Lab - RC Circuits

AP Physics C – E&M

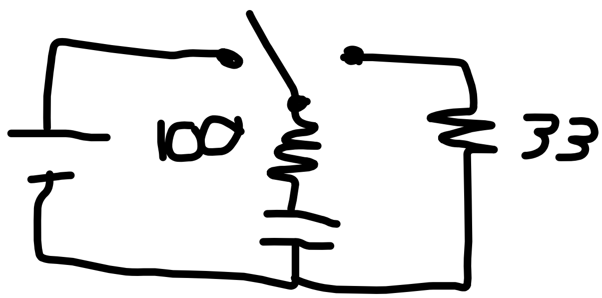
Objective: I can describe the current through an RC circuit as a function of time by calculating the time constant of an RC circuit.

In this lab, you will be connecting a resistor (or resistors) and a capacitor in a circuit with a battery (or both batteries together). Your goal is to analyze the effect of equivalent resistance on the time constant (and therefore the amount of time required to charge and discharge the capacitor) and also the emf voltage on the time it takes to charge and discharge the capacitor. You will want to compare the theoretical and experimental time constants for each circuit.

Pre-lab Questions

1. Detail an example of charging/discharging an RC circuit in real life.
2. Is it possible to fully charge/discharge a capacitor? How do you know?
3. Which quantities might affect the rate of charging/discharging? Justify your answers.

Procedure



1. Construct the circuit above.
2. Connect the Voltmeter in Capstone and drag a Graph display to the workspace. Set it to record Voltage and time.
3. Discharge the capacitor across your resistor.
4. Click “Record” in Capstone as you flip the switch to connect the 1.5 V battery and charge your capacitor.
5. Stop recording once the capacitor’s voltage remains approximately constant and fill out the first half of the data table. You can use the “Add Multi Coordinates tool” button in capstone to get accurate readings for voltage and time.

6. Add a “Natural Exponential” trendline to your graph in capstone and use the coefficient in the exponent to find your experimental time constant.
7. Click “Record” again, disconnecting the battery with the switch and discharging the capacitor. Fill out the remainder of the data table and use the Natural Exponential trendline once again to find your time constant.
8. Repeat the experiment but remove the 33 ohm resistor from your circuit.

Results and Discussion

Table 1. Voltage measurements through the capacitor as a function of time while charging and discharging (133 ohms while discharging).

Charging w/ 1.5 V, 100 Ω resistance							
Time (s)	13.55	14.15	14.7	15.8	17	19.35	1.426
Approximate Voltage (V)	0	0.903	1.007	1.148	1.248	1.354	24.9
Theoretical τ R*C (s): 22			**Experimental τ (s): 30**			**Percent difference: 36.4**	
Discharging w/ 1.5 V, 133 Ω resistance							
Time (s)	8.15	9.8	13.35	17.25	20.35	27.6	37.55
Voltage (V)	1.45	1.251	1.037	0.852	0.73	0.513	0.322
Theoretical τ (s): 29.26			**Experimental τ (s): 36**			**Percent difference:** 20%	

What the

Table 2. Voltage measurements through the capacitor as a function of time while charging and discharging with 100 ohms of resistance.

Charging w/ 1.5 V, 100 Ω resistance							
Time (s)	0.6	0.85	1.25	2	3	5.7	9.5
Approximate Voltage (V)	0.013	0.809	0.921	1.052	1.169	1.338	1.418
Theoretical τ R*C (s): 22			**Experimental τ (s): 30**			**Percent difference: 36.4**	
Discharging w/ 1.5 V, 100 Ω resistance							
Time (s)	1.95	3.4	7.7	10.45	16.1	21.1	40
Voltage (V)	1.456	1.19	0.896	0.754	0.528	0.39	0.132
Theoretical τ (s): 22			**Experimental τ (s): 30**			**Percent difference:** 36.4	

Discuss your results, for each circuit. Analyze whether your time constant makes sense, and why it should be big or small. Discuss sources of errors and ways to minimize them.

Out results and constants both made sense. The time the capacitor takes to charge or discharge is long due to its very large capacitance, which is reflected in our experimental data. Possible sources of error could be that our voltage meter actually drained the capacitor slightly as it was being used, likely due to internal resistance. A more advanced device could counteract this, or the internal resistance of the volt meter could be measured and accounted for along with the resistors.