AP® Physics C: Mechanics: Syllabus 3

Syllabus 1058825v1

Scoring Components		Page(s)
SC1	The course covers Newtonian mechanics in depth and provides instruction in kinematics.	3
SC2	The course covers Newtonian mechanics in depth and provides instruction in Newton's laws of motion.	3
SC3	The course covers Newtonian mechanics in depth and provides instruction in work.	3
SC4	The course covers Newtonian mechanics in depth and provides instruction in energy.	3
SC5	The course covers Newtonian mechanics in depth and provides instruction in power.	3
SC6	The course covers Newtonian mechanics in depth and provides instruction in systems of particles.	3
SC7	The course covers Newtonian mechanics in depth and provides instruction in linear momentum.	3
SC8	The course covers Newtonian mechanics in depth and provides instruction in circular motion.	4
SC9	The course covers Newtonian mechanics in depth and provides instruction in rotation.	4
SC10	The course covers Newtonian mechanics in depth and provides instruction in oscillations.	4
SC11	The course covers Newtonian mechanics in depth and provides instruction in gravitation.	4
SC12	Introductory differential and integral calculus are used throughout the course.	2
SC13	The course utilizes guided inquiry and student-centered learning to foster the development of critical thinking skills.	4
SC14	Students spend a minimum of 20% of instructional time engaged in laboratory work.	5
SC15	A hands-on laboratory component is required.	5
SC16	Each student should complete a lab notebook or portfolio of lab reports.	5

AP® Physics

The three sections of AP Physics C typically begin with 80 to 90 students enrolled, and of these, usually 70 to 75 complete the course. All enrolled students are required to take the AP Physics C Exam. Completion of or concurrent enrollment in a first-semester calculus course is required.

Texts

I currently use Raymond A. Serway and Robert J. Beichner's *Physics for Scientists and Engineers,* 6th ed.; however, *Fundamentals of Physics* by David Halliday, Robert Resnick, and Jearl Walker would also fit my style.

Summer Assignment

To begin the school year on a solid mathematical footing, all students enrolled for the following year are given a programmed elementary calculus book, *Quick Calculus: A Self-Teaching Guide* by Daniel Kleppner and Norman Ramsey, and assignments to be completed over the summer. The book helps students initially learn or review the basic differentiation and integration needed for the course. Quizzes on the material are given the first week of school. **[SC12]**

SC12—Introductory differential and integral calculus are used throughout the course.

Schedule

All classes meet five days a week in 53-minute periods. The semester is 90 days. With this calendar, it is necessary to organize the course with a tight schedule that includes assignments during some holiday breaks. I find it useful to lay out a calendar by which to measure progress through the material to ensure completion with time for sufficient review before the AP Physics Exam. The calendar reflects the day-by-day unit assignment schedule outlined below.

Mechanics Outline

Mechanics is covered during the fall semester, with each subject covered in the same order as in Serway and other standard texts. Concepts and problem-solving techniques are introduced through a combination of lectures, demonstrations, question-and-answer sessions, and teacher-generated worksheets, with the text acting as a back-up resource. Calculus is used where appropriate throughout.

Unit	Topics	Chapters in Serway	Number of Days
Unit 1	**SI Units, Dimensional Analysis, and Vectors**	**1, 2**	**5**
	Introduction to lab		
Unit 2	**Rectilinear Motion**	**3**	**5**
	Kinematics with time-varying acceleration		
	Kinematics with constant acceleration **[SC1]**		
Unit 3	**Planar Motion**		**7**
	General motion where *x* and *y* vary with time		
	Kinematics of projectiles		
	Kinematics of circular motion **[SC1]**		
Unit 4	**Introduction to Newton's Laws [SC2]**	**5**	**5**
	Newton's three laws		
	Free-body diagrams		
	Introduction to weight, normal, and friction forces		
Unit 5	**Applications of Newton's Laws [SC2]**	**5, 6**	**8**
	Pulley system		
	Uniform circular motion		
	Nonuniform circular motion		
	Nonconstant friction force		
Unit 6	**Vector Multiplication**	**7, 11**	**3**
Unit 7	**Work, Energy, and Power [SC3, SC4 & SC5]**	**7**	**4**
	Work by constant force		
	Work by position-varying force		
	Work-energy theorem		
	Power		
Unit 8	**Conservation of Energy**	**8**	**8**
	Energy conservation		
	Work by nonconservative forces		
	Potential energy functions		
	Potential energy vs. position graphs		
Unit 9	**Impulse, Momentum, and Collisions [SC6 & SC7]**	**10, 11**	**7**
	Impulse-momentum relationship		
	Conservation of linear momentum		
	Elastic and inelastic collisions		
	Position and velocity of center of mass		
Unit 10	**Rotational Kinematics**	**10, 11**	**4**
	Kinematics with time-varying angular acceleration		
	Kinematics with constant angular acceleration		
	Introduction to torque and angular momentum		

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SC4—The course covers Newtonian mechanics in depth and provides instruction in energy.

SC5—The course covers Newtonian mechanics in depth and provides instruction in power.

SC6—The course covers Newtonian mechanics in depth and provides instruction in systems of particles.

SC7—The course covers Newtonian mechanics in depth and provides instruction in linear momentum.

Unit 11	**Rotational Dynamics [SC8 & SC9]**	**10, 11**	**7**
	Moment of inertia		
	Newton's laws for rotation		
	Conservation of energy with rotation		
	Conservation of angular momentum		
Unit 12	**Translational and Rotational Equilibrium [SC8 & SC9]**	**12**	**4**
Unit 13	**Gravitation**	**14**	**6**
	Kepler's laws		
	Newton's law of gravitation		
	Energy and angular momentum		
Unit 14	**Simple Harmonic Motion (SHM) [SC10 & SC11]**	**13**	**6**
	Kinetics of SHM		
	Dynamics of SHM		

SC8—The course course covers Newtonian mechanics in depth and provides instruction in circular motion.

SC9—The course covers Newtonian mechanics in depth and provides instruction in rotation.

SC10—The course covers Newtonian mechanics in depth and provides instruction in oscillations.

SC11—The course covers Newtonian mechanics in depth and provides instruction in gravitation.

Teaching Strategies

Lecture and Question-and-Answer Sessions

Other than lab experiments, class time is taken up with lecture and question-and-answer sessions. A lecture consumes 20 to 30 minutes during which a concept presented in the reading is reviewed, stressing important definitions and limitations.

The remainder of the period usually involves showing relevant demonstrations (toys are frequently used) and then introducing an assigned problem or set of problems related to the demonstration. The students are then guided in a discussion (whole class or small group) to develop solutions to the problem(s). During all of these activities, I encourage discussion, questions, hypotheses, and proposals to flow among the students and between the students and me. Demonstrations are chosen to give the students as many different "looks" at the application of a concept as possible, so an appreciation of the universality of physical concepts is developed. Live demonstrations with simple equipment, often done by the students themselves for the rest of the class, are preferred. Computer simulations and video demonstrations have their place when real equipment is not available. Whenever possible, I use the analogies, conceptual discoveries, and problem-solving techniques that helped my understanding when I was a student. **[SC13]**

SC13—The course utilizes guided inquiry and student-centered learning to foster the development of critical thinking skills.

Problem Assignments

At the beginning of each unit, I give students a list of "what you should know and be able to do" by the end of the unit, a day-to-day schedule with assignments, the experiments scheduled, and when a quiz on the material can be expected. Providing this informs the students about the work required to master the objectives of the unit.

The assigned problems are either from the textbook or from a supplementary problem handout. Problems are chosen to give students experience with a wide range of applications of the subject covered in the unit. When the textbook does not have a problem covering a particular application, I use one from another text or write one. These make up the supplementary problem list. I also make extensive use of worksheets that are designed to help students develop coherent problem-solving techniques. When working problems or in question-and-answer sessions, I always stress starting from a general principle and moving toward a specific application. Instead of spending class time on working a problem all the way through to the answer, we work on building a general-to-specific routine in solving problems. This is an important skill to develop for success in future course work in the long term and for success on the AP Exam in the short term, since most problems students encounter will not be of the specific type they have worked before.

Lab Experiments

Approximately 20 percent of class time is taken up by lab work. **[SC14]** The experience gained by manipulating equipment **[SC15]**, recording and organizing data, and drawing conclusions through data and error analysis should be a vital part of any physics course; most labs extend beyond one class period. Much of the newer technology-based lab equipment does not fit my style because once it is set up, the data is taken and necessary calculations are performed, graphs are produced at the push of a button without much thought by the students. To me, a valuable learning opportunity is lost when students are not required to work with the data and organize it into a form in which a conclusion can be drawn. In my labs, students use simple equipment with a minimum of “black boxes.” Lab experiments are, for the most part, written by me and chosen to provide students with experiences that reinforce concepts being covered in class. Lab reports are required and are kept in a lab notebook. **[SC16]**

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SC15—A hands-on laboratory component is required.

SC16—Each student should complete a lab notebook or portfolio of lab reports.

Mechanics Labs

1. **Analysis of an Experiment.** Introduction to graphing techniques to derive an equation relating to experimental quantities (adapted from *PSSC Physics Laboratory Guide*).
2. **Motion with Uniform Acceleration.** Air track and interval timers (photogates or CBL™) used to gather data to produce a v versus t graph. Covers slope differential and area-integral concepts. Acceleration of gravity (g) is found experimentally. Introduction to least squares fit.
3. **Measuring the Acceleration of Gravity, g.** Choice of three experimental methods for measuring g.
4. **Newton’s Second Law.** This demonstration experiment uses an air track, pulley, and decade timer combination to derive the second law.
5. **Atwood’s Machine.** A simple mass-pulley, Atwood’s machine is used to measure the acceleration of the system and compare it with the theoretical acceleration found using Newton’s laws. The apparatus is then used to measure the mass of a penny.
6. **The Coefficient of Kinetic Friction, u_k.** This demonstration experiment is used to determine the coefficient of friction between an air track cart and masking tape.

7. **The Conical Pendulum.** Measurements are made with a toy airplane moving as a conical pendulum; centripetal force is related to the period of rotation of the plane, the radius of its circular path, and the tension in its support string.
8. **Changes in Potential Energy.** Energy exchanges in a spring-mass system. A relationship is determined between the area of F versus x graph and potential energy integral (adapted from *PSSC Physics Laboratory Guide*).
9. **Explosions and Collisions.** Photo slides of an "explosion" and collisions of discs on a low-friction surface are used to investigate energy exchanges and conservation of momentum, position, and velocity of the center of mass.
10. **Energy, Momentum, and a Crossbow.** Using a ballistic pendulum and toy crossbow, momentum and energy conversions are investigated.
11. **Jupiter Satellite Orbit.** The mass of Jupiter is determined using the period and radius of the orbit of its moon Io (Project Physics film loop #12, currently available as part of *Physics: Cinema Classics* video-disc from AAPT).
12. **The Physical Pendulum.** The experimental and calculated period of a physical pendulum are compared.

Evaluation

Quizzes are given approximately every two units. The quizzes are purposely similar in construction to the AP Exam. Each consists of 8 to 12 multiple-choice questions and a multipart free-response question. A teacher-constructed "anti-memorization" sheet is permitted on all quizzes. While going through the course material, the stress is on developing concepts and problem-solving strategies, not on memorization.

The multiple-choice questions come from many sources, such as AP Released Exams, New York Regents Exam review books, and questions I have written. The free-response questions have the same format as those on the AP Exam, and most are modified AP Exam questions. All are constructed to test current material and material previously covered. For example, an energy free-response question might require a free-body diagram and have a part involving a trajectory. The day after the quizzes are given, students score one another's papers using a rubric similar to those used to score the free-response questions on the AP Exam. The solution is projected on a screen, showing where points are to be given. Before students begin scoring papers, each section of the solution is carefully explained. This requires them to go through the solution carefully, perhaps recognizing their own mistakes and perhaps learning a little from the mistakes of others.

The only cumulative examination given before AP Exam review time is the first semester final. It consists of the 35-question multiple-choice section from an AP Physics C: Mechanics Released Exam. This exam is taken, scored, and reviewed during a two-hour final exam period.

Homework

Homework is assigned through a day-by-day assignment sheet, which students are given at the beginning of each unit. After they have had the chance to ask about a group of assigned problems or a worksheet, two to five problems, a worksheet, or both are handed in at random intervals during the unit. Homework is accepted only when asked for. This encourages students to stay current in their assignments. Because they have had the chance to ask questions, the homework they hand in is expected to be correct.

Grading

Lab reports are worth 20 points. Quizzes are worth 25 to 30 points, with the multiple-choice questions worth one point apiece and the free-response questions worth the remainder of the points. The homework collected in each unit is worth roughly half a quiz grade. The semester final and review exams are worth 35 points each. Extra credit — which can range from helping set up labs, building a car within stated design parameters, and working out amusement park problems — is liberally sprinkled throughout the course. All points are added and the percentage of points possible is determined. Grades are assigned according to the following schedule:

A = 85–100%; B = 70–84%; C = 55–69%; D = 45–54%; F = below 45%

Having taught the course for more than 20 years, I calibrate the points available to result in half to two-thirds of the students earning grades of A or B.

AP Exam Review

Formal review begins two weeks before the beginning of the AP Exam administration. Each student is given an exam review booklet consisting of the multiple-choice sections from two AP Physics C Released Exams and the free-response questions from the last five exams. In the booklet is a listing of the multiple-choice questions sorted by subject (i.e., kinematics, Newton's laws, and so on). During the early part of the review, several of these subject areas are assigned as homework. The first part of each class period is used to answer questions on the previous day's assignment. The rest of the period is divided up into 15-minute intervals, and one free-response question is assigned during each interval. Students may work alone or in groups of no more than three. Solution notebooks are available in the classroom for students to check their work. At the end of the first week of review, the mechanics multiple-choice questions from an AP Released Physics C Exam are given for credit. After the end of the second week, the multiple-choice questions from the E&M exam are given.