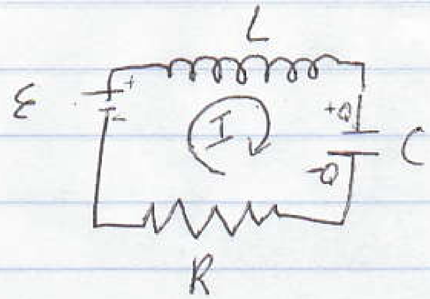
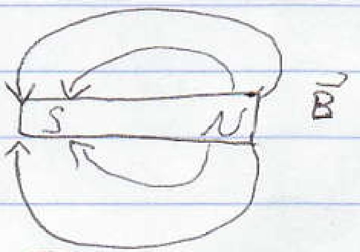
Notes

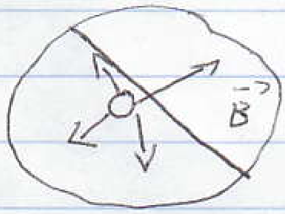
KCL



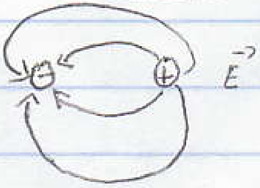
$$0 = \mathcal{E} - L\frac{dI}{dt} - \frac{Q}{C} - IR$$

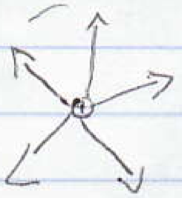
Magnetism





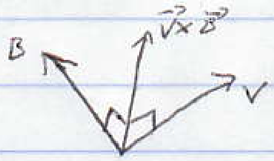
$m\vec{a} = \vec{F} = q\vec{v} \times \vec{B}$





$\vec{E}$

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



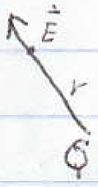
energy density $u =$

like inside a coil

Ampere's Law:

$\vec{B}\cdot d\vec{\ell} = \mu$

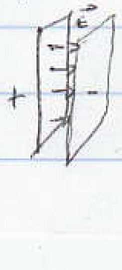
I



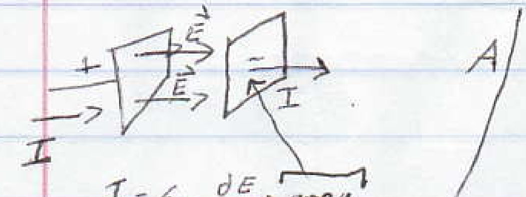
e

energy density $u = \varepsilon_0 E^2$

like between capacitor plates

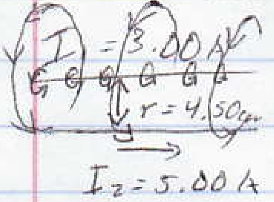


$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$



$I = \varepsilon_0 \frac{dE}{dt} \cdot \text{area}$

What is the force per unit length on a long straight wire with 3.00 current that is parallel to and 4.50cm from a long straight wire with 5.00A current in the same direction?
Give magnitude & direction



$\vec{B}_1$

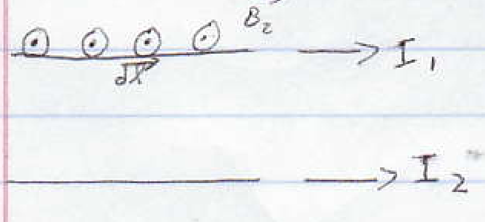
$\vec{B}_2$: Ampere's law
$2\pi r B_2 = \mu_0 I_2$

Ampere's Law for B_2

$\frac{dF_1}{dl} = ?$ $\quad d\vec{F}_1 = I_1 \, d\vec{l} \times \vec{B}_2$

$dF_1 = I_1 (dl) B_2$

$B_2 = \frac{\mu_0 I_2}{2\pi r} \rightarrow \frac{dF_1}{dl} = \frac{\mu_0 I_1 I}{2\pi r}$



$\frac{(4\pi \cdot 10^{-7} T \cdot m/A) 15A^2}{2\pi \cdot 4.5 \times 10^{-2} m}$
$= \boxed{6.67 \times 10^{-5} T \cdot A}$

$d\vec{l} \perp \vec{B}_2 \Rightarrow |d\vec{l} \times \vec{B}_2| = |d\vec{l}||\vec{B}_2|$
$= B_2 \, dl$

$|\vec{w} \times \vec{z}| = wz \sin\theta$

$d\vec{F} = I d\vec{l} \times \vec{B}$

$N = A \cdot m \cdot T$

$\frac{N}{m} = A \cdot T$

$d\vec{F}_1$ points $\boxed{\text{towards the other wire}}$

$\vec{F} = q\vec{v} \times \vec{B}$ $\quad \frac{N}{m} = \frac{C}{s} \cdot T \quad \frac{N}{m} = A \cdot T$

$N = C \cdot \frac{m}{s} \cdot T$

(Faraday) changing $\vec{B}$ creates $\vec{E}$: $\frac{d}{dt}\int \vec{E}\cdot d\vec{A}$

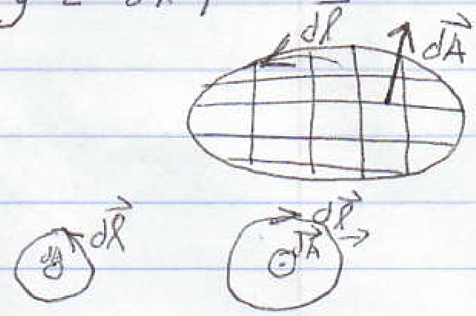
~~closed~~ surface

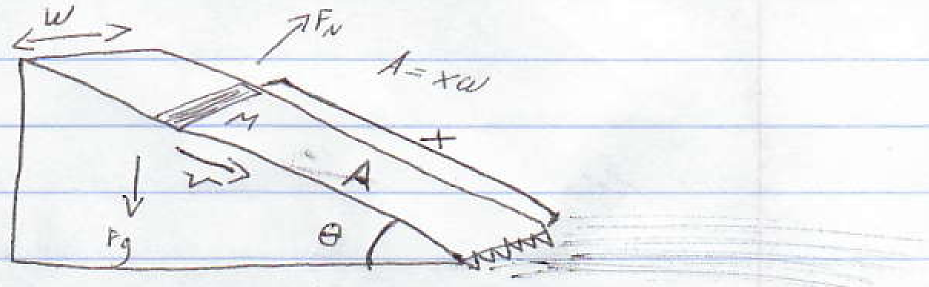
(Ampere) { changing $\vec{E}$ creates $\vec{B}$

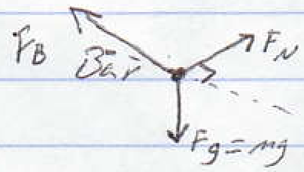
{ moving charges create $\vec{B}$

$$\left(-\frac{d\Phi_B}{dt} = \oint \vec{E}\cdot d\vec{l}\right)$$

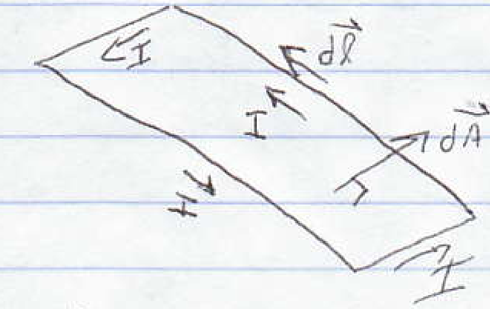
$$\oint \vec{B}\cdot d\vec{l} = \mu_0 \left(I + \underbrace{\varepsilon_0 \frac{d\Phi_E}{dt}}_{\text{displacement current}}\right)$$







$V_{ab} \approx \mathcal{E} = IR$



Given v, you can find F_B. or by requiring $\Sigma \vec{F} = \vec{0}$ you can find F_B, and then find v, which would be the terminal velocity.

↑

You'd also need to know the current I (or know $\vec{B}$).

$$IR = \mathcal{E} = -\frac{dI_B}{dt} = \underbrace{\frac{-dA}{dt}}_{-vw} B = Bvw$$

$$d\vec{F}_B = I\,d\vec{l} \times \vec{B}$$

$$dF_B = I(dl)_B$$

$$F_B = IwB = Iw\cdot\frac{IR}{vw} = \frac{I^2R}{v}$$