Force and Motion

The cheetah is the fastest land animal, able to run at speeds exceeding 60 miles per hour. Nonetheless, the rabbit has an advantage in this chase. It can *change* its motion more quickly and will likely escape. How can you tell, by looking at the picture, that the cheetah is changing its motion?
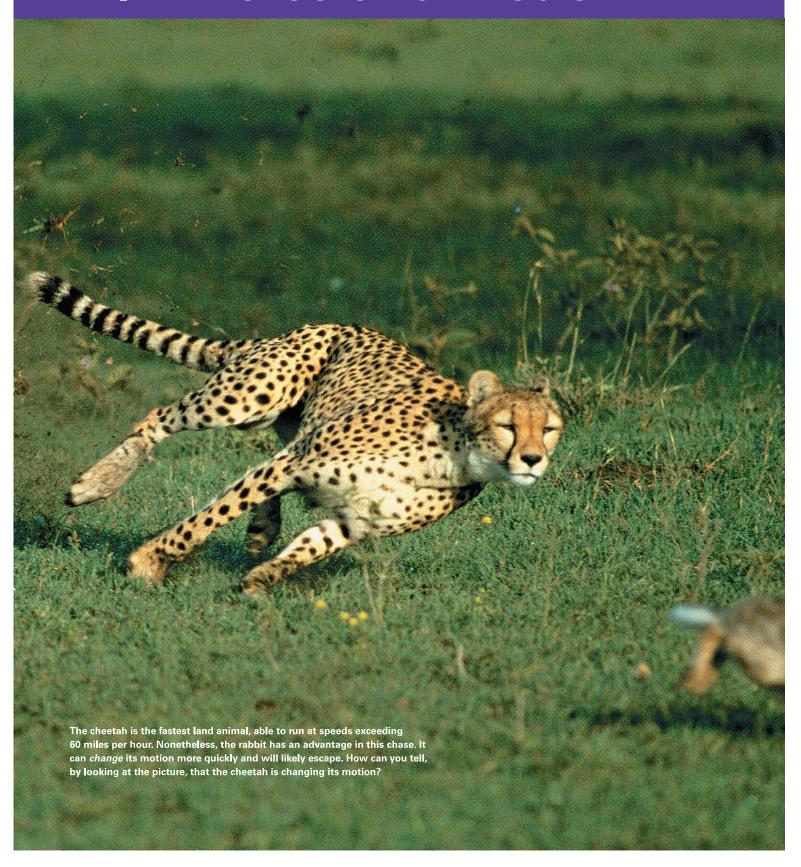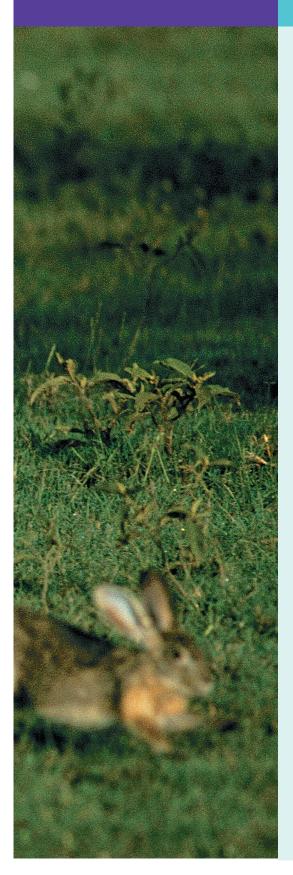
The Science of Physics

Physics is the foundational science that underlies biology, chemistry, earth sciences, and all other fields that attempt to understand our natural world. Physicists couple careful experimentation with deep theoretical insights to build powerful and predictive models of how the world works. A key aspect of physics is that it is a *unifying* discipline: A relatively small number of key concepts can explain a vast array of natural phenomena. In this text, we have organized the chapters into parts according to seven of these unifying principles. Each of the seven parts of this text opens with an overview that gives you a look ahead, a glimpse of where your journey will take you in the next few chapters. It's easy to lose sight of the big picture while you're busy negotiating the terrain of each chapter. In Part I, the big picture is, in a word, *change*.

Why Things Change

Simple observations of the world around you show that most things change. Some changes, such as aging, are biological. Others, such as the burning of gasoline in your car, are chemical. We will look at changes that involve *motion* of one form or another—running and jumping, throwing balls, lifting weights.

There are two big questions we must tackle to study how things change by moving:

- **How do we describe motion?** How should we measure or characterize the motion if we want to analyze it mathematically?
- **How do we explain motion?** Why do objects have the particular motion they do? Why, when you toss a ball upward, does it go up and then come back down rather than keep going up? What are the "laws of nature" that allow us to predict an object's motion?

Two key concepts that will help answer these questions are *force* (the "cause") and *acceleration* (the "effect"). Our basic tools will be three laws of motion worked out by Isaac Newton. Newton's laws relate force to acceleration, and we will use them to explain and explore a wide range of problems. As we learn to solve problems dealing with motion, we will learn basic techniques that we can apply in all the parts of this text.

Simplifying Models

Another key aspect of physics is the importance of models. Suppose we want to analyze a ball moving through the air. Is it necessary to analyze the way the atoms in the ball are connected? Or the details of how the ball is spinning? Or the small drag force it experiences as it moves? These are interesting questions, of course. But if our task is to understand the motion of the ball, we need to simplify!

We can conduct a perfectly fine analysis of the ball's motion if we treat the ball as a single particle moving through the air. This is a *model* of the situation. A model is a simplified description of reality that is used to reduce the complexity of a problem so it can be analyzed and understood. Model building is a major part of the strategy that we will develop for solving problems throughout the text. Learning how to simplify a situation is the essence of successful modeling—and successful problem solving.