Name: ______________________________ Section: __________ Date: ______________

Datasheet - Exp 20: Exponentials and RC Circuits

Objective: To investigate an exponential curve by analysis of an RC circuit. Our RC circuit will be a resistor R and a capacitor C connected in parallel.

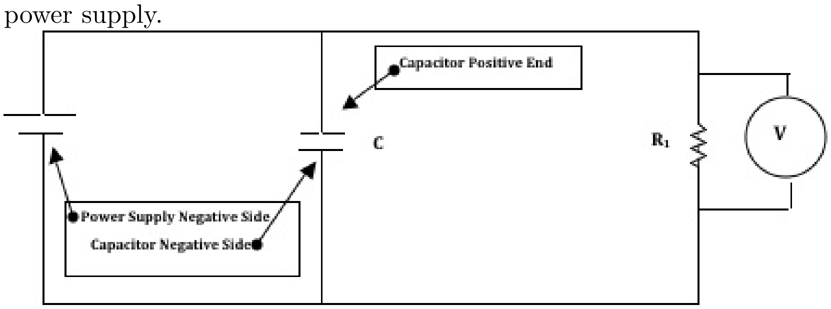
Theory: Any quantity whose rate of change is proportional to its own value will vary in an exponential fashion. We will model such processes by looking at the decay of charge in an RC circuit. In order to describe the speed of the decay, we look at how long it takes voltage in the circuit to drop to 1/e of its original value (about 37%)

This time is a called the *time constant*, τ, and for RC circuits it can be calculated as $\tau = RC$. If voltage continues to decay beyond this time, it will drop by another factor of 1/e (to about 14%) in the same time, and so on. Voltage across a discharging RC circuit is modeled as follows: $V(t) = V_0 e^{-t/(RC)}$

Part 1: RC Circuit

The capacitors are electrolytic. They must be connected with the negative end of the capacitor on the negative side of the power supply; failure to do so will damage the capacitor. Refer to the diagram below

1. Determine the nominal resistance of R_1. Then measure R_1 with the DMM. Record these in the table provided.
2. Measure the capacitance, C, of the capacitor using the DMM at the TA's table. ***Take care not to plug it in backwards - this will damage the capacitor***.
3. Construct the circuit shown below. Connect, but do not plug in, the power supply.



R_1 (nominal)	R_2 (nominal)
R_1 (measured)	R_2(measured)
Req_1	Req_2
Capacitance	Capacitance
τ_1 (calculated)	τ_2 (calculated)

4. Measuring voltage with a voltmeter changes the equivalent resistance of the circuit. To account for this, calculate $R_{eq}$of the resistor in parallel with the 10 MΩ voltmeter. Use the measured value of R_1. Show your work.

5. Calculate the value of the time constant, τ, using R_{eq} and C.

6. Ask your TA to approve the circuit. Plug in and turn on the power supply. Charge the capacitor by applying 10.0 V across the circuit.

7. Disconnect one power supply lead from the circuit. Take voltage measurements every five seconds for three minutes. [The voltage should drop to the mV range, requiring you to adjust the voltmeter scale twice. If voltage drops to zero, check your circuit.]
8. ***Repeat steps 2 through 8 for R_2.***
9. Disassemble the circuit. Turn off the DMM.

t(s)	V_1	V_2
0		
5		
10		
15		
20		
25		
30		
35		
40		
45		
50		
55		
60		
65		
70		
75		
80		
85		
90		
95		
100		
105		
110		
115		
120		
125		
130		
135		
140		
145		
150		
155		
160		
165		
170		
175		
180		

Part 2: Graphing

Obtain the theoretical value of τ from the previous table of the Exponentials and Oscilloscopes data sheet.

τ (calculated)	τ (graph)	% Difference

10. Graph V *vs.* t using Graphical Analysis. Analyze the curve using a natural exponent fit. Determine the time constant from your curve fit. Print the graph and staple it to the back of this worksheet.

Questions

11. Compare your two values of τ for each resistor by calculating their percent difference. Are they similar? What could cause these values to differ?
12. Show that RC has units of seconds; use Ohm's law and the definitions of capacitance and current.
13. If an RC circuit has $\tau = 5$ seconds, how long would it take for the circuit to discharge to $1/e^7$ its original value?