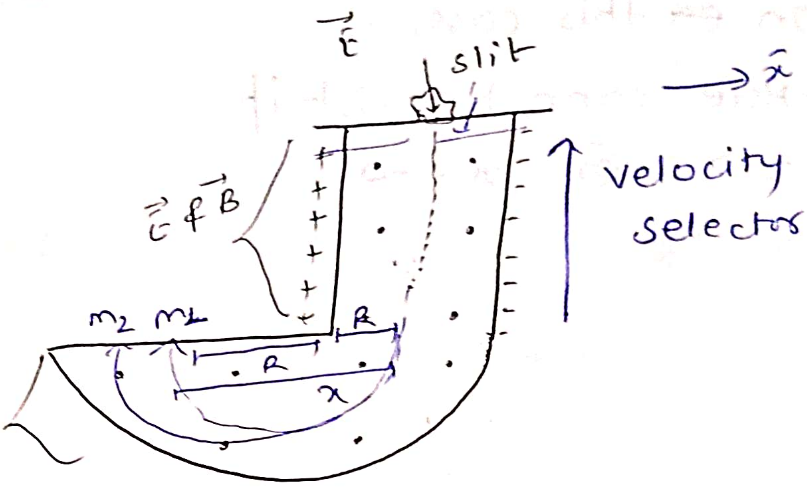
Nuclear Physics

- Bainbridge mass spectograph:-



$q\vec{E} = qvB$

$$\boxed{v = \frac{E}{B}}$$

$x = 2R$

$$\Rightarrow \boxed{R = \frac{mv}{qB}}$$

$q(\vec{v} \times \vec{B}) \Rightarrow -x$ direction

$v' > v$

$$x = \frac{2mv}{qB}$$

$$x_1 = \frac{2m_1 E}{qB^2} \quad , \quad x_2 = \frac{2m_2 E}{qB^2}$$

$$\star \ \boxed{x = \frac{2mE}{qB^2}}$$

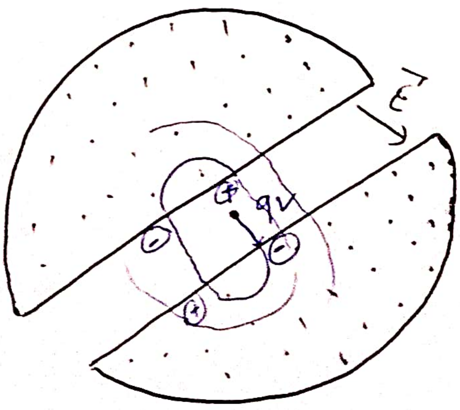
$$\boxed{x_2 - x_1 = \frac{2(m_2 - m_1)E}{qB^2}}$$

$x \propto m$

$x\uparrow\uparrow \rightarrow m\uparrow\uparrow$

$$\Rightarrow \boxed{1\,\text{amu} = 1.67 \times 10^{-27}\ \text{kg}}$$

- Cyclotron:- (Particle Acceleration):-



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

$$\boxed{\nu = \frac{qB}{2\pi m}} \qquad \nu = \frac{1}{T}$$

$TE = \frac{1}{2} m v^2$, $R = \frac{m v_{max}}{qB}$

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

$$\boxed{T.E = \frac{R^2 q^2 B^2}{2m}}$$

1 Rotation = $2qB$

Energy

N Rotation

$= \boxed{2qBN}$

Energy

$E \neq f(V)$ [voltage]

$T \neq f(V)$

→ Limitation :-

* Radius limitation :-

(*) $T = \frac{2\pi m}{qB}$ → varies

↓

changes

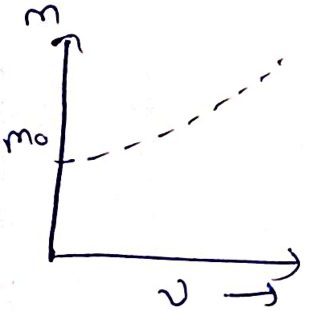
Resonance frequency =

$\nu_0 = \frac{qB}{2\pi m}$

Put V = kuchh bhi

= same energy

If $V\uparrow$ → Rotations ↓



special theory of relativity

(when $v > 10^5$ m/s)

purpose of device is not fulfilled as polarity properly change nahi hoti.

Soln - * Calculate step frequency. After 10^5 m/s, calculation is done taking values of mass & ν, seperately in various step.

Device - synchrocyclotron (single D) uses step frequency.

Betatron:- On the principle of third law of maxwell. (flux changes → Emf generated)

$$\boxed{\vec{\nabla}\times\vec{E} = -\frac{\partial \vec{B}}{\partial t}}$$

$V = -\frac{d\phi}{dt}$, $\phi = BA$

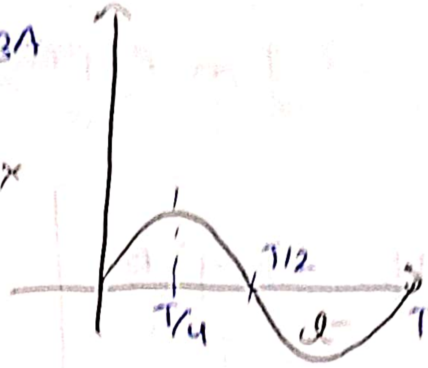
3rd maxwell's equation,

$\downarrow$

curl $\vec{E}$

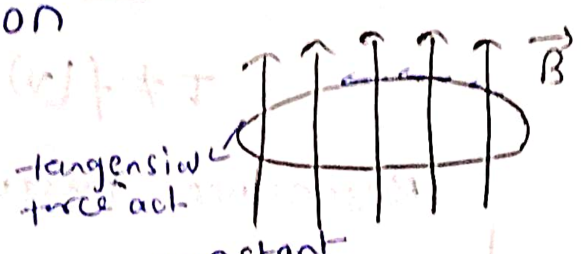
$\downarrow$

Rotation



$$V = -\frac{d\phi}{dt}$$

$\phi = BA$.



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

constant

$\uparrow r = \frac{mv}{qB}$

$\boxed{v\uparrow \Rightarrow E\uparrow \Rightarrow R\uparrow}$

$\boxed{T \neq f(v)}$

In betatron, both r & B increases.

by same rate, hence $r \rightarrow$ constant

work done on the particle in the single rotation $\Rightarrow eV = e\frac{\partial\Phi}{\partial t}$

in a single ratation, work done can also be written like $=$ $f \cdot 2\pi r = e\frac{\partial\Phi}{\partial t}$

$\cancel{F}$ $f \cdot 2\pi r = e\frac{\partial\Phi}{\partial t}$

$$\boxed{f = \frac{e\,\partial\Phi}{2\pi r\,\partial t}} \quad \text{—(1)}$$

$$mv = eBr$$

$$\frac{\partial}{\partial t}(mv) = er\frac{\partial B}{\partial t}$$

Now, from eq. (1) :-

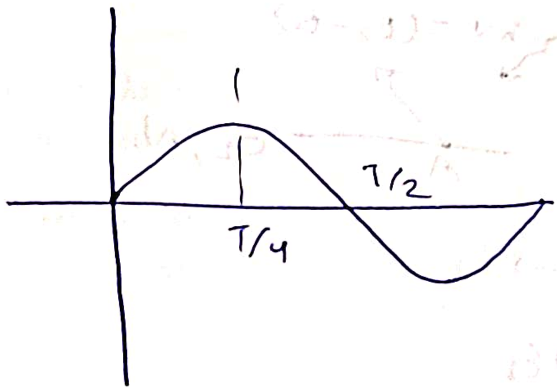
$$\frac{e}{2\pi r}\frac{\partial \phi}{\partial t} = er\frac{\partial B}{\partial t}$$

$$\partial \phi = 2\pi r^2 \partial B$$

$$\Rightarrow \boxed{\phi = 2\pi r^2 B} \Rightarrow \text{Betatron condition.}$$

Distance travelled by β-particle during the interval T/4, $= \boxed{c\left(\frac{T}{4}\right)}$.

No. of rotation of β-particle $= \frac{c(T/4)}{2\pi r} = \frac{\text{distance travelled}}{\text{circumference}}$



$$\boxed{= \frac{cT}{8\pi r}} \quad \because T = \frac{1}{\nu}$$

$$= \frac{c}{4(2\pi\nu)r} \quad \omega = 2\pi\nu$$

$$\Rightarrow \boxed{= \frac{c}{4\omega r}}$$

In case of photon,

Energy of β-particle:-

$$E^2 = p^2c^2 + m_0^2c^4$$

in photon, $m_0 = 0$

$$\Rightarrow \boxed{E = pc}$$

$$p = \frac{E}{c}$$

$$mv = \frac{E}{c}$$

$$eBr = \frac{E}{c}$$

$\Rightarrow$ $\boxed{E = eBrc}$

True for ~~pr~~ proton.
also used for
β-particle.