

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. 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	<ol style="list-style-type: none">1. The syllabus cites a textbook from the AP Example Textbook List for AP Physics 2: 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 2 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 all of the big ideas connected to thermodynamics.
The syllabus must explicitly include the laws of thermodynamics, ideal gases, and kinetic theory.

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, thermodynamics is included and is connected to Big Ideas 1, 4, 5, and 7.

Unit: Thermodynamics (Big Ideas 1, 4, 5, and 7)
 - The Laws of Thermodynamics
 - Ideal Gases
 - The Kinetic Theory of Gases
2. The syllabus indicates instruction in thermal energy transfer (by conduction, convection, or radiation), the laws of thermodynamics, entropy and ideal gases, the kinetic theory of gases, and connects these to Big Ideas 1, 4, 5, and 7.
3. The laboratory section of the syllabus includes investigative questions related to the relationship between temperature, pressure, and volume in an ideal gas and the role of those variables in the 1st and 2nd laws of thermodynamics. The syllabus includes an activity using a PhET simulation to investigate aspects of the kinetic theory and connects them to Big Ideas 1, 4, 5, and 7.



Curricular Requirement 2

The course design provides opportunities for students to develop understanding of the AP Physics 2 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 fluids 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 fluids.

The syllabus must explicitly include fluid statics and dynamics.

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, fluid mechanics is included and connected to Big Ideas 1, 3, and 5.

Unit: Fluid Mechanics (Big Ideas 1, 3, and 5).

- Fluid Statics (pressure, density, Archimedes' principle, Pascal's principle)
- Fluid Dynamics (continuity, Bernoulli's theorem)

2. The syllabus indicates instruction in the buoyant force and Archimedes' principle, Bernoulli's equation, and the continuity equation and connects these to Big Ideas 1, 3, and 5.
3. The laboratory section of the syllabus includes investigative questions related to the relationship between pressure and velocity in moving fluids and connects them to Big Ideas 1, 3, and 5.

The laboratory section of the syllabus includes investigative questions related to a quantitative investigation of densities and buoyant forces 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 2 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 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 force, electric field, and electric potential.

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 forces, electric fields, and electric potential are connected to Big Ideas 1, 2, 3, 4, and 5.

Unit: Electrostatics (Big Ideas 1, 2, 3, 4, and 5)

- Electric Force (Coulomb's law)
 - Electric Field
 - Electric Potential
2. The syllabus indicates instruction in Coulomb's law, electric field, and electric potential and connects these to Big Ideas 1, 2, 3, 4, and 5.
 3. The laboratory section of the syllabus includes investigative questions related to the relationship between the sizes of electric charge, the separation distance, and the electrostatic force between objects and connects them to Big Ideas 1, 2, 3, 4, and 5.



**Samples of Evidence
(continued)**

The laboratory section of the syllabus includes investigative questions related to the measurement of electric potential difference and its connection to the corresponding electric field, and places the results in the context of Big Ideas 1, 2, 3, 4, and 5.



Curricular Requirement 2	The course design provides opportunities for students to develop understanding of the AP Physics 2 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 electric circuits in the context of the big ideas that organize the curriculum framework.
Evaluation Guideline(s)	<p>The syllabus must identify all of the big ideas connected to electric circuits.</p> <p>The syllabus must explicitly include Ohm's law and Kirchhoff's laws as applied to complex DC circuits, including steady-state RC circuits.</p>
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	<ol style="list-style-type: none">1. In a list or chart of topics covered, Ohm's law, Kirchhoff's laws, DC circuits, and steady-state RC circuits are included and connected to Big Ideas 1, 4, and 5. <p>Unit: DC Circuits (Big Ideas 1, 4, and 5)</p> <ul style="list-style-type: none">• Current, Potential difference, and Ohm's law• Resistivity of conductors• Kirchhoff's laws• Analysis of DC Circuits• Capacitors and capacitance• RC Circuits (steady-state)



Samples of Evidence (continued)

2. The syllabus indicates instruction in analysis of DC and steady-state RC circuits using Ohm's law and Kirchhoff's laws and connects these to Big Ideas 1, 4, and 5.
3. The laboratory section of the syllabus includes investigative questions related to the relationship between resistance, capacitance, and charging time for an RC circuit and connects them to Big Ideas 1, 4, and 5.

The laboratory section of the syllabus includes investigative questions related to the relationship between potential differences and currents in various single and multiloop DC circuits and connects them to Big Ideas 1, 4, and 5.



Curricular Requirement 2

The course design provides opportunities for students to develop understanding of the AP Physics 2 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 magnetism and electromagnetic induction 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 magnetism and electromagnetic induction. The syllabus must explicitly include magnetic forces and fields, and electromagnetic induction.

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, magnetism and electromagnetic induction are included and connected to Big Ideas 1, 2, 3, and 4.

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

- Magnetic forces
- Magnetic fields
- Interaction of moving charges in a magnetic field

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

- Motional EMF
- Faraday's law
- Lenz's law



Samples of Evidence (continued)

2. The syllabus indicates instruction in properties of magnets, magnetic forces and magnetic fields, and how electricity and magnetism are interconnected, and connects these to Big Ideas 1, 2, 3, and 4.
3. The laboratory section of the syllabus includes investigative questions related to the size and direction of current flow in a wire and the resulting magnetic field near the wire, and connects them to Big Ideas 1, 2, 3, and 4.

The laboratory section of the syllabus includes investigative questions related to the relationship between the number of loops of wire in a coil, motion of magnet, and current induced in the coil, 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 2 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 principles of optics in the context of the big ideas that organize the curriculum framework.
Evaluation Guideline(s)	<p>The syllabus must identify the big idea connected to optics.</p> <p>The syllabus must explicitly include geometric and physical optics.</p>
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	<ol style="list-style-type: none">In a list or chart of topics covered, geometric and physical optics are included and connected to Big Idea 6. Unit: Optics (Big Idea 6)<ul style="list-style-type: none">Geometrical Optics (index of refraction, lenses, mirrors)Wave/Physical Optics (interference, superposition, diffraction)The syllabus indicates instruction in reflection, refraction, interference, and diffraction and connects these to Big Idea 6.The laboratory section of the syllabus includes investigative questions related to the formation and properties of images produced by lenses and mirrors and connects them to Big Idea 6. The laboratory section of the syllabus includes investigative questions related to the relationship between slit spacing and the diffraction pattern, and connects them to Big Idea 6.

Curricular Requirement 2	The course design provides opportunities for students to develop understanding of the AP Physics 2 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 modern physics in the context of the big ideas that organize the curriculum framework.
Evaluation Guideline(s)	<p>The syllabus must identify all of the big ideas connected to modern physics.</p> <p>The syllabus must explicitly include quantum physics, atomic physics, and nuclear physics.</p>
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	<ol style="list-style-type: none">1. In a list or chart of topics covered, quantum physics, atomic physics, and nuclear physics are included and connected to Big Ideas 1, 3, 4, 5, 6, and 7. Unit: Modern Physics (Big Ideas 1, 3, 4, 5, 6, and 7)<ul style="list-style-type: none">• Quantum Physics (photoelectric effect, wavelike behavior of particles, mass–energy equivalence, the probabilistic description of matter)• Atomic Physics (Bohr model, atomic structure, energy states and radiation)• Nuclear Physics (nuclear properties, nuclear decay and half-life, types of radioactive emissions, nuclear forces, nuclear fission and fusion)2. The syllabus indicates instruction in atomic structure and energy states, photoelectric effect and wavelike behavior of particles, and nuclear properties and reactions and connects these to Big Ideas 1, 3, 4, 5, 6, and 7.3. The laboratory section of the syllabus includes investigative questions related to the photoelectric effect and atomic spectra, and connects them to Big Ideas 1, 3, 4, 5, 6, and 7.



**Samples of Evidence
(continued)**

The laboratory section of the syllabus, or an activity utilizing a PhET simulation, includes investigative questions related to the radioactive decay and half-life, and connects them to Big Ideas 1, 3, 4, 5, 6, and 7.



Curricular Requirement 3

Students have opportunities to apply AP Physics 2 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 build a model of a house applying their knowledge of circuits and explain in writing how the different elements in a household circuit work and the role of grounded connections, parallel circuits, and circuit breakers. The group then presents their findings to the class and participates in a Q & A session with the class. (LOs: 4.E.5.1, 5.B.9.6, 5.C.3.4, 5.C.3.5.)

Learning Objectives:

4.E.5.1 The student is able to make and justify a quantitative prediction of the effect of a change in values or arrangements of one or two circuit elements on the currents and potential differences in a circuit containing a small number of sources of emf, resistors, capacitors, and switches in series and/or parallel.

5.B.9.6 The student is able to mathematically express the changes in electric potential energy of a

Samples of Evidence (continued)

loop in a multiloop electrical circuit and justify this expression using the principle of the conservation of energy.

5.C.3.4 The student is able to predict or explain current values in series and parallel arrangements of resistors and other branching circuits using Kirchhoff's junction rule and relate the rule to the law of charge conservation.

5.C.3.5 The student is able to determine missing values and direction of electric current in branches of a circuit with resistors and NO capacitors from values and directions of current in other branches of the circuit through appropriate selection of nodes and application of the junction rule.

2. Students investigate how the human eye works and then research how to determine which types of lenses are appropriate to correct visual eye defects such as myopia and hyperopia, and how the quantum efficiency of a cell phone camera compares with that of the receptors in the retina of the eye. As an extension, the students may investigate how laser eye surgery (LASIK) works. **(LOs: 6.E.3.3, 6.E.5.1, 6.E.5.2, 6.F.4.1, EK 1.D.2)**

Learning Objectives:

6.E.3.3 The student is able to make claims and predictions about path changes for light traveling across a boundary from one transparent material to another at non-normal angles resulting from changes in the speed of propagation.

6.E.5.1 The student is able to use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the refraction of light through thin lenses.

6.E.5.2 The student is able to plan data collection strategies, perform data analysis and evaluation of evidence, and refine scientific questions about the formation of images due to refraction for thin lenses.

6.F.4.1 The student is able to select a model of radiant energy that is appropriate to the spatial or temporal scale of an interaction with matter.

EK 1.D.2 Certain phenomena classically thought of as waves can exhibit properties of particles.



Samples of Evidence (continued)

- a. *The classical models of waves do not describe the nature of a photon.*
 - b. *Momentum and energy of a photon can be related to its frequency and wavelength.*
3. Using PhysicsQuest: Atomic and Nuclear Physics (or similar), students investigate the different types of radiation, nuclear fission and fusion, and the principles behind nuclear power plants and weapons. (LOs: 1.C.4.1, 5.B.8.1, 5.B.11.1, 5.C.1.1, 7.C.3.1)

Learning Objectives:

1.C.4.1 The student is able to articulate the reasons that the theory of conservation of mass was replaced by the theory of conservation of mass-energy.

5.B.8.1 The student is able to describe emission or absorption spectra associated with electronic or nuclear transitions as transitions between allowed energy states of the atom in terms of the principle of energy conservation, including characterization of the frequency of radiation emitted or absorbed.

5.B.11.1 The student is able to apply conservation of mass and conservation of energy concepts to a natural phenomenon and use the equation $E = mc^2$ to make a related calculation.

5.C.1.1 The student is able to analyze electric charge conservation for nuclear and elementary particle reactions and make predictions related to such reactions based upon conservation of charge.

7.C.3.1 The student is able to predict the number of radioactive nuclei remaining in a sample after a certain period of time, and also predict the missing species (alpha, beta, gamma) in a radioactive decay.



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

1. Real World Activity:

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. Real World Application:

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. Real World Investigation:

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 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 a variety of investigations that support the foundational AP Physics 2 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 16 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 foundational physics principles** are addressed.

For example, the syllabus includes the following description:

Topic: Electric Force

Lab Title: How does the electric force between two charged objects depend on the distance between them?

Guided-Inquiry Lab Description and Science Practices: Students will design an experiment to investigate qualitatively how electric force between two objects depends on the distance between them. (SP 4.2) Students will describe observations with words and using free-body diagrams (SP 1.1) and will use their observations to determine how the electric force between charged objects depends on the distance between them. (SP 5.1)



Samples of Evidence (continued)

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:

Topic: Physical Optics

Lab Title: Guided-Inquiry Investigation: Double-Slit Interference

Science Practices and Lab Description: (SP 1.4, 2.2, 4.2, 5.1, 6.1)

Students design a data collection strategy to replicate Young's double slit experiment and apply the results of the experiment to predict the location of bright and dark fringes.

3. All 18 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:

TOPIC: Simple Harmonic Motion (Guided-Inquiry)

Lab Investigation and Description:

Design an experiment to test if the period of a simple pendulum is proportional to its length.

Science Practices:

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.

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 16 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 foundational physics principles are addressed.

For example, the syllabus includes the following description:

Topic: Electric Force

Lab Title: How does the electric force between two charged objects depend on the distance between them?

Guided-Inquiry Lab Description and Science Practices: Students will design an experiment to

Samples of Evidence (continued)

investigate qualitatively how electric force between two objects depends on the distance between them. **(SP 4.2)** Students will describe observations with words and using free-body diagrams **(SP 1.1)** and will use their observations to determine how the electric force between charged objects depends on the distance between them. **(SP 5.1)**

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:

Topic: Physical Optics

Lab Title: **Guided-Inquiry** Investigation: Double-Slit Interference

Science Practices and Lab Description: (SP 1.4, 2.2, 4.2, 5.1, 6.1)

Students design a data collection strategy to replicate Young's double slit experiment and apply the results of the experiment to predict the location of bright and dark fringes.

3. All 18 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:

TOPIC: Simple Harmonic Motion (**Guided-Inquiry**)

Lab Investigation and Description:

Design an experiment to test if the period of a simple pendulum is proportional to its length.

Science Practices:

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



**Samples of Evidence
(continued)**

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.



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 analysis, and conclusions.
2. Students are required to keep a lab portfolio. Each lab is to be included in the portfolio and must contain questions, predictions, data, data analysis, error analysis, statistics, and a conclusion. This 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. Scientific Argumentation:

Students first use PhET *Gas Properties* simulation to visualize the behavior of an ideal gas at the molecular level. They are asked to propose a mechanism, consistent with considering molecules as objects, by which the ideal gas exerts pressure on the container walls. They are also asked to provide a written argument for a specific collision type, elastic or inelastic, between molecules in an ideal gas and between gas molecules and the container wall. Interactions between gas molecules are analyzed in terms of Newton's Third Law of Motion, the Law of Conservation of Linear Momentum, and the Law of Conservation of Energy. Student must share their written argument with a partner and they must analyze whether their claims are valid.

2. Scientific Argumentation:

Students are asked to either support or refute the claim: "*Incandescent lightbulbs in your home are most likely to burn out when first being turned on.*" Students are then asked to support their claims based on evidence they collect through research, complete with appropriate references. After each student has shared their findings, the class will discuss what evidence they believe exists to support the reason for the phenomena.

3. Scientific Argumentation:

Students are provided with three statements they must either support or refute based on models and



Samples of Evidence (continued)

physics principles:

- 1) A student that is 175 cm tall will need a mirror that at least equals his or her total height in order to see a full reflection.
- 2) It does not matter how far the student stands from the mirror with regard to seeing his or her full reflection.
- 3) It does not matter where the mirror is hung vertically on the wall with regard to seeing his or her full reflection.

Students will present the models used to support or refute claims. The teacher will guide a whole-class discussion and peer critique on the models used to support their claims.