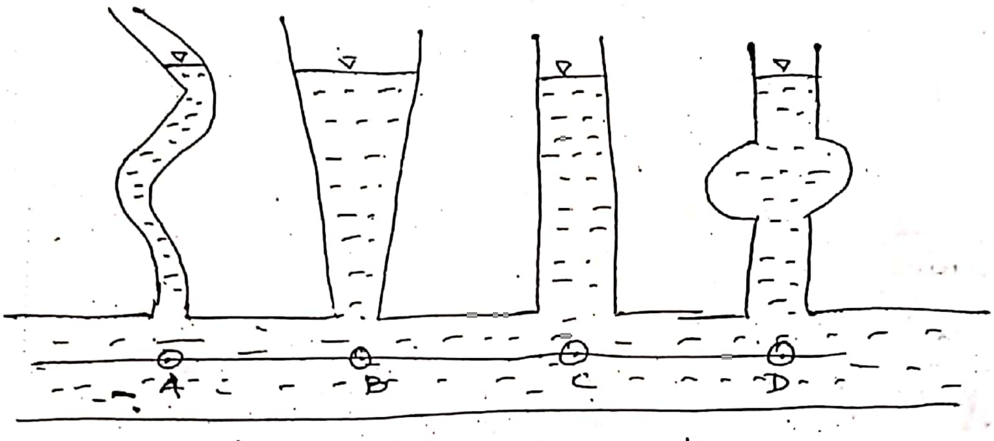
The ratio of force ~~per~~ and unit area is known as the intensity of pressure.

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

1 bar = 10^5 N/m²
1 Pa = 1 N/m²

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.



$$p_A = p_B = p_C = p_D$$

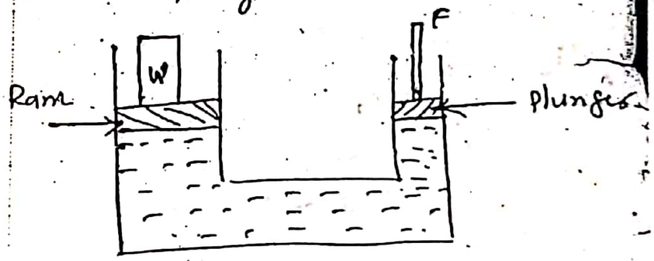
A hydraulic press/Jack has a ram of 20 cm diameter and a plunger of 3 cm diameter. It is used for lifting a weight of 30 kN. Find the force required at the plunger.

Given data:

D_R = 20 cm = 20×10^{-2} m

d_p = 3 cm = 3×10^{-2} m

F_R = 30 kN = 30×10^3 N



$$p_R = p_p$$

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

$$F_p = \frac{F_R}{A_R} \times A_P = \frac{30 \times 10^3}{\frac{\pi}{4} \times (20 \times 10^{-2})^2} \times (3 \times 10^{-2})^2 \times \frac{\pi}{4} = \frac{21.20}{0.031} = 675.14 \text{ N}$$

~~Hydrostatical~~

Hydrostatic law:

States that rate of increase of pressure in a vertical direction is equal to weight density of the fluid at that point.

$$\boxed{p = \gamma h}$$ h - pressure head

$$\boxed{p = \rho g h}$$

1. The pressure intensity at a point in a fluid is given 3.924 N/cm². Find the corresponding height of fluid when fluid is: (a) water, and (b). oil of sp. gr. = 0.9.

Given data:

$p = 3.924\ N/cm^2 = 3.924 \times 10^4\ N/m^2$

$S_0 = 0.9$

Solution

(Water)

$p = \rho g h_w$

$$h_w = \frac{p}{\rho g} = \frac{3.924 \times 10^4}{1000 \times 9.81} = 4\ m \text{ of water}$$

(Oil)

$$h_o = \frac{p}{\rho g}$$

$$S = \frac{\rho_o}{\rho_w}$$

$\rho_o = 0.9 \times 1000 = 900\ kg/m^3$

$h_w S_w = h_E S_e$

$h_m S_m = h_e S_e$

$$\therefore h_o = \frac{3.924 \times 10^4}{900 \times 9.81} = 4.44\ m \text{ of oil}$$

Go to Problems (21) & (22) and Come back to problem (20)

(2) The diameters of a small piston and a large piston of a hydraulic jack at 3 cm and 10 cm respectively. A force of 80N 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 kg/m³. (25)

Given data:

$D = 10\,cm = 10\times10^{-2}\,m$

$d = 3\,cm = 3\times10^{-2}\,m$

$F_s = 80\,N$ $\quad F_L = ?$ (a) & (b)

Solution

(a) $p_S = p_L$

$$\frac{F_S}{A_S} = \frac{F_L}{A_L}; \quad F_L = \frac{F_S}{A_S}\times A_L = \frac{80}{\frac{\pi}{4}(3\times10^{-2})^2}\times\frac{\pi}{4}(10\times10^{-2})^2$$

$= 888.89\,N$

(b). S at 40 cm above the large piston. So,

$$p_S = \frac{F_S}{A_S} + (\rho\times g\times h)$$

$$= \frac{80}{\frac{\pi}{4}(3\times10^{-2})^2} + 1000\times9.81\times40\times10^{-2}$$

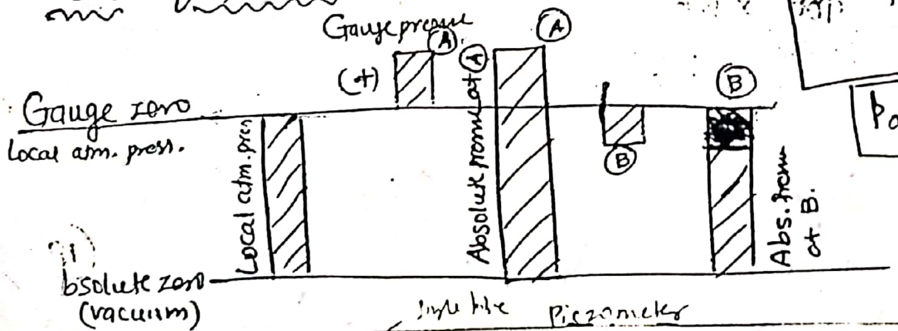
$= 117.10\times10^3\,N/m^2$

$\therefore F_L = 117.10\times10^3\times A_L = 919.70\,N$

Scale of pressure measurement

Abs. pressure = atm. pressure ± gauge pressure

$p_{abs} = p_{atm} \pm p_{gauge}$

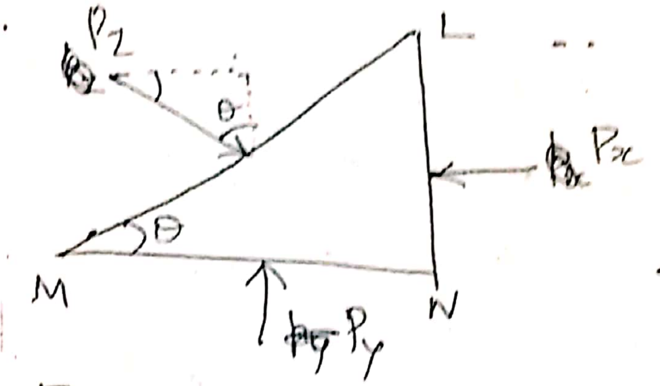


(19)

Single tube   Piezometer

Manometer – Simple – U-tube manometer; Single column manometer – Vertical, inclined
– Differential – Two tubes – U-tube, inverted U tube

Mech gauges – * Diaphragm   * Bourdon
* Dead weight   * Bellows



$P_x = p_x \times LN$
$P_y = p_y \times MN$
$P_z = p_z \times LM$

~~Hyd~~ Pascal's law

For equilibrium condition,

Σ Horizontal force = ~~0~~ ~~&~~ Σ Vertical forces = 0.

~~$P_z \sin\theta = P_x$~~

$$P_z \sin\theta = P_x$$

$$p_z \, LM \sin\theta = p_x \, LN$$

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

$LN = LM \sin\theta$

$$\boxed{p_z = p_x}$$

Vertical forces → $P_y - P_z \cos\theta = 0$

$$P_z \cos\theta = P_y$$

$$p_z \, LM \cos\theta = p_y \, MN$$

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

$MN = LM \cos\theta$

$$p_z = p_y$$

$$\therefore \boxed{p_x = p_y = p_z}$$

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sure head in terms of equivalent liquid column

$$h_w S_w = h_l S_l$$
$$h_m S_m = h_l S_l$$

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

Give data:

$h_w = 15$ m
$S_w = 1$.
$S_l = 0.75$
$h_l = ?$

Team 2

Solution

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

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

Solution

$$h_m S_m = h_l S_l$$

$$h_l = \frac{600 \times 13.6}{0.75 \times 1000} = 10.88\text{m of oil}$$

Scale of pressure measurement ~~formula~~: (Problem)

① What are the gauge pressure & abs. pressure at a point 3 m below the free surface of liquid having a density of 1.53×10^3 kg/m³ if the atmospheric pressure is equivalent to 750 mm of mercury? The specific gravity of mercury is 13.6 and density of water = 1000 kg/m³.

Given data:

$\rho = 1.53 \times 10^3 \times 9.81$ N/m³

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

$S_m = 13.6$

$\rho_w = 1000$ kg/m³ $= 1000 \times 9.81$ N/m³.