

1.

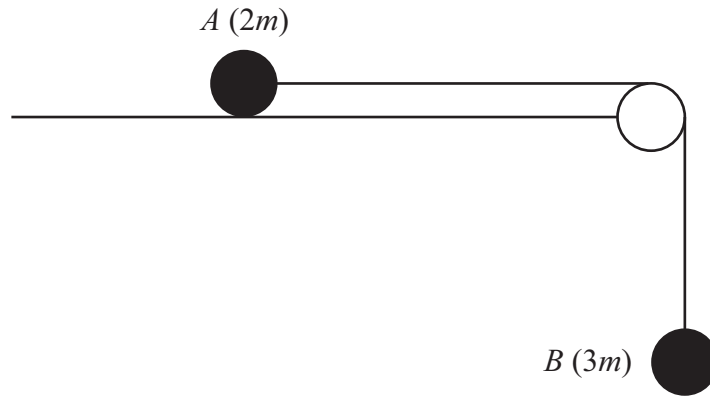


Figure 2

Two particles A and B have masses $2m$ and $3m$ respectively. The particles are attached to the ends of a light inextensible string. Particle A is held at rest on a smooth horizontal table. The string passes over a small smooth pulley which is fixed at the edge of the table. Particle B hangs at rest vertically below the pulley with the string taut, as shown in Figure 2. Particle A is released from rest. Assuming that A has not reached the pulley, find

- (a) the acceleration of B , (5)
- (b) the tension in the string, (1)
- (c) the magnitude and direction of the force exerted on the pulley by the string. (4)

2.

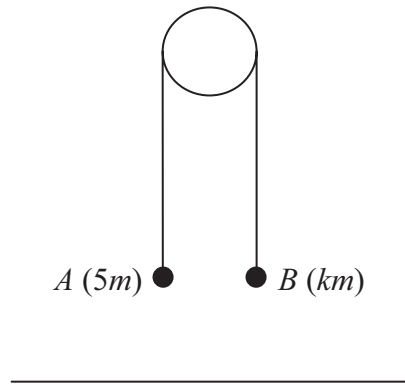


Figure 4

Two particles A and B have masses $5m$ and km respectively, where $k < 5$. The particles are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut, the hanging parts of the string vertical and with A and B at the same height above a horizontal plane, as shown in Figure 4. The system is released from rest. After release, A descends with acceleration $\frac{1}{4}g$.

(a) Show that the tension in the string as A descends is $\frac{15}{4}mg$. (3)

(b) Find the value of k . (3)

(c) State how you have used the information that the pulley is smooth. (1)

After descending for 1.2 s, the particle A reaches the plane. It is immediately brought to rest by the impact with the plane. The initial distance between B and the pulley is such that, in the subsequent motion, B does not reach the pulley.

(d) Find the greatest height reached by B above the plane. (7)

3.



Figure 3

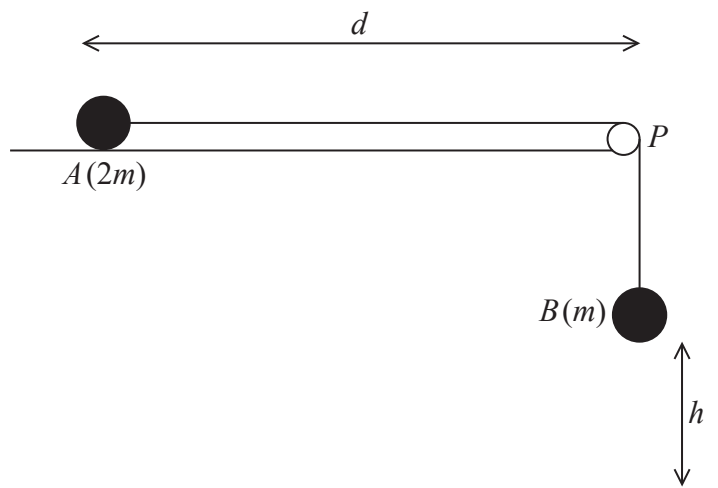
Two particles P and Q have masses 1.5 kg and 3 kg respectively. The particles are attached to the ends of a light inextensible string. Particle P is held at rest on a fixed rough horizontal table. The coefficient of friction between P and the table is $\frac{1}{5}$. The string is parallel to the table and passes over a small smooth light pulley which is fixed at the edge of the table. Particle Q hangs freely at rest vertically below the pulley, as shown in Figure 3. Particle P is released from rest with the string taut and slides along the table.

Assuming that P has not reached the pulley, find

- (a) the tension in the string during the motion, (8)
- (b) the magnitude and direction of the resultant force exerted on the pulley by the string. (4)

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

4.

**Figure 3**

Two particles, A and B , have masses $2m$ and m respectively. The particles are attached to the ends of a light inextensible string. Particle A is held at rest on a fixed rough horizontal table at a distance d from a small smooth light pulley which is fixed at the edge of the table at the point P . The coefficient of friction between A and the table is μ , where $\mu < \frac{1}{2}$.

The string is parallel to the table from A to P and passes over the pulley. Particle B hangs freely at rest vertically below P with the string taut and at a height h , ($h < d$), above a horizontal floor, as shown in Figure 3. Particle A is released from rest with the string taut and slides along the table.

(a) (i) Write down an equation of motion for A .

(ii) Write down an equation of motion for B .

(4)

(b) Hence show that, until B hits the floor, the acceleration of A is $\frac{g}{3}(1 - 2\mu)$.

(3)

(c) Find, in terms of g , h and μ , the speed of A at the instant when B hits the floor.

(2)

After B hits the floor, A continues to slide along the table. Given that $\mu = \frac{1}{3}$ and that A comes to rest at P ,

(d) find d in terms of h .

(5)

(e) Describe what would happen if $\mu = \frac{1}{2}$

(1)

5.

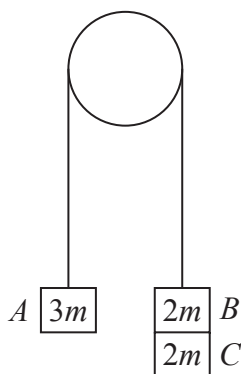


Figure 5

Three particles A , B and C have masses $3m$, $2m$ and $2m$ respectively. Particle C is attached to particle B . Particles A and B are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 5. The system is released from rest and A moves upwards.

- (a) (i) Show that the acceleration of A is $\frac{g}{7}$
- (ii) Find the tension in the string as A ascends.
- (7)

At the instant when A is 0.7 m above its original position, C separates from B and falls away. In the subsequent motion, A does not reach the pulley.

- (b) Find the speed of A at the instant when it is 0.7 m above its original position. (2)
- (c) Find the acceleration of A at the instant after C separates from B . (4)
- (d) Find the greatest height reached by A above its original position. (3)

6.

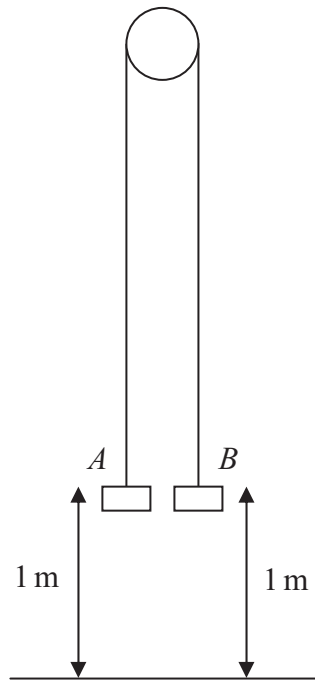


Figure 3

Two particles A and B have mass 0.4 kg and 0.3 kg respectively. The particles are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed above a horizontal floor. Both particles are held, with the string taut, at a height of 1 m above the floor, as shown in Figure 3. The particles are released from rest and in the subsequent motion B does not reach the pulley.

(a) Find the tension in the string immediately after the particles are released. (6)

(b) Find the acceleration of A immediately after the particles are released. (2)

When the particles have been moving for 0.5 s , the string breaks.

(c) Find the further time that elapses until B hits the floor. (9)

7.

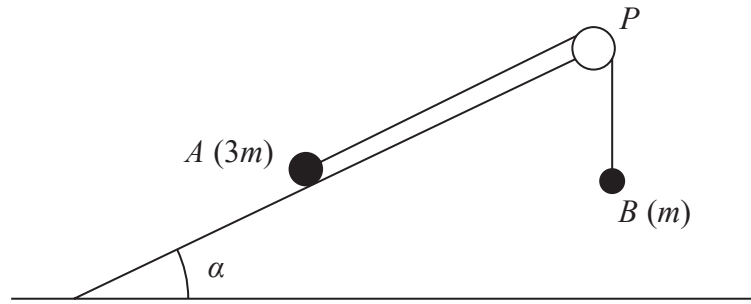


Figure 1

A small stone A of mass $3m$ is attached to one end of a string.

A small stone B of mass m is attached to the other end of the string.

Initially A is held at rest on a fixed rough plane.

The plane is inclined to the horizontal at an angle α , where $\tan \alpha = \frac{3}{4}$

The string passes over a pulley P that is fixed at the top of the plane.

The part of the string from A to P is parallel to a line of greatest slope of the plane.

Stone B hangs freely below P , as shown in Figure 1.

The coefficient of friction between A and the plane is $\frac{1}{6}$

Stone A is released from rest and begins to move down the plane.

The stones are modelled as particles.

The pulley is modelled as being small and smooth.

The string is modelled as being light and inextensible.

Using the model for the motion of the system before B reaches the pulley,

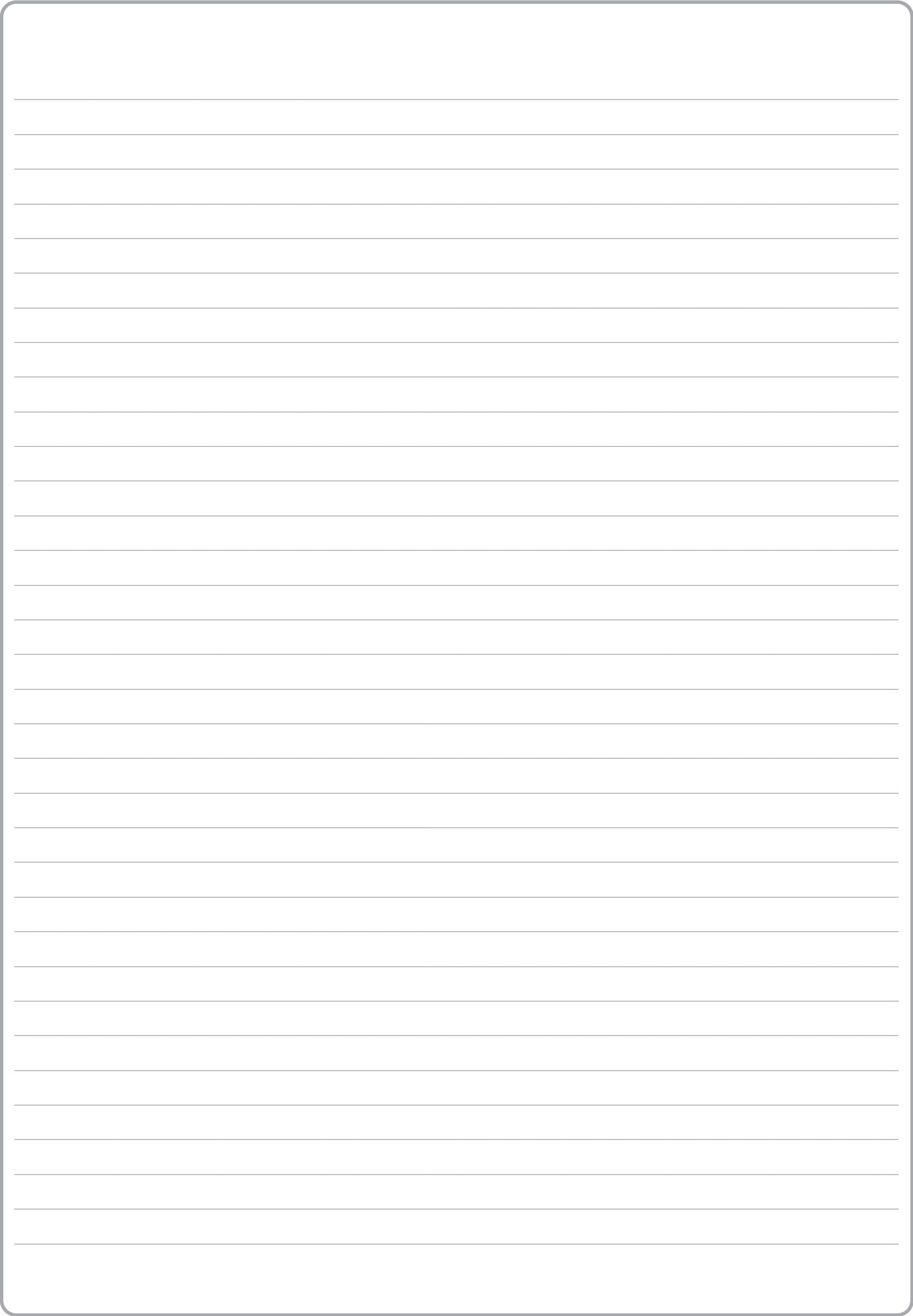
(a) write down an equation of motion for A (2)

(b) show that the acceleration of A is $\frac{1}{10}g$ (7)

(c) sketch a velocity-time graph for the motion of B , from the instant when A is released from rest to the instant just before B reaches the pulley, explaining your answer. (2)

In reality, the string is not light.

(d) State how this would affect the working in part (b). (1)



8.

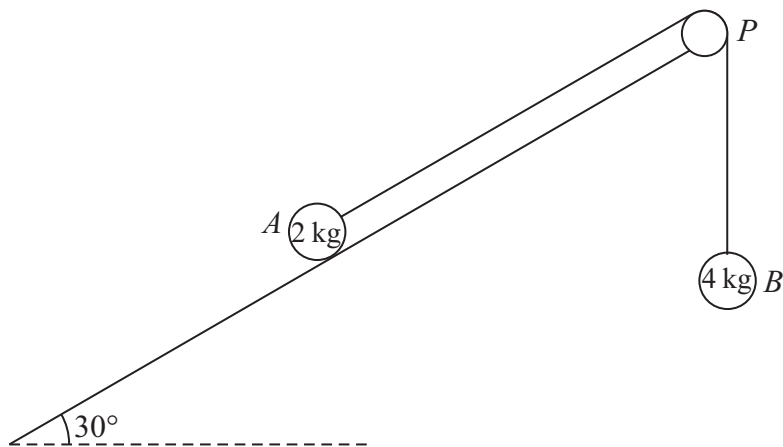


Figure 2

A fixed rough plane is inclined at 30° to the horizontal. A small smooth pulley P is fixed at the top of the plane. Two particles A and B , of mass 2 kg and 4 kg respectively, are attached to the ends of a light inextensible string which passes over the pulley P . The part of the string from A to P is parallel to a line of greatest slope of the plane and B hangs freely below P , as shown in Figure 2. The coefficient of friction between A and the plane is $\frac{1}{\sqrt{3}}$. Initially A is held at rest on the plane. The particles are released from rest with the string taut and A moves up the plane.

Find the tension in the string immediately after the particles are released.

(9)

9.

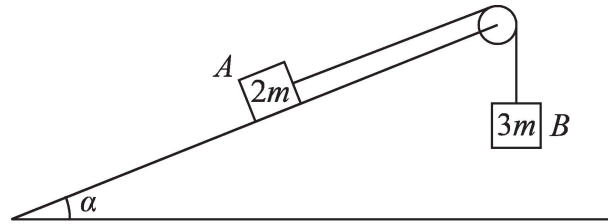


Figure 1

Two blocks, A and B , of masses $2m$ and $3m$ respectively, are attached to the ends of a light string.

Initially A is held at rest on a fixed rough plane.

The plane is inclined at angle α to the horizontal ground, where $\tan \alpha = \frac{5}{12}$

The string passes over a small smooth pulley, P , fixed at the top of the plane.

The part of the string from A to P is parallel to a line of greatest slope of the plane. Block B hangs freely below P , as shown in Figure 1.

The coefficient of friction between A and the plane is $\frac{2}{3}$

The blocks are released from rest with the string taut and A moves up the plane.

The tension in the string immediately after the blocks are released is T .

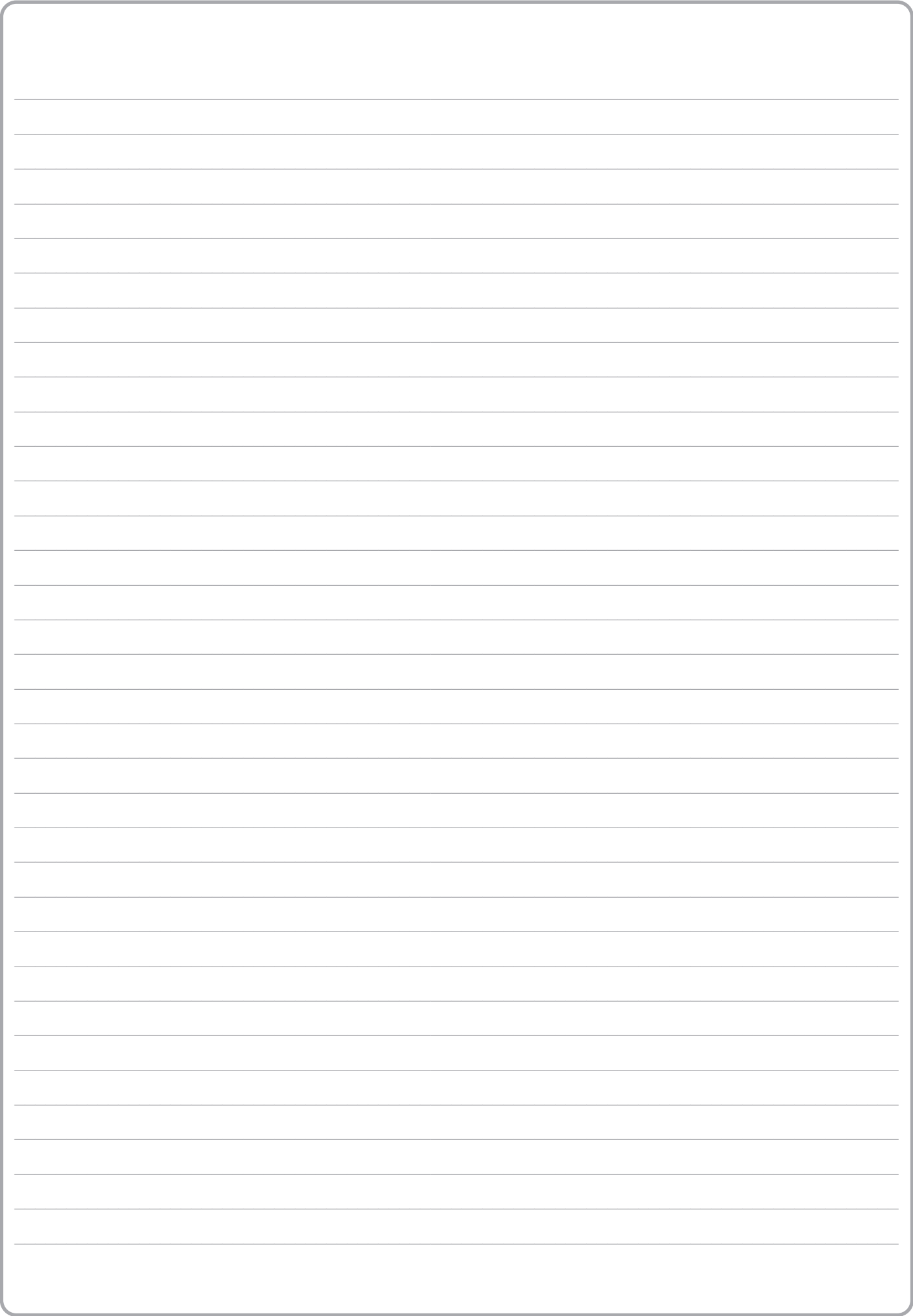
The blocks are modelled as particles and the string is modelled as being inextensible.

(a) Show that $T = \frac{12mg}{5}$ (8)

After B reaches the ground, A continues to move up the plane until it comes to rest before reaching P .

(b) Determine whether A will remain at rest, carefully justifying your answer. (2)

(c) Suggest two refinements to the model that would make it more realistic. (2)



10.

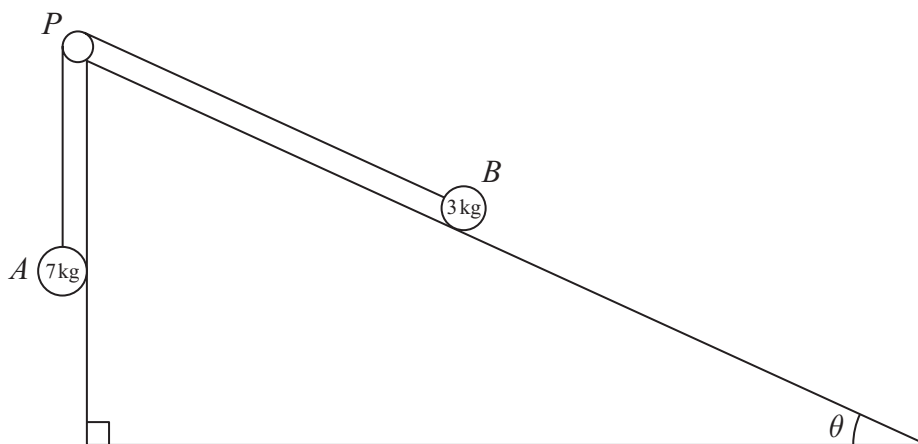


Figure 4

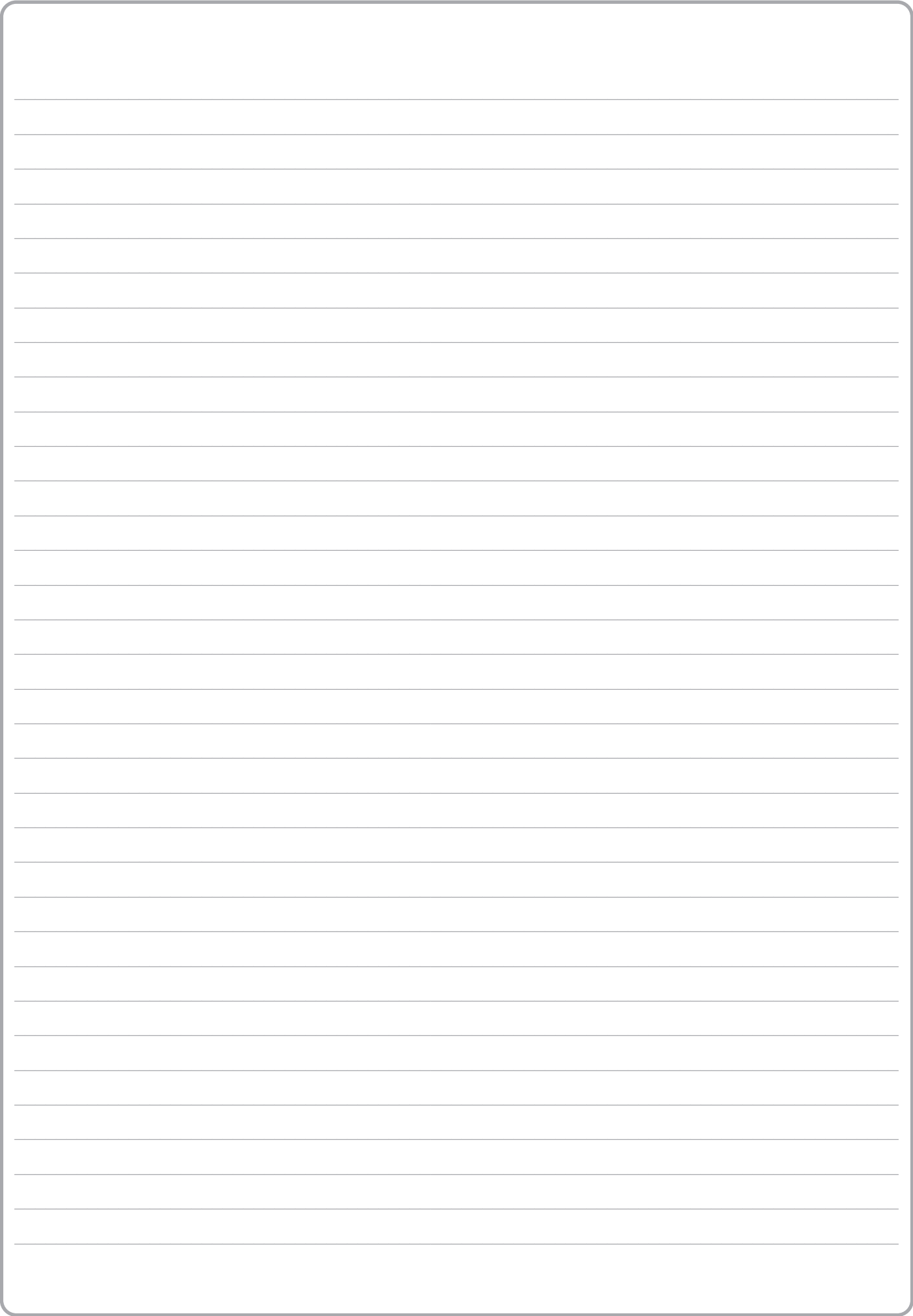
Two particles A and B , of mass 7 kg and 3 kg respectively, are attached to the ends of a light inextensible string. Initially B is held at rest on a rough fixed plane inclined at angle θ to the horizontal, where $\tan \theta = \frac{5}{12}$. The part of the string from B to P is parallel to a line of greatest slope of the plane. The string passes over a small smooth pulley, P , fixed at the top of the plane. The particle A hangs freely below P , as shown in Figure 4. The coefficient of friction between B and the plane is $\frac{2}{3}$. The particles are released from rest with the string taut and B moves up the plane.

(a) Find the magnitude of the acceleration of B immediately after release. (10)

(b) Find the speed of B when it has moved 1 m up the plane. (2)

When B has moved 1 m up the plane the string breaks. Given that in the subsequent motion B does not reach P ,

(c) find the time between the instants when the string breaks and when B comes to instantaneous rest. (4)



11.

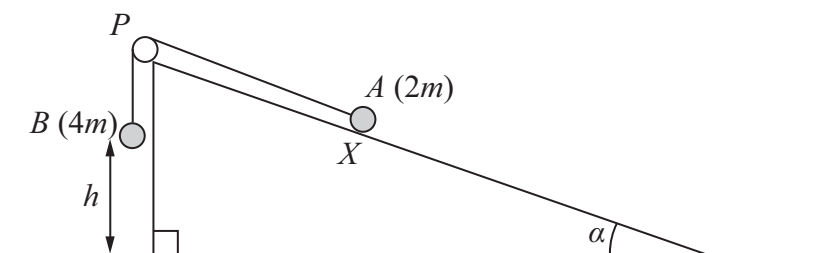


Figure 5

Figure 5 shows two particles A and B , of mass $2m$ and $4m$ respectively, connected by a light inextensible string. Initially A is held at rest on a rough inclined plane which is fixed to horizontal ground. The plane is inclined to the horizontal at an angle α , where $\tan \alpha = \frac{3}{4}$. The coefficient of friction between A and the plane is $\frac{1}{4}$. The string passes over a small smooth pulley P which is fixed at the top of the plane. The part of the string from A to P is parallel to a line of greatest slope of the plane and B hangs vertically below P . The system is released from rest with the string taut, with A at the point X and with B at a height h above the ground.

For the motion until B hits the ground,

- (a) give a reason why the magnitudes of the accelerations of the two particles are the same,

(1)

- (b) write down an equation of motion for each particle,

(4)

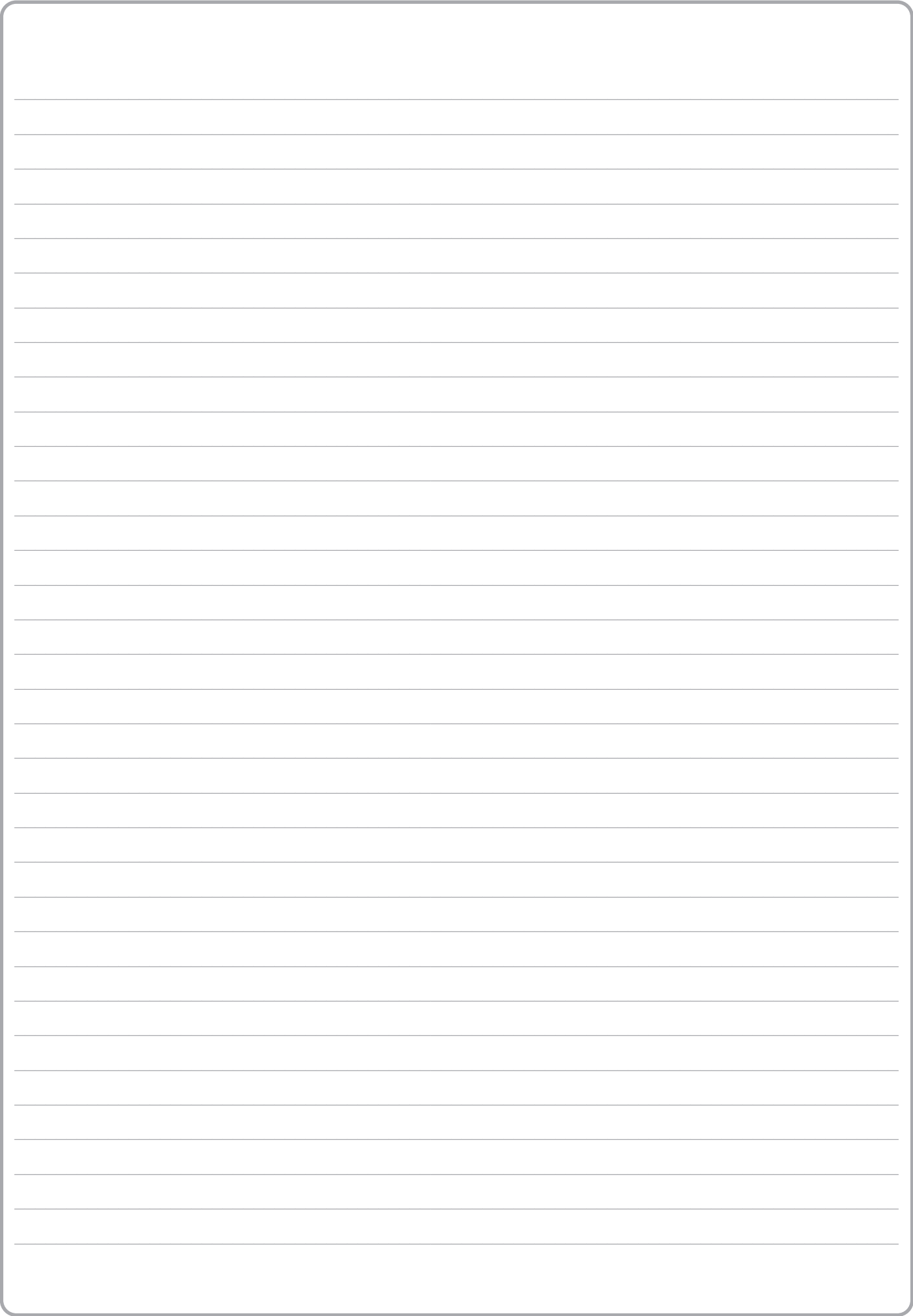
- (c) find the acceleration of each particle.

(5)

Particle B does not rebound when it hits the ground and A continues moving up the plane towards P . Given that A comes to rest at the point Y , without reaching P ,

- (d) find the distance XY in terms of h .

(6)



12.

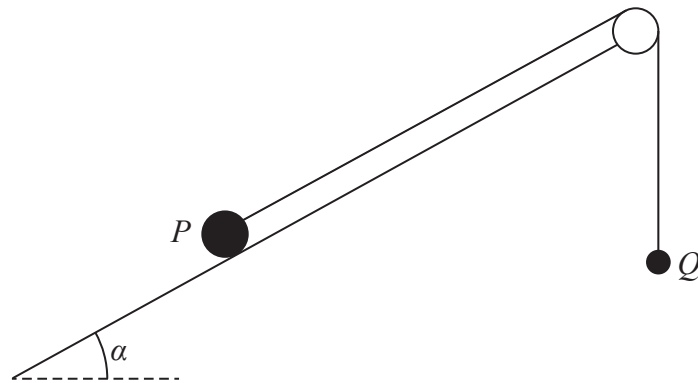


Figure 4

Two particles P and Q have mass 4 kg and 0.5 kg respectively. The particles are attached to the ends of a light inextensible string. Particle P is held at rest on a fixed rough plane, which is inclined to the horizontal at an angle α where $\tan \alpha = \frac{4}{3}$. The coefficient of friction between P and the plane is 0.5. The string lies along the plane and passes over a small smooth light pulley which is fixed at the top of the plane. Particle Q hangs freely at rest vertically below the pulley. The string lies in the vertical plane which contains the pulley and a line of greatest slope of the inclined plane, as shown in Figure 4. Particle P is released from rest with the string taut and slides down the plane.

Given that Q has not hit the pulley, find

- (a) the tension in the string during the motion,

(11)

- (b) the magnitude of the resultant force exerted by the string on the pulley.

(4)

[illegible]

A diagram of a mechanical system. A pulley is at the top left corner of a right-angled triangle. A rope passes over the pulley, with one end attached to a mass Q and the other end attached to a mass P . Mass Q is a square hanging vertically. Mass P is a rectangle resting on the hypotenuse of the triangle. The angle between the horizontal base and the hypotenuse is labeled α . A right-angle symbol is shown at the vertex where the vertical side and the horizontal base meet.

Two particles P and Q have masses 0.3 kg and $m \text{ kg}$ respectively. The particles are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed at the top of a fixed rough plane. The plane is inclined to the horizontal at an angle α , where $\tan \alpha = \frac{3}{4}$. The coefficient of friction between P and the plane is $\frac{1}{2}$.

The system is released from rest and Q accelerates vertically downwards at 1.4 m s^{-2} . Find

- When the particles have been moving for 0.5 s, the string breaks. Assuming that P does not reach the pulley,