# AP Physics 1 Syllabus

**Class Meeting Time**: Four 45 minutes periods and one 90 minute period per week.

AP Physics 1 is an algebra-based college-level introductory physics course. General physics topics presented during the course closely follow those outlined by the College Board and are 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.

The structure of the course is designed to allow students to discover and master these big ideas on their own as much as possible. To facilitate this more than 25% of the course is devoted to laboratory experiments and other student centered activities. In these activities students are typically expected to design a procedure and collect data to determine the relationship between variables and/or to derive a physics equation. Students will be expected to carefully collect and organize data, to use the collected data to reach a scientific conclusion and to perform an experimental error analysis during the lab experiments. Students are required to keep laboratory notes for each experiment and will have to write formal lab reports and present their findings to their peers for review for some experiments.

Besides the laboratory work the course will consistently include other types of activities. A normal week in the course consists of one or two teacher-centered instructional periods, two or three student-centered instructional periods and the extended lab period. The teacher-centered instructional periods typically begin with a demonstration or video clip that students are asked to interpret through guided inquiry. This is followed by a presentation of new material pertaining to the demonstration or video clip and the period finishes with a problem solving session based on any new equations related to the material. The student-centered periods typically consist of either a collaborative problem solving session using a released AP exam question that students will work on in small groups or a short experiment/ simulation based activity that students will use to explore fundamental concepts.

Each unit in the AP Physics 1 course will follow the same outline. It will begin with the presentation of a pre-test problem that will be used to initiate discussion of the topics included in the unit and to check for prior knowledge and misconceptions students may have. The pre-test problem will not be collected until the end of the unit and students will be encouraged to work on it over the course of the unit as they learn new material. Each unit will also have an associated problem set that will be available on-line while the unit is being covered. These problems will stress basic equation manipulation and are set up so that students can retry the problem set as many times as they wish as the software will generate new numbers for each attempt. This is meant to develop mastery of the math skills required for the unit. About halfway through the unit a multiple choice quiz will be administered to check student understanding of concepts and equations covered to that point. At the end of each unit there will be a two part exam. The first part will be an in-class collaborative free response question that students will have one period to complete. The question will be based on a released AP question and will serve as both part of the exam grade for the unit and as a final review before the individual assessment, which will be given on the following day. The individual section of the exam will consist of two or three free response topics that stress the main concepts of the unit.

**Grading System**:

AP Physics 1 students are evaluated using a hybrid grading system. Fifty points of the marking period grade will be standards based. Students are expected to demonstrate mastery of ten identified standards over the course of the marking period through a variety of assessments. The standards reflect fundamental physics principles (for example "Apply conservation laws to situations involving energy") and sound scientific practices (for example "Perform data analysis and evaluation of evidence"). Students will have multiple opportunities to show mastery of each standard and must have demonstrated continued mastery of every standard to receive the fifty points.

The other fifty points of the marking period grade will be based on traditional assessments according to the following distribution:

25 points – Unit exams and lab presentations
15 points – Laboratory work (Including reports and notebooks)
10 points – Quizzes, problem sets and pre-tests

**Primary Text**:

Urone, Paul Peter., Roger Hinrichs, Kim Dirks, and Manjula Sharma. College Physics. Houston, TX: OpenStax College, Rice University, 2013.

**Secondary Text (Classroom set)**:

Serway, Raymond A., Robert J. Beichner, and John W. Jewett. Physics for Scientists and Engineers. 5th ed.

Pacific Grove, CA: Brooks/Cole, 2000.

**Additional Resources**:

Lewin, Walter. 8.01 Physics I: Classical Mechanics, Fall 1999. MIT OpenCourseWare: Massachusetts Institute of Technology. < http://ocw.mit.edu>

Lewin, Walter, John Belcher, and Peter Dourmashkin. 8.02SC Physics II: Electricity and Magnetism, Fall 2010. MIT OpenCourseWare: Massachusetts Institute of Technology. < http://ocw.mit.edu>

Mavalvala, Nergis, Walter Lewin, and Wolfgang Ketterle. 8.03 Physics III: Vibrations and Waves, Fall 2004. MIT OpenCourseWare: Massachusetts Institute of Technology. < http://ocw.mit.edu>

MIT Department of Physics Technical Services Group. RES.8-003 Physics Demonstration Videos, Spring 2012 MIT OpenCourseWare: Massachusetts Institute of Technology. < http://ocw.mit.edu>

"PhET: Free Online Physics, Chemistry, Biology, Earth Science and Math Simulations." PhET Project: University of Colorado. <http://phet.colorado.edu/>.

## Course Outline and Correlation to Big Ideas

| Unit | BI 1 | BI 2 | BI 3 | BI 4 | BI 5 | BI 6 |
|---|---|---|---|---|---|---|
| **Math and Lab Techniques** | ✓ | | | ✓ | | |
| • Significant Digits<br>• Absolute and Relative Error<br>• Sources of Uncertainty vs. Avoidable Errors<br>• Scientific Method and Engineering Process<br>• Graphing Data | | | | | | |
| **Dynamics and Statics** | ✓ | ✓ | ✓ | ✓ | | |
| • Forces and Free Body Diagrams<br>• Newton's Laws of Motion<br>• Vectors and Vector Math<br>• Friction<br>• Torque<br>• Mechanical Equilibrium | | | | | | |
| **Kinematics** | ✓ | | ✓ | ✓ | | |
| • Definitions of Kinematic Terms<br>• Equations for Linear Motion with Constant Acceleration<br>• Graphs of Linear Motion<br>• Motion on a Ramp<br>• Projectile Motion | | | | | | |
| **Momentum, Work and Energy** | ✓ | | ✓ | ✓ | ✓ | |
| • Momentum and Types of Collisions<br>• Impulse<br>• Center of Mass<br>• Work and Power<br>• Mechanical Energy<br>• Conservation of Energy and the Work-Energy Theorem | | | | | | |
| **Rotational Dynamics and Kinematics** | ✓ | ✓ | ✓ | ✓ | ✓ | |
| • Centripetal Force and Acceleration<br>• Angular Velocity and Acceleration<br>• Rotational Form of Newton's 2nd Law<br>• Rotational Kinematics and Dynamics<br>• Rotational Energy<br>• Angular Momentum<br>• Newton's Law of Gravitation<br>• Kepler's Laws | | | | | | |
| **Simple Harmonic Motion, Waves and Sound** | ✓ | | ✓ | ✓ | ✓ | ✓ |
| • Simple Harmonic Motion Definitions<br>• Mass and Spring and Pendulum<br>• Energy and Simple Harmonic Motion<br>• General Wave Terms and Equations<br>• Wave Speed Equation<br>• Refraction, Reflection and Diffraction<br>• Superposition and Interference<br>• Sound: Loudness and Pitch<br>• Standing Waves and Harmonics | | | | | | |

| Unit | BI 1 | BI 2 | BI 3 | BI 4 | BI 5 | BI 6 |
|---|---|---|---|---|---|---|
| **Electrostatics and DC Circuits** | ✓ | ✓ | ✓ | ✓ | ✓ | |
| • Atomic Structure and Charge<br>• Methods of Electrostatic Charging<br>• Conservation of Charge<br>• Coulomb's Law<br>• Current and Potential Difference<br>• Ohm's Law and Resistance<br>• Series and Parallel Resistors<br>• Kirchhoff's Rules | | | | | | |
| **Capstone Projects** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| • Engineering Projects<br>Students will design, construct and test model structures (towers, bridges, etc.) to meet given criteria and demonstrate real world applications of physics concepts. Students will present a "bid" at the end of the project as if they were attempting to win a contract to build a real structure.<br>• Research And Presentation<br>Students will investigate topics of interest to them (sports, movies, technology, etc.) from a physics standpoint and present the results to their peers. Topics should stress the application of physics principles, theories, or models to everyday situations, phenomena, or experiences found outside of the classroom. | | | | | | |

## Lab Experiments and Activities

Experiments and activities are classified according to the following categories:

- Teacher Directed (**TD**): Short activities in which students follow given instructions to collect data and reach a conclusion
- Guided Inquiry (**GI**): An experiment in which students are given a problem statement or objective and are required to create a procedure to reach a conclusion
- Computer-based Inquiry (**CBI**): Activity in which students use a computer simulation to collect data and reach a conclusion
- Open Inquiry (**OI**): Experiment in which students are responsible for the entire process of creating a hypothesis and testing it with the teacher only acting as a consultant

| **Experiment/Activity** | **Type** | | | |
|---|---|---|---|---|
| | **TD** | **GI** | **CBI** | **OI** |
| **Mass of a washer** – Students will learn about absolute error and relative error as they determine the average mass of a washer | | ✓ | | |
| **Galileo's Experiment (Part 1)** – Students will examine the motion of a ball down a ramp to graph its displacement vs. time | | ✓ | | |
| **Paper Tower Challenge** – Students will construct a paper tower (using the engineering process) to meet given criteria | | ✓ | | |
| **Galileo's Experiment (Part 2)** – Students will learn to use video analysis software and compare data collected from it to previously collected data | ✓ | | | |
| **Graphing 1: Extrapolation and Interpolation** – Students will collect data using pull back cars and then make predictions based on their results | ✓ | | | |
| **Force Table** – Students will establish an equilibrium between three forces and then calculate the net force to see if it matches the conditions for mechanical equilibrium | | ✓ | | |
| **Force in a Collision** – Students will determine the force on each cart involved in a collision | | ✓ | | |
| **Friction** – Students will use Newton's Laws to investigate friction in a variety of situations | | | | ✓ |
| **Suspension Bridge** – Students will use the conditions of mechanical equilibrium to determine two unknown weights placed on a "suspension bridge". | | ✓ | | |
| **Balloon Rockets** – Students will construct a balloon powered rocket and analyze the motion in terms of fundamental physics concepts. | | ✓ | | |
| **Graphing 2: Displacement vs. time for constant speed** – Students will examine the motion of battery powered cars to determine if the motion is truly constant speed | | ✓ | | |
| **Galileo's Experiment (Part 3)** – Students will examine the motion of a ball using dynamics and kinematics | | | | ✓ |
| **Free Fall** – Students will calculate the local acceleration due to gravity | | ✓ | | |
| **Horizontally Launched Projectiles**- Students will examine the motion of a horizontally launched projectile and use their data to attempt to hit a target | | ✓ | | |
| **Projectile Range and Maximum Height** – Students will use video analysis to examine actual versus theoretical values of projectile range and height | | ✓ | | |
| **Conservation of Momentum** – Students will examine an inelastic collision using video analysis to determine if momentum is conserved | | ✓ | | |
| **Energy Conservation: Ball Drop** – Students will examine the mechanical energy of a ball to reach a conclusion about conservation of energy | | ✓ | | |

| Experiment/Activity | Type | | | |
|---|---|---|---|---|
| | TD | GI | CBI | OI |
| **Energy and Motion on a Ramp** – Students will examine the motion of different objects on a ramp in terms of energy | | | ✓ | |
| **Egg Drop** – Students will design a "vehicle" using the engineering process that will protect an egg when dropped from various heights. Students will be then be asked to connect aspects of their designs to real world examples (air bags and seatbelts in cars for example) and to present their results to their peers for review and critique. | | | | ✓ |
| **Atwood Machine** – Students will examine the correlation of mass ratio and mass difference to the angular acceleration of an Atwood Machine | | ✓ | | |
| **Centripetal Force** – Students will determine the effect of angular speed, mass and radius on centripetal force | | | ✓ | |
| **Moment of Inertia** – Student will use rotational dynamics to determine the moment of inertia of an object | | ✓ | | |
| **Rotational Kinetic Energy** – Students revisit the mechanical energy of a ball rolling down a ramp | | ✓ | | |
| **Gravitational Constant** – Students will determine the value of G | | | ✓ | |
| **Kepler's Third Law** – Students will collect data to verify Kepler's Third Law | | | ✓ | |
| **Hooke's Law** – Students determine a spring constant using Hooke's Law | ✓ | | | |
| **Pendulum Period** – Students examine the variables that affect the period of a pendulum | | | | ✓ |
| **Spring Constant** – Students determine a spring constant by using simple harmonic motion | | ✓ | | |
| **Standing Waves** – Students will examine the effect of string length and tension on the frequency of the second harmonic of a string fixed at both ends | | ✓ | | |
| **End Correction** – Students will determine the end correction factor for a pipe open at both ends | | ✓ | | |
| **Soda Bottle Music** – Students will examine the frequencies produced as the amount of water in a bottle is varied | | | | ✓ |
| **Electrostatics** - Students will determine the charge on various objects through observation | ✓ | | | |
| **Coulomb's Law** – Students will collect data and use it to derive Coulomb's Law for the electrostatic force | | | ✓ | |
| **Ionic Conductors and Resistance** – Students will examine the effect of length and diameter on the resistance of a Play-Doh conductor | | ✓ | | |
| **Ohm's Law** – Students will examine the relationship between voltage, current and resistance | | | | ✓ |
| **Circuit Design** – Students will design a circuit to meet the given criteria and then analyze the circuit in terms of Kirchhoff's Rules | | ✓ | | |

## Readings and Suggested Problems

Solutions to all the suggested problems are found in the student solution manual.

| **Math and Lab Techniques** | |
|---|---|
| Readings | Suggested Problems |
| Chapter 1 | Ch 1: 21, 27 |
| **Dynamics and Statics** | |
| Readings | Suggested Problems |
| Chapter 4 | Ch 4: 7, 13, 30 |
| Chapter 9 | Ch 9: 1, 14, 32 |
| Chapter 5 section 1 | Ch 5: 8, 14 |
| **Kinematics** | |
| Readings | Suggested Problems |
| Chapter 2 | Ch 2: 14, 21, 41, 47 |
| Chapter 3 | Ch 3: 19, 30, 40, 46 |
| **Momentum, Work and Energy** | |
| Readings | Suggested Problems |
| Chapter 7 | Ch 7: 1, 7, 13, 16, 36, 42 |
| Chapter 8 | Ch 8: 1, 15, 23, 38, 44 |
| **Rotational Dynamics and Kinematics** | |
| Readings | Suggested Problems |
| Chapter 6 | Ch 6: 1, 7, 18, 26, 33, 45 |
| Chapter 10 | Ch 10: 3, 16, 24, 36 |
| **Simple Harmonic Motion, Waves and Sound** | |
| Readings | Suggested Problems |
| Chapter 16 | Ch 16: 2, 7, 15, 30, 36, 50, 62, 71 |
| Chapter 17 | Ch 17: 7, 45 |
| **Electrostatics and DC Circuits** | |
| Readings | Suggested Problems |
| Chapter 18 sections 1 – 3 | Ch 18: 1, 13, 25 |
| Chapter 20 | Ch 20: 1, 19, 31, 65 |
| Chapter 21 sections 1 - 4 | Ch 21: 1, 31, 37 |