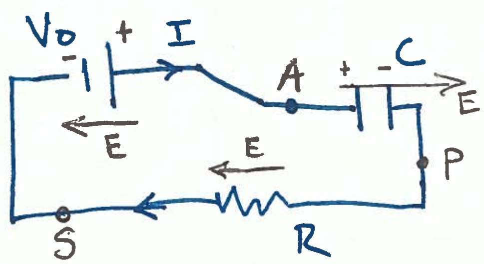
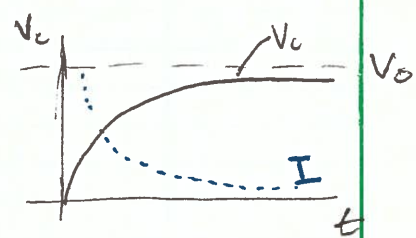
RC Circuits



$V_C = V_A - V_P$

$V_R = V_P - V_S = IR$



__Capacitor__

at $t=0$ no charge on capacitor, $V_c = 0$

at $t>0$, $V_c \uparrow$, $I \downarrow$

as $t \to \infty$, cap is fully charged $V_c \to V_0$, $I = 0$

Now, $\oint \vec{E} \cdot d\vec{l} = 0$ (was not true w/ inductor)

__Kirchoff:__

$$+V_c + IR - V_0 = 0$$

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

$V_c = Q/C$

$$\boxed{\frac{Q}{C} + \frac{dQ}{dt} R - V_0 = 0}$$

__Sol'n:__ $Q = V_0 C (1 - e^{-t/RC})$

$$I = \frac{V_0}{R} e^{-t/RC}$$

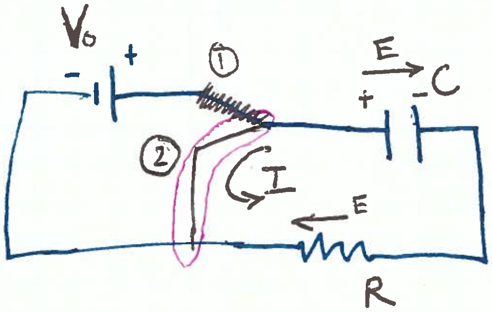
$$V_c = \frac{Q}{C} = V_0 (1 - e^{-t/RC})$$

__Table:__

t	I	V_c
0	V_0/R	0
∞	0	V_0
RC	$\frac{1}{e}\frac{V_0}{R}$	$(1-\frac{1}{e})V_0$

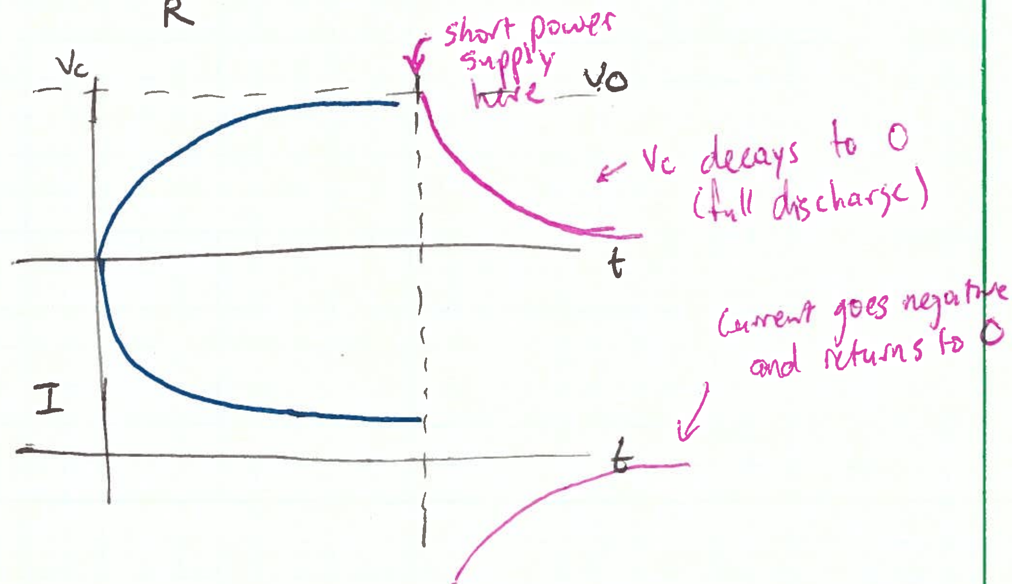
R	C	RC
1Ω	1mF	1ms
100MΩ	1mF	10^5 s

Add to previous circuit...



Capacitor is charged, now short power supply, now capacitor is discharging and resistor dissipates energy as heat (I^2R ... power)

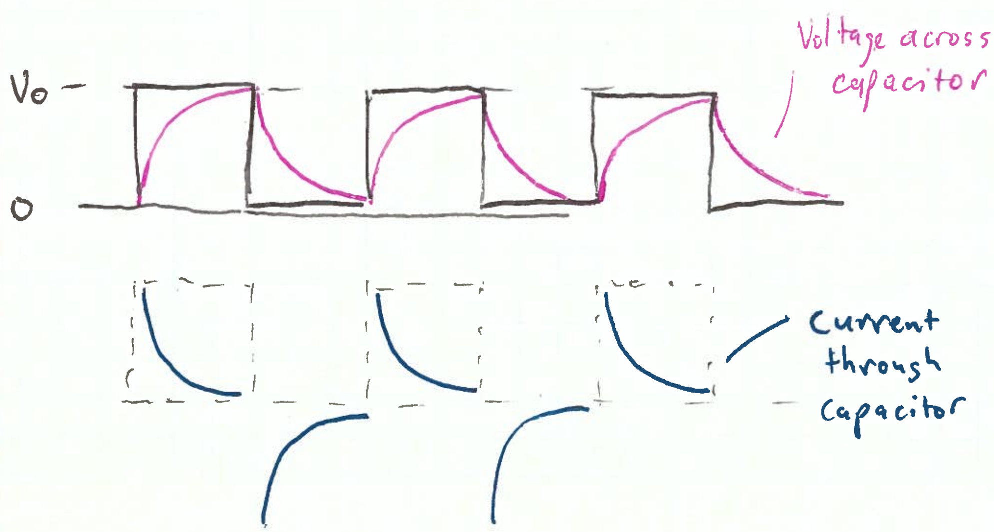
We can modify our figure

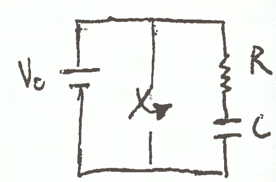


DEMO

Flip switch from position 1 (charge capacitor) to position 2 (discharge capacitor, short power supply). $V_0 = 1\,v$, $R = 6\,k\Omega$, $C = .1\,\mu F$

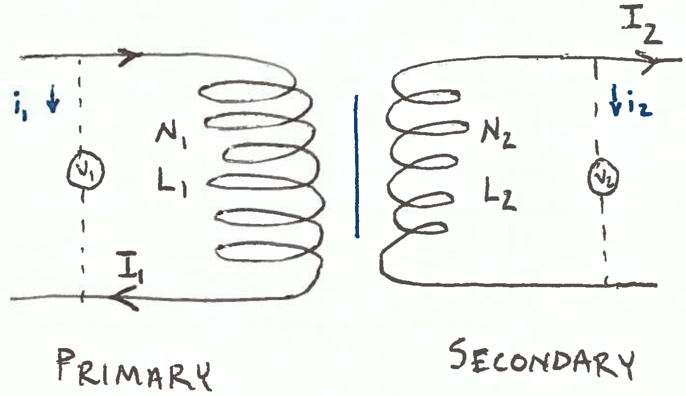
So $\underline{RC} = 6 \times 10^{-4}\,s = .6\,ms$





TRANSFORMERS

ALWAYS AC



FARADAY $\oint E \cdot dl = -\frac{d}{dt}\Phi_B$

$$0 - V_1 = -L_1 \frac{dI_1}{dt} = \mathcal{E}_1 = -N_1 \frac{d\phi_1}{dt}$$

$$0 + V_2 = -L_2 \frac{dI_2}{dt} = \mathcal{E}_2 = -N_2 \frac{d\phi_1}{dt}$$

$$\downarrow$$

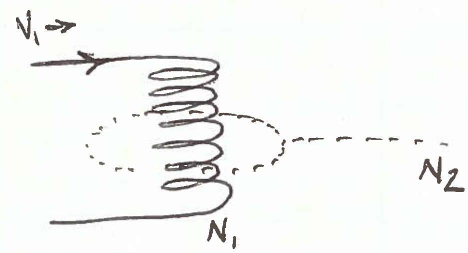
$$\left|\frac{V_2}{V_1}\right| = \frac{N_2}{N_1}$$

DEMO Transformer

$N_1 = 220$ $\quad N_2 = 1$

$V_1 = 110\,V$, $f = 60\,Hz$

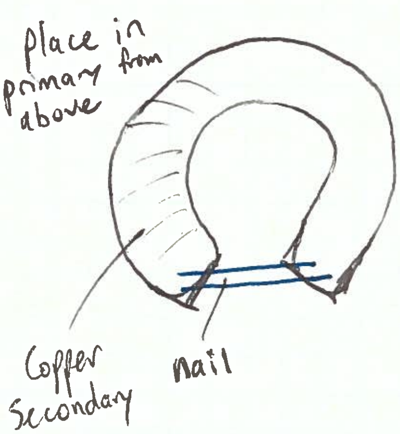
$\hookrightarrow V_1 = 110\sqrt{2}\cos(120\pi t)$



w/ $N_2 = 1$ we expect $V_2 = \sim \frac{110\,V}{220} = .5\,V$

$N_2 = 4$ we expect $V_2 = \frac{4}{220} \cdot 110 \approx 2\,V$

DEMO Transformer w/ huge secondary current $\left|\frac{I_2}{I_1}\right| = \frac{N_2}{N_1}$



$L_2 = 5 \times 10^{-7}\,H$

$R_2 = 4 \times 10^{-4}\,\Omega$

$I_1 = 20\,A$

$\downarrow$?

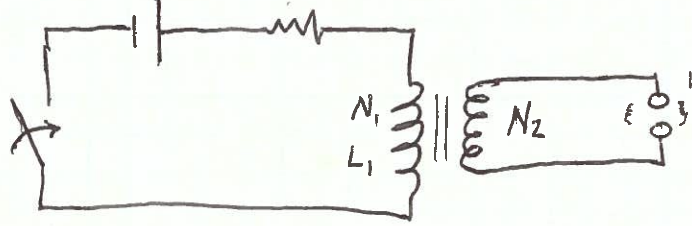
$I_2 = 220 \times 20 = 4400\,A$?

(probably not... $\omega L \simeq R$)

A lot of power through nail, it will glow red hot!

DEMO: Spark Plugs in Cars

$N_2 \gg N_1$



Time Constant: $\frac{L}{R}$

1. Close switch, build up current in loop
2. Open switch, current drops ~~immediately~~ quickly at L/R_{new}

$R_{new} \approx \infty$ (open)

So...

$\frac{dI_1}{dt}$ (really big when switch opened) → $\mathcal{E}_{ind\,1}$ (huge EMF)

$\frac{d\Phi_B}{dt}$ (huge change in magnetic flux couples to current)

$$\mathcal{E}_{ind_2} = \frac{N_2}{N_1}\mathcal{E}_{ind\,1}$$ ($\mathcal{E}_{ind_2}$ can be really big!)