

RLC Circuits

Use the following PhET simulation to complete the experiment. Include this document, figures, and typed summary (Part 4) in your submission.

<https://phet.colorado.edu/en/simulation/circuit-construction-kit-ac-virtual-lab>

Part 1 – LC Circuit

1. Create a circuit with a battery and a capacitor in series to charge the capacitor. Right click the capacitor, click **Change Capacitance**, and note down the capacitance.
2. Press pause at the bottom of the screen and disconnect the battery and remove it from the simulation.
3. Connect an inductor in series with the capacitor. Right click the inductor, click **Change Inductance**, and write down the inductance. Press play arrow. Note any observations you see.
4. Click **Current Chart** and place the detector on a wire in the circuit between the capacitor and inductor. Adjust the y-axis using the +/- arrows so that you can see the full sinusoidal curve and maximum current. Note the maximum/minimum current. To your best ability write down the period between maximum peaks.
5. Using the inductance and capacitance values you write down calculate the resonant frequency $\omega_0 = 1 / \sqrt{LC}$. Convert the period you measured in #4 to an angular frequency $\omega = 2\pi / \text{Period}$. How do ω_0 and ω relate?
6. Click **Voltage Chart** and place the detectors on either side of the capacitor. Add a second chart on both sides of the inductor. Make sure the polarity of the detectors is consistent. Adjust the y-axis using the +/- arrows so that you can see the full sinusoidal curve and maximum voltage on each graph. Qualitatively note the similarities and differences between the curves. Note the maximum/minimum voltages. To your best ability write down the period between maximum peaks.
7. Screen grab your circuit and include the picture in your lab report. Save the circuit for your own records.

Part 2 – RLC Circuit

1. Create a circuit with an **AC Voltage** in series with a resistor, inductor, and capacitor. Note also the capacitance, inductance, and resistance as was done in Part 1.
2. Right click the AC Voltage and click **Change Voltage** and note the current value of the voltage. Click **Change Frequency** and note the current value of frequency.
3. Place **Voltage Chart** around each element in the circuit, include the AC Voltage. Make sure the polarity is consistent.
4. Mark the maximum/minimum voltage on each graph. Qualitatively note the similarities and differences between the graphs. Which graphs are in phase with one another? Which graphs are not? What about the sign of the amplitude?
5. Using the RMS voltages ($V_{\text{RMS}} = V_0 / \sqrt{2}$) show that the RMS voltage on the AC Voltage is consistent with the voltage sum of each element $V_{\text{RMS}} = \sqrt{[(V_{\text{RMS,R}})^2 + (V_{\text{RMS,L}} - V_{\text{RMS,C}})^2]}$.
6. Using the resistance, capacitance, inductance, and the frequency of the AC Voltage calculate the impedance Z.
7. Place a **Current Chart** after the battery in the circuit. Note the maximum value of the current. Using the RMS current show that the RMS voltage from the AC Voltage is consistent with the RMS current and impedance.

8. Change the frequency of the AC Voltage to the resonant frequency and click **Reset Dynamics**. Allow the simulation to run for at least one minute to adjust. Repeat steps #4-7. What similarities and differences do you see between the two tests.

9. Screen grab your circuit and include the picture in your lab report. Save the circuit for your own records.

Part 3 – Average Power

1. Create an RLC circuit with resonant frequency of your own choosing. Initially set the resistance to $10\ \Omega$. For at least 7 values of frequency fill out the table below. Make sure you have at least three points above, below, and including the resonant frequency. Note I_{RMS} and V_{RMS} are the values leaving the AC Voltage. Refer to your lecture notes on how to calculate average power.

R=10 [Ω]

f [Hz]	ω [rad/s]	Z [Ω]	I_{RMS} [A]	V_{RMS} [V]	P_{AVE} [W]

2. Using Microsoft Excel or Google Sheets make a graph of the average power (y-axis) versus ω (x-axis). Make sure the graph has axes labeled with units included. Save a copy of the graph and include it in your submission.
3. Repeat #1-2 now with $R=100\ \Omega$ and the circuit otherwise unchanged. Save a copy of the graph and include it in your submission.

R=100 [Ω]

f [Hz]	ω [rad/s]	Z [Ω]	I_{RMS} [A]	V_{RMS} [V]	P_{AVE} [W]

4. Compare the two graphs qualitatively. What role does the resistance play in an RLC circuit?

5. Screen grab your circuit and include the picture in your lab report. Save the circuit for your own records.

Part 4 – Reflection

Research at least one practical application of RLC circuits and write a short paragraph summarizing it. Include references.