Engineering physics

1st year

Chapter 3: Fluids

Lecture 1 and 2

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Objectives:

- Explain the density and pressure.
- The relationship between the pressure and depth, Atmospheric pressure.
- Pascal's law, Archimedes' principle.
- The continuity equation.
- Bernoulli's equation.
- The Venturi meter.

Chapter-3

Fluids

Density:

Mean as the mass per unit volume of any material.

In cgs system:

$$\frac{g}{cm^3}$$

In mks system:

$$\frac{kgm}{m^3}$$

$$1\frac{g}{cm^3} = 1000\frac{kgm}{m^3}$$

$$\frac{g}{cm^3} = \frac{10^{-3}}{10^{-6}}\frac{kgm}{m^3} = 10^3\frac{kgm}{m^3}$$

Such as

$$\rho = 1 \times 10^3 \frac{kg}{m^3} \; for\ water$$

For silver

$$\rho = 10.5 \times 10^3 \frac{kg}{m^3}$$

$$Cooper \Longrightarrow \rho = 8.9 \times 10^3 \frac{kg}{m^3}$$

$$Gold \Longrightarrow \rho = 19.3 \times 10^3 \frac{kg}{m^3}$$

$$Platinum \Longrightarrow \rho = 21.4 \times 10^3 \frac{kg}{m^3}$$

Ex: Find the mass and weight of the air in a living room with a $4m \times 5m$ floor and ceiling $3m$ high. What is the mass and weight of an equal volume of the water?

Sol:

$$volume \Longrightarrow V = 3 \times 4 \times 5 = 60m^3$$

$$m_{air} = \rho_{air} V$$

$$= 1.2 \times 60 = 72kgm$$

$$\text{الوحدات} \Longrightarrow \frac{kg}{m^3} \times m^3 = kgm$$

...

The weight of the air is:

$$w_{air} = m_{air} \times g$$

$$= 72 \times 9.8 = 700N$$

The mass of an equal volume of water is:

$$m_{water} = \rho_w V = 1000 \frac{kg}{m^3} * 60m^3$$

$$= 6 * 10^4 kg$$

The weight is:

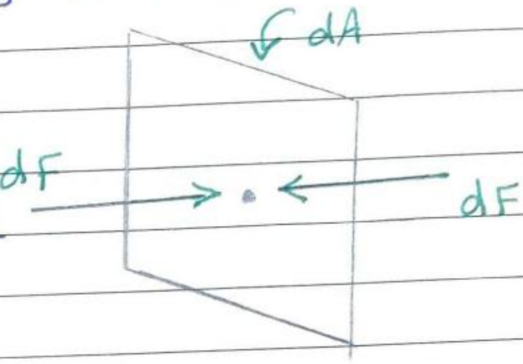
$$w_{water} = mg = 6 * 10^4 * 9.8$$

$$= 5.9 * 10^5 N$$

$$\text{نيوتن} \Longrightarrow N = \frac{kgm \cdot m}{sec^2}$$

Pressure: consider a small surface of area dA centered on a point in the fluid. تتمحور حول نقطة في السائل
The normal force exerted by the fluid on each side is $dF_\perp$.

$\therefore$ the pressure P at that point as the normal force per unit area



$$P = \frac{dF}{dA} \qquad (1)$$

If the pressure is the same at all points of a finite plane surface with area A, then,

$$P = \frac{F_{\perp}}{A} \qquad (2)$$

The unit, الوحدات:

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

$$1 \text{ bar} = 10^5 \text{ pa}$$

$$m\text{bar} = 100 \text{ Pa}$$

Atmospheric pressure: الضغط الجوي

P_a

this pressure varies with weather changes الطقس and with elevation.

$$1 \text{ atmosphere (atm)} = 101.325 \text{ Pa}$$

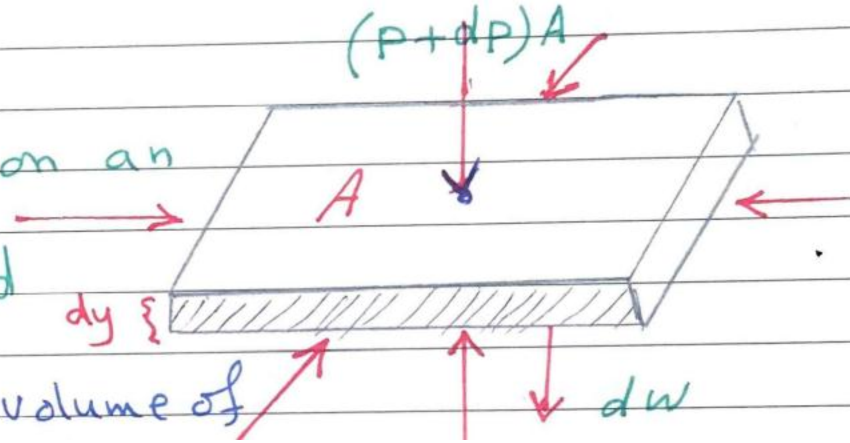
$$(P_a)_{av} = 1 \text{ atm} = 1.013 \times 10^5 \text{ Pa}$$

Pressure, Depth, and Pascal's Law:

we shall derive a general relation between the pressure p and the elevation y, Assume that ρ density and g the accelerati

- If the fluid is in equilibrium.

- consider a thin element of fluid with thickne dy

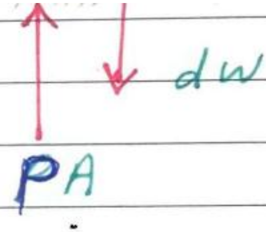


* Fig. the forces on an element of fluid in equilibrium.

- the volume of

in equilibrium.

— the volume of the fluid element is:



$$dV = A\,dy$$

$$dm = \rho\, dV$$

$$dm = \rho A\, dy$$

its weight is

$$dW = dm\, g$$

$$dW = \rho g A\, dy$$

the pressure at the bottom surface P,

The pressure at the top surface is $(p+dp)$,

The total force on the top surface is

$$-(p+dp)A.$$

the total force, including the weight and the forces at the bottom and top surfaces, must be zero,

$$\sum F_s = 0$$

so,

$$PA - (p + dp)A - \rho g A\, dy = 0$$

$$PA - PA - dp\, A - \rho g A\, dy = 0$$

when we divide out the area A and we get:

$$\frac{dp}{dy} = -\rho g \quad \text{———} \quad (3)$$

this equation, shows that when y increases, p decreases, as we move upward in the fluid, pressure decreases.

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