Electrical Fundamentals

Feedback from Lecture 1

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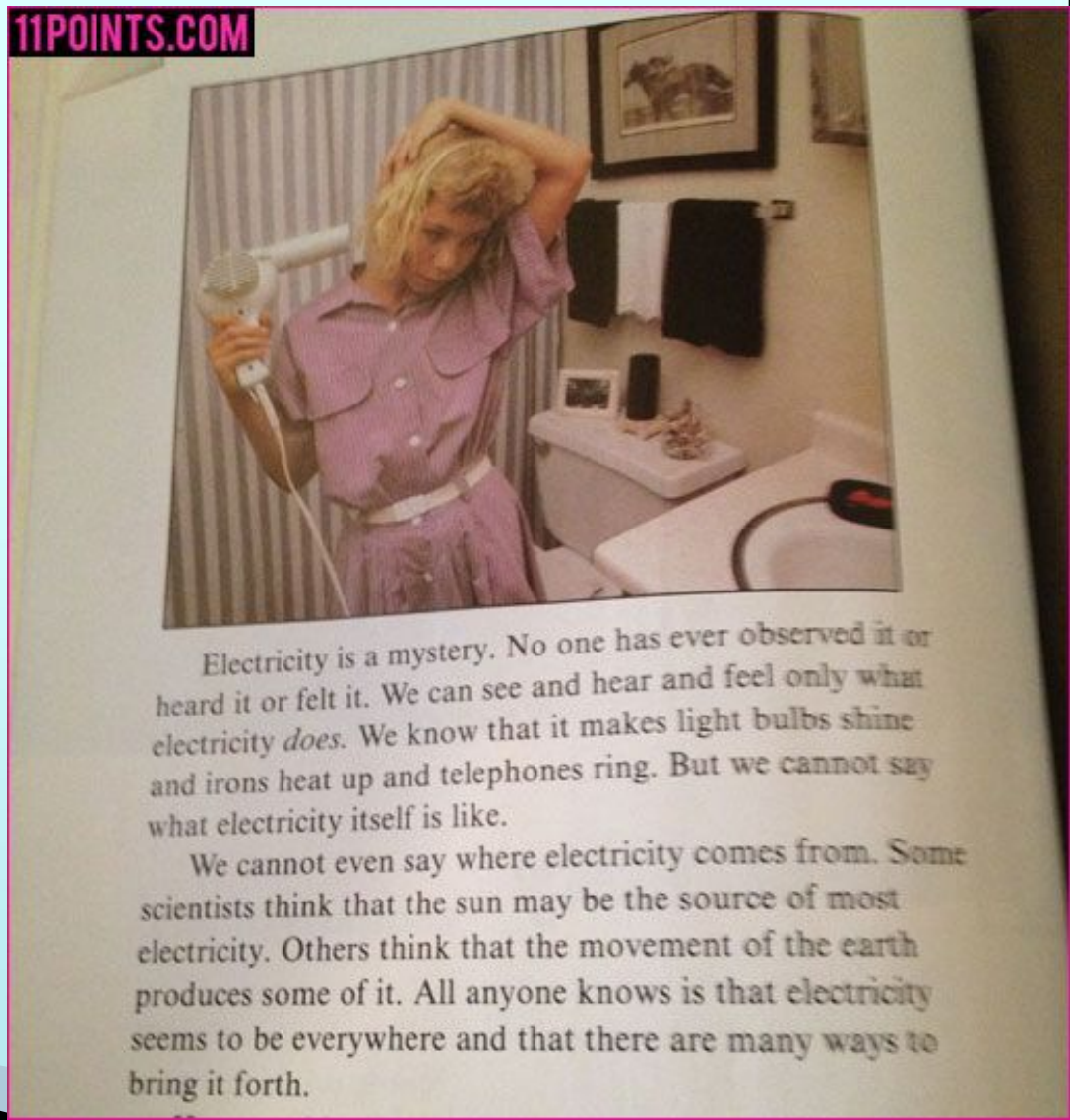
What is your biggest concern regarding this class?

- Electricity itself – 30%
- Course demands / time requirements – 21%
- Remembering prerequisite material – 14%



Feedback from Lecture 1

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What concerns you most about how this class will operate?

- Lab partner issues – 38%
- In class exams (limited test time) – 25%
- Other lab concerns – 13%

Clarification from Lecture 1

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Overall course outcome:

The course is intended to give non-EE major students an introduction to electrical power applications.

Class makeup:

CET Majors – 31

Other – 4

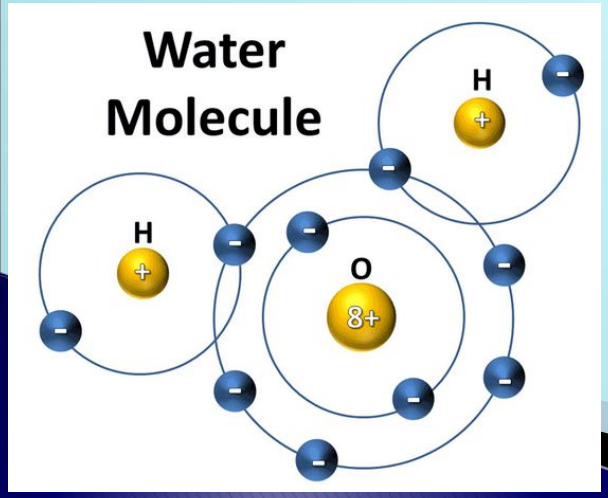
Course will teach electrical fundamentals for anyone interested.

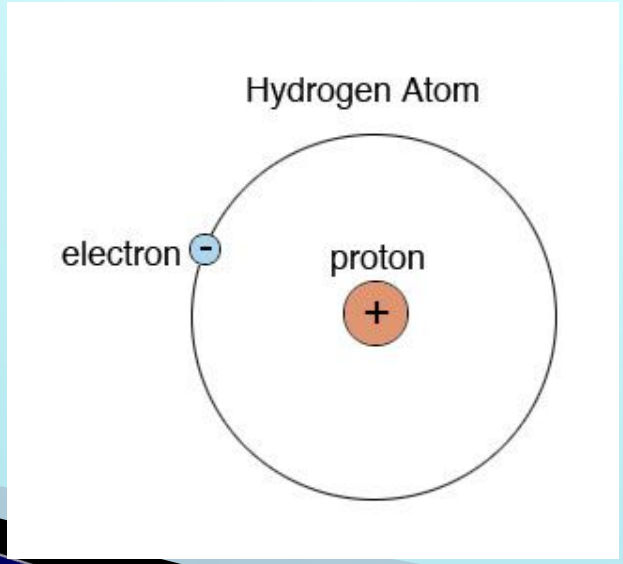
Course not specific to construction field.

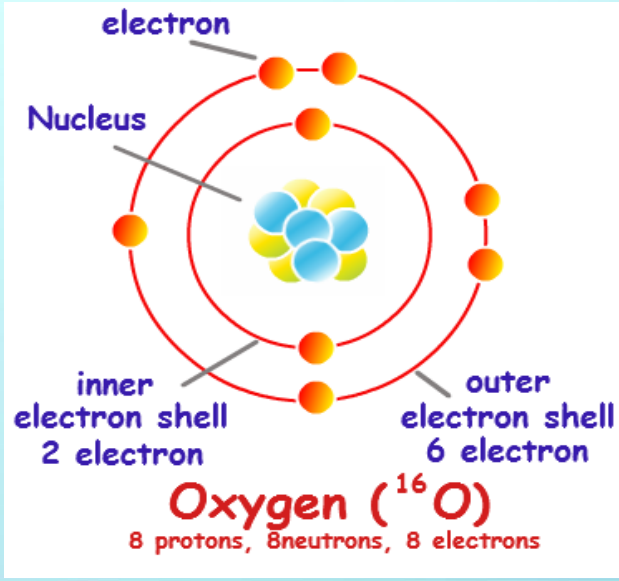
Material covered, lab applications, etc. highly applicable to construction industry.

Structure of Matter

- Matter
  - Anything that occupies space and has mass
  - Made up of molecules (smallest parts that retain properties of matter)
- Atoms (elements) make up molecules
  - Nucleus made up of protons and neutrons
  - Electrons orbit around the nucleus





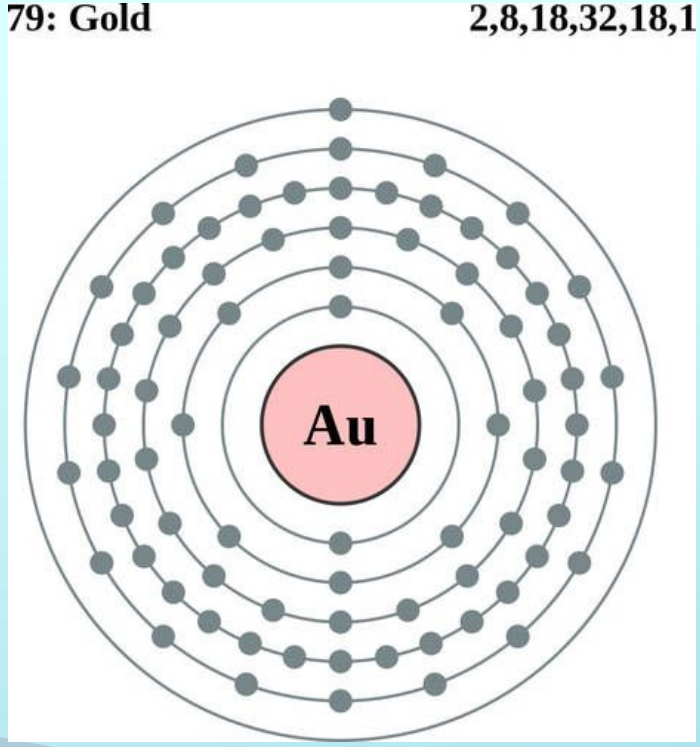


Structure of Matter (cont'd)

- Electron shells (rings)
  - Hold limited number of electrons
  - Max number of electrons depends on shell number

Shell Number	Max number electrons
1 (Innermost)	2
2	8
3	18
4	32
5	18
6	18
7	2

Example: Gold (Au)



Structure of Matter (cont'd)

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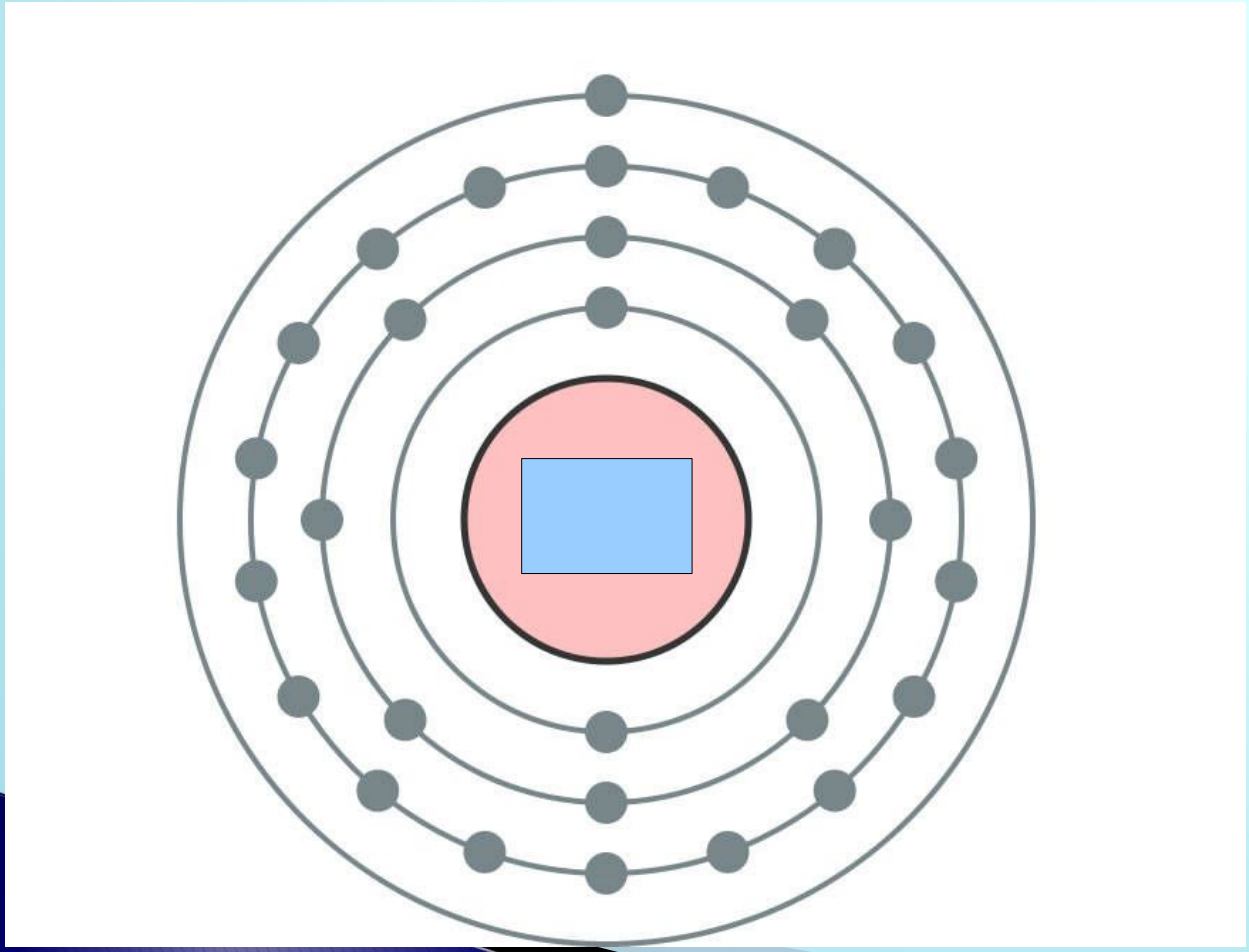
- Matter can be good conductors, poor conductors (e.g. semiconductors), or insulators
- For ATOMS which are good conductors (metals):
  - Electrons in outer band can freely dissociate from their parent atom
  - Generally: corresponds to atoms with 1 – 4 electrons in outer shell (electron ring furthest from the nucleus)

Example

- Is this a good conductor?



Example

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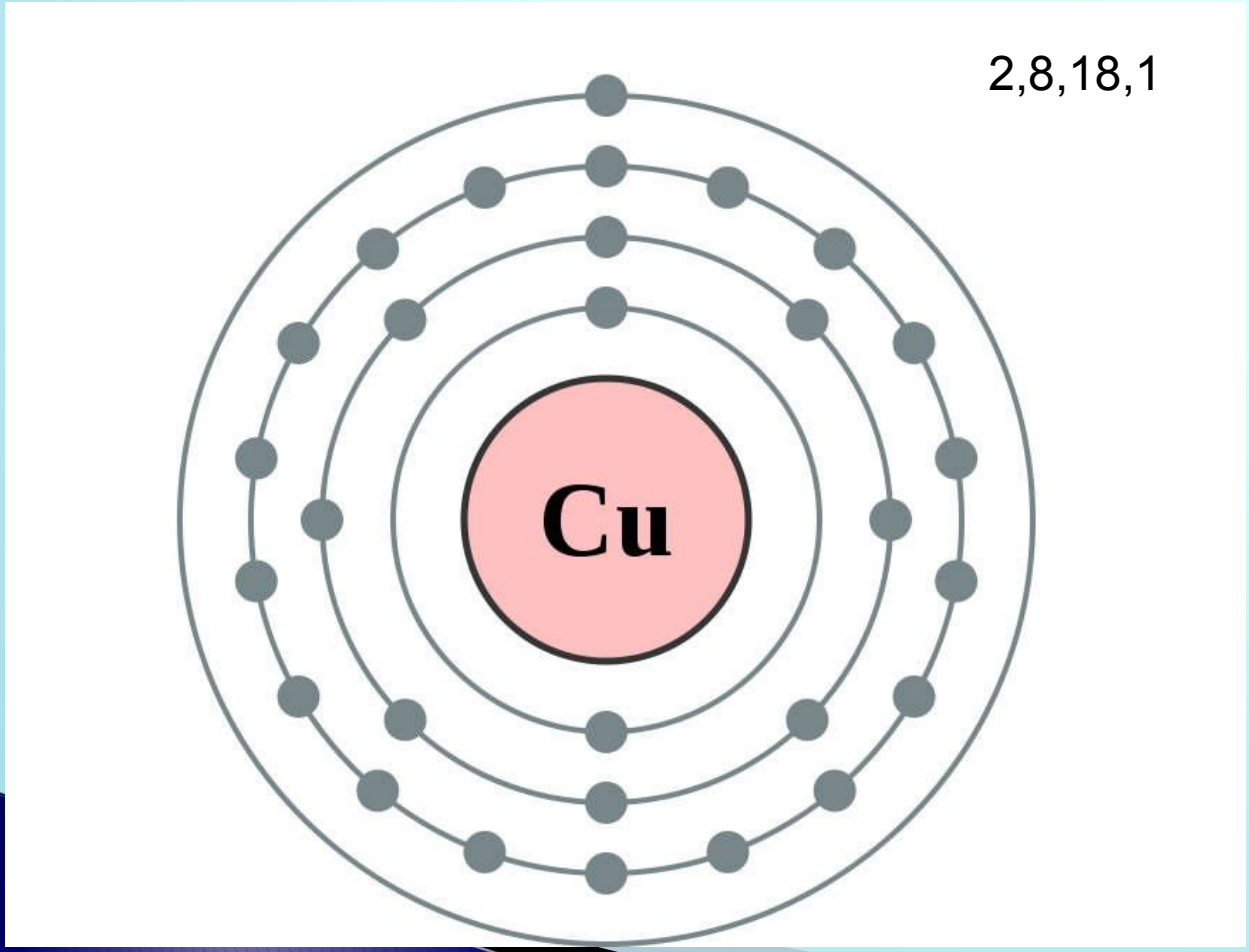

Yes!

This is a copper atom

Conductivity:
~ 6 * 10^7 S/m

Example

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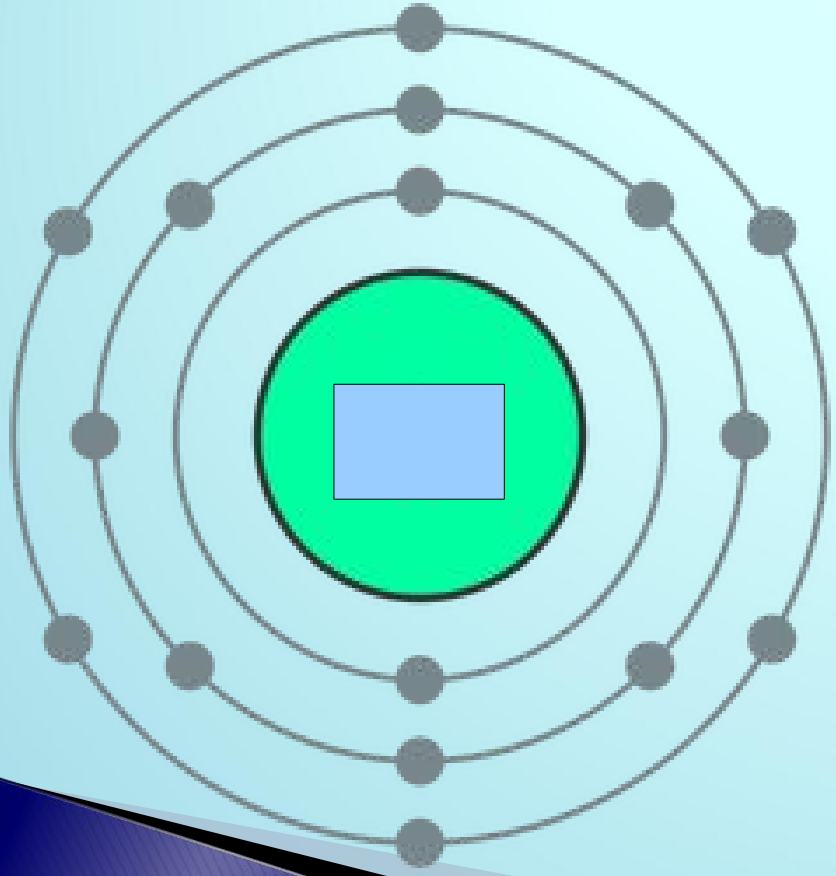
- Is this a good conductor?

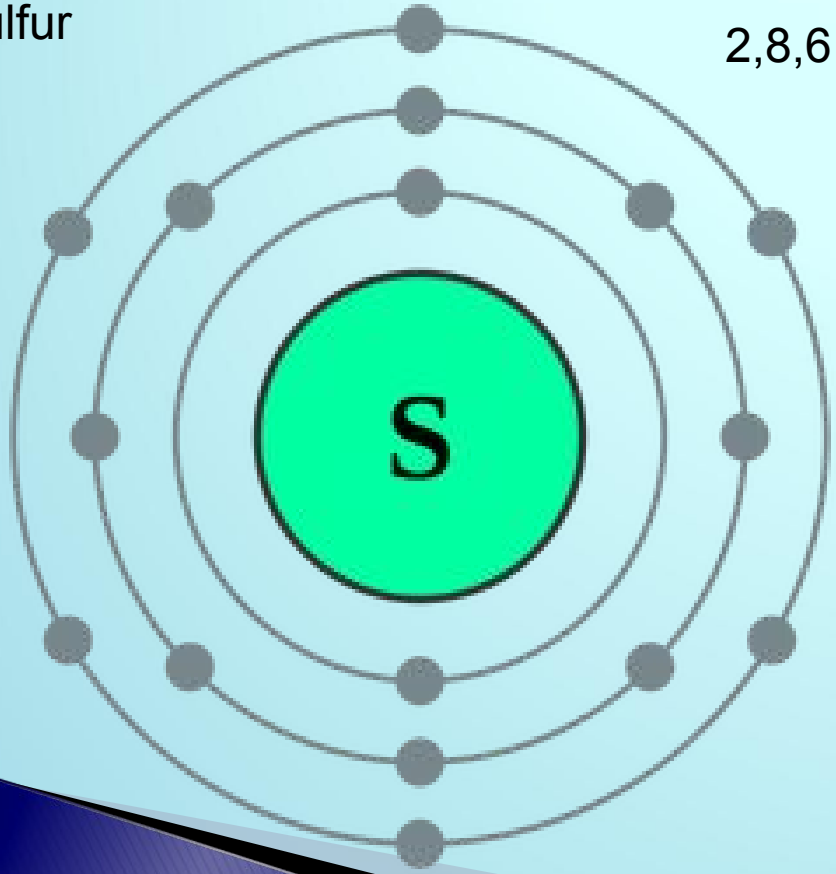


Example

- Is this a good conductor?

Sulfur

2,8,6



No!

This is a sulfur atom

Conductivity:
~ 10^{-16} S/m

Electric current

- Electricity in motion
- Flow rate of electrons (charge flow per second)
- Conductors contain free electrons
- Insulators do not contain free electrons

IMPORTANT:

- Standard convention: Direction of electric current is the opposite of electron flow.
- Book uses opposite definition. We will use standard convention.

Units of Measure

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- Q: Quantity of charge, measured in Coulombs (C)
- I: Quantity of current, measured in Amps (A)
- The charge of a single electron is $1.59\ 10^{-19}$ C

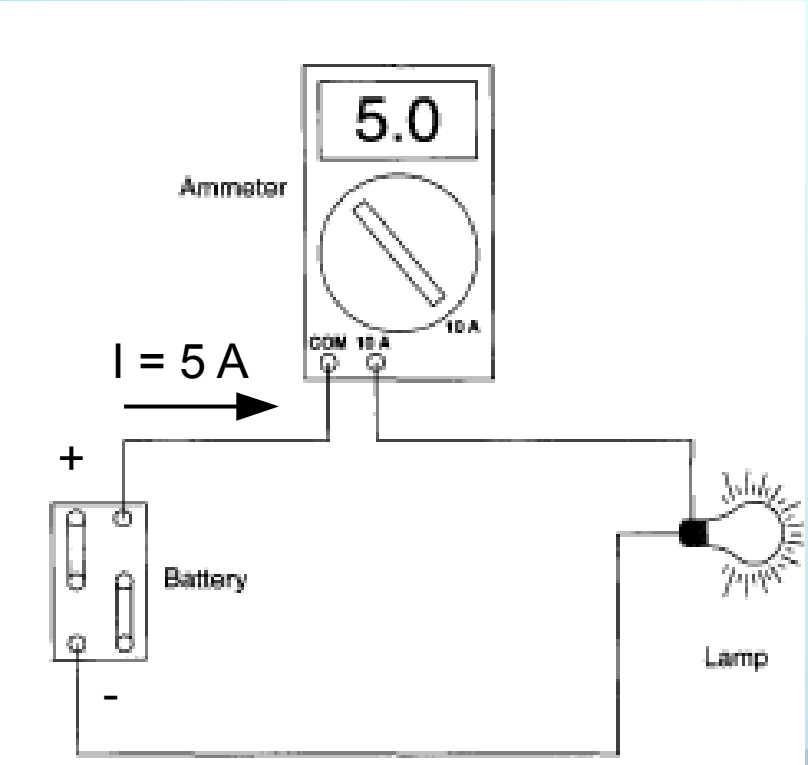
$I = Q/t$ where t is time (s)

1 A = 1 C / 1 s

- Measurement of current taken using an Ammeter

Example

A battery forces a current of 5 A through a circuit for 1 hour. (a) How many coulombs will flow through the circuit? (b) How many electrons per second will flow through the circuit?



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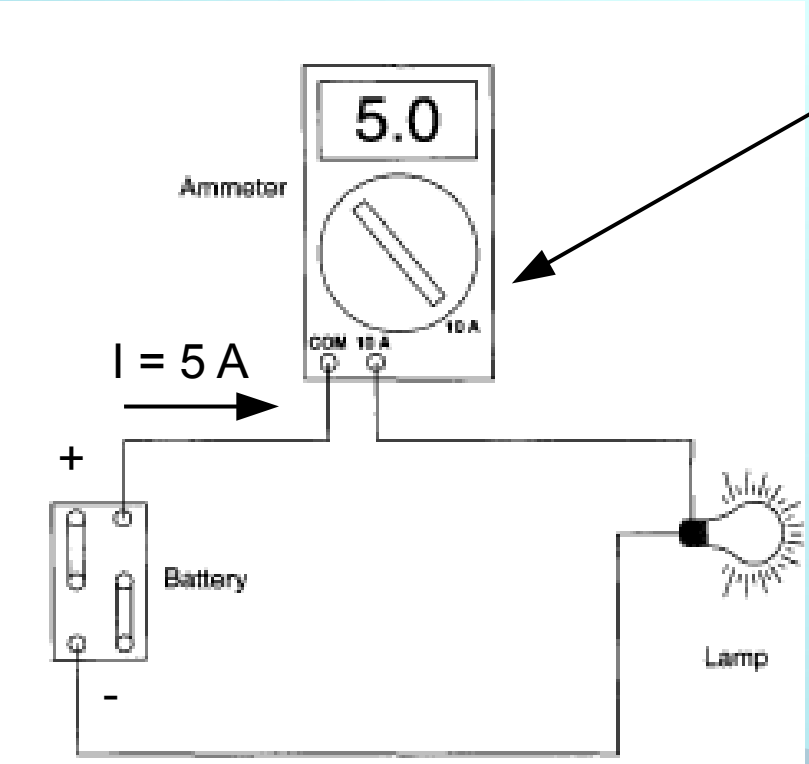


Notice ammeter connection is in SERIES

(a) $I = Q/t$ so $Q = It$

$Q = 5\ A * 3600\ s$

$Q = 18{,}000\ C$

(b) 1 electron = $1.59 * 10^{-19}$ C

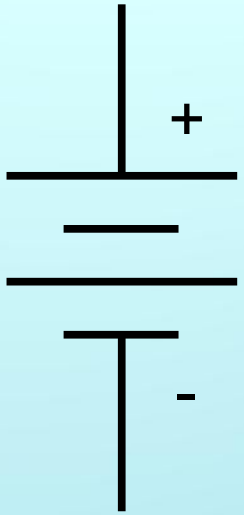
$I = 5\ A / (1.59 * 10^{-19}\ C)$

$I = 3.14 * 10^{19}$ electrons / sec

Voltage

- For current to flow through a conductor, a force is required.
  - Force produced by an imbalance of electric charge

Example: Battery
- Chemical energy is converted to electrical energy
- Mix of chemicals produce an imbalance of electric charge across two terminals
  - Electrons in connected circuit flow from negative terminal (anode) to positive (cathode)



Voltage Sources

- Generators
  - Produce voltage by induction
  - Rotate coils of wire through magnetic field

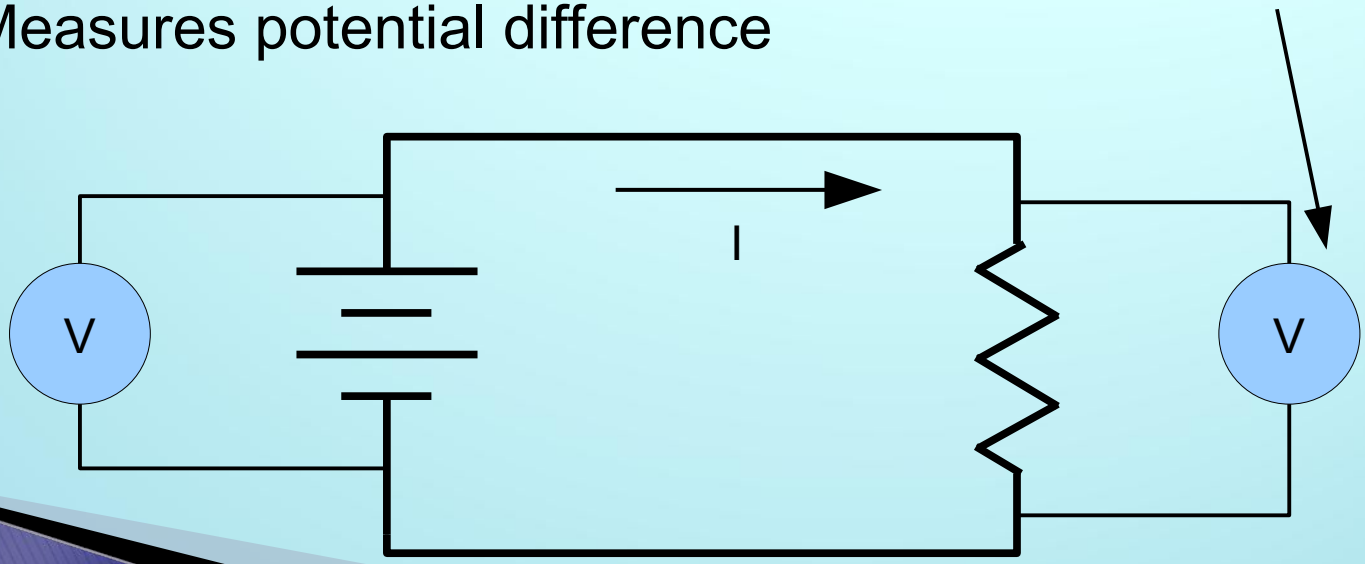
- Batteries
  - Use chemicals to produce voltage

- Thermoelectric
  - Two dissimilar materials connected together and heated to produce voltage across cold ends
- Photovoltaic
  - Voltage produced in device of two dissimilar materials, induced by light

Voltage Measurements

- Voltage (or potential difference)
  - Amount of current that flows depends on voltage
  - Similar to water flow depending on pressure difference in a hydraulic system
- Voltmeter
  - Measures potential difference

Connected in parallel



Electric circuit vs. Hydraulic System

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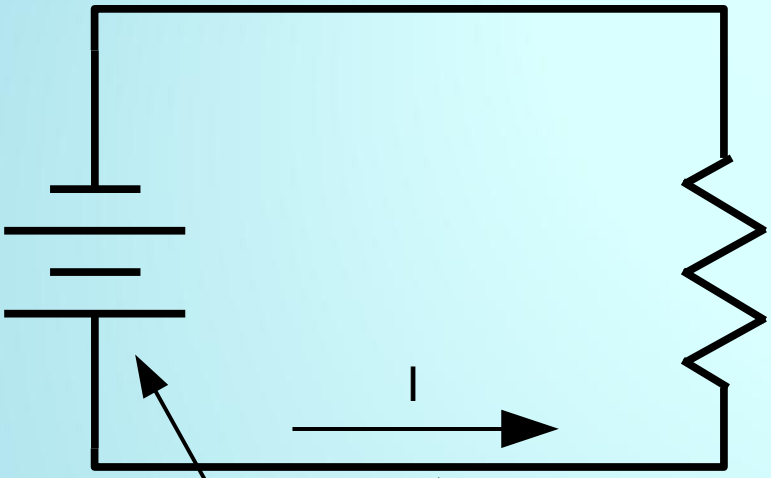
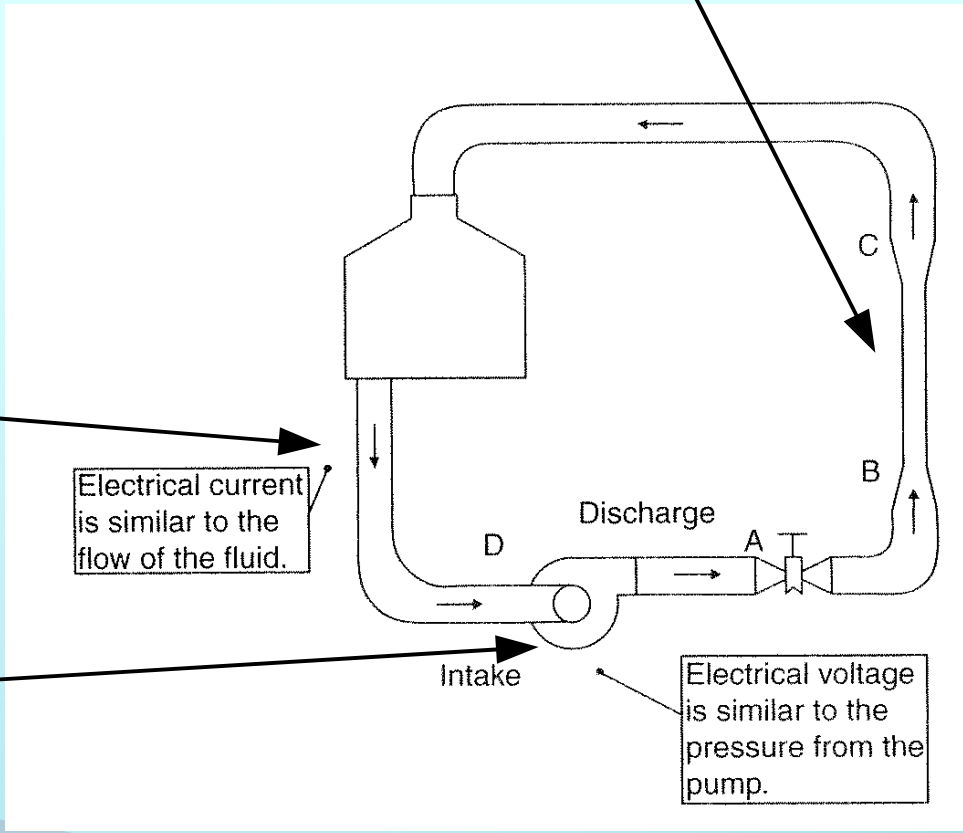


Resistance = High friction pipe

Current = Water flow

Voltage = Pressure



Resistance

- Opposition to current flow
- Conductors have low resistance
- Insulators have high resistance
- Unit of measuring resistance is Ohm ( )
- Measurement of resistance taken using an Ohmmeter

Resistance of a 40-Watt light bulb: ~ 360

Resistance of 1 m long, 10 mm copper wire: ~ $2 * 10^{-4}$

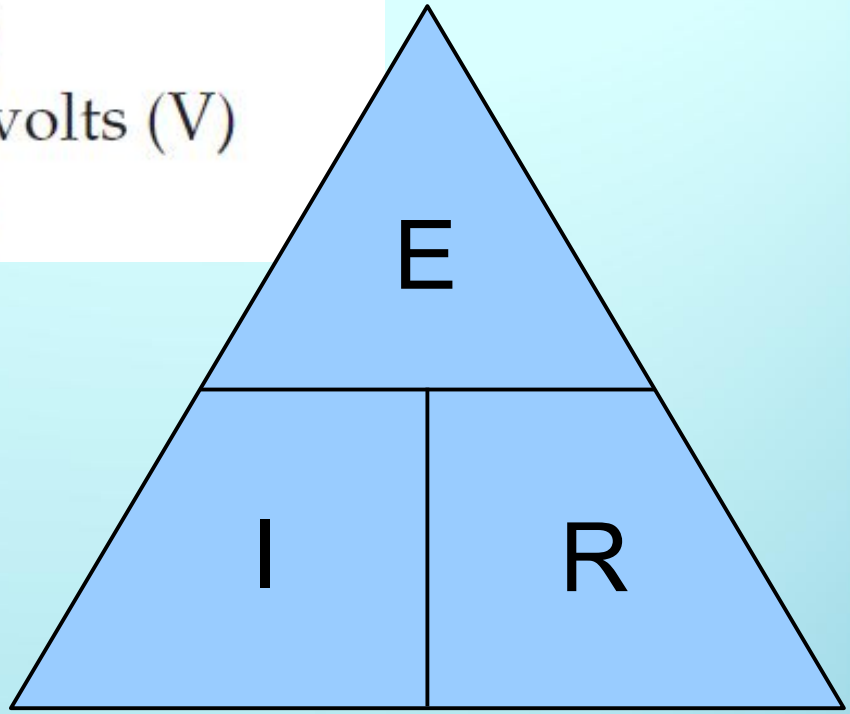
When using Ohmmeter, disconnect circuit!!

Ohm's Law

Relates the current flowing through a circuit to the voltage (electromotive force) and resistance

$$I = \frac{E}{R}\left(\text{or } E = IR, \text{ or } R = \frac{E}{I}\right) \qquad \text{(Eq. 2.2)}$$

where I = current, in amperes (A)
E = electromotive force, in volts (V)
R = resistance, in ohms (Ω)



Example

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A flashlight powered by 3 D cell batteries (1.5 V each) draws 50 mA of current when turned on. What is the resistance of the lightbulb in the flashlight?

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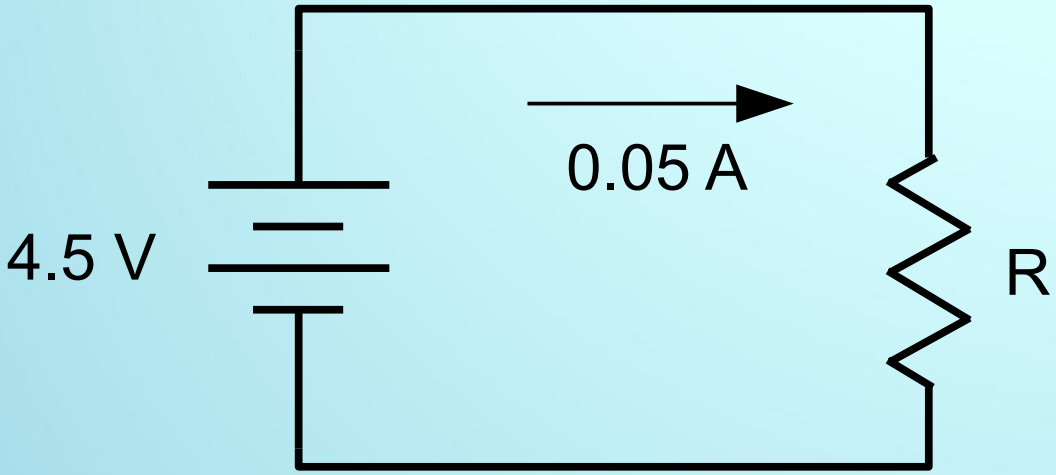

$R = E/I$

$R = 4.5\ V / 0.05\ A$

$R = 90$

Quick Word on Lab Safety

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- We have not had any accident in this laboratory since it was built! **Please help keep it that way!**

- **Safety first, always!** In this laboratory you will work with 110/208 V electricity. For your own safety, you need to make some necessary precautionary measures in your work. **We have to enforce safety measures!**

- **Make sure your circuit connections are solid** so that the terminals of wires in your circuit won't come loose. Always have your lab instructor check your circuit before energizing it; otherwise, you will loose credit for the lab experiment you are doing.

Lab Safety (cont'd)

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- **Absolutely no drinks in the laboratory:** Electrical equipment and any kind of fluid just don't get along! **Expect this to be enforced by your lab instructor!**
- **Locate the two RED emergency circuit breakers in the laboratory.**
- **For any emergency, dial 911 and university police will respond.**
- **Come to the lab on time and prepared!**
- **In the lab, be cooperative, practice team work, one report per team!**

Homework

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Answer the **multiple choice** questions 1 through 10.

Solve problems 1, 2, 4, 6, 7, 8.

Due: Week from today. Wednesday 9/4/13