Objective
Observe more complex transient voltages present in RC, and RLC circuits.

Equipment and materials from stockroom:
- Wire kit

PARTS:
Many of these items have been used in previous labs.
- 100 Ω (brn,blk,brn), 2.2 kΩ (red,red,red), and 22 kΩ (red,red,org) resistors
- 0.22 µF (may be marked 224) capacitor
- 3 mH inductor

Experiment
General Setup
In this lab you will use two signal generators. The Krohn-Hite will produce a slow square wave that will trigger the Wavetek. The Wavetek will be set up to produce a much higher frequency sine wave which will be controlled by the slower square wave. This combination of signal generators will produce a switched sine wave. That is, a sine wave that turns on and off with the output of the Krohn-Hite. It will mimic the action of a switch that is alternately connected to a 10 Vpp sine wave source and ground.

Construct the RC circuit at right and setup the instruments as shown. Set the Krohn-Hite frequency to about 30 Hz and the Wavetek frequency to about 3 kHz. Connect the TTL output of the Krohn-Hite to TRIGger input of the Wavetek. Observe the output of the Wavetek with the scope CH2. It should look like a sine wave switched on and off 30 times per second. If you don’t see this, Make sure that the GEN MODE switch on the Wavetek is set to GATED, and try adjusting its center knob. If you still don’t see a switched sine wave, get help.
Set the Wavetek signal generator to produce a 10 Vpp output. This will be the input signal for all the circuits that follow. You will observe the output voltage of several different circuits and compare them to LaPlace transform calculations. WAIT! RELAX! Before vomiting on the lab bench at the prospect of making these calculations yourself, notice that I’ve made them for you. All you’ll have to do is confirm the transfer functions. The calculations are on the last three pages of this lab handout. Actually, this lab is primarily making observations, and you should be out of here soon.

**Series RC Circuit**
Set the scope to view CH1 and observe the transient. Compare what you see on the scope with the graph made from the LaPlace transform calculations for this circuit. It is quite possible that you don’t see exactly the right waveform. If the Wavetek is even slightly out of calibration there may be a completely different curving effect at the start. Find the TRIG START/STOP knob on the Wavetek. Switch it to VAR and adjust the center knob. You will find that a very small change to the input waveform results in big changes to the output. Adjust this knob until you get the waveform shown in the calculations.

Make some measurements to accurately compare the two waveforms. Good comparison measurements would be: The start and peak values of the very first wave, the time constant of the exponential decay, and the steady-state amplitude and DC values. Note: If you have trouble finding the exponential time constant from the calculated graph, try looking at the $v(t)$ equation. I think you can figure it out from that. You could also figure out the starting value (at $t=0$) and steady-state values from $v(t)...$ if you were ambitious. Another note: The amplitude of this particular waveform is quite small and even a very small DC offset from the Wavetek will show up as a large fraction of the output, i.e. your DC measurement may not be very close.

You have just looked at the transient that occurs when the sine wave starts (is switched in by the Krone-hite). Now I'd like you to see if there's an interesting transient that occurs when the sine wave is switched off. To see this, change the scope trigger slope (\_\_\_\_\_) or increase the TIME/DIV. You don’t have to do anything, just observe it. Return the scope trigger slope to the positive (\_\_\_) position if you changed it.

**Parallel RLC Circuit**
Make the circuit shown at right. Turn up the Wavetek’s frequency to about 6 kHz, and the Krohn-Hite’s to about 60 Hz. Fine adjust the Wavetek frequency to find resonance.

Adjust the the TRIG START/STOP knob a little to convince yourself that it doesn’t affect this circuit much, then switch the outside knob to 0°CAL.
Make some accurate comparisons between the measured and calculated waveforms like you did in the last section (start and peak values of the very first wave, the time constant, and the steady-state amplitude and DC values)

Change the scope trigger slope or decrease the TIME/DIV to see the circuit transient that occurs when the sine wave is turned off. Notice that the sine wave at the output doesn’t turn off abruptly like the input sine wave, instead it decays exponentially. Why? Think of an analogous mass-spring system which is vibrated at its natural frequency. Would the oscillations abruptly cease when the forcing vibration stopped? If fact, that same analogy can also be used to make sense of the starting transient.

Return the scope trigger slope to the positive position if you changed it. Vary the frequency of the Wavetek and observe the odd transients that you get when you’re not on resonance.

**Series RLC Circuit**

Construct the circuit shown at right. Turn up the Wavetek’s frequency to about 5 times the resonant frequency, or about 31 kHz. Observe the transients and make some accurate comparisons like you did in the last section.

**Conclude**

As always, check off your notebook.

Confirm that my three transfer functions are correct, that is, calculate them yourself. My transfer functions are all in the form:

\[ H(s) = \frac{V_o(s)}{V_i(s)} \]

I simply used the LaPlace impedances and voltage divider equations to find these.

Also comment on the abilities of LaPlace transform calculations in your conclusion.