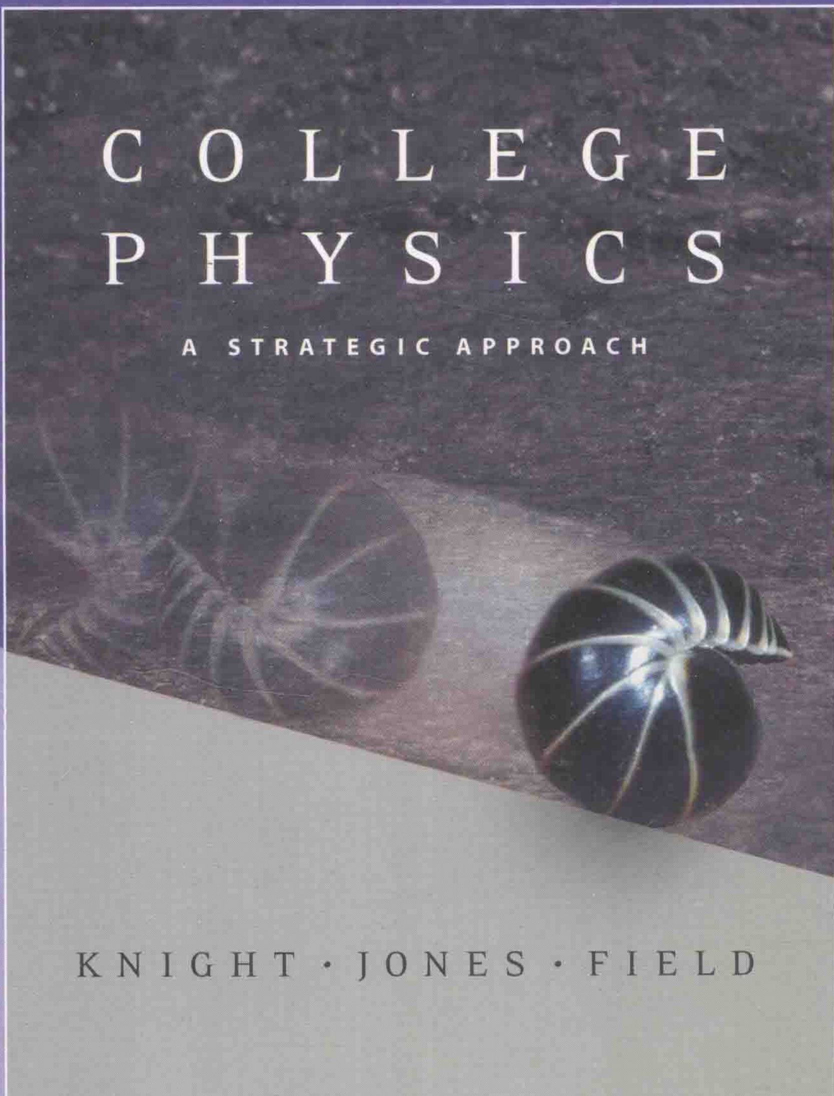
STUDENT WORKBOOK

COLLEGE PHYSICS

A STRATEGIC APPROACH

KNIGHT · JONES · FIELD



VOLUME 1

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Preface

It is highly unlikely that one could learn to play the piano by only reading about it. Similarly, reading physics from a textbook is not the same as doing physics. To develop your ability to do physics, your instructor will assign problems to be solved both for homework and on tests. Unfortunately, it is our experience that jumping right into problem solving after reading and hearing about physics often leads to poor "playing" techniques and an inability to solve problems for which the student has not already been shown the solution (which isn't really "solving" a problem, is it?). Because improving your ability to solve physics problems is one of the major goals of your course, time spent developing techniques that will help you do this is well spent.

Learning physics, as in learning any skill, requires regular practice of the basic techniques. That is what this *Student Workbook* is all about. The workbook consists of exercises that give you an opportunity to practice techniques and strengthen your understanding of concepts presented in the textbook and in class. These exercises are intended to be done on a daily basis, right after the topics have been discussed in class and are still fresh in your mind. Successful completion of the workbook exercises will prepare you to tackle the more quantitative end-of-chapter homework problems in the textbook.

You will find that many of the exercises are *qualitative* rather than *quantitative.* They ask you to draw pictures, interpret graphs, use ratios, write short explanations, or provide other answers that do not involve calculations. A few math-skills exercises will ask you to explore the mathematical relationships and symbols used to quantify physics concepts, but do not require a calculator. The purpose of all of these exercises is to help you develop the basic thinking tools you'll later need for quantitative problem solving. It is highly recommended that you do these exercises *before* starting the end-of-chapter problems

One example from Chapter 4 illustrates the purpose of this *Student Workbook.* In that chapter, you will read about a technique called a "free-body diagram" that is helpful for solving problems involving forces. Sometimes students mistakenly think that the diagrams are used by the instructor only for teaching purposes and may be abandoned once Newton's laws are fully understood. On the contrary, professional physicists with decades of problem-solving experience still routinely use these diagrams to clarify the problem and set up the solution. Many of the other techniques practiced in the workbook, such as ray diagrams, graphing relationships, sketching field lines and equipotentials, etc., fall in the same category. They are used at all levels of physics, not just as a beginning exercise. And many of these techniques, such as analyzing graphs and exploring multiple representations of a situation, have important uses outside of physics. Time spent practicing these techniques will serve you well in other endeavors.

You will find that the exercises in this workbook are keyed to specific sections of the textbook in order to let you practice the new ideas introduced in that section. You should keep the text beside you as you work and refer to it often. You will usually find Tactics Boxes, figures, or examples in the textbook that are directly relevant to the exercises. When asked to draw figures or diagrams, you should attempt to draw them so that they look much like the figures and diagrams in the textbook.

Because the exercises go with specific sections in the text, you should answer them on the basis of information presented in *just* that section (and prior sections). You may have learned new ideas in Section 7 of a chapter, but you should not use those ideas when answering questions from Section 4. There will be ample opportunity in the Section 7 exercises to use that information there.

You will need a few "tools" to complete the exercises. Many of the exercises will ask you to *color code* your answers by drawing some items in black, others in red, and perhaps yet others in blue. You need to purchase a few colored pencils to do this. The authors highly recommend that you work in pencil, rather than ink, so that you can easily erase. Few are the individuals who make so few mistakes as to be able to work in ink! In addition, you'll find that a small, easily carried six-inch ruler will come in handy for drawings and graphs.

As you work your way through the textbook and this workbook, you will find that physics is a way of *thinking* about how the world works and why things happen as they do. We will primarily be interested in finding relationships, seeking explanations, and developing techniques to make use of these relationships, only secondarily in computing numerical answers. In many ways, the thinking tools developed in this workbook are what the course is all about. If you take the time to do these exercises regularly and to review the answers, in whatever form your instructor provides them, you will be well on your way to success in physics.

To the instructor: The exercises in this workbook can be used in many ways. You can have students work on some of the exercises in class as part of an active-learning strategy. Or you can do the same in recitation sections or laboratories. This approach allows you to discuss the answers immediately, to answer student questions, and to improvise follow-up exercises when needed. Having the students work in small groups (2 to 4 students) is highly recommended.

Alternatively, the exercises can be assigned as homework. The pages are perforated for easy tear-out, and the page breaks are in logical places so that you can assign the sections of a chapter that you would likely cover in one day of class. Exercises should be assigned immediately after presenting the relevant information in class and should be due at the beginning of the next class. Collecting them at the beginning of class, then going over two or three that are likely to cause difficulty, is an effective means of quickly reviewing major concepts from the previous class and launching a new discussion.

If used as homework, it is *essential* for students to receive *prompt* feedback. Ideally this would occur by having the exercises graded, with written comments, and returned at the next class meeting. Posting fairly detailed answers on a course website also works. Lack of prompt feedback can negate much of the value of these exercises. Placing similar qualitative/graphical questions on quizzes and exams, and telling students at the beginning of the term that you will do so, encourages students to take the exercises seriously and to check the answers.

One of the authors has been successful with assigning *all* exercises in the workbook as homework, collecting and grading them every day through Chapter 4, then collecting and grading them on about one-third of subsequent days on a random basis. The other author uses the exercises in class as immediate practice of the techniques demonstrated in the text and on the chalkboard. Student feedback from end-of-term questionnaires reveals three prevalent attitudes toward the workbook exercises:

i. They think it is an unreasonable amount of work.
ii. They agree that the assignments force them to keep up and not get behind.
iii. They recognize, by the end of the term, that the workbook is a valuable learning tool.

However you choose to use these exercises, they will significantly strengthen your students' conceptual understanding of physics.

Following the workbook exercises are optional Dynamics Worksheets, Momentum Worksheets, and Energy Worksheets for use with end-of-chapter problems in Parts I and II of the textbook. Their use is recommended to help students acquire good problem-solving habits early in the course. End-of-chapter problems marked with the icon are intended to be done on worksheets.

Answers to all workbook exercises are provided as pdf files on the *Media Manager* CD-ROM.

Acknowledgments: The authors would like to thank Rebecca L. Sobinovsky and Jared Sterzer.

Table of Contents

1 Concepts of Motion and Mathematical Background

1.1 Motion: A First Look

Exercises 1–5: Draw a motion diagram for each motion described below.

- Use the particle model to represent the object as a particle.
- Six to eight dots are appropriate for most motion diagrams.
- Number the positions in order, as shown in Figure 1.4 in the text.
- Be neat and accurate!

1. A car accelerates forward from a stop sign. It eventually reaches a steady speed of 45 mph.

2. An elevator starts from rest at the 100th floor of the Empire State Building and descends, with no stops, until coming to rest on the ground floor. (Draw this one *vertically* since the motion is vertical.)

3. A skier starts *from rest* at the top of a 30° snow-covered slope and steadily speeds up as she skies to the bottom. (Orient your diagram as seen from the *side*. Label the 30° angle.)

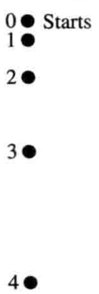
4. The space shuttle orbits the earth in a circular orbit, completing one revolution in 90 minutes.

5. Bob throws a ball at an upward 45° angle from a third-story balcony. The ball lands on the ground below.

Exercises 6–9: For each motion diagram, write a short description of the motion of an object that will match the diagram. Your descriptions should name *specific* objects and be phrased similarly to the descriptions of Exercises 1 to 5. Note the axis labels on Exercises 8 and 9.

6.

7.



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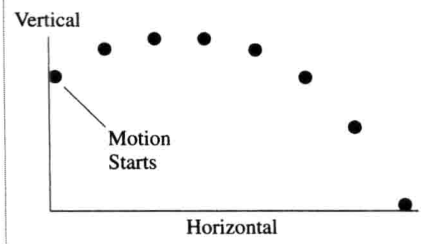

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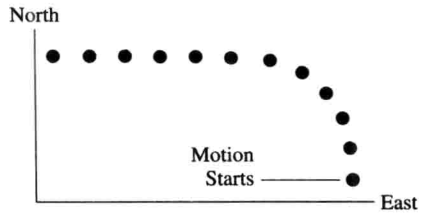
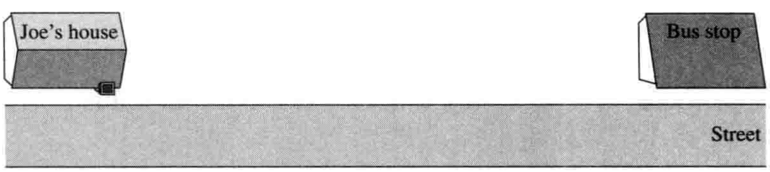


1.2 Position and Time: Putting Numbers on Nature

10. Redraw each of the motion diagrams from Exercises 1 to 3 in the space below. Add a coordinate axis to each drawing and label the initial and final positions. Draw an arrow on your diagram to represent the displacement from the beginning to the end of the motion.

11. In the picture below Joe starts walking casually at constant speed from his house on Main Street to the bus stop 200 m down the street. When he is halfway there, he sees the bus and steadily speeds up until he reaches the bus stop.
    a. Draw a motion diagram in the street of the picture to represent Joe's motion.
    b. Add a coordinate axis below your diagram with Joe's house as the origin. Label Joe's initial position at the start of his walk as x_1, his position when he sees the bus as x_2, and his final position when he arrives at the bus stop as x_3. Draw arrows above the coordinate axis to represent Joe's displacement from his initial position to his position when he first sees the bus and the displacement from where he sees the bus to the bus stop. Label these displacements Δx_1 and Δx_2, respectively.



    c. Repeat part b in the space below but with the origin at the location where Joe starts to speed up.

    d. How do the displacement arrows change when you change the location of the origin?

1.3 Velocity

12. A moth flies a distance of 3 m in only one-third of a second.
    a. What does the ratio 3/(1/3) tell you about the moth's motion? Explain.

    b. What does the ratio (1/3)/3 tell you about the moth's motion?

    c. How far would the moth fly in one tenth of a second?

    d. How long does it take the moth to fly 4 m?

13. a. If someone drives at 25 miles per hour, is it necessary that they do so for an hour?

    b. Is it necessary to have a cubic centimeter of gold to say that gold has a density of 19.3 grams per cubic centimeter? Explain.

1.4 A Sense of Scale: Significant Figures, Scientific Notation, and Units

14. How many significant figures does each of the following numbers have?

a. 6.21 ______ e. 0.0621 ______ i. 1.0621 ______

b. 62.1 ______ f. 0.620 ______ j. 6.21×10^3 ______

c. 6210 ______ g. 0.62 ______ k. 6.21×10^{-3} ______

d. 6210.0 ______ h. .62 ______ l. 62.1×10^3 ______

15. Compute the following numbers, applying the significant figure standards adopted for this text.

a. $33.3 \times 25.4 =$ ______ e. $2.345 \times 3.321 =$ ______

b. $33.3 - 25.4 =$ ______ f. $(4.32 \times 1.23) - 5.1 =$ ______

c. $33.3 \div 45.1 =$ ______ g. $33.3^2 =$ ______

d. $33.3 \times 45.1 =$ ______ h. $\sqrt{33.3} =$ ______

16. Express the following numbers and computed results in scientific notation, paying attention to significant figures.

a. $9{,}827 =$ ______ d. $32{,}014 \times 47 =$ ______

b. $0.000000550 =$ ______ e. $0.059 \div 2{,}304 =$ ______

c. $3{,}200{,}000 =$ ______ f. $320. \times 0.050 =$ ______

17. Convert the following to SI units. Work across the line and show all steps in the conversion. Use scientific notation and apply the proper use of significant figures. **Note:** Think carefully about g and h. A picture may help.

a. 9.12 μs ×

b. 3.42 km ×

c. 44 cm/ms ×

d. 80 km/hr ×

e. 60 mph ×

f. 8 in ×

g. 14 in^2 ×

h. 250 cm^3 ×

18. Use Tables 1.4 and 1.5 and Examples 1.2 and 1.3 to assess whether or not the following statements are *reasonable*.

a. Joe is 180 cm tall.

b. I rode my bike to campus at a speed of 50 m/s.

c. A skier reaches the bottom of the hill going 25 m/s.

d. I can throw a ball a distance of 2 km.

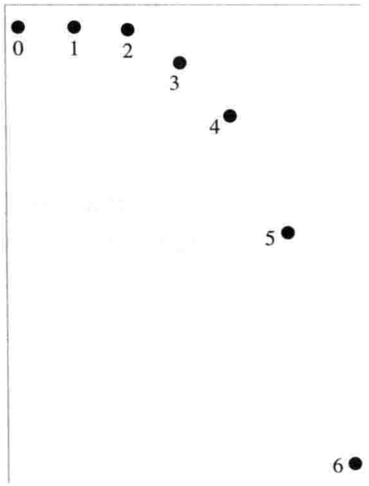
e. I can throw a ball at a speed of 50 km/hr.

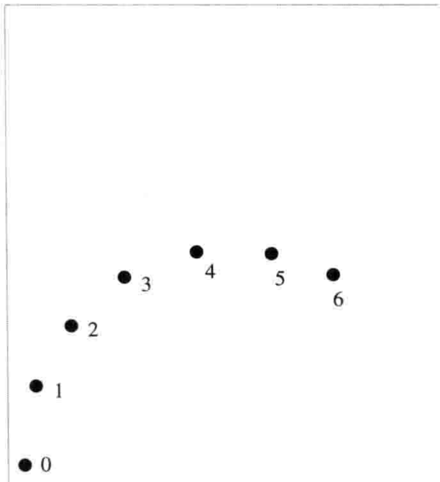
f. Joan's newborn baby has a mass of 33 kg.

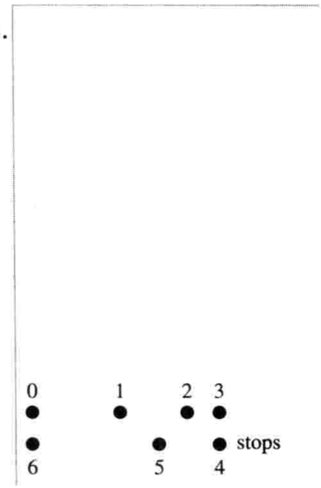
g. A typical hummingbird has a mass of 3.3 g.

1.5 Vectors and Motion: A First Look

19. For the following motion diagrams, draw an arrow to indicate the displacement vector between the initial and final positions.

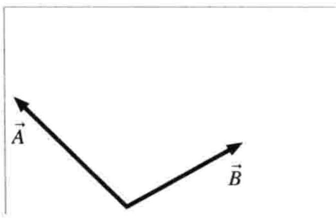
a.


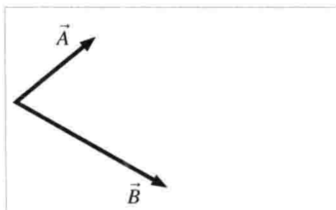
b.


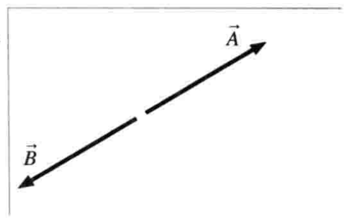
c.


20. In Exercise 19, is the object's displacement equal to the distance the object travels? Explain.

21. Draw and label the vector sum $\vec{A} + \vec{B}$.

a.


b.


c.


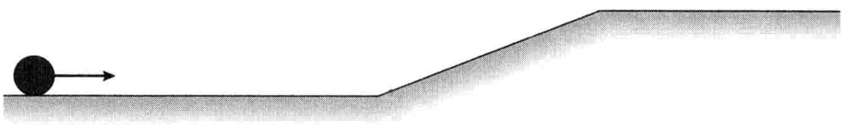
Exercises 22–26: Draw a motion diagram for each motion described below.

- Use the particle model.
- Show and label the *velocity* vectors.

22. Galileo drops a ball from the Leaning Tower of Pisa. Consider the ball's motion from the moment it leaves his hand until a microsecond before it hits the ground. Your diagram should be vertical.

23. A rocket-powered car on a test track accelerates from rest to a high speed, then coasts at constant speed after running out of fuel. Draw a dotted line across your diagram to indicate the point at which the car runs out of fuel.

24. A bowling ball being returned from the pin area to the bowler starts out rolling at a constant speed. It then goes up a ramp and exits onto a level section at very low speed. You'll need 10 or 12 points to indicate the motion clearly.



25. A car is parked on a hill. The brakes fail, and the car rolls down the hill with an ever-increasing speed. At the bottom of the hill it runs into a thick hedge and gently comes to a halt.

26. Andy is standing on the street. Bob is standing on the second-floor balcony of their apartment, about 30 feet back from the street. Andy throws a baseball to Bob. Consider the ball's motion from the moment it leaves Andy's hand until a microsecond before Bob catches it.

1.6 Making Models: The Power of Physics

27. One of the difficulties some students have in beginning physics is with the use of algebra involving unfamiliar symbols. As a warmup for what's to come, algebraically solve the following equations for the specified variables in terms of the other symbols given:

a. Solve for t: $v = v_0 + at$

b. Solve for x: $t = \left(\frac{2x}{a}\right)^{1/2}$

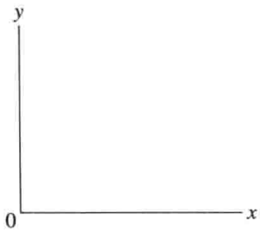
c. Solve for s: $\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$

d. Eliminate T from the two equations and solve for a:

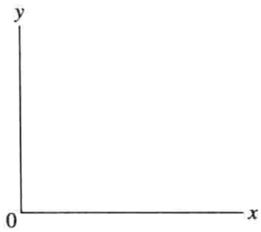
$$T - m_1 g = m_1 a$$
$$m_2 g - T = m_2 a$$

28. On the axes below, sketch a graph of y versus x if y is given by the equation shown. Assume that m and b are both positive numbers. The goal is to sketch a graph with the proper *shape*.

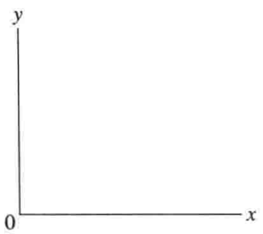
a. $y = mx + b$



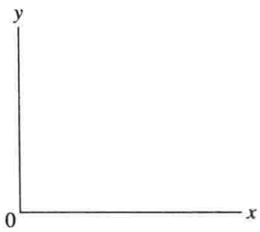
b. $y = mx^2$



c. $y = m/x^2$



d. $y^2 = mx$



1.7 Where Do We Go from Here?

No exercises for this section.

2 Motion in One Dimension

2.1 Describing Motion

1. Sketch position-versus-time graphs for the following motions. Include a numerical scale on both axes with units that are *reasonable* for this motion. Some numerical information is given in the problem, but for other quantities make reasonable estimates.

   Note: A *sketched* graph simply means hand-drawn, rather than carefully measured and laid out with a ruler. But a sketch should still be neat and as accurate as is feasible by hand. It also should include labeled axes and, if appropriate, tick-marks and numerical scales along the axes.

   a. A student walks to the bus stop, waits for the bus, then rides to campus. Assume that all the motion is along a straight street.

   b. A student walks slowly to the bus stop, realizes he forgot his paper that is due, and *quickly* walks home to get it.

   c. The quarterback drops back 10 yards from the line of scrimmage, then throws a pass 20 yards to the tight end, who catches it and sprints 20 yards to the goal. Draw your graph for the *football*. Think carefully about what the slopes of the lines should be.