Pressure

Definition

force acting normally per unit area

$$\text{Pressure} = \frac{\text{Force}}{\text{area}} \Rightarrow \text{Force} = \text{Pressure} \times \text{Area}$$

- Pressure is a scalar quantity
- SI unit $N\,m^{-2}$ or Pascal (Pa)

* Pressure decreases when contact area increases

Example: A rectangular box of mass 20 kg is placed on a table, the area in contact is $0.6\ m^2$, find the pressure exerted by the box.

Sol:

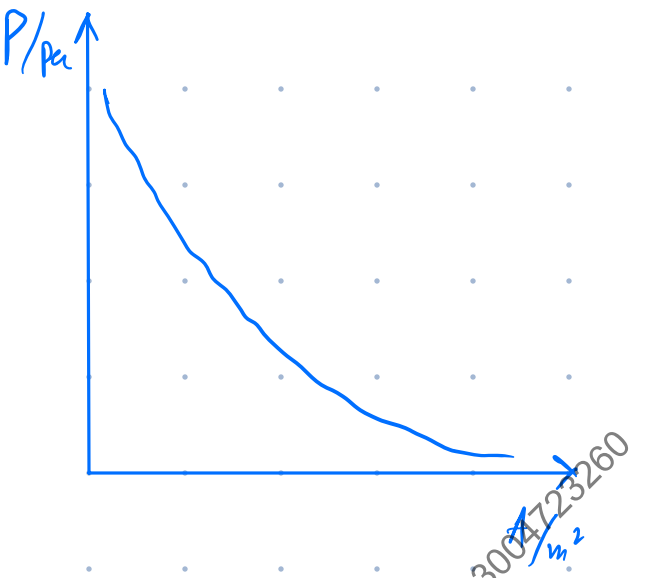
$$\text{Force} = \text{Weight of box} = \frac{mg}{A}$$

$$= \frac{20 \times 9.8}{0.6} = 327\ Pa$$

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* Inverse relationship of pressure with area can be demonstrated graphically as:

$$P \propto \frac{1}{A}$$



- If you stand on one foot, area is smaller, so pressure is greater. Standing on both feet, increases area so less pressure.

Liquid Pressure

Pressure in a liquid increases with depth. Deeper we go in a liquid, more is it's exerted pressure. Mathematically,

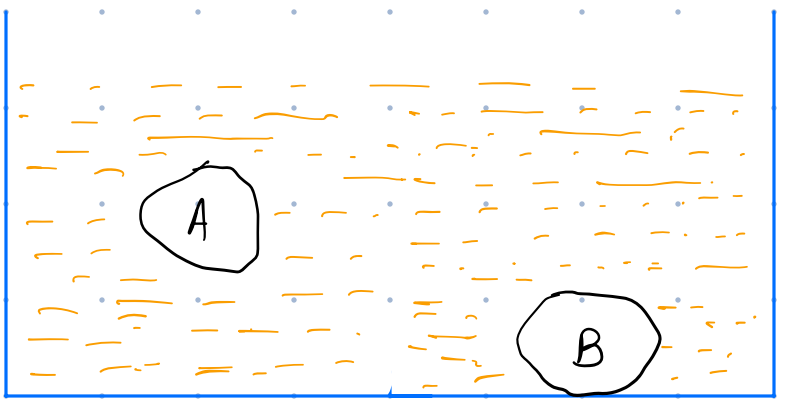
Pressure due to liquid = density of liquid × gravity × depth

$$P = \rho g h$$

* Pressure varies directly with density of liquid, and depth inside the liquid.

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* object B will experience more pressure as its depth is more



* At the surface of liquid, there is atmospheric pressure too which will be transferred throughout the liquid. Thus,

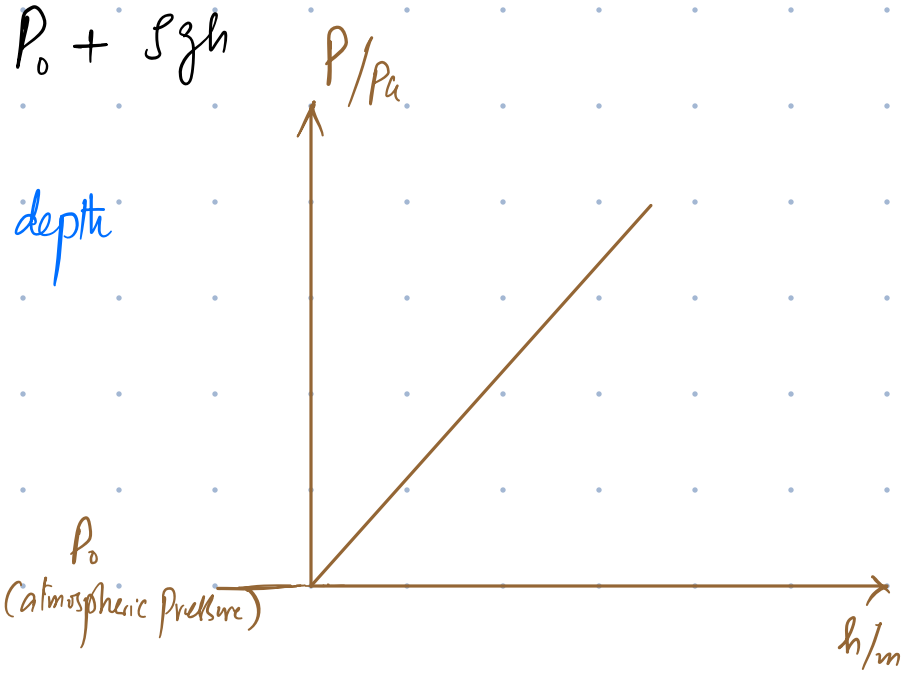
Total Pressure = atmospheric pressure + pressure due to liquid

$$P = P_0 + \rho g h$$

Pressure due to liquid $\propto$ depth

$P \propto h$

* Gradient $= \rho g$



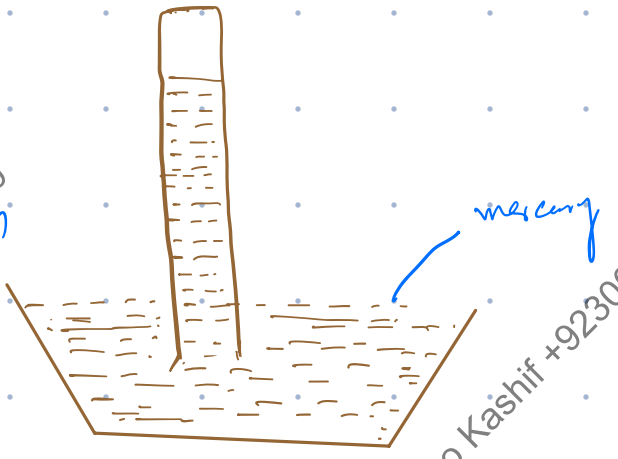
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Atmospheric Pressure

The pressure exerted by atmosphere is known as atmospheric pressure. under standard conditions, its value is 1.0×10^5 Pa.

* Mercury Barometer

The height of mercury column at Standard atmospheric pressure is 76 Cm. Height varies directly with atmospheric pressure.

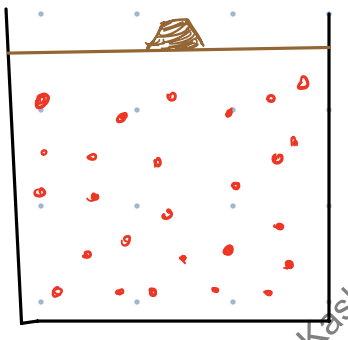


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Pressure of Gas

Gas molecules move randomly at high speed. Collision of gas molecules to the walls of container causes gas pressure.

Explaination (important)



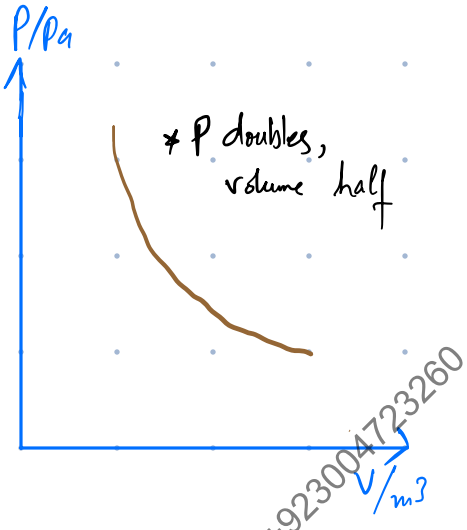
Gas molecule bounces back when it collides the wall of container which causes its momentum to change. This change of momentum creates force due to which pressure is exerted.

Pressure / volume relationship

When a gas is compressed at constant temperature, its pressure increases

Thus $P \propto \frac{1}{V} \Rightarrow \boxed{PV = \text{Constant}}$

or $P_1 V_1 = P_2 V_2$



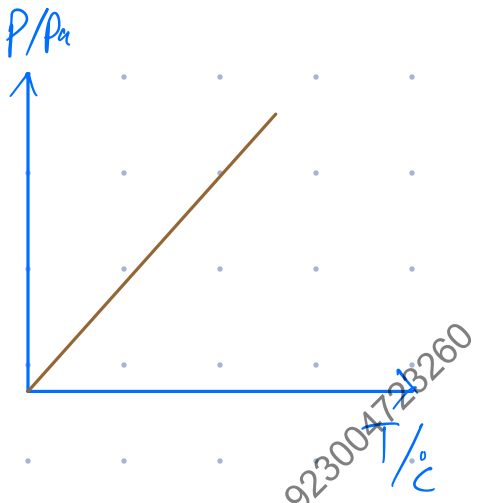
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Pressure / Temperature relationship

When a gas is heated at constant volume, the pressure increases

Thus

$$P \propto T \Rightarrow \boxed{\frac{P}{T} = \text{Constant}}$$



* A gas that follows both laws stated above is known as Ideal Gas

$$\frac{PV}{T} = \text{Constant} \quad \text{(for an ideal gas)}$$

(Energy changes during Compression and heating)

- When a gas is compressed, the separation between molecules decreases and Potential Energy decreases
- When a gas is heated, the speed of molecules increases, and Kinetic Energy increases

* To verify pressure / volume relationship, we keep temperature constant and to verify pressure / temperature relationship, we keep volume constant

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11 A block of weight W rests on a side of area A. The gravitational field strength is g.

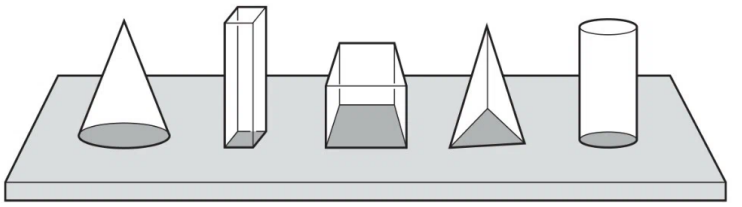
What is the pressure exerted on the ground due to the block?

Force = weight

A WA **B** $\frac{W}{A}$ **C** $\frac{WA}{g}$ **D** $\frac{W}{g}$

QUESTION # 2: M/J 18 P11

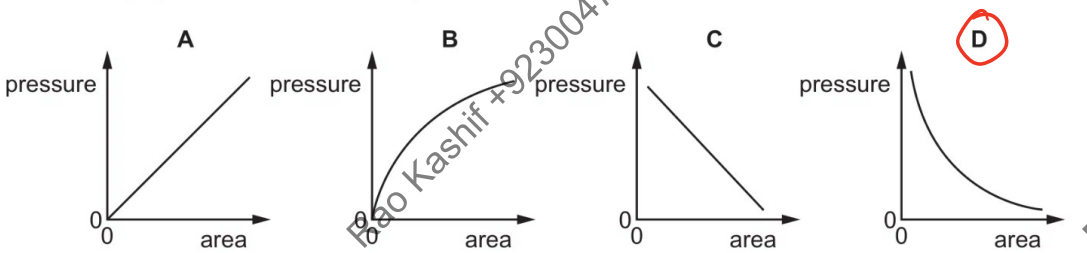
14 Five blocks have the same mass but different base areas. They all rest on a horizontal table.



A graph is plotted to show the relationship between the pressure exerted on the table and the base area of the block.

* Inverse relation

Which graph shows this relationship?



QUESTION # 3: M/J 18 P11

15 Each tyre of a car has an area of 100 cm^2 in contact with the ground.

The car has a mass of 1600 kg. The weight of the car is equally distributed amongst the four tyres.

The gravitational field strength g is 10 N/kg.

What is the pressure exerted on the ground?

A 4.0 N/cm^2 **B** 16 N/cm^2 **C** 40 N/cm^2 **D** 160 N/cm^2

weight of Car = mg = 16000 N

area of 4 tyres = 400 cm^2

Pressure = $\frac{1600}{400}$

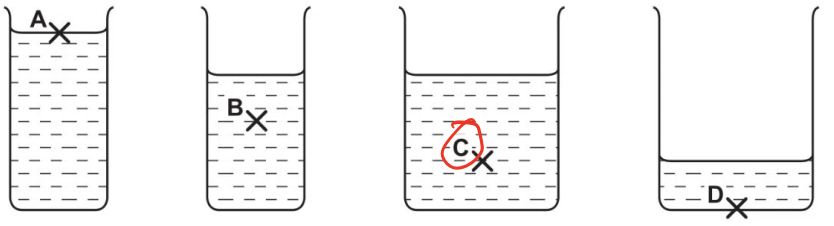
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QUESTION # 1: M/J 16 P11

15 Four beakers contain the same liquid.

At which point is the pressure the greatest?



QUESTION # 2: M/J 16 P11

16 Water of depth 10 m exerts a pressure equal to atmospheric pressure.

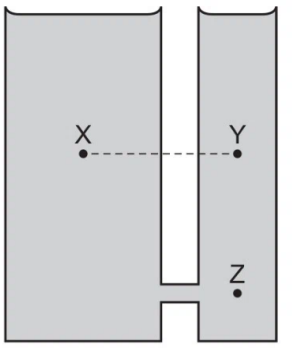
An air bubble rises to the surface of a lake which is 20 m deep. When the bubble reaches the surface, its volume is 6.0 cm^3.

What is the volume of the air bubble at the bottom of the lake?

A 2.0 cm^3 **B** 3.0 cm^3 **C** 12 cm^3 **D** 18 cm^3

Let
Atmospheric Pressure = P
at 20m depth, pressure = 3P
use $P \propto \frac{1}{V}$
. volume at bottom will be three times

16 Two cylindrical vessels are joined together and filled with water as shown.



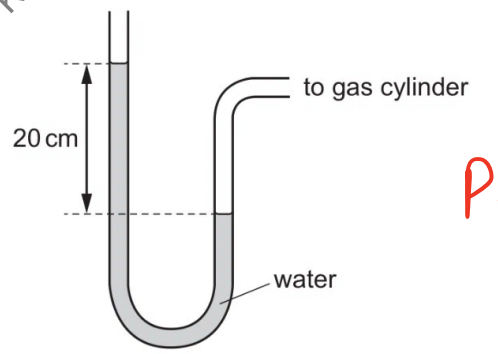
How does the pressure at point X compare to the pressure at points Y and Z?

	compared to Y	compared to Z
A	pressure at X is higher	pressure at X is lower
B	pressure at X is higher	pressure at X is the same
C	pressure at X is the same	pressure at X is lower
D	pressure at X is the same	pressure at X is the same

X is at same depth as Y, but Z is deeper

QUESTION # 4: M/J 17 P11

17 The pressure of a gas in a cylinder is measured using a water manometer.



$P = \rho g h$
$= 1000 \times 10 \times 20$
$= 200,000$ Pa

The density of water is 1000 kg / m^3 and the gravitational field strength g is 10 N / kg.

What is the pressure, above atmospheric pressure, of the gas in the cylinder?

A 200 Pa **B** 2000 Pa **C** 20 000 Pa **D** 200 000 Pa

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