Vikash Polytechnic, Bargarh

Vikash Polytechnic
Campus: Vikash Knowledge Hub, Barahaguda Canal Chowk, NH6
PO/DIST: Bargarh-768028, Odisha

Lecture Note
on
Applied Physics-I

Diploma 1st Semester

Submitted By:- *Mr. Rupesh Ku. Pradhan*

UNIT : 1 UNITS AND DIMENSIONS

Physics

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

Engineering Physics

Engineering physics deals with uses or applications of the principles of physics in the field of engineering.

What is a event ?

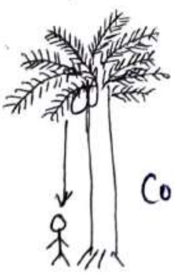
Ans - Examples of event

(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.

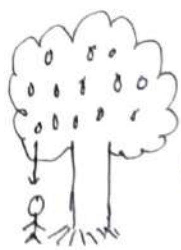
Physical quantities

Q. What are the physical quantities ?

Event 1 : Falling Fruit from a tree



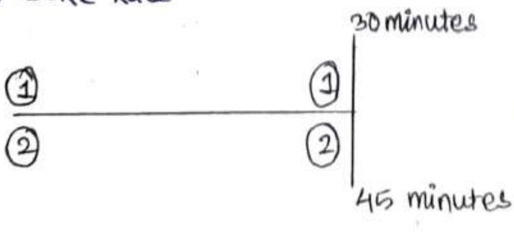
Coconut tree



Oak tree

force
mass

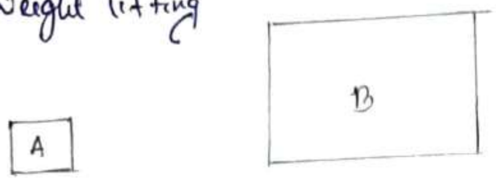
Event 2 : Bike Race



winner : 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

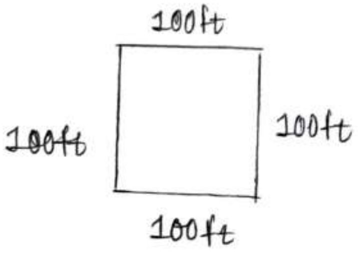
There are 7 number of fundamental physical quantities in physics.

sl.no.	Name of fundamental physical quantities	Symbol
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	I_v

Derived physical quantities

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

Example 1



Area of square = length × length

$= L \times L$

$= L^2$

Example 2

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

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

Example 3

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

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

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

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)

Sl.no.	Name of fundamental / Base quantity	SI unit	Symbol of SI unit
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 it's 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) Volume = length x breadth x height

$= L \times L \times L$

$= [L^3]$

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

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

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

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

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 -

$$Area = Length \times Length$$
$$= [L \times L]$$
$$= [L^2] = [M^0 L^2 T^0]$$

$$Volume = Length \times Length \times Length$$
$$= [L \times L \times L]$$
$$= [L^3]$$

$$Speed = \frac{Distance}{Time}$$
$$= \frac{Length}{time}$$
$$= \left[\frac{L}{T}\right] = [L^1 T^{-1}]$$

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

$$Force = mass \times \frac{Length}{(Time)^2}$$
$$= \frac{ML}{T^2} = [M^1 L^1 T^{-2}]$$

$$Pressure = \frac{Force}{Area}$$
$$= \left[\frac{F}{A}\right]$$
$$= \frac{[M^1 L^1 T^{-2}]}{[L^2]}$$
$$= [M^1 L^1 T^{-2}] \times [L^{-2}] = [M^1 L^{-1} T^{-2}]$$

$$\text{Work} = \text{force} \times \text{distance}$$
$$= [M^1 L^1 T^{-2}] \times [L^1]$$
$$= [M^1 L^2 T^{-2}]$$

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

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

Note: Pure numbers have no dimensions

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

$$\text{Power} = \frac{\text{Work}}{\text{time}}$$
$$= \frac{\text{Force} \times \text{distance}}{\text{time}}$$
$$= \frac{[M^1 L^2 T^{-2}]}{[T]}$$
$$= [M^1 L^2 T^{-2}] \times [T^{-1}]$$
$$= [M^1 L^2 T^{-3}]$$

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) $F = \frac{W}{S} + ma$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

(iv) $V^2 - u^2 = 9as$

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

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

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

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

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

(v) $v - u = at$

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

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

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

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

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

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

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

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

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

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

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

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

$$s = [L^1]$$

$$ut = [L^1 T^{-1}] \times [T^1]$$
$$= [L^1 T^0]$$

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

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

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

(viii) $V = \sqrt{\frac{Fr}{m}}$

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

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

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

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

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

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

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.

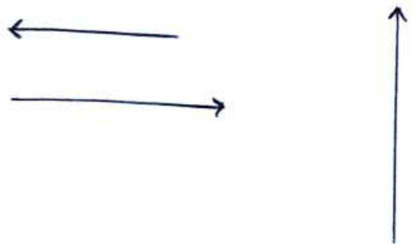
Q. Define vector quantities ?

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 a arrow head.



Magnitude : Length of the line segment gives magnitude.

Direction : Arrow head gives direction.

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

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

$\boxed{\vec{A} = A\hat{A}}$ OR $\boxed{\vec{A} = |\vec{A}|\,\hat{A}}$

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'.

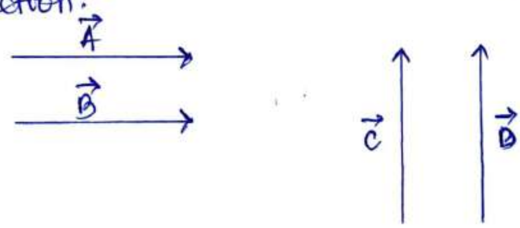
(ii) Null vector

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.

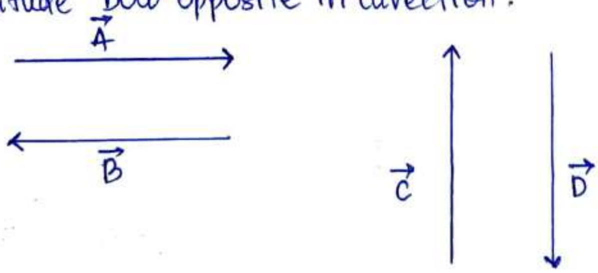
Ex –



(iv) Negative vector

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

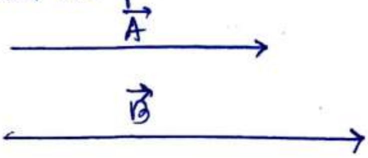
Ex –



(v) Parallel vector

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

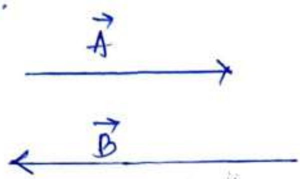
Ex –



(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.

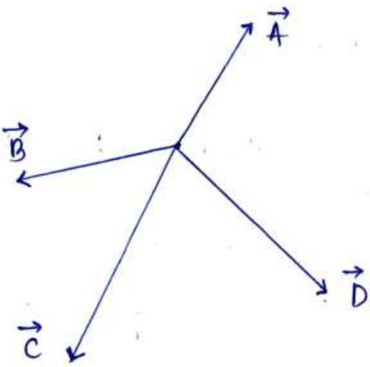
Ex -



(vii) Co-initial vectors

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

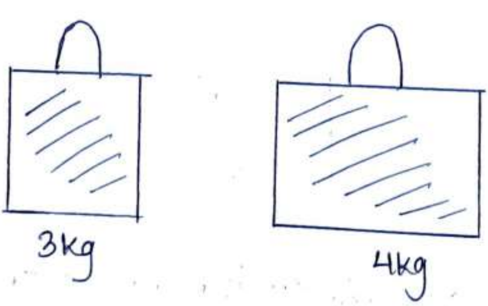
Ex -



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

Scalar addition

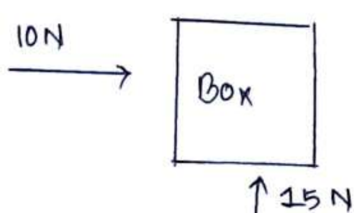
Mass



3kg + 4kg = 7kg

* Scalar addition obey simple rule of algebra.

Vector addition



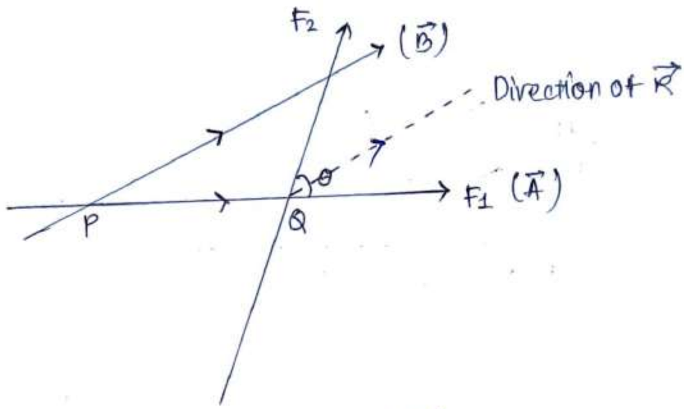
* Vector addition doesn't obey simple rule of algebra.

Laws of vector addition

(i) Triangle law of vector addition

(ii) Parallelogram law of vector addition

Triangle law of vector addition

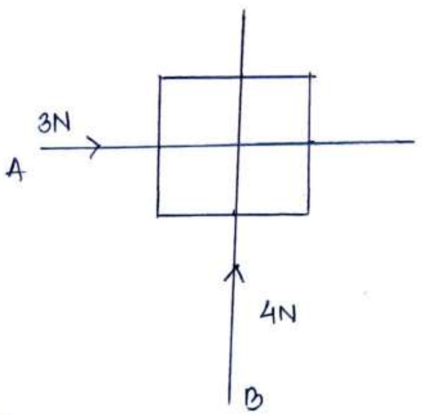


Total force / Resultant vector $(\vec{R})$

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

θ is the angle between $\vec{A}$ and $\vec{B}$.

Example 1



Ans -

$A = 3$

$B = 4$

$\theta = 90^\circ$

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

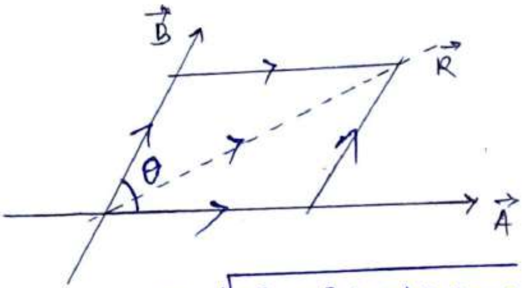
$= \sqrt{3^2 + 4^2 + 2 \times 3 \times 4 \cos 90^\circ}$

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

$= \sqrt{25 + 0}$

$= \sqrt{25} = 5N$

Parallelogram law of vector addition



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

Example 2

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

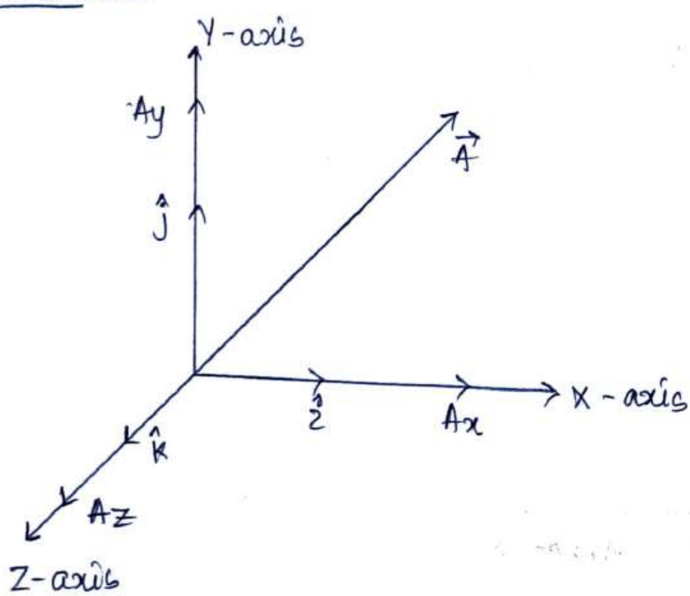
Ans - $R = \sqrt{1^2 + 2^2 + 2 \times 1 \times 2 \cos 60'}$

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

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

$= \sqrt{7}$

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

$z \rightarrow$ 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 $\vec{B}$

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

$$\begin{aligned}\vec{A} \cdot \vec{B} &= AB\cos\theta \\ &= 3 \times 4 \times \cos 60° \\ &= 12 \times \frac{1}{2} \\ &= 6 \text{ units}\end{aligned}$$

Dot product in component form

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

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

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

$$\boxed{\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z}$$

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 – $A_x = 2$, $A_y = 3$, $A_z = -4$

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

$$\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$$
$$= (2\times1) + (3\times(-2)) + ((-4)\times3)$$
$$= 2 + (-6) + (-12)$$
$$= 2 - 6 - 12$$
$$= -16$$

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 – $A_x = 1$, $A_y = 2$, $A_z = -4$

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

$$\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$$
$$= (1\times3) + (2\times4) + (-4\times-1)$$
$$= 3 + 8 + 4$$
$$= 15$$

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 – $A_x = 2$, $A_y = -3$, $A_z = 1$

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

$$\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$$
$$= (2\times 2) + ((-3)\times 1) + (1\times 0)$$
$$= 4 + (-3) + 0$$
$$= 4 - 3 = 1$$

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

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

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

$$\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$$
$$= (1\times 2) + (1\times 0) + (4\times 0)$$
$$= 2 + 0 + 0$$
$$= 2$$

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

$\theta = 90°$

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

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

$$= 12$$

$\vec{A} \times \vec{B}$ 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 $A = \hat{i} - 3\hat{j}$

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

Ans –

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

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

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

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

(Ans)

UNIT : 3 KINEMATICS

Q. What is Rest ?

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

Q. What is motion ?

Ans - A body is said to be in motion when it's 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.

→ It's 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.

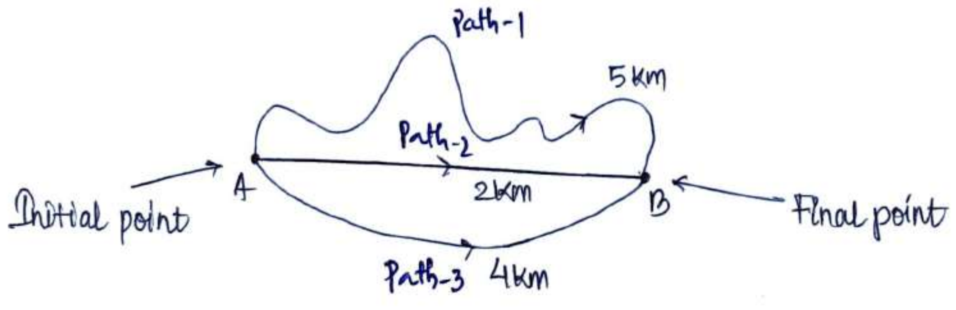
magnitude of displacement : It is the length of the shortest path between initial point and final point.

Direction of displacement : It's direction is always from initial point to final point $(A \longrightarrow B)$.

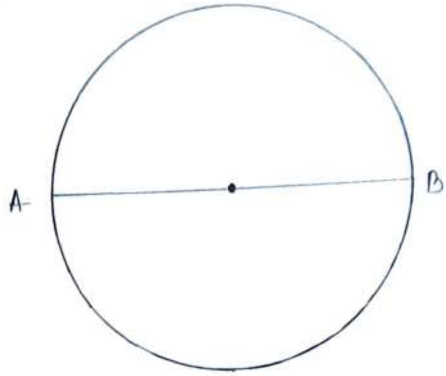
→ It's symbol is $\vec{s}$.

→ It's S.I unit is meter (m).

→ It's D.F is $[\vec{s}] = [L^1]$



Example 1



$r = 70m$

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

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

displacement $= 2r = 2 \times 70$

$= 140\ m$

Note

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

Distance → length of the path → scalar quantity → Only magnitude

Displacement → shortest path → Vector quantity → magnitude & direction

Speed

→ It is a scalar quantity.

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

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

→ Symbol : u or v

→ D.F is $[u] = [L^1T^{-1}]$

Velocity

→ It is a vector quantity.

→ Velocity $= \frac{displacement}{time}$

→ Direction is the same as that of displacement.

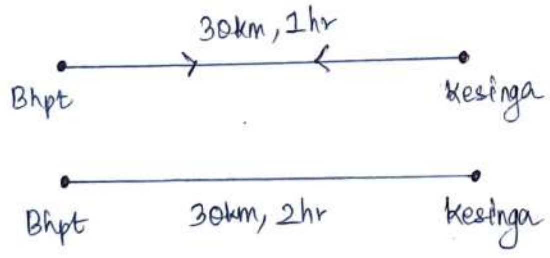
→ Symbol : $\vec{u}$ or $\vec{v}$

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

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

→ D.F is [velocity] = $[L^1 T^{-1}]$

Example 2



Distance = ?
Time = ?
Displacement = ?
speed = ?
velocity = ?

Ans - Distance = 30+30 = 60 Km
Time = 1+2 = 3hr
Displacement = 0

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

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

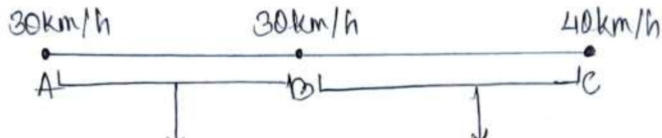
Acceleration and force

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

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

a → Acceleration

$u \rightarrow$ Initial velocity
$v \rightarrow$ Final velocity
$t \rightarrow$ time



acceleration = 0

acceleration $= \frac{40-30}{1} = \frac{10}{1} = \frac{10\ km}{h^2}$

→ It is a vector quantity.

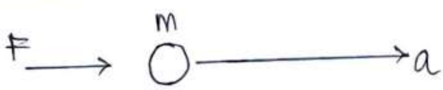
→ Symbol : $\vec{a}$

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

→ S.I unit : $\frac{m}{s^2}$

→ D.F is $[a] = [L^1 T^{-2}]$

Force



m = mass

a = acceleration

F = Force

Relation between F & a

$$\boxed{F = ma}$$

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

→ S.I unit of force is $\frac{kg\,m}{s^2}$ or Newton.

$$\boxed{1N = \frac{1\,kg\,m}{s^2}}$$

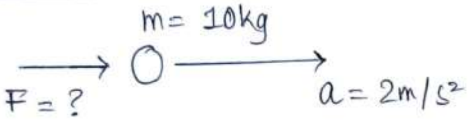
→ Dimensional formula of force

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

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

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

Example 3

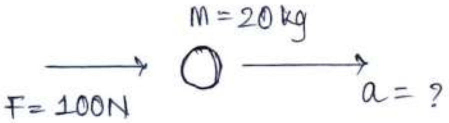


Ans -

$F = m \cdot a$

$= 10 \times 2 = 20N$

Example 4



Ans -

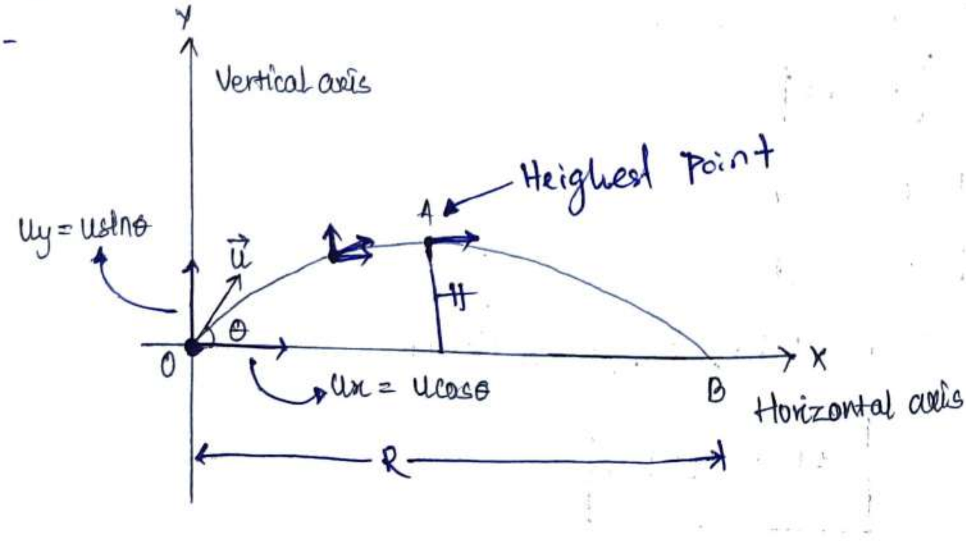
$a = \frac{F}{m}$

$= \frac{100}{20}$

$= 5 m/s^2$

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

Ans -



R → Horizontal Range

H → Maximum Height

Expression for time of flight (T)

Time of flight [$O \to B$]

= Time of ascent ($O \to A$) + Time of descent ($A \to B$)

$$\boxed{T = t_a + t_d}$$

At 'O' point

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

At 'A' point

$v_y = 0$

$a_y = -g$

$a_x = 0$

Time of ascent

We have, $v = u + at$

vertical motion, $v_y = u_y + a_y t$

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

$$0 = u\sin\theta - gt_a$$

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

Time of descent

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

$\therefore t_a + t_d$

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

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

Maximum height (H)

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

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

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

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

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

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

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

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 $\theta = 45°$, $R = R_{max}$.

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

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

P-1

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

Solution: Given $u = 4.9$ m/s

$\theta = 30°$

$g = 9.8$ m/s^2

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

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

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

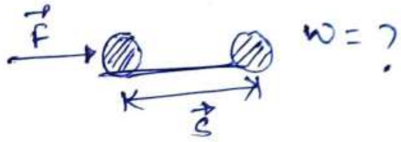
(iii) $R = \frac{u^2\sin 2\theta}{g} = \frac{(4.9)^2 \times \sin 60}{9.8} = 1.22\sqrt{3}$ m.

UNIT 4 : WORK AND FRICTION

Q. What is work ?

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

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



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

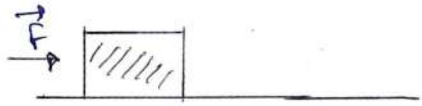
θ is the angle between $\vec{F}$ and $\vec{S}$.

Note

* Zero work ($W=0$)

→ when $S = 0$

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

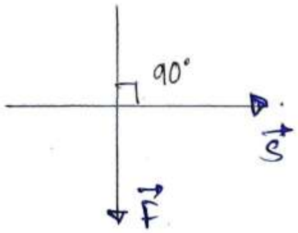


(No displacement)

→ When $\theta = 90°$

$W = F \times S \times \cos 90°$

$= F \times S \times 0 = 0$



* Work is a scalar quantity.
* S.I unit of work is Newton × Meter (Nm)
* Dimensional formula of work is

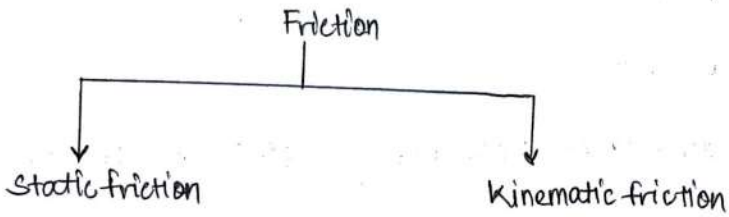
$$[W] = [M^1 L^2 T^{-2}]$$

Q. What is friction?

Ans - * Friction is a force.

* Defination - 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

$$\boxed{F \propto R}$$

$$\Rightarrow F = \mu R$$

μ — constant and is called co-efficient of friction

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

Limiting friction

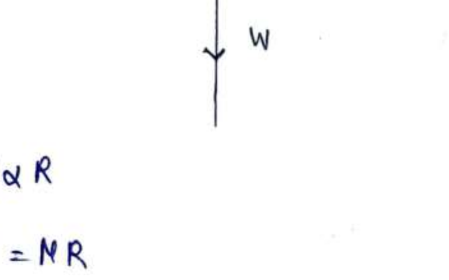
* Maximum value of a static friction.

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.

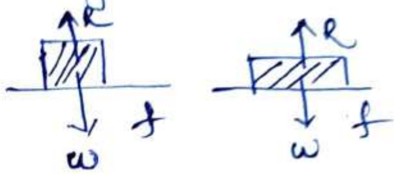


$$f \propto R$$

$$\therefore f = \mu R$$

(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.

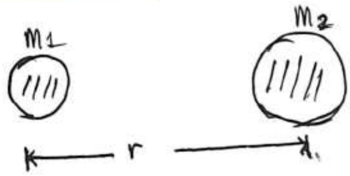
UNIT 5 : GRAVITATION

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 → masses of two bodies

r → Distance between two bodies

Let F → Gravitational force between two bodies

According to the newton's law of gravitation

$F \propto m_1 m_2$

→ Gravitational force is directly proportional to the product of two masse

→ 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)

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

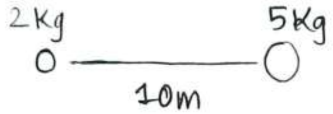
$$\Rightarrow \boxed{F = G\frac{m_1 m_2}{r^2}} \quad \text{— (3)}$$

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

Value of G in SI unit is

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

Example 1



$m_1 = 2\ kg$

$m_2 = 5\ kg$

$r = 10\ m$

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

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

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

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

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

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

Ans - Dimensional formula of 'G'

$$[G] = \frac{[F] \times [r^2]}{[M_1] \times [m_2]}$$

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

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

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

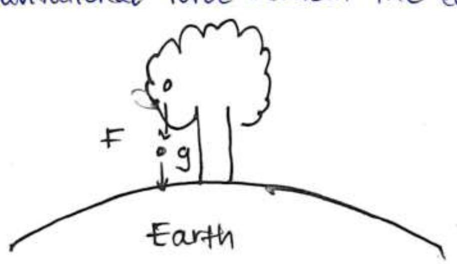
$$= [M^1 L^3 T^{-2}] \times [M^{-2}]$$

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

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

Acceleration due to gravity

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



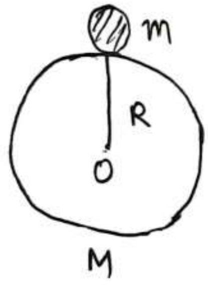
→ It's symbol is 'g'. [a = g]

→ It's 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 defination, $F = mg$ — (2)

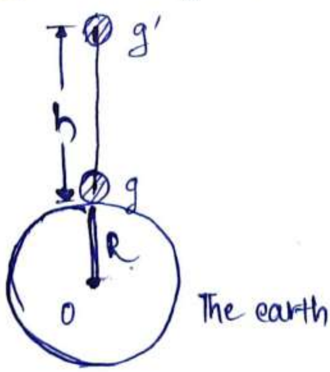
From eqn (1) & eqn (2)

$$G\frac{\cancel{m}M}{R^2} = \cancel{m}g$$

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

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

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

$h = 1600$ km

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

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

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

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

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

Variation of g with depth

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

Where, d = depth

R = Radius of the earth

Explanation

On the surface of the earth

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

$d = 1600$ km

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

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

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

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

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

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

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

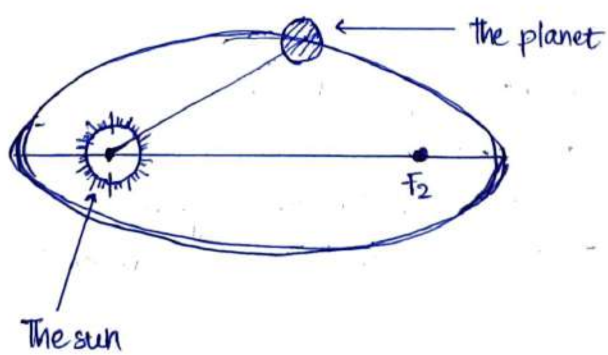
Q. State kepler's laws of planetary motion.

Ans - Kepler's laws of planetary motion

Kepler's has proposed three laws.

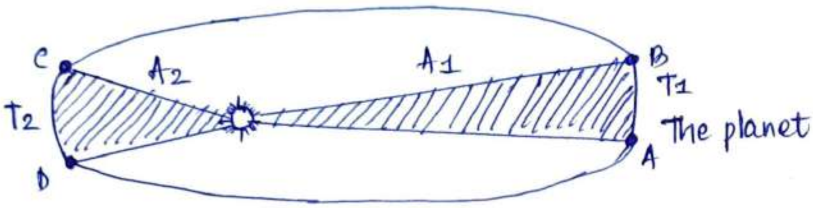
1st law (law of orbit) : The path/orbit of the planets around the sun is an ellipse.

The sun is situated at the focus.



2nd law (law of arial 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)

UNI 7: HEAT AND THERMODYNAMICS

Q. What is heat?

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

Heat

Specific heat | Latent heat

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

→ $\boxed{Q = cm\Delta T}$

→ No phase change.

→ Only temperature changes.

→ Specific Heat of ice is 0.5 cal / gm°c.

→ Specific Heat of water is 1 cal / gm°c.

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

Ans - Given, mass = 10gm

$C = 1 \text{ cal/gm}^\circ c$

$\Delta T = 100 - 80 = 20$

$Q = Cm\Delta T$

$= 1 \times 10 \times 20$

$= 200 \text{ Cal}$

Q2. Calculate amount of heat required to raise the temperature of 50gm of ice at $-5^\circ c$ to $0^\circ c$.

Ans - Given, mass = 50gm

$c = 0.5 \text{ cal/gm}^\circ c$

$\Delta T = 5$

$Q = Cm\Delta T$

$= 0.5 \times 50 \times 5$

$= 125$

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

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

SI unit of c is $\frac{J}{Kg\,K}$

Latent Heat

Q4. What is latent heat?

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

→ It's symbol is 'L'.

→ $L = \frac{Q}{m}$

→ $\boxed{Q = Lm}$

→ Phase changes at constant temperature.

Q5. Write dimensional formula and SI unit of latent heat?

Ans - Dimensional formula of 'L'

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

S.I unit of 'L' $\rightarrow$ 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

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

Note

ice 1gm $\longrightarrow$ water 1gc (0°c)

L = 80 cal/g

water 1gm $\longrightarrow$ Steam 1gm

L = 540 cal/g

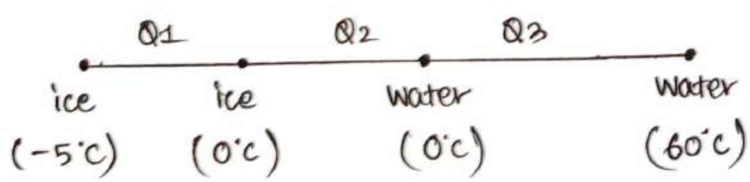
Q7. Calculate amount of heat required to convert 5gm of water at 100°c to steam at 100°c.

Ans - Given, mass = 5gm

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

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 -



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

$Q_2 = Lm$

$= 80 \times 5$

$= 400$ cal

$Q_3 = Cm\Delta T$

$= 1 \times 5 \times 60$

$= 300$ cal

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

$= 12.5 + 400 + 300$

$= 712.5$ cal

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

Ans-

	Q_1		Q_2		Q_3		Q_4		Q_5	
ice $(-10°c)$		ice $(0°c)$		water $(0°c)$		water $(100°c)$		steam $(100°c)$		steam $(120°c)$

$Q_1 = Cm\Delta T$

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

$= 0.5 \times 10 \times 10$

$= 0.5 \times 100$

$= 50$ cal

$Q_2 = Lm$

$= 80 \times 10$

$= 800$ cal

$Q_3 = Cm\Delta T$

$= 1 \times 10 \times 100$

$= 1 \times 1000$

$= 1000$ cal

$Q_4 = Lm$

$= 540 \times 10$

$= 5400$ cal

$Q_5 = Cm\Delta T$

$= 0.5 \times 10 \times 20$

$= 0.5 \times 200$

$= 100$ cal

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

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

$= 7350$ cal

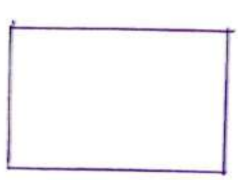
Thermal expansion

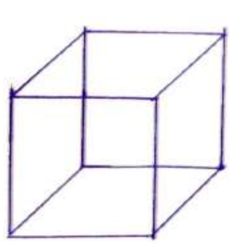
Expansion due to heat / thermal energy.

Thermal expansion

- Linear expansion
- Superficial expansion
- Cubical expansion

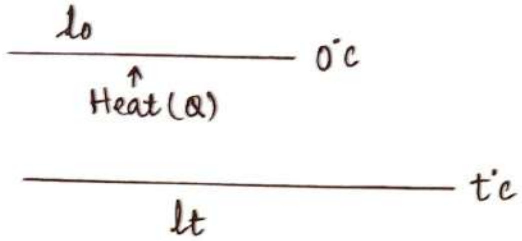
1D Iron rod

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°c

change in length $= l_t - l_0$

$$l_t - l_0 \propto l_0 \quad —(1)$$

$$l_t - l_0 \propto t \quad —(2)$$

Combining eqn (1) and eqn (2)

$$l_t - l_0 \propto l_0 t$$

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

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

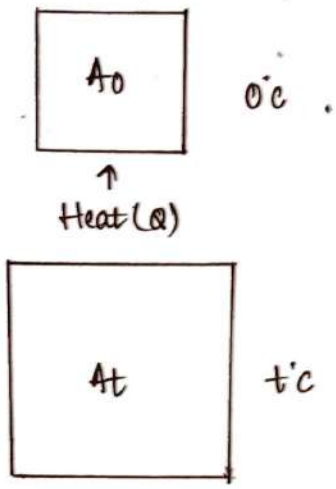
From eqn (3), $l_t = \alpha l_0 t + l_0$

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

from eqn (3),

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

Superficial expansion



Let, $A_0 \rightarrow$ length at 0°c

$A_t \rightarrow$ length at t°c

Change in area = $A_t - A_0$

$$A_t - A_0 \propto A_0 \quad — (1)$$

$$A_t - A_0 \propto t \quad — (2)$$

Combining eqn (1) and eqn (2)

$$A_t - A_0 \propto A_0 t$$

$$\Rightarrow A_t - A_0 = \beta A_0 t \quad — (3)$$

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

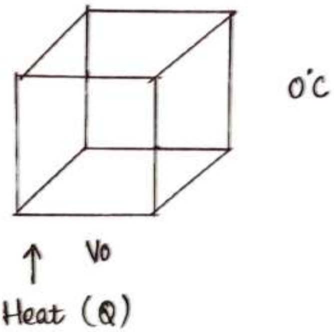
from eqn (3), $A_t = \beta A_0 t + A_0$

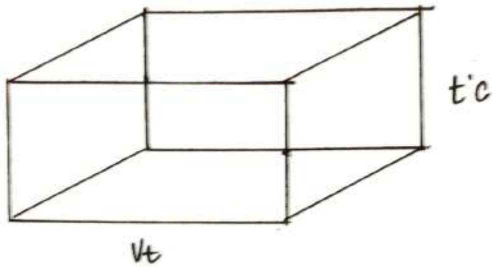
$$\Rightarrow A_t = A_0 (\beta t + 1) \quad — (4)$$

From eqn (3),

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

Cubical expansion





$V_0 \rightarrow$ Volume at 0°c

$V_t \rightarrow$ Volume at t°c

change in volume $= V_t - V_0$

$V_t - V_0 \propto V_0$ — (1)

$V_t - V_0 \propto t$ — (2)

Combining eqn(1) & eqn(2)

$V_t - V_0 \propto V_0 t$

$\Rightarrow V_t - V_0 = \gamma V_0 t$ — (3)

Where γ (Gamma) is a constant and is called co-efficient of cubical expansion.

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

$\Rightarrow V_t = V_0(\gamma t + 1)$ — (4)

From eqn(3),

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

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

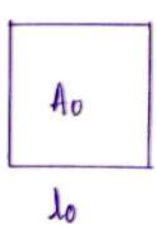
$$V_t = V_0(\gamma t + 1) \quad -(4)$$

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

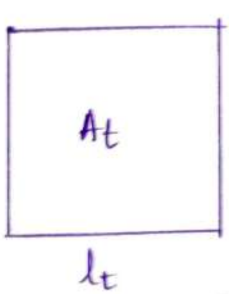
Imp

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

Soln - Relation between α and β



$0^\circ C$ $\boxed{A_0 = l_0 \times l_0 = l_0^2}$



$t^\circ C$ $\boxed{A_t = l_t \times l_t = l_t^2}$

We have, $A_t = A_0(\beta t + 1)$

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

$$\Rightarrow \{l_0(\alpha t + 1)\}^2 = l_0^2(\beta t + 1)$$

$$\Rightarrow \cancel{l_0^2}(\alpha t + 1)^2 = \cancel{l_0^2}(\beta t + 1)$$

$$\Rightarrow (\alpha t + 1)^2 = (\beta t + 1)$$

$$\Rightarrow (\alpha t)^2 + 2 \cdot \alpha t \cdot 1 + (1)^2 = (\beta t + 1)$$

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

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

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

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

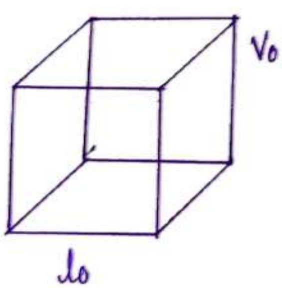
$$\Rightarrow \alpha^2 t + 2\alpha = \beta$$

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

$$2\alpha = \beta$$

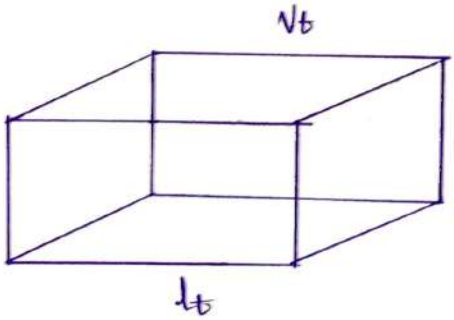
$$\boxed{\alpha = \frac{\beta}{2}} \quad -(1)$$

Relation between α and γ



$0°C$

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



$t°C$

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

We have, $V_t = V_0(\gamma t + 1)$

$\Rightarrow l_t^3 = l_0^3(\gamma t + 1)$

$\Rightarrow \{l_0(\alpha t + 1)\}^3 = l_0^3(\gamma t + 1)$

$\Rightarrow \cancel{l_0^3}(\alpha t + 1)^3 = \cancel{l_0^3}(\gamma t + 1)$

$\Rightarrow (\alpha t + 1)^3 = \gamma t + 1$

$\Rightarrow (\alpha t)^3 + 3.(\alpha t)^2 \cdot 1 + 3(\alpha t) \cdot (1)^2 + (1)^3 = \gamma t + 1$

$\Rightarrow \alpha^3 t^3 + 3\alpha^2 t^2 + 3\alpha t + \cancel{1} = \gamma t + \cancel{1}$

$\Rightarrow \alpha^3 t^3 + 3\alpha^2 t^2 + 3\alpha t = \gamma t$

$\Rightarrow t(\alpha^3 t^2 + 3\alpha^2 t + 3\alpha) = \gamma t$

$\Rightarrow \alpha^3 t^2 + 3\alpha^2 t + 3\alpha = \frac{\gamma \cancel{t}}{\cancel{t}}$

$\Rightarrow \alpha^3 t^2 + 3\alpha^2 t + 3\alpha = \gamma$

Neglecting $\alpha^3 t^2$ and $3\alpha^2 t$

$$3\alpha = \gamma$$

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

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.

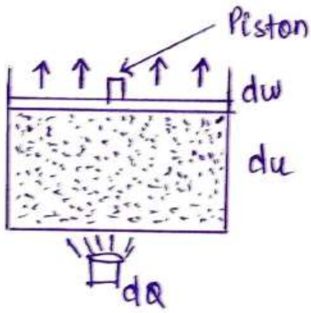
$\therefore \frac{W}{Q} = J$ If, $Q = 1$ unit, then $J = W$

Defination

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

Q. State 1^{st} 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	Units of heat
SI unit	Joule
MKS unit	Joule
CGS unit	Calorie
FPS unit	BTU (British Thermal Unit)