

Pressure





Pressure : " Force per unit area "

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

$$\rightarrow P = \frac{F}{A}$$

\rightarrow N
 \rightarrow m²
N/m²
(Pa)

\rightarrow pressure is a scalar quantity.

\rightarrow the force is assumed to be acting perpendicular (90°) to the area

Relationship b/w pressure and area (if force is constant)

$$P = \frac{F}{A} \quad \rightarrow \quad p \propto \frac{1}{A} \quad (\text{they are inversely proportional})$$



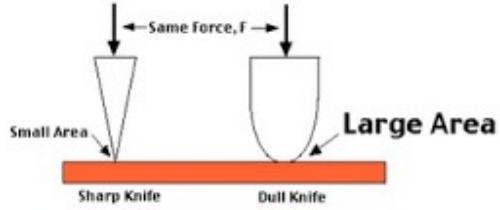
→ Two identical blocks (same weight) are placed on the table.
→ Which block exerts more pressure?

Ans: Block 2 exerts more pressure. B/c block 2 has less area in contact with the surface.

☆ If force is kept constant, but area is doubled ($\times 2$), then pressure will be halved ($\div 2$)

Examples

Illustration of Force in Knife Blades



Sharper Knife = Higher Mechanical Advantage



Relationship b/w pressure and force (if area is kept constant)

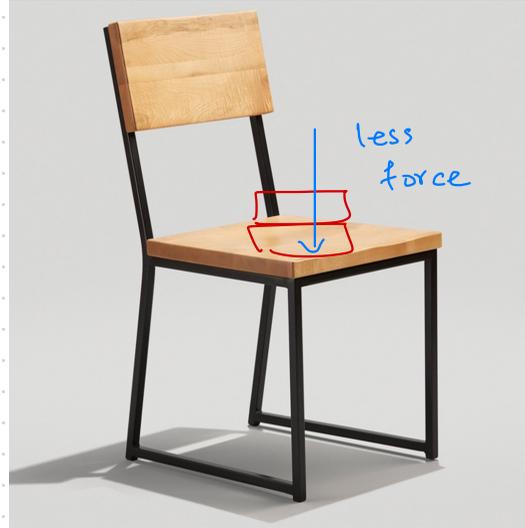


→ All blocks are identical (same weight)

→ When 3 blocks are stacked, pressure will be more.

B/c force exerted by 3 blocks is more where as area of contact is the same.

Examples

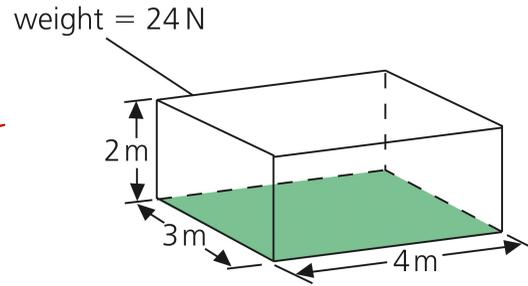


same area of contact with ground

more pressure

less pressure

Q: Find the maximum and minimum pressure that can be exerted by the block.



Ans: For max pressure, area should be minimum:

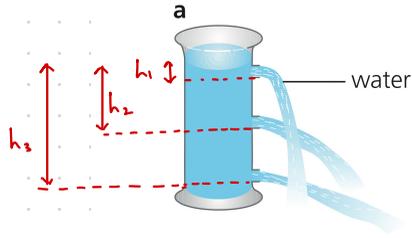
$$P_{\max} = \frac{F}{A_{\min}} = \frac{24}{2 \times 3} = 4 \text{ Pa}$$

For min. pressure, area should be maximum:

$$P_{\min} = \frac{F}{A_{\max}} = \frac{24}{4 \times 3} = 2 \text{ Pa}$$

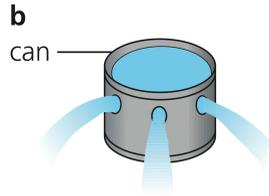
Pressure exerted by liquids

1) Pressure in liquid is directly proportional to depth. ($P \propto h$)



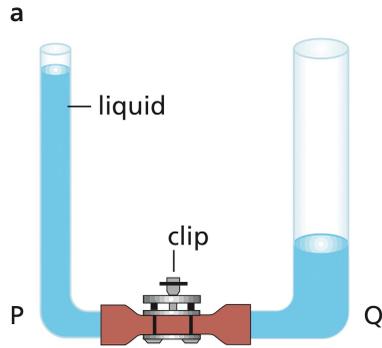
water comes out with most pressure from the point that is at the greatest depth from the top surface.

2) Pressure at one depth acts equally in all directions



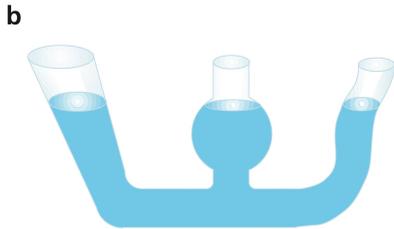
water comes out with same pressure from all holes in different directions.

3) A liquid finds its own level.



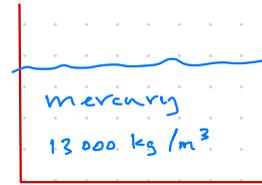
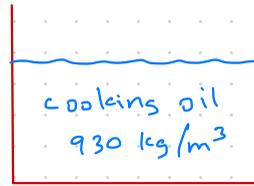
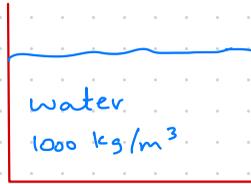
→ Valve is closed
Initially pressure at P is greater than Q
b/c of greater depth.

→ Valve is then opened.
Water flows P to Q (high pressure to low pressure)
Water stops flowing when depth of P and Q is same. Now pressure at P and Q will be same.



★ Even though weight of water above Q will be more but cross-sec area will also be more so pressure at Q and P will be same.

4) Pressure in liquids is directly proportional to density of liquids.



→ We have 3 liquids all at same depth.

→ Mercury will exert the greatest pressure on the base b/c it has the greatest density.

→ Pressure exerted by static liquids is called hydrostatic pressure.

Hydro static pressure = density × gravitational field strength × depth

$$(Pa) \ N/m^2 \leftarrow P = \underset{\substack{\uparrow \\ kg/m^3}}{\rho} g h \rightarrow m$$

Proof of $P = \rho g h$ equation

$$P = \frac{F}{A} \rightarrow \text{weight of liquid}$$

$$P = \frac{W}{A} = \frac{mg}{A}$$

$$\text{Since } m = \rho V$$

$$P = \frac{(\rho V)g}{A}$$

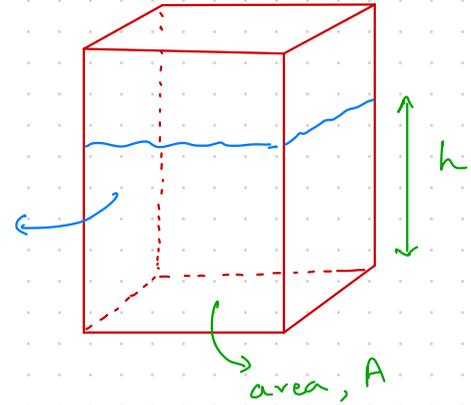
$$\text{Since } V = Ah$$

$$P = \frac{\rho (\cancel{Ah})g}{\cancel{A}}$$



$$P = \rho g h$$

liquid
of density
 ρ



Test yourself

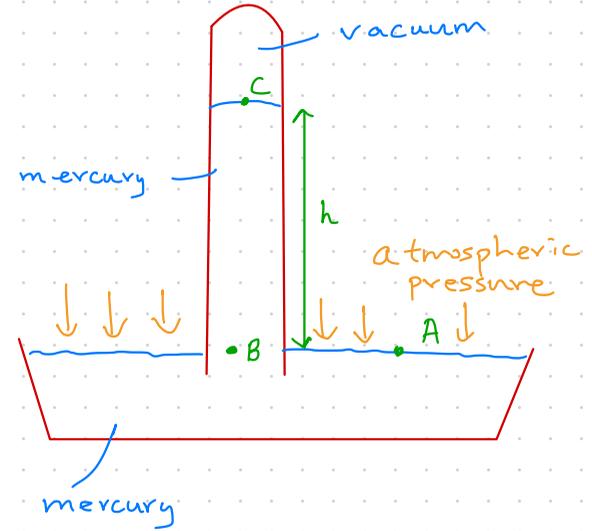
- 3 Calculate the increase in pressure at a depth of 2 m below the surface of water of density 1000 kg/m^3 .
- 4 Calculate the depth of water of density 1020 kg/m^3 where the pressure is $3.0 \times 10^6 \text{ Pa}$.

$$\begin{aligned} 3) \quad p &= \rho gh \\ &= 1000 \times 9.8 \times 2 \\ &= 19600 \text{ Pa} \quad \checkmark \end{aligned}$$

$$\begin{aligned} 4) \quad p &= \rho gh \\ h &= \frac{p}{\rho g} \\ h &= \frac{3.0 \times 10^6}{1020 \times 9.8} = 300 \text{ m} \quad \checkmark \end{aligned}$$

Barometer

- Atmospheric pressure is exerted by the weight of the air above
- In the barometer, the mercury that is exposed to the air will experience atmospheric pressure (point A)
- The liquid always flows from high pressure region to low pressure region. So mercury is pushed up the tube.
- At point B the mercury column exerts a pressure. This is equal to $\rho g h$
- At point C the pressure is zero
- The pressure at A and B is equal.



→ Therefore ρgh also gives the value of atmospheric pressure.

→ The greater the height difference b/w B and C, the more atmospheric pressure there is.

→ In weather stations, instead of using ρgh to calculate the pressure in Pa, they just record the height in mm of Hg.

for example → pressure today in Karachi is 760 mm of Hg

Calculate the pressure in Pascals. Density of

Hg is 13000 kg/m^3

↓
symbol
of
mercury

$$760 \text{ mm} \rightarrow 0.760 \text{ m} = h$$

$$P = \rho gh = 13000 \times 9.8 \times 0.760 = 96824 \approx 1.0 \times 10^5 \text{ Pa}$$

→ In hilly areas (mountains) atmospheric pressure is less than sea level.