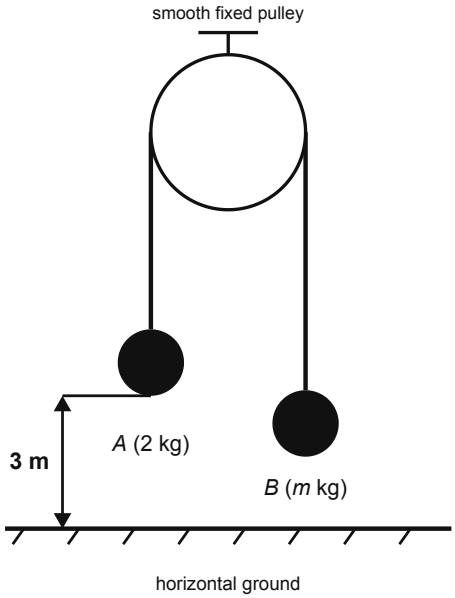
1 Two particles A and B have mass of 2 kg and m kg respectively, where $m < 2$. The particles are connected by a light inextensible string which passes over a smooth, fixed pulley. Initially A is 3 m above horizontal ground. The string is released from rest with the string taut and the hanging parts 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

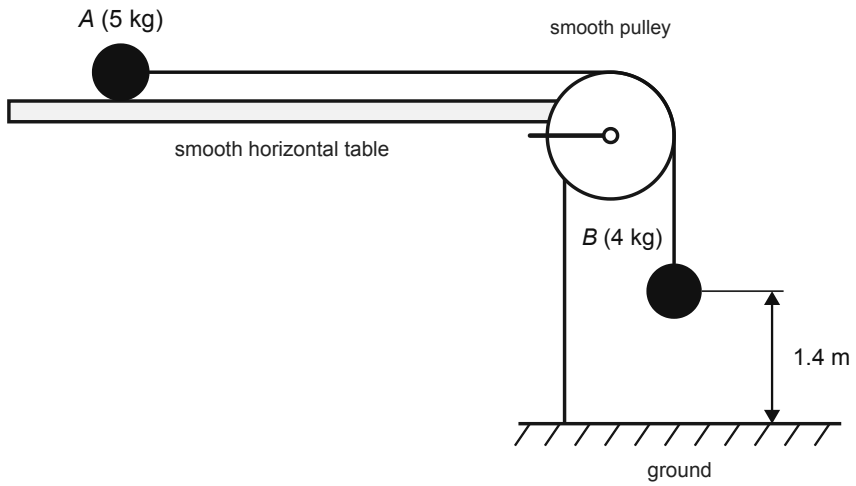
(6)

(c) State how you have used the information that the string is inextensible.

(1)

(Total for question 1 is 10 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.

(a) Find the acceleration of the car and trailer.

(3)

(b) Find the magnitude of the tension in the towbar.

(3)

(c) 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, 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.

(a) Find the acceleration of the car.

(3)

(b) Find 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)

(d) 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, 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.



(a) Find the acceleration of the particles as the system moves under the action of the 30 N force.

(3)

(b) Find the speed of the particles after 5 seconds.

(2)

(c) Find the tension in the rod as the system moves under the action of the 30 N force.

(3)

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

---

6 Three forces $(3\mathbf{i} + 2p\mathbf{j})$ N, $(-2\mathbf{i} + 5\mathbf{j})$ N and $(4q\mathbf{i} + 5\mathbf{j})$ N act on a particle A.
Given A is in equilibrium find the values of p and q.

(Total for question 6 is 4 marks)

---

7 A particle P of mass 0.8kg moves under the action of a force F N. The acceleration of P is $(-3\mathbf{i} + 5\mathbf{j})$.

(a) Find the angle between the acceleration and the vector $\mathbf{i}$.

(2)

(b) Find the magnitude of F.

(3)

(Total for question 7 is 5 marks)

8 A particle P of mass 2kg moves with constant acceleration under the action of a force F N. The initial velocity of P is $(-2\mathbf{i} + 6\mathbf{j})$ ms^{-1} and after 4 seconds the velocity of P is $(7\mathbf{i} + 2\mathbf{j})$ ms^{-1}.

(a) Find the magnitude of the acceleration.

(3)

(b) Find the angle between F and the vector $\mathbf{i}$.

(3)

(Total for question 8 is 6 marks)

9 The resultant of two forces F_1 and F_2 is $(\mathbf{i} - 14\mathbf{j})$ N. Given that $F_1 = (2p\mathbf{i} - 4q\mathbf{j})$ N and $F_2 = (3q\mathbf{i} + 4p\mathbf{j})$ N find the values of p and q.

Find the values of p and q.

(Total for question 9 is 5 marks)

10 A particle P moves with a constant velocity of $(4\mathbf{i} - \mathbf{j})$ ms^{-1}.

(a) Find the speed of P.

(2)

(b) Find the direction of motion of P, giving your answer as a bearing.

(3)

(Total for question 10 is 5 marks)

11 A particle P moves with constant acceleration $(3\mathbf{i} - 4\mathbf{j})$ ms^{-2}. At time $t = 0$, P has speed u ms^{-1}. At time $t = 3$, P has velocity $(-5\mathbf{i} + 2\mathbf{j})$ ms^{-1}.
Find the value of u.

(Total for question 11 is 5 marks)

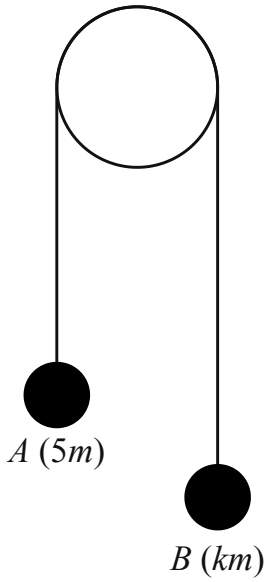
---

12 The resultant of two forces F_1 and F_2 is parallel to $\mathbf{i} + \mathbf{j}$. Given that $F_1 = (3\mathbf{i} - 2\mathbf{j})$ N and $F_2 = (p\mathbf{i} + 2p\mathbf{j})$ N, where p is a positive constant.
Find the value of p.

(Total for question 12 is 5 marks)

---

13 Two particles A and B have mass of $5m$ and km respectively, where $k < 5$. The particles are connected by a light inextensible string which passes over a smooth, fixed pulley. The string is released from rest with the string taut and the hanging parts of the string vertical. In the subsequent motion A moves downwards with acceleration of magnitude $\frac{3}{4}g$.



(a) Explain why the acceleration of B also has magnitude $\frac{3}{4}g$

(1)

(b) Find in terms of m and g, the tension in the string.

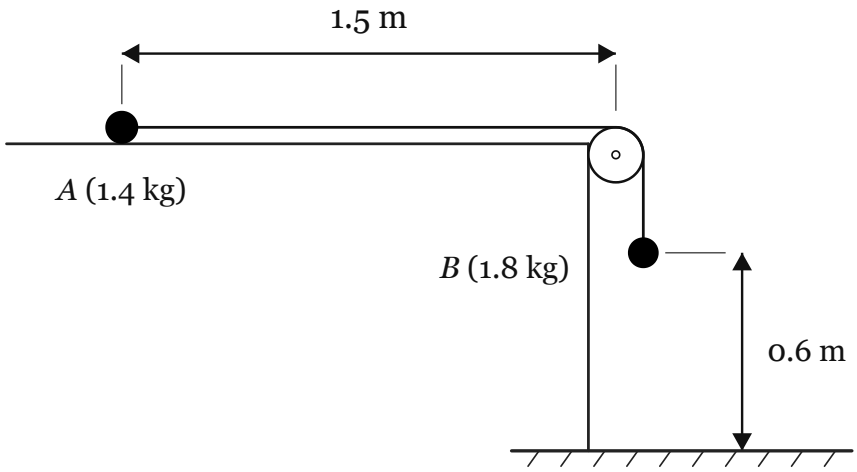
(3)

(c) Find the value of k.

(3)

(Total for question 13 is 7 marks)

14 A ball A of mass 1.4 kg rests on a smooth horizontal table. Ball A is attached to one end of a rope which passes over a pulley fixed to the edge of the table. The other end of the rope is attached to ball B of mass 1.8 kg which hangs freely below the pulley. The system is released from rest with the string taut, with ball A 1.5 m from the pulley and ball B 0.6 m above the ground. Ball B descends, hits the floor and does not rebound. The balls are modelled as particles, the rope as a light inextensible string, and the pulley as small and smooth.



(a) Find the acceleration of B as it falls.

(5)

(b) Find the time taken for A to reach the pulley from the time the system was released.

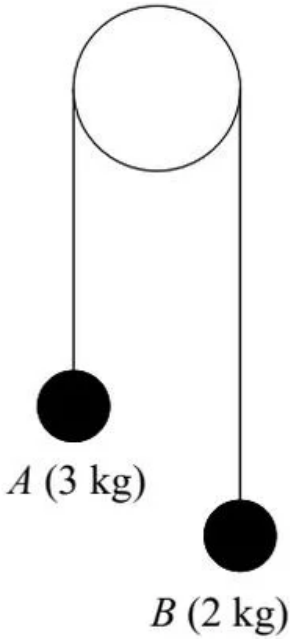
(6)

(c) State one limitation of the model that will affect your answer to part (a).

(1)

(Total for question 14 is 12 marks)

15 Two balls A and B have mass of 3 kg and 2 kg respectively. The balls are connected by a string which passes over a fixed pulley. Ball A is held at rest with the string taut and the hanging parts of the string vertical. Ball A is released. The string is modelled as being light and inextensible, the balls are modelled as particles, the pulley is modelled as being smooth and air resistance is ignored.



(a) Using the model, find, in terms of g, the magnitude of the force exerted on the pulley by the string while A is falling and before B hits the pulley.

(8)

(b) State one limitation of the model, apart from ignoring air resistance, that will affect the accuracy of your answer to part (a).

(1)

(Total for question 15 is 9 marks)