8.022 Lecture Notes Class 22 - 10/24/2006

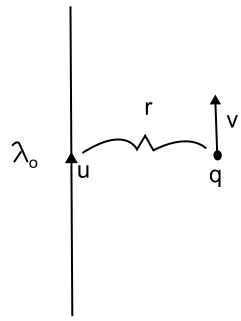
$$F' = \gamma_v \cdot qv \cdot \tfrac{u \cdot \lambda_0}{2\pi r \epsilon_0 c^2} \quad \mu_0 = \frac{1}{\epsilon_0 c^2}$$

$$F' = \gamma_v qv \cdot \tfrac{\mu_0 u \lambda_0}{2\pi r} \quad \mu_0 \epsilon_0 = \frac{1}{c^2}$$

$$F = qv \cdot \mu_0 \tfrac{u\lambda_0}{2\pi r} \quad F' = \gamma_v F$$

$$= q \cdot v \cdot [\tfrac{\mu_0 I}{2\pi r}]$$

$$= q \cdot v \cdot B$$



$$\mu \lambda_0 = I$$

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

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B}) \quad \text{(Lorentz Force Law)}$$

Magnetostatics

- Simplest nontrivial case:
  A particle w/ charge q in $\vec{B} = B_0 \hat{z}$

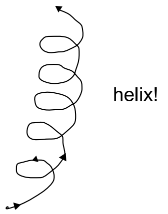
$$\vec{B} = q\vec{v} \times \vec{B} = m\vec{a} = \frac{d\vec{p}}{dt}$$

  $F_z = 0$ since $\vec{B}$ is in $\hat{z}$ direction, so $v_z = \textit{constant}$ particle moves in xy-plane, cross product, implies cosines and sines, circle

- Static field (doesn't change overtime) is not necessarily constant (doesn't change over space)

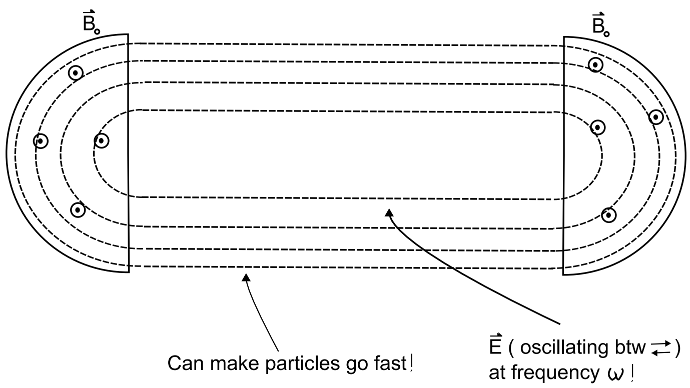
$$\frac{m|v^2|}{R} = q|\vec{v}||\vec{B}| \qquad |v| << c$$

Frequency: $\omega = \frac{V}{R} = \frac{qB}{m}$ cyclotron frequency (not dependent on v when non-relativistic)



add in some $v_2 \neq 0$

What is useful? In cyclotrons!



Can make particles go fast!

When speeds get relativistic, ω no longer constant.

Synchotron $\begin{cases} \omega = & \omega(v) \\ \beta = & \beta(t) \quad \text{(increase B to keep R smaller)} \end{cases}$

(Nonlinear particle accelerators all us this - curving particles to accelerate with them - essentially synchotron) CERN - Large Hadron Collider

- Can't do this with uncharged particles-
  (Neutron not found until 1930's, 1940's - very late)

Tommorow's problem: particle with charge q in $\vec{B} = B_0\hat{z}$ and $\vec{E} = E_0\hat{y}$