

1. A train travels along a straight horizontal track between two stations A and B .

The train starts from rest at station A and accelerates uniformly for T seconds until it reaches a speed of 20 m s^{-1}

The train then travels at a constant speed of 20 m s^{-1} for 3 minutes before decelerating uniformly until it comes to rest at station B .

The magnitude of the acceleration of the train is twice the magnitude of the deceleration.

- (a) On the axes below, sketch a speed–time graph to illustrate the motion of the train as it moves from station A to station B .



If you need to redraw your graph, use the axes on page 3

(3)

Stations A and B are 4.8 km apart.

- (b) Find the value of T

(5)

- (c) Find the acceleration of the train during the first T seconds of its motion.

(2)



2. Two particles, A and B , are moving in a straight line in opposite directions towards each other on a smooth horizontal surface when they collide directly.

Particle A has mass $3m$ kg and particle B has mass m kg.

Immediately before the collision, both particles have a speed of 1.5 m s^{-1}

Immediately after the collision, the direction of motion of A is unchanged and the difference between the speed of A and speed of B is 1 m s^{-1}

- (a) Find (i) the speed of A immediately after the collision,
(ii) the speed of B immediately after the collision. (5)

- (b) Find, in terms of m , the magnitude of the impulse exerted on B in the collision. (3)

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3. A particle P is moving with constant acceleration $(-4\mathbf{i} + \mathbf{j})\text{ms}^{-2}$

At time $t = 0$, P has velocity $(14\mathbf{i} - 5\mathbf{j})\text{ms}^{-1}$

(a) Find the speed of P at time $t = 2$ seconds.

(3)

(b) Find the size of the angle between the direction of \mathbf{i} and the direction of motion of P at time $t = 2$ seconds.

(3)

At time $t = T$ seconds, P is moving in the direction of vector $(2\mathbf{i} - 3\mathbf{j})$

(c) Find the value of T

(4)

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4.

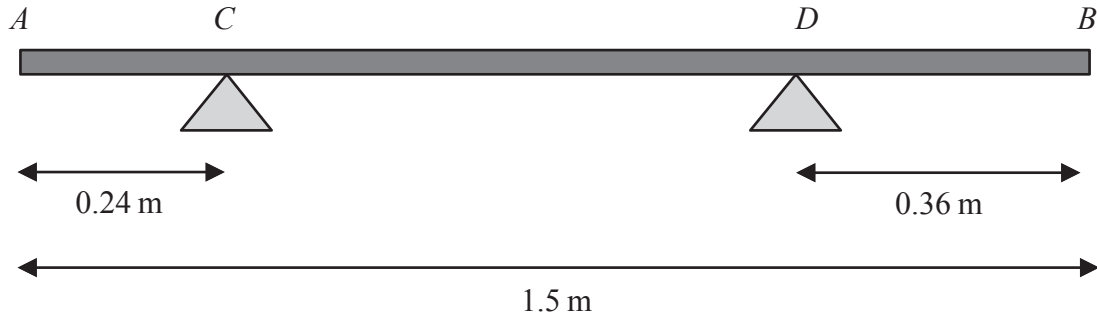


Figure 1

A branch AB , of length 1.5 m , rests horizontally in equilibrium on two supports.

The two supports are at the points C and D , where $AC = 0.24\text{ m}$ and $DB = 0.36\text{ m}$, as shown in Figure 1.

When a force of 150 N is applied vertically upwards at B , the branch is on the point of tilting about C .

When a force of 225 N is applied vertically downwards at B , the branch is on the point of tilting about D .

The branch is modelled as a non-uniform rod AB of weight W newtons.

The distance from the point C to the centre of mass of the rod is x metres.

Use the model to find

- (i) the value of W
- (ii) the value of x

(8)

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5.

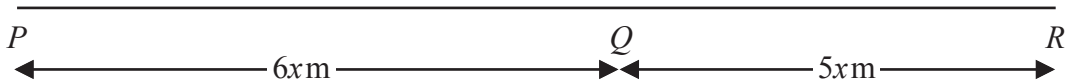


Figure 2

Three points P , Q and R are on a horizontal road where PQR is a straight line.

The point Q is between P and R , with $PQ = 6x$ metres and $QR = 5x$ metres, as shown in Figure 2.

A vehicle moves along the road from P to Q with constant acceleration.

The vehicle is modelled as a particle.

At time $t = 0$, the vehicle passes P with speed $u \text{ m s}^{-1}$

At time $t = 12$ s, the vehicle passes Q with speed $2u \text{ m s}^{-1}$

Using the model,

- (a) show that $x = 3u$ (2)

As the vehicle passes Q , the acceleration of the vehicle changes instantaneously to 1.5 m s^{-2}

The vehicle continues to move with a constant acceleration of 1.5 m s^{-2} and passes R with speed $3u \text{ m s}^{-1}$

Using the model,

- (b) find the value of u , (3)
- (c) find the distance travelled by the vehicle during the first 14 seconds after passing P (4)

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6.

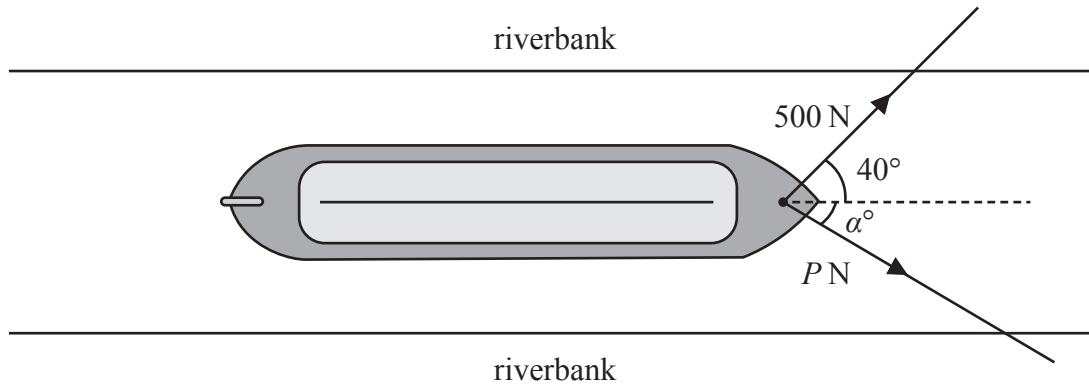


Figure 3

A boat is pulled along a river at a constant speed by two ropes.

The banks of the river are parallel and the boat travels horizontally in a straight line, parallel to the riverbanks.

- The tension in the first rope is 500 N acting at an angle of 40° to the direction of motion, as shown in Figure 3.
- The tension in the second rope is P newtons, acting at an angle of α° to the direction of motion, also shown in Figure 3.
- The resistance to motion of the boat as it moves through the water is a constant force of magnitude 900 N

The boat is modelled as a particle. The ropes are modelled as being light and lying in a horizontal plane.

Use the model to find

- the value of α
- the value of P

(8)

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7.

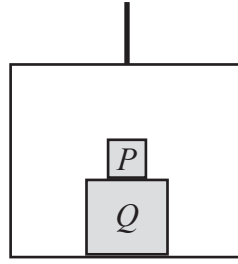


Figure 4

A simple lift operates by means of a vertical cable which is attached to the top of the lift.

The lift has mass m

A box Q is placed on the floor of the lift.

A box P is placed directly on top of box Q , as shown in Figure 4.

The cable is modelled as being light and inextensible and air resistance is modelled as being negligible.

The tension in the cable is $\frac{42mg}{5}$

The lift and its contents move vertically upwards with acceleration $\frac{2g}{5}$

Using the model,

(a) find, in terms of m , the combined mass of boxes P and Q (4)

During the motion of the lift, the force exerted on box P by box Q is $\frac{14mg}{5}$

Using the model,

(b) find, in terms of m , the mass of box P (3)

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8.

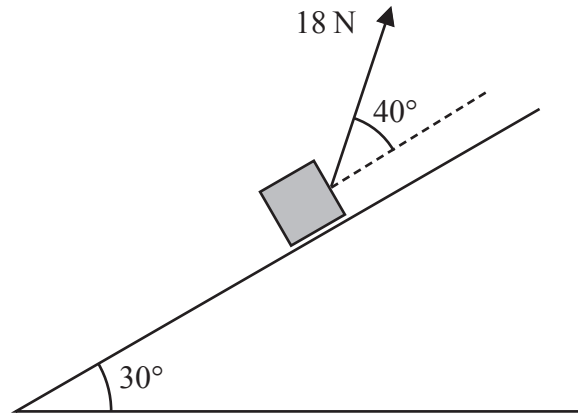


Figure 5

A parcel of mass 2 kg is pulled up a rough inclined plane by the action of a constant force.

The force has magnitude 18 N and acts at an angle of 40° to the plane.

The line of action of the force lies in a vertical plane containing a line of greatest slope of the inclined plane.

The plane is inclined at an angle of 30° to the horizontal, as shown in Figure 5.

The coefficient of friction between the plane and the parcel is 0.3

The parcel is modelled as a particle P

- (a) Find the acceleration of P (8)

The points A and B lie on a line of greatest slope of the plane, where $AB = 5$ m and B is above A . Particle P passes through A with speed 2 m s^{-1} in the direction AB .

- (b) Find the speed of P as it passes through B . (3)

The force of 18 N is removed at the instant P passes through B . As a result, P comes to rest at the point C .

- (c) Determine whether P will remain at rest at C . You must show all stages of your working clearly. (4)

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