Padasalai's
Telegram Groups!

(தலைப்பிற்கு கீழே உள்ள லிங்கை கிளிக் செய்து குழுவில் இணையவும்!)

- Padasalai's NEWS - Group
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- Padasalai's Channel - Group
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- Lesson Plan - Group
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- 12th Standard - Group
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- 6th to 8th Standard - Group
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- TET - Group
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1. Convert 76 cm of mercury pressure into Nm^{-2}.

The dimensional formula of Pressure $[P] = [ML^{-1}T^{-2}]$

$$P_2 = P_1\left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

$\boxed{\because P_1 = 76 \times 13.6 \times 980 \text{ dyne } cm^{-2}}$

$M_1 = 1g$; $L_1 = 1\,cm$; $T_1 = 1s$

$M_2 = 1kg$; $L_2 = 1m$; $T_2 = 1s$

So $\boxed{a = 1}$; $\boxed{b = -1}$; $\boxed{c = -2}$

sub all known values,

$$P_2 = 76 \times 13.6 \times 980 \times \left[\frac{1g}{1kg}\right]^1 \times \left[\frac{1\,cm}{1m}\right]^{-1} \times \left[\frac{1s}{1s}\right]^{-2}$$

$$\boxed{P_2 = 1.01 \times 10^5\ Nm^{-2}}$$

2. If the value of universal gravitational constant in SI is $6.6 \times 10^{-11}\ Nm^2 kg^{-2}$, then find its value in CGS system?

$$\boxed{G_{SI} = 6.6 \times 10^{-11}\ Nm^2 kg^{-2}}$$

The dimensional formula for G is $[M^{-1}L^3T^{-2}]$

$$G_{cgs} = G_{SI}\left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

$M_1 = 1kg$; $L_1 = 1m$; $T_1 = 1s$

$M_2 = 1g$; $L_2 = 1cm$; $T_2 = 1s$

$\boxed{a = -1}$; $\boxed{b = 3}$; $\boxed{c = -2}$

Sub all known values,

$$G_{cgs} = 6.6 \times 10^{-11} \times \left[\frac{1kg}{1g}\right]^{-1} \times \left[\frac{1m}{1cm}\right]^3 \times \left[\frac{1s}{1s}\right]^{-2}$$

$$\boxed{G_{cgs} = 6.6 \times 10^{-8}\ \text{dyne } cm^2 g^{-2}}$$

3. The force F acting on a body moving in a circular path depends on mass of the body [m], velocity [v] and radius [r] of the circular path. Obtain the expression for the force by dimensional analysis method. [k=1]

$$F \propto m^a v^b r^c$$

$$F = k m^a v^b r^c$$

$$[MLT^{-2}] = [M]^a [LT^{-1}]^b [L]^c$$

$$[MLT^{-2}] = [M^a][L^{b+c}][T^{-b}]$$

Comparing the powers of M, L & T

$\boxed{a=1}$; $\boxed{b=2}$; $\boxed{c=-1}$

$$\boxed{F = \frac{mv^2}{r}} \quad [\because k=1]$$

4. Obtain ~~the~~ an expression for the time period T of a simple pendulum. The time period T depend upon [i] mass [m] of the bob [ii] length of the pendulum [iii] acceleration due to gravity. [k = 2π]

$$T \propto m^a l^b g^c$$

$$T = k m^a l^b g^c$$

$$[M^0L^0T^1] = [M^a][L^b][LT^{-2}]^c$$

$$[M^0L^0T^1] = [M^a][L^{b+c}][T^{-2c}]$$

Comparing the powers of M, L & T

$\boxed{a=0}$; $\boxed{b = 1/2}$; $\boxed{c = -1/2}$

$$T = k\sqrt{\frac{l}{g}} \Rightarrow \boxed{T = 2\pi\sqrt{\frac{l}{g}}}$$

5. Obtain an expression for the frequency ν of a vibrating string depend on [i] applied force [F] (ii) length [l] [iii] mass per unit length [m], prove that $\nu \propto \frac{1}{l}\sqrt{\frac{F}{m}}$ using dimensional analysis.

$$\nu \propto F^a l^b m^c$$

$$[M^0 L^0 T^{-1}] = [MLT^{-2}]^a [L]^b [ML^{-1}]^c$$

$$[M^0 L^0 T^{-1}] = [M^{a+c}] [L^{a+b-c}] [T^{-2a}]$$

Comparing the powers of M, L & T,

$\boxed{a = 1/2}$; $\boxed{b = -1}$; $\boxed{c = -1/2}$

$$\nu \propto F^{1/2} . l^{-1} . c^{-1/2}$$

$$\boxed{\nu \propto \frac{1}{l}\sqrt{\frac{F}{m}}}$$

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6. Types of errors :-

1. Systematic Errors
   - Instrumental errors
   - Imperfections in experimental technique
   - Personal errors
   - Errors due to external causes
   - Least count error

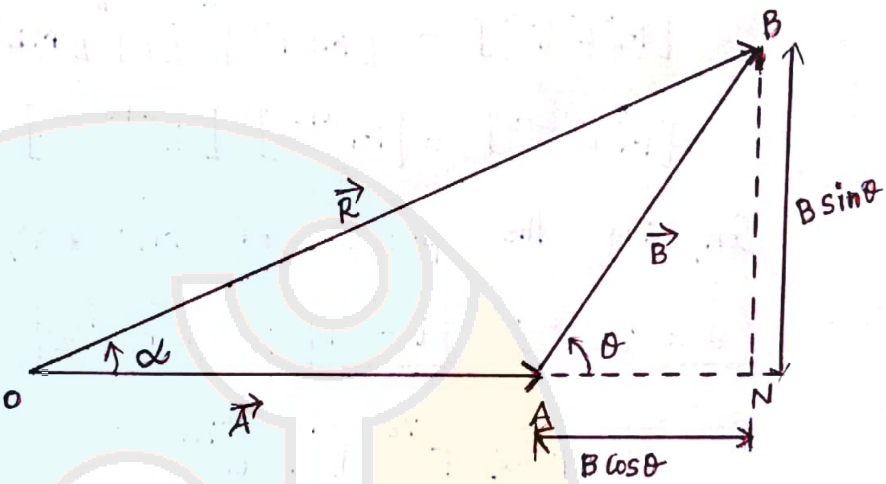
2. Random Errors

3. Gross Error

7. Triangle law of addition.

- Represent the vectors $\vec{A}$ and $\vec{B}$ by the two adjacent sides of a triangle taken in the same order. Then the resultant is given by the third side of the triangle.

Magnitude of Resultant :



$AN = B\cos\theta$

$BN = B\sin\theta$

$$\boxed{R = \sqrt{A^2 + B^2 + 2AB\cos\theta}}$$

Direction of Resultant :

$$\tan\alpha = \frac{BN}{ON} = \frac{BN}{OA + AN}$$

$$\boxed{\alpha = \tan^{-1}\left[\frac{B\sin\theta}{A + B\cos\theta}\right]}$$

8. Scalar product and its properties :

- The product of the magnitudes of the two vectors and the cosine of the angle between them.

$$\boxed{\vec{A}\cdot\vec{B} = AB\cos\theta}$$

Properties :

- The scalar product is commutative
  i.e. $\vec{A}\cdot\vec{B} = \vec{B}\cdot\vec{A}$

- Its obey distributive law
  i.e. $\vec{A}\cdot[\vec{B} + \vec{C}] = \vec{A}\cdot\vec{B} + \vec{A}\cdot\vec{C}$

- The angle between the vectors
  $$\theta = \cos^{-1}\left[\frac{\vec{A}\cdot\vec{B}}{AB}\right]$$

- It will be maximum when $\cos\theta = 1$, i.e. $\theta = 0^\circ$

$$[\vec{A}\cdot\vec{B}]_{max} = AB$$

- It will be minimum when $\cos\theta = -1$, i.e. $\theta = 180^\circ$

$$[\vec{A}\cdot\vec{B}]_{min} = -AB$$

- It will be zero when $\cos\theta = 0$; i.e. $\theta = 90^\circ$

$$\vec{A}\cdot B = 0$$

- In the case of orthogonal unit vector $\hat{i}, \hat{j}$ and $\hat{k}$

$$\hat{i}\cdot\hat{j} = \hat{j}\cdot\hat{k} = \hat{k}\cdot\hat{i} = 0$$

9. Vector product & its properties:

- The vector product of two vectors is defined as another vector having a magnitude equal to the product of the magnitudes of two vectors and sine of the angle between them.

$$\boxed{\vec{A}\times\vec{B} = AB\sin\theta\ \hat{n}}$$

Properties :-

- It is not Commutative

i.e. $\vec{A}\times\vec{B} \neq \vec{B}\times\vec{A}$

- It will be maximum when $\sin\theta = 1$, i.e. $\theta = 90^\circ$

$$[\vec{A}\times\vec{B}]_{max} = AB\ \hat{n}$$

- It will be minimum when $\sin\theta = 0$, i.e $\theta = 0^\circ$ [OR] $\theta = 180^\circ$

$$[\vec{A}\times\vec{B}]_{min} = 0$$

- The self-cross product is the null vector.

$$\vec{A}\times\vec{A} = \vec{0}$$

- In the case of orthogonal unit vectors,

$$\hat{i}\times\hat{j} = \hat{k}, \quad \hat{j}\times\hat{k} = \hat{i}, \quad \hat{k}\times\hat{i} = \hat{j}$$

- In the case of orthogonal unit vectors,

$$\hat{i} \times \hat{i} = \hat{j} \times \hat{j} = \hat{k} \times \hat{k} = \vec{0}$$

- In terms of components, the vector product of two vectors,

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

10. Equations of motion for constant acceleration :

- Velocity - time relation :

$$a = \frac{dv}{dt}$$

$$dv = a \cdot dt$$

$$\int_u^v dv = \int_0^t a\, dt$$

$$\boxed{v = u + at}$$

- Displacement - time relation :

$$v = \frac{ds}{dt} \Rightarrow ds = v\, dt$$

$$ds = [u + at]\, dt$$

$$\int_0^s ds = \int_0^t [u + at]\, dt$$

$$\boxed{s = ut + \frac{1}{2}at^2}$$

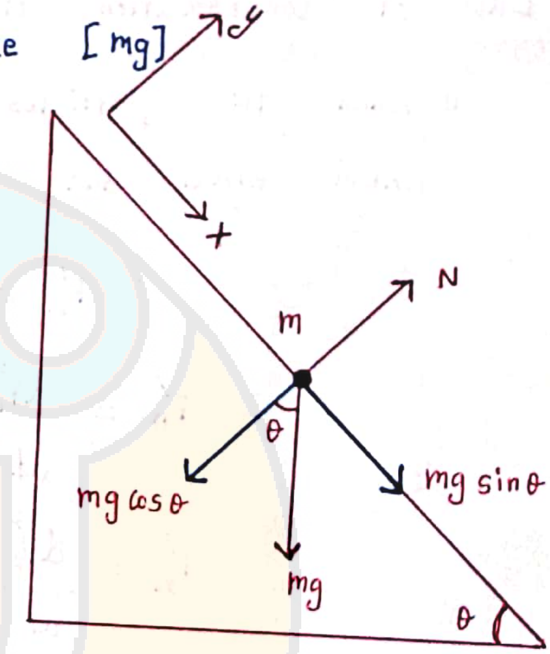
- Velocity - displacement relation :

$$a = \frac{dv}{dt} = \frac{dv}{dt} \times \frac{ds}{ds} \Rightarrow a = v\frac{dv}{ds}$$

$$\boxed{v^2 = u^2 + 2as}$$

11) The particle moving in an inclined plane.

- When an object of mass 'm' slides on a frictionless surface inclined at an angle θ.
- The force acting on the object is
  1. Downward gravitational force [mg]
  2. Normal force [N]



Applying Newton's II law in y axis,

$$N = mg\cos\theta$$

Applying Newton's II law in x-axis,

$$mg\sin\theta = ma$$

$$\boxed{a = g\sin\theta}$$

Newton's kinematic eq.

$$v^2 = u^2 + 2as$$

$$\boxed{u=0} \Rightarrow \boxed{v = \sqrt{2gs\sin\theta}}$$

12. Newton's law:

- Newton's first law:

Every object continues to be in the state of rest or of uniform motion unless there is external force acting on it.

- Newton's II law:

The force acting on an object is equal to the rate of change of its momentum. $\boxed{\vec{F} = \frac{d\vec{p}}{dt}}$

▫ Newton's III law:

For every action there is an equal and opposite reaction.

$$\boxed{\vec{F}_{12} = -\vec{F}_{21}}$$

13. Law of conservation of linear momentum:

▫ When two particles interact with each other, they exert equal and opposite forces on each other.

$$\vec{F}_{21} = -\vec{F}_{12} \longrightarrow (1)$$

$$\vec{F}_{12} = \frac{d\vec{P}_1}{dt} \longrightarrow (2)$$

$$\vec{F}_{21} = \frac{d\vec{P}_2}{dt} \longrightarrow (3)$$

Sub eq (2) & (3) in eq (1)

$$\frac{d\vec{P}_2}{dt} = -\frac{d\vec{P}_1}{dt}$$

$$\frac{d\vec{P}_1}{dt} + \frac{d\vec{P}_2}{dt} = 0$$

$$\frac{d}{dt}[\vec{P}_1 + \vec{P}_2] = 0$$

$$\Rightarrow \vec{P}_1 + \vec{P}_2 = \text{constant}$$

If there are no external forces acting on the system, then the total linear momentum of the system is always a constant vector.

14] Work energy principle. and its examples.

The work [W] done by the constant force [F] for a displacement [s] in the same direction is

$$W = F.S \longrightarrow (1)$$

The constant force, $F = ma \longrightarrow (2)$

Third eq of motion, $v^2 = u^2 + 2as$

$$a = \frac{v^2 - u^2}{2s} \longrightarrow (3)$$

sub eq (3) in eq (2)

$$F = m\left[\frac{v^2 - u^2}{2s}\right] \longrightarrow (4)$$

Sub eq (4) in eq (1),

$$W = m\left[\frac{v^2 - u^2}{2\cancel{s}}\right]\cancel{s}$$

$$W = \frac{mv^2}{2} - \frac{mu^2}{2}$$

$$W = KE_f - KE_i$$

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

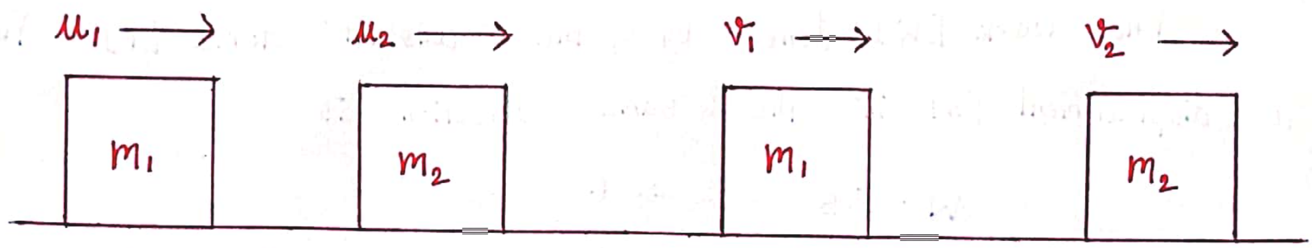
- The work done by the force on the body changes the kinetic energy of the body.

⇒ If the work done is positive. Its kinetic energy increases.

⇒ If the work done is negative. Its kinetic energy decreases.

⇒ If there is no work done. There is no change in its kinetic energy.

15 Elastic collisions in one dimension.



Before collision After collision

From the law of conservation of linear momentum,

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

$$m_1 [u_1 - v_1] = m_2 [v_2 - u_2] \longrightarrow [1]$$

For elastic collision,

$$\cancel{\frac{1}{2}} m_1 u_1^2 + \cancel{\frac{1}{2}} m u_2^2 = \cancel{\frac{1}{2}} m_1 v_1^2 + \cancel{\frac{1}{2}} m_2 v_2^2$$

$$m_1 [u_1^2 - v_1^2] = m_2 [v_2^2 - u_2^2]$$

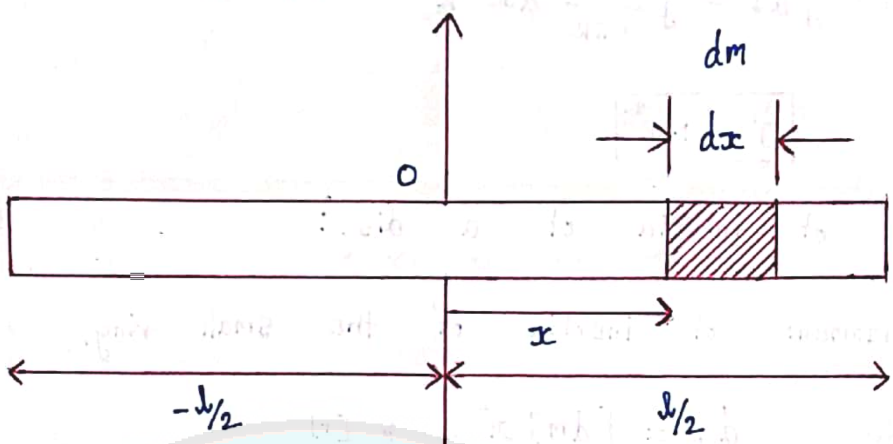
$$m_1 [u_1 + v_1][u_1 - v_1] = m_2 [v_2 + u_2][v_2 - u_2] \longrightarrow [2]$$

$$\frac{[2]}{[1]} \Rightarrow \frac{\cancel{m_1} [u_1 + v_1] \cancel{[u_1 - v_1]}}{\cancel{m_1} \cancel{[u_1 - v_1]}} = \frac{\cancel{m_2} [v_2 + u_2] \cancel{[v_2 - u_2]}}{\cancel{m_2} \cancel{[v_2 - u_2]}}$$

$$\boxed{\begin{gathered} V_1 = V_2 + u_2 - u_1 \\ \text{[OR]} \\ V_2 = u_1 + V_1 - u_2 \end{gathered}}$$

$$\boxed{\begin{gathered} v_1 = \left[\frac{m_1 - m_2}{m_1 + m_2}\right] u_1 + \left[\frac{2 m_2}{m_1 + m_2}\right] u_2 \\[1em] v_2 = \left[\frac{m_2 - m_1}{m_1 + m_2}\right] u_2 + \left[\frac{2 m_1}{m_1 + m_2}\right] u_1 \end{gathered}}$$

16. Moment of inertia of a rod :



The moment of inertia of mass [dm]

$$dI = [dm]\,x^2 \longrightarrow ①$$

$$dm = \frac{M}{l}\,dx \longrightarrow ②$$

sub eq ② in eq ①

$$dI = \frac{M}{l}\,dx\,x^2$$

The moment of inertia of the entire rod,

$$\int dI = \int \frac{M}{l}\,x^2\,dx$$

$$\boxed{I = \frac{1}{12}\,ml^2}$$

17. Moment of inertia of a ring :

The moment of inertia of mass [dm]

Fig 5.22

$$dI = [dm]\,R^2 \longrightarrow [1]$$

$$dm = \frac{M}{2\pi R}\,dx \longrightarrow [2]$$

sub eq [2] in eq [1]

$$dI = \frac{M}{2\pi R}\,dx\,R^2$$

The moment of inertia of the entire ring,

$$\int dI = \int \frac{M}{2\pi R}\, dx\, R^2$$

$$\boxed{I = MR^2}$$

18] Moment of inertia of a disc:

The moment of inertia of the small ring,

Fig. 5.23

$$dI = [dm]\, r^2 \longrightarrow [1]$$

$$dm = \frac{2M}{R^2}\, r\, dr \longrightarrow [2]$$

Sub eq [2] in eq [1],

$$dI = \frac{2M}{R^2}\, r^3\, dr$$

The moment of inertia of the entire disc,

$$\int dI = \int \frac{2M}{R^2}\, r^3\, dr$$

$$\boxed{I = \frac{1}{2} MR^2}$$

19] Parallel axis theorem:

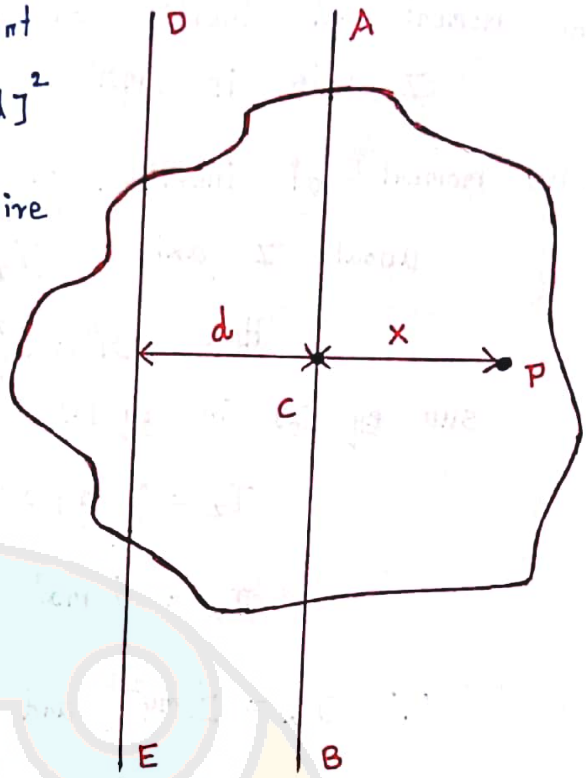
- The moment of inertia of a body about any axis is equal to the sum of its moment of inertia about a parallel axis through its center of mass and the product of the mass of the body and the square of the perpendicular distance between the two axes.

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

Proof:

The moment of inertia of the point mass about the axis DE, $m[x+d]^2$

The moment of inertia of the entire body about DE,



$$I = \sum m[x+d]^2$$

$$I = \sum m[x^2+d^2+2xd]$$

$$I = \sum [mx^2+md^2+2mxd]$$

$$I = \sum mx^2 + \sum md^2 + \sum 2mxd$$

$\because \sum mx = 0 \; ; \; \sum mx^2 = I_c \; ; \; \sum m = M$

Sub all the values in above eq.

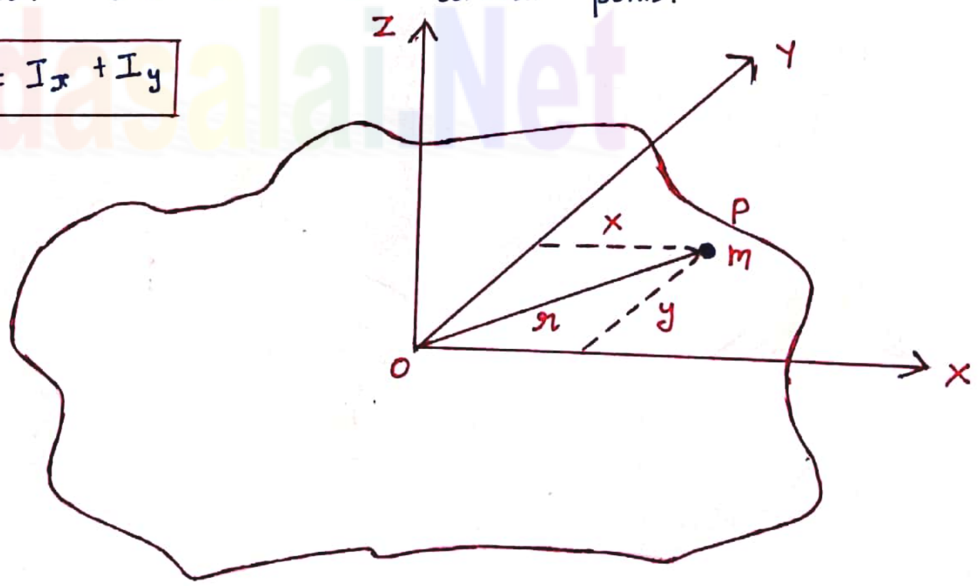
$$\boxed{I = I_c + Md^2}$$

20] Perpendicular Axis theorem :

- The moment of inertia of a plane laminar body about an axis perpendicular to its plane is equal to the sum of moments of inertia about two perpendicular axes lying in the plane of the body such that all the three axes are mutually perpendicular and have a common point.

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

Proof :



The moment of inertia of the particle about z axis is, mr^2

The moment of inertia of the entire lamina about z axis, $I_z = \sum mr^2 \longrightarrow [1]$

Here, $r^2 = x^2 + y^2 \longrightarrow [2]$

sub eq [2] in eq [1]

$$I_z = \sum m[x^2+y^2]$$

$$I_z = \sum mx^2 + \sum my^2$$

$\because$ $I_x = \sum my^2$ and $I_y = \sum mx^2$

sub the values in above eq

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