Cambridge (CIE) IGCSE Physics

Your notes

Pressure

Contents

Pressure

What is pressure?

- **Pressure** is defined as

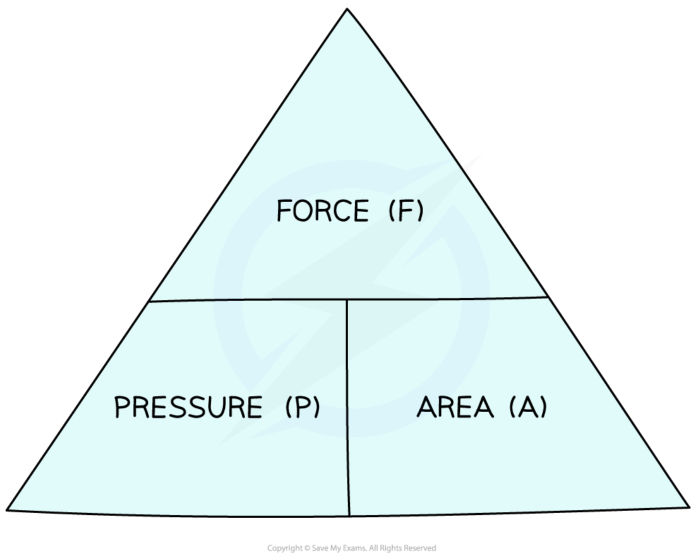
The force per unit area

- Pressure is measured in pascals (Pa)
  - 1 pascal is equivalent to 1 newton per metre squared
  - 1 Pa = 1 N/m^2
- It can be calculated using the following pressure equation:

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

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

- Where:
  - p = pressure measured in pascals (Pa) or newtons per metre (N/m^2)
  - F = force measured in newtons (N)
  - A = area measured in metres squared (m^2)
- This equation can be rearranged with the help of a formula triangle:



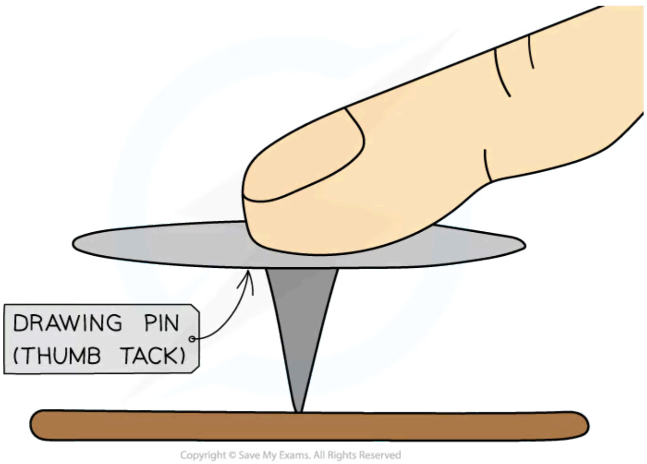
A formula triangle can help rearrange the pressure equation

- For more information on how to use a formula triangle refer to the revision note on speed & velocity
- This equation tells us that:
  - If a force is spread over a **large** area it will result in a **small** pressure
  - If it is spread over a **small** area it will result in a **large** pressure

Examples of applications of pressure

- **Example 1:** Tractors
  - Tractors have **large tyres**
  - This spreads the weight (force) of the tractor over a large area
  - This reduces the pressure which prevents the heavy tractor from sinking into the mud
- **Example 2:** Drawing pins
- Drawing pins have **sharp pointed ends** with a very small area
- This concentrates the force, creating a large pressure over a small area
- This allows the drawing pin to be pushed into a wall

Applying a force to a drawing pin



When you push a drawing pin, it goes into the surface (rather than your finger)

- **Example 3:** High heels
  - High heels have small, sharp points with a small area
  - This concentrates the weight (force), creating a large pressure over a small area

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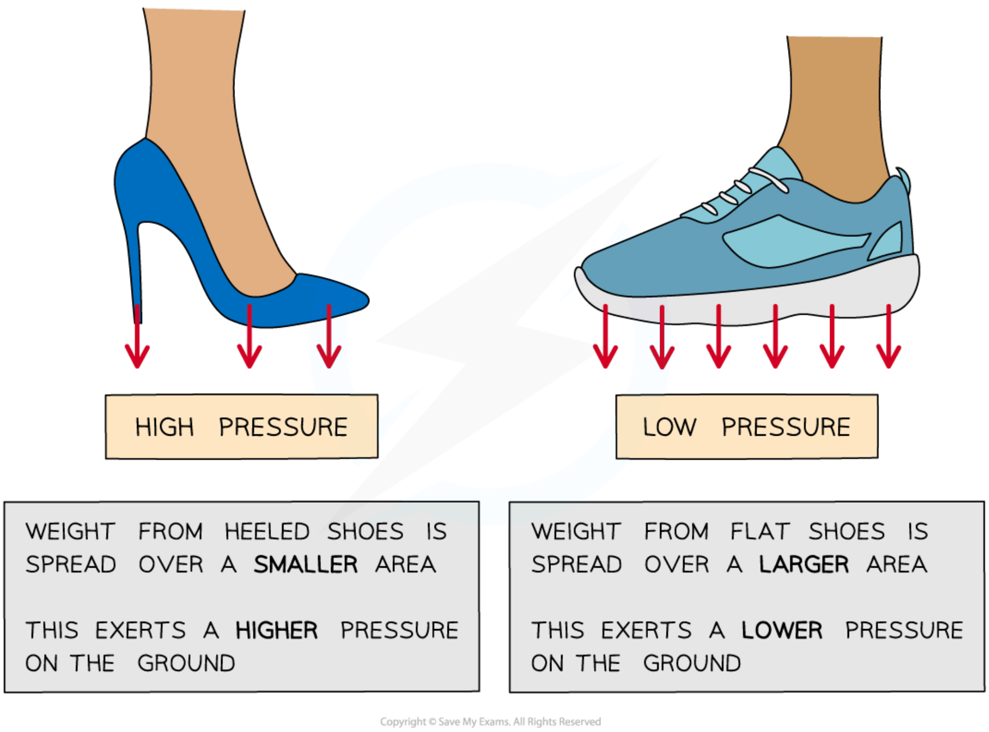
- Flat shoes have a larger area which the weight (force) is spread over resulting in a lower pressure
- This explains why high heels sink into soft surfaces more easily than flat shoes

The effect of surface area on pressure



High heels produce a higher pressure on the ground because of their smaller area, compared to flat shoes

Worked Example

The diagram below shows the parts of the lifting machine used to move the platform up and down.

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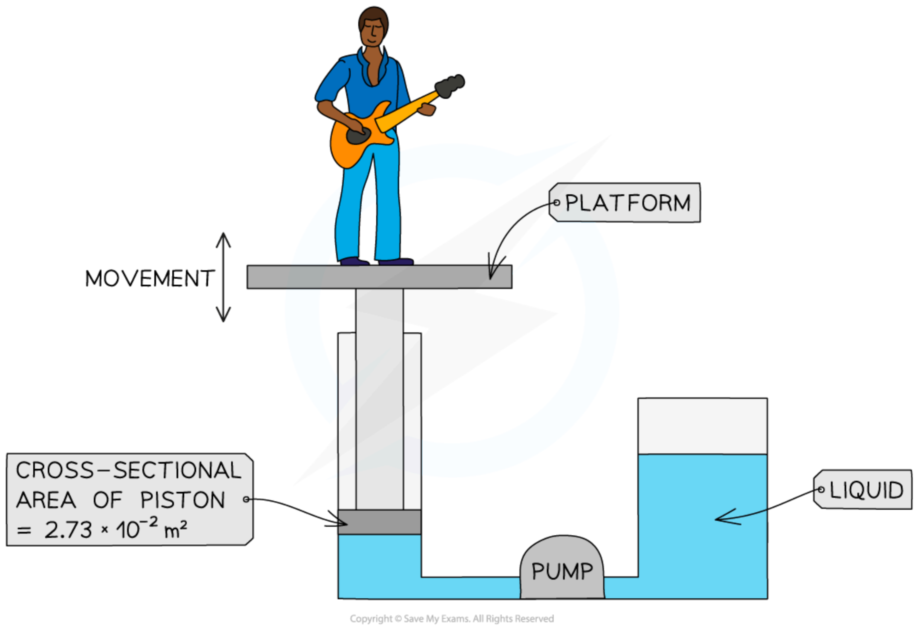

The pump creates pressure in the liquid of 5.28 × 10^5 Pa to move the platform upwards.

Calculate the force that the liquid applies to the piston.

Answer:

Step 1: List the known quantities

- Cross-sectional area = 2.73 × 10^{-2} m^2
- Pressure = 5.28 × 10^5 Pa

Step 2: Write down the relevant equation

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

Step 3: Rearrange for the force, *F*

$$F = p \times A$$

Step 4: Substitute the values into the equation

$$F = \left(5.28 \times 10^5\right) \times \left(2.73 \times 10^{-2}\right) = 14\,414.4$$

Step 5: Round to the appropriate number of significant figures and quote the correct unit

$$F = 14\,400\ N = 14.4\ \text{kN}\ (3\ \text{s.f})$$

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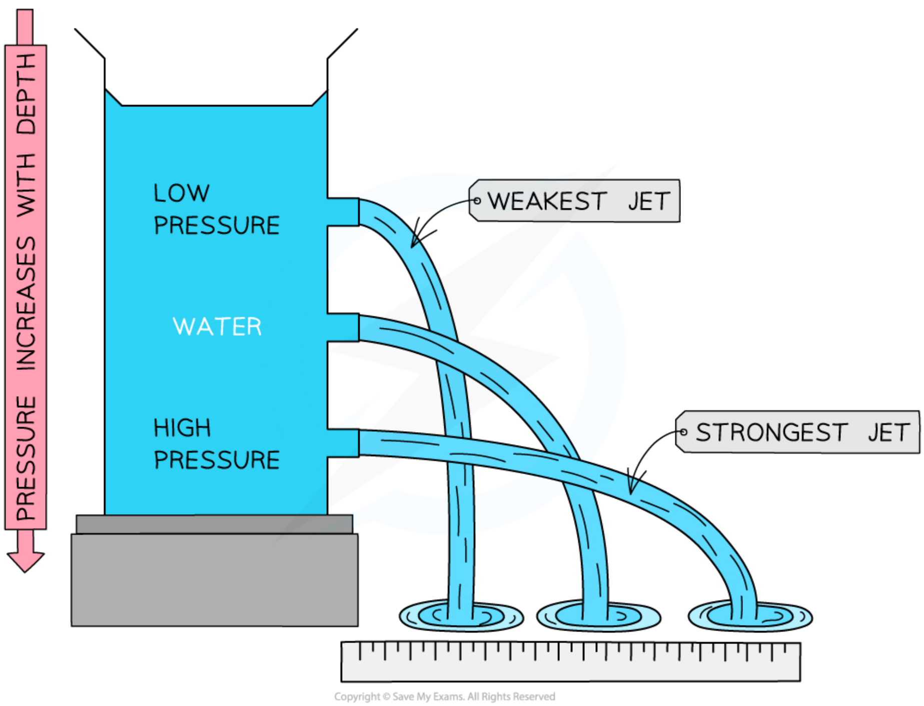
Liquid pressure

Factors affecting pressure in a liquid

- The **pressure** beneath the surface of a liquid will **increase** with the **depth** of the liquid
  - This is because the pressure in a liquid is caused by the force of the **weight** of the liquid above it
  - As the depth increases, there is increasingly more liquid above which causes the pressure to increase
- Pressure in a liquid also depends on the **density** of the liquid
  - The more dense the liquid, the greater the pressure it exerts

Pressure in a column of water

- In a column of water, the **highest pressure** would be at the **bottom**
  - If a hole is made at the bottom of the column, the water will pour out with a **large** force
  - If a hole was made at the top of the column, the water will pour out with a **small** force
  - This is because of the **difference in pressure** in the column caused by the weight of the water



Pressure in a column of water increases with depth, shown by the strong and weak jet of water

- If several holes were made at the same height, the water would spurt out the same distance from each hole
  - This is because pressure at the **same** depth acts **equally** in all directions

Examiner Tips and Tricks

Remember, a fluid can be either a **liquid** or a **gas**. In all fluids, pressure is affected by depth and density. This means that, like in liquids, the pressure within gases also changes with depth and density.

Calculating liquid pressure

Extended tier only

- The pressure acting on an object in a liquid changes with **depth**
  - The **deeper** the object, the higher the pressure exerted upon it and vice versa
- The equation for the pressure difference at different depths in a liquid is given by the equation:

$$\Delta p = \rho g \Delta h$$

- Where:
  - Δp = change in pressure, measured in pascals (Pa)
    - Where 1 Pa = 1 N/m^2
  - ρ = density of the liquid, measured in kilograms per metre cubed (kg/m^3)
  - g = gravitational field strength on Earth, measured in newtons per kilogram (N/kg)
  - Δh = change in height of the column, measured in metres (m)

Pressure in a liquid with a density is applied at a depth

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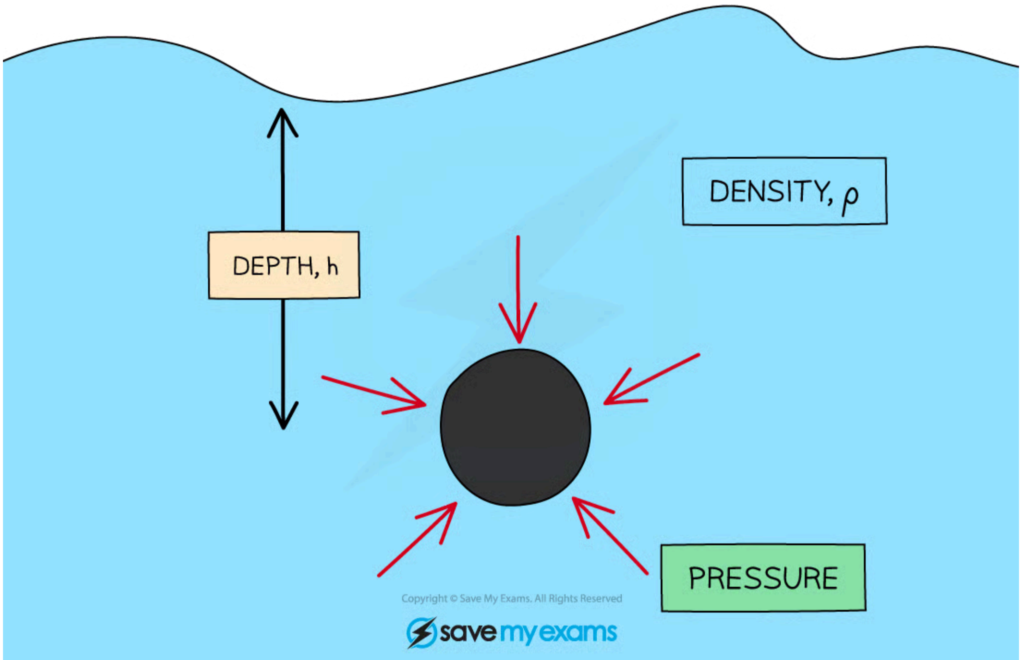

The force from the pressure of objects in a liquid is exerted evenly across its whole surface

Worked Example

Calculate the depth of water in a swimming pool where a pressure of 20 kPa is exerted. The density of water is 1000 kg/m^3 and the gravitational field strength on Earth is 9.8 N/kg.

Answer:

Step 1: List the known quantities

- Pressure, $\Delta p = 20 \text{ kPa}$
- Density of water, $\rho = 1000 \text{ kg/m}^3$
- Gravitational field strength, $g = 9.8 \text{ N/kg}$

Step 2: List the relevant equation

$$\Delta p = \rho g \Delta h$$

Step 3: Rearrange for height, Δ*h*

$$\Delta h = \frac{\Delta p}{\rho g}$$

Step 4: Convert any units

$$20 \text{ kPa} = 20\,000 \text{ Pa}$$

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Step 5: Substitute in the values

$$\Delta h = \frac{20\,000}{1000 \times 9.8}$$

$$\Delta h = 2.0408 = 2.0 \text{ m}$$

Examiner Tips and Tricks

You need to be able to recall the equation for the change in pressure and make sure you are comfortable rearranging it for the variable required in the question!

Some exam questions may ask about the total pressure exerted on an object or surface within the liquid; in this case, you need to account for the atmospheric pressure as well. Atmospheric pressure is approximately 100 kPa.