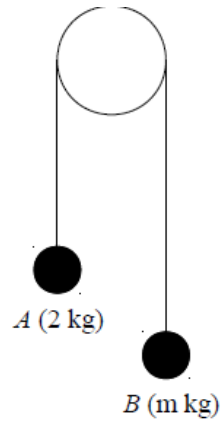


Year 1 Various Connected Particles

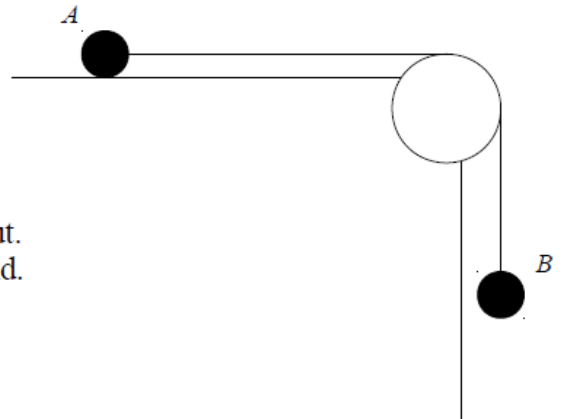
- 1 Two particles A and B have mass of 2 kg and m kg respectively, where $m < 2$. The particles are connected by a light inextensible string which passes over a smooth, fixed pulley. Initially A is 3 m above horizontal ground. The string is released from rest with the string taut and the hanging parts of the string vertical. After A has been descending for 2.5 s it strikes the ground. Particle A reaches the ground before B reaches the pulley.



- (a) Show that the acceleration of A as it descends is 0.96 ms^{-2} (3)
- (b) Show that the mass of B is 1.64 kg (7)
- (c) State how you have used the information that the string is inextensible. (1)

(Total for question 1 is 11 marks)

- 2 A particle A of mass 5 kg rests on a smooth horizontal table. Particle A is attached to one end of a light inextensible string which passes over a smooth pulley fixed to the edge of the table. The other end of the string is attached to particle B of mass 4 kg which hangs freely below the pulley 1.4 m above the ground. The system is released from rest with the string taut. Particle A does not reach the pulley before B reaches the ground.



- (a) Find the tension in the string before B hits the ground. (4)
- (b) Find the time taken by B to reach the ground. (5)

(Total for question 2 is 9 marks)

- 3 A car of mass 750 kg pulls a trailer of mass 300 kg along a straight horizontal road using a light towbar which is parallel to the road. The horizontal resistances to motion of the car and the trailer have magnitudes 250 N and 100 N respectively. The engine of the car produces a constant horizontal driving force on the car of magnitude 1600 N. Find

- (a) the acceleration of the car and trailer, (3)
- (b) the magnitude of the tension in the towbar. (3)

The car is moving along the road when the driver sees a hazard ahead. He reduces the force produced by the engine to zero and applies the brakes. The brakes produce a force on the car of magnitude F newtons and the car and trailer decelerate. Given that the resistances to motion are unchanged and the magnitude of the thrust in the towbar is 80 N,

- (c) find the value of F . (7)

(Total for question 3 is 13 marks)

- 4 A car is towing a trailer along a straight horizontal road by means of a horizontal tow-rope. The mass of the car is 1400 kg. The mass of the trailer is 700 kg. The car and the trailer are modelled as particles and the tow-rope as a light inextensible string. The resistances to motion of the car and the trailer are assumed to be constant and of magnitude 630 N and 280 N respectively. The driving force on the car, due to its engine, is 2380 N. Find

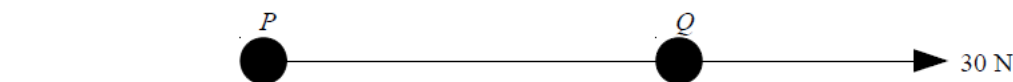
- (a) the acceleration of the car, (3)
- (b) the tension in the tow-rope (3)
- (c) state how you have used the assumption that the car and trailer are modelled as particles. (1)

When the car and trailer are moving at 12 m s^{-1} , the tow-rope breaks. Assuming that the driving force on the car and the resistances to motion are unchanged,

- (d) find the distance moved by the car in the first 4 s after the tow-rope breaks. (6)

(Total for question 4 is 13 marks)

5



Two particles P and Q , of mass 4 kg and 6 kg respectively, are joined by a light horizontal rod. The particles are initially at rest when a constant force F of magnitude 30 N is applied to Q , as shown in the diagram. The force is applied for 5 s. During the motion, the resistance to P has a constant magnitude of 2 N and the resistance to Q has a constant magnitude of 4 N. Find

- (a) the acceleration of the particles as the system moves under the action of the 30 N force. (3)
- (b) the speed of the particles after 5 seconds. (2)
- (c) the tension in the string as the system moves under the action of the 30 N force. (3)

After 5 seconds the force is removed and the system decelerates to rest. The resistances to motion are unchanged.

- (d) Find the distance moved by P as the system decelerates. (4)
- (e) Find the thrust in the rod as the system decelerates. (3)

(Total for question 5 is 15 marks)