Unit 11 Electric & Magnetic Forces and Fields

Unit Overview

This unit is designed to introduce the electric and magnetic fields and their effects on matter. The chapter will begin with the development of "action at a distance" and the conceptual framework used to explain these effects. The students will learn about electrostatic and magnetic forces and the propagation of those forces through their respective fields. Ultimately, this chapter acts as an excellent review of many topics covered previously including: vector addition, Newton's 2nd Law, Newton's 1st Law, centripetal acceleration, one & two dimensional kinematics, momentum conservation and energy conservation.

Lesson 11:1 Electrostatic Forces & Charge

Objective(s):

- To introduce the concept of fields.
- To begin the development of Electrostatic and Residual charge.

Skills attained: The students will

- become aware of the mechanisms of "action at a distance" through both gauge and field theories.
- learn how to mechanically generate positive and negative electrostatic charges.
- be able to determine how residual charge is distributed among and on conducting and insulating surfaces.
- be able to predict whether charged and uncharged objects will attract or repel one another.
- begin to understand the atomic basis of the electrostatic force.
- be able to explain the differences between conductors and insulators.

Topics Addressed:

- positive and negative charge generation
- conductors and insulators
- electroscopes and residual charge
- forces acting at a distance: field theory and gauge theory

Materials list: glass rod, silk, polyethylene dry cleaning bag, pith balls on silk threads, ring stand, wood meter stick, right angle clamp, rubber rod, fur or wool, dry/empty soda can, van de Graff generator[?]

Class Preparation: Preview *Class Notes 11:1a-d Field Theory* and *Class Notes 11:2a-k Electric Charge and Residual Charge*

- Test and prepare the following demonstrations:
  - Generate positive and negative charges by rubbing rubber with fur and rubbing glass with silk or polyethylene. Transfer that charge to pith balls suspended from the ends of silk threads that are in turn suspended from the end of a meterstick.
  - Demonstrate the generation of residual charge on an electroscope using both positive and negative charges. [Play with this thoroughly before class.]
  - Attract an empty soda can with both positively and negatively charged rods through induction.
  - Use a Van de Graff generator to generate an electrostatic charge. Use the generator to note that a spark of 1" corresponds to approximately 10,000 Volts. The Van de Graph is very safe because although the potential generated is very high, the current is on the order of pico-micro Amperes! I would not, however, use one with someone with a pacemaker or someone with a known heart problem!
  - One of the first pictures in the Class Notes on this subject shows two donut shaped magnets repelling one another on a wooden dowel. These magnets are FREE because they can be found in EVERY discarded microwave oven. I have collected dozens. They are incredible!

Procedure / Suggested Teaching Strategies:

- Using both *Class Notes 11:1a-d Field Theory* and *Class Notes 11:2a-k Electric Charge and Residual Charge* as guides, develop the ideas of electrostatic charge. As you proceed through the notes integrate as many demonstrations as possible with the Class Notes. Seeing reality is believing!
- Assign *HW 11:1 #1-6 Charge & Residual Charge* for tomorrow.
- If any time remains at the end of the class allow students to work on the homework at their desks.

Special Considerations: This is a really neat subject. The students will find the demonstrations intriguing. When I demonstrate the soda can, I try to get students to predict what will happen! They will invariably be wrong! Contradictions of this sort help to make the information stick.

Lecture Support: *Class Notes 11:1a-d Field Theory* and *Class Notes 11:2a-k Electric Charge and Residual Charge*

Assessment: none

Homework Assignment: *HW 11:1 #1-6 Charge & Residual Charge*

Lesson 11:2 Electrostatic Forces – Coulomb's Law

Objective(s): To introduce Coulomb's Law.

Skills attained: The students will

- be able to calculate the electrostatic force between charged objects.
- be able to predict the direction of the electrostatic force between two charged particles.
- be able to treat the electrostatic force as a vector quantities.

Topics Addressed:

- Coulomb's Law [$F = k \cong q_1 \cong q_2 / r^2$]
- the Electrostatic proportionality constant and permittivity
- review vector addition

Materials list: none

Class Preparation:

- Preview *Class Notes 11:3a-h Coulomb's Law*

Procedure / Suggested Teaching Strategies:

- Review *HW 11:1 #1-6 Residual Charge*
- Briefly review the generation of electric charge with a particular emphasis on induction.
- Introduce Coulomb's Law using *Class Notes 11:3a-h*
- Review the addition of vectors through both graphical and quantitative methods. It might be useful here to begin by placing two known vectors on the board and have students come to the board and go through the addition process with class support.
- Assign *HW 11:1 #7-11 Coulomb's Law*

Special Considerations: The review of vector addition here is critical. If students cannot add vectors together successfully, they will not be successful at solving problems involving Coulomb's Law and later the addition of electric and magnetic field vectors. If necessary, take an extra day and just focus on the addition of vectors.

Lecture Support: *Class Notes 11:3a-h Coulomb's Law*

Assessment: none

Homework Assignment: *HW 11:1 #7-11 Coulomb's Law*