

Solutionbank M1

Edexcel AS and A Level Modular Mathematics

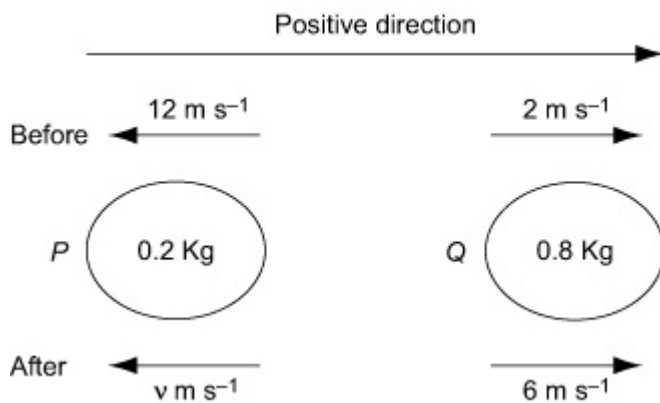
Examination style paper
Exercise A, Question 1

Question:

A particle P of mass 0.2 kg is moving along a straight horizontal line with constant speed 12 m s^{-1} . Another particle Q of mass 0.8 kg is moving in the same direction as P , along the same straight horizontal line, with constant speed 2 m s^{-1} . The particles collide. Immediately after the collision, Q is moving with speed 6 m s^{-1} .

- a** Find the speed of P immediately after the collision.
- b** State whether or not the direction of motion of P is changed by the collision.
- c** Find the magnitude of the impulse exerted on Q in the collision.

Solution:



- a** Conservation of linear momentum

$$0.2 \times 12 + 0.8 \times 2 = 0.2 \times v + 0.8 \times 6$$

$$0.2v = -0.8 \Rightarrow v = -4$$

the speed of P immediately after the collision is 4 m s^{-1}

- b** The direction of motion of P has been changed by the collision.

- c** For Q , $I = 0.8 \times 6 - 0.8 \times 2 = 3.2$

the magnitude of the impulse on Q is 3.2 N s

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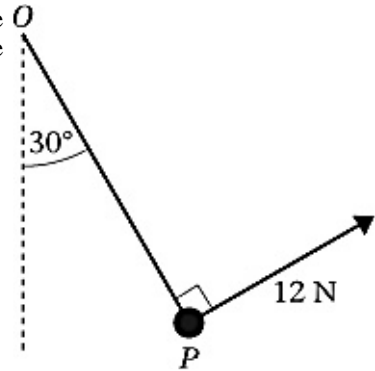
Exercise A, Question 2

Question:

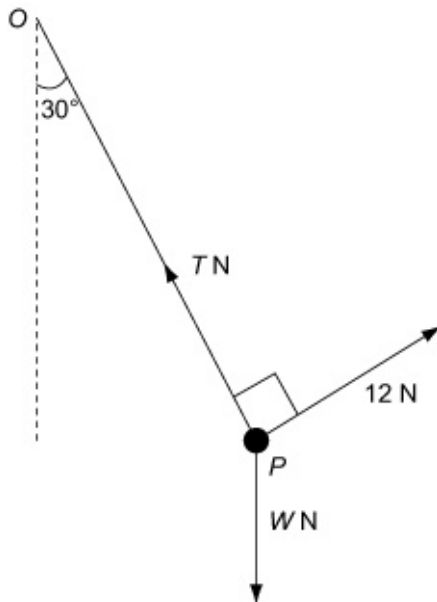
A particle P of weight W newtons is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point O . The string is taut and makes an angle 30° with the vertical. The particle P is held in equilibrium under gravity by a force of magnitude 12 N acting in a direction perpendicular to the string, as shown. Find

a the tension in the string,

b the value of W .



Solution:



$$\mathbf{a} \text{ R (} \rightarrow \text{) } T \cos 60^\circ = 12 \cos 30^\circ$$

$$T = 12\sqrt{3} \text{ (} \approx 20.8 \text{)}$$

the tension in the string is $12\sqrt{3}\text{ N}$

b

$$\begin{aligned} \mathbf{R (} \uparrow \text{) } W &= T \sin 60^\circ + 12 \sin 30^\circ \\ &= 12\sqrt{3} \times \frac{\sqrt{3}}{2} + 12 \times \frac{1}{2} = 24 \end{aligned}$$

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Examination style paper
Exercise A, Question 3

Question:

A car is moving along a straight horizontal road. At time $t = 0$, the car passes a sign A with speed 8 m s^{-1} and this speed is maintained for 6 s. The car then accelerates uniformly from 8 m s^{-1} to 12 m s^{-1} in 9 s. The speed of 12 m s^{-1} is then maintained until the car passes a second sign B . The distance between A and B is 390 m.

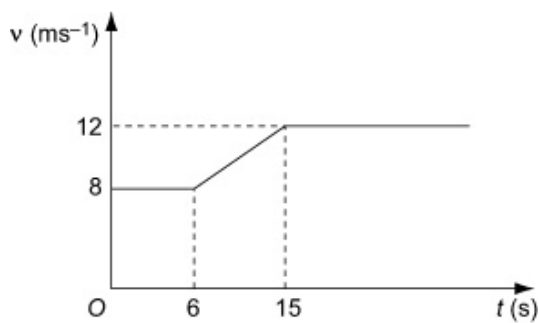
a Sketch a speed-time graph to illustrate the motion of the car as it travels from A to B .

b Find the time the car takes to travel from A to B .

c Sketch a distance-time graph to illustrate the motion of the car as it travels from A to B .

Solution:

a



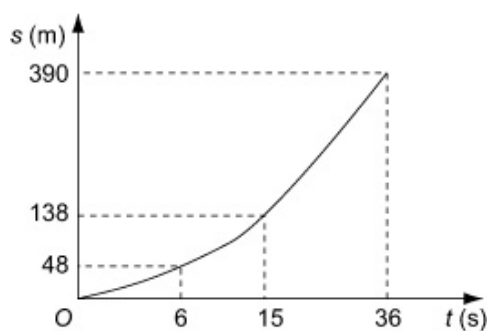
b Let the time travelled at 12 m s^{-1} be T seconds.

$$6 \times 8 + \frac{1}{2} (8 + 12) \times 9 + 12 \times T = 390$$

$$12T = 390 - 48 - 90 = 252 \Rightarrow T = 21$$

the time the car takes to travel from A to B is 36 s

c



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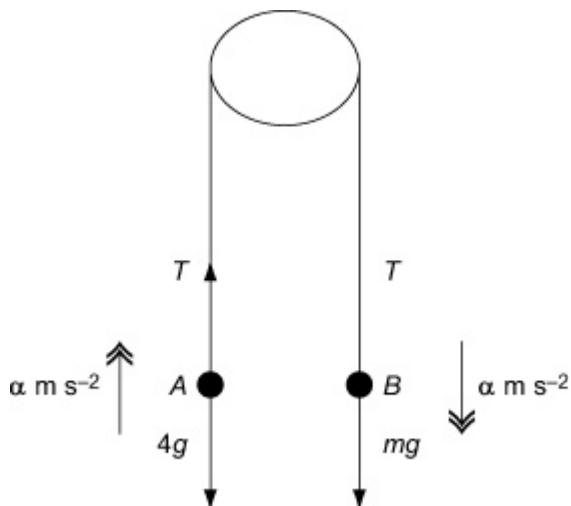
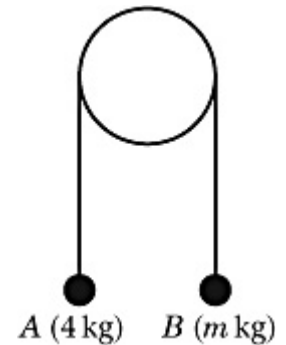
Examination style paper
Exercise A, Question 4

Question:

Two particles A and B are connected by a light inextensible string which passes over a fixed smooth pulley. The mass of A is 4 kg and the mass of B is m , where $m > 4 \text{ kg}$. The system is released from rest with the string taut and the hanging parts of the string vertical, as shown.

After release, the tension in the string is $\frac{1}{4}mg$.

- Find the magnitude of the acceleration of the particles.
- Find the value of m .
- State how you have used the fact that the string is inextensible.



a For B

$$R(\downarrow) \quad mg - T = ma$$

$$\left[mg - \frac{1}{4}mg \right] = [ma]$$

$$a = \frac{3}{4}g$$

the magnitude of the acceleration of the particles is $\frac{3}{4}g$

b For A

$$R(\uparrow) \quad T - 4g = 4a$$

$$\frac{1}{4}m\sqrt{g} - 4\sqrt{g} = 4 \times \frac{3}{4}\sqrt{g}$$

$$m = 28$$

c the accelerations of the particles have the same magnitude.

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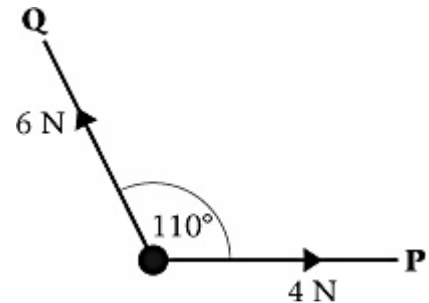
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Examination style paper
Exercise A, Question 5

Question:

A particle of mass 0.8 kg is moving under the action of two forces **P** and **Q**. The force **P** has magnitude 4 N and the force **Q** has magnitude 6 N. The angle between **P** and **Q** is 110° , as shown. The resultant of **P** and **Q** is **F**. Find

- a the angle between the direction of **F** and the direction of **P**.
b the magnitude of the acceleration of the particle.



Solution:

(i)

$$R(\rightarrow) \quad X = 4 - 6 \cos 70^\circ = 1.947879 \dots$$

$$R(\uparrow) \quad Y = 6 \sin 70^\circ = 5.638155 \dots$$

$$\tan \theta = \frac{Y}{X} = 2.89451 \dots$$

$$\theta = 70.9^\circ \quad (3 \text{ s.f.})$$

the angle between the direction of **F** and the direction of **P** is 70.9° (3 s.f.)

(ii)

$$|F|^2 = X^2 + Y^2 = 35.583 \dots$$

$$|F| = \sqrt{35.583 \dots} = 5.96515 \dots$$

$$F = ma$$

$$5.96515 \dots = 0.8a \Rightarrow a = 7.456 \dots$$

the acceleration of **P** is 7.46 m s^{-2} (3 s.f.)

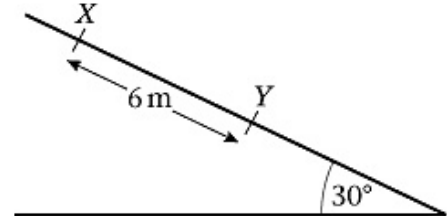
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Examination style paper
Exercise A, Question 6

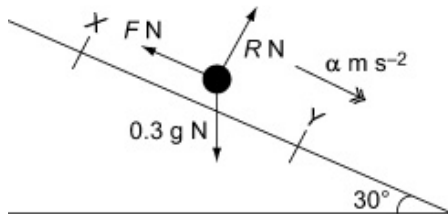
Question:

A small stone, S , of mass 0.3 kg , slides with constant acceleration down a line of greatest slope of a rough plane, which is inclined at 30° to the horizontal. The stone passes through a point X with speed 1.5 m s^{-1} . Three seconds later it passes through a point Y , where $XY = 6 \text{ m}$, as shown. Find.



- a the acceleration of S ,
- b the magnitude of the normal reaction of the plane on S ,
- c the coefficient of friction between S and the plane.

Solution:



$$\mathbf{a} \quad u = 1.5, t = 3, s = 6, a = ?$$

$$s = ut + \frac{1}{2}at^2$$

$$6 = 1.5 \times 3 + \frac{1}{2}a \times 9$$

$$1.5 = 4.5a \Rightarrow a = \frac{1}{3}$$

the acceleration of S is $\frac{1}{3} \text{ m s}^{-2}$

$$\mathbf{b} \quad R (\uparrow) \quad R = 0.3g \cos 30^\circ = 2.546 \dots$$

the magnitude of the normal reaction of the plane on S is 2.5 N (2 s.f.)

$$\mathbf{c} \quad \text{Friction is limiting } F = \mu R = \mu \times 0.3g \cos 30^\circ$$

$$R (\searrow) \quad 0.3g \sin 30^\circ - \mu 0.3g \cos 30^\circ = 0.3 \times \frac{1}{3}$$

$$\mu = \frac{g \sin 30^\circ - \frac{1}{3}}{g \cos 30^\circ} = 0.538 \dots$$

The coefficient of friction between S and the plane is 0.54 (2 s.f.)

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Examination style paper
Exercise A, Question 7

Question:

In this question the unit vectors \mathbf{i} and \mathbf{j} are due east and north respectively and position vectors are given with respect to a fixed origin O .

A ship S is moving with constant velocity $(2\mathbf{i}-3\mathbf{j})$ km h⁻¹ and a ship R is moving with constant velocity $6\mathbf{i}$ km h⁻¹.

a Find the bearing along which S is moving.

At noon S is at the point with position vector $8\mathbf{i}$ km and R is at O . At time t hours after noon, the position vectors of S and T are \mathbf{s} km and \mathbf{r} km respectively.

b Find \mathbf{s} and \mathbf{r} , in terms of t .

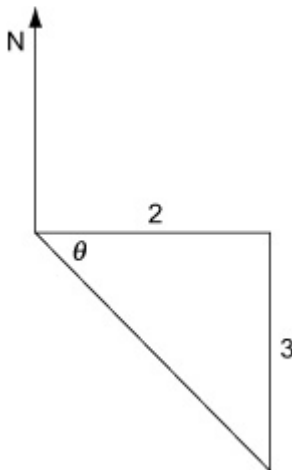
At time T hours, R is due north-east of S . Find

c the value of T ,

d the distance between S and R at time T hours.

Solution:

a



$$\tan\theta = \frac{3}{2} \Rightarrow \theta \approx 56.3^\circ$$

the bearing along which S is moving is 146

b

$$\mathbf{s} = 8\mathbf{i} + (2\mathbf{i} - 3\mathbf{j})t$$

$$\mathbf{r} = 6t\mathbf{i}$$

c At time $t = T$, $\mathbf{r} - \mathbf{s} = (4T - 8)\mathbf{i} + 3T\mathbf{j}$

If S is north-east of R ,

$$\frac{3T}{4T - 8} = 1 \Rightarrow T = 8$$

d When $T = 8$

$$r - s = 24i + 24j$$

$$SR^2 = 24^2 + 24^2 \Rightarrow SR = 24\sqrt{2}$$

The distance between S and R is $24\sqrt{2}$ km.

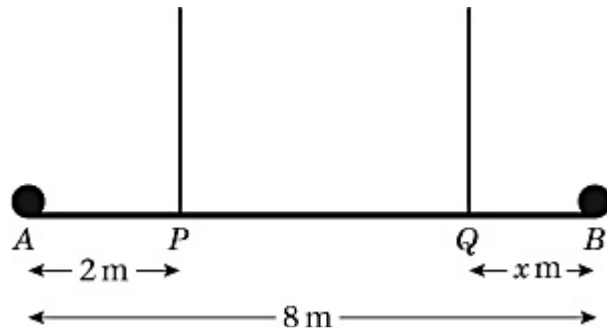
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Examination style paper
Exercise A, Question 8

Question:



A uniform steel girder AB has length 8 m and weight 400 N. A load of weight 200 N is attached to the girder at A and a load of weight W newtons is attached to the girder at B . The girder and the loads hang in equilibrium, with the girder horizontal. The girder is held in equilibrium by two cables attached to the girder at P and Q , where $AP = 2$ m and $QB = x$ m, as shown. The girder is modelled as a uniform rod, the loads as particles and the cables as light inextensible strings.

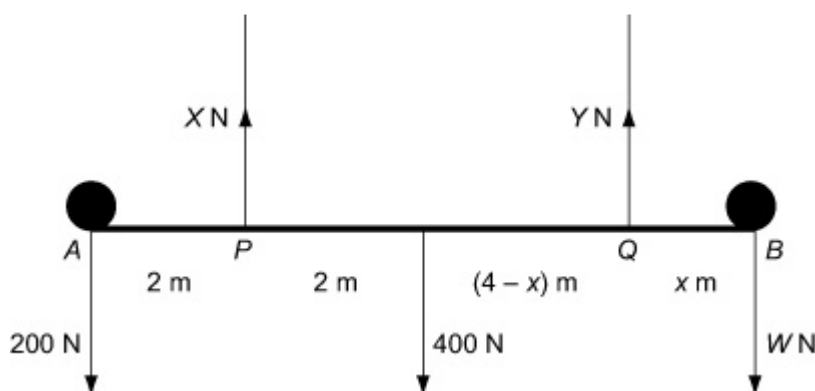
a Show that the tension in the cable at Q is $\left(\frac{400 + 6W}{6 - x} \right)$ N.

Given that the tension in the cable attached at P is five times the tension in the cable attached to Q ,

b find W in terms of x ,

c deduce that $x < 2$.

Solution:



a

$$\begin{aligned} M(P) \quad Y(6-x) + 200 \times 2 &= 400 \times 2 + W \times 6 \\ Y(6-x) &= 800 - 400 + 6W \end{aligned}$$

$$Y = \frac{400 + 6W}{6 - x}$$

the tension in the cable at Q is $\left(\frac{400 + 6W}{6 - x} \right)$ N

b

$$\begin{aligned} R(\uparrow) \quad X + Y &= 600 + W \\ X &= 600 + W - \frac{400 + 6W}{6 - x} \\ &= \frac{3200 - 600x - Wx}{6 - x} \end{aligned}$$

$$\begin{aligned} X = 5Y &\Rightarrow 3200 - 600x - Wx = 5(400 + 6W) \\ 1200 - 600x &= (30 + x)W \\ W &= \frac{600(2 - x)}{30 + x} \end{aligned}$$

$$\mathbf{c} \quad W \geq 0 \Rightarrow x \geq 2$$

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