APPLIED MECHANICS

Attempt SIX questions only.

All questions carry equal marks.

Marks for each part question are shown in brackets.

1. A T-beam is fabricated with the cross-section shown in Fig Q1.

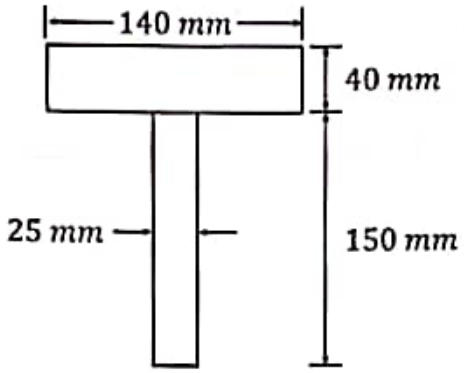

Fig Q1

Calculate the maximum bending stress induced in the beam by a 5 kNm bending moment. (16)

2. An engine is being aligned on its seating using steel wedges under its base. The wedges have a taper of 4°. The coefficient of friction at the contact surfaces of the taper is 0.26 and the coefficient of friction at the horizontal contact surfaces is 0.3. The vertical load on a single wedge is 180 kN as shown in Fig Q2.

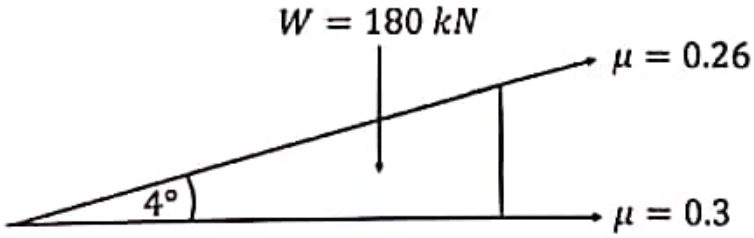

Fig Q2

Calculate the operational efficiency when raising the engine 3 mm vertically. (16)

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3. A body initially at rest freely slides 10 m down a slope inclined 30° above the horizontal in a time of 2.4 s. At the end of the slope is a 40 m sheer drop to horizontal ground below as shown in Fig Q3.

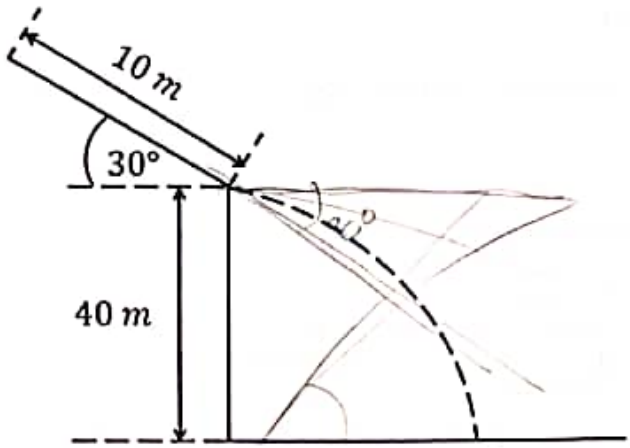

Fig Q3

Calculate the horizontal displacement of the body from the end of the slope when it impacts the ground. (16)

4. In a flat belt pulley arrangement, the tension in the flat belt is 125 N when stationary. During operation a 300 mm diameter drive wheel rotates at 1200 rpm. The coefficient of friction between contact surfaces is 0.32 and the angle of lap is 172°. Using the relationship:

$$\frac{F_1}{F_2} = e^{\mu\theta}$$

Calculate the output power of the belt drive. (16)

Note: F_1 = *force in the tight side of the belt*
F_2 = *force in the slack side of the belt*
μ = *the coefficient of friction*
θ = *the angle of lap in radians*

5. Masses A, B and C are fixed to a balanced disc at radii 150 mm, 60 mm and 120 mm respectively as shown in Fig Q5.

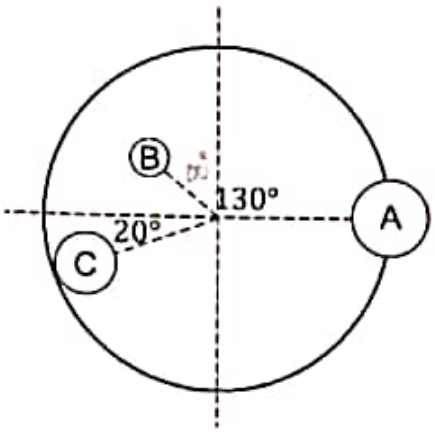

Fig Q5

Masses A, B and C are 800 g, 200 g and 700 g respectively and the disc rotates at a constant speed of 600 rpm. A fourth mass D is required to be added to statically balance the system and is to be positioned at a radius of 50 mm.

Calculate EACH of the following:

(a) the magnitude of the balancing mass; (12)

(b) the position of the balancing mass in relation to mass B. (4)

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6. A piston reciprocating with simple harmonic motion moves 300 mm from point A to point B in a time of 2 seconds. It returns to point B 1.5 seconds later.

Points A and B are the same distance from the mid-travel position.

Calculate EACH of the following:

(a) the stroke of the piston; (12)

(b) the linear acceleration of the piston at point B. (4)

7. A 1500 kg cage is lowered down a mine shaft that is 800 m deep using a 4 mm diameter mild steel core rope wound in 6 alloy wires that are all 2 mm in diameter. During the descent the cage accelerates uniformly from rest for 8 s, moves at a constant velocity for 20 s and then uniformly decelerates to rest at the bottom of the shaft in 12 s.

Calculate the maximum stress induced in the steel core of the rope. (16)

Note: Modulus of Elasticity for steel = 210 GN/m²
Modulus of Elasticity for wire material = 70 GN/m²

8. A valve is fitted with 2 concentric close-coiled helical springs with the same free length that are made from steel. The outer spring has a mean diameter of 130 mm with 12 coils and is made from 10 mm diameter wire. The inner spring is made from 6 mm diameter wire with 18 coils.

The shear stress in the springs due to compression is to be equal.

Calculate EACH of the following:

(a) the minimum mean diameter of the inner spring; (12)

(b) the stiffness of the concentric spring assembly. (4)

Note: Modulus of Rigidity for steel = 90 GN/m²

9. An 8 m length of steel pipe carries the flow of steam between two bulkheads. The pipe has an external diameter of 200 mm, is 8 mm thick and is fitted horizontally at an ambient temperature of 20°C. Linear expansion of the pipe is restricted to 10 mm.

Calculate EACH of the following:

(a) the strain energy stored within the pipe when heated to 250°C; (12)

(b) the force exerted by the pipe on the bulkhead. (4)

Note: Modulus of Elasticity for steel = 206 GN/m²
Coefficient of linear expansion for steel = 12 x 10^{-6} / °C