

1. A car of mass 1500 kg is moving up a straight road, which is inclined at an angle θ to the horizontal, where $\sin \theta = \frac{1}{14}$. The resistance to the motion of the car from non-gravitational forces is constant and is modelled as a single constant force of magnitude 650 N. The car's engine is working at a rate of 30 kW.

Find the acceleration of the car at the instant when its speed is 15 m s^{-1} .

(5)



2.

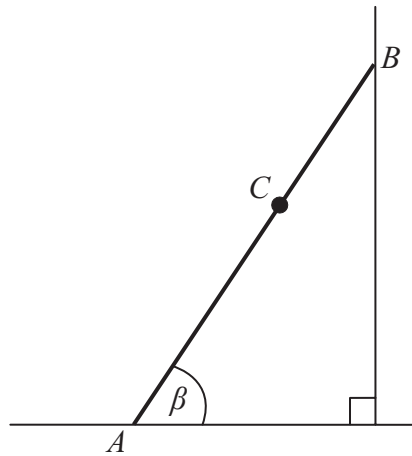


Figure 1

Figure 1 shows a ladder AB , of mass 25 kg and length 4 m, resting in equilibrium with one end A on rough horizontal ground and the other end B against a smooth vertical wall. The ladder is in a vertical plane perpendicular to the wall. The coefficient of friction between the ladder and the ground is $\frac{11}{25}$. The ladder makes an angle β with the ground. When Reece, who has mass 75 kg, stands at the point C on the ladder, where $AC = 2.8$ m, the ladder is on the point of slipping. The ladder is modelled as a uniform rod and Reece is modelled as a particle.

- (a) Find the magnitude of the frictional force of the ground on the ladder. (3)

- (b) Find, to the nearest degree, the value of β . (6)

- (c) State how you have used the modelling assumption that Reece is a particle. (1)



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Question 2 continued

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3. A block of mass 10 kg is pulled along a straight horizontal road by a constant horizontal force of magnitude 70 N in the direction of the road. The block moves in a straight line passing through two points *A* and *B* on the road, where $AB = 50$ m. The block is modelled as a particle and the road is modelled as a rough plane. The coefficient of friction between the block and the road is $\frac{4}{7}$.

(a) Calculate the work done against friction in moving the block from *A* to *B*.

(4)

The block passes through *A* with a speed of 2 m s^{-1} .

(b) Find the speed of the block at *B*.

(4)



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Question 4 continued

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(Total 8 marks)

Q4



5.

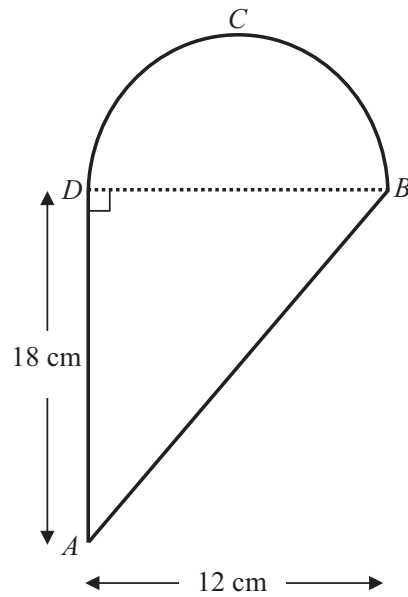


Figure 2

A uniform lamina $ABCD$ is made by joining a uniform triangular lamina ABD to a uniform semi-circular lamina DBC , of the same material, along the edge BD , as shown in Figure 2. Triangle ABD is right-angled at D and $AD = 18$ cm. The semi-circle has diameter BD and $BD = 12$ cm.

- (a) Show that, to 3 significant figures, the distance of the centre of mass of the lamina $ABCD$ from AD is 4.69 cm. (4)

Given that the centre of mass of a uniform semicircular lamina, radius r , is at a distance $\frac{4r}{3\pi}$ from the centre of the bounding diameter,

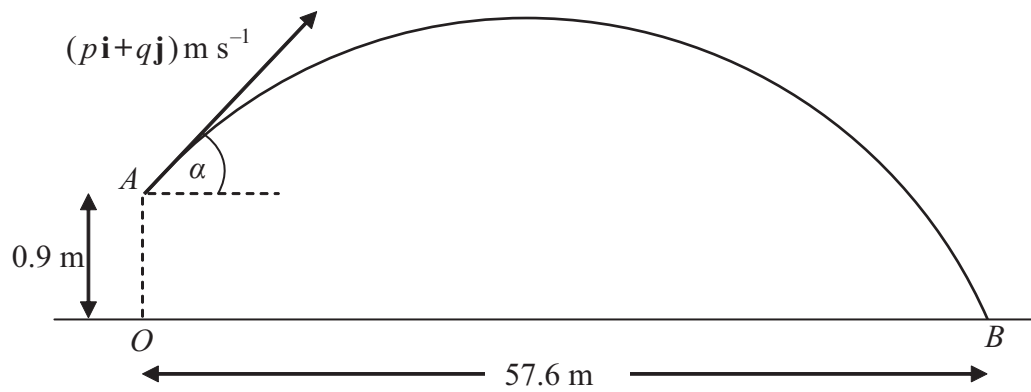
- (b) find, in cm to 3 significant figures, the distance of the centre of mass of the lamina $ABCD$ from BD . (4)

The lamina is freely suspended from B and hangs in equilibrium.

- (c) Find, to the nearest degree, the angle which BD makes with the vertical. (4)



6.

**Figure 3**

A cricket ball is hit from a point A with velocity of $(p\mathbf{i} + q\mathbf{j}) \text{ m s}^{-1}$, at an angle α above the horizontal. The unit vectors \mathbf{i} and \mathbf{j} are respectively horizontal and vertically upwards. The point A is 0.9 m vertically above the point O , which is on horizontal ground.

The ball takes 3 seconds to travel from A to B , where B is on the ground and $OB = 57.6 \text{ m}$, as shown in Figure 3. By modelling the motion of the cricket ball as that of a particle moving freely under gravity,

- (a) find the value of p , (2)
- (b) show that $q = 14.4$, (3)
- (c) find the initial speed of the cricket ball, (2)
- (d) find the exact value of $\tan \alpha$. (1)
- (e) Find the length of time for which the cricket ball is at least 4 m above the ground. (6)
- (f) State an additional physical factor which may be taken into account in a refinement of the above model to make it more realistic. (1)



Question 6 continued

Lined area for writing the answer to Question 6 continued.



7. A particle P of mass $3m$ is moving in a straight line with speed $2u$ on a smooth horizontal table. It collides directly with another particle Q of mass $2m$ which is moving with speed u in the opposite direction to P . The coefficient of restitution between P and Q is e .

(a) Show that the speed of Q immediately after the collision is $\frac{1}{5}(9e + 4)u$. (5)

The speed of P immediately after the collision is $\frac{1}{2}u$.

(b) Show that $e = \frac{1}{4}$. (4)

The collision between P and Q takes place at the point A . After the collision Q hits a smooth fixed vertical wall which is at right-angles to the direction of motion of Q . The distance from A to the wall is d .

(c) Show that P is a distance $\frac{3}{5}d$ from the wall at the instant when Q hits the wall. (4)

Particle Q rebounds from the wall and moves so as to collide directly with particle P at the point B . Given that the coefficient of restitution between Q and the wall is $\frac{1}{5}$,

(d) find, in terms of d , the distance of the point B from the wall. (4)



