An aluminium pointer is fixed with the coil, which moves on a graduated scale. It is kept inside a non-magnetic box, to protect it from air and dust.

The front portion of box is made up of glass in order to see the pointer and scale.

In the given figure.

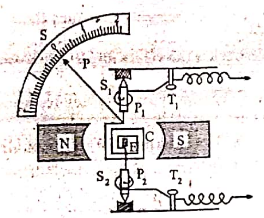


**Fig. Weston (pivoted) galvanometer**

N, S $\rightarrow$ Pole pieces of horseshoe magnet, C $\rightarrow$ Coil, E $\rightarrow$ Core, $P_1$, $P_2$ $\rightarrow$ Pivots, $S_1$, $S_2$ $\rightarrow$ Springs, $T_1$, $T_2$ $\rightarrow$ Terminals and P $\rightarrow$ Pointer.

**Working :** When the current is passed through the coil, a deflecting couple acts on it hence the coil is deflected. At the same time the springs produce restoring couple. In equilibrium, both the moment of couple are equal and opposite.

Let $\theta$ be the deflection in the galvanometer when I current is passed through its coil, then $I \propto \theta \Rightarrow I = k\theta$,

where $k = \dfrac{C}{NBA}$.

In this way, deflection in a galvanometer is directly proportional to current flowing through its coil.

In order to make it more sensitive,

(i) The number of turns in the coil should be increased.

(ii) Use strong magnet as horseshoe magnet.

(iii) Increase the area of the coil.

**Or**

**Explain construction, principle and working of a cyclotron. Derive an expression for maximum K.E. of charged particle.**

**Or**

**Explain the cyclotron under follwoing points : (i) Construction, (ii) Principle and working process.**

**Ans. Construction :** It consist of two hollow D-shaped metallic chambers $D_1$ and $D_2$, called dees. These dees are separated by a small gap where a source of positively charged particle is placed. Dees are connected to a high frequency oscillator, which provide high frequency electric field across the gap of the dees. This arrangement is placed between two poles of strong electromagnet. The magnetic field due to this electromagnet is perpendicular to the plane of the dees.

**Principle :** When a positively charged particle is made to move again and again under the influence of magnetic field and high frequency electric field, then gain large amount of energy.

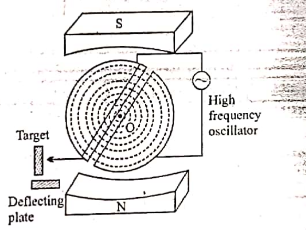


**Fig.**

**Working :** If a positively charged particle (proton) is emitted from O, when $D_2$ is negatively charged and the dee $D_1$ is positively charged, it will accelerate towards $D_2$. As soon as it enters $D_2$, it is shielded from the electric field by metallic chamber (enclosed space). Inside $D_2$, it moves at right angles to the magnetic field and hence describe a semi-circle inside it. After completing the semicircle, it enters the gap between the dees at the time when the polarities of the dees have been reversed. Now, the proton is further accelerated towards $D_1$. Then it enters $D_1$ and again describes the semicircle due to the magnetic field which is perpendicular to the motion of the proton. This motion continues till the proton reaches the periphery of the dee system. At this stage, the proton is deflected by the deflecting plate which then comes out through the window and hits the target.





**Theory :** When a proton (or any other positively charged particle) moves at right angle to the magnetic field $\vec{B}$ inside the dees, Lorentz force acts on it.

*i.e.*, $F = qvB \sin 90^\circ = qvB$

Where, $q$ = Charge of particle

and $v$ = Velocity of particle

The force provides the necessary centripetal force $\dfrac{mv^2}{r}$ to the charged particle to move in a circular path of radius $r$.

$$\therefore \quad qvB = \frac{mv^2}{r}$$

$$\text{or} \quad r = \frac{mv}{qB} \qquad ...(1)$$

Time taken to complete one semicircle inside a dees,

$$t = \frac{\text{Distance}}{\text{Speed}} = \frac{\pi r}{v}$$

$$\text{or} \quad t = \frac{\pi}{v} \times \frac{mv}{qB}, \qquad \text{[from equ. (1)]}$$

$$\therefore \quad t = \frac{\pi m}{qB} \qquad ...(2)$$

Thus, time taken to complete one semi-circle does not depend upon radius of path.

If T is the time-period of the alternate electric field, then the polarities of the dees changes in time T/2.

$$\frac{T}{2} = \frac{\pi m}{qB}$$

$$\text{or} \quad T = \frac{2\pi m}{qB} \qquad ...(3)$$

cyclotron frequency

$$\upsilon = \frac{1}{T}$$

$$i.e., \quad \upsilon = \frac{qB}{2\pi m}$$

**Expression of K.E.**

$$K.E. = \frac{1}{2}mv^2$$

$$K.E. = \frac{1}{2}m\left(\frac{qBr}{m}\right)^2, \qquad \left(\because v = \frac{qBr}{m}\right)$$

K.E. of charged particle

$$= \frac{1}{2}\frac{q^2B^2r^2}{m}$$

$$\text{or} \quad K.E. \propto r^2, \qquad \left(\because \frac{q^2B^2}{2m} = \text{constant}\right)$$

*i.e.* K.E. becomes maximum at circumference of dees.

**Q. 25. Derive the formula for refraction at convex spherical surface.** 5

$$\frac{\mu}{v} - \frac{1}{u} = \frac{\mu - 1}{R},$$

**where symbols have their usual meanings.**

**Ans.** Let APB be main cross-section of convex refracting surface. There is an air on its left side and a medium of refractive index $\mu$ on its right side. O is object and its real image is formed at I. As per diagram

$\angle OML = i$ = angle of incidence

$\angle IMC = r$ = angle of refraction

Let $\angle MOC = \alpha$, $\angle MCP = \gamma$ and $\angle MIP = \beta$

As per Snell's law

$$\mu = \frac{\sin i}{\sin r} \Rightarrow \mu = \frac{i}{r},$$

($\because$ for smaller values of $i$ and $r$, $\sin i = i$ and $\sin r \approx r$)

$$\text{or} \quad i = \mu r \qquad ...(1)$$

In $\Delta OMC$, $i = \alpha + \gamma$ and in $\Delta IMC$, $\gamma = r + \beta$ or $r = \gamma - \beta$

From equation (1)

$$(\alpha + \gamma) = \mu(\gamma - \beta) \qquad ...(2)$$

$$\because \quad \text{angle} = \frac{\text{arc}}{\text{radius}}$$

$$\therefore \quad \alpha = \frac{PM}{OP}, \beta = \frac{PM}{PI}, \gamma = \frac{PM}{PC}$$

Putting these values in equation (2)

$$\left(\frac{PM}{OP} + \frac{PM}{PC}\right) = \mu\left(\frac{PM}{PC} - \frac{PM}{PI}\right)$$