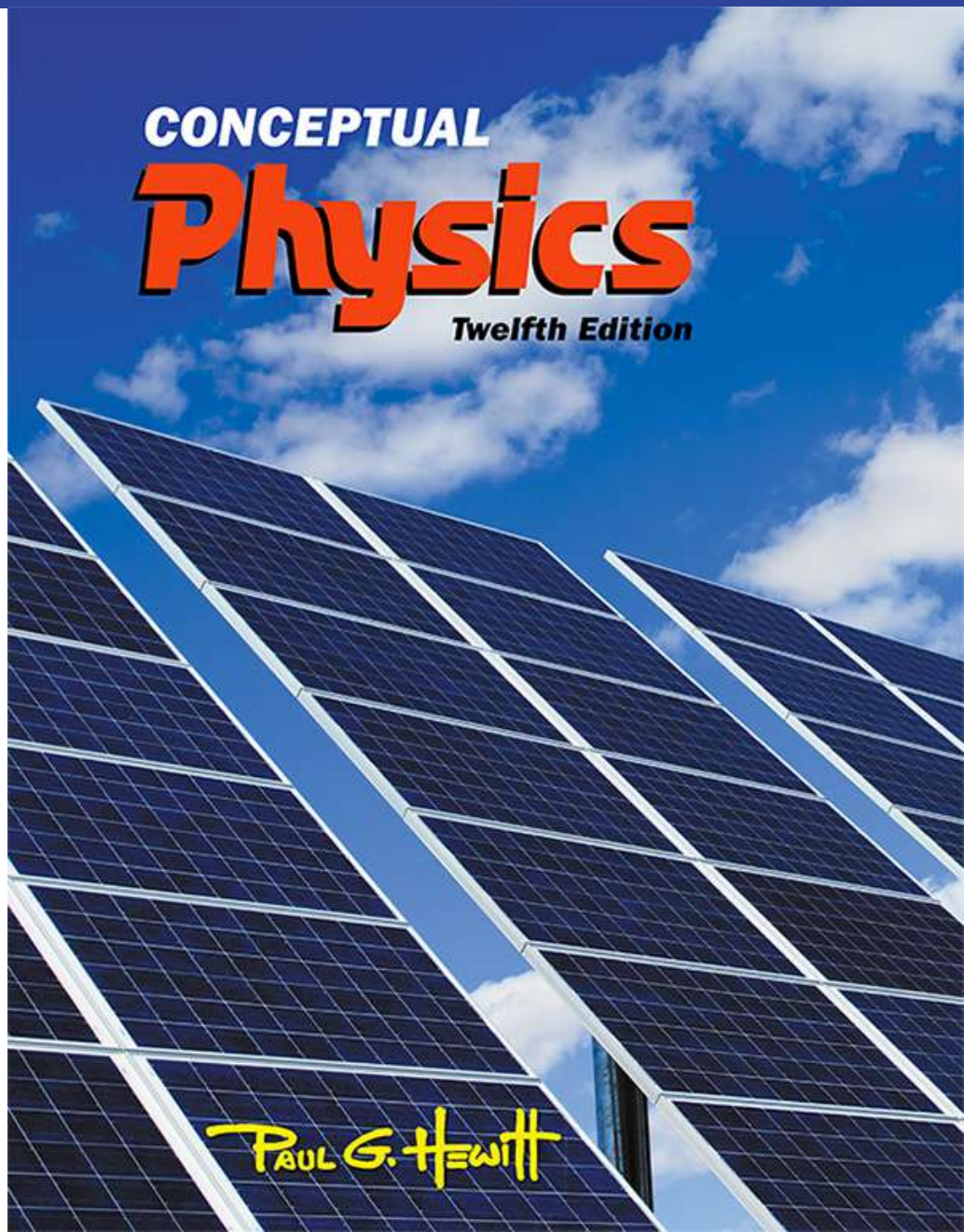
Lecture Outline

Chapter 23: Electric Current

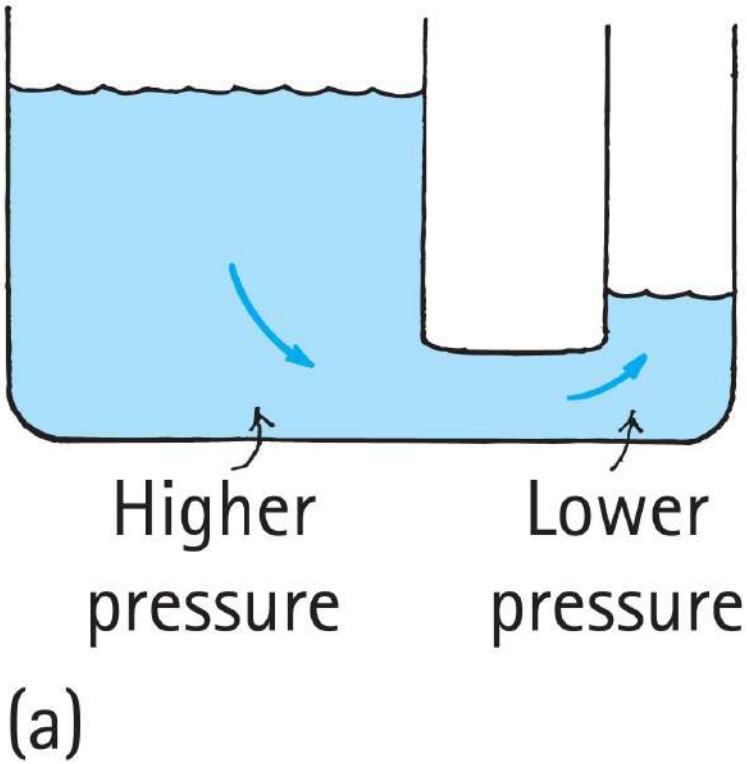
Sections 1-3:

- Flow of Charge (Electric Current)
- Voltage Sources
- Electrical Resistance



23.1 The Flow of Charge

- When the ends of an electrical conductor are at different electric potentials—when there is a **potential difference**—charge flows from one end to the other.
  - Analogous to water flowing from higher pressure to lower pressure:
  - Water flows from
  - Higher pressure…
  - …to…
  - …lower pressure.
  - This flow of water is a *current*.



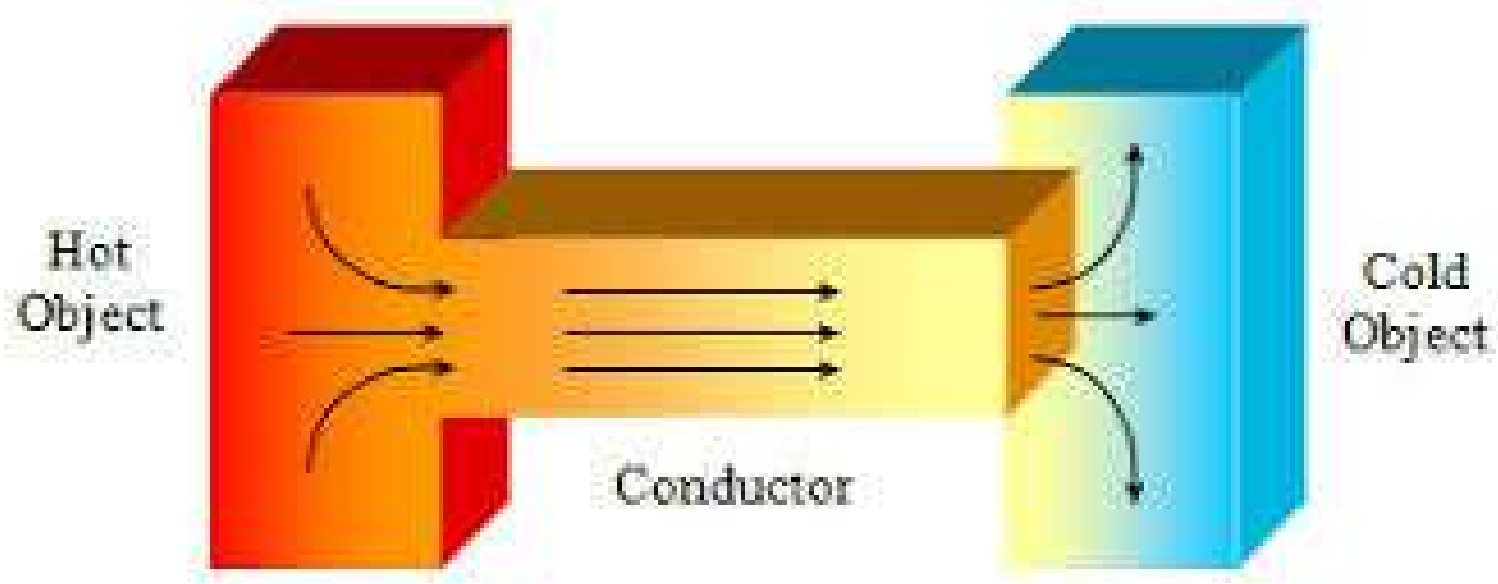
Also analogous to the flow of heat:

Heat is the energy that flows when there is a temperature difference.

Heat flows from hot to cold.

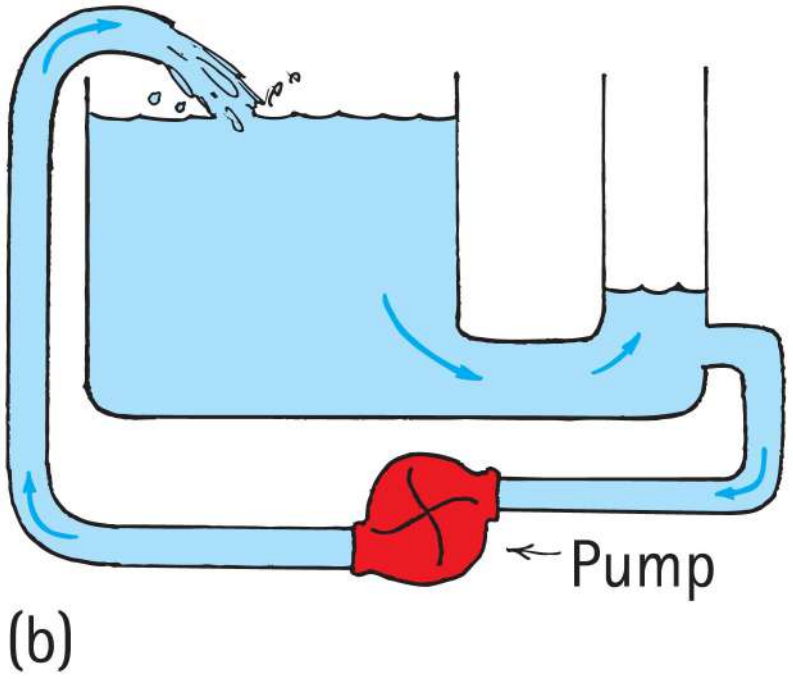
No temperature difference?

No heat flow.



Flow of Charge, Continued

- To attain a sustained flow of **charge** in a conductor, some arrangement must be provided to maintain a difference in potential while charge flows from one end to the other.
  - A continuous flow is possible if the difference in water levels—hence the difference in water pressures—is maintained with the use of a pump.



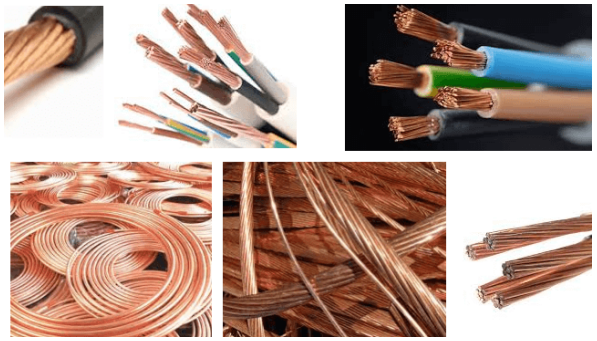
3 Analogies

what flows	what causes it
water in a pipe	pressure difference
heat in 2 objects	temperature difference
charge	potential difference (aka, a *voltage*).

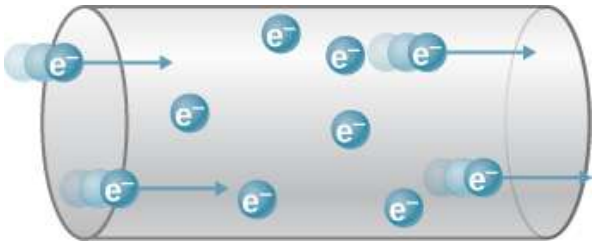
- Electric current

current = flow of charged particles

-In metal wires:

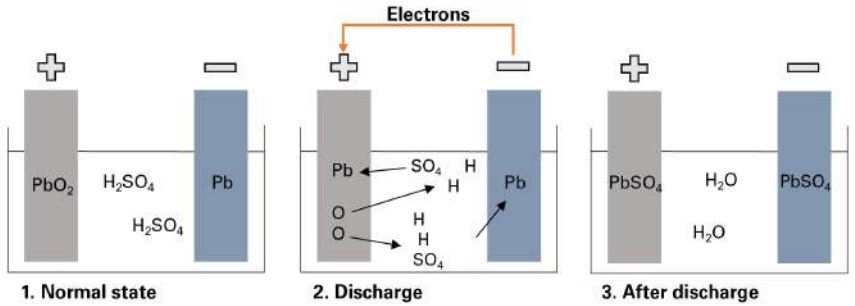


- **Conduction electrons** are charge carriers that are free to move throughout atomic lattice.
- Protons are bound within the nuclei of atoms.



-In fluids:

Positive ions and negative ions constitute electric charge flow.



Discharge: $Pb + PbO_2 + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$

Charge: $2PbSO_4 + 2H_2O \rightarrow Pb + PbO_2 + 2H_2SO_4$

Electric Current
CHECK YOUR NEIGHBOR

Which of these statements is true?

A. Electric current is a flow of electric charge.
B. Electric current is stored in batteries.
C. Both A and B are true.
D. Neither A nor B are true.

Electric Current
CHECK YOUR ANSWER

Which of these statements is true?

A. Electric current is a flow of electric charge.

Explanation:

Voltage, not current, is stored in batteries. The voltage will produce a current in a connecting circuit. The battery moves electrons already in the wire, but not necessarily those in the battery.

Electric Current, Continued

- Current = the *rate* of electric charge flow

$$\text{current} = \frac{charge}{time}$$

- Units: amperes (1 coulomb of charge per second).
  - 1 ampere = $\frac{1\ coulomb}{1\ second}$ or 1 A = 1 $\frac{C}{s}$

Ex: 20 Coulombs of charge pass a point in 4 seconds. Calculate the current:

- Current = $\frac{charge}{time}$

$$= \frac{20\ C}{} = \frac{5\ C}{s} = 5\ A$$

Take sheet out. Name at top. Answer:

1. What condition is necessary for the flow of heat? What analogous condition is necessary for the flow of charge?

2. What condition is necessary for the sustained flow of water in a pipe? What analogous condition is necessary for the sustained flow of charge in a wire?

3. Why are *electrons*, rather than *protons*, the principal charge carriers in metal wires?

4. What exactly is an ampere?

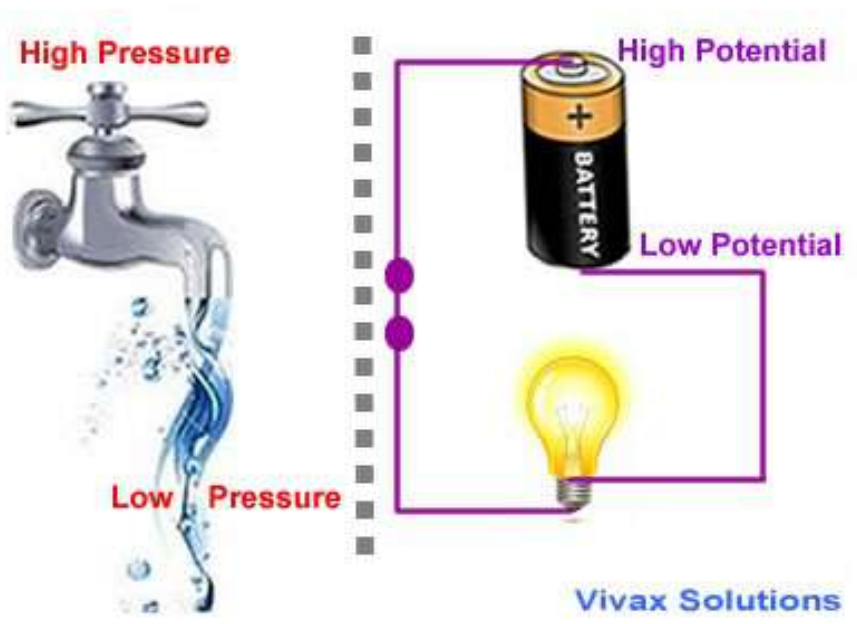
23.2 Voltage Sources

- A van de Graaff or a capacitor is not a good source because their potential difference does not last long.

- Batteries and generators are good sources because they maintain a potential difference.

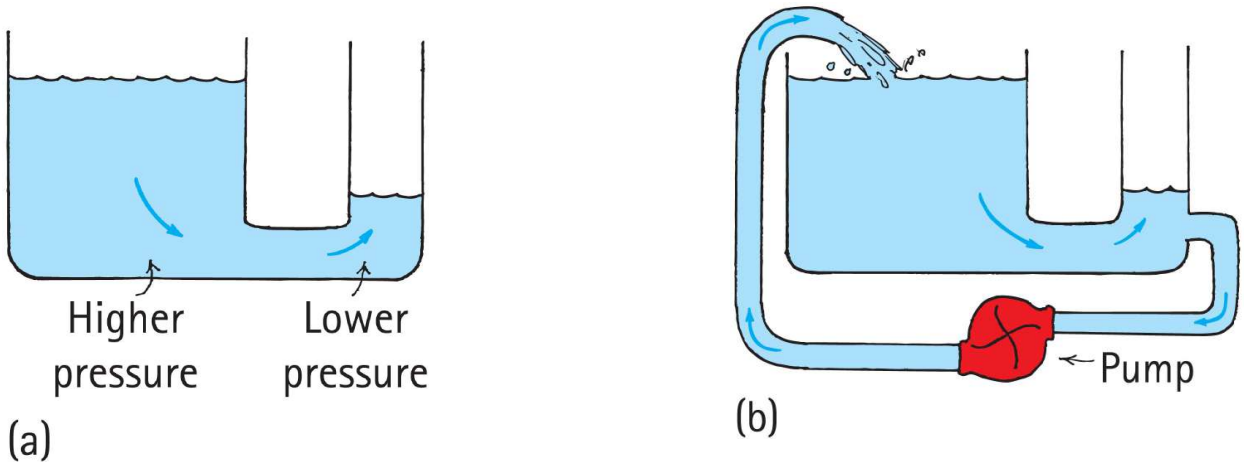
Voltage Sources, Continued

- Electric potential difference
  - Difference in potential between two points
    - Charges in conductor flow from higher potential to lower potential.
    - Flow of charge persists until both ends of conductor reach the same potential.
    - Maintained for continuous flow by pumping device.



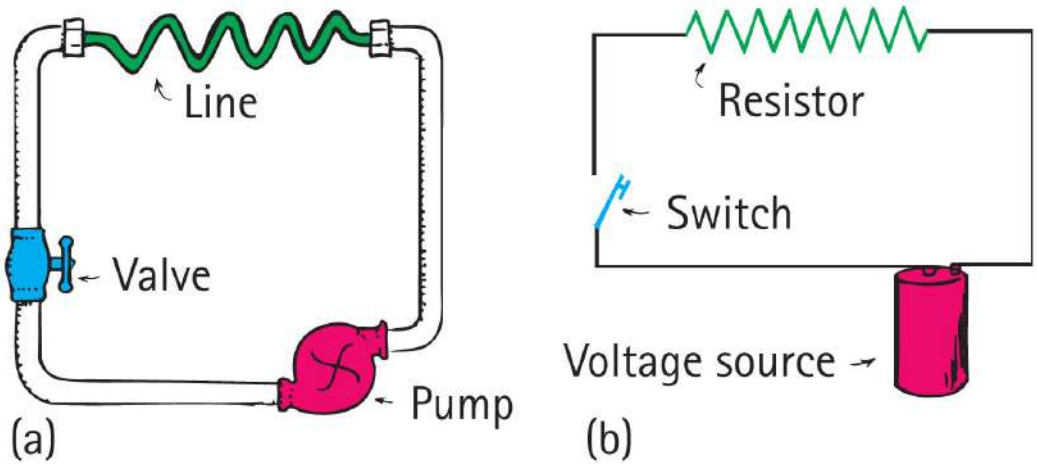
Voltage Sources, Continued-1

- Electric potential difference (continued)
  - Example: Water from a higher reservoir to a lower one—flow continues until no difference



  - No flow of charge occurs when potential difference is zero.

A battery or generator is a “pump” that can maintain a steady flow of charge.



- Work is done in pulling negative charges apart from positive ones.
- Charge flows *through* a circuit (water in pipe.)
- Voltage is established *across* a circuit, just like a pressure difference across ends of a pipe.

In chemical **batteries:**

- Work by chemical disintegration of zinc or lithium or lead in acid.

- Energy stored in chemical bonds is converted to electric potential energy.

In **generators**: Electromagnetic induction at terminals provides the electrical pressure to move electrons through the circuit.

Add these Answers to your Classwork

5. Name two kinds of practical "electric pumps."

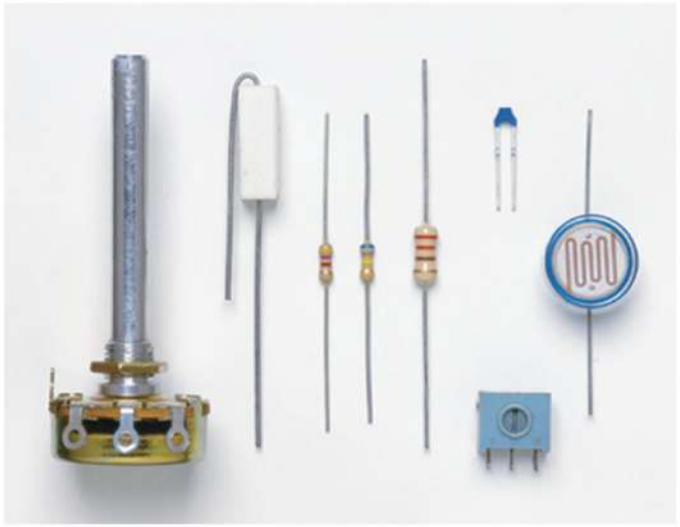
6. How much energy is supplied to each coulomb of charge that flows through a 12-V battery?

7. Does electric charge flow *across* a circuit or *through* a circuit? Does voltage flow *across* a circuit or is it *impressed across* a circuit?

23.3 Electric Resistance

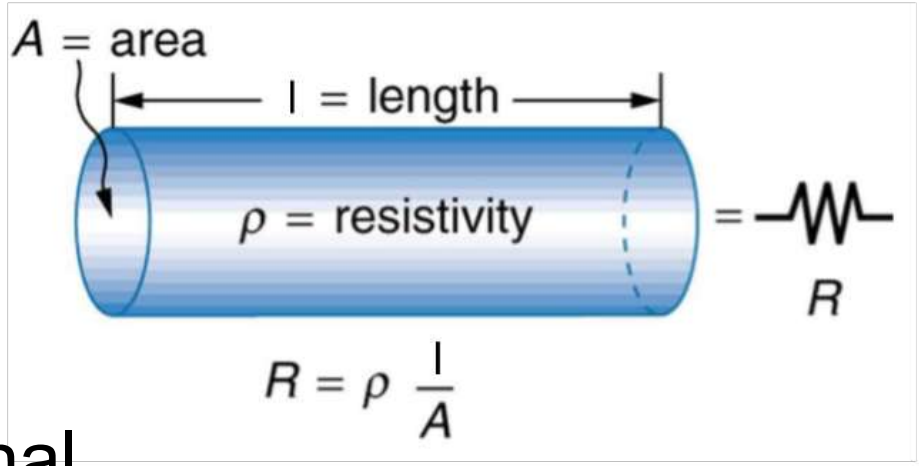
- Current in a circuit is dependent on
  - voltage.
  - electrical resistance R in ohms, Ω.
- **Resistors**
  - circuit elements that regulate current inside electrical devices

The symbol of a resistor in an electric circuit is:



More resistance R means its is harder for electrons to move through, so there is less current

Factors affecting electrical resistance:



1. Inversely proportional to cross-sectional area A
   - thin wires have more resistance than thick wires
2. Directly proportional to length l
   - doubling the length, doubles the resistance

Ex. A wire resistor has a resistance of 8 Ω. What will its new resistance be if …

A) …its length is doubled? 16 Ω

B) …its cross sectional area is doubled?

4 Ω

FIGURE 23.5
More water flows through a thick hose than through a thin hose connected to a city's water system (same water pressure). Likewise for electric current in thick and thin wires connected across the same potential difference.

Ex. A wire resistor has a resistance of 30 Ω. What will its new resistance be if …

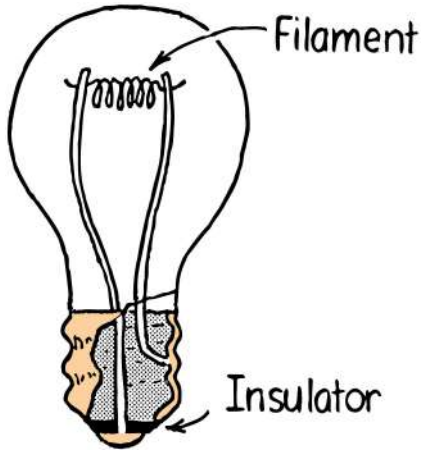
A) …its length is halved? 15 Ω

B) …its cross sectional area is tripled? 10 Ω

- Factors affecting electrical resistance (continued)

3. Material
    - rubber—much more resistance than copper
    - Among metals, silver (Ag) has the *least* resistance.

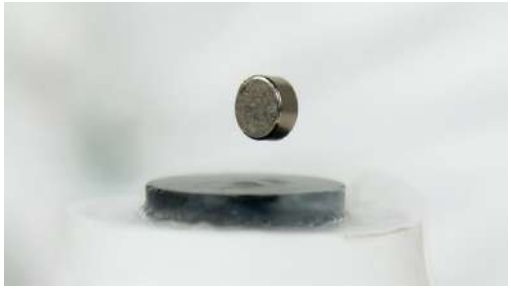
4. Temperature
    - the higher the temperature, the more the resistance.



Electric Resistance, Continued-2

- Semiconductors
  - Refers to materials that can alternate between being conductors and insulators (if pure)
  - Examples:
    - germanium (Ge) and silicon (Si)

- Superconductors
  - Materials with zero electrical resistance to the flow of charge.
  - Flow of charge is without heat.



- High-temperature superconductors are newer ceramic materials that can carry conduct at relatively high (95 K) temperatures.

Add these to your Classwork:

8. Will water flow more easily through a wide pipe or a narrow pipe? Will current flow more easily through a thick wire or a thin wire?

9. Does heating a metal wire increase or decrease its electrical resistance?

10. What is the unit of electrical resistance?

Now turn in your classwork!