Paper 1

1.

A ball falls through a liquid at a constant speed. It is acted upon by three forces: an upthrust, a drag-force and its weight.

Which statement is correct?

A The drag-force increases with increasing depth.

B The drag-force is equal to the sum of the upthrust and weight.

C The upthrust is constant with increasing depth.

D The weight is greater than the sum of the drag-force and the upthrust.

Ans: C

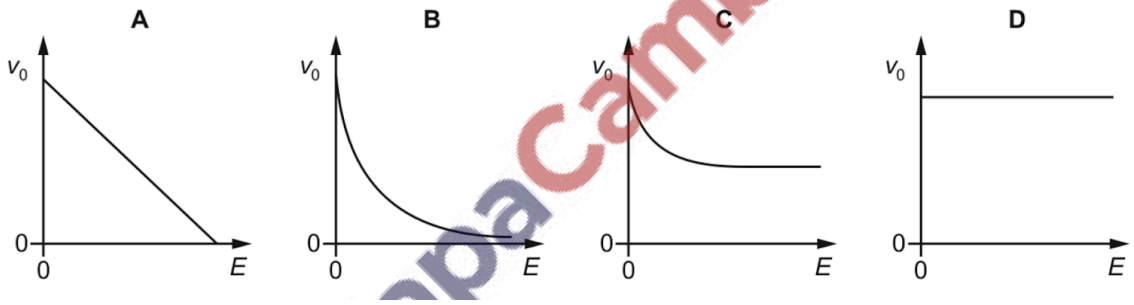
- Option A is incorrect: Drag force depends on speed. Since speed is constant, there is no effect on drag force.
- Weight = drag force + upthrust, so option B and D are incorrect.
- Upthrust depends on volume of water displaced by the object, which is not affected by the depth, so option C is correct.

2.

A positively charged oil droplet falls in air in a uniform electric field that is vertically upwards. The droplet has a constant terminal speed v_0 and the electric field strength is E.

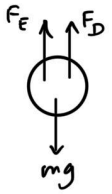
The magnitude of the force due to air resistance acting on the droplet is proportional to the speed of the droplet.

Which graph shows the variation with E of v_0?



Ans: A

electric force (F_E) = point charge (q) × electric field strength (E)



$$F_E = qE$$
$$F_D = kv_0$$

at v_0, $mg = F_E + F_D$

$\Rightarrow mg = qE + kv_0 \quad \Rightarrow v_0 = -\frac{qE}{k} + \frac{mg}{k}$

$y = -mx + c$

$\therefore$ linear w/ -ve gradient

3.

An astronaut throws a stone horizontally near to the surface of the Moon, where there is no atmosphere.

Which row describes the horizontal and vertical forces acting on the stone after release?

	horizontal force	vertical force
A	non-zero and constant	constant
B	non-zero and constant	decreasing
C	zero	constant
D	zero	decreasing

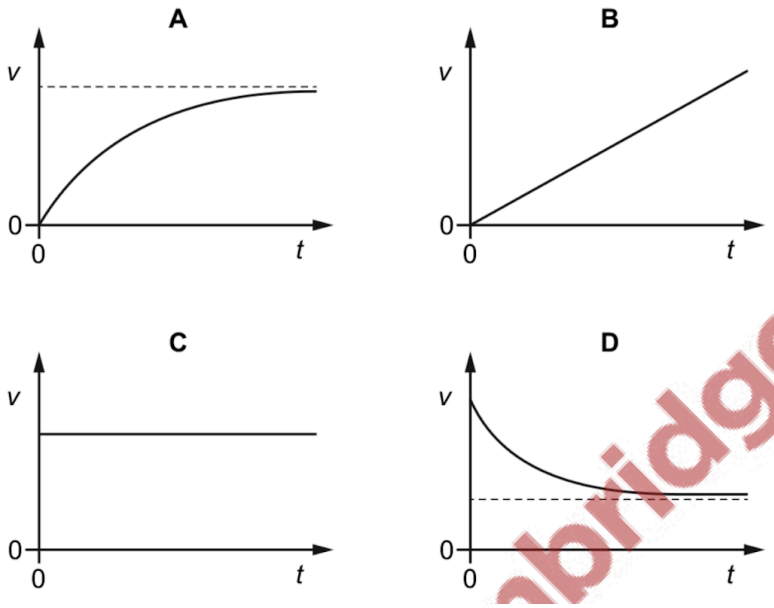
Ans: C

- There is no horizontal force because it has already left the hand.
- No atmosphere = no air resistance!!
- Thus resultant force acting on it is constant; resultant force = weight.

4.

A rigid, hollow sphere is immersed deep in water and released from rest. It experiences an upthrust which propels it towards the surface of the water.

Which graph best shows the variation with time t of its upward velocity v?

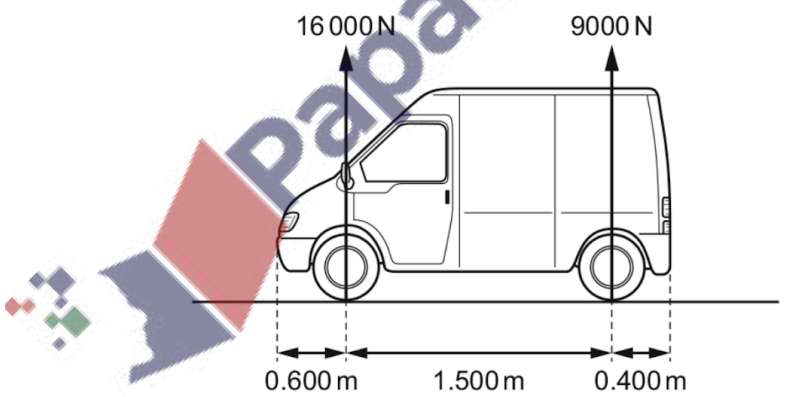


Ans: A

- Upthrust causes it to move upwards with constant acceleration initially.
- As speed increases, drag force increases, so acceleration decreases.

5.

The vertical forces that the ground exerts on a stationary van are shown.



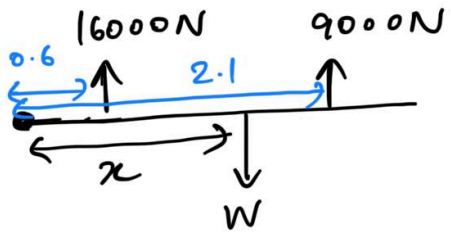
The van is 2.50 m long with the wheels at a distance of 0.600 m from the front of the van and 0.400 m from the rear of the van.

What is the horizontal distance of the van's centre of gravity from the front of the van?

A 0.540 m **B** 0.960 m **C** 1.14 m **D** 1.36 m

Ans: C

you can choose the pivot to be anywhere.
For convenience, pivot = front of the van.
It is easier to find distance from front.



W = clockwise
the other 2 are anticlockwise

Since there's no net force, $W = 16000 + 9000$
$= 25000\ N$

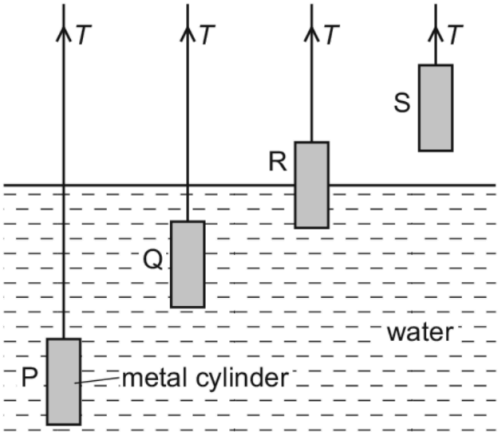
$$25000 \times x = 16000 \times 0.6 + 9000 \times 2.1$$

$$\Rightarrow x = \frac{28500}{25000} = 1.14$$

NOTE: the force of upthrust is caused by a pressure difference!

6.

A metal cylinder is suspended vertically in equilibrium by a cord. The diagram shows the cylinder in four different positions P, Q, R and S.



Which statement explains the variation of the tension *T* in the cord?

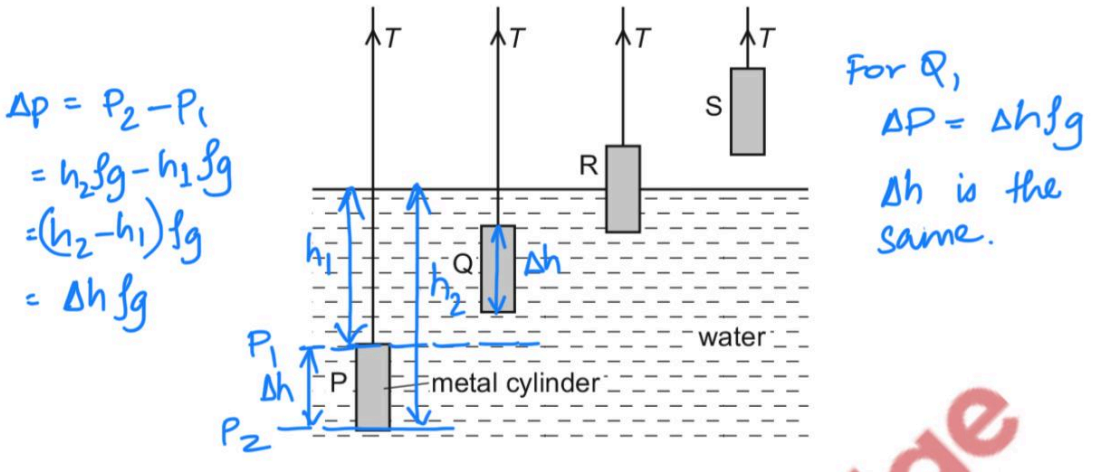
A At P and at Q, the tension *T* in the cord is the same because the difference in pressure between the top and bottom of the cylinder is the same.

B At Q, the tension *T* in the cord is less than at P because, at smaller depth, liquid pressure is smaller.

C At R, the tension *T* in the cord is less than at P because atmospheric pressure is less than water pressure.

D At S, the tension *T* in the cord is greater than at P because atmospheric pressure at S exerts no force on the top or bottom of the cylinder.

Ans: A



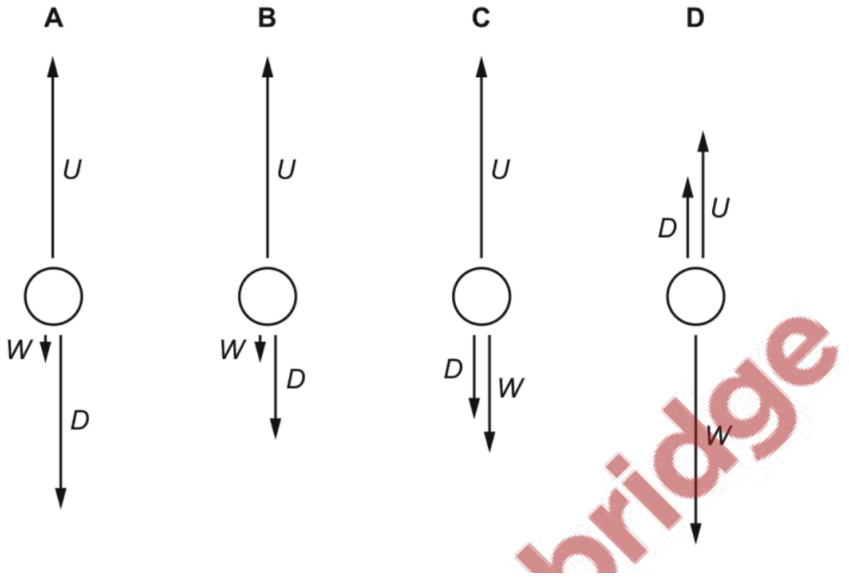
- P and Q displace the same amount of water, thus upthrust is same. Thus tension also has to be same.
- Upthrust + T = weight
- If upthrust and weight are the same for P and Q, then T must also be same.
  NOTE: absolute pressure at P1 is greater than at P2. but question is referring to the difference in pressure!

- At R, the tension is greater than at P, because upthrust is less, as only less water is displaced. Since upthrust + T = weight, when upthrust decreases, tension increases.

7.

An air bubble is rising through a liquid at a constant speed. The forces on it are the upthrust *U*, the viscous drag *D* and its weight *W*.

Which diagram shows the directions and relative sizes of the forces?



Ans: A

- Drag force acts down NOT up!!!
- Bubble is rising up, and drag force must act opposite to the direction of motion of the bubble.

8.

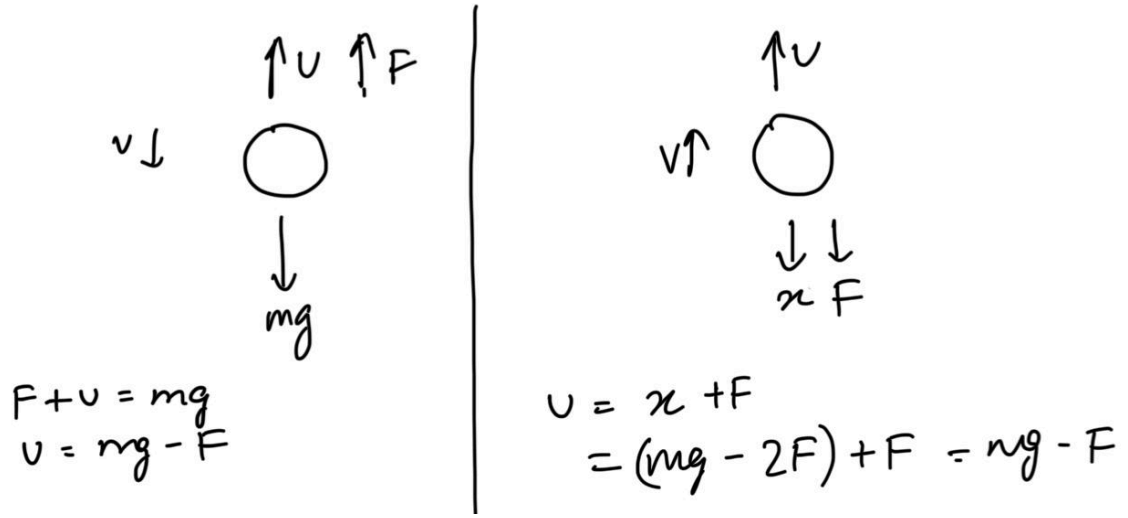
The three forces acting on a hot-air balloon that is moving vertically are its weight, the force due to air resistance and the upthrust force.

The hot-air balloon descends vertically at constant speed. The force of air resistance on the balloon is *F*.

Which weight of material must be released from the balloon so that it ascends vertically at the same constant speed?

A *F* **B** 2*F* **C** 3*F* **D** 4*F*

Ans: B

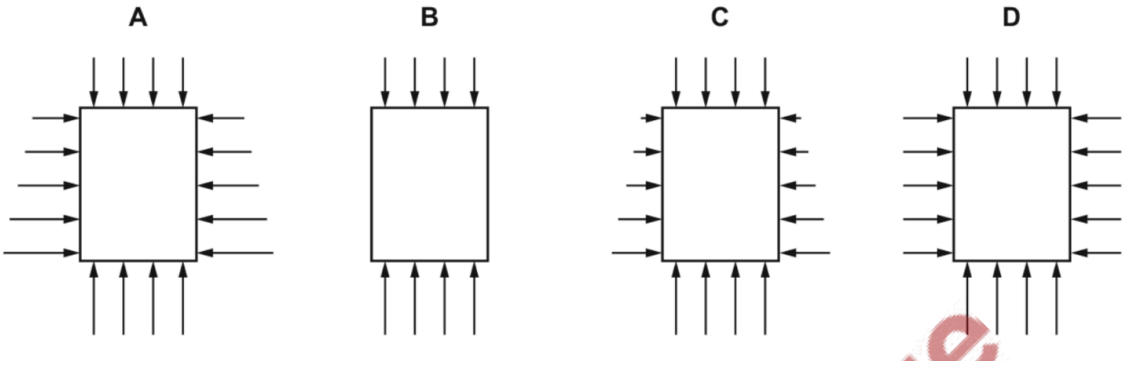


F is the same, since it depends on velocity, and velocity is the same.

9.

A block is submerged vertically in a liquid. The four diagrams show, to scale, the forces exerted by the liquid on the block.

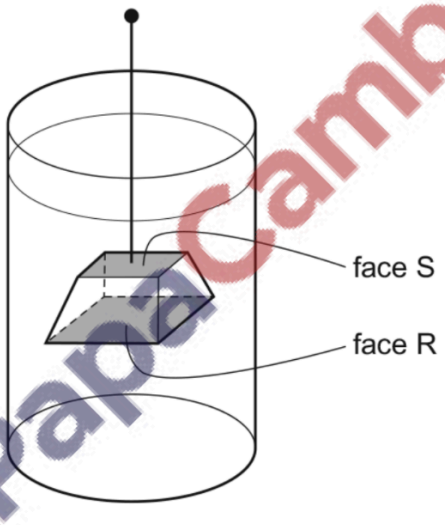
Which diagram correctly shows a possible situation as viewed from the side?



Ans: A

10.

The diagram shows a block of copper suspended in water.



The block experiences an upthrust from the water.

Which statement is the basis of an explanation for this upthrust?

A Copper is more dense than water.

B The area of face R is greater than the area of face S.

C The density of water increases with depth.

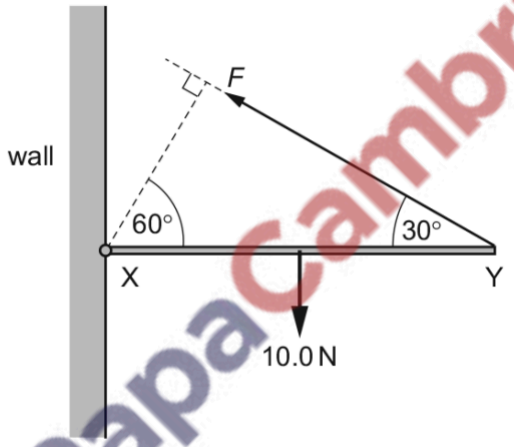
D The pressure of water increases with depth.

Ans: D
Upthrust is due to pressure difference!

NOTE: a couple is a pair of forces of equal magnitude acting in opposite directions, which produce rotational motion but not translational motion.

11.

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

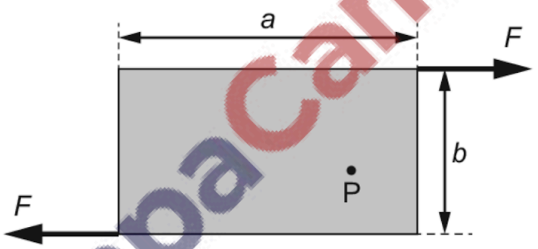
Ans: C

$F(X4\cos 60) = 10\left(\frac{X4}{2}\right)$

$\Rightarrow F = \frac{10}{2\cos 60} = 10$

12.

Two forces, each of magnitude *F*, act along the edges of a rectangular metal plate, as shown.



The plate has length *a* and width *b*.

What is the torque about point P?

A *Fa* **B** *Fb* **C** *2Fa* **D** *2Fb*

Ans: B

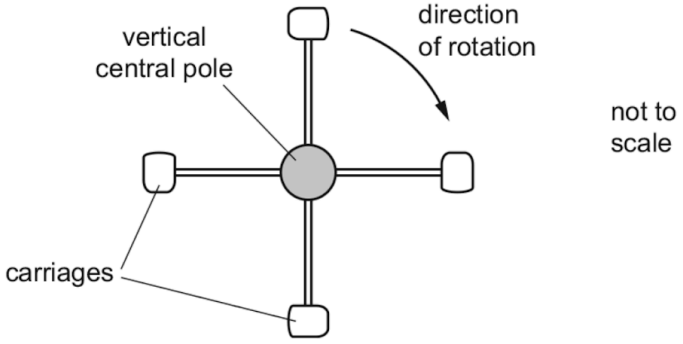
$F(x) + F(y)$

$x + y = b$

$F(x+y) = Fb$

13.

A fairground ride consists of four carriages connected to a central vertical pole, as shown in the following view from above.



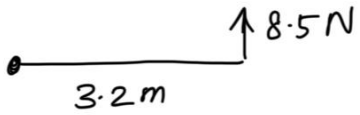
A motor rotates the central pole about its axis. This results in the four carriages each moving along a circular path.

The distance from the middle of each carriage to the centre of the pole is 3.20 m. When they are moving, each carriage experiences an air resistance force of 85.0 N. Assume that there are no other significant resistive forces.

Which torque does the motor need to apply to the pole to keep the system rotating at constant maximum speed?

A 5.44 N m **B** 272 N m **C** 544 N m **D** 1090 N m

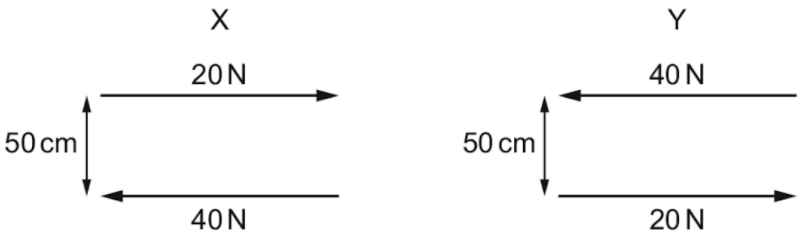
Ans: D



Torque on 4 carriages = 4 x 3.2 x 85 = 1090

14.

The diagram shows two pairs X and Y of parallel forces.



Which statement is correct?

A X is equivalent to a clockwise torque of 10 N m and a force of 20 N to the left.

B X is equivalent to a clockwise torque of 20 N m only.

C Y is equivalent to an anticlockwise torque of 30 N m and a force of 20 N to the left.

D Y is equivalent to an anticlockwise torque of 30 N m only.

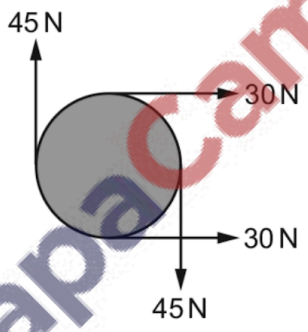
Ans: A

For X:

- This is not a couple, since forces are not equal in magnitude
- Resultant force = 40 – 20 = 20N to left
- Torque = 20 x 0.5 = 10Nm

15.

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	non-zero	non-zero
B	non-zero	zero
C	zero	non-zero
D	zero	zero

Ans: A

$\Sigma F_x = 30 + 30 = 60\,N$ (moving right)

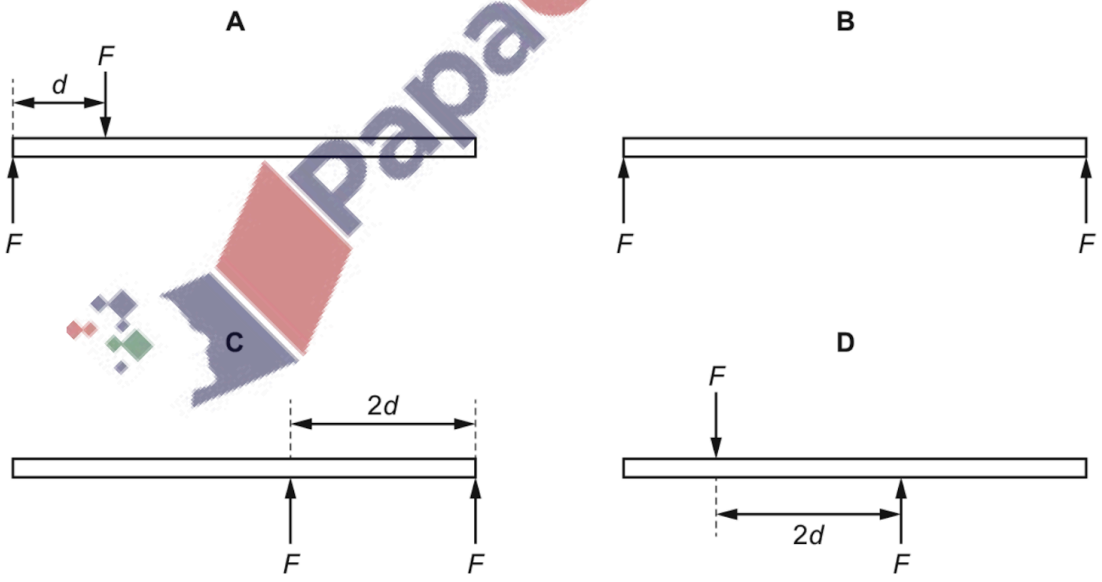
$\Sigma F_y = 45 - 45 = 0\,N$ (not moving up/down)

$\Sigma \tau = 45 + 30 + 45 - 30 = 90\,Nm$

16.

Two parallel forces, each of magnitude *F*, act on a rod of length 5*d*.

Which diagram shows the positions of the two forces that will produce the largest torque on the rod?

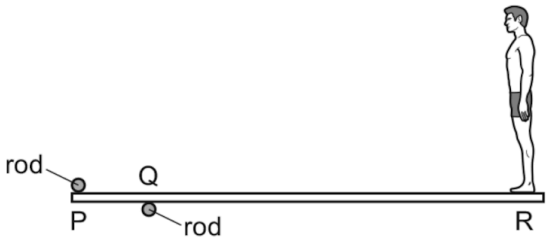


Ans: D

- In B, there is no turning effect because they are the same direction and equal in magnitude.
- The same for C.
- A and D produce turning effect.
- Couple in A = Fd
- Couple in D = F x 2d = 2Fd
- Thus D produces larger torque

17.

A uniform diving-board is held by two fixed rods at points P and Q. A person stands at end R of the diving-board, as shown.



The forces exerted by the rods on the board are vertical. The board remains in equilibrium as the person slowly moves towards point Q from end R.

Which row describes the changes to the forces exerted by the rods on the board?

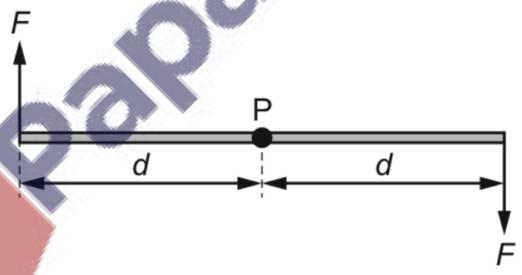
	force at P	force at Q
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

Ans: A

- For the board to be in equilibrium, resultant moment = 0
- Person's weight causes clockwise moment
- P causes downward force & Q causes upward force
- P and Q causes a moment that that balances the moment caused by weight
- Pivot can be P or Q:
    - When pivot = P, upward force at Q causes anticlockwise moment
    - When pivot = Q, downward force at P causes anticlockwise moment
- As person moves towards the rods, moment of weight at P and Q decreases, so forces exerted by rods at P and Q also decrease.

18.

Two forces, each of magnitude F, act in opposite directions on a rod.



Each force acts on the rod at a distance d from the pivot P.

What is the torque of this couple about P?

A 0 **B** $F \times d$ **C** $2F \times d$ **D** $2F \times 2d$

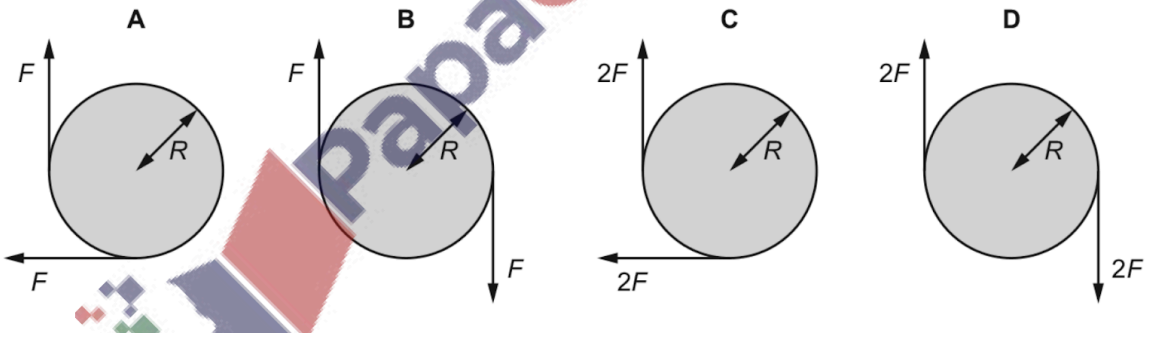
Ans: C

19.

A flat metal disc has radius R.

Forces of magnitude F are applied tangentially at the edge of the disc. The forces are in the plane of the disc.

Which arrangement of forces produces only a torque of magnitude $2FR$?



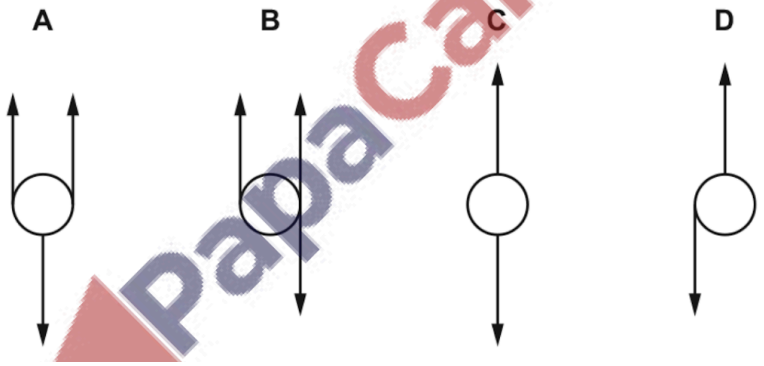
Ans: B

NOTE: distance between the 2 forces = 2R!! Not R!

20.

A sphere is acted upon by various forces, all of the same magnitude.

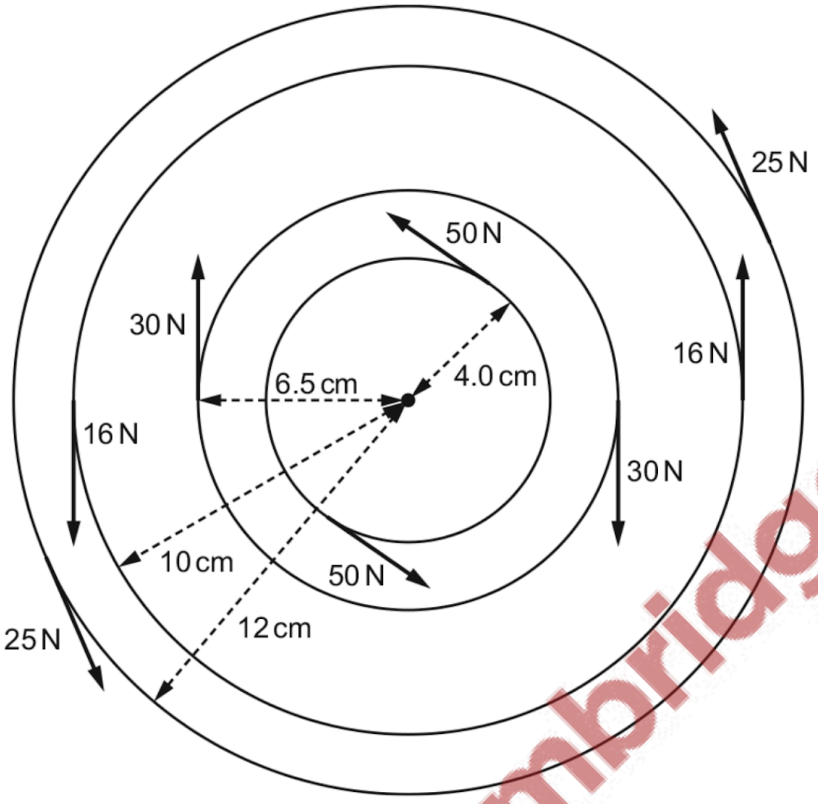
Which system of forces provides a resultant torque but zero resultant force on the sphere?



Ans: D

21.

In a machine, many couples act on a rotating object as shown.



What is the resultant torque acting on the rotating object?

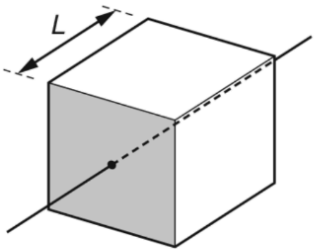
A 4.7 N m **B** 8.6 N m **C** 9.3 N m **D** 17.1 N m

Ans: C

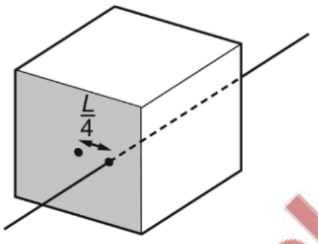
Check the direction of each torque!!

22.

The diagram shows a solid cube with weight W and sides of length L. It is supported at rest 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 $\frac{L}{4}$ 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 keep the cube at rest?

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

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

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

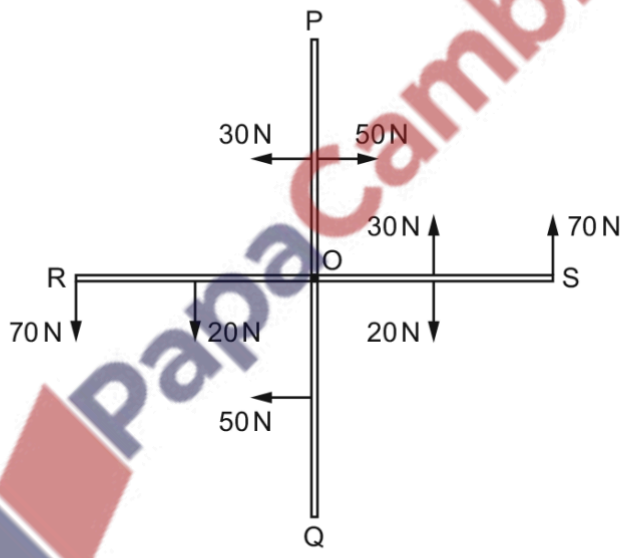
D $\frac{WL}{2}$ clockwise

Ans: B

- When the spindle is moved, the cube tries to move anticlockwise
- Thus a clockwise torque is needed to keep the cube at rest
- The centre point has W downwards and the spindle point has W upwards
- Torque = W x L/4

23.

A rigid cross-shaped structure having four arms PO, SO, QO and RO, each 1.00 m long, is pivoted at O. Forces act on the ends of the arms and on the midpoints of the arms as shown.



What is the magnitude of the resultant moment on the structure about O?

A 45 N m **B** 90 N m **C** 120 N m **D** 190 N m

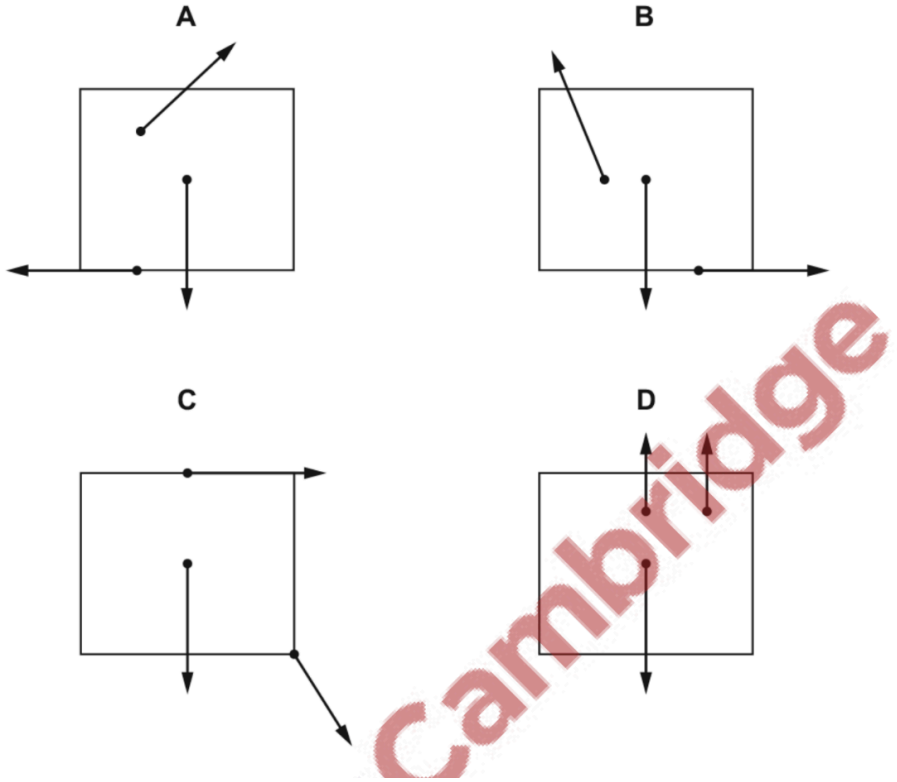
Ans: C

- $70 \times 2 - 50 \times 1 - 20 \times 0.5 + 20 \times 0.5 + 30 \times 0.5 + 30 \times 0.5 = 120$

24.

Three coplanar forces act on a block.

Which diagram shows the directions of the forces such that the block could be in equilibrium?



Ans: B

Condition for 3 forces to be in equilibrium:

- The vectors must be in a closed loop when arranged tip-tail
- They must be in a cycle

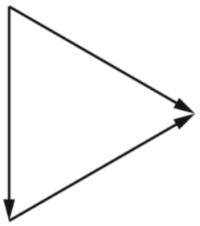
25.

Four combinations of vectors are shown, each representing all the forces acting on an object. The forces all act in the same plane.

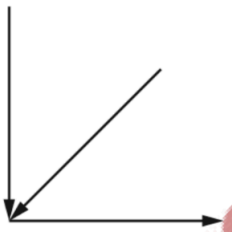
The object is in equilibrium.

Which combination of vectors could represent the forces acting on the object?

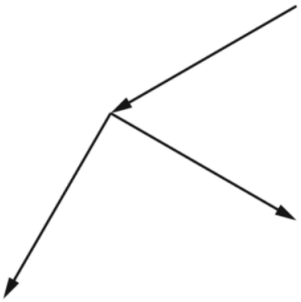
A



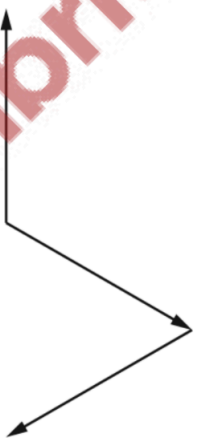
B



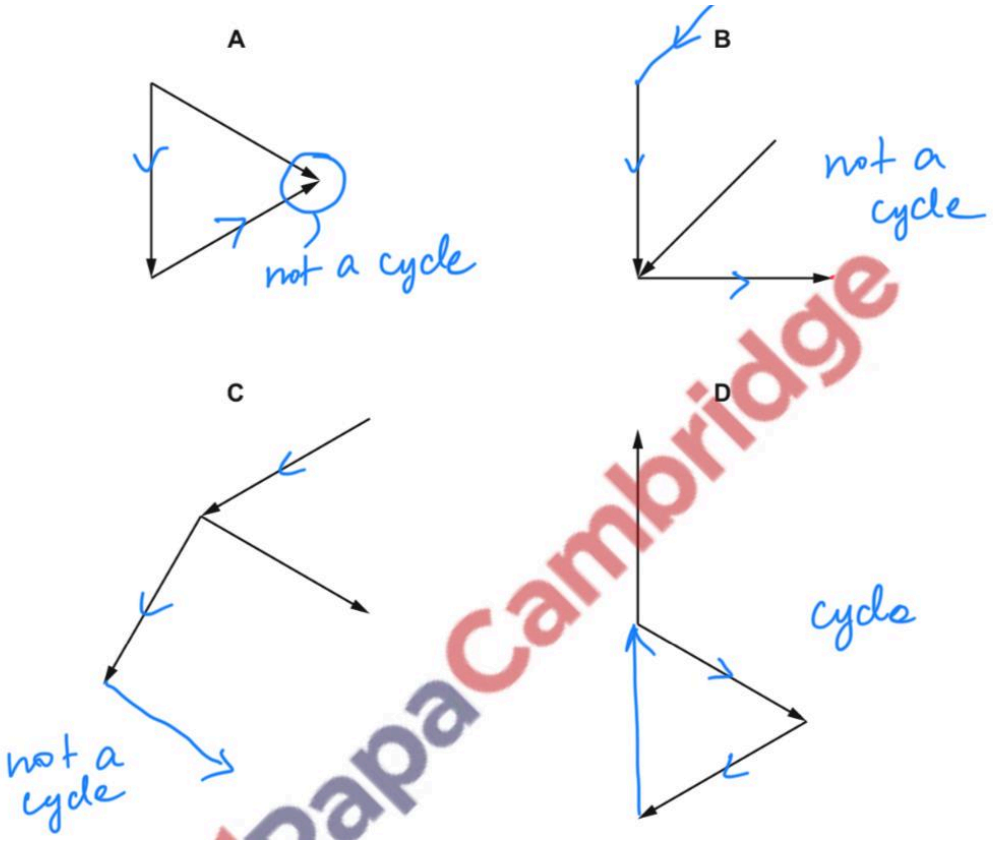
C



D

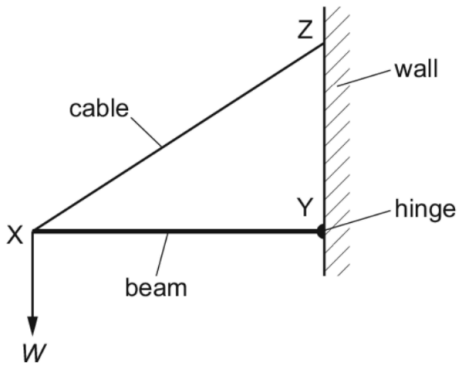


Ans: D



26.

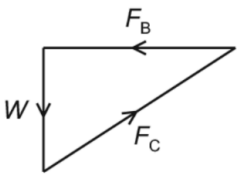
A thin horizontal beam XY is freely hinged at point Y to a vertical wall. The beam is held stationary by a cable XZ which is attached to the wall at point Z.



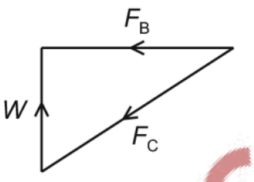
The beam supports a weight *W* at point X. The forces in the cable and the beam are F_C and F_B respectively.

Which vector triangle represents the forces acting on point X?

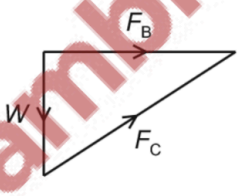
A



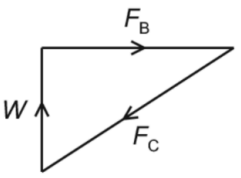
B



C



D

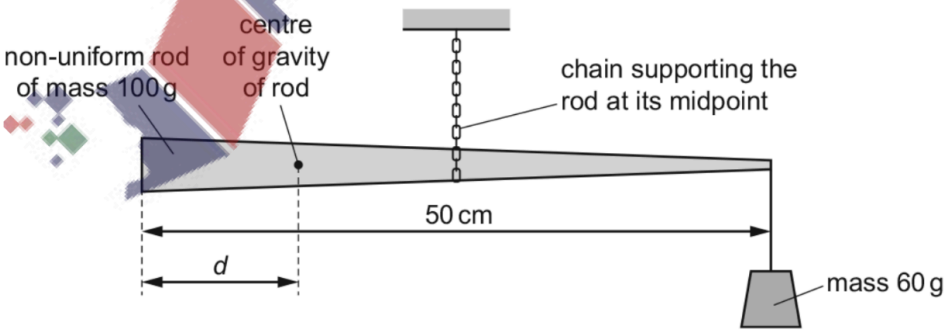


Ans: A

- Fc = tension, which acts away from X, pulling X up.
- If you draw F_B to the right, then there will be resultant force to the right.
- So FB will have to be to the left.

27.

A non-uniform rod has a mass of 100 g and a length of 50 cm. It is supported by a chain at its midpoint. The rod is held in equilibrium by having a mass of 60 g suspended from its right-hand end, as shown.



The centre of gravity of the rod is a distance *d* from its left-hand end.

What is the value of *d*?

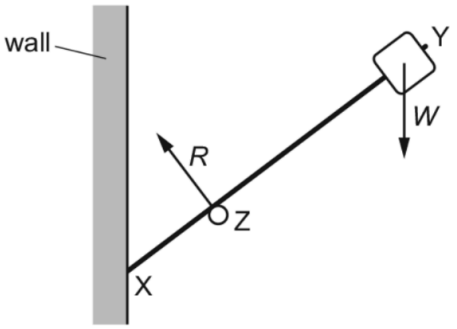
A 10 cm **B** 15 cm **C** 25 cm **D** 40 cm

Ans: A

- Take LH end to be pivot
- W acts clockwise (0.981)
- At 50cm, 0.981 acts anticlockwise (same as W)
- At 100cm, 0.5886 (0.6 x 9.81) acts clockwise
- These add up to 0

28.

A light rigid rod XY has an object of weight *W* fixed at one end. The rod is in equilibrium, resting on a support at Z and a vertical wall at X. The support exerts a force *R* on the rod as shown. The diagram shows the directions, but not the magnitudes, of the forces *R* and *W*.



What is the direction of the force on the rod at X?

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

Ans: D

NOTE: diagram does not show magnitudes!! Length of arrows are NOT to scale.

- Net force = 0
  - W acts vertically down; R has a vertical component that acts vertically upwards. These 2 vertical components balance out.
  - R also has a horizontal component which acts to the left. Thus, there must be a horizontal component to the right to balance this out.
  - This rules out B and C.
- Net moment = 0
  - Take Z as pivot.
  - W causes clockwise moment.
  - Thus X will need to cause anticlockwise moment to cancel out.
  - X will need to act downwards to produce anticlockwise moment.
  - Hence, D

Another method: extend the lines of actions of each of the forces. They must pass through the same point.

29.

Three parallel forces act on an object. As a result of these forces, the object is in equilibrium.

What **must** be correct for these forces?

A They all act along the same line.

B They all have the same magnitude.

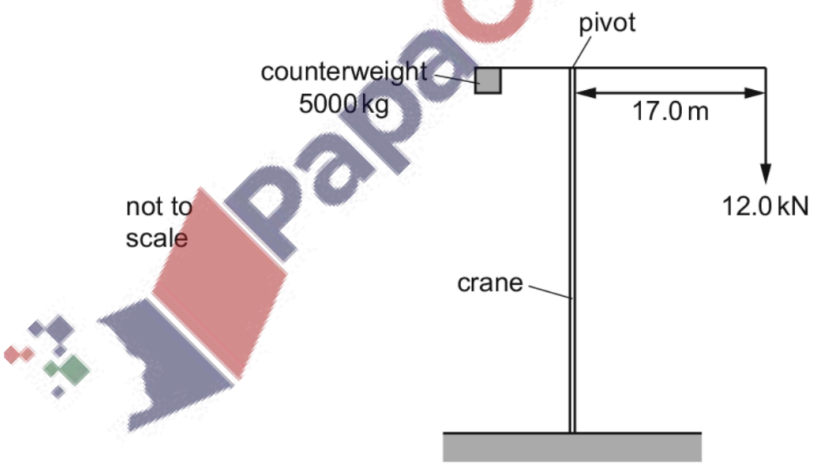
C They do **not** all act along the same line.

D They do **not** all have the same magnitude.

Ans: D

30.

A crane uses a counterweight to stop it from toppling over when lifting a load, as shown.



The counterweight has a mass of 5000 kg. The crane is required to lift a load of 12.0 kN and the horizontal distance from the pivot to the load is 17.0 m.

How far from the pivot should the centre of gravity of the counterweight be positioned in order to keep the crane in equilibrium?

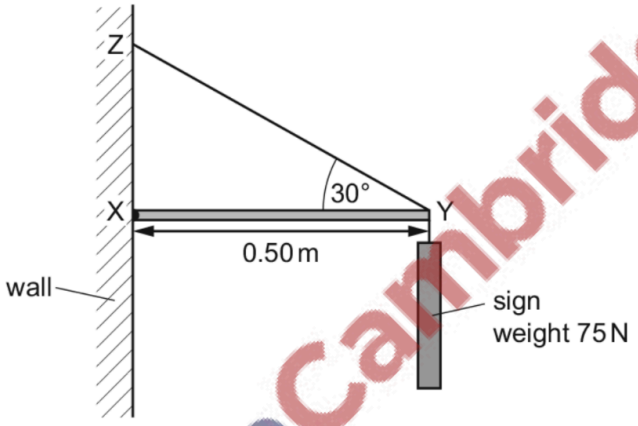
A 0.0408 m **B** 0.240 m **C** 4.16 m **D** 40.8 m

Ans: C

REMEMBER to multiply by 9.81!!!!

31.

A shop sign weighing 75 N hangs from a frame attached to a vertical wall.



The frame consists of a horizontal rod XY and a rod YZ that is at an angle of 30° to the horizontal. Rod XY is attached to the wall by a hinge at X and has length 0.50 m. Assume that the weights of the rods are negligible.

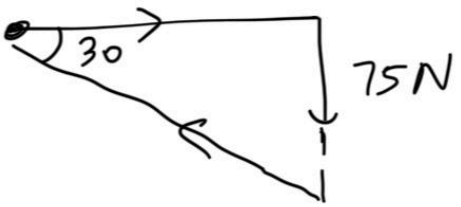
What is the horizontal force exerted by the wall on rod XY?

A 0 N **B** 43 N **C** 130 N **D** 150 N

Ans: C

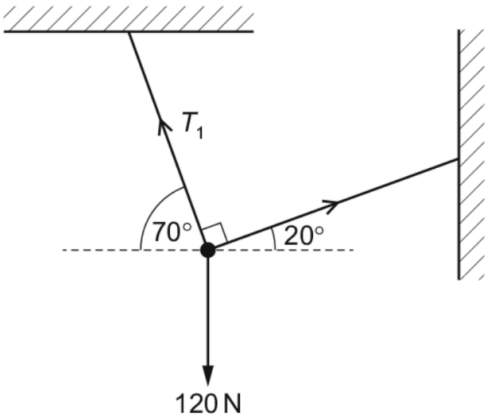
$\tan 30 = \frac{75}{A}$

$A = 130$



32.

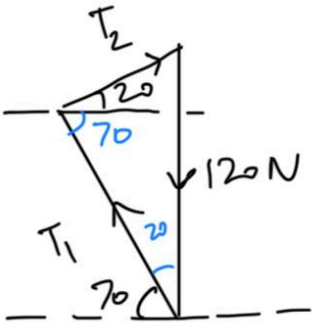
An object of weight 120 N is supported in equilibrium by two strings as shown.

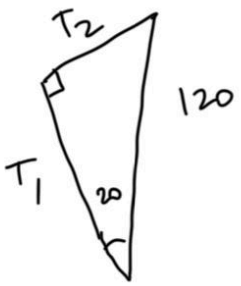


What is the tension T_1 in the left-hand string?

A 41 N **B** 77 N **C** 113 N **D** 128 N

Ans: C





$\cos 20 = \frac{T_1}{120}$

$\Rightarrow T_1 = 120 \cos 20$

$= 112.76 \approx 113$

OR:

$$T_1 \sin 70 + T_2 \sin 20 = 120$$

$$T_1 \cos 70 = T_2 \cos 20$$

$$T_2 \cos 20 = \frac{T_1 \cos 70}{\cos 20}$$

$$T_1 \sin 70 + \left(\frac{T_1 \cos 70}{\cos 20}\right)(\sin 20) = 120$$

$$\Rightarrow T_1 \left(\sin 70 + \frac{\cos 70 \sin 20}{\cos 20}\right) = 120$$

$$\Rightarrow T_1 = \frac{120}{\sin 70 + \frac{\cos 70 \sin 20}{\cos 20}} = 112.8 = 113$$

33.

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

A An aeroplane climbs at a steady rate.

B An aeroplane tows a glider at a constant altitude.

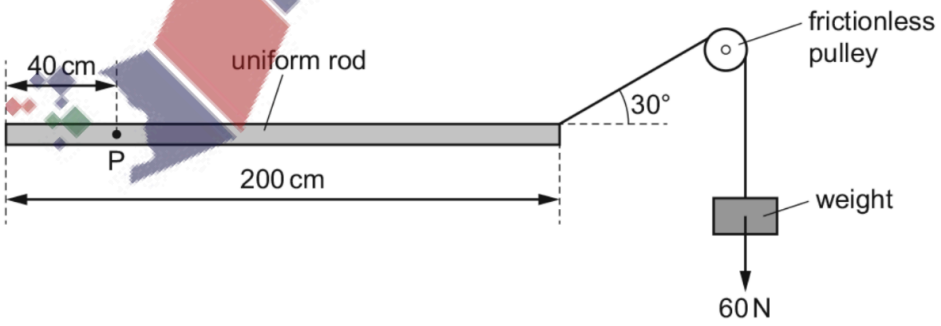
C A speedboat changes direction at a constant speed.

D Two boats tow a ship into harbour.

Ans: C

34.

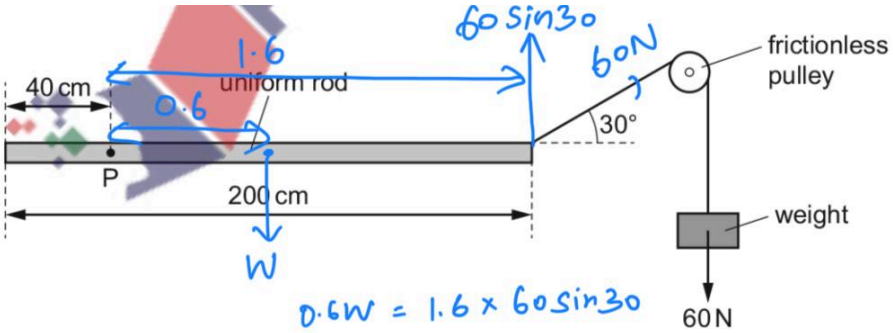
A uniform rod of length 200 cm is freely pivoted at point P. The rod is held horizontally in equilibrium by a 60 N weight that is attached to the rod by a string passing over a frictionless pulley.



What is the weight of the rod?

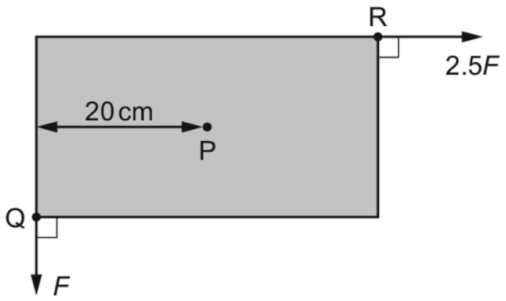
A 30 N **B** 60 N **C** 80 N **D** 140 N

Ans: C



35.

A uniform rectangular board is supported by a frictionless pivot at its centre point P.

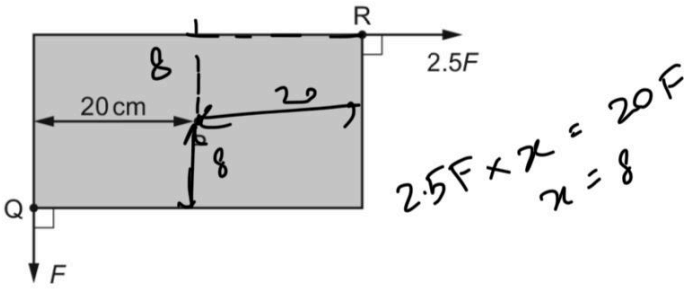


Two forces act in the plane of the board. Force *F* acts at corner Q and force 2.5*F* acts at corner R. The perpendicular distance between the line of action of force *F* and point P is 20 cm. The board is in equilibrium.

What is the area of the board?

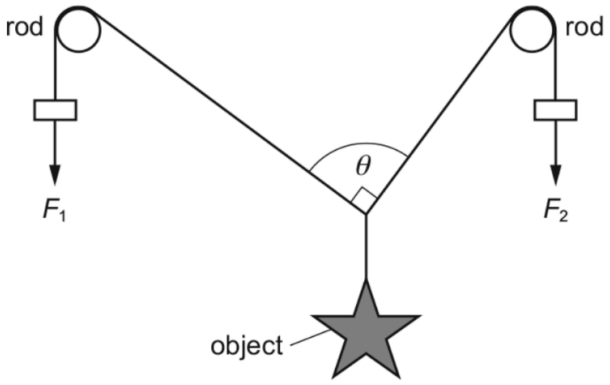
A 160 cm^2 **B** 320 cm^2 **C** 640 cm^2 **D** 1600 cm^2

Ans: C



36.

An object hangs by means of two cords around two rods, as shown.

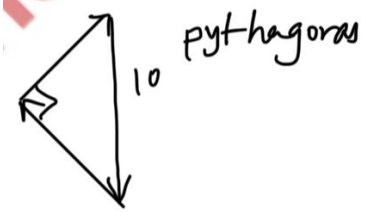


The object is held in equilibrium by the forces F_1 and F_2. The object weighs 10 N. There is negligible friction between the rods and cords. Angle θ is 90°.

Which row of the table gives an angle θ of 90°?

	F_1 / N	F_2 / N
A	4.0	6.0
B	6.0	4.0
C	6.0	8.0
D	8.0	6.0

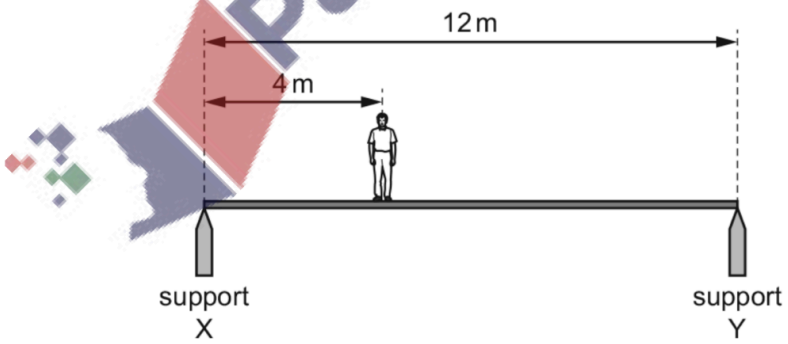
Ans: C



Use pythagoras, 6 and 8 are the values.
F2 > F1 since its closer

37.

A uniform horizontal footbridge is 12 m long and weighs 4000 N. It rests on two supports X and Y as shown.

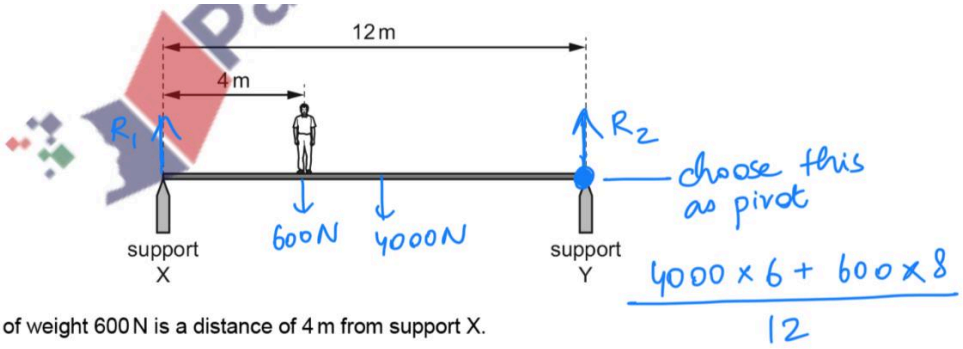


A man of weight 600 N is a distance of 4 m from support X.

What is the upward force on the footbridge from support X?

A 2200 N **B** 2300 N **C** 2400 N **D** 2600 N

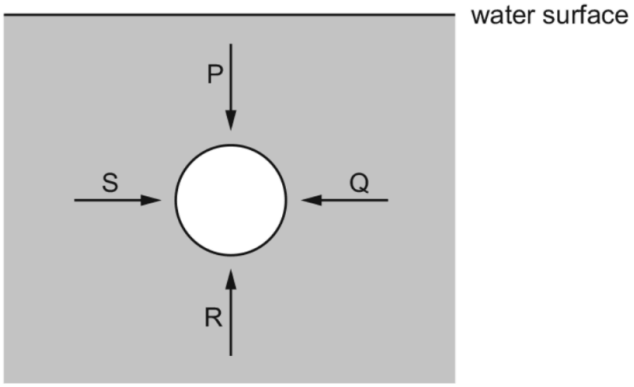
Ans: C



A man of weight 600 N is a distance of 4 m from support X.

38.

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 $S = Q$

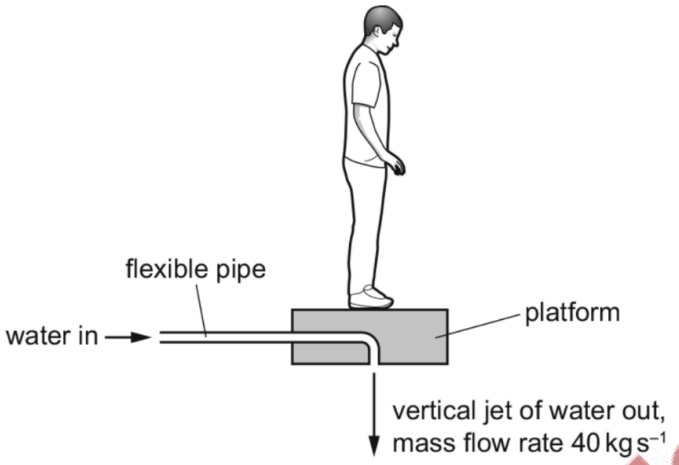
C $P = R$ and $S = Q$ and $P < S$

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

Ans: A

39.

The diagram shows a man standing on a platform that is attached to a flexible pipe. Water is pumped through the pipe so that the man and platform remain at a constant height.



The resultant vertical force on the platform is zero. The combined mass of the man and platform is 96 kg. The mass of water that is discharged vertically downwards from the platform each second is 40 kg.

What is the speed of the water leaving the platform?

A 2.4 m s^{-1} **B** 6.9 m s^{-1} **C** 24 m s^{-1} **D** 47 m s^{-1}

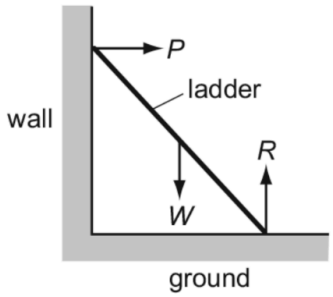
Ans: C

40.

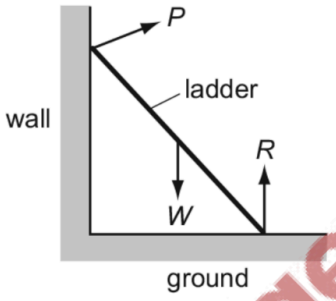
A ladder is positioned on icy (frictionless) ground and is leant against a rough wall. At the instant of release it begins to slide.

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

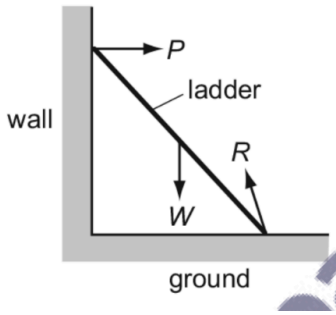
A



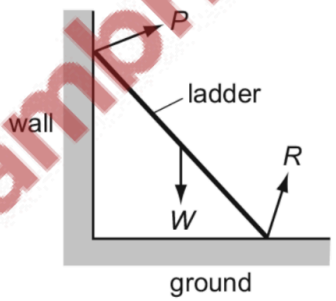
B



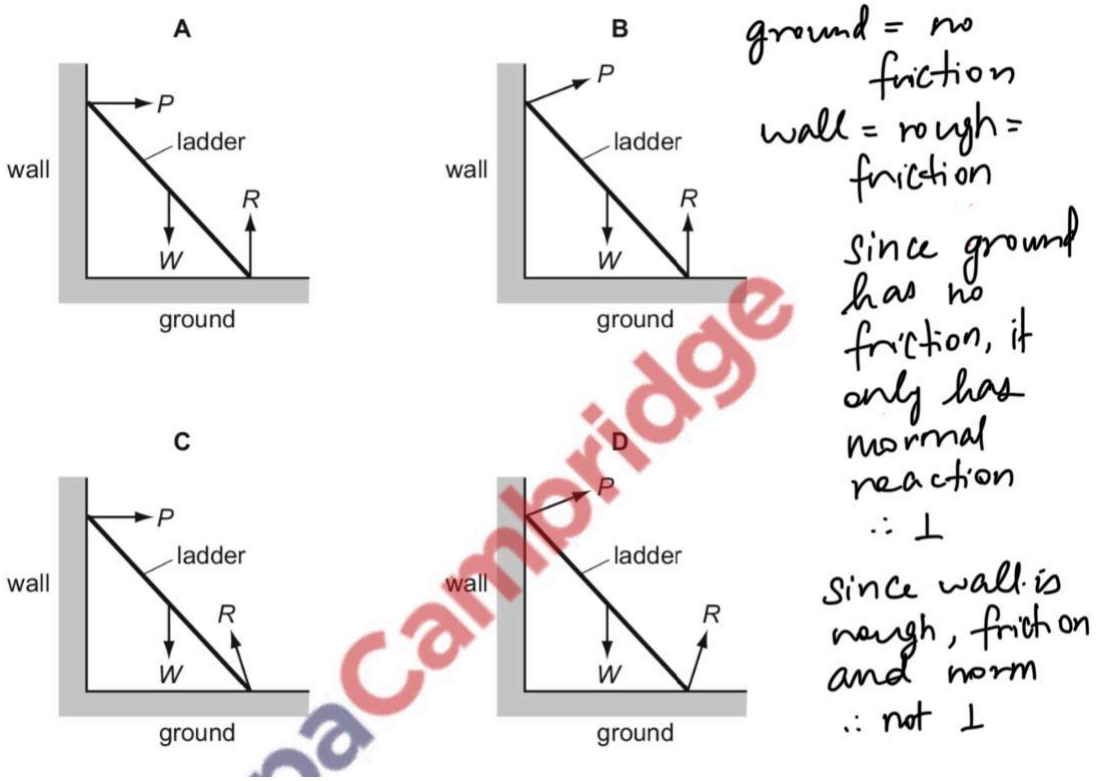
C



D

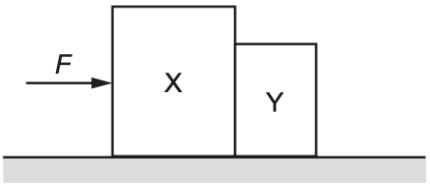


Ans: B



41.

A single horizontal force *F* is applied to a block X which is in contact with a separate block Y, as shown.



The blocks remain in contact as they accelerate along a horizontal frictionless surface. Air resistance is negligible. X has a greater mass than Y.

Which statement is correct?

A The acceleration of X is equal to force *F* divided by the mass of X.

B The force that X exerts on Y is equal to *F*.

C The force that X exerts on Y is less than *F*.

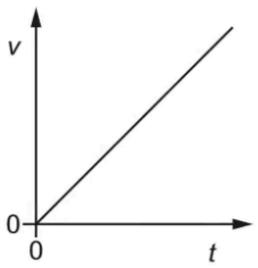
D The force that X exerts on Y is less than the force that Y exerts on X.

Ans: C

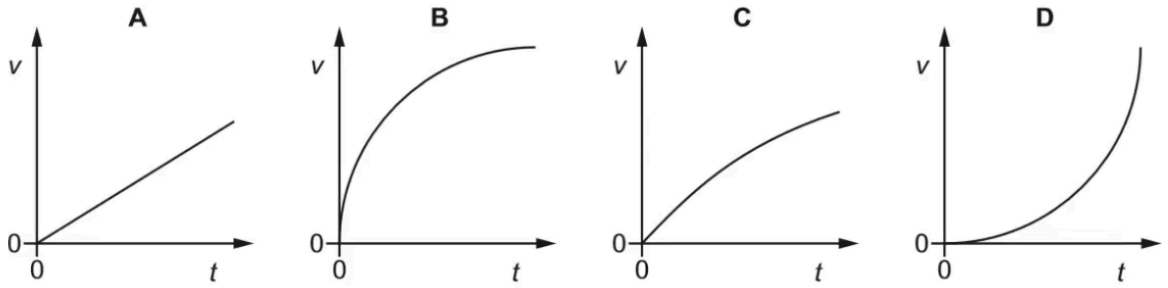
- The 2 blocks have the same acceleration since they are touching.
- F will be divided between the 2 blocks.
- Since X has greater mass, it receives a greater proportion of force F than Y.
  F = ma; since acceleration is same, greater mass of X = greater F!

42.

An object falls freely from rest in a vacuum. The graph shows the variation with time t of the velocity v of the object.



Which graph, **using the same scales**, represents the object falling in air?

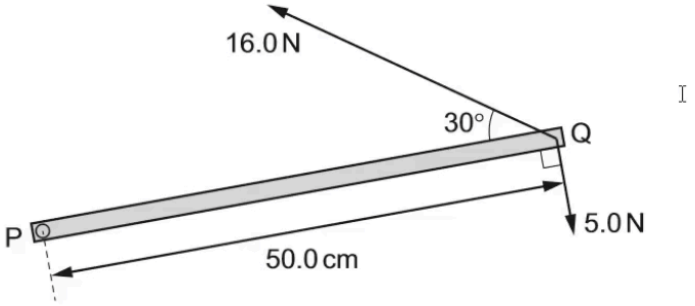


Ans: C

- <u>Using the same scales!!</u> In B, the initial acceleration and velocity is much higher than when there is no air resistance; this is not possible!

43.

A horizontal metal bar PQ of length 50.0 cm is hinged at end P. The diagram shows the metal bar viewed from above.



Two forces of 16.0 N and 5.0 N are in the horizontal plane and act on end Q, as shown.

What is the resultant moment about P due to the two forces?

A 1.5 N m **B** 4.4 N m **C** 6.5 N m **D** 9.4 N m

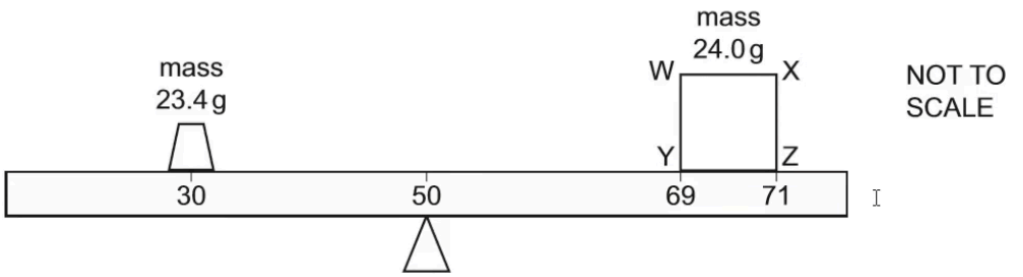
Ans: A

- 16N has a horizontal component and a vertical component.
- The horizontal component passes through the pivot P, so doesn't need to be considered.

- Net moment = 16sin30 x 0.5 – 5 x 0.5 = 1.5 Nm

44.

A cube WXZY has sides of length 2.0 cm and mass 24.0 g. The cube rests on a metre rule of negligible mass. The geometrical centre of the cube is vertically above the 70.0 cm mark on the scale of the rule.



The cube has a non-uniform density so that its centre of gravity is **not** at its geometrical centre. The centre of gravity of the cube is in the plane of the diagram.

The rule rests on a pivot at the 50.0 cm mark. A mass of 23.4 g is placed vertically above the 30.0 cm mark. The rule is horizontal and in equilibrium.

What can be determined about the position of the centre of gravity of the cube?

A It must be somewhere along a horizontal line that is 0.5 cm from line WX.

B It must be somewhere along a horizontal line that is 0.5 cm from line YZ.

C It must be somewhere along a vertical line that is 0.5 cm from line WY.

D It must be somewhere along a vertical line that is 0.5 cm from line XZ.

Ans: C

- Centre of mass of cube can be calculated at 69.5 on the scale.

45.

In a large container in an oil refinery, three oils of different densities are mixed. No chemical activity occurs.

The mixture consists of:

1200 kg of oil of density 1100 kg m^{-3}

1500 kg of oil of density 860 kg m^{-3}

4000 kg of oil of density 910 kg m^{-3}.

What is the density of the mixture?

A 927 kg m^{-3} **B** 933 kg m^{-3} **C** 957 kg m^{-3} **D** 1045 kg m^{-3}

Ans: A

Add up total mass and divide by total volume calculated.

46.

The diagrams show two ways of hanging the same picture.

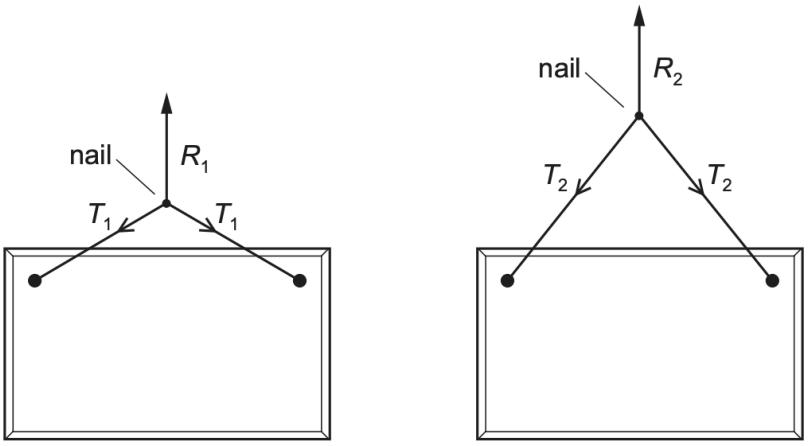


diagram 1 diagram 2

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 $R_1 > R_2$ $T_1 < T_2$

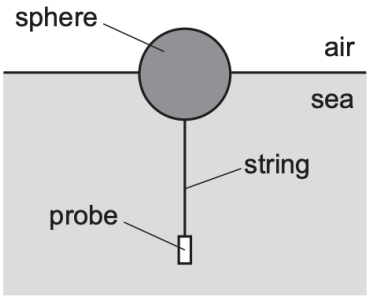
D $R_1 < R_2$ $T_1 = T_2$

Ans: B

- R1 and R2 is equal to weight of picture, which is same
- Equate 2T1costheta and 2T2cosbeta (they are both equal to weight)
- Take a larger value for theta than beta; this will show that T1 > T2

47.

A probe is used to monitor the quality of the water in the sea. The probe is suspended by a vertical string which is attached to a sphere. The stationary sphere floats in equilibrium on the surface of the sea, as shown.



The sphere has a weight of 5.00 N. The probe and string have a combined weight of 2.00 N.

The density of the seawater is $1.03 \times 10^3 \text{kg m}^{-3}$. The upthrust acting on the probe and thread is negligible.

What is the volume of the sphere below the surface of the sea?

A $1.98 \times 10^{-4} \text{m}^3$

B $2.97 \times 10^{-4} \text{m}^3$

C $4.95 \times 10^{-4} \text{m}^3$

D $6.93 \times 10^{-4} \text{m}^3$

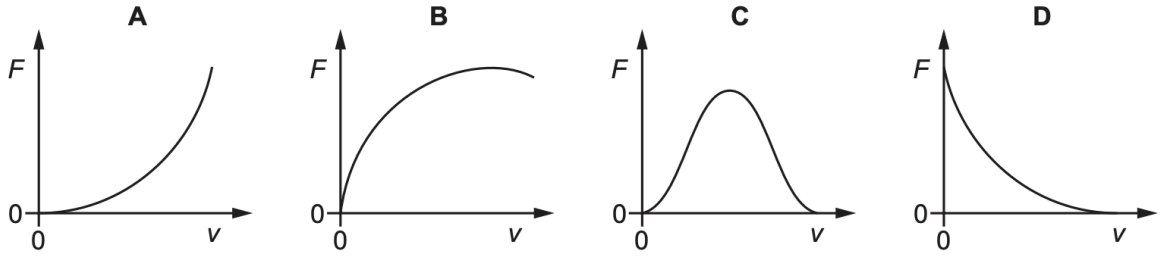
Ans: D

- Only the part of sphere immersed experiences upthrust
- Since it is in equilibrium, upthrust = weight
- Upthrust = $V\rho g$ = 5+2 (V = volume of sphere immersed; ρ = density of seawater)

48.

9 A small ball is held at the surface of liquid oil in a container. The ball is released from rest and falls through the oil. The ball has velocity *v*. A viscous (drag) force *F* acts on the ball.

Which graph could show the variation with *v* of *F*?

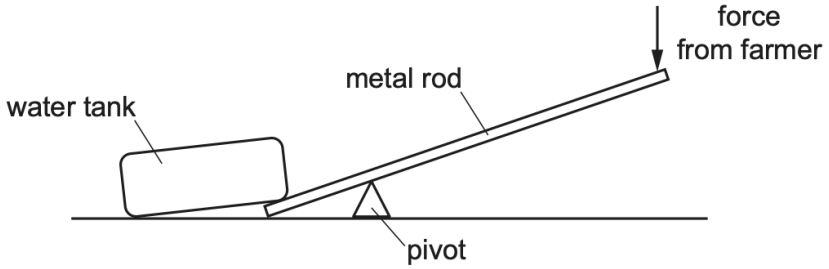


Ans: A

- As velocity increases, drag force increases.

49.

A farmer is trying to lift the corner of a large water tank. She uses a metal rod as a lever.



The vertical force from the farmer is constant and is always applied to the end of the rod.

Which change **must** increase the upward force on the water tank?

A using a longer rod and moving the pivot closer to the tank

B using a longer rod and moving the pivot further away from the tank

C using a shorter rod and moving the pivot closer to the tank

D using a shorter rod and moving the pivot further away from the tank

Ans: A

50.

A ball has a mass of 0.50 kg and a volume of $1.3 \times 10^{-3}\,m^3$. The ball is floating in equilibrium on still water. The two forces that act on the ball are its weight and the upthrust due to the water.

The density of the water is $1.0 \times 10^{3}\,kg\,m^{-3}$.

What is the percentage of the volume of the ball above the surface of the water?

A 3.9% **B** 38% **C** 62% **D** 96%

Ans: C

NOTE: q asks for percentage <u>above</u> surface not below!

51.

Some small solid cubes each have mass 1.0 kg and sides of length 5.0 cm. These small cubes are stacked together to form a large solid cube with sides of length 2.0 m.

What is the weight of the large cube?

A 0.39 kN **B** 0.39 MN **C** 0.63 MN **D** 0.63 GN

Ans: C

- Volume of large cube = 2x2x2 = 8m3
- Volume of small cube = 0.05x0.05x0.05 = 1.25×10^{-4} m3
- Number of small cubes = $8 / 1.25 \times 10^{-4}$ = 64000
- 64000 x 9.81 = 627840 = 0.63 MN

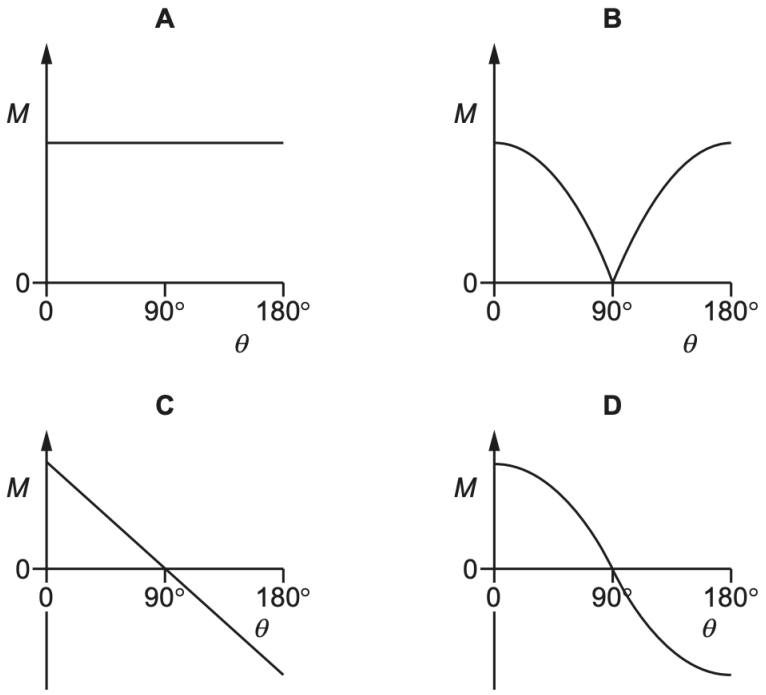
52.

A rod is pivoted at one end. Initially the angle θ of the rod to the horizontal is 0°.

The weight of the rod causes a moment *M* about the pivot.

The rod is then rotated in the vertical plane so that the angle θ of the rod increases from 0° to 180°.

Which graph shows the variation of *M* with θ?



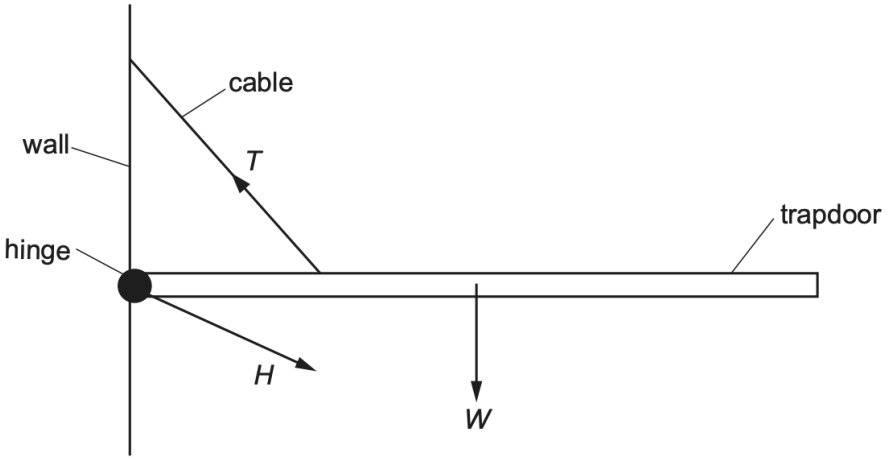
Ans: D

- M = weight of rod x perpendicular distance; M = W x dcosθ
- When θ = 90, cosθ = 0; When θ = 180, cosθ = −1
- This will be a cosine curve, hence answer is D

53.

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

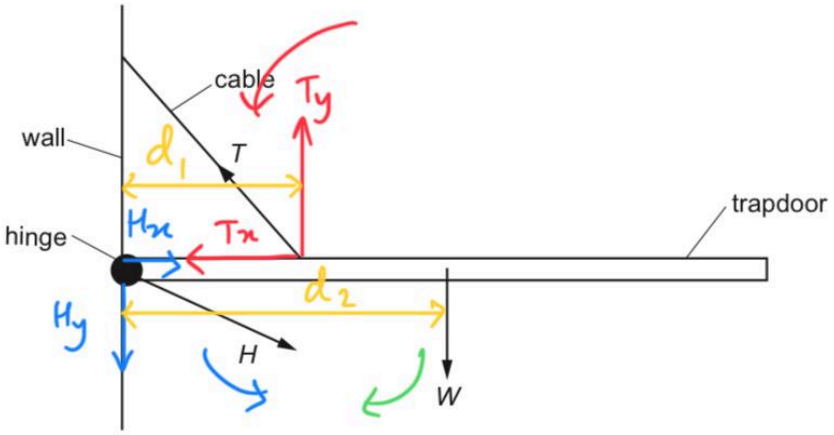
Three forces act on the trapdoor: the weight *W* of the door, the tension *T* in the cable and the force *H* at the hinge.



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*

Ans: C



$W \times d_2 = T_y \times d_1$

$d_2 > d_1 \Rightarrow W < T_y \therefore W < T$

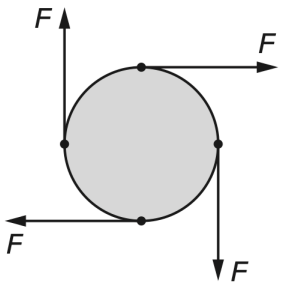
$T_y = W + H_y \Rightarrow H_y = T_y - W$

$\Rightarrow H_y < T_y$

$\therefore W < H < T$

54.

The diagram shows four forces acting on a circular disc.



Each force has magnitude *F*. Two of the forces act vertically and the other two forces act horizontally.

All four forces act in the same plane as the disc. No other forces act on the disc.

The disc has diameter *d*.

Which statement is correct?

A The disc is in equilibrium because the resultant force is zero.

B The disc is **not** in equilibrium because the resultant force is 4*F*.

C The disc is in equilibrium because the resultant torque is zero.

D The disc is **not** in equilibrium because the resultant torque is 2*Fd*.

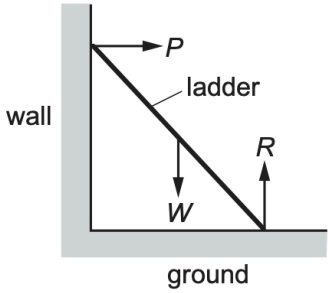
Ans: D

55.

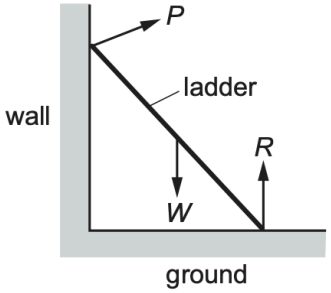
A ladder is positioned on icy (frictionless) ground and is leant against a rough wall. At the instant of release it begins to slide.

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

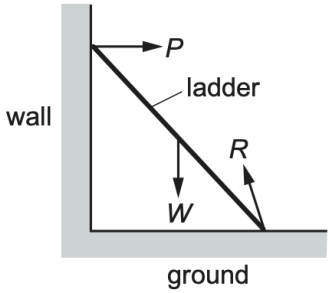
A



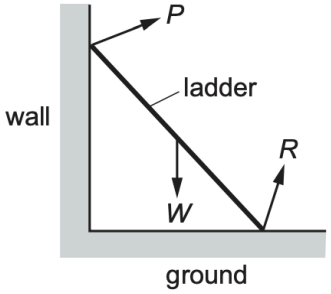
B



C



D



Ans: B

- Rough wall, so friction, hence not perpendicular
- Frictionless ground, so no friction, hence perpendicular

56.

A solid sphere, which is less dense than water, is held completely immersed in water a few metres below the surface. The density of the water is uniform.

The sphere is released. Immediately after release, the sphere rises.

Which row describes the changes in the magnitudes of the upthrust on the sphere and the resultant force on the sphere as it rises?

	upthrust on the sphere	resultant force on the sphere
A	constant	decreasing
B	constant	increasing
C	decreasing	decreasing
D	decreasing	increasing

Ans: A

- Upthrust depends on volume of water displaced, which is constant
- Immediately after release, the sphere accelerates upwards due to the upthrust being greater than the weight.
- As the sphere rises, drag force increases, opposing the motion.
- This increased drag force reduces the resultant upward force on the sphere.
- Eventually, when the drag force balances the excess upthrust, the sphere reaches terminal velocity, and the resultant force becomes zero.

57.

A football is kicked so that it moves vertically upwards through the air.

What is the variation in the air resistance and the resultant force acting on the ball as it moves vertically upwards?

	air resistance	resultant force
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

Ans: A

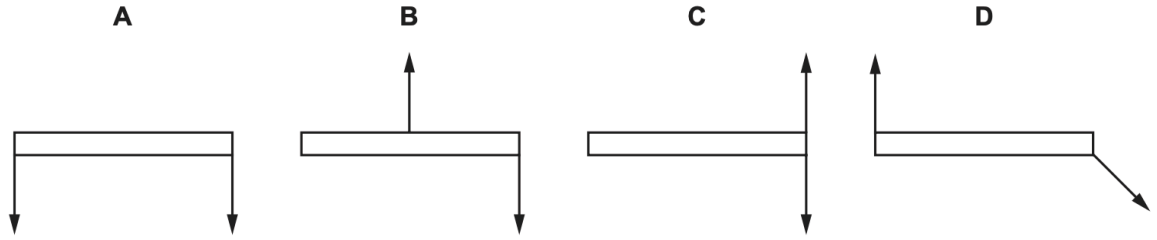
- As the ball moves upward, its speed decreases due to gravity and air resistance. Air resistance depends on the speed of the ball. Since speed decreases, air resistance decreases.
- Resultant force = weight + air resistance

- As air resistance decreases, resultant force becomes dominated by gravity (mg). Hence, resultant force decreases as the air resistance decreases.

58.

17 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?



Ans: B

59.

A solid cube is floating in equilibrium in liquid mercury. The cube is made of iron of density $7900\,kg\,m^{-3}$.

The cube floats with 42% of its volume above the surface of the mercury.

What is the density of the mercury?

A $3300\,kg\,m^{-3}$

B $4600\,kg\,m^{-3}$

C $14\,000\,kg\,m^{-3}$

D $19\,000\,kg\,m^{-3}$

Ans: C

$$U = W$$

$$V\rho g = mg \qquad V = \frac{m}{7900}$$

$$0.58 V\rho g = mg$$

$$0.58 \times \frac{m}{7900} \times \rho \times g = m \times g$$

$$\Rightarrow \rho = \frac{7900}{0.58} = 13620.7 \approx 14000$$

60.