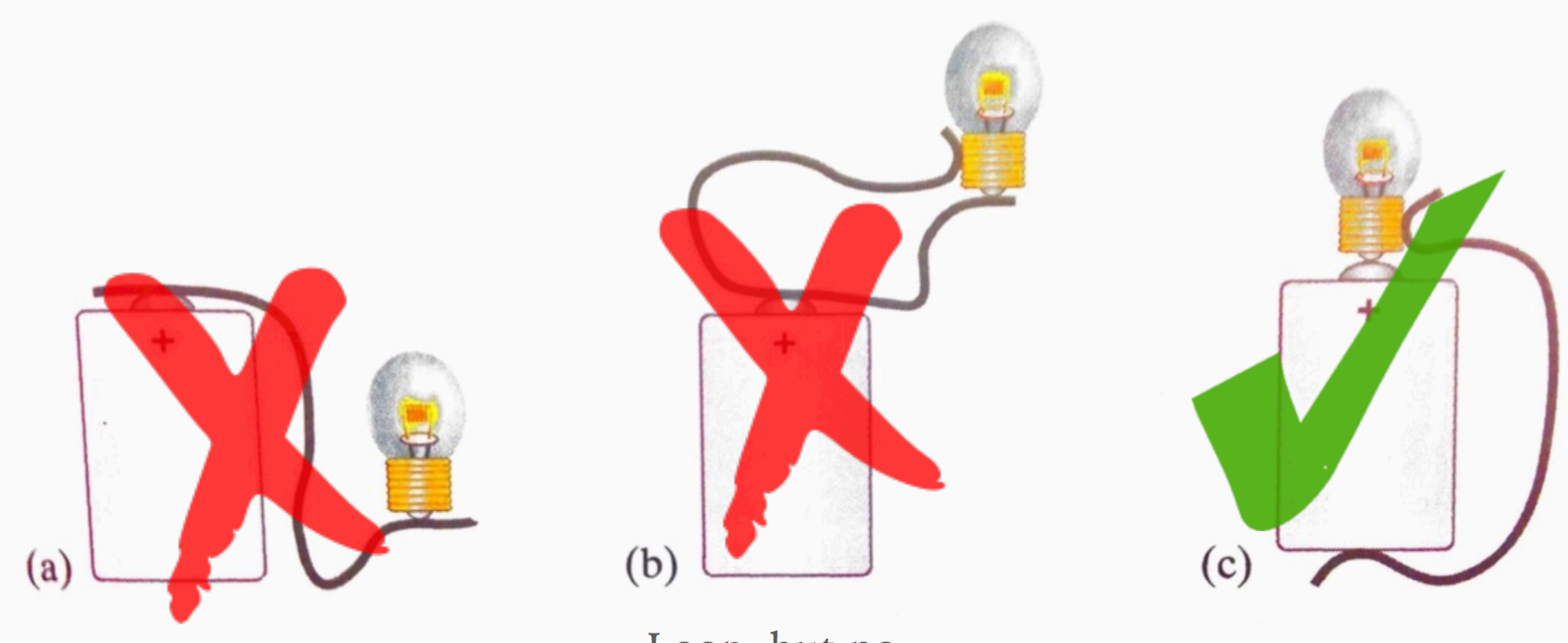
Electrostatics is the study of charges at rest
Electricity puts those charges in motion
For that, you need a **potential difference**
(a.k.a voltage) and a conductive loop for
electrons to flow.

➤ What's wrong with each of the pictures below?



No loop for current to flow around

Loop, but no potential difference to push charge

All good!

Current: Flow of electric charge

I (unit: amperes) = Q/t = Coulombs/second

0.001 A can be felt

0.005 A is painful

0.010 A causes involuntary muscle contractions

0.015 A causes loss of muscle control

0.070 A can be fatal if the current last for more than 1 second

Light goes on ‘instantly’ when switch turned on

- Electrons do not move at speed of light
  - Speed of light (c) = 3×10^8 m/s
  - Electrons – 6×10^5 m/s in random directions
- Signal (energy) moves at speed of light due to electric energy field

Electrons in circuit do not come from battery but are from the wire

Batteries supply electric energy to a system

- ➤ They do NOT create charge
- ➤ They do NOT supply electric charge
- ➤ they **push** charge
- ➤ Batteries use a chemical reaction to create a potential difference across its positive and negative terminals

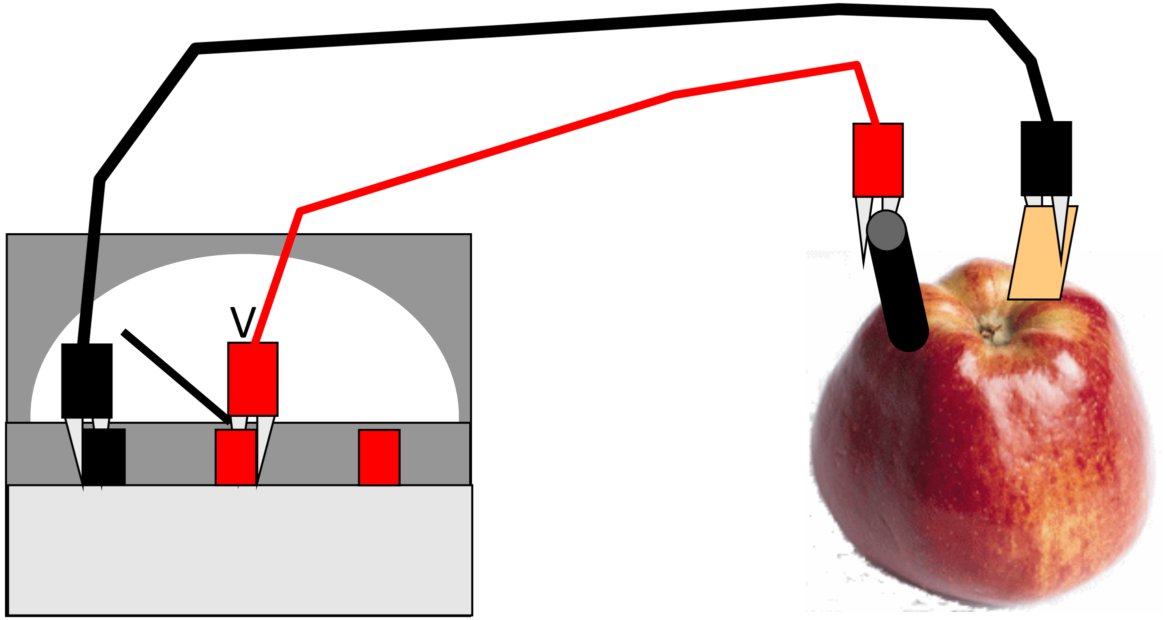
Think of voltage as a kind of electric pressure, like a hose. More voltage = greater “push” onto electrons

How to jump a dead car battery (don't need to memorize for quiz)

1. Make sure both cars are turned off.
2. Connect one end of the red (positive) jumper cable to the positive terminal on the stalled battery.
3. Connect the other red (positive) cable to the positive terminal of the good battery.
4. Connect one end of the black (negative) jumper cable to the negative terminal of the good battery.
5. Connect the other black (negative) cable to a clean, unpainted metal surface under the disabled car's hood.

Somewhere on the engine block is a good place. Unless you want to see flying sparks and a possible explosion, do not connect the negative cable to the negative terminal of the dead battery.

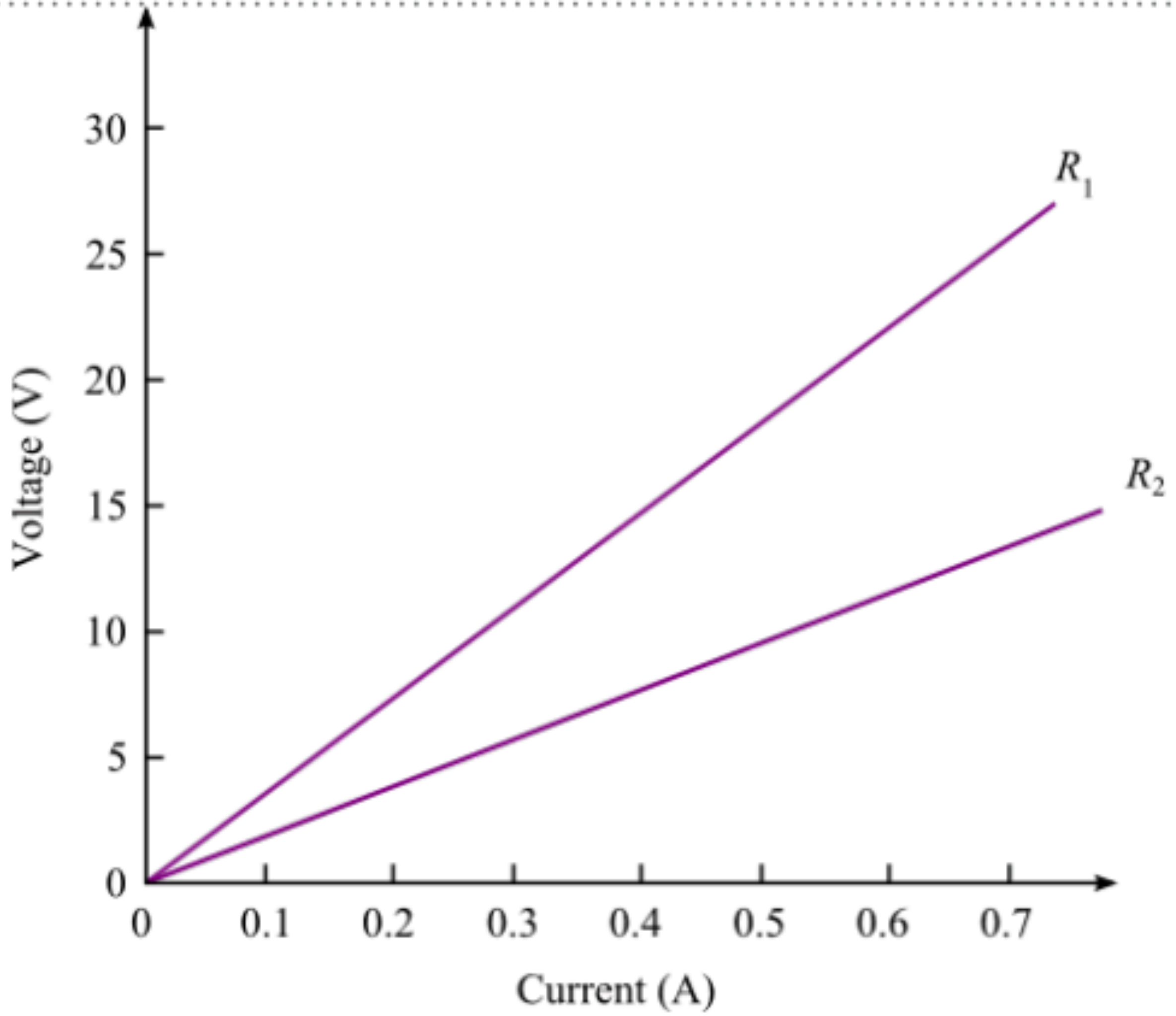
6. Start the car that's doing the jumping; run for 2 to 3 minutes before starting dead car.
7. Remove cables in reverse order.
8. Keep jumped car running for at least 30 minutes to give battery sufficient time to recharge.

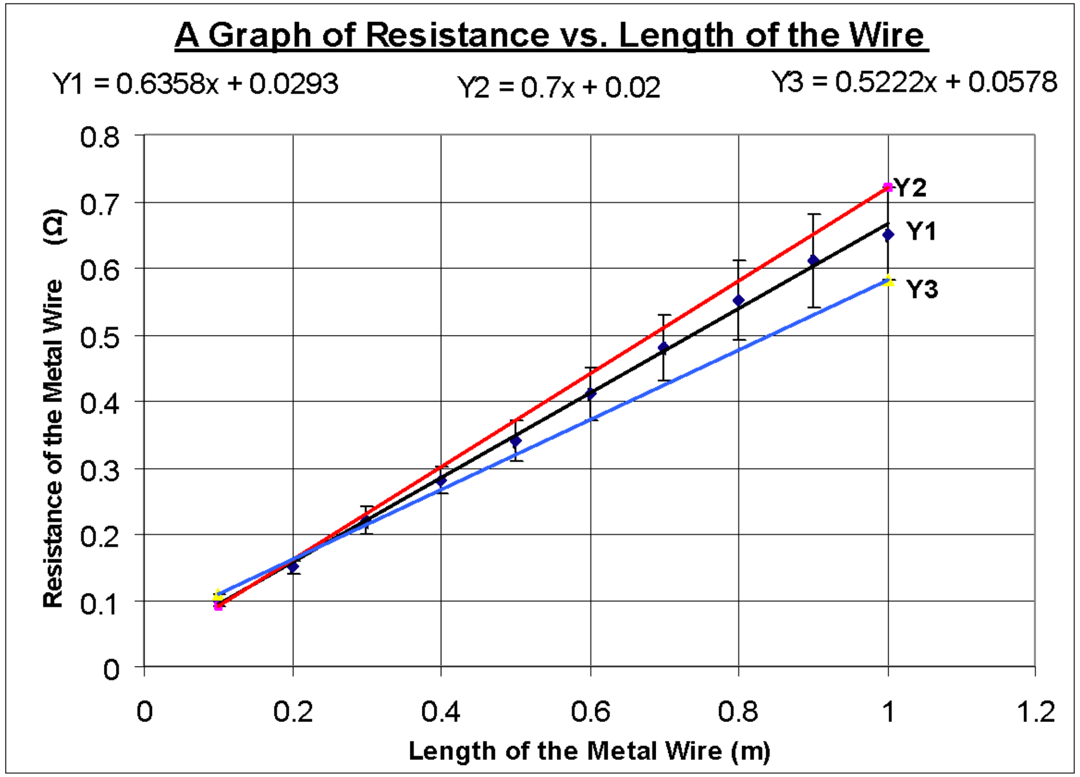


To know for quiz:

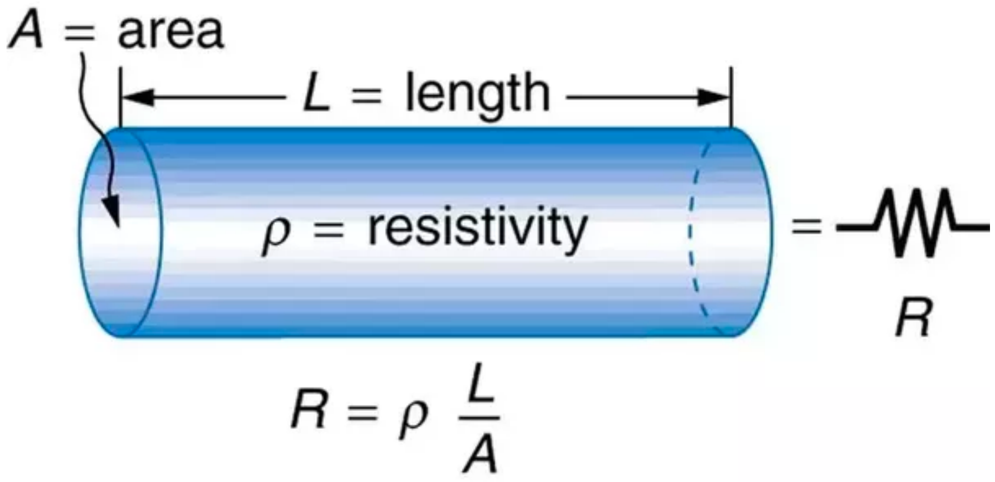
- Electrons move from anode, through wire, into cathode
- Current moves from cathode, through wire, into anode
- Anode and cathode can't be same metal- you need a potential difference in order for current to flow
- Fruit isn't generating electricity – it is providing the acid that reacts with the anode (zinc) to produce free electrons that leave through the wire

Acid removes electrons from the zinc (anode, black)
Positively charged zinc ions move into solution
Electrons removed by the acid flow into the wire into the copper (cathode, red)
Copper wants electrons more than zinc does
Hydrogen ions in the acid meet electrons in the copper, making bubbles of hydrogen gas on the copper





Blue (Y3): thickest wire, red (Y2): thinnest wire



Which has a greater resistance?

R1: greatest slope

Ohm's Law Equation : **V = IR**

V = voltage (a.k.a. potential difference, in volts)

I = Current (in amperes)

R = resistance (in Ohms)

Resistance: measure of a material's ability to resist the flow of of electrons

Ω (ohms)

Conductor – low resistivity

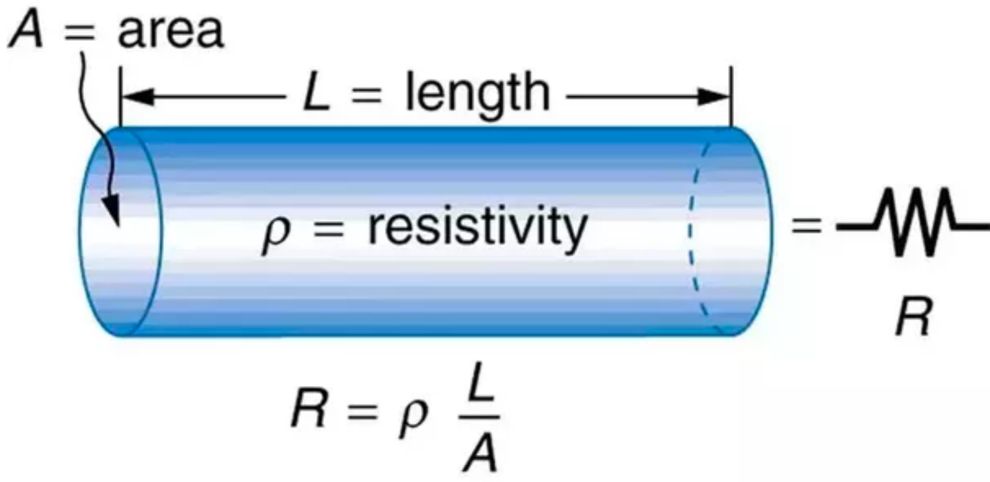
materials with free electrons

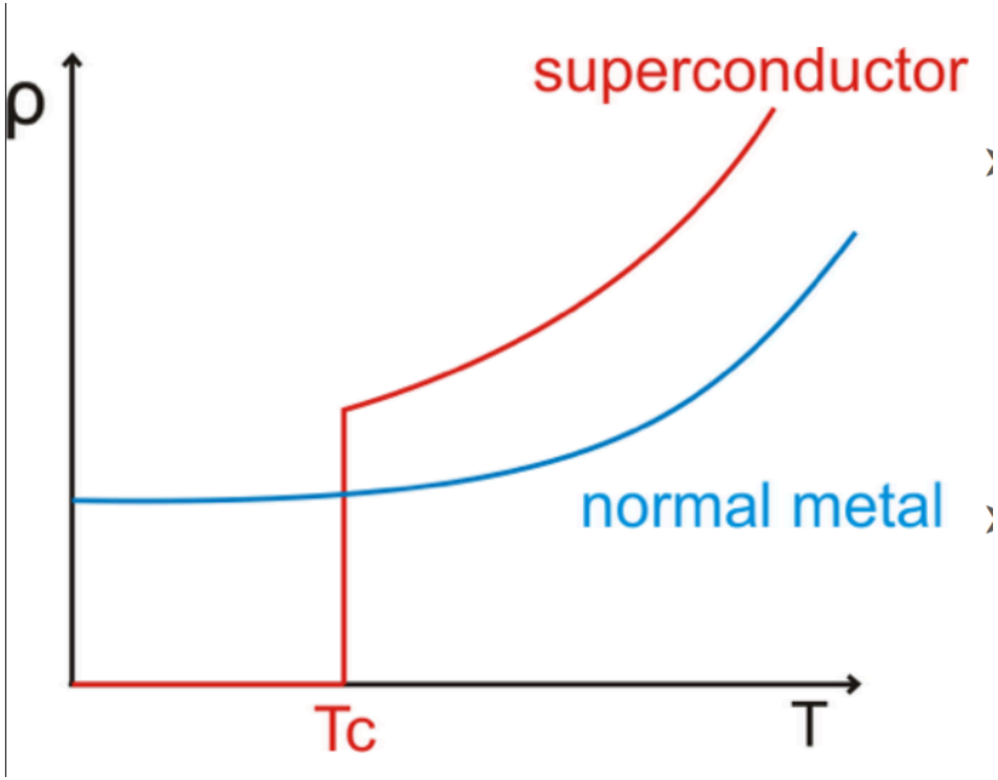
e.g. copper, aluminum, gold, most metals

Insulator – high resistivity

materials with no free electrons

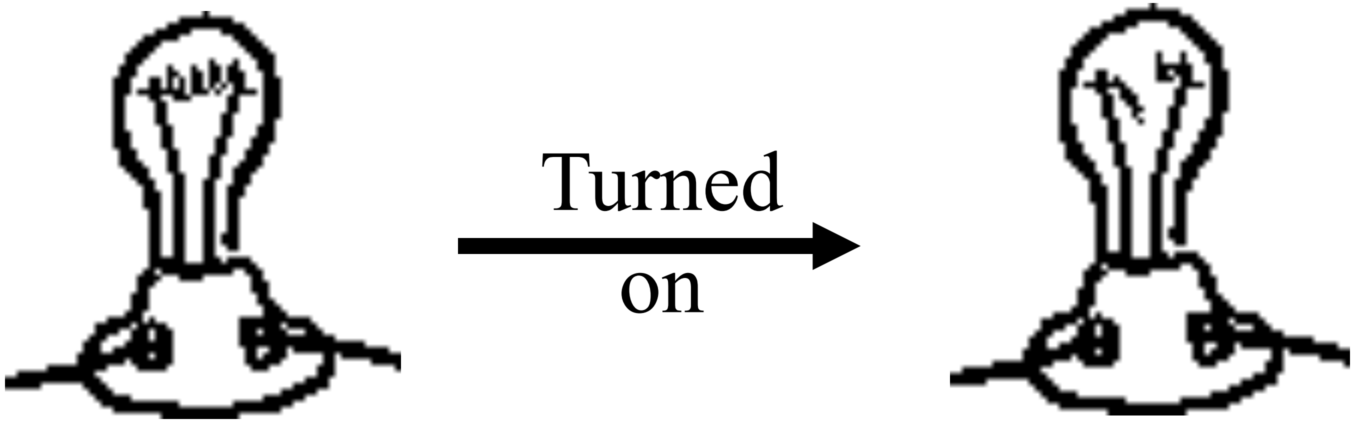
e.g. glass, plastics, ceramics, wood





SUPERCONDUCTORS

- ➢ Even the best conductors put up some resistance to electric current
- ➢ The resistivity of a material depends somewhat on temperature
- ➢ Generally, resistivity increases with temperature
- ➢ Some materials, once cooled below a particular critical temperature, will offer exactly zero resistance
- ➢ Materials in such a state are said to be superconducting



Resistivity also dependent on temperature

Lightbulb is most likely to burn out right after you turn it on –

Filament is cold, so it has lower resistance, so higher current. (V = **I**R)

When it gets warmer, its resistance increases, so it has a lower current. (V = I**R**)

When we say an appliance “uses electricity”, we are really saying that

A. Current disappears

B. Electric charges are dissipated

C. The main power voltage is lowered

D. Electrons are taken out of the circuit

E. Electron kinetic energy is converted into heat energy, light energy, or mechanical work.

Power

P = Energy/time

P = IV

All electronic devices offer resistance to the flow of current

- ➢ Anything that offers resistance “eats up” electric energy
- ➢ often (read inevitably) by converting it to heat energy
- ➢ sometimes in order to do work

Electric energy is useful because it can be easily transformed into other forms of energy

- ➢ motors turn it into mechanical work
- ➢ electric heaters, stoves, toasters, and hair dryers turn it into thermal energy
- ➢ lightbulbs turn it into light and thermal energy ➢

An electric iron draws a current of 4A at 250V. What is its power usage?

A. 0.0166W
B. 60W
C. 1000W

A common lightbulb reads 60W, 120V. How much current in amperes will flow through the bulb?

A. 7200 amps
B. 0.5 amps
C. 2.0 amps

What voltage is this lightbulb meant for? (120 V)

How much current is passing through this? (110 mA = 0.11 A)

Most bulb sockets deliver either 12 or 120 V. What would happen if we plugged this bulb into a 12 V socket?

P = IV

Calculate resistance: V = IR, R = V/I = 120/.11 = 1100 Ohms

Determine the cost of using the following appliances for the time indicated if the average cost is 9 cents/kWh.

(a) 160W color TV for 3 hours and 30 minutes

$$\frac{0.16 \text{ kW} \times (3.5\text{h})}{} \times \frac{9 \text{ cents}}{\text{kWh}} = 5.04 \text{ cents}$$

(b) Six 60W bulbs for 7 hours.

$$\frac{6 \times .06 \text{ kW} \times (7\text{h})}{} \times \frac{9 \text{ cents}}{\text{kWh}} = 22.68 \text{ cents}$$

Question:

Two conducting wires, W_1 and W_2, are made of two different materials, the first with a resistivity of ρ_1, the second with resistivity $\rho_2 = \frac{\rho_1}{2}$. Which of the following pairs of cylindrical wires, with indicated cross sectional area and length, will have equal resistances?