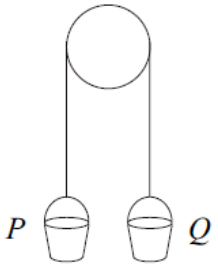
Mechanics 1 Newton's Laws Questions

7 A builder ties two identical buckets, P and Q, to the ends of a light inextensible rope. He hangs the rope over a smooth beam so that the buckets hang in equilibrium, as shown in the diagram.



The buckets are each of mass 0.6 kg.

(a) (i) State the magnitude of the tension in the rope. *(1 mark)*

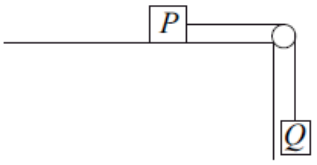
(ii) State the magnitude and direction of the force exerted on the beam by the rope. *(2 marks)*

(b) The bucket Q is held at rest while a stone, of mass 0.2 kg, is placed inside it. The system is then released from rest and, in the subsequent motion, bucket Q moves vertically downwards with the stone inside.

(i) By forming an equation of motion for each bucket, show that the magnitude of the tension in the rope during the motion is 6.72 newtons, correct to three significant figures. *(6 marks)*

(ii) State the magnitude of the force exerted on the beam by the rope while the motion takes place. *(1 mark)*

5 A small block P is attached to another small block Q by a light inextensible string. The block P rests on a rough horizontal surface and the string hangs over a smooth peg so that Q hangs freely, as shown in the diagram.



The block P has mass 0.4 kg and the coefficient of friction between P and the surface is 0.5 .

The block Q has mass 0.3 kg.

The system is released from rest and Q moves vertically downwards.

(a) (i) Draw a diagram to show the forces acting on P. *(1 mark)*

(ii) Show that the frictional force between P and the surface has magnitude 1.96 newtons. *(2 marks)*

(b) By forming an equation of motion for each block, show that the magnitude of the acceleration of each block is $1.4\,\mathrm{m\,s^{-2}}$. *(5 marks)*

(c) Find the speed of the blocks after 3 seconds of motion. *(2 marks)*

(d) After 3 seconds of motion, the string breaks. The blocks continue to move. Comment on how the speed of each block will change in the subsequent motion. For each block, give a reason for your answer. *(4 marks)*

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2 A lift rises vertically from rest with a constant acceleration.

After 4 seconds, it is moving upwards with a velocity of $2\,\mathrm{m\,s^{-1}}$.

It then moves with a constant velocity for 5 seconds.

The lift then slows down uniformly, coming to rest after it has been moving for a total of 12 seconds.

(a) Sketch a velocity–time graph for the motion of the lift. *(4 marks)*

(b) Calculate the total distance travelled by the lift. *(2 marks)*

(c) The lift is raised by a single vertical cable. The mass of the lift is 300 kg. Find the maximum tension in the cable during this motion. *(4 marks)*

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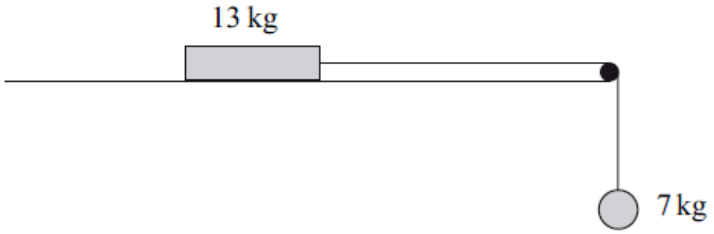
4 The diagram shows a block, of mass 13 kg, on a rough horizontal surface. It is attached by a string that passes over a smooth peg to a sphere of mass 7 kg, as shown in the diagram.



The system is released from rest, and after 4 seconds the block and the sphere both have speed $6\,\text{m}\,\text{s}^{-1}$, and the block has **not** reached the peg.

(a) State **two** assumptions that you should make about the string in order to model the motion of the sphere and the block. *(2 marks)*

(b) Show that the acceleration of the sphere is $1.5\,\text{m}\,\text{s}^{-2}$. *(2 marks)*

(c) Find the tension in the string. *(3 marks)*

(d) Find the coefficient of friction between the block and the surface. *(6 marks)*

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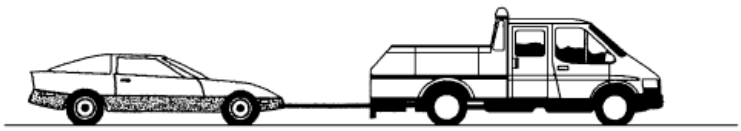
4 A car, of mass 1200 kg, is connected by a tow rope to a truck, of mass 2800 kg. The truck tows the car in a straight line along a horizontal road. Assume that the tow rope is horizontal. A horizontal driving force of magnitude 3000 N acts on the truck. A horizontal resistance force of magnitude 800 N acts on the car. The car and truck accelerate at $0.4\,\text{m}\,\text{s}^{-2}$.



(a) Find the tension in the tow rope. *(3 marks)*

(b) Show that the magnitude of the horizontal resistance force acting on the truck is 600 N. *(4 marks)*

(c) In fact, the tow rope is **not** horizontal. Assume that the resistance forces and the driving force are unchanged.

Is the tension in the tow rope greater or less than in part (a)?

Explain why. *(2 marks)*
