ENGINEERING PHYSICS

Semester: 1ST

STUDY MATERIAL

PHYSICS

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Physics

Science :

Science is a knowledge which is gained in a Systematic way and supported by Experiment Observation

Classification of Science :-

(i) Biological Science
(ii) Physical Science

(i) Biological Science :-

Biological Science is that category of Science which deals with living organisms.

Biology $\longrightarrow$ Bio + Logous
(Living) (study)

(ii) Physical Science :-

Physical Science is that category of Science which deals with Physical characteristics of Universe.

deals with

Basic Science   Applied Science

Scientific Methods :-

To understand a Phenomenon and rules related to it :-

(i) Observation
(ii) Controlled Experiment
(iii) Qualitative Analysis $\quad s = ut + \frac{1}{2}at^2$
(iv) Quantitative reasoning $\quad v^2 = u^2 + 2as$
(v) Mathematical
(vi) Prediction
(vii) Verification / calculation.

Physics :-

It comes from a Greek word

Phusis $\longrightarrow$ Nature
Phusike $\longrightarrow$ knowledge of Nature

It is the branch of Science which deals with study of Natural phenomenon happening to our nature or in our Enviorment.
or It is the branch of Science which deals with study of matter and Energy.

Matter :-

It is having mass and occupies same space :-

- Solid
- Liquid
- Gas.

Solid :-

It is that type of matter which posses a fix shape and fix volume. The molecules of Solids are very close to Each other. as a result of this the Force of attraction between different molecules is so large that there relative position cannot be altered Easily.

Liquid :-

It is that type of matter which possesses a fixed volume and does not possess a fixed shape. The molecules in case of liquids are situated at comparatively large distances. The force between them is small as compared to that in case of Solids

Gases :-

It is that type of matter which neither possesses a definite shape nor a definite volume. The distance Between the molecule of this type of matter is so large that the force between them ~~fast~~ practically negligble So gases do not possesses fixed volume or fixed shape.

Energy:-

Energy of an agent is defined as its capacity to do work.

Ex- Light, Sound, Electricity.

Branches of Physics:-

(i) Heat and Thermodynamics
(ii) Sound
(iii) Heat
(iv) Light
(v) Electricity
(vi) Electromagnetism
(vii) Electronics
(viii) Other Branch

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UNIT AND DIMENSIONS

Fundamental Quantities

Mass — kilogram (kg)
Length — meter (m)
Time — Second (s)
Electric current — Ampere (A)
Luminous Intensity — Candela (cd)
Amount of Substance — Mole (mol)
Temperature — kelvin (k)

Fundamental Units - The Units are used to measure Fundamental Quantities are known as Fundamental Units.

Eg - kilogram, meter, Second, Ampere etc

Derived Units :- The Unit that are used to measure derived Quantities are known as derived Units.

Eg - m^2, m^3, meter per second, kilogram meter Second.

Some more Special Units :-

Quantity	Unit	Symbol.
1. Potential difference or EMF	Volt	V
2. Resistance	Ohm	Ω
3. Inductance	Henry	H
4. Capacitance	Farad	F
5. Charge	Coulomb	C
6. Magnetic Flux density	Tesla	T

Systems of Units :-

System	Length	Mass	Time
1. FPS	Foot	Pound	Second
2. CGS	Centimeter	Gram	Second.
3. MKS	Metere	Kilogram	Second.

System of International

Energy · S·I Unit → Joule

Merits

1. It is internationally accepted
2. S·I System is metric System.
3. S·I System is rational
(A System of Unit in which all physical Quantities are Qualitative similar at Expressed in one Unit called Rational system)

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Dimensions :-

(*) Dimensions are made from Quantity
(*) The Power of Fundamental Quantities are called Dimensions
(*) "Dimensions of a Physical Quantity are the Powers to which the fundamentals Quantities are raised in order to represent that Quantity

1) How to write dimensions of Quantities?
a) First write the Formula of the Given Quantity with L·H·S of the Equation.
b) Convert all the Quantities into Fundamental Quantities · Mass, Length and Time respectively M, L and T

c) Substitute M, L and T for Mass, Length and Time

d) Collect the Powers of Fundamental Quantities and calculate the resultant power which gives the dimension of that Quantity.

Example - <u>Quantity</u> <u>Formula</u>

1. Area Length x Breadth

Dimension - $[M^0 L^2 T^0]$.

Unit - m^2

2. Volume $l \times b \times h$

Dimension - $[M^0 L^3 T^0]$

Unit - M^3

3. Velocity $\frac{\text{Displacement}}{\text{Time}}$

Dimension - $[M^0 L^1 T^{-1}]$

Unit - m/s

4. Speed $\frac{\text{Distance}}{\text{Time}}$

Dimension = $[M^0 L^1 T^{-1}]$

Unit = ms^{-1}

5. Acceleration $\frac{\text{Velocity}}{\text{Time}}$

Dimension = $[M^0 L^1 T^{-2}]$

Unit = ms^{-2}

Quantity — Formula

6. Momentum : Mass x velocity

Dimension - $[M^1L^1T^{-1}]$

Unit - kg m/s

7. Density — Mass/volume

Dimension $[M^1L^{-3}T^0]$

Unit = kg m^{-3}.

8. Force — Mass x acceleration

Dimension $[M^1L^1T^{-2}]$

Unit - kg m/s^{-2}

9. Pressure — Force/Area.

Dimension - $[M^1L^{-1}T^{-2}]$

Unit - kg $m^{-1}s^{-2}$

10. Work — Force x displacement

Dimension - $[M^1L^2T^{-2}]$

Unit - kg m^2s^{-2}

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	Physical Quantity.	Formula	Dimensions	Unit
1.	Kinetic Energy	$1/2\ mv^2$	$[M^1 L^2 T^{-2}]$	$kg m^2 s^{-2}$
2.	Potential Energy	mgH	$[M^1 L^2 T^{-2}]$	J
3.	Torque	Force x distance	$[M^1 L^2 T^{-2}]$	Nm
4.	Strain	$\frac{\text{Change in Length}}{\text{Original Length}}$	$[M^0 L^0 T^0]$	
5.	Angle.	$\frac{\text{Length of arc}}{\text{Radius}}$	$[M^0 L^0 T^0]$	Radian
6.	Angular velocity	$\frac{\text{Angular displacement}}{\text{Time}}$	$[M^0 L^0 T^{-1}]$	$radia\ s^{-1}$
7.	Angular acceleration	$\frac{\text{Angular velocity}}{\text{Time}}$	$[M^0 L^0 T^{-2}]$	$radia\ s^{-2}$
8.	Angular Momentum	Momentum X Distance	$[M^1 L^2 T^{-1}]$	$kg m^2 s^{-1}$
9.	Surface Tension	Force/length	$[M^1 L^0 T^{-2}]$	$kg ms^{-2}$
10.	Gravitational constant	$\frac{\text{Force x distance}}{\text{Mass}}$	$[M^{-1} L^3 T^{-2}]$	$kg^{-1} m^3 s^{-2}$
11.	Impulse	Force X Time	$[M^1 L^1 T^{-1}]$	$kg ms^{-1}$

12.	Gas constant	Pressure × Volume / Temperature	$[M^1L^2T^{-2}]K^{-1}$	
13.	Charge	$i = \frac{q}{t}$	$[M^0L^0T^1A]$	As
14.	Electric Potential	Work done / Charge	$[M^1L^2T^{-3}A^{-1}]$	$kg\,m^2s^{-3}A^{-1}$
15.	Resistance	Potential difference / Current	$[M^1L^2T^{-3}A^{-1}]$	$kg\,m^2s^{-2}A^{-2}$

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Classification of Physical Quantities :-

1. Dimensional Constants.
2. Dimensional Variables
3. Non-Dimensional Constants.
4. Non-Dimensional Variables.

(*) Dimensional Constants:-

These are the Quantities which do not changes and Posses Dimensions.

Eg - Plank's constant, Gravitational Constant, Gas constant, Boltman's constant etc...

(*) Dimensional Variables:-

These are the Quantities which are liable to changes and Possess Dimensions.

Eg - Velocity, Acceleration, Force, Momentum etc.

(x) Non-Dimensional Constant :-

These are the Quantities which donot changes and donot Posses Dimension

Eg - Natural numbers (1, 2, 3 . . . .), π, e

(x) Non - Dimensional Variables :-

These are the Quantities which are liable to changes and Possesses Dimension.

Eg - Specific Gravity, Angle, strain.

Characterstics of Dimensions :-

(a) Dimension of a Physical Quantity are Independent of System of Units.

(b) Dimension can be Obtained from its Units or Vice Versa.

(c) Quantities having Similar dimensions can be added or Subtracted from Each other.

(d) Multiplication / Division of dimension of two Physical Quantities results in production of third Quantity which gives the dimension of that Quantity.

(e) Two Quantities may have similar dimensions

Principle of Homogeneity :-

It states that " The Dimensional Formula of Every term on two sides of a correct relation must be same"

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

$a = 1,\ b = -2,\ c = 2$

Uses of Dimensional Analysis :-

1) To Check the Corectness of a Given Relation
2) To convert the values of Physical Quantity from one system to other.
3) To derive the Relation between Various Physical Quantities.

To Check the Corectness Dimension :-

1) $S = ut + \frac{1}{2} at^2$

L.H.S - S = Displacement $= [L] = [M^0 L^1 T^0]$

R.H.S - $ut = [M^0 L^1 T^{-1}] \times [T]$

$= [M^0 L^1 T^0]$

$\frac{1}{2} at^2 = [M^0 L^1 T^{-2}] \times [T^2]$

$= [M^0 L^1 T^0]$

$\therefore$ The Above Equation is dimensionaly correct.

2) $v^2 - u^2 = 2as$

L.H.S = $v^2 = [M^0 L^1 T^{-2}]^2 = [M^0 L^2 T^{-2}]$

$u^2 = [M^0 L^1 T^{-1}]^2 = [M^0 L^2 T^{-2}]$

R.H.S = $2as = [M^0 L^1 T^{-2}] \times [L] = [M^0 L^2 T^{-2}]$

$\therefore$ The Above Equation is dimensionaly correct.

L.H.S = R.H.S.

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- To Check the correctness of the Given Relation

$$F = G \frac{m_1 m_2}{r^2}$$

where F is Force of attraction between two masses m_1 and m_2, r is radius in between Them.

Ans) L.H.S = F = $[M^1 L^1 T^{-2}]$

R.H.S = G = $[M^{-1} L^{-3} T^{-2}]$

Mass = $m_1 = [M]$

$m_2 = [M]$

Radius = $r^2 = [L^2]$

$$\frac{M^{-1} L^{-3} T^{-2} \, [M^2]}{[L^2]}$$

L.H.S = $[M^1 L^1 T^{-2}]$

R.H.S = L.H.S

$\therefore$ The Above Equation is dimensionally correct.

2. Check the correctness of the Equation.

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

R.H.S = T = Time Period

L.H.S = 2π l = length

g = acceleration.

$$T = [M^0 L^0 T^1]$$

$$2\pi\sqrt{\frac{[M^0 L^1 T^0]}{[M^0 L^1 T^{-2}]}}$$

$$= [M^0 L^0 T^1]$$

R.H.S = L.H.S

∴ The Above Equation is dimensionally correct.

3. Check the correctness of the Equation.

$$\frac{GM}{R^2}$$

$$G\,[M^{-1} L^{-3} T^{-2}]$$

$$M = [M^1]$$

$$\frac{[M^{-1} L^{-3} T^{-2}]\,[M^1]}{L^2}$$

$$= [M^0 L^1 T^{-2}]$$

∴ L.H.S = R.H.S

∴ $\frac{GM}{R_2}$ is a acceleration.

4. Check the correctness of the Relation

$$V_e = \sqrt{\frac{2GM}{R}}$$

R.H.S $[M^0 L^1 T^{-1}]$

$$L.H.S = 2\sqrt{\frac{[M^{-1}L^{3}T^{-2}] \times [M^1]}{L^2}}$$

$$= \sqrt{M^0 L^{-2} T^{-2}}$$

$$= [M^0 L^1 T^{-1}]$$

so R.H.S = L.H.S

∴ so The Above Equation is dimensionally correct.

Uses of Dimensional Analysis

To convert the values of Physical Quantity from One System to another.

For M.K.S System = $n_1 [M_1^a L_1^b T_1^c]$

For C.G.S System = $n_2 [M_2^a L_2^b T_2^c]$

$$\frac{n_1 [M_1^a L_1^b T_1^c]}{n_2 = x} = n_2 [M_2^a L_2^b T_2^c]$$

$$n_2 = n_1 \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

1. Convert the Unit of work from M.k.S System to C.G.S System.

work = $[M^1 L^2 T^{-2}]$

	M.k.S System	C.G.S System
a = 1	M_1 = 1kg	M_2 = 1gm
b = 2	L_1 = 1m	L_2 = 1cm
c = -2	T_1 = 1s	T_2 = 1s
	n_1 = 1	

Physical Quantity as represented in System 1

$$= n_1 [M_1^a L_1^b T_1^c]$$

Physical Quantity as represented in System 2

$$= n_2 [M_2^a L_2^b T_2^c]$$

$$n_1 [M_1^a L_1^b T_1^c] = n_2 [M_2^a L_2^b T_2^c]$$

$$n_2 = n_1 \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

$$\Rightarrow 1 \left[\frac{Kg}{1gm}\right]^1 \left[\frac{1m}{1cm}\right]^2 \left[\frac{1s}{1s}\right]^{-2}$$

$$\Rightarrow 1 \left[\frac{1000gm}{1gm}\right]^1 \left[\frac{100cm}{1cm}\right]^2 \cdot [1]^{-2}$$

$$\Rightarrow 10^3 \times 10^4 = 10^7 \text{ (Ans)}$$

M.k.S - Joule

C.G.S = erg

2. Convert the Unit of density from M.K.S to C.G.S System

$$\text{Density} = \frac{\text{Mass}}{\text{volume}} \quad [ML^{-3}T^0]$$

	M.K.S System	C.G.S System
$a = 1$	$M_1 = 1kg$	$M_2 = 1g$
$b = -3$	$L_1 = 1m$	$L_2 = 1cm$
$c = 0$	$T_1 = 1s$	$T_2 = 1s$
	$n_1 = 1$	

Physical Quantity represented in System 1

$$n_1 [M_1^a L_1^b T_1^c]$$

Physical Quantity represented in System 2

$$n_2 [M_2^a L_2^b T_2^c]$$

$$n_1 [M_1^a L_1^b T_1^c] = n_2 [M_2^a L_2^b T_2^c]$$

$$n_2 = n_1 \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

$$= 1 \left[\frac{1000\,gm}{1gm}\right]^1 \left[\frac{100\,cm}{1cm}\right]^{-3} \left[\frac{1s}{1s}\right]^0$$

$$= 10^3 \times 10^{-6}$$

$$= 10^{-3}$$

M.K.S - Joule

C.G.S = erg $- 10^{-3}\, gm/cm^3$.

3. To Convert the Unit of Torque From M·K·S System to C·G·S System:

Torque = Force x distance

$$= [M^1 L^2 T^{-2}]$$

	M·K·S System	C·G·S System
a = 1	M_1 = 1kg	M_2 = 1g
b = 2	L_1 = 1m	L_2 = 1cm
c = -2	T_1 = 1s	T_2 = 1s
	n_1 = 1	n_2 = ?

Physical Quantity as Represented in System 1

$$n_1 [M_1^a L_1^b T_1^c]$$

Physical Quantity as Represented in System 2

$$n_2 [M_2^a L_2^b T_2^c]$$

$$n_1 [M_1^a L_1^b T_1^c] = n_2 [M_2^a L_2^b T_2^c]$$

$$n_2 = n_1 \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

$$= 1 \left[\frac{1000gm}{1gm}\right]^1 \left[\frac{100cm}{1cm}\right]^2 \left[\frac{1}{1}\right]^{-2}$$

$$= 10^3 \times 10^4$$

$$= 10^7 \cdot (Am)$$

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1. Find the Relation connecting the physical Quantities Centripetal force, mass, velocity and radius of the Path by dimensional method.

$$F \propto M^a$$
$$F \propto V^b$$
$$F \propto r^c$$

$$F \propto M^a V^b r^c$$

$$F = k\, M^a V^b r^c \text{ ——— (i)}$$

$$[M]^a \, [M^0 L^1 T^{-1}]^b \, [L]^c$$

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

$a = 1$, $b + c = 1$, $-b = -2$

$b = 2$, $2 + c = 1$

$c = -1$, $c = -1 - 2 = -1$

$$F = k\, M^1 \cdot V^2 r^{-1}$$

$$k \frac{MV^2}{R}$$

$$F = \boxed{k \frac{MV^2}{R}}$$

2. The time Period of oscilliation of Pendulam depends on its Mass, length and accliration due to Gravity

$T \propto M^a$

$T \propto L^b$

$T \propto g^c$

$T \propto M^a L^b g^c$

$T = k M^a L^b g^c$ ——— (i)

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

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

$a = 0$

$L = b+c = 0$

$T = -2c = 1$

$2c = -1$

$c = \frac{-1}{2}$

$b + c = 0$

$b - \frac{1}{2} = 0$

$b = \frac{1}{2}$

$T k M^a L^b g^c$

$= k M^0 L^{1/2} g^{-1/2}$

$T = k \sqrt{\frac{l}{g}}$ (Ans)

3. Velocity (v) of sound depends upon the coefficient Elasticity (E) of the Medium and density (ρ) of the Medium obtain the Expression for v by the Method of dimensional analysis.

$$v \propto E^a$$
$$v \propto \rho^b$$

$$v \propto E^a \rho^b$$
$$v = k E^a \rho^b \text{ ——— (i)}$$

$$v = [M^1 L^{-1} T^{-2}]^a [M^1 L^{-3} T^0]^b$$

$$[M^0 L^1 T^{-1}] = [M^{a+b} L^{-a-3b} T^{-2a}]$$

$$a+b = 0$$
$$-a-3b = 1$$
$$-2a = -1$$
$$a = \frac{1}{2}$$
$$\left(\frac{1}{2} + b = 0\right)$$
$$b = -1/2$$
$$v = kE^{1/2} \rho^{-1/2}$$
$$v = \sqrt{\frac{E}{\rho}}$$

Convert the Unit of Force from M·K·S System to C·G·S System.

Force = Mass x acceleration

$[M^1 L^1 T^{-2}]$

	M·K·S System	C·G·S System
a = 1	M_1 = 1kg	M_2 = 1g
b = 1	L_1 = 1m	L_2 = 1cm
c = -2	T_1 = 1s	T_2 = 1s
	n_1 = 1	

Physical Quantity as represented in System 1

$$n_1 [M_1^a L_1^b T_1^c]$$

Physical Quantity as represented in System 2

$$n_2 [M_2^a L_2^b T_2^c]$$

$$n_1 [M_1^a L_1^b T_1^c] = n_2 [M_2^a L_2^b T_2^c]$$

$$n_2 = n_1 \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

$$1 \left[\frac{kg}{1gm}\right]^1 \left[\frac{1m}{1cm}\right]^1 \left[\frac{1s}{1s}\right]^{-2}$$

$$= 1 \left[\frac{1000gm}{1gm}\right]^1 \left[\frac{100\,cm}{1cm}\right]^1 [1]^{-2}$$

$$= 10^3 \times 10^2 = 10^5 \text{ (Ans)}$$

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Scalar And Vectors

Scalar Quantity

The Physical Quantity which has magnitude only but no specified direction is called Scalar Quantity.

Eg- Mass, Length, Time, Temperature, Density, Area, Work, Energy etc.

Vector Quantity

The Physical Quantity which has magnitude as well as specified direction is called Vector Quantity.

Eg- Acceleration, Momentum, Impulse, Velocity, Force etc.

Representation of a Vector Quantity :-

$\vec{a}$ $\vec{F}$ (Magnitude $\vec{F} = |\vec{F}|$)

Types of Vectors:-

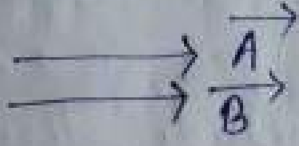
(i) Null vector — $|\vec{A}| = 0$

(ii) Unit Vector — $|\vec{A}| = 1$ $(\hat{A})$ (A cap)

$$\Rightarrow \vec{A} = |\vec{A}| \times \hat{A} \Rightarrow \hat{A} = \frac{\vec{A}}{|\vec{A}|}$$

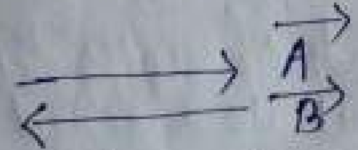
(iii) Proper vector — $|\vec{A}| \neq 0$

(iv) Equal Vector



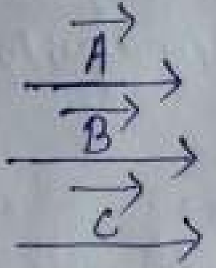
$= |\vec{A}| = |\vec{B}|$

(v) Negative vector



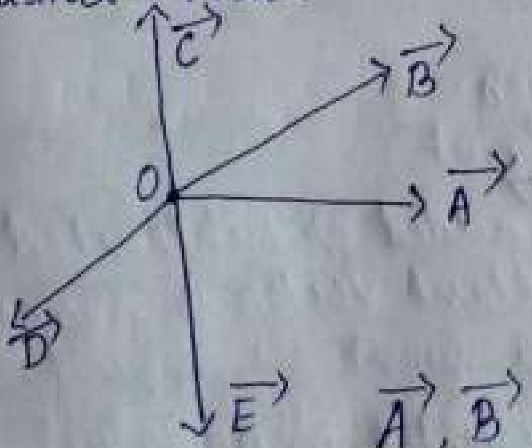
$\vec{A} = -\vec{B}$ or $\vec{B} = -\vec{A}$

(vi) Parallel Vector.



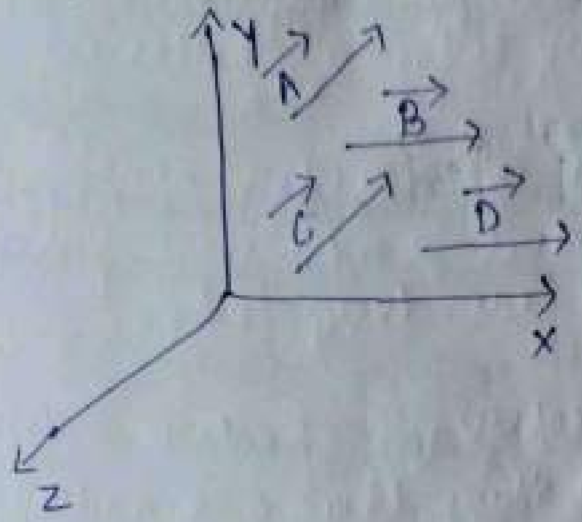
$\theta = 0°$

(vii) Coinitial Vector.

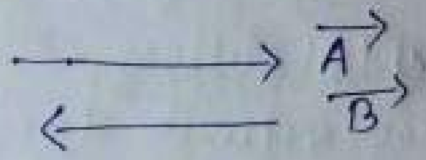


$\vec{A}, \vec{B}, \vec{C}, \vec{D}, \vec{E}$ are Coinitial vector because they were drawn from same initial point O

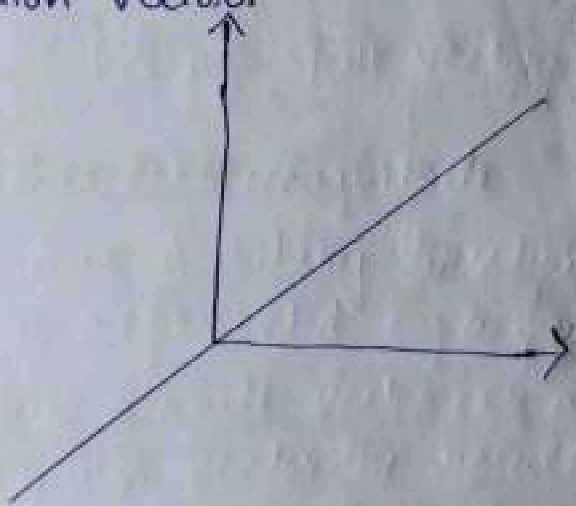
viii) Co-planer vector



(ix) Anti-parallel vectors



(x) Position vectors.



1. Null Vector :- The Vector whose magnitude is zero is called null vector.

If $|\vec{A}| = 0$

If A vector Magnitude is Zero than $\vec{A}$ is called null vector or Zero Vector.

2. Unit Vector :- The Vector whose magnitude is Unity is called Unit vector.

If $|\vec{A}| = 1$ Then $\vec{A}$ vector is called Unit Vector.

The Unit Vector in the direction of Vector $\vec{A}$ is represented by $\hat{A}$ (A cap)

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

3. Equal Vectors :- The Vectors having same magnitude and same direction are called Equal Vectors.

4. Negative Vectors :- The Vector having Same magnitude and opposite direction to the Given vector is called Negative vectors.

5. Parallel vectors :- The Vectors having same direction irrespectively of their magnitude are called parallel vectors.

6. Co-Intial vectors :- The vectors having same intial point irrespective of their magnitude and direction are called co-Intial vectors

7. Co-planer vectors :- The vectors lying in a same plane irrespective of their magnitude, direction and Intial point are called co-planner vectors.

8. Position vector :- The vector which specifies the position of a point with respect to a fixed point is called position vector.

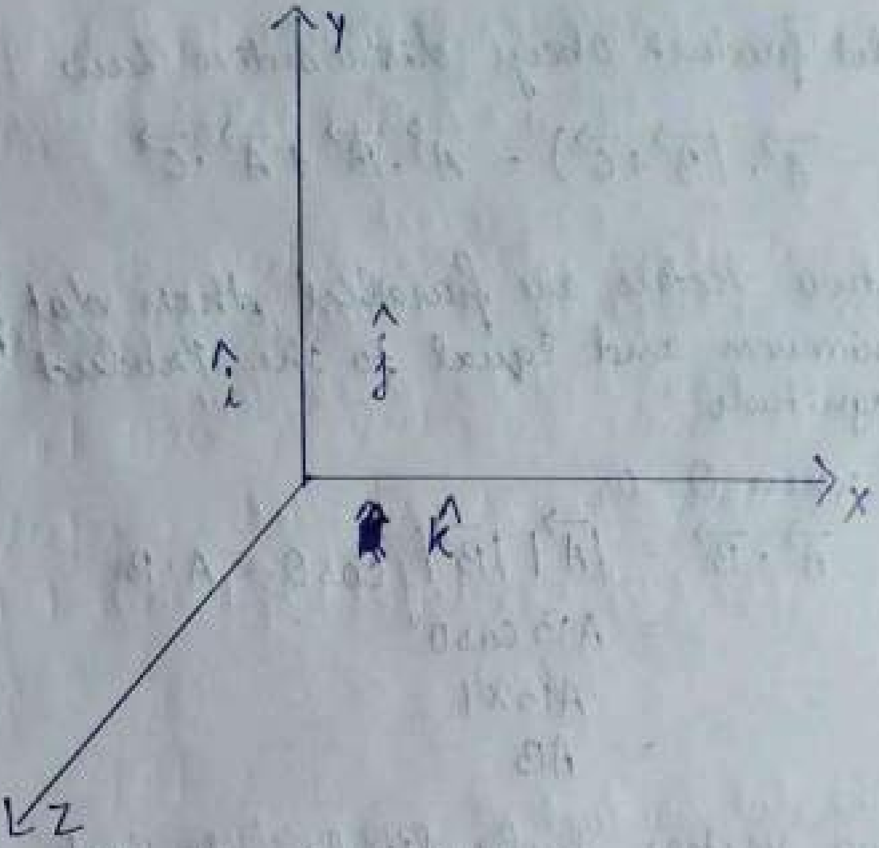
9. Anti-parallel vectors :- The vectors having in opposite direction irrespective of their magnitude are called Antiparallel vectors.

Properties of Null vectors :-

(*) It has Zero magnitude
(*) It has Arbitary direction.
(*) It is represented by a point
(*) when a null vector is added or subtracted from a Given vector the resultant vector is same as the Given vector.
(*) Dot product of a null vector with any vector is always Zero
(*) Cross product of a null vector with any other vector is also a null vector

Orthogonal Unit Vectors :-

The Unit Vectors which are perpendicular to Each other is known as orthogonal Unit Vectors.



Properties of Dot product

$$\vec{A} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$$

$$\vec{B} = b_x\hat{i} + b_y\hat{j} + b_z\hat{k}$$

$$\vec{A}\cdot\vec{B} = (a_x\hat{i} + a_y\hat{j} + a_z\hat{k})\cdot(b_x\hat{i} + b_y\hat{j} + b_z\hat{k})$$

$$\Rightarrow a_x\hat{i}\cdot b_x\hat{i} + a_x\hat{i}\cdot b_y\hat{j} + a_x\hat{i}\cdot b_z\hat{k} + a_y\hat{j}\cdot b_x\hat{i} +$$
$$a_y\hat{j}\cdot b_y\hat{j}\cdot b_z\hat{k}\cdot a_z\hat{k}\cdot b_x\hat{j} + B_z\hat{k}\cdot b_y\hat{j} + A_z\hat{k}\cdot B_z\hat{k}$$

$$= a_xb_x + 0 + 0 + 0 + a_yb_y + 0 + 0 + 0 + a_z + b_z$$

$$= a_xb_x + a_yb_y + a_zb_z \quad (\hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\cdot\hat{k} = 1)$$

(ii) The Dot product Obeys commulatives law

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

(iii) The dot product obeys distributive law

$$\vec{A} \cdot (\vec{B} + \vec{C}) = \vec{A} \cdot \vec{B} + \vec{A} \cdot \vec{C}$$

(iii) If two vectors are parallel their dot product is maximum and Equal to the Product of their magnitude

when $\theta = 0$

$$\vec{A} \cdot \vec{B} = |\vec{A}| \, |\vec{B}| \cos\theta = A \cdot B$$

$$= AB \cos 0^\circ$$

$$= AB \times 1$$

$$= AB$$

(iv) If Two vectors perpendicular to Each other their dot product is Zero

when $\theta = 90^\circ$

$$\vec{A} \cdot \vec{B} = AB \cdot \cos 90^\circ$$

$$AB \times 0$$

$$= 0$$

(v) If two vectors acting at a point are opposite to Each other. their dot product is the product of their magnitude with a negative sign

when $\theta = 180^\circ$

$$\vec{A} \cdot \vec{B} = AB \cos 180^\circ$$

$$= \vec{A} \cdot \vec{B} = -AB.$$

(vi) If two vectors are Equal vectors their dot product is $\vec{A} \cdot \vec{B}$

$$\text{when } \theta = 0 \quad \vec{A} \cdot \vec{B} = |\vec{A}| \, |\vec{A}| \cos\theta$$
$$= A^2 \times 1$$
$$= A^2$$

(vii) If the Angle between the Two vectors is acute angle their dot product is (+ve)

(viii) If the Angle between the Two vectors is obtuse their dot product is (−ve)

(ix) If ideal vector is multiplies by a Scalar k then the dot product is

$$(k\vec{A}) \cdot \vec{B} = k(\vec{A} \cdot \vec{B}) = kAB\cos\theta$$
$$\vec{A} \cdot (k\vec{B}) = k(\vec{A} \cdot \vec{B}) = kAB\cos\theta$$

(x) If $\vec{i} \cdot \vec{j}$ and $\vec{k}$ are the Unit vector along the axis of a contain system.

$$\vec{i} \cdot \vec{i} = \vec{j} \cdot \vec{j} = \vec{k} \cdot \vec{k} = 1$$
$$\vec{i} \cdot \vec{i} = \vec{j} \cdot \vec{k} = \vec{k} \cdot \vec{j} = 0$$

(xi) If $\vec{A} = A_x\vec{i} + A_y\vec{j} + A_z\vec{k}$

$$\vec{A} \cdot \vec{A} \left(A_x\hat{i} + A_y\hat{j} + A_z\hat{k} \right) \cdot \left(A_x\hat{i} + A_y\hat{j} + A_z\hat{k} \right)$$
$$= \left(A_x^2 + A_y^2 + A_z^2 \right)$$

(xiii)

If $\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$

$\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$

$$\vec{A}\cdot\vec{B} = (A_x\hat{i} + A_y\hat{j} + A_z\hat{k})(B_x\hat{i} + B_y\hat{j} + B_z\hat{k})$$

$$= A_xB_x + A_yB_y + A_zB_z$$

Q1) A Force $6\hat{i}+12\hat{j}+8\hat{k}$ Produces a displacement of $2\hat{i}+3\hat{j}+5\hat{k}$ Find the work done.

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

$$= (6\hat{i}+12\hat{j}+8\hat{k})\cdot(2\hat{i}+3\hat{j}+5\hat{k})$$

$$= 88 \text{ (Ans)}$$

2) Find the dot product of Two vectors

$\vec{A} = 2\hat{i}+5\hat{j}+7\hat{k}$

$\vec{B} = 3\hat{i}+8\hat{j}-4\hat{k}$

$$\vec{A}\cdot\vec{B} = (2\hat{i}+5\hat{j}+7\hat{k})\cdot(3\hat{i}+8\hat{j}-4\hat{k})$$

$$= 18 \text{ Ans)}$$

3) $\vec{A} = \hat{i} + \cdot\hat{j} + 2\hat{k}$

$\vec{B} = 2\hat{i}+\hat{j}+\hat{k}$ are Two vectors Find. the Angle.

$$|\vec{A}| = \sqrt{(1)^2+(-1)^2+(2)^2}$$

$$= \sqrt{1+1+4} = \sqrt{6}$$

$$|\vec{B}| \sqrt{2^2+1^2+1^2}$$
$$= \sqrt{6}$$

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

$$\cos\theta = \frac{\vec{A} \cdot \vec{B}}{|\vec{A}|\ |\vec{B}|}$$

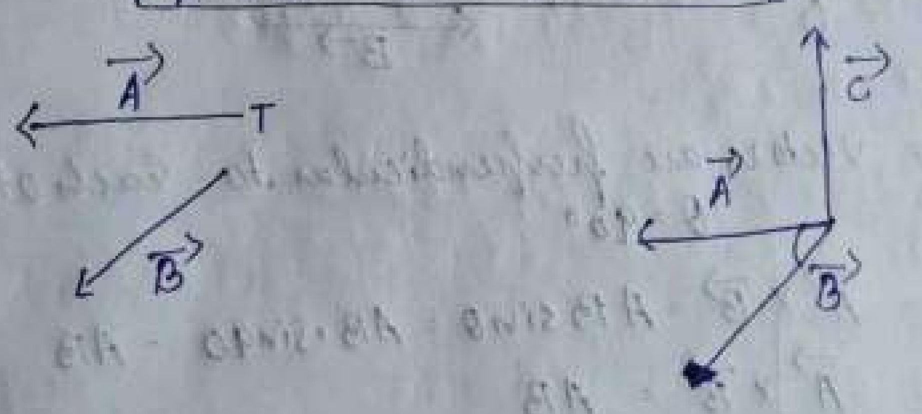
$$= \frac{3}{\sqrt{6}\cdot\sqrt{6}} = \frac{3}{6} = \frac{1}{2} \quad \cos 60^\circ$$

09|12|21

Cross product (Vector Product)

Cross product between Two vector $\vec{A}$ and $\vec{B}$ is defined as a single vector $\vec{C}$ whose magnitude is Equal to the product of their Individual magnitude of two vectors and sine of the Smaller angle between them and it is directed along the normal to the plane containing $\vec{A}$ and $\vec{B}$

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



Right Hand Thumb Rule:-

when the Right hand is placed at the common tail between two vectors, the curlded fingers shows the ~~reto~~ rotation from $\vec{A}$ to $\vec{B}$ and the Extended Thumb gives the direction of cross product.

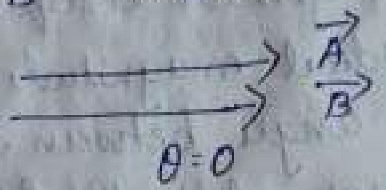
Properties of Cross product :-

1. $\vec{A} \times \vec{B} \neq \vec{B} \times \vec{A}$

2. $\vec{A} \times (\vec{B} + \vec{C}) = \vec{A} \times \vec{B} + \vec{A} \times \vec{C}$

3. when Two vectors are parallel

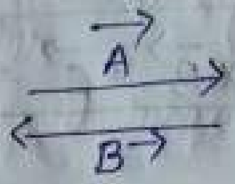
$$\vec{A} \times \vec{B} = AB \sin\theta = 0$$



4. when Two vectors are Anti parallel

$$\theta = 190^\circ$$

$$\vec{A} \times \vec{B} = AB \sin\theta = 0$$



5. when Two vectors are perpendicular to Each other

$$\theta = 90^\circ$$

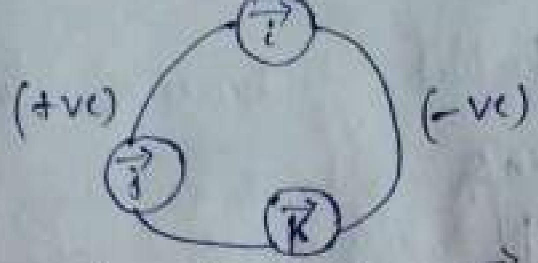
$$\vec{A} \times \vec{B} = AB \sin\theta = AB \cdot \sin 90 = AB$$

$$\vec{A} \times \vec{B} = AB$$

6. $\vec{A} \times \vec{A} = |A| \cdot |A| \sin\theta = 0$

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

7)



$\vec{i} \times \vec{j} = \vec{k}$ | $\vec{j} \times \vec{i} = -\vec{k}$

$\vec{i} \times \vec{k} = \vec{j}$ | $\vec{k} \times \vec{i} = -\vec{j}$

$\vec{k} \times \vec{j} = \vec{i}$ | $\vec{j} \times \vec{k} = -\vec{i}$

8) $\vec{A} = \vec{A_x}\vec{i} + \vec{A_y}\vec{j} + \vec{A_z}\vec{k}$

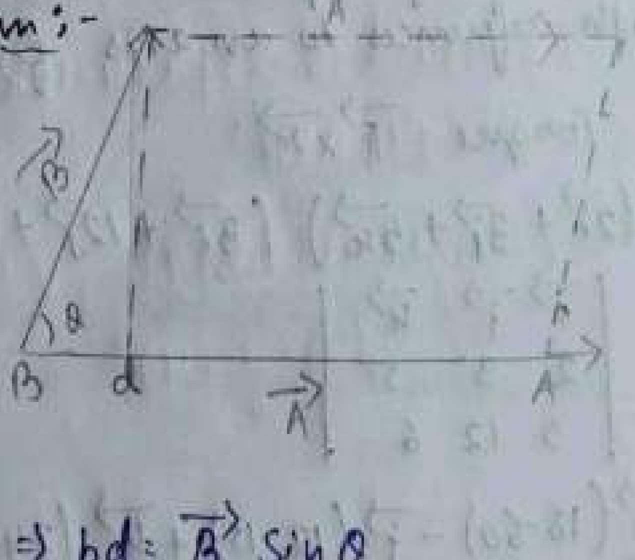
$\vec{B} = \vec{B_x}\vec{i} + \vec{B_y}\vec{j} + \vec{B_z}\vec{k}$

$\vec{A} \times \vec{B} = (\vec{A_x}\vec{i} + \vec{A_y}\vec{j} + \vec{A_z}\vec{k})(\vec{B_x}\vec{i} + \vec{B_y}\vec{j} + \vec{B_z}\vec{k})$

$$\begin{vmatrix} i & j & k \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$= i(A_y B_z - A_x B_y) - j(B_z \times A_y - A_z B_x) + k (A_x B_y - A_y \cdot B_x)$

Area of a Parallelogram :-



Base × Height

= oa × bd.

In ΔOBD

$\sin\theta = \frac{bd}{ob} = \frac{bd}{\vec{B}} \Rightarrow bd = \vec{B}\sin\theta$

$\Rightarrow \vec{A} = B\sin\theta$

$\Rightarrow |\vec{A} \times \vec{B}|$

2. Area of a Triangle

$$= \frac{1}{2} |\vec{A} \times \vec{B}|$$

$$= \vec{A} \times \vec{B} \sin\theta$$

$$= |\vec{A} \times \vec{B}|$$

11/12/21

1) If $\vec{A} = 2\vec{i} + 3\vec{j} + 5\vec{k}$

$\vec{B} = 3\vec{i} - 4\vec{j} + 5\vec{k}$

find $\vec{A} \times \vec{B}$

(Ans) $\vec{A} \times \vec{B} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 2 & 3 & 5 \\ 3 & -4 & 5 \end{vmatrix}$

$= \vec{i}\,(15+20) - \vec{j}\,(10-15) + \vec{k}\,(-8-9)$

$= 35\vec{i} + 5\vec{j} - 17\vec{k}$

2) A force $\vec{F}$ of $(2\vec{i} + 3\vec{j} + 5\vec{k})$ newtons act on a object having a position vector of $\vec{r}\,(3\vec{i} + 12\vec{j} + 6\vec{k})$ with references to an axis find Torque

Ans) Torque $= \vec{F} \times \vec{r}$

$T = (2\vec{i} + 3\vec{j} + 5\vec{k})\,(3\vec{i} + 12\vec{j} + 6\vec{k}$

$T = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 2 & 3 & 5 \\ 3 & 12 & 6 \end{vmatrix}$

$= \vec{i}\,(18-60) - \vec{j}\,(12-15) + \vec{k}\,(24-9)$

$= -42\vec{i} + (-3\vec{j}) + 15\vec{k}$

$= 42\vec{i} - 3\vec{j} - 15\vec{k}$

3) Find the Unit Vector in the direction of
$\vec{A} = 3\vec{i} + 4\vec{j}$

(Ans) $|\vec{A}| = \sqrt{(3)^2 + (4)^2}$

$\sqrt{9+16} = \sqrt{25} = 5$

$\hat{A} = \dfrac{3\vec{i} + 4\vec{j}}{5}$

4) Find the area of the Parallelogram formed by two vectors $\vec{A} = 2\vec{i} + 3\vec{j} + \vec{k}$ and
$\vec{B} = \vec{i} - 2\vec{j} + 2\vec{k}$ are two adjacent

(Ans) $\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 2 & 3 & 1 \\ 1 & -2 & 2 \end{vmatrix}$

$\Rightarrow (6+2)\vec{i} - (4-1)\vec{j} + (-4-3)\vec{k}$
$\Rightarrow 8\vec{i} - 3\vec{j} - 7\vec{k}$

$|\vec{A} \times \vec{B}| = \sqrt{64+9+49}$
$= \sqrt{64+58}$
$= \sqrt{122}$
$= 11.04$ Sq unit (Ans)

5) The magnitude of cross product is equal to $\frac{1}{\sqrt{2}}$ times the dot product. Find the angle between the Two Vectors.

Magnitude of cross product = $\frac{1}{\sqrt{2}}$ times of dot product

$$|\vec{A} \times \vec{B}| = \frac{1}{\sqrt{2}} |\vec{A} \cdot \vec{B}|$$

$$|\vec{A}|\,|\vec{B}| \sin\theta = \frac{1}{\sqrt{2}} |\vec{A}|\,|\vec{B}| \cos\theta$$

$$\frac{\sin\theta}{\cos\theta} = \frac{1}{\sqrt{2}} \Rightarrow \tan\theta = \frac{1}{\sqrt{2}}$$

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

$$= \theta = 30^\circ$$

6) If $\vec{A} = 2\vec{i} + \vec{j} + 2\vec{k}$

$\vec{B} = \vec{i} + 2\vec{j} + 3\vec{k}$

From the Two side of a Triangle find the area formed by them.

(Ans)
$$\begin{vmatrix} i & j & k \\ 2 & 1 & 2 \\ 1 & 2 & 3 \end{vmatrix}$$

$$= (3-4)i - (6-2)j + (4-1)k$$

$$= -1i - 4j + 3k$$

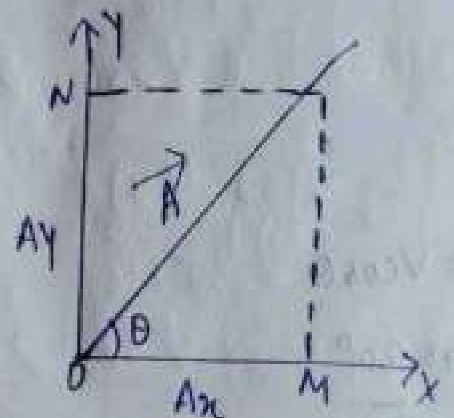
$$= \sqrt{\frac{(-1)^2 + (-4)^2 + (3)^2}{2}} = \sqrt{\frac{1+16+3}{2}} = \frac{\sqrt{26}}{2}$$

$$= 2.54 \text{ unit}$$

13/12/21

Resolution of vectors :-

Resolution of vectors is the Process of obtaining components of vectors, which when added by the laws of addition of vectors gives the Given vector.



In ΔOPM

$\cos\theta = \frac{OM}{OP} = \frac{Ax}{A}$

$\boxed{Ax = A\cos\theta}$

$\sin\theta = \frac{PM}{OP} = \frac{AY}{A}$

$\boxed{AY = A\sin\theta}$

Ax and AY are Scalar Components of a Vector.

Vector Components :-

$\overrightarrow{OP} = \overrightarrow{OM} + \overrightarrow{PM}$

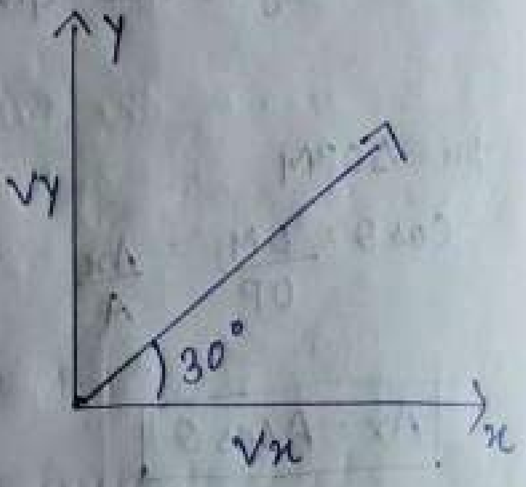
$\vec{A} = \overrightarrow{Ax} + \overrightarrow{AY}$

$\tan\theta = \frac{PM}{OM} = \frac{AY}{AX}$

$\boxed{\theta = \tan^{-1}\frac{AY}{AX}}$

$$\vec{A} = \sqrt{(Ax)^2 + (Ay)^2}$$

1. Find the components of a velocity of 8 m/s when one of its components makes an angle of 30° with the resultant.



$Vx = V\cos\theta$

$V\cos 30°$

$\overset{4}{\cancel{8}} \times \frac{\sqrt{3}}{\cancel{2}}$

$Vx = 4\sqrt{3}$ m/s

$Vy = V\sin\theta$

$= V\sin 30°$

$= 8 \times \frac{1}{2}$

$Vy = 4$ m/s

$$\vec{A} = \sqrt{(Ax)^2 + (Ay)^2}$$

$$= \sqrt{(4\sqrt{3})^2 + (4)^2}$$

2) Two Forces Equal in Magnitude have magnitude of their resultant Equal to Either Find the Angle Between them.

(Ans) $F_1 = F_2 = F = R$

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1 F_2 \cos\theta}$$

$$= \sqrt{F^2 + F^2 + 2F^2 \cos\theta}$$

$$= \sqrt{2F^2 + 2F^2 \cos\theta}$$

$$F = \sqrt{2F^2(1+\cos\theta)}$$

$$F^2 = 2F^2(1+\cos\theta)$$

$$\cos\theta = \frac{-1}{2} \quad \theta = 120° \text{ (Ans)}$$

3. Resultant of Two Forces equal in magnitude at right angles to each other in 1414N. Find the magnitude of Each force.

$F_1 = F_2 = F$

$R = F = 1414N$

$$F = \sqrt{F_1^2 + F_1^2 + 2F_1 . F_2 \cos\theta}$$

$$F = \sqrt{F^2 + F^2 + 2F^2 \cos 90°}$$

$$1414 = \sqrt{2F^2 + 2F^2 \cos\theta}$$

$F = 999.84N$ (Ans)

4) If $\vec{P}$ vector $= 3\vec{i} - 4\vec{j}$

$\vec{Q} = 6\vec{i} + 4\vec{j}$

Find the magnitude of $\vec{P}$ and $\vec{Q}$

(Ans) $|\vec{P}| = \sqrt{(3)^2 + (-4)^2}$

$= \sqrt{9+16}$

$= \sqrt{25} = 5$ (Ans)

$|\vec{Q}| = \sqrt{(6)^2 + (4)^2}$

$= \sqrt{36+16}$

$= \sqrt{52} = 2\sqrt{13}$ (Ans)

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KINEMATICS

Science

↓

Physics

↓

Mechanics

Static | kinematics | Dynamics

(*) <u>Static</u> - It is the Branch of Physics which deals with the study of object is at rest.

(*) <u>Kinematics</u> - It is the Branch of Physics which deals with the ~~motion~~ only description of motion of Bodies.

(*) <u>Dynamics</u> - It is the Branch of Physics which deals with the motion of Bodies along with the cause of motion.

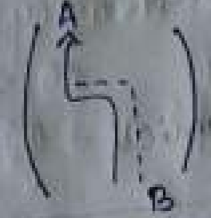
(*) <u>Rest</u> - A body is said to be at rest if it does not change its Position which respect to another body or surroundings.

(*) <u>Motion</u> - A body is said to be in motion if it changes its postion with respect to another body and Surroundings.

Types of Motion :-

1. Linear Motion / Rectilinear motion :- 

If a Body moves in a straight line then it is called Linear motion.

2. Curvilinear Motion :- 

If a Body Moves in a curve Path then it is called Curvlinear Motion.

3. Rotational Motion :-

If a Body moves in a such a way that it's distance from the fixed position remains constant then it is called Rotational Motion.

4. Oscillatory Motion :- 

To and fro motion is called Oscillary motion

5. Periodic Motion :-

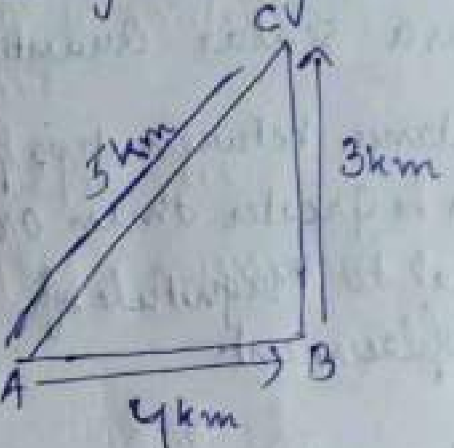
The motion which repeats itself after an Equal Interval of time is called Perodic motion

6. Non Perodic Motion :-

The motion which does not repeat itself after an Equal Interval of time is called A perodic motion / Non-perodic Motion.

Distance (d) :-

The Total ~~the~~ length of the actual path Travelled by a body is called Distance Travelled by a body.



Unit - m or cm

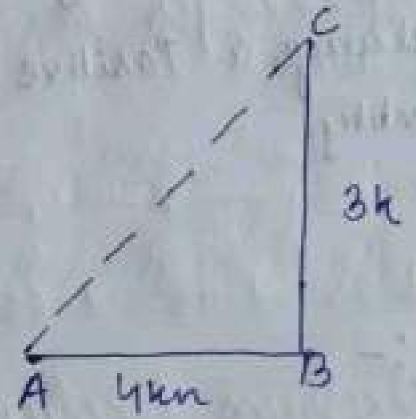
Distance (d) = 4km + 3km + 5km
= 12km

It is a Scalar Quantity.

Displacement (s) :-

The Shortest distance Between the Initial position and final position of a Body is called displacement

It is a vector Quantity



The Shortest Path is AC

so $(AC)^2 = (AB)^2 + (BC)^2$

$(AC)^2 = (4)^2 + (3)^2$

$AC = \sqrt{16+9}$

$= \sqrt{25} = 5\ km.$

Difference Between Distance and Displacement

Distance (d)	Displacement (s)
It is a Scalar Quantity	1. It is a vector Quantity.
Distance between two points can be Greater than or Equal to Magnitude of displacement.	2. Magnitude of displacement between two points is always less than or Equal to the distance Between them.
3. Distance Between two points depends upon the Path followed.	3. It is Independent of the Path followed.
4. It is added algebrically	4. It is added vectorially
5. For a Body in motion Its value is never zero	5. For a Body in motion. It may be Zero value.
6. It is always a Positive Quantity.	6. It can have positive and negative value.

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Speed :-

Speed of a Body is defined as the distance covered by its per unit Second.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Unit - M/S · Speed $\frac{70}{10}$

Dimension $[M^0L^1T^{-1}]$

Velocity :-

The rate of change of displacement is called velocity.

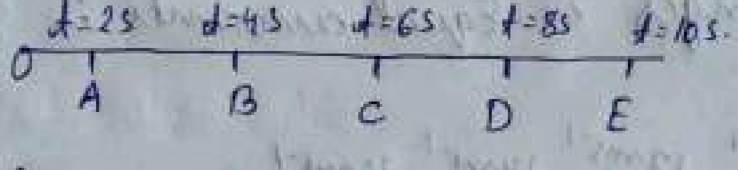
$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

It is a vector Quantity.

Dimension = $[M^0L^1T^{-1}]$

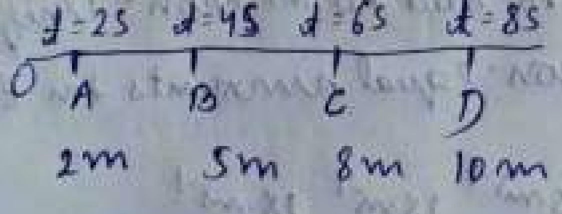
Uniform Velocity :-

Velocity of a Body is said to be uniform if it maintain a constant displacement with Equal Interval of time.



Non-Uniform Velocity :-

Velocity of a Body is said to be Non-Uniform If it does not maintain constant displacement in Equal Interval of time.



Acceleration :-

The rate of change of velocity is called acceleration

$$\text{Acceleration} = \frac{\text{Velocity}}{\text{Time}}$$

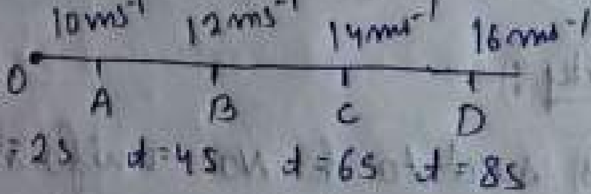
Unit - m/s

Dimension $[M^0 L^1 T^{-2}]$

$$\boxed{a = \frac{v-u}{t}}$$

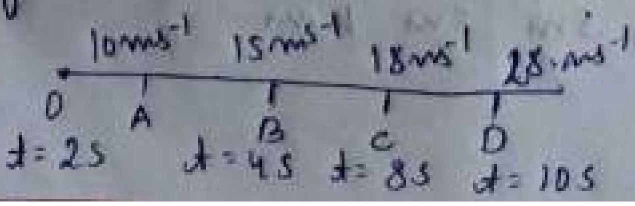
Uniform Acceleration :-

Acceleration of a Body is said to be Uniform if velocity changes in Equal amounts in Interval of time.



Non-Uniform Acceleration :-

Acceleration of a Body is said to be non-Uniform if velocity Changes in non-equal amounts in Equal Interval of time



Equation of Kinematics :-

1. $\vec{v} = \vec{u} + \vec{a}t$
2. $\vec{S} = \vec{u}t + \frac{1}{2}\vec{a}t^2$
3. $\vec{v}^2 - \vec{u}^2 = 2\vec{a}\vec{s}$
4. $\vec{S_{nth}} = \vec{u} + \frac{\vec{a}}{2}(2n-1)$

Q1) A Bus decreases its speed from $80ms^{-1}$ to $60ms^{-1}$ in 5s Find the acceleration of the Bus.

Ans) $a = \frac{v-u}{t}$

Intial velocity = $V = 80m/s$

Final Velocity = $V_f = 60m/s$

$t = 5s$

$a = \frac{V_f - V}{t} = \frac{60-80}{5} = \frac{-20}{5}$ $a = -4m/s^2$ (Ans)

2) A railway train takes 8 hours to cover a distance of 400km between 2 stations. What is the speed of the Train assuming it to be Uniform.

Ans) Distance $x = 400km = 400 \times 10^3 = 4 \times 10^5 m$.

time $t = 8hr$

Speed $= \frac{Distance}{Time} = \frac{4 \times 10^5}{8 \times 3600} = 13.89 ms^{-1}$ (Ans)

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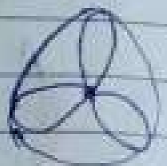
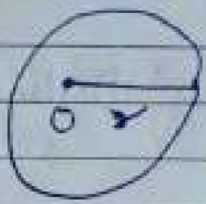
Circular Motion

If a body moves in a Such a way that it maintained a constant distance from another point

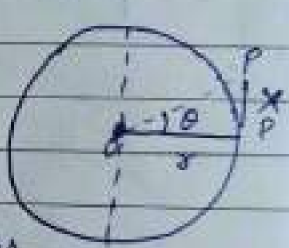
The centre Point is 'O' and distance from the centre point is called radius of the circle





Angular displacement (θ)

Angular displacement of a Particle in Uniform circular motion is defined as the Angle turned by its radius vector and its unit is radian.



$$\theta = \frac{Arc}{Radius} = \frac{x}{r} = \boxed{x = r\theta}$$

Angular Velocity (ω)

Angular Velocity of a Particle in Uniform circular motion is rate of change of angular displacement with time.

Angular velocity (ω) = $\frac{\text{Angular displacement}}{\text{time}}$

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

Relation Between Linear Velocity and Angular Velocity :-

Linear displacement = x

Linear velocity = $\frac{\text{Linear displacement}}{\text{time}}$

$$v = \frac{x}{t} = \frac{r\theta}{t}$$

$\theta = \frac{x}{r}$

But $x = r\theta$

$v = r\omega$

$\boxed{\text{Linear Velocity} = \text{radius} \times \text{Angular Velocity}}$

Angular Frequency

Angular velocity = $\frac{\text{Angular displacement}}{\text{time}}$

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

For complete revolution of a circle / radius of a circle.

$$\frac{\theta = 2\pi}{t = T}$$

$\theta = 2\pi$, $t = T$

$$\omega = \frac{2\pi}{t}$$

$$\boxed{\omega = 2\pi f}$$

<u>Angular acceleration :-</u> (α)

Angular acceleration of body is defined as rate of change of angular velocity with time.

Angular acceleration = $\frac{\text{Angular velocity}}{\text{Time}}$

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

$$\frac{d}{dt}\left(\frac{d\theta}{dt}\right) = \frac{d^2\theta}{dt^2}$$

Relation Between Linear acceleration and Angular Acceleration :-

Angular acceleration $= \frac{d\omega}{dt}$

$\frac{dv}{dt} \cdot \frac{1}{r}$

$\alpha = \frac{a}{r}$

or $\boxed{a = r\alpha}$

[Linear acceleration = radius x Angular Acceleration.]

Speed $= \frac{2\pi r}{t}$

1. An Ant is travelling in a circle of radius. 21m with a speed of ~~...~~ $11 ms^{-1}$. Its motion is a Uniform circular motion. Find the time taken to cover half a round.

Sol Distance $= \frac{2\pi r}{2} = \pi r$

$r = 21m$

speed $= 11 m/s$

Time $= \frac{\text{Distance}}{\text{Speed}} = \frac{\pi r}{11} = \frac{\pi \times 21}{11}$

$= 6s$ (Ans)

23/12/21

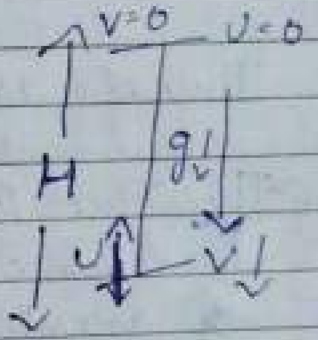
Physics

Projectile Motion :-

A projectile is an object that is thrown into air and moves the Influence of Gravity alone.

Example - 1) A cricket ball fall into Ground.
2) A bag falls from an aeroplane.

Verticle Projection



1. Maximum height
2. Time of ascent
3. Time of descent
4. Time of flight
5. Velocity on which it reaches the Ground.

Maximum Height (H) :-

It is the Maximum distance travelled by a vertically Projected body before its velocity becomes Zero is called Maximum height (H)

Conditions

Initial velocity = u
Acceleration due to gravity $a = -g$
Final velocity $v = 0$
Distance = H

Kinematics Equation.

$$v^2 - u^2 = 2as$$
$$0 - u^2 = 2(-g)H$$
$$= -u^2 = -2gH$$
$$= u^2 = 2gH \text{ or } \boxed{H = \frac{u^2}{2g}} \text{ or } \boxed{H \propto u^2}$$

2) Time of ascent (t_1) :-

The Time Taken by a vertically Projected body to reach the Maximum height is called time of ascent.

Conditions

Initial velocity = u
Acceleration due to Gravity $a = -g$
Time = t_1
Final velocity $v = 0$

Using kinematic Equation :-

$V = u + at$
$0 = V - g t_1$
$-u = -g t_1$
$V = g t_1$

$$\boxed{t_1 = \frac{u}{g}}$$

3) <u>Time of descent (t_2)</u>

The time taken by a vertically projected body to fall on the ground is called time of descent

<u>condition</u>

Intial velocity $U = 0$
Acceleration due to Gravity $a = g$
Final velocity $= V$
Distance $= h = \frac{V^2}{2g}$

<u>Using kinematics Equation</u>:-

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

$\frac{V^2}{2g} = 0 \times t + \frac{1}{2} g t_2^2$

$\Rightarrow \frac{V^2}{2g} = \frac{1}{2} g t_2^2 \Rightarrow t_2 = \frac{V^2}{g^2} \Rightarrow \boxed{t_2 = \frac{u}{g}}$

4. Time of flight :-

The time interval between the time of Projection and the time of Striking on ground is called time of flight.

Conditions

$$T = t_1 + t_2$$

$$T = \frac{u}{g} + \frac{u}{g} \quad \boxed{T = \frac{2u}{g}}$$

5) Velocity on which it reaches the Ground.

It is the velocity with which a body reaches the ground.

Conditions

Initial velocity $U = 0$
Acceleration due to gravity $a = g$
Final velocity $= V$
Height(S) $H = \frac{U^2}{2g}$

Using kinematics Equation

$$V^2 - u^2 = 2as$$

$$V^2 - 0 = 2 \times g \times \frac{U^2}{2g} \Rightarrow V^2 = U^2 \Rightarrow \boxed{V = U}$$

1. A Body projected ~~a~~ vertically upwards from the ground reaches a maximum height 44.1 m and falls to the Ground. Find the time taken by the body to reach the ground.

Height = 44.1

Acceleration due to gravity = $9.8 ms^{-2}$

$T = t_1 + t_2$

$T = \frac{u}{g} + \frac{u}{g} = \frac{u}{9.8} + \frac{u}{9.8}$

$H = \frac{U^2}{2g}$

$= 44.1 = \frac{u^2}{2 \times 9.8}$

$= U^2 = 44.1 \times 2 \times 9.8$

$U = \sqrt{44.1 \times 2 \times 9.8}$

$U = 29.4\ ms^{-1}$

Time of Flight

$= T = \frac{2u}{g}$

$= T = \frac{2 \times 29.4}{9.8}$

$= 6s$ (Ans)

2. A ball is dropped from the Top of a building and its found to reach the ground in 4s. Find the height of the Building.

Initial velocity $u = 0$ (a) $g = 9.8$

Time = 4s

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

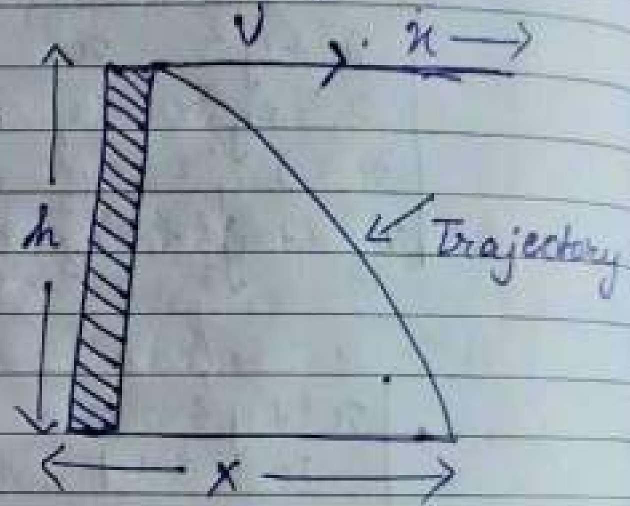
$$s = 0 \times 4 + \frac{1}{2} \times 9.8 \times (4)^2$$

$h = 78.4m$ (Ans)

Physics

24/12/21

Projectile Fired Horizontally :-



1. Equation of Trajectory :-

It is an Equation Connecting horizontal and Vertical distances Travelled by a Projectile

Using Kinematics Equation (Horizontal Equation

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

$$X = u_x t + \frac{1}{2}gt^2$$

$$x = u_x t$$

or $x = ut$ ——— (i)

Vertical Equation :-

Using kinematic Equation

$$S = ut + \frac{1}{2}at^2 \qquad (v_v = 0)$$

$$h = v_v t + \frac{1}{2}gt^2$$

$$h = 0 \times t + \frac{1}{2}gt^2$$

$$h = \frac{1}{2}gt^2 \quad \text{——} \quad (ii)$$

From Equation -(i)

$$x = ut$$

$$\Rightarrow t = \frac{x}{u}$$

Substituting the value of 't' in Eq no (ii)

$$h = \frac{1}{2}g\left(\frac{x}{v}\right)^2 \Rightarrow \frac{1}{2}g\frac{x^2}{v^2}$$

$$\Rightarrow h = \frac{1}{2}g\frac{x^2}{v^2}$$

$$\Rightarrow 2h = g\frac{x^2}{v^2}$$

or $\frac{2v^2}{g}h = x^2$ where $K = \frac{2u^2}{g}$ (which is constant)

$$\boxed{\therefore x^2 = Ky}$$

(Equation of a Parabola)

2. <u>Time of descent</u> :-

It is the time taken by the Projectile to strikes on the Ground is called Time of descent.

Using the Relation

$$S = ut + \frac{1}{2}at^2 \qquad (u_v = 0)$$

$$h = u_v t + \frac{1}{2}gt^2$$

$$h = 0 \times t + \frac{1}{2}gt^2$$

$$\text{Or } h = \frac{1}{2}gt^2$$

$$2h = gt^2$$

$$\text{or } t^2 = \frac{2h}{g}$$

$$\boxed{t = \sqrt{\frac{2h}{g}}}$$

3. <u>Horizontal Range</u> :-

It is the distance travelled by the Projectile in the horizontal direction

$$x = ut$$

$$= u_x t$$

$$= x = \boxed{u_x \times \sqrt{\frac{2h}{g}}}$$

Q1) An Aeroplane Flying Horizontally at a height of 490 m with a velocity of 360 km/hs^{-1}. A bag is dropped to the Jawans on the Ground. How Far from there should the bag be released so that ~~of~~ it falls over them.

Ans) Given :, height = 490 m

$g = 9.8$

$$h = \frac{1}{2} g t^2$$

$$490 = \frac{1}{2} \times 9.8 \times t^2$$

$$t^2 = \frac{490}{4.9} = 100$$

$$t = \sqrt{100} = 10s$$

$$t = 10s.$$

Velocity of an aeroplane $V = 360 \text{ kmh}^{-1}$

$$360 \times \frac{5}{18} = 100 \text{m/s}$$

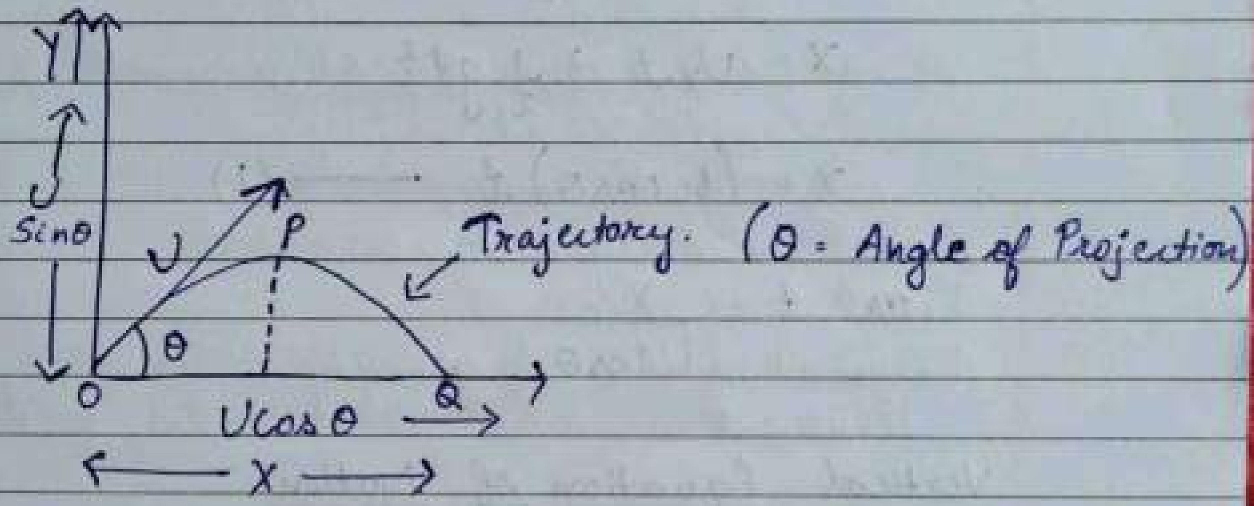
$$x = ut$$

$$x = 100 \times 10 \Rightarrow 1000 \text{m} \Rightarrow 1 \text{km (Ans)}$$

27/12/21

Physics

- Projectile fired at an angle θ with the Horizontal



Resolving U in two components

$U \rightarrow U_x$

$= U\cos\theta$ (This component is Uniform)

$U \rightarrow U_y$
$= U\sin\theta$

1) Equation of Trajectory (Path)

This is the Equation connecting Horizontal and Vertical distances travelled by the Projectile.

Horizonal Equation of motion

Using kinematics Equation

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

$$x = V_x t + \frac{1}{2}gt^2$$

$$x = (u\cos\theta)\,t \quad —— (1)$$

$$\text{or } t = \frac{x}{V\cos\theta}.$$

Vertical Equation of Motion

Using kinematics Equation

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

$$Y = V_y t - \frac{1}{2}gt^2$$

$$= (V\sin\theta)\,t - \frac{1}{2}gt^2 \quad —— (2)$$

Putting Eq-(1) in Eq (2)

$$(V\sin\theta)\cdot\frac{x}{V\cos\theta} - \frac{1}{2}g\left(\frac{x}{V\cos\theta}\right)^2$$

$$= x \tan\theta - \frac{1}{2}\frac{gx^2}{v^2\cos^2\theta}$$

$$\text{Or } x\tan\theta - \frac{gx^2}{2v^2\cos^2\theta}$$

2) Maximum Height (y)

It is the Maximum Position by a projectile in a vertical direction.

Using kinematics Equation

$$= v^2 - u^2 = 2as$$

Intial velocity = $v\sin\theta$

Final velocity = 0

Acceleration due to Gravity = $-g$

Distance = y

$$v^2 - u^2 = 2as$$
$$= 0 - (v\sin\theta)^2 = 2(-g)y$$
$$= v^2\sin^2\theta = -2gy$$

Or $v^2\sin^2\theta = 2gy$ or $\boxed{y = \frac{v^2\sin^2\theta}{2g}}$

3) Time of ascent :-

It is the time taken by the Projectile to rise the highest Point

Using kinematics Equation
$= V = V + at$

Intial velocity $= V\sin\theta$
Final velocity $= 0$
Acceleration due to gravity $= -g$
Time $= t$

$V = u + at$
$0 = V\sin\theta - gt$

or $V\sin\theta = gt$
or $\boxed{t = \frac{V\sin\theta}{g}}$

4) Time of Flight :-

It is the time taken by the Projectile to come back to the Surface of Earth from it was Projected

$$\boxed{T = 2t = \frac{2V\sin\theta}{g}}$$

5) Horizontal Range (x) :-

It is the distance travelled by a Projectile in the horizontal direction

$$X = VT$$

$$= V_x T$$

$$\boxed{X = (v\cos\theta) \times \frac{2(v\sin\theta)}{g}}$$

Or $$X = \frac{V^2 \times 2\sin\theta\cos\theta}{g}$$

$$\boxed{X = \frac{V^2 \sin 2\theta}{g}}$$

6) Condition For Maximum Range :-

For Maximum Range

$$\sin 2\theta = 1$$
$$\sin 2\theta = \sin 90^\circ$$
$$2\theta = 90^\circ$$
$$\boxed{\theta = 45^\circ}$$

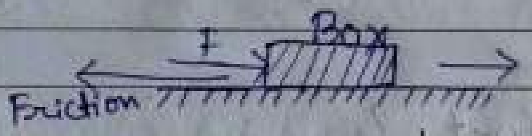
Physcis

3/1/22 Friction

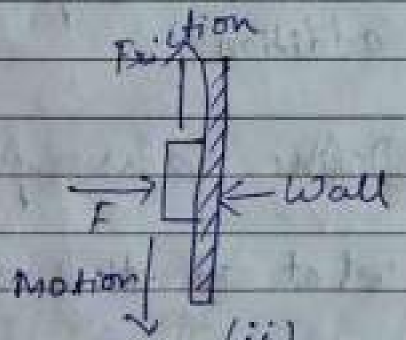
Defination

Friction is a force which is develofied between two Surfaces contact if they relative motion or intention of Motion

1. It always tries to Offose the motion
2. It tries to Offose the intention of motion



(i)



(ii)

Factores

1) Materials in contact
2) Surface Finish
3) Force between the two Surfaces.
4) Lubrication of the ~~Surfaces~~ Substances.

Types of Friction

- Friction
  - Static Friction
    - Auto Adjusting
    - Limiting
  - Kinetic / Dynamic Friction
    - Sliding
    - Rolling

Static Friction (F_s)

The Force of Friction that keeps a Body Stationary against an applied force is called Static friction.

Limiting Friction

The maximum force of friction present when a body just tends to slides over a Surface is Limiting friction

Laws of Static Friction :-

1. Static friction opposes the Tedency of motion of one surface over the other

2. It always act Tangentional to the Surfaces in Contact and opposite to the direction of Applied Force.

3. Static Friction is Independent of the area of the Surfaces in Contact and depends on the Nature of the Surfaces and on their roughness.

4. The Magnitude of Static friction Increases with Increase in applied force and reaches a maximum value called Limiting Friction.

5. The Limiting Friction is directly proporti-onal to the normal reaction between the ~~ki~~ Surfaces in contact

Kinetic Friction / Dynamic Friction.

The Force of Friction that comes into play between the Surfaces in contact when one body slides over a Surface is called kinetic friction It is also called Dynamic Friction

Laws of kinetic Friction :-

1. kinetic Friction Opposes the relative motion between the Two surfaces in contact

2. It is transantical to the Surfaces and acts opposite to the Direction of Motion.

3. kinetic friction depends on the Nature and condition of the Surfaces in contact

4. kinetic friction is Independent of velocities of the Surfaces.

5. The kinetic friction is directly proportional to the normal reaction between the Surface in contact.

Auto Adjusting :-

Friction Automatically adjust The Magnitude Equal to applied Force (upto certain limit) so it is self adjusting

Sliding Friction :- when the point of contact of moving body donot change then it is called Sliding Friction.

Rolling Friction :- when the point of contact is continously changing then it is rolling motion and the Friction produce is called rolling Friction.

Eg- vechile

Advantages of Friction

1. A matchstick is fired due to friction

2. Friction Enables us to hold Objects

3. Friction Between Floor and Feet Enables us to walk on the floor.

4. Friction Enables us to write with pen on paper.

5. Friction Between the Tyres of the veichles and Road enables to drive the veichles

Disadvantages of Friction

1. when we walk Barefooted on wet and polished Floor we will skid due to low friction.
2. Friction reduces the Efficiency of Machine
3. Veichels skid ~~of~~ on road due to Low friction between the Tyres of the veichles and road.
4. Extra Energy is required to overcome the friction among the parts of the machine
5. The heat produced due to friction Between the parts of the Machine, Damages it.

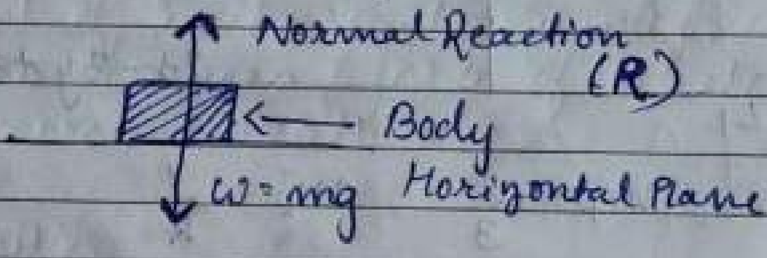
6/1/22 Friction

Friction is a necessary Evil.

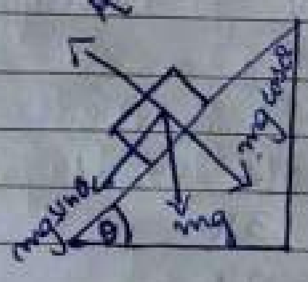
Normal Reaction (R)

when a body is resting or sliding over a Surface, the force Exerted by the Surface Perpendicular to itself on the Body known as normal reaction.

1. Body is on Horizontal plane :-



2. Body is on Inclined plane :-



$\boxed{R = mg\cos\theta}$

3. Laws of Limiting Friction.

1. The Force of Friction tries to oppose the intention of Motion.

2. It depends upon the roughness of the Surface

3. It is directly proportional to the normal Reaction. (R)

4. It does not depends upon the Surface Area.

1. Coefficient of Static Friction :- (μ_s)

The Force of static friction is directly propor-tional to the normal Reaction.

$$F_s \propto R$$

$$F_s = \mu_s R$$

$$\boxed{\mu_s = \frac{F_s}{R}}$$

Coefficient of Static friction is defined as the ratio between force of Static friction to the normal Reaction.

→ It is unitless
→ No Dimension

2. Coefficient of kinetic Friction. (μ_k) :-

The Force of kinetic Friction is directly proportional to the normal Reaction:

$$F_k \propto R$$

$$F_k = \mu_k R$$

$$\boxed{\mu_k = \frac{F_k}{R}}$$

Coefficient of kinetic friction is defined as the Ratio between force of kinetic friction to the normal Reaction.

It is unitles
No Dimension.

3. Coefficient of Rolling Friction. (μ_R)

The Force of Rolling Friction is directly proportional to the Normal Reaction.

$$F_R \propto R$$

$$F_R = \mu_R$$

$$\mu_R = \frac{F_R}{R}$$

Coefficient of rolling Friction is defined as the ratio between force of Rolling friction to the Normal Reaction

→ It is ~~the~~ Unitless
→ No Dimension