

SYLLABUS DEVELOPMENT GUIDE

AP[®] Physics 2: Algebra-Based

The guide contains the following sections and 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 2: Algebra-Based 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.

Clarifying Terms

These statements define terms in the Syllabus Development Guide that may have multiple meanings.

Samples of Evidence

For each curricular requirement, 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.

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.	<i>See page:</i> 4
CR2	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 1: Fluids.	<i>See page:</i> 5
CR3	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 2: Thermodynamics.	<i>See page:</i> 6
CR4	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 3: Electric Force, Field, and Potential.	<i>See page:</i> 7
CR5	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 4: Electric Circuits.	<i>See page:</i> 8
CR6	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 5: Magnetism and Electromagnetic Induction.	<i>See page:</i> 9
CR7	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 6: Geometric and Physical Optics.	<i>See page:</i> 10
CR8	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 7: Quantum, Atomic, and Nuclear Physics.	<i>See page:</i> 11
CR9	The course provides opportunities for students to develop the skills related to Science Practice 1: Modeling.	<i>See page:</i> 12
CR10	The course provides opportunities for students to develop the skills related to Science Practice 2: Mathematical Routines.	<i>See page:</i> 13
CR11	The course provides opportunities for students to develop the skills related to Science Practice 3: Scientific Questioning.	<i>See page:</i> 14
CR12	The course provides opportunities for students to develop the skills related to Science Practice 4: Experimental Methods.	<i>See page:</i> 15
CR13	The course provides opportunities for students to develop the skills related to Science Practice 5: Data Analysis.	<i>See page:</i> 16
CR14	The course provides opportunities for students to develop the skills related to Science Practice 6: Argumentation.	<i>See page:</i> 17
CR15	The course provides opportunities for students to develop the skills related to Science Practice 7: Making Connections.	<i>See page:</i> 18
CR16	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.	<i>See page:</i> 19

CR17

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.

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CR18

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).

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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 syllabus must cite the title, author, and publication date of an algebra-based, college-level textbook.

Samples of Evidence

1. *Physics*, 5th Edition
James S. Walker, Western Washington University
©2017, Pearson.
2. The syllabus cites an online textbook from the example textbook list on AP Central for AP Physics 2: Algebra Based.
For example:
Ingram, Douglas, and David Anderson. *OpenStax College Physics for AP Course 2*. 1st edition. OpenStax. 2015.
3. *College Physics: A Strategic Approach*, 4th Edition, by Knight, Jones, and Field, published in 2019.

Curricular Requirement 2

The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 1: Fluids, as described in the AP Course and Exam Description.

Required Evidence

- The syllabus must include the Unit 1 content listed below with the associated Big Ideas 1, 3, 5, and 7: Systems (SYS), Force Interactions (INT), Conservation (CON), and Probability (PRO):
 - Pressure and Density
 - Fluid Statics
 - Fluid Dynamics

Samples of Evidence

1. *Unit 1: Fluids (Big Ideas: 1, 3, 5, and 7)*
 - Density
 - Pressure: atmospheric and fluid pressure
 - Pascal's principle
 - Buoyant force
 - Archimedes' principle
 - Continuity equation
2. *Fluid Statics and Dynamics*
 - Density (BI 1)
 - Pressure (BI 1, BI 3)
 - Pascal's Principle (BI 1, BI 3)
 - Buoyant Force (BI 1, BI 3)
 - Archimedes' Principle (BI 1, BI 3)
 - Flow Rate and Continuity (BI 1, BI 5, BI 7)
 - Bernoulli's Principle (BI 1, BI 3, BI 5)
3. *Unit 1: Fluid Physics*

Density and Pressure (including specific gravity), Fluid Statics (buoyant force, Archimedes' principle), and Fluid Dynamics (continuity and Bernoulli's equation)

Big Ideas: BI 1 (SYS), BI 3 (INT), BI 5 (CON), and BI 7 (PRO)

Curricular Requirement 3

The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 2: Thermodynamics, as described in the AP Course and Exam Description.

Required Evidence

- The syllabus must include the Unit 2 content listed below with the associated Big Ideas 1, 3, 4, and 5: Systems (SYS), Force Interactions (INT), Change (CHA), and Conservation (CON):
 - First and Second Laws of Thermodynamics
 - Kinetic Theory
 - Thermal Conductivity
 - Ideal Gas Law

Samples of Evidence

1. Unit 2: Thermal Physics

Kinetic model of matter, temperature and Zeroth law, heat transfer, and mechanical equivalent, thermal expansion, ideal gas, first law of thermodynamics, second law of thermodynamics and engines, efficiency, and thermal conductivity

Big Ideas: 1 3, 4, and 5

2. Unit 2: Thermodynamics (SYS, INT, CHA, and CON)

- Thermal Conductivity
- Kinetic Theory and the Ideal Gas Law
- First Law of Thermodynamics
- Second Law of Thermodynamics

3. Thermodynamics (BI 1, BI 3, BI 4, and BI 5)

- a. Thermal energy transfer by conduction, convection, and radiation
- b. Laws of thermodynamics
- c. Entropy
- d. Ideal gases
- e. Kinetic theory

Curricular Requirement 4

The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 3: Electric Force, Field, and Potential, as described in the AP Course and Exam Description.

Required Evidence

- The syllabus must include the Unit 3 content listed below with the associated Big Ideas 1–5: Systems (SYS), Fields (FLD), Force Interactions (INT), Change (CHA), and Conservation (CON):
 - Charge and Electric Force
 - Electric Field
 - Electric Potential
 - Electric Potential Energy

Samples of Evidence

1. Electric forces, fields, and potential (Big Ideas 1, 2, 3, 4, and 5)
 - a. Electric Charge and Coulomb’s Law
 - b. Electric Fields
 - c. Electric Potential and Electric Potential Energy

2. Unit 3: Electrostatics (BIs: SYS, FLD, INT, CHA, CON)
Charge; electric field; potential; electric potential energy; charging by contact, friction, and induction; Coulomb’s law; insulators; conductors; force on a test charge and force field diagrams; motion of a particle in an electric field; capacitance; energy; and charge stored on parallel plate capacitor.

3. Electrostatics (BI 1, BI 2, BI 3, BI 4, and BI 5)
 - Elementary Charges and Fundamental Particles
 - Charging and Redistribution of Charge
 - Electric Forces and Coulomb’s Law
 - Electric Fields
 - Electric Potential and Equipotential
 - Electric Potential Energy
 - Capacitors
 - Dipoles

Curricular Requirement 5

The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 4: Electric Circuits, as described in the AP Course and Exam Description.

Required Evidence

- The syllabus must include the Unit 4 content listed below with the associated Big Ideas 1, 2, 4, and 5: Systems (SYS), Fields (FLD), Change (CHA), and Conservation (CON):
 - Ohm's Law
 - Kirchhoff's Rules
 - Complex DC Circuits
 - Steady-State RC Circuits

Samples of Evidence

1. Unit 4: Electric Circuits (Chapters 18 & 19)
 - Ohm's Law
 - Simple and Complex DC Circuits
 - Kirchhoff's Laws
 - Steady-State RC CircuitsBig Ideas: 1,2,4,5

2. Unit 4—BI1: Systems (SYS); BI2: Fields (FLD); BI4: Change (CHA); BI5: Conservation (CON)
 - Capacitors: Capacitance, Energy and Charge Stored, Parallel Plates
 - Electric Current: Definition of Direction of Current, Ohm's Law, Resistance and Resistivity, Power
 - Complex DC Circuits: Schematic Diagrams/Kirchhoff's Laws, Resistors (In Series, In Parallel), Capacitors (In Series, In Parallel), Terminal Voltage and Internal Resistance, Steady-State RC Circuits

3. **Electric Circuits** [CR5]
 - Electric Resistance
 - Ohm's Law
 - DC Circuits with Resistors Only
 - Kirchhoff's Laws
 - Series, Parallel, and Combination Circuits
 - Capacitance
 - DC Circuits with Resistors and CapacitorsBig Ideas 1, 2, 4, 5

Curricular Requirement 6

The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 5: Magnetism and Electromagnetic Induction, as described in the AP Course and Exam Description.

Required Evidence

- The syllabus must include the Unit 5 content listed below with the associated Big Ideas 1–4: Systems (SYS), Fields (FLD), Force Interactions (INT), and Change (CHA):
 - Magnetic Fields
 - Magnetic Forces
 - Faraday’s Law
 - Lenz’s Law

Samples of Evidence

1. Unit 5: Magnetism and Electromagnetic Induction

Big Ideas: 1, 2, 3, and 4

- Magnetic Force
- Magnetic Field
- Magnetic Flux
- Ampère’s Law
- Faraday’s Law of Electromagnetic Induction and Lenz’s Law
- Inductance

2. Unit 5: Magnetism and EM Induction

Magnetic field, magnetic forces on a charged particle and a current-carrying wire, magnetic flux, EM induction and Faraday’s law, Lenz’s law, motional emf

BI 1-4

3. UNIT 5: MAGNETISM AND ELECTROMAGNETIC INDUCTION [CR6]

- Magnetism and Sources of Magnetic Fields; Magnetic Forces
- Charged Particles Moving in Magnetic Fields
- Electromagnetic Induction (Faraday’s and Lenz’s laws)
- AC Circuits (introduction with transformers and other practical applications)

Big Ideas: Systems (SYS), Fields (FLD), Force Interactions (INT), and Change (CHA)

Curricular Requirement 7

The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 6: Geometric and Physical Optics, as described in the AP Course and Exam Description.

Required Evidence

- The syllabus must include the Unit 6 content listed below with the associated Big Idea 6: Waves (WAV):
 - Reflection and Refraction
 - Lenses and Mirrors
 - Interference, Diffraction, and Polarization

Samples of Evidence

1. Optics (chapters 17 & 18)
 - Big Idea 6 [CR7]
 - Science Practices 1.D, 5.D, 6.A, 6.B, 6.C, 6.D, 6.E, 6.F, and 6.G
 - Physical Optics
 - The electromagnetic spectrum, interference, diffraction, thin films, polarization
 - Geometric Optics
 - Reflection and refraction, images formed by mirrors, images formed by lenses
 2. Unit 6: Geometric and Physical Optics (BI: WAV)
 - Reflection and Refraction
 - Mirrors and Lenses
 - Interference, Diffraction, and Polarization
 3. Geometric and Physical Optics
 - Electromagnetic Waves
 - Reflection and Refraction
 - Interference, Diffraction, and Polarization
 - Optical Instruments: Mirrors and Lenses
- Big Idea: BI 6 (WAV)

Curricular Requirement 8

The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 7: Quantum, Atomic, and Nuclear Physics, as described in the AP Course and Exam Description.

Required Evidence

- The syllabus must include the Unit 7 content with the associated Big Ideas 1, 3, 4, 5, 6, and 7: Systems (SYS), Force Interactions (INT), Change (CHA), Conservation (CON), Waves (WAV), and Probability (PRO).

Samples of Evidence

1. *Unit 7: Modern Physics*

- Quantum Physics
- Atomic Physics
- Nuclear Physics

Big Ideas: Systems (SYS), Force Interactions (INT), Change (CHA), Conservation (CON), Waves (WAV), and Probability (PRO)

2. Modern Physics (Big Ideas 1, 3, 4, 5, 6, and 7)

- Atomic physics, energy levels of the electrons in atoms
- Nuclear physics, nuclear reactions
- Quantum physics

3. Unit 7 (CR 8): Atomic and Nuclear Physics

Big Ideas: BI 1, BI 3, BI 4, BI 5, BI 6, BI 7

- Bohr Model of the Atom (Quantization)
- Particle Nature of Light (Photoelectric Effect, Compton Effect)
- Wave Nature of Particles (de Broglie Wavelength, Electron Diffraction, Electron Wave Function)
- Nuclear Physics (Nuclear Processes, Mass-Energy Equivalence)

Curricular Requirement 9

The course provides opportunities for students to develop the skills related to Science Practice 1: Modeling, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- The syllabus must include one assignment, activity, or lab describing how students use representations and models to communicate scientific phenomena and solve scientific problems.
- The assignment, activity, or lab must be labeled with the relevant practice(s) (e.g., “1.2”) associated with Science Practice 1. As long as one practice under Science Practice 1 is represented, evidence is sufficient.

Samples of Evidence

1. Students will use a wiring diagram to construct an electrical circuit and determine both the theoretical and experimental resistance of the circuit. **(SP 1)**

2. In this magnetism activity, students will work in small groups to create a representation of the magnetic field due to a current-carrying wire. Students will discuss their representations and then describe them to their peer groups. **(SP 1: 1.1, 1.2)**

3. In this course we will be using **Science Practice 1: Modeling** to help us communicate scientific phenomena we observe in lab. One example will be the use of energy-level diagrams of electrons in an atom that we will construct using data from a spectroscopy lab (Learning Objective 1.A.4.1, Science Practice 1.1).

Curricular Requirement 10

The course provides opportunities for students to develop the skills related to Science Practice 2: Mathematical Routines, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- The syllabus must include one assignment, activity, or lab describing how students use mathematics appropriately.
- The assignment, activity, or lab must be labeled with the relevant practice(s) associated with Science Practice 2. As long as one practice under Science Practice 2 is represented, evidence is sufficient.

Samples of Evidence

1. During lens labs, students will use mathematical routines to determine the focal length of a lens using the object distance and the image distance. **(SP 2.2)**
2. The laboratory section of the syllabus has activities related to Science Practice 2: Mathematical Routines. The syllabus includes investigations that require appropriately using mathematics, such as a resistivity lab in which the students vary the geometry of conductive clay and measure the resistance. **(SP 2.2)**
3. In this course, we will be using **Science Practice 2: Mathematical Routines** to help us solve numerical problems. One example will be solving Bernoulli's equation for final velocity during a Torricelli's law experiment in which we determine the speed of water squirting out a small hole in a bottle of water. **(Science Practice 2.2)**

Curricular Requirement 11

The course provides opportunities for students to develop the skills related to Science Practice 3: Scientific Questioning, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- The syllabus must include one assignment, activity, or lab describing how students engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.
- The assignment, activity, or lab must be labeled with the relevant practice(s) associated with Science Practice 3. As long as one practice under Science Practice 3 is represented, evidence is sufficient.

Samples of Evidence

1. In this course we will be using **Science Practice 3: Scientific Questioning** to help us guide our laboratory investigations and refine our questions. One example will be when we are given an incorrect relationship between ideal gas law quantities and then refine our experiment to determine the correct relationship. **(SP 3.2)**
2. Using a single resistor, students will create a plot of current versus potential difference and pose scientific questions to investigate how these quantities are related (Ohm's law). **(SP 3)**
3. The students will create and pose a series of questions that allow them to investigate the following: How do you form different types of images using a thin convex lens? **(Science Practice 3.2)**

Curricular Requirement 12

The course provides opportunities for students to develop the skills related to Science Practice 4: Experimental Methods, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- The syllabus must include one assignment, activity, or lab describing how students plan and implement data collection strategies in relation to a particular scientific question.
- The assignment, activity, or lab must be labeled with the relevant practice(s) associated with Science Practice 4. As long as one practice under Science Practice 4 is represented, evidence is sufficient.

Samples of Evidence

1. The students will form small groups to design and perform activities to determine the qualitative relationship between the strength of the force between two current-carrying wires by using an ammeter and a compass. **(SP 4)**

Activity 1: With a long, straight current-carrying wire lying on the table, design a procedure to measure the amount of deflection of the needle on the compass as it is brought closer to the wire from far away.

Activity 2: Design an experimental procedure that will allow the amount of deflection in the compass needle to be measured when the compass is placed at a fixed distance from a long, straight current wire. [Note: The compass needle deflects due to an applied force.]

2. The RC Circuits Lab #3 is a guided three-part inquiry-based investigation in which students design and perform a series of investigations of RC circuits in order to observe and analyze the relationships that exist when resistors, capacitors, and emf sources are arranged in different ways (series, parallel, or combinations). **(SP 4)**
3. The laboratory section of the syllabus has activities related to **Science Practice 4: Experimental Methods**. The syllabus includes laboratory activities that require students to design a plan to collect data; for example, to determine the thermal conductivity of a material (Science Practice 4.2).

Curricular Requirement 13

The course provides opportunities for students to develop the skills related to Science Practice 5: Data Analysis, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- The syllabus must include one assignment, activity, or lab describing how students perform data analysis and evaluation of evidence.
- The assignment, activity, or lab must be labeled with the relevant practice(s) associated with Science Practice 5. As long as one practice under Science Practice 5 is represented, evidence is sufficient.

Samples of Evidence

1. The laboratory section of the syllabus has activities related to **Science Practice 5: Data Analysis**. The syllabus requires students to analyze data that they collect; for example, during a Snell's law lab where they identify the relationship between the angle of incidence and the angle of refraction for light crossing a boundary into a new medium. (Skill 5.1)
2. **Lab on Physical Optics (Science Practice: 5)**
Diffraction Grating: Students attempt to determine the wavelength of a pen laser using a diffraction grating. (Guided-Inquiry)
Double-Slit Interference: Students will determine the spacing between two narrow slits based upon an analysis of the interference pattern from monochromatic light. (Guided-Inquiry)
3. In small groups, students will complete an activity based on the Millikan Oil Drop Experiment. In this activity, students will analyze data to determine the charge of a single electron represented by an object. Student groups will compare and evaluate each other's data. (SP 5: 5.1, 5.2, 5.3)

Curricular Requirement 14

The course provides opportunities for students to develop the skills related to Science Practice 6: Argumentation, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- The syllabus must include one assignment, activity, or lab describing how students work with scientific explanations and theories.
- The assignment, activity, or lab must be labeled with the relevant practice(s) associated with Science Practice 6. As long as one practice under Science Practice 6 is represented, evidence is sufficient.

Samples of Evidence

1. Using mathematical support, students will explain why one object sinks in water while another floats.
Activity: The student will identify and estimate the forces acting on a solid aluminum cube weighing one kilogram in the air when it is submerged in water. The student will repeat the exercise for a cubical aluminum box with a volume of $2,000 \text{ cm}^3$ and compute the net force acting on each object.
The student will provide a real-world example similar to the two different objects considered in the activity. (**Science Practice 6**)
2. The laboratory section of the syllabus has activities related to **Science Practice 6: Argumentation**. The syllabus includes activities in which the student must make claims and/or predictions during laboratory work, such as during a photoelectric effect lab where they must use the photon model of energy. (Skill 6.4)
3. In this course, we will be applying **Science Practice 6: Argumentation** to make claims using scientific theories. One example will be during a diffraction grating lab to make claims about the pattern light will make after passing through a grating and how the pattern will change if the wavelength of the light is altered. (**Science Practice 6.4**)

Curricular Requirement 15

The course provides opportunities for students to develop the skills related to Science Practice 7: Making Connections, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- The syllabus must include one assignment, activity, or lab describing how students connect and relate knowledge across various scales, concepts, and representations in and across domains.
- The assignment, activity, or lab must be labeled with the relevant practice(s) associated with Science Practice 7. As long as one practice under Science Practice 7 is represented, evidence is sufficient.

Samples of Evidence

1. In this course we will be applying **Science Practice 7: Making Connections** to make connections across various concepts. During an activity using data from a nuclear reactor, students will use Einstein's equation to observe the relationship between mass and energy. (Skill 7.2)
2. The student will describe the effects of greenhouse gases on gradual changes in Earth's climate.
Activity: Consider Earth as a thermodynamically closed system. Energy from the Sun is absorbed by Earth, and Earth radiates energy back into space. By applying the conservation of energy principle, explain how Earth's climate will change as some of the energy radiated from Earth is reflected back due to the presence of greenhouse gases. (**SP 7**)
3. The RC Circuits Lab #3 is a guided three-part inquiry-based investigation in which students perform a series of investigations of RC circuits in order to observe, make connections between and analyze the relationships that exist when resistors, capacitors, and emf sources are arranged in different ways (series, parallel, or combinations). (**SP 7**)

Curricular Requirement 16

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.

Required Evidence

- 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.

Samples of Evidence

1. Students are required to do a case study for which they are hired as consultants in a court case involving an electrical power surge in an apartment building that damaged many residents' electronic equipment. They are asked to analyze the circuit data to determine if the power company is at fault and to provide expert testimony with their results.
2. A small town is facing a traffic issue. Students will design a smart traffic light system that would maximize traffic flow safely and relate the electrical features of the design to the local traffic control system. A presentation of their work will include connections to electric circuit principles used to design the network.
3. For a term paper, students will analyze an advertisement and/or product that makes scientific claims. The students must write a summary that would answer the following questions: What scientific principles are they using? (What is the scientific basis for this product?) What is correct or incorrect about their claims? Explain. What sources are used? Are those sources scientifically credible? Explain.

Curricular Requirement 17

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.

Required Evidence

- 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 investigation titles must be listed along with a brief description.

Clarifying Terms

Guided-inquiry: at this level, students investigate a teacher-presented question using student-designed/selected procedures.

Open-inquiry: at this level, students investigate topic-related questions that are formulated through student-designed/selected procedures.

See Chapter 4 in the AP Physics 1 and 2 Inquiry-Based Lab Investigations book for more information on levels of inquiry.

Samples of Evidence

- Students in this course are engaged in laboratory work more than 25% of the instructional time. The labs are listed and described below. Eight of these labs are guided-inquiry labs, as labeled. In these guided-inquiry labs, students are given a general question to answer and will work in small groups of 2–3 to develop their own procedures. Students will have their procedures approved by the instructor before they begin.
 - Charging an electroscope by induction and conduction and investigating Coulomb's law [GI]
 - Investigating electric field using conductive paper
 - Making a tangential galvanometer, converting a galvanometer to an ammeter and calibrating it, converting a galvanometer to a voltmeter and calibrating it, and investigating Ohm's law to determine the resistance of an unknown resistor
 - Investigating the factors affecting the amount of current produced by a wire by moving a magnet [GI]
 - Mapping the magnetic field of a magnet [GI]
 - Measuring the equivalent resistance of multiple circuits [GI]
 - Determining the resistivity of a wire, and investigating a Wheatstone bridge
 - Investigating RC circuits
 - Constructing a motor using a battery, a magnet, and a wire
 - Determining thermal conductivity of a material [GI]
 - Investigating Boyle's law and the ideal gas law with a syringe
 - Investigating Bernoulli's principle with a three-hole can [GI]
 - Measuring the density of a liquid using Archimedes' principle with a graduated cylinder, force sensor, and loose weights
 - Investigating half-lives with Skittles [GI]

- Photoelectric effect lab using Pasco lab set
 - Investigating lenses and their image formation using an optical bench and various concave and convex lenses [GI]
2. Labs are all hands-on and spaced throughout the instructional year. Students will spend at least 25% of class time in laboratory investigations. Labs can be either teacher-directed or guided-inquiry (GI)/open-inquiry (OI), but fewer than half will be teacher-directed.
- Density Exploration (OI): To design an experiment to determine graphically the density of a fluid given a spring of unknown K and a set of masses.
 - Archimedes' Principle Lab: To determine the densities of a liquid and two unknown objects by using the method that is attributed to Archimedes.
 - Bernoulli's Principle Lab: Students will investigate the relationship between water level and the exit velocity of water at the bottom of a vessel.
 - Thermal Conductivity Lab (OI): Students will design and conduct an experiment to determine the thermal conductivity of a material.
 - Heat Engine Lab (GI): To determine how the work done by an engine that raises mass during each of its cycles is related to area enclosed by its PV diagram.
 - Static Electricity Interactions (GI): To investigate the behavior of electric charges, charging processes, and the distribution of charge on a conducting object.
 - Electric Field and Equipotential: Students will draw lines of equal electrostatic potential and electric field lines for various charge configurations and determine the dependence of the electrostatic potential on the distance from a point charge.
 - Brightness Investigation (GI): To make predictions about the brightness of light bulbs in a variety of DC circuit configurations (series, parallel, and series-parallel) when some of the bulbs are removed.
 - Resistance and Resistivity (OI): To explore the microscopic factors that influence the electrical resistance of conducting materials. Students will investigate how geometry affects the resistance of ionic conductors.
 - Series and Parallel Circuits (GI): Students wire three identical resistors in series, in parallel, and in a series-parallel combination to investigate the current and power generated in each combination.
 - Magnetic Field of Earth: To measure the horizontal component of the Earth's magnetic field using solenoid and a compass.
 - Electromagnetic Induction (OI): The students move a bar magnet in and out of a solenoid and observe the deflection of a galvanometer. They will examine the effects of a changing magnetic field by observing currents induced in a solenoid and determine whether the observations agree with the theory of electromagnetic induction and Lenz's law.
 - Lenses Exploration (GI): Students will measure the focal length of convex lenses and the focal length of concave lenses by combining them with a convex lens.
 - Mirrors Exploration (GI): Students will be able to measure the focal length of various concave mirrors, and they will be able to calculate the magnification of the images.
 - Rayleigh Scattering: To determine why the sky has a bluish tint, but at sunrise/sunset the sky is reddish.
 - Quantum Wave Interference (GI): Students will be able to observe diffraction of light through both a single slit and a double slit and observe patterns of maxima and minima.
 - Photoelectric Effect (GI): Students will be able to determine Planck's constant from data collected from a circuit with an LED color strip.
 - Radioactive Candy (GI): Students will simulate radioactive decay and determine half-life.

3. The syllabus describes the course as a modeling kind and states that total hands-on lab time will be more than 25 percent of total instructional time, with investigations distributed throughout the course over a majority of the identified units. Sample investigations are described below, noting what activities students engage in. One-third of them are labeled “guided-inquiry” and another one-third are labeled “open-inquiry.”
- Fluid Pressure Lab: Using a pressure sensor dipped deeper and deeper into a graduated cylinder of water, students investigate the relationship between depth and pressure to determine the density of unknown liquids. (GI)
 - Torricelli’s Law Lab: Use a 2-liter soda bottle to investigate an application of Bernoulli’s equation.
 - Thermal Conductivity Lab: Compare thermal conductivities of materials by connecting Styrofoam cups filled with hot and cold water with a bridge of various wires and measure how long it takes to get the temperatures to equal out. (GI)
 - Gas Laws: Using pressure sensors and temperature probes, students recreate the three gas laws. (OI)
 - Snell’s Law Lab: Investigate the indices of refraction of various materials. (GI)
 - Thickness of Hair Lab: Using single-slit interference equation, determine the thickness of a student’s hair using a laser and meter sticks to measure distance to a screen and separation of the diffraction pattern. (GI)
 - Photoelectric Effect Lab: Using LEDs in a circuit, determine Planck’s constant from the lab described in the AP lab manual.
 - Half-Life Lab using flipped pennies and rolled dice. (OI)
 - Coulomb’s Law Lab using charged pieces of tape.
 - Electric Potential 3-D Graph using voltmeters and conductive paper.
 - Ohm’s Law Lab: Vary the potential difference across a resistor and measure the current to determine the resistance. (GI)
 - Play-Doh Resistivity Lab: Determine the resistivity of Play-Doh by varying its geometry. (OI)
 - Magnetic Field in a Slinky Lab: Using a magnetic field sensor, measure the magnetic field in a slinky acting as a solenoid. (OI)
 - Magnetic Field from a Current-Carrying Wire Lab: Magnets taped to cardboard are placed on an electric balance with a current-carrying wire running between them. Adjust the current and measure the change in force.

Curricular Requirement 18

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 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.

Samples of Evidence

1. Students work in lab groups, but each student must record raw data in their own lab notebook. For every unit, each student will submit one formal lab report.

The report must include the following components:

- Statement of the problem
- Hypothesis
- Discussion or outline of how the procedure will be carried out, including equipment used
- Data collected from the experiment
- Data analysis
- Conclusion, including error analysis and extension/outside application
- Peer review (if included in this lab)

Students are required to keep an organized lab notebook.

2. In this class you will be required to keep a lab notebook in which you keep all your lab reports. Your lab reports must include a description of the lab, the equipment used, the data collected, how it was analyzed, error analysis, and the conclusions that you arrived at.
3. Students will complete an electronic lab report submitted to a website that vets documents for plagiarism for each lab done in class consisting of an abstract, introduction/background section, purpose statement, equipment used, procedure, data, sample calculations, results, discussion of results, error analysis, conclusions, and bibliography.