**General Physics eJournal 5**

**RC Time Constant**

**Instructions:**

Follow the Writeup and fill out the eJournal as you complete the lab activities. Submit your eJournal report by uploading the completed WORD or PDF document to our class Learninghub site. If the Learninghub site is down, email the completed report file directly to a lab TA.

**Preliminaries:**

* Title:
* Name(s):
* Date:
* Time In & Out:

**Plan:**

**Hypothesis**

Form hypotheses regarding the charging and discharging of capacitors through a resistor and the resulting time constant. Sketch the circuits you plan to use for both charging and discharging and insert them below.

*Insert images of your circuit diagram sketches*

**Experiment Outline**

Briefly describe your plan for testing your hypotheses.

**Equipment List**

* List
* Equipment
* Here

**Action:**

Describe the techniques used to collect data by responding to the bullet point questions:

* How did you measure resistance?
* How did you measure the battery voltage?
* How did you use your smartphone (or webcam) to record the voltages over time?
* How long did you record the charging voltages? …the discharging voltages?
* How did you obtain the time and voltage data for the charging/discharging experiments?
* What changes did you make to the circuit to convert it from a charging circuit to a discharging circuit?

*Insert labeled image of your apparatus*

**Results:**

Record the measured battery voltage, Vbattery, resistance, R, and capacitance, C, used in your RC charging and discharging circuits. Record each measurement in standard units (V, Ω, F).
Predict the time constant, τpred = RC, for the circuits.

**Table I: RC Circuit Parameters**

|  |  |  |  |
| --- | --- | --- | --- |
| **Vbattery (V)** | **R (Ω)** | **C (F)** | **τpred = RC (s)** |
|  |  |  |  |

Use the provided spreadsheet to record the times and voltages (in roughly 0.5V increments) for each experiment (charging and discharging). Then copy the data for each experiment from the time column, t, and the voltage column, V into Tables II and III.

**Table II: RC Charging Circuit Time and Voltage Data**

|  |  |
| --- | --- |
| **Time, t (s)** | **Capacitor Voltage, V (V)** |
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**Table III: RC Discharging Circuit Time and Voltage Data**

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| --- | --- |
| **Time, t (s)** | **Capacitor Voltage, V (V)** |
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**Analysis:**

**Charging Capacitor Analysis**

Scroll through the charging data and identify the time it took for the voltage to rise to 63.2% of the battery voltage, V0. Record this estimated time constant, τest, in Table IV. Copy the predicted time constant, τpred, from Table I, and calculate the percent difference between the two.

**Table IV: RC Charging Circuit Estimated Time Constant**

|  |  |  |
| --- | --- | --- |
| **τpred (s)** | **τest (s)** | **% Difference** |
|  |  |  |

Generate a plot of V (y-axis) vs. t (x-axis) for the charging data. Fit a natural exponential curve to the data and record the fit parameters, “a” and “c”.

*Insert graph of V vs t*

a = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ V

c = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 1/s

Record the battery voltage, V0, and predicted time constant, τpred, in Table V. Also record the modified fit parameters, “-a” and “1/c” from the V vs. t graph. Calculate the percent differences to compare “- a” with V0 and “1/c” with τpred.

**Table V: RC Charging Graph Parameters**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **V0 (V)** | **- a (V)** | **% Difference V0** | **τpred (s)** | **1/c (s)** | **% Difference τ** |
|  |  |  |  |  |  |

**Discharging Capacitor Analysis**

Scroll through the discharging data and identify the time it took for the voltage to fall to 36.8% of the initial capacitor voltage, V0. Record this estimated time constant, τest, in Table VI. Copy the predicted time constant, τpred, from Table I, and calculate the percent difference between the two.

**Table VI: RC Discharging Circuit Estimated Time Constant**

|  |  |  |
| --- | --- | --- |
| **τpred (s)** | **τest (s)** | **% Difference** |
|  |  |  |

Generate a plot of V (y-axis) vs. t (x-axis) for the discharging data. Fit a natural exponential curve to the data and record the fit parameters, “a” and “c”.

*Insert graph of V vs t*

a = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ V

c = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 1/s

Record the initial capacitor voltage, V0, and predicted time constant, τpred, in Table VII.
Also record “a” and “1/c” from the V vs. t graph. Calculate the percent differences to compare “a” with V0 and “1/c” with τpred.

**Table VII: RC Discharging Graph Parameters**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **V0 (V)** | **a (V)** | **% Difference V0** | **τpred (s)** | **1/c (s)** | **% Difference τ** |
|  |  |  |  |  |  |

Generate a plot of ln(V) (y-axis) vs. t (x-axis) for the discharging data. Apply a linear fit to the data and record the slope, m.

*Insert graph of ln(V) vs t*

slope = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 1/s

Record the predicted time constant, τpred, and 1/slope in Table VIII. Calculate the percent difference between the two.

**Table VIII: RC Discharging Graph Parameter Analysis**

|  |  |  |
| --- | --- | --- |
| **τpred (s)** | **1/slope (s)** | **% Difference** |
|  |  |  |

**Conclusion:**

Interpret your results in light of your hypothetical predictions. How well did your hypotheses agree with the measured results? Which method of analysis appears to be the most accurate – estimated time constant, plot of V vs. t, or plot of ln(V) vs. t? How might you improve this experiment or explore it further?