

- T** 27. Sketch the graph of the curve  $C$  described by the parametric equation

$$\mathbf{r} = \mathbf{r}(t) = \langle t - t^2, t + 2t^2 \rangle,$$

where  $-3 \leq t \leq 3$ . Eliminate the parameter to obtain an equation in  $x$  and  $y$ . Show that the curve described by this equation includes the curve  $C$ . Calculate the slope of  $C$  at the point  $(-2, 10)$ .

28. Let  $\mathbf{r} = \mathbf{r}_0 + \mathbf{a}$  describe a line  $L$ , and let  $\mathbf{q}$  be the position vector of a point  $Q$  not on  $L$ . Show that the distance  $d$  from  $L$  to  $Q$  can be calculated as follows. Let  $\mathbf{p}$  be the vector projection of  $\mathbf{q} - \mathbf{r}_0$  onto  $\mathbf{a}$  and  $\mathbf{n} = \mathbf{q} - \mathbf{r}_0 - \mathbf{p}$ . Then  $d = \|\mathbf{n}\|$ . Use this procedure to calculate the distance from the line through  $(1, 5)$  and  $(7, 2)$  to the point  $(-5, -3)$ .

## STUDENT PROJECT

### A. TIMING A RIFLE BULLET

A method for calculating the time taken in seconds for a rifle ball to travel from muzzle to target was published in the July 1893 issue of *Scientific American*. This was reported in the “50 and 100 Years Ago” column of the July 1993 issue.

It may be of interest to amateur riflemen to know the following simple method for ascertaining the effect of gravity upon a bullet: Sight the rifle upon the target, keeping the sights plumb above the center line of the bore of the rifle. Mark where the ball strikes. Then reverse the rifle, so as to have the sights exactly beneath the line of the bore. In this reversed position sight it on the target as before, and mark where the bullet strikes. Divide the difference in elevation of the two bullet marks by 32 and extract the square root. This will give the time in seconds that it took the ball to travel the distance. The distance divided by the time will give the speed of the bullet per second.  
–J. A. G., Grand Rapids, Michigan

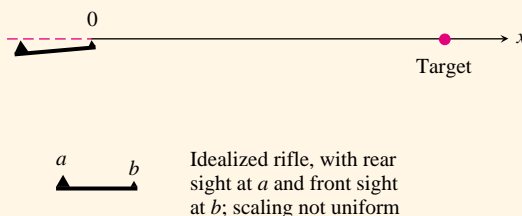


FIGURE 3.62 Diagram for Problem 1.

**PROBLEM 1** Verify J. A. G.’s assertions and conclusions, and comment on the assumptions that you and J. A. G. made. See Fig. 3.62.

**PROBLEM 2** The word *extract* used by J. A. G. suggests that it was somewhat more difficult to calculate a square root in 1893 than now. Write a short paragraph discussing and contrasting the techniques used by typical students in 1900 and 2000 to calculate, say,  $\sqrt{5.73}$ .

### B. THE QUARTERBACK’S PROBLEM

Figure 3.63 shows a quarterback and receiver at points  $QB$  and  $R$  on a level playing field. The point  $R$  is 15 yards downfield from  $QB$  and 10 yards to one side. According to plan A, the receiver will run along the line  $L$  at 6 yards per second and receive a pass from the quarterback. The quarterback must pass within 5 seconds after the receiver starts running. The dotted line in the figure is the projection onto the field of the trajectory of the ball in a successful pass. A pass is “successful” if the receiver