

APOLLO

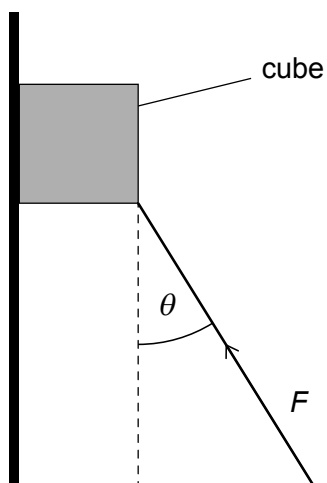
Forces and momentum SL

Physics

First assessment 2025

22 questions | questions

3. A force acts on a cube of mass m that accelerates upwards along a vertical frictionless surface. The magnitude of the force is F and it acts at θ to the vertical.



What is the magnitude of the acceleration of the cube?

- A. $\frac{(F \cos \theta - mg)}{m}$
- B. $\frac{(F \sin \theta - mg)}{m}$
- C. $\frac{(F \cos \theta - g)}{m}$
- D. $\frac{(F \sin \theta - g)}{m}$

4. A sphere of density ρ and radius R rests on the bottom of a tank of water. The buoyancy force on the sphere is F_1 .

A sphere of density 2ρ and radius $\frac{R}{2}$ is at the bottom of the same tank. The buoyancy force on the second sphere is F_2 .

What is $\frac{F_1}{F_2}$?

- A. 2
- B. 4
- C. 8
- D. 16

— T —

Turn over
4425-0710

6. An object of mass 5.0 kg is initially at rest. An impulse of 2.0 N s acts on the object.

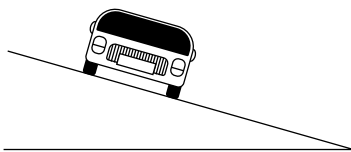
What is the final kinetic energy of the object?

- A. 0.40 J
- B. 10 J
- C. 20 J
- D. 40 J

— 3 —

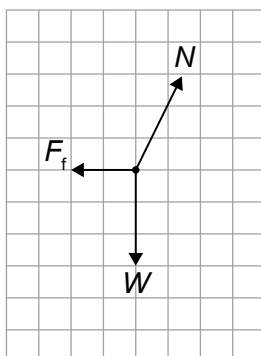
2225-0710

4. A car of weight W is travelling at maximum speed in a circular path along a horizontal banked road. The surface exerts a normal force N and a friction force F_f .

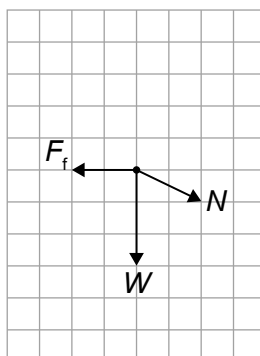


What is the correct free-body diagram for the car?

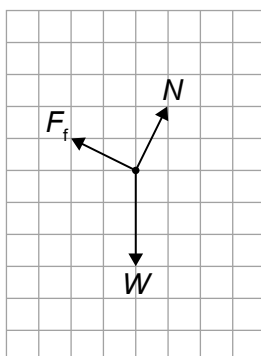
A.



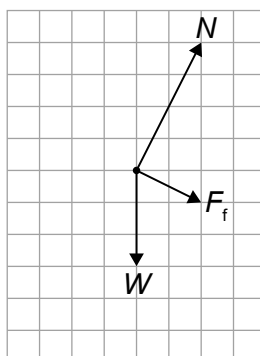
B.



C.



D.



5. Sphere X falls through a fluid with terminal velocity v . Sphere Y is made of the same material and falls through the same fluid. The radius of sphere Y is double that of sphere X.

What is the terminal velocity of sphere Y?

- A. $\frac{v}{2}$
- B. v
- C. $2v$
- D. $4v$

— 3 —

2225-0710

3. Two identical blocks, X and Y, each of mass 2.0 kg are connected by a string. They move on the same surface.

A force F accelerates the blocks at 0.5 m s^{-2} . The frictional force on block X is 4.0 N .



What is the tension in the string?

- A. 1 N
- B. 2 N
- C. 5 N
- D. 10 N

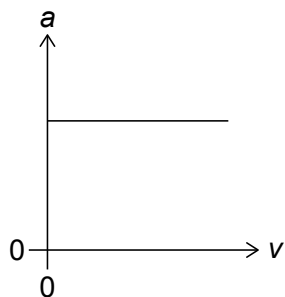
— 3 —

2225-0122

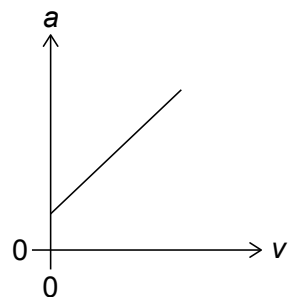
4. A raindrop falls from rest through air with velocity v and acceleration a .

Which graph best represents the variation of a with v ?

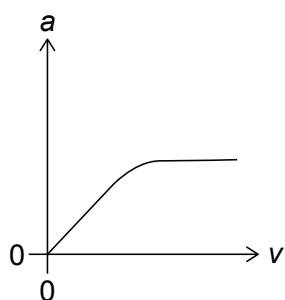
A.



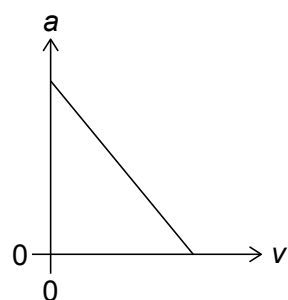
B.



C.



D.



5. A ball of mass m collides with a stationary ball of mass $3m$. After colliding, the two balls move together.

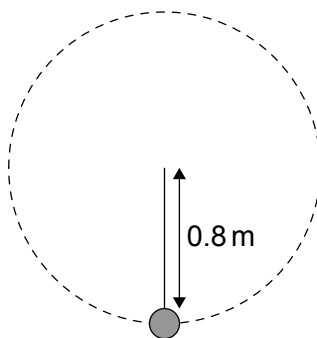
What is the percentage loss in kinetic energy of the system?

- A. 0 %
- B. 25 %
- C. 50 %
- D. 75 %

— T —

Turn over
4445-0144

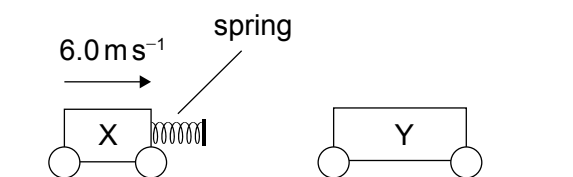
6. A ball of mass 0.4 kg is attached to a string of length 0.8 m . The ball is rotated in a vertical circle such that the speed at the lowest position is 6.0 m s^{-1} .



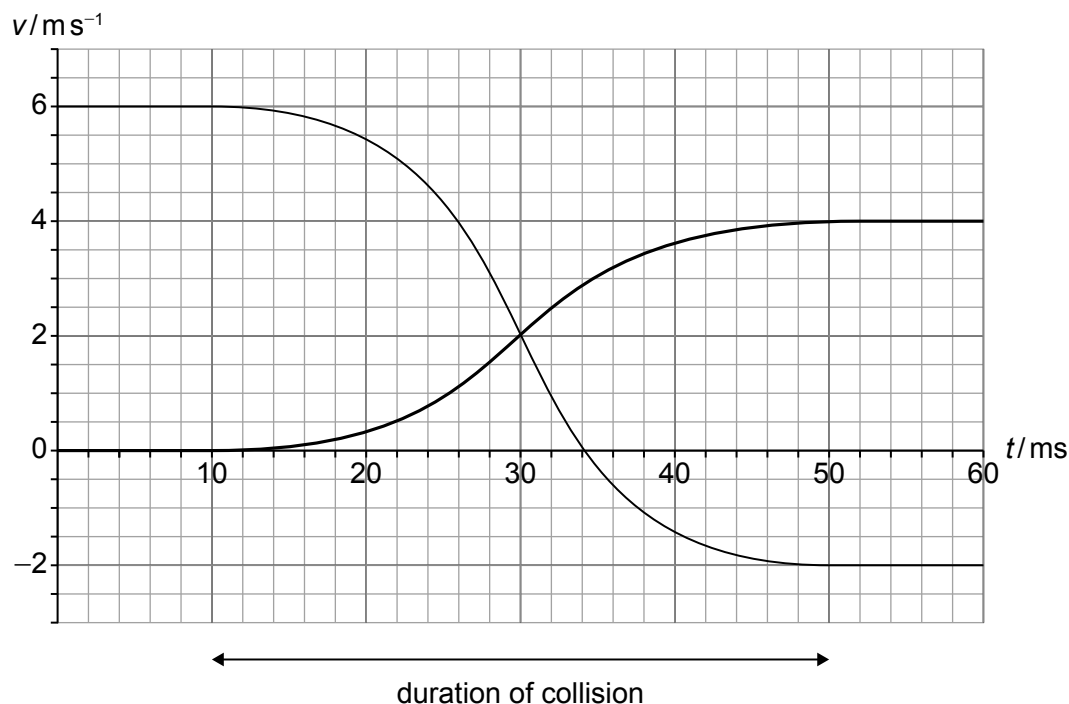
What is the tension in the string when the ball is at the lowest position?

- A. 4.0 N
- B. 14 N
- C. 18 N
- D. 22 N

1. A cart X of mass 3.0 kg moving at 6.0 ms^{-1} collides with a stationary cart Y of mass 6.0 kg . A spring is attached to X as shown.



The graph shows the velocities of X and Y before, during and after the collision.



The collision lasted for 40 ms.

- (a) Show that the collision is elastic.

[2]

.....

.....

.....

.....

(This question continues on the following page)



(Question 1 continued)

(b) Determine

(i) the magnitude of the average force exerted on Y, [2]

.....

.....

.....

.....

(ii) the average power delivered to Y, [2]

.....

.....

.....

.....

(iii) the elastic energy stored in the spring at $t = 30\text{ ms}$. [2]

.....

.....

.....

.....



Turn over

— T —

4425-0110

1. A box of mass 1.2 kg is lying at rest on a surface. The coefficient of static friction between the box and the surface is 0.36 and the coefficient of dynamic friction between the box and the surface is 0.28 .

(a) Outline why the coefficients of friction have no units.

[1]

.....

.....

(b) Show that the minimum force needed to accelerate the box is about 4 N .

[2]

.....

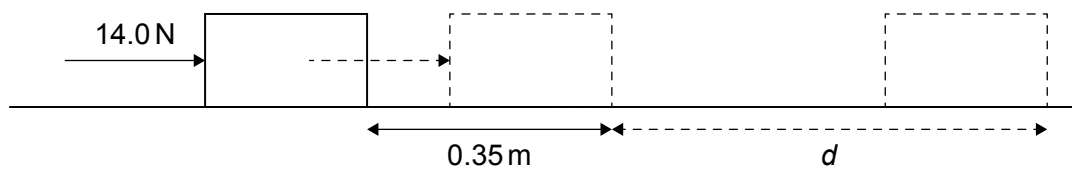
.....

.....

.....

A force of 14.0 N acts on the box for 0.35 m as shown. The force is then removed and the box continues to move. The box comes to rest after a further displacement d .

diagram not to scale



(c) Determine d .

[3]

.....

.....

.....

.....

.....

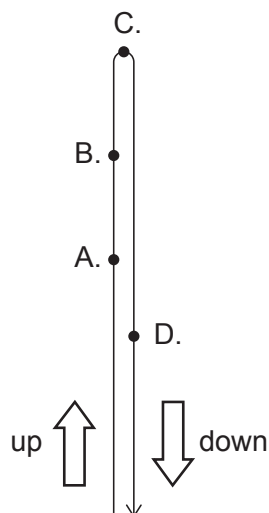
.....



— T —

Turn over
4445-0147

3. A ball is thrown vertically upwards. Air resistance is **not** negligible. Four positions of the ball are shown: A and B on the way up, C at the maximum height, and D on the way down. At which position does the acceleration of the ball have its greatest magnitude?



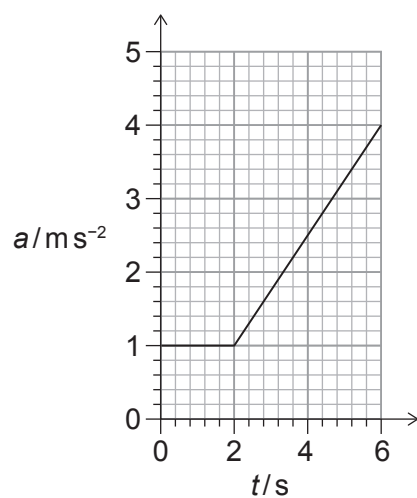
4. Cart X, of mass 2 kg, is moving at a speed of 3 m s^{-1} to the right and collides on a horizontal track with cart Y of mass 1 kg. Y is initially stationary.



The velocity of Y immediately after the collision is 4 m s^{-1} to the right. What is the velocity of X immediately after the collision?

- A. 1 m s^{-1} to the right
- B. 1 m s^{-1} to the left
- C. 2 m s^{-1} to the right
- D. 2 m s^{-1} to the left

3. A force is applied to a mass of 3 kg. The graph shows the variation with time t of the acceleration a of the mass.



What is the average force acting on the mass?

- A. 5 N
- B. 6 N
- C. 12 N
- D. 24 N

— 5 —

0020-0122

4. An object of mass m , moving with a speed v , collides with a stationary object of mass m . The objects stick together.

What is the change in kinetic energy in the collision?

A. Zero

B. $\frac{mv^2}{8}$

C. $\frac{mv^2}{4}$

D. $\frac{3mv^2}{8}$

1. A group of students is trying to determine the density and the viscosity of a liquid.

To determine the density, they use a balance to read the mass m of a sphere in air and immersed in the liquid.

They use a sphere of volume $V = 1.827 \times 10^{-7} \text{ m}^3$.

The readings are $m_{\text{air}} = 1.427 \text{ g}$ in air and $m_{\text{immersed}} = 1.208 \text{ g}$ in the liquid.

The readings are different due to buoyancy. The buoyancy force F_b is given by

$$F_b = \rho V g,$$

where V is the volume of the sphere and ρ is the density of the liquid.

- (a) State the level of precision in the measurement of m . [1]

.....

- (b) Show that F_b is about 2 mN. [1]

.....

- (c) Calculate the density of the liquid. [2]

.....

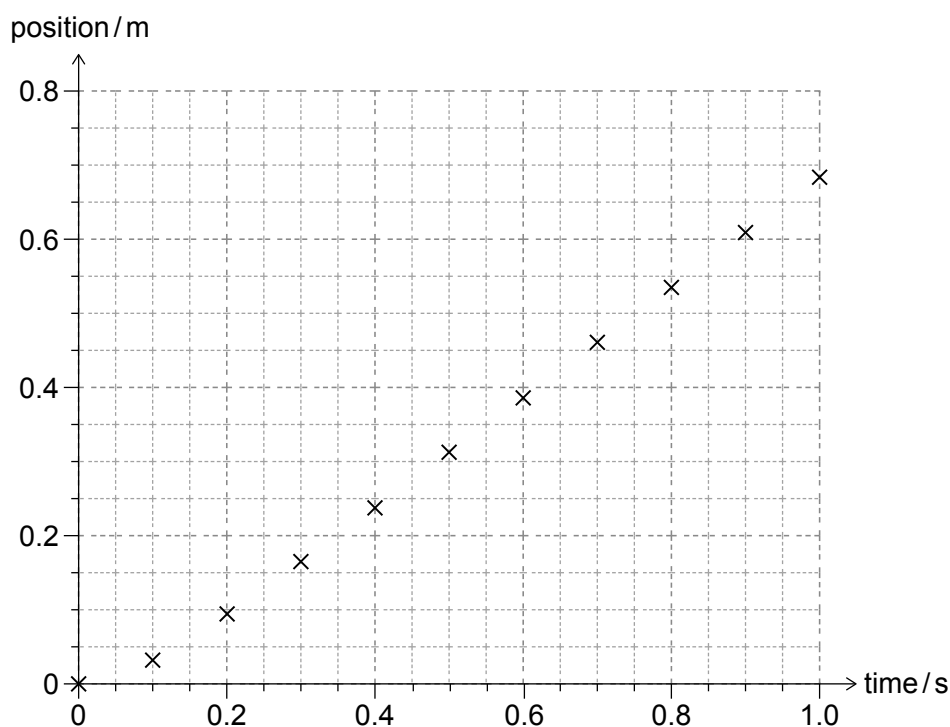
(This question continues on the following page)



(Question 1 continued)

To determine the viscosity, they immerse the sphere in the liquid and drop it from rest.

They collect values and plot a graph of the position d of the sphere from the moment they drop it. They verify that the sphere reaches terminal velocity v_t after 0.5 s.



(d) Draw the line of best fit on the graph.

[2]

(e) Outline how the students may verify that the sphere reaches terminal velocity.

[1]

.....

(This question continues on page 5)



Turn over

— T —

0025-0125

Please **do not** write on this page.

Answers written on this page
will not be marked.



(Question 1 continued)

They repeat the experiment several times and estimate an average for

$$v_t = (0.71 \pm 0.05) \text{ m s}^{-1}.$$

They use the equation

$$\eta = \frac{m_{\text{air}}g - \rho Vg}{6\pi r v_t},$$

where

r = radius of the sphere,

v_t = terminal velocity of the sphere,

η = viscosity of the liquid.

The radius r of the sphere is 3.520 mm.

- (f) Calculate the viscosity of the liquid and its absolute uncertainty. Ignore uncertainties in the mass, radius and volume of the sphere. Give your answer in the form $\eta \pm \Delta\eta$, to an appropriate number of significant figures, including units.

[4]

.....

.....

.....

.....

.....

.....

.....

The students search literature values and find the viscosity of this liquid to be 0.24, when expressed in SI base units.

- (g) Suggest a conclusion reached by the students.

[1]

.....

.....

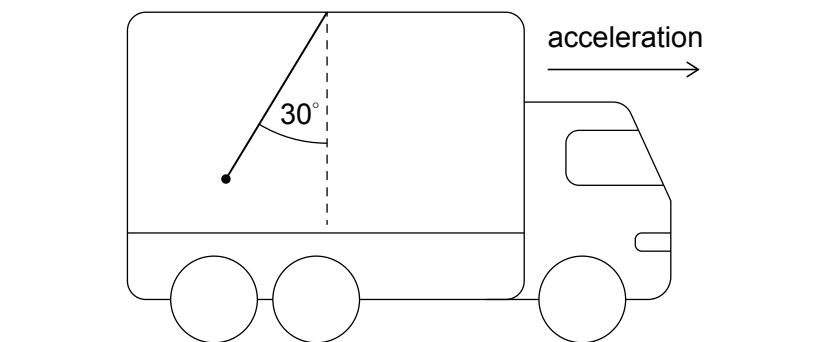


Turn over



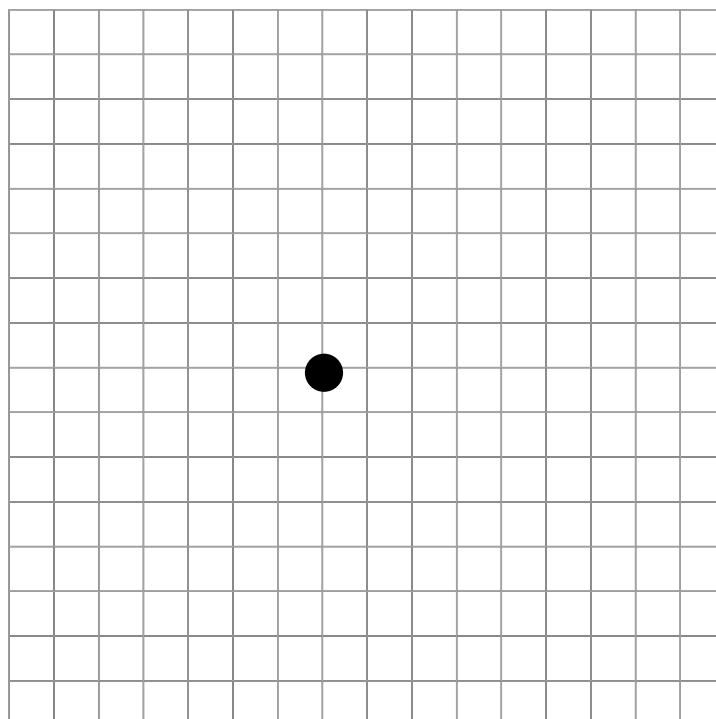
0020-0720

2. A ball is connected to a string that is attached to the ceiling of a truck. The truck accelerates to the right on a horizontal road. The string makes an angle of 30° with the vertical.



- (a) (i) Draw a labelled free-body diagram of the forces on the ball.

[2]



(This question continues on the following page)



(Question 2 continued)

(ii) Determine the acceleration of the truck. [2]

.....

.....

.....

.....

(b) The truck now moves at **constant** speed up an incline that makes an angle of 10° to the horizontal. State and explain the angle between the string and the vertical. [2]

.....

.....

.....

.....

(This question continues on page 7)



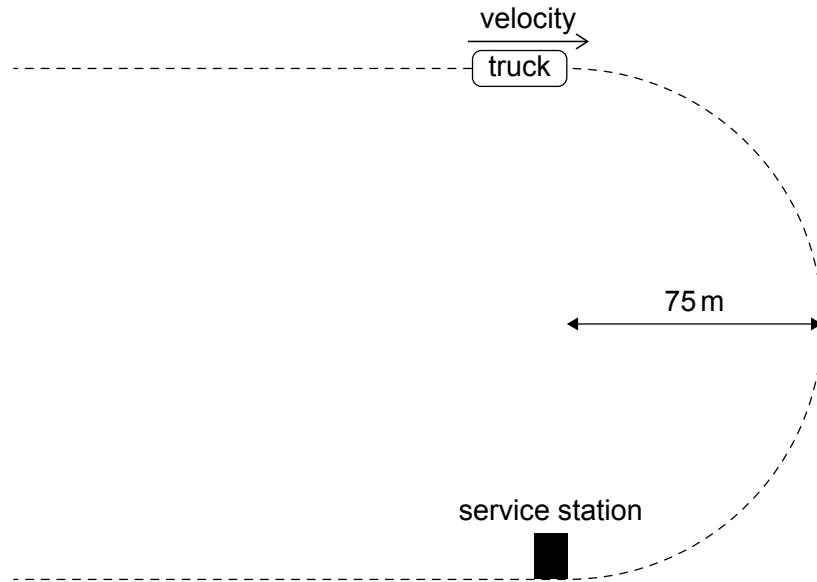
Turn over

Please **do not** write on this page.
 Answers written on this page
 will not be marked.



(Question 2 continued)

On another occasion, the truck enters a horizontal semicircular road of radius of 75 m. The coefficient of static friction between the road and the tyres is 0.60.



- (c) Calculate the maximum speed at which the truck can travel on this road. [2]

.....

.....

.....

.....

- (d) The truck runs out of fuel just as it enters the semicircle with speed 15 m s^{-1} . The resultant force opposing the motion has magnitude 520 N. The mass of the truck is 1400 kg. A service station is at the other end of the semicircle.

Determine whether the truck will be able to reach the service station. [3]

.....

.....

.....

.....

.....

.....



Turn over

— 5 —

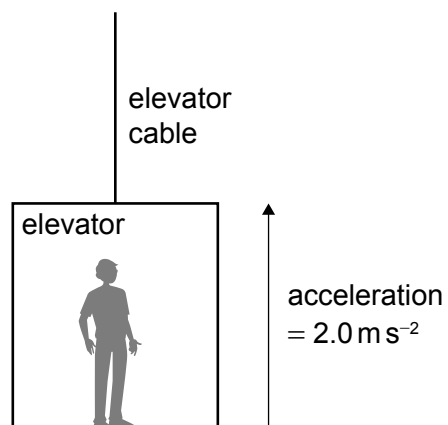
0020-0124

- 2.** A block of mass 2.0 kg accelerates from a speed of 15 m s^{-1} to a speed of 20 m s^{-1} without changing its direction.

What impulse acts on the block?

- A. 2.5 N s
- B. 5.0 N s
- C. 10 N s
- D. 17.5 N s

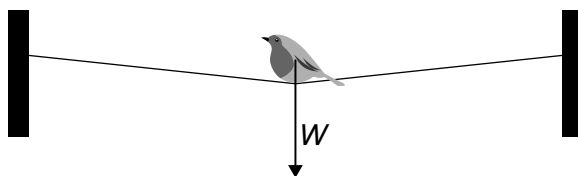
4. A person stands in an elevator (lift). The total mass of the person and the elevator is 800 kg. The elevator accelerates upward at 2.0 m s^{-2} .



What is the tension in the cable?

- A. 1.6 kN
- B. 6.4 kN
- C. 8.0 kN
- D. 9.6 kN

6. A bird of weight W sits on a thin rope at its midpoint. The rope is almost horizontal and has negligible mass.

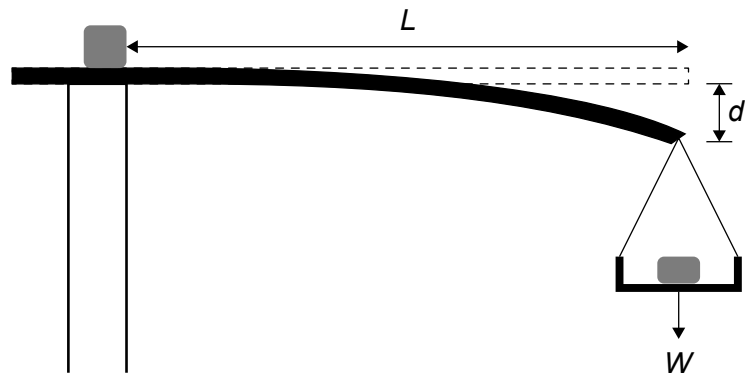


The tension in the rope is

- A. less than $\frac{W}{2}$
- B. equal to $\frac{W}{2}$
- C. between $\frac{W}{2}$ and W
- D. greater than W

2. A group of students investigate the bending of a plastic ruler that is clamped horizontally at one end. A weight W attached to the other end causes the ruler to bend. The weight is contained in a scale pan.

The students fix the length L of the ruler and vary W . For each value of W , the group measures the deflection d of the end of the ruler to which the weight is attached.



- (a) The group obtains the following repeated readings for d for **one** value of W .

Reading	1	2	3	4	5	6
d / cm	2.7	2.9	3.6	2.7	2.8	2.9

The group divides into two subgroups, A and B, to analyse the data.

Group A quotes the mean value of d as 2.93 cm.

Group B quotes the mean value of d as 2.8 cm.

Discuss the values that the groups have quoted.

[2]

.....

.....

.....

.....

.....

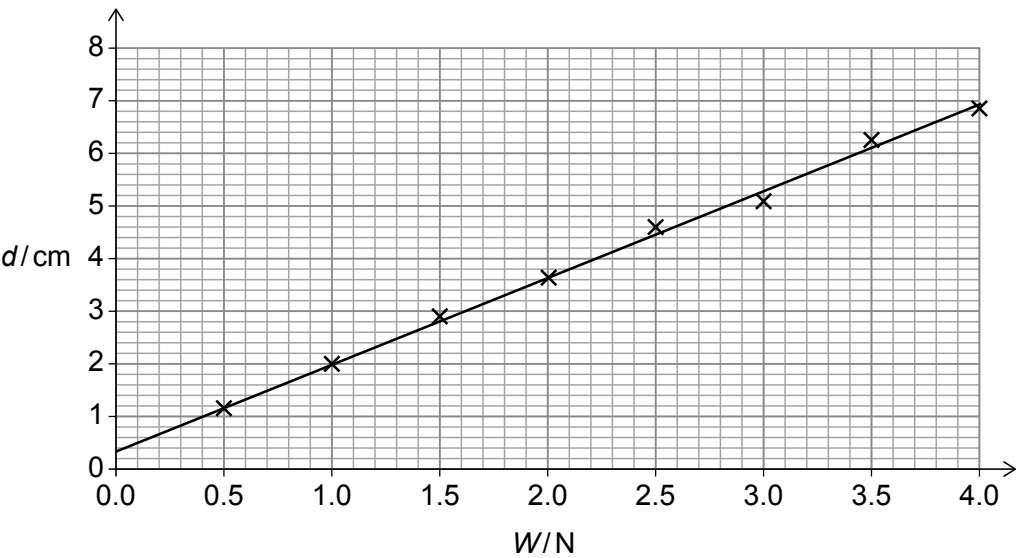
.....

(This question continues on the following page)



(Question 2 continued)

(b) The variation of d with W is shown.



Outline **one** experimental reason why the graph does not go through the origin. [1]

(c) Theory predicts that

$$d \propto \frac{W^x L^y}{EI}$$

where E and I are constants. The fundamental units of I are m^4 and those of E are $\text{kg m}^{-1} \text{s}^{-2}$.

Calculate x and y . [2]

(This question continues on the following page)



Turn over

(Question 2 continued)

(d) The ruler has cross-sectional area $A = a \times b$, where $a = (28 \pm 1)\text{ mm}$ and $b = (3.00 \pm 0.05)\text{ mm}$.

(i) Suggest an appropriate measuring instrument for determining b . [1]

.....

(ii) Calculate the percentage uncertainty in the value of A . [2]

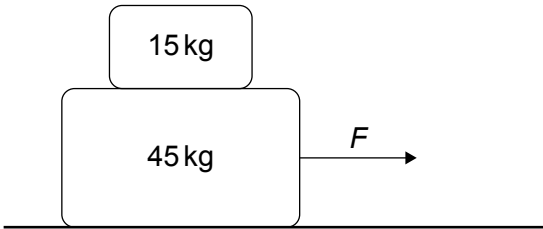
.....



- A block of mass 45 kg is placed on a horizontal table. There is no friction between the block and the table.

An object of mass 15 kg is placed on top of the block.

A force F acts on the block so that it accelerates. The acceleration of the object and the acceleration of the block are the same so that they do not move relative to each other.



The coefficient of static friction between the block and the object is 0.60.

- State the nature and direction of the force that accelerates the 15 kg object. [1]

.....

.....

- Determine the largest magnitude of F for which the block and the object do not move relative to each other. [3]

.....

.....

.....

.....

.....

.....



Turn over
 0000-0000