Chapter 10:Fluids

Lecture 1
The University of Jordan/Physics Department
Prof. Mahmoud Jaghoub
أ.د. محمود الجاغوب

10-1] Phases of Matter

There are three common phases of matter:

i) Solid: fixed shape and fixed volume.
ii) Liquid: Variable shape and fixed volume
iii) Gas : variable shape and variable volume

Gases and Liquids don't maintain their shape (No fixed shape) ⇒ can flow and collectively referred to as Fluids.

A fourth less common type of matter is plasma. It is a collection of positive ions and free electrons. This requires very high temperatures.

10-2] Density and Specific Gravity

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \rightarrow \overset{\text{rho}}{\rho} = \frac{m}{V}$$

has units of $\underbrace{kg/m^3}_{\text{SI unit}}$ or g/cm^3

e.g $\rho_{water} = 1000\ kg/m^3$ or $\rho_w = 1\ g/cm^3$

Example 10-1]

What is the mass of a solid iron wrecking ball of radius 18 cm?

$\rho_{iron} = 7800\ kg/m^3$.

$V = \frac{4}{3}\pi r^3$

$$m = \rho V = 7800 \times \frac{4}{3}\pi(0.18)^3$$
$$= 190\ kg.$$

Specific Gravity (SG)

$$SG = \frac{\text{density of the material}}{\text{density of water at } 4^\circ C}$$

At $4^\circ C$, $\rho_w = 1000\ kg/m^3$.

For iron: $SG = \frac{7800}{1000} = 7.8$

Specific Gravity (SG)

$$SG = \frac{\text{density of the material}}{\text{density of water at } 4^\circ C}$$

At $4^\circ C$, $\rho_w = 1000 \ kg/m^3$.

For iron: $SG = \frac{7800}{1000} = 7.8$

10-3] Pressure in Fluids

Pressure: magnitude of the force per unit area, where the force is perpendicular to the area.

Pressure is a scalar quantity. F is perpendicular to the area.

$p = \frac{F\sin\theta}{A}$

units of pressure $p = \frac{F}{A} \Rightarrow [P] = \frac{N}{m^2} \equiv$ Pascal.

Example 10-2]

Calculating pressure. A 60-kg person's two feet cover an area of $500\ cm^2$.
(a) Determine the pressure exerted by the two feet on the ground. (b) If the person stands on one foot, what will be the pressure under that foot?

a) $p = \frac{F}{A} = \frac{mg}{A} = \frac{60 \times 9.8}{500 \times 10^{-4}} \simeq 12 \times 10^3\ \frac{N}{m^2} = 12 \times 10^3\ Pa$

b) $p' = \frac{F}{(A/2)} = 2\frac{mg}{A} = 24 \times 10^3\ Pa.$

91%

Static Fluids (Fluids at rest)

Two important properties

1) At a point inside the liquid, the pressure is the same in all directions.

Evidence: the very small volume of the shown cube of the fluid is at rest. If the

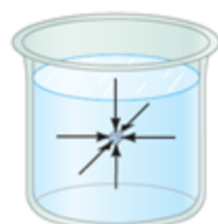


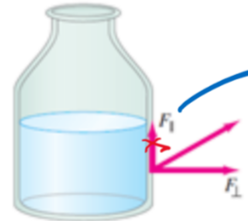
FIGURE 10–1 Pressure is the same in every direction in a nonmoving fluid at a given depth. If this weren't true, the fluid would be in motion.

91%

pressures were different ⇒ cube of liquid would move.

2) The pressure of any static fluid is always perpendicular to any surface that is in touch with the fluid.

FIGURE 10–2 If there were a component of force parallel to the solid surface of the container, the liquid would move in response to it. For a liquid at rest, $F_{\parallel} = 0$.



$F_{\parallel} = 0$ for a static fluid.

If the force of the fluid on the container had a component $F_{\parallel}$ parallel to the bottle's wall ⇒ the wall will act on the fluid with an opposite force downwards, which would move the fluid. But since the fluid is at rest ⇒ $F_{\parallel} = 0$.

Calculating the Pressure due to the liquid at a height h below the surface of the liquid.

The pressure of the liquid on the area A is due to the weight of the liquid.

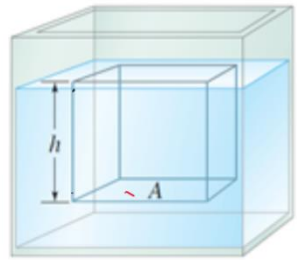


FIGURE 10–3 Calculating the pressure at a depth h in a liquid, due to the weight of the liquid above.

$$P = \frac{F}{A} = \frac{mg}{A}$$ — weight of the liquid.

density of the fluid

density of the fluid

$$P = \frac{\rho_f V g}{A} = \frac{\rho_f (Ah) g}{\cancel{A}} = \rho_f g h$$

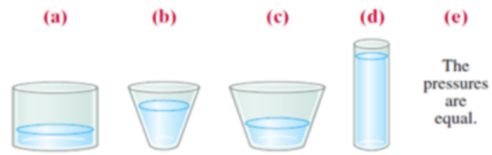
$$\boxed{P = \rho_f g h}$$

fluid pressure increases with depth below the fluid surface.

NOTE that the pressure is independent of the area A.

Example

Which container has the largest pressure at the bottom?



$P = \rho g h$

Container (d) since h is largest

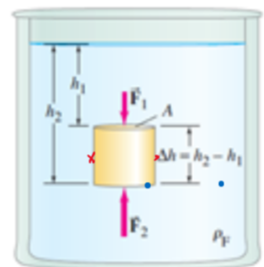
$P = \rho g h$

Pressure at the top surface is

$P_1 = \rho_f g h_1$

Pressure at the bottom surface

$P_2 = \rho_f g h_2$ NOTE $P_2 > P_1$



due to fluid

$\vec{F}_R = \vec{F}_2 - \vec{F}_1$

upwards since $F_2 > F_1$

$\Delta P = P_2 - P_1 = \rho_f g (h_2 - h_1)$

$\Delta P = \rho_f g \Delta h$

$A \Delta P = A \rho_F g (A \Delta h)$

F_R

F_R ← called buoyant force

قوة الطفو

F_B

mg

$F_R > mg \Rightarrow$ object floats.

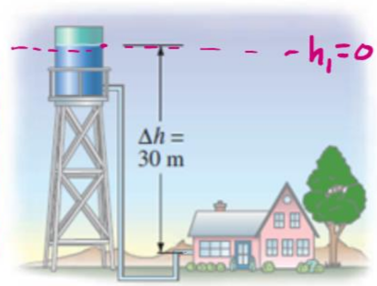
$F_R < mg \Rightarrow$ object sinks.

Example 10-3]

Pressure at a faucet

The surface of the water in a storage tank is 30 m above a water faucet in the kitchen of a house. Calculate the difference in water pressure between the faucet and the surface of the water in the tank.

h_2



$\Delta P = \rho_f g \Delta h$

$h_2 - h_1 = 30$

$\Delta P = (1000)(9.8)(30) = 2.9 \times 10^5 \ \frac{N}{m^2} = 2.9 \times 10^5$ Pa.