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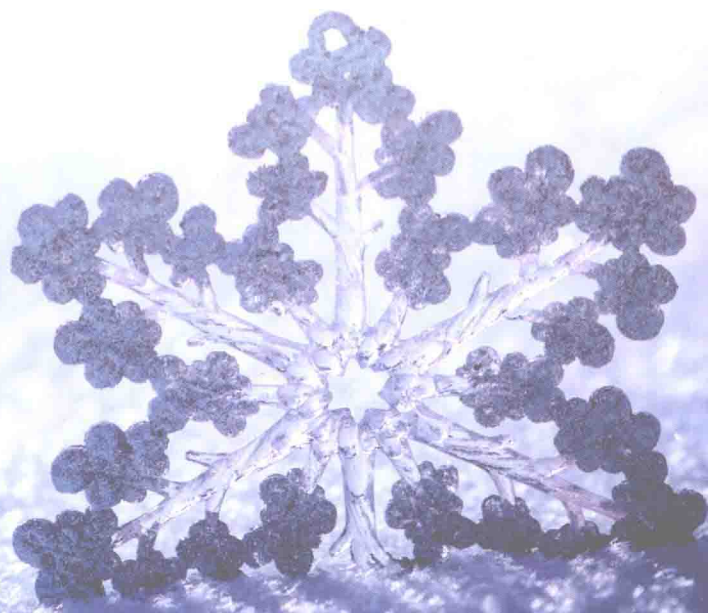
## 物理 B (第5版)

[美] 乔纳森·沃尔夫 (Jonathan Wolf) 编著

**Barron's AP  
Physics B  
5<sup>th</sup> Edition**

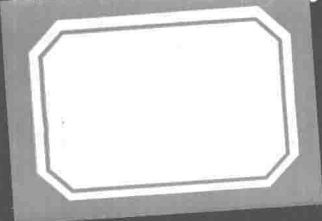
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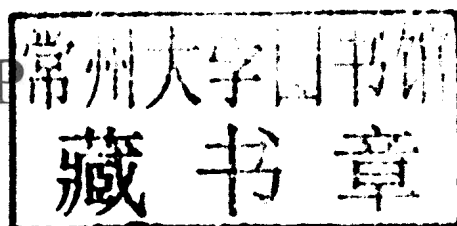
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# AP

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5<sup>th</sup> Edition



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by JONATHAN WOLF

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# Preface 前言

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In this review book, you will be taught several strategies for making your learning and studying more efficient. These are skills that will always be useful and that you can apply across the curriculum for many different subjects.

Each topical review chapter contains multiple-choice questions that differ in variety, style, and level of difficulty. Their purpose is to provide you with a balanced set of questions that test your level of understanding of the review material. Some questions may be easier or more difficult than the actual AP Physics B exam questions because, unlike the actual test, which covers a broad range of subjects, each chapter in this book deals with a specific topic. In addition to the multiple-choice questions there are free-response problems that also vary in difficulty. Full solutions and explanations follow the questions. Additional problem-solving strategies are also provided.

Before the review chapters, there is a diagnostic examination designed to measure your initial level of understanding or to use for practice. At the end of the book, two additional sample examinations are provided. Each examination is fully explained with solutions and guidelines.

This new fifth edition includes many changes. Included with some books is a CD-ROM, which has two more practice exams. Each exam has a self-assessment scoring guide as well as a guide for score improvement. I would like to thank a student, Alex Ramek, for helping me with the score improvement guide and helping me from a student's perspective. Additionally, more sample problems have been included in each of the chapters, and the practice tests have been updated. Each content chapter review begins with a listing of key concepts and ends with a brief summary of main ideas. My colleagues Robert Draper, Patricia Jablonowski, and Joseph Vaughan have been very helpful with insight and ideas for improvement.

I am grateful to Linda Turner, Senior Editor at Barron's Educational Series, for all her ideas and suggestions, and to my wife, Karen, and my daughters, Marissa and Ilana, for their understanding, love, and support.

Scarsdale, New York  
July 2010

Jonathan S. Wolf

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# Introduction to Advanced Placement Physics B AP物理B介绍

## KEY CONCEPTS

- About the Course
- About the Exam
- How to Use This Book

## 1.1 ABOUT THE COURSE 关于课程

Advanced Placement Physics B is a one-year, algebra-based survey course in college-level physics. If you have registered for this course, you should cover many different topics to prepare for the AP Physics B exam given in May of each year.

The curriculum guidelines for this course have been established by the College Board. You should consult their website [www.collegeboard.com](http://www.collegeboard.com) to obtain further information. Your teacher and guidance counselors will advise you on registration procedures. As a survey course in physics, you will explore motion, forces, energy, heat, waves, light, optics, electricity, magnetism, and modern physics. You can use many different textbooks, and the College Board's website lists several commonly used ones.

If this is your first physics class, you should be prepared to devote at least 30–45 minutes of work per night to keep up with the material. The types of problems you will be solving will vary in depth and detail. Learning how to solve problems in physics can be tricky, especially when they are not the traditional “plug and chug.” I hope this book will help you not only prepare for the examination in May but also help you during the year.

If this is your second physics course, then you have already been exposed to some of the major concepts of physics. You may have taken conceptual physics or project physics classes. These first courses may or may not have been algebra based. However, they did expose you to basic concepts early in your high school career. In that case, this year you will be exposed to some new concepts as well as a more in-depth look at some old concepts.

In either case, be assured that physics is a fundamental science that teaches you about how the universe works. These are exciting times for physics and engineering. Learning how to become an effective problem solver is a lifelong skill that is highly valued.

## 1.2 ABOUT THE EXAM 关于考试

The AP Physics B exam is designed by the Educational Testing Service (ETS) in Princeton, New Jersey. The exam is 3 hours long and consists of 2 parts that are 90 minutes each.

- Part I: 70 multiple-choice questions. No calculators or formulas are allowed for this part, but you will be given a table of information.
- Part II: 6–8 free-response problems of varying lengths and score weightings. You will be provided with a table of formulas, and you may use approved calculators for this part. Consult the College Board's website for further details.

Each part of the exam is worth 50 percent of your grade. Within Part II, though, each question may not be worth the same amount of points. For the multiple-choice questions, you will be graded on the number of correct answers.

Your final grade on the examination is based on a weighted curve that varies from year to year and is established by ETS after the exam is given. Final grades range from 1–5, with 5 being the highest. We will discuss test-taking strategies and study skills in the next chapter.

Since ETS copyrights their examinations, all practice examinations in review books are necessarily simulated. This means knowing exactly how you will do on an actual exam is difficult. However, if you study hard, practice, and use all of your skills, this book can help you to improve your score. This book contains three practice exams. If you purchased the edition with the CD-ROM, two additional exams are provided. All exams have answers fully explained and offer suggestions for self-assessment and score improvement. The general topics and approximate distribution of material for the AP Physics B exam are shown in the following table.

**TABLE 1.1**

### Test Topics and Distribution

Content Area	Approximate Percentage
<b>I. Newtonian Mechanics</b>	<b>35%</b>
<b>Kinematics</b> (which includes vectors, vector algebra, coordinate systems, displacement, velocity, acceleration, one-dimensional motion, and projectile motion)	7%
<b>Newton's laws</b> (which includes static and dynamic equilibrium, dynamics on one body, accelerated systems of two bodies, and friction)	9%
<b>Work, energy, and power</b> (which includes the work-energy theorem, work on a body, kinetic energy, gravitational and elastic potential energy, conservation of energy, and power)	5%
<b>Linear momentum</b> (which includes impulse, conservation of momentum, and collisions of systems of particles)	4%
<b>Circular motion and rotation</b> (which includes torque, uniform circular motion, and rotational equilibrium)	4%
<b>Oscillations and gravitation</b> (which includes simple harmonic motion, mass on a spring, simple pendulum, Newton's law of gravitation, and circular orbits)	6%

TABLE 1.1

**Test Topics and Distribution (*continued*)**

Content Area	Approximate Percentage
<b>II. Fluid Mechanics and Thermal Physics</b>	15%
<b>Fluid mechanics</b> (which includes hydrostatic pressure, buoyancy, fluid flow, and Bernoulli's equations)	6%
<b>Temperature and Heat</b> (which includes mechanical equivalent of heat, heat transfer, and linear expansions)	2%
<b>Kinetic theory and thermodynamics</b> (which includes ideal gases; kinetic model; first law of thermodynamics— $pV$ diagrams; second law of thermodynamics—heat engines)	7%
<b>III. Electricity and Magnetism</b>	25%
<b>Electrostatics</b> (includes static charges, Coulomb's law, electric fields, and electric potential)	5%
<b>Conductors and capacitors</b> (includes capacitance, parallel plates, and electrostatics with conductors)	4%
<b>Electric circuits</b> (includes direct current, Ohm's law, resistance, resistivity, power, simple circuits, series circuits, parallel circuits, combination circuits, and capacitors in steady state)	7%
<b>Magnetic fields</b> (includes forces on moving charges, forces on wires in external magnetic fields, and fields of long wires)	4%
<b>Electromagnetism</b> (includes induction, induced EMF, Faraday's law, and Lenz's law)	5%
<b>IV. Waves and Optics</b>	15%
<b>Wave motion</b> (includes traveling waves, sound, superposition, and standing waves)	5%
<b>Geometric optics</b> (includes light, reflection, refraction, mirrors, and lenses)	5%
<b>Physical optics</b> (includes diffraction, interference, dispersion, and electromagnetic radiation)	5%
<b>V. Atomic and Nuclear Physics</b>	10%
<b>Atomic physics and quantum effects</b> (includes photons, the photoelectric effect, the Compton effect, X rays, matter waves, wave-particle duality, and atomic energy levels)	7%
<b>Nuclear physics</b> (includes conservation of mass number and charge, and mass-energy equivalence)	3%

### 1.3 HOW TO USE THIS BOOK 如何使用本书

If you are using this book throughout the year, study each chapter as the topics are covered in class. At the end of each chapter are a series of multiple-choice questions and free-response problems. Since you will be reviewing specific content material, some of the multiple-choice questions may require you to use a calculator. Remember that on the actual AP exam, you cannot use a calculator for the multiple-choice questions. All of the multiple-choice questions in this book reflect the level of difficulty found on the exam.

The free-response questions at the end of the chapters review the content material. You may find that some of these questions are a bit difficult. On the practice exams, the free-response questions simulate the level of difficulty on the actual exam. As you proceed during the year, doing the end-of-chapter questions will help you to understand the material, help you in the classroom, and also help you prepare for the actual AP exam. When March arrives (see Chapter 2 for a timeline schedule), you can begin to do the diagnostic and practice exams. These are cross-indexed back to the appropriate content areas.

If you are using this book just before the AP exam, take the diagnostic test, assess what content areas you need to review, and then go back to those appropriate areas. You can then work through the appropriate content review followed by the remaining practice exams.

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## Chapter Summary 本章总结

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- AP Physics B is an algebra-based survey course in college physics.
- The AP Physics B exam is given in May of each year.
- The AP Physics B exam consists of 2 parts that are 90 minutes each. Part I consists of 70 multiple-choice questions. No calculators or formulas are allowed. Part II consists of 6–8 free-response problems. Calculators are allowed, and a formula sheet is provided.
- Contact the College Board at [www.collegeboard.com](http://www.collegeboard.com) for registration and exam information.
- Make sure all of your registration information is complete, and make a plan for studying during the year and before the examination.

# Study Skills and Tips

## 学习的技巧和提示

# 2

CHAPTER

### KEY CONCEPTS

- Units
- Relationships and Review of Mathematics
- Tips For Answering Multiple-Choice Questions
- Tips For Solving Free-Response Questions
- Study Skills and Scheduling Your Review

## 2.1 UNITS 单元

Preparing for an AP exam takes time and planning. In fact, your preparation should begin in September when you start the class. As mentioned in the last chapter, if you are using this review book during the year, the content review chapters should parallel what you are covering in class. If you are using this review book a few weeks prior to the exam in May, your strategy needs to change. The review material should help you refresh your memory as you work on the practice exams. In either case, you should have a plan.

In this chapter, we will look at study skills and tips for helping you do well on the Physics B exam. One of the most important things to remember is that most physical quantities have units associated with them. You must memorize units since you can be asked questions about them in the multiple-choice section. In the free-response questions, you must include all units when using equations, making substitutions, and writing final answers.

A list of standard fundamental (SI) units as well as a list of some derived units are shown in the following two tables. As you work through the different chapters, make a note (on index cards, for example) of each unit.

### TIP



Make sure you set up a review schedule.

### TIP



Make sure you memorize all units. Be sure to include them with all calculations and final answers.

**Table 2.1**

### Fundamental SI Units Used in Physics

Quantity	Unit Name	Abbreviation
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Amount of substance	Mole	mol

Table 2.2

## Some Derived SI Units Used in Physics

Quantity	Unit Name	Abbreviation	Expression in Other SI Units
Area			$\text{m}^2$
Velocity			$\text{m/s}$
Acceleration			$\text{m/s}^2$
Force	Newton	N	$\text{kg} \cdot \text{m/s}^2$
Momentum			$\text{kg} \cdot \text{m/s}$
Impulse			$\text{N} \cdot \text{s} = \text{kg} \cdot \text{m/s}$
Spring constant		N/m	$\text{kg/s}^2$
Frequency	Hertz	Hz	$\text{s}^{-1}$
Pressure	Pascal	Pa	$\text{N/m}^2 = \text{kg}/(\text{m} \cdot \text{s}^2)$
Work, energy	Joule	J	$\text{N} \cdot \text{m} = \text{kg} \cdot \text{m}^2/\text{s}^2$
Power	Watt	W	$\text{J/s} = \text{kg} \cdot \text{m}^2/\text{s}^3$
Electric charge	Coulomb	C	$\text{A} \cdot \text{s}$
Electric field		N/C	$\text{kg} \cdot \text{m}/(\text{A} \cdot \text{s}^3)$
Electric potential	Volt	V	$\text{J/C} = \text{kg} \cdot \text{m}^2/(\text{A} \cdot \text{s}^3)$
Resistance	Ohm	$\Omega$	$\text{V/A} = \text{kg} \cdot \text{m}^2/(\text{A}^2 \cdot \text{s}^3)$
Capacitance	Farad	F	$\text{C/V} = \text{A}^2 \cdot \text{s}^4/(\text{kg} \cdot \text{m}^2)$
Magnetic flux	Weber	Wb	$\text{V} \cdot \text{s} = \text{kg} \cdot \text{m}^2/(\text{A} \cdot \text{s}^2)$
Magnetic flux density	Tesla	T	$\text{Wb/m}^2 = \text{N}/(\text{A} \cdot \text{m}) = \text{kg}/(\text{A} \cdot \text{s}^2)$
Inductance	Henry	H	$\text{Wb/A} = \text{kg} \cdot \text{m}^2/(\text{A}^2 \cdot \text{s}^2)$

## 2.2 RELATIONSHIPS AND REVIEW OF MATHEMATICS

## 数学知识的联系和复习

## Reminder

These relationships are also useful for analyzing data to answer laboratory-based questions. A laboratory-based question is usually on the exam. See the Appendix for a review of graphing skills and data analysis techniques.

Since AP Physics B is an algebra-based course, the Appendix reviews some essential aspects of algebra. In physics, we often discuss how quantities vary using proportional relationships. Four special relationships are commonly used. You can review them in more detail by referring to Appendix A. You should memorize these relationships.

- Direct relationship—This is usually represented by the algebraic formula  $y = kx$ , where  $k$  is a constant. This is the equation of a straight line, starting from the origin. An example of this relationship is Newton's Second Law of Motion,  $\mathbf{a} = \frac{\mathbf{F}_{\text{net}}}{m}$ , which states that the acceleration of a body is directly proportional to the net force applied (see Chapter 7).

- Inverse relationship—This is usually represented by the algebraic formula  $y = \frac{k}{x}$ . This is the equation of a hyperbola. An example of this relationship can be seen in a different version of Newton's Second Law,  $\mathbf{F}_{\text{net}} = m\mathbf{a}$ . In this version, if a constant net force is applied to a body, the mass and acceleration are inversely proportional to each other. Some special relationships, such as gravitation and static electrical forces, are known as inverse square law relationships. The forces are inversely proportional to the square of the distances between the two bodies (see Chapters 12 and 15).
- Squared (quadratic) relationship—This is usually represented by the algebraic formula  $y = kx^2$  and is the equation of a parabola starting from the origin. An example of this relationship can be seen in the relationship between the displacement and uniform acceleration of a mass from rest  $\mathbf{d} = \frac{1}{2} \mathbf{a}t^2$  (see Chapter 5).
- Square root relationship—This is usually represented by the algebraic formula  $y = k\sqrt{x}$  and is the equation of a “sideways” parabola. This relationship can be seen in the relationship between the period of a simple pendulum and its length,  $T = 2\pi\sqrt{L/g}$  (see Chapter 11).
- As you review your material, you should know each of these relationships and their associated graphs (see Appendix A for more details).

## 2.3 TIPS FOR ANSWERING MULTIPLE-CHOICE QUESTIONS 选择题解答贴士

Without a doubt, multiple-choice questions can be tricky. The AP Physics B exam asks 70 multiple-choice questions. These can range from a simple recall of information to questions about units, graphs, proportional relationships, formula manipulations, and simple calculations (without a calculator). The questions cover all areas of the course. An approximate distribution of concepts was presented in Chapter 1.

One tip to remember is that there is no penalty for wrong answers. This means that you may want to try to answer all questions. Instead of randomly guessing, however, you can improve your chances of getting a correct answer if you can eliminate at least two answer choices. Guess intelligently.

When you read a multiple-choice question, try to get to the essential aspects. You have 90 minutes for this part, so do not waste too much time per question. Try to eliminate two or three choices. If a formula is needed, you may try to use approximations (or simple multiplication and division). For example, the magnitude of the acceleration due to gravity ( $g$ ) can be approximated as  $10 \text{ m/s}^2$ . You can also use estimations or order of magnitude approximations to see if answers make sense.

Remember, no formulas or calculators are allowed for this part. However, you are supplied with a table of information. As you work on the multiple-choice questions in the practice exams, look for distractors. These are choices that may look reasonable but are incorrect. For example, if the question is expecting you to divide to get an answer, the distractor may be an answer obtained by multiplying. Watch out for quadratics (such as centripetal force) or inverse squares (such as gravitation).

If you cannot recall some information, perhaps another similar question will cue you as to what you need to know. (You may work on only one part of the exam at a time.) When you read the question, try to link it to the overall general topic, such as

kinematics, dynamics, electricity. Then narrow down the specific area and the associated formula. Finally, you must know which quantities are vectors and which quantities are scalars (see Chapter 4).

Each multiple-choice question in the practice exams is cross-indexed with the general topic area of physics to guide you on your review. As you work on the exams and check your answers, you can easily go back to the topic area to review. At the start of your review, you may want to work on the multiple-choice questions untimed for the diagnostic and first practice exam. A few days before the exam (see the timeline schedule later in this chapter), you should do the last practice exam timed (90 minutes).

## 2.4 TIPS FOR SOLVING FREE-RESPONSE QUESTIONS

### 笔答题解答贴士

The AP Physics B exam includes 6–8 free-response questions. You have 90 minutes for this section. You may use an approved calculator. (Check the College Board's website for details.) A formula sheet is provided. One of the first things you may notice is that you are not given every formula you ever learned. Some teachers may let you use a formula sheet on their classroom exams, and some teachers may require you to memorize formulas. Even if you get to use a formula sheet on a classroom exam, you should memorize derivations and variations of formulas.

Since you are not given specific formulas for some concepts, you should begin learning how these formulas are derived starting at the beginning of the year. For example, you are not given the specific formulas for projectile motion problems since these are easily derived from the standard kinematics equations. If you begin reviewing a few weeks before the AP exam, you may want to make index cards of formulas to help you to memorize them.

For the free-response questions, each question may be worth a different amount. In fact, each subsection may be worth a different amount. However, each part of the exam is worth 50 percent of your grade to determine your “raw score.” As previously discussed, the curve for the exam changes from year to year.

You must read the entire question carefully before you begin. Make sure you know where the formulas and constants can be found on the supplied tables. Also, make sure that you have a working calculator with extra batteries.

As you begin to solve the problem, make sure that you write down the general concept being used, for example, conservation of mechanical energy or conservation of energy. Then, you must write down the equations you are using. For example, if the problem requires you to use conservation of mechanical energy (potential and kinetic energies), write out those equations:

Initial total mechanical energy = Final total mechanical energy

$$mgh_i + \frac{1}{2} m\mathbf{v}_i^2 = mgh_f + \frac{1}{2} m\mathbf{v}_f^2$$

When you are making substitutions, you must include the units! For example, if you are calculating net forces on a mass (such as a 2 kg mass that has an acceleration of 4 m/s<sup>2</sup>), you must write as neatly as possible:

$$\Sigma \mathbf{F} = \mathbf{F}_{\text{net}} = m\mathbf{a} = (2 \text{ kg})(4 \text{ m/s}^2) = 8 \text{ N}$$

#### TIP



Make sure you show all of your work on Part II. Include all formulas, substitutions with units, and general concepts used. Remember to label all diagrams. Communicate with the grader!

Include all relevant information. Communicate with the grader by showing him/her that you understand what the question is asking. You may want to make a few sketches or write down your thoughts in an attempt to find the correct solution path. If a written response is requested, make sure that you write neatly and answer the question in full sentences.

Sometimes the question refers to a lab experiment typically performed in class or simulated data is given. In that case, you may be asked to make a graph (refer to Appendix A). Make sure the graph is labeled correctly (with axes labeled and units clearly marked), points plotted as accurately as possible, and best-fit lines or curves used. Do not connect the dots. Always use the best-fit line for calculating slopes. Make sure you include your units when calculating slopes. Always show all of your work.

If you are drawing vectors, make sure the arrowheads are clearly visible. For angles, there is some room for variation. However, make sure you use your protractor correctly.

Since angles are measured in degrees, be sure your calculator is in the correct mode. If scientific notation is used, make sure you know how to input the numbers into your calculator correctly. Remember, each calculator is different.

If you are asked to draw a free-body diagram (see Chapter 7), make sure you include only actual applied forces. Do not include component forces. Centripetal force is not an applied force and should not be included on a free-body diagram.

What do you do if you are not sure how to solve a problem? Follow these 10 tips.

1. Make sure you understand the general concepts involved, and write them down.
2. Write down all appropriate equations.
3. Try to see how this problem may be similar to one you may have solved before.
4. Make sure you know which information is relevant and which information is irrelevant to what is being asked.
5. Rephrase the question in your mind. Maybe the question is worded in a way that is different from what you are used to.
6. Draw a sketch of the situation if one is not provided.
7. Write out what you think is the best way to solve the problem. This sometimes triggers or cues a solution.
8. Use numbers or estimations if the solution is strictly algebraic manipulation, such as deriving a formula in terms of given quantities or constants.
9. Relax. Sometimes if you move on to another problem, take a deep breath, close your eyes, and just relax for a moment, the tension and anxiety may go away and allow you to continue.
10. Do not leave anything out. Unlike on the multiple-choice questions, you need to show all of your work to earn credit.



### TIP

Make sure you have pencils, pens, a calculator, extra batteries, a metric ruler, and a protractor with you for the exam!

## 2.5 STUDY SKILLS AND SCHEDULING YOUR REVIEW 学习技巧和复习规划

Preparing for any Advanced Placement exam takes practice and time. Effective studying involves managing your time so that you efficiently review the material. Do not cram a few days before the exam. Getting a good night's sleep before the exam and

having a good breakfast the day of the exam is a better use of your time than “pulling an all-nighter.” Working in a study group is a good idea. Using index cards to make your own flash cards of key concepts, units, and formulas can also be helpful.

When you study, try to work in a well-lighted, quiet environment, when you are well rested. Studying late at night when you are exhausted is not an effective use of your time. Although some memorization may be necessary, physics is best learned (and studied) by actively solving problems. Remember, if you are using this book during the year, working through the chapter problems as you cover each topic in class, memorizing the units, and familiarizing yourself with the formulas at that time will make your studying easier in the days before the exam.

If you are using this book in the weeks before the exam, make sure you are already familiar with most (if not all) of the units, equations, and topics to be covered. You can either use the chapter review for a quick overview and practice or dive right in to the diagnostic exam. You do not need to take the diagnostic test under timed conditions. See how you do, and then review the concepts for those questions that you got wrong. You can use the end-of-chapter questions (some of which may be more difficult than the actual AP exam) to test your grasp of specific topics and then work on the remaining practice exams.

Setting up a workable study schedule is also vital to success. Each person's needs are different. The following schedule is just one example of an effective plan.

**Table 2.3**

**Test Prep Schedule**

September 1–April 15	As the year progresses, make sure you memorize units and are comfortable with formulas. If you are using this book during the year, do end-of-chapter problems as they are covered in class. Make sure you register for the exam, following school procedures, and refer to the College Board's website for details: <a href="http://www.collegeboard.com">www.collegeboard.com</a>
Four weeks before the exam	Most topics should be covered by now in class. If you are using this book for the first time, begin reviewing concepts and doing the end-of-chapter problems. Begin reviewing units and formulas. Devote at least 30 minutes each day to studying.
Three weeks before the exam	Start working on the diagnostic exam. Go back and review topics that you are unsure of or feel that you answered incorrectly.
Two weeks before the exam	Begin working on practice exams. The CD-ROM edition of this book has two additional practice exams. Continue to review old concepts.
One week before the exam	Do the remaining practice exams timed. Make sure you are comfortable with the exam format and know what to expect. Review any remaining topics and units.
The day before the exam	Pack up your registration materials, pens, pencils, calculator, extra batteries, metric ruler, and a protractor. Put them by the door, ready to go. Get a good night's sleep.
The day of the exam	Have a good breakfast. Make sure you take all the items you prepared the night before. Relax!

## Chapter Summary 本章总结

- Make sure you set up a manageable study schedule well in advance of the exam.
- Make sure you memorize all units and are familiar with the exam format.
- Multiple-choice questions do not have a penalty for wrong answers, so do not skip any. If you are unsure of the answer, try to eliminate as many choices as you can, and then guess!
- Do not leave any question out on the free-response part! Show all of your work. Write down all fundamental concepts, write all equations used, and include units for all substitutions and in your final answer.
- Read each question carefully. Write your answers clearly. On the multiple-choice questions, make sure you have a #2 pencil and bubble in all information carefully. Write out short-answer questions in full sentences. Clearly label graphs with units and use best-fit lines or curves.
- Try to relax and do all of the practice exams. Work on the chapter questions to review concepts as needed.
- Get a good night's sleep before the exam.
- On the day of the exam, bring all registration materials with you, as well as pens, pencils, calculators, extra batteries, a metric ruler, and a protractor.

Relax and Good Luck!

