AP Physics-B **Basic Circuitry**

Introduction: When two points at different potentials are connected, charge flows from one point to the other in such a way as to equalize the potential difference. In a device such as a dry cell battery, a chemical reaction is used to maintain a potential difference even when the circuit is complete. In this manner, an electric current is maintained. The electric current is measured in amperes or Amps where 1 Amp is equal to 1 Coulomb/sec. Electric current or electricity is used in millions of devices in today's society. It is arguably the most useful form of energy. There are many ways to produce electricity, from chemical reactions to electromagnetic techniques. Some of these sources produce direct current while others produce alternating current. For simple circuits which contain only resistors, the same laws and analysis techniques can be used for both dc and ac circuits.

All materials provide some resistance to the flow of electricity. Materials that provide little resistance to the flow of electrons are known as conductors. Other materials impede the flow of electrons a great deal. These types of materials are known as insulators. Energy is dissipated in a resistor in the form of heat.

Performance Objectives: Upon completion of the readings, exercises, and problems and when asked to diagram, demonstrate, or respond either orally or on a written test, you will:

- Explain the concept of electric current. Define the unit of electric current. Give examples of current sources.
- Recognize the basic components of a circuit diagram, read resistor color codes, and build a circuit according to a circuit diagram.
- Recognize batteries and resistors connected in series or parallel and the characteristics of each configuration.
- State Ohm's Law. Solve problems involving simple series and parallel circuits using Ohm's Law.
- State Kirchoff's Laws. Solve problems involving simple and complex circuits using Kirchoff's Laws.
- Calculate power dissipated by a load.
- Distinguish between ammeters and voltmeters. State how each is used and wired into a circuit.
- Understand that a cell has internal resistance. Use this understanding to calculate its terminal voltage and internal resistance. Show that its terminal voltage need not equal the emf.

"We call that fire of the black thunder cloud, electricity.
But what is it? What made it? Whence comes it?
- Thomas Carlyle

Textbook Reference:

Current Conventions and Ohm's Law:

In our study of circuits we will use the convention for current flow which states that current flows from positive to negative. We will use the positive to negative convention throughout our analysis of dc circuits. One of the basic tools for analyzing dc circuits is Ohm's Law. This law is named for the German physicist Georg Simon Ohm who discovered it. Ohm's Law states that - in a closed circuit – the ratio of the emf of the source to the current in the circuit is a constant known as the resistance of the circuit. Stated mathematically: Emf = $I\cdot R$ for the circuit and $V = I\cdot R$ for the components of the circuit, where E is the emf of the source in volts, V is the change in potential across a circuit element in volts, I is the current in the circuit in Amps, and R is the resistance in the circuit in Ohms. The symbol for Ohm is Ω where $1\ \Omega = 1$ V/A. The rate (Power) at which energy is dissipated through the components of a circuit is simply the rate at which charge flows though the circuit times the potential difference across the component or $P = I\cdot V$.

Problems and Questions:

1.) The current through a light bulb connected across the terminals of a 120 V outlet is 0.5 A. At what rate dies the bulb use electricity? *60 W*

2.) A lamp is connected across a 24 V difference of potential. The current flowing through the lamp is 4.0 A. a.) What power does the lamp use? b.) How much electric energy does the lamp use in 10 minutes? *96 W 57.6 kJ*

3.) A lamp draws 0.5 A from a 120 V generator. a.) How much power does the generator deliver? b.) How much energy does the lamp use is 5 minutes? *60 W* *18 kJ*

4.) A resistance of 30 Ω is placed across a 90 V battery. What current flows through the circuit? *3 A*

5.) Draw a diagram to show a circuit that indicates a 90 V battery, an ammeter, and a resistance of 60 Ω. Indicate the ammeter reading. *1.5 A*

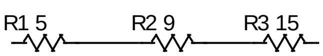
6.) Draw a circuit diagram to include a 16 Ω resistor, a battery, and an ammeter that reads 1.75 A. Indicate the voltage of the battery. *28 V*

7.) Draw a diagram to show a circuit that indicates a 60 V battery, an ammeter, and a resistance of 12.5 Ω. Indicate the ammeter reading. *4.8 A*

Basic Circuit Diagram Analysis:

In the following circuit diagrams: R1 – indicates "Resistor 1", R2 – indicates "Resistor 2", etc… The size (resistance) of each resistor is indicated by the number directly above the resistor.

8.) Find the total resistance of the series resistors below (each resistance in measured in Ohms): *29 Ω* *41 Ω*

a.)


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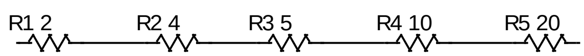
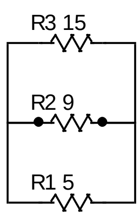


9.) Find the total resistance of the parallel resistors below: *2.65 Ω* *0.91 Ω*

a.)


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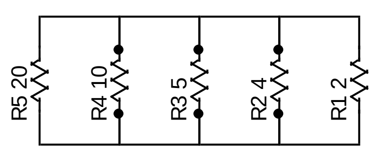
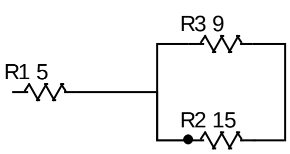
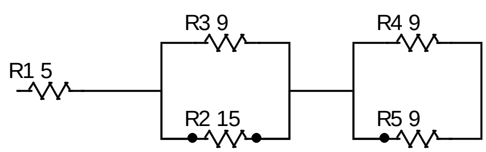
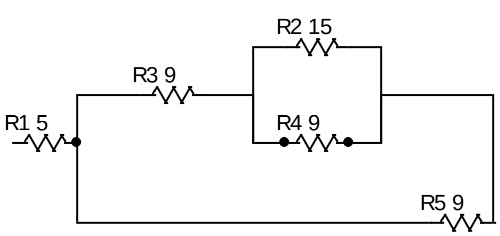


10.) Find the total resistance of the combination parallel-series resistors below: *10.625 Ω* *15.125 Ω* *10.571 Ω*

a.)


b.)


c.)


Heating Effects of Electric Currents:

11.) A 15 Ω electric heater operates on a 120 volt outlet. a.) What current flows through the heater? b.) How much energy is used by the heater in 30 seconds? c.) How much heat is liberated by the heater in this time?
8 *A* *28.8 kJ*

12.) A 30 Ω resistor is connected to a 60 V battery. a.) What is the current in the circuit? b.) How much energy is used by the resistor in 5 minutes? *2 A* *36 kJ*

13.) A 100 watt light bulb is 20% efficient. a.) How much energy is converted into light each minute it is in operation? b.) How many joules of heat does the light bulb produce each minute? *1200 J* *4800 J*

Series Circuits:

14.) Three resistors of 3 Ω, 5 Ω and 4 Ω are connected in series across a 12 volt battery. a.) What is the combined resistance of the three resistors? b.) What current flows in the circuit? c.) What is the voltage drop across each resistor? d.) What is the total voltage drop across the circuit? *12 Ω* *1 A* *3 V, 5 V, 4 V* *12V*

15.) Four 6 Ω resistors are connected in series and placed across a voltage source. The current flowing in the circuit is 1.6 Amps. a.) What is the total resistance of the circuit? b.) What is the voltage of the source? c.) What is the voltage drop across each of the resistors? *24 Ω* *38.4 V* *9.6 V*

16.) A 10 Ω resistor and a variable resistor are connected in series and placed across a 12 V source. the variable resistor is adjusted until the current flowing in the circuit is 0.6 A. a.) At what resistance is the variable resistor set? b.) What are the voltage drops across the resistor and across the variable resistor? *10 Ω* *6 V*

Parallel Circuits:

17.) A 120 Ω resistor, a 60 Ω resistor and a 40 Ω resistor are connected in parallel and placed across a potential difference of 120 V. a.) What is the total resistance of the parallel circuit? b.) What current flows through the entire circuit? c.) What current flows through each branch of the circuit? *20 Ω* *6 A* *1 A, 2 A, 3 A*

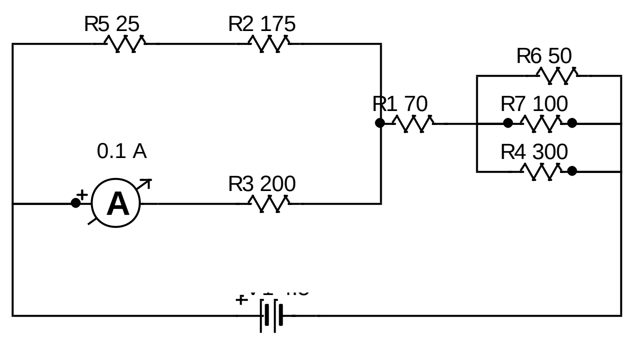
18.) Three resistors of 60 Ω, 30 Ω and 20 Ω are connected in parallel across a 90 volt battery. a.) Find the total resistance of the circuit. b.) Find the current flowing through the entire circuit. c.) Find the current flowing through each branch of the circuit. *10 Ω* *9 A* *1.5 A, 3 A, 4.5 A*

Series-Parallel Circuits:

19.) A 30 Ω resistor is connected in parallel with a 20 Ω resistor. The parallel connection is placed in series with an 8 Ω resistor. The entire circuit is placed across a 60 volt battery. a.) What is the total resistance in the circuit? b.) What current flows in the circuit? c.) What is the voltage drop across the 8 Ω resistor? d.) What is the voltage drop across the parallel portion of the circuit? e.) What current flows through each line of the parallel portion of the circuit?

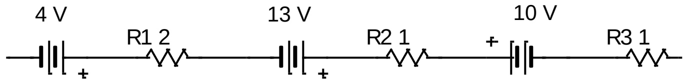
20.) In the circuit below, label each resistance with the current flowing through it and the voltage dropped across it. Also, what is the total resistance and the total voltage?

Resistor (Ω)	Current (A)	Voltage (V)
25		
175		
200		
70		
50		
100		
300		
Total Resistance =		
Total Voltage Dropped =		



Sources of EMF in Series:

When several sources of emf are connected in series, they can be replaced by a single emf equal to the algebraic sum of the individual emfs. Note: Pay close attention to the signs!

For example: 

EMF = + 4V + 13V – 10V = 7V

21.) What is the current in the 5 Ω resistor below?