Exams on Feb. 7 and Feb 21

DON'T READ SECTIONS 3-2 and the first part of 3-3.   Start chapter 3 at eqn M-2

Magnetic force: This lecture covers Shadowitz section 3-3 plus material not in text

Assume magneto-statics:

$$\vec{\nabla} \cdot \vec{J} = -\frac{\partial \rho}{\partial t} = 0$$

$$\vec{J} = \rho \vec{v}$$

Questions:

no moving point charges

current in wire is same everywhere even though the wire may change shape

Force law:

$$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$$

Lorentz force

What evidence is there that a moving q is the same as a stationary one?

What have we done?

What are we going to do?

Calculate B given currents

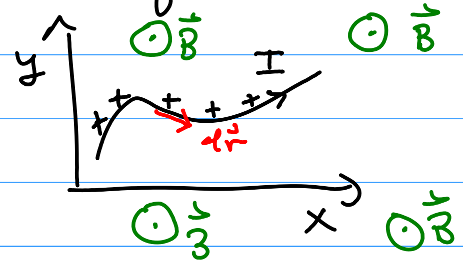
Calculate the force given currents and B

Given B find F $\vec{F} = q\vec{v} \times \vec{B}$

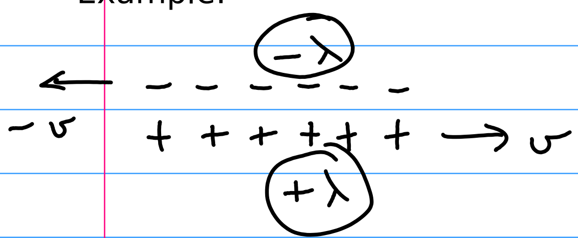
1.) charge moving along a line $dq = \lambda \underbrace{|d\vec{r}|}_{} $ ($d\ell = |d\vec{r}|$)

$d\vec{F} = \lambda |d\vec{r}| \vec{v} \times \vec{B}$

$\underset{\frac{c}{m}\ \frac{m}{s}}{\lambda v} = I\left(\frac{c}{s}\right)$



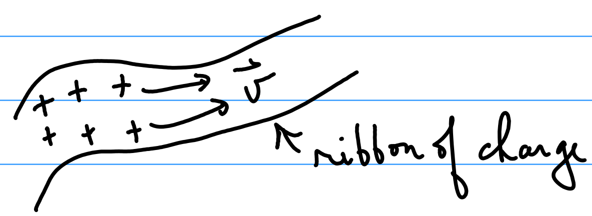
Example:



What is $I_{total} =$

For charge moving in 1-D $\vec{F} = \int I \, d\vec{\ell} \times \vec{B}$ ($d\vec{\ell} = d\vec{r}$)

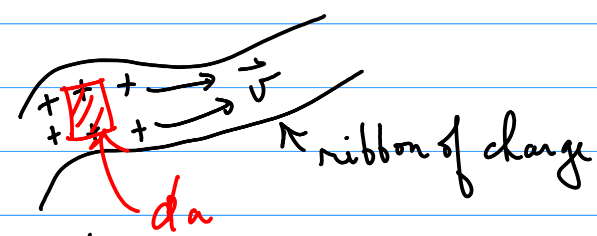
2.) Charge moving along a surface.



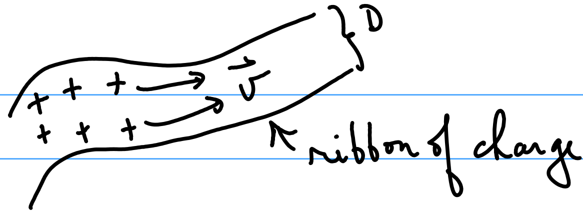
$dq = \sigma \, da$

$d\vec{F} = dq \, \vec{v} \times \vec{B}$

$= \sigma \, da \, \vec{v} \times \vec{B}$



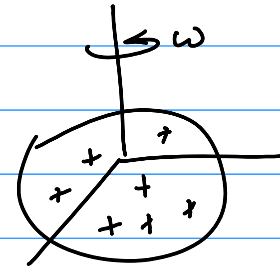
$\underset{\frac{c}{m^2}\ \frac{m}{s}}{\sigma v} = K\left(\frac{c}{m \cdot s}\right)$



KD $\quad \frac{C}{m\cdot s}\, m \to I$ Amps $\left(\frac{C}{s}\right)$

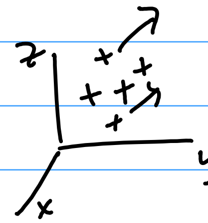
$\sigma \vec{v} = \vec{K}$ $\qquad d\vec{F} = q\vec{v}\times\vec{B} = \vec{K}\times\vec{B}\, da$

Hmwk: charged record



For a charge moving in 2-D $\quad \vec{F} = \int \vec{K}\times\vec{B}\, da$

3.) Charge moving through a volume



Plasma

$d\vec{F} = dq\, \vec{v}\times\vec{B}$ $\qquad dq = \rho\, d\text{volume}$, $d\text{volume} = d\tau$

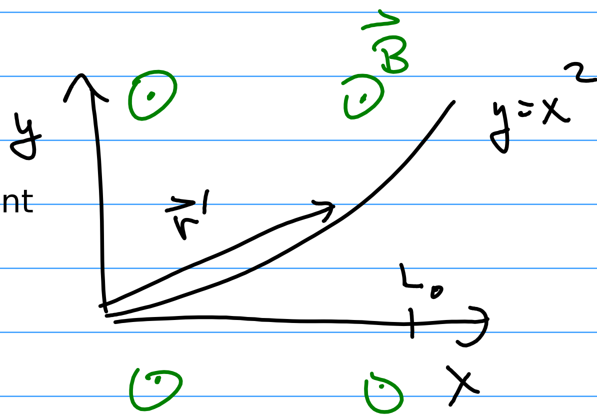
$d\vec{F} = \rho\, d\tau\, \vec{v}\times\vec{B}$ $\qquad \vec{J} = \rho v$ current density

Remember $\nabla\cdot\vec{J} = -\frac{\partial \rho}{\partial t}$

$d\vec{F} = \vec{J}\times\vec{B}\, d\tau$

Example:

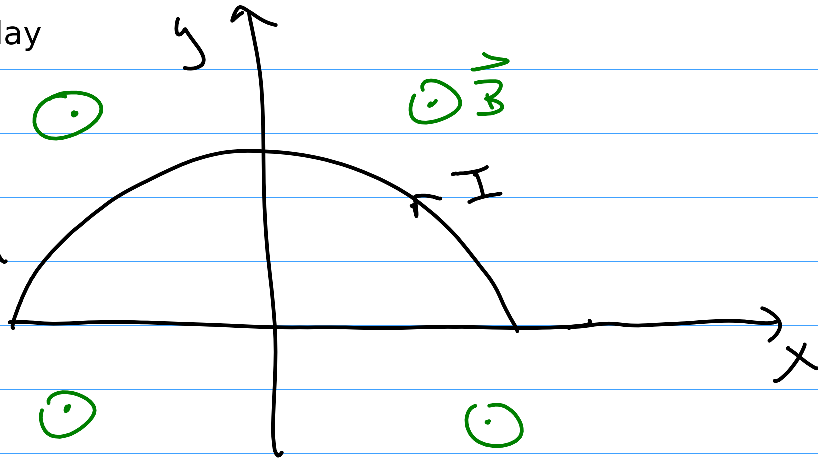
Find the force on the wire segment from x=0 to x=L



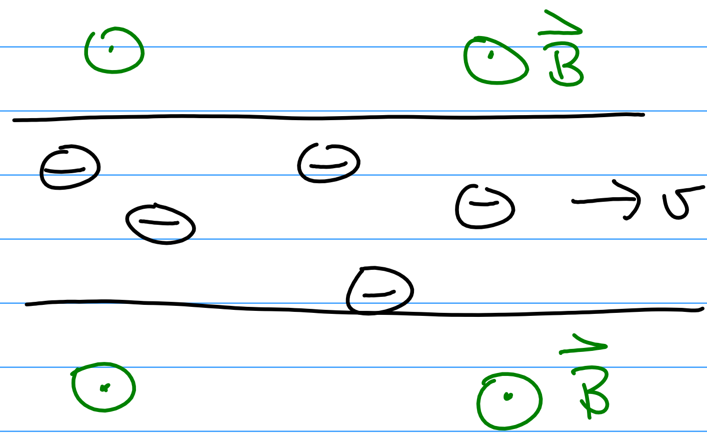
For a charge moving in 3-D $\quad \vec{F} = \int \vec{J}\times\vec{B}\, d\tau$

InkSurvey question for Friday

Find $d\vec{\ell} = d\vec{r}$ needed to determine $d\vec{F}$



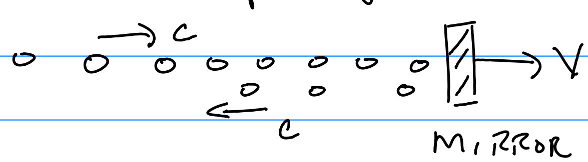
InkSurvey question for Friday



How can there be a force on a wire if the electrons are free to move?

Example: conservation of photons in a laser beam reflecting from a moving mirror

Photons reflecting as a stream of particles 1-D



$\vec{J}_{in} = \rho_{in} \vec{v}_{in} \rightarrow \lambda_{in} c$

$J_{reflected} = \rho_{ref} \vec{v}_{ref} \rightarrow \lambda_{ref} c$

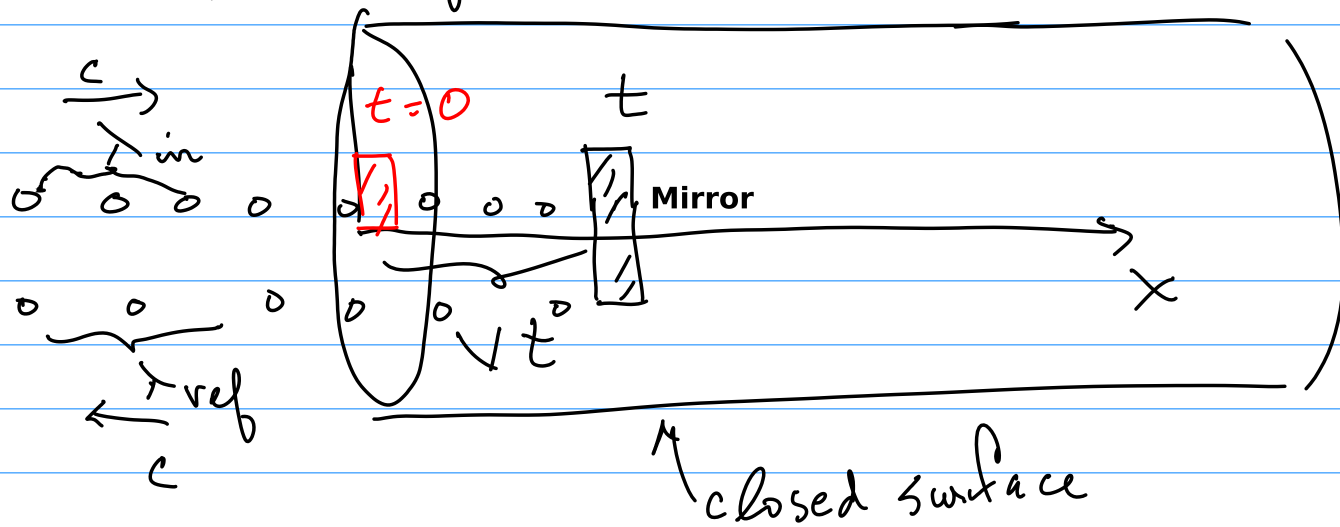
Model

$\vec{J}_{in} = \lambda_{in} c \hat{x}$

$\vec{J}_{ref} = -\lambda_{ref} c \hat{x}$

Reality

$10^{14} \frac{\text{photons}}{\text{sec}} \pm \sqrt{10^{14}}$



Conservation eqn?

$$J_{in} - J_{ref} = \frac{\partial N_{inside}}{\partial t}$$

time rate of change of # inside

flux of particles out surface

flux of particles into surface

$$\lambda_{in} c - \lambda_{ref} c = \frac{d}{dt}(\lambda_{in} + \lambda_{ref}) vt = (\lambda_{in} + \lambda_{ref}) v$$

$$\lambda_{ref} = \frac{c-v}{c+v} \lambda_{in} = \frac{c(1 - v/c)}{c(1 + v/c)} \lambda_{in} \simeq \lambda_{in}\left(1 - \frac{2v}{c}\right)$$

$$J_{ref} = J_{in}\left(1 - \frac{2v}{c}\right)$$

Photodetector (photodiode or photomultiplier) measures photon flux

Questions:

Incongruous:

Congruous:

Modifying:

Generalizing/Analogy:

Causal/Creative: