Lesson

1-5 Using a Graphing Calculator

BIG IDEA By letting $y =$ the value of an expression with variable x, a graphing calculator or computer can automatically generate a graph of the relationship between x and y.

Vocabulary

window
Xmin
Xmax
Ymin
Ymax
Xscl
Yscl
standard window

Mental Math

Evaluate $3n + (5 - n) - 2n$ when:

a. $n = 3$.

b. $n = 0$.

c. $n = -2$.

d. $n = 1{,}000$.

Graphing with Technology

An algebraic expression such as $x^2 - 15x$ shows calculations that are performed on a variable. In Lesson 1-4, you evaluated expressions by substituting variables with numbers taken from tables. In much the same way, graphing calculators find values and graph the points they describe. These machines were first introduced in 1985 and are popular today because they perform repeated calculations quickly and allow a person to focus on the mathematical relationships shown by graphs and tables.

Activity 1

To graph values of an expression on a graphing calculator, a second variable *y* is used. It represents the value of the expression that is calculated for each *x*-value.

Step 1 Go to the Y= menu on your graphing calculator.

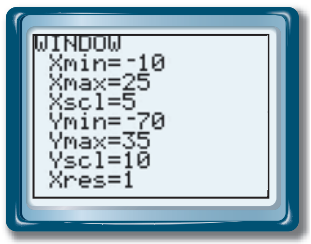
Step 2 Type in $x^2 - 15x$.

Since the calculator can display several graphs on the same window, it uses names like Y_1, Y_2, and Y_3 in its equations.

When you draw a graph by hand, you must decide what portion of the coordinate grid to display. The same decision must be made when using a graphing calculator. The part that is shown is called the **window.** The window can be described by two inequalities.

Step 3 Go to the WINDOW menu on your calculator.

Step 4 Enter the same values as in the screen at the right. The information in this window can be expressed with the inequalities $-10 \leq x \leq 25$ and $-70 \leq y \leq 35$.



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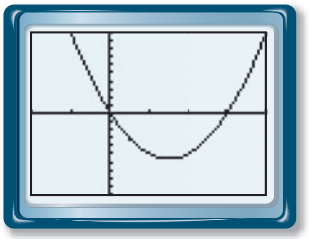
Step 5 Press the GRAPH command. Your graph should look like the one at the right.



Most graphing calculators use the variables x and y for graphing. If a problem uses other letters for variables, you must replace those letters with x and y. On a calculator, the four numbers that describe the boundaries of the window are each given a name. For the x-coordinates, the minimum edge, or least value displayed, is called **Xmin** or x-min (the left edge of the screen) and the maximum edge, or greatest value, is **Xmax** or x-max (the right edge of the screen). Similarly, **Ymin** (or y-min) and **Ymax** (or y-max) are the least (bottom edge) and greatest (top edge) values for the y-coordinates.

The calculator does not put coordinates by the tick marks on the axes, so you need to look carefully at the window description to understand what numbers are being shown. In the graph above, the tick marks are spaced 5 units apart on the x-axis, and 10 units apart on the y-axis. This scale is described by **Xscl** (x-scale) and **Yscl** (y-scale) on the window settings screen.

Activity 2

Step 1 Go to the [Y=] menu and enter $-7x^2 + 3x - 4$.

Step 2 Go to the WINDOW menu and enter the settings $-3 \leq x \leq 3$ with x-scale of 1 and $-25 \leq y \leq 0$ with a y-scale of 5.

Step 3 Copy your window screen and sketch the graph your calculator displays.

Activity 3

Step 1 Enter $y = \frac{5}{x^2 + 1}$ into the [Y=] menu. (Type in as $5 \div (x^2 + 1)$.)

Step 2 Go to the ZOOM menu. Press STANDARD.

Step 3 Copy your graph down on a sheet of paper.

Step 4 Describe the window by completing the inequalities below.

$\underline{?} \leq x \leq \underline{?}$ and $\underline{?} \leq y \leq \underline{?}$

x-scale $= \underline{?}$ y-scale $= \underline{?}$

Anytime you use the **standard window**, your calculator will display in the above window.

You may find that when you try to graph an equation, no graph appears. This may mean that your window settings are not appropriate for your equation. Deciding on a good window is an important skill, so learn to think about it each time you graph!

Activity 4

Step 1 Enter $y = 5x(x + 4)(x - 3)$ into the Y= menu. (*Caution:* You may need to enter multiplication symbols that are not shown in the expression.)

Step 2 Use your calculator to match the windows below and graphs of $y = 5x(x + 4)(x - 3)$ at the right.

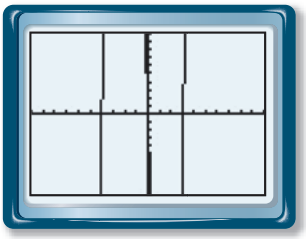
Window 1
$-6 \leq x \leq 6$ with x-scale of 1
$-100 \leq y \leq 150$ with y-scale of 25

Window 2
$-2.8 \leq x \leq -2.1$ with x-scale of 0.1
$40 \leq y \leq 145$ with y-scale of 10

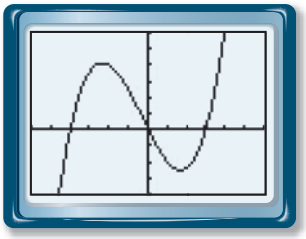
Window 3 (Standard window)
$-10 \leq x \leq 10$ with x-scale of 1
$-10 \leq y \leq 10$ with y-scale of 1

Window 4
$-30 \leq x \leq 30$ with x-scale of 5
$-500 \leq y \leq 500$ with y-scale of 100

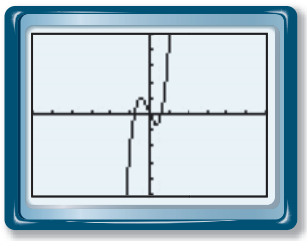
Graph 1



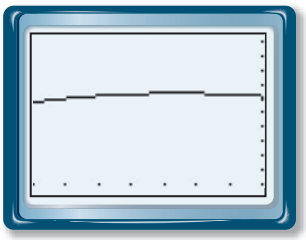
Graph 2



Graph 3

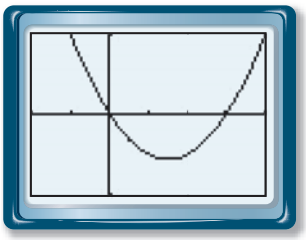


Graph 4



Activity 5

Step 1 The graph at the right shows $y = x^2 - 15x$ graphed on the window $-10 \leq x \leq 20$ and $-100 \leq y \leq 100$. Use the tick marks on the graph to find the coordinates of the points where the curve crosses the x-axis.



Step 2 Use the TRACE or VALUE commands to verify your answers to Step 1.

Step 3 Substitute those x-values into $x^2 - 15x$ and evaluate.

Step 4 Do your results match the y-coordinates?

Tables from a Graphing Calculator

In Lesson 1-4, you drew graphs from tables you had created. The graphing calculator will also make a table of values for an expression entered in the Y= menu.

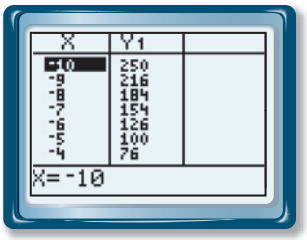
Activity 6

Step 1 Enter $y = x^2 - 15x$ into the Y= menu.

Step 2 Go to TABLE SETUP.

Step 3 Start table at −10 and have the table increment or △TABLE equal 1.

Step 4 Go to TABLE. Your screen should match the one at the right.



Step 5 Notice that the first x-value is −10 and that the x-values go up by 1 each step.

Step 6 In TABLE SETUP menu, change table start to 2 and △TABLE to 3. Write down the x- and y-values that appear in the table.

Step 7 Scroll up to where $x = -4$. What is the corresponding y-value?

Step 8 Scroll down to where $x = 35$. Give the corresponding y-value.

Comparing Expressions with Technology

You can also use your graphing calculator to see how the values of the two expressions are similar or different. Be careful in setting the window so you can see the important features of both graphs.

Activity 7

Compare the expressions $(x - 3)^2$ and $(x + 3)^2$ by graphing.

Step 1 Graph $y = (x - 3)^2$ and $y = (x + 3)^2$ in a standard window. Sketch your results.

Step 2 Give the coordinates of the intersection of the graph of $y = (x - 3)^2$ and the x-axis.

Step 3 Give the coordinates of the intersection of the graph of $y = (x + 3)^2$ and the x-axis.

Since the graphs are different, the two expressions $(x - 3)^2$ and $(x + 3)^2$ are not equivalent.

STOP **See Quiz Yourself 1 at the right.**

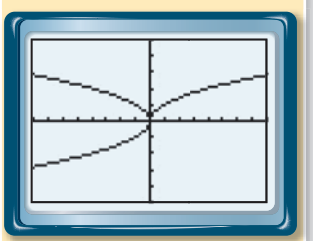
▶ QUIZ YOURSELF 1

Use your calculator to determine which equation below is represented by the given graph.

$y = \sqrt{x}$

$y = \sqrt{-x}$

$y = -\sqrt{-x}$



Creating Scatterplots with Technology

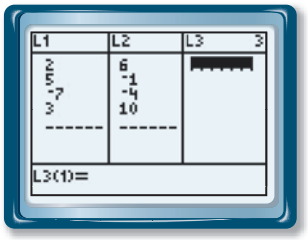
A graphing calculator can plot individual points. To do this, enter a table of values into lists. Many calculators use names L1, L2, and L3 for the lists (just as Y1, Y2, and Y3 are used for the graphing of equations).

Activity 8

Step 1 Clear any equations in the Y= menu and turn on the STAT PLOT function.

Step 2 Enter the table below in the STAT lists. Then graph the points.

x	*y*
2	6
5	–1
–7	–4
3	10

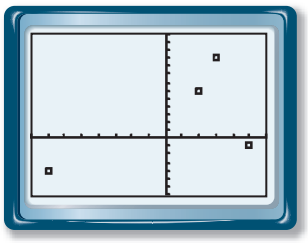


To decide on a window for a scatterplot, look at the values you are graphing. Find the least *x*-value in the table of values. Your *x*-minimum in the window should always be *less than* that value. Likewise, find the greatest *x*-value in the table and set the *x*-maximum in the window to a *greater* value. Follow the same procedure for the *y*-minimum and *y*-maximum in the window.

Step 3 Complete the following using the table above.

least *x*-value ___?___ a lesser *x*-value for *x*-min ___?___
greatest *x*-value ___?___ a greater *x*-value for *x*-max ___?___
least *y*-value ___?___ a lesser *y*-value for *y*-min ___?___
greatest *y*-value ___?___ a greater *y*-value for *y*-max ___?___

Step 4 Use your results to graph the points. One possible graph is shown below.



STOP **See Quiz Yourself 2 at the right.**

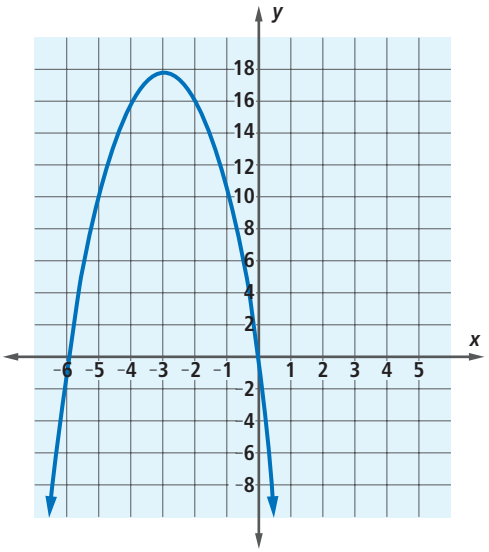
▶ QUIZ YOURSELF 2

Plot the following table of values using lists and a proper window.

x	*y*
61	–681
64	–661
58	–661
67	–651
55	–651
70	–661
52	–661
50.5	–681
71.5	–681
70	–705
52	–705
67	–725
55	–725
64	–745
58	–745
61	–765

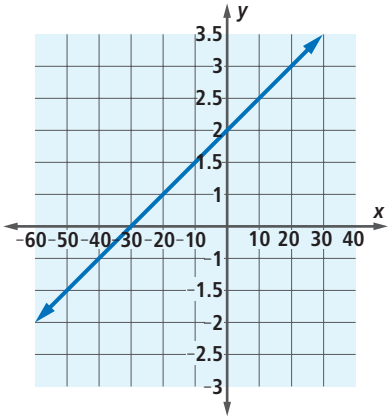
Questions

COVERING THE IDEAS

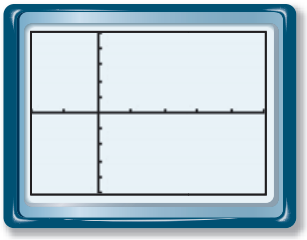


1. Write the two inequalities that describe the window for the graph at the right.
   ___?___ $\le x \le$ ___?___ and ___?___ $\le y \le$ ___?___

2. a. Write the two inequalities that describe the window below.
   b. Find the distance between tick marks on the x-axis and on the y-axis.



3. The window at the right is described by $-10 \le x \le 25$ and $-10 \le y \le 10$. Copy the window and label the tick marks with their coordinates.



4. Use the graphing calculator screen below to make a table of values for the expression $2x + 1$. List the first five ordered pairs in the table.

5. Use a graphing calculator to make a table of values and graph for $y = x^2 + 3$ using the window $-6 \le x \le 6$ and $0 \le y \le 40$. Adjust your table settings so that x increases by 2 for each row in the table.

6. **a.** Use lists on a calculator to graph the ordered pairs in the table below.

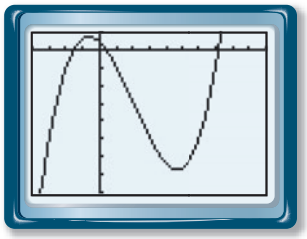
x	−59	−41	67	13	103	58	31	85	−23	4	121	49	31	−5
y	371	375	383	387	375	379	391	379	379	379	371	387	379	383

b. Use inequalities to show a window that contains all the points.

c. Sketch the graph using your window from Part b.

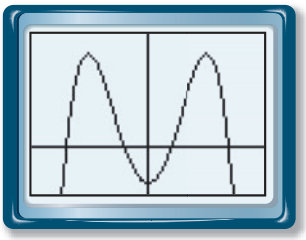
7. **a.** Graph $y = x^3 - 6x^2 - 9x + 4$ on a graphing calculator in a standard window.

b. Now change the values in the window so the graph looks like the image at the right. Give the values of your window's Xmin, Xmax, Ymin, and Ymax.

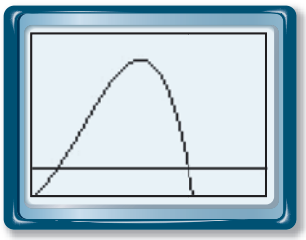


8. **a.** Graph the equation $y = -0.04x^4 + 2.12x^2 - 7.84$ on a graphing calculator's standard window. Sketch the graph on paper.

b. Change the y-max value in the window so the graph looks like the letter M, as shown at the right.



c. Change the x-values and the y-values in the window so only the right "bump" of the graph appears, as shown below.



d. Enlarge the window to $-100 \le x \le 100$ with x-scale of 10, and $-500 \le y \le 500$ with y-scale of 100. Copy this graph on your paper.

e. Change to a window of $-3 \le x \le 3$ with x-scale of 0.5 and $-3 \le y \le 3$ with y-scale of 1. Copy this graph on your paper.

APPLYING THE MATHEMATICS

In 9 and 10, an equation is given.

a. Graph the equation in a standard window.

b. Label at least three points on the graph with their coordinates.

9. $y = 3x - 4$

10. $y = x^2 - 3$

In 11 and 12, first graph the equation using the window $-10 \le x \le 10$ and $-10 \le y \le 10$. The result will be a line. Then adjust the window so the points where the line crosses both the *x*- and *y*-axes are visible. Describe your window with two inequalities.

11. $y = -4x - 32$

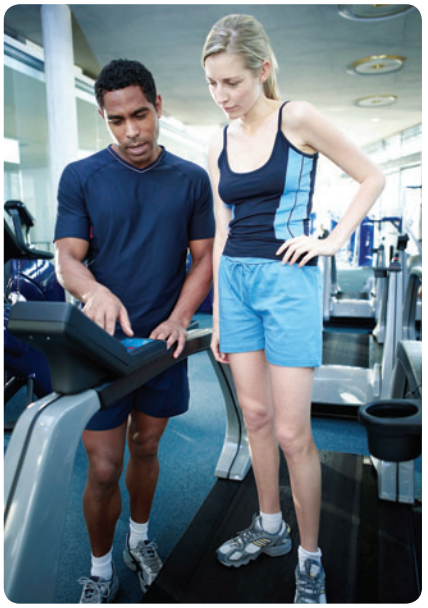
12. $y = \frac{1}{2}x - 12$

13. Test to see if $(6x - 14) - (x + 11)$ and $5x + 3$ are equivalent using a graphing calculator. Explain your conclusion.

14. Graph $y = \sqrt{x}$ on a calculator. Use the window $-10 \le x \le 10$ and $-10 \le y \le 10$.

REVIEW

15. Ayita's Gym charges new members a sign-up fee of \$54, which they pay only once. For every month a person is a member, there is a fee of \$26. Let m = the number of months of membership. **(Lessons 1-1, 1-4)**
    a. Write an expression for the cost of membership for m months.
    b. Make a table of values and plot the graph.



Walking for 20–45 minutes four to five times per week at 3 miles per hour is a great way to stay fit.

In 16–18, choose the most reasonable domain for the variable. (Lesson 1-4)

a. the set of whole numbers
b. the set of integers
c. the set of real numbers
d. the set of positive real numbers

16. the number of students n in your math class

17. the time t it takes to drive to school

18. the temperature T of a location on Earth

19. An air conditioning unit with a high energy efficient ratio (EER) gives more cooling with less electricity. To find the EER of a unit, divide the BTU (British Thermal Unit) number by the number of watts the unit uses. The higher the EER, the more efficient the air conditioner. **(Lesson 1-1)**

$$\text{EER} = \frac{\text{BTU}}{\text{number of watts}}$$

    a. Find the EER to the nearest tenth for an air conditioner having 8,500 BTUs and 925 watts.
    b. Find the EER to the nearest tenth for an air conditioner having 12,700 BTUs and 1,500 watts.
    c. Which of the two air conditioners above is more efficient? Justify your answer.

20. Evaluate the expression $\frac{a+b}{3} + 3(a-b)$ for the given values of a and b. **(Lesson 1-1)**

a. $a = 11, b = 4$ **b.** $a = 7, b = 2$

In 21–26, compute in your head. (Previous Course)

21. $15 + -19 + 4$ **22.** $-10{,}000 - 20{,}000$

23. $\frac{-16+8}{2}$ **24.** $-6 - -10 + 3$

25. $-8 - 16 + 5$ **26.** $\frac{1}{3} + \frac{1}{2} - \frac{1}{5}$

EXPLORATION

27. Explain what the following features do on your graphing calculator.

a. `Zoom In`

b. `Zoom Out`

c. `ZBox`

28. Graph $y = \frac{19x}{x^2+4}$ on your graphing calculator. Experiment with the values of the window until the graph looks like each of the following. Give the values for your window's Xmin, Xmax, Ymin, and Ymax.

a. a horizontal line

b. a diagonal crossing from the lower left corner to the upper right corner of the window

c. a vertical line

d. a diagonal crossing from the upper left corner to the lower right corner of the window

QUIZ YOURSELF ANSWERS

1. Each equation is represented in the graph.

2. The window $45 \leq x \leq 65$, and $-800 \leq y \leq -600$ displays the scatterplot.