



1. A lorry of mass 2000 kg is moving down a straight road inclined at angle α to the horizontal, where $\sin \alpha = \frac{1}{25}$. The resistance to motion is modelled as a constant force of magnitude 1600 N. The lorry is moving at a constant speed of 14 m s^{-1} .
Find, in kW, the rate at which the lorry's engine is working.

(6)

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Question 1 continued

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Q1

(Total 6 marks)



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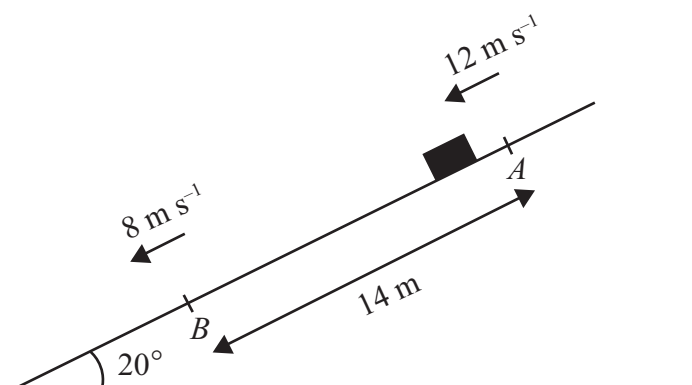


Figure 1

A package of mass 3.5 kg is sliding down a ramp. The package is modelled as a particle and the ramp as a rough plane inclined at an angle of 20° to the horizontal. The package slides down a line of greatest slope of the plane from a point A to a point B , where $AB = 14 \text{ m}$. At A the package has speed 12 m s^{-1} and at B the package has speed 8 m s^{-1} , as shown in Figure 1. Find

(a) the total energy lost by the package in travelling from A to B , (5)

(b) the coefficient of friction between the package and the ramp. (5)

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Question 3 continued

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Q3

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4. A particle P of mass 0.5 kg is moving under the action of a single force \mathbf{F} newtons. At time t seconds,

$$\mathbf{F} = (6t - 5)\mathbf{i} + (t^2 - 2t)\mathbf{j}.$$

The velocity of P at time t seconds is \mathbf{v} m s $^{-1}$. When $t = 0$, $\mathbf{v} = \mathbf{i} - 4\mathbf{j}$.

- (a) Find \mathbf{v} at time t seconds. (6)

When $t = 3$, the particle P receives an impulse $(-5\mathbf{i} + 12\mathbf{j})$ N s.

- (b) Find the speed of P immediately after it receives the impulse. (6)



Question 4 continued

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Q4

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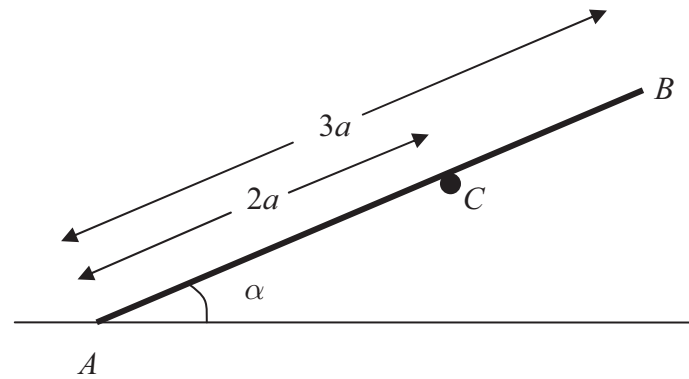
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Figure 2

A plank rests in equilibrium against a fixed horizontal pole. The plank is modelled as a uniform rod AB and the pole as a smooth horizontal peg perpendicular to the vertical plane containing AB . The rod has length $3a$ and weight W and rests on the peg at C , where $AC = 2a$. The end A of the rod rests on rough horizontal ground and AB makes an angle α with the ground, as shown in Figure 2.

(a) Show that the normal reaction on the rod at A is $\frac{1}{4}(4 - 3 \cos^2 \alpha) W$. (6)

Given that the rod is in limiting equilibrium and that $\cos \alpha = \frac{2}{3}$,

(b) find the coefficient of friction between the rod and the ground. (5)





Question 5 continued

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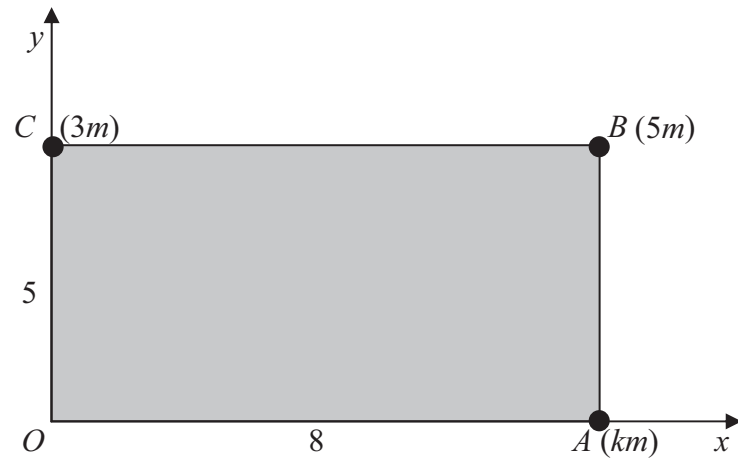


Figure 3

Figure 3 shows a rectangular lamina $OABC$. The coordinates of O , A , B and C are $(0, 0)$, $(8, 0)$, $(8, 5)$ and $(0, 5)$ respectively. Particles of mass km , $5m$ and $3m$ are attached to the lamina at A , B and C respectively.

The x -coordinate of the centre of mass of the three particles *without the lamina* is 6.4 .

- (a) Show that $k = 7$. (4)

The lamina $OABC$ is uniform and has mass $12m$.

- (b) Find the coordinates of the centre of mass of the combined system consisting of the three particles and the lamina. (6)

The combined system is freely suspended from O and hangs at rest.

- (c) Find the angle between OC and the horizontal. (3)



Question 6 continued

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Q6

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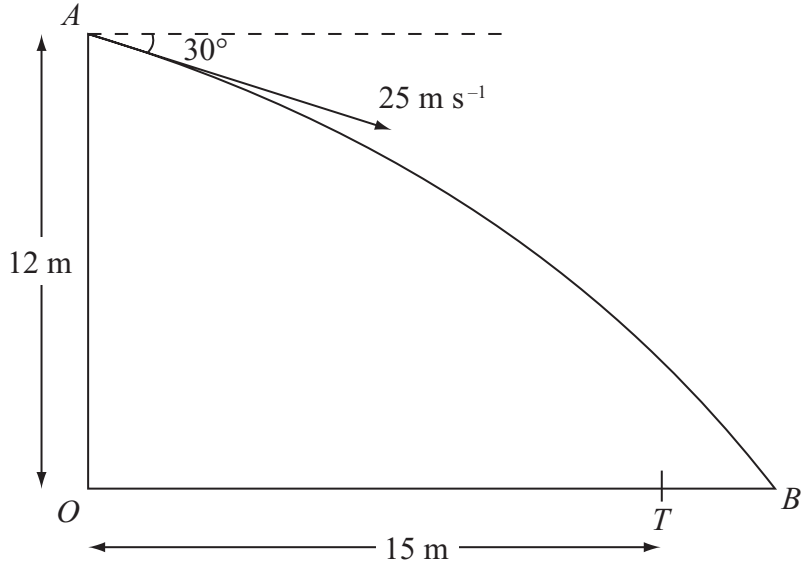


Figure 4

A ball is thrown from a point A at a target, which is on horizontal ground. The point A is 12 m above the point O on the ground. The ball is thrown from A with speed 25 m s^{-1} at an angle of 30° below the horizontal. The ball is modelled as a particle and the target as a point T . The distance OT is 15 m. The ball misses the target and hits the ground at the point B , where OTB is a straight line, as shown in Figure 4. Find

(a) the time taken by the ball to travel from A to B , (5)

(b) the distance TB . (4)

The point X is on the path of the ball vertically above T .

(c) Find the speed of the ball at X . (5)



Question 7 continued

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