APPLIED MECHANICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A 100 kg block on a horizontal plane is tethered to a 300 kg block on a plane inclined at 60° above the horizontal as shown in Fig Q1.
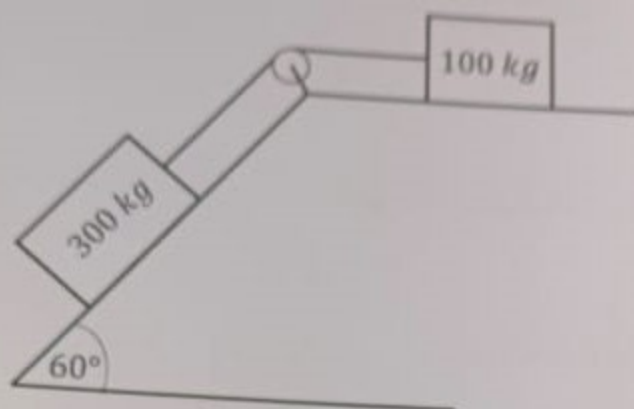

Fig Q1

The tether is attached via a frictionless pulley system such that it runs parallel to both planes. The coefficient of friction between all contact surfaces is 0.2. A force is to be applied to the 100 kg block that will cause motion to the right at constant velocity.

Calculate the difference in magnitude between force applied horizontally to the 100 kg block and the minimum applied force which will cause this motion.

2. A homogeneous door weighing 225 N is supported on a smooth track by frictionless rollers A and B. The centre line of each roller is 125 cm on either side of the doors centre of gravity, marked by the letter G, and a force of 10 N is applied 100 cm above the horizontal datum of G as shown in Fig Q2:
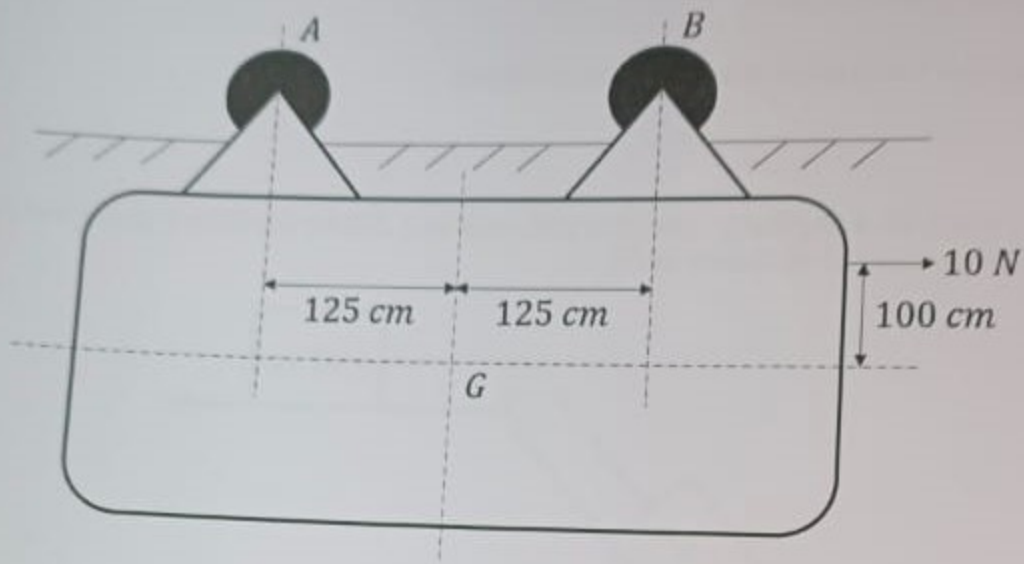

Fig Q2

Calculate EACH of the following:

(a) the velocity of the door 5 seconds after starting from rest;

(6)

(b) the support reactions at roller A and roller B.

(10)

A projectile is launched from level ground with an initial horizontal velocity component equal to 60% of the initial vertical velocity component. The maximum height reached by the projectile is 800 m above the horizontal launch site.

Calculate the range of the projectile.

(16)

4. The tension in a flat belt pulley system is 90 N when stationary. The 200 mm diameter drive wheel rotates at a constant speed of 1800 rpm whilst in operation with a coefficient of friction between contact surfaces of 0.34. The power output is 1.75 kW.

Using the relationship:

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

where: 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

Calculate the angle of lap in degrees.

(16)

. The pulley system shown in Fig Q5 has a 1.2 m radius of gyration and a mass of 120 kg. The angular acceleration of the system is 0.8 rad/s².

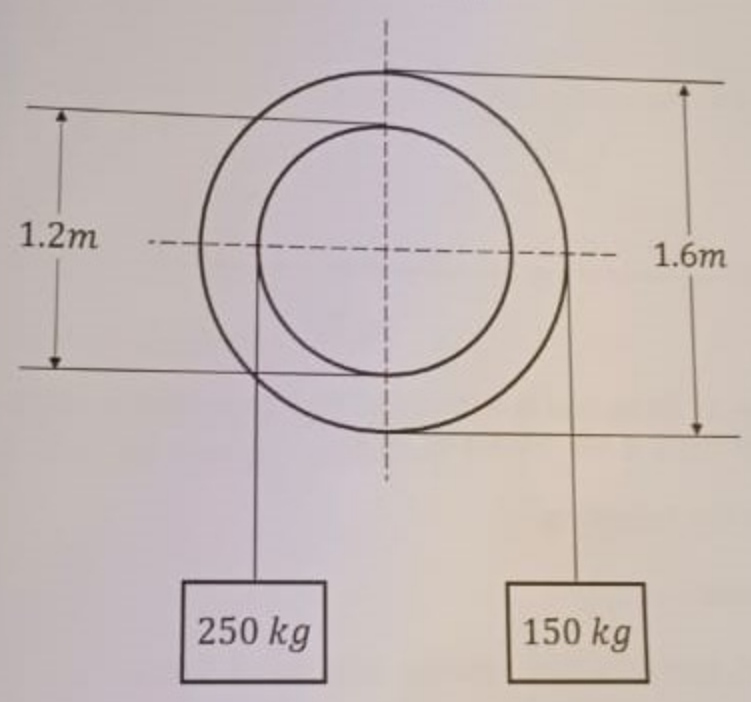1.2m   1.6m

250 kg   150 kg

Fig Q5

Calculate the work done by the constant bearing friction after 10 seconds of motion when the pulley system is released from rest.

6. A 1 tonne pile driver drives a 180 kg post into horizontal ground to a vertical depth of 700 mm. The average resisting force offered by the ground is 48 kN and there is no rebound.

Calculate EACH of the following:

(a) the initial vertical height of the pile driver above the post; (12)

(b) the percentage loss of energy due to impact. (4)

7. Block A is connected to block B by a cable that runs on a pulley system comprised of TWO identical massless, frictionless pulleys as shown in Fig Q7.
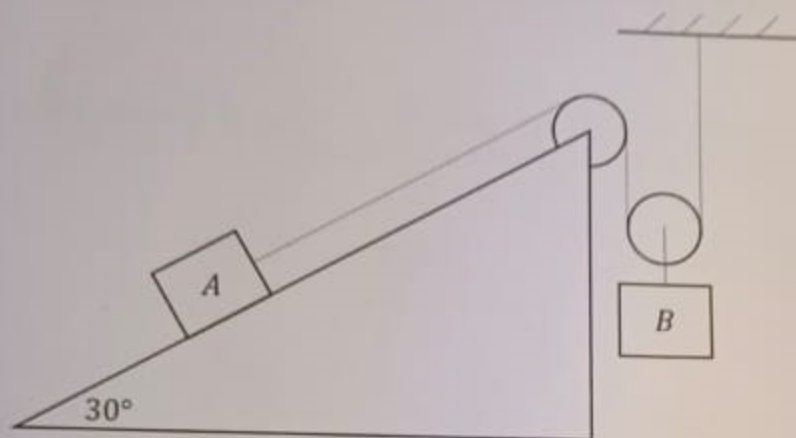

Fig Q7

Block A has a mass of 25 kg and is initially at rest on a smooth plane inclined at 30° above the horizontal and block B has a mass of 30 kg.

Calculate EACH of the following:

(a) the cable tension; (14)

(b) the time taken for block A to attain a velocity of 3 m/s. (2)

8. A single plate clutch with both sides effective has an outside diameter of 380 mm and an inside diameter of 140 mm. The clutch is designed to transmit 12 kW at 600 rpm.

The axial thrust on the clutch face is provided by 6 identical springs each with a stiffness of 8 kN/m. The coefficient of friction between the clutch plate and flywheel is 0.6.

Calculate EACH of the following:

(a) the required compression of each spring to deliver the design power when the clutch is new;

(b) the percentage drop in transmitted power when a total of 2 mm plate wear occurs due to wear.

Note: For constant pressure $T = \frac{2}{3}\mu n W \frac{r_o{}^3 - r_i{}^3}{r_o{}^2 - r_i{}^2}$

For constant wear $T = \mu n W \frac{(r_o + r_i)}{2}$

Number of effective sides = n

9. A solid steel shaft 240 mm diameter has a bronze liner shrunk over its entire length, the outside diameter of the liner being 290 mm. The maximum torque transmitted by the composite shaft is 100 kNm.

Calculate EACH of the following:

(a) the maximum stress in the liner;

(b) the maximum stress in the shaft.

Note: Modulus of Rigidity for steel = 90 GN/m²
Modulus of Rigidity for bronze = 42 GN/m²