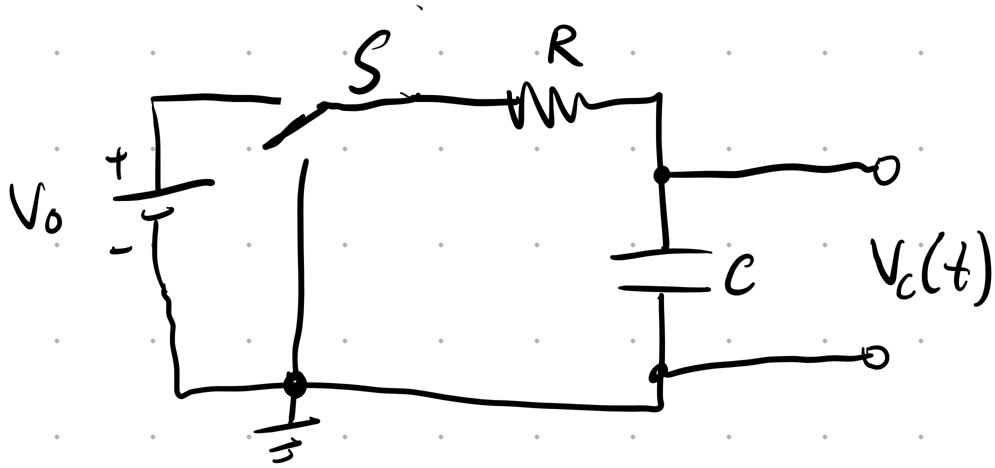
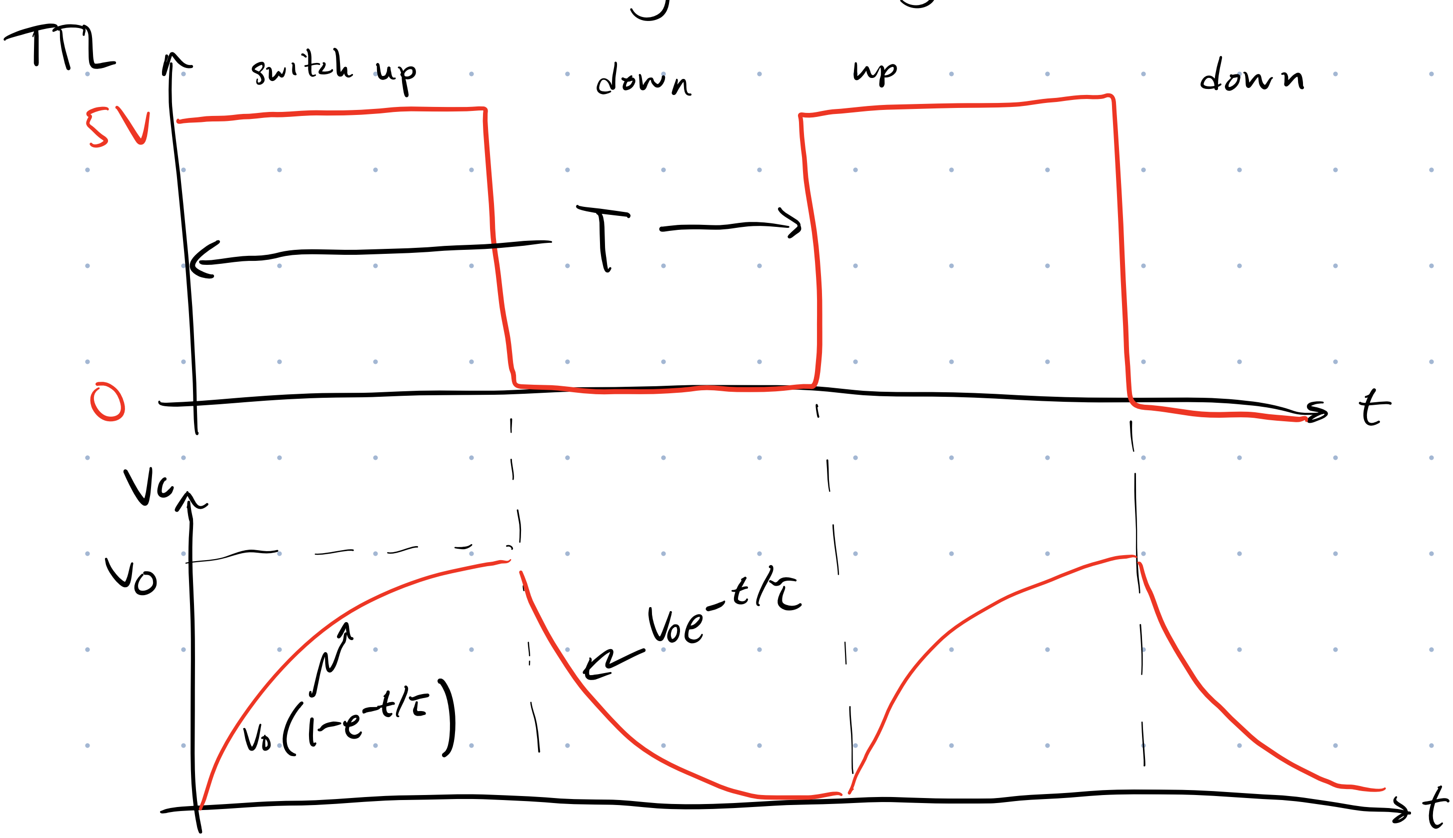
PHYS 231 Sept. 25, 2024

Lab #3 Preview



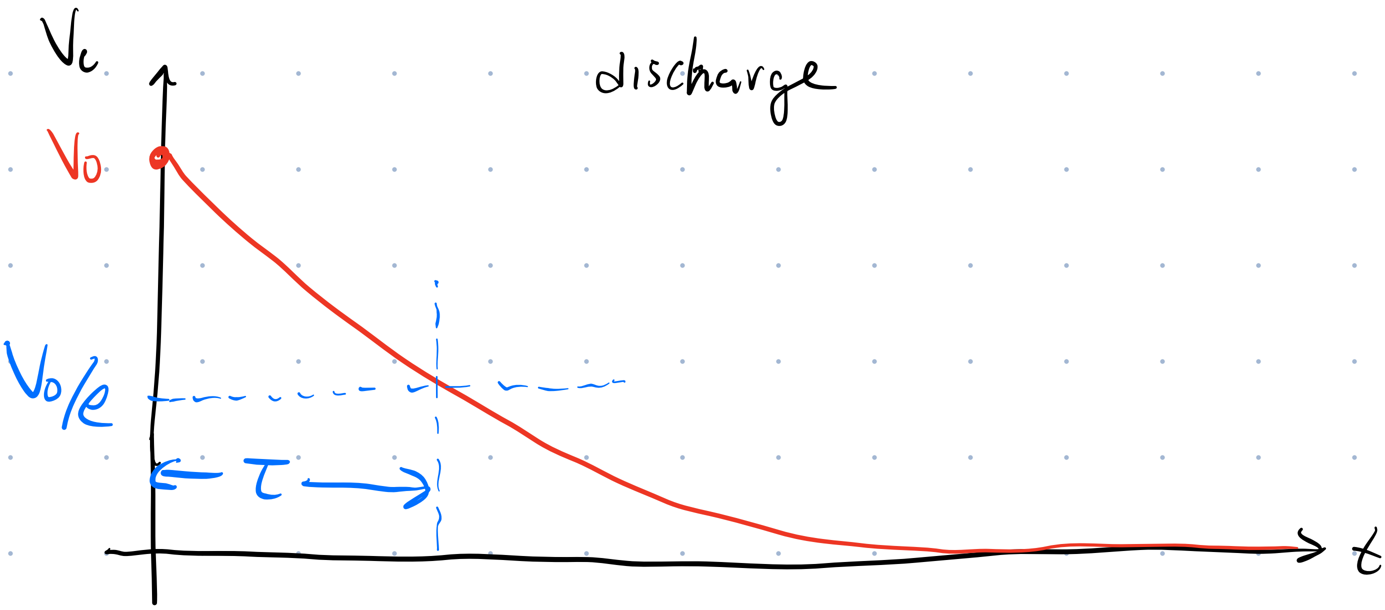
Use square wave TTL output of fcn generator to simulate openning & closing of switch.



In Lab #3, we focus on discharge of cap

$$V_c(t) = V_0 e^{-t/\tau}$$

Goal: Make a <u>quick</u> est. of τ.



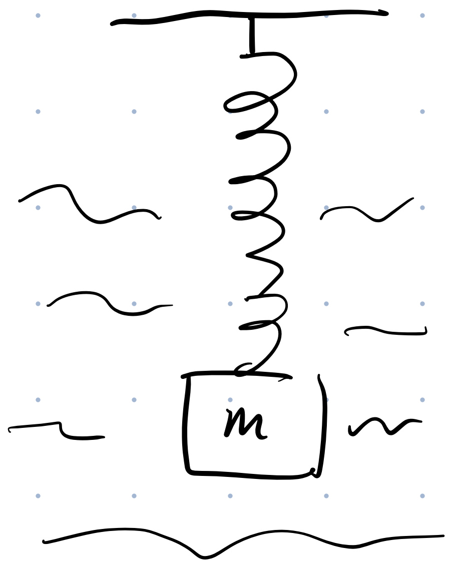
At time $t = \tau$ $\quad V_c(t=\tau) = V_0 e^{-\tau/\tau}$

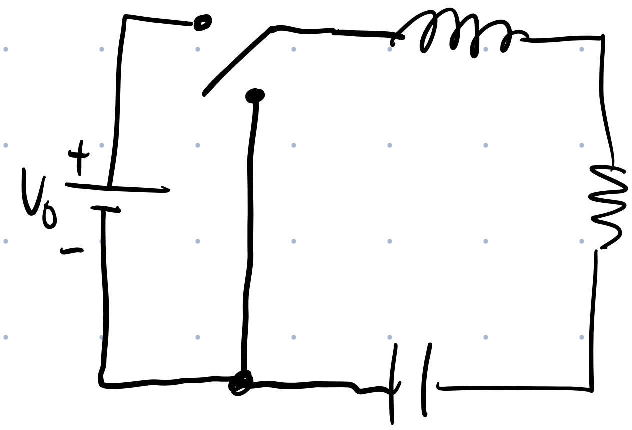
$$= \frac{V_0}{e} = 0.368\, V_0$$

1. Set up scope to observe discharge of cap.
2. Meas. V_0, the max voltage across cap.
3. Calc. and then find $V_0/e = 0.368\, V_0$
4. Est. $\tau \pm \Delta\tau$ by finding the time required

for cap to discharge from V_0 to V_0/e.

$$\tau = RC$$

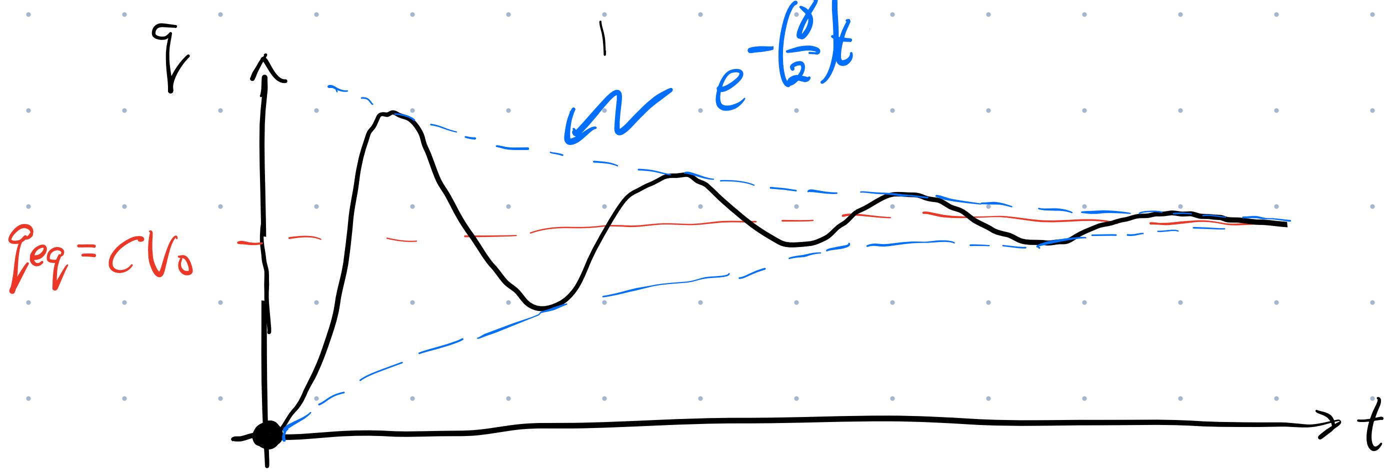




Previously found

$$g = \frac{d^2x}{dt^2} + \frac{b}{m}\frac{dx}{dt} + \frac{k}{m}x \qquad\qquad \frac{V_0}{L} = \frac{d^2q}{dt^2} + \frac{R}{L}\frac{dq}{dt} + \frac{q}{LC}$$

$$x_{eq} = \frac{mg}{k} \qquad\qquad q_{eq} = CV_0$$



If $q=0$ @ $t=0$ (initial condition), then for an underdamped LRC circuit (R small), the sol'n for charge on the cap. as a fcn of time is:

$$\boxed{q(t) = CV_0\left[1 - e^{-\left(\frac{\gamma}{2}\right)t}\cos(\omega_1 t)\right] \quad \text{where} \quad \gamma = \frac{R}{L} \quad \omega_1 = \sqrt{\omega_0^2 - \left(\frac{\gamma}{2}\right)^2} \quad \omega_0 = \frac{1}{\sqrt{LC}}}$$

In Lab #4, you will meas. the volt. across the resistor which is $V_R = IR$

Need to evaluate $I = \frac{dq}{dt}$

$$\therefore \frac{I}{CV_0} = +\frac{\gamma}{2}e^{-\left(\frac{\gamma}{2}\right)t}\cos(\omega_1 t) + \omega_1 e^{-\left(\frac{\gamma}{2}\right)t}\sin(\omega_1 t)$$

complicated!

For very underdamped circuits, R is small $\Rightarrow \gamma$ is small. $\therefore$ can ignore the first term in I compared the second term. Notice also that

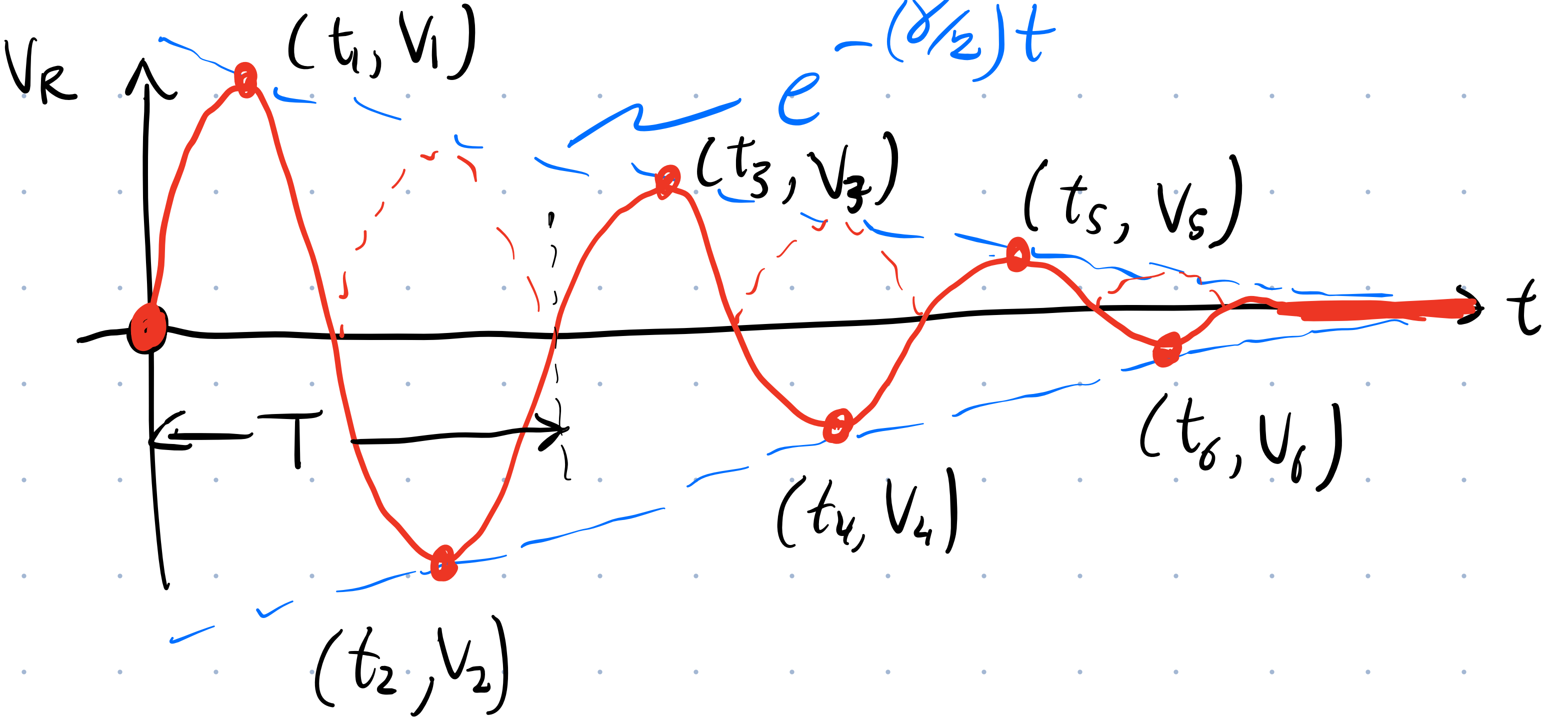
$$\omega_1 = \sqrt{\omega_0^2 - \left(\frac{\gamma}{2}\right)^2} \approx \omega_0 \quad \text{when } R, \gamma \text{ small.}$$

$$\boxed{I \approx \omega_0 C V_0 e^{-\left(\frac{\gamma}{2}\right)t} \sin(\omega_0 t) \quad \text{where } \gamma = \frac{R}{L} \quad \omega_0 = \frac{1}{\sqrt{LC}}}$$

$\therefore$ The voltage across the resistor is

$$\boxed{V_R = IR = \omega_0 R C V_0 e^{-\left(\frac{\gamma}{2}\right)t} \sin(\omega_0 t)}$$

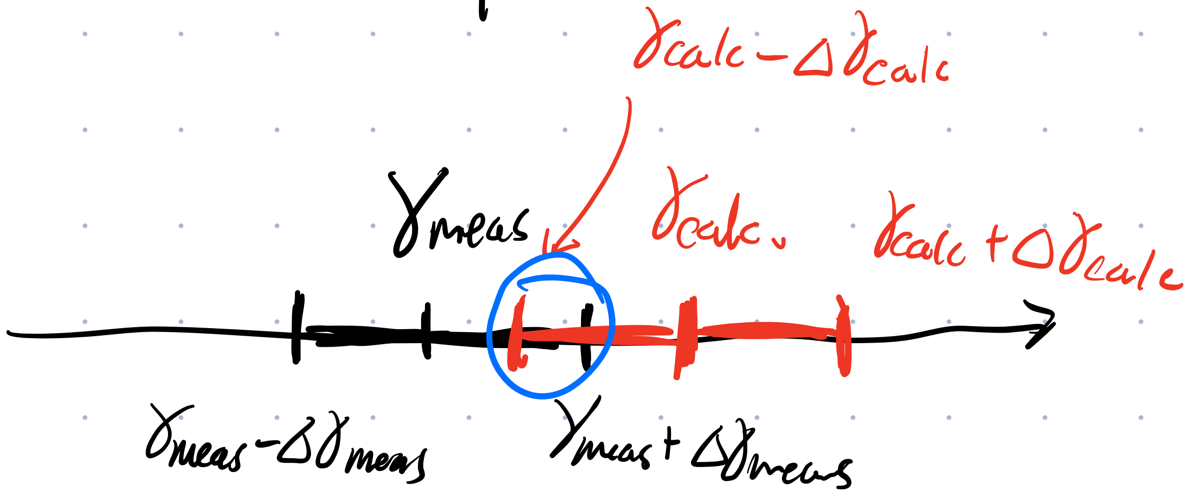
Lab #4 - day 1.



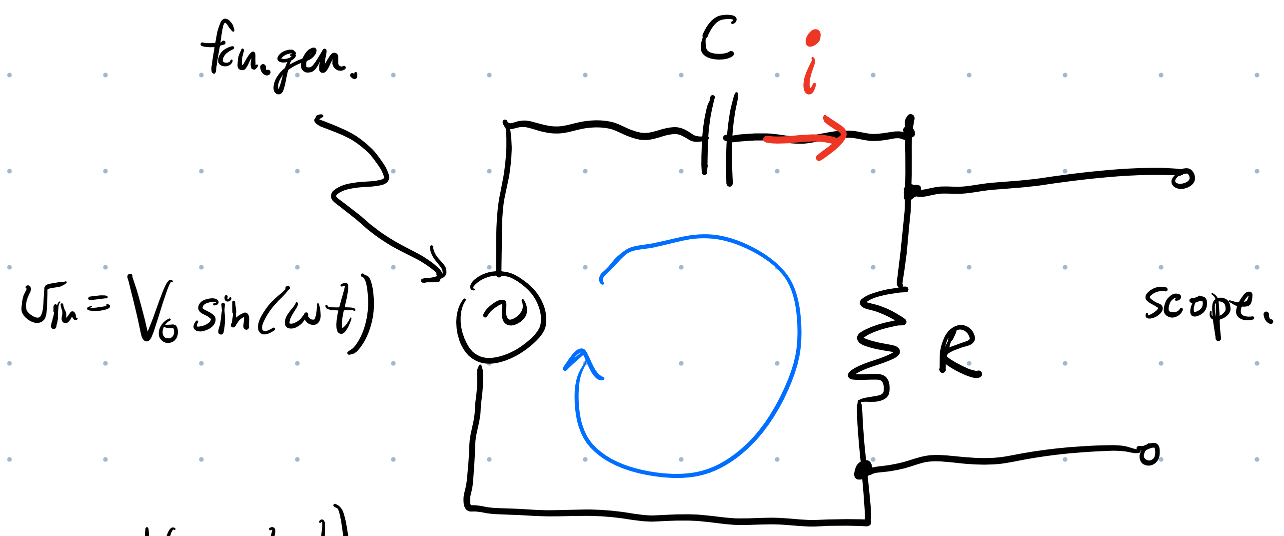
Plot of $|V_j|$ vs t_i → use the data to meas. γ

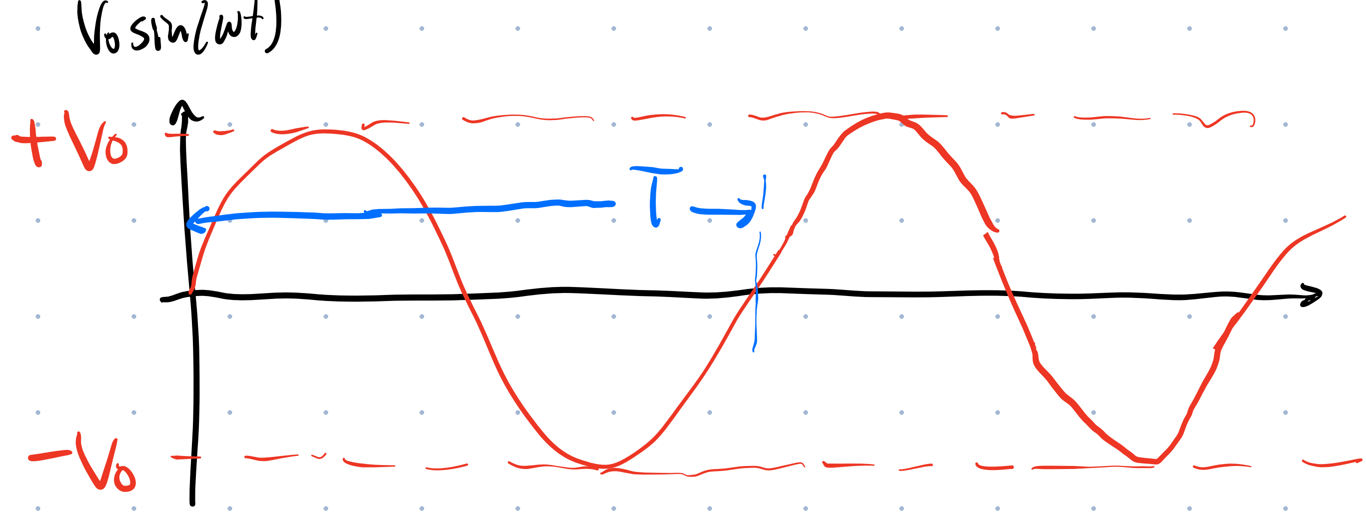
Meas. the peroid T

$$\omega_0 = \frac{2\pi}{T} \Rightarrow T = \frac{2\pi}{\omega_0} = 2\pi\sqrt{LC}$$



Next topic: Analysis of the freq. response of an RC circuit. i.e. how does i vary w/ freq.?





V_0 : amplitude

tune w/ fcn gen. $\begin{cases} T : \text{period / time to complete one full cycle.} \\ f : \quad f = \frac{1}{T} \text{ freq. (freq.)} \end{cases}$

ω : $2\pi f = \frac{2\pi}{T}$ (angular freq).

Observations from Part 4 of Lab #2.

- current osc. sinusoidally at same freq. as v_{in}
- current was out of phase w/ v_{in}
- the amplitude of current depends on ω.

Assume that the current in RC circuit is of the form:

$$i = \underbrace{I_0(\omega)}_{\text{freq. dependent amp.}} \sin\left[\omega t + \underbrace{\phi(\omega)}_{\text{freq. dep. phase.}}\right]$$

Goal is to find expressions for $I_0(\omega)$ & $\phi(\omega)$

KLR of series RC circuit:

$$v_{in} - \frac{q}{C} - iR = 0 \quad (*)$$

To make a diff. eq. in i, take deriv. of (A)

$$\frac{dv_{in}}{dt} - \frac{1}{C} i - R \frac{di}{dt} = 0$$

Solve for $i(t)$

$\vdots$