MODULE 3: Basic Circuits - Resistance

SUMMER CHALLENGE

Electrical Engineering: Smart Lighting

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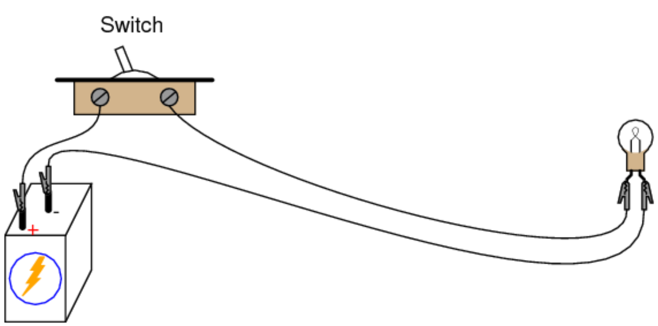
Overview

- Circuits Review
- Resistance and Resistors
- Ohms Law
- Breadboards
- Capacitance
- Experiments
  - Resistive Circuit
  - Voltage Divider
  - RC Circuit

Recap - What is a Circuit?

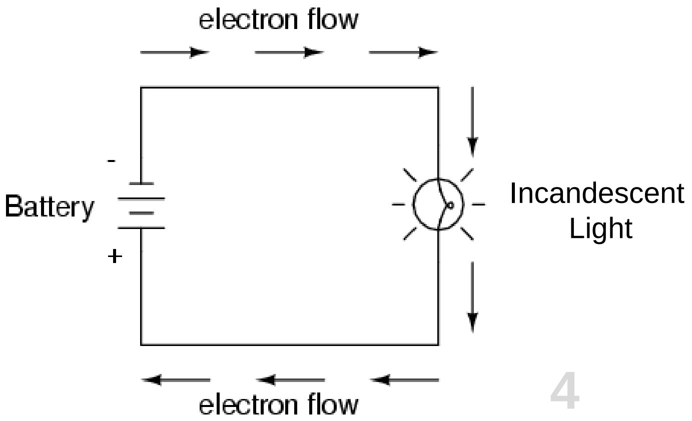
- In a circuit, how are the start and end related?
  - They're the same!
- What happens if there isn't a continuous path?
  - Open Circuit – No flow of charge (or electrons)
- What happens when a conduit connects two points?
  - Charge (and electrons) can flow between the points
  - Short Circuit – Directly connecting two points of different voltage
- Switch
  - Device that can open or close a circuit



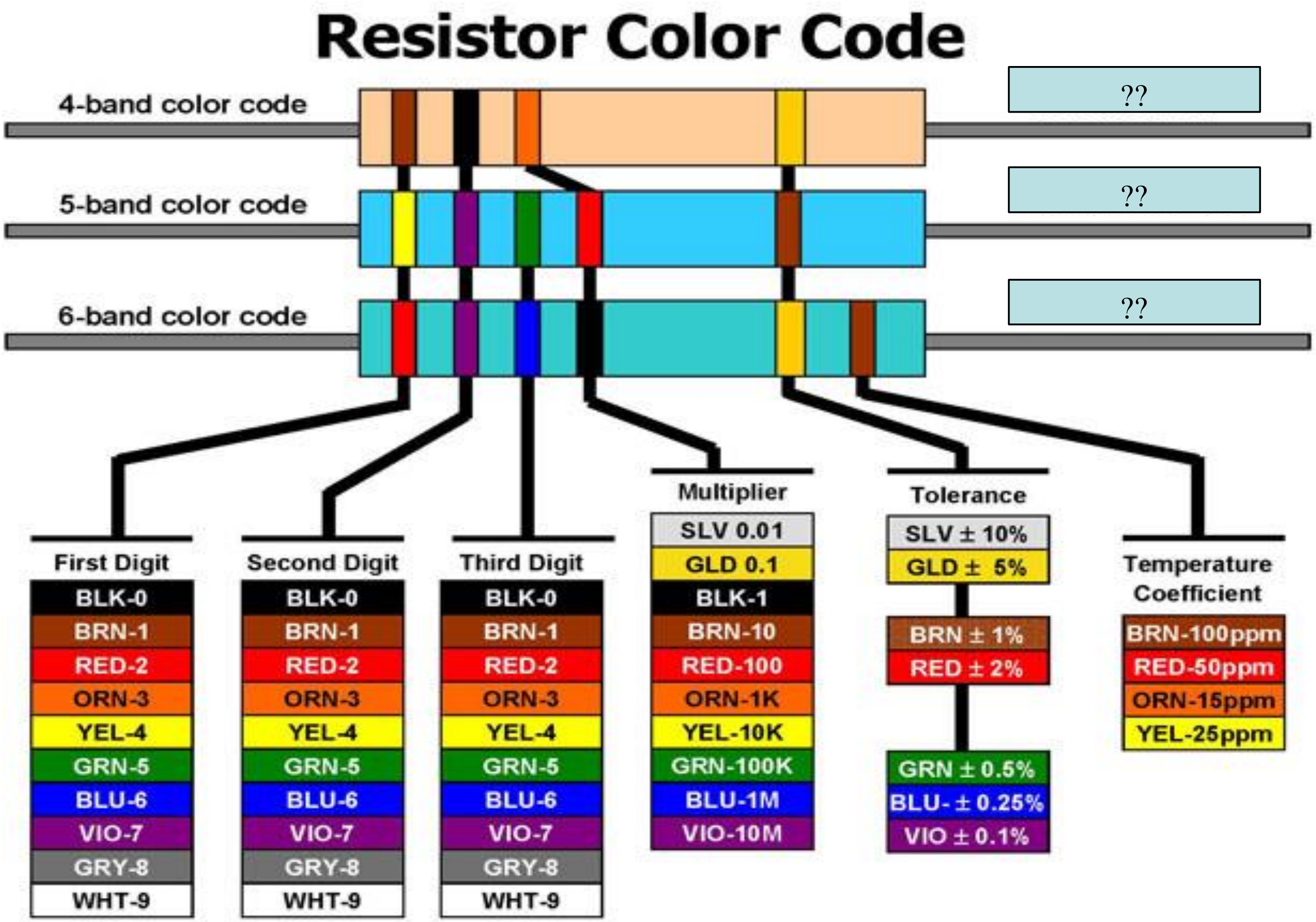



Resistance

- As charge flows from high to low V, energy is released
  - Where does it go??
- As electrons flow, they encounter *resistance*
  - Friction from electrons moving against the resistance generates heat
  - Resistance is a function of material, length, and cross-sectional area
  - Resistance is measured in Ohms [Ω]
- Wires have resistance, but it is minimal and a direct connection between different voltage levels is a *short*
- The filament in an incandescent light introduces resistance
  - The heat energy causes the filament to "glow" white-hot and produce light



Resistors



Resistor Color Code
4-band color code
5-band color code
6-band color code
??
??
??
Multiplier
SLV 0.01
GLD 0.1
BLK-1
BRN-10
RED-100
ORN-1K
YEL-10K
GRN-100K
BLU-1M
VIO-10M
Tolerance
SLV ± 10%
GLD ± 5%
BRN ± 1%
RED ± 2%
GRN ± 0.5%
BLU- ± 0.25%
VIO ± 0.1%
First Digit
Second Digit
Third Digit
BLK-0
BRN-1
RED-2
ORN-3
YEL-4
GRN-5
BLU-6
VIO-7
GRY-8
WHT-9
Temperature Coefficient
BRN-100ppm
RED-50ppm
ORN-15ppm
YEL-25ppm

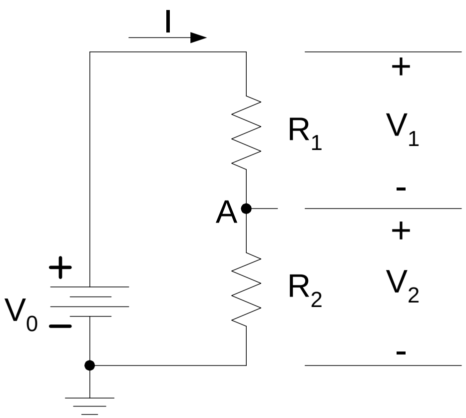
?? Law

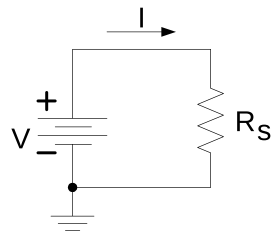
$$V = IR$$

- What happens in the case of an open circuit (i.e., $R \approx \infty$)?
- What happens in the case of a short circuit (i.e., $R \approx 0$)?

Series vs Parallel

- Series Resistance



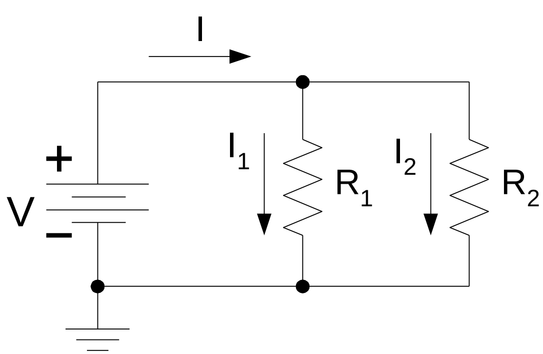


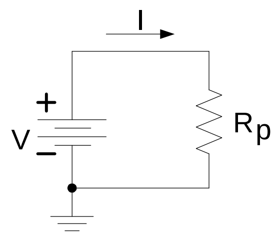
$$V_0 = V_1 + V_2 = IR_1 + IR_2$$
$$= I\left(R_1 + R_2\right)$$
$$= IR_s$$

$$R_s = R_1 + R_2$$

- Parallel Resistance

$$I = I_1 + I_2 = \frac{V}{R_1} + \frac{V}{R_2} = V\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{V}{R_p}$$

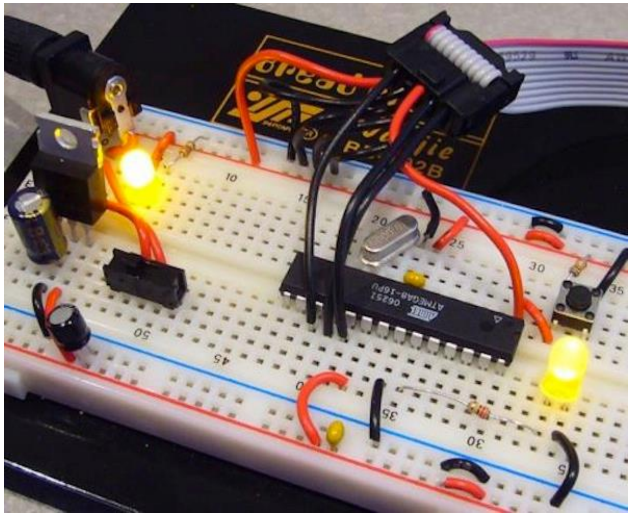




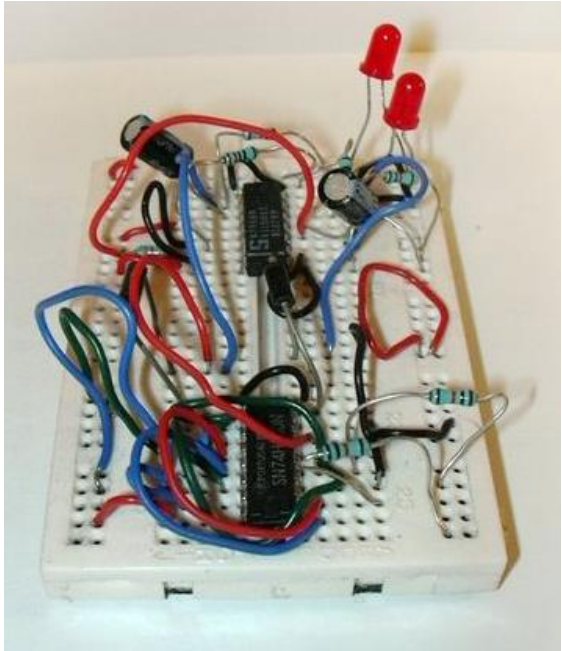
$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$$

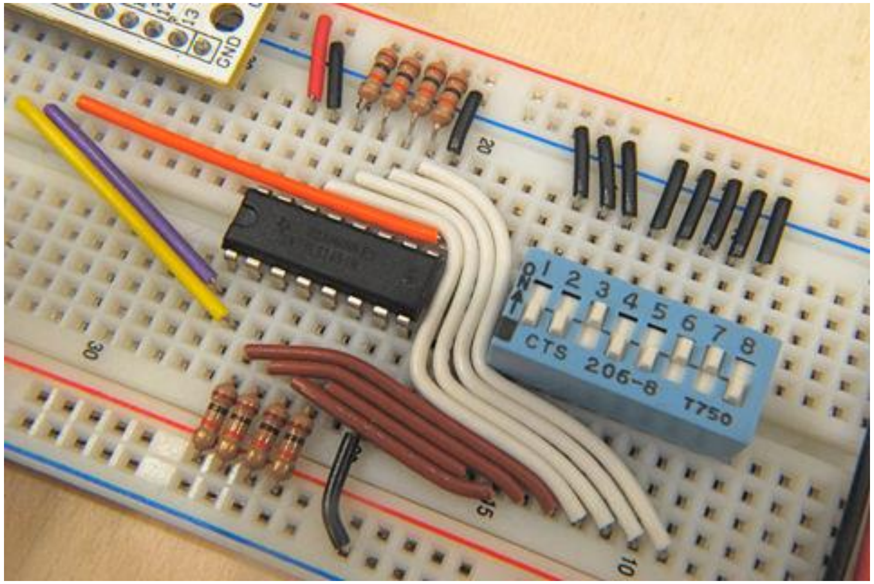
$$R_p = \frac{R_1 R_2}{R_1 + R_2}$$

Breadboards

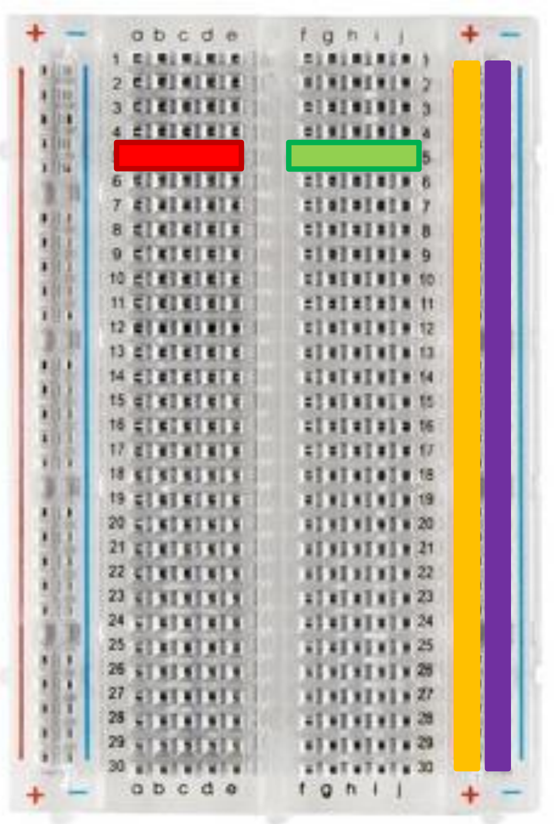


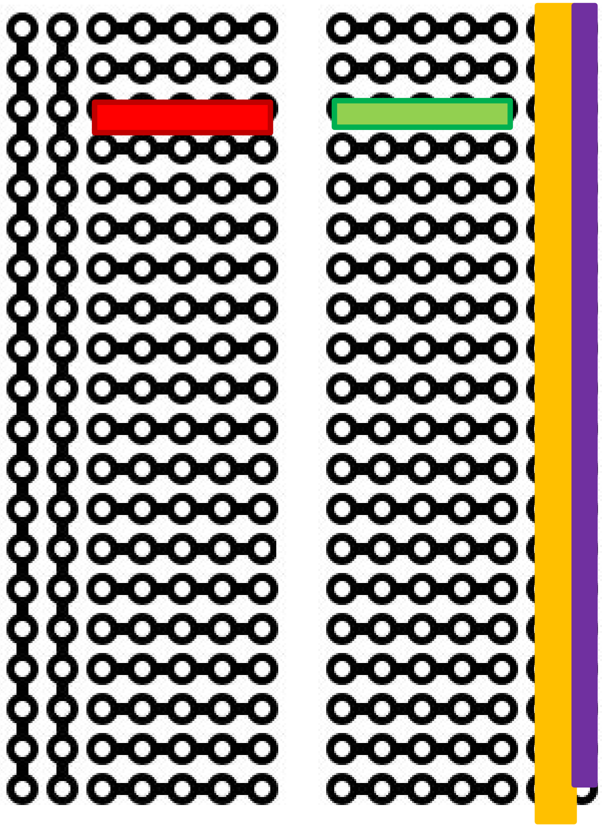
- Why do we use breadboards?
  - Temporary Circuits
  - Prototyping
  - No Soldering





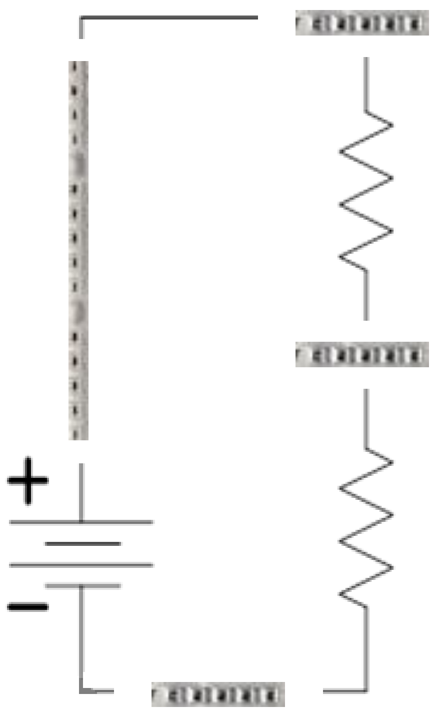
Anatomy of a Breadboard

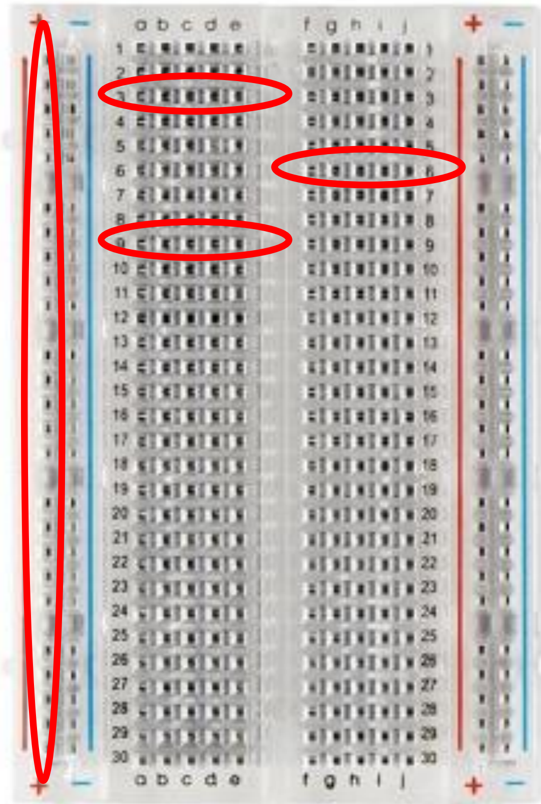




Schematics and Breadboards

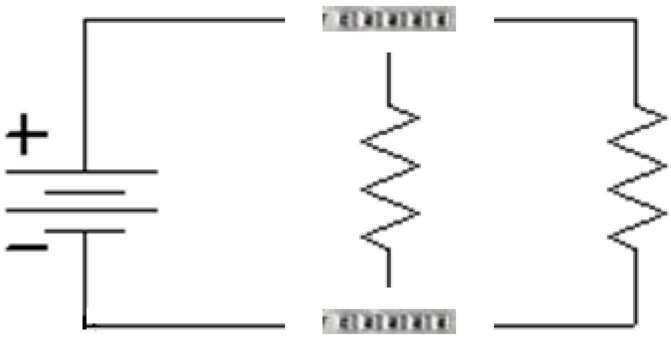
- *Connect nodes of a schematic to a connected row of the breadboard*

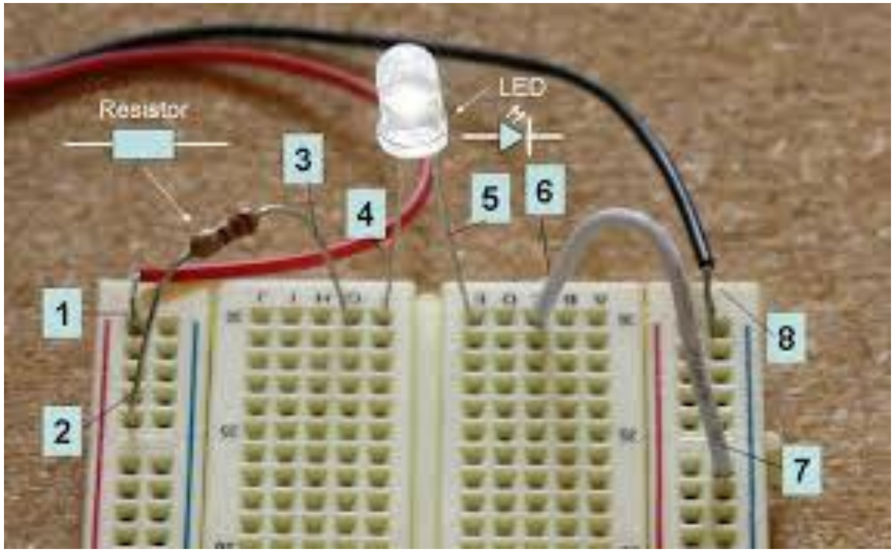


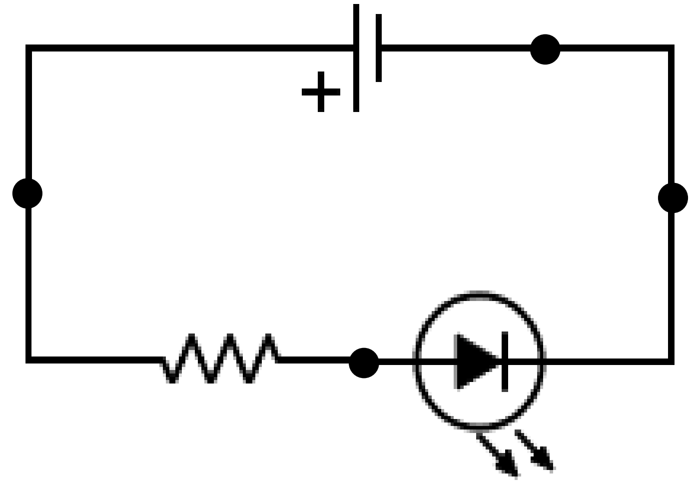


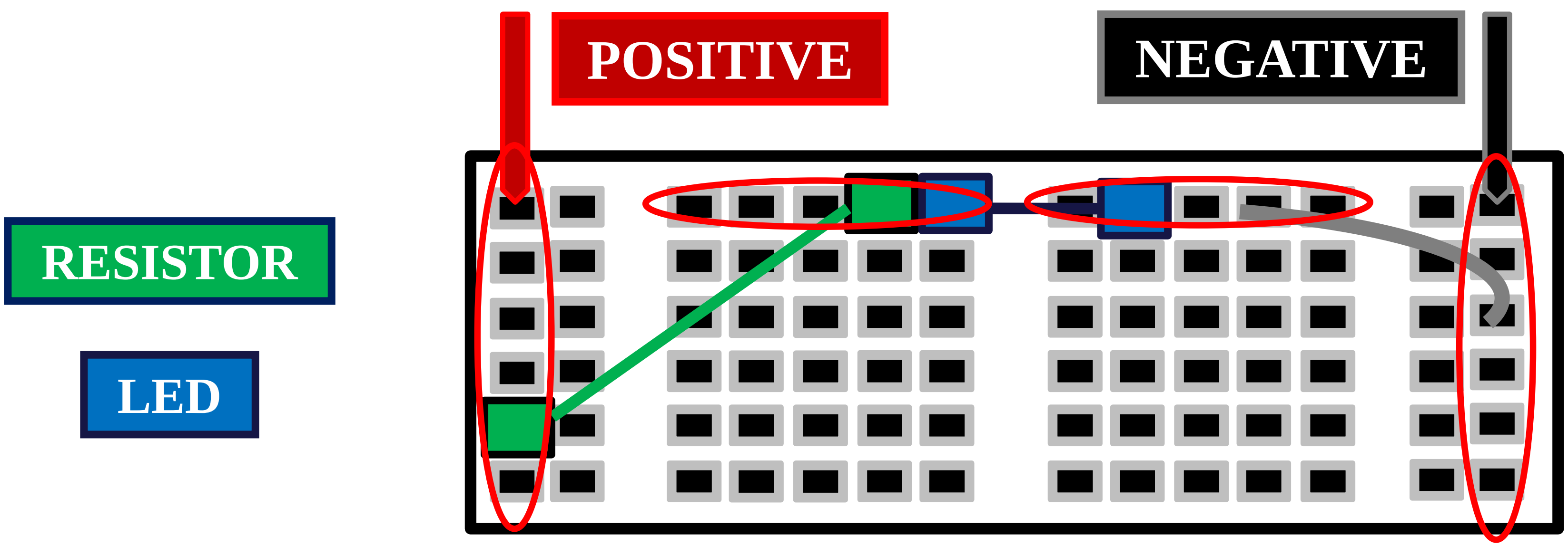
Schematics and Breadboards

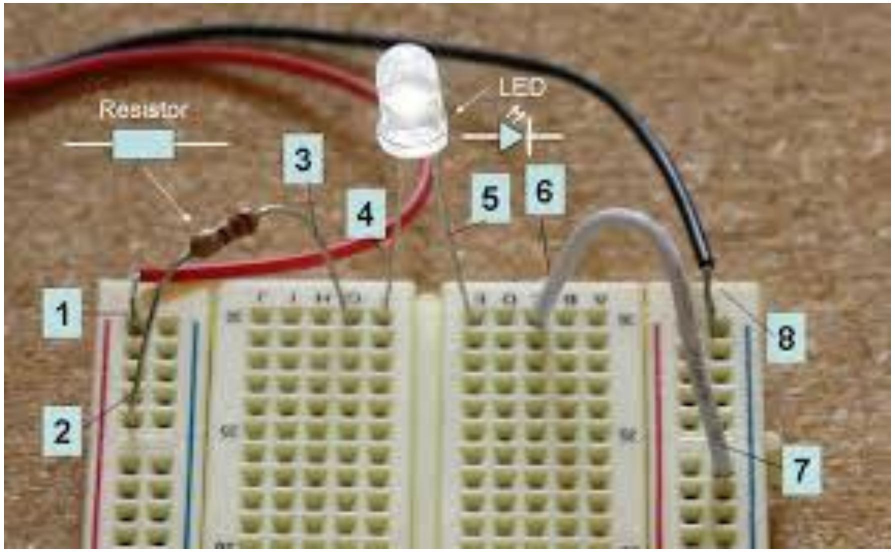
- *Connect nodes of a schematic to a connected row of the breadboard*




Resistor
LED
1
2
3
4
5
6
7
8

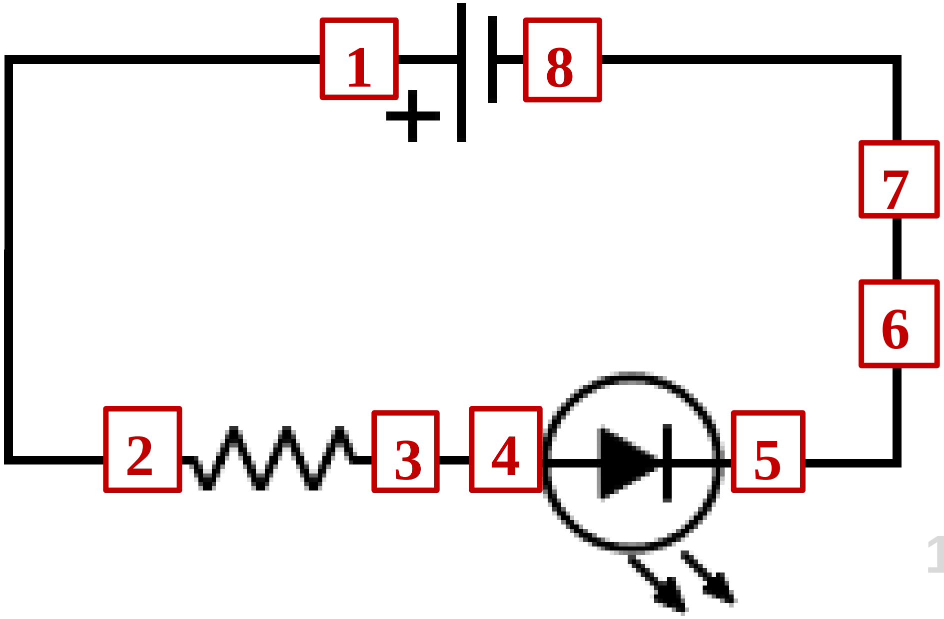

+


RESISTOR
LED
POSITIVE
NEGATIVE

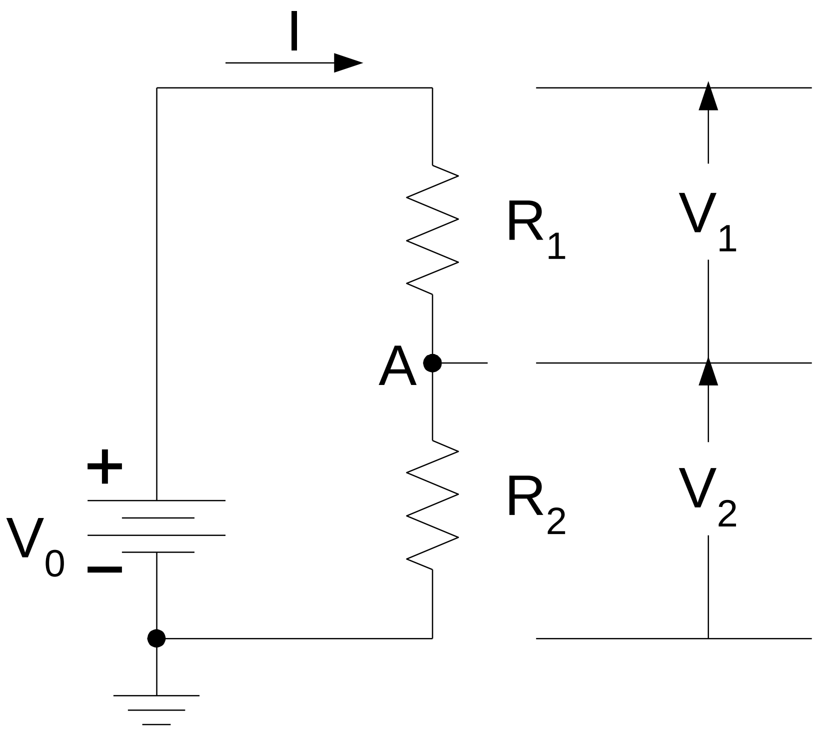


SHORT EXERCISE

1. Copy the schematic.
2. Label where each of the numbers are.



Voltage Divider Circuit



$$I = \frac{V_0}{R_s} = \frac{V_0}{R_1 + R_2}$$

$$V_2 = IR_2 = \frac{V_0}{(R_1 + R_2)} R_2$$

Also $V_1 = \frac{R_1}{(R_1 + R_2)} V_0$

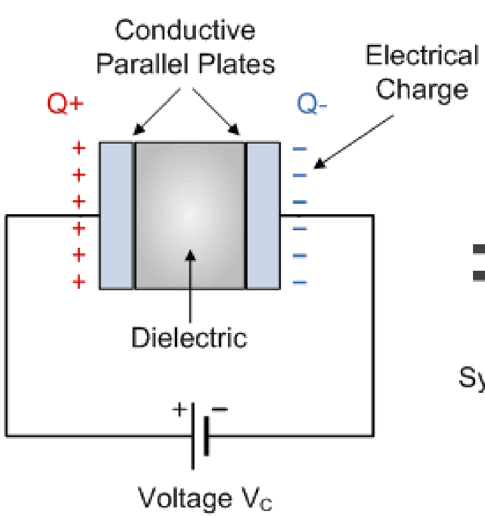
$$V_2 = \frac{R_2}{(R_1 + R_2)} V_0$$

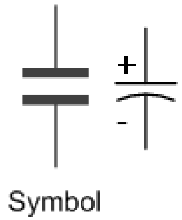
Experiment I

- Voltage Divider
- Resistive Circuits

Capacitance

- A **capacitor** has capacity to store energy in the form of electrical charge producing a voltage across plates
- Storage of energy leads to time dependency
  - This was NOT the case in purely resistive circuits.
- Capacitance is measured in Farads [F]





$$i = C\frac{\mathrm{d}v}{\mathrm{d}t}$$

i = Instantaneous Current

$\frac{\mathrm{d}v}{\mathrm{d}t}$ = Instantaneous rate of voltage change

Capacitors are *sometimes* polarized

$$C = \frac{\varepsilon A}{d}$$

ε = Permittivity of dielectric

A = Area of plate overlap

d = distance between plates

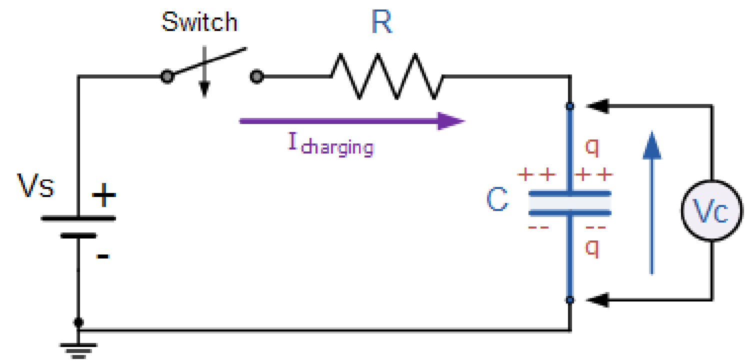
NOTE: Directly connecting a capacitor to a voltage supply isn't practical

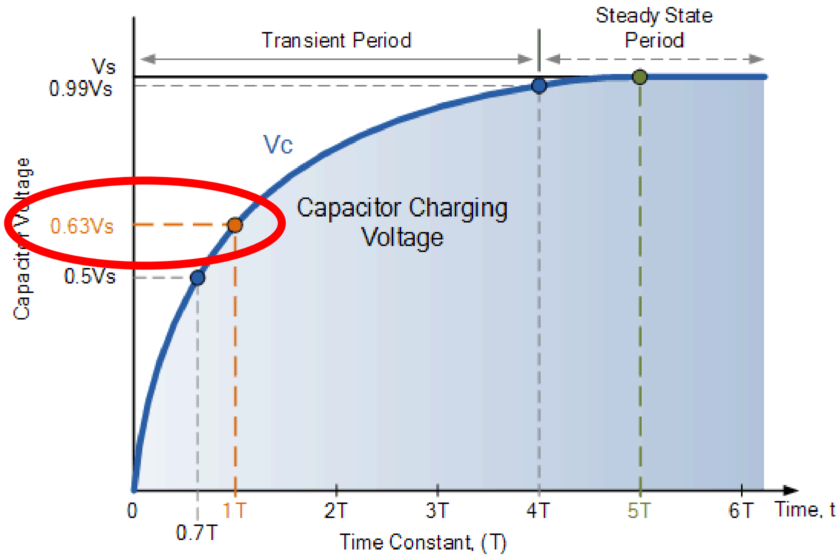
RC Circuits

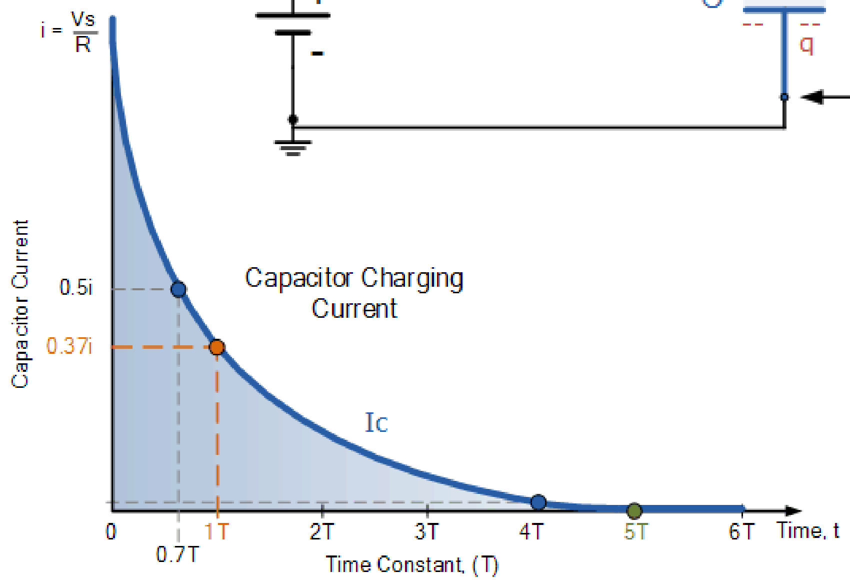
- RC circuits consist of a resistor and capacitor in series
- How do capacitors react to a sudden change in voltage?

$$\tau \equiv RC$$

$$V_c = V_s\left(1 - e^{-t/\tau}\right)$$

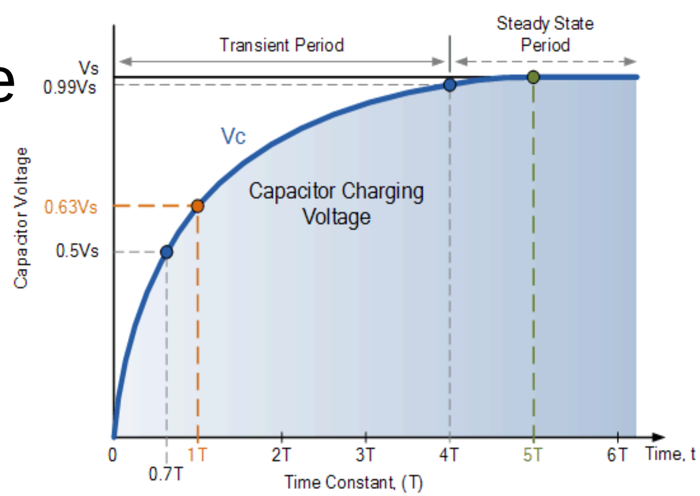


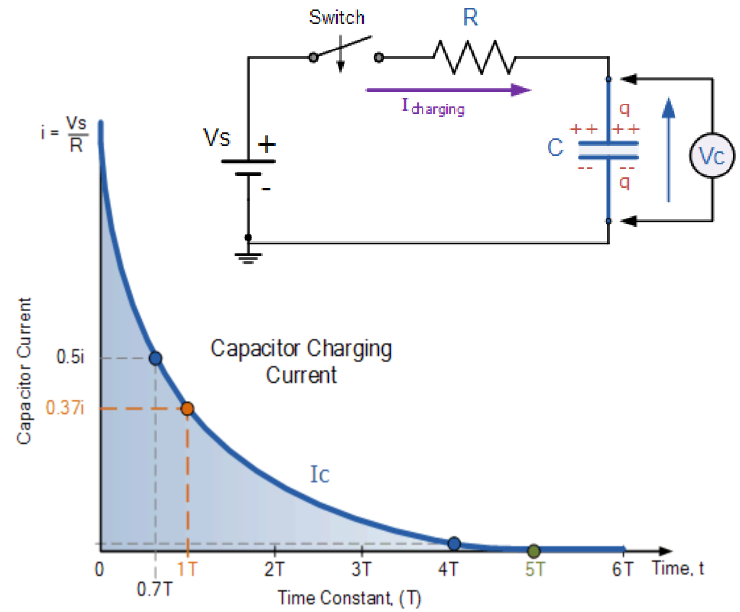




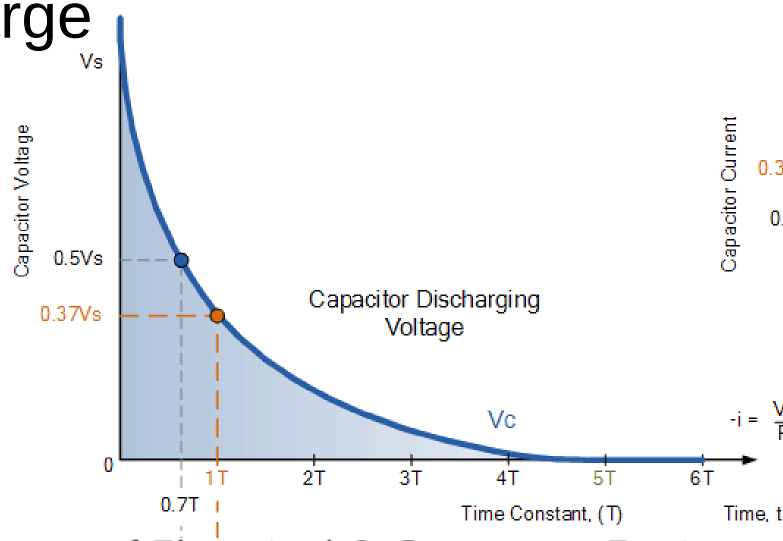
RC Circuits

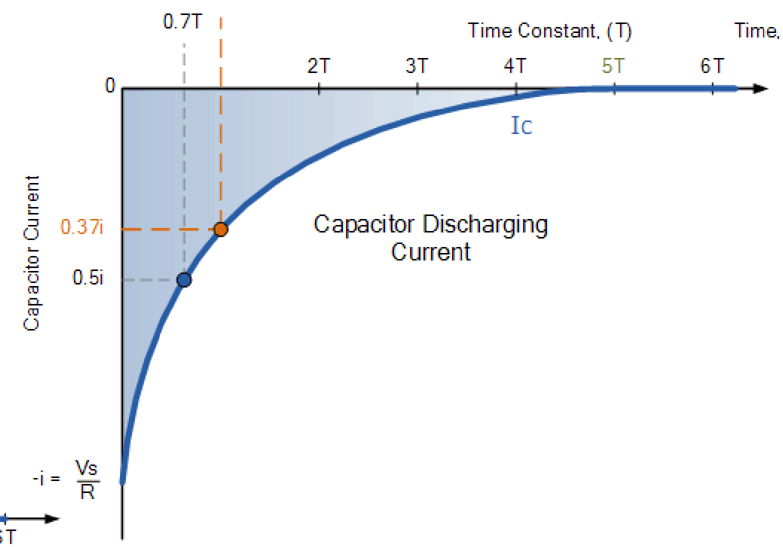
- Charge





- Discharge





Experiment II

- Resistor – Capacitor (RC) Circuits

Recap

- What did you 

today?