SAMPLE SYLLABUS #1

AP® Physics C: Electricity and Magnetism

Curricular Requirements

CR1	Students and teachers have access to college-level resources including a college-level textbook and reference materials in print or electronic format.	*See page:* 3
CR2	The course provides opportunities to develop student understanding of the required content outlined in each of the Unit Guides of the AP Course and Exam Description.	*See pages:* 4, 5
CR3	The course provides opportunities for students to develop the skills related to Science Practice 1: Visual Interpretation.	*See page:* 7
CR4	The course provides opportunities for students to develop the skills related to Science Practice 2: Question and Method.	*See page:* 7
CR5	The course provides opportunities for students to develop the skills related to Science Practice 3: Representing Data and Phenomena.	*See page:* 7
CR6	The course provides opportunities for students to develop the skills related to Science Practice 4: Data Analysis.	*See page:* 7
CR7	The course provides opportunities for students to develop the skills related to Science Practice 5: Theoretical Relationships.	*See page:* 7
CR8	The course provides opportunities for students to develop the skills related to Science Practice 6: Mathematical Routines.	*See page:* 7
CR9	The course provides opportunities for students to develop the skills related to Science Practice 7: Argumentation.	*See page:* 7
CR10	The course provides students with opportunities to apply their knowledge of AP Physics concepts to real-world questions or scenarios to help them become scientifically literate citizens.	*See page:* 8

CR11	Students spend a minimum of 25 percent of instructional time engaged in a wide range of hands-on laboratory investigations with an emphasis on inquiry-based labs to support the learning of required content and development of science practice skills throughout the course.	*See pages:* 3, 4, 8, 9
CR12	The course provides opportunities for students to record evidence of their scientific investigations in a portfolio of lab reports or a lab notebook (print or digital format).	*See page:* 4

Advanced Placement Physics C: Electricity and Magnetism Sample Syllabus #1

Course Description

AP® Physics C: Electricity and Magnetism is a calculus-based, college-level physics course, especially appropriate for students planning to specialize or major in the physical sciences or engineering. Introductory differential and integral calculus are used throughout the course. The laboratory portion of the course focuses on students asking questions, making observations and predictions, designing experiments, analyzing data, and constructing arguments in a collaborative setting where they direct and monitor their progress. Each student completes a lab notebook or portfolio of lab reports. Students who take this course are required to take the AP Physics C: Electricity and Magnetism Exam.

Text

Serway, Raymond A., and John W. Jewett, *Physics for Scientists and Engineers* 8th ed. 2012. Brooks/Cole Cengage Learning. **CR1**

Schedule

AP Physics C: Electricity and Magnetism is a yearlong course that meets for 270 minutes per week. The modified block scheduling allows for the course to meet 3 times a week for 90 minutes, one 90-minute period per week is dedicated to laboratory practice. **CR11**

Student Practice

Throughout each unit, **Topic Questions** will be provided to help students check their understanding. The Topic Questions are especially useful for confirming understanding of difficult or foundational topics before moving on to new content or skills that build upon prior topics. Topic Questions can be assigned before, during, or after a lesson, and as in-class work or homework. Students will get rationales for each **Topic Question** that will help them understand why an answer is correct or incorrect, and their results will reveal misunderstandings to help them target the content and skills needed for additional practice.

At the end of each unit, **Personal Progress Checks** will be provided in class or as homework assignments in AP Classroom. Students will get a personal report with feedback on every topic, skill, and question that they can use to chart their progress, and their results will come with rationales that explain every question's answer. One to two class periods are set aside to re-teach skills based on the results of the Personal Progress Checks.

CR1
The syllabus must cite the title, author, and publication date of a calculus-based, college-level textbook.

CR11
The syllabus must include an explicit statement that at least 25 percent of instructional time is spent engaged in hands-on laboratory investigations, with an emphasis on inquiry-based labs.

AND

Laboratory investigations must be listed with a title and brief description. Guided- and open-inquiry labs must be labeled.

Evaluation

Students will be graded on problem sets, quizzes, laboratory work, projects, and exams. Exams are typically worth 100 points and will consist of questions similar to those on the AP Exam. Homework assignments and quizzes will consist of problems from the textbook, supplements, and old AP Exams. Projects include challenge labs and current events essays. Laboratory work is student-centered and primarily composed of guided-inquiry or open-inquiry investigations. Grades will be determined by taking the number of points a student has earned and dividing it by the total number of points that the student could have achieved. This decimal is multiplied by 100, and that will be the student's grade.

Laboratory Practical

One 90-minute class period per week is dedicated to laboratory work, accounting for approximately 30% of the course. The majority of labs are either guided- or open-inquiry based activities in which students engage in hands-on, inquiry-based laboratory experiences across a variety of course topics. CR11

Each student is required to maintain an electronic portfolio of laboratory work for every laboratory experience throughout the course. Each lab report must contain a claim/question/hypothesis, experimental procedure and lab equipment used, a visual representation of the experimental setup, experimental data, data analysis, error analysis, and conclusion(s). CR12

CR12
The syllabus must include the components of the written reports required of students for all laboratory investigations.

AND

The syllabus must include an explicit statement that students are required to maintain a lab notebook or portfolio (hard copy or electronic) that includes all their lab reports.

Outline of Course Content CR2

AP Physics C: Electricity and Magnetism Course and Exam Description (CED) Units

- Unit 1: Electrostatics
- Unit 2: Conductors, Capacitors, and Dielectrics
- Unit 3: Electric Circuits
- Unit 4: Magnetic Fields
- Unit 5: Electromagnetism

CR2
The syllabus must include an outline of the course content using any organizational approach that demonstrates the inclusion of all required course topics and big ideas listed in the AP Course and Exam Description (CED).

Unit	Topic	Science Practices	Big Ideas
1: Electrostatics	1.1 Electrostatics: Charge and Coulomb's Law	1.A, 6.B, 6.C	2, 3, and 4
	1.2 Electrostatics: Electric Field and Electric Potential	1.A, 3.A, 3.D, 4.A, 4.B, 6.B, 6.C	
	1.3 Electrostatics: Electric Potential Due to Point Charges and Uniform Fields	1.B, 5.A, 5.B, 5.C, 6.B, 6.C	
	1.4 Electrostatics: Gauss's Law	1.A, 5.A	
	1.5 Electrostatics: Fields and Potentials of other charge distributions	6.B, 7.A, 7.C, 7.D	
	Assign Unit 1 Progress Check: MCQ		
	Assign Unit 1 Progress Check: FRQ		

Unit	Topic	Science Practices	Big Ideas
2: Conductors, Capacitors, Dielectrics	2.1: Conductors, Capacitors, Dielectrics: Electrostatics with Conductors	1.A, 1.E, 5.A, 7.C, 7.D	2, 3, and 4
	2.2: Conductors, Capacitors, Dielectrics: Capacitors	1.A, 2.A, 2.B, 2.E, 5.B, 7.A, 7.D	
	2.3: Conductors, Capacitors, Dielectrics: Dielectrics	2.B, 3.C, 3.D, 5.B, 6.C, 7.A, 7.B	
	Assign Unit 2 Progress Check: MCQ		
	Assign Unit 2 Progress Check: FRQ		
3. Electric Circuits	3.1. Electric Circuits: Current and Resistance	3.A, 6.A, 6.B, 7.D	3 and 4
	3.2. Electric Circuits: Current, Resistance, and Power	1.A, 1.C, 1.D, 2.C, 2.D, 3.A	
	3.3. Electric Circuits: Steady-State Direct-Current Circuits with Batteries and Resistors Only	1.B, 2.F, 3.B, 4.A, 4.B, 4.C, 4.D, 7.F	
	3.4 Capacitors in Circuits	1.A, 1.D, 2.D, 3.C, 3.D, 6.C, 7.B	
	Assign Unit 3 Progress Check: MCQ		
	Assign Unit 3 Progress Check: FRQ		
4. Magnetic Fields	4.1. Magnetic Fields: Forces on Moving Charges in Magnetic Fields	2.B, 3.D, 6.C, 7.A, 7.C, 7.D	1, 3, and 4
	4.2. Magnetic Fields: Forces on Current Carrying Wires in Magnetic Fields	2.C, 2.D, 2.F, 3.A, 6.B, 7.D, 7.E, 7.F	
	4.3. Magnetic Fields: Fields of Long Current-Carrying Wires	3.B, 3.C, 5.E, 7.C	
	4.4 Magnetic Fields: Biot-Savart Law and Ampere's Law	5.D, 5.E, 7.A	
	Assign Unit 4 Progress Check: MCQ		
	Assign Unit 4 Progress Check: FRQ		
5. Electromagnetism	5. Electromagnetism: Electromagnetic Induction (Including Faraday's Law and Lenz's Law)	1.D, 1.E, 6.D, 7.A, 7.E	2, 3, and 4
	5. Electromagnetism: Inductance (Including LR Circuits)	5.A, 6.B, 6.C, 7.D	
	5. Electromagnetism: Maxwell's Equations	1.E, 4.C, 4.E, 5.E, 7.D	
	Assign Unit 5 Progress Check: MCQ		
	Assign Unit 5 Progress Check: FRQ		

The Big Ideas of the Course CR2

- Big Idea 1: Interactions produce changes in motion
- Big Idea 2: Forces characterize interactions between objects or systems
- Big Idea 3: Fields predict and describe interactions
- Big Idea 4: Conservation Laws constrain interactions

SAMPLE ACTIVITIES

Big Idea	Activities	CED Units
1	In Units 4 and 5, Big Idea 1 is developed through problem solving involving the presence of a magnetic field around a moving charged particle, such as in a mass spectrometer problem that causes a change in motion of the charged particle. Problems in Unit 5 address Big Idea 1, for instance, students are required to describe qualitatively how electromagnetic braking can cause changes in motion.	4, 5
2	In Units 1 and 2, Big Idea 2 is developed through application of Coulomb's Law governing the force that characterizes interactions between charged conductors and induced charge on insulators. For instance, students will experiment qualitatively with sticky tape that is statically charged, neutral paper, and neutral aluminum foil to investigate the claim that like charges repel and opposite charges attract. Students will also apply this in the study of capacitors and dielectrics in their ability to store electrical potential and increase capacitance respectively.	1, 2
3	In Units 1, 2, and 4, Big Idea 3 is developed. For instance, in studying electrostatics, students will work in small groups to determine the electric field strength at the center of a conducting spherical shell using symmetry arguments; in Unit 2, students will create sketches of a simple, parallel-plate capacitor and the field between the plates and then a sketch of the same capacitor once a dielectric is inserted in order to explain how the capacitance of the capacitor changes upon insertion of the dielectric; in Unit 4, students will predict and experimentally determine the forces acting on two current-carrying wires and use their understanding of fields to predict what direction the wires will accelerate depending on the direction of current flow in each wire.	1, 2, 4
4	In Units 1, 2, and 3, Big Idea 4 is developed. Students will engage in activities and labs relevant to conservation of charge in Units 1 and 2; in Unit 3 students will analyze DC circuits using Kirchhoff's Rules and relate them to Conservation of Charge and Conservation of Energy.	1, 2, 3

The Science Practices of the Course

- Science Practice 1: Visual Representations
- Science Practice 2: Question and Method
- Science Practice 3: Representing Data and Phenomena
- Science Practice 4: Data Analysis
- Science Practice 5: Theoretical Relationships
- Science Practice 6: Mathematical Routines
- Science Practice 7: Argumentation

SAMPLE ACTIVITIES

Science Practice	Activities
SP1	Field-Lines, Equipotentials, and Free-Body Diagrams: Throughout the course students will be required to graphically represent electric field lines around groups of charges and conductors, such as through the Mapping the E-Field Lab, magnetic field lines around differently shaped magnets in the Mapping the B-Field Lab, and visually representing the forces acting on current carrying wires or charged objects using Free-Body Diagrams. **[SP1.A, 1.B, 1.C, 1.D]** CR3
SP2	DC Circuit Lab: In this guided-inquiry lab, students are provided with a number of different types of unlabeled resistors, and students must design an investigation to determine whether each resistor is ohmic or non-ohmic. **[SP2.A, 2.B, 2.C, 2.D, 2.F]** CR4
SP3	RC Circuits Lab: Students will be required to sketch graphs of potential difference vs. time and current vs. time across charging and discharging capacitors and across resistors in the circuit. **[SP3.A, 3.C]** CR5
SP4	Slinky Solenoid Lab: In this guided-inquiry lab, students will use a conducting slinky and voltage source to graphically determine a value for μ_0. **[SP4.C, 4.D, 4.E]** CR6
SP5	Problem-Solving: Students will be required to apply Gauss's Law to determine electric field strength at some radial distance from the source using appropriate Gaussian surfaces, such as using cylindrical gaussian surfaces for finding E-Field strength at some height above a uniformly charged large, thin sheet conductor. **[SP5.A, 5.E]** CR7
SP6	Time-Varying Current Analysis in RC Circuits: Students will work in groups to derive an expression for current as a function of time while a capacitor in an RC circuit is charging or discharging by solving a differential equation. Students will assess and discuss the reasonableness of their resulting expressions by examining the output of the derived equation given certain extreme inputs, e.g., t = 0. **[SP6.A, 6.B, 6.D]** CR8
SP7	TIPER Activity: Students will individually complete ranking tasks throughout the course; for instance, students may be asked to rank the relative magnitude and direction of an induced current due to changing magnetic flux. After individually completing the task, students will share their answers in groups and collaborate to form a consensus ranking to share with the class. **[SP7.A, 7.C, 7.D]** CR9

CR3
The syllabus must include one activity or lab describing how students analyze and/or use nonnarrative/nonmathematical representations of physical situations, excluding graphs. The activity or lab must be labeled with the relevant skill(s) (e.g., "1.B") associated with Science Practice 1.

CR4
The syllabus must include one activity or lab describing how students determine scientific questions and methods. The activity or lab must be labeled with the relevant skill(s) associated with Science Practice 2.

CR5
The syllabus must include one activity or lab describing how students create visual representations or models of physical situations. The activity or lab must be labeled with the relevant skill(s) associated with Science Practice 3.

CR6
The syllabus must include one assignment, activity, or lab describing how students analyze quantitative data represented in graphs. The assignment, activity, or lab must be labeled with the relevant skill(s) associated with Science Practice 4.

CR7
The syllabus must include one assignment, activity, or lab describing how students determine the effects on a quantity when another quantity or the physical situation changes. The assignment, activity, or lab must be labeled with the relevant skill(s) associated with Science Practice 5.

CR8
The syllabus must include one assignment, activity, or lab describing how students solve problems of physical situations using mathematical relationships. The assignment, activity, or lab must be labeled with the relevant skill(s) associated with Science Practice 6.

CR9
The syllabus must include one assignment, activity, or lab describing how students develop an explanation or a scientific argument. The assignment, activity, or lab must be labeled with the relevant skill(s) related to Science Practice 7.

As long as one skill under Science Practice 7 is represented, evidence is sufficient.

Real-World Applications in the Course

Students will be exposed to multiple real-world applications of calculus-based physics throughout the course. Within each unit there will be opportunities for students to explore direct application of concepts.

Sample Activities CR10

Electric Motor Challenge: Students are challenged to apply their understanding of electricity and magnetism to construct electric motors from basic construction materials, magnets, and batteries. Students are required to create a short presentation of physical laws relevant to the construction of a working motor and to demonstrate the efficacy of their motor by having it lift a small mass from the ground to the top of the lab table using a simple pulley attachment.

Building an Electromagnet: Students are challenged to create a solenoid wrapping around a ferrite core and connect the ends of their magnet wire to a voltage source. Students test their electromagnets by seeing how many paperclips can be suspended from their magnet when it is turned on. Students then use compasses and a Hall-effect sensor to detect the magnetic field strength and magnetic field lines around their electromagnet and compare their findings to other permanent magnets they have encountered earlier in the course.

CR10
The syllabus must label and provide a description of at least one assignment or activity requiring students to apply their knowledge of AP Physics concepts to understand real-world questions or scenarios.

LIST OF LABORATORY PRACTICAL

CED Unit	Topics	Lab Activities CR11
1	Electrostatics	**Sticky Tape Lab –** Students use scotch tape, aluminum foil, and paper to investigate like and opposite charge interactions as well as charging by induction. **Electroscope Investigation –** Students use electroscopes and charging rods to investigate charging by conduction, induction, and grounding. **Coulomb's Law Lab (Guided-Inquiry) –** Students are challenged to devise a method to determine Coulomb's Constant using charged pith balls hanging from insulated threads. **Mapping Electric Field and Equipotential Lab –** Students use multimeters to identify equipotential lines around charged objects and trace the electric field lines.
2	Conductors, Capacitors, and Dielectrics	**Construct a Capacitor Lab** – Students use transparency sheets, paper, tape, paperclips, and aluminum foil to construct and test a capacitor.
3	Electric Circuits	**Ohm's Law Lab (Guided-Inquiry) –** Students are provided with different ohmic resistors and develop a procedure by which they can determine Ohm's Law with a simple circuit. **Ohmic Resistors Investigation (Guided-Inquiry) –** Students are provided with different types of resistors and develop a procedure by which they can determine whether each resistor is ohmic or non-ohmic. **Resistivity Lab (Guided-Inquiry) –** Students are provided with carbon graphite and are challenged to determine the resistivity of the material. **Simple Circuits Lab (Open-Inquiry) –** Students investigate equivalent resistance and Kirchhoff's Rules using simple circuits. **RC Circuits Lab –** Students predict and experimentally verify the time constant for an RC circuit charging and discharging.

CR11
The syllabus must include an explicit statement that at least 25 percent of instructional time is spent engaged in hands-on laboratory investigations, with an emphasis on inquiry-based labs.

AND

Laboratory investigations must be listed with a title and brief description. Guided- and open-inquiry labs must be labeled.

CED Unit	Topics	Lab Activities CR11
4	Magnetic Fields	**Mapping Magnetic Fields Lab (Open-Inquiry) –** Students investigate and map magnetic fields generated by various sources using a wide range of measurement techniques.
5	Electromagnetism	**Construct an Electromagnet Lab –** Students use magnet wire and a ferrite core to construct and test an electromagnet. **Slinky Solenoid Lab (Guided-Inquiry) –** Students are challenged to find a value for μ_0 using a metal slinky as a solenoid. **Electromagnetic Induction Lab (Guided-Inquiry) –** Students are challenged to design an experiment to determine the variables that affect the EMF that can be induced in a coil by a permanent magnet. **LR/LC Circuits Lab –** Students predict and experimentally verify the time constant for LR circuits and the behavior of LC circuits. **Electric Motor Challenge (Guided-Inquiry) –** Students are challenged to design and construct a working electric motor that can lift a known mass from the ground to the top of a lab table.