



1. A parcel of mass  $2.5\text{ kg}$  is moving in a straight line on a smooth horizontal floor. Initially the parcel is moving with speed  $8\text{ m s}^{-1}$ . The parcel is brought to rest in a distance of  $20\text{ m}$  by a constant horizontal force of magnitude  $R$  newtons. Modelling the parcel as a particle, find

(a) the kinetic energy lost by the parcel in coming to rest, (2)

(b) the value of  $R$ . (3)

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2. At time  $t$  seconds ( $t \geq 0$ ), a particle  $P$  has position vector  $\mathbf{p}$  metres, with respect to a fixed origin  $O$ , where

$$\mathbf{p} = (3t^2 - 6t + 4)\mathbf{i} + (3t^3 - 4t)\mathbf{j}.$$

Find

- (a) the velocity of  $P$  at time  $t$  seconds, (2)

- (b) the value of  $t$  when  $P$  is moving parallel to the vector  $\mathbf{i}$ . (3)

When  $t = 1$ , the particle  $P$  receives an impulse of  $(2\mathbf{i} - 6\mathbf{j})$  N s. Given that the mass of  $P$  is 0.5 kg,

- (c) find the velocity of  $P$  immediately after the impulse. (4)

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3. A car of mass 1000 kg is moving at a constant speed of  $16 \text{ m s}^{-1}$  up a straight road inclined at an angle  $\theta$  to the horizontal. The rate of working of the engine of the car is 20 kW and the resistance to motion from non-gravitational forces is modelled as a constant force of magnitude 550 N.

(a) Show that  $\sin \theta = \frac{1}{14}$ . (5)

When the car is travelling up the road at  $16 \text{ m s}^{-1}$ , the engine is switched off. The car comes to rest, without braking, having moved a distance  $y$  metres from the point where the engine was switched off. The resistance to motion from non-gravitational forces is again modelled as a constant force of magnitude 550 N.

(b) Find the value of  $y$ . (4)

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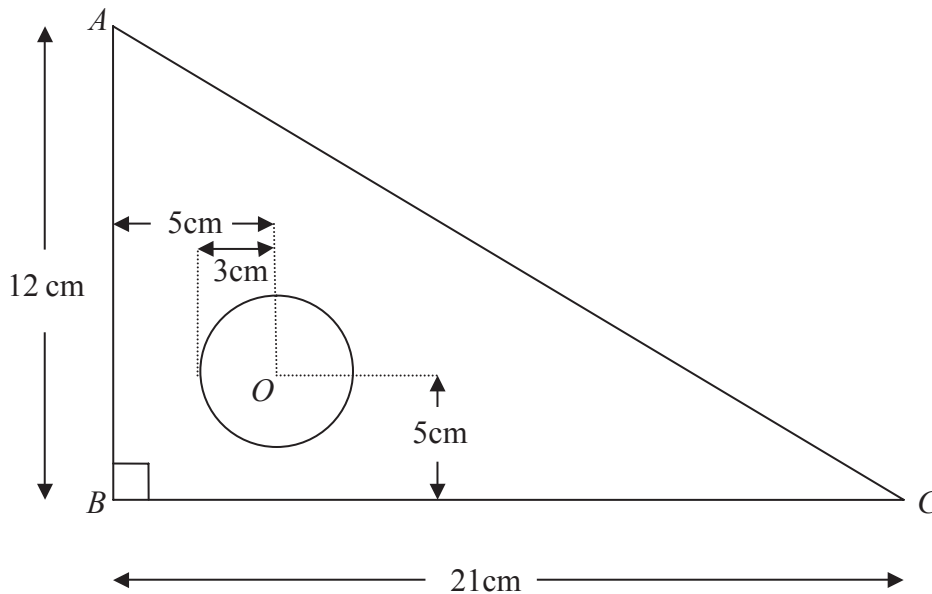
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4.

**Figure 1**

A set square  $S$  is made by removing a circle of centre  $O$  and radius 3 cm from a triangular piece of wood. The piece of wood is modelled as a uniform triangular lamina  $ABC$ , with  $\angle ABC = 90^\circ$ ,  $AB = 12$  cm and  $BC = 21$  cm. The point  $O$  is 5 cm from  $AB$  and 5 cm from  $BC$ , as shown in Figure 1.

(a) Find the distance of the centre of mass of  $S$  from

(i)  $AB$ ,

(ii)  $BC$ .

**(9)**

The set square is freely suspended from  $C$  and hangs in equilibrium.

(b) Find, to the nearest degree, the angle between  $CB$  and the vertical.

**(3)**


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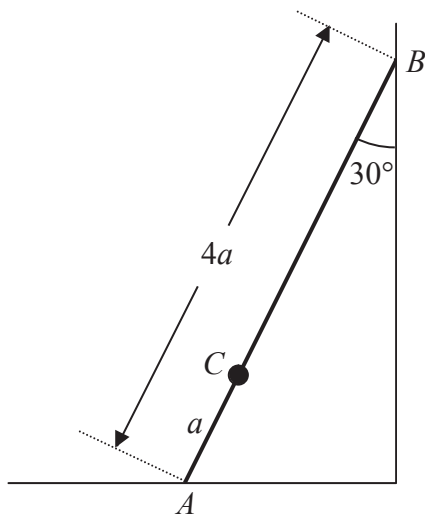


Figure 2

A ladder  $AB$ , of mass  $m$  and length  $4a$ , has one end  $A$  resting on rough horizontal ground. The other end  $B$  rests against a smooth vertical wall. A load of mass  $3m$  is fixed on the ladder at the point  $C$ , where  $AC = a$ . The ladder is modelled as a uniform rod in a vertical plane perpendicular to the wall and the load is modelled as a particle. The ladder rests in limiting equilibrium making an angle of  $30^\circ$  with the wall, as shown in Figure 2.

Find the coefficient of friction between the ladder and the ground.

(10)

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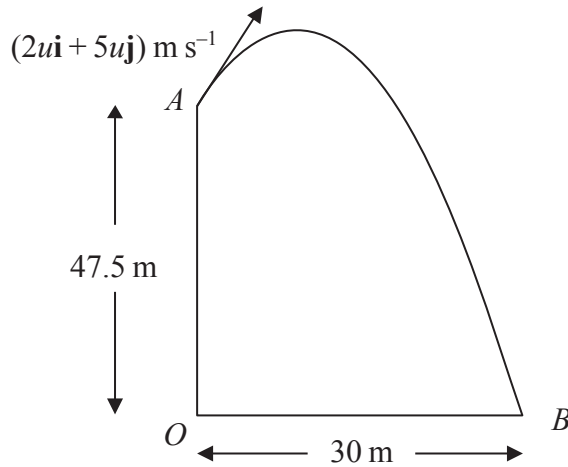
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6.

**Figure 3**

[In this question, the unit vectors  $\mathbf{i}$  and  $\mathbf{j}$  are in a vertical plane,  $\mathbf{i}$  being horizontal and  $\mathbf{j}$  being vertical.]

A particle  $P$  is projected from the point  $A$  which has position vector  $47.5\mathbf{j}$  metres with respect to a fixed origin  $O$ . The velocity of projection of  $P$  is  $(2u\mathbf{i} + 5u\mathbf{j}) \text{ m s}^{-1}$ . The particle moves freely under gravity passing through the point  $B$  with position vector  $30\mathbf{i}$  metres, as shown in Figure 3.

- (a) Show that the time taken for  $P$  to move from  $A$  to  $B$  is 5 s. (6)
- (b) Find the value of  $u$ . (2)
- (c) Find the speed of  $P$  at  $B$ . (5)

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7. A particle  $P$  of mass  $2m$  is moving with speed  $2u$  in a straight line on a smooth horizontal plane. A particle  $Q$  of mass  $3m$  is moving with speed  $u$  in the same direction as  $P$ . The particles collide directly. The coefficient of restitution between  $P$  and  $Q$  is  $\frac{1}{2}$ .

(a) Show that the speed of  $Q$  immediately after the collision is  $\frac{8}{5}u$ . (5)

(b) Find the total kinetic energy lost in the collision. (5)

After the collision between  $P$  and  $Q$ , the particle  $Q$  collides directly with a particle  $R$  of mass  $m$  which is at rest on the plane. The coefficient of restitution between  $Q$  and  $R$  is  $e$ .

(c) Calculate the range of values of  $e$  for which there will be a second collision between  $P$  and  $Q$ . (7)

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