

## Syllabus Development Guide: AP<sup>®</sup> Physics 1: Algebra-Based

The guide contains the following sections and information:

### **Curricular Requirements**

The curricular requirements are the core elements of the course. Your syllabus must provide clear evidence that each requirement is fully addressed in your course.

### **Scoring Components**

Some curricular requirements consist of complex, multipart statements. These particular requirements are broken down into their component parts and restated as “scoring components.” Reviewers will look for evidence that each scoring component is included in your course.

### **Evaluation Guideline(s)**

These are the evaluation criteria that describe the level and type of evidence required to satisfy each scoring component.

### **Key Term(s)**

These ensure that certain terms or expressions, within the curricular requirement or scoring component that may have multiple meanings are clearly defined.

### **Samples of Evidence**

For each scoring component, three separate samples of evidence are provided. These statements provide clear descriptions of what acceptable evidence should look like.



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## Curricular Requirement 1

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

## Evaluation Guideline(s)

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

## Key Term(s)

None at this time.

## Samples of Evidence

1. The syllabus cites a textbook from the AP Example Textbook List for AP Physics 1: Algebra-Based.
2. The syllabus cites a recently published college-level textbook for an introductory, algebra-based physics course.
3. In the resources section of the syllabus, the syllabus cites a college-level physics textbook (either algebra-based or calculus-based).



## Curricular Requirement 2

The course design provides opportunities for students to develop understanding of the AP Physics 1 foundational physics principles in the context of the big ideas that organize the curriculum framework.

## Scoring Component 2a

The course design provides opportunities for students to develop understanding of the foundational principles of kinematics in the context of the big ideas that organize the curriculum framework.

## Evaluation Guideline(s)

The syllabus must identify the big idea connected to kinematics.

The syllabus must explicitly include 1D and 2D kinematics.

## Key Term(s)

**Big ideas:** encompass the core scientific principles, theories, and processes of physics that cut across traditional content boundaries and provide students a broad way of thinking about the physical world.

## Samples of Evidence

1. In a list or chart of topics covered, kinematics is included and connected to Big Ideas 3 and 4.

Unit: Kinematics (Big Ideas 3 and 4)

- 1D kinematics
  - 2D kinematics
2. As a class, students derive equations of motion and perform numerical calculations in solving 1D and 2D kinematics problems and connect them to Big Ideas 3 and 4.
  3. The laboratory section of the syllabus includes investigative questions related to 1D kinematics and projectile motion and connects them to Big Ideas 3 and 4.



## Curricular Requirement 2

The course design provides opportunities for students to develop understanding of the AP Physics 1 foundational physics principles in the context of the big ideas that organize the curriculum framework.

## Scoring Component 2b

The course design provides opportunities for students to develop understanding of the foundational principles of dynamics in the context of the big ideas that organize the curriculum framework.

## Evaluation Guideline(s)

The syllabus must identify all of the big ideas connected to dynamics.

The syllabus must explicitly include Newton's laws.

## Key Term(s)

**Big ideas:** encompass the core scientific principles, theories, and processes of physics that cut across traditional content boundaries and provide students a broad way of thinking about the physical world.

## Samples of Evidence

1. In a list or chart of topics covered, dynamics is included and connected to Big Ideas 1, 2, 3, and 4.

Unit: Dynamics (Big Ideas 1, 2, 3, and 4)

- Newton's laws
2. The syllabus indicates instruction in Newton's laws and connects these to Big Ideas 1, 2, 3, and 4.
  3. The laboratory section of the syllabus includes investigative questions related to the relationship between force and motion (Newton's laws) and connects them to Big Ideas 1, 2, 3, and 4.



## Curricular Requirement 2

The course design provides opportunities for students to develop understanding of the AP Physics 1 foundational physics principles in the context of the big ideas that organize the curriculum framework.

## Scoring Component 2c

The course design provides opportunities for students to develop understanding of the foundational principles of circular motion and gravitation in the context of the big ideas that organize the curriculum framework.

## Evaluation Guideline(s)

The syllabus must identify all of the big ideas connected to the universal law of circular motion and gravitation.

## Key Term(s)

**Big ideas:** encompass the core scientific principles, theories, and processes of physics that cut across traditional content boundaries and provide students a broad way of thinking about the physical world.

## Samples of Evidence

1. In a list or chart of topics covered, the universal law of gravitation is included and connected to Big Ideas 1, 2, 3, and 4.

Unit: Universal Gravitation (Big Ideas 1, 2, 3, and 4)

- Newton's Law of Universal Gravitation
- Circular Motion

2. The syllabus indicates instruction in Newton's Law of Universal Gravitation and circular motion and connects it to Big Ideas 1, 2, 3, and 4.
3. The laboratory section of the syllabus includes investigative questions related to the universal law of gravitation and circular motion and connects them to Big Ideas 1, 2, 3, and 4.



## Curricular Requirement 2

The course design provides opportunities for students to develop understanding of the AP Physics 1 foundational physics principles in the context of the big ideas that organize the curriculum framework.

## Scoring Component 2d

The course design provides opportunities for students to develop understanding of the foundational principles of simple harmonic motion in the context of the big ideas that organize the curriculum framework.

## Evaluation Guideline(s)

The syllabus must identify all of the big ideas connected to simple harmonic motion.

The syllabus must explicitly include simple pendulum and mass-spring systems.

## Key Term(s)

**Big ideas:** encompass the core scientific principles, theories, and processes of physics that cut across traditional content boundaries and provide students a broad way of thinking about the physical world.

## Samples of Evidence

1. In a list or chart of topics covered, simple harmonic motion is included and connected to Big Ideas 3 and 5.

Unit: Simple Harmonic Motion (Big Ideas 3 and 5)

- Simple pendulum
  - Spring-mass systems
2. The syllabus indicates instruction in simple pendulum and mass-spring systems and connects these to Big Ideas 3 and 5.
  3. The laboratory section of the syllabus includes investigative questions related to the period of a simple pendulum and spring-mass systems and connects them to Big Ideas 3 and 5.





## Curricular Requirement 2

The course design provides opportunities for students to develop understanding of the AP Physics 1 foundational physics principles in the context of the big ideas that organize the curriculum framework.

## Scoring Component 2e

The course design provides opportunities for students to develop understanding of the foundational principles of linear momentum in the context of the big ideas that organize the curriculum framework.

## Evaluation Guideline(s)

The syllabus must identify all of the big ideas connected to linear momentum.

The syllabus must explicitly include impulse, momentum, and conservation of linear momentum.

## Key Term(s)

**Big ideas:** encompass the core scientific principles, theories, and processes of physics that cut across traditional content boundaries and provide students a broad way of thinking about the physical world.

## Samples of Evidence

1. In a list or chart of topics covered, linear momentum is included and connected to Big Ideas 3, 4, and 5.

Unit: Linear Momentum (Big Ideas 3, 4, and 5)

- Impulse
  - Momentum
  - Conservation of linear momentum
2. The syllabus indicates instruction in impulse, linear momentum, and conservation of linear momentum and connects these to Big Ideas 3, 4, and 5.
  3. The laboratory section of the syllabus includes investigative questions related to collisions (impulse, linear momentum, and conservation of linear momentum) and connects them to Big Ideas 3, 4, and 5.



## Curricular Requirement 2

The course design provides opportunities for students to develop understanding of the AP Physics 1 foundational physics principles in the context of the big ideas that organize the curriculum framework.

## Scoring Component 2f

The course design provides opportunities for students to develop understanding of the foundational principle of energy in the context of the big ideas that organize the curriculum framework.

## Evaluation Guideline(s)

The syllabus must identify all of the big ideas connected to energy.

The syllabus must explicitly include work, energy, power, and conservation of energy.

## Key Term(s)

**Big ideas:** encompass the core scientific principles, theories, and processes of physics that cut across traditional content boundaries and provide students a broad way of thinking about the physical world.

## Samples of Evidence

1. In a list or chart of topics covered, energy is included and connected to Big Ideas 3, 4, and 5.

Unit: Energy (Big Ideas 3, 4 and 5)

- Energy
  - Work
  - Power
  - Conservation of energy
2. The syllabus indicates instruction in work, power, kinetic energy, potential energy, and conservation of mechanical energy and connects these to Big Ideas 3, 4, and 5.
  3. The laboratory section of the syllabus includes investigative questions related to the work-energy theorem, power and energy conservation, and connects them to Big Ideas 3, 4, and 5.



## Curricular Requirement 2

The course design provides opportunities for students to develop understanding of the AP Physics 1 foundational physics principles in the context of the big ideas that organize the curriculum framework.

## Scoring Component 2g

The course design provides opportunities for students to develop understanding of the foundational principles of rotational motion in the context of the big ideas that organize the curriculum framework.

## Evaluation Guideline(s)

The syllabus must identify all of the big ideas connected to rotational motion.

The syllabus must explicitly include torque, rotational kinematics, rotational dynamics, energy and momentum in rotation, and conservation of angular momentum.

## Key Term(s)

**Big ideas:** encompass the core scientific principles, theories, and processes of physics that cut across traditional content boundaries and provide students a broad way of thinking about the physical world.

## Samples of Evidence

1. In a list or chart of topics covered, rotational motion is included and connected to Big Ideas 3, 4, and 5.

Unit: Rotational Motion (Big Ideas 3, 4, and 5)

- Torque
  - Rotational kinematics
  - Rotational dynamics
  - Rotational energy
  - Conservation of angular momentum
2. The syllabus indicates instruction in torque, rotational equilibrium, rotational kinematics, rotational dynamics, rotational energy, and conservation of angular momentum and connects these to Big Ideas 3, 4, and 5.



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**Samples of Evidence  
(continued)**

3. The laboratory section of the syllabus includes investigative questions related to torque and Newton's 2<sup>nd</sup> Law for rotational motion, rotational kinematics, rotational energy, as well as conservation of angular momentum, and connects them to Big Ideas 3, 4, and 5.



## Curricular Requirement 2

The course design provides opportunities for students to develop understanding of the AP Physics 1 foundational physics principles in the context of the big ideas that organize the curriculum framework.

## Scoring Component 2h

The course design provides opportunities for students to develop understanding of the foundational principles of electrostatics in the context of the big ideas that organize the curriculum framework.

## Evaluation Guideline(s)

The syllabus must identify all of the big ideas connected to electrostatics.

The syllabus must explicitly include electric charge, conservation of charge, and electric force.

## Key Term(s)

**Big ideas:** encompass the core scientific principles, theories, and processes of physics that cut across traditional content boundaries and provide students a broad way of thinking about the physical world.

## Samples of Evidence

1. In a list or chart of topics covered, electrostatics is connected to Big Ideas 1, 3, and 5.

Unit: Electrostatics (Big Ideas 1, 3, and 5)

- Electric charge
  - Conservation of charge
  - Electric force
2. The syllabus indicates instruction in conservation of electric charge and Coulomb's law and connects these to Big Ideas 1, 3, and 5.
  3. The laboratory section of the syllabus includes investigative questions related to the interactions between charges (conservation of charge and electric force) and connects them to Big Ideas 1, 3, and 5.

## Curricular Requirement 2

The course design provides opportunities for students to develop understanding of the AP Physics 1 foundational physics principles in the context of the big ideas that organize the curriculum framework.

## Scoring Component 2i

The course design provides opportunities for students to develop understanding of the foundational principles of electric circuits in the context of the big ideas that organize the curriculum framework.

## Evaluation Guideline(s)

The syllabus must identify all of the big ideas connected to electric circuits.

The syllabus must explicitly include Ohm's law and Kirchhoff's laws applied to simple DC resistor circuits.

## Key Term(s)

**Big ideas:** encompass the core scientific principles, theories, and processes of physics that cut across traditional content boundaries and provide students a broad way of thinking about the physical world.

## Samples of Evidence

1. In a list or chart of topics covered, electric circuits is connected to Big Ideas 1 and 5.

Unit: Simple DC Circuits

- Introduction to Current, Potential Difference, and Resistance
  - Analyzing Simple, Series and Parallel Circuits using Ohm's law and Kirchhoff's laws
2. The syllabus indicates instruction in how Ohm's law and Kirchhoff's laws are used to analyze simple series and parallel DC circuits with resistors and connects these to Big Ideas 1 and 5.
  3. The laboratory section of the syllabus includes investigative questions related to relationships between current, potential difference, resistance, conservation of energy, and conservation of charge using simple DC circuits including series and parallel configurations and connects them to Big Ideas 1 and 5.

|                                 |   |
|---------------------------------|---|
| <b>Curricular Requirement 2</b> | <b>The course design provides opportunities for students to develop understanding of the AP Physics 1 foundational physics principles in the context of the big ideas that organize the curriculum framework.</b>   |
| <b>Scoring Component 2j</b>     | The course design provides opportunities for students to develop understanding of the foundational principles of mechanical waves in the context of the big ideas that organize the curriculum framework.   |
| <b>Evaluation Guideline(s)</b>  | <p>The syllabus must identify the big idea connected to mechanical waves.</p> <p>The syllabus must explicitly include mechanical waves and sound.</p>   |
| <b>Key Term(s)</b>              | <b>Big ideas:</b> encompass the core scientific principles, theories, and processes of physics that cut across traditional content boundaries and provide students a broad way of thinking about the physical world.  |
| <b>Samples of Evidence</b>      | <ol style="list-style-type: none"><li>1. In a list or chart of topics covered, mechanical waves is included and connected to Big Idea 6.<br/><br/>Unit: Mechanical Waves (Big Idea 6)<ul style="list-style-type: none"><li>• Wave description</li><li>• Longitudinal and transverse waves</li><li>• Traveling and standing waves</li><li>• Energy and momentum in waves</li><li>• Superposition and interference of waves</li><li>• Sound wave</li></ul></li><li>2. The syllabus indicates instruction in properties and behavior of mechanical waves, including traveling and standing waves, energy and momentum in waves, and superposition and interference of waves, as exemplified by sound and connects these to Big Idea 6.</li></ol> |



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**Samples of Evidence  
(continued)**

3. The laboratory section of the syllabus includes investigative questions related to relationships between velocity, frequency, and wavelength using musical instruments and connects them to Big Idea 6.



## Curricular Requirement 3

Students have opportunities to apply AP Physics 1 learning objectives connecting across enduring understandings as described in the curriculum framework. These opportunities must occur in addition to those within laboratory investigations.

## Evaluation Guideline(s)

The syllabus must provide a brief description of at least one assignment or activity outside the laboratory experience designed to apply learning objectives connecting across two or more enduring understandings.

The syllabus must label the learning objectives drawn from at least two enduring understandings.

## Key Term(s)

**Enduring understandings:** incorporate the core concepts that students should retain from the learning experience.

**Learning objectives:** provide clear and detailed articulation of what students should know and be able to do. Learning objectives are numbered to correspond with each of the big ideas, enduring understandings, and essential knowledge. For example: LO 6.A.1.1 indicates the big idea (6), enduring understanding (6.A), and essential knowledge (6.A.1).

## Samples of Evidence

1. Students use (or collect simulated) data on the orbital positions of the Galilean moons of Jupiter to determine the mass of Jupiter. A freely available program from the Project CLEA website can be used to simulate telescopic collection of positions and times, or any number of online ephemeris can provide tables of positions and times. (LOs: 3.A.1.3, 3.A.3.1, 3.A.3.3, 3.C.1.2.)

*Learning Objectives:*

*3.A.1.3: The student is able to analyze experimental data describing the motion of an object and is able to express the results of the analysis using narrative, mathematical, and graphical representations.*

*3.A.3.1: The student is able to analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces.*

## Samples of Evidence (continued)

*3.A.3.3: The student is able to describe a force as an interaction between two objects and identify both objects for any force.*

*3.C.1.2: The student is able to use Newton's law of gravitation to calculate the gravitational force between two objects and use that force in contexts involving orbital motion.*

2. Students plan and execute class demonstration(s) of charging by induction using an electroscope and various conducting and nonconducting objects/materials. Each demonstration is accompanied by student explanation of how and why charge is being transferred (or not) as it is. **(LOs: 1.B.1.1, 1.B.1.2, 3.C.2.1)**

### *Learning Objectives:*

*1.B.1.1 The student is able to make claims about natural phenomena based on conservation of electric charge.*

*1.B.1.2 The student is able to make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits.*

*3.C.2.1 The student is able to use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges.*

3. Students build wind and string instruments out of recycled materials. Instruments must play a 5-note scale. Students compare and contrast the physics involved in the waves produced by their instruments. **(LOs: 6.A.1.1, 6.D.1.1, 6.D.3.2)**

### *Learning Objectives:*

*6.A.1.1 The student is able to use a visual representation to construct an explanation of the distinction between transverse and longitudinal waves by focusing on the vibration that generates the wave.*

*6.D.1.1 The student is able to use representations of individual pulses and construct representations to model the interaction of two wave pulses to analyze the superposition of two pulses.*



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**Samples of Evidence  
(continued)**

*6.D.3.2 The student is able to predict properties of standing waves that result from the addition of incident and reflected waves that are confined to a region and have nodes and antinodes.*



## Curricular Requirement 4

The course provides students with opportunities to apply their knowledge of physics principles to real world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.

## Evaluation Guideline(s)

The syllabus must label and provide a brief description of at least one assignment or activity requiring students to apply their knowledge of physics principles to understand real world questions or scenarios.

## Key Term(s)

**Real world:** application of physics principles, theories, or models to everyday situations, phenomena, or experiences found outside of the classroom.

## Samples of Evidence

- Real World Activity:**  
Students do a case study, for which they are hired as consultants in a court case involving a car crash. They are asked to analyze the crash data to determine which driver is at fault, and to provide expert testimony with their results.
- Real World Application:**  
Students design a car that would protect an egg in a collision and relate the features of the car design to the safety features in an automobile. Descriptions include connections to the physics principles used to inform the design of the car.
- Real World Investigation:**  
Students will analyze an advertisement and/or product that makes scientific claims. The students 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 5

Students are provided with the opportunity to spend a minimum of 25 percent of instructional time engaging in hands-on laboratory work with an emphasis on inquiry-based investigations.

## Evaluation Guideline(s)

The syllabus must include an explicit statement that at least 25 percent of instructional time is spent in laboratory experiences.

## Key Term(s)

None at this time.

## Samples of Evidence

1. The syllabus includes the following statement: “Students are engaged in laboratory work, integrated throughout the course, which accounts for 25 percent of the course.”
2. The syllabus states that the total lab time will be a minimum of 25 percent of total instructional time, with investigations distributed throughout the course.
3. The syllabus includes a statement to indicate that 25 percent of this course is spent doing laboratory investigations.



## Curricular Requirement 6

Students are provided the opportunity to engage in inquiry-based laboratory investigations that support the foundational principles and apply all seven science practices defined in the curriculum framework.

## Scoring Component 6a

The laboratory work used throughout the course includes investigations that support the foundational AP Physics 1 principles.

## Evaluation Guideline(s)

The syllabus **must** list and provide a brief description for a minimum of 14 hands-on laboratory investigations that collectively support a majority of the foundational principles in the course.

## Key Term(s)

None at this time.

## Samples of Evidence

1. The syllabus briefly describes all of the 17 investigations used throughout the course and provides the corresponding science practices for the description of each investigation. Throughout all lab experiences in the course, all of the seven science practices and **a majority of the 10 foundational physics principles** are addressed.

For example, the syllabus includes the following description:

**Topic: Rotational Motion:** Angular Momentum

Lab Title: Guided-Inquiry Investigation of Conservation of Angular Momentum

Lab Description and Science Practices:

Students design an investigation to determine how the angular momentum of a rotating system responds to changes in the moment of inertia. (SP 4.2)

The experiment involves the collection of data of angle vs. time and angular velocity vs. time. (SP 4.2)

## Samples of Evidence (continued)

The students will analyze the graphs before and after the changes in the moment of inertia. (SP 1.4, SP 2.2, SP 5.1) On their lab report, the students will justify the effect of changes in the moment of inertia on the angular momentum of the system. (SP 6.1).

2. The syllabus provides a list of the 14 hands-on labs used during the course and lists the appropriate science practices for each lab. Throughout all lab experiences in the course, all seven science practices and **a majority of the foundational physics principles** are addressed.

For example:

Lab(s): Guided-Inquiry Investigation: Roller Coaster Design

### Topic: Conservation of Energy

Science Practices and Lab Description: (SP 1.1, 1.4, 1.5, 2.1, 2.2, 4.2, 5.1, 5.3)

Design a simple roller coaster with the set given (track, loop-the-loop, and Hot Wheels cars) to test whether the total energy of a car-earth system is conserved if there are no external forces exerted on it by other objects.

Students use multiple representations of energy to provide evidence for their claims. They should include a bar chart graph, the mathematical expression of conservation of energy, and the corresponding calculations to evaluate whether the outcome of the experiment supports the idea of energy conservation.

3. All 16 labs used in the course are listed in a table illustrating which **Science Practices** are covered and how they are used by teachers and students for each laboratory investigation. Throughout all lab experiences in the course, all seven science practices and **a majority of the foundational physics principles** are addressed.

For example:

## Samples of Evidence (continued)

### TOPIC: Rotational Motion (Guided-Inquiry)

Lab Investigation and Description:

Rotational Inertia:

Students design a data collection strategy to determine the rotational inertia of a cylinder from the slope of a graph of an applied torque versus angular acceleration.

The students are able to verify their claims by comparing their evidence with the moment of inertia found directly by measuring the mass and radius of the cylinder.

Science Practice:

1.4 The student can use representations and models to analyze situations or solve problems qualitatively and quantitatively.

2.2 The student can apply mathematical routines to quantities that describe natural phenomena.

4.2 The student can design a plan for collecting data to answer a particular scientific question.

5.1 The student can analyze data to identify patterns or relationships.

6.1 The student can justify claims with evidence.





## Curricular Requirement 6

Students are provided the opportunity to engage in inquiry-based laboratory investigations that support the foundational principles and apply all seven science practices defined in the curriculum framework.

## Scoring Component 6b

The laboratory work used throughout the course includes guided-inquiry laboratory investigations allowing students to apply all seven science practices.

## Evaluation Guideline(s)

Descriptions of laboratory investigations must indicate how, collectively, the lab experiences provide students opportunities to apply all seven science practices. (It is not required that all seven practices be included within any one laboratory investigation.)

A minimum of seven investigations must be labeled with the term guided-inquiry and/or open-inquiry.

## Key Term(s)

**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.

## Samples of Evidence

1. The syllabus briefly describes all of the 17 investigations used throughout the course and provides the corresponding science practices in each investigation description. Throughout all lab experiences in the course, **all of the seven science practices** and a majority of the 10 foundational physics principles are addressed.

For example, the syllabus includes the following description:

Topic: Rotational Motion: Angular Momentum

Lab Title: **Guided-Inquiry Investigation** of Conservation of Angular Momentum

## Samples of Evidence (continued)

### Lab Description and Science Practices:

Students design an investigation to determine how the angular momentum of a rotating system responds to changes in the moment of inertia. (SP 4.2)

The experiment involves the collection of data of angle vs. time and angular velocity vs. time. (SP 4.2)

The students will analyze the graphs before and after the changes in the moment of inertia. (SP 1.4, SP 2.2, SP 5.1) On their lab report, the students will justify the effect of changes in the moment of inertia on the angular momentum of the system. (SP 6.1)

2. The syllabus provides a list of the 14 hands-on labs used during the course and lists the appropriate science practices for each lab. Throughout all lab experiences in the course, **all seven science practices** and a majority of the foundational physics principles are addressed.

For example:

Lab(s): **Guided-Inquiry Investigation:** Roller Coaster Design

Topic: Conservation of Energy

### Science Practices and Lab Description: (SP 1.1, 1.4, 1.5, 2.1, 2.2, 4.2, 5.1, 5.3)

Design a simple roller coaster with the set given (track, loop-the-loop, and Hot Wheels cars) to test whether the total energy of a car-earth system is conserved if there are no external forces exerted on it by other objects.

Students use multiple representations of energy to provide evidence for their claims. They should include a bar chart graph, the mathematical expression of conservation of energy, and the corresponding calculations to evaluate whether the outcome of the experiment supports the idea of energy conservation.

3. All 16 labs used in the course are listed in a table illustrating which Science Practices are covered and how they are used by teachers and students for each laboratory investigation. Throughout all lab



## Samples of Evidence (continued)

experiences in the course, **all seven science practices** and a majority of the foundational physics principles are addressed.

For example:

TOPIC: Rotational Motion (**Guided-Inquiry**)

Lab Investigation and Description:

Rotational Inertia:

Students design a data collection strategy to determine the rotational inertia of a cylinder from the slope of a graph of an applied torque versus angular acceleration.

The students are able to verify their claims by comparing their evidence with the moment of inertia found directly by measuring the mass and radius of the cylinder.

Science Practice:

1.4 The student can use representations and models to analyze situations or solve problems qualitatively and quantitatively.

2.2 The student can apply mathematical routines to quantities that describe natural phenomena.

**4.2 The student can design a plan for collecting data to answer a particular scientific question.**

5.1 The student can analyze data to identify patterns or relationships.

6.1 The student can justify claims with evidence.



## Curricular Requirement 7

The course provides opportunities for students to develop their communication skills by recording evidence of their research of literature or scientific investigations through verbal, written, and graphic presentations.

## Evaluation Guideline(s)

The syllabus must include the components of the lab reports required of students for all the laboratory investigations engaged in throughout the course.

The syllabus must include an explicit statement that students are required to maintain a lab journal, notebook, or portfolio (hard-copy or electronic) that includes evidence of their lab work.

## Key Term(s)

**Components:** examples include questions, predictions, explanation of phenomena, data collection, data analysis/graphs, error analysis/sources of uncertainty, statistics, and conclusions.

## Samples of Evidence

1. Students are required to keep a lab journal. The required contents of that lab journal include predictions, observations, data, data analysis, and conclusions.
2. Students are required to keep a lab portfolio. Each lab included in the portfolio must contain questions, predictions, data, data analysis, error analysis, statistics, and a conclusion. The portfolio may include reports presented in both poster format and video format.
3. The syllabus describes the type of lab notebook that the student is required to maintain, and lists the components of each lab report that will be contained within the lab notebook.



## Curricular Requirement 8

The course provides opportunities for students to develop written and oral scientific argumentation skills.

## Evaluation Guideline(s)

The syllabus must label and provide a brief description of at least one activity or assignment where students engage in dialogue or peer critique where they offer evidence and make or refute claims based on available evidence supported by physics reasoning or rationale.

## Key Term(s)

**Scientific argumentation:** articulate reasons for making and refuting claims, engage in conversation or critique with a peer, and respond to counter claims.

**Physics reasoning:** using foundational physics principles to make or refute claims based on evidence.

## Samples of Evidence

### 1. Argumentation Skills Applied:

Students work in small groups on a project for an egg drop contest. Groups must collaborate to construct the mathematical models and predictions that will inform their overall design. As a group they must decide what to use, how to do it, and how to analyze and interpret the results. Each group will provide a written summary of the models used, predications and assumptions made, final analysis of the project, and present their summary to the class. Each student presentation will respond to peer critique of their investigation and support their claims or justifications with evidence from their investigation.

### 2. Argumentation Skills Applied:

Students will work in groups to create energy-bar charts to analyze five points identified along a roller-coaster picture. Each student group is given a different roller-coaster design. They will share their energy-bar charts with a neighboring group where they will critique their charts that depict the conservation of total mechanical energy and the transformation of potential energy and kinetic energy at the five different locations.

### 3. Scientific Argumentation:

Students are given a scenario such as: two tubes of different length, open at one end only, are placed in front of a speaker set to a specific low frequency. At this low frequency neither tube resonates.



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**Samples of Evidence  
(continued)**

As the frequency increases, one tube resonates. At higher frequencies, it is possible for both tubes to resonate.

Students are asked to work in groups and provide an argument, with supporting diagrams/models and/or equations, to justify what is happening in the scenario above. Each group will share their justifications and the class will provide peer critique of their claims and supporting evidence.