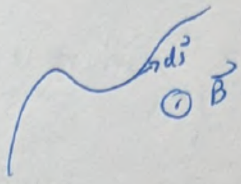
EXAM 2 REVIEW

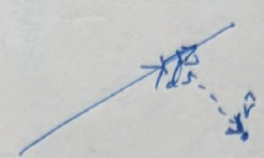
Magnetic Force on a wire: $\boxed{\vec{F} = \int I\, d\vec{s} \times \vec{B}}$



$\vec{F}$ from RHR

Point charge $\boxed{F = q\vec{v} \times \vec{B}}$

Charges causing magnetic field: $\boxed{\vec{B} = \frac{\mu_0}{4\pi} I \int \frac{d\vec{s} \times \hat{r}}{r^2}}$

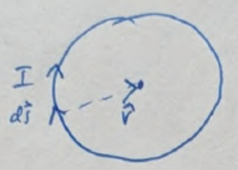


pt measuring field at

$\vec{B}$ from RHR

(I is thumb, field is hand)

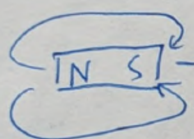
Ex - a circle



$$\vec{B} = \frac{\mu_0}{4\pi} I \int \frac{d\vec{s} \times \hat{r}}{r^2}$$ *Notice $d\vec{s}$ is $\perp$ to $\hat{r}$ always

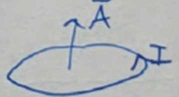
$$= \frac{\mu_0 I}{4\pi r^2} \int ds = \frac{\mu_0 I}{4\pi r^2} \cdot (2\pi r) = \boxed{\frac{\mu_0 I}{2R}}$$

Torque, Dipole



— magnets are always in dipoles

Dipole moment $\boxed{\vec{\mu} = I A \hat{n} = I\vec{A}}$ A is the area of current loop



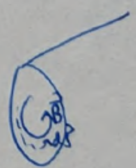
$\vec{\mu} \uparrow$

Torque on a Current Loop = $\boxed{\vec{\tau} = I\vec{A} \times \vec{B} = \vec{\mu} \times \vec{B}}$

Ampere's Law → finding the field caused by a current using a loop

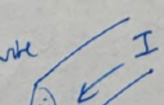
I
$\otimes = +$
$\odot = -$

$$\boxed{\oint \vec{B} \cdot d\vec{s} = \mu_0 \iint \vec{J} \cdot \hat{n}\, dA = \mu_0 I_{enc}}$$



$d\vec{s}$ is the loop

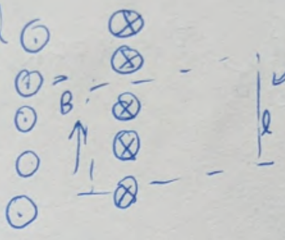
Ex wire



$$\oint \vec{B} \cdot ds = B(2\pi r) = \mu_0 I_{enc} = \mu_0 \frac{I r^2}{R^2}$$

$$= \mu_0 \frac{I r}{2\pi R^2} \hat{\theta}$$

EX Solenoid



B here is 0 bc symmetry

$\vec{B} \cdot d\vec{s} = \mu_0 I_{enc}$

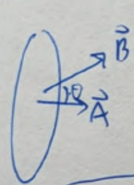
$d\vec{s}$ is only valid inside solenoid

$\vec{B} \cdot l = \mu_0 n l I$

↳ # turns/length

$$\boxed{\vec{B} = \mu_0 n I}$$

Faraday's Law: Changing magnetic flux induces a current



$$\boxed{\Phi = \vec{B} \cdot \vec{A} = BA\cos\theta}$$

$$\boxed{\varepsilon = -\frac{d\Phi}{dt}}$$

- changed B?
- changed A?
- changed θ?

Lenz's Law:

ε, I in the direc to resist charge

Inductance

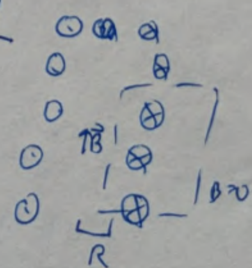
Mutual: $\Phi_{12} = M_{12} I_2$

$$\frac{B_{caused\ by\ 1} \cdot Area_{of\ 2}}{I} = M_{12}, \quad I \text{ cancels}$$

Self: $\Phi_B = LI$

1) Assume Current
2) Calculate B field
3) Calculate flux
4) Calculate Inductance (B ∝ I)

Ex solenoid



$\oint \vec{B} \cdot d\vec{s} = Bl = \mu_0 I_{enc}$

$B = \frac{\mu_0 N I}{l}$

$\Phi_{turn} = B \cdot \pi R^2$

$L = \frac{N\Phi}{I} = \frac{\mu_0 N^2 \pi R^2}{l}$

Inductors - resist change in current

$$\varepsilon_{emp} = -L\frac{dI}{dt}$$

initial - acts like really big resistance

steady-state - wire

Capacitors ~ ~~ta~~ takes up all current

$$\varepsilon_{emp} = \frac{Q}{C}$$

initial - acts like wire

steady final - no current flows through

Energy Density $u_B = \frac{1}{2} B^2/\mu_0 \Rightarrow \frac{1}{2\mu_0}\int B^2\, dV = U$

$u_E = \frac{1}{2}\varepsilon_0 E^2$

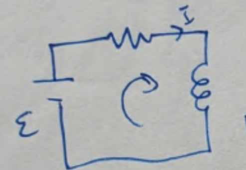
Charging an inductor $W = \frac{1}{2}LI^2$

$W = \frac{1}{2}C\Delta V^2$

In series → inverse

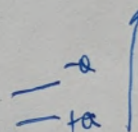
in parallel → summation

Circuits



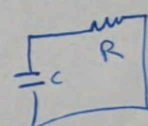
RL circuit

$$\varepsilon - IR - L\frac{dI}{dt} = 0$$



$I = \frac{dQ}{dt}$ charge

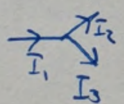
Discharge :



$\frac{Q}{C} - IR = 0$

$I = -\frac{dQ}{dt}$

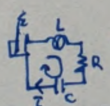
Kirchoffs Rule #1:



$I_{in} = I_{out}$

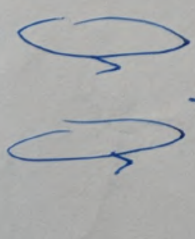
$I_1 = I_2 + I_3$

#2: Loop rule



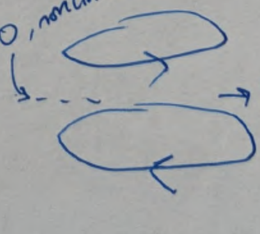
$\varepsilon - L\frac{dI}{dt} - IR - \frac{Q}{C} = 0$

Helmholtz Coil



→ Field is uniform (torque, no force)

O, nonuniform



→ Force, no torque