Full Name:

AP PHYSICS SUMMER ASSIGNMENT 2026

INTRODUCTION: THE NATURE OF SCIENCE AND PHYSICS

DUE THE FIRST DAY OF SCHOOL!

There is a total of three parts:
Part A – open stax questions
Part B – math fundamentals review questions
Part C – 5 Steps reading assignment

Part A:

1. Go to the OpenStax College Physics for AP Courses online textbook at https://openstax.org/books/college-physics-ap-courses/pages/1-connection-for-ap-r-courses

2. Study all sections of Chapter 1:
   1.1 Physics: An introduction
   1.2 Physical Quantities and Units
   1.3 Accuracy, Precision and Significant Figures
   1.4 Approximation

3. Answer Conceptual Questions #1-11
   https://openstax.org/books/college-physics-ap-courses/pages/1-conceptual-questions
   Answer in complete sentences. Clearly number each answer. Put "Conceptual Questions" and your name at the top right of each page.

4. Answer Problems and Exercises #1-36
   https://openstax.org/books/college-physics-ap-courses/pages/1-problems-exercises
   Show your work for each problem and circle/highlight your answers. Clearly number each question. Put "Problems and Exercises" and your name at the top right of each page.

When complete, staple all your answer papers together. Put your name at the top right on each page. At the top left of the first page, put "AP Physics Summer Assignment 2024". Have this ready to turn in on the first day of school.

Have Questions? Need Help?
Email Mr. DiFabio: ddifabio@tusd.net

AP Physics 1 Summer Assignment - Math Review

1. Scientific Notation:

The following are ordinary physics problems. Write the answer in scientific notation and simplify the units (π=3).

a. $T_s = 2\pi\sqrt{\dfrac{4.5\times10^{-2}\,kg}{2.0\times10^{3}\,kg/s^2}} =$ $_s$=_____

b. $F = \left(9.0\times10^{9}\,\dfrac{N\cdot m^2}{C^2}\right)\dfrac{\left(3.2\times10^{-9}C\right)\left(9.6\times10^{-9}C\right)}{\left(0.32m\right)^2}$ F=_____

c. $\dfrac{1}{R_p} = \dfrac{1}{4.5\times10^{2}\,\Omega} + \dfrac{1}{9.4\times10^{2}\,\Omega}$ R_p=_____

d. $K_{max} = \left(6.63\times10^{-34}\,J\cdot s\right)\left(7.09\times10^{14}\,s\right) - 2.17\times10^{-19}\,J$ K_{max}=_____

e. $\gamma = 1\Big/\sqrt{1-\dfrac{2.25\times10^{8}\,m/s}{3.00\times10^{8}\,m/s}}$ γ=_____

f. $K = \dfrac{1}{2}\left(6.6\times10^{2}\ \text{kg}\right)\left(2.11\times10^{4}\ \text{m/s}\right)^2 =$ K=_____

g. $\left(1.33\right)\sin 25.0^\circ = \left(1.50\right)\sin\theta$ θ=_____

2. Solving Equations:

Often problems on the AP exam are done with variables only. Solve for the variable indicated. Don't let the different letters confuse you. Manipulate them algebraically as though they were numbers.

a. $K = \frac{1}{2}kx^2$, $x =$ _____

b. $T_p = 2\pi\sqrt{\frac{\ell}{g}}$, $g =$ _____

c. $F_g = G\frac{m_1 m_2}{r^2}$, $r =$ _____

d. $mgh = \frac{1}{2}mv^2$, $v =$ _____

e. $x = x_o + v_o t + \frac{1}{2}at^2$, $t =$ _____

f. $B = \frac{\mu_o}{2\pi}\frac{I}{r}$, $r =$ _____

g. $x_m = \frac{m\lambda L}{d}$, $d =$ _____

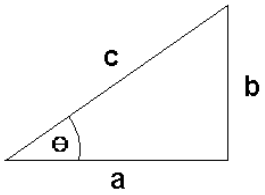
h. $pV = nRT$, $T =$ _____

i. $\sin\theta_c = \frac{n_1}{n_2}$, $\theta_c =$ _____

j. $qV = \frac{1}{2}mv^2$, $v =$ _____

3. Trigonometry

Using the generic triangle to the right, Right Triangle Trigonometry and Pythagorean Theorem solve the following. ***Your calculator must be in degree mode.***



g. $\theta = 55^o$ and $\boldsymbol{c} = 32\ m$, solve for $\boldsymbol{a}$ and $\boldsymbol{b}$.

_____

h. $\theta = 45^o$ and $\boldsymbol{a} = 15\ m/s$, solve for $\boldsymbol{b}$ and $\boldsymbol{c}$.

_____

i. $\boldsymbol{b} = 17.8\ m$ and $\theta = 65^o$, solve for $\boldsymbol{a}$ and $\boldsymbol{c}$.

_____

j. $\boldsymbol{a} = 250\ m$ and $\boldsymbol{b} = 180\ m$, solve for θ and $\boldsymbol{c}$.

_____

k. $\boldsymbol{a} = 25\ cm$ and $\boldsymbol{c} = 32\ cm$, solve for $\boldsymbol{b}$ and θ.

_____

l. $\boldsymbol{b} = 104\ cm$ and $\boldsymbol{c} = 65\ cm$, solve for $\boldsymbol{a}$ and θ.

_____

Physics
Scientific notation practice with calculations

CLASS SET

***Part A:** Express each of the following in standard form.*

1. 5.2×10^{3} _____
2. 9.65×10^{-4} _____
3. 8.5×10^{-2} _____
4. 2.71×10^{4} _____
5. 3.6×10^{1} _____
6. 6.452×10^{2} _____
7. 8.77×10^{-1} _____
8. 6.4×10^{-3} _____

***Part B:** Express each of the following in scientific notation.*

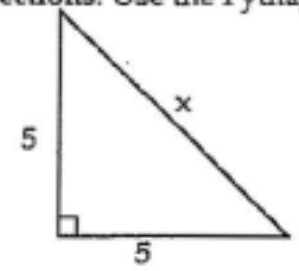
1. 78,000 _____
2. 0.00053 _____
3. 250 _____
4. 2,687 _____
5. 16 _____
6. 0.0043 _____
7. 0.875 _____
8. 0.012654 _____

***Part C:** Use your calculator to compute the following. Give ALL answers in scientific notation.*

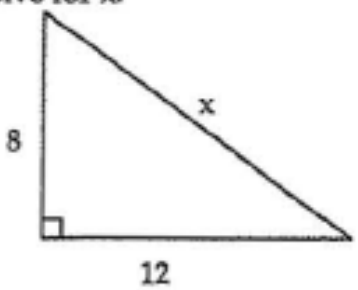
1. $(6.02 \times 10^{23})(8.65 \times 10^{4})$ _____
2. $(6.02 \times 10^{23})(9.63 \times 10^{-2})$ _____
3. $\dfrac{5.6 \times 10^{-18}}{8.9 \times 10^{8}}$ _____
4. $(-4.12 \times 10^{-4})(7.33 \times 10^{12})$ _____
5. $\dfrac{(5.4 \times 10^{4})(2.2 \times 10^{7})}{4.5 \times 10^{5}}$ _____
6. $\dfrac{(6.02 \times 10^{23})(-1.42 \times 10^{-15})}{6.54 \times 10^{-6}}$ _____
17. $\dfrac{(6.02 \times 10^{23})(-5.11 \times 10^{-27})}{-8.23 \times 10^{5}}$ _____
8. $\dfrac{(3.1 \times 10^{14})(4.4 \times 10^{-12})}{-6.6 \times 10^{-14}}$ _____

Directions: Use the Pythagorean Theorem to solve for x.

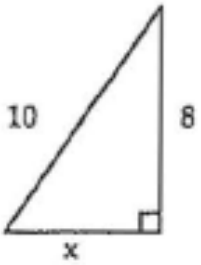
1.



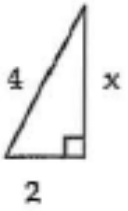
2.



3.

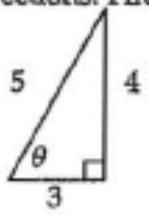


4.

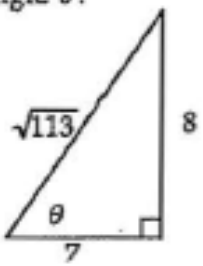


Directions: Find the sin, cos, and tan of the angle θ.

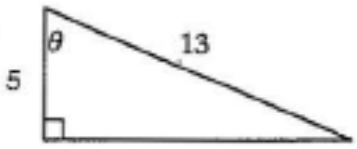
5.



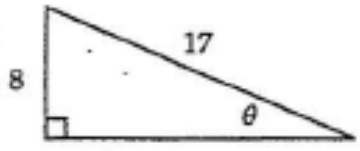
6.



7.



8.



CLASS SET

Unit Conversion Practice

Using the table of unit unit conversions on the back of this sheet, and your metric conversion line perform the following operations. SHOW ALL OF YOUR WORK!!!!

1. Convert 50 L to kiloliters.

2. Convert 200 cm to meters.

3. Convert 7000 mg to grams.

4. Convert 8900 mm to centimeters.

5. Convert 6 km to meters.

6. Convert 50 cg to milligrams.

7. Convert 42 feet to inches.

8. Convert 658 miles to kilometers.

9. Convert 100 cm to inches.

10. Convert 6 square feet to square meters.

11. Convert 25 lbs of force to newtons.

12. Convert 650 Newtons of force to lbs.

13. Convert 35,420 Watts of power to Horsepower (hp).

14. For an object on the earth, convert 180 lbs to kg.

Unit Conversions (Equivalents)

Giancoli, Douglas, Physics 5th ed. New York: Prentice Hall, 1998. P. inside front cover.

Length

1 in. = 2.54 cm
1 cm = 0.394 in.
1 ft = 30.5 cm
1 m = 39.37 in. = 3.28 ft
1 mi = 5280 ft = 1.61 km
1 km = 0.621 mi
1 nautical mile (U.S.) = 1.15 mi = 6076 ft = 1.852 km
1 fermi = 1 femtometer (fm) = 10^{-15} m
1 angstrom (Å) = 10^{-10} m
1 light-year (ly) = 9.46×10^{15} m
1 parsec = 3.26 ly = 3.09×10^{16} m

Volume

1 liter (L) = 1000 mL = 1000 cm^3 = 1.0×10^{-3} m^3 = 1.057 quart (U.S.) = 61.02 $in.^3$
1 gallon (U.S.) = 4 qt (U.S.) = 231 $in.^3$ = 3.79 L = 0.83 gal (Imperial)
1 m^3 = 35.31 ft^3

Angle

1 radian (rad) = 57.30° = 57°18′
1° = 0.01745 rad
1 rev/min (rpm) = 0.1047 rad/s

Time

1 day = 8.64×10^4 s
1 year = 3.156×10^7 s

Mass

1 atomic mass unit (u) = 1.6605×10^{-27} kg
1 kg = 0.0685 slug
[1 kg has a weight of 2.20 lb where $g = 9.81\ m/s^2$.]

Force

1 lb = 4.45 N
1 N = 10^5 dyne = 0.225 lb

Energy and Work

1 J = 10^7 ergs = 0.738 ft·lb
1 ft·lb = 1.36 J = 1.29×10^{-3} Btu = 3.24×10^{-4} kcal
1 kcal = 4.186×10^3 J = 3.97 Btu
1 eV = 1.602×10^{-19} J
1 kWh = 3.60×10^6 J = 860 kcal

Power

1 W = 1 J/s = 0.738 ft·lb/s = 3.42 Btu/h
1 hp = 550 ft·lb/s = 746 W

Pressure

1 atm = 1.013 bar = 1.013×10^5 N/m^2
= 14.7 $lb/in.^2$ = 760 torr
1 $lb/in.^2$ = 6.90×10^3 N/m^2
1 Pa = 1 N/m^2 = 1.45×10^{-4} $lb/in.^2$

SI Derived Units and Their Abbreviations

Quantity	Unit	Abbreviation	In Terms of Base Units†
Force	newton	N	$kg \cdot m/s^2$
Energy and work	joule	J	$kg \cdot m^2/s^2$
Power	watt	W	$kg \cdot m^2/s^3$
Pressure	pascal	Pa	$kg/(m \cdot s^2)$
Frequency	hertz	Hz	s^{-1}
Electric charge	coulomb	C	$A \cdot s$
Electric potential	volt	V	$kg \cdot m^2/(A \cdot s^3)$
Electric resistance	ohm	Ω	$kg \cdot m^2/(A^2 \cdot s^3)$
Capacitance	farad	F	$A^2 \cdot s^4/(kg \cdot m^2)$
Magnetic field	tesla	T	$kg/(A \cdot s^2)$
Magnetic flux	weber	Wb	$kg \cdot m^2/(A \cdot s^2)$
Inductance	henry	H	$kg \cdot m^2/(s^2 \cdot A^2)$

†kg = kilogram (mass), m = meter (length), s = second (time), A = ampere (electric current).

Metric (SI) Multipliers

Prefix	Abbreviation	Value
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^9
mega	M	10^6
kilo	k	10^3
hecto	h	10^2
deka	da	10^1
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}



Frequently Asked Questions About the AP Physics 1 Exam

IN THIS CHAPTER

Summary: This chapter provides the basic information you need to know about the AP Physics 1 Exam. Learn how the test is structured, what topics are tested, how the test is scored, as well as basic test-taking information.



Key Ideas

- ✪ It's not possible to "game" this test. In order to get a good score, *you must know your physics.*
- ✪ Half of the test consists of multiple-choice questions and the other half of free-response questions. Each section accounts for half of your score.
- ✪ A score of 3 or above makes you qualified for credit from most colleges and universities.
- ✪ Topics on the exam include the following:

I. Force and Motion
   - How things move
   - Rotation
   - Gravitation

II. Conservation Laws
   - Collisions: impulse and momentum
   - Work and energy
   - Rotation

01_Jacobs_AP Physics 1_Ch01.indd 3 04/11/24 5:24 PM

✪ The focus of the test is not numbers and equations. You may use a calculator and an equation sheet, but these will not be very helpful because far more explanations and verbal responses are required than calculations and numerical answers.

FAQs: The AP Physics Program

Chapter 2 contains the answers to some of the most frequently asked questions about the AP Physics 1 course and exam. If you have additional questions, check out the College Board's "AP Central" web pages (http://apcentral.collegeboard.com). Another helpful resource for the test is the author's physics teaching blog at https://jacobsphysics.blogspot.com.

What Is AP Physics 1, Algebra-Based, and How Is It Different from a Typical Advanced Physics Course?

AP Physics 1 is a first-time, no-calculus physics course covering mechanics. The AP Physics 1 Exam involves fewer topics than typical high school or college introductory courses, but it requires far more explanations and verbal responses than calculations and numerical answers.

Even though most advanced physics courses require loads of numerical answers and mathematical manipulation, AP Physics 1 requires you to be able to do only two things mathematically: (1) solve straightforward algebraic equations, and (2) use the basic definitions of the trigonometric functions sine, cosine, and tangent. There's no completing the square, no trigonometric identities—just the basic stuff you learned in your algebra and geometry courses.

The next chapter contains more information about how the AP Physics 1, Algebra-Based curriculum differs from traditional, calculation-heavy advanced physics courses.

Who Should Take the AP Physics 1, Algebra-Based Course?

The AP Physics 1 course is ideal for *all* college-bound high school students. For those who intend to major in math or the heavy-duty sciences, Physics 1 serves as a perfect introduction to college-level work. For those who want nothing to do with physics after high school, Physics 1 is a terrific terminal course—you get exposure to many facets of physics at a rigorous yet understandable level.

Most important, for those who aren't sure in which direction their college career may head,[1] the Physics 1 course can help you decide: "Do I like this stuff enough to keep studying it, or not?"

What Are the Other AP Physics Courses?

In addition to AP Physics 1, the College Board now offers three other AP Physics courses.

AP Physics 2 is designed as an algebra-based follow-up to AP Physics 1. In the same style of requiring depth of understanding and verbal explanation, AP Physics 2 covers electricity, magnetism, thermal physics, and atomic and nuclear physics.

[1] That may be most of you reading this book.

The AP Physics C courses are *only* for those who have already taken a solid introductory physics course and are considering a career in the physical sciences or math. Physics C consists of two separate, calculus-based courses: (1) Newtonian Mechanics, and (2) Electricity and Magnetism. Of course, the Physics 1 and Physics 2 courses cover these topics as well. However, the C courses go into greater mathematical depth and detail. The problems are more involved, and they demand a higher level of mathematical ability, including differential and integral calculus, and some differential equations. You can take either or both Physics C exams. The AP Physics C exams have not changed in many years. If you decide to attempt the Physics C Exam, try *5 Steps to a 5: AP Physics C*.

Is One Exam Better than the Other? Should I Take More than One?

We strongly recommend taking only one exam—and make sure it's the one your high school AP course prepared you for! Physics C is not considered "better" than Physics 1 or 2 in the eyes of colleges and scholarship committees. They are different courses with different intended audiences. It is far better to do well on the one exam you prepared for than to attempt something else and do poorly.

Why Should I Take an AP Physics Exam?

Many of you take an AP Physics exam because you are seeking college credit. A score of 3 or above makes you qualified for credit from most colleges and universities. This means you are one or two courses closer to graduation before you even start college!

Therefore, one compelling reason to take an AP exam is economic. How much does a college course cost, even at a relatively inexpensive school? You're talking several thousands of dollars. If you can save those thousands of dollars by paying less than a hundred dollars now, why not do so? Even if you do not score high enough to earn college credit, the fact that you elected to enroll in an AP course tells admissions committees that you are a high achiever and are serious about your education.

You'll hear a whole lot of misinformation about AP credit policies. Don't believe anything a friend (or even a teacher) tells you; instead, find out for yourself. One way to learn about the AP credit policy of the school you're interested in is to look it up on the College Board's official website, at http://collegesearch.collegeboard.com/apcreditpolicy/index.jsp. Even better, contact the registrar's office or the physics department chair at the college directly.

FAQs: The AP Physics 1 Exam

"I've heard that no one does well on AP Physics 1. Is that true?" That's a rather melodramatic and, um, *false* statement. For example, in 2023, 73,000 students passed (i.e. earned 3 or better on) the AP Physics 1 exam. That's 18,000 more students than the number who even took the AP Physics C Mechanics exam!

Now, it's certainly true that Physics 1 is a difficult exam. There's no way to guess, to game the test, to pass without a true understanding of physics. But college professors and admissions committees now understand just how well Physics 1 prepares students to continue their study of physics. Physics C scores have skyrocketed over the past eight years, as has performance in college-level calculus-based physics classes. Why? Because so many students have such an improved grounding in the conceptual underpinnings of physics . . . which they gained through taking AP Physics 1.

The good news is, colleges know well how this exam has changed. Those students who pass AP Physics 1 are showing a significantly higher level of accomplishment than those who pass AP English or AP US History. Good scores—not just 5s, but 4s and 3s, too—are being rewarded in college admissions and credit.

All AP physics exams underwent a college comparability study in 2025. This means the historic pass rate from the 2015–2024 exams is now out of date; it's likely that more students will pass the AP Physics 1 exam each year as of the 2025 administration, but firm statistics won't be available until after the 2025, 2026, and 2027 administrations.

What Is the Format of the AP Physics 1 Exam?

The following table summarizes the format of the AP Physics 1 Exam.

Table 1.1 AP Physics 1 Exam Structure

	AP PHYSICS 1		
SECTION	NUMBER OF QUESTIONS	TIME LIMIT	PERCENT OF SCORE
I. Multiple Choice	40	80 minutes	50%
II. Free Response	4	100 minutes	50%

What Types of Questions Are Asked on the Exam?

The 40 multiple-choice questions all have four choices and a single correct answer. The free response questions will consist of four questions in this exact order:

Question 1	Mathematical Routines	10 points
Question 2	Translating Between Representations	12 points
Question 3	Experimental Design	10 points
Question 4	Qualitative-Quantitative Translation	8 points

These question types are described thoroughly in Chapter 5.

Who Writes the AP Physics Exam?

Development of each AP exam is a multiyear effort that involves many folks. At the heart of the effort is the AP Physics Development Committee, a group of college and high school physics teachers who are typically asked to serve for three years. The committee and other physics teachers create a large pool of multiple-choice questions. With the help of the testing

experts at Educational Testing Service (ETS), these questions are then pretested with college students for accuracy, appropriateness, clarity, and assurance that there is no ambiguity in the choices. The results of this pretesting allow each question to be categorized by degree of difficulty. After several more months of development and refinement, Section I of the exam is ready to be administered.

The free-response questions that make up Section II go through a similar process of creation, modification, pretesting, and final refinement so that the questions cover the necessary areas of material and are at appropriate levels of difficulty and clarity. The committee includes the chief reader of the exams, who ensures that the proposed free-response problems can be graded consistently, fairly, and rapidly. An ETS specialist works with the committee to ensure that topic coverage and the scope of the exam are appropriate; the specialist makes sure that the exam tests what it's supposed to test.

At the conclusion of each AP reading and scoring of exams, the exam itself and the results are thoroughly evaluated by the committee and by ETS. In this way, the College Board can use the results to make suggestions for course development in high schools and to plan future exams.

What Topics Appear on the Exam?

The AP Physics 1 *Course and Exam Description* divides the course into eight units:

1. Kinematics (Chapter 7 in this book)
2. Force and motion (Chapter 8, Chapter 12)
3. Work, energy, and power (Chapter 10)
4. Linear momentum (Chapter 9)
5. Torque and rotation (Chapter 11)
6. Rotation: energy and momentum (Chapter 11)
7. Oscillations (Chapter 13)
8. Fluids (Chapter 14)

Of course, many exam questions overlap multiple units. Units 1–4 are fundamental to all of physics. Then units 5–8 can be thought of as more specific applications of motion, force, energy, and momentum.

Do I Get to Use a Calculator? An Equation Sheet?

Well, yes. But please don't expect these things to help you much. The course is not about numbers and equations. If you come into the exam thinking you'll find the right equation on the equation sheet and then solve that equation with a calculator, you're going to be blown out of the water. In fact, I wish the College Board had decided *not* to allow calculators and equation sheets. They give a false sense of what kinds of questions will be asked on the exam and of how to prepare for them. (See Chapter 7 for more information about the types of questions you will encounter.)

Suffice it to say that you don't need the equation sheet because by test day, you will already know and understand the important relationships between quantities that underlie the physics questions that will be asked. And if you don't know the correct relationship, I don't advise picking through the dense and incomprehensible equation sheet; you're more likely to waste time than to find something useful there.

Regarding the calculator, you probably shouldn't use it more than a few times on the entire exam. Most problems won't involve calculation at all, but rather reasoning with

equations and facts. Many of the problems that at first glance look like calculations can be solved more quickly and easily with semiquantitative reasoning.[2] The few problems that do require calculation will usually involve straightforward arithmetic (e.g., the mass of the cart will be 1 kg or 0.5 kg, not 0.448 kg).

How Is My Multiple-Choice Section Scored?

The multiple-choice section of the AP Physics 1 Exam is worth half of the final score. Your answer sheet is run through a computer, which adds up your correct responses. The number of correct responses is your raw score on the multiple-choice section. No partial credit is awarded.

If I Don't Know the Answer, Should I Guess?

Yes. There is no penalty for guessing.

Who Grades My Free-Response Questions?

Every June, a group of physics teachers gathers for a week to assign grades to test takers' hard work. Each of these readers spends a day or so getting trained on only one question. Because each reader becomes an expert on that question, and because each exam book is anonymous, this process provides for consistent and unbiased scoring of that question.

During a typical day of grading, a random sample of each reader's scores is selected and cross-checked by experienced "table leaders" to ensure that consistency is maintained throughout the day and the week. Each reader's scores on a given question are also statistically analyzed to make sure scores are not given that are significantly higher or lower than the mean scores given by other readers of that question.

Will My Exam Remain Anonymous?

You can be absolutely sure that your exam will remain anonymous. Even if your high school teacher happens to randomly read your booklet, there is virtually no way they will know that exam is yours.[3] To the reader, each student is a number, and to the computer, each student is a bar code.

What about that permission box on the back? The College Board uses some exams to help train high school teachers so that they can help the next generation of physics students to avoid common mistakes. If you check this box, you simply give permission to use your exam in this way. Even if you give permission, your anonymity is maintained.

How Is My Exam Score Determined, and What Does It Mean?

Each section counts for 50 percent of the exam. The total composite score is thus a sum of the multiple-choice and free-response sections. In the end, when all of the numbers have

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[2]By *semiquantitative reasoning* I mean something like, "If I double the net force with the same mass, I also double acceleration by $F_{net} = ma$. So the new acceleration is twice the old acceleration of 1.2 m/s per second, so the answer is 2.4 m/s per second."

[3]Well, unless you write something like, "Hi, please kick Mr. Kirby in the butt for me. Thank you! Sincerely, George."

been crunched, the chief faculty consultant converts the range of composite scores to the five-point scale of the AP grades.

This conversion is not a true curve; it's not that there's some target percentage of 5s to give out. This means you're not competing against other test takers. Rather, the five-point scale is adjusted to reflect the same standards every year. The goal is that students who earn 5s this year are just as strong as those who earn 5s next year, and every year into the future.

Historically, it's taken about 70% of the available points to earn a 5, 55% or so to earn a 4, and 40% or so to earn a 3. I've used similar percentages in the tables at the end of the practice exams in this book to give a rough example of a conversion. When you complete the practice exam, you can use this to give yourself a hypothetical grade.

Point is, you are NOT expected to get classroom-style scores of 90% for an A. The exam is intended to differentiate between levels of students, and the exam tests far more than pure recall, so 70% is a very strong score, not a weak score.

You should receive your AP grade in early July.

How Do I Register and How Much Does It Cost?

Registration for AP exams must be completed by mid-November.[4] You do not have to be enrolled in an officially titled AP Physics course to register for the exam. In many schools, an honors or college prep class, plus this book and some out-of-class practice, will prepare you just fine for the exam.

In 2024, the fee for taking the exam was $98. Students who demonstrate financial need may receive a reduction—you can find out more from your school's AP coordinator or the College Board website.

What if I'm Not Sure in November Whether I Want to Take the Exam?

Sign up anyway.

If you're in an official AP class, the College Board has provided all sorts of excellent resources that your teacher can share with you—including an outstanding workbook of activities, including personal progress checks that can be used throughout the year, including a bank of extra questions written by the development committee. Between these resources and this book, you will not encounter any surprises on the exam.

The College Board has done considerable research at pilot schools to determine whether requiring registration in November has an effect on student performance. They found out that it does—a dramatic effect. Students who committed in November to taking the exam outperformed those who didn't commit until March by an enormous margin.

I'm sure some wiseacres will say, "but I just know I'm gonna fail." That's called defeatism, and you shouldn't tolerate that from yourself. If you were to tell your softball coach, "Hey, I'm going to strike out at the plate, let grounders go through my legs, and drop all the fly balls hit to me," would the coach let you play? More likely, they would kick you off the team! When you pretend that you can't do anything in physics, you do yourself a tremendous disservice.

When in doubt regarding registration procedures, the best source of information is the College Board's website apcentral.collegeboard.org.

[4] *For those who are taking a second-semester-only class, the registration deadline is in March.*



Understanding the Exam: The AP Physics 1 Revolution

IN THIS CHAPTER

Summary: The AP Physics 1 Exam requires less calculation and more written explanations of physics than any previous standardized physics exam. This chapter provides a deeper analysis of the AP Physics 1 Exam, explaining what the test is like and how it is different from traditional physics tests.



Key Ideas

- The AP Physics 1 Exam is less focused on getting the "right" numerical answer to a problem and more focused on explaining and applying the concepts of physics.
- The AP Physics 1 Exam is no walk in the park. Although it covers fewer topics, has fewer questions, and contains less math than many high school or college physics exams, it requires a deeper understanding of physics. The AP Physics 1 Exam is more difficult than a typical introductory college-level physics exam.

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What Happened to the AP Physics Test?

The AP Physics 1 Exam is not like anything your parents, or even possibly your older cousins, took. The AP Physics 1 curriculum has undergone a radical transformation that has eliminated the advanced mathematics but added a profound understanding of the science of physics.

A Little History

In the 1970s and 1980s, a typical physics professor gave lectures heavily focused on mathematics to first-year students and then administered exams that demanded clever algebraic manipulation. The AP Physics B exams of that era reflected the mathematical nature of college physics.

In the 1990s, a new generation of physics professors promoted a different kind of physics teaching that was just as rigorous but that demanded more explanation and less algebraic skill. The meaning of the math became more important than the math itself. AP exams began to include more questions asking for descriptions of experimental techniques, for justification of numerical answers, and for explanations in words.

When the College Board received a grant to redesign their science courses in the early 2000s, the curriculum design committee decided to move even further away from calculation and more toward verbal explanation. They minimized the number of topics on the newest AP physics exams, and they decreased the number of questions on the exams. That way, they reasoned, the exam could demand more writing and more detailed explanations in the responses.

Goal of the AP Physics 1 Revolution: The *Best* College Physics Course, Not Just the "Typical" College Physics Course

The fundamental purpose of the College Board's AP program has always been to give advanced high school students access to college-level coursework. Historically, the goal was to create exams that mimic the content and level of the typical, average courses at an American university.

However, in redesigning their science courses, the development committees aimed higher—the stated goal now is for the AP exams to reflect best practices as well as the content and difficulty level of only the best college courses. In general, the "best" college classes include lots of demonstrations, laboratory work, and descriptive as well as calculational physics.

What Is AP Physics 1? Eleven Things You Should Know About the Course and Exam



You'll do better on a test if you understand the test and what's being tested. In this section you'll learn key facts about the AP Physics 1 Exam—facts that will help you know what to expect and, as a result, better prepare for the test.

1. AP Physics 1 Is Not a Broad Course

It covers **motion, force, energy, and momentum**. That's it. Yes, the later units discuss those topics in the context of rotations, vibrations, and fluids; but everything in the entire exams boils down to those four fundamental concepts.

As of 2021, mechanics has been the *only* major topic area of physics. Subtopics of mechanics primarily include motion, force, momentum, energy, harmonic motion, and

rotation. AP Physics 1 is designed to replicate the first semester of an algebra-based first-year college course. (AP Physics 2 covers the second-semester material.)

2. AP Physics 1 Is Designed to Be a First-Time Introduction to Physics

Many high school students want to, and are ready to, dive right into algebra-based physics at the college level. AP Physics 1 has been designed to set up these students for success. If you've had an introduction to physics, like a conceptual, Regents, or "college prep" course, that will give you good background, but such a prerequisite is in no way necessary. (In fact, AP Physics 1 is sometimes *more* difficult for those who have previously done calculational physics than for those who take AP Physics 1 as their first physics course ever—it's hard to adjust if you've practiced just doing math rather than communicating physics principles!)

3. AP Physics 1 Is Not a Math Course

There are only three middle- and high-school mathematical skills you need in order to understand AP Physics 1 material:

- You must be able to solve algebraic equations in a single variable.
- You must be able to calculate, and to understand the meaning of, the slope and area of a graph.[1]
- You must be able to use the definitions of the basic trig functions sine, cosine, and tangent.[2]

That's it. You studied these things in your middle school, Algebra 1, and geometry courses. You don't need matrices, factoring of polynomials, the quadratic formula, trigonometric identities, conic sections, or whatever else you are studying in Algebra II or precalculus.

4. AP Physics 1 Is Not About Numbers

Yes, you must use numbers occasionally. Yet you must understand that the number you get in answer to a question is always subordinate to what that number represents.

Many misconceptions about physics start in math class. There, your teacher shows you how to do a type of problem, and then you do several variations of that same problem for homework. The answer to one of these problems might be 30,000,000, and another 16.5. It doesn't matter . . . in fact, the book (or your teacher) probably made up random numbers to go into the problem to begin with. The "problem" consists of manipulating these random numbers a certain way to get a certain answer.

In physics, though, *every number has meaning*. Your answer will not be 30,000,000; the answer may be 30,000,000 joules, or 30,000,000 seconds, but not just 30,000,000. If you don't see the difference, you're missing the fundamental point of physics.

We use numbers to represent *real* goings-on in nature. The amount 30,000,000 joules (or 30 megajoules) is an energy; it could be the kinetic energy of an antitank weapon or the gravitational energy of an aircraft carrier raised up a foot or so.[3] Thirty million seconds is a time, not a few hours or a few centuries, but about one year. These two "30,000,000" responses mean entirely different things. If you simply give a number as an answer, you're doing a math problem. It is only when you can explain the meaning of a result that you may truly claim to understand physics.

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[1]Note that the calculus extensions of these concepts as "derivatives" and "integrals" are utterly irrelevant to and useless in AP Physics 1.

[2]This knowledge is often expressed as "SOHCAHTOA": In a right triangle, the **S**ine is **O**pposite over **H**ypotenuse. …

[3]Interestingly, when you use this much electrical energy in your house, it would cost you in the neighborhood of $1.

5. AP Physics 1 Requires Quantitative and Semiquantitative Reasoning

You'll only occasionally be asked to make numerical calculations. But you'll often be required to use mathematical *reasoning*.

"Quantitative" reasoning means not only performing direct calculations, but also explaining why those calculations come out the way they do. You'll be asked to explain whether quantities increase or decrease just by looking at the relevant equation, and without necessarily performing the calculations. You'll need to recognize that a problem is solvable when one equation with a single variable can be written, or when two equations with two variables can be written, or even when three equations with three variables can be written. You'll not be asked to solve even mildly complicated multivariable problems, but you must recognize when and explain why they are or aren't solvable.

"Semiquantitative" reasoning involves anticipating how the structure of an equation will affect the result of a calculation, even when no values in the equation are known. Increasing a variable in the numerator of an equation increases the quantity being calculated; increasing a variable in the denominator decreases the quantity being calculated. Doubling a term in the numerator also doubles the entire quantity, except if that term is squared (in which case the quantity is quadrupled) or square-rooted (in which case the quantity is multiplied by 1.4).

For example, the question "Calculate the acceleration of the 250-g cart" will be legitimate on the AP Physics 1 Exam. But more often the question will be rephrased to get at the heart of your ability to reason about physics, not just at your math skills. For example:

- Rank the accelerations of these carts from greatest to least; justify your ranking.
- Can the acceleration of the 250-g cart be calculated from the given information? If not, what other information is required?
- Explain how you would use a graph to determine the acceleration of the 250-g cart.
- How would the acceleration of a 500-g cart compare to the acceleration of the 250-g cart?
- Is the acceleration of the cart greater than, less than, or equal to g?

6. AP Physics 1 Requires Familiarity with Lab Work

Every physics problem that asks for calculation, quantitative reasoning, or semiquantitative reasoning is, in truth, asking for an experimental prediction.

When doing calculations, what differentiates physics from math class? In physics, every calculation can, in principle, be verified by an experimental measurement. Merely using an equation to calculate that a cart's acceleration is 2.8 m/s per second is a math problem, one that you might see in an Algebra 1 class. It's only a physics problem because you can, in fact, go to a cabinet and pull out a 250-g cart and a motion detector that will measure the cart's acceleration. If you set up the situation that was described in the problem, you'd better get an acceleration of 2.8 m/s per second; otherwise, either the calculational approach was incorrect (e.g., the equation you used might not apply to this situation), or the experiment was set up inappropriately (e.g., the problem assumed a level surface, but your track was slanted).

What's particularly nice about AP Physics 1 is that almost every problem posed in this course can be set up for experimental measurement within the realm of most students' experience. Carts can be set up to collide in your classroom. It's straightforward to take smartphone video of cars on a freeway or of a roller coaster. Computerized data collection—generally using equipment from PASCO or Vernier—should be part of your

classroom experience, so that you're familiar with using force probes, motion detectors, photogates, and so on.[4]

Any physical situation can spawn a laboratory-based experimental question. Be prepared to describe experiments and to analyze data produced by experiments:

- Describe an experiment that uses commonly available laboratory equipment to measure the acceleration of the 250-g cart.
- In the laboratory, this table of the cart's speed as a function of time was produced. Use the data to determine the car's acceleration.
- The acceleration of the cart is calculated to be 2.8 m/s per second, but in the laboratory, a student measures the cart to have an acceleration of 4.1 m/s per second. Which of the following might explain the discrepancy between theory and experiment?

7. AP Physics 1 Does Not Require That You Perform a Specific Set of Programmed Laboratory Exercises

In AP Biology, students are expected to be familiar with, and to have actually done, a set of experiments. Biology exam questions will refer to these common experiments, expecting prior knowledge to carry students. This approach is completely different from that in AP Physics.

AP Physics certainly requires experimental skills, as described above. Teachers are required by the Course Audit to spend at least 25 percent of class time doing live, hands-on laboratory exercises. Yet, the actual nature of those exercises is left to the teacher. Since virtually every possible AP Physics 1 question can be set up as an experiment, there are limitless possibilities for lab work. Creativity in lab work is prized on the AP Physics exams.

It's critical that you don't think of the "lab" as a place where you follow the steps in a procedure to produce a canned result that matches your teacher's expectation. Rather, think of the lab as a place to play, a place to re-create the calculational problems you've been solving in class. Lab is a place where you test the equations and concepts to see if they work.

> That's silly. Of course these equations and concepts work. Do you really expect me, a high school student, to disprove the conservation of momentum in a collision? Really!

Yeah, no one expects you to win a Nobel Prize in your AP Physics 1 laboratory. What is expected is that you go beyond stating "facts" of physics as gospel. A physicist always asks, "What's the evidence?" "How do we know that?" The AP exam expects you to be able to use conservation of momentum to calculate the speed of a cart after collision, sure; but it also expects you to explain why conservation of momentum is valid in this situation and, this is important, to explain *what evidence exists that conservation of momentum is a valid principle in the first place.*

The "evidence" for each physics fact comes from an experiment. You should be able to articulate how an experiment could be designed to test the validity of any fact; you should be able to use equipment creatively to make a measurement of any quantity that might show up in a calculational problem.

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[4]If your classroom does *not* have at least one set of PASCO or Vernier probes, your school probably doesn't meet the requirements of the AP Course Audit. Access to some of the same type of laboratory equipment that is available in most colleges is a prerequisite for the College Board allowing a school to label its course as "AP." See the "AP Central" portion of the College Board's official website for details about the Course Audit.

8. AP Physics 1 Requires Writing

The free-response questions on the AP Physics 1 Exam will be more similar to those on the AP Biology or AP Economics exams than to those on AP Calculus exams. Do not expect to answer exclusively in mathematical symbols and numbers. Whereas a typical honors physics question asks primarily for a numerical result, the AP Physics 1 exam will ask for short answers, descriptions, and explanations "without equations or calculations."

This doesn't mean you need to develop your storytelling skills. The writing required is always straightforward and to the point. A perfect response on the AP Physics 1 Exam might draw all sorts of complaints from your English teacher. While you need to use (reasonably) grammatically correct sentences, your language and vocabulary should be simple, not flowery. Your sentence structure doesn't need to be varied and interesting. You don't need to grab your reader's attention or to segue appropriately between paragraphs and ideas.

Just write, without worrying about how your writing sounds to a professional. Imagine that the person reading your writing is a student at the same level of physics as you. Don't explain your answers the way you think a college professor would; explain your answers the way you wish your teacher would explain them—simply and clearly, but completely. Practice this sort of writing on your problem sets.

9. AP Physics 1 Requires "Multiple Representations" of Physics Concepts

This means you should be comfortable explaining physics with words, equations, diagrams, and numbers. When you solve problems in your physics class, practice using these elements in every solution—even if your teacher doesn't explicitly require them. In my own class, if a student doesn't use at least three of these four elements in response to a homework question, the student usually is required to redo the problem.

Don't be shy about drawing diagrams. Try doing your homework on graph paper or unlined paper, rather than on standard notebook paper. Think of the paper as a blank canvas that needs to be filled in with your understanding of the solution to a problem. Lined notebook paper is far too restricting. It implies that you should be writing rows of words, with maybe an equation. Words can be written on a diagram, possibly with arrows to point out the important parts. Graphs and pictures can be drawn anywhere. Equations don't have to be placed one after the other in columns. A series of equations, however you present them, should always include some words describing the purpose of the equations in the problem's solution.

Then on the exam, you'll be well practiced in interpreting every possible representation of a physics explanation. Don't worry: you'll be asked for such interpretations on the multiple-choice section, and you'll be asked to use multiple representations of concepts on the free-response questions.

10. The AP Physics 1 Exam Is Designed to Give You the Time You Need to Answer the Questions Posed

As the new exams were in the development process, it became clear that the heightened demands for writing, for experimental interpretation and description, and for multiple representations of physics concepts would require a lot of time and thought. The committees in charge of creating AP Physics 1 were in agreement that students must be given the time necessary to respond in a complete way.

The rule of thumb is to spend in the neighborhood of *two* minutes per point. You'll get 40 multiple choice questions to be completed in 80 minutes. Knock a few off quickly, and you can really think carefully about some while easily maintaining

the two-minute-per-problem pace. The free response section will include 40 points in 100 minutes. Yes, you'll need to work steadily without dawdling; otherwise, you might run out of time even on this exam. But you'll have time to think before you write; then you'll have time to write everything you need to communicate your answer.

Practice this sort of time management on your homework for physics class. Instead of doing a zillion homework problems as quickly as you can, try picking one or two for a full-on, long-form treatment. Answer using multiple representations. Explain the answer, how you got it, how it would change if the problem inputs changed, and why you used the fundamental approach you used. Make the solution so complete that it could serve as the basis for a set of PowerPoint slides that could present your solution to a classmate. And do it all in less than 30 minutes. When you can do that, you're ready for the AP Physics 1 Exam.

11. AP Physics 1 Is a Difficult, High-Level College Course

Some may get the impression that because calculation is minimized and so few topics are covered, this course will be a "piece of cake." Wrong. My own impression, and the impression of countless AP teachers, is that AP Physics 1 is substantially more difficult than any calculational physics course - *including AP Physics C mechanics.*

People have the false impression that "lots of writing" means "easy to get some credit, because I can use lots of big words full of sound and fury." You will find that the AP readers are as adept at recognizing baloney as they are at recognizing good physics. You will not be awarded points just for writing an equation, or just for using physics-sounding words. While partial credit on the free response will copiously available, that credit requires a good understanding of physics, even if that understanding is incomplete. Guesswork will not earn credit, even partial credit.

Every year, I hear wailing and gnashing of teeth from too many folks when score come out, because too many teachers and students still think of physics as plugging numbers into equations. But *you* won't wail, of course, because you've read this book; you know what to expect; and you know that a true understanding of physics requires that you be able to solve problems, explain how you solved them, explain what concepts you used to solve them, explain why those concepts apply, and explain how you could experimentally demonstrate your solution. Meanwhile, those with gnashed teeth remain stuck with the idea that just producing an answer is enough.

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How to Use Your Time

IN THIS CHAPTER

Summary: You'll need to set up a study plan that's personalized to fit your needs and the amount of time you have to prep for the test. This chapter provides information and advice to get you started and outlines what you can do if you have a full year, a semester, or only a few weeks left until test day.



Key Ideas

- It's not possible to "game" the test—you have to really know your physics. Last-minute cramming won't work since the exam tests your skills and understandings, not your ability to remember facts and formulas.
- The most important part of your test prep plan is your AP Physics 1 course.
- Personalize your study plan. Focus your test prep on the topics and types of questions that you find the most troublesome.
- Essential elements of any test prep plan are (1) familiarizing yourself with the test, (2) learning the best strategies to use in approaching each of the question types, and (3) taking practice tests.

Personalizing Your Study Plan

First, it's important for you to know that the AP Exam is an authentic physics test. What this means is that it's not possible to "game" this test—in order to do well, *you must know your physics*. It's not possible to slack off and then cram for the test and expect to do well.

The most important part of your study plan is your AP Physics 1 class, which is in fact designed to teach the knowledge and skills required on the exam. Diligent attention to all

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your lectures, demonstrations, and assignments will save you preparation time in the long run. (See Chapter 6 for strategies to get the most out of your class.)

Your study plan should be personalized based on your needs. Use the diagnostic tools in Step 2 to identify your weaknesses and then build a plan that focuses on these. If you're comfortable with kinematics and projectile problems, why would you spend any time on these? On the other hand, if you're worried about, say, collisions, then spend a couple of evenings reviewing and practicing how to deal with them. Focusing on weaknesses, rather than starting at the beginning and trying to review everything, will allow you to use the time you have to produce the maximum benefit.

Every reader of this book will have a different study plan. You can't follow some one-size-fits-all timetable, and you shouldn't start at the beginning of your course and try to review absolutely everything—you won't be able to do it. Your study plan depends not only on the topics you most need to review, but also on the types of exam questions you find most difficult, and the amount of time you have to study. Develop a realistic plan, and stick to it.

Regardless of when you start to prepare or how much content you want to review, your study plan should include these essential elements:

- Familiarize yourself with the test (Chapters 1 and 2).
- Learn the best strategies to approach each type of test question (Chapters 7 through 9).
- Take complete practice tests (Step 5).

Plan A: You Have a Full School Year to Prepare

If you're opening this book at the beginning of the school year, you're off to a good start. Here's what you can do:

First Semester

- Read Chapter 5 on how to get the most out of your AP Physics 1 class.
- Begin to familiarize yourself with the test (Chapters 1 and 2).
- Start practicing the strategies to approach the different types of questions found on the test (Chapters 7 through 9).
- You can work through the review chapters in this book (Chapters 10 to 18) as you study the same topics in your AP course. This will help you by providing a different perspective on the key content and ensuring you really understand the physics you need to know. Practice using the strategies presented in Chapters 7 through 9 to approach the test-like free-response questions at the end of each review chapter.

Second Semester

- Keep working through the review chapters as you progress through the physics course.
- About three months before the AP exam, use the diagnostic tools in Chapters 4 and 5 to assess your weaknesses. Try to identify both the content areas and types of questions you have the most difficulty with. Then focus your test prep review on the weaknesses you identify.

Six Weeks Before the Test

- Continue to focus on the areas of weakness that you identified based on the self-tests in Chapters 4 and 5.

- Review the strategies in Chapters 7 through 9 to make sure you approach the questions in ways that will help you get your best score.
- Be sure to take the practice tests (Step 5) a couple of weeks before the real test. These tests closely resemble the actual AP Physics 1 Exam. They will help you learn to pace yourself and allow you to experience what the test is really like. Then focus any final content review on the areas that proved troublesome on the practice tests. Also allocate some time to practice answering the question types that gave you the biggest problems.
- Be confident. You've worked all year, and you're really set to do your best.

Plan B: You Have One Semester to Prepare

Most students begin a test prep plan in the second semester. You should still have time to use this book to familiarize yourself with the test, learn the best strategies to approach each type of question, review the topics you find most troublesome, and take practice tests. Here's what you can do:

Second Semester

- Read Chapter 5 on how to get the most out of your AP Physics 1 class.
- Familiarize yourself with the test (Chapters 1 and 2).
- Practice the strategies to approach the different types of questions found on the test (Chapters 7 to 9).
- Two or three months before the AP exam, use the diagnostic tools in Chapters 4 and 5 to assess your weaknesses. Try to identify both the content areas and types of questions you have the most difficulty with. Then focus your test prep review on the topics you identify.

Six Weeks Before the Test

- Continue to focus on the areas of weakness that you identified based on the self-tests in Chapters 4 and 5.
- Review the strategies in Chapters 7 through 9 to make sure you approach the questions in ways that will help you get your best score.
- Be sure to take the practice tests (Step 5) a couple of weeks before the real test. They will help you learn to pace yourself and allow you to experience what the test is really like. Then focus any final content review on the areas in which you didn't do as well. Also practice the question types that proved problematic.
- Be confident. You know the test and the best strategies for the different question types. In addition, you've reviewed the areas in which you felt weakest, and you've taken a practice test. You're set to get a good score.

Plan C: You Have Six Weeks to Prepare

Six weeks should be plenty of time to prepare for the AP exam. You've been working diligently in your class all year, learning the topics as they've been presented. These last weeks should be spent putting it all together. Focus on the topics you feel you most need to review and on problems that cover multiple concepts in one question. Use your test prep time not to try to cram for the test (it won't work), but to familiarize yourself with the exam and

learn the best strategies to use to approach the different question types. Most important, take the practice tests in Step 5 of this book. Here's what you can do:

Six Weeks Before the Test

- Familiarize yourself with the test (Chapters 1 and 2).
- Practice the strategies to approach the different types of questions found on the test (Chapters 7 to 9).
- Use the diagnostic tools in Chapters 4 and 5 to assess your weaknesses. Try to identify both the content areas and types of questions you have the most difficulty with. Then pick only a few areas on which to focus your test prep review and learn them well. Don't try to cover everything.
- Be sure to take the practice tests (Step 5) at least a week before the real test. They will help you learn to pace yourself and give you a trial run so you can experience what the test is really like. Then focus any final content review on the areas on which you didn't do as well. Also focus on the question types that gave you the biggest problems.
- Be confident. You know the test and the best strategies for the different question types. In addition, you've reviewed the areas in which you felt weakest and you've taken a practice test. If you've also used your AP course to really learn physics, you're set to get a good score.