Appendix
Using Calculator on Demand

Objectives

After completing this lesson, you should be able to:

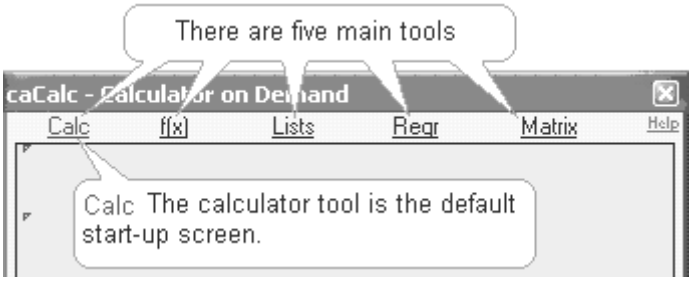
- Use the "Calc" tool of Calculator on Demand to perform arithmetic operations.
- Use the "f(x)" tool of Calculator on Demand to graph functions with different viewing windows.

Getting to Know Your Graphing Calculator

A Windows-based graphing calculator called Calculator on Demand is provided with this course (it may also be referred to as "caCalc," which stands for "college algebra calculator"). It will help you evaluate arithmetic expressions and graph and analyze functions. This appendix explains the basic features and functions of the calculator.

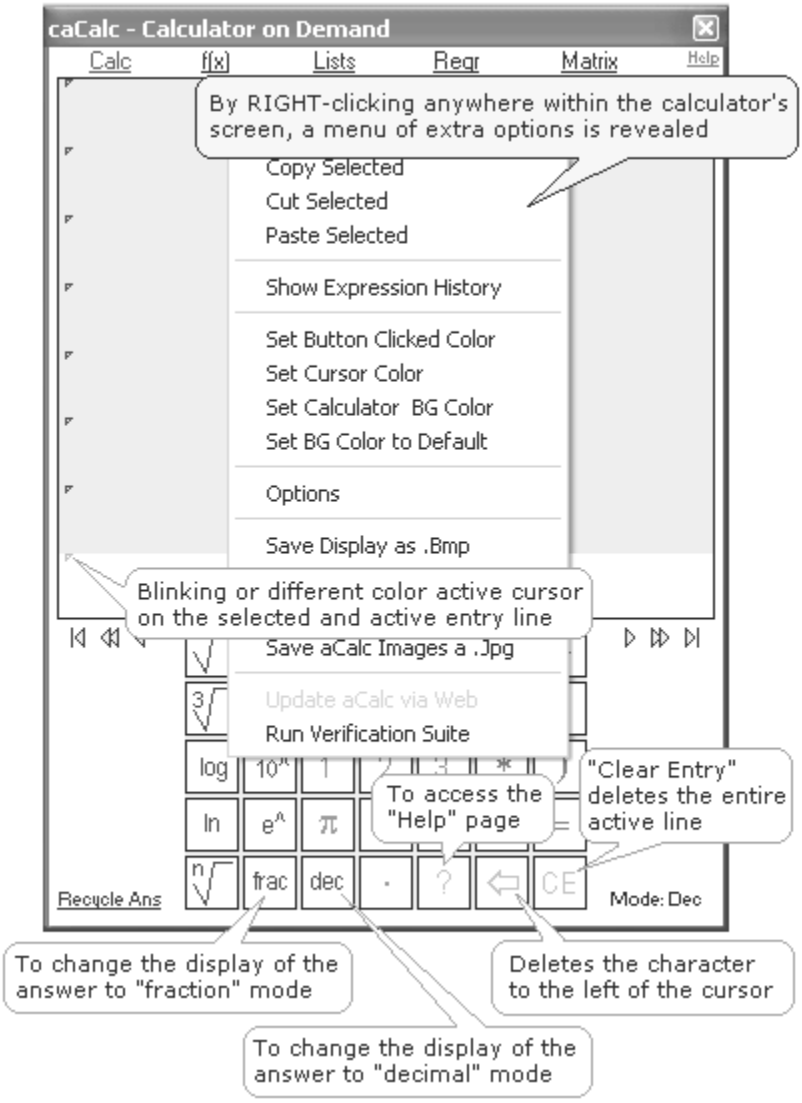
Once you have downloaded the program onto your computer and created a shortcut to it on the desktop, you open it by double-clicking on the icon (below).

You will see the default screen of the calculator when you open the program. The calculator has five main screens (or main tools) which you select from its top menu.



1) "**Calc**" → The "Calculator" tool, where we perform arithmetic operations that may involve special mathematical symbols.
2) "**f(x)**" → The tool that allows us to graph function expressions on the x-y plane in terms of the variable x.
3) "**Lists**" → Where we enter sets of data points to be plotted or to be fitted using different functional forms.
4) "**Regr**" → The "Regression" tool, which we use to find the function expression that best fits a set of data points.
5) "**Matrix**" → The tool that allows us to perform operations with some special mathematical objects called matrices.

The "Calc" screen allows the simultaneous visualization of eight lines of arithmetic expression entries and their results. A basic description of this start-up screen and its keypad is given in the next image.


caCalc - Calculator on Demand
Calc
f(x)
Lists
Regr
Matrix
Help
By RIGHT-clicking anywhere within the calculator's screen, a menu of extra options is revealed
Copy Selected
Cut Selected
Paste Selected
Show Expression History
Set Button Clicked Color
Set Cursor Color
Set Calculator BG Color
Set BG Color to Default
Options
Save Display as .Bmp
Blinking or different color active cursor on the selected and active entry line
Save aCalc Images a .Jpg
Update aCalc via Web
Run Verification Suite
log
10^
ln
e^
π
n√
frac
dec
?
CE
"Clear Entry" deletes the entire active line
To access the "Help" page
Recycle Ans
Mode: Dec
To change the display of the answer to "fraction" mode
To change the display of the answer to "decimal" mode
Deletes the character to the left of the cursor

Basic examples of how to use the "Calc" screen to operate with fractions, exponents, and radicals are given below.

Operations with Fractions

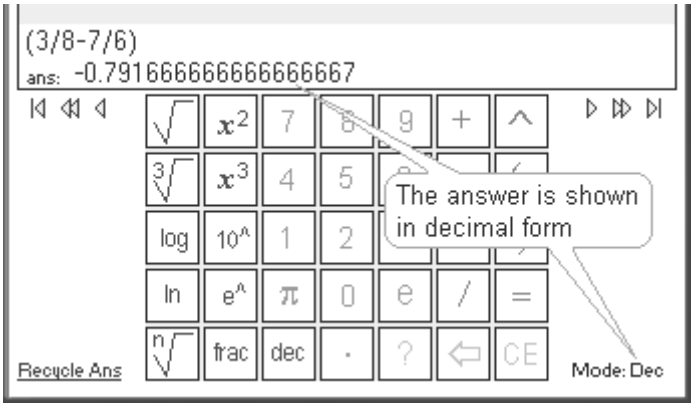
Use parentheses to indicate fractions and use the division operation key for the fraction line.

- The following subtraction of fractions:

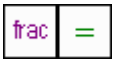
$$\frac{3}{8}-\frac{7}{6}$$

Can be typed with the following sequence of keypad clicks:

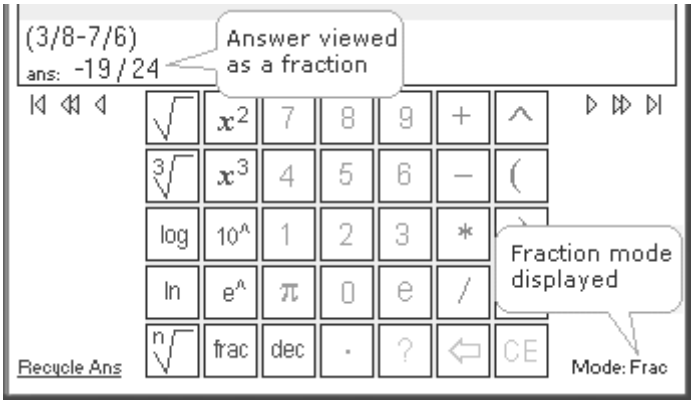
which produces the following:



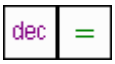
In order to have the answer displayed in fraction form instead of decimal form as in the previous image, use the "**frac**" key followed by the equal sign to change the display mode. Make sure that the line you are interested in is the active one (left-button click on it to select it and make it active), and perform the following sequence of keypad clicks:



which produces the following:



- If preferred, use the "**dec**" key in a similar fashion to go back to decimal form:



View the animated sequence in the lesson online that illustrates the five main tools of the calculator and the fraction example described above.

Operations with Exponents

There are keys to facilitate typing squares (x^2) and cubes (x^3) of numbers. Exponents different from these should be entered by using the caret key: (^).

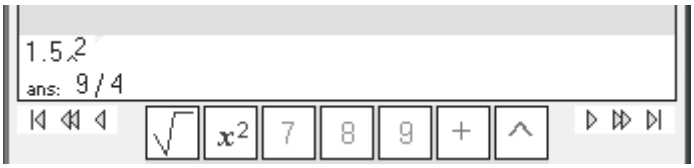
- The following expression involving a square:

  $$1.5^2$$

  Can be typed with the following sequence of keypad clicks:

  which produces the following in fraction ("frac") mode:

- The following expression involving a cube:

  $$(-3.2)^3$$

  Can be typed with the following sequence of keypad clicks:

  which produces the following in decimal ("dec") mode:

- The following expression:

  $$(-4)^5$$

  Can be typed with the following sequence of keypad clicks:

  which produces the following:

Operations involving Radicals

There are keys to facilitate typing square roots, cubic roots and roots of various indices.

- The following expression involving a square root:

  $$\sqrt{169}$$

  Can be typed with the following sequence of keypad clicks:

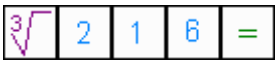
  which produces the following:

- The following expression involving a cubic root:

  $$\sqrt[3]{216}$$

  Can be typed with the following sequence of keypad clicks:

  which produces the following:

- The following radical expression:

  $$\sqrt[4]{625}$$

  Can be typed with the following sequence of keypad clicks:

  which produces the following:

View the animated sequence in the lesson online that illustrates the operations with exponents and radicals described above.

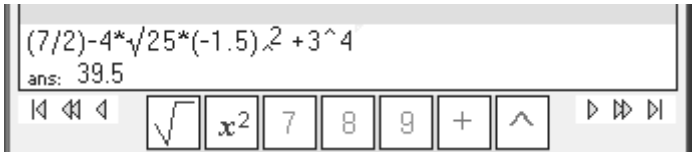
More Complex Operations

Arithmetic expressions that involve several mathematical operations can be easily typed and evaluated. Always keep in mind that Calculator on Demand follows the mathematical conventions of the order of operations strictly.

- The following expression:

$$\frac{7}{2}-4\sqrt{25}(-1.5)^2+3^4$$

can be entered and evaluated by using several keypad operations and symbols, as shown in the following screen capture:



View the animated sequence in the lesson online that illustrates the procedure described above.

Practice Exercise

On your own, use the "Calc" tool to evaluate $f(0)$, $f(6)$ and $f\left(\frac{3}{4}\right)$, given that: $f(x)=\sqrt{x+\frac{1}{4}}$

View the animated sequence in the lesson online that illustrates this practice exercise.

Practice Exercise

On your own, use the "Calc" tool to evaluate the expression

$$\frac{x^3 - x}{x^2 - 5}$$

for $x = -2$ by typing this expression:

$$\frac{(-2)^3 - (-2)}{(-2)^2 - 5}$$

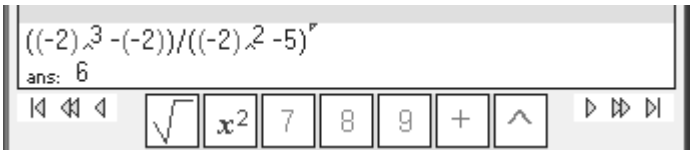
in your calculator.

Also evaluate it for $x = -3$ by typing this expression:

$$\frac{(-3)^3 - (-3)}{(-3)^2 - 5}$$

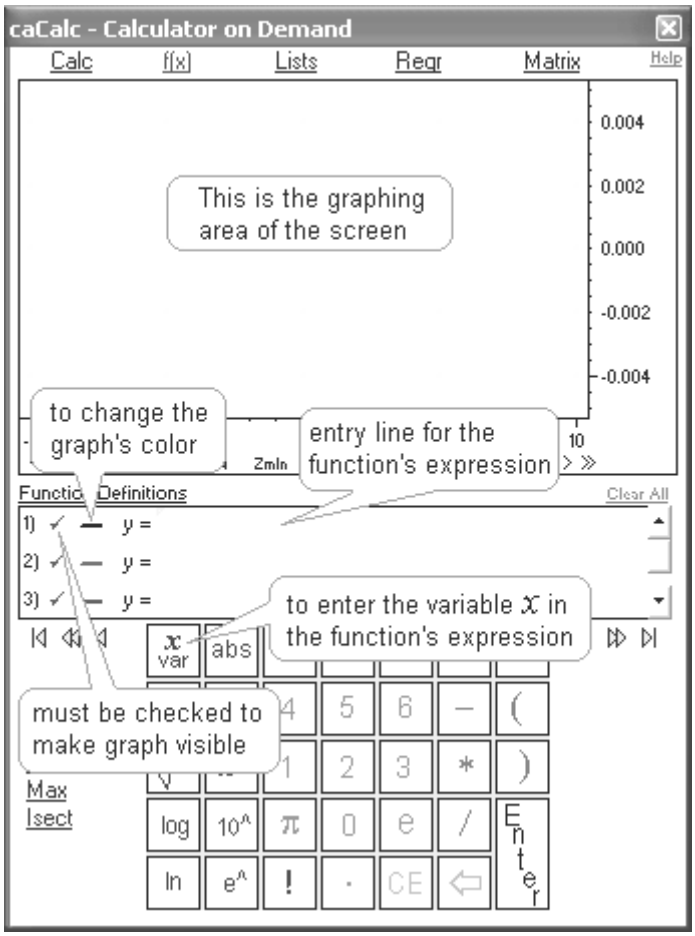
in your calculator.

Use parentheses to indicate the expression that goes
in the numerator and the one that goes in the denominator.



The "f(x)" Graphing Tool

Access the graphing screen by clicking on the "**f(x)**" menu option:



Let's use the following four functions as examples in order to learn how to graph functions:

$$f(x) = -3x + 5 \qquad f(x) = x^2 - 6x + 4 \qquad f(x) = \frac{x+2}{x-5} \qquad f(x) = |x^2 - 4x - 1|$$

Click on the first entry line below the "Function Definitions" title and start typing the expression $-3x + 5$. Use the $\boxed{\begin{matrix} x \\ \text{var} \end{matrix}}$ key on the keypad to type the x-variable.

Click on "**Enter**" on the keypad to have the function graphed:

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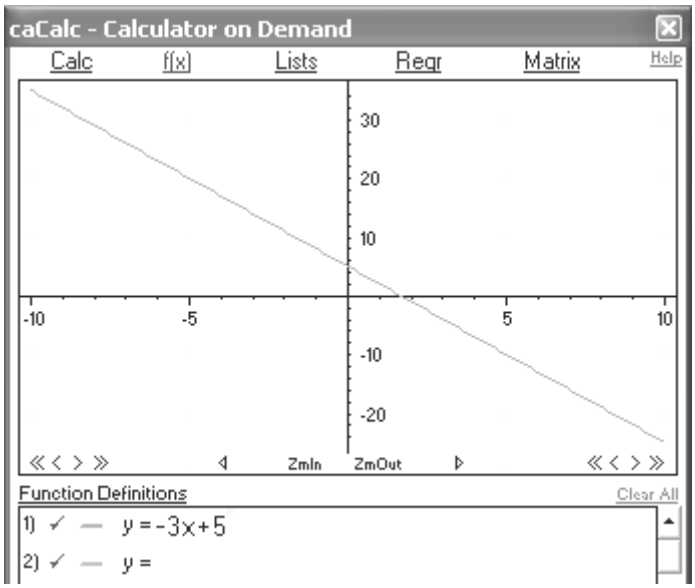
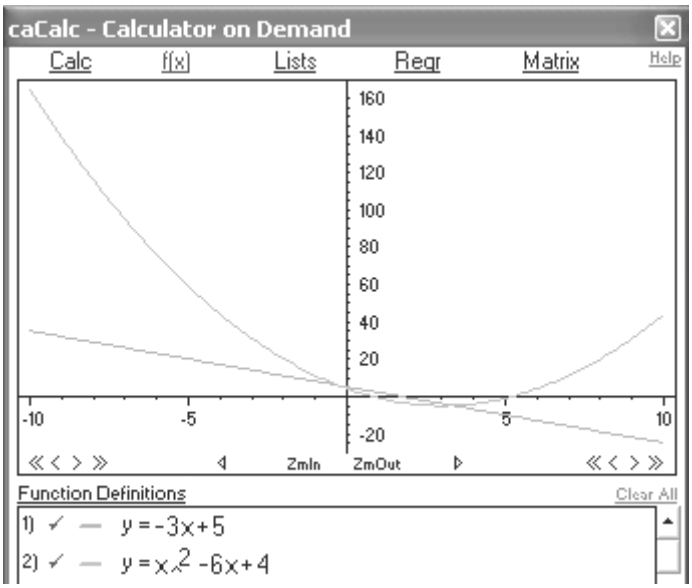


Next type the second function, $y = x^2 - 6x + 4$, on the second entry line, using the $\boxed{\underset{\text{var}}{x}}$ key again for the variable, followed by the $\boxed{x^2}$ key to express the square of the first term. Click "**Enter**" to obtain the graph.



If you want to visualize only **one** of the graphs for clarity, the display of the other functions can be turned off by clicking on the check mark (✓) by the function's definition. This action toggles between showing or hiding a function's graph.

Now type the expression for the third function, $y = \frac{x+2}{x-5}$, on the third entry line. Use parentheses to clearly indicate the numerator and the denominator of the expression. Hide the previous two functions by "un-checking" their display, so only the last function is been displayed, and click on "Enter" to obtain the function's graph.

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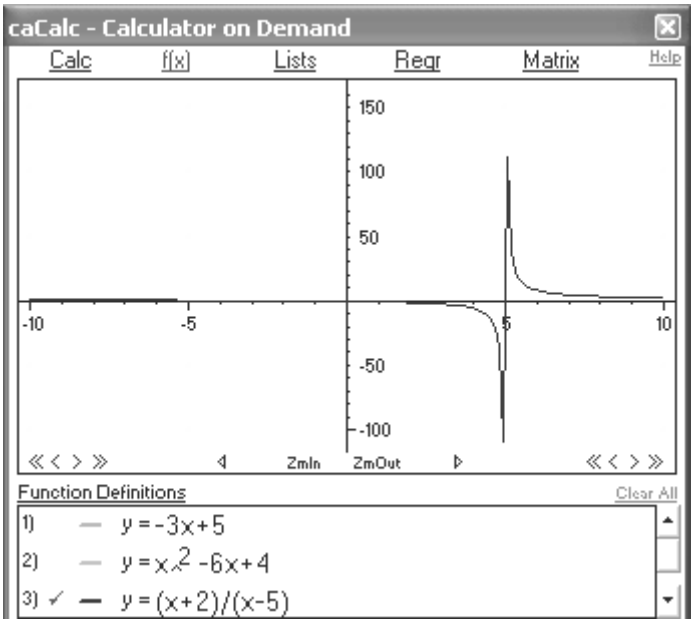
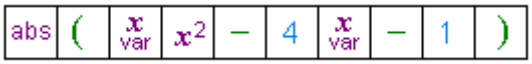
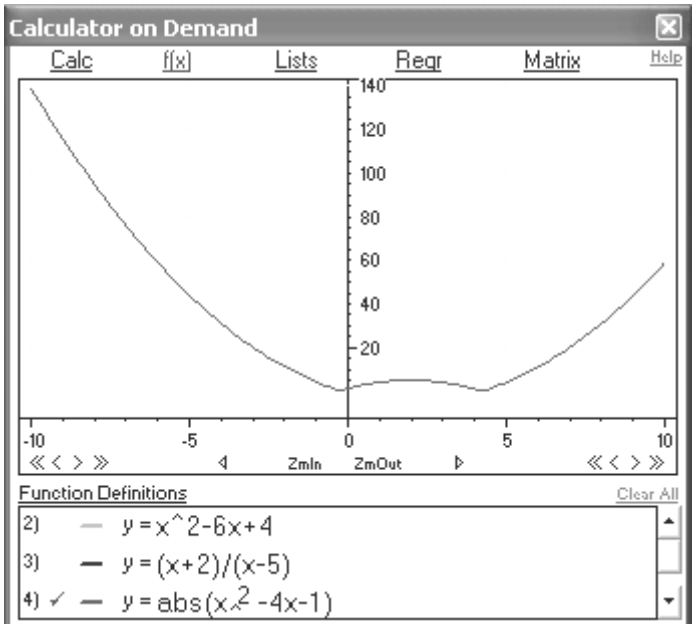
continued…



The next function, $y = \left|x^2 - 4x - 1\right|$, contains the absolute value of an expression. We use the abs key to invoke this function, and type the algebraic expression in parentheses with the following sequence of keypad clicks:



Hide the previous function by "un-checking" its display, so only the last function is been graphed, and click on "Enter" to obtain the function's graph.

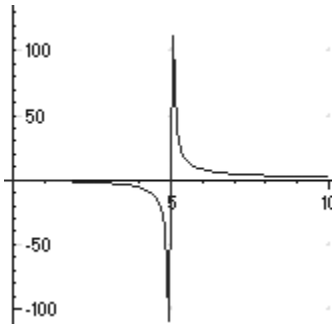


View the animated sequence in the lesson online that illustrates these procedures described.

The Appearance of Graphs in the Calculator

It is important to note that the graphing calculator displays a graph made up of pixels (little dots that create the picture on the screen), and the graph produced is limited by the pixel resolution of the computer screen and by the graphing program itself. The calculator is programmed to find the y values for a number of x values, plot those points, and then join them with segments to make it look like a continuous trace to your eye. Sometimes the fine details of the graphed function are misrepresented. An example of this is a function you graphed earlier (on page 9): $y = \frac{x+2}{x-5}$.

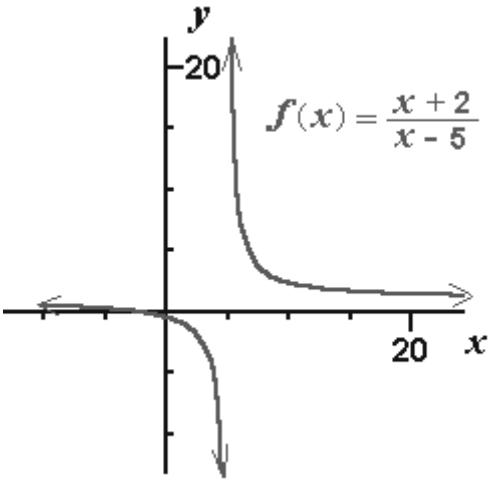
The vertical broken line seen around the value $x = 5$ is **not** part of the actual graph:



From mathematics we know perfectly well that this function is not defined for $x = 5$ (since this would give a zero in the denominator). We also know that vertical lines are not functions—as such, the graph of a function cannot show vertical lines.

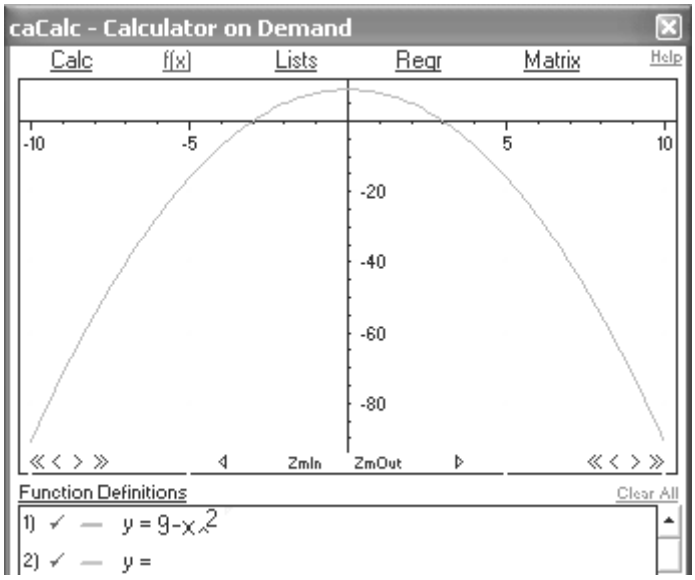
The broken vertical line shown by the graphing tool is a by-product of the attempt made by the tool to present a continuous trace to the viewer's eye as clearly as possible. The graphs obtained with graphing devices should be viewed with caution and be thoroughly analyzed by you—you need to use your understanding of the math involved to make up for the tool's misrepresentation.

View the precisely correct graph for the third function:



Changing the Viewing Window of the Graphing Tool

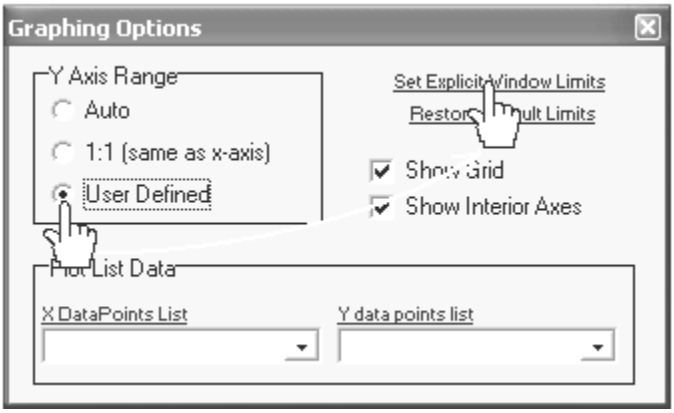
You may have noticed already that, by default, the graphing tool automatically adjusts the scale of the displayed y-axis to always show the trace of the graph for the set of x-values shown in the graphing window. For example, look at the span of y-values in the display window that the graphing tool automatically displays for the function $f(x) = 9 - x^2$:



The y-values span from approximately -90 to +10. In some cases you may want to specify fixed window limits of your own in order to have a specific y scale. You may also want to zoom in or out to study the behavior of the function around a small region, or at x-values far away from the origin, in detail. The graphing tool is flexible and can be set to your requirements.

If we want to specify the limits (left, right, bottom and top) of the viewing window to cover a standard x and y span of, let's say, $-10 \le x \le 10$ and $-10 \le y \le 10$, we do the following:

a) **Right mouse-click** within the graphing window. This action opens the "Graphing Options" window. Change the default "Y Axis Range" from **Auto** to **User defined** (by clicking on the appropriate radio button), and then click on the title that reads: Set Explicit Window Limits.



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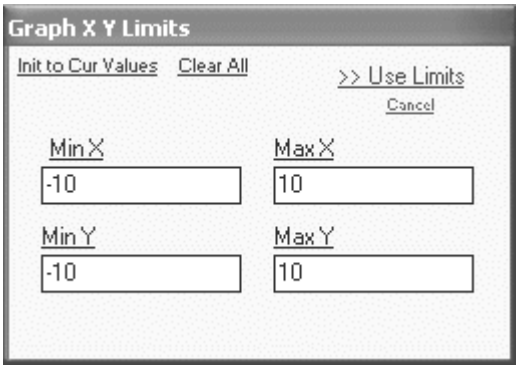
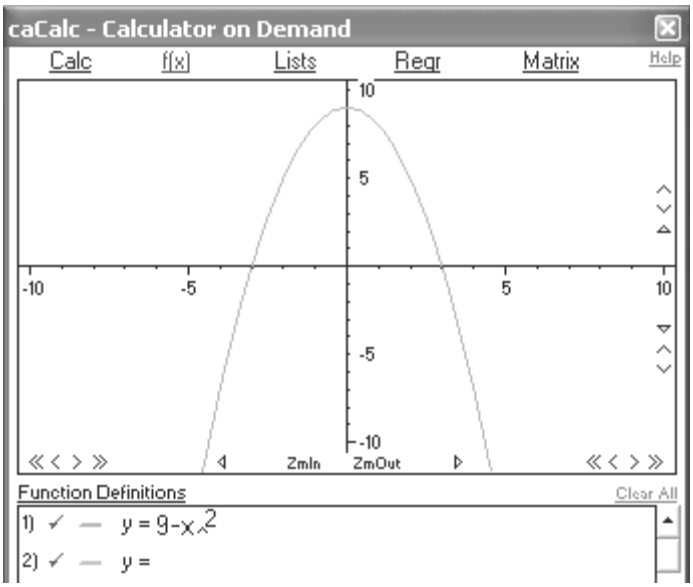
b) Now you see the “Graph X Y Limits” window where you can type your values:



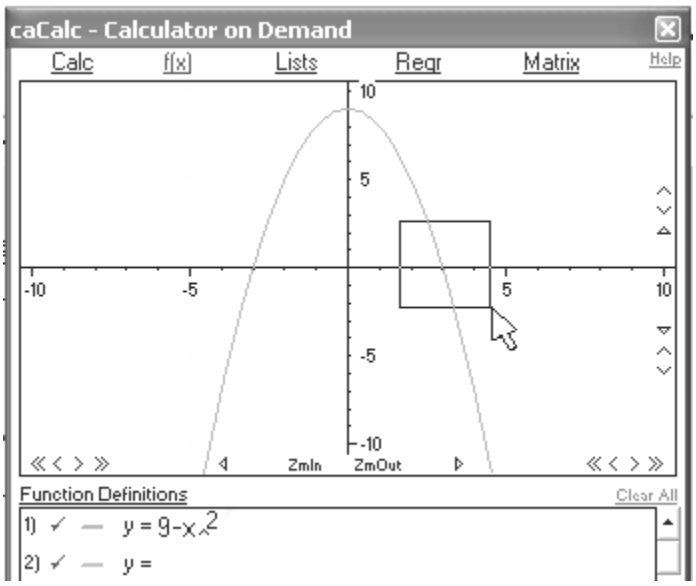
c) Close both small windows and the function’s graph will appear within the requested window limits:



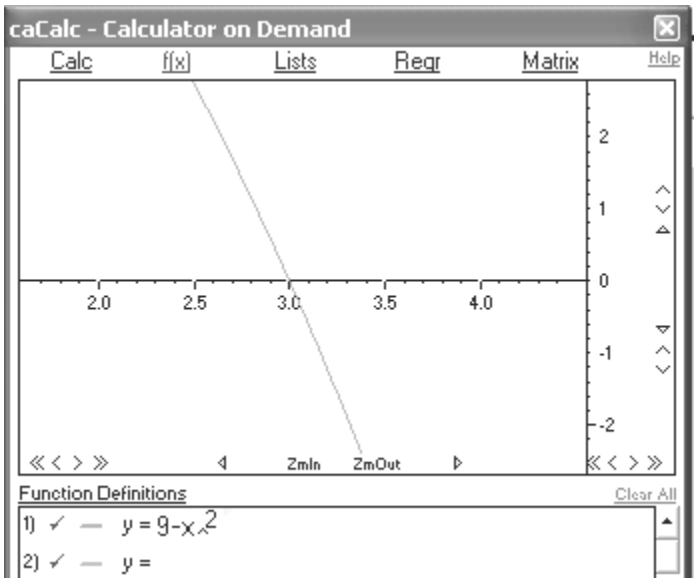
View the animated sequence in the lesson online that illustrates the procedure described above.

Zooming within the Graphing Window

It is also possible to zoom on a rectangular region of the graphing window selected with the mouse. This is done by clicking and holding the right mouse button to define the opposite corners of a chosen rectangular region:



A new expanded graph for the selected region will be shown as the mouse button is released:

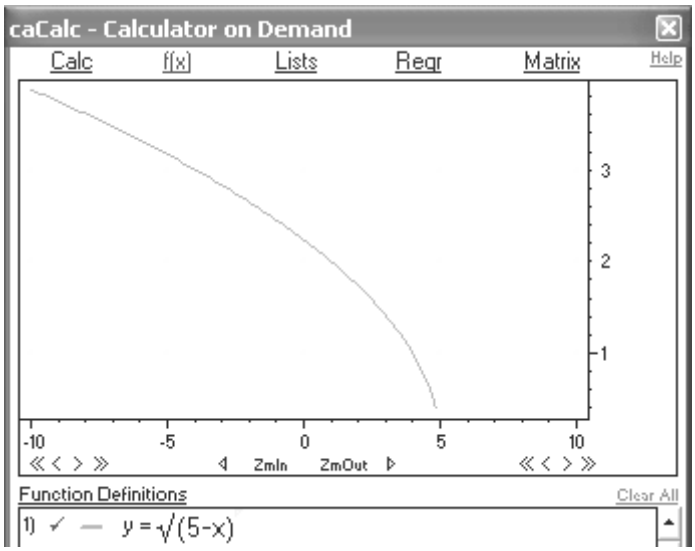


View the animated sequence in the lesson online that illustrates the procedure described above.

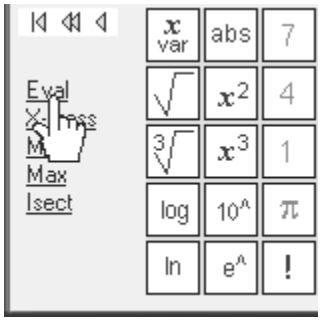
Evaluating $f(x)$ for a given x-value with the Graphing Tool

While looking at the graph of a function on the screen of the graphing tool, you can use the "Eval" function to obtain the y-value of the plotted function for any x-value within the function's domain. This graphing tool differs from other graphing calculators in that even x-values not contained within the displayed window can readily be found.

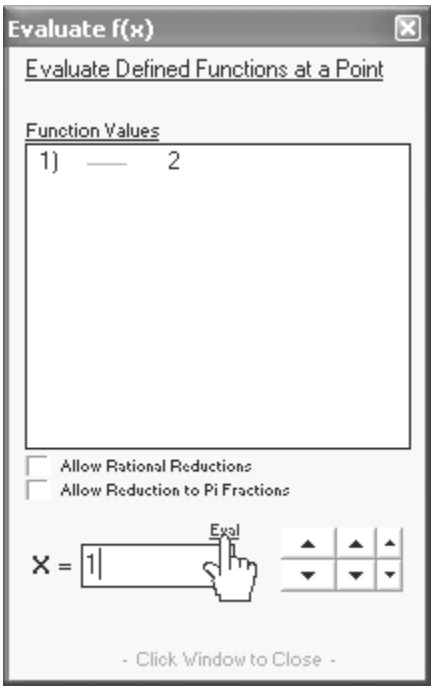
For example, let's evaluate the function $f(x)=\sqrt{5-x}$ at different x-values (1, 0, 6 and −20). Type the function's expression on one of the "Function Definition" lines of the graphing tool. Use the square root symbol and express the radicand within brackets to imply that the square root symbol applies to the full expression. Click on "**Enter**." The graphing tool will show this:



Now click on the "Eval" title option on the menu list to the left of the keypad:



This action will open the "Evaluate f(*x*)" window. Type the value "1" in the box for the requested "x-value", and click on "Eval" on the top right of the box:



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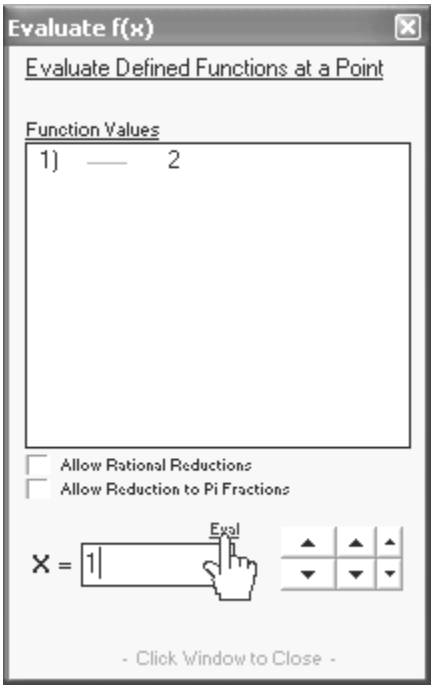
The result of the evaluation $y = f(1) = \sqrt{5-1} = \sqrt{4} = 2$ appears within the "Function Values" box.

Now type the next x-value to use: "0", and request the evaluation as before. This time the decimal approximation to the square root of 5 (y =2.236067977...) is shown. When trying the value $x = 6$, a "-no value-" message is returned. This is a value larger than five, for which there is no real $f(x)$ and no graph.

Next evaluate the function at $x = -20$, which is a point to the left of 5 (where the function is defined), but beyond the limits of the present graphing window. Even in such a case, the evaluation is performed and the value returned is:
$y = f(-20) = \sqrt{5-(-20)} = \sqrt{25} = 5$.



View the animated sequence in the lesson online that illustrates the procedure described above.

End of Lesson