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Q. No. MAC - 331

ND/B.Tech./ODD

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MATHEMATICS - III

MAC - 331

Full Marks : 60 Time : Three Hours

The figures in the margin indicate full marks.

Answer any *six* questions.

Symbols have their usual meanings.

No extra material is required.

1. (a) If $f(z)$ and $\overline{f(z)}$ are analytic functions in a domain D, show that f is constant there. 5 [CO#3]

   (b) Show that the function $u(x, y) = 2\sin x \sinh y - 3x^2y + y^3$ is harmonic. Hence find $v(x, y)$ such that $f(z) = u(x, y) + iv(x, y)$ is analytic. 5 [CO#3]

2. (a) Expand the function $f(z) = \dfrac{z}{(z+1)(z+2)}$ about $z = 0$ and find the radius of convergence. 5 [CO#3]

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(b) Evaluate the following contour integrals :

(i) $\oint_{|z|=4} \frac{z^4}{(z-i)^3} dz$;

(ii) $\oint_{|z|=5} \frac{z+5}{z^2-3z-4} dz$. 2.5+2.5 [CO#3]

3. (a) Find the bilinear transformation which maps $z = i$, 1, -1 onto $w = 1, 0, \infty$ respectively. Hence show that the unit circle $|z| = 1$ in z-plane maps onto the real axis of the w-plane. 5 [CO#3]

(b) Form the partial differential equation from the following equation

$$z = xf(x+y) + g(x+y),$$

where f and g are arbitrary functions. 5 [CO#1]

4. (a) Solve the partial differential equation (PDE) $p^2x^2 + q^2y^2 = z^2$. 5 [CO#1]

(b) Solve the PDE $(y^2 + z^2 - x^2)p - 2xyq + 2zx = 0$. 5 [CO#1]

5. (a) Find the general solution of the PDE

$$(D^2 - DD' - 2D'^2)z = (2x^2 + xy - y^2)\sin xy - \cos xy.$$

5 [CO#1]

(b) Reduce the PDE $xu_{xx} - 3u_{yy} = 0, x > 0$ into its canonical form. 5 [CO#1]

6. (a) Using Newton's interpolation formula, find the value of $f(0.33)$ correct upto 4-decimal places from the following data :

x	0.30	0.32	0.34	0.36	0.38	0.40
$f(x)$	1.7596	1.7698	1.7804	1.7912	1.8024	1.8139

5 [CO#2]

(b) Estimate the value of $\log_e 2$ from the integration

$$\int_0^7 \frac{1}{1+x}dx$$

by Simpson's 1/3rd rule with six sub-intervals.

5 [CO#2]

7. (a) Find a root of the equation $x^x + 2x - 6 = 0$ correct upto 8 decimal places using Newton-Raphson method which lies in (1, 2). 5 [CO#2]

(b) Find $y(1)$, by Euler's method, from the differential equation

$$\frac{dy}{dx} = -\frac{y}{1+x},$$

when $y(0.3) = 2$, correct upto 4-decimal places, taking step length h = 0.1. 5 [CO#2]

8. (a) A person wants to decide the constituents of a diet which will fulfill his daily requirements of proteins, fats and

P.T.O.

carbohydrates at the minimum cost. The choice is to be made from four different types of foods. The yields per unit of these foods are given in the following table.

Food Type	Proteins/ unit	Fats/ unit	Carbohydrates/ unit	'Cost (Rs.)/ unit
1	3	2	6	115
2	4	2	4	200
3	7	7	7	285
4	6	5	4	165
Minimum Requirement	900	300	800	

Formulate the linear programming model for the problem. 5 [CO#4]

(b) Define basic solution in a linear programming problem. Find basic feasible solutions of the following system of equations

$$2x_1 + x_2 - x_3 = 2$$
$$3x_1 + 2x_2 + x_3 = 3.$$

Identify the degenerate solution, if any. 5 [CO#4]

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Q. No. MEC - 303

ND/B.Tech./ODD
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FLUID MECHANICS

MEC - 303

Full Marks : 60 Time : Three Hours

The figures in the margin indicate full marks.

Materials to be supplied : Gas Table.

Use the following data for air at STP : $R = 287$ J/kg.K, $C_P = 1000$ J/kg.K, $C_V = 716$ J/kg.K and $\gamma = 1.4$

Group - A

Answer any *four* questions.

1. (a) Draw a neat sketch of Venturimeter with U-tube Mercury Manometer connected to it.

   (b) A horizontal venturimeter, with inlet and throat diameters 300 mm and 100 mm, respectively is used to measure the flow of oil of specific gravity 0.88. The pressure intensity at inlet is 130 kN/m^2 while the vacuum pressure head at the throat is 350 mm of Hg. Assuming = 0.92 find, actual discharge (Q_{actual}). 1+4=5 [CO2]

2. Considering the steady and fully developed incompressible flow in a $x-y$ plane through parallel plates where bottom plate is fixed and top plate is moving with a velocity U and distance between the plates is a,

   (a) Find the expression of velocity (u) within gap between the plates using Navier-Stokes equation.

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(b) Find the shear stress (τ_{xy})

(c) Find volume flow rate (Q)

(d) Find the average velocity $(\bar{V})$

2.5+0.5+1.5+0.5=5 [CO3]

3. Air at the rate of 10 kg/s is flowing in an adiabatic duct. At one section the pressure is $2 * 10^5$ N/m^2 the temperature is **650°C** and area is 50 cm^2. At a downstream section the Mach number is 1.2.

(a) Sketch the general shape of the duct.

(b) Find A_2 if the flow is isentropic.

(c) Find A_2 if there is an entropy change of **42** J/kg.K.

1+2+2=5 [CO3]

4. A converging-diverging nozzle is designed to operate with an exit Mach number of M = 2.25. It is fed by a large chamber of air at 15.0 MPa and 600 K and exhausts into the room at 14.7 MPa. Assuming the losses to be negligible, compute the velocity in the nozzle throat. 5 [CO3]

5. A converging-diverging nozzle receives air from a tank at 100 MPa and 600 K. The pressure is 28.0 MPa immediately preceding a plane shock that is located in the diverging section. The Mach number at the exit is 0.5 and the flow rate is 10 kg/s. Determine : 1×5=5 [CO3]

(a) The throat area.

(b) The area at which the shock is located.

(c) The outlet pressure required to operate the nozzle in the manner described above.

(d) The outlet area.

(e) The design Mach number.

Group - B

6. (i) What is the definition of the velocity potential?

(ii) What is definition of the stream function?

(iii) Write the condition of irrotationality as a function of the velocity potential. 2+2+2=6 [CO1]

7. Considering the following velocity field $V_x = 2x$ and $V_y = -2y$. Is the motion irrotational? In the affirmative, what is the velocity potential? 2+2=4 [CO2]

8. A fluid flow is given by $\vec{V} = 8x^3\hat{t} - 10x^2y\hat{f}$. Find shear strain rate and the magnitudes of translation vector, rotational vector also the vorticity of fluid element at (1,2).
1+1+1+1=4 [CO2]

9. Derive the relation between tangential velocity and radius for free vortex flow. 4 [CO3]

10. Derive an expression for maximum centrifugal height for cylindrical forced vortex flow. 4 [CO3]

P.T.O.

Group - C

Answer any *three* questions.

(Answer of Group - C to be given in one separate cluster in question sequence)

(2 marks are reserved for neatness)

11. (a) Describe Buckingham Pi Theorem to formulate a dimensionally homogeneous equation between the various physical quantities. 2 [CO1]

(b) Define and formulate the following dimensionless numbers and state their significance for fluid problems :

(i) Reynolds Number

(ii) Mach Number 2×2=4 [CO1]

12. (a) For a steady and uniform laminar flow through a circular pipe, prove that the velocity distribution across the section is parabolic and average velocity is half of the maximum local velocity. 4 [CO1]

(b) An oil of viscosity 0.9 PaS and specific gravity 0.9 is flowing through a horizontal pipe of 60 mm diameter. If the pressure drop in 100 m length of pipe is 1800 KN/m^2, determine the centreline velocity. 2 [CO2]

13. (a) Derive an expression for the loss of head due to friction in pipes in turbulent flow regimes. 3 [CO1]

(b) Derive the expressions for Momentum Thickness and Energy Thickness and from that define the terms Momentum Thickness and Energy Thickness. 3 [CO1]

14. (a) An oil of specific gravity 0.92 and viscosity 0.003 PaS is to be transported at the rate of 2.5 m^3/s through a 1.2 m diameter pipe. Tests were conducted on a 12 cm diameter pipe using water at 20°C. Given viscosity of water at 20°C is 0.001 PaS. Find :

(i) Velocity of flow in the model

(ii) Rate of flow through the model 2.5 [CO2]

(b) A lubricating oil of density 850 kg/m^3 and viscosity 0.375 PaS flows through a 10 cm diameter pipe at the rate of 0.8 m^3/min. Find :

(i) Whether the flow is laminar or turbulent.

(ii) Frictional head loss in a length of 100 m.

(iii) Pressure gradient.

(iv) Wall shear stress. 3.5 [CO2]

Course Outcomes :

- CO1 : To understand the fundamental concepts of fluid mechanics
- CO2 : To formulate the fundamental equations in mathematical form to solve the fluid mechanics problems
- CO3 : To apply the conservation equations to analyse both viscous and inviscid flow.

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Q. No. MEC - 302

ND/B.Tech./ODD
Reg/2022-23

2022-23

THEORY OF MACHINES AND MECHANISMS

MEC - 302

Full Marks : 60 Time : Three Hours

The figures in the margin indicate full marks.

Group - A

Answer Question no. 1 and
any *three* from rest of the following questions.

1. (a) What is quick return mechanism? — Explain it with a suitable diagram. 3 [CO1]

   (b) Describe different inversions of four bar chain with necessary neat sketches. 3 [CO1]

   (c) Explain velocity and acceleration diagram of a slider crank mechanism. 3 [CO1]

2. (a) With neat sketches explain advantages of compound gear trains over the simple ones. 5 [CO1]

   (b) An epicyclic gear train shown in Fig. 1 is composed of a fixed annular wheel A having 150 teeth. $Z_B = 25$, $Z_D = 40$ and C is an idle gear. Gear D is concentric with gear A. Wheels B and C are carried on an arm E which revolves clockwise at 120 rpm about the axis of A. Find

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the number of teeth of gear C and its speed and sense of rotation. 7 [CO1]

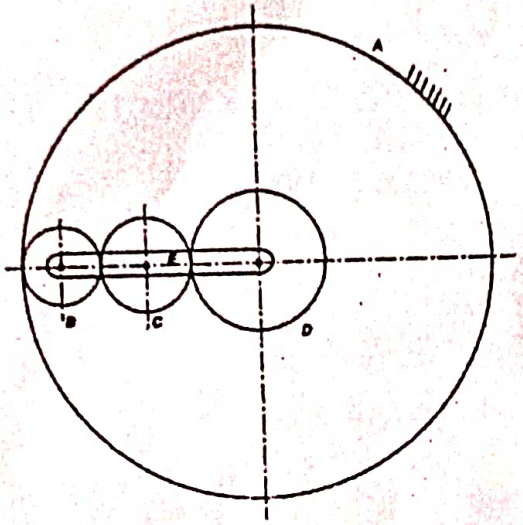

Fig.1

3. (a) What is piston effort? Derive expression of Turning moment in term of piston effort. 5 [CO1]

(b) A horizontal steam engine running at 180 rpm has a bore of 320 mm and stroke 560 mm. The connecting rod is 1 m long and the mass of the reciprocating parts is 50 kg. When the crank is 50° past inner dead centre, the steam pressure on the cover side of the piston is 1.2 MPa, while that on the crank side is 0.15 Mpa. Neglecting the area of the piston rod, determine (i) The force on the piston, and (ii) turning moment on the crankshaft. 7 [CO1]

4. (a) What is a turning moment diagram? With the help of a turning moment diagram, explain the function of a flywheel of a four stroke I C engine. 5 [CO1]

(b) The turning moment diagram for a petrol engine is drawn to a vertical scale of 1 mm = 500 Nm and a horizontal scale of 1 mm = 3°. The turning moment diagram repeats itself after every half revolution of the crankshaft. The areas above and below the mean torque line are 260, –580, 80, –380, 870 and –250 mm^2. The rotating parts have a mass of 55 kg and radius of gyration of 2.1 m. If the engine speed is 1600 rpm, determine the coefficient of fluctuation of speed. 7 [CO1]

5. (a) With a neat sketch derive the following expression of height of a Porter governor.

$$h = \frac{895}{N^2}\left(\frac{2mg + (Mg \pm f)(1+k)}{2mg}\right)m \qquad 5\ [CO1]$$

(b) The arms of a Porter governor are each 200 mm long. The weight of each ball is 40 N and that of the sleeve is 200 N. The radius of rotation of the balls is 125 mm when the sleeve begins to rise and reaches a value of 150 mm for maximum speed. Determine the speed range of the governor. If the friction at the sleeve is equivalent to 20 N of load at the sleeve, determine how the speed range is modified. 7 [CO1]

Group - B

Answer any *one* of the following questions.

6. (a) Determine the lengths of the links of a four bar mechanism to generate $y = 1/x$ over the range $1 \leq x \leq 2$

P.T.O.

using three accuracy points with Chebyshev's spacing. The length of the smallest link is 1 cm. Assume initial angle and final angle of input link and output link are 30° and 240° respectively whereas total swing angle of input the link is 90° and total swing angle of output the link is also 90°. 5 [CO2]

(b) A pinion having 40 teeth drives a gear having 90 teeth. The profile of the gears is involute with 20° pressure angle, 10 mm module and addendum equal to one module. Find the path of contact and the contact ratio. 5 [CO1]

(c) A constant velocity cam that is designed for Simple Harmonic Motion (SHM). If the flat-faced follower displaces 20 mm for 180° of cam rotation. If the cam angular velocity is constant at 100 rpm, what is the acceleration of the follower at a cam angle of 45°. 4 [CO1]

(d) Define pressure angle of a cam-follower mechanism. 1 [CO1]

7. (a) In an offset slider-crank mechanism, the rotation of the crank from 60° to 150° (Counter Clockwise) has to be converted into a 20 cm translation of the slider from left to right so that the translation is proportional to the rotation of the crank. Determine the kinematic dimension of the links using three Chebyshev's accuracy points. 4 [CO2]

(b) Two involute spur gears in a mesh externally have a

module 4 mm and pressure angle of 20°. The gear ratio is 3 and the addendum is equal to 1.2 module. If the pinion rotates at 120 rpm, determine the : (i) minimum number of teeth on each wheel to avoid interference, (ii) contact ratio. 5 [CO1]

(c) A cam that is designed for cycloidal motion drives a flat-faced follower. During the rise, the follower displaces 10 mm for 180° of cam rotation. If the cam angular velocity is constant at 100 rpm, what is the displacement of the follower at a cam angle of 60°. 5 [CO1]

(d) What do you mean by pressure angle of a gear? 1 [CO1]

Course Outcomes :

- CO1 : Knowledge of dynamics of elementary mechanisms and machines
- CO2 : One of the fundamental subject for machine design

20 x 5

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Q. No. MEC - 304

ND/B.Tech./ODD
Reg/2022-23

2022-23

ENGINEERING THERMODYNAMICS

MEC - 304

Full Marks : 60 Time : Three Hours

The figures in the margin indicate full marks.

Assume suitable data if necessary.
Symbols used carry their usual meanings.
Use Steam Table/Mollier Diagram to find out steam properties.

Section - A

Answer any *two* questions.

1. (a) Explain in words : 5 [CO1]

(i) Thermodynamic cycle

(ii) Thermodynamic equilibrium

(iii) Quasi-static process

(iv) Dead-state of a system

(v) Zeroth law of thermodynamics

(b) A fluid, contained in a horizontal cylinder fitted with a frictionless leak-proof piston, is continuously agitated by means of a stirrer passing through the cylinder cover. The cylinder diameter is 0.40 m. During the stirring process

P.T.O.

lasting 10 minutes, the piston slowly moves out a distance of 0.485 m against the atmosphere. The net work done by the fluid during the process is 2 kJ. The speed of the electric motor driving the stirrer is 840 rpm. Determine the torque in the shaft and the power output of the motor. 5 [CO2]

2. (a) Give the Kelvin-Planck statement of the second law. 1 [CO2]

(b) Show that the efficiency of a reversible heat engine operating between two given constant temperature is maximum. 3 [CO2]

(c) A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which the engine rejects heat to it. If the efficiency of the engine is 40% of the maximum possible and the COP of the heat pump is 50% of the maximum possible, what is the temperature of the reservoir to which the heat pump rejects heat? What is the rate of heat rejection from the heat pump if the rate of heat supply to the engine is 50 kW? 6 [CO2]

3. (a) What is available energy and unavailable energy? 1 [CO2]

(b) Two kg of water at 80°C are mixed adiabatically with 3 kg of water at 30°C in a constant pressure process of 1 atmosphere. Find the increase in the entropy of the total mass of water due to the mixing process (c_p of water = 4.187 kJ/kg K). 4 [CO2]

(c) A fluid undergoes a reversible adiabatic compression from 0.5 MPa, 0.2 m^3 to 0.05 m^3 according to the law, $pv^{1.3}$ = constant. Determine the change in enthalpy, internal energy and entropy and the heat transfer and work transfer during the process. 5 [CO2]

Section - B

Answer any *two* questions.

4. (a) Derive the expression of air standard efficiency and mean effective pressure for Diesel cycle. 3+4=7 [CO3]

(b) The stroke and cylinder diameter of a diesel cycle are 150 mm and 125 mm respectively. If the clearance volume is 0.0001 m^3 and fuel injection takes place for 7 percent of the stroke, determine the air standard efficiency of the engine. 3 [CO3]

5. (a) Explain briefly the Brayton cycle and derive the expression for air standard efficiency of it. 3 [CO3]

(b) Derive the expression of pressure ratio for maximum work of a Brayton cycle. 3 [CO3]

(c) Air enters the compressor of a gas turbine operating on Brayton cycle at 1 bar, 27°C. The pressure ratio of the cycle is 6. Calculate the power developed of the cycle and the exhaust gas temperature if the maximum temperature is limited to 1000°C. 4 [CO3]

6. (a) Briefly discuss the reversed Carnot cycle and derive an expression for C.O.P. 3 [CO3]

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(b) Briefly explain the reversed Brayton cycle. 3 [CO3]

(c) A Bell-Coleman refrigerator operates between pressure limits of 1 bar and 6 bar. Air is drawn from the cold chamber at 10°C, compressed and then it is cooled to 30°C before entering the expansion cylinder. Expansion and compression follow the law $pv^{1.35} = \text{constant}$. Calculate the theoretical C.O.P. of the system. 4 [CO3]

Section - C

Answer Q.7 (compulsory) and any *one* question from the rest.

7. (a) Draw the Carnot cycle and Rankine cycle of steam on temperature-entropy plane and derive the expression of cycle efficiencies in terms of temperatures only. Also compare the two cycles. 5 [CO4]

(b) What is binary vapour cycle? With necessary diagram explain the working principle of mercury-steam binary cycle. 4 [CO4]

8. (a) When is reheating of steam recommended in a steam power plant? Draw the Rankine cycle with reheat on Temperature-Entropy plane and derive the expressions of turbine work, pump work, heat addition, heat rejection and cycle efficiency in terms of enthalpy only. What is the optimum reheat pressure for achieving maximum cycle efficiency? 5 [CO4]

(b) A steam power plant operates on an ideal reheat Rankine cycle between the pressure limits of 9 MPa and 10 kPa. The mass flow rate of steam through the cycle is 25 kg/s. Steam enters both stages of the turbine at 500°C. If the

moisture content of the steam exiting the low-pressure turbine should not to exceed 10%, determine :

(i) the reheat pressure,

(ii) total rate of heat input in the boiler,

(iii) network output, and

(iv) the thermal efficiency of the cycle. 6 [CO4]

9. (a) Draw the flow diagram, temperature-entropy diagram of regenerative Rankine cycle for superheated steam with single open-type feed water heater. Determine the mass flow rate of the extracted steam, work done at turbine and pumps, heat addition and rejection and plant efficiency. 5 [CO4]

(b) An ideal regenerative cycle operates with steam supplied at 30 bar, 400°C and a condenser pressure of 0.1 bar. For the cycle find the cycle efficiency. Also, calculate the amount of steam extracted and quality of steam at condenser inlet, if the point of extraction is at 5 bar pressure. Consider open type of feed water heater. Neglect pump work. 6 [CO4]

Course Outcomes :

- CO1 : Knowledge of thermodynamical system
- CO2 : Mastering laws of thermodynamics
- CO3 : Study of air standard thermodynamic cycles
- CO4 : Properties of pure substance
- CO5 : Thermodynamic relations

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Q. No. MEC - 301

ND/B.Tech./ODD
Reg/2022-23

2022-23

SOLID MECHANICS

MEC - 301

Full Marks : 60 Time : Three Hours

The figures in the margin indicate full marks.

Answer *all* the questions.

Graph paper shall be supplied, if required.

1. Answer any *two* questions : 5×2=10 [CO1]

   (a) Establish the relation among uniformly distributed load (w), Induced shear force (F) and Induced bending moment (M) for a transversely loaded beam.

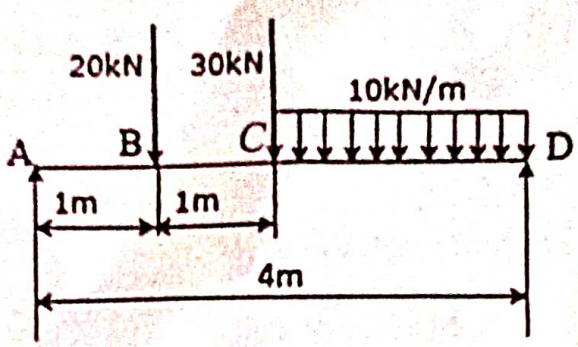
   (b) Define 'shear center' and 'shear flow' with appropriate diagrams. (No derivation required)

   (c) Define 'Maximum shear strain energy theory (Von Mises' theory)' of failure and represent it graphically with explanation.

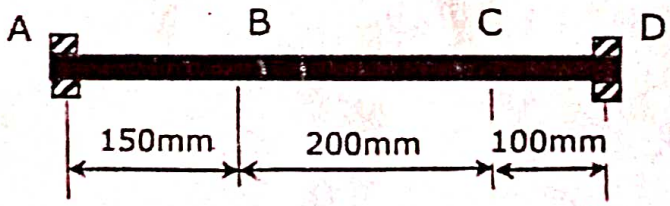
2. Answer any *one* question :

   (a) Draw the Bending Moment and Shear Force diagrams of the loaded beam shown in the figure. If the beam is of 75 mm wide and 150 mm depth, estimate the maximum bending stress induced. 7+3=10 [CO2]

P.T.O.



(b) A 50 mm diameter solid cylindrical shaft is supported by bearings at A and D. It transmits 25 kW at 720 RPM from section B to section C, as shown in the figure. The resultant bending forces at section B is 30 kN vertically downward and at section C is 10 kN vertically upward respectively. Find the maximum shear stress developed in the shaft and its location. If the yield normal strength of the material is 360 MPa, find the factor of safety considering failure by shear. 8+2=10 [CO2]



3. (a) When a cylinder can be considered as a thin cylinder? Deduce the stresses developed in terms of internal fluid pressure, internal diameter of the cylinder and the shell thickness. Which one of these stresses cause failure?

(b) What is the maximum safe pressure of a thin cylinder of 400 mm internal diameter made from 3 mm thick steel sheet of allowable normal stress 90 MPa.

7+3=10 [CO4]

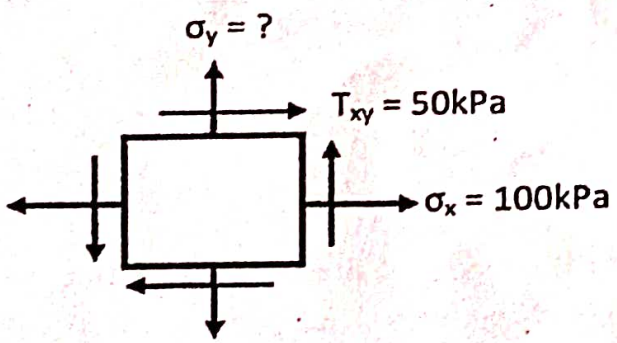
4. (a) Derive Euler's crippling load for a long column with both ends fixed.

(b) Find the Euler's crushing load for a hollow cylindrical cast iron column 120 mm external diameter and 20 mm thick, if it is 4.2 m long and is hinged at both ends. Take $E = 80\ kN/mm^2$. Compare this load with the crushing load as given by Rankine's formula using constants $\sigma_c = 550\ N/mm^2$ and $a = 1/1600$. For what length of strut does the Euler's formula cease to apply?

3+7=10 [CO4]

5. (a) The state of stress at a point, for a body in plane stress, is shown in the figure below. If the minimum principal stress is 10 kPa, then the normal stress σ_y (in kPa) is :

2 [CO1]



(b) State and prove the Castigliano's theorem. 3 [CO1]

(c) A simply supported beam of length 6 m is subjected to uniformly distributed load of 54 kN/m. Determine the deflection at the supporting ends and centre of the beam

P.T.O.

using strain energy method. Consider $E = 210$ GPa and $I = 28.9 \times 10^6$ mm^4. 5 [CO1]

6. A simply supported beam of length 10 m is loaded with a couple moment of 1 kN-m at the centre of the beam as shown below. Determine the following :

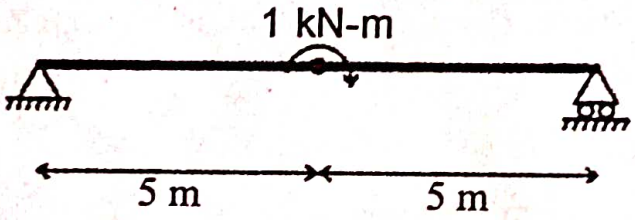
   (a) The equation for elastic deflection

   (b) The maximum deflection and its location

   (c) The slope at the ends

   Consider $E = 2.1 \times 10^5$ N/mm^2 and $I = 3000$ cm^4.

   3+4+3=10 [CO3]



Course Outcomes :

- CO1 : Understand the analysis of stress, strains, elasticity properties of materials, strain energy principles.
- CO2 : Demonstrate the members subjected to shear force, bending moments, flexure loads, torsional loads.
- CO3 : Calculate deflection of beams.
- CO4 : Estimate the members subjected to compressive loads.

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Q. No. PHC - 333

ND/B.Tech./ODD

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$\bar{v} = \frac{eE\tau}{m}$

PHYSICS OF ENGINEERING MATERIALS

PHC - 333

Full Marks : 60 Time : Three Hours

The figures in the margin indicate full marks.

Question No. 1 is compulsory.

Answer any *five* questions from question no. 2 to 9.

1. Answer any *five* short questions : 2×5=10

   (a) Distinguish between free-electron and independent-electron approximations in Drude's model. [CO1]

   (b) What is the origin of discrete energy levels in Sommerfeld model ? [CO4]

   (c) What is orientational polarizability ? [CO4]

   (d) Define Young modulus of a substance. [CO4]

   (e) Discuss how the mobility of the semiconductor changes with temperature. [CO1]

   (f) What is a primitive unitcell ? Given an example of primitive unitcell. [CO2]

   (g) Why are direct bandgap materials preferred for constructing LEDs ? [CO3]

P.T.O.

(h) Define tilt boundaries and twin boundaries of a solid.
[CO4]

2. (a) Draw a generic band diagram of a crystal, showing clearly the valence and conduction bands over the entire range of the First Brillouin Zone (FBZ).

(b) Explain what happens to the velocity of a hole and an electron at the edge of the FBZ.

(c) How does the velocity of the hole change as we approach the center of FBZ from left ? Provide the physical interpretation for such an anomalous behavior of the hole velocity.

(d) How do you relate this anomalous behavior of hole to its effective mass ? (Hint : Effective Mass is negative!)
2+3+3+2, [CO2]

3. What is the physical origin of the appearance of energy gap between valence and conduction bands ? Draw a diagram of electronic charge density on the lattice of positive ions for energy states at the top of the valence band and at the bottom of the conduction band. Justify the difference in the energies between E_c and E_v using the above diagram.
4+3+3 [CO1]

4. Beginning with the equation relating the thermal current in a material, j_q, to the temperature gradient, dT/dx, using Drude model, derive the thermal conductivity κ of the material.

Using the above result, show that $\kappa/\sigma T = 3/2\left(k_B/e\right)^2$ (Wiedemann-Franz law). Here σ is the electrical conductivity. Drude's model over-estimated the specific heat by a factor

$\kappa = \frac{1}{3} n v^2 \tau c_v$

of 100. Describe qualitatively how Sommerfeld's model corrected Drude's prediction using Fermi Distribution function instead of classical Maxwell-Boltzmann distribution. Which factor in the expression for the electronic specific heat accounted for the correction of Drude's result ? 5+3+2 [CO1]

5. Show that the supercurrent of superconducting pairs across the junction depends on the phase difference. For a specimen of V_3Ga, the critical fields are 1.4×10^5 and 4.2×10^5 ampere/metre for 14K and 13K respectively. Calculate the critical fields at 4.2K.

   Explain how Clausius-Mosotti equation can be used to determine the dipole moment of a polar molecule from the dielectric constant measurements. 3+3+4 [CO4]

6. Explain the terms dielectric loss and dielectric breakdown. The dielectric constant and density of S at 300K are 3.75K and 2050 kgm^{-3}, respectively. Calculate the electronic polarizability of S. Given : atomic weight of S is 32 and internal field constant is 1/3. Young's modulus of a substance is equal to 7×10^4 Nm^{-2} and rigidity modulus for same material is 3×10^4 Nm^{-2}. Calculate bulk modulus of elasticity for the material. 4+3+3 [CO4]

7. What are the differences between a normal diode and a Zener diode ? What are the uses of Zener diode ? A Zener diode has 1.0×10^{25} acceptor atoms/m^3 of the p-region and 5.3×10^{25} dónor atoms/m^3 of the n-region. Calculate the width of depletion region and the value of the electric field developed across the unbiased junction at room temperature.

P.T.O.

Given that the intrinsic carrier density of the semiconductor is $2.3\times10^{19}/m^3$ and relative permittivity of the semiconductor is 14. 3+2+3+2 [CO2]

8. Name different types of bonding of solids. Define Schottky and Frankel defects of solids. Define the plane and screw dislocation of a crystal. What is Burger vector ? How it can locate the position and different types of defects that take place in a perfect crystal ? Explain four different methods of strengthening the mechanism of material. 2+2+2+1+1+2 [CO4]

9. Calculate the internal quantum efficiency of a LED in terms of the internal power. Explain the effects of internal quantum efficiency on the external efficiency of a LED. Derive the expression for LED output power. What are the advantages of hetero-junction LED ? Design a simple dc biasing circuit with a 9V battery for a LED that has a maximum forward current of 2 mA at 2V. 3+1+2+2+2 [CO2]

Course Outcomes :

CO1 : To understand fundamental theory of metal.

CO2 : To comprehend theory and device applications of semiconductor materials.

CO3 : To be familiar with fundamental of laser and its applications.

CO4 : To know about the super conductivity, dielectric and mechanical properties of material.

$$P = \frac{\eta_0 \, i \, n_r}{e}$$