

The ratio of force per and unit area is known as the intensity of pressure.

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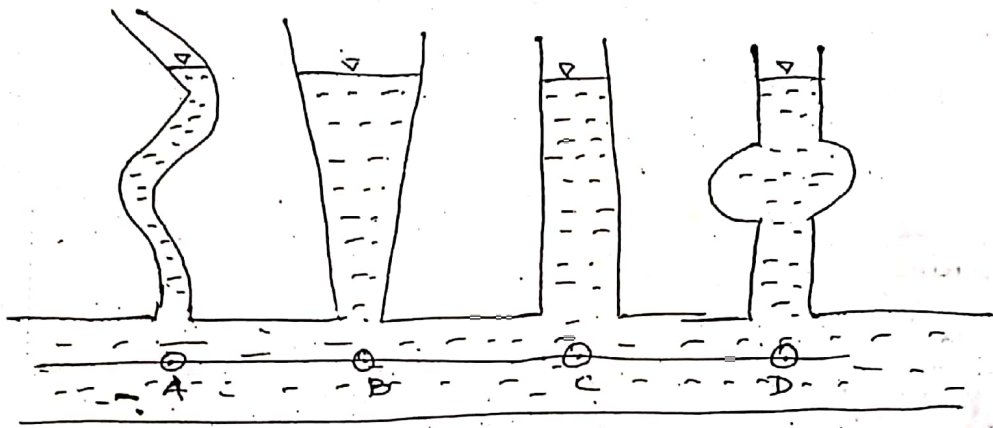
$$p = \frac{F}{A} \quad \frac{N}{m^2}$$

$$1 \text{ bar} = 10^5 \text{ N/m}^2$$

$$1 \text{ Pa} = 1 \text{ N/m}^2$$

Pascal's law:

It states that the pressure (or) intensity of pressure at a point in a static fluid is equal in all directions. This law applied in Hydraulic press, hydraulic jack, hydraulic brake.



$$p_A = p_B = p_C = p_D$$

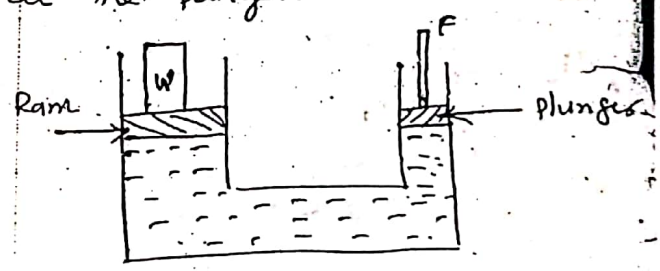
A hydraulic press/jack has a ram of 20 cm diameter and a plunger of 3 cm diameter. It is used for lifting a weight of 30 kN. Find the force required at the plunger.

Given data:

$$D_R = 20 \text{ cm} = 20 \times 10^{-2} \text{ m}$$

$$d_P = 3 \text{ cm} = 3 \times 10^{-2} \text{ m}$$

$$F_R = 30 \text{ kN} = 30 \times 10^3 \text{ N}$$



Team 2

$$p_R = p_P$$

$$\frac{F_R}{A_R} = \frac{F_P}{A_P}$$

$$F_P = \frac{F_R}{A_R} \times A_P = \frac{30 \times 10^3}{\frac{\pi}{4} \times (20 \times 10^{-2})^2} \times \frac{(3 \times 10^{-2})^2 \times \pi}{4} = \frac{21.24}{0.031} = 675.14 \text{ N}$$



(2) The diameters of a small piston and a large piston of a hydraulic jack are 3 cm and 10 cm respectively. A force of 80 N is applied on the small piston. Find the load lifted by the large piston when (a) the pistons are at the same level (b) small piston is 40 cm above the large piston. The density of the liquid in the jack is given as  $1000 \text{ kg/m}^3$ . (25)

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Given data:

$D = 10 \text{ cm} = 10 \times 10^{-2} \text{ m}$   
 $d = 3 \text{ cm} = 3 \times 10^{-2} \text{ m}$   
 $F_s = 80 \text{ N}$   
 $F_L = ?$

Solution

(a)  $P_s = P_L$

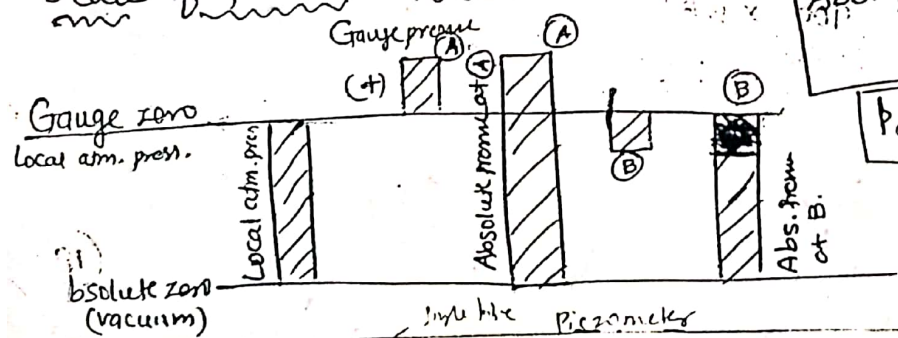
$\frac{F_s}{A_s} = \frac{F_L}{A_L}$  ;  $F_L = \frac{F_s}{A_s} \times A_L = \frac{80}{\frac{\pi}{4}(3 \times 10^{-2})^2} \times \frac{\pi}{4}(10 \times 10^{-2})^2$   
 $= 888.89 \text{ N}$

(b)  $s = l$  at 40 cm above the large piston. So,

$p = \frac{F_s}{A_s} + (\rho \times g \times h)$   
 $= \frac{80}{\frac{\pi}{4}(3 \times 10^{-2})^2} + 1000 \times 9.81 \times 40 \times 10^{-2}$   
 $= 117.10 \times 10^3 \text{ N/m}^2$

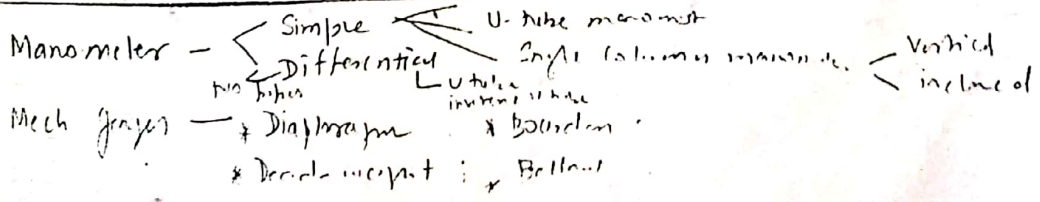
$F_L = 117.10 \times 10^3 \times A_L = 919.70 \text{ N}$

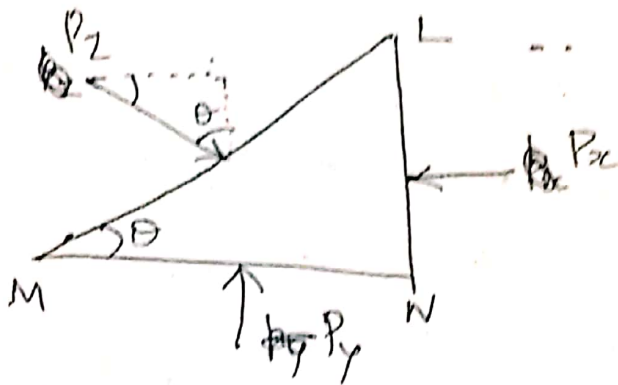
Scale of pressure measurement



Abs. pressure = atm. pressure + gauge pressure

$P_{abs} = P_{atm} + P_{gauge}$





$$P_x = p_x \times LN$$

$$P_y = p_y \times MN$$

$$P_z = p_z \times LM$$

Hydro (Pascal's law)

For equilibrium condition,

$$\sum \text{Horizontal force} = 0 \quad \sum \text{Vertical forces} = 0$$

$$P_z \sin \theta = P_x$$

$$P_z LM \sin \theta = p_x LN$$

$$p_z = p_x$$

$$\sin \theta = \frac{LN}{LM}$$

$$LN = LM \sin \theta$$

Vertical forces

$$P_z \cos \theta = P_y$$

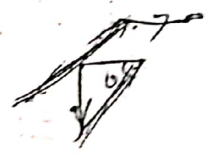
$$P_z LM \cos \theta = p_y MN$$

$$p_z = p_y$$

$$\cos \theta = \frac{MN}{LM}$$

$$MN = LM \cos \theta$$

$$p_x = p_y = p_z$$



same head in terms of equivalent liquid column

$$\boxed{h_w S_w = h_l S_l}$$

$$\boxed{h_m S_m = h_l S_l}$$

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1) Convert a pressure head of 15m of water to metres of oil of relative density 0.75.

Give data:

Solution

(21)

$h_w = 15 \text{ m}$   
 $S_w = 1$   
 $S_l = 0.75$   
 $h_l = ?$

$h_l = \frac{h_w S_w}{S_l} = \frac{15 \times 1}{0.75} = 20 \text{ m of oil}$

Team 2

2) Convert a pressure head of 600mm of mercury into metres of oil of relative density 0.75

Solution

$h_m S_m = h_l S_l$

$h_l = \frac{600 \times 13.6}{0.75 \times 1000} = 1088 \text{ m of oil}$

Team 2 = -1  
= 71 (22)

Scale of pressure measurement formulae: (Problem)

① What are the gauge pressure at a point 3m below the free surface of liquid having a density of  $1.53 \times 10^3 \text{ kg/m}^3$  if the atmospheric pressure is equivalent to 750 mm of mercury? The specific gravity of mercury is 13.6 and density of water =  $1000 \text{ kg/m}^3$ .

Given data:

$\rho = 1.53 \times 10^3 \times 9.81 \text{ N/m}^3$

$P_{atm} = 750 \text{ mm} = 750 \times 10^{-3} \text{ m of mercury}$

$S_m = 13.6$

$\rho_w = 1000 \text{ kg/m}^3 = 1000 \times 9.81 \text{ N/m}^3$

(20)