Paper Id: 170013 SECTION-A

Applied Physics-I

Q1 a) Define principle of homogeneity.

Sol^n ⇒ According to this law dimension of all the equations present on both the sides of any physical equation must always be same.

Q2 b) Define fundamental unit.

Sol^n ⇒ The units selected for measuring the fundamental quantities are called fundamental units. For eg: metre, kg.

(c.) Give dimensional formula for velocity.

Sol^n ⇒ Dimensional formula for velocity is $[L^1T^{-1}]$

(d.) Give M.K.S unit of force.

Sol^n → M.K.S unit of force is Newton.

(e.) Define scalar quantity.

Sol^n: ⇒ The quantity which has magnitude only is known as scalar quantity. For eg: Mass, time etc.

(f) Give the full form of MKS unit.

Sol^n: Full form of M.K.S unit is:

(i.) M stands for Metre (m)

(ii.) K stands for kilogram (kg)

(iii.) S stands for second (sec).

(g.) Define force.

Sol^n: It is defined as push or pull which changes or tries to change the state of rest or motion of a body.

Eg: When football is kicked by players it starts to move.

(h) Define time period.

Soln: It is defined as the time taken by body to complete one revolution in circular path.

(i) Define energy

Soln: The ability of a body to do some work is called energy.

(J) Define Power.

Soln: Rate of doing work is called Power.

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

(K) Define Rotational Motion.

Soln: The Rotation of a body about a fixed axis is called Rotational Motion.

(l) Define Torque.

Soln: The Turning effect of force about the axis of rotation is called Torque.

$$\text{Torque} = \text{Force} \times \text{Perpendicular distance}$$

(m) Define Stress.

Soln: It is defined as the restoring force per unit area.

(n) Define Surface Tension.

It is the property of a liquid due to which the free surface of liquid at rest behaves like a stretched elastic membrane which tries to contract to have minimum surface area.

o) Give formula for Potential Energy

Solⁿ: Pot. Energy = mgh

where m — mass
g — accⁿ due to gravity
h — height

p) Give dimensional formula for Pressure.

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

q) Define positive work.

when Force and displacement are in same direction i.e $\theta = 0$, Work is said to be Positive.

eg when a body falls freely under gravity then work done by gravity is positive.

r) Define Potential Energy.

The Energy Possessed by a body due to its position, state or configuration is called Potential Energy.

eg water stored in a dam has P.E

Section : B

Q2 (i) Check the correctness of

(a) $V = u + at$ — ①

Here $V = LT^{-1}$ $u = LT^{-1}$ $a = LT^{-2}$ $t = T$

Put all the dimensional formulas in eqⁿ ①

we get,

$$[LT^{-1}] = [LT^{-1}] + [LT^{-2}][T]$$

$$[LT^{-1}] = [LT^{-1}] + [LT^{-1}]$$

Correct

(b) $F = ma$ — ①

Here $F = [MLT^{-2}]$, $m = [M]$, $a = [LT^{-2}]$

Put all the dimensional formulas in eqⁿ ①

we get

$$[MLT^{-2}] = M[LT^{-2}]$$

$$[MLT^{-2}] = MLT^{-2}$$

Correct.

(ii) Convert force of 25 Newton into dyne

Dim. formula of Force $= [MLT^{-2}]$.

$x = 1$ $y = 1$ $z = -2$

MKS	CGS
$n_1 = 25$	$n_2 = ?$
$m_1 = 1kg$	$m_2 = 1g$
$L_1 = 1m$	$L_2 = 1cm$
$T_1 = 1 sec$	$T_2 = 1 sec$

$$n_2 = n_1 \left[\frac{1kg}{1g}\right]^1 \left[\frac{1m}{1cm}\right]^2 \left[\frac{1sec}{1sec}\right]^{-2}$$

$$= 25\left[\frac{1000g}{1g}\right]\left[\frac{100cm}{1cm}\right][1]$$

$$= 25[1000][100]$$

$$= 2500000$$

$$= 25\times10^5$$

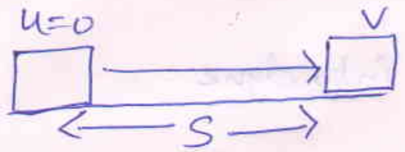
Define K.E. Desire Expression for it.

(Q) iii) The energy of a body due to its motion is called kinetic energy. Every moving body has kinetic energy.

Ex→ Moving car has K.E
Running water has K.E

<u>Expression for K.E</u>

Consider a body of mass m lying on surface of earth at Rest $(u=0)$



Let,

F = force applied
u = initial velocity
v = final velocity

Now,

$$W = FS \quad -(1)$$

Also $F = ma \quad -(2)$

Using

$$v^2 - u^2 = 2as$$
$$v^2 - 0 = 2as$$
$$v^2 = 2as$$
$$a = \frac{v^2}{}$$

Put value of a in eq ②

$$F = m\left(\frac{v^2}{2s}\right)$$

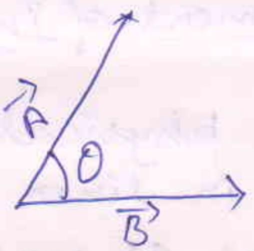
Put value of f in ①

$$W = m\left(\frac{v^2}{2\cancel{s}}\right)\cancel{s}$$

$$W = \frac{1}{2} mv^2$$

$$\therefore \quad K \cdot E = W = \cancel{\tfrac{1}{2}} mc^2$$

iv) Scalar Product : It is also called dot product
It is the product of magnitude of two vectors and cosine of angle b/w them.



If $\vec{A}$ & $\vec{B}$ are two vectors and θ is angle b/w them then

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

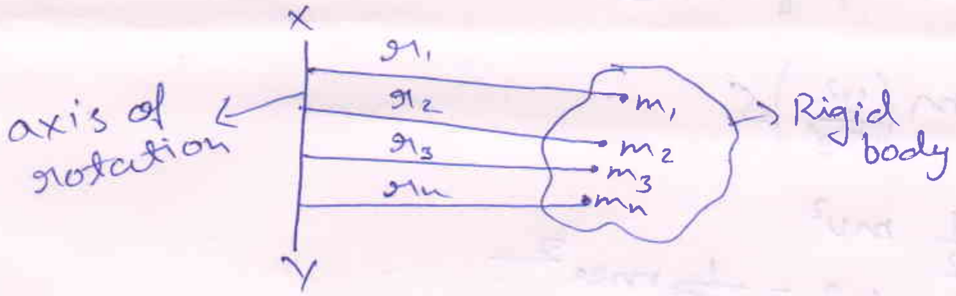
Vector Product : It is a product of magnitude of two vectors and sine of angle between them

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

$$= AB \sin\theta \, \hat{n}$$

(iv) Define moment of Inertia and radius of Gyration. What is Physical Significance.

V) Moment of Inertia :- It is defined as sum of product of masses and square of distance of different particles from axis of rotation. It is denoted by I



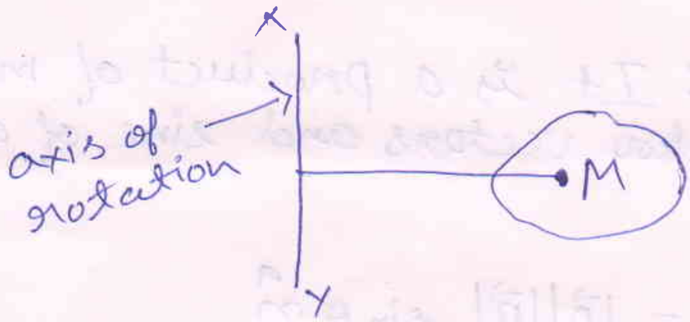
$$I = m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2 + \cdots\cdots + m_n r_n^2$$

$$I = \Sigma m r^2$$

Physical significance of moment of Inertia

It ~~is defined~~ has same physical significance in rotational motion as mass in liner motion that is moment of Inertia is same as mass in linear motion.

Radius of Gyration :- It is defined as distance of point from the axis of rotation where the whole mass of body is concentrated.



$$K = \sqrt{\frac{r_1^2 + r_2^2 + \cdots r_n^2}{n}}$$

K = Root mean distance.

VI) Calculate the Kinetic energy of body if mass of the body is 2 kg and velocity of the body is 1 mtr/sec

VI) Ans $K.E = \frac{1}{2} m v^2$

$m = 2 kg$
$V = 1$ mtr/sec

$K.E = \frac{1}{2} \times 2 \times 1$

$K.E = 1 J$

Define strain. what are types of strain.

VII) Strain :- Strain is defined as ratio of change in dimension to original dimension.

$$\text{Strain} = \frac{\text{Change in dimension}}{\text{original dimension}}$$

Types

(i) Longitudnal strain :- It is ratio of change in length to the original length.

$$\text{longitudnal strain} = \frac{\text{Change in length}}{\text{original length}} = \frac{\Delta L}{L}$$

ΔL = Change in length
L = original length.

(ii) Volumetric strain ⇒ It is ratio of change in volume to original volume.

$$\text{Volumetric strain} = \frac{\text{Change in volume}}{\text{original volume}} = \frac{\Delta V}{V}$$

ΔV = change in volume
V = original volume.

(iii) Shear strain :

$$\text{Shear strain} = \frac{\text{lateral displacement}}{\text{dist. b/w two surface}} = \frac{\Delta L}{L}$$

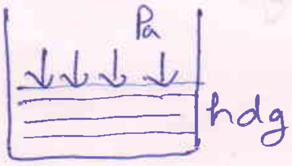
Write short Note on Gauge and Absolute Pressure

VIII) Gauge Pressure (P_g) :- It is a difference of absolute pressure and atmospheric pressure

$$P_g = P_t - P_a$$

P_g = Gauge Pressure
P_t = Absolute Pressure
P_a = Atmospheric Pressure.

Absolute Pressure (P_t) :- It is sum of atmospheric pressure and pressure due to liquid column is called absolute pressure, it is denoted by P_t. It is total pressure inside any liquid.



P_t = Atmospheric pressure + pressure due to liquid Column.

$P_t = P_a + hdg$

P_t = absolute pressure

P_a = atmospheric pressure

h = height of liquid

d = density of liquid

g = acc. due to gravity.

ix) Surface Tension :- The property ~~of~~ by which the free surface of liquid at rest behaves like stretched membrane and try to occupy minimum area is called surface tension.

Denoted by T

$$\text{Surface Tension} = \frac{\text{Force}}{\text{Length}}$$

$$T = \frac{F}{L}$$

Units M.K.S = N/m

C.G.S = Dyne/cm

Ex→ A Duck is able to float on water due to low surface tension.

Effect of temperature on surface tension.

$$T_t = T_0(1-\alpha t) \quad \text{— (B)}$$

T_0 = surface tension at 0°c

T_t = surface tension at t°c

α = Cofficient of temp.

Surface tension of liquid decreases with rise in temp. for small temperature changes expression is given by eq^n (1)

x) Explain Heat and Temperature on the basis of Kinetic theory.

Ans

Heat :- Heat is defined as total kinetic energy of all molecules.

Heat = sum of Kinetic Energy of all molecules.

$$\text{Heat} = K\left[\frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 + \frac{1}{2}mv_3^2 + \cdots + \frac{1}{2}mv_n^2\right]$$

m → mass of molecules

$v_1, v_2, v_3 \ldots v_n$ be velocities of molecules.

K → constant

Unit = Joule.

Temperature :- Temperature is defined as average kinetic energy of all molecules.

$$\text{Temp.} = \frac{\text{Total K.E of all molecules}}{\text{no. of molecules}}$$

$$\text{Temp.} = \frac{K\left[\frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 + \cdots + \frac{1}{2}mv_n^2\right]}{n}$$

m = mass of molecules

$v_1, v_2, v_3 \ldots v_n$ be velocities of molecules.

K = constant.

x1) Define thermal conductivity and derive an expression for cofficient of thermal conductivity.

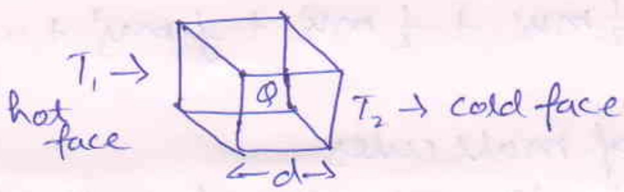
Ans

It is defined as ability of a body to pass heat through it.

Ex→ all metals are good conductors.

Expression→

Let us consider a cube with two faces one is hot and other is cold



Let

A = Area of each face

T_1 = Temp. of hot face

T_2 = Temp. of cold face

t = time of conduction

d = distance b/w two faces.

Q = heat flowing from hot face to cold face.

$T_1 - T_2$ = temp. difference.

Q depends on

$Q \propto A$

$Q \propto (T_1 - T_2)$

$Q \propto t$

$Q \propto \frac{1}{d}$

Combining all factors

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

$$Q = \frac{KA(T_1 - T_2)t}{d}$$

K is cofficient of thermal conductivity

$$\frac{Q \cdot d}{A(T_1 - T_2)t} = K \quad \text{—(1)}$$

Put $d = 1m$

$A = 1m^2$

$t = 1sec$

$T_1 - T_2 = 1K$

Put all values in eq(1)

$$K = \frac{Q(1)}{1(1)1}$$

$$Q = K$$

So, K is defined as amount of heat flowing from one face to another if Area of each face is $1m^2$ having temp. difference 1Kelvin and distance between faces is 1 meter.

xiii) Define and give formula and units of Angular velocity and Angular acceleration.

Ans

Angular Velocity :- It is rate of change of angular displacement.

Denoted by ω

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

$$\omega = \frac{rad.}{sec.} \quad \text{(units)}$$

Angular acceleration: It is the rate of change of angular velocity.

Denoted by α

$$\alpha = \frac{\omega}{t} = \frac{rad}{sec^2} \text{ (units)}$$

xiii) Explain different system of units.

Ans:

1) C.G.S system ⇒ In CGS system Length is in Centimeter, mass is in gram and Time is in second.

II) M.K.S System ⇒ In M.K.S system Length is in meter, mass is in Kilogram and time is in second,

III) F.P.S system ⇒ In FPS system Length is in Foot, mass is in pound and Time in second,

xiv) Derive relation b/w linear velocity and angular velocity ($v = r\omega$)

Ans Consider a body moving in a circle from point A to B in time t.

Let

R = radius of circle

θ = angular displacement

V = velocity of particle

let $\angle AOB = \theta$

and time = t

Q9.

Let angular velocity $\omega = \frac{\theta}{t}$

$$AB = r\theta \quad -(1)$$
$$AB = vt \quad -(2)$$

Equating (1) & (2)

$$r\theta = vt$$
$$r\frac{\theta}{t} = v \qquad \left[\frac{\theta}{t} = \omega\right]$$

$$\boxed{V = r\omega}$$

Section : C

Q.3 Define elasticity. Explain different types of modulus of elasticity.

Ans->

Elasticity: It is the property of matter by virtue of which the body regains its original shape and size after removing the deforming force.

There are three types of modulus of elasticity:

(i) **Young's modulus (Y)**:->

It is defined as the ratio of normal stress to the longitudinal strain. It is represented by 'Y' and its value is different types of material.

$$Y = \frac{\text{Normal stress}}{\text{Longitudinal Strain}}$$

$$Y = \frac{F/A}{\Delta L/L}$$

$$Y = \frac{FL}{A\Delta L}$$

where, F = Force
A = Area
L = original length
ΔL = Change in length

(ii) **Bulk modulus (K)**:->

It is defined as the ratio of normal stress to the volumetric strain. It is denoted by 'K'. Its value is also different types of substance.

$$K = \frac{\text{Normal stress}}{\text{Volumetric strain}} = \frac{F/A}{\Delta V/V}$$

$$K = \frac{F}{A} \times \frac{V}{\Delta V} = \frac{FV}{A\Delta V}$$

where, F = Force
A = Area
V = original volume
ΔV = Change in volume

(iii) Modulus of rigidity (n) :→
It is defined as the ratio of tangential stress to shear strain. It is also called shear modulus and is denoted by 'n'.

$$\eta = \frac{\text{Tangential stress}}{\text{Shear strain}}$$

$$\eta = \frac{F/A}{\theta}$$

$$\eta = \frac{F}{A\theta}$$

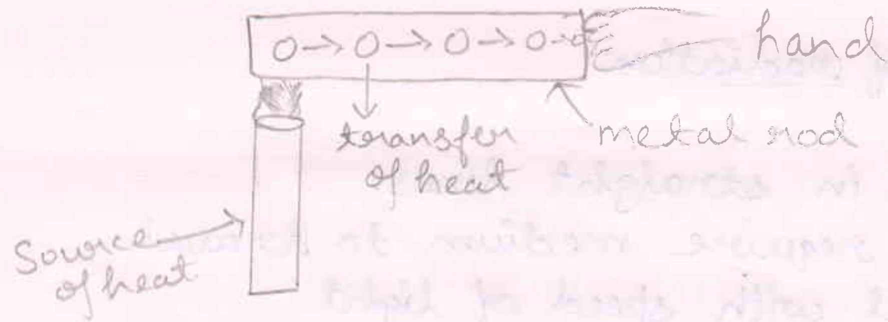
where,
F = Force
A = Area
θ = Shear strain.

Q.4 Explain conduction, convection and radiation with example.

Ans:

Conduction: The process of transfer of heat in a material medium in which heat energy is transferred from molecule to molecule, in the direction of fall of temperature, without the actual motion of the molecules of the medium is called Conduction.

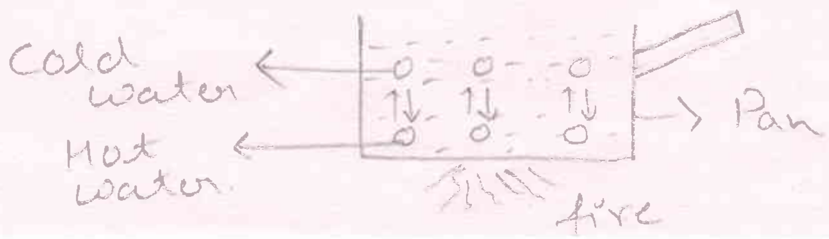
Example ⇒ (i) When one end of an iron rod is placed in fire and the other end is held in hand, then the heat passes from one point to another without the actual motion of molecule.



(ii) Ironing of clothes.
(iii) Touching of hot pan.

Convection: The process of transfer of heat in which heat is transferred from one point to another by the actual motion of heated particles away from the source of heat is called convection.

Example ⇒ (i) Hot air balloon.
(ii) Boiling of water



The heat passess from burner to the pan having water. The water acting get hot and rises up and cold water moves down to get hot. In this way all the water get hot and the cycle moves. This process is called boiling of water.

Radiation: Radiation is the process of heat transfer in which heat is transferred from one place to another in straight lines, in the form of heat waves, with the velocity of light without heating the medium through which it passes.

Examples → (i) Heat of the fire place.
(ii) Heat from the sun reaches us in the form of radiation.

Properties of radiation

1. They travel in straight lines.
2. They don't require medium to travel.
3. They travel with speed of light.
4. They are reflected.
5. They are refracted.
6. They do not heat up the medium through which they pass.
7. They follow inverse square law.

Q.5 Define resolution of force and derive an expression for resolving a single force into two components.

Ans:-

i) The process of splitting single force into two forces is called resolution of force.

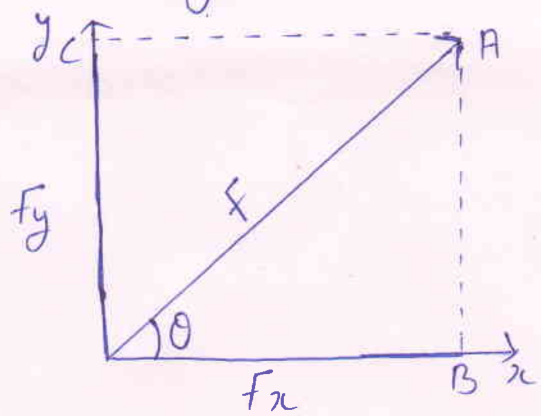
ii) The two parts are called resolved part.

Let a force F acts in a direction OA making an angle θ with the Horizontal. The force can be split into two component F_x and F_y

F_x = Horizontal component.

F_y = Vertical component.

The rectangular component of force F are reprensted by OB and OC along x-axis and y-axis.



$F_x = OB$

$F_y = OC$

In ΔOBA

$$\cos\theta = \frac{OB}{OA}$$

$$\Rightarrow \quad OA\cos\theta = OB$$

$$F\cos\theta = F_x$$

$$F_x = F\cos\theta \quad \text{--- (1)}$$

In ΔOBA

$$\sin\theta = \frac{AB}{OA}$$

$OA \sin\theta = AB$

$F \sin\theta = F_y$

$F_y = F \sin\theta$ — ②

Sq. both side on eq ① & ②

$F_x^2 = F^2 \cos^2\theta$ — ③

$F_y^2 = F^2 \sin^2\theta$ — ④

Adding ③ & ④

$\cos^2\theta + \sin^2\theta = 1$

$F_x^2 + F_y^2 = F^2(\cos^2\theta + \sin^2\theta)$

$F_x^2 + F_y^2 = F^2(1)$

$F_x^2 + F_y^2 = F^2$

$F = \sqrt{F_x^2 + F_y^2}$

Divide ② by ①

$$\frac{F \sin\theta}{F \cos\theta} = \frac{F_y}{F_x}$$

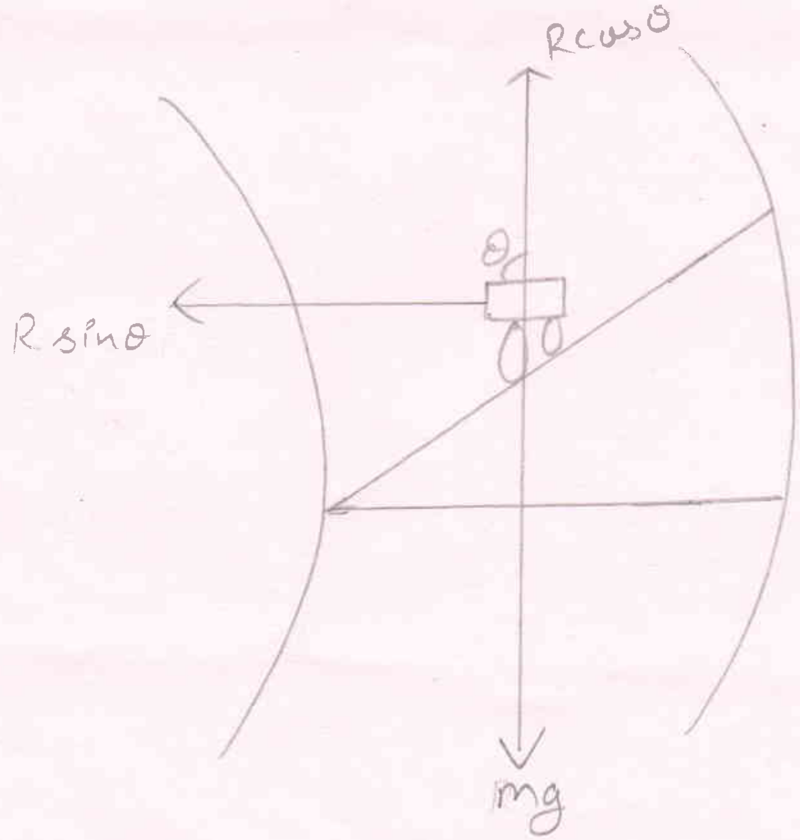
$$\tan\theta = \frac{F_y}{F_x}$$

Q.6 Define banking of roads. Derive an expression for banking of roads.

Ans:- In order to give centripital force to keep the vehicles moving on sharp bends of the road. Banking of Road is done.
The outer edge is raised than the inner edge. To prevent the vechiles from sliding is called Banking of Road.

Consider a car of mass m having velocity V radius r of road and angle of inclination θ.

Various forces acting on Car are (i) weight mg acting downward (ii) R acting upward, has two components $R\cos\theta$ and $R\sin\theta$



$R\cos\theta$ is balanced by mg

$$R\cos\theta = mg \quad -① $$

$R\sin\theta$ is equal to centripital force

$$R\sin\theta = \frac{mv^2}{r} \quad - ②$$

Divide ② by ①

$$\frac{\cancel{R}\sin\theta}{\cancel{R}\cos\theta} = \frac{\cancel{m}v^2/r}{\cancel{m}g}$$

$$\tan\theta = \frac{v^2}{rg}$$

Q.7 Write short note on

(a) Newton first law and second law with example
(b) Limitation of dimensional analysis.

Ans: (a)(i) Newton first Law :-> Every body continues to remain in its state of rest or uniform motion in a straight line unless it is compelled by external force to change its state of rest or uniform motion

Example :- ① If the book is put on table it will not move until an external force applied on it.
(ii) Passengers standing in a bus.

(ii) Newton Second Law :->
The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction of force.

Example ->
① If ball is kicked it will move due to applied force. more the force more will be speed.

(ii) If the brakes are applied it will stop due to frictional force.

$$F \propto \frac{d}{dt}(mv - mu)$$

V -> final velocity
U -> initial velocity

(b) Limitation of dimensional analysis is

(i) It do not help to find value of dimensional constant.

(ii) It do not tell whether a physical quantity is scalar or vector.

(iii) This is used in power functions only.

(iv) This method fails to derived physical relation which depends on more than 3 factore

(v) It fails for exponential function.