4. Forces, Density and Pressure

4.3 Density and pressure

Paper 1

Question Paper

1 A thin horizontal plate of area $0.036\,m^2$ is beneath the surface of a liquid of density $930\,kg\,m^{-3}$. The force on one side of 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** 1.1 m **C** 1.8 m **D** 8.7 m

2 Water has a density of $1.0\,g\,cm^{-3}$.

Glycerine has a density of $1.3\,g\,cm^{-3}$.

A student measures out a volume of $40\,cm^3$ of glycerine into a container.

The student adds water to the container to make a mixture of water and glycerine. Assume that the total volume of water and glycerine does not change when the two liquids are mixed.

Which volume of water needs to be added to make a mixture of density $1.1\,g\,cm^{-3}$?

A $4.0\,cm^3$ **B** $8.0\,cm^3$ **C** $34\,cm^3$ **D** $80\,cm^3$

3 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

4 A rectangular block of lead of density $1.13 \times 10^4\,\text{kg m}^{-3}$ has sides of length 12.0 cm, 15.0 cm and 10.0 cm.

What is the maximum pressure the block can exert when resting on a table?

A 1.13 kPa **B** 1.70 kPa **C** 11.1 kPa **D** 16.6 kPa

5 Which expression for pressure is correct?

A force per unit area

B force per unit volume

C mass per unit area

D mass per unit volume

6 A ball has a mass of 0.50 kg and a volume of $1.3 \times 10^{-3}\,\text{m}^3$. 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 $1.0 \times 10^3\,\text{kg m}^{-3}$.

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%

7 A stone sinks in water.

What is a possible value for the density of the stone?

A $8 \times 10^2\,\text{kg m}^{-3}$

B $2 \times 10^3\,\text{kg m}^{-3}$

C $8 \times 10^3\,\text{N m}^{-3}$

D $2 \times 10^4\,\text{N m}^{-3}$

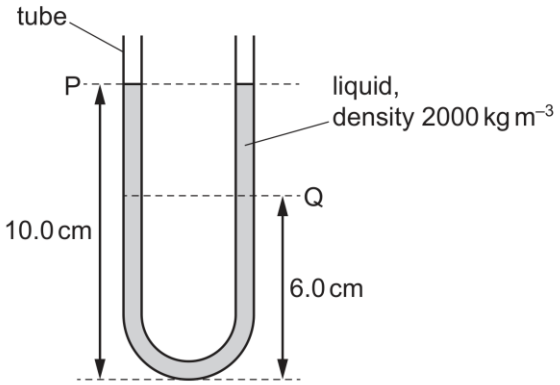
8 Two solid cubes X and Y are made of material of the same density. Cube X has twice the mass of cube Y.

Cube X has sides of length x. Cube Y has sides of length y.

What is the ratio $\frac{x}{y}$?

A 1.26 **B** 1.41 **C** 2.00 **D** 8.00

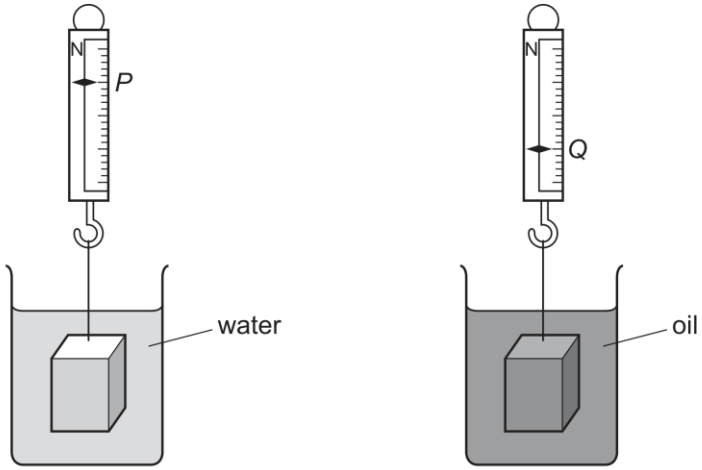
9 A U-shaped glass tube contains liquid of density 2000 kg m^{-3}, as shown.



What is the difference in pressure due to the liquid between levels P and Q?

A 780 Pa **B** 1200 Pa **C** 1600 Pa **D** 2000 Pa

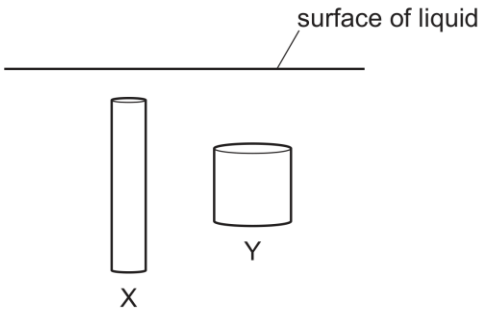
10 An object of weight W is suspended from a newton meter. When the object is completely immersed in water, the newton meter reads P. When the object is completely immersed in oil, the newton meter reads Q.



What is the ratio $\frac{\text{density of oil}}{\text{density of water}}$?

A $\frac{W-P}{Q-P}$ **B** $\frac{Q-P}{W-P}$ **C** $\frac{W-P}{W-Q}$ **D** $\frac{W-Q}{W-P}$

11 Two solid cylindrical objects X and Y are held fully submerged in a liquid, as shown.



The objects have the same volume. The density of the material of Y is twice the density of the material of X. Both objects are stationary.

Which statement is correct?

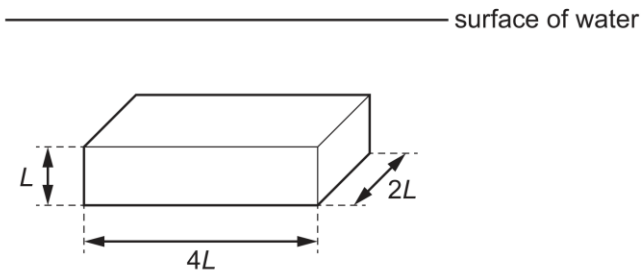
A The force due to the liquid acting on the top surface of X is greater than that acting on the top surface of Y.

B The pressure difference due to the liquid between the top and bottom surfaces of X is the same as that for Y.

C The upthrust acting on X is the same as the upthrust acting on Y.

D The weight of X is the same as the weight of Y.

12 A solid block has sides of length L, $2L$ and $4L$. The block is submerged in water of uniform density so that the faces with the largest area are horizontal, as shown.



The upthrust acting on the block is U.

The block is now rotated to a new position so that the faces with the smallest area are horizontal. The block remains fully submerged in the water.

What is the upthrust acting on the block in its new position?

A $\frac{U}{4}$ **B** U **C** $2U$ **D** $4U$

13 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}

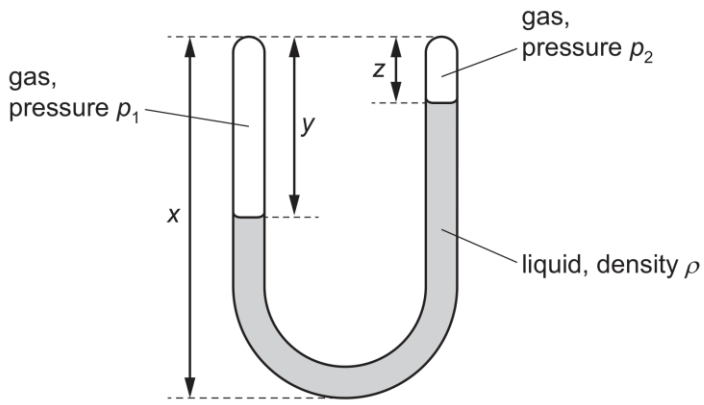
14 A granite rock at the surface of the Earth has density ρ. The rock is transported to the surface of another planet.

The acceleration of free fall on the surface of the other planet is twice that on the surface of the Earth.

What is the density of the rock on the other planet?

A 0.5ρ **B** ρ **C** 2ρ **D** 4ρ

15 A closed U-shaped tube contains a stationary liquid of density ρ. One side of the tube contains a gas at pressure p_1 and the other side contains a gas at pressure p_2, as shown.



The acceleration of free fall is g.

Which equation is correct?

A $p_1 = \rho g y$

B $p_2 = \rho g(x - z)$

C $p_1 - p_2 = \rho g(y - z)$

D $p_1 + p_2 = \rho g x$

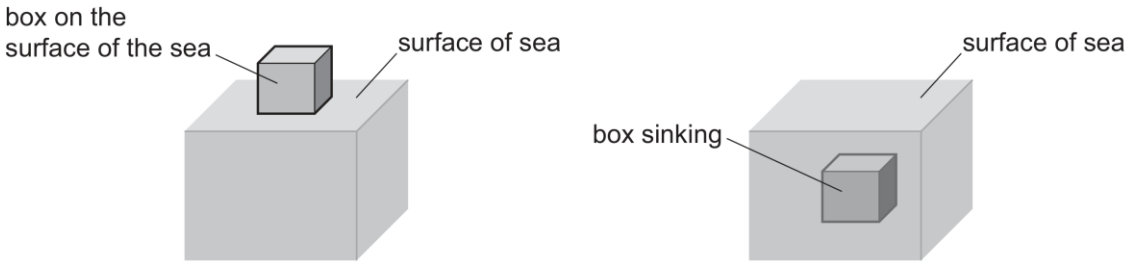
16 The density of water is $1.0\,\text{g cm}^{-3}$ and the density of glycerine is $1.3\,\text{g cm}^{-3}$.

Water is added to a measuring cylinder containing $40\,\text{cm}^3$ of glycerine so that the density of the mixture is $1.1\,\text{g cm}^{-3}$. Assume that the mixing process does not change the total volume of the liquid.

What is the volume of water added?

A $40\,\text{cm}^3$ **B** $44\,\text{cm}^3$ **C** $52\,\text{cm}^3$ **D** $80\,\text{cm}^3$

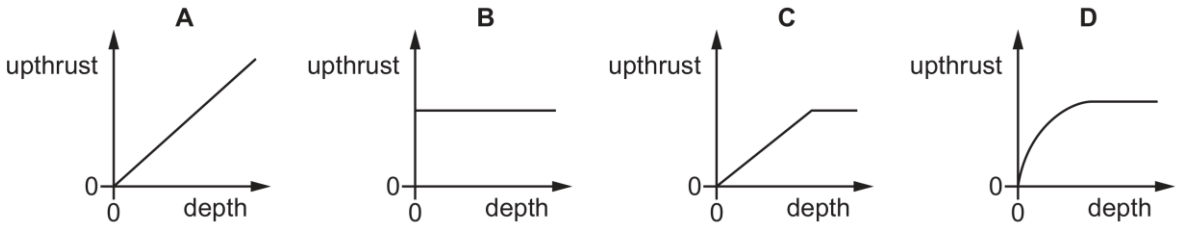
17 A box, in the shape of a cube, falls from a ship into the sea. The box lands with its lower face level with the surface of the sea.



The box begins to sink, becomes totally submerged and then sinks deeper into the sea.

As the box sinks, its lower face is always parallel to the surface of the sea.

Which graph best represents the variation of the upthrust acting on the box with the depth of its lower face below the surface of the sea?



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

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

What is the density of the mercury?

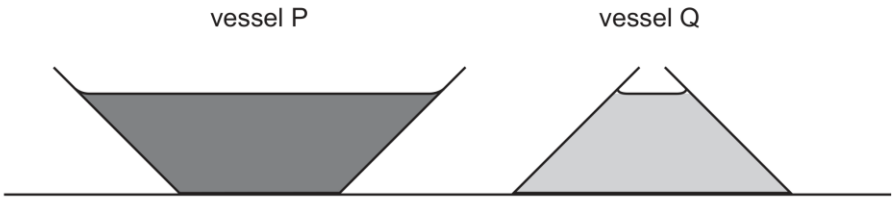
A $3300\,\text{kg}\,\text{m}^{-3}$

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

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

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

19 The diagram shows two vessels, P and Q, both with sides inclined at 45° to the horizontal.



Vessel P tapers outwards and vessel Q tapers inwards, as shown.

Both vessels contain a liquid. The depth of the liquid in the vessels is the same. The liquid in vessel P is twice as dense as the liquid in vessel Q.

What is the ratio $\frac{\text{pressure due to the liquid on the base of P}}{\text{pressure due to the liquid on the base of Q}}$?

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

20 Water of depth 9.0 cm is covered by oil of depth 5.0 cm in a measuring cylinder.

The density of the water is 1000 kg m^{-3} and the density of the oil is 800 kg m^{-3}.

What is the total pressure exerted on the base of the measuring cylinder due to the oil and water?

A 390 Pa **B** 880 Pa **C** 1200 Pa **D** 1300 Pa

21 Each foot of an elephant has a circular cross-section with a circumference of 1.4 m. The elephant has a mass of 5400 kg.

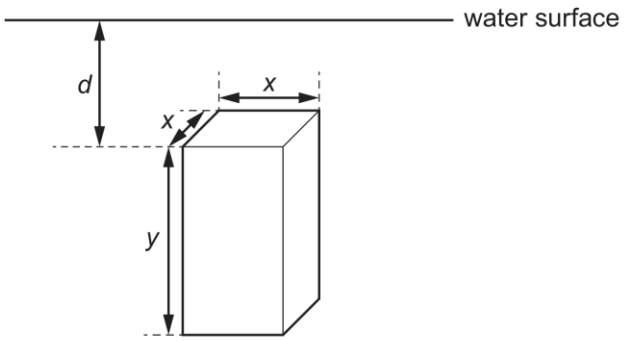
The elephant is standing still with all four feet on the ground. Assume the pressure under each foot is the same.

What is the approximate pressure exerted on the ground by each of the elephant's feet?

A 8.7 kPa **B** 35 kPa **C** 85 kPa **D** 340 kPa

22 A uniform solid block is fully submerged in a tank of water.

The dimensions of the block are *x* and *y,* as shown.



The block is held vertically in the position shown. The density of the block is the same as the density of the water.

If the block is always held at the same depth *d* below the surface of the water, which single change would **increase** the magnitude of the upthrust force on the block?

A decrease the density of the block

B hold the block horizontally

C increase dimension *y*

D increase the density of the block

23 A bird dives to a depth of 1.50 m below the surface of a lake. Atmospheric pressure is 101 kPa. The density of water is 1000 kg m^{-3}.

What is the pressure at this depth?

A 14.7 kPa **B** 86.3 kPa **C** 103 kPa **D** 116 kPa

24 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.

What is the upthrust on the block?

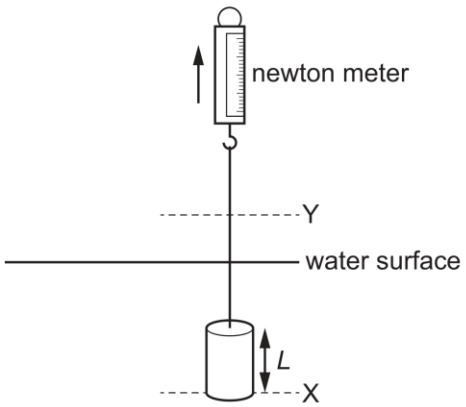
A $(p_b - p_t)$

B $(p_b - p_t)A$

C $(p_b - p_t)A - W$

D $(p_b - p_t)A + W$

25 A metal cylinder, totally immersed in water, is hung from a newton meter.

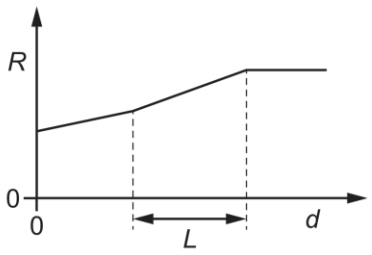


The cylinder, of height L, is slowly raised vertically by lifting the newton meter.

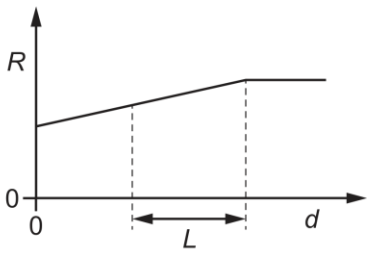
As the base of the cylinder moves from line X in the water to line Y above the surface of the water, the reading R on the newton meter is recorded. The velocity of the cylinder is constant.

Which graph best shows the variation of R with the distance d of the base of the cylinder from line X?

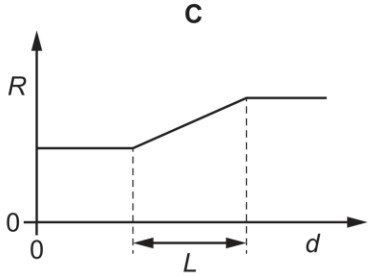
A



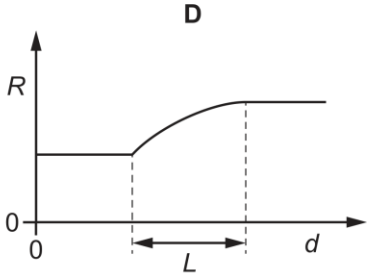
B



C



D



26 A rectangular metal bar exerts a pressure of 15 200 Pa on the horizontal surface on which it rests.

The height of the metal bar is 80 cm.

What is the density of the metal?

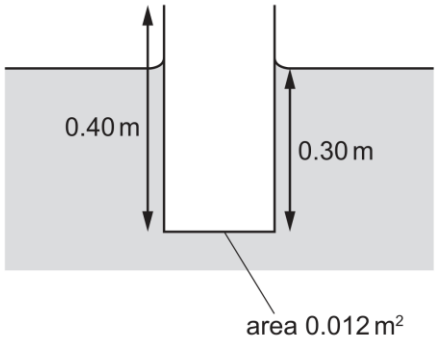
A 190 kg m^{-3}

B 1900 kg m^{-3}

C 19 000 kg m^{-3}

D 190 000 kg m^{-3}

27 A pipe, open at one end, floats in a liquid as shown.

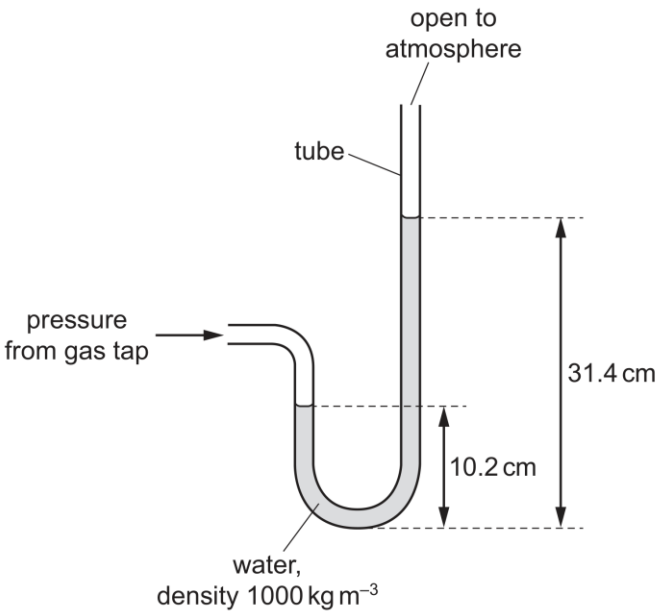


The cross-sectional area of the pipe is 0.012 m^2. The weight of the pipe is 32 N.

What is the density of the liquid?

A 680 kg m^{-3} **B** 910 kg m^{-3} **C** 6700 kg m^{-3} **D** 8900 kg m^{-3}

28 One end of a U-shaped tube is attached to a gas tap, with its other end open to the atmosphere. It contains water of density 1000 kg m^{-3} and the heights of both sides of the water column are shown.



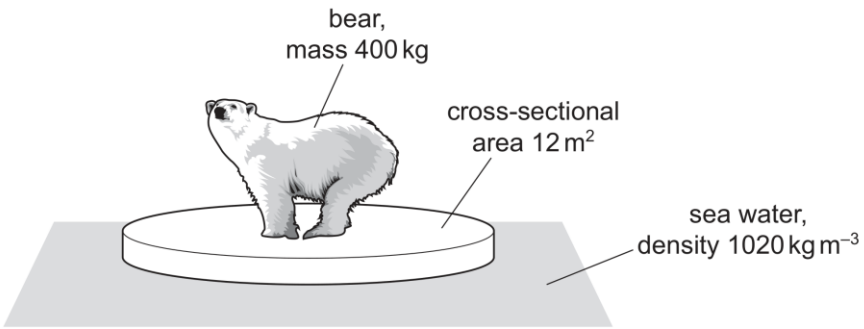
The atmospheric pressure is 101 kPa.

What is the pressure of the gas from the gas tap?

A 99 kPa **B** 100 kPa **C** 102 kPa **D** 103 kPa

29 A cylindrical block of ice of cross-sectional area 12 m^2 is floating, partially submerged, in the sea.

The density of the sea water is 1020 kg m^{-3}. A polar bear of mass 400 kg steps onto the block of ice.

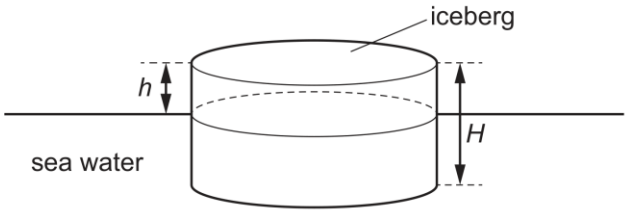


The block of ice sinks a vertical distance *d*.

What is the value of *d*?

A 3.3 mm **B** 3.3 cm **C** 0.32 m **D** 3.1 m

30 A cylindrical iceberg of height H floats in sea water. The top of the iceberg is at height h above the surface of the water.



The density of ice is ρ_i and the density of sea water is ρ_w.

What is the height h of the iceberg above the sea water?

A $\left(1-\frac{\rho_i}{\rho_w}\right)H$ **B** $\left(\frac{\rho_i}{\rho_w}-1\right)H$ **C** $\frac{\rho_w}{\rho_i}H$ **D** $\frac{\rho_i}{\rho_w}H$

31 An empty glass beaker has a mass of 103 g. When filled with water, it has a total mass of 361 g. When filled with cooking oil, it has a total mass of 351 g.

The density of water is $1.00\,\text{g cm}^{-3}$.

What is the density of the cooking oil?

A $0.961\,\text{g cm}^{-3}$ **B** $0.972\,\text{g cm}^{-3}$ **C** $1.03\,\text{g cm}^{-3}$ **D** $1.04\,\text{g cm}^{-3}$

32 A submarine descends vertically at constant velocity. The three forces acting on the submarine are viscous drag, upthrust and weight.

Which relationship between their magnitudes is correct?

A weight < drag

B weight = drag

C weight < upthrust

D weight > upthrust

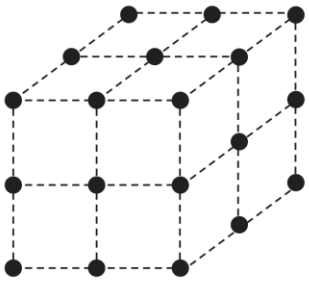
33 A volume of $1.5\,m^3$ of water is mixed with $0.50\,m^3$ of alcohol. The density of water is $1000\,kg\,m^{-3}$ and the density of alcohol is $800\,kg\,m^{-3}$.

The volume of the mixture is $2.0\,m^3$.

What is the density of the mixture?

A $850\,kg\,m^{-3}$ **B** $900\,kg\,m^{-3}$ **C** $940\,kg\,m^{-3}$ **D** $950\,kg\,m^{-3}$

34 The diagram shows the arrangement of atoms in a particular crystal.



Each atom is at the corner of a cube.

The mass of each atom is 3.5×10^{-25} kg. The density of the crystal is $9.2 \times 10^{3}\,kg\,m^{-3}$.

What is the shortest distance between the centres of two adjacent atoms?

A 3.8×10^{-29} m

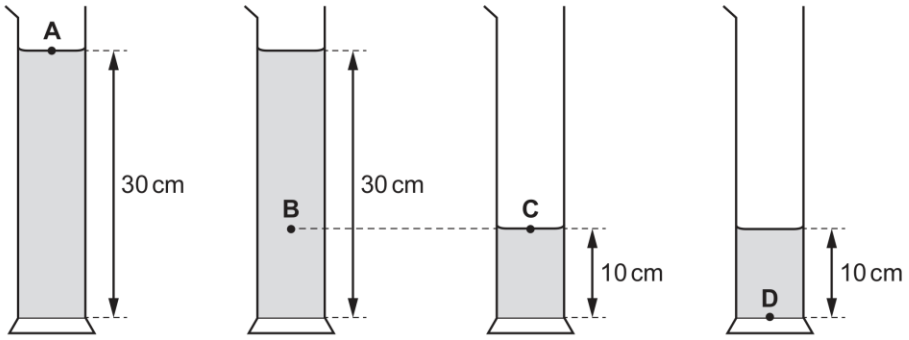
B 6.2×10^{-15} m

C 3.4×10^{-10} m

D 3.0×10^{-9} m

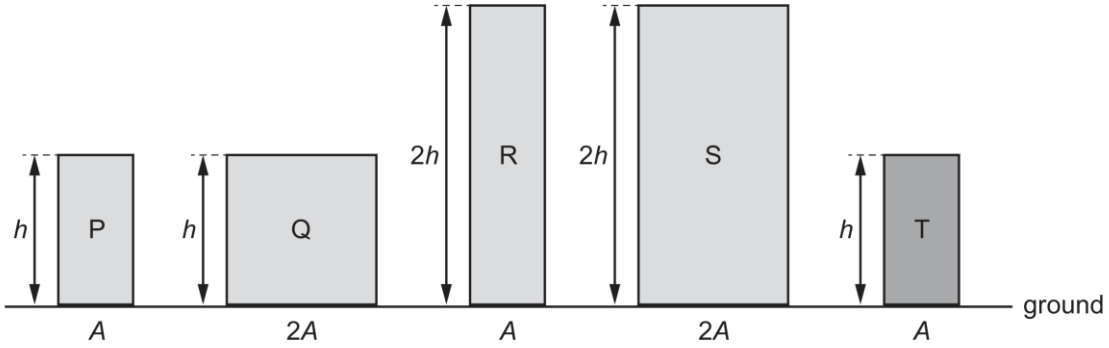
35 Four measuring cylinders are filled with the same liquid to the heights shown.

At which position is the pressure the greatest?



36 Blocks P, Q, R and S are made from material of the same density. Block T is made from a material of twice the density of the material of the other blocks.

The cross-sectional area and height of each of the blocks are shown.



Which two blocks exert the same pressure on the ground?

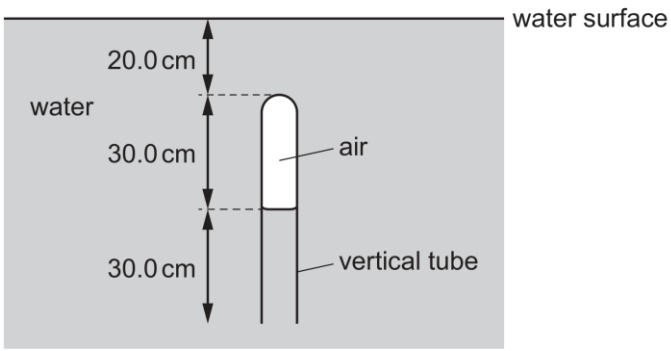
A P and T **B** Q and R **C** Q and S **D** S and T

37 Liquids X and Y are stored in large open tanks. Liquid X has a density of 800 kg m^{-3} and liquid Y has a density of 1200 kg m^{-3}.

At which depths are the pressures equal?

	depth in liquid X / m	depth in liquid Y / m
A	8	20
B	10	15
C	15	10
D	20	8

38 A vertical tube, closed at one end, is immersed in water. A column of air is trapped inside the tube.



The density of water is 1000 kg m^{-3}.

What is the difference between the pressure of the air in the tube and the atmospheric pressure?

A 1960 Pa **B** 2940 Pa **C** 4910 Pa **D** 7850 Pa

39 The density of the air in the atmosphere decreases as the height *h* above the surface of the Earth increases.

Which graph best shows the variation with height *h* of the pressure *p* of the air?

