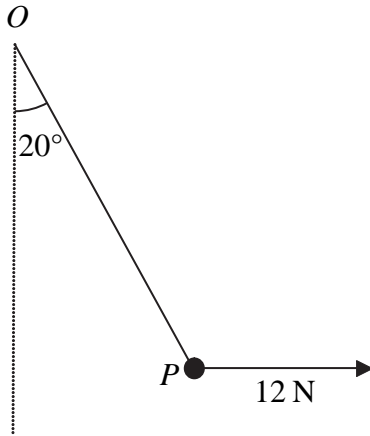


1.

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 N is applied to P . The particle P is in equilibrium with the string taut and OP making an angle of 20° with the downward vertical, as shown in Figure 1.

Find

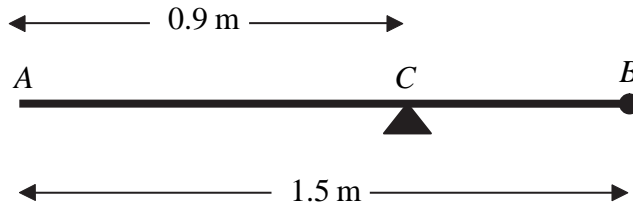
(a) the tension in the string, (3)

(b) the weight of P . (4)



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)



4. A car is moving along a straight horizontal road. At time $t = 0$, the car passes a point A with speed 25 m s^{-1} . The car moves with constant speed 25 m s^{-1} until $t = 10 \text{ s}$. The car then decelerates uniformly for 8 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)

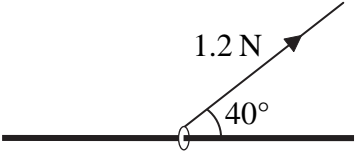
(c) the deceleration of the car between $t = 10 \text{ s}$ and $t = 18 \text{ s}$.

(3)



5.

Figure 3



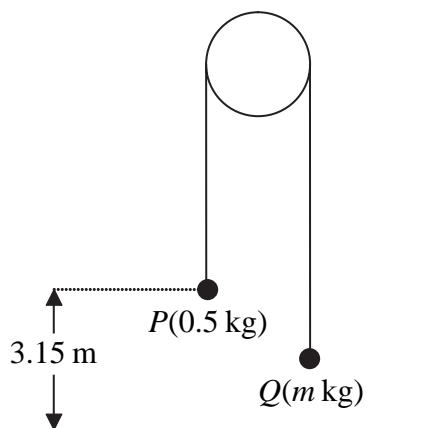
A small ring of mass 0.25 kg is threaded on a fixed rough horizontal rod. The ring is pulled upwards by a light string which makes an angle 40° with the horizontal, as shown in Figure 3. The string and the rod are in the same vertical plane. The tension in the string is 1.2 N and the coefficient of friction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

- (a) the normal reaction between the ring and the rod, (4)
- (b) the value of μ . (6)



6.

Figure 4



Two particles P and Q have mass 0.5 kg and m 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 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 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 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)



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 λ is a constant. Given that C intercepts B ,

(c) find the value of λ , (5)

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



