

# PH102 Lab: ac Circuits

**GROUP MEMBER NAMES:**

**Prelab Questions:**

**Q1.** *At very low frequencies does the capacitor have a high or a low reactance?*

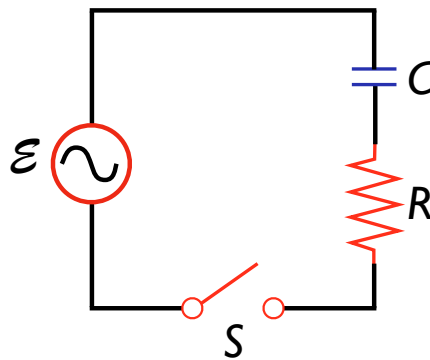
**Q2.** *At low frequencies, will the current through the capacitor be large or small?*

## Introduction

Now start up the “Circuits Tutorial” software and make sure the black “labjack” box is connected.

**Needed:** 4 “banana” wires, 1 capacitor 1 resistor 1 laboratory “black box”  
Your capacitor should be  $\sim 500\mu\text{F}$  or larger, your resistor 100-1500 Ohms.

In this experiment we will measure the phase shift of the response of a capacitor in an RC circuit when a time-varying signal is applied. This would allow us to determine the time constant of an RC circuit or design a signal filter. Figure 1 below shows the basic circuit we will consider.



**Figure 1:** A basic “RC” circuit

In the actual lab, the ac source is controlled by the software, including the value of  $E$  and its frequency. The voltage applied ( $E$ ) is given by:

$$V(t) = V_0 \sin(\omega t) + V_{\text{offset}}$$

$V_0$  can be chosen in the program (it corresponds to the peak voltage) and  $V_{\text{offset}}$  is automatically chosen such that the output is always positive for technical reasons ( $V_{\text{offset}} = V_0$ ). In other words, the “offset” voltage just shifts the sin wave up the y axis.

The actual output voltage then looks like this:

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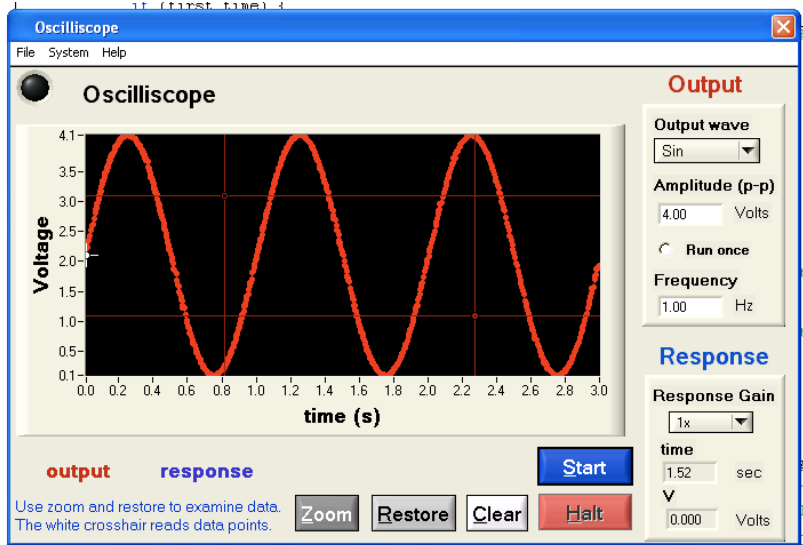
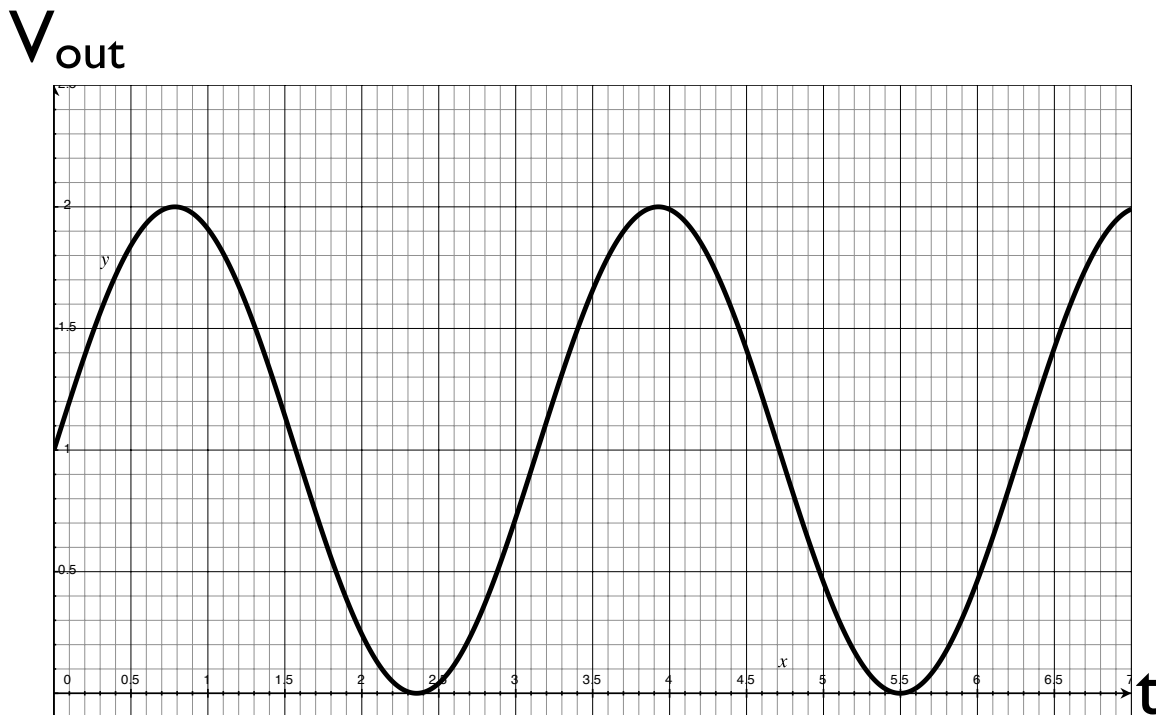


Figure 2: The waveform applied to your circuit

What you are going to verify is that in the above circuit, the voltage on the resistor and the voltage on the capacitor are *not* the same at any given time, but have a constant phase shift.

**Q3:** If the waveform above is applied to the R and C in series, on the plot below sketch the resulting voltages on the capacitor **and** resistor relative to  $V_{out}$ .



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## Part I: Voltage on the resistor

This laboratory uses the tutorial software and hardware you were introduced to previously.

- Connect your resistor and capacitor in series by stacking the “banana” plugs.
- Connect the free end of the resistor to the “+Vout” terminal on the black box, and the free end of the capacitor to “-Vout” to complete the circuit as shown. This is for applying a voltage to the R and C in series.
- Connect wires from “+Vin” and “-Vin” to either end of the **resistor**. Keep the polarity preserved, i.e., connect the “-Vin” to the same point that “-Vout” is connected. This is for measuring the voltage on the resistor..
- In the tutorial software, choose “Oscilloscope” from the “ac Circuits” menu.

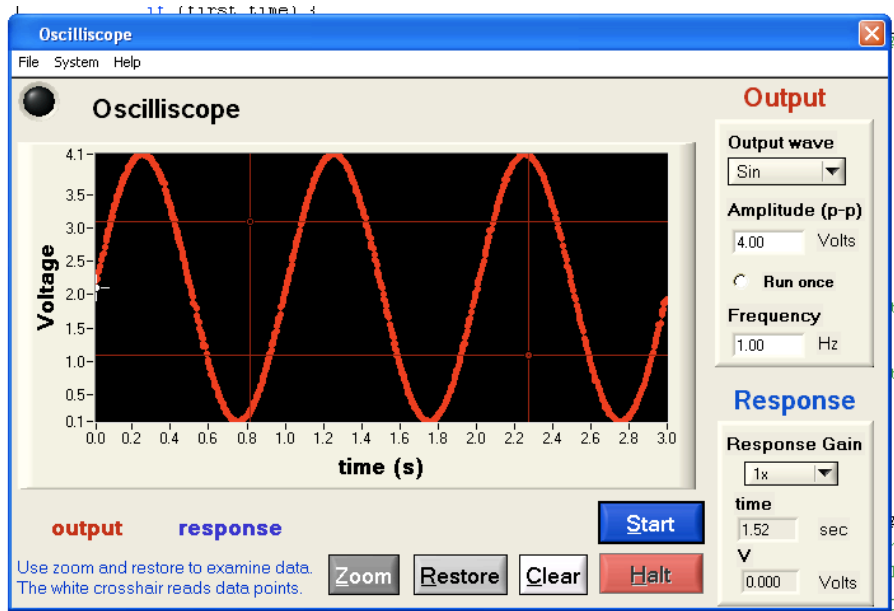


Figure 3: The oscilloscope panel.

e) We do not need to change most of the default settings. Keep the **frequency** at **1Hz**, and amplitude at 4V. When you run the scope the first time, it will trace out the waveform selected. After the first time, it will only update every three cycles until “Halt” is pressed.” The output is displayed in red, the response (measured on  $V_{in}$ ) is displayed in blue. Ignore the “bias current” option.

Run the scope a few times and explore its behavior. *If strange behavior results, be sure that under “settings” you have “ $V_{in}$  gain” set to 1.0.*

f) With  $V_{in}$  connected to the resistor, *you are measuring the response of the resistor to the ac voltage.*

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**Q4:** What is the relationship between the output and response for the resistor?

**Q5:** What is the phase shift of the resistor's voltage, relative to the output?

g) Have an instructor verify that your graph is OK and **INITIAL HERE** \_\_\_\_\_

### Part II: Voltage on the Capacitor

a) Now switch the "+Vin" and "-Vin" connections to measure the voltage on the **capacitor** instead of the resistor.

**Q6:** What is the phase shift of the voltage on the capacitor?

b) Try the other "Output Waves" (you do not need to try "none") and examine their behavior.

c) Have an instructor verify that your graph is OK and **INITIAL HERE** \_\_\_\_\_

**Q7:** When is the power delivered to the resistor maximum? ( $P = IV$ )

**Q8:** When is the power delivered to the capacitor maximum, relative to the output voltage?

**Q9:** What can you say about the sum of the resistor and capacitor voltages?

**Q10:** Why do the different waveforms give the response they do? (Hint: think about the slope of the waveform at any given time.) Briefly describe each in a couple of sentences. You may want to do this on another sheet of paper.

***Turn in a hard copy of your report. You do not need to print graphs.***