

Physics

ch1
Lee1

* Properties of matter

* Chapter one: Units and Dimensions

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DATE: 7/10/2023

1 units

Each Physical quantity, either fundamental or derived, has a measuring unit. bec:
a quantity without its unit is meaningless

Three Systems of units

(SI) or (MKS)

(CGS)
System

British
System

Length: Meter
(M)

Centimeter
(cm)

Foot
(ft)

Mass: Kilogram
(kg)

gram
(g)

slug or Pound
(lb)

Time: Second
(s)

Second
(s)

second
(s)

* Another measuring units in SI.

Electric current intensity: Ampere (A), Solid angle measure: steradian

The absolute Temp: Kelvin (K), Angle measure: Radian

Amount of material: Mole (mol), Luminous intensity: Candela (cd)

* Dimensions equation (Dim. eq.)

is the relation between the three fundamental physical quantities and any derivative physical quantity

* Fundamental Physical quantities: They are physical quantities that can't be defined in terms of other physical quantities.
(Length - Time - Mass)

* Derived Physical quantities: They are physical quantities that can be defined in terms of fundamental physical quantities

Mass
M

Length
L

Time
T

- Area = $L^2 = m^2$

- Volume = $L^3 = m^3$

- Density = $\frac{\text{Mass}}{\text{Volume}} = ML^{-3} = \text{kg}/m^3$

- Velocity = $\frac{d}{t} = LT^{-1} = m/s$

- acceleration = $\frac{v}{t} = LT^{-2} = m/s^2$

- Force = $Ma = MLT^{-2} = \text{kg} \cdot m/s^2$

- Pressure = $\frac{\text{Force}}{\text{Area}} = \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2} = \text{kg}/m \cdot s^2$

- Work = Force $\times$ displacement = $MLT^{-2} \times L = ML^2T^{-2} = \text{kg} \cdot m^2/s^2$

- Power = $\frac{\text{Work}}{\text{Time}} = \frac{ML^2T^{-2}}{T} = ML^2T^{-3} = \text{kg} \cdot m^2/s^3$

- Momentum = Mass $\times$ Velocity = $M \times \frac{d}{t} = MLT^{-1} = \text{kg} \cdot m/s$

- P.E = $M \cdot g \cdot h = M \times LT^{-2} \times L = ML^2T^{-2} = \text{kg} \cdot m^2/s^2$

- K.E = $\frac{1}{2}MV^2 = M \times (LT^{-1})^2 = ML^2T^{-2} = \text{kg} \cdot m^2/s^2$

- Frequency = $\frac{1}{T} = T^{-1}$

- Periodic time = T



* Application of Dimensions equation:

ch 1
Lec 2

① Testing the correctness of physical equations:

$$\boxed{1} \quad T = 2\pi \sqrt{\frac{L}{g}}$$

$$T^2 = 4\pi^2 \left(\frac{L}{g}\right)$$

$$L.H.S : T^2 = T^2$$

$$R.H.S : 4\pi^2 \frac{L}{g} = \frac{L}{L T^{-2}} = T^2$$

L.H.S = R.H.S, correct relation

$$\boxed{2} \quad \overset{\text{Velocity}}{V} = \sqrt{\frac{T}{m}}$$

$$V^2 = \frac{T}{m}$$

$$L.H.S = V^2 = L^2 T^{-2}$$

$$R.H.S = \frac{T}{m} = \frac{MLT^{-2}}{M} = L^2 T^{-2}$$

L.H.S = R.H.S, correct relation

$$\boxed{3} \quad \overset{\text{Velocity}}{V} = \sqrt{\frac{E}{D}}$$

$E \rightarrow \text{Young's modulus} = \frac{\text{Stress}}{\text{Strain}}$, $\text{Stress} = \frac{\text{Force}}{\text{Area}}$
 $D \rightarrow \text{Density} = \frac{\text{Mass}}{\text{Volume}}$, $\text{Strain} = \frac{\Delta L}{L_0}$

$$V^2 = \frac{E}{D}$$

$$L.H.S = V^2 = L^2 T^{-2}$$

$$R.H.S = \frac{\frac{F}{A}}{\frac{M}{Vol}} = \frac{\frac{MLT^{-2}}{L^2}}{\frac{M}{L^3}} = \frac{MLT^{-2}}{ML^{-3}} = L^2 T^{-2}$$

L.H.S = R.H.S, correct relation

$$\boxed{4} \quad V_f^2 = V_i^2 - 2gt \sin \alpha + g^2 t^2$$

$$L.H.S \quad V^2 = L^2 T^{-2}$$

$$R.H.S \quad \begin{cases} \textcircled{1} V^2 = L^2 T^{-2} \\ \textcircled{2} gt = LT^{-2} \end{cases}$$

$$\textcircled{3} g^2 t^2 = L^2 T^{-2}$$

L.H.S $\neq$ R.H.S, in correct relation

② Deciding the nature of any constant in any Physical Quantity:

$$\boxed{1} \quad F = G \frac{M_1 M_2}{r^2}, \quad G = \frac{Fr^2}{M_1 M_2}$$

$$G = \frac{MLT^{-2} \cdot L^2}{M^2} = M^{-1} L^3 T^{-2} = \text{m}^3 / \text{kg} \cdot \text{s}^2$$

dimensional

$$\boxed{2} \quad T = k \sqrt{\frac{L}{g}}, \quad T^2 = k^2 \left(\frac{L}{g}\right), \quad k^2 = \frac{T^2 \cdot g}{L}$$

$$k^2 = \frac{T^2 \cdot LT^{-2}}{L} = 1, \quad k = 1$$

not dimensional

③ Determination of dimension of unknown Physical quantity:

$$* F = k \frac{Q_1 Q_2}{d^2} = \frac{k Q^2}{d^2}, \quad Q^2 = \frac{F \cdot d^2}{k}$$

$$Q^2 = \frac{M L T^{-2} \cdot L^2}{k} = \frac{M L^3 T^{-2}}{k}$$

④ Discovery of new equation:

* Tuning fork:

$$\begin{array}{l} \text{Periodic Time} \left\{ \begin{array}{l} T \propto L \rightarrow \text{Length of fork} \\ T \propto E \rightarrow \text{young modulus} \\ T \propto D \rightarrow \text{Density} \end{array} \right. \end{array}$$

$$- T \propto L^x D^y E^z$$

$$T = \text{Const. } L^x D^y E^z, \quad \text{Let const.} = k$$

$$T = k \cdot L^x \cdot D^y \cdot E^z$$

$$M^0 L^0 T^1 = L^x \cdot (M L^{-3})^y \cdot (M T^{-2})^z$$

$$M^0 L^0 T^1 = M^{y+z} \cdot L^{x-3y-z} \cdot T^{-2z}$$

$$\begin{array}{l} -2z = 1 \quad \left\{ \begin{array}{l} y+z=0 \\ y-\frac{1}{2}=0 \end{array} \right. \quad \left\{ \begin{array}{l} x-3y-z=0 \\ x-\frac{3}{2}+\frac{1}{2}=0 \end{array} \right. \end{array}$$

$$\boxed{z = -\frac{1}{2}} \quad \text{①}$$

$$\boxed{y = \frac{1}{2}} \quad \text{②}$$

$$\boxed{x = 1} \quad \text{③}$$

From ①, ②, ③

$$T = k \cdot L^{-1} \cdot D^{\frac{1}{2}} \cdot E^{-\frac{1}{2}} = k \cdot \frac{1}{L} \cdot \sqrt{\frac{D}{E}} = \frac{k L}{\sqrt{E}} \sqrt{\frac{D}{E}}$$

Elasticity

ch 2
lec 3

مراجعة
DATE 21/10/2023

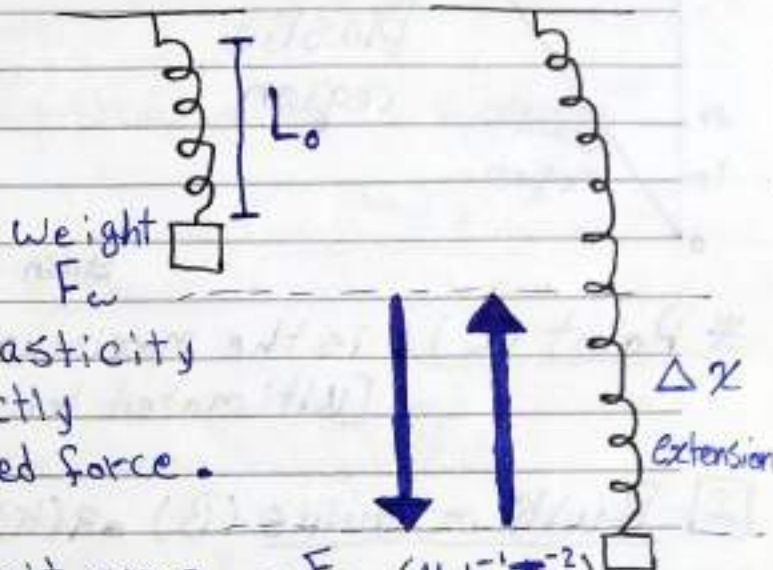
It is a physical property of a material which return to the original shape & size after the applied force was removed.

* Hook's Law:

$$F \propto \Delta x$$

$$F = k \Delta x$$

Direction



Within the limit of elasticity the extension is directly proportional to the applied force.

* Stress: Force per unit area = $\frac{F}{A}$ ($ML^{-1}T^{-2}$)
(kg/ms^2)

* Strain: The extension in Length per the original Length
strain = $\frac{\Delta L}{L_0}$ no unit & no dimension

* Modulus of elasticity = $\frac{\text{stress}}{\text{strain}}$ = $ML^{-1}T^{-2}$
unit MKS $kgm^{-1}s^{-2} \approx N/m^2$
cgs $gcm^{-1}s^{-2} \approx dyne/cm^2$

1 Young's modulus (E), (y)

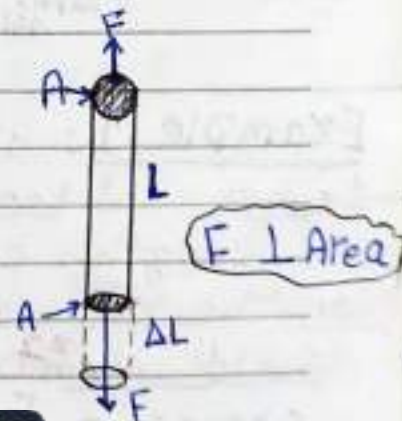
* Tension force

$$\text{Tensile Stress} = \frac{F}{A}$$

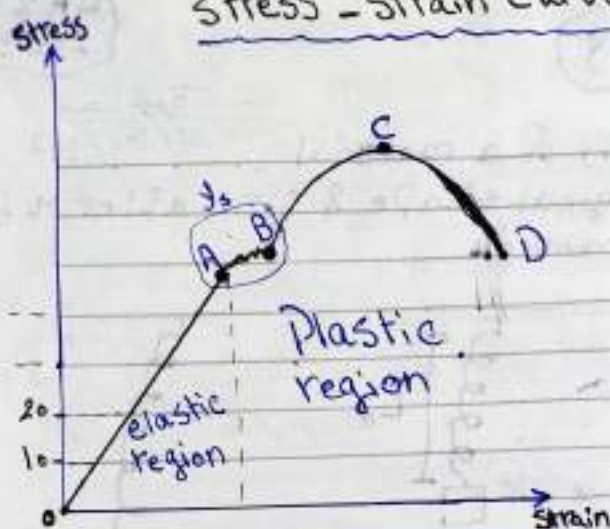
$$\text{Tensile Strain} = \frac{\Delta L}{L}$$

$$\text{Young's modulus} = \frac{\text{Tensile stress}}{\text{Tensile strain}}$$

$$E = \frac{F/A}{\Delta L/L} = \frac{F \cdot L}{\Delta L \cdot A}$$



Stress - Strain Curve



* OA - elastic region

- 1 - applicable to Hooke's law
- 2 - Slope = Modulus of elasticity

* Point (B)

yield Point

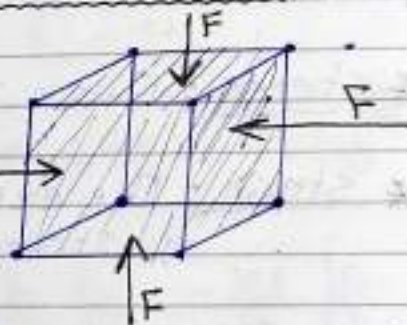
yield stress (y_s):
is stress which caused
at the onset of Plastic
region.

* Point (C): is the maximum stress in the curve
[Ultimated tensile Strength]

[2] Bulk modulus (B) • R(k)

* Bulk stress = $\frac{F}{A}$ = Pressure (P)

* Bulk strain = $-\frac{\Delta Vol}{Vol_0}$



Bulk modulus = $\frac{\text{Bulk stress}}{\text{Bulk strain}}$

$$B = -\frac{P}{\frac{\Delta Vol}{Vol}} = -\frac{F/A}{\frac{\Delta Vol}{Vol}} = -\frac{F \cdot Vol}{A \cdot \Delta Vol}$$

Example 1: A structural steel rod has a radius of 10 mm and Length of 1 m & 100 kN force stretches it along its length, calculate stress, elongation & strain on the rod. Young's modulus, of structural steel is $2 \times 10^{11} \text{ N/m}^2$

Solution

$$\text{stress} = \frac{F}{A} = \frac{100 \times 10^3}{\pi (10 \times 10^{-3})^2} = 3.18 \times 10^8 \text{ N/m}^2$$

$$E = \frac{F \cdot L}{\Delta L \cdot A}, \Delta L = \frac{F \cdot L}{E \cdot A} = \frac{100 \times 10^3 \times 1}{2 \times 10^{11} \times 3.14 \times (10 \times 10^{-3})^2} = 1.59 \times 10^{-3} \text{ m}$$

$$\text{strain} = \frac{\Delta L}{L} = 1.59 \times 10^{-3}$$

Example 2: A steel wire 1 m long with diameter 1 mm has a 10 kg mass hung from it, $E = 21 \times 10^{10} \text{ N/m}^2$.
 $F = 10 \times 9.8 = 98 \text{ N}$
 $r = 0.5 \times 10^{-3} \text{ m} = 0.0005$

(a) How much will the wire stretch?

$$E = \frac{F \cdot L}{\Delta L \cdot A}, \Delta L = \frac{F \cdot L}{E \cdot A} = \frac{98 \times 1}{21 \times 10^{10} \times 3.14 \times (0.0005)^2} = 5.94 \times 10^{-4} \text{ m}$$

(b) What is the stress on the wire?

$$\text{Stress} = \frac{F}{A} = \frac{9.8}{3.14 \times (0.0005)^2} = 1.25 \times 10^8 \text{ N/m}^2$$

(c) What's the strain? Strain = $\frac{\Delta L}{L} = 5.94 \times 10^{-4}$

Example 3: A copper wire of length 2.2 m and steel wire of length 1.6 m both of diameter 3 mm are joined end to end when stretched by a load, the net elongation is found to be 0.7 mm . Obtain the load applied.

$$Y_s = 2 \times 10^{11} \text{ N/m}^2$$

Solution

$$Y_c = 1.1 \times 10^{11} \text{ N/m}^2$$

$$L_c = 2.2\text{ m}, L_s = 1.6\text{ m}, r = 1.5 \times 10^{-3} \text{ m}, \Delta L = 0.7\text{ mm}$$

$$Y = \frac{F \cdot L}{\Delta L \cdot A}, F = \frac{Y_c \Delta L_c \cdot A}{L_c} = \frac{Y_s \Delta L_s \cdot A}{L_s} \quad \Delta L_c + \Delta L_s = 0.7\text{ mm}$$

$$\frac{\Delta L_c}{\Delta L_s} = \frac{Y_s \cdot A \cdot L_c}{Y_c \cdot A \cdot L_s} = \frac{2 \times 10^{11} \times 2.2}{1.1 \times 10^{11} \times 1.6} = 2.5 \quad (1)$$

$$\Delta L_c + \Delta L_s = 7 \times 10^{-4} \text{ m} \quad (2)$$

From (1) & (2)

$$\Delta L_c = 2.5 \Delta L_s \rightarrow 2.5 \Delta L_s + \Delta L_s = 7 \times 10^{-4}$$

$$F = \frac{2 \times 10^{11} \times 2 \times 10^{-4} \times 7.065 \times 10^{-6}}{1.6} \quad \Delta L_s = \frac{7 \times 10^{-4}}{3.5} = 2 \times 10^{-4} \text{ m}$$

$$= 1.8 \times 10^{-2} \text{ N}$$

$$\Delta L_c = 5 \times 10^{-4} \text{ m}$$

Example 4: A solid copper sphere of 0.5 m^3 volume is placed 30.5 m below ocean where pressure $3 \times 10^5 \text{ N/m}^2$. What's the change in volume of sphere? The bulk modulus for copper is $14 \times 10^{10} \text{ N/m}^2$.

$$E = \frac{\text{Stress}}{\text{Strain}} = \frac{-P}{\Delta V/V_0}$$

$$\Delta V = \frac{-P \cdot V_0}{E} = \frac{-3 \times 10^5 \times 0.5}{14 \times 10^{10}} = -1.07 \times 10^{-6} \text{ m}^3$$



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Example 5: The average depth of Indian Ocean is about 3000 m. Calculate the fractional compression ($\Delta V/V$) of water at bottom of ocean, given that bulk modulus of water is $2.2 \times 10^9 \text{ N/m}^2$. (Take $g = 10 \text{ m/s}^2$)

$\rho = 1000 \text{ kg/m}^3$.

Solution

$$P = \text{stress} = h \cdot \rho \cdot g = 3000 \times 1000 \times 10 = 3 \times 10^7 \text{ N/m}^2$$

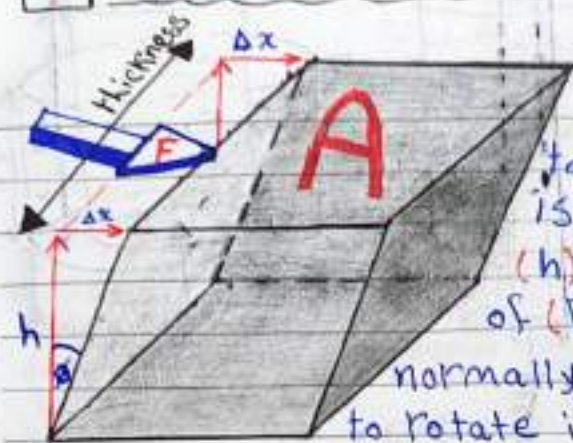
$$\text{Strain} = \frac{\Delta V}{V} = \frac{P}{B} = \frac{3 \times 10^7}{2.2 \times 10^9} = 1.36 \times 10^{-2}$$



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3 Shear Modulus (Tangential Force)

Ch. 2
Lec 4



A cube fixed to surface. A tangential force (F) is applied at top of cube, distance (h) above the bottom. The value of (F) time height (h) of cube would normally cause a torque to act on cube to rotate it. However, cube isn't free to rotate, the body instead become **deformed**. The tangential force causes a change in shape of body that is measured by the angle (θ), called the angle of shear.

* **Shear Modulus (R)** (or modulus of Rigidity) = $\frac{\text{shearing stress}}{\text{shearing strain}} = \frac{F \cdot h}{\Delta x \cdot A} = \frac{F}{\theta_{rad} \cdot A}$

* **Shearing Stress** = $\frac{F}{A}$ * **Shearing Strain** = $\frac{\Delta x}{h} = \tan \theta = \theta_{rad}$

* **Shear Modulus** = $ML^{-1}T^{-2} = Kg/m.s^2 = N/m^2$
 $= g/cm.s^2 = dyne/cm^2$

Example 6: A sheet of copper one meter high, base Length 0.75 m and 5 cm thick is acted on by tangential force 50000 N. The value for R of copper is $4.2 \times 10^{10} N/m^2$.

(a) Find shearing stress.

$$\text{shearing stress} = \frac{F}{A} = \frac{50000}{0.75 \times 0.005} = 1.33 \times 10^7 N/m^2$$

(b) Find shearing strain.

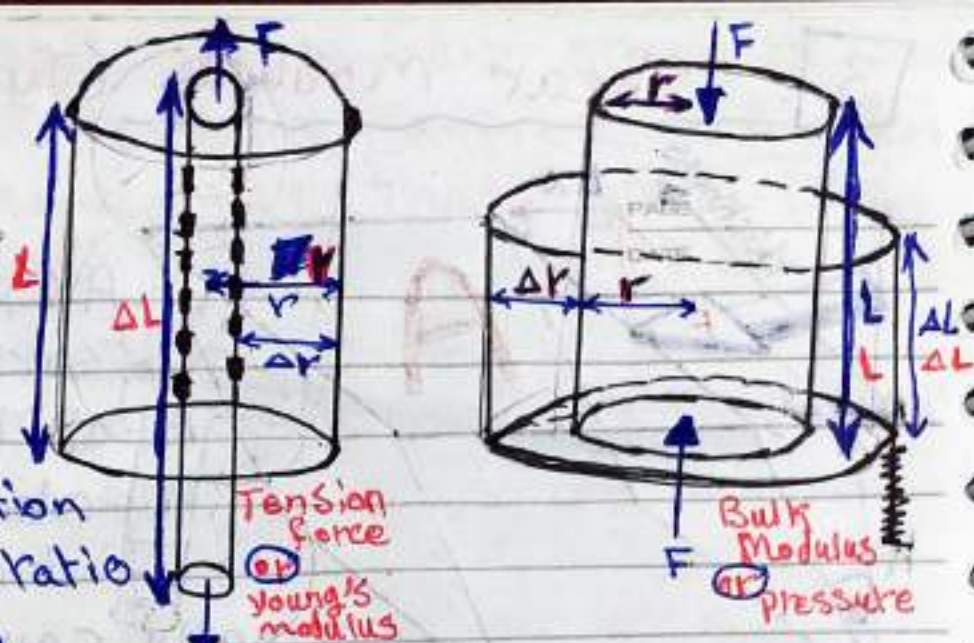
$$\text{shearing strain} = \frac{\Delta x}{h} = \frac{\text{stress}}{R} = \frac{1.33 \times 10^7}{4.2 \times 10^{10}} = 3.17 \times 10^{-4} \text{ rad}$$

(c) Find linear displacement (Δx).

$$\Delta x = h \theta = 1 \times 3.17 \times 10^{-4} = 3.17 \times 10^{-4} \text{ m} = 0.317 \text{ mm}$$

* Poisson's Ratio

it's when an object is compressed or extended. It is observed that it expands or contracts perpendicular to the direction of applied stress. The ratio of transverse strain to longitudinal strain is Poisson's ratio.



* Longitudinal Length $\rightarrow L, \Delta L$

* transverse Length $\rightarrow r, \Delta r$

$$\text{Poisson's ratio } (\sigma) = \frac{\text{transverse strain}}{\text{Longitudinal strain}} = \frac{\Delta r / r}{\Delta L / L} = \frac{\Delta r \cdot L}{\Delta L \cdot r}$$

(has no unit, dimensionless)

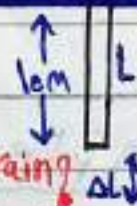
Example 7: A steel wire 10^L m Long and 2 mm in diameter is attached to ceiling and a 200^F N weight is attached to the end. What's the applied stress?

$$\text{Stress} = \frac{F}{A} = \frac{200}{3.14 \times (10^{-3})^2} = 63.69 \times 10^6 \text{ N/m}^2$$

- When wire stretch with 3.08 mm , find longitudinal strain

$$\text{Strain} = \frac{\Delta L}{L} = \frac{3.08 \times 10^{-3}}{10} = 3.08 \times 10^{-4}$$

$r = 10^{-3} \text{ m}$



200 N

Motion

Chs
Lec 5

Translational Motion

- Motion has starting Point & different end Point.

Example:

- Motion in straight Line.
- Motion in curved Path (Projectile motion).

Periodic Motion

- Motion repeated regularly in equal intervals of time.

Example:

- Oscillatory motion.
- Wave motion.

Oscillatory Motion

- 1) displacement (x): The distance that the Pendulum or (Mass Spring System) makes from (rest Position) at any moment is called displacement or (equilibrium Position).

- 2) Amplitude (A): The maximum displacement from equilibrium Position.

- 3) Complete Oscillation:

The Pendulum Passed by Equilibrium Position two successive times in same direction and with same Velocity.



- 4) Periodic time (T): The time of one complete Oscillation.

$$T = \frac{t}{N}, \quad \nu = \frac{N}{t}, \quad \nu = \frac{1}{T}$$

- 5) Frequency (ν): Its no. of complete Oscillation per second

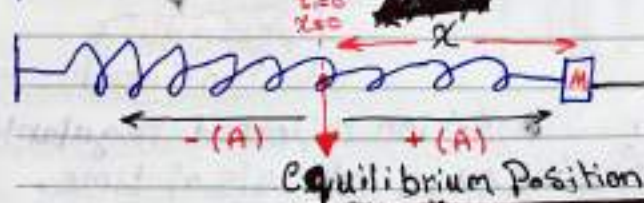
- 6) Simple harmonic motion: [SHM]



CS

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* Mass Spring System:



* المسافة إلى هتقطع
هي هي إلى هتخرج

$$F_s \propto x$$

Restoring Force

$$F_s = -kx \quad (1)$$

Spring Constant

From 2nd Law of Newton

$$F_s = ma \quad (2)$$

$$k = \frac{F_s}{x} = N/m$$

$$v = \frac{dx}{dt}$$

$$a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$

From (1) & (2)

$$Ma = -kx$$

$$a = \frac{-kx}{M}$$

$$\frac{d^2x}{dt^2} = \frac{-kx}{M}$$

$$\frac{d^2x}{dt^2} + \frac{kx}{M} = 0$$

هتبقى
عن طريق
إشارات مشتق
علينا

$$x = A \cos(\omega t + \phi)$$

$$v = -A\omega \sin(\omega t + \phi)$$

$$a = -A\omega^2 \cos(\omega t + \phi)$$

$$x_{max} = A$$

$$v_{max} = \pm A\omega$$

$$a_{max} = \pm A\omega^2$$

(ϕ)
Phase
Constant

$\omega \rightarrow$ angular frequency

$$\omega = \sqrt{\frac{k}{m}} = 2\pi f = \frac{2\pi}{T}$$

$$\omega^2 = \frac{k}{m}$$

Energy

$$E = K.E + P.E$$

$$K.E = \frac{1}{2}mv^2$$

$$= \frac{1}{2}m[-A\omega \sin(\omega t + \phi)]^2$$

$$P.E = \frac{1}{2}kx^2$$

$$= \frac{1}{2}k[A \cos(\omega t + \phi)]^2$$

$$E = \frac{1}{2}m\omega^2 A^2 \sin^2(\omega t + \phi)$$

$$+ \frac{1}{2}k A^2 \cos^2(\omega t + \phi)$$

$$= \frac{1}{2}m \left(\frac{k}{m} \right) A^2 \sin^2(\omega t + \phi)$$

$$+ \frac{1}{2}k A^2 \cos^2(\omega t + \phi)$$

$$= \frac{k}{2} A^2 [\sin^2(\omega t + \phi) + \cos^2(\omega t + \phi)]$$

$$= \frac{1}{2}k A^2 [1]$$

$$E = \frac{1}{2}k A^2$$

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خواص مادية

Lec 6
18/11/2023

$$K.E = \frac{1}{2} m v^2, \quad P.E = \frac{1}{2} k x^2$$

$$E = P.E + K.E = \frac{1}{2} k A^2$$

$$\frac{1}{2} k x^2 + \frac{1}{2} M v^2 = \frac{1}{2} k A^2$$

$$k x^2 + M v^2 = k A^2$$

$$M v^2 = k A^2 - k x^2$$

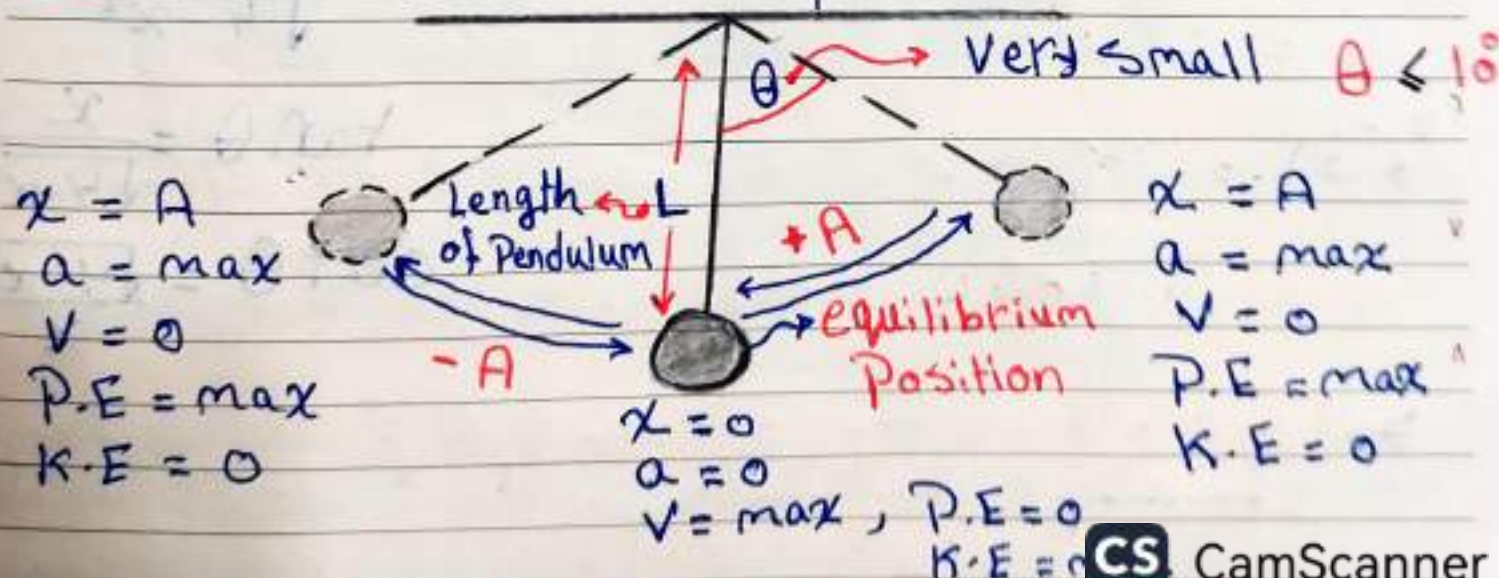
$$v^2 = \frac{k}{M} (A^2 - x^2)$$

$$\omega = \sqrt{\frac{k}{M}} = 2\pi f$$

$$v^2 = \omega^2 (A^2 - x^2)$$

$$v = \pm \omega \sqrt{A^2 - x^2}$$

* Simple Pendulum : رسمنا على graph في الآخر



$$\sin \theta = \frac{x}{L} \approx \theta$$

$$L \sin \theta = x$$

$$x = L \theta$$

$$F = -Mg \sin \theta \quad (1)$$

From Newton's Law $\rightarrow F = Ma \quad (2)$

From (1) & (2)

$$-Mg \sin \theta = Ma$$

$$-g \sin \theta = a = \frac{d^2 x}{dt^2} = \frac{d^2 L \theta}{dt^2}$$

$$\frac{d^2 L \theta}{dt^2} + g \theta = 0 \quad \div L$$

$$\frac{d^2 \theta}{dt^2} + \frac{g}{L} \theta = 0$$

$$\frac{d^2 \theta}{dt^2} + \omega^2 \theta = 0$$

هناك قانون
ثلاث قوانين

Note

$$\omega = 2\pi f = \frac{2\pi}{T} = \sqrt{\frac{k}{m}} = \sqrt{g/L}$$

(Angular Position) $\theta = \theta_0 \cos(\omega t + \phi)$ rad

(Angular velocity) $\dot{\theta} = -\theta_0 \omega \sin(\omega t + \phi)$ rad/s

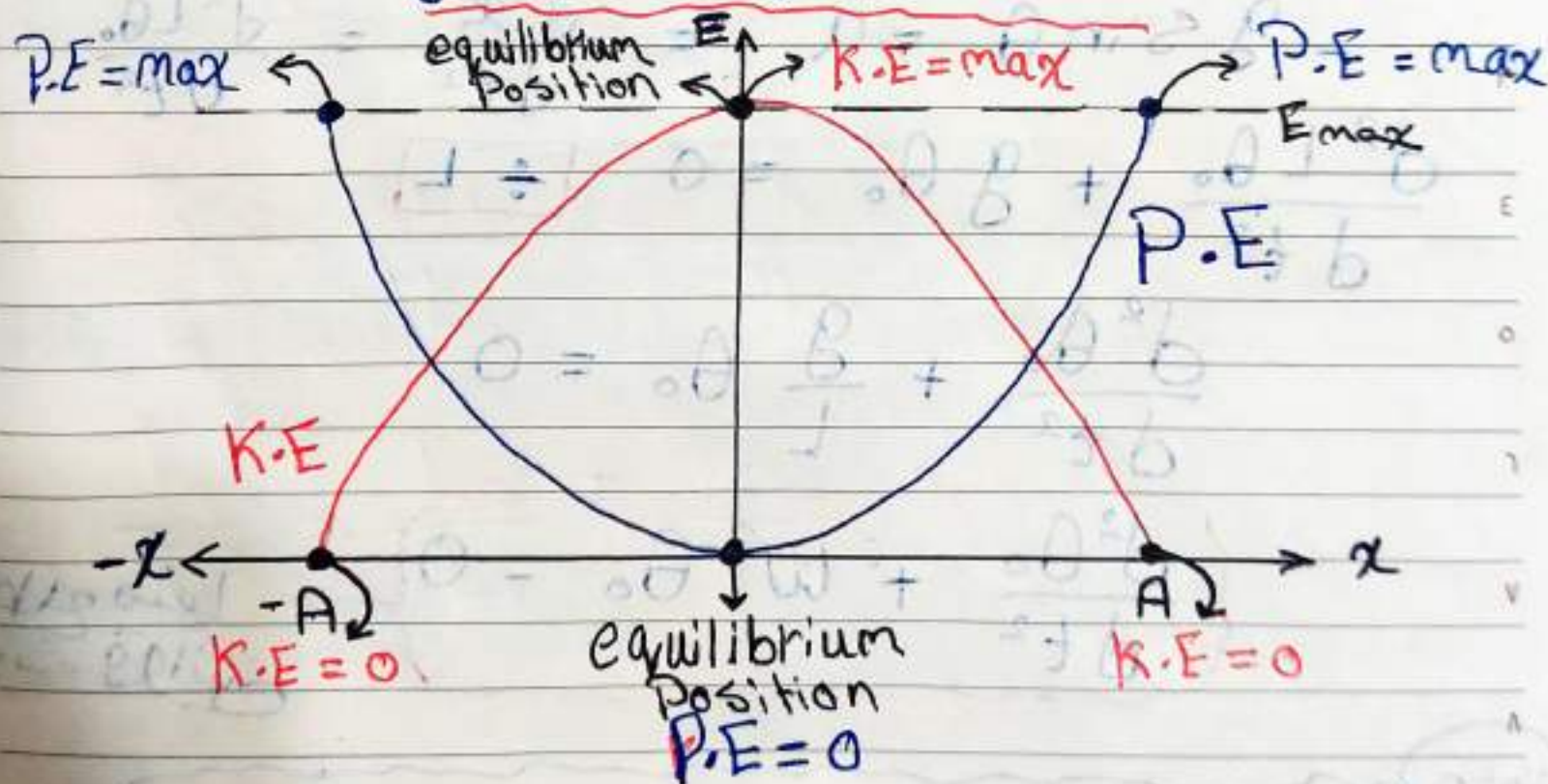
(Angular acceleration) $\ddot{\theta} = -\theta_0 \omega^2 \cos(\omega t + \phi)$ rad/s²

(Linear Position) $x = A \cos(\omega t + \phi)$ m

(Linear velocity) $v = -A \omega \sin(\omega t + \phi)$ m/s

(Linear acceleration) $a = -A \omega^2 \cos(\omega t + \phi)$ m/s²

Graph of Pendulum

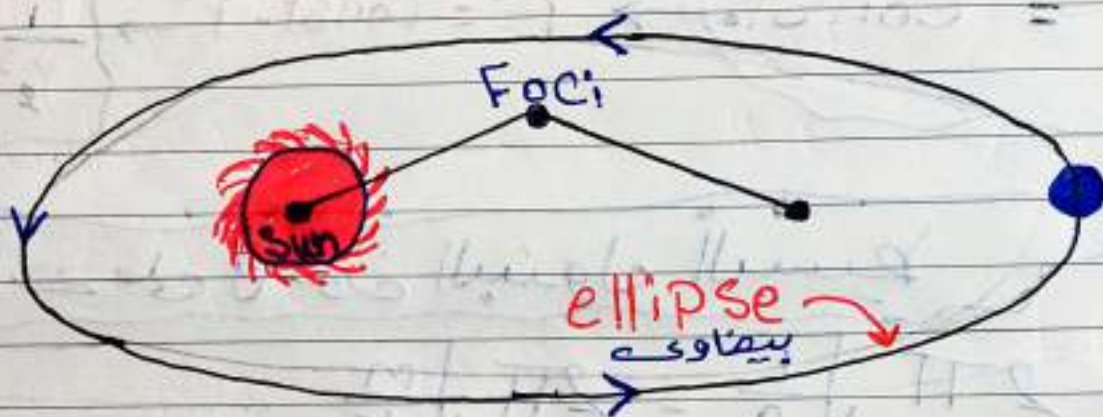


(E_T) Total Energy is cons. CS CamScanner

Kepler's Law

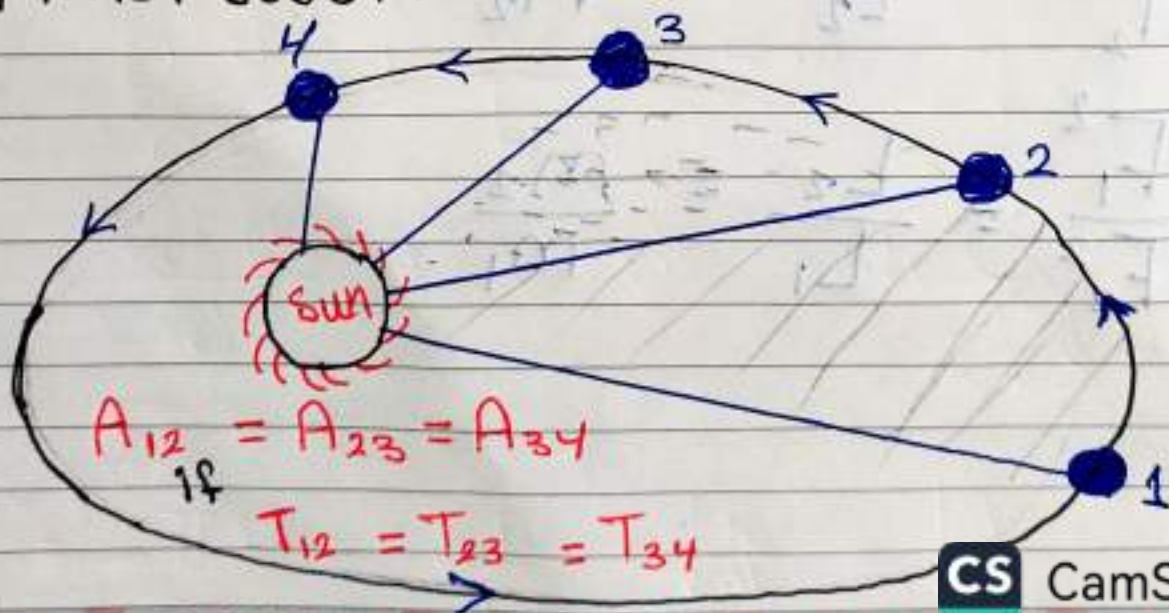
* 1st Law of Kepler: (Law of orbitals)

All the planets move in elliptical orbits with the sun at one focus of the ellipse.



* 2nd Law of Kepler (Law of area):

The line joining the sun & a planet sweeps out equal areas in equal times
i.e. Planet doesn't move at constant speed.



* 3rd Law of Kepler: The ratio of the cube of the radius to the square of time for Planet to make one complete cycle around the sun is constant.

$$\frac{r^3}{T^2} = \text{const.} \rightarrow r^3 = \text{const.} \cdot T^2 \rightarrow \frac{r_1^3}{r_2^3} = \frac{T_1^2}{T_2^2}$$

ملاحظات على قانون البندول البسيط

$$T = 2\pi \sqrt{\frac{L}{g}} = 2\pi \sqrt{\frac{m}{k}}$$

$$F = \frac{1}{2\pi} \sqrt{\frac{g}{L}} = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$

$$\frac{T_1^2}{T_2^2} = \frac{L_1}{L_2} = \frac{m_1}{m_2}$$

$$\frac{F_1^2}{F_2^2} = \frac{L_2}{L_1} = \frac{m_2}{m_1}$$

The three Phases of matter

	Solid	Liquid	gas
Shape	definite	indefinite	indefinite
Volume	definite	definite	indefinite

SO, Liquids & gases are sometimes grouped together as fluids because they flow very readily under the applications of external force while Solids do not.

Definitions

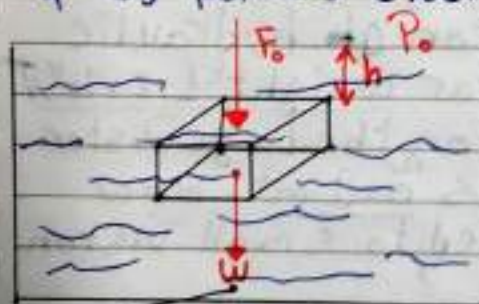
1 Pressure (P): The amount of force exerted on an object per area. $P = \frac{F}{A}$

2 Density (ρ): is a measure of how heavy it's for amount measured.

OR The mass of object per unit volume. $\rho = \frac{\text{mass}}{\text{Vol.}}$

Fluid

It is a collection of molecules that are randomly arranged & held together by weak cohesive force & by forces exerted by the wall of container.



total force on object

$$F = W + F_0$$

$$PA = Mg + P_0 A$$

$$PA = \rho h A g + P_0 A$$

$$m = \rho \cdot V$$

$$m = \rho h A$$

$$P = P_0 + \rho g h$$

gauge Pressure

weight of object

Atmospheric pressure

Depth

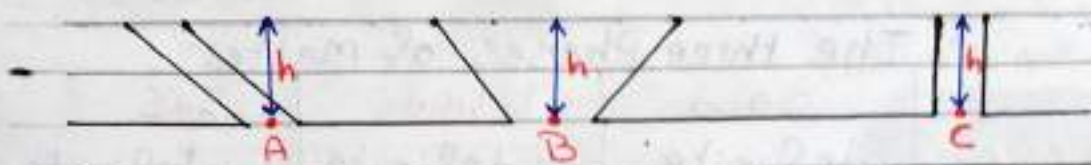
height

CS

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$$P = P_0 + \rho gh \rightarrow P \propto h$$

Don't depend on Area

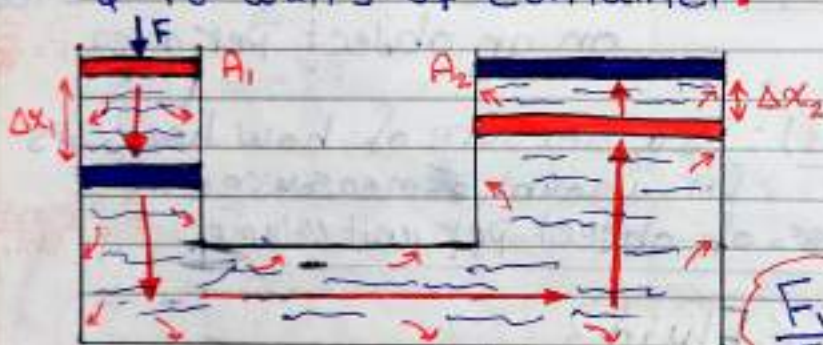


$$P_A = P_B = P_C$$

* All Points at the same horizontal level surface within a body of Liquid are at same pressure, as long as the Liquid is at rest.

Pascal's Law

The change in pressure applied to fluid is transmitted undiminished to every point of fluid & to walls of container.



$$P_1 = P_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

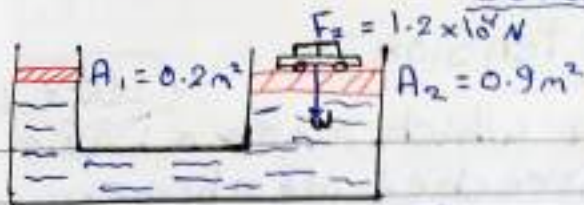
$$\frac{F_1}{F_2} = \frac{A_1}{A_2} = \frac{\Delta x_2}{\Delta x_1}$$

$$\Delta x \propto \frac{1}{A}$$

$$A_1 \Delta x_1 = A_2 \Delta x_2$$

Example: The Small piston of hydraulic lift has area $A_1 = 0.2 \text{ m}^2$. A car weight $F_2 = 1.2 \times 10^4 \text{ N}$ sits on a rack mounted on the Large piston. The Area of Large piston is $A_2 = 0.9 \text{ m}^2$. How large force must be applied to small piston to support the car.

Solution



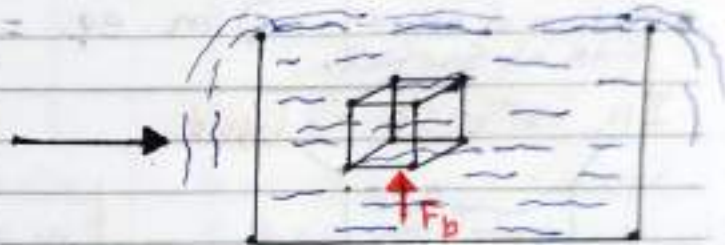
$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$F_1 = \frac{A_1 F_2}{A_2}$$

$$F_1 = \frac{0.2 \times 1.2 \times 10^4}{0.9} = 2.7 \times 10^3 \text{ N}$$

Archimedes' Principle

Any object partially or completely immersed in a fluid, it has upthrust force equal to weight of displaced liquid.



* Buoyant Force (F_B) = Real weight - Apparent weight
 = weight of displaced liquid

$$\text{Real } W = m_s g = \rho_s \cdot \text{Vol} \cdot g \quad \text{--- (1)}$$

$$\text{Apparent } W = W_L + W_s = m_L g + m_s g = \rho_L \cdot V \cdot g + \rho_s \cdot V \cdot g \quad \text{--- (2)}$$

From (1) & (2)

$$F_b = \rho_s \cdot \text{Vol} \cdot g - \rho_s \cdot \text{Vol} \cdot g - \rho_L \cdot \text{Vol} \cdot g$$

$$F_b = -\rho_L \cdot \text{Vol} \cdot g$$

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$$F_b = \rho_L \cdot \text{Vol} \cdot g$$

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المزاحة

Chapter 5

Surface tension

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It is a physical property which makes a liquid surface as an elastic stretched membrane.

* Surface tension coefficient (γ or T):

It is the work done to increase the area of liquid surface.

depends on $\gamma = \frac{W}{A} = \frac{F \cdot x}{L \cdot x} = \frac{F}{L}$ (N/m or dyne/cm)

- Temp. of liquid.
- medium of other side of surface.

Dim. eq. = $\frac{F}{L} = \frac{M \cdot L \cdot T^{-2}}{L} = M T^{-2}$

In surface of liquid



In bulk of liquid



* There's no attractive force above the object but, There's attractive force pointing toward liquid interior.

So,

* This net attractive force causes the liquid surface to contract toward interior.

* The attractive force balance the repulsive force.

So,

* The average intermolecular force between object & surrounding molecules is zero.

* Capillary Action:

1 Cohesive force: is the attraction force between molecules of the liquid.

2 Adhesive Force : is the attraction force between molecules of Liquid & molecules of Solid Surface

3 Contact Angle (θ) : is the angle between the tangent of the molecules of the Liquid Surface & the Solid Surface.

capillary tube

$\propto$
Concave

$\cap$
Convex

Water

Mercury

- | | |
|---------------------------------------|---------------------------------------|
| - has a Concave Shape. | - has a Convex Shape. |
| - Adhesive F. > Cohesive F. | - Cohesive F. > Adhesive F. |
| - Contact angle $\theta < 90^\circ$. | - Contact angle $\theta > 90^\circ$. |
| - Acute Angle. | - Obtuse Angle. |
| - good wettability. | - bad wettability. |

* **The Relation between (γ, θ)** :-

$$F = mg$$

$$m = \rho \cdot \text{Vol}$$

$$h \times \pi r^2$$

$$F = \rho \times h \pi r^2 \times g$$

$$F_1 = \rho \pi r^2 gh \rightarrow (1)$$

$$F_2 = F \cos \theta \rightarrow (2)$$

$$\gamma = \frac{F}{L} = \frac{F}{2\pi r}$$

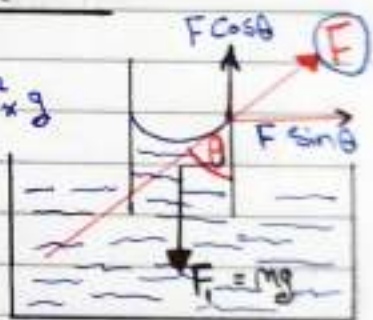
at equilibrium

$$F_1 = F_2$$

$$\rho \pi r^2 h = F \cos \theta$$

$$\rho \pi r^2 h = 2\pi r \gamma \cos \theta$$

$$\gamma = \frac{\rho \cdot r \cdot h}{2 \cos \theta}$$



Chapter 6

Viscosity

It is a physical quantity that describes the fluid's resistance to the flow.

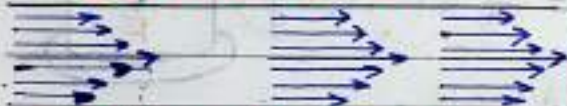
OR

It is friction force between different layers of fluid as they move past one another.

* Laminar Flow (Stream Line flow):

OCCURS when a fluid flows in parallel layers without ^{mix}distruption between layers.

Laminar Flow



moving without mixing
between layers

Turbulent Flow



moving with mixing
between layers

• سر (Laminar flow) لا يختلص بين الطبقات (*)



- The speed is smaller near the wall of the tube & flow velocity is bigger in the center of the tube.
- There is internal friction (Viscous force) between two close layers that caused by the interaction forces between molecules.

* Viscosity coefficient (η):

The frictional tangential force between two layers of the fluid of unit area separated by unit distance & the velocity gradient between them equal unity.

- $F \propto A$
- $F \propto v$
- $F \propto \frac{1}{d}$

$$F \propto \frac{A \cdot v}{d} \rightarrow F = \eta \cdot \frac{A \cdot v}{d}$$

MLT
 Kg/m.s
 g/cm.s

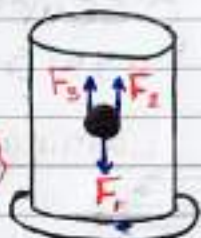
dim unit $\eta = \frac{F \cdot d}{A \cdot v}$ unit N.s/m^2
 dyne.s/m^2
 Pa.s
 Poise

* Stock's Law & Terminal Velocity:

When a solid object "ball" is allowed to fall into viscous liquid, it's subjected to 3 forces

1. $F_1 \rightarrow$ due to the weight of ball to downward.

$$(F_1) = mg = \rho_s \cdot \text{Vol} \cdot g = \left(\frac{4}{3} \pi r^3 \cdot \rho_s \cdot g \right)$$



$\rho_s \rightarrow$ Density of solid ball.

Vol $\rightarrow$ Volume of sphere = $\frac{4}{3} \pi r^3$.

$r \rightarrow$ radius of the sphere.

2. $F_2 \rightarrow$ upthrust force (upward).

$$F_2 = \frac{4}{3} \pi r^3 \cdot \rho_L \cdot g, \rho_L \rightarrow \text{Density of liquid}$$

3. $F_3 \rightarrow$ Force due to viscosity.

$$F_3 = 6 \pi r \cdot \eta \cdot v, v \rightarrow \text{Velocity of sphere.}$$

$$\eta \rightarrow \text{Viscosity coefficient.}$$

- When the sphere reaches a uniform flowing velocity then upward forces equal downward forces (at equilibrium).

$$F_1 = F_2 + F_3$$

$$\frac{4}{3} \pi r^3 \cdot \rho_s \cdot g = \frac{4}{3} \pi r^3 \cdot \rho_L \cdot g + 6 \pi r \cdot \eta \cdot v$$

$$\frac{2}{3} r^2 \cdot \rho_s \cdot g = \frac{2}{3} r^2 \cdot \rho_L \cdot g + 3 \eta \cdot v$$

$$3 \eta \cdot v = \frac{2}{3} r^2 (\rho_s - \rho_L) g$$

$$\eta = \frac{2}{9} \cdot \frac{r^2}{V} \cdot (\rho_s - \rho_L) \cdot g$$

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 η 

Viscosity coefficient.

 r 

Radius of sphere.

 V 

Velocity of sphere.

 ρ_s 

Density of sphere.

 ρ_L 

Density of Liquid.

 g 

gravity acceleration



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