

# Preview of Period 12: Electric Circuits

## 12.1 Voltage, Current, and Resistance

How are voltage, current, and resistance related?

## 12.2 Resistance and Voltage of Resistors in Connected in Series

How does current flow through a series circuit?

## 12.3 Resistance and Voltage of Resistors Connected in Parallel

How does current flow through a parallel circuit?

## 12.4 Voltage, Resistance, and Current in Combination Circuits

How does current flow through a circuit composed of series and parallel resistors?

## Voltage, Current and Resistance

**Voltage = Current x Resistance**

$$V = I R$$

$V$  = voltage (in volts)

$I$  = current (in amps)

$R$  = resistance (in ohms)

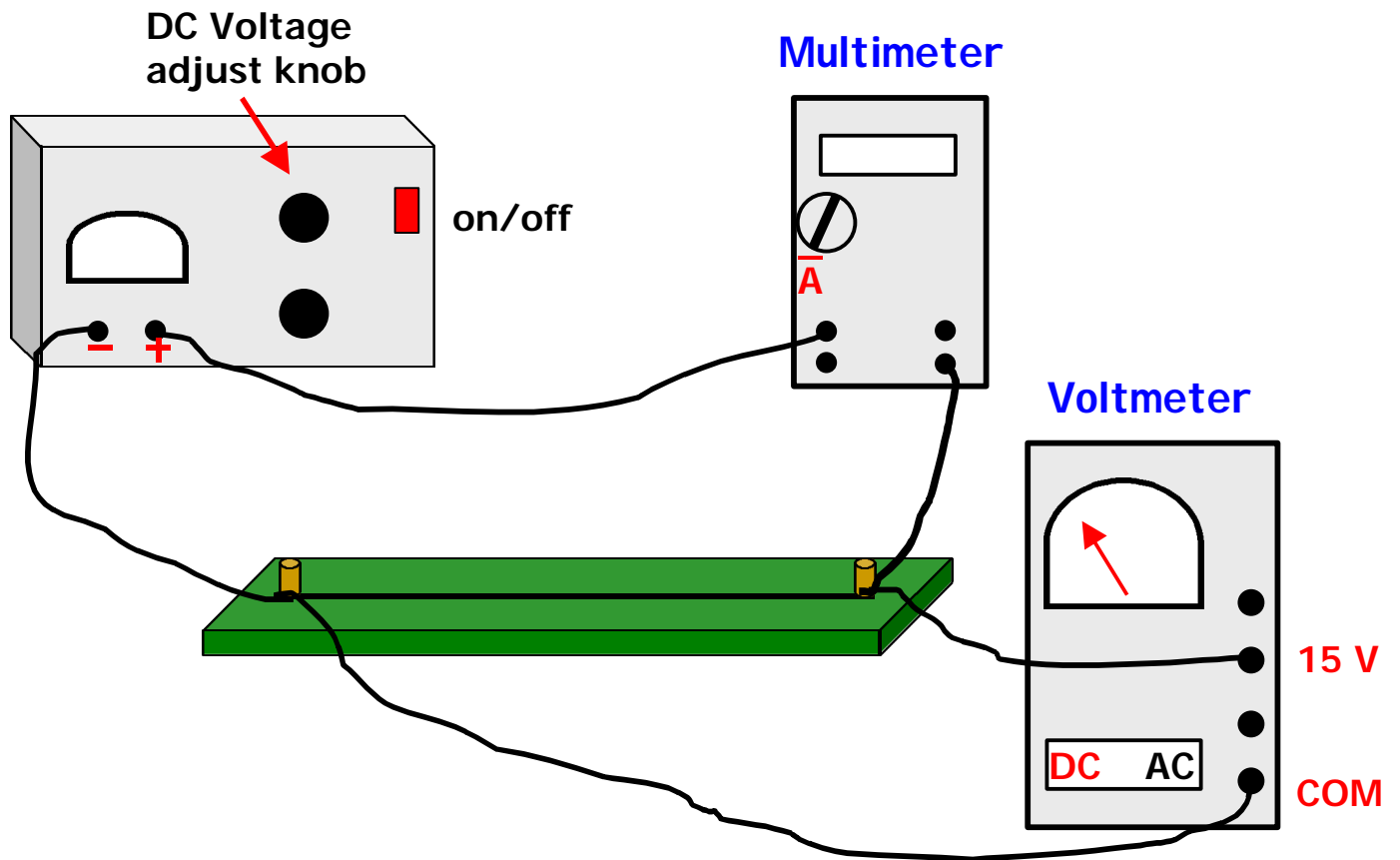
(Ex. 12.1)

What is the resistance of a circuit that requires 5 volts of voltage to push 10 amps of current through a circuit?

Solve  $V = I R$  for  $R$  by dividing both sides of the equation by  $I$ :

$$R = \frac{V}{I} = \frac{5 \text{ volts}}{10 \text{ amps}} = 0.5 \text{ ohms}$$

## Act. 12.1: Voltage and Current



1. Connect the meters to the **thin** 30 cm wire.
2. Set the multimeter to "**A**" to measure DC current.
3. Set the voltmeter switch to "**DC**"  
Read the voltage from the 0 - 15 V scale.
4. Adjust the DC voltage adjust knob on the power source to provide the correct voltage for each measurement. (For accuracy, use the voltage reading on the voltmeter.)

## Graph of Voltage vs. Current

To find the slope of the graph:

- 1) Pick any two points on the line.
- 2) Slope =  $\frac{\text{vertical distance between the points}}{\text{horizontal distance between the points}}$

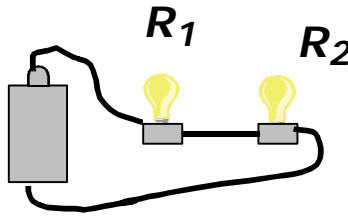
What is the physical meaning of the slope?

- 1) The graph represents voltage/current
- 2) Compare to  $V/I = R$

## Act. 12.2: Resistors in Series

When circuit elements (sources and loads) are connected so that the **same current flows through each element**, the elements are connected in **series**.

### Bulbs connected in series



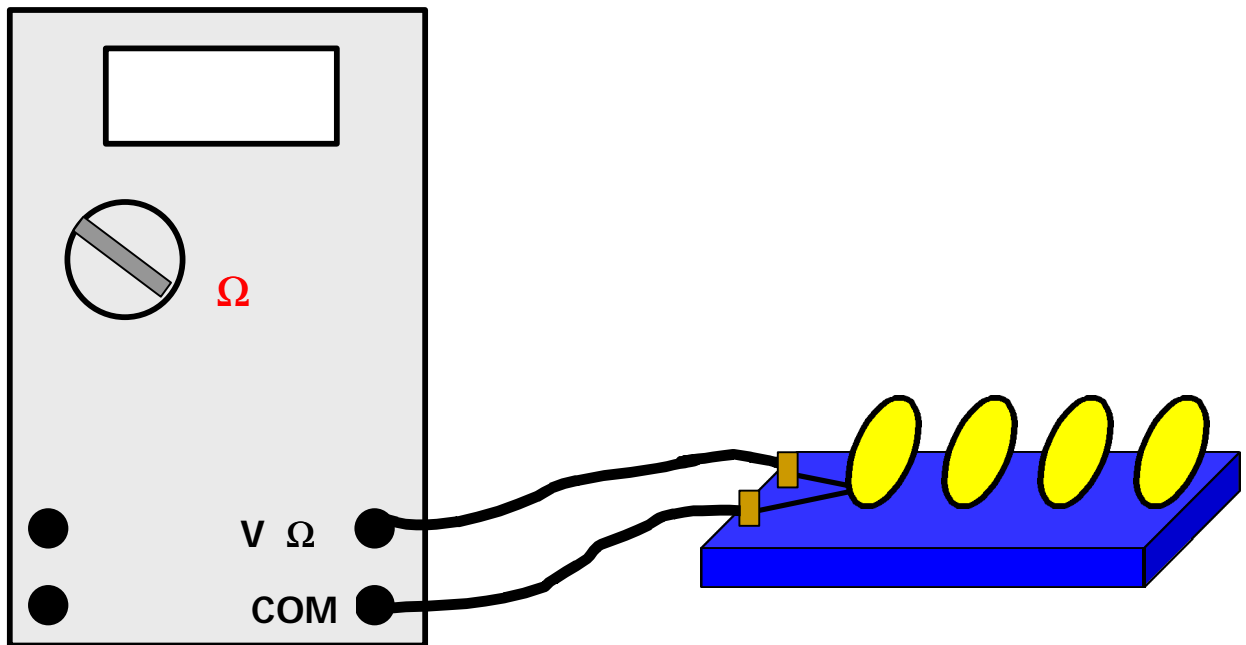
The **total resistance** of a series circuit is

$$R_{Tot} = R_1 + R_2 + R_3 + \dots$$

- ◆ When resistors are connected in series, the largest voltage drop occurs across the load device with the largest resistance.
- ◆ The sum of the voltage drops across the loads in a circuit equals the sum of the voltage boosts from the sources.

## Measuring the Resistance of A Bulb

1. Turn the dial to the ohm symbol ( $\Omega$ ).
2. Check that the wire leads are attached to the outlets on the **lower right** of the meter.
3. To measure resistance of one bulb, attach the leads to either side of the bulb.
4. To measure resistance of the entire tray, attach the leads as shown below.

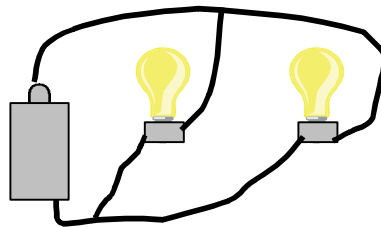


**Do not connect the bulbs to a battery.**

## Act. 12.3: Resistors in Parallel

When circuit elements are connected so that the current has **multiple paths** to flow through, the elements are connected in **parallel**.

**Bulbs connected in parallel**



The **total resistance** of a parallel circuit is:

$$\frac{1}{R_{Tot}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$

- ◆ A circuit with two parallel resistors has less total resistance than a circuit with one resistor.
- ◆ Current flows more easily through a parallel circuit because it has multiple paths through the resisting material.
- ◆ The more parallel paths for current flow, the lower the resistance.

## Calculating Resistance in Parallel

(Example 12.6)

Three resistors with resistances of 3 ohms, 4 ohms, and 6 ohms are connected in parallel in a circuit. What is the total resistance of this parallel circuit?

$$\frac{1}{R_{Tot}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} =$$

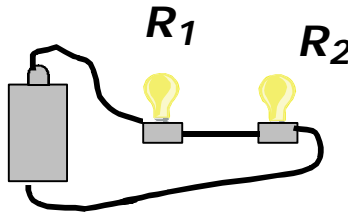
$$\frac{1}{3} + \frac{1}{4} + \frac{1}{6} \Omega = \frac{4}{12} + \frac{3}{12} + \frac{2}{12} \Omega = \frac{9}{12} \Omega$$

To find  $R_{Tot}$  invert the fraction and divide the numerator by the denominator.

$$\frac{1}{R_{Tot}} = \frac{9}{12} \Omega \quad R_{Tot} = \frac{12}{9} \Omega = 1.33 \Omega$$

## Comparison of Series and Parallel Circuits

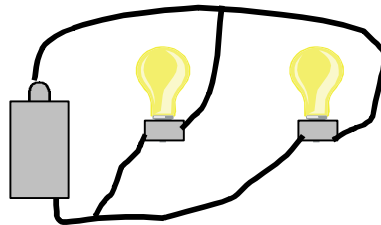
When the **same current flows through each element**, the elements are connected in **series**.



The total resistance of a series circuit is

$$R_{Tot} = R_1 + R_2 + R_3 + \dots$$

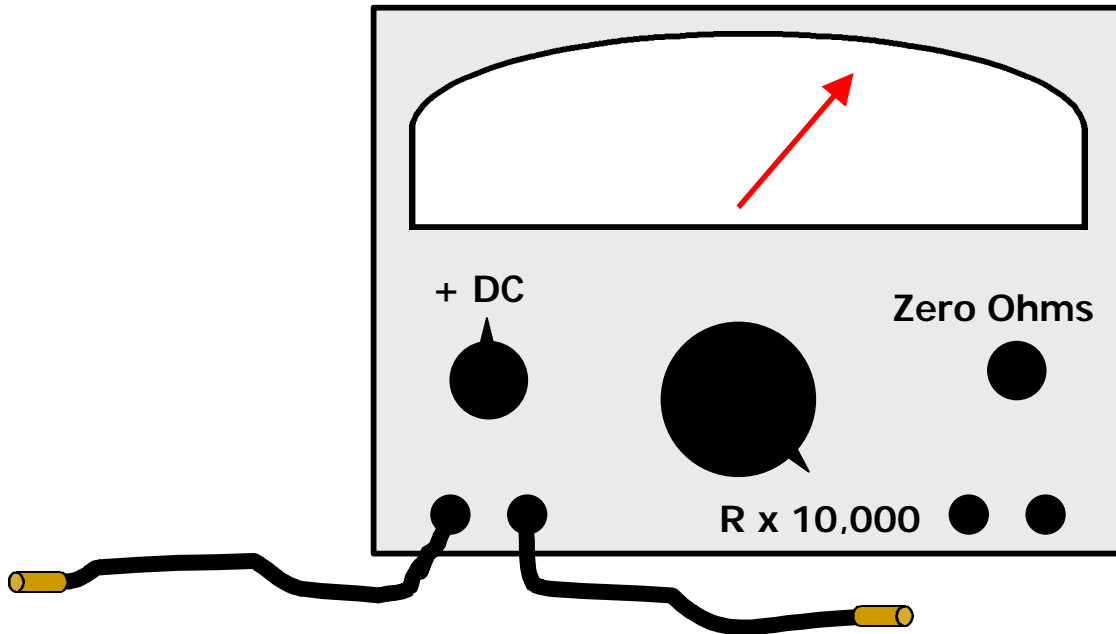
When the current has **multiple paths** to flow through, the elements are connected in **parallel**.



The total resistance of a parallel circuit is:

$$\frac{1}{R_{Tot}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$

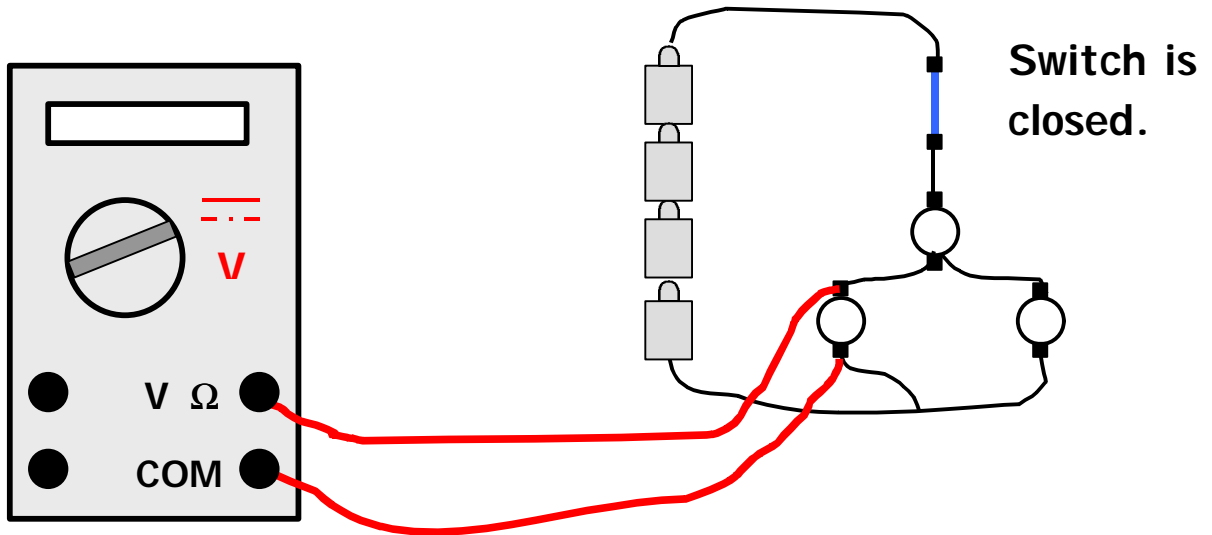
## Act. 12.3 Measuring Your Resistance



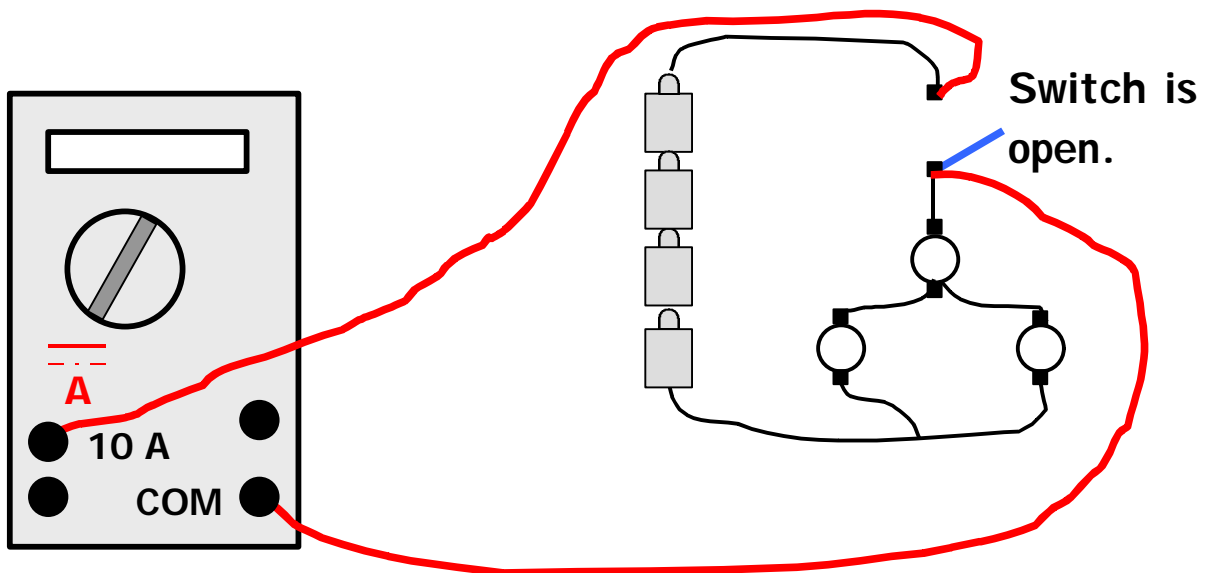
1. Set the meter to **R x 10,000** and **+ DC**.
2. Clip one metal rod to each lead. Hold the rods together and adjust **the zero ohm knob** until the top scale reads "0."
3. Grasp one rod in each hand.
4. To measure resistance in series, have people grasp a rod in each hand to form a circle. Clip the leads to two rods.
5. To measure resistance in parallel, have people grasp the same two rods, one in each hand. Clip the leads to the rods.

## Act 12.4: Measuring Current and Voltage

Measuring the voltage across a bulb.



Measuring the current through a bulb.



## Act 12.4: Current Flow through Resistors in Parallel

Why does more current flow through the circuit when bulb #3 is lit?

- ◆ Screwing in bulb #3 adds another parallel pathway for the current to follow.
- ◆ The more parallel pathways in a circuit, the lower the circuit's resistance.
- ◆ Lower resistance means more current can flow through the circuit.

## Period 12 Summary

**12.1** The relationship among voltage, current and resistance is  $V = I R$

The slope of the graph of voltage versus current gives the value of the resistance.

**12.2** The resistances of resistors in series add.

$$R_{Tot} = R_1 + R_2 + R_3 + \dots$$

- ◆ The larger the resistance, the greater the voltage drop across the resistor.
- ◆ The voltage drops across these resistors must equal the voltage boosts across the circuit's energy sources.

**12.3** Resistors in parallel provide additional paths for current flow and reduce the total resistance of the circuit.

- ◆ The more resistors in parallel, the lower the circuit's resistance

$$\frac{1}{R_{Tot}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_2} + \dots$$

## Period 12 Review Questions

- R.1** A circuit consists of a battery connected to a light bulb. If a second bulb is added in series, does the current in the circuit change? Why?
- R.2** A circuit consists of a battery connected to a light bulb. If a second battery is added in series with the first battery, does the circuit's voltage change? Does the current change?
- R.3** What happens to the total resistance of a circuit if resistors are added in series? If resistors are added in parallel? Why?
- R.4** Three 1.5 volt batteries in series are connected in series to a 15 cm resistor wire and a 30 cm resistor wire. What is the total voltage boost from the batteries? How much of a voltage drop is across each resistor? (Assume the connecting wires have no resistance.)
- R.5** When a graph of the voltage and current of a circuit results in a straight line, what is the meaning of the slope of the graph line?