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Introduction

Physics is about the world and everything in it. Physics describes that world and the kinds of things that take place in it. Sometimes, however, physics seems like an imposition from outside — a requirement you have to get through.

That's a shame, because it's your world that physics describes. Under the burden of physics problems, though, things can get tough. That's where this book comes in, because it's designed to let you tackle those problems with ease.

Kirchhoff's laws? No problem. Carnot engines? No worries. This book addresses these topics and more. After you're done reading, you'll be a problem-solving pro.

About This Book

This book is crammed with physics example problems and practice questions that are designed to show you solutions for the kinds of problems you may encounter in physics classes. And when you see how the solutions to problems are done step by step, solving similar problems should be a breeze.

Many books have endless conventions that you have to learn before you can start reading. Not this one. In fact, all you need to know is that new terms are given in italics, like *this,* when they're introduced. You should also know that vectors, which are those items that have both a magnitude and a direction, are given in bold, like this: **B**.

Foolish Assumptions

We're assuming that you're using this book in conjunction with a physics class or textbook, because this book keeps the derivation of physical formulas to a minimum. The emphasis here is on solving problems, not deriving formulas. So some knowledge of the physics you're going to be using here is helpful. This book is designed to help you with the nitty-gritty, not to introduce the topics from scratch.

You should also know some algebra. You don't need to be an algebra pro, but you should know how to move items from one side of an equation to another and how to solve for values. Take a look at the discussion in Chapter 1 if you're unsure.

You also need a little knowledge of trigonometry, but not much. Again, take a look at the discussion in Chapter 1, where all the trig you need to know — a grasp of sine and cosine — is reviewed in full.

Icons Used in This Book

You find a few icons in this book, and here's what they mean:

This icon points out helpful hints, ideas, or shortcuts that save you time or that give you alternative ways to think about a particular concept.

This icon marks something to remember, such as a law of physics or a particularly juicy equation.

This icon means that what follows is technical, insider stuff. You don't have to read it if you don't want to, but if you want to become a physics pro (and who doesn't?), take a look.

This icon highlights examples that show you how to work each type of problem.

Beyond the Book

In addition to what you're reading right now, this book has a free access-anywhere Cheat Sheet for when you need a quick physics refresher. To get this Cheat Sheet, simply go to `www.dummies.com` and type **Physics I Workbook For Dummies Cheat Sheet** in the Search box. There you'll find common mistakes to avoid, the values of important constants, and equations to remember.

This book also comes with over 200 online practice questions that you can use to test your knowledge of different physics topics. To gain access to the online practice, all you have to do is register. Just follow these simple steps:

1. **Register your book or ebook at Dummies.com to get your PIN. Go to `www.dummies.com/go/getaccess`.**
2. **Select your product from the dropdown list on that page.**
3. **Follow the prompts to validate your product, and then check your email for a confirmation message that includes your PIN and instructions for logging in.**

If you do not receive this email within two hours, please check your spam folder before contacting us through our Technical Support website at `http://support.wiley.com` or by phone at 877-762-2974.

Now you're ready to go! You can come back to the practice material as often as you want — simply log on with the username and password you created during your initial login. No need to enter the access code a second time.

Your registration is good for one year from the day you activate your PIN.

Where to Go from Here

You're ready to jump into Chapter 1. You don't have to start there, of course. You can read this book in any order you like instead of reading it from beginning to end. But if you want some important, general, problem-solving background, take a look at Chapter 1 first.

1 Getting Started with Physics

IN THIS PART . . .

Grasp fundamental physics measurements, scientific notation, and converting among units, distances, and time.

Master the motion of displacement, velocity, and acceleration.

Point yourself in the right direction with vectors.

IN THIS CHAPTER

- Laying down measurements
- Simplifying with scientific notation
- Practicing conversions
- Drawing on algebra and trigonometry

Chapter 1
Reviewing Physics Basics

This chapter gets the ball rolling by discussing some fundamental physics measurements. At its root, physics is all about making measurements (and using those measurements as the basis of predictions), so it's the perfect place to start! As you go through the process of converting measurements from one unit to another, you'll practice applying math skills to physics problems.

Measuring the Universe

A great deal of physics has to do with making measurements — that's the way all physics gets started. For that reason, physics uses a number of measurement systems, such as the CGS (centimeter-gram-second) system and the MKS (meter-kilogram-second) system. You also use the standard English system of inches and feet and so on — that's the FPI (foot-pound-inch) system.

REMEMBER

In physics, most measurements have units, such as meters or seconds. For example, when you measure how far and how fast a hockey puck slid, you need to measure both the distance in centimeters and the time in seconds.

For reference, Table 1-1 gives you the primary units of measurement in the MKS system.

Table 1-1 MKS Units of Measurement

Measurement	Unit	Abbreviation
Length	meter	m
Mass	kilogram	kg
Time	second	s or sec
Force	newton	N
Energy	joule	J
Pressure	pascal	P
Electric current	ampere	A
Magnetism	tesla	T
Electric charge	coulomb	C

These are the measuring sticks that will become familiar to you as you solve problems and triumph over the math in this workbook. Also for reference, Table 1-2 shows the primary units of measurement (and their abbreviations) in the CGS system. (Don't bother memorizing the ones you're not familiar with now; you can come back to them later as needed.)

Table 1-2 CGS Units of Measurement

Measurement	Unit	Abbreviation
Length	centimeter	cm
Mass	gram	g
Time	second	s or sec
Force	dyne	dyn
Energy	erg	erg
Pressure	barye	Ba
Electric current	biot	Bi
Magnetism	gauss	G
Electric charge	franklin	Fr

EXAMPLE

Q. You're told to measure the length of a racecar track using the MKS system. What unit(s) will your measurement be in?

A. The correct answer is meters. The unit of length in the MKS system is the meter.

1 You're told to measure the mass of a marble using the CGS system. What unit(s) will your measurement be in?

2 You're asked to measure the time it takes the moon to circle the Earth using the MKS system. What will your measurement's units be?

3 You need to measure the force a tire exerts on the road as it's moving using the MKS system. What are the units of your answer?

4 You're asked to measure the amount of energy released by a firecracker when it explodes using the CGS system. What are the units of your answer?

Putting Scientific Notation to Work

Physics deals with some very large and very small numbers. To work with such numbers, you use *scientific notation.* Scientific notation is expressed as a number multiplied by a power of 10.

For example, suppose you're measuring the mass of an electron in the MKS system. You put an electron on a scale (in practice, electrons are too small to measure on a scale — you have to see how they react to the pull of magnetic or electrostatic forces to measure their mass), and you measure the following:

$$0.00000000000000000000000000000091 \text{ kg}$$

What the heck is that? That's a lot of zeros, and it makes this number very unwieldy to work with. Fortunately, you know all about scientific notation, so you can convert the number into the following:

$$9.1 \times 10^{-31} \text{ kg}$$

That is, 9.1 multiplied by a power of 10, 10^{-31}. Scientific notation works by extracting the power of 10 and putting it on the side, where it's handy. You convert a number to scientific notation by counting the number of places you have to move the decimal point to get the first digit in front of that decimal point. For example, 0.050 is 5.0×10^{-2} because you move the decimal point two places to the right to get 5.0. Similarly, 500 is 5.0×10^{2} because you move the decimal point two places to the left to get 5.0.

Check out this example question about scientific notation:

EXAMPLE

Q. What is 0.000037 in scientific notation?

A. The correct answer is 3.7×10^{-5}. You have to move the decimal point five times to the right to get 3.7.

5 What is 0.0043 in scientific notation?

6 What is 430,000.0 in scientific notation?

7 What is 0.00000056 in scientific notation?

8 What is 6,700.0 in scientific notation?

Converting between Units

Physics problems frequently ask you to convert between different units of measurement. For example, you may measure the number of feet your toy car goes in three minutes and thus be able to calculate the speed of the car in feet per minute, but that's not a standard unit of measure, so you need to convert feet per minute to miles per hour, or meters per second, or whatever the physics problem asks for.

For another example, suppose you have 180 seconds — how much is that in minutes? You know that there are 60 seconds in a minute, so 180 seconds equals three minutes. Here are some common conversions between units:

- 1 m = 100 cm = 1,000 mm (millimeters)
- 1 km (kilometer) = 1,000 m
- 1 kg (kilogram) = 1,000 g (grams)
- 1 N (newton) = 10^5 dynes
- 1 J (joule) = 10^7 ergs
- 1 P (pascal) = 10 Ba
- 1 A (amp) = 0.1 Bi
- 1 T (tesla) = 10^4 G (gauss)
- 1 C (coulomb) = 2.9979×10^9 Fr

The conversion between CGS and MKS almost always involves factors of 10 only, so converting between the two is simple. But what about converting to and from the FPI and other systems of measurement? Here are some handy conversions that you can come back to as needed:

- **Length:**
  - $1\text{ m} = 100\text{ cm}$
  - $1\text{ km} = 1{,}000\text{ m}$
  - $1\text{ in (inch)} = 2.54\text{ cm}$
  - $1\text{ m} = 39.37\text{ in}$
  - $1\text{ mile} = 5{,}280\text{ ft} = 1.609\text{ km}$
  - $1\text{ Å (angstrom)} = 10^{-10}\text{ m}$
- **Mass:**
  - $1\text{ kg} = 1{,}000\text{ g}$
  - $1\text{ slug} = 14.59\text{ kg}$
  - $1\text{ u (atomic mass unit)} = 1.6605 \times 10^{-27}\text{ kg}$
- **Force:**
  - $1\text{ lb (pound)} = 4.448\text{ N}$
  - $1\text{ N} = 10^{5}\text{ dynes}$
  - $1\text{ N} = 0.2248\text{ lb}$
- **Energy:**
  - $1\text{ J} = 10^{7}\text{ ergs}$
  - $1\text{ J} = 0.7376\text{ ft-lb}$
  - $1\text{ BTU (British thermal unit)} = 1{,}055\text{ J}$
  - $1\text{ kWh (kilowatt hour)} = 3.600 \times 10^{6}\text{ J}$
  - $1\text{ eV (electron volt)} = 1.602 \times 10^{-19}\text{ J}$
- **Power:**
  - $1\text{ hp (horsepower)} = 550\text{ ft-lb/s}$
  - $1\text{ W (watt)} = 0.7376\text{ ft-lb/s}$

Because conversions are such an important part of physics problems, and because you have to keep track of them so carefully, there's a systematic way of handling conversions: You multiply by a conversion constant that equals 1, such that the units you don't want cancel out.

EXAMPLE

Q. A ball drops 5 meters. How many centimeters did it drop?

A. The correct answer is 500 centimeters. To perform the conversion, you do the following calculation:

$$5.0 \text{ meters} \times \frac{100 \text{ centimeters}}{1 \text{ meter}} = 500 \text{ centimeters}$$

Note that 100 centimeters divided by 1 meter equals 1 because there are 100 centimeters in a meter. In the calculation, the units you don't want — meters — cancel out.

9 How many centimeters are in 2.35 meters?

10 How many seconds are in 1.25 minutes?

11 How many inches are in 2.0 meters?

12 How many grams are in 3.25 kg?

Converting through Multiple Units

Sometimes you have to make multiple conversions to get what you want. That demands multiple conversion factors. For example, if you want to convert from inches to meters, you can use the conversion that 2.54 centimeters equals 1 inch — but then you have to convert from centimeters to meters, which means using another conversion factor.

Try your hand at this example question that involves multiple conversions:

EXAMPLE

Q. Convert 10 inches into meters.

A. The correct answer is 0.254 m.

1. You know that $1 \text{ inch} = 2.54 \text{ centimeters}$, so start with that conversion factor and convert 10 inches into centimeters:

$$10 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 25.4 \text{ cm}$$

2. Convert 25.4 cm into meters by using a second conversion factor:

$$2.54 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} = 0.254 \text{ m}$$

13 Given that there are 2.54 centimeters in 1 inch, how many centimeters are there in 1 yard?

14 How many centimeters are in a kilometer?

15 How many inches are in an angstrom, given that 1 angstrom (Å) $= 10^{-8}$ cm?

16 How many inches are in 3.0 meters, given that there are 2.54 cm in 1 inch?

Converting Times

Physics problems frequently ask you to convert between different units of time: seconds, minutes, hours, and even years. These times involve all kinds of calculations because measurements in physics books are usually in seconds, but can frequently be in hours.

EXAMPLE

Q. An SUV is traveling 2.78×10^{-2} kilometers per second. What's that in kilometers per hour?

A. The correct answer is 100 km/hr.

1. You know that there are 60 minutes in an hour, so start by converting from kilometers per second to kilometers per minute:

$$2.78 \times 10^{-2} \frac{\text{km}}{\cancel{\text{sec}}} \times \frac{60 \ \cancel{\text{sec}}}{1 \text{ minute}} = 1.67 \text{ km/minute}$$

2. Because there are 60 minutes in an hour, convert this to kilometers per hour using a second conversion factor:

$$\frac{1.67 \text{ km}}{1 \ \cancel{\text{minute}}} \times \frac{60 \ \cancel{\text{minute}}}{1 \text{ hour}} = 100 \text{ km/hour}$$

17 How many hours are in 1 week?

18 How many hours are in 1 year?

Counting Significant Figures

You may plug numbers into your calculator and come up with an answer like 1.532984529045, but that number isn't likely to please your instructor. Why? Because in physics problems, you use significant digits to express your answers. *Significant digits,* also often called *significant figures,* represent the accuracy with which you know your values.

For example, if you know only the values you're working with to two significant digits, your answer should be 1.5, which has two significant digits, not 1.532984529045, which has 13! Here's how it works: Suppose you're told that a skater traveled 10.0 meters in 7.0 seconds. Note the number of digits: The first value has three significant figures, the other only two. The rule is that when you multiply or divide numbers, the result has the number of significant digits that equals the smallest number of significant digits in any of the original numbers. So if you want to figure out how fast the skater was going, you divide 10.0 by 7.0, and the result should have only two significant digits — 1.4 meters per second.

On the other hand, when you're adding or subtracting numbers, the rule is that the last significant digit in the result corresponds to the last significant digit in the least accurate measurement. How does that work? Take a look at this addition example:

$$\begin{array}{r} 5.1 \\ 12 \\ +\ 7.73 \\ \hline 24.83 \end{array}$$

So is the result 24.83? No, it's not. The 12 has no significant digits to the right of the decimal point, so the answer shouldn't have any either. That means you should round the value of the result up to 25.

REMEMBER

Zeros used just to fill out values down to (or up to) the decimal point aren't considered significant. For example, the number 3,600 has only two significant digits by default. That's not true if the value was actually measured to be 3,600, of course, in which case it's usually expressed as 3,600; the final decimal indicates that all the digits are significant.

Rounding numbers in physics usually works the same way as it does in math: When you want to round to three places, for example, and the number in the fourth place is a five or greater, you add one to the third place (and ignore or replace with zeros any following digits).

EXAMPLE

Q. You're multiplying 12.01 by 9.7. What should your answer be, keeping in mind that you should express it in significant digits?

A. The correct answer is 120.

1. The calculator says the product is 116.497.
2. The number of significant digits in your result is the same as the smallest number of significant digits in any of the values being multiplied. That's two here (because of 9.7), so your answer rounds up to 120.

19 What is 19.3 multiplied by 26.12, taking into account significant digits?

20 What is the sum of 7.9, 19, and 5.654, taking into account significant digits?

Coming Prepared with Some Algebra

It's a fact of life: You need to be able to do algebra to handle physics problems. Take the following equation, for example, which relates the distance something has traveled (s) to its acceleration and the time it has been accelerated:

$$s = \frac{1}{2}at^2$$

Now suppose that the physics problem asks you for the acceleration, not the distance. You have to rearrange things a little here to solve for the acceleration. So when you multiply both sides by 2 and divide both sides by t^2, here's what you get:

$$\frac{2}{t^2} \cdot s = \frac{2}{t^2} \cdot \frac{1}{2}at^2$$

Cancelling out and swapping sides, you solve for a like this:

$$a = \frac{2s}{t^2}$$

So that's putting a little algebra to work. All you had to do was move variables around the equation to get what you wanted. The same approach works when solving physics problems (most of the time). On the other hand, what if you had to solve the same problem for the time, t? You would do that by rearranging the variables like so:

$$t = \sqrt{2s / a}$$

The lesson in this example is that you can extract all three variables — distance, acceleration, and time — from the original equation. Should you memorize all three versions of this equation? Of course not. You can just memorize the first version and use a little algebra to get the rest.

The following practice questions call on your algebra skills:

EXAMPLE

Q. The equation for final speed, v_f — where the initial speed is v_o, the acceleration is a, and the time is t — is $v_f = v_o + at$. Solve for acceleration.

A. The correct answer is $a = (v_f - v_o) / t$

To solve for a, divide both sides of the equation by time, t.