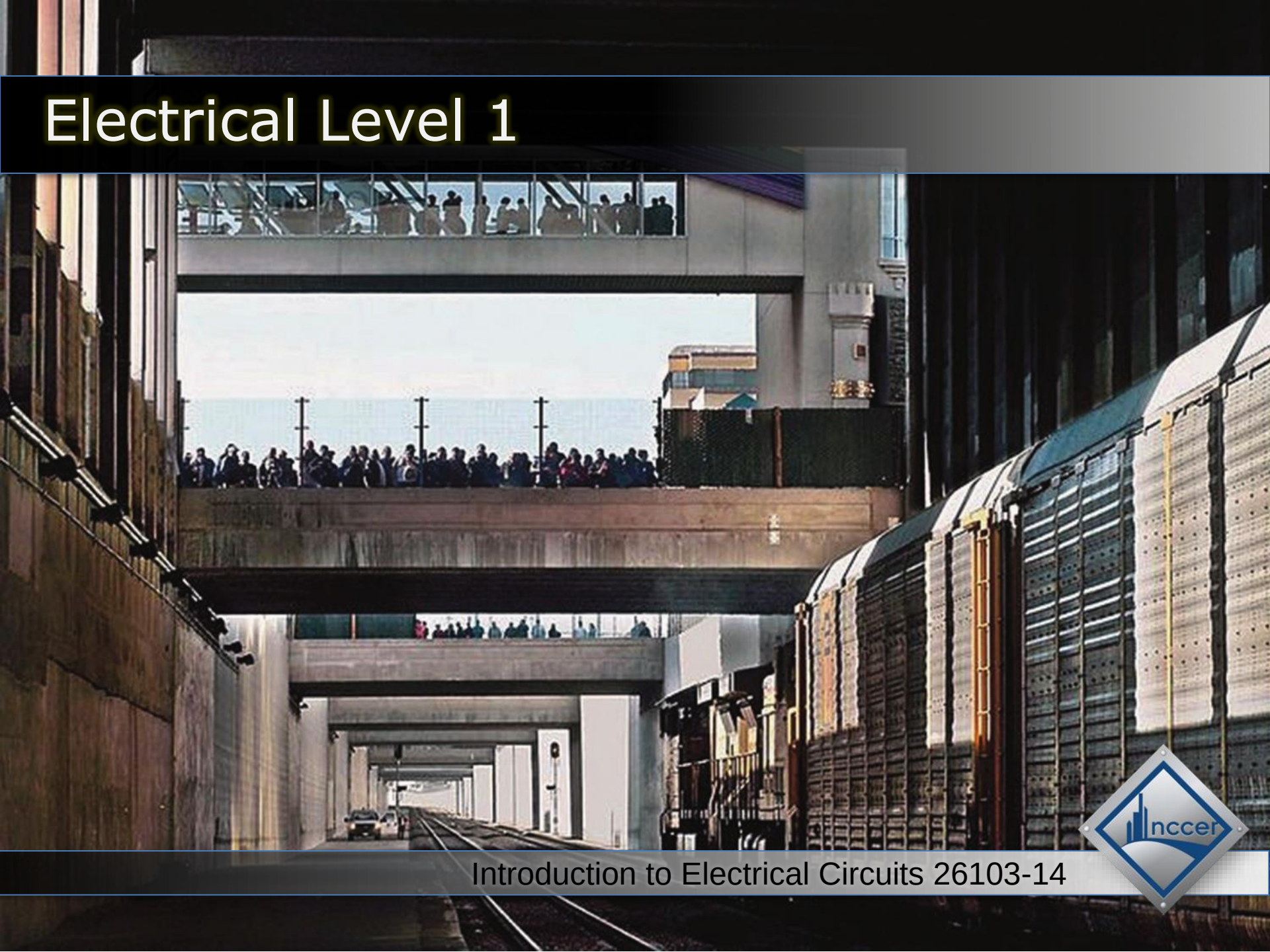
Electrical Level 1



Introduction to Electrical Circuits 26103-14

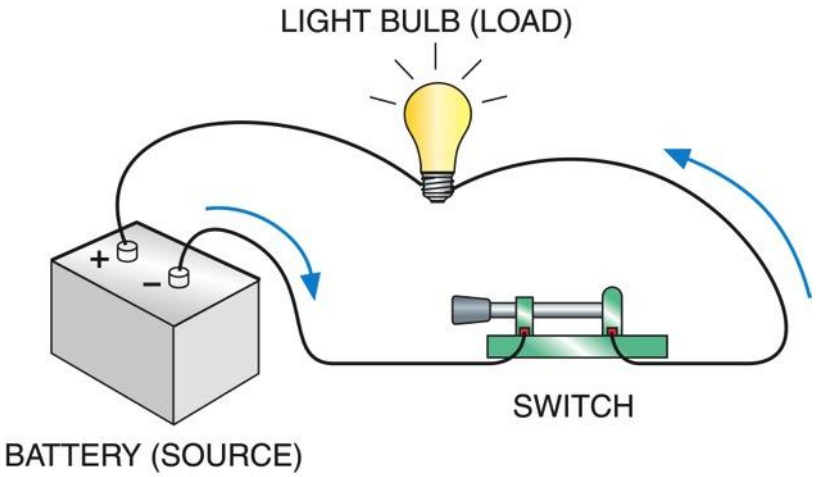
Objectives

When trainees have completed this session, they should be able to do the following:

1. Define voltage and identify the ways in which it can be produced.
2. Explain the difference between conductors and insulators.
3. Define the units of measurement that are used to measure the properties of electricity.
4. Identify the meters used to measure voltage, current, and resistance.
5. Explain the basic characteristics of series and parallel circuits.

This is a knowledge-based module; there are no Performance Tasks.

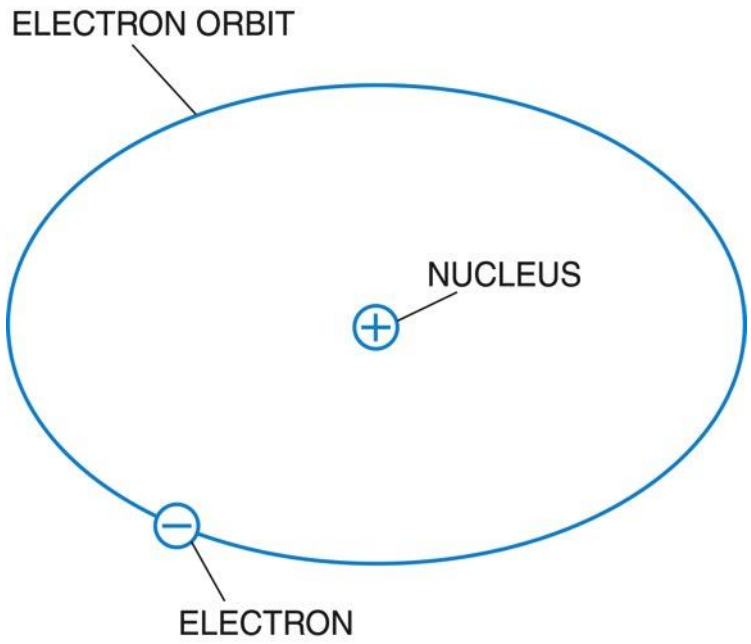
Introduction



- A basic electrical circuit contains a voltage source, a load, and conductors to carry the current.
- Current flow (in amps) is affected by the resistance (in ohms) presented by the load.
- The amount of energy consumed by a load is often expressed in watts (W).

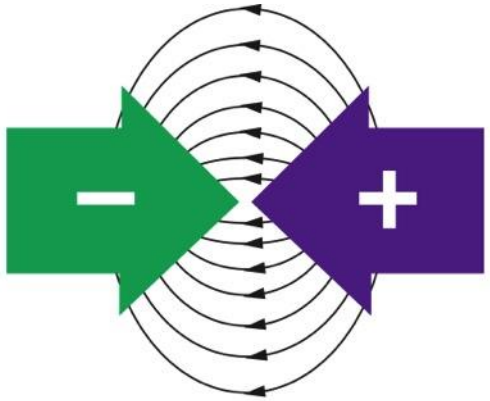
Atomic Theory

The nucleus of an atom contains one or more positive particles (protons) and is orbited by one or more negative particles (electrons).

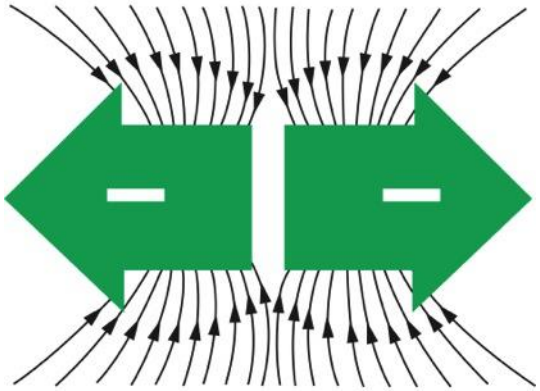


Electrical Charges

Like charges repel one another, while unlike charges attract one another. This is known as the Law of Electrical Charges.



UNLIKE CHARGES ATTRACT



LIKE CHARGES REPEL

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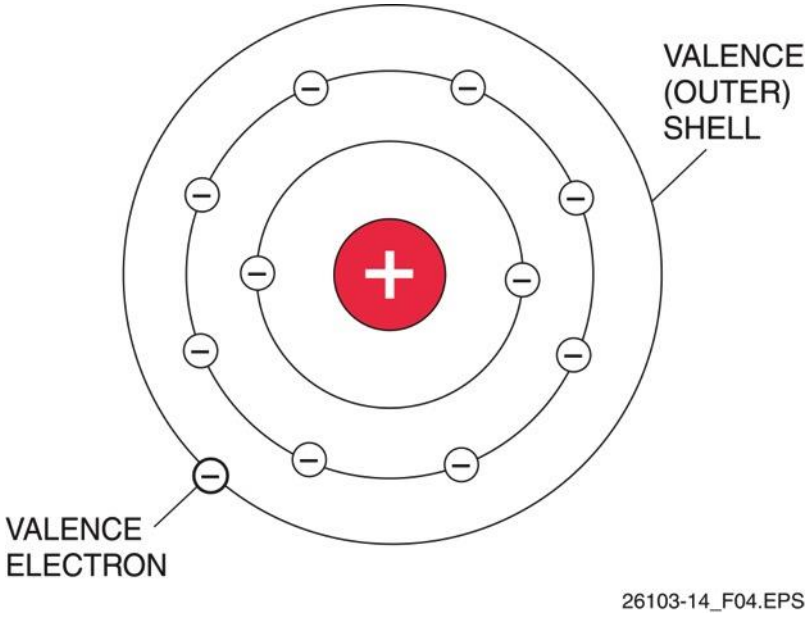
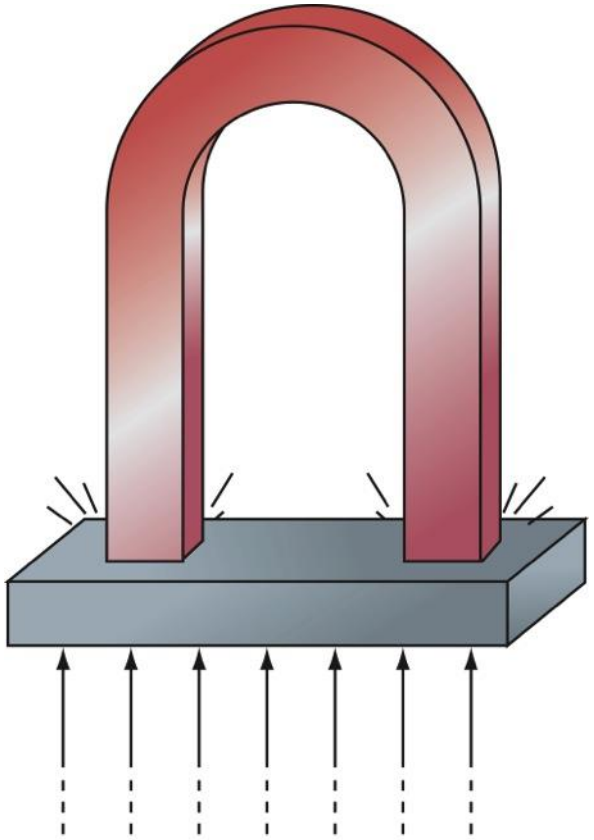
Conductors and Insulators



- Whether or not a substance is a good conductor or insulator depends on the number of electrons in the outermost (valence) shell of an the atom.
- A conductor has three or fewer electrons in the outer shell, an insulator has five or more, and a semiconductor has four.

Magnetism

- Magnetic fields are used to operate motors, relays, transformers, and solenoids.
- Magnetic objects have a north and south pole. Opposing poles attract while like poles repel.



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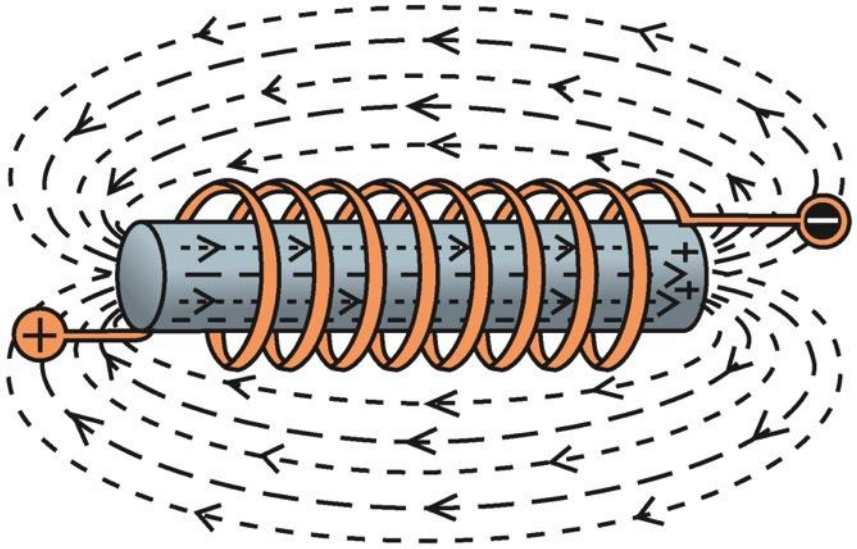
Electromagnet

- Current flow through a conductor produces a magnetic field. When wrapped around an iron bar, it produces an electromagnet.
- The opposing forces in a rotating magnetic field can be used to turn a motor.



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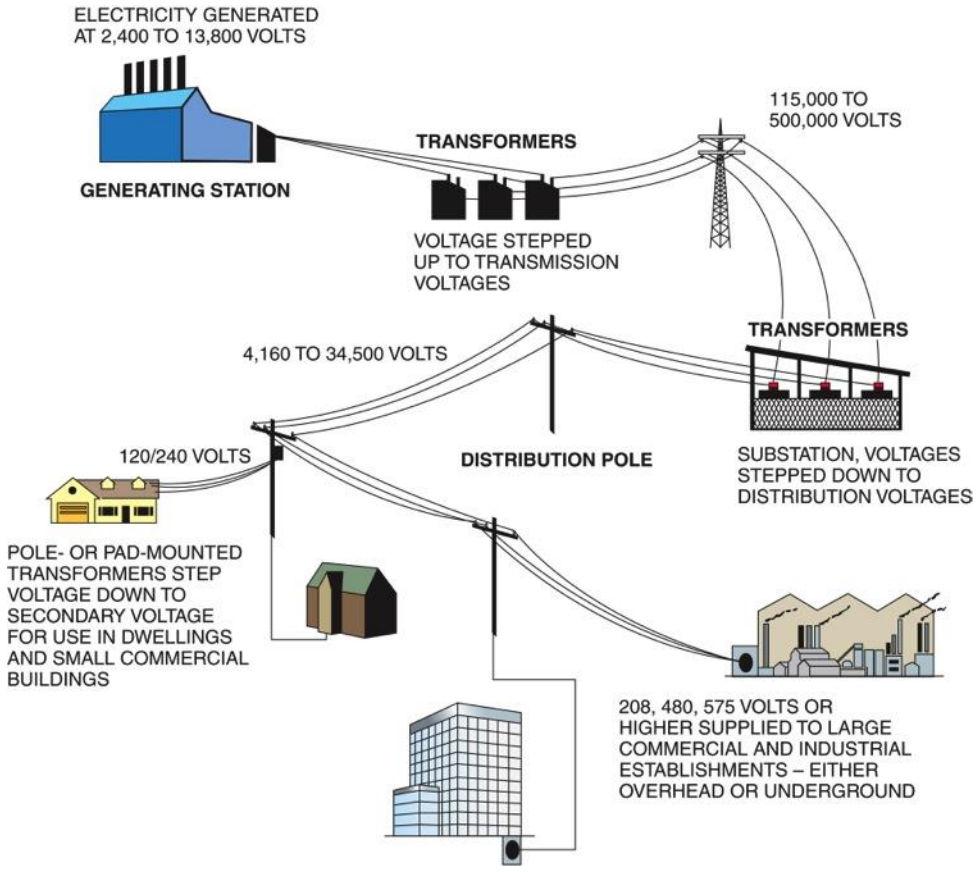
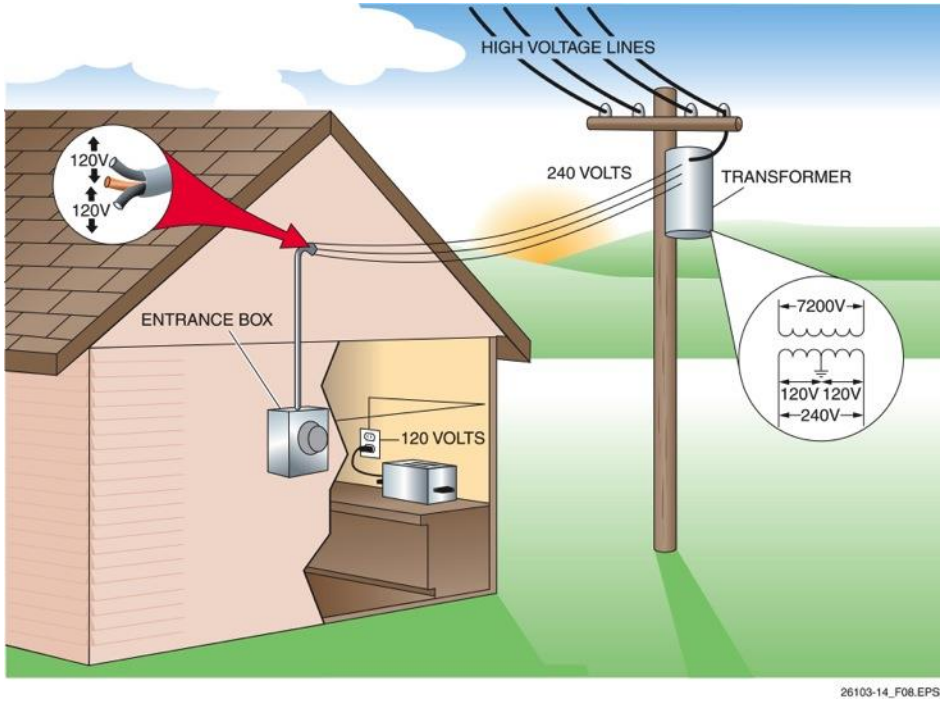
Electrical Power Generation and Distribution



- Electric power can be generated using coal-burning, nuclear, hydroelectric, solar, and wind power plants.
- Power is stepped up for transmission and stepped down for distribution to the end user using transformers.

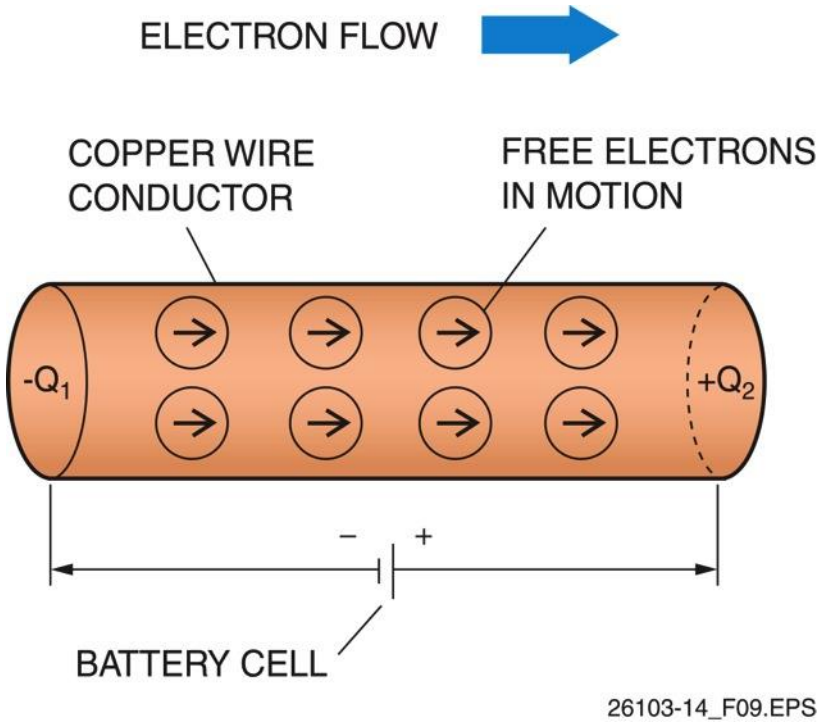
Internal Power Distribution

- The typical residence receives voltage at 240 volts (V), which is used to operate large appliances such as stoves and clothes dryers. Small appliances such as toasters and hair dryers operate on 120V.
- Commercial power is typically three-phase and supplied at 208V, 480V, or 575V.



Electric Charge and Current

- The ability of a charge to do work is called potential. The sum of the electrical charges in a field is the electromotive force (emf) or voltage (V), which is expressed in equations as E.
- Electric charge is measured in coulombs.
- A battery creates an electric charge by chemically producing free electrons at its negative terminal.



Next Session…

Ohm's Law

- Current flow is measured in amps (A) and the intensity of current flow is represented in equations by the letter I.
- Resistance is the opposition to current flow. It is measured in ohms (Ω) and represented in equations by the letter R. The hotter a wire, the greater its resistance.

Conductor Properties

Table 1 Conductor Properties

Metal	Specific Resistance (Resistance of 1 CM/ft in ohms)	
	32°F or 0°C	75°F or 23.8°C
Silver, annealed	8.831	9.674
Copper, pure annealed	9.390	10.351
Copper, annealed	9.590	10.505
Copper, hard-drawn	9.810	10.745
Gold	13.216	14.404
Aluminum	15.219	16.758
Zinc	34.595	37.957
Iron	54.529	62.643

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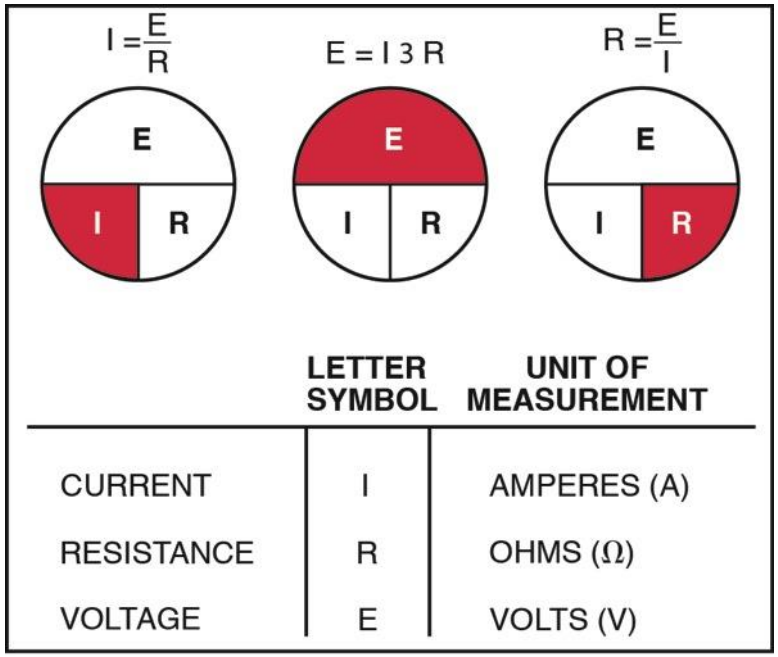
Ohm's Law

- Ohm's law defines the relationships between voltage (E), current (I), and resistance (R).
- The formula can be rearranged to find any of the three values.



	LETTER SYMBOL	UNIT OF MEASUREMENT
CURRENT	I	AMPERES (A)
RESISTANCE	R	OHMS (Ω)
VOLTAGE	E	VOLTS (V)

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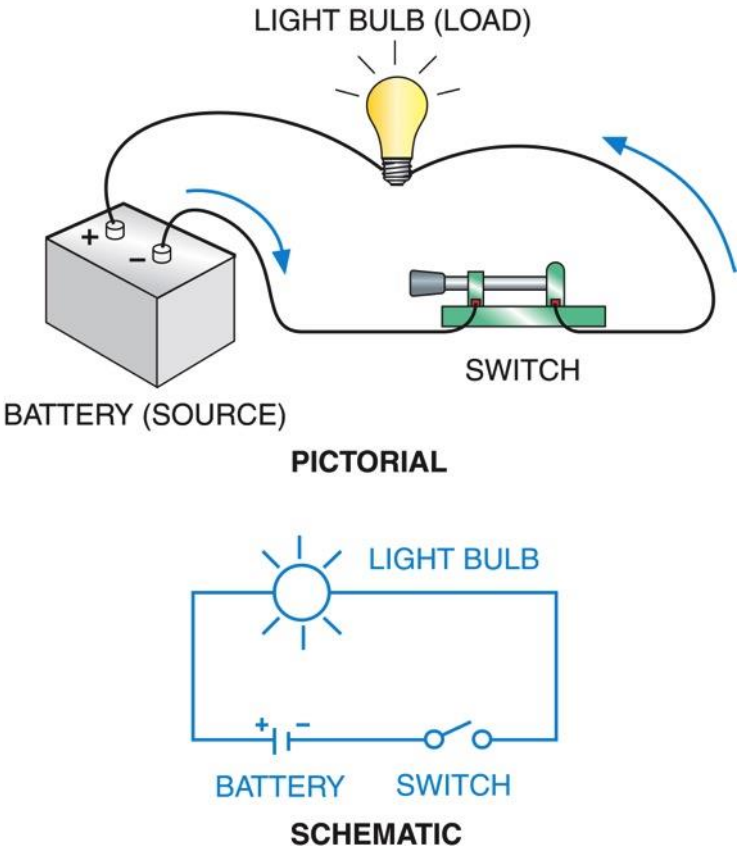
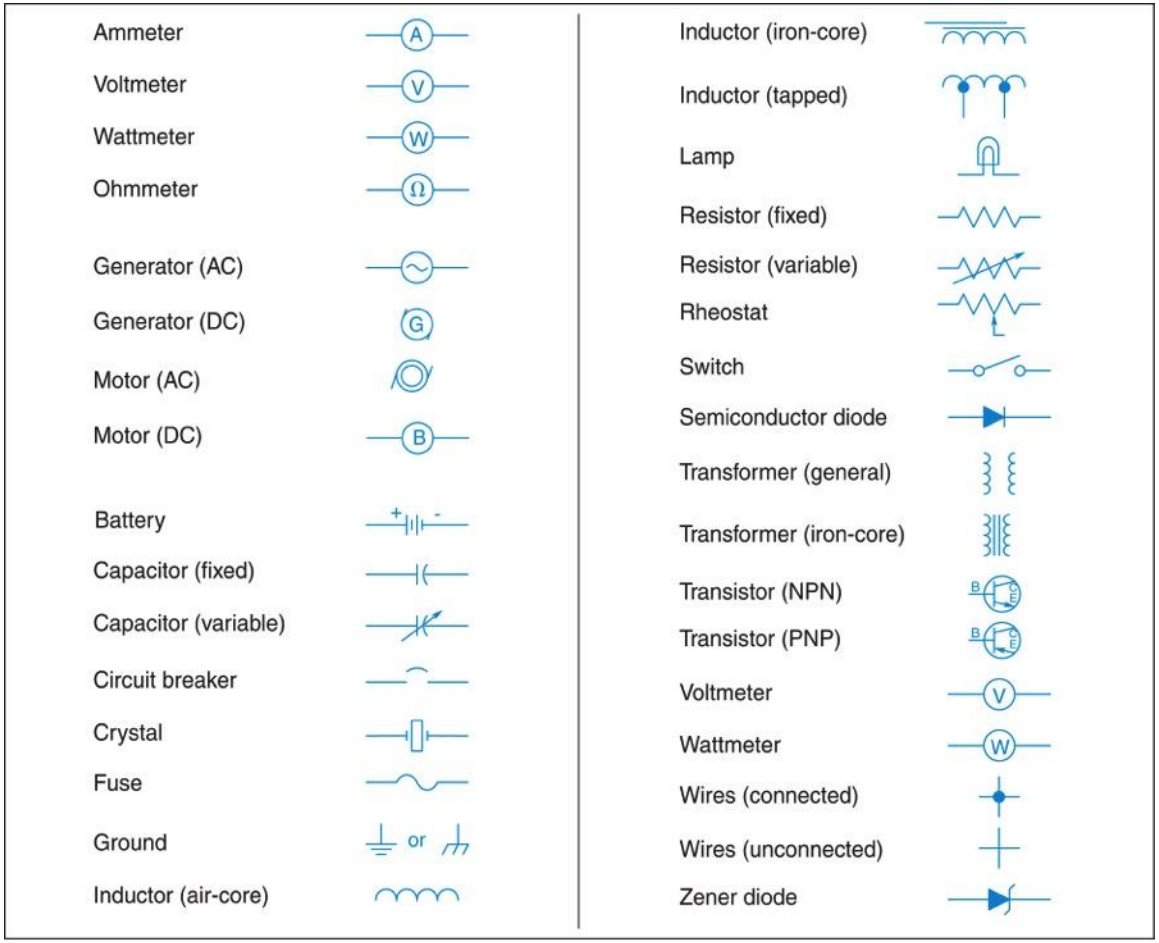
Schematic Representation of Circuit Elements



A schematic diagram shows circuit paths and components using lines and symbols.

Standard Schematic Symbols



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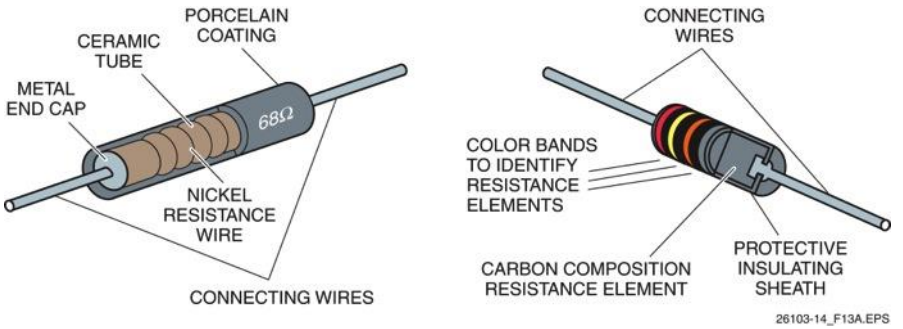
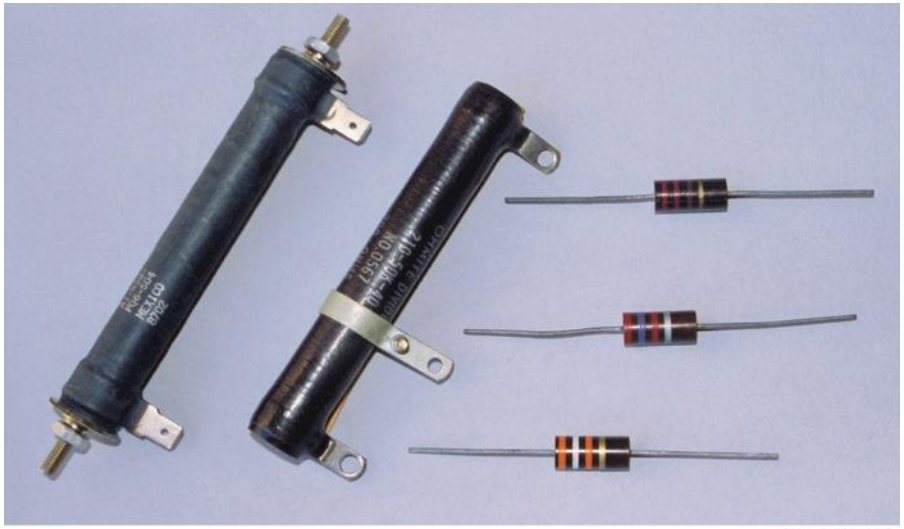
Resistors

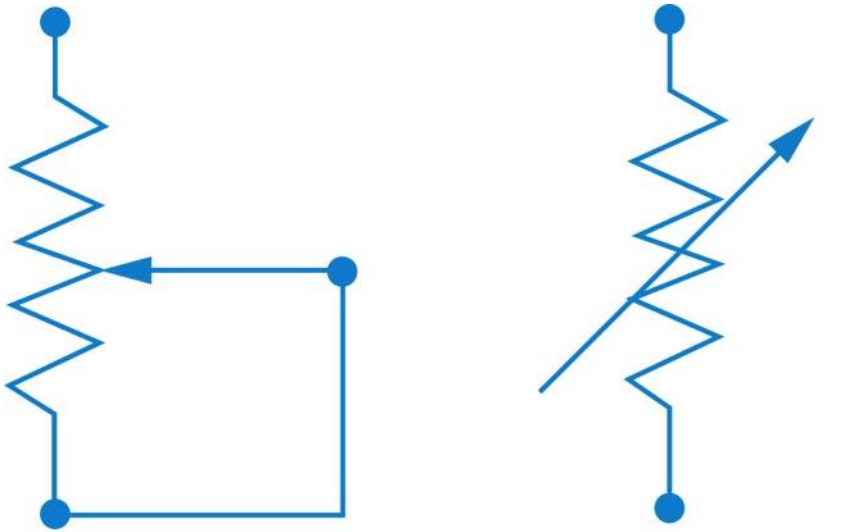




- Resistors are typically made of nickel resistance wire covered in porcelain.
- Fixed resistors are the most common, but variable resistors are also available.

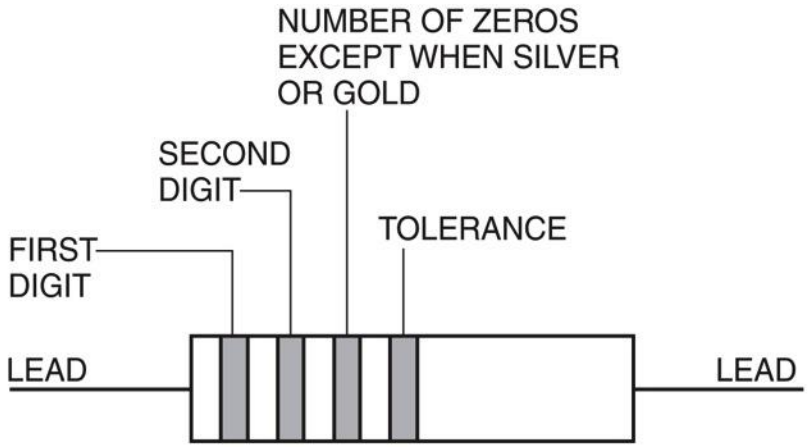
Symbols Used for Variable Resistors

- Variable resistors include rheostats (such as dimmers) and potentiometers.
- The resistance is adjusted using a movable contact.



Resistor Color Codes

Resistors are color-coded to show their value.



0	BLACK	7	VIOLET
1	BROWN	8	GRAY
2	RED	9	WHITE
3	ORANGE	0.1	GOLD
4	YELLOW	0.01	SILVER
5	GREEN	5%	GOLD – TOLERANCE
6	BLUE	10%	SILVER – TOLERANCE

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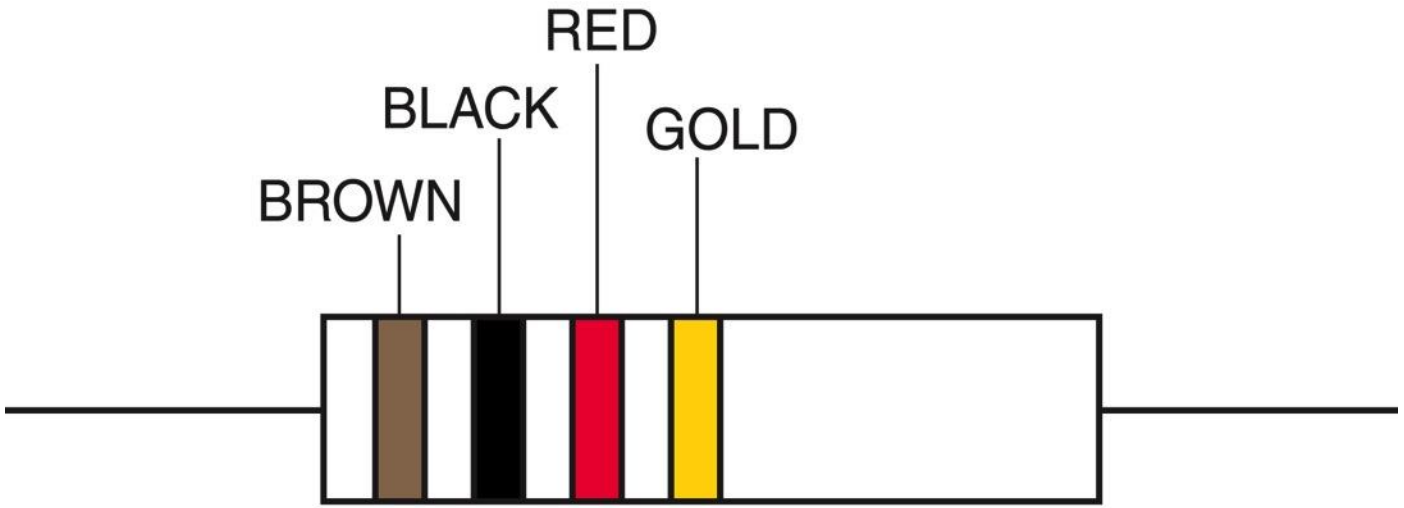
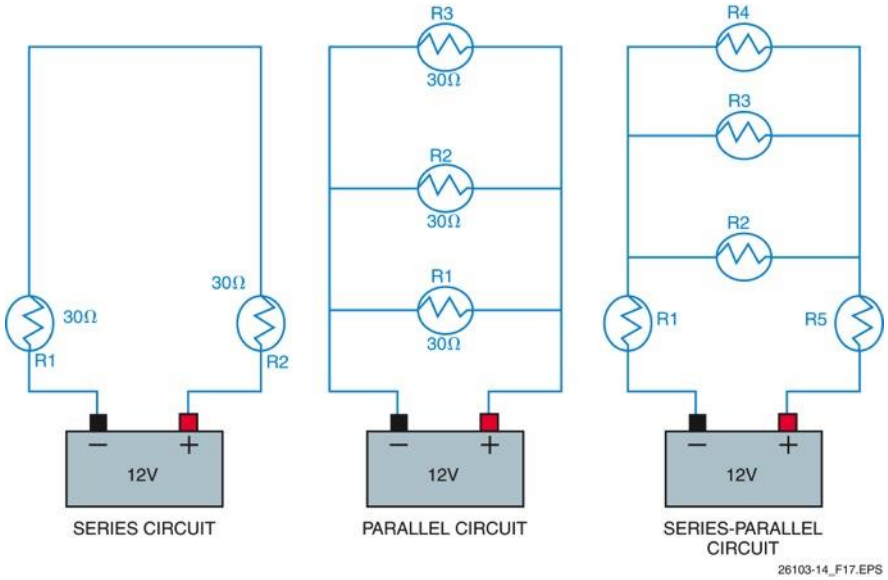
Sample Color Codes on a Fixed Resistor

- Brown = 1, black = 0, red = 2 zeros, gold = tolerance of +/-5%.
- This resistor has a value of 1,000Ω, +/-5%.



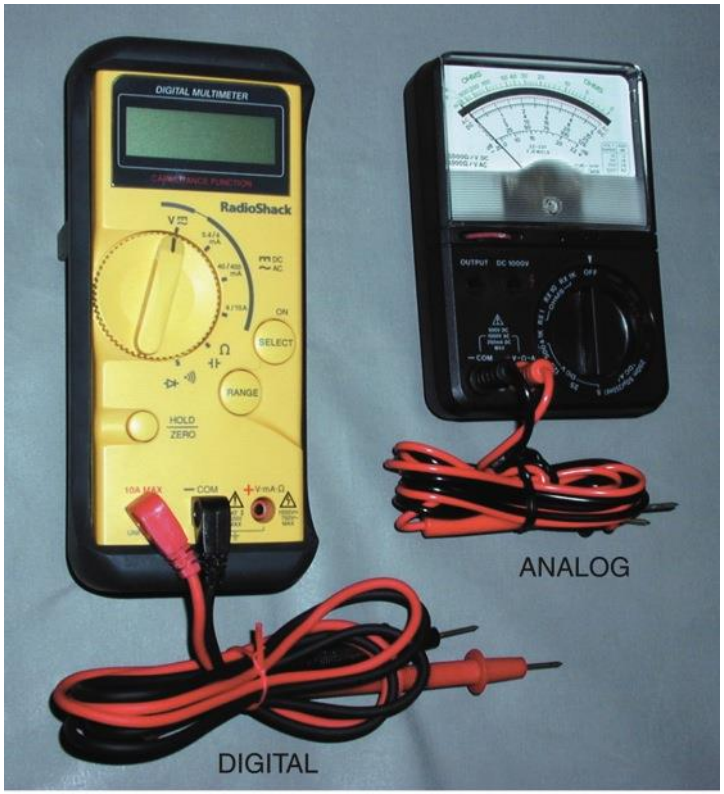
Electrical Circuits

- Circuits can be categorized by the way in which the loads are connected.
- Common connections include series, parallel, and series-parallel. Most household circuits are wired in parallel.
- The type of circuit determines the method used to calculate the resistance.



Electrical Measuring Instruments

The most common test meter is the volt-ohm-milliammeter (VOM). Both analog and digital versions are available.



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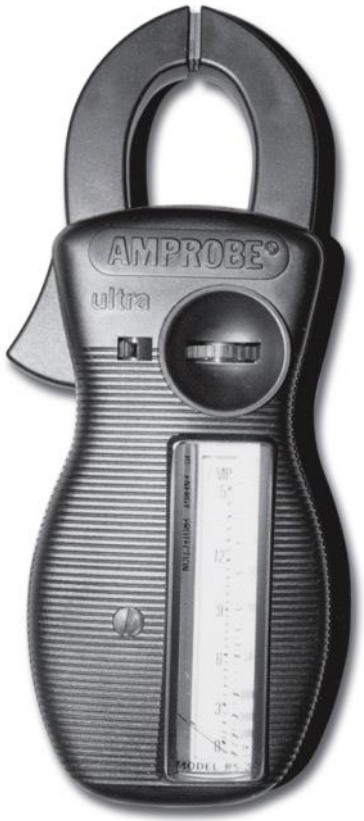
Clamp-On Ammeter

- A clamp-on ammeter is used to measure the current through a conductor by clamping the jaws of the meter around the wire.
- The magnetic field created by the current in the conductor is then measured by the meter.



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Measuring Current

- Do not use a clamp-on ammeter with dirty or misaligned jaws.
- Use the meter on only one conductor at a time.

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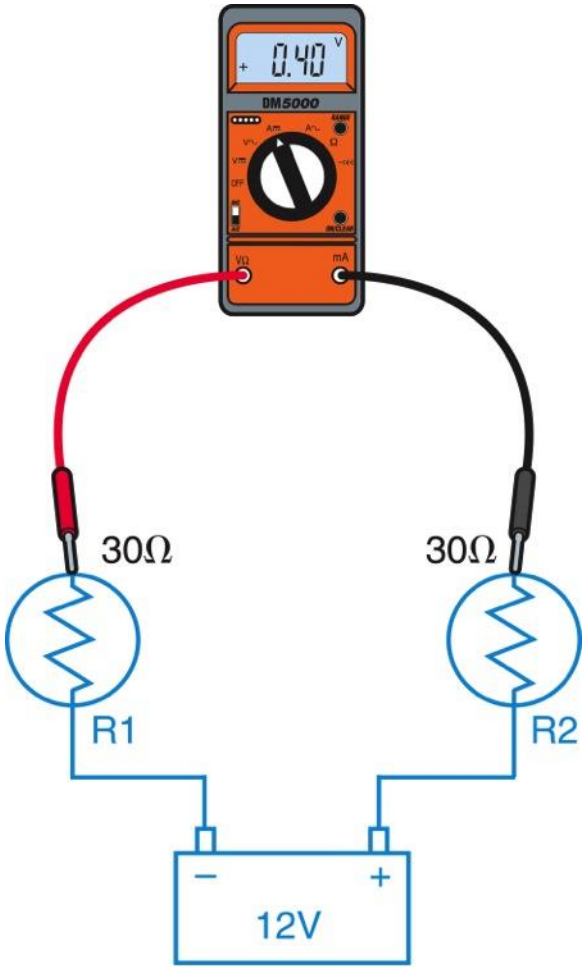
In-Line Ammeter Test Setup

Inline ammeters are connected in series with the circuit and are much less common because they require the circuit to be opened.



SERIES CIRCUIT

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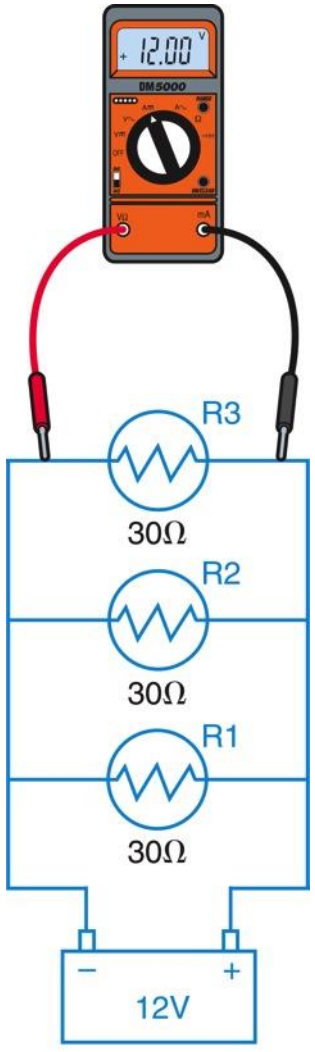
Measuring Voltage

- A voltmeter is connected in parallel with (across) the component or circuit to be tested to check whether the correct voltage is being supplied.
- Like an ammeter, a voltmeter is used with the power on.



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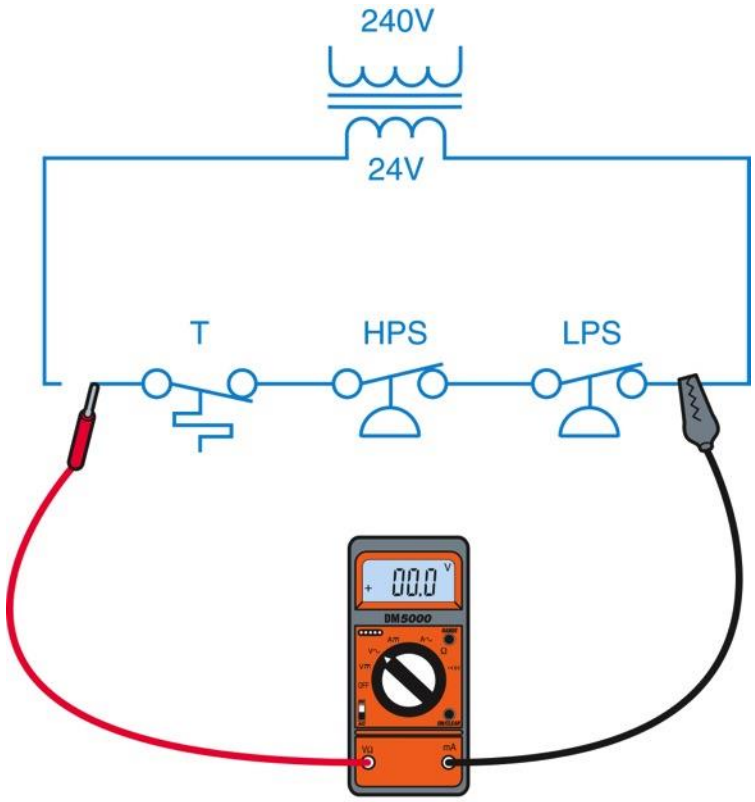
Measuring Resistance

- Resistance is measured using an ohmmeter with the power to the circuit shut off.
- Ohmmeters can be used to check the resistance of motor windings and to check for electrical continuity in a circuit.



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Continuity Tester

- A simple continuity tester can also be used to check for continuity or to identify multiple wires in a circuit.
- A continuity tester uses a beep and/or light to indicate a continuous circuit. If there is no signal, the circuit is open.

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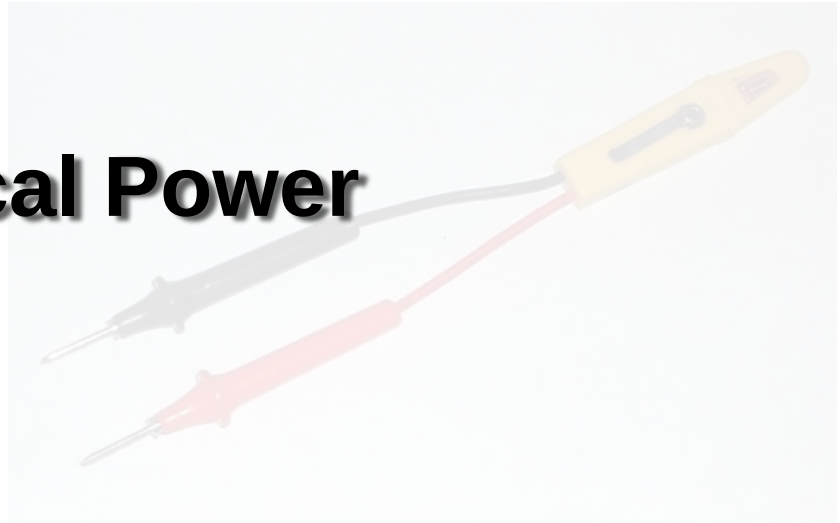
Next Session…

Voltage Testers

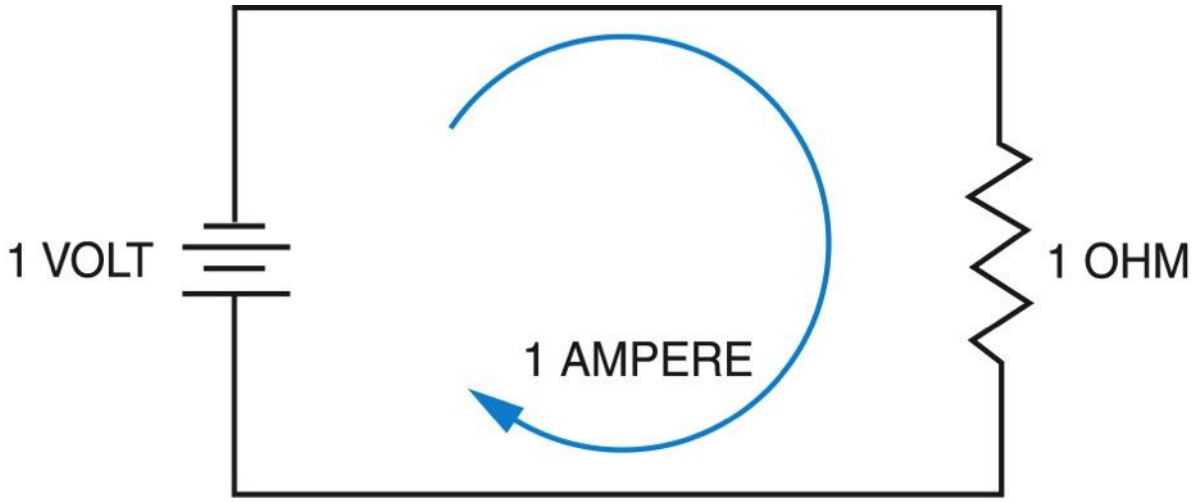
- Voltage testers can be used to check for the presence of voltage when troubleshooting a circuit or to make sure the voltage is off before handling components.
- Voltage testers typically only show the presence/absence of voltage and are not meant for precise circuit measurements.



Electrical Power

Electrical Power

- Power is defined as the rate of doing work or the energy used. Electrical power is measured in joules (J). One watt (W) is the measure of the number of joules per second (J/s).
- One watt is also equal to one ampere of current flowing through a potential difference of one volt.



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Conversion Table

- Mechanical power is measured in terms of horsepower (hp).
- To convert horsepower to watts, multiply by 746. For example, a 2hp motor draws 1,492W.
- A kilowatt (kW) is equal to 1,000W.

Table 2 Conversion Table

1,000 watts (W)	=	1 kilowatt (kW)
1,000,000 watts (W)	=	1 megawatt (MW)
1,000 kilowatts (kW)	=	1 megawatt (MW)
1 watt (W)	=	0.00134 horsepower (hp)
1 horsepower (hp)	=	746 watts (W)

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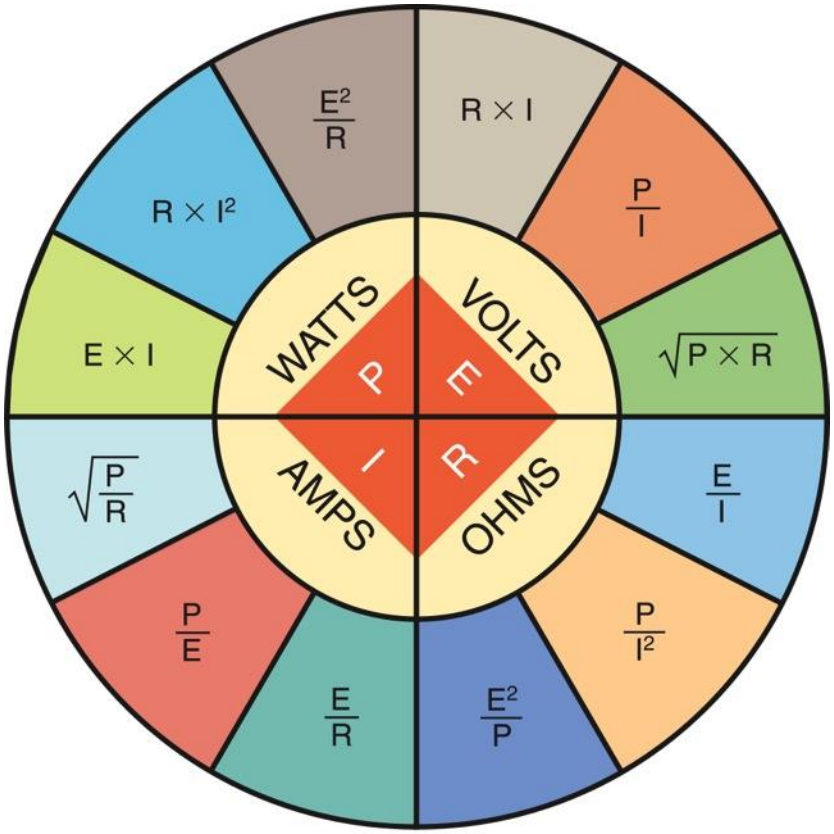
Power Equation; Power Rating of Resistors



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- Power is calculated using the formula: Power (P) = Current (I) x Voltage (E). The formula can be rearranged to find any unknown value.
- Resistors are given power ratings to show how much heat the resistor can withstand before burning out.

Wrap Up

3-2-1

3 – Write 3 important things learned during class

2 – Write 2 questions you have about the material

1 – Write 1 thought you had about the material

Next Session…

MODULE EXAM

Review the complete module to prepare for the module exam. Complete the Module Review as a study aid.