that some important features are hidden from view. In Fig. 1.17, we ZOOM-IN on the flat portion and see a local high point and a local low point. By using the scale marks, we can estimate from Fig. 1.17 that the high point is about $(0.3, -29.8)$ and the low point is about $(1, -30)$.

Notice that the *y-intercept* is $y = -30$. We have to look back to Fig. 1.16(c) to estimate the *x*-intercept to be about 4. Thus, it takes *both* Figs. 1.16(c) and 1.17 to constitute a complete graph of the equation.
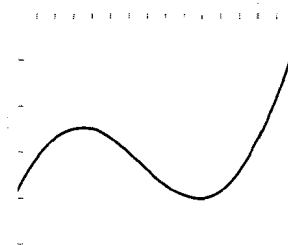
[0, 1.5] by [-30.2, -29.6]

1.17   Using ZOOM-IN on the view in Fig. 1.16(c) gives this closer look at the flat portion of the graph of $y = x^3 - 2x^2 + x - 30$. To help you understand ZOOM-IN, compare the view dimensions and the scales on the axes here with those in Fig. 1.16(c).

Exercises 1.1

In Exercises 1 and 2, determine which points lie in the indicated viewing window.

1. Viewing window: $[-5, 5]$ by $[-10, 10]$
   Points: $(-6, 2), (0, 6), (5, -5), (-4, 12)$

2. Viewing window: $[0, 10]$ by $[0, 100]$
   Points: $(1.5, 17.5), (0.5, -1), (90, 8), (10, 100)$

In Exercises 3 and 4, determine a viewing window that contains the three indicated points.

3. Points: $(-17, 3), (21, -12), (18, 76)$

4. Points: $(-42, 31), (8, -6), (53, -89)$

In Exercises 5–8, view dimensions for a grapher are given. Choose appropriate values for *x*-scale and *y*-scale. Explain why your choices are reasonable.

5. $[-10, 50]$ by $[-50, 50]$ 6. $[-1, 1.5]$ by $[1, 2]$

7. $[-1, 0]$ by $[-100, 100]$ 8. $[-50, 150]$ by $[-2, 2]$

Find the intercepts and sketch a graph of each equation in Exercises 9–14. Remember, "sketch" means to graph without using a graphing utility.

9. $y = x + 1$ 10. $y = -x + 1$
11. $y = -x^2$ 12. $y = 4 - x^2$
13. $x = -y^2$ 14. $x = 1 - y^2$

In Exercises 15–20, which view gives the best complete graph of the indicated equation?

15. $y = 2x^2 - 40x + 150$
    a) $[-5, 5]$ by $[-5, 5]$ b) $[-10, 10]$ by $[-10, 10]$
    c) $[10, 30]$ by $[-50, 100]$
    d) $[-100, 100]$ by $[-10, 10]$
    e) $[-10, 30]$ by $[-100, 100]$

16. $y = -3x^2 + 9x - 20$
    a) $[-10, 10]$ by $[-10, 10]$
    b) $[-10, 10]$ by $[-100, 100]$
    c) $[2, 10]$ by $[-100, 10]$
    d) $[-10, 10]$ by $[-3000, 3000]$
    e) $[-300, 300]$ by $[-100, 100]$

17. $y = 20 + 9x - x^3$
    a) $[-10, 10]$ by $[-10, 10]$
    b) $[-1, 10]$ by $[-30, 40]$
    c) $[-5, 0]$ by $[0, 100]$ d) $[-5, 5]$ by $[-500, 1000]$
    e) $[-10, 10]$ by $[-50, 50]$

18. $y = x^3 - x + 15$
    a) $[-5, 5]$ by $[-10, 10]$
    b) $[-10, 10]$ by $[-100, 100]$
    c) $[-10, 10]$ by $[-30, 30]$
    d) $[-5, 5]$ by $[-5, 15]$
    e) $[-100, 100]$ by $[-100, 100]$

19. $y = 3x - 800$
   a) $[0, 500]$ by $[0, 500]$ **b)** $[260, 270]$ by $[-10, 10]$
   c) $[-10, 10]$ by $[-810, -790]$
   d) $[-10, 10]$ by $[-10, 10]$
   e) $[-100, 500]$ by $[-1000, 500]$

20. $y = -2x^2 + 500$
   a) $[-10, 10]$ by $[-10, 10]$
   b) $[240, 260]$ by $[-10, 10]$
   c) $[-10, 10]$ by $[490, 510]$
   d) $[-100, 400]$ by $[-200, 800]$
   e) $[0, 400]$ by $[0, 400]$

Draw a complete graph of the equation in Exercises 21–26. Use the graph to estimate the intercepts. Confirm the intercepts algebraically.

21. $y = 3x - 5$ **22.** $y = 4 - 5x$
23. $y = 10 + x - 2x^2$ **24.** $y = 2x^2 - 2x - 12$
25. $y = 2x^2 - 8x + 3$ **26.** $y = -3x^2 - 6x - 1$

Draw a complete graph of the equation in Exercises 27–34. Use the graph to estimate the intercepts and the coordinates of any local high or low points.

27. $y = x^2 + 4x + 5$ **28.** $y = -3x^2 + 12x - 8$
29. $y = 12x - 3x^3$ **30.** $y = 2x^3 - 2x$
31. $y = -x^3 + 9x - 1$ **32.** $y = x^3 - 4x + 3$
33. $y = x^3 + 2x^2 + x + 5$ **34.** $y = 2x^3 - 5.5x^2 + 5x - 5$

Exercises 35–40 refer to a grapher that uses N horizontal pixels and M vertical pixels on its display screen. (You can replace N and M with the values for your grapher, or you can use $N = 127$ and $M = 63$ if you wish.) Using (x_i, y_j) for the screen coordinates associated with each pixel, the four corner points have the following coordinates:

$$(x_1, y_M) = (x\text{Min}, y\text{Max}) \quad (x_N, y_M) = (x\text{Max}, y\text{Max})$$

$$(x_1, y_1) = (x\text{Min}, y\text{Min}) \quad (x_N, y_1) = (x\text{Max}, y\text{Min})$$

35. To find the pixel with screen coordinates (x_i, y_j), we count i pixels to the right and j pixels up beginning in the lower left corner where $(x_1, y_1) = (x\text{Min}, y\text{Min})$. Show that

$$(x_i, y_j) = (x\text{Min} + (i - 1)\delta x, y\text{Min} + (j - 1)\delta y)$$

where

$$\delta x = \frac{x\text{Max} - x\text{Min}}{N - 1}, \qquad \delta y = \frac{y\text{Max} - y\text{Min}}{M - 1}.$$

(The symbol δ is the lowercase Greek letter "delta," and a symbol like δx is read "delta x." It is a single symbol and not "δ times x." Note that δx is the horizontal distance between the midpoints of any two adjacent pixels.)

36. Let (a, b) be a point in the coordinate plane and (x_i, y_j) the corresponding screen coordinate.
   a) Explain why the error in using x_i as an approximation to a is at most $\delta x/2$.
   b) Explain why the error in using y_j as an approximation to b is at most $\delta y/2$.

In Exercises 37–40, determine a and b so that the screen coordinates of the $[-10, a]$ by $[-10, b]$ viewing window have the indicated property.

37. $\delta x = \delta y = 1$ **38.** $\delta x = \delta y = 0.1$
39. $\delta x = 0.5, \delta y = 2$ **40.** $\delta x = 2, \delta y = 10$

Decompression Stops

Scuba divers often have to make decompression stops on their way to the surface after deep or long dives. A stop, which may vary from a few minutes to more than an hour, provides time for the safe release of nitrogen and other gases absorbed by the tissues and blood while the body was under pressure. Dives to 33 ft or less do not require decompression stops. Dives to greater depths can be made without return stops if the diver does not stay down too long. The graph in Fig. 1.18 shows the longest times that a diver breathing compressed air may spend at various depths and still surface directly (at 60 ft/min). The times shown are total lengths of the dives, not just the times spent at maximum depth.
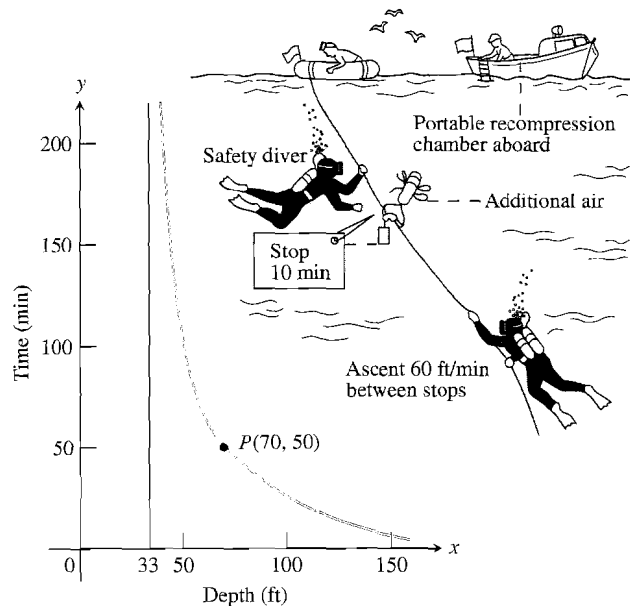
1.18 The coordinates of the points on the curve show how long scuba divers breathing compressed air can safely stay below the surface without a decompression stop. (Data from *U.S. Navy Diving Manual*, NAVSKIPS 250-538.)