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# Physics II

FOR

# DUMMIES®

## Learn to:

- Grasp physics terminology
- Get a handle on quantum and nuclear physics
- Understand waves, forces, and fields
- Make sense of electric potential and energy

**Steven Holzner, PhD**

*Author of Physics For Dummies*



# Physics II For Dummies®

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# ***Physics II For Dummies***<sup>®</sup> **by Steven Holzner, PhD**



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## About the Author

**Steven Holzner** taught Physics at Cornell University for more than a decade, teaching thousands of students. He's the award-winning author of many books, including *Physics For Dummies*, *Quantum Physics For Dummies*, and *Differential Equations For Dummies*, plus *For Dummies* workbooks for all three titles. He did his undergraduate work at MIT and got his PhD from Cornell, and he has been on the faculty of both MIT and Cornell.

## Dedication

To Nancy, of course.

## Author's Acknowledgments

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# Introduction

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For many people, physics holds a lot of terror. And Physics II courses do introduce a lot of mind-blowing concepts, such as the ideas that mass and energy are aspects of the same thing, that light is just a mix of electric and magnetic fields, and that every electron zipping around an atom creates a miniature magnet. In Physics II, charges jump, light bends, and time stretches — and not just because your instructor lost the class halfway through the lecture. Throw some math into the mix, and physics seems to get the upper hand all too often. And that's a shame, because physics isn't your enemy — it's your ally.

The ideas may have come from Albert Einstein and other people who managed to get laws and constants and units of measurement named after them, but you don't have to be a genius to understand Physics II. After all, it's only partially rocket science — and those are ultra-cool, nearing-the-speed-of-light rockets.

Many breakthroughs in the field came from students, researchers, and others who were simply curious about their world, who did experiments that often didn't turn out as expected. In this book, I introduce you to some of their discoveries, break down the math that describes their results, and give you some insight into how things work — as physicists understand it.

## About This Book

*Physics II For Dummies* is for the inquiring mind. It's meant to explain hundreds of phenomena that you can observe all around you. For example, how does polarized light really work? Was Einstein really right about time dilation at high speeds? Why do the electromagnets in electric motors generate magnetism? And if someone hands you a gram of radioactive material with a half-life of 22,000 years, should you panic?

To study physics is to study the world. *Your* world. That's the kind of perspective I take in this book. Here, I try to relate physics to your life, not the other way around. So in the upcoming chapters, you see how telescopes and microscopes work, and you find out what makes a properly cut diamond so brilliant. You discover how radio antennas pick up signals and how magnets make motors run. You see just how fast light and sound can travel, and you get an idea of what it really means for something to go radioactive.

When you understand the concepts, you see that the math in physics isn't just a parade of dreadful word problems; it's a way to tie real-world measurements to all that theory. Rest assured that I've kept the math in this book relatively simple — the equations don't require any knowledge beyond algebra and trigonometry.

*Physics II For Dummies* picks up where a Physics I course leaves off — after covering laws of motion, forces, energy, and thermodynamics. Physics I and Physics II classes have some overlap, so you do find info on electricity and magnetism in both this book and in *Physics For Dummies*. But in *Physics II For Dummies*, I cover these topics in more depth.

A great thing about this book is that *you* decide where to start and what to read. It's a reference you can jump into and out of at will. Just head to the table of contents or the index to find the information you want.

## Conventions Used in This Book

Some books have a dozen stupefying conventions that you need to know before you can start reading. Not this book. All you need to know is the following:

New terms are given in italics, like *this*, and are followed by a definition.

Variables, like *m* for *mass*, are in italics. If you see a letter or abbreviation in a calculation and it isn't italicized, you're looking at a unit of measurement; for instance, 2.0 m is 2.0 meters.

Vectors — those items that have both a magnitude and a direction — are given in bold, like this: ***B***.

And those are all the conventions you need to know!

## What You're Not to Read

Besides the main text of the book, I've included some extra little elements that you may find enlightening or interesting: sidebars and paragraphs marked with Technical Stuff icons. The sidebars appear in shaded gray boxes, and they give you some nice little examples or tell

stories that add a little color or show you how the main story of physics branches out. The Technical Stuff paragraphs give you a little more technical information on the matter at hand. You don't need this to solve problems; you may just be curious.

If you're in a rush, you can skip these elements without hurting my feelings. Without them, you still get the main story.

## **Foolish Assumptions**

In this book, I assume the following:

You're a student who's already familiar with a Physics I text like *Physics For Dummies*. You don't have to be an expert. As long as you have a reasonable knowledge of that material, you'll be fine here. You should understand ideas such as mass, velocity, force, and so on, even if you don't remember all the formulas.

You're familiar with the metric system, or SI (the International System of Units). You can convert between units of measurement, and you understand how to use metric prefixes. I include a review of working with measurements in Chapter 2.

You know basic algebra and trigonometry. I tell you what you need in Chapter 2, so no need to worry. This book doesn't require any calculus, and you can do all the calculations on a standard scientific calculator.



# How This Book Is Organized

Like physics itself, this book is organized into different parts. Here are the parts and what they're all about.

## Part I: Understanding Physics Fundamentals

Part I starts with an overview of Physics II, introducing the goals of physics and the main topics covered in a standard Physics II course. This part also brings you up to speed on the basics of Physics I — just what you need for this book. You can't build without a foundation, and you get the foundation you need here.

## Part II: Doing Some Field Work: Electricity and Magnetism

Electricity and magnetism are a big part of Physics II. Over the years, physicists have done a great job of explaining these topics. In this part, you see both electricity and magnetism, including info on individual charges, AC (alternating current) circuits, permanent magnets, and magnetic fields — and perhaps most importantly, you see how electricity and magnetism connect to create electromagnetic waves (as in light).

## **Part III: Catching On to Waves: The Sound and Light Kinds**

This part covers waves in general, as well as light and sound waves. Of the two, light is the biggest topic — you see how light waves interact and interfere with each other, as well as how they manage when going through single and double slits, bouncing off objects, passing through glass and water, and doing all kinds of other things. The study of optics includes real-world objects such as lenses, mirrors, cameras, polarized sunglasses, and more.

## **Part IV: Modern Physics**

This part brings you into the modern day with the theory of special relativity, the particle-wave duality of matter, and radioactivity. Relativity is a famous one, of course, and you see a lot of Einstein in this part. You also see many other physicists who chipped in on the discussion of matter's travels as waves. You read all about radioactivity and atomic structure, too.

## **Part V: The Part of Tens**

The chapters in this part cover ten topics in rapid succession. You take a look at ten physics experiments that changed the world, leading to discoveries in everything from special relativity to radioactivity. You also look at ten online calculators that can assist you in solving physics problems.

# Icons Used in This Book

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



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



Tips offer ways to think of physics concepts that can help you better understand a topic. They may also give you tips and tricks for solving problems.



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.

## Where to Go from Here

In this book, you can jump in anywhere you want. You can start with electricity or light waves or even relativity. But if you want the full story, start with Chapter 1. It's just around the corner from here. Happy reading!

If you don't feel comfortable with the level of physics taken for granted from Physics I, check out a Physics I text. I can recommend *Physics For Dummies* wholeheartedly.

# Part I

## Understanding Physics Fundamentals



### In this part . . .

In this part, you make sure you're up to speed on the skills you need for Physics II. You start with an overview of the topics I cover in this book. You also review Physics I briefly, making sure you have a good foundation in the math, measurements, and main ideas of basic physics.

# Chapter 1

## Understanding Your World: Physics II, the Sequel

---

### *In This Chapter*

Looking at electricity and magnetism

Studying sound and light waves

Exploring relativity, radioactivity, and other modern physics

---

Physics is not really some esoteric study presided over by guardians who make you take exams for no apparent reason other than cruelty, although it may seem like it at times. Physics is the human study of *your* world. So don't think of physics as something just in books and the heads of professors, locking everybody else out.

Physics is just the result of a questioning mind facing nature. And that's something everyone can share. These questions — what is light? Why do magnets attract iron? Is the speed of light the fastest anything can go? — concern everybody equally. So don't let physics scare you. Step up and claim your ownership of the topic. If you don't understand something, demand that it be explained to you better — don't assume the fault is with you. This is the human study of the natural world, and you own a piece of that.

Physics II takes up where Physics I leaves off. This book is meant to cover — and unravel — the topics normally covered in a second-semester intro physics class. You get the goods on topics such as electricity and magnetism, light waves, relativity (the special kind), radioactivity, matter waves, and more. This chapter gives you a sneak preview.

# **Getting Acquainted with Electricity and Magnetism**

Electricity and magnetism are intertwined. Electric charges in motion (not static, nonmoving charges) give rise to magnetism. Even in bar magnets, the tiny charges inside the atoms of the metal cause the magnetism. That's why you always see these two topics connected in Physics II discussions. In this section, I introduce electricity, magnetism, and AC circuits.

## **Looking at static charges and electric field**

Electricity is a very big part of your world — and not just in lightning and light bulbs. The configuration of the electric charges in every atom is the foundation of chemistry. As I note in Chapter 14, the arrangement of electrons gives rise to the chemical properties of matter, giving you everything from metals that shine to plastics that bend. That electron setup even gives you the very color that materials reflect when you shine light on them.