

1.8 Pressure

Name: _____ Class: _____ Date: _____

Total: 23 marks

KEY WORDS pressure • depth • density • force • weight

Objective

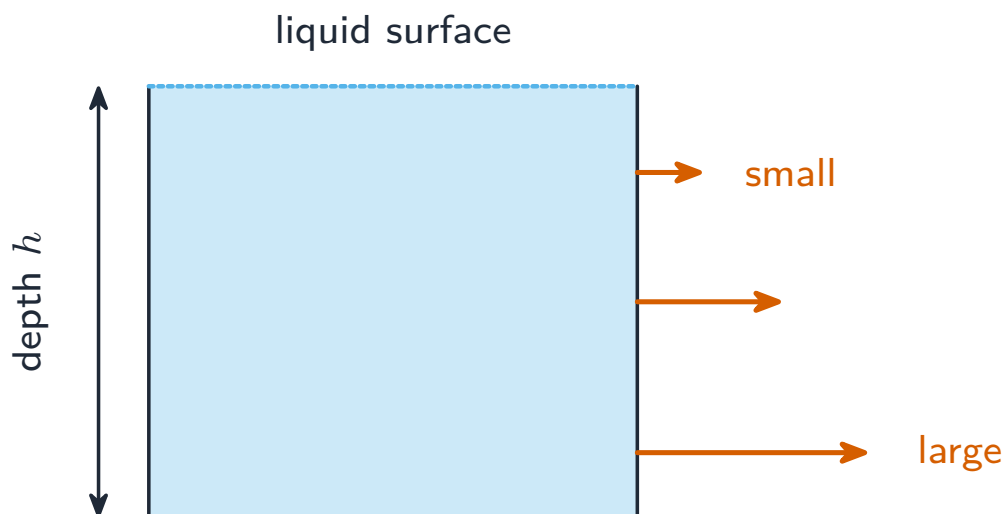
Build the skills to answer exam questions on **pressure** — $p = \frac{F}{A}$, and **pressure in a liquid** $\Delta p = \rho g \Delta h$.

You must be able to:

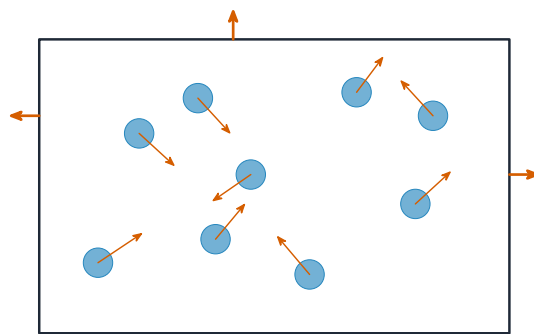
- use $p = \frac{F}{A}$ and explain area effects (sharp knife, snowshoes)
- use $\Delta p = \rho g \Delta h$ for pressure with depth
- state that liquid pressure acts in all directions and grows with depth

1 Key knowledge and worked examples

■ Pressure in a liquid



Pressure increases with depth and with density: $\Delta p = \rho g \Delta h$



gas particles hit the walls — each hit is a tiny force.
Pressure = force per unit area

Gas pressure comes from particles colliding with the walls

Depth 2.0 m in water ($\rho = 1000$, $g = 10$): $\Delta p = 1000 \times 10 \times 2.0 = 20\,000$ Pa.

Area effect: a small area under a force gives a large pressure.

■ Choosing the right pressure equation

Use $p = \frac{F}{A}$ for a **solid pressing on a surface**: the force is the weight (or the push) and the area is the area in contact. Use $\Delta p = \rho g \Delta h$ for the pressure **inside a liquid** at a depth: it does not depend on the shape or the width of the container, only on the depth and the density.

$\triangle$ Convert areas before substituting. An area given in cm^2 must become m^2 by dividing by 10 000, because $1 \text{ m}^2 = 100 \times 100 = 10\,000 \text{ cm}^2$.

Worked example 1 (solid). A block of weight 16 N rests on a face measuring 4.0 cm by 5.0 cm.

1. Area = $4.0 \times 5.0 = 20 \text{ cm}^2 = 20 \div 10\,000 = 0.0020 \text{ m}^2$.
2. $p = \frac{F}{A} = \frac{16}{0.0020} = 8000 \text{ Pa}$.

Worked example 2 (liquid, then force). An oil tank has a base of area 2.5 m^2 and holds oil of density 800 kg/m^3 to a depth of 1.2 m. Take $g = 10 \text{ N/kg}$.

1. Pressure at the base: $\Delta p = \rho g \Delta h = 800 \times 10 \times 1.2 = 9600 \text{ Pa}$.
2. Force on the base: rearrange $p = \frac{F}{A}$ to $F = pA = 9600 \times 2.5 = 24\,000 \text{ N}$.

Pressure in a liquid acts in **all directions** and grows with depth, which is why a dam is thicker at the bottom.

2 Practice

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

2.2 State why a sharp knife cuts more easily than a blunt one. [1]

2.3 A box of weight 60 N stands on a base of 0.25 m^2 . Calculate the pressure on the floor. [2]

2.4 A block rests on a face of 20 cm^2 . Convert this area into m^2 . [1]

3 Exam-style questions

3.1 The pressure in a liquid increases with: [1]

- ☐ **A** depth only
B density only
C both depth and density
D neither

3.2 A diver is 15 m below the surface of sea water of density 1030 kg/m^3 ($g = 10 \text{ N/kg}$).

(a) Find the extra pressure due to the water. [2]

(b) State the direction(s) in which this pressure acts on the diver. [1]

3.3 A box weighing 240 N stands on the ground on a base of area 0.30 m^2 . Find the pressure it exerts on the ground. [2]

3.4 A rectangular water tank has a base of area 3.0 m^2 and is filled with water to a depth of 1.5 m . The density of water is 1000 kg/m^3 and $g = 10 \text{ N/kg}$.

(a) Calculate the pressure due to the water at the base of the tank. [2]

(b) Calculate the force the water exerts on the base. [2]

(c) A second tank has the same depth of water but twice the base area. State and explain how the pressure at its base compares with your answer to (a). [2]

(d) A concrete block of weight 750 N stands on the ground on a face measuring 50 cm by 30 cm . Calculate the pressure it exerts on the ground. [3]

(e) Explain why the walls of a dam are made thicker at the bottom than at the top. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- $p = F/A$

$$p = \frac{F}{A} = \frac{200 \text{ N}}{0.50 \text{ m}^2} = \mathbf{400 \text{ Pa}}$$

2.2

- its edge has a very small area, so the same force gives a very large pressure

2.3

- $p = F/A$

$$p = \frac{F}{A} = \frac{60 \text{ N}}{0.25 \text{ m}^2} = \mathbf{240 \text{ Pa}}$$

2.4

$$A = \frac{20 \text{ cm}^2}{10\,000} = \mathbf{0.0020 \text{ m}^2}$$

3.1 C

- liquid pressure increases with both depth and density

3.2

- (a) $\Delta p = \rho g \Delta h$

$$\Delta p = \rho g \Delta h = (1030 \text{ kg/m}^3)(10 \text{ N/kg})(15 \text{ m}) = \mathbf{154\,500 \text{ Pa}}$$

- (b) in all directions

3.3

- $p = F/A$

$$p = \frac{F}{A} = \frac{240 \text{ N}}{0.30 \text{ m}^2} = \mathbf{800 \text{ Pa}}$$

3.4

- (a) $\Delta p = \rho g \Delta h$

$$\Delta p = \rho g \Delta h = (1000 \text{ kg/m}^3)(10 \text{ N/kg})(1.5 \text{ m}) = \mathbf{15\,000 \text{ Pa}}$$

- (b) $F = pA$

$$F = pA = (15\,000 \text{ Pa})(3.0 \text{ m}^2) = \mathbf{45\,000 \text{ N}}$$

- (c) the pressure is the same

- because $\Delta p = \rho g \Delta h$ depends only on the depth and the density, not on the area or shape of the container

(d) area $A = lw = 50 \text{ cm} \times 30 \text{ cm} = 1500 \text{ cm}^2 = 0.15 \text{ m}^2$

- $p = F/A$

$$p = \frac{F}{A} = \frac{750 \text{ N}}{0.15 \text{ m}^2} = \mathbf{5000 \text{ Pa}}$$

(e) the pressure in the water increases with depth

- so the wall must be thicker at the bottom to withstand the greater outward force there