Solutionbank M1
Edexcel AS and A Level Modular Mathematics

Examination style paper
Exercise A, Question 1

Question:

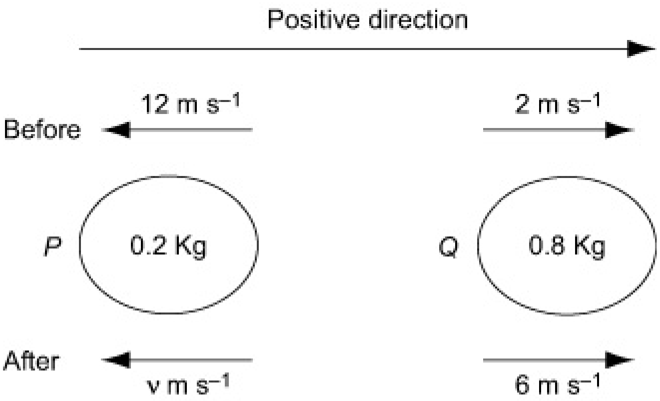
A particle P of mass 0.2 kg is moving along a straight horizontal line with constant speed 12 m s^{-1}. Another particle Q of mass 0.8 kg is moving in the same direction as P, along the same straight horizontal line, with constant speed 2m s^{-1}. The particles collide. Immediately after the collision,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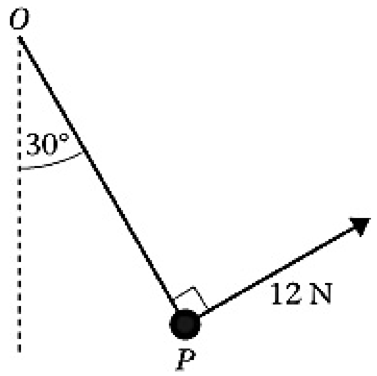
Exercise A, Question 2

Question:

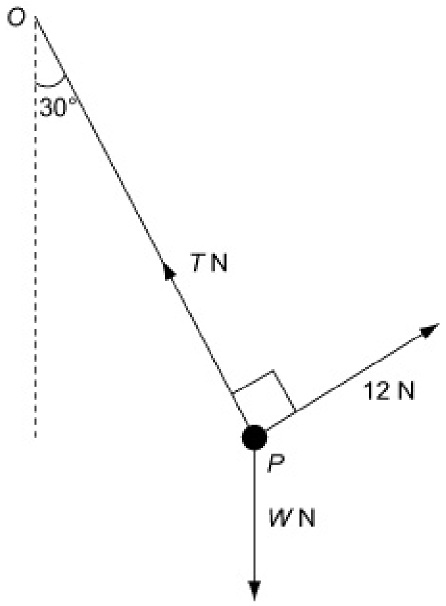
A particle P of weight W newtons is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point O. The string is taut and makes an angle 30° with the vertical. The particle P is held in equilibrium under gravity by a force of magnitude 12 N acting in a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



a the tension in the string,

b the value of W.

Solution:



a R (→) $T\cos 60° = 12\cos 30°$

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

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

b

R (↑) $W = T\sin 60° + 12\sin 30°$

$$= 12\sqrt{3} \times \frac{\sqrt{3}}{2} + 12 \times \frac{1}{2} = 24$$

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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.

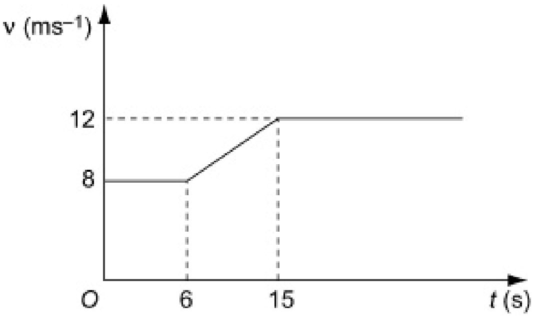
a Sketch a speed-time graph to illustrate the motion of the car as it travels from *A* to *B*.

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



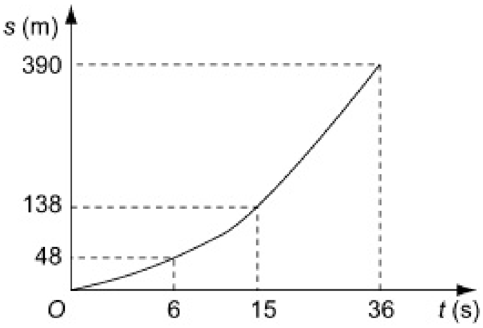
b Let the time travelled at 12 m s^{-1} be T seconds.

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

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

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

c



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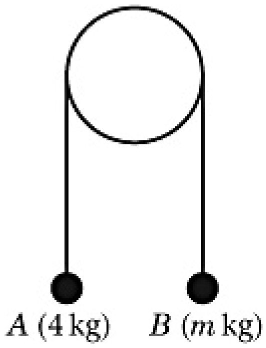
Exercise A, Question 4

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 $m > 4kg$. The system is released from rest with the string taut and the hanging parts of the string vertical, as shown.



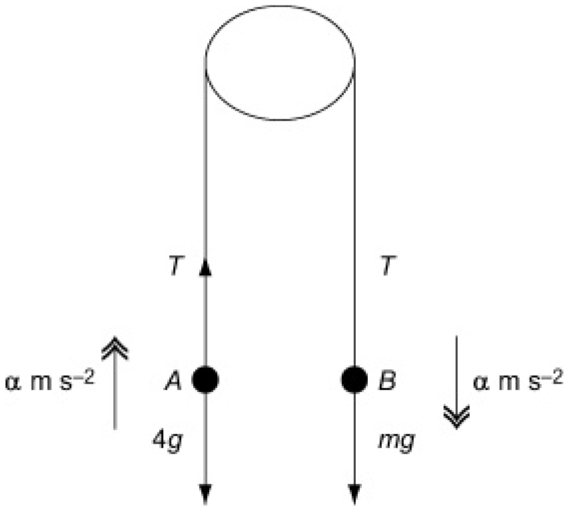
After release, the tension in the string is $\frac{1}{4}mg$.

a Find the magnitude of the acceleration of the particles.

b Find the value of m.

c State how you have used the fact that the string is inextensible.

Solution:



a For B

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

$$\cancel{m}g - \frac{1}{4}\cancel{m}g = \cancel{m}a$$

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

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

b For A

R (↑) $T - 4g = 4a$

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

$m = 28$

c the accelerations of the particles have the same magnitude.

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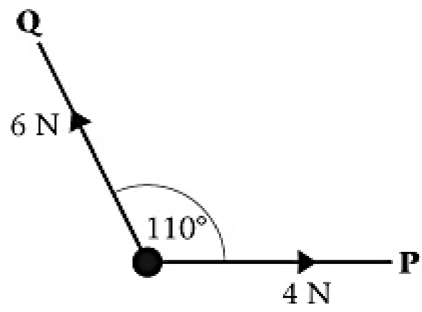
Examination style paper
Exercise A, Question 5

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 (→) $X = 4 - 6\cos 70° = 1.947879\ldots$
R (↑) $Y = 6\sin 70° = 5.638155\ldots$

$\tan\theta = \frac{Y}{X} = 2.89451\ldots$
$\theta = 70.9°$ (3 s.f.)

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

(ii)

$|F|^2 = X^2 + Y^2 = 35.583\ldots$
$F = |F| = \sqrt{35.583\ldots} = 5.96515\ldots$
$F = ma$

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

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

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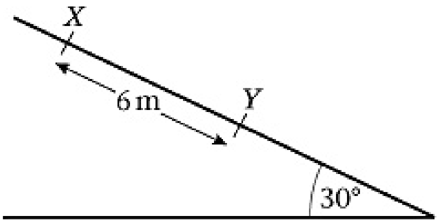
Examination style paper
Exercise A, Question 6

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 m, as shown. Find.

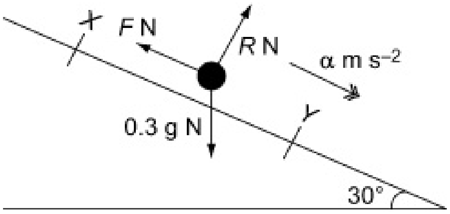


a the acceleration of *S*,

b the magnitude of the normal reaction of the plane on *S*,

c the coefficient of friction between *S* and the plane.

Solution:



a $u = 1.5, t = 3, s = 6, a = \ ?$

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

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

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

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

b R (↑) $R = 0.3g \cos 30° = 2.546 \ldots$

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

c Friction is limiting $F = \mu R = \mu \times 0.3g \cos 30°$

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

$$\mu = \frac{g \sin 30° - \frac{1}{3}}{g \cos 30°} = 0.538 \ldots$$

The coefficient of friction between *S* and the planeis 0.54 (2 s.f.)

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Examination style paper
Exercise A, Question 7

Question:

In this question the unit vectors **i** *and* **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 **s** km and **r** km respectively.

b Find **s** and **r**, in terms of t.

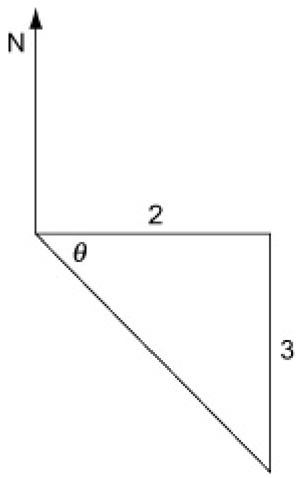
At time T hours, R is due north-east of S. Find

c the value of T,

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

Solution:

a



$\tan\theta = \frac{3}{2} \Rightarrow \theta \approx 56.3\,°$

the bearing along which S is moving is 146

b

$s = 8i + (2i - 3j)\,t$
$r = 6ti$

c At time $t = T$, $r - s = (4T - 8)\,i + 3Tj$

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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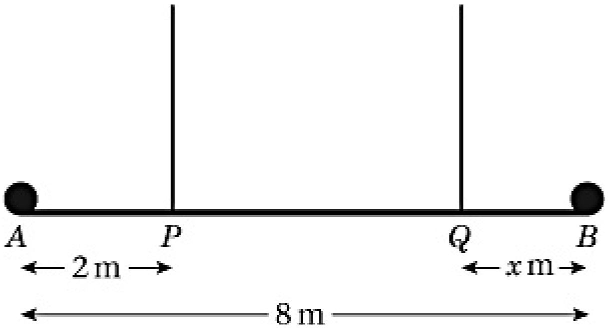
Examination style paper
Exercise A, Question 8

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.

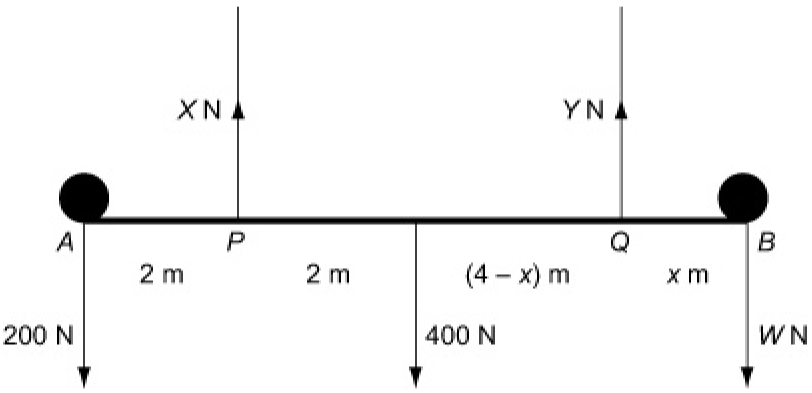
a Show that the tension in the cable at Q is $\left(\frac{400 + 6W}{6 - x} \right)$ N.

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

$$M(P) \quad Y(6 - x) + 200 \times 2 = 400 \times 2 + W \times 6$$
$$Y(6 - x) = 800 - 400 + 6W$$

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

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

b

$$\text{R}(\uparrow) \quad X + Y = 600 + W$$

$$X = 600 + W - \frac{400 + 6W}{6 - x}$$

$$= \frac{3200 - 600x - wx}{6 - x}$$

$$X = 5Y \Rightarrow 3200 - 600x - Wx = 5(400 + 6W)$$

$$1200 - 600x = (30 + x)W$$

$$W = \frac{600(2 - x)}{30 + x}$$

c W □ ≥ □ 0 □ ⇒ □ x □ ≥ □ 2