APPLIED MECHANICS 1 OCT 12

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A steel shaft 240mm outside diameter is 2 m long. The shaft is solid for 0.8 m of its length and hollow for the remainder, with an inside diameter of 160 mm. The shaft is fixed at both ends and a torque of 25 kNm is applied at the junction of the solid and hollow sections.

   Calculate the maximum shear stress in the shaft material. (16)

2. A solid rectangular section beam is loaded as shown in Fig Q2. It is simply supported at points B and D and carries a uniformly distributed load of 6 kN/m over a 3 m length from A to C. The breadth of the beam is 80 mm and the maximum stress due to bending is not to exceed 140 MN/m^2.

   (a) Sketch the shear force diagram, indicating the values of shear force at points A, B, C and D. (4)

   (b) Sketch the bending moment diagram, stating the maximum bending moment and where it occurs. (6)

   (c) Calculate the minimum allowable depth of the beam. (6)

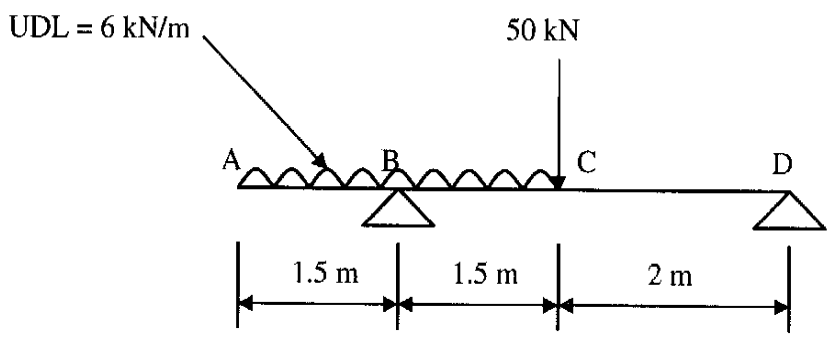

Fig Q2

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3. An overhead camshaft operated valve moves with Simple Harmonic Motion. The valve lift is 40 mm and the valve is opened and closed within 120° of camshaft rotation. The mass of the valve is 0.8 kg. The valve moves against a spring and the maximum and minimum spring forces are 900 N and 180 N respectively. The camshaft speed is 480 rev/min.

Calculate EACH of the following:

(a) the maximum velocity of the valve; (4)

(b) the maximum acceleration of the valve; (2)

(c) the force between the valve and the cam when the valve first starts to open; (5)

(d) the force between the valve and the cam when the valve is fully open. (5)

4. A winch drum has a mass of 300 kg and a radius of gyration of 320 mm. The winch has a single brake shoe acting on a brake drum of 0.4 m diameter. The coefficient of friction between the shoe and the drum is 0.8. Friction in the winch bearings is constant at 4 Nm.

Calculate EACH of the following:

(a) the force to be applied at the brake shoe to slow the winch down from 240 rev/min to 120 rev/min in 30 seconds; (10)

(b) the work done by the brake to bring the drum to rest from 240 rev/min using the brake force calculated in Q4(a). (6)

5. A Hartnell governor has three rotating balls each of mass 0.3 kg. The length of the ball arms are 150 mm and the length of the sleeve arms are 100 mm. When at the mean speed of 480 rev/min and rising the balls are at a radius of 110 mm. The governor spring stiffness is 14 kN/m and friction at the sleeve is 50 N.

Calculate EACH of the following:

(a) the spring compression at the mean speed; (8)

(b) the vertical movement of the sleeve if the speed increases by 5%. (8)

6. A short vertical hollow cylindrical column, 160 mm high and fixed at the base, is 70 mm outside diameter and 8 mm thick. It carries concentrated loads of 10 kN and 6 kN as shown in Fig Q6.

Calculate EACH of the following:

(a) the maximum compressive stress in the column; (8)

(b) the maximum tensile stress in the column. (8)

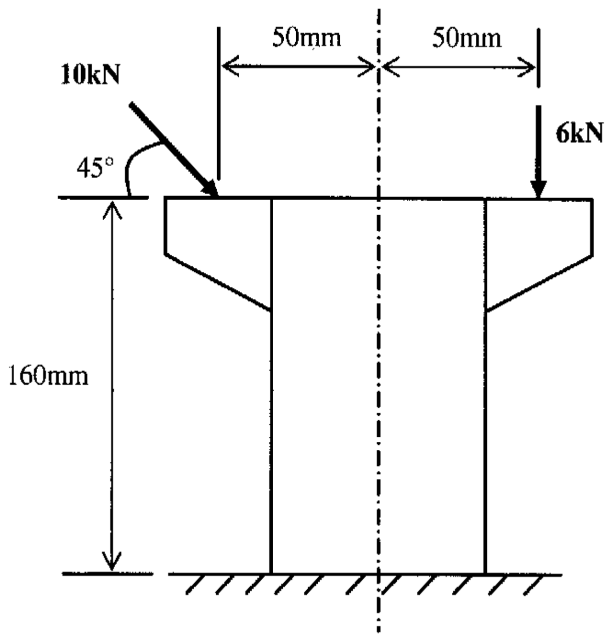

Fig Q6

7. A horizontal nozzle is supplied with sea water at a gauge pressure of 5 bar. The water inlet velocity may be assumed to be negligible. The nozzle has a diameter of 30 mm and a coefficient of velocity of 0.95. Water from the nozzle then strikes a curved fixed vane that deflects the water jet through 45°. Due to friction across the vane, the velocity of the water leaving the fixed vane is 6% lower than the initial velocity of the jet.

Calculate EACH of the following:

(a) the velocity of the water jet leaving the nozzle; (4)

(b) the magnitude and direction of the force exerted by the jet on the fixed vane. (12)

Note: Density of sea water = 1025 kg/m³

8. Two oil tanks are separated by a vertical bulkhead fitted with a circular flap valve, 600 mm diameter. The valve is hinged at its top edge, which is 2.5 m above the bottom of the tank. Both tanks contain oil of relative density 0.9, one to a depth of 2.5 m, the other to a depth of 3.2 m.

   Calculate the horizontal force required at the bottom edge of the door to open the door against the hydrostatic force. (16)

9. A hydraulic control piston is shown in Fig Q9. The input piston of 20 mm diameter is displaced by the input force P. The system is filled with an incompressible liquid and the movement of the 80 mm diameter output piston is resisted by a spring of stiffness 60 kN/m.

   Calculate the force P required to achieve a 40 mm movement of the input piston (16)

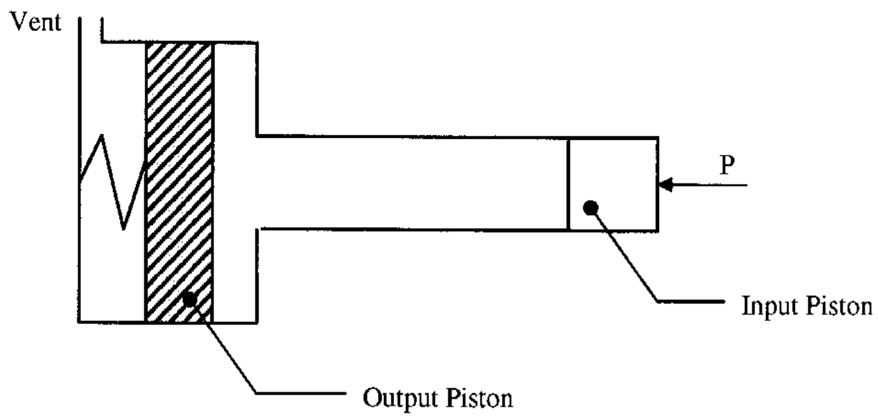

Fig Q9