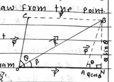
<1> State and derive the magnitude & direction of resultant vector.

⇒ "If two vector acting at a point simultaneously be represented in magnitude and direction by two adjecent sides of a parallelogram draw from the point.



Consider two vector $\vec{P}$ & $\vec{Q}$ inclined at angle 'θ' be acting at a point at a same time. $\vec{OA}$ & $\vec{OC}$ of a parallelogram OABC. $\vec{OB}$ represented resultant '$\vec{R}$' both in magnitude & direction.

From Δ ANB, we have,

$$\cos\theta = \frac{AN}{AB}$$

$$AN = AB\cos\theta$$

$$\therefore AN = Q\cos\theta$$

Ily,

$$BN = Q\sin\theta$$

Now, from Right angle triangle ONB'

$$(OB)^2 = (ON)^2 + (NB)^2$$

$$R^2 = (OA+AN)^2 + (NB)^2$$

$$R^2 = (P+Q\cos\theta)^2 + (Q\sin\theta)^2$$

$$R^2 = P^2 + 2PQ\cos\theta + Q^2\cos^2\theta + Q^2\sin^2\theta$$

$$R^2 = P^2 + Q^2\sin^2\theta + Q^2\cos^2\theta + 2PQ\cos\theta$$

$$R^2 = P^2 + Q^2(\sin^2\theta + \cos^2\theta) + 2PQ\cos\theta$$

$$R^2 = P^2 + Q^2 + 2PQ\cos\theta$$

$$\therefore R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

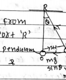
Direction of $\vec{R}$

$$\tan\beta = \frac{NB}{ON} = \frac{NB}{OA+AN} = \frac{Q\sin\theta}{P+Q\cos\theta}$$

$$\therefore \beta = \tan^{-1}\left(\frac{Q\sin\theta}{P+Q\cos\theta}\right)$$

<3> What S.H.M? Show that the motion of simple pendulam is Harmonic motion.

⇒ Simple harmonic motion is any motion where a restoring force is applied that is proportional to the displacement and the oposite direction of that displacement.



Let a point mass 'm' be suspended from a string of length 'l' to rigid support 'R' in the equilibrium position. The pendulum lies in position RO. The weight 'mg' & the tension 'T'.

Now, Driving force = mass × Accleration.

$$\text{Accleration} = \frac{\text{Driving force}}{\text{mass}} = \frac{mg\sin\theta}{m} = g\sin\theta$$

If amplitude is very small $\sin\theta \approx \theta$ then,

$$\text{Accleration} = g\theta = g\times\frac{x}{l} = \frac{gx}{l} \quad \left(\because \theta = \frac{x}{l}\right)$$

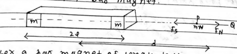
Since, $\frac{g}{l}$ is constant.

∴ Accleration ∝ displacement.

For S.H.M.

$$\text{time period (T)} = 2\pi\sqrt{\frac{\text{displacement}}{\text{accleration}}} = 2\pi\sqrt{\frac{x}{\frac{gx}{l}}} = 2\pi\sqrt{\frac{l}{g}}$$ proved.

<5> Axial line of a bar magnet.



Consider a bar magnet of length '2l' and each pole of strength 'm', the axial line distance 'd' from the center of the bar magnet.

For north-pole

$$F_N = \frac{\mu_0 m\times 1}{4\pi(d-l)^2}$$ along PQ

For south-pole

$$F_S = \frac{\mu_0 m\times 1}{4\pi(d+l)^2}$$ along PN

Hence,

$$B = F_N - F_S = \frac{\mu_0 m\times 1}{4\pi(d-l)^2} - \frac{\mu_0 m\times 1}{4\pi(d+l)^2}$$

$$= \frac{\mu_0 m}{4\pi}\left(\frac{1}{(d-l)^2} - \frac{1}{(d+l)^2}\right)$$

$$= \frac{\mu_0 m}{4\pi}\left(\frac{(d+l)^2 - (d-l)^2}{(d-l)^2(d+l)^2}\right)$$

$$= \frac{\mu_0 m}{4\pi}\left(\frac{(d^2+2dl+l^2) - (d^2-2dl+l^2)}{(d-l)^2(d+l)^2}\right)$$

$$= \frac{\mu_0 m}{4\pi}\left(\frac{d^2+2dl+l^2-d^2+2dl-l^2}{(d-l)^2(d+l)^2}\right)$$

$$= \frac{\mu_0 m}{4\pi}\times\frac{4dl}{(d-l)^2(d+l)^2}$$

$$= \frac{\mu_0 m}{4\pi}\times\frac{2l\times 2d}{(d-l)^2(d+l)^2}$$

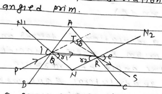
$$\therefore B = \frac{\mu_0 M\times 2d}{4\pi(d-l)^2(d+l)^2} \quad \left(\because m = \frac{M}{2l}\right)$$

if $l \lll d$

$$B = \frac{\mu_0 M\times 2d}{4\pi\times d^2\times d^2}$$

$$B = \frac{\mu_0 M 2d}{4\pi d^4} \therefore B = \frac{\mu_0 2M}{4\pi d^3}$$

<7> Derive a relation for deviation produce by a small angled prim.



Consider a small angle prism ABC. we have,

$$\delta = (i-r_1) + (e-r_2)$$

$$\therefore \delta = (i+e) - (r_1+r_2) \quad \text{— (I)}$$

From face AB, we have,

$$\mu = \frac{\sin i}{\sin r_1}$$

$$\mu = \frac{i}{r_1}$$

$$\therefore i = \mu r_1 \quad \text{— (II)}$$

Ily, face AC, we have,

$$\mu = \frac{\sin e}{\sin r_2}$$

$$\mu = \frac{e}{r_2}$$

$$\therefore e = \mu r_2 \quad \text{— (III)}$$

From eqn (I), (II) & (III) we get,

$$\delta = (\mu r_1 + \mu r_2) - (r_1+r_2)$$

$$= \mu(r_1+r_2) - (r_1+r_2)$$

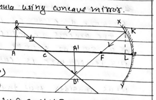
$$= (r_1+r_2)(\mu-1) \quad (\because A = r_1+r_2)$$

$$= A(\mu-1)$$

$$\therefore \delta = (\mu-1)A$$ proved.

<9>
* Deduce the mirror formula using concave mirror.

⇒ Let us consider a concave mirror of 'XPY' where,



PA = u (object distance)

PA' = v (image distance)

PF = f (focal length)

From similar triangle KLF & B'A'F, we have,

$$\frac{A'B'}{LK} = \frac{A'F}{FL}$$

$$\frac{A'B'}{KP} = \frac{PA'-PF}{PF} \quad \text{— (I)}$$

From Δ BAC & B'A'C

$$\frac{A'B'}{AB} = \frac{A'C}{AC}$$

Since, AB ≈ KP

$$\frac{A'B'}{KP} = \frac{A'C}{AC} \quad \text{— (II)}$$

From eqn (I) & (II) we get,

$$\frac{A'C}{AC} = \frac{PA'-PF}{PF}$$

$$\text{or, } \frac{PC-PA'}{PA-PC} = \frac{PA'-PF}{PF} \quad (\because PC = 2F)$$

$$\text{or, } \frac{2F-v}{u-2F} = \frac{v-F}{F}$$

or, (2F − v) × F = (u − 2F) × (v − F)

or, $2F^2 - vF = uv - uF - 2vF + 2F^2$

or, $uv - uF - 2vF + 2F^2 - 2F^2 + vF = 0$

or, $uv - uF - vF = 0$

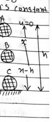
or, $uv - vF = uF$

dividing b.s. by uvF we get,

$$\frac{uv}{uvF} - \frac{vF}{uvF} = \frac{uF}{uvF} \Rightarrow \frac{1}{F} - \frac{1}{u} = \frac{1}{v} \Rightarrow \frac{1}{F} = \frac{1}{u} + \frac{1}{v}$$

<11> Prove that the total mechanical energy of a freely falling body under the gravity is constant.

⇒ Consider a body of mass 'm' at point 'A' at hight 'h' from the surface of earth. at point 'A' the body is rest u = 0.



$$E_T = E_K + E_P$$

$$E_T = 0 + mgh$$

$$E_T = mgh \quad \text{— (I)}$$

At point 'B'

$$v^2 = u^2 + 2gs$$

$$v^2 = 0^2 + 2gx$$

$$v^2 = 2gx \quad \text{— (II)}$$

$$\text{total Energy at B} = E_K + E_P = \frac{1}{2}m(2gx) + mg(h-x) = mgx + mgh - mgx = mgh.$$

At point 'C'

$$v^2 = u^2 + 2gs$$

$$v^2 = 0^2 + 2gh$$

$$v^2 = 2gh$$

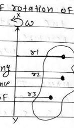
i.e, total Energy at 'C' $E_T = E_K + E_P = \frac{1}{2}mv^2 + mg\cdot 0 = \frac{1}{2}m(2gh) = mgh$

Hence, $E_T = E_K + E_P = 0 + mgh = mgh.$

<13> Define Moment of inertia and discuss it's significance deduce a relation betn moment of inertia and rotational K.E. of a body.

⇒ It is the sum of product of masses and square of the distance from the axis of rotation of all particles. i.e, $I = \sum mr^2$.

Relation



Consider a rigid body made up of large number of particles having masses $m_1, m_2, \& m_3 \ldots m_n$ at distance $r_1, r_2, \& r_3 \ldots r_n$ from the axis of rotation XY with the velocity $v_1, v_2, v_3 \ldots v_n$.

Total K.E. of particle is –

$$K.E. = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 + \frac{1}{2}m_3v_3^2 + \ldots \frac{1}{2}m_nv_n^2$$

Since, all particles have same angular velocity,

$$K.E. = \frac{1}{2}m_1(r_1\omega)^2 + \frac{1}{2}m_2(r_2\omega)^2 + \frac{1}{2}m_3(r_3\omega)^2 + \ldots \frac{1}{2}m_n(r_n\omega)^2$$

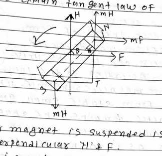
$$K.E. = \frac{1}{2}(m_1r_1^2 + m_2r_2^2 + m_3r_3^2 + \ldots m_nr_n^2)\,\omega^2$$

$$K.E. = \frac{1}{2}\left(\sum_{i=1}^{n} m_ir_i^2\right)\omega^2$$

$$\therefore K.E. = \frac{1}{2}I\omega^2$$

This is the required eqn and relation.

<15> State and Explain tangent law of magnetism.



When a bar magnet is suspended is in two uniform perpendicular 'H' & F.

i.e, $\tan\theta = \frac{F}{H}$

Anticlock wise moment acting on magnet = mH × ST

= mH × NS sinθ

= mH × 2l sinθ

= MH sinθ

Clockwise moment acting on magnet = mF × NT

= mF × NS cosθ

= mF × 2l cosθ

= MF cosθ

Now, we have,

$$MH\sin\theta = MF\cos\theta$$

$$\frac{\sin\theta}{\cos\theta} = \frac{MH}{MF}$$

$$\tan\theta = \frac{H}{F}$$

$$\therefore F = H\tan\theta$$

15. Orbital velocity.

→ A heavenly body which revolve the planet is called satellite. The velocity of revolution of satellite velocity satellite velocity or orbital velocity.

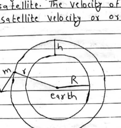


Fig: Orbital velocity.

Let, us consider a satellite of mass m is revolving in the circular orbit of radius r = R+h from the centre of earth. let, mass and radius of earth are M and R respectively,

The gravitational force between earth and planet provide the necessary centripetal force for satellite.

i.e, $\frac{GMm}{r^2} = \frac{mv_0^2}{r}$

$$\therefore v_0 = \sqrt{\frac{GM}{r}}$$

if r = R

$$v_0 = \sqrt{\frac{GM}{R}}$$

$$\text{or, } v_0 = \sqrt{\frac{GM}{R^2}\cdot R}$$

$$\therefore v_0 = \sqrt{gR}$$

18. Lens maker formula.

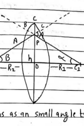


Fig: lens as an small angle triangle

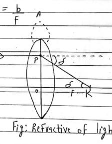
A relation connecting the focal length of lens to radii of curvature and refractive index is called lens maker formula. let, us consider a thin convex lens of focal length F. A ray of light deviated through an angle of δ by the prism of small angle A.

If μ be the refractive index of the prism then, we have,

$$\delta = (\mu-1)A \quad \text{— (i)}$$

From Figure, (b)

$$\tan\delta = \frac{OP}{PK} = \frac{h}{F}$$



Since, δ is very small so that,

$$\tan\delta \simeq \delta$$

$$\delta = \frac{h}{F} \quad \text{— (i)}$$

From eqn (i) & (ii) we have,

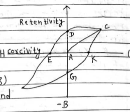
$$\frac{h}{F} = (\mu-1)A$$

Fig: Refractive of light.

$$\frac{1}{F} = (\mu-1)\frac{A}{h} \quad \text{— (iii)}$$

let, the centre of curveture of lens surface be C_1 and C_2 which are joined to B and C such that C_1B and C_2C are the normal at the point B and C.

20. Explain Hysteresis? With it's points.



→ Hysteresis of magnetic material is the property by virtue of which flux density (B) of the material lags behind the magnetzing force (H).

Hysteresis curve represent the relation between magnetic induction with magnetizing intensity (H) of Ferromagnetic material.

i. When intensity of magnetic field H is increased from the value of B also increased.

ii. Further increasing the value of H ~~increased~~ value of B also increased and finally reach to saturation point c.

iii. Decreasing the value of H value of B also decrease but at H = 0, B is not zero. The degree to which the material gains magnetism when H = 0 is called retentivity

iv. Further decreasing the value of H is negative side the value of B also decreases at the point E value of B becomes zero & the negative value of H at which B becomes zero is called Coercivity.

v. This cycle is continue in opposite direction as shown in figure.

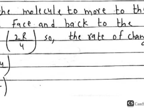
$$L = m_1r_1^2\omega + m_2r_2^2\omega + \ldots m_nr_n^2\omega$$

$$\text{or, } L = \omega(m_1r_1^2 + m_2r_2^2 \ldots m_nr_n^2)$$

$$\text{or, } L = \omega\sum_{i=1}^{n} m_ir_i^2 \quad (i = 1, 2, 3, \ldots n)$$

∴ $L = \omega I$ This is the relation between moment of inertia and angular momentum.

22. Pressure exerted by the gas on the wall of container.



→ Let, us consider N molecules of gas each of mass m contained in a cubical box of length l as shown in the figure. let, a particular molecule has velocity c whose component are u.v. and w along x, y and z. direction respectively. so,

Fig: Gas in cubical vessel

$$c^2 = u^2 + v^2 + w^2 \quad \text{— (i)}$$

The x-component of the momentum of a molecule before impact on the face A is mu and after impact is −mu. Thus, the change in momentum is,

$$mu - (-mu) = 2mu$$

Now,

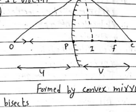
time taken by the molecule to more to the face A, to the opposite face and back to the opposite face is $t = \left(\frac{2l}{u}\right)$ so, the rate of change of momentum $= \left(\frac{2mu}{t}\right)$

$$= \left(\frac{2mu^2}{2l/u}\right)$$

23. Derive the mirror formula $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ for convex mirror, where, symbols have their uses meanings.

↳ mirror formula for convex mirror.

Suppose a real object 'O' lies in front of a convex mirror. It virtual image 'I' is formed behind the as shown in the figure,



OP = object distance

IP = Image distance

FP = Focal length.

Formed by convex mirror.

As CA produced externally bisects ∠AOI, we can have,

$$\frac{OA}{IA} = \frac{OC}{IC}$$

Since, the aperture of a mirror is being small, we have,

OA ≃ OP

and, IA = IP

$$\therefore \frac{OP}{IP} = \frac{OC}{IC}$$

But, OC = OP + CP

and, IC = CP − IP

with these values eqn (i) becomes

$$\frac{OP}{IP} = \frac{OP+CP}{CP-IP}$$

Applying sign convention for the concave mirror, we have,

OP = +u

IP = −v

and,

CP = −r

then, eqn (2) becomes,

$$\frac{u}{-v} = \frac{u+(-r)}{-r-(-v)}$$

$$\text{or, } \frac{u}{-v} = \frac{u-r}{v-r}$$

or, $uv - ur = -uv + vr$

or, $ur + vr = 2uv$

Dividing both side by u.v.r, we,

$$\frac{1}{u} + \frac{1}{v} = \frac{2}{r}$$

using r = 2f, we get,

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

This is the mirror formula, for the convex mirror.

25. State Newton's first and second law of motion. Show that ~~Number~~ Newton's first law is the special case of Newton second law of motion.

↳ First law

An object at rest always tends to remain at rest and an object in motion always tends to remain in motion with constant speed along the same direction until acted upon by an external agent. (Force).

Second law

The rate of change of momentum of a body is directly proportional to the impressed force and takes place along the direction of the impressed force.

~~The state~~ Newton's first law as a special case of second law of motion. Since,

Newton's second law of motion gives the equation as F = ma. If Force 'F' acting on the mass is zero, then,

$$ma = 0$$

As, m ≠ 0

$$a = 0$$

For either v = constant $\left[\because a = \frac{dv}{dt}\right]$

$$v = 0$$

This means the body moves with constant velocity uniform velocity with no acceleration or it will be at rest which is the statement of the first law:

Since, value of α is very small so, higher power of α will be very small, ~~Thus, the terms containing higher power of α can be neglected,~~

$$\therefore V_t = V_0(1+3\alpha t) \quad \text{— (i)}$$

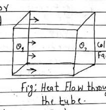
But, from the definition of the ~~[struck]~~ coefficient of cubical expansion, we have,

$$V_t = V_0(1+\gamma t) \quad \text{— (ii)}$$

Hence, comparing (i) & (ii), $\gamma = 3\alpha$

28. Explain Thermal conductivity? Derive formula of thermal conductivity.

↳ When, one end of the conductor is heated, it's another end heated itself. This property of conductor is called thermal conductivity,



Let, us consider a cube of thickness x and area of each face A. as shown in the figure.

Fig: Heat Flow through the tube.

Let, Q be the amount of heat flowing for t sec between the two surface each surface seperated by the distance x.

Then if is found that,

$$Q \propto (\theta_1 - \theta_2) \quad \text{— (i)}$$

Where θ_1 and θ_2 be the temperature of opposite face.

$$Q \propto A \quad \text{— (ii)}$$

$$Q \propto t \quad \text{— (iii)}$$

$$Q \propto \frac{1}{x} \quad \text{— (iv)}$$

Combining eqn (i), (ii), (iii) & (iv), we get,

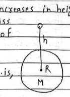
$$Q = \frac{k(\theta_1-\theta_2)tA}{x}$$

Where k is called proportionality constant called thermal conductivity.

So, thermal conductivity of a material is defined as the amount of heat flowing per see. between the two surfaces maintained at unit temperature gradient.

30. Show that g decreases with increases in height.

↳ Let, us consider a body of mass m is at the height h from the surface of earth.



Now, the force of gravity on the bodys is, given by, $\frac{GMm}{(R+h)^2}$ — (i)

The weight of the body is given by

$$W = mg \quad \text{— (ii)}$$

Since, Weight = force of gravity so,

$$\frac{GMm}{(R+h)} = mg$$

$$g' = \frac{GM}{(R+h)^2} \quad \text{— (iii)}$$

This is the acceleration due to gravity at the height h from earth surface.

Since, g at surface of earth is,

$$g = \frac{GM}{R^2} \quad \text{— (iv)}$$

Dividing eqn (iii) & (iv)

$$\frac{g'}{g} = \frac{\frac{GM}{(R+h)^2}}{\frac{GM}{R^2}}$$

$$\frac{g'}{g} = \frac{GM}{(R+h)^2}\times\frac{R^2}{GM}$$

$$\frac{g'}{g} = \frac{R^2}{(R+h)^2}$$

Let, r = R+h and as 'R' is constant,

$$g_A \propto \frac{1}{r^2}$$