MECHANICAL SCIENCE

***Time**: Three Hours*

***Maximum Marks**: 100*

Answer five questions, taking ANY TWO from Group A, any two from Group B and all from Group C.

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

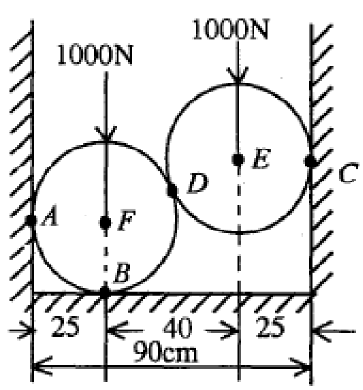
Group A

1. (a) Derive an expression for the time taken by a body, projected vertically upwards with a velocity u, to reach a height A. 6

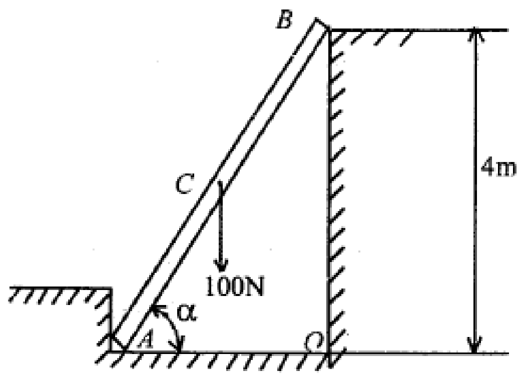
   (b) A stone after falling from rest for 4 sec breaks a glass plane and in breaking it looses 25% of its velocity. How far will it fall in the next second? 6

   (c) A projectile is fired with an angle of projection a. Find the expression for the trajectory of the projectile. Also, find the maximum range and maximum height of the flight of the projectile. 8

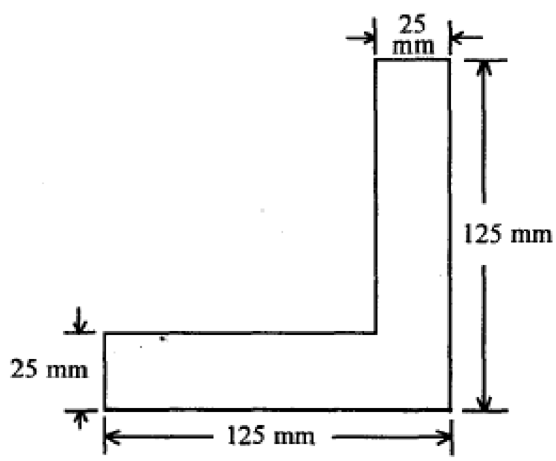
2. (a) Two spheres each of weight 1000N and of radius 25 cm rest in a horizontal channel of width as shown in Fig.. Find the reactions on the points of contacts A, B and C. 8



(b) A man weighing 100N stands on the middle point of a ladder AB whose weight can be neglected. Assuming that the floor and wall are perfectly smooth and that slipping is prevented by a stop at A, find the reactions at A and B. Given $\alpha = 60^0$. 6



(c) Determine the moment of inertia of the composite figure about an axis through its centre of gravity and parallel to the base. 6



3. (a) A screw thread of a screw jack has a mean diameter of 10 cm and a pitch of 1.25 cm. The coefficient of friction between the screw and its nut-housing is 0.25. Determine the force F that must be applied at the end of a 50 cm lever arm to raise a mass of 5000 kg. Is the device self-locking? Also, determine its efficiency? 6

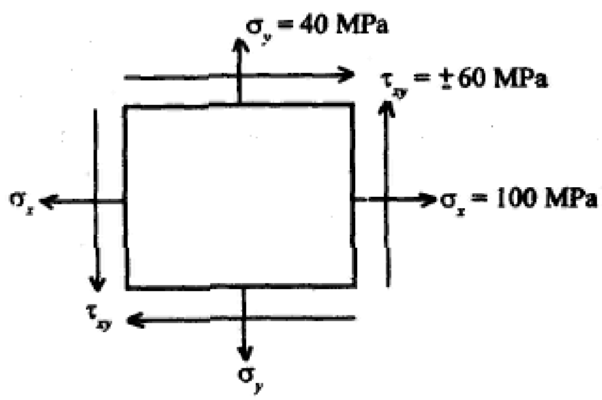
(b) A man wishes to climb a 5m long ladder placed at 60° on a horizontal surface (μ = 0.3) against a vertical wall (μ = 0.2). How far can he climb without the ladder slipping? The man and the ladder weigh 800 N and 150 N, respectively. 6

(c) Describe the experimental procedure of a tensile test on a round steel bar. Draw the stress-strain curve and show the salient points on the curve. How do you determine Young's modulus (E) and Poisson's ratio (ν) from this test? 8

4. (a) Two vertical wires are suspended from a ceiling at a distance of 500 mm apart. Their upper ends are firmly secured at the ceiling and their lower ends support a rigid horizontal bar which carries a load W. The left wire has a diameter of 1.6 mm and is made of copper and the right wire has a diameter of 0.9 mm and is made of steel. Both wires initially are 4.5 m long. Determine the position of the line of action of W, if the rigid bar is to remain horizontal after loading. Take: $E_s = 2.1 \times 10^5$ N/mm^2 and Ec = 3×10^5 N/mm^2. 6

(b) What do you mean by principal stresses? What is Mohr's circle? What is its significance? 8

A state of stress at a given point in a loaded member is shown in Fig.. Find the principal stresses. What is the value, of maximum shear stress?



(c) Prove $\frac{\tau}{R} = \frac{T}{J} = \frac{C\theta}{I}$ for a circular shaft. State the assumptions made for the derivation. Calculate the diameter of the solid shaft required to transmit a torque of 4500 Nm. The twist of the shaft not to exceed 1° over a length of 2 m. The shear modulus G of the shaft material is 133 GN/m^2. Also, calculate the maximum shear stress in the shaft. 6

Group B

5. (a) Define (i) ideal fluid, (ii) real fluid, (iii) Newtonian fluid, and (iv) non- 6

Newtonian fluid. (v) specific weight (vi) specific gravity

(b) The space between two square flat parallel plates is filled with oil. Each side of the plate is 60 cm. The thickness of the oil film is 12.5 mm. The upper plate, which moves at 2.5 m/s, requires a force of 98.1 N to maintain the speed. Determine the (i) dynamic viscosity of the oil (in poise), and (ii) kinematic viscosity of oil in stokes, if the specific gravity of oil is 0.95. 6

(c) What do you understand by total pressure and centre of pressure? Derive an expression for the force exerted on a submerged vertical plane surface by the static liquid. 6

6. (a) A circular plate of 3 m diameter is immersed in water in such a way that its greatest and least depth below the free surface are 4 m and 15m respectively. Determine the total pressure on one face of the plate and position of centre of pressure. 8

(b) A rectangular plane surface is 2 m wide and 3 m deep. It lies in vertical plane in water. Determine the total pressure and position of centre of pressure on the plane surface when its upper edge is horizontal and (i) coincides with water surface, and (ii) 2.5 m below the free water surface. 6

(c) Distinguish between the following : (i) Steady flow and unsteady flow (ii) Uniform and non-uniform flow (iii) Compressible and incompressible flow (iv) Rotational and irrotational flow (v) Laminar and turbulent flow (vi) Stream function. 6

7. (a) Explain conservation of energy and the first law of thermodynamics. Write expressions for the first law applied to (i) a cycle, and (ii) a process. State the limitations of first law of thermodynamics. 8

(b) A gas is compressed in a cylinder by a moveable piston to a volume one half of its original volume. During this process, it was found that 80 kcal of heal was left the gas, and internal energy of the gas remained the same. Considering the gas as the system, calculate the work done. 6

(c) A Carnot engine operates between two reservoirs at temperatures T_1 °K and T_2 °K. The output of the heat engine is 0.6 limes the heat rejected. Given that the difference in temperatures between source and sink is 200°C, calculate the (i) source temperature; (ii) sink temperature, and (iii) thermal 6 efficiency.

8. (a) For a reversible adiabatic process, prove that Pv^r = constant, where r is the ratio of specific heats. Show the process on P-v and T-s co-ordinates. 8

(b) A reversible power cycle operates between a reservoir at temperature T and a lower temperature reservoir at 200 K. At steady state, the cycle develops 40 kW of power while rejecting 1000 kJ/min by heat transfer to the cold reservoir. Determine the value of T. 6

(c) A perfect gas undergoes the following three separate and distinct processes to execute a cycle: 6

(i) Constant volume process during which 80 kJ of heat is supplied to the gas.

(ii) Constant pressure process during which 85 kJ of heat is lost to the surrounding and 20 kJ of work is done on it.

(iii) Adiabatic process which restores the gas back to its initial state.

Evaluate the work done during adiabatic process and the value of internal energy at all the state point, if initially its value is 95 kJ.

Group C

9. Answer the following in brief: 20

(i) Work done in a free expansion process is

(a) zero

(b) minimum

(c) maximum

(d) positive

(ii) For a reversible adiabatic process, the change in entropy is

(a) zero

(b) minimum

(c) maximum

(d) unity.

(iii) The value of C_p/C_v for air is

(a) 1

(b) 1.4

(c) 1.8

(d) 2.31

(iv) Stream lines and path lines always coincide in

(a) steady flow

(b) uniform flow

(c) non-uniform flow

(d) laminar flow.

(v) Discharge is measured by

(a) current meter

(b) venturimeter

(c) pitot tube

(d) hot wire anemometer.

(vi) The shear stress in case of a pipe flow at the centre of the pipe, is

(a) maximum

(b) minimum

(c) zero

(d) negative.

(vii) The relation between modulus of elasticity E, modulus of rigidity, G, and Poisson's ratio μ, is

(a) $E = G(\mu + 1)$

(b) $G(\mu - 1)$

(c) $E = 2G(\mu + 1)$

(d) $E = 2G(\mu - 1)$

(viii) The radius of Mohr's circle for two unlike principal stresses of magnitude P is

(a) P

(b) P/2

(c) P/4

(d) None of the above.

(ix) A point of contraflexure in a beam occurs at a point, where

(a) B.M. changes sign

(b) S.F. changes sign

(c) loading becomes zero

(d) B.M. and S.F. become zero.

(x) The path traced by a projectile is

(a) circular

(b) parabolic

(c) elliptic

(d) hyperbolic.

(Refer our course material for answers)