

## 4-9 Problem Solving—A General Approach

A basic part of a physics course is solving problems effectively. The approach discussed here, though emphasizing Newton's laws, can be applied generally for other topics discussed throughout this book.

### PROBLEM SOLVING In General

- 1. Read** and reread written problems carefully. A common error is to skip a word or two when reading, which can completely change the meaning of a problem.
- 2. Draw** an accurate picture or diagram of the situation. (This is probably the most overlooked, yet most crucial, part of solving a problem.) Use arrows to represent vectors such as velocity or force, and label the vectors with appropriate symbols. When dealing with forces and applying Newton's laws, make sure to include all forces on a given object, including unknown ones, and make clear what forces act on what object (otherwise you may make an error in determining the *net force* on a particular object). A separate **free-body diagram** needs to be drawn for each object involved, and it must show *all* the forces acting on a given object (and only on that object). Do not show forces that act on other objects.
- 3.** Choose a convenient  $xy$  **coordinate system** (one that makes your calculations easier, such as one axis in the direction of the acceleration). Vectors are to be resolved into components along the coordinate axes. When using Newton's second law, apply  $\Sigma \vec{F} = m\vec{a}$  separately to  $x$  and  $y$  components, remembering that  $x$  direction forces are related to  $a_x$ , and similarly for  $y$ . If more than one object is involved, you can choose different (convenient) coordinate systems for each.
- 4.** List the knowns and the unknowns (what you are trying to determine), and decide what you need in order to find the unknowns. For problems in the present Chapter, we use Newton's laws. More generally, it may help to see if one or more **relationships** (or **equations**) relate the unknowns to the knowns. But be sure each relationship is applicable in the given case. It is very important to know the limitations of each formula or relationship—when it is valid and when not. In this book, the more general equations have been given numbers, but even these can have a limited range of validity (often stated in brackets to the right of the equation).
- 5.** Try to solve the problem approximately, to see if it is doable (to check if enough information has been given) and reasonable. Use your intuition, and make **rough calculations**—see “Order of Magnitude Estimating” in Section 1-7. A rough calculation, or a reasonable guess about what the range of final answers might be, is very useful. And a rough calculation can be checked against the final answer to catch errors in calculation, such as in a decimal point or the powers of 10.
- 6.** **Solve** the problem, which may include algebraic manipulation of equations and/or numerical calculations. Recall the mathematical rule that you need as many independent equations as you have unknowns; if you have three unknowns, for example, then you need three independent equations. It is usually best to work out the algebra symbolically before putting in the numbers. Why? Because (a) you can then solve a whole class of similar problems with different numerical values; (b) you can check your result for cases already understood (say,  $\theta = 0^\circ$  or  $90^\circ$ ); (c) there may be cancellations or other simplifications; (d) there is usually less chance for numerical error; and (e) you may gain better insight into the problem.
- 7.** Be sure to keep track of **units**, for they can serve as a check (they must balance on both sides of any equation).
- 8.** Again consider if your answer is **reasonable**. The use of dimensional analysis, described in Section 1-8, can also serve as a check for many problems.

## Summary

**Newton's three laws of motion** are the basic classical laws describing motion.

**Newton's first law** (the **law of inertia**) states that if the net force on an object is zero, an object originally at rest remains at rest, and an object in motion remains in motion in a straight line with constant velocity.

**Newton's second law** states that the acceleration of an object is directly proportional to the net force acting on it, and inversely proportional to its mass:

$$\Sigma \vec{F} = m\vec{a}. \quad (4-1)$$

Newton's second law is one of the most important and fundamental laws in classical physics.