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Physics Essentials

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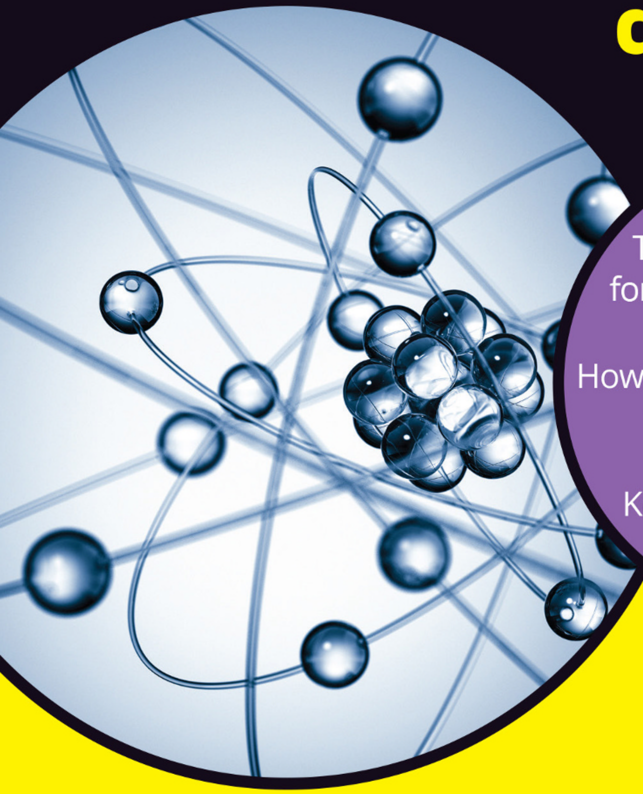

The fundamentals of force, work, and energy

How to connect physics laws with the real world

Key concepts in quick, focused lessons

Steven Holzner, PhD

Author of *Quantum Physics For Dummies*

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Contents at the Glance

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Introduction

Physics is what it's all about.

What *what's* all about?

Everything. That's the whole point. Physics is present in every action around you. And because physics has no limits, it gets into some tricky places, which means that it can be hard to follow. It 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. Has no brave soul ever wanted to write a book on physics from the *reader's* point of view? Yes, one soul is up to the task, and here I come with such a book.

About This Book

Physics Essentials For Dummies is all about physics from *your* point of view. I've taught physics to many thousands of students at the university level, and from that experience, I know that most students share one common trait: confusion. As in, "I'm confused as to 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, I write it from the reader's point of view.

After thousands of one-on-one tutoring sessions, I know where the usual book presentation of this stuff starts to confuse people, and I've taken great care to jettison the top-down kinds of explanations. 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, I designed this book 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. Here's all you need to know:

- New terms appear in italic, like *this,* the first time I discuss them. If you see a word in italic, look for a definition close by.
- Physicists use several different *measurement systems,* or ways of presenting measurements. (See how the italic/definition thing works?) In Chapter 1, I introduce the most common systems and explain that I use the meter-kilogram-second (MKS) system in this book. I suggest that you spend a few minutes with the last section of Chapter 1 so you're familiar with the measurements you see in all the other chapters.
- *Vectors* — items that have both a magnitude and a direction — appear in bold, like **this.** However, when I discuss the magnitude of a vector, the variable appears in italic.

Foolish Assumptions

I assume that you have very little knowledge of physics when you start to read this book. Maybe you're in a high school or first-year college physics course, and you're struggling to make sense of your textbook and your instructor.

I also assume that you have some math prowess. In particular, you should know some algebra, such as how to move items from one side of an equation to another and how to solve for values. You also need a little knowledge of trigonometry, but not much.

Icons Used in This Book

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

REMEMBER

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

TIP

When you run across this icon, be prepared to find a little extra info designed to help you understand a topic better.

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 has been 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 on the necessary vector algebra you should know; or you can jump in anywhere you like if you know exactly what topic you want to study. For a taste of how truly astounding physics can be, you may want to check out Chapter 12, which introduces some of the amazing insights provided to us by Einstein's theory of special relativity.

IN THIS CHAPTER

» Recognizing the physics in your world

» Getting a handle on motion and energy

» Wrapping your head around relativity

» Mastering measurements

Chapter 1 Viewing the World through the Lens of Physics

Physics is the study of your world and the world and universe around you. You may think of physics as a burden — an obligation placed on you in school. But in truth, physics is a study that you undertake naturally from the moment you open your eyes.

Nothing falls beyond the scope of physics; it's an all-encompassing science. You can study various aspects of the natural world, and, accordingly, you can study different fields in physics: the physics of objects in motion, of forces, of what happens when you start going nearly as fast as the speed of light, and so on. You enjoy the study of all these topics and many more in this book.

Figuring Out What Physics Is About

You can observe plenty going on around you all the time in the middle of your complex world. Leaves are waving, the sun is shining, the stars are twinkling, 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:

- Why do I slip when I try to climb that snow bank?
- What are those stars all about? Or are they planets? Why do they seem to move?
- What's the nature of this speck of dust?
- Are there hidden worlds I can't see?
- Why do blankets make me warm?
- What's the nature of matter?
- What happens if I touch that high-tension line? (You know the answer to that one; as you can see, a little knowledge of physics can be a lifesaver.)

Physics is an inquiry into the world and the way it works, from the most basic (like coming to terms with the inertia of a dead car that you're trying to push) to the most exotic (like peering into the very tiniest of worlds inside the smallest of particles to try to make sense of the fundamental building blocks of matter). At root, physics is all about getting conscious about your world.

Paying Attention to 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 will you have to move to get out of its way? (Hang on just a moment while I get out my calculator . . .) Motion was one of the earliest explorations of physics, and physics has proved great at coming up with answers.

This book handles objects in motion — from balls to railroad cars and most objects in between. Motion is a fundamental fact of life and one that most people already know a lot about. You put your foot on the accelerator, and the car takes off.

But there's more to the story. Describing motion and how it works is the first step in really understanding physics, which is all about observations and measurements and making mental and mathematical models based on those observations and measurements. This process is unfamiliar to most people, which is where this book comes in.

Studying motion is fine, but it's just the very beginning of the beginning. 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 the 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.

Motion changes all the time as the result of *force.* You may know the basics of force, but sometimes it takes an expert to really know what's going on in a measurable way. In other words, sometimes it takes a physicist like you.

Getting Energized

You don't have to look far to find your next piece of physics. You never do. As you exit your house in the morning, for example, you may hear a crash up the street. Two cars have collided at a high speed, and, locked together, they're sliding your way.

Thanks to physics you can make the necessary measurements and predictions to know exactly how far you have to move to get out of the way. You know that it's going to take a lot to stop the cars. But a lot of *what?*

It helps to have the ideas of energy and momentum mastered at such a time. You use these ideas to describe the motion of objects with mass. The energy of motion is called *kinetic energy,* and when you accelerate a car from 0 to 60 miles per hour in 10 seconds, the car ends up with plenty of kinetic energy.

Where does the kinetic energy come from? Not from nowhere — if it did, you wouldn't have to worry about the price of gas. Using gas, the engine does work on the car to get it up to speed.

Or say, for example, that you don't have the luxury of an engine when you're moving a piano up the stairs of your new place. But there's always time for a little physics, so you whip out your calculator to calculate how much work you have to do to carry it up the six floors to your new apartment.

After you move up the stairs, your piano will have what's called *potential energy* simply because you put in a lot of work against gravity to get the piano up those six floors.

Unfortunately, your roommate hates pianos and drops yours out the window. What happens next? The potential energy of the piano due to its height in a gravitational field is converted into *kinetic energy*, the energy of motion. It's an interesting process to watch, and you decide to calculate the final speed of the piano as it hits the street.

Next, you calculate the bill for the piano, hand it to your roommate, and go back downstairs to get your drum set.

Moving as Fast as You Can: Special Relativity

Even when you start with the most mundane topics in physics, you quickly get to the most exotic. In Chapter 12, you discover ten amazing insights into Einstein's theory of special relativity.

But what exactly did Einstein say? What does the famous $E = mc^2$ equation really mean? Does it really say that matter and energy are equivalent — that you can convert matter into energy and energy into matter? Yep, sure does.

And stranger things happen when matter starts moving near the speed of light, as predicted by your buddy Einstein.

"Watch that spaceship," you say as a rocket goes past at nearly the speed of light. "It appears compressed along its direction of travel — it's only half as long as it would be at rest."

"What spaceship?" your friends all ask. "It went by too fast for us to see anything."

"Time measured on that spaceship goes more slowly than time here on Earth, too," you explain. "For us, it will take 200 years for the rocket to reach the nearest star. But for the rocket, it will take only 2 years."

"Are you making this up?" everyone asks.