Principles of Engineering

Unit 1.2.3 – Electrical circuits

Introduction to Electricity

• Movement of ____________.

• Invisible force that provides __________, __________, __________, __________.

Electricity at the Atomic Level

___________ - The simplest form of matter.

_________ - Smallest piece of an element containing all of the properties of that element.

Components of an Atom

__________: The center portion of an atom containing the protons and neutrons

__________: Positively charged atomic particles

__________: Uncharged atomic particles

Atomic Number

The atomic number is equal to the number of __________ in the nucleus of an atom.

The atomic number __________ the element.

How many protons are in this nucleus? ______

__________: Negatively charged particles

__________ ____________: Orbits in which electrons move around the nucleus of an atom

__________ ____________: The outermost ring of electrons in an atom

Electron Orbits

Orbits closest to the nucleus fill first

<table>
<thead>
<tr>
<th>Orbit Number</th>
<th>Maximum Electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
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<tr>
<td>5</td>
<td></td>
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<tr>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Valence Orbit
Atoms like to have their valence ring either ______ (8) or ______ (0) of electrons.

How many electrons are in the valence orbit? ______

Is copper a conductor or insulator? ____________________

How many electrons are in the valence orbit? ______

Is sulfur a conductor or insulator? ____________________

**Electron Flow**

An electron from one orbit can ______ out an electron from another orbit.

When an atom ______ an electron, it seeks another to fill the vacancy.

Electricity is created as electrons _________ and __________ from atom to atom.

**Conductors and Insulators**

*Conductors:*

Electrons flow ______ between atoms.

_______ valence electrons in outer orbit. Examples: Silver, Copper, Gold, Aluminum

*Insulators:*

Electron flow is _________ between atoms

_______ valence electrons in outer orbit. Examples: Mica, Glass, Quartz, Plastic, Rubber

**Electrical Circuit**

A system of conductors and components forming a complete ______ for current to travel.

Properties of an electrical circuit include:

- **Voltage** ______ V
- **Current** ______ A
- **Resistance** ______ Ω

**Current**

The _______ of electric charge. Current is measured in ___________ (A or amps)
Current in a Circuit

When the switch is _____, there is ____ current.
When the switch is ____, there ____ current.

Current Flow

_____________ ____________ : assumes that current flows out of the positive side of the battery, through the circuit, and back to the negative side of the battery. This was the convention established when electricity was first discovered, but it is incorrect!

_____________ ____ : is what actually happens. The electrons flow out of the negative side of the battery, through the circuit, and back to the positive side of the battery.

Engineering vs. Science

The direction that the current flows does not affect what the current is doing; thus, it doesn’t make any difference which convention is used as long as you are consistent.

Both Conventional Current and Electron Flow are used. In general, the science disciplines use Electron Flow, whereas the engineering disciplines use Conventional Current.

Since this is an engineering course, we will use Conventional Current.

Voltage

The _______ (pressure) that causes current to flow - measured in _______ (V)

Voltage in a Circuit

The battery provides ___________ that will push current through a load (bulb) when the switch is on.

Resistance

The ___________ to current flow - measured in _______ (______)

Resistors are components that create _____________.

Reducing current causes the bulb to become more _______.

Measuring Voltage

Set multimeter to the proper V range. Measure __________ a component.

Multimeter

An ____________ used to measure the properties of an electrical circuit, including:

Voltage (_______)  Current (_______)  Resistance (_______)
Measuring Current

Set multimeter to the proper ______ range (DC or AC).

Circuit flow must go __________ the meter.

Measuring Resistance

Set multimeter to the proper ______ range. Measure __________ the component being tested.

Power must be ______ or removed from the circuit.

Ohm’s Law

*Current in a resistor varies in direct proportion to the voltage applied to it and is inversely proportional to the resistor’s value.*

Ohm’s Law explains the __________ ________ between current, voltage, and resistance.

\[ V = IR \quad I = \frac{V}{R} \quad R = \frac{V}{I} \]

Example: Ohm’s Law

The flashlight shown uses a 6 volt battery and has a bulb with a resistance of 150 Ω. When the flashlight is on, how much current will be drawn from the battery? __________

Circuit Configuration

Components in a circuit can be connected in one of two ways.

_______ Circuits

• Components are connected end-to-end.
• There is only a _______ ______ for current to flow.

_______ Circuits

• Both ends of the components are connected together.
• There are _______ ______ for current to flow.

Kirchhoff’s Laws

**Kirchhoff’s Voltage Law (KVL):**

The sum of all voltage drops in a ________ circuit ________ the total applied voltage.

**Kirchhoff’s Current Law (KCL):**

The total current in a ________ circuit equals the ______ of the individual branch currents.
**Series Circuits**: A circuit that contains only _____ path for current flow. If the *path* is open anywhere in the circuit, current ________ flowing to all components.

**Characteristics of a series circuit:**

- The current flowing through every series component is _________.
- The total resistance (R_T) is equal to the _______ of all of the resistances (i.e., R_1 + R_2 + R_3).
- The sum of all voltage drops (V_{R1} + V_{R2} + V_{R3}) is ________ to the total applied voltage (V_T). This is called _______________ ________ ______.

**Example: Series Circuit**

For the series circuit shown, use the laws of circuit theory to calculate the following:

- The total resistance (R_T)
- The current flowing through each component (I_T, I_{R1}, I_{R2}, & I_{R3})
- The voltage across each component (V_T, V_{R1}, V_{R2}, & V_{R3})
- Use the results to verify Kirchhoff’s Voltage Law

![Series Circuit Diagram]

<table>
<thead>
<tr>
<th>Total Resistance</th>
<th>= ____________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Current</td>
<td>= ____________</td>
</tr>
<tr>
<td>Voltage Total</td>
<td>= ____________</td>
</tr>
<tr>
<td>Voltage_{R1}</td>
<td>= ____________</td>
</tr>
<tr>
<td>Voltage_{R2}</td>
<td>= ____________</td>
</tr>
<tr>
<td>Voltage_{R3}</td>
<td>= ____________</td>
</tr>
</tbody>
</table>

**Verify Kirchhoff's Voltage Law:**

Voltage_{R1} ________ + Voltage_{R2} ________ + Voltage_{R3} ________ = 12 volts

**Parallel Circuits**

A circuit that contains ________ than one path for current flow.

If a component is removed, then it is possible for the current to take ____________ path to reach other components.
Characteristics of a Parallel Circuit

- The __________ across every parallel component is ________.

- The total __________ (R<sub>T</sub>) is equal to the __________ of the sum of the reciprocal:
  \[
  \frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \\
  R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}
  \]

- The sum of all of the __________ in each branch (I<sub>R1</sub> + I<sub>R2</sub> + I<sub>R3</sub>) is ________ to the ________ current (I<sub>T</sub>). This is called Kirchhoff’s Current Law.

Example: Parallel Circuits

For the parallel circuit shown, use the laws of circuit theory to calculate the following:

- The total resistance (R<sub>T</sub>)
- The voltage across each component (V<sub>T</sub>, V<sub>R1</sub>, V<sub>R2</sub>, & V<sub>R3</sub>)
- The current flowing through each component (I<sub>T</sub>, I<sub>R1</sub>, I<sub>R2</sub>, & I<sub>R3</sub>)
- Use the results to verify Kirchhoff’s Current Law

Verify Kirchoff’s Current Law:

Current<sub>R1</sub> ________ + Current<sub>R2</sub> ________ + Current<sub>R3</sub> ________ = Current<sub>Total</sub> ________

Combination Circuits

Contain both ________ and ________ arrangements.

What would happen if you removed light 1? Light 2? Light 3?

Electrical Power

Electrical power is directly related to the amount of current and voltage within a system.

\[ P = \] Power is measured in ________.