AP Physics 1 Standards

Synthesis Standards

Synthesis standards assess physics content from multiple science practices and often across physics topics. These standards will be assessed using specific AP Free Response question types. More detail about each question type is included [at the end of this document](#).

- SYNTH.1 The **Mathematical Routines (MR) question** assesses students' ability to use mathematics to analyze a scenario and make predictions about that scenario. Students will be expected to symbolically derive relationships between variables, as well as calculate numerical values. Students will be expected to create and use representations that describe the scenario and to justify claims with a logical and sequential application of physics concepts.
- SYNTH.2 The **Translation Between Representations (TBR) question** assesses students' ability to connect different representations of a scenario. Students will be expected to create visual representations, derive equations, and draw graphs that are relevant to the given scenario. Students will then compare and contrast their representations, use them to make predictions and/or predict changes if the scenario were changed.
- SYNTH.3 The **Experimental Design and Analysis (LAB) question** assesses students' ability develop a scientifically sound method by which a question about a given physical scenario could be answered and describe a method by which the collected data could be analyzed in order to answer the posed question, by either graphical or comparative analyses. Students will then be asked to graphically analyze experimental data for a similar, but not identical, question to what was asked in the Design portion of the question.
- SYNTH.4 The **Qualitative/Quantitative Translation (QQT) question** assesses students' ability to connect the nature of the scenario, the physical laws that govern the scenario, and mathematical representations of that scenario to each other. Students will be asked to make and justify a claim about a given scenario, as well as derive an equation related to that scenario. Students will then compare and contrast their answers for different parts, use them to make predictions and/or predict changes if the scenario were changed.

Content Standards

These standards will be assessed on unit labs, quizzes, and tests. Most units will have the following three standards:

- Create multiple representations of physics scenarios. (Drawing Physics)
- Use quantitative problem solving to derive, calculate, compare, or predict physics quantities. ("Mathing" Physics)
- Use physics content to develop qualitative explanations of and justify claims about physical phenomena. (Writing Physics)

Unit 1 - Kinematics Particle Model (KPM)

Standard	**Content addressed**
KPM 1.1 - Create multiple representations of physics scenarios.	● Draw motion maps for one and two dimensional motion ● Create position vs. time, velocity vs. time, and acceleration vs. time graphs ● Use arrows to represent vectors and vector components
KPM 1.2 - Use quantitative problem solving to derive, calculate, compare, or predict physics quantities.	● Use kinematic equations to solve problems and predict values of displacement, velocity, and acceleration ● Solve relative motion problems ● Solve two-dimensional projectile motion problems
KPM 1.3 - Use physics content to develop qualitative explanations of and justify claims about physical phenomena.	● Distinguish between vector and scalar quantities ● Make and justify claims about motion in one and two dimensions ● Explain observations of motion in which the observer and the subject are moving relative to each other.

Unit 2 - Force Particle Model (FPM)

Standard	**Content addressed**
FPM 2.1 - Create multiple representations of physics scenarios.	● Draw qualitatively accurate free-body diagrams, vector addition diagrams and system schema for balanced and unbalanced force scenarios. ● Represent circular motion with motion maps and free-body diagrams.
FPM 2.2 - Use quantitative problem solving to derive, calculate, compare, or predict physics quantities.	● Solve problems using Newton's 2nd Law ($a=\sum F/m$) and sum of force equations. ● Apply a mathematical model of friction force. ● Apply Newton's 2nd Law and Newton's Law of Universal Gravitation to particles in circular motion.
FPM 2.3 - Use physics content to develop qualitative explanations of and justify claims about physical phenomena.	● Distinguish between vector and scalar quantities. ● Make and justify claims about balanced/unbalanced forces and an object's constant/changing velocity. ● Use Newton's 3rd Law to predict and explain force values on multiple objects.

Unit 3 - Conservation of Energy Model (COEM)

Standard	Content addressed
COEM 2.1 - Create multiple representations of physics scenarios.	● Create energy bar charts to represent the way the storage category (e.g. K, U_g, U_S), and total amount of energy in a system changes (or doesn't change). ● Draw graphs of energy as a function of time or position. ● Represent energy added or removed from a system as the area under a F vs. Δx graph.
COEM 2.2 - Use quantitative problem solving to derive, calculate, compare, or predict physics quantities.	● Solve problems using conservation of energy, including mechanical energy being transferred to thermal energy. ● Use the relationship between the force and displacement to calculate the energy added or removed from the system by working, and solve problems involving the rate of energy transfer (power).
COEM 2.3 - Use physics content to develop qualitative explanations of and justify claims about physical phenomena.	● Make and justify claims about energy conservation in systems. ● Explain how nonconservative forces can dissipate mechanical energy and use this to analyze physics scenarios.

Unit 4 - Conservation of Momentum Model (COMM)

Standard	Content addressed
COMM 2.1 - Create multiple representations of physics scenarios.	● Create momentum and impulse bar charts to represent momentum transfers for 1-D interactions. ● Draw graphs to represent the momentum or velocity of a system.
COMM 2.2 - Use quantitative problem solving to derive, calculate, compare, or predict physics quantities.	● Solve problems using conservation of momentum, for elastic or inelastic interactions. ● Determine the center of mass of a system or its velocity.
COMM 2.3 - Use physics content to develop qualitative explanations of and justify claims about physical phenomena.	● Make and justify claims about momentum conservation in systems. ● Reason about the motion of the center of mass of a system.

Unit 5 - Rotational Dynamics Model (RDM)

Standard	Content addressed
RDM 5.1- Apply kinematics principles to rotational motion.	● Define and graphically represent angular displacement, velocity and acceleration. ● Solve problems using rotational kinematic equations. ● Explain the connection between rotational and linear quantities.
RDM 5.2 - Apply Newton's Laws principles to rotational motion.	● Use force diagrams to represent the torques applied in systems in equilibrium or in rotational motion. ● Use torque and Newton's 2nd Law of Rotation to solve problems and predict values of angular position, velocity and acceleration. ● Describe how the rotational inertia of a rotating system affects its motion.

Unit 6 - Rotational Energy and Momentum Model (REMM)

Standard	Content addressed
REMM 6.1 - Apply conservation of energy principles to rotational motion.	● Create energy bar charts to represent translational and rotational energy quantities, and energy added or removed from a system by working. ● Use conservation of energy to predict and determine physics quantities, including the motion of rolling objects and satellites. ● Describe how the rotational inertia of a rotating system affects the energy of the system.
REMM 6.2 - Apply conservation of momentum principles to rotational motion.	● Use momentum vs. time graphs to represent momentum in a system, and reason about momentum changes due to angular impulses. ● Use conservation of momentum to predict and determine physics quantities, including the motion of rolling objects and satellites. ● Describe how the rotational inertia of a rotating system affects the angular momentum of the system.

Unit 7 - Oscillating Particle Model (OPM)

Standard	Content addressed
OPM 7.1 - Create multiple representations of physics scenarios.	● Create free-body diagrams for objects in SHM. ● Create energy bar charts for oscillating systems. ● Draw motion, force, and energy graphs for an oscillating particle.
OPM 7.2 - Use quantitative problem solving to derive, calculate, compare, or predict physics quantities.	● Use mathematical models of SHM to solve problems involving oscillating systems. ● Use Newton's Laws and conservation of energy to solve problems involving oscillating systems.
OPM 7.3 - Use physics content to develop qualitative explanations of and justify claims about physical phenomena.	● Make and justify claims about oscillating systems. ● Identify SHM and relate it to a linear restoring force.

Unit 8 - Fluids (Static and Dynamic Models)

Standard	Content addressed
FM 8.1 - Apply Newton's Laws principles to fluids.	● Create free-body diagrams for static fluid scenarios. ● Solve statics fluids problems involving force and pressure. ● Use a microscopic model to predict and explain force and pressure differences in static fluid scenarios. ● Energy bar charts for dynamic fluid scenarios.
FM 8.2 - Apply conservation of matter and energy principles to fluids.	● Create energy bar charts for dynamic fluid scenarios. ● Solve flow rate problems using the principle of continuity. ● Use Bernoullis' equation to find pressure, velocity and depth in dynamic fluid problems.
FM1.3 - Use physics content to develop qualitative explanations of physical phenomena	● Use a microscopic model to predict and explain force and pressure differences in static fluid scenarios ● Use continuity and conservation of energy to explain pressure and velocity differences in dynamic fluid scenarios.

Lab Standards

The laboratory standards will be assessed through the lab write-ups of classroom experiments.

LAB.1 I can identify independent and dependent variables in an experiment, the tools used to measure them, and the quantities kept constant.
LAB.2 I can describe the procedure used to measure identified variables and properly record qualitative and quantitative data, including uncertainty in measurement.
LAB.3 I can represent data with graphs, linearizing as needed and write the equation for the trend in lab data, using variables and units appropriately.
LAB.4 I can make a scientific claim addressing the experimental question, support the claim with evidence, and provide the reasoning that connects the claim to the evidence.
LAB.5 I can explain the relationship between variables, the physical significance of the slope and y-intercept (and area if applicable), and relate the results to a general formula.
LAB.6 I can determine the uncertainty in my experimental measurements and calculate percent uncertainty to determine how well data compares to any expected results and give reasons for any discrepancies.

The habits of mind objectives will be used for reflection by the teacher of student performance.

Habits of Mind
HOM.1 I show individual responsibility and preparation by coming to class on time and ready to learn with appropriate physics work completed.
HOM.2 I demonstrate collaborative social skills which contribute to a positive learning environment by ensuring that classmates feel their contributions and presence are acknowledged and valued.
HOM.3 I demonstrate collaborative academic skills by contributing to the group/class learning and work.
HOM.4 I show initiative to actively promote my own learning by working to practice and show proficiency on standards and seek help when needed.
HOM.5 I stay focused intellectually and energetically on the work and learning of the day.

Free Response Question Types

The **Mathematical Routines (MR) question** assesses students' ability to use mathematics to analyze a scenario and make predictions about that scenario. Students will be expected to symbolically derive relationships between variables, as well as calculate numerical values. Students will be expected to create and use representations that describe the scenario, either to help guide the mathematical analysis (such as drawing a free-body diagram) or that are applicable to the scenario (such as sketching velocity as a function of time).
For AP Physics 1 and AP Physics 2, the MR question will ask students to make a claim or prediction about the scenario and use appropriate physics concepts and principles to support and justify that claim. The justification is expected to be a logical and sequential application of physics concepts that demonstrates a student's ability to connect multiple concepts to each other.

The **Translation Between Representations (TBR) question** assesses students' ability to connect different representations of a scenario. Students will be expected to create a visual representation that describes a given scenario. Students will derive equations that are mathematically relevant to the scenario. Students will draw graphs that relate quantities within the scenario. Finally, students will be asked to do any one of the following:

- Justify why their answers to any two of the previous parts do/do not agree with each other.
- Use their representations, mathematical analysis, or graph to make a prediction about another situation and justify their prediction using that reasoning or analysis.
- Use their representations, mathematical analysis, or graph to make a prediction about how those representations would change if properties of the scenario were altered and justify that claim using consistent reasoning or analysis.

The **Experimental Design and Analysis (LAB) question** assesses students' ability to create scientific procedures that can be used with appropriate data analysis techniques to determine the answer to given questions. The LAB question can roughly be divided into two sections: Design and Analysis. In the Design portion of the LAB question, students will be asked to develop a method by which a question about a given physical scenario could be answered. The experimental procedure is expected to be scientifically sound: vary a single parameter, and measure how that change affects a single characteristic. Methods must be able to be performed in a typical high school laboratory. Measurements must be made with realistically obtainable equipment or sensors. Students will be expected to describe a method by which the collected data could be analyzed in order to answer the posed question, by either graphical or comparative analyses.
Students will then be given experimental data collected in order to answer a similar, but not identical, question to what was asked in the Design portion of the question. Students will be asked to use the data provided to create and plot a graph that can be analyzed to determine the answer to the given question. For instance, the slope or intercepts of the line may be used to determine a physical quantity or perhaps the nature of the slope would answer the posed question.

The **Qualitative/Quantitative Translation (QQT) question** assesses students' ability to connect the nature of the scenario, the physical laws that govern the scenario, and mathematical representations of that scenario to each other. Students will be asked to make and justify a claim about a given scenario, as well as derive an equation related to that scenario. Finally, students will be asked to do any one of the following:

- Justify why their answers to any of the previous parts do/do not agree with each other.
- Use their representations or mathematical analysis to make a prediction about another situation and justify their prediction using that reasoning or analysis.
- Use their representations and mathematical analysis to make a prediction about how those representations would change if properties of the scenario were altered and justify that claim using consistent reasoning or analysis.

While students may not be directly assessed on their ability to create diagrams or other representations of the system to answer the QQT, those skills may still help students to answer the QQT. For instance, some students may find that drawing a free-body diagram is useful when determining the acceleration of a system. However, the student will earn points for the explanation and conclusions that diagram indicates (or perhaps the derivation that results from the diagram), rather than for creating the diagram itself.

AP Science Practices

Creating Representations Create representations that depict physical phenomena.	1.A Create diagrams,tables, charts, or schematics to represent physical situations. 1.B Create quantitative graphs with appropriate scales and units, including plotting data. 1.C Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system.
Mathematical Routines Conduct analyses to derive, calculate, estimate, or predict.	2.A Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway. 2.B Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway. 2.C Compare physical quantities between two or more scenarios or at different times and locations in a single scenario. 2.D Predict new values or factors of change of physical quantities using functional dependence between variables.
Scientific Questioning and Argumentation Describe experimental procedures, analyze data, and support claims.	3.A Create experimental procedures that are appropriate for a given scientific question. 3.B Apply an appropriate law, definition, theoretical relationship, or model to make a claim. 3.C Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.