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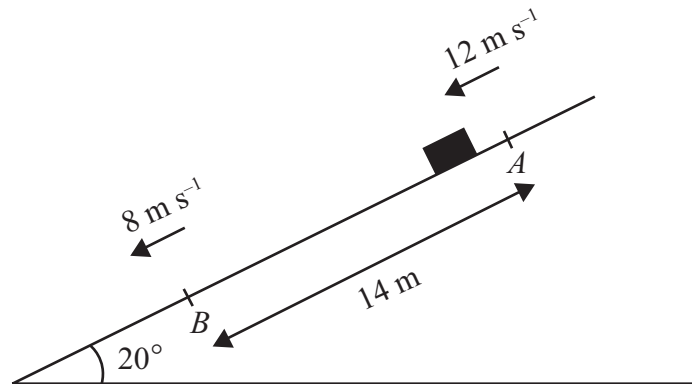


Figure 1

A package of mass  $3.5 \text{ kg}$  is sliding down a ramp. The package is modelled as a particle and the ramp as a rough plane inclined at an angle of  $20^\circ$  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  $12 \text{ m s}^{-1}$  and at  $B$  the package has speed  $8 \text{ m s}^{-1}$ , 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 4 continued**

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Question 4 continued

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Q4

(Total 12 marks)



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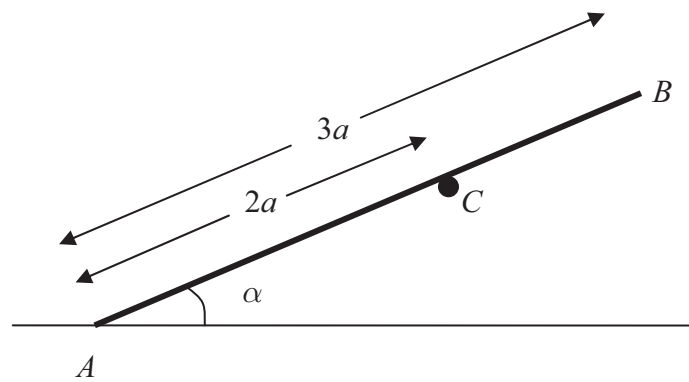


Figure 2

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  $\alpha$  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)

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**Question 5 continued**

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Handwriting practice lines for the response to Question 5.





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**Question 5 continued**

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**(Total 11 marks)**

Q5



6.

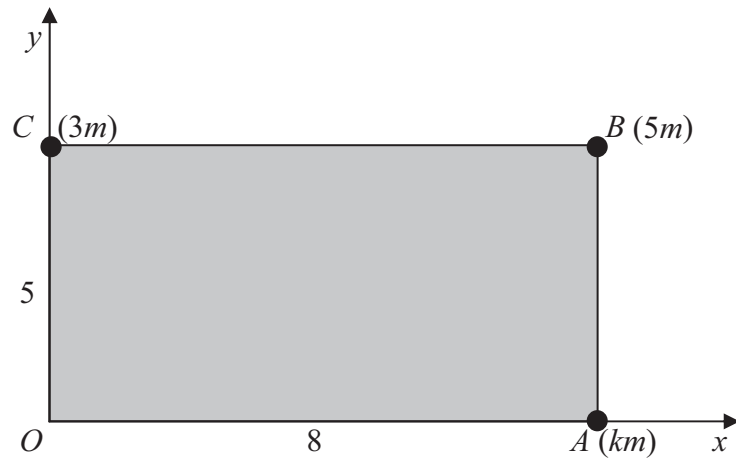


Figure 3

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)

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**Question 6 continued**

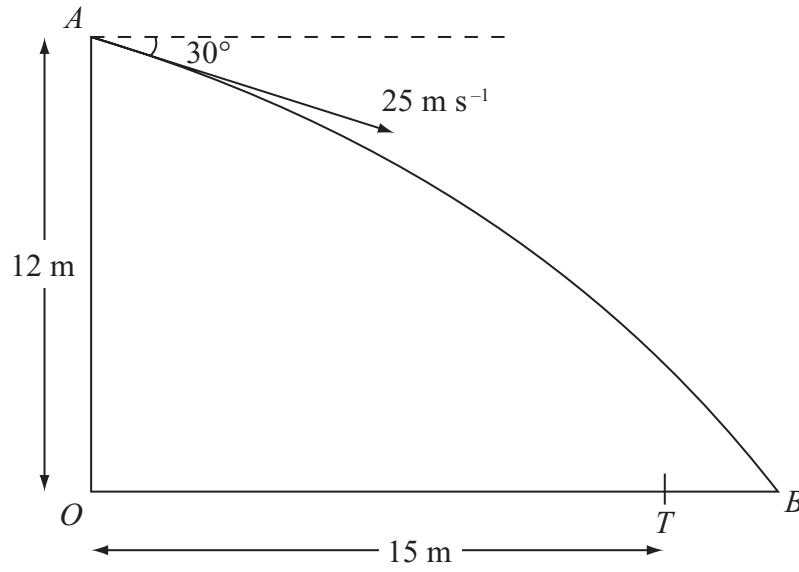
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7.



**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  $25 \text{ m s}^{-1}$  at an angle of  $30^\circ$  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)

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