

Course and Section \_\_\_\_\_

Names \_\_\_\_\_

Date \_\_\_\_\_

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## RESISTOR SIMULATION

### Introduction

Resistors are passive electronic devices which have fixed values. The resistance follows **Ohm's Law**

$$I = \frac{1}{R}V$$

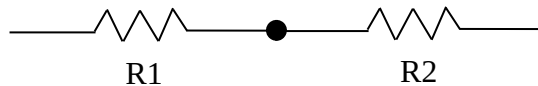
The SI unit of resistance is the ohm,  $1 \Omega = 1 \text{ V/A}$ . The schematic symbol for a resistor is



Resistors can be connected in an electronic circuit in a series or parallel combination.

#### Series:

In a series connection the components are connected at a single point, end to end as shown below:

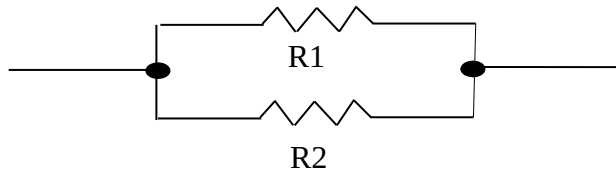


For a series combination the current through each resistor is the same while the voltage drops will add. Using this we can find the equivalent capacitance,  $R_{eq}$

$$R_{EQ} = R_1 + R_2$$

#### Parallel:

In the parallel connection, the components are connected together at both ends as shown below:



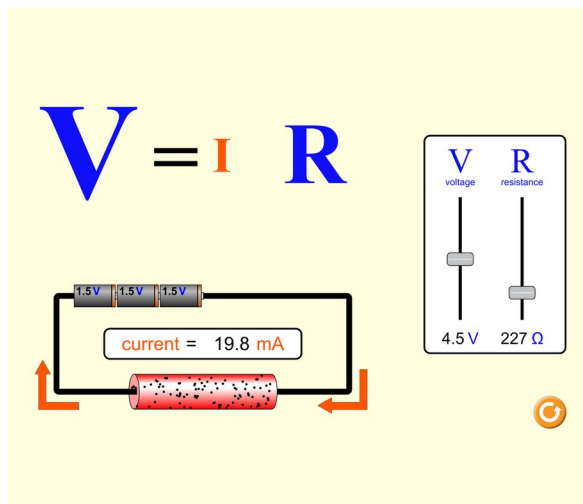
For a parallel combination the current through each resistor will add while the voltage drops are equal. Using this we can find the equivalent capacitance,  $R_{eq}$

$$\frac{1}{R_{EQ}} = \frac{1}{R_1} + \frac{1}{R_2}$$

Submit your answers using Blackboard.

## 1 – Ohms Law

To gain some familiarity with Ohm's law open the simulation ([https://phet.colorado.edu/sims/html/ohms-law/latest/ohms-law\\_en.html](https://phet.colorado.edu/sims/html/ohms-law/latest/ohms-law_en.html)).



The simulation allows you change the voltage or resistance and see how this effects the current using the sliders on the page.

1. How does the current change as you decrease the voltage?
2. How does the current change as you increase the resistance?
3. With  $V = 4.5 \text{ V}$  and  $R = 149 \text{ } \Omega$  what is the current? (mA) (m-milli  $10^{-3}$ )

## 2 – Current vs Voltage

Ohm's Law written as  $I = V/R$  states that current goes linearly with the voltage.

4. What does the slope  $m$  of the line correspond to?

Suppose a resistor is connected to a power supply. You vary the voltage and measure the current passing through the resistor. The table below displays the data: the voltage in V and the current in mA.

V	1	2	3	4	5	6	7	8	9	10
I	0.183	0.359	0.543	0.73	0.905	1.076	1.258	1.45	1.62	1.839

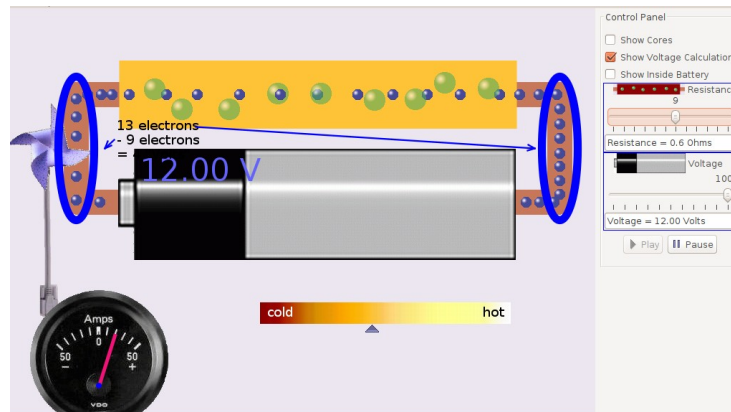
Make a plot of  $I$  vs  $V$  (Remember to set the  $y$  intercept to zero).

5. Fitting the data with a line what is the value of slope? ( $1/\Omega$ )
6. What is the resistance of the resistor? ( $\Omega$ )

### 3 – Joule Heating

When current passes through a resistive element (for example a light bulb) power is dissipated (the light bulbs emits light). The power dissipated is  $P=IV$ . Using Ohm's law this can be rewritten in two other ways  $P = I^2R = V^2/R$ .

Open the link (<https://phet.colorado.edu/en/simulation/legacy/battery-resistor-circuit>) and download/run the applet.



The simulation shows a resistor and battery. The process of dissipate power causes the restive element to heat up (the light bulbs get hot); that's the name Joule heating. There is ammeter which shows the current and a bar displays how hot the resistor gets. The controls on the right allow you to change the voltage of the battery and the value of the resistance.

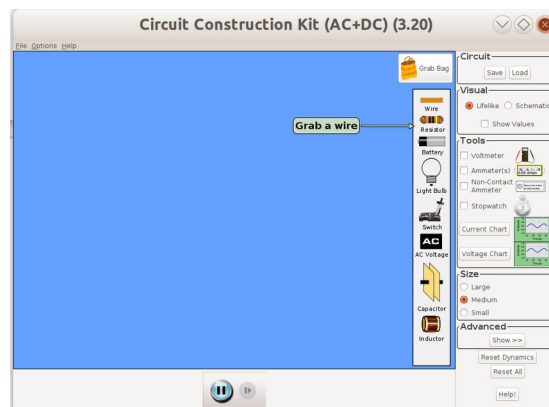
7. How does the temperature of the resistor change as you decrease the voltage from zero to  $V=-12$ ?
8. How does the temperature of the resistor change as you increase the voltage from zero to  $V=12$ ?
9. Using your results from the previous questions does the direction of the current flow change the behavior of the temperature of the resistor?
10. How does the temperature of the resistor change as you decrease the resistance?

Set the resistance to  $R = 0.8\Omega$  and the voltage of the battery to  $V = 12V$ .

11. What is the power being dissipated through the resistor? (J/s)
12. What is the current through the resistor? (A)

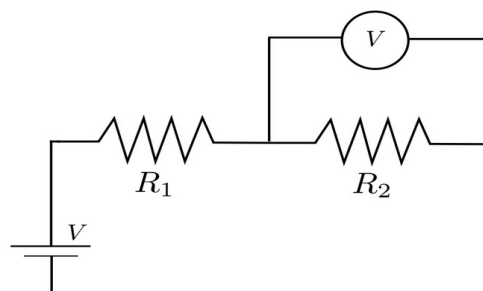
## 4 – Series and Parallel Combinations

Open the link (<https://phet.colorado.edu/en/simulation/legacy/circuit-construction-kit-ac>) and download/run the simulation. You will see a blank canvas



Click the schematic button on the right hand side. This simulation will let you construct circuits of different kinds (become familiar with this simulation since you will use it again several times).

The circuit elements are displayed in bar on the right hand side and can be dragged into the blue canvas. Once you have a circuit element in the canvas it can be modified by right clicking on the object. This will let you change the value of voltage of the batteries or resistance of the resistors. Click the voltmeter button. This will give you a meter to measure the voltage across elements in your circuit. To do this move the two probes (1 red 1 black) to touch each side of the wire connecting to a circuit element, the voltmeter will display the voltage across that object. An example of this is shown in the circuit diagram below with a measurement being conducted of the voltage across  $R_2$ . Construct the following circuit in the simulation.

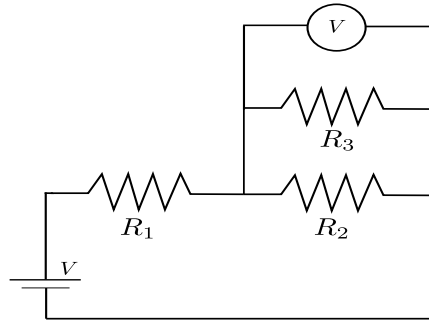


Choose the following:  $R_1 = 10\Omega$ ,  $R_2 = 25\Omega$ ,  $V = 10V$

13. What is the voltage measured across  $R_1$ ? (V)
14. What is the voltage measured across  $R_2$ ? (V)
15. Using Ohm's law what is the current through  $R_1$ ? (A)
16. What is the current through  $R_2$ ? (A)
17. What is the equivalent resistance  $R_{eq}$  in this case? ( $\Omega$ )

18. What is the current flowing through the equivalent resistor? (A)

Construct the following circuit in the simulation by adding a third resistor in parallel with resistor 2.



Choose the following:  $R_1 = 10\Omega$ ,  $R_2 = 25\Omega$ ,  $R_3 = 50\Omega$ ,  $V = 10V$

19. What is the voltage measured across  $R_1$ ? (V)

20. What is the voltage measured across  $R_2$ ? (V)

21. What is the voltage measured across  $R_3$ ? (V)

22. Using Ohm's law what is the current flowing through  $R_1$ ? (A)

23. What is the current through  $R_2$ ? (A)

24. What is the current through  $R_3$ ? (A)

25. What is the equivalent resistance  $R_{23}$  of the parallel combination of  $R_2$  and  $R_3$ ? ( $\Omega$ )

26. What is the equivalent resistance  $R_{eq}$  of the whole system? i.e. the series combination of  $R_1$  with  $R_{23}$ ? ( $\Omega$ )

27. What is the current flowing through the equivalent resistor  $R_{23}$ ? (A)

28. What is the current flowing through the equivalent resistance  $R_{eq}$  in this case? i.e. the total current? (A)