LEARNING MADE EASY

3rd Edition

Physics I for dummies

A Wiley Brand

Find clear, concise explanations of formulas

Learn about motion, force, work, and heat

Connect physics concepts with the real world

Steven Holzner, PhD

Physics I

3rd Edition

Steven Holzner, PhD

for dummies
A Wiley Brand

Physics I For Dummies®, 3rd Edition

Published by: **John Wiley & Sons, Inc.,** 111 River Street, Hoboken, NJ 07030-5774, www.wiley.com

For general information on our other products and services, please contact our Customer Care Department within the U.S. at 877-762-2974, outside the U.S. at 317-572-3993, or fax 317-572-4002. For technical support, please visit `https://hub.wiley.com/community/support/dummies`.

Wiley publishes in a variety of print and electronic formats and by print-on-demand. Some material included with standard print versions of this book may not be included in e-books or in print-on-demand. If this book refers to media such as a CD or DVD that is not included in the version you purchased, you may download this material at http://booksupport.wiley.com. For more information about Wiley products, visit www.wiley.com.

Library of Congress Control Number: 2022931882

ISBN 978-1-119-87222-1 (pbk); ISBN 978-1-119-87223-8 (ebk); ISBN 978-1-119-87224-5 (ebk)

Physics I For Dummies®

To view this book's Cheat Sheet, simply go to www.dummies.com and search for “Physics I For Dummies Cheat Sheet” in the Search box.

Table of Contents

List of Tables

Chapter 15

List of Illustrations

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Chapter 7

Chapter 8

Chapter 9

Chapter 10

Chapter 11

Chapter 12

Chapter 13

Chapter 14

Chapter 15

Chapter 16

Chapter 17

Introduction

Physics is what it's all about. What *what's* all about? Everything. Physics is present in every action around you. And because physics is everywhere, it gets into some tricky places, which means it can be hard to follow. Studying physics can be even worse when you're reading some dense textbook that's hard to follow.

For most people who come into contact with physics, textbooks that land with 1,200-page *whumps* on desks are their only exposure to this amazingly rich and rewarding field. And what follows are weary struggles as the readers try to scale the awesome bulwarks of the massive tomes. What's vastly different about this physics book is that it's written from the *reader's* point of view.

About This Book

Physics I For Dummies, 3rd Edition, is all about physics from your point of view. We know that most students share one common trait: confusion. As in, "I'm confused about what I did to deserve such torture."

This book is different. Instead of writing it from the physicist's or professor's point of view, we wrote it from the reader's point of view. We've taken great care to jettison the top-down kinds of explanations instead of the usual book presentation of this topic. You don't survive one-on-one tutoring sessions for long unless you get to know what really makes sense to people — what they want to see from *their* points of view. In other words, this book is designed to be crammed full of the good stuff — and *only* the good stuff. You also discover unique ways of looking at problems that professors and teachers use to make figuring out the problems simple.

Conventions Used in This Book

Some books have a dozen conventions that you need to know before you can start. Not this one. All you need to know is that variables and new terms appear in italics, like *this,* and that vectors — items that have both a magnitude and a direction — appear in **bold.** Web addresses appear in `monofont`.

What You're Not to Read

We provide two elements in this book that you don't have to read at all if you're not interested in the inner workings of physics — sidebars and paragraphs marked with a Technical Stuff icon.

Sidebars provide a little more insight into what's going on with a particular topic. They give you a little more of the story, such as how some famous physicist made a discovery or an unexpected real-life application of the point under discussion. You can skip these sidebars, if you like, without missing any essential physics.

The Technical Stuff material gives you technical insights into a topic, but you don't miss any information that you need to do a problem. Your guided tour of the world of physics won't suffer at all.

Foolish Assumptions

In writing this book, we made some assumptions about you:

- You have no or very little prior knowledge of physics.
- You have some math prowess. In particular, you know algebra and a little trigonometry. 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.
- You want physics concepts explained clearly and concisely, and you want examples that let you see those concepts in action.

How This Book Is Organized

The natural world is, well, *big.* And to handle it, physics breaks the world down into different parts. The following sections present the various parts you see in this book.

Part 1: Putting Physics into Motion

You usually start your physics journey with motion, because describing motion — including acceleration, velocity, and displacement — isn't very difficult. You have only a few equations to deal with, and you can get them under your belt in no time at all. Examining motion is a great way to understand how physics works, both in measuring and in predicting what's going on.

Part 2: May the Forces of Physics Be with You

"For every action, there is an equal and opposite reaction." Ever heard that one? The law (and its accompanying implications) comes up in this part. Without forces, the motion of objects wouldn't change at all, which would make for a very boring world. Thanks to Sir Isaac Newton, physics is particularly good at explaining what happens when you apply forces. You also take a look at the motion of fluids.

Part 3: Manifesting the Energy to Work

If you apply a force to an object, moving it around and making it go faster, what are you really doing? You're doing work, and that work becomes the kinetic energy of that object. Together, work and energy explain a whole lot about the whirling world around you, which is why we dedicate Part 3 to these topics.

Part 4: Laying Down the Laws of Thermodynamics

What happens when you stick your finger in a candle flame and hold it there? You get a burned finger, that's what. And you complete an experiment in heat transfer, one of the topics you see in Part 4, which is a roundup of thermodynamics — the physics of heat and heat flow. You also see how heat-based engines work, how ice melts, how the ideal gas behaves, and more.

Part 5: The Part of Tens

The Parts of Tens is made up of fast-paced lists of ten items each. You discover all kinds of amazing topics here, like some far-out physics — everything from black holes and the Big Bang to wormholes in space — as well as some famous scientists whose contributions made a big difference in the field.

Icons Used in This Book

You come across some icons that call attention to certain tidbits of information in this book. Here's what the icons mean:

REMEMBER This icon marks information to remember, such as an application of a law of physics or a particularly juicy equation.

TIP When you run across this icon, be prepared to find a shortcut in the math or info designed to help you understand a topic better.

WARNING This icon highlights common mistakes people make when studying physics and solving problems.

TECHNICAL STUFF This icon means that the info 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.

Beyond the Book

In addition to what you’re reading right now, this book comes with a free access-anywhere Cheat Sheet for when you need a quick physics refresher on important constants and equations. To get this Cheat Sheet, simply go to `www.dummies.com` and type **Physics I For Dummies Cheat Sheet** in the search box.

Where to Go from Here

You can leaf through this book; you don’t have to read it from beginning to end. Like other *For Dummies* books, this one was designed to let you skip around as you like. This is your book, and physics is your oyster. You can jump into Chapter 1, which is where all the action starts; you can head to Chapter 2 for a discussion of the necessary algebra and trig you should know; or you can jump in anywhere you like if you know exactly what topic you want to study. And when you're ready for more-advanced topics, from electromagnetism to relativity to nuclear physics, you can check out *Physics II For Dummies*.

Part 1

Putting Physics into Motion

IN THIS PART ...

Part 1 is designed to give you an introduction to the ways of physics. Motion is one of the easiest physics topics to work with, and you can become a motion meister with just a few equations. This part also arms you with foundational info on math and measurement to show how physics equations describe the world around you. Just plug in the numbers, and you can make calculations that astound your peers.

Chapter 1

Using Physics to Understand Your World

IN THIS CHAPTER

- » **Recognizing the physics in your world**
- » **Understanding motion**
- » **Handling the force and energy around you**
- » **Getting hot under the collar with thermodynamics**

Physics is the study of the world and universe around you. Luckily, the behavior of the matter and energy — the stuff of this universe — is not completely unruly. Instead, it strictly obeys laws, which physicists are gradually revealing through the careful application of the *scientific method,* which relies on experimental evidence and sound rigorous reasoning. In this way, physicists have been uncovering more and more of the beauty that lies at the heart of the workings of the universe, from the infinitely small to the mind-bogglingly large.

Physics is an all-encompassing science. You can study various aspects of the natural world (in fact, the word *physics* is derived from the Greek word *physika,* which means "natural things"), and accordingly, you can study different fields in physics: the physics of objects in motion, of energy, of forces, of gases, of heat and temperature, and so on. You enjoy the study of all these topics and many more in this book. In this chapter, we give an overview of physics — what it is, what it deals with, and why mathematical calculations are important to it — to get you started.

What Physics Is All About

Many people are a little on edge when they think about physics. For them, the subject seems like some highbrow topic that pulls numbers and rules out of thin air. But the truth is that physics exists to help you make sense of the world. Physics is a human adventure, undertaken on behalf of everyone, into the way the world works.

REMEMBER At its root, physics is all about becoming aware of your world and using mental and mathematical models to explain it. The gist of physics is this: You start by making an observation, you create a model to simulate that situation, and then you add some math to fill it out — and voilà! You have the power to predict what will happen in the real world. All this math exists to help you see what happens and why.

In this section, we explain how real-world observations fit in with the math. The later sections take you on a brief tour of the key topics that comprise basic physics.

Observing the world

You can observe plenty going on around you in your complex world. Leaves are waving, the sun is shining, light bulbs are glowing, cars are moving, computer printers are printing, people are walking and riding bikes, streams are flowing, and so on. When you stop to examine these actions, your natural curiosity gives rise to endless questions such as these

- Why do I slip when I try to climb that snowbank?
- How distant are other stars, and how long would it take to get there?
- How does an airplane wing work?
- How can a thermos flask keep hot things warm *and* keep cold things cool?
- Why does an enormous cruise ship float when a paper clip sinks?
- Why does water roll around when it boils?

Any law of physics comes from very close observation of the world, and any theory that a physicist comes up with has to stand up to experimental measurements. Physics goes beyond qualitative statements about physical things — "If I push the child on the swing harder, then she swings higher," for example. With the laws of physics, you can predict precisely how high the child will swing.

Making predictions

Physics is simply about modeling the world (although an alternative viewpoint claims that physics actually uncovers the truth about the workings of the world; it doesn't just model it). You can use these mental models to describe how the world works: how blocks slide down ramps, how stars form and shine, how black holes trap light so it can't escape, what happens when cars collide, and so on.

When these models are first created, they sometimes have little to do with numbers; they just cover the gist of the situation. For example, a star is made up of this layer and then that layer, and as a result, this reaction takes place, followed by that one. And pow! — you have a star. As time goes on, those models become more numeric, which is where physics students sometimes start having problems. Physics class would be a cinch if you could simply say, “That cart is going to roll down that hill, and as it gets toward the bottom, it’s going to roll faster and faster.” But the story is more involved than that — not only can you say that the cart is going to go faster, but in exerting your mastery over the physical world, you can also say how much faster it’ll go.

There’s a delicate interplay between theory, formulated with math, and experimental measurements. Often experimental measurements not only verify theories but also suggest ideas for new theories, which in turn suggest new experiments. Both feed off each other and lead to further discovery.

Many people approaching this subject may think of math as something tedious and overly abstract. However, in the context of physics, math comes to life. A quadratic equation may seem a little dry, but when you’re using it to work out the correct angle to fire a rocket at for the perfect trajectory, you may find it more palatable! Chapter 2 explains all the math you need to know to perform basic physics calculations.

Reaping the rewards

So what are you going to get out of physics? If you want to pursue a career in physics or in an allied field such as engineering, the answer is clear: You’ll need this knowledge on an everyday basis. But even if you’re not planning to embark on a physics-related career, you can get a lot out of studying the subject. You can apply much of what you discover in an introductory physics course to real life:

- In a sense, all other sciences are based upon physics. For example, the structure and electrical properties of atoms determine chemical reactions; therefore, all of chemistry is governed by the laws of physics. In fact, you could argue that everything ultimately boils down to the laws of physics!

- Physics does deal with some pretty cool phenomena. Many videos of physical phenomena have gone viral on YouTube; take a look for yourself. Do a search for "non-Newtonian fluid," and you can watch the creeping, oozing dance of a cornstarch/water mixture on a speaker cone.
- More important than the applications of physics are the problem-solving skills it arms you with for approaching any kind of problem. Physics problems train you to stand back, consider your options for attacking the issue, select your method, and then solve the problem in the easiest way possible.

Observing Objects in Motion

Some of the most fundamental questions you may have about the world deal with objects in motion. Will that boulder rolling toward you slow down? How fast do you have to move to get out of its way? (Grab your calculator… .) Motion was one of the earliest explorations of physics.

When you take a look around, you see that the motion of objects changes all the time. You see a motorcycle coming to a halt at a stop sign. You see a leaf falling and then stopping when it hits the ground, only to be picked up again by the wind. You see a pool ball hitting other balls in just the wrong way so that they all move without going where they should. Part 1 of this book handles objects in motion — from balls to railroad cars and most