SEMESTER -3

CODE MET201	COURSE NAME MECHANICS OF SOLIDS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble:

This course helps the students to understand the concept of stress and strain in different types of structure/machine under various loading conditions. The course also covers simple and compound stresses due to forces, stresses and deflection in beams due to bending, torsion in circular section, strain energy, different theories of failure, stress in thin cylinder thick cylinder and spheres due to external and internal pressure.

Prerequisite: EST100 ENGINEERING MECHANICS

Course Outcomes:

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

CO 1	Determine the stresses, strains and displacements of structures by tensorial and graphical (Mohr's circle) approaches
CO 2	Analyse the strength of materials using stress-strain relationships for structural and thermal loading
CO 3	Perform basic design of shafts subjected to torsional loading and analyse beams subjected to bending moments
CO 4	Determine the deformation of structures subjected to various loading conditions using strain energy methods
CO 5	Analyse column buckling and appreciate the theories of failures and its relevance in engineering design

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	2									1
CO 2	3	3	2									1
CO 3	3	3	1									2
CO 4	3	3	1									1
CO 5	3	3	1									1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	30
Apply	20	20	50
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 and 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 carries 14 marks and can have a maximum of 2 subdivisions.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Determine the resultant traction at a point in a plane using the stress tensor.

2. Evaluate the principal stresses, principal strains and their directions from a given state of stress or strain.

3. Write the stress tensor and strain tensor.

Course Outcome 2 (CO2)

1. Write the generalized Hooke's law for stress-strain relations.

2. Estimate the state of strain from a given state of stress.

3. Analyse the strength of a structure subjected to thermal loading.

Course Outcome 3(CO3):

1. Design a shaft to transmit power and torque.

2. Draw the shear force and bending moment diagrams.

3. Determine the bending stress on a beam subjected to pure bending.

Course Outcome 4 (CO4):

1. Apply strain energy method to estimate the deformation of a structure.

2. Use strain energy method to calculate deformations for multiple loads.

3. Use strain energy method to estimate the loads acting on a structure for a maximum deflection.

Course Outcome 5 (CO5):

1. Analyse a column for buckling load.

2. Use Rankine formula to determine the crippling load of columns.

3. A bolt is subjected to a direct tensile load of 20 kN and a shear load of 15 kN. Suggest suitable size of this bolt according to various theories of elastic failure, if the yield stress in simple tension is 360 MPa. A factor of safety 2 should be used. Assume Poisson's ratio as 0.3.

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 a point in the form of a matrix. Equality of cross shear, Cauchy's equation. Displacement, gradient of displacement, Cartesian strain matrix, strain- displacement relations (small-strain only), Simple problems to find strain matrix.Stress tensor and strain tensor for plane stress and plane strain conditions. Principal planes and principal stress,meaning of stress invariants, maximum shear stress. Mohr's circle for 2D case.

Module 2

Stress-strain diagram, Stress–Strain curves of Ductile and Brittle Materials, Poisson's ratio.
Constitutive equations-generalized Hooke's law, equations for linear elastic isotropic solids in terms of Young's Modulus and Poisson's ratio, Hooke's law for Plane stress and plane strain conditions
Relations between elastic constants E, G, ν and K(derivation not required).
Calculation of stress, strain and change in length in axially loaded members with single and composite materials, Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed supports.

Module 3

Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, derivation of torsion formula Torsional rigidity, Polar moment of inertia, basic design of transmission shafts. Simple problems to estimate the stress in solid and hollow shafts.
Shear force and bending moment diagrams for cantilever and simply supported beams. Differential equations between load, shear force and bending moment.
Normal and shear stress in beams: Derivation of flexural formula, section modulus, flexural rigidity, numerical problems to evaluate bending stress, economic sections.
Shear stress formula for beams: (Derivation not required), shear stress distribution for a rectangular section.

Module 4

Deflection of beams using Macauley's method
Elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads. Expressions for strain energy in terms of load, geometry and material properties of the body for axial, shearing, bending and torsional loads. Castigliano's second theorem, reciprocal relation(Proof not required for Castigliano's second theorem, reciprocal relation).
Simple problems to find the deflections using Castigliano's theorem.

Module 5

Fundamentals of bucking and stability, critical load, equilibrium diagram for buckling of an idealized structure. Buckling of columns with pinned ends, Euler's buckling theory for long columns. Critical stress, slenderness ratio, Rankine's formula for short columns.
Introduction to Theories of Failure, Rankine's theory for maximum normal stress, Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain, Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy

Text Books

1. Mechanics of materials in S.I. 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

2. Mechanics of Materials S. I. units, Beer, Johnston, Dewolf, McGraw Hills 2017

3. Mechanics of Materials, Pytel A. and Kiusalaas J. Cengage Learning India Private Limited, 2nd Edition, 2015

4. Strength of Materials, Rattan, McGraw Hills 2011

5. Strength of Materials, Surendra Singh, S. K. Kataria& Sons

COURSE PLAN

No	Topic	No of lectures
1	**Module 1: Stress and Strain Analysis**	**9 hours**
1.1	Describe the deformation behaviour of elastic solids in equilibrium under the action of a system of forces. Describe method of sections to illustrate stress as resisting force per unit area. Stress vectors on Cartesian coordinate planes passing through a point and writing stress at a point in the form of a matrix.	2 hr
1.2	Equality of cross shear (Derivation not required). Write Cauchy's equation (Derivation not required),Find resultant stress, Normal and shear stress on a plane given stress tensor and direction cosines (no questions for finding direction cosines).	2 hr
1.3	Displacement, gradient of displacement, Cartesian strain matrix, Write strain-displacement relations (small-strain only), Simple problems to find strain matrix given displacement field (2D and 3D), write stress tensor and strain tensor for Plane stress and plane strain conditions.	1 hr
1.4	Concepts of principal planes and principal stress, characteristic equation of stress matrix and evaluation of principal stresses and principal planes as an eigen value problem, meaning of stress invariants, maximum shear stress	2 hrs
1.5	Mohr's circle for 2D case: find principal stress, planes, stress on an arbitrary plane, maximum shear stress graphically using Mohr's circle	2 hrs
2	**Module 2: Stress - Strain Relationships**	**9 hours**
2.1	Stress-strain diagram, Stress–Strain curves of Ductile and Brittle Materials, Poisson's ratio	1 hr
2.2	Constitutive equations-generalized Hooke's law, equations for linear elastic isotropic solids in in terms of Young's Modulus and Poisson's ratio (3D). Hooke's law for Plane stress and plane strain conditions Relations between elastic constants E, G, ν and K(derivation not required), Numerical problems	2 hrs
2.3	Calculation of stress, strain and change in length in axially loaded members with single and composite materials, Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed supports.	2 hrs
2.4	Numerical problems for axially loaded members	4 hrs
3	**Module 3: Torsion of circular shafts, Shear Force-Bending Moment Diagrams and Pure bending**	**9 hours**
3.1	Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, derivation of torsion formula	1 hr
3.2	Torsional rigidity, Polar moment of inertia, comparison of solid and hollow 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 externally 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
3.6	Normal and shear stress in beams: Derivation of flexural formula, section modulus, flexural rigidity, numerical problems to evaluate bending stress, economic sections Shear stress formula for beams: (Derivation not required),numerical problem to find shear stress distribution for rectangular section	3 hrs
4	**Module 4: Deflection of beams, Strain energy**	**8 hours**
4.1	Deflection of cantilever and simply supported beams subjected to point load, moment and UDL using Macauley's method (procedure and problems with multiple loads)	2 hrs
4.2	Linear elastic loading, elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads (short derivations in terms of loads and deflections).	2 hr
4.3	Expressions for strain energy in terms of load, geometry and material properties of the body for axial, shearing, bending and torsional loads. Simple problems to solve elastic deformations	2 hrs
4.4	Castigliano's second theorem to find displacements, reciprocal relation, (Proof not required for Castigliano's second theorem and reciprocal relation).	1 hr
4.5	Simple problems to find the deflections using Castigliano's theorem	1 hr
5	**Module 5: Buckling of Columns, Theories of Failure**	**8 hours**
5.1	Fundamentals of bucking and stability, critical load, Euler's formula for long columns, assumptions and limitations, effect of end conditions(derivation only for pinned ends), equivalent length	2 hr
5.2	Critical stress, slenderness ratio, Rankine's formula for short columns, Problems	3 hr
5.3	Introduction to Theories of Failure. Rankine's theory for maximum normal stress, Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain	2 hr
5.4	Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy	1 hr

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET201

Course Name : MECHANICS OF SOLIDS

Max. Marks : 100 Duration : 3 Hours

PART – A

(*ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS*)

1. Express the stress invariants in terms of Cartesian components of stress and principal stress.
2. Write down the Cauchy's strain displacement relationships.
3. Distinguish between the states of plane stress and plane strain.
4. Explain the generalized Hooke's law for a Linear elastic isotropic material.
5. List any three important assumptions in the theory of torsion.
6. Write the significance of flexural rigidity and section modulus in the analysis of beams.
7. Discuss reciprocal relation for multiple loads on a structure.
8. Express the strain energy for a cantilever beam subjected to a transverse point load at free end.
9. Discuss Saint-Venant's theory of failure.
10. Explain the term 'critical load' with reference to the buckling of slender columns.

PART – B

(*ANSWER ONE FULL QUESTION FROM EACH MODULE*)

MODULE – 1

11. a) The state of stress at a point is given by σ_{xx} = 12.31 MPa, σ_{yy} = 8.96 MPa, σ_{zz} = 4.34 MPa, τ_{xy} = 4.2 MPa, τ_{yz} = 5.27 MPa, τ_{xz} = 0.84 MPa. Determine the principal stresses. (7 marks)

    b) The displacement field for a body is given by **u**= $(x^2 + y)$***i***+ $(3 + z)$ ***j*** + $(x^2 + 2y)$***k***. What is the deformed position of a point originally at (3,1,–2)? Write the strain tensor at the point (−3,−1,2).

    (7 marks)

OR

12. a) The state of plane stress at a point is given by σ_{xx} = 40 MPa, σ_{yy} = 20 MPa and τ_{xy} = 16 MPa. Using Mohr's circle determine the i) principal stresses and principal planes and ii) maximum shear stress. (7 marks)

b) The state 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)

$$\sigma_{ij} = \begin{bmatrix} 10 & 5 & -10 \\ 5 & 20 & -15 \\ -10 & -15 & -10 \end{bmatrix} MPa$$

MODULE – 2

13. a) Calculate Modulus of Rigidity and Young's Modulus of a cylindrical bar of diameter 30 mm and of 1.5 m length if the longitudinal strain in a bar during a tensile stress is four times the lateral strain. Find the change in volume when the bar is subjected to a hydrostatic pressure of 100 N/mm^2. Take E = 10^5 N/mm (9 marks)

b) A straight bar 450 mm long is 40 mm in diameter for the first 250 mm length and 20 mm diameter for the remaining length. If the bar is subjected to an axial pull of 15 kNfind the maximum axial stress produced and the total extension of the bar. Take E = 2x10^5 N/mm^2 (5 marks)

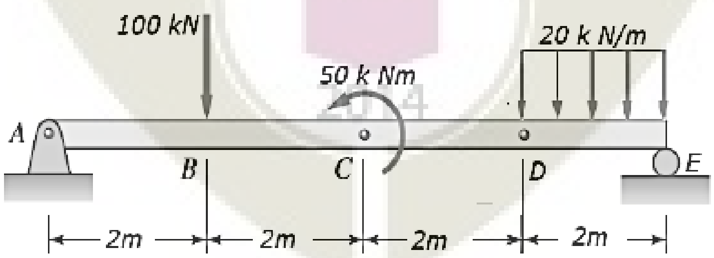
OR

14. a) A brass bar 20mm diameter is enclosed in a steel tube of 25mm internal diameter and 50mm external diameter. Both bar and tube is of same length and fastened rigidly at their ends. The composite bar is free of stress at 20°C. To what temperature the assembly must be heated to generate a compressive stress of 48MPa in brass bar? Also determine the stress in steel tube. E_{steel} = 200GPa and E_{brass} = 84GPa, α_{steel} = 12 × 10^{-6} / °C and α_{brass}= 18 × 10^{-6} / °C. (9 marks)

b) Draw the stress-strain diagram for a ductile material and explain the salient points. (5 marks)

MODULE – 3

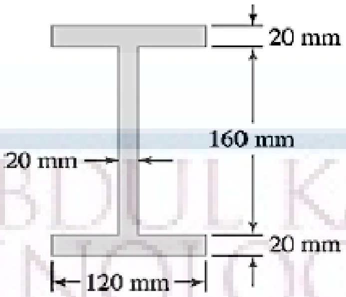
15. a) Draw shear force and bending moment diagram for the beam given in the figure. (9 marks)



b) Compare the strength of a hollow shaft of diameter ratio 0.75 to that of a solid shaft by considering the permissible shear stress. Both the shafts are of same material, of same length and weight. (5 marks)

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. (9 marks)



b) The shear stress of a solid shaft is not to exceed 40 N/mm^2 when the power transmitted is 20 kW at 200 rpm. Determine the minimum diameter of the shaft. (5 marks)

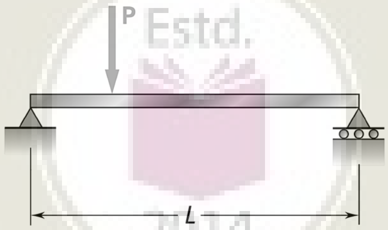
MODULE – 4

17. a) A horizontal girder of steel having uniform section is 14 m long and is simply supported at its ends. It carries concentrated loads of 120 kN and 80 kN at two points 3 m and 4.5 m from the two ends respectively. Moment of inertia for the section of the girder is 16×10^8 mm^4 and E_s = 210 kN/mm^2. Calculate the deflection of the girder at points under the two loads and maximum deflection using Macaulay's method. (8 marks)

b) Derive the expressions for elastic strain energy in terms of applied load/moment and material property for the cases of a) Axial force b) Bending moment. (6 marks)

OR

18. a) Calculate the displacement in the direction of load P applied at a distance of L/3 from the left end for a simply supported beam of span L as shown in the figure.



(10 marks)

b) State Castigliano's second theorem and explain its significance. (4 marks)

MODULE – 5

19. a) Find the crippling load for a hollow steel column 50mm internal diameter and 5mm thick. The column is 5m long with one end fixed and other end hinged. Use Rankine's formula and Rankine's constant as 1/7500 and σ_c = 335 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 (tensile) and 55 N/mm^2 (compressive). If the elastic limit in simple tension is 210 N/mm^2, then determine whether the failure of material will occur or not according to Maximum principal stress theory, Maximum shear stress theory and maximum distortion energy theory. (9 marks)

b) Derive Euler's formula for a column with both ends hinged. (5 marks)

CODE	COURSE NAME	CATEGORY	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

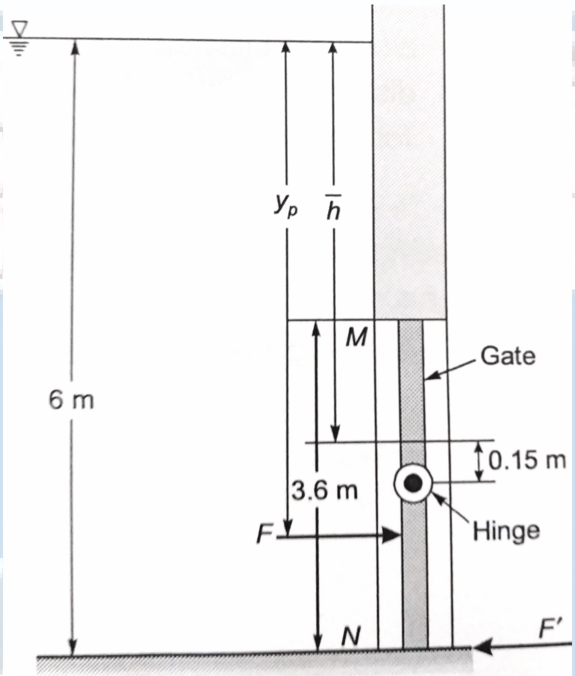
End semester pattern:

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 stratified so that its density is $\rho_0(1+h)$ at a depth h below the free surface. At a depth h in this liquid, what is the pressure in excess of $\rho_0 g h$?

3. If the velocity profile of a fluid 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 fluid as 8.5 poise.

Course Outcome 2

1. Differentiate between the Eulerian and Lagrangian method of representing fluid motion.

2. A velocity field is given by $u = 3y^2$, $v = 2x$ and $w = 0$ in arbitrary units. Is this flow steady or unsteady? Is it two or three dimensional? At (x,y,z)=(2,1,0), compute

   (a) velocity

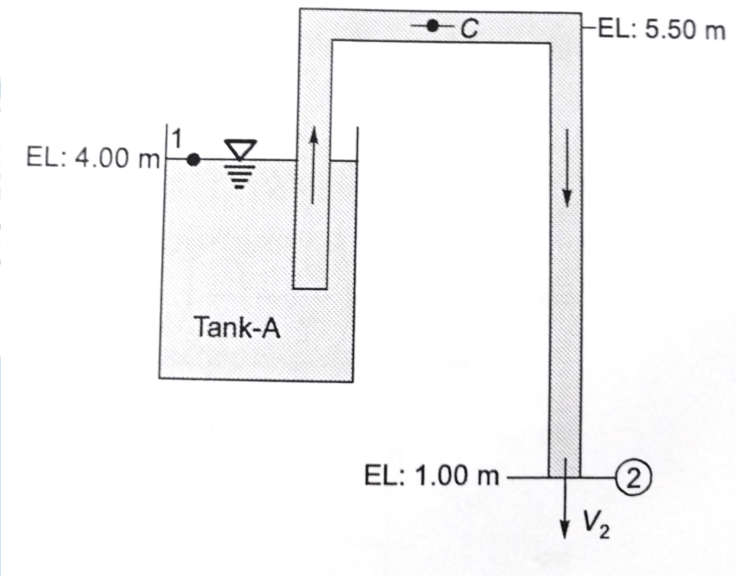
   (b) local acceleration

   (c) convective acceleration

3. A stream function in two dimensional flow is $\psi = 2xy$. Show that the flow is irrotational and determine the corresponding velocity potential ϕ.

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 different cases of water hammer. Derive the expression for pressure rise in any one of the case.

Course Outcome 4

1. Two reservoir with a difference 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 specific gravity 0.9 flows 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 flow

(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

$$\frac{u}{U_\infty} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$$

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 measurements: 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 specific gravity of a liquid is 3.0. What are its specific weight, specific mass and specific 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 different forces present in a fluid flow. For the Euler's equation of motion, which forces are taken into consideration.
6. Differentiate between pitot tube and pitot static tube.
7. Define and explain the terms (*i*) Hydraulic gradiant line and (*ii*) Total energy line.
8. Show that the coefficient of friction for viscous flow 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 flow is attached flow, detached flow 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.

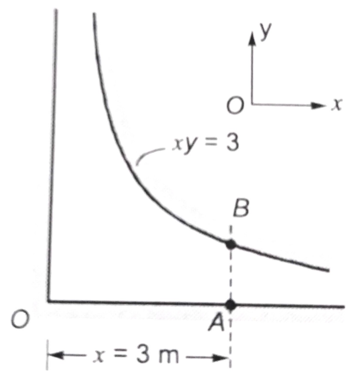
    (7 Marks)

    (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 field 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. $\phi = 2x + 5y$

ii. $\phi = 4x^2 - 5y^2$

(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 difference of level is found to be 170 mm. Find the speed of the submarine knowing that the specific 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 flow of water through the pipe, if the mean velocity of flow is 0.85 times central velocity. Assume coefficient 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 flow and the head loss between the two sections. The fluid in the pipe is water. (8 Marks)

(b) Petrol of specific 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

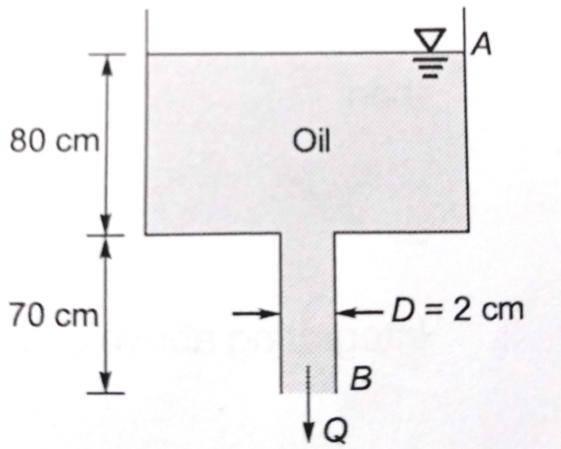
17. (a) Assuming viscous flow through a circular pipe derive the expression for,

i. Velocity distribution

ii. Shear stress distribution

Also plot the velocity and shear stress distribution. (7 Marks)

(b) A large tank shown in the figure 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 off 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

$$\frac{u}{U_\infty} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$$

If the boundary thickness is given as

$$\delta = \sqrt{\frac{280\nu x}{13U_\infty}}$$

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

$$\sqrt{2gH}\phi\left[\frac{D}{H}, \frac{\mu}{\rho V H}\right]$$

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 Fe-C alloys.

Examine the mechanisms of materials failure through fatigue and creep.

To determine properties of unknown materials and develop an awareness to apply this 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 to

CO 1	Understand the basic chemical bonds, crystal structures (BCC, FCC, and HCP), and their relationship with the properties.
CO 2	Analyze the microstructure of metallic materials using phase diagrams and modify the 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 materials for specific applications.
CO 5	Define and differentiate engineering materials on the basis of structure and properties 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 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

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 a polymorphism?
4. Draw the (112) and (111) planes in simple cubic cell.

Course Outcome 2 (CO2): Analyze the microstructure of metallic materials using phase diagrams 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 in strength?

Part -B

Course Outcome 3 (CO3): How to quantify mechanical integrity and failure in materials

1. A small hole is drilled through a steel plate ahead of a crack, whether it can stop the crack's 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 non-ferrous metals. Explain different methods to improve fatigue resistance.
3. Explain different stages of creep; Give an application of creep phenomenon. What is superplasticity?

Course Outcome 4 (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 on the composition, properties and typical applications of any five non-ferrous alloys.

Course Outcome 5 (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 carbon at the two faces are 0.65 and 0.30kgC/m^3Fe, which are maintained constant. If the pre-exponential and activation energy are 6.2x$10^{-7}m^2$/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.
2. Explain the fundamental effects of alloying elements in steel on polymorphic transformation temperatures, grain growth, eutectoid point, retardation of the transformation rates, formation 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 covalent, 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 crack 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, fick's 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 affecting 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, super 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, Cambridge 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 spacecraft, about the size of a small car, will travel directly into the Sun's atmosphere about 4 million miles from the earth surface. Postulate the coolant used in the parker solar probe with chemical 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 and (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 a 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 systems (7 marks).

OR

12. Explain the effect of: (i) Grain size; (ii) Grain size distribution and (iii) Grain orientation (iv) 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 carbon at the two faces are 0.65 and 0.30 kgC/m^3Fe, which are maintained constant. If the pre-exponential and activation energy are $6.2x10^{-}7m^2/s$ 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 8º35' when the first order Bragg's reflection occurs calculate the glancing 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 sketches 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 label (1) A time temperature path that will produce 100% pure 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 stability of carbides, grain growth, displacement of the eutectoid point, retardation of the transformation 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 Mottled iron, (v) SG iron and Vermicullar Graphite Iron (14 marks).

MODULE – 5

19. a A small hole is drilled through a steel plate ahead of a crack, whether it can stop the crack's progress until repairs can be made or not? Explain in detail and derive the equation (7 marks).

b What is ductile to brittle transition in steel DBTT? What are the factors affecting ductile to 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; correlation of atomic radius to strength; electron configurations; - Primary bonds: - characteristics of covalent, ionic and metallic bond: attributes of bond energy, cohesive force, density, directional and non-directional - properties based on atomic bonding:- attributes of deeper energy well and shallow energy well to melting temperature, coefficient of thermal expansion - attributes of modulus of 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 for 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 nuclei formation, under cooling, dendritic growth, grain boundary irregularity - Effects of grain size, grain size distribution, grain shape, grain orientation on dislocation/strength and creep resistance - Hall - Petch theory, simple 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 of 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 concept, 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 size- Fundamentals and crystal structure determination by X – ray diffraction, simple problems –SEM and TEM.	2	CO2 CO5
2.6	Diffusion in solids, fick’s laws, mechanisms, applications of diffusion in 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, special 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, hardening, spheroidizing.		
3.5	Tempering:- austermpering, martempering and ausforming - Comparative study on ductility and strength with structure of pearlite, bainite, spherodite, 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, laser and electron beam hardening processes- change in surface composition 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 movement, polymorphic transformation temperature, alpha and beta stabilizers, formation and stability of carbides, grain growth, displacement of the eutectoid point, retardation of the transformation rates, improvement in corrosion resistance, mechanical properties	1	CO4
4.3	Nickel steels, Chromium steels etc. – change of steel properties by adding alloying elements: - Molybdenum, Nickel, Chromium, Vanadium, Tungsten, Cobalt, Silicon, Copper and Lead - High speed steels - Cast irons: Classifications; grey, white, malleable and spheroidal graphite cast iron etc, composition, microstructure, properties and applications - Principal Non ferrous Alloys: - Aluminum, Copper, Magnesium, Nickel, study of composition, properties, applications, reference shall be made to the phase diagrams whenever necessary.(Topic 4.3 may be considered as a assignment).	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, surface roughness, change in surface properties, surface residual stress - Ways to improve fatigue life – effect of temperature on fatigue, thermal fatigue and its 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 crack 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 DBTT, applications.	1	
5.3	Creep: - Creep curves – creep tests - Structural change:- deformation by slip, sub-grain formation, grain boundary sliding - Mechanism of creep deformation - threshold for creep, prevention against creep - Super plasticity: need and 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 and 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 related to machines and components.

To make studentsfamiliarize 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 ofdrawings of assembled and disassembled view of important valves and machine components used in mechanical engineering applications.

To introduce standard CAD packages for drafting andmodelingof engineering components.

Prerequisite: EST 110 - Engineering Graphics

Course Outcomes - At the end of the course students will be able to

CO1	Apply the knowledge of engineering drawings and standards to prepare standard dimensioned drawings of machine parts and other engineering components.
CO2	Preparestandard assembly drawings of machine components and valvesusing part drawings and bill of materials.
CO3	Apply limits and tolerances to components and choose appropriate fits for given assemblies
CO 4	Interpret the symbols of welded, machining and surface roughness on the component drawings.
CO 5	Prepare part and assembly drawings and Bill of Materials of machine components and 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 tests)	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 the Chairmen/Chairperson will conduct the practical examination with the approval from the University and bonafide work / laboratory record, hall ticket, identity card issued by college are mandatory for appearing practical University examinations. No practical examination should be conducted without the presence of an external examiner appointed by the University.

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:

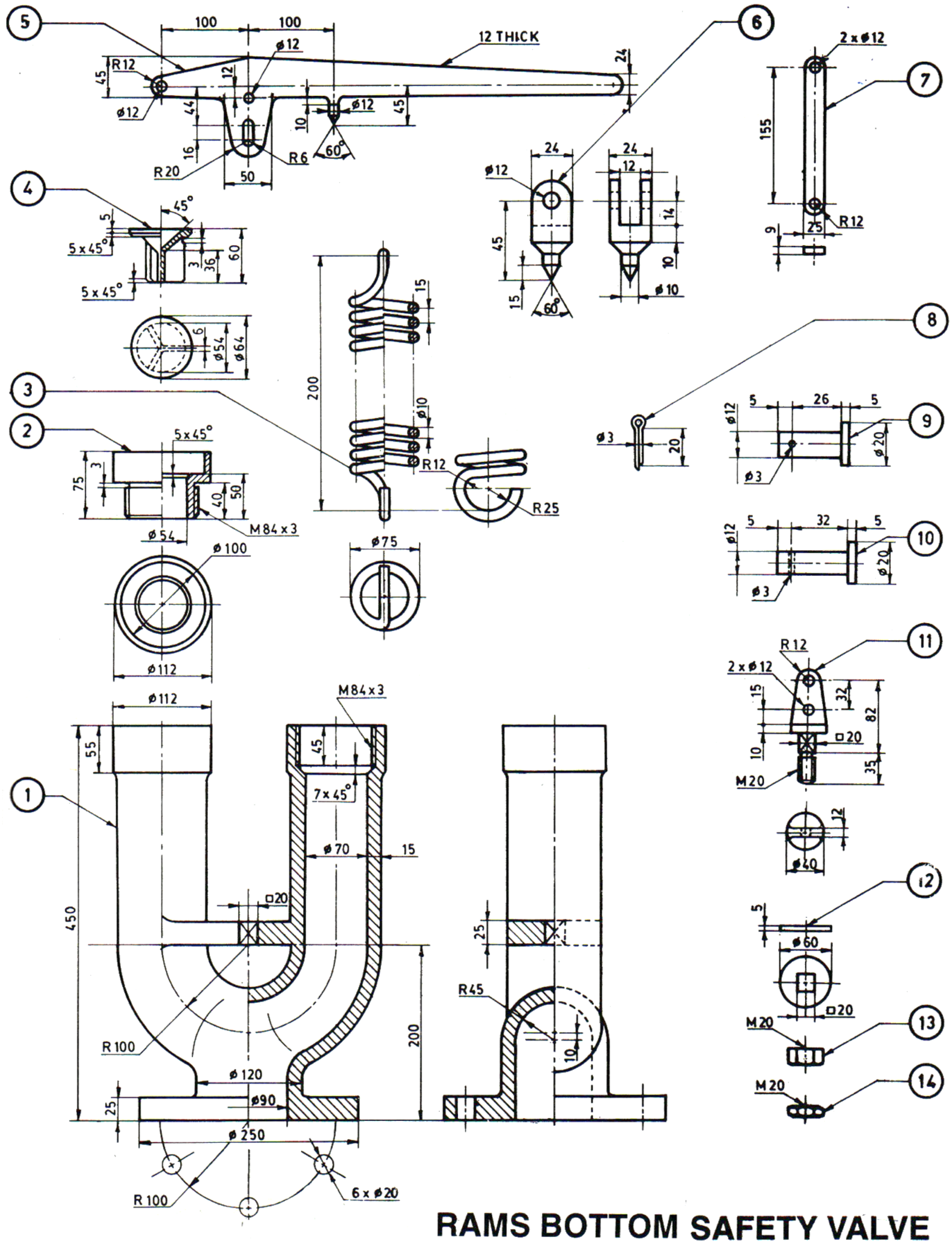
   Basic size= ϕ30 mm
   Minimum clearance = 0.007 mm
   Tolerance on hole = 0.021 mm
   Tolerance on shaft= 0.021 mm

   Check the calculated dimensions. Represent the limit dimensions schematically.

PART B (CAD DRAWING) **50 marks**

4. Draw any two assembled views of the Rams Bottom 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 McGraw-hill.
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. BIScode of practice for Engineering Drawing, lines, types of lines, dimensioning, scales of drawing, sectional views, **Riveted joints.**	CO 1	**3**
2	**Fasteners:** Sketching of conventional representation of welded joints,Bolts and Nuts **or** 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 MEL203	COURSE NAME MATERIALS TESTING LAB	CATEGORY	L	T	P	CREDIT
		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 fundamentals of 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 required

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 of design and manufacturing.

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							
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 S-N 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 , McGarw Hill,1991

3. Baldev Raj, Jayakumar T, Thavasimuthu M., Practical Non destructive testing, Narosa Book

Distributors,2015

SEMESTER -3

MINOR

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET281	MECHANICS OF MATERIALS	VAC	3	1		4

Preamble:

This course helps the students to understand the concept of stress and strain, and practice the methodologies to analyze different types of structures under various loading conditions. The course also covers simple and compound stresses due to forces, stresses and deflection in beams due to bending, torsion of shafts.

Prerequisite: EST100 ENGINEERING MECHANICS

Course Outcomes:

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

CO 1	Discuss the concepts of stress and strain in deformable bodies due to structural and thermal loading
CO 2	Analyse the behaviour of materials under shear stress due to torsional loads acting in simple structural members
CO 3	Analyse beams using graphical and analytical methods to determine slope, deflection and stress
CO 4	Transform stresses and strains for plane stress problems mathematically and graphically and determine the principal stresses and its directions
CO 5	Analyze simple structures subjected to compound stresses, and columns subjected to buckling conditions

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	2									1
CO 2	3	2	2									2
CO 3	3	3	2									1
CO 4	3	3	2									1
CO 5	3	2	2									1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	50
Apply	20	20	30
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 normal strain and shear strain.

2. Determine the deformation of axially loaded bars.

3. State the principle of superposition.

Course Outcome 2 (CO2)

1. Compare the strength of a hollow shaft and a solid shaft.

2. List four important assumptions in the theory of torsion.

3. Determine the shear stress developed in a circular shaft subjected to torsional loading.

Course Outcome 3 (CO3):

1. Draw the Shear Force Diagram and Bending Moment Diagram of a beam.

2. Determine the bending stress and shear stresses in beams.

3. Explain pure bending with example.

Course Outcome 4 (CO4):

1. Estimate the deflection of the beam.

2. Discuss principal planes and principal stresses.

3. Determine principal stresses, maximum shear stress, plane of maximum shear stress and the resultant stress on the plane of maximum shear stress

Course Outcome 5 (CO5):

1. Draw the Mohr's circle.

2. Discuss the behaviour of structures under compound loading.

3. Calculate the safe buckling load.

MODEL QUESTION PAPER

THIRD SEMESTER MECHANICAL ENGINEERING

Time: 3 hrs **MET281 MECHANICS OF MATERIALS** **Max. Marks: 100**

PART – A

(*ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS*)

1. Discuss the significance of Poisson’s ratio.
2. Explain Hooke’s law for linearly elastic isotropic material.
3. List the important assumptions in the theory of torsion.
4. Explain the term 'point of inflection'.
5. Define i) section modulus and ii) flexural rigidity
6. Explain how shear stress is distributed over the cross section of a rectangular beam.
7. Explain how double integration method can be used to obtain slope and deflection of beams.
8. Define principal stresses and principal planes and explain its significance
9. Draw the Mohr’s circle for uniaxial tensile load acting on a mild steel bar.
10. Write a short note on Rankine's crippling load for a column.

PART – B

(*ANSWER ONE FULL QUESTION FROM EACH MODULE*)

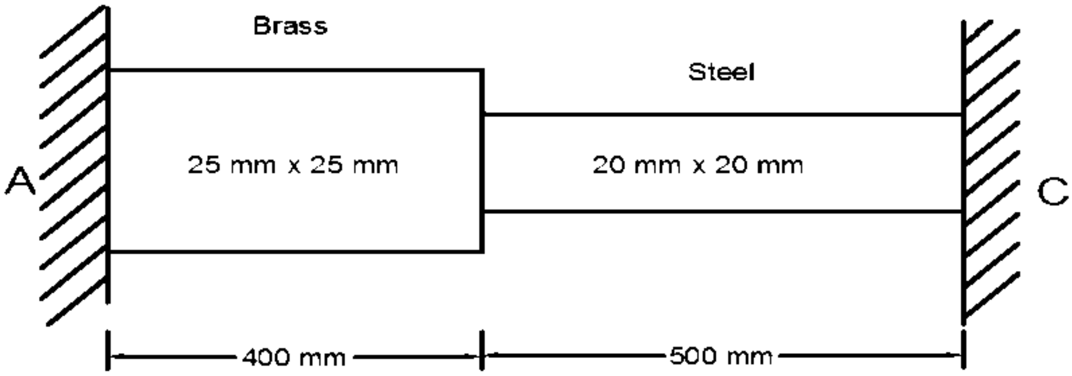
MODULE – 1

11. a) Draw a typical stress strain curve for mild steel under tension, describing briefly the salient points . (7 marks)

    b) A steel bar is fastened between two copper bars as shown in figure. The assembly is subjected to loads at positions as in figure. Calculate the total deformation of the bar and stresses at each section. E_{steel} = 200 GPa and E_{copper} = 110 GPa. (7 marks)

OR

12. a) A bar made of brass and steel as shown in figure is held between two rigid supports A and C. Find the stresses in each material if the temperature rises by 40°C. Take $E_b = 1 \times 10^5$ N/mm^2; $\alpha_b = 19 \times 10^{-6}$ / °C, $E_s = 2 \times 10^5$ N/mm^2 ; $\alpha_s = 12 \times 10^{-6}$ / °C. (9 marks)



b) A straight bar 450 mm long is 40 mm in diameter for the first 250 mm length and 20 mm diameter for the remaining length. If the bar is subjected to an axial pull of 15 kN, find the maximum and minimum stresses produced in it and the total extension of the bar. Take $E = 2 \times 10^5$ N/mm^2. (5 marks)

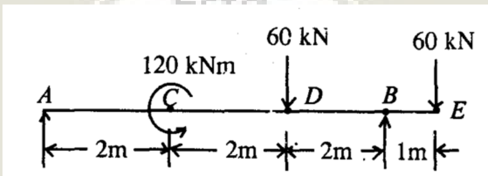
MODULE – 2

13. a) A solid aluminium shaft 1 m long and 50 mm diameter is to be replaced by a tubular steel shaft of the same length and the same outside diameter such that each of the two shafts could have the same angle of twist per unit torsional moment over the total length. What must the inner diameter of the tubular steel shaft be? Modulus of rigidity of the steel is three times that of aluminium. (10 marks)

b) A solid steel shaft transmits 20 kW at 120 rpm. Determine the smallest safe diameter of the shaft if the shear stress is not to exceed 40 MPa. (4 marks)

OR

14. a) Draw shear force and bending moment diagram for the beam given in the figure and mark all the salient points. (10 marks)

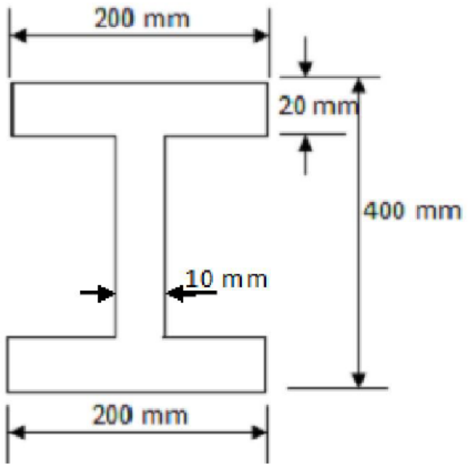


b) Explain the sign conventions used for shear forces and bending moments. (4 marks)

MODULE – 3

15. a) Derive the flexure formula for pure bending of a beam. State the assumptions (9 marks)

b) A rolled steel joist of I section has the dimensions as shown in figure. The beam carries a uniformly distributed load of 40 kN/mm^2 run on a span of 10 m, calculate the maximum stress produced due to bending. (5 marks)



OR

16. a) At the critical section of a beam of rectangular cross section with height 200 mm and width 100 mm, the value of the vertical shear force is 40 kN. Draw the shear stress distribution across the depth of the section. (9 marks)

    b) Derive the expression for shear stress in a beam. (5 marks)

MODULE – 4

17. a) A horizontal girder of steel having uniform section is 14 m long and is simply supported at its ends. It carries concentrated loads of 120 kN and 80 kN at two points 3 m and 4.5 m from the two ends respectively. Moment of inertia for the section of the girder is 16×10^8 mm^4 and E_s = 210 kN/mm^2. Calculate the deflection of the girder at points under the two loads and maximum deflection using Macaulay's method. (10 marks)

    b) A rectangular block of material is subjected to a tensile stress of 110 N/mm^2 on one plane and a tensile stress of 47 N/mm^2 on a plane at right angles, together with shear stresses of 63 N/mm^2 on the same planes. Find the magnitude of the principal stresses and maximum shear stress. (4 marks)

OR

18. a) Derive the transformation equations to determine normal and shear stress on an oblique plane. (10 marks)

    b) Define state of stress at point. Show the components of stress on a 3D rectangular element (4 marks)

MODULE – 5

19. a) At a point in a bracket the stresses on two mutually perpendicular planes are 120 N/mm^2 and 60 N/mm^2 both tensile. The shear stress across these planes is 30 N/mm^2. Find using the Mohr's stress circle i) Principal stresses at the point, ii) Maximum shear stress and iii) resultant stress on a plane inclined at 60° to the axis of the major principal stress. (10 marks)

b) Explain with the help of an example, how to calculate the normal stress when axial and transverse loads act simultaneously. (4 marks)

OR

20. a) Find the crippling load for a hollow steel column 50mm internal diameter and 5mm thick. The column is 5m long with one end fixed and other end hinged. Use Rankine's formula and Rankine's constant as 1/7500 and σ_c = 335 N/mm^2. (9 marks)

b) Derive Euler's formula for a column with both ends hinged. (5 marks)

SYLLABUS

Module 1

Introduction to analysis of deformable bodies – internal forces – method of sections – assumptions and limitations. Stress – stresses due to normal, shear and bearing loads – strength design of simple members. Definition of linear and shear strains.
Material behavior – uniaxial tension test – stress-strain diagrams – Hooke's law for linearly elastic isotropic material under axial and shear deformation, Poisson's ratio, Relationship between Young's modulus, Poisson's ratio and rigidity modulus(no derivations)
Deformation in axially loaded bars – thermal effects – statically indeterminate problems – principle of superposition.

Module 2

Torsion: Shafts - torsion theory of elastic circular bars – assumptions and limitations – polar modulus - torsional rigidity – economic cross-sections – statically indeterminate problems – shaft design for torsional load.
Beams- classification - diagrammatic conventions for supports and loading - axial force, shear force and bending moment in a beam.

Shear force and bending moment diagrams for simply supported, cantilever and overhanging beams (with concentrated loads, moment and uniformly distributed loads only), point of inflection and contraflexure

Module 3

Stresses in beams: Pure bending – flexure formula for beams assumptions and limitations – section modulus – flexural rigidity – economic sections, Problems to calculate bending stress for rectangular and I cross sections.

Shearing stress formula for beams – assumptions and limitations – Problems to calculate shear stress for beams of rectangular cross section.

Module 4

Deflection of beams: Moment-curvature relation – assumptions and limitations - double integration method – Macaulay's method.

Transformation of stress and strains: Definition of state of stress at a point (introduction to stress and strain tensors and its components only) -plane stress – plane strain - equations of transformation (2D) - principal planes and stresses - analogy between stress and strain transformation

Module 5

Mohr's circles of stress (2D)
Compound stresses: Combined axial, flexural and shear loads – combined bending and twisting loads.

Theory of columns: Buckling theory – Euler's formula for long columns – assumptions and limitations – effect of end conditions – slenderness ratio – Rankine's formula for intermediate columns.

Text Books

1. S.S Rattan, "Strength of Materials", McGraw Hill, 2nd edition, 2011.

Reference Books

1. Surya Patnaik, Dale Hopkins, Strength of Materials, Butterworth-Heinemann, 1st edition, 2003.
2. S. H. Crandal, N. C. Dhal, T. J. Lardner, An introduction to the Mechanics of Solids, McGraw Hill, 1999.
3. Mechanics of Materials, Pytel A. and Kiusalaas J. Cengage Learning India Private Limited, 2nd Edition, 2015
4. R. C. Hibbeler, Mechanics of Materials, Pearson Education, 2008.
5. I.H. Shames, J. H. Pitarresi, Introduction to Solid Mechanics, PHI, 2006.
6. James M. Gere, Mechanics of Materials, Brooks/Cole–Thomson Learning, 2004.
7. F. P. Beer, E. R. Johnston, J. T. DeWolf, Mechanics of Materials, Tata McGraw Hill, 2011.
8. MIT Open Courseware web course http://web.mit.edu/emech/dontindex-build/
9. Egor P. Popov, "Engineering Mechanics of Solids", PHI, 2nd edition, 2002.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
1	**Module 1: Introduction to Stress and Strain Analysis**	**9**
1.1	Introduction to analysis of deformable bodies – internal forces – method of sections – assumptions and limitations.	1
1.2	Stress – stresses due to normal, shear and bearing loads – strength design of simple members. Definition of linear and shear strains.	2
1.3	Material behavior – uniaxial tension test – stress-strain diagrams for ductile and brittle materials under axial loading, significance of various points on the diagram	1
1.4	Hooke's law for linearly elastic isotropic material under axial and shear deformation, Poisson's ratio.	1
1.5	Relationship between Young's modulus, Poisson's ratio and rigidity modulus(no derivations)	1
1.6	Deformation in axially loaded bars – thermal effects – statically indeterminate problems – principle of superposition	3
2	**Module 2: Torsion and Introduction to beams**	**9**
2.1	Introduction to Torsion of Shafts – torsion theory of elastic circular bars – assumptions and limitations	1
2.2	Polar modulus - torsional rigidity – economic cross-sections – statically indeterminate problems	2
2.3	Shaft design for torsional load and numerical problems	1
2.4	Introduction to beam bending – sign conventions for supports, loads and moments, classifications of beams, demonstration of the behaviour of beams for various types of loads	2
2.5	Shear force and bending moment diagrams for simply supported, cantilever and overhanging beams (with concentrated loads, moment and uniformly distributed loads only), point of inflection and contraflexure (simple problems to draw the SF and BM diagrams)	3
3	**Module 3: Beam Bending**	**9**
3.1	Stresses in beams: Pure bending – flexure formula for beams assumptions, limitations and derivation	3
3.2	Section modulus – flexural rigidity – economic sections –, numerical problems to analyze the strength of beams (rectangular and I sections only)	3
3.3	Shearing stress in beams – assumptions and limitations – derivation of formula for shear stress, problems to calculate shear stress for beams of rectangular cross section	3
4	**Module 4: Deflection of Beams and Stress-Strain transformations**	**9**
4.1	Introduction to deflection of beams: Moment-curvature relation – assumptions and limitations	1

4.2	Double integration method – Macaulay's method – Simple problems to calculate deflection of cantilever and simply supported beams subjected to point load, moment and UDL	3
4.3	Definition of stress at a point (introduction to stress and strain tensors and its components only), plane stress, plane strain	2
4.4	Stress and strain transformations in 2D – transformation equations - analogy between stress and strain transformation	1
4.5	Determination of principal stresses and principal planes	2
5	**Module 5: Mohr's Circle, Compound Stress and Column Buckling**	**9**
5.1	Mohr's circles of stress (2D) – problems	2
5.2	Compound stresses: Combined axial, flexural and shear loads – discussion of practical situations of combined loading and compound stresses	2
5.3	Combined bending and twisting loads	1
5.4	Introduction to Buckling of columns – Buckling theory – Euler's formula for long columns – assumptions and limitations	2
5.5	Effect of end conditions – slenderness ratio – Rankine's formula for intermediate columns – numerical problems for maximum buckling	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET283	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

Course Outcome 1

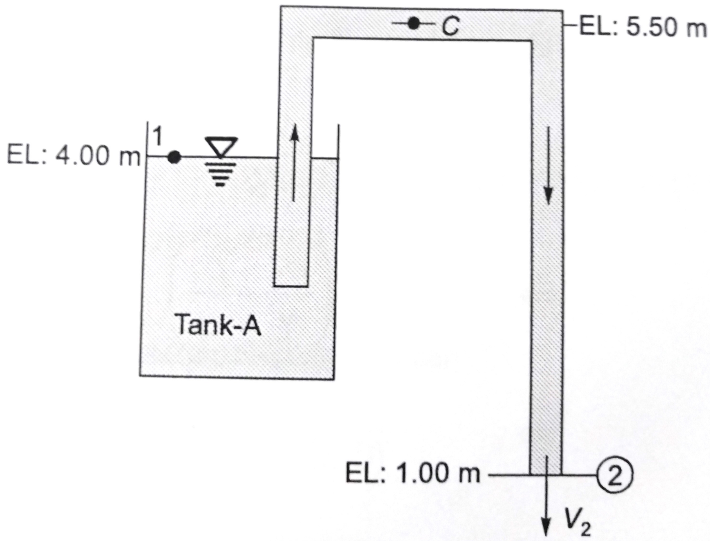
1. Define total pressure on a surface and center of pressure on a surface. What do you understand by the term hydrostatic pressure ?
2. An isosceles triangle of base 3m and altitude 6m is immersed vertically in water with its axis of symmetry horizontal. If the head on its axis is 9m, locate the center 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. Define the following and give one practical example for each of the following:
   (a) laminar flow
   (b) Turbulent flow
   (c) Steady flow
   (d) Uniform flow
2. A two dimensional flow 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 specific gravity 0.8 flows 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. Differentiate between impulse and reaction turbine.

2. Prove that for a single jet Pelton wheel, the specific speed is given by the relation

$$N_s = 219.78 \frac{d}{D} \sqrt{\eta_o}$$

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 efficiency of the wheel, if coefficient 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 significance 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’s 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

IV SEMESTER B.TECH DEGREE EXAMINATION

MET283: FLUID MECHANICS AND MACHINERY

Maximum: 100 Marks | Duration: 3 hours

PART A

Answer all questions, each question carries 3 marks

1. Define a fluid. What is the difference between ideal and real fluid?
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. Define 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 specific gravity 0.8 flows 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. Differentiate between impulse and reaction turbine
8. Explain the functions of Draft tube
9. Define slip and percentage slip of a reciprocating pump, what are the reasons for negative slip.
10. What are the different classifications 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)

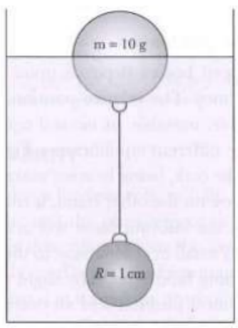
12. (a) A U-tube is made up of two capillaries of bores 1mm and 2.2mm respectively. The tube is held vertically with zero contact angle. It is partially filled with liquid of surface tension 0.06 N/m. If the estimated difference in the level of two menisci is 15mm, determine the mass density of the liquid. (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)

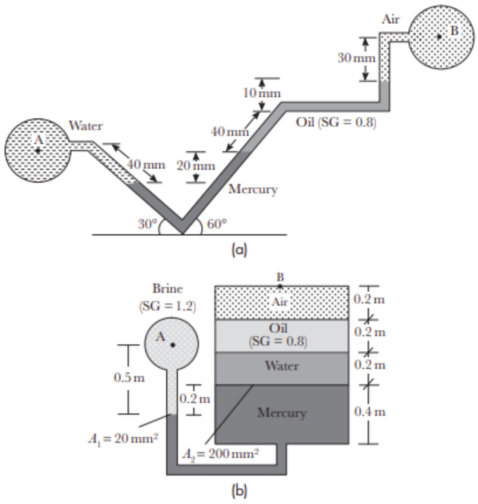
MODULE-II

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^2 (7 marks)



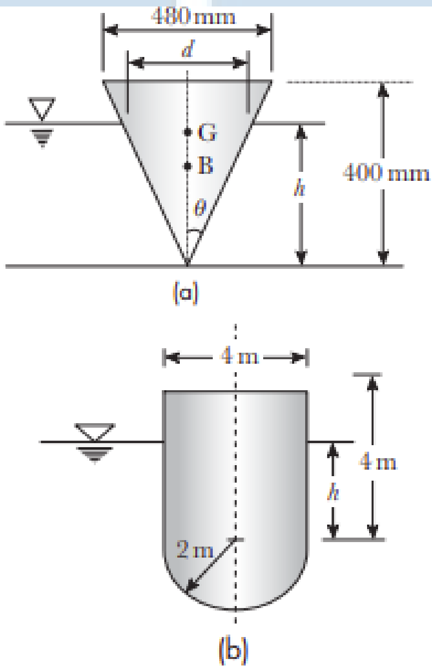
    (b) If the velocity distribution for a 2D ideal flow is given by $u = \frac{x}{2+t}, v = \frac{y}{1+3t}$ Obtain the equation of (a) the streamlines, (b) the pathlines, and (c) the streaklines that pass through point (1, 2) at t = 0. (7 marks)

14. (a) Find out the pressure difference between points A and B for the manometers shown in the figures



(7 marks)

(b) Check whether the floating objects having specific gravity 0.8 shown in Fig. are stable or not.

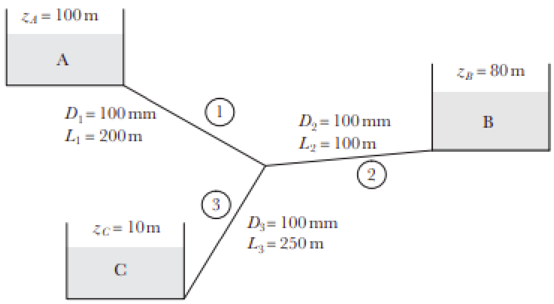


(7 marks)

MODULE-III

15. (a) The maximum velocity for the viscous flow 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 efficiency. Take the friction factor f = 0.04 (7 marks)

MODULE-IV

17. (a) A double jet Pelton wheel has a specific 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 efficiency = 85% (10 marks)

    (b) Define 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 fluid jet in its direction of flow on a semicircular vane is twice that exerted on a flat plate, both plates being fixed 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, flow ratio 0.65, and total efficiency 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. Specific speed of the turbine.

MODULE-V

19. (a) Draw the performance curves of a centrifugal pump. Also discuss the effect 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 efficiency 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 efficiency : 80% Overall effrciency :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 285	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 to

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 an 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 properties 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 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 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): 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 and 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. A small hole is drilled through a steel plate ahead of a crack, whether it can stop the crack's 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 device 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 this 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 structure and properties for engineering applications

1. Explain the slip systems of BCC, FCC and HCP. Why BCC and HCP exhibit brittle nature and 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 by 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 in solids, fick's laws - 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 285

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 the size of a small car, will travel directly into the Sun's atmosphere about 4 million miles from the earth surface. Postulate the coolant used in the parker solar probe with chemical bonds.
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 (i) 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) Grain 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 of alloying? Explain the fundamental rules governing the alloying with neat sketches and how is it 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 polyvinylchloride 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 wave number (7 marks).
   (b) The resistivity of silver at room temperature is 1.6 x 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 a full 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 anomalous 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 in solids, fick's laws, mechanisms, applications - dislocation density and attributes of nano structures.	3	

2.3	Mechanism of crystallization: Homogeneous and heterogeneous nuclei formation, under cooling, dendritic growth, grain boundary irregularity.	1	CO1 CO2
2.4	Effects of grain size, grain size distribution, grain shape, grain orientation 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	CO2 CO5
3.2	Fatigue: - Stress cycles – Primary and secondary stress raisers - Characteristics of fatigue failure, fatigue tests, S-N curve attributes.	2	
3.3	Factors affecting fatigue strength: stress concentration, size effect, surface 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 super 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 effects, 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 grade silicon, semiconductor grade silicon, single crystal growth, wafer manufacture, oxidation, photolithography, doping.	3	CO4
5.4	Ion implantation, epitaxial growth, metallization.	1	
5.5	Some semiconductor devices: - junction diodes, lasers and transistor, photon detectors.	2	CO4