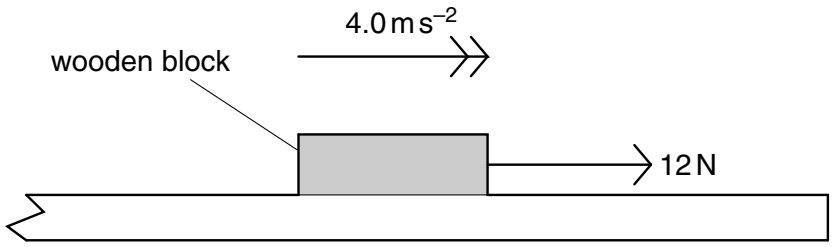
10 A wooden block of mass 0.60 kg is on a rough horizontal surface. A force of 12 N is applied to the block and it accelerates at 4.0 m s^{-2}. 9702/1/M/J/02



What is the magnitude of the frictional force acting on the block?

A 2.4 N

B 9.6 N

C 14 N

D 16 N

12 A submarine descends vertically at constant velocity. The three forces acting on the submarine are viscous drag, upthrust and weight. 9702/1/M/J/02

Which relationship between their magnitudes is correct?

A weight < drag

B weight = drag

C weight < upthrust

D weight > upthrust

14 A cylindrical block of wood has a cross-sectional area A and weight W. It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively. 9702/1/M/J/02

Which of the following expressions is equal to the upthrust on the block?

A $(p_b - p_t)A + W$

B $(p_b - p_t)$

C $(p_b - p_t)A$

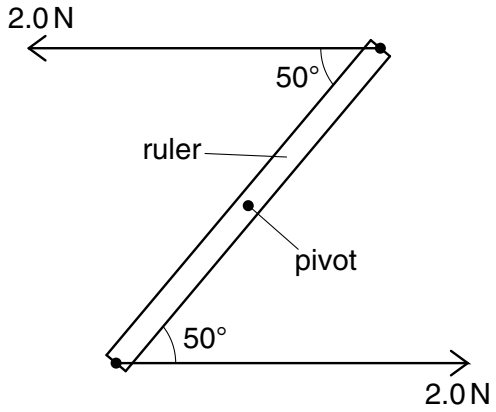
D $(p_b - p_t)A - W$

16 A horizontal force of 90 N is used to push a box across a horizontal floor. The frictional force on the box is 50 N. 9702/01/O/N/04

What is the gain in kinetic energy of the box when it is moved through a distance of 6.0 m?

A 240 J **B** 300 J **C** 540 J **D** 840 J

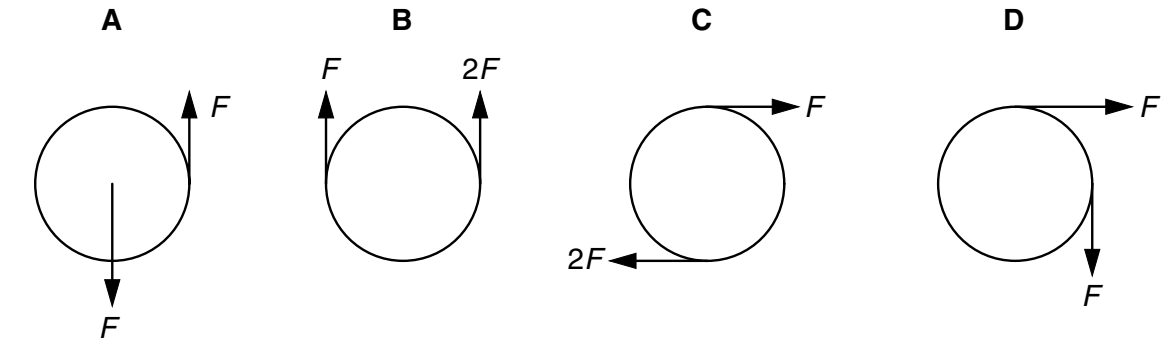
13 A ruler of length 0.30 m is pivoted at its centre. Equal and opposite forces of magnitude 2.0 N are applied to the ends of the ruler, creating a couple as shown. 9702/1/M/J/02



What is the magnitude of the torque of the couple on the ruler when it is in the position shown?

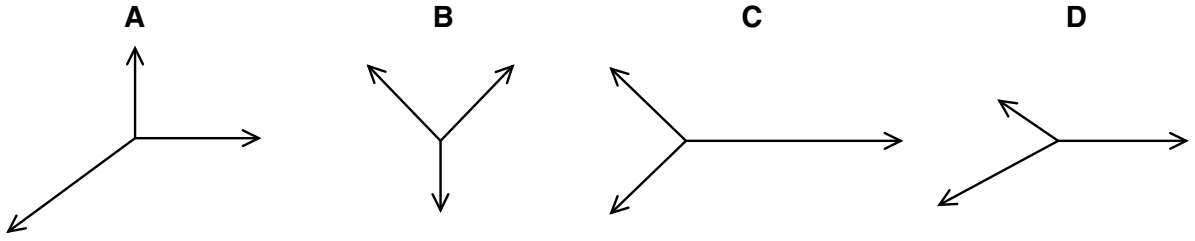
A 0.23 Nm **B** 0.39 Nm **C** 0.46 Nm **D** 0.60 Nm

13 Which of the following pairs of forces, acting on a circular object, constitutes a couple? 9702/1/O/N/02



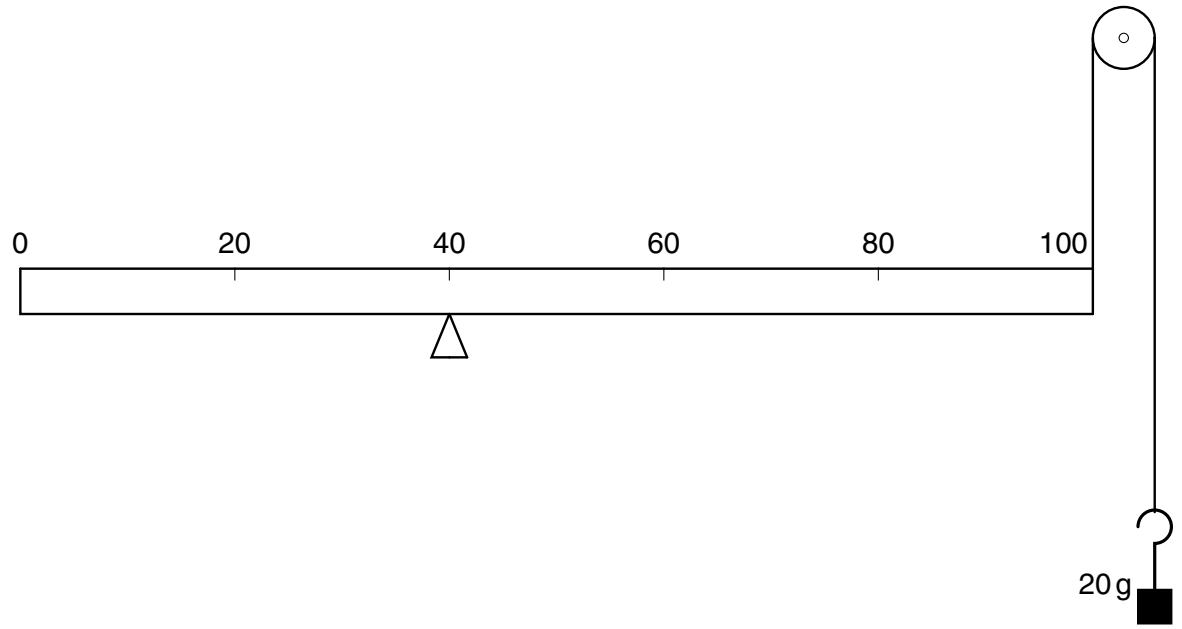
15 The diagrams represent systems of coplanar forces acting at a point. The lengths of the force vectors represent the magnitudes of the forces. 9702/1/O/N/02

Which system of forces is in equilibrium?



14 A uniform metre rule of mass 100 g is supported by a knife-edge at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.

9702/1/O/N/02

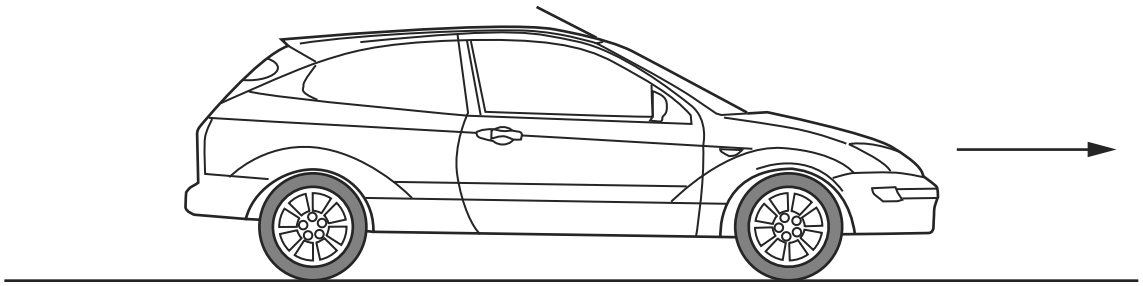


At which mark on the rule must a 50 g mass be suspended so that the rule balances?

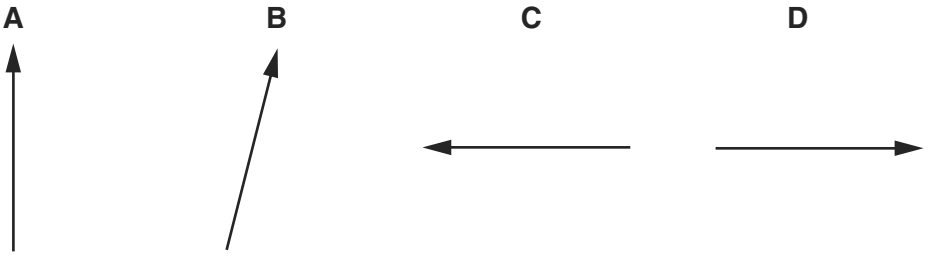
A 4 cm **B** 36 cm **C** 44 cm **D** 96 cm

11 A car with front-wheel drive accelerates in the direction shown.

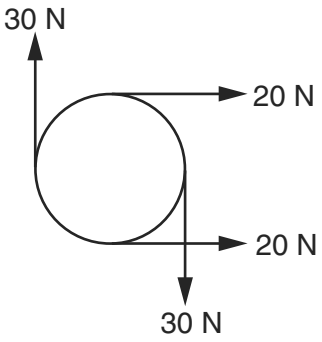
9702/01/M/J/03



Which diagram best shows the direction of the total force exerted by the road on the front wheels?



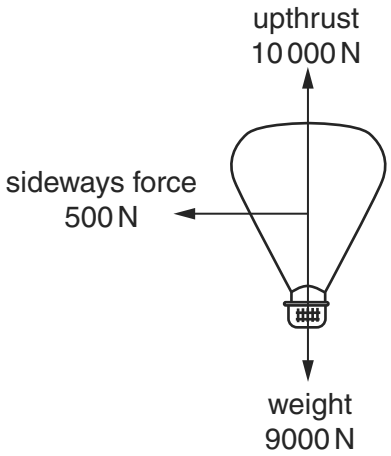
13 The diagram shows four forces applied to a circular object. 9702/01/M/J/03



Which of the following describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

14 A balloon is acted upon by three forces, weight, upthrust and sideways force due to the wind, as shown in the diagram. 9702/01/M/J/03



What is the vertical component of the resultant force on the balloon?

A 500 N **B** 1000 N **C** 10 000 N **D** 10 500 N

14 A steel sphere is dropped vertically onto a horizontal metal plate. The sphere hits the plate with a speed u, leaves it at a speed v, and rebounds vertically to half of its original height. 9702/11/M/J/11

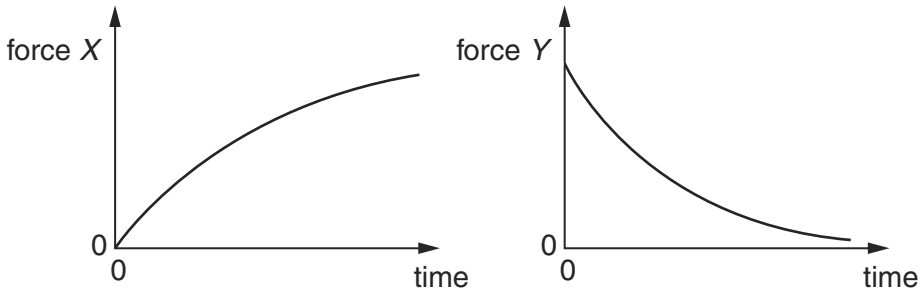
Which expression gives the value of $\frac{v}{u}$?

A $\frac{1}{2^2}$ **B** $\frac{1}{2}$ **C** $\frac{1}{\sqrt{2}}$ **D** $1 - \frac{1}{\sqrt{2}}$

15 A ball falls from rest through air and eventually reaches a constant velocity.

9702/01/M/J/03

For this fall, forces *X* and *Y* vary with time as shown.



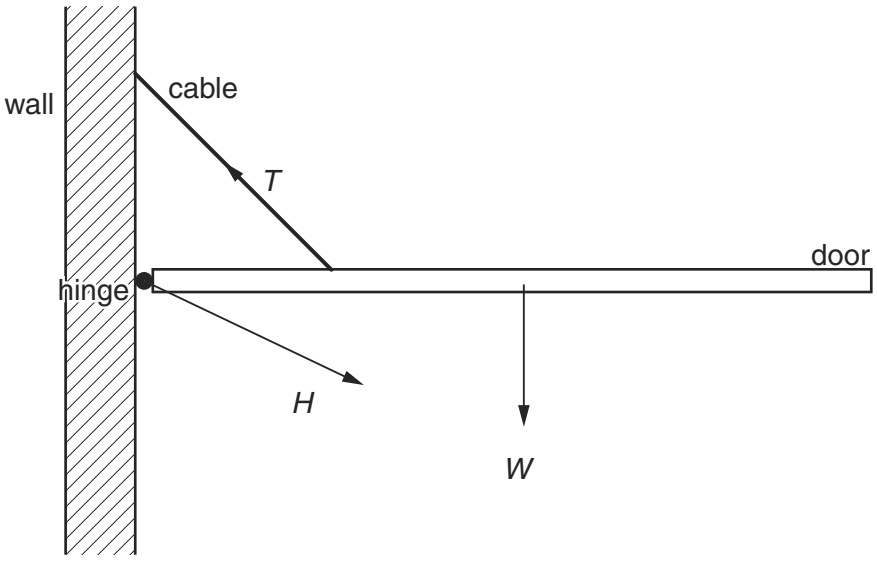
What are forces *X* and *Y*?

	force *X*	force *Y*
A	air resistance	resultant force
B	air resistance	weight
C	upthrust	resultant force
D	upthrust	weight

16 A hinged door is held closed in the horizontal position by a cable.

Three forces act on the door: the weight *W* of the door, the tension *T* in the cable, and the force *H* at the hinge.

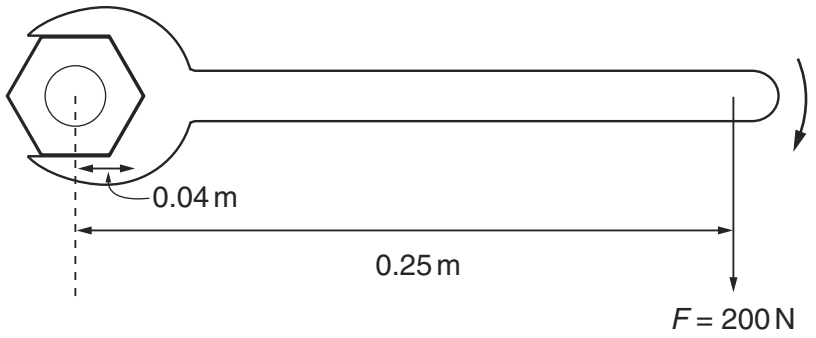
9702/01/O/N/03



Which list gives the three forces in **increasing** order of magnitude?

A *H*,*T*,*W** **B** *T*,*H*,*W** **C** *W*,*H*,*T** **D** *W*,*T*,*H*

13 A spanner is used to tighten a nut as shown. 9702/01/O/N/03



A force *F* is applied at right-angles to the spanner at a distance of 0.25 m from the centre of the nut. When the nut is fully tightened, the applied force is 200 N.

What is the resistive torque, in an anticlockwise direction, preventing further tightening?

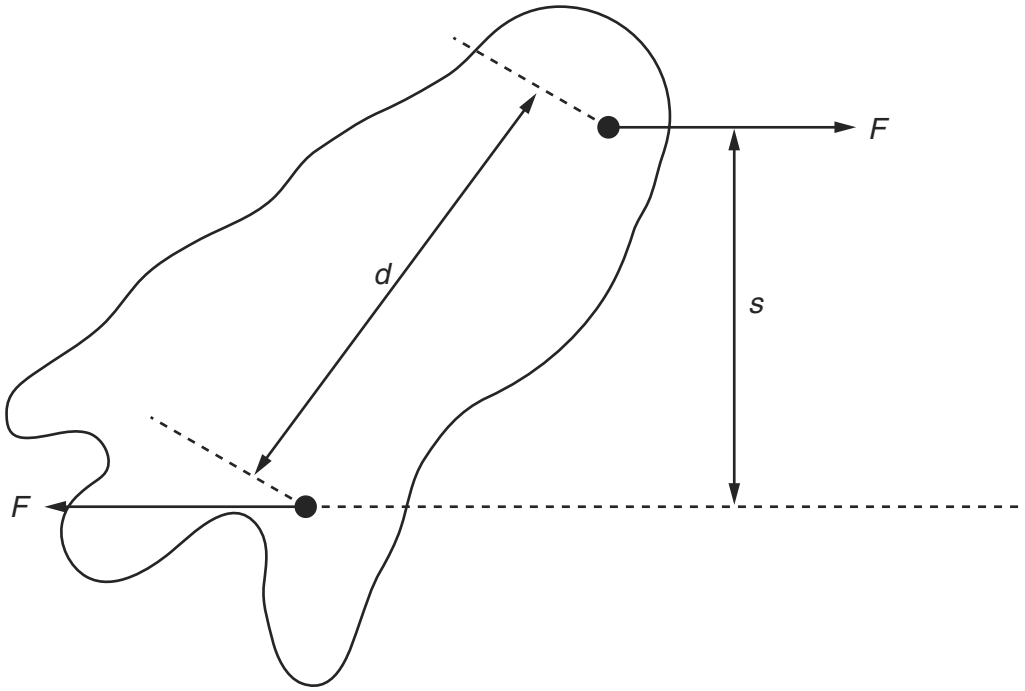
A 8 N m

B 25 N m

C 50 N m

D 800 N m

14 Two parallel forces, each of magnitude *F*, act on a body as shown. 9702/01/O/N/03



What is the magnitude of the torque on the body produced by these forces?

A *Fd** **B** *Fs** **C** 2*Fd** **D** 2*Fs*

15 A force *F* is applied to a freely moving object. At one instant of time, the object has velocity *v* and acceleration *a*. 9702/01/O/N/03

Which quantities **must** be in the same direction?

A *a* and *v* only

B *a* and *F* only

C *v* and *F* only

D *v*, *F* and *a*

10 A ball falls vertically and bounces on the ground. 9702/01/M/J/04

The following statements are about the forces acting while the ball is in contact with the ground.

Which statement is correct?

A The force that the ball exerts on the ground is always equal to the weight of the ball.

B The force that the ball exerts on the ground is always equal in magnitude and opposite in direction to the force the ground exerts on the ball.

C The force that the ball exerts on the ground is always less than the weight of the ball.

D The weight of the ball is always equal in magnitude and opposite in direction to the force that the ground exerts on the ball.

12 An object, immersed in a liquid in a tank, experiences an upthrust. 9702/01/M/J/04

What is the physical reason for this upthrust?

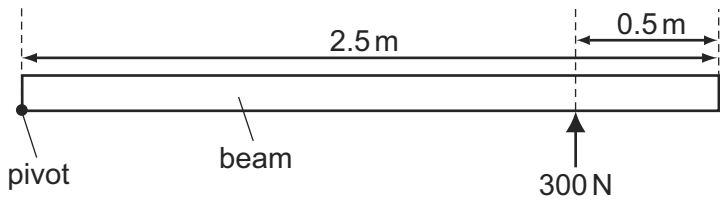
A The density of the body differs from that of the liquid.

B The density of the liquid increases with depth.

C The pressure in the liquid increases with depth.

D The value of *g* in the liquid increases with depth.

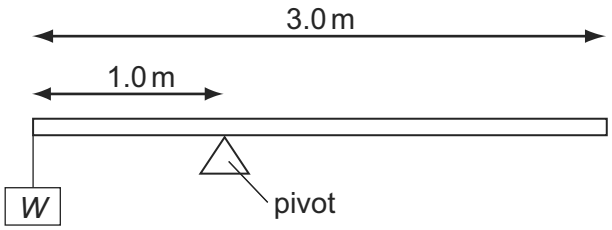
13 A long uniform beam is pivoted at one end. A force of 300 N is applied to hold the beam horizontally. 9702/01/O/N/04



What is the weight of the beam?

A 300 N **B** 480 N **C** 600 N **D** 960 N

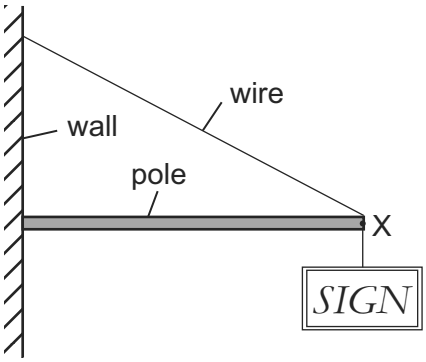
13 A uniform beam of weight 50 N is 3.0 m long and is supported on a pivot situated 1.0 m from one end. When a load of weight *W* is hung from that end, the beam is in equilibrium, as shown in the diagram. 9702/01/M/J/04



What is the value of *W*?

A 25 N **B** 50 N **C** 75 N **D** 100 N

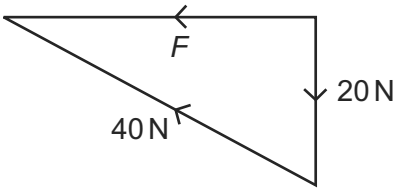
14 The diagram shows a sign of weight 20 N suspended from a pole, attached to a wall. The pole is kept in equilibrium by a wire attached at point X of the pole. 9702/01/M/J/04



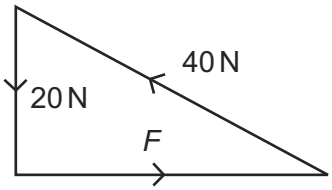
The force exerted by the pole at point X is *F*, and the tension in the wire is 40 N.

Which diagram represents the three forces acting at point X?

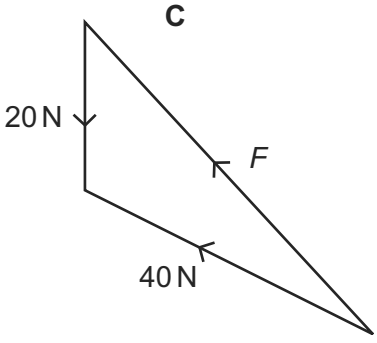
A



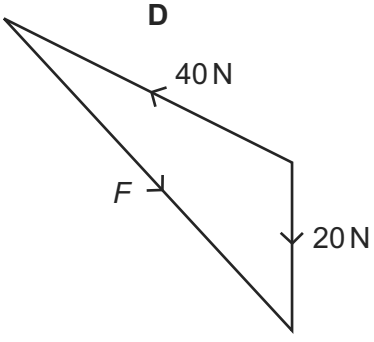
B



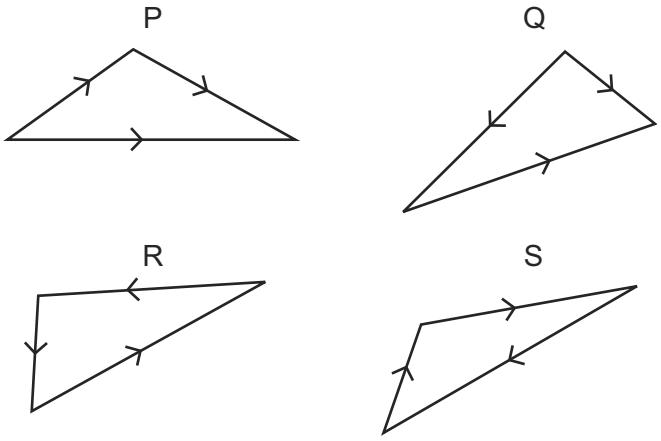
C



D



12 Which two vector diagrams represent forces in equilibrium? 9702/01/O/N/04



A P and Q

B Q and R

C R and S

D S and P

12 What is the centre of gravity of an object? 9702/01/M/J/05

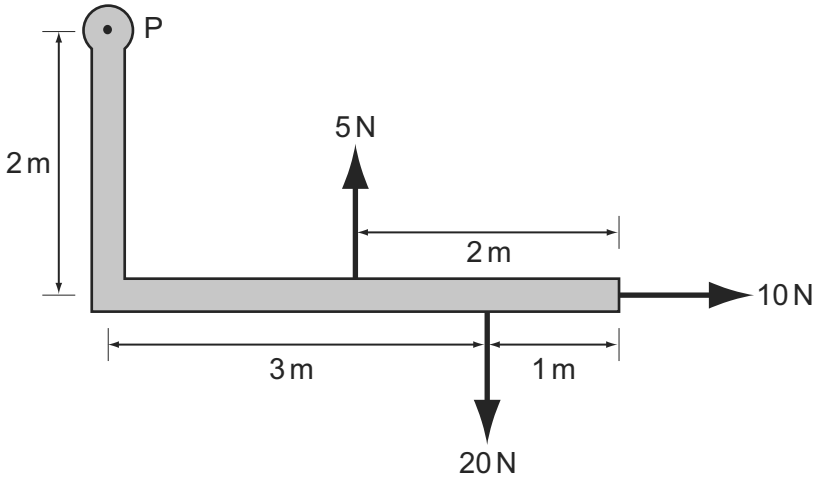
A the geometrical centre of the object

B the point about which the total torque is zero

C the point at which the weight of the object may be considered to act

D the point through which gravity acts

13 An L-shaped rigid lever arm is pivoted at point P. 9702/01/M/J/05



Three forces act on the lever arm, as shown in the diagram.

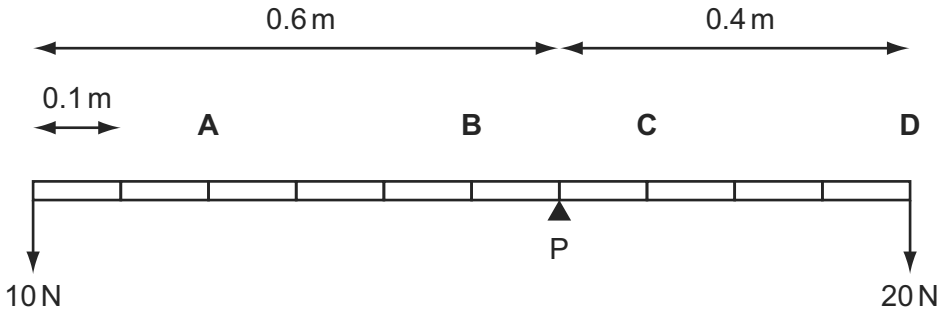
What is the magnitude of the resultant moment of these forces about point P?

A 30 N m **B** 35 N m **C** 50 N m **D** 90 N m

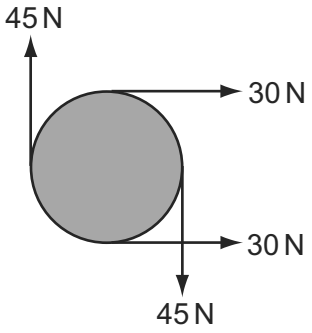
12 A uniform beam of weight 100 N is pivoted at P as shown. Weights of 10 N and 20 N are attached to its ends. 9702/01/O/N/05

The length of the beam is marked off at 0.1 m intervals.

At which point should a further weight of 20 N be attached to achieve equilibrium?



13 The diagram shows four forces applied to a circular object. 9702/01/O/N/05



Which of the following describes the resultant force and resultant torque on the object? 9702/01/O/N/05

	resultant force	resultant torque
A	non-zero	non-zero
B	non-zero	zero
C	zero	non-zero
D	zero	zero

10 A cyclist is riding at a steady speed on a level road. 9702/01/M/J/06

According to Newton's third law of motion, what is equal and opposite to the backward push of the back wheel on the road?

A the force exerted by the cyclist on the pedals

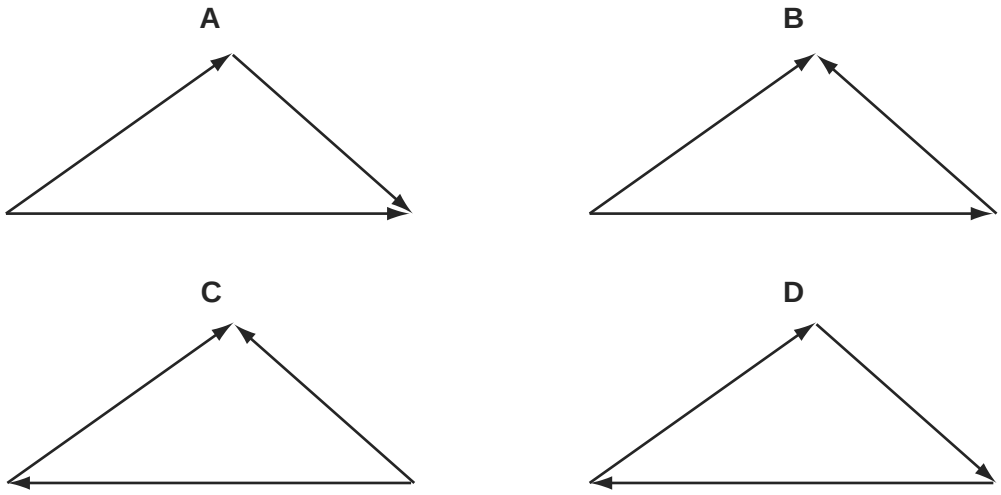
B the forward push of the road on the back wheel

C the tension in the cycle chain

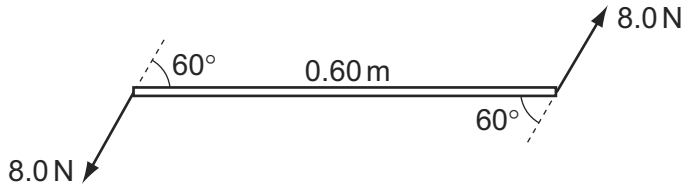
D the total air resistance and friction force

13 The diagrams show three forces acting on a body. 9702/01/M/J/06

In which diagram is the body in equilibrium?



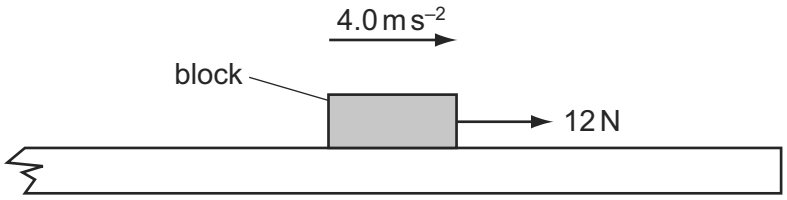
13 Two 8.0 N forces act at each end of a beam of length 0.60 m. The forces are parallel and act in opposite directions. The angle between the forces and the beam is 60°. 9702/01/M/J/07



What is the torque of the couple exerted on the beam?

A 2.4 N m **B** 4.2 N m **C** 4.8 N m **D** 9.6 N m

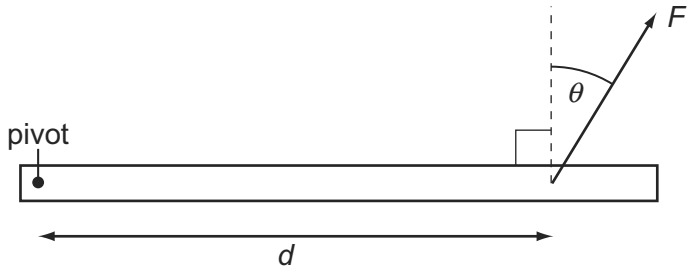
10 A block of mass 0.60 kg is on a rough horizontal surface. A force of 12 N is applied to the block and it accelerates at 4.0 m s^{-2}. 9702/01/O/N/07



What is the magnitude of the frictional force acting on the block?

A 2.4 N **B** 5.3 N **C** 6.7 N **D** 9.6 N

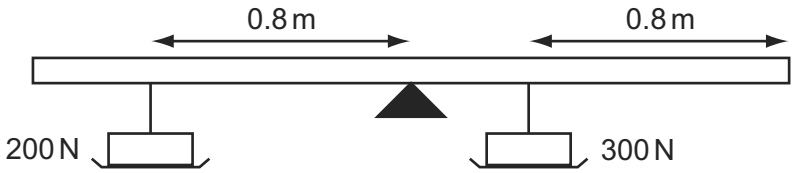
14 A force *F* is applied to a beam at a distance *d* from a pivot. The force acts at an angle θ to a line perpendicular to the beam. 9702/01/M/J/06



Which combination will cause the largest turning effect about the pivot?

	F	*d*	θ
A	large	large	large
B	large	large	small
C	small	small	large
D	small	large	small

15 A rigid uniform bar of length 2.4 m is pivoted horizontally at its mid-point. 9702/01/M/J/06



Weights are hung from two points of the bar as shown in the diagram. To maintain horizontal equilibrium, a couple is applied to the bar.

What is the torque and direction of this couple?

A 40 N m clockwise

B 40 N m anticlockwise

C 80 N m clockwise

D 80 N m anticlockwise

12 A ball is falling at terminal speed in still air. The forces acting on the ball are upthrust, viscous drag and weight. 9702/01/M/J/08

What is the order of increasing magnitude of these three forces?

A upthrust → viscous drag → weight

B viscous drag → upthrust → weight

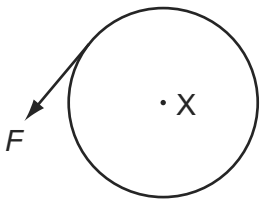
C viscous drag → weight → upthrust

D weight → upthrust → viscous drag

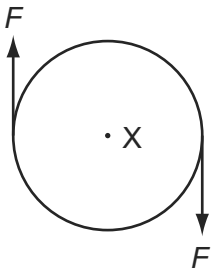
14 A rigid circular disc of radius *r* has its centre at X. A number of forces of equal magnitude *F* act at the edge of the disc. All the forces are in the plane of the disc. 9702/01/O/N/06

Which arrangement of forces provides a moment of magnitude 2*Fr* about X?

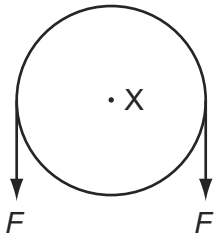
A



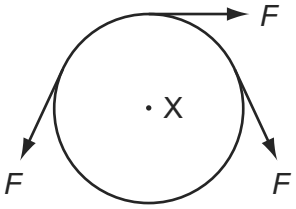
B



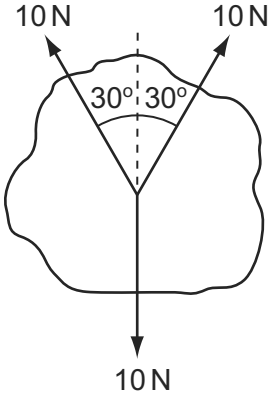
C



D



15 Three coplanar forces, each of magnitude 10 N, act through the same point of a body in the directions shown. 9702/01/O/N/06



What is the magnitude of the resultant force?

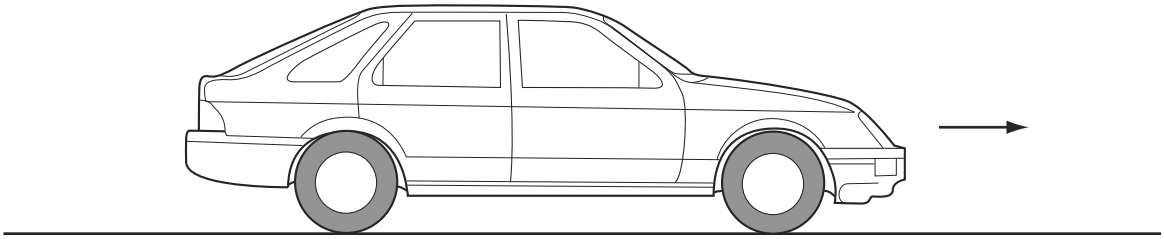
A 0 N **B** 1.3 N **C** 7.3 N **D** 10 N

9 A supermarket trolley, total mass 30 kg, is moving at 3.0 m s^{-1}. A retarding force of 60 N is applied to the trolley for 0.50 s in the opposite direction to the trolley's initial velocity. 9702/12/O/N/09

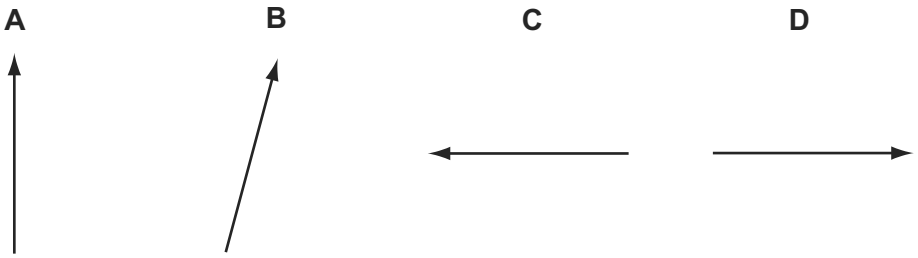
What is the trolley's new velocity after the application of the force?

A 1.0 m s^{-1} **B** 1.5 m s^{-1} **C** 2.0 m s^{-1} **D** 2.8 m s^{-1}

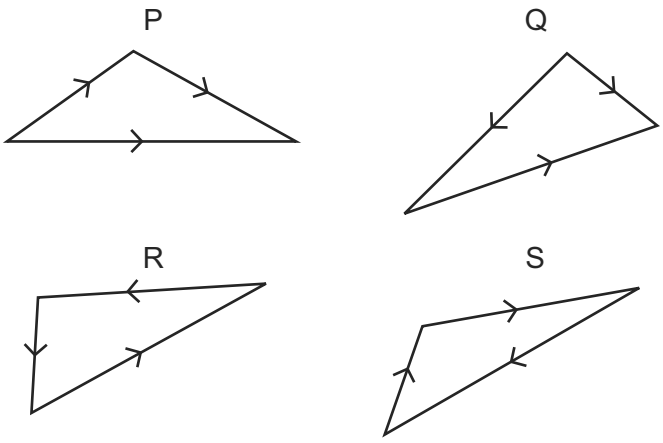
11 A car with front-wheel drive accelerates in the direction shown. 9702/01/O/N/07



Which diagram best shows the direction of the total force exerted by the road on the front wheels?

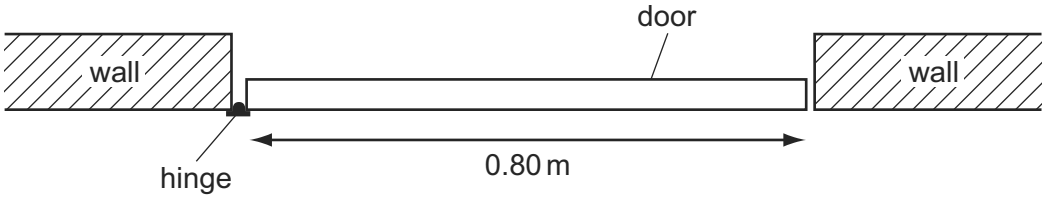


13 Which two vector diagrams represent forces in equilibrium? 9702/01/O/N/07



A P and Q **B** Q and R **C** R and S **D** S and P

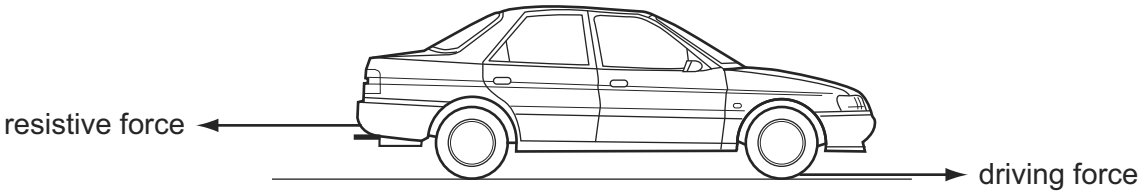
14 The diagram shows a plan view of a door which requires a moment of 12 N m to open it. 9702/01/O/N/07



What is the minimum force that must be applied at the door's midpoint to ensure it opens?

A 4.8 N **B** 9.6 N **C** 15 N **D** 30 N

11 A car of mass 750 kg has a horizontal driving force of 2.0 kN acting on it. It has a forward horizontal acceleration of 2.0 m s^{-2}. 9702/01/M/J/08



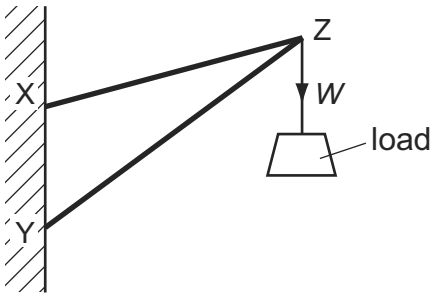
What is the resistive force acting horizontally?

A 0.5 kN **B** 1.5 kN **C** 2.0 kN **D** 3.5 kN

13 Two rigid rods, XZ and YZ, are fixed to a vertical wall at points X and Y. 9702/01/M/J/08

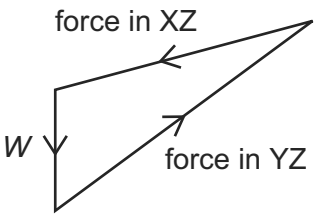
A load of weight *W* is hung from point Z.

The load is not moving.

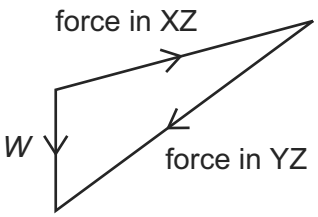


Which diagram shows the forces acting at point Z?

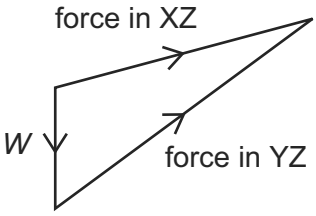
A



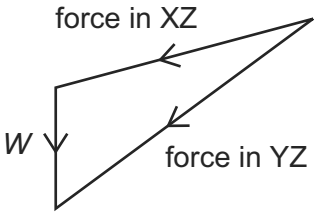
B



C

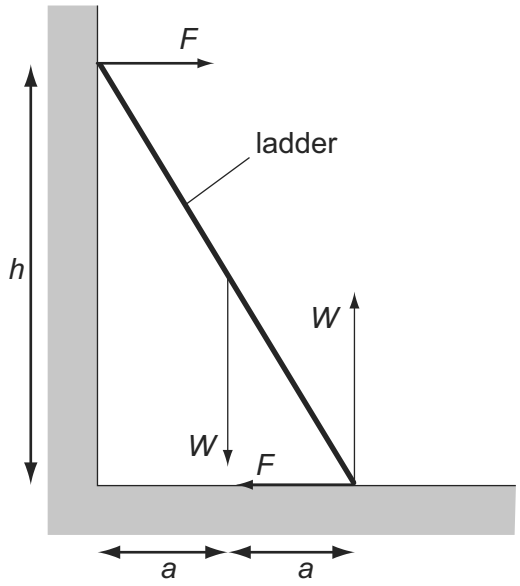


D



14 A uniform ladder rests against a vertical wall where there is negligible friction. The bottom of the ladder rests on rough ground where there is friction. The top of the ladder is at a height *h* above the ground and the foot of the ladder is at a distance 2*a* from the wall. 9702/01/M/J/08

The diagram shows the forces which act on the ladder.



Which equation is formed by taking moments?

A $Wa + Fh = 2Wa$

B $Fa + Wa = Fh$

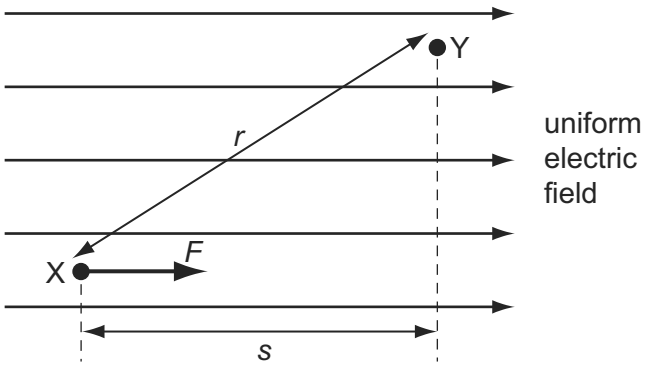
C $Wa + 2Wa = Fh$

D $Wa - 2Wa = 2Fh$

16 A positive charge experiences a force *F* when placed at point X in a uniform electric field. 9702/01/M/J/08

The charge is then moved from point X to point Y.

Distances *r* and *s* are shown on the diagram.



What is the change in the potential energy of the charge?

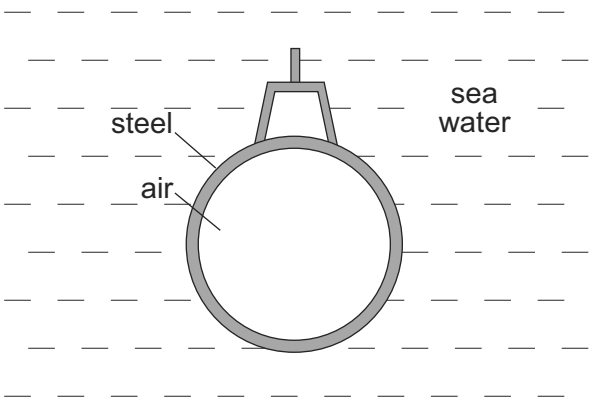
A decreases by *Fs*

B increases by *Fs*

C decreases by *Fr*

D increases by *Fr*

15 A submarine is in equilibrium in a fully submerged position. 9702/01/M/J/08



What causes the upthrust on the submarine?

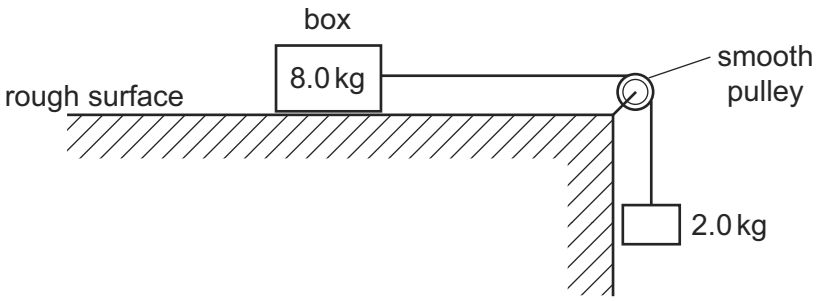
A The air in the submarine is less dense than sea water.

B The sea water exerts a greater upward force on the submarine than the weight of the steel.

C The submarine displaces its own volume of sea water.

D There is a difference in water pressure acting on the top and bottom of the submarine.

11 A box of mass 8.0 kg rests on a horizontal, rough surface. A string attached to the box passes over a smooth pulley and supports a 2.0 kg mass at its other end. 9702/01/O/N/08



When the box is released, a friction force of 6.0 N acts on it.

What is the acceleration of the box?

A $1.4\,m\,s^{-2}$ **B** $1.7\,m\,s^{-2}$ **C** $2.0\,m\,s^{-2}$ **D** $2.5\,m\,s^{-2}$

12 An object, made from two equal masses joined by a light rod, falls with uniform speed through air. 9702/01/M/J/09

The rod remains horizontal.

Which statement about the equilibrium of the system is correct?

A It is not in equilibrium because it is falling steadily.

B It is not in equilibrium because it is in motion.

C It is not in equilibrium because there is a resultant torque.

D It is in equilibrium because there is no resultant force and no resultant torque.

9 A ball falls vertically and bounces on the ground. 9702/01/O/N/08

The following statements are about the forces acting while the ball is in contact with the ground.

Which statement is correct?

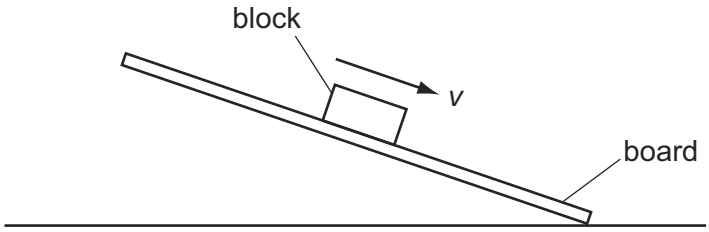
A The force that the ball exerts on the ground is always equal to the weight of the ball.

B The force that the ball exerts on the ground is always equal in magnitude and opposite in direction to the force the ground exerts on the ball.

C The force that the ball exerts on the ground is always less than the weight of the ball.

D The weight of the ball is always equal in magnitude and opposite in direction to the force that the ground exerts on the ball.

12 A wooden block rests on a rough board. The end of the board is then raised until the block slides down the plane of the board at constant velocity *v*. 9702/01/O/N/08

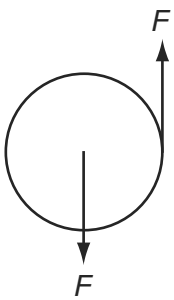


Which row describes the forces acting on the block when sliding with constant velocity?

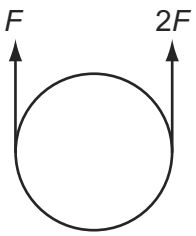
	frictional force on block	resultant force on block
A	down the plane	down the plane
B	down the plane	zero
C	up the plane	down the plane
D	up the plane	zero

14 Which pair of forces acts as a couple on the circular object? 9702/01/O/N/08

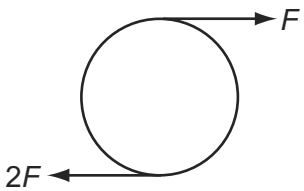
A



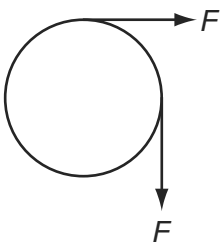
B



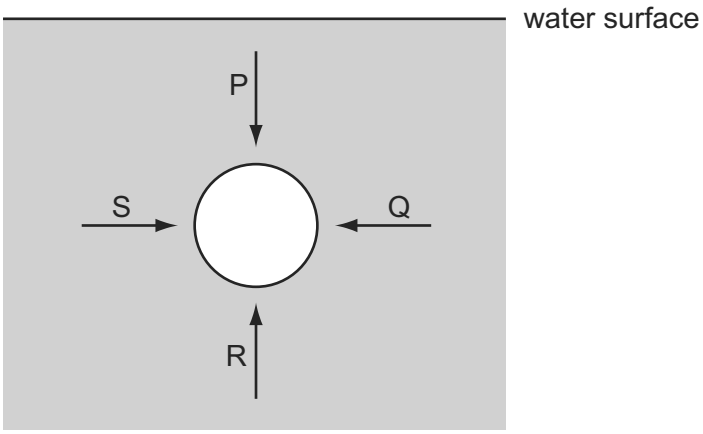
C



D



11 The diagram represents a sphere under water. P, Q, R, and S are forces acting on the sphere, due to the pressure of the water. 9702/01/M/J/09



Each force acts perpendicularly to the sphere's surface. P and R act in opposite directions vertically. Q and S act in opposite directions horizontally.

Which information about the magnitudes of the forces is correct?

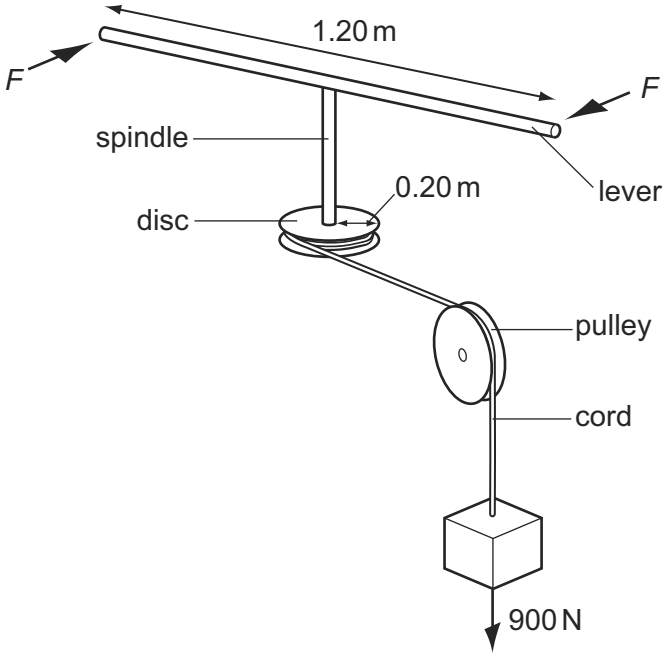
A P < R ; S = Q

B P > R ; S = Q

C P = R ; S = Q

D P = R = S = Q

13 A spindle is attached at one end to the centre of a lever 1.20 m long and at its other end to the centre of a disc of radius 0.20 m. A cord is wrapped round the disc, passes over a pulley and is attached to a 900 N weight. 9702/01/M/J/09



What is the minimum force *F*, applied to each end of the lever, that could lift the weight?

A 75 N **B** 150 N **C** 300 N **D** 950 N

11 What is the centre of gravity of an object? 9702/11/O/N/09

A the geometrical centre of the object

B the point about which the total torque is zero

C the point at which the weight of the object may be considered to act

D the point through which gravity acts

12 The diagrams show two ways of hanging the same picture. 9702/11/O/N/09

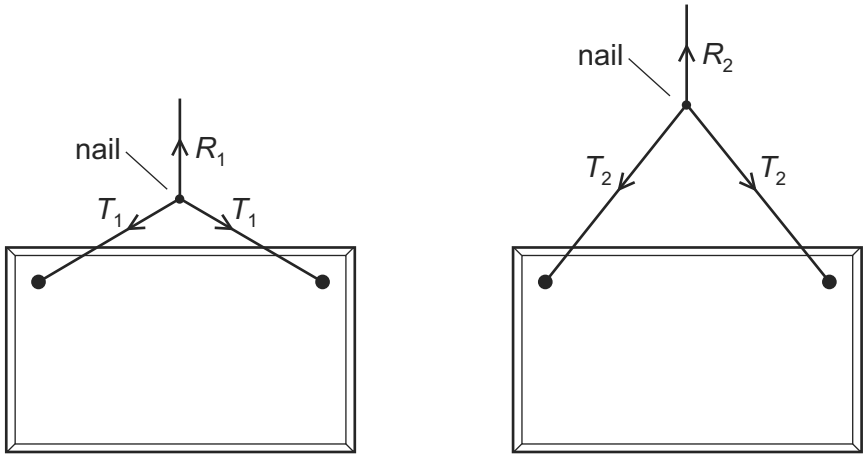


diagram 1 diagram 2

In both cases, a string is attached to the same points on the picture and looped symmetrically over a nail in a wall. The forces shown are those that act on the nail.

In diagram 1, the string loop is shorter than in diagram 2.

Which information about the magnitude of the forces is correct?

A $R_1 = R_2$ $T_1 = T_2$

B $R_1 = R_2$ $T_1 > T_2$

C $R_1 > R_2$ $T_1 < T_2$

D $R_1 < R_2$ $T_1 = T_2$

13 An object, immersed in a liquid in a tank, experiences an upthrust. 9702/12/M/J/10

What is the physical reason for this upthrust?

A The density of the body differs from that of the liquid.

B The density of the liquid increases with depth.

C The pressure in the liquid increases with depth.

D The value of g in the liquid increases with depth.

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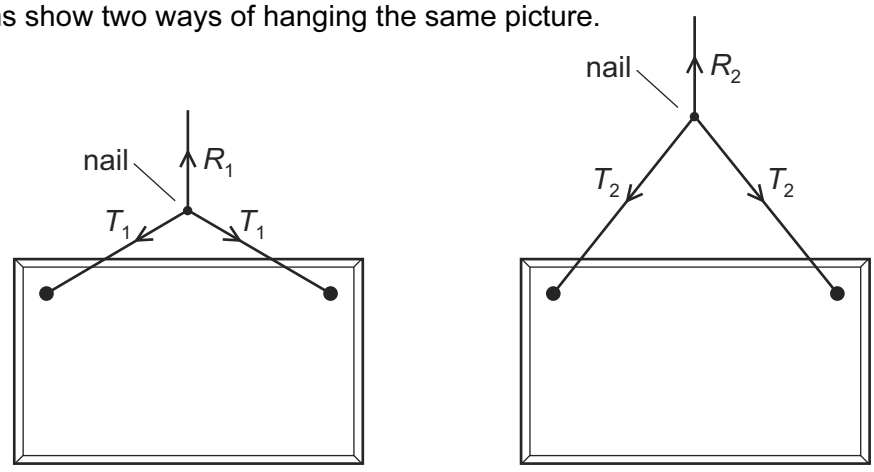

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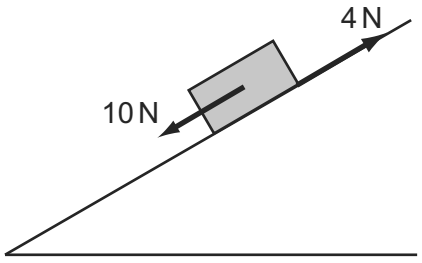
D $R_1 < R_2$ $T_1 = T_2$

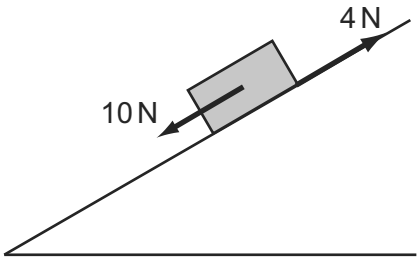
11 A brick weighing 20 N rests on an inclined plane. The weight of the brick has a component of 10 N parallel with the plane. The brick also experiences a frictional force of 4 N. 9702/11/M/J/10



What is the acceleration of the brick down the plane? Assume that the acceleration of free fall g is equal to 10 m s^{-2}.

A 0.3 m s^{-2} **B** 0.8 m s^{-2} **C** 3.0 m s^{-2} **D** 8.0 m s^{-2}

14 A brick weighing 20 N rests on an inclined plane. The weight of the brick has a component of 10 N parallel with the plane. The brick also experiences a frictional force of 4 N. 9702/12/M/J/10



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10 An object, immersed in a liquid in a tank, experiences an upthrust. 9702/13/M/J/10

What is the physical reason for this upthrust?

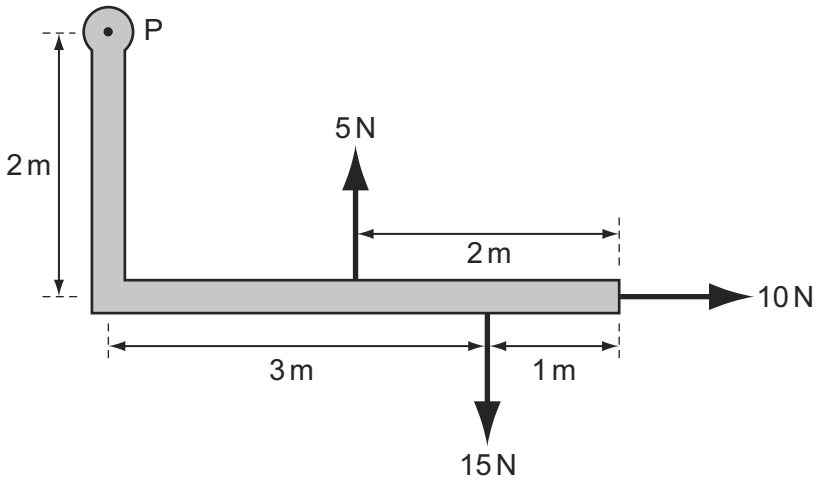
A The density of the body differs from that of the liquid.

B The density of the liquid increases with depth.

C The pressure in the liquid increases with depth.

D The value of *g* in the liquid increases with depth.

13 A rigid L-shaped lever arm is pivoted at point P. 9702/11/O/N/10

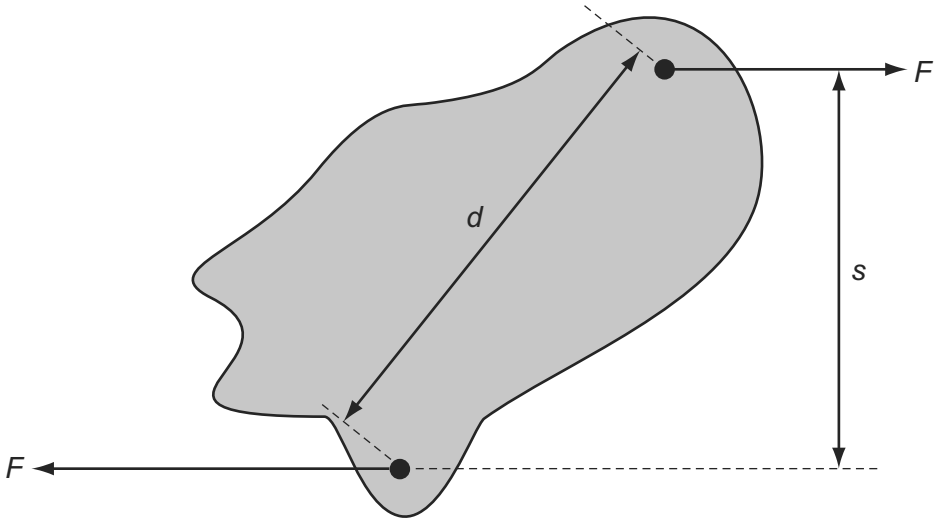


Three forces act on the lever arm, as shown in the diagram.

What is the magnitude of the resultant moment of these forces about point P?

A 15 N m **B** 20 N m **C** 35 N m **D** 75 N m

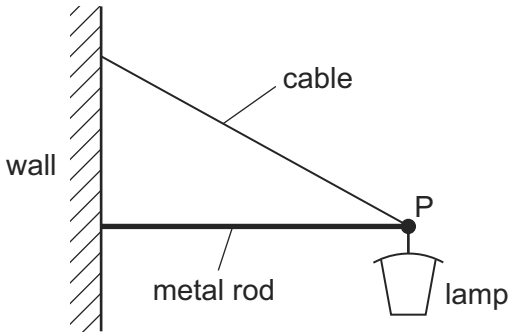
14 Two parallel forces, each of magnitude *F*, act on a body as shown. 9702/11/O/N/10



What is the magnitude of the torque on the body produced by these forces?

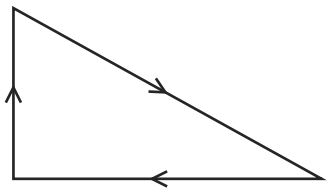
A Fd **B** Fs **C** $2Fd$ **D** $2Fs$

15 A street lamp is fixed to a wall by a metal rod and a cable. 9702/11/O/N/10

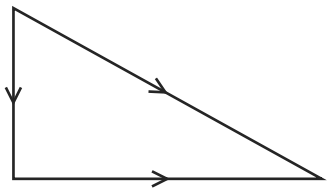


Which vector triangle represents the forces acting at point P?

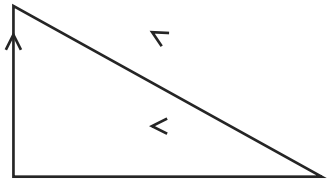
A



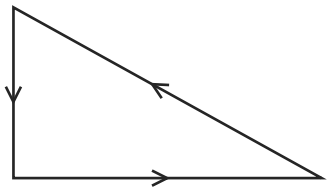
B



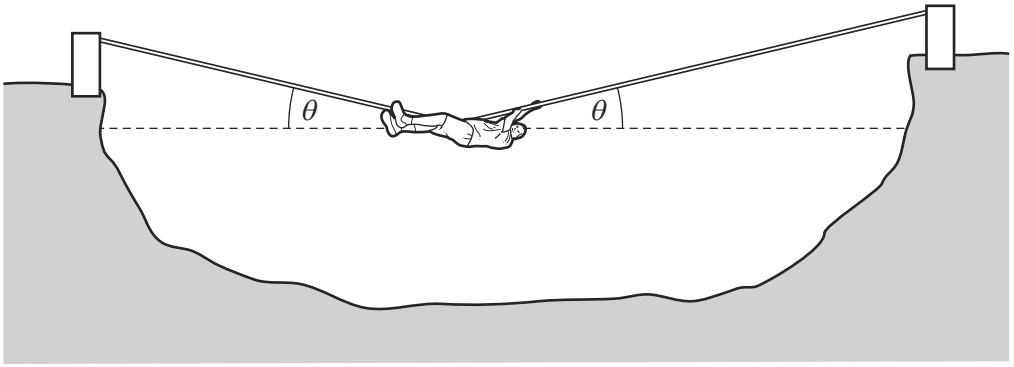
C



D



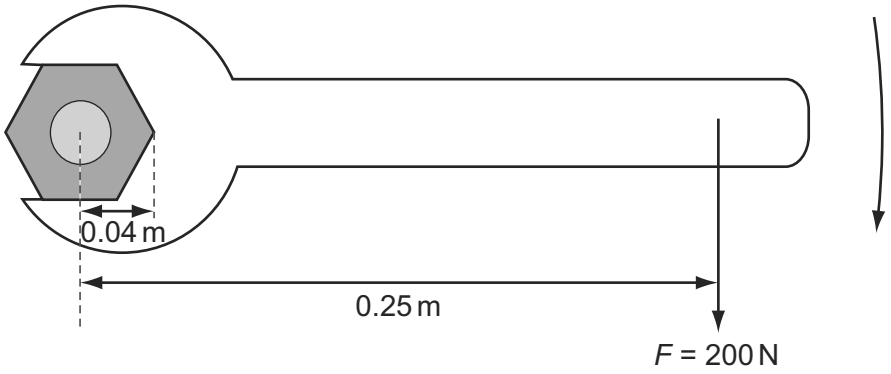
11 The diagram shows a rope bridge that a student makes on an adventure training course. The student has a weight *W*. 9702/12/O/N/10



Which formula gives the tension *T* in the rope?

A $T = \frac{W}{2\cos\theta}$ **B** $T = \frac{W}{2\sin\theta}$ **C** $T = \frac{W}{\cos\theta}$ **D** $T = \frac{W}{\sin\theta}$

12 A spanner is used to tighten a nut as shown. 9702/12/O/N/10



A force *F* is applied at right-angles to the spanner at a distance of 0.25 m from the centre of the nut. When the nut is fully tightened, the applied force is 200 N.

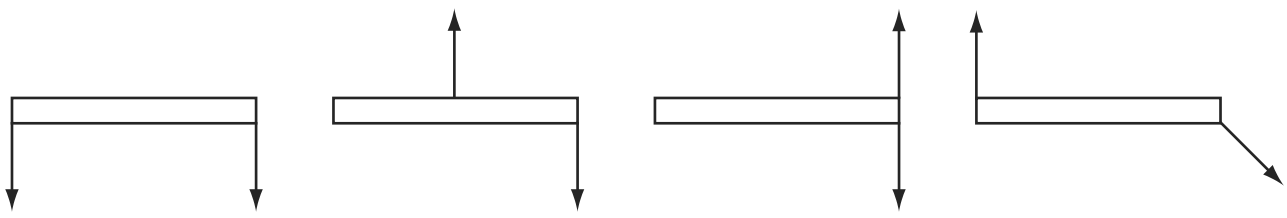
What is the resistive torque, in an anticlockwise direction, preventing further tightening?

A 8 N m **B** 42 N m **C** 50 N m **D** 1250 N m

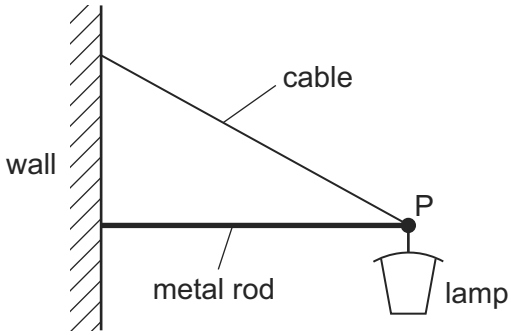
15 The diagrams all show a pair of equal forces acting on a metre rule.

Which diagram shows forces that provide a couple and zero resultant force?

A **B** **C** **D**

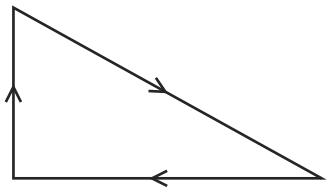


13 A street lamp is fixed to a wall by a metal rod and a cable. 9702/13/O/N/10

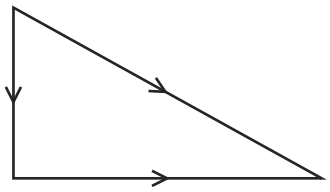


Which vector triangle represents the forces acting at point P?

A

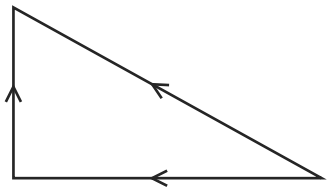


B

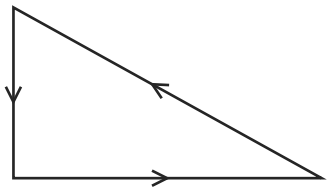


9702/13/O/N/10

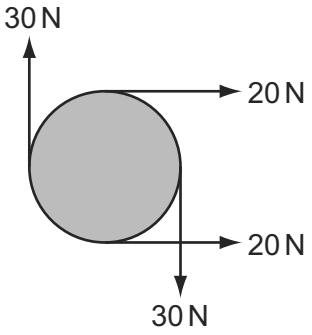
C



D



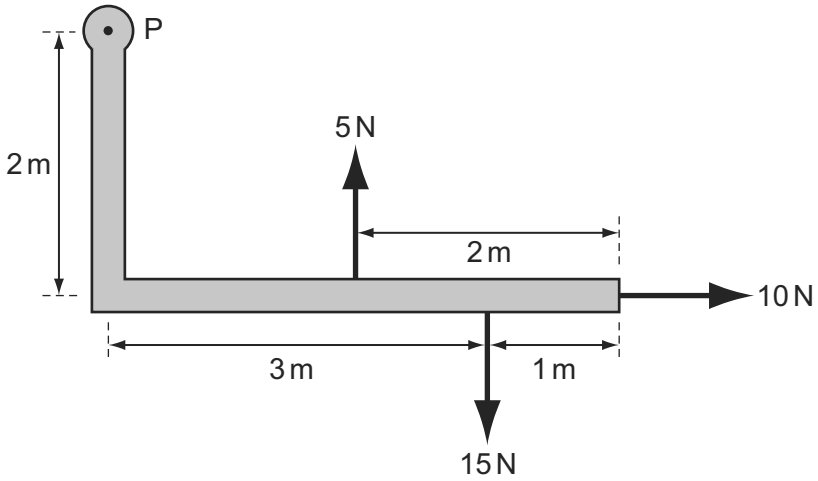
12 The diagram shows four forces applied to a circular object. 9702/11/M/J/11



Which row describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

14 A rigid L-shaped lever arm is pivoted at point P. 9702/13/O/N/10



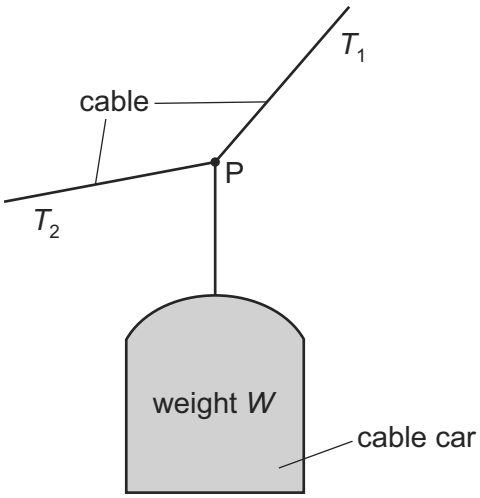
Three forces act on the lever arm, as shown in the diagram.

What is the magnitude of the resultant moment of these forces about point P?

A 15 N m **B** 20 N m **C** 35 N m **D** 75 N m

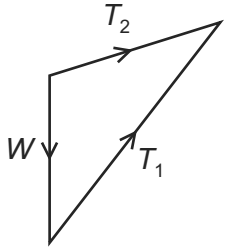
11 A cable car of weight W hangs in equilibrium from its cable at point P. 9702/11/M/J/11

The cable has tensions T_1 and T_2 as shown.

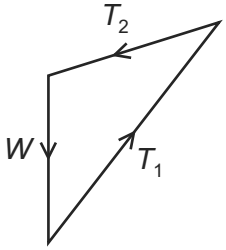


Which diagram correctly represents the forces acting at point P?

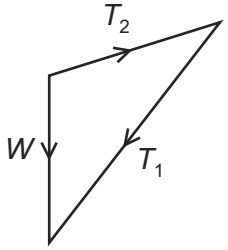
A



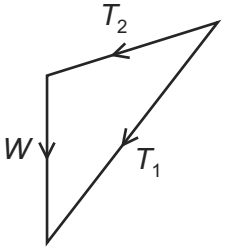
B



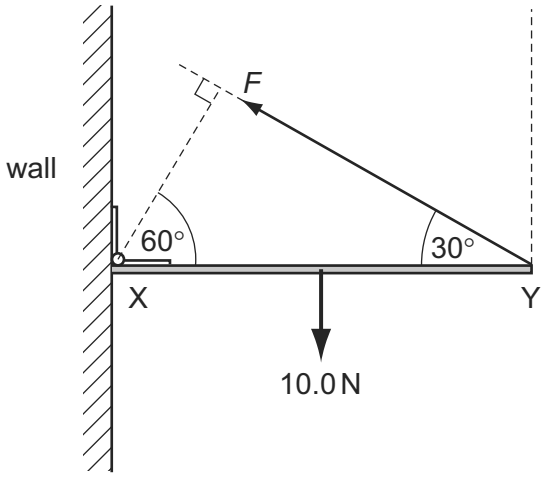
C



D



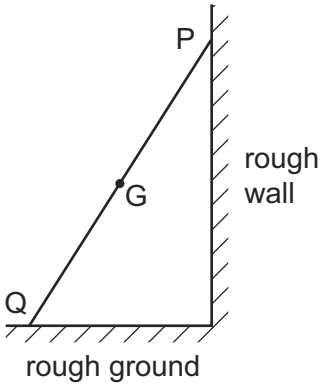
16 A uniform rod XY of weight 10.0 N is freely hinged to a wall at X. It is held horizontal by a force *F* acting from Y at an angle of 30° to the horizontal, as shown. 9702/12/M/J/11



What is the value of *F*?

A 5.0 N **B** 8.7 N **C** 10.0 N **D** 20.0 N

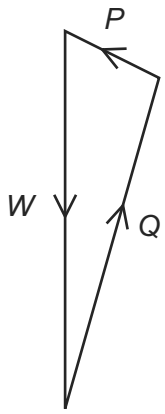
13 A ladder rests in equilibrium on rough ground against a rough wall. 9702/11/O/N/11



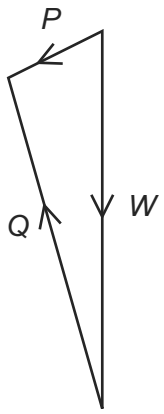
Its weight *W* acts through the centre of gravity G. Forces also act on the ladder at P and at Q. These forces are *P* and *Q* respectively.

Which vector triangle represents the forces on the ladder?

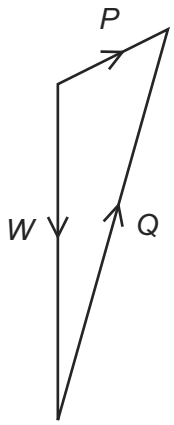
A



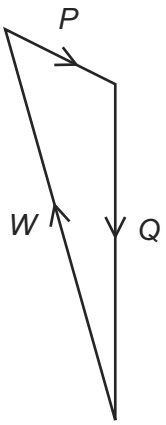
B



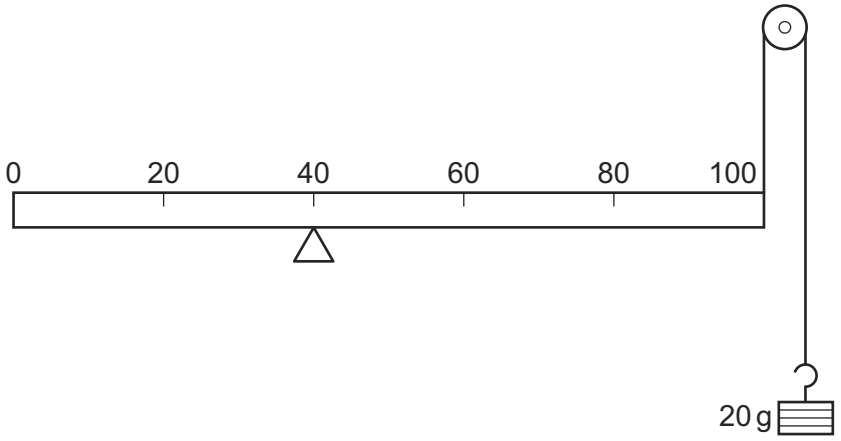
C



D



13 A uniform metre rule of mass 100 g is supported by a pivot at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram. 9702/11/M/J/11

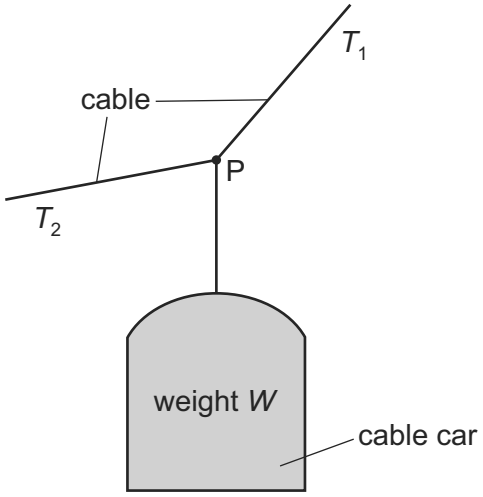


At which mark on the rule must a 50 g mass be suspended so that the rule balances?

A 4 cm **B** 36 cm **C** 44 cm **D** 64 cm

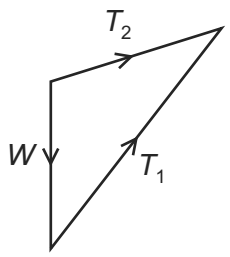
13 A cable car of weight W hangs in equilibrium from its cable at point P. 9702/13/M/J/11

The cable has tensions T_1 and T_2 as shown.

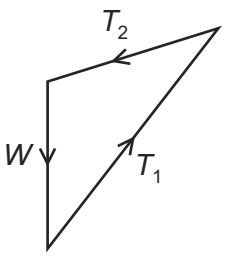


Which diagram correctly represents the forces acting at point P?

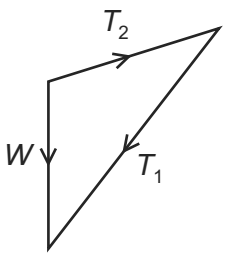
A



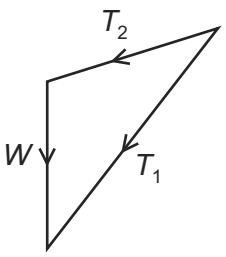
B



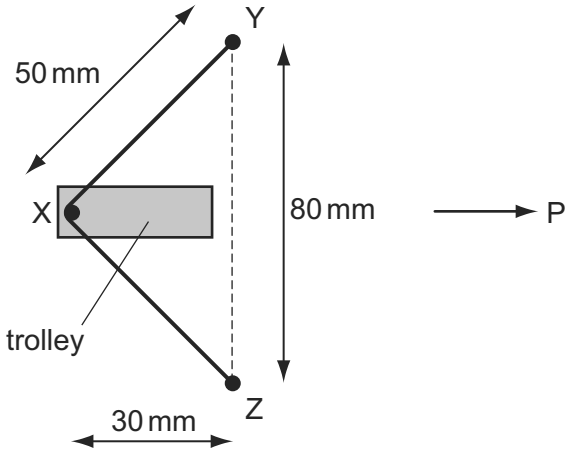
C



D



17 The diagram shows two fixed pins, Y and Z. A length of elastic is stretched between Y and Z and around pin X, which is attached to a trolley. 9702/12/M/J/11

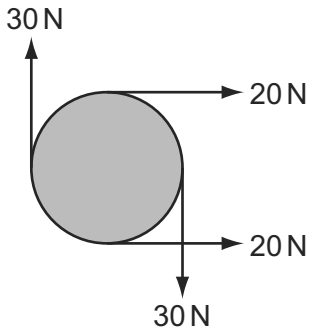


X is at the centre of the elastic and the trolley is to be propelled in the direction P at right angles to YZ. The tension in the elastic is 4 N.

What is the force accelerating the trolley in the direction P when the trolley is released?

A 2.4 N **B** 3.2 N **C** 4.8 N **D** 6.4 N

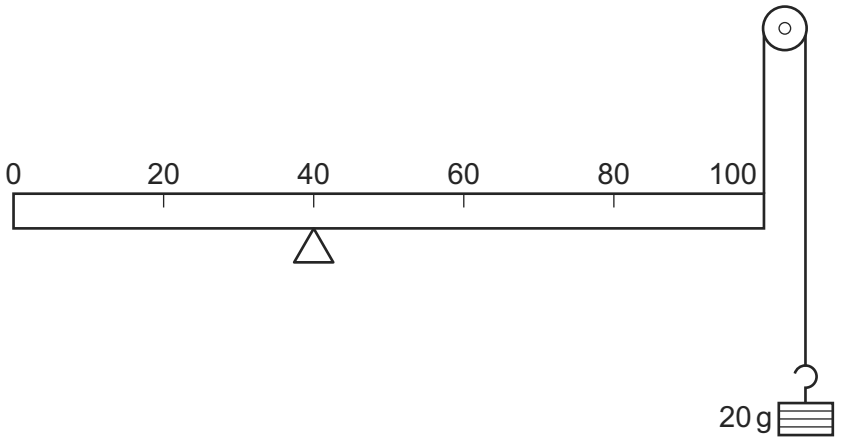
11 The diagram shows four forces applied to a circular object. 9702/13/M/J/11



Which row describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

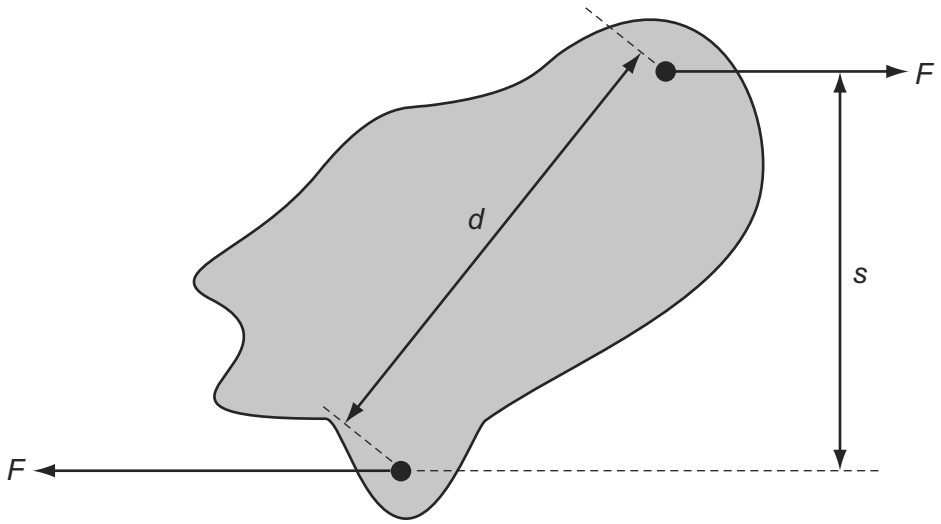
12 A uniform metre rule of mass 100 g is supported by a pivot at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram. 9702/13/M/J/11



At which mark on the rule must a 50 g mass be suspended so that the rule balances?

A 4 cm **B** 36 cm **C** 44 cm **D** 64 cm

15 Two parallel forces, each of magnitude *F*, act on a body as shown. 9702/13/O/N/10

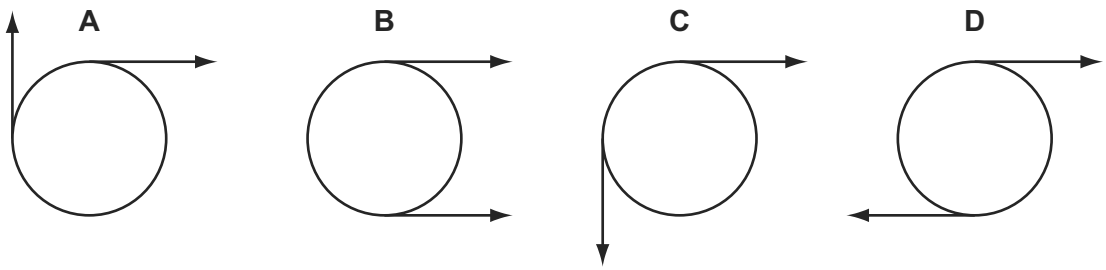


What is the magnitude of the torque on the body produced by these forces?

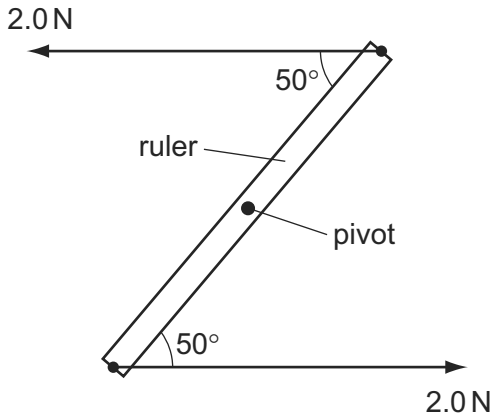
A Fd **B** Fs **C** $2Fd$ **D** $2Fs$

13 Two co-planar forces act on the rim of a wheel. The forces are equal in magnitude. 9702/12/O/N/11

Which arrangement of forces provides only a couple?



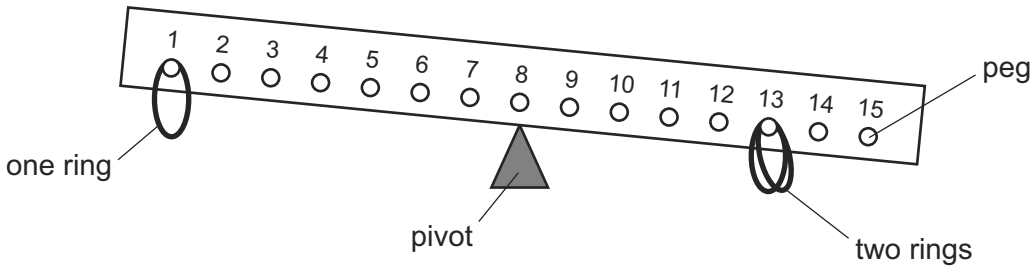
14 A ruler of length 0.30 m is pivoted at its centre. Equal and opposite forces of magnitude 2.0 N are applied to the ends of the ruler, creating a couple as shown. 9702/11/O/N/11



What is the magnitude of the torque of the couple on the ruler when it is in the position shown?

A 0.23 N m **B** 0.39 N m **C** 0.46 N m **D** 0.60 N m

15 The diagram shows a child's balancing game. 9702/11/O/N/11

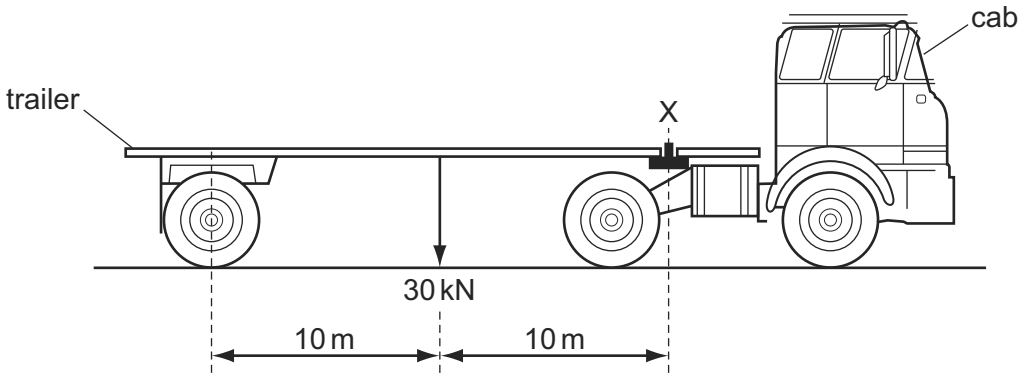


The wooden rod is uniform and all the rings are of equal mass. Two rings are hung on peg 13 and one on peg 1.

On which hook must a fourth ring be hung in order to balance the rod?

A 2 **B** 3 **C** 5 **D** 6

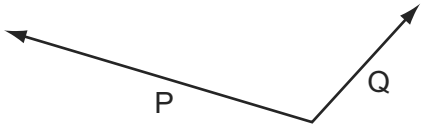
14 A trailer of weight 30 kN is hitched to a cab at X, as shown in the diagram. 9702/12/O/N/11



What is the upward force exerted by the cab on the trailer at X?

A 3 kN **B** 15 kN **C** 30 kN **D** 60 kN

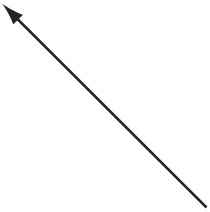
12 Two possible displacements of an object are represented by the vectors P and Q. 9702/12/O/N/11



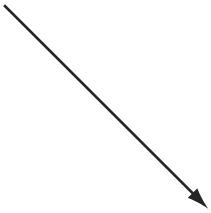
Which vector best represents the resultant displacement (P – Q) of the object?

A

B

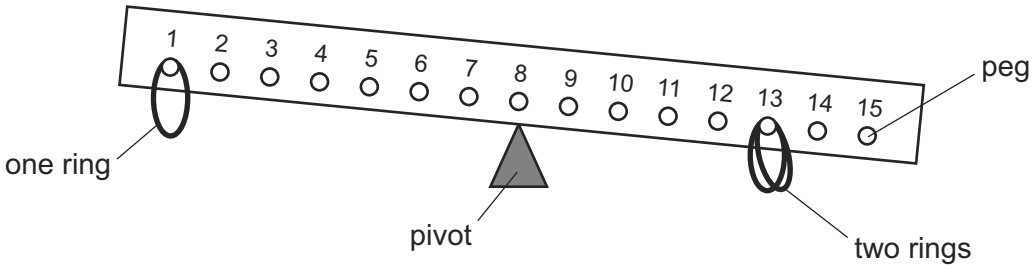


C



D

13 The diagram shows a child's balancing game. 9702/13/O/N/11



The wooden rod is uniform and all the rings are of equal mass. Two rings are hung on peg 13 and one on peg 1.

On which hook must a fourth ring be hung in order to balance the rod?

A 2 **B** 3 **C** 5 **D** 6

13 A cylindrical block of wood has cross-sectional area A and weight W. It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively. 9702/11/M/J/12

Which expression is equal to the upthrust on the block?

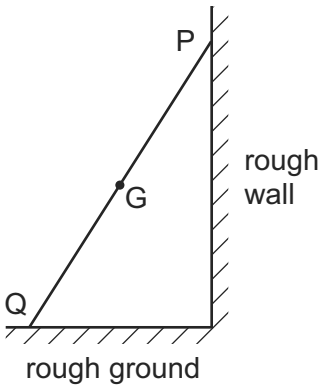
A $(p_b - p_t)A + W$

B $(p_b - p_t)$

C $(p_b - p_t)A$

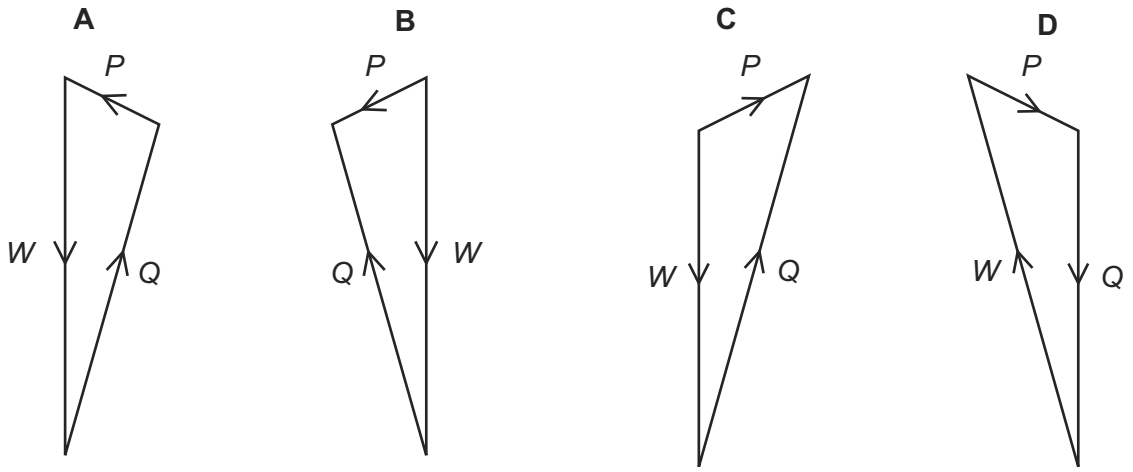
D $(p_b - p_t)A - W$

14 A ladder rests in equilibrium on rough ground against a rough wall. 9702/13/O/N/11

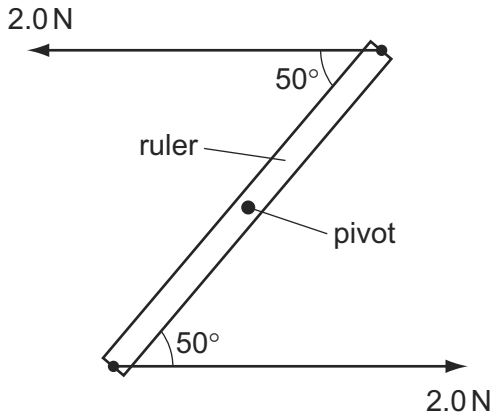


Its weight *W* acts through the centre of gravity G. Forces also act on the ladder at P and at Q. These forces are *P* and *Q* respectively.

Which vector triangle represents the forces on the ladder?



15 A ruler of length 0.30 m is pivoted at its centre. Equal and opposite forces of magnitude 2.0 N are applied to the ends of the ruler, creating a couple as shown. 9702/13/O/N/11

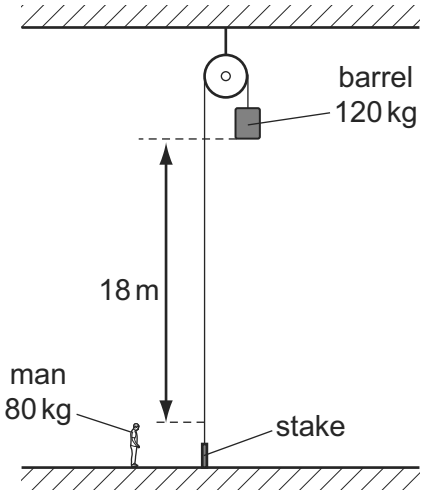


What is the magnitude of the torque of the couple on the ruler when it is in the position shown?

A 0.23 N m **B** 0.39 N m **C** 0.46 N m **D** 0.60 N m

12 The diagram shows a barrel suspended from a frictionless pulley on a building. The rope supporting the barrel goes over the pulley and is secured to a stake at the bottom of the building.

9702/11/M/J/12



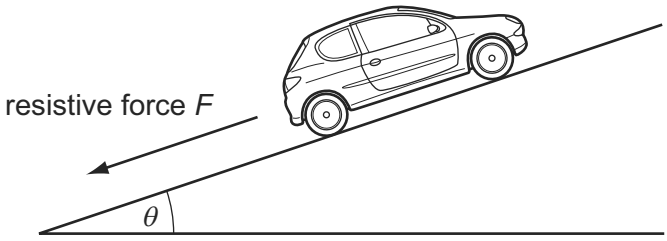
A man stands close to the stake. The bottom of the barrel is 18 m above the man's head. The mass of the barrel is 120 kg and the mass of the man is 80 kg.

The man keeps hold of the rope after untying it from the stake and is lifted upwards as the barrel falls.

What is the man's upward speed when his head is level with the bottom of the barrel? (Use $g = 10\,\text{m s}^{-2}$.)

A $6\,\text{m s}^{-1}$ **B** $8\,\text{m s}^{-1}$ **C** $13\,\text{m s}^{-1}$ **D** $19\,\text{m s}^{-1}$

14 A car of mass m travels at constant speed up a slope at an angle θ to the horizontal, as shown in the diagram. Air resistance and friction provide a resistive force F. 9702/11/M/J/12



What force is needed to propel the car at this constant speed?

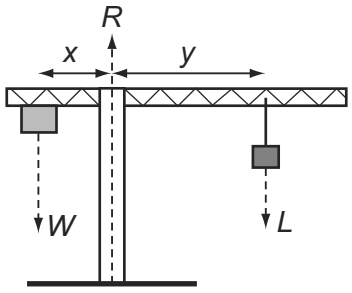
A $mg \cos \theta$

B $mg \sin \theta$

C $mg \cos \theta + F$

D $mg \sin \theta + F$

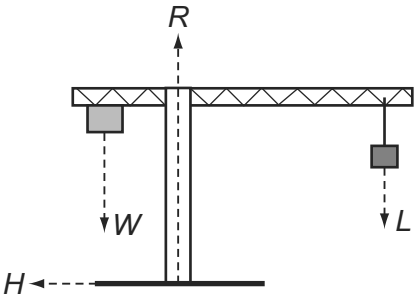
15 The diagram shows a crane supporting a load *L*.



A mass provides a balancing load *W*. The position of the load is such that the system is perfectly balanced with $Wx = Ly$. The ground provides a reaction force *R*. The distance *x* does not change.

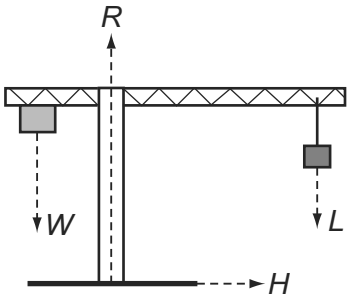
If the load is moved further out so that the distance *y* increases and the crane does not topple, which statement is correct?

A



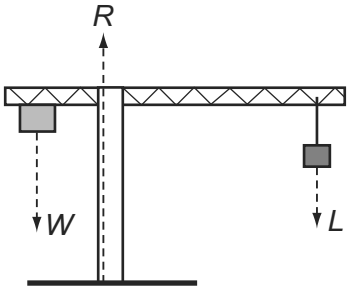
A horizontal force *H* acts on the base of the support column towards the left.

B



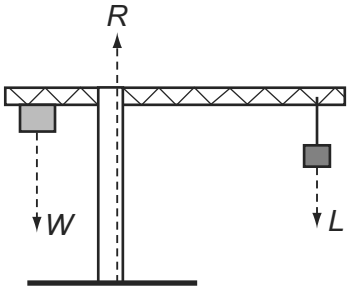
A horizontal force *H* acts on the base of the support column towards the right.

C



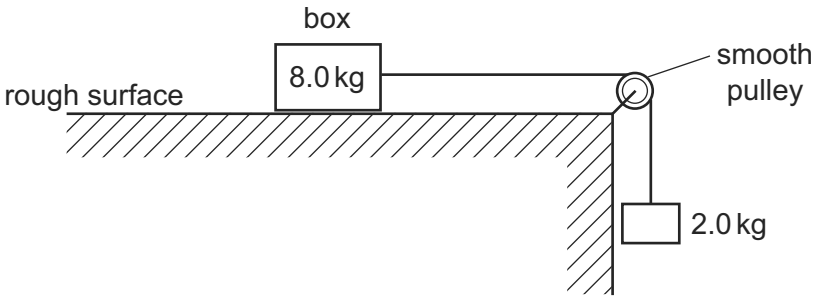
The reaction force *R* moves to the left.

D



The reaction force *R* moves to the right.

13 A box of mass 8.0 kg rests on a horizontal, rough surface. A string attached to the box passes over a smooth pulley and supports a 2.0 kg mass at its other end. 9702/12/M/J/12



When the box is released, a frictional force of 6.0 N acts on it.

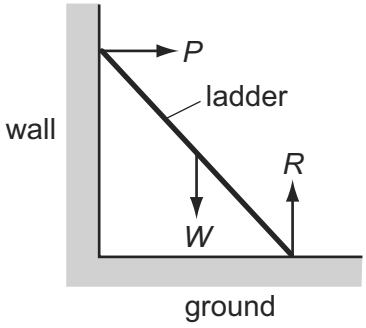
What is the acceleration of the box?

A $1.4\,m\,s^{-2}$ **B** $1.7\,m\,s^{-2}$ **C** $2.0\,m\,s^{-2}$ **D** $2.5\,m\,s^{-2}$

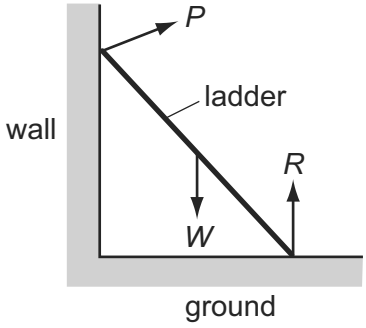
14 A ladder is positioned on icy (frictionless) ground and is leant against a rough wall. At the instant of release it begins to slide. 9702/12/M/J/12

Which diagram correctly shows the directions of the forces *P*, *W* and *R* acting on the ladder as it begins to slide?

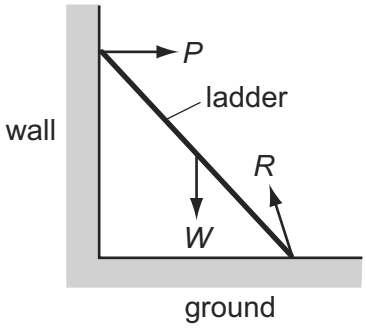
A



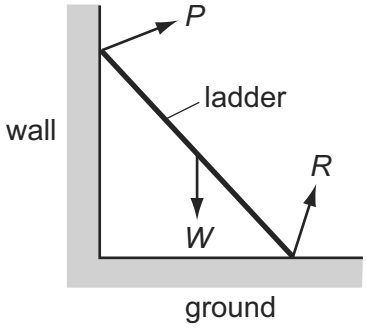
B



C

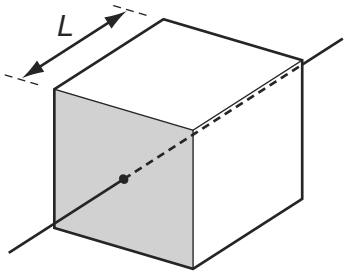


D

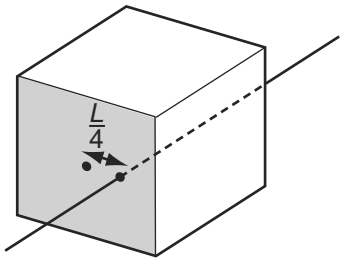


15 The diagram shows a solid cube with weight W and sides of length L. It is supported by a frictionless spindle that passes through the centres of two opposite vertical faces. One of these faces is shaded.

9702/12/M/J/12



The spindle is now removed and replaced at a distance $\frac{L}{4}$ to the right of its original position.



When viewing the shaded face, what is the torque of the couple that will now be needed to stop the cube from toppling?

A $\frac{WL}{2}$ anticlockwise

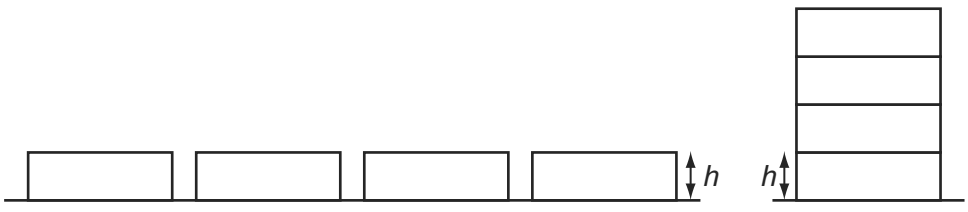
B $\frac{WL}{2}$ clockwise

C $\frac{WL}{4}$ anticlockwise

D $\frac{WL}{4}$ clockwise

17 Initially, four identical uniform blocks, each of mass m and thickness h, are spread on a table.

9702/12/M/J/12

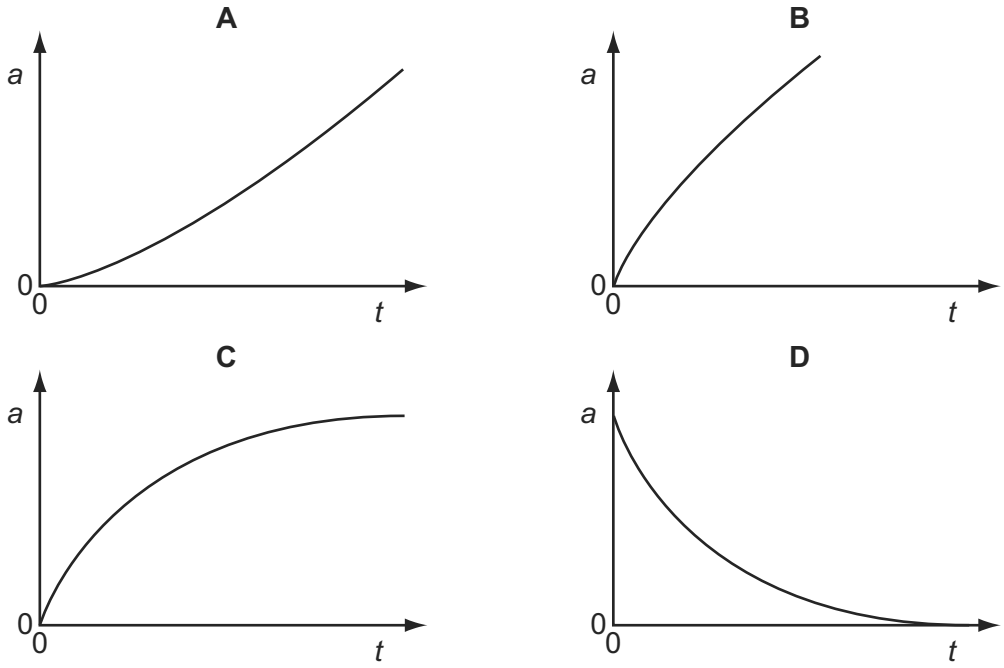


How much work is done on the blocks in stacking them on top of one another?

A 3 mgh **B** 6 mgh **C** 8 mgh **D** 10 mgh

16 A sphere is released from rest in a viscous fluid. 9702/12/M/J/12

Which graph represents the variation with time t of the acceleration a of the sphere?



11 Each option gives a correct word equation involving force. 9702/13/M/J/12

Which option gives the definition of force?

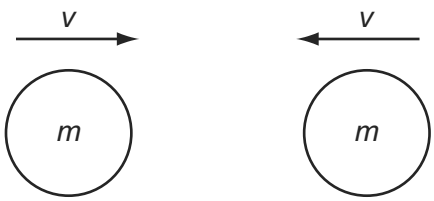
A force = energy divided by displacement

B force = mass × acceleration

C force = pressure × area

D force = rate of change of momentum

12 Two similar spheres, each of mass m and travelling with speed v, are moving towards each other. 9702/13/M/J/12



The spheres have a head-on elastic collision.

Which statement is correct?

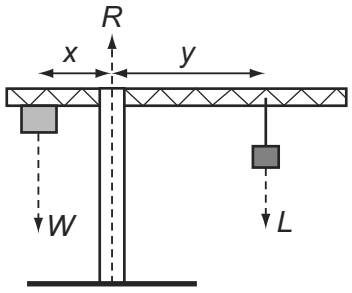
A The spheres stick together on impact.

B The total kinetic energy after impact is mv^2.

C The total kinetic energy before impact is zero.

D The total momentum before impact is $2mv$.

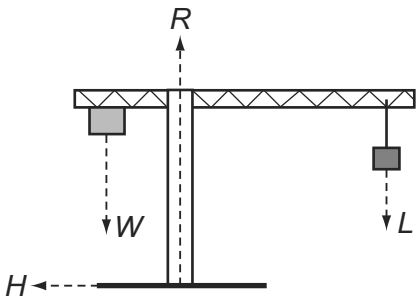
13 The diagram shows a crane supporting a load *L*.



A mass provides a balancing load *W*. The position of the load is such that the system is perfectly balanced with $Wx = Ly$. The ground provides a reaction force *R*. The distance *x* does not change.

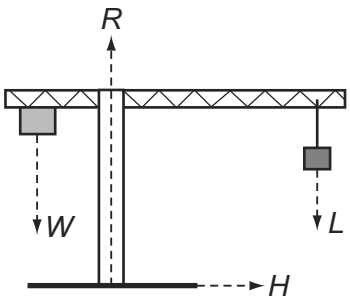
If the load is moved further out so that the distance *y* increases and the crane does not topple, which statement is correct?

A



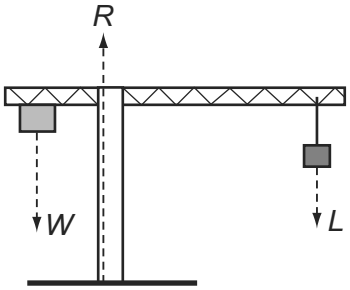
A horizontal force *H* acts on the base of the support column towards the left.

B



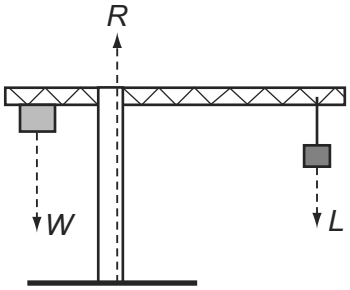
A horizontal force *H* acts on the base of the support column towards the right.

C



The reaction force *R* moves to the left.

D



The reaction force *R* moves to the right.

14 A cylindrical block of wood has cross-sectional area A and weight W. It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively. 9702/13/M/J/12

Which expression is equal to the upthrust on the block?

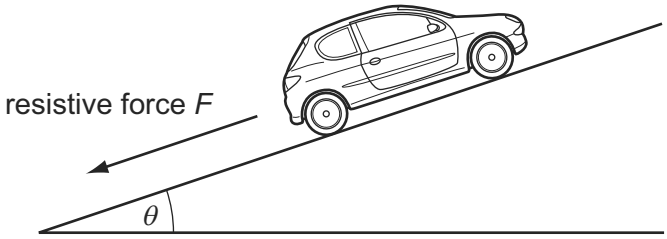
A $(p_b - p_t)A + W$

B $(p_b - p_t)$

C $(p_b - p_t)A$

D $(p_b - p_t)A - W$

15 A car of mass m travels at constant speed up a slope at an angle θ to the horizontal, as shown in the diagram. Air resistance and friction provide a resistive force F. 9702/13/M/J/12



What force is needed to propel the car at this constant speed?

A $mg \cos \theta$

B $mg \sin \theta$

C $mg \cos \theta + F$

D $mg \sin \theta + F$

15 A lorry of mass 20 000 kg has a constant resultant force F acting on it. 9702/12/O/N/12

It accelerates from 6.0 m s^{-1} to 30.0 m s^{-1} in a time of 300 s.

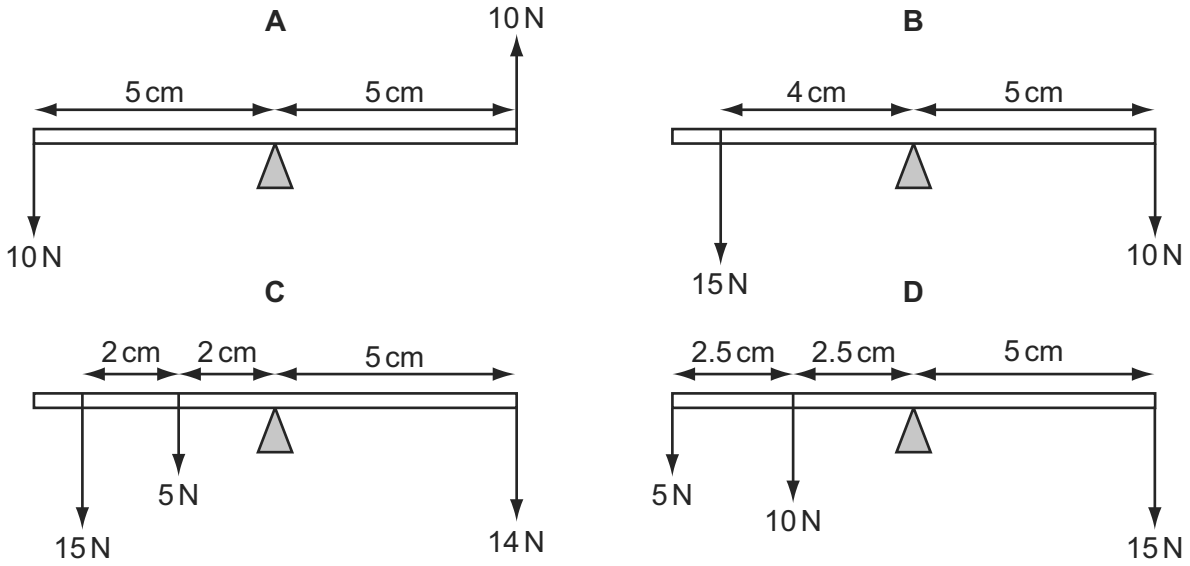
What is the change in momentum of the lorry and the value of F?

	change in momentum / N s	force F / N
A	48 000	160
B	480 000	1600
C	600 000	2000
D	600 000	20 000

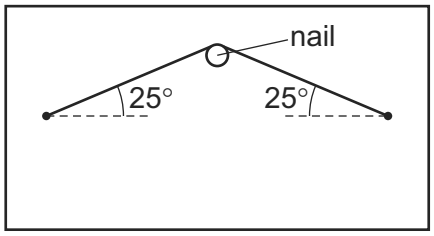
17 A rigid uniform beam is pivoted horizontally at its midpoint. 9702/12/O/N/12

Different vertical forces are applied to different positions on the beam.

In which diagram is the beam in equilibrium?



18 A picture on a wall is supported by a wire looped over a nail. 9702/12/O/N/12

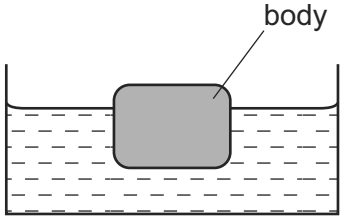


The mass of the picture is 4.2 kg.

What is the tension in the supporting wire?

A 5.0 N **B** 23 N **C** 49 N **D** 97 N

16 A stationary body floats in water. 9702/12/O/N/12



Which statement about the forces acting on the body is correct?

A The gravitational force is equal to the viscous force.

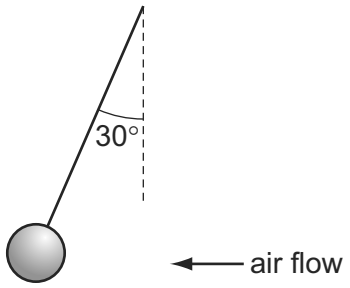
B The gravitational force is greater than the upthrust.

C The upthrust is zero.

D The viscous force is zero.

15 The diagram shows an experiment to measure the force exerted on a ball by a horizontal air flow.

9702/11/O/N/12



The ball is suspended by a light string and weighs 0.15 N.

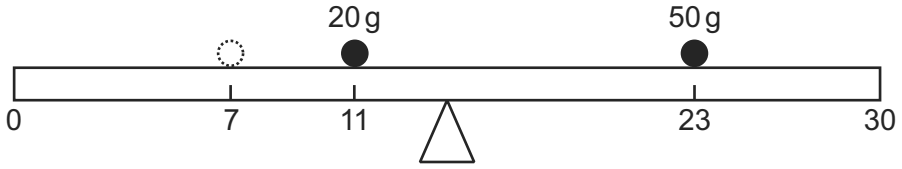
The deflection of the string from vertical is 30°.

What is the force on the ball from the air flow?

A 0.075 N **B** 0.087 N **C** 0.26 N **D** 0.30 N

16 A student balances a 30 cm ruler on a fulcrum set at the 15 cm mark. She then places a 50 g mass on the 23 cm mark and a 20 g mass on the 11 cm mark, as shown.

9702/11/O/N/12



Which mass should she place on the 7 cm mark to restore the balance?

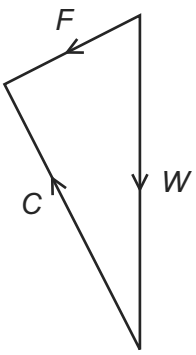
A 30 g **B** 40 g **C** 47 g **D** 133 g

17 A sledge slides down a slope at a constant velocity. The three forces that act on the sledge are the normal contact force *C*, the weight *W* and a constant frictional force *F*.

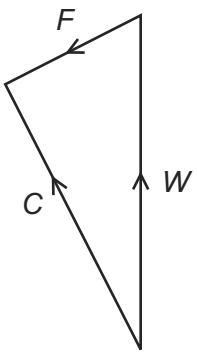
9702/11/O/N/12

Which diagram represents these forces acting on the sledge?

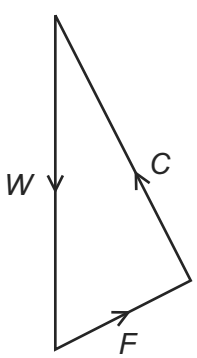
A



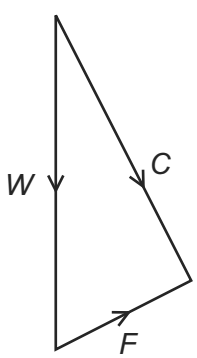
B



C

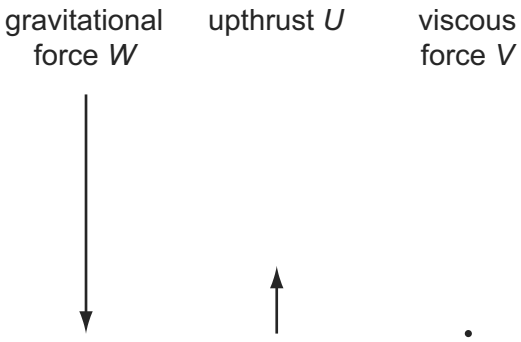


D



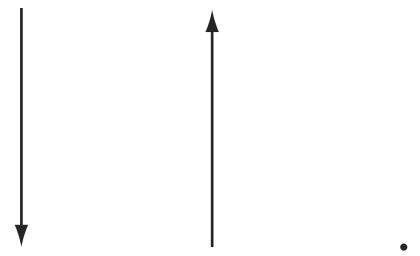
15 A hailstone, initially stationary at the base of a cloud, falls vertically towards the Earth. The diagram shows the magnitudes and directions of the forces acting on the hailstone as it starts to drop.

9702/13/O/N/12

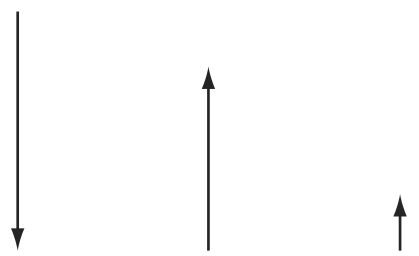


Which diagram shows the magnitudes and directions of these forces when the hailstone attains a terminal (constant) speed in the air (of uniform density)?

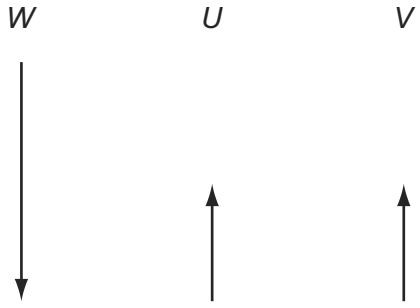
A



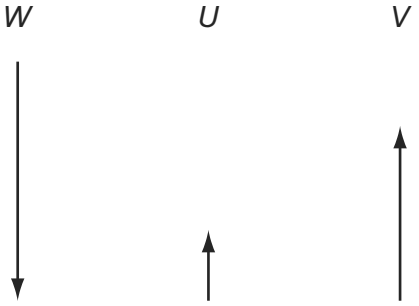
B



C



D



18 A car travelling with speed $28\,m\,s^{-1}$ leaves a motorway on an exit road. The end of the exit road is 22 m higher than the motorway.

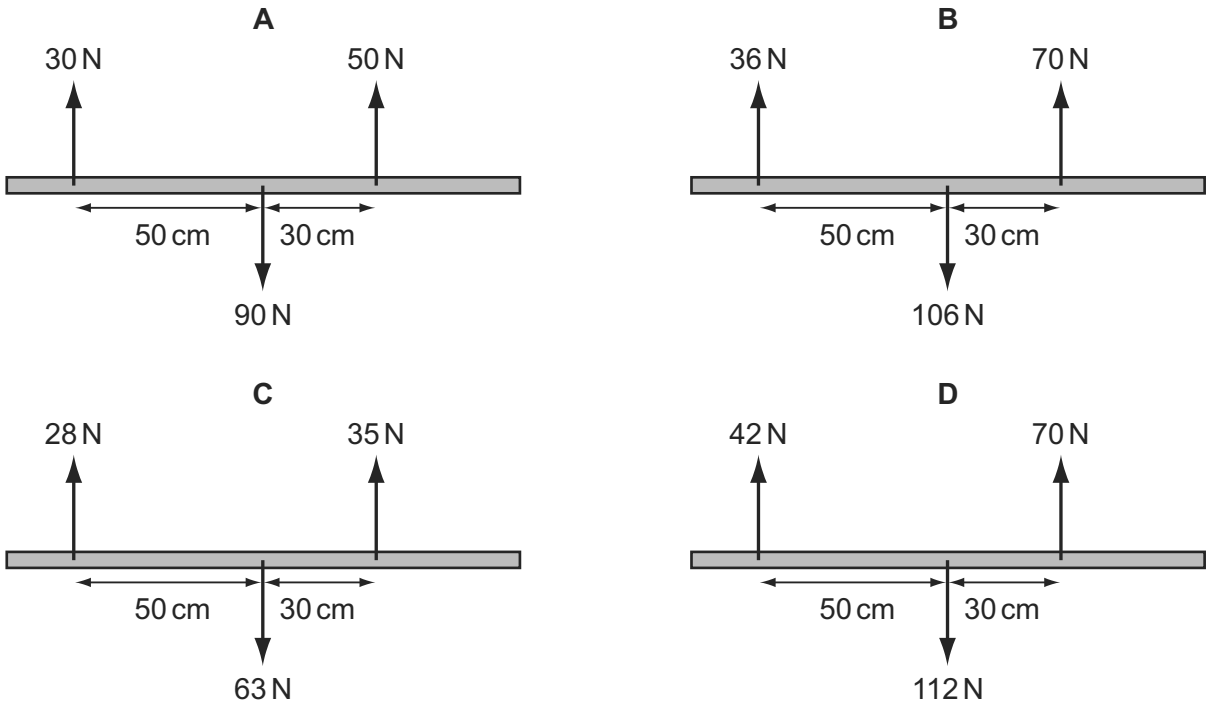
9702/13/O/N/12

If only the force of gravity is considered, what will be the speed of the car at the end of the exit road?

A $7.3\,m\,s^{-1}$ **B** $19\,m\,s^{-1}$ **C** $21\,m\,s^{-1}$ **D** $24\,m\,s^{-1}$

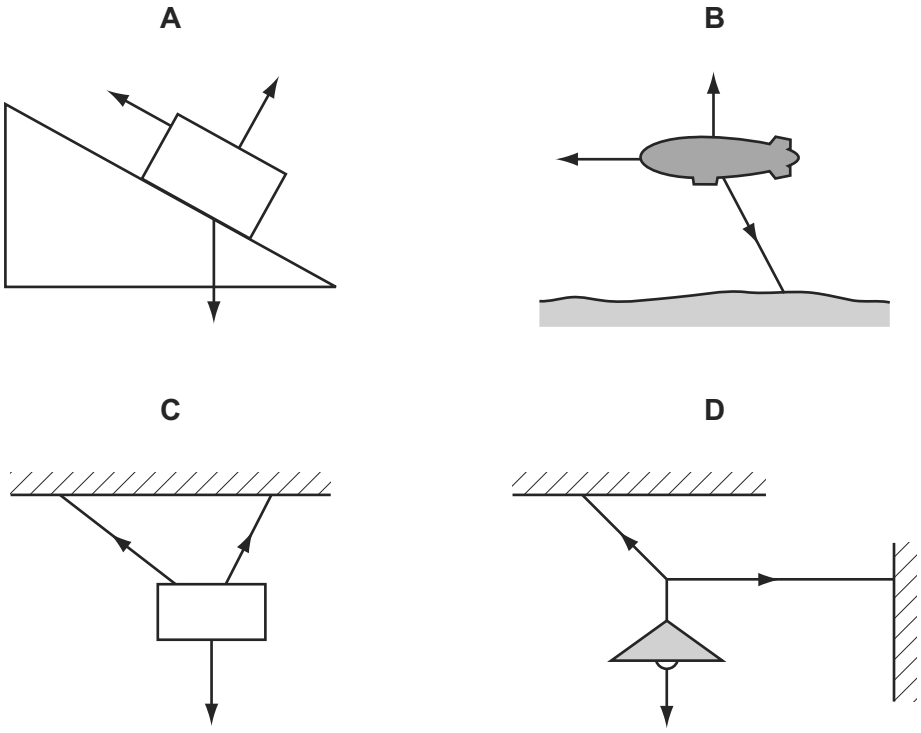
16 Four beams of the same length each have three forces acting on them. 9702/13/O/N/12

Which beam has both zero resultant force and zero resultant torque acting?

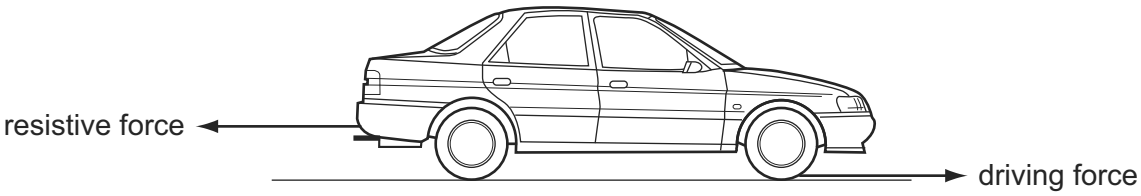


17 The diagrams show the forces acting on different bodies. 9702/13/O/N/12

Which body **cannot** be in equilibrium?



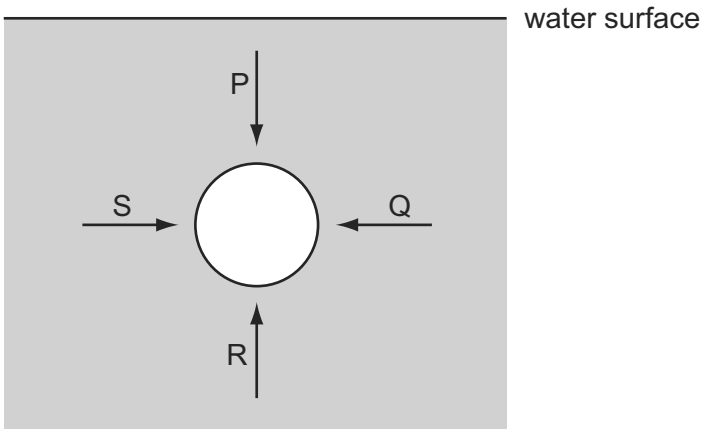
12 A car of mass 750 kg has a horizontal driving force of 2.0 kN acting on it. It has a forward horizontal acceleration of 2.0 m s^{-2}. 9702/11/M/J/13



What is the resistive force acting horizontally?

A 0.50 kN **B** 1.5 kN **C** 2.0 kN **D** 3.5 kN

15 The diagram represents a sphere under water. P, Q, R and S are forces acting on the sphere, due to the pressure of the water. 9702/11/M/J/13



Each force acts perpendicularly to the sphere's surface. P and R act in opposite directions vertically. Q and S act in opposite directions horizontally.

Which information about the magnitudes of the forces is correct?

A $P < R$ and $S = Q$

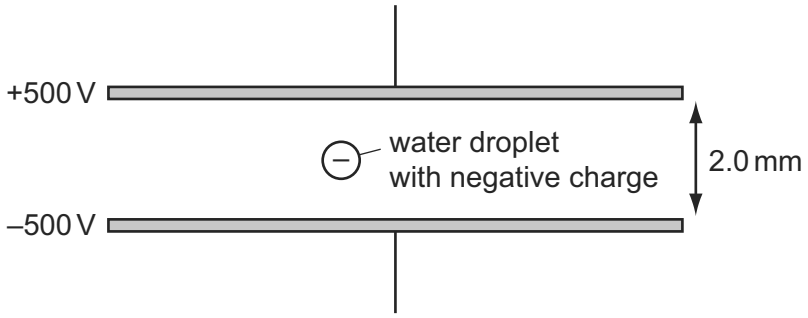
B $P > R$ and $S = Q$

C $P = R$ and $S = Q$ and $P \neq S$

D $P = R$ and $S = Q$ and $P = S$

13 A small water droplet of mass 3.0 μg carries a charge of -6.0×10^{-11} C. The droplet is situated in the Earth's gravitational field between two horizontal metal plates. The potential of the upper plate is +500 V and the potential of the lower plate is –500 V.

9702/11/M/J/13



What is the motion of the droplet?

A It accelerates downwards.

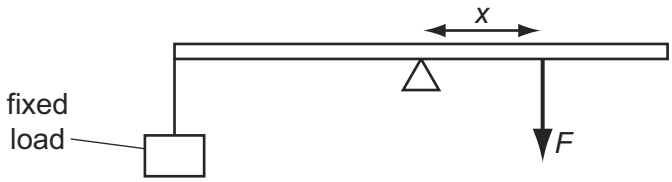
B It remains stationary.

C It accelerates upwards.

D It moves upwards at a constant velocity.

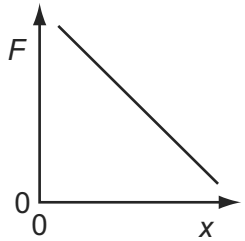
14 A horizontal bar is supported on a pivot at its centre of gravity. A fixed load is attached to one end of the bar. To keep the bar in equilibrium, a force *F* is applied at a distance *x* from the pivot.

9702/11/M/J/13

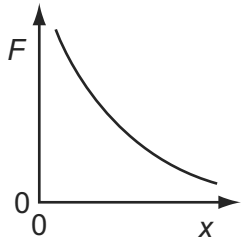


How does *F* vary with *x*?

A



B



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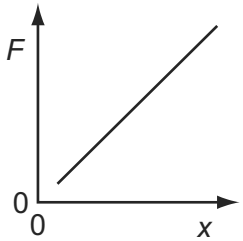
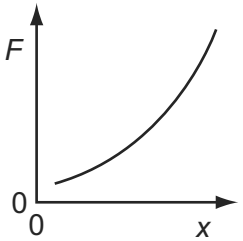
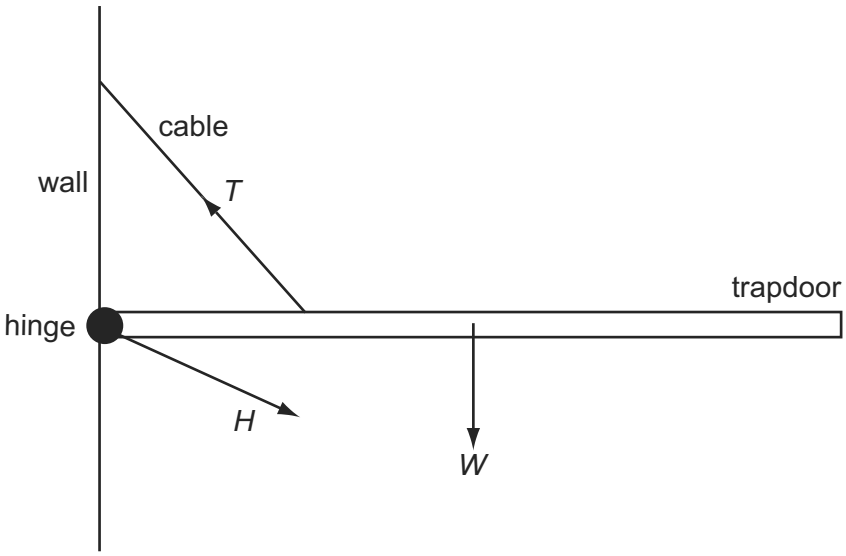


D



16 A hinged trapdoor is held closed in the horizontal position by a cable. 9702/11/M/J/13

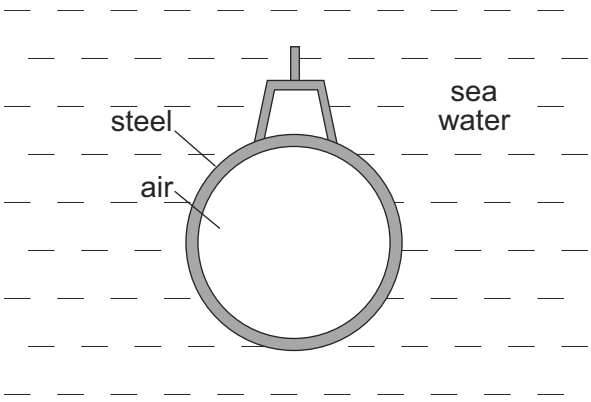
Three forces act on the trapdoor: the weight *W* of the door, the tension *T* in the cable and the force *H* at the hinge.



Which list gives the three forces in **increasing** order of magnitude?

A *H*,*T*,*W** **B** *T*,*H*,*W** **C** *W*,*H*,*T** **D** *W*,*T*,*H*

11 A submarine is in equilibrium in a fully submerged position. 9702/12/M/J/13



What causes the upthrust on the submarine?

A The air in the submarine is less dense than sea water.

B The sea water exerts a greater upward force on the submarine than the weight of the steel.

C The submarine displaces its own volume of sea water.

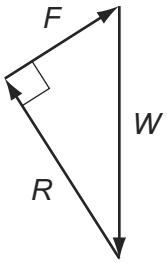
D There is a difference in water pressure acting on the top and on the bottom of the submarine.

12 A vehicle is at rest on a slope. It is considered to have three forces acting on it to keep it in equilibrium. 9702/12/M/J/13

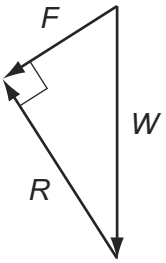
They are its weight *W*, a normal reaction force *R* and a frictional force *F*.

Which triangle of forces is correct?

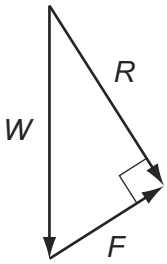
A



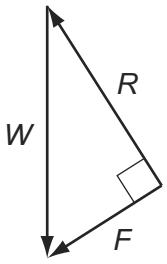
B



C



D



13 All external forces on a body cancel out. 9702/12/M/J/13

Which statement **must** be correct?

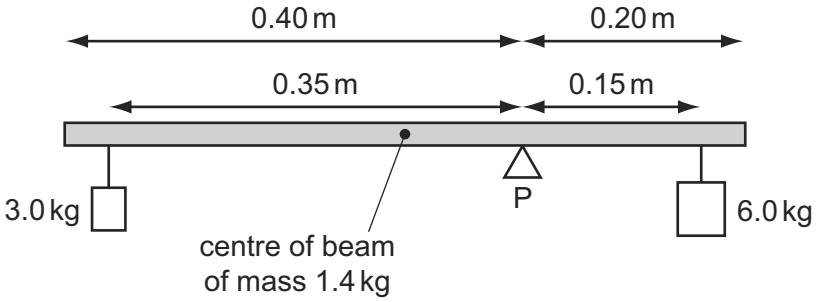
A The body does not move.

B The momentum of the body remains unchanged.

C The speed of the body remains unchanged.

D The total energy (kinetic and potential) of the body remains unchanged.

14 A uniform beam of mass 1.4 kg is pivoted at P as shown. The beam has a length of 0.60 m and P is 0.20 m from one end. Loads of 3.0 kg and 6.0 kg are suspended 0.35 m and 0.15 m from the pivot as shown. 9702/12/M/J/13

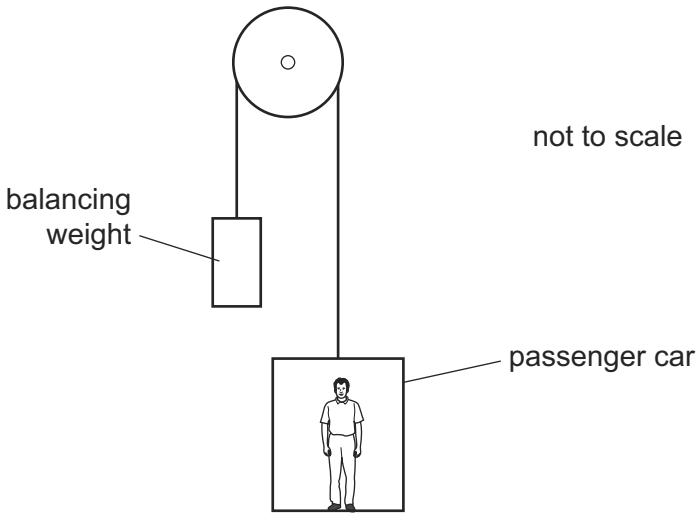


What torque must be applied to the beam in order to maintain it in equilibrium?

A 0.010 N m **B** 0.10 N m **C** 0.29 N m **D** 2.8 N m

9 A lift (elevator) consists of a passenger car supported by a cable which runs over a light, frictionless pulley to a balancing weight. The balancing weight falls as the passenger car rises.

9702/13/M/J/13



Some masses are shown in the table.

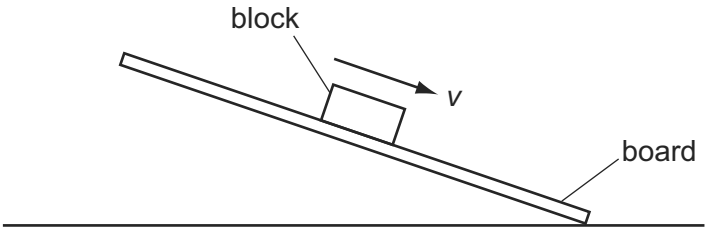
	mass / kg
passenger car	520
balancing weight	640
passenger	80

What is the magnitude of the acceleration of the car when carrying just one passenger and when the pulley is free to rotate?

A $0.032\,m\,s^{-2}$ **B** $0.32\,m\,s^{-2}$ **C** $0.61\,m\,s^{-2}$ **D** $0.65\,m\,s^{-2}$

13 A wooden block rests on a rough board. The end of the board is then raised until the block slides down the plane of the board at constant velocity *v*.

9702/13/M/J/13

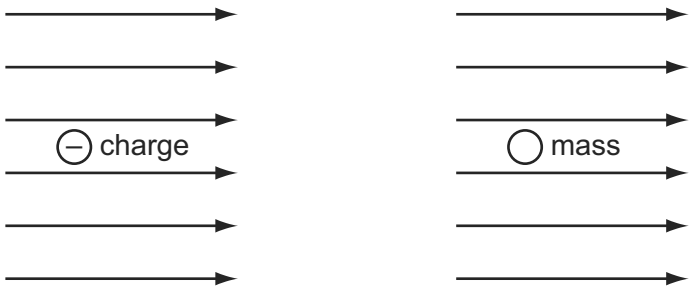


Which row describes the forces acting on the block when sliding with constant velocity?

	frictional force on block	resultant force on block
A	down the plane	down the plane
B	down the plane	zero
C	up the plane	down the plane
D	up the plane	zero

12 The diagrams show a negative electric charge situated in a uniform electric field and a mass situated in a uniform gravitational field.

9702/13/M/J/13



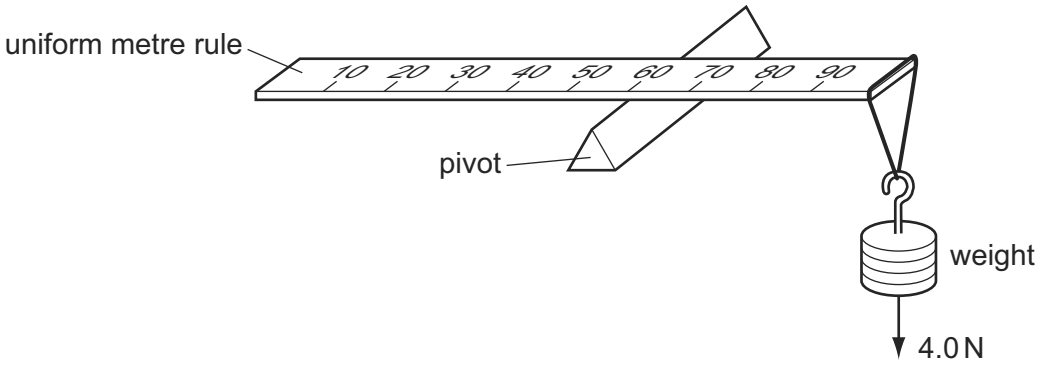
uniform electric field uniform gravitational field

Which row shows the directions of the forces acting on the charge and on the mass?

	charge	mass
A	⊖→	○→
B	←⊖	○→
C	⊖→	○↓
D	←⊖	○↓

15 A uniform metre rule of weight 2.0 N is pivoted at the 60 cm mark. A 4.0 N weight is suspended from one end, causing the rule to rotate about the pivot.

9702/11/O/N/13



At the instant when the rule is horizontal, what is the resultant turning moment about the pivot?

A zero **B** 1.4 N m **C** 1.6 N m **D** 1.8 N m

10 An astronaut of mass m in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad.

9702/11/O/N/13

What is the gravitational force on the astronaut when the spacecraft is launched vertically upwards with an acceleration of $0.2g$?

A $1.2mg$ **B** mg **C** $0.8mg$ **D** 0

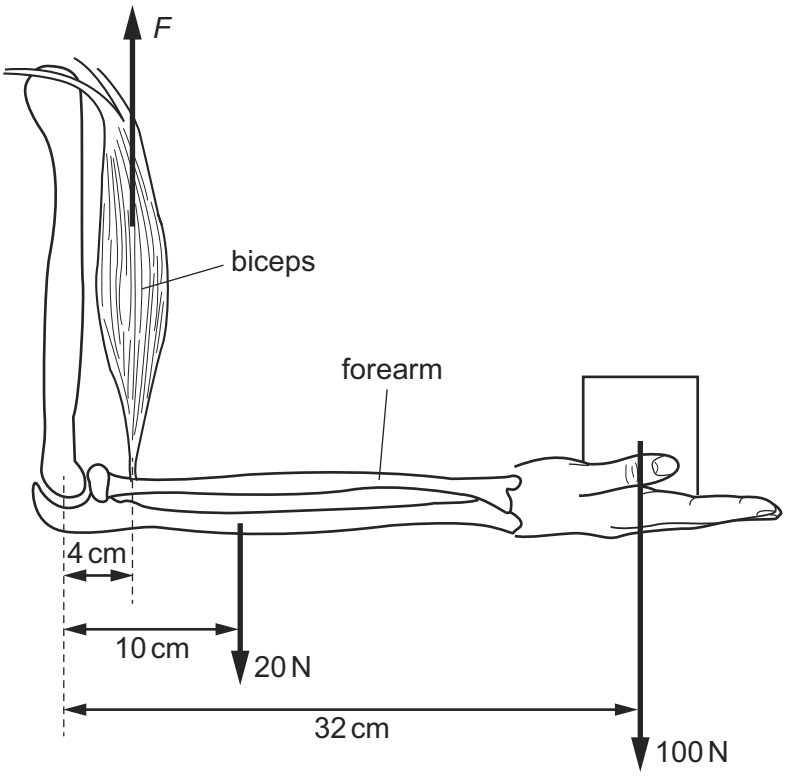
9 What is meant by the mass and by the weight of an object on the Earth?

9702/11/O/N/13

	mass	weight
A	its momentum divided by its velocity	the work done in lifting it one metre
B	the gravitational force on it	the property that resists its acceleration
C	the pull of the Earth on it	its mass divided by the acceleration of free fall
D	the property that resists its acceleration	the pull of the Earth on it

12 A man holds a 100 N load stationary in his hand. The combined weight of the forearm and hand is 20 N. The forearm is held horizontal, as shown.

9702/11/M/J/14



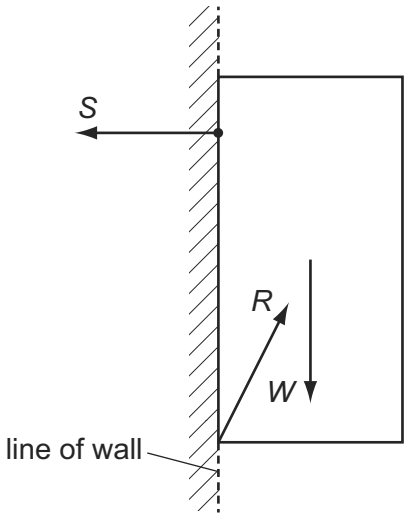
What is the vertical force F needed in the biceps?

A 750 N **B** 800 N **C** 850 N **D** 900 N

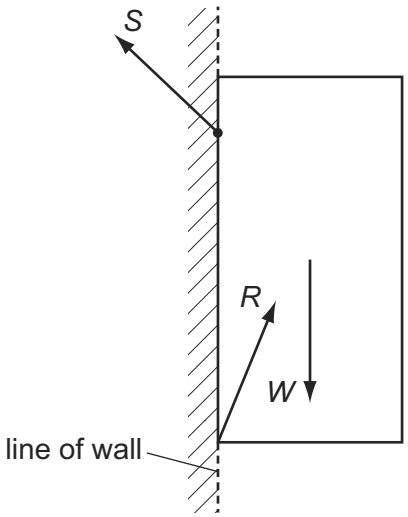
14 A cupboard is attached to a wall by a screw. 9702/13/O/N/13

Which force diagram shows the cupboard in equilibrium, with the weight *W* of the cupboard, the force *S* that the screw exerts on the cupboard and the force *R* that the wall exerts on the cupboard?

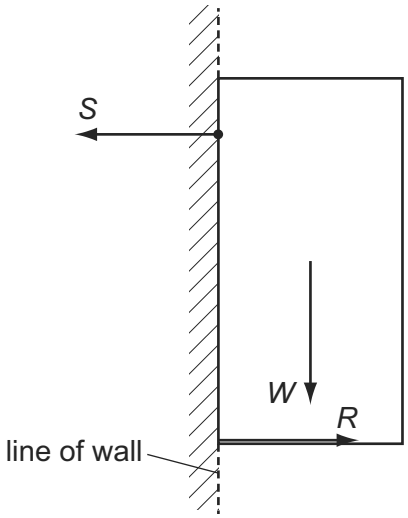
A



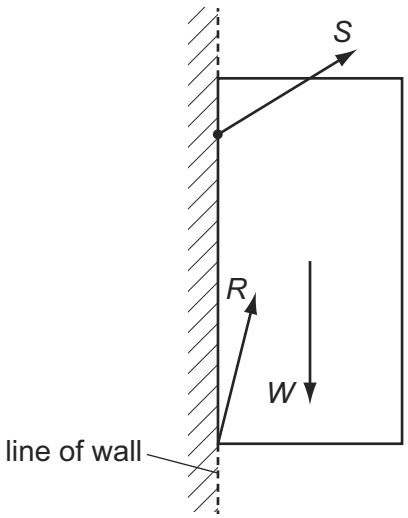
B



C



D



11 The diagrams show two ways of hanging the same picture. 9702/11/M/J/14

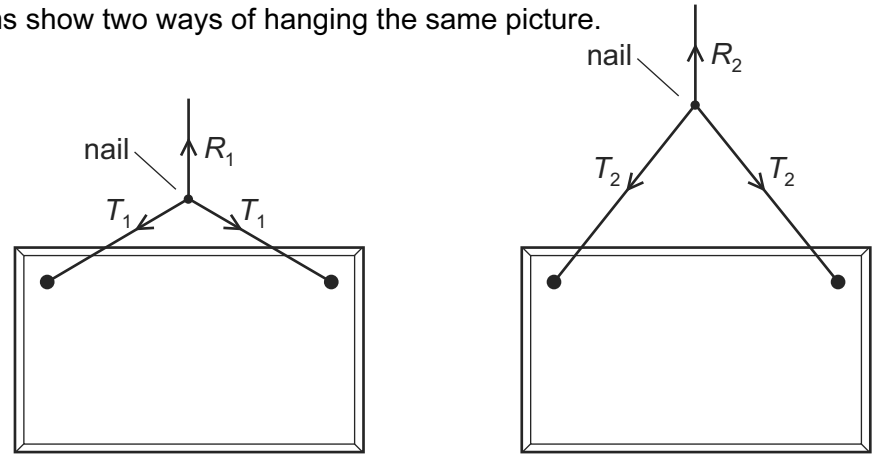


diagram 1 diagram 2

In both cases, a string is attached to the same points on the picture and looped symmetrically over a nail in a wall. The forces shown are those that act on the nail.

In diagram 1, the string loop is shorter than in diagram 2.

Which information about the magnitude of the forces is correct?

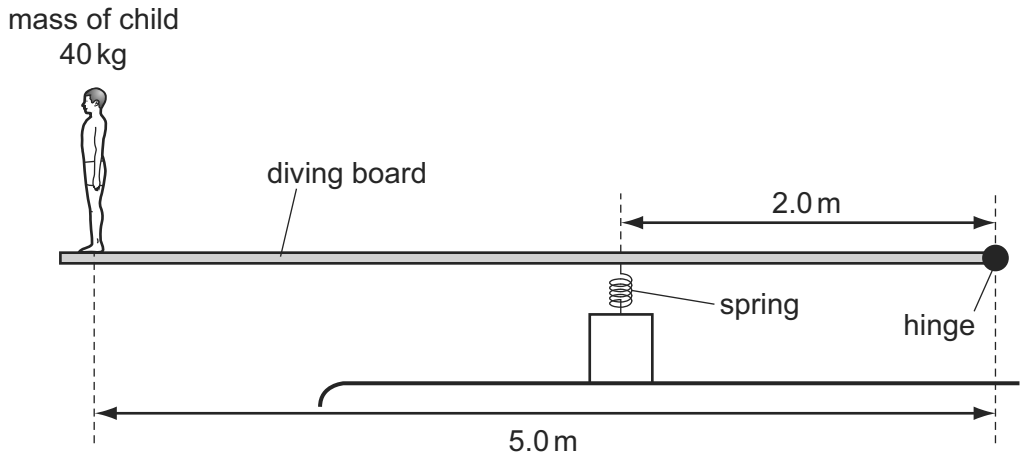
A $R_1 = R_2$ $T_1 = T_2$

B $R_1 = R_2$ $T_1 > T_2$

C $R_1 > R_2$ $T_1 < T_2$

D $R_1 < R_2$ $T_1 = T_2$

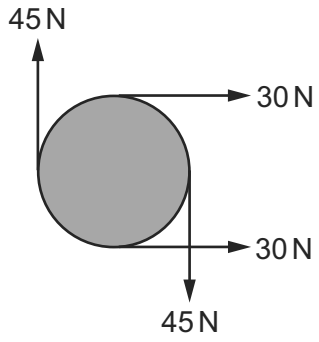
15 A diving board of length 5.0 m is hinged at one end and supported 2.0 m from this end by a spring of spring constant 10 kN m^{-1}. A child of mass 40 kg stands at the far end of the board. 9702/13/O/N/13



What is the extra compression of the spring caused by the child standing on the end of the board?

A 1.0 cm **B** 1.6 cm **C** 9.8 cm **D** 16 cm

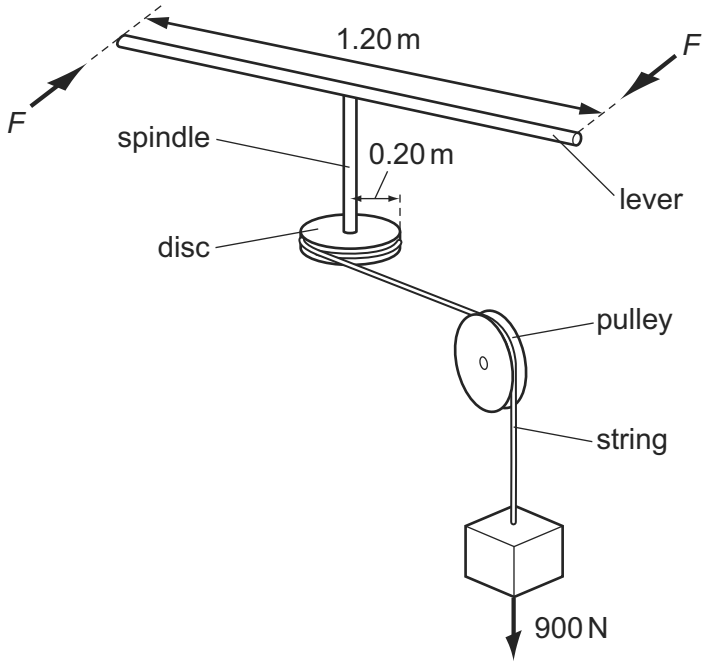
13 The diagram shows four forces applied to a circular object. 9702/12/M/J/14



Which of the following describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	non-zero	non-zero
B	non-zero	zero
C	zero	non-zero
D	zero	zero

13 A spindle is attached at one end to the centre of a lever of length 1.20 m and at its other end to the centre of a disc of radius 0.20 m. A string is wrapped round the disc, passes over a pulley and is attached to a 900 N weight. 9702/11/M/J/14

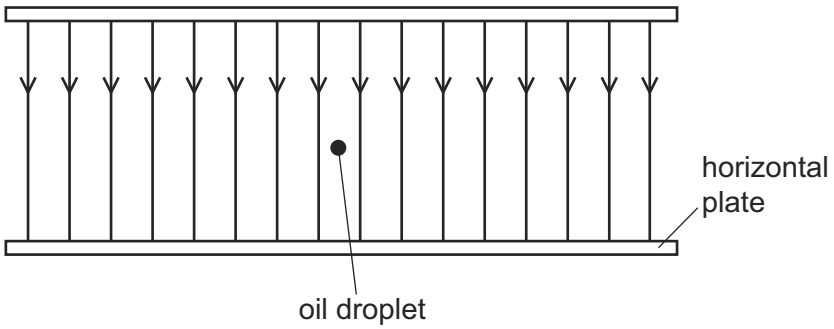


What is the minimum force *F*, applied to each end of the lever, that could lift the weight?

A 75 N **B** 150 N **C** 300 N **D** 950 N

12 A tiny oil droplet with mass 6.9×10^{-13} kg is at rest in an electric field of electric field strength 2.1×10^{7} N C^{-1}, as shown.

9702/12/M/J/14



The weight of the droplet is exactly balanced by the electrical force on the droplet.

What is the charge on the droplet?

A 3.3×10^{-20} C

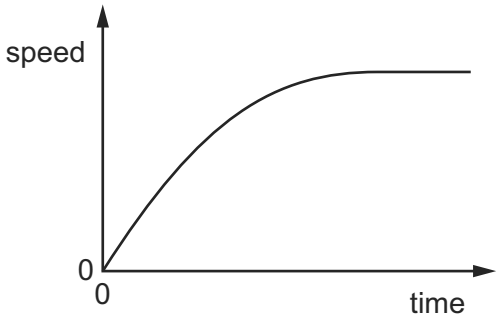
B -3.3×10^{-20} C

C 3.2×10^{-19} C

D -3.2×10^{-19} C

11 The graph shows the variation with time of the speed of a raindrop falling vertically through air.

9702/12/M/J/14



Which statement is correct?

A The acceleration decreases to produce a steady speed.

B The acceleration increases as the speed increases.

C The air resistance decreases as the speed increases.

D The resultant force increases as the speed increases.

13 What is the condition for an object to be in equilibrium? 9702/13/M/J/14

A The object's velocity and the resultant torque on it must both be zero.

B The object's velocity must be zero.

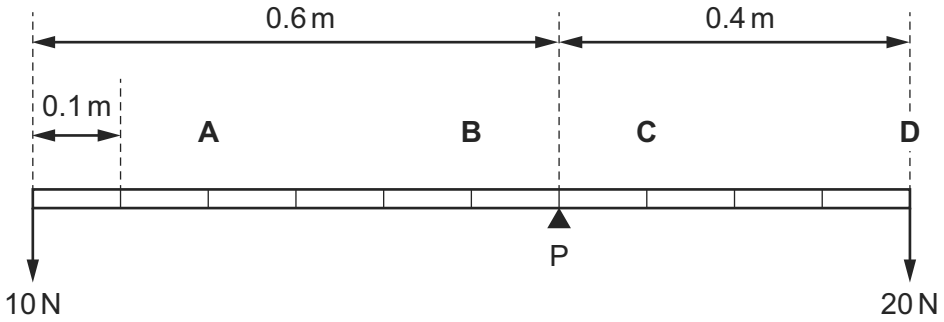
C The resultant force and the resultant torque on the object must both be zero.

D The resultant force on the object must be zero.

15 A uniform beam is pivoted at P as shown. Weights of 10 N and 20 N are attached to its ends.

The length of the beam is marked at 0.1 m intervals. The weight of the beam is 100 N.

At which point should a further weight of 20 N be attached to achieve equilibrium? 9702/13/M/J/14



14 A uniform solid cuboid of concrete of dimensions 0.50 m × 1.20 m × 0.40 m and weight 4000 N rests on a flat surface with the 1.20 m edge vertical as shown in diagram 1. 9702/13/M/J/14

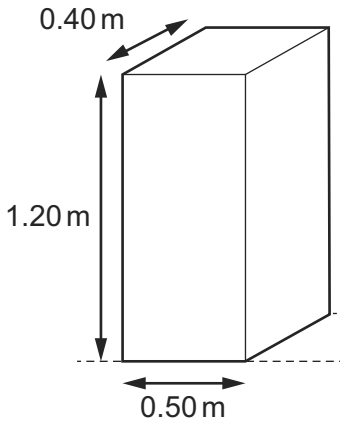


diagram 1

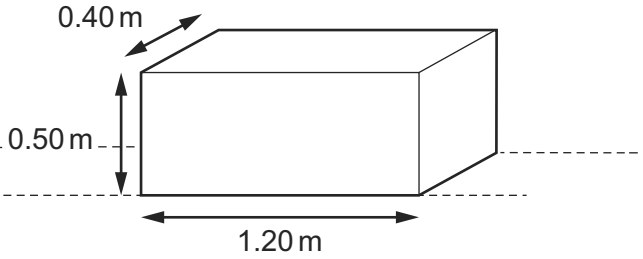


diagram 2

What is the minimum energy required to roll the cuboid through 90° to the position shown in diagram 2 with the 0.50 m edge vertical?

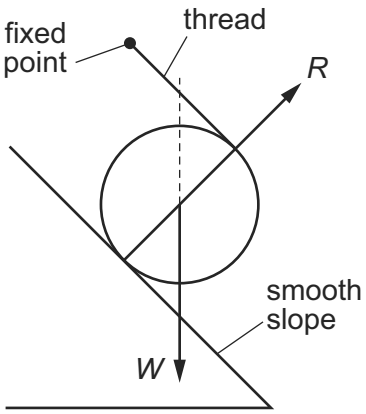
A 200 J **B** 400 J **C** 1400 J **D** 2600 J

13 A cylinder of weight *W* is placed on a smooth slope. The contact force of the slope on the cylinder is *R*. A thread is attached to the surface of the cylinder. The other end of the thread is fixed.

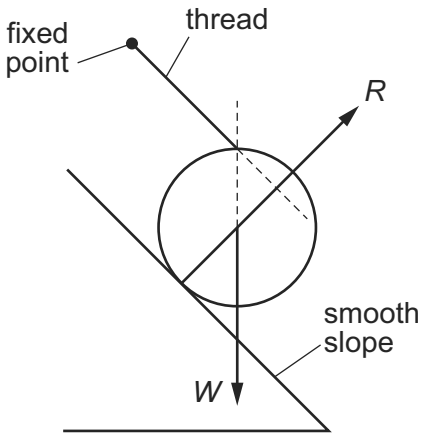
9702/13/O/N/14

Which diagram shows the cylinder in equilibrium?

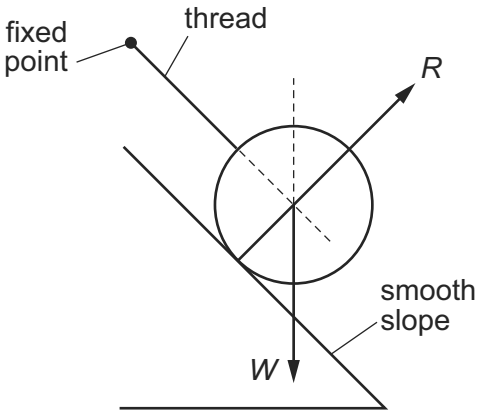
A



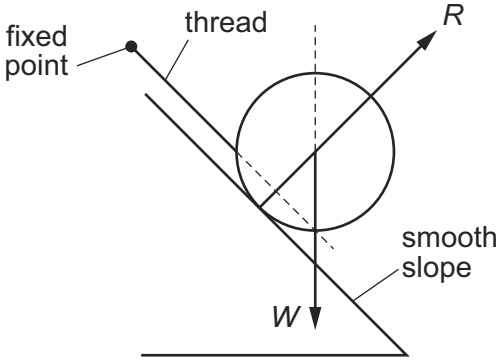
B



C

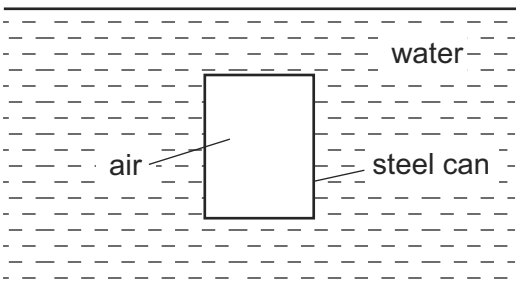


D



12 A sealed cylindrical steel can is situated below the surface of water.

9702/13/O/N/14



What is the origin of the upthrust that acts on the can?

A The air pressure in the can is less than the water pressure outside the can.

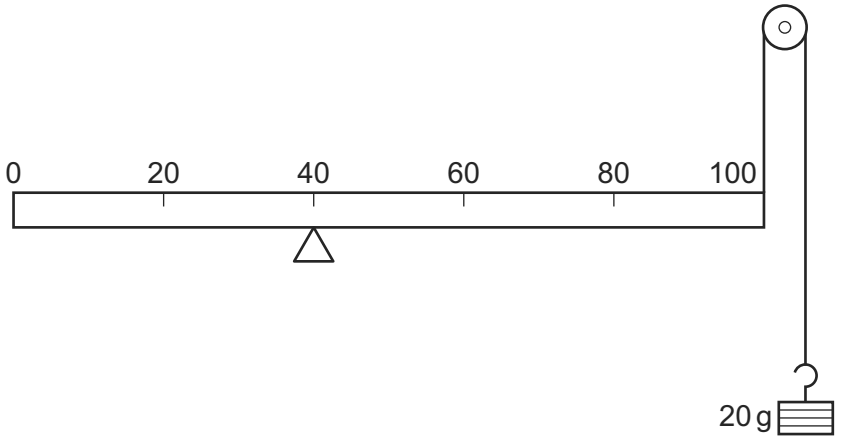
B The average density of the air and steel is less than the density of water.

C The water pressure on the bottom of the can is greater than the water pressure on the top.

D The weight of displaced water acts upwards on the can.

14 A uniform metre rule of mass 100 g is supported by a pivot at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.

9702/13/O/N/14

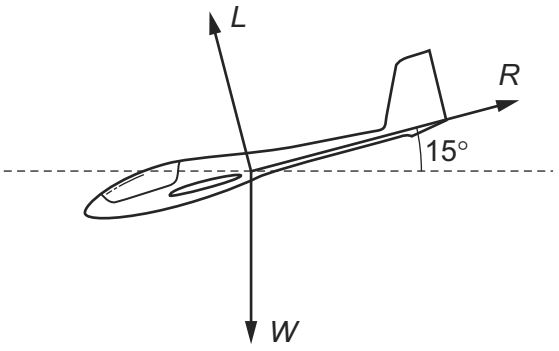


At which mark on the rule must a 50 g mass be suspended so that the rule balances?

A 4 cm **B** 36 cm **C** 44 cm **D** 64 cm

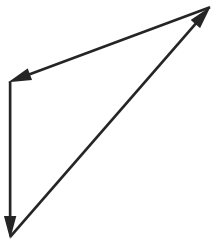
10 A glider is descending at constant speed at an angle of 15° to the horizontal. The diagram shows the directions of the lift *L*, air resistance *R* and weight *W* acting on the glider.

9702/11/O/N/14



Which vector triangle could represent the forces acting on the glider?

A



B

C

D

11 A ball is falling at terminal speed in still air. The forces acting on the ball are upthrust, viscous drag and weight. 9702/11/O/N/14

What is the order of increasing magnitude of these three forces?

A upthrust → viscous drag → weight

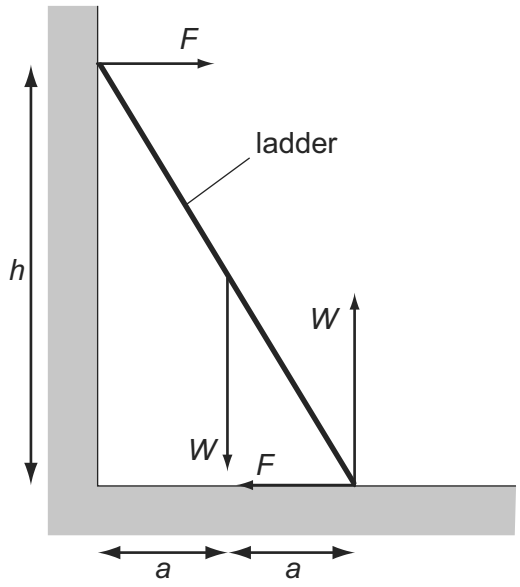
B viscous drag → upthrust → weight

C viscous drag → weight → upthrust

D weight → upthrust → viscous drag

12 A uniform ladder rests against a vertical wall where there is negligible friction. The bottom of the ladder rests on rough ground where there is friction. The top of the ladder is at a height *h* above the ground and the foot of the ladder is at a distance 2*a* from the wall. 9702/11/O/N/14

The diagram shows the forces that act on the ladder.



Which equation is formed by taking moments?

A $Wa + Fh = 2Wa$

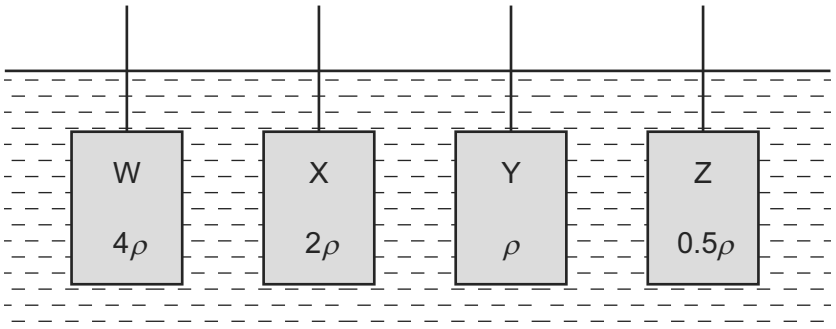
B $Fa + Wa = Fh$

C $Wa + 2Wa = Fh$

D $Wa - 2Wa = 2Fh$

14 Four cuboids with identical length, breadth and height are immersed in water. The cuboids are held at the same depth and in identical orientations by vertical rods, as shown.

9702/13/M/J/15



Water has density ρ.
Cuboid W is made of material of density 4ρ.
Cuboid X is made of material of density 2ρ.
Cuboid Y is made of material of density ρ.
Cuboid Z is made of material of density 0.5ρ.

Which statement is correct?

A The upthrust of the water on each of the cuboids is the same.

B The upthrust of the water on W is twice the upthrust of the water on X.

C The upthrust of the water on X is twice the upthrust of the water on W.

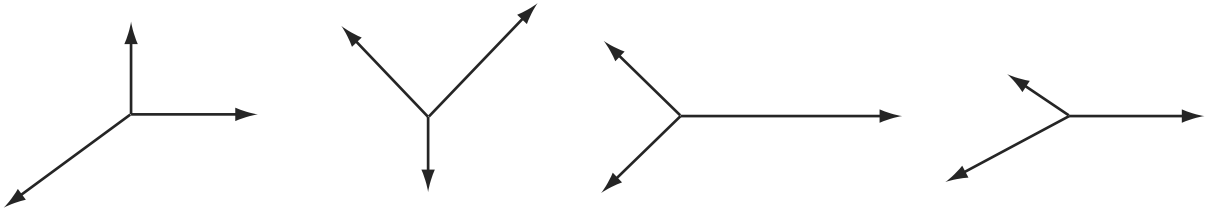
D The upthrust of the water on Y is zero.

16 The diagrams represent systems of coplanar forces acting at a point. The lengths of the force vectors represent the magnitudes of the forces.

9702/13/M/J/15

Which system of forces is in equilibrium?

A **B** **C** **D**



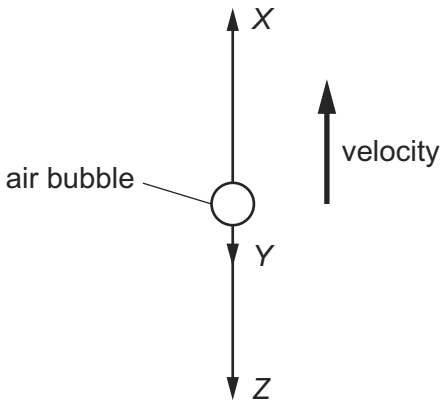
10 What is a reasonable estimate of the average gravitational force acting on a fully grown woman standing on the Earth?

9702/11/M/J/15

A 60 N **B** 250 N **C** 350 N **D** 650 N

15 An air bubble in a tank of water is rising with constant velocity. The forces acting on the bubble are *X*, *Y* and *Z* as shown.

9702/13/M/J/15



What describes the three forces?

A *Z* is the viscous drag on the bubble, *Y* is the weight of the bubble, *X* is the upthrust on the bubble and $X = Y + Z$.

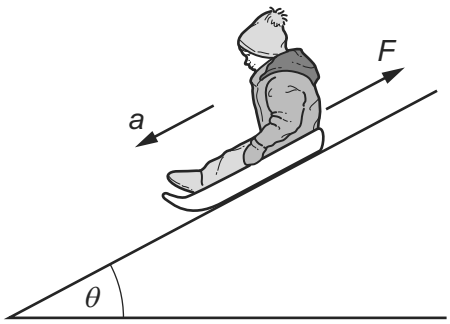
B *Z* is the viscous drag on the bubble, *Y* is the weight of the bubble, *X* is the upthrust on the bubble and $X > Y + Z$.

C *Z* is the weight of the bubble, *Y* is the viscous drag on the bubble, *X* is the upthrust on the bubble and $X = Y + Z$.

D *Z* is the weight of the bubble, *Y* is the viscous drag on the bubble, *X* is the upthrust on the bubble and $X > Y + Z$.

12 A child on a sledge slides down a hill with acceleration *a*. The hill makes an angle θ with the horizontal.

9702/11/M/J/15



The total mass of the child and the sledge is *m*. The acceleration of free fall is *g*.

What is the friction force *F*?

A $m(g\cos\theta - a)$

B $m(g\cos\theta + a)$

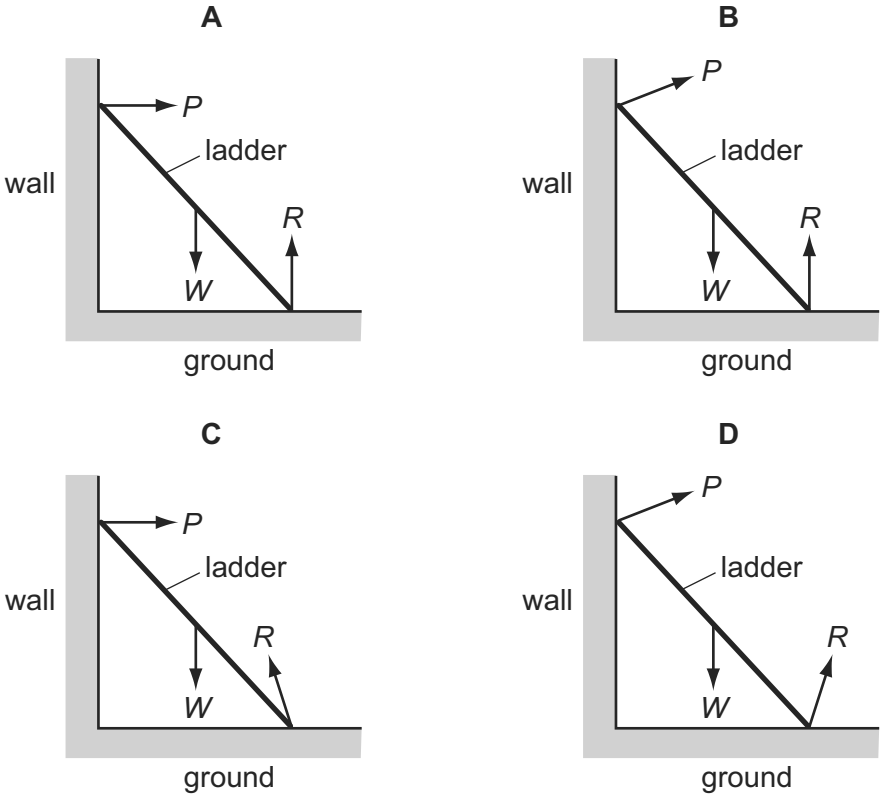
C $m(g\sin\theta - a)$

D $m(g\sin\theta + a)$

14 A ladder is positioned on icy (frictionless) ground and is leant against a rough wall. At the instant of release it begins to slide.

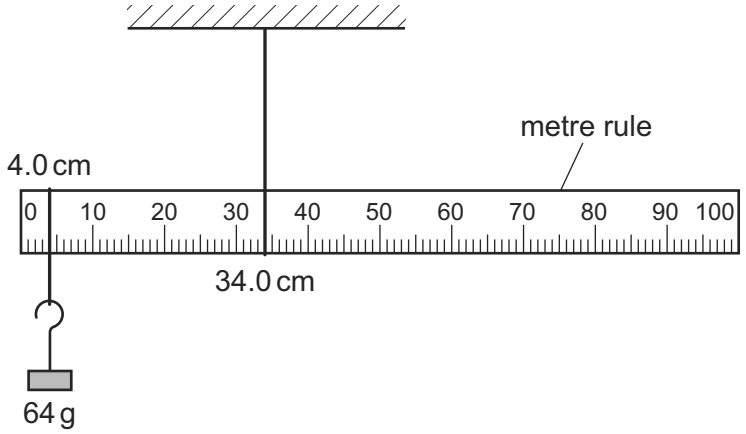
9702/12/M/J/15

Which diagram correctly shows the directions of the forces *P*, *W* and *R* acting on the ladder as it slides?



15 A uniform metre rule is pivoted at the 34.0 cm mark, as shown.

9702/11/M/J/15



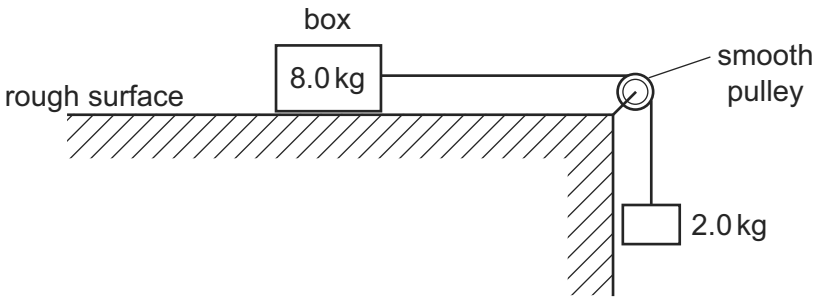
The rule balances when a 64 g mass is hung from the 4.0 cm mark.

What is the mass of the metre rule?

A 38 g **B** 44 g **C** 120 g **D** 136 g

13 A box of mass 8.0 kg rests on a horizontal rough surface. A string attached to the box passes over a smooth pulley and supports a 2.0 kg mass at its other end.

9702/11/M/J/15



When the box is released, a frictional force of 6.0 N acts on it.

What is the acceleration of the box?

A $1.4\,m\,s^{-2}$ **B** $1.7\,m\,s^{-2}$ **C** $2.0\,m\,s^{-2}$ **D** $2.6\,m\,s^{-2}$