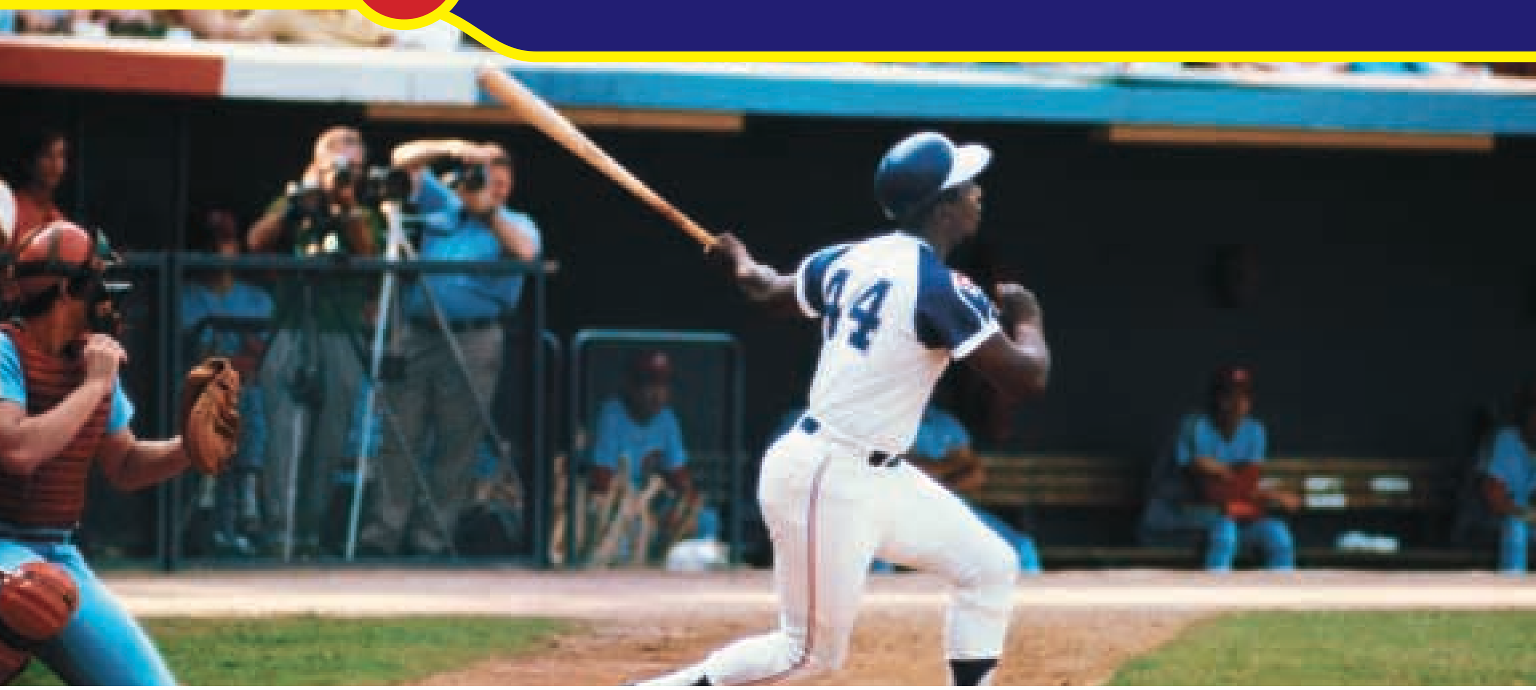
CHAPTER 11

Projectiles and Circular Motion



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In the ninth inning, the team at bat is behind by two runs, with the bases loaded. With the game on the line, a nervous batter walks to the plate. The pitcher hurls a fast ball, and the batter connects, sending the ball in an arc towards the left field fence. Will it be a home run?

Any object, such as a baseball, that is launched near Earth's surface and is subject only to the force of gravity is said to exhibit projectile motion. Such objects will experience air friction, but you must first understand the ideal case in which you neglect air friction before adding such complications. By knowing the initial velocity alone, you can predict the object's maximum height, the horizontal distance it will travel, and its position and velocity at any time after launch. That is, you can predict whether the ball will go over the fence.

An object following the path of a perfect circle at a constant speed, such as an airplane at an airshow, is undergoing uniform circular motion. Even if the object follows only a short arc of a circle, such as a car going around a curve, you can treat that motion with the mathematical techniques of uniform circular motion. You could calculate the optimum angle at which a curve on a highway should be banked to prevent a vehicle from skidding off the road while taking the curve at a specific speed. In this chapter, you will study these two types of motion that are observed so often in so many different situations that they warrant special attention.

MULTI LAB

Motion in Two Dimensions

TARGET SKILLS
- Performing and recording
- Analyzing and interpreting

CAUTION Wear impact-resistant safety goggles. Also, do not stand close to other people or equipment while doing these activities.

Race to the Ground

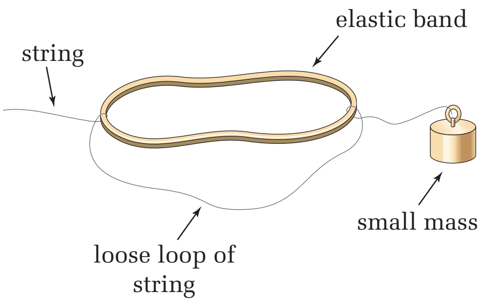
If your school has a vertical acceleration demonstrator, set it up to make observations. If you do not have a demonstrator, devise a method for launching one object, such as a small metal ball, in the horizontal direction, while at the same instant dropping a second object from exactly the same height. Perform several trials, observing the paths of the objects very carefully.

Analyze and Conclude

1. Describe in detail the paths of the two objects. Compare the motion of the two objects.
2. Which object hit the floor first?
3. Did the horizontal motion of the first object appear to affect its vertical motion? Explain your reasoning for your conclusion.

Feel the Force

According to the law of inertia, objects must experience an unbalanced force to change the direction of their motion. What does this suggest about an object moving in a circle? Assemble the apparatus as shown in the diagram to obtain information on the forces involved in circular motion. Gently swing the mass in a horizontal circle. Carefully increase the speed of rotation and observe the effect on the elastic band and the path of the object. Change the angle so that the object moves first in an inclined plane and then in a vertical plane and repeat your observations.



Analyze and Conclude

1. How does the force exerted on the object by the elastic band change as the elastic band stretches?
2. How does the force exerted on the object change as the speed of the mass increases?
3. Sketch free-body diagrams showing the forces acting on the object as it moves in a
   (a) horizontal plane
   (b) vertical plane (at the top of the swing, the bottom of the swing, and when it is at one side of the circle)
4. Describe and attempt to explain any other changes you observed in the object's motion as its speed varied.
5. Was there any difference in the force exerted by the elastic band at the highest and lowest points of the mass's path when it moved in a vertical plane? If so, suggest an explanation.