Preview of Period 11: Electric Current

11.1 Electric Charge
How does electric charge do work?

11.2 Electric Circuits
How does a flashlight work?

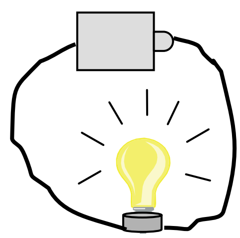
11.3 Electric Current
What is electric current?

11.4 Voltage Boosts and Drops
What happens to the voltage of electric charge as it flows through a circuit?

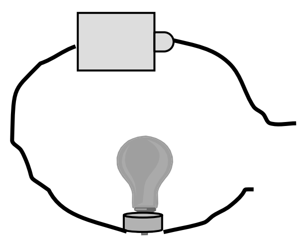
11.5 Electrical Resistance
What resists the flow of electric current?

Act. 11.2 Electric Circuits

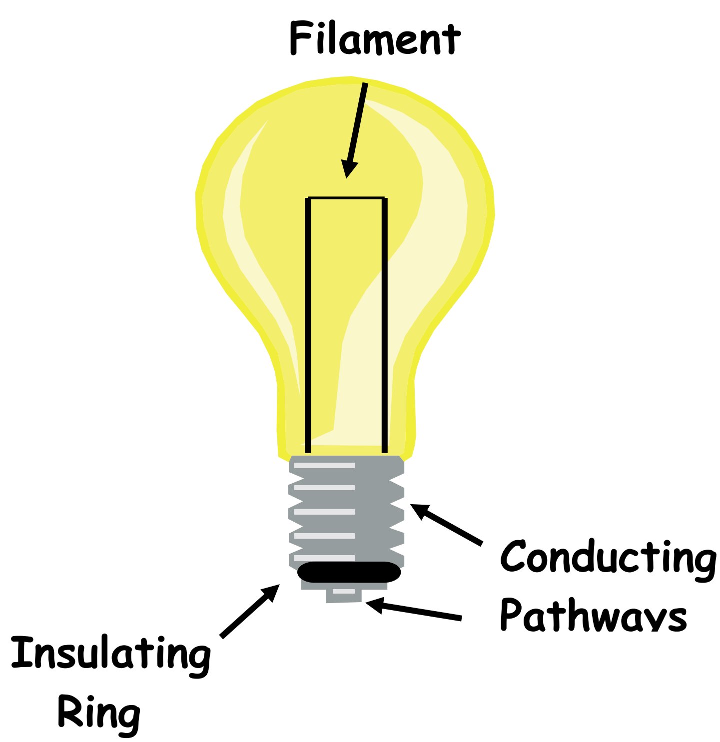
Closed and Open Circuits



With a closed circuit the bulb lights



With an open circuit the bulb does not light.



Act. 11.3: Electric Current

$$\text{Current} = \frac{\text{Amount of Charge moved}}{\text{Elapsed Time}}$$

$$I = \frac{Q}{t}$$

I = current (in amperes)

Q = charge (in coulombs)

t = time elapsed (in seconds)

(Ex. 11.1)

How much charge must flow to provide a current of 10 amps for 20 seconds?

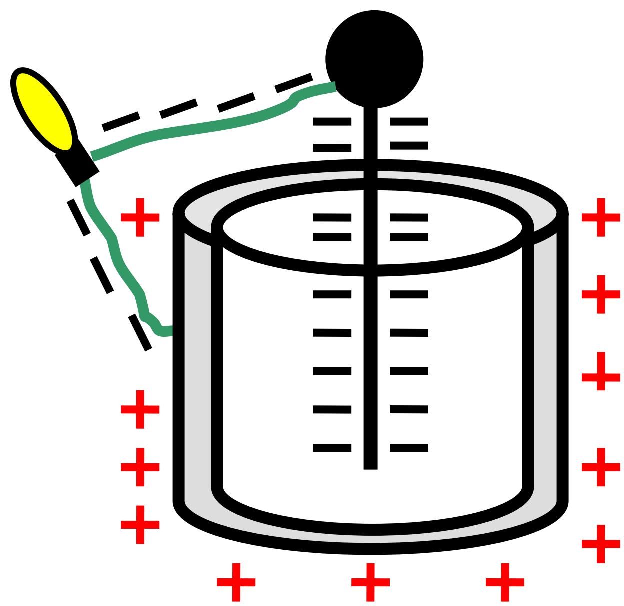
Solve the current equation for Q by multiplying both sides by t:

$$Q = I\ t = 10 \text{ amps} \times 20 \text{ sec} = 200 \text{ coul}$$

Flowing Charge = Electric Current

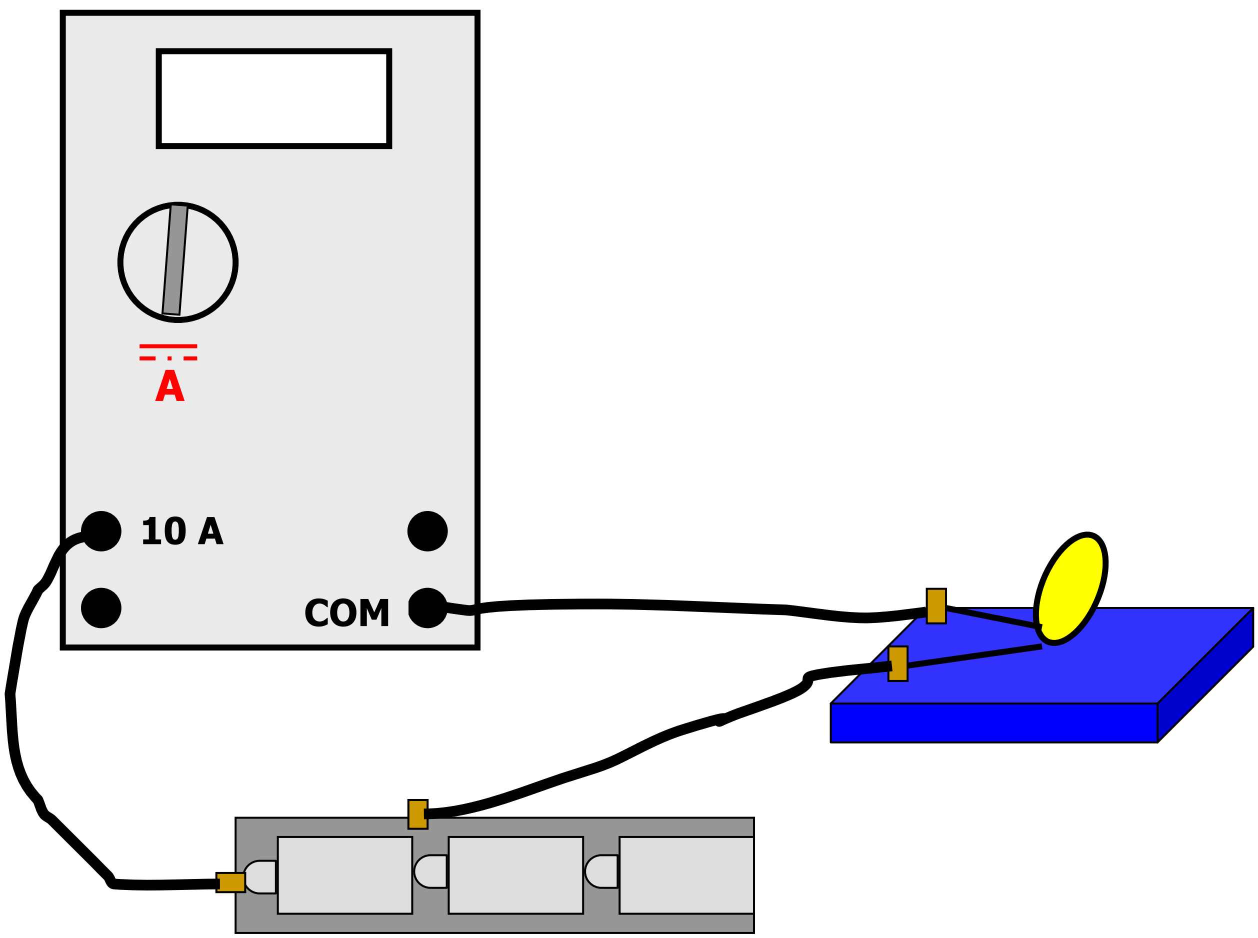
Negative charges flow from the inner Leyden jar, through the bulb filament, and onto the positively charged outer Leyden jar.

This flow of charge is an electric current.



Measuring Current with a Multimeter

1. Turn the dial to the current symbol (A).
2. Place one wire lead in the bottom right outlet (marked "COM"). Place the other lead in the top left outlet (marked "10 A").
3. To measure the current through the bulb, clip the ends of the leads into the circuit.



Act.11.4: Voltage Boosts and Drops

Voltage Boosts

- As a battery pushes charge through a circuit, it increases the electrical potential energy of the charge.
- The potential energy per unit charge, or voltage, increases when charge flows through a battery.
- When batteries are connected in series, charges get a voltage boost from each battery.

Voltage Drops

- Voltage drops occur as current flows through load devices (resistors) in the circuit.
- The voltage boost from the battery is divided among the load devices in the circuit.
- The sum of the voltage boosts and drops in a closed circuit are equal.

Measuring Voltage across a Battery

1. Turn the dial to the voltage symbol ($\overline{\text{V}}$).
2. Attach the two wire leads to the two outlets on the lower right of the meter.
3. To measure voltage across a battery, touch the ends of the leads to each end of the battery.

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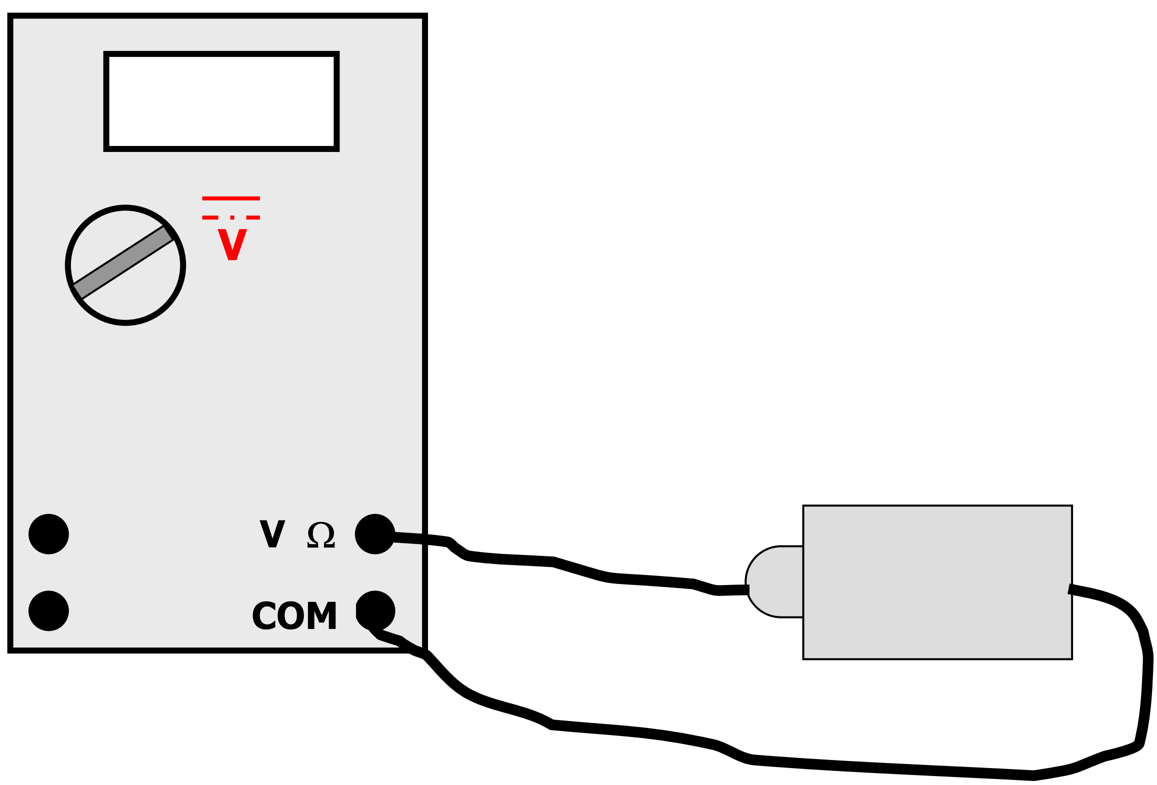

Measuring the Voltage across a Bulb

1. Turn the dial to the voltage symbol (V).
2. Attach the two wire leads to the two outlets on the lower right of the meter.
3. To measure voltage across a bulb or other circuit element, attach the ends of the leads to each side of the circuit element.

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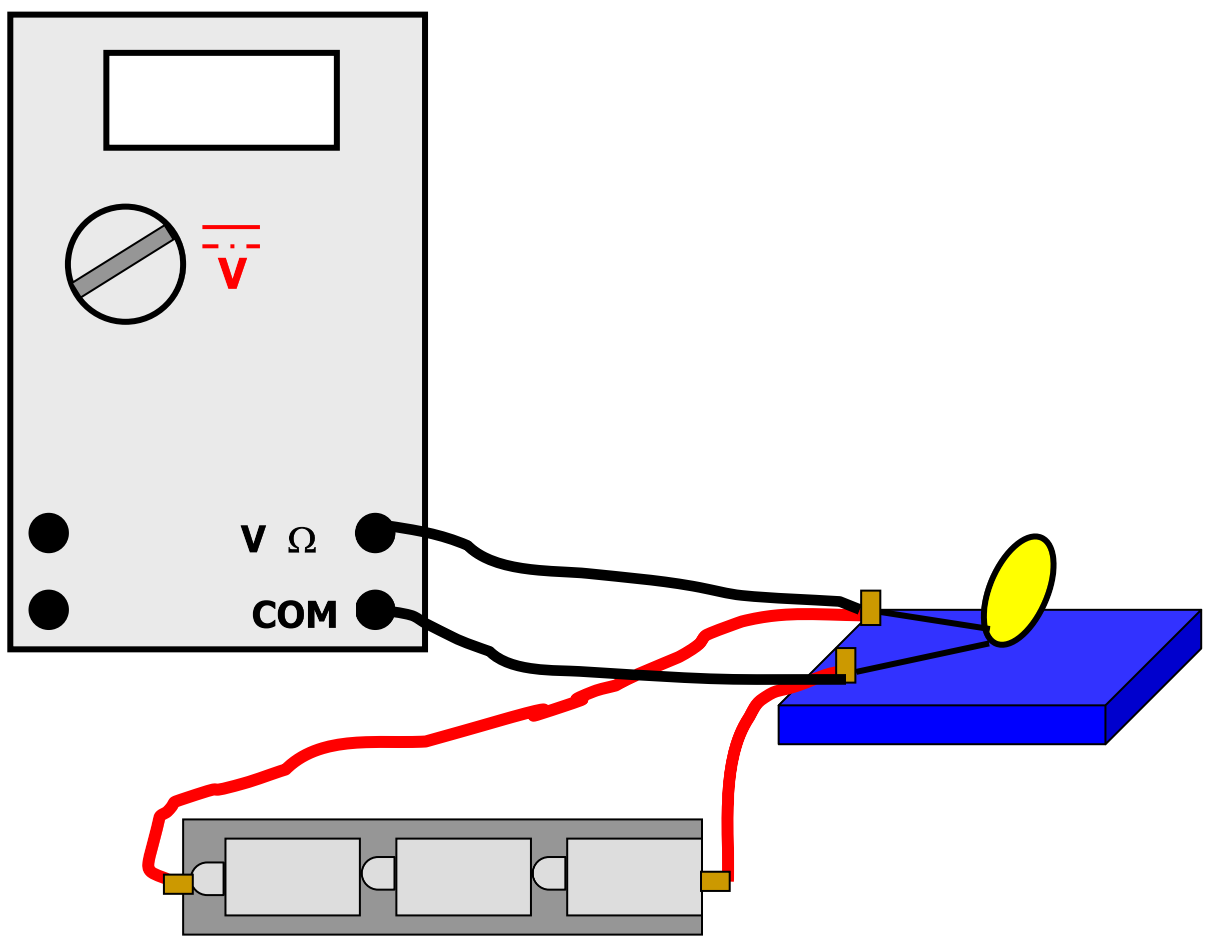
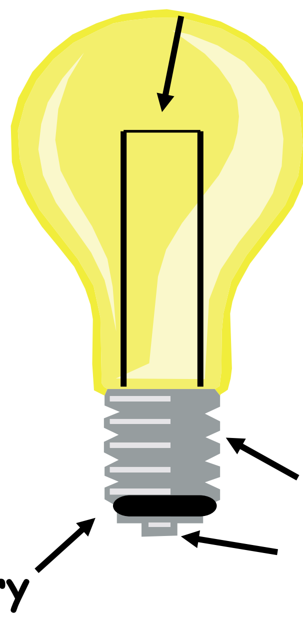


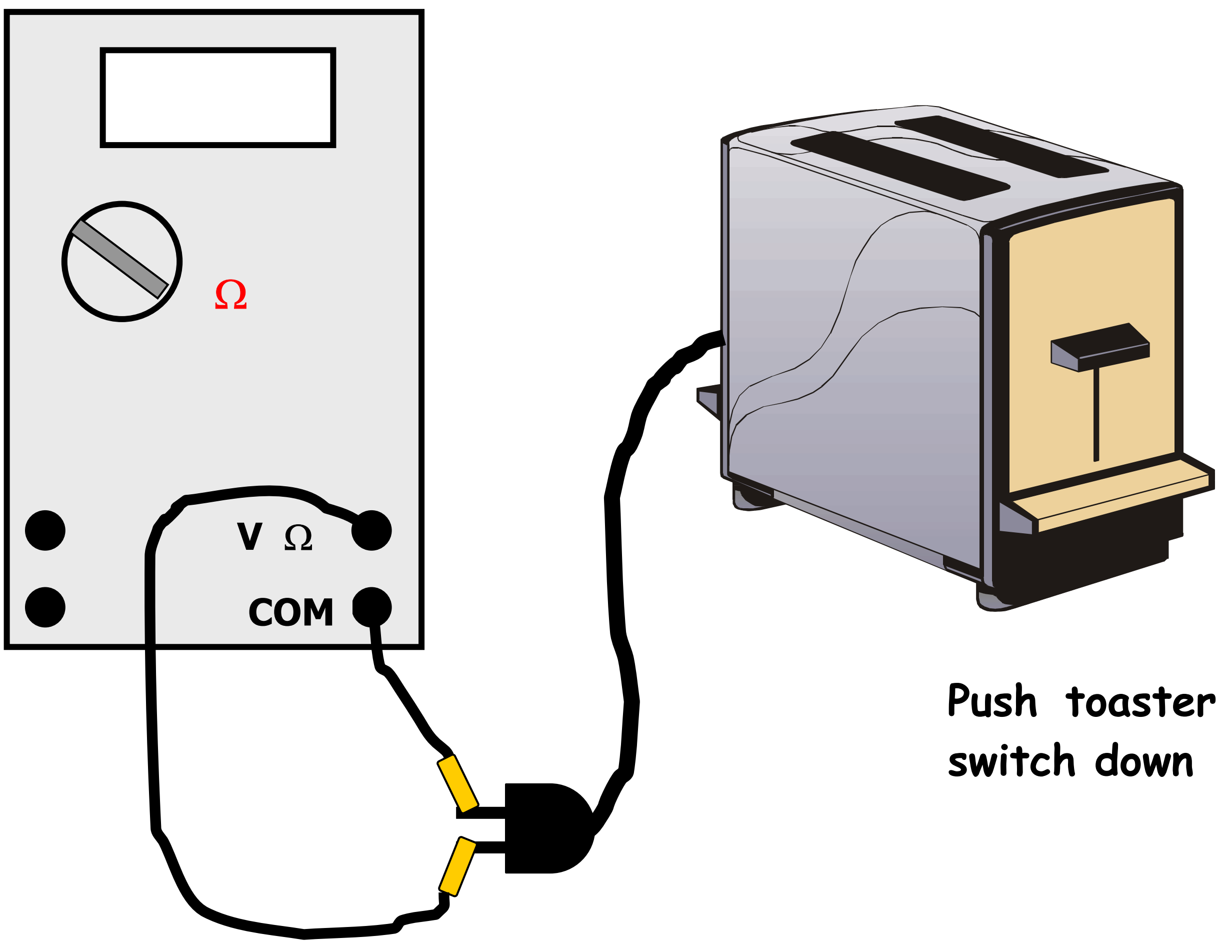
Act.11.5: Electrical Resistance

- Electrical resistance is the ability of an object to prevent a current from flowing
- Glass is a good insulator with high resistance.
- Thick copper wire is a good conductor with low resistance.
- Resistance is measured in units of ohms (Ω).

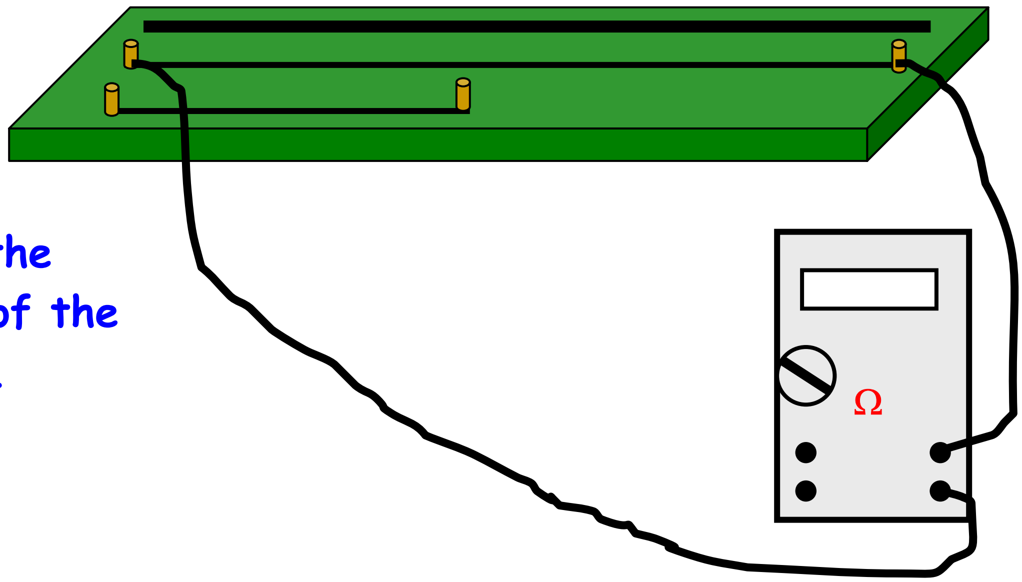


Measuring the Resistance of Appliances

1. Turn the dial to the ohm symbol (Ω).
2. Check that the wire leads are attached to the outlets on the lower right of the meter.
3. To measure resistance, connect the leads to the prongs of the appliance's plug. Caution: do not plug the appliance into an outlet!



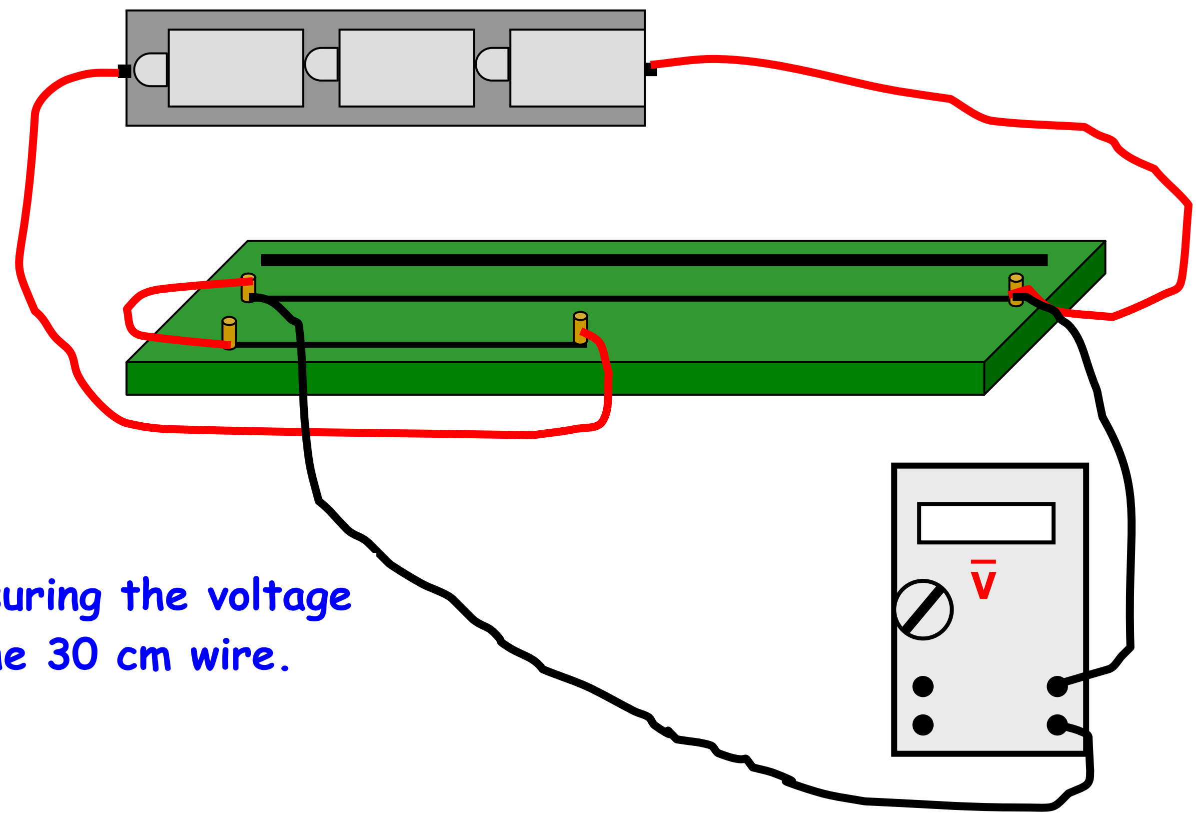
Act. 11.5.b: Measuring the Resistance of the Wire Resistors



Measuring the resistance of the 30 cm wire.

1. Do not connect the battery tray to the green board with resistance wires.
2. Set the multimeter to " Ω " to measure resistance.
3. Touch the ends of the multimeter leads across the thin 30 cm wire to measure its resistance. Then move the multimeter leads to the ends of the 15 cm wire to measure its resistance.

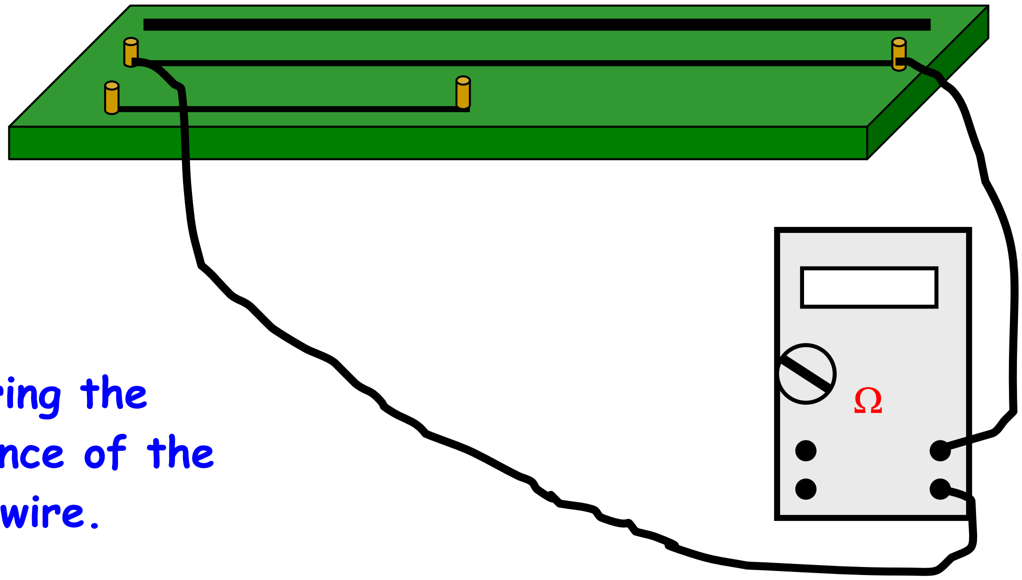
Act. 11.5.b: Measuring Voltage Drops Across Wire Resistors



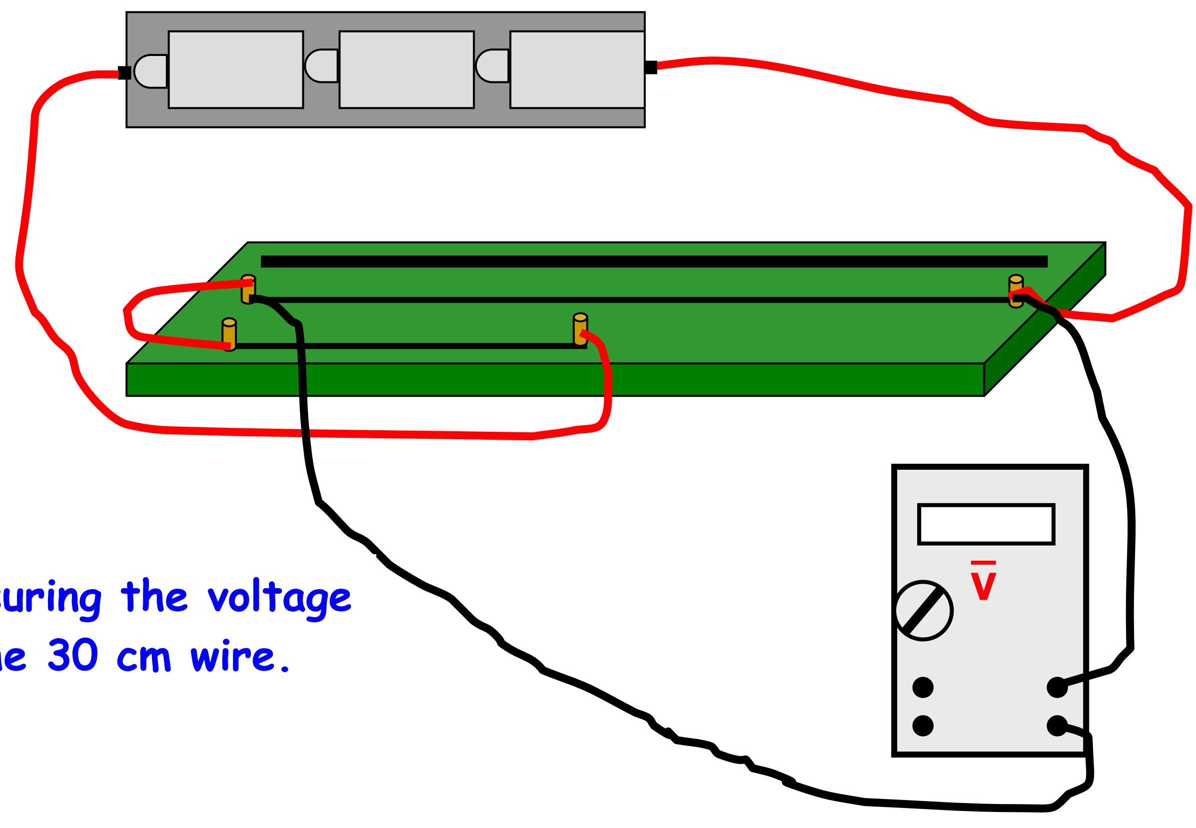
Measuring the voltage of the 30 cm wire.

1. Connect the battery tray, the thin 30 cm wire, and the 15 cm wire in series.
2. Set the multimeter to "V" to measure DC voltage.
3. Touch the ends of the multimeter leads across the 30 cm wire to measure its voltage. Then move the multimeter leads to the ends of the 15 cm wire.

Act 11.5.b: Measuring Resistance and Voltage

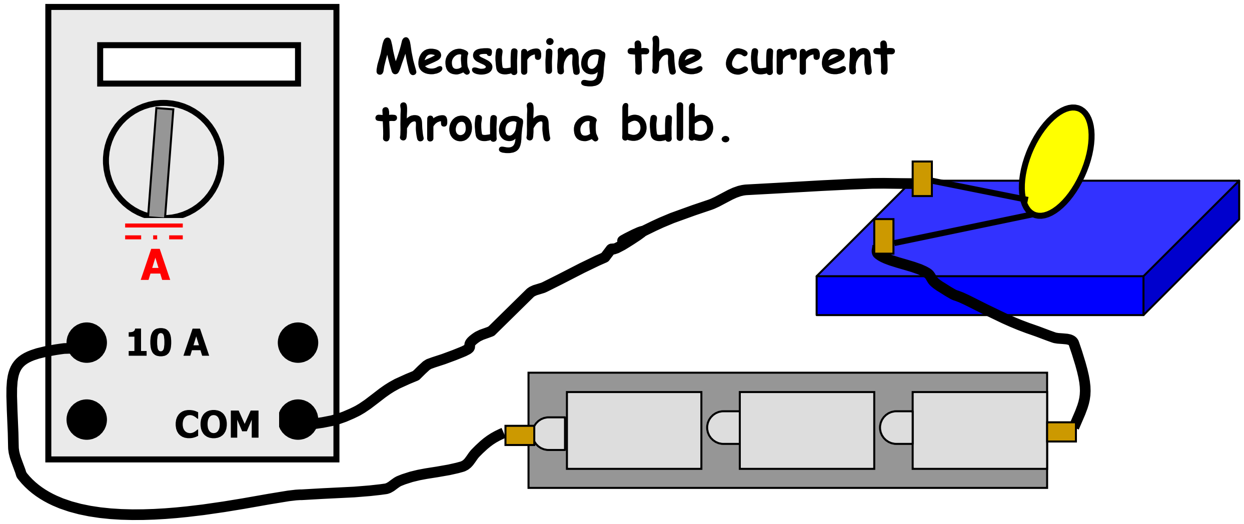


Measuring the resistance of the 30 cm wire.

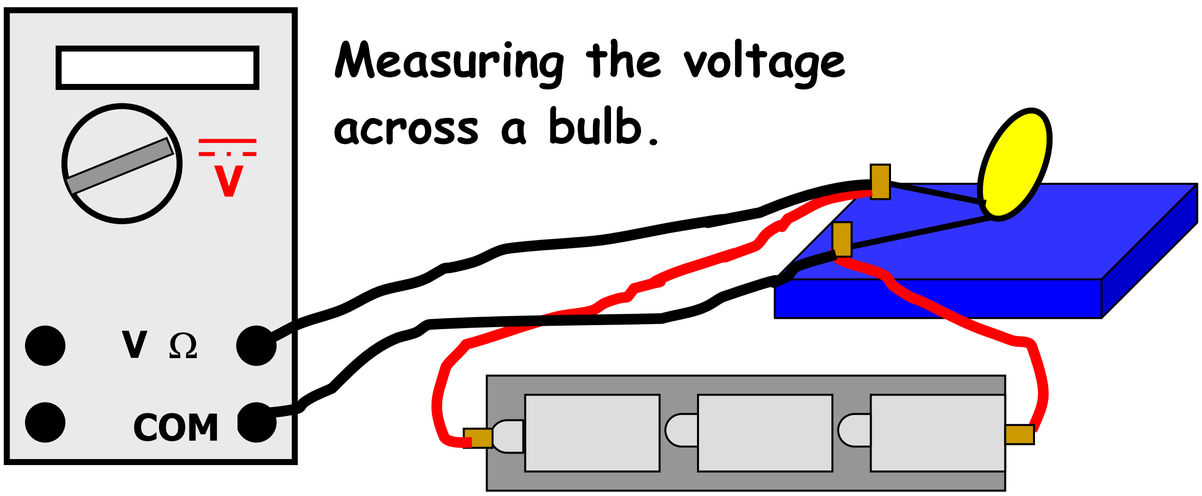


Measuring the voltage of the 30 cm wire.

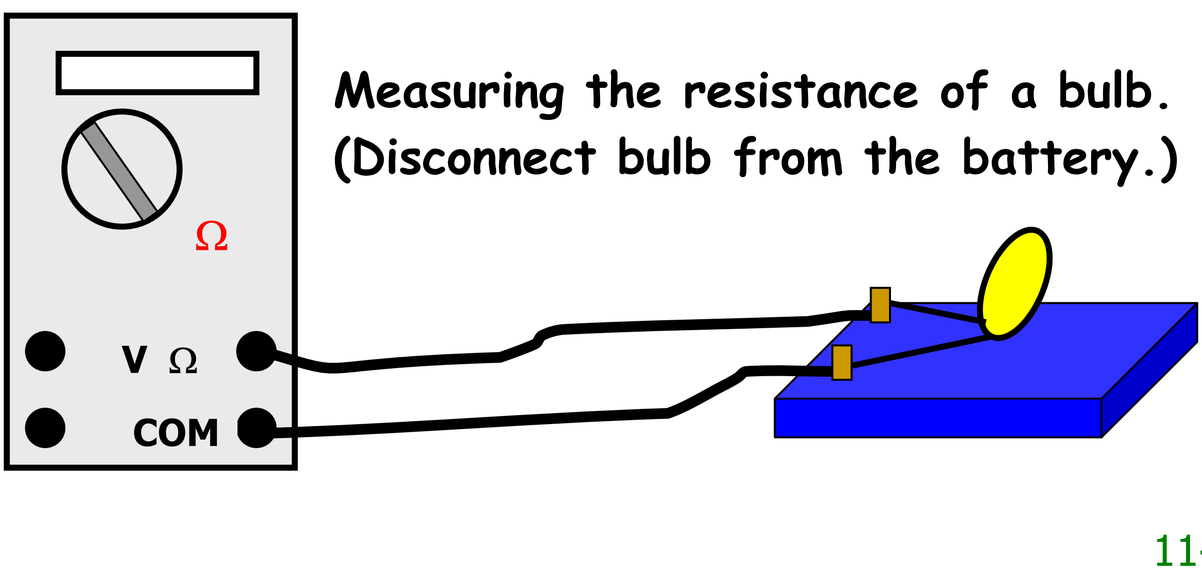
Measuring the current through a bulb.



Measuring the voltage across a bulb.



Measuring the resistance of a bulb. (Disconnect bulb from the battery.)

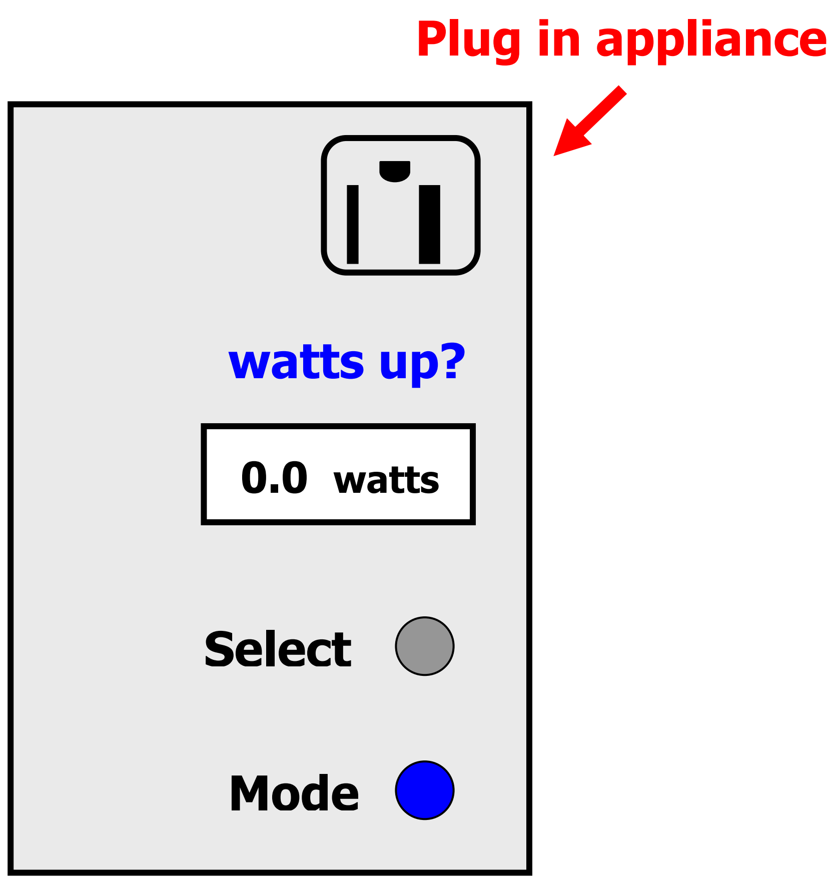


Power, Voltage, or Current with a Wattmeter

Power: Plug the appliance into the outlet in the front of the wattmeter and turn the appliance on. The appliance wattage appears in the display screen.

Voltage: Press the MODE button 4 times until voltage appears in the display screen.

Current: Press the MODE button once more and amps appear in the display screen.



Act 11.6: Power Equations

In Period 8 we defined power as the rate of energy transferred:

$$P = \frac{E}{t}$$

In Period 10, we found that electrical potential energy is the product of voltage and charge.

$$E_{pot} = Q\ V$$

Divide both sides of the equation by *t:*

$$\frac{E_{pot}}{t} = P = \frac{Q\ V}{t}$$

Substitute $Q/t = I$ *to find* a relationship between power, current and voltage.

$$P = \frac{Q}{t} V = I\ V$$

P = power (in watts)

I = current (in amps)

V = voltage (in volts)

Period 11 Summary

11.1-2: Separated positive and negative electric charges can do work when they are allowed to come back together.

Closed electric circuits provide continuous conducting pathways for charge movement.

11.3 Electric current I is the rate of flow of electric charge, usually electrons.

11.4: Voltage V is the electrical potential energy per charge.

Voltage is increased when charge moves through a charge pump (such as a battery) and is decreased as charge moves through a resistor.

The sum of voltage boosts and drops is equal in a closed circuit.

11.5:Electrical resistors restrict the flow of current and transform electrical energy into other forms of energy.

Summary of electrical units

Coulomb (coul) is the most common unit of electric charge. One coulomb = the charge on 6.24×10^{18} electrons.

Ampere (amp) is the most common unit of electric current. One amp equals a current flow of one coulomb of charge per second:

$$1 \text{ amp} = (1\text{coul})/(1 \text{ sec})$$

Volt The difference in voltage (or electrical potential) between two points is measured in volts. One volt is one joule of energy per each coulomb of charge:

$$1 \text{ volt} = (1 \text{ joule})/(1 \text{ coul.})$$

Ohm The resistance of an object to the flow of electric current through it is measured in ohms.

$$1 \text{ ohm} = (1 \text{ volt})/(1 \text{ amp})$$

Watt Power is measured in watts. One watt equals one joule of energy per second.

$$1 \text{ watt} = (1 \text{ joule})/(1 \text{ sec})$$

Period 11 Review Questions

R.1 What is electric current? How is current different from electric charge? List some sources of electric current.

R.2 How is a battery similar to a capacitor? How is it different?

R.3 What is necessary for an electrical device to operate? Why can't we use string instead of wires to connect light bulbs?

R.4 What is electrical resistance? What does the amount of resistance depend upon? Is resistance in an electric circuit desirable or undesirable?

R.5 What are voltage boosts and voltage drops? What could cause a voltage boost in a circuit? What could cause a voltage drop?

R.6 What is the difference between direct current (DC) and alternating current (AC)?