FORCES

Challenging **MCQ** questions by The Physics Cafe

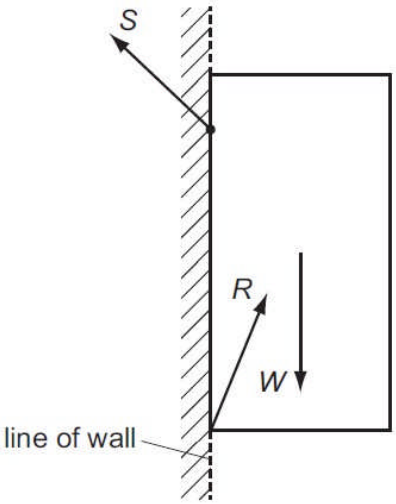
Compiled and selected by The Physics Cafe

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

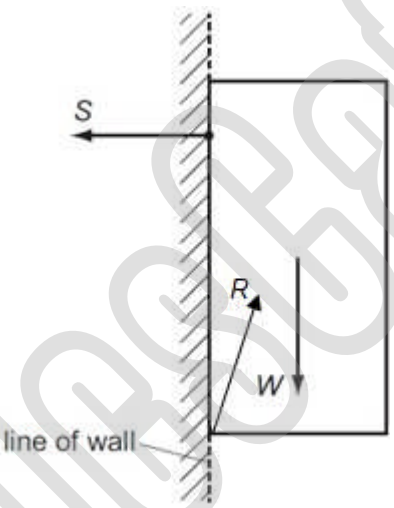
Which force diagram shows the cupboard in equilibrium, with the weight W of the cupboard, the force S that the screw exerts on the cupboard and the force R that the wall exerts on the cupboard?

The magnitude of the forces are not drawn to scale.

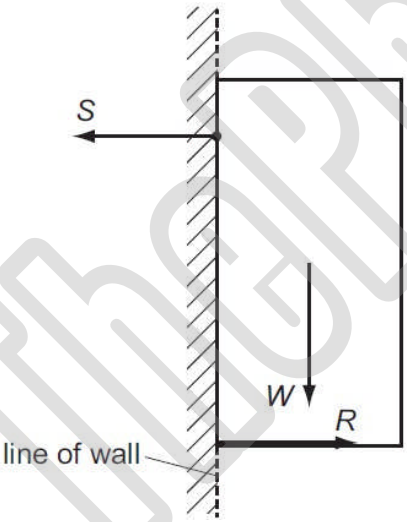
A



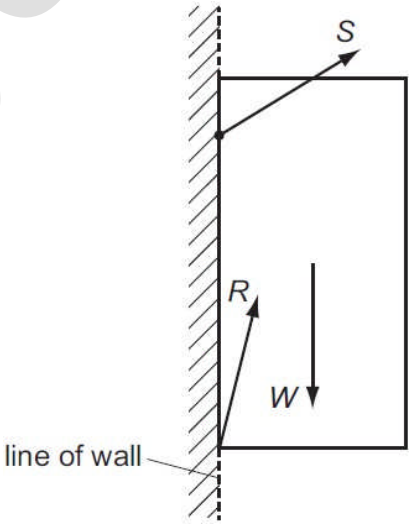
B



C



D



2 The hull of a ship may be assumed to have a uniform horizontal cross-sectional area in the region above and below the water line.

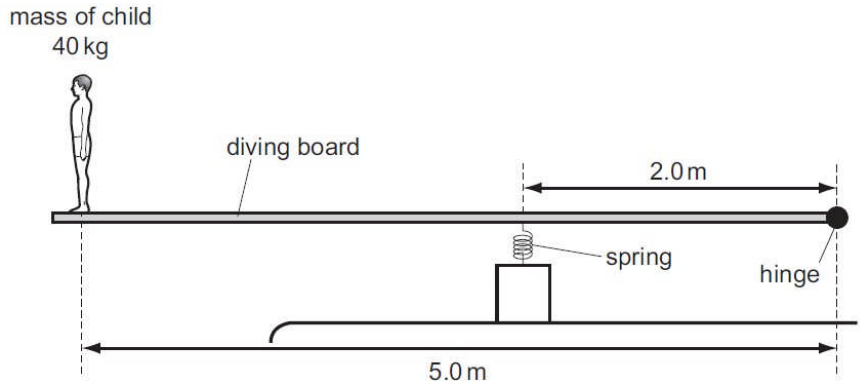
When in seawater of density 1.06 x 10^3 kg m^{-3}, the ship floats with 3.00 m of its hull below water. The ship then travels into a river estuary when the density of the water is 1.01 x 10^3 kg m^{-3}.

What is the new submerged depth of the hull?

A 3.35 m **B** 3.15 m **C** 3.05 m **D** 2.86 m

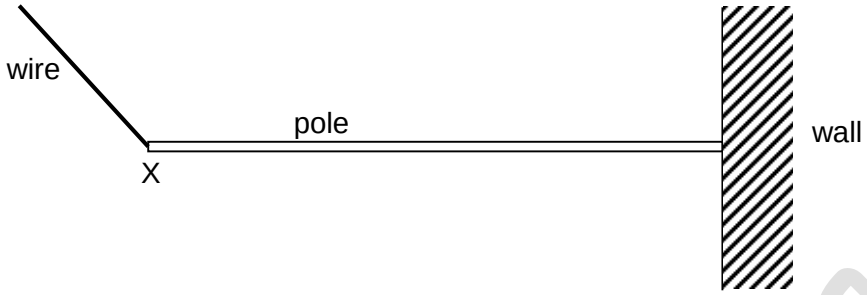
3 A uniform diving board of length 5.0 m and mass 35 kg hangs horizontally in equilibrium when it is hinged at one end and supported 2.0 m from this end by a spring of spring constant 10 KN m^{-1}.

When a child of mass 40 kg stands at the far end of the board as shown in the diagram below, what is the extra compression of the spring caused by the child standing on the end of the board?



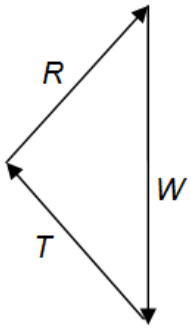
A 1.0 cm **B** 5.9 cm **C** 9.8 cm **D** 19.6 cm

4 A pole of weight *W* is attached to a wall. It is held horizontal by a wire attached at point X of the pole where *T* is the force of the wire. The pole experiences a reaction force *R* from the wall.

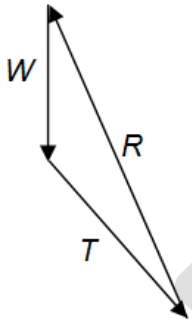


Which triangle of forces could correctly represent the three forces acting on the pole?

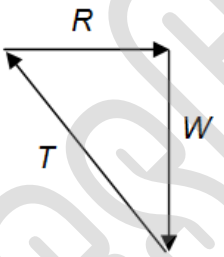
A



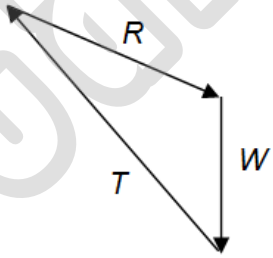
B



C

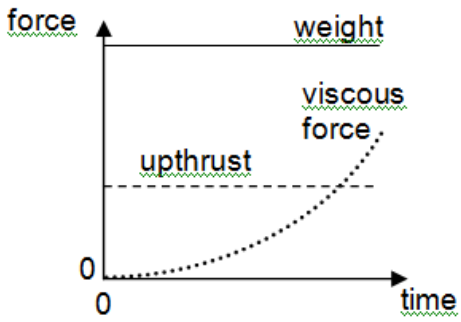


D

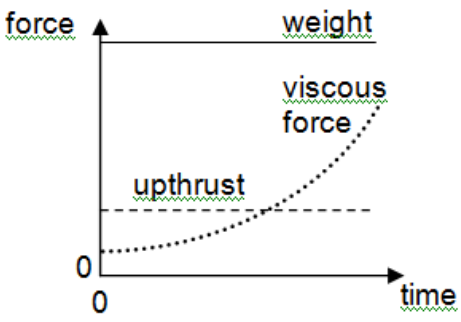


5 A ball bearing was released from rest in a viscous liquid. Which of the following graphs would represent the variation of the forces acting on the ball bearing with time?

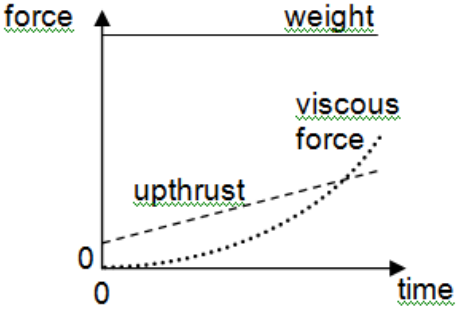
A



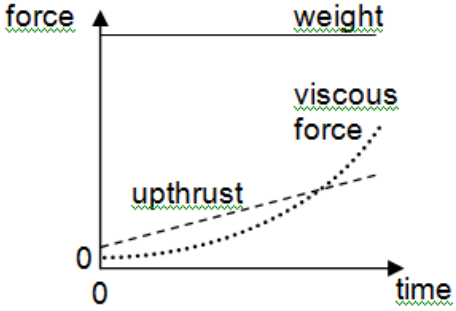
B



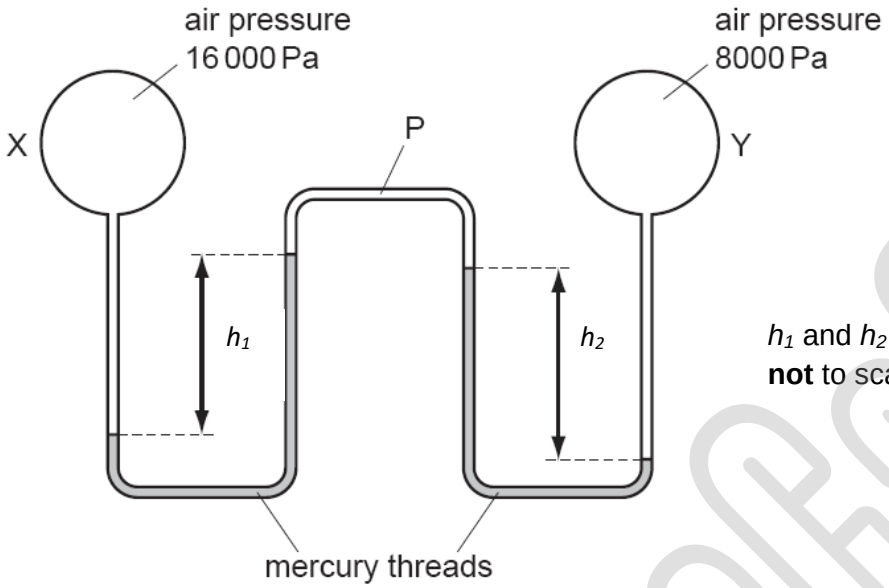
C



D



6 Two bulbs X and Y containing air at different pressures are connected by a tube P which contains two mercury threads.



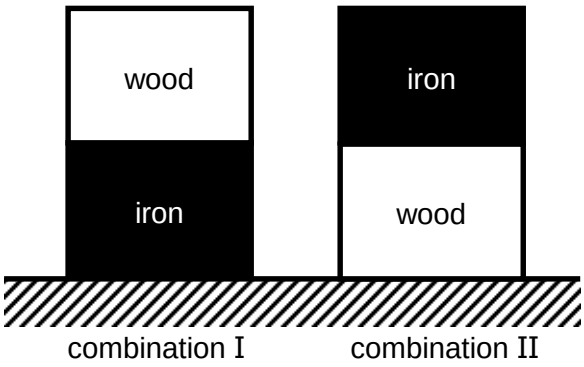
h_1 and h_2 are **not** to scale

The density of mercury is 13 600 kg m^{-3}.

Which pair of values of h_1 and h_2 is possible?

	h_1 / cm	h_2 / cm
A	2.0	8.0
B	4.0	2.0
C	6.0	6.0
D	8.0	2.0

7 Two blocks, one made of wood and the other of iron, are arranged at rest on the ground as depicted in combination I and II below.



Which one of the following statements is correct?

A The force by the iron block on the wooden block in I is greater than that by the wooden block on the iron block in II.

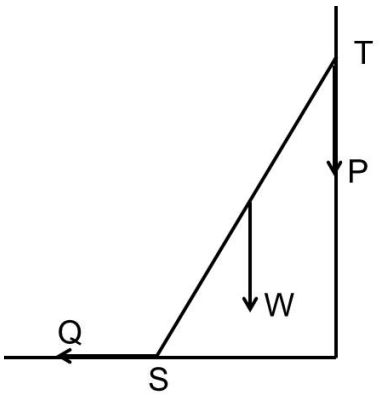
B The force by the wooden block on the iron block in I is the same as that by the iron block on the wooden block in II by virtue of Newton's 3rd law.

C The force by the wooden block on the iron block is equal to the weight of the wooden block in I while the force by the iron block on the wooden block is equal to the weight of the iron block in II.

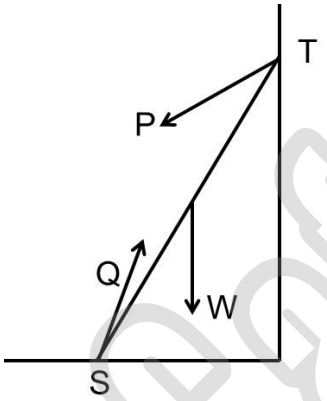
D The force by the ground on the iron block in I is greater than the force by the ground on the wooden block in II because the iron block, being denser than the wooden block, exerts more force on the ground.

8 A ladder ST, resting on a rough floor and learning against a rough wall, is on the point of slipping. The ladder has weight W. The contact forces exerted on the ladder by the wall and floor are P and Q respectively. Which one of the following diagrams correctly shows the directions of these forces?

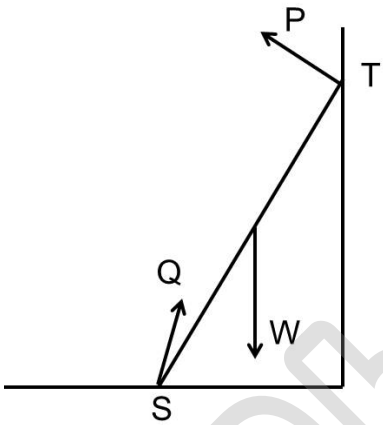
A



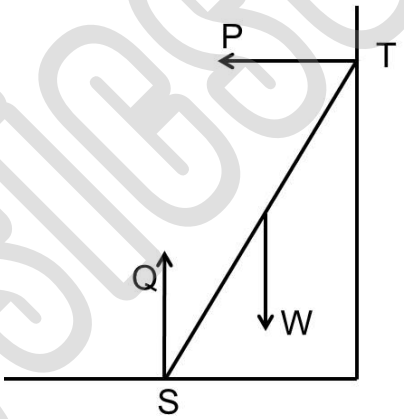
B



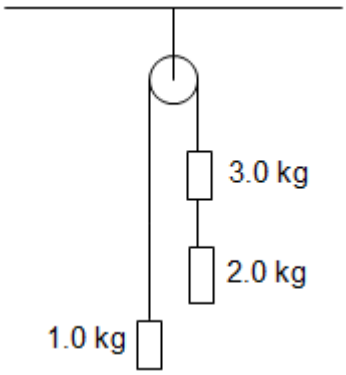
C



D

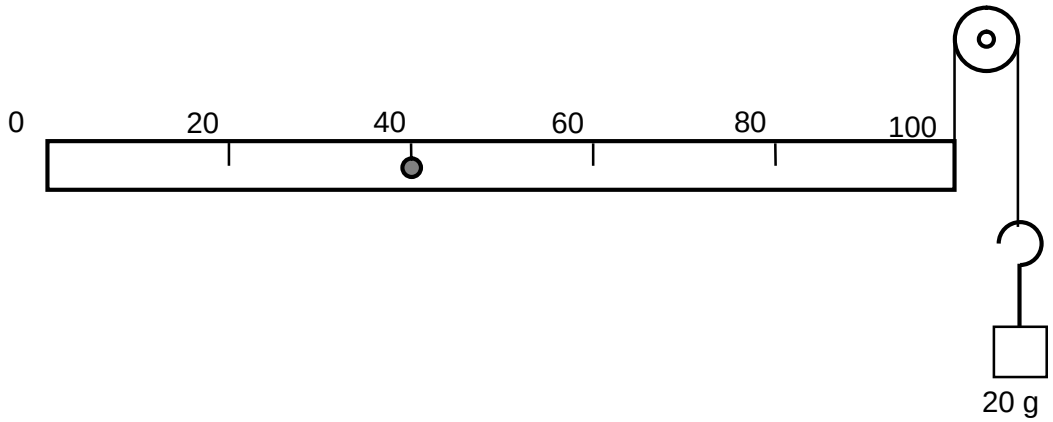


9 A light inextensible string is wound, as shown, over a frictionless, light pulley. What is the tension in the string between the 2.0 kg and the 3.0 kg masses when the system is released?



A 6.5 N **B** 16 N **C** 20 N **D** 39 N

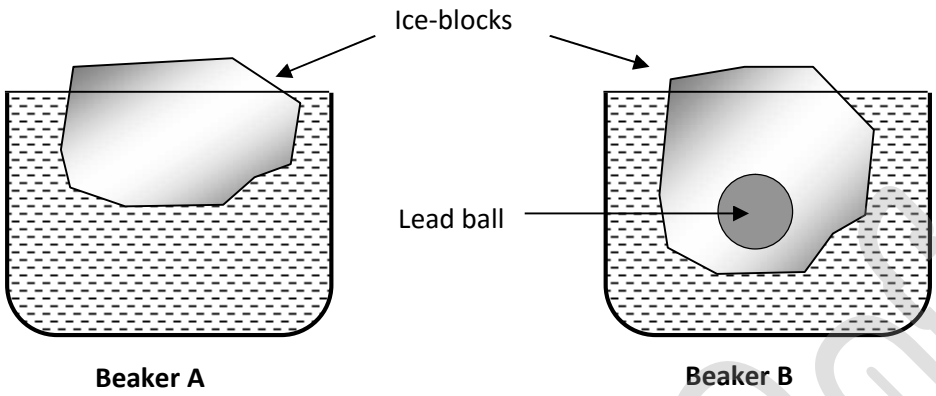
10 A uniform metre ruler of mass 100 g freely rotates around a pivot at the 40 cm mark. At the 100 cm mark, a string is secured and passed round a frictionless pulley, carrying a mass of 20 g as shown in the diagram.



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

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

11 Two beakers of water are shown below. Beaker A is brim-full of cold water with a solid ice-block floating in it. Beaker B is also brim-full with an ice-block floating in it, but the ice-block has a trapped lead ball within it.



When both ice-blocks melt, what will happen?

A Both beakers will remain brim-full.

B Beaker A will remain brim-full whereas beaker B will spill over.

C Beaker A will spill over whereas the water-level in beaker B will get lower.

D Beaker A will remain brim-full whereas the water-level in beaker B will get lower.

12 A tennis ball approaches a tennis player who gives it a hard hit with a swing of his racket, returning the ball to his opponent.

During the time of contact between the racket and the ball,

A the force on the racket due to the ball is smaller than the force on the ball due to the racket because the ball is much smaller and lighter than the racket.

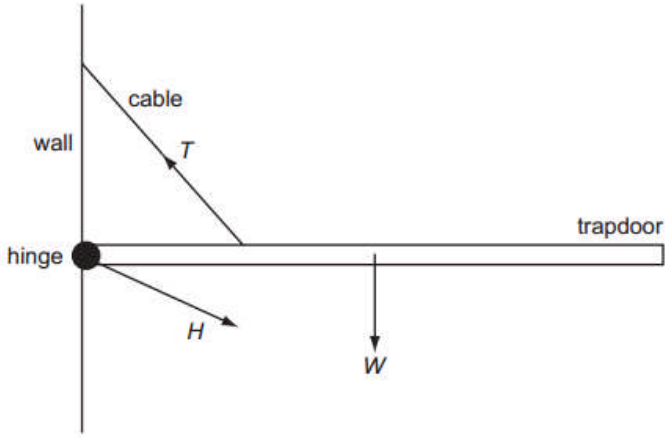
B the force on the racket due to the ball is smaller than the force on the ball due to the racket because the ball moves off with high speed after the contact whereas the racket does not.

C the force on the racket due to the ball is larger than the force on the ball due to the racket because smaller mass means smaller force.

D the force on the racket due to the ball is equal to the force on the ball due to the racket.

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

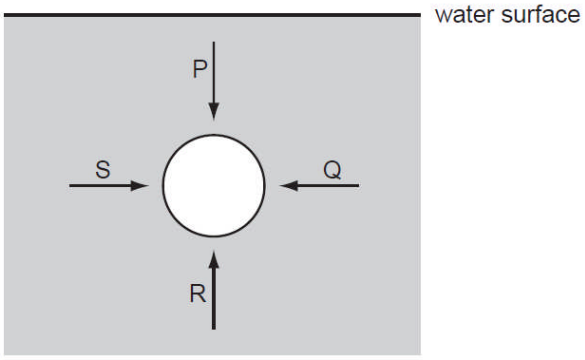
Three forces act on the trapdoor: the weight *W* of the trapdoor, the tension *T* in the cable and the force *H* at the hinge.



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*

14 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?

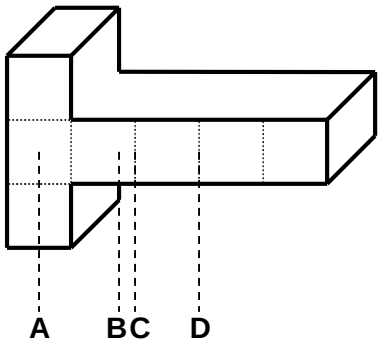
A P < R and S = Q

B P > R and S = Q

C P = R and S = Q and P ≠ S

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

15 An object of uniform density with uniform cross sectional area is shown in the diagram (drawn to scale). Along which vertical line is its centre of gravity most probably located?



FORCES WORKED SOLUTIONS

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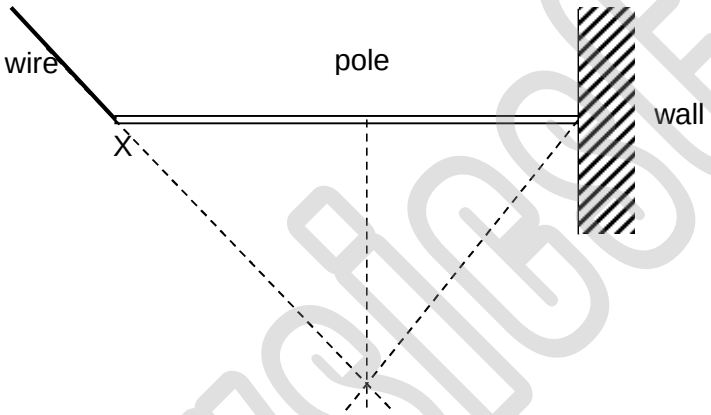
1 Ans: **A**
No resultant force
3 forces in equilibrium must be concurrent

2 Ans: **B**
When floating, U = W
Hence $\rho_1 h_1 Ag = \rho_2 h_2 Ag$

3 Ans: **C**
The additional clockwise moment of spring on board = additional anti-clockwise moments when man steps on board.

4 Ans: **A**
The three forces must through a common point. Hence direction of R must act along the dotted line from the wall.

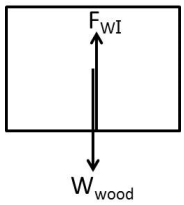


5 Ans: **A**
Since object is released from rest, no viscous force would act on it at the start. Upthrust is dependent on the pressure difference acting on the object. As pressure difference remain the same as object falls, upthrust will remain unchanged.

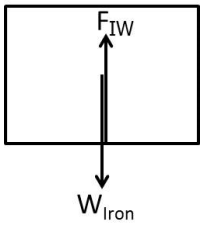
6 Ans: **D**
For pressure in P, $16000 - \rho g h_1 = 8000 - \rho g h_2$,
$h_1 - h_2 = [16000 - 8000]/[13600 \times 9.81] = 0.05996$ m = 6.0 cm
since pressure in X > pressure in Y, $h_1 > h_2$ hence **D** is the answer.

7 Ans: **C**

Consider FBD of the wooden block in I. Since it is at equilibrium, its weight is equal to the normal contact force on the wooden block by the iron block for I. (Note: Both are not an action-reaction pair)



Consider FBD of the iron block in II, since it is at equilibrium, its weight is equal to the normal contact force on the iron block by the wooden block for II. (Note: Both are not an action-reaction pair)



Note: Weight of wooden block is LESSER than weight of iron block.

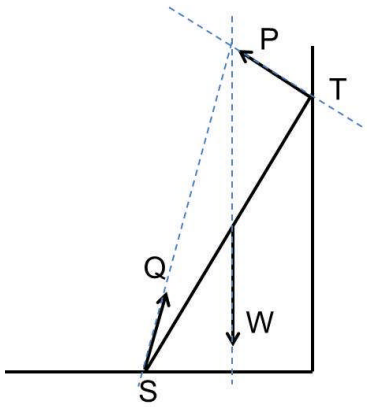
A is wrong as force by iron block on wooden block in I should be LESSER not greater.

B is wrong as force by wooden block on the iron block in I is LESSER than force by iron block on the wooden block in II.

For D, treat the iron and wooden block as one object. At equilibrium, their combined weight is equal to the force by the ground on the iron block for I. At equilibrium, their combined weight is equal to the force by the ground on the wooden block for II. The statement should be the force by the ground on the iron block in I is the SAME as the force by the ground on the wooden block in II since their combined weights are the same for both scenarios.

8 Ans: **C**

All the lines of action of forces acting on the ladder intersect at a single point when it is in equilibrium.



For option B, though the line of actions of the forces act at a single point, the force P is made up of both the normal and frictional forces and the frictional force should act upwards.

9 Ans: **A**

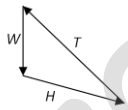
Let T be the tension in between the 3.0 kg and 1.0 kg masses and a be the acceleration of the system (The direction of a is assumed to be in the downward direction of the 2 kg and 3 kg masses).
Consider the 3.0 kg and 2.0 kg masses as one system, taking downwards as positive
$5.0g - T = 5.0a$ (1)
Consider the FBD of the 1.0 kg mass, taking upwards as positive
$T - 1.0g = 1.0a$ (2)
Solving simultaneously, $a = (2/3)g$
Consider the FBD of the 2.0 kg mass,
Let T' be the tension between the 3.0 kg and 2.0 kg masses,
$2.0g - T' = 2.0a$
$T' = 6.5$ N

10 Ans: **C**

11 Ans: **D**

12 Ans: **D**
The force on the racket must be equal and opposite to the force on the ball based on Newton's 3rd Law.

13 Ans: **B**
Sketch a possible force diagram with the 3 forces forming a closed triangle.



14 Ans: **A**
P<R – pressure is higher at deeper water.
S = Q – pressures at the same at the same depth.

15 Ans: **B**
A and D obviously wrong.
Let x = length of each cube and W = weight of each cube
Try taking moments about C,
clockwise moment = $(3W)(1.5x) = 4.5Wx$
anti-clockwise moment = $(3W)(1.5x) + (W)(0.5x) = 4.5Wx + 0.5Wx = 5\ Wx$
Therefore C is also wrong and centre of gravity is slightly to the left side of C.