Name: _____

Class: _____

Due Date: _____

B.5 Current and Circuits

Understandings

- Cells provide a source of emf.
- Chemical cells and solar cells as the energy source in circuits.
- Circuit diagrams represent the arrangement of components in a circuit.
- Direct current (dc) I as a flow of charge carriers as given by $I = \frac{\Delta q}{\Delta t}$.
- The electric potential difference V is the work done per unit charge on moving a positive charge between two points along the path of the current as given by $V = \frac{W}{q}$.
- The properties of electrical conductors and insulators in terms of mobility or charge carriers.
- Electric resistance and its origin.
- Electrical resistance R as given by $R = \frac{V}{I}$.
- Resistance as given by $\rho = \frac{RA}{L}$.
- Ohm's law.
- The ohmic and non-ohmic behavior of electrical conductors, including the heating effect of resistors.
- Electrical power P dissipated by a resistor as given by $P = IV = I^2R = \frac{V^2}{R}$.
- The combinations of resistors in series and parallel circuits.

Series circuits	Parallel circuits
$I = I_1 = I_2 = \cdots$	$I = I_1 + I_2 + \cdots$
$V = V_1 + V_2 + \cdots$	$V = V_1 = V_2 = \cdots$
$R_s = R_1 + R_2 + \cdots$	$\frac{1}{R_s} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

- Electric cells are characterized by their emf ε and internal resistance r as given by $\varepsilon = I(R + r)$.

- Resistors can have variable resistance.

Equations

$I = \frac{\Delta q}{\Delta t}$

$V = \frac{W}{q}$

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

$\rho = \frac{RA}{L}$

$P = IV = I^2R = \frac{V^2}{R}$

Series circuits	Parallel circuits
$I = I_1 = I_2 = \cdots$ $V = V_1 + V_2 + \cdots$ $R_s = R_1 + R_2 + \cdots$	$I = I_1 + I_2 + \cdots$ $V = V_1 = V_2 = \cdots$ $\frac{1}{R_s} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

$\varepsilon = I(R + r)$

If you are interested in learning more about electricity and magnetism then please read the book *Electricity and Magnetism* by Edward M. Purcell and David J. Morin.

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Use your favorite sources to answer the following questions

1. Define *electric potential difference*. Units?

2. What are the units of *voltage*?

3. **Use a pencil and ruler!** The work done in moving a charge is given by the equation $W = q \times \Delta V$. Draw and label a diagram to describe this equation.

4. What is *charge q*? Units?

5. Define *electric current I* and state its equation and units. Do not confuse *current I* with *impulse* $\vec{J}$!

6. What is the relationship in magnitude and direction between *electron flow* and *current* in a conductor?

7. Define resistance. Give the units of *resistance* Ω.

8. What is the resistance of an ideal wire?

9. Define *resistor*. Do resistors increase or decrease the current in a circuit? Why is it necessary to have a resistor in a circuit?

10. Define *resistivity* ρ. Do not confuse resistivity ρ with density ρ!

11. What is the *resistance* of a non-ideal wire directly proportional to?

12. What is the resistance of a non-ideal wire inversely proportional to?

13. Define *Ohm's Law*. Draw a current vs. voltage graph of a resistor obeying Ohm's law.

14. What does a *thermistor* do? Draw a *resistance vs. temperature* graph of a thermistor.

15. What does a *light-dependent resistor* (LDR) do?

16. What does a *potentiometer* do?

17. Define *non-ohmic*.

18. Give three versions of the equation for *electrical power*.

19. Define *electromotive force emf*. What are its units?

20. Resistors in series have the same _____.

21. Resistors in parallel have the same _____.

22. How can we simplify many *resistors in series*?

23. How can we simplify many *resistors in parallel*?

24. What does an *ammeter* do? Draw its symbol. What is a characteristic of an *ideal ammeter*? How/Where do we insert an *ammeter* in a circuit?

25. What does a *voltmeter* do? Draw its symbol. What is a characteristic of an *ideal voltmeter*? How/Where do we insert a *voltmeter* in a circuit?

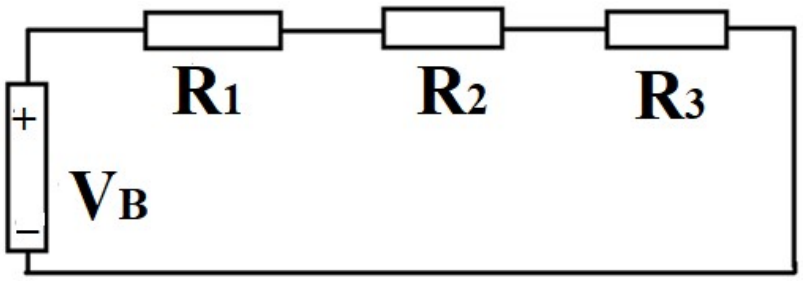
26. What is a *potential/voltage divider*?

27. Define *internal resistance r*. Units?

28. Define the following variables for the equation $\varepsilon = I(R + r)$. Draw an image to describe this equation.

Part 2: Circuits

1. A circuit is shown below:

	Given: $V_B = 10\ V$ $R_1 = 2\Omega$ $R_2 = 4\Omega$ $R_3 = 6\Omega$

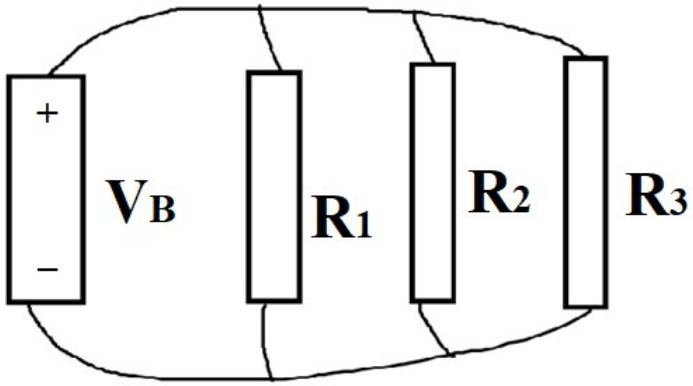
Solve for the unknowns. Fractions only.

$R_{\text{equivalent}} =$ $I_{\text{battery}} =$	$V_1 =$ $V_2 =$ $V_3 =$	$I_1 =$ $I_2 =$ $I_3 =$

What will happen to the current leaving the battery if the number of resistors in series increases? Will the current increase, decrease, or stay the same?

What will happen to the overall resistance of the circuit if the number of resistors in series increases? Will the overall resistance increase, decrease, or stay the same?

2. A circuit is shown below:



Given:

$V_B = 10\ V$

$R_1 = 2\ \Omega$

$R_2 = 4\ \Omega$

$R_3 = 6\ \Omega$

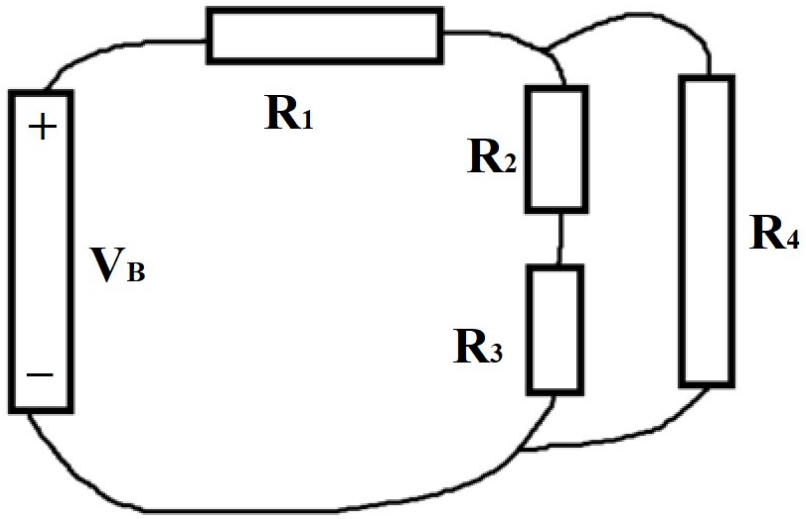
Solve for the unknowns. Fractions only.

$R_{equivalent} =$ $I_{battery} =$	$V_1 =$ $V_2 =$ $V_3 =$	$I_1 =$ $I_2 =$ $I_3 =$

What will happen to the current leaving the battery if the number of resistors in parallel increases? Will the current increase, decrease, or stay the same?

What will happen to the overall resistance of the circuit if the number of resistors in parallel increases? Will the overall resistance increase, decrease, or stay the same?

3. A circuit is shown below:



Given:

$V_B = 10\ V$

$R_1 = 2\Omega$

$R_2 = 4\Omega$

$R_3 = 6\Omega$

$R_4 = 8\Omega$

Solve for the unknowns. Fractions only.

	$V_1 =$	$I_1 =$
$R_{\text{equivalent}} =$	$V_2 =$	$I_2 =$
$I_{\text{battery}} =$	$V_3 =$	$I_3 =$
	$V_4 =$	$I_4 =$

4. A cell with internal resistance is connected to a 3 Ω resistor. Determine the internal resistance r of the cell if the current going through it is 2 Amps when its ε is 12 V.

5. A battery with internal resistance is connected to a variable resistor. When the resistor has a resistance R of 12 Ω the current is 2 Amps. When the resistor has a resistance R of 6 Ω the current is 3 Amps. Determine the emf ε and internal resistance r of the battery.