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ECE401

Perspectives In Electrical and Computer Engineering

Lecture 5

1

Last Time

- Student Stress?
- What the Hell was it last Friday
- Final Tips for surviving classes
  - Text books
  - Writing
- Homework 3
- Learning styles
- How can I determine what is my learning style is?
  - How do I understand how I learn?

2

Today

- Finish up Learning Styles
- What the Hell is it Friday
- Mysteries of Materials
- Electrical Engineering Basics
  - Charge
    - The Coulomb and the Elementary Charge
  - Concept of "Free Electrons"
  - Insulators and Conductors
- Concept of a Circuit
  - Complete (closed) Circuit vs. Broken (open) circuit
  - Concept of Charge Storage
  - Defining Measures
    - Ampere, Volt, Ohm
  - Single Loop Closed Circuit
  - Switches
  - Schematic Symbols

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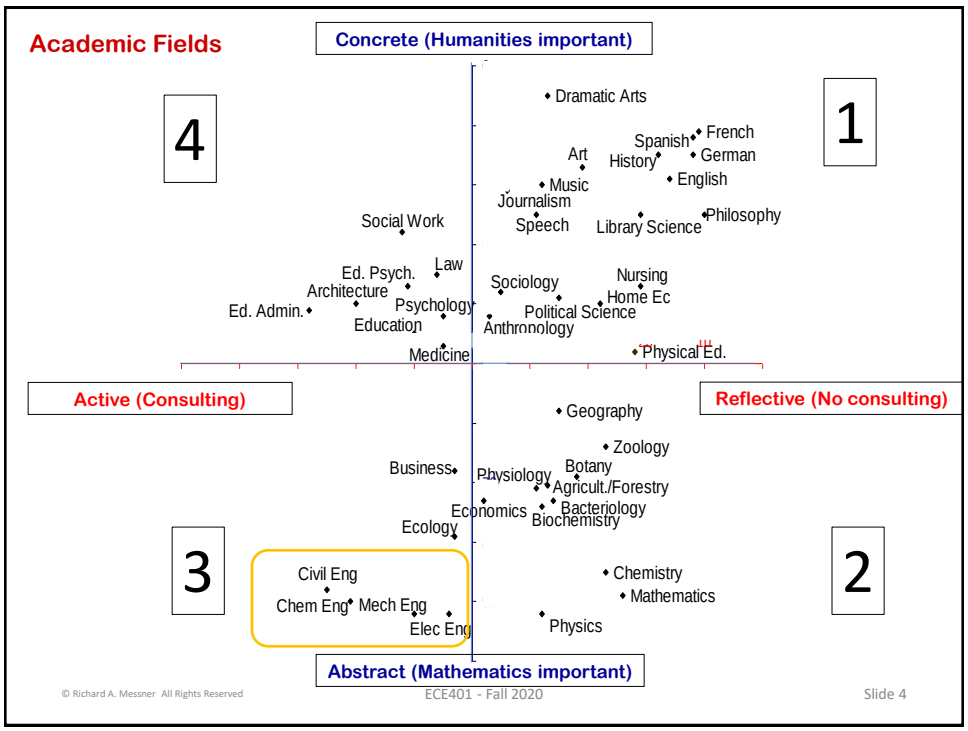

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Type One Learners

Like to:

- Integrate experience with Self
- Listen and share ideas
- View from many perspectives
- Work for harmony
- Be personally involved
- Be innovative
- Clarify values

Favorite question: WHY?

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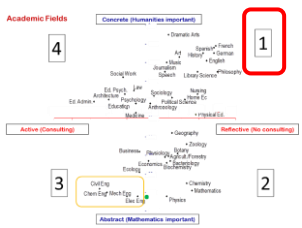
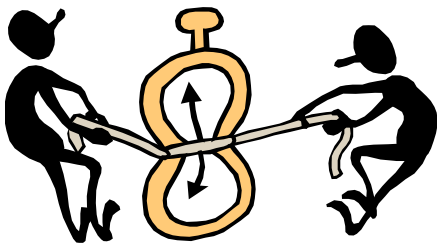
Type One Learners

Dislike:

- Timed tests, pop quizzes
- No student interaction
- Insensitive teachers
- Individual work
- Skill development
- Lack of thinking time
- Coverage rather than depth
- Colorless environments





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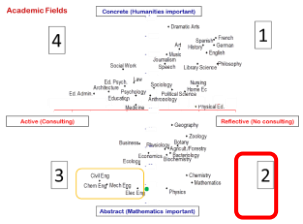
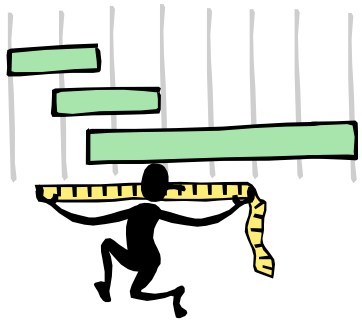
Type Two Learners

Like to:



- Integrate observations into what is known
- Seek continuity
- Know what experts think
- Think through ideas
- Think linearly
- Work with detail
- Critique information and collect data



Favorite question: WHAT?

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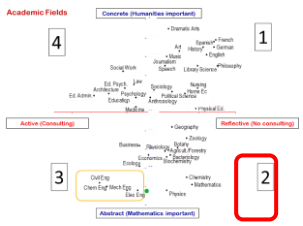
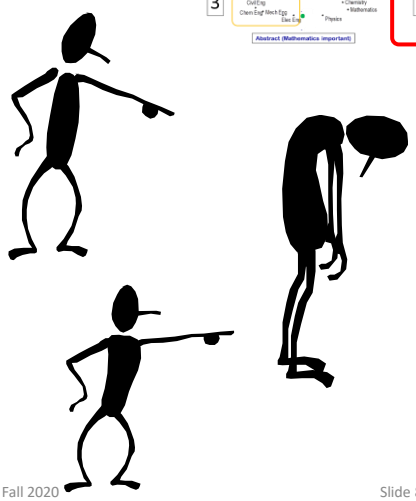
Type Two Learners

Dislike:



- Information out of sequence
- Multiple authorities
- Pass/fail grading
- Criticism
- Group projects
- Disorganization
- Unknown expectations



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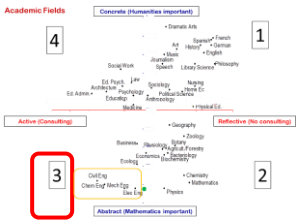
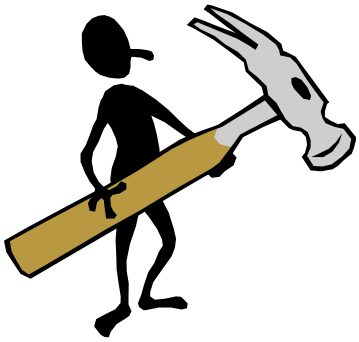
Type Three Learners

Like to:

- Integrate theory and practice
- Test theories and apply common sense
- Solve "down-to-earth problems"
- Use skills
- Know how things work





Favorite question:

HOW DOES THIS WORK?

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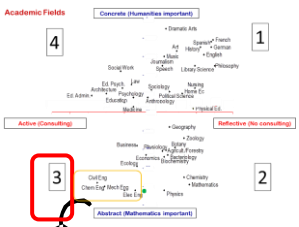
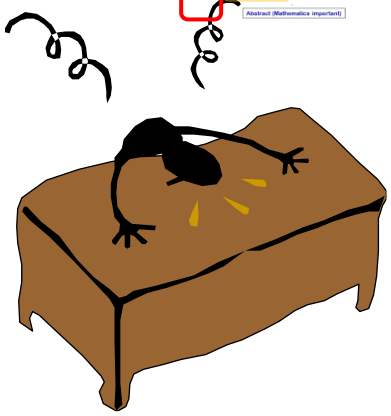
Type Three Learners

Dislike:

- Reading from books
- Memorization
- Confined nature of lectures
- Lack of application
- Restricted environments
- Group work
- Lack of hands-on work
- Labs that don't work
- Written assignments





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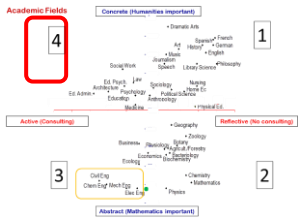
Type Four Learners

Like to:

- Integrate experience and application
- Learn by trial and error
- Discover new ideas by themselves
- Get excited by new things
- Adapt to new situations
- Reach good conclusions by intuition
- Take risks

Favorite question:

IF?



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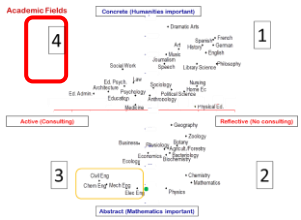
Type Four Learners

Dislike:

- Long lectures
- Teacher-oriented classrooms
- Standard routines
- Repetition and drill
- Assignments without options
- Knowledge for its own sake



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Now you have some idea as to what type of learner you are!

Hopefully, this exercise will help you in your ability to adapt and learn from the variety of instructor styles you will be exposed to

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What the Hell is it Friday

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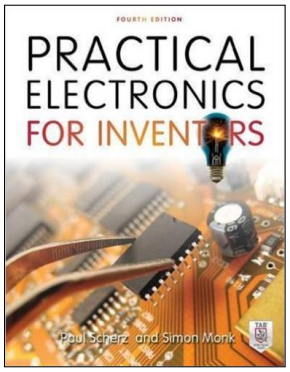
Reading 2



Reading 3
Sections 2.5, 2.6, 2.9, 2.11, 2.12
Keep Reading

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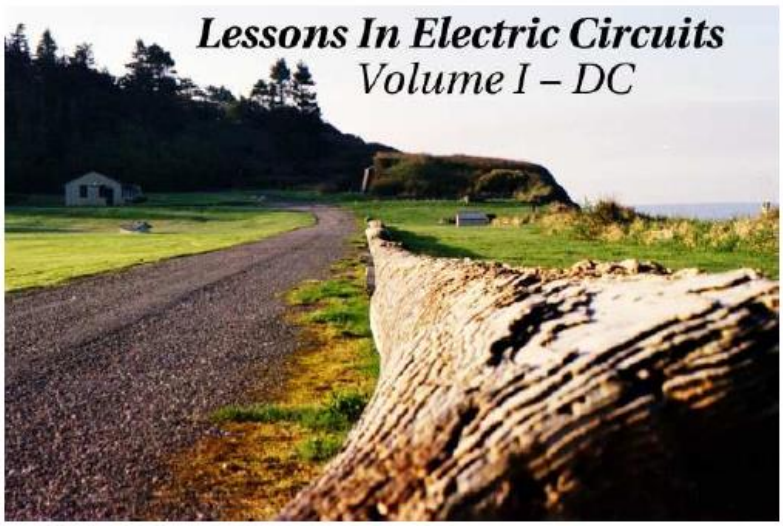

Fifth Edition, last update October 18, 2006

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Electrical and Computer Engineering

- It is a discipline founded by some of the greatest inventors in modern history
- Their inventions have dramatically transformed our world
  - Light bulb: brought light to the darkness
  - Motors and Generators: power and energy to machines
  - Telegraph and Radio: wired and wireless communication to connect the world
- Computer engineering is a specialty that grew out of electrical engineering
  - It has similarly transformed our society as dramatically as electrical engineering
    - Calculator
    - General purpose computer
    - sensing and information retrieval, dissemination, and understanding to the masses
- ECE has maintained close ties with industry throughout its history
- Today, ECE is a leader in:
  - The generation of novel ideas
  - Intellectual property, and technology transition impacting our:
    - Economy
    - Health care
    - Security
    - Environment.

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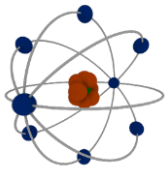

What is the Underlying Physical Basis for ECE?

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Mysteries of Materials

- Centuries ago it was discovered that certain types of materials would mysteriously be attracted to each other after being rubbed together
- What was this mysterious attraction?

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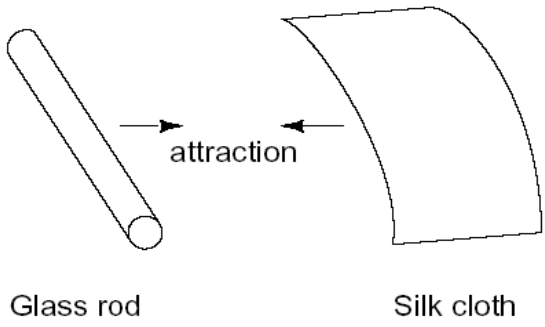
Static Electricity



Other materials also exhibit this phenomena

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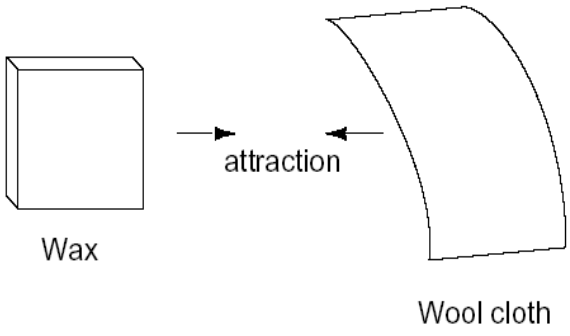
Another Example



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But what about repulsion?

- If some materials attract when rubbed together then it might be deduced that some materials repel each other when rubbed
- It was discovered that when identical materials had been rubbed with their respective cloths those materials would repel each other

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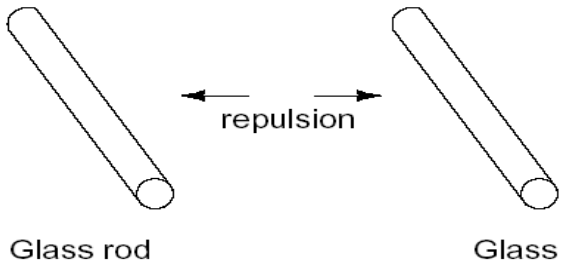

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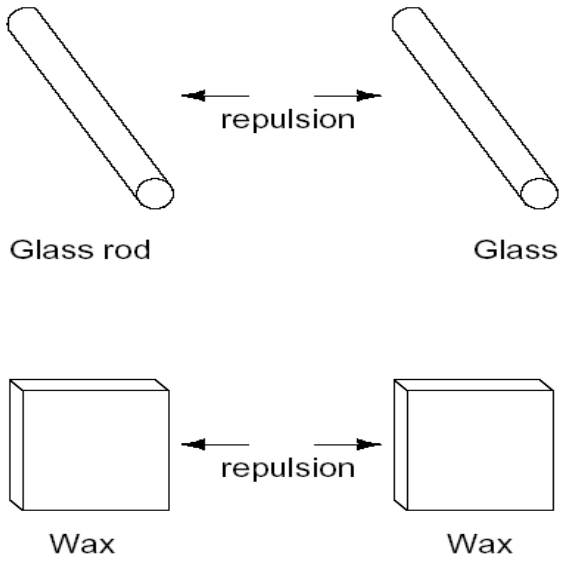

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Early Experimentation

- Some experimenters speculated that invisible “Fluids" were being transferred from one object to another during the process of rubbing, and that these “Fluids" were able to erect a physical force over a distance

- **Charles François de Cisternay DuFay**
  Demonstrated that there were definitely two different types of changes wrought by rubbing certain pairs of objects together. The fact that there was more than one type of change manifested in these materials was evident by the fact that there were two types of forces produced: attraction and repulsion
- The hypothetical Fluid transfer became known as a **CHARGE**

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Benjamin Franklin’s Idea

- Benjamin Franklin, came to the conclusion that there was only one fluid exchanged between rubbed objects, and that the two different "charges" were nothing more than either an excess or a deficiency of that one fluid
- After experimenting with wax and wool, Franklin suggested that the coarse wool removed some of this invisible Fluid from the smooth wax, causing an excess of Fluid on the wool and a deficiency of Fluid on the wax

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Franklin's Speculation

- Following Franklin's speculation of the wool rubbing something off of the wax, the type of charge that was associated with rubbed wax became known as "negative" (because it was supposed to have a deficiency of Fluid) while the type of charge associated with the rubbing wool became known as "positive" (because it was supposed to have an excess of Fluid)
- Little did he know that his innocent conjecture would cause much confusion for students of electricity in the future!

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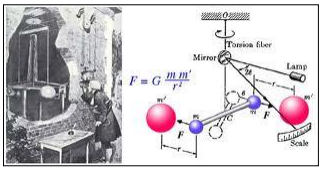
Charge Measurement

- Precise measurements of electrical charge were carried out by the French physicist Charles-Augustin de Coulomb



- This was accomplished in the 1780's using a device called a torsional balance measuring the force generated between two electrically charged objects. The results of Coulomb's work led to the development of a unit of electrical charge named in his honor, the **COULOMB**

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Enter the Atom

- It was discovered much later that this “Fluid" was actually composed of extremely small bits of matter called electrons
- Experimentation has since revealed that all objects are composed of extremely small "building-blocks" known as atoms, and that these atoms are in turn composed of smaller components known as particles
- The three fundamental particles comprising atoms are called
  - **PROTONS, NEUTRONS, and ELECTRONS**

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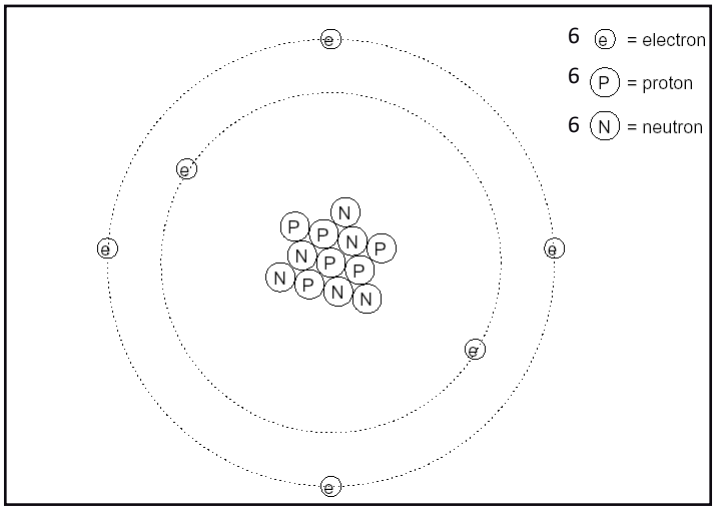
Can you guess the Element in this diagram????



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The Answer!

- The element depicted is **CARBON**
- In any atom, the protons and neutrons are very tightly bound together, which is an important quality
- The tightly-bound clump of protons and neutrons in the center of the atom is called the nucleus
  - The number of protons in an atom's nucleus determines its elemental identity
  - Change the number of protons in an atom's nucleus, and you change the type of atom that it is

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Making Gold From Lead

Atomic Data for Lead (Pb)
Atomic Number = 82
Atomic Weight = 207.2

Atomic Data for Gold (Au)
Atomic Number = 79
Atomic Weight = 196.966543

- If you could remove three protons from the nucleus of an atom of lead, you will have achieved the old alchemists' dream of producing an atom of gold!
  - The tight binding of protons in the nucleus is responsible for the stable identity of chemical elements, and the failure of alchemists to achieve their dream

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But what about electrons?

- Electrons have significantly more freedom to move around in an atom than either protons or neutrons
  - They can be knocked out of their respective positions (even leaving the atom entirely!) by far less energy than what it takes to dislodge particles in the nucleus
  - If this happens, the atom still retains its chemical identity, but an important charge imbalance occurs
- Electrons and protons are unique in the fact that they are attracted to one another over a distance
  - It is this attraction over distance which causes the attraction between rubbed objects, where electrons are moved away from their original atoms to reside around atoms of another object

Electric Charge

- Electrons tend to repel other electrons over a distance, as do protons with other protons
  - The only reason protons bind together in the nucleus of an atom is because of a much stronger force called the ***strong nuclear force*** which has effect only under very short distances
- Because of this attraction/repulsion behavior between individual particles, electrons and protons are said to have opposite electric charges
  - That is, each electron has a negative charge, and each proton a positive charge

Electron arrival and departure

- If electrons leave (or extra electrons arrive), the atom's net electric charge will be imbalanced, leaving the atom "charged" as a whole
  - This causes it to interact with charged particles and other charged atoms nearby
- The process of electrons arriving or leaving is exactly what happens when certain combinations of materials are rubbed together
  - electrons from the atoms of one material are forced by the rubbing to leave their respective atoms and transfer over to the atoms of the other material

Measurement

- The operational definition of a coulomb as the unit of electrical charge (in terms of force generated between point charges) was found to be equal to an excess or deficiency of about 6,250,000,000,000,000,000 electrons

$$\mathbf{6.25 \times 10^{18}}$$

  - Or, stated in reverse terms, one electron has a charge of about 0.00000000000000000016 coulombs

$$\mathbf{1.6 \times 10^{-19}}$$

- Being that one electron is the smallest known carrier of electric charge, this last figure of charge for the electron is defined as the ***elementary charge***

What have we learned?

- All materials are made up of tiny "building blocks" known as atoms
- All atoms contain particles called electrons, protons, and neutrons
- Electrons have a negative (-) electric charge.
- Protons have a positive (+) electric charge.
- Neutrons have no electric charge
- Electrons can be dislodged from atoms much easier than protons or neutrons
- The number of protons in an atom's nucleus determines its identity as a unique element

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Measure

- **1 Coulomb** = **6.25 x 10^{18} electrons**
- **Electron Charge = 1.6 x 10^{-19} Coulombs**

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Conductors, Insulators, and Electron Flow

- With some types of materials the outermost electrons in the atoms are so loosely bound that they chaotically move in the space between the atoms of that material by nothing more than the influence of room-temperature (i.e., heat energy)
- In other types of materials such as glass, the atoms' electrons have very little freedom to move around
  - While external forces such as physical rubbing can force some of these electrons to leave their respective atoms and transfer to the atoms of another material, they do not move between atoms within that material very easily

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Is anything in this world "free"?

- Concept of "free electrons"
  - Electrons that are free to move about from atom to atom in materials are called ***free electrons***
- This relative mobility of electrons within a material is known as:

ELECTRIC CONDUCTIVITY

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Conduction vs Insulation

- Materials with high electron mobility (many free electrons) are called: **CONDUCTORS**
- Materials with low electron mobility (few or no free electrons) are called: **INSULATORS**

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Conductors

Some are Better than Others

- silver
- copper
- gold
- aluminum
- iron
- steel
- brass
- bronze
- mercury
- graphite
- dirty water
- concrete

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Insulators

Some are Better than Others

- glass
- rubber
- oil
- asphalt
- fiberglass
- porcelain
- ceramic
- quartz
- (dry) cotton
- (dry) paper
- (dry) wood
- plastic
- air
- diamond
- pure water

Remember

- not all conductive materials have the same level of conductivity
- not all insulators are equally resistant to electron motion

Electrical conductivity is analogous to the transparency of certain materials to light: materials that easily "conduct" light are called "transparent," while those that don't are called "opaque." However, not all transparent materials are equally conductive to light. Window glass is better than most plastics, and certainly better than "clear" fiberglass

What else effects conductivity

- Physical dimension also impacts conductivity
- if we take two strips of the same conductive material (one thin and the other thick) the thick strip will prove to be a better conductor than the thin for the same given length
- If we take another pair of strips (this time both with the same thickness but one shorter than the other) the shorter one will offer easier passage to electrons than the long one
  - This is analogous to water flow in a pipe
    - a fat pipe offers easier passage of water than a skinny pipe
    - a short pipe is easier for water to move through than a long pipe of the same diameter

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What else effects conductivity?

- Temperature also effects conductivity
- Some materials experience changes in their electrical properties under different conditions
  - Glass, for instance, is a very good insulator at room temperature, but becomes a conductor when heated to a very high temperature
  - Gases such as air, normally insulating materials, also become conductive if heated to very high temperatures
  - Most metals become poorer conductors when heated, and better conductors when cooled
  - Many conductive materials become perfectly conductive (this is called superconductivity) at extremely low temperatures

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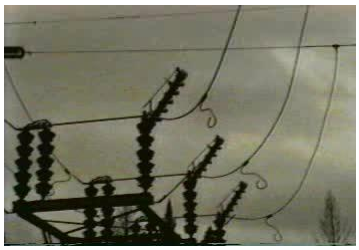
When Air Becomes Conductive



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End

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