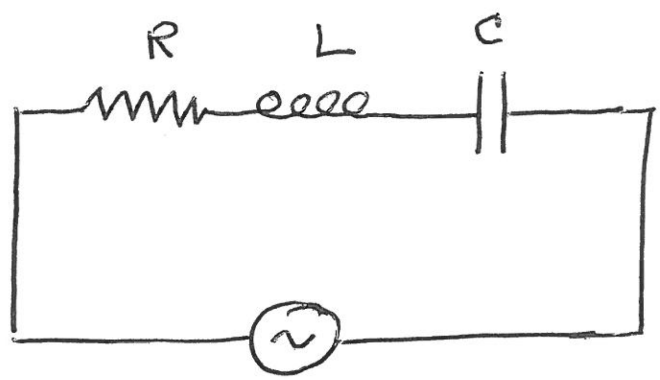
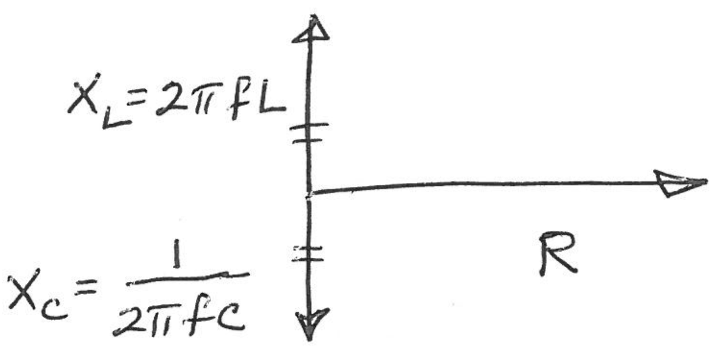
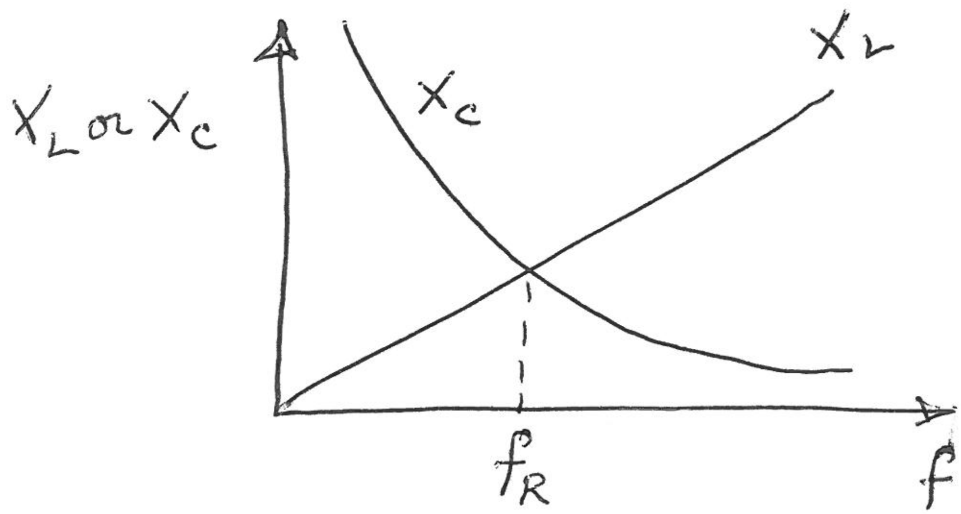
Physics 264 - Lecture 4

Resonant Circuit







$$X_L = X_C$$

$$2\pi f_R L = \frac{1}{2\pi f_R C}$$

$$f_R = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$

$$Z = \sqrt{(\underbrace{X_L - X_C}_{=0})^2 + R^2}$$

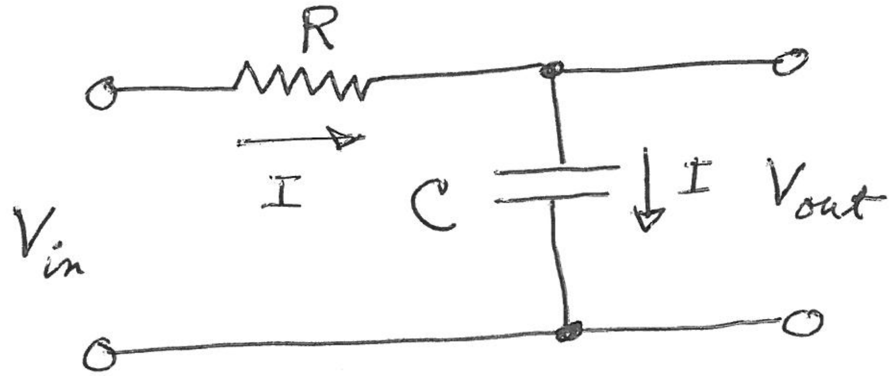
$Z = R$ at resonance

$$\theta = \tan^{-1}\left(\frac{\overbrace{X_L - X_C}^{=0}}{R}\right)$$

$$\boxed{\theta = 0^\circ}$$

Filters

$$X_c = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$



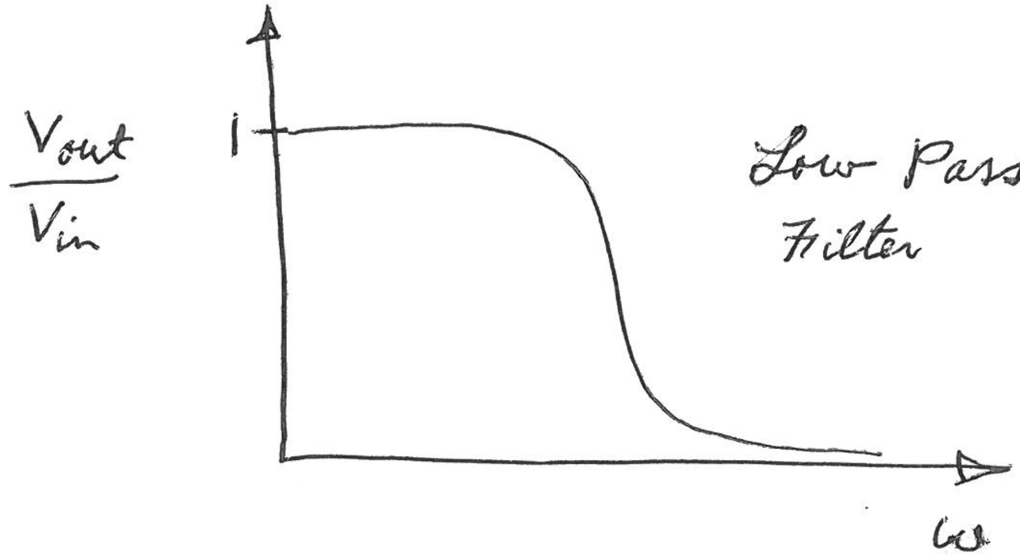
Low Pass

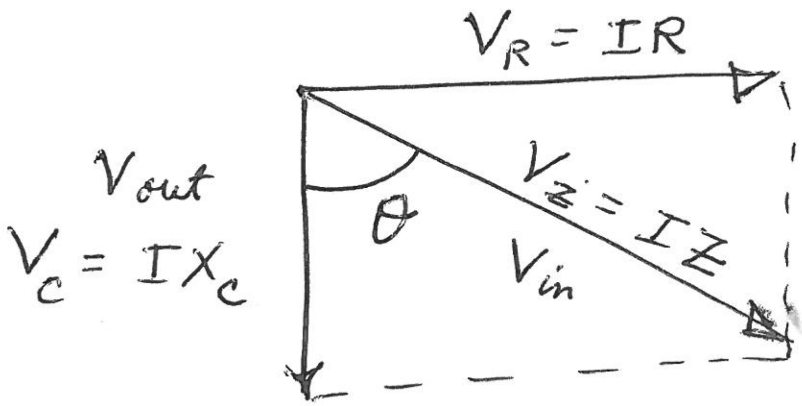
$$\frac{V_{out}}{V_{in}} = \frac{\cancel{I} X_c}{\cancel{I} Z} = \frac{X_c}{\sqrt{X_c^2 + R^2}}$$

$$\frac{V_{out}}{V_{in}} = \frac{1}{\sqrt{1 + \left(\frac{R}{X_c}\right)^2}} = \frac{1}{\sqrt{1 + \omega^2 R^2 C^2}}$$

$\omega \to 0 \qquad \frac{V_{out}}{V_{in}} = 1$

$\omega \to \infty \qquad \frac{V_{out}}{V_{in}} = 0$

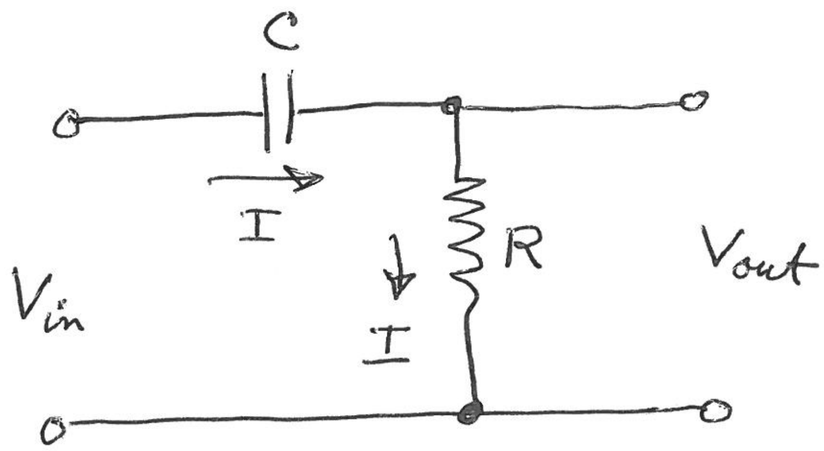




$$X_c = \frac{1}{2\pi f C}$$

$$\theta = \tan^{-1}\left(\frac{\cancel{I}R}{\cancel{I}X_c}\right)$$

$$\theta = \tan^{-1}(2\pi f RC)$$



High Pass

$$\frac{V_{out}}{V_{in}} = \frac{\cancel{I}R}{\cancel{I}Z} = \frac{R}{\sqrt{R^2 + X_C^2}}$$

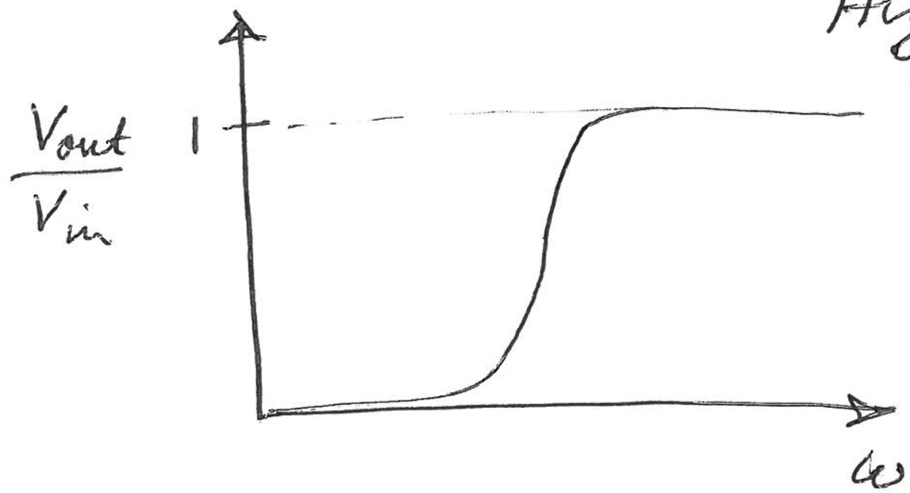
$$\frac{V_{out}}{V_{in}} = \frac{1}{\sqrt{1 + \left(\frac{X_C}{R}\right)^2}} = \frac{1}{\sqrt{1 + \frac{1}{(2\pi f R C)^2}}}$$

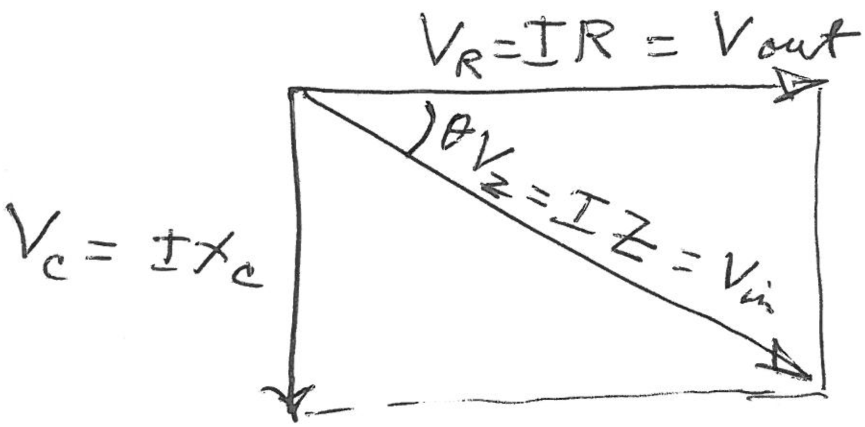
$$\frac{V_{out}}{V_{in}} = \frac{1}{\sqrt{1 + \frac{1}{\omega^2 R^2 C^2}}}$$

$\omega \to 0 \qquad \frac{V_{out}}{V_{in}} = 0$

$\omega \to \infty \qquad \frac{V_{out}}{V_{in}} = 1$

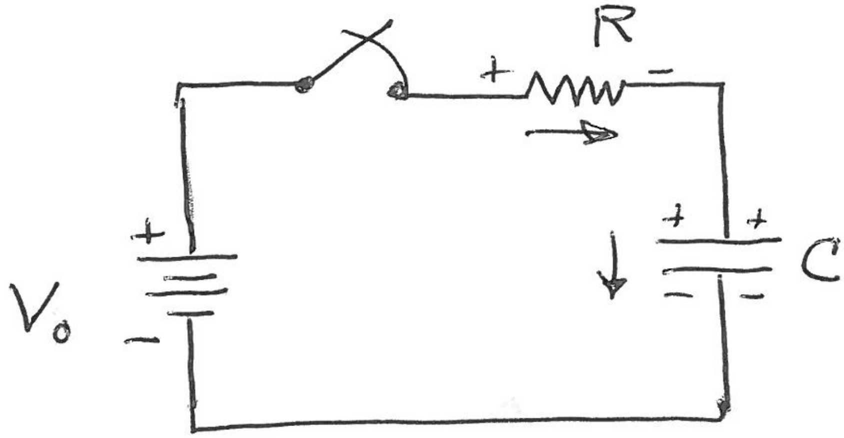
High Pass Filter

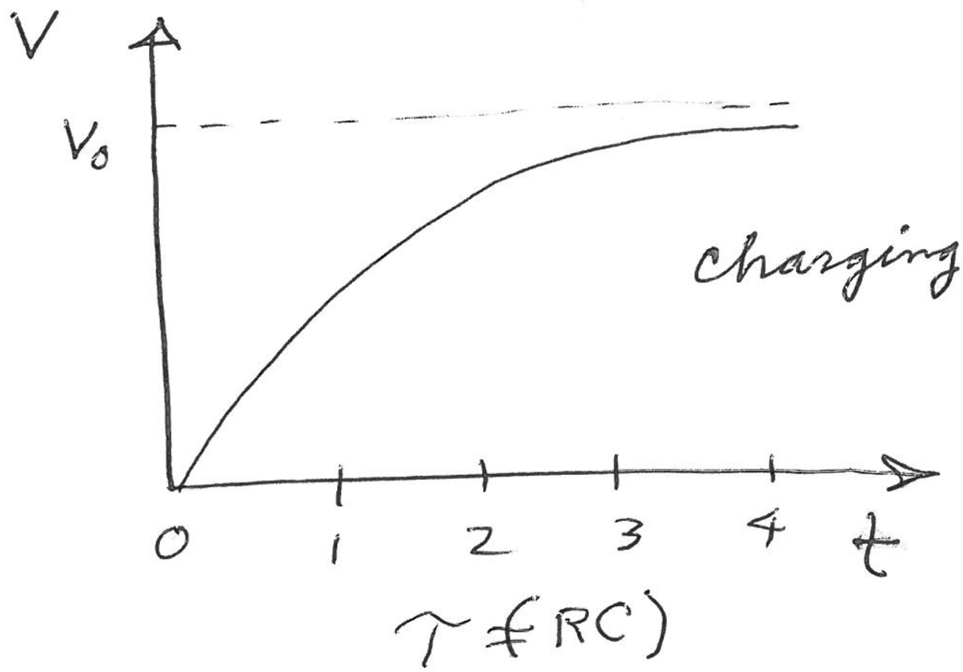




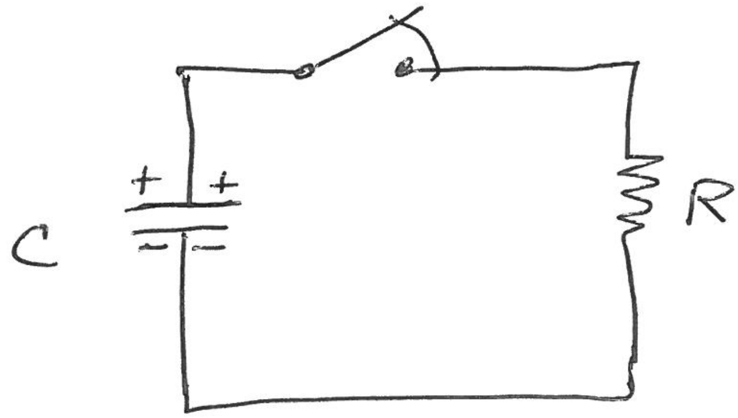
$$\theta = \tan^{-1}\left(\frac{\cancel{I}X_C}{\cancel{I}R}\right)$$

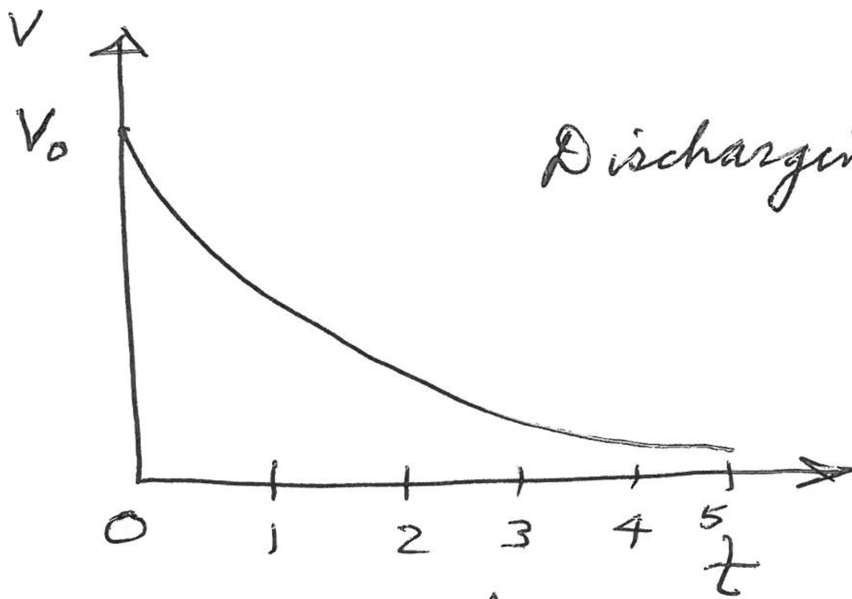
$$\theta = \tan^{-1}\left(\frac{1}{2\pi f RC}\right)$$





$$V = V_0 \left(1 - e^{-\frac{t}{RC}}\right)$$

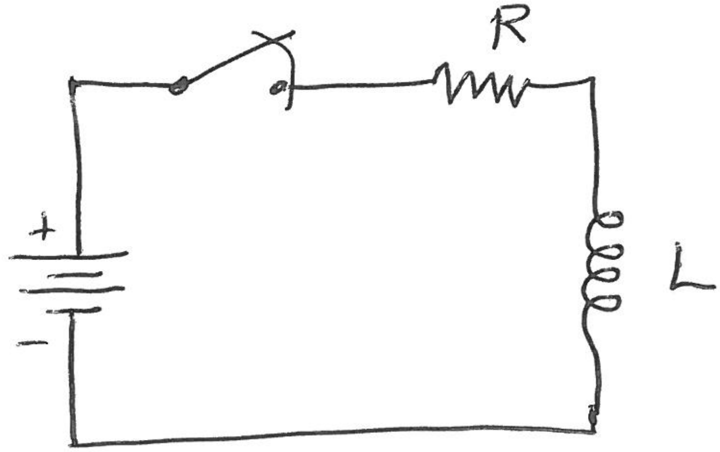


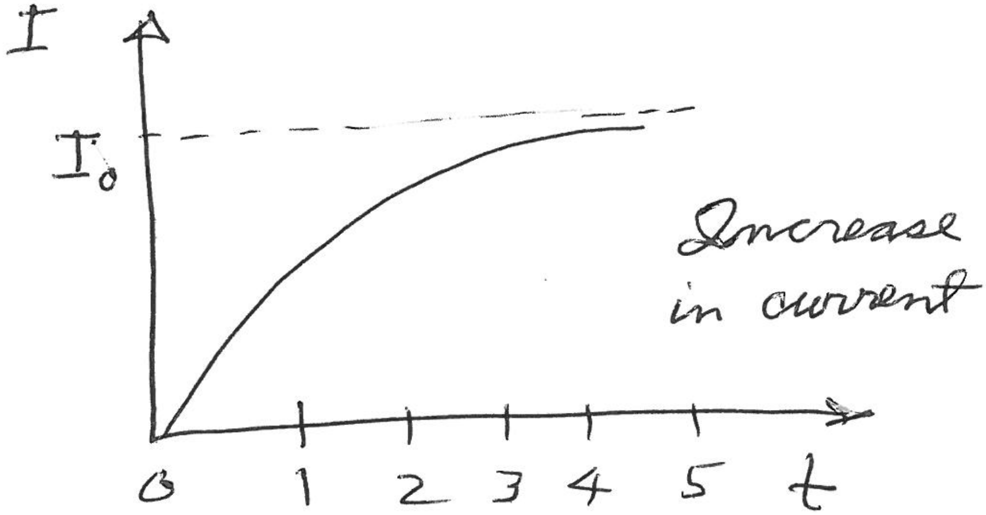


Discharging

$\tau = RC$

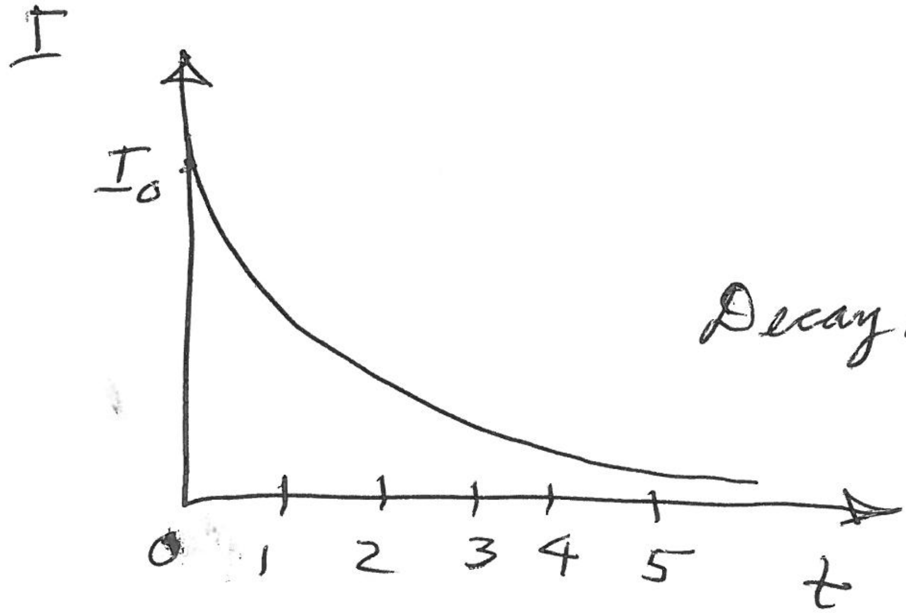
$$V = V_0 e^{-\frac{t}{RC}}$$





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

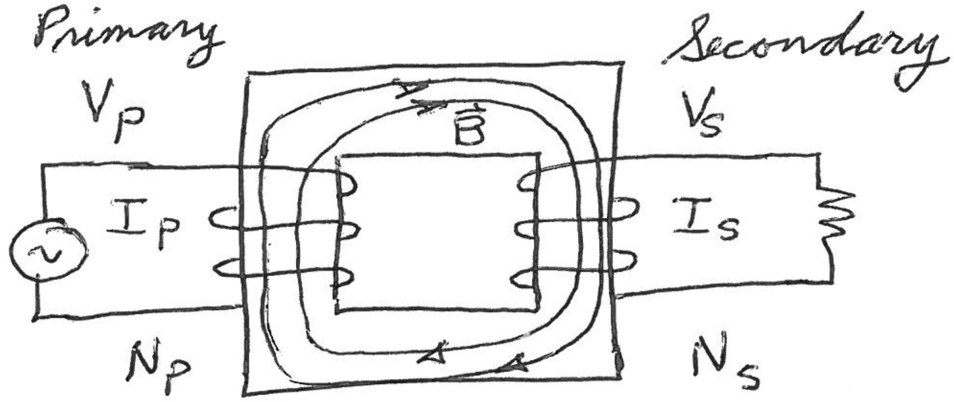
$$I = I_0\left(1 - e^{-\frac{t}{\left(\frac{L}{R}\right)}}\right)$$



Decay of current

$$I = I_0 \, e^{-\frac{t}{\left(\frac{L}{R}\right)}}$$

Transformers



$$\frac{V_p = N_p \cancel{\frac{d\phi}{dt}}}{V_s = N_s \cancel{\frac{d\phi}{dt}}}$$

$\frac{d\phi}{dt}$ = flux change

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{\text{number of turns Primary}}{\text{number of turns Secondary}}$$

$$\text{Power} = V_p I_p = V_s I_s$$

$$\frac{V_p}{V_s} = \frac{I_s}{I_p}$$