Green Globs & Graphing Equations
Version 3 for PC

Teachers' Manual

by Sharon Dugdale and David Kibbey

Teachers have permission to reproduce the student worksheets in this manual
for classroom use.

Note to users who are upgrading from an earlier version:

The Green Globs Records files you have been using with your previous version can be converted to work with the current version. See the "Getting Started" section of this manual.

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Getting Started

System Requirements

4 MB of disk space, less if “Escape!” or “Relating Graphs to Events” has been installed.

A monitor with screen resolution at least 1024 by 768. The graphing displays in Green Globs.exe use most of a 1024 by 768 screen. These windows assume a display DPI setting of “Normal” (96 DPI), which is the default. (In Windows XP, you see the DPI setting by choosing Control Panel – Display – Settings – Advanced – General.) If you need a screen resolution or DPI setting which the current program does not display well, contact us.

Installing *Green Globs*

The software in this package is distributed as one compressed file named “PC Green Globs & Graphing Equations.zip”. Opening the .zip file will result in several files, including these two:

- ✓ Read Me Install Green Globs.txt - a text file about installing the PC version.
- ✓ Manual for PC Green Globs & Graphing Equations.pdf - a teacher’s manual for the PC version.

The above two files are available without running the installation program. The installer does not do anything with them. You can copy them like other files in Windows to another folder. (If you want, you can copy them to the same folder you designate for the installer.)

The remaining files in the distribution .zip file are for installing the Green Globs application. Run file setup.exe when you are ready to install Green Globs. You will be asked to select or create a folder where you want the installation program to place *Green Globs.exe*. *Green Globs.exe* will run in any folder, as long as *Green Globs Records.ggg* is in the same folder (see the next paragraph). The remaining files in the package are support files (compressed along with the application file in a “CAB” file) for running *Green Globs.exe,* which is a Visual Basic 6 (32-bit) application. The installation program will automatically place those support files in the appropriate Windows or System folders, if needed. (File SETUP.LST lists where each file goes.) The installation program will not replace an existing file on your disk with an older version.

After the above installation, you need to copy your *Green Globs Records.ggg* file to the folder you designated during installation. You will then have these three files in that folder:

- ✓ *Green Globs.exe* - an application file whose title screen says “Green Globs & Graphing Equations”. The file name is shortened for convenience in Windows.

- ✓ *Green Globs Records.ggg* - a document file (called a Records file). This file contains your license information displayed on the title screen. The highest scoring games in Green Globs and Tracker are saved in ".ggg" files. Teacher Options lets you create more of these files.

- ✓ *ST6UNST.LOG* (or with file extension ".000" or ".001", etc.) – a text file created automatically by the installation program during installation to record which files were installed in which folders. It is used by the Windows Control Panel if you uninstall Green Globs.

Teachers should put a password on their Records file(s) before students use them. See the section "Teacher Options Password" on page 8.

If the folder you designated for installation is one where users do not have "write" access, you can start *Green Globs.exe*, select Teacher Options, and choose the option to create new Records files in folders where users do have "write" access.

File Name Extensions, and Upgrading from an Earlier Version

If you are upgrading from the previous version of *Green Globs & Graphing Equations*, your Records files (with file extension ".rec") and List files (with file extension ".rex") must be converted to the new format (file extension ".ggg" for Records files, and file extension ".ggx" for List files). Start *Green Globs.exe*, select Teacher Options in the Programs menu, and there will be two menu items at the bottom of the Teacher Options menu for converting old Records files and old List files to their respective new formats.

Incomplete Green Globs games saved to disk in the previous version cannot be converted automatically to the new format, for security reasons. New format incomplete games saved to disk (with security checks) have file extension ".ggm".

Displays from Equation Grapher saved to disk under the previous version (with file extension ".egg") will work with the new version. The new version saves displays using file extension ".gge". You can manually change the ".egg" extension to ".gge". (".egg" is not a unique file extension.)

The file extensions used in the new version all start with ".gg", and appear to be unique. You can tell Windows to start *Green Globs.exe* when a ".ggg" file or a ".ggx" file is opened – just open one of them, and Windows will ask you to identify which program it should use. Navigate to *Green Globs.exe*, and be sure to check the box to "always use the selected program to open this kind of file".

Starting *Green Globs & Graphing Equations*

There are four ways you can start *Green Globs & Graphing Equations*:

1. Open a shortcut to *Green Globs.exe*. (See the next section on shortcuts.) The Records file(s) to be used for saving or replaying games depend on how you set up the shortcut.

2. Open *Green Globs.exe*. If you use this method, *Green Globs.exe* will save games in Records file *Green Globs Records.ggg* in the same folder as *Green Globs.exe*.

3. Open a Records file (extension ".ggg"). If you use this method, *Green Globs.exe* will save games in the Records file you are opening.

4. Open a List file (extension ".ggx"). *Green Globs.exe* will save games in the first Records file on this list, and the remaining Records files on the list will be available for viewing.

Shortcuts

To create a shortcut, select file *Green Globs.exe*, and then either right-click or open the File menu to choose "create shortcut". This will create the shortcut in the same folder, but you can rename the shortcut and move it to another folder. Opening the shortcut will act like opening *Green Globs.exe*.

An option available by right-clicking on a shortcut is "Properties". If you select Properties, you will see the complete file name for *Green Globs.exe* after the word "Target". You can specify Records files and List files for *Green Globs.exe* to use by appending them (separated by spaces) to the file name given in the Target box.

The default folder is the folder containing Green Globs.exe, so you can specify files in that folder just by giving the file name.

Example 1. append a Records file name (with extension ".ggg") to the Target (separated by a space). *Green Globs.exe* will save games in that Records file.

Example 2. append a List file name (with extension ".ggx") to the Target (separated by a space). *Green Globs.exe* will save games in the first Records file in that list, and the remaining Records files in that list will be available for viewing.

Example 3. append a Records file name (with extension ".ggg") and then a List file name (with extension ".ggx") to the Target (separated by a spaces). *Green Globs.exe* will save games in the first Records file, and the Records files in the list will be available for viewing. It's not a problem if the Records file where games will be saved also appears in the List file.

The basic setup is that you can specify (individually, or in lists) up to eleven Records files for *Green Globs.exe* to use. The first Records file will be the one where games are saved. The remaining Records files (up to ten of them) will be available for viewing.

Uninstalling

To uninstall Green Globs, go to the Windows Control Panel and choose "Add or Remove programs", then select "Green Globs" and "Remove".

File Setup.lst in your original unzipped package lists the files which are to be installed (if necessary) during the installation process, and where they are to be placed.

File ST6UNST.LOG is created during installation and placed in the folder you designate for *Green Globs.exe*. It records what the installation process did. The uninstall process needs to refer to this file in order to uninstall Green Globs.

Introduction

Green Globs & Graphing Equations provides mathematical environments for students to manipulate and explore. This may be quite different from the mathematics activities students have experienced in the past. Students who use *GREEN GLOBS* become creative learners, developing new strategies and innovative techniques.

The mathematical content of this package focuses on the relationship between equations and their graphs. The programs are appropriate for a wide range of student abilities and experience levels. Beginning algebra students or pre-algebra students who are familiar only with graphs of straight lines can benefit from these programs. Math analysis students who use trigonometric and discontinuous algebraic functions will also be challenged.

Brief Program Descriptions

EQUATION GRAPHER is a utility program that plots the graphs of entered equations.

LINEAR & QUADRATIC GRAPHS displays a graph of a certain type (line, parabola, circle, ellipse, hyperbola). The student enters an equation that matches the graph.

GREEN GLOBS is a game in which thirteen green globs are randomly placed on the grid. Students earn points by entering equations that pass through as many green globs as possible.

TRACKER is a game in which graphs are hidden on a grid. The student gathers clues to determine the equations of the hidden graphs by using “probes” (horizontal and vertical lines) to find the location of the graphs.

TEACHER OPTIONS provides tools for the teacher to manage the Records file(s). A Records file holds the top ten scores recorded by students playing *GREEN GLOBS* or *TRACKER* games.

The four programs (*EQUATION GRAPHER*, *LINEAR & QUADRATIC GRAPHS*, *GREEN GLOBS*, and *TRACKER*) and *TEACHER OPTIONS* are all combined into one application file called “*Green Globs.exe”*.

Suggested Program Uses

EQUATION GRAPHER is effective as a demonstration tool in classroom presentations to introduce graphs of equations and to illustrate the concept of “what if.” (For example, “What if we changed the equation? How would the graph change?”) It is also valuable as a student activity with worksheets such as those included in this guide.

LINEAR & QUADRATIC GRAPHS is an individual or small group activity that will help students master methods of transforming graphs by altering basic equations.

GREEN GLOBS is an individual or small group activity that enables students to apply concepts relating equations and their graphs in a motivating, problem-solving situation. It helps students develop creative strategies using equations.

TRACKER is an individual or small group activity that reinforces the understanding of linear and quadratic relations in a game setting.

Order of Use

The programs can be used in any order. Students can move within or between programs without losing their work. For example, students could start playing a game, go back to check the rules again, and then continue their game at the same point they left it.

LINEAR & QUADRATIC GRAPHS is recommended as preparation for *TRACKER*. The "target" graphs shown in *LINEAR & QUADRATIC GRAPHS* are of the same types as the hidden graphs in *TRACKER*.

Time Requirements

The amount of time needed for effective use of these programs varies greatly. A few minutes is sufficient for a demonstration using *EQUATION GRAPHER*. A thirty-minute session is enough to use one part of *LINEAR & QUADRATIC GRAPHS* .

Several-hour sessions are necessary to develop a range of strategies for playing *GREEN GLOBS*. Students who want to continue an unfinished *GREEN GLOBS* game at another time can save it on disk using the "Save" option in the File menu. Teachers may find the time commitment of these activities greater than the time they typically devote to class presentations of this content. However, it should be noted that students here are actually applying mathematics and developing creative strategies, not seeing or listening to a demonstration.

The Teacher's Role

Teachers who use *Green Globs & Graphing Equations* effectively act as facilitators. By planting a few carefully-placed comments and asking questions, they encourage students to explore their own ideas.

Teachers should encourage students to learn from each other, to build on others' ideas, and to explain their ideas to their group. Teachers can spark continued interest and creativity in students by subtly guiding them toward new strategies that suit their ability level and experience.

It is not an easy task to be aware of the students' current strategies, share their enthusiasm about their latest discovery, allow them to enjoy this achievement by applying the idea several times and extending it to new cases, and yet at the same time encourage them to move on to new ideas.

The Student's Role

Students should try to develop basic strategies that can be applied to many graphs rather than to memorize formulas. They can do this by experimenting, by using guess and check, and by learning from their "mistakes". Students should be encouraged to be creative and innovative, to share ideas, and to build on others' ideas.

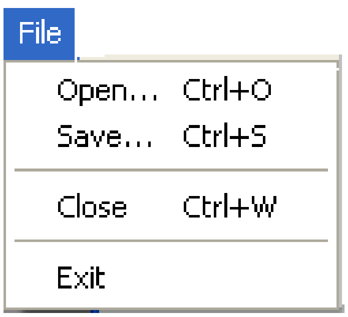
Students may want to work individually or in groups of two or three.

Teacher Instructions

General Instructions

The File, Edit and Programs menus are always on the menu bar at the top of the screen. After you select a program from the Programs menu, a specific menu for that program will be added to the menu bar. When you have more than one window open, a "Windows" menu lists all open windows. Each item you select appears in its own window. You can have up to 12 windows open at one time, not counting the *TEACHER OPTIONS* window. Program title display windows are automatically closed when you leave them. For security reasons, the *TEACHER OPTIONS* window is automatically closed whenever you leave it. Other windows remain open until you close them.

File Menu



- Open...
- Save...

Open… and Save… use the standard Windows dialog boxes for opening and saving files.

Save… is available only in *EQUATION GRAPHER* and *GREEN GLOBS*. Save... is used to save on disk the current equations and display in *EQUATION GRAPHER* (with file extension ".gge") or a game (in progress or finished) in *GREEN GLOBS* (.with file extension ".ggm") You can also use Save... to save displays prepared in *EQUATION GRAPHER* or *GREEN GLOBS*.

Open... is available anywhere; it is used to retrieve work saved on disk. The dialog box for Open... will offer for selection files with extension ".ggm" (work saved in *GREEN GLOBS*) or files with extension ".gge" or ".egg" (work saved in *EQUATION GRAPHER)*.

When you are finished with a file of saved work, you can delete it in Windows. *Green Globs & Graphing Equations* does not provide tools for managing files of saved work. Users cannot open a saved work file in Windows to start *Green Globs & Graphing Equations*. Users who try that will see an alert box asking them to open *Green Globs & Graphing Equations* first, then open the saved work file. (However, users can open a Records file in Windows to start *Green Globs & Graphing Equations*.)

- Close

This closes the active window. It is the same as clicking the close symbol at the right end of the window's title bar.

- Exit

This exits the application. The only work saved after a user chooses Exit is:

- ✓ work that was saved on disk using the File menu item Save...
- ✓ games in *Green Globs* or *Tracker* which scored in the top ten, if the user accepted the program's offer to save them for others to see. A game saved this way is not saved permanently; it will be bumped off the list and deleted if/when enough other games with higher scores are saved.

Edit Menu

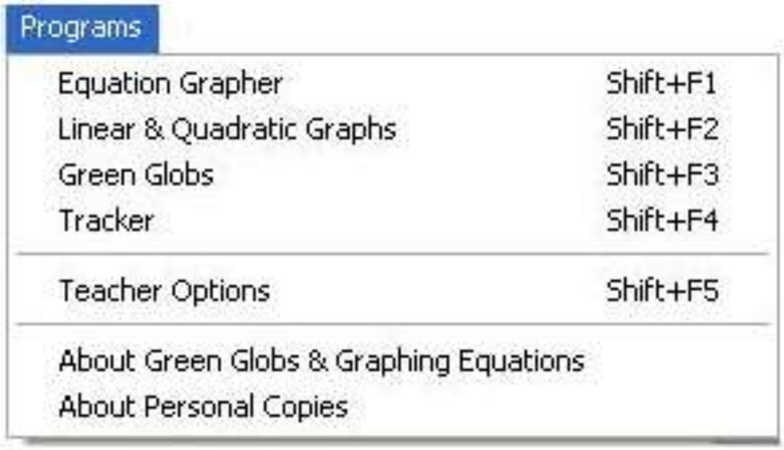
- Cut
- Copy
- Paste
- Clear

These are available when entering an equation or a name.

- Undo

Undo is available when entering an equation. The only other Undo options are the Undo Last Shot button in *Green Globs* and the Undo All Zooms button in *Equation Grapher*. Those buttons appear on the user's screen at the appropriate times.

Programs Menu



This menu is always available. It lists the four programs for students, plus *Teacher Options*. They are assigned key equivalents for convenience.

"About Green Globs & Graphing Equations" includes your license information and registration number, and gives the authors' web site for contact information.

"About Personal Copies" only appears on the menu for sites where a personal copy is allowed. It lists the conditions governing the use of a personal copy of the software.

Teacher Options

Teacher Options is the last item on the Programs menu. These options allow the teacher to manage the record scoring games saved by students playing *Green Globs* and *Tracker*. In *Teacher Options*, a teacher can do the following:

- ✓ Change a misspelled or inappropriately chosen student name on a record game
- ✓ See a replay of one or more record games
- ✓ Delete one or more record games
- ✓ Copy selected games from one records file to another records file
- ✓ Create new records files and lists of records files
- ✓ Convert old format Records files and List files to the new format

See the *Teacher Options* chapter on page 81 for detailed descriptions of those options.

Teacher Options Password

Access to *Teacher Options* is restricted to those who know the password. The password is kept (encrypted) in the records file. When a records file has not been assigned a password yet, the first user to select *Teacher Options* will be asked to set the password for that records file. The teacher should do this before students start using *Green Globs & Graphing Equations*; nothing further is required. For detailed descriptions of password options, see page 84 in the *Teacher Options* chapter.

How to Write Equations

After you choose one of the four programs (*Equation Grapher*, *Linear & Quadratic Graphs*, *Green Globs*, or *Tracker*), you will see a menu specifically for that program. However, the first menu item on that menu will always be How to Write Equations. This selection goes to a practice screen which tells the student how to enter equations and provides a place to practice entering equations. The standard editing keys and mouse conventions are used, except that exponents are displayed as superscripts. Exponents are limited to one-digit positive whole numbers.

The practice screen in How to Write Equations is the same for all four programs. It is included in each program's menu for convenience getting started and so students can easily refer to it.

Here is what the students see when they select How to Write Equations:

How to Write Equations

Exponents

To write an exponent (as in x^2), type the " **^** " key, then type the exponent.
Exponents are limited to one digit positive whole numbers.

Convenience Keys

Key " **↑** " acts like exponent key " **^** ".
Key " **[** " acts like left parenthesis " **(** ".
Key " **]** " acts like right parenthesis " **)** ".

Equation Editing

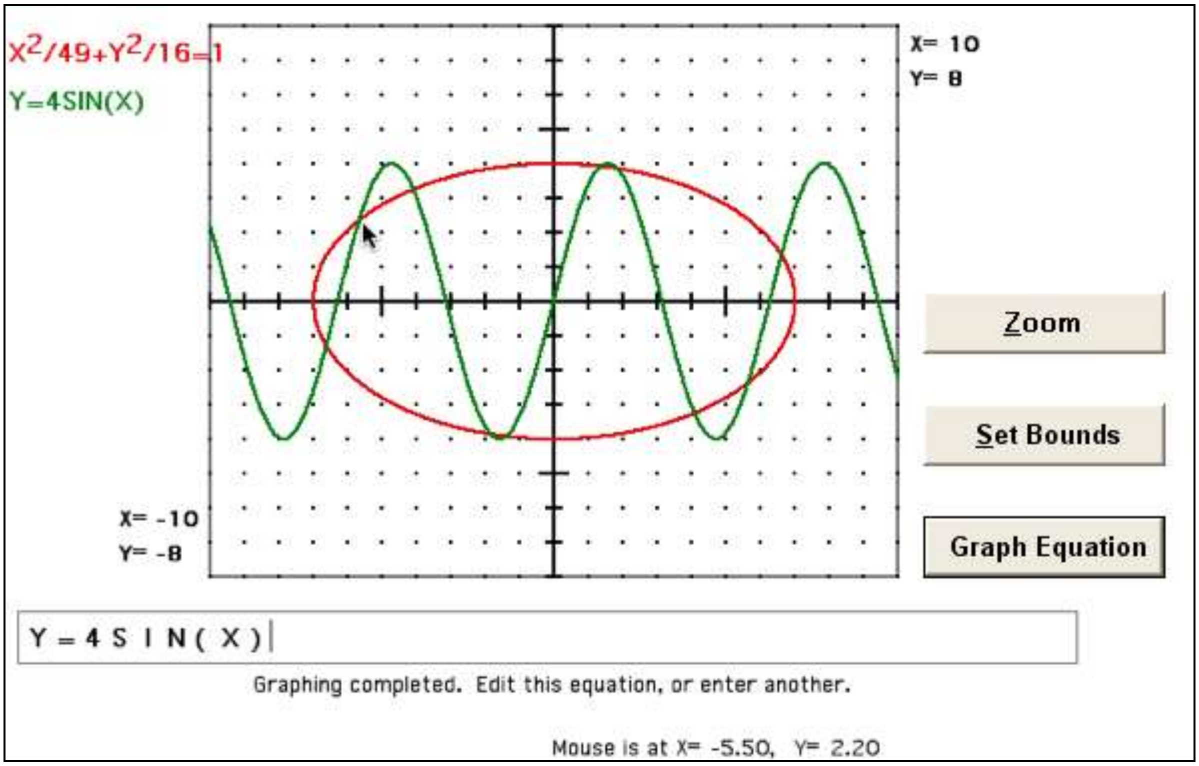
Use the mouse or the "←" and "→" keys to move the pointer " | " to the place you want to change.
Delete to the left of the pointer, or insert at it. You can also select from the Edit menu on the menu bar.

Undo (on the Edit menu) un-does one editing change to your equation each time you select it.

To erase everything in the equation entry box, press **Shift-Backspace** or **Shift-Delete**.

Practice here:

EQUATION GRAPHER



Overview

Grade Level:	6 - adult
Prerequisite Skills:	use of a coordinate grid, graphing equations
Type:	graphing utility for student or teacher use

Description

EQUATION GRAPHER plots the graphs of equations entered at the keyboard. The grid can be either rectangular (as used in the other programs in this package) or square. The grid bounds can be specified, and the user can zoom in or out. Acceptable forms of equations include conics, as well as equations where:

y equals a function of x, or

x equals a function of y.

Functions may include trigonometric, square root, absolute value, natural logarithm, and exponential functions.

Objectives

1. recognize basic shapes of graphs of equations
2. discover relationships between equations and their graphs

3. manipulate graphs by altering the corresponding equation

(Note: Objectives may vary depending on the instructional activities.)

EQUATION GRAPHER Menu Items

Equation Grapher

- How to Write Equations
- See Instructions
- Start Graphing on a Rectangular Grid: $-10 \le X \le 10, \ -8 \le Y \le 8$
- Start Graphing on a Rectangular Grid: $-2\pi \le X \le 2\pi, \ -5 \le Y \le 5$
- Start Graphing on a Square Grid: $-8 \le X \le 8, \ -8 \le Y \le 8$
- ✓ Show Equations Beside Grid
- Hide Equations Beside Grid

• How to Write Equations

This is the practice screen described under "How to Write Equations " on page 9. It is the same for all programs.

• See Instructions

These are the instructions shown to students, on several screens. Buttons at the bottom of each instruction screen allow students to navigate to the next and previous screens. Here is what the students see (the buttons the students see are not shown here):

Instructions

Types of Graphs

You can graph **lines**, **parabolas**, **circles**, **ellipses**, and **hyperbolas**.
For example:

y = 3	2x+y = 3	$x = 1/3y^2$
x = -6	$x^2+y^2 = 64$	$3(x-1)^2 - 4(y-2)^2 = 50$

You can do **other kinds of graphs** if you write them as either:
y = an expression in x, for example: $y = 3x^3 - 2x^2$
or **x = an expression in y**, for example: $x = 3y^2 - 5/(y-4)^4$

Graphed equations are shown beside the grid unless you select the menu option to hide them.

Exponents

To write an exponent (as in x^2), type the " **^** " key, then type the exponent. Exponents are limited to one digit positive whole numbers.

(Instructions are continued on the next page.)

Function Names

Special Functions

You can also use these functions:
abs, sqr, log, exp, sin, cos, tan, csc, sec, cot, atn.

abs means absolute value
sqr means square root
log means natural log, the inverse of the exponential function **exp**
atn means arctangent

Parentheses

Use parentheses around function arguments. Write "sin(2x)", not "sin2x".

Pi

To make the symbol π (pi), type **p**.

Zoom

Coordinates

To show the coordinates of a point on the grid, just move the mouse to it (without clicking).

Zoom

To improve the accuracy of graphs (such as in an area where graphs intersect), click the **Zoom** button, set the Zoom Center Point in that area, and click **Zoom In** several times.

You can click on **Zoom In** or **Zoom Out** several times at once, without waiting for the graphs to be re-drawn after each click.

To return to the grid boundaries you had before you started zooming, click on **Undo All Zooms**.

Grid Boundaries

To set upper and lower grid boundaries, click on **Set Bounds**.

Copying, Erasing, and Saving

Copying

To copy a previously graphed equation to your clipboard, click on it and select **Copy** from the Edit menu. Then you can **Paste** it into the equation you're working on.

Erasing

You can have up to 10 graphs on the screen at once. To erase a graph you don't want, click on its equation (to the left of the grid) and press the **Delete** key. To delete several at once, hold down the **Ctrl** key as you click each equation (or hold down the mouse button as you drag across the equations), then press the **Delete** key.

Saving

To save your work, select **Save...** from the File menu. Saved work can be continued later by selecting **Open...** from the File menu.

EQUATION GRAPHER Menu Items (continued):

- Start Graphing on a Rectangular Grid: $-10 \le X \le 10$, $-8 \le Y \le 8$
- Start Graphing on a Rectangular Grid: $-2\pi \le X \le 2\pi$, $-5 \le Y \le 5$
- Start Graphing on a Square Grid: $-8 \le X \le 8$, $-8 \le Y \le 8$

The above three menu items all lead to the graphing display. The differences are the shape of the grid (rectangular or square) and the initial values for grid boundaries. All three choices result in a grid where one unit horizontally looks about the same length as one unit vertically. On the graphing display, the grid keeps its shape as the grid boundaries are changed by clicking the Set Bounds or Zoom buttons (described below).

- Show Equations Beside Grid
- Hide Equations Beside Grid

The last two items on the *EQUATION GRAPHER* menu control whether equations for the current graph are shown at the left of the grid. When the program is started, the setting is Show Equations Beside Grid. The current setting has a check mark next to it. You can change the setting at any time—select the setting you want from the menu and the check mark will switch to it. The setting remains in effect as long as you are in the program. When you select Open... from the File menu to get a previously saved *EQUATION GRAPHER* display, the program uses your current setting for Show Equations Beside Grid / Hide Equations Beside Grid, not the setting in effect when the display was saved.

Graphing Display Features and Buttons

The graphing display shows the coordinate grid, a box for entering an equation, and three buttons (Zoom, Set Bounds, and Graph Equation).

When the mouse pointer is moved (without being clicked) over a point on the grid, that point's grid coordinates are shown at the bottom of the screen. The mouse pointer's coordinates will usually have two or three more significant digits than the grid boundaries, up to a maximum of ten significant digits.

You can have up to ten equations graphed on the grid at one time. If you try to graph an eleventh equation, you will be asked to erase one of the existing equations first.

Each graph's equation will be displayed at the upper left of the screen, unless you have checked the menu item to hide equations.

To erase one or more equations and their graphs, first select the equations by clicking on them to the left of the grid. (Don't click on the grid – that would set the Zoom center point, not select the equation.) To select more than one graph, either drag the mouse through them or hold down the Ctrl key while you click each one. Then press the Delete key, or select Edit menu items "Cut" or "Clear". (If you select an equation and then select Edit menu item "Copy " or "Cut", a copy of the equation will be placed in your clipboard.)

After entering an equation, click the graph equation button to graph the equation. If there is no equation entered, or the entered equation has just been graphed, this button will be inactive. If the equation cannot be evaluated, a diagnostic message will be displayed when this button is clicked. Pressing the Enter key is equivalent to clicking this button.

Click this button to set one or more grid boundaries. You will see a dialog box showing the current values for Lower X, Upper X, Lower Y, and Upper Y. To change the number in a box, click in the box or use a key to move to that box. The tab key cycles through all four boxes with repeated presses; shift+ tab cycles in the reverse direction. You may also use the up arrow or down arrow keys to move. Your changes do not take effect until you click OK. To ignore all changes, click Cancel. Grid boundary numbers can use up to five digits and can include π(pi). For example, [.003, .004] and [-3π/2, 2π] are valid grid boundaries. To enter π, press the letter p.

When you click the Zoom button, you will be instructed to click the mouse on the grid point you want to be the center point for zooming. (As a shortcut to start zooming, just click on the grid without pressing Zoom.) You can move the zoom center point at any time just by clicking another grid point. If you hold down the Shift key when you click the mouse (Shift-click) to set the Zoom center point, the Zoom center point will be set to the nearest grid mark. For example, you can set the Zoom center point exactly at (0,0) by moving the mouse pointer somewhere close to (0,0) and then Shift-clicking.

After you set the Zoom center point, the Zoom button is replaced by four new buttons:

This draws a new grid with the zoom center point in the middle of the screen and about half the previous grid's horizontal and vertical dimensions.

This draws a new grid with the zoom center point in the middle of the screen and about twice the previous grid's horizontal and vertical dimensions.

This removes the four Zoom buttons and erases the zoom center point marker from the grid, without affecting the current graphs and grid boundaries.

This restores the grid boundaries to the values they had before you started zooming. For example, if you were comparing two graphs and zoomed in several times to determine their intersection point more accurately, you can quickly restore your original grid boundaries by clicking Undo All Zooms.

You can add or delete graphs while the zoom buttons are available. The zoom buttons remain available until you click Exit Zoom, or until you click Set Bounds and set grid boundaries which do not enclose the zoom center point.

Zoom In and Zoom Out become inactive when their respective limits are reached in either the x or the y dimension. The limit is reached when there would not be enough room to display all the digits required to accurately indicate the new boundary. If you want to zoom in or out further and the respective button is inactive, you can click Set Bounds and enter the boundaries you want.

Ideas for Classroom Use

Teacher Demonstration Tool

As a classroom demonstration tool for teachers, *EQUATION GRAPHER* quickly and accurately plots graphs of equations. It can be used on a large-screen monitor or video projector to enhance presentations involving graphs of equations.

The teacher or students can choose equations to be graphed and see the result on the screen. The general "what if" question can be asked and the outcome quickly observed. For example, "What if we added 4 to the right side of the equation?", or "What if we divided this expression by 2?"

The teacher may want to enter an equation and show only the graph to the students. Then the class might discuss ways to determine an equation that matches the graph. This activity is recommended as preparation for the *LINEAR & QUADRATIC GRAPHS* program.

Student Utility

Students can use this graphing utility to explore the relationships between equations and graphs. Using worksheets such as those included in this manual, students can learn mathematical concepts and experiment with graphing techniques.

EQUATION GRAPHER **Worksheets for Students – Overview**

Worksheet 1 is a summary of the instructions students see in the program.

Worksheets 2 through 6 are introductory activities which may be useful as preparation for *LINEAR & QUADRATIC GRAPHS* and *TRACKER*. They also provide computer graphing activities to accompany the corresponding chapters in a textbook.

Worksheets 7 and 8 target techniques that students may find useful in playing *GREEN GLOBS*.

Worksheets 9 through 12 are intended for students who have had considerable experience with *GREEN GLOBS* and are ready to investigate advanced mathematical concepts.

Worksheet 1: Instructions for EQUATION GRAPHER

EQUATION GRAPHER plots graphs of equations on a coordinate grid. You enter the equations from the keyboard. While you are graphing, you can review the instructions in the program without losing your work.

Changing Bounds on the Grid

You select either a rectangular or square grid. You can change the bounds at any time by clicking the Set Bounds button or the Zoom button. The bounds can be expressed in terms of π (pi) by typing the letter "p" for π. You may need to change the bounds in order to see your graph more accurately or to examine its behavior over a larger or smaller range.

Entering Equations

The equations you enter can include the following:

- lines, parabolas, circles, ellipses, hyperbolas
  (for these, write your equation using x and y only once)
- equations where y equals a function of x
- equations where x equals a function of y
- trigonometric functions: SIN, COS, TAN, CSC, SEC, COT, ATN (arc tangent)
- square root: SQR
- absolute value: ABS
- natural logarithm: LOG
- exponential function: EXP

Erasing Graphs

You can graph up to ten equations on one grid. To erase a graph, click on its equation to the left of the grid, and then press the delete key. Be sure to click on the equation to the left of the grid, not on the grid – clicking on the grid sets the Zoom center point.

Changing the Equation

Your equation remains on the screen after it has been graphed. You can edit it to make your next equation, or you can delete it and enter a new equation.

Worksheet 2: Graphing Lines (page 1 of 2)

Enter each set of equations on the same coordinate grid. Observe the differences and similarities among the graphs.

Sketch the graphs on the grids at the right.

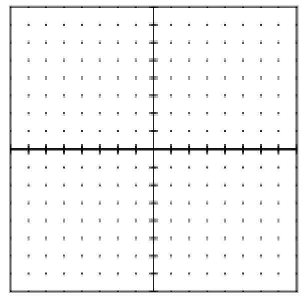
1. x = 5

x = -6

x = 3.5

How might you describe all of

these lines? ____________________



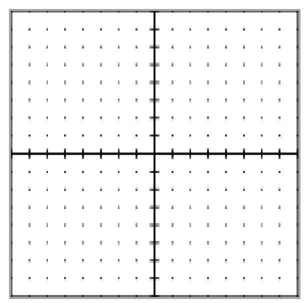
2. y = 2

y = -4

y = -5.5

How might you describe all of

these lines? ____________________



3. y = x

y = x + 3

y = x + 6

y = x - 4

y = x - 1

a. What is alike about all these

lines? __________________________

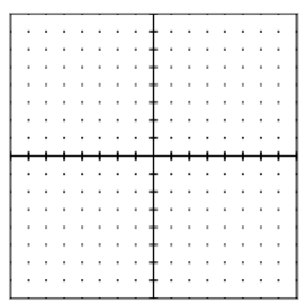
b Where does each line cross the

y axis? _________________________

c. What happens to the graph when a

constant is added to y = x?_________

____



EQUATION GRAPHER

Worksheet 2: Graphing Lines (page 2 of 2)

4. y = x

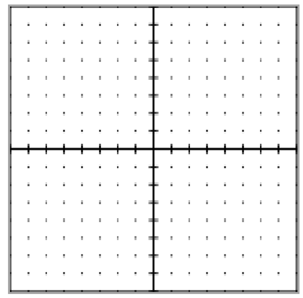
y = 2x

y = 5x

y = -3x

a. What happens to the graph when x is multiplied by a positive number greater than 1? _________________

b. What happens to the graph when x is multiplied by a negative number less than -1?_____________



5. y = 1/2x

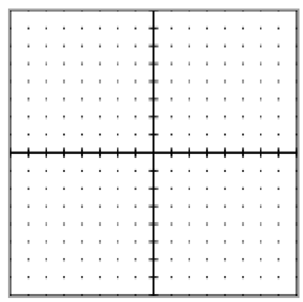
y = 1/4x

y = -1/3x

y = -1/5x

a. What happens to the graph when x is multiplied by a number between 0 and 1?_________________

b. What happens to the graph when x is multiplied by a number between -1 and 0? _______________________



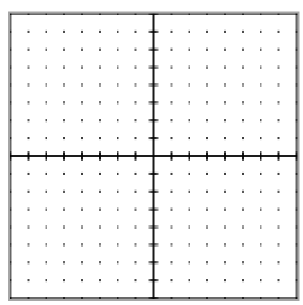
6. y = 2x

y = 2x + 3

y = 2x - 7

y = -2x

y = -2x + 5



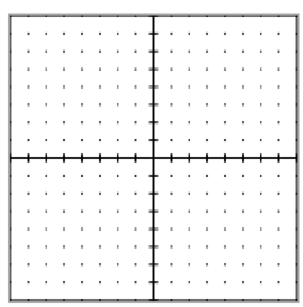
7. y = .5x

y = .5x + 2

y = .5x - 4

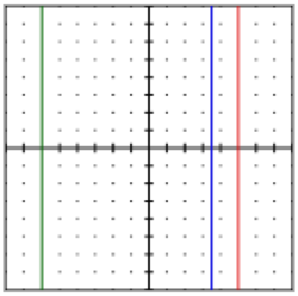
y = -.5x

y = -.5x + 5

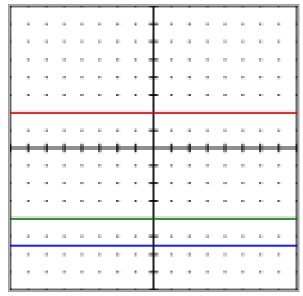


ANSWERS Worksheet 2: Graphing Lines

1. All are vertical.



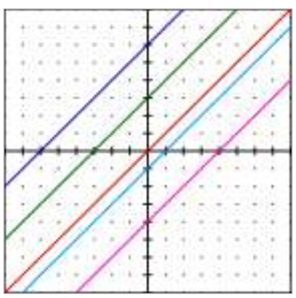
2. All are horizontal.



3a. All have the same slope (same tilt, same direction).

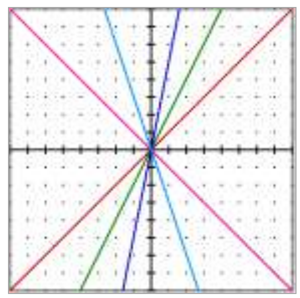
3b. (0.0), (0.3), (0.6), (0,-4), (0,-1)

3c. It moves up or down on the grid.



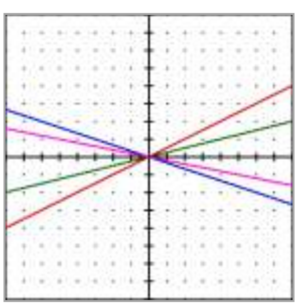
4a. It gets steeper, closer to vertical.

4b It gets steeper, closer to vertical, but it slopes in the opposite direction.

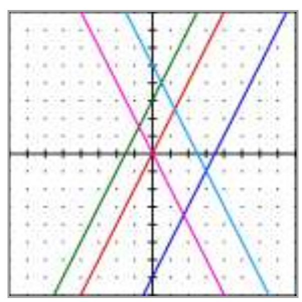


5a. It gets flatter, closer to horizontal.

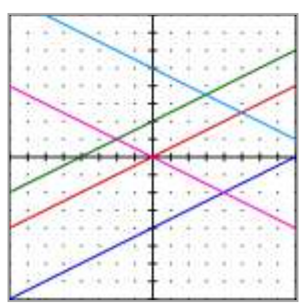
5b. It gets flatter.



6.



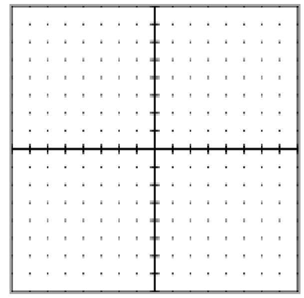
7.



Equation Grapher

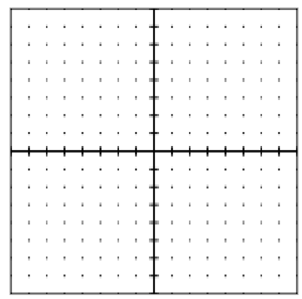
Worksheet 3: Graphing Parabolas (page 1 of 2)

Graph each set of equations on the same coordinate grid using the program *Equation Grapher*. Observe the differences and similarities among the graphs. Sketch your results in the grids.



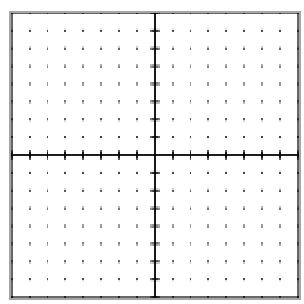
	vertex
1. $y = x^2$	______
$y = (x+1)^2$	______
$y = (x+3)^2$	______
$y = (x-2)^2$	______
$y = (x-5)^2$	______

What happens to the graph when you add a constant to the x term before it is squared?



2.	vertex	Does it touch or cross the x-axis? List the points.
$y = x^2$	______	______ ______
$(y+2) = x^2$ or $y = x^2-2$	______	______ ______
$(y+4) = x^2$ or $y = x^2-4$	______	______ ______
$(y-3) = x^2$ or $y = x^2+3$	______	______ ______
$(y-6) = x^2$ or $y = x^2+6$	______	______ ______

What happens to the graph when you add a constant to the y term in the equation?



3. $y = x^2$

$y = 2x^2$

$y = 5x^2$

$y = 1/2x^2$

$y = 1/6x^2$

What happens to the graph when you multiply the x^2 term by a positive constant?

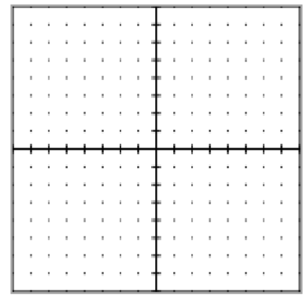
4. $y = x^2$

$y = -x^2$

$y = -(x+3)^2$

$y = -1/5x^2$

What happens to the graph when you multiply the x^2 term by a negative number?



5. $x = y^2$

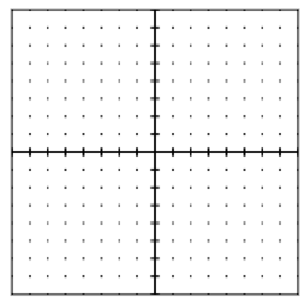
$x = (y-3)^2$

$x = 4y^2$

$x = 1/2y^2 + 4$

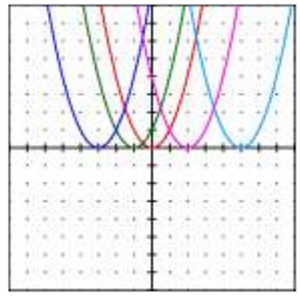
$x = -3y^2$

What happens to the graph when you reverse the x and the y in the equation?



ANSWERS Worksheet 3: Graphing Parabolas (page 1 of 2)

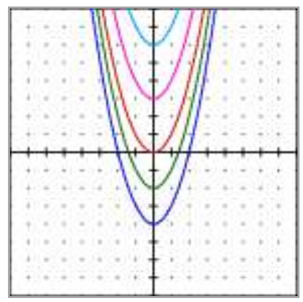
1. vertex
   - (-1,0)
   - (-3,0)
   - (0,0)
   - (2,0)
   - (5,0)



The graph moves right or left.

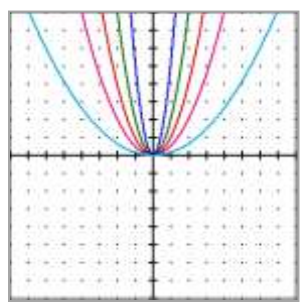
2. vertex Does it touch or cross x-asix?

vertex	Does it touch or cross x-asix?
(0,0)	yes
(0,-2)	yes, at (-1.4,0) and (1.4,0)
(0,-4)	yes, at (-2,0) and (2,0)
(0,3)	no
(0,6)	no



The graph moves up or down.

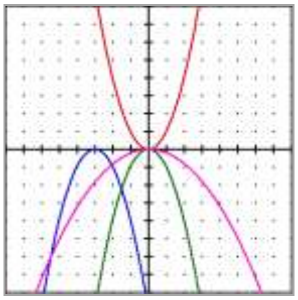
3.



The graph becomes steeper or flatter.

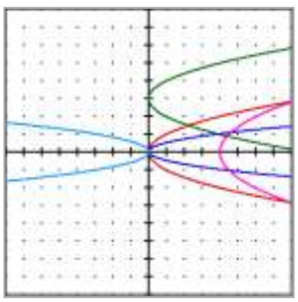
ANSWERS Worksheet 3: Graphing Parabolas (page 2 of 2)

4.



The graph is "upside down" -- it opens downward.

5.

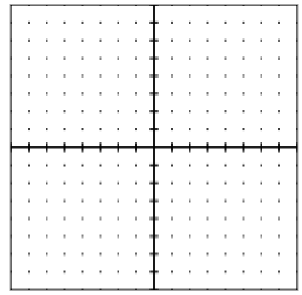


The graph opens to the left or right instead of up or down.

Worksheet 4: Graphing Circles

Graph each set of equations on the same coordinate grid in EQUATION GRAPHER. Observe the differences and similarities among the graphs.

Sketch the graphs.



1. $x^2 + y^2 = 4$

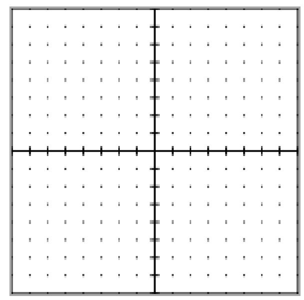
$x^2 + y^2 = 9$

$x^2 + y^2 = 16$

$x^2 + y^2 = 25$

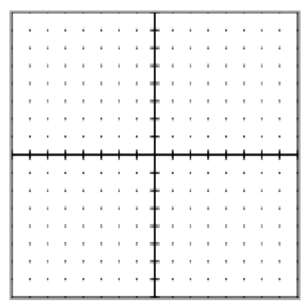
a. How does the graph of the circle change when the constant term increases?____

b. Where is the center of each of these circles? ______________



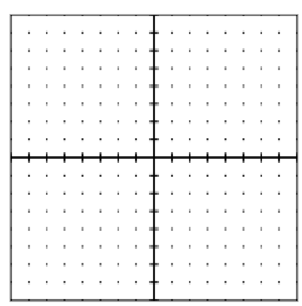
2.	center
$(x+1)^2 + y^2 = 16$	______
$(x+3)^2 + y^2 = 16$	______
$(x-4)^2 + y^2 = 16$	______
$(x-6)^2 + y^2 = 16$	______

How does the graph change when a constant is added to the x term before it is squared? _____________________________________



3.	center
$x^2 + (y+4)^2 = 25$	______
$x^2 + (y+1)^2 = 25$	______
$x^2 + (y-1)^2 = 25$	______
$x^2 + (y-5)^2 = 25$	______

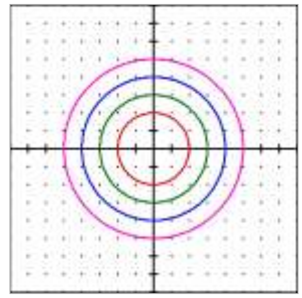
How does the graph change when a constant is added to the y term before it is squared? _____________________________________



4.	center
$(x+1)^2 + (y-2)^2 = 16$	______
$(x-3)^2 + (y-4)^2 = 25$	______
$(x+4)^2 + (y+5)^2 = 36$	______
$(x-2)^2 + (y+3)^2 = 9$	______

EQUATION GRAPHER
ANSWERS Worksheet 4: Graphing Circles

1.



$x^2 + y^2 = 4$

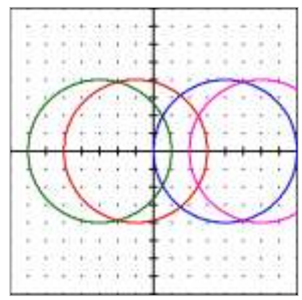
$x^2 + y^2 = 9$

$x^2 + y^2 = 16$

$x^2 + y^2 = 25$

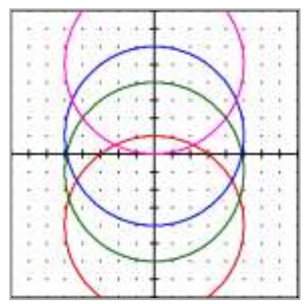
a) the radius increases

b) (0, 0)



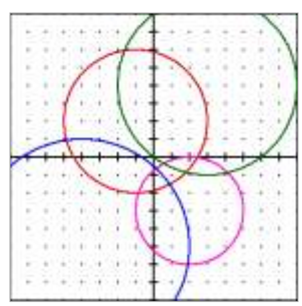
2.	center
$(x+1)^2 + y^2 = 16$	(-1, 0)
$(x+3)^2 + y^2 = 16$	(-3, 0)
$(x-4)^2 + y^2 = 16$	(4, 0)
$(x-6)^2 + y^2 = 16$	(6, 0)

The center moves right or left (on the x axis)



3.	center
$x^2 + (y+4)^2 = 25$	(0, -4)
$x^2 + (y+1)^2 = 25$	(0, -1)
$x^2 + (y-1)^2 = 25$	(0, 1)
$x^2 + (y-5)^2 = 25$	(0, 5)

The center moves up or down (on the y axis)



4.	center
$(x+1)^2 + (y-2)^2 = 16$	(-1, 2)
$(x-3)^2 + (y-4)^2 = 25$	(3, 4)
$(x+4)^2 + (y+5)^2 = 36$	(-4, -5)
$(x-2)^2 + (y+3)^2 = 9$	(2, -3)

EQUATION GRAPHER

Worksheet 5: Graphing Ellipses

Graph each set of equations on the same coordinate grid in *EQUATION GRAPHER*. Observe the differences and similarities among the graphs. Sketch the graphs.

1. vertices

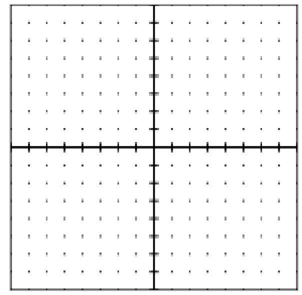
$x^2/9 + y^2 = 1$ ____________________________

$x^2/9 + y^2/4 = 1$ ____________________________

$x^2/9 + y^2/9 = 1$ ____________________________

$x^2/9 + y^2/25 = 1$ ____________________________

How does the graph change as the denominator of the y term changes?_______________



2. vertices

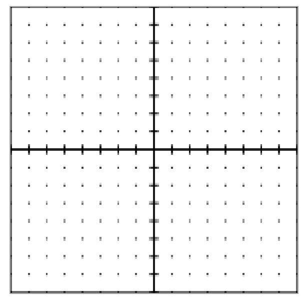
$x^2 + y^2/16 = 1$ ____________________________

$x^2/4 + y^2/16 = 1$ ____________________________

$x^2/16 + y^2/16 = 1$ ____________________________

$x^2/25 + y^2/16 = 1$ ____________________________

How does the graph change as the denominator of the x term changes?__________________

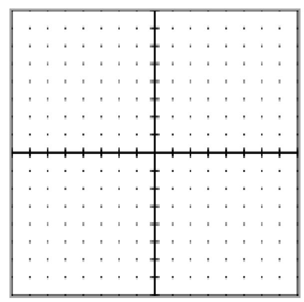


3. vertices

$x^2/9 + y^2/4 = 1$ ____________________________

$(x-2)^2/9 + y^2/4 = 1$ ____________________________

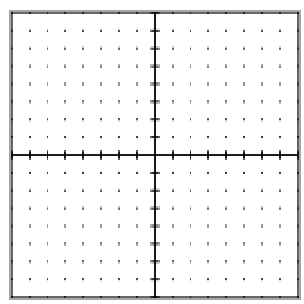
$(x+3)^2/9 + y^2/4 = 1$ ____________________________



4. vertices

$x^2/9 + (y-4)^2/4 = 1$ ____________________________

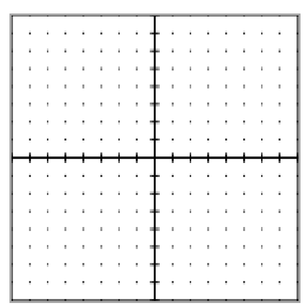
$x^2/9 + (y+5)^2/4 = 1$ ____________________________



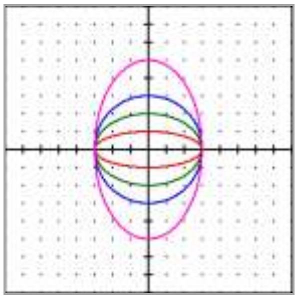
5. vertices

$(x-3)^{2/}16 + (y+2)^2/25 = 1$ ____________________________

$(x+4)^2/36 + (y-3)^2/9 = 1$ ____________________________



ANSWERS Worksheet 5: Graphing Ellipses



1. vertices:

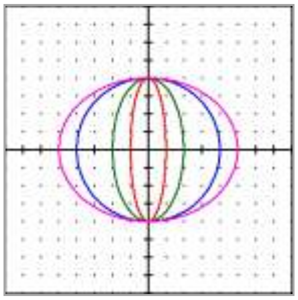
(3,0) (-3,0) (0,1) (0,-1)

(3,0) (-3,0) (0,2) (0,-2)

(3,0) (-3,0) (0,3) (0,-3) (a circle)

(3,0 (-3,0) (0,5) (0,-5)

The graph becomes shorter or taller. The vertices move farther out along the y-axis as the denominator increases.



2. vertices:

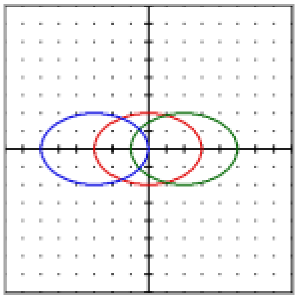
(1,0) (-1,0) (0,4) (0,-4)

(2,0) (-2,0) (0,4) (0,-4)

(4,0) (-4,0) (0,4) (0,-4) (a circle)

(5,0) (-5,0) (0,4) (0,-4)

The graph becomes wider or narrower. The vertices move farther out along the x-axis as the denominator increases.

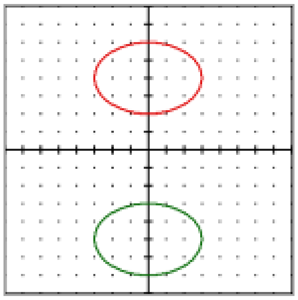


3. vertices:

(3,0) (-3,0) (0,2) (0,-2)

(5,0) (-1,0) (2,2) (2,-2)

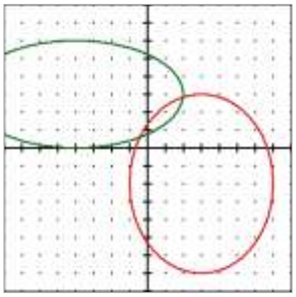
(0,0) (-6,0) (-3,2) (-3,-2)



4. vertices:

(3,4) (-3,4) (0,2) (0,6)

(3,-5) (-3,-5) (0,-3) (0,-7)



5. vertices:

(-1,-2) (7,-2) (3,3) (3,-7)

(-10,3) (2,3) (-4,6) (-4,0)

Worksheet 6: Graphing Hyperbolas (page 1 of 2)

Graph each set of equations on the same coordinate grid in *EQUATION GRAPHER*. Observe the differences and similarities among the graphs. Sketch the graphs on the grids below.

1. vertices

$x^2 - y^2 = 1$ ________

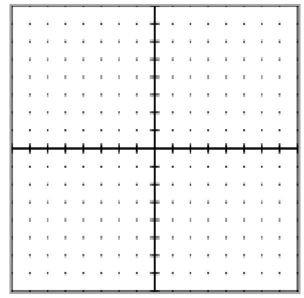
$x^2/4 - y^2 = 1$ ________

$x^2/9 - y^2 = 1$ ________

$x^2/25 - y^2 = 1$ ________

How does the graph change when the denominator of the x term changes?

____



2. vertices

$x^2 - y^2 = 1$ ________

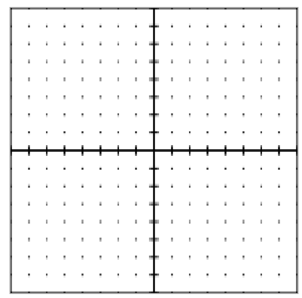
$x^2 - y^2/4 = 1$ ________

$x^2 - y^2/36 = 1$ ________

$x^2 - y^2/64 = 1$ ________

How does the graph change when the denominator of the y term changes?

____



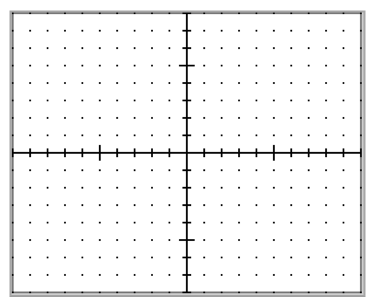
3. vertices

$x^2/16 - y^2/25 = 1$ ________

$(x-3)^2/16 - y^2/25 = 1$ ________

$(x+2)^2/16 - y^2/25 = 1$ ________

How does the graph change when a constant is added to the x term before squaring?____

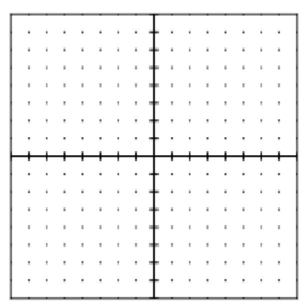


4. vertices

$x^2/16 - (y-2)^2/25 = 1$ ________

$x^2/16 - (y+4)^2/25 = 1$ ________

How does the graph change when a constant is added to the y term before squaring?____



Worksheet 6: Graphing Hyperbolas (page 2 of 2)

vertices

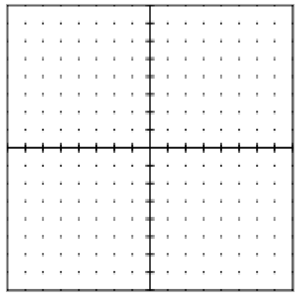
5. $(x+2)^2/25 - (y-1)^2/16 = 1$ ______________

6. $y^2/16 - x^2/9 = 1$ ______________

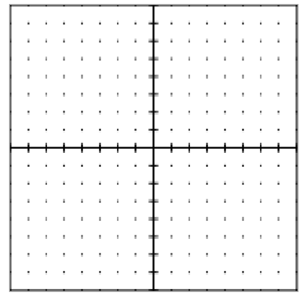
$y^2/9 - x^2/4 = 1$ ______________

How does the graph change when the x and y are reversed in the equation?

____



5



6

7. The graphs of these equations are also hyperbolas. How are these graphs different from those above?

____

vertices

7a. $xy = 1$ ________________

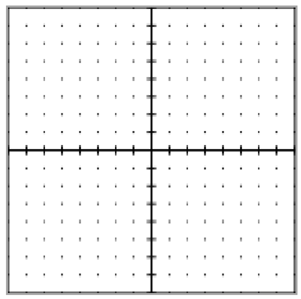
$xy = 9$ ________________

$xy = 25$ ________________

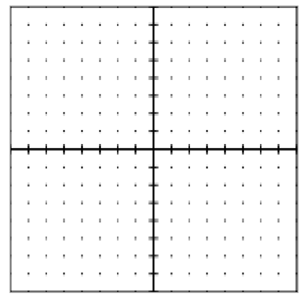
7b. $xy = -16$ ________________

$xy = -4$ ________________

What are the equations of the lines on which the vertices lie?________________________________



7a



7b

8a. $(x-3)y = 1$

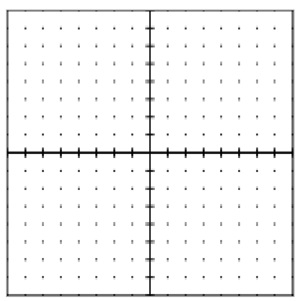
$x(y+4) = 1$

8b. $(x+2)y = -1$

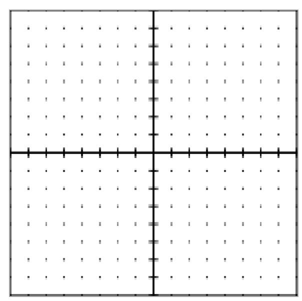
$x(y-5) = -1$

How does the graph change when you add a constant to the x or the y term?

____



8a



8b

9a. $xy = 4$

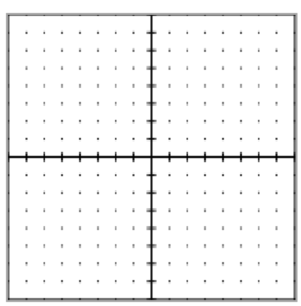
$x(y+4) = 4$

$(x-2)y = 4$

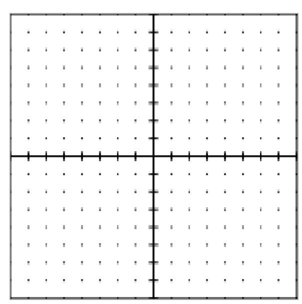
9b. $xy = -9$

$(x+3)(y-2) = -9$

How does the graph change when you change the constant term?________________________________



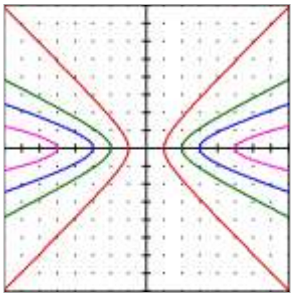
9a



9b.

ANSWERS Worksheet 6: Graphing Hyperbolas (page 1 of 2)

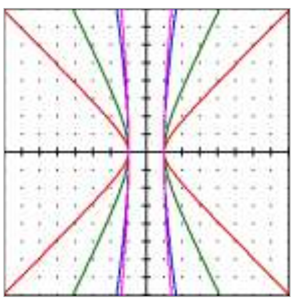
1.



(1,0) and (-1,0)
(2,0) and (-2,0)
(3,0) and (-3,0)
(5,0) and (-5,0)

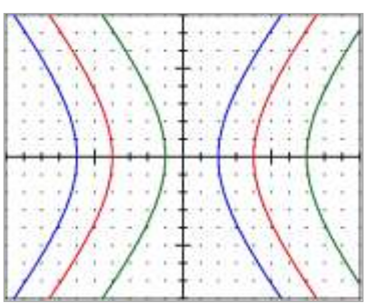
The vertices move farther out along the x-axis as the denominator increases.

2.



Vertices for all graphs are (1,0) and (-1,0). The graph becomes more vertical as the denominator increases.

3

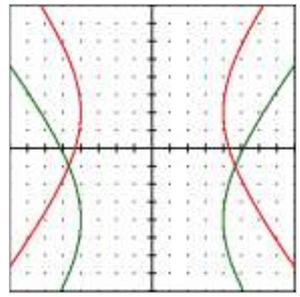


.

(4,0) and (-4,0)
(7,0) and (-1,0)
(0,0) and (-8,0)

The graph moves right or left.

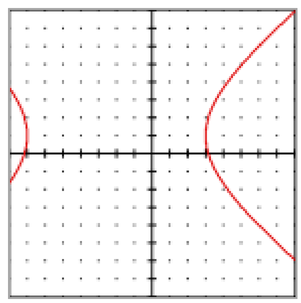
4.



(4,2) and (-4,2)
(4,-4) and (-4,-4)

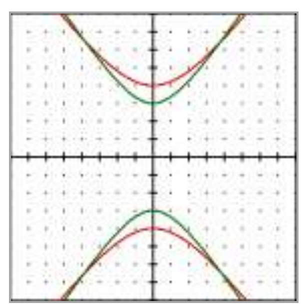
The graph moves up or down.

5.



(3,1) and (-7,1)

6.



(0,4) and (0,-4)
(0,3) and (0,-3)

The graph opens upwards and downwards instead of sideways.

ANSWERS Worksheet 6: Graphing Hyperbolas (page 2 of 2)

7.

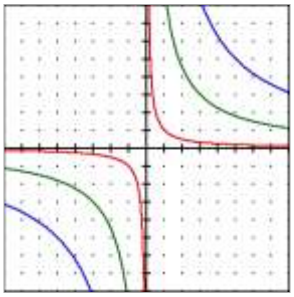
The graphs are rotated. They lie entirely inside the first and third quadrants of the grid.

(1,1) and (-1,-1)

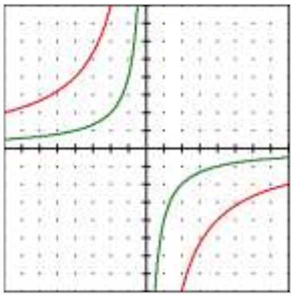
(3,3) and (-3,-3)

(5,5) and (-5,-5)

7a.



7b.



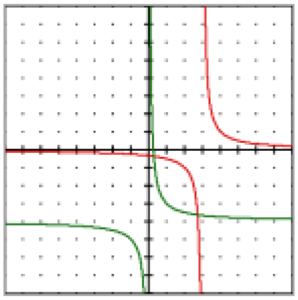
The graphs here lie entirely inside the second and fourth quadrants of the grid.

(-4,4) (4,-4)

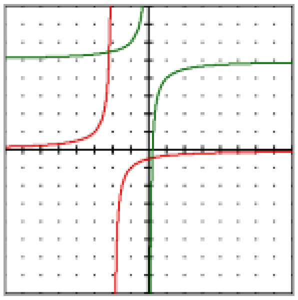
(-2,2) (2,-2)

The equations of the lines on which the vertices lie are y = x and y = -x.

8a.



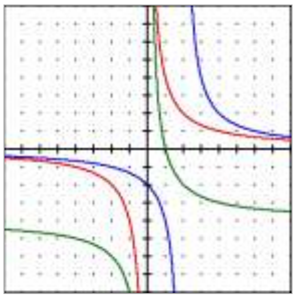
8b.



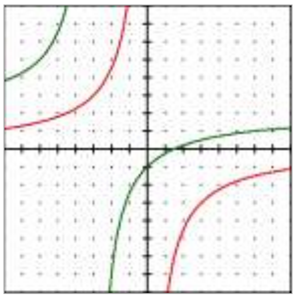
8.

The graph is shifted horizontally or vertically.

9a.



9b.



9.

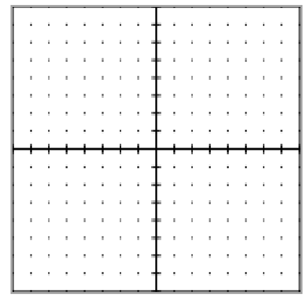
Changing the size of the constant term changes the curvature of the graph and the distance between its vertices.

Changing the sign of the constant term reflects the graph with respect to an asymptote.

Worksheet 7: Exploring Roots

Use the program *EQUATION GRAPHER* to plot the graphs of the equations in the exercises below.

A. Plot the graph of $y = x^2 - 4x + 3$.



Where does the graph cross the x axis (What are the roots of the equation?) ______________________________

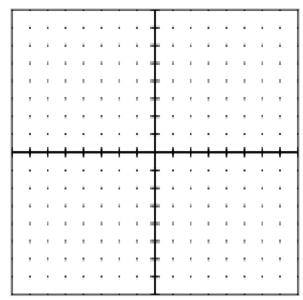
Factor the right side of the equation $y = x^2 - 4x + 3$

y = (   )(   )

Compare the factors with the roots. What do you notice?____

____

B. Plot the graph of $y = x^2 - 3x - 10$.



Where does the graph cross the x axis (What are the roots of the equation?) ______________________________

Factor the right side of the equation $y = x^2 - 3x + 3$

y = (   )(   )

Compare the factors with the roots.

____

1. Write an equation of a parabola that crosses the x axis at the points (-2,0) and (2,0).

___________________________________ Plot it and see if you are correct.

2. Write an equation of a parabola that crosses the x axis at the points (2,0) and (6,0).

___________________________________ Plot it and see if you are correct.

3. Write an equation of a parabola that crosses the x axis at (-5,0) and (1,0).

____

4. Write an equation of a parabola that crosses the x axis at (1.5,0) and (4.5,0).

____

5. Write an equation of a parabola that passes through the points (-4,3) and (4,3).

____

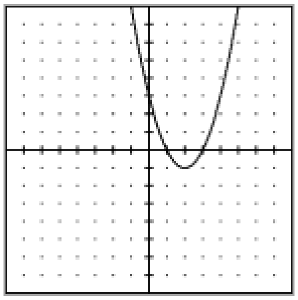
6. Write an equation of a parabola that passes through the points (2,-4) and(6,-4).

____

EQUATION GRAPHER

ANSWERS Worksheet 7: Exploring Roots

A.



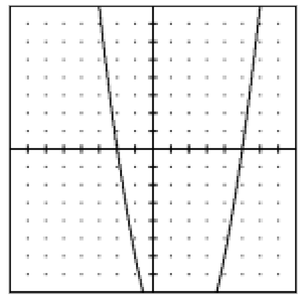
The graph crosses the x axis at (1,0) and (3,0).

The roots are 1 and 3.

y = (x - 1)(x - 3)

For each root R, there is a factor (x-R).

B.



The graph crosses the x axis at (-2,0) and (5,0).

The roots are -2 and 5.

y = (x - 5)(x + 2)

For each root R, there is a factor (x-R).

In the equations below , "c" can be any non-zero constant and the equation will be a correct answer.

1. $y = c(x + 2)(x - 2)$ for example, $y = x^2 - 4$

2. $y = c(x - 2)(x - 6)$ for example, $y = x^2 - 8x + 12$

3. $y = c(x + 5)(x - 1)$ for example, $y = x^2 + 4x - 5$

4. $y = c(x - 1.5)(x - 4.5)$ for example, $y = x^2 - 6x + 6.75$

5. $y = c(x + 4)(x - 4) + 3$ for example, $y = x^2 - 13$

6. $y = c(x - 2)(x - 6) - 4$ for example, $y = (x^2 - 8x + 8)$

Worksheet 8: Passing Through Points (page 1 of 2)

This worksheet describes one way to find an equation whose graph crosses the x axis at (-4,0) and (5,0) and that also passes through the point (3,-7).

First, locate these points on a grid. Clearly, a straight line will not pass through these three points, so consider a second degree equation.

Using the divide and conquer strategy, consider just the two points on the x axis: (- 4,0) and (5,0).

At these points, y equals zero.

Using guess and check, create two factors to multiply together and set them equal to y.

The factors must be chosen so that when x = - 4 or x = 5, the product of the two factors is zero.

y = (   )(   )

Check that this graph does cross the x axis at x = - 4 and at x = 5 by entering it into the *Equation Grapher* program and observing the graph.

(If your first try did not work, modify the equation on the basis of what you see and try again.)

Look to see if this graph passes through the other point, (3,-7). It probably does not.

We want a graph that passes through (3,-7). So we want an equation which is true for x = 3 and y = -7.

First, substitute 3 for x in the equation above, to find the value of the equation we have at x = 3.

y = (x   )(x   )

y = (3   )(3   )

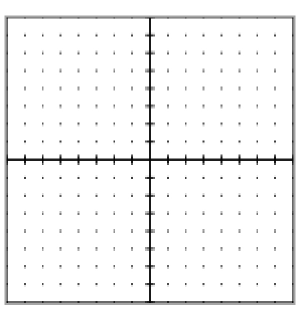
y = (   )(   )

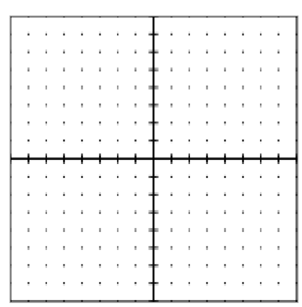
y = -14

We want the value of y to be -7, not -14. Since -14/2=-7, we need to divide the expression on the right side of our equation by 2.

y = (x + 4) (x - 5) / 2

Graph this equation to see if it passes through all three points.





Worksheet 8: Passing Through Points (page 2 of 2)

1. Now change your equation y = (x + 4) (x - 5) / 2 to get a new equation whose graph crosses the x axis at the same points, but passes through the point shown below instead of the point (3,-7).

a. (3, 28) y = ________________________

b. (3, -21) y = ________________________

c. (1, -10) y = ________________________

d. (1, 5) y = ________________________

2. Write an equation whose graph crosses the x axis at (-2,0) and (3,0) and passes through the point (-1,-1).

y = ____

3. Write an equation whose graph crosses the y axis at (0,-1) and (0,3) and passes through the point (6,0).

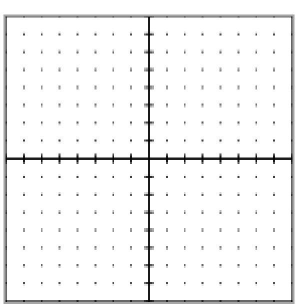
x = ____

4. Write an equation whose graph crosses the x axis at (2,0), (-2,0), (-5,0) and passes through the point (-4,6).

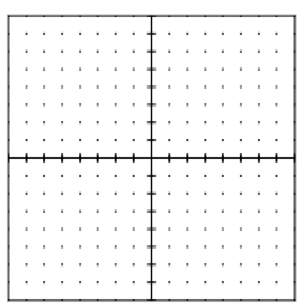
y = ____

Here are some grids for sketching (optional).

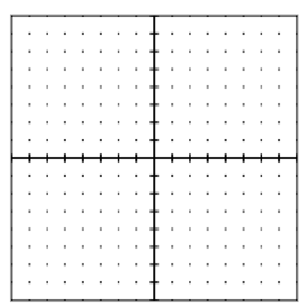
2.



3.



4.

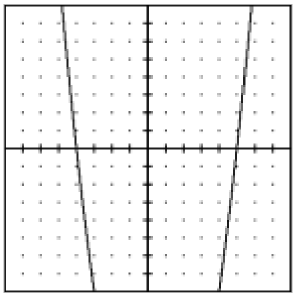


ANSWERS Worksheet 8: Passing Through Points

Answers for Page 1:

y = (x + 4) (x – 5) goes through the points (- 4,0) and (5,0).

It does not go through the point (3, - 7).



Calculating the value of y when x = 3

in equation y = (x + 4) (x – 5):

y = (x + 4) (x - 5)

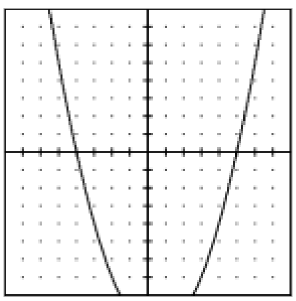
y = (3 + 4) (3 - 5)

y = (7) (-2)

y = -14

y = (x + 4) (x – 5) / 2 goes through the points (- 4,0) and (5,0).

It also goes through the point (3, - 7).



Answers for Page 2:

1a. y = - 2 (x + 4) (x - 5)

1b. y = 3/2 (x + 4) (x - 5)

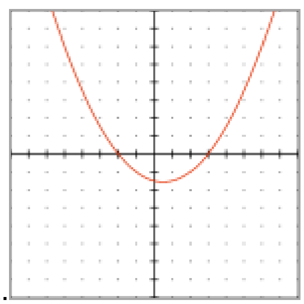
1c. y = 1/2 (x + 4) (x - 5)

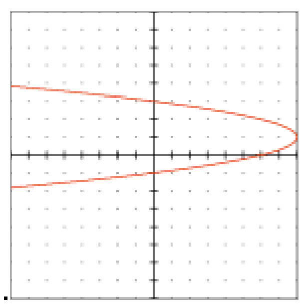
1d. y = - 1/4 (x + 4) (x - 5)

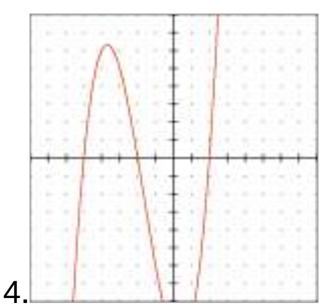
2. y = (x + 2) (x - 3) / 4 or y = 1/4 (x + 2) (x - 3)

3. x = -2 (y + 1) (y - 3)

4. y = 1/2 (x - 2) (x + 2) (x + 5)

2.


3.


4.


Equation Grapher

Worksheet 9: Advanced Techniques – Sums of Functions

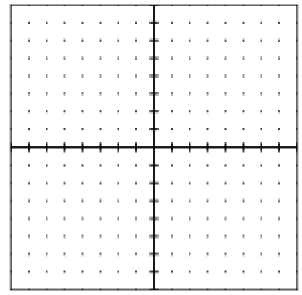
This activity demonstrates the effect of adding a term of the form 1/x to a function.

1. Using the *Equation Grapher* program, graph the following rational functions:

y = 1/x, y = 1/(x - 2), and y = 1/(x + 4)

Observe the results. What happens at the values x = 0 in the first graph, x = 2 in the second graph, and x = - 4 in the third?____

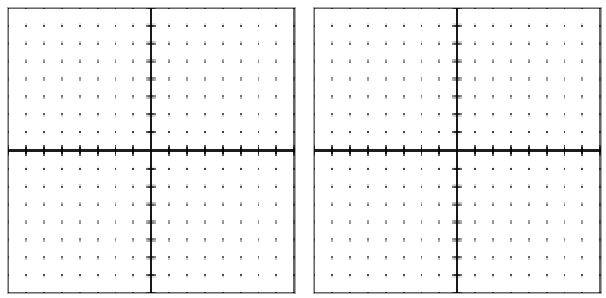
What happens to the denominator in each equation at these values of x? ____



2a. Using *Equation Grapher* and a

blank grid, graph the equation y = 1/(x - 2).

Sketch the graph on the first grid at the right.



2b. Recall the graph of the line y = x.

Graph it on the computer if you wish.

Sketch its graph also on the first grid at the right.

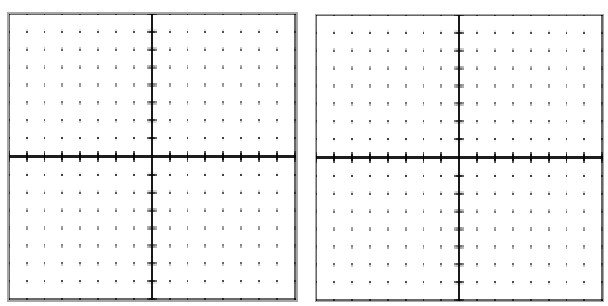
2c. Now use the computer to graph the equation formed by adding the term 1/(x - 2) to the equation of the line y = x to get y = x + 1/(x - 2).

Sketch the graph on the second grid at the right.

Describe the graph.

____

3a. Graph the equation y = 1/(x - 1). Sketch the graph on the first grid at the right.



3b. Graph the parabola $y = x^2/4$. Sketch the graph also on the first grid at the right..

3c. Use the computer to graph the equation

formed by adding $x^2/4$ and 1/(x – 1) to get

$y = x^2/4 + 1/(x - 1)$. Sketch the graph on the second grid at the right. Describe the graph.

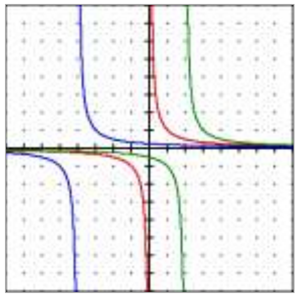
____

ANSWERS Worksheet 9: Advanced Techniques – Sums of Functions

1.

The graph is not defined at those values of x.

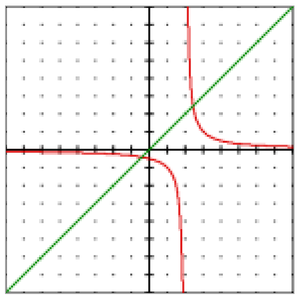
The denominator is zero.

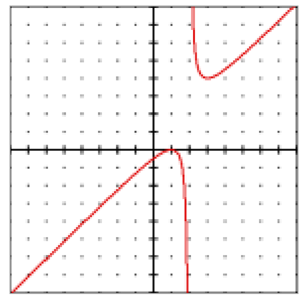


2.

The graph of $y = x + 1/(x – 2)$ looks like the graph of $y = x$ except near $x = 2$.

Near $x = 2$, the graph looks like the graph of $y = 1/(x – 2)$.

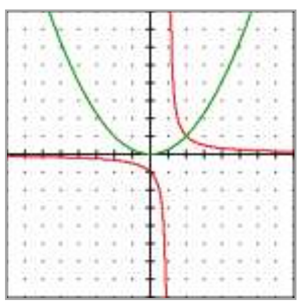


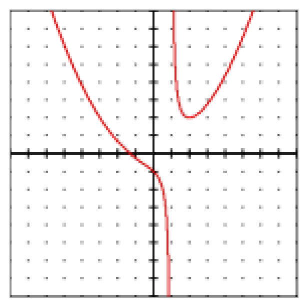


3.

The graph of $y = x^2/4 + 1/(x -1)$ looks like the graph of $y = x^2/4$ except near $x = 1$.

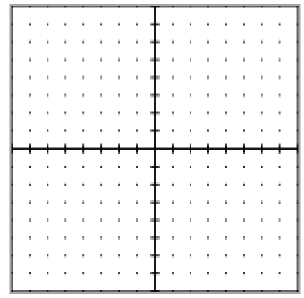
Near $x = 1$, the graph looks like the graph of $y = 1/(x – 1)$.





Worksheet 10: Advanced Techniques – Trigonometric Functions

Graph each set of equations on the same coordinate grid. Notice the similarities and differences. Sketch the graphs. The ideas you get from these activities may help you play the Expert Game in *GREEN GLOBS*.



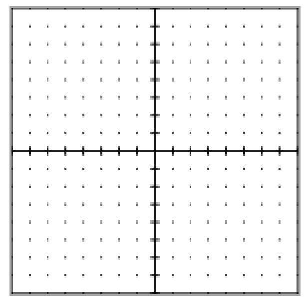
1. Graph y = SIN(x)

    y = 5SIN(x)

    y = SIN(5x)

a. What is the effect of putting a coefficient in front of the SIN function?___________________________________

b. What is the effect of putting a coefficient in front of the x inside the SIN function?___________________________



2. Graph x = SIN(y)

    x = 6SIN(y)

    x = 6SIN(4y)

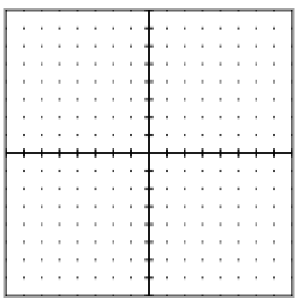
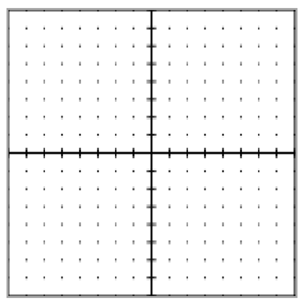
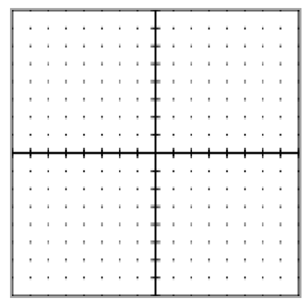
What differences are there between the graphs in this set and those above? ______________________________________

3. Graph

a. y = TAN(x)

b. y = TAN(x)/8

c. y = TAN(3x)

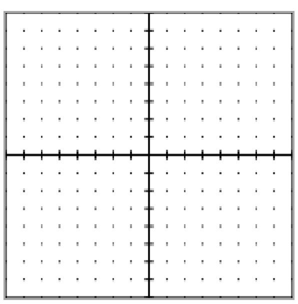
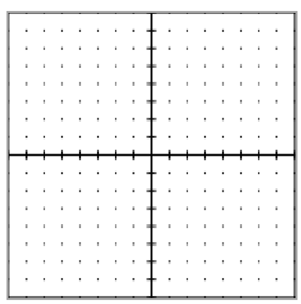
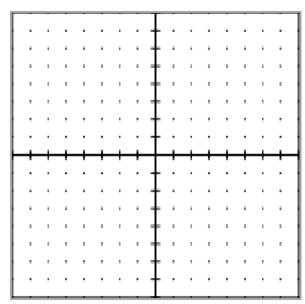




4. Graph

a. x = TAN(y)

b. x = TAN(5y)/2

c. x= TAN(y)/3

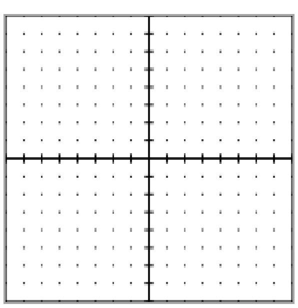
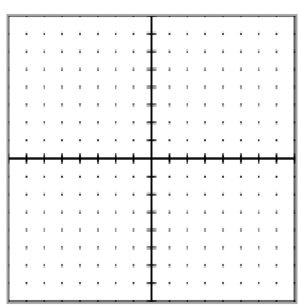
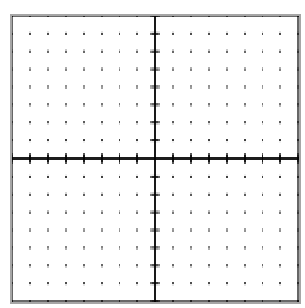




5. Graph

a. y = SEC(x)

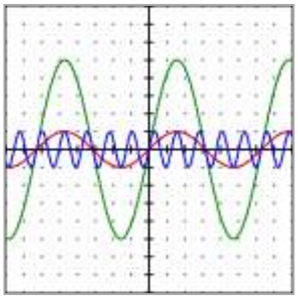
b. y = SEC(3x)

c. x = SEC(y)

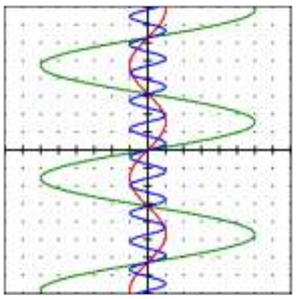
EQUATION GRAPHER

ANSWERS Worksheet 10: Advanced Techniques – Trigonometric Functions



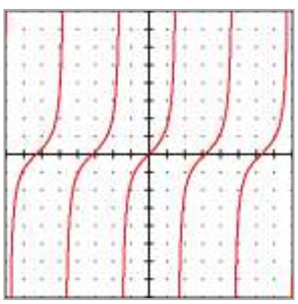
1a. The height of the graph is increased. It is stretched up and down.

1b. The period is smaller. The graph is squeezed together sideways.

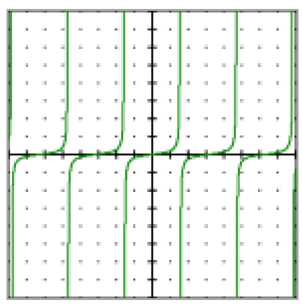


2. These graphs lie along the y-axis rather than the x-axis.

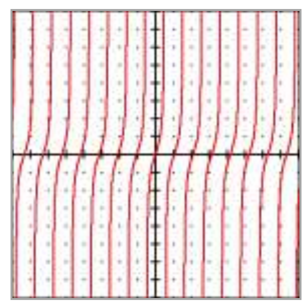
3a



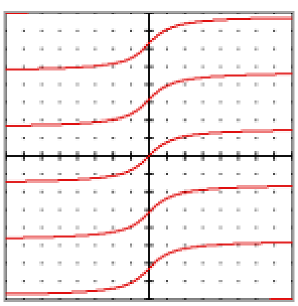
3b



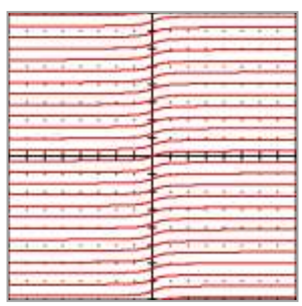
3c



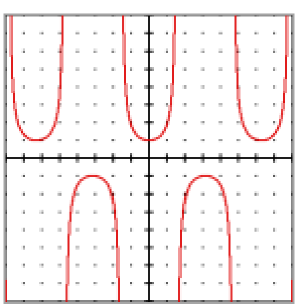
4a



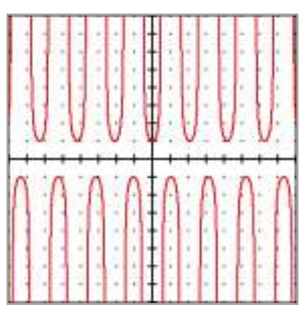
4b



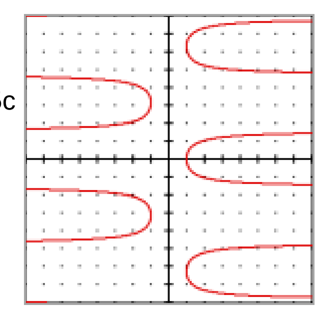
5a



5b



5c



Worksheet 11: Advanced Techniques – Sums with Trigonometric Functions

Interesting graphs can be produced by adding two functions. Try these examples of sums of functions, then create some combinations of your own.

Graph the equations on the computer with *EQUATION GRAPHER*, then sketch the graphs on paper so you'll have a record of them. The ideas you get from these sum equations may prove helpful when you play the Expert Game in *GREEN GLOBS*.

1. Graph y = x

   y = SIN(x)

   and y = x + SIN(x)

   Describe the graph of the sum equation y = x + SIN(x)

   .________________________

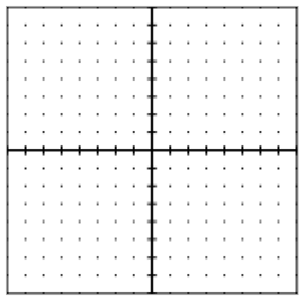
2. Graph y = - x/2

   and y = - x/2 + 3SIN(x)

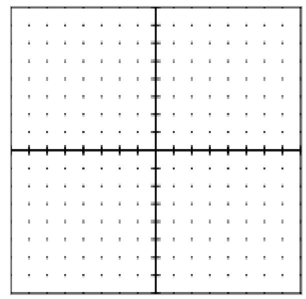
   Describe the graph.

   ____

1.



2.



3. Graph x = y

   and x = y + 4SIN(y)

   Describe the graph.

   ____

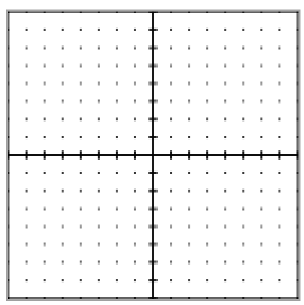
4. Graph y = 2x - 3

   and y = 2x - 3 + 4SIN(3x)

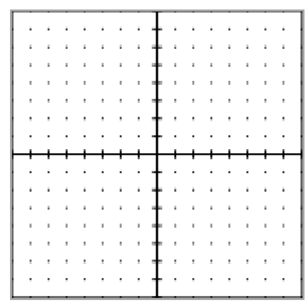
   Describe the graph.

   ____

3.



4.



5. Graph $y = x^2/4$

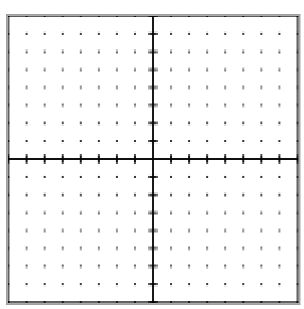
   and $y = x^2/4$ + SIN(4x)

   Describe the graph.

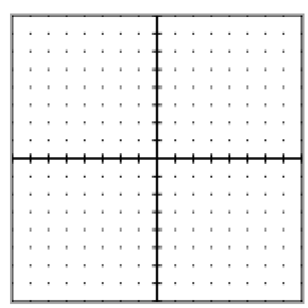
   ____

6. Try using COS(x) and other variations of the above equations.

5.

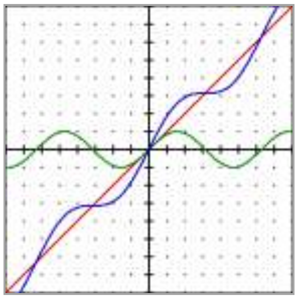


6.

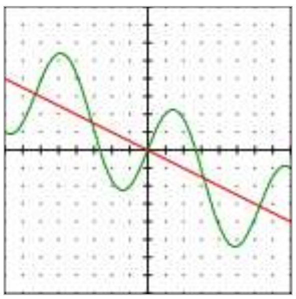


EQUATION GRAPHER

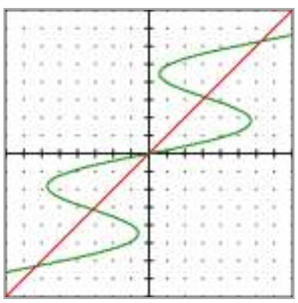
ANSWERS Worksheet 11: Advanced Techniques – Sums with Trigonometric Functions



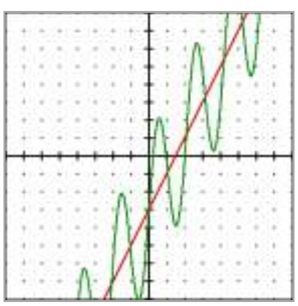
1. The graph is a slightly wavy curve along the path of y = x.



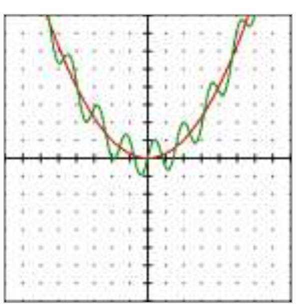
2. The graph is a bumpy curve along the path of y = - x/2



3. The graph is a very wavy curve along the path of x = y.



4. The graph is a very sharp curve along the path of y = 2x - 3.



5. The graph is a wavy curve along the path of $y = x^2/4$.

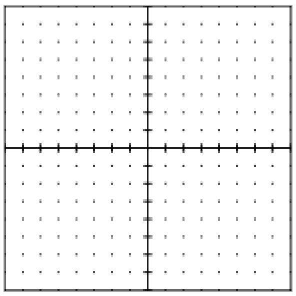
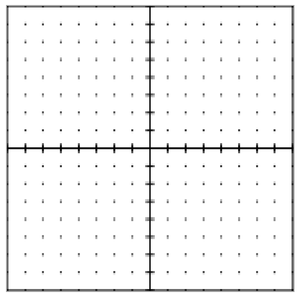
Worksheet 12: Advanced Techniques – Absolute Value Function (page 1 of 2)

The absolute value function can be combined with other functions to produce interesting effects.

Try these examples, then create innovative graphs of your own.

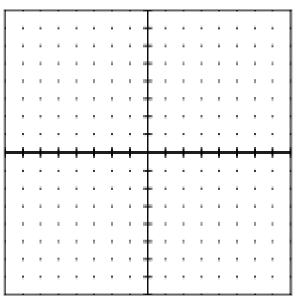
Graph the equations on the computer using *EQUATION GRAPHER*, then sketch the graphs on paper, so you will have a record of them to refer to when you play *GREEN GLOBS*.

1. Sketch the graphs of $y = x$ and $y = ABS(x)$.

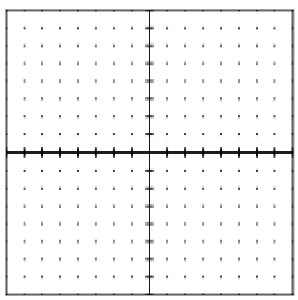



2. Use the computer to graph these equations. Sketch them on the grids below. Describe each graph.

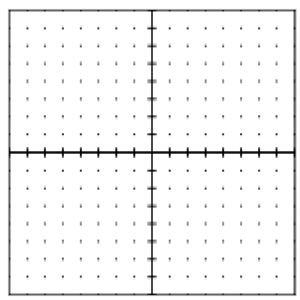
y = 2x – 3



y = ABS(2x - 3)

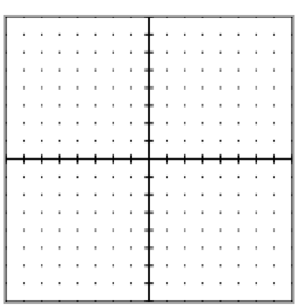


y = ABS(2x) – 3



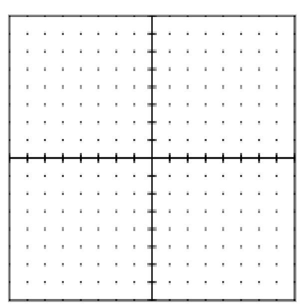
3. Graph x = ABS(y) and x = ABS(y/4).

Sketch the graphs on the grid below.
Describe the graphs.



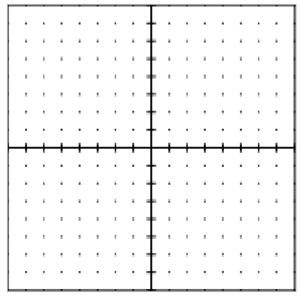
4. You know the graph of $y = x^2$.

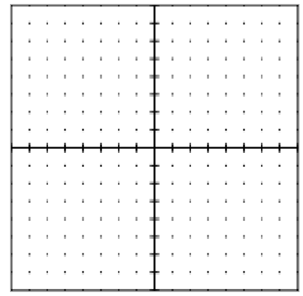
What does the graph of $y = ABS(x^2)$ look like?



5a. Graph $y = x^2 - 5$ and $y = ABS(x^2 - 5)$.
Describe the graphs.

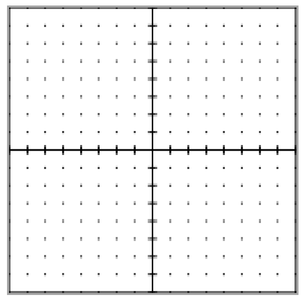
____





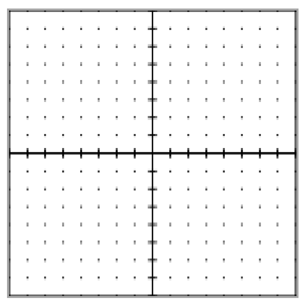
5b. Graph $y = ABS(x^2 - 5) - 7$. Describe the graph.

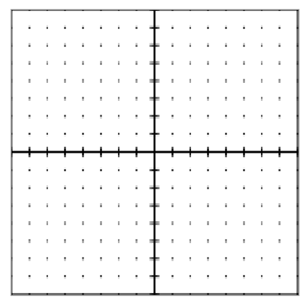
____



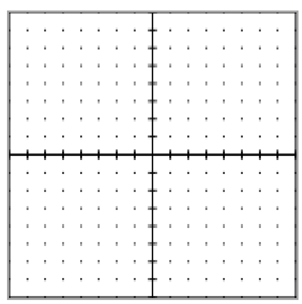
6. Try using the absolute value function with trigonometric functions.

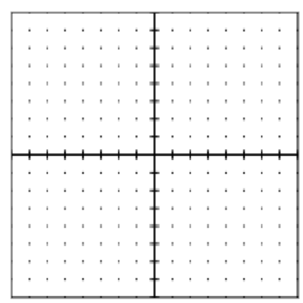
6a. Graph y = TAN(x) and y = ABS(TAN(x))





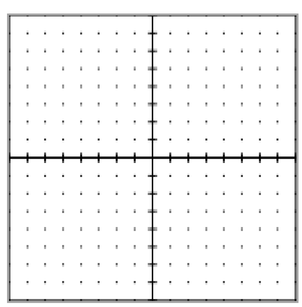
6b. Graph x = TAN(y) and x = ABS(TAN(y))





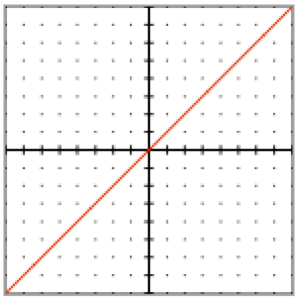
7. Try using the absolute value function with another function.

Graph y = ABS(3TAN(x)) + x

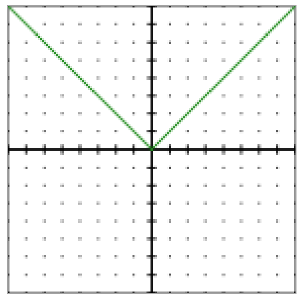


ANSWERS Worksheet 12: Advanced Techniques – Absolute Value Function (p. 1 of 2)

1. y = x



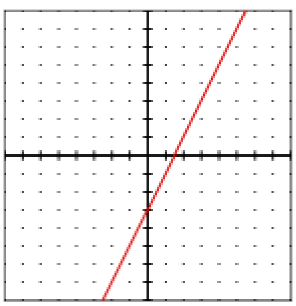
y = ABS(x).



2.

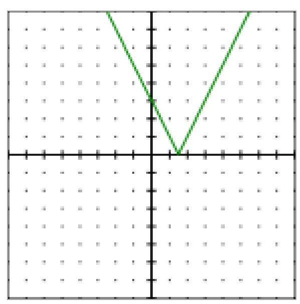
. y = 2x – 3

straight line



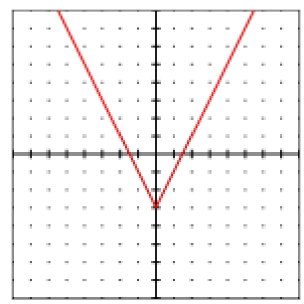
y = ABS(2x - 3)

a V-shaped graph



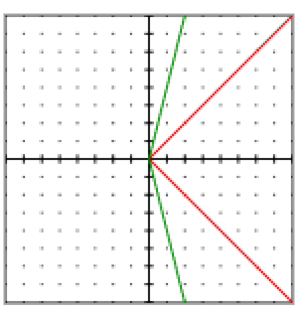
y = ABS(2x) – 3

a V-shaped graph

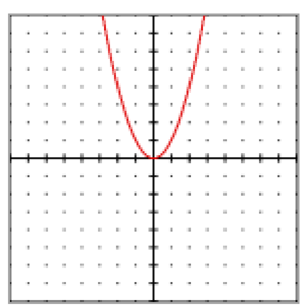


3. x = ABS(y) and x = ABS(y/4)

are V-shaped and open to the right.

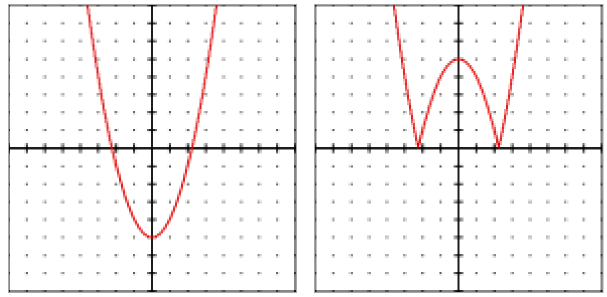


4. y = ABS(x^2) looks the same as y = ABS(x).



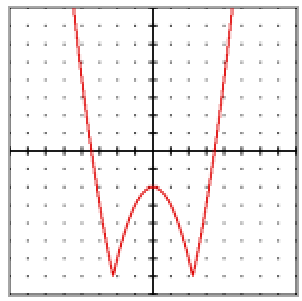
5a. $y = x^2 - 5$ and $y = ABS(x^2 - 5)$

$y = ABS(x^2 – 5)$ looks like $y = x^2 – 5$, except the part of the parabola where y is negative has been flipped around the x-axis.

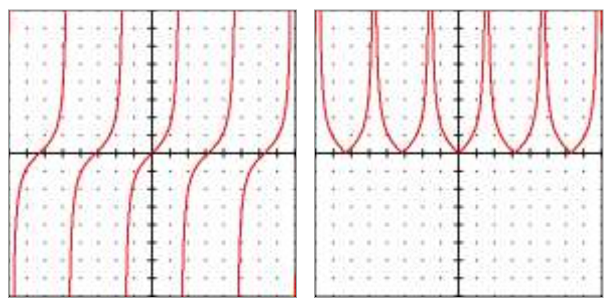


5b. $y = ABS(x^2 - 5) - 7$

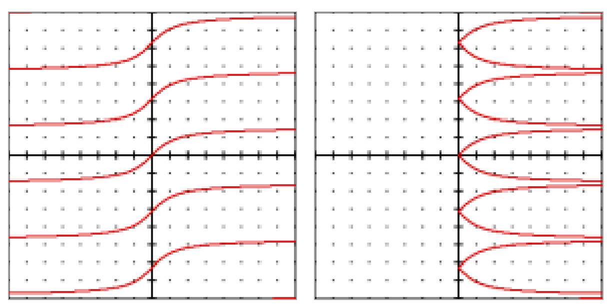
. $y = ABS(x^2 - 5) – 7$ is the same shape as
. $y = ABS(x^2 - 5)$, but 7 lower.



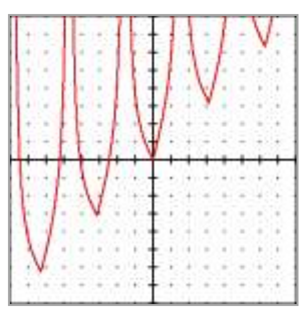
6a. y = TAN(x) and y = ABS(TAN(x))



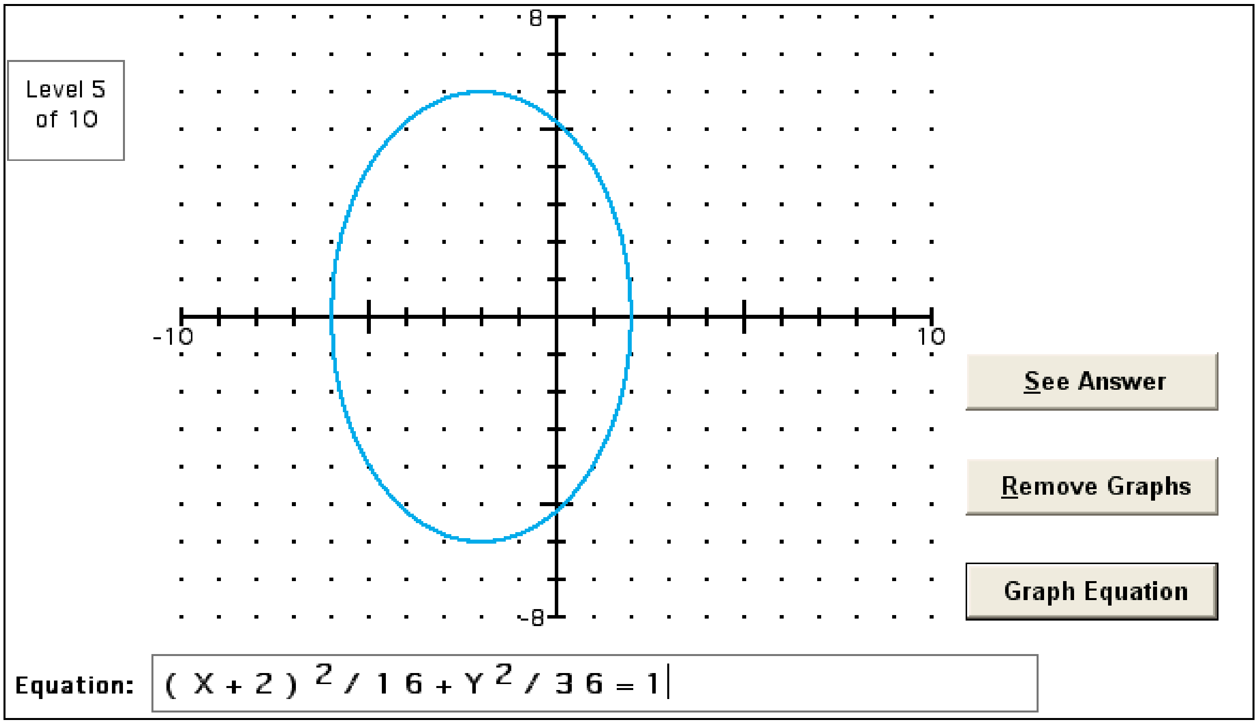
6b. x = TAN(y) and x = ABS(TAN(y))



7. y = ABS(3TAN(x)) + x



LINEAR & QUADRATIC GRAPHS



Teacher's Note:

For a monochrome monitor, the target graph will be drawn using dashes, and your graph will be drawn solid, so you can tell them apart. This information is included in the instructions shown to students who are using monochrome monitors.

Overview

Grade Level: 8 - adult

Prerequisite Skills: an introduction to linear and quadratic graphs

Type: practice in relating equations to graphs

Description

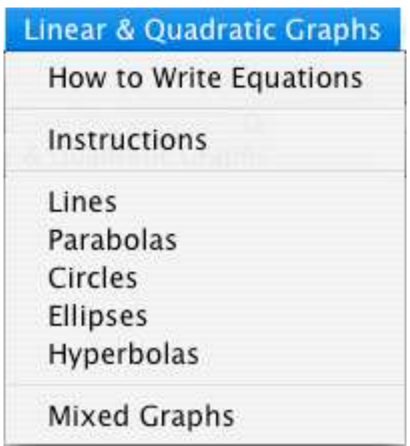
Students choose the type of linear or quadratic graph to be used: line, parabola, circle, ellipse, or hyperbola. A graph is displayed on a coordinate grid. Students enter equations to match the target graph shown.

The graph of each equation entered is plotted on the screen in a different color from the target graph. (On a monochrome screen, the target graph is dashed, and the student's graphs are solid.) Students continue entering equations and observing their graphs until the equation matches the target graph.

Objectives

1. to recognize basic shapes of linear and quadratic graphs
2. to relate graphs to their equations
3. to translate graphs horizontally and vertically
4. to manipulate graphs by altering the corresponding equation
5. to generalize transformation concepts and strategies from simple to more complex graphs
6. to use guess and check to diagnose errors and revise hypotheses

LINEAR & QUADRATIC GRAPHS **Menu Items**



• How to Write Equations

This is the practice screen described under "How to Write Equations" on page 9. It is the same for all programs.

• Instructions

These are the instructions shown to students:

Instructions

A target graph will be drawn. You type an equation to match the target graph.

Your equation will be graphed on the same grid as the target graph.

If your equation is wrong, you can see how your graph is different from the target graph and try again. If you need help, you can choose to see an answer.

When you get a problem correct on the first try without asking to see the answer, you move to the next higher level.

The five menu items below lead to practice with the chosen kind of graph.

- Lines
- Parabolas
- Circles
- Ellipses
- Hyperbolas

If you choose Hyperbolas, you will be asked whether you want hyperbolas like $x^2/4 - y^2/9 = 1$ or hyperbolas like $xy = 4$.

You will then see a screen (headed by the type of graph you selected) where you specify the difficulty level you want. Lines and Parabolas each have difficulty levels 1 (easiest) through 20. Circles, Ellipses and Hyperbolas each have levels 1 through 10. You can click on one of three radio buttons to set your level:

- ○ Begin with easy problems and work up to hard ones
- ○ Choose a starting level and work up from there
- ○ Practice problems of mixed difficulty

"<u>Begin with easy problems...</u>"

> This starts at level 1 and moves up one level when you enter a correct equation on your first try, without clicking the <u>See Answer</u> button. Your current level is shown on the graphing display (e.g., "level 1 of 20"). When you are correct at the top level on your first try, the program congratulates you and waits for you to select from the menu bar.
>
> Most levels include several similar graphs, but a few levels contain only one graph. For example, Level 6 for parabolas includes the graphs $y = -(x - 1)^2$, $y = -(x - 2)^2$ and so on, but Level 1 is always the graph $y = x^2$.

"<u>Choose a starting level...</u>"

> This is like "Begin with easy problems..." except that you set the starting level.

"<u>Practice problems of mixed difficulty</u>"

> This selects problems randomly from all difficulty levels for the type of graph you selected. The level is not shown on the graphing display, and the sequence of problems is not affected by whether you are correct on your first try. This section does not end.

- Mixed Graphs

This menu item provides practice with randomly selected types of graphs at randomly selected difficulty levels. First, you see a dialog screen where you mark checkboxes to specify the types of graphs you want to practice (you can mark one or several):

Lines

Parabolas

Circles

Ellipses

Hyperbolas (both kinds)

On the display grid, the program presents one of each type of graph you marked (in random order, at a randomly selected difficulty level). The program then generates a new random order for the types of graphs you selected and presents a randomly selected difficulty level of each graph type. The sequence of problems is not affected by whether you are correct on your first try. This section does not end.

Graphing Display Features and Buttons

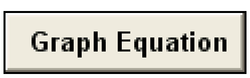
The coordinate grid is $-10 \le X \le 10$ and $-8 \le Y \le 8$. When the mouse is over a grid point, the grid coordinates of that point are displayed at the bottom of the screen.

The target graph is drawn in one color, incorrect answers are drawn in a second color, and a correct (or “close enough”) answer is drawn in a third color. (On a monochrome screen, the target graph is drawn dashed, and all other graphs are drawn solid.)

In *LINEAR & QUADRATIC GRAPHS*, the equations you enter must be in a form which uses X and Y at most once each.

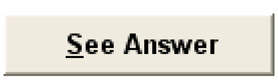
If your graph is exactly correct, the program says “Right.” If your equation is not exactly correct, but it is the correct type of graph and is within a few screen dots of the target graph, the program says “Close enough” and continues as if you were correct. If your graph is not close enough, it remains on the screen. You can compare it with the target graph, edit your equation, and try again.

See Worksheet 13 — Instructions and Tips for details on using this program.



After entering an equation, click this button to graph the equation. If there is no equation entered, or the entered equation has just been graphed, this button will be inactive. If the equation cannot be evaluated, a diagnostic message will be displayed when this button is clicked. Pressing the Enter key is equivalent to clicking this button.

Click this button to erase the incorrect graphs on your display.



If you click the <u>See Answer</u> button, one possible answer will be shown at the bottom of the screen. You still must enter a correct equation to move on to another problem. If you are on a display where the difficulty level is shown, that level will not increase if you answer a problem correctly after clicking the <u>See Answer</u> button.

There is an additional button labeled <u>Show Asymptotes</u> on displays where the target graph is a hyperbola. Clicking this button will draw the asymptotes in gray. On displays where the difficulty level is shown, you can click Show Asymptotes and still move up one level if you are correct on your first try.

Ideas for Classroom Use

Before Students Use the Program

Students should have seen the basic equations and corresponding graphs of the types they will use on the computer. For example, the program section on parabolas should accompany or follow a unit of study on parabolas, and students should be familiar with the equation $y = x^2$ and its graph.

Use the *EQUATION GRAPHER* program to play "what if" for the type of equations under study. For example, graph the equation $y = x^2$, then ask "what if there were a minus sign before the x^2 term?" Graph $y = - x^2$ and observe the results. Another example would ask "what if x were replaced by (x+2)?" Graph this equation and observe the changes.

Demonstrate *LINEAR & QUADRATIC GRAPHS* to the class, using example problems such as those on the sample classroom demonstration on page 53.

Distribute copies of Worksheet 13 - Instructions and Tips to the students.

Using the Program

Encourage students to begin with easy problems, to use guess and check problem solving, and to persevere. Point out that "mistakes" can be valuable learning experiences in this activity. Often the graph of an incorrect equation provides important clues to the correct equation. Discuss the information obtained by comparing its graph to the target graph. Remind students that their goal is to develop general strategies that can be applied to many types of graphs, rather than memorize formulas.

Ask students to use Worksheet 14—Recording Sheet to keep track of their progress.

Follow-up

Encourage students to generalize their results. How does the equation change if the graph —

is moved up or down on the grid?

is moved to the right or left?

is "upside down" or slanting down?

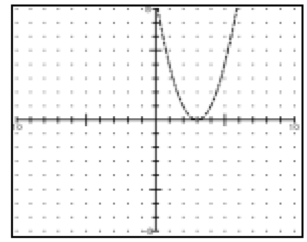
is steeper or flatter?

Play *GREEN GLOBS* Novice game.

Play *TRACKER* Novice game, using the type of graphs practiced in this program.

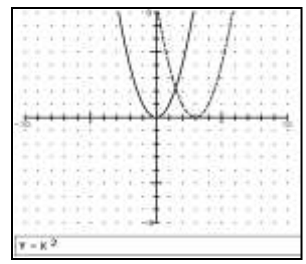
Sample Classroom Demonstration on Parabolas

On the screen displays for this example, the target graph is dashed, as it would be on a monochrome monitor. On a color monitor, the target graph will be solid but a different color from your graphs.

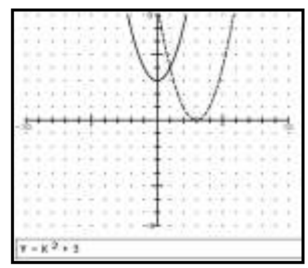


Note that your examples may differ slightly from these. Be open to suggestions and ideas from the students, even if they might take you off the track of the planned demonstration.

Here is a graph of some equation. We need to figure out what the equation is. (If you choose a starting level of 5, you will see a problem similar to this one.)

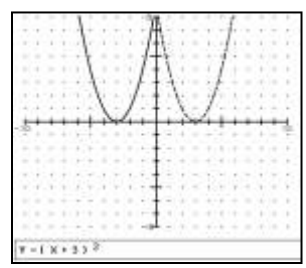


We know it is a parabola, so we can start with the basic equation for a parabola, $y=x^2$. Let's graph that equation for comparison.



Looking at the graphs we see that the target graph is shifted to the right 3 units from the origin. Let's experiment. What if we added 3 to the x^2 term in the equation? $y = x^2 + 3$

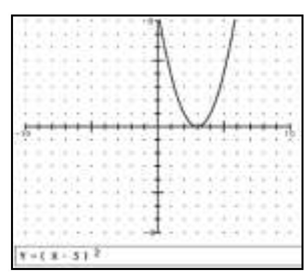
Let's graph $y = x^2 + 3$ and see.



Well, that's not what we want. It moved the parabola up, not to the right. What else could we try? Let's try using x+3 in place of x

$y = (x+3)^2$

and graph that.

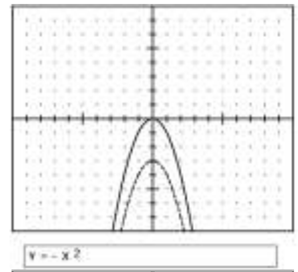


That's not it, either! This time the graph is shifted to the left by 3. The form of the equation is right but the direction is wrong, so let's change from +3 to -3.

$y = (x-3)^2$

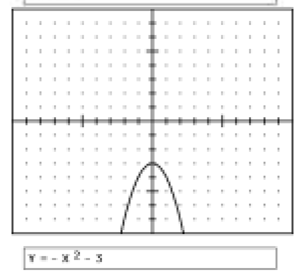
That works!

Here's another target graph (shown dashed). We know it's a parabola, but it's upside down (inverted). What can we change in the equation $y = x^2$ to invert the graph? Try changing from $+ x^2$ to $– x^2$.



$y = - x^2$

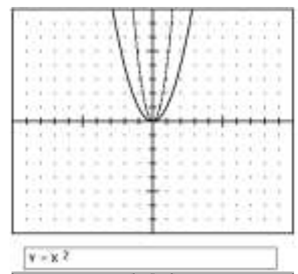
That works.



Now how can we move that inverted parabola down three units? We need to subtract 3 from the expression used to determine Y, so try

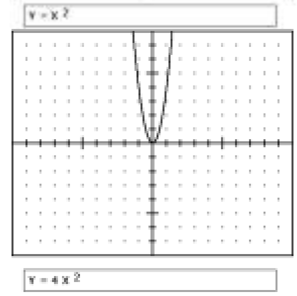
$y = - x^2 - 3$

Graph it. That's it!



Here's another target parabola (dashed), so we' ll start with $y = x^2$ again. Its vertex is at the origin, but it's higher at each x value than the basic parabola.

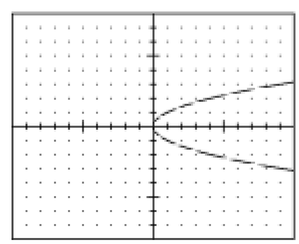
It appears to be 4 times higher at each x value (e.g., (1,4) is on the graph instead of (1,1)).



Let's try multiplying the function by 4.

$y = 4x^2$

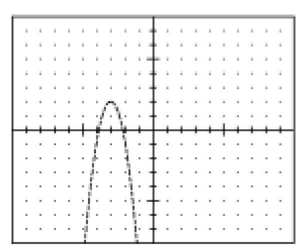
That's it.



Here is a parabola that is "going sideways." How could we change the basic equation to match this graph?

Switch the x and the y.

$x = y^2$



How could we combine several of these ideas to find the equation of almost any parabola?

LINEAR & QUADRATIC GRAPHS **Worksheets for Students - Overview**

Worksheet 13 summarizes the instructions students see in the program and suggests some problem-solving strategies to use.

Worksheet 13: Instructions and Tips (page 56)

Worksheet 14 provides a form where students can record the types of graphs and levels of difficulty they have completed.

Worksheet 14: Recording Sheet (page 57)

Worksheet 13: Instructions and Tips

A graph is displayed on a coordinate grid. Your job is to enter an equation that matches that graph. The equation you enter is plotted in a different color on the same grid. Compare your graph with the original graph, analyze the differences, and modify your equation as needed.

You may enter as many equations as you like until you match the original graph.

You can choose the type of graph:

- straight line
- parabola
- circle
- ellipse
- hyperbola
- a mixture of your choice

You also choose

1. to begin at the easiest problems
2. to begin at more challenging problems, or
3. to work problems of mixed difficulty levels.

Start with option 1. If you leave the program before finishing, record your current level on your recording sheet. The next time you use the program, choose option 2 and start at the level you recorded. You will advance to the next level of difficulty when you match the target graph on your first try without clicking the <u>See Answer</u> button. When the target graph is a hyperbola, you can click the <u>Show Asymptotes</u> button and still advance one level if you are correct on your first try.

Tips for Success

Use these problem-solving strategies:

Simplify the Problem -- Start with the basic equation of the type of graph (for example, $y=x^2$ for a parabola).

Divide and Conquer -- Break the problem down into smaller parts. If the graph shifted, inverted, stretched, or squeezed, change the basic equation for each of these one at a time.

Guess and Check -- Make your best guess for the equation, then carefully compare its graph and the target graph. Then improve your equation to make a better guess on your next try.

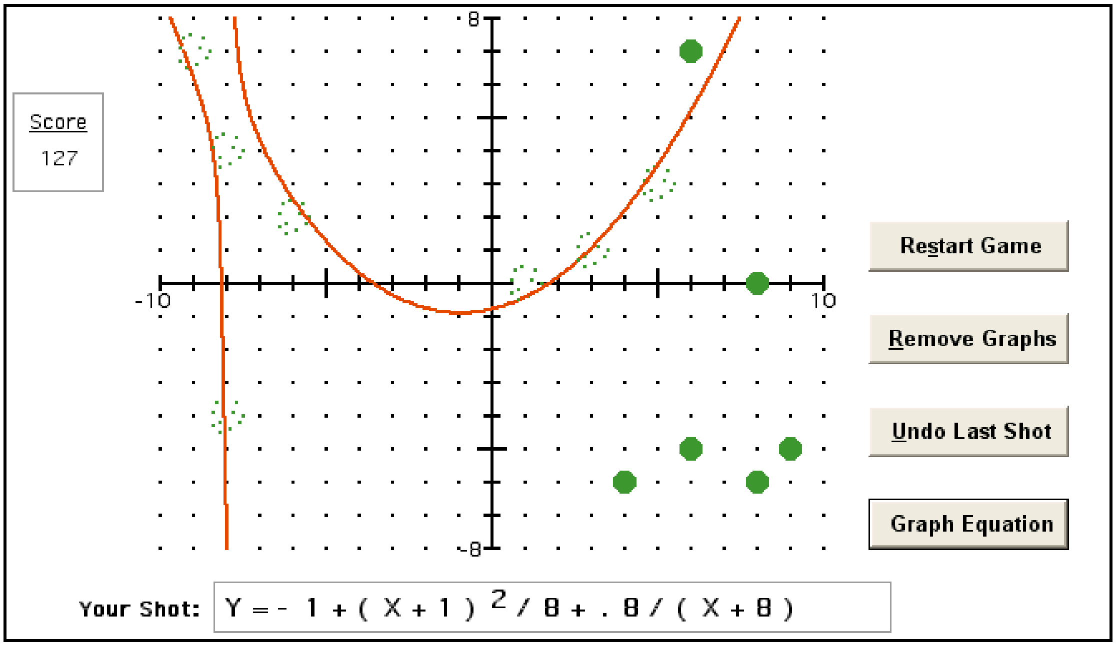
Do <u>not</u> try to memorize formulas for every graph!

LINEAR & QUADRATIC GRAPHS
Worksheet 14: Recording Sheet

Circle the numbers to show the levels you complete.

Type of Graph Used	Level Completed
straight line	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
parabola	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
circle	1 2 3 4 5 6 7 8 9 10
ellipse	1 2 3 4 5 6 7 8 9 10
hyperbola like $x^2 - y^2 = 1$	1 2 3 4 5 6 7 8 9 10
hyperbola like $xy = 1$	1 2 3 4 5 6 7 8 9 10
mixed graphs	number of problems completed __________

GREEN GLOBS



Overview

Grade Level: 8 - adult

Prerequisite Skills: introduction to graphing equations

Type: strategy game using graphing concepts

Description

Thirteen randomly scattered green globs are displayed on a coordinate grid. The students' goal is to explode all the globs by hitting them with the graphs of equations entered at the keyboard. The scoring algorithm encourages students to hit as many globs as possible with each equation. The top ten Novice Game scores and the top ten Expert Game scores are recorded along with the games that produced them. Students can review these games to learn strategies to apply to future games. You can have different groups of students in different records files — see the section "*Using More Than One Records File*" on page 89.

Objectives

1. to apply skills in relating equations to their graphs
2. to construct equations to fit specified criteria
3. to discover and explore relationships between equations and their graphs
4. to create strategies to maximize the number of hits per equation
5. to transform basic graphs by modifying their equations

6. to work cooperatively in a group
7. to explore types of equations not found in standard texts
8. to strengthen skills in problem solving: guess and check, simplify, and divide and conquer
9. to apply graphically a wide range of algebraic concepts and techniques

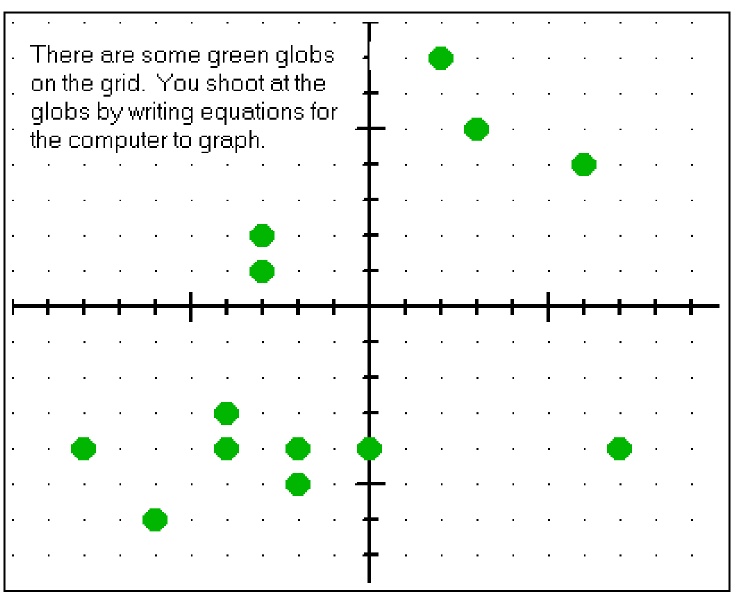
GREEN GLOBS Menu Items

- How to Write Equations

This is the practice screen described under “How to Write Equations” on page 9. It is the same for all programs.

- See Novice Game Rules

Below are the instructions shown to students. Buttons (not shown) at the bottom of each instruction screen allow students to navigate back and forth among the screens.



The object of this game is to hit as many green globs as possible with each shot. The game ends when all the green globs have been hit.

Score

Your score for each shot is:

1 point for the first glob hit on that shot
2 for the second
4 for the third
8 for the fourth
16 for the fifth
... and so on.

Types of Graphs

You can use **lines**, **parabolas**, **circles**, **ellipses**, and **hyperbolas**.
For example:

$y = 3$	$2x+y = 3$	$x = 1/3y^2$
$x = -6$	$x^2+y^2 = 64$	$3(x-1)^2 - 4(y-2)^2 = 50$

You can do **other kinds of graphs** if you write them as either:
y = an expression in x, for example: $y = 3x^3 - 2x^2$
or **x = an expression in y**, for example: $x = 3y^2 - 5/(y-4)^4$

Exponents

To write an exponent (as in x^2), type the **^** key, then type the exponent.
Exponents are limited to one digit positive whole numbers.

Special Functions

You can also use these functions: **abs**, **sqr**, **log**, **exp**.

abs means absolute value
sqr means square root
log means natural log, the inverse of the exponential function **exp**

Parentheses

Use parentheses around function arguments.
Write "abs(2X)", not "abs2X".

Trig Functions

Trig functions are not allowed in the Novice Game.

Saving a Game

To save your game, select 'Save...' from the File menu. Saved games can be continued later by selecting 'Open...' from the File menu.

Undo Changes to Your Equation

Undo on the Edit menu (or CTRL+Z) will undo one change to your equation each time you select it.

Undo Last Shot

To take back one or more shots, click the Undo Last Shot button. It will undo another shot each time you click it. (A shot that hits no globs is erased automatically on your next shot.)

If a shot doesn't do what you want, you do not need to click the Undo Last Shot button immediately. You can leave the graph on the screen while you make changes to your equation, then click Undo Last Shot, then click Graph Equation.

- Start a Novice Game

This goes directly to the Novice Game display, which is a coordinate grid with $-10 \le X \le 10$ and $-8 \le Y \le 8$. Thirteen green globs are scattered randomly on the grid, in a different arrangement for each game. You enter an equation, the graph of your equation is drawn, and any green globs which the graph hits will explode and disappear.

Strategies and graphing techniques will apply from one game to another, but specific equations will not, because the arrangement of green globs is different for each game. When you finish a game (by hitting all the green globs), the program compares your game score to those in the *GREEN GLOBS* Novice Game section of your Records file. If your score is higher than the lowest score currently in the Novice Game section, or the Novice Game section has fewer than ten scores saved in it, you will be offered the opportunity to add your game to the Records.

A game added to the Records will be erased when it is no longer in the top ten scores for that game. To save a game permanently, use the Save... option described below and/or see the section titled *Using More Than One Records File* on page 89. When your game is eligible for the Records, you will be asked if you want to add your game to the Records. If you accept, you will be asked to enter your name(s), and you can type any string up to 40 characters which fits within the bounds of the text entry box. (See *TEACHER OPTIONS* on page 81 for tools teachers can use to change these typed names.) The program then adds the name, score, date, and game to the Records.

In the File menu, Save... is available while playing a game. Saving a game saves all the information necessary to continue the game at another time. Save... uses the standard Save… dialog box, where you select the disk drive and folder and enter a file name.

To resume a saved game, select Open... from the File menu. Open... uses the standard dialog box. Any user can open and continue any saved game if the user can access the file where the game was saved.

A file containing a saved game can be moved, renamed or deleted in Windows like other files. The *TEACHER OPTIONS* provide management tools only for Records files, not for files containing saved games.

A game can be saved at any stage, including the “finished” stage. To determine eligibility for inclusion of a game in the Records, the score of a finished game (including an opened game which had been saved at the “finished” stage) is compared to the tenth score of the records section in the current Records file, not the Records file the user had when the game was saved.

If you want to include in the Records a game whose score does not qualify for the Records, the player can save it using Save..., then Open... the saved game file at a later time — after you have deleted some games from the Records file or created more Records files. (The *TEACHER OPTIONS* chapter on page 81 explains how to do both of those.)

• See Novice Game Records

This shows a display of the name, date and score for each of the ten highest scoring *GREEN GLOBS* Novice games. (The *TEACHER OPTIONS* chapter on page 81 provides tools for managing these records.) You can select a game with the mouse to watch a shot-by-shot replay of the game. After each shot is replayed, you can click a button to see the next shot, or a button to cancel watching the replay and return to the display of record scores and names.

For a user who has started *Green Globs & Graphing Equations* with more than one records file (see page 89 for how to set this up), the menu item

See Novice Game Records

is replaced by the following two menu items:

See Novice Game Records for your group

See Novice Game Records for another group

The first item shows records in the file where the user’s own record-qualifying games will be added; the second item offers a choice of other Records files to look at. The user can select one of the other Records files and watch replays of games in that Records file.

• See Expert Game Rules

These are the instructions shown to students:

Expert Game Rules

The rules for the Expert Game are the same as the rules for the Novice Game, with these additional features:

<u>Shot Absorbers</u>
There are five shot absorbers which stop any shots that hit them.

<u>Functions</u>
The Expert Game allows these functions:
abs, sqr, log, exp, sin, cos, tan, csc, sec, cot, atn(arctangent).

<u>Parentheses</u>
Use parentheses around function arguments. Write "sin(2X)", not "sin2X".

<u>Pi</u>
To make the symbol π (pi), type **p**.

- Start an Expert Game

The display for an Expert game looks and operates like the display for a Novice game, except that the grid also has five shot absorbers and trig functions are allowed.

- See Expert Game Records

The top ten *Green Globs* Expert Game record scores are kept independently of the *Green Globs* Novice Game records. (The *Teacher Options* provide tools for managing these records – see page 82.) For a user who starts *Green Globs & Graphing Equations* with more than one records file (see page 89 for how to set this up), the menu item

See Expert Game Records

is replaced by the following two menu items: (see the description under See Novice Game Records)

See Expert Game Records for your group

See Expert Game Records for another group

- Sound On
- Sound Off

The sound feature makes a sound when a glob is hit (a medium-pitch tone) or a shot absorber is hit (a lower-pitch tone). Teachers can specify whether users are allowed to switch sound on and off, and whether sound is initially set to on or off. See the *Teacher Options* section Change Sound Settings on page 85. The initial sound settings allow users to switch sound on and off, with sound initially on.

When users are allowed to switch sound on and off, the last two menu items on the *Green Globs* menu will be Sound On and Sound Off, with a check mark next to the current setting. To change the setting, select the setting you want from the menu. The change remains in effect until you change it or select Quit from the File menu.

When users are not allowed to switch sound on and off, Sound On and Sound Off are removed from the menu, and the sound status remains at the initial setting specified in *TEACHER OPTIONS*.

Graphing Display Features and Buttons

When the mouse is over a point on the grid, the coordinates of that point are shown at the bottom of the screen.

After entering an equation, click this button to graph the equation. If there is no equation entered, or the entered equation has just been graphed, this button will be inactive. If the equation cannot be evaluated, a diagnostic message will be displayed when this button is clicked. Pressing the Enter key is equivalent to clicking this button.

This button is inactive (i.e., gray lettering) unless you have one or more shots (graphs) on the grid. Pressing this button will undo your most recent shot — the graph will be erased, any globs hit by that graph will be restored to their original un-hit state, and the score will revert to what it was before the shot was made. Whatever you have typed in the equation entry box will not be affected. Each successive press of this button will undo one more shot.

Instead of calculating all the coefficients in an equation before making a shot, you can make a guess at the general form of the graph you want, click Graph Equation, use the result to decide how to modify your equation, then click Undo Last Shot. You can then click Graph Equation to see the revised version of that shot and repeat the Undo - Revise - Graph cycle as many times as you want. Undo Last Shot does not need to be chosen immediately — you can leave the graph on the screen until you have finished revising the equation, then click Undo Last Shot. If you forget to click Undo Last Shot before clicking Graph Equation for the revised shot, just click Undo Last Shot twice, then click Graph Equation.

If the graphs of earlier shots start to clutter the display, you can click this button to erase all the graphs on the grid. This does not affect the game in any way, and in fact the program does not record that the graphs were erased; the graphs will be redrawn if the screen is refreshed (for example, if you switch to another window and back) or when Undo Last Shot is clicked once or twice (depending on the situation). If some graphs are redrawn in those cases and you don't want them, just click Remove Old Graphs again.

Click this button to start the game at the beginning, with the same arrangement of green globs on the grid and no shots made. When you click this button, a dialog box will ask "Do you want to restart this game?" If you click Cancel, the game continues unaffected. If you click OK, the game irrevocably restarts, erasing all your previous equations, but leaving whatever is in the equation entry box.

Ideas for Classroom Use

Before Using the Program

If a new class is starting to use the program at a lower experience level than the previous class which used the program, teachers may want to delete the top ten record scores or create a new Records file for the new class. The *TEACHER OPTIONS* section on page 81 explains how to do these things.

Students should have had practice in writing equations for graphs. The program *LINEAR & QUADRATIC GRAPHS* and the utility *EQUATION GRAPHER* may be used as preparatory or concurrent activities. The *TRACKER* game also provides useful experience in manipulating equations and graphs.

Teachers should understand that *GREEN GLOBS* is a challenging game that may require a considerable amount of time and mathematical experimentation. They should allow students to play the game over a period of days or weeks. *GREEN GLOBS* can be fascinating and highly rewarding. Students of all mathematical ability levels can gain satisfaction and new insights. Students will strengthen their problem-solving skills as well as learn significant mathematical concepts. Students are encouraged to share their ideas with each other. Reviewing the top ten games stored in the records is one way to share discoveries. Working in groups of two or three students can also increase the exchange of ideas.

Using the Program

Groups of two or three students often work well. However, some students, especially the more advanced students, may prefer to work independently. Students should be encouraged to develop their own strategies. Teachers should not routinely give students strategies to try. Students should be encouraged to share their ideas and to build on and apply others' ideas to their own situations.

Worksheets 7 and 8 (pages 33 - 37) in the *EQUATION GRAPHER* section of this guide provide ideas that may be useful in *GREEN GLOBS*.

Worksheets 9 through 12 (pages 38 - 47) in the *EQUATION GRAPHER* section of this guide present several advanced techniques and are intended for students who have considerable experience with *GREEN GLOBS*.

The following are examples of strategies students have developed using *GREEN GLOBS*:

General Math (9th Grade)

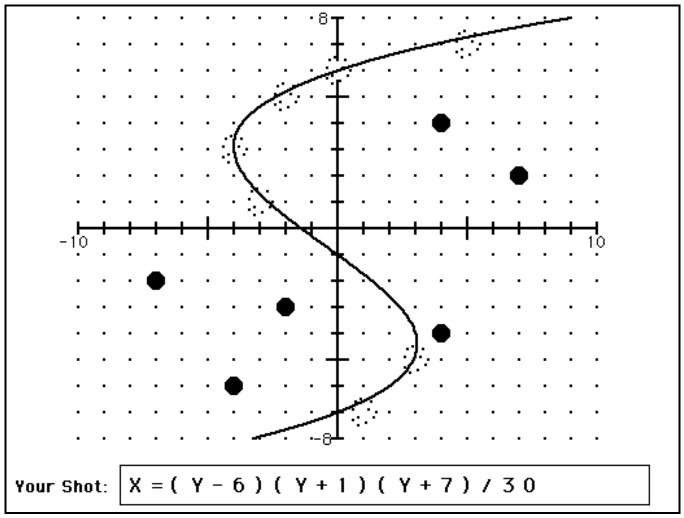
Students used horizontal and vertical lines. The first strategy was to use lines that would hit two globs when possible and to be careful not to hit either of these globs singly with an earlier shot. After viewing top score games done by algebra students, they began experimenting with curved graphs using equations like those they saw in the top score games.

Algebra — Using Roots of Equations

Students who can factor binomials and relate the factors to roots of the equations can discover that the graphs of $y = (x+5)(x-2)$ or $y = x^2+3x - 10$ will cross the x axis at -5 and

2. They may be able to extend this idea to higher order polynomial equations, such as y = (x+5) (x-2) (x-7).

EQUATION GRAPHER Worksheet 7 provides discovery activities and practice with this strategy. The following example builds a polynomial from roots, then uses coordinates of a target glob to determine appropriate coefficients for the equation. *EQUATION GRAPHER* Worksheet 8 (page 35) guides students through this process.



Write the equation of a graph that will cross the y axis at 6, -1, -7.

x = (y-6) (y+1) (y+7)

Use the glob at (-4, 3) to figure a scaling factor. Let y = 3.

x = (3-6) (3+1) (3+7) = (-3) (4) (10) = -120

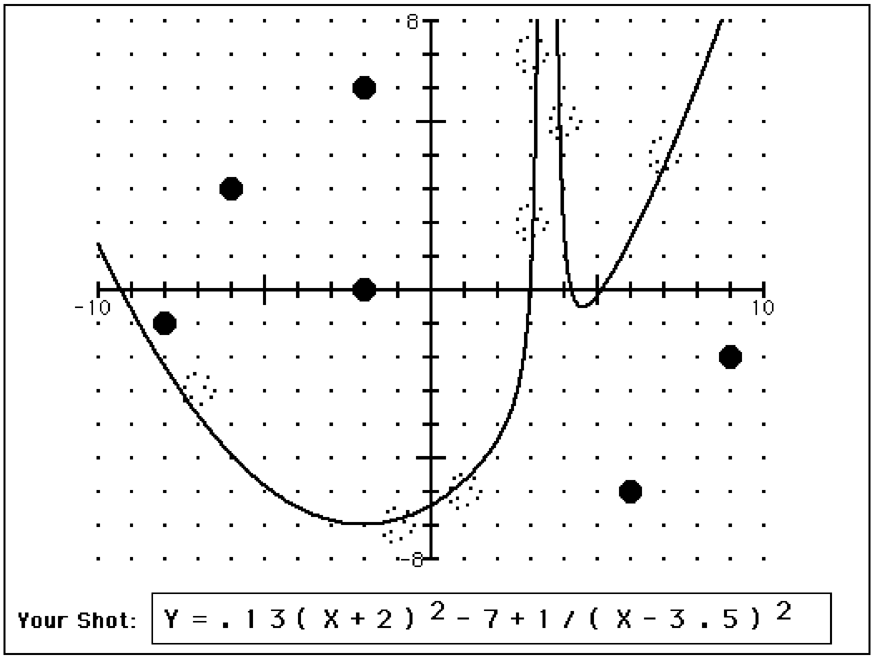
When y is 3, we want x to be -4, not -120, so multiply the expression by (-4/-120), which equals 1/30.

x = ((y-6) (y+1) (y+7))/30

This strategy may lead to the creating of "super-stretched" polynomials. These are equations built in factored form with many roots and a numerical factor included to stretch the graph. If the numerical factor is large enough, the parts of the graph crossing the screen are a set of nearly vertical (or horizontal) lines. "Super-stretched" polynomials must be carefully constructed, since the screen space available for writing factors is limited.

<u>Math Analysis — Adding Terms of the Form 1/(x - a)</u>

Adding a term of the form 1/(x - a) to a function creates a discontinuity at x = a. While students at the pre-calculus level may not have studied discontinuities, they can see through experimentation that the graph of the equation rises (or falls) sharply to the left and right of the point (a,0). Thus the graph may hit globs that are almost above (or below) that point.



Note that for most values of x, the term 1/(x - a) is very small, so it has a negligible effect on the graph, except where x is close to a.

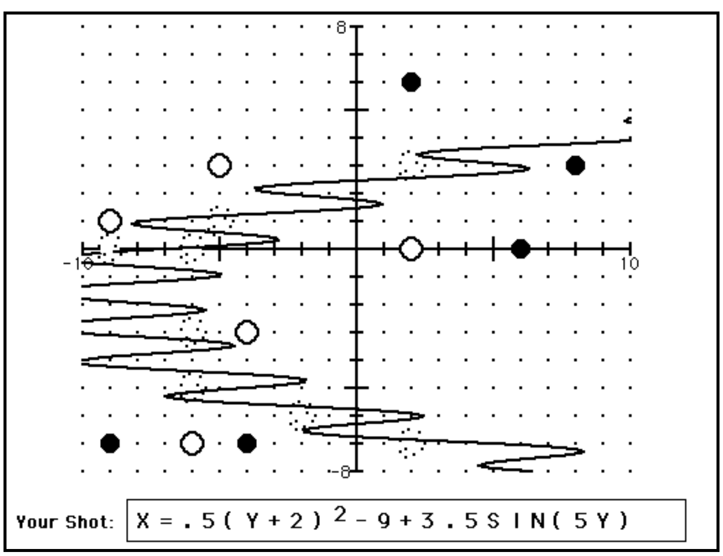
Interesting graphs can result from adding several of these fractional forms together to produce discontinuities at several points.

*E*QUATION *G*RAPHER Worksheet 9 (page 38) provides activities using this strategy.

Math Analysis - Sums of Functions

Although most textbooks do not emphasize sums of functions, except simple cases such as y = x + SIN (x), the computer's calculating power makes these types of equations easy to explore. The Expert Game allows the use of trigonometric functions.

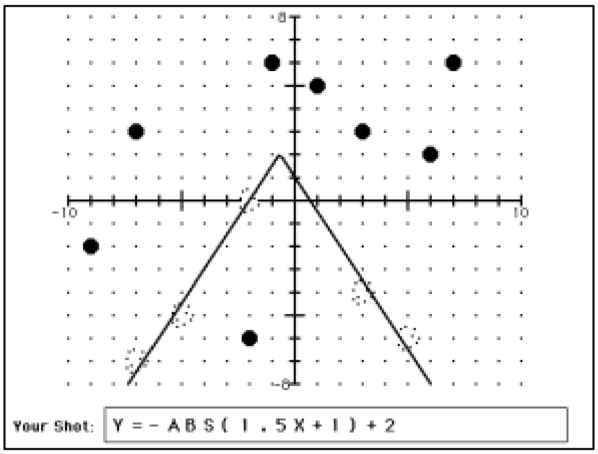
Here is an example of the sum of a parabola and a sine function. The effect of adding the sine function is to make the graph cover a wider path, thereby hitting more globs, while still avoiding the "shot absorbers."

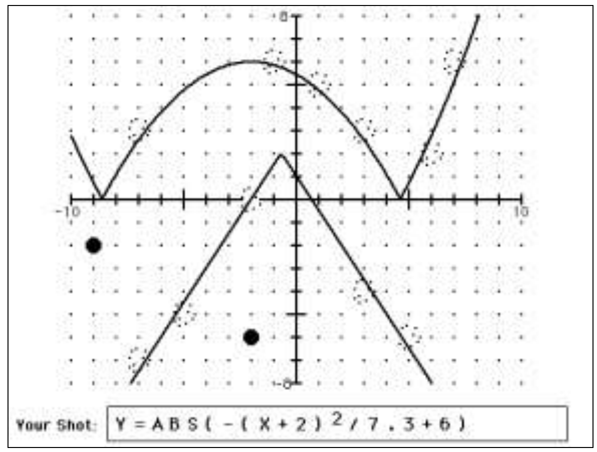


EQUATION GRAPHER Worksheet 11 (page 42) provides discovery activities and practice in using this strategy.

Math Analysis - Absolute Value Functions

Combining the absolute value function with other functions can provide a useful strategy. For example:





EQUATION GRAPHER Worksheet 12 (page 44) provides discovery activities and practice in using this strategy.

***GREEN GLOBS* Worksheets for Students - Overview**

Worksheet 15 summarizes the instructions students see in the program.

Worksheet 15: Instructions and Tips (page 69)

Worksheet 16 provides a form where students can record a game.

Worksheet 16: Recording Sheet (page 70)

GREEN GLOBS

Worksheet 15: Instructions and Tips

GREEN GLOBS is a strategy game using graphs of equations. Thirteen randomly scattered green globs are displayed on a coordinate grid.

Your goal is to explode all of the globs. The glob explode when they are hit by the graph of an equation that passes through them. You enter equations at the keyboard.

Levels of Difficulty

The Novice Game is the best place to start. You cannot use trigonometric functions in the Novice game.

The Expert Game is more difficult. You can use trigonometric functions; but there are five "shot absorbers" displayed on the grid. The shot absorbers stop any graphs that hit them.

Scoring

For each equation you enter, the first glob hit is worth one point, the second glob is worth two points, the third is worth four points, the fourth is worth eight points, and so on.

For example, if you hit four globs with one equation, you score is 1 + 2 + 4 + 8 = 15 points.

Equations

Try to hit as many globs as possible with each graph.

You may use equations of the following types:

- straight lines
- functions beginning with y = or x =
- equations for conics (such as circles and hyperbolas)
- functions using square roots or absolute value
- equations using logarithmic or exponential functions

Trigonometric functions can be used only in the Expert Game.

Top Scores and Games

In both the Novice and Expert Games, the top ten scores and the games that produced them can be shown in the records. After you try a few games of *GREEN GLOBS*, you may want to look at the records.

Worksheet 16: Recording Sheet

On the grid below, sketch the green globs.

Record your successful equations.

____

____

____

____

____

Sketch the graphs of successful equations.

Briefly describe the strategies you used.

____

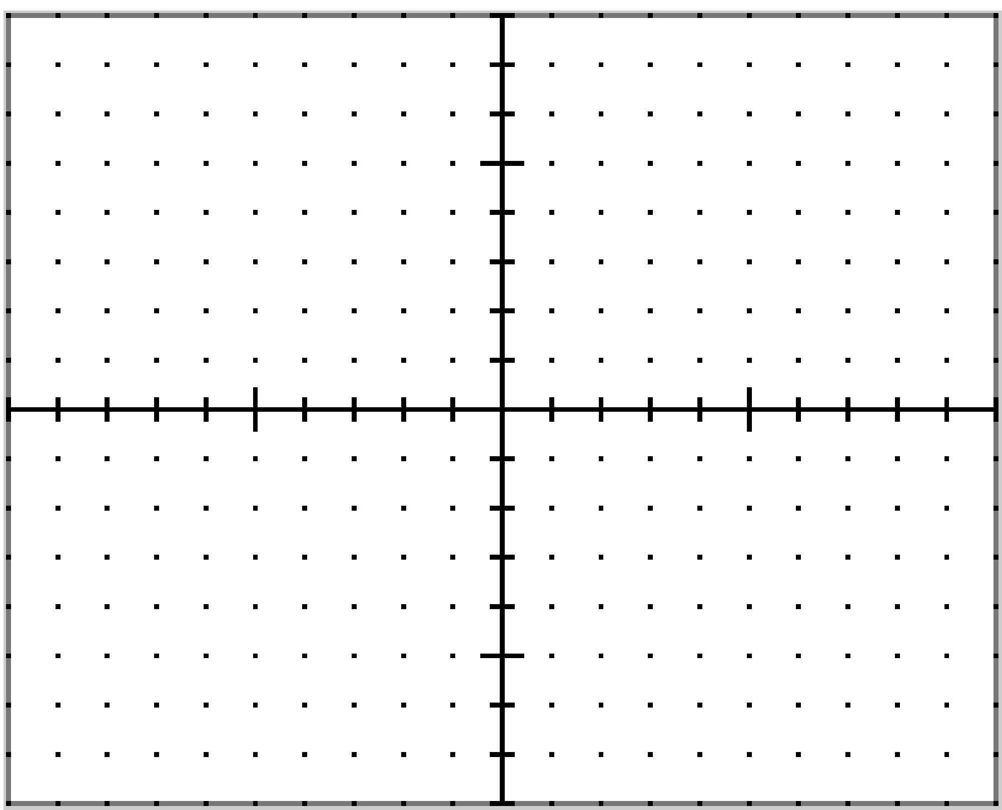
____

____

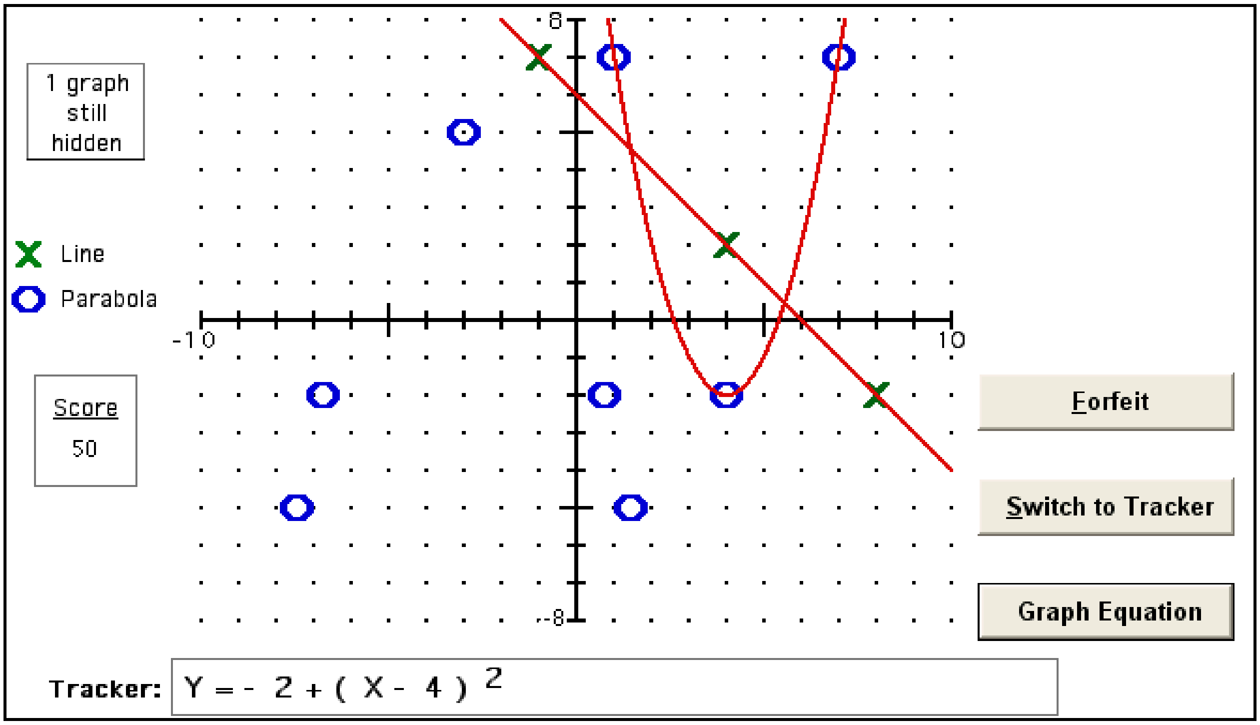
____

____

Your score_______



TRACKER



Overview

Grade Level: 8 - adult

Prerequisite Skills: ability to write equations to match linear and quadratic graphs

Type: game using strategy and graphing concepts

Description

In the *TRACKER* game, graphs are hidden on a coordinate grid. Students gather clues about the location of the graphs by using "probe shots." These probe shots are horizontal and vertical lines. Each point where the probe crosses the hidden graphs is marked on the screen. After using probes to locate a graph, students send a "tracker" along the graph by entering its equation.

TRACKER includes a Practice section, a Novice Game and an Expert Game. The top ten Novice Game scores and the top ten Expert Game scores are recorded along with the games that produced them. You can have different groups of students in different records files — see the chapter *Using More Than One Records File* on page 89.

Objectives

1. to relate graphs to their equations
2. to apply transformation concepts to graphs of equations
3. to develop efficient strategies for locating useful points on hidden graphs
4. to generalize strategies for use with many types of graphs

5. to analyze characteristics of various types of graphs
6. to apply geometric properties, such as symmetry

TRACKER Menu Items

- How to Write Equations

This is the practice screen described under “How to Write Equations” on page 9. It is the same for all programs.

- See Instructions

These are the instructions shown to students, on several screens. Buttons at the bottom of each instruction screen allow students to navigate to the next and previous screens. (The buttons the students see are not shown here).

Rules for Tracker

The object of this game is to find the equations for several hidden graphs.

The hidden graphs may be lines, parabolas, circles, ellipses, or hyperbolas, but there will be only two types of graphs for a game.

You have two kinds of "shots" in this game: Probes and Trackers.

You shoot Probes across the screen to get clues about the hidden graphs.

When you think you've figured out one of the hidden graphs, you shoot a Tracker along its path to see if you are correct.

Probes and Trackers

A Probe is a horizontal or vertical line like Y = -3 or X = 4. As a Probe goes across the screen, it marks each point where it crosses a hidden graph.

Graphs of one type will be marked with an X , and graphs of the other type will be marked with an O . Some of the X 's and O 's may overlap.

Depending on where you shoot a Probe, you may hit several hidden graphs or none at all. A hidden graph will never be a horizontal or vertical line.

You can switch between shooting Probes (when you need clues) and Trackers (when you think you've found a graph). If you get stuck, you can forfeit and see the remaining hidden graphs.

Scoring

Probes
Your first Probe costs 1 point, your second Probe costs 2 points, your third Probe costs 3 points, ...and so on.

Correct Trackers
The points scored for a correct Tracker depend on what kind of graph it is:

30 points for a line
35 points for a parabola
40 points for a circle
45 points for an ellipse
50 points for a hyperbola

Wrong Trackers
Each wrong Tracker costs 10 points.

- Practice

In the Practice section, you choose the type of graph that is hidden and whether one or two graphs are hidden. This lets you concentrate on strategies for locating just one or two hidden graphs of the same type. No score is kept in this section.

- Start a Novice Game

In the Novice Game, you choose two types of graphs to be hidden on the grid. There are always three hidden graphs: two of one type and one of the other. One type of graph is marked with X's and the other with O's when crossed by a probe shot. If a hidden graph is a hyperbola, it could be of either kind and not necessarily the same kind as another hidden hyperbola.

The pool of possible hidden graphs in *TRACKER* is the same as the pool of possible target graphs in *LINEAR & QUADRATIC GRAPHS*, except that hidden graphs are never horizontal or vertical lines.

The game ends when you have found all the hidden graphs. When you finish a game with a positive score, the program compares your game score to those in the *TRACKER* Novice Game section of your Records file. If your score is higher than the lowest score currently in the Novice Game section, or the Novice Game section has fewer than ten scores saved in it, you will be offered the opportunity to add your game to the Records.

A game added to the Records will be erased when it is no longer in the top ten scores for that game. To save a game permanently, see the chapter *Using More Than One Records File* on page 89. Save... from the File menu is not available for *TRACKER* games. (If it were, the Records could be compromised easily — someone could save a game before making any shots, forfeit to see the hidden graphs and their equations, open the saved game, and begin the game already knowing the answers.)

When your game is eligible for the Records, you will be asked if you want to add your game to the Records. If you accept, you will be asked to enter your name(s), and you can type any string up to 40 characters which fits within the bounds of the text entry box. (See *TEACHER OPTIONS* on page 82 for tools teachers can use to change these typed names.) The program then adds the name, score, date, and game to the Records.

• See Novice Game Records

This shows a display of the name, date and score for each of the ten highest scoring *TRACKER* Novice Games. (See Teacher Options on page 82 for tools to manage these records.) You can select a game to watch a shot-by-shot replay of the game. After each shot is replayed, you can click a button to see the next shot, or a button to cancel watching the replay and return to the display of record scores and names.

For a user who starts *Green Globs & Graphing Equations* with more than one records file (see page 89 for how to set this up), the menu item

See Novice Game Records

is replaced by the following two menu items:

See Novice Game Records for your group

See Novice Game Records for another group

The first item shows records in the file where the user's own record-qualifying games will be added; the second item offers a choice of other Records files to look at. The user can select one of the other Records files and watch replays of games in that Records file.

• Start an Expert Game

In the Expert Game, the program randomly chooses the two types of graphs, and you do not know what types of graphs are hidden. You must use probes to determine the types of graphs as well as their locations. You choose how many graphs will be hidden — from three to six. Although higher scores are possible when there are more hidden graphs, it can be challenging to sort out five or six graphs on the screen. The display for an Expert game looks and operates like the display for a Novice game, except you do not know what types of graphs are hidden.

- See Expert Game Records

The top ten *Tracker* Expert Game record scores are kept independently of the *Tracker* Novice Game records. (See *Teacher Options* on page 82 for tools to manage these records.) For a user who has started *Green Globs & Graphing Equations* with more than one records file (see page 89 for how to set this up), the menu item

See Expert Game Records

is replaced by the following two menu items: (see the description under See Novice Game Records)

See Expert Game Records for your group

See Expert Game Records for another group

Graphing Display Features and Buttons

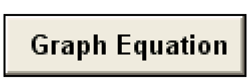
The game display is a coordinate grid with $-10 \leq X \leq 10$ and $-8 \leq Y \leq 8$.

When the mouse is over a point on the grid, the coordinates of that point are shown at the bottom of the screen. At the upper left, the display shows the number of graphs hidden (or the number still hidden, if you have found some but not all). The number is updated each time you find a hidden graph. Below that, in Practice and the Novice Game, the display reminds you which type of graph is marked with an "X" and which type is marked with an "O". In the Novice Game and Expert Game, the score is displayed at the lower left.

At the start of the game, you are prompted to enter an equation for a Probe. You can switch the prompt from Probe to Tracker at any time by clicking the Switch to Tracker button. When the prompt changes to Tracker, the button label changes to say Switch to Probe. You can switch between Probe and Tracker as often as you want.

If you accidentally enter an equation for a Tracker when the prompt says Probe, you will be told "Probes are horizontal or vertical. If you meant 'Tracker,' click the Switch button." Your score is not changed by this.

If you accidentally enter an equation for a Probe when the prompt says Tracker, you will be told "Horizontal and vertical lines are Probes. For a Probe, click the Switch button." Your score is not changed by this.



When you are prompted to enter an equation for a Probe, you enter an equation like Y = 3 or X = - 5 and press the Enter key (or click the Graph Equation button). All intersections between your Probe and any remaining hidden graphs will be marked with an "X" or an "O". If your Probe does not intersect any of the remaining hidden graphs, you will be told "No intersections found on the screen." If your Probe is off the screen (like Y = 20), you will be told "This Probe is off the screen." The cost of the Probe will be deducted from your score, even if it is off the screen or intersects no hidden graphs.

When you are prompted to enter a Tracker, you enter an equation for a hidden graph and press Return (or click the Graph Equation button). The graph of your equation is drawn and your score is updated. If your Tracker was correct, it will remain on the screen. If your Tracker was not correct, it will remain on the screen until your next Tracker, to help you decide where you need to send Probes. If your Tracker is not correct, but it is the correct type of graph and is within a few screen dots of the correct graph, you will be told that it is "close enough" and it will be scored the same as a correct Tracker.

Click the Forfeit button if you want to give up. If you click Forfeit, a dialog box will ask "Do you want to forfeit this game?" Click Cancel to continue the game, or OK to forfeit. If you click OK, the remaining hidden graphs will be drawn and their equations shown at the lower left of the grid. A forfeited game is not eligible for the Records, regardless of its score.

Ideas For Classroom Use

Before Using the Program

If a new class is starting to use the program at a lower experience level than the previous class which used the program, teachers may want to delete the top ten record scores or create a new Records file for the new class. The *TEACHER OPTIONS* chapter on page 81 explains how to do these things. The *EQUATION GRAPHER* program can provide introductory activities in graphs of equations. Worksheets 1 through 6 (pages 17 - 32) in the *EQUATION GRAPHER* section of this manual are preparation for playing *TRACKER*. The *LINEAR & QUADRATIC GRAPHS* program is recommended preparation for playing *TRACKER*. The graphs used in *TRACKER* are chosen from the same pool as those in *LINEAR & QUADRATIC GRAPHS* . The evaluation of equations is the same, i.e., an equation which is "close enough" in one program is also "close enough" in the other.

Distribute copies of *TRACKER* Worksheet 17—Instructions and Tips. This sheet explains how to play *TRACKER* and describes the scoring system. Demonstrate one Practice section and one Novice Game of *TRACKER* with the class, so that students understand the process of using probes and trackers. Use their ideas in the demonstration. Emphasize the guess and check strategy and point out the advantage of carefully analyzing the information gained from probes and any incorrect trackers.

Use the *TRACKER* Worksheet 18—Sample Problem in addition to the demonstration or as a substitute if necessary. It provides an introduction to some types of problem-solving thinking that students use in playing the game.

Using the Program

Distribute copies of the *TRACKER* Worksheet 19 Recording Sheet for students to use to record their activities. Encourage students to plan strategies and to share and reuse successful strategies. After students have played the game several times, discuss their strategies in either large or small groups. If students seem to become discouraged, subtly aid them by asking relevant questions to help them find a new approach. Here are some examples of the kinds of strategies students may develop. Avoid telling students these or other strategies. The problem-solving process of developing strategies is a most important part of the activity.

> If the sides of a parabola have been located, how can the vertex be found? Try using a probe halfway between the sides, along the axis of symmetry.
>
> What are the key points of a circle? If a probe has crossed a circle, what additional probes are necessary to determine the center? Does it matter whether some of the circle is off the screen?
>
> Is the slope of a line more accurately computed from points that are close together or far apart?
>
> Are four points sufficient to determine two straight lines?

Remind students to apply the transformation skills used in *LINEAR & QUADRATIC GRAPHS* -- to start with the basic equation and modify it as needed.

If students need to end a game before they find all the hidden graphs, they can forfeit by clicking the Forfeit button.

TRACKER **Worksheets for Students – Overview**

Worksheet 17 summarizes the instructions students see in the program.

Worksheet 17: Instructions and Tips (page 78)

Worksheet 18 provides an introduction to some types of problem-solving thinking students use in playing the game.

Worksheet 18: Sample Problem (page 79)

Worksheet 19 provides a form where students can record a game.

Worksheet 19: Recording Sheet (page 80)

Worksheet 17: Instructions and Tips

TRACKER is an equation-graphing game. Graphs are hidden on a coordinate grid. You enter their equations to “track” them.

You get clues to the graphs’ locations by using probe shots. Probe shots are equations of horizontal or vertical lines. When a probe shot crosses a hidden graph, it marks that point with an X or an O.

The types of graphs you choose include the following:

- straight line
- parabola
- circle
- ellipse
- hyperbola (two kinds)

There are three levels of difficulty:

Practice	is a good place to start. You choose the type of hidden graph. Either one or two graphs are hidden on the grid. No score is kept.
Novice Game	allows you to choose two types of graphs. Three graphs are hidden on the grid (two of one type and one of the other). One type of graph is marked by X’s and the other by O’s when hit by a probe. When you have enough clues, you send a tracker along the graph by entering its equation.
Expert Game	chooses the two types of graphs at random, so you’ll need to discover what type they are as well as where they are! You choose how many graphs are hidden, from three to six.

Scoring

You score points for correctly tracking each graph:

Graph Type	Points Scored
straight line	30 points
parabola	35 points
circle	40 points
ellipse	45 points
hyperbola	50 points

You lose points for each probe and for incorrect trackers:

Action	Points Lost
first probe	1 point
second probe	2 points
third probe	3 points
..and so forth	
incorrect tracker	10 points

The top ten scores are stored in the records. Scores are kept separately for Novice and Expert Games. Games that are forfeited and scores of zero or less are not eligible for the records.

TRACKER

Worksheet 18: Sample Problem

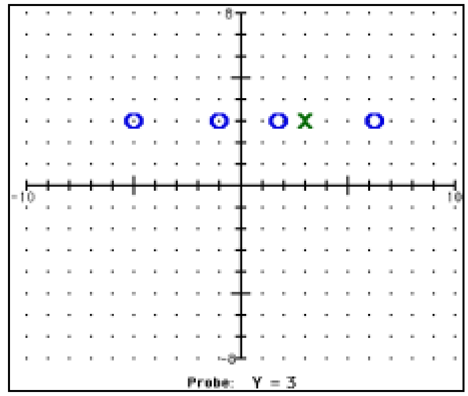
Here is an example of one type of problem you might encounter in *TRACKER*. The questions are the kind you will want to ask yourself when you work similar problems.

You have chosen parabolas and straight lines. There are three graphs in all.

The first probe is

y = 3.

It hits graphs at several points.



One type of graph is marked with X, the other type with O.

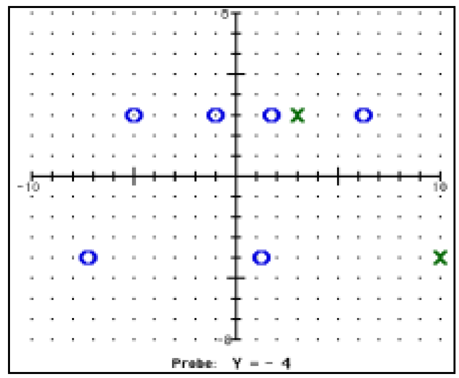
Which type is marked with O in this game? (Since the hidden line(s) cannot be horizontal in this game, it must be parabolas that are marked with O.)

Do the parabolas open up or down?

Which two points do they pass through?

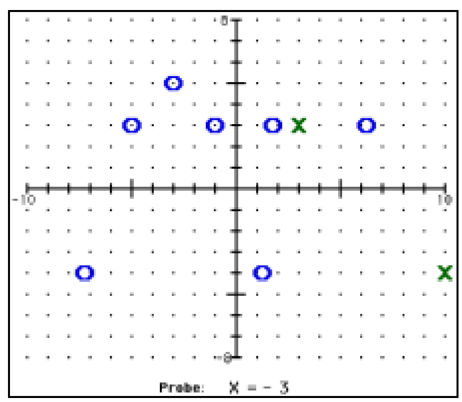
Try another probe. Where should it be? It could be another horizontal line, either above or below y = 3.

Try y = - 4.



It looks like one parabola opens down. Try to locate the vertex. Use a vertical probe through the parabola, halfway between the sides.

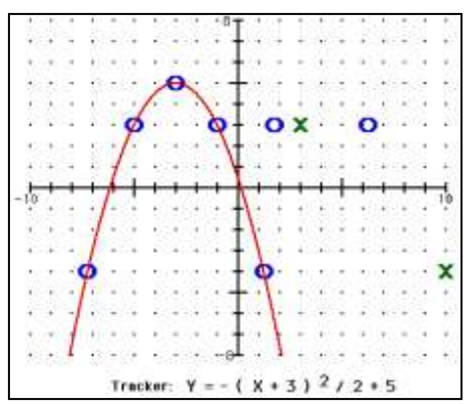
Try x = -3.



The vertex must be at (-3,5).

The X marked at (10,- 4) marks a second point on the hidden line graph.

Now write an equation for the parabola you found. Send a tracker by entering that equation.



You need to write an equation for the line, also.

Finally, you will locate and track the other parabola, using methods similar to those above.

TRACKER

Worksheet 19: Recording Sheet

Practice Section

Mark the types of graphs you practiced finding.

	One Graph	Two Graphs
straight line	__________	__________
parabola	__________	__________
circle	__________	__________
ellipse	__________	__________
hyperbola	__________	__________

Novice Game

1. Choice of graph types __________________________ ______________________________

Score ___________ Number of probes used _________

Strategies used ____

____

2. Choice of graph types __________________________ ______________________________

Score ___________ Number of probes used _________

Strategies used ____

____

Expert Game

1. Number of graphs ___________

List of graphs discovered ____

____

Score ____________ Number of probes ______________ Number of Trackers_____________

Strategies used ____

____

2. Number of graphs ___________

List of graphs discovered ____

____

Score ____________ Number of probes ______________ Number of Trackers_____________

Strategies used ____

____

TEACHER OPTIONS

Overview

Two of the programs, *GREEN GLOBS* and *TRACKER*, record the highest scoring games and the names of the students who played them. The *TEACHER OPTIONS* allow teachers to manage these records. The *TEACHER OPTIONS* section is protected by a password to prevent unauthorized deletion or changing of the data. You need to keep the password confidential. For instructions and discussion about passwords, see the description below for menu item Change the Passwords of this Records File on page 84.

NOTE: For security reasons, the *TEACHER OPTIONS* window closes automatically when you move to another window or switch to another application.

These are things you can do in *TEACHER OPTIONS*:

- See replays of selected games
- Change name or date on selected games
- Delete selected games
- Copy selected games from one Records file to another Records file
- Set passwords to control access to the Records file
- Set the title for the Records file
- Set sound on or off
- Create new Records files
- Make lists of Records files and save them as List files
- Convert Records files and List files from the old format to the new format

Records Files

The names of the Records file(s) with which you started the *Green Globs & Graphing Equations* application are the ones in effect each time you start *TEACHER OPTIONS* and when you leave *TEACHER OPTIONS* to go to another program — regardless of anything you do with other Records files while in *TEACHER OPTIONS*. For example, if you choose to look at another Records file in *TEACHER OPTIONS*, and then you leave *TEACHER OPTIONS* to play a *GREEN GLOBS* Novice Game, the Records file in effect for you in *GREEN GLOBS* will be the Records file you started *Green Globs & Graphing Equations* with, not the Records file you last dealt with in *TEACHER OPTIONS*.

A Records file contains four sections:

- *GREEN GLOBS* Novice Game
- *GREEN GLOBS* Expert Game
- *TRACKER* Novice Game
- *TRACKER* Expert Game

Each section holds the ten highest scores recorded for that game. Each score is accompanied by the player's name(s), date, and the shots used by the player(s) to obtain that score.

A Records file also contains a title you specify and the passwords you set to restrict access to *TEACHER OPTIONS* for that Records file.

After the menu item descriptions, there is a chapter *Using More Than One Records File* on page 89 that includes an example showing how to create a List of Records files.

TEACHER OPTIONS Menu Items

Editing Record Games

- See or Change *GREEN GLOBS* Novice Game Records
- See or Change *GREEN GLOBS* Expert Game Records
- See or Change *TRACKER* Novice Game Records
- See or Change *TRACKER* Expert Game Records

The four menu items listed above go to a display where you can rename, delete, copy or see replays of record games. The display shows the score, name and date for each of up to ten games. Start by selecting one or more record games, then click one of the following five buttons.

This lets you watch a shot-by-shot replay of each of the selected games. After the completion of each replayed game, there will be a button labeled Next Game. There will always be a button labeled Cancel Replay which returns immediately to the list of record games. The replay you see is the same as the replay option available to students in the respective games; it is included here for convenience.

This lets you edit the name and date associated with each record game. Text edit boxes show the space limits. Any characters are allowed. If you do not want a date displayed, just erase it and leave its text edit box blank. If you selected more than one record game before clicking this button, the selected records' names and dates will be presented one at a time for editing.

This deletes all the selected record games — their names, scores, dates and shots. A caution warning dialog box will ask for confirmation; click Cancel to return to the Records display with no changes. If you click Delete in the warning dialog box, the deletion is done. Deletions are permanent; there is no undo option for them. To reinitialize a Records section (to start over with no record games in that section), select all record games and click the Delete button.

If you select one or more records and click Copy to Another File, all the information about those records is copied from the current Records file into an area of the program's computer memory (the records in the Records file are still there, unchanged). You can then move to another Records file (if you know its password) and click Paste from Another File to add them to that Records file. If the number of records you paste would overfill that records section (the limit is ten games), then only the highest ten scores will be saved and a message will tell you if some of your games were not added. Clicking Paste from Another File does not remove the information from the program's computer memory, so you can move to yet another Records file (or create new Records files) and paste the information there, also.

Change the Title of this Records File

For each Records file, you can specify a title to be displayed when the record games in a Records file are displayed. The title can be up to 61 characters and you can change it at any time. You do not need to give a Records file a title, but if you have more than one Records file, users will find titles helpful.

In *TEACHER OPTIONS*, the password entry screen display and the Records screen display include both the file name and the title (if any) of the Records file you are currently dealing with. The screen displays where students see Records show the title (if any) you have assigned. They show the file name only if the students are dealing with more than one Records file and the files have not been assigned titles.

Change the Passwords of this Records File

Each Records File has both a password and a master password kept in it. Each time you enter *TEACHER OPTIONS* for that Records file, you will be asked to type the password. (In this program, you can ignore capitalization when typing your password: frog = FROG.) If your typed password matches the password, you will be allowed access to *TEACHER OPTIONS* for that Records file, and you will be allowed to change the password.

If your typed password matches the master password, you will be allowed access to *TEACHER OPTIONS* for that Records file, and you will be allowed to change both the password and the master password. If you enter *TEACHER OPTIONS* by typing the password, and you try to change a master password which already has been set, then you will first be asked to type the current master password.

The master password is convenient for a support person (e.g., a technology coordinator supporting teachers or a teacher supporting a student teacher). If the password is forgotten, or a user learns the password and changes it, the master password will allow access to fix things.

In the distribution folder, you will find one Records file ("Globs/Tracker Records"), on which the password and master password are blank. When the password is blank, the first person to choose *TEACHER OPTIONS* for that Records file will be asked to set the password. When the master password is blank, it is ignored. (But if the master password is blank, anyone who matches the password can set the master password.) If you received the program from someone else (like a technology coordinator), ask if a Records file was created for you and/or the password or master password was set.

If you forget the password (or someone learns it and changes it), your alternatives are:

- Find someone who knows the password
- Find someone who knows the master password
- Replace the Records file with a new Records file

If you are your own support person for this software, you can do several things:

- Keep one or two unchanged copies of the original Globs/Tracker Records file — empty, with no passwords — in a folder with read-only access. You can use these to replace a Records file if all else fails.
- Set the master password and write it down at home (or at least not anywhere near the location where the software is being used). Since the master password will probably be used infrequently, it may be harder to remember.

Passwords saved in a Records file are encrypted. Even if someone could see the contents of a Records File, it would be difficult to determine from that information what the passwords are. Records files are not text files; attempting to edit them like text files would probably just make them unreadable by the *Green Globs & Graphing Equations* program.

Change the Sound Settings for Users of this Records File

These settings control the availability of sound during a *GREEN GLOBS* game when a shot hits a glob or a shot absorber. You can specify whether users are allowed to switch sound on and off, and whether sound is initially set to on or off. The initial sound settings allow users to switch sound on and off, with sound set to on. If this is the arrangement you want, you do not need to do anything.

When users are allowed to switch sound on and off, the last two menu items on the *GREEN GLOBS* menu will be Sound On and Sound Off, with a check mark next to the current setting. When users are not allowed to switch sound on and off, Sound On and Sound Off are removed from the *GREEN GLOBS* menu, and the sound status remains at the initial setting you selected. For example, you can turn sound off and keep it off for users by selecting the sound settings “Sound is initially Off” and “Users cannot switch sound from its initial setting”.

Sound settings are kept in Records files. Two Records files can have two different sets of sound settings. To see or change the sound settings for a given user, look in the Records file where that user's record scoring games would be saved. Sound settings are checked only when a user opens the application, so changes you make to sound settings will not affect users already using the software until they quit and re-open the application. For convenience when creating new Records files, the passwords and sound settings of the new Records file are copied from the Records file with which you started. You can change the sound settings in the new Records file if you want.

Menu Items for Multiple Records Files

The remaining menu items in Teacher Options deal with having more than one Records file. If you are using just one Records file (like the Globs/Tracker Records file which is included in the package), then you can skip to the last section, titled *Tips for Using Green Globs & Graphing Equations on a Network*, on page 92.

After these menu item descriptions , there is a discussion and example in the section titled *Using More Than One Records File* on page 89.

Choose a Records File from your current list

This item is available only when you are dealing with a List of Records files. It allows you to select one of the Records files on your list and then use the menu items described above to see or change the records in that Records file. If the password kept in the Records file you select is different from the password you last typed, you will be asked to type the password for the selected Records file. If you cannot type the correct password, you will have to start *TEACHER OPTIONS* again from the Programs menu, using the Records file you started with.

Choose a Records File from the disk directory

This menu item allows you to select a Records file from any disk and folder you can access, then use the menu items described above to see or change the records in that

Records file. If the password kept in the Records file you select is different from the password you last typed, you will be asked to type the password for the selected Records file. If you cannot type the correct password, you will have to start *TEACHER OPTIONS* again from the Programs menu. This uses the standard "Open…" files dialog box, but only file names for Records-type files (with file extension ".ggg") can be selected.

Choose a List File [list of records file] from the disk directory

A List file contains a list of Records files. See the discussion Using More Than One Records File after these *TEACHER OPTIONS* menu item descriptions. This menu item allows you to select a List file from any folder you can access, then use the menu items described above to see or change the Records files in that List. (You can also use menu item "Edit or Save your current List of Records Files" to edit the List and save your edited List on disk.) You will need to match the password of the first Records file in the List. If the password kept in the Records file is different from the password you last typed, you will be asked to type the correct password. If you cannot type the correct password, you will have to start *TEACHER OPTIONS* again from the Programs menu. After you have typed the correct password, you can select any Records file on the list by selecting the menu item "Choose a Records File from your current list" described above.

This uses the standard "Open…" files dialog box, but only file names for List-type files (with file extension ".ggx") can be selected.

Create a new Records File

This menu item allows you to create new Records files. It uses the standard "Save…" dialog, where you select the disk drive and folder you want the new file to be in, then type the new file name and click "Save" (or press Enter). If you click Cancel, nothing will be created and you will return to the main *TEACHER OPTIONS* display for your current Records file. When you create a new Records file, the application will write each section (1024 bytes) of the file to disk. A counter on your screen will show how many sections remain to be written. A Records file uses about 50KB (50,000 bytes) of disk space. Once a Records file has been created, it has all the disk space it will need. A Records file does not increase or decrease in length as it is used. After your new Records file has been created, it becomes the Records file you are currently working on, to make it convenient for you to set the title and passwords — just pull down the *TEACHER OPTIONS* menu and select "Change the Title of this Records File" or "Change the Passwords of this Records File". The title is initially blank, and the passwords are initially copies of the password and master password on the Records file you had when you started *TEACHER OPTIONS*.

If you are going to be using your new Records files in a List, remember that a List identifies a file by the file name and the folder the file is in. If you change a file's name or move it out of its folder after including it in a List, that entry in the List will be incorrect. (If this happens, you can fix it by using menu item "Edit or Save your current List of Records Files" described later.)

Create a List of existing Records Files

This menu item allows you to create and save a List of Records files. The Records files must already exist before you select this menu item. (If they do not exist, select the menu item above this, called "Create a New Records File".) You should know the password for the first file on your List. The Records files in a List do not need to be on the same disk drive. This uses the standard Open… " files dialog. This shows all folder names, but shows file names only for Records-type (".ggg") and List-type (".ggx") files. Select the files you want on your list, clicking Open after each file selection. If you open a List-type file, its List of Records files will be appended to the list (if any) of files that you have so far.

When you are finished selecting files, click Cancel. This menu item only creates the List, it does not save it on disk. When you click Cancel (or when your List hits the limit of eleven Records files), you will be taken directly to the display for the next menu item, "Edit or Save your current List of Records Files," where you can make changes to your List and save it as a List file on disk. If you want to discard your list and start over, just select the menu item "Create a List of existing Records Files" again and you will start over.

Edit or Save your current List of Records Files

This menu item allows to you edit a List, verify that the entries in a List are valid, and save a List to disk. This is the only place where a List is saved on disk. Any changes you make to a List in *TEACHER OPTIONS* do not affect the disk copy (if any) of the List until you select this menu item and subsequently click the Save button. The other items on the *TEACHER OPTIONS* menu are inactive while you are in this editing display. To leave this display, click Exit. Remember that when someone starts *Green Globs & Graphing Equations* with a List of Records files, any record scoring *GREEN GLOBS* or *TRACKER* games will be saved in the first Records file on the List. The games in the other Records files will just be available for watching replays. At the bottom of this display are eight buttons:

Use this to add more files to the list. A standard "Open…" dialog box will let you identify the additional Records files — click Cancel when you are finished adding. Added files are added to the end of the list, but you can move them after you finish adding files. This button will be inactive if your list is already at the limit of eleven Records files. The Records files in a list do not need to be on the same disk drive.

Select a file to be replaced, then click Replace. A standard "Open…" dialog box will let you identify the replacement Records file. If a list entry has become incorrect because of changes, use this option to update that entry, or use the Delete option described below to remove it from the List. The Records files in a list do not need to be on the same disk drive.

Select a file to move, click Move, then click at the position in the list where you want the file to be.

Select a file to delete, click Delete, and the file will be removed from the list. Files below it on the list will be moved up. This just deletes a Records file from this list; it does not affect that Records file in any way.

This exits the editing display. If your list has changes which have not been saved to disk, you will see an alert dialog asking if you want to save the list before exiting. After exiting, you will be taken to the password entry display, where you will be asked to match the password of the first Records file on your list.

This provides a one screen help display about List files. When you click OK, you return to the editing display for your list.

This provides a standard “Save…” dialog box to save your list as a List file. If you got this list by opening a List file, that file name will be shown as a default file name. You can save your list as a replacement for an existing file, or as a new file. A List file does not need to be saved on the same disk or in the same folder as the Records files in the list. After you save your list as a List file, users who open that List file (or a shortcut for it) in Windows will start *Green Globs & Graphing Equations* with that list as their list of Records files.

Use this to verify that each entry in the list is valid. A file name entered in a list can become invalid after you create the list if someone renames that file, deletes that file, or moves that file to another folder.

Verification will check that:

- ✓ Each file name exists in the named folder and is a Records-type file
- ✓ The first file on the list (where users’ record scoring games will be saved) is not Read Only

Convert an old format Records file to new format

A standard “Open…” dialog box will let you select a Records file in the old format (with file extension “.rec”). The information will be read and converted to the new Records file format. You will then see a standard “Save…” dialog box, where you can save the information as a new format Records file (with file extension “.ggg”). The old format file itself is not changed.

Convert an old format List file to new format

A standard “Open…” dialog box will let you select a List file in the old format (with file extension “.rex”). The information will be read and converted to the new List file format. You will then see a standard “Save…” dialog box, where you can save the information as a new format List file (with file extension “.ggx”). The old format file itself is not changed.

Using More Than One Records File

One of the *TEACHER OPTIONS* lets you create additional Records files. Each Records file uses about 50KB of disk space. You can name a Records file anything with file extension ".ggg". A Records file does not need to be in the same folder (or even on the same disk drive) as *Green Globs.exe*.

Here are some possible reasons to create additional Records files:

• You have two or more classes with different experience levels using the software (e.g., a ninth grade and an eleventh grade).

• You have several classes using the software, and you want the records to hold the top ten scores from each class instead of the top ten scores from all the classes combined.

• You want an archive where you can copy selected games before they are bumped off the top ten scores by higher scoring games.

• You want an archive where you can copy selected games from last year's records before reinitializing the records section for this year's classes.

In Windows, if you open the application *Green Globs.exe* by selecting it and choosing Open from the File menu (or double-clicking its icon), the application will use the Records file named "Green Globs Records.ggg" in the same folder. (These two files are in the Green Globs distribution package, and they must be in the same folder so that *Green Globs.exe* can read your license information from "Green Globs Records.ggg". An alternative way is to start *Green Globs.exe* from Windows indirectly by opening any Records file (or opening any List file, which holds a list of Records files, as discussed below). This is just like opening a word processor's document in order to start the word processor with that particular document. If you start *Green Globs.exe* by opening a Records file (or List of Records files), the Records file (or List of Records files) can have any name and can be anywhere — it does not need to be in the same folder as *Green Globs.exe*. If you create additional Records files for use by students, you may want the students to be able to see other Records files besides the one where their own record games are saved. If so, you can make a list of these Record files and save the list in what this package calls a "List" file. An example of this is described below.

Green Globs.exe must be able to find at least one Records file in order to run.

List Files

When you have more than one Records file, you can arrange for users to start *Green Globs.exe* by opening a List file (which contains a list of Records files). When this happens, *Green Globs.exe* will assume the first Records file on the list is the file where the user's record games should be saved, and the other Records files on the list are just to be available for seeing their record games.

To create a list, you create the individual Records files, then you make a list of them in the order you want (remember, the user's record games will be saved in the first file on the list), then you save the list in a new file (which we call a List File). The user then opens this List file to start *Green Globs.exe*. See the example in the next section on this page. There is one caution in using List files: a List file saves a list of Records files by saving each Records file's name and the identification of the folder the Records file is in. If you create a List file and then someone changes the name of one of the Records files in your list, or moves that Records file to another folder, that entry in your List file becomes invalid. To correct an invalid entry in a List file, choose *TEACHER OPTIONS* and update that list entry by doing the following:

- If you didn't start *Green Globs.exe* with that List file, select "Choose a List file from the disk directory" and open that List file. Or select menu item Create a List of Existing Records Files to just create the list again.
- Edit your list to make any necessary changes.
- Save the updated list on the disk.

An Example using Records files, List files, and Shortcuts

One way to specify Records files and List files is described in the Shortcuts section of the Getting Started chapter on page 3.

Here is another example of one possible network installation. If you are not using a network, the example still applies — you put all the files on your individual computer(s). For this example, file *Green Globs.exe* could either be on the server or on each computer on the network. The Records file(s) — with file extension ".ggg" — would be on the network server's hard disk drive.

Step 1: On the server create a folder (or use an existing one) to which everyone has read and write access, but students cannot copy, rename, or delete the folder or the files in it.

Step 2: Create the Records files you want in that folder (or move them to that folder if they already exist). For this example, suppose there are three ninth grade classes and you create three Records files named "GG Records 9A.ggg",
"GG Records 9B.ggg", and "GG Records 9C.ggg". (The names could be anything.)

Step 3: If you want to have Lists of those Records files, create them. They can go in that folder, or another folder on the server. For this example, you could create three List files this way:

First, make this list (assuming the Records file names used above):

GG Records 9A.ggg

GG Records 9B.ggg

GG Records 9C.ggg

and save it as List file "Green Globs List 9A.ggx".

Then make the following list (you can make it by editing your previous list using "Move" to change the order):

GG Records 9B.ggg

GG Records 9A.ggg

GG Records 9C.ggg

and save it as List file "Green Globs List 9B.ggx".

Then make a third list (by changing the order of your previous list):

GG Records 9C.ggg

GG Records 9A.ggg

GG Records 9B.ggg

and save it as List file "Green Globs List 9C.ggx".

Note that each list has the same files as the other lists, only with a different one first. Each class will have its own Records file in which to save record games, and each class will be able to see the record games saved by the other two classes.

Step 4. Quit *Green Globs.exe* and, in Windows, create a shortcut for each of your List files. For example:

Right-click on List file "Green Globs List 9A.ggx" and create a shortcut to it, then rename your new shortcut to "Start Green Globs —9A". (The name could be anything you want.)

Similarly, create shortcuts to List files "Green Globs List 9B.ggx" and "Green Globs List 9C.ggx".

You can move the shortcuts to whatever folder is convenient, on the server or on each computer on the network.

A nice feature of the above example is that the shortcuts point to List files on the server, not to individual Records files. That means you could make a change to the list of Records files in a List file on the server, and the change would be implemented without needing to update any files on the individual computers on the network.

Tips for Using *Green Globs & Graphing Equations* on a Network

For students who will be starting *Green Globs.exe* with a single Records file, consider putting the Records file on the network server disk and putting a Shortcut for that Records file on each computer on the network. (The same idea applies if the students are starting with a List file -- a list of Records files.) This allows you to make changes to the Records file on the server without needing to make any changes to the individual computers on the network.

If a computer on the network requests from the server the top ten scores in e.g., the *TRACKER* Novice Game, that will involve sending about 1KB over the network. If the user then chooses to watch a replay of one of those record games, that will involve sending about 1KB over the network for each game replayed. (Although a Records file uses about 50KB of disk space, the application requests just the section of data that it needs; each section is about 1KB long. The application never requests the entire Records file.)

Whenever a student or a teacher sees a display showing record scores, the application has just read that data from the Records file on disk — so the information is current at the moment it is displayed. This is also the case even when the window is just being refreshed, e.g., when you return to it after switching to other windows.

On a network, though, the information in a shared Records file on the server can be changed by other users at any time, so it is possible for a student or teacher to select a game which is no longer in that (or possibly any) position in the Records file.

When this obsolete display problem happens to a student, the student will see this message:

> "The record you selected has been moved to another position, deleted, or incompletely recorded. Please select again."

After the student presses Enter, the updated record scores will be read from the Records file and displayed. Regardless of the number or frequency of changes to a Records file, a student will never see one person's record game attributed to another person's name.

When this obsolete display problem happens to someone using the *TEACHER OPTIONS*, that person will see this message:

> "That Records Section was just updated by someone else. Since the records you were seeing were not current, your action was canceled. You can request it again. Press Enter to see the current records."

After the teacher presses Enter, the updated record scores will be read from the Records file and displayed.

One or more teachers can make changes to a Records file at the same time students are saving and replaying games in that Records file, without risking loss of data or unintended changes to data. When a student saves a record game, or a teacher makes a change to a Records file, the application holds other requests to change that Records file until the change is complete. (This guarantees data to be written in two places in the Records file gets to both places before the next person starts making changes.) This process usually takes just a second, but the application protects against two users trying to make changes simultaneously, and anyone who is asked to wait will see this message:

> "Someone else is saving something in the Records file at this moment. Please wait — this program will try again automatically every 5 seconds. To cancel trying, click the mouse. Number of tries so far: [followed by a number that starts at one and increments once every five seconds]."

In most cases, the student will succeed on the second try (five seconds after the first try found someone else in the process of saving something). If the displayed number continues to increment, some possible explanations are:

1. The application and the Records file are working correctly, but the network is sending information at an extremely slow rate. (A computer needs to transfer only about 3KB over the network to save a record game, though.)

2. The application and the Records file are working correctly, but you have to wait a little longer for several persons in line ahead of you to make changes. (For example, in a new Records section with no games saved, when ten students simultaneously save their games.)

3. The Records file has been reserved by one of the computers and that computer has not released it. This could happen if someone has opened the Records file from a utility program, or it might happen if a computer or a network had a hardware malfunction while updating the Records file.