STUDY GUIDE
STUDENT SOLUTIONS MANUAL

BO LOU

COLLEGE
PHYSICS

JERRY D. WILSON/ANTHONY J. BUFFA

HIRD EDITION

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Preface

This **Study and Guide and Student Solutions Manual** for **College Physics**, third edition, was prepared to help students gain a greater understanding of the principles of their introductory physics courses. Most of us learn by summary and examples, and this manual has been organized along these lines. For each chapter you will find:

- **Chapter Objectives**
  states the learning goals for the chapter. The objectives tell you what you should know upon completion of chapter study. Your instructor may omit some topics.

- **Key Terms**
  lists the key terms for the chapter. The definitions and/or explanations of the most important key terms can be found in the next section.

- **Chapter Summary and Discussion**
  outlines the important concepts and provide a brief overview of the major chapter contents. Extra worked out examples are included to further strengthen the concepts and principles. This review allows you to check the thoroughness of your study and serves as a last minute quick review (about 30 minutes) before quizzes or tests. Common students' mistakes and misconceptions are noted.

- **Mathematical Summary**
  lists the important mathematical equations in the chapter. The purpose is for self-review. You should be identify each symbol in an equation and explain what relationship the equation describes. The equation number in the text is included for reference. A last glance of this section is helpful before taking a test or quiz.

- **Solutions to Selected Exercises and Paired Exercises**
  provides the worked out solutions of the even-numbered annotated (blue dot) end-of-chapter text exercises. The paired exercises are similar in nature. You should try to work out the even-numbered paired text exercise independently and then check your work with solutions in this manual. After working the odd-numbered exercise of a pair, you can check your answer in the Answers to Odd-

Numbered Exercises at the back of the text. Solutions for some additional end-of-the-chapter exercises are also included.

- **Practice Quiz**

  consists of multiple choice questions and problems of the most fundamental concepts and problem solving skills in the chapter. This allows you to self-check your knowledge of the chapter. The answers to the quizzes are also given.

As you can see, this manual provides a through review for each chapter. The conscientious student can make good use of the various sections to assist in understanding and mastering the course contents and preparing for exams. I hope you find it so.

ACKNOWLEDGMENT

I would like to thank the following people and organizations for their enormous help and support.

First to the authors, Jerry D. Wilson and Anthony J. Buffa, for their meticulous checking of my work and numerous constructive and helpful comments and discussions.

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To the editors of Prentice Hall, Tim Bozik, Paul Corey, Alison Reeves, and Wendy Rivers, for their guidance, and Pam Holland-Moritz for assistance.

To Carolyn Gauntt for proof-reading this manual.

Last but not the least, to my family, Lingfei and Alina, for their essential and generous support and love. I dedicate this manual to them.

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CHAPTER 1

Units and Problem Solving

I. Chapter Objectives

Upon completion of this chapter, you should be able to:

1. distinguish standard units and system of units.
2. describe the SI and specify the references for the three main base quantities of this system.
3. use common metric prefixes and nonstandard metric units.
4. explain the advantage of and apply dimensional analysis and unit analysis.
5. explain conversion factor relationships and apply them in converting units within a system, or from one system of units to another.
6. determine the number of significant figures in a numerical value and report the proper number of significant figures after performing simple calculations.
7. establish a problem-solving procedure and apply it to typical problems.

II. Key Terms

Upon completion of this chapter, you should be able to define and/or explain the following key terms:

standard unit
system of units
International System of Units (SI)
SI base units
SI derived units
meter (m)
kilogram (kg)
second (s)
mks system
cgs system
fps system
liter (L)
dimensional analysis
unit analysis
density (ρ)
conversion factor
exact number
measured number
significant figures (sf).

The definitions and/or explanations of the most important key terms can be found in the following section: **III. Chapter Summary and Discussion**.

III. Chapter Summary and Discussion

1. International System of Units (SI)

Objects and phenomena are measured and described using **standard units**, a group of which makes up a **system of units**.

(1) The International System of Units (SI), or the metric system, has only seven (see Table 1.1) base units. The base units for length, mass, and time are the **meter** (m), the **kilogram** (kg), and the **second** (s), respectively. A derived unit is a combination of the base units. For example, the units of speed, **meters per second**, are a combination of **meter** and **second**. There are many derived units.

(2) The metric system is a base-10 (decimal) system, which is very convenient in changing measurements from one unit to another. Metric multiples are designated by prefixes, the most common of which are **kilo–** (1000), **centi–**(1/100), and **milli–**(1/1000). For example, a centimeter is 1/100 of a meter, etc. A complete list of the metric prefixes is given in Table 1.2. A unit of volume or capacity is the **liter** (L), and 1 L = 1000 mL = 1000 cm^3 (cubic centimeters).

2. Dimensional Analysis

Fundamental base quantities, such as length, mass, and time are called **dimensions**. These are commonly expressed by bracketed symbols [L], [M], and [T], respectively. **Dimensional analysis** is a procedure by which the dimensional correctness of an equation may be checked. Both sides of an equation must not only be equal in numerical value, but also in dimension; and dimensions can be treated like algebraic quantities. Units, instead of symbols, may be used in **unit analysis**.

Dimensional analysis can be used to

(1) check whether an equation is **dimensionally correct**, i.e., if an equation has the same dimension (unit) on both sides.

(2) find out dimension or units of derived quantities.

Example 1.1: Check whether the equation $v^2 = 2ax$ is dimensionally correct, where x is length, v is velocity, and a is acceleration.

Solution: The dimensions and units of x, v, and a, are [L], m; $\frac{[L]}{[T]}$, m/s; and $\frac{[L]}{[T]^2}$, m/s^2; respectively.

Dimensional analysis: Dimension of left side is $\left(\frac{[L]}{[T]}\right)^2 = \frac{[L]^2}{[T]^2}$.

Dimension of right side is $2\frac{[L]}{[T]^2}[L] = 2\frac{[L]^2}{[T]^2}$.

So the dimension of the left side is equal to the dimension of the right side and the equation is dimensionally correct. Note: dimensionally correct does not necessarily mean the equation is correct. For example, the "equation", 2 tables = 3 tables, is dimensionally correct, but not numerically correct.

Unit analysis: Units of the left side are $(m/s)^2 = m^2/s^2$.

Units of the right side are $2\,(m/s^2)(m) = 2\,m^2/s^2$.

So the units of the left side are equal to the units of the right side and the equation is dimensionally correct.

Example 1.2: Newton's second law states that the force on a body is equal to its mass times its acceleration. Determine the dimension and units for force.

Solution: Since force is equal to mass times acceleration, the dimension (units) of force must be equal to the dimension (units) of mass times the dimension (units) of acceleration.

So the dimension of force is $[M] \times \frac{[L]}{[T]^2} = \frac{[M]\cdot[L]}{[T]^2}$, and the units of force is $kg \times m/s^2 = kg\cdot m/s^2$, which is called newton (N).

---

3. Conversions of Units

A quantity may be expressed in other units through the use of **conversion factors** such as (1 mi/1609 m) or (1609 m/1 mi). Note that any conversion factor is equal to 1 and so they can be multiplied or divided to any quantity without altering the quantity. The appropriate form of a conversion factor is easily determined by dimensional (unit) analysis.

Example 1.3: Convert 3200 meters to miles.

Solution: Here we need to convert meters to miles. We can accomplish this by using the conversion factor (1 mi/1609 m). The result units will be $m \times (mi/m) = mi$. We cannot multiply (1609 m/1 mi) because the result units would be $m \times (m/mi) = m^2/mi$.

$$(3200\ \text{m}) \times \frac{1\ \text{mi}}{1609\ \text{m}} = 1.99\ \text{mi} \approx 2.0\ \text{mi}.$$ Note the cancellation of the units m.

We can also use the conversion factor (1609 m/1 mi). Then we have to divide 3200 m by (1609 m/1 mi) in order to get mi. $\dfrac{3200\ \text{m}}{\dfrac{1609\ \text{m}}{1\ \text{mi}}} \approx 2.0\ \text{mi}.$

Example 1.4: Convert 55 mi/h (miles per hour) to m/s.

Solution: Here we need to convert miles to meters *and* hours to seconds. We can use the conversion factor (1609 m/1 mi) to convert miles to meters and (1 h/3600s) to convert 1/h to 1/s [why can't we use (3600 s/1 h)?]

$$(55\ \text{mi/h}) \times \frac{1609\ \text{m}}{1\ \text{mi}} \times \frac{1\ \text{h}}{3600\ \text{s}} = 25\ \text{m/s}.$$

We can also use the direct conversion (1 mi/h = 0.447 m/s). $(55\ \text{mi/h}) \times \dfrac{0.447\ \text{m/s}}{1\ \text{mi/h}} = 25\ \text{m/s}.$

---

4. Significant Figures

The number of **significant figures** in a quantity is the number of reliably known digits it contains. In general, *the final result of a multiplication and/or division should have the same number of significant figures as the quantity with the least number of significant figures used in the calculation. The final result of an addition and/or subtraction should have the same number of decimal places as the quantity with the least number of decimal places used in the calculation.* The proper number of figures or digits is obtained by rounding off a result.

Example 1.5: Perform the following operations:

(a) $0.586 \times 3.4 =$

(b) $13.90 \div 0.580 =$

(c) $(13.59 \times 4.86) \div 2.1 =$

(d) $4.8\times10^{5} \div 4.0\times10^{-3} =$

(e) $(3.2\times10^{8})(4.0\times10^{4}) =$

Solution: The final result of the multiplication and/or division should have the same number of significant figures as the quantity with the least number of significant figures.

(a) $0.586 \times 3.4 = 2.0$.

(b) $13.90 \div 0.580 = 24.0$.

(c) $13.59 \times 4.86 \div 2.1 = 31$.

(d) $4.8 \times 10^5 \div 4.0 \times 10^{-3} = 1.2 \times 10^8$.

(e) $(3.2 \times 10^8)(4.0 \times 10^4) = 1.3 \times 10^{13}$.

Example 1.6: Perform the following operations:

(a) $23.1 + 45 + 0.68 + 100 =$

(b) $157 - 5.689 + 2 =$

(c) $23.5 + 0.567 + 0.85 =$

(d) $4.69 \times 10^{-6} - 2.5 \times 10^{-5} =$

(e) $8.9 \times 10^4 + 2.5 \times 10^5 =$

Solution: The final result of the addition and/or subtraction should have the same number of decimal places as the quantity with the least number of decimal places.

(a) $23.1 + 45 + 0.68 + 100 = 169$.

(b) $157 - 5.689 + 2 = 153$.

(c) $23.5 + 0.567 + 0.85 = 24.9$.

(d) $4.69 \times 10^{-6} - 2.5 \times 10^{-5} = 0.469 \times 10^{-5} - 2.5 \times 10^{-5} = -2.0 \times 10^{-5}$.

(e) $8.9 \times 10^4 + 2.5 \times 10^5 = 8.9 \times 10^4 + 25 \times 10^4 = 34 \times 10^4 = 3.4 \times 10^5$.

---

5. Problem Solving

Problem solving is a skill that has to be learned and accumulated gradually. We can not learn this skill in a lecture or overnight. It takes practice, lots of practice and the exact procedure you adopt will probably be unique to you. The point is to develop one that works for you. However, there are some suggested problem solving procedures that can be followed.

(1) Say it in words.

(2) Say it in pictures.

(3) Say it in equations.

(4) Simplify the equations.

(5) Check the units.

(6) Insert numbers and calculate; check significant figures.

(7) Check the answer: is it reasonable?

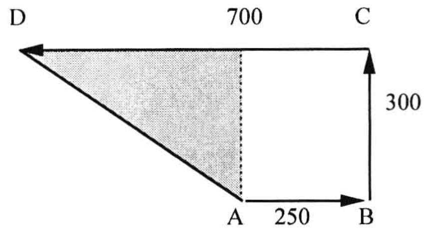
The details of these procedures can be found on page 20 in the text.

Example 1.7: Starting from city A, an airplane flies 250 miles east to city B, then 300 miles north to city C, and finally 700 miles west to city D. What is the distance from city A to D?

Solution: Given: the distances and directions of each trip.

Find: the distance from city A to D.

Following the problem statement, we draw a diagram. From the diagram, it is easy to see that the distance from A to D is the hypotenuse of the shaded right-angle triangle. The sides perpendicular to each other are 300 mi and (700 mi − 250 mi) = 350 mi.



To find the hypotenuse of a right-angle triangle, we use Pythagorean theorem:

$c^2 = a^2 + b^2$, where a and b are the sides perpendicular to each other and c is the hypotenuse.

$$c = \sqrt{a^2 + b^2} = \sqrt{(300\text{ mi})^2 + (350\text{ mi})^2} = 461\text{ mi}.$$

Obviously, the units, miles, are right; the answer, 461, is reasonable; and the number of significant figures, 3, in the final result, is the same as the least number of significant figures between 350 mi and 350 mi.

Example 1.8: The density of air is 1.29 kg/m^3. Find the mass of air in the room having the dimensions: 13 ft × 16 ft × 9.0 ft.

Solution: Given: the dimensions of the room and the density of air. Find: the mass of the air.

First find the volume of the room. Be aware of the different units in the problem; so we first convert the room dimensions to meters.

$L = 13$ ft (0.3048 m/ft) = 4.0 m, $W = 16$ ft (0.3048 m/ft) = 4.9 m,

$H = 9.0$ ft (0.3048 m/ft) = 2.7 m. So the volume is $V = L \times W \times H = (4.0\text{ m})(4.9\text{ m})(2.7\text{ m}) = 53\text{ m}^3$.

Next find the mass of the air.

$\rho = \frac{m}{V}$. Multiplying V on both sides yields $m = \rho V$. So $m = (1.29\text{ kg/m}^3)(53\text{ m}^3) = 68$ kg.

IV. Mathematical Summary

Density	$\rho = \dfrac{m}{V}\left(\dfrac{\text{mass}}{\text{volume}}\right)$ (1.1)	Define density in terms of mass and volume.

V. Solutions of Selected Exercises and Paired Exercises

4. (a) No, different ounces are used for volume and weight measurements.

(b) Two different pound units are used. Avoirdupois lb = 16 oz, troy lb = 12 oz.

12. The units of the left side are m^2. The units of the right side are $(m)^2 = m^2$.

So the equation is dimensionally correct.

16. Since $x = \dfrac{gt^2}{2}$, $g = \dfrac{2x}{t^2}$. So units of g are m/s^2.

22. Since $mgx = -kx^2$, $k = -\dfrac{mgx}{x^2} = -\dfrac{mg}{x}$. So the units of k are $\dfrac{\text{kg(m/s}^2)}{\text{m}} = \text{kg/s}^2$.

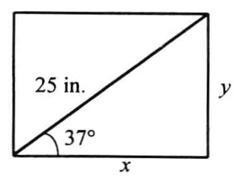
40. 1 gal = 3.785 L. So 15 gal = (15 gal) $\times \dfrac{3.785\text{ L}}{1\text{ gal}}$ = 57 L.

46. (a) The length of the tube is $x = (25\text{ in.})\cos 37° = 20$ in.

and the width of the tube is $y = (25\text{ in.})\sin 37° = 15$ in.

So the area $A = xy = (20\text{ in.})(15\text{ in.}) = 3.0\times10^2\text{ in.}^2$

(b) $A = 3.0\times10^2\text{ in.}^2 = (3.0\times10^2\text{ in.}^2)\times\left(\dfrac{2.54\text{ cm}}{1\text{ in.}}\right)^2 = 1.9\times10^3\text{ cm}^2$.



56. Since the last digit is estimated in measurements, the smallest division is 0.001 m or 1 mm.

58. (a) 4.

(b) 3.

(c) 5.

(d) 2.

65. The area is the sum of that of the top, the bottom and the side. The side of the can is a rectangle with a length equal to the circumference and width equal to the height of the can.

So $A = \frac{\pi d^2}{4} + \frac{\pi d^2}{4} + C\,h = \frac{\pi d^2}{4} + \frac{\pi d^2}{4} + (\pi d)h$

$$= \frac{\pi(12.559 \text{ cm})^2}{4} + \frac{\pi(12.559 \text{ cm})^2}{4} + \pi(12.559 \text{ cm})(5.62 \text{ cm}) = 470 \text{ cm}^2.$$

71. $\rho = \frac{m}{V} = \frac{6.0\times 10^{24} \text{ kg}}{1.1\times 10^{21} \text{ m}^3} = 5.5\times 10^3 \text{ kg/m}^3.$

78. A better buy gives you more AREA (more pepperoni) per dollar. Calculating the ratio of area to dollar.

For the 9.0-in.: $\frac{\pi(4.5 \text{ in})^2}{\$7.95} = 8.0 \text{ in.}^2\text{/dollar.}$ For the 12-in.: $\frac{\pi(6.0 \text{ in})^2}{\$13.50} = 8.4 \text{ in.}^2\text{/dollar.}$

So the larger one is the better buy.

90. $V = AH = (\pi r^2)H = \pi(4.0 \text{ cm})^2(12 \text{ cm}) = 6.03\times 10^2 \text{ cm}^3 = (6.03\times 10^2 \text{ cm}^3) \times \frac{1 \text{ L}}{1000 \text{ cm}^3} = 0.60 \text{ L}.$

94. $3.36 \text{ g/cm}^3 = (3.36 \text{ g/cm}^3) \times \frac{1 \text{ kg}}{1000 \text{ kg}} \times \left(\frac{100 \text{ cm}}{1 \text{ m}}\right)^3 = 3.36\times 10^3 \text{ kg/m}^3.$

Since $\rho = \frac{m}{V}$, $m = \rho V = (3.36\times 10^3 \text{ kg}) \times \frac{4\pi}{3} \times [(1080 \text{ mi})(1609 \text{ m/mi})]^3 = 7.39\times 10^{22} \text{ kg},$

which is very close to 7.4×10^{22} kg listed in the inside back cover.

VI. Practice Quiz

1. In the SI, the base units for length, mass, and time are

(a) meters, grams, seconds. (b) kilometers, kilograms, seconds. (c) centimeters, kilograms, seconds. (d) meters, kilograms, seconds. (e) kilometers, grams, seconds.

2. If v has units of m/s and t has the units of s. What are the units of the quantity $a = v/t$?

(a) m (b) m/s^2 (c) s/m (d) s/m^2 (e) m/s^3

3. Which one of the following has the same dimension as time?

(x is length, v is velocity, and a is acceleration)

(a) $\frac{x}{a}$ (b) $\sqrt{\frac{2x}{a}}$ (c) $\sqrt{\frac{v}{x}}$ (d) vx (e) xa

4. Which one of the following is *not* equivalent to 2.50 miles?

(a) 1.32×10^4 ft (b) 1.58×10^5 in. (c) 4.02×10^3 km (d) 4.02×10^5 cm (e) 4.40×10^3 yd

5. When (3.5×10^4) is multiplied by (4.00×10^2), the product is which of the following expressed to the correct number of significant figures?

(a) 1.40×10^2 (b) 1.4×10^6 (c) 1.40×10^7 (d) 1.4×10^7 (e) 1.40×10^6

6. The density of water is 1.0×10^3 kg/m^3. Find the mass of water needed to fill a 2.0 L soft drink bottle.

(a) 0.020 kg (b) 0.20 kg (c) 2.0 kg (d) 20 kg (e) 200 kg

7. The area of a room floor is 15 m^2. How many cm^2 are there on the floor?

(a) 0.15 cm^2 (b) 1.5×10^{-3} cm^2 (c) 1.5×10^3 cm^2 (d) 1.5×10^4 cm^2 (e) 1.5×10^5 cm^2

8. An iron cube has a mass of 30 kg. What is the length of each side of the cube? (the density of iron is 7.86×10^3 kg/m^3)

(a) 3.8×10^{-3} m (b) 0.16 m (c) 0.062 m (d) 5.5×10^{-8} m (e) 2.6×10^2 m

9. A person stands 35.0 m from a flag pole. With a protractor at eye-level, he finds that the angle the top of the flag pole makes with the horizontal is 25.0°. How high is the flag pole? (the distance from his feet to his eyes is 1.7 m)

(a) 16.5 m (b) 33.4 m (c) 18.0 m (d) 76.8 m (e) 61.7 m

10. A rectangular garden measures 15 m long and 13.7 m wide. What is the length of a diagonal from one corner of the garden to the other?

(a) 29 m (b) 1 m (c) 18 m (d) 4.1×10^2 m (e) 20 m

Answers to Practice Quiz:

1.d 2.b 3.b 4.c 5.d 6.c 7.e 8.b 9.c 10.e

CHAPTER 2

Kinematics: Description of Motion

I. Chapter Objectives

Upon completion of this chapter, you should be able to:

1. distinguish between scalars and vectors and define distance and displacement.
2. define and calculate speed and velocity, and perform graphical analyses of velocity.
3. explain the relationship between velocity and acceleration and perform graphical analyses of acceleration.
4. explain kinematic equations and apply them in physical situations.
5. analyze free fall using the kinematic equations.

II. Key Terms

Upon completion of this chapter, you should be able to define and/or explain the following key terms:

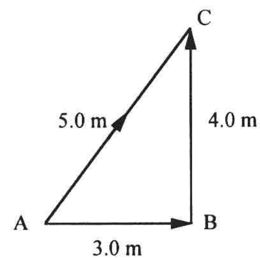
mechanics
kinematics
dynamics
motion
distance
scalar (quantity)
vector (quantity)
displacement
speed
average speed
instantaneous speed
velocity
average velocity
instantaneous velocity
acceleration
average acceleration
instantaneous acceleration
acceleration due to gravity
free fall.

The definitions and/or explanations of the most important key terms can be found in the following section: **III. Chapter Summary and Discussion.**

III. Chapter Summary and Discussion

1. Distance and Displacement

Motion is related to change of position. The length traveled in changing position may be expressed in terms of **distance**, the actual path length between two points. Distance is a scalar quantity, which has only a magnitude with no direction. The direct straight line from the initial point to the final point is called **displacement** (change in position). It only measures the change in position, not the details involved in the change in position. Displacement is a vector quantity, which has both magnitude and direction. In the Figure shown, an object goes from point A to point C by following paths AB and BC. The distance traced is 3.0 m + 4.0 m = 7.0 m, and the displacement is 5.0 m in the direction of the arrow.



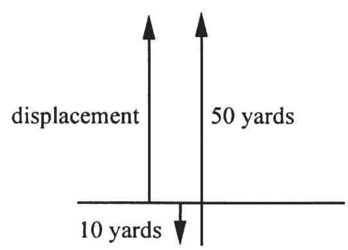
Example 2.1: In a soccer game, a midfielder kicks the ball back 10 yards to a goalkeeper. The goalkeeper then kicks the ball straight up the field 50 yards to a forward. What is the distance traveled by the football? What is the displacement of the football?

Solution: Sketch a diagram of the situation. For clarity, the arrows are laterally displaced.

It is obvious from the diagram that the soccer ball traveled 10 yards, then 50 yards. So the *distance traveled* is 10 yards + 50 yards = 60 yards.

Displacement is the straight line from the initial point to the final point. The ball displaced only 50 yards − 10 yards = 40 yards **straight up the field**.

Try to solve this problem without the diagram. You will find it is very difficult to do. That is why you are encouraged to try to draw a diagram for every problem.



2. Speed and Velocity

In describing motion, the rate of change of position may be expressed in several ways.

Average speed is defined as the distance traveled divided by the time interval to travel that distance, $\bar{s} = \frac{\Delta d}{\Delta t}$, where $\bar{s}$ is average speed (the bar above s stands for average), Δd is distance traveled, and Δt is time interval (change in time). **Instantaneous speed**, s, is the speed at a particular time instant (Δt is close to zero). Since