AP Physics 1

Course Overview

AP Physics 1, as described by the *College Board AP Physics 1 Course Overview*, “is an algebra-based, introductory college-level physics course that explores topics such as Newtonian mechanics (including rotational motion); work, energy, and power; mechanical waves and sound; and introductory, simple circuits. Through inquiry-based learning, students will develop scientific critical thinking and reasoning skills.” This is a junior and senior level course with no prerequisites. Since Juniors will be enrolled in either Algebra II or Pre-Calculus concurrently with the course, it is recommended that those in Algebra II have a past history of success in their math classes. Otherwise, waiting until the senior year may be preferred. However, students may still opt to take AP Physics 1, as long as they have completed Geometry and are currently in Algebra II or Pre-Calculus.

Class meets every day for 52 minutes for 180 days. The school year begins in September and ends in mid-June. At least 25% of the instructional time for the course will be doing hands-on laboratory work, with an emphasis on inquiry-based activities that provide students the chance to apply the science practices. Since block-timing is not possible with our school’s structure, lab activities may extend into a 2- day period. Pre-planning for an inquiry based lab may also be required outside of class time. Keeping a laboratory notebook will be required. In many instances, a flipped classroom approach may be used so that lecture can take place outside of the normal school day, and time in class can be devoted to lab exercises and exploring the content more deeply.

AP Physics 1 is based on six Big Ideas (The College Board, *AP Physics 1 Course Description,* Spring 2014):

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

Bid 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.

AP Physics 1 also incorporates the following science practices to ensure that students understand the principles of scientific inquiry. (The College Board, *AP Physics 1 Course Description,* Spring 2014):

1. Use representations and models to communicate scientific phenomena and solve scientific problems;
2. Use mathematics appropriately;

3. Engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course;
4. Plan and implement data collection strategies in relation to a particular scientific question;
5. Perform data analysis and evaluation of evidence;
6. Work with scientific explanations and theories; and
7. Connect and relate knowledge across various scales, concepts, and representations in and across domains.

Textbook

Knight, Randall D., Brian Jones, and Stuart Field. College *Physics: A Strategic Approach*, AP® Edition, 3rd ed. Boston: Pearson, 2015. ISBN: 978-0-13-353967-7

This text also allows students access to the e-text and the online Mastering Physics platform. This gives students access to video lectures and demonstrations, immediate feedback on problems, Socratic questioning and hints on problems when students struggle, and other student study review and preparation materials.

Supplemental Resources

O'Kuma, Thomas L., David P. Maloney, and Curtis J. Hieggelke. *Ranking Task Exercises in Physics*. Boston: Addison-Wesley Publishing, 2004.

Hieggelke, Curtis, David Maloney, and Stephen Kanim. *Newtonian Tasks Inspired by Physics Education Research: nTIPERs*. Upper Saddle River, NJ: Pearson, 2012.

Tracker. Douglas Brown. Video analysis and modeling software. Accessed March 11, 2014. http://www.cabrillo.edu/~dbrown/tracker

Grading

- Tests will represent 40% of the grade. Tests will be administered after each unit of material. Each test will consist of 3 sections:
  1. Multiple-choice questions
  2. Free-response problems
  3. Lab-based question that may include questions on labs done in class or questions regarding lab development or a lab that was not performed in class
- Labs will represent 30% of the grade. Most labs will be inquiry based so that students are given the objective and available equipment, and they will design their own procedure, data gathering, and data analysis.
- Problem Sets will represent 20% of the grade. This will include homework and class work problems. These may come from the Mastering Physics online assignments, AP Released Exams, Physlet® problems, Ranking Tasks, or nTIPERs.
- Reading quizzes and notes will represent 10% of the grade. Notes will be required for each chapter to be done at home, and reading quizzes will be conducted to ensure that students are gathering information on their own, rather than expecting the teacher to be the source of all information.

Course Outline

Unit 1: Kinematics in One and Two Dimensions (Chapters 1-3) (4.5 weeks)
- Big Idea (3)
- Topics:
  A. Vectors/Scalars
  B. One Dimensional Motion (including graphing position, velocity, and accelerations)
  C. Two Dimensional Motion

Unit 2: Dynamics/Newton's Laws of Motion (Chapters 4,5) (4.5 weeks)
- Big Ideas (1, 2, 3, and 4)
- Topics
  A. Newton's 3 Laws of Motion
  B. Friction
  C. Interacting Objects (ropes and pulleys)

Unit 3: Gravitation and Circular Motion (Chapter 6) (2 weeks)
- Big Ideas (1, 2, 3, and 4)
- Topics
  A. Circular Motion
  B. Newton's Law of Universal Gravitation

Unit 4: Impulse, Linear Momentum, and Conservation of Momentum (Chapter 9) (3 weeks)
- Big Ideas (3, 4, and 5)
- Topics
  A. Impulse
  B. Momentum
  C. The Law of Conservation of Linear Momentum in Collisions

Unit 5: Work and the Conservation of Energy (Chapter 10) (4 weeks)
- Big Ideas (3, 4, and 5)
- Topics
  A. Work
  B. Energy
  C. Conservation of Energy
  D. Power

Unit 6: Simple Harmonic Motion (Chapter 8.3 and Chapter 14) (2 weeks)
- Big Ideas (3 and 5)
- Topics
  A. Simple Pendulums
  B. Mass-Spring Oscillators

Unit 7: Torque and Rotational Motion (Chapter 7, 8, and 9.7) (3.5 weeks)
- Big Ideas (3, 4, and 5)
- Topics
  A. Rotational Kinematics and Energy
  B. Torque
  C. Rotational Dynamics
  D. Angular Momentum
  E. Conservation of Angular Momentum

Unit 8: Mechanical Waves and Sound (Chapters 15 and 16) (2.5 weeks)

- Big Idea (6)
- Topics
  A. Mechanical Waves
  B. Sound
  C. Superposition Principle

Unit 9: Electrostatics and Simple DC Circuits (Chapter 20, 22, 23) (3 weeks)

- Big Ideas (1, 3, and 5)
- Topics
  A. Electric Charge and Conservation of Electric Charge
  B. Electrostatic Forces
  C. Introduction to Current, Potential Difference, and Resistance
  D. Analyzing Simple, Series and Parallel Circuits using Ohm's law and Kirchhoff's laws

Lab Activities

Labs will be a combination of hands-on labs with the occasional lab relying on a simulation, such as PhET. Many labs will be student-directed and open-ended, although some will be more teacher-directed. For a teacher-directed lab, procedures will be provided. For open-ended or inquiry labs, students will create their own experimental design and determine the most appropriate way to analyze and present their data. After these labs, students will have the opportunity to present their results to their peers and defend their results. They will then evaluate one other group's approach to the problem and offer a critique of their procedure and results.

Students will work in lab groups, but each student will submit a lab report in their lab notebook. This notebook will be kept for the entire year and will include the completed lab report as well as raw data, tables, and notes. Each lab report will include the following:

- Title
- Statement of the problem/Objective
- Hypothesis
- Outline of the procedure/equipment needed (if applicable)
- Data collected from the experiment
- Data analysis (calculations/graphs)
- Conclusion with an error analysis
- Peer review (if included in the lab activity)

Laboratory activities and simulations are included in the following table. The 7 science practices are also referenced.

Name	Inquiry Lab? O = Open G = Guided	Short Description	Science Practices
Unit 1: Kinematics in One and Two Dimensions			
Car Velocity Lab	N	Determine the velocity and acceleration of a toy car.	1.4, 2.1, 2.2, 3.3, 4.1, 5.1, 6.2
Initial Vertical Velocity	Y (O)	Determine the initial vertical velocity of a popper toy.	1.2, 1.4, 2.1, 2.2, 4.1, 4.2, 4.3
Reaction Time	Y (O)	Create a procedure to determine reaction time.	4.2, 1.1, 4.1, 4.3, 5.1, 5.3
Free Fall Investigation	N	Use a motion detector to determine the value of *g*.	1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2
Projectile Motion Lab	Y (G)	Determine the landing location of a ball launched at an angle from a table.	1.1, 1.4, 2.1, 2.2, 3.3, 5.1, 6.1
Unit 2: Dynamics/Newton's Laws of Motion			
Force Table and Vectors	N	Determine missing forces to produce translational equilibrium.	1.4, 2.1, 2.2, 3.3, 5.1, 5.2, 6.2
Terminal Velocity	Y (G)	Use a motion detector to determine the terminal velocity of a coffee filter.	1.2, 1.4, 2.1, 2.2, 3.3, 4.1, 4.2, 4.3, 6.2, 6.4
Forces Inventory	Y (G)	Perform a qualitative and quantitative investigation on a variety of interactions between objects.	1.1, 1.4, 1.5, 2.1, 2.2, 3.3, 4.1, 4.2, 4.3, 5.1, 6.1, 6.2, 6.4, 7.2
Newton's 2nd Law	Y (G)	Investigate the relationship between an object's net force, its inertial mass, and its acceleration.	4.2, 1.1, 4.1, 4.3, 5.1, 5.3
Friction	Y (O)	What is the relationship between friction force, normal force, and coefficient of friction?	1.4, 2.2, 3.3, 4.1, 4.2, 4.3, 4.4, 5.1, 5.3, 6.1, 6.2, 7.1
At wood's Machine	N	Determine the formula for the acceleration of a simple Atwood's machine.	1.4, 2.1, 2.2, 3.3, 5.1, 5.2, 6.2
Unit 3: Gravitation and Circular Motion			
When Pigs Fly	Y (G)	Investigate the tension in a string attached to an object moving in a circle as well as the centripetal force.	2.1, 2.2, 2.3, 3.3, , 4.3, 5.1, 6.2, 7.1, 7.2
Circular Motion	N	Determine the relationship between linear and centripetal force.	1.1, 1.4, 2.1, 2.2, 3.3., 4.1, 4.2, 4.3, 5.1, 6.1, 6.2, 6.4
Gravity Force Lab	Y (G)	Use of the PhET simulation to determine the relationships involved in gravitational force and the	1.2, 1.4, 2.2, 2.3, 5.1, 6.1, 6.2

		magnitude of the universal gravitational constant.	
My Solar System	Y (G)	Use of the PhET simulation to investigate how a planet's mass, velocity, and distance from a star are related to the planet's orbit.	1.2, 1.4, 2.2, 2.3, 5.1, 6.1, 6.2
Unit 4: Impulse, Momentum, and Conservation of Momentum			
Conservation of Momentum	Y (G)	Use conservation of momentum to find the initial speed of a dart.	2.2, 3.1, 4.1, 4.3, 4.4, 5.1, 6.1, 6.4, 7.2
Conservation of Momentum in 2D	N	Determine if momentum is conserved in more than one direction.	1.4, 1.5, 2.1, 2.2, 4.3, 4.4, 6.1, 6.4, 7.2
Impulse and Change in Momentum	Y (G)	Measure the change in momentum of a dynamics cart and compare it to the impulse received.	1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.4, 7.2
Unit 5: Work and the Conservation of Energy			
Conservation of Energy	Y (G)	Experiment with the concept of conservation of energy qualitatively investigating the relationship between elastic potential energy and gravitational potential energy.	2.2, 3.1, 4.1, 4.3, 4.4, 5.1, 6.1, 6.4, 7.2
Work done by a Force	N	Determine how force, distance travelled, and time affect work done on an object.	1.4, 1.5, 2.1, 2.2, 4.3, 4.4, 6.1, 6.4, 7.2
Force vs. Displacement Graphs	Y (O)	Construct simple F vs .d graphs using spring scales and rubber bands and summarize the significance of the area under the curve.	1.1, 1.5, 4.2, 4.3, 5.1, 5.2
<u>Real World Application:</u> Tire Manufacturing Investigation	Y (G)	Determine the coefficient of kinetic friction between the tires of a car (represented with a tissue box) and the road (represented by the table.)	2.1, 2.2, 2.3, 3.2, 3.3, 4.1, 4.2, 4.3, 5.2, 6.1, 7.1, 7.2
Unit 6: Simple Harmonic Motion			
Pendulum Properties	Y (O)	Determine what factors affect the period of a pendulum.	1.1, 2.1, 2.2, 3.1, 4.1, 4.2, 5.1, 5.2, 6.1, 6.2, 7.2
Mass-Spring Oscillator Lab	Y (O)	Determine the spring constant of a spring and the mass of three unknown masses.	1.1, 1.4, 2.1, 2.2, 3.3, 4.1, 4.2, 4.3, 4.4, 5.1, 6.1, 6.2, 6.4
Pendulum length on alternate planet	Y (G)	Given a long pendulum, determine the required length the pendulum would have on a different planet in order to have the exact same period.	2.1, 2.2, 2.3 4.2
Unit 7: Torque and Rotational Motion			
Rotational Equilibrium	Y (G)	Determine the reading of a force scale attached to a horizontal meter stick with a mass attached.	1.1, 2.1, 2.3, 5.2

Lever Lab	N	Determine how the concept of torque related to different types of levers.	1.4, 1.5, 2.1, 2.2, 4.3, 4.4, 6.1, 6.4, 7.2
Conservation of Energy – Rotation	N	Determine how rotational inertia for various shaped objects affects the speed of rolling objects at the bottom of an incline.	1.1, 1.4, 2.1, 2.2, 3.3, 4.1, 4.2, 4.3, 4.4, 5.1, 6.1, 6.2, 6.4
Lady Bugs	Y (G)	Discover the basics of rotational kinematics using the “Lady Bug: Angular Kinematics” and “Ladybug Revolution” PhET simulations.	1.2, 1.4, 2.2, 2.3, 5.1, 6.1, 6.2
Unit8: Mechanical Waves and Sound			
Speed of sound	Y (G)	Determine the speed of sound in a resonance tube.	1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 5.1, 5.2, 6.1, 6.2, 7.2
Speed of a pulse wave	Y (O)	Use a spring toy to test whether frequency, wavelength, and amplitude affect the speed of a pulse wave.	1.2, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.2, 6.4, 7.2
Wave boundary behavior	Y (O)	Compare what happens when a spring toy pulse is reflected from various types of boundaries.	1.4, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 6.4, 7.2
Unit 9: Electrostatics and Simple Circuits			
Static Electricity Interactions	Y (G)	Use sticky tape and a variety of objects to make qualitative observations of the interactions when objects are charged, discharged, and recharged.	1.2, 3.1, 4.1, 4.2, 5.1, 6.2, 7.2
Brightness Investigation	Y (G)	Make predictions about the brightness of light bulbs in a variety of series and parallel circuits when some bulbs are removed.	1.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2
Series and Parallel Circuits	Y (G)	Investigate the behavior of resistors in series and parallel and complex circuits, including measurements of voltage and current.	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.4, 7.2

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, students will 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. Students will 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)

Learning Objective 1.A.5.1

The student is able to model verbally and visually the properties of a system based on its substructure and to relate this to changes in the system properties over time as external variables are changed.

Learning Objective 3.A.4.3

The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces.
Learning Objective 3.B.1.1
The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations with acceleration in one dimension.

Scientific Argumentation:

In the course, students become familiar with the three components of scientific argumentation. The first element is the claim, which is the response to a prediction. A claim provides an explanation for why or how something happens in a laboratory investigation. The second component is the evidence, which supports the claim and consists of the analysis of the data collected during the investigation. The third component consists of questioning, in which students examine and defend one another's claims. Students receive explicit instruction in posing meaningful questions that include questions of clarification, questions that probe assumptions, and questions that probe implications and consequences. As a result of the scientific argumentation process, students are able to revise their claims and make revisions as appropriate. The following is an example activity in which students will engage in the process of scientific argumentation:

Laboratory Investigation – Speed of Sound

Description: Working in small groups, students design two different procedures to determine the speed of sound in air. They brainstorm their approaches and write them on the whiteboard. Each of the teams presents their ideas to the class. They receive feedback from their peers and then conduct their experiments. They record the revised procedures in their lab journals. During the post-lab discussion, the students discuss their results (evidence) by examining and defending on e another's claims. Then as a class we reach consensus about the estimated value for the speed of sound.
Learning Objective 6.A.2.1
The student is able to describe sound in terms of transfer of energy and momentum in a medium and relate the concepts to everyday examples.
Learning Objective 6.A.4.1
The student is able to explain and/or predict qualitatively how the energy carried by a sound wave relates to the amplitude of the wave, and/or apply this concept to a real-world example.
Learning Objective 6.B.4.1
The student is able to design an experiment to determine the relationship between periodic wave speed, wavelength, and frequency, and relate these concepts to everyday examples.

Real World Physics Solutions:

In order for students to become scientifically literate citizens, students are required to use their knowledge of physics while looking at a real world problem. Students may pick from one of the following solutions:

- Students will pick a Hollywood movie and will point out three (or more) instances of bad physics. They will present this information to the class, describing the inaccuracies both qualitatively and quantitatively.
- Students will research a thrill tide at an amusement park. They will present the information to the class on the safety features of the ride, and why are in place.
- Students will present information to the class on noise pollution, and its danger to both human and animal life. They will also propose solutions to noise pollution problems.

- Students will go the insurance institute of highway safety website (iihs.org) and will look at the safest cars in a crash. They will present information as to why these cars are safer and how the safety features keep people safe.