SYLLABUS DEVELOPMENT GUIDE

AP® Physics C: Electricity and Magnetism

The guide contains the following information:

Curricular Requirements

The curricular requirements are the core elements of the course. A syllabus must provide explicit evidence of each requirement based on the required evidence statement(s). The Unit Guides and the "Instructional Approaches" section of the *AP® Physics C: Electricity and Magnetism Course and Exam Description* (CED) may be useful in providing evidence for satisfying these curricular requirements.

Required Evidence

These statements describe the type of evidence and level of detail required in the syllabus to demonstrate how the curricular requirement is met in the course.

Note: Curricular requirements may have more than one required evidence statement. Each statement must be addressed to fulfill the requirement.

Samples of Evidence

For each curricular requirement, two to three separate samples of evidence are provided. These samples provide either verbatim evidence or clear descriptions of what acceptable evidence could look like in a syllabus. In some samples, the specific language that addresses the required evidence is highlighted in **bold** text.

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 units described in the AP Physics C: Electricity and Magnetism Course and Exam Description.	*See page:* 4
CR3	The course provides opportunities for students to develop the skills related to Science Practice 1: Creating Representations.	*See page:* 6
CR4	The course provides opportunities for students to develop the skills related to Science Practice 2: Mathematical Routines.	*See page:* 7
CR5	The course provides opportunities for students to develop the skills related to Science Practice 3: Scientific Questioning & Argumentation.	*See page:* 8
CR6	Students spend a minimum of 25% of instructional time engaged in hands-on laboratory investigations.	*See page:* 9
CR7	Students engage in hands-on laboratory investigations representative of the topics outlined in the AP Physics C: Electricity and Magentism Course and Exam Description.	*See page:* 10
CR8	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:* 12

Curricular Requirement 1

Students and teachers have access to college-level resources, including a college-level textbook and reference materials in print or electronic format.

Required Evidence

- ☐ The teacher must provide the title, author, and publication date of a calculus-based, college-level textbook on their course audit form.

Samples of Evidence

1. The teacher selects an approved college-level textbook on their course audit form.
2. The teacher provides the title, author, and publication date of a calculus-based, college-level textbook on their course audit form.

Curricular Requirement 2

The course provides opportunities to develop student understanding of the required content outlined in each of the units described in the AP Physics C: Electricity and Magnetism Course and Exam Description.

Required Evidence

- ☐ The syllabus must include an outline of course content by unit title to demonstrate the inclusion of the required course content listed in the current AP Physics C: Electricity and Magnetism Course and Exam Description.

  Note: If the syllabus demonstrates a different sequence than the units outlined in the current AP Physics C: Electricity and Magnetism Course and Exam Description, the teacher must include the following specific statement: All the content in the current AP Physics C: Electricity and Magnetism Course and Exam Description will be covered in this course.

Samples of Evidence

1. The syllabus will follow the units below as listed in the current AP Physics C: Electricity and Magnetism Course and Exam Description:

   Unit 8: Electric Charges, Fields, and Gauss's Law

   Unit 9: Electric Potential

   Unit 10: Conductors and Capacitors

   Unit 11: Electric Circuits

   Unit 12: Magnetic Fields and Electromagnetism

   Unit 13: Electromagnetic Induction

2. All the content in the current AP Physics C: Electricity and Magnetism Course and Exam Description will be covered in this course. The following topics will be covered throughout the year:

   1. **Electric Circuits:** Current, simple circuits, resistivity and Ohm's law, power, complex circuits, Kirchhoff's loop and junction rules, RC circuits
   2. **Electrostatics:** Electric charge and force, transfer of charge, electric force vs. gravitational force, electric fields, electric field of charge distributions, electric flux, Gauss's law, electric permittivity, electric potential, capacitors, conservation of electric energy, electric potential energy, electrostatics with conductors, distribution of charge with conductors, dielectrics
   3. **Magnetism and Electromagnetism:** Magnetic field, magnetic dipoles, magnetic permeability, magnetism and moving charges, magnetism and current-carrying wires/Biot-Savart law, electromagnetic induction and Faraday's law, Ampere's law, magnetic flux, induced forces, inductions, LR and LC circuits

3. All the content in the current AP Physics C: Electricity and Magnetism Course and Exam Description will be covered in this course. We will cover these chapters of our calculus-based, university-level textbook:

   Chapter 5: Electric Charges and Fields

   Chapter 6: Gauss's Law

   Chapter 7: Electric Potential

   Chapter 8: Capacitance

   Chapter 9: Current and Resistance

   Chapter 10: Direct-Current Circuits

   Chapter 11: Magnetic Forces and Fields

   Chapter 12: Sources of Magnetic Fields

   Chapter 13: Electromagnetic Induction

   Chapter 14: Inductance

Curricular Requirement 3

The course provides opportunities for students to develop the skills related to Science Practice 1: Creating Representations.

Required Evidence

- ☐ The syllabus must include a section labeled "Science Practice 1" describing one assignment, activity, or lab where students create representations that depict physical phenomena.

Clarifying Terms

The following task verbs are commonly associated with Science Practice 1: sketch, draw, or plot.

Samples of Evidence

1. **Science Practice 1**

   A lab activity in which students explore the relationship between 1) resistance and cross-sectional area, 2) resistance and length of wires of the same material to obtain the resistivity.

   a) **Draw a circuit diagram** with proper symbols for different circuit elements

   b) **Graph** resistance vs. length, and resistance vs. area (keeping the voltage constant) with proper units, scale, and axes labels.

2. **SP1**

   Students will **draw a map** of electric potentials in the lab and determine the direction of the electric fields from the equipotential lines.

3. **Science Practice 1**

   Students will **sketch graphs** showing the electric field and the electric potential in several different spherical continuous charge distributions.

Curricular Requirement 4

The course provides opportunities for students to develop the skills related to Science Practice 2: Mathematical Routines.

Required Evidence

- ☐ The syllabus must include a section labeled "Science Practice 2" describing one assignment, activity, or lab where students use mathematical routines.

Clarifying Terms

The following task verbs are commonly associated with Science Practice 2: calculate, compare, derive, determine, estimate, or show.

Samples of Evidence

1. **Science Practice 2**

   A problem-solving activity where students are asked to conceptualize the existence of two types of charges by doing the tape activity

   1. **Derive** the correct expression for the charge transferred from tape A to B.
   2. **Calculate** the amount of charge quantitatively by performing a rigorous force analysis.
   3. **Compare** charge transferred from one tape to the other for multiple situations.

2. **SP2**

   Using Gauss's law, students **determine** the electric field in and around a charged insulating sphere of radius *R*.

3. **Science Practice 2**

   Determine what happens to the induced current in a loop of wire given changes in the resistance and the rate of change of the magnetic field.

Curricular Requirement 5

The course provides opportunities for students to develop the skills related to Science Practice 3: Scientific Questioning & Argumentation.

Required Evidence

- ☐ The syllabus must include a section labeled “Science Practice 3” describing one assignment, activity, or lab where students design experimental procedures, and make and justify claims.

Clarifying Terms

The following terms are commonly associated with Science Practice 3: claim, describe, design, explain, indicate, justify, predict, or state.

Samples of Evidence

1. **Science Practice 3**
    1. **Design** an experiment to obtain time constant in an RC-circuit.
    2. **Analyze** the data to obtain an exponential relationship between voltage and time.
    3. **Predict** the time constant of an RC circuit.

2. **SP3**

    Lab Investigation:
    Students will assemble a Wheatstone bridge and **design a procedure** to determine the resistance of an unknown resistor. Students will change the known resistors in the circuit to determine the relationship between the known resistors and the accuracy of the circuit.

3. **Science Practice 3**

    Are the resistors ohmic or non-ohmic? Students will be provided with different types of resistors and **develop a procedure** by which they can determine whether each resistor is ohmic or non-ohmic after graphing the data.

Curricular Requirement 6

Students spend a minimum of 25% of instructional time engaged in hands-on laboratory investigations.

Required Evidence

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

Samples of Evidence

1. Students in this course are engaged in laboratory work more than 25% of the instructional time.
2. Students will spend a minimum of 25% of the course engaged in hands-on laboratory investigations.
3. 25% of course time is spent engaged in hands-on labs.

Curricular Requirement 7

Students engage in hands-on laboratory investigations representative of the topics outlined in the AP Physics C: Electricity and Magnetism Course and Exam Description.

Required Evidence

- ☐ The syllabus must include a title and brief description for each laboratory investigation. The labs listed should be representative of the topics outlined in the AP Physics C: Electricity and Magnetism Course and Exam Description.

Samples of Evidence

1. The labs are listed and described below:
    - Resistivity of Play-Doh Lab: Students determine factors that affect the resistance of a wire while determining the resistivity of Play-Doh.
    - Complex Circuits Lab: Students predict the behavior of bulbs in a complex circuit.
    - Unknown Resistance: Students determine the value of an unknown resistor in a complex circuit.
    - Capacitor Variables: Students determine what/how variables affect the capacitance of a capacitor.
    - RC Circuits Lab: Students predict and experimentally verify the time constant for an RC circuit charging and discharging.
    - LR Circuits Lab: Students predict and experimentally verify the time constant for an LR circuit.
    - LC Circuits Lab: Students predict and experimentally verify the behavior of an LC circuit.
    - Electrostatics Labs: Students determine how charges are transferred between materials.
    - Equipotential Lines Lab: Students create a 3D model of equipotential lines around charge distributions.
    - Magnetic Field Mapping: Students create model of magnetic field lines around different-shaped magnets.
    - Solenoids: Students determine the value of μ0 using a slinky solenoid.
    - Variables Affecting Induced EMF: Students determine what/how certain variables affect the induced emf.
    - Faraday/Lenz: Students design a lab to show Faraday's law/Lenz's law.

2.

1. Ohmic vs. Non-Ohmic Lab – Students design a lab to determine which circuit elements are ohmic or non-ohmic.
2. Resistivity of Play-Doh Lab – Students design a lab to determine the resistivity of Play-Doh.
3. Mystery Circuits – Students design a lab to determine how each mystery circuit is wired.
4. Capacitance Lab – Students design a lab to determine the relationship between capacitance and certain variables.
5. RC Circuit Lab – Students design a lab to verify the predicted time constant for several RC circuits.
6. Electrostatics Lab – Students determine how charge is transferred by contact and induction.
7. Gauss's Law Lab – Students determine the relationship between electric field and the distance from a variety of continuous charge distributions.
8. Electric Potential Lab – Students make a 3D map of electric potentials around a variety of charge distributions.
9. Slinky Lab – Students design a lab to verify $\mu_0=4\pi(10)^{-14}$ Tm/A.
10. Induction Lab – Students design a lab to show how specific variable affect the amount of induced current.

3.

Unit 8: Electric Charges, Fields, and Gauss's Law
Sticky tape lab: Students use scotch tape, aluminum foil, and paper to investigate like and opposite charge interactions as well as charging by induction.

Unit 9: Electric Potential
Mapping potential lab: Draw equipotential lines of various shapes drawn with conductive paint on conductive paper.

Unit 10: Conductors and Capacitors
Construct a capacitor lab: Students use transparency sheets, paper, tape, paperclips, and aluminum foil to construct and test a capacitor.

Unit 11: Electric Circuits
Are the resistors ohmic or non-ohmic? Students will be provided with different types of resistors and develop a procedure by which they can determine whether each resistor is ohmic or non-ohmic after graphing the data.

Unit 12: Magnetic Fields and Electromagnetism
Mapping magnetic fields lab: Students investigate and map magnetic fields generated by various sources using a wide range of measurement techniques.

Unit 13: Electromagnetic Induction
Electromagnetic induction lab: 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.

Curricular Requirement 8

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).

Required Evidence

- ☐ 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.

Samples of Evidence

1. After performing the lab, students are expected to submit a lab report electronically or maintain the lab notebook for each experimental activity.
2. Students are expected to keep a lab notebook where they will maintain a record of their laboratory work.
3. All investigations are reported in a laboratory journal. Students are expected to record their observations, data, and data analyses. Data analyses include identification of the sources and effects of experimental uncertainty, calculations, results and conclusions, and suggestions for further refinement of the experiment as appropriate.