INDEX

NAME : Aditya Shriwastava STD. : N·A SEC. : N·A ROLL NO. : N·A

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High School

Physics

Mechanics

Fundamental Terms

1. <u>Position</u> ($\vec{r}$) ⇒ Position refers to the spatial location of an intity.
2. <u>Distance</u> (x) ⇒ Distance is numerical description of how far apart objects are.
3. <u>Displacement</u> ($\vec{s}$) ⇒ Displacement is the shortest path between the final and initial Position.
4. <u>Speed</u> (v) ⇒ Rate of change of distance.

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

5. <u>Velocity</u> ($\vec{v}$) ⇒ Rate of change of displacement.

$$\boxed{\vec{v} = \frac{\delta \vec{s}}{dt}}$$

6. <u>Acceleration</u> ($\vec{a}$) ⇒ Rate of change of velocity.

$$\boxed{\vec{a} = \frac{\delta \vec{v}}{\delta t}}$$

7. <u>Momentum</u> ($\vec{p}$) ⇒ Numerical description of dynamic State of body.
8. <u>Impulse</u> ($\vec{J}$) ⇒ Change in momentum.

$$\boxed{\vec{J} = \Delta \vec{p}}$$

9. Force ($\vec{F}$) ⇒ Rate of change of momentum.

$$\boxed{\vec{F} = \frac{\delta P}{\delta t}}$$

10. Angular displacement (θ) ⇒ Angle rotated when viewed from a point.

11. Angular velocity (ω) ⇒ Rate of change of Angular displacement.

$$\boxed{\omega = \frac{\delta \theta}{\delta t}}$$

12. Angular acceleration (α) ⇒ Rate of change of angular velocity.

$$\boxed{\alpha = \frac{\delta \omega}{\delta t}}$$

13. Torque ($\vec{\Gamma}$) ⇒ Rate of change of angular momentum.

$$\boxed{\vec{\Gamma} = \frac{\delta \vec{L}}{\delta t}}$$

14. Angular momentum ($\vec{L}$) ⇒ Moment of momentum.

$$\boxed{\vec{L} = \vec{r} \times \vec{P}}$$

15. Angular Impulse ($\vec{J}$) ⇒ ~~Rate of~~ Change in Angular momentum.

$$\boxed{\vec{J} = \Delta \vec{L}}$$

16. Inertia (m) ⇒ Inertia is how badly an object opposes its change in ~~motion~~ velocity. ($\equiv$ Mass).

17. Moment of Inertia (I) ⇒ Moment of Inertia is how badly an object opposes its change in angular velocity.

$$\boxed{I = \int r^2 dm}$$

18. Centre of mass ⇒ Center of mass of a distribution of mass in space is the unique point where the weighed relative poition of the distributed mass sums to zero.

$$\boxed{X = \frac{1}{M}\int x\,dm \, ; \; Y = \frac{1}{M}\int y\,dm \, ; \; Z = \frac{1}{M}\int z\,dm}$$

19. Work (W) ⇒ $\int \vec{F} \cdot d\vec{s}$.

20. Power (P) ⇒ Rate of doing work.

$$\boxed{P = \frac{dW}{\delta t}}$$

21. Field ($\vec{E}$) ⇒ A field is a physical quantity that has a value for each point in space and time.

22. Pressure (P) ⇒ Force per unit area.

$$\boxed{P = \frac{Force}{Area}}$$

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Fundamental understanding

1. Concept of Space

There are three dimention of real space in which every dimentions are indipendent of each other (ie. Laws of physics are valid in any dimention ignoring others)

2. Concept of Spring

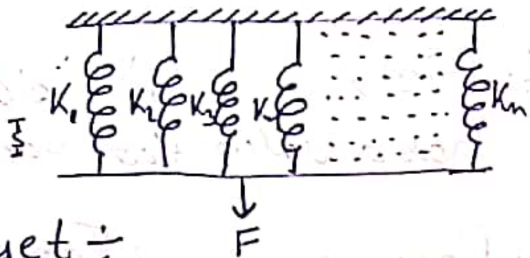
When a Spring is expanded or compressed then there is a need of force equal to $-K\vec{S}$ to keep it in equilibrium.

$F = -KS$ —⊛ { where K is Constat for a particular Spring. }

ⓐ Springs Connected in Parallel

$$\vec{F} = (-K_1\vec{S}) + (-K_2\vec{S}) + \cdots (-K_n\vec{S})$$

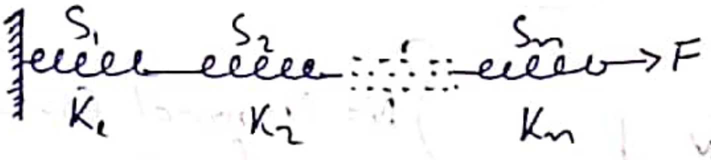
$$\vec{F} = -\sum_{j=1}^{n} K_j\vec{S} \quad \text{—①}$$



// relating eq ① with ⊛ we get:–

$$\boxed{K_{eff} = \sum_{j=1}^{n} K_j}$$

(b) Springs connected in Searees



$$F = K_n S_n = K_2 S_2 = K_1 S_1 \quad \{\text{Law of dynamics}\}$$

$$\sum_{i=1}^{n} S_i = S$$

$$S_i = \frac{K_n S_n}{K_i} \Rightarrow \sum_{i=1}^{n} S_i = K_n S_n \sum_{i=1} \frac{1}{K_i} = S$$

$$\Rightarrow K_n S_n = \left(\frac{1}{\sum_{i=1}^{n} \frac{1}{K_i}} \right) S$$

$$F = K_n S_n = \left(\frac{1}{\sum_{i=1}^{n} \frac{1}{K_i}} \right) S \quad \text{— (ii)}$$

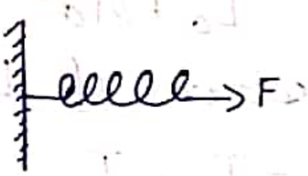
relating eq (ii) with (*) we get

$$\boxed{\frac{1}{K_{eff}} = \sum_{i=1}^{n} \frac{1}{K_i}}$$

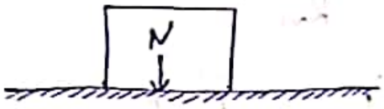
(c) Energy Stored in an Spring

$$W = \int \vec{F} \cdot d\vec{s} = \int K s \cdot ds = \frac{1}{2} K s^2$$

$$\boxed{U = \frac{1}{2} K s^2}$$



3. Concept of Friction



{N = Normal Contact force}

* Static friction $\leq \mu N$
* Kinetic friction $= \mu N$

{μ = It is constant for a particular two surface in contact}

4. Concept of Collision

* Coefficient of restitution, $e = \dfrac{(\text{Velocity of Separation})}{(\text{Velocity of approach})}$

* Perfectly elastic Collision $\Rightarrow e = 1$
* Perfectly Inelastic Collision $\Rightarrow e = 0$
* Headon Collision $\Rightarrow$ Collision in Single line.
* oblique Collision $\Rightarrow$ Collision not in Single line (ie.. in plane).

5. Theorems on moment of Inertia.

(a) Theorem of $\parallel$ axis

$$\boxed{I = I_0 + Md^2}$$

(b) Theorem of $\perp$ axis {for planer distribution}

$$\boxed{I_z = I_x + I_y}$$

{when object is in x-y plane}

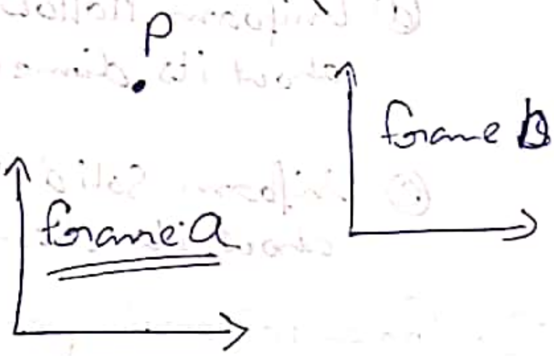
6. Concept of Radius of Gyration (K)

For a planar distribution of mass rotating about some axis in the plane of the mass, the radius of gyration is the distance from the axis, such that all mass can be concentrated there to obtain the same moment of inertia.

$$\boxed{K = \sqrt{\frac{I}{M}}}$$

7. Concept of Relative motion

$$\boxed{\vec{V}_{Pa} = \vec{V}_{Pb} - \vec{V}_{ab}}$$



$\left\{ \vec{V}_{ab} = \text{Velocity of a with respect to b} \right\}$

8. Fundamental Forces ~~of Nature~~

1. Gravitational {Responsible for attraction between masses}
2. Electromagnetic {Responsible for attraction & repulsion between charges}
3. Strong nuclear {Responsible for stability of nucleus}
4. Weak nuclear {Responsible for Radioactive decay}

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Data's

1. Moment of Inertia

(a) Uniform rod about a Perpendicular bisector $= \frac{Ml^2}{12}$

(b) Uniform circular ring about its area vector $= MR^2$

(c) Uniform disc about its area vector $= \frac{1}{2}MR^2$

(d) Uniform Hollow Sphere about its diameter $= \frac{2}{3}MR^2$

(e) Uniform Solid Sphere about its diameter $= \frac{2}{5}MR^2$

2. Gravitational potential {Similar for Electric potential}

(a) Uniform ring at a point on axis $= \frac{-GM}{\sqrt{r^2+x^2}}$

(b) Uniform thin Shell

* Outside $= -\frac{GM}{x}$
* Inside $= -\frac{GM}{r}$

© Uniform Solide Sphere

*outside = $-\frac{GM}{x}$

*Inside = $-\frac{GM}{2r^3}(3r^2-x^2)$

3. Gravitational field {Similar for Electric field}

@ Uniform ring at a point on axis = $\frac{GM\cancel{x}}{(r^2+x^2)^{3/2}}$

ⓑ Uniform thin Shell

*Inside ⇒ Zero

*outside = $\frac{GM}{r^2}$

© Uniform Solide Sphere

*Inside ⇒ $\frac{GM}{r^3}x$

*outside = $\frac{GM}{x^2}$

4. Constants

- $G = 6.6 \times 10^{-11}\ N\text{-}m^2/Kg^2$
- Mass of earth = 6×10^{24} Kg
- Radius of earth = 6.37×10^6 m
- $C = 3 \times 10^8$ m/s

Contents

5. Fluid

- Hydrostatics (1)
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  - Hydrostatic pressure (2)
  - Surface Tension & Energy (3)
  - Excess pressure (4)
  - Contact angle & shape of Meniscus (5)
  - Rise of liquid in capillary tube (6)
- Hydrodynamics (2)
  - Pressure difference in accelerating fluid (1)
  - Equation of continuity (2)
  - Bernoulli's Equation (3)
  - Viscosity (4)
  - Reynolds number (5)
  - Efflux (6)
  - Venturi tube (7)

6. Strength of material

- Stress (1)
- Strain (2)
- Modules (3)
- Poissones ratio (4)

7. Measuring Instrument

- Vernier callipers
- Screw gauge

Kinematics

(1.1) Linear motion

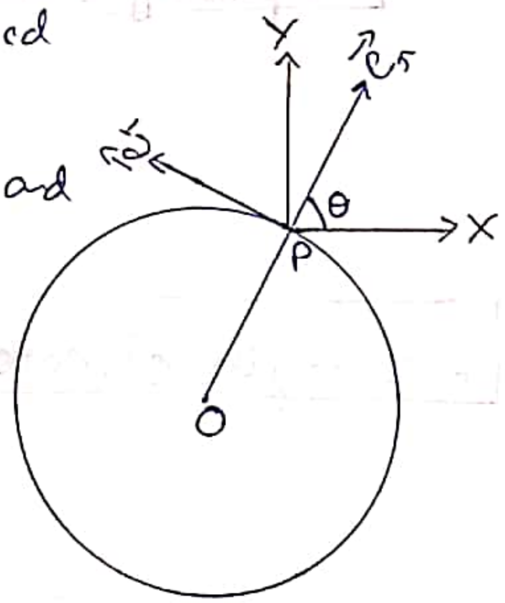
* In case of constant acceleration the following results can be used ÷

$$\boxed{\begin{aligned} V &= V_0 + at \\ S &= V_0 t + \tfrac{1}{2}at^2 \\ 2as &= V^2 - V_0^2 \\ S_n &= u + \tfrac{a}{2}(2n-1) \end{aligned}}$$

{Can be verified using calculus}

* In case of variable acceleration solve differential equation obtained

(1.2) Circular motion



Let $\vec{e}_r$ be radial unit vector and $\vec{e}_t$ be tangential unit vector.

$$\vec{e}_r = \cos\theta\,\hat{i} + \sin\theta\,\hat{j}$$

$$\vec{e}_t = -\sin\theta\,\hat{i} + \cos\theta\,\hat{j}$$

Let $\vec{r}$ be position vector

$\vec{r} = r\,\vec{e}_r$ {r = radius of the circle}

$$\vec{v} = \frac{d\vec{r}}{dt} = r\frac{d}{dt}(\cos\theta\,\hat{i} + \sin\theta\,\hat{j}) = r\omega[-\hat{i}\sin\theta + \hat{j}\cos\theta]$$

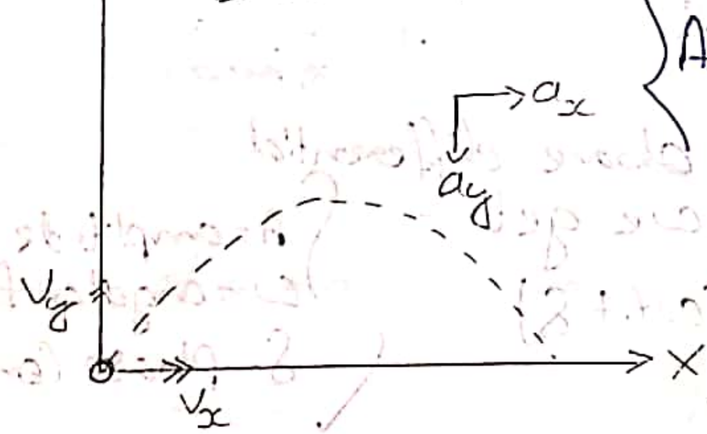
$$\vec{a} = \frac{d\vec{v}}{dt} = r\left[\omega\frac{d}{dt}\{-\hat{i}\sin\theta + \hat{j}\cos\theta\} + \frac{d\omega}{dt}[-\sin\theta\,\hat{i} + \cos\theta\,\hat{j}]\right]$$

$$\boxed{\vec{a} = -\omega^2 r\,\vec{e}_r + \frac{dv}{dt}\vec{e}_t}$$

(1.3) Projectile motion

$$\boxed{y = \frac{V_y}{V_x}x - \frac{g}{2V_x^2}x^2}$$ {Equation of trajectory}

{As per law of Space}



$$H_{max} = \frac{V_y^2}{2g}$$
$$T = \frac{2V_y}{g}$$
$$R = \frac{u^2\sin 2\alpha}{g}$$

$$\boxed{\begin{aligned} H_{max} &= \frac{V_y^2}{2a_y} \\ T &= \frac{2V_y}{a_y} \\ R &= V_xT + \frac{1}{2}a_xT^2 \end{aligned}}$$

{Can be Verified}

(1.4) Simple harmonic motion

Simple harmonic motion is a type of Periodic motion where the restoring force is directly proportional to the displacement.

or

$$F = -KS$$

$$\Rightarrow a = -\frac{K}{m}S = -\omega^2 S \; \{\text{Suppose}\}$$

$$\left\{\omega = \sqrt{\frac{K}{m}}\right\}$$

$$\frac{dv}{dt} = -\omega^2 S \qquad \left\{A = \frac{V}{\sqrt{K/m}}\right\}$$

On Solving above differential Equation we get :-

$$\boxed{S = A \sin(\omega t + \delta)}$$

$\{A$ = amplitude
ω = angular frequency
δ = phase Constant$\}$

* **Simple pendulum**

→ Time period $= 2\pi\sqrt{\frac{l}{g}}$

* **Damped Oscillation**

$$\boxed{A = A_0 e^{-\frac{bt}{2m}} \sin(\omega' t + \delta)}$$

$$\boxed{\left\{\text{Energy of oscillation} = \frac{1}{2} m\omega^2 A^2\right\}}$$

2

Dynamics

(2.1) Linear dynamics

$$\boxed{\text{* Momentum (Dynamic state of body)} = \sum m\vec{v}}$$

{Fundamental Law of dynamics}

(2.2) Rotational dynamics

$$\boxed{\begin{aligned} \vec{\Gamma} &= I\vec{\alpha} \\ \vec{L} &= I\vec{\omega} \end{aligned}}$$

{Can be verified}

* Energy of a rotating body $= \frac{1}{2} I \omega^2$

★ ICOR {Instantaneous Centre of rotation}

"ICOR is the point in a body undergoing planar movement that has zero velocity at a particular instant of time"

3

Work Energy Theorem

$$\boxed{W = \Delta KE = -\Delta PE}$$

4

Gravitation

4.1 Newton Law of gravitation

$$\boxed{F = -\frac{G M_1 M_2}{r^3}\vec{r}} \rightarrow \{\text{fundamental law}\}$$

4.2 Variation in the value of g

* At depth h

$$\boxed{g_0 = g\left(1 - \frac{h}{R}\right)}$$

* At height h

$$\boxed{g_0 = g\left(1 - \frac{2h}{R}\right)}$$

4.3 Escape velocity $\geqslant \sqrt{\frac{2GM}{R}}$

(4.4) Equivalence principle

"An observer in a closed laboratory cannot distinguish between the effect produced by a gravitational field and those produced by an acceleration of the laboratory".

(4.5) Keplers law

(i) All planets move in elliptical orbit with the sun at a focus

(ii) The radius vector from the sun to the planet sweeps equal area in equal time.

(iii) The square of the time period of a planet is proportional to the cube of the semimajor axis of the ellipse.

2

5

Fluid

5.1 Hydrostatics

5.1.1 Fundamental Principles

* Pascal's Law ⇒ Pressure applied in an inclosed liquid is transmitted equally in all direction.

* Archimede's principle ⇒ When a Solid is wholly or partialy immersed in a fluid, it experiences an upward thrust or buoyant force equal to the weight of the fluid displaced by it.

5.1.2 Hydrostatic Pressure

⇒ The pressure exerted by a fluid at equilibrium at a given point within the fluid due to gravity is hydrostatic pressure.

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

5.1.3 Surface Tension and Energy

* Surface ⇒ An Interaction between two medium {few molicular thick}.

→ fluid has general tendency to decrease there surface area.

→ This tendency of liquid at surface keeps them under a kind of stress known as Surface Tension.

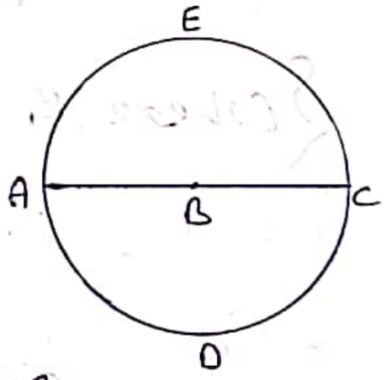
$$\boxed{S = \frac{dF}{dl}}$$

* Surface energy ⇒ Surface energy can be defined as energy per unit area of an exposed surface of a liquid.

$$\boxed{U = SA}$$

5.1.4 Excess pressure

(a) Excess pressure inside a drop.



⇒ Force acting on hemispherical surface ABCD ÷

(i) F_1 due to surface tension of ABCE

$F_1 = 2\pi R S$ (↑)

(ii) F_2 due to outside air of the surface ABCD:

$F_2 = \pi R^2 P_0$ (↑)

(iii) F_3 due to liquid inside the surface ABCD.

$F_3 = \pi R^2 P$ (↓)

// For equilibrium

$F_3 = F_1 + F_2$

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$$\Rightarrow \pi R^2 P = 2\pi R S + \pi R^2 P_0$$

$$\Rightarrow P = \frac{2S}{R} + P_0$$

$$\boxed{P_{ex} = P - P_0 = \frac{2S}{R}}$$

(b) Excess pressure inside a Sope bubble

⇒ It contain two Surface So,

$$\boxed{P_{ex} = \frac{4S}{R}}$$

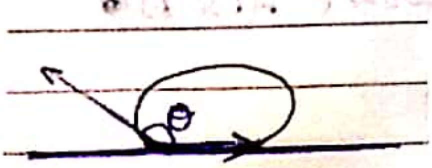
(c) Laplace Relation for excess pressure

$$\boxed{P_{ex} = S\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}$$

{where, R_1 and R_2 are principle radii of the drop}

5.1.5 Contact angle and Shape of Meniscus

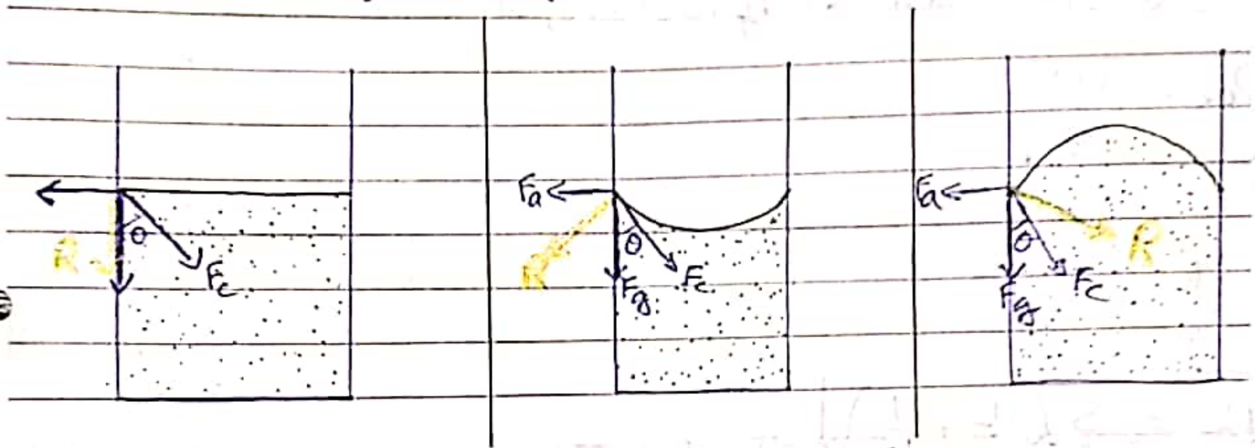
* Contact angle ⇒ Angle substended by tangent to solid {within the liquid} and tangent to liquid {away from solide} at the contact point.



{θ = Contact angle}

* Shape of Miniscus

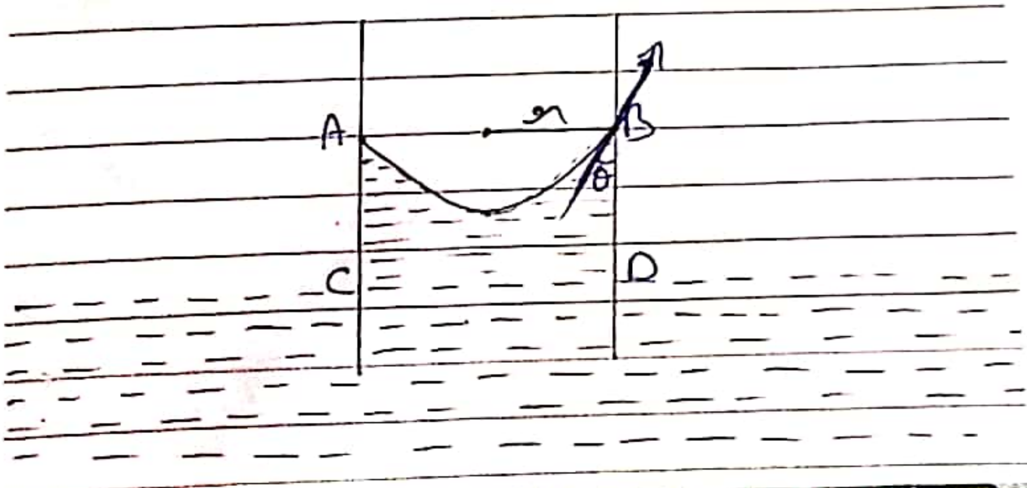
⇒ The free Surface of liquid called meniscus obtains a flat, Convex, Concave shape depending on the Solid and liquid Surface.



⇒ Surface of fluid become ⊥ to resultant force acting.

(5.1.6) Rise of liquid in a Capillary tube

* Capillary tube ⇒ Cyllendrical tube with Small radius.



Forces acting on the part of liquid raised in the tube :-

(I) F_1 by the Surface of the tube on the Surface AB of the liquid.

$$F_1 = 2\pi r S \cos\theta \ (\uparrow)$$

(II) F_2 due to the pressure of the air above the Surface AB.

$$F_2 = \pi r^2 P_0 \ (\downarrow)$$

(III) F_3 due to Pressure of liquid bellow CD.

$$F_3 = \pi r^2 P_0 \ (\uparrow)$$

(IV) Weight of liquid inclosed in ABCD.

$$W = \pi r^2 h \rho g \ (\downarrow)$$

For equillibrium :-

$$F_1 + F_3 = F_2 + W$$

$$\boxed{h = \frac{2S\cos\theta}{\rho g r}}$$

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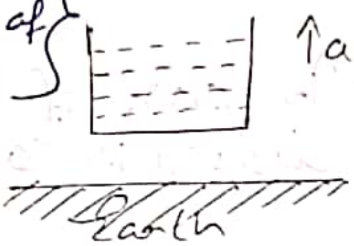
5.2 Hydrodynamics

5.2.1 Pressure difference in accelerating fluid

// Case 1: liquid placed in an Elevator

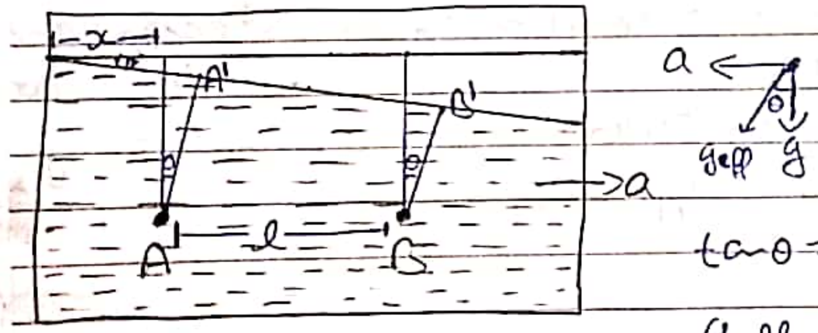
$g_{eff} = (g + a_0)$ {using Principle of Equivalence}



$\Delta P = \rho g_{eff} h - \rho g h$

$\boxed{\Delta P = \rho a h}$

// Case 2: liquid placed in horizontal accelerator



$\tan\theta = \frac{a}{g}$

$g_{eff} = \sqrt{a^2 + g^2}$

$\Rightarrow AA' = \{h - x\tan\theta\}\cos\theta$; $BB' = \{h - (x+l)\tan\theta\}\cos\theta$ {Using Geometry}

$\Delta P = \rho g_{eff}\{AA' - BB'\} = \rho\sqrt{g^2+a^2}\, l \sin\theta$

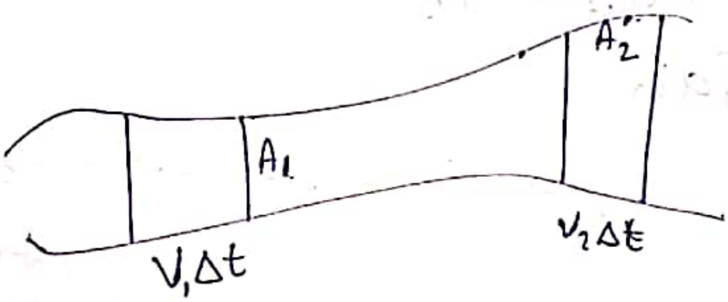
$= \rho\sqrt{g^2+a^2}\, \frac{l \times a}{\sqrt{g^2+a^2}}$

$\Rightarrow \boxed{\Delta P = \rho a l}$

5.2.2 Equation of continuity

A continuity equation in physics is an equation that describes the transport of a conserved quantity. {example ⇒ Energy, Charge etc...}

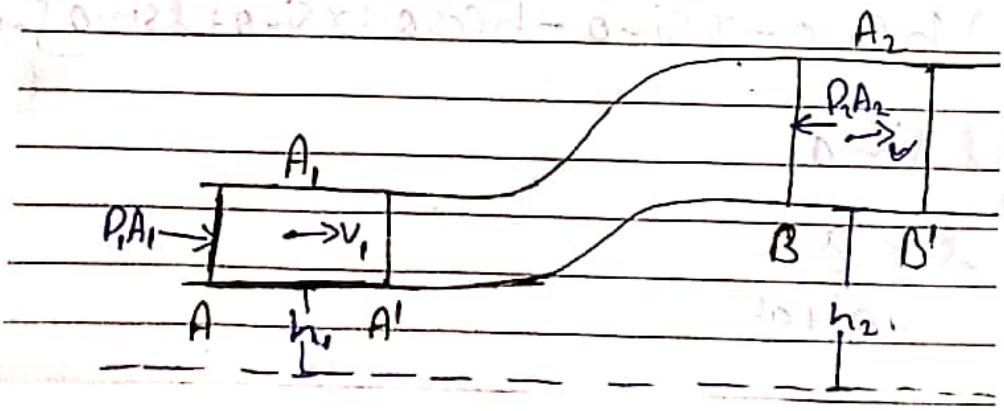
⇒ In case of incompressible liquid volume of liquid is conserved.



$$\Rightarrow A_1 V_1 \Delta t = A_2 V_2 \Delta t$$

$$\Rightarrow \boxed{A_1 V_1 = A_2 V_2}$$

5.2.3 Bernoullis Equation



$\Rightarrow$ An ideal fluid contained in AB moved forward and gets localized at A'B' in short time Δt.

// Mass of liquid displaced

$$\Delta m = \rho A_1 V_1 \Delta t = \rho A_2 V_2 \Delta t$$

// Force acting on the portion of liquid considered.

(i) $P_1 A$ by the liquid on the left and $P_2 A_2$ by the liquid on the right.

$$W_1 = (P_1 A_1)(v_1 \Delta t) = P_1 \left(\frac{\Delta m}{\rho}\right)$$

$$W_2 = -(P_2 A_2)(v_2 \Delta t) = -P_2 \left(\frac{\Delta m}{\rho}\right)$$

(ii) Δmg the weight of the liquid

$$W_3 = \Delta mg(h_1 - h_2)$$

// Using Work Energy theorem we get :-

$$W_1 + W_2 + W_3 = \Delta KE$$

$$P_1\left(\frac{\Delta m}{\rho}\right) - P_2\left(\frac{\Delta m}{\rho}\right) + \Delta mg(h_1 - h_2) = \frac{1}{2}\Delta m\{v_2^2 - v_1^2\}$$

$$\Rightarrow P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$$

$$\Rightarrow \boxed{P + \rho g h + \frac{1}{2}\rho v^2 = \text{Constant}}$$

{This is bernollies Equation}

5.2.4 Viscosity

Viscosity ~~of an~~ is a measure of the resistance of a fluid which is being deformed by either shear stress or tensile stress.

$$\boxed{f_v = -\eta A \frac{dv}{dz}}$$

5.2.5 Reynolds Number

⇒ Reynolds number is a dimensionless quantity that gives a measure of the ratio of inertial force to viscous force.

$$\boxed{R_e = \frac{\rho v d}{\eta}}$$

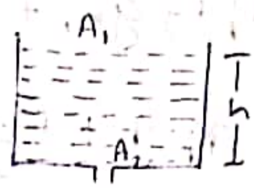
→ for $R_e < 2000$, flow is stedy

→ for $R_e > 3000$, flow is turbulent

→ for $3000 > R_e > 2000$ {flow may be steady or may suddenly changes to turbulent}

5.2.6 Efflux

Let v_1 and v_2 be the speed of liquid at A_1 and A_2.



$A_2 \ll A_1$

* $P_0 + \frac{1}{2}\rho v_1^2 + \rho g h = P_0 + \frac{1}{2}\rho v_2^2$ — (I)

* $A_1 v_1 = A_2 v_2$ — (II)

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// Using Eq(I) and Eq(II) we get ÷

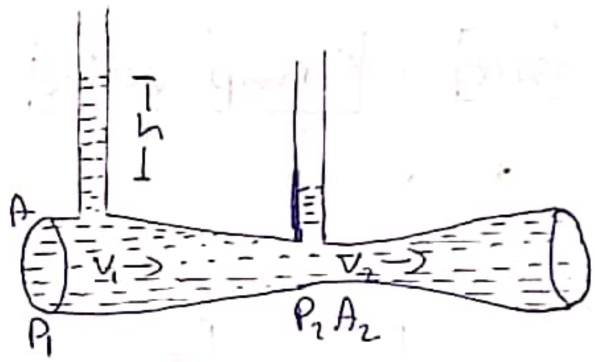
$$\frac{1}{2}\rho\left(\frac{A_2}{A_1}\right)^2 v_2^2 + \rho g h = \frac{1}{2}\rho v_2^2$$

$$\Rightarrow \left[1-\left(\frac{A_2}{A_1}\right)^2\right]v_2^2 = 2gh$$

$\Rightarrow$ as $A_2 \ll A_1$; $\Rightarrow v_2^2 = 2gh$

$$\boxed{v = \sqrt{2gh}}$$

5.2.7 Ventury Tube



* $A_1 v_1 = A_2 v_2$ —(I)

$$\Rightarrow P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$$

$$\Rightarrow P_1 - P_2 = \frac{1}{2}\rho(v_2^2 - v_1^2) \text{ —(II)}$$

* Let h be the difference in the height of liquid in the tube ÷

$$P_1 - P_2 = \rho g h$$

// Putting in eq (II) we get ÷

$$v_2^2 - v_1^2 = 2gh \text{ —(III)}$$

// Using eq (I) and (II) we can obtain the value of v_1 and v_2 ÷

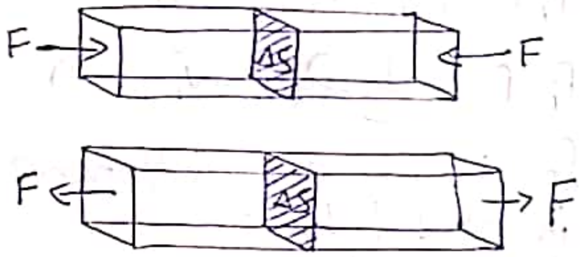
Strength of Material

6.1 Stress

- Stress
  - Longitudinal
    - Tensile
    - Compressive
  - Shearing
  - Volumetic

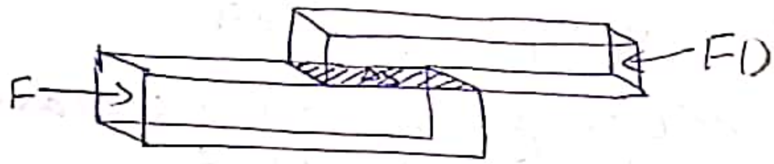
* Longitidunal Stress

$$\boxed{\Gamma_L^{o} = \frac{F}{\Delta S}}$$



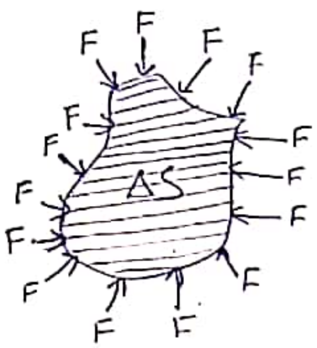
* Shearing Stress

$$\boxed{\Gamma_s^{o} = \frac{F}{\Delta S}}$$



* Volumetic Stress

$$\boxed{\Gamma_V^{o} = \frac{F}{\Delta S}}$$



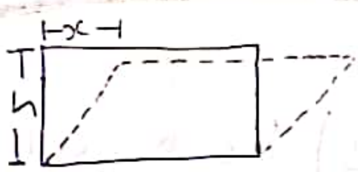
(6.2) Strain

Longitudional | Shearing | Volumatic

* *Longitudional Strain* = $\frac{\Delta L}{L}$

* *Shearing Strain* ⇒ Shearing Strain can be defined as the displacement of a layer divided by its distace from the fixed layer.

⇒ $\frac{x}{h}$



* *Volume Strain* = $\frac{\Delta V}{V}$

(6.3) Modulus = $\frac{\text{Stress}}{\text{Strain}}$

Longitudional Youngs | Shearing Torsional | Volumatic Bulk

(6.4) Poissones ratio {σ} = $\frac{\Delta d/d}{\Delta l/l}$

(6.5) Energy Stored in a Strained wire

$$U = \frac{1}{2} \times (\text{Stress}) \times (\text{Strain}) \times (\text{Volume})$$

2

Appendix 1 {Errors in measurement}

If $Y = \frac{A^n}{B^m}$ and error in measurement of A is a and B is b then percentage error in Y is:-

$$y = \left[n\frac{a}{A} + m\frac{b}{B}\right] \times 100$$

General approach

Let $y = f(A,B)$ be objective function
Let uncertainty in A be $\pm a$ and uncertainty in B be $\pm b$.

$\Rightarrow$ Uncertainty in y, $\boxed{dy = df(A,B)}$

Example

$y = 2A^2 + e^B$ {suppose}

$dy = 4A\,dA + dB\,e^B$

$\boxed{dy = 4aA + be^B}$

Electromagnetism

Fundamental Terms

★ Electro and Magneto States

① Electric field ⇒ Electric field at a point is amount of force a point Unit Positive charge will experience when kept at that very point.

Magnetic field ⇒ Magnetic field at a point is amount of force a point unit positive magnetic charge will experience when kept at that very point.

② Electric potential ⇒ Electric potential at a Point is amount of work done in bringing a point unit positive electric charge from infinitive to that very point.

Magnetic potential ⇒ Magnetic potential at a Point is amount of work done in bringing a point unit positive magnetic charge from infinitive to that very point.

③ Electric dipole moment ⇒ Electric dipole moment is defined as the product of magnitude of electric charge and separation between them. It is directed from negative to positive.

Magnetic dipole moment ⇒ Magnetic dipole moment is defined as the product of magnitude of magnetic charge and separation between them. It is directed from negative to positive.

(4) Electric flux ⇒ $\Phi_E = \int \vec{E} \cdot d\vec{s}$

Magnetic flux ⇒ $\Phi_B = \int \vec{B} \cdot d\vec{s}$

(5) Permittivity ⇒ Permittivity is the measure of the resistance that is encountered when forming an electric field.
{ε}

Permeability ⇒ Permeability is the measure of the ability of a material to support the formation of a magnetic field.
{μ}

(6) Relative Permittivity ⇒ Relative permittivity of a given metarial is ratio of Permittivity of that material to that of Permittivity of free space.
{K}

Relative Permeability ⇒ Relative permeability of a given metarial is ratio of Permeability of that material to that of ~~permitti~~ permeability of free space.
{μ_r}

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⑦ Electric Susceptibility ⇒ Electric Susceptibility (X_e) is a dimensionless proportionality constant that indicates degree of polarization of a dielectric material in response to applied electric field.

Magnetic Susceptibility ⇒ Magnetic Susceptibility (X_b) is a dimensionless proportionality constant that indicate the degree of magnetic polarization of a material in response to applied magnetic field.

⑧ Electric polarization density (Polarization)

⇒ Polarization is the vector field that expresses the density of permanent or induced electric dipole moment in a dielectric material.

Magnetic polarization ⇒ Magnetic polarization is the vector field that expresses the density of permanent or induced magnetic dipole moment in a magnetic material.

⑨ Dielectric ⇒ A dielectric material is an electric insulator that can be polarized by an applied electric field.

Diamagnetic ⇒ A diamagnetic material is a magnetic substance that can be magnetically polarized by an applied magnetic field.

(10) Capacitance ⇒ Capacitance is the ability of a body to store an electrical energy.

Inductance ⇒ Inductance is the ability of a body to store ~~a~~ magnetic energy.

(11) Dielectric Strength ⇒ Dielectric Strength of a material is the maximum electric field that a Pure material can withstand under ideal conditions without breakdown.

(12) Dielectric breakdown ⇒ Dielectric breakdown refers to a rapid reduction in the resistance of an electrical insulator when the voltage applied across it exceeds the breakdown voltage.

" Electric charge can be seperated whereas magnetic charge cannot. "

★ Electrodynamics

① Electric current ⇒ Rate of flow of electric charge.

② Displacement Current ⇒ Rate of change of electric displacement field.

③ Current density ⇒ Electric Current flowing per unit area of crossection.

④ Drift speed ⇒ Drift speed is the average speed that a particle, such as an electron, attains due to an electric field.

⑤ Resistance ⇒ Resistance is a factor opposing the passage of electric current.

⑥ Impedance ⇒ Impedance is the measure of the opposition that a circuit presents to a current when a voltage is applied.

⑦ Emf {Electromotive force} ⇒ Emf is the voltage developed by any source of electrical energy such as battery or dynamo.

Formula

$$K = 8.9 \times 10^{9}$$
$$\varepsilon_0 = 8.8 \times 10^{-12}$$
$$\mu_0 = 4\pi \times 10^{-7}$$
$$h = 6.6 \times 10^{-34}$$

★ Fundamental

① $\vec{F} = \dfrac{q_1 q_2}{4\pi\varepsilon_0 r^2}\hat{r}$ ② $\vec{E} = \dfrac{q}{4\pi\varepsilon_0 r^2}\hat{r}$

(Issues over point Charges)

③ $U = \dfrac{q_1 q_2}{4\pi\varepsilon_0 r}$ ④ $V = \dfrac{q}{4\pi\varepsilon_0 r}$

⑤ $V(\vec{r}) = -\displaystyle\int_{\infty}^{r} \vec{E}\cdot d\vec{r}$

(Relation between field & Potential)

⑥ $\vec{E} = \cancel{\nabla\left(\dfrac{\delta V}{\delta x} + \dfrac{\delta V}{\delta y} + \dfrac{\delta V}{\delta z}\right)} = -\vec{\nabla}\cdot\vec{V}$

⑦ $\oint \vec{E}\cdot d\vec{s} = \dfrac{q_{in}}{\varepsilon_0}$ (Gauss's Law)

⑧ $Q = CV$ (Charge inclosed in capacitor)

⑨ $u = \dfrac{1}{2}\varepsilon_0 E^2 + \dfrac{B^2}{2\mu_0}$ (Energy density)

⑩ $Q_p = Q\left(1 - \dfrac{1}{K}\right)$ (Induced charge in dielectric Placed inside capacitor)

⑪ $i = dQ/dt$ ⑫ $\vec{J} = di/d\vec{s}$ ⑬ $\vec{V_d} = (\text{constant})\cdot\vec{E}$

⑭ $\vec{J} = ne\vec{V_d}$ ⑮ $j = \sigma E$ ⑯ $R = \rho\dfrac{l}{A}$

(Ohm's Law)

2

(17) $i(\rightarrow) = i(\leftarrow)$

(18) $\sum \Delta V = 0$

(Kirchhoff's Law)

(19) $d\vec{B} = \dfrac{\mu_0 i(d\vec{l} \times \hat{r})}{4\pi r^2}$ (Biot-Savart Law)

(20) $\oint \vec{B} \cdot d\vec{l} = \mu_0 \sum i$ (Ampere's Law)

(21) $\mathcal{E} = -\dfrac{\delta \phi_B}{dt}$ (Faraday's Law)

(22) $\mathcal{E} = V_{\perp} B_{\perp} l_{\perp}$ (Motional Emf)

(23) $i_{rms} = \dfrac{i_0}{\sqrt{2}}$ (24) $V_{rms} = \dfrac{V_0}{\sqrt{2}}$

(25) $P = \mathcal{E}_{rms}\, i_{rms} \cos\phi$

(for Alternating current)

(26) $C = \dfrac{1}{\sqrt{\mu_0 \varepsilon_0}}$

(27) $E_0 = C B_0$

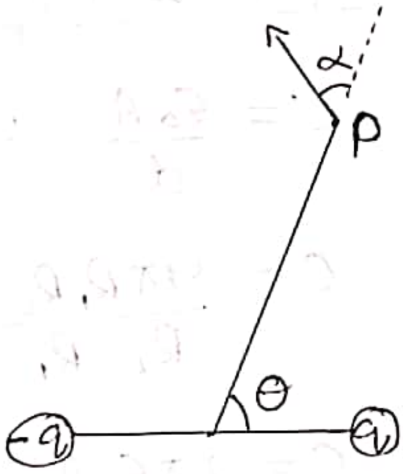
(Relating Electricity & Magnitism)

(28) $U = \frac{1}{2} L i^2$ (Energy Stored in Inductor)

★ $H = \dfrac{B}{\mu_0}$ (Magnatic field strength)

★ Derived

① Results of Electric dipole



① $\vec{P} = q\vec{d}$ ② $V = \dfrac{P\cos\theta}{4\pi\varepsilon_0 r^2}$

③ $\vec{E} = \dfrac{P}{4\pi\varepsilon_0 r^3}\sqrt{3\cos^2\theta + 1}$

$\alpha = \tan^{-1}\left(\frac{1}{2}\tan\theta\right)$

④ $\vec{\Gamma} = \vec{P} \times \vec{E}$ ⑤ $V = -\vec{P}\cdot\vec{E}$

② Applications of Gauss's Law

① $E = \begin{cases} \dfrac{Qr}{4\pi\varepsilon_0 R^3} & \forall\, r \leq R \\ \dfrac{Q}{4\pi\varepsilon_0 r^2} & \forall\, r > R \end{cases}$ {Field due to uniformly Charged Sphere of Radius R at a radial distance r}

② $E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$ {Field due to linear charge}

③ $E = \dfrac{\sigma}{2\varepsilon_0}$ {Field due to plane sheet of charge}

③ Resistance and Heat

① $\rho(T) = \rho(T_0)\left[1 + \alpha\Delta T\right]$

② $H = i^2 R t$

7

④ Capacitance of different type of Capacitor

① $C = \frac{\varepsilon_0 A}{d}$ {Parallel plate Capacitor}

② $C = \frac{4\pi R_1 R_2}{R_2 - R_1}$ {Spherical Capacitor}

③ $C = \frac{2\pi \varepsilon_0 l}{\ln(R_2/R_1)}$ {Cylindrical capacitor}

⑤ Force and Energy in || plate Capacitor

(i) $F = \frac{Q^2}{2A\varepsilon_0}$

(ii) $U = \frac{Q^2}{2C} = \frac{CV^2}{2} = \frac{QV}{2}$

⑥ Charging and discharging of Capacitor

① $q = C\varepsilon\{1 - e^{-t/RC}\}$ {Charging}

② $q = Qe^{-t/RC}$ {Discharging}

⑦ Force on electric element due to Magnetic field

① $\vec{F} = -q\vec{V} \times \vec{B}$ (Force on moving charge)

② $d\vec{F} = i\, d\vec{l} \times B$ (Force on current element)

③ $\vec{\tau} = ni\vec{A} \times \vec{B} = \vec{\mu} \times \vec{B}$ (Torque of current loop)

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⑦ $\vec{B} = \frac{\mu_0 q}{4\pi r^2}(\vec{v} \times \hat{r})$ {Magnetic field due to moving charge}

⑧ Magnetic field due to electric element

① $B = \frac{\mu_0 i}{4\pi d}(\sin\alpha + \sin\beta)$ {Field due to a finite wire}

② $B = \frac{\mu_0 i}{2\pi d}$ {Field due to infinite wire}

③ $B = \frac{\mu_0 i}{2a}$ {Fied at centre of circular current}

④ $B = \frac{\mu_0 i a^2}{2(a^2+d^2)^{3/2}}$ {Field at axial point of circular current}

⑤ $B = \mu_0 n i$ {field inside long Solenoid}

⑥ $B = \frac{\mu_0 N i}{2\pi r}$ {field insid toroid of radius r}

⑨ Growth and decay of current in L-R circuit $\{\tau = L/R\}$

① $i = \varepsilon\{1 - e^{-\frac{t}{\tau}}\}$ {Growth of current}

② $i = i_0 e^{-t/\tau}$ {Decay of current}

⑩ ~~Frequency of~~ LC-Oscillation

① $f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$

② $q = q_0 \cos\left(\frac{t}{\sqrt{LC}}\right)$ {Oscillation of Charge in Capacitor}

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Modern physics

① $K_{max} = E - \varphi$ {K_{max} = Maximum kinetic energy of electron
E → Energy supplied
φ = Work function of metal}

② $V = \dfrac{hf - \varphi}{e}$ {V = Stopping potential}

③ $\lambda = \dfrac{h}{p}$ {Wave nature of particle}

④ $R_n = \dfrac{\varepsilon_0 h^2}{\pi m e}\left(\dfrac{n^2}{Z}\right) = 0.529 \times \left(\dfrac{n^2}{Z}\right) Å$

$V_n = \dfrac{e^2}{2\varepsilon_0 h}\left(\dfrac{Z}{n}\right) = 2.2 \times 10^6 \left(\dfrac{Z}{n}\right) m/s$

⑤ $E = -13.6\left(\dfrac{Z}{n}\right)^2 eV$ {Total energy of electron in n^{th} principle quantum number}

→ $\boxed{E_p = -2E_K}$ {E_p = Potential energy
E_K = Kinetic energy}

⑥ $R = R_0 A^{1/3}$ { R ⇒ Radius of nucleus, A ⇒ Mass number, $R_0 = 1.1$ fm }

⑦ $dN = -\lambda N dt$ { Law of radioactive decay }

→ $\boxed{N = N_0 e^{-\lambda t}}$

→ $\boxed{A = A_0 e^{-\lambda t}}$

⑧ $t_{1/2} = \frac{\ln 2}{\lambda}$

$t_{av} = \frac{1}{\ln 2} t_{1/2} = \frac{1}{\lambda}$

{ $t_{1/2}$ = half life, t_{av} = Average life }

⑨ $\Delta E_{n \to m} = 13.6 Z^2 \left(\frac{1}{n^2} - \frac{1}{m^2}\right)$ { Energy released when electron jumps from n shell to m }

{ Z ⇒ Atomic number }

⑩ Probability of Survival $= \frac{N(t)}{N_0} = \frac{N_0 e^{-\lambda t}}{N_0} = e^{-\lambda t}$

OPTICS

① Spherical mirror

$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$$

$$f=R/2$$

$$m=-V/2$$

② Apparent depth

$$\frac{\text{Real depth}}{\text{Apparent depth}}=\frac{\text{Object's side } \mu_1}{\text{Viewer's side } \mu_2}$$

$$\Delta t=\left(1-\frac{\mu_1}{\mu_2}\right)t$$

③ Critical angle

$$\theta_c=\sin^{-1}\left(\frac{\mu_2}{\mu_1}\right)$$

④ Prism

$$\mu=\sin\left(\frac{\delta+A}{2}\right)\Big/\sin\left(\frac{A}{2}\right)$$

$$i=\frac{\delta+A}{2} \qquad i+e=A+\delta$$

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⑤ Refraction at Spherical Surface

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$m = \frac{R-v}{R-u} = \frac{\mu_1 v}{\mu_2 u}$$

⑥ Refraction through lenses

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$m = \frac{v}{u} \qquad P = 1/f$$

⑦ Thin lenses in contact

$$P_{eff} = \sum P$$

⑧ Two thin lenses separated by a distance

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

$$S_2 = \frac{dF}{f_1} \qquad \{S_2 = \text{distance from second lenses}\}$$

⑨ Magnification

$$m_s = 1 + \frac{D}{f} \qquad \{\text{Simple microscope}\}$$

$$m_c = \frac{LD}{f_o f_e} \qquad \{\text{Compound microscope}\}$$

Heat

Content

1. Thermal Expansion
2. Kinetic theory of gases
3. Heat Capacity
4. Laws of Thermodynamics
5. Heat Transfer

Heat → Heat may be defined as energy in transit from a high temperature object to a lower temperature object.

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Thermal expantion

"Thermal expansion is the tendency of matter to change in volume in responce to a change in temperature"

$$\boxed{\begin{aligned}\Delta(L) &= L_0 \alpha_L \Delta(T)\\ \Delta(A) &= A_0 \alpha_A \Delta(T)\\ \Delta(V) &= V_0 \alpha_V \Delta(T)\end{aligned}}$$

$L, A, V \Rightarrow$ Length, area, Volume.
$L_0 \Rightarrow$ Initial length
$\alpha_L \Rightarrow$ Cofficient of linear expantion
$T \Rightarrow$ Temperature

$\alpha_V = 3\alpha_L$ & $\alpha_A = 2\alpha_L$

Kinetic theory of gases

① Ideal gas equation

$$\boxed{PV = nRT = \frac{1}{3} M V_{rms}^2}$$

Equation that entirly describe Kinetic and dynamic state of Ideal gas

$\{R = KN_0\}$

R = Universal gas constant (8.3 J/mol-K)
N_0 = Avogadro's number (6×10^{23})
K = Boltzmann Constant (1.38×10^{-23} J/K)

(M = Total mass of the gas)

2

② Molecular Speed

(i) Root mean Square Speed (V_{rms})

$$V_{rms} = \sqrt{\frac{3RT}{M_m}}$$

(ii) Average speed (V_{avg})

$$V_{avg} = \sqrt{\frac{8RT}{\pi M_m}}$$

(iii) Most probable speed (V_{mp})

$$V_{mp} = \sqrt{\frac{2RT}{M_m}}$$

③ Graham's law of diffusion

"When two gasses at the same temperature and pressure are allowed to diffuse into each other, then the rate of diffusion of each gas is inversly proportional to the square root of the density or molicular weight of the gas.

$$\boxed{\text{Rate} \propto \frac{1}{\sqrt{\text{density}}} \propto \frac{1}{\sqrt{\text{Molicular weight}}}}$$

④ Maxwell's speed distribution Law

"In a gas at thermal equilibrium all its molecule dose not move with same speed. Some move with greater speed while some move with smaller speed".

$$\boxed{dN = 4\pi N\left(\frac{m}{2\pi KT}\right)^{3/2} v^2 e^{\frac{-mv^2}{2KT}}\, dv}$$

⑤ Energy associated

(i) Total Kinetic energy of gas

$$U = \frac{3}{2} nRT$$

(ii) Average Kinetic energy of a molecule

$$U_{av} = \frac{3}{2} KT$$

⑥ Real gas equation

$$\left(P + \frac{an^2}{V^2}\right)\left(V - nb\right) = nRT$$

$$\left\{ STP \Rightarrow T = 273K \quad P = 10^5 Pa \right\}$$

Heat Capacity

★ Specific heat capacity ⇒ Specific heat capacity of a substance is defined as the ~~exx~~ heat supplied per unit mass of the substance per unit rise in the temperature.

$$\boxed{S = \frac{\Delta Q}{m \Delta T}}$$

★ Molar heat capacity ⇒ Molar heat capacity of a gas is defined as the ~~b~~heat given per mole of the gas per unit rise in the temperature.

$$\boxed{C = \frac{\Delta Q}{n \Delta T}}$$

⇒ To define the ~~specific~~ Molar heat capacity of a gas the process should be specified.

(i) ~~Specific~~ Molar heat capacity at constant volume. (C_V)

(ii) Molar heat capacity at constant pressure (C_P)

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① Relation between Cp and Cv

$$\boxed{C_p - C_v = R} \qquad \boxed{\Delta U = n C_v \Delta T}$$

② Relation between PVT in an reversible adiabatic process

$$\boxed{\begin{array}{l} \Delta(PV^{\gamma}) = 0 \\ \Delta\left(\frac{T^{\gamma}}{P^{\gamma-1}}\right) = 0 \\ \Delta(TV^{\gamma-1}) = 0 \end{array}} \qquad \left\{ \gamma = \frac{C_p}{C_v} \right\}$$

$$\boxed{C_p = \frac{2R}{2}\left(1+\frac{2}{Z}\right)}$$

③ Work done in an adiabatic process

$$\boxed{W = \frac{\Delta(PV)}{\gamma - 1}} \qquad \boxed{\frac{C_p}{C_v} = \gamma = 1 + \frac{2}{Z}} \qquad \boxed{C_v = \frac{2R}{Z}}$$

Z {monoatomic} = 3
Z {Diatomic} = 5

④ Equipartition of energy {monoatomic gas}
{Z = degree of freedom}

"Equipartition of energy states that the average energy of a molecule in a gas associated with each degree of freedom is $\frac{1}{2}KT$"

★ Degree of freedom ⇒ In statistics, the number of degree of freedom is the number of values in the final calculation of a statistic that are free to vary.

Laws of Thermodynamics

① Zeroth Law

"If two system are in thermal equilibrium with a third system, they must be is thermal equilibrium with each other"

② First law

"It states that change in internal energy of a System is equal to heat given to the System minus work down by the system"

$$\boxed{\Delta U = \Delta Q - \Delta W}$$

③ Work done

$$W = \int_{V_1}^{V_2} P\,dV$$

④ Second Law

"The entropy of any isolated system cannot decrease"

★ Entropy ⇒ Entropy is the measure of disorder of a system.

$$\Delta S = \int_i^f \frac{\Delta Q}{T}$$

⑤ Carnot Engine

$$\boxed{\eta \leqslant 1 - \frac{T_2}{T_1}}$$

⑥ Third Law

"The entropy of any pure substance in thermal equilibrium approaches zero as the temperature approacese zero"

$$\lim_{T \to 0} S = 0$$

★ Enthalpy ⇒ Enthalpy of a system is defined as sum of internal energy and product of pressure and volume of the system.

$$\boxed{H = U + PV}$$

★ Gibbs free energy ⇒ Gibbs free energy is the maximum amount of non-expansion work that can be extracted from a closed system.

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⑦ Gibbs Helmholtz Equation

$$\boxed{\Delta G = \Delta H - T\Delta S}$$

Heat Transfer

- Conduction
- Convection
- Radiation

① Thermal Conductivity

If ΔQ is the amount of heat crosses through any cross-section in time Δt then:-

$$\frac{\Delta Q}{\Delta t} = -KA\frac{dT}{dx}$$

→ The quantity $\Delta Q/\Delta t$ is called heat current.

→ The quantity dT/dx is called temperature gradient.

→ The quantity dx/KA is called thermal resistance.

$$R = \frac{x}{KA}$$

Series Connection

$$R_{eq} = \sum R$$

Parallel Connection

$$\frac{1}{R_{eq}} = \sum \frac{1}{R}$$

② Thermal Convection

"Thermal convection is the transfer of heat from one place to another by the movement of fluids"

③ Thermal Radiation

"Thermal radiation is electromagnetic radiation generated by the thermal motion of charged particles in matter"

→ All matter with a temperature greater than absolute zero emits thermal radiation.

④ Blackbody Radiation

★ Blackbody ⇒ A body that absorbs all the radiation following on it is called a blackbody.

→ The radiation emitted by a black body is called black body radiation.

⑤ Kirchhoff's Law

★ Emissive power, $E = \dfrac{\Delta U}{(\Delta A)(\Delta \omega)(\Delta t)}$

★ Absorptive power, $a = \dfrac{\text{energy absorbed}}{\text{energy incident}}$

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★ Kirchhoff's Law

"The ratio of emissive power to absorptive power is the same for all bodies at a given temperature and is equal to the emissive power of a blackbody at that temperature"

$$\boxed{\frac{E(\text{body})}{a(\text{body})} = E(\text{black body})}$$

⑥ Wien's displacement law

"Wien's displacement law states that the wavelength distribution of thermal radiation from a black body at any temperature has essentially the same shape as the distribution at any other temperature except that each wavelength is displaced on the graph"

$$\boxed{\lambda_m T = b}$$

{for blackbody $b = 0.288$ cm-K and is known as Wien constant}

⑦ Stefan-boltzmann Law

The energy of thermal radiation emitted per unit time by a blackbody of surface area A is given by:-

$$\boxed{U = \sigma A T^4}$$

{ where σ is a universal constant known as Stefan-boltzmann constant
$\sigma = 5.67 \times 10^{-8} \, W/m^2 K^4$ }

// For general body ÷

$$\boxed{U = e\sigma A T^4} \; ; \; 0 < e < 1$$

→ e is called the emissivity of the surface.

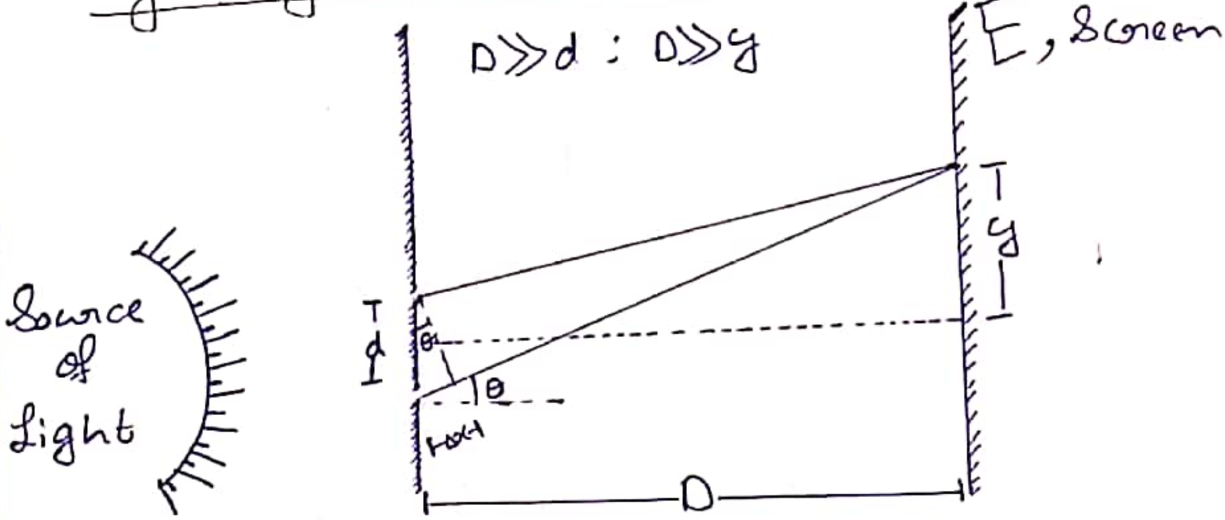
(8) Newton law of Cooling

"It States that the rate of heat loss of a body is proportional to the difference in temperature between the body and its Surroundings"

$$\boxed{\frac{d\theta}{dt} = -bA(\theta - \theta_0)}$$

Light Wave

young double slit Experiment



(I) $E = E_0 \sin(kx - \omega t + \phi)$

(II) $\Delta x = \frac{yd}{D}$

(III) fringe width $= \frac{D\lambda}{d}$

(IV) $\Delta x = n\lambda$ {for Constructive interference}

(V) $\Delta x = (2n+1)\frac{\lambda}{2}$ {for distructive interference}

(VI) $I = 4I_0 \cos^2\frac{\delta}{2}$

(VII) Optical path $= \mu x$

② Screw Gauge

Metal piece

Huygens principle

"According to huygens principle, each point of the wavefront is the source of secondary disturbance. wavelet emerging from these Point spreads out in all direction with speed of the wave. A comon tagent to all these wavelet, gives the new position of the wave front at a later time"

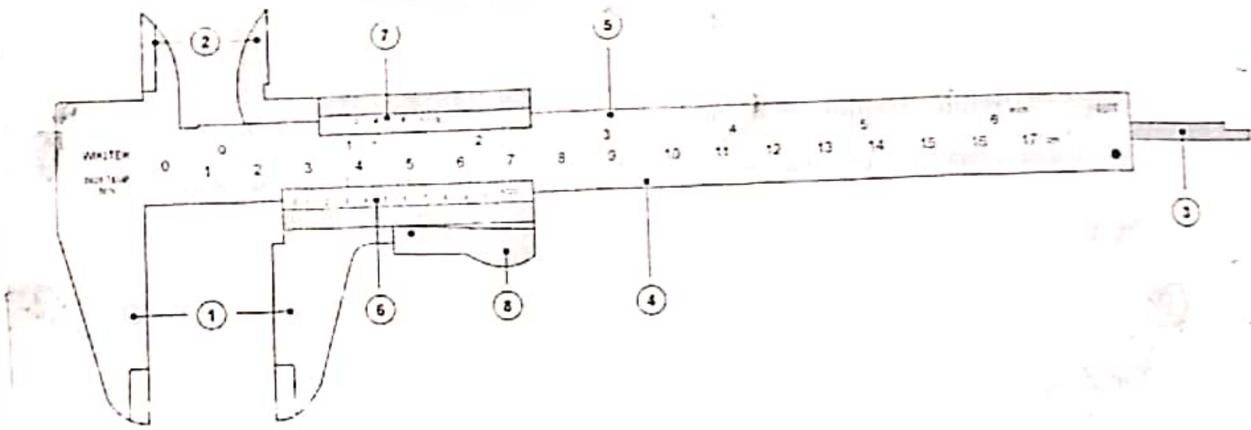
on)

2)

Scanned by CamScanner

Measuring Instruments

(1) Vernier Callipers



$\Rightarrow$ n Vernier scale division = $(n-1)$ Main Scale division

$$\Rightarrow 1\,VSD = \frac{n-1}{n}\,MSD$$

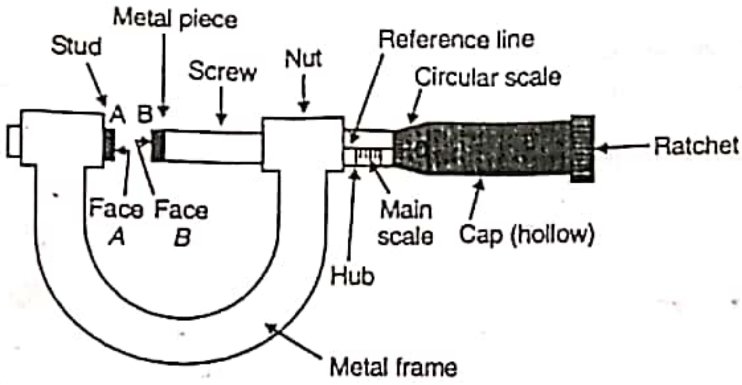
$$\Rightarrow 1\,MSD - 1\,VSD = \underbrace{L.C}_{\text{Least Count}} = \frac{MSD}{n}$$

* **Reading** $\Rightarrow$ {Main Scale Reading} + (L.C) × {No. of division VS that coincide with a division on MS}

* **Zero Error** $\Rightarrow$ When jaws of vernier touch each other, zero of main scale and vernier scale should coincide. If it is not so, the instrument has a zero error.

$\Rightarrow$ Zero Error are Substructed from the reading taken

2 Screw Gauge



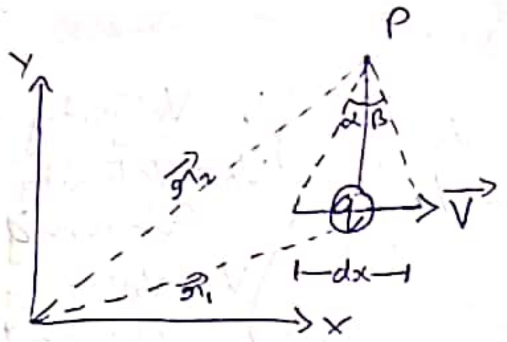
⇒ LC = (Main scale division value) or (Linear distance advanced in one Rotation) / (Number of division on circular scale)

{Least Count}

$$LC = \frac{\text{(Main scale division value) or (Linear distance advanced in one Rotation)}}{\text{(Number of division on circular scale)}}$$

* Reading = (Main Scale Reading) + n (L.C)

Electromagnatic field due to moving Point charge



Let us concider moving charge as current carrying wire of length dx.

$$\cancel{q}\ i = \frac{dq}{dt} = \frac{dq\,V}{dx}$$

$$\sin\alpha = \sin\beta = \tan\alpha = \tan\beta = \frac{dx}{2r}$$

$$B = \frac{\mu_0 i}{4\pi r}\,|\sin\alpha + \sin\beta|\,(\hat{V}\times\hat{r})$$

$$\{|\vec{B}|\} \Rightarrow \frac{\mu_0 i}{4\pi r}\times\frac{dx}{r} = \frac{\mu_0}{4\pi r}\times\frac{qV}{dx}\times\frac{dx}{r} = \frac{\mu_0 q V}{4\pi r^2}$$

$$\boxed{\vec{B} = \frac{\mu_0 q}{4\pi r^2}(\vec{V}\times\hat{r})}$$

$$\boxed{\vec{E} = \frac{q\,\hat{r}}{4\pi\varepsilon_0 r^2}} \quad \Rightarrow \vec{B} = \mu_0\varepsilon_0(\vec{V}\times\vec{E})$$

$$\boxed{\vec{B} = \frac{1}{c^2}(\vec{V}\times\vec{E})}$$

⇒ Zero Error are Substructed from the ...

* Specific charge ⇒ Ratio of charge to mass is called Specific charge.

Problem Solving

① Whenever possible, draw a diagram elucidating the essence of the problem

{Diagram Should be Simple and clear}

② Solve each problem, as a rule in the general form:

③ Having obtained the solution in the general form, check to see if it has right dimensions, Symmetry and verify it with special case.

④ When starting calculations use approximation.

⑤ Having obtained the numerical answer, evaluat its plausibility.

{ Elucidating ⇒ Making clear
Plausibility ⇒ apparent validity }

Format of problem solving

① Diagram elucidating the essence of the Problem

② Given or logically derived quantity

③ Objective problem solving

④ Partial non-objective Problem solving

① Diagram should be simple and clear.
② Try to minimize as far as possible
③ It will include the solution of actual Problem in progressive manner.
④ May include rough, calculation or partial solution.

Wave

① Wave Equation

$\boxed{y = f(t - x/v)}$ represents wave motion along positive x-axis where f is a function representing motion of individual particle or $\boxed{y = g(x - vt)}$ represents wave motion along positive x-axis where g is a function representing the shave of wave.

② Velocity

$$v = \sqrt{\frac{\text{Elasticity}}{\text{density}}} = \sqrt{\frac{E}{\rho}}$$

$E = \gamma P$ $\{\gamma = \frac{C_p}{C_v}, P = \text{pressure}\}$ $\{\forall \text{gas}\}$

$E = Y$ {Youngs modulus} {∀ Solid}

$E = B$ {Bulk modulus} {∀ liquid}

$\rho = \frac{\text{mass}}{\text{length}} = \mu$ {∀ String}

~~E = Tension~~

$E = \text{Tension}$ {∀ String}

③ Interferance of wave in same direction

$y_1 = A_1 \sin(Kx - \omega t)$ & $y_2 = A_2 \sin(Kx - \omega t + \delta)$

$y = y_1 + y_2$ {Principle of superposition}

$$\boxed{y = A \sin(Kx - \omega t + \varepsilon)}$$

$$\left\{ \boxed{A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos\delta}} \quad \boxed{\tan\varepsilon = \frac{A_2 \sin\delta}{A_1 + A_2 \cos\delta}} \right\}$$

④ Intensity ~~&~~ and power of wave

★ Power ⇒ Rate of transfer of Energy

★ Intensity ⇒ Intensity is power transferred per unit area.

- $\boxed{P_{av} = 2\pi^2 \mu v A^2 f^2}$ {for wave in string}

- $\boxed{I = \frac{P_0^2}{2\rho V}}$ {for sound wave}

(5) Standing wave

Suppose two sine waves of equal amplitude and frequency, propagate on a long string in opposit direction.

$y_1 = A \sin(\omega t + Kx)$ $y_2 = A \sin(\omega t - Kx)$

→ These wave interfere to produce what we call standing wave.

- $y = 2A \cos Kx \sin \omega t$

(i) Vibration of string fixed at both end or Vibration of air column in organ pipe open at both end

$$\boxed{f = \frac{nV}{2L}}$$

(ii) Vibration of string fixed at one end or Vibration of air column in organ pipe open at one end

$$\boxed{f = \left(n + \frac{1}{2}\right)\frac{V}{2L}}$$

- End Correction $e = 0.3D$ {In case of soundwave}

{D = diameter of pipe}

6. Doppler Effect

$$\boxed{f = f_0\left(\frac{V + V_0}{V - V_s}\right)}$$

f_0 = frequency at reference frame.

f = frequency at observer frame.

V = Velocity of wave wrt reference frame.

V_0 = Velocity of observer toward source wrt reference frame.

V_s = Velocity of source toward observer wrt reference frame.

★ Triple point ⇒ Triple point of a substance is the temperature and pressure at which the three phases (Solid, liquid, gas) of that substance coexist.

$$\boxed{F = \frac{9}{5}C + 32}$$

Liquid state

* **Critical temperature** ⇒ The temperature above which a gas cannot be liquified irrespective of how much Pressure is applied.

* **Vapour** ⇒ A Vapour is a gas which can be liquified by increasing the pressure without changing the temperature.

* **Evaporation** ⇒ Evaporation is a pressure in which molecules escape slowly from the surface of a liquid.

* **Saturated and Unsaturated Vapour**

"When a space actually contains the maximum Possible amount of vapour, the vapour is called saturated. If the amount is less than the maximum Possible, the vapour is called unsaturated"

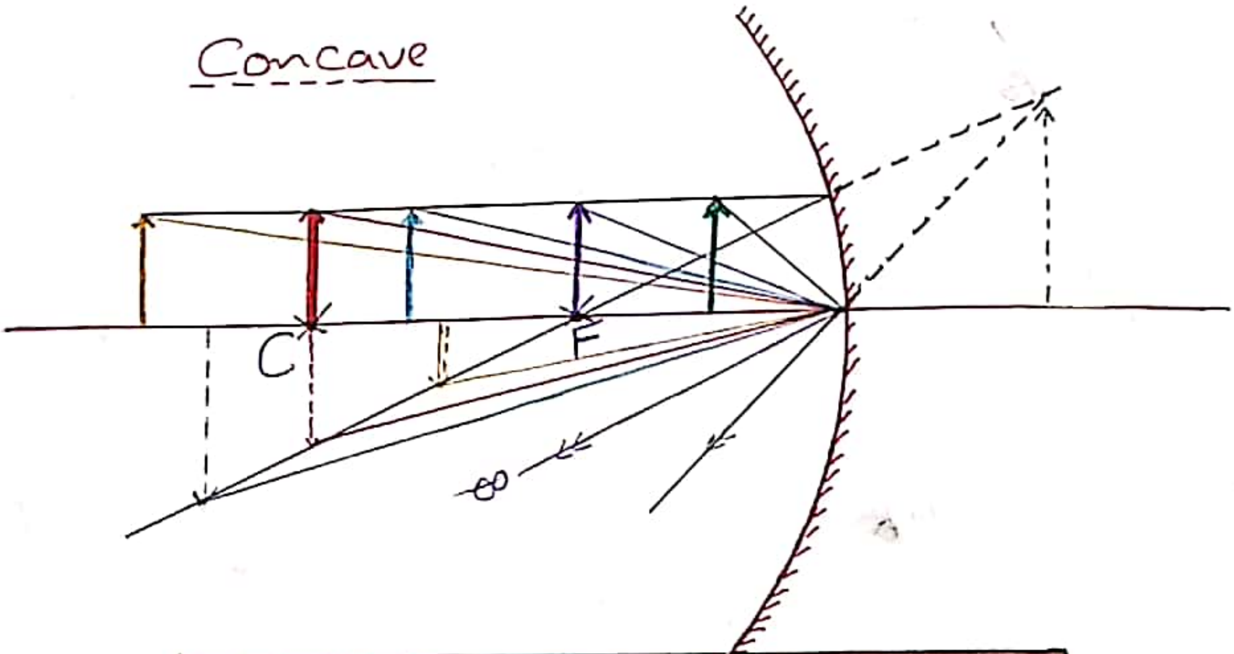
⇒ The maximum amount depends on the temperature.

* **Boiling point** ⇒ The boiling point of a substance is the temperature at which the vapour pressure of the liquid equals the pressure surrounding the liquid.

* **Dew Point** ⇒ The temperature at which the saturation Vapour pressure is equal to the present vapour Pressure called the dew point.

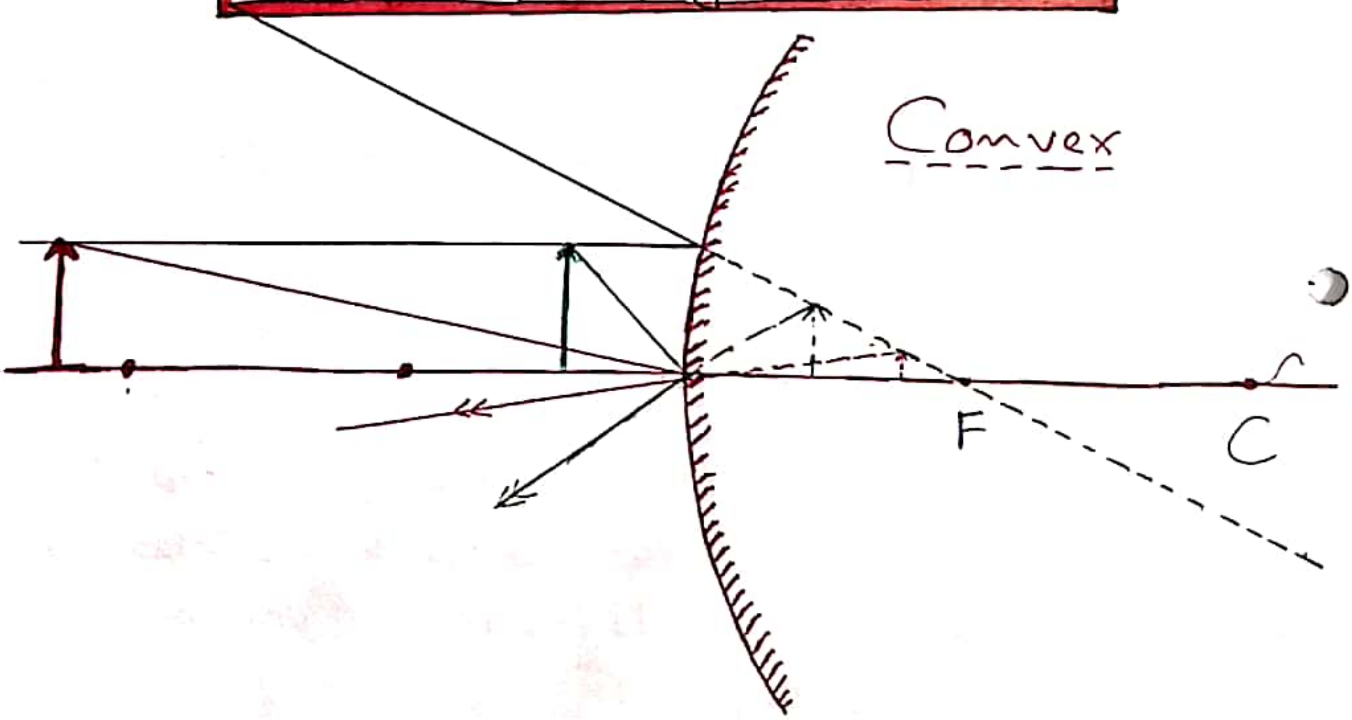
* **Relative Humidity** = $\dfrac{\text{Vapour pressure of air}}{\text{SVP at the same temperature}} = \dfrac{\text{SVP at dew Point}}{\text{SVP at air temperature}}$

Concave



Nature of Image formation

Convex



★ Pseudo force

"Pseudo force is an apparent force that acts on all masses whose motion is described using a non-inertial frame of reference"

(I) Rectilinear ~~acc~~ Force ⇒ Due to Rectilinear ~~Constant~~ acceleration of reference frame.

(II) Centrifugal force

(III) Coriolis force

⇒ Due to Constant angular acceleration of reference frame

(IV) Euler force ⇒ Due to variable angular acceleration of reference frame

—— X —— X ——