

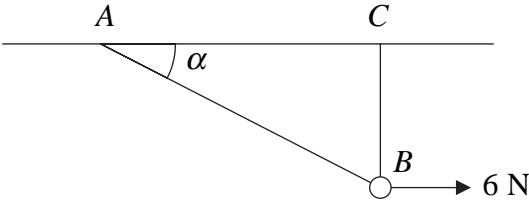






3.

Figure 1



A smooth bead  $B$  is threaded on a light inextensible string. The ends of the string are attached to two fixed points  $A$  and  $C$  on the same horizontal level. The bead is held in equilibrium by a horizontal force of magnitude  $6\text{ N}$  acting parallel to  $AC$ . The bead  $B$  is vertically below  $C$  and  $\angle BAC = \alpha$ , as shown in Figure 1. Given that  $\tan \alpha = \frac{3}{4}$ , find

(a) the tension in the string, (3)

(b) the weight of the bead. (4)

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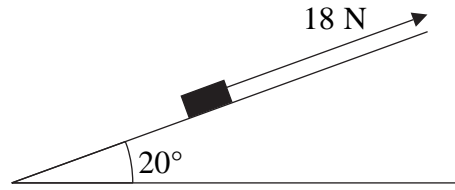
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4.

Figure 2



A box of mass 2 kg is pulled up a rough plane face by means of a light rope. The plane is inclined at an angle of  $20^\circ$  to the horizontal, as shown in Figure 2. The rope is parallel to a line of greatest slope of the plane. The tension in the rope is 18 N. The coefficient of friction between the box and the plane is 0.6. By modelling the box as a particle, find

(a) the normal reaction of the plane on the box, (3)

(b) the acceleration of the box. (5)

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5. A train is travelling at  $10 \text{ m s}^{-1}$  on a straight horizontal track. The driver sees a red signal 135 m ahead and immediately applies the brakes. The train immediately decelerates with constant deceleration for 12 s, reducing its speed to  $3 \text{ m s}^{-1}$ . The driver then releases the brakes and allows the train to travel at a constant speed of  $3 \text{ m s}^{-1}$  for a further 15 s. He then applies the brakes again and the train slows down with constant deceleration, coming to rest as it reaches the signal.

(a) Sketch a speed-time graph to show the motion of the train, (3)

(b) Find the distance travelled by the train from the moment when the brakes are first applied to the moment when its speed first reaches  $3 \text{ m s}^{-1}$ . (2)

(c) Find the total time from the moment when the brakes are first applied to the moment when the train comes to rest. (5)

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**Question 6 continued**

Lined writing area for the answer to Question 6.

**(Total 10 marks)**

**Q6**



7.

Figure 4

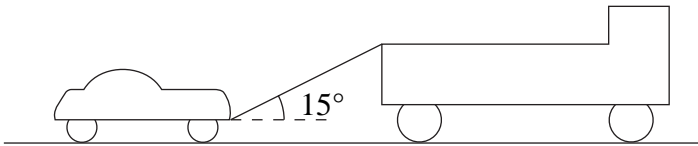


Figure 4 shows a lorry of mass 1600 kg towing a car of mass 900 kg along a straight horizontal road. The two vehicles are joined by a light towbar which is at an angle of  $15^\circ$  to the road. The lorry and the car experience constant resistances to motion of magnitude 600 N and 300 N respectively. The lorry's engine produces a constant horizontal force on the lorry of magnitude 1500 N. Find

(a) the acceleration of the lorry and the car, (3)

(b) the tension in the towbar. (4)

When the speed of the vehicles is  $6 \text{ m s}^{-1}$ , the towbar breaks. Assuming that the resistance to the motion of the car remains of constant magnitude 300 N,

(c) find the distance moved by the car from the moment the towbar breaks to the moment when the car comes to rest. (4)

(d) State whether, when the towbar breaks, the normal reaction of the road on the car is increased, decreased or remains constant. Give a reason for your answer. (2)

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**Question 7 continued**

Horizontal lines for writing.



8. [In this question, the unit vectors **i** and **j** are horizontal vectors due east and north respectively.]

At time  $t = 0$ , a football player kicks a ball from the point  $A$  with position vector  $(2\mathbf{i} + \mathbf{j})$  m on a horizontal football field. The motion of the ball is modelled as that of a particle moving horizontally with constant velocity  $(5\mathbf{i} + 8\mathbf{j})$  m s<sup>-1</sup>. Find

- (a) the speed of the ball, **(2)**
  
- (b) the position vector of the ball after  $t$  seconds. **(2)**

The point  $B$  on the field has position vector  $(10\mathbf{i} + 7\mathbf{j})$  m.

- (c) Find the time when the ball is due north of  $B$ . **(2)**

At time  $t = 0$ , another player starts running due north from  $B$  and moves with constant speed  $v$  m s<sup>-1</sup>. Given that he intercepts the ball,

- (d) find the value of  $v$ . **(6)**
  
- (e) State one physical factor, other than air resistance, which would be needed in a refinement of the model of the ball’s motion to make the model more realistic. **(1)**

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