Paradise High School AP Physics 1 Course Syllabus

Curricular Requirements		Page(s)
CR1	Students and teachers have access to college-level resources including college-level textbooks and reference materials in print or electronic format.	2, 3
CR2a	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.	3, 4
CR2b	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.	3, 5
CR2c	The course design provides opportunities for students to develop understanding of the foundational principles of **gravitation and circular motion** in the context of the big ideas that organize the curriculum framework.	3, 5, 9
CR2d	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.	3, 9
CR2e	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.	3, 6
CR2f	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.	3, 6
CR2g	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.	3, 8
CR2h	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.	3, 11
CR2i	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.	3, 11
CR2j	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.	3, 10
CR3	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.	5, 12
CR4	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.	6, 7,12
CR5	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.	2
CR6a	The laboratory work used throughout the course includes **investigations** that support the foundational AP Physics 1 principles.	4, 5-12
CR6b	The laboratory work used throughout the course includes **guided-inquiry** laboratory investigations allowing students to apply all seven science practices.	4, 5-12
CR7	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.	2, 5, 6, 8, 9
CR8	The course provides opportunities for students to develop written and oral scientific argumentation skills.	2, 7

Paradise High School AP Physics 1 Course Syllabus

Course Introduction

Textbooks: **[CR1]**

Physics by Douglas Giancoli, 6th Edition (primary text & source of problems)

Conceptual Physics by Paul Hewitt, 8th Edition (resource for conceptual depth)

Study guide by the teacher (focus & reinforcement of key concepts)

About this course:

The AP Physics 1 course will meet for 56 minutes every day. Lab work is integral to the understanding of the concepts in this course. The AP Physics 1 Course has been designed by the College Board as a course equivalent to the algebra-based college-level physics class. At the end of the course, students will take the AP Physics 1 Exam, which will test their knowledge of both the concepts taught in the classroom and their use of the correct formulas.

The content for the course is based on six big ideas:

Big Idea 1 – Objects and systems have properties such as mass and charge. Systems may have internal structure.

Big Idea 2 – Fields existing in space can be used to explain interactions.

Big Idea 3 – The interactions of an object with other objects can be described by forces.

Big Idea 4 – Interactions between systems can result in changes in those systems.

Big Idea 5 – Changes that occur as a result of interactions are constrained by conservation laws.

Big Idea 6 – Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena.

Students spend 25% of the instructional time engaged in laboratory work. **[CR5]** Experiments designed by the instructor are used to demonstrate procedural guidelines and to learn how to use specific laboratory equipment. The majority of labs are inquiry-based where students are given an objective and a set of materials. They are tasked with designing a procedure and collecting data to determine specific quantities, determine the relationship between variables, and/or to derive fundamental physics equations. Laboratory design, experimentation, data gathering, data presentation, analysis, drawing conclusions, and experimental error analysis are elements in these lab activities.

Laboratory work is recorded in a laboratory notebook, and students will have opportunities to present their laboratory work to their peers. All aspects of the laboratory work including any pre-lab work, question/hypothesis, experimental procedure, data, analysis, graphs, conclusion, and error analysis will be recorded. **[CR7]** Additional information as indicated in the following pages will also be included in the lab notebook. At the end of completing the lab work for the investigations that are labeled “Guided-Inquiry,” the students will present their method, data and conclusions on whiteboards. The class will then engage in peer critique of each group’s results, and discuss strategies to decrease error and suggest further investigations. **[CR8]**

Evaluation:

Students will get grades on homework, quizzes, laboratory work, projects, and exams. Exams are typically worth 100 points and will consist of questions similar to ones students will see on the AP Exam. Homework assignments and quizzes will consist of problems from the textbook, supplements, and old AP Exams. Projects are long-term, and typically will involve groups of students developing a plan, collecting data and/or research, and presenting conclusions in a meaningful way. Laboratory work is student centered and inquiry based and is discussed below. **[CR1-8]**

Grades will be determined by taking the number of points a student has earned and dividing it by the total number of points that the student could have achieved. This decimal is multiplied by 100, will be the student's grade.

Topics Covered:

1. Kinematics (Big Idea 3) **[CR2a]**
    a. Vectors/Scalars
    b. One Dimensional Motion (including graphing position, velocity, and acceleration)
    c. Two Dimensional Motion
2. Dynamics (Big Ideas 1, 2, 3, and 4) **[CR2b]**
    a. Newton's Laws of Motion and Forces
3. Universal Law of Gravitation (Big Ideas 1, 2, 3, and 4) **[CR2c]**
    a. Circular Motion
4. Simple Harmonic Motion (Big Ideas 3 and 5) **[CR2d]**
    a. Simple Pendulums
    b. Mass-Spring Oscillators
5. Momentum (Big Ideas 3, 4, and 5) **[CR2e]**
    a. Impulse and Momentum
    b. The Law of Conservation of Momentum
6. Energy (Big Ideas 3, 4, and 5) **[CR2f]**
    a. Work
    b. Energy
    c. Conservation of Energy
    d. Power
7. Rotation (Big Ideas 3, 4, and 5) **[CR2g]**
    a. Rotational Kinematics
    b. Rotational Energy
    c. Torque and Rotational Dynamics
    d. Angular Momentum
    e. Conservation of Angular Momentum
8. Electrostatics (Big Ideas 1, 3, and 5) **[CR2h]**
    a. Electric Charge
    b. The Law of Conservation of Electric Charge
    c. Electrostatic Forces
9. Circuits (Big Ideas 1 and 5) **[CR2i]**
    a. Ohm's Law
    b. Kirchhoff's Laws c. Simple DC Circuits
10. Mechanical Waves and Sound (Big Idea 6) **[CR2j]**

<table>
<tr><td colspan="2">Unit 1: Kinematics [CR2a]
Big Idea 3: The interactions of an object with other objects can be described by forces.
Big Idea 4: Interactions between systems can result in changes in those systems.</td></tr>
<tr><th>Course Sequence</th><th>Student Labs and Activities [CR6a]</th></tr>
<tr><td>Course Introduction
Physics conventions
Measurements
Significant figures
Orientation
Intro to center of mass
Objects and systems
Inertial frames
Coordinate system
Scalars and vectors
Kinematic variables and rates
Position
Distance, Displacement
Speed, Velocity
Acceleration
Deriving kinematic equations and problem solving techniques
One-dimensional kinematics
Qualitatively describing motion associated with experimental results and real world examples</td><td>Read 1.1 to 1.8 and 2.1 to 2.8, 3.1 to 3.8 and 5-1 to 5.2

Groups discuss how a system, such as a bicycle, a car, the solar system, an atom, etc., can be viewed as a particle(s), an object(s), and as a system in different situations. (EU 1.A)

Lab 1: Constant velocity. Structured lab to demonstrate lab format and expectations. Record and graph displacement versus time data. Generate velocity and acceleration graphs. (EU 3.A, 4.A) (SP 2, 5)

Lab 2: [Guided-Inquiry] Design an experiment. Given a track (capable of being inclined to a measureable angle), a low friction cart, a meter stick, and a timing device, students will design a lab to determine the acceleration of the cart. Students will describe the observed motion qualitatively, organize the data into a meaningful table, and construct a graph that can be used to determine the acceleration of the object. (EU 3.A, 4.A) (SP 2, 3, 4, 5) [CR6b]

Lab 3: Free fall. Structured lab to demonstrate computer data acquisition. Using computer-based data collection, students will record the time for a free falling object from various heights. Students will graph results in order to determine the value of the acceleration of gravity. (EU 3.A, 4.A) (SP 2, 5)</td></tr>
<tr><td>Graphical motion analysis
Position, velocity, and acceleration time graphs
Freefall
Acceleration of gravity
Two-dimension kinematics
Vector components
Vector addition
Relative motion
Projectile motion
Uniform Circular Motion
Period
Tangential velocity
Centripetal acceleration</td><td>Lab 4: Projectile motion. Students will fire a projectile horizontally and mathematically use the results to determine the launch velocity. Subsequently students will fire the projectile at several launch angles while experimentally determining maximum height and maximum range. Results will be compared to calculated values. Students will also construct a variety of graphs involving displacement, velocity, and acceleration. (EU 3.A, 4.A) (SP 2, 4, 5)

Groups given scenarios involving actual uniform circular motions will draw vectors representing tangential velocity and centripetal acceleration. For each scenario, the period, speed, and acceleration will be determined. Record in lab book.
(EU 3.A, 3.B) (SP 1, 2, 7)</td></tr>
</table>

<table>
<tr><td colspan="2">Unit 2: Dynamics [CR2b] [CR2c]
Big Idea 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.
Big Idea 2: Fields existing in space can be used to explain interactions.
Big Idea 3: The interactions of an object with other objects can be described by forces.
Big Idea 4: Interactions between systems can result in changes in those systems.</td></tr>
<tr><th>Course Sequence</th><th>Student Labs and Activities [CR6a]</th></tr>
<tr><td>Inertial mass, Law of Inertia

Force
Agent and object
Contact forces
Long-range forces
Gravity field
Identifying forces
Weight
Tension
Normal force
Force of springs
Friction
Drag
Objects and systems
Force vectors
Free-body diagrams
Newton's Second Law
Newton's Third Law
Problem solving
Net force
Statics
Dynamics
Inclines

Compound bodies

Advanced equilibrium and dynamics problems involving a variety of forces and interacting objects

Uniform circular motion
Centripetal force
Force problems involving uniform circular motion</td><td>Read 4.1 to 4.8, and 9.1 to 9.2

Define inertia and its connection to mass. Given several examples of motion of objects, all having differing masses, assess the general effect of mass on motion. (EU 3.A)

Groups research weight, tension, normal force, restoring force, friction, drag, and applied forces. Identify the agent, the magnitude of the force, and the direction of the force. Share the results with the class. (EU 2.A, 3.A, 3.C) (SP 6)

List the requirements for an object to experience a force. Explain why there must be an action-reaction pair, and explain why objects cannot place a force on themselves. Share your explanation with a partner. (EU 3.A) (SP 6)

[Connecting Across Enduring Understandings] – Given pictures of common objects in real world settings, students will identify one object and one system. For each object/system, identify the forces acting on the object and system, identify the action-reaction pair, construct a free-body diagram, and predict the motion of the object and the system. Share the results with another student and critique each other. (LO 1.A.5.1, 3.A.4.3, 3.B.1.1) (SP 1, 6, 7) [CR3] [CR7]

Given a variety of scenarios, students will construct a free body diagram, assess the type of motion experienced by the object, determine the magnitude and direction of the sum of the force vectors, and determine the objects acceleration. (EU 3.B, 4.A)

Lab 5: Statics. Using masses, strings, and spring scales, students will suspend the masses in several configurations while recording the tension in each string. The results will also be compared to free-body diagrams of each suspended mass. (EU 3.A, 3.B) (SP 1, 2, 5, 7)

Groups will be given diagrams consisting of compound bodies in various configurations. Identify objects/systems and prepare free-body diagram.
(LO 1.A.5.1, 3.A.4.3) (SP 1)
Lab 6: [Guided-Inquiry] Atwood's Machine. Determine the acceleration of gravity using two masses, a string, a pulley, a meter stick, and a timer. (EU 1.A, 1.C, 3.A, 3.B) (SP 2, 4, 5) [CR6b]

Lab 7: [Guided-Inquiry] Given a ramp, a pulley, a string, unequal masses, a meter stick, a timer, and a spring scale, design a series of experiments to determine the coefficients of static and kinetic friction. In addition, determine the acceleration of</td></tr>
</table>

Course Sequence	Student Labs and Activities
Apparent weight in circular motion	*the object when forces are unbalanced. (EU 1.A, 1.C, 3.A, 3.B) (SP 1, 2, 3, 4, 5, 6, 7)* **[CR6b]** Students will research, design, build, and test a simple rocket. Students present launch and flight results along with suggested improvements. Students apply their improvements and rebuild the rocket to assess the change in performance. **[CR4]** Groups given real world scenarios involving uniform circular motion will draw vectors representing tangential velocity, centripetal acceleration and centripetal force, complete free-body diagrams, determine equations solving for the centripetal force, acceleration, and tangential velocity for the object. Share and critique the results with another group. (EU 1.A, 3.A, 3.B) (SP 1, 2, 7) **[CR7]** *Lab 8: Determine the speed of a mass moving as a conical pendulum using two methods: kinematics of uniform circular motion and by summing forces. Compare the results obtained by both methods. (EU 1.A, 3.A, 3.B) (SP 1, 2, 4, 5, 7)* Students will analyze various real world scenarios that create apparent weight. Record in lab book. (EU 3.A, 3.B) (SP 1, 2, 3, 7) **[CR4]**

Unit 3: Conservation Laws [CR2e] [CR2f]

Big Idea 3: The interactions of an object with other objects can be described by forces.

Big Idea 4: Interactions between systems can result in changes in those systems.

Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws.

Course Sequence	Student Labs and Activities
Energy Energy model Internal energy Total mechanical energy Kinetic energy Potential energy Gravitational Elastic Work Dot product of vectors Conservative forces Non-conservative forces Constant force Variable force Work-Kinetic Energy Theorem Conservation of energy Conservative forces Non-conservative forces	Read 6.1 to 6.10 and 7.1 to 7.7 Class will create an energy model to visualize the relationships between energies within a system. The conditions for both an open and closed system will be established, and examples of each will be discussed. Given specific examples, students will use the model to suggest the source of a change in energy and the resulting effect on both the system and the environment. Record in lab book. (4.C, 5.A, 5.B) (SP 1, 2) Students will be given a variety of diagrams showing systems in various positions. Students will access the energies comprising the system's internal energy. Students will qualitatively and quantitatively determine changes to these energies as a result of changes within the system. (EU 4.C, 5.B) (SP 1, 2, 6) Students will categorize previously learned forces as either conservative or non-conservative. (EU 5.B) (SP 1) Work will be demonstrated by applying a variety of forces to various objects. Students will make predictions regarding the resulting motion. Students will use their observations to determine how a force must be applied to change the internal energy of a system. Record in lab book. (EU 4.C, 5.B) (SP 1)

Course Sequence	Student Labs and Activities
Power Graphing energy, work, and power Linear momentum Impulse Open and closed systems Conservation of linear momentum Elastic collisions Inelastic collisions Perfectly inelastic collisions Explosions Energy in collisions Graphing Impulse	*Lab 9: [Guided-Inquiry] Design a lab to determine the effect on internal energy due to non-conservative forces. Data collected will be presented graphically in order to determine the work done. In addition, students will calculate changes in kinetic energy to the work done. Students will share the results with the class and discuss whether or not the results are consistent with the work energy theorem (EU 3.E, 4.C, 5.B) (SP 1, 2, 4, 5, 6)* **[CR6b]** Students will make qualitative predictions on changes in kinetic energy given force and velocity vectors. Students will also solve quantitative problems using the work-kinetic energy theorem. Students will compare the work values obtained with their qualitative observations and with the results obtained using force and distance to determine work. (EU 3.E, 4.C) (SP 2) Given a variety of systems, students will use conservation of energy to determine key data at various locations for a moving object or changing system. (EU 5.A, 5.B) (SP 2) *[Real World Application]* Students will be assigned to several teams, and each team will research sources of energy (solar, fossil fuels, wind, geothermal, hydroelectric, etc.) and the cost-benefit of each. Student teams present findings to the class and argue the merits of their assigned energy source. **[CR4] [CR8]** Students will determine the change in momentum of various objects given their mass and initial velocity along with either: the objects resulting velocity; the force acting to change momentum and the time during which it acts; or graphical representation of force and time. (EU 3.D, 4.B) (SP 2, 5, 6) Given a real world scenario, students will design a plan to collect and organize data in order to determine the relationship between changes in momentum and average force. Articulate the difference between open and closed systems and their affect on conserved quantities. (EU 5.A) (SP 6, 7) Given various collisions students must identify them as elastic, inelastic, or perfectly elastic. Students must predict the resulting motion of colliding objects, and verify their predictions using the appropriate conservation of momentum calculations. When relevant, calculations may include kinetic energy lost. Record in lab book. (EU 5.D) (SP 2, 3, 6, 7) *Lab 10: [Guided-Inquiry] Using low friction carts, capable of colliding elastically and inelastically, students will design experiments to verify conservation of momentum and kinetic energy for both types of collisions. Analysis will include graphing the motion of each cart before during and after the collision. (EU 5.D) (SP 2, 3, 4, 5, 6, 7)* **[CR6b]**

Unit 4: Rotation [CR2g]

Big Idea 3: The interactions of an object with other objects can be described by forces.

Big Idea 4: Interactions between systems can result in changes in those systems.

Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws.

Course Sequence	**Student Labs and Activities**
Center of mass	Read 8.1 to 8.9
Rotational objects viewed as systems	Given various symmetrical objects and systems, students will locate the center of mass and state its relationship to the linear and rotational motion of a freely moving object. (EU 4.A) (SP 5)
Rotational kinematics Angular displacement Angular velocity Angular acceleration Related tangential quantities	After seeing several demonstrations, students will compare the effect on the center of mass due to forces acting within a system to forces acting on the system. In addition, students must recognize that if no external forces act, the system will move at constant velocity. (EU 4.A, 5.D) (SP 1, 2, 6) Describe how a rotating system can be visualized as a collection of objects in circular motion. (EU 1.A) (SP 1)
Moment of inertia Parallel axis theorem	Students will compare rotational and linear quantities and solve rotational kinematic problems using previously learned techniques. (EU 4.D) (SP 2, 7)
Torque Torque vectors Cross product of vectors Right hand rule Rotational statics Rotational dynamics	Groups will be given a scenario where a compound body is experiencing rotation. Students will identify the components of force creating torque, characterize each torque as positive or negative, determine the net torque, and determine the resulting motion of the system. Groups will share their scenarios and findings and critique each other. They will record their own and the other group's findings in the lab book. (EU 3.F) (SP 1) **[CR7]** *Lab 11: [Guided-Inquiry] Students will design a lab to demonstrate rotational statics. (EU 3.F) (SP 4, 5)* **[CR6b]**
Conservation of energy in rotation	*Lab 12: Given an apparatus that rotates horizontally due to the vertical motion of a mass draped over a pulley, students will collect a variety of data to determine the moment of inertia of the rotating system, the net torque acting on the system, the angular and linear acceleration, the final velocity of the system, the work done during the motion. Students will also use conservation of energy to determine the final velocity and compare this to the value obtained using torque and kinematics. (EU 3.F, 4.D, 5.B) (SP 4, 5)*
Angular momentum Angular momentum vectors Right hand rule Change in angular momentum Conservation of angular momentum	Given a rotating system, students will determine angular momentum using both linear and rotational variables. Students will make predictions and compare how interactions with external objects or changes within the system can influence angular momentum. (EU 4.D, 5.E) (SP 1, 2, 3, 7) *Lab 13: [Guided-Inquiry] Using a pulley and a rotating platform, students will design a lab involving a rotating system where a net torque results in angular acceleration. Students will also make changes to the system's configuration to explore the effect on angular momentum. Students will compare the change in angular momentum to the change in average torque multiplied by time. (EU 3.F, 4.D, 5.E) (SP 1, 2, 4, 5)* **[CR6b]**

Unit 5: Oscillations and Gravity [CR2c] [CR2d]

Big Idea 1: Objects and systems have properties such as mass and charge. Systems have internal structure.

Big Idea 2: Fields existing in space can be used to explain interactions.

Big Idea 3: The interactions of an object with other objects can be described by forces.

Big Idea 4: Interactions between systems can result in changes in those systems.

Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws.

Course Sequence	Student Labs and Activities
Restoring forces Hooke's Law Equilibrium Simple harmonic motion Spring Simple pendulum Physical pendulum Period and frequency Force and energy relationships during an oscillation Graphing oscillations Fundamental forces Long range forces Gravity field Mass and weight Newton's Law of Gravity Inverse Square Law Elliptical orbits Kepler's Laws Conservation of angular momentum Conservation of energy Circular orbits Orbital speed Escape speed	*Read 11.1 and 11.3 and 5.1 to 5.10* *Working in groups, students will predict which properties influence the motion of an oscillating spring and an oscillating pendulum. Students will share their predictions. (EU 3.B) (SP 6, 7)* Lab 14: *[Guided-Inquiry] Hooke's Law and oscillations. Students will design a two-part lab. In the first part, they will determine the relationship between a spring's restoring force, spring constant, and displacement. In the second part of the lab, students will examine the oscillation of the spring determining the period of the oscillation, the energy of the system, and the force and speed acting on the mass at various locations during the oscillation. (EU 3.B, 5.B) (SP 4, 5)* **[CR6b]** Students will compare and contrast a simple pendulum and a physical pendulum. (EU 3.B, 5.B) (SP 6, 7) Given potential energy graphs of an oscillation, students working in groups will qualitatively and quantitatively analyze the motion. Analysis will include determining frequency and period, identifying equilibrium, identifying the significance of minima and maxima, determining the force constant, determining values of force and acceleration, and determining kinetic energy and total energy. Results will be shared with another group and critiqued, and then both sets of results will be added to the lab book. (EU 3.B, 5.B) (SP 3) **[CR7]** *Lab 15: [Guided-Inquiry] Using a pendulum, students will design a lab to determine the strength of the gravity field on Earth. (EU 3.B, 5.A, 5.B) (SP 2, 3, 4, 5, 7)* **[CR6b]** Discuss gravity as a fundamental force, how it is represented as gravity field, and the relationship between the gravitational field and gravitational force. (EU 2.A, 2.B, 3.G) Compare and contrast inertial mass and gravitational mass. (EU 1.C) Diagram and compare the uniform gravitational field near Earth's surface with the radial field surrounding Earth. Determine the magnitude and direction of the gravity field and the gravitational force acting on a smaller mass inserted into the field. Investigate the effect of moving objects in each field. (EU 1.A, 1.C, 2.A, 2.B, 3.A, 3.B, 3.C) (SP 1, 2, 6, 7) Use the inverse square law to predict the magnitude of the gravity field at a specific location in space. (EU 2.B) Students will compare elliptical and circular orbits, listing Kepler's Laws, using conservation of angular momentum and/or energy to determine the orbiting

Course Sequence	Student Labs and Activities
	bodies speed in various parts of an elliptical orbit, and determine speed and escape speed in circular orbits. (EU 3.A, 5.A, 5.B, 5.E) Lab 16: Students will use the PhET simulation "My Solar System" to construct a planetary system consisting of a sun and a single planet. They will vary the radius and determine the speed required for uniform circular motion, and graph the data to calculate "G" for the PhET "universe." (EU 3.A, 5.A, 5.B, 5.E) (SP 1,2,4,5,6)

Unit 6: Mechanical Waves and Sound [CR2j]

Big Idea 6: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena.

Course Sequence	Student Labs and Activities

Medium
    Dependence on medium for mechanical waves, but not for electromagnetic waves
Mechanical waves
    Transverse waves
    Waves on a string
    Longitudinal waves
    Sound
Period and frequency
Wavelength
Amplitude
Interference
    Constructive
    Destructive
Superposition
Reflection
Standing waves
Sound specific
    Resonance
    Loudness
    Doppler effect
    Beats
	Read 11.1 to 11.9 and 12.1 to 12.7
	
	Students will see demonstrations of transverse and longitudinal waves. Working in groups, they will create a wave model explaining how independent oscillators act in characteristic patterns in order to transmit energy. Students will diagram each type of wave and label key elements such as equilibrium, wavelength, and amplitude. Particular attention will be focused on examining the direction of the oscillations as compared to the direction of energy transfer. Students will site real world examples of mechanical waves, such as strings and sound. (EU 1.A, 6.A, 6.B) (SP 1, 6, 7)
	
	Given a variety of interfering wave functions, students will add the waves pictorially to visualize wave superposition, noting areas of constructive and destructive interference. (EU 6.D) (SP 1)
	
	Students will see demonstrations of mechanical waves reflecting at a boundary between two mediums with differing densities. Students will diagram the types of reflections seen compared to the medium densities. Students will be given other scenarios involving mediums with differing densities and then will predict how each reflection will behave. (SP 1)
	
	Lab 17: Using an adjustable wave driver, students will generate standing waves in a string. In the first part of the lab, the medium will remain constant (constant string tension and length) while frequency is varied to identify the fundamental frequency and several harmonics. In the second phase of the lab, the tension will be varied to access the effect on frequency, wavelength, and wave speed of altering the medium. In the third phase, the affect of changing wave amplitude will be explored. Students will quantitatively determine period, frequency, wavelength and wave speed. Students will access the affect on wave energy due to changes in frequency, wavelength, and amplitude. (EU 6.A, 6.B, 6.D) (SP 4, 5)
	
	Students will describe how sound moves in a medium and how it transfers energy. Real world examples involving the relationship of energy to frequency, wavelength, and amplitude will be discussed. (EU 6.A, 6.B) (SP 1, 6)
	
	Students will diagram the waves associated with the fundamental frequency, 1st harmonic, 2nd harmonic, and 3rd harmonic for a string, an open tube, and a closed tube. The dependence of wavelength on the size of the region, as opposed to the frequency, will be discussed. Students will calculate wavelengths and frequencies associated with each wave form. (EU 6.D) (SP 1, 2, 6)

Course Sequence	**Student Labs and Activities**
	Lab 18: [Guided-Inquiry] Using a tube submerged in water, a set of tuning forks, and a meter stick, design an experiment to determine the speed of sound in air. (EU 6.B, 6.D) (SP 4, 5, 6, 7) ***[CR6b]*** *Given a series of wave front diagrams, showing sound waves emitted from a moving source, students will determine the direction of motion and qualitatively access the speed of the source compared to the speed of sound in air. (EU 6.B)(SP 1)* *Students will superimpose diagrams of two waves having different frequencies. The waves will be added graphically to demonstrate beats. (EU 6.D) (SP 1)*

Unit 7: Charge, Current, and Circuits [CR2h] [CR2i]

Big Idea 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.

Big Idea 3: The interactions of an object with other objects can be described by forces.

Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws.

Course Sequence	**Student Labs and Activities**
Charge Electric field Electric force Conductors and insulators Conservation of charge Charging Friction Conduction Induction Current Batteries and EMF Resistance Ohm's Law Power Kirchhoff's Laws DC resistor circuits	Read 16.1 to 16.6 and 18.1 to 18.7 and 19.1 to 19.4 Students will identify the atomic particles having the property of charge and list their characteristics, including the charge on an electron, proton, and neutron. (EU 1.B) (SP 6) The statement that charge is conserved and quantized will be analyzed, with students predicting its significance. Given a variety of charged objects/systems, students will characterize each as an object/system depending on given parameters. Students will discuss the meaning of net charge and determine the net charge for each object/system. (EU 1.A, 1.B) (SP 1, 7) Students will diagram and compare the uniform electric field between plates with the field surrounding spherical point charges. The direction of force on a point charge placed in each field will be diagrammed. Compare and contrast the electric field and force to the gravity field and gravitational force. Using Coulomb's Law, students will determine the magnitude of force between two point charges. (EU 3.C) (SP 1, 2, 7) Various objects will be charged and students will use the principle of conservation of charge to predict the resulting charge and the sign of the charge on each object. (EU 1.B, 5.A) (SP 6, 7) A model of electric current *in a simple circuit will be proposed and diagrammed. How emf and resistivity affect current will be modeled. Students will be asked to make analogies to real world systems that have similarities to electric circuits. (EU 1.A) (SP 1)* *Given a variety of data, students will select data relevant in determining the resistivity of a substance, and will determine and test the resistance in a length wire. (EU 1.E) (SP 2, 4)* Lab 19: Ohm's Law. Using a multi-meter, students will explore the relationships between emf, current, and resistance in a simple circuit. The rate that electric energy is consumed by the circuit will also be determined. (EU 5.B) (SP 5, 6)

Course Sequence	Student Labs and Activities
	Lab 20: Students construct one series and one parallel circuit involving the same three resistors. Measurements of potential, current, and resistance will be used to deduce Kirchhoff's Laws. The connections to conservation of charge and energy will be stressed. (EU 5.B) (SP 1, 6, 7) *Lab 21: Students will design their own circuit mixing series and parallel pathways. They will prepare a schematic of the circuit, and use Kirchhoff's laws to predict the current and potential drops across each resistor. Using a multi-meter, students will then confirm their predictions. (EU 5.C) (SP 2, 4, 5, 6)* Given a variety of circuit schematics, students will be able to determine the current, voltage drops, and power consumption in all components comprising the circuit. (EU 5.C) (SP 1, 2, 5)

In the three to four-week period between the AP Exam and year-end, the course work will be focused in two primary areas:

1. Continued instruction to prepare students who intend further course work in physics (graduating seniors planning to take physics in college and underclassmen intending to enroll in additional physics courses).

   Introduction to electric fields and electric force
   Introduction to electric potential and electric potential energy

2. Summary activities:

   Students are tasked with designing and testing an apparatus or a structure, similar to a Science Olympiad event. Some examples are bridges, catapults, etc. Rules and limitations regarding materials and dimensions are set (LO 1.C.1.1, 3.A.3.3, 3.B.1.2). Students are given the opportunity to test and refine their project. The finished products are then showcased in a competitive, yet friendly setting. **[CR3] [CR4]**