ADVANCED PLACEMENT PHYSICS C – Electricity and Magnetism   2007-2008

OVERVIEW

C Electricity and Magnetism is the second semester of a year-long calculus-based physics course. All students in this class are seniors who have had a previous physics course and are enrolled in calculus. The introductory course emphasizes classical mechanics, and one or more additional topics based on instructor preference. This class meets every day on an alternating schedule, 85 minutes one day, 40 minutes the next. Labs are reserved for long periods and may carry over into the next period. Other than labs, class time is typically spent in interactive lecture-discussions, homework presentations, tests, and quizzes. All students are required to take both AP Physics C exams.

The method of instruction is guided inquiry, influenced by the Modeling Method of High School Physics Instruction (Arizona State University, http://modeling.asu.edu). Students are led to see concepts as models with multiple representations: graphical, mathematical, and verbal.

Homework problems are assigned from the text, the University of Texas online Homework Service, and past AP papers. The course is designed to encourage students to apply concepts to the problems, rather than algorithms. Daily homework directly addresses concepts discussed in class. Example problems are not worked in class in advance of the homework assignment. All students are expected to attempt all problems and a few students are chosen to present their solutions to the class on whiteboards. The class discusses whether the approach is reasonable, whether the correct model has been applied, and if the calculations are correct. The goal is to make all students think analytically about the nature of the problem, including the content and the solution process. The due dates on the online University of Texas Homework are set for the day after the class discussion of the homework. This allows students the chance to benefit from the class discussion and rework problems they had trouble with initially.

There are frequent quizzes, many designed to assess whether students understand the concepts in the homework from the night before. This provides a reason to not procrastinate in completing the online homework, and encourages students to be concerned with understanding the problems, rather than just completing the assignment.

There are seven units based on the AP Physics C Electricity and Magnetism course description. Units average 10 class days, or approximately 10.4 hrs of class time to complete. A test constructed from past AP papers concludes every unit. Students work the multiple-choice section without calculator or equation sheet. In due time, students are provided solutions to all quiz, test, and homework problems.

Text: *Physics: Principles with Applications* (5th Revised Edition) by Douglas C. Giancoli, 1997

This text is an algebra and trigonometry-based textbook. Even though it incorporates calculus concepts without calculus notation in many sections, it is not adequate on its own as a reference for a calculus-based physics course. Students refer to class notes, to the HyperPhysics website (http://hyperphysics.phy-astr.gsu.edu/) and instructor-created supplementary materials for calculus-based derivations. The University of Texas Homework Service, past AP Papers, and other texts are a source of calculus-based physics problems for homework. Students are expected to apply the calculus where appropriate in all labs and assignments.

COURSE OUTLINE ***with corresponding text reference***

Second Semester

Unit 8, Charge and Electric Field – ***Chapter 16, Electric Charge and Electric Field***
Electrostatic behavior of macroscopic objects, electrostatic devices, conductors, point charges, Coulomb's law, sketching electric field of arrangements of point charges

Unit 9, Gauss's Law – ***Appendix D, Gauss's Law***
Distributed charge (linear, areal, volume charge densities), electric flux, finding electric field of symmetrical charge distributions using Gauss's Law

Unit 10, Electric Potential – ***Chapter 17, Electric Potential and Electric Energy; Capacitance***
Electrostatic energy, work, potential and potential difference, equipotential maps

Unit 11, Capacitors – ***Chapter 17, Capacitance***
Conductors and dielectrics, capacitors (parallel plate, spherical, cylindrical), networks of capacitors

Unit 12, DC Circuits – ***Chapter 18, Electric Currents; Chapter 19, DC Circuits***
Current, resistance, power, Ohm's law, circuits, networks of resistors, Kirchhoff's rules, RC circuits including transients, terminal voltage

Unit 13, Magnetostatics – ***Chapter 20, Magnetism***
Magnetic fields, forces on charges and wires in magnetic fields, Ampere's Law, Biot-Savart Law

Unit 14, Induction – ***Chapter 21, Induction and Faraday's Law; Chapter 22, Electromagnetic Waves***
Magnetic flux, induction, Faraday's and Lenz's laws, inductance, LR and LRC circuits, Maxwell's equations

LABS

All labs are designed to be guided inquiry. Many units begin with a laboratory investigation preceding any other instruction. The subject of the lab is designed to introduce one or more concepts important in the unit. These labs begin with a demonstration for the students to discuss. In the discussion they are prompted to brainstorm variables that might be reasonably presumed to govern the behavior of the demonstration apparatus. They then design and conduct an investigation to find relationships between the variables. A class discussion follows in which the class describes models for the behavior observed. Afterwards the model becomes explanatory, and can be invoked in explaining phenomena and solving problems.

Other labs are presented as open-ended lab problems. For example, in the Capacitors unit, students will attempt to design and build a capacitor with the highest storage capacity in the class. This lab necessarily precedes the presentation of mathematical equations for evaluating capacitors, although they will be used to evaluate the results of the investigation. In most labs, qualitative conceptual questions are asked for in addition to the mathematical analysis.

All labs require written work. Students are required to keep a binder or notebook with all of their completed, graded labs in it. Some labs consist of a challenging lab problem and don't lend themselves to a traditional lab report. For these, students submit a narrative (with sketches and calculations, where appropriate) of their attempts to solve the problem, and an analysis of their success.

Class time for labs is allotted only for pre-lab discussion, data collection, and class discussion of results. Students who fail to complete data collection during class must make arrangements to complete it during lunch, a free block, or break. Students must complete data analysis, answers to questions, and report writing outside of class. Labs account for 25% of the grade in the class. Some labs are followed up with "virtual lab" homework assignments using open-ended simulations by the University of Colorado's Physics Education Technology (PhET) project (http://phet.colorado.edu).

All students are required to have a laptop computer. The school has a large number of Vernier LabPro computer interfaces and a good selection of probes.

ELECTRICITY AND MAGNETISM LABS

LAB TITLE	TIME	DESCRIPTION
1. **Electrostatic Devices**	1.5 hrs	Students are challenged to explain how electrostatic devices such as the electroscope, Leyden jar, Van de Graaff generator, and electrophorus work.
2. **Coulomb's Law**	1.5 hrs	Using charged balloons and a pith ball, students confirm the inverse-square dependence of Coulomb's Law. A challenge to estimate the number of excess electrons on a piece of tape repelled by an electric charge follows.
3. **Surfing an E-field**	1.5 hrs	Students measure and plot the voltage field around charged objects in a pan of water. They relate the potential to E-field and energy. Virtual labs on E-field and Equipotentials to follow as homework, using the PhET "Charges and Fields" simulation.
4. **Capacitor Challenge**	1.0 hrs	Students are challenged to design and build a capacitor that will store the greatest amount of charge using household materials.
5. **RC circuits**	1.0 hrs	Students collect charging and discharging curves for an RC circuit and build a model for the behavior of capacitors under transient conditions.
6. **DC Circuits**	1.5 hrs	Given batteries, bulbs, resistors, capacitors, and connectors, students are challenged to produce circuits with the given characteristics. Develops concepts of series, parallel, combination, and RC circuits in terms of voltage, current, and energy dissipation. Virtual lab on DC Circuits follows as a homework assignment, using PhET "Circuit Construction Kit".
7. **Magnetic field of a slinky**	1.5 hrs	Students perform measurements of the magnetic field of a slinky solenoid and deduce a map of the field and models for the strength of the field.
8. **Levitation Field**	1.0 hrs	Thin rods are suspended within a strong magnetic field. When current flows through them, they are deflected and reach equilibrium. Students build a model for the Lorentz force.
9. **Motor, generator, speaker**	1.5 hrs	Students are challenged to build a motor, a generator, and a speaker out of household materials.
10. **Faraday's Law**	1.5 hrs	A model for induction is derived from observations of the voltage induced when a magnet is dropped through a coil. Virtual lab for homework using PhET "Faraday's Lab" simulation.
11. **Inductance**	1.0 hrs	Students design a circuit to measure the time constant of an inductor.
12. **The electron**	1.0 hrs	An e/m apparatus is used to find the charge-to-mass ratio of the electron.
TOTAL TIME	15.5 hrs	There are approximately 76 hrs of class time in the first semester before the AP exam