AQA · GCSE · PHYSICS • EXERCISE SHEET

5.5 Pressure and fluids

Name: _____ Class: _____ Date: _____ **Total: 27 marks**

KEY WORDS upthrust

Objective

Use $p = F/A$, (HT) $p = h\rho g$, explain upthrust and floating, and the variation of atmospheric pressure with height. Physics only. Original questions for spec statements 4.5.5.1–4.5.5.2.

1 Key knowledge and worked examples

A **fluid** is a liquid or a gas. Fluid pressure acts **normal (at right angles)** to any surface:

$$p = \frac{F}{A}$$

- p in pascals Pa; F force normal to the surface in N; A area in m^2.
- 1 Pa = 1 N/m^2. Convert cm^2 to m^2 before substituting.

(HT) Pressure in a **column of liquid**:

$$p = h\rho g$$

- h column height in m; ρ liquid density in kg/m^3; g given.
- Pressure at a point rises with the **height** of liquid above it and with the liquid's **density**; differences in depth give differences of pressure.

Upthrust : a submerged object feels **larger pressure on its bottom than its top** → a resultant force **upwards**. Floating at rest: upthrust = weight. A released object initially accelerates downwards if weight exceeds upthrust. Once it moves, fluid drag also contributes; a sinking object may reach a constant speed.

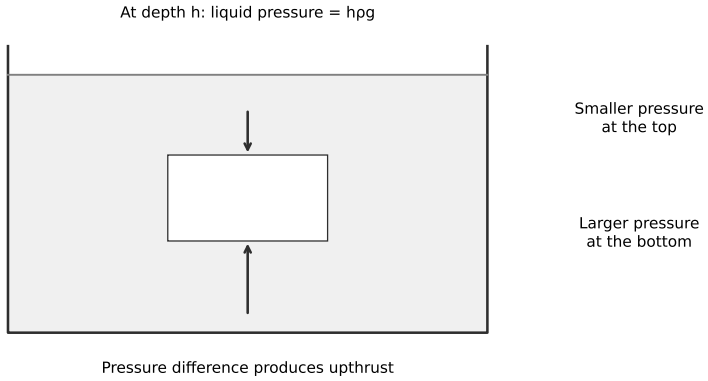
Atmospheric pressure decreases as height increases: fewer air molecules above the surface (less weight of air pressing down), and the atmosphere gets **less dense with altitude** – a thin layer relative to Earth's radius. Colliding air molecules make the pressure.

Worked example. A box of base area 0.50 m^2 is pressed down with 150 N.

$$p = \frac{F}{A} = \frac{150}{0.50} = 300 \text{ Pa}$$

Worked example (HT). A 4.0 m deep pool of water ($\rho = 1000$ kg/m^3, $g = 9.8$).

$$p = h\rho g = 4.0 \times 1000 \times 9.8 = 39\,200 \text{ Pa} \approx 39 \text{ kPa}$$



2 Practice

2.1 A force of 200 N acts on an area of 0.25 m^2. Calculate the pressure. [2]

2.2 (HT) State the two factors in the liquid column that raise the pressure at a point below the surface. [2]

2.3 A submerged balloon is released from rest and starts to rise. Explain its initial acceleration in terms of the forces on it. [2]

3 Exam-style questions

3.1 A swimming pool is filled to a depth of 2.0 m ($\rho = 1000$ kg/m^3, $g = 9.8$ N/kg; HT).

(a) Calculate the pressure due to the water at the bottom. [3]

(b) Explain why the pressure on the side walls near the bottom is greater than near the top. [2]

(c) The pool's bottom has an area of 50 m^2. Calculate the water's force on the bottom. [2]

3.2 A submarine dives.

(a) Explain what happens to the pressure on the hull as the depth increases. [2]

(b) (HT) At 30 m the water pressure is 294 kPa greater than at the surface, where atmospheric pressure is 101 kPa. A sealed flexible bag initially contains 6.0 L of air. Use $p_1V_1 = p_2V_2$ to estimate its volume at this depth, assuming constant temperature. [2]

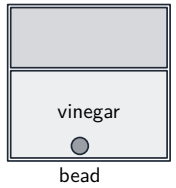
(c) Explain why the submarine's hull must be strong, using pressure and force. [2]

3.3 A jar contains oil floating on vinegar with a solid bead at the bottom (oil $\rho = 920$, vinegar $\rho = 1010$ kg/m^3).

(a) Explain, with densities, why the oil floats on the vinegar. [2]

(b) The bead (volume 1.0×10^{-6} m^3, density 2500 kg/m^3) sits in the vinegar. Calculate the upthrust on it in the vinegar ($g = 9.8$ N/kg, HT method $F = pA$ not needed: use $\rho V g$). [3]

(c) Calculate the bead's weight and state whether it stays on the bottom. [3]



Solutions

2.1

$$p = F/A = 200/0.25 = \mathbf{800}\ \text{Pa}$$

(C1, A1)

2.2 The height (depth) of liquid above the point and the liquid's density.

2.3 The water exerts a larger pressure on the balloon's bottom than its top ; the water's resultant force (upthrust) is upwards. Initially upthrust exceeds weight, giving an upward total resultant and acceleration.

3.1 (a)

$$p = h\rho g = 2.0 \times 1000 \times 9.8 = \mathbf{19\,600}\ \text{Pa}\ (\approx 20\ \text{kPa})$$

(equation C1, substitution C1, answer A1) (b) Pressure grows with the height of water above that point, so near the bottom the column above is taller – greater pressure. (c) $F = pA = 19\,600 \times 50 = \mathbf{980\,000}$ N ≈ 980 kN (C1, A1).

3.2 (a) The height of water above the hull increases with depth, and pressure increases with column height ($p = h\rho g$). (b) Use absolute pressure: $p_2 = 101 + 294 = 395$ kPa. At constant temperature, $V_2 = p_1V_1/p_2 = 101 \times 6.0/395 = \mathbf{1.5}$ L. The supplied gas relationship is used here; it is not a new fluid-pressure recall equation. (c) The pressure acts on a large hull area, and $F = pA$ gives a very large force trying to crush it – the hull must resist that.

3.3 (a) Oil is less dense than vinegar: a floating layer displaces until upthrust = weight, which needs the lighter liquid on top. (b) Upthrust = weight of vinegar displaced:

$$F = \rho_{\text{vinegar}} V g = 1010 \times 1.0 \times 10^{-6} \times 9.8 = \mathbf{9.9 \times 10^{-3}}\ \text{N}$$

(equation C1, substitution C1, answer A1) (c) Weight:

$$F_W = mg = \rho_{\text{bead}} V g = 2500 \times 1.0 \times 10^{-6} \times 9.8 = \mathbf{2.45 \times 10^{-2}}\ \text{N}$$

(C1, A1) – greater than the upthrust (0.0099 N), so the bead **stays on the bottom**.