

2. Particle P has mass 3 kg and particle Q has mass 2 kg . The particles are moving in opposite directions on a smooth horizontal plane when they collide directly. Immediately before the collision, P has speed 3 m s^{-1} and Q has speed 2 m s^{-1} . Immediately after the collision, both particles move in the same direction and the difference in their speeds is 1 m s^{-1} .
- (a) Find the speed of each particle after the collision. (5)
- (b) Find the magnitude of the impulse exerted on P by Q . (3)



3.

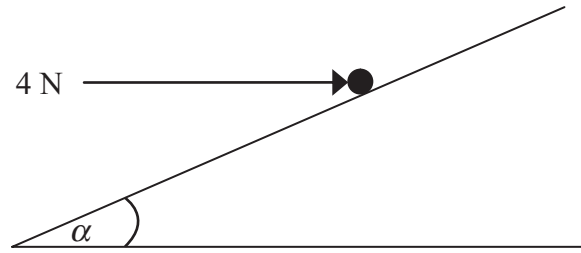


Figure 1

A particle of weight W newtons is held in equilibrium on a rough inclined plane by a horizontal force of magnitude 4 N. The force acts in a vertical plane containing a line of greatest slope of the inclined plane. The plane is inclined to the horizontal at an angle α , where $\tan \alpha = \frac{3}{4}$, as shown in Figure 1.

The coefficient of friction between the particle and the plane is $\frac{1}{2}$.

Given that the particle is on the point of sliding down the plane,

- (i) show that the magnitude of the normal reaction between the particle and the plane is 20 N,
- (ii) find the value of W .

(9)



Question 3 continued

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4. A girl runs a 400 m race in a time of 84 s. In a model of this race, it is assumed that, starting from rest, she moves with constant acceleration for 4 s, reaching a speed of 5 m s^{-1} . She maintains this speed for 60 s and then moves with constant deceleration for 20 s, crossing the finishing line with a speed of $V \text{ m s}^{-1}$.
- (a) Sketch, in the space below, a speed-time graph for the motion of the girl during the whole race. (2)
- (b) Find the distance run by the girl in the first 64 s of the race. (3)
- (c) Find the value of V . (5)
- (d) Find the deceleration of the girl in the final 20 s of her race. (2)



Question 4 continued

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5. A plank PQR , of length 8 m and mass 20 kg, is in equilibrium in a horizontal position on two supports at P and Q , where $PQ = 6$ m.

A child of mass 40 kg stands on the plank at a distance of 2 m from P and a block of mass M kg is placed on the plank at the end R . The plank remains horizontal and in equilibrium. The force exerted on the plank by the support at P is equal to the force exerted on the plank by the support at Q .

By modelling the plank as a uniform rod, and the child and the block as particles,

(a) (i) find the magnitude of the force exerted on the plank by the support at P ,
(ii) find the value of M . (10)

(b) State how, in your calculations, you have used the fact that the child and the block can be modelled as particles. (1)



6.

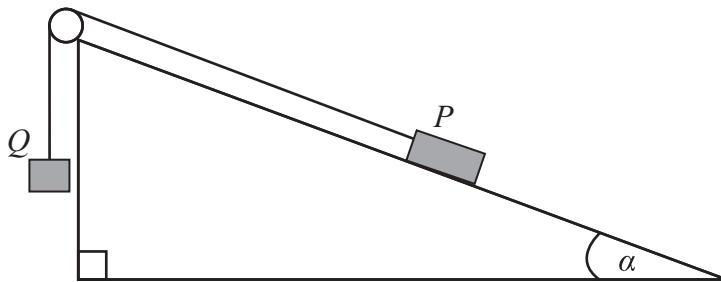


Figure 2

Two particles P and Q have masses 0.3 kg and $m \text{ kg}$ respectively. The particles are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed at the top of a fixed rough plane. The plane is inclined to the horizontal at an angle α , where $\tan \alpha = \frac{3}{4}$. The coefficient of friction between P and the plane is $\frac{1}{2}$.

The string lies in a vertical plane through a line of greatest slope of the inclined plane. The particle P is held at rest on the inclined plane and the particle Q hangs freely below the pulley with the string taut, as shown in Figure 2.

The system is released from rest and Q accelerates vertically downwards at 1.4 m s^{-2} . Find

- (a) the magnitude of the normal reaction of the inclined plane on P , (2)
- (b) the value of m . (8)

When the particles have been moving for 0.5 s , the string breaks. Assuming that P does not reach the pulley,

- (c) find the further time that elapses until P comes to instantaneous rest. (6)

7. [In this question \mathbf{i} and \mathbf{j} are unit vectors due east and due north respectively. Position vectors are given relative to a fixed origin O .]

Two ships P and Q are moving with constant velocities. Ship P moves with velocity $(2\mathbf{i} - 3\mathbf{j}) \text{ km h}^{-1}$ and ship Q moves with velocity $(3\mathbf{i} + 4\mathbf{j}) \text{ km h}^{-1}$.

(a) Find, to the nearest degree, the bearing on which Q is moving. (2)

At 2 pm, ship P is at the point with position vector $(\mathbf{i} + \mathbf{j}) \text{ km}$ and ship Q is at the point with position vector $(-2\mathbf{j}) \text{ km}$.

At time t hours after 2 pm, the position vector of P is $\mathbf{p} \text{ km}$ and the position vector of Q is $\mathbf{q} \text{ km}$.

(b) Write down expressions, in terms of t , for

- (i) \mathbf{p} ,
- (ii) \mathbf{q} ,
- (iii) \overrightarrow{PQ} .

(5)

(c) Find the time when

- (i) Q is due north of P ,
- (ii) Q is north-west of P .

(4)



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Question 7 continued

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Q7

(Total 11 marks)

TOTAL FOR PAPER: 75 MARKS

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