AP® Physics C: Electricity and Magnetism: Syllabus 4

Syllabus 1058841v1

Scoring Components		Page(s)
SC1	The course provides in depth instruction in electricity and magnetism and provides instruction in electrostatics.	3
SC2	The course provides in depth instruction in electricity and magnetism and provides instruction in conductors.	3
SC3	The course provides instruction in electricity and magnetism in depth and provides instruction in capacitors.	3
SC4	The course provides in depth instruction in electricity and magnetism and provides instruction in dielectrics.	3
SC5	The course provides in depth instruction in electricity and magnetism and provides instruction in electric circuits.	3
SC6	The course provides in depth instruction in electricity and magnetism and provides instruction in magnetic fields.	3
SC7	The course provides in depth instruction in electricity and magnetism and provides instruction in electromagnetism.	3
SC8	Introductory differential and integral calculus are used throughout the course.	2
SC9	The course utilizes guided inquiry and student-centered learning to foster the development of critical thinking skills.	4
SC10	Students spend a minimum of 20% of instructional time engaged in laboratory work.	5
SC11	A hands-on laboratory component is required.	5
SC12	Each student should complete a lab notebook or portfolio of lab reports.	5–6

AP Physics

The three sections of AP Physics C typically begin with 80 to 90 students enrolled, and of these, 70 to 75 usually finish the course. All enrolled students are required to take the AP Physics C Exam. The course requires completion of or concurrent enrollment in integral calculus.

Texts

While I currently use Raymond A. Serway and Robert J. Beichner's *Physics: for Scientists and Engineers*, 5th ed., for part of the course, *Fundamentals of Physics* by David Halliday, Robert Resnick, and Jearl Walker would also fit my style. **[SC8]**

SC8—Introductory differential and integral calculus are used throughout the course.

The primary text for Electricity and Magnetism is an eight-unit, unpublished text/workbook I have written that specifically covers the AP Physics C: Electricity and Magnetism (E & M) syllabus. The workbook is definitely my style and is still in my handwriting. The school district prints a copy for each student to keep. The Serway text serves as a backup resource for E & M.

Summer Assignment

To begin the school year on a solid mathematical footing, give all students enrolled for the following year a programmed elementary calculus book, *Quick Calculus: A Self-Teaching Guide* by Daniel Kleppner and Norman Ramsey, and assignments to complete over the summer. The book helps students initially learn or review the basic differentiation and integration skills needed for the course. You will give quizzes on the material the first week of school.

Schedule

All classes meet five days a week in 53-minute periods. With our school's calendar, it is necessary to organize the course within a tight schedule that includes assignments during some holiday breaks. I find it useful to lay out a calendar by which to measure progress through the material, and to ensure completion, with extra time for sufficient review before the AP Exam. The calendar reflects the day-by-day unit assignment schedule outlined below.

Electricity and Magnetism (E & M) Outline

Electricity and Magnetism is divided into eight units, covered between mid-January and the administration of the AP Exam. Introduce concepts and problem-solving techniques through a combination of lectures, demonstrations, lab experiments, small group problem-solving sessions with the instructor acting as a guide, question–answer sessions, assignments from the E & M text/workbook, and teacher-generated worksheets, with the text acting as a back-up resource. Use calculus throughout, where appropriate.

Workbook Unit	Topics	Number of Days
I	**Charged Particles and Electric Fields [SC1]**	7
	Review of the field concept and the definition of the electric field	
	Coulomb's law	
	Statics and dynamics of point charges in electric fields	
II	**Electrostatic Fields and Gauss's Law [SC2 & SC1]**	10
	By integration: electric fields of a uniformly charged rod, circular loop, disk, and sheet	
	The flux concept and Gauss's law	
	Using Gauss's law to determine the electric fields of cylindrically symmetric, spherically symmetric, and planar charge distributions	
	Using Gauss's law to determine the charge distribution on a conductor	
III	**Electric Potential**	9
	The concept of electric potential	
	Calculating the electric potential of various charge distributions	
	Equipotential lines and surfaces	
	Electric fields as the derivative of the potential	
	Capacitors and dielectrics	
IV	**Ohm's Law and Direct Current Circuits [SC5]**	11
	Resistivity and resistance	
	Ohm's law and Kirchhoff's rules applied to DC Circuits **[SC3 & SC4]**	
	Equivalent resistance	
	RC circuits	
V	**Magnetic Forces and Fields [SC6]**	7
	The field concept applied to magnetism	
	Charged particles in magnetic fields, mass spectrometer	
	Current-carrying wires in magnetic fields	
VI	**Calculating Magnetic Fields [SC6]**	8
	Introduction to and applying the Biot-Savart law	
	Introduction to and applying Ampere's law	
VII	**Electromagnetic Induction [SC7]**	10
	Introduction to Faraday's law and Lenz's law	
	Using Faraday, Lenz, and Ohm to determine the induced *emf* and the magnitude and direction of an induced current	
	Inductance and RL circuits	
	Maxwell's equations	

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SC7—The course provides in depth instruction in electricity and magnetism and provides instruction in electromagnetism.

Teaching Strategies

Lecture/Question–Answer Sessions

Other than lab experiments, lecture and question–answer sessions take up class time. A "lecture" consumes 20 to 30 minutes in which I review a concept presented in the reading, stressing important definitions and limitations. The remainder of the period usually involves showing relevant demonstrations (toys are frequently used), and then introducing an assigned problem or set of problems related to the demonstration. Then I guide the students in a discussion (whole class or small group) to develop solutions to the problem(s). During all of these activities, I encourage discussion, questions, hypotheses, and proposals to flow among the students themselves and between the students and me. I chose demonstrations to give the students as many different "looks" at the application of a concept as possible, so students can develop an appreciation of the universality of physical concepts. I prefer live demonstrations with simple equipment, often done by the students themselves for the rest of the class. Computer simulations and video demonstrations have their place when real equipment is not available. Whenever possible, I use the analogies, conceptual discoveries, and problem-solving techniques that helped my understanding when I was a student. **[SC9]**

SC9—The course utilizes guided inquiry and student-centered learning to foster the development of critical thinking skills.

Problem Assignments

At the beginning of each unit, I give students a list of "what you should know and be able to do" by the end of the unit, a day-to-day schedule with assignments, a schedule of the experiments, and an idea of when they can expect a quiz on the material. Providing this information informs the students about the work required to master the objectives of the unit.

Because of time constraints, the objectives closely parallel the AP Physics C syllabus. Demonstrations, assigned textbook and supplementary problems, worksheets, question–answer sessions, and labs are designed and chosen to aid in the "know-and-do" learning process.

The assigned problems come from either the textbook or from a supplementary problem handout. I chose problems that give students experience with a wide range of applications of the subject covered in the unit. When the textbook does not have a problem covering a particular application, I use one from another text or write one. These problems make up the supplementary problem list. I also make extensive use of worksheets designed to help students develop orderly, step-by-step problem-solving techniques. When working on problems or in question–answer sessions, I always stress starting from a general principle and moving toward a specific application. Instead of spending class time working a problem all the way through to the answer, we work on building a general-to-specific routine in solving problems. This is an important skill for students to develop. Developing this skill will help students have success in future coursework in the long term and will help them have success on the AP Exam in the short term, since most problems students encounter will not be of the specific type on which they have worked.

Lab Experiments

Lab work takes up greater than 20 percent of class time. **[SC10]** Students are required to keep lab reports in a lab notebook. **[SC12]** The experience gained by manipulating equipment, recording and organizing data, and drawing conclusions should be a vital part of any physics course. Much of the newer technology-based lab equipment does not fit my style because once the equipment is set up, data is taken and calculations are performed, graphs are produced all at the push of a button without much thought by the students. To me, a valuable learning opportunity is lost when students are not required to work with the data and organize it into a form in which a conclusion can be drawn. In my labs, students use simple equipment with a minimum of "black boxes." **[SC11]** My students perform all or most of the Electricity and Magnetism labs from the College Board's *AP Physics Lab Guide*, including all the calculus treatments of the data. Other lab experiments are, for the most part, written by me and chosen to provide students with experiences that reinforce concepts being covered in class. They are listed below:

SC10—Students spend a minimum of 20% of instructional time engaged in laboratory work.

SC12—Each student should complete a lab notebook or portfolio of lab reports.

SC11—A hands-on laboratory component is required.

Electricity and Magnetism Labs

1. **Equipotentials and Electric Fields.** Students map equipotential lines between electrodes of various shapes and sketch the electric field in the region.
2. **Direct Current Circuits.** This lab introduces the concepts of current, potential difference, power, and resistance. It also investigates series and parallel circuits. Students experimentally derive Ohm's law.
3. **RC Circuits.** Using a simple RC series circuit, students measure the voltages across R and C and the current in the circuit and plot them as functions of time as the capacitor charges and discharges.
4. **Forces on Currents.** Students determine the relationship between the magnetic force between two wires and each of three factors: current moving through the wires, the wires' separation, and the length of the parallel segments. Also, students determine the relationship between the magnetic field of a straight wire and each of two factors: the distance from the wire and the current flowing through the wire.

Evaluation

Give quizzes approximately every two units. The quizzes are purposely similar in construction to the AP Exam. Each quiz consists of 8 to 12 multiple-choice questions and a multipart free-response question. I permit students to have a teacher-constructed "antimemorization" sheet on all quizzes. While going through the course material, the stress is on developing concepts and problem-solving strategies, not on memorization.

The multiple-choice questions come from many sources, such as AP Released Exams, New York Regents Exam review books, and questions I have written. The free-response questions have the same format as those on the AP Exam, and most are modified AP Exam questions. All are constructed to test current material and material previously covered. For example, an energy free-response question might require a free-body diagram and have a part involving a trajectory.

The day after students take the quizzes, students score each other's papers using a rubric similar to those used to score the free-response questions on the AP Exam.

Project the solution on a screen, and show where to give points. Before students begin scoring papers, carefully explain each section of the solution. This requires students to go through the solution carefully, perhaps recognizing their own mistakes and perhaps learning a little from the mistakes of others.

Homework

Assign homework through a day-by-day assignment sheet, which you give to students at the beginning of each unit. After they have had the chance to ask about a group of assigned problems or a worksheet, have them hand in two to five problems and/or a worksheet at random intervals during the unit. Only accept homework when you ask for it. This encourages students to stay current in their assignments.

Since students have had the chance to ask questions, the homework they hand in is expected to be correct.

Grading

Formal reports worth 20 points are required for all labs. Students will write an introduction, purpose, procedure, data analysis, and conclusion complete with error analysis. **[SC12]** Quizzes are worth 25 to 30 points, with the multiple-choice questions worth one point apiece and the free-response questions worth the remainder of the points. Make the homework collected in each unit worth roughly half of a quiz grade.

SC12—Each student should complete a lab notebook or portfolio of lab reports.

Make the semester final and review exams worth 35 points each. Liberally sprinkle extra credit — which can include helping to set up labs, building a car within stated design parameters, or working out amusement park problems — throughout the course. To determine a final grade, add all points and calculate the percentage of points possible.

Assign grades according to the following schedule:

A = 85–100%; B = 70–84%; C = 55–69%; D = 45–54%; E = below 45%

Having taught the course for more than 20 years, I calibrate the points available to result in half to two-thirds of the students earning grades of A or B.

AP Exam Review

Formal review begins two weeks before you administer the AP Exam. Give each student an exam review booklet consisting of the multiple-choice sections from two AP Physics C Released Exams and the free-response questions from the last five exams. The booklet contains a listing of the multiple-choice questions sorted by subject (i.e., electrostatics, circuits, and so on). During the early part of the review, assign several of these subject areas as homework. Use the first part of each class period to answer questions on the previous day's assignment. Divide the rest of the period into 15-minute intervals, and assign one free-response question during each interval. Students may work alone or in groups of no more than three. Have solution notebooks available in the classroom for students to check their work. At the end of the first week of review, give for credit the Mechanics multiple-choice questions from an AP Physics C Released Exam. After the end of the second week, give the multiple-choice questions from the E & M exam.

Resources

McGehee, John. *AP Physics C: Electricity and Magnetism Workbook*. Unpublished.

Kleppner, Daniel, and Norman Ramsey. *Quick Calculus: A Self-Teaching Guide*. 2nd ed. New York: John Wiley, 1985.

Serway, Raymond A., and Robert J. Beichner. *Physics: for Scientists and Engineers*. 5th ed. Fort Worth: Saunders, 2000.