Exam Questions – Forces and motion (Mechanics Chapter 10)

Q1.

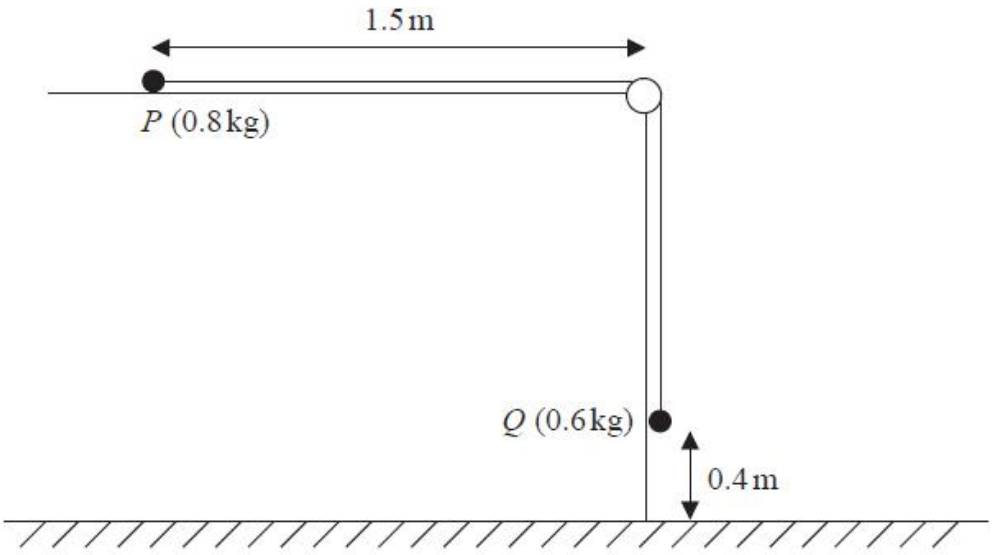

Figure 1

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 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)

(Total for question = 12 marks)

Q2.

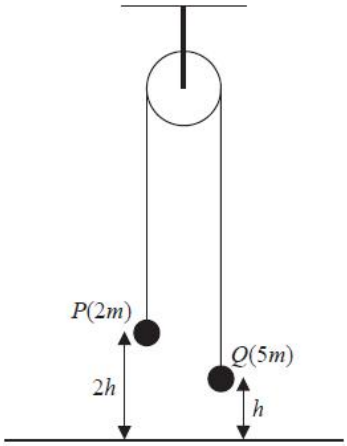

Figure 1

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

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

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 2*h* 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)

(Total for question = 13 marks)

Q3.

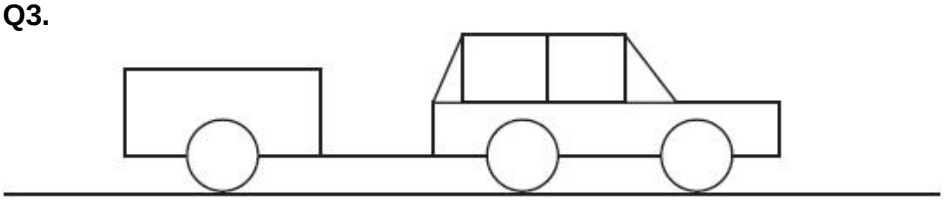

Figure 2

Figure 2 shows a car towing a trailer along a straight horizontal road.

The mass of the car is 800 kg and the mass of the trailer is 600 kg.

The trailer is attached to the car by a towbar which is parallel to the road and parallel to the direction of motion of the car and the trailer.

The towbar is modelled as a light rod.

The resistance to the motion of the car is modelled as a constant force of magnitude 400 N.

The resistance to the motion of the trailer is modelled as a constant force of magnitude R newtons.

The engine of the car is producing a constant driving force that is horizontal and of magnitude 1740 N.

The acceleration of the car is 0.6 ms^{-2} and the tension in the towbar is T newtons.

Using the model,

(a) show that $R = 500$

(3)

(b) find the value of T.

(3)

At the instant when the speed of the car and the trailer is 12.5 ms^{-1} , the towbar breaks.

The trailer moves a further distance d metres before coming to rest.

The resistance to the motion of the trailer is modelled as a constant force of magnitude 500 N.

Using the model,

(c) show that, after the towbar breaks, the deceleration of the trailer is $\frac{5}{6}\,ms^{-2}$

(1)

(d) find the value of d.

(3)

In reality, the distance d metres is likely to be different from the answer found in part (d).

(e) Give two **different** reasons why this is the case.

(2)

(Total for question = 12 marks)

Q4.

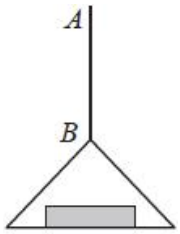

Figure 1

A vertical rope *AB* has its end *B* attached to the top of a scale pan. The scale pan has mass 0.5 kg and carries a brick of mass 1.5 kg, as shown in Figure 1. The scale pan is raised vertically upwards with constant acceleration 0.5 m s^{-2} using the rope *AB*. The rope is modelled as a light inextensible string.

(a) Find the tension in the rope *AB*.

(3)

(b) Find the magnitude of the force exerted on the scale pan by the brick.

(3)

(Total for question = 6 marks)

Q5.

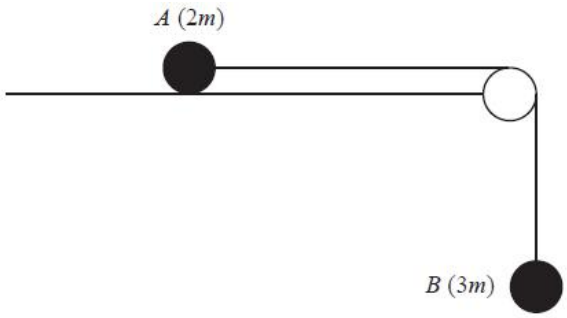

Figure 2

Two particles *A* and *B* have masses 2*m* and 3*m* 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)

(Total 10 marks)

Q6.

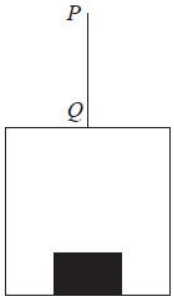

Figure 1

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 ms^{-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)

(Total for question = 6 marks)

Q7.

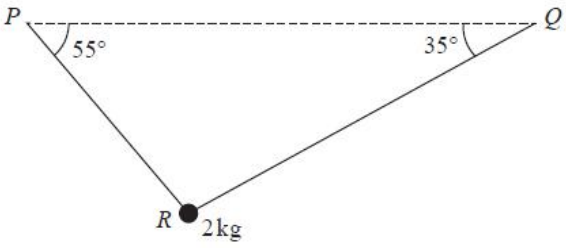

Figure 1

A particle of mass 2 kg is suspended from a horizontal ceiling by two light inextensible strings, *PR* and *QR*. The particle hangs at *R* in equilibrium, with the strings in a vertical plane. The string *PR* is inclined at 55° to the horizontal and the string *QR* is inclined at 35° to the horizontal, as shown in Figure 1.

Find

(i) the tension in the string *PR*,

(ii) the tension in the string *QR*.

(7)

(Total for question = 7 marks)