Fluids

AS Level Physics 9702

J. Rowing • Vijay International School Praslin

By the end of this topic I can...

- derive and use $p = \rho gh$
- use manometers and barometers
- explain upthrust and use Archimedes' principle

Pressure in a fluid

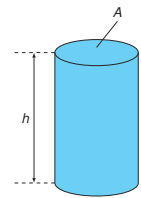
Pressure at depth

Weight of fluid above gives pressure that depends on **depth**, not container shape.

- same depth, same pressure
- $\Delta p = \rho g \Delta h$

$$p = \rho g h$$

$$P = P_{\text{atm}} + \rho g h$$



Example: sea water

Example: sea water

$$P = P_{\text{atm}} + \rho g h = 1.0 \times 10^5 + 1020 \times 9.81 \times 50 \approx 6.0 \times 10^5 \text{ Pa}.$$

Example: oil on water

Example: oil on water

Let the oil depth be x: $840 \times 9.81\, x + 1000 \times 9.81\, (10 - x) = 89 \times 10^3$.

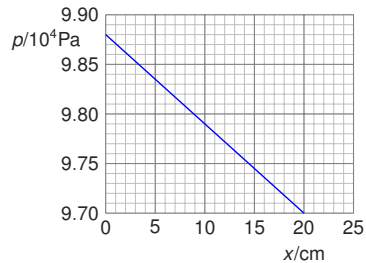
$10 - 0.16x = 9.07 \quad \Rightarrow \quad x \approx 5.8$ m.

Example: reading a graph

The pressure p of a liquid varies with height x above the base of its container as shown (total depth 20 cm). (a) Find the atmospheric pressure. (b) Find the density of the liquid.

Example: reading a graph

The pressure p of a liquid varies with height x above the base of its container as shown (total depth 20 cm). (a) Find the atmospheric pressure. (b) Find the density of the liquid.



(a) At the surface ($x = 20$ cm) only the atmosphere acts: $P_{\text{atm}} = 9.70 \times 10^4$ Pa.

(b)

$$\rho = \frac{\Delta p}{g \Delta h} = \frac{(9.88 - 9.70) \times 10^4}{9.81 \times 0.20} \approx 9.2 \times 10^2 \ \text{kg m}^{-3}.$$

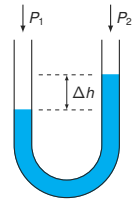
Manometer

Manometer

U-tube of liquid: height difference gives **pressure difference**.

- mercury: high density

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



Example: gas supply

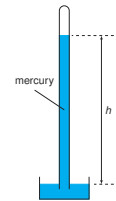
Example: gas supply

$P_{\text{atm}} - P_{\text{gas}} = \rho g h \quad \Rightarrow \quad P_{\text{gas}} = 1.01 \times 10^5 - 1.36 \times 10^4 \times 9.81 \times 0.14 \approx 8.2 \times 10^4$ Pa.

Barometer

Barometer

Column of mercury supported by the **atmosphere**: $P_{\text{atm}} = \rho g h$.



Example: mercury vs water

Example: mercury vs water

(a) $P_{\text{atm}} = 1.36 \times 10^4 \times 9.81 \times 0.760 \approx 1.01 \times 10^5$ Pa.

(b) $h' = \dfrac{P_{\text{atm}}}{\rho g} = \dfrac{1.01 \times 10^5}{1000 \times 9.81} \approx 10.3$ m.

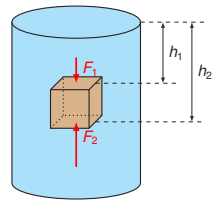
Upthrust

Archimedes' principle

Upthrust = **weight of fluid displaced**; it arises from the pressure difference across the object.

- $\rho_o > \rho_l$: sinks; $\rho_o < \rho_l$: rises

$$F_U = \rho g V$$



Example: block on a string

Example: block on a string

$T + F_U = W \quad \Rightarrow \quad T = mg - \rho g V = 0.080 \times 9.81 - 1000 \times 9.81 \times 50 \times 10^{-6} \approx 0.29$ N.

Key equations

pressure $p = \rho g h$

total pressure $P = P_{\text{atm}} + \rho g h$

upthrust $F_{\text{U}} = \rho g V$