Syllabus

Textbook: University Physics

Pearson: Pearson Course Homepage

Syllabus: Syllabus

Day 1: 1/20

General Information

The main book will be *University Physics*, homework are pulled from the 14th Edition but older/newer versions are fine. Homework is worth 20% of grade so be sure to keep track of deadlines.

There will be **12** chapters in total, and Prof. Lumata expect to finish one chapter every week (2 lectures). There will be **10** quizzes in total.

The grading criteria is:

1. Homework: 20%
2. Quizzes: 10%
3. Midterm 1: 23.33%
4. Midterm 2: 23.33%
5. Final: 23.33%

Note: all three exams are **not** cumulative. Exams are heavily influenced by homework and quizzes questions, and they will also be open note. Don't cheat!

The final exam is held *before* the actual finals week so we can finish early. Tentative dates for major exams is as follows:

1. Midterm 1: Feb 17
2. Midterm 2: Mar 31
3. Final: May 5

Honorlock usage will be decided later by the entire physics department.

Lecture

Electromagnetic force is one of the fundamental forces in nature:

1. **Strong**: force holding nucleus together
2. **Electromagnetic**: force between positive and negative charges
3. **Weak**: neutrino interaction, induces beta decay
4. **Gravity**: gravitation force

The main goal is to study how **electricity** and **magnetism** unite into **electromagnetism**.

Chapter 21

The word **electric** came from the word **elektron** (Greek), which means amber. When amber is rubbed with wool, amber is attracted to other objects because it becomes charged.

Atoms are made up of the **nucleus**, which contains **protons** and **neutrons**, as well as **electrons**. Electrons are negatively charged, protons are positively charged, and neutrons are uncharged. Electrons are 4 order of magnitudes lighter compared to protons and neutrons.

A neutral atom has the same number of protons and electrons, whereas a **positive ion** is an atom with one or more electrons removed. Similarly, a **negative ion** has additional electrons gained.

Protons and neutrons can be further subdivided into **quarks**.

Protons contain two up quarks and one down quark, and neutrons contain one up quark and two down quarks. Note that there are 6 types of quarks.

On the other hand, electrons can not be divided further. They belong to a group called **leptons**.

Conservation of Charge

Protons and electrons have the same magnitude charge, which is set as a natural unit. All other charges are *quantized* in this unit.

1. **Conductor**: permits easy movement of charge through it. **Insulators** do not.
2. Most metals are good conductors, and most nonmetals are insulators
3. Semiconductors are intermediate depending on various properties (ex. temperature)

Charging by induction happens when there is an imbalance of positive and negative charges in an object because of an external force. If the object is connected to ground, the object will now become positively charged because electrons moved to ground.

Definition

Coulomb's Law: for charges q_1 and q_2 separated by a distance r, the magnitude of the electric force on either charge is proportional to the product $q_1 q_2$ and inversely proportional to r^2.

$$F = \frac{1}{4\pi\epsilon_0}\frac{|q_1 q_2|}{r^2}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 N \cdot \frac{m^2}{c^2}$$

Where ϵ_0 is electrical permittivity.

Example

Example 1: An alpha particle has mass $m = 6.64 \times 10^{-27}$ kg and charge $q = 2e = 3.2 \times 10^{-19} C$. Compare the magnitude of the electric repulsion between the two α particles with that of the gravitational attraction between them.

$$F_e = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r^2}$$

$$F_g = G\frac{m^2}{r^2}$$

$$\frac{F_e}{F_g} \approx 3.1 \times 10^{35}$$

Electric Field

We can measure the electric field produced an object with a test charge. The electric field is the force per unit charge. **Electric force** is produced by an electric field, it points in the same direction as the electric field for positive charges, and opposite direction for negative charges. All charges have an electric field, radially inwards for negative charge and radially outwards for positive charges.

Day 2: 1/25

Review

1. Mastering Physics (Pearson) due Saturday
2. **Coulomb's Law** is important

Electric Field

Formula

If something is charged, then there is an *aura* of around it called the **electric field**.

$$E = \frac{F_0}{q_0} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}$$

The electric field of a positive charge is radially outwards, while the electric field of a negative charge is radially inwards. Remember to use a **positive** test charge.

Cool fact: sharks can sense weak electric fields by muscle contractions of their prey.

Electric field lines represents the tangent of the electric field direction at each individual point along the line. For a single positive charge, the lines will be straight and radially outward, so the tangents (directions) are all the same for each direction. However, for fields with two opposite charges, there is a lot more variation.

Example

A point charge $q = -8.0nC$ is located at the origin, find the electric field vector at the fidl point $x = 1.2m$ and $y = -1.6m$.

Solution:

Since $r = \sqrt{x^2 + y^2} = 2m$, the unit vector is normalized to $\hat{r} = \frac{r}{|r|} = (0.6, -0.8)$. $E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r} = (-11\frac{N}{c}, 14\frac{N}{c})$

Electric Dipoles

Electric dipole is a pair of point charges having equal but opposite sign and separated by a distance. Water molecules (H_2O) is an example of a dipole, since the two hydrogen atoms' electrons stay in the oxygen atom more often, so the hydrogen sides have a slight positive charge and the oxygen side has a slight negative charge. The dipole momentum points from negative to positive, so it points towards the hydrogen atoms in this case.