Forces, Density and Pressure
(Past Year Topical Questions 2010-2015)

<u>May/June 2010 (11)</u>

14 An object, immersed in a liquid in a tank, experiences an upthrust.

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.

17 Atmospheric pressure at sea level has a value of 100 kPa.
The density of sea water is 1020 kg m^{-3}.

At what depth in the sea would the total pressure be 110 kPa?

    A 1.0 m   B 9.8 m   C 10 m   D 11 m

18 When ice melts, it contracts.

Which row is correct for ice turning into water?

	distance between atoms	density
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

May/June 2010 (12)

12 Forces of 3 N, 4 N and 5 N act at one point on an object. The angles at which the forces act can vary.

What is the value of the **minimum** resultant force of these forces?

A   0

B   between 0 and 2 N

C   2 N

D   between 2 N and 4 N

13 An object, immersed in a liquid in a tank, experiences an upthrust.

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.

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.
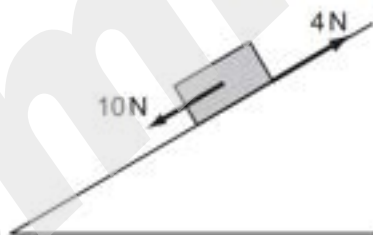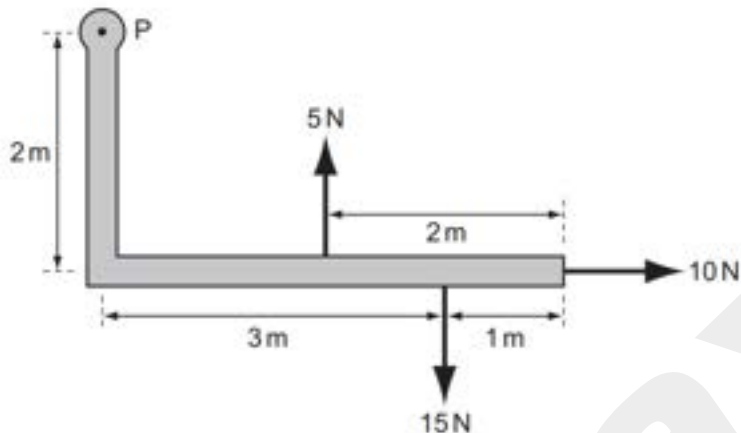

What is the acceleration of the brick down the plane? Assume that the acceleration of free fall g is equal to $10 \, \text{m s}^{-2}$.

A $0.3 \, \text{m s}^{-2}$ B $0.8 \, \text{m s}^{-2}$ C $3.0 \, \text{m s}^{-2}$ D $8.0 \, \text{m s}^{-2}$

2

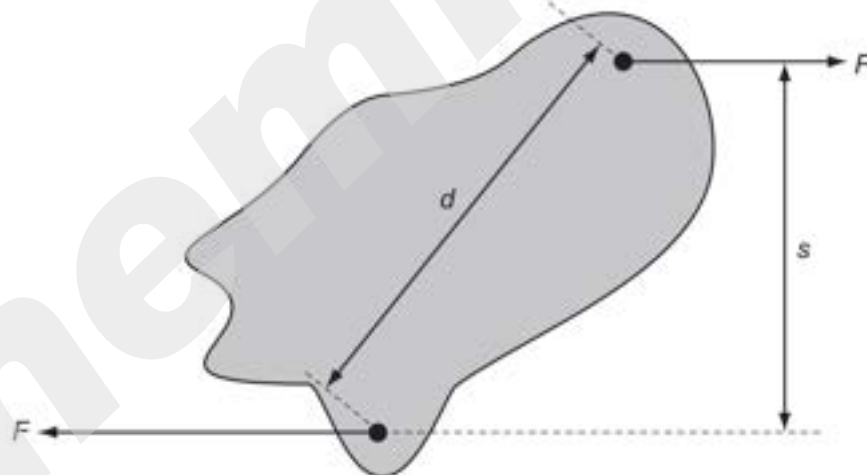**13** A rigid L-shaped lever arm is pivoted at point P.

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

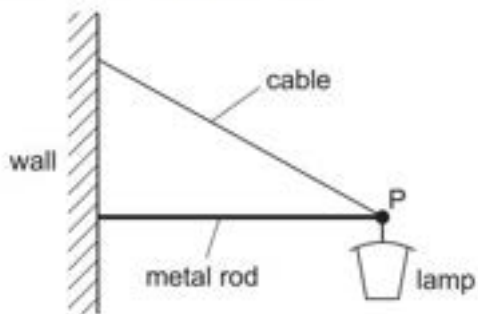**14** Two parallel forces, each of magnitude F, act on a body as shown.

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.

Which vector triangle represents the forces acting at point P?

A

B

C

D
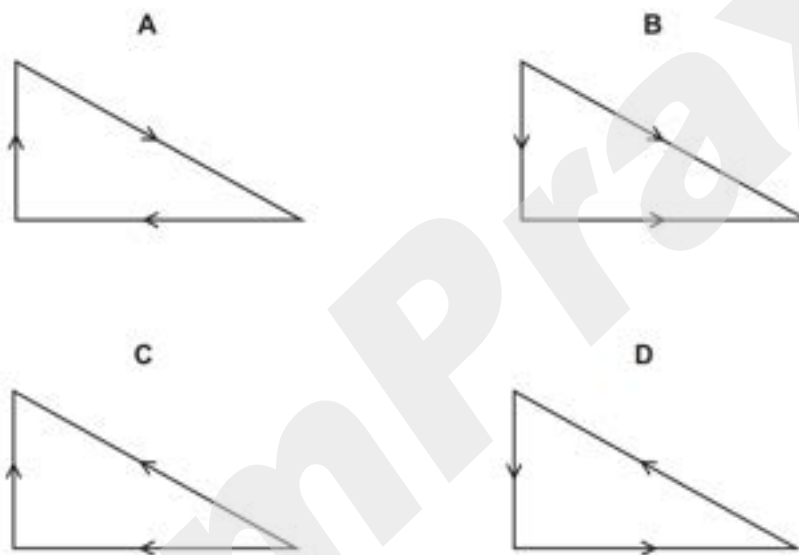
19 The Mariana Trench in the Pacific Ocean has a depth of about 10 km.

Assuming that sea water is incompressible and has a density of about 1020 kg m^{-3}, what would be the approximate pressure at that depth?

A 10^5 Pa   B 10^6 Pa   C 10^7 Pa   D 10^8 Pa

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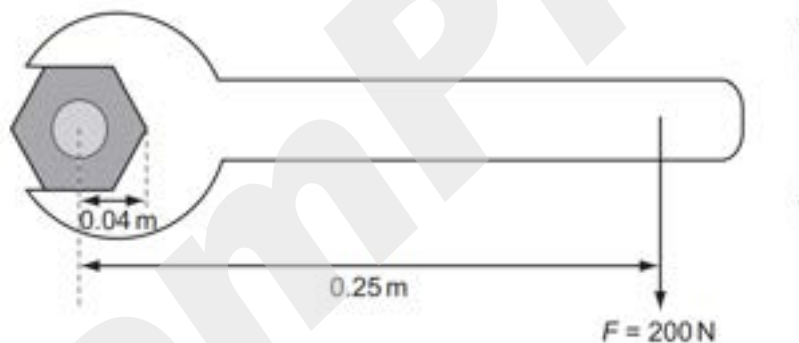
11 The diagram shows a rope bridge that a student makes on an adventure training course. The student has a weight W.
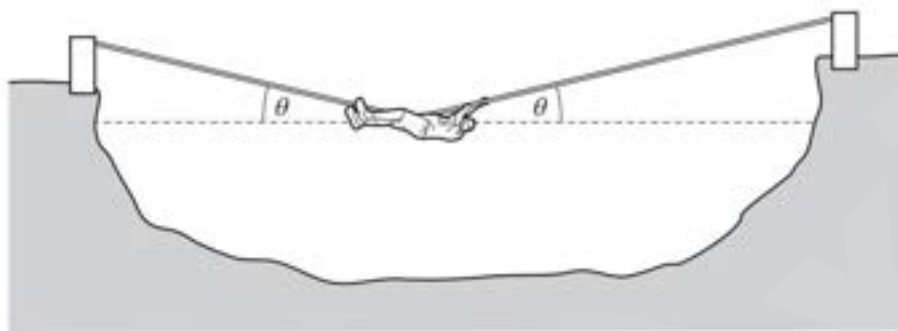
Which formula gives the tension T in the rope?

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

12 A spanner is used to tighten a nut as shown.

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

13 The diagrams show a metal cube suspended from a spring balance before and during immersion in water.

before
immersion
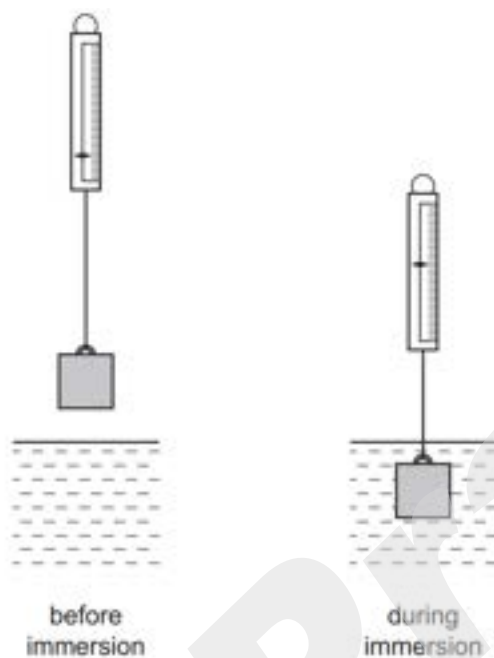
during
immersion

A reduction in the balance reading occurs as a consequence of the immersion.

Which statement is correct?

A   The balance reading will be further reduced if the cube is lowered further into the water.

B   The balance reading during immersion corresponds to the upthrust of the water on the cube.

C   The forces acting on the vertical sides of the cube contribute to the change in the balance reading.

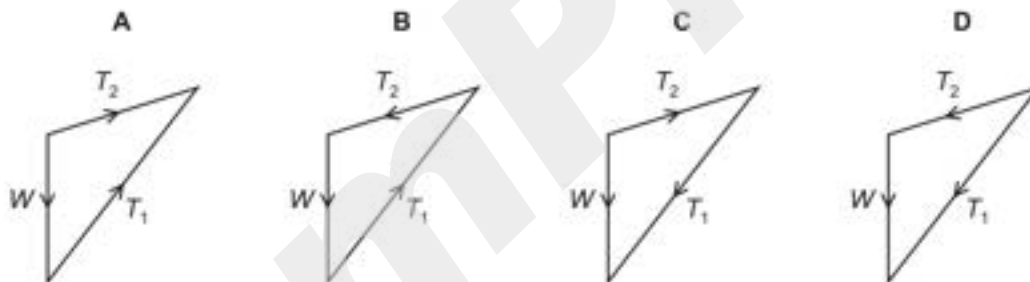D   The gravitational pull on the cube is unchanged by the immersion.

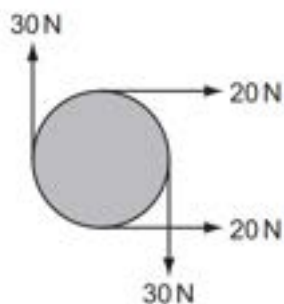11 A cable car of weight W hangs in equilibrium from its cable at point P.

The cable has tensions T_1 and T_2 as shown.
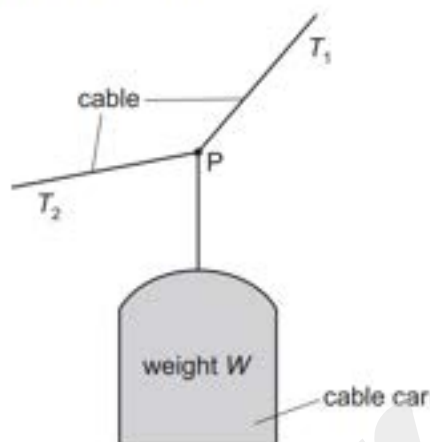
Which diagram correctly represents the forces acting at point P?

12 The diagram shows four forces applied to a circular object.

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

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.
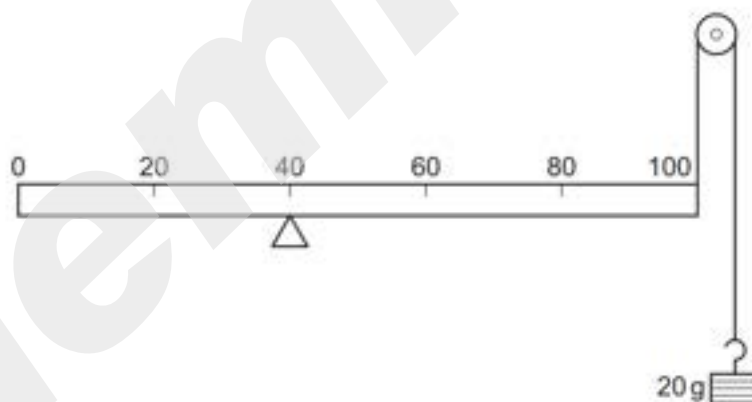
At which mark on the rule must a 50 g mass be suspended so that the rule balances?
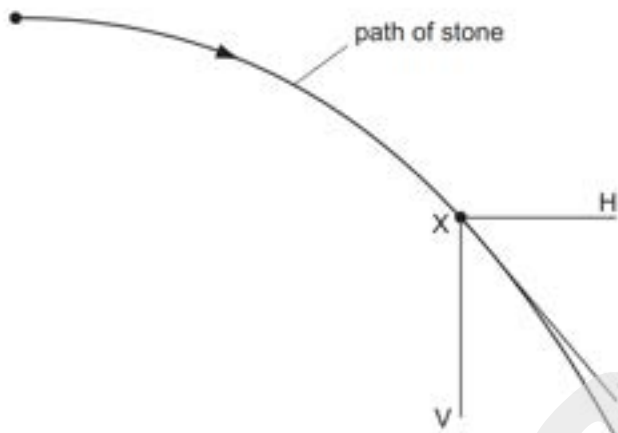
A 4 cm   B 36 cm   C 44 cm   D 64 cm

19 1.5 m³ of water is mixed with 0.50 m³ of alcohol. The density of water is 1000 kg m⁻³ and the density of alcohol is 800 kg m⁻³.

What is the density of the mixture with volume 2.0 m³?

A 850 kg m⁻³   B 900 kg m⁻³   C 940 kg m⁻³   D 950 kg m⁻³

14 A stone is projected horizontally in a vacuum and moves along the path shown.


X is a point on this path. XV and XH are vertical and horizontal lines respectively through X. XT is the tangent to the path at X.

Along which directions do forces act on the stone at X?

A XV only   **B** XH only   **C** XV and XH   **D** XT only

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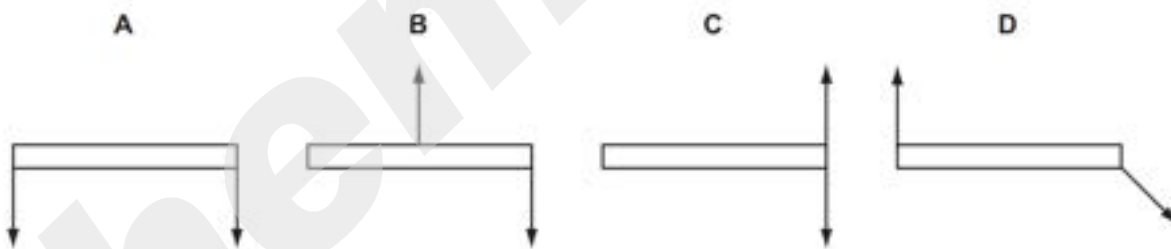
16 A uniform rod XY of weight 10.0 N is freely hinged to a wall at X. It is held horizontal by a force *F* acting from Y at an angle of 30° to the horizontal, as shown.
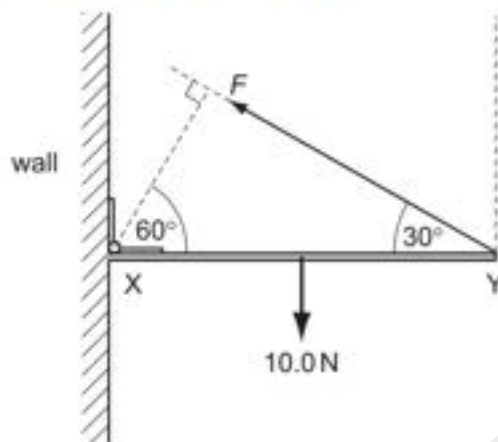
What is the value of *F*?

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

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.
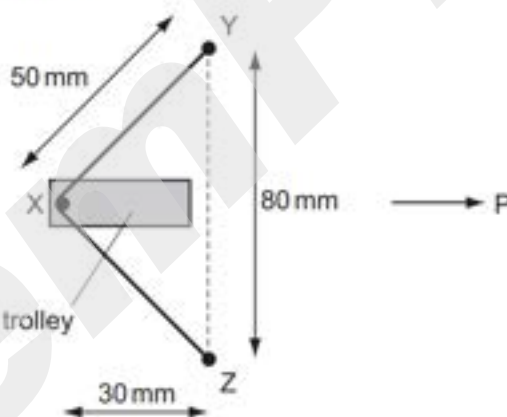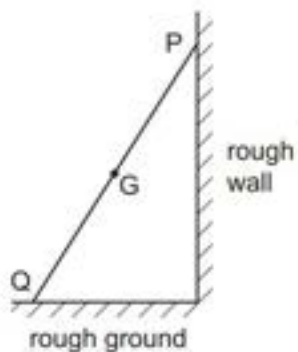

X is at the centre of the elastic and the trolley is to be propelled in the direction P at right angles to YZ. The tension in the elastic is 4 N.

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

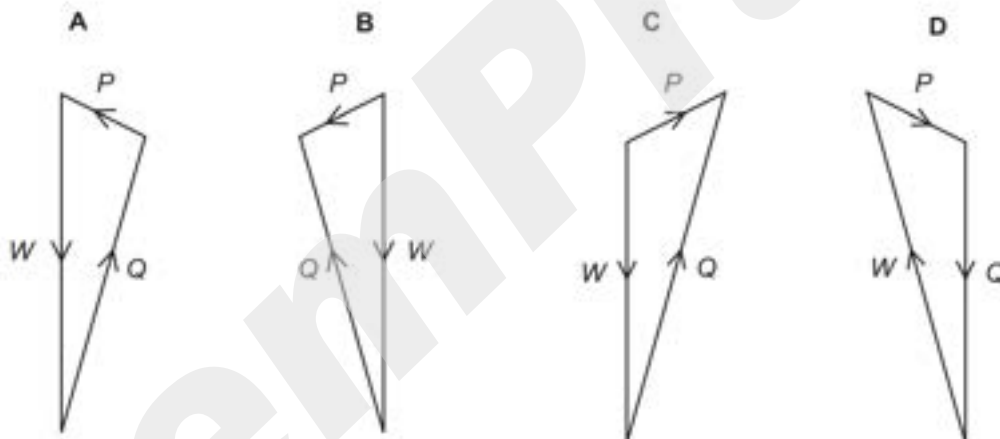A   2.4 N   B   3.2 N   C   4.8 N   D   6.4 N

13 A ladder rests in equilibrium on rough ground against a rough wall.
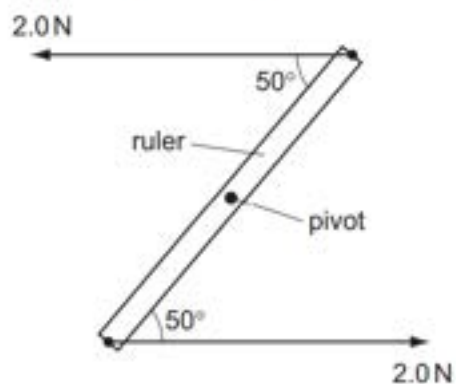

Its weight *W* acts through the centre of gravity G. Forces also act on the ladder at P and at Q. These forces are *P* and *Q* respectively.

Which vector triangle represents the forces on the ladder?

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.

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

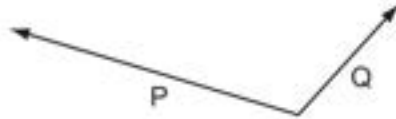15 The diagram shows a child's balancing game.
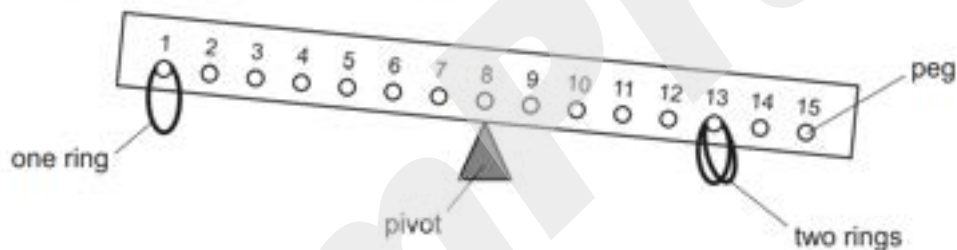
The wooden rod is uniform and all the rings are of equal mass. Two rings are hung on peg 13 and one on peg 1.

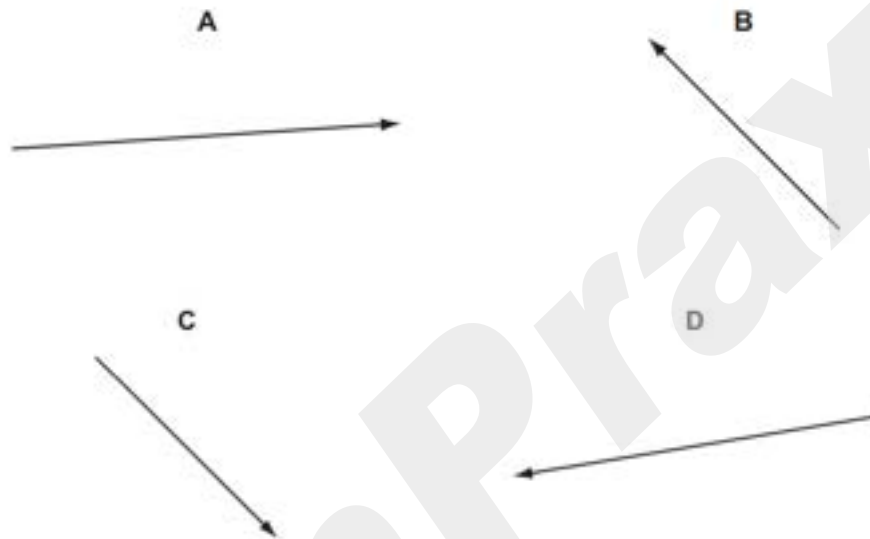On which hook must a fourth ring be hung in order to balance the rod?

A   2   B   3   C   5   D   6

12 Two possible displacements of an object are represented by the vectors P and Q.
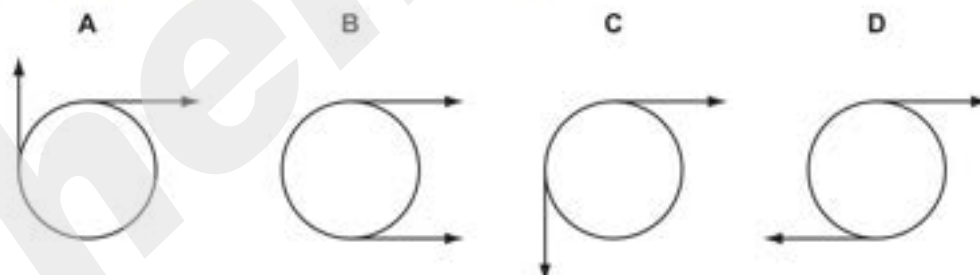

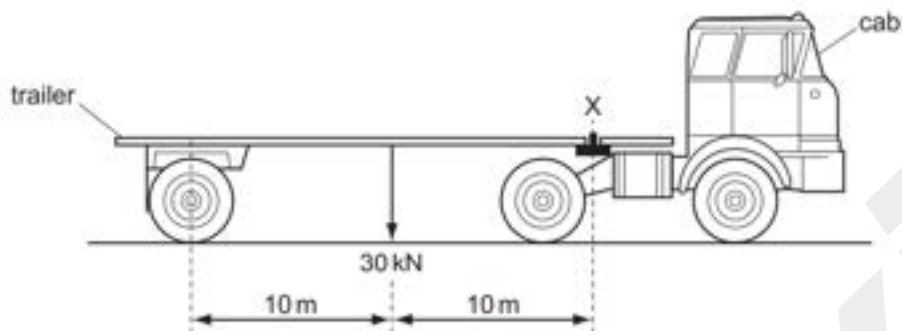Which vector best represents the resultant displacement (P – Q) of the object?

13 Two co-planar forces act on the rim of a wheel. The forces are equal in magnitude.

Which arrangement of forces provides only a couple?

14 A trailer of weight 30 kN is hitched to a cab at X, as shown in the diagram.

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 |

20 A horizontal plate of area 0.036 m² is beneath the surface of a liquid of density 930 kg m⁻³. The force on the plate due to the pressure of the liquid is 290 N.

What is the depth of the plate beneath the surface of the liquid?

| A | 0.88 m | B | 1.13 m | C | 8.7 m | D | 9.1 m |

May/June 2012 (11)

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.

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 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.


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.
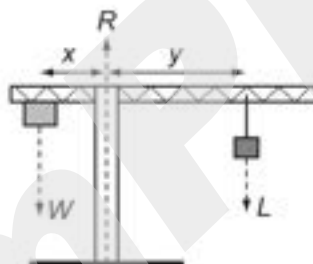
A mass provides a balancing load W. The position of the load is such that the system is perfectly balanced with $Wx = Ly$. The ground provides a reaction force R. The distance x does not change.
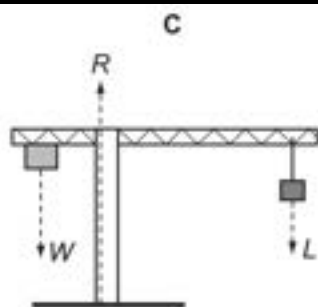
If the load is moved further out so that the distance y increases and the crane does not topple, which statement is correct?
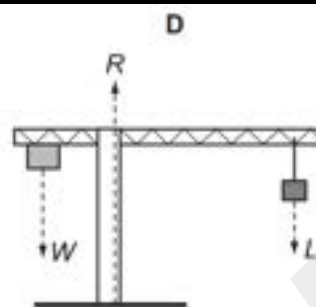
A

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

B
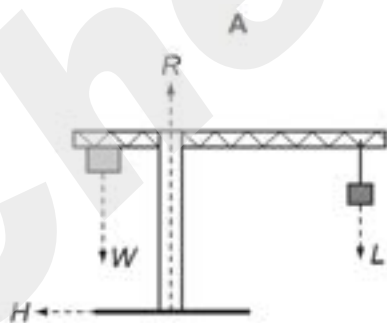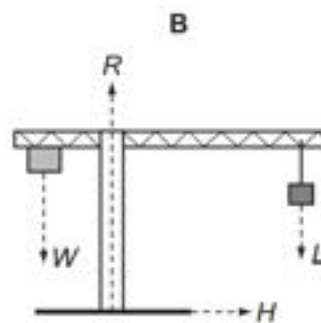
A horizontal force H acts on the base of the support column towards the right.
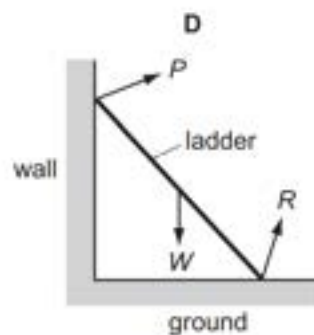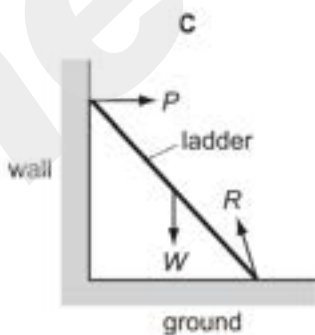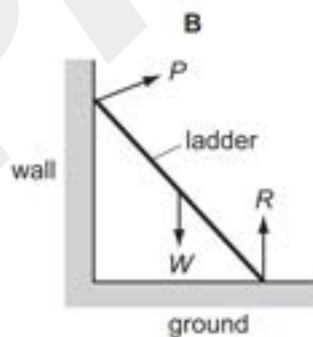
The reaction force R moves to the left.
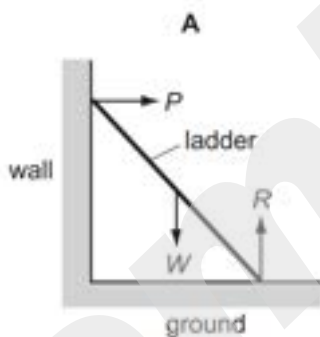

The reaction force R moves to the right.

May/June 2012 (12)

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.

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

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.
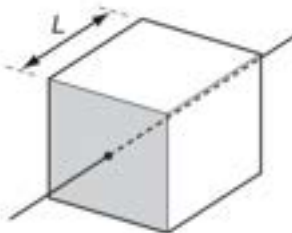
The spindle is now removed and replaced at a distance $\dfrac{L}{4}$ to the right of its original position.
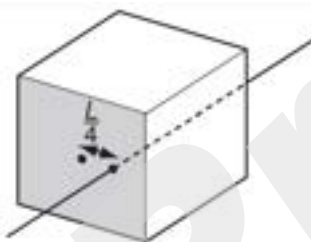
When viewing the shaded face, what is the torque of the couple that will now be needed to stop the cube from toppling?

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

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

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

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

16 A sphere is released from rest in a viscous fluid.

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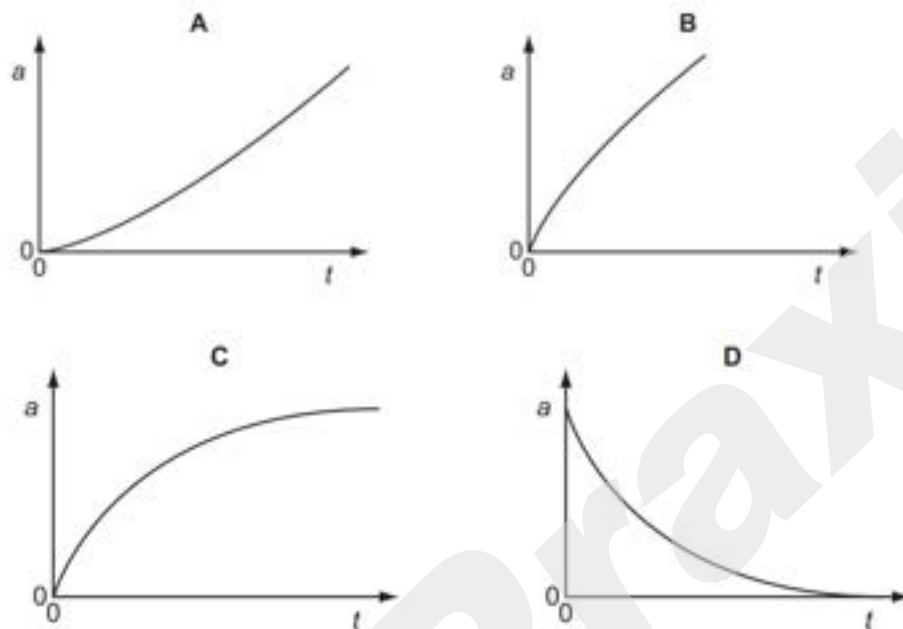

May/June 2012 (13)

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.

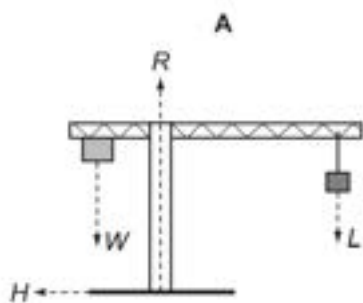14 A cylindrical block of wood has cross-sectional area A and weight W. It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

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.

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 $mg \sin \theta + F$

October/November 2012 (11)

15 The diagram shows an experiment to measure the force exerted on a ball by a horizontal air flow.
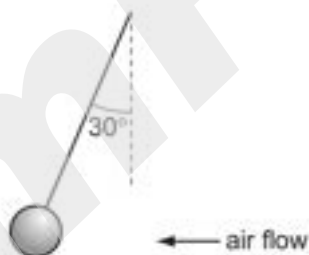
The ball is suspended by a light string and weighs 0.15 N.

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.

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.

Which diagram represents these forces acting on the sledge?
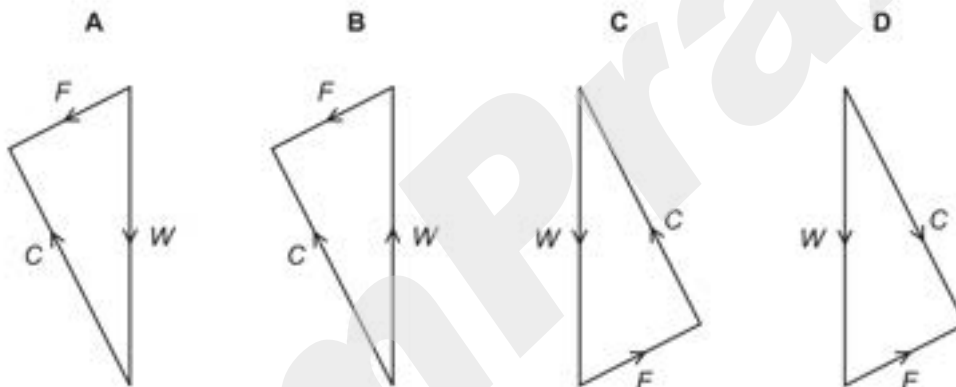
October/November 2012 (12)

14 A 1.2 kg mass is supported by a person's hand and two newton-meters as shown.

weight 12 N
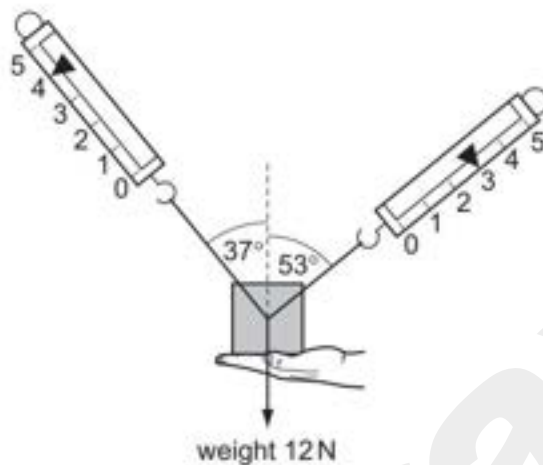
When the person's hand is removed, what is the initial vertical acceleration of the mass?

A $0.6 \, ms^{-2}$ B $2 \, ms^{-2}$ C $4 \, ms^{-2}$ D $6 \, ms^{-2}$

16 A stationary body floats in water.
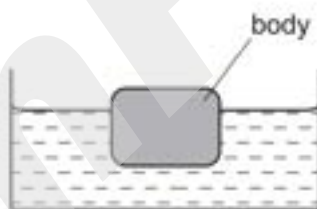
body

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.

17 A rigid uniform beam is pivoted horizontally at its midpoint.

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

In which diagram is the beam in equilibrium?
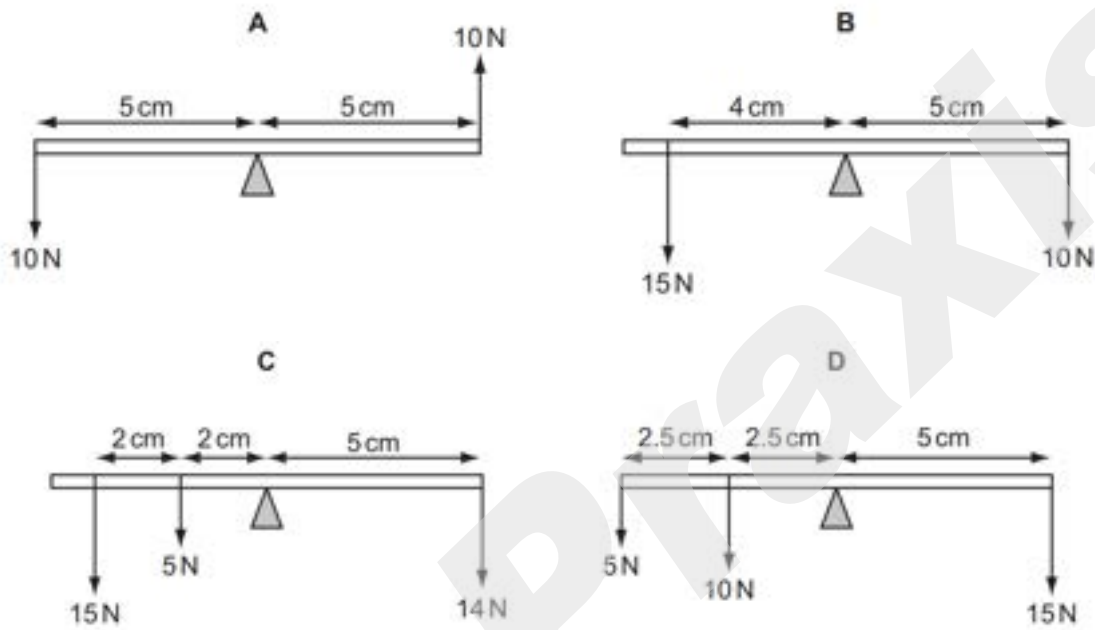
18 A picture on a wall is supported by a wire looped over a nail.

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

13 The IKAROS satellite has mass 320 kg and moves through space using a solar sail of area $20\,m^2$. The average solar wind pressure is $1.0 \times 10^{-5}\,N\,m^{-2}$.

What is the acceleration of the satellite caused by the solar wind?

A $3.1 \times 10^{-8}\,m\,s^{-2}$

B $6.3 \times 10^{-7}\,m\,s^{-2}$

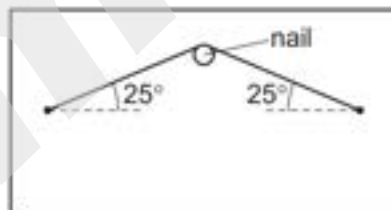**C** $3.2 \times 10^{-3}\,m\,s^{-2}$

D $6.4 \times 10^{-2}\,m\,s^{-2}$

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.

gravitational force W   upthrust U   viscous force V
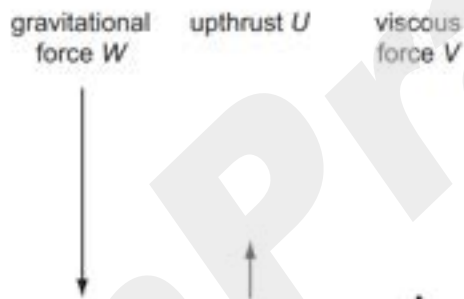
Which diagram shows the magnitudes and directions of these forces when the hailstone attains a terminal (constant) speed in the air (of uniform density)?

A

W   U   V

B

W   U   V

C

W   U   V

D

W   U   V
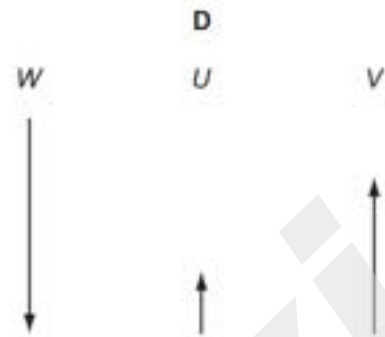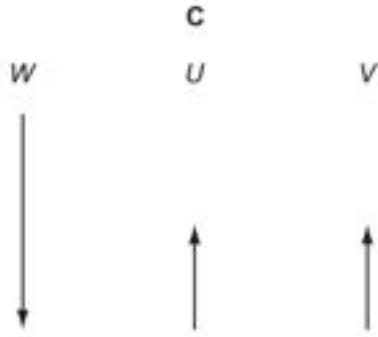
16 Four beams of the same length each have three forces acting on them.

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

A

30 N   50 N

50 cm   30 cm

90 N

B

36 N   70 N

50 cm   30 cm

106 N

C

28 N   35 N

50 cm   30 cm

63 N

D

42 N   70 N

50 cm   30 cm

112 N
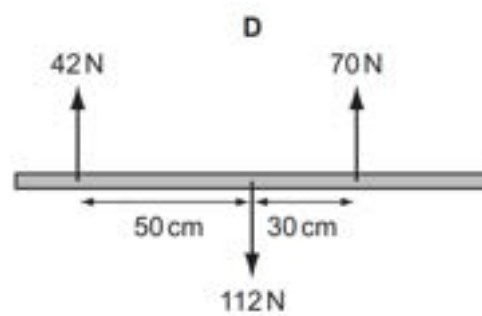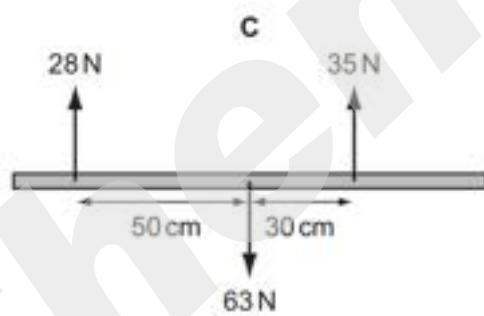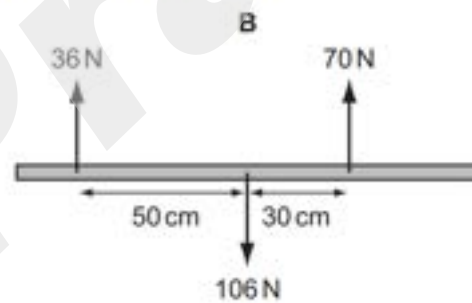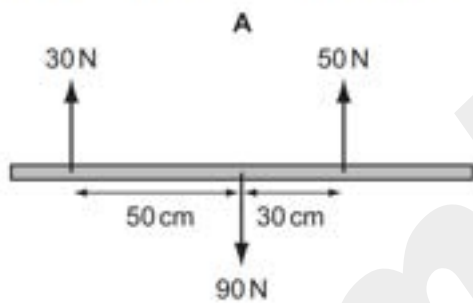
17 The diagrams show the forces acting on different bodies.

Which body **cannot** be in equilibrium?

A

B

C

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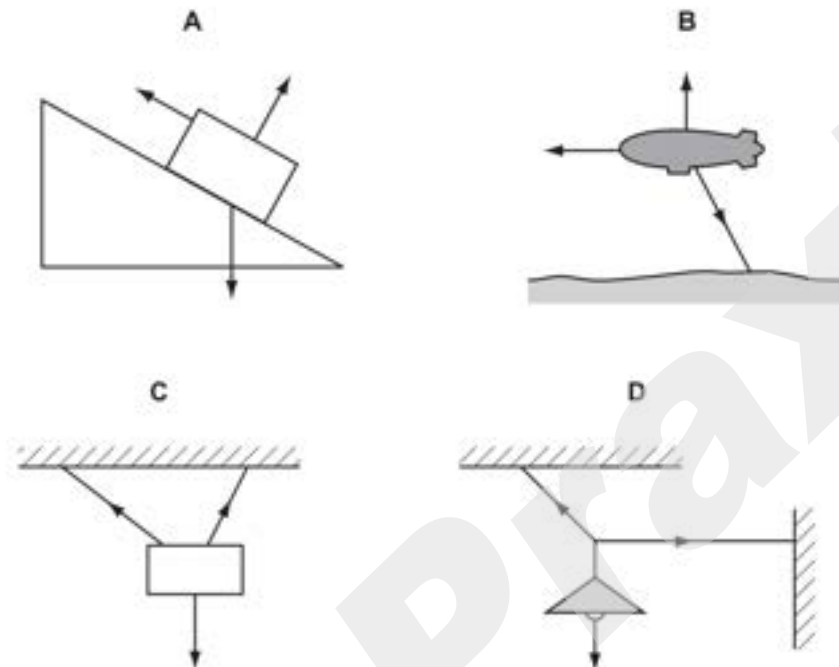
18 A car travelling with speed $28\,m\,s^{-1}$ leaves a motorway on an exit road. The end of the exit road is $22\,m$ higher than the motorway.

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 $24\,m\,s^{-1}$

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 $2.0\,ms^{-2}$.

resistive force ←

→ driving force
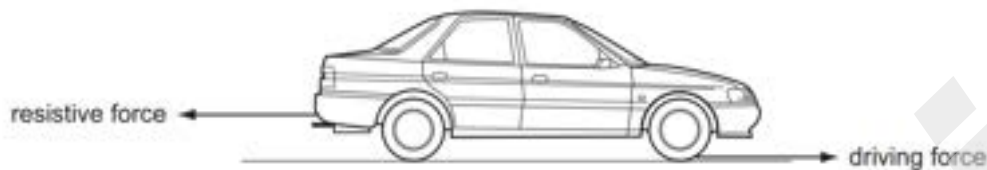
What is the resistive force acting horizontally?

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

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.

fixed load

How does F vary with x?

A   **B**   **C**   **D**
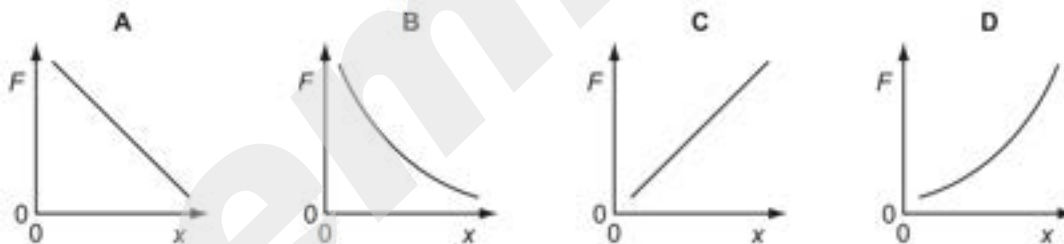
15 The diagram represents a sphere under water. P, Q, R and S are forces acting on the sphere, due to the pressure of the water.
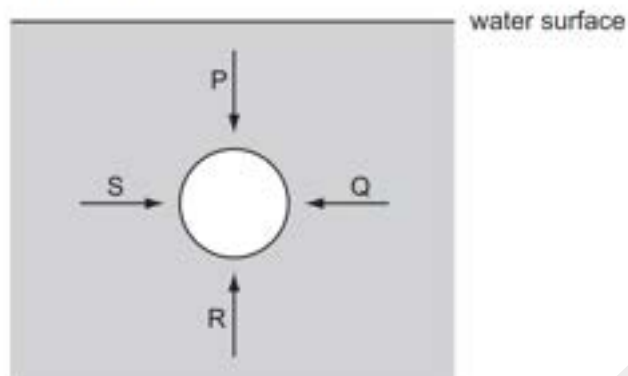
Each force acts perpendicularly to the sphere's surface. P and R act in opposite directions vertically. Q and S act in opposite directions horizontally.

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 $P = S$

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

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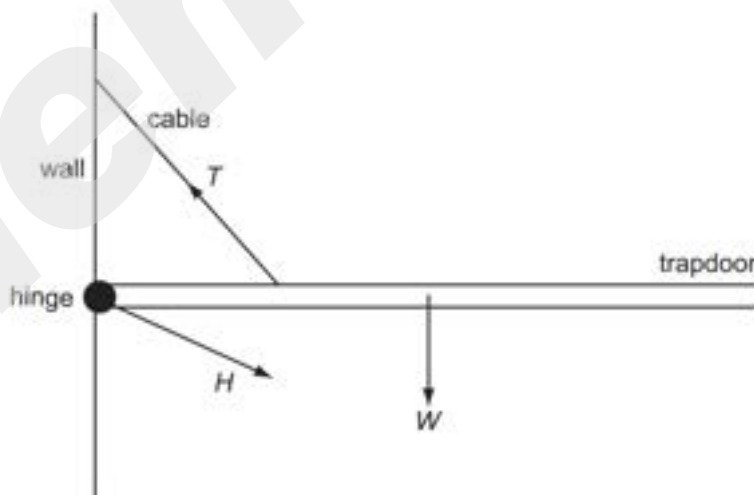
Which list gives the three forces in **increasing** order of magnitude?

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.
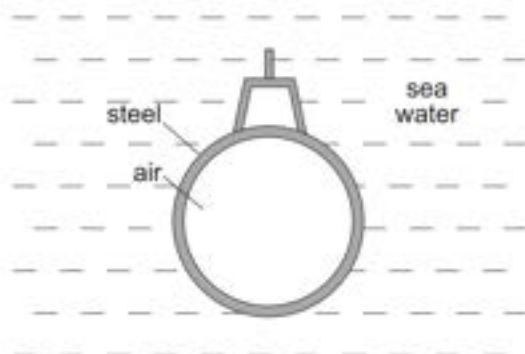
What causes the upthrust on the submarine?

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.

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

Which triangle of forces is correct?
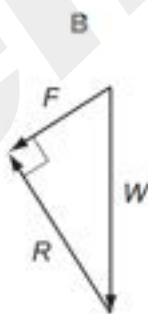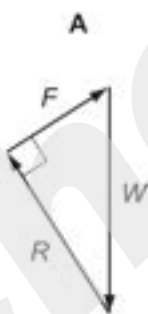
13 All external forces on a body cancel out.

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.

centre of beam
of mass 1.4 kg
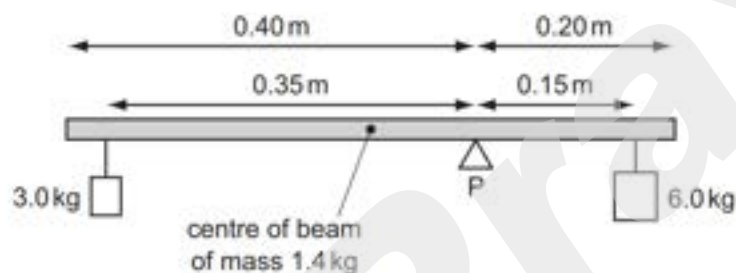
What torque must be applied to the beam in order to maintain it in equilibrium?

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

May/June 2013 (13)

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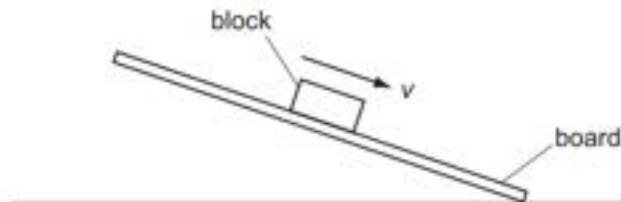
Which row describes the forces acting on the block when sliding with constant velocity?

	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

October/November 2013 (11)

11 A beam of α-particles collides with a lead sheet. Each α-particle in the beam has a mass of 6.6×10^{-27} kg and a speed of 1.5×10^{7} m s^{-1}.

5.0×10^{4} α-particles per second collide with an area of 1.0 cm^{2} of lead. Almost all of the α-particles are absorbed by the lead so that they have zero speed after collision.

What is an estimate of the average pressure exerted on the lead by the α-particles?

A 5.0×10^{-15} Pa

B 5.0×10^{-13} Pa

C 5.0×10^{-11} Pa

D 5.0×10^{-9} Pa

12 An object in air is thrown upwards and towards the left.

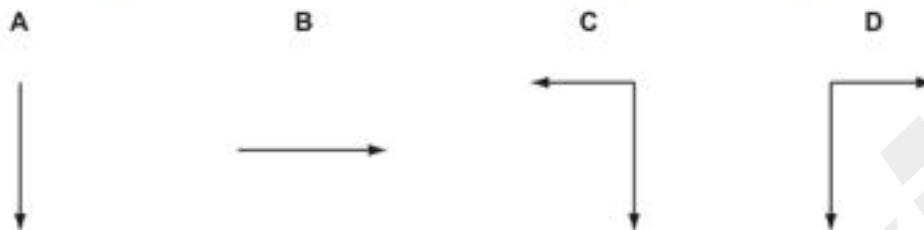Which diagram shows the force(s) acting on the body when it is at its highest point?

14 An archer draws his bowstring back to position X. The bowstring and arrow are shown. The tension T in the string is also shown. Then he draws the bowstring back further to position Y.

The resultant force on the arrow is greater when the arrow is released from position Y.

What is the increase in force?

A   15 N   B   27 N   C   40 N   D   53 N

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.

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

11 A beam of α-particles collides with a lead sheet. Each α-particle in the beam has a mass of 6.6×10^{-27} kg and a speed of $1.5 \times 10^{7}\,m\,s^{-1}$.

   5.0×10^{4} α-particles per second collide with an area of $1.0\,cm^{2}$ of lead. Almost all of the α-particles are absorbed by the lead so that they have zero speed after collision.

   What is an estimate of the average pressure exerted on the lead by the α-particles?

   A $5.0 \times 10^{-15}\,Pa$

   B $5.0 \times 10^{-13}\,Pa$

   C $5.0 \times 10^{-11}\,Pa$

   D $5.0 \times 10^{-9}\,Pa$

12 An object in air is thrown upwards and towards the left.

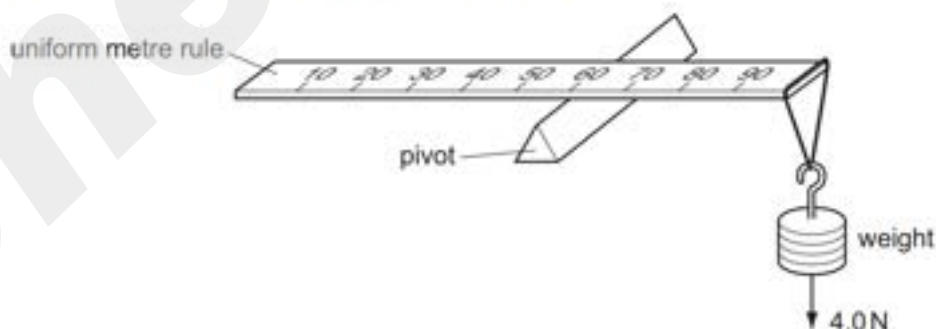   Which diagram shows the force(s) acting on the body when it is at its highest point?

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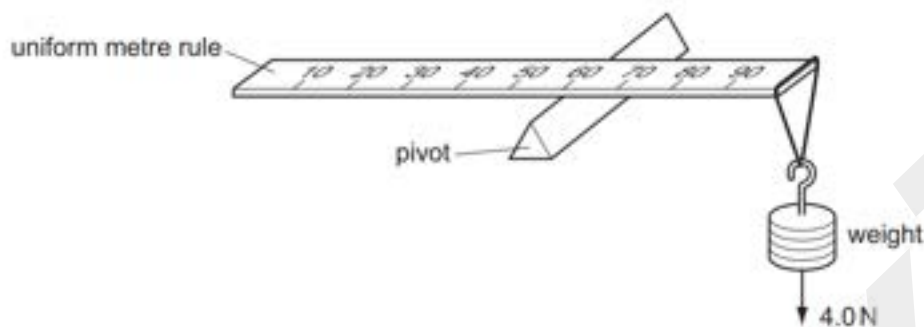

   The resultant force on the arrow is greater when the arrow is released from position Y.

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33

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

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

October/November 2013 (13)

14 A cupboard is attached to a wall by a screw.

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?

34

C

D

line of wall

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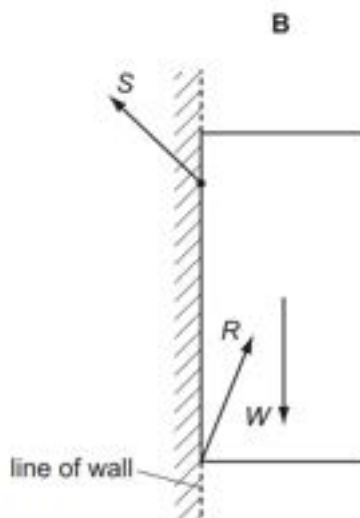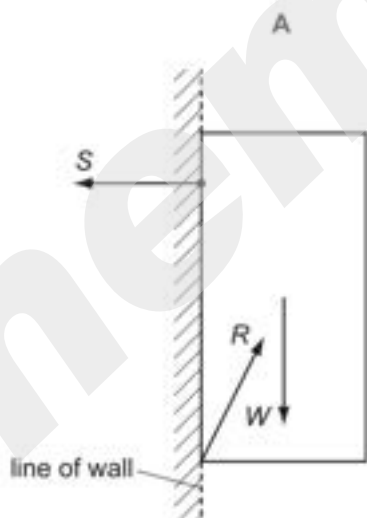
15 A diving board of length 5.0 m is hinged at one end and supported 2.0 m from this end by a spring of spring constant 10 kN m^{-1}. A child of mass 40 kg stands at the far end of the board.
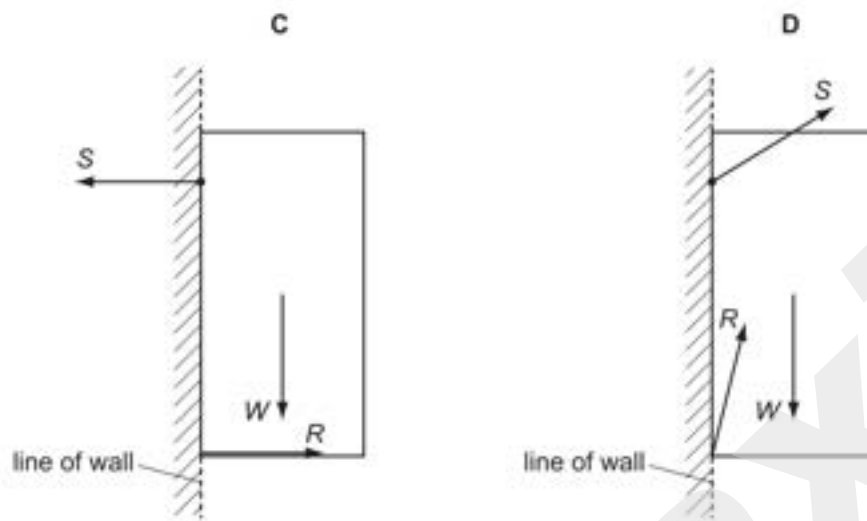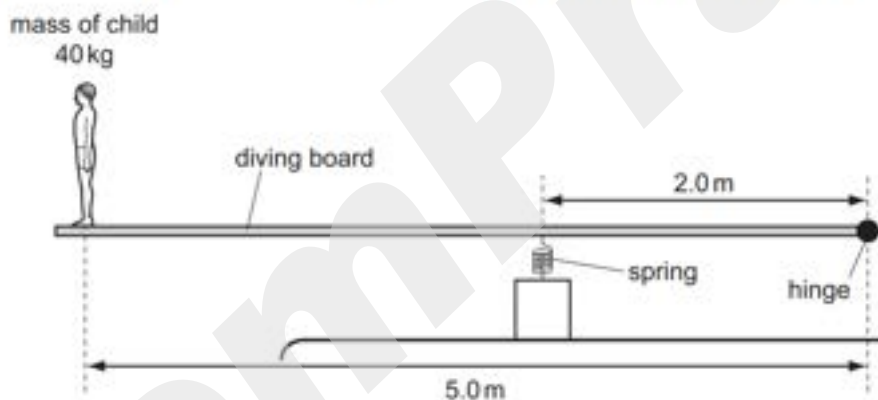

mass of child
40 kg

diving board

2.0 m

spring

hinge

5.0 m

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

16 The graph shows how the total resistive force acting on a train varies with its speed.

Part of this force is due to wheel friction, which is constant. The rest is due to wind resistance.
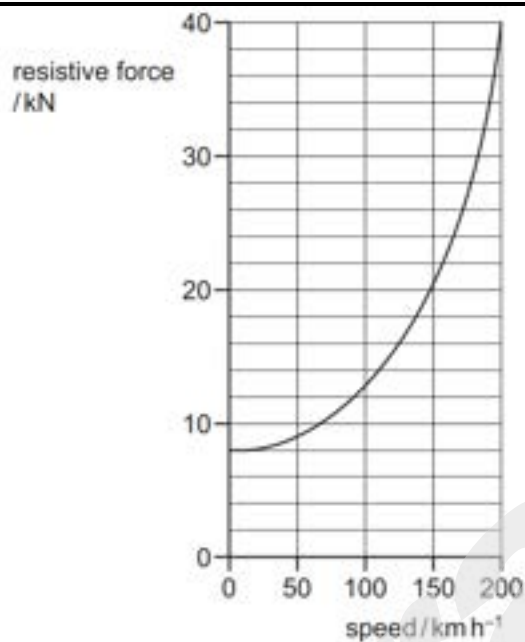
What is the ratio $\dfrac{\text{wind resistance}}{\text{wheel friction}}$ at a speed of $200\,\text{km}\,\text{h}^{-1}$?

A 4   B 5   C 8   D 10

May/June 2014 (11)

11 The diagrams show two ways of hanging the same picture.

diagram 1   diagram 2

36

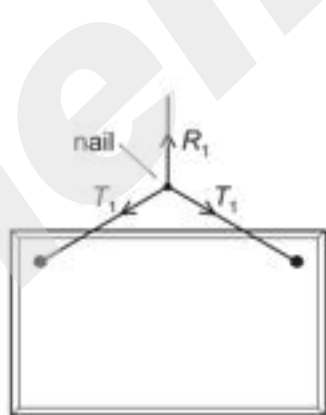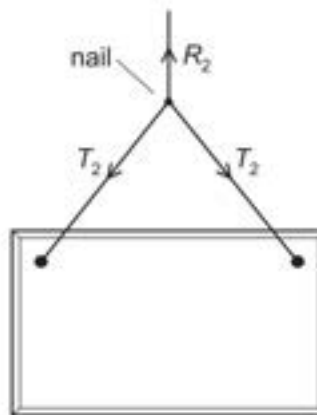In both cases, a string is attached to the same points on the picture and looped symmetrically over a nail in a wall. The forces shown are those that act on the nail.

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 $R_1 < R_2$ $T_1 = T_2$

12   A man holds a 100N load stationary in his hand. The combined weight of the forearm and hand is 20N. The forearm is held horizontal, as shown.
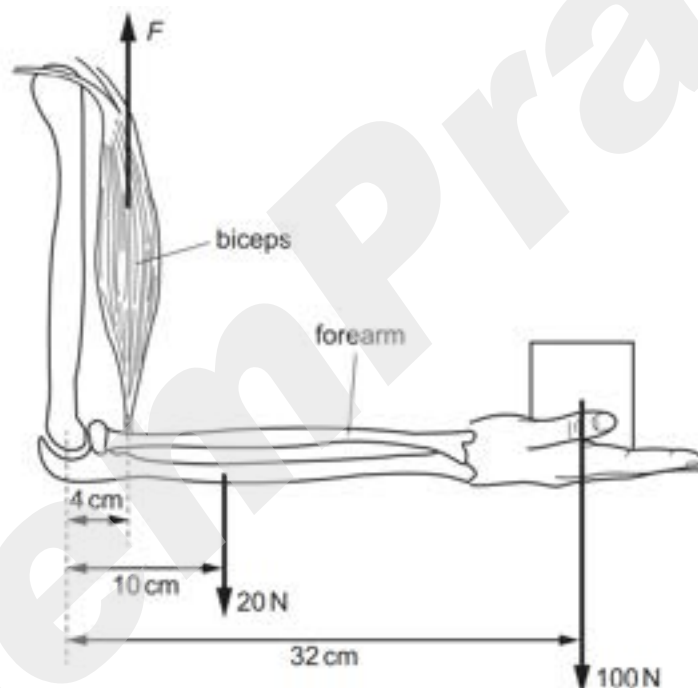
What is the vertical force F needed in the biceps?

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

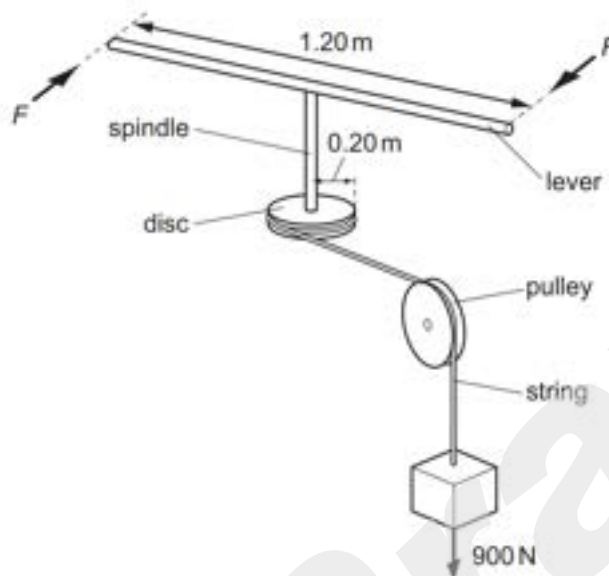13 A spindle is attached at one end to the centre of a lever of length 1.20 m and at its other end to the centre of a disc of radius 0.20 m. A string is wrapped round the disc, passes over a pulley and is attached to a 900 N weight.

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

<u>May/June 2014 (12)</u>

9 A ship of mass 8.4×10^7 kg is approaching a harbour with speed 16.4 m s^{-1}. By using reverse thrust it can maintain a constant total stopping force of 920 000 N.

How long will it take to stop?

    A   15 seconds

    B   150 seconds

    C   25 minutes

    D   250 minutes

10 A tractor of mass 1000 kg is connected by a tow-bar to a trailer of mass 1000 kg. The total resistance to motion has a constant value of 4000 N. One quarter of this resistance acts on the trailer.

When the tractor and trailer are moving along horizontal ground at a constant speed of 6 m s^{-1}, what is the force exerted on the tractor by the tow-bar?

   **A**   0 N   **B**   1000 N   **C**   3000 N   **D**   4000 N

11 The graph shows the variation with time of the speed of a raindrop falling vertically through air.
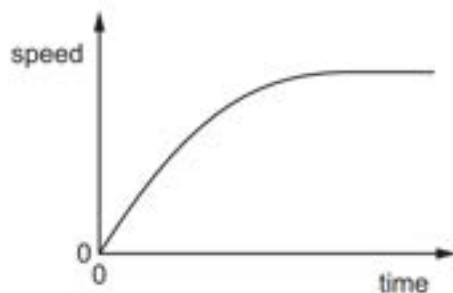
Which statement is correct?

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 The diagram shows four forces applied to a circular object.
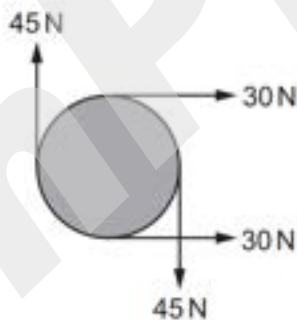

Which of the following describes the resultant force and resultant torque on the object?

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

10 A tennis ball is dropped onto a table and bounces back up. The table exerts a force F on the ball.

Which graph best shows the variation with time t of the force F while the ball is in contact with the table?
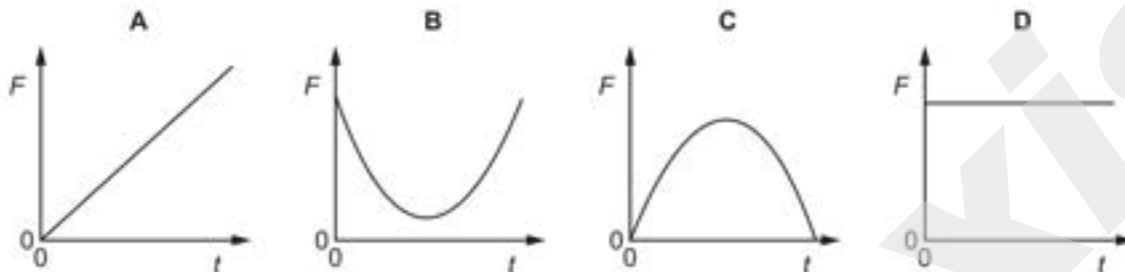
13 What is the condition for an object to be in equilibrium?

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.

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

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 $2a$ from the wall.

The diagram shows the forces that act on the ladder.
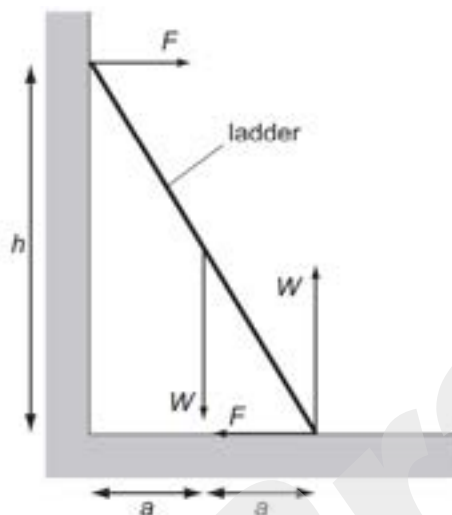
Which equation is formed by taking moments?

A $Wa + Fh \quad = 2Wa$

B $Fa + Wa \quad = Fh$

C $Wa + 2Wa = Fh$

D $Wa - 2Wa = 2Fh$

October/November 2014 (12)

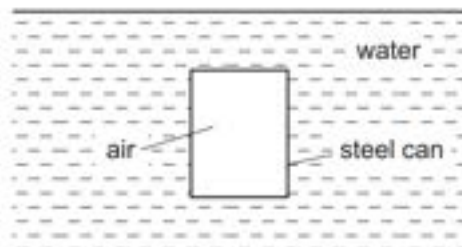**8** Water is pumped through a hose-pipe at a rate of 90 kg per minute. It emerges from the hose-pipe horizontally with a speed of $20 \, \text{ms}^{-1}$.

Which force is required from a person holding the hose-pipe to prevent it moving backwards?

A   30 N   **B**   270 N   **C**   1800 N   **D**   10 800 N

October/November 2014 (13)

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


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.

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.

Which diagram shows the cylinder in equilibrium?

C

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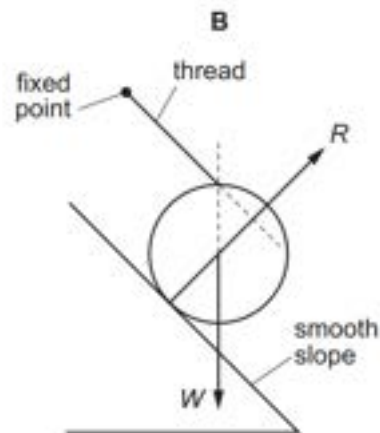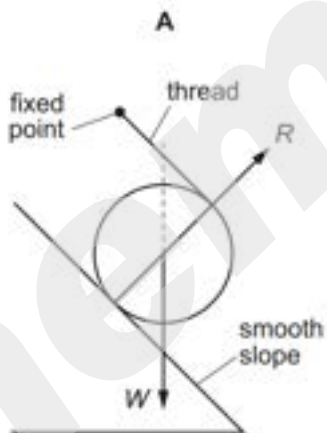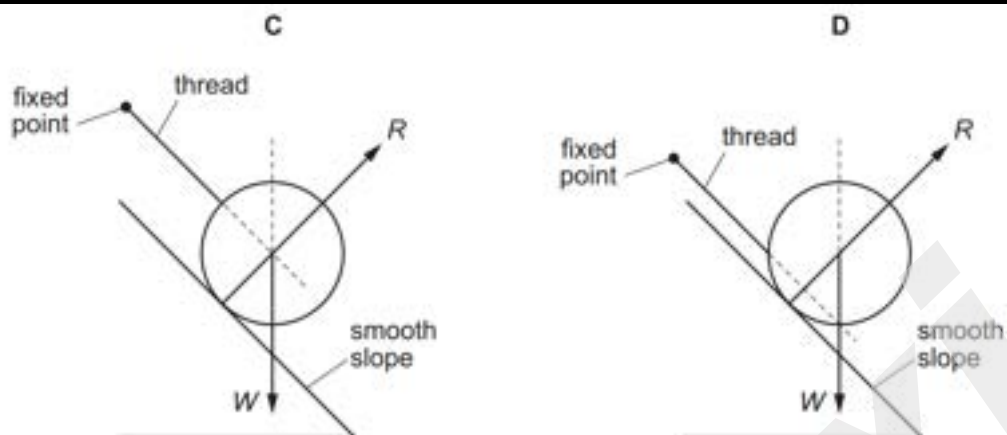
14 A uniform metre rule of mass 100 g is supported by a pivot at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.

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 A constant force F, acting on a car of mass m, moves the car up a slope through a distance s at constant velocity v. The angle of the slope to the horizontal is α.
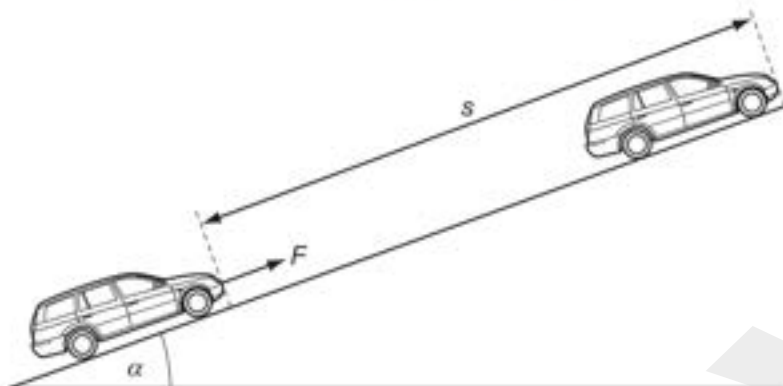
Which expression gives the efficiency of the process?

A $\dfrac{mgs \sin\alpha}{Fv}$ B $\dfrac{mv}{Fs}$ C $\dfrac{mv^2}{2Fs}$ D $\dfrac{mg \sin\alpha}{F}$

May/June 2015 (11)

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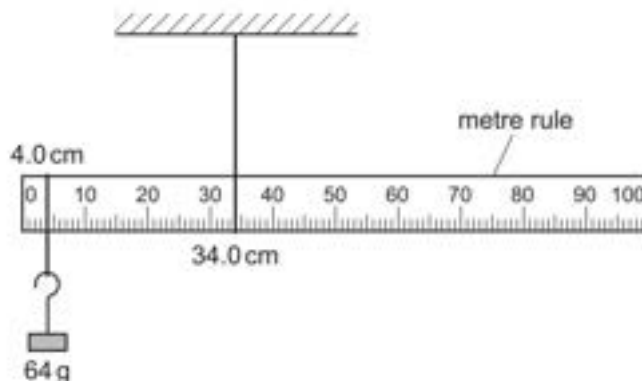

The total mass of the child and the sledge is m. The acceleration of free fall is g.

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

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

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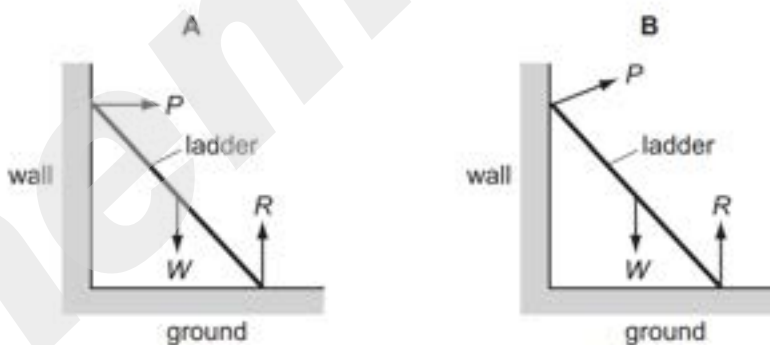
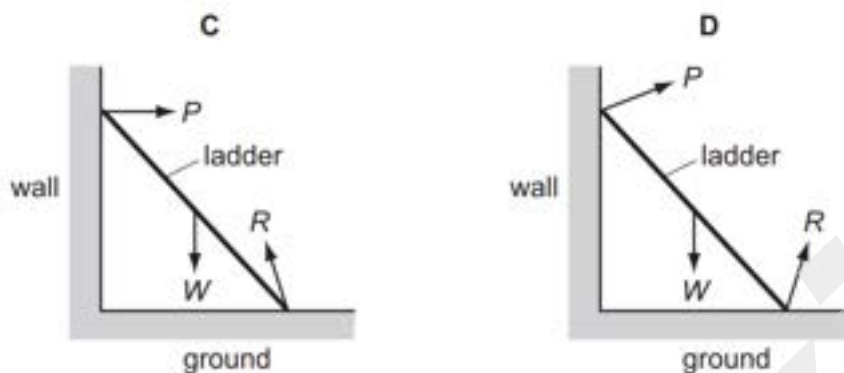What is the mass of the metre rule?

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

May/June 2015 (12)

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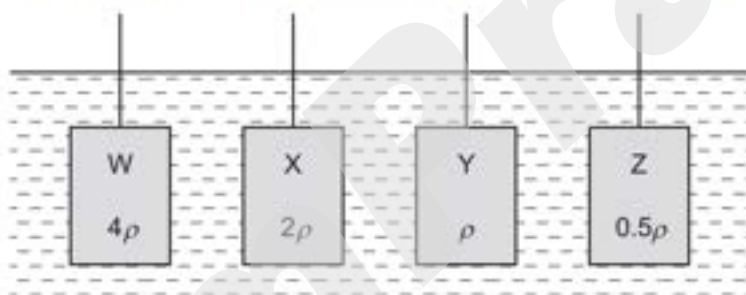
Which diagram correctly shows the directions of the forces P, W and R acting on the ladder as it slides?

C

wall — ladder — P — R — W — ground

D

wall — ladder — P — R — W — ground

May/June 2015 (13)

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.

| W | X | Y | Z |
| 4ρ | 2ρ | ρ | 0.5ρ |

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.

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.
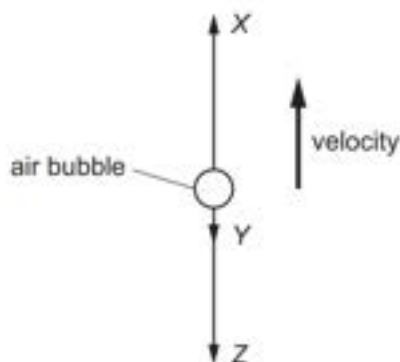

What describes the three forces?

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 $X > Y + Z$.

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

Which system of forces is in equilibrium?

| A | B | C | D |
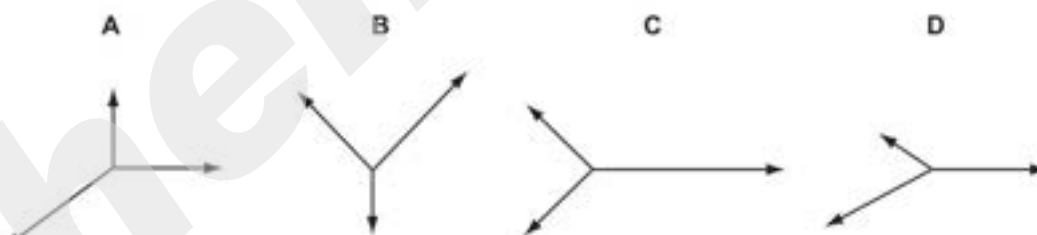
11 A glider of mass 1500 kg is launched from rest on a straight and level track using a catapult. The graph shows the variation with time of the resultant force.
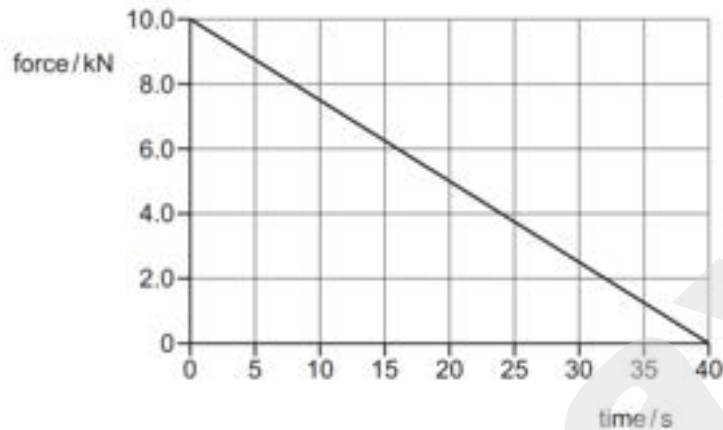
What is the speed of the glider when the resultant force acting on it reaches zero?

A 133 m s⁻¹   **B** 200 m s⁻¹   **C** 250 m s⁻¹   **D** 267 m s⁻¹

13 In which example is it **not** possible for the underlined body to be in equilibrium?

A   an <u>aeroplane</u> climbs at a steady rate

B   an aeroplane tows a <u>glider</u> at a constant altitude

C   a <u>speedboat</u> changes direction at a constant speed

D   two tug boats tow a <u>ship</u> into harbour

14 Two blocks X and Y are falling through a vacuum in a uniform gravitational field, as shown.
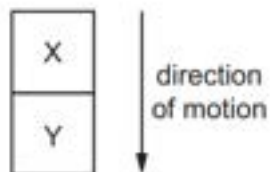
Block X has weight 2*w*.

Block Y has weight *w*.
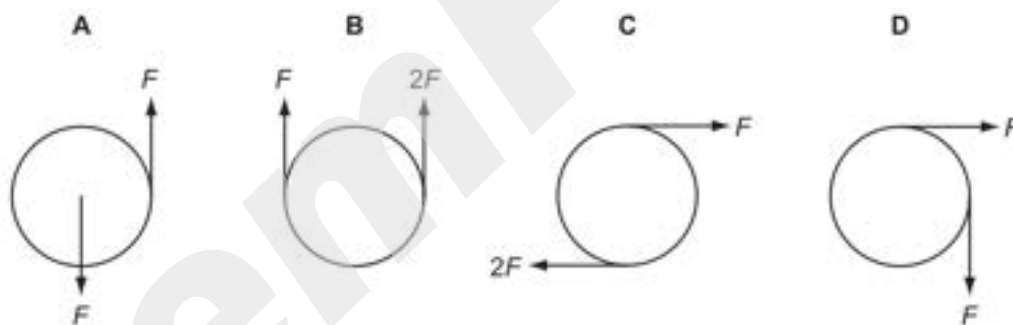
The blocks do not move apart.

Which value best represents the force exerted by block X on block Y?

A 0   **B** *w*   **C** 1.5*w*   **D** 2*w*
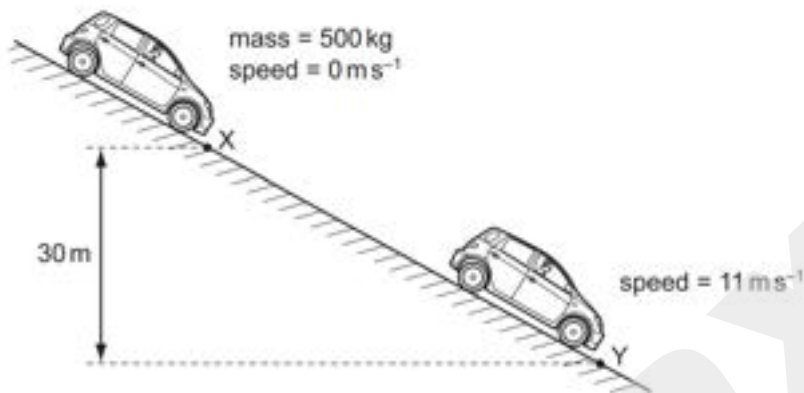
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15 Which pair of forces acts only as a couple on the circular object?

16 A car of mass 500 kg is at rest at point X on a slope, as shown.

The car's brakes are released and the car rolls down the slope with its engine switched off. At point Y the car has moved through a vertical height of 30 m and has a speed of $11 \, ms^{-1}$.
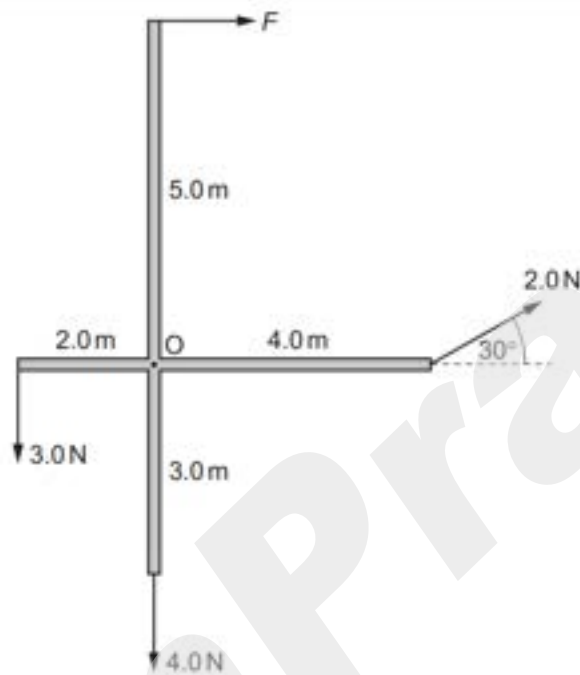

What is the energy dissipated by frictional forces when the car moves from X to Y?

A $3.0 \times 10^4 \, J$ **B** $1.2 \times 10^5 \, J$ **C** $1.5 \times 10^5 \, J$ **D** $1.8 \times 10^5 \, J$

15 A cross-shaped structure, freely pivoted at O, has arms of lengths 5.0m, 4.0m, 3.0m and 2.0m. It is acted on by forces of 2.0N, 3.0N, 4.0N and an unknown force F. The structure is in rotational equilibrium.

What is the magnitude of force F?

A 0.40N   B 2.0N   C 2.6N   D 4.4N