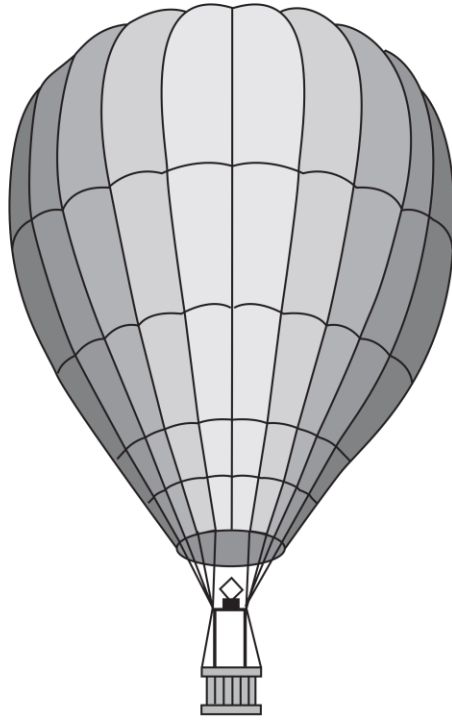


Practice questions for Fluids and Waves

- 1** A hot air balloon consists of an 'envelope' containing hot air, with a wicker basket suspended from it. The balloon flies because the heated air in the envelope is less dense than the surrounding air.



- (a) The total volume of the hot air balloon is 2830 m^3 . The total weight of the balloon, including the hot air in the envelope, is $33\,100 \text{ N}$. The density of the surrounding air is 1.20 kg m^{-3} .
- (i) Show that the resultant upward force on the balloon at the moment it is released is about 200 N .

(3)

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- (ii) Calculate the initial upward acceleration of the balloon. The mass of the balloon is 3370 kg .

(2)

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Acceleration =

(iii) The balloon is rising through air of viscosity $1.8 \times 10^{-5} \text{ kg m}^{-1} \text{ s}^{-1}$, at a speed of 2.0 m s^{-1} .

The effect of viscous drag on the balloon is negligible provided the air flow around the balloon is laminar.

Justify the statement in bold with the aid of a calculation. You may treat the whole balloon as a single sphere of radius 8.8 m.

(3)

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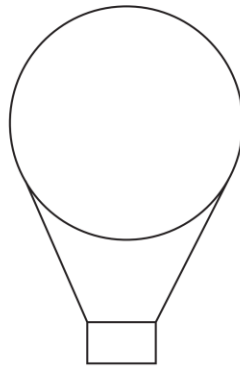
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(b) Add labelled arrows to the diagram below to show the forces acting on a vertically ascending balloon.

(2)



(c) As the balloon rises the density of the surrounding air decreases. Explain why this density change limits the height to which the balloon will rise.

(2)

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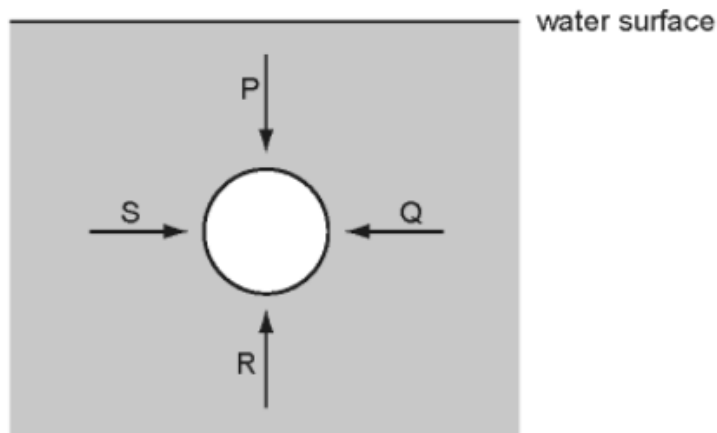
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(Total for Question 17 = 12 marks)

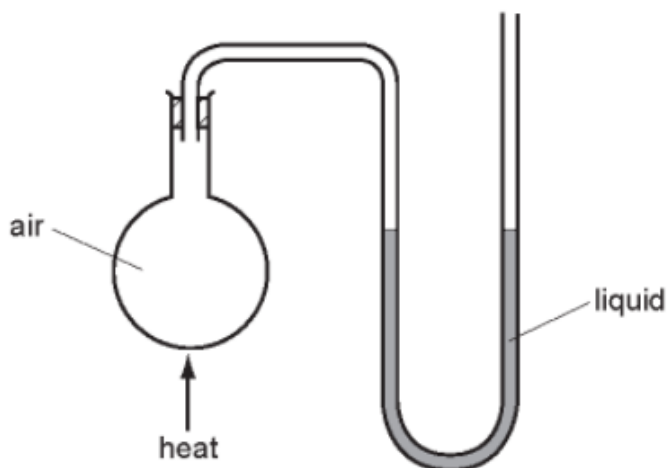
- 2 The diagram represents a sphere under water. P, Q, R, and S are forces acting on the sphere, due to the pressure of the water.



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 $P < R$; $S = Q$
 - B $P > R$; $S = Q$
 - C $P = R$; $S = Q$
 - D $P = R = S = Q$
- 3 The diagram shows a flask connected to a U-tube containing liquid. The flask contains air at atmospheric pressure.



The flask is now gently heated and the liquid level in the right-hand side of the U-tube rises through a distance h . The density of the liquid is ρ .

What is the increase in pressure of the heated air in the flask?

- A $h\rho$
- B $\frac{1}{2} h\rho g$
- C $h\rho g$
- D $2h\rho g$

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

If 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 $19\,000 \text{ kg m}^{-3}$
- D $190\,000 \text{ kg m}^{-3}$

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

What is the physical reason for this upthrust?

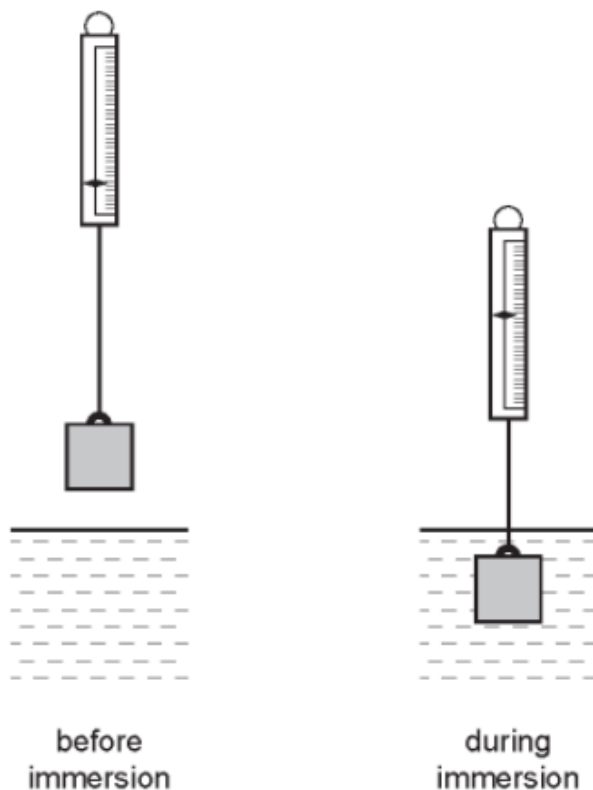
- A The density of the body differs from that of the liquid.
- B The density of the liquid increases with depth.
- C The pressure in the liquid increases with depth.
- D The value of g in the liquid increases with depth.

6 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

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



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.

8 The diagram shows two vessels, P and Q, both with sides inclined at 45° .



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 $\frac{1}{2}$

9 A horizontal plate of area 0.036 m^2 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

10 (a) Define *density*.

.....
..... [1]

(b) Explain how the difference in the densities of solids, liquids and gases may be related to the spacing of their molecules.

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.....
..... [2]

(c) A paving slab has a mass of 68 kg and dimensions 50 mm × 600 mm × 900 mm.

(i) Calculate the density, in kg m^{-3} , of the material from which the paving slab is made.

density = kg m^{-3} [2]

(ii) Calculate the maximum pressure a slab could exert on the ground when resting on one of its surfaces.

pressure = Pa [3]

11 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 $(p_b - p_t)A - W$

12 One method used to find the viscosity of a liquid is to measure the terminal velocity of a solid spherical object falling through it.

In such an experiment the following data are provided:

- weight of sphere = 4.8×10^{-3} N
- radius of sphere = 2.5×10^{-3} m
- volume of sphere = 6.5×10^{-8} m³
- density of liquid = 1300 kg m⁻³

(a) Show that the upthrust is about 8×10^{-4} N.

(2)

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(b) The terminal velocity is found to be 4.6×10^{-2} m s⁻¹. Use this value to show that the viscosity of the liquid is about 2 kg m⁻¹ s⁻¹.

(3)

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(c) The students carrying out this experiment wish to repeat it on another day using the same equipment. State another relevant variable that needs to be controlled to make this a fair test.

(1)

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(Total for Question 14 = 6 marks)

13 (a) (i) A small solid particle is falling through water. Add labelled arrows to the diagram below to show the forces acting on the particle.

(3)



(ii) Explain the condition for the particle to fall at its terminal velocity.

(2)

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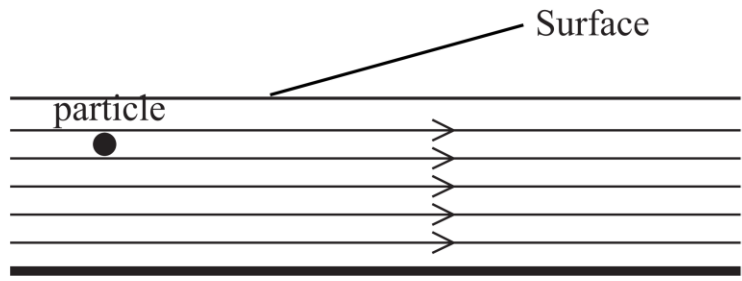
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(b) Flowing water can be used to move solid particles from one place to another.

(i) The diagram below shows water moving horizontally with a laminar flow.

Add to the diagram to show the path of the particle falling through this water flow.

(1)

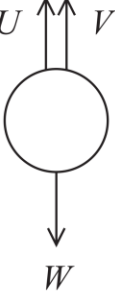
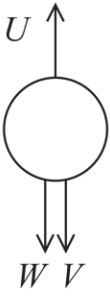
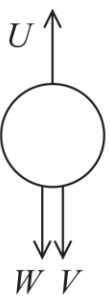
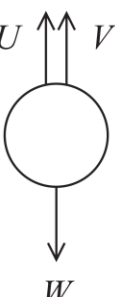


14 A small bubble is rising through a liquid at a constant speed.

Which row of the table correctly summarises the forces in both the diagram and the equation?

V = viscous drag, U = upthrust, W = weight

The force arrows are not drawn to scale.

<input type="checkbox"/>	A		$W = V + U$
<input type="checkbox"/>	B		$W = V + U$
<input type="checkbox"/>	C		$U = W + V$
<input type="checkbox"/>	D		$U = W + V$

(iii) Write an expression showing the relationship for these forces when the particle is falling at a steady speed.

(1)

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(b) A typical particle of sand in the sample has the following properties:

diameter = 1.6×10^{-3} m

volume = 2.1×10^{-9} m³

density = 2.7×10^3 kg m⁻³

weight = 5.7×10^{-5} N

(i) Show that the upthrust acting on the particle is about 2×10^{-5} N.

density of water = 1.0×10^3 kg m⁻³

(2)

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(ii) Calculate the steady downwards speed this particle would achieve if allowed to fall through water.

viscosity of water = 1.2×10^{-3} Pa s

(3)

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Speed =

(c) The different types of particles in soil can be defined according to their diameters, as in the following table.

Soil particle	Particle diameter
clay	less than 0.002 mm
silt	0.002 mm – 0.05 mm
sand	0.05 mm – 2.00 mm
fine pebbles	2.00 mm – 5.00 mm
medium pebbles	5.00 mm – 20.00 mm
coarse pebbles	20.00 mm – 75.00 mm

The photograph shows that when soil is allowed to settle in water, the pebbles tend to be found towards the bottom, followed by sand, silt and clay in succession.

Explain why this happens. Assume that all particles have the same density.

(3)

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(Total for Question 17 = 15 marks)

16

We have a cork attached to a free metallic chain (not pinned to the bottom) in a measuring cylinder (see picture). The cork is stable at a height of 16cm from the basis. Data: (density of water) $\rho_{\text{water}}=1.00 \text{ g/cm}^3$, (Volume of the cork) $V=8.41 \text{ cm}^3$, (mass of the cork) $M=7.55 \text{ g}$, (linear density of the chain) $d_{\text{chain}}=0.365 \text{ g/cm}$, $g=9.81 \text{ N/Kg}$.

a) Draw and name the forces acting on the cork. (3)

b) Compute the upthrust acting on the cork.

(2)

c) Compute the weight of the cork and of the 16cm of chain.

(3)

d) With the previous results, find out the upthrust upon the 16cm of chain.

(3)

(Total 11 marks)

