Exercise walk-through

Pressure ▪ 1.8

eXercise

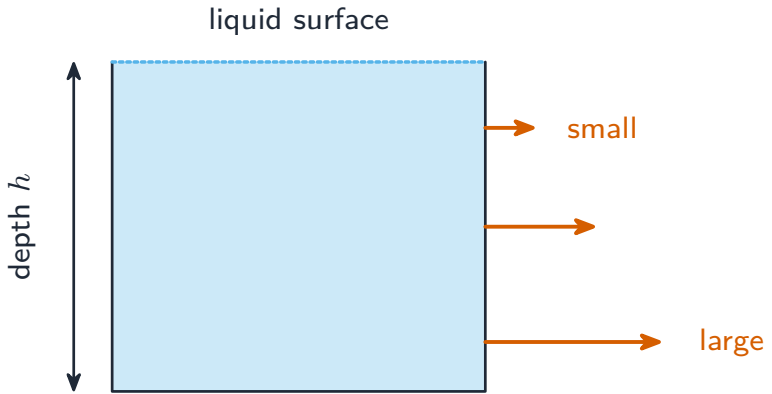
You must be able to

- 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

Method — Pressure in a liquid

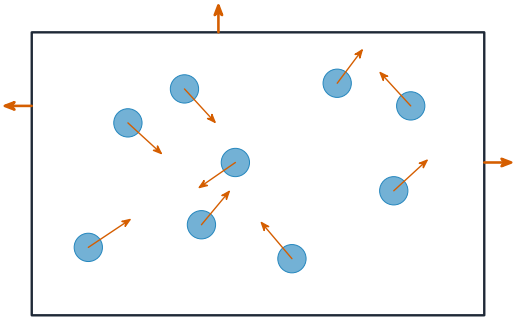
Depth 2.0 **m in water (**$\rho = 1000$**,** $g = 10$**):** $\Delta p = 1000 \times 10 \times 2.0 = 20\,000$ Pa.
Area effect: a small area under a force gives a large pressure.

Method — Pressure in a liquid



A tank of liquid: the outward push on the wall grows with depth

Method — Pressure in a liquid



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

Method — 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. $p = \dfrac{F}{A} = \dfrac{16}{0.0020} = 8000$ Pa.

Method — Choosing the right pressure equation

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

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

Practice 2.1 ▪ 2 marks

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

Solution 2.1

Method: Choosing the right pressure equation

Worked steps

$$p = \frac{F}{A} = \frac{200}{0.50} = 400 \text{ Pa}$$ M1 A1.

Practice 2.2 ▪ 1 mark

State why a sharp knife cuts more easily than a blunt one.

Solution 2.2

Worked steps

its edge has a very small area, so the same force gives a very large pressure B1.

Practice 2.3 ▪ 2 marks

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

Solution 2.3

Method: Choosing the right pressure equation

Worked steps

$$p = \frac{F}{A} = \frac{60}{0.25} = 240 \text{ Pa}$$ M1 A1.

Practice 2.4 ▪ 1 mark

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

Solution 2.4

Method: Choosing the right pressure equation

Worked steps

$20 \div 10\,000 = 0.0020$ m^2 B1.

Exam-style 3.1 ▪ 1 mark

The pressure in a liquid increases with:

A depth only

B density only

C both depth and density

D neither

Solution 3.1

Method: Pressure in a liquid

A depth only

B density only

C both depth and density ✓

D neither

Worked steps

C. Liquid pressure increases with both depth and density.

Exam-style 3.2 ▪ 2 marks

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

Solution 3.2

Method: Choosing the right pressure equation

Worked steps

(a) $\Delta p = \rho g \Delta h = 1030 \times 10 \times 15 = 154\,500$ Pa **M1** **A1**.

(b) in all directions **B1**.

Exam-style 3.3 ▪ 2 marks

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.

Solution 3.3

Method: Choosing the right pressure equation

Worked steps

(a) $\Delta p = \rho g \Delta h = 1000 \times 10 \times 1.5$ M1 $= 15\,000$ Pa A1.
(b) $F = pA = 15\,000 \times 3.0$ M1 $= 45\,000$ N A1.
(c) The pressure is the same B1, because $\Delta p = \rho g \Delta h$ depends only on the depth and the density, not on the area or shape of the container B1.
(d) Area $= 50 \times 30 = 1500$ cm^2 $= 0.15$ m^2 B1; $p = \dfrac{750}{0.15}$ M1 $= 5000$ Pa A1.
(e) The pressure in the water increases with depth B1, so the wall must be thicker at the bottom to withstand the greater outward force there B1.

Exam-style 3.3 ▪ 2 marks

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.
(b) Calculate the force the water exerts on the base.
(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).
(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.
(e) Explain why the walls of a dam are made thicker at the bottom than at the top.

Solution 3.3

Method: Choosing the right pressure equation

Worked steps

(a) $\Delta p = \rho g \Delta h = 1000 \times 10 \times 1.5$ M1 $= 15\,000$ Pa A1.
(b) $F = pA = 15\,000 \times 3.0$ M1 $= 45\,000$ N A1.
(c) The pressure is the same B1, because $\Delta p = \rho g \Delta h$ depends only on the depth and the density, not on the area or shape of the container B1.
(d) Area $= 50 \times 30 = 1500$ cm^2 $= 0.15$ m^2 B1; $p = \dfrac{750}{0.15}$ M1 $= 5000$ Pa A1.
(e) The pressure in the water increases with depth B1, so the wall must be thicker at the bottom to withstand the greater outward force there B1.