RC Circuit Activity

Purpose

Using an RC circuit, students will determine time constants by varying the resistance of the circuit and analyzing the exponential decay. After determining several time constants, the students will determine an experimental value of the capacitance using a time constant vs resistance scatter plot. In addition, students will review series and parallel combinations of resistors in the process of varying the resistance of the RC circuit.

Part I (30pts total)
Determining Time Constants

Before collecting data, it is recommended to review the list of hints that are located on the first page of the Data Sheet.

Log on to the computer and select the COSAM pool. Double click the 'phy-lab' icon on the desktop, and open the PASCO Capstone program. Under File, select Open Experiment, choose the file folder named "capstone-activities", and then select the *RC Circuit Activity*. After the file opens, there should be a graph of voltage vs time displayed.

Retrieve a power cord and a voltage sensor from the wire rack hanging on the wall in the lab room.

Connect the PASCO Power Amplifier to Port A and the Voltage Sensor to Port B. Use the power cord to plug the Power Amplifier into an AC outlet, and turn the Power Amplifier on.

The Power Amplifier has been set to the following conditions:

Wave Form	Amplitude (V)	Frequency (Hz)
Positive Square Wave	4.0	0.04

Build a RC circuit using a 330 µF capacitor and a 2000 Ω resistor. Connect the Voltage Sensor across the capacitor.
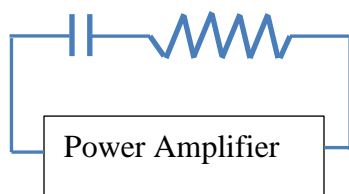
The Power Amplifier will supply a 4 volt amplitude positive square wave. If a complete cycle were observed, the voltage would be at 4 volts half of the time and at zero volts for the other half. When the square wave is at 4 volts, the capacitor will charge. When the square wave drops to zero volts, the capacitor will discharge.

Collect data by pressing the 'Record' button. The capacitor will begin to charge, and the charging curve should be displayed for approximately 12.5 seconds. After 12.5 seconds, the charging data will disappear, and

discharge data will be collected for 9.5 seconds. Capstone will automatically stop collecting data after 9.5 seconds of discharge data has been collected.

Open a Multi-Coordinates Tool by clicking on the ⊹ icon found in the graph's toolbar. Use the Multi-Coordinates Tool to determine the time it took the capacitor to drop from 100% charge to 36.8% charge. How is this time related to the time constant τ?

Fit the discharge curve with an appropriate fit and use the fit coefficients to determine the time constant τ. The fit coefficients need to be displayed to a minimum of 4 decimal places. The number of decimal places can be changed by right clicking within the fit box and selecting "Curve Fit Properties". Select "Numerical Properties" → "Coefficients" and change the "Number of Significant Figures" to 5. This process will need to be repeated for each curve's fit.

Complete the Data Sheet for Part I.

Part II (30pts total)
Experimentally Determining the Capacitance of the Capacitor

Resistance Values (Ω)					
Group A	Group B	Group C	Group D	Group E	Group F
560	560	560	560	560	560
719.1	719.1	876.4	876.4	719.1	876.4
1226.7	1000	1226.7	1000	1000	1000
1560	1560	1560	1437.5	1437.5	1560
2000	2359.0	2000	2000	2000	2359.0
3000	3000	3000	3000	3000	3000

The TA will assign each group a different set of resistances from the table above. Note that the resistance values in the table are based on nominal values. Use the assigned resistance values to vary the RC circuit and collect time constants for each circuit by fitting the discharge curve and using the appropriate fit coefficients as in Part I. Note that the resistances that are shown to one decimal place will require the 560Ω, 1000Ω, and 2000Ω resistors to be configured in a series/parallel combination to achieve these resistances. The group may build the circuit and request the TA to verify the total resistance for these series/parallel combinations with a multimeter.

After data has been collected for each RC Circuit, a τ vs resistance scatter plot should be created using Excel. Use the plot to determine the value of the capacitor.

Complete the Data Sheet for Part II.

Part III (40pts total)
Determining the value of an Unknown Resistor

After the TA has verified that you have used a method to correctly determine the value of the capacitor, the TA will give you an unknown resistor. The goal of the group is to experimentally determine the value of the resistor using the RC circuit.

After completing Part III, return the power cord and voltage sensor to the appropriate wire rack located on the lab room wall.

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Name: _____   **Banner ID:** _____

Lab Group ID: _____   **Number of Lab Partners:** _____

Data Sheet

Hints:
1. The PASCO Power Amplifiers needs to be plugged in to an AC outlet.
2. Voltage sensors and Power cords can be found hanging in the lab room.
3. The fit coefficients for the τ vs resistance scatter plot must be displayed to a minimum of 7 decimal places.
4. Determine the actual values of the resistors using a multimeter, and use the actual values for the plot(s).
5. The τ vs resistance scatter plot should be utilized to determine the unknown resistor for Part III.

Part I (30pts total)

Time to drop from 100% charge to 36.8% of Charge (s)	
Time Constant τ (s) as determined from the time above	

Time Constant τ (s) as calculated from the fit.	

Explain which fit coefficient was used and how it was used to determine τ?

Time Constant τ (s) calculated from the nominal value of the capacitor and actual value of the resistor used for the circuit.	

Assuming the capacitor has a tolerance of +/- 20%, are the experimental values within reason?

Print the discharge curve and attach the data sheet.

Part II (30pts total)

Set of resistance values assigned to the group by the TA: A B C D E F

Capacitance as determined from the τ vs resistance scatter plot (μF)	

Assuming the capacitor has a tolerance of +/- 20%, is the experimental capacitance within reason?

The time constant data and resistance values should be tabulated in Excel and printed with the scatter plot. Attach the data and scatter plot to the Data Sheets.

Print the actual discharge curves from Capstone, and attach to the Data Sheet.

Part III (40pts total)

(A) Group's Predicted Value for the Resistor: _____

(B) Value of the Resistor as read by the TA with a Multimeter: _____

Percent Error = $\frac{|A-B|}{B}$ x 100% = _____

Percent Error	<=3%	<=4%	<=5%	<6%	<=7%	>7%
Points	40	35	30	25	20	15

Group Points for Prediction of the Unknown Resistor: _____