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**Class**: AP Physics

**Period**: 2

**Group #**: 6

**Lab # and Title**: #9- RC Circuits

Laboratory Report

**Purpose**

Discover the relationship between the RC value (resistance times capacitance) and time.

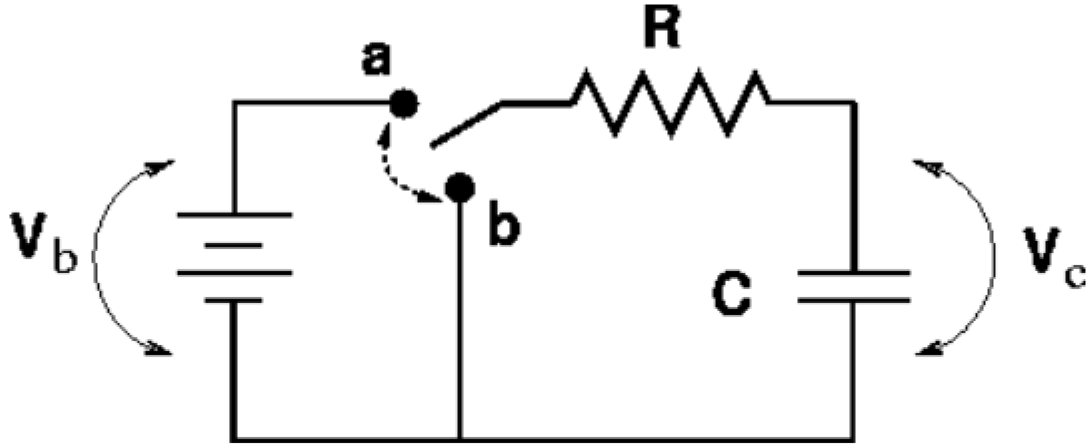
**Equipment Used**

PASCO Circuit board kit, PASCO Voltmeter, Sparkvue App, Red and Black Cables

**Background**

An RC circuit is a circuit with both a resistor (R) and a capacitor (C). RC circuits are frequent element in electronic devices. They also play an important role in the transmission of electrical signals in nerve cells.

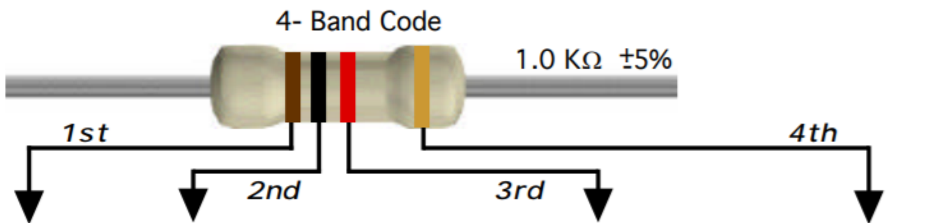
A capacitor can store energy and a resistor placed in series with it will control the rate at which it charges or discharges. This produces a characteristic time dependence that turns out to be exponential. The crucial parameter that describes the time dependence is the **"time constant"** *R C* . The far-sighted student might guess this just by observing that *R C* has the dimensions of time: *(1 Ohm) x (1 Farad) = (1 second)*.



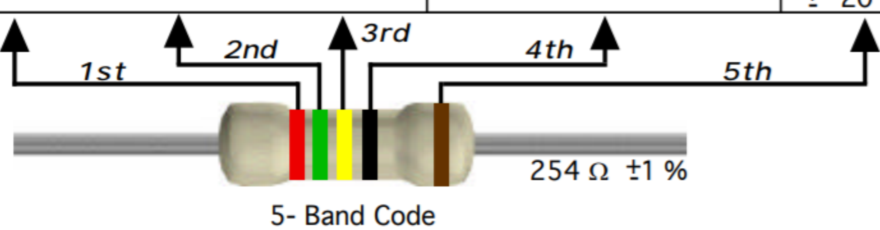

In our experiment, we will be exploring two different scenarios:

1. **Discharging the capacitor**: The capacitor initially is connected (switch in position ***a***) for a long time and is then disconnected by moving the switch to ***b*** at time ***t = 0***. The capacitor then discharges, leaving the capacitor without charge or voltage after a long time.
2. **Charging the capacitor**: The switch is in position ***b*** for a long time, allowing the capacitor to have no charge. At time ***t = 0***, the switch is changed to ***a*** and the capacitor charges.

# RESISTOR COLOR CODE GUIDE

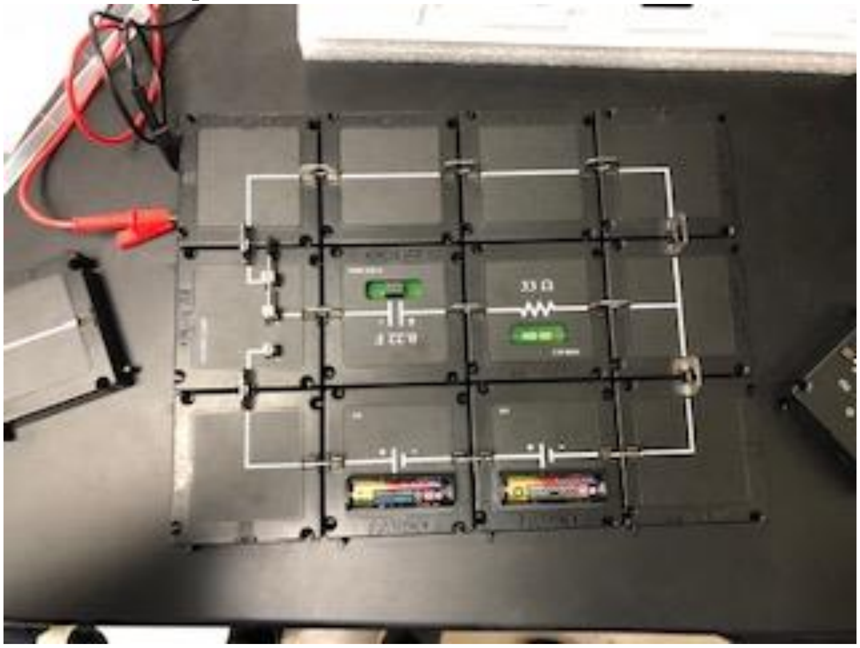



| Color | 1st Band | 2nd Band | 3rd Band | Decimal Multiplier | | Tolerance |
|---|---|---|---|---|---|---|
| Black | 0 | 0 | 0 | 1 | 1 | |
| Brown | 1 | 1 | 1 | 10 | 10 | ± 1 % |
| Red | 2 | 2 | 2 | 100 | 100 | ± 2 % |
| Orange | 3 | 3 | 3 | 1K | 1,000 | |
| Yellow | 4 | 4 | 4 | 10K | 10,000 | |
| Green | 5 | 5 | 5 | 100K | 100,000 | |
| Blue | 6 | 6 | 6 | 1M | 1,000,000 | |
| Violet | 7 | 7 | 7 | 10M | 10,000,000 | |
| Gray | 8 | 8 | 8 | | 100,000,000 | |
| White | 9 | 9 | 9 | | 1,000,000,000 | |
| Gold | | | | | 0.1 | ± 5 % |
| Silver | | | | | 0.01 | ± 10 % |
| None | | | | | | ± 20 % |



**Procedure**

1. As seen in the picture, build the correct circuit.




2. Connect the Voltmeter across the capacitor using the Red and Black cables. Using the Sparkvue App, connect to your voltmeter.


3. Flip the switch in which the battery will charge the capacitor. Monitor your graph on Sparkvue to find the time it will take to fully charge the capacitor (when the line reaches its maximum height). Record the time in the data table and screenshot the graph from Sparkvue.
4. Flip the switch in which the battery will discharge the capacitor. Monitor your graph on Sparkvue to find the time it will take to fully discharge the capacitor (when the line reaches its maximum height). Screenshot the graph from Sparkvue.

5. Next, replace the 33 Ω resistor with another resistor (10 Ω, 68 Ω, 47 Ω, 22 Ω, 15 Ω). In order to determine which resistor is which, you must use the color code guide that is found in the background section. Repeat step 3 and step 4 and record the charge time in the data table.
**6.** Place everything back in the circuit kit box correctly. Refer to the packet in your circuit kit in case you forgot the order.



3: 47 Ohms
Voltage (V)
Run 3
Run 4
Run 5
Run 6
Voltage 0.013 V
Periodic: 10 Hz
Start
00:00:57.8
1.23

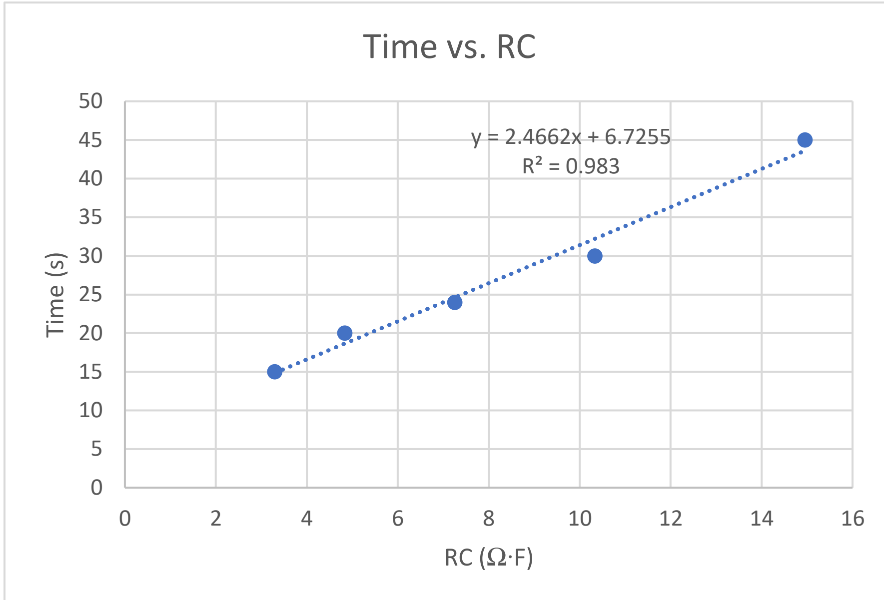

4: 22 Ohms
Voltage (V)
Run 5
Run 6
Run 7
Run 8
Voltage 0.010 V
Periodic: 10 Hz
Start
00:00:33.4
1.23


5: 15 Ohms
Voltage (V)
Run 7
Run 8
Run 9
Run 10
Voltage 0.007 V
Periodic: 10 Hz
Start
00:00:32.8
1.23


5: 15 Ohms
Voltage (V)
Run 1
Run 2
Run 3
Run 4
Voltage 0.006 V
Periodic: 10 Hz
Start
00:00:32.8
1.23

## Data

| RC (Ω * F) | Time (s) |
|---|---|
| 7.26 | 24 |
| 14.96 | 45 |
| 10.34 | 30 |
| 4.84 | 20 |
| 3.3 | 15 |
| | |




**Analysis Questions**

1. What is the relationship between the RC value and time? Justify your answer with your $r^2$ value.

The relationship between the RC and time is linear, with an $r^2$ value of 0.983

2. How does the charging time compare to the discharging time? What can account for the difference?

The capacitor takes the same amount of time to charge and discharge, because the resistance does not change.

3. How does the voltage discharge rate for the 33 Ω resistor compare to the 100(68) Ω resistor? Why is the discharge time different for each resistor?

The voltage discharge rate is lower for higher resistances. This is due to the higher resistance reducing the amperage of the circuit.

**Synthesis Questions**

1. Attach the screenshots of the graphs from steps 3 and 4 for the 33 Ω resistor.


2. A 200 Ω resistor, a 5000 microfarads capacitor, a switch, and a 10 V battery are in series in a single circuit loop. Determine the initial and steady state currents. How long will the circuit take to reach steady state (approximately).

- The initial current will be 0 A, and the steady state current will be 0.05 A
- The capacitor will reach steady state in 1 second

3. A pair of 2 F capacitors (in parallel) is in series with another pair of 1 F capacitors (in parallel). What is the equivalent capacitance of this configuration?

| |
|---|
| 4/3 F |