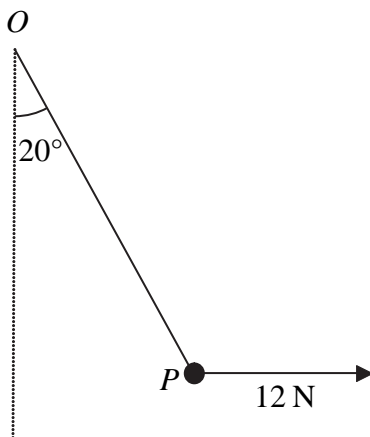




1.

Figure 1



A particle  $P$  is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point  $O$ . A horizontal force of magnitude  $12\text{ N}$  is applied to  $P$ . The particle  $P$  is in equilibrium with the string taut and  $OP$  making an angle of  $20^\circ$  with the downward vertical, as shown in Figure 1.

Find

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

(b) the weight of  $P$ . (4)

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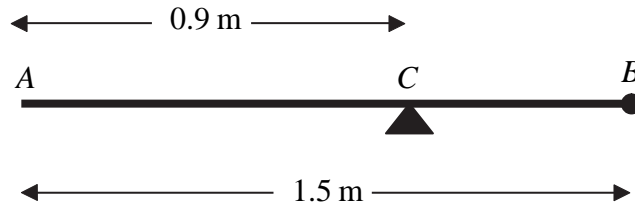
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3.

**Figure 2**



A uniform rod *AB* has length 1.5 m and mass 8 kg. A particle of mass  $m$  kg is attached to the rod at *B*. The rod is supported at the point *C*, where  $AC = 0.9$  m, and the system is in equilibrium with *AB* horizontal, as shown in Figure 2.

(a) Show that  $m = 2$ . (4)

A particle of mass 5 kg is now attached to the rod at *A* and the support is moved from *C* to a point *D* of the rod. The system, including both particles, is again in equilibrium with *AB* horizontal.

(b) Find the distance *AD*. (5)

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4. A car is moving along a straight horizontal road. At time  $t = 0$ , the car passes a point  $A$  with speed  $25 \text{ m s}^{-1}$ . The car moves with constant speed  $25 \text{ m s}^{-1}$  until  $t = 10 \text{ s}$ . The car then decelerates uniformly for  $8 \text{ s}$ . At time  $t = 18 \text{ s}$ , the speed of the car is  $V \text{ m s}^{-1}$  and this speed is maintained until the car reaches the point  $B$  at time  $t = 30 \text{ s}$ .

(a) Sketch, in the space below, a speed–time graph to show the motion of the car from  $A$  to  $B$ . (3)

Given that  $AB = 526 \text{ m}$ , find

(b) the value of  $V$ , (5)

(c) the deceleration of the car between  $t = 10 \text{ s}$  and  $t = 18 \text{ s}$ . (3)

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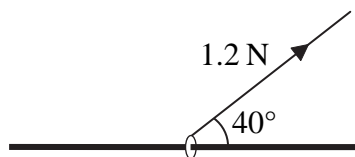
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5.

Figure 3



A small ring of mass 0.25 kg is threaded on a fixed rough horizontal rod. The ring is pulled upwards by a light string which makes an angle  $40^\circ$  with the horizontal, as shown in Figure 3. The string and the rod are in the same vertical plane. The tension in the string is 1.2 N and the coefficient of friction between the ring and the rod is  $\mu$ . Given that the ring is in limiting equilibrium, find

(a) the normal reaction between the ring and the rod, **(4)**

(b) the value of  $\mu$ . **(6)**

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Question 5 continued

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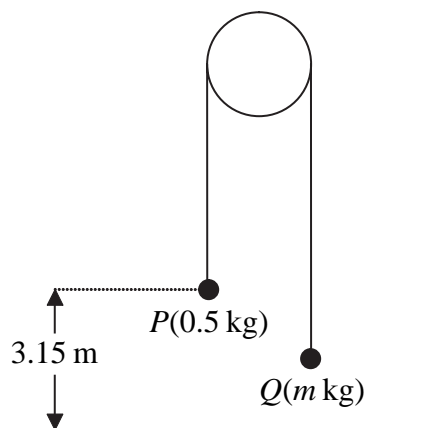
Q5

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6.

Figure 4



Two particles  $P$  and  $Q$  have mass  $0.5\text{ kg}$  and  $m\text{ kg}$  respectively, where  $m < 0.5$ . The particles are connected by a light inextensible string which passes over a smooth, fixed pulley. Initially  $P$  is  $3.15\text{ m}$  above horizontal ground. The particles are released from rest with the string taut and the hanging parts of the string vertical, as shown in Figure 4. After  $P$  has been descending for  $1.5\text{ s}$ , it strikes the ground. Particle  $P$  reaches the ground before  $Q$  has reached the pulley.

- (a) Show that the acceleration of  $P$  as it descends is  $2.8\text{ m s}^{-2}$ . (3)
- (b) Find the tension in the string as  $P$  descends. (3)
- (c) Show that  $m = \frac{5}{18}$ . (4)
- (d) State how you have used the information that the string is inextensible. (1)

When  $P$  strikes the ground,  $P$  does not rebound and the string becomes slack. Particle  $Q$  then moves freely under gravity, without reaching the pulley, until the string becomes taut again.

- (e) Find the time between the instant when  $P$  strikes the ground and the instant when the string becomes taut again. (6)

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7. A boat  $B$  is moving with constant velocity. At noon,  $B$  is at the point with position vector  $(3\mathbf{i} - 4\mathbf{j})$  km with respect to a fixed origin  $O$ . At 1430 on the same day,  $B$  is at the point with position vector  $(8\mathbf{i} + 11\mathbf{j})$  km.

(a) Find the velocity of  $B$ , giving your answer in the form  $p\mathbf{i} + q\mathbf{j}$ . (3)

At time  $t$  hours after noon, the position vector of  $B$  is  $\mathbf{b}$  km.

(b) Find, in terms of  $t$ , an expression for  $\mathbf{b}$ . (3)

Another boat  $C$  is also moving with constant velocity. The position vector of  $C$ ,  $\mathbf{c}$  km, at time  $t$  hours after noon, is given by

$$\mathbf{c} = (-9\mathbf{i} + 20\mathbf{j}) + t(6\mathbf{i} + \lambda\mathbf{j}),$$

where  $\lambda$  is a constant. Given that  $C$  intercepts  $B$ ,

(c) find the value of  $\lambda$ , (5)

(d) show that, before  $C$  intercepts  $B$ , the boats are moving with the same speed. (3)

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**Q7**

(Total 14 marks)

**TOTAL FOR PAPER: 75 MARKS**

**END**

