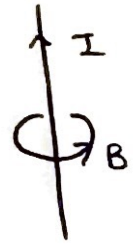
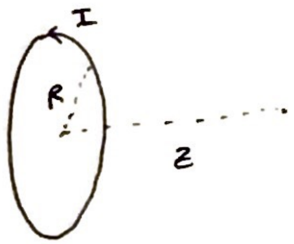
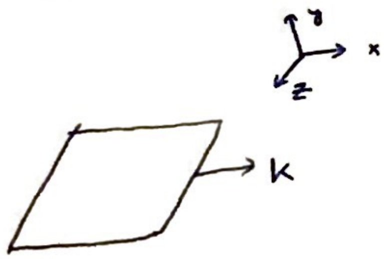
Formula Sheet 2



$$B = \frac{\mu_0 I}{2\pi r}\,\hat{\theta}$$



$$|\vec{B}_z| = \frac{\mu_0 I R^2}{2(R^2+z^2)^{3/2}}$$



$$\vec{B} = \begin{cases} \mu_0 K/2, & y>0 \\ -\dfrac{\mu_0 K}{2}, & y<0 \end{cases}$$

$$\vec{E}_{\text{due to a moving charge}} = \frac{1}{4\pi\epsilon_0}\,\frac{q\,(1-v^2/c^2)}{(1-v^2/c^2\,\sin^2\theta)^{3/2}}\,\frac{\hat{R}}{R^2}$$

If a frame exists where there is no electric field, in any other boosted frame

$$\vec{E}' = \vec{v}\times\vec{B}'$$

~~When~~ If a frame exists where there is no magnetic field, in any other boosted fram

$$\vec{B}' = -\frac{\vec{v}}{c^2}\times\vec{E}'$$

Transformation of Fields

$$E_x' = E_x, \quad E_y' = \gamma(E_y - vB_z), \quad E_z' = \gamma(E_z + vB_y)$$

$$B_x' = B_x, \quad B_y' = \gamma(B_y + v/c^2\,E_z), \quad B_z' = \gamma(B_z - v/c^2\,E_y)$$

or

$$E_\parallel' = E_\parallel, \quad \vec{E}_\perp' = \gamma(\vec{E}_\perp + \vec{v}\times\vec{B}_\perp)$$

$$B_\parallel' = B_\parallel, \quad \vec{B}_\perp' = \gamma(\vec{B}_\perp - \vec{v}/c^2\times\vec{E}_\perp)$$

Transformation of Forces

$$F'_x = \frac{F_x - \frac{V}{c^2}\left(F_y v_y + F_z v_z\right)}{1 - \frac{V v_x}{c^2}}$$

$$F'_y = F_y \Big/ \gamma\left(1 - \frac{V v_x}{c^2}\right)$$

$$F'_z = F_z \Big/ \gamma\left(1 - \frac{V v_x}{c^2}\right)$$

where v_x, v_y, v_z is the velocity of particle of S frame and V is the velocity of S' frame in S frame.

Faraday's Law

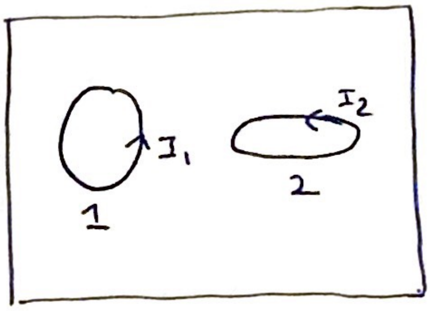
$$\mathcal{E} = \int f \cdot dl = \int \vec{v} \times \vec{B} \cdot dl \Big/ \int \vec{E} \cdot d\vec{l}$$

for a loop,

$$\mathcal{E} = -\frac{\partial \Phi}{\partial t} = -\frac{\partial}{\partial t}\left(\int_S \vec{B} \cdot d\vec{a}\right)$$

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \quad \left(\text{analogous to } \vec{\nabla} \times \vec{B} = \mu_0 \vec{J}\right)$$

Inductance

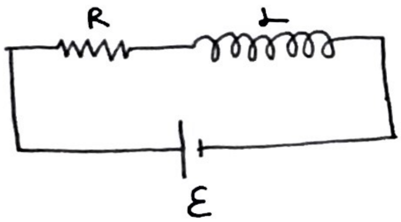


$$\Phi_{12} = M_{12} I_2 \quad , \quad \Phi_{21} = M_{21} I_1$$

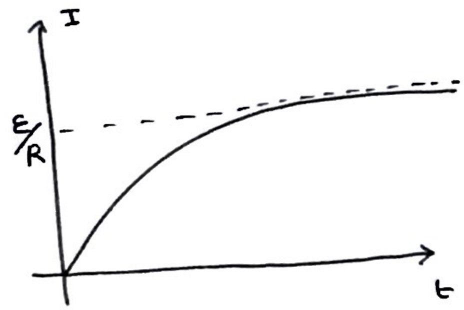
$\llcorner$ flux in 1 due to current in 2

$$M_{12} = M_{21}$$

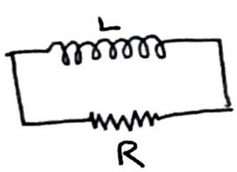
RL Circuit Charging



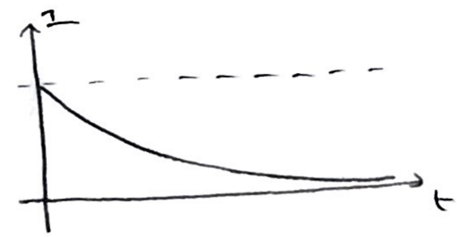
$$I = \mathcal{E}/R \left(1 - e^{-Rt/L}\right)$$



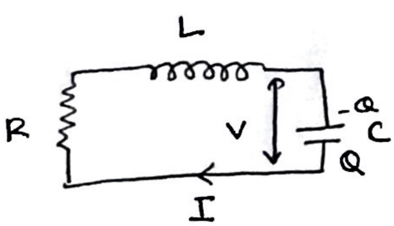
RL Circuit Discharging (where L has I_0 initially flowing in it)



$$I = I_0 e^{-Rt/L}$$



RLC Circuit (Undriven)



$$\cancel{Q = Q_0 e^{-Rt/2L}}$$

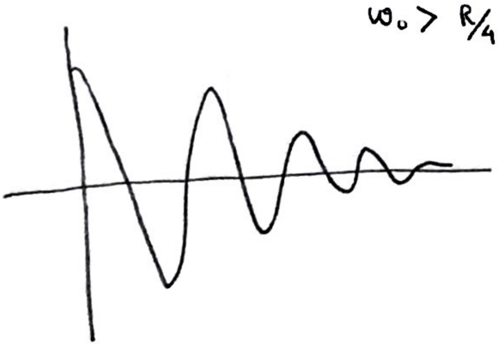
$$Q = Q_0 e^{-Rt/2L} \cos(\omega t + \phi)$$

where $\omega = \sqrt{\omega_0^2 - \frac{R^2}{4L^2}}$

$\omega_0 = 1/\sqrt{LC}$ ← natural or resnant frequency.

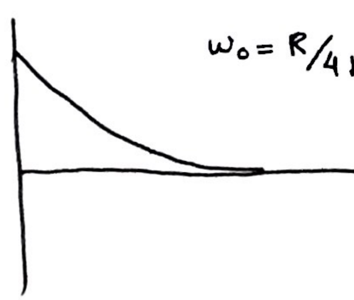
Underdamped

$\omega_0 > R/4L$



Critically Damped

$\omega_0 = R/4L$



Overdamped

$\omega_0 < R/4L$