

“Electricity is actually made up of extremely tiny particles called electrons, that you cannot see with the naked eye unless you have been drinking.”

“Magnetism, as you recall from physics class, is a powerful force that causes certain items to be attracted to refrigerators.”

*Dave Barry, American humorist (1947 - )*

“If it weren't for electricity we'd all be watching television by candlelight.”

*George Gobel, American comedian (1919-1991)*

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## Current Assignments ... 1

### For today:

- Read 8.1, 8.2, 8.3, 8.5, 8.6

### For Lecture 9:

- Read Sections 9.1, 9.2, 9.3

### Suggested Conceptual Exercises:

- Chapter 8: 1,3,7,9,11,19,21,31,33,35,37,39

### Attend your third tutorial this week

- Quiz is on material covered last week

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## Current Assignments ... 2

### Homework #1

- Due 11:00 AM, today in the Drop Boxes
- The tutors are collecting them now!
- Late penalty = 5% per day (also applies to weekends) for a maximum of 7 days.
- Absolute last date: 11 AM, Thursday, Feb 7

### Writing Assignment #1

- Due 11:00 AM, Thursday, February 28

### Homework #2

- Available today
- Due 11:00 AM, Thursday, February 14

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## Review of Lecture 7

### Textbook, Sections 6.1- 6.6

- Work and energy
- Gravitational and kinetic energy
- The Law of Conservation of Energy
- Transformations of energy

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## Plan for Lecture 8

### Textbook, Sections 8.1, 8.2, 8.3, 8.5, 8.6

- Electricity
- Atoms and electrons
- Force fields
- Magnetism and electromagnetism

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“ELECTRICITY, n. The power that causes all natural phenomena not known to be caused by something else.

... Electricity seems destined to play a most important part in the arts and industries. The question of its economical application to some purposes is still unsettled, but experiment has already proved that it will propel a street car better than a gas jet and give more light than a horse.”

*Ambrose Bierce, The Devil's Dictionary,  
US author & satirist (1842-1914)*

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## Electricity

- When certain materials are rubbed together, we observe attractive and repulsive forces.
  - Examples: pith balls and rods, a balloon and hair, transparencies and tissues.
- We say such objects are **electrically charged**.
- The electric force between two charged objects decreases with distance.
  - Like the  $1/d^2$  dependence of gravitational force.
- Two types of charge, positive and negative.
- Like charges repel and unlike charges attract.

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## The Electric Force Law

- Electrically charged objects exert forces on each other, even when they are some distance apart.
- Objects may be charged in either of two ways, known as positive and negative.
- Two objects possessing like charges (both positive, or both negative) repel each other, and two objects possessing unlike charges (one positive, the other negative) attract each other.

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## Coulomb's Law of the Electric Force

- The force between two charged objects is
  - Proportional to amount of charge on each object
  - Proportional to inverse of the square of the distance between them
- Electric force = (charge on object 1) x (charge on object 2) / square of distance between them
- $F \propto q_1 \times q_2 / d^2$
- $F = 9 \times 10^9 q_1 \times q_2 / d^2$  when charge is measured in Coulombs (C)

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## Atomic Theory - Some History

- John Dalton (1808) - elements made of atoms
  - billiard ball model of indivisible atoms
- J.J. Thomson (1897) - discovered electron
  - plum pudding model of negative electrons embedded in a sea of positive charge
- Ernest Rutherford (1911) - discovered nucleus
  - planetary model of electrons in orbit around a small nucleus of positive charge
- James Chadwick (1932) - discovered neutron
  - neutral particles in the nucleus

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## The Planetary Model of the Atom

### Textbook Figure 8.3

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- Explains electromagnetism
- A small, relatively massive nucleus is surrounded by a much larger set of orbiting electrons.
- The nucleus is made of protons and neutrons.
- An atom has a diameter of about  $10^{-10}$  m, while the nucleus is about  $10^{-14}$  m.

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## Components of the Atom

- **Electrons:** negative charge; very little mass
- **Protons:** positive charge; 2000 times more massive than electrons
- **Neutrons:** no electric charge; their mass is almost the same as the mass of the proton
- Electric attraction between the protons and electrons keeps the electrons in their orbits.
- Electrons can be easily removed from, or added to, an atom (e.g., rubbing)
  - results in an atom with an excess or deficit of electrons – an **ion**

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## The Planetary Model of the Atom: A Useful Theory

### Key ideas:

- The planetary model of the atom can explain many (but not all!) aspects of electromagnetism.
- Electric charge is conserved: no net charge can be created or destroyed.
- Electric current is due to the flow of electrons (although we talk about current as if it is the flow of positive charge!).
- It is orbiting electrons that make magnets magnetic.
- Definitions of elements and their atomic number (= number of protons)

Read Section 8.3 – nothing to add

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“MAGNET, n. Something acted upon by magnetism.

MAGNETISM, n. Something acting upon a magnet.

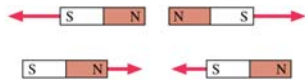
The two definitions immediately foregoing are condensed from the works of one thousand eminent scientists, who have illuminated the subject with a great white light, to the inexpressible advancement of human knowledge.”

*Ambrose Bierce, The Devil's Dictionary,  
American author & satirist (1842-1914)*

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## Magnetism

- Certain materials are magnetic - they have two poles, a north pole and a south pole.
- Magnetic forces are similar to electric forces:
  - Like poles repel
  - Unlike poles attract



The end of a magnet that points north is its **north pole**. The other end is the magnet's **south pole**.

- It has been shown that all magnetic forces are due to the motion of charged particles.

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## The Magnetic Force Law

- Charged objects that are moving exert and feel an additional force beyond the electric force that exists when they are at rest.
- This additional force is called the magnetic force.
- All magnetic forces are caused by the motion of charged objects.

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Two carts, initially at rest, have magnets on them so that they move towards each other. Which description best matches the figure?



- (A) The carts move toward each other with constant speed.  
 (B) The carts move toward each other with constant acceleration.  
 (C) The carts will start with constant acceleration, but the acceleration will increase once the carts are very close.  
 (D) The acceleration of the two carts will constantly increase as they move closer together.

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## Electromagnetism

- Electricity and magnetism are two aspects of the electromagnetic force.
- Both are caused by charged particles.
- The unification of electricity and magnetism into a single electromagnetic theory was one of the accomplishments of 19<sup>th</sup> century physics.
  - This led to an understanding of the nature of light and the development of special relativity.

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### Forces at a Distance: Fields

- How do the gravitational, electric, and magnetic forces act across space, between objects that are not in contact?
- Consideration of this puzzle led to the idea of **fields** (Michael Faraday, ~1830).
- A field transmits a force:
  - It is a property of space.
  - It requires a source.  
e.g., Earth, an electric charge, a magnet
  - An object placed in a field experiences a force.

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