

ENGINEERING PHYSICS

LECTURE NOTE



Based on New syllabus (2018-19) circulated by SCTE&VT, Odisha for 1st and 2nd Semester Diploma Engineering courses approved by AICTE, New Delhi

CONTENTS:

1. UNIT-1: Units & Dimensions
2. UNIT-2: Scalars & Vectors
3. UNIT-3: Kinematics
4. UNIT-4: Work & Friction
5. UNIT-5: Gravitation
6. UNIT-6: Oscillations & Waves
7. UNIT-7: Heat & Thermodynamics
8. UNIT-8: Optics
9. UNIT-9: Electrostatic & Magnetostatic
10. UNIT-10: Electric Current
11. UNIT-11: Electromagnetism & Electromagnetic Induction
12. UNIT-12: Modern Physics

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UNIT : 1 UNITS AND DIMENSIONS

Physics

Physics is the study of ^{the} nature and it's laws.

Engineering Physics

Engineering physics deals with use or applications of ^{the} principles of physics in the field of engineering.

What is a event ?

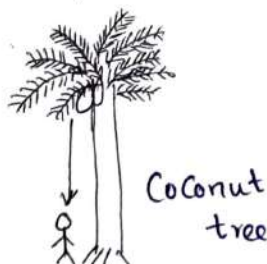
Ans - Examples of event

- (i) falling of fruits from trees.
- (ii) floating of ships in the sea.
- (iii) Rotation of planets around the sun.
- (iv) Thunder and lightening in The sky. etc.

Physical quantities

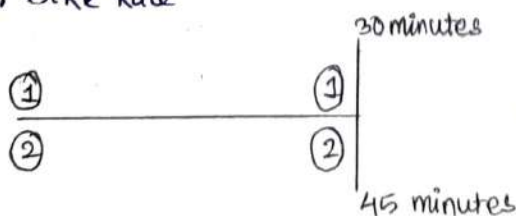
Q. What are the physical quantities ?

Event 1: Falling Fruit from a tree.



force
mass

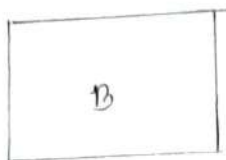
Event 2: Bike Race



winners : ①

Speed

Event 3: weigul lifting



Weight

Definition of Physical quantities

Physical quantities are the quantities used in physics to explain events qualitatively and quantitatively.

Ex - force, mass, speed, weight, time, length, distance, displacement etc.

Types of physical quantities

Physical quantities are of two types :-

- (i) Fundamental physical quantities / base physical quantities
- (ii) Derived physical quantities

Fundamental physical quantities

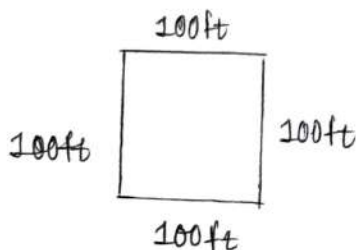
There are 7 number of fundamental physical quantities in physics.

<u>s.no.</u>	<u>Name of fundamental physical quantities</u>	<u>Symbol</u>
01	Mass	m or M
02	length	l or L
03	Time	t or T
04	electric current	i or I
05	Temperature	K
06	Amount of substance	n
07	Luminous intensity	Iv

Derived physical quantities

Derived physical quantities are the quantity which are derived from the fundamental physical quantities either by multiplication and division.

Example 1



$$\begin{aligned}\text{Area of square} &= \text{length} \times \text{length} \\ &= l \times l \\ &= l^2\end{aligned}$$

Example 2

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$= \frac{\text{length}}{\text{time}} = \frac{L}{T}$$

Example 3

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

$$= \frac{\text{length/time}}{\text{time}}$$

$$= \frac{\text{length}}{\text{time} \times \text{time}} = \frac{\text{length}}{(\text{time})^2} = \frac{L}{T^2}$$

Example 4

$$\text{Force} = \text{mass} \times \text{acceleration}$$

$$= \text{mass} \times \frac{\text{length}}{(\text{time})^2}$$

$$= \frac{ML}{T^2}$$

Unit

The quantitative measurement of a physical quantity needs it's unit.

System of units

(i) MKS system

Unit of length is Meter.

Unit of mass is Kilogram.

Unit of time is Second.

(ii) CGS system

Unit of length is Centimeter.

Unit of mass is Gram.

Unit of time is second.

(iii) FPS System

Unit of length is Foot.

Unit of mass is Pound.

Unit of time is Second.

(iv) S.I unit (International System of units)

<u>S.No.</u>	<u>Name of fundamental / Base quantity</u>	<u>SI unit</u>	<u>Symbol of SI unit</u>
01	Length	Meter	m
02	Mass	Kilogram	kg
03	Time	Second	s
04	Electric current	Ampere	A
05	Temperature	Kelvin	K
06	Amount of substance	mole	mol
07	Luminous intensity	Candela	cd

Q. Write base SI units ?

Ans - Base SI units

Meter (m)

Kilogram (kg)

Second (s)

Ampere (A)

Kelvin (K)

mole (mol)

Candela (cd)

Q. Write base quantities ?

Ans - Length

mass

time

electric current

Temperature

Amount of substance

Luminous intensity

Dimensions

The dimensions of a derived physical quantity may be defined as the powers to which its base units must be raised to represent it completely.

'OR'

Dimension of a physical quantity are the powers on the fundamental physical quantities.

Dimensional formula

A dimensional formula is an expression which shows how and which of the fundamental units must be used to express a physical quantity.

Example -

$$(i) \text{ Volume} = \text{length} \times \text{breadth} \times \text{height}$$

$$= L \times L \times L$$

$$= [L^3]$$

$$= [M^0 L^3 T^0]$$

$$(ii) \text{ Acceleration} = \frac{\text{Length}}{(\text{time})^2}$$

$$= \frac{[L]}{[T^2]}$$

$$[T^2]$$

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

Q. Find dimensional formulae of following physical quantities.

(i) Area

(ii) Volume

(iii) speed

(iv) Velocity

(v) Acceleration

(vi) Force

(vii) Pressure

(viii) Work

(ix) stress

(x) Kinetic energy

(xi) Power

Ans -

$$\text{Area} = \text{Length} \times \text{Length}$$

$$= [L \times L]$$

$$= [L^2] = [M^0 L^2 T^0]$$

$$\text{Volume} = \text{Length} \times \text{Length} \times \text{Length}$$

$$= [L \times L \times L]$$

$$= [L^3]$$

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

$$= \frac{\text{Length}}{\text{time}}$$

$$= \left[\frac{L}{T} \right] = [L^1 T^{-1}]$$

$$\text{Acceleration} = \frac{\text{Length}}{(\text{Time})^2}$$

$$= \left[\frac{L}{T^2} \right] = [L^1 T^{-2}]$$

$$\text{Force} = \text{mass} \times \frac{\text{Length}}{(\text{Time})^2}$$

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

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$= \left[\frac{F}{A} \right]$$

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

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

$$\text{Work} = \text{force} \times \text{distance}$$

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

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

$$\text{stress} = \frac{\text{force}}{\text{Area}}$$

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

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

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

$$\text{Kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{velocity})^2$$

$$= \left[\frac{1}{2} \times \text{mass} \times (\text{velocity})^2 \right]$$

$$= [\text{mass} \times (\text{velocity})^2]$$

$$= [M] \times [(L^1 T^{-1})^2]$$

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

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

Note: Pure numbers have no dimensions

$$\text{Power} = \frac{\text{Work}}{\text{time}}$$

$$= \frac{\text{force} \times \text{distance}}{\text{time}}$$

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

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

$$= [M^1 L^2 T^{-3}]$$

$$\text{Note: } [\text{Energy}] = [\text{Work}] = [M^1 L^2 T^{-2}]$$

$$[\text{Pressure}] = [\text{stress}] = [M^1 L^{-1} T^{-2}]$$

Q. What is the principle of Homogeneity?

Ans - This principle states that a physical equation is correct if and only when the dimensional formulae of all the terms in the equation are equal.

Q. Check the correctness of the equation?

$$(i) F = \frac{W}{g} + ma$$

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

$$\left[\frac{W}{g}\right] = \frac{[M^1 L^2 T^{-2}]}{[L^1]}$$

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

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

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

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

Since, all the terms have the same dimensional formula, the equation is correct.

$$(ii) \frac{F}{A} = \frac{W}{SA} + \frac{ms}{T^2}$$

$$\frac{F}{A} = \frac{[M^1 L^1 T^{-2}]}{[L^2]}$$

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

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

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

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

$$= [M^1 L^2 T^{-2}] \times [L^{-3}] = [M^1 L^{-1} T^{-2}]$$

$$\frac{m a}{T^2} = \frac{[M^1] \times [L^1]}{[T^2]}$$

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

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

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

Since, all the terms have different formula the equation is incorrect.

$$(iii) F = \frac{mv^2}{r}$$

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

$$\frac{mv^2}{r} = \frac{[M^1] \times [(L^1 T^{-1})^2]}{[L^1]}$$

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

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

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

Since, all terms have same dimensional formula the equation is correct.

$$(iv) V^2 - u^2 = 2as$$

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

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

$$as = [L^1 T^{-2}] \times [L^1]$$

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

Since, all the terms have same dimensional formula the equation is correct.

$$(v) \quad v - u = at$$

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

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

$$v = [L^1 T^{-1}]$$

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

Since, all terms have same dimensional formula the equation is correct.

$$(vi) \quad a = \left(\frac{F}{m} \right)^{\frac{1}{2}}$$

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

$$\left(\frac{F}{m} \right)^{\frac{1}{2}} = \left(\frac{M^1 L^1 T^{-2}}{M^1} \right)^{\frac{1}{2}}$$

$$= \left([M^1 L^1 T^{-2}] \times [M^{-1}] \right)^{\frac{1}{2}}$$

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

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

Since, all terms have different dimensional formula the equation is incorrect.

$$(vii) \quad s = ut + \frac{1}{2} at^2$$

$$s = [L^1]$$

$$ut = [L^1 T^{-1}] \times [T^1]$$

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

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

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

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

Since, all terms have same dimensional formula the equation is correct.

$$(viii) \quad v = \sqrt{\frac{F_r}{m}}$$

$$v = [L^1 T^{-1}]$$

$$\sqrt{\frac{F_r}{m}} = \left(\frac{[M^1 L^1 T^{-2}] \times [L^1]}{[M^1]} \right)^{\frac{1}{2}}$$

$$= \left(\frac{[M^1 L^2 T^{-2}]}{[M^1]} \right)^{\frac{1}{2}}$$

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

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

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

Since, all terms have same dimensional formula the equation is correct.

UNIT : 2 SCALARS AND VECTORS

Q. Define scalar quantities ?

Ans - Scalar quantities are the physical quantities which have magnitude only.

Magnitude - A number with a unit.

Example -

Magnitude of length are :-

200 meters

2 Km

50 cm

magnitude of weights are:

50 kg

200gm

5 quintal

Examples of scalar quantities

mass, length, time, temperature, work, energy etc.

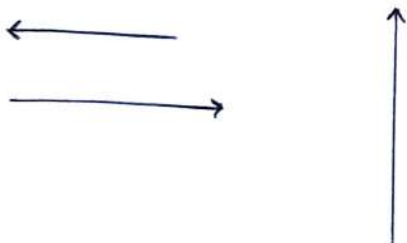
Q. Define vector quantities ?

Ans - Vector quantities are the physical quantities which have both magnitude and direction.

Ex - Displacement, velocity, acceleration, force, pressure etc.

Representation of a vector

(1) Graphically, a vector is represented by a line segment with an arrow head.



Magnitude : Length of the line segment gives magnitude.

Direction : Arrow head gives direction.

(2) Symbolically, a vector is represented as follows :-

suppose A is a vector, then it is written as \vec{A} and is given by

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

OR

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

A - Magnitude of \vec{A}

\hat{A} = Unit vector of \vec{A} and gives direction of \vec{A}

Types of vector

(i) Unit vector

It is a vector whose magnitude is unit or '1'.

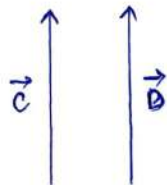
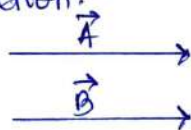
(ii) Null vector

It is a vector whose magnitude is zero.

(iii) Equal vector

Two vectors are said to be equal, if they have the same magnitude and direction.

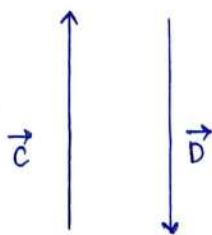
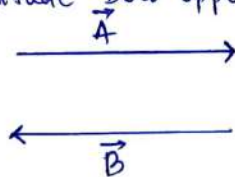
Ex -



(iv) Negative vector

A vector is said to be negative of another if it has same magnitude but opposite in direction.

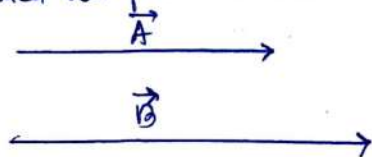
Ex -



(v) Parallel vector

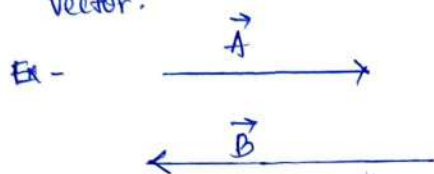
Two vectors acting along same direction irrespective of their magnitude are called as parallel vector.

Ex -



(vi) Anti-parallel vectors

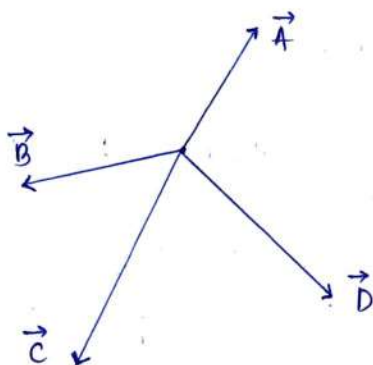
Two vectors are said to be anti-parallel if they are in opposite direction irrespective of their magnitude are called anti-parallel Vector.



(vii) Co-initial vectors

If the starting points of vectors are the same, then they are called co-initial vectors.

Ex -



$\vec{A}, \vec{B}, \vec{C}, \vec{D}$ are co-initial vectors.

Scalar addition

Mass



3kg

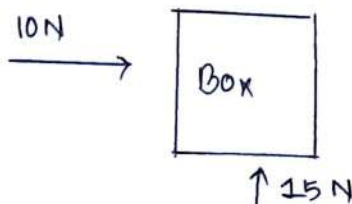


4kg

$$3\text{kg} + 4\text{kg} = 7\text{kg}$$

* Scalar addition obey simple rule of algebra.

Vector addition

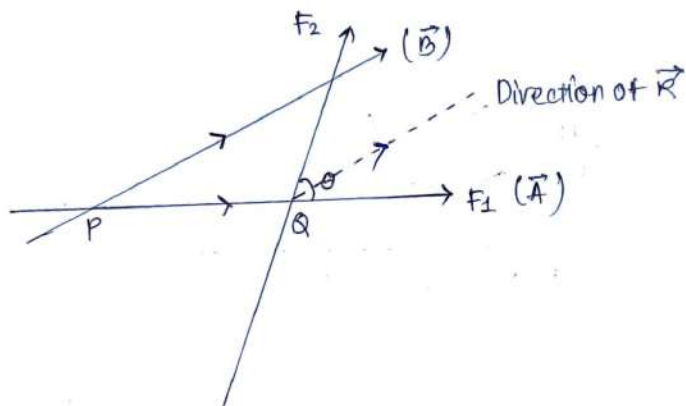


* Vector addition doesn't obey simple rule of algebra.

Laws of vector addition

- (i) Triangle law of vector addition
- (ii) Parallelogram law of vector addition

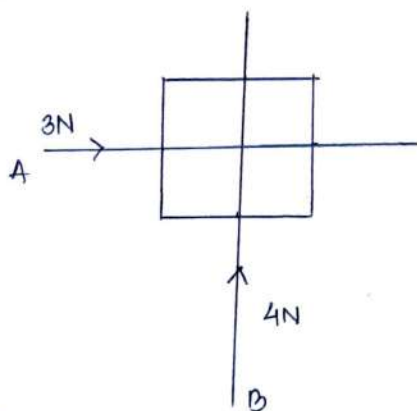
Triangle law of vector addition



Total force / Resultant vector (\vec{R})

magnitude, $R = \sqrt{A^2 + B^2 + 2AB \cos \theta}$
 θ is the angle between \vec{A} and \vec{B} .

Example 1



Ans -

$$A = 3$$

$$B = 4$$

$$\theta = 90^\circ$$

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

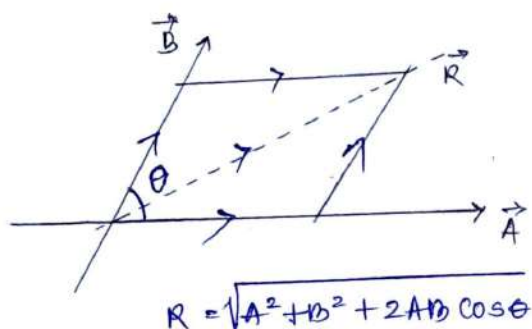
$$= \sqrt{3^2 + 4^2 + 2 \times 3 \times 4 \cos 90^\circ}$$

$$= \sqrt{9 + 16 + 24 \cos 90^\circ}$$

$$= \sqrt{25 + 0}$$

$$= \sqrt{25} = 5 \text{ N}$$

Parallelogram law of vector addition



Example 2

Two forces of magnitude 1N & 2N are acting at an angle 60° . Find the resultant force.

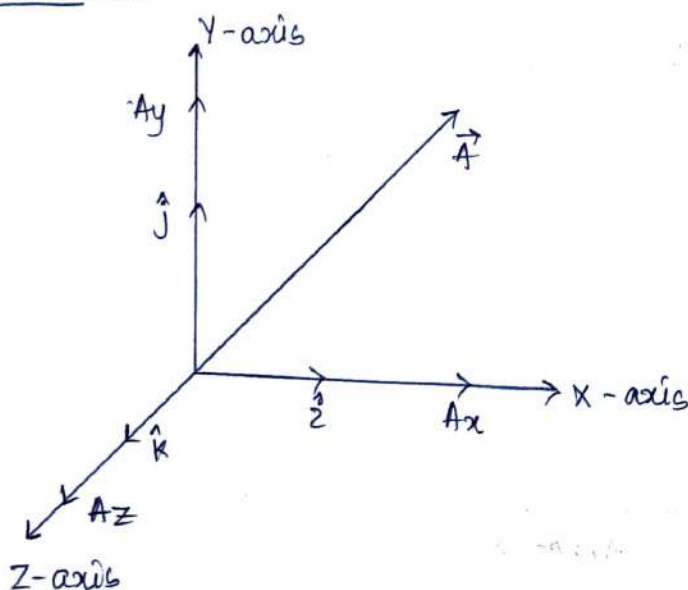
Ans -
$$R = \sqrt{1^2 + 2^2 + 2 \times 1 \times 2 \cos 60^\circ}$$

$$= \sqrt{1 + 4 + 4 \left(\frac{1}{2}\right)}$$

$$= \sqrt{1 + 4 + 2}$$

$$= \sqrt{7}$$

Resolution of a vector



Let \vec{A} is a vector on xyz co-ordinate system.

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

$A_x \rightarrow$ x - Component of \vec{A}

$A_y \rightarrow$ y - Component of \vec{A}

$A_z \rightarrow$ z - Component of \vec{A}

$\hat{i} \rightarrow$ Unit vector along x-axis

$\hat{j} \rightarrow$ Unit vector along y-axis

$\hat{k} \rightarrow$ Unit vector along z-axis

Vector multiplication / Vector product

Are of two types

(i) Dot product

(ii) Cross product

Q. Define dot product?

Ans - The dot product of two vectors \vec{A} and \vec{B} is defined as

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

A - Magnitude of \vec{A}

B - Magnitude of \vec{B}

θ - Angle between \vec{A} and \vec{B}

$$\vec{A} \cdot \vec{B} \Rightarrow \text{Scalar}$$

Example 3

Find the dot product of two vectors whose magnitude are 3 units and 4 units, when the angle between them is 60° .

Ans - Given, A = 3 units

B = 4 units

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

$$= 3 \times 4 \times \cos 60^\circ$$

$$= 12 \times \frac{1}{2}$$

$$= 6 \text{ units}$$

Dot product in component form

Let \vec{A} and \vec{B} are two vectors

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

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

$$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z$$

Example 4

Find $\vec{A} \cdot \vec{B}$ if $\vec{A} = 2\hat{i} + 3\hat{j} - 4\hat{k}$, $\vec{B} = \hat{i} - 2\hat{j} + 3\hat{k}$

Ans - $A_x = 2, A_y = 3, A_z = -4$

$B_x = 1, B_y = -2, B_z = 3$

$$\begin{aligned}\vec{A} \cdot \vec{B} &= A_x B_x + A_y B_y + A_z B_z \\ &= (2 \times 1) + (3 \times (-2)) + ((-4) \times 3) \\ &= 2 + (-6) + (-12) \\ &= 2 - 6 - 12 \\ &= -16\end{aligned}$$

Example 5

find $\vec{A} \cdot \vec{B}$ if $\vec{A} = \hat{i} + 2\hat{j} - 4\hat{k}$, $\vec{B} = 3\hat{i} + 4\hat{j} - \hat{k}$

Ans - $A_x = 1, A_y = 2, A_z = -4$

$B_x = 3, B_y = 4, B_z = -1$

$$\begin{aligned}\vec{A} \cdot \vec{B} &= A_x B_x + A_y B_y + A_z B_z \\ &= (1 \times 3) + (2 \times 4) + (-4 \times -1) \\ &= 3 + 8 + 4 \\ &= 15\end{aligned}$$

Example 6

(i) find $\vec{A} \cdot \vec{B}$ if $\vec{A} = 2\hat{i} - 3\hat{j} + \hat{k}$, $\vec{B} = 2\hat{i} + \hat{j}$

Ans - $A_x = 2, A_y = -3, A_z = 1$

$B_x = 2, B_y = 1, B_z = 0$

$$\begin{aligned}
 \vec{A} \cdot \vec{B} &= A_x B_x + A_y B_y + A_z B_z \\
 &= (2 \times 2) + (-3 \times 1) + (1 \times 0) \\
 &= 4 + (-3) + 0 \\
 &= 4 - 3 = 1
 \end{aligned}$$

(ii) find $\vec{A} \cdot \vec{B}$ if $\vec{A} = \hat{i} + \hat{j} + 4\hat{k}$, $\vec{B} = 2\hat{i}$

Ans - $A_x = 1, A_y = 1, A_z = 4$
 $B_x = 2, B_y = 0, B_z = 0$

$$\begin{aligned}
 \vec{A} \cdot \vec{B} &= A_x B_x + A_y B_y + A_z B_z \\
 &= (1 \times 2) + (1 \times 0) + (4 \times 0) \\
 &= 2 + 0 + 0 \\
 &= 2
 \end{aligned}$$

Cross product

Q. Define cross product?

Ans - The cross product of two vectors \vec{A} and \vec{B} is defined as

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

where, $A \rightarrow$ Magnitude of \vec{A}

$B \rightarrow$ Magnitude of \vec{B}

$\theta \rightarrow$ Angle between \vec{A} and \vec{B}

$\hat{n} \rightarrow$ Unit vector gives direction of $\vec{A} \times \vec{B}$

Note

(i) $\vec{A} \times \vec{B}$ is a vector

magnitude $\rightarrow |\vec{A} \times \vec{B}| = AB \sin \theta$

direction \rightarrow It is given by \hat{n}

Example 7

Find the magnitude of cross product of two vectors whose magnitudes are 3 units and 4 units and angle between them is 90° .

Ans - Let \vec{A} and \vec{B} are two vectors

So, $A = 3$ units

$B = 4$ units

$\theta = 90^\circ$

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

$$|3 \times 4| = 12 \sin 90^\circ$$

$$= 12$$

$\vec{A} \times \vec{B}$ in component form

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

Example 8

Find $\vec{A} \times \vec{B}$ if $A = 2\hat{i} + \hat{j} + 2\hat{k}$
 $B = \hat{i} + 3\hat{j} + 4\hat{k}$

Ans -

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 1 & 2 \\ 1 & 3 & 4 \end{vmatrix}$$

$$= (4-6)\hat{i} - (8-2)\hat{j} + (6-1)\hat{k}$$

$$= -2\hat{i} - 6\hat{j} + 5\hat{k}$$

Example 9

Find $\vec{A} \times \vec{B}$ if $A = \hat{i} - 2\hat{j} + 4\hat{k}$
 $B = 2\hat{i} - 3\hat{j} - \hat{k}$

Ans -

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -2 & 4 \\ 2 & -3 & -1 \end{vmatrix}$$

$$= (2-(-12))\hat{i} - (-1-8)\hat{j} + (-3-(-4))\hat{k}$$

$$= (2+12)\hat{i} + (9)\hat{j} + (-1)\hat{k}$$

$$= 14\hat{i} + 9\hat{j} - \hat{k}$$

Example 10

Find $\vec{A} \times \vec{B}$ if $A = 2\hat{i} - 3\hat{j}$
 $B = 2\hat{i} + 3\hat{j} + \hat{k}$

Ans -

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -3 & 0 \\ 2 & 3 & 1 \end{vmatrix}$$

$$= (-3-0)\hat{i} - (1-0)\hat{j} + (3-(-6))\hat{k}$$

$$= -3\hat{i} - (1)\hat{j} + (3+6)\hat{k}$$

$$= -3\hat{i} - \hat{j} + 9\hat{k}$$

(Ans)

UNIT : 3 KINEMATICS

Q. What is Rest?

Ans - A body is said to be at rest when its position doesn't change with time.

Q. What is motion?

Ans - A body is said to be in motion when its position changes with time.

Distance and displacement

Q. What is distance?

Ans - Distance covered by a body is defined as the length of the path covered by the body.

- Distance is a scalar quantity.
- S.I unit of distance is meter (m).
- Others units of distance are cm, km, miles, millimeter etc.
- Its symbol is 's'.
- D.F of distance is

$$[s] = [L^1]$$

Q. What is displacement?

Ans - The shortest distance between initial and final position of the body is called as displacement.

→ It is a vector quantity.

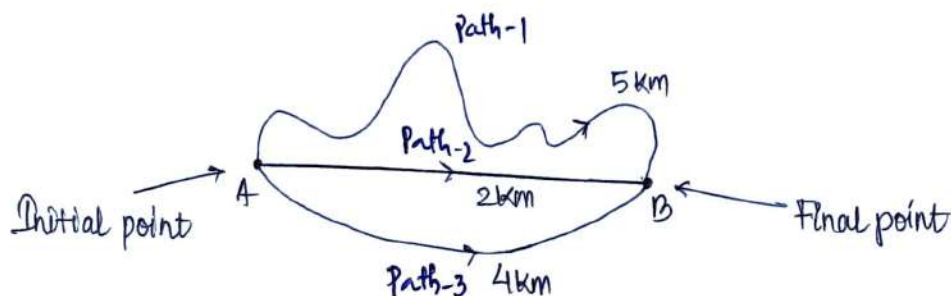
Magnitude of displacement: It is the length of the shortest path between initial point and final point.

Direction of displacement: Its direction is always from initial point to final point ($A \rightarrow B$).

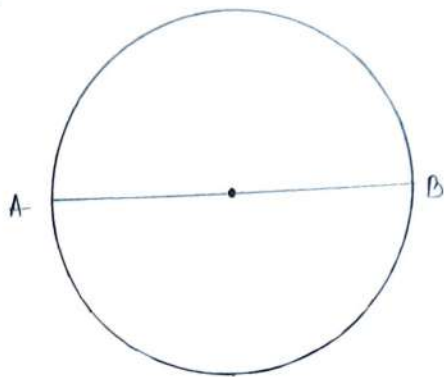
→ Its symbol is \vec{s} .

→ Its S.I unit is meter (m).

→ Its D.F is $[\vec{s}] = [L^1]$



Example 1



$$r = 70 \text{ m}$$

$$\text{length / Perimeter / circumference} = \frac{2\pi r}{2} = \pi r$$

$$= \frac{22}{7} \times \frac{10}{\cancel{70}} = 220 \text{ m}$$

$$\begin{aligned} \text{displacement} &= 2r = 2 \times 70 \\ &= 140 \text{ m} \end{aligned}$$

Note

When initial point and final point of a body are the same, the displacement is zero.

Distance \rightarrow length of the path \rightarrow scalar quantity \rightarrow Only magnitude

Displacement \rightarrow shortest path \rightarrow Vector quantity \rightarrow magnitude & direction

Speed

\rightarrow It is a scalar quantity.

\rightarrow Units : $\frac{\text{km}}{\text{h}}$, $\frac{\text{m}}{\text{h}}$, $\frac{\text{m}}{\text{s}}$, $\frac{\text{m}}{\text{min}}$, $\frac{\text{mile}}{\text{h}}$

\rightarrow S.I unit : $\frac{\text{meter}}{\text{second}}$ or $\frac{\text{m}}{\text{s}}$

\rightarrow Symbol : u or v

\rightarrow D.F is $[u] = [L^1 T^{-1}]$

Velocity

\rightarrow It is a vector quantity.

\rightarrow Velocity = $\frac{\text{displacement}}{\text{time}}$

→ Direction is the same as that of displacement.

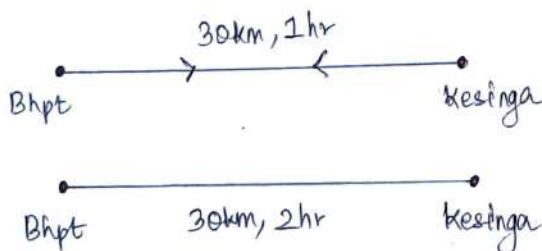
→ Symbol: \vec{u} or \vec{v}

→ Units: $\frac{\text{km}}{\text{h}}$, $\frac{\text{m}}{\text{s}}$, $\frac{\text{mile}}{\text{h}}$, $\frac{\text{km}}{\text{s}}$ etc.

→ S.I unit: $\frac{\text{meter}}{\text{second}}$ or $\frac{\text{m}}{\text{s}}$

→ D.F is [velocity] = $[L^1 T^{-1}]$

Example 2



Distance = ?

Time = ?

Displacement = ?

Speed = ?

Velocity = ?

Ans - Distance = $30 + 30 = 60 \text{ km}$

Time = $1 + 2 = 3 \text{ hr}$

Displacement = 0

$$\text{Speed} = \frac{\text{Distance}}{\text{time}} = \frac{60 \text{ km}}{3 \text{ h}} = \frac{20 \text{ km}}{\text{h}}$$

$$\text{Velocity} = \frac{\text{Displacement}}{\text{time}} = \frac{0}{3} = 0$$

Acceleration and force

Acceleration = $\frac{\text{Change in velocity}}{\text{Time}}$

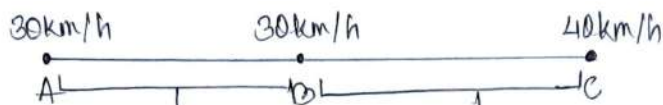
$$a = \frac{v - u}{t}$$

$a \rightarrow$ Acceleration

$u \rightarrow$ Initial velocity

$v \rightarrow$ Final velocity

$t \rightarrow$ time



\rightarrow It is a vector quantity.

\rightarrow Symbol: \vec{a}

\rightarrow units: $\frac{\text{km}}{\text{h}^2}$, $\frac{\text{m}}{\text{s}^2}$, $\frac{\text{km}}{\text{s}^2}$

\rightarrow S.I unit: $\frac{\text{m}}{\text{s}^2}$

\rightarrow D.F is $[a] = [L^1 T^{-2}]$

Force



$m =$ mass

$a =$ acceleration

$F =$ Force

Relation between F & a

$$F = ma$$

$$\frac{F}{m} = a$$

\rightarrow S.I unit of force is $\frac{\text{kgm}}{\text{s}^2}$ or Newton.

$$1\text{N} = \frac{1\text{kgm}}{\text{s}^2}$$

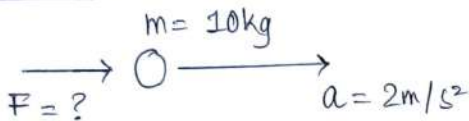
\rightarrow Dimensional formula of force

$$[F] = [m] \times [a]$$

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

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

Example 3

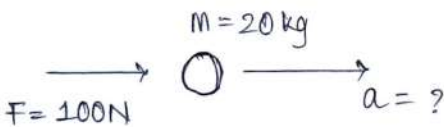


Ans -

$$F = m \cdot a$$

$$= 10 \times 2 = 20 \text{ N}$$

Example 4



Ans -

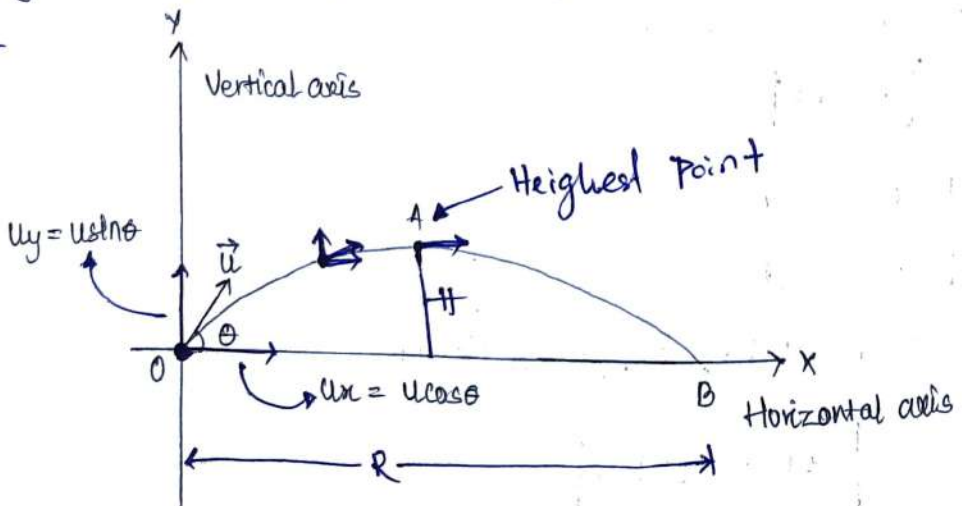
$$a = \frac{F}{m}$$

$$= \frac{100}{20}$$

$$= 5 \text{ m/s}^2$$

Q. Derive expressions for time of flight, maximum height and horizontal range of a projectile projected at an angle θ with horizontal.

Ans -



$R \rightarrow$ Horizontal Range
 $H \rightarrow$ Maximum Height

Expression for time of flight (T)

Time of flight $[O \rightarrow B]$

$$= \text{Time of ascent } (O \rightarrow A) + \text{Time of descent } (A \rightarrow B)$$

$$T = t_a + t_d$$

Time of ascent

We have, $v = u + at$

Vertical motion, $v_y = u_y + a_y t$

Here, $v_y = 0$, $u_y = u \sin \theta$, $a_y = -g$, $t = t_a$

$$0 = u \sin \theta - g t_a$$

$$\Rightarrow \frac{g t_a}{g} = u \sin \theta \Rightarrow t_a = \frac{u \sin \theta}{g}$$

Time of descent

Similarly $t_d = \frac{u \sin \theta}{g}$

$$\therefore t_a + t_d$$

$$= \frac{u \sin \theta}{g} + \frac{u \sin \theta}{g}$$

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

Maximum height (H)

We have, $v^2 = u^2 + 2as$

Vertical motion, $v_y^2 = u_y^2 + 2a_y s_y$

$v_y = 0$, $u_y = u \sin \theta$, $a_y = -g$, $s_y = H$

$$\therefore 0^2 = (u \sin \theta)^2 + 2(-g)(H)$$

$$= u^2 \sin^2 \theta - 2gH$$

$$2gH = u^2 \sin^2 \theta$$

$$H = \frac{u^2 \sin^2 \theta}{2g}$$

At 'O' point

$$u \begin{cases} u_x = u \cos \theta \\ u_y = u \sin \theta \end{cases}$$

At 'A' point

$$v_y = 0$$

$$a_y = -g$$

$$a_x = 0$$

Horizontal range (R)

We have, $s = ut + \frac{1}{2} at^2$

Horizontal motion $\rightarrow S_x = u_x t + \frac{1}{2} a_x t^2$

Here, $S_x = R$, $u_x = u \cos \theta$, $t = \frac{2u \sin \theta}{g}$

$$\therefore R = u \cos \theta \times \frac{2u \sin \theta}{g} + \frac{1}{2} \times 0 \times \left(\frac{2u \sin \theta}{g} \right)^2$$

$$R = \frac{u^2 2 \sin \theta \cos \theta}{g}$$

$$\boxed{R = \frac{u^2 \sin 2\theta}{g}}$$

Maximum Horizontal Range
(R_{\max})

when $\theta = 45^\circ$, $R = R_{\max}$

$$\therefore R_{\max} = \frac{u^2 \sin 90}{g}$$

$$\Rightarrow \boxed{R_{\max} = \frac{u^2}{g}}$$

P-1

A projectile is projected with initial velocity 4.9 m/s at an angle 30° with horizontal. Find time of flight, maximum height and horizontal Range covered by the projectile.

Solution: Given $u = 4.9 \text{ m/s}$

$$\theta = 30^\circ$$

$$g = 9.8 \text{ m/s}^2$$

$$(i) T = \frac{2u \sin \theta}{g} = \frac{2 \times 4.9 \times \sin 30}{9.8} = \frac{9.8 \times \frac{1}{2}}{9.8} = \frac{1}{2} \text{ sec}$$

$$(ii) H = \frac{u^2 \sin^2 \theta}{2g} = \frac{(4.9)^2 \times (\sin 30)^2}{2 \times 9.8} = \frac{4.9 \times 4.9 \times \frac{1}{4}}{2 \times 9.8}$$

$$= \frac{4.9}{16} = 0.3 \text{ m}$$

$$(iii) R = \frac{u^2 \sin 2\theta}{g} = \frac{(4.9)^2 \times \sin 60}{9.8} = 1.22\sqrt{3} \text{ m}$$

UNIT 4 : WORK AND FRICTION

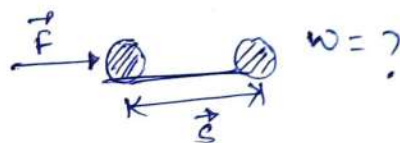
Q. What is work?

Ans - Work is defined as the dot product of force and displacement.

$$\therefore W = \vec{F} \cdot \vec{s}$$

$$\Rightarrow W = FS \cos \theta$$

θ is the angle between \vec{F} and \vec{s} .

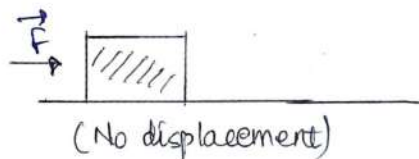


Note

* Zero work ($w=0$)

→ When $s = 0$

$$W = F \times 0 \times \cos \theta = 0$$

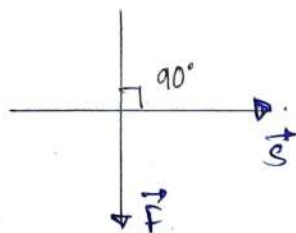


(No displacement)

→ When $\theta = 90^\circ$

$$W = F \times s \times \cos 90^\circ$$

$$= F \times s \times 0 = 0$$



* Work is a scalar quantity.

* S-I unit of work is Newton \times Meter (Nm)

* Dimensional formula of work is

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

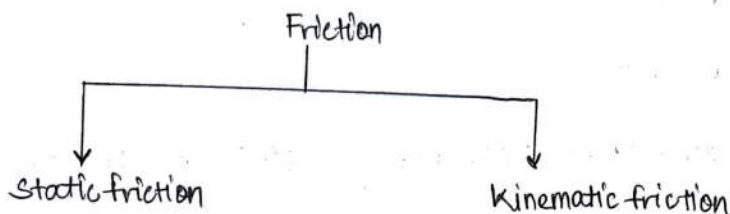
Q. What is friction?

Ans - * Friction is a force.

* Definition - Friction is the opposing force between two surfaces (bodies), when they are in contact.

* It opposes the motion.

Types of friction



Static friction - It is the friction between two surfaces (bodies), when they are at rest. (No motion) (F_s)

Kinematic friction - It is the friction between two surfaces (bodies), when one or both the surfaces are in motion. (f_k)

Co-efficient of friction

friction \propto Normal reaction

$$F \propto R$$

$$\Rightarrow F = NR$$

N - Constant and is called co-efficient of friction

$$\therefore \frac{F}{R} = N$$

Limiting friction

* Maximum value of a static friction.

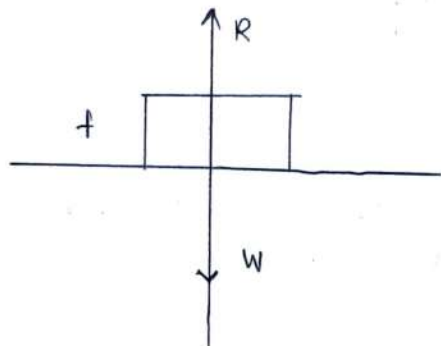
Q. Write laws of limiting friction.

Ans - Laws of limiting friction / laws of friction

(i) The direction of friction is always opposite to the direction of motion.



(ii) Friction is proportional to normal reaction.



$$f \propto R$$

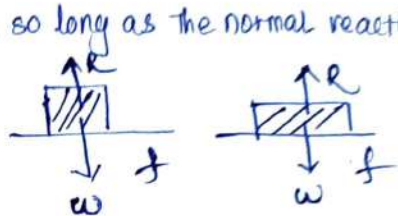
$$\therefore f = NR$$

(iii) friction depends on smoothness and polishness of a surface.

(iv) friction doesn't depend on shape and size so long as the normal reaction remains the same.

Q. Write methods to reduce friction?

Ans - Methods to reduce friction



- * By using lubricants (oil, grease etc)
- * By polishing a surface.
- * By converting sliding friction into rolling friction.
- * By streamlining.

UNIT 5: GRAVITATION

Introduction

- * There exists an attractive force between ^{any} two bodies (masses) of the universe.
- * This attractive force is known as gravitational force. (F)

Q. State Newton's law of gravitation?

Ans - Newton's law of gravitation



m_1 and $m_2 \rightarrow$ masses of two bodies

$r \rightarrow$ Distance between two bodies

Let $F \rightarrow$ Gravitational force between two bodies

According to the Newton's law of gravitation

$$F \propto m_1 m_2$$

\rightarrow Gravitational force is directly proportional to the product of two masses

\rightarrow Gravitational force is inversely proportional to the square of the distance between two bodies.

Mathematically,

$$F \propto m_1 m_2 \quad \text{--- (1)}$$

$$F \propto \frac{1}{r^2} \quad \text{--- (2)}$$

Combining equation (1) & (2)

$$F \propto \frac{m_1 m_2}{r^2}$$

$$\Rightarrow \boxed{F = G \frac{m_1 m_2}{r^2}} \quad \text{--- (3)}$$

$G \rightarrow$ constant and is called Universal Gravitational constant.

value of G in SI unit is

$$G = 6.67 \times 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2}$$

Example 1



$$m_1 = 2 \text{ kg}$$

$$m_2 = 5 \text{ kg}$$

$$r = 10 \text{ m}$$

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

$$= \frac{6.67 \times 10^{-11} (2 \times 5)}{(10)^2}$$

$$= \frac{6.67 \times 10^{-11} \times 10}{10 \times 10}$$

$$= \frac{6.67}{10} \times 10^{-11}$$

$$F = 0.667 \times 10^{-11} \text{ N}$$

Q. Write SI unit and dimensional formula of ' G '.

Ans - Dimensional formula of ' G '

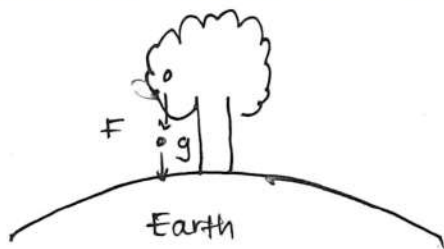
$$[G] = \frac{[F] \times [r^2]}{[m_1] \times [m_2]}$$

$$\begin{aligned}
 &= \frac{[M^2 L^1 T^{-2}] \times [L^1]^2}{[M^1] \times [M^1]} \\
 &= \frac{[M^2 L^1 T^{-2}] \times [L^2]}{[M^2]} \\
 &= \frac{[M^2 L^3 T^{-2}]}{[M^2]} \\
 &= [M^2 L^3 T^{-2}] \times [M^{-2}] \\
 &= [M^{-1} L^3 T^{-2}]
 \end{aligned}$$

S.I unit of G is $\frac{Nm^2}{kg^2}$

Acceleration due to gravity

Definition: It is the acceleration produced in a body due to gravitational force between the earth and the body.



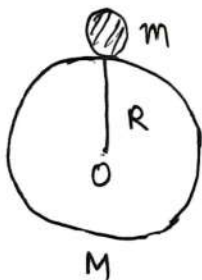
→ Its symbol is 'g'. $[a = g]$

→ Its SI unit is m/s^2 or ms^{-2}

Q. Derive the relation between ' G ' & ' g '.

G → Universal Gravitational constant

g → Acceleration due to gravity



$m \rightarrow$ mass of the body
 $M \rightarrow$ mass of the earth
 $O \rightarrow$ Centre of the earth
 $R \rightarrow$ Radius of the earth

Gravitational force between m & M

$$F = G \frac{mM}{R^2} \quad \text{--- (1)}$$

By definition, $F = mg$ --- (2)

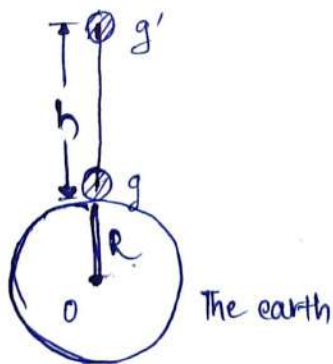
From eqn (1) & eqn (2)

$$G \frac{mM}{R^2} = mg$$

$$\boxed{\frac{GM}{R^2} = g}$$

Q. Write variation of g with height and depth.

Ans - Variation of g with height (altitude)



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

Where, $h =$ height

$R =$ Radius of the earth

The value of g decreases with increase in height from the surface of the earth.

On the surface of the earth

Explanation

$$g = 9.8 \text{ m/s}^2 \approx 10 \text{ m/s}^2$$

$$h = 1600 \text{ km}$$

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

$$= 10 \left[1 - \frac{2 \times 1600}{6400} \right]$$

$$= 10 \left[1 - \frac{3200}{6400} \right]$$

$$= 10 \left[1 - \frac{1}{2} \right]$$

$$= 10 \left[\frac{2-1}{2} \right] = 10 \left[\frac{1}{2} \right] = 5 \text{ m/s}^2$$

Variation of g with depth



$$g' = g \left(1 - \frac{d}{R} \right)$$

Where, d = depth

Explanation R = Radius of the earth

On the surface of the earth

$$g = 9.8 \text{ m/s}^2 \approx 10 \text{ m/s}^2$$

$$d = 1600 \text{ km}$$

$$g' = g \left(1 - \frac{d}{R} \right)$$

$$= 10 \left[1 - \frac{1600}{6400} \right]$$

$$= 10 \left[1 - \frac{1}{4} \right]$$

$$= 10 \left[\frac{4-1}{4} \right]$$

$$= 10 \left[\frac{3}{4} \right]$$

$$= \frac{30}{4} = 7.5 \text{ m/s}^2$$

The value of g decreases with increase in depth and becomes zero at the centre of the earth.

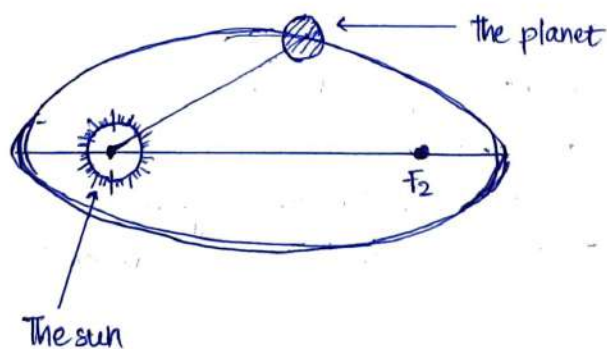
Q. State Kepler's laws of planetary motion.

Ans - Kepler's laws of planetary motion

Kepler's has proposed three laws.

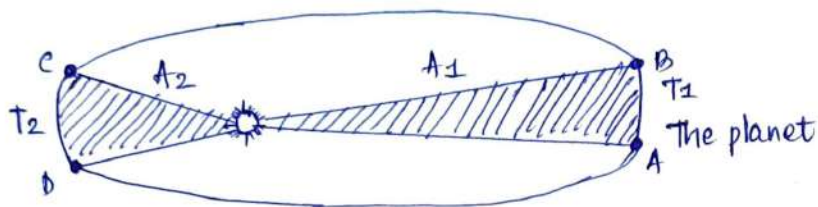
1st law (law of orbit) : The path/orbit of the planets around the sun is an ellipse.

The sun is situated at the focus.



2nd law (law of areal velocity) : Each planet covers equal area in equal time interval.

i.e If $T_1 = T_2$, then $A_1 = A_2$



3rd law (law of time period)

$$(\text{Time period})^2 \propto (\text{semi major axis})^3$$

$$\Rightarrow \boxed{T^2 \propto a^3}$$

Define mass and weight

Mass

- The amount of materials contained in a body is known as mass.
- The unit of mass is kilogram (kg).
- It is a scalar quantity.
- Mass can't never be zero.

Weight

- The force on a body due to Earth's gravity. $\boxed{W = mg}$
- S.I unit of weight is Newton.
- It is a vector quantity.
- It's symbol is W and is given by $W = mg$
 - $m \rightarrow$ mass
 - $g \rightarrow$ Acceleration due to gravity
- Weight can be zero when $g=0$ (at the centre of the earth)

UNIT 6 : OSCILLATIONS AND WAVE

Q. What is wave?

Ans - Wave

* It is a disturbance which carries energy.

Waves

Mechanical waves

They need a medium for their propagation)

Ex - Sound waves

Non-mechanical waves

(They don't need any medium for their propagation)

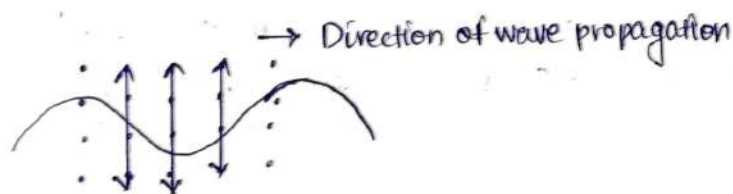
Ex - light wave, Radio signal

∴ Mechanical wave: A mechanical wave propagates due to vibration / oscillation of particles or molecules of the medium.

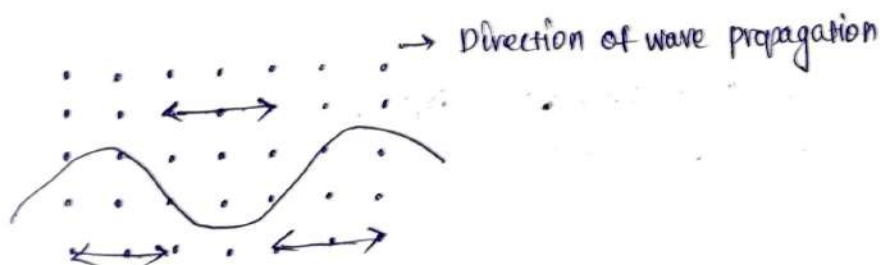
Mechanical wave

Transverse waves

Longitudinal waves



Transverse waves (perpendicular)



Longitudinal waves (Parallel)

Q. Distinguish between transverse wave and longitudinal waves?

Ans -

Transverse wave

Longitudinal waves

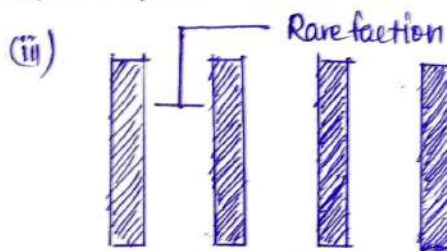
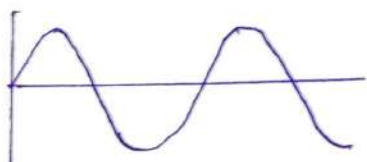
(i) Particles of the medium are vibrating perpendicular to the wave propagation.

(i) Particles of the medium are vibrating parallel to the wave propagation.

(ii) Example: Water wave

(ii) Example: Sound wave

(iii)

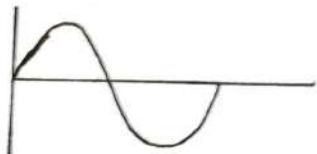


(iv) Transverse wave consists of crests and troughs.

(iv) Longitudinal wave consists of compression and rarefaction.

Wave parameters

(i) Wave cycle



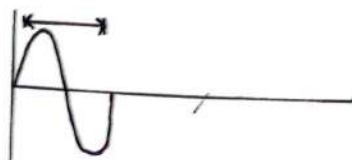
or



* A wave cycle consists of a crest and a trough, in case of a transverse wave

* A wave cycle consists of a compression and a rarefaction in case of a longitudinal wave.

(ii) Wavelength

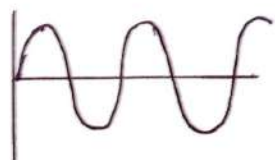
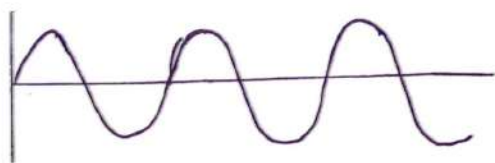


It is the length of a wave length cycle.

* It's symbol is ' λ '. (lambda)

* It's S.I unit is meter (m).

(iii) Time period

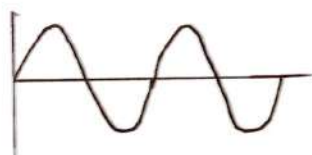


It is the time taken by a wave to complete the wave cycle.

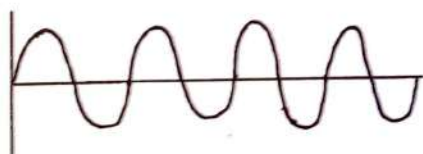
* It's symbol is ' T '.

* It's S.I unit is second ' s '.

(iv) Frequency



2 Hz



4 Hz

It is the number of wave cycles completed by a wave in one second.

* It is denoted by ' f ' or ' n '.

* It's S.I unit is $\frac{1}{\text{Second}}$ or s^{-1} or Hertz (Hz).

$$1 \text{ Hz} = 1 s^{-1}$$

(v) Wave velocity (v)

It is the velocity with which the waves travel or propagate.

* It's symbol is ' v '.

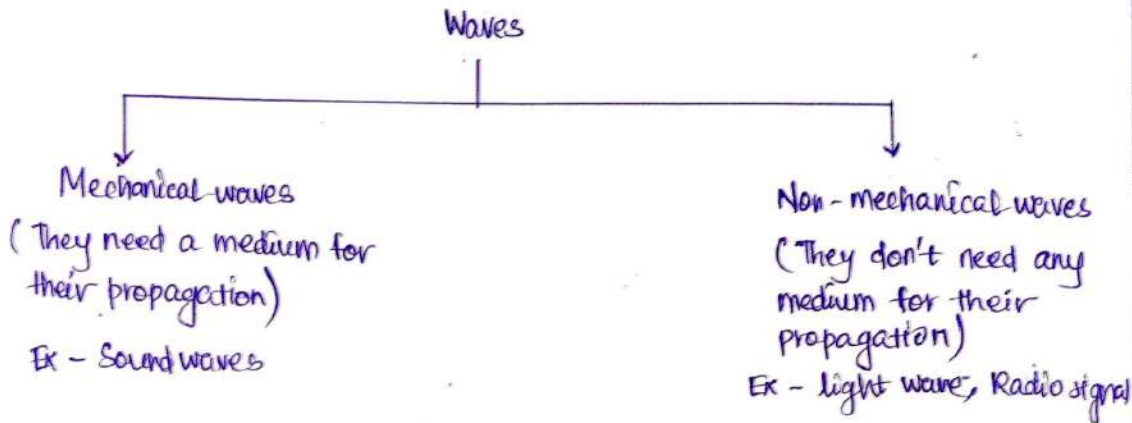
* It's S.I unit is meter/second or m/s or ms^{-1}

UNIT 6 : OSCILLATIONS AND WAVE

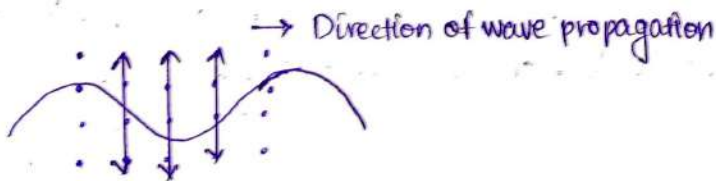
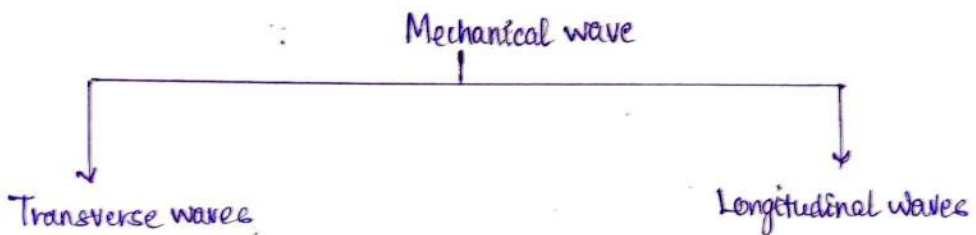
Q. What is wave?

Ans - Wave

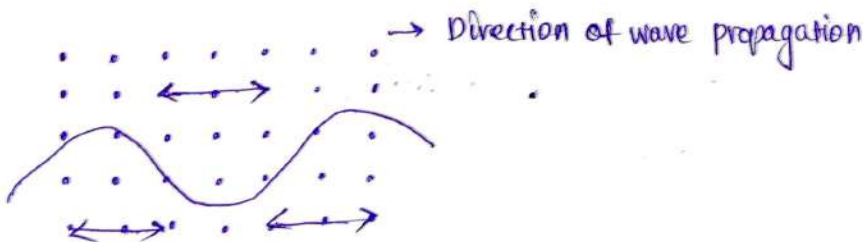
* It is a disturbance which carries energy.



∴ Mechanical wave: A mechanical wave propagates due to vibration / oscillation of particles or molecules of the medium.



Transverse waves (perpendicular)



Longitudinal waves (Parallel)

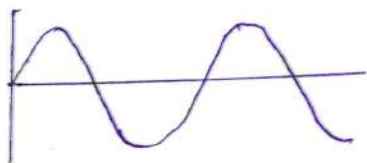
Q. Distinguish between transverse wave and longitudinal waves?

Ans - Transverse wave

(i) Particles of the medium are vibrating perpendicular to the wave propagation.

(ii) Example: Water wave

(iii)



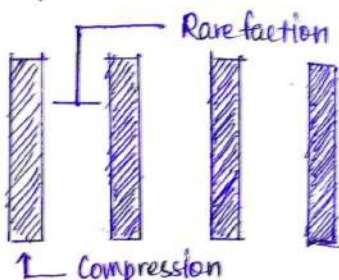
(iv) Transverse wave consists of crests and troughs.

Longitudinal waves

(i) Particles of the medium are vibrating parallel to the wave propagation.

(ii) Example: Sound wave

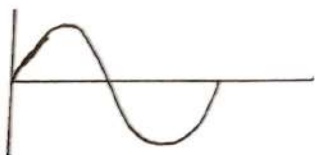
(iii)



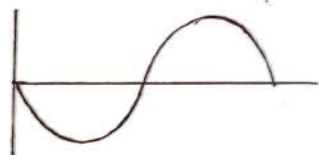
(iv) Longitudinal wave consists of compression and rarefaction.

Wave parameters

(i) Wave cycle



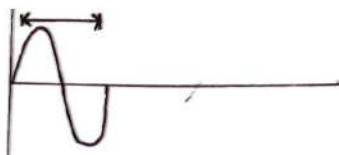
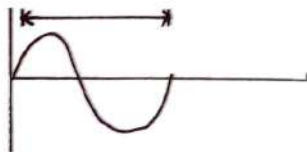
or



* A wave cycle consists of a crest and a trough, in case of a transverse wave

* A wave cycle consists of a compression and a rarefaction in case of a longitudinal wave.

(ii) Wavelength

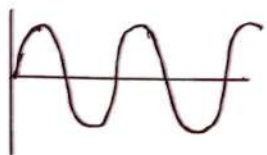


It is the length of a wave cycle.

* Its symbol is ' λ '. (lambda)

* Its S.I unit is meter (m).

(iii) Time period

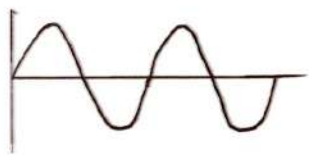


It is the time taken by a wave to complete the wave cycle.

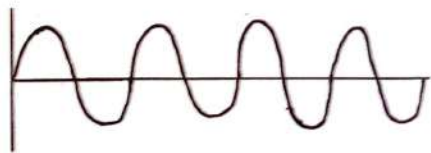
* It's symbol is ' T '.

* It's S.I unit is second ' s '.

(iv) Frequency



2 Hz



4 Hz

It is the number of wave cycles completed by a wave in one second.

* It is denoted by ' f ' or ' n '.

* It's S.I unit is $\frac{1}{\text{Second}}$ or s^{-1} or Hertz (Hz).

$$1 \text{ Hz} = 1 s^{-1}$$

(v) Wave velocity (v)

It is the velocity with which the waves travel or propagate.

* It's symbol is ' v '.

* It's S.I unit is meter/second or m/s or ms^{-1}

Relation between time period and frequency

Q. What is ultrasonic / ultrasound?

Ans - Ultrasonic

The sound whose frequency is greater than $20,000\text{ Hz}$ is known as ultrasonic.

Audible frequency range for human ears

$20\text{ Hz} - 20,000\text{ Hz}$

frequency $< 20\text{ Hz}$ Infrasonic (Not audible)

frequency $> 20,000\text{ Hz}$ Ultrasonic (Not audible)

Q. Write properties of ultrasonic?

Ans - Properties of ultrasonic

- (i) It is a longitudinal wave.
- (ii) Its frequency is greater than $20,000\text{ Hz}$.
- (iii) It carries high energy.

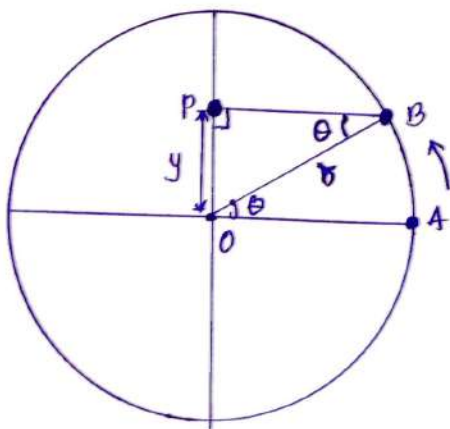
Q. Uses / Application of ultrasonic?

Ans - Uses of ultrasonic :-

- (i) Medical uses
- (ii) Welding purposes
- (iii) SONAR navigation system.
- (iv) Cleaning purpose

Q. Derive expressions for displacement, velocity and acceleration of a body executing Simple Harmonic Motion (SHM).

Ans -



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

$$V = \frac{s}{t}$$

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

ω = Angular velocity

θ = Angular momentum

Displacement (y)

In ΔOBP

$$\sin \theta = \frac{y}{r}$$

$$\boxed{y = r \sin \theta}$$

$$\Rightarrow \boxed{y = r \sin \omega t} \quad \text{--- (1)}$$

Velocity (v)

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

$$\Rightarrow v = \frac{d}{dt} (r \sin \omega t)$$

$$v = r \frac{d}{dt} (\sin \omega t)$$

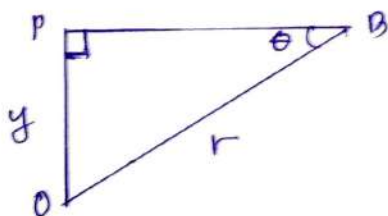
$$v = r \cdot \cos \omega t \times \frac{d}{dt} (\omega t)$$

$$= r \cdot \cos \omega t \times \omega \times \frac{d}{dt} (t)$$

$$\Rightarrow \boxed{v = r \omega \cos \omega t} \quad \text{--- (2)}$$

$$\boxed{v = r \omega \cos \theta} \quad \text{--- (3)}$$

In ΔOBP



$$\cos \theta = \frac{b}{h} = \frac{PB}{OB}$$

$$\boxed{\cos \theta = \frac{\sqrt{r^2 - y^2}}{r}} \quad \text{--- (4)}$$

$$\therefore v = r \omega \times \frac{\sqrt{r^2 - y^2}}{r}$$

$$v = w\sqrt{r^2 - y^2} \quad - (5)$$

Acceleration (a)

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

$$a = \frac{d}{dt} (r w \cos wt)$$

$$a = r w \frac{d}{dt} (\cos wt)$$

$$= r w \times -\sin wt \times \frac{d}{dt} (wt)$$

$$= -r w \sin wt \times w \times \frac{d}{dt} (t)$$

$$a = -r w^2 \sin wt \quad - (6)$$

$$a = -r w^2 \sin \theta \quad - (7)$$

In $\triangle OBP$

$$\sin \theta = \frac{p}{h} = \frac{OP}{OB}$$

$$\Rightarrow \sin \theta = \frac{y}{r} \quad - (8)$$

$$a = -r w^2 \times \frac{y}{r}$$

$$a = -w^2 y \quad - (9)$$

UNIT 10: ELECTRIC CURRENT

Q. What is current?

Ans - Flow of charge.

Current due to positive charge \rightarrow conventional current

Current due to negative charge \rightarrow electric current

\rightarrow Symbol of current $\rightarrow i$ or I

S.I unit of current \rightarrow Ampere (A)

$$\text{Current} = \frac{\text{charge}}{\text{time}}$$

$$\Rightarrow i = \frac{q}{t}$$

Q. What is Ohm's law?

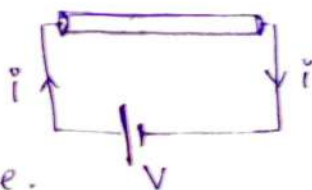
Ans - It states that at constant temperature current flowing through a conductor is directly proportional to the potential difference between the two ends of the conductor.

Mathematically, we have

$$V \propto i$$

$$\Rightarrow V = Ri$$

R is a constant and is called resistance.



$$\Rightarrow \frac{V}{R} = i$$

Resistor (—mm—)

\rightarrow It opposes the flow of current.

Resistance

\rightarrow The property of resistor to oppose the current is called resistance.

\rightarrow S.I unit : Ohm (Ω)

Other unit : milli ohm ($m\Omega$)

micro ohm ($\mu\Omega$)

$$1 \Omega = 1000 m\Omega = 10^3 m\Omega$$

$$1 \Omega = 1000000 \mu\Omega = 10^6 \mu\Omega$$

Capacitor

→ It stores charge.

Capacitance

The capacity of a capacitor is called capacitance.

→ Symbol: C

→ SI unit: Farad (F)

→ Other unit: milliFarad (mF)

Micro Farad (μF)

$$1\text{F} = 10^3\text{mF}$$

$$1\text{F} = 10^6\mu\text{F}$$

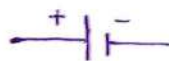
Equipment

Battery

Resistor

Capacitor

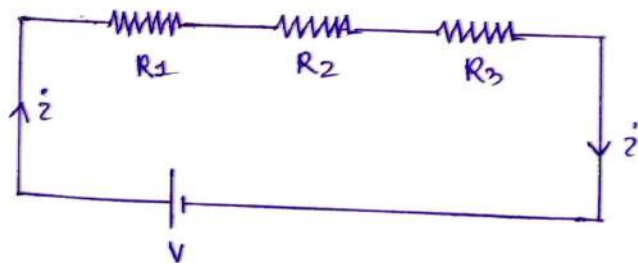
symbol



Grouping of resistors

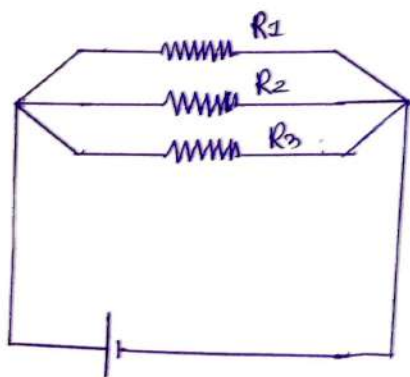
(i) Series grouping or series connection

(ii) Parallel grouping or parallel connection



Series connection

$$R = R_1 + R_2 + R_3$$



Parallel connection

$$R = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Problem 1

Find equivalent resistance of four resistors of resistance 2Ω , 4Ω , 1Ω and 3Ω when connected in series and parallel.

Ans - Resistance when connected in series

$$R = 2\Omega + 4\Omega + 1\Omega + 3\Omega \\ = 10\Omega$$

Resistance when connected in parallel

$$\frac{1}{R} = \frac{1}{2} + \frac{1}{4} + \frac{1}{1} + \frac{1}{3} = \frac{12 + 6 + 24 + 8}{24} = \frac{50}{24} \cdot \frac{25}{12}$$

$$R = \frac{12}{25} = 0.48\Omega$$

Problem 2

Three resistors of resistance 2Ω , $100\mu\Omega$ and 10Ω are connected in series. Find total resistance.

Ans - Given,

$$R_1 = 2\Omega$$

$$R_2 = 100\mu\Omega = 100 \times \frac{1}{1000} = \frac{1}{10} = 0.1\Omega$$

$$R_3 = 10\Omega$$

Resistance when connected in series

$$R_{\text{total}} = 2\Omega + 0.1\Omega + 10\Omega \\ = 12.1\Omega$$

Grouping of Capacitors

$$\text{Series} \rightarrow \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} = \frac{1}{C_{\text{total}}}$$

$$\text{parallel}:- C_1 + C_2 + C_3 = C_{\text{total}}$$

Problem 3

Three capacitor of capacitance 2F, 1000 mF and 10F when connected in series and parallel.

Ans - Capacitance when connected in series

$$\frac{1}{C_t} = \frac{1}{2} + \frac{1}{1} + \frac{1}{10}$$

$$= \frac{10+20+2}{20}$$

$$= \frac{32}{20}$$

$$C_t = \frac{20}{32}$$

Capacitance when connected in parallel

$$C_t = C_1 + C_2 + C_3$$

$$= 2 + 1 + 10$$

$$= 13 \text{ F}$$

Q. State Kirchhoff's laws.

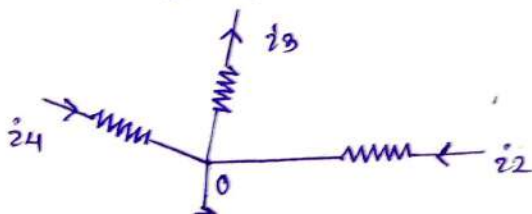
Ans - Kirchhoff's laws

(i) KCL (Kirchhoff's current law)

(ii) KVL (Kirchhoff's voltage law)

KCL

The algebraic sum of current meeting at a junction is zero.



Sign of convention

- (i) The currents leaving the junction are taken as negative.
- (ii) The currents entering the junction are taken as positive.

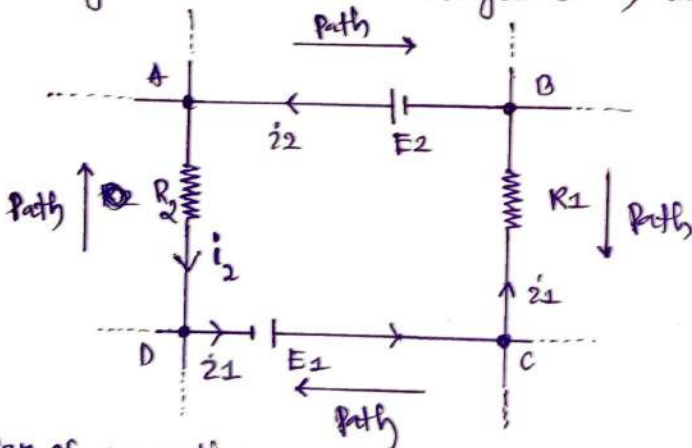
Applying KCL to the given figure, we get

$$\begin{aligned} & (-i_1) + (i_2) + (-i_3) + (i_4) \\ &= -i_1 + i_2 - i_3 + i_4 \\ &= i_4 + i_2 = i_1 + i_3 \end{aligned}$$

KVL

statement

The algebraic sum of the voltages (emf) across a closed loop is zero.

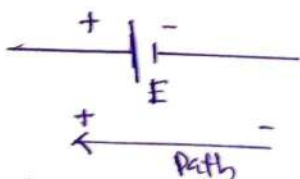


Sign of convention



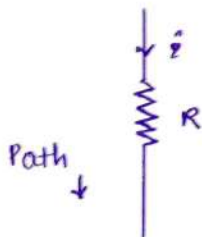
Voltage will taken as negative.

(ii)

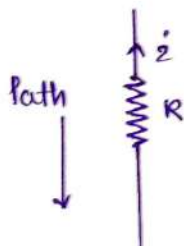


Voltage will taken as positive.

(iii) The direction of current are opposite, then IR is positive.



(iv) The direction of path and direction of current are the same, then IR is negative.



By applying KVL to the given loop ABCDA, we get

$$-E_1 + i_1 R_1 + (-E_2) + i_2 R_2 = 0$$

$$-E_1 + i_1 R_1 - E_2 + i_2 R_2 = 0$$

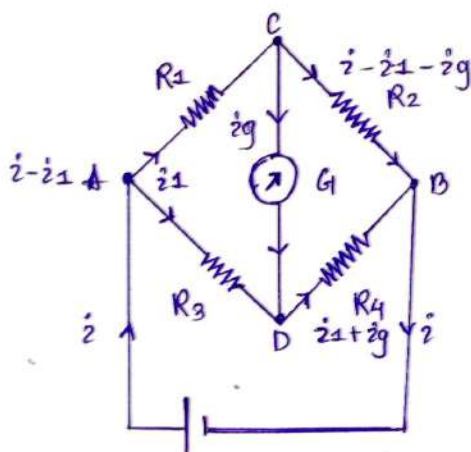
Q. State Kirchhoff's laws, Find balance condition for wheatstone bridge by applying Kirchhoff's laws.

Ans - Kirchhoff's laws

KCL: The algebraic sum of currents meeting at a junction is zero.

KVL: The algebraic sum of voltages across a closed loop is zero.

Balance condition for wheatstone bridge



Applying KVL to the loop ACDA

$$-(i-i_1)R_1 + [-igG] + i_1R_3 = 0$$

$$= -(i-i_1)R_1 - igG + i_1R_3 = 0 \quad \text{--- (1)}$$

Applying KVL to the closed loop CBDC

$$-(i-i_1-ig)R_2 + (i_1+ig)R_4 + igG = 0 \quad \text{--- (2)}$$

$$\text{For balanced wheatstone bridge, } ig = 0 \quad \text{--- (3)}$$

Putting $ig=0$ in eqn (1)

$$-(i-i_1)R_1 + i_1R_3 = 0$$

$$\Rightarrow i_1R_3 = (i-i_1)R_1 \quad \text{--- (4)}$$

Putting $ig=0$ in eqn (2)

$$-(i-i_1-0)R_2 + (i_1+0)R_4 + 0 \cdot G$$

$$= -(i-i_1)R_2 + (i_1)R_4 = 0$$

$$= i_1R_4 = (i-i_1)R_2 \quad \text{--- (5)}$$

Divide eqn (4) by eqn (5)

$$\frac{i_1R_3}{i_1R_4} = \frac{(i-i_1)R_1}{(i-i_1)R_2}$$

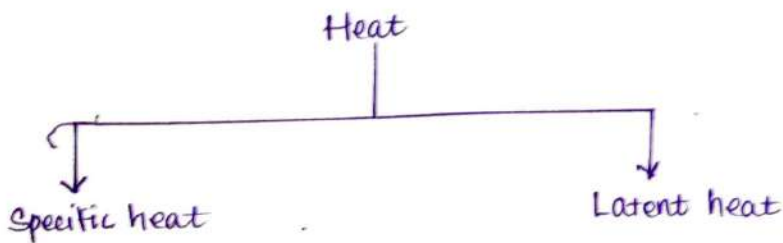
$$\Rightarrow \boxed{\frac{R_3}{R_4} = \frac{R_1}{R_2}}$$

This is the ~~buton~~ required solution.

UNI 7 : HEAT AND THERMODYNAMICS

Q. What is heat?

Ans - Heat is a form of energy and is called thermal energy.



Note

When we supply heat to a body:-

- (i) Temperature of the body changes.
- (ii) Phase of the body changes.

Specific heat

Amount of heat required to rise temperature of a body of mass 1gm through 1°C, without changing the phase of the body.

→ It's symbol is c .

→ Formula, $c = \frac{Q}{m\Delta T}$

$c \rightarrow$ Specific heat

$Q \rightarrow$ Heat

$m \rightarrow$ mass

$\Delta T \rightarrow$ change in temperature

→ $Q = cm\Delta T$

→ No phase change.

→ Only temperature changes.

→ Specific Heat of ice is $0.5 \text{ cal/gm}^\circ\text{C}$.

→ Specific Heat of water is $1 \text{ cal/gm}^\circ\text{C}$.

Q1. Find amount of heat required to raise the temperature of 10gm of water at 80°C to 100°C .

Ans - Given, mass = 10 gm
 $C = 1 \text{ cal/gm}^\circ\text{C}$
 $\Delta T = 100 - 80 = 20$

$$Q = Cm\Delta T$$

$$= 1 \times 10 \times 20$$

$$= 200 \text{ cal}$$

Q2. Calculate amount of heat required to raise the temperature of 50 gm of ice at -5°C to 0°C .

Ans - Given, mass = 50 gm
 $C = 0.5 \text{ cal/gm}^\circ\text{C}$
 $\Delta T = 5$

$$Q = Cm\Delta T$$

$$= 0.5 \times 50 \times 5$$

$$= 125$$

Q3. Write dimensional formula and SI unit of 'C'.

Ans - $[C] = [L^2 T^{-2} K^{-1}]$
 SI unit of C is $\frac{J}{\text{kg K}}$

Latent Heat

Q4. What is latent heat?

Ans - Amount of heat required to change phase of a substance of mass 1 gm with temperature remaining constant / without increase in temperature.

→ It's symbol is 'L'.

$$\rightarrow L = \frac{Q}{m}$$

$$\rightarrow \boxed{Q = Lm}$$

→ Phase changes at constant temperature.

Ans - Dimensional formula of 'L'

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

S.I unit of 'L' $\rightarrow \text{J/kg}$

Q6. Calculate the amount of heat required to convert 10gm of ice at 0°C to water at 0°C .

Ans - Given, mass = 10gm




$$Q = Lm$$
$$= 80 \times 10$$
$$= 800 \text{ cal}$$

Q7. Calculate amount of heat required to convert 5gm of water at 100°C to steam at 100°C .

Ans - Given, mass = 5gm

$$Q = Lm$$
$$= 540 \times 5$$
$$= 2700 \text{ cal}$$

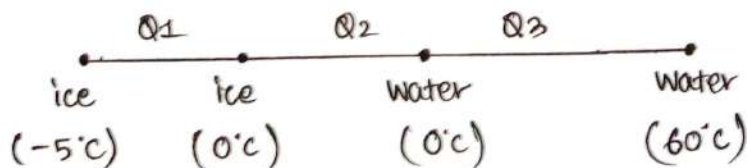
| Note

Water \rightarrow Steam
 1gm 1gm
 $L = 540 \text{ cal/g}$

Q8. Calculate the amount of heat required to convert 5gm of ice at -5°C to water at 60°C . Given specific heat of ice = 0.5 cal/gm and Latent heat of ice = 80 cal/gm .

Ans -



$$\begin{aligned} Q_1 &= Cm\Delta T \\ &= 0.5 \times 5 \times [0 - (-5)] \\ &= 0.5 \times 5 \times 5 \\ &= \frac{5}{10} \times 25 \\ &= \frac{125}{10} = 12.5 \text{ cal} \end{aligned}$$

$$Q_2 = Lm$$

$$= 80 \times 5$$

$$= 400 \text{ cal}$$

$$Q_3 = Cm\Delta T$$

$$= 1 \times 5 \times 60$$

$$= 300 \text{ cal}$$

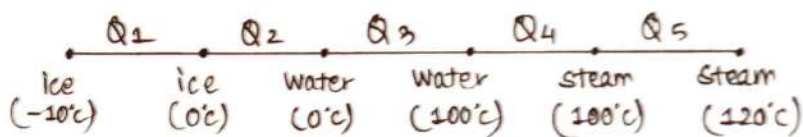
$$Q_{\text{total}} = Q_1 + Q_2 + Q_3$$

$$= 12.5 + 400 + 300$$

$$= 712.5 \text{ cal}$$

Q9. Calculate the amount of heat required to convert 10gm of ice at -10°C to steam at 120°C .

Ans-



$$Q_1 = Cm\Delta T$$

$$= 0.5 \times 10 \times [0 - (-10)]$$

$$= 0.5 \times 10 \times 10$$

$$= 0.5 \times 100$$

$$= 50 \text{ cal}$$

$$Q_2 = Lm$$

$$= 80 \times 10$$

$$= 800 \text{ cal}$$

$$Q_3 = Cm\Delta T$$

$$= 1 \times 10 \times 100$$

$$= 1 \times 1000$$

$$= 1000 \text{ cal}$$

$$Q_4 = Lm$$

$$= 540 \times 10$$

$$= 5400 \text{ cal}$$

$$Q_5 = Cm\Delta T$$

$$= 0.5 \times 10 \times 20$$

$$= 0.5 \times 200$$

$$= 100 \text{ cal}$$

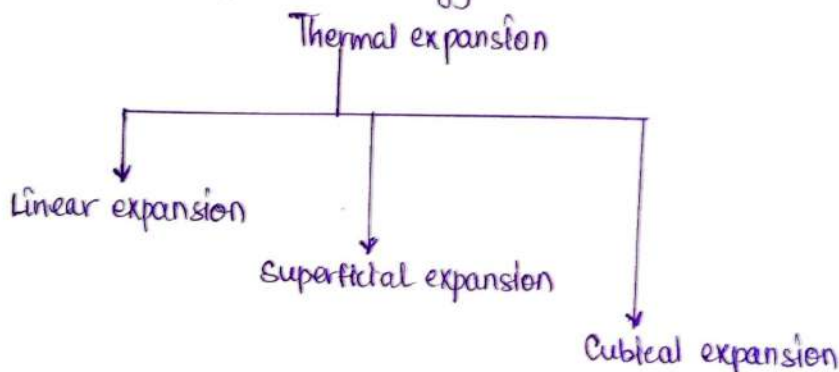
$$Q_{\text{total}} = Q_1 + Q_2 + Q_3 + Q_4 + Q_5$$

$$= 50 + 800 + 1000 + 5400 + 100$$

$$= 7350 \text{ cal}$$

Thermal expansion

Expansion due to heat / thermal energy.

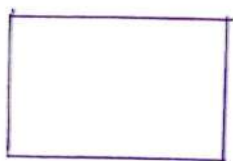


1D



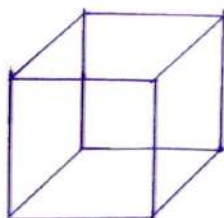
Iron rod

2D



Iron sheet

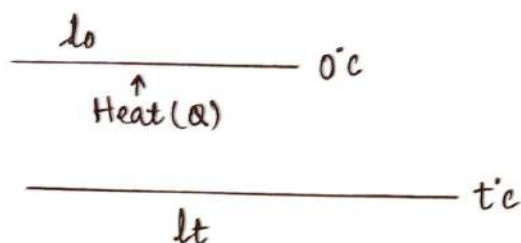
3D



Iron cube

- Linear expansion - Expansion along length
- superficial expansion - Expansion along length & breadth
- Cubical expansion - Expansion along all the three dimensions
[Length, breadth & height]

Linear expansion



Let, $l_0 \rightarrow$ length at 0°C

$l_t \rightarrow$ length at $t^\circ\text{C}$

change in length = $l_t - l_0$

$$l_t - l_0 \propto l_0 \quad \text{--- (1)}$$

$$l_t - l_0 \propto t \quad \text{--- (2)}$$

Combining eqn (1) and eqn (2)

$$l_t - l_0 \propto l_0 t$$

$$\Rightarrow l_t - l_0 = \alpha l_0 t \quad \text{--- (3)}$$

where α (alpha) is a constant and is called co-efficient of linear expansion.

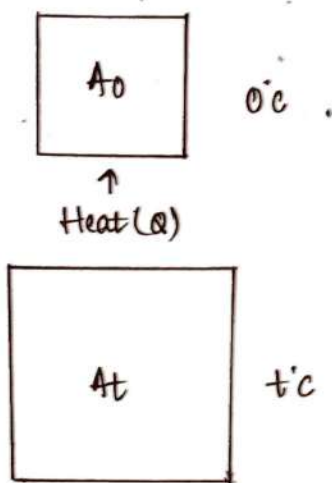
From eqn (3), $l_t = \alpha l_0 t + l_0$

$$\Rightarrow l_t = l_0 (\alpha t + 1) \quad \text{--- (4)}$$

from eqn (3),

$$\boxed{\alpha = \frac{l_t - l_0}{l_0 t}} \quad \text{--- (5)}$$

Superficial expansion



Let, $A_0 \rightarrow$ length at $0^{\circ}C$

$A_t \rightarrow$ length at $t^{\circ}C$

change in area $= A_t - A_0$

$$A_t - A_0 \propto A_0 \quad \text{--- (1)}$$

$$A_t - A_0 \propto t \quad \text{--- (2)}$$

Combining eqn (1) and eqn (2)

$$A_t - A_0 \propto A_0 t$$

$$\Rightarrow A_t - A_0 = \beta A_0 t \quad \text{--- (3)}$$

where β (Beta) is a constant and is called co-efficient of superficial expansion.

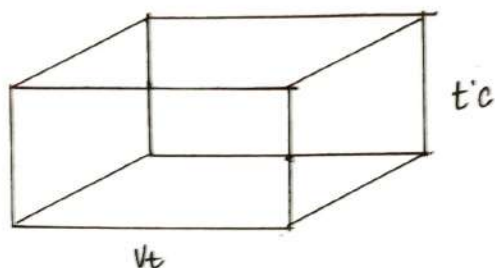
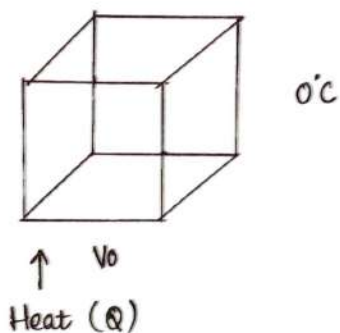
from eqn (3), $A_t = \beta A_0 t + A_0$

$$\Rightarrow A_t = A_0 (\beta t + 1) \quad \text{--- (4)}$$

From eqn (3),

$$\boxed{\beta = \frac{A_t - A_0}{A_0 t}} \quad \text{--- (5)}$$

Cubical expansion



$V_0 \rightarrow$ Volume at 0°C

$V_t \rightarrow$ Volume at $t^{\circ}\text{C}$

change in volume $= V_t - V_0$

$$V_t - V_0 \propto V_0 \quad \text{--- (1)}$$

$$V_t - V_0 \propto t \quad \text{--- (2)}$$

Combining eqn(1) & eqn(2)

$$V_t - V_0 \propto V_0 t$$

$$\Rightarrow V_t - V_0 = \gamma V_0 t \quad \text{--- (3)}$$

where γ (gamma) is a constant and is called co-efficient of cubical expansion.

From eqn(3), $V_t = \gamma V_0 t + V_0$

$$\Rightarrow V_t = V_0 (\gamma t + 1) \quad \text{--- (4)}$$

From eqn(3),

$$\boxed{\gamma = \frac{V_t - V_0}{V_0 t}} \quad \text{--- (5)}$$

Summary

Linear expansion

$\alpha \rightarrow$ co-efficient of linear expansion

$$l_t = l_0 (\alpha t + 1) \quad - (4)$$

$$\alpha = \frac{l_t - l_0}{l_0 t} \quad - (5)$$

Superficial expansion

$\beta \rightarrow$ co-efficient of superficial expansion

$$A_t = A_0 (\beta t + 1) \quad - (4)$$

$$\beta = \frac{A_t - A_0}{A_0 t} \quad - (5)$$

Cubical expansion

$\gamma \rightarrow$ co-efficient of cubical expansion

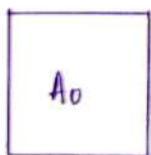
$$V_t = V_0 (\gamma t + 1) \quad - (4)$$

$$\gamma = \frac{V_t - V_0}{V_0 t} \quad - (5)$$

Ques

Q. Derive the relation between α , β and γ .

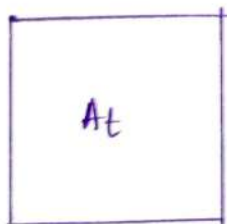
Soln - Relation between α and β



l_0

O.C

$$A_0 = l_0 \times l_0 = l_0^2$$



l_t

I.C

$$A_t = l_t \times l_t = l_t^2$$

We have, $A_t = A_0 (p_t + 1)$

$$\Rightarrow l_t^2 = l_0^2 (p_t + 1)$$

$$\Rightarrow \{l_0 (\alpha_t + 1)\}^2 = l_0^2 (p_t + 1)$$

$$\Rightarrow \cancel{l_0^2} (\alpha_t + 1)^2 = \cancel{l_0^2} (p_t + 1)$$

$$\Rightarrow (\alpha_t + 1)^2 = (p_t + 1)$$

$$\Rightarrow (\alpha_t)^2 + 2 \cdot \alpha_t \cdot 1 + (1)^2 = (p_t + 1)$$

$$\Rightarrow \alpha^2 t^2 + 2\alpha t + \cancel{1} = p_t + \cancel{1}$$

$$\Rightarrow \alpha^2 t^2 + 2\alpha t = p_t$$

$$\Rightarrow t(\alpha^2 t + 2\alpha) = p_t$$

$$\Rightarrow \alpha^2 t + 2\alpha = \frac{p_t}{t}$$

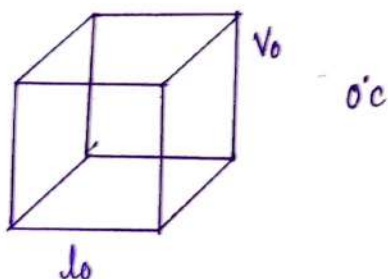
$$\Rightarrow \alpha^2 t + 2\alpha = p$$

Since α is very small, $\alpha^2 t$ can be neglected

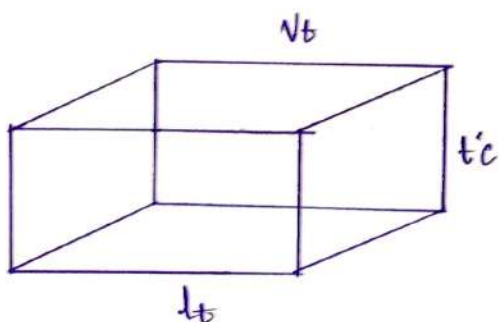
$$2\alpha = p$$

$$\boxed{\alpha = \frac{p}{2}} \quad - (1)$$

Relation between α and x



$$\boxed{V_0 = l_0 \times l_0 \times l_0 = l_0^3}$$



$$\boxed{V_t = l_t \times l_t \times l_t = l_t^3}$$

We have, $v_t = v_0 (x_t + 1)$

$$\Rightarrow L_t^3 = L_0^3 (x_t + 1)$$

$$\Rightarrow \left(L_0 (x_t + 1) \right)^3 = L_0^3 (x_t + 1)$$

$$\Rightarrow L_0^3 (x_t + 1)^3 = L_0^3 (x_t + 1)$$

$$\Rightarrow (x_t + 1)^3 = x_t + 1$$

$$\Rightarrow (x_t)^3 + 3(x_t)^2 \cdot 1 + 3(x_t) \cdot (1)^2 + (1)^3 = x_t + 1$$

$$\Rightarrow x^3 t^3 + 3x^2 t^2 + 3x t + 1 = x t + 1$$

$$\Rightarrow x^3 t^3 + 3x^2 t^2 + 3x t = x t$$

$$\Rightarrow t(x^3 t^2 + 3x^2 t + 3x) = x t$$

$$\Rightarrow x^3 t^2 + 3x^2 t + 3x = \frac{x t}{t}$$

$$\Rightarrow x^3 t^2 + 3x^2 t + 3x = x$$

Neglecting $x^3 t^2$ and $3x^2 t$

$$3x = x$$

$$\boxed{\alpha = \frac{\gamma}{3}} \quad - (2)$$

from eqn (1) & eqn (2)

$$\alpha = \frac{\beta}{2} = \frac{\gamma}{2}$$

Q. What is Joule's mechanical equivalent of heat?

Ans - Joule's mechanical equivalent of heat

$W \propto Q$

$W \rightarrow$ Work done

$Q \rightarrow$ Heat produced

$$\Rightarrow W = JQ$$

where J is a constant and is called Joule's mechanical equivalent of heat.

$$\therefore \frac{W}{Q} = J$$

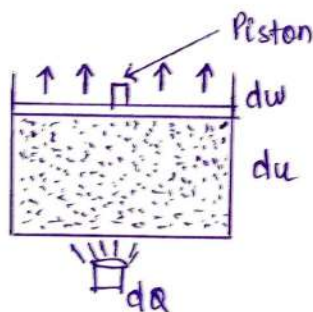
If, $Q = 1$ unit, then $J = W$

Definition

J is equal to w , when $Q = 1$ unit

Q. State 1st law of thermodynamics.

Ans - First law of thermodynamics



This law states that, $\boxed{du = dQ - dw}$ or $\boxed{du + dw = dQ}$

Where,

$dQ \rightarrow$ Amount of heat supplied

$dw \rightarrow$ Amount of work done

$du \rightarrow$ Change in internal velocity

Q. Write units of heat?

Ans - Units of heat

System of units

SI unit

MKS unit

CGS unit

FPS unit

Units of heat

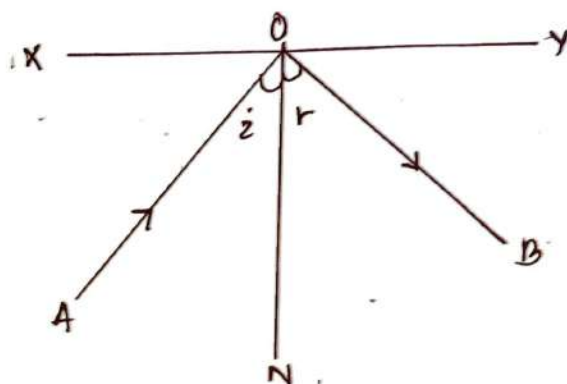
Joule

Joule

Calorie

BTU (British Thermal Unit)

UNIT 8 : OPTICS



AO \rightarrow Incident Ray

OB \rightarrow Reflected Ray

XY \rightarrow Reflecting surface

O \rightarrow Point of reflection

ON \rightarrow Normal to XY

i \rightarrow Angle of incidence

r \rightarrow Angle of reflection

Q. Write laws of reflection?

Ans - Laws of reflection

(i) Angle of incidence is equal to angle of reflection.

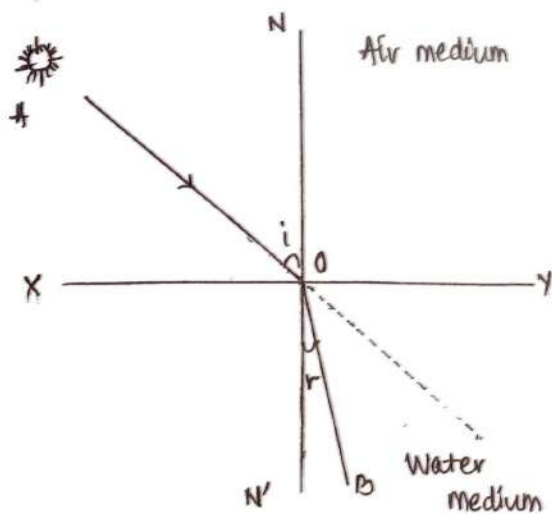
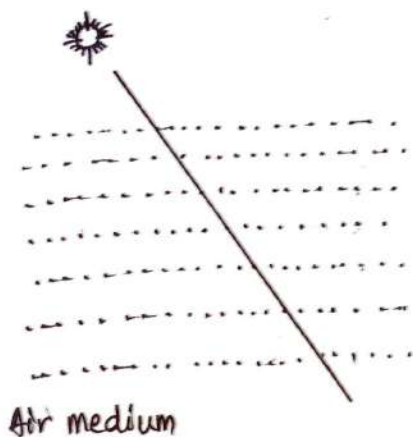
$$\angle i = \angle r$$

(ii) The incident ray, reflected ray and normal all lie on one plane and the plane is perpendicular to the reflecting surface.

Q. What is refraction?

Ans - Refraction

It is the property of light in which a ray of light travelling from one medium to another undergoes a change in its speed and direction.



AO \rightarrow Incident Ray

OB \rightarrow Refracted Ray

O \rightarrow Point of refraction

XY \rightarrow Interface

NN' \rightarrow Normal to XY at point 'O'

i \rightarrow Angle of incidence

r \rightarrow Angle of refraction

Q. Write laws of refraction.

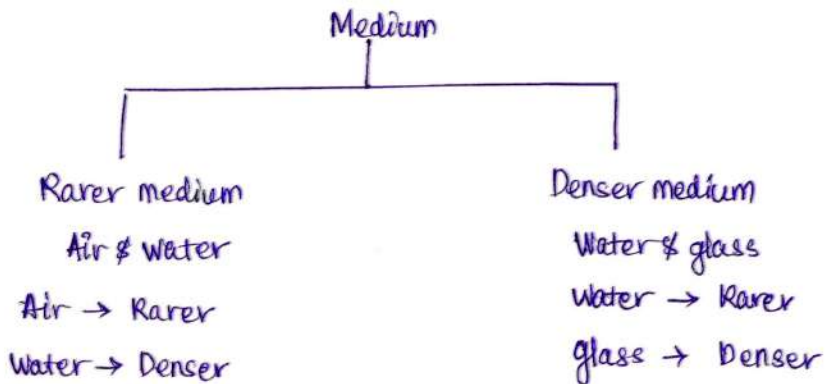
Ans - laws of refraction

(i) $\frac{\sin i}{\sin r} = \text{Constant}$

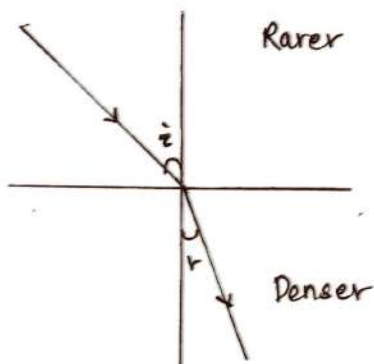
Constant is called refractive index of the medium (n).

(ii) The incident ray, refracted ray and the normal all lie in one plane and the plane is perpendicular to the interface.

Note

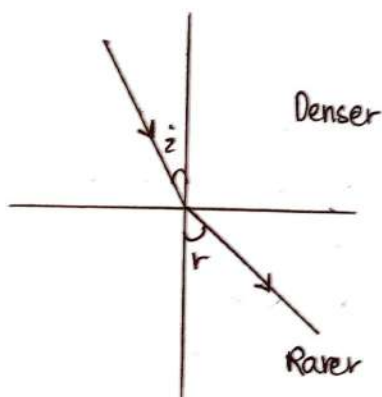


Case 1



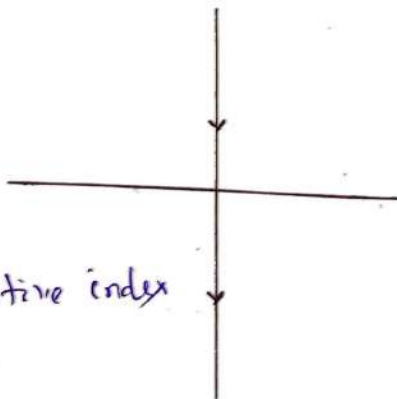
$$i > r$$

Case 2



$$i < r$$

Case 3



Q: what is refractive index of a medium.

Refractive Index

It is defined as, $\mu = \frac{c}{v}$

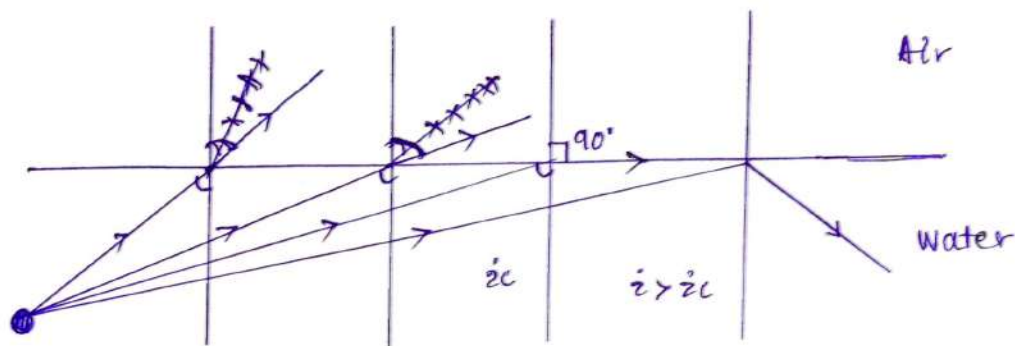
$c \rightarrow$ Speed of the light in vacuum
 $v \rightarrow$ Speed of the light in the given medium

Q. What is critical angle and total internal reflection (TIR)?

Ans - Critical angle

It is the angle of incidence for which angle of refraction is 90°

i.e. $\angle i = \angle i_c$ when $\angle r = 90^\circ$



Total internal reflection

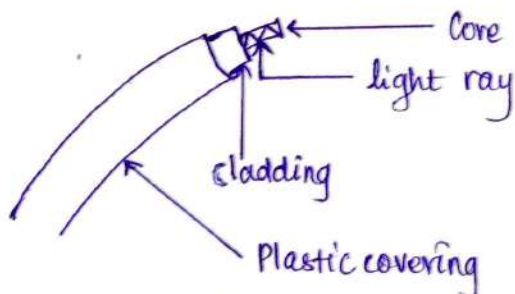
Total internal reflection occurs.

- (i) When $i > i_c$ (Angle of incidence is greater than critical angle).
- (ii) Ray must travel from denser medium to rarer medium.

Q. What is optical fiber?

Ans - Optical fiber

Optical fiber is a wave guide which transmits light along its axis through the process of total internal reflection.



Q. Write uses of optical fiber?

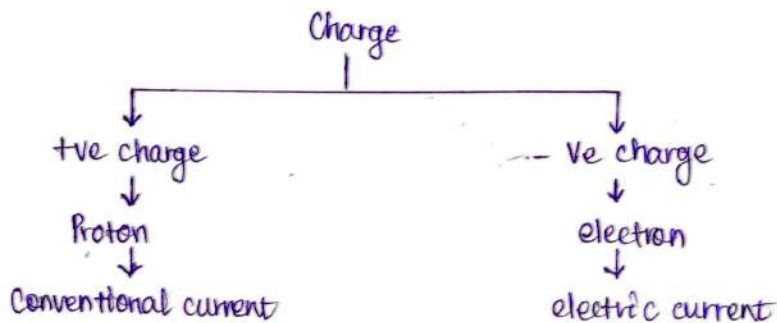
Ans - Uses of optical fiber

- (i) Medical Industry
- (ii) Communication
- (iii) Lighting & Decoration
- (iv) Broadcasting

UNIT 9 : ELECTROSTATICS & MAGNETOSTATICS

Electro static — charge at rest

Magnetostatic — Magnet at rest



Note

- Symbol of charge is q or Q .
- SI unit of charge is coulomb (C).

Electric force

- force between two charges.
- Two type — (i) Attractive (ii) Repulsive

Q. State and explain coulomb law in electrostatic.

Ans — Coulomb's law

Consider two charges : q_1 & q_2

r → Distance between q_1 and q_2



Let, F → Electric force between q_1 and q_2

Statement

- (i) Electric force is proportional to the product of two charges.
- (ii) Electric force is inversely proportional to the square of distance between two charges.

Explanation

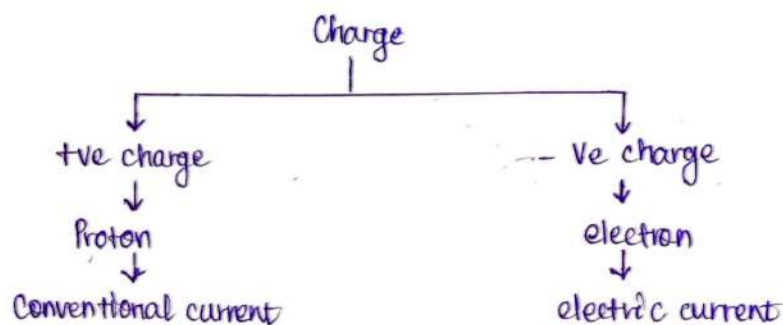
(i) $F \propto q_1 q_2$ — (1)

(ii) $F \propto \frac{1}{r^2}$ — (2)

UNIT 9 : ELECTROSTATICS & MAGNETOSTATICS

Electro static — charge at rest

Magnetostatic — Magnet at rest



Note

- Symbol of charge is q or Q .
- SI unit of charge is coulomb (C).

Electric force

- force between two charges.
- Two type — (i) Attractive (ii) Repulsive

Q. State and explain coulomb law in electrostatics.

Ans — Coulomb's law

Consider two charges : q_1 & q_2

r → Distance between q_1 and q_2



Let, F → Electric force between q_1 and q_2

Statement

- Electric force is proportional to the product of two charges.
- Electric force is inversely proportional to the square of distance between two charges.

Explanation

(i) $F \propto q_1 q_2$ — (1)

(ii) $F \propto \frac{1}{r^2}$ — (2)

Combining eqn (1) & eqn (2)

$$F \propto \frac{q_1 q_2}{r^2}$$

$$\Rightarrow F = K \frac{q_1 q_2}{r^2}$$

Where K is a constant and $K = \frac{1}{4\pi\epsilon_0}$

$$= 9 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2}$$

$\epsilon_0 \rightarrow$ Permittivity of the free space

$$\boxed{F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{r^2}} \quad - (3)$$

In SI units

$$\boxed{F = 9 \times 10^9 \frac{q_1 q_2}{r^2}} \quad - (4)$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2}$$

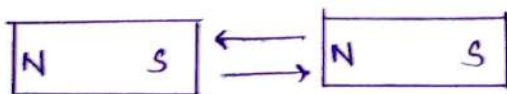
Magnetostatic

It deals with magnet.

Magnetic force

Force between two magnets or magnetic pole.

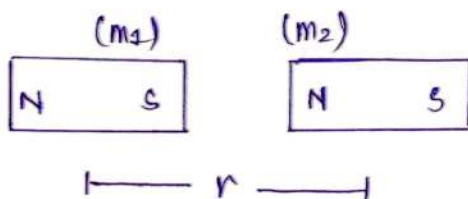
Attractive



Repulsive.

Q. State and explain Coulomb's law in magnetostatics?

Ans - Coulomb's law in magnetostatics



Consider two poles of strength m_1 & m_2 .
Let, 'r' be the distance between two poles.

'F' be the force between two poles.

Statement

- (i) Magnetic force between two poles is directly proportional to product of two poles.
- (ii) Magnetic force is inversely proportional to the square of distance between two poles.

Explanation

$$F \propto m_1 m_2 \quad \text{--- (1)}$$

$$F \propto \frac{1}{r^2} \quad \text{--- (2)}$$

Combining eqn(1) & eqn(2)

$$F \propto \frac{m_1 m_2}{r^2}$$

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

Where K is a constant and $K = \frac{\mu_0}{4\pi}$

$\mu_0 \rightarrow$ permeability of free space

$$\therefore F = \frac{\mu_0}{4\pi} \frac{m_1 m_2}{r^2} \quad \text{--- (3)}$$

$$\Rightarrow \boxed{F = 10^{-7} \frac{m_1 m_2}{r^2}} \quad \text{--- (4)}$$

In SI units

$$\frac{\mu_0}{4\pi} = 10^{-7} \frac{\text{wb}}{\text{Am}}$$

Q. Define unit charge?

Ans - Unit charge

$$\text{When, } F = 9 \times 10^9 \text{ N}$$

$$r = 1 \text{ meter}$$

$$q_1 = q_2 = q$$

$$\therefore 9 \times 10^9 = 9 \times 10^9 \times \frac{q_1 q_2}{1^2}$$

$$\Rightarrow \frac{9 \times 10^9}{9 \times 10^9} = \frac{q^2}{1}$$

$$\Rightarrow 1 = q^2$$

$$\Rightarrow q = \sqrt{1} = \pm 1$$

Defination

Unit charge is that amount of charge when placed in air at a distance of one meter from another charge experience a force of $9 \times 10^9 \text{ N}$.

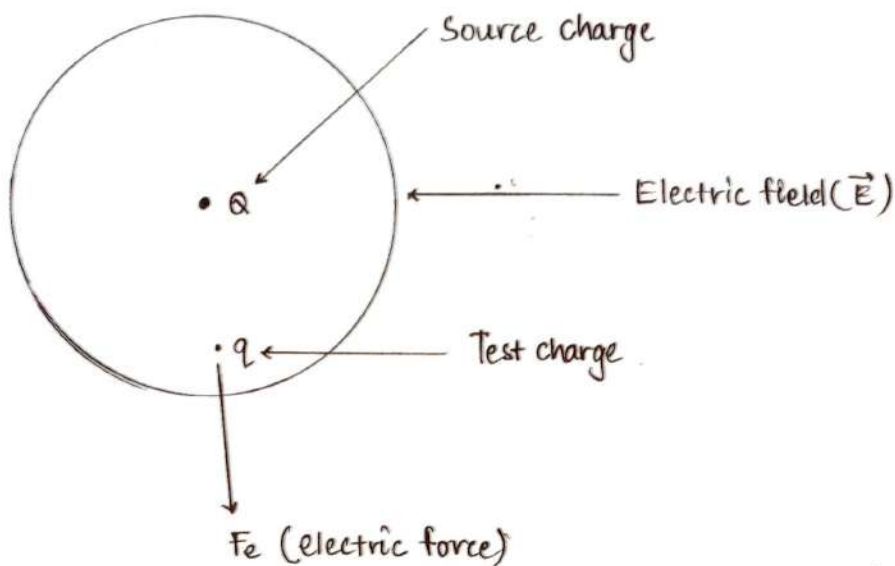
Q. Define unit pole.

Ans - Unit pole

Unit pole is that pole when placed in air at a distance of one meter from another pole experience a force of 10^{-7} N .

UNIT - 11 ELECTROMAGNETISM & ELECTROMAGNETIC INDUCTION

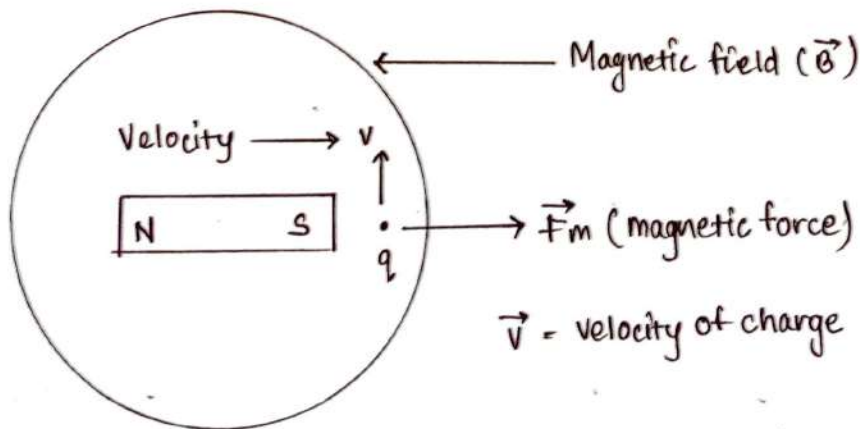
Electric field



$$\vec{E} = \frac{\vec{F}_e}{q}$$

$$\vec{F}_e = q\vec{E}$$

Magnetic field

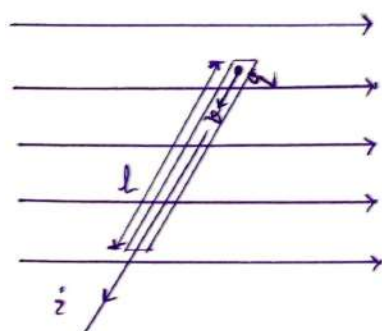


$$\vec{F}_m = q(\vec{v} \times \vec{B})$$

$$\Rightarrow \vec{F}_m = qvB \sin \theta \hat{n}$$

Q. Derive an expression for the force acting on a current carrying conductor placed in a uniform magnetic field.

Ans - Expression for force acting on a current carrying conductor placed in a uniform magnetic field.



Uniform magnetic field (\vec{B})

Let, $l \rightarrow$ length of the conductor

We have, $\vec{F}_m = q(\vec{v} \times \vec{B})$

$$\Rightarrow \vec{F}_m = qvB \sin\theta \hat{n}$$

$$\Rightarrow \vec{F}_m = q \frac{l}{t} B \sin\theta \hat{n}$$

$$\Rightarrow \vec{F}_m = IlB \sin\theta \hat{n}$$

$$\Rightarrow \vec{F}_m = I(\vec{l} \times \vec{B})$$

This is the required expression.

Q. State Faraday's law of electromagnetic induction.

Ans - Faraday's laws of electromagnetic induction

1st law

Whenever a magnetic flux linked with a circuit changes, an emf is induced in the circuit.

2nd law

The induced emf exist in the circuit so long as the change in magnetic flux linked with the circuit continues.

3rd law

Induced emf \propto negative rate of change of magnetic flux.

$$E \propto -\frac{d\phi_B}{dt}$$

Q. What is Lenz's law.

Ans - Lenz's law : The law states that the direction of induced emf is such that it oppose the cause which produce it. (Induced emf oppose it's cause)

Q. Distinguish between Fleming's left hand rule (FLHR) and Fleming's right hand rule (FRHR).

Ans - FLHR

(i) It gives direction force on current carrying conductor placed in a uniform magnetic field.

(ii) It is applicable to DC motors.

(iii) Mid finger \rightarrow direction of magnetic field (\vec{B}).

fore finger \rightarrow direction of current.

Thumb \rightarrow direction of force

FRHR

(i) It gives the direction of induced ^{emf} (induced current) due to change in magnetic flux linked with circuit.

(ii) It is applicable to DC generators.

(iii) Thumb - direction of motion.

middle finger - direction of magnetic field.

fore finger - direction of induced emf.