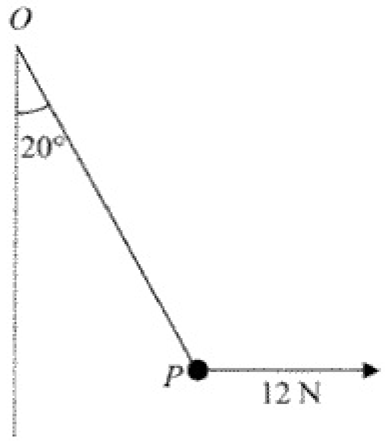
Mechanics-M1 - 2007-June

Question 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)

Question 2

Two particles A and B, of mass 0.3 kg and m kg respectively, are moving in opposite directions along the same straight horizontal line so that the particles collide directly. Immediately before the collision, the speeds of A and B are 8 m s^{-1} and 4 m s^{-1} respectively. In the collision the direction of motion of each particle is reversed and, immediately after the collision, the speed of each particle is 2 m s^{-1}. Find

(a) the magnitude of the impulse exerted by B on A in the collision,

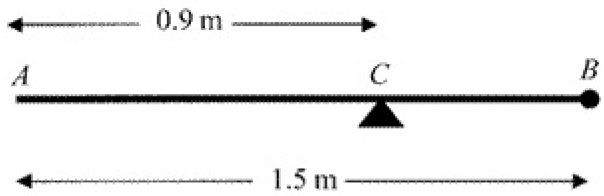
(3)

(b) the value of m.

(4)

Question 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)

Question 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 $t = 10$ s. The car then decelerates uniformly for 8 s. At time $t = 18$ s, the speed of the car is V m s^{-1} and this speed is maintained until the car reaches the point B at time $t = 30$ 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 $AB = 526$ m, find

(b) the value of V,

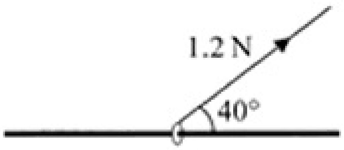
(5)

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

(3)

Question 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,

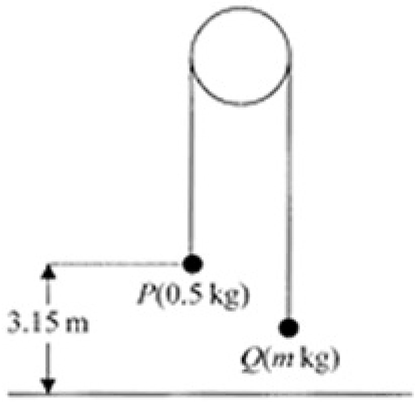
(4)

(b) the value of μ.

(6)

Question 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)

Question 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)