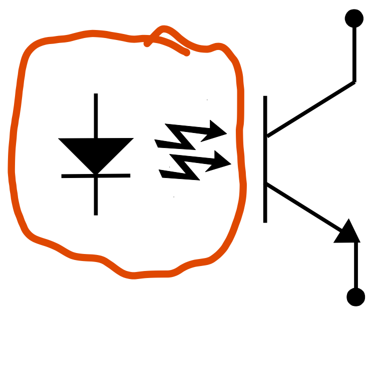
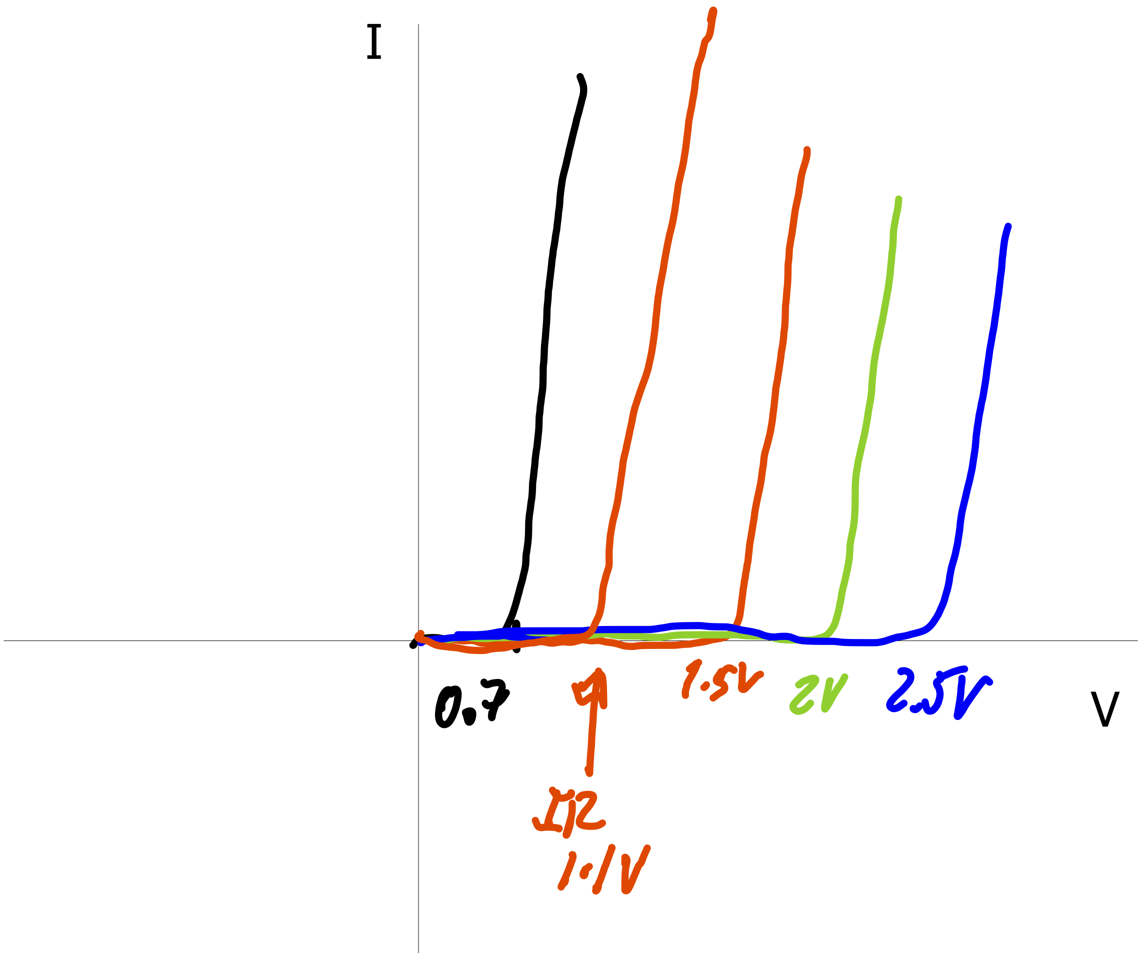
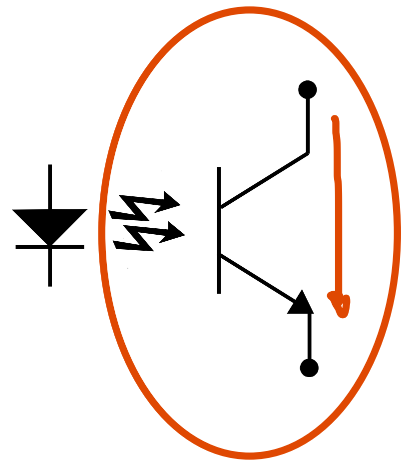
LED I-V CURVE





PHOTOTRANSISTOR I-V CURVE



TRANSIENTS

Transients occur everywhere!

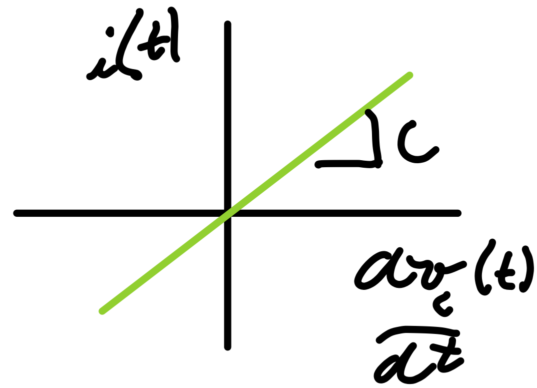
- Ice cube tray
- Car accelarating from red light
- Oven warmup
- Response to Federal Reserve Interest Change
- Acceptance of social change

They non-zero response times to instantaneous changes.

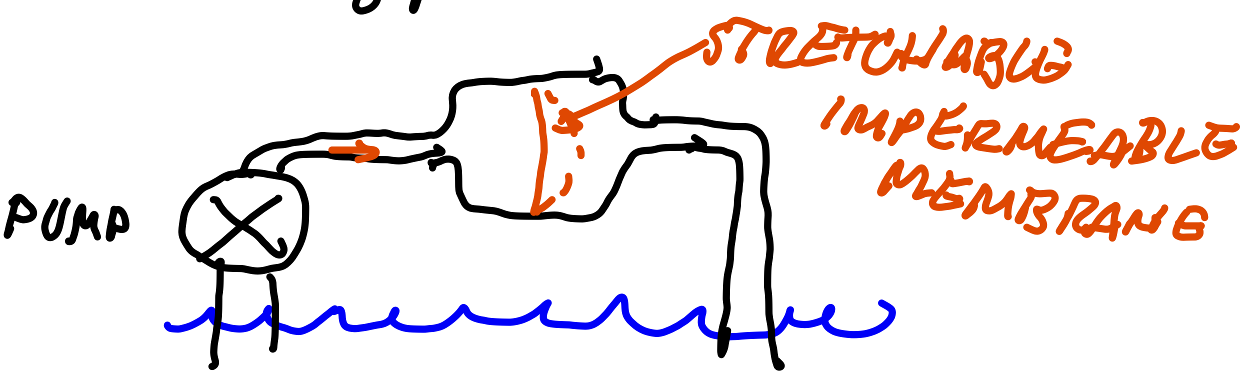
Systems with transients are called Dynamical Systems. They have dynamics.

CAPACITORS & INDUCTORS HAVE DYNAMICS

$$i(t) = C\,\frac{dv_c(t)}{dt}$$

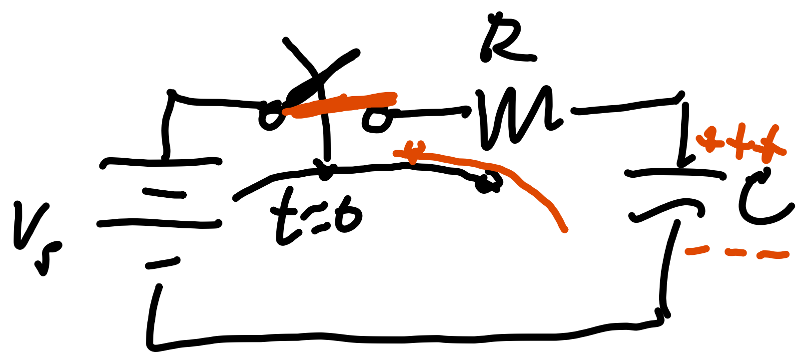


Water analogy:



Pump forces water into tank, causing membrane to stretch. Membrane tries to force water back out of tank.

ELECTRICAL VERSION OF WATER TANK MEMBRANE



$v_C(0^-)=0$

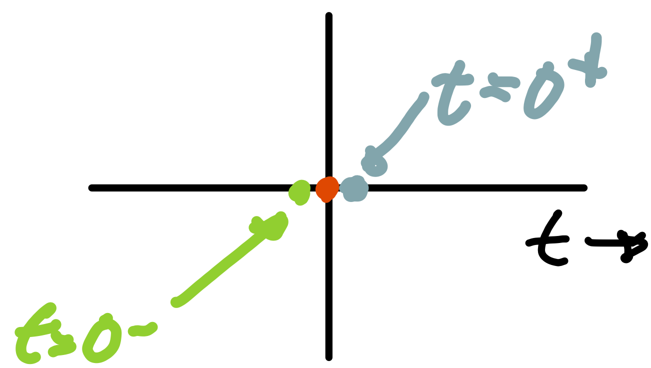
$Q=CV$

As $q\uparrow$, $v_C\uparrow$ & pushes harder on carriers to move clockwise.

When $v_C=V_s$, current stops.

CAPACITORS HATE CHANGE IN VOLTAGE

and will <u>cause</u> or <u>allow</u> any amount of current to prevent a change, at least for an infinitesimal amount of time.

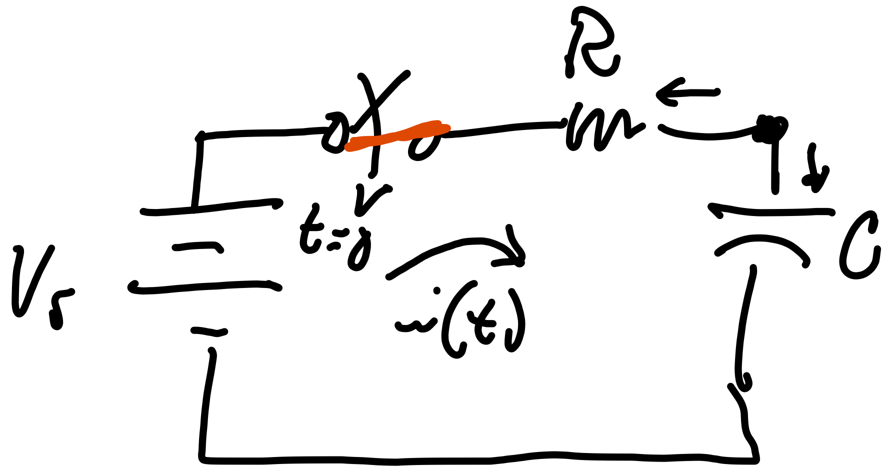


$t=0^-$ to $t=0^+$ is important!

$$i_C = C\frac{dv_c(t)}{dt}$$

For a step change in $v_c(t)$, the cap acts like a <u>short</u> OR an <u>ideal voltage source</u>, for an infinitesimal amount of time: Whatever is needed to prevent a change in v_c.

$$v_c(0^+) = v_c(0^-)$$



$v_c(0^-) = 0$

We want $v_c(t)$.

$$i_R(t) + i_c(t) = 0 \rightarrow \frac{v_R(t)}{R} + C\frac{dv_c(t)}{dt}$$

$$\frac{v_c - V_s}{R} + C\frac{dv_c(t)}{dt} = 0$$

$$\frac{dv_c}{dt} + \frac{1}{RC}v_c = \frac{V_s}{RC}$$

$$\frac{dv_c}{dt} + \frac{1}{RC} v_c = \frac{V_s}{RC} \qquad P = \frac{1}{RC} \qquad Q = \frac{V_s}{RC}$$

$$e^{\int_0^t P\,dx} = e^{\int_0^t \frac{1}{RC}\,dx} = e^{\frac{1}{RC}x\big|_0^t} = e^{t/RC}$$

$$\underbrace{e^{t/RC}\frac{dv_c}{dt} + \frac{1}{RC}e^{t/RC} v_c}_{} = e^{t/RC}\frac{V_s}{RC}$$

$$\frac{d}{dt}\left(v_c e^{t/RC}\right) = e^{t/RC}\frac{V_s}{RC}$$

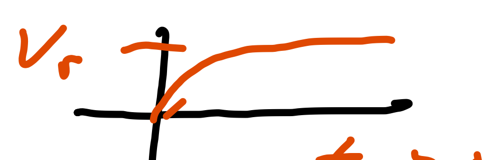
$$v_c e^{t/RC} = \frac{V_s}{RC}(RC)e^{t/RC} + C = V_s e^{t/RC} + C$$

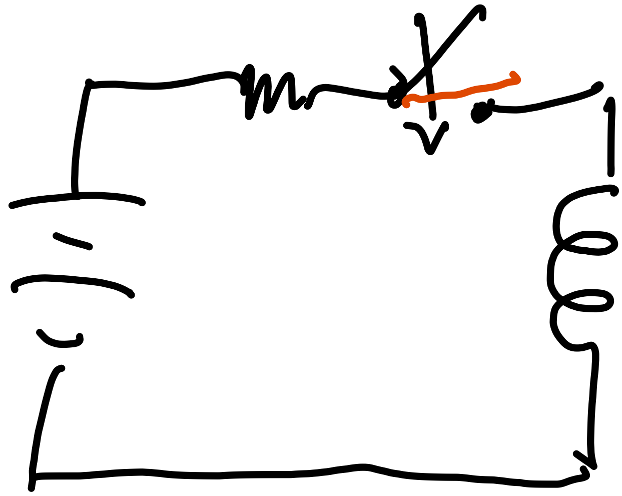
$$v_c = V_s + Ce^{-t/RC} \qquad v_c(0^-) = 0 \Rightarrow v_c(0^+) = 0$$

$$v_c(0^+) = V_s + Ce^0 = 0$$

$$C = -V_s$$

$$v_c(t) = V_s - V_s e^{-t/RC} = V_s\left(1 - e^{-t/RC}\right)$$





$i(0^-) = 0$

$$-V_s + iR + L\frac{di}{dt} = 0$$

TIME CONSTANT

The time it takes for $v_c(t)$ to complete 63.2% of its journey.

Symbol: τ (lower case tau)

$$1 - \frac{1}{e} = 0.632$$

$$1 - e^{-t/RC} = 1 - \frac{1}{e^{t/RC}}; \text{ if } t = RC, \; 1 - \frac{1}{e}$$

LONG TIME: 5τ (all transients have died out)