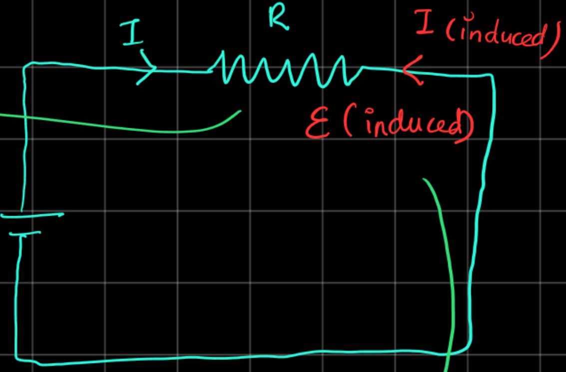
$I_{max} = \frac{\mathcal{E}}{R}$



measures the opposition of current

self inductance

measures the opposition to the CHANGE in the current

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

$= -L \frac{dI}{dt}$ → current

induced voltage

inductance (Henry, H)

$L = \frac{-\mathcal{E}_L}{dI/dt} = \frac{N\Phi_B}{i}$

↳ current

lowercase signifies changing value

Solenoid

$L = \mu_0 n^2 V$ ↳ Volume of the solenoid = Area × Length of solenoid

↓ area of one loop

$\frac{N}{l}$ → number of loops in solenoid

l → length of solenoid

Example

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

$= -2 \left(-0.5 \right)$

$$= \left(\frac{\quad}{10\times10^{-3}} \right)$$

$$= 100 \text{ V}$$

Example

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

$$= -90\times10^{-3}(2t-6)$$

@ $t = 1$

$$\mathcal{E} = -90\times10^{-3}(-11)$$

$$= 360\times10^{-3} \text{ V}$$

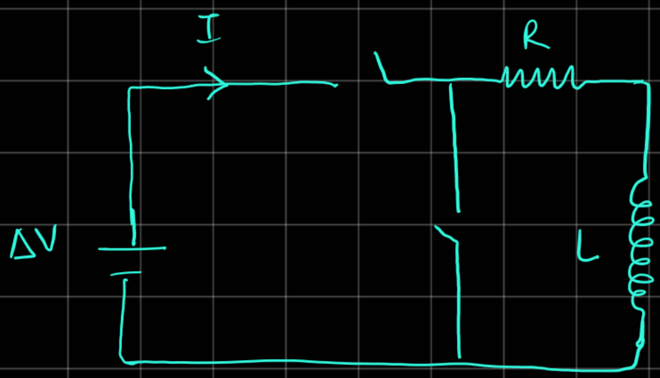
@ $t = 4$

$$\mathcal{E} = -90\times10^{-3}(8-6)$$

$$= -180\times10^{-3} \text{ V}$$

RL Circuit

$$I_{max} = \frac{\Delta V}{R}$$



Charging an inductor

$$i = \frac{\mathcal{E}}{R}\left(1 - e^{-tR/L}\right) = \frac{\mathcal{E}}{R}\left(1 - e^{-t/\tau}\right)$$

@ $t=0$

$$i = 0$$

@ $t = \infty$

$$i = \frac{\mathcal{E}}{R}$$

$\tau = \frac{L}{R} \Rightarrow$ Time for current to reach $[0.632\, I_{max}]$.

Discharging

$$i = \frac{\mathcal{E}}{R} e^{-t/\tau}$$

@ $t = 0$

$$i = \frac{\mathcal{E}}{R}$$

@ $t = \infty$

$i = 0 \Rightarrow$ Fully discharged

Example

i) $L = \mu_0 n^2 V$

$$= 4\pi \times 10^{-7} \left(\frac{510}{0.14}\right)^2 \left(\pi (8 \times 10^{-3})^2 \times 0.14\right)$$

ii) $\tau = \frac{L}{2.5}$

Example

$$RC = \frac{L}{R}$$

$$R^2 = \frac{L}{C}$$

$$R = \sqrt{\frac{L}{C}}$$

$$= \sqrt{\frac{3}{3 \times 10^{-6}}}$$

$$= \sqrt{1 \text{ M}\Omega}$$

$$0.8 = \frac{6}{4}\left(1 - e^{-t/2 \times 10^{-3}}\right)$$

$$\frac{8}{10} = 1 - e^{-t/2\times10^{-3}}$$

$$\frac{2}{10} = e^{-t/2\times10^{-3}}$$

$$\frac{-t}{2\times10^{-3}} = \ln\left(\frac{2}{10}\right)$$

$$t = -2\times10^{-3}\ \ln\left(\frac{2}{10}\right)$$

Inductor stores magnetic potential energy

$$U_L = \frac{1}{2} L i^2$$

Solenoid $\Rightarrow$ $B = \mu_0 n I = \mu_0 \frac{N}{l} I$

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

$$= \frac{1}{2}\left[\mu_0 n^2 V\right]\left[\frac{B}{\mu_0 n}\right]^2$$

$$= \frac{1}{2}\frac{V B^2}{\mu_0}$$

$$u = \frac{U_L}{V} = \frac{1}{2}\frac{B^2}{\mu_0} \quad \frac{J}{m^3}$$

Energy Density

Mutual Inductance

I I (induced)

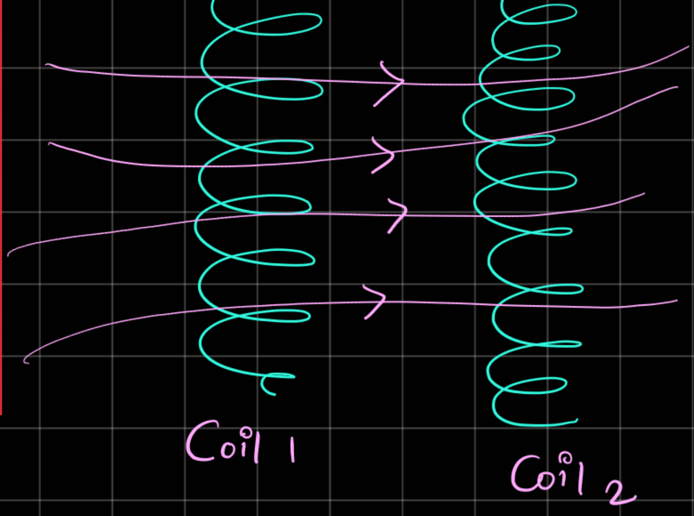
$$M_{12} = \frac{N_2 \Phi_{12}}{i_1} \quad (H)$$

$$\mathcal{E}_2 = -M_{12} \frac{di_1}{dt}$$

If I in Coil 2

$$M_{21} = \frac{N_1 \Phi_{21}}{i_2}$$

$$\mathcal{E}_1 = -M_{21} \frac{di_2}{dt}$$

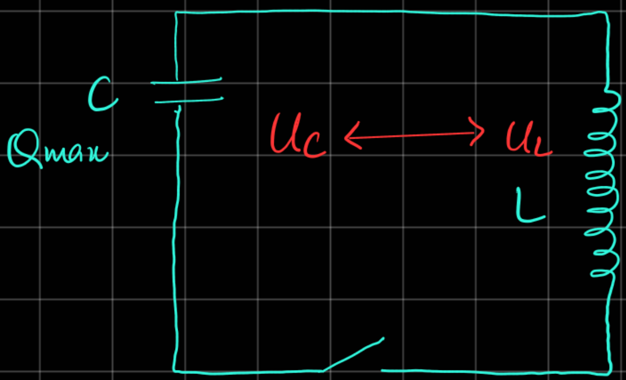


$$\boxed{M_{12} = M_{21} = M}$$

Example

$$M = \frac{-\mathcal{E}_L}{di/dt} = \frac{96 \times 10^{-3}}{1.2}$$

$$U_C = \frac{Q_{max}^2}{2C}$$



$$U_T = \frac{q^2}{2C} + \frac{1}{2} L i^2$$

$$= \frac{Q_{max}^2}{2C} = \frac{1}{2} L I_{max}$$

Oscillation Frequency

$$\omega = 2\pi f = \frac{1}{\sqrt{LC}}$$