Chapter 1

Using Physics to Understand Your World

In This Chapter

- Recognizing the physics in your world
- Putting the brakes on motion
- Handling the force and energy around you
- Getting hot under the collar with thermodynamics
- Introducing electricity and magnetism
- Wrapping your head around some wild 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, mostly to be nasty — but it isn't like that. 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 electricity, of magnetism, 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.

TECHNICAL STUFF

Physics has been around as long as people have tried to make sense of their world. The word "physics" is derived from the Greek word "physika," which means "natural things."

What Physics Is All 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:

- How can I see?
- Why am I hot?
- What's the air I breathe made up of?
- 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?
- What's light?
- 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.

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 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.

Part I of 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,* which is what Part II is all about. 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.

Absorbing the Energy Around You

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 (and, more specifically, Part III of this book), 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.

Feeling Hot but Not Bothered

Heat and cold are parts of your everyday life, so, of course, physics is there with you in summer and winter. Ever take a look at the beads of condensation on a cold glass of water in a warm room? Water vapor in the air is being cooled when it touches the glass, and it condenses into liquid water. The water vapor passes thermal energy to the cold drink, which ends up getting warmer as a result.

Thermodynamics is what Part IV of this book is all about. Thermodynamics can tell you how much heat you're radiating away on a cold day, how many bags of ice you need to cool a lava pit, the temperature of the surface of the sun, and anything else that deals with heat energy.

You also discover that physics isn't limited to our planet. Why is space cold? It's empty, so how can it be cold? It isn't cold because you can measure its temperature as cold. In space, you radiate away heat, and very little heat radiates back to you. In a normal environment, you radiate heat to everything around you, and everything around you radiates heat back to you. But in space, your heat just radiates away, so you can freeze.

Radiating heat is just one of the three ways heat can be transferred. You can discover plenty more about the heat happening around you all the time, whether created by a heat source like the sun or by friction, through the topics in this book.

Playing with Charges and Magnets

After you master the visible world of objects hurtling around in motion, you can move on to the invisible world of work and energy. Part V offers more insight into the invisible world by dissecting what goes on with electricity and magnetism.

TECHNICAL STUFF

You can see both electricity and magnetism at work, but you can't see them directly. However, when you combine electricity and magnetism, you produce pure light — the very essence of being visible. How light works and how it gets bent in lenses and other materials comes up in Part V.

A great deal of physics involves taking apart the invisible world that surrounds you. Matter itself is made up of particles that carry electric charges, and an incredible number of these charges exist in all people.

When you get concentrations of charges, you get static electricity and such attention-commanding phenomena as lightning. When those charges move, on the other hand, you get normal, wall-socket-brand electricity and magnetism.

From lightning to light bulbs, electricity is part of physics, of course. In this book, you see not only that electricity can flow in circuits but also how it does so. You also come to an understanding of the ins and outs of resistors, capacitors, and inductors.

Preparing for the Wild, Wild Physics Coming Up

Even when you start with the most mundane topics in physics, you quickly get to the most exotic. In Part VI, you discover ten amazing insights into Einstein's Special Theory of Relativity and ten amazing physics facts.

Einstein is one of the most well-known heroes of physics, of course, and an iconic genius. He typifies the lone physics genius for many people, striking out into the universe of the unknown and bringing light to dark areas.

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.

That's a pretty wild physics fact, and it's one you may not think you'll come across in everyday life. But you do. To radiate as much light as it does, the sun converts about 4.79 million tons of matter into radiant energy *every second.*

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. 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.

Physics is all around you, in every commonplace action. But if you want to get wild, physics is the science to do it. This book finishes off with a roundup of some wild physics: the possibility of wormholes in space, for example, and how the gravitational pull of black holes is too strong for even light to escape. Enjoy!