Work the Problems

Sample Problems, followed by associated **Practice** problems, build your reasoning and problem-solving skills by guiding you through explicit example problems.

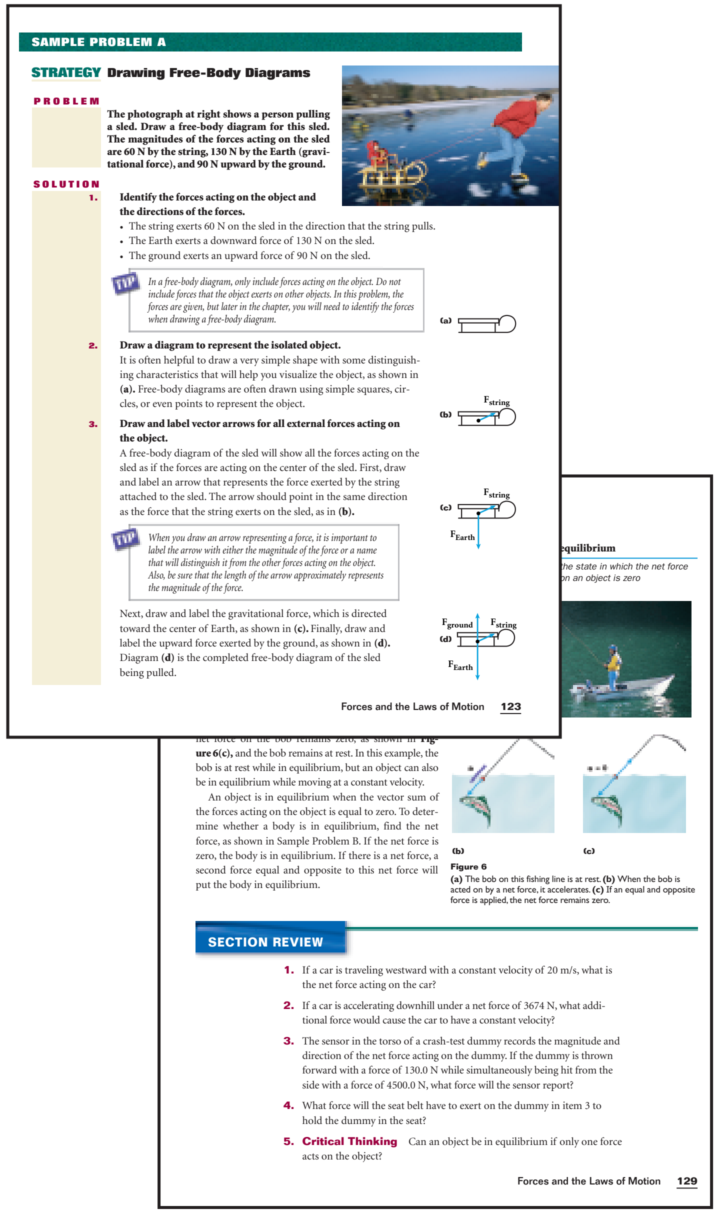
Prepare for Tests

Section Reviews and **Chapter Reviews** test your knowledge of the main points of the chapter. Critical Thinking items challenge you to think about the material in different ways and in greater depth. The **Standardized Test Prep** that is located after each Chapter Review helps you sharpen your test-taking abilities.

STUDY TIP Reread the Section Objectives and Chapter Highlights when studying for a test to be sure you know the material.

Use the Appendix

Your **Appendix** contains a variety of resources designed to enhance your learning experience. A **Mathematical Review** sharpens your math skills. The appendices **Symbols, Equations, SI Units,** and **Useful Tables** summarize essential problem-solving information. **Additional Problems** provides more practice in math and problem-solving skills. **Advanced Topics** allows you to delve deeper into areas of physics that lie beyond material presented in the chapters.



SAMPLE PROBLEM A

STRATEGY **Drawing Free-Body Diagrams**

PROBLEM

The photograph at right shows a person pulling a sled. Draw a free-body diagram for this sled. The magnitudes of the forces acting on the sled are 60 N by the string, 130 N by the Earth (gravitational force), and 90 N upward by the ground.

SOLUTION

1. **Identify the forces acting on the object and the directions of the forces.**
   - The string exerts 60 N on the sled in the direction that the string pulls.
   - The Earth exerts a downward force of 130 N on the sled.
   - The ground exerts an upward force of 90 N on the sled.

TIP *In a free-body diagram, only include forces acting on the object. Do not include forces that the object exerts on other objects. In this problem, the forces are given, but later in the chapter, you will need to identify the forces when drawing a free-body diagram.*

2. **Draw a diagram to represent the isolated object.**
   It is often helpful to draw a very simple shape with some distinguishing characteristics that will help you visualize the object, as shown in **(a).** Free-body diagrams are often drawn using simple squares, circles, or even points to represent the object.

3. **Draw and label vector arrows for all external forces acting on the object.**
   A free-body diagram of the sled will show all the forces acting on the sled as if the forces are acting on the center of the sled. First, draw and label an arrow that represents the force exerted by the string attached to the sled. The arrow should point in the same direction as the force that the string exerts on the sled, as in **(b).**

TIP *When you draw an arrow representing a force, it is important to label the arrow with either the magnitude of the force or a name that will distinguish it from the other forces acting on the object. Also, be sure that the length of the arrow approximately represents the magnitude of the force.*

Next, draw and label the gravitational force, which is directed toward the center of Earth, as shown in **(c).** Finally, draw and label the upward force exerted by the ground, as shown in **(d).** Diagram **(d)** is the completed free-body diagram of the sled being pulled.

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equilibrium the state in which the net force on an object is zero

ure 6(c), and the bob remains at rest. In this example, the bob is at rest while in equilibrium, but an object can also be in equilibrium while moving at a constant velocity.

An object is in equilibrium when the vector sum of the forces acting on the object is equal to zero. To determine whether a body is in equilibrium, find the net force, as shown in Sample Problem B. If the net force is zero, the body is in equilibrium. If there is a net force, a second force equal and opposite to this net force will put the body in equilibrium.

(b) (c)

Figure 6
(a) The bob on this fishing line is at rest. **(b)** When the bob is acted on by a net force, it accelerates. **(c)** If an equal and opposite force is applied, the net force remains zero.

SECTION REVIEW

1. If a car is traveling westward with a constant velocity of 20 m/s, what is the net force acting on the car?
2. If a car is accelerating downhill under a net force of 3674 N, what additional force would cause the car to have a constant velocity?
3. The sensor in the torso of a crash-test dummy records the magnitude and direction of the net force acting on the dummy. If the dummy is thrown forward with a force of 130.0 N while simultaneously being hit from the side with a force of 4500.0 N, what force will the sensor report?
4. What force will the seat belt have to exert on the dummy in item 3 to hold the dummy in the seat?
5. **Critical Thinking** Can an object be in equilibrium if only one force acts on the object?

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