1.8 Pressure

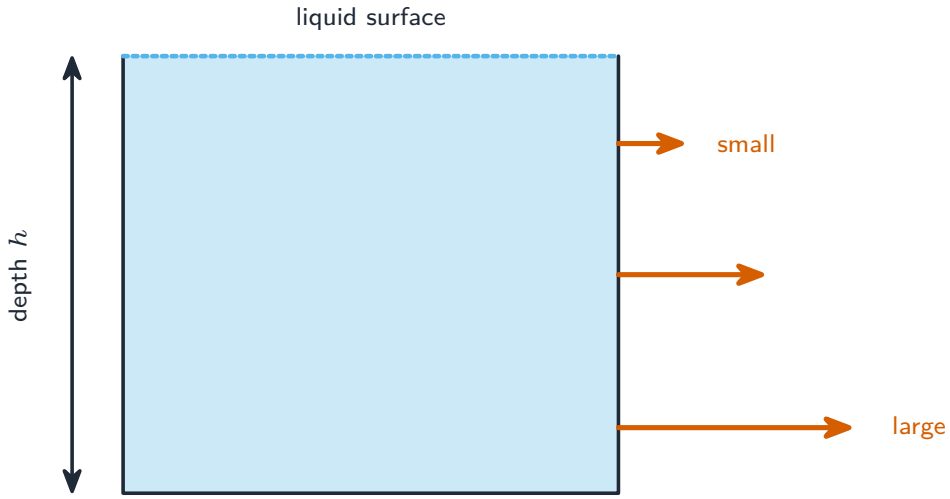
Name: _____ Class: _____ Date: _____ **Total: 23 marks**

0 Vocabulary

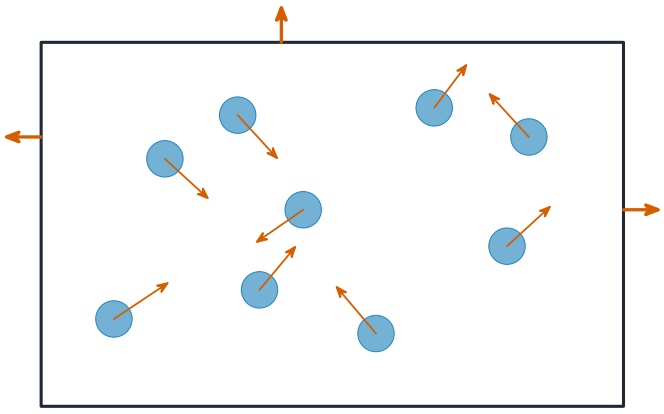
Word	Example
temperature /ˈtemprɪtʃə/ 温度	The thermometer shows the water's **temperature**. 温度计显示水的**温度**。
force /fɔːs/ 力	You use a **force** to push a door open. 你用一个**力**把门推开。
weight /weɪt/ 重力	Your **weight** is the pull of the Earth on you. 你的**重力**是地球对你的引力。
density /ˈdensɪti/ 密度	Iron has a higher **density** than wood, so it sinks in water. 铁的**密度**比木头大，所以铁会沉入水中。
shape /ʃeɪp/ 形状	A force can change an object's **shape**. 力可以改变物体的**形状**。
nuclear /ˈnjuːklɪə/ 核能	A **nuclear** power station gets energy from splitting atoms. **核能**发电站通过原子分裂获得能量。
pressure /ˈpreʃə/ 压强	A sharp knife puts a large **pressure** on the bread. 锋利的刀对面包产生很大的**压强**。
pascal /ˈpæskl/ 帕斯卡	The **pascal** is the unit of pressure. **帕斯卡**是压强的单位。
depth /depθ/ 深度	The pressure grows with **depth** under water. 水下的压强随**深度**增加而增大。

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 $p = \dfrac{F}{A}$ 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.

△ 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. $p = \dfrac{F}{A} = \dfrac{16}{0.0020} = 8000\ \text{Pa}$.

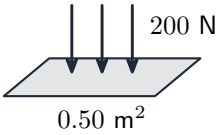
Worked example 2 (liquid, then force). An oil tank has a base of area $2.5\ \text{m}^2$ and holds oil of density $800\ \text{kg/m}^3$ to a depth of 1.2 m. Take $g = 10\ \text{N/kg}$.

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 $p = \dfrac{F}{A}$ to $F = pA = 9600 \times 2.5 = 24\,000\ \text{N}$.

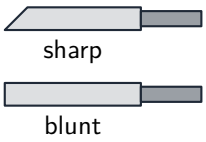
Pressure in a liquid acts in **all directions** and grows with depth, which is why a dam is thicker at the bottom.

2 Practice

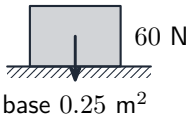
2.1 A force of 200 N acts on an area of $0.50\ \text{m}^2$. Find the pressure. [2]



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 $0.25\ \text{m}^2$. Calculate the pressure on the floor. [2]



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

$20\ \text{cm}^2$

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3 Exam-style questions

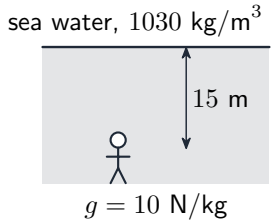
3.1 The pressure in a liquid increases with: [1]



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

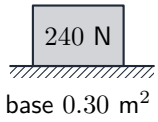
3.2 A diver is 15 m below the surface of sea water of density 1030 kg/m^3 ($g = 10$ N/kg).

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



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

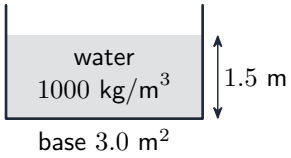
3.3 A box weighing 240 N stands on the ground on a base of area 0.30 m^2. Find the pressure it exerts on the ground. [2]



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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 $g = 10$ 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]

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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

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

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