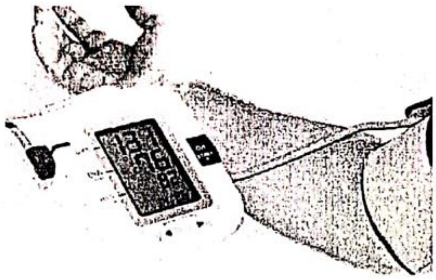
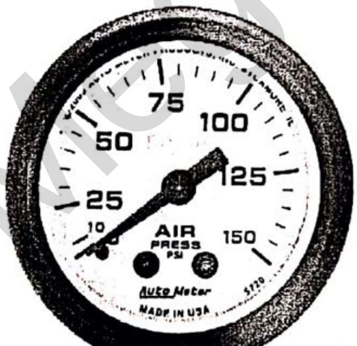
O Level Physics Syllabus Content for CAIE 2019-22 Exams

CHAPTER 7

PRESSURE





Syllabus Content

2.1 Speed, velocity and acceleration

2.2 Graphical analysis of motion

2.3 Free-fall

Learning outcomes

Candidates should be able to:

a) Define the term pressure in terms of force and area, and do calculations using the equation pressure = force/area.

b) Explain how pressure varies with force and area in the context of everyday examples.

c) Describe how the height of a liquid column may be used to measure the atmospheric pressure.

d) Explain quantitatively how the pressure beneath a liquid surface changes with depth and Density of the liquid in appropriate examples.

e) Recall and use the *equation for* hydrostatic pressure *p = ρgh*.

f) Describe the use of a manometer in the measurement of pressure difference.

g) Describe and explain the transmission of pressure in hydraulic systems with particular reference to the hydraulic press and hydraulic brakes on vehicles.

h) Describe how a change in volume of a fixed mass of gas at constant temperature is caused by a change in pressure applied to the gas.

i) Recall and use $p_1V_1 = p_2V_2$.

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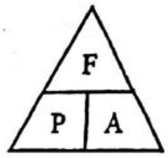
PRESSURE

Definition

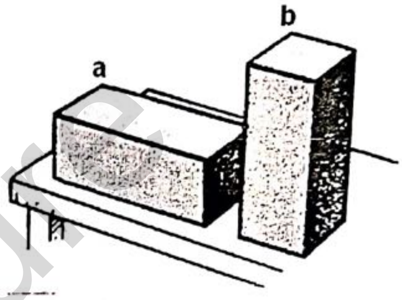
Pressure is the force acting normally per unit area

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} \quad \text{Unit } N/m^2 = \text{Pascal (Pa)} \leftarrow$$



The weight of a block is the same, but the pressure which it exerts on a surface depends on the base area.

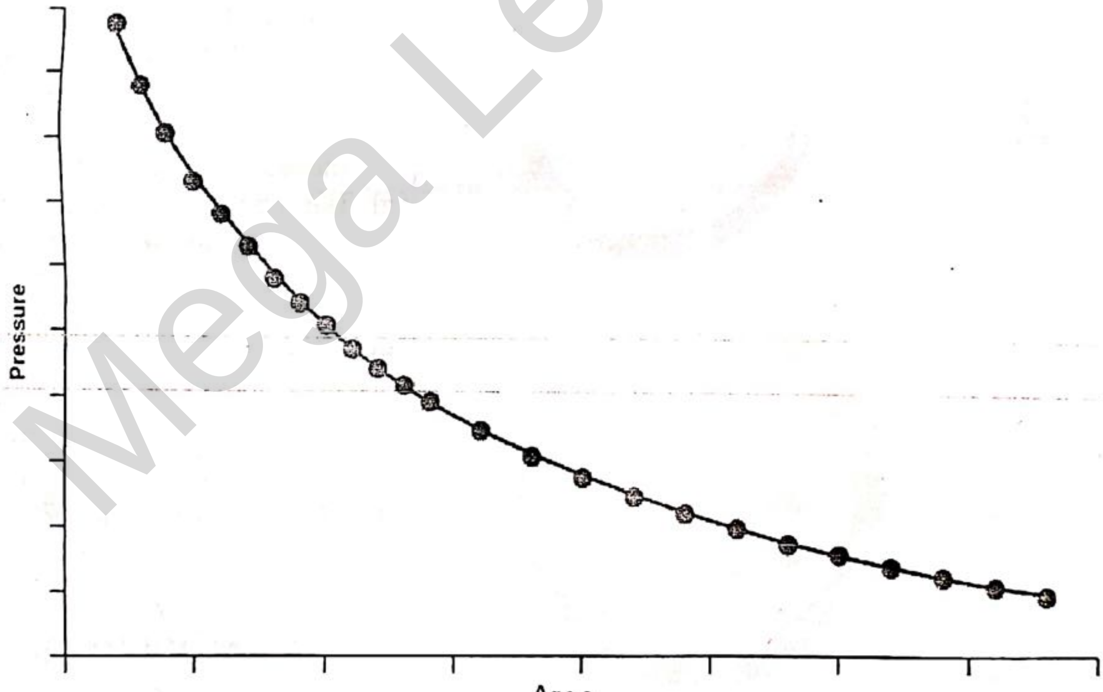
Unit: N/m^2, or Pa (Pascals)

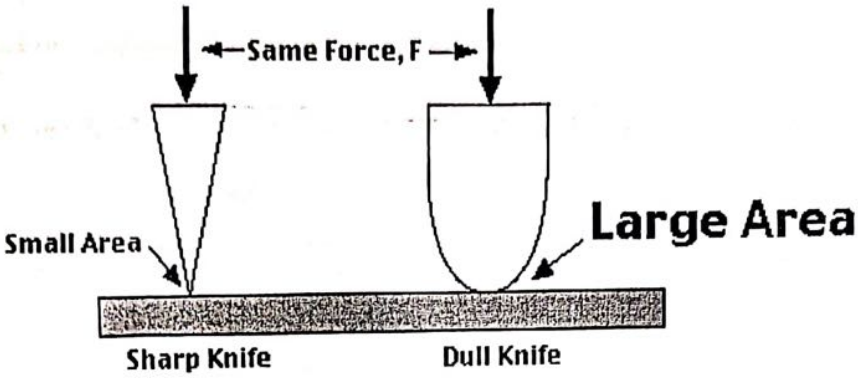


The pressure in *a* is less than that of *b* because area in *a* is greater,

The pressure is inversely proportional to the base area (for a constant force). This rule can:-

- Explain why one dose not has to use great force when using a very sharp knife, also
- Explain the piercing action of a needle or a drawing pin.



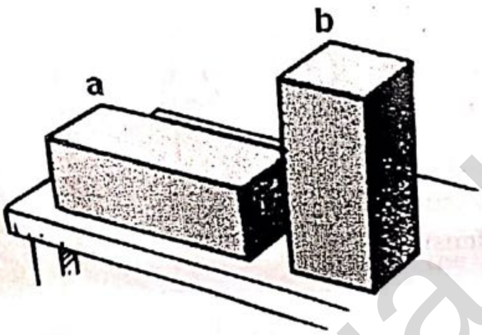


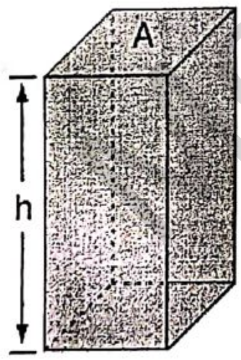
The sharp knife exerts a **large pressure** on the surface, due to the small area of contact.

$$\frac{\text{Force}}{\text{Area}} = \textbf{Pressure}$$

The dull knife exerts a small pressure on the surface, due to the **large area** of contact.

$$\frac{\text{Force}}{\textbf{Area}} = \text{Pressure}$$



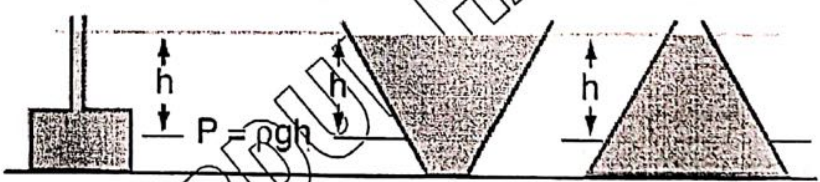


V = hA = volume

weight = mg

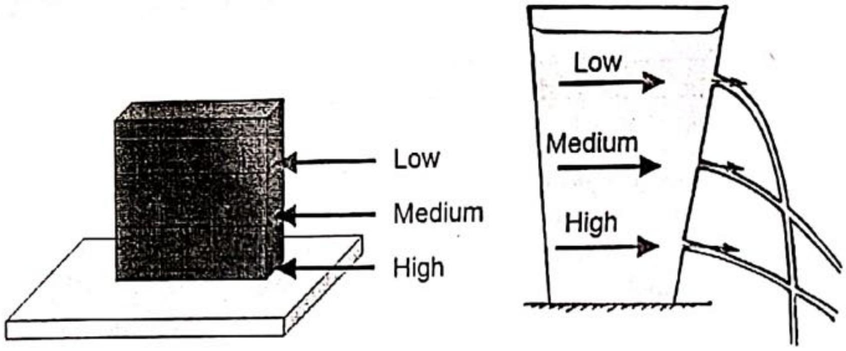
Static fluid pressure does not depend on the shape, total mass, or surface area of the liquid.

$$\text{Pressure} = \frac{\text{weight}}{\text{area}} = \frac{mg}{A} = \frac{\rho V g}{A} = \rho g h$$



Pressure in Liquids

Pressure in liquid depends on depth as with Bricks, weight of what's above determines pressure.



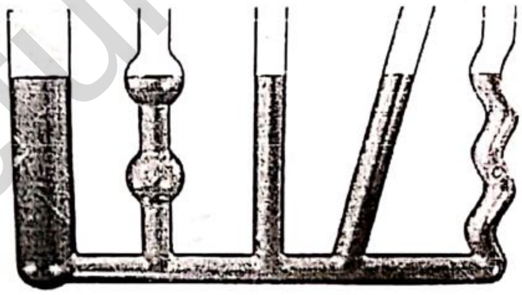
a. Pressure in a liquid increases with depth.

b. Pressure at any point in a fluid, acts in all directions.

c. $\text{Pressure} = \dfrac{\text{Weight}}{\text{area}} = \dfrac{mg}{A}$

Pressure = $h \rho g$ (N / m^2)

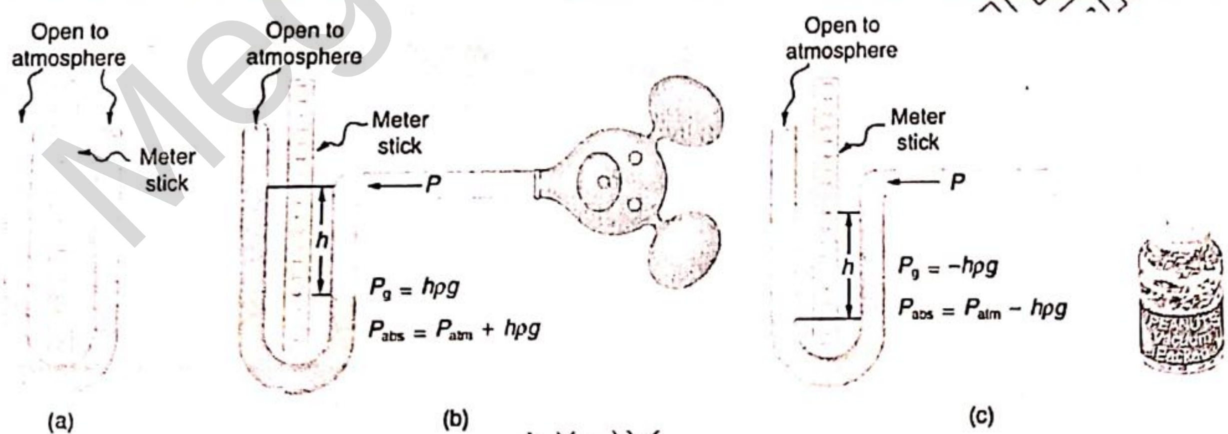
For a fluid (gas or liquid)



- Pressure of a liquid does not depend on the cross-sectional area ... Pressure depends on liquid's height and density only.
- In communicating tubes, liquid surfaces are at same level.

The Manometer

It is used to measure the pressure of a gas by comparing it to atmospheric pressure.



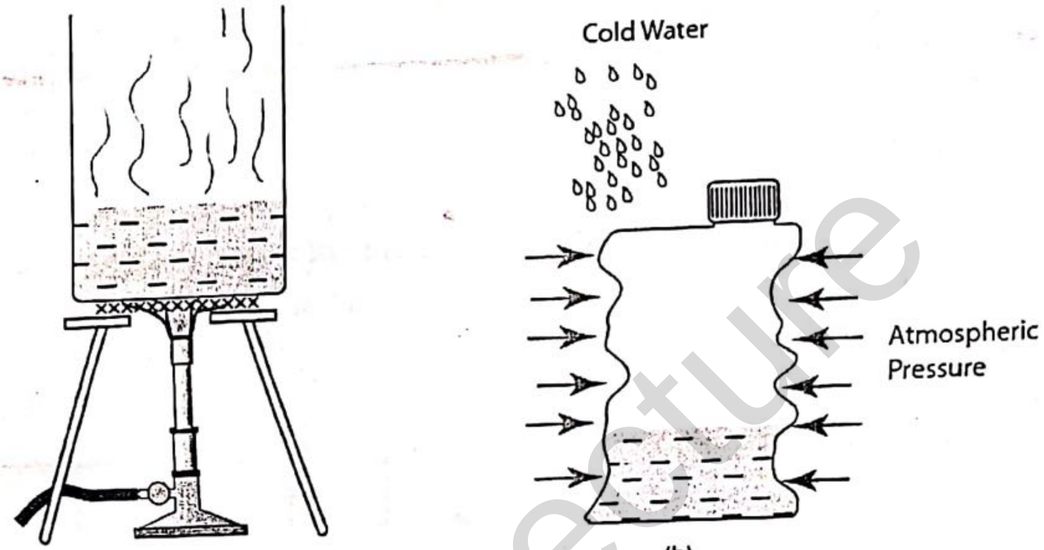
In the figure, the pressure of the gas is greater than that of the atmosphere because the mercury level in the gas side is lower by the difference "h"

For example, if h = 12 cm Hg and atmospheric pressure were 76 cm Hg,

Then the pressure of gas = 76 + 12 = 88 cm Hg

(If the level of Hg in the gas side is higher than at the side of the atmosphere by a difference "h", the value of h is subtracted from atmospheric pressure in this case).

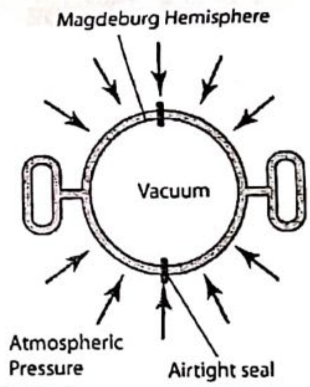
- If the difference "h" is too small, its measurement would not be accurate, and it is better to use water or oil in the manometer so that the difference "h" would be greater and easier to measure accurately.



(a)
Water in a can is heated

(b)
The can is closed and is Cooled

Atmospheric Pressure is due to the weight of a large air mass (the atmosphere above and around us). The pressure of air can be shown by the collapsing can experiment. When the can is full of air, the inside and outside pressures balance, but when the air is pumped out the can collapses due to the unbalanced atmospheric pressure from outside.



Pulling against atmospheric pressure

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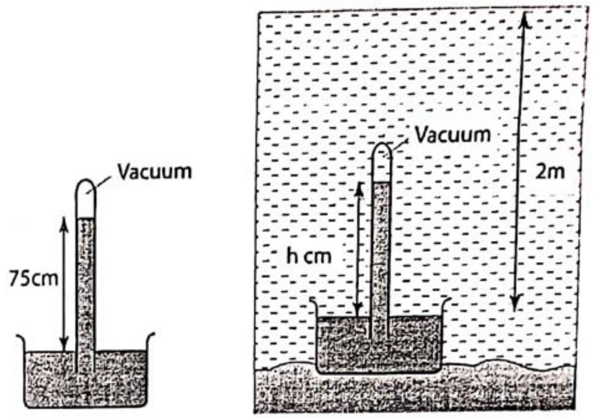
The Simple Barometer:

It is used to measure the atmospheric pressure. A long tube is completely filled with mercury. The mercury level falls to about 76 cm; above the mercury there is vacuum.



The pressure of Hg can be calculated.

$P = h\rho g$

$= 0.76 \times 136000 \times 10$

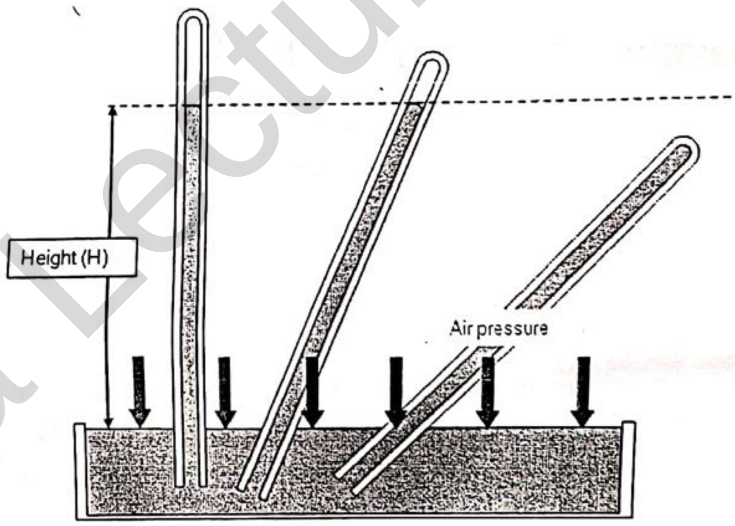
$= 103360$ Pa

To "balance" the atmospheric with a column of water, the height required would be given by

$P = h\rho \text{ (water) } g$

$103360 = h \times 1000 \times 10$

$\therefore h = 10.3$ m of water



Note that

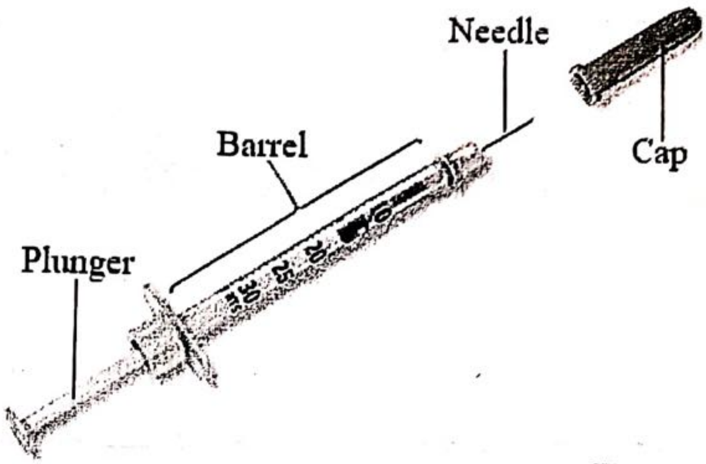
1. *Tilting the barometer* tube makes no difference to the vertical height of mercury column (the pressure depends on the vertical height).
2. The total pressure on a diver equals the sum of atmospheric pressure plus the pressure of the water above him.
3. In aviation, the atmospheric pressure decreases at high altitudes, this can be used to measure the height of an aircraft using an "altimeter".
4. The width of the barometer tube has no effect on the height of mercury in the tube.

The function of many machines depends on the action of atmospheric pressure, for example:

Syringes:

When the end of the syringe is placed in the liquid, and the piston is drawn up the tube, the pressure inside the tube is reduced. The atmospheric pressure on the liquid surface forces the liquid into the syringe.

When the syringe is taken out of the liquid, the contents can be forced out by pushing the piston down again.

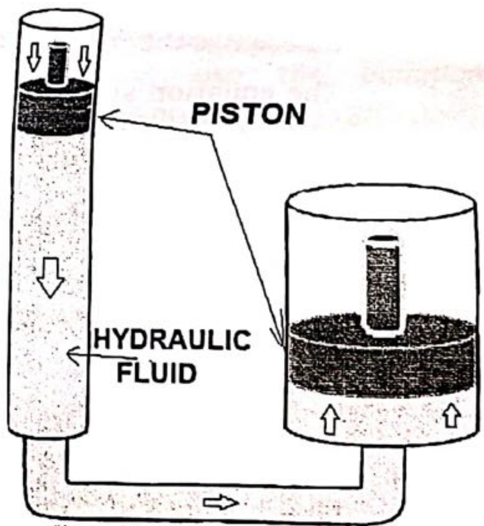


Drinking straw:

In meteorology, the standard atmospheric pressure is used as a unit called the "bar" 1 bar = $105\ N/m^2$ ← amillibar is more commonly used 1 millibar (mbar) = $100\ N/m^2$.

Hydraulic System

A hydraulic drive system is a quasi-hydrostatic drive or transmission system that uses pressurized hydraulic fluid to power hydraulic machinery. The term hydrostatic refers to the transfer of energy from pressure differences, not from the kinetic energy of the flow.

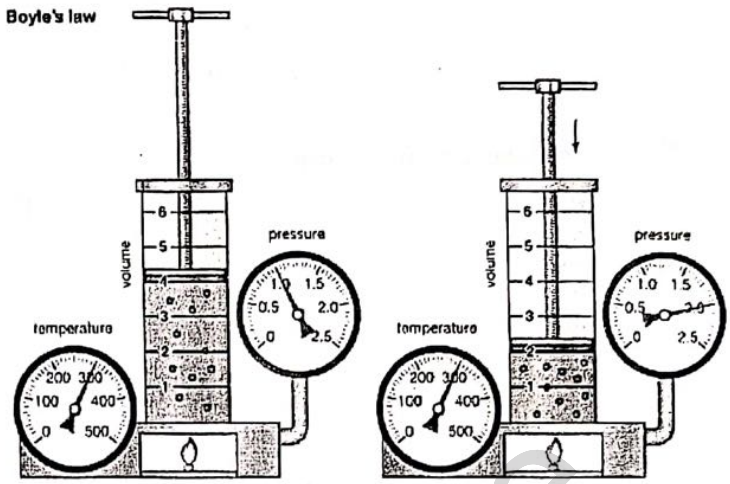


The hydraulic system works on the principle of Pascal's law which says that the pressure in an enclosed fluid is uniform in all the directions. The Pascal's law is illustrated in the figure. ... As the pressure is same in all the direction, the smaller piston feels a smaller force and a large piston feels a large force.

Boyle's Law

A law stating that the pressure of a given mass of an ideal gas is inversely proportional to its volume at a constant temperature.

The absolute pressure exerted by a given mass of an ideal gas is inversely proportional to the volume it occupies if the temperature and amount of gas remain unchanged within a closed system.



Mathematically, Boyle's law can be stated as

$$P \propto \frac{1}{V}$$ Pressure is inversely proportional to the volume.

or

$$PV = k$$ Pressure multiplied by volume equals some constant k

Where P is the pressure of the gas, V is the volume of the gas, and k is a constant.

The equation states that the product of pressure and volume is a constant for a given mass of confined gas and this holds as long as the temperature is constant. For comparing the same substance under two different sets of conditions, the law can be usefully expressed as $P_1V_1 = P_2V_2$.

The equation shows that, as volume increases, the pressure of the gas decreases in proportion. Similarly, as volume decreases, the pressure of the gas increases.