

Features

WinGraph is an equation graphing program designed primarily for use by students and teachers of High School and Junior High School mathematics.

WinGraph's features include:

- 1) Expression parsing,
- 2) Cartesian coordinate graphs in two and three dimensions,
- 3) Polar coordinate graphs,
- 4) Simultaneous graphing of two equations (two-dimensional graphs only),
- 5) Solutions to equations (two-dimensional graphs only),
- 6) Variable solution ranges,
- 7) Full rotational and zoom capability for graphs in three dimensions,
- 8) Printing of graphs to devices supported in Microsoft Windows,
- 9) Use of Microsoft Windows clipboard facility for transferring images created in WinGraph to other Windows programs,
- 10) User configurable display features and colors.

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Axes

Lines intersecting at right angles to form the basis for coordinate systems. Their point of intersection is called the origin. Points in the coordinate system are represented by ordered series of values.

Two-dimensional coordinate systems are defined by the intersection of two lines at right angles. Points in these systems are represented by (x,y) .

Three-dimensional coordinate systems are defined by the intersection of three lines at right angles. Points in these systems are represented by (x,y,z) .

Polar coordinate systems are defined by a single axis called the polar axis and a point on the polar axis called the pole. Points in these systems are represented by $(\text{radius}, \text{theta})$.

See Also: [Cartesian Coordinates](#), [Polar Coordinates](#), [Two-dimensional Graphs](#), [Three-dimensional Graphs](#)

Cartesian Coordinates

Rectangular coordinate system based on the intersection of lines (axes) at right angles. Points in a cartesian coordinates system are referenced by their distance and direction from the point at which the axes intersect (origin).

WinGraph generates graphs in Cartesian and Polar coordinate systems.

See Also: [Axes](#), [Polar Coordinates](#), [Two-dimensional Graphs](#), [Three-dimensional Graphs](#)

Clipboard

The Windows Clipboard is used for transferring text or images between Windows applications. At anytime you can see what is stored in the Clipboard by double-clicking the Clipboard icon in the Windows Main Program Group.

WinGraph can transfer images it creates into the Windows Clipboard.

See Also: [Using the Windows Clipboard](#)

Constants

A value that does not change. Constants that WinGraph understands are: Real Numbers, e, pi.

See Also: [Functions](#), [Operators](#), [Symbols](#), [Variables](#)

Coordinates

Ordered series of numbers that identify specific points in a coordinate system.

WinGraph can display the location of the cursor in Cartesian or Polar coordinates.

See Also: [Cartesian Coordinates](#), [Polar Coordinates](#), [Two-dimensional Graphs](#), [Three-dimensional Graphs](#)

Defaults

Standard values that WinGraph uses for certain graphing options. For certain options clicking the "Default" button will reset that option to the WinGraph standard value.

Equations

A statement that two algebraic expressions are equal.

Equations entered in WinGraph must be entered in the form

$f(x) = \text{expression}$
 $f(y) = \text{expression}$
 $f(x,y) = \text{expression}$

Users only enter the expression, WinGraph determines 'f(x),' 'f(y),' or 'f(x,y)' based on the variable(s) contained in the expression.

See Also: [Entering Equations](#), [Entering Overlay Equations](#)

Functions

In WinGraph the term 'Function' has two meanings:

One: In the context of equations a function is an equation that has one and only one solution for each solution argument. WinGraph solves for only one solution for each argument.

Two: In WinGraph certain functions can be entered as part of an equation to be graphed. E.g., sin, cos, tan, abs, ln, log.

See Also: [Equations](#), [Operators](#), [Symbols](#), [Variables](#)

Grid, background

Dotted grid of lines in the background of two-dimensional graphs. This feature can be turned on or off simply by selecting the menu item

Operators

Symbols that represent mathematical operations. Examples of operators are +, -, *, /, ~.

There are two types of operators -- binary and unary. Binary operators require two operands, e.g., $5 + 6$, where the numbers are the operands and '+' is a binary operator. Unary operators only require a single operand, e.g. ~ 6 , where the number '6' is the operand and '~' means minus. This operator is distinguished from the binary subtraction operator, e.g., $5 - 6$.

See Also: [Functions](#), [Symbols](#), [Variables](#)

Origin

In Cartesian coordinate systems the point where the axes intersect.

In Polar coordinate systems the point designated as the pole lying on the polar axis.

See Also: [Cartesian Coordinates](#), [Polar Coordinates](#)

Overlay

A second graph plotted simultaneously. Clicking the "Overlay" button in the "Graph..." dialog box brings up a second dialog box where users can enter another equation for graphing. This feature is accessible for two-dimensional graphing only.

Pitch

Degree of rotation of three-dimensional image around the x axis.

See Also: [Roll](#), [Yaw](#), [Rotations](#), [Changing the Viewing Angle](#)

Polar Coordinates

Coordinate system where points in the plane are located in reference to a single point (pole) on a single fixed axis (polar axis). A point in the polar plane is referenced by drawing a line from that point to the pole, this line is the radius, and the angle created by the radius and the polar axis is theta. These two quantities comprise the polar coordinates (radius, theta).

See Also: Radius, Theta, angle

Radius

In polar coordinate systems the distance from a given point to the pole (origin lying on the polar axis).

See Also: [Polar Coordinates](#), [Theta, angle](#)

Range

Range of solution arguments substituted for variables as equations are solved. Users can change the range over which WinGraph solves equations.

See Also: [Solution Argument](#)

Resolution

Number of data points that WinGraph solves in a given range. Low resolution solves fewer points than medium or high. However, high resolution yields graphs with greater detail than medium or low.

See Also: [Range](#)

Roll

Degree of rotation of three-dimensional image around the z axis.

See Also: [Pitch](#), [Yaw](#), [Rotations](#)

Rotations

Changing orientation in space of three-dimensional image.

See Also: [Pitch](#), [Roll](#), [Yaw](#)

Settings

The current values that WinGraph uses for calculating and displaying graphs. WinGraph can be set to display the current settings in a status line located at the bottom of the main window

Solution Argument

A value that replaces the variable in an equation that is to be solved.

See Also: [Variables](#)

Symbols

Terms or characters that WinGraph understands. Choosing the menu option "Symbols..." or clicking the "Symbols" button in the "Graph..." dialog box brings up a window containing all the symbols and their definitions that WinGraph understands.

The types of symbols that WinGraph understands fall into the following categories: Constants, Functions, Operators, Variables, and Parentheses.

See Also: [Constants](#), [Functions](#), [Operators](#), [Variables](#)

Theta, angle

In a polar coordinate system the angle created by the line drawn from a specific point in the plane to the pole (radius) and the polar axis.

See Also: [Polar Coordinates](#), [Radius](#)

Three-dimensional graphs

Pictorial representations of equations containing two variables.

Two-dimensional graphs

Pictorial representations of equations containing a single variable.

Variables

Place holder for a value in an equation. A solution argument replaces the variable when an equation is solved.

WinGraph only recognizes the letters 'x' and 'y' as variables.

See also: [Functions](#), [Operators](#), [Solution Argument](#), [Symbols](#)

Yaw

Degree of rotation of three-dimensional image around the y axis.

See Also: [Pitch](#), [Roll](#), [Rotations](#)

Zoom

Movement of three-dimensional image into or away from viewer.

GRAPH...

Invokes a dialog box where users enter equations for graphing.

Clicking the "Overlay" button invokes a secondary dialog box where users enter another equation for simultaneous graphing (two-dimensional graphing only).

Clicking the "Symbols" button invokes a dialog box containing a table of symbols that WinGraph understands. This dialog box may remain on the screen while users enter equations or invoke other WinGraph features.

The "Plot Type" box contains "radio buttons" indicating type of graph -- Cartesian or Polar.

See Also: [Cartesian Coordinates](#), [Entering Equations](#), [Entering Overlay Equations](#), [Polar Coordinates](#), [Symbols](#)

COPY

Copies the image presently displayed in WinGraph's main window to the Windows clipboard.

Users can transfer images created in WinGraph to other Windows applications supporting bit-mapped images.

See Also: [Using the Windows Clipboard](#)

PRINT

Prints the image currently displayed in WinGraph's main window.

ABOUT

Invokes a dialog box identifying the WinGraph version number and developers.

Clicking the "Info..." button invokes the Microsoft Windows Notepad and loads the file "Wingraph.doc" which contains information about registering WinGraph.

QUIT

Exits WinGraph.

RANGE...

Invokes a dialog box where users specify the solution range for graphed equations.

The maximum solution range varies depending on two factors: resolution, and graph type (2D or 3D).

See Also: [Changing the Resolution](#), [Changing the Solution Range](#), [Resolution](#)

ROTATE...

Invokes a dialog box where users swivel the viewing angle of three-dimensional graphs.

Users can rotate graphs 360 degrees around each axis.

This option is not accessible for two-dimensional graphs.

See Also: [Changing the Viewing Angle](#)

COLORS...

Invokes a dialog box where users choose the colors in which WinGraph draw graphs.

Users can specify different colors for drawing the graphs, individual axes, and the background grid.

See Also: [Changing the Graph Colors](#)

ZOOM...

Invokes a dialog box where users adjust the viewing distance of three-dimensional graphs.

Users can "zoom" into or away from the image in WinGraph's main window.

This option is not accessible for two-dimensional graphs.

See Also: [Changing the Viewing Distance](#)

RESOLUTION...

Invokes a dialog box where users select WinGraph's drawing resolution -- Low, Medium, or High.

High Resolution is not available for two-dimensional graphs with ranges greater than 12, or three-dimensional graphs with ranges greater than 7.

Polar graphs are unaffected by this option.

See Also: [Changing the Resolution](#), [Changing the Solution Range](#), [Range](#)

AXES

Toggle's WinGraph's display of axes in the main window.

When checked axes are displayed or printed; when not checked axes are hidden.

See Also: [Changing the Display Options](#)

TEXT

Toggles WinGraph's display of equation text in lower right corner of main window.

When checked equation text is displayed or printed; when not checked equation text is hidden.

See Also: [Changing the Display Options](#)

GRID

Toggles WinGraph's display of background grid for two-dimensional equations.

When checked grid is displayed or printed; when not checked grid is hidden.

See Also: [Changing the Display Options](#)

COORDINATES

Toggles WinGraph's display of coordinate window in top right corner of WinGraph's main window.

When checked coordinate window is displayed; when not checked coordinate window is not displayed.

When checked WinGraph's cursor changes to the shape of a cross and the coordinate window indicates the coordinates at the location of the cross.

This option is not accessible for three-dimensional graphs.

The coordinate window indicates (x,y) coordinates for Cartesian graphs, and (radius, angle) for Polar graphs.

See Also: [Changing the Display Options](#)

SOLUTIONS

Toggles WinGraph's display of solution window(s) in top right corner of WinGraph's main window.

When checked solution window(s) are displayed; when not checked solution window(s) are hidden.

When checked WinGraph's cursor changes to the shape of a cross.

If two equations are graphed simultaneously two solution windows appear -- one for each graph.

User's can solve equations simply by clicking the left mouse button. When the left mouse button is clicked WinGraph determines the solution argument (the value placed in the variable) based on the location of the cross in the window. WinGraph solves the equation with that solution argument and displays both the solution argument and the solution to the equation in the solution window(s).

If the equation contains an 'x' variable, WinGraph replaces 'x' with the solution argument and solves for 'y' (or $f(x)$). If the equation contains a 'y' variable, WinGraph replaces 'y' with the solution argument and solves for 'x' (or $f(y)$). WinGraph determines the solution argument based on which variable the equation contains and the location of the cursor.

For Polar graphs WinGraph determines the angle where the cursor is located and solves for the radius.

The solution window(s) indicate (abscissa,ordinate) for Cartesian graphs, and (radius, angle) for Polar graphs.

This option is not accessible for three-dimensional graphs.

See Also: [Solving Equations](#)

SYMBOLS...

Invokes a dialog box containing a table of Operators, Constants, Functions, and Variables and the corresponding symbols that WinGraph understands.

This dialog box can remain on the screen while users enter equations.

See Also: [Displaying the Symbols Table](#)

SETTINGS

Displays the current values for WinGraph's graphing options. The option values displayed are: Range, Resolution, Roll, Yaw, Pitch, and Distance.

See Also: [Changing the Display Options](#)

Entering Equations

Menu Selection: "Graphs..."

Procedure:

- 1) Choose the "Graphs..." menu option.
- 2) Enter an expression in the equation text box.
- 3) Click the "Ok" button.

Comments:

WinGraph only graphs equations that are functions, that is, equations where there is one and only one solution for each solution argument.

WinGraph determines from the text of the expression whether it is to render a two-dimensional or three-dimensional graph. If an expression contains only one variable, x or y , but not both WinGraph generates a two-dimensional graph. If an expression contains two variables, both x and y , WinGraph generates a three-dimensional graph.

Valid Symbols:

- 1) Operators: $+$, $-$, $*$, $/$, \sim (unary minus)
- 2) Functions: **sin, cos, tan, ln, log, sqrt, abs**
- 3) Constants: **0 - 9, e, pi**
- 4) Variables: **x, y**
- 5) Parentheses: **(,)**

Consecutive unary minus (\sim) signs must be separated by parentheses. Consecutive functions must be separated by parentheses. Use of π or e with functions must be separated by parentheses. Implied multiplication (e.g. $3x$) is not supported.

See Also: [Example](#)

Entering Overlay Equations

Menu Selection: "Graphs..."

Procedure:

- 1) Choose the "Graphs..." menu option and enter an expression in the equation text box.
- 2) Click the "Overlay" button.
- 3) Enter an expression in the overlay equation text box.
- 4) Click the "Ok" button in the "Overlay" dialog box.
- 5) Click the "Ok" button in the "Graph" dialog box.

Comments:

WinGraph cannot overlay three-dimensional graphs.

See Also: [Example](#)

Solving Equations

Menu Selection: "Solutions"

Procedure:

- 1) Turn on the coordinates window by clicking the "Coordinates" menu option. A checkmark appears next to the option indicating that it is active.
- 2) Turn on the solution window(s) by clicking the "Solutions" menu option. A checkmark appears next to the option indicating that it is active.
- 3) Position the cursor, which is now a cross, at the point in the WinGraph main window where the Coordinates window displays your desired solution argument.
- 4) Click the left mouse button once.
- 5) The solution(s) appear in the Solutions window(s) located directly below the coordinates window.

Comments:

If you are solving for y (i.e., you entered an expression containing a 'x' variable) position the cross at the location where the **x value** you wish as your solution argument is displayed in the coordinates window.

If you are solving for x (i.e., you entered an expression containing a 'y' variable) position the cross at the location where the **y value** you wish as your solution argument is displayed in the coordinates window.

See Also: [Example](#)

Graphing Simultaneous Equations

Menu Selection: "Graphs..."

Procedure:

- 1) Choose the "Graphs..." menu option.
- 2) Enter an expression in the equation text box.
- 3) Click the "Overlay" button
- 4) Enter an expression in the overlay equation text box.
- 5) Click the "Ok" button in the "Overlay" dialog box.
- 6) Click the "Ok" button in the "Graph" dialog box.

Comments:

WinGraph cannot graph simultaneous three-dimensional equations.

See Also: [Example](#)

Specifying Coordinate Systems

Menu Selection: "Graphs..."

Procedure:

- 1) Choose the "Graphs..." menu option.
- 2) Click either the "Cartesian" radio button or the "Polar" radio button in the "Plot Type" box.
- 3) Click the "Ok" button.

Comments:

Cartesian is the default WinGraph Plot Type.

Changing the Solution Range

Menu Selection: "Range..."

Procedure:

- 1) Choose the "Range..." menu option.
- 2) Using the scroll bar controls set the desired solution range.
- 3) Click the "Ok" button.

Comments:

The maximum solution range varies depending on the type of graph (2D or 3D) and the resolution.

In High Resolution the maximum solution range for two-dimensional graphs is 12. For three-dimensional graphs it is 7.

In Low or Medium Resolution the maximum solution range for two-dimensional graphs is 20. For three-dimensional graphs it is 10.

WinGraph default range values are as follows:

| Graph Type | Range |
|------------------------------------|--------------|
| Two-dimensional Cartesian Graphs | 10 |
| Three-dimensional Cartesian Graphs | 4 |
| Two-dimensional Polar Graphs | 4 |

See Also: [Example](#)

Changing the Viewing Angle

Menu Selection: "Rotate..."

Procedure:

- 1) Choose the "Rotate..." menu option.
- 2) Using the scroll bar controls spin the axes until the desired viewing angle appears.
- 3) Click the "Ok" button.

Comments:

The "Rotate..." option is not available for two-dimensional graphs.

Yaw rotates the axes around the y axis.

Pitch rotates the axes around the x axis.

Roll rotates the axes around the z axis.

Default rotation values:

| Rotation | Degrees |
|-----------------|----------------|
| Roll | 300 |
| Yaw | 0 |
| Pitch | 60 |

See Also: [Example](#)

Changing the Graph Colors

Menu Selection: "Colors..."

Procedure:

- 1) Choose the "Colors..." menu option.
- 2) Select a "Graphic Item" from the "Graphic Items" listbox by clicking on it.
- 3) Select a Color radio button from the "Colors" box.
- 4) Click the "Ok" button.

Comments:

You can change the Window background color using the Windows Control Panel. The Control Panel is accessible from the Main Program Group.

Users with monochrome or gray-scale monitors will not be able to view all color options.

All printing is done in black.

See Also: [Example](#)

Changing the Viewing Distance

Menu Selection: "Zoom"

Procedure:

- 1) Choose the "Zoom..." menu option.
- 2) Using the scroll bar controls zoom the displayed axes until the desired depth appears.
- 3) Click the "Ok" button.

Comments:

The "Zoom..." option is not available for two-dimensional graphs.

The default zoom value is 50.

See Also: [Example](#)

Changing the Resolution

Menu Selection: "Resolution..."

Procedure:

- 1) Choose the "Resolution..." menu option.
- 2) Select Low, Medium, or High Resolution by clicking on one of the radio buttons.
- 3) Click the "Ok" button.

Comments:

The "Resolution..." option is not available for polar graphs.

The maximum resolution varies depending on the type of graph (2D or 3D) and the solution range.

Two-dimensional graphs with ranges greater than 12 and three-dimensional graphs with ranges greater than 7 are limited to low or medium resolution.

The default resolution is Low.

See Also: [Example](#)

Changing the Display Options

Menu Selections: "Axes", "Text", "Grid", "Coordinates", "Settings"

Procedure:

1) Select or de-select an option simply by choosing it from the menu.

Comments:

Menu items that are active have checkmarks, inactive menu items do not.

Printing a Graph

Menu Selection: "Print"

Procedure:

- 1) Choose the "Graphs..." menu option and enter an expression in the equation text box for graphing.
- 2) Choose the "Print" menu option.

Comments:

Using the Windows Control Panel users can control printing options such as printer resolution and orientation.

Using the Windows Clipboard

Menu Selection: "Copy"

Procedure:

- 1) Choose the "Graphs..." menu option and enter an expression in the equation text box for graphing.
- 2) Choose the "Copy" menu option.
- 3) Run another Windows program that supports bit-mapped images.
- 4) In most Windows applications a "Paste" option is available. Choosing this option will copy the contents of the Windows clipboard into that application's document.

Comments:

User's can view the contents of the Windows Clipboard by double clicking the Clipboard icon located in the Main Program Group.

Displaying the Symbols Table

Menu Selection: "Symbols..."

Procedure:

1) Choose the "Symbols..." menu option.

Secondary Procedure:

2) Choose the "Graphs..." menu option.

3) Click the "Symbols" button.

Comments:

The Symbols table can remain on the screen while users enter equations or invoke other WinGraph features.

See Also: [Example](#)

Examples: Two-dimensional Cartesian Equations

x

x^2

$\sin x$

$\sin x^2$

$\ln x$

$\sin(\pi/x)$

e^x

$\tan x$

$\text{abs}(x)$

$3x^2 + 2x - 1$

$\sim x$

y

y^2

$\sin y$

Examples: Three-dimensional Cartesian Equations

$$x^2+y^2$$

$$\sin x * \sin y$$

$$\sin(x^2+y^2)$$

$$\sqrt{x^2+y^2}$$

Examples: Polar Equations

$$\frac{\sin x}{\cos(2x)}$$
$$3$$

Example: Entering Equations

1) Enter the following expression in the equation text box: $x + 1$, and click the "Ok" button.

2) Now try these:

$$x^2$$

$$\sin x$$

$$x^2 + 2*x - 1$$

$$\text{abs } x$$

$$\sin y$$

$$y^3$$

$$\sin x * \sin y$$

$$x^2 + y^2$$

Example: Entering Overlay Equations

- 1) Enter the following expression in the equation text box: ***sinx***
- 2) Click the "Overlay" button.
- 3) Enter the following expression in the overlay equation text box: **x^2**
- 4) Click the "Ok" button in the "Overlay" dialog box.
- 5) Click the "Ok" button in the "Graph" dialog box.

Example: Solving Equations

1) Choose the "Graphs..." menu option and enter the following expression in the equation text box: $1/x$

2) Turn on the "Coordinates" and "Solutions" options.

3) Position the cross so the following appears in the "Coordinates" window:
1.00, 0.00

4) Click the left mouse button once.

5) The following should appear in the solution window in the same color as the graph lines: 1.00, 1.00

Interpretation:

The solution of the equation " $f(x) = 1/x$ " at $x = 1.00$ is 1.00.

6) Position the cross so the following appears in the "Coordinates" window:
2.00, 0.00

7) Click the left mouse button once.

8) The following should appear in the solution window: 2.00, 0.50

Interpretation:

The solution of the equation " $f(x) = 1/x$ " at $x = 2.00$ is 0.50.

Example: Graphing Simultaneous Equations

- 1) Choose the "Graphs..." menu option and enter the following expression in the equation text box: ***sinx***
- 2) Click the "Overlay" button.
- 3) Enter the following expression in the overlay equation text box: **x^2**
- 4) Click the "Ok" button in the "Overlay" dialog box.
- 5) Click the "Ok" button in the "Graph" dialog box.

Example: Specifying Coordinate Systems

- 1) Choose the "Graphs..." menu option.
- 2) Enter the following expression in the equation text box: ***sin(2*x)***
- 3) Click the "Cartesian" radio button (if it isn't already on).
- 4) Click the "Ok" button.
- 5) After viewing the graph, choose the "Graphs..." menu option once again.
- 6) Click the "Polar" radio button.
- 7) Click the "Ok" button.

Example: Changing the Solution Range

- 1) Choose the "Graphs..." menu option and enter the following expression in the equation text box: ***sinx * x***
- 2) Click the "Ok" button.
- 3) Choose the "Range..." option.
- 4) Change the range using the scroll bar.
- 5) Click the "Ok" button.

Example: Changing the Viewing Angle

- 1) Choose the "Graphs..." menu option and enter the following expression in the equation text box: **$\sin(x^2+y^2)$**
- 2) Click the "Ok" button.
- 3) Choose the "Rotate..." menu option.
- 4) Rotate the axes using the three scroll bar controls.
- 5) Click the "Ok" button.

Example: Changing the Graph Colors

- 1) Choose the "Graphs..." menu option and enter the following expression in the equation text box: **$\sqrt{x^2+y^2}$**
- 2) Click the "Ok" button.
- 3) Choose the "Colors..." menu option.
- 4) Select a "graphic item" by clicking on it.
- 5) Select a color by clicking on it.
- 6) Click the "Ok" button.

Example: Changing the Viewing Distance

- 1) Choose the "Graphs..." menu option and enter the following expression in the equation text box: **$\cos(x^2)/(x^2+y^2)$**
- 2) Click the "Ok" button.
- 3) Choose the "Zoom..." menu option.
- 4) Using the scroll bar controls zoom the displayed axes until the desired depth appears.
- 5) Click the "Ok" button.

Example: Changing the Resolution

- 1) Choose the "Graphs..." menu option and enter the following expression in the equation text box: x^2
- 2) Click the "Ok" button.
- 3) Choose the "Resolution..." menu option.
- 4) If it is already selected choose the "Low" radio button.
- 5) Click the "Ok" button.
- 6) Choose the "Resolution..." menu option.
- 7) Select the "High" radio button.
- 8) Click the "Ok" button.

Example: Displaying the Symbols Table

- 1) Choose the "Graphs..." menu option.
- 2) Click the "Symbols" button.
- 3) Click inside the equation text box located in the "Graphs..." dialog box.
- 4) Enter an equation.
- 5) Click the "Ok" button.

