REVIEW LECTURE

BEFORE SPRING BREAK

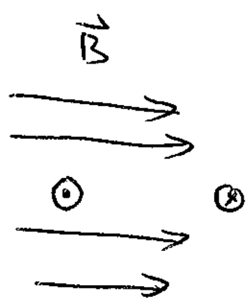
MAGNETIC FIELD

$$\vec{B} \quad \Rightarrow \quad \vec{F} = q(\vec{v} \times \vec{B}) + q\vec{E}$$

TORQUE ON CURRENT LOOP

$$\vec{\mu} = I\vec{A}$$

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

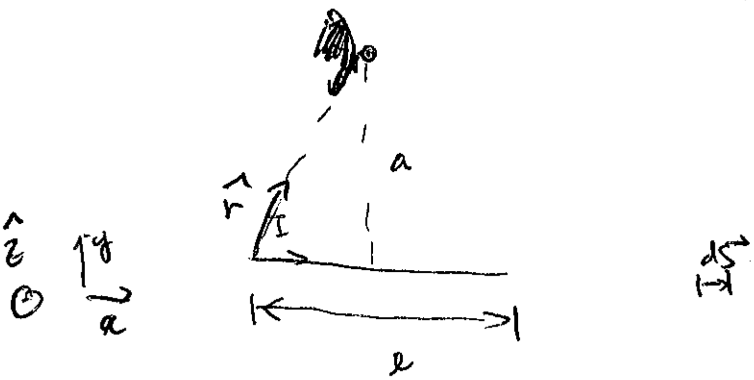


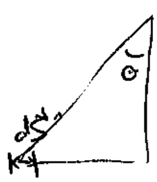
$$\rightarrow \boxed{\vec{\tau} = 0}$$

SOURCES OF MAGNETIC FIELD

BIOT-SAVART LAW

$$d\vec{B} = \frac{\mu_0}{4\pi}\,\frac{I\,d\vec{s}\times\hat{r}}{r^2}$$



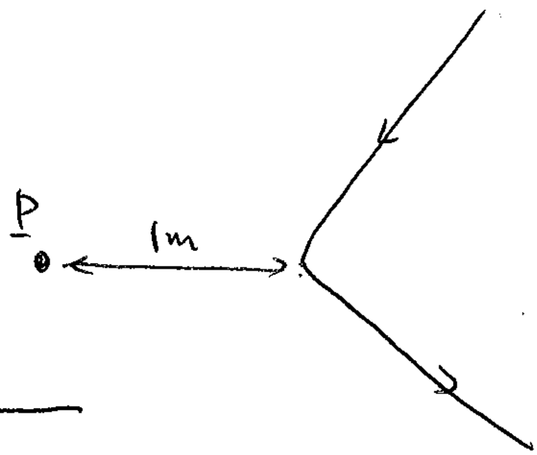


$$d\vec{s}\times\hat{r} = \sin(90-\theta)\,dx = \cos\theta\,dx\,\hat{z}$$

$$d\vec{B} = \frac{\mu_0 I}{4\pi\, r^2}\,dx\cos\theta\,\hat{z}$$

$$r = \frac{a}{\cos\theta}$$

$$x = -a\tan\theta \quad \cdots \quad dx = -a\sec^2\theta\,d\theta$$



MAGNETIC FIELD?

$$d\vec{B} = \frac{\mu_0 I}{4\pi} \frac{\cancel{a}\, d\theta}{\cancel{\cos^2\theta}} \cos\theta \cdot \frac{\cancel{\cos^2\theta}}{\cancel{a^2}\, a}$$

$$= -\frac{\mu_0 I}{4\pi} \cos\theta \, d\theta$$

AMPERE'S LAW

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I$$

FORCES ON CURRENT CARRYING WIRE

$$\boxed{\vec{F} = I\vec{L} \times \vec{B}}$$

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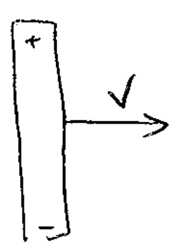
FARADAY'S LAW

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

MOTIONAL EMF

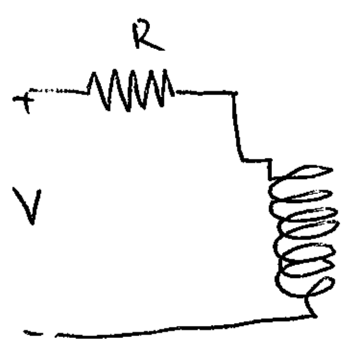


INDUCED EMF AND ELECTRIC FIELDS

$$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$$

INDUCTANCE

$$\mathcal{E}_L = -L\frac{dI}{dt}$$



$V = IR + \underline{\underline{\mathcal{E}_L}}$

EMF OPPOSES THE APPLIED VOLTAGE

FOR A COIL

$$\mathcal{E} = -N\frac{d\Phi}{dt}$$

$$\Downarrow$$

$$L = \frac{\mu N^2 A}{l}$$

RL CIRCUIT

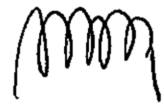
ENERGY IN $\vec{B}$ FIELD

$$U = \frac{1}{2} L I^2$$

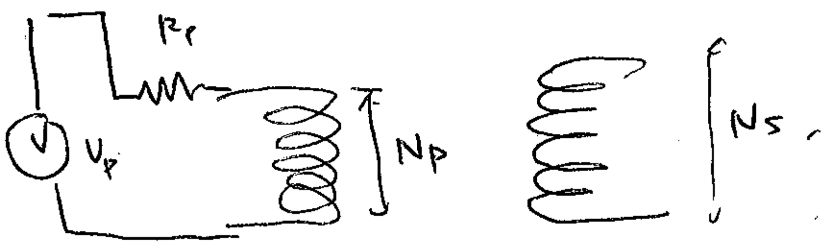
$$\mu_B = \frac{U}{V} = \frac{B^2}{2\mu_0}$$

MUTUAL INDUCTANCE

$$\left(M_{12} = \frac{N_2 \Phi_{12}}{I_1} \right)$$



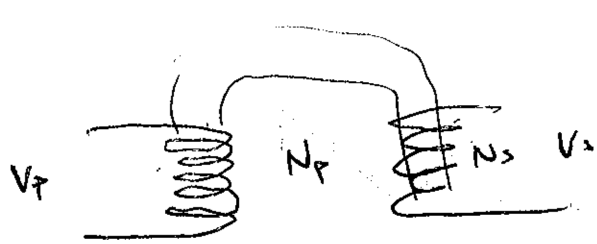
$$\mathcal{E}_2 = -M_{12} \frac{dI_1}{dt}$$



$$V_p = I_p R_p + L\frac{dI_p}{dt} - M\frac{dI_s}{dt}$$

$$V_s \Rightarrow \quad M\frac{dI_p}{dt} = I_s R_2 + L_2 \frac{dI_s}{dt}$$

COMPLICATED



$$V_p = N_p \frac{d\Phi}{dt}$$

$$V_s = N_s \frac{d\Phi}{dt}$$

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

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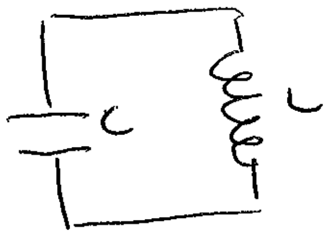
LC CIRCUIT



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

$$\frac{Q}{C} + L\frac{dI}{dt} = 0$$

$$\frac{Q}{C} + L\frac{d^2Q}{dt} = 0$$

$$Q = Q_0 e^{i\omega t}$$

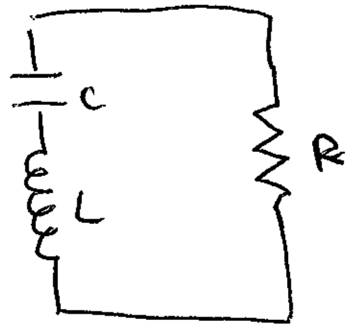
$$\omega = \frac{1}{\sqrt{LC}}$$

$$\frac{\cancel{Q_0}}{C}\cancel{e^{i\omega t}} + (-\omega^2)L\,\cancel{Q_0 e^{i\omega t}} = 0$$

$$\frac{1}{C} = \omega^2 L$$

$$\boxed{\omega^2 = \frac{1}{\sqrt{LC}}}$$

RLC CIRCUIT



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

$$IR + \frac{Q}{C} + L\frac{dI}{dt}$$

$$\frac{Q}{C} + I\frac{dQ}{dt} + L\frac{d^2Q}{dt^2} = 0$$

$$Q = Q_0 e^{i\omega t}$$

$$\frac{\cancel{Q_0 e^{i\omega t}}}{C} + R i\omega \cancel{Q_0 e^{i\omega t}} + L\cancel{Q_0}(-\omega^2)\cancel{e^{i\omega t}} = 0$$

$$\frac{1}{C} + i\omega R \cancel{+} - L\omega^2 = 0$$

$$\omega =$$

$$\omega^2 - \frac{i\omega R}{L} - \frac{1}{LC} = 0 \qquad (-i)^2 = -1$$

$$\omega = \frac{\frac{iR}{L} \pm \sqrt{\mp\frac{w^2}{L^2} + \frac{4}{LC}}}{2}$$

$$e^{-\frac{R}{2L}t}\, e^{i\sqrt{\frac{1}{LC} - \frac{w^2}{4L^2}}}$$