APPLIED MECHANICS

Attempt SIX questions only.

All questions carry equal marks.

Marks for each part question are shown in brackets.

1. A 250 kg mass is supported by three wires which are fixed at points B, C and D and all are concurrent at point A as shown in Fig Q1.

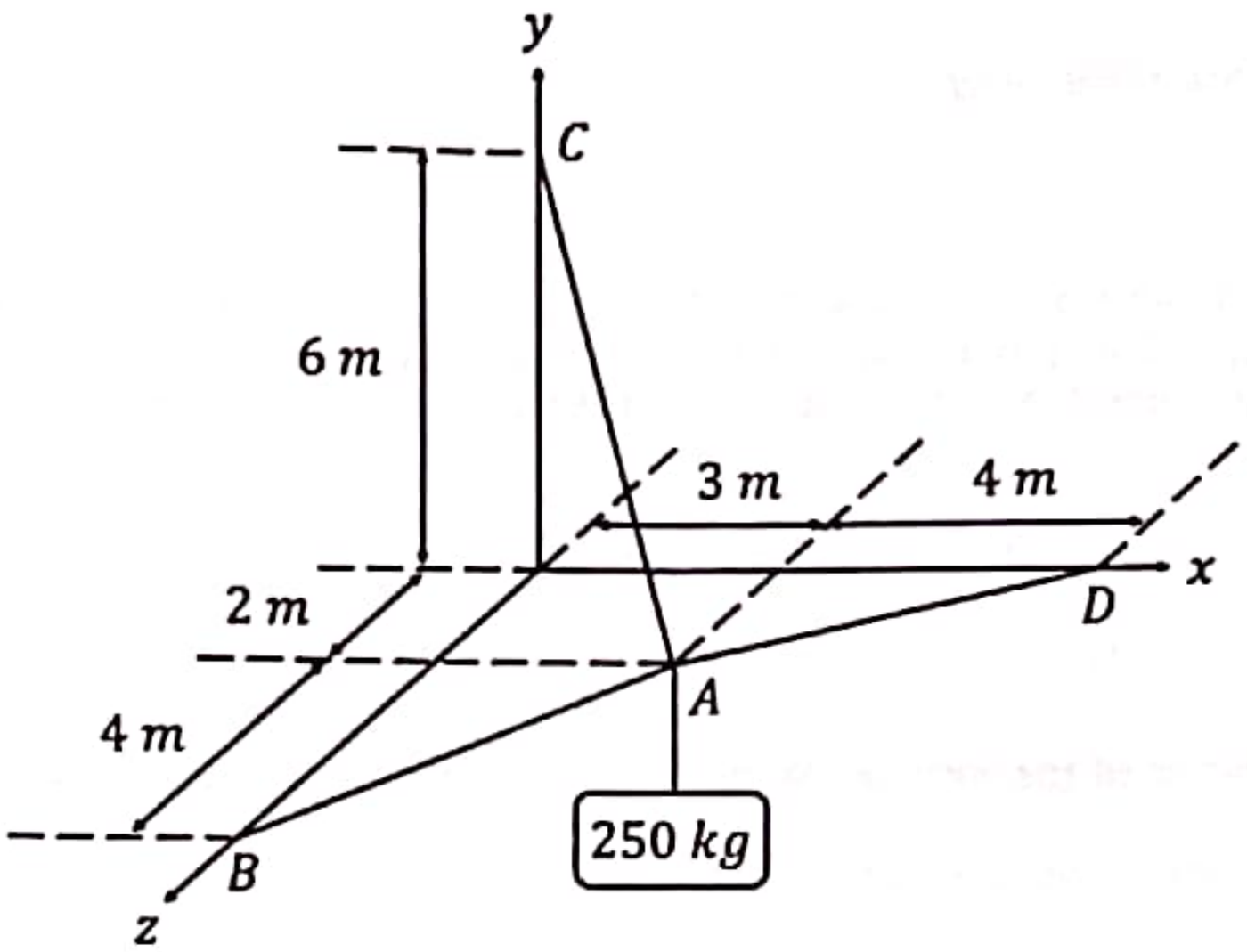

Fig Q1

Wires AB and AD define a horizontal xz-plane.

Determine the tension in EACH of the wires. (16)

2. A body initially at rest on a plane inclined at 12° above horizontal ground can be moved up the plane at constant velocity by a 1.5 kN force acting parallel to the plane. It can also be moved up the plane at constant velocity by a force of 1.62 kN acting horizontally on the body and into the plane as shown in Fig Q2.

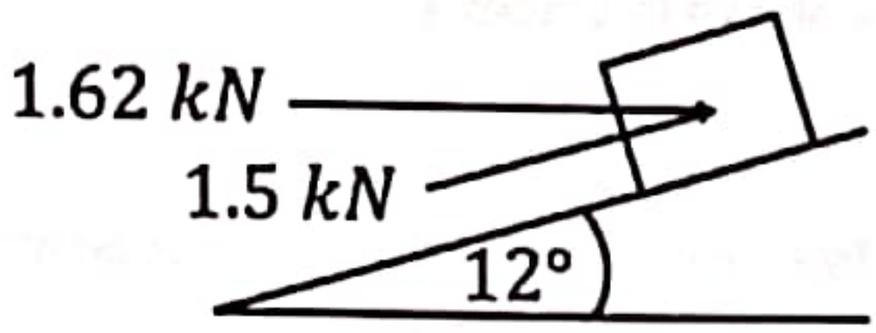

Fig Q2

Calculate the mass of the body. (16)

3. A weather balloon with a total mass of 15 kg is moving vertically upwards at a constant velocity of 8 m/s at a height of 100 m above horizontal ground. At this instant a 2 kg instrument module breaks free from the balloon and freely falls to the ground.

Calculate EACH of the following:

(a) the impact velocity at which the instrument module hits the ground; (10)

(b) the acceleration of the weather balloon as a result of the falling module. (6)

4. A worm and wheel lifting machine is rotated by a 400 mm diameter pulley. The axial thrust produced by the 80 mm diameter worm is absorbed by a thrust bearing as shown in Fig Q4.

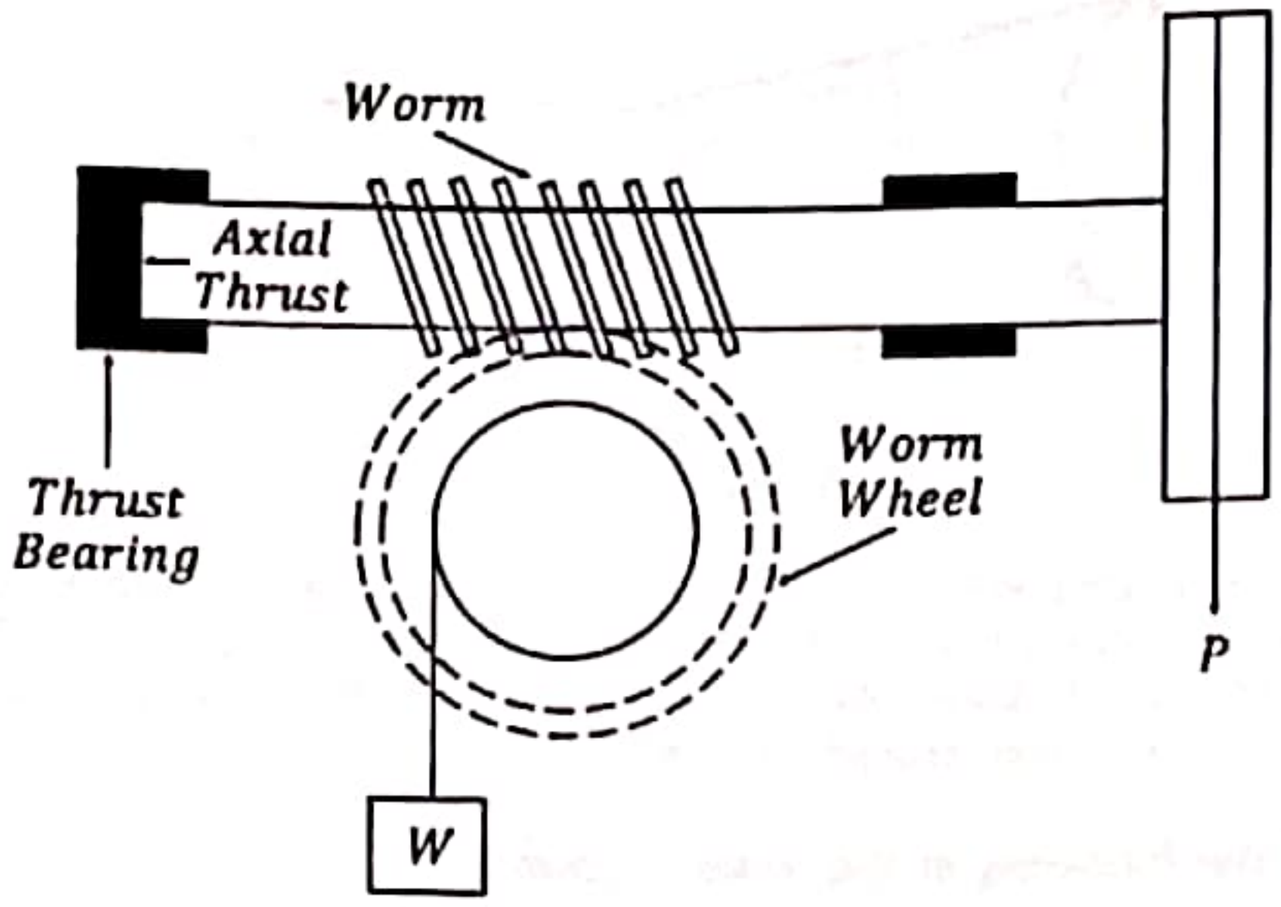

Fig Q4

The lifting machine is 65% efficient when new and a pulley effort of 30 N produces an axial thrust of 1.85 kN on the thrust bearing.

Wear increases the coefficient of friction at the thrust bearing from its original value of 0.002 to 0.01.

Calculate EACH of the following:

(a) the effort required to lift the same load due to the increased coefficient of friction; (8)

(b) the decrease in the efficiency of the lifting machine. (8)

5. A slider crank mechanism drives a block between two parallel, horizontal guides as shown in Fig Q5.

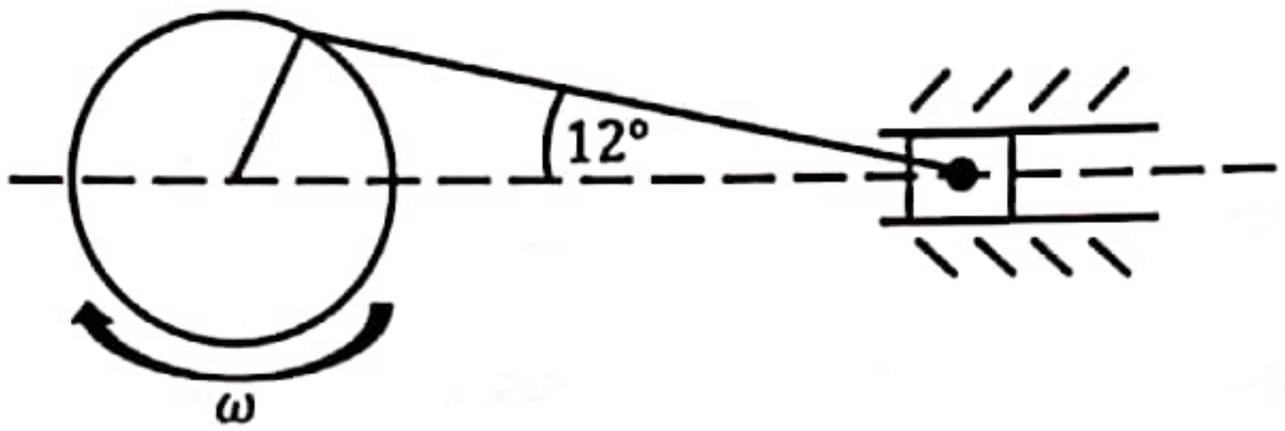

Fig Q5

The 1.8 kg block oscillates with simple harmonic motion at a frequency of 1.25 Hz and has a 150 mm stroke. The coefficient of friction at the contact surfaces of the guide is 0.1. When the connecting rod is 12° above the line of stroke, the block is 35 mm from the mid-stroke position.

Calculate EACH of the following at the instant shown:

(a) the kinetic energy of the block; (6)

(b) the force in the connecting rod. (10)

6. In a four-ram hydraulic steering gear the diameter of the rams is 300 mm and the distance between the centre line of the rams and the rudder stock is 815 mm. The maximum rudder angle is 35° and the by-pass valves lift at a pressure of 7.6 MN/m^2.

The tiller arms are of parallel circular section and the maximum stress in the arms occurs at the junction to the rudder stock, which is 610 mm from the rudder stock centre.

Calculate EACH of the following:

(a) the minimum rudder stock diameter for a maximum torsional stress of 75 MN/m^2; (6)

(b) the minimum diameter of the tiller arms for a maximum bending stress of 105 MN/m^2. (10)

7. A 15 kg wheel and shaft runs in horizontal bearings. The shaft is 60 mm in diameter and has a cord wound around it with a hook at its free end as shown in Fig Q7.

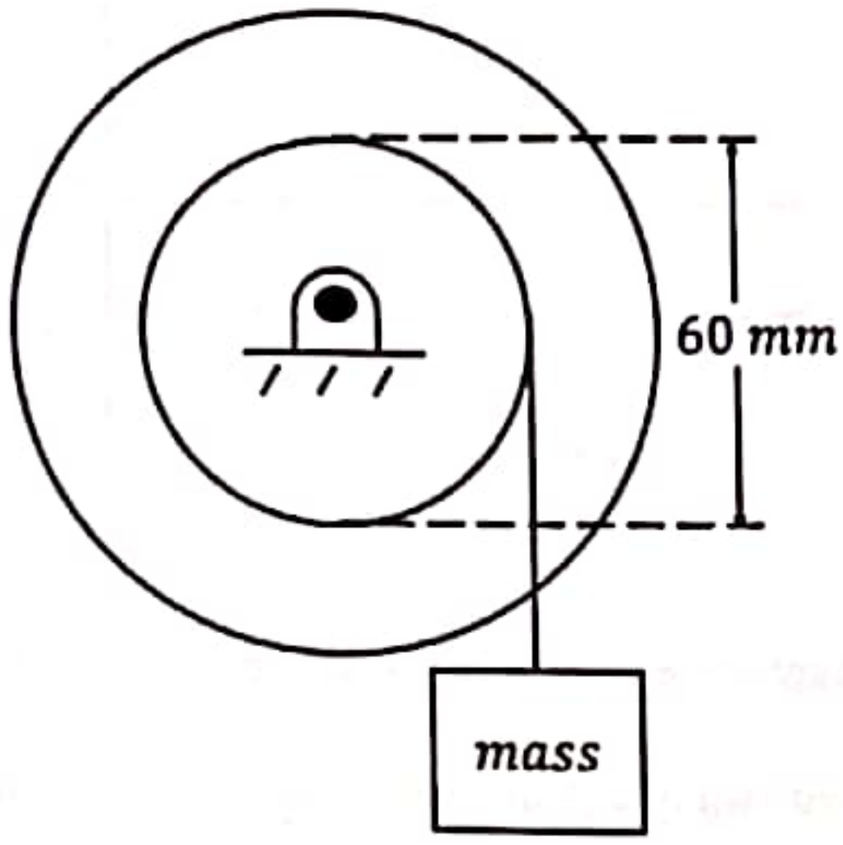

Fig Q7

A 0.4 kg mass hanging from the hook is just sufficient to overcome friction, whilst a 1.8 kg mass falls 960 mm in 6 seconds from rest.

Calculate EACH of the following:

(a) the radius of gyration for the combined wheel and shaft; **(10)**

(b) the impulse transmitted to the wheel and shaft by the falling mass during the 6 seconds. **(6)**

8. A square box-section cantilever beam fabricated from 12 mm thick mild steel plate has external dimensions of 120 mm. The beam is loaded as shown in Fig Q8.

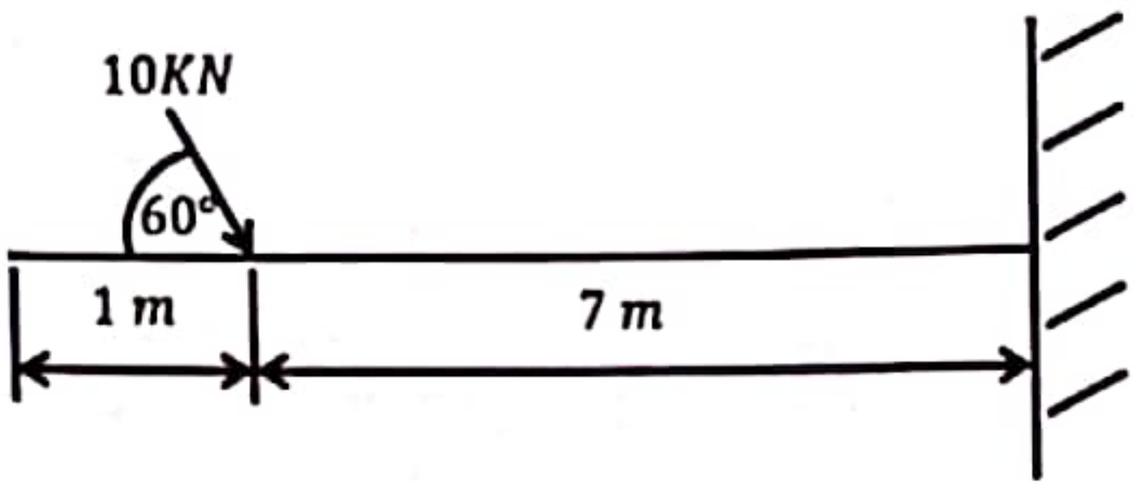

Fig Q8

(a) Sketch the shear force diagram and the bending moment diagram. (10)

(b) Calculate the magnitude of the maximum bending stress within the beam. (6)

Note: Density of mild steel = 7800 kg/m³

9. A composite spring has two close coiled springs connected in series with a combined stiffness of 1.2 kN/m. Each spring has a mean coil diameter 9 times its wire diameter.

The primary spring has 14 coils made from 3 mm diameter wire. The secondary spring has 16 coils.

Calculate EACH of the following:

(a) the minimum wire diameter of the secondary spring; (12)

(b) the strain energy within the composite spring when supporting a 70 N axial load. (4)

Note: Modulus of Rigidity for spring material = 90 GN/m²