4.3 Density and pressure

Name: ______________ Class: __________ Date: ____________ **Total: 14 marks**

Objective

Build the skills to answer exam questions on **density and pressure** —including hydrostatic pressure and upthrust.

You must be able to:

- use **density** $\rho = m/V$ and **pressure** $p = F/A$
- derive and use **hydrostatic pressure** $\Delta p = \rho g \Delta h$
- find **upthrust** with $F = \rho g V$ (Archimedes' principle)

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

Density and pressure

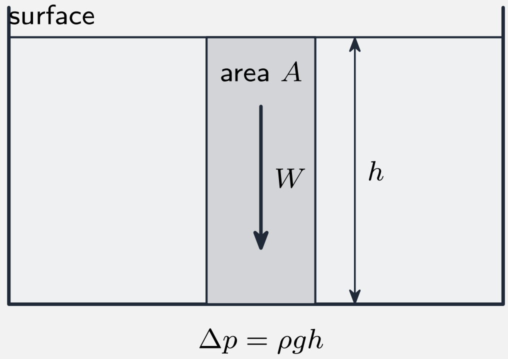
$$\rho = \frac{m}{V}\ (\text{kg m}^{-3}), \qquad p = \frac{F}{A}\ (\text{Pa} = \text{N m}^{-2}).$$

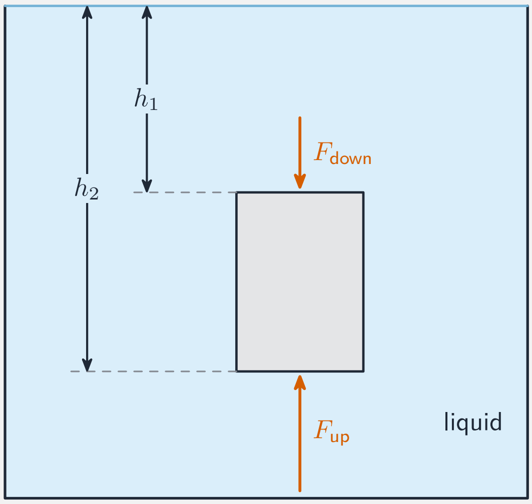
Water has $\rho = 1000$ kg m^{-3}.

Hydrostatic pressure

A column of liquid (area A, depth h) has weight $W = \rho A h g$ pressing on its base, so the **extra** pressure is

$$\Delta p = \frac{W}{A} = \rho g h.$$





Upthrust arises from the pressure difference with depth

It depends only on **depth and density** —not on the container's shape. (For total pressure, add atmospheric pressure $\approx 1.0 \times 10^5$ Pa.)

■ Upthrust

A submerged object feels a larger pressure on its **bottom** than its top —this pressure difference gives an upward **upthrust**:

$$F = \rho g V,$$

where V is the volume of fluid displaced (Archimedes' principle).

2 Practice

Now apply the methods above.

2.1 Define **density** and give its SI unit. [1]

2.2 A block has mass 2400 kg and volume 0.30 m^3. Find its **density**. [2]

2.3 A force of 200 N acts on an area of 0.50 m^2. Find the **pressure**. [2]

2.4 State what causes the **upthrust** on a submerged object. [1]

3 Exam-style questions

3.1 The extra pressure at the bottom of a liquid column depends on: [1]

- **A** the cross-sectional area only
- **B** the depth and the density
- **C** the shape of the container
- **D** the total volume of liquid

3.2 Calculate the extra pressure due to the water at the bottom of a pool 2.5 m deep. ($\rho = 1000$ kg m^{-3}, $g = 9.81$ m s^{-2}.) [2]

3.3 A block of volume 2.0×10^{-3} m^3 is fully submerged in water ($\rho = 1000$ kg m^{-3}). Calculate the **upthrust** on it. [2]

3.4 Derive the hydrostatic pressure equation $\Delta p = \rho g h$ from the definitions of **pressure**

and **density**. [3]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **4.3 Density and pressure** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/24 N25 —Q2 (hydrostatic pressure and upthrust)
- 9702/22 N25 —Q1 (density and pressure)
- 9702/11 N25 —Q16 (upthrust)
- 9702/21 N24 —Q1 (pressure calculation)

Solutions

2.1 Density is **mass per unit volume**, unit kg m^{-3}.

2.2 $\rho = m/V = 2400/0.30 = 8000$ kg m^{-3}.

2.3 $p = F/A = 200/0.50 = 400$ Pa.

2.4 The **difference in pressure** between the bottom and top of the object (the bottom is deeper, so at higher pressure).

3.1 **B** —the depth and the density.

3.2 $\Delta p = \rho g h = 1000 \times 9.81 \times 2.5 = 2.5 \times 10^4$ Pa.

3.3 $F = \rho g V = 1000 \times 9.81 \times 2.0 \times 10^{-3} = 19.6$ N.

3.4 The column's mass $m = \rho V = \rho A h$; its weight $W = mg = \rho A h g$ presses on area A; so $\Delta p = W/A = \rho g h$.