**1.**

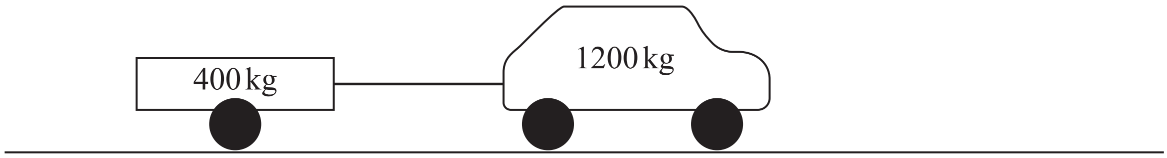


**Figure 2**

A car of mass 1200 kg is towing a trailer of mass 400 kg along a straight horizontal road using a tow rope, as shown in Figure 2.
The rope is horizontal and parallel to the direction of motion of the car.

- The resistance to motion of the car is modelled as a constant force of magnitude $2R$ newtons
- The resistance to motion of the trailer is modelled as a constant force of magnitude $R$ newtons
- The rope is modelled as being light and inextensible
- The acceleration of the car is modelled as $a\,\text{m s}^{-2}$

The driving force of the engine of the car is 7400 N and the tension in the tow rope is 2400 N.

Using the model,

(a) find the value of $a$

**(5)**

In a refined model, the rope is modelled as having mass and the acceleration of the car is found to be $a_1\,\text{m s}^{-2}$

(b) State how the value of $a_1$ compares with the value of $a$

**(1)**

(c) State one limitation of the model used for the resistance to motion of the car.

**(1)**

**2.**

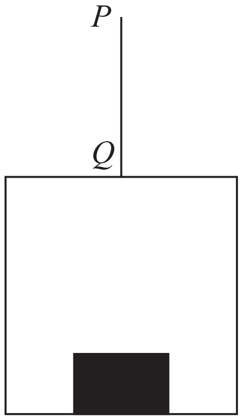


**Figure 1**

A vertical rope $PQ$ has its end $Q$ attached to the top of a small lift cage.

The lift cage has mass 40 kg and carries a block of mass 10 kg, as shown in Figure 1.

The lift cage is raised vertically by moving the end $P$ of the rope vertically upwards with constant acceleration $0.2\,\mathrm{m\,s^{-2}}$

The rope is modelled as being light and inextensible and air resistance is ignored.

Using the model,

(a) find the tension in the rope $PQ$

**(3)**

(b) find the magnitude of the force exerted on the block by the lift cage.

**(3)**

**3.**

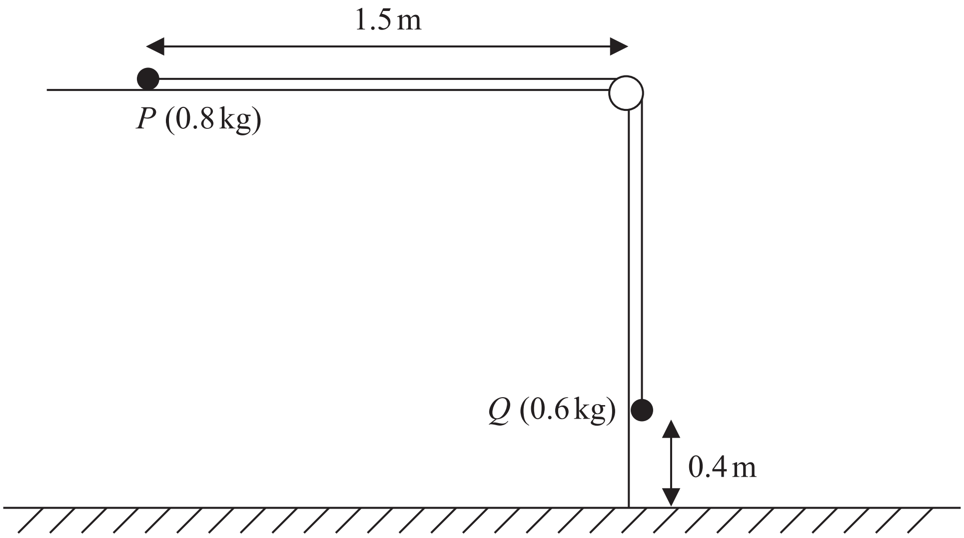


**Figure 1**

A small ball, $P$, of mass 0.8 kg, is held at rest on a smooth horizontal table and is attached to one end of a thin rope.

The rope passes over a pulley that is fixed at the edge of the table.

The other end of the rope is attached to another small ball, $Q$, of mass 0.6 kg, that hangs freely below the pulley.

Ball $P$ is released from rest, with the rope taut, with $P$ at a distance of 1.5 m from the pulley and with $Q$ at a height of 0.4 m above the horizontal floor, as shown in Figure 1.

Ball $Q$ descends, hits the floor and does not rebound.

The balls are modelled as particles, the rope as a light and inextensible string and the pulley as small and smooth.

Using this model,

(a) show that the acceleration of $Q$, as it falls, is $4.2\,\mathrm{m\,s^{-2}}$

**(5)**

(b) find the time taken by $P$ to hit the pulley from the instant when $P$ is released.

**(6)**

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

**(1)**

**4.**

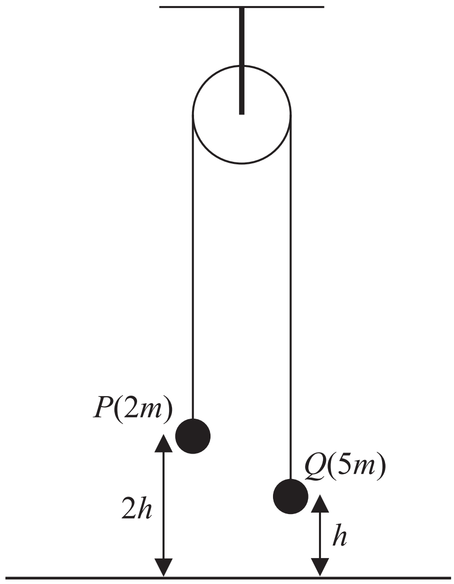


**Figure 1**

A ball $P$ of mass $2m$ is attached to one end of a string.

The other end of the string is attached to a ball $Q$ of mass $5m$.

The string passes over a fixed pulley.

The system is held at rest with the balls hanging freely and the string taut.

The hanging parts of the string are vertical with $P$ at a height $2h$ above horizontal ground and with $Q$ at a height $h$ above the ground, as shown in Figure 1.

The system is released from rest.

In the subsequent motion, $Q$ does not rebound when it hits the ground and $P$ does not hit the pulley.

The balls are modelled as particles.

The string is modelled as being light and inextensible.

The pulley is modelled as being small and smooth.

Air resistance is modelled as being negligible.

Using this model,

(a) (i) write down an equation of motion for $P$,

(ii) write down an equation of motion for $Q$,

**(4)**

(b) find, in terms of $h$ only, the height above the ground at which $P$ first comes to instantaneous rest.

**(7)**

(c) State one limitation of modelling the balls as particles that could affect your answer to part (b).

**(1)**

In reality, the string will not be inextensible.

(d) State how this would affect the accelerations of the particles.

**(1)**

**5.**

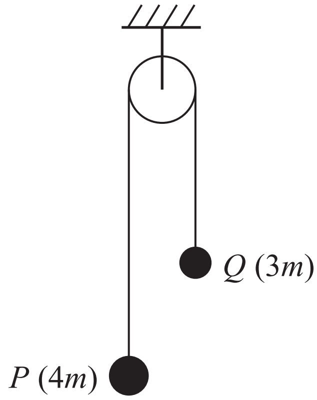


**Figure 1**

One end of a string is attached to a small ball $P$ of mass $4m$.

The other end of the string is attached to another small ball $Q$ of mass $3m$.

The string passes over a fixed pulley.

Ball $P$ is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 1.

Ball $P$ 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 $m$ and $g$, the magnitude of the force exerted on the pulley by the string while $P$ is falling and before $Q$ 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)**

**6.**

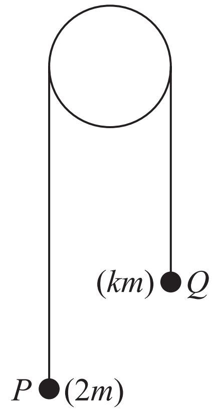


**Figure 1**

Two small balls, $P$ and $Q$, have masses $2m$ and $km$ respectively, where $k < 2$.
The balls are attached to the ends of a string that passes over a fixed pulley.
The system is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 1.

The system is released from rest and, in the subsequent motion, $P$ moves downwards with an acceleration of magnitude $\frac{5g}{7}$

The balls are modelled as particles moving freely.
The string is modelled as being light and inextensible.
The pulley is modelled as being small and smooth.

Using the model,

(a) find, in terms of $m$ and $g$, the tension in the string,

**(3)**

(b) explain why the acceleration of $Q$ also has magnitude $\frac{5g}{7}$

**(1)**

(c) find the value of $k$.

**(4)**

(d) Identify one limitation of the model that will affect the accuracy of your answer to part (c).

**(1)**