AP® Physics C—Mechanics
Syllabus 1

Overview of AP® Physics

Any student who has completed a year of physics and either has completed one term of calculus or will be concurrently enrolled in calculus may register for an AP® Physics C: Mechanics course. While students who completed the qualitative introductory course have generally been at a disadvantage, we recently created accelerated sections in that class to better prepare students for advanced coursework.

Textbooks

We use *Physics for Scientists and Engineers* by Raymond Serway for mechanics. Serway is a traditional calculus-level textbook with derivations, examples, and a great selection of problems to solve.

Schedule

Laboratory experiments are interspersed throughout the course where they are appropriate for the subjects we are studying. On average, we spend one period per week performing an experiment. Tests come once every two to three weeks, generally covering more than one topic.

In the term, classes meet three times a week for 50 minutes and once a week for 105 minutes. While we don't always do experiments in the long period, it is nice to have for those times when we want to do an extended experiment. **[C9]**

C9—The course includes a laboratory component comparable to a semester long, college-level physics laboratory. Students spend a minimum of 20 percent instructional time engaged in laboratory work. A hands-on laboratory component is required. Each student should complete a lab notebook or portfolio of lab reports. Note: Online course providers utilizing virtual labs(simulations rather than hands-on) should submit their laboratory materialsfor the audit. If these lab materials are determined to develop the skills and learning objectives of hands-on labs, then courses that use these labs may receive authorization to use the "AP" designation. Online science courses authorized to use the "AP" designation will be posted on the AP Central® Web site.

Course Design, Objectives, and Strategies

Our goal in the AP Physics courses is to provide an excellent first-year college-level calculus-based physics education. **[C8]**

C8—Introductory differential and integral calculus is used throughout the course.

Students coming out of the courses should have a strong conceptual understanding of physics and well-developed skills in performing and analyzing laboratory experiments. They should also be able to apply their understanding to approach and solve problems that are essentially new to them. **[C7]**

C7—The course utilizes guided inquiry and student-centered learning to foster the development of critical thinking skills.

Organization Around Experiments

The course is organized around experiments, rather than physics topics. Each experiment incorporates several aspects of physics, so students don't see them as isolated examples of particular concepts. Instead, they learn to look at a physical situation and see how it involves principles of dynamics, kinematics, energy, etc. While this is not the best way to introduce a new powerful concept, such as energy conservation, our students are already familiar with the basic tools of physics. We don't want to simplify our experiments to highlight a particular concept in order to make it clear. Instead, we want our students to deepen their understanding and be able to pick out familiar concepts from more complicated (and realistic) situations. **[C7]** Early in the course, we use experiments to introduce new topics, such as air resistance and rotation. After seeing new phenomena in the lab, there is motivation to explore them in class through demonstrations and theory.

C7—The course utilizes guided inquiry and student-centered learning to foster the development of critical thinking skills.

Since each experiment involves several aspects of physics, our classroom discussions and homework assignments must mirror that *spiraling* approach. For example, we never have a unit or a test that covers energy specifically. Instead, we cover bits and pieces of energy when appropriate. It is easy to find problems in the text that require students to work with just those bits and pieces. Eventually, students are able to handle any problem involving energy. What is more important is that they learn to recognize how energy is involved in any situation and they learn when it is the best approach to solving a problem. Free-response questions from past AP Exams are great resources for us. When students do a problem from the energy chapter in a book, they have been given a huge hint that energy is the best approach to the problem. The AP free-response questions (FRQs) rarely give such a hint, so students need to learn to recognize good approaches. Additionally, most AP FRQs have several parts requiring different techniques, perfect for our spiraling approach. In fact, some of our experiments are modeled after past AP FRQs.

Whiteboard Problem Solving

Another technique we have developed and used with great success is *whiteboard* problem solving. When solving problems in class, rather than having each student solve it in his or her own notebook, we give each pair of students a whiteboard (about 1m x .7m) and a dry erase marker. Because they have only one marker, they must communicate effectively with each other to work through the problem. The teacher can see their work clearly and offer suggestions when appropriate. When they are done, one pair of students presents their solution. We emphasize clarity of the written work as well as the oral presentation. Attention to clarity is critical in developing good problem-solving skills. **[C7]**

Labs and Syllabus

Many of our experiments are technology-intensive. Students use VideoPoint and Vernier Universal Lab Interface for data collection and Microsoft Excel for analysis. Early on, students learn to develop models on a spreadsheet and graph the predictions alongside the actual data. The numerical integration involved in these models is a key to their understanding and success throughout the course. Excel also makes least square error analysis convenient. Students are required to keep all lab data, calculations, etc., in a lab notebook.

Fall Term

Mechanics labs strongly dictate the introduction of topics.

Weeks 1–3

Projectile Video. Students learn to use VideoPoint as they analyze a movie of a projectile. **[C1]** The movie is made with the camera (secretly) tilted.

C1—Kinematics

Falling Coffee Filters. A short stack of coffee filters is dropped onto a motion detector in order to introduce air resistance as a force that contributes to acceleration **[C2]** and spreadsheet modeling.

C2—Newton's laws of motion

Moon Shot. Students use Excel to model a rocket's trip from earth to the moon and explore Newton's laws. They learn about superposition of forces, orbits and circular motion, universal gravitation, **[C2] [C5] [C6]** and the basics of rocket propulsion. Euler's Method makes the predictions more accurate.

C5—Circular motion and rotation

C6—Oscillations and gravitation

Weeks 4–5

Spring Oscillator. The lab interface is used to collect data on **[C6]** a damped and undamped mass bouncing on a spring. The analysis involves varying forces and energy.

Double Spring Lab. A cart is attached to two angled springs that accelerate it to some maximum speed. Students learn about work, energy, and power; integration is introduced in class. **[C3]**

C3—Work, energy, and power

Test

Weeks 6–8

Ball in Cup. Students predict the landing position of a ball that rolls down a hill and gets launched horizontally. Rolling energy is encountered for the first time. **[C3]** Students also learn about propagation of error in this experiment.

Inertia Machine. A mass is attached to a string and hung over a pulley. The string pulls on the axle of a rotating device with an adjustable moment of inertia. Rotational dynamics is introduced. **[C4] [C5]**

Ruler Drop. A video is made of a ruler pivoted about its end as it falls from horizontal, allowing measurement of linear acceleration **[C1]** of various points to relate them to angular acceleration.

Bicycle Wheel Lab. A wheel with a rope wrapped around its perimeter (and tied to the ceiling) is dropped. Linear and angular accelerations are explored. Once the moment of inertia is found, the same wheel is used with a fixed axis and accelerated by a rope attached to a hanging mass. This series of experiments introduces most topics in angular dynamics and kinematics. **[C1] [C5]**

C1—Kinematics

Test

Weeks 9–11

Falling Chain Lab. A chain falls into a cup attached to a force sensor. Students learn about impulse and change in momentum. **[C4]**

C4—Systems of particles, linear momentum

Exploding Carts. A rigid frame made of meter sticks is attached to rolling carts. Two carts within it pop apart and stick to the frame, the first pushing it one way, the second stopping it. Students learn about conservation of momentum **[C4]** and center of mass through predicting the stopping point of this complicated system.

Pendulum Bash. A pivoted ruler falls from horizontal and strikes a ball. This involves energy conservation and linear momentum; it introduces angular momentum. **[C3] [C4] [C5]**

C4—Systems of particles, linear momentum

Test

Weeks 11–14

Rotating Accelerometer. A liquid accelerometer is placed on a turntable and rotated. Analysis of the shape of the water surface in this video applies concepts of circular motion. **[C5]**

C5—Circular motion and rotation

SkyLab Video and Gyroscopes. Students are introduced to the vector aspects of angular momentum through measurement of precessional frequencies. Conservation of momentum is also discussed.

Orbit Simulations. Students use Interactive Physics (Knowledge Revolution) to explore Universal Gravitation and orbits. **[C6]**

C6—Oscillations and gravitation

Test