The College Board's Advanced Placement Program is currently undergoing a comprehensive course redesign project to ensure that each course reflects the most current thinking in each discipline. This process, which relies on input from eminent educators nationwide, produces redesigned courses that promote focused, hands-on learning. Learning that helps students develop the ability to think critically, construct solid arguments, and see many sides of an issue — skills that prepare them for college and career.

The redesigns build upon the strong foundations of existing courses. To illustrate more clearly the evolution that has occurred from Physics B to Physics 1 and 2, we've put together a series of real examples:

For Physics 1 and 2, the examples aim to illuminate the following key changes:

- Content Expanded and Divided
- Course Structure
- Defined Expectations
- Exam Design & Examples

Current Course Content

AP Physics B includes a wide breadth of topics to be covered in a single year.

- kinematics;
- Newton's laws of motion;
- torque;
- gravitation and circular motion; work, energy, and power;
- linear momentum;
- oscillations,
- mechanical waves and sound;
- fluid statics and dynamics;
- thermodynamics with kinetic theory, PV diagrams;
- electrostatics;
- electrical circuits;
- magnetic fields;
- electromagnetism;
- physical and geometric optics;
- topics in modern physics

Content for New Courses (Fall 2014)

The new courses decrease breadth of content to allow time to promote conceptual reasoning and understanding.

AP Physics 1

- kinematics
- Newton's laws of motion;
- torque;
- rotational motion and angular momentum*;
- gravitation and circular motion;
- work, energy, and power;
- linear momentum;
- oscillations, mechanical waves and sound;
- introduction to electric circuits

AP Physics 2

- fluid statics and dynamics;
- thermodynamics with kinetic theory, PV diagrams and probability;
- electrostatics;
- electrical circuits;
- magnetic fields;
- electromagnetism;
- physical and geometric optics;
- topics in modern physics

Current Course Structure

Course Topic Outline, Lab Objective Checklist and Learning Objectives

Course Outline

An outline of topics shared between current AP Physics B course and the AP Physics C courses

Laboratory and Experimental Objectives

A check-list of objectives for students engaging in experimentation [minimum of 12 lab experiences]

Learning Objective

A representation of the cumulative content that could be covered on a exam. However, there may be occasional questions that are within the scope of the topic outline but not covered by one of the listed objectives.

Structure for New Courses (Fall 2014)

Curriculum Framework with 7 Big Ideas, Enduring Understandings, Essential Knowledge, with the 7 Science Practices that lead to Learning Objectives

Big Ideas

7 overarching *big ideas* encompass the core scientific principles, theories and processes of physics that cut across traditional content boundaries and provide students a broad way of thinking about the physical world.

Enduring Understandings

Enduring understandings incorporate the core concepts that students should retain from the learning experience

Essential Knowledge + **Science Practices**

Learning Objective

Statements that pair the essential knowledge to the appropriate science practice(s), articulate specifically what students should *know* and be able *to do*. All exam questions are based on the learning objectives

Current Course Structure

Content Outline includes a checklist of topics to cover.

Content Outline for Physics B and Physics C

A more detailed topic outline is contained in the "Learning Objectives for AP Physics," which follow this outline.

Content Area	Percentage Goals for Exams: Physics B	Percentage Goals for Exams: Physics C: Mechanics
I. Newtonian Mechanics	35%	100%
A. Kinematics (including vectors, vector algebra, components of vectors, coordinate systems, displacement, velocity, and acceleration)	7%	18%
1. Motion in one dimension	√	√
2. Motion in two dimensions, including projectile motion	√	√
B. Newton's laws of motion	9%	20%
1. Static equilibrium (first law)	√	√
2. Dynamics of a single particle (second law)	√	√
3. Systems of two or more objects (third law)	√	√
C. Work, energy, power	5%	14%
1. Work and work–energy theorem	√	√
2. Forces and potential energy	√	√
3. Conservation of energy	√	√
4. Power	√	√
D. Systems of particles, linear momentum	4%	12%
1. Center of mass		√
2. Impulse and momentum	√	√
3. Conservation of linear momentum, collisions	√	√
E. Circular motion and rotation	4%	18%
1. Uniform circular motion	√	√
2. Torque and rotational statics	√	√
3. Rotational kinematics and dynamics		√
4. Angular momentum and its conservation		√

Structure for New Courses (Fall 2014)

Curriculum Framework is structured around 7 Big Ideas that articulate the foundational principles in introductory physics.

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.

Big Idea 7: The mathematics of probability can be used to describe the behavior of complex systems and to interpret the behavior of quantum mechanical systems.

Current Course Expectations

A topic outline provides the general concepts that should be covered in the course.

Objectives for the AP® Physics Courses
I. NEWTONIAN MECHANICS
A. Kinematics (including vectors, vector algebra, components of vectors, coordinate systems, displacement, velocity, and acceleration)
1. Motion in one dimension

Expectations for New Courses (Fall 2014)

Curriculum Framework incorporates multiple *enduring understandings* for each big idea.

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

Enduring Understanding 1.B: Electric charge is a property of an object or system that affects its interactions with other objects or systems containing charge.

Boundary statements provide guidance to teachers and show the contextual differences of how the big ideas and enduring understandings are applied in both courses.

Boundary Statement: Full coverage of electrostatics occurs in Physics 2. A basic introduction to the concepts that there are positive and negative charges, and the electrostatic attraction and repulsion between these charges, is included in Physics 1 as well.

Current Course Expectations

A checklist of learning objective statements are provided. The learning objectives do not incorporate science practices.

Objectives for the AP® Physics Courses	AP Course	
	B	C
I. NEWTONIAN MECHANICS		
A. Kinematics (including vectors, vector algebra, components of vectors, coordinate systems, displacement, velocity, and acceleration)		
1. Motion in one dimension		
a) Students should understand the general relationships among position, velocity, and acceleration for the motion of a particle along a straight line, so that:		
(1) Given a graph of one of the kinematic quantities, position, velocity, or acceleration, as a function of time, they can recognize in what time intervals the other two are positive, negative, or zero and can identify or sketch a graph of each as a function of time.	✓	✓
(2) Given an expression for one of the kinematic quantities, position, velocity or acceleration, as a function of time, they can determine the other two as a function of time, and find when these quantities are zero or achieve their maximum and minimum values.		✓

Expectations for New Courses (Fall 2014)

Each learning objective is designed to integrate science practices and provide clear guidance on what a student should know and be able to do.

Each *essential knowledge* statement references the big idea and enduring understanding that it supports.

PHYSICS 1

PHYSICS 2

Essential Knowledge 1.B.1: Electric charge is conserved. The net charge of a system is equal to the sum of the charges of all the objects in the system.

a. An electrical current is a movement of charge through a conductor.

b. A circuit is a closed loop of electrical current.

Learning Objective (1.B.1.1):
The student is able to make claims about natural phenomena based on conservation of electric charge.
[See Science Practice 6.4]

Each *learning objective* integrates the essential knowledge with the science practices .

Current Course Expectations

Laboratory objectives provide a brief list of skills students should be able to do.

Laboratory

Importance and Rationale

Laboratory experience must be part of the education of AP Physics students and should be included in all AP Physics courses, just as it is in introductory college physics courses. In textbooks and problems, most attention is paid to idealized situations: friction is often assumed to be constant or absent; meters read true values; heat insulators are perfect; gases follow the ideal gas equation. It is in the laboratory that the validity of these assumptions can be questioned, because there the student meets nature as it is rather than in idealized form. Consequently, AP students should be able to:

- design experiments;
- observe and measure real phenomena;
- organize, display, and critically analyze data;
- analyze sources of error and determine uncertainties in measurement;
- draw inferences from observations and data; and
- communicate results, including suggested ways to improve experiments and proposed questions for further study.

Expectations for New Courses (Fall 2014)

Content, inquiry and reasoning are all equally important. Each learning objective combines all 3 as described in the *science practices.*

Science Practices for AP Physics 1 and 2

Science Practice 1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.

Science Practice 2: The student can use mathematics appropriately.

Science Practice 3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

Science Practice 4: The student can plan and implement data collection strategies in relation to a particular scientific question.
[Note: Data can be collected from many different sources, e.g., investigations, scientific observations, the findings of others, historic reconstruction, and/or archived data.]

Science Practice 5: The student can perform data analysis and evaluation of evidence.

Science Practice 6: The student can work with scientific explanations and theories.

Science Practice 7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

Current Exams

Emphasis on questions that require only mathematical routines used for solution.

- **70 multiple-choice questions | 90 minutes**

  discrete items & items in sets

  5 answer choices, each question

- **6-7 free-response questions | 90 minutes**

  1 laboratory-related question

  questions of varying length

Redesigned Exams (Spring 2015)

Students continue to solve problems mathematically but the use of proportional and symbolic reasoning and ability to translate between multiple representations will be emphasized.

Physics 1 and 2 Exams

- **50 multiple-choice questions | 90 minutes**

  45 discrete items & items in sets

  5 multiple-correct items

  4 answer choices, each question

Physics 1

- **5 free-response questions | 90 minutes**

  1 experimental design question

  1 qualitative/quantitative translation

  3 short-answer questions

Physics 2

- **4 free-response questions | 90 minutes**

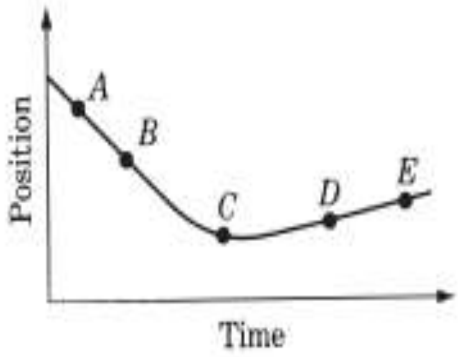
  1 experimental design question

  1 qualitative/quantitative translation

  2 short-answer questions

Current Exam

Multiple Choice Question: Students show understanding of motion using only one representation

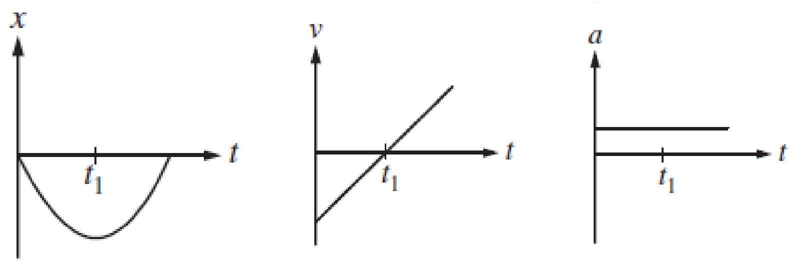


2. The motion of a particle along a straight line is represented by the position versus time graph above. At which of the labeled points on the graph is the magnitude of the acceleration of the particle greatest?

   (A) A
   (B) B
   (C) C
   (D) D
   (E) E

Exams for New Courses (Spring 2015)

Multiple Choice Question: Students must reconcile understanding of motion using multiple representations

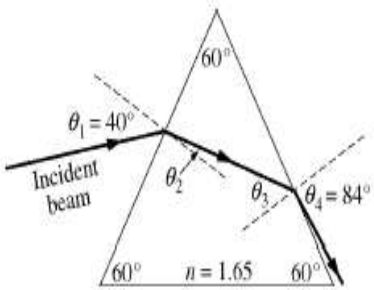


The graphs above represent the position *x*, velocity *v*, and acceleration a as a function of time *t* for a marble moving in one dimension. Which of the following could describe the motion of the marble?

(A) Rolling along the floor and then bouncing off a wall
(B) Rolling down one side of a bowl and then rolling up the other side
(C) Rolling up a ramp and then rolling back down
(D) Falling and then bouncing elastically off a hard floor

Current Exam

Free-Response Question emphasizes mathematical reasoning about physics principles



Note: Figure not drawn to scale.

5. (10 points)

As shown above, a beam of red light of wavelength 6.65×10^{-7} m in air is incident on a glass prism at an angle θ_1 with the normal. The glass has index of refraction $n = 1.65$ for the red light. When $\theta_1 = 40°$, the beam emerges on the other side of the prism at an angle $\theta_4 = 84°$.

(a) Calculate the angle of refraction θ_2 at the left side of the prism.

(b) Using the same prism, describe a change to the setup that would result in total internal reflection of the beam at the right side of the prism. Justify your answer.

(c) The incident beam is now perpendicular to the surface. The glass is coated with a thin film that has an index of refraction $n_f = 1.38$ to reduce the partial reflection of the beam at this angle.

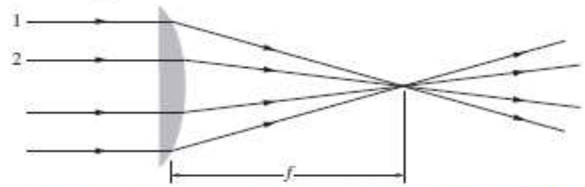
i. Calculate the wavelength of the red light in the film.

ii. Calculate the minimum thickness of the film for which the intensity of the reflected red ray is near zero.

Exams for New Courses (Spring 2015)

Free-Response Question emphasizes both qualitative and quantitative reasoning to assess conceptual understanding of physics principles

Quantitative/Qualitative Translation



1. The figure above represents a glass lens that has one flat surface and one curved surface. After incoming parallel rays pass through the lens, the rays pass through a focal point. The focal length f is the distance from the center of the lens to the focal point.

(a) The rays undergo refraction and change direction at the right surface of the lens, as shown. Explain why the angle of refraction of ray 1 is greater than that of ray 2.

(b) The index of refraction of the glass is n_{glass}, and the radius of curvature of the lens's right edge is R. (The radius of curvature is the radius of the sphere of which that edge is a part. A smaller R corresponds to a lens that curves more.) A teacher who wants to test a class's understanding about lenses asks the students if the equation $f = n_{glass} R$ makes sense for the focal length of the lens in air. Is the teacher's equation reasonable for determination of the focal length? Qualitatively explain your reasoning, making sure you address the dependence of the focal length on both R and n_{glass}.

(c) An object is placed a distance $f / 2$ (half of the focal length) to the left of the lens. On which side of the lens does the image form, and what is its distance from the lens in terms of f? Justify your answer. (Assume this is a thin lens.)

(d) The lens is now placed in water, which has an index of refraction that is greater than air but less than the glass. Indicate below whether the new focal length is greater than, less than, or equal to the focal length f in air.

____ Greater than in air
____ Less than in air
____ The same as in air

Justify your answer qualitatively, with no equations or calculations.