APPLIED MECHANICS I

JULY 12

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A Porter governor has arms of equal length, three flyweights each of mass 3 kg and a central mass of 18 kg. Friction at the sleeve is constant at 22 N.

   Calculate the maximum and minimum speeds for a governor height of 120 mm. (16)

2. A hollow propeller shaft of 380 mm outside diameter and 320 mm inside diameter runs at 90 rev/min and propels a ship through the water at 17 knots. The total resistance of the ship through the water at this speed is 300 kN and the propeller efficiency is 78%.

   Calculate EACH of the following:

   (a) the power transmitted by the shaft; (6)

   (b) the angel of twist of the shaft per metre length in degrees; (6)

   (c) the maximum torsional stress in the shaft. (4)

   Note *Modulus of Rigidity of Shaft Material 80 GN/m^2*
   1 knot = 0.514 m/s

3. A short vertical column consists of a hollow steel tube of 52 mm outside diameter and 40 mm inside diameter with a concentric solid brass rod of 35 mm diameter within it. The steel tube is 380 mm long and the brass rod is 1 mm shorter.

   The maximum allowable stress in the brass rod is 55 MN/m^2.

   Calculate the maximum vertical compressive load that can be placed on the column. (16)

   Note: Modulus of Elasticity for Steel = 210 GN/m^2
   Modulus of Elasticity for Brass = 80 GN/m^2

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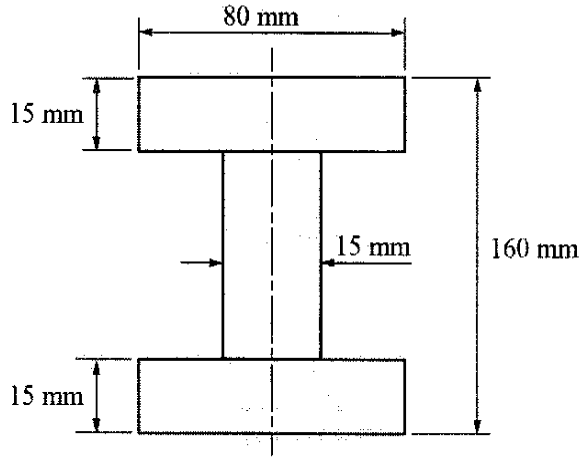
4. An "I" section beam as shown in Fig Q4 is simply supported at both ends. It carries a uniformly distributed load of 6 kN/m along its entire length and has a concentrated load of 18 kN at mid-span. The safety coefficient (factor of safety) of the beam is limited to 4.

Determine the maximum permissible length of the beam. (16)

Note: UTS of Beam Material = 120 MN/m²



Cross Section
(not to scale)

Fig Q4

5. When subjected to a tensile load of 80 kN, a uniform metal rod 30 mm diameter and 3 m long extends by 1.8 mm.

The unloaded rod is then placed vertically with its upper end fixed and a collar fitted at its free lower end. A load mass is then allowed to drop onto the collar from a height of 180 mm, and the instantaneous extension of the rod is found to be 3.6 mm.

Calculate EACH of the following:

(a) the Modulus of Elasticity for the rod; (4)

(b) the magnitude of the load mass. (12)

6. An engine has rotating parts of mass 160 kg with a radius of gyration of 0.5 m. The frictional torque for the engine may be assumed constant at 8 Nm. It is to be accelerated from rest to its full speed of 720 rev/min and then clutched on to a stationary pump having rotating parts of mass 50 kg and radius of gyration 0.3 m.

Calculate EACH of the following:

(a) the driving torque required to accelerate the engine from rest to 720 rev/min in 15 seconds; (6)

(b) the common speed of the engine and pump just after engagement; (5)

(c) the loss of kinetic energy due to the clutching operation. (5)

7. A connecting rod has a mass of 1.43 tonne, is 3 m long and its centre of gravity is 1.8 m from the top. It is to be freely suspended from the crosshead bearing, with the bottom end bearing removed.

Calculate EACH of the following:

(a) the horizontal force required at the lower end of the con-rod to hold the rod at 20° to the centre-line of the engine; (5)

(b) the magnitude and direction of the minimum force required at the lower end of the con-rod to hold the rod at 20° to the centre-line of the engine; (5)

(c) the magnitude and direction of the reaction at the crosshead for condition in Q7(b). (6)

8. A sluice has a square door with sides of length 1.8 m hinged at point A, 3 m below the waterline as shown in Fig Q8. The mass of the door is 700 kg. The channel is full of sea water on the left hand side of the door.

Calculate the magnitude of the minimum force, applied at right angles to the door at B to open the door. (16)

Note; Density of Sea Water = 1025 kg/m^3

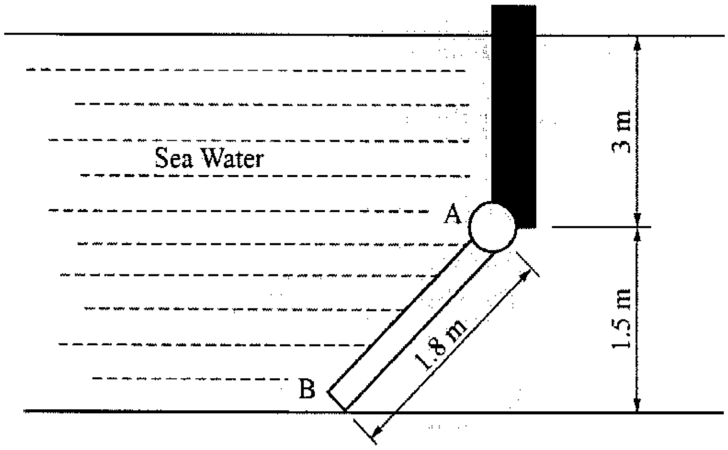


Fig Q8

9. A centrifugal pump has an impeller with inner and outer diameters of 280 mm and 580 mm respectively. The pump runs at 8 rev/sec and the fluid enters the pump with a radial velocity of 2.8 m/s. The absolute velocity of the water at exit from the pump is 11 m/s.

Calculate EACH of the following:

(a) the angles of the impeller vanes at entry and exit so that the fluid enters and leaves the impeller without shock; (10)

(b) the theoretical head delivered by the pump. (6)