 11.5 % O_2 and 76.5% N_2 by volume. The u]Æšµ Œ š íìì Æ‰ v • Œ À Œ•] o $pv^{1.25}$ = constant to 7 times its initial volume. Determine the work transfer and heat transfer per unit mass of the mixture.

SYLLABUS

Module 1: Role of Thermodynamics and it's applications in Engineering and Science – Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe, Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function. Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.

Module 2: Energy - Work - Pdv work and other types of work transfer, free expansion work, heat and heat capacity. Joule's Experiment- First law of Thermodynamics - &]Œ•š o Á ‰‰o] š} E}v G}Á Process- Enthalpy - •‰]. ZPMM1, First law applied to Flow Process, Mass and Energy balance in simple •š Ç G}Á ‰Œ} ••X ‰‰o] š]}v• Filling and Emptying Process, •š G}Á Limitations of the First Law.

Module 3: Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements, Equivalence of two statements, Reversibility, Irreversible Process, Causes of Irreversibility, PMM2, Carnot's theorem and its corollaries, Absolute Thermodynamic Temperature scale. Clausius Inequality, Entropy - Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Entropy generation, Entropy and Disorder, Reversible adiabatic process- isentropic process, Third law of thermodynamics, Available Energy, Availability and Irreversibility- }v o Á 8] v ÇX

Module 4: Pure Substances, Phase Transformations, Triple point, properties during change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface, Saturation pressure and Temperature, T-h and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables. The ideal Gas Equation, Characteristic and Universal Gas constants, Deviations from ideal Gas Model: Equation of state of real substances, Vander Waals Equation of State, Virial Expansion, Compressibility factor, Law of corresponding state, Compressibility charts.

Module 5: Mixtures of ideal Gases – Mole Fraction, Mass fraction, Gravimetric and volumetric Analysis, Dalton's Law of partial pressure, Amagat's Laws of additive volumes, Gibbs-Dalton's law Equivalent Gas constant and Molecular Weight, Properties of gas mixtures: Internal Energy, všZ o‰ÇU •‰]. Z š• v všŒ}‰ÇU /•}šZ Œu o Œ }u‰Œ ••]]o]šÇ v }o µu Œ]. General Thermodynamic Relations – Combined First and Second law equations – Helmholtz and Gibb's functions - Maxwell's Relations, Tds Equations. The Clapeyron Equation, equations for internal v ŒPÇU všZ o‰Ç v všŒ}‰ÇU •‰]. Z š•U dZŒ}ššo]vP ‰Œ} inversion curve.

Text Books

1. P. K. Nag, Engineering Thermodynamics, McGraw Hill, 2013

2. E. Rathakrishnan Fundamentals of Engineering Thermodynamics, PHI, 2005

3. Y. A. Cengel and M. A. Boles, Thermodynamics an Engineering Approach, McGraw Hill, 2011

Reference Books:

1. Moran J., Shapiro N. M., Fundamentals of Engineering Thermodynamics, Wiley, 2006

2. R. E. Sonntag and C. Borgnakke, Fundamentals of Thermodynamics, Wiley, 2009

3. Holman J. P. Thermodynamics, McGraw Hill, 2004

4. M. Achuthan, Engineering Thermodynamics, PHI, 2004

COURSE PLAN

Module	Topics	Hours Allotted
1	Role of Thermodynamics and it's applications in Engineering and Scie Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe	1L
	Thermodynamic properties, Process, Cycle, Thermodynamic Equilibriu Quasi – static Process, State, Point and Path function.	1L
	Zeroth Law of Thermodynamics, Measurement of Temperature, refere Points, Temperature Scales.	2L + 1T
2	Energy - Work - Pdv work and other types of work transfer, free expansi work, heat and heat capacity.	2L +1T
	Joule's Experiment - First law of Thermodynamics - First law applied to Non G } Á W Œ} Enthalpy • ‰] . Z PMM1	2L +1T
	First law applied to Flow Process, Mass and Energy balance in simple • š Ç G } Á ‰ Œ} • • X ‰ ‰ o] š] } v • } (^ &	2L +1T
	d Œ v •] v š Filling and Emptying Process, Limitations of the First La	1L + 1T
3	Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements, Equivalence of two statements	2L
	Reversibility, Irreversible Process, Causes of Irreversibility, PMM2, Ca theorem and its corollaries, Absolute Thermodynamic Temperature scale.	2L + 1T
	Clausius Inequality, Entropy - Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Entropy generation, Entropy and Disorder, Reversible adiabatic process - isentropic process, Third law of thermodynamics	2L +1T
	Available Energy, Availability and Irreversibility - } v o Á 8] v	2L + 1T
	Pure Substances, Phase Transformations, Triple point, properties duri change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface,	2L

4	Saturation pressure and Temperature, h-T and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables	2L + 1T
	The ideal Gas Equation, Characteristic and Universal Gas constants, Deviations from ideal Gas Model: Equation of state of real substances, Vander Waals Equation of State, Virial Expansion, Compressibility factor, Law of corresponding state, Compressibility charts.	2L + 1T
5	Mixtures of ideal Gases – Mole Fraction, Mass fraction, Gravimetric and volumetric Analysis, Dalton's Law of partial pressure, Amagat's Laws of additive volumes, Gibbs-Dalton's law.	2L
	Equivalent Gas constant and Molecular Weight, Properties of gas mixtures / v š Œ v o v Œ P Ç U v š Z o ‰ Ç U • ‰] . Z š • v v š Œ } ‰ Ç	1L + 1T
	Introduction to real gas mixtures – Kay's rule	1L
	General Thermodynamic Relations – Combined First and Second law equations – Helmholtz and Gibb's functions – Maxwell's Relations	2L
	Tds Equations. The Clapeyron Equation, equations for internal energy v š Z o ‰ Ç v v š Œ } ‰ Ç U • ‰] . Z š • U d Z Œ } š š o] v P ‰ Œ } • • U } 8] v š U] v À Œ •] } v µ Œ À X	2L + 1T

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

& K h Z d , SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET202

Course Name : ENGINEERING THERMODYNAMICS

(Permitted to use Steam Tables and Mollier Chart)

Max. Marks : 100 Duration : 3 Hours

Part – A

Answer all questions

1. Define thermodynamics. List a few of its applications

2. Differentiate between intensive and extensive properties

3. Differentiate between heat and work

4. Explain system approach and control volume approach as applied in the analysis of a flow process.

5. An inventor claims to have developed an engine that delivers 26 kJ of work using 82 kJ of heat while operating between temperatures 120°C and 30°C. Is his claim valid ? Give the reason for your answer.

6. Show that two reversible adiabatics cannot intersect.

7. Define (i) critical point and (ii) triple point, with respect to water

8. Why do real gases deviate from ideal gas behaviour? When do they approach ideal behaviour?

9. Define Helmholtz function and Gibbs function and state their significance

10. Explain Kay's rule of real gas mixtures

(3 x 10 = 30 marks)

Part – B

Answer one full question from each module.

Module - 1

11. a] Explain macroscopic and microscopic approach to thermodynamics . (7 marks)

b] With the aid of a suitable diagram, explain the working of constant volume gas thermometer.
(7 ma

OR

12.a] What is meant by thermodynamic equilibrium ? What are the essential conditions for a system to be in thermodynamic equilibrium ? (7 marks)

b • Æ ‰ Œ • • š Z š u ‰ Œ š µ Œ } (õ í ö] v ~] • & Œ v Z] š ~]] • < o À] v (7 marks)

Module – 2

13.a] A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas – tight, frictionless piston – cylinder device. The air is now compressed to a final pressure of 600 kPa . During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process. (7 marks)

b] A 2 m^3 Œ] P] š v l] v] š] o o Ç } v š] v •] Œ š í ì ì l W v î î ö X The tank is connected to a supply line through a valve. Air is flowing in the supply line š ò ì ì l W v î î ö X d Z À o À] • opened, and air is allowed to enter the tank until the pressure in the tank reaches the line pressure, at which point the valve is closed. A thermometer placed in the tank indicates that š Z] Œ š u ‰ Œ š µ Œ š š Z ( ] v o • š š] • ó ó ö X š Œ u] v U ~] • the tank and (ii) the amount of heat transfer. (7 marks)

OR

14.a] A turbine operates under steady flow conditions, receiving steam at the following conditions : pressure 1.2 MPa, temperature 188°C, enthalpy 2785 kJ/kg, velocity 33.3 m/s and elevation 3m. The steam leaves the turbine at the following conditions : pressure 20 kPa, enthalpy 25kJ/kg, velocity 100 m/s, and elevation 0 m. Heat is lost to the surroundings at the rate of 0.29 kJ/s. If the rate of steam flow through the turbine is 0.42 kg/s, what is the power output of the turbine in kW ? (7 marks)

b] State the general energy balance equation for an unsteady flow system and from it, derive the energy balance equation for a bottle filling process, stating all assumptions. (7 marks)

Module – 3

15.a] State the Kelvin-Planck and Clausisus statements of the second law of thermodynamics and prove their equivalence. (7 marks)

b] A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which the engine rejects heat to it. If the efficiency of the engine is 40 % of the maximum possible and the COP of the heat pump is 50 % of the maximum possible, what is the temperature of the reservoir to which the heat pump rejects heat ? What is the rate of heat rejection from the heat pump, if the rate of heat supply to the engine is 50kW ? (7 marks)

OR

16.a] A house is to be maintained at 21°C during winter and at 26°C during summer. Heat leakage through the walls, windows and roof is about 3000 kJ/hr per degree temperature difference between the interior of the house and the environment. A reversible heat pump is proposed for realising the desired heating and cooling. What is the minimum power required to run the heat pump in the reverse, if the outside temperature during summer is 36°C? Also find the lowest environment temperature during winter for which the inside of the house can be maintained at 21°C consuming the same power. (7 marks)

b] Air enters a compressor in steady flow at 140 kPa, 17°C and 70 m/s and leaves at 350 kPa, 127°C and 110 m/s. The environment is at 100 kPa and 7°C. Calculate per kg of air (a) the actual work required (b) the minimum work required and (c) the irreversibility of the process. (7 marks)

Module – 4

17.a] Show the constant pressure transformation of unit mass of ice at atmospheric pressure and - î ì ö š } • µ ‰ Œ Z š • š -v, T-s and P-T coordinate systems and explain their salient features . (7 marks)

b] A rigid vessel of volume 0.3 m^3 contains 10 kg of oxygen at 300 K. Using (i) the perfect gas equation and (ii) the Van der Waal's equation of state, determine the pressure of oxygen in the vessel. Take the Van der Waal's constants for oxygen as a = 0.1382 m^6 Pa/ mol^2 and b=0.03186 m^3/ kmol . (7 marks)

OR

18. • ^ š u š î ñ Œ v ï ì ì ö Æ ‰ v •] • v š Œ } ‰] o o Ç š } ñ Œ X o ‰ volume and temperature of unit mass of steam during this process using steam tables and Mollier chart and compare the values (7 marks)

b]Explain law of corresponding states and its significance to the generalized compressibility chart. 7(marks)

Module – 5

19.a] Derive the expressions for the equivalent molecular weight and characteristic gas constant for a mixture of ideal gases (6 marks)

b] ì X ñ l P } (, o] µ u v ì X ñ l P } (E] š Œ } P v Œ u] Æ š î ì ö v š
Find (i) volume of the mixture (ii) partial volumes of the components (iii) partial pressures of the

components (iv) the specific heats of the mixture and (v) the gas constant of the mixture. Take ratio of specific heats for Helium and Nitrogen to be 1.667 and 1.4 respectively. (8 marks)

OR

20.a] 2 kg of carbon dioxide at 38°C and 1.4 bar is mixed with 5 kg of nitrogen at 150°C and 1.03 bar to form a mixture at a final pressure of 70 kPa. The process occurs adiabatically in a steady flow apparatus. Calculate the final temperature of the mixture and the change in entropy during the mixing process. Take specific heat at constant pressure for CO_2 and N_2 as 0.85 kJ/kg.K and 1.04 kJ/kg respectively. (7 marks)

b] Derive the Maxwell relations. Explain their significance.? (7 marks)

MET 204	MANUFACTURING PROCESS	CATEGORY	L	T	P	Credits	Year of Introduction
		PCC	3	1	0	4	2019

Preamble:

1. To gain theoretical and practical knowledge in material casting processes and deve understanding of the dependent and independent variables which control materia casting in a production processes.
2. Provide a detailed discussion on the welding process and the physics of w Introduce students to different welding processes weld testing and advanced proc be able to appreciate the practical applications of welding.
3. The course will also provide methods of analysis allowing a mathematical/ph description of forming processes.
4. Correlate the material type with the possible fabrication processes
5. Generate solutions to problems that may arise in manufacturing engineering

Prerequisite: MET 205 Metallurgy and material science

Course Outcomes - At the end of the course students will be able

CO 1	Illustrate the basic principles of foundry practices and special casting processes, th advantages, limitations and applications
CO 2	Categorize welding processes according to welding principle and material
CO 3	Understand requirements to achieve sound welded joint while welding different simil dissimilar engineering materials.
CO 4	Student will estimate the working loads for pressing, forging, wire drawing processes
CO 5	Recommend appropriate part manufacturing processes when provided a set of fun requirements and product development constraints.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-		-	-
CO 2	-	-	-	-	-	-	-	-	-	-	-	2
CO 3	-	-	3	-	-	-	-	-	-	-	-	-
CO 4	-	-	-	3	-	-	-	-	-	-	-	-
CO 5	-	4	-	-	-	-	-	-	-	-	-	-

Assessment Pattern

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test I (Marks)	Test II (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyse	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments	15 marks
Continuous Assessment Test (Minimum 2 numbers)	25 marks

End semester pattern:- There will be two parts; Part A and Part B. Part A contain questions with 2 questions from each module, having 3 marks for each ques Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Part -A

Course Outcome 1 (CO1):- Illustrate the basic principles of foundry practices ar special casting processes, their Advantages, Limitations and Applications

1. Why draft allowances are important for patterns.
2. What are the importances of permeability of molding sand?
3. How runner extension is helpful for good casting quality.
4. Internal corners are more prone to solidification shrinkages than external corne Explain?
5. Which of the casting processes would be suitable for making small toys in la numbers? Why?

Course Outcome 2 (CO2):

Categorize welding processes according to welding principle and material

1. Why is the quality of welds produced by submerged arc welding very good?
2. What does the strength of a weld nugget in resistance spot welding depends on?
3. What is the strength of a welded joint inferior or superior to the parent metal? Why?
4. Why some joints may have to be preheated prior to welding.

Part -B

Course Outcome 3 (CO3): Understand requirements to achieve sound welded joint while we different similar and dissimilar engineering materials.

1. Assume that you are asked to inspect a weld for a critical application. Describe the procedure you would follow. If you find a flaw during your inspection, how would you go ab determining whether or not this flaw is important for the particular application?
2. In the building of large ships, there is a need to weld large sections of steel together to form hull, for this application, which welding process would you select? Why?

Course Outcome 4 (CO4): Student will estimate the working loads for pressing, forging, wire drawing etc. processes

1. How can you tell whether a certain part is forged or cast? Describe the features that yo would investigate to arrive at a conclusion.
2. Two solid cylindrical specimens A and B, made of a perfectly plastic material, are forged with friction and isothermally at room temperature to a reduction in height of specimen A has a height of 2 inch and cross sectional area of 1 square inch, and s B has a height of is 1 inch and a cross sectional area of 2 square inch. Will the work done be the same for the two specimens? Explain.

Course Outcome 5 (CO5): Recommend appropriate part manufacturing processes when prov set of functional requirements and product development constraints.

1. Many missile components are made by spinning. What other methods would you use to ma missile components if spinning process were not available? Describe the relative advantages ar limitations of each method.
2. Suggest a suitable casting process for making an engine piston with Aluminium alloy. What type of mould can be used?
3. Suggest and explain a suitable welding method for welding railway tracks for trains.
4. Suggest a suitable manufacturing process for screw jack, postulate the fundamentals.

SYLLABUS

Module I

Casting: Characteristics of sand - patterns cores - chaplets simple problems solidification of metals and Chvorinov's rule - Elements of gating system risering - chills - simple problems Special casting process - Defects in castings - Super alloy Production Methods.

Module II

Welding: - welding metallurgy - heat affected zone - grain size and hardness - stress reliving joint quality -heat treatment of welded joints - weldability - destructive and non destructive tests of welded joi

Thermit welding, friction welding - Resistance welding: HAZ, process and correlation of pro parameters with welded joints - applications of each welding process - Arc welding: HAZ, process anc correlation of process parameters with welded joints - simple problems applications of each weldin process - Oxyacetylene welding: chemistry, types of flame and its applications - brazing - soldering - adhesive bonding.

Module III

Rolling: - principles - types of rolls and rolling mills mechanics of flat rolling - Defects - vibration and chatter - flat rolling - miscellaneous rolling processes - simple problems - Bulk deformation of metals - : State of stress; yield criteria of Tresca, von Mises, comparisons; Flow rules; power and ener deformations; Heat generation and heat transfer in metal forming process -

Module IV

Forging: methods analysis, applications, die forging, defects in forging - simple problems - Metal extrusion: - metal flow, mechanics of extrusion, miscellaneous process, defects, simple problems, applications - Wire, Rod, and tube drawing: - mechanics of rod and wire drawing, simple problems, drawing defects - swaging, applications - deep drawing.

Module V

Locating and clamping methods - locating methods - locating from plane, circular, irregular surface. Locating methods and devices - simple problems - Basic principles of clamping - Sheet meta operations Press tool operations - Tension, Compression, tension and compression operatic applications - Fundamentals of die cutting operations - simple problems types of die construction.

Text Books

1. Donalson cyril, LeCain, Goold, Ghose - Tool design, McGraw Hill.
2. Serope Kalpakjian, Steven R. Schmid - Manufacturing Engineering and Technology, Pearson.

Reference

1. Joseph R. Davis, S. L. Semiatin, American Society for Metals - ASM Metals Handbook, Vol. 1 Forming and Forging ASM International (1989).
2. Peter Beeley, Foundry Technology, Butterworth-Heinemann
3. Rao P.N., Manufacturing Technology - Volume 1, Tata McGraw Hill.
4. Taylan Altan, Gracious Ngaile, Gangshu Shen - Cold and Hot Forging Fundamentals and Applications - ASM International (2004).
5. Matthew J. Donachie, Stephen J. Donachie, Superalloys A Technical Guide, Second Edition, 2002 ASM International.

MODEL QUESTION PAPER

MANUFACTURING PROCESS - MET 204

Max. Marks : 100 Duration : 3 Hours

Part - A

Answer all questions, each question carries 3 marks

1. Why does porosity have detrimental effects on the mechanical properties of castings? Which physical properties like thermal and electrical conductivity are also affected by porosity? explain

2. Large parts cannot be manufactured by the centrifugal casting, comment on the statemen
3. What does the strength of a weld nugget in resistance spot welding depends on?
4. Explain how the atmosphere around the work piece affect the weld obtained in electron bea welding.
5. What is the importance of roll velocity and strip velocity?
6. Explain a suitable rolling process for making threaded fasteners.
7. Explain why forged parts withstand high loads compared to cast parts.
8. Explain why the die pressure in drawing process decreases towards the exit of the die
9. What is the basic rule for applying clamping forces?
10. What is generally used as the basic reference plane for locating?

PART - B

Answer one full question from each module.

MODULE ±1

11. What is gating ratio? What considerations affect its selection? What are the typical ratios for the following applications? (a) Grey iron bed castings made in cast steel, (b) body castings made in cast steel, (c) Aluminum pistons for automobiles, (d) Large gun me bushes for bearings. (14 marks)

OR

12. Explain different types of casting defeats in detail with effects of each defect on quality casting. (14 marks)

MODULE ±2

13. a. Two plates were welded together and then the strength of the joint was tested. It is found that the weld was stronger than either of the plates. Do you think that the statement incorrect? Postulate, giving valid reasons with neat sketches. (7 marks)
    b. what are the methods available for controlling the distortions in welded assembly str Describe their relative effects and application. (7 marks)

OR

14. a. Two 1-mm thick, flat Copper sheets are being spot welded using a current of 5000A and a current flow time of t=0.18 seconds the electrodes are 5mm in diameter. Estimate t generated in the weld zone. (7 marks)
    b. Explain why some joints may have to be preheated prior to welding? If the parts to be welded are preheated, is the likelihood that porosity will form increased or decreased? Explain. (7 marks)

MODULE ±3

15. a. An annealed Copper strip 228mm wide and 25mm thick is rolled to a thickness 20 one pass. The roll radius is 300mm and the rolls rotate at 100rpm. Calculate the roll fo the power required in this operation. (7 marks)
    b. A 100mm square billet is to be rolled into a rod of 12.5mm diameter. Draw the sequen operations. (7 marks)

OR

16. Explain the yield criteria of Tresca, von Mises and compare each other. (14 marks)

MODULE ±4

17. a. Explain why crankshaft of an automobile is manufactured by forging and not by casti
(7 marks)
b. Estimate the limiting drawing ratio that you would expect from a sheet metal that,
stretched by 23 percentages in length, decreases in thickness by 10 percentages (7 marks)

OR

18. a. Assume that you are reducing the diameter of two round rods, one by simple tension
other by indirect extrusion. Which methods would be better? Explain (7 marks)
b. A cylindrical specimen made of annealed 4135 steel has a diameter of 6 inches and
high. It is upset by open die forging with flat dies to a height of 2inch at room temper
Assuming that the coefficient of friction is 0.2, calculate the force required at the end of th
stroke. Use average pressure formula (7 marks)

MODULE ±5

19. Estimate the force required in punching a 25mm diameter hole through a 3.2mm
annealed Titanium Ti6Al-4V sheet at room temperature (5 marks)
b. Explain 3-2-1 principle of locating with neat sketches (9 marks)

OR

20. a. determine the die and punch sizes for blanking a circular disc of 20mm diameter from
steel sheet whose thickness is 1.5mm (7 marks)
b. Explain how is unevenness compensated for when locating against an irregular surfa
more than three locating points? (7 marks)

Course content and lecture schedules.

Module	TOPIC	No. of hours	Course outcomes
1.1	Casting:- Characteristics of sand- pattern and allowances- type of patterns- cores- core prints- chaplets- simple problems.	2	CO1
1.2	Elements of gating system- gating system, pouring time, choke are risering Caine's method- chills ± simple problems	2	CO1 CO5
1.3	Special casting process- shell molding, precision investment, die casti centrifugal casting, continues casting, squeeze casting surface rou obtainable and application of each casting process.	2	
1.4	Defects in castings – Shaping faults arising in pouring, Inclusions a sand defects, Gas defects, Shrinkage defects, Contraction d Dimensional errors, Compositional errors and segregation- significance of defects on Mechanical properties (Kalpakjian, Beeley, Rao)	2	CO1
1.5	Superalloy Production Methods: Vacuum Induction Melting; Electro Remelting; Vacuum Arc Remelting (ASM).	1	
2.1	Welding:- welding metallurgy, diffusion, heat affected zone, driving fo for grain growth, grain size and hardness- joint quality: porosity, slag inclusions, cracks, surface damage, residual stress lamellar tears, reliving, heat treatment of welded joints- weldability (Kalpakjian, Lindberg)- destructive and non destructive tests of welded joints (ma provided as class assignment- Lindberg).	2	CO2

2.2	Resistance welding: HAZ, process and correlation of process parameters with welded joints of spot, seam, projection, stud arc, percussion wel applications of each welding process ± simple problems. (Kalpakjian).	3	CO2 CO5
2.3	Arc welding: HAZ, process and correlation of process parameters welded joints of shielded metal arc, submerged, gas metal, flux core electrogas, electroslag, gas tungsten, plasma arc, electron beam beam ± simple problems - Thermit welding, friction welding applications of each welding process (Kalpakjian, Lindberg).	3	CO2
2.4	Oxyacetylene welding: chemistry, types of flame and its application brazing - soldering - adhesive bonding.	1	
3.1	Rolling: - principles - types of rolls and rolling mills mechanics of flat rolling, roll pressure distribution, neutral point, front and back tensio torque and power, roll forces in hot rolling, - friction, deflection a flattening, spreading ± simple problems	3	CO4 CO5
3.2	rolling defects vibration and chatter - flat rolling - miscellaneous rolling process: shape roll forging, ring, thread and gear, rotary tube pierci tube rolling - applications ± simple problems. (Kalpakjian).	2	CO4
3.3	Plastic deformation of metals - stress strain relationships State of stress yield criteria of Tresca, von Mises, and comparison - applications.	2	
3.4	Flow rules - power and energy deformations - Heat generation and he transfer in metal forming process - temperature in forging. (ASM - Taylan Altan).	1	CO4
4.1	Forging: material characterization; grain flow and strength - Forging - classification - open die forging, forces and work of deformation Forging methods analysis: slab method only, solid cylindrica rectangular work piece in plane strain, forging under sticking condition - simple problems - applications.	3	CO4
	Deformation zone geometry ± die forging - impression, close, coining skew rolling etc. ± simple problems ± defects in forging. (Kalpakjian).	1	
4.2	Metal extrusion - metal flow - mechanics of extrusion - deformation and friction, actual forces, die angle, forces in hot extrusion - miscellaneous process defects - ± simple problems applications. (Kalpakjian, Lindberg).	2	
4.3	Wire, Rod, and tube drawing - mechanics of rod and wire drawing: deformation, friction, die pressure and angle, temperature, reductio pass, drawing flat strip and tubes - simple problems drawing defects - swaging - applications. (Kalpakjian, Lindberg, Rao).	2	CO4
4.4	Deep drawing - deep drawbility, simple problems - different drawing practices	1	
5.1	Locating and clamping methods: basic principle of location; locatin methods; degrees of freedom; locating from plane, circular, irre surface ± simple problems.	2	CO4
	Locating methods and devices - pin and button locators, rest pads a plates, nest or cavity location.	1	

5.2	Basic principles of clamping: strap, cam, screw, latch, wedge, hydraulic and pneumatic clamping – simple problems. (Donaldson, Wilson F.W.).	2	CO4
5.3	Sheet metal operations: Press tool operations: shearing action, sh operations: blanking, piercing, simple problems, trimming, shaving nibbing, notching ± simple problems – applications.	2	CO4 CO5
5.4	Tension operations: stretch forming, Compression operations: coining, sizing, ironing, hobbing, tension and compression operations: drawing, spinning, bending, forming, embossing ± simple problems, applications. (Donaldson, Wilson F.W., Rao P.N).	2	CO4
	Fundamentals of die cutting operations - inverted, progressive an compound die simple problems. (Donaldson)	1	

CODE	COURSE NAME	CATEGOR	L	T	P	CREDIT
MET206	FLUID MACHINERY	PCC	3	1	-	4

Preamble :

This course provides an understanding of reciprocating and rotary fluid machinery. The course consist of hydraulic pumps, turbines, air compressors and gas turbines

Prerequisite: NIL

Course Outcomes

After completion of the course the student will be able to

CO1	Explain the characteristics of centrifugal and reciprocating pumps
CO2	Calculate forces and work done by a jet on fixed or moving plate and curved plates
CO3	Explain the working of turbines and Select a turbine for specific application.
CO4	Analyse the working of air compressors and Select the suitable one based on application.
CO5	Analyse gas turbines and Identify the improvements in basic gas turbine cycles.
CO6	Explain the characteristics of centrifugal and reciprocating pumps

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2									
CO2	3	3	2									
CO3	3	3	2									
CO4	3	3	2									
CO5	3	3	2									

Assessment Pattern

Blooms Category	CA			ESA
	Assignment	Test- 1	Test- 2	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

Mark distribution & Duration of Examination :

Total Marks	CA	ESE	ESE Duration
150	50	100	3 Hours

End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Outcome 1

1. A centrifugal pump discharges 0.15 m^3=s of water against a head of 12.5 m, the speed of the impeller being 600 r.p.m. The outer and inner diameters of impeller are 500 mm and 250 mm respectively and the vanes are bent back at 35 to the tangent at exit. If the area of ow remains 0.07m^2 from inlet to outlet, calculate :

   (a) Manometric e ciency of pump,

   (b) Vane angle at inlet, and

   (c) Loss of head at inlet to impeller when discharge is reduced by 40% without changing the speed.

2. (a) What is slip in a reciprocating pump. What is the reason for negative slip in a reciprocating pump.

   (b) A single acting reciprocating pump having a bore of 150 mm and a stroke of 300 mm length, discharges 250 of water per minute at 50 rpm. Neglecting losses, nd theoretical discharge and slip of the pump.

   (c) With a neat sketch explain the working of a gear pump.

3. Explain the following terms as they are applied to a centrifugal pump:

   (a) Static suction lift,

   (b) static suction head,

   (c) static discharge head and

   (d) total static head.

Course Outcome 2

1. Prove that the force exerted by a jet of water on a xed semi-circular plate in the direction of the jet when the jet strikes at the centre of the semi-circular plate is two times the force exerted by the jet on an xed vertical plate.

2. Show that the angle of swing of a vertical hinged plate is given by

$$\sin = \frac{aV^2}{W}$$

   where V = Velocity of the jet striking the plate, a = Area of the jet, and W = Weight of the plate.

3. A jet of water moving at 60 m=s is de ected by a vane moving at 25 m=s in a direction at 30 to the direction of the jet. The water jet leaves the blade normally to the motion of the vanes. Draw the inlet and outlet velocity triangles and nd the vane angles for no shock at entry or exit. Take the relative velocity at outlet to be 0.85 of the relative velocity at inlet.

Course Outcome 3

1. Explain the purpose of providing
   (a) scroll casing
   (b) stay vanes
   (c) guide vanes, for a reaction turbine.
2. A Pelton wheel turbine has a mean bucket speed of $12 m/s$ with a jet of water flowing at a rate of $900 l/s$ under a head of 40 m. The bucket deflects the jet at an angle of 165 Calculate the power given by the water to the runner and the hydraulic efficiency of the turbine. Draw the velocity triangle. Assume the coefficient of velocity to be 0.96.
3. (a) What are the unit quantities used to analyze the performance of hydraulic turbines. Explain its importance.
   (b) What is specific speed of a turbine.

Course Outcome 4

1. With a neat sketch explain the working of centrifugal compressors.
2. An ideal single stage single acting reciprocating compressor logs a displacement volume of 14 litres and a clearance volume of 5%. It intakes air at 1 bar and delivers the same at 7 bar. The compression is polytropic with an index of 1.3 and re-expansion is isentropic with an index of 1.4. Determine the indicated work of a cycle.
3. What is surging in axial flow compressor? What are its effects? Describe briefly.

Course Outcome 5

1. A gas turbine unit operates at a mass flow of $30 kg/s$. Air enters the compressor at a pressure of 1 bar and temperature 15C and is discharged from the compressor at a pressure of 10.5 bar. Combustion occurs at constant pressure and results in a temperature rise of 420 K. If the flow leaves the turbine at a pressure of 1.2 bar, determine the net power output from the unit and also the thermal efficiency. Take $C_p = 1.005 kJ/kgK$ and $\gamma = 1.4$.
2. Derive the expression for maximum specific work output of a gas turbine considering machine efficiencies.
3. Write a short note on different type of compression chambers used in a gas turbine engine.

SYLLABUS

Module 1: Impact of jets: Introduction to hydrodynamic thrust of jet on a fixed and moving surface (flat and curve), – Series of vanes - work done and efficiency Hydraulic Turbines : Impulse and Reaction Turbines – Degree of reaction – Pelton Wheel – Constructional features - Velocity triangles – Euler's equation – Speed ratio, jet ratio and work done, losses and efficiencies, design of Pelton wheel – Inward and outward flow reaction turbines- Francis Turbine – Constructional features – Velocity triangles, work done and efficiencies. Axial flow turbine (Kaplan) Constructional features – Velocity triangles - work done and efficiencies.

Module 2: Characteristic curves of turbines - theory of draft tubes – surge tanks – Cavitation in turbines – Governing of turbines – Specific speed of turbine, Type Number – Characteristic curves, scale Laws – Unit speed – Unit discharge and unit power- Rotary motion of liquids – free, forced and spiral vortex flows Rotodynamic pumps - centrifugal pump impeller types, velocity triangles - manometric head - work, efficiency and losses, H-Q characteristic, typical flow system characteristics, operating point of a pump. Cavitation in centrifugal pumps - NPSH required and available - Type number - Pumps in series and parallel operations. Performance characteristics - Specific speed - Shape numbers – Impeller shapes based on shape numbers

Module 3: Positive displacement pumps - reciprocating pump – Single acting and double acting- slip, negative slip and work required and efficiency - indicator diagram - acceleration head - effect of acceleration and friction on indicator diagram - speed calculation - Air vessels and their purposes, saving in work done to air vessels multi cylinder pumps. Multistage pumps - selection of pumps - pumping devices - hydraulic ram, Accumulator, Intensifier, Jet pumps, gear pumps, vane pump and lobe pump

Module 4: Compressors: classification of compressors, reciprocating compressor - single stage compressor, equation for work with and without clearance volume, efficiencies, multistage compressor, intercooler, free air delivered (FAD)
Centrifugal compressor: working, velocity diagram, work done, power required, width of blades of impeller and diffuser, isentropic efficiency, slip factor and pressure coefficient, surging and choking.
Axial flow compressors: working, velocity diagram, degree of reaction, performance. Roots blower, vane compressor, screw compressor.

Module 5: Gas turbines: classification, Thermodynamic analysis of gas turbine cycles-open, closed and semi closed cycle; ideal working cycle - Brayton cycle - P-v and T-s diagram, thermal efficiency. Effect of compressor and turbine efficiencies. Optimum pressure ratio for maximum specific work output with and without considering machine efficiencies. Comparison of gas turbine and IC engines, Analysis of open cycle gas turbine, Improvements of the basic gas turbine cycle - regeneration, intercooling and reheating - cycle efficiency and work output - Condition for minimum compressor work and maximum turbine work. Combustion chambers for gas turbines - pressure loss in combustion process and stability loop.

Text books

Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017

Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010

Reference Books

Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.

Sawhney G.S, Thermal and Hydraulic Machines, Prentice Hall India Learning Private Limited, 2nd edition , 2011

COURSE PLAN

Module	Topics	Hours Allotted
I	Impact of jets: Introduction to hydrodynamic thrust of jet on a fixed and moving surface (flat and curve), Series of vanes - work done and efficiency Hydraulic Turbines : Impulse and Reaction Turbines – Degree of reaction – Pelton Wheel – Constructional features - Velocity triangles – Euler's equation – Speed ratio, jet ratio and work done, losses and efficiencies, design of Pelton wheel - Inward and outward flow reaction turbines – Francis Turbine - Constructional features - Velocity triangles, work done and efficiencies. Axial flow turbine (Kaplan) Constructional features – Velocity triangles - work done and efficiencies	6-3-0
II	Characteristic curves of turbines – theory of draft tubes – surge tanks – Cavitation in turbines – Governing of turbines – Specific speed of turbine , Type Number – Characteristic curves, scale Laws – Unit speed – Unit discharge and unit power. Rotary motion of liquids – free, forced and spiral vortex flows Rotodynamic pumps – centrifugal pump - impeller types, - velocity triangles - manometric head - work, efficiency and losses, H-Q characteristic, typical flow system characteristics, operating point of a pump. Cavitation in centrifugal pumps- NPSH required and available - Type number - Pumps in series and parallel operations. Performance characteristics - Specific speed - Shape numbers – Impeller shapes based on shape numbers.	7-2-0
III	Positive displacement pumps - reciprocating pump – Single acting and double acting - slip, negative slip and work required and efficiency - indicator diagram - acceleration head - effect of acceleration and friction on indicator diagram – speed calculation - Air vessels and their purposes, saving in work done to air vessels multi cylinder pumps. Multistage pumps - selection of	7-2-0

	pumps-pumping devices-hydraulic ram, Accumulator, Intensifier, Jet pumps, gear pumps, vane pump and lobe pump.	
IV	Compressors: classification of compressors, reciprocating compressor- single stage compressor, equation for work with and without clearance volume, efficiencies, multistage compressor, intercooler, free air delivered (FAD) Centrifugal compressor-working, velocity diagram, work done, pow required, width of blades of impeller and diffuser, isentropic efficiency, slip factor and pressure coefficient, surging and chocking. Axial flow compressors-working, velocity diagram, degree of reaction, performance. Roots blower, vane compressor, screw compressor.	7-2-0
V	Gas turbines: classification, Thermodynamic analysis of gas turbine cyc open, closed and semi closed cycle; ideal working cycle-Brayton cycle-P-v and T-s diagram, thermal efficiency. Effect of compressor and turbine efficiencies. Optimum pressure ratio for maximum specific work output with and without considering machine efficiencies. Comparison of gas turbine and IC engines, Analysis of open cycle gas turbine, Improvements of the basic gas turbine cycles-regeneration, intercooling and reheating-cycle efficiency and work output-Condition for minimum compressor work and maximum turbine work. Combustion chambers for gas turbines. pressure loss in combustion process and stability loop.	7-2-0

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

IV SEMESTER B.TECH DEGREE EXAMINATION

MET206: FLUID MACHINERY

Mechanical Engineering

Maximum: 100 Marks Duration: 3 hours

PART A

Answer all questions, each question carries 3 marks

1. What is degree of reaction? What will be the degree of reaction for a Pelton wheel.
2. Explain speed ratio and jet ratio.
3. What is governing of a turbine? Why is it important?
4. Explain the term speci c speed of a pump. How is it di erent from speci c speed of a turbine.
5. De ne slip, percentage slip and negative slip of a reciprocating pump.
6. What is the purpose of air vessels in multi-cylinder reciprocating pump.
7. What are the classi cations of compressors? Explain brie y.
8. Write a short note on axial ow compressors. Why is it preferred in aerospace applications.
9. Explain brie y the process of regeneration in a gas turbine engine.
10. Draw the p-v diagram and T-s diagram of Brayton cycle.

(10 3=30 Marks)

PART B

Answer one full question from each module

MODULE-I

11. (a) A 50 mm diameter jet having a velocity of 25m=s, strikes a at plate, the normal of which is inclined at 30 to the axis of the jet. Calculate the normal force exerted on the plate

    i. when the plate is stationary,
    ii. when the plate is moving with a velocity of 10m=s in the direction of the jet.

    Find also the work done and the e ciency of the jet when the plate is moving. (7 Marks)

(b) A Pelton wheel has a mean bucket speed of 10 m=s with a jet of water owing at the rate of 700litres=s under a head of 30 m. The buckets de ect the jet through an angle of 160. Calculate the power given by the water to the runner and the hydraulic e ciency of the turbine. Assume coe cient of velocity as 0.98. (7 Marks)

12. (a) A reaction turbine works at 450 rpm under a head of 120 m. Its diameter at inlet is 120 cm and the ow area is 0.4m^2. The angles made by absolute and relative velocities at inlet are 20 and 60 respectively with the tangential velocity. Determine:

i. The volume ow rate,

ii. The power developed, and

iii. Hydraulic e ciency.

Assume whirl at outlet to be zero. (7 Marks)

(b) A Kaplan turbine runner is to be designed to develop 7357.5 kW shaft power. The net available head is 10 m. Assume that the speed ratio is 1.8 and ow ratio is 0:6: If the overall e ciency is 70% and diameter of the boss is 0.4 times the diameter of the runner, nd the diameter of the runner, its speed and speci c speed. (7 Marks)

MODULE-II

13. (a) A Pelton wheel is revolving at a speed of 190 rpm and develops 5150.25 kW when working under a head of 220 m with an overall e ciency of 80%. Determine unit speed, unit discharge and unit power. The speed ratio for the turbine is given as 0.47. Find the speed, discharge and power when this turbine is working under a head of 140 m. (7 Marks)

(b) What do you understand by the characteristic curves of a turbine? Describe the important types of characteristic curves. (7 Marks)

14. (a) Why are centrifugal pumps used sometimes in series and sometimes in parallel? Draw the following characteristic curves for a centrifugal pump:
Head, power and e ciency versus discharge with constant speed. (7 Marks)

(b) State the e ects of cavitation on the performance of water turbines and also state how to prevent cavitation in water turbines. (7 Marks)

MODULE-III

15. (a) Draw an indicator diagram, considering the e ect of acceleration and friction in suction and delivery pipes. Find an expression for the work done per second in case of single-acting reciprocating pump. (7 Marks)

(b) Di erentiate :

i. Between a single-acting and double-acting reciprocating pump,

ii. Between a single cylinder and a double cylinder reciprocating pump. (7 Marks)

16. (a) A single-acting reciprocating pump running at 30 r.p.m, delivers 0.012 m^3=s of water. The diameter of the piston is 25 cm and stroke length is 50 cm. Determine :

i. The theoretical discharge of the pump,

ii. Coe cient of discharge, and

iii. Slip and percentage slip of the pump. (8 Marks)

(b) Write a short note on gear pumps. Why gear pump is known as positive displacement pump. (6 Marks)

MODULE-IV

17. (a) With a neat sketch explain the working of an axial ow compressor. (7 Marks)

    (b) Derive the expression for the work done in a reciprocating compressor with and without clearance volume. (7 Marks)

18. (a) A single stage double acting air compressor is required to deliver 14 m^3 of air per minute measured at 1.013 bar and 15C. The delivery pressure is 7 bar and the speed 300 rpm. Take clearance volume as 5% of the swept volume with compression and expansion index n=1.3. Calculate

    i. Swept volume of the cylinder,
    ii. Delivery temperature,
    iii. Indicated power.

    (10 Marks)

    (b) Draw the velocity diagram of an axial ow compressor. (4 Marks)

MODULE-V

19. (a) The air enters the compressor of an open cycle constant pressure gas turbine at a pressure of 1 bar and temperature 20C. The pressure of air after compression is 4 bar. The isentropic e ciencies of compressor and turbine are 80% and 85% respectively. The air fuel ratio is 90:1. If ow rate of air is 3.0kg=s, nd

    i. Power developed
    ii. Thermal e ciency of cycle

    (7 Marks)

    (b) A gas turbine has a pressure ratio of 6:1 and a maximum cycle temperature of 600C. The isentropic e ciencies of compressor and turbine are 0.82 and 0.85 respectively. Calculate the power output in kW of an electric generator geared to turbine when the air enters the compressor at 15C at the rate of 15 kg=s. Assume the working uid to be air with $C_p = 1{:}005$ and $= 1{:}4$. (7 Marks)

20. (a) What are the improvements made to the basic gas turbine cycle. Explain with temperature entropy diagram. (8 Marks)

    (b) Di erentiate between open, closed and semi closed gas turbine cycles. (6 Marks)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MEL202	& D ˜ , D LAB	PCC	0	0	3	2

Preamble:

This lab is mainly focussed to develop a platform where the students can enhance their engineering knowledge in the fluid mechanics domain by applying their theoretical knowledge acquired.

Prerequisite: MET203 Mechanics of Fluids

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Determine the coefficient of discharge of flow measuring devices (notches, orifice meter and Venturi meter)
CO 2	Calibrate flow measuring devices (notches, orifice meter and Venturi meter)
CO 3	Evaluate the losses in pipes
CO 4	Determine the metacentric height and stability of floating bodies
CO 5	Determine the efficiency and plot the characteristic curves of different types of pumps and turbines

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PO 10	PO 11	PO 12
CO 1	2	1						2	3	2		2
CO 2	2	1						2	3	2		2
CO 3	2	1						2	3	2		2
CO 4	2	1						2	3	2		2
CO 5	2	1						2	3	2		2

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions:

Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

A minimum of 10 experiments are to be performed.

SYLLABUS

LIST OF EXPERIMENTS

1. Determination of coefficient of discharge and calibration of Notches

2. Determination of coefficient of discharge and calibration of Orifice meter

3. Determination of coefficient of discharge and calibration of Venturi meter.

4. Determination of hydraulic coefficients of orifices

5. Determination of Chezy's constant and Darcy's coefficient on pipe friction apparatus

6. Determine the minor losses in pipe.

7. Experiments on hydraulic ram.

8. Reynolds experiment

9. Bernoulli's experiment.

10. Determination of metacentric height and radius of gyration of floating bodies.

11. Performance test on positive displacement pumps

12. Performance test on centrifugal pumps, determination of operating point and efficiency

13. Performance test on gear pump.

14. Performance test on Impulse turbines.

15. Performance test on reaction turbines (Francis and Kaplan Turbines).

16. Speed variation test on Impulse turbine.

17. Determination of best guide vane opening for Reaction turbine.

18. Impact of jet.

Reference Books

1. Yunus A. Cenegel, John M. Cimbala; Fluid Mechanics Fundamentals and Applications (in SI Units); McGraw Hill, 2010.
2. Bansal R.K, Fluid Mechanics and Hydraulic Machines (SI Units); Laxmi Publications, 2011.
3. Modi P.N and Seth S.M, "Hydraulics and Fluid Mechanics Including Hydraulic Machines" Standard Book House, New Delhi, 20th Edition, 2015
4. Graebel. WP, "Engineering Fluid Mechanics", Taylor & Francis, Indian Reprint, 2011
5. Robert W.Fox, Alan T. McDonald, Philip J Pritchard, "Fluid Mechanics and Machinery", John Wiley and sons, 2015.
6. J. Frabzini, 'Fluid Mechanics with Engineering Applications', McGraw Hill, 1997.

MEL 204	MACHINE TOOLS LAB I	CATEGORY	L	T	P	Credits	Year of Introduction
		PCC	0	0	3	2	2019

Preamble:

1. To understand the parts of various machine tools and impart hands on experience lathe, drilling, shaping, milling, slotting, grinding, tool and cutter grinding machines.
2. To develop knowledge and importance of metal cutting parameters such as feed, velocity and depth of cut etc on cutting force and surface roughness obtainable.
3. To develop fundamental knowledge on tool materials, cutting fluids and tool wear Mechanisms
4. To apply knowledge of basic mathematics to calculate the machining paramet different machining processes.
5. To study process parameters and practice on arc and gas welding technologies.
6. To gain knowledge on the structure, properties, heat treatment, testing and applications ferrous and non ferrous metals.

Prerequisite: MET 204 - Manufacturing Process

Course Outcomes - At the end of the course students will be abl

CO 1	The students can operate different machine tools with understanding of work h and operating principles to produce different part features to the desired quality.
CO 2	Apply cutting mechanics to metal machining based on cutting force and p consumption.
CO 3	Select appropriate machining processes and process parameters for different metals.
CO 4	Fabricate and assemble various metal components by welding and students will be able to visually examine their work and that of others for discontinuities and defects.
CO 5	Infer the changes in properties of steel on annealing, normalizing, hardening and tempering

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	-	-	3	-	-	-	-	-	-	-	-	-
CO 2	-	3	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	2	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	2	-	-	-	-	-	-	-

Assessment Pattern

Bloom's taxonomy	Continuous Assessment Tests	
	Test 1 (Marks)	Test 2 (Marks)
Remember	20	20
Understand	10	10
Apply	30	30
Analyse	20	20
Evaluate	10	10
Create	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	75	75	2.5 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	15 marks
Regular class work/Laboratory Record and Class Performance	30 marks
Continuous Assessment Test	30 marks

7 K H   V W X G H Q W ¶ V   D V V H V V P H Q W   F R Q W L Q X R X V   H Y marks, oral examination etc. should be carried out only by the assistant professor or abov Any two experiments mentioned in part B, and any eight experiments in part A and to of minimum of ten experiments are to be performed.

End semester examination pattern

The Practical Examination will comprise of three hours. Oral examination should be conduct and distribution of marks will be decided by the examiners.

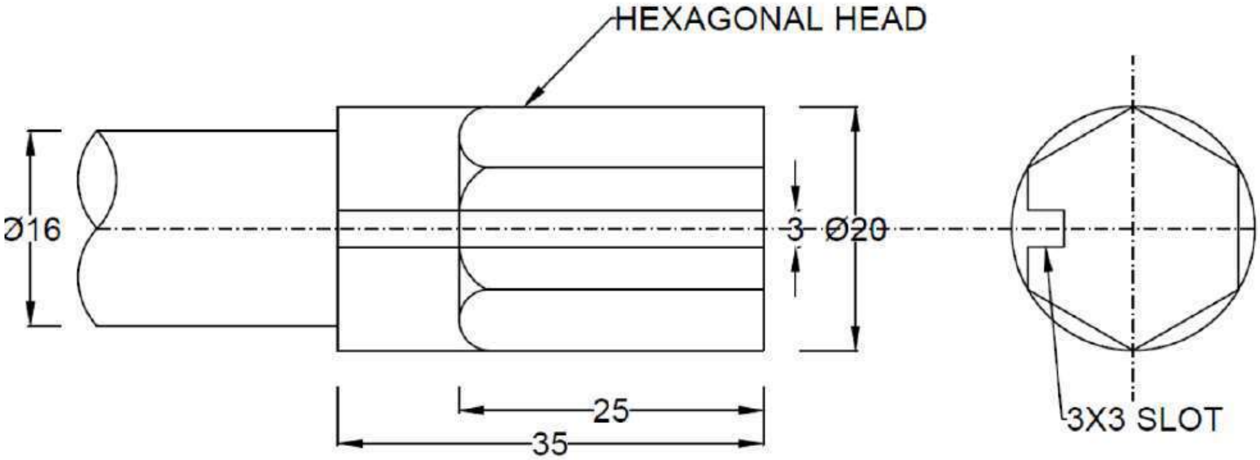
Conduct of University Practical Examinations

The Principals of the concerned Engineering Colleges with the help of Chairmen/Chairperson will conduct the practical examination with the approval from University and bonafide work / laboratory record, hall ticket, identity card issued by colle are mandatory for appearing practical University examinations. To conduct practical examination, an external examiner and an internal examiner should be appointed by th University.

END SEMESTER EXAMINATION
MODEL QUESTION PAPER

Maximum Marks : 75 Duration: 2.5 hours

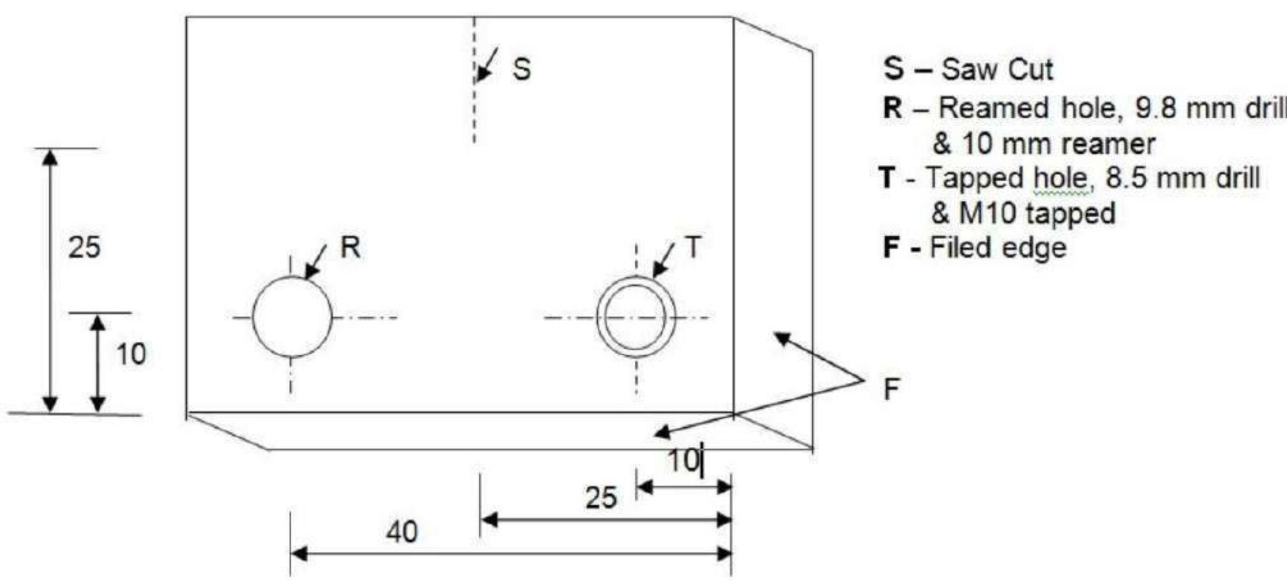
1. To machine the hexagonal head and the slot shown in the sketch on the specimen and measure the tool wear using toolmaker's microscope



ALL DIMENSIONS ARE IN MM

OR

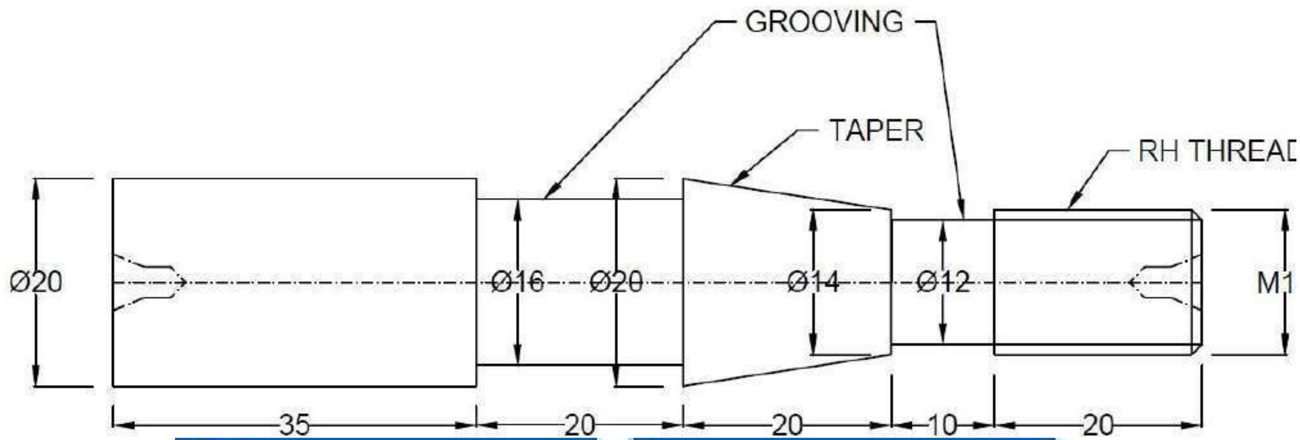
2. To drill, file, as shown in the sketch, ream and tap holes on the mild steel plate and measure the tool wear using toolmaker's microscope.



(All dimensions are in MM)

OR

3. To make the part shown in the sketch on a mild steel rod on a Lathe and measure the tool flank wear using toolmaker's microscope.



OR

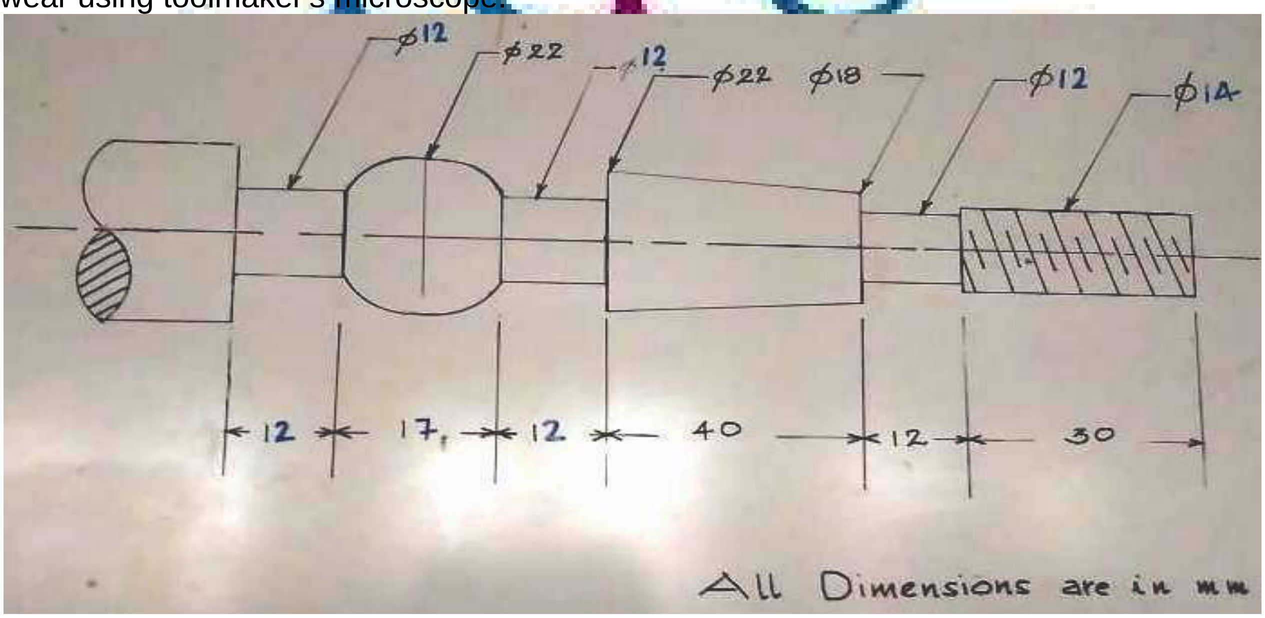
4. Prepare a metallurgical sample and determine the grain size using optical microscope.

OR

5. To prepare a butt joint with mild steel strips using suitable welding technique and infer on the welded joint.

OR

6. To make the part shown in the sketch on a mild steel rod on a Lathe and measure the tool fla
wear using toolmaker's microscope.



SYLLABUS

PART - A

Safety precautions in machine shop – Exercises on machine tools: turning, knurling, drilling, boring, reaming, trepanning, milling, hobbing, planning, shaping, slotting, broaching, grinding, lapping, honing etc. – Welding practice

PART - B

Metallurgy, heat treatment and testing.

Text Books:

1. $FKHUNDQ 1 6 ³0DFKLQH 7RRO´ 9RO , ,, ,,, DQ
2. HMT, Production Technology, Tata McGraw Hill.
3. W. A. J. Chapman, Workshop Technology Part I, ELBS & Edward Arnold Publishers.

Course content and drawing schedules.

	List of Experiments A minimum of ten experiments are to be carried out	Course outcomes	No. of hours
Experiments	PART -A (minimum eight experiments)		
1	Centre Lathe Study of lathe tools: - tool materials - selection of tool for different operations tool nomenclature and attributes each tool angles on cutting processes – effect of nose radius, side cutting edge angle, end cutting edge angle feed on surface roughness obtainable – tool grinding. x Study the different methods used to observe the -w piece is precisely fixed on lathe. x Study the optimum aspect - ratio of work-piece to avoid vibration and wobbling during turning. x Machine tool alignment test on lathe. x Re-sharpening of turning tool to specific geometry	CO 1	3
2,3,4,5,6	Exercises on centre lathe Facing, plain turning, step turnin and parting – groove cutting, knurling and chamfering - form turning and taper turning – eccentric turning, multi-start thread square thread and internal thread etc.	CO 1 CO 2	3
	Exercises on lathe: - Measurement of cutting forces in turni process and correlate the surface roughness obtainab varying feed, speed, feed, nose radius, side and end cutting e angles.		6

7	Measurement of cutting temperature and tool life in turning a machine tool alignment test on lathe machine	CO 2	3
86	Exercises on Drilling machine x Exercises on drilling machine - drilling, boring, reaming, taping and counter sinking etc. x Exercises on drilling machine.- Measurement of cuttin forces in drilling process and correlate with process parameters.	CO 1 CO 2	3
9	Exercises on Shaping machine x Exercises on shaping machine - flat surfaces, grooves ar key ways. Exercises on Slotting machine x Exercises on slotting machine - flat surfaces, grooves and key ways.	CO 2	3
10	Planing and Broaching machine Study and demonstration of broaching and hobbing machine. x Exercises on planing machine	CO 1	3
11	Exercises on Grinding machine x Exercise on surface grinding, cylindrical grinding and t grinding etc. x Measurement of cutting forces and roughness in grin process and correlate with process parameters. x Study and demonstration of lapping and honing machines	CO 1	3
12	Exercises on Welding machine x Exercises on arc and gas welding-butt welding and lap welding of M.S. sheets.	CO 4	3
	PART - B - Metallurgy (minimum two experiments)	CO 5	6
13	x Specimen preparation, etching & microscopic study o Steel, Cast iron and Brass and grain size measurement.		
14	x Heat treatment study: - Effect on mechanical propertie and microstructure of ferrous and non ferrous metals x Studies of various quenching mediums, Carryout heat treatments on steel based on ASM handbook vol.4 a observe the hardness obtained.	CO 5	6

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CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET202	THEORY OF MACHINES	VAC	3	1	0	4

Preamble:

Goal of this course is to expose the students to the fundamentals of kinematics of mechanisms, design of cams, theory and analysis of gears, gear trains, clutches, brakes. The students will also be exposed to velocity and acceleration analysis of different mechanisms. It provides the knowledge on balancing of rotating and reciprocating masses, Gyroscopes, Energy fluctuation in Machines

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Interpret basic principles of mechanisms and machines. Analyse a given mechanism based on velocity and acceleration. List the basic selection requirements of different types of mechanical clutches.
CO 2	Describe the theories of gears and gear trains. List the basic selection requirements of different types of mechanical brakes.
CO 3	Develop the profile of CAMs as per the requirements and understand cam profile.
CO 4	Explain the dynamic balancing of revolving and reciprocating masses. Describe the fundamentals of gyroscope and its application
CO 5	Analyse the performance of governors and flywheels.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	2		3						2
CO 2	3	3	2	2		3						2
CO 3	3	3	2	2		3						2
CO 4	3	3	3	2								1
CO 5	3	3	3	3		1						3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	30	40	80
Apply		10	10
Analyse	20		10
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 (CO1): Interpret basic principles of mechanisms and machines. Analyse a given mechanism based on velocity and acceleration. List the basic selection requirements of different types of mechanical clutches.

1. Explain the inversions of a four bar mechanism.
2. Explain with neat sketches, the working of single plate clutch.
3. The crank of a slider crank mechanism rotates clockwise at a constant speed of 300 r.p.m. The crank is 150 mm and the connecting rod is 600 mm long. Determine: 1. Linear velocity and acceleration of the midpoint of the connecting rod, and 2. angular velocity and angular acceleration of the connecting rod, at a crank angle of 45° from inner dead centre position

Course Outcome 2 (CO2): Describe the theories of gears and gear trains. List the basic selection requirements of different types of mechanical brakes.

1. State and prove the law of gearing
2. In an epicyclic gear train, an arm carries two gears A and B having 36 and 45 teeth respectively. If the arm rotates at 150 rpm in the anticlockwise direction about the centre of the gear A which is fixed, determine the speed of gear B. If the gear A instead of being fixed makes 300 rpm in the clockwise direction, what will be the speed of gear B?
3. Discuss the various types of the brakes

Course Outcome 3 (CO3): Develop the profile of CAMs as per the requirements and and to understand cam profile.

1. Explain the different classifications of cam and followers.
2. Draw the displacement, velocity and acceleration diagrams when the follower moves in SHM.
3. A cam with 30 mm as minimum diameter is rotating clockwise at a uniform speed of 1200 r.p.m. and has to give the following motion to a roller follower 10 mm in diameter:

   a) Follower to complete outward stroke of 25 mm during 120° of cam rotation with equal uniform acceleration and retardation;

   b) (b) Follower to dwell for 60° of cam rotation;

   c) (c) Follower to return to its initial position during 90° of cam rotation with equal uniform acceleration and retardation;

   d) (d) Follower to dwell for the remaining 90° of cam rotation.

   Draw the cam profile if the axis of the roller follower passes through the axis of the cam.

Course Outcome 4 (CO4): Explain the static and dynamic balancing of revolving and reciprocating masses Describe the fundamentals of gyroscope and its application

1. Four masses m1, m2, m3 and m4 are 200 kg, 300 kg, 240 kg and 260 kg respectively. The corresponding radii of rotation are 0.2 m, 0.15 m, 0.25 m and 0.3 m respectively and the angles between successive masses are 45°, 75° and 135°. Find the position and magnitude of the balance mass required, if its radius of rotation is 0.2 m.

2. Explain with neat sketches, the terms Swaying Couple and Hammer Blow.

3. A ship propelled by a turbine rotor which has a mass of 5000 kg and a speed of 2100 r.p.m. The rotor has a radius of gyration of 0.5 m and rotates in a clockwise direction when viewed from the stern. Find the gyroscopic effects in the following conditions:

   a. The ship sails at a speed of 30 km/h and steers to the left in a curve having 60 m radius.

   b. The ship pitches 6 degree above and 6 degree below the horizontal position. The bow is descending with its maximum velocity. The motion due to pitching is simple harmonic and the periodic time is 20 seconds.

   c. The ship rolls and at a certain instant it has an angular velocity of 0.03 rad/s clockwise when viewed from stern.

   Determine also the maximum angular acceleration during pitching. Explain how the direction of motion due to gyroscopic effect is determined in each case.

Course Outcome 5 (CO5): Analyse the performance of governors and flywheels.

1. The turning moment diagram for a petrol engine is drawn to the following scales : Turning moment, 1 mm = 5 N-m ; crank angle, 1 mm = 1°. The turning moment diagram repeats itself at every half revolution of the engine and the areas above and below the mean turning moment line taken in order are 295, 685, 40, 340, 960, 270 mm^2. The rotating parts are equivalent to a mass of 36 kg at a radius of gyration of 150 mm. Determine the coefficient of fluctuation of speed when the engine runs at 1800 r.p.m

2. Explain the different types of governors.

3. The arms of a Porter governor are each 250 mm long and pivoted on the governor axis. The mass of each ball is 5 kg and the mass of the central sleeve is 30 kg. The radius of rotation of the balls is 150 mm when the sleeve begins to rise and reaches a value of 200 mm for maximum speed. Determine the speed range of the governor. If the friction at the sleeve is equivalent of 20 N of load at the sleeve, determine how the speed range is modified.

SYLLABUS

Module 1: Kinematics - Links, mechanism, Degrees of freedom, Grashoff's law, Four-bar chain, Slider crank chain - Inversions and practical applications. Velocity and acceleration diagrams of simple mechanisms. Coriolis acceleration (Theory only). Friction clutch - Pressure and wear theories, pivot and collar friction, Single and multiple disc clutches.

Module 2: Gear – Classification of gears, Gear terminology, Law of gearing, Gear trains - Simple, compound gear trains and epicyclic gear trains. Brakes- Block and band brakes, self-energizing and self-locking in braking.

Module 3: Cams- Types of cams, cam profiles for knife edged and roller followers with and without offsets for SHM, constant acceleration-deceleration, and constant velocity

Module 4: Static and dynamic balancing of rotating mass- Single and several masses in different planes. Balancing of reciprocating mass. Gyroscope- Gyroscopic torque, gyroscopic stabilization of ships and aeroplanes.

Module 5: Governors- Types of governors- simple watt governor - Porter governor - Theory of Proell governor- Isochronism, hunting, sensitivity and stability. Flywheel- Turning moment diagrams, fluctuation of energy

Text Books

1. Ballaney P.L, Theory of Machines, Khanna Publishers,1994

2. S. S. Rattan, Theory of Machines, Tata McGraw Hill, 2009

3. V. P. Singh, Theory of Machines, Dhanpat Rai,2013

Reference Books

1. C. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education,2005
2. D. H. Myszka, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education,2013
3. G. Erdman, G. N. Sandor, Mechanism Design: Analysis and synthesis Vol I & II, Prentice Hall of India,1984.
4. Ghosh, A. K. Malik, Theory of Mechanisms and Machines, Affiliated East West Press,1988
5. J. E. Shigley, J. J. Uicker, Theory of Machines and Mechanisms, McGraw Hill,2010
6. Holowenko, Dynamics of Machinery, John Wiley,1995

COURSE PLAN

No	Topic	No. of Lectures
1	Module 1 (CO1)	
1.1	Introduction to link, constrained motions, mechanism, machine	1
1.2	Degrees of freedom Problem, Grashof's law	1
1.3	Inversion – Four Bar chain – Single Slider Chain Practical Applications	2
1.4	Velocity Analysis – I Centre Methos – Relative Velocity Method	2
1.5	Acceleration Analysis – Four Bar Mechanism – Single Slider Chain	2
1.6	Corriolis Component of Acceleration Quick Return Mechanisms	2
1.7	Clutches – Theories – Classifications	1
2	Module 2 (CO2)	
2.1	Gear – Classifications – Terminology – Law of Gearing – Velocity of Sliding – Interference – Problems	3
2.2	Gear Train – Classifications Problems on Epi cyclic gear trains	3
2.3	Brake – Theory – Classifications	2
3	Module 3 (CO3)	
3.1	Cam – Introduction – Classifications	1
3.2	Velocity and Acceleration Diagrams – Uniform Velocity – Uniform Acceleration and Deceleration – SHM – Calculations	2
3.3	Construction of Cam Profile	4
4	Module 4 (CO4)	
4.1	Static and dynamic balancing of rotating masses – Single and several masses in different plane	2
4.2	Balancing of reciprocating masses	3
4.3	Gyroscope – Introduction – Stabilization of Ships	2
4.4	Stabilization of Air Planes	2
5	Module 5 (CO5)	
5.1	Governors – Introduction – Classifications	2
5.2	Analytical Problems	2
5.3	Hunting – Sensitivity – Isochronism – Stability	2
5.4	Flywheels – Turning Moment Diagrams – Fluctuation of Energy	2
5.5	Analytical Problems	2

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET02

Course Name : THEORY OF MACHINES

Max. Marks : 100 Duration : 3 Hours

PART – A

(ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS)

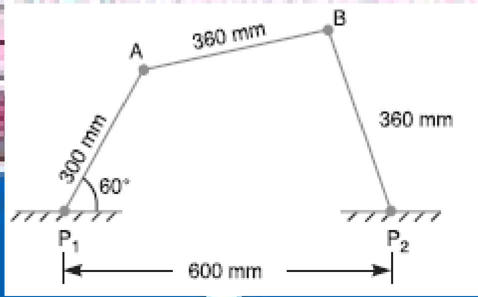
1. Write down the Kutzbach criterion of movability of plane mechanisms. Derive the Grubler's equation from it.
2. Explain the types of constrained motions with neat sketches.
3. With a neat sketch prove the common normal at the point of contact between a pair of teeth must always pass through the pitch point.
4. Explain the terms : (i) Module, (ii) Pressure angle, and (iii) Addendum.
5. Explain the different classifications of followers.
6. Define the following terms as applied to cam with a neat sketch :-(a) Base circle, (b) Pitch circle, (c) Pressure angle
7. Why reciprocating masses is cannot be completely balanced by revolving mass?
8. Derive the formula for the magnitude of gyroscopic couple.
9. Write down the differences between a gyroscope and a flywheel.
10. Explain the term hunting and isochronism.

PART – B

(ANSWER ONE FULL QUESTION FROM EACH MODULE)

MODULE – 1

11. The dimensions and configuration of the four bar mechanism, shown in Figure, are as follows : P_1A = 300 mm; P_2B = 360 mm; AB = 360 mm, and P_1P_2 = 600 mm. The angle AP_1P_2 = 60°. The crank P_1A has an angular velocity of 10 rad/s and an angular acceleration of 30 rad/s2, both clockwise. Determine the angular velocities and angular accelerations of P_2B, and AB and the velocity and acceleration of the joint B. (14 marks)



OR

12. a) With neat sketches explain the inversions of a four bar mechanism. (7 marks)

 b) Derive the equation for the corrioli's component of acceleration. (7 marks)

MODULE – 2

13. An internal wheel B with 80 teeth is keyed to a shaft F. A fixed internal wheel C with 82 teeth is concentric with B. A compound wheel D-E gears with the two internal wheels; D has 28 teeth and gears with C while E gears with B. The compound wheels revolve freely on a pin which projects from a disc keyed to a shaft A co-axial with F. If the wheels have the same pitch and the shaft A makes 800 r.p.m., what is the speed of the shaft F ? Sketch the arrangement. (14 marks)

OR

14. a) What do you mean by a self-energizing brake and self-locking brake. (4 Marks)

 b) A simple band brake operates on a drum of diameter 600 mm that is running at a speed of 200 rpm The coefficient of friction is 0.3. The brake band has an angle of contact of 270° One end of it is fastened to a fixed pin and the other end to the brake arm 125 mm and is placed perpendicular to the line bisecting the angle of contact.

 i. What is the effort necessary at the end of brake arm to stop the wheel if 30 kW power is absorbed? What is the direction of rotation of drum for minimum pull?

 ii. What is the width of steel band required for this brake if the maximum tensile stress is not to exceed 50 N/mm^2 and the thickness of band is 2.5 mm.

(10 marks)

MODULE – 3

15. A cam rotating clockwise at a uniform speed of 1000 r.p.m. is required to give a roller follower the motion defined below : 1. Follower to move outwards through 50 mm during 120° of cam rotation, 2. Follower to dwell for next 60° of cam rotation, 3. Follower to return to its starting position during next 90° of cam rotation, 4. Follower to dwell for the rest of the cam rotation. The minimum radius of the cam is 50 mm and the diameter of roller is 10 mm. The line of stroke of the follower is offset by 20 mm from the axis of the cam shaft. If the displacement of the follower takes place with uniform and equal acceleration and retardation on both the outward and return strokes, draw profile of the cam. (14 marks)

OR

16. From the following data, draw the profile of a cam in which the follower moves with simple harmonic motion during ascent while it moves with uniformly accelerated motion during descent : Least radius of cam = 50 mm ; Angle of ascent = 48° ; Angle of dwell between ascent and descent = 42° ; Angle of descent = 60° ; Lift of follower = 40 mm ; Diameter of roller = 30 mm ; Distance between the line of action of follower and the axis of cam = 20 mm. If the cam rotates at 360 r.p.m. anticlockwise, find the maximum velocity and acceleration of the follower during descent. (14 marks)

MODULE – 4

17. a) A shaft carries four masses A, B, C and D of magnitude 200 kg, 300 kg, 400 kg and 200 kg respectively and revolving at radii 80 mm, 70 mm, 60 mm and 80 mm in planes measured from A at 300 mm, 400 mm and 700 mm. The angles between the cranks measured anticlockwise are A to B 45°, B to C 70° and C to D 120°. The balancing masses are to be placed in planes X and Y. The distance between the planes A and X is 100 mm, between X and Y is 400 mm and between Y and D is 200 mm. If the balancing masses revolve at a radius of 100 mm, find their magnitudes and angular positions. (10 marks)

b) Explain the terms swaying couple and hammer blow (4 marks)

OR

18. A ship propelled by a turbine rotor which has a mass of 5000 kg and a speed of 2100 r.p.m. The rotor has a radius of gyration of 0.5 m and rotates in a clockwise direction when viewed from the stern. Find the gyroscopic effects in the following conditions: 1. The ship sails at a speed of 30 km/h and steers to the left in a curve having 60 m radius. 2. The ship pitches 6 degree above and 6 degree below the horizontal position. The bow is descending with maximum velocity. The motion due to pitching is simple harmonic and the periodic time is 20 seconds. 3. The ship rolls and at a certain instant it has an angular velocity of 0.03 rad/s clockwise when viewed from stern. Determine also the maximum angular acceleration during pitching. Explain how the direction of motion due to gyroscopic effect is determined in each case.

(14 marks)

MODULE – 5

19. a) A Porter governor has all four arms 250 mm long. The upper arms are attached on the axis of rotation and the lower arms are attached to the sleeve at a distance of 30 mm from the axis. The mass of each ball is 5 kg and the sleeve has a mass of 50 kg. The extreme radii of rotation are 150 mm and 200 mm. Determine the range of speed of the governor. (10 marks)

b) What is stability of a governor? How does it differ from sensitiveness? (4 marks)

OR

20. A three cylinder single acting engine has its cranks set equally at 120° and it runs at 600 r.p.m. The torque-crank angle diagram for each cycle is a triangle for the power stroke with a maximum torque of 90 N-m at 60° from dead centre of corresponding crank. The torque on the return stroke is sensibly zero. Determine : 1. power developed. 2. coefficient of fluctuation of speed, if the mass of the flywheel is 12 kg and has a radius of gyration of 80 mm, 3. coefficient of fluctuation of energy, and 4. maximum angular acceleration of the flywheel. (14 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET2 ô4	THERMODYNAMICS	VAC	3	1	-	4

Preamble:

Thermodynamics is the study of energy. Without energy life cannot exist. Activities from breathing to the launching of rockets involves energy transactions and are subject to thermodynamic analysis. Engineering devices like engines, turbines, refrigeration and air conditioning systems, propulsion systems etc., work on energy transformations and must be analysed using principles of thermodynamics. So, a thorough knowledge of thermodynamic concepts is essential for a mechanical engineer. This course offers an introduction to the basic concepts and laws of thermodynamics

Prerequisite NIL

Course Outcomes

After completion of the course the student will be able to

CO1	Understand basic concepts and laws of thermodynamics
CO2	Conduct first law analysis of open and closed systems
CO3	Determine entropy changes associated with different processes
CO4	Understand the application and limitations of the ideal gas equation of state
CO5	Determine change in properties of pure substances during phase change processes
CO6	Evaluate properties of ideal gas mixtures

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										2
CO2	2	2	1	1								1
CO3	3	3	2	2								1
CO4	2	2	2	2								1
CO5	3	3	2	1								1
CO6	3	3	2	2								1

Assessment Pattern

Blooms Category	CA			ESA
	Assignment	Test- 1	Test- 2	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

Mark distribution & Duration of Examination :

Total Marks	CA	ESE	ESE Duration
150	50	100	3 Hours

End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1

1. Discuss the limitations of first law of thermodynamics.
2. Second law of thermodynamics is often called a directional law . Why?
3. Explain Joule-Kelvin effect. What is the significance of the inversion curve ?

Course Outcome 2

1. A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas-tight, frictionless piston – cylinder device. The air is now compressed to a final pressure of 600 kPa . During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process.

2. Carbon dioxide enters an adiabatic nozzle steadily at 1 MPa and 500°C with a mass flow rate of 600 kg/hr and leaves at 100 kPa and 450 m/s. The inlet area of the nozzle is 40 cm^2. Determine (a) the inlet velocity and (b) the exit temperature.

3. Water is being heated in a closed pan on top of a range while being stirred by a paddle-wheel. During the process, 30 kJ of heat is transferred to the water and 5 kJ of heat is lost to the surrounding air. The paddle-wheel work amounts to 500 N-m. Determine the final energy of the system, if its initial energy is 10 kJ.

Course Outcome 3

1. An adiabatic vessel contains 2 [illegible] wheel work transfer, the [illegible] of water is assumed to be constant at 4.186 kJ/kg.K, find the entropy change of the universe.

2. Two kilograms of water at 80°C is mixed adiabatically with 3 kg of water at 30°C in a constant pressure process at 1 atm. Find the increase in entropy of the total mass of water due to the mixing process.

3. v]Œ}v o} l }(µvlv}Áv u•• š ôñö]• Œ}‰‰]vš} vof]v•µo š š Áš Œ š îìö X š šZ • -wheel driven by a 200 W motor is activated to stir the water. Then u o ‹µ]o] Œ]µu]• •š o]•Z (š Œ îì u]vµš• ÁZ v šZ (]v o Determine the mass of the iron block and the entropy generated during this process.

Course Outcome 4

1. Discuss the limitations of ideal gas equation.

2. Discuss law of corresponding states and its role in the construction of compressibility chart.

3. A rigid tank contains 2 kmol of N_2 and 6 kmol of CH_4 gases at 200 K and 12 MPa. Estimate the volume of the tank, using (a) ideal gas equation of state (b) the compressibility chart and Amagat's law

Course Outcome 5

í X ^š u]• šZŒ}ššo (Œ}u to 2.5 MPa. Determine the temperature of the steam at the end of the throttling process.

2. Determine the change in specific volume, specific enthalpy and quality of steam as saturated steam at 15 bar expands isentropically to 1 bar. Use steam tables

3. Estimate the enthalpy of vapourization of steam at 500 kPa, using the Clapeyron equation and compare it with the tabulated value

Course Outcome 6

1. A gaseous mixture contains , by volume, 21% nitrogen, 50% hydrogen and 29 % carbon dioxide. Calculate the molecular weight of the mixture, the characteristic gas constant of the mixture and the value of the reversible adiabatic expansion index v X š íì c_p values of nitrogen, hydrogen and carbon dioxide are 1.039, 14.235 and 0.828 kJ/kg.K respectively.

2. A mixture of 2 kmol of CO_2 v ï l u}o }( ]Œ]• }vš]v]v š v Treating õ õ l W v air to be a mixture of 79% N_2 and 21% O_2 by volume , calculate (a) the individual mass of CO_2, N_2 and O_2, (b) the percentage content of carbon by mass in the mixture and (c) the molar mass , characteristic gas constant and the specific volume of the mixture

3. A gas mixture in an engine cylinder has 12% CO_2, 11.5 % O_2 and 76.5% N_2 by volume. The u]Æšµ Œ š íìì Æ‰ v • Œ À Œ•] o $v^{1.25}$ = constant, to 7 times its initial volume. Determine the work transfer and heat transfer per unit mass of the mixture.

SYLLABUS

Module 1: Role of Thermodynamics and it’s applications in Engineering and Science – Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and }všŒ}o s}oµu U ^µŒŒ}µv]vPU }µv Œ] •U dÇ‰ • properties, }(^Ç•š u•U hv]À Process, Cycle, Thermodynamic Equilibrium, Quasi-static Process, State, Point and Path function. Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.

Module 2: Energy - Work - Pdv work and other types of work transfer, free expansion work, heat and heat capacity. Joule’s Experiment, First law of Thermodynamics, &]Œ•š o Á ‰‰o] š} E}v G}Á Process, Enthalpy - •‰]. Z PMM1, First law applied to Flow Process, Mass and Energy balance in simple •š Ç G}Á ‰Œ} ••X ‰ Limitations of the First Law.

Module 3: Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements, Equivalence of two statements, Reversibility, Irreversible Processes, Causes of Irreversibility, PMM2, Carnot’s theorem and its corollaries, Absolute Thermodynamic Temperature scale. Clausius Inequality, Entropy - Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Entropy generation, Entropy and Disorder, Reversible adiabatic process - isentropic process, Third law of thermodynamics

Module 4: Pure Substances, Phase Transformations, Triple point, properties during change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface, Saturation pressure and Temperature, T-h and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables. The ideal Gas Equation, Characteristic and Universal Gas constants, Limitations of ideal Gas Model: Equation of state of real substances, Compressibility factor, Law of corresponding state, Compressibility charts.

Module 5: Mixtures of ideal Gases – Mole Fraction, Mass fraction, Gravimetric and volumetric Analysis, Dalton’s Law of partial pressure, Amagat’s Laws of additive volumes, Gibbs-Dalton’s law Equivalent Gas constant and Molecular Weight, Properties of gas mixtures: Internal Energy, všZ o‰ÇU •‰]. Z General Thermodynamic Relations – Combined First and Second law equations – Helmholtz and Gibb’s functions - Maxwell’s Relations, Tds Equations. The o ‰ ÇŒ}v ‹µ š]}vU ‹µ š]}v• (}Œ]vš Œv o v ŒPÇU všZ o‰Ç v ‰Œ} ••U :}µo dZ}u•}v } 8] všU]vÀ Œ•]}v µŒÀ X

Text Books

1. P. K.Nag, Engineering Thermodynamics, McGraw Hill, 2013

2. E.Rathakrishnan Fundamentals of Engineering Thermodynamics, PHI, 2005

3. Y. A. Cengel and M. A.Boles, Thermodynamics an Engineering Approach, McGraw Hill, 2011

Reference Books:

1. Moran J., Shapiro N. M., Fundamentals of Engineering Thermodynamics, Wiley, 2006

2. R. E. Sonntag and C. Borgnakke, Fundamentals of Thermodynamics, Wiley, 2009

3. Holman J. P. Thermodynamics, McGraw Hill, 2004

4. M. Achuthan, Engineering Thermodynamics, PHI, 2004

COURSE PLAN

Module	Topics	Hours Allotted
1	Role of Thermodynamics and it's applications in Engineering and Scie Basic Concepts Macroscopic and Microscopic viewpoints, Concept of }vš]vµµuU dZ Œu} Çv u] ^Ç•š u v }všŒ}o s}oµu U ^µŒŒ Boundaries, Types of Systems, Universe	2L
	Thermodynamic properties, Process, Cycle, Thermodynamic Equilibri Quasi – static Process, State, Point and Path function.	2L
	Zeroth Law of Thermodynamics, Measurement of Temperature, refere Points, Temperature Scales.	2L + 1T
2	Energy - Work - Pdv work and other types of work transfer, free expans work, heat and heat capacity.	2L +1T
	Joule's Experiment - First law of Thermodynamics - First law applied to E}v G}Á W Œ} - Enthalpy • ‰] ... – PMM1	2L +1T
	First law applied to Flow Process, Mass and Energy balance in simple •š Ç G}Á ‰Œ} ••X ‰‰ limitations of first law &	2L +1T
3	Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, H pump – Kelvin-Planck and Clausius Statements, Equivalence of two statements	3L
	Reversibility, Irreversible Process, Causes of Irreversibility, PMM2, Carnot's theorem and its corollaries, Absolute Thermodynamic Temperature scale.	2L + 1T
	Clausius Inequality, Entropy - Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Entropy generation, Entropy and Disorder, Reversible adiabatic process- isentropic process, Third law of thermodynamics	2L + 2T
4	Pure Substances, Phase Transformations, Triple point, properties during change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface,	3L
	Saturation pressure and Temperature, T-h and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables	2L +1T

	The ideal Gas Equation, Characteristic and Universal Gas constants, Limitations of ideal Gas Model: Equation of state of real substances, Compressibility factor, Law of corresponding state, Compressibility ch	2L +1T
5	Mixtures of ideal Gases – Mole Fraction, Mass fraction, Gravimetric and volumetric Analysis, Dalton's Law of partial pressure, Amagat's Laws of additive volumes, Gibbs-Dalton's law.	2L
	Equivalent Gas constant and Molecular Weight, Properties of gas u]Æšµ Œ •W /vš Œv o v ŒPÇU všZ o‰ÇU •‰]. Z š• v	2L +1T
	General Thermodynamic Relations – Combined First and Second law equations – Helmholtz and Gibb's functions - Maxwell's Relations	2L
	Tds Equations. The Clapeyron Equation, equations for internal energy všZ o‰Ç v všŒ}‰ÇU •‰]. Z š•U dZŒ}ššo]vP ‰Œ} •• Coe8cient, inversion curve.	2L + 1T

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET2 ô4

Course Name : THERMODYNAMICS

(Permitted to use Steam Tables and Mollier Chart)

Max. Marks : 100 Duration : 3 Hours

Part – A

Answer all questions

1. Define thermodynamics. List a few of its applications

2. Differentiate between intensive and extensive properties.

3. Differentiate between heat and work

4. Explain system approach and control volume approach as applied in the analysis of a flow process.

5. An inventor claims to have developed an engine that delivers 26 kJ of work using 82 kJ of heat while operating between temperatures 120°C and 30°C. Is his claim valid ? Give the reason for your answer.

6. Show that two reversible adiabatics cannot intersect

7. Define (i) critical point and (ii) triple point, with respect to water

8. Why do real gases deviate from ideal gas behaviour? When do they approach ideal behaviour?

9. Define Helmholtz function and Gibbs function and state their significance

10. State Dalton's law and Amagat's laws for ideal gas mixtures.

(3 x 10 = 30 marks)

Part – B

Answer any two full questions from each module.

Module - 1

11. a] Explain macroscopic and microscopic approach to thermodynamics . (7 marks)

b] With the aid of a suitable diagram, explain the working of constant volume gas thermometer. (7 marks)

OR

12. a] What is meant by thermodynamic equilibrium ? What are the essential conditions for a system to be in thermodynamic equilibrium ? (7 marks)

b] Express š Z š u‰ Œ šµŒ }(õíö]v ~]• & Œ vZ] š ~]] marks) oÀ]v ~]]]

Module – 2

13.a] A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas – tight, frictionless piston – cylinder device. The air is now compressed to a final pressure of 600 kPa . During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process. (7 marks)

a] Air enters a 28 cm diameter pipe steadily at 200 kPa and 20°C with a velocity of 5m/s. Air is heated as it flows and leaves the pipe at 180 kPa and 40°C. Determine (i) the volume flow rate of air at the inlet (ii) the mass flow rate of air and (iii) the velocity and volume flow rate at the exit. (7 marks)

OR

14.a] A turbine operates under steady flow conditions, receiving steam at the following conditions : pressure 1.2 MPa, temperature 188°C, enthalpy 2785 kJ/kg, velocity 33.3 m/s and elevation 3m. The steam leaves the turbine at the following conditions : pressure 20 kPa, enthalpy 25kJ/kg, velocity 100 m/s, and elevation 0 m. Heat is lost to the surroundings at the rate of 0.29 kJ/s. If the rate of steam flow through the turbine is 0.42 kg/s, what is the power output of the turbine in kW ? (7 marks)

b] Derive the steady flow energy equation, stating all assumptions. (7 marks)

Module – 3

15.a] State the Kelvin-Planck and Clausius statements of the second law of thermodynamics and prove their equivalence. (7 marks)

b] A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which the engine rejects heat to it. If the efficiency of the engine is 40 % of the maximum possible and the COP of the heat pump is 50 % of the maximum possible, what is the temperature of the reservoir to which the heat pump rejects heat ? What is the rate of heat rejection from the heat pump, if the rate of heat supply to the engine is 50kW ? (7 marks)

OR

16.a] A house is to be maintained at 21°C during winter and at 26°C during summer. Heat leakage through the walls, windows and roof is about 3000 kJ/hr per degree temperature difference between the interior of the house and the environment. A reversible heat pump is proposed for realising the desired heating and cooling. What is the minimum power required to run the heat pump in the reverse, if the outside temperature during summer is 36°C? Also find the lowest environment temperature during winter for which the inside of the house can be maintained at 21°C consuming the same power. (8 marks)

b] Give the Nernst statement of the third law and explain its significance. (6 marks)

Module – 4

17.a]Show the constant pressure transformation of unit mass of ice at atmospheric pressure and -îìö š} •µ‰ŒZ š •š -v, Tv and PT coordinate systems and explain their salient features . (8 marks)

b]Nitrogen enclosed in a piston cylinder arrangement is at a pressure of 2 bar and temperature 75°C. Calculate the specific volume of Nitrogen using ideal gas equation. What would be the specific volume of this Nitrogen , if its compressibility factor at the prevailing condition is 0.9. . (6 marks)

OR

18.a]Steam at 25 bar and ìì ö Æ‰ v •]• všŒ}‰] o o Ç š} ñ ŒX o µ o š šZ volume and temperature of unit mass of steam during this process using steam tables and Mollier chart and compare the values (8 marks)

b]Explain law of corresponding states and its significance to the generalized compressibility chart. (6 marks)

Module – 5

19.a] Derive the expressions for the equivalent molecular weight and characteristic gas constant for a mixture of ideal gases (6 marks)

b]ìXñ lP }(, o]µu v ìXñ lP }(E]šŒ}P v Œ u]Æ š îìö v š Find (i) volume of the mixture (ii) partial volumes of the components (iii) partial pressures of the components (iv) the specific heats of the mixture and (v) the gas constant of the mixture. Take ratio of specific heats for Helium and Nitrogen to be 1.667 and 1.4 respectively. (8 marks)

OR

20.a] 2 kg of carbon dioxide at 38°C and 1.4 bar is mixed with 5 kg of nitrogen at 150°C and 1.03 bar to form a mixture at a final pressure of 70 kPa. The process occurs adiabatically in a steady flow apparatus. Calculate the final temperature of the mixture and the change in entropy during the mixing process. Take specific heat at constant pressure for CO_2 and N_2 as 0.85 kJ/kgK and 1.04 kJ/kgK respectively. (7 marks)

b] Derive the Maxwell relations. Explain their significance? (7 marks)

MET 2 6	MANUFACTURING TECHNOLOGY (MINOR)	CATEGORY	L	T	P	Credits	Year of Introduction
		VAC	3	1	0	4	2019

Preamble:

1. To understand basic manufacturing processes of casting and welding.
2. Provide a detailed discussion on the welding process and the physics of welding.
3. To understand mechanisms of material removal in LBM and EBM process
4. To introduce the different forming process of forging, extrusion and drawing.
5. To introduce the different fabrication of microelectronic devices

Prerequisite: MET 255 - Material Science & Technology (Minor)

Course Outcomes - At the end of the course students will be abl

CO 1	Illustrate the basic principles of foundry practices and special casting processes, th advantages, limitations and applications
CO 2	Categorize welding processes according to welding principle and material
CO 3	Understand the advantages of LBM and EBM over fusion welding process
CO 4	An ability to understand the principles of the basic microelectronic proce technology.
CO 5	Learn about key aspects of the microelectronics industry, from device desi processing, to photolithography, to manufacturing and packaging. Students will com out knowing the core processes of ion implantation, diffusion, oxidation, depos etching, including the fundamental physical mechanisms, and the nec understanding for using these processes in a manufacturing environ

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-		-	-
CO 2	-	-	-	-	-	-	-	-	-	-	-	2
CO 3	-	-	3	-	-	-	-	-	-	-	-	-
CO 4	-	-	-	3	-	-	-	-	-	-	-	-
CO 5	-	4	-	-	-	-	-	-	-	-	-	-

ASSESSMENT PATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test I (Marks)	Test II (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyze	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments	15 marks
Continuous Assessment Test (2 numbers)	25 marks

End semester pattern:- There will be two parts; Part A and Part B. Part A contain questions with 2 questions from each module, having 3 marks for each ques Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):- Illustrate the basic principles of foundry practices ar special casting processes, their advantages, limitations and applications.

1. Explain Why casting is an important manufacturing processes
2. Name the important factors in selecting sand for molds.
3. Why does die casting produce the smallest cast parts?
4. What is the difference between sand mold and shell mold casting?

Course Outcome 2 (CO2):Categorize welding processes according to welding principle material.

1. Describe the functions and characteristics of electrodes. What functions do coatings have? electrodes classified?
2. Describe the role of filler metals in welding.
3. Explain the significance of the stiffness of the components being welded on both weld qua part shape.

Course Outcome 3 (CO3):Understand the advantages of LBM and EBM over fusion welding process.

1. What is the power of LBM and EBM used for welding?
2. Why LBM and EBM are better quality than fusion welding?
3. What is the HAZ of LBM as compared to fusion welding process.

Course Outcome 4 (CO4): An ability to understand the principles of the basic microelectron processing technology.

1. Why is silicon the semiconductor most used in IC technology?
2. Define selectivity and isotropy and their importance in relation to etching.
3. Explain the differences between wet and dry oxidation.
4. How is epitaxy different from other techniques used for deposition? Explain.

Course Outcome 5 (CO5):Learn about key aspects of the microelectronics industry, from d design, to processing, to photolithography, to manufacturing and packaging. Students will come out knowing the core processes of ion implantation, diffusion, oxidation, deposition, etching, includ fundamental physical mechanisms, and the necessary understanding for using these proce manufacturing environment.

1. Describe bulk and surface micromachining.
2. Lithography produces projected shapes, so true three dimensional shapes are more di produce. What lithography processes are best able to produce three dimensional shapes, such lenses? Explain.
3. Explain how you would produce a spur gear if its thickness was one-tenth of its diameter and i diameter was (a) 10 um, (b) 100 um, (c) 1 mm, (d) 10 mm, and (e) 100 mm.

SYLLABUS

Module I

Metal casting: sand casting: shell molding, evaporative pattern casting, investment casting, permanent mold casting, vacuum casting, slush casting, pressure casting, die casting, centrifugal casting, squeez casting, semi solid metal forming, casting for single crystal, casting defects.

Module II

Powder metallurgy-powder production methods, powder characteristics, blending, mixing compaction of metal powders, sintering fundamentals and mechanisms, infiltration and impregnation Welding: arc welding non consumable electrodes, heat affected zone, quality, case study and weld ability of metals.

Module III

Consumable electrodes, electron and laser beam welding, heat affected zone, power density, weld quality, case study, applications - Brazing - filler metals, fluxes, joint strength; brazing metho applications - Soldering - solders and fluxes soldering methods solder ability, case study, typic joint designs, applications.

Module IV

Metal forging: quality, defects - Metal extrusion: process, defects, applications Metal drawing process, drawing practice, defects, applications - Fabrication of microelectronic devices crystal growing and wafer preparation - Film deposition - oxidation - Photolithography

Module V

Different lithography methods Etching wet etching dry etching - diffusion and Ion implantation - metallization and testing wire bonding and packing yield and reliability - fabrication of micro electro mechanical devices

Text Books

1. Serope Kalpakjian, Steven R. Schmid - Manufacturing Engineering and Technology, seventh edition, Pearson.

Reference

1. https://nptel.ac.in/courses/103106075/
2. Principles of Metal Casting ±Hine and Rosenthal
3. Materials and Processes in Manufacturing - Paul Degarma E and Ronald A. Kosher
4. Manufacturing Technology Foundry, Forming and Welding - P. N. Rao

MODEL QUESTION PAPER

MANUFACTURING PROCESS - MET 2 6 Max. Marks : 100 Duration : 3 Hours

Part ±A

Answer all questions.

Answer all questions, each question carries 3 marks

1. What are composite molds? Why are they used?
2. What are the advantages of pressure casting over other processes?
3. Describe what occurs to metal powders during sintering.
4. Explain the basic principles of arc-welding processes.
5. Are fluxes necessary in brazing? If so, why?
6. Soldering is generally applied to thinner components. Explain Why.
7. Why is control of the volume of the blank important in closed-die forging?
8. Define selectivity and isotropy and their importance in relation to etching.
9. Describe the difference between isotropic etching and anisotropic etching.
10. What is the difference between chemically reactive ion etching and dry-plasma etching?

PART -B

Answer one full question from each module.

MODULE -1

11. Explain why squeeze casting produces parts with better mechanical properties, dime accuracy, and surface finish than do expendable-mold processes (14 marks).

OR

12. Explain different types of casting defeats in detail (14 marks).

MODULE -2

13. a. Explain the difference between impregnation and infiltration. Give some applications o (7 marks).
    b. Describe the relative advantages and limitations of cold and hot isostatic pre (7 marks).

OR

14. Explain the factors that contribute to the differences in properties across a welded (14 marks).

MODULE -3

15. a. What are the principles of (a) wave soldering and (b) reflow soldering? (7 marks).
    b. It is common practice to tin-plate electrical terminals to facilitate soldering. Why is it tin t is used? (7 marks).

OR

16. Examine various household products and describe how their components are joined a assembled. Explain why those particular processes were used and not others (14 marks).

MODULE -4

17. a. Describe the factors involved in precision forging (7 marks).
    b. Explain why cold extrusion is an important manufacturing process (7 marks).

OR

18. a. A common problem in ion implantation is channeling, in which the high-velocity ions travel deep into the material via channels along the crystallographic planes before finally stopped. How could this effect be avoided? Explain (7 marks).
    b. Describe your understanding of the important features of clean rooms and how they ar maintained (7 marks).

MODULE -5

19. a. List the advantages and disadvantages of surface micromachining compared wi micromachining (7 marks).
    b. What is the difference between chemically reactive ion etching and plasma etching? (7 marks).

OR

20. a. What is the main limitation to successful application of MEMS? (7 marks).
    b. What is the purpose of a spacer layer in surface micromachining? (7 marks).

Course content and lecture schedules.

Module	TOPIC	No. of hours	Course outcomes
1.1	Metal casting: sand casting: sand, types of sand mold, pattern, co casting operations.	2	CO1
1.2	Shell molding, plaster and ceramic mold casting; evaporative patte casting, investment casting,	3	CO1 CO5
1.3	Permanent mold casting, vacuum casting, slush casting, pressure c die casting,	2	

1.4	Centrifugal casting, squeeze casting, semi solid metal formi- applications of each process.	2	CO1
1.5	Casting for single crystal, applications of each process, casting defects.	1	
2.1	Powder metallurgy- powder production methods, atomization, reduct electrolytic deposition, carbonyls, comminution.	2	CO2
2.2	Powder characteristics: particle size, shape and distribution	1	CO2 CO5
2.3	Blending, mixing and compaction of metal powders, isostatic pressin	2	CO2
2.4	Sintering fundamentals and mechanisms, filtration and impregnation.	1	
2.5	Welding: arc welding non consumable electrodes, heat transfer i welding, gas tungsten arc, plasma arc and atomic hydrogen welding, heat affected zone, weld ability, weld quality, applications of each processes	3	CO4 CO5
3.1	Consumable electrodes- shielded metal, submerged, gas metal welding, heat affected zone, weld ability, weld quality, applications of each processes	3	CO4
3.3	Electron and laser beam welding, heat affected area, power density quality, heat affected zone, case study, applications of each processes	1	
3.4	Brazing- filler metals, fluxes, joint strength; brazing methods, torc furnace, induction, resistance, dip brazing, applications of each processes	2	CO4
3.5	Soldering- types of solders and fluxes, different soldering methods solder ability, case study, typical joint designs, applications of each processes	2	CO4
4.1	Metal forging- open die, impression die, closed die, precision die, qua defects.	3	CO4
4.2	Metal extrusion- process, hot, cold, impact and hydrostatic extrus defects, applications. Metal drawing process, drawing practice, defects, applications of each processes	3	
4.3	Fabrication of microelectronic devices- clean rooms- semiconductors an silicon- crystal growing and wafer preparation	2	CO4
4.4	Film deposition- oxidation- Photo lithography	1	
5.1	electron beam lithography, X-ray, Ion beam, photo resistant lithograpl scattering with angular limitations projection electron beam lithograph	1	CO4
5.2	Etching- wet etching- isotropic etchants, anisotropic etching- dry etching- sputter, reactive plasma, physical chemical and cryogenic etching.	2	CO4
5.3	Diffusion and Ion implantation- metallization and testing- Wire bonding and packing- yield and reliability- printed circuit boards	3	CO4 CO5
5.4	Fabrication of micro electro-mechanical devices- micromachining of MEMS devices: bulk and surface micro machining, single crystal sil reactive etching and metallization, silicon micromachining by single plasma etching, etching combined with diffusion bonding with suitab example and applications.	3	CO4

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CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET2 õ2	CONTINUUM MECHANICS	VAC	3	1	0	4

Preamble:

At the end of the course the students will have comprehensive, systematic and integrated knowledge of the principles of continuum mechanics. They be conversant with physical laws and analytical tools such as tensor calculus required to formulate and solve continuum problems. Also they have an in-depth understanding of the common principles which underlie the disciplines of solid mechanics and fluid mechanics – hitherto considered mostly separate.The course equip the students to pursue further specialized areas of study such as aeroelasticity, nonlinear mechanics, biomechanics etc. which are essentially based on continuum mechanics.

Prerequisite

MECHANICS OF SOLIDS

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Make use of the concepts of tensor formalism for practical applications
CO 2	Apply deformation and strain concepts for practical situations
CO 3	Identify stresses acting on components subjected to complex loads
CO 4	Make use of fundamental laws for problem formulations and mathematical modeling
CO 5	Develop constitutive relations and solve 2 D elasticity problems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3				2				2			3
CO 2	3	3	3		2	1			2			3
CO 3	3	3	3		2	1			2			3
CO 4	3								2			3
CO 5	3	3	3		2	1			2			3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1

1. With the help of mathematical derivations obtain the relation between circulation of a vector field per unit area around a point in a plane and curl of the vector.
2. Prove the vector identity Q× (R× S) = (Q S) R F(Q R) S
3. Show that a) ÜR = R b) Ü #= #

Course Outcome 2

1. Discuss the physical interpretations of components of Linearized strain tensor.
2. Given the displacement components $Q_5 = G\,T_6^6$, $Q_6 = 0$, $Q_7 = 0$, $G = 10^{?8}$, obtain infinitesimal strain tensor E
3. Given $T_5 = :_5 + 2:_6$, $T_6 = :_6$, $T_7 = :_7$, obtain the right Cauchy Green deformation tensor, right stretch tensor and rotation tensor.

Course Outcome 3

1. Given a continuum, where the stress state is known at one point and is represented by the Cauchy stress tensor components $c\,\hat{e}_{ij}g = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 2 \end{bmatrix}$ Pa, find the principal stresses and principal directions.
2. The stress state at one point is represented by the Cauchy stress components $c\,\hat{e}_{ij}g = \begin{bmatrix} \hat{e} & =\hat{e} & \hat{e} \\ =\hat{e} & \hat{e} & ?\hat{e} \\ >\hat{e} & ?\hat{e} & \hat{e} \end{bmatrix}$, where $=, >, ?$ constants are and $\hat{e}$ is the value of the stress. Determine the constants such that the traction vector on the octahedral plane is zero.
3. Find the maximum principal stress, maximum shear stress and their orientations for the state of stress given $c\,\hat{e}_{ij}g = \begin{bmatrix} 6 & 9 & 0 \\ 9 & F6 & 0 \\ 0 & 0 & 3 \end{bmatrix} / 2 =$

Course Outcome 4

1. Explain Reynold's Transport Theorem
2. Prove the symmetry of stress using principle of conservation of angular momentum.
3. Obtain the Eulerian form of continuity equation.

Course Outcome 5

1. From linear elastic constitutive relation for isotropic materials, deduce the strain stress relation $Y_{ij} = \frac{5>}{¾}\,\hat{e}_{ij}\,F\,\frac{-}{¾}\,\hat{e}_{pp}\,U_{ij}$
2. Formulate the stress compatibility equation for plain strain problems in the absence of body force.
3. Derive the stress compatibility equation for a plain stress problem with body force. State the condition under which it becomes the biharmonic equation.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

IV SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET2 õ2

Course Name: CONTINUUM MECHANICS

PART A

Each question carries three marks

1. Differentiate between vector space and inner product space
2. Prove div (A x B) = curl A.B – curl B.A, using indicial notation.
3. Differentiate between Lagrangian and Eulerian description of fluid motion.
4. The Lagrangian coordinate of a material particle is (T(P), U(P), V(P)). Obtain the mathematical expression for the component of acceleration along the direction of motion of the material particle.
5. Derive an equation for octahedral shear stress in terms of the stress invariants.
6. The Cauchy stress tensor at a point P is given by $\begin{bmatrix} 5 & 6 & 7 \\ 6 & 8 & 9 \\ 7 & 9 & 2 \end{bmatrix}$ GPa. Obtain the deviatoric and volumetric parts of the tensor.
7. Deduce the equilibrium equations from linear momentum principle.
8. Express the local and global form of Reynold's Transport Theorem.
9. Write down the stress strain relations of a linear elastic isotropic material.
10. Write down the radial and tangential components of stress in terms of Airy's stress function.

PART B

Answer one full question from each module.

MODULE 1

11 a) Evaluate using indicial notation (8)

i. × (×)

ii. ( ) ÷( )

b) Expand using summation convention (6)

iii. é R Ü = 6 é > Ü + ê ÜÝÝ

iv. A Ü = 3à Ü Aà

OR

12 a) Prove that [# $ %& ' ( ] = [#.& #' #.(; $.& $' $.(; %& %' %( ], from there show that

Ay Ap = N Üå Üæ Üç ; Üå Üæ Üç ; Üå Üæ Üç O (9)

b) Establish the identity Ay Ap = Üå Üå F Üå Üå (5)

MODULE 2

13 a) Given the motion of a body T = : + 0.2 P Ü for a temperature field given by à = 2 T_5 + (T_6)^6, find the material description of temperature and the rate of change of temperature of a particle at time t=0 , which was at the place (0,1,0). (8)

b) Derive compatibility equation (6)

OR

14 a) Given that [ ] = [3√3 1 0 ; 0 2 0 ; 0 0 1], determine the left and right stretch tensors. (14)

b) Explain infinitesimal deformation theory.

c) Obtain an expression for Linearized strain.

MODULE 3

15 a) The stress matrix in MPa when refereed to axes T_5 T_6 T_7 is (14)

$$c \hat{e} g = \begin{bmatrix} 3 & 10 & 0 \\ 10 & 0 & 30 \\ 0 & 30 & -27 \end{bmatrix}$$

Determine

i. the principal stresses
ii. principal planes
iii. maximum shear stress
iv. Octahedral normal and shear stress

OR

16 a) The principal stresses of stress at a point are σ_1, σ_2 and σ_3 with $\sigma_1 > \sigma_2 > \sigma_3$. Now derive equations of the direction cosines of a plane passing through this point, which is subjected to normal and shear stress σ_n and τ_n respectively. (6)

b) For the stress state given

$$[\sigma_{ij}] = \begin{bmatrix} 12 & 9 & 0 \\ 9 & -12 & 0 \\ 0 & 0 & 6 \end{bmatrix}$$

where the Cartesian coordinate variables x_i are in meters and the unit of stress are MPa. Determine the principal stresses and principal directions of stress at the point $x = e_1 + 2e_2 + 3e_3$. (8)

MODULE 4

17 a) Derive the differential form of conservation of energy. (4)

b) What is localization theorem? Write down its relevance in the derivation of differential equations. (6)

c) Derive the Cauchy's equation of motion using the conservation of linear momentum principle (4)

OR

18 a) Prove the symmetry of stress $\sigma_{ij} = \sigma_{ji}$ using principle of conservation of angular momentum. (8)

b) Obtain the Eulerian form of continuity equation. (6)

MODULE 5

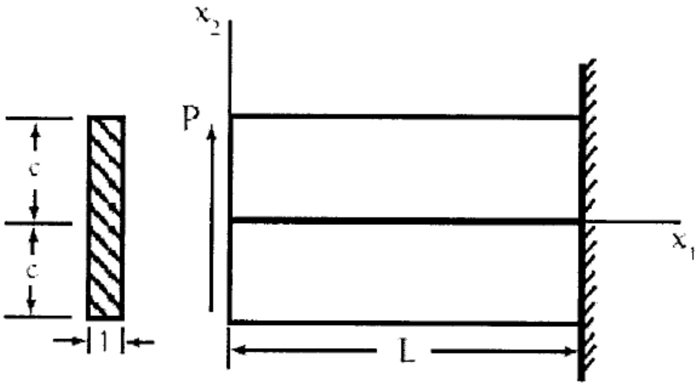
19 a) Show that for an isotropic elastic medium (6)

a. $\lambda = \frac{\nu E}{(1+\nu)(1-2\nu)}$ b) $\mu = \frac{E}{2(1+\nu)}$

b. Determine the radial stress and tangential stress developed in a thick cylinder of internal radius "a" and external radius "b" subjected internal pressure p_i and external pressure p_o using stress function method. (8)

OR

20 Consider a special stress function having the form $\phi = \$_6 T_5 T_6 + \&_8 T_5 T_7$. Show that this stress function ma)'be adapted to solve for the stresses in an- end loaded cantilever beam as shown in the sketch. Assume the body forces are zero for this problem. (14)



SYLLABUS

Module 1

Mathematical preliminaries -Index notation, Einstein's summation convention- Kronecker delta and Levi-Civita symbols, Cartesian basis-Concept of tensor- Tensor as a linear transformation - Vector as a first order tensor-Coordinate transformation of vectors and tensors.

Principal values, trace and invariants-Gradient, divergence and curl of vector and tensor fields-Vector identities-Gauss' divergence and Stokes' theorems.

Module 2

Concept of continua-Reference and current configuration-Deformation gradient tensor-Lagrangian and Eulerian description of motion.

Polar decomposition theorem- Right and left Cauchy Green tensors- Infinitesimal deformation theory- Linearized strain- Principal strains Saint Venant's compatibility equations

Module 3

Traction- Cauchy stress tensor-Stress component along orthonormal basis vector-Components of Cauchy stress tensor on any plane.

Principal planes- Principal stress components-Normal and shear stresses-Stress transformation- Equilibrium equations

Module 4

Balance Laws Reynold's transportation theorem-Localization theorem-Lagrangian and Eulerian forms of equation for mass balance.

Balance of linear momentum equation-Balance of angular momentum-Symmetry of stress tensor-Balance of energy

Module 5

Constitutive relations-Generalized Hooke's law for isotropic materials in indicial and matrix forms- Relation connecting Lame's constants with Young's modulus, Poisson's ratio and Bulk modulus.

2D formulation of field equations; Airy's stress function-Biharmonic equation-Uni axial tension and pure bending of a beam; End loaded cantilever-Polar coordinates-Axisymmetric formulation-Lame's thick cylinder problem-Quarter circle cantilevered beam with radial load.

Text Books

1. G. Thomas Mase, George E. Mase.. Ronald E. Smelser. Continuum mechanics for engineers 3rd ed CRC Press
2. . Lawrence E. Malvern. Introduction to the Mechanics of a Continuous Medium – Prentice Hall

Reference Books

1. J.H. Heinbockel, Introduction to Tensor Calculus and Continuum Mechanics – Open Source
2. W. Michael Lai, David Rubin, Erhard Kaempl, Introduction to Continuum Mechanics 4th Ed., Butterworth-Heinemann
3. J. N. Reddy, An Introduction to Continuum Mechanics with applications – Cambridge University Press
4. Y. C. Fung, A First Course in Continuum Mechanics for Physical and Biological Engineers and scientists – Prentice Hall
5. Han-Chin W, Continuum mechanics and plasticity – CRC Press
6. Sudhakar Nair, Introduction to Continuum Mechanics – Cambridge University press
7. Morton E. Gurtin, An introduction to continuum mechanics, Academic Press
8. S.P. Timoshenko., J.N. Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Publishing

COURSE CONTENTS AND LECTURE SCHEDULE

Sl. No.	Topic	Number of lecture hours
1	Index notation, Einstein's summation convention- Kronecker delta and Levi-Civita symbols	2
2	Cartesian basis- Concept of tensor- Tensor as a linea transformation- Vector as a first order tensor	1
3	Coordinate transformation of vectors and tensors.	2
4	Principal values, trace and invariants	2
5	Gradient, divergence and curl of vector and tensor fields	2
6	Vector identities- Gauss' divergence and Stokes' theorems.	1
7	Concept of continua- Reference and current configuratio Lagrangian and Eulerian description of motion	2
8	Deformation gradient tensor, Right and left Cauchy Gr tensors	2

9	Infinitesimal deformation theory-Linearized strain	2
10	Principal strains	1
11	Polardecomposition theorem	1
12	Saint Venant’s compatibility equations	1
13	Traction- Cauchy stress tensor- Stress component along orthonormal basis vector	2
14	Components of Cauchy stress tensor on any plane., Normal shear stresses	2
15	Principal planes- Principal stress components	2
16	Stress transformation	2
17	Reynold's transportation theorem- Localization theorem Introduction on Balance Laws	1
18	Lagrangian and Eulerian forms of equation for mass balance.	1
19	Balance of linear momentum, equilibrium equations	1
20	Balance of angular momentum, Symmetry of stress tensor	1
21	Balance of energy	1
22	Constitutive relations- Generalized Hooke's law for isotropic materials in indicial and matrix forms	1
23	Relation connecting Lame's constants with Young's modulus, Poisson's ratio and Bulk modulus.	1
24	2D formulation of field equations; Airy's stress function Biharmonic equation	4
25	Uni axial tension and pure bending of a beam; End load cantilever	1
26	Polar coordinates; Axisymmetric formulation	2
27	Lame's thick cylinder problem	2
28	Quarter circle cantilevered beam with radial load.	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET2õ4	ADVANCED MECHANICS K & & > h	VAC	3	1	0	4

Preamble

This course is a survey of principal concepts and methods of fluid dynamics. Topics include conservation equations, exact solutions of Navier-Stokes Equations, potential flow solutions, Boundary layers, introduction to turbulence and turbulence modelling

Prerequisite:

MET 203-Mechanics of Fluids

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply conservation equations of fluid mechanics
CO 2	Use potential flow theory in fluid problems
CO 3	Utilize approximate solutions of the Navier-Stokes equations
CO 4	Compute effect on boundary layer
CO 5	Explain turbulence and turbulence modelling

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											
CO 2	3	2	1									
CO 3	3	2	1	1								
CO 4	3	2	1									
CO 5	3	1										

Assessment Pattern

Blooms Category	CA			ESA
	Assignment	Test- 1	Test- 2	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

Mark distribution & Duration of Examination :

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 Hours

End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Outcome 1

1. What is the signi cance of RTT in the study of transport phenomena.
2. Explain the relationship between the stress tensor and the rate of deformation.
3. Derive the expression for the Navier-Stokes equation and explain the di erent terms involved.

Course Outcome 2

1. Derive the expression for stream function and potential function of a doublet using the potential ow theory.
2. Derive the expression for lift for ow past a cylinder with circulation.
3. What is the signi cance of conformal mapping?

Course Outcome 3

1. Derive the expression for the pressure gradient for Couette ow.
2. Explain the working of a Viscometer based on the ow through a rotating annulus.
3. What is Stokes' rst problem?

Course Outcome 4

1. Explain the development of boundary layer along a thin at plate held parallel to a uniform ow. Point out the salient features.
2. Discuss on the e ect of pressure gradient on boundary layer separation.
3. Find the thickness of the boundary layer at the trailing edge of a smooth plate of length 5 m and width 1.2 m when the plate is moving at 5 m/s in stationary air. Take the kinematic viscosity of air as 0.11 stokes.

Course Outcome 5

1. What are the semi-empirical theories associated with turbulent ow?
2. Explain the two equation models used in turbulent ow.
3. Distinguish between DNS and LES.

Syllabus

Module 1: Concept of viscosity, stress tensor, relation between stress and rate of deformation, Stokes hypothesis, Reynolds Transport Theorem, Mass, Momentum and Energy conservation, Derivation of Navier-Stokes equations.

Module 2: Potential flow: Uniform flow, source flow, sink flow, free vortex flow and super imposed flow: source and sink pair, doublet, plane source in a uniform flow(flow past a half body), source and sink pair in a uniform flow(flow past a Rankine oval body), doublet in a uniform flow(flow past a circular cylinder). Pressure distribution on the surface of the cylinder. Flow past a cylinder with circulation, Kutta-Joukowsky's law. Complex flow potential, complex flow potentials for source, sink, vortex and doublet. Potential flow between two parallel plates, potential flow in a sector. Introduction to conformal transformation, conformal mapping.

Module 3: Exact Solutions of Navier Stokes Equations: Parallel flow through straight channel and couette flow. Couette flow for negative, zero and positive pressure gradients, flow in a rotating annulus, Viscometer based on rotating annulus. Flow at a wall suddenly set to motion (Stokes first problem)

Module 4: Boundary layer equations; Boundary layer on a flat plate, Prandtl boundary layer equations, Blasius solution for flow over a flat plate, Von Karman momentum integral equations, Pohlhausen approximation solution of boundary layer for zero-pressure gradient flow, favorable and adverse pressure gradients, flow separation and vortex shedding. Boundary layer control.

Module 5: Introduction Statistical approach to turbulent flows, Length and time scales and Kolomogrov's energy cascading theory, Reynolds averaged Navier Stokes equations, Turbulence modeling. Concept of eddy viscosity and Prandtl's mixing length hypothesis. Zero, one and two equation turbulence models and Reynold's stress models. Concepts of LES and DNS

Text Books

(1) White, F. M. Viscous Fluid Flow, McGraw Hill Education; 3 edition, 2017

(2) Schlichting, H. Boundary layer theory. McGraw Hill Education; 7 edition, 2014

COURSE PLAN

Module	Topics	Hours Allotted
I	Concept of viscosity, stress tensor, relation between stress and rate of deformation, Stokes hypothesis, Reynolds Transport Theorem, Mass, Momentum and Energy conservation, Derivation of Navier-Stokes equations.	6-2-0
II	Potential flow: Uniform flow, source flow, sink flow, free vortex flow and super imposed flow-source and sink pair, doublet, plane source in a uniform flow(flow past a half body), source and sink pair in a uniform flow(flow past a Rankine oval body), doublet in a uniform flow(flow past a circular cylinder). Pressure distribution on the surface of the cylinder. Flow past a cylinder with circulation, Kutta-Juokowsky's law. Complex flow potential, complex flow potentials for source, sink, vortex and doublet. Potential flow between two parallel plates, potential flow in a sector. Introduction to conformal transformation, conformal mapping.	7-2-0
III	Exact Solutions of Navier Stokes Equations-Parallel flow through straight channel and couette flow. Couette flow for negative, zero and positive pressure gradients, flow in a rotating annulus, Viscometer based on rotating annulus. Flow at a wall suddenly set to motion (Stokes first problem)	6-2-0
IV	Boundary layer equations: Boundary layer on a flat plate, Prandtl boundary layer equations, Blasius solution for flow over a flat plate, Von-Karman momentum integral equations, Pohlhausen approximation solution of boundary layer for non-zero pressure gradient flow, favorable and adverse pressure gradients, flow separation and vortex shedding. Boundary layer control.	8-3-0
V	Introduction Statistical approach to turbulent flows, Length and time scale and Kolomogrov's energy cascading theory Reynolds averaged Navier Stokes equations, Turbulence modeling. Concept of eddy viscosity and Prandtl's mixing length hypothesis Zero, one and two equation turbulence models and Reynold's stress models. Concepts of LES and DNS	7-2-0

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

IV SEMESTER B.TECH DEGREE EXAMINATION

MET2 4 ADVANCED MECHANICS 0 ' ' - 6 * % 4

Mechanical Engineering

Maximum: 100 Marks Duration: 3 hours

PART A

Answer all questions, each question carries 3 marks

1. What is Stokes hypothesis?
2. What is the importance of RTT in the study of transport phenomena?
3. What are the di erent elementary ows used in potential ow theory?
4. Draw the stream-lines and potential lines for a doublet in a uniform ow and mark the di erent regions.
5. With a neat sketch explain the Stokes rst problem.
6. Draw the velocity pro le in Couette ow for negative, zero and positive pressure gradients.
7. With a neat sketch explain the di erent regions of boundary layer ow over a at plat
8. What are the di erent methods employed in controlling the boundary layer separation?
9. Explain Prandtl's Mixing length theory.
10. What is the importance of Turbulence Modeling in uid dynamics?

(10 3=30 Marks)

PART B

Answer one full question from each module

MODULE-I

11. (a) Derive Reynolds Transport Theorem. (7 Marks)

 (b) Derive the expression for the law of conservation of mass from RTT. (7 Marks)

12. (a) Derive Navier-Stokes equations in Cartesian coordinate system. (10 Marks)

 (b) Write the expanded form of Navier-Stokes equations in Cartesian coordinate system. (4 Marks)

MODULE-II

13. (a) Explain uniform ow with source and sink. Obtain an expression for stream and velocity potential function and show their approximate distribution. (7 Marks)

 (b) A uniform ow with a velocity of 2m =s is owing over a source placed at the origin. The stagnation point occurs at (0:398;0): Determine: (i) Strength of the source, (ii) Maximum width of Rankine half-body and (iii) Other principal dimensions of the Rankine half-body. (7 Marks)

14. (a) A uniform ow with a velocity of 3m =s is owing over a plane source of strength $30m^2$=s: The uniform ow and source ow are in the same plane. A point P is situated in the ow eld. The distance of the point P from the source is 0.5m and it is at an angle of 30 to the uniform ow. Determine: (i) stream function at point P (ii) resultant velocity of ow at P and (iii) location of stagnation point from the source.h ll (10 Marks)

 (b) Describe the following terms: i)Complex ow potential ii) Conformal mapping(4 Marks)

MODULE-III

15. (a) An oil of viscosity 18 poise ows between two horizontal xed parallel plates which are kept 150mm apart. The maximum velocity of ow is 1.5m/s. Find:

 i. The pressure gradient
 ii. The shear stress at the two horizontal parallel plates
 iii. The discharge per unit width for laminar ow of oil.

 (7 Marks)

 (b) Explain the signi cance of Navier-Stokes equation in viscous uid ow. Derive the expression for ow in a rotating annulus from the Navier-Stokes Equation. (7 Marks)

16. (a) Derive the expression for pressure gradient in the parallel ow through a straight channel. (7 Marks)

 (b) Explain the working of a Viscometer based on the ow through a rotating annulus. (7 Marks)

MODULE-IV

17. (a) Explain the essential features of Blasius method of solving laminar boundary layer equations for a at plate. Derive an expression for boundary layer thickness from this solution. (7 Marks)

(b) For the velocity pro le for laminar boundary layer ows given as

$$\frac{u}{U} = 2(y= \ ) \quad (y= \ )^2$$

nd an expression for boundary layer thickness ( ), shear stress ($_0$) and co-e cient of drag (C_D) in terms of Reynold number. (7 Marks)

18. (a) For the velocity pro le in laminar boundary layer as,

$$\frac{u}{U} = \frac{3}{2}\frac{y}{\ } \quad \frac{1}{2}\frac{y}{\ }^{3}$$

nd the thickness of the boundary layer and the shear stress 1.5 m from the leading edge of a plate. The plate is 2m long and 4m wide and is placed in water which is moving with a velocity of 200mm per second. Find the total drag force on the plate if for water = :01 poise. (7 Marks)

(b) Derive Von Karman momentum integral equation for boundary layer ows.(7 Marks)

MODULE-V

19. (a) Explain and di erentiate DNS and LES. (7 Marks)

(b) What is the di erence between zero equation, one equation and two equation models in turbulent ow? (7 Marks)

20. (a) Explain in detail any one of the two equation models. (7 Marks)

(b) Explain Kolmogrovs energy cascade theory. (7 Marks)

MET 2 6	MATERIALS IN MANUFACTURING (HONORS)	CATEGORY	L	T	P	Credits	Year of Introduction
		VAC	3	1	0	4	2019

Preamble: Understanding of the correlation between the chemical bonds and crystal struc metallic materials to their mechanical properties.

Recognize the importance of deformation of metals at high temperature.

Enrich knowledge of various behavior and property changes inside the material struc raised temperature and methods to strengthening the material.

Provide in-depth proficiency in material science and engineering fields for elevated temperatur applications.

Prerequisite: MET 202 - Metallurgy and Material Science

Course Outcomes - At the end of the course students will be able	
CO 1	Understand the chemical bonds, crystal structures and their relationship wi properties.
CO 2	Correlate structure and properties relationship for high temperature applications.
CO 3	Understand the attributes and purity obtainable through triple vacuum induction meltin process.
CO 4	To have knowledge in improving material strength against high temperature environment and predict life time
CO 5	Understand the properties of superalloys and its strengthening processes

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	-	3	-	-	-	-	-	-	-		-	-
CO 2	-	-	3	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	-	-	3

ASSESSMENT PATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 11 (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyze	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments	15 marks
Continuous Assessment Test (2 numbers)	25 marks

End semester pattern:- There will be two parts; Part A and Part B. Part A contain questions with 2 questions from each module, having 3 marks for each ques Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Part -A

Course Outcome 1 (CO1): Understand the chemical bonds, crystal structures and their relationship with the properties

1. Why electrons of higher principal quantum number form weaker bonds.
2. Postulate why ionic and covalent bonded material exhibit bad conductors of heat electricity?
3. What are the roles of surface imperfections on crack initiation
4. Which mechanism of strengthening is the Hall-Petch equation related to?

Course Outcome 2 (CO2): Correlate structure and properties relationship for high temper
applications.

1. Nickel has an atomic weight of 58.71, a number which arises from the relative proportion isotopes of weights 58, 60, 61, 62 and 64. Why is there little contribution from the isoto weight 59 and 63?
2. Comparison of the rates of interdiffusion of the transition group elements (the solutes) with nicke (the solvent) indicates that (i) the interdiffusion rate increases with increasing misfit strain b solvent and solute and (ii) the activation energy for interdiffusion decreases with increasing strain. Why might these observations be contrary to expectation? How might this app anomaly be rationalised?

Course Outcome 3 (CO3): Understand the attributes and purity level obtainable through triple vacuum induction melting process.

1. What is the need of vacuum for obtaining purifying metals?
2. What are conditions for freckle formation and how can be eliminated?
3. Explain the need of electrode quality in ESR and VAR process?
4. Which are the factors governs the quality of vacuum arc melting process.

Course Outcome 4 (CO4): To have knowledge in improving material strength against temperature environment and predict life time.

1. Explain why it might not be sensible, even for single-crystal superalloys, to eliminate complete the grain-boundary strengtheners such as carbon and boron from the melt chemistry.
2. The rate of oxide formation in Al_2O_3 forming singlecrystal superalloys is greatly increased wit additions of Ti to the alloy chemistry. Explain why this effect occurs.
3. Non-conductive material will you recommend to use at high temperature explain?
4. Both titanium and steel melt at temperatures in excess of 1500C. Steel can be used at temperatur as high as 1000C but titanium cannot. Why is this?

Course Outcome 5 (CO5): Understand the properties of super alloys and its strength processes.

1. The following defects can occur during the casting of single-crystal components: (i) high-angle grain boundaries, (ii) freckles and (iii) spurious grains. What is meant by these terms? Give explanation of the origin of each effect.
2. Suggest a high electrical conductive material which can use at 1100C.
3. Give two reasons why the use of titanium alloys is increasing at the expense of aluminum in civil and military aircraft.

SYLLABUS

MODULE - 1

Atomic structure chemical bonds - crystallography - miller indices - slip - dislocation - crystallization - frank-reed source Structural parameters in high-temperature deformed metals dislocation structure distances between dislocations in sub-boundaries sub-boundaries as dislocation sources and obstac -dislocations inside sub-grains - vacancy loops and helicoids - structural peculiarities of high-temperature deformation

MODULE - II

Characteristics of high-temperature materials - The super alloys as high-temperature materials The requirement: the gas turbine engine – Larson–Miller approach for the ranking of creep performan- development of the super alloys – Nickel as a high-temperature material: justification – super alloy production methods: vacuum induction melting (VIM), vacuum arc remelting (VAR), VIM electroslag remelting (ESR), VIM, ESR, VAR Freckles, three rings, white spot cleanliness

MODULE - III

Superalloys – metallurgy characteristics – wrought, cast superalloys, properties – crystal structures phases in superalloys, Iron-Nickel-base superalloys, Nickel-base superalloys, Cobalt-base superalloys - elements causing brittle phase formation, detrimental tramp elements, elements producing and hot corrosion resistance – microstructure, gamma prime, gamma double prime, Carbide and Bor phases, strengthening mechanism – Heat treatment

MODULE - IV

Single-crystal super alloys for blade applications – solidification, heat transfer, defects – mechanical behavior, performance in creep, fatigue – Titanium: binary phase diagram – production of ingot- forgings - shear bands pickling - Ti alloys - machining and welding of Titanium - Heat Treatment – properties of titanium aluminides – Niobium: production of niobium - niobium in steel making – niobium alloys characteristics and applications – Niobium products for the superalloy industry.

MODULE - V

Molybdenum: Ferromolybdenum production of molybdenum – properties - effect of molybdenum alloying – applications - TZM, TZC - Maraging steel: reaction in austenite austenite to martensit transformation – reaction in martensite time of maraging - precipitate size - fracture toughness welding and ageing attributes superior features - applications - cobalt free maraging steel intermetallics: phase diagrams – Hume-Rothery phases structures of $MgCu_2$, $MgZn_2$, $MgNi_2$.

Text Books

1. Callister William. D., Material Science and Engineering, John Wiley, 2014

2. Matthew J. Donachie, Stephen J. Donachie, Superalloys A Technical Guide, Second Edition, 2002 ASM International.

Reference

1. Barrett, C. S. and Massalski, T. B. Structure of metals, Third edition New York, N.Y., McGraw-Hill Book Company, 1966.
2. Decker, Raymond Frank, Source book on maraging steels: A comprehensive collectio outstanding articles from the periodical and reference literature, Published by American Society for Metals (1979)
3. Gerd Lutjering James C.Williams, Titanium, springer.
4. Roger C. Reed, The Super alloys Fundamentals and Applications, Cambridge university press.
5. Valim Levitin - High temperature strain of metals and alloys, physical fundamentals, Wiley-VCH (2006)
6. https://www.phase-trans.msm.cam.ac.uk/teaching.html

MODEL QUESTION PAPER

MATERIALS IN MANUFACTURING - (HONORS) - MET -2 6

Max. Marks : 100 Duration : 3 Hours

Part ±A

Answer all questions.

Answer all questions, each question carries 3 marks

1. NASA's Parker solar probe will be the first-ever mission to "Touch" the Sun. The spacecraft, about size of a small car, will travel directly into the Sun's atmosphere about 4 million miles from the surface. Postulate the coolant used in the parker solar probe with chemical bonds.
2. Explain the structural parameters in time and creep curve for nickel.
3. Explain the characteristics required for high-temperature materials.
4. Explain the ways and means to improve super alloy cleanliness
5. What are the elements causing brittle phase formation in super alloys.
6. Explain the process and need of stress relieving used for super alloys
7. The preferred growth direction of a single-crystal superalloy is (100) Why?
8. Where is hundred percentage pure Titanium is used ?
9. What are the special attributes of marging steel welded joint after ageing process?
10. How the structure of intermetallics are determined ?

PART -B

Answer one full question from each module.

MODULE -1

11. a. Explain the basic mechanism involved for metal deformation (7 marks).

b. Explain process involved in high temperature strain of metals and alloys (7 marks).

OR

12. What are the roles played by the fan, compressor, combustor and turbine arrangements in a ty turbine engine? How do these affect (i) the pressure and (ii) the average temperature of the gas s Explain why your findings justify the use of nickel based superalloys in the combustor and sections, but not in the compressor region (14 marks).

MODULE -2

13. Explain the justification for the development of super alloys as high temperature alloys (14 marks).

OR

14. Explain the conditions of freckles, three rings and white spots formation and its implications (14 marks).

MODULE -3

15. Explain with neat sketches of different strengthening mechanisms of super alloys w microstructure (14 marks).

OR

16. Explain different types of heat treatments employed for super alloys (14 marks).

MODULE -4

17. The materials used for high-pressure turbine blade aerofoils are often referred to as single-crystal superalloys ([S O D L Q Z K \ W K H X V-H F U \ V W D O ¶ W L H V (14 marks) Q J O H X R X V

OR

18. Explain the process of closed die forging for Titanium alloy manufacturing (14 marks).

MODULE -5

19a. Explain the different reaction in austenite in maraging steel (7 marks).

19b. Explain the Maraging steel hardness produced with aging time versus aging time and dif temperatures with neat sketches (7 marks).

OR

20a. Explain the synergetic effect of cobalt and molybdenum in maraging steel with graphs and (7 marks).

20b. Explain structures of $MgCu_2$, $MgZn_2$, $MgNi_2$ with neat sketches (7 marks).

Course content and lecture schedules.

Module	TOPIC	No. of hours	Course outcomes
1.1	Earlier and present development of atomic structure Primary bonds Secondary bonds crystallography- miller indices slip- crystallization- frank reed source	1	CO1
1.2	Structural parameters in high-temperature deformed metals: structu parameters.	2	CO1
1.3	Dislocation structure distances between dislocations in sub-boundaries- sub-boundaries as dislocation sources and obstacles.	3	CO1
1.4	Dislocations inside sub-grains- vacancy loops and helicoids structural peculiarities of high-temperature deformation (levitin).	3	
2.1	Characteristics of high-temperature materials- The superalloys as high temperature materials	3	CO1 CO2
2.2	The requirement: the gas turbine engine- Larson-Miller approach for the ranking of creep performance		
2.3	Development of the super alloys- Nickel as a high-temperature materia justification. (Reed).	2	CO2
2.4	Super alloy production methods: melt routes for super alloys characteristics, process parameters, application of each process V induction melting (VIM), Vacuum arc remelting (VAR), VIM, electrosl remelting (ESR),VIM, ESR, VAR.	3	CO2 CO3
2.5	Freckles, conditions of freckles, three rings, white spot Super alloy cleanliness: ways and means to improve super alloy cleanlin advantages of improved cleanliness, homogenization oxide cleanliness (ASM).	2	CO3
3.1	Superalloys- metallurgy of superalloys, superalloy characteristics applications- service temperatures for superalloys.	1	CO2

3.2	Wrought superalloys, cast superalloys, properties of superal, mechanical properties and the application of superalloys, sele superalloys	1	CO2
3.3	Crystal structures, phases in superalloys, Iron-Nickel-base superalloys Nickel-base superalloys, Cobalt-base superalloys alloy elements and microstructural effects in superalloys, elements causing brittle p formation, detrimental tramp elements, elements producing oxidatio hot corrosion resistance.	3	CO2
3.4	Microstructure, gamma prime gamma double prime, Carbide and Boride phases, strengthening mechanisms precipitate, gamma prime, gamma double prime, Carbides, M7C3 Carbides, Borides and other beneficial minor elements.	3	CO5
3.5	Heat treatment types- stress relieving, annealing, quenching precipitation, (ASM).	1	CO2
4.1	Single crystal super alloys for blade applications - directional solidification, heat transfer, formation of defects during direction solidification - mechanical behavior of the single crystal super alloys performance in creep, performance in fatigue (Reed).	3	CO4
4.2	Titanium: Ti-based binary phase diagram production of ingot, Vacuum Arc Remelting - effect of forging temperature and forging pressur closed die forgings shear bands pickling of titanium - Ti alloys - scrap recycling - problems in machining Titanium - welding of titanium - Heat Treatment of Ti - properties of titanium aluminides applications.	4	CO2 CO5
4.3	Niobium: Production of niobium - niobium alloys - niobium in steel making ± niobium alloys characteristics and applications - Niobium products for the superalloy industry.	2	CO2
5.1	Molybdenum: Ferromolybdenum - production of molybdenum ± properties - effect of molybdenum alloying on hot strength, corros resistance, and toughness - applications - TZM, TZC.	2	CO2
5.2	Maraging steel - Maraging steel chronology - reaction in austenite austenite to martensite transformation reaction in martensite time of maraging - precipitate size - fracture toughness welding and ageing attributes - superior features - applications - cobalt free maraging steel ar comparisons.	4	CO2 CO4
5.3	Intermetallics - Electronegativity, characteristics, property predictio phase diagrams - Magnesium - Lead, Copper ± Zinc, Nickel - Titanium phase diagram - - The Hume-Rothery phases, electron phases /compounds, laves phases - Strukturbericht C15, C14, C36, etc structures of $MgCu_2$, $MgZn_2$, $MgNi_2$.	3	CO2 CO4