This lab concerns the behavior of second-order *RLC* circuits.

**Part A**

1. Consider the *RLC* circuit of Fig. 1. Given that

\[ \omega_0 = \frac{1}{\sqrt{LC}} \]

and

\[ Q = \frac{\omega_0 L}{R}, \]

determine *R* and *C* such that \( \omega_0 = 10^5 \text{ rad/s} \) and \( Q = 2.5 \). Let \( L = 10 \text{ mH} \). Assume that the inductor has a parasitic resistance of 60 \( \Omega \), and remember that the signal source has a Thevenin resistance \( (R_s) \) of 50 \( \Omega \).
2. Build the circuit of Fig. 1 (using previous design values for $R$ and $C$), and let the signal source be a 5-V step. Observe $v_R(t)$, $v_L(t)$, and $v_C(t)$ with the oscilloscope. Sketch your results.

3. Measure $V_{n+1}$, $V_n$, and $\tau_1$ (see Appendix A), then calculate $\omega_0$, $\alpha$, and $Q$. Do the measured values for $\omega_0$ and $Q$ agree with your design?

3. Replace $R$ with a 10-kΩ potentiometer. Vary the potentiometer to observe all possible types of responses. Identify and sketch each type of response. Were you able to observe a lossless response? Why or why not?

**Part B**

1. Construct the circuit of Fig. 2 and let $v_s(t) = 5 \cos (1000\pi t)$.


3. Measure the phase angle of phasors $V_C$, $V_L$, and $I$ with respect to the (zero) phase angle of the signal source (see Appendix B).

4. Plot $|H(j\omega)| = |V_C/V_S|$ vs. $\log_{10} f$ over the range $f = 10$ to 100 kHz. To do this, measure the amplitude of $v_C(t)$ as you vary frequency over the desired frequency range. Be sure to obtain enough data for a smooth plot — 20 data points should be sufficient up to 100 kHz.
Part C

In your lab report...

1. Use PSpice to plot $v_C(t)$ for the circuit of Fig. 1 with a 5-V step input.

2. Plot $|H(j\omega)|$ (as previously defined) for the circuit of Fig 2. Let the input ($V_o$) be an ac voltage source with 1-V magnitude, then sweep over the range from 10 to 100 kHz with 50 points per decade.
For an under damped signal, as shown in the graph below, $\alpha$, $Q$, and $\omega_o$, can be determined using equations (10), (11), and (12) respectively.

\[
\frac{V_{n+1}}{V_n} = e^{-\alpha \tau_1}
\]

(10)

\[
Q = \sqrt{\frac{1}{4} + \left(\frac{\pi}{ln\left(\frac{V_n}{V_{n+1}}\right)}\right)^2}
\]

(11)

\[
\omega_o = \frac{(2\pi/\tau_1)}{\sqrt{\frac{1}{4} - \frac{1}{4Q^2}}}
\]

(12)
You can determine the phase angle from the oscilloscope using either one of two methods:

**Method 1:**
Using the X-Y mode of the oscilloscope, apply $v_1(t)$ to the X-axis, and $v_2(t)$ to the Y-axis. The resulting plot is called the Lissajous pattern.

**Method 2:**
Display both $v_1(t)$ and $v_2(t)$ using the oscilloscope CHOP mode.

The phase angle of $v_2$ w.r.t. $v_1$ is:

$$\theta = \sin^{-1}\left(\frac{A}{B}\right)$$

The phase angle of $V_2$ w.r.t. $V_1$ is: $\theta = \Delta t \left(\frac{2\pi}{\tau}\right)$, where $\tau$ is the period.