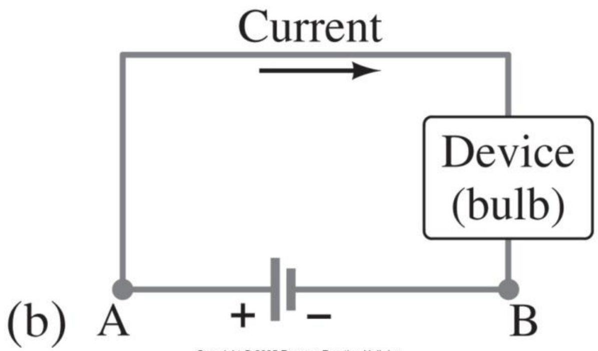
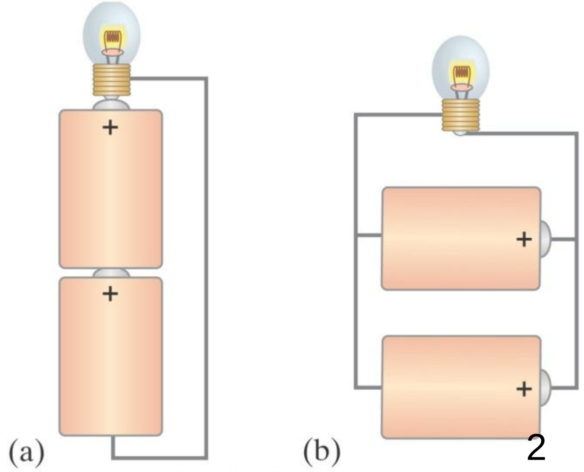
Chapter 18
Current, Resistance & Power

Electric Current & Circuits

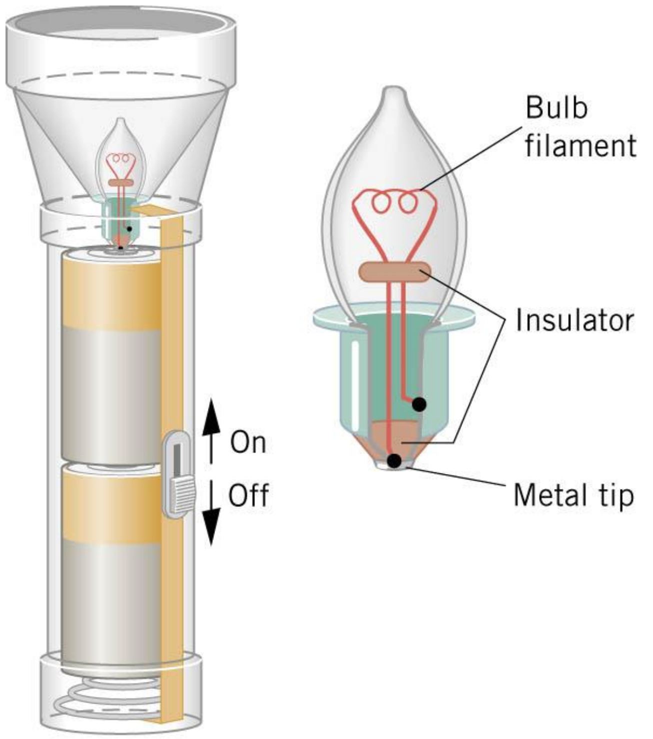
- 3 things necessary for electric current to flow at a useable rate through a circuit

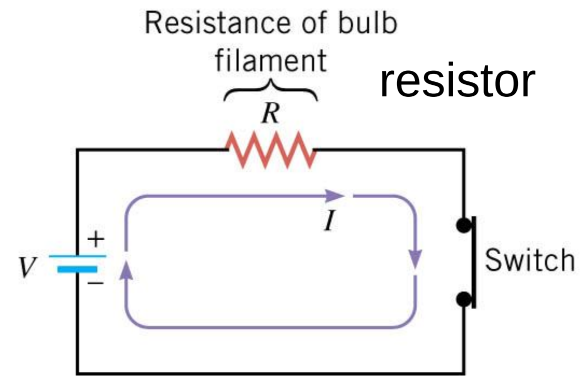
1. Source of potential difference (increase)
   - battery
2. Closed loop conducting pathway
   - connecting wires
3. Potential downhill (decrease)
   - resistor





You need to be able to read and draw circuit diagrams and identify direction of current flow





resistor

battery

Voltage (potential increase) source

- battery or power supply
- "charge pump" does work on charges supplying them with electric potential energy
- creates a potential difference (ΔV)
  - higher potential (V) at +, lower potential at – terminal
- current flow through circuit results
- does NOT supply charge carriers
  - where are they?

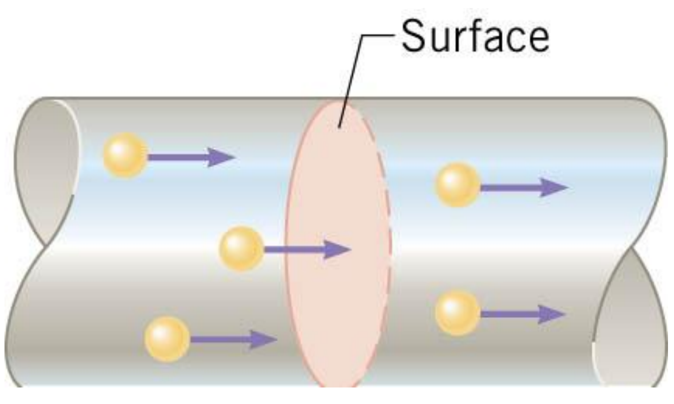
Electric Current

- number of + charge carriers passing through a cross-sectional area per second

$$I = \frac{\Delta q}{\Delta t}$$

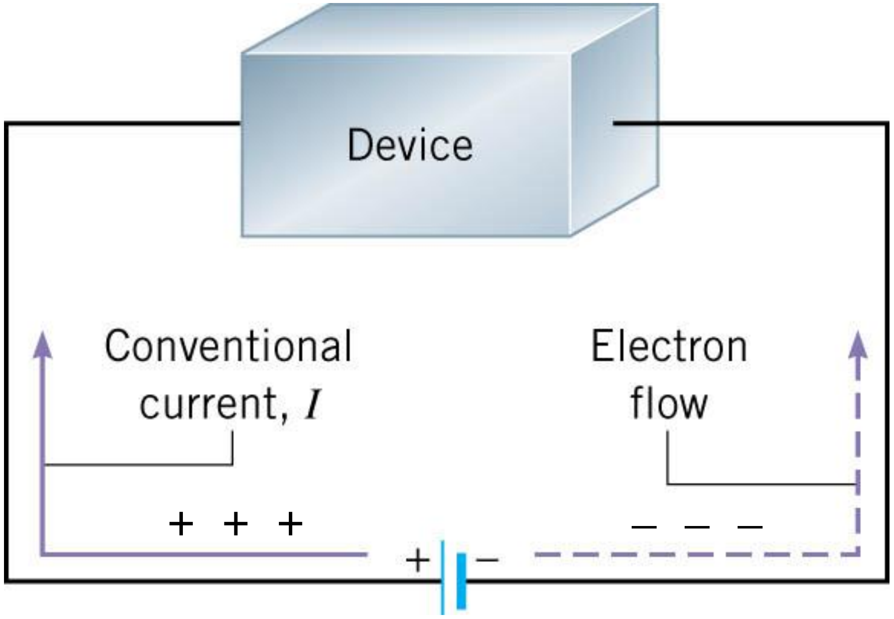
Units: $\frac{1\,coulomb}{1\,\text{second}} = 1\,Ampere\ (A)$

- not velocity of charge carriers – water flow through pipe or hose is good equivalent



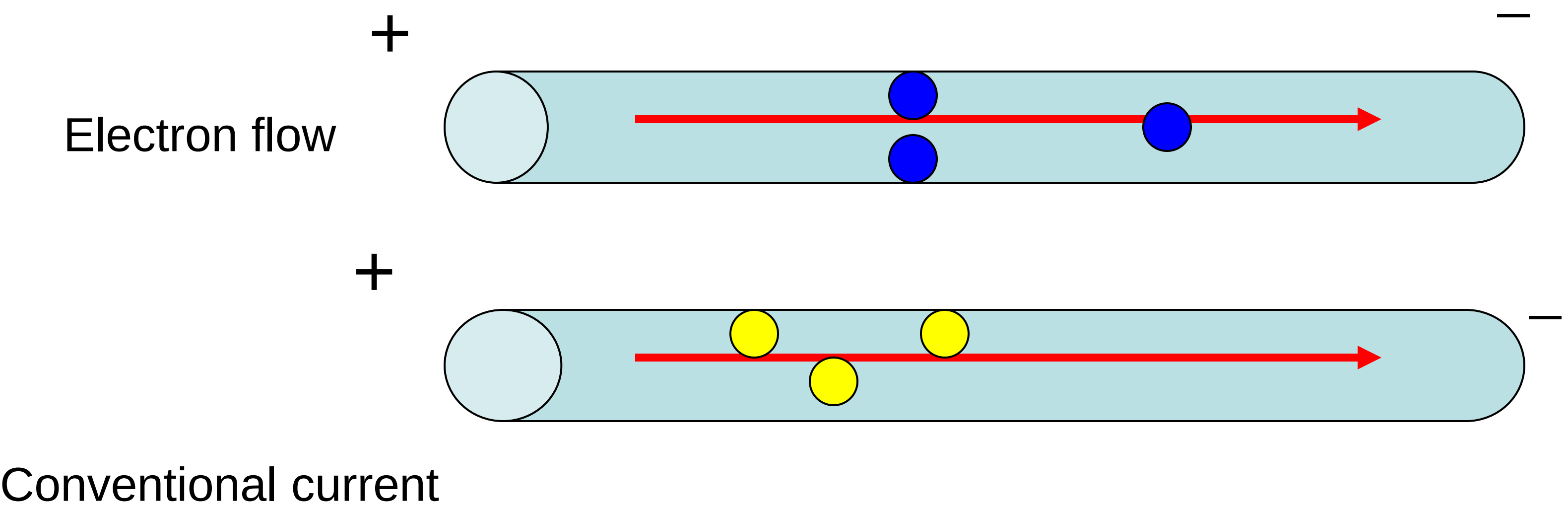
Electric Current

- conventional current = movement of + charge carriers
- electrons actually move through wires



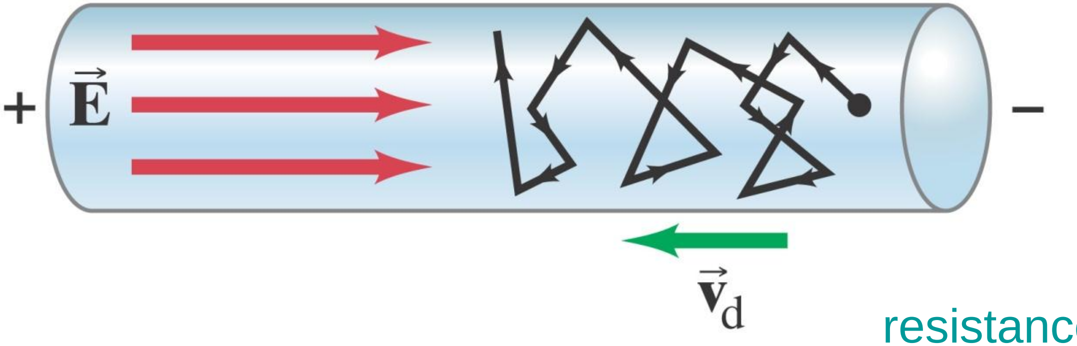
Conventional current

What could be done to increase the flow of charges through the conductor?



Electrical Resistance

- impedance or opposition to the flow of electric charge by the conductor that the current is moving through
- “electrical friction”
- all conductors have resistance
  - electrons contacting atoms in metal



[drift velocity 1]

[resistance]

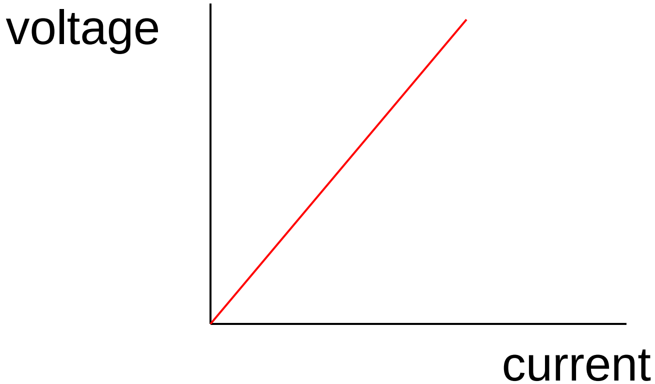
Ohm’s Law

- definition of resistance

$$R = \frac{V}{I}$$

Units: $$\frac{1\,Volt}{1\,Ampere} = 1\,ohm\ (\Omega)$$

- what does resistance depend on?
- this ratio is constant for resistors that obey Ohm’s Law,; resistance is independent of voltage and current



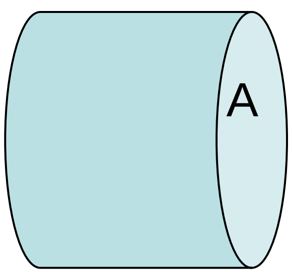
graph of voltage vs current is linear

greater potential difference causes increased current

Resistance depends on

- material property called resistivity ρ
- length of conductor L
- cross sectional area A

$$R = \rho \frac{L}{A}$$



L

short and wide =
low resistance

long and narrow =
high resistance

capacitor   C=Q/V was definition; capacitance depended on A, d

Current Control

- 2 ways to increase current

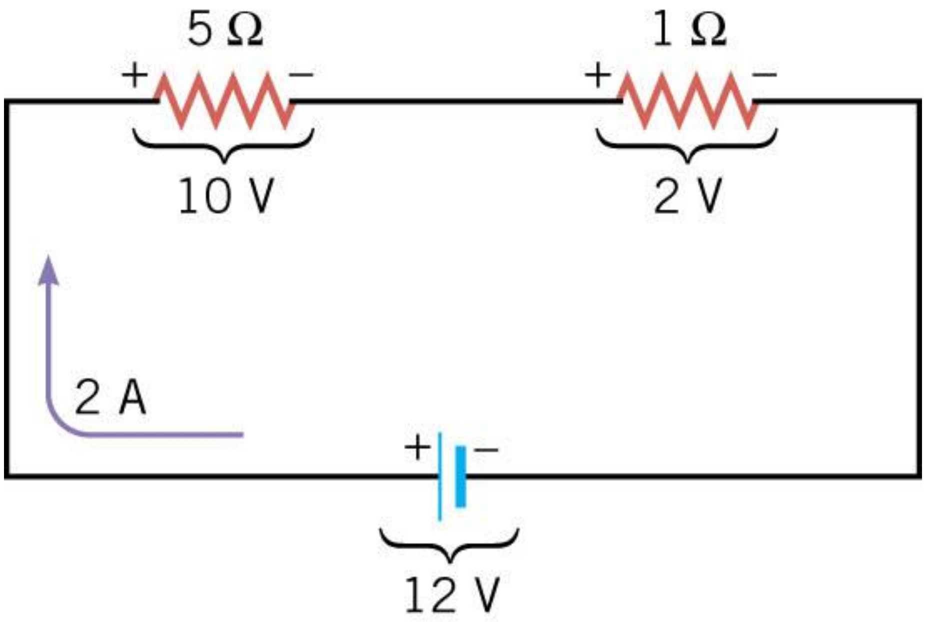
$$I = \frac{V}{R}$$

- increase voltage (greater potential difference supplying more energy to charge carriers
- decrease resistance by changing length, area

Resistors

- Electrical circuit element with purpose to
  - regulate current flow
  - create a potential “downhill”
    - decrease in potential
  - take energy (potential) out of the charge carriers that flow through resistor
- Resistors do NOT take charge carriers out of the circuit
- Baseboard hot water heating system in house

Voltage drop across resistor



When current flows through a resistor there is a voltage decrease according to V=IR

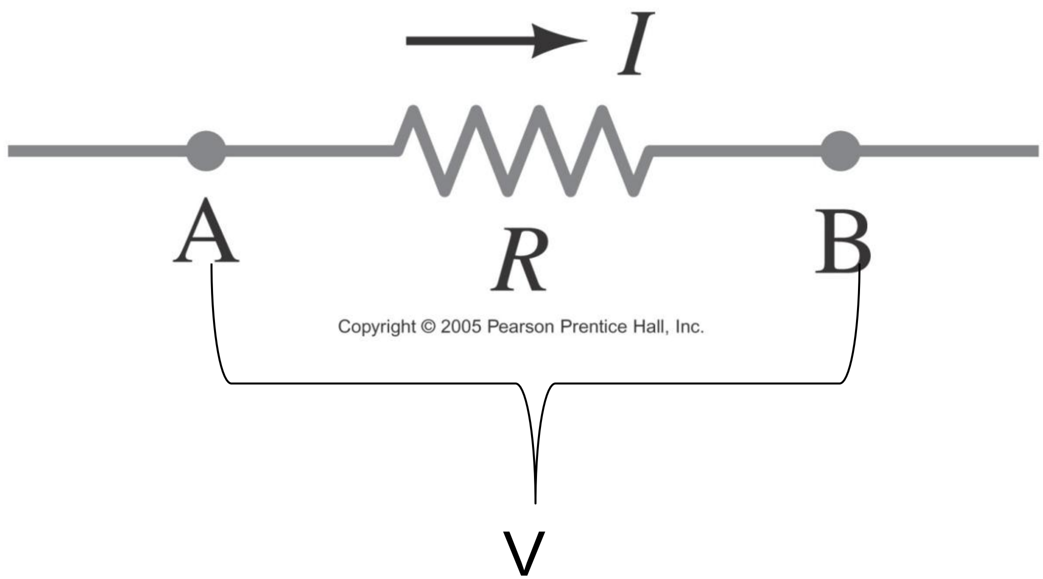
2 Amperes of current flow through both resistors
V_1 = (2A)(5Ω) = 10 Volts of potential decrease

V_2=(2A)(1 Ω) = 2 Volts of voltage drop

Total potential increase from battery (12V) = total voltage drop from R's = 12 V

Voltage drop is due to the electrical energy usage by the device or resistor

3 ways to use Ohm's Law expression



1) I = V/R to calculate current

2) R = V/I to calculate resistance of resistor

3) V = IR to calculate either

- voltage drop when current flows through resistor
- voltage required to cause current flow through resistor

Power

$$Work = change \text{ in energy} = \mathrm{q} \bullet \Delta \mathrm{V}$$

$$Power = \frac{Work}{time} = \frac{energy\ transfer}{time} = \frac{q \bullet \Delta V}{t}$$

$$Power = I \bullet V \quad \text{Units} = \text{Watts}$$

alternative expressions based on substituting Ohm's Law V=IR or I=V/R

$$P = I \bullet IR = I^2 R$$

$$P = \frac{V}{R} \bullet V = \frac{V^2}{R}$$

Energy Transfer Rate

- Watt = Joules of energy used per second

- Energy used (J) = Power • time

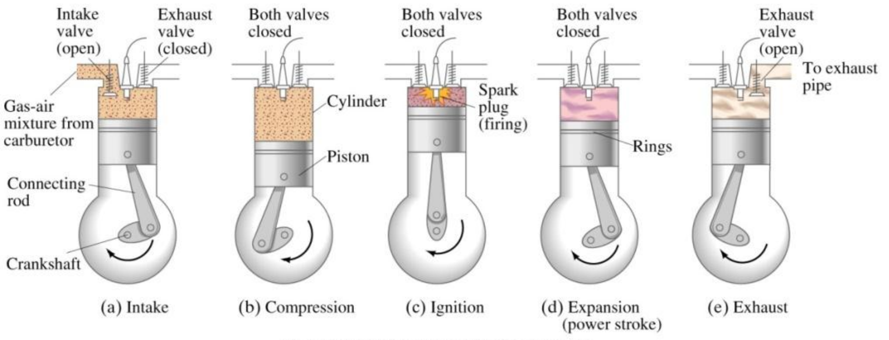
$$Joules = \frac{Joules}{\text{second}} \; x \; \text{seconds}$$

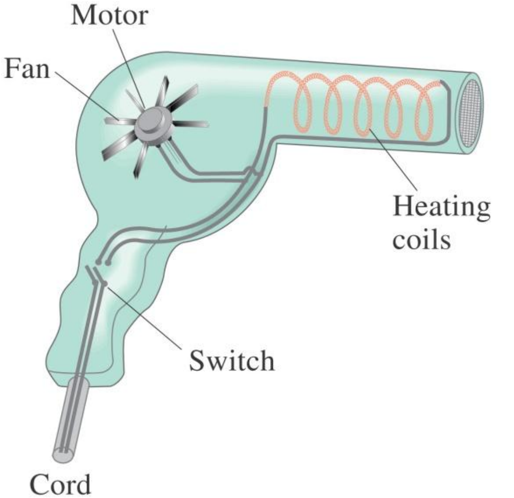
Electrical Power

- Heating of resistor or brightness of bulb is result of taking EPE from charge carriers in current
- Resistors use (dissipate) electrical energy at a certain rate = power
- Rate of energy transfer

Efficiency of a heat engine or electrical device

$$\text{efficiency} \quad e = \frac{\text{power output}}{\text{power input}} = \frac{\text{work output}}{\text{energy input}}$$





all devices and machines are less than 100% efficient