UNIT: 1st Physical World, Unit and Measurement :

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- Physical Quantity :- The quantity which can be measured is called physical quantity.

There are two types of physical quantity.
1) Fundamental quantity.
2) Derived quantity.

[1]. Fundamental quantity or base quantity :-
The physical quantity which close not depend on another quantity is called fundamental quantity.

There are total seven fundamental quantities :-
1) Length (m)
2) Mass (kg)
3) Time (s)
4) Electric current. (A)
5) Temprature (k)
6) Luminous Intensity (cd)
7) Amount of substriance (mol)

[2] Derived Quandity :- The physical quantity which depends on fundamental quantities are called derived quantity.
Ex :- Area, volume, force, Momentum etc.

- Unit :- The term in which physical quantity is measured. (expressed) is called unit.

There are two types of units :-
1.) Fundamental units.
2.) Derived units.

(1) Fundamental unit :- The unit of fundamental quantity is called fundamental units.
Ex → length - metre, current - Amp
Mass - kg, Temp. - K ... etc.
Time - Sec.

(2) Derived unit :- The unit of derived quantity is called derived unit.
Ex → 1) Area = $l \times b$
$= m \times m$
$= m^2$
2) $v = \frac{s}{t} = \frac{m}{s} = ms^{-1}$

- System of unit :- A group of unit is called system of unit.

→ Types of System of units :-

(1) M.K.S System :- The system in which unit of length, mass and time are metre, kg and Sec. respectively is called M.K.S System.

(2) C.G.S System :- The system in which unit of length, mass and time are meter, kg and Sec. respectively is called CGS system.

(3) F.P.S System :- The systen in which unit of length, mass and time are, foot, Pound and sec. ~~are cattle~~ respectively is called F.P.S system.

(4) S.I unit System :- Its full form is system of International unit. The unit of physical quantity which is considerable in all over

world is called SI unit system.

- Dimension :- The exponent of a fundamental quantity which enter into the expression is called dimension.

To decide the dimension of physical quantity the unit of fundamental quantities are expressed by the following

$L^a M^b T^c$ ⟶ length (L)
Mass (M)
Time (T)

- Dimensional formula or Dimensional equation :- The equation which gives relation between fundamental quantity and derived quantity in the form of dimension is called dimensional equation or formula.

In physics length, mass and time are taken as 3 base dimension and they are represented by L, M, T or respectively.

Ex → 1) Area = $l \times b$
$= l \times l$
$= [L] \times [L]$
$= [L^2]$

2) $V = \frac{\text{distance}}{\text{time}}$
$= \frac{L}{T}$
$= [LT^{-1}]$

3) Volume = lbh
$= [LLL]$
$= [L^3]$

4) $a = V/t = \frac{[LT^{-1}]}{[T]} = [LT^{-2}]$

5) $F = ma$
$= [M][LT^{-2}]$
$= [MLT^{-2}]$

- Dimensional Analysis :- It is the practice of checking the relation between fundamental quantity and derived quantity by identifying the dimension of physical quantity.

These dimension are independent of numerical multiple or constant. All the physical quantity can be expressed as a function of fundamental dimension.

- Dimensional Constant :- The physical quantities which have dimension and a fixed value is called dimensional constant
  Ex - Gravitational Constant (G)
  Planks Constant (h)
  Universal Gas Constant (R)
  Velocity of light in vacuume (c)

- Dimensionless Quantities :- The physical quantities which do not have dimension but a fixed value is called dimensionless quantities.

→ Dimensionless quantities without unit :-
Pure number, π, $\sin\theta$, etc

→ Dimensionless quantities with unit.
Angular Displacement — Radian.

- Dimensional Variables :- The physical quantities which having dimension but on having a fixed value is called dimensional variables.
  Ex - Velocity, acceleration, force work etc.

- Dimensionless Variables :- The physical quantities which dose not having dimension and fixed value is called dimensionless variable.
Ex- Refractive Index, coefficient of friction, poission's ratio etc.

- Principle of Homogenity :- Principle of homogeneity states that in any correct equation of physical quantity the dimension of each term should be same in both side.
Ex- $S = ut + \frac{1}{2}at^2$

$$[L] = \frac{d}{t} \cdot t + \frac{v}{t} \cdot t^2$$

$$[L] = [L] + \frac{d}{t} \times t$$

$$[L] = [L] + [L]$$

- Limitations of Dimensional Analysis :-

1.) Dimensionless quantities can not be determined by this method.
2.) This method is not applicable to trigonometric, logrithmic and exponential function.
3). It is fail when physical quantities depend on more than three fundamental quantities.
4). If one side of the equation contains addition or subtraction of physical quantities then this method is fail.
5). It also fail when constant of proportionality pie possesses dimension.

- Checking of dimensional equation is correct or not :-

→ **Case I**

If dimension of LHS and RHS in a equation are equal then dimensional eqⁿ is correct.

→ **Case II**

If dimension of LHS is not equal to dimension of RHS in a eqⁿ then dimensional eqⁿ is not correct.

- Measurement :- Measuring process of unknown value of a physical quantity is called measurement.

→ There are two types of Measurement.
1). Direct Measurment
2). Indirect Measurement.

① Direct Measurement :- The measurment in which any physical quantity can be measured directly is called direct measurment.
Ex → Length, Mass, Time, current, voltage etc.

② Indirect Measurement :- The measurement in which any physical quantity can not be measured directly is called indirect measurement.

→ In this method mathematical formula is used to measure the value of physical quantities.

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- Least Count :- The smallest and the accurate value that can be measured by scale of instrument is called least count.

- Significant figures or Significant digit :- The digit which are used to express any number is called significant figure or digit.

Ex → 2853 - 4
23456 - 5
26 - 2
7 - 1

- Rules for significant figure :-

(1) All non-zero digits are significant figure

Ex - 2853 - 4 27 - 2
23456 - 5 7 - 1

(2) All ~~no~~ zero between non-zero digit are significant figure.

Ex - 406 - 3
2003 - 4
23056 - 5

(3) Zero just before and of after decimal are not significant figure

Ex - 0.02 - 1
0.003 - 1

(4) All zero after non-zero digit are ~~not~~ significant figure. Ex - 500 - 1
6000 - 1
1600 - 2

(5) All zero after non-zero digit and having decimal just before all zero than all zero are significant figure.

Ex - 5.00 - 3

6.0 - 2

16.00 - 4

(6) Power of 10 are not significant figure

Ex - 2×10^2 - 1

- Error :- The difference between measured value and true value is called error.

* Absolute error :- The difference between measured value and true value is called absolute error

→ It is denoted by Δx.

$$\Delta x = x_0 - x$$

Where, x_0 = measured value

x = true value.

* Mean Absolute error :- The average value of absolute error is called mean absolute error.

→ It is denoted by $\overline{\Delta x} = \frac{\sum_{i=1}^{n} \Delta x_i}{n}$

$$\overline{\Delta x} = \frac{\Delta x_1 + \Delta x_2 + \dots + \Delta x_n}{n}$$

* Relative error :- The ratio between absolute error and true value is called relative error.

Relative error = $\frac{\text{Absolute error}}{\text{True value}} = \frac{\Delta x}{x}$

* Percentage error :- When relative error is represented in percentage is called percentage error.

Percentage error = $\frac{\text{Absolute error}}{\text{True value}} \times 100$

$= \frac{\Delta x}{x} \times 100.$

* Gross error :- The error which occurs due to human mistake is called gross error.
Ex → Error due to mobile using at working, Error due to speak, listen etc.

• Systematic Error :- The error which always present in the system is called systematic error.

→ There are three types of systematic error.
1). Instrumental error.
2) Enviromental error.
3). Observational error.

(1) Instrumental Error :- The error which occurs due to imperfact designing of instrument or wrong connection of instrument is called instrumental error.

(2) Enviromental Error :- The error which occurs due to enviromental effect is called enviromental

error.

③ Observational Error :- The error which occurs due to unexperienced or unskilled of a observer is called observational error.

* Random Error :- The error which occurs due to unknown cause is called random error.

Heat and Thermometer.

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- **Heat :-**

→ Heat is a form of energy which give sensenation of hotness and coldness.
→ Transfer of heat takes place from hot body to cold body.
→ C.G.S unit of heat is calorie.
→ S.I unit of heat is joule.
→ 1 calorie = 4.18 Joule.

- **Temprature :-** The degree of hotness or coldness is called temprature.

- **Difference between heat and temprature.**

Heat	Temprature.
1) It is the form of energy which produce sensation of hotness or coldness.	1) It is degree of hotness or coldness.
2) When some heat is applied on a body its temprature increases.	2) It is an effect depend on heat
3) It represents the total K.E of the moleaule of a body.	3) It represents the average K.E of the molecules of a body.
4) Its units is calorie or joule.	4) Its unit is kelvin, °C or farhenit.
5) It is transferd from higher temp. to lower temprature	5) It decide the dimension of direction of flow of heat.

• Temprature Scale :-

→ The range between two fixed temprature is called fundamental interval.

→ This interval is divided in different equal parts is called temprature scale.

• Different types of temprature scale :-

[1.] The celsius scale :-

→ In this scale the melting point of water is 0°C and boiling point of water is 100°C.

→ In this scale the interval between two fixed point is divided into 100 equal parts and each part is called 100°C

[2.] The fahrenhite scale :-

→ In this scale the melting point of water is 32°F and boiling point of water is 212°F

→ In this scale the interval between two fixed point is divided into 180 equal parts and each part is called 1°F

[3.] The Reaumur Scale :-

→ In this scale the melting point of water is 0°R and boiling point is 80°R.

→ The interval between two fixed paint is divided into 80 equal each part is called 1°R.

[4.] Kelvin Scale :-

→ In this scale the melting point of water is 273.15 K and boiling point of water

is 373.15 K.

→ The interval between two fixed point is divided into 100 equal parts and each parts is called 1K.

- Conversion of temprature :-

→ $\frac{\text{Temp. of one scale - lower fixed value}}{\text{Upper fixed point - lower fixed point}} = \frac{\text{Temp. of another scale - lower fixed point}}{\text{Upper fixed point - lower fixed point}}$

→ $\frac{°C - 0}{100 - 0} = \frac{F - 32}{212 - 32} = \frac{R - 0}{80 - 0} = \frac{K - 273.15}{373.15 - 273.15}$

$\Rightarrow \frac{°C}{100} = \frac{F - 32}{80} = \frac{R}{80} = \frac{K - 273.15}{100}$

- Heat Transfer Method :-

→ The movement of heat across border of the system due to a differente in temprature between the system and its surrounding.

→ There are three modes of transfer of heat :-

1) Conduction
2) Convection
3) Radiation.

(1). Conduction :- The process of heat transfer in which heat is transferred from hot body to cold body without any actual movement of molecules.

→ It takes place in solid
→ In this method heat is transfered due to vibration motion of molecules.

(2.) Convection :- The process of heat transfer in which heat is transferd from hot to cold body due to actual movement of molecules is called convection.
→ It take place in liquid and gass.

(3.) Radiation :- The method of transfer of heat in which heat is tranfered from hot body to cold body without molecular medium is called Radiation.

- Difference between Conduction, Convection and Radiation :-

	Conduction	Convection	Radiation
(1)	Medium is required	Medium is required	It doesn't requires any Medium.
(2)	It is done without movement of molecules	Movement of molecules occurs in this.	Molecules are not required
(3)	It is due to temprature difference.	It is due to density difference	It is due to high temprature
(4)	It is slow process.	It is faster than conduction	It is faster than other Methods.

- Law of thermal Conduction :-

→ ①. The rate of heat transfer is directly proportional to temprature difference.

$$Q \propto (T_1 - T_2)/\Delta T \quad \text{— (i)}$$

② The rate of heat transfer is directly proportional to cross sectional area.

$$Q \propto A \quad \text{— (ii)}$$

③. The rate of heat transfer is directly proportional to time.

$$Q \propto T \quad \text{— (iii)}$$

④. The rate of heat transfer is inversely proportional to distance between them.

$$Q \propto 1/d \quad \text{— (iv)}$$

From eqn (i), (ii), (iii) and (iv).

$$Q \propto \frac{(T_1 - T_2) A t}{d}$$

$$Q \propto \frac{\Delta T A t}{d}$$

$$\boxed{Q = K \cdot \frac{A t \Delta T}{d}}$$

Where, K = Coefficient of thermal Conduction.

$$K = \frac{Q d}{A t \Delta t}$$

$$\boxed{\text{Unit} = J m^{-1} s^{-1} K^{-1}}$$

- Thermal expansion :- When a body is heated than it expands its expansion is called thermal expansion.

→ There are three types of thermal expansion.
1) Linear expansion
2) Superfacial expansion
3) Cubical expansion.

[1.] Linear expansion :- When a body is heated its length increases the increase in length is called linear expension.
Let length of body is l at temp. 'T' when it is heated at temprature $(T+\Delta t)$ its length become $(l+\Delta l)$.
Δl depens on two factors :-

$$\Delta l \propto l \quad \text{---(i)}$$
$$\Delta l \propto \Delta t \quad \text{---(ii)}$$
$$\therefore \Delta l \propto l \Delta t$$
$$\Delta l = \alpha l \Delta t$$
$$\boxed{\alpha = \frac{\Delta l}{l \Delta t}}$$

Where, α = coefficient of linear expansion.

[2.] Superfacial expansion :-
→ When a body is heated its area increases the increase in area is called superfacial expansion.
→ If at initial temp. 'T' area of the body is 'A' when it is heated at temprature $(T+\Delta t)$.
area becomes $(A+\Delta A)$ The increased area depends on two factor.

$$\Delta A \propto A \quad \text{---(i)}$$
$$\Delta A \propto \Delta t \quad \text{---(ii)}$$
$$\Delta A \propto A \Delta t$$

$$\Delta A = \beta A \Delta t$$

$$\boxed{\beta = \frac{\Delta A}{A \Delta t}}$$

Where, β = Coefficient of expension of (superfacial) or superfacial expension.

[3.] Cubical expension or volume expension :-
When a body is heated its volume increase. the increased volume is called cubical expansion.
Let 'V' is the volume at initial temp. 'T' and volume becomes $(V + \Delta V)$ at temprature $(T + \Delta t)$, increased volume ΔV depends on two factors.

$$\Delta V \propto V$$
$$\Delta V \propto \Delta T$$
$$\therefore \Delta V \propto V \Delta T$$
$$\Delta V = \gamma . V \Delta T$$

$$\boxed{\gamma = \frac{\Delta V}{V . \Delta t}}$$

Where, γ is the coefficient of cubical expension.

- Thermometer :- The instrument which measures the value of temprature is called thermometer.

→ The liquid which is used in thermometer is called thermometry liquid.

- Property of thermometry liquid :-
(1.) The liquid should be visiual.
(2.) Its thermal expansion should be uniform.
(3.) Its freezing point should be low.

Q. Why Mercury is used in thermometer?

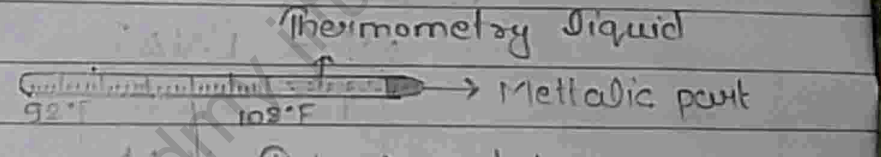
Ans The Mercury is used in thermometer due to following reasons :-

1). It is visiual at room temprature.
2.) Its thermal coefficient is hei high.
3.) It dose not stic on the glass surface.

- Mercury thermometer :-
The thermometer in which Mercury is used in the form of thermometry liquid is called Mercury thermometer.

- Working principle of Mercury thermometer :-
It works on the principle of linear expension.

- Construction :-



It consist a long thin glass tube. Its one end is mettalic. Mercury is filled in this tube. Its temprature rang is 92°F to 108°F that is marked on the tube.

- Procedure :-

Step I : Checking the temprature of thermometer before using.

Step II : keep the mettalic tip of the thermometer in arm pit for 1 or 2 Minutes

Step III : Check the level of mercury in the tube and observe the value of temprature.

- Platinum Resistance Thermometer :-
The Thermometer in which platinum wire is used as resistance is called as platinum resistance thermometer.

→ Procedure :-
1) We take a platinum wire.
2) A known value of current is flowed through this wire.
3) By using voltmeter we measure the voltage across their terminal.
4) By using ohm's law we can easily find the value of Resistance.
5) Since we known that temprature is directly propotional to resistance.
6) So, by using the graph between temprature and resistance we can easily measure the value of temprature.

- Bymettalic Thermometer :-
The thermometer in which two metals are used for measuring temprature is called bymetallic thermometer.

→ Working principle :-
It works on the principle of different metals have different thermal expension coefficient.

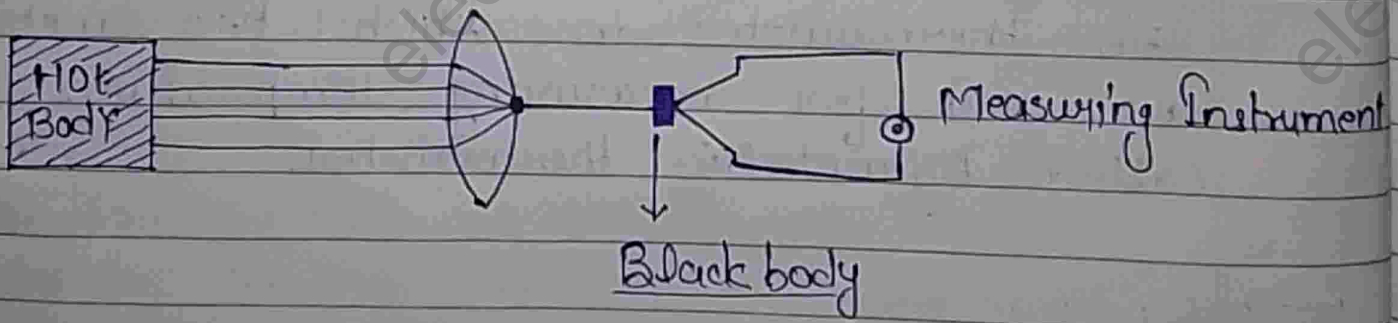
→ Construction :-
It consist of two metal sheet. One above another. upper sheet is Aluminium (Al) and lower sheet is copper (Cu). Its one end is fixed. and Heat is given at the another end.

→ Working : (Procedure) :-
When its free end is heated it band toward upper side. because thermal expension coefficient of Al is more than Cu. Now deflection (θ) occurs between their normal position and after heated position 'θ' is directly propotional to change in temprature of the body

- Pyrometer thermometer :-

→ The thermometer which measure temprature of the body by absorbing radiation of ~~the body by~~ is called pyrometer thermometer.

- Construction :-



→ It works by measuring radiation from the body whose to be measured it is also called infrared thermometer or

radiation thermometer.

→ It is used to dectact the tempriature of the (body) objec. When hot body radiate then these radiation are focused at a point by using conver lense. Now these radiation are measured by a thermometer.

Friction.

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- **Friction:** The resistance offered by the surface that are in contact with each other and move one over another is called friction.

- Reasons for friction :-

(1) Force of adhesion :-

When two bodies come into contact molecular forces attract the molecules of both surfaces to each other so the body do not slide easily on each other. due to this reason friction occurs between them.

(2) Roughness of Surface :-

When the rough surface of two bodies comes in contact with each other then a force exist b/w them. which oppose relative motion.

Roughness of Surface $\propto$ friction

or, Smoothness $\propto \frac{1}{\text{friction}}$.

(3) Plowing effect :-

When two bodies are in contact and move on each other. if one body get deformed under pressure then a force exist b/w them which oppose relative motion.

- Types of friction :-

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(1) Static friction :- The friction present b/w two or more bodies that do not move with respect to each other called ~~kinetic~~ static friction.

(2) kinetic friction :- The friction present b/w two or more bodies that move with respect to each other called kinetic friction.

- Note :-

1) Magnitude of static friction is greater than kinetic friction.

2) Coficient of static friction is greater than cofficient of kinetic friction.

- Limiting friction :- Maximum value of static friction is called limiting friction.

→ There are two types of kinetic friction :-
1) Cylinding friction
2) Rolling friction

(1) Cylinding friction :- When one body cylides on another body then a friction occurs between them is called cylinding friction.

(2) Rolling friction :- When one body rolls on another body then friction occur is called rolling friction.

- Cyliding friction is always greater than rolling friction.

- Normal reaction force :- The force which act on a body in vertically upward direction is called normal reaction force it is denoted by N.

- Laws of friction :-

(1) Frictional force is directly proposinal to Normal reaction

$$\therefore f_r \propto N$$

$$\boxed{f_r = \mu N}$$

$$\text{or, } \mu = \frac{f_r}{N}$$

Where μ is called coefficient of friction

* The ratio between frictional force and normal reaction is called coefficient of friction.

(2) Friction depens upon nature of surface

Friction $\propto$ roughness of surface

$$\text{Friction} \propto \frac{1}{\text{Smoothness of surface}}$$

(3) friction dose not depends on area of contact

(4) Kinetic friction dosenot depends on velocity

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(5) Coefficient of ~~kine~~ static friction is greater than coefficient of kinetic friction.

(6) Frictional force always act in opposite direction of motion.

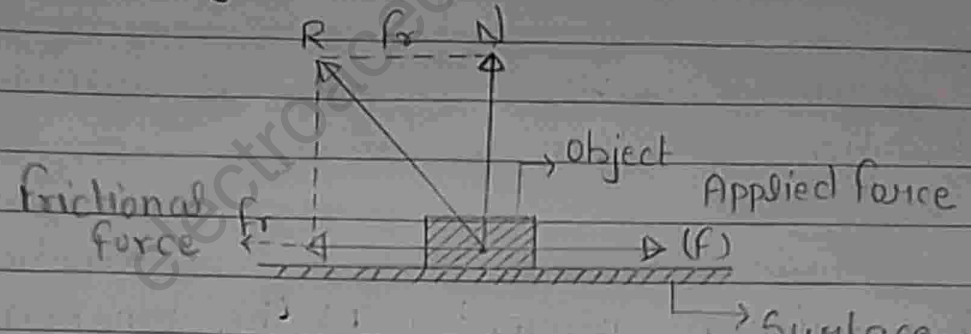
- Difference between Static friction and kinetic friction.

Ans

Static friction	Kinetic friction
(1) The friction present between two or more bodies that do not move with respect to each other is called static friction.	(1) The friction present between two or more bodies that move with respect to each other is called kinetic friction.
(2) It is denoted by f_s.	(2) It is denoted by f_k.
(3) Its magnitude is more than kinetic friction.	(3) Its magnitude is less than static friction.
(4) Coefficient of static friction is more.	(4) Coefficient of kinetic friction is less.
(5) $\mu_s = \frac{f_r}{N}$ (Eqn of static friction) $\boxed{f_s = \mu_s N}$	(5) Eqn of kinetic friction is $\boxed{f_k = \mu_k N}$
(6) It can be zero.	(6) It never can be zero.
(7) Example - A pencil on the table.	(7) Example - A car moving on the road.

- **Angle of friction :-**

The angle between Normal reaction force and resultant of frictional force and normal reaction is called angle of friction.



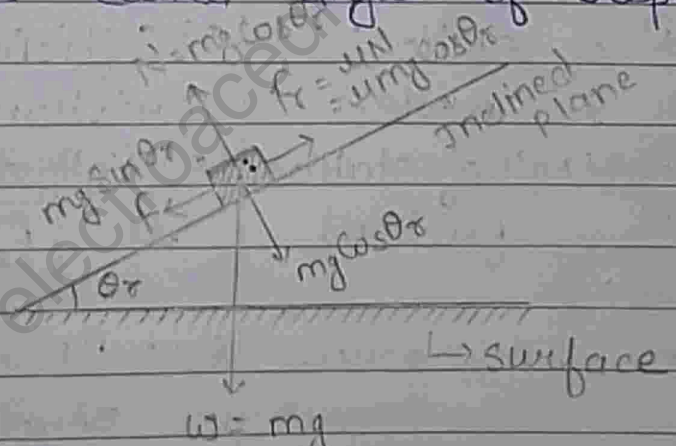
$$\tan\theta = \frac{f_r}{N}$$

$$\tan\theta = \mu$$

$$\boxed{\theta = \tan^{-1}(\mu)}$$

- **Angle of Repose :-**

The maximum inclination of a plane to surface at which a body can remain in rest is called angle of repose.



At balance condition

$$f = f_r$$

$$mg \sin\theta_r = \mu mg \cos\theta_r$$

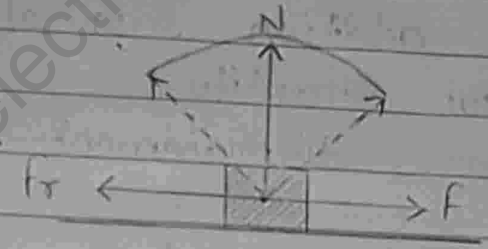
$$\mu = \frac{\sin\theta_r}{\cos\theta_r}$$

$\mu = \tan\theta_r$

$\theta_r = \tan^{-1}(\mu)$

$\theta_r = \theta$

- Cone of friction :- When resultant are rotates around the normal reaction force then a cone is formed it is called cone of friction.



- Advantage of friction :-

(1) Friction help us to walk on the ground.
(2) We can write on a paper due to friction.
(3) We apply break in vehicle due to friction.
(4) Heat can be generated by friction by rubbing our hands.
(5) We polish the wall due to friction.
(6) Asteroids burns in the atmosphere before reaching the earth due to friction.

- Disadvantage of friction :-

(1) Friction produces a lots of heat it leads to wastage of energy as heat.
(2) We spend more energy to pull the object due to friction.
(3) Noise produced due to friction which irritates us.
(4) Forest fire are cause due to friction.
(5) Tyers are rubbing due to friction.

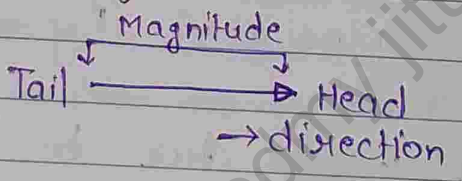
Force and Motion

* Scalar quantity :- The physical quantity which having only magnitudes not direction is called scalar quantity.
example : Length, mass, time, speed etc.

* Vector quantity : The physical quantity which haveing both magnitude and direction and also follow addition law of ~~ve~~ vector is called vector quantity.
Example : force, displacement, velocity etc.

* Note :- Current has both magnitude and direction but dose not follow vector law of addition so it is called scalar quantity.

* Representation of Vector :-



Tail : It is starting point of a vector.
Head : It is the terminal point of vector
Direction : Arrow represents the direction of the vector.
Magnitude : It is the length of vector

⟹ Types of Vector :-

(1) Zero Vector :- The vector which having zero magnitude is called zero vector.
→ Its starting point conincides with terminal point.

→ Direction of zero vector is indeterminate.

(2) Unit Vector :- The vector which having magnitude of one unit is called unit vector.

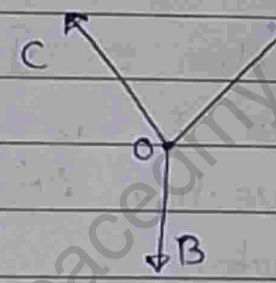
→ Unit vector of vector $\vec{A}$ is represented by

$$\hat{a} = \frac{\vec{a}}{|\vec{a}|}$$

(3) Position vector :- The vector which starting point is origin is called position vector.

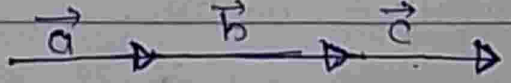
Here, $\vec{OP}$ is position vector.

(4) Co-initial vector :- The vectors which have same starting point are co-initial vector.

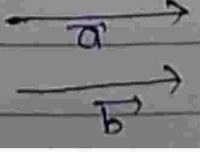


Here $\vec{OA}$, $\vec{OB}$ and $\vec{OC}$ are co-initial vector.

(5) Co-liniear vector :- The vector which lie along the same line are called co-linear vector.



(6) Like vector :- The vectors having same direction is called like vector.

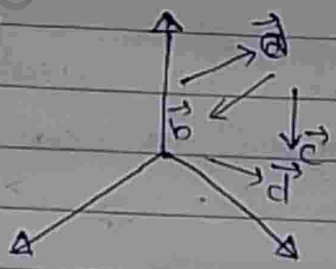


(7) Unlike vector :- The vector which having opposite direction is called unlike vectors.

$\vec{a}$ →

← $\vec{b}$

(8) Co-planer vector :- Three or more than three vectors lies in the same plane is called co-planer vector.



(9) Equal vector :- The vector which having same magnitude and direction is called equal vector.

$\vec{a}$ →

$\vec{b}$ →

(10) Displacement vector :- If a point is displaced from position A to B the displacement AB represent a vector $\vec{AB}$. then it is called displacement vector.

(11) Negative vector :- The vector which having same magnitude but opposite in direction is called negative vector.

$\vec{a}$ →

← $-\vec{a}$

- **Addition of Vectors :-**

→ Addition of vectors are not possible algebrically.

→ Addition of vector is done by geometrically

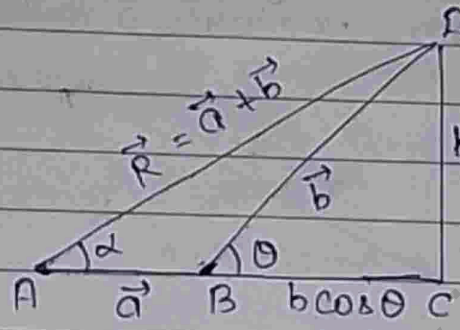
→ There are two law for addition of vector.

ⓐ Triangle Law

ⓑ Parallogram Law.

[a] **Triangle law :**

If two sides of a triangle is represented by two vectors in a sequence then there resultant will be third side which is opposite in sequence.



Since, $h^2 = p^2 + b^2$

In $\triangle ACD$:-

$(AD)^2 = (CD)^2 + (AC)^2$

$R^2 = (b\sin\theta)^2 + (a + b\cos\theta)^2$

$= b^2\sin^2\theta + a^2 + b^2\cos\theta + 2ab\cos\theta$

$= b^2(\sin^2\theta + \cos^2\theta) + a^2 + 2ab\cos\theta$

$= b^2 + a^2 + 2ab\cos\theta$

$R = \sqrt{a^2 + b^2 + 2ab\cos\theta}$

* **Direction of resultant :-**

$$\tan\alpha = \frac{b\sin\theta}{a + b\cos\theta}$$

$$\alpha = \tan^{-1}\left(\frac{b\sin\theta}{a + b\cos\theta}\right)$$

[b] Parallelogram law :-
If two adjacent side of a parallelogram are represented by two vector then there resultant will be diagonal which pass through their common initial point.

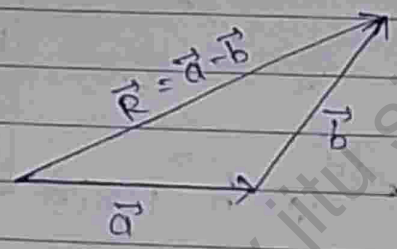
$$R = \sqrt{a^2 + b^2 + 2ab\cos\theta}$$

$$\alpha = \tan^{-1}\left(\frac{b\sin\theta}{a + b\cos\theta}\right)$$

- Subtraction of vector :-

Subtraction of vector is similar as that of addition of vector.

→ If vector $\vec{b}$ is negative vector and this is subtracted from vector $\vec{a}$ then,



- Multiplication of vector :-

- Scalar x Vector = Vector.

$$\vec{a} = x\hat{i} + y\hat{j} + z\hat{k}$$

$$k\vec{a} = kx\hat{i} + ky\hat{j} + kz\hat{k}$$

Ex → $\vec{a} = 2\hat{i} + \hat{j} - 3\hat{k}$

$$2\vec{a} = 4\hat{i} + 2\hat{j} - 6\hat{k}$$

- Dot product or scalar product :-

If product of two vector is scalar then product is called scalar product.

→ To obtain scalar product we use (·)

between two vector. so, it is also called dot product.

vector · vector = Scalar.

$\vec{a} \cdot \vec{b} = |\vec{a}||\vec{b}| \cos\theta$

Where, $|\vec{a}|$ = magnitude of $\vec{a}$

$|\vec{b}|$ = magnitude of $\vec{b}$

θ = angle between $\vec{a}$ and $\vec{b}$

→ Mathematically it is product of magnitude of two vector and cosine angle between two vectors.

* Note:- If $\vec{a} = x\hat{i} + y\hat{j} + z\hat{k}$

then $|\vec{a}| = \sqrt{x^2 + y^2 + z^2}$

$$\cos\theta = \frac{\vec{a} \cdot \vec{b}}{|\vec{a}||\vec{b}|}$$

$$\theta = \cos^{-1}\left[\frac{\vec{a} \cdot \vec{b}}{|\vec{a}||\vec{b}|}\right]$$

if vector are given in the form

$\vec{a} = x_1\hat{i} + y_1\hat{j} + z_1\hat{k}$

$\vec{b} = x_2\hat{i} + y_2\hat{j} + z_2\hat{k}$

$\vec{a} \cdot \vec{b} = (x_1x_2 + y_1y_2 + z_1z_2)$

$\hat{i} \cdot \hat{i} = 1$ $\quad \hat{j} \cdot \hat{j} = 1$ $\quad \hat{k} \cdot \hat{k} = 1$

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

* Note :- Dot product follows communicative law.

$\vec{a} \cdot \vec{b} = |\vec{a}||\vec{b}| \cos\theta$.

$\vec{b} \cdot \vec{a} = |\vec{b}||\vec{a}| \cos(360 - \theta)$

$\vec{b} \cdot \vec{a} = |\vec{a}||\vec{b}| \cos\theta$

$\vec{a} \cdot \vec{b} = \vec{b} \cdot \vec{a}$

- Cross product or Vector product :-
If product of two vectors is also a vector then it is called vector product.

→ (×) sign is used between product

$$\vec{a} \times \vec{b} = |\vec{a}||\vec{b}| \sin\theta \, \hat{n}$$

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

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

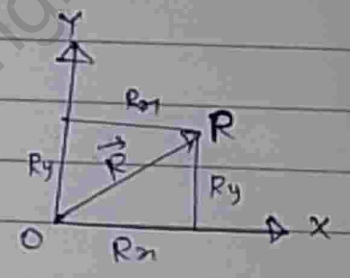
$\hat{k} \times \hat{k} = 0$ $\quad$ $\hat{k} \times \hat{i} = \hat{j}$

- Resolution of Vector :-

Breaking of two ~~component~~ vectors into different components is called resolution of vectors.

- Resolution in 2D :-

If any vector is break down into two component (Horizontal to Vertical) is called resolution in 2D.



Let a point P is placed in x-y plane of their position is $\vec{R}$ its two component is R_x and R_y.

R_x = Component of R in x-direction

R_y = Component of R in y-direction.

Now, $R_x = R\cos\theta$

$R_y = R\sin\theta$

Where, θ = angle between RP x-axis.

$\hat{i}$ = Unit vector in x-direction

$\hat{j}$ = Unit vector in y-direction

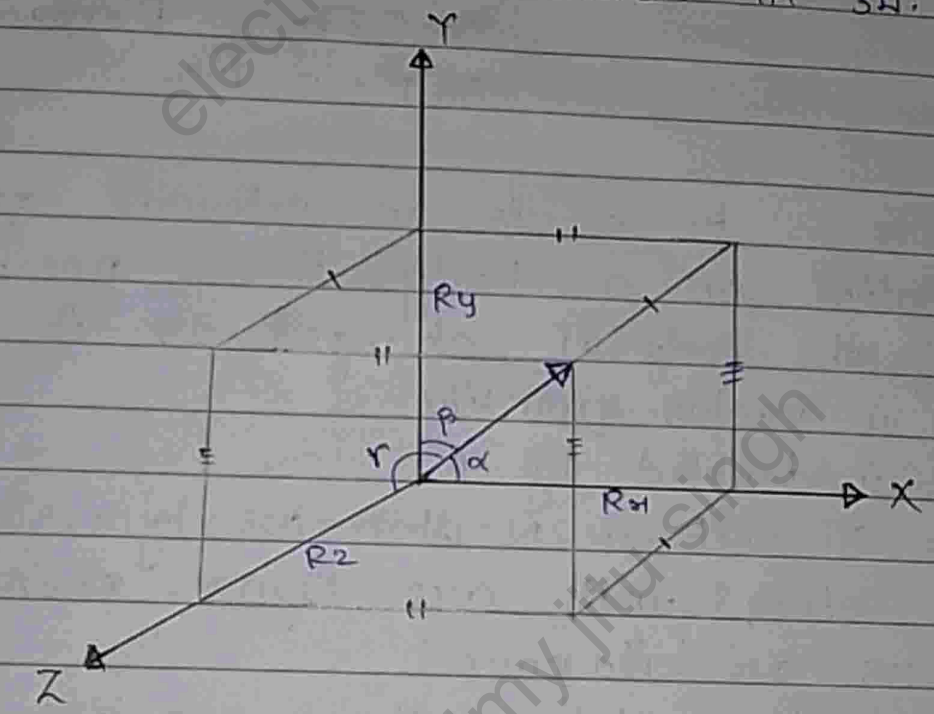
So,

$$\vec{R} = R_x\hat{i} + R_y\hat{j}$$
$$R = \sqrt{R_x^2 + R_y^2}$$

$$\tan\theta = R_y/R_x$$
$$\theta = \tan^{-1}(R_y/R_x)$$

- **Resolution in 3D:-**

When a vector is broken down in three components (along x, y and z-axis) is called resolution in 3D.



Let vector $\vec{R}$ makes an angle α, β and γ with x-axis, y-axis and z-axis respectively.

R_x = Component of R in x-direction
R_y = Component of R in y-direction
R_z = Component of R in z-direction.

Now,

$$R_x = R\cos\alpha$$
$$R_y = R\cos\beta$$
$$R_z = R\cos\gamma$$

Now $\hat{i}$ = unit vector in x-direction
$\hat{j}$ = unit vector in y-direction
$\hat{k}$ = unit vector in z-direction

$$\vec{R} = R_x\hat{i} + R_y\hat{j} + R_z\hat{k}$$

$$\therefore R = \sqrt{R_x^2 + R_y^2 + R_z^2}$$

$$\Rightarrow R^2 = \sqrt{(R\cos\alpha)^2 + (R\cos\beta)^2 + (R\cos\gamma)^2}$$

$$\Rightarrow R = \sqrt{R^2\cos^2\alpha + R^2\cos^2\beta + R^2\cos^2\gamma}$$

$$R = R\sqrt{\cos^2\alpha + \cos^2\beta + \cos^2\gamma}$$

$$\text{or } \sqrt{l^2 + m^2 + n^2} = 1$$

$$\boxed{l^2 + m^2 + n^2 = 1}.$$

Where, $\cos\alpha = l$, $\cos\beta = m$, $\cos\gamma = n$ } Respectively.

- **Force :-** Force is an external agent when it applied on a body then position or nature of the body is changed or it try to change.
  - → It is vector quantity.
  - → It is denoted by F.
  - → Its S.I unit is Newton or kgm/s^2
  - → Its other units are Dyne, poundal, pound force or kilo pound.
  - → Derivation from other quantity.

$$F = ma$$

  - → Its dimension is $[MLT^{-2}]$

- **Effect of force :-**
  - i) It can change the speed of any object.
  - ii) It can change the direction of any object.
  - iii) Force can make a body in at rest to move
  - iv) It can stop a moving body.
  - v) It can accelerate the body.
  - vi) It can deaccelerate the body.
  - vii) It can change shape and size of the body.
  - viii) It can maintain any object in equilibrium

formula for force,

$$F \propto \frac{dp}{dt}$$

$$F \propto \frac{d\,mv}{dt}$$

$$F \propto m\,\frac{dv}{dt}$$

$$F \propto ma$$

$$F = kma$$

$$\boxed{F = ma} \quad [\text{Where } k = 1]$$

- **Centripetal Force :-**

The force which applied toward the center are called centripetal force.

→ The unit of centripetal force is Newton.

→ Calculating centripetal force :
The centripetal force formula is given as the product of mass and tangential velocity square divided by the radius of curvature.

→ Mathematically it is written as.

$$F_{cp} = \frac{mv^2}{r}$$

where,

F_{cp} = Centripetal force
v = Velocity of object
r = radius of curvature
m = Mass of object

→ Example of centripetal force in daily life :- Turning a car, planents revolving around the sun etc.

- **Centrifugal force :-**

The force which applied away from center of curvature is called centrifugal force.

→ Unit of centrifugal force is Newton.

→ Calculation of Centrifugal force :-

The centrifugal force formula given by the negative product is mass and velocity square and divided by radius of curvature.

$$F_{cf} = \frac{mv^2}{r}$$

→ Example of Centrifugal force : Turning a car, Planets revolving around the sun etc.

- **Momentum :-** Momentum is tendency of object to be in motion.

→ It is a vector quantity.

→ It is denoted by P

→ Mathematicaly it is ~~divided~~ defined as the product of mass and velocity.

$$P = m \times v$$

Where P = momentum
m = Mass
v = Velocity

→ Its unit is kgm/s

→ Dimension - $[MLT^{-1}]$

- **Conservation of Momentum :-**

→ Total momentum remains constant if any external force dose not act on the system.

OR,

The total momentum of an object remains constant if net resulting force acting on the body is zero.

→ The momentum before collision is equal to momentum after collission.

- **Recoil gun Velocity :-**

When a bullet is fired from a gun then bullet move with large velocity and then same time gun moves in backward in small velocity (jerk) is called recoil gun velocity.

if m_1 = mass of bullet

m_2 = mass of gun

v_1 = mass of velocity of bullet

v_2 = Velocity of gun.

∴ Accoarding to law of conservation of momentum

$$\boxed{m_1 v_1 = m_2 v_2}$$

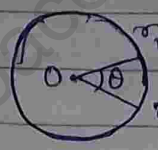
- **Circular motion :-**

When any particle moves along a circular path then motion of object is called circular motion.

- **Displacement :-** The smallest distance between two points is called displacement.

- **Angular displacement :-** The angle subtended by a particle at the center is called angular displacement.

→ It is denoted by 'θ'.
→ It is measured in radian
→ In the figure angular displacement is measured between r and r1



- Velocity :- The rate of change of displacement with respect to time is called velocity.

→ It is denoted by v

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

→ Its unit is m/s.
→ Dimension → $[LT^{-1}]$

- Angular Velocity :- The rate of change of angular displacement with respect to the time is called angular velocity.

→ It is denoted by 'ω'

$$\omega = \frac{d\theta}{dt}$$

→ It is measured in radian/sec

- Acceleration :- The rate of change of velocity with respect to time is called acceleration.

→ It is denoted by a

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

→ Unit – $m/s^2 = [LT^{-2}]$

- Angular acceleration :-

The rate of change of angular velocity with respect to time is called angular acceleration.

→ It is denoted by α

$$\boxed{\alpha = \frac{d\omega}{dt}}$$

→ Its S.I unit is radian/sec^2.

Elasticity

- Deforming force :- The force that produce changing in the body is called deforming force.
- Restoring force :- The force which restore the body in their original form after removal of deforming force is called restoring force.
- Magnitude of deforming force = Magnitude of Restoring force.
- Deformation :- If an external force applied on a body then it result in a change in shape or size or both shuch a change in the body is called deformation and the force is called deforming force.

→ Deformation ∝ Deforming force.

Eg :- Streching of rubber, spring etc.

- Elasticity :- When a force is applied on the body. It get deformed if after removal of deforming force the body comes in their original form this phenomen -an is called elasticity and such type of body is called elastic body.
Eg - Tube, rubber etc.
- Plasticity :- When a force is applied on the body they get deformed and if

after removal of deforming force body can not again returns in their original form it called plasticity.
Such type of body is called plastic body.
Eag- paye, pen etc.

- **Stress :-**

The internal restoring force. acting per unit area of cross sectional of deformed body is called stress. It is denoted by (σ) small sigma.

$$\text{Stress } (\sigma) = \frac{\text{internal restoring force}}{\text{Area}}$$

$$= \frac{\text{External deforming force}}{\text{Area}}$$

$$\boxed{\sigma = \frac{F}{A}}$$

Where,

σ = stress
F = Applied force
A = Area of cross section

- Unit of stress : N/m^2
  Dimension = $[ML^{-1}T^{-2}]$

- Types of stress :

(1) Normal stress :-

When a deforming force act at right angle to the surface of a body then restoring force developed normally

per unit of the body is called normal stress.

→ There are also two types of normal stress.

(a) Tensile stress :-

The stress which occurs due to tensile force is called tensile stress. In tensile stress length of body increased and diameter of body reduced.

(b) Compressional stress :

The stress which occurs due to compressive force is called compressional stress. In compressional stress length of the body reduced and diameter of body increased.

(2) Tangential Stress :-

The stress which occurs due to tangential force is called tangential stress.

- **STRAIN :-**

The ratio between change in dimension and original dimension is called strain. It is denoted by (e)

$$\text{Strain } (e) = \frac{\text{change in dimension}}{\text{Original dimension}}$$

→ Strain is unit less.

- Types of strain :-

(1) Linear / Longitudnal strain :-

The ratio between change in length and Original length is called Linear strain.

$$\text{Linear strain} = \frac{\text{Change in length}}{\text{Original length}}$$

$$= \frac{\Delta l}{l}$$

(2) Volumetric strain :-

The ratio between change in volume and original volume is called volumetric strain.

$$\text{Volumetric strain} = \frac{\text{Change in volume}}{\text{Original volume.}}$$

$$= \frac{\Delta V}{V}$$

(3) Sharing strain :-

The ratio between relative displacement between two parallel faces and distance between parallel faces is called sharing strain.

$$\text{Sharing strain} = \frac{\text{relative displacemen b/w two ll face}}{\text{distance b/w ll faces.}}$$

(4) Lateral strain :-

The ratio between change in diameter and original diameter is called lateral strain.

$$\text{Lateral strain} = \frac{\text{Chang in diameter}}{\text{Original diameter}}$$

- Elastic limit :-

The maximum stress that a material can withstand before the permanent deformation is called Elastic limit.

- Hook's law :-

Accoarding to this law within elastic limit the stress is directly proportional to strain.

$$\text{Stress} \propto \text{Strain}$$

$$\sigma \propto e$$

$$\sigma = Ee$$

$$\boxed{E = \frac{\sigma}{e}}$$

Where, E = modulas of elasticity

σ = Stress

e = Strain

→ Unit = N/m^2

→ Dimension = $[ML^{-1}T^{-2}]$

- **Young's Modulas:**

The ratio between linear stress and linear strain is called young's modulas of elasticity It is denoted by (Y).

$$\text{Youngs modulas } (Y) = \frac{\text{Linear stress}}{\text{Linear strain}}$$

$$= \frac{F}{A} \times \frac{l}{\Delta l}$$

$$\boxed{Y = \frac{Fl}{A\Delta l}}$$

Unit = N/m^2

- **Bulk Modulus:** → Hrong

The ratio between shearing stress and shearing strain is called bulk modulas. It is denoted by (K).

- **Bulk modulas of Elasticity:**

The ratio between volumetric stress and volumetric strain is called Bulk modulas of elasticity.

It is denoted by K.

$$\text{Bulk modulas of elasticity} = \frac{\text{Volumetric stress}}{\text{Volumetric strain}}$$

$$K = \frac{f/A}{\Delta V/V}$$

$$\boxed{K = \frac{f}{A} \times \frac{V}{\Delta V}}$$

- Modulas of rigidity :-
The ratio between sharing stress and sharing strain is called modulas of rigidity.

→ It is denoted by η

$$\eta = \frac{\text{sharing stress}}{\text{sharing strain}}.$$

$$\eta = \frac{F/A}{\Delta l/l}$$

$$\boxed{\eta = \frac{f}{A} \times \frac{l}{\Delta l}}$$

- Relation between modulas of elasticity :

Relation between young's modulus, bulk modulus and modulas of rigidity is given by

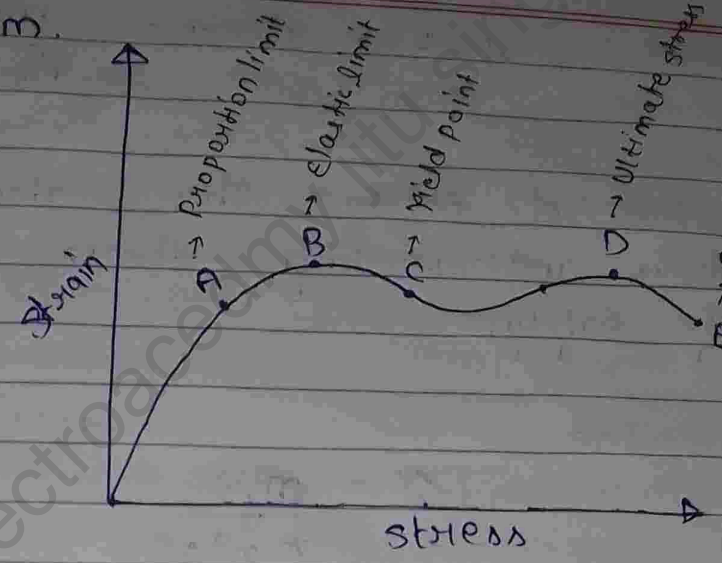
$$\frac{9}{Y} = \frac{3}{\eta} = \frac{1}{K}$$

$$\text{or, } Y = \frac{3K\eta}{3K+\eta}$$

where, Y = young's modulus
K = Bulk modulus
η = rigidity modulus

- Stress - strain Diagram :
The curve which gives relation between stress and strain is called strain.

stress diagram.



- Proportional Limit : (A) :- The point (A) on the stress, strain diagram upto which stress ∝ strain.
- Elastic limit (B) : It is the point on stress strain diagram upto which the material remains elastic
- Yield point (C) : It is the point at which the material starts to deform plasticity.
- Ultimate stress (D) : The maximum stress which failure is called ultimate stress.
- Breaking stress (E) : It is the stress at which the material breaks.
- Working stress : The maximum safe stress a material can carry is called working stress

Working stress = $\frac{\text{Ultimate stress}}{\text{Factors of Safety.}}$

- Factors of Safety :- The ratio between Ultimate stress and working stress is called factors of safety.

→ Formulae

$$Y = \frac{mgl}{\pi r^2 \Delta l}$$

Q. $F = 10\,N$, $r = 1\,mm$

$$\text{Stress} = \frac{F}{A} = \frac{10}{\frac{22}{7} \times 10^{-3} \times 10^{-3}} = 0.35 \times 10^{7}\ N/m^2$$

- Viscosity :

The friction force which occurs between two layers of liquid or gass which oppose relative motion. is called Viscous force and this property is called Viscocity.

Eg. We walk in the air freely but when we walk in water our speed is reduces due to viscocity.

- Causes of Viscosity :- Change in velocity between two layers of liquid.

- **Working stress :-**
  The maximum safe stress that can be carried out by any material is called working stress.
  Working stress = $\frac{\text{altimate stress.}}{\text{factor of safety.}}$

- **Factor of safety :-**
  The ratio between altimate stress and working stres is called factor of safety.
  ∴ factor of safety = $\frac{\text{altimate stress}}{\text{Working stress.}}$

- **Viscocity :-** The frictional force which occur between two layers of a liquid or gass which opposes relative motion between them is called viscous force, and this opposing properting is called viscocity.

- **Cause of Viscocity :-** change in velocity between two layers of liquid on gass.

- **Velocity gradiant :-**
  The ratio between change in velocity and distance between two layers in called velocity gradiant. It is denoted by V_g.

$$\boxed{V_g = \frac{dv}{dx}}$$

Where, dv = change in velocity between two layers
dx = distance between two layers.

→ Its unit is s^{-1}.
→ Its dimension $[M^0L^0T^{-1}]$

- Newton's law of Viscocity :-

(1.) Viscous force is directly proportional to surface are of liquid layer.

$$F \propto A \quad ----(1)$$

(2.) Viscous force is directly proportional to velocity gradiant.

$$Fv \propto Vg \quad ----(2)$$

From eqn (1) and (2) We get.

$$Fv \propto A\, Vg.$$

$$Fv = -\eta A \cdot \frac{dv}{dx}$$

$$\eta = -\frac{Fv}{A}\left(\frac{dx}{dv}\right)$$

Where, η = coefficient of viscocity.
→ Its unit is $Nm^{-2}s$ or Ns/m^2
→ Its dimension is $[ML^{-1}T^{-1}]$.

- Factor effecting Viscocity :-

(1) Effect of temprature on viscocity :-
→ If temprature increases of a liquid then its kinetic energy also increased so, intermolecular force of liquid molecules becomes weaker so viscocity is reduced. Thus we can say that.

viscocity is inversly proportional to temprature.

$\therefore$ Viscocity $\propto \frac{1}{\text{temprature}}$.

② Effect of pressure on Viscocity :-

→ Viscocity is directly proportional to pressure.

Viscocity $\propto$ Pressure.

→ Except - Water.

③ Effect of adultration on Viscocity :-

→ Adultration is directly proportional to Viscocity.

Adultration $\propto$ Viscocity.

- Stream line flow :- The flow of liquid in such a way that of every particles of liquid passes though same path and with same velocity is called steam line flow.

- Proportional of stream line flow :-

→ At any point of ste stream line flow. fluid velocity remain constant.

→ It dosen't cross each other.

→ The tengent at any point on stream line flow gives the direction of velocity of fluid particles at that point.

- Turbulant flow :- The flow of liquid in such a way that every particles

of liquid do not passes through same path and with same velocity is called turbulant flow.

- Surface tension :-

The property of fluid to remain in minimum area is called surface tension.

OR,

The force applied per unit length on a liquid surface is ~~calle~~ called surface tension.

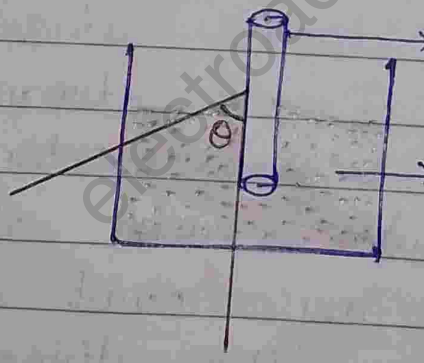
→ It is denoted by S.

$$S = \frac{F}{l}$$

→ Unit Nm^{-1}

→ Dimension $[ML^0T^{-2}]$.

- Contact Angle :- The angle between tangent on liquid, surface away from solid and tangent on solid toward the liquid is called contact angle.



- Cohesive force :- The force which occur between same kind of molecules is called cohesive force.

ex- Force between water molecules.

- Adhesive force :- The force which occurs between different kinds of molecules is called adhesive force. eg- force between water and glass molecules.

Water ← ○ → Mercury

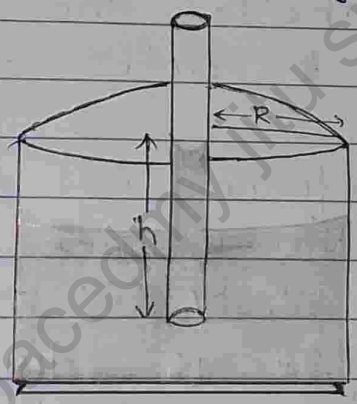
$f_{w-w} < f_{w-g}$ $\quad f_{m-m} > f_{m-g}$

- Capallary action :-

The phenomena when ascension of liquid through a tube take place is called capallary action.

→ It occurs due to cohesive and adhesive forces.

→ Narrower the tube, higher will the liquid rise.



→ We know that pressure below concave miniscus will be less than pressure above the miniscus by $2T/R$.

→ If pressure above the miniscus is P_0 than pressure below the miniscus is $P_0 - 2T/R$. liquid will rise into tube than.

$$P_0 = (P_0 - 2T/R) + \rho hg$$

$$\frac{2T}{R} = \rho hg$$

$$h = \frac{2T\cos\theta}{\rho h g}$$

Where, $\frac{R}{r} = \cos\theta \quad \therefore r = R/\cos\theta$.

Where,
- h = Rise of liquid in tube
- T = Surface tension.
- θ = Contact angle
- r = Radius of tube
- ρ = density of liquid
- g = gravitional acceleration

- Stoke's Laid :-

→ Stoke's gives a law about how much force is exprinced by a body during moving inside the fluid.

According to stoke's law :

1) Viscus force is directly proportional to the velocity of the body

$\therefore F_v \propto V$ --- (1)

2) Viscus fore is directly proportional to radius of spherical body.

$F_v \propto r$ ---- (2)

3) Viscus force is directly proportianal to cofficient of Viscocity.

$F_v \propto \eta$ ---- (3)

$\therefore$ from eqn (1), (2) and (3)

$F_v \propto v r \eta$

$F_v = k v r \eta$

→ By using dimensional analysis we find

the degree of ρ, v and η

Let, degree of ρ, v and η are a, b and c respectively.

$\therefore fv = k\rho v\eta$

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

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

$c = 1$ $\quad -2 = -b-c$

$b+a-c = 1$ $\quad -2 = -b-1$

$\therefore 1+a-1 = 1$ $\quad b = -1+2$

$a = 1$ $\quad b = 1.$

$\therefore fv = k\rho v\eta$

- Pressure :- The force applied per unit area of object is called pressure. It is denoted by 'p'.

$$\therefore \boxed{P = \frac{F}{A}}$$

→ If area will be less than pressure will be high.

→ Its S.I unit is N/m^2 or pa (Pascal), or, Torr.

→ Its dimension is $[ML^{-1}T^{-2}]$.

- Types of pressure :-

(1) Absolute pressure :- The pressure which is taken as refrence is called Absolute pressure.

(2) Differential pressure :- The difference two pressure is called differential

pressure.

③ Atmospheric pressure :- The pressure which is related to atmosphere and that occure around the earth is called atmospheric pressure.

④ Guage pressure :- The difference between atmospheric pressure and absolute pressure is called guage pressure.

- Barometer :- The instrument which measure the value of pressure is called barometer.
- Construction :-
The Fortin barometer

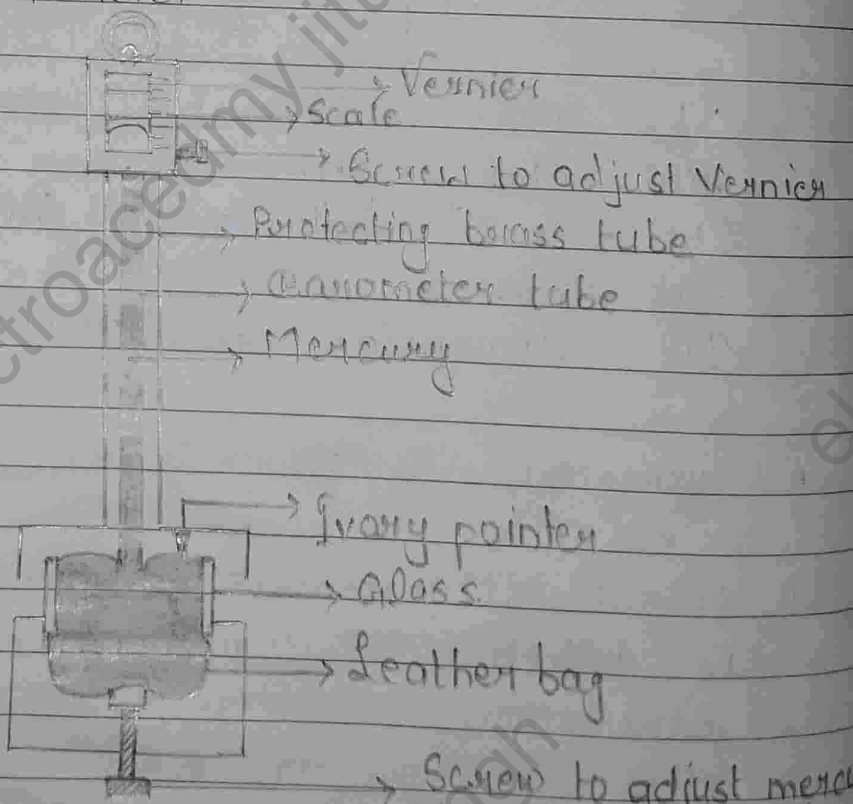


Fig: Fortin Barometer.

→ It consist a narrow glass tube of length about 90 cm.
→ This tube is closed at one end.
→ This tube is completely filled with mercury.
→ This tube kept inverted in a cistern filled with dry Mercury.
→ This tube is protected by brass tube.
→ The upper part of brass tube has a slit. That inables the leval of mercury to be seen.
→ A vernier scale is used to measure the value of atmospheric pressure.
→ The Vernier can be moved up and down using a screw.
→ The bottom of cistern is made up of textile leather.
→ The mercury leval can be adjusted by a screw.
→ The whole apparatus is fixed in a vertical position.

→ Working :-
Due to any change in atmospheric pressure an immediate change in the level of Mercury in glass tube. the change in leval of Mercury is dected by Vernier scale and measure the value of atmospheric presswre.

- Work :- Work is said to be done when a force produce motion.
OR,
→ All the reasons due to which a body moves along the direction of force is called work.
→ It is denoted by 'W'.
→ Mathematically work is the product of horizontal component of force and displacement of body along the direction of force.

$$\therefore \boxed{W = FS\cos\theta}$$

→ Its S.I unit is joule (J).
→ Its dimension is $[ML^2T^{-2}]$.

- Types of Work :-

(1) Zero Work :- If angle between force and displacement is 90°, then work is called zero work.
ex - For a body moving on circular path with a centripetal force acting on it at 90° angle.

When $\theta = 90°$

$$\therefore W = FS\cos 90°$$

$$W = F \cdot S \cdot 0$$

$$\boxed{W = 0}$$

- Positive work :- If angle between force and displacement is 0° then work is called positive work.
eg - Energy of a spring.

∴ When $\theta = 0°$

$\therefore W = F \cdot S \cdot \cos 0°$

$$\boxed{W = F \cdot S}$$

- **Negative Work :-** If angle between force and displacement is $180°$ then work is called Negative work.

eg - Frictional force.

When $\theta = 180°$

$\therefore W = F \cdot S \cdot \cos 180°$

$W = -F \cdot S \cdot (-1)$

$$\boxed{W = -F \cdot S}$$

- **1 Joule :-** If 1 N force is applied on a body and body displaced 1 m then work is called 1 joule.

→ Work is a scalar quantity.

→ The formula of work $W = FS\cos\theta$ is only valid when work done is in horizontal plane.

→ If height is given the work is the product of weight of body and height.

∴ Work = Weight × height

$W = \omega \times h$

$$\boxed{W = mgh}$$

Where, { m = Mass of body in kg.
g = g acceleration due to gravity ($9.8\ m/s^2$).
h = height, from inital position.

- Energy :- The capacity of doing work is called energy.
→ It's S.I unit is joule. (J).
→ The unit of energy is named after James presscoat joule.
→ Other unit of energy :-
  1) Erg
  2) Calori
  3) British thermal unit (B.T.U)
  4) kilo Watt hour (KWH)
  5) kilo Calori etc.

- Types of Energy :- There are two types of energy
  1) kinetic energy
  2) Potential energy.

① Kinetic energy :- The energy posses by a body due to its motion. is called kinetic energy.
→ It is denoted by 'K.E'.

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

→ If mass of a body is doubled then, its kinetic enery is also get doubled.
→ If velocity of a body is doubled then, kinetic energy increased by fourth times.
→ kinetic energy depends on mass and velocity of the body

→ Its S.I unit is joule.
→ Dimension = $[ML^2T^{-2}]$.

- Derivation of Kinetic Energy:

→ Let us consider, a body of mass 'm' moves with velocity 'v' from rest and covers displacement 's' in time 't'.

$$\because v^2 = u^2 + 2as$$
$$v^2 = 0 + 2as$$
$$v^2 = 2as$$
$$a = \frac{v^2}{2s}$$

$$\because f = ma$$
$$f = m\frac{v^2}{2s}$$

$$W = f \cdot s$$
$$= \frac{mv^2}{2s} \times s$$

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

- Potential Energy: Energy posses by a body due to its position is called potential energy.

→ It is denoted by P.E
→ Mathematically potential energy is the product of mass of body, acceleration due to gravity and height.

→ $$\boxed{P.E = mgh}$$

→ There are two types of potential energy.
1) gravitational potential energy.
2) Elastic potential energy.

① Gravitational potential Energy :-

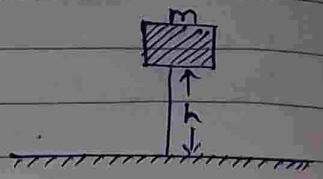
→ The energy posses by a body when it raised against gravity is called gravitational potential energy.

Work done = Force × displacemem

$W = F \cdot S$

$W = mg \cdot h$

$\therefore \boxed{P.E = mgh}$



② Elastic potential Energy :-

→ The energy stored in the object that can be compressed or streached is called elastic potential energy.

→ It is denoted by 'U'.

→ $\boxed{U = \frac{1}{2} k x^2}$

Where, { U = Elestic potential energy
K = Spring Constant
x = streached or compressed length.

- Power :- The rate of doing work is called power.

→ It is denoted by 'P'.

→ Mathematicall power is the ratio between work and time.

$P = \frac{W}{t}$ $\frac{(Work)}{(time)}$

→ S.I unit = Watt or Js^{-1}

→ It is a scalar quantity.

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→ It's dimension is $[ML^2T^{-3}]$.

→ Another unit of power is HP (horsepower).

→ 1 hp = 746 Watt.

ROTATIONAL MOTION

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- Translatory Motion :-

→ If each particles of a body under goes the same displacement in the same direction in given time interval then, such type of motion is called Translatory motion.

eg- Motion of a car on straight road.
The motion of a bullet.

→ In translatory motion particles moves on straight path.

- Curvelinear Motion :-

→ If each particle of a body travels on same displacement on a curve path in same direction in given time interval then such type of motion is called curvelinear motion.

eg- Motion of a car on turning of a road etc.

- Rotational Motion :-

→ If each particles of a body travels same displacement on a circular path in same direction in a given time interval than, such type of a motion is called rotational Motion.

eg- Motion of a wheel etc.

- Torque :-

→ Rotational effect of a force is called Torque.

→ Mathematically Torque is the product of

force and perpendicular distance

→ It is denoted by τ

$$\boxed{\text{Torque} = F \times \perp r}$$

$$\boxed{\tau = Fr\sin\theta}$$

→ Torque is a vector quantity.

→ Its S.I unit is Nm.

- Momentum :- The tendency of a body to be continue in motion is called Momentum.

→ Mathematically momentum is product of mass and velocity.

→ It is denoted by 'P'.

$$\boxed{P = mv}$$

→ Any body moving with mass posses momentum.

- Angular Momentum :- The tendency of a body to be continue in rotational motion is called Angular Momentum.

→ It is denoted by 'L'.

→ Mathematically Angular Momentum is the product of mass of the body, velocity of body and radius of circular path.

$$\therefore \boxed{L = mvr}$$

Where, $\begin{cases} L = \text{Angular Momentum} \\ m = \text{Mass of body}, \ v = \text{Velocity of body} \\ r = \text{Radius of circular path} \end{cases}$

→ Its unit is $kg\,m^2s^{-1}$

→ Dimensional formula is $[ML^2T^{-1}]$

→ It is a vector quantity.

→ Angular Momentum Formula :-

→ Case I : For point object

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

Where, $\begin{cases} L = \text{Angular Momentum} \\ \vec{r} = \text{Radius of circular path} \\ \vec{p} = \text{Linear momentum} \end{cases}$

eg. Angular momentum when earth moves around the sun.

→ Case II : For extended object.

$$\boxed{\vec{L} = \vec{I} \times \vec{\omega}}$$

Where, $\begin{cases} \vec{I} = \text{Rotational inertia} \\ \vec{\omega} = \text{Angular velocity} \end{cases}$

• Conservation of Angular Momentum :-

→ Angular Momentum of a system is conserved as long as not any external torque acting on the system.

Torque is defined as,

$$\tau = \frac{dL}{dt}$$ (It represents the change in angular momentum w.r.t. time).

$$\frac{0}{I} = \frac{dL}{dt}$$

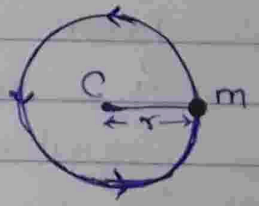
$$\therefore dL = 0$$

Here, change in angular momentum is zero it means if $\tau = 0$, then angular momentum is constant.

- Application of law of Conservation of Angular Momentum:
  1) Revolution of a planet
  2) Circus acrobate.
  3) Aircraft engine
  4) Spinning chair

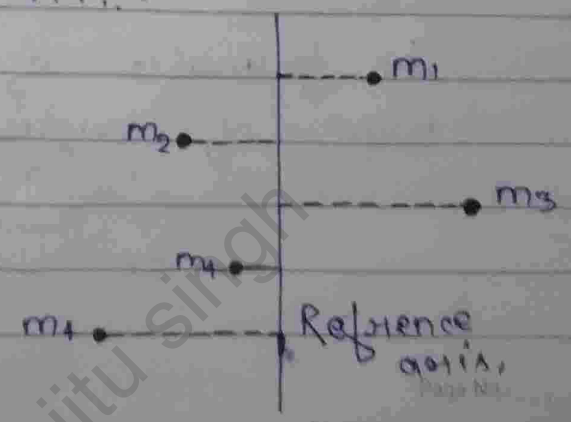
- Moment of Inertia:
  → The property of a body due to which it opposes any change in the state of rest or uniform motion.
  → It is denoted by 'I'.
  → Mathematically moment of inertia is the product of mass of body and square of ~~dis~~ distance from refrence axis.

$$\therefore \boxed{I = mr^2}$$



- If body is made up of number of particles than moment of inertia of body is.

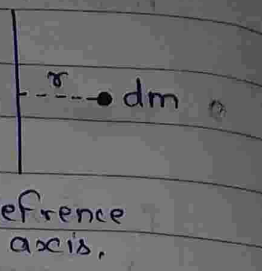
$$I = m_1r_1^2 + m_2r_2^2 + \ldots$$



→ Moment of inertia of a body made up of contineous distribution of mass.

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

or, $I = r^2 \int dm$.



→ Its S.I unit is kgm^2

→ Dimension $= [ML^2T^0]$

→ Moment of inertia depends on mass, distribution of mass and position of particles from refrence axis.

→ Moment of inertia dose not depend on angular velocity, angular acceleration, angular momentum, torque and kinetic energy.

• Radius of Gyration :-

→ The perpendicular distance of a point from axis where whole mass of body is concentrated is called radius of Gyration.

→ It is denoted by 'k'.

$$k = \sqrt{\frac{r_1^2 + r_2^2 + r_3^2 + \dots + r_n^2}{n}}$$

→ The formula of moment of inertia in term of radius of Gyration

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

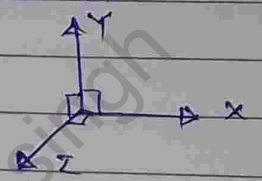
or $k = \sqrt{\frac{I}{m}}$

→ Radius of Gyration depends on shape and size of the body.
→ Radius of Gyration dose not depends on mass of the body.
→ Its S.I unit is meter.
→ Its dimension is $[M^0LT^0]$ or $[L]$

- **Theorem of perpendicular axis :-**

→ It states that the moment of inertia for any axis which is perpendicular to the plane is equal to sum of moment of inertia along any two perpendicular axis of the body which intersect with the first axis.

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



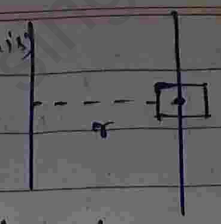
- **Parallel axis theorem :-**

→ Accoarding to parallel axis theorem the moment of inertia of a body about an axis is equal to the sum of moment of inertia of body passing via center of mass and the product of square of distance and mass of body

OR,

It states that moment of inertia of a body about any parallel axis is sum of moment of inertia of body and moment of inertia of body via center of mass.

$$I = I_c + mr^2$$



Where, I = Moment of inertia of body about any ∥ axis

I_c = Moment of inertia about the center of mass.

m = Mass of body.

r = Distance between two ∥ axis's