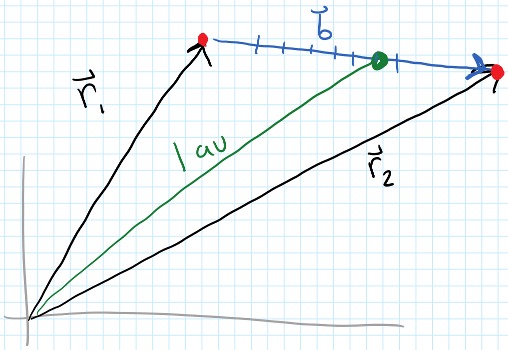


$$\vec{b}(t) = \vec{r}_1 + (\vec{r}_2 - \vec{r}_1)\, t$$

$$\underset{1\,au}{\text{dist}} = \underbrace{\sqrt{b_x^2 + b_y^2 + b_z^2}}_{t}$$

$$1\,au = f(t, t^2)$$

↓ solve

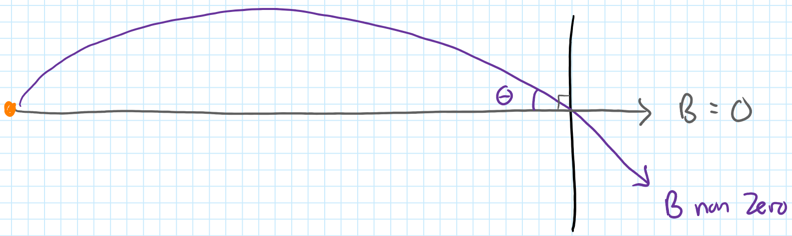
$$t = \underline{\qquad}$$

$$F = q\, \vec{v} \times \vec{B}$$

$$F = q\, \vec{c} \times \vec{B}$$

$$\boxed{\vec{a} = \frac{q}{E}\, \vec{c} \times \vec{B}}$$

Top Down

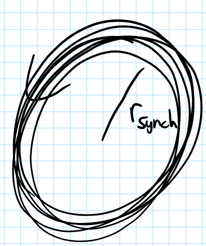


Compare B nonzero to B zero

$$\phi = \underbrace{\phi_{B\,!=0} - \phi_{B=0}}$$

$$\varepsilon = \frac{r_{earth}}{r_{synch}} \leftarrow E, B$$

Valid only if $\varepsilon \ll 1$

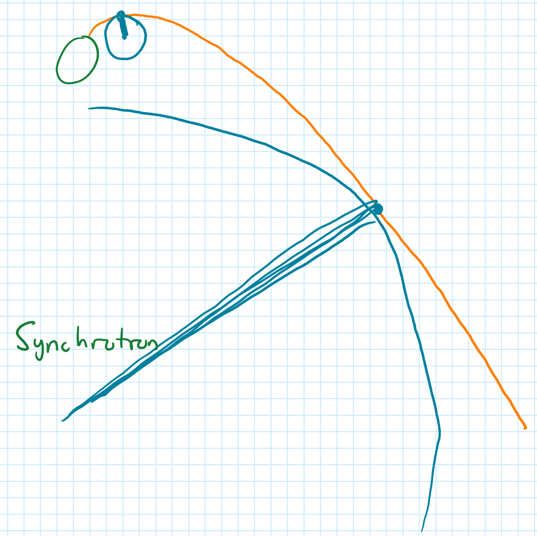


$B \sim \frac{1}{r}$

$r_{synch} \leftarrow E, B$

Valid only if $\varepsilon \ll 1$

$B \sim \frac{1}{r}$



Getting r_{synch}

$m \neq 0$, classical, e^- in $\vec{B} = (0,0,1)$

$F = ma$

$\downarrow$

$$qV \times B = m\,\boxed{a_{centripetal} = \frac{V^2}{r}}$$

Why is $a_{cent} = \frac{V^2}{r}$

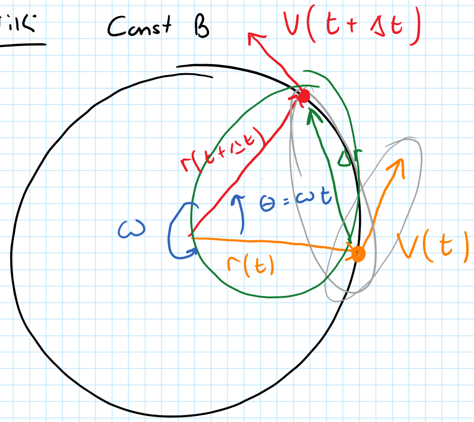
$$\dot{V} = \frac{V^2}{r}$$

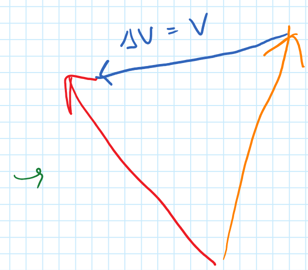
$$V^{-2}\, dV = \frac{1}{r}\, dt, \quad \text{const } r, \ \text{const } B$$

$$-\frac{1}{V} = \frac{1}{r} t + C_0$$

$$r = vt + c$$

Will: Const B





$$\boxed{\vec{a} = \frac{\Delta \vec{V}}{\Delta t}}$$

$$\vec{a} = \frac{\vec{V}(t+\Delta t) - \vec{V}(t)}{\Delta t}$$

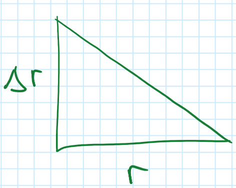
$$\frac{\Delta r}{\Delta t} = \Delta V$$

$\vec{V}$ are always $\perp$ to $\vec{r}$

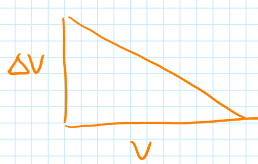
So the position and velocity triangles

are mathematically similar (same scaling)

Position



Velocity



$$\boxed{\frac{\Delta r}{r} = \frac{\Delta V}{V}}$$

$$\Delta V = V \frac{\Delta r}{r}$$

$$a = \frac{\Delta v}{\Delta t} = v \frac{\Delta r}{r} \frac{1}{\Delta t}$$

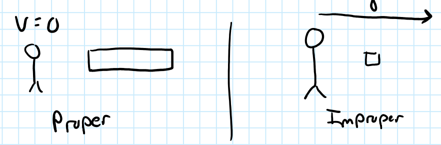
$$= \frac{v}{r} \frac{\Delta r}{\Delta t}$$

$$= \frac{v^2}{r}$$

Potential problems

(1) length contraction

only in direction of motion



$$6 \times 1 = 2 \times 3$$

$$\ell = \gamma \ell'$$

Proper = γ (Improper)

- Always moving $\perp$ to $\vec{r}$ (location)
- Change Δr ? Yes

$$\Delta r \rightarrow \gamma \Delta r$$

$$\frac{\gamma \Delta r}{r} = \frac{\Delta v}{v} \rightarrow \frac{v}{r} \gamma \frac{\Delta r}{\Delta t} = \boxed{\gamma \frac{v^2}{r} = a_{cent}}$$

- $\gamma = \gamma(v)$, what v is this ?

v in γ is the same v as the v in v^2/r

- r_{synch} ?

$$F = qv \times B$$

$$\boxed{m\gamma} \frac{v^2}{r} = qv \times B$$

Total Energy E

Punchline

$$E \frac{v^2}{r} = qv \times B$$

non relativistic: $F_{cent} = m\, a_{cent}$

relativistic: $F_{cent} = E\, a_{cent}$

$$r_{synch} = \frac{E v^2}{qvB} = \boxed{\frac{Ev}{qB}}$$

relativistic

$$v^2 = \frac{q}{E} K v B,$$

Curvature

location from origin

$\hookrightarrow V^2 = \frac{q}{E} \, K \, V \, B$,

location from origin

$$V^2(\quad) = \frac{q}{E} \, \underline{K(r)} \, V(\quad) \, \underline{B(r)}$$

$$\boxed{K(\vec{r}) = \frac{E V}{q B(\vec{r})}}$$

For us
$B(r) \sim \#/r$

$$K = \frac{E V}{q \, \#/r}$$

$$\underline{K} = \#_2 \, \underline{r} \quad .$$ Matches intuition