FX Graph 3

Powerful Graphing Made Dead Simple

FX Graph 3

User's Guide

by Efofex Software

Efofex Software is distributed in the UK and Ireland by Chartwell-Yorke

Always check our website for our current postal, phone and fax details

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FX Graph 3

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1 Features

1.1 Basic Concept

FX Graph is a dead simple, but powerful, graphing program. It is designed to be used, with minimal training, by twelve and thirteen year old students but is powerful enough to support the graphing needs of all secondary school students.

2 Licence Statement

2.1 General Conditions

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3 Installation

3.1 System Requirements

FX Graph will run on any computer running Windows 95 or later. FX Graph is compatible with Windows 95/98/Me/NT/2000 and XP.

3.2 Installing FX Graph on Your Computer

To install FX Graph onto your system:

- Put the CD into your computer.
- If the CD does not Auto run,
  Win 95/98/NT/2000/XP Choose Run from the Start menu
  Type d:\setup Where d is your CDRom's drive letter.
- Push the Products button
- Push the Install FX Graph button

The install program will ask you which directory you would like FX Graph to be placed in and will then make all necessary adjustments to your system.

The CD will install a time-limited version of the product. If you do not enter registration information within 30 days of installation, the product will begin to operate in evaluation mode. If you have purchased a registration for FX Graph, you should have received a Registration Sticker and CD booklet with your copy of the software that explains the registration process more fully.

3.3 Installation Notes

3.3.1 Administrator Privileges

FX Graph needs to write to the registry to do its job. On some systems you might require administrator privileges to achieve this. Your IT supervisor will be able to do this.

3.3.2 Adding To Word

Adding FX Graph to Word is automatic. You need to know which version of Word you are using and make sure you select the correct option in the setup program.

We recommend that Word is not running when you install FX Graph.

3.3.3 Registration

If you are evaluating the software and wish to purchase:

- Choose the licence you require. For a full description of the licences available, read the licence information file on this disk.
- Contact Efofex or your local distributor by post, fax or email for the latest prices. Alternatively the latest prices are available from our web site at www.efofex.com
- Purchase a registration code from Efofex or your local distributor and use the instructions below to register your copy.

If you have purchased the software and have received a CD with attached Registration Information:

You have all the information necessary to register your copy of the software.

To Register your copy:

- From the Help menu of FX Graph, choose Register FX Graph...
- Press the Register Now! button.
- Type in your Registered Name and Registration Code EXACTLY as supplied by Efofex. You MUST enter your registered name using the same abbreviations, even the same spelling errors (if we have made any) as the registered name we have supplied.

FX Graph will now operate correctly past the thirty day evaluation period.

3.3.4 Adobe Acrobat

All manuals are provided in Adobe Acrobat PDF format. In order to read and print the manuals you will need to obtain a copy of Acrobat Reader V3.0 or later.

The Acrobat reader is available as a free download from www.adobe.com and is included on our CD.

Before downloading a copy of the reader, try clicking on the supplied PDF files. You are quite likely to already have a copy of Acrobat Reader installed on your system.

3.3.5 Changes FX Graph Makes (Advanced)

A standard installation of FX Graph makes the following changes to a system.

- FXG300.exe, word documents and templates, PDF versions of manuals and quick reference cards, an uninstall program and log are all placed in the installation directory (c:\Program Files\Efofex\FXG3 by default).

- FX Graph's uninstall information is included in the Add/Remove Programs section of Control Panel. This can be disabled by removing the uninstall program and log from the installation subdirectory.

- FX Graph registers itself as an OLE object in the registry (HKEY_CLASSES_ROOT).

- Registration information is stored in an ini file saved to the All Users profile. (c:\Documents and Settings\All Users\Application Data\Efofex is a likely location). If FX Graph cannot determine profile information, it will store the ini file in FX Graph's application directory.

- Individual users preferences are stored in a .ini file that is saved into their profile. (c:\Documents and Settings\%username%\Application Data\Efofex is a likely location). This file also contains any entered registration information. Copying this file to the Default User profile or All Users profile can assist in network installations. If FX Graph cannot determine profile information, it will store the ini file in FX Graph's application directory.

- Word macros and toolbars are stored in FXGraph3.dot. By default, this file is placed in Word's application startup directory (C:\Program Files\Microsoft Office\Office\Startup for example). In networked installations, you may wish to move this file to another startup directory – see below for details. This file has been digitally signed by Efofex Software and must be trusted to install.

- It is likely that installation of FX Graph will require Administrator privileges.

3.3.6 Automatic Registration and Configuration (Advanced)

FX Graph has a number of built-in systems that make automatic registration and configuration easy.

Simple Configuration File
FXG300.ini is a normal .ini file that can be copied into anyone's profile or placed into the default user profile.

Default Configuration & Registration System
At any stage, you can write a default configuration file. Set up a registered copy of FX Graph and choose Write Default Configuration File from the Tools menu. This file, FXG3_Default.ini, will be written to FX Graph's application directory. This file can greatly simplify your installation.

When FX Graph first starts, it checks to see if there is a Default Configuration file in its directory. If there is, it loads all the options from the file, saves these options into the user's profile, and then attempts to delete the default configuration file. No error is generated if FX Graph cannot delete the file. This behaviour means that you can use the default configuration file in one of two ways:

- Ensure that there is a copy of FXG3_Default.ini in FX Graph's directory and let it customise FX Graph for you. Once it is automatically deleted, the user is free to customise their copy of FX Graph.
- You can make FXG3_Default.ini read only (or make it part of the standard operating environment) so that FX Graph is ALWAYS reset back to your standard configuration when it is run.

Integrate with Word

Configuring Word involves copying FXGraph3.dot into a startup directory that is accessible to the user. Word, by default, loads all templates that are located in a startup directory. There are three startup directories that can be used.

- The application has its own startup directory. This will often be C:\Program Files\Microsoft Office\Office\Startup but this obviously depends on your setup. The FX Graph setup program will automatically copy the FXGraph3.dot into this directory.

- The All Users profile has a Word startup directory. This will often be C:\Documents and Settings\All Users\Application Data\Microsoft\Word\STARTUP.

- Each user has a Word startup directory. This will often be C:\Documents and Settings\%username%\Application Data\Microsoft\Word\STARTUP

You should only have the FXGraph3.dot file in ONE of these locations.

Locking Preferences

You can prevent users from accessing the Tools/Preferences menu, writing Default Configuration files and resetting all options.

- Open your standard FXG300.ini in an editor (eg Notepad)

- Find **`AllowPreferenceChanges=1`** and change it to **`AllowPreferenceChanges=0`**

- Save FXG300.ini

4 FX Graph and Word

4.1 Adding FX Graph to Word

Adding FX Graph to Word is handled automatically by the installation program. When you first use Word after installing FX Graph, you may be asked if you trust the document and macros that have been signed by Efofex Software. You MUST trust the macros if you are to use FX Graph properly.

When you open Word you will see a new toolbar with an FX Graph button.

The button inserts a new graph into your document.

4.2 Using FX Graph in Microsoft Word

FX Graph is designed to be used in Word to generate publication quality graphics for tests, examinations, worksheets and assignment. The easiest way to insert graphics into Word is:

- Push the toolbar button
- Type in your structure into the box at the top and see it displayed, fully formatted, in the lower half of the window.
- Click the Green tick

Alternatively you can use Insert Object from the Insert menu in Word and select FX Graph 3 Graph.

When you insert an FX Graph object into your document, FX Graph will start and you can use it in the same way you use FX Graph as a standalone program. The only real difference is how you return to Word.

The green tick will return your image to Word showing all changes you have made. The red cross returns to Word without any changes being updated.

Once you have finished drawing your structure, push the appropriate button to return to Word.

5 Using FX Graph

5.1 Accessing FX Graph

There are two main ways of using FX Graph – as a standalone program, or as an object from within a word-processor or other "object aware" program.

Standalone Mode

If you accept FX Graph default installation, you can run it as a standalone program by finding FX Graph in the Program Files section of the Start menu. This is often the best way of using FX Graph, especially with students.

Document Object Mode

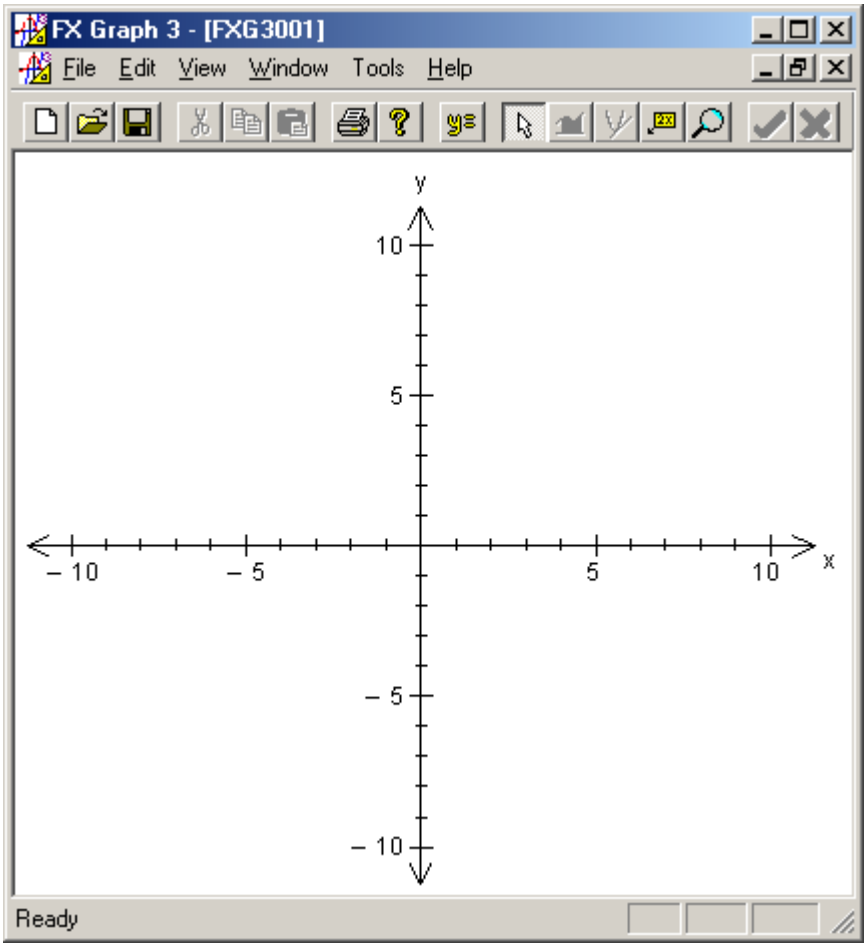
FX Graph is designed to be inserted as an object into a document. You can insert an FX Graph object into a document by either pushing the FX Graph toolbar button (see the section on using FX Graph in Word) or load your favourite Windows word processor and choose Insert / Object from the menus. You will be given a list of available objects and FX Graph 3 Graph will be on the list. Select it and FX Graph will start. You use it the same way you use FX Graph as a standalone program. The only real difference is how you return to Word.

The green tick will return your image to Word showing all changes you have made. The red cross returns to Word without any changes being updated.

When you have finished your image, just **"Click the Tick"** and your diagram will be inserted into your word document.

5.2 Getting Started

When you first start FX Graph, you will see a blank set of axes.



We believe that large numbers of options just confuse students and we have designed FX Graph with as simple an interface as possible.

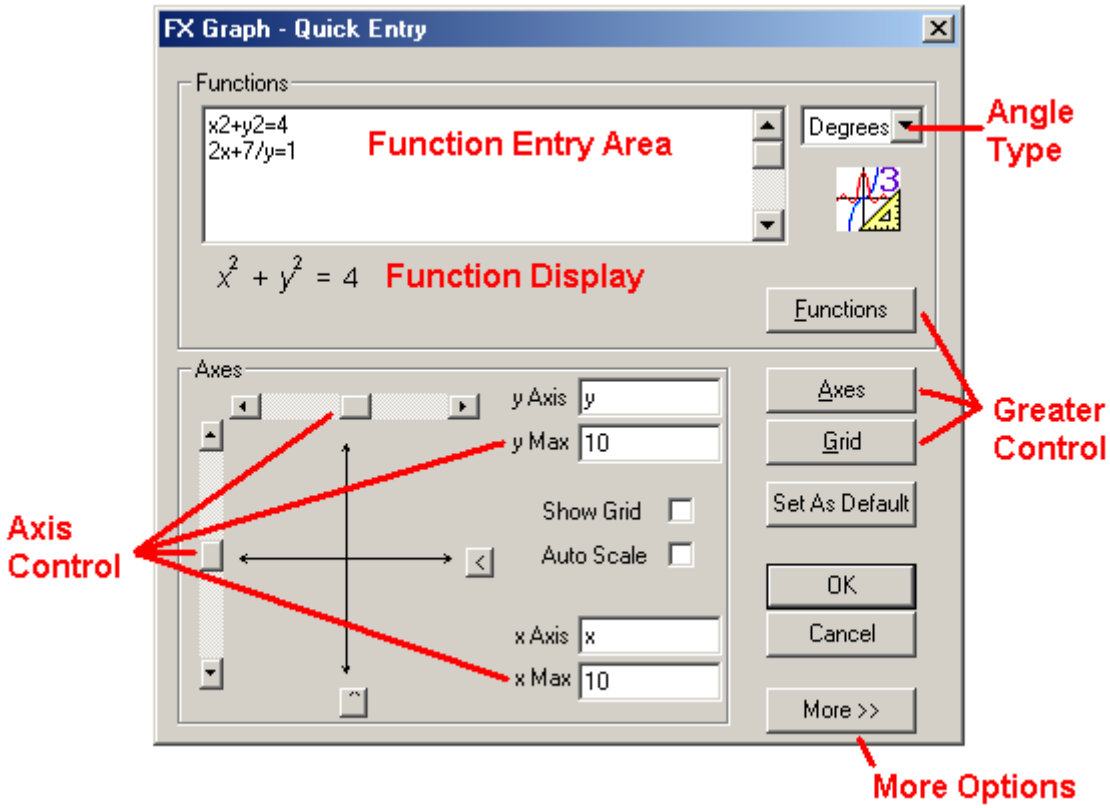
To start entering functions, either

Push the button
or Click the right mouse button
or Choose Edit/Functions from the menus

The Quick Entry screen will appear. This screen is your gateway to FX Graph.

5.3 Quick Entry Screen

The Quick Entry screen gives you access to most of the capabilities of FX Graph in a quick and simple manner. You can achieve much greater control over FX Graph's output using its other interfaces but you will spend most of your time using this screen.



Function Entry Area
Enter your functions - one per line - in this area. FX Graph's function entry utilizes our equation technology which is discussed in more detail later in this manual.

Function Display
Displays the currently selected function using our equation technology. Notice how the x2+y2=4 that we typed has been converted to a formatted equation.

Axis Control
Provides basic, extremely fast, control over the axis settings for FX Graph. Setting the axes using this system is a two stage process.

1. Set the SHAPE you require using the two sliders.
2. Set the MAXIMUM x and y values.

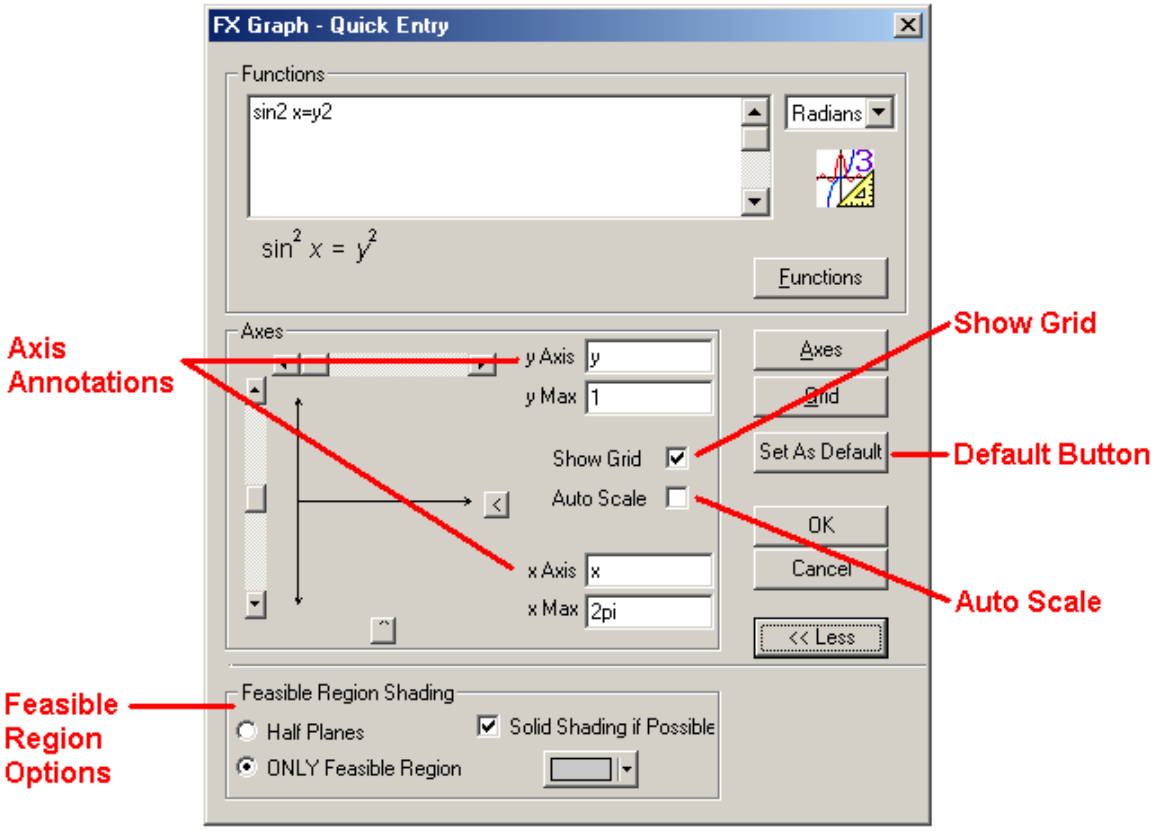
FX Graph does everything else automatically.

Angle Type
Degrees, Radians and Grads can be set here.

Greater Control
The Functions, Axes and Grid buttons give you much greater control over the output of FX Graph.

More Options

The More >> button expands the screen and provides access to more options - in this case Feasible Region settings. Many of FX Graph's screens contain a More >> button.



This diagram shows the Quick Entry screen with the More >> button depressed. Notice that we have set the axes to a different shape and set the x Max to 2pi. This forces FX Graph to mark the x scale in fractional parts of pi.

Axis Annotations
By default, FX Graph marks the axes as x and y. You can change these annotations here.

Show Grid
Turns the grid on and off.

Auto Scale
Autoscaling makes the setting of the axes even easier. If this box is checked, FX Graph will automatically detect any points of interest (local maxima and minima, x intercepts and intersections) from -500 to 500 and adjust the axes so that all of the points of interest are visible. Once you have selected Autoscaling, FX Graph takes full responsibility for the axes. **Please note that the autoscaling feature slows down the response time of FX Graph.**

Feasible Region Options
These settings are discussed in the Inequations & Feasible Regions section of the manual.

5.4 Function Entry

FX Graph uses the equation engine from FX Equation so entering functions is extremely easy AND you can see a fully formatted version of your function as you type.

Functions are entered into FX Graph by typing what you see WITHOUT any formatting. On most occasions FX Graph will automatically format your function for you.

For example. If you want to graph the function $3x^3 + 2x^2 - 7$ simply enter **3x3+2x2-7** into the function entry area. FX Graph automatically recognises and formats the powers and displays the formatted function for you to check your entry.
Simple fractions are also entered as you see them. In other words if you want to graph

$$y = \frac{3x^3}{2x^4}$$

you enter **3x3/2x4** and FX Graph will automatically build the appropriate fraction. Most simple functions can be entered this way, with NO formatting on your part. More complicated functions will require some limited extra input on your part.

Regional Issues:

FX Graph automatically detects which style of decimal point you use (3.2 or 3,2). If you use a , as a decimal point, you must use a semi colon to separate coordinates in points and vectors (eg (3,2; 1,7)) and a colon to separate domains from functions or the two components of parametric functions.

5.5 Special Points About Function Entry

Because of the restrictions of a computer interface, there are some special points you will need to understand to enter all functions.

Special Symbols
Because mathematicians use many symbols not normally found on a computer keyboard, FX Graph uses a small number of special symbols, codes and abbreviations in order to allow you to enter functions.

	Normal Symbol	FX Graph	Notes
Multiplication	×	*	
Exponentiation (Powers)	none (eg 2^x)	^ (eg 2^x)	Only needed when FX Graph fails to automatically recognise the power.
Division	÷	/ (followed by a space)	The / character is more often used (without the space) to enter fractions.
Pi	π	pi	Can be used in both functions and axes.
Theta	θ	th	Used in polar functions
Greater than or equal to	≥	>=	
Less than or equal to	≤	<=	
Plus Minus	±	+-	FX Graph will automatically graph both arms of the function.

Most of these symbols are in common use in computer based mathematics.

Brackets
Many functions, especially fractions, contain assumed brackets. FX Graph will sometimes require you to enter these brackets even though you cannot see them. For example, if you enter y = 3/x+3 does this mean

$$y = \frac{3}{x} + 3 \quad \text{or} \quad y = \frac{3}{x + 3} ?$$

To graph the second function you need to add logical brackets to your function and type y = 3/(x+3). These brackets will not be displayed but will influence how your function is interpreted.

As a general rule, if the function is not shown formatted correctly by FX Graph, add some brackets to make your meaning clear.

A very important use of brackets is to logically identify the numerator and denominator in complicated fractions. For example: (x+2)/(x-3) needs the brackets to be interpreted as $\frac{x+2}{x-3}$ rather than $x+\frac{2}{x}-3$.

Brackets are also used to logically identify powers and ensure that FX Graph interprets your function correctly.

All three bracket types {, [and (may be used interchangeably in FX Graph and

FX Graph makes no distinction between them. FX Graph does not even check to see if brackets are paired. You are responsible for this. If there is a fraction inside a bracket, the bracket is automatically resized.

Example:

$3\left[(x-2)^2+\frac{1}{2}\right]$ is entered as **3[(x-2)2+1/2]**

Powers
Most powers will be automatically recognized by FX Graph. FX Graph will not automatically recognize powers if

- you require a variable as a power
- you require a function as a power
- you require a power of a number
- you require a complicated power.

In these cases you need to explicitly indicate the power using the ^ symbol. As with fractions, complicated powers need to be surrounded with brackets. These brackets will not be displayed.

Examples:

$e^{\sin\theta}$ is entered as **e^sinth**

x^{2y+3} is entered as **x^(2y+3)**

Spaces
Spaces change the way a particular equation is formatted and therefore interpreted. This can best be illustrated using these examples.

$\sin^2\theta$ is entered as **sin2 th**

$\sin 2\theta$ is entered as **sin 2th**

The only difference between the two equations is the **location of a space**.

5.6 Types of Functions

5.6.1 Cartesian

Normal Cartesian functions (y = ...) can be entered into FX Graph with or without the y=.

y = 3x - 7

OR

3x - 7

Normal Cartesian functions are the most supported type of in FX Graph. Cartesian functions are REQUIRED for some of FX Graph's features.

FX Graph will rearrange functions into normal Cartesian functions if possible.

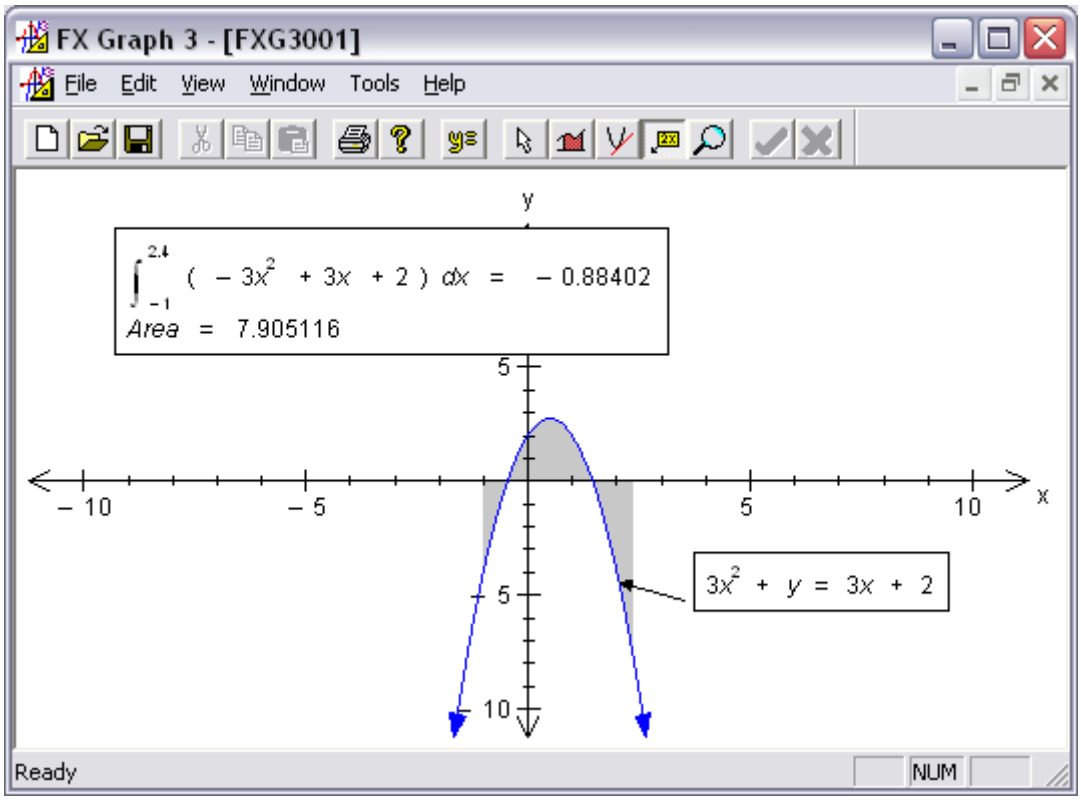
For example:

3x2 + y = 3x + 2

will be internally rearranged by FX Graph into:

y = -3x2 + 3x + 2

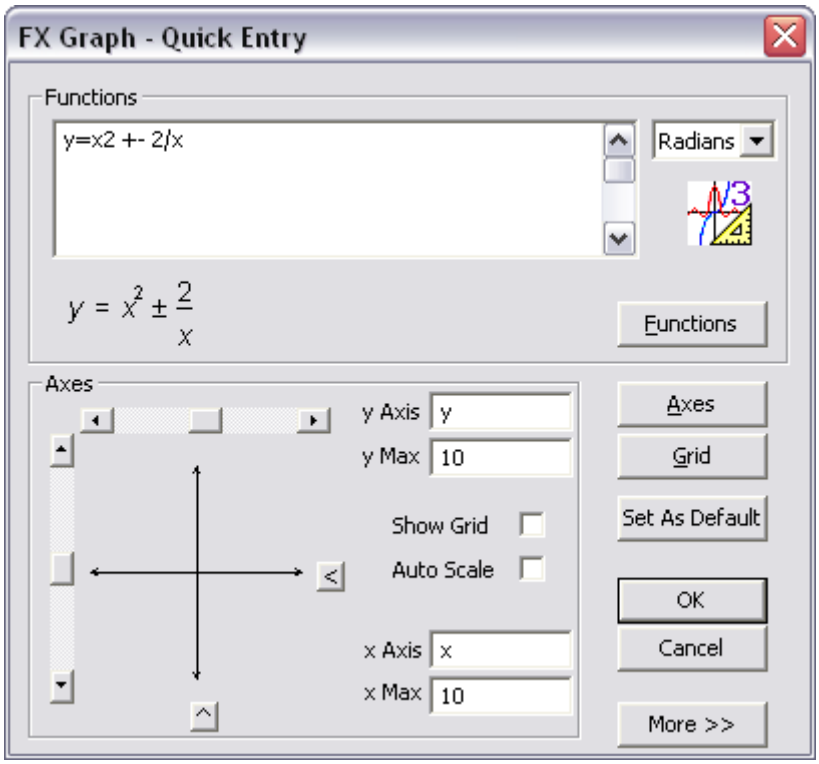
and all features will be available.

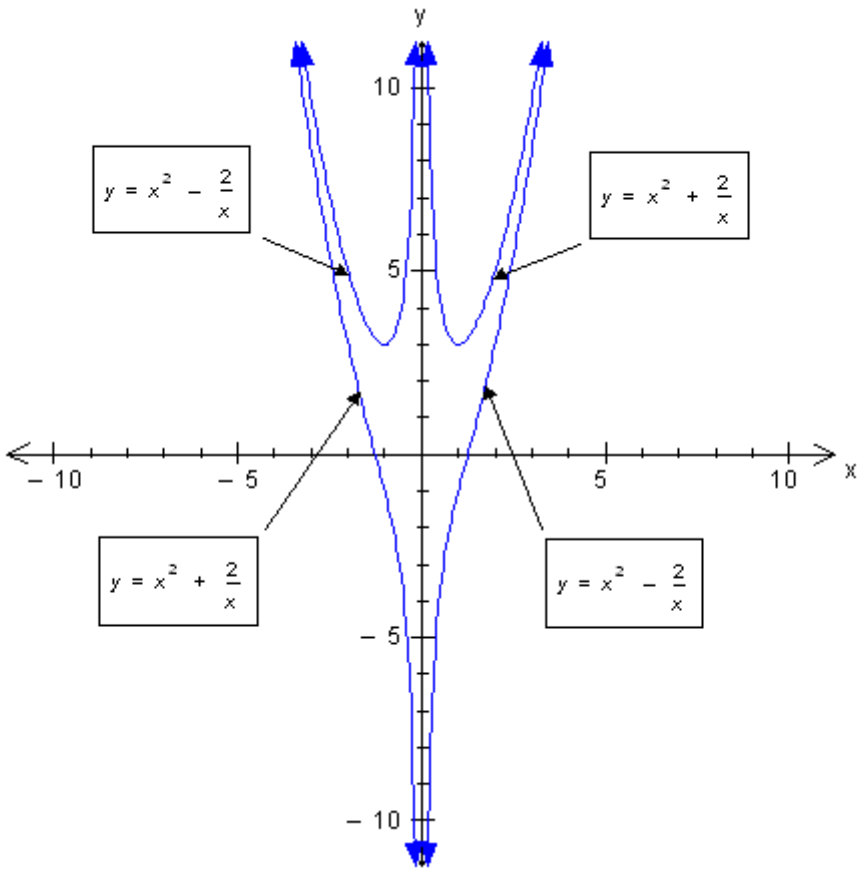


In the diagram above, notice how we entered the function as 3x2 + y = 3x + 2 but FX Graph has rearranged the function when finding the integral.

5.6.2 "Two Armed" Functions

FX Graph supports the use of ± in functions.





5.6.3 Polar

Polar functions are entered in terms of r and θ. Because there is no θ key on a computer keyboard, FX Graph uses th to represent θ.

You can enter a normal polar equation such as r = 5 sin 3θ by typing

r = 5 sin 3th

or

5 sin 3th

The r = is optional and will be assumed if you do not enter it.

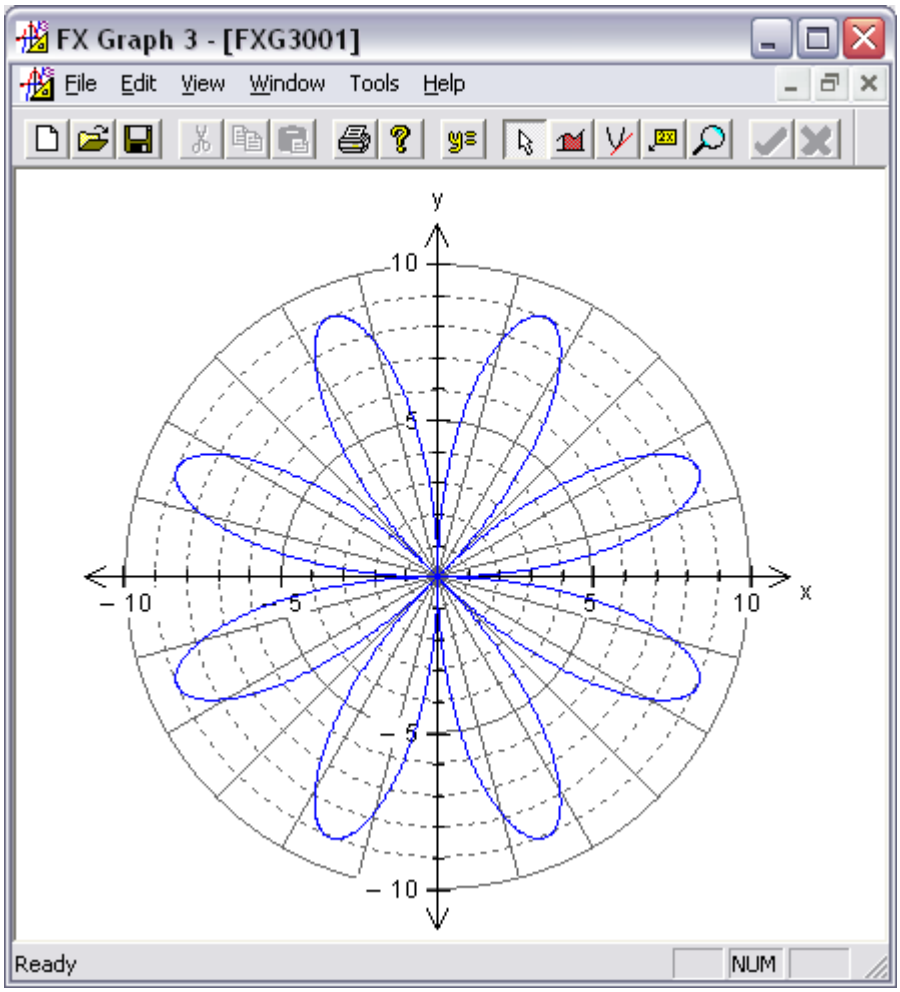
FX Graph can also draw inverse Polar functions - just enter them in terms of r.

th = 3r

th = 1/r

th = pi/4

Don't forget that FX Graph can draw polar grids.



5.6.4 Inverse

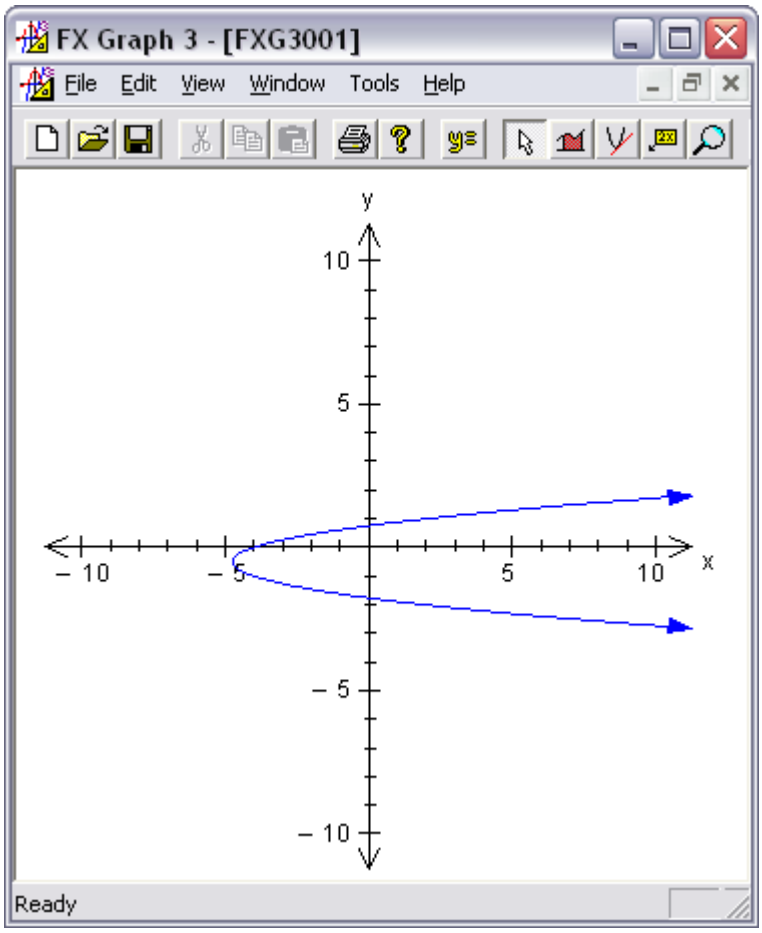
Inverse Cartesian functions (x =) can be entered as

x = 3y2+3y-4

or

3y2+3y-4

the x = is optional



FX Graph will rearrange functions if possible. 3xy + y = 4x will be internally rearranged into y = 4x/(3x+1) to provide access to more of FX Graph's features.

5.6.5 Implicitly Defined

Implicitly defined functions are treated in two stages.

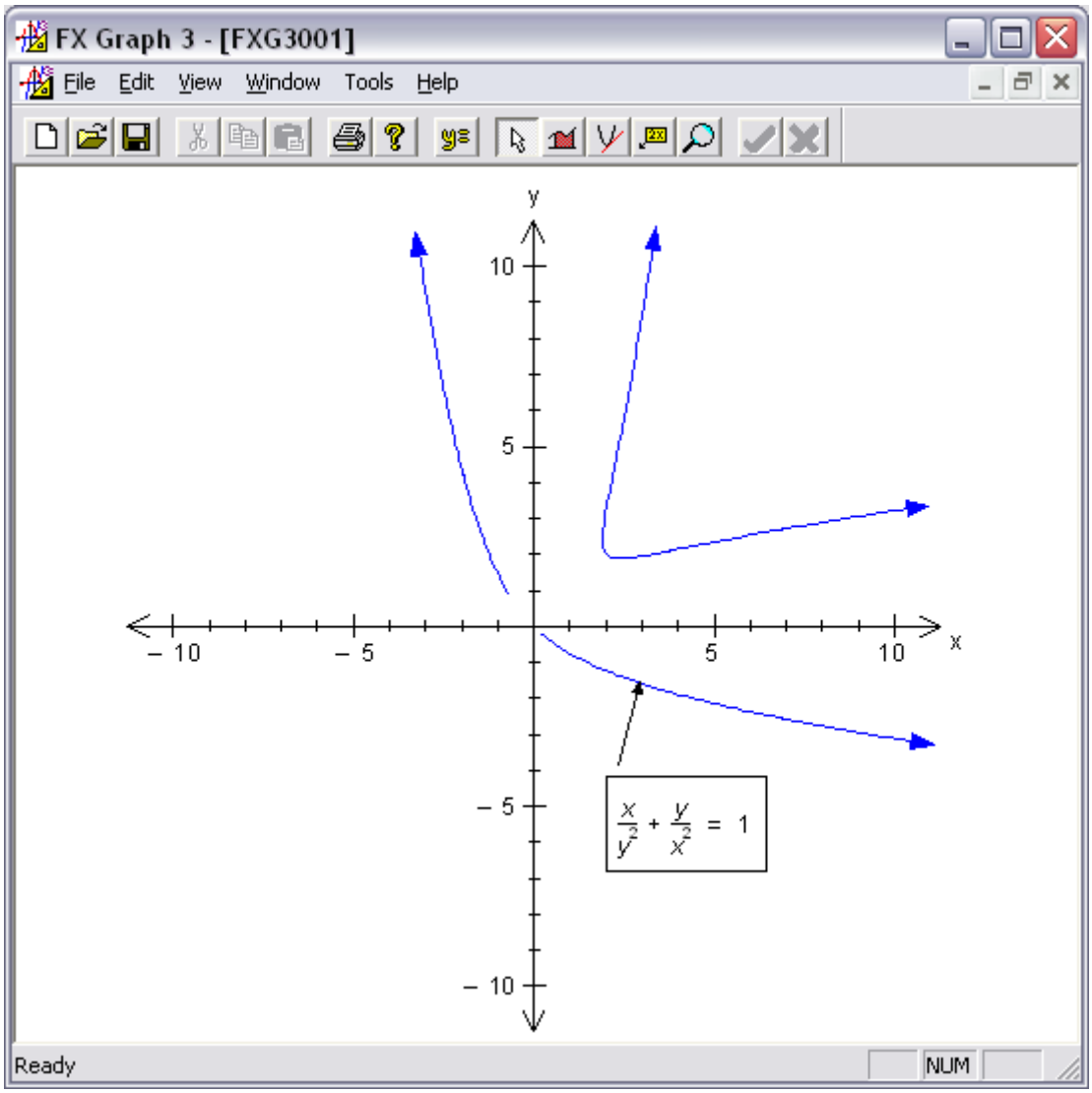
1. FX Graph tries to rearrange the function to be in terms of

   y =
   x =
   y2 =
   x2 =

   and will then graph the function.

2. If FX Graph CANNOT rearrange the function, it uses a more generalised approach to graphing. For example,

   x/y2+y/x2 = 1

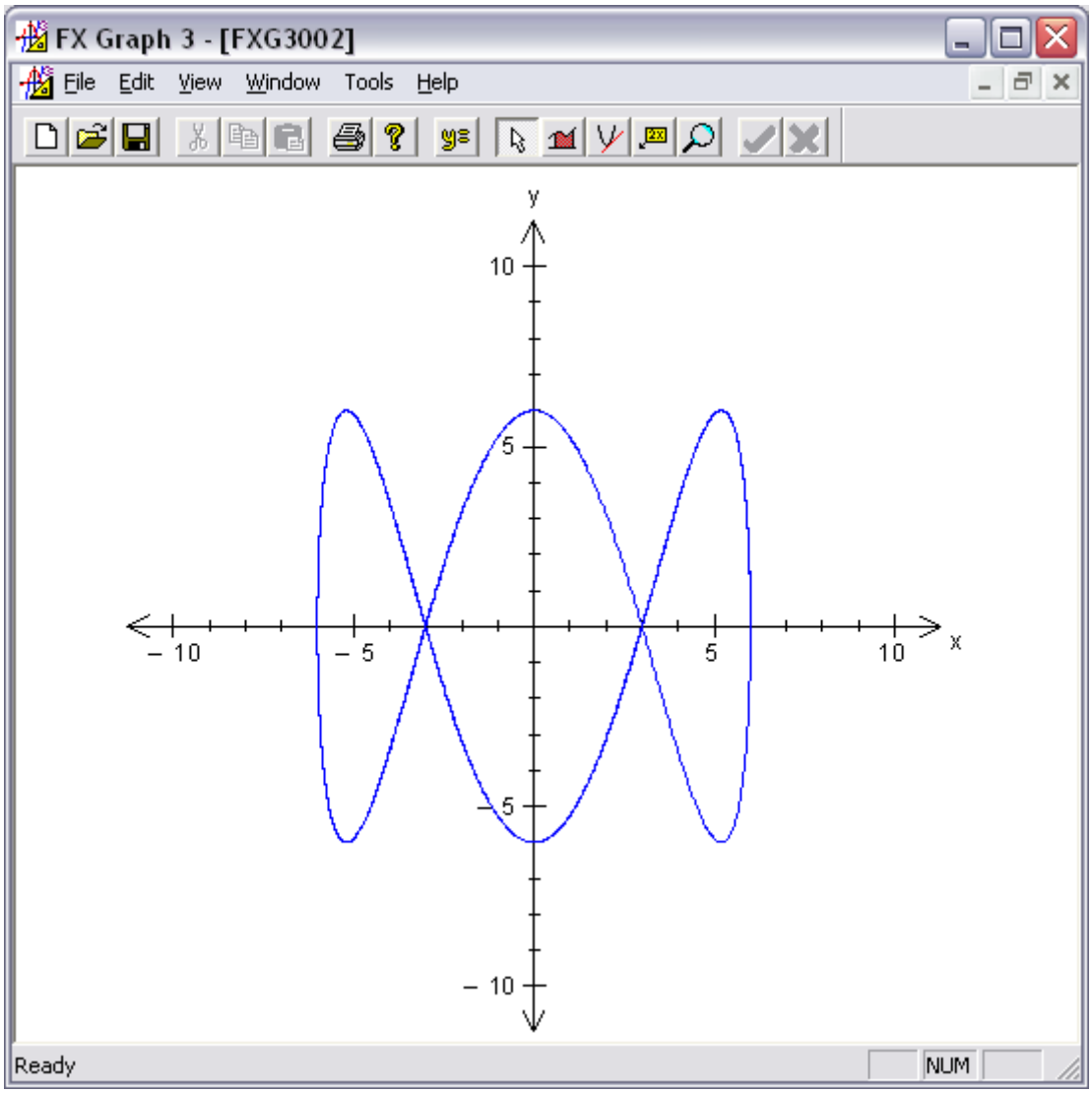


This approach basic looks for equality between the two sides of the equation. When using this form of graphing, FX Graph CANNOT perform detailed analysis of the curve.

5.6.6 Parametric

Parametric curves are entered as two equations in terms of t - separated by a semicolon (see regional issues).

x = 6cos t ; y = 6sin 3t



Regional Issues

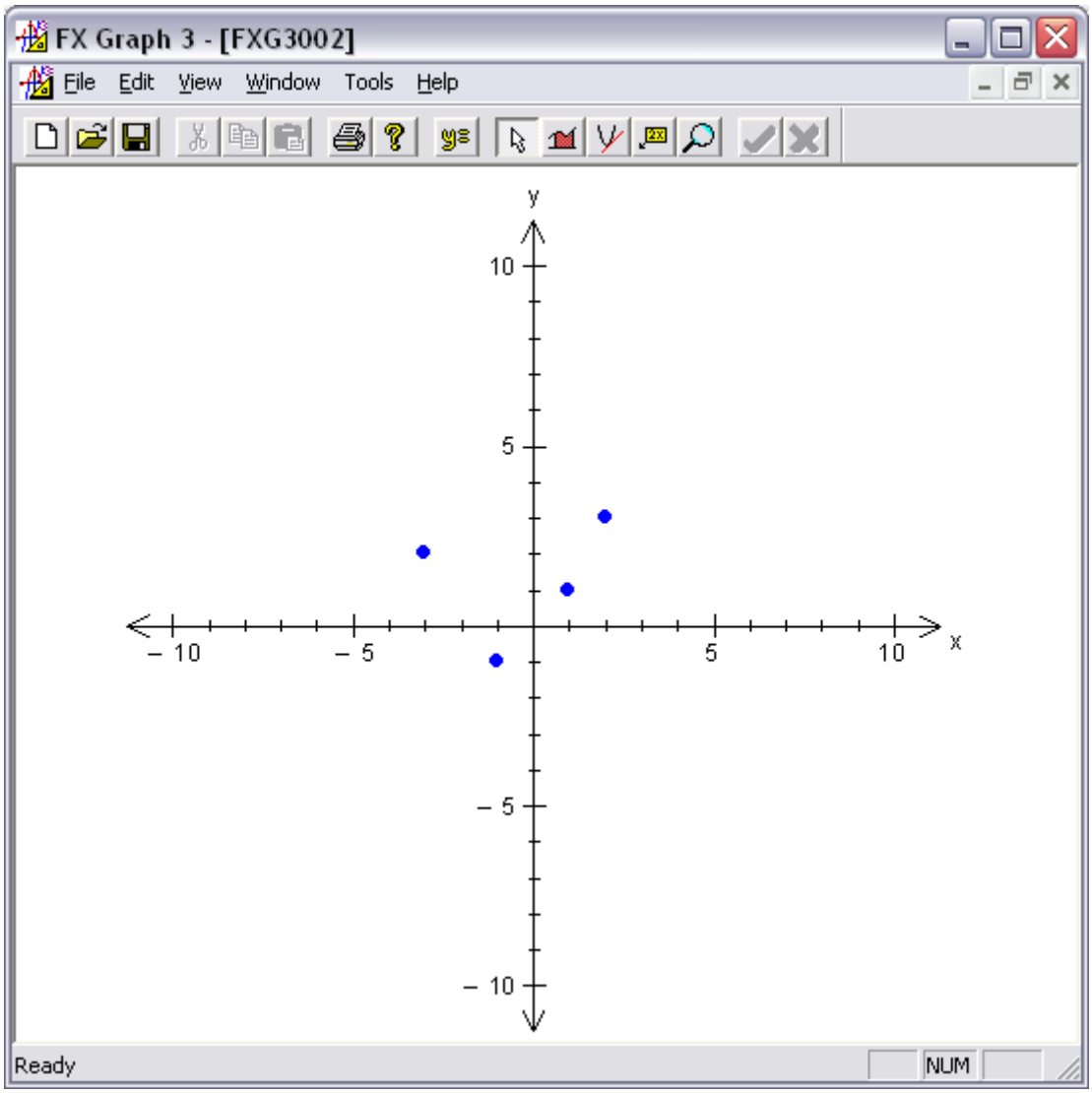
If you use a comma as a decimal point (eg 3,2) you must use a colon to separate the two parts of a parametric equation.

x = 6cos t : y = 6sin 3t

5.6.7 Points

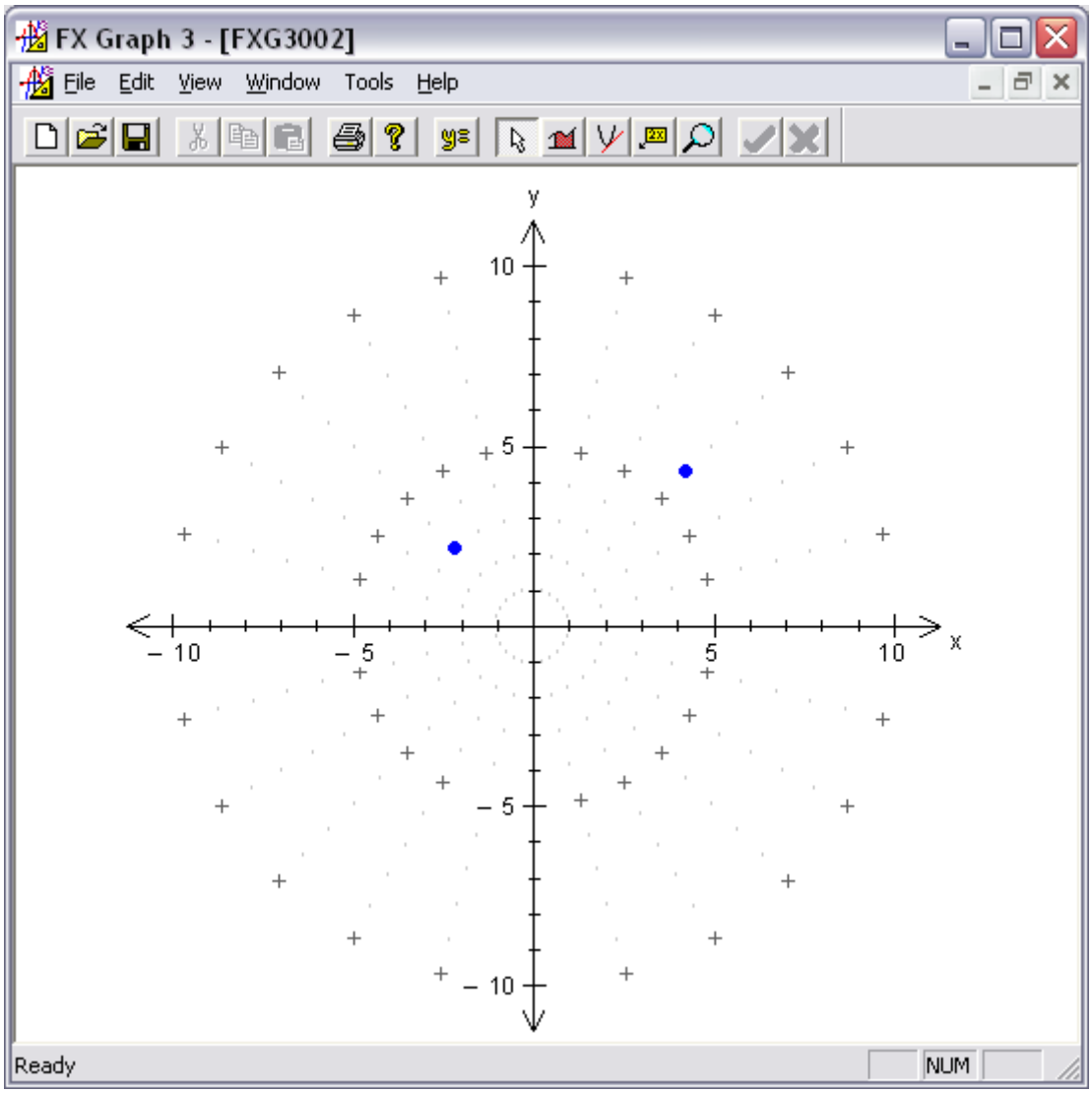
Points are entered as ordered pairs - optionally separated by semicolons (see regional issues).

(2,3) (1,1); (-1,-1) (-3,2)



By prefixing one of the points by a P, FX Graph will interpret all of the points as being in polar form, (r, θ). When entering points in polar form, you need to enter the angle in the currently selected angle type.

P(6,pi/4) (3,3pi/4) - angle set to Radians



Constants

Points can contain constants which are discussed later in this manual. You can enter a point of (-3a,b) for example.

Regional Issues

If you use a comma as a decimal point (eg 3,2) you must use a semicolon to separate the two coordinates and (optionally) a colon to separate the individual points.

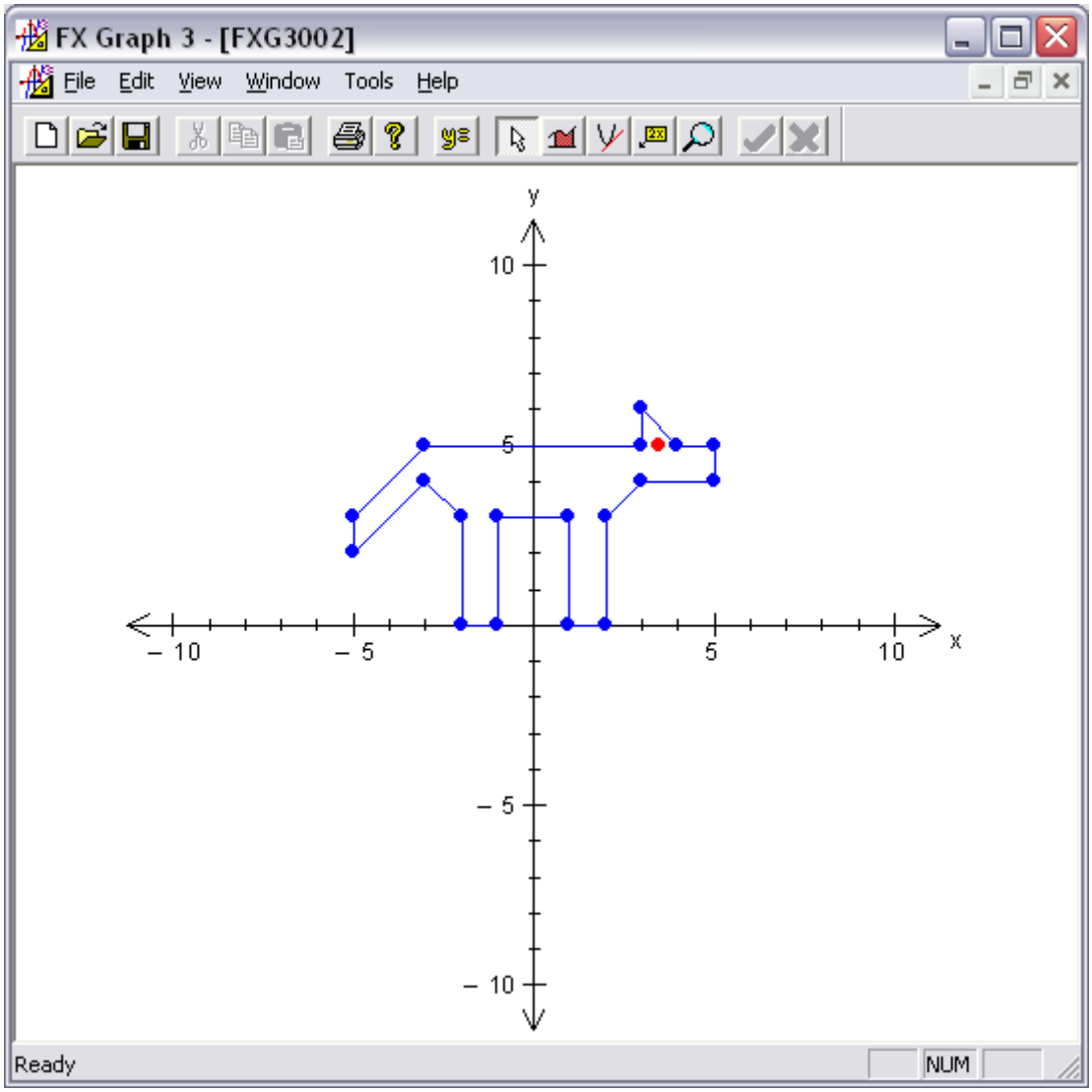
(2;3) (1,1;1,1) : (-1;-1) (-3;2)

5.6.8 Groups of Points

FX Graph can plot groups of points and join them together. Simply place a + sign between the points. See regional issues.

(3,5)+(3,6)+(4,5)+(5,5)+(5,4)+(3,4)+(2,3)+(2,0)+(1,0)+(1,3)+(-1,3)+(-1,0)+(-2,0)+(-

2,3)+(-3,4)+(-5,2)+(-5,3)+(-3,5)+(3,5)



You can mix points and groups of points in the same function.

Regional Issues

If you use a comma as a decimal point (eg 3,2) you must use a semicolon to separate the two coordinates.

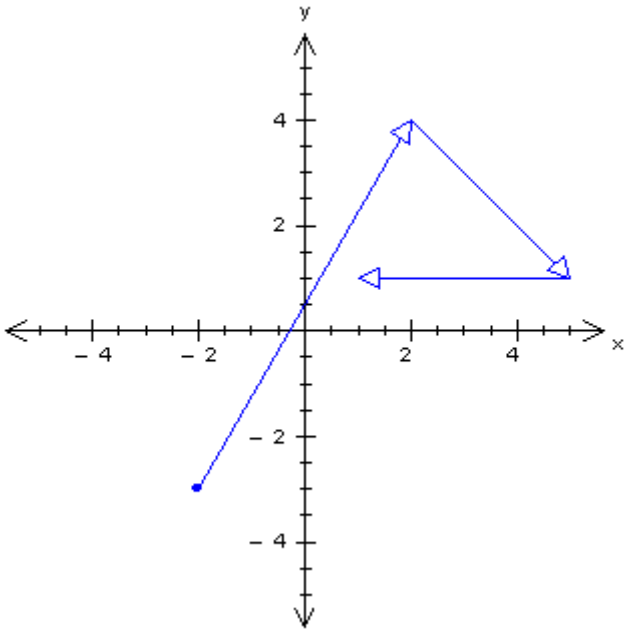
(3;5)+(3;6)+(4;5)+(5;5)+(5;4)+(3;4)+(2;3)+(2;0)+(1;0)+(1;3)+(-1;3)+(-1;0)+(-2;0)+(-2;3)+(-3;4)+(-5;2)+(-5;3)+(-3;5)+(3;5)

5.6.9 Vectors

Vectors are entered as <2,3>. They can be added, subtracted and combined with a point. See regional issues

For example:

(-2,-3) + <4,7> + <3,-3> - <4,0>



Constants

Vectors can contain constants which are discussed later in this manual. You can enter a vector of <-3a,b> for example.

Regional Issues

If you use a comma as a decimal point (eg 3,2) you must use a semicolon to separate the two coordinates.

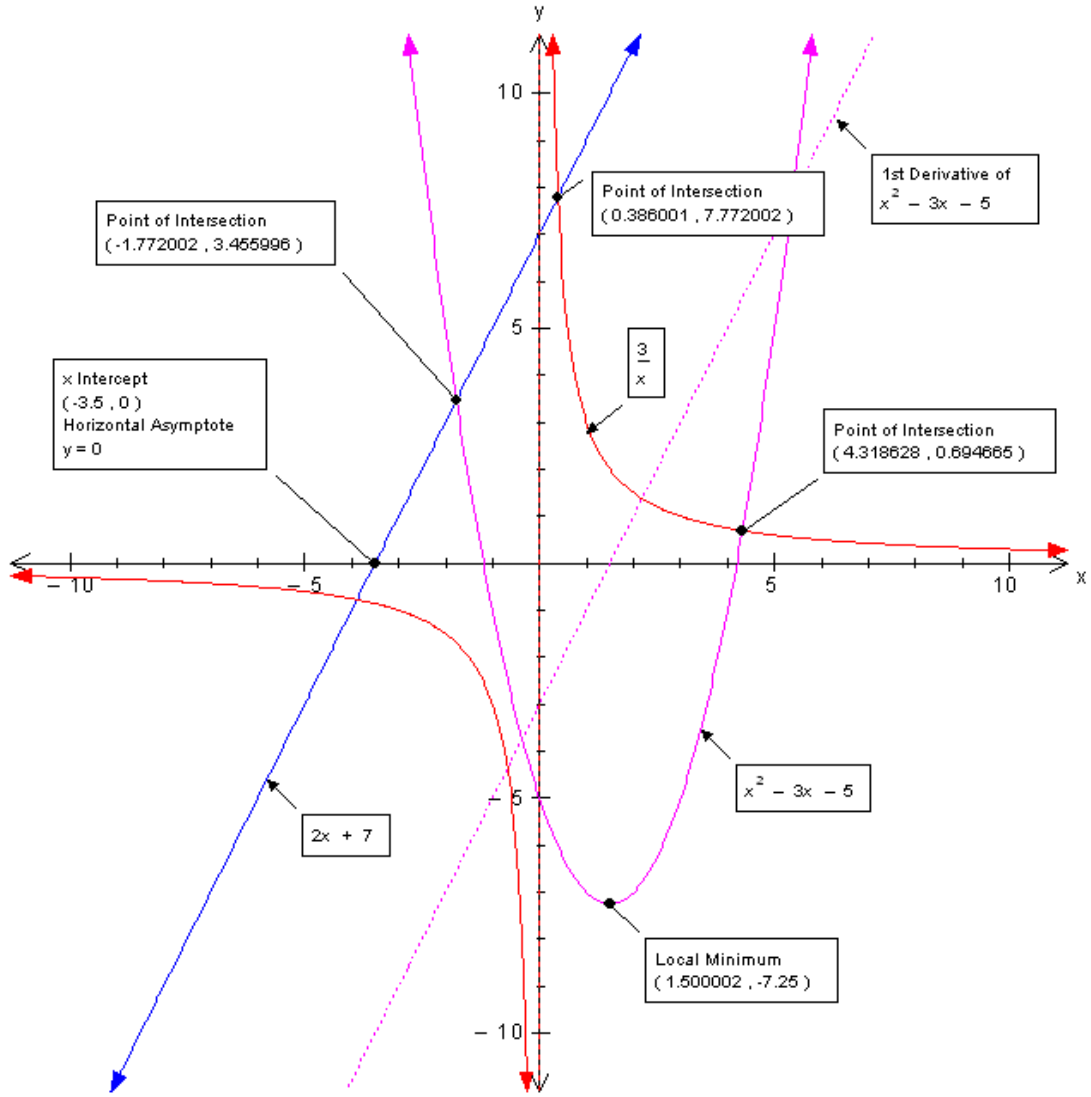
(-2;-3) + <4;7> + <3;-3> - <4;0>

5.7 Function Reference

Command	Description	Example
e	constant e = 2.18281828…	y = e^x
pi	constant π = 3.141592654…	y = pi x2
sin	sine of an angle	y = sin 2x
cos	cosine of an angle	y = cos3 x
tan	tangent of an angle	r = 2tan th
asin or sin-1	arcsine or inverse sine	y = asin (x) y = sin-1(x)
acos or cos-1	arccosine or inverse cosine	as above
atan or tan-1	arctangent or inverse tangent	as above
sec	secant of an angle	y = sec2 x
cosec	cosecant of an angle	as above
cot	cotangent of an angle	as above
cosh	hyperbolic cosine	y = cosh x
sinh	hyperbolic sine	y = sinh x
tanh	hyperbolic tangent	y = tanh x
ln	natural logarithm	y = ln(2 x)
log	base 10 logarithm	y = log(

5.8 Points of Interest

FX Graph finds most points of interest for you - automatically. You do not need to "do" anything - just move the mouse around the graph. Any points of interest will be marked and a short message giving the coordinates and why it is "interesting". All of the points in this diagram have been found automatically and displayed by hovering the mouse over the point.



5.9 Right Clicking

Much of FX Graph's functionality is accessed by right-clicking.

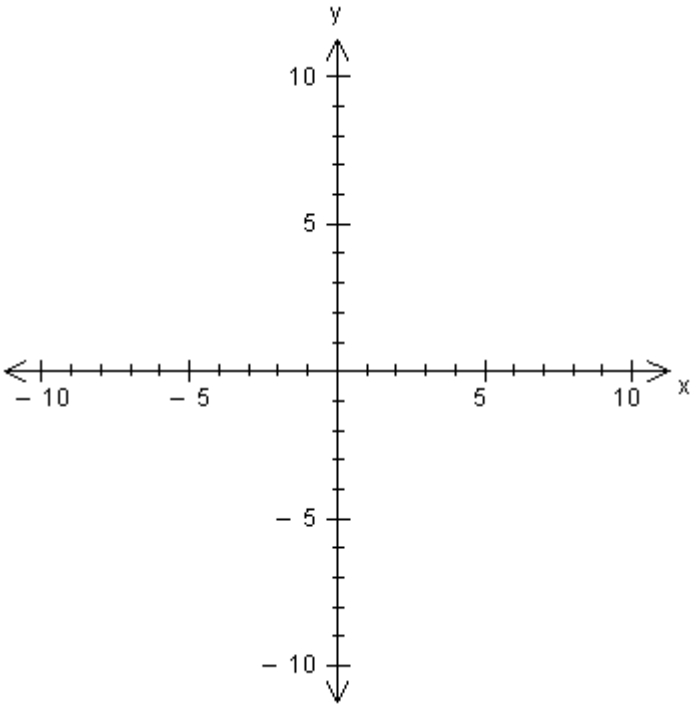
- If you right click on blank space, the Quick Entry screen is displayed.
- If you right click on a function, a mini-menu is displayed.
- If you right click on an integral, annotation or tangent line, you can edit their properties.
- If you right click on the axes, the axes screen is displayed (this feature can be disabled in Tools/Preferences)

5.10 Select Mode

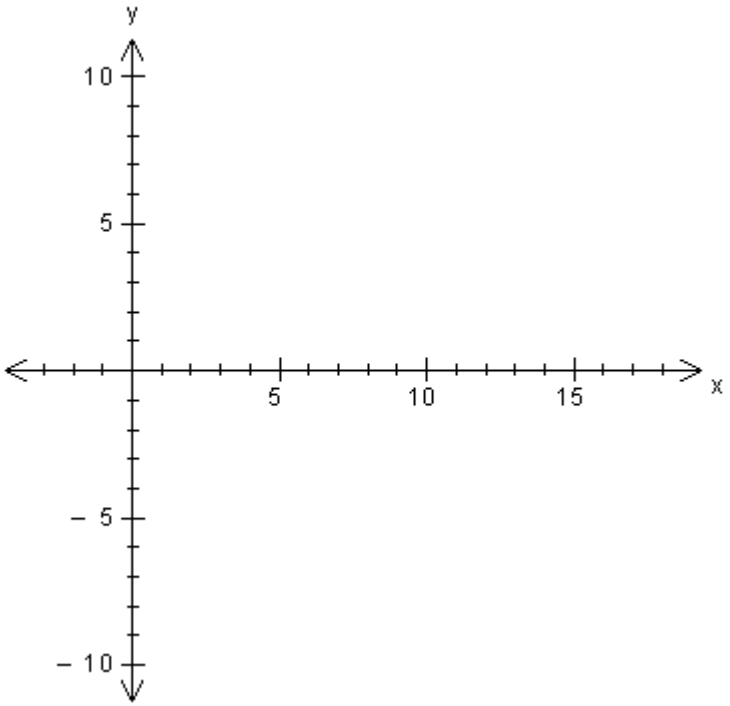
Select Mode is the basic mode of FX Graph. You can choose select mode by pressing the button on the toolbar. When in select mode, you can select most objects in a graph.

5.11 Moving Around The Plane

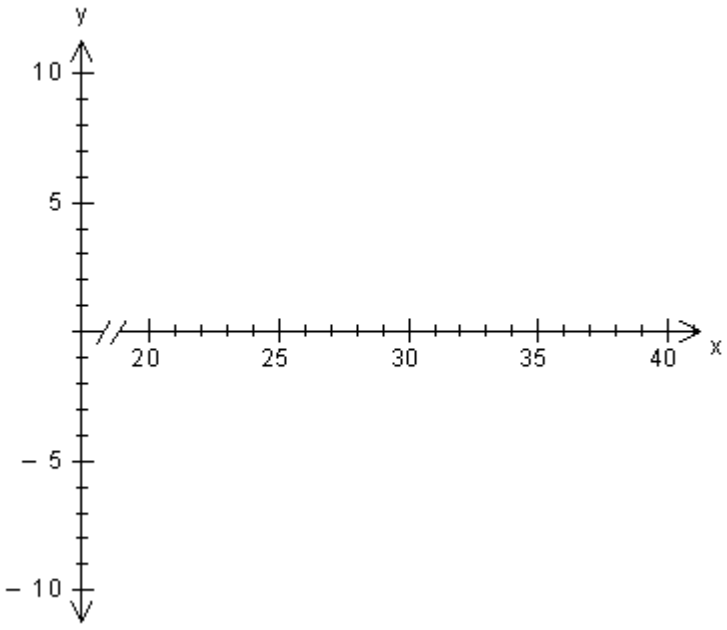
You can move around your axes using the arrow keys on your computer. If we have a set of axes such as



pushing the right arrow a few times will result in



We have moved to the right. If we push the right arrow a few more times we will see



FX Graph will break the scale (if you have allowed it to) and move further to the right of the plane.

You can use all four arrow keys to move anywhere on the plane.

The Home Key

Pressing the home key at any stage will return you to the origin.

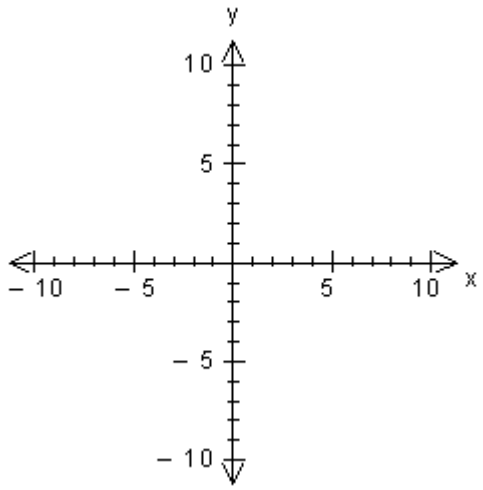
5.12 Zooming

FX Graph's Point of Interest system greatly reduces the number of times you will wish to zoom into a graph but FX Graph supports zooming in a number of ways.

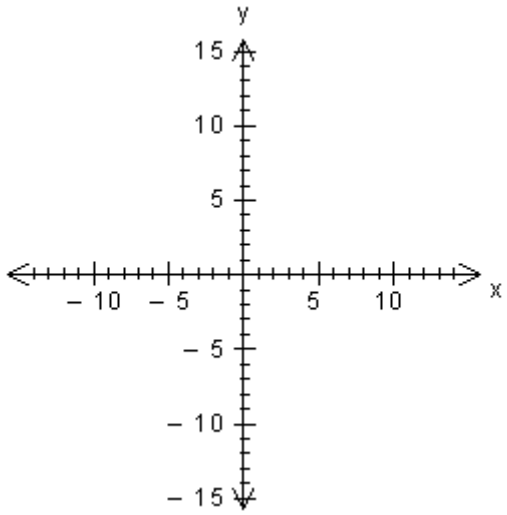
5.12.1 Zooming with the Keyboard

You can zoom in and out using the keyboard.

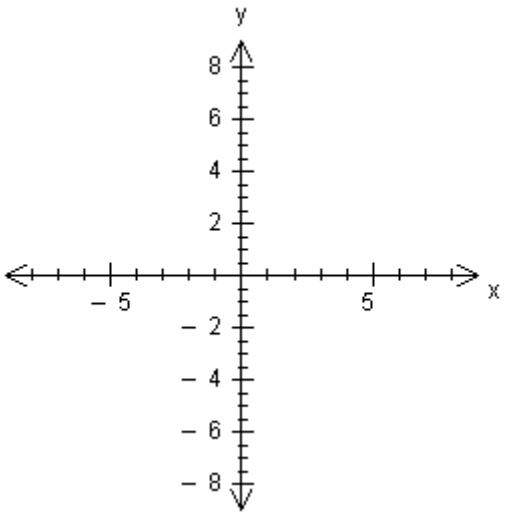
Starting Axes



Page Up - Zooms OUT by 33%



Page Down - Zooms IN by 33%



5.12.2 Zooming with the Mouse

5.12.2.1 Zoom Mode

Before using your mouse to zoom, you must first enter Zoom Mode. Push the button on FX Graph's toolbar. The cursor will change to to remind you that you are using Zoom mode.

Once in Zoom mode you can use the mouse to Zoom into and out from functions.

5.12.2.2 Click Zooming

If you click the left mouse button somewhere on the plane, FX Graph will zoom into the point you click on. This allows you to quickly and easily zoom in on points of interest.

5.12.2.3 Rectangle Zooming

If you sweep out a rectangle while holding down the left mouse button, FX Graph will zoom into the rectangle you have defined.

5.12.2.4 Right Click in Zoom Mode

FX Graph remembers the axes' settings as you zoom in. If you right-click while in Zoom mode, FX Graph will go back one step. This is sort of an "undo" for zoom.

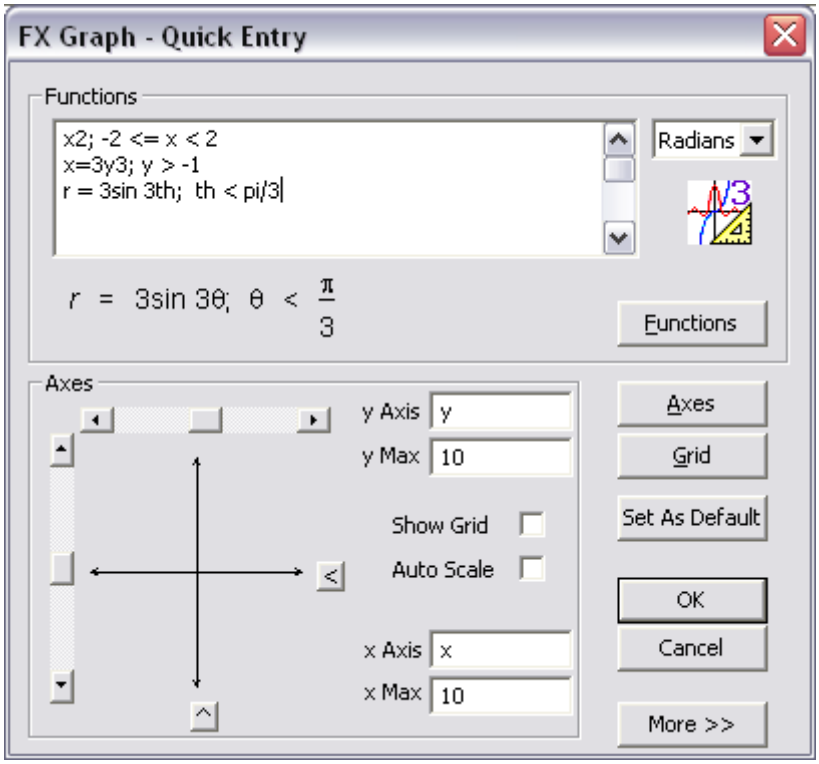
5.13 Domains

Domains can be entered for most functions using one of two formats.

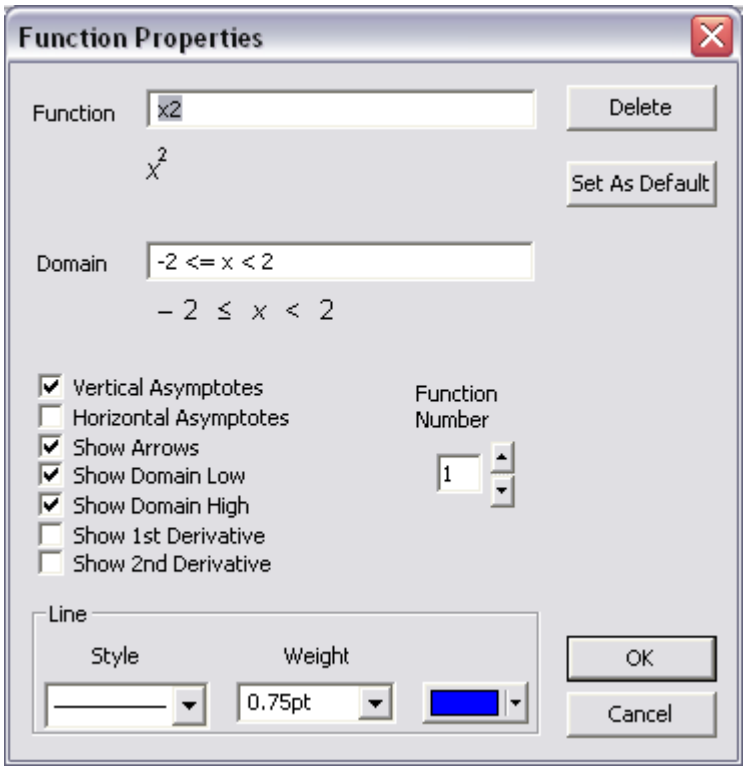
1. Using greater than, less than, greater than or equal to and less than or equal to signs. These are typed after a semicolon (or colon if you use a , as a

decimal point) after the function when entering functions in the Quick Entry screen.

For example:

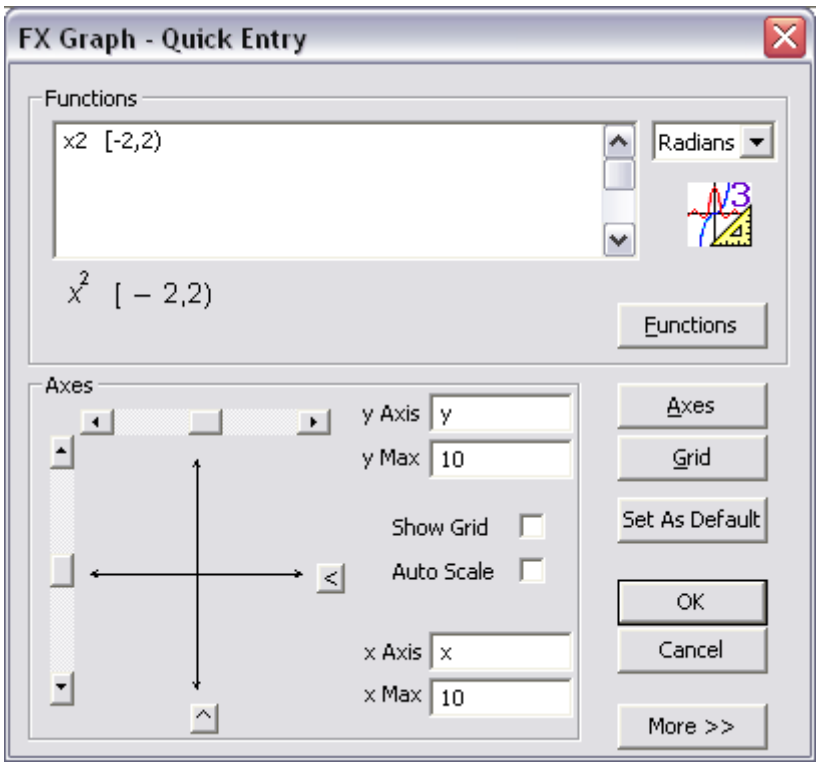


By pushing the function button, you can see the domain of the function as a separate entity.



2. You can also enter domains using bracket notation, (-2,3] for example. Parentheses indicate > or < and square brackets ≤ or ≥. This style of domain is quicker to use and does not require a semicolon (or colon).

For example:



Constants

Domains can contain constants which are discussed later in this manual. You can have a domain of [-3a,b) for example.

Regional Issues

If you use a comma as a decimal point (eg 3,2) you must enter domains either as

x2 : -2<=x<2
or
x2 [-2;2)

5.14 Default Domains

If you have not explicitly set a domain, FX Graph will choose one for you.

Cartesian and inverse graphs have a domain implied by the size of the axes and FX Graph will automatically draw a graph for this implied domain.

Polar and parametric graphs have no implied domain so FX Graph uses:

Polar graphs	**$0 \le \theta \le$ 360 (degrees mode)**
	$0 \le \theta \le 2\pi$ (radian mode)
	$0 \le \theta \le$ 400 (grad mode)
Parametric graphs	**$0 \le$ t $\le$ 20**

If your polar or parametric graph is incomplete, you may need to set your own domain.

5.15 Constants

5.15.1 Entering Constants

FX Graph understands seven constants.

Fixed Constants

e ~ 2.718281828
pi ~ 3.141592654

These constants can be used in functions, axes, domains, points and vectors.

Variable Constants

Variable constants (now there is an interesting concept - they probably should be called parameters) allow you to examine how changing numbers in a function

affects the function's shape.

FX Graph reserves a, b, c, d and m as constants that can be included in functions. They are entered in the same way as the variables x, y, r, t and th.

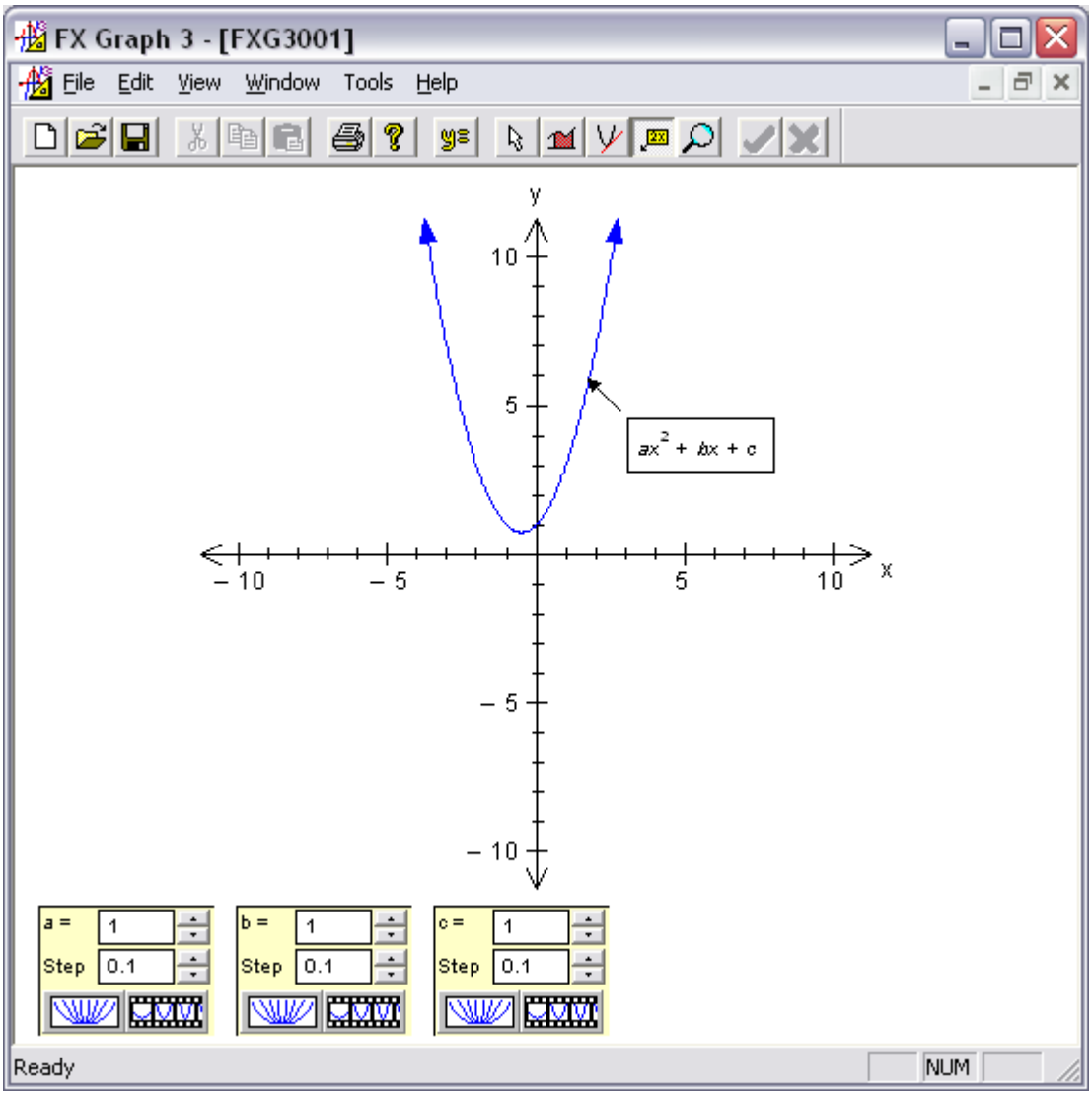
For example, you can enter the following function

y = ax2 + bx + c

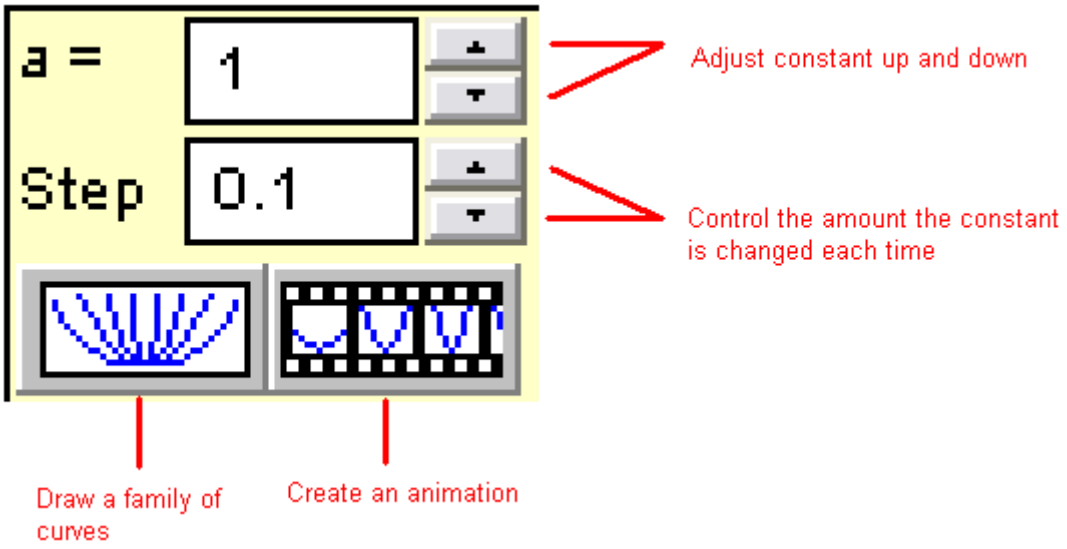
and examine how changing a, b and c affects the parabola.

5.15.2 Changing Constants

When FX Graph detects a constant in a function, it automatically adds a constant controller to the bottom of its screen. FX Graph adds one constant controller for each constant.



Let's look at a constant controller in more detail.



The top two buttons control the constant. Pushing the up arrow will increase a from 1 to 1.1. Pushing the down arrow will decrease it to 0.9.

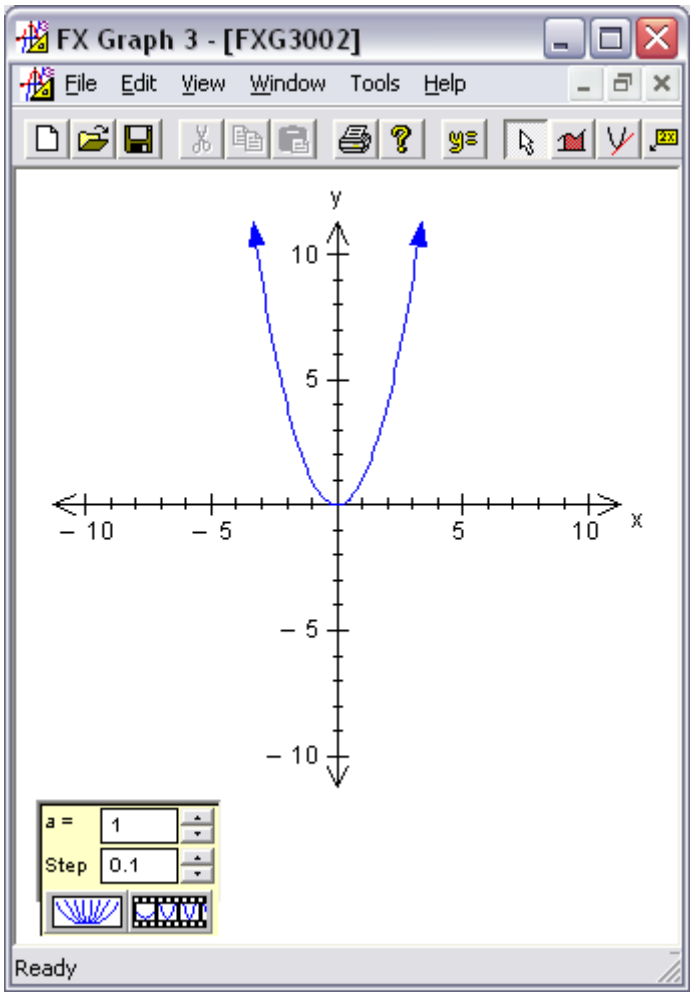
The step buttons allow you to control how much a is changed each time. At the moment the step is 0.1. Pushing the up arrow will increase it to 0.25. Pushing the down arrow will decrease it to 0.05.

You can also type new values for a and Step directly into to the boxes.

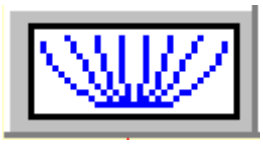
We will discuss Families of Curves and Animations later in the next sections.

5.15.3 Families of Curves

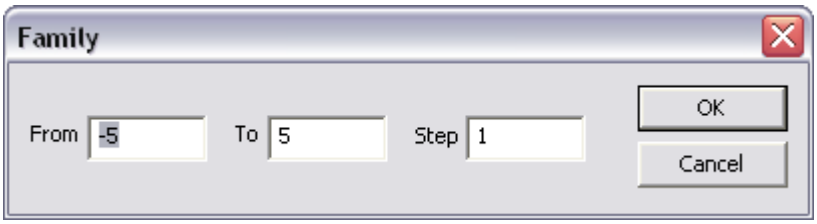
Entering y = ax2 into FX Graph gives you the following screen.

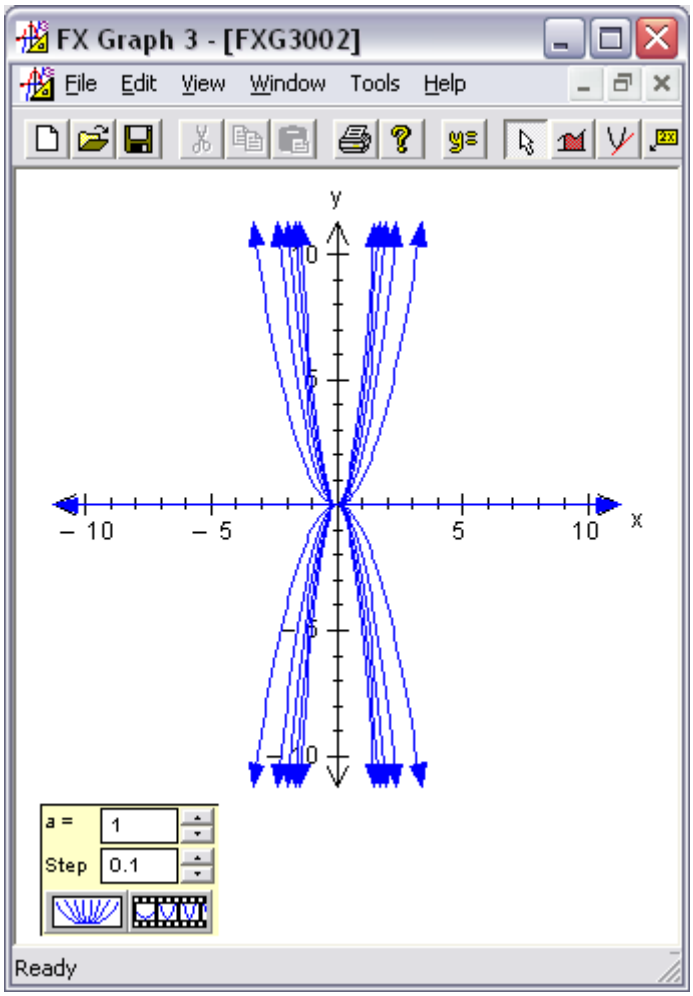


Pushing the Family of Curves button



allows you to set the start, finish and step for a family of curves.



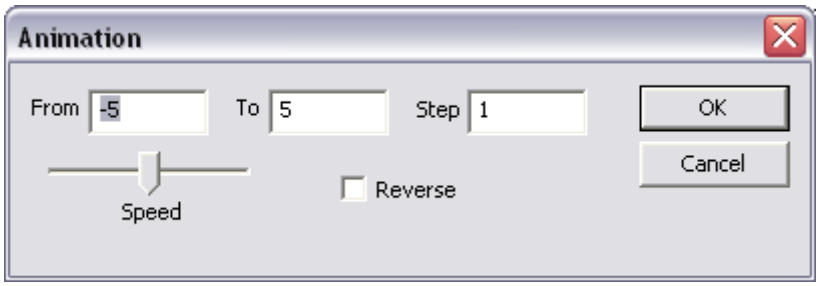


Here we can see all the parabolas in the family: $-5x^2$, $-4x^2$, $-3x^2$, $-2x^2$, $-1x^2$, $0x^2$, x^2, $2x^2$, $3x^2$, $4x^2$, $5x^2$,

5.15.4 Animations

A constant in a function can be animated - changed over time. Using the parabola from the last section, this time push the Animation button

You will see the following screen.



This is very similar to the Family of Curves screen, the only differences being the Speed bar and Reverse. Speed controls the speed of the animation.

Put in your settings and push OK. FX Graph will animate your function by changing a and regraphing the curve.

If you used the settings above, FX Graph would replace a with

-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, **5, -5**, -4, -3, -2, -1, 0, 1, 2, 3, 4, **5, -5**, -4, -3, -2, -1...

Notice that when FX Graph gets to 5, it starts again at -5. Checking the Reverse box forces FX Graph to animate slightly differently.

-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, **5, 4**, 3, 2, 1, 0, -1, -2, -3, -4, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, **5, 4**, 3, 2, 1, ...

Instead of starting again at -5, FX Graph counts down in Reverse, back to -5.

Brain Drain

Animating functions in FX Graph is very computationally intensive because FX Graph has so much to calculate each time. Intercepts, maxima and minima, integrals, derivatives... everything is recalculated. This means that on slower computers, the animations may not be as fast as you would like.

Stopping an Animation

You can stop an animation by left-clicking anywhere on the graph.

Animation with Multiple Constants

If you have more than one constant, you can change the other constants **during** the animation. Try animating the c constant in y = ax2 + bx + c. While the animation is running, change a and b.

5.16 Inequations & Feasible Regions

5.16.1 Entering Inequations

Inequations are entered by replacing the = sign in your equation by either,

>, <, >= or <=

Inequations can be entered for all function types except parametric.

x + y <= 4

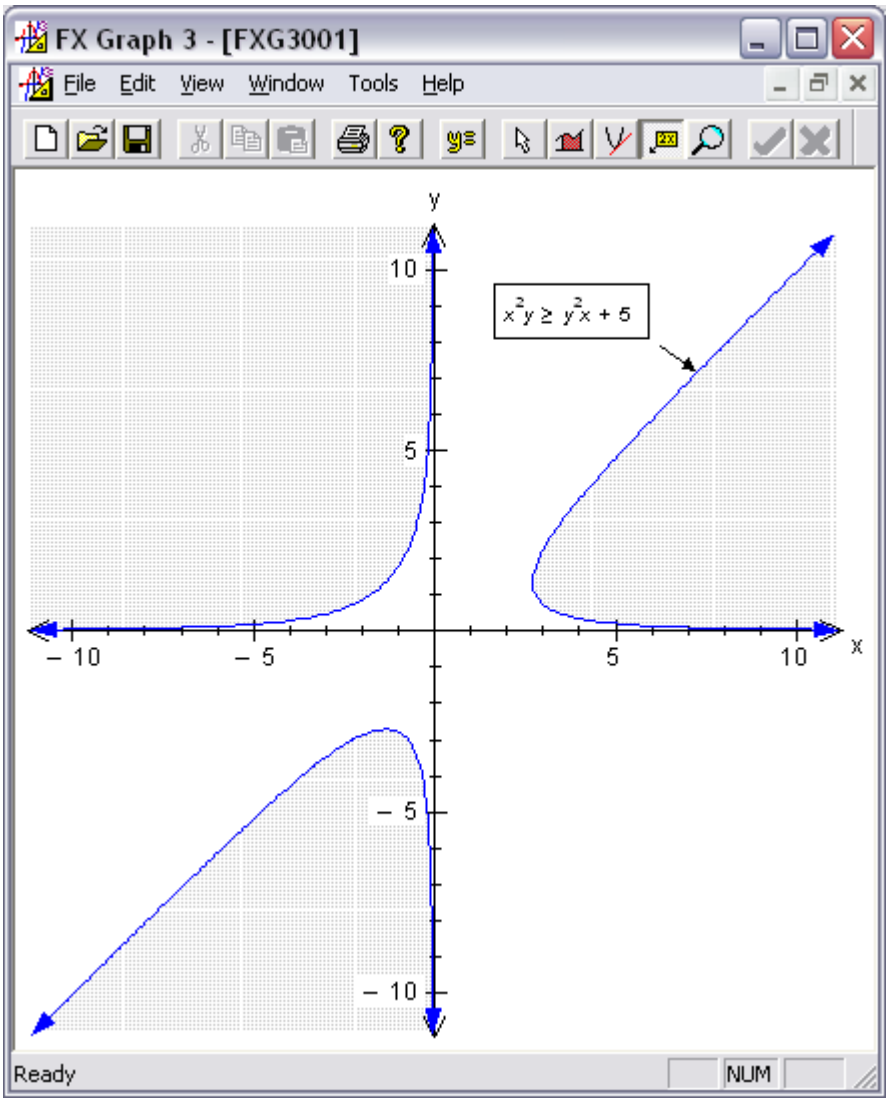
r > 2 sin th

xy2 >= yx2 + 4

y >= 2x-7

x > 0

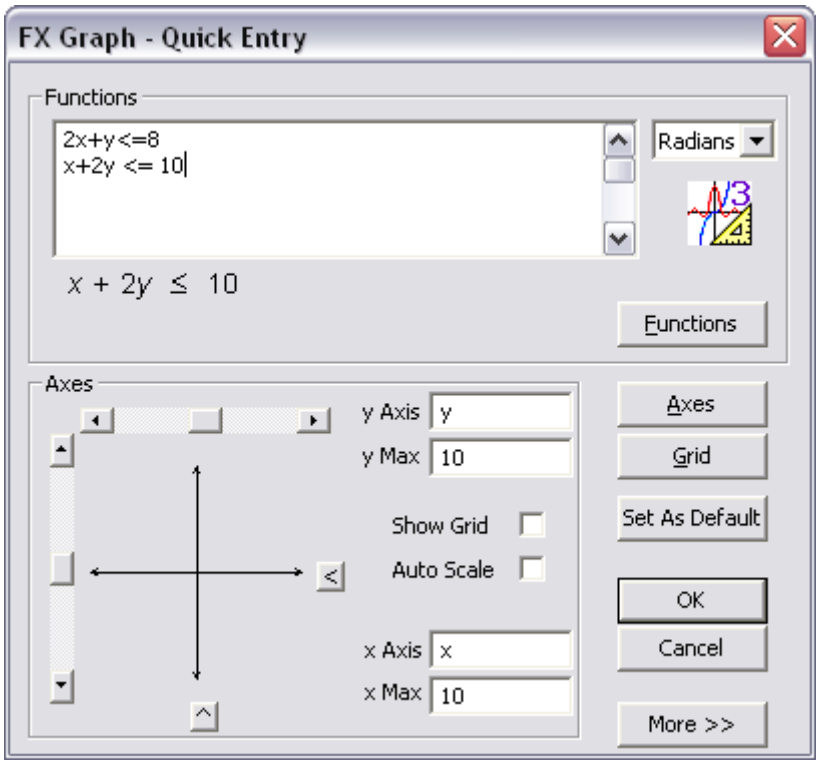
FX Graph will produce a shaded graph depending on your Feasible Region Options.



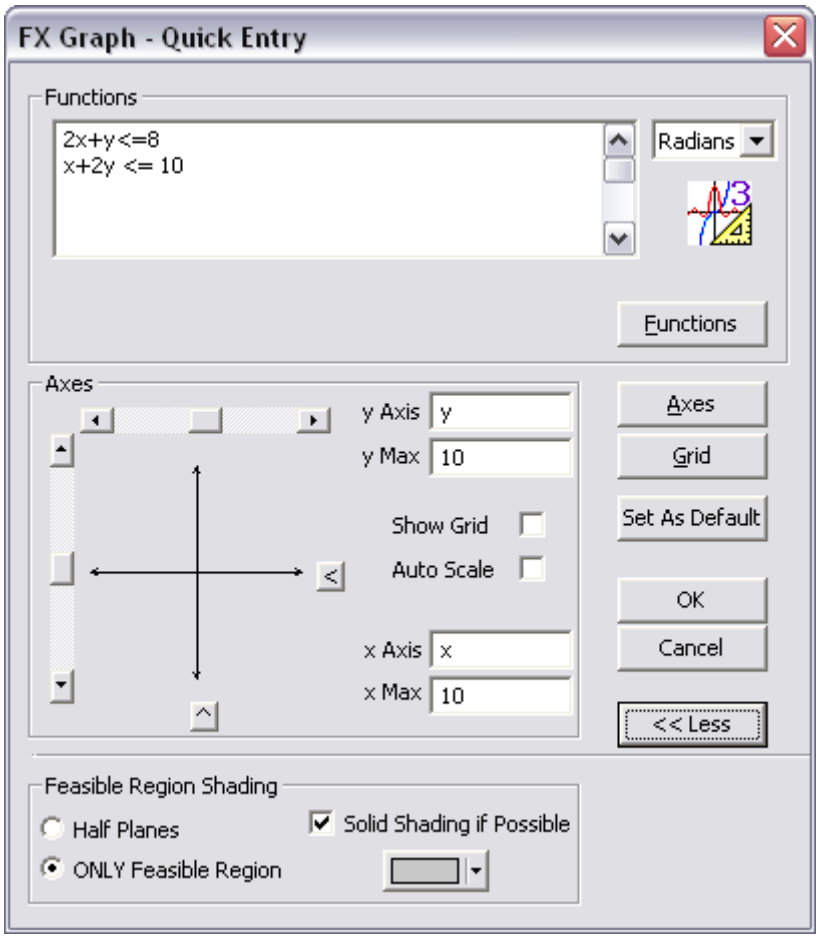
5.16.2 Feasible Region Options

On many occasions, you will be entering a number of inequations and trying to identify the region that satisfies ALL the inequations - also known as the feasible region.

FX Graph can show the feasible region in a number of ways - depending on your needs. The feasible region options can be changed by opening the Quick Entry screen



and pushing the More>> button.



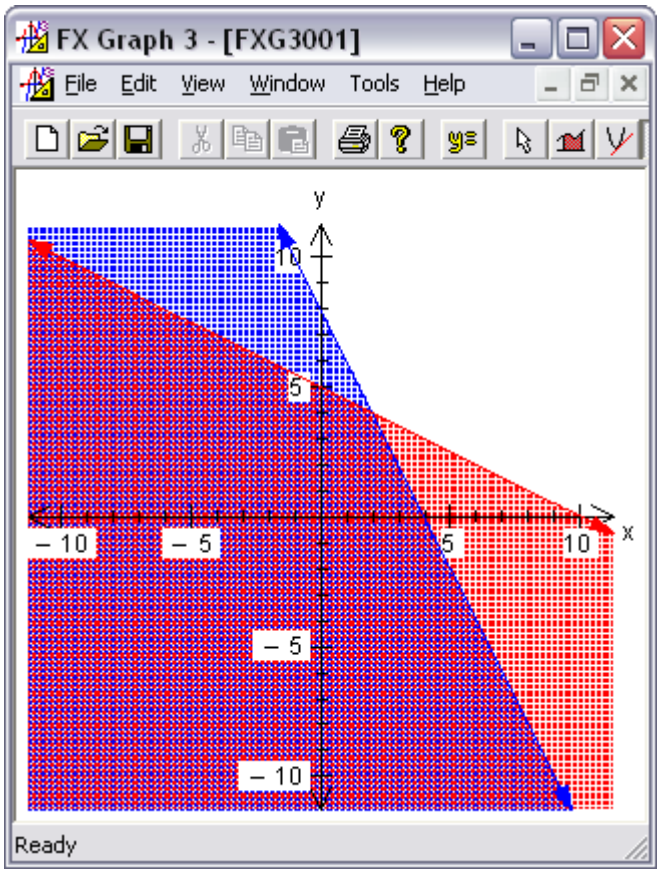
The Feasible Region options are described in the next sections.

5.16.2.1 Half Planes or Feasible Region

When graphing multiple inequations, FX Graph can graph each as a half plane, or combine the inequations and shade ONLY the feasible region.

For example, if we graph **2x + y <= 8** and **x + 2y <= 10**

Half Planes

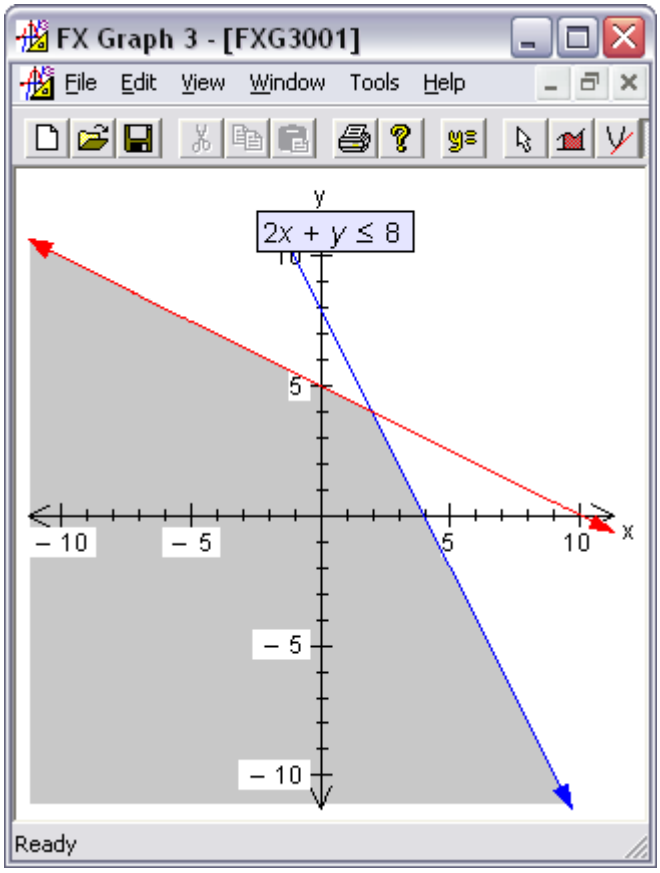


Shading half planes

When shading half planes, FX Graph shades the region which satisfies each equation INDIVIDUALLY. In the above example, the region which satisfies both inequations has been shaded twice. FX Graph uses each function's color for its shading.

If you prefer, you can set FX Graph to shade the half plane that does NOT satisfy the inequation. This option is available by choosing Preferences from the Tools menu.

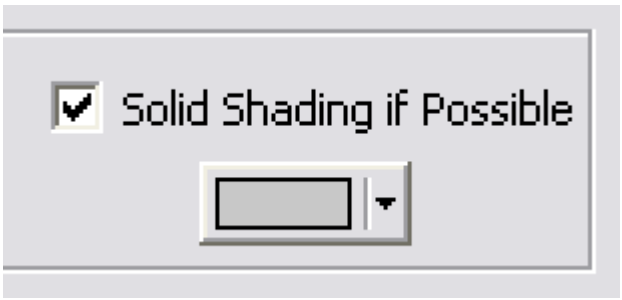
Only Feasible Region

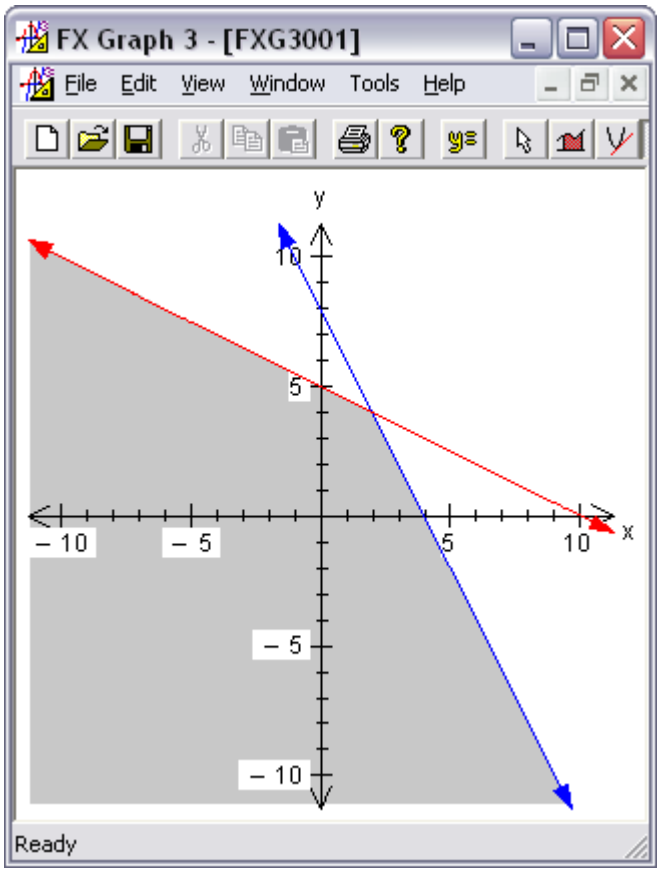


Shading ONLY feasible region

In the second graph, FX Graph has calculated the region which satisfies BOTH inequations and has shaded just that region. This is often more clear. The area is shaded using the color selected in the Quick Entry screen.

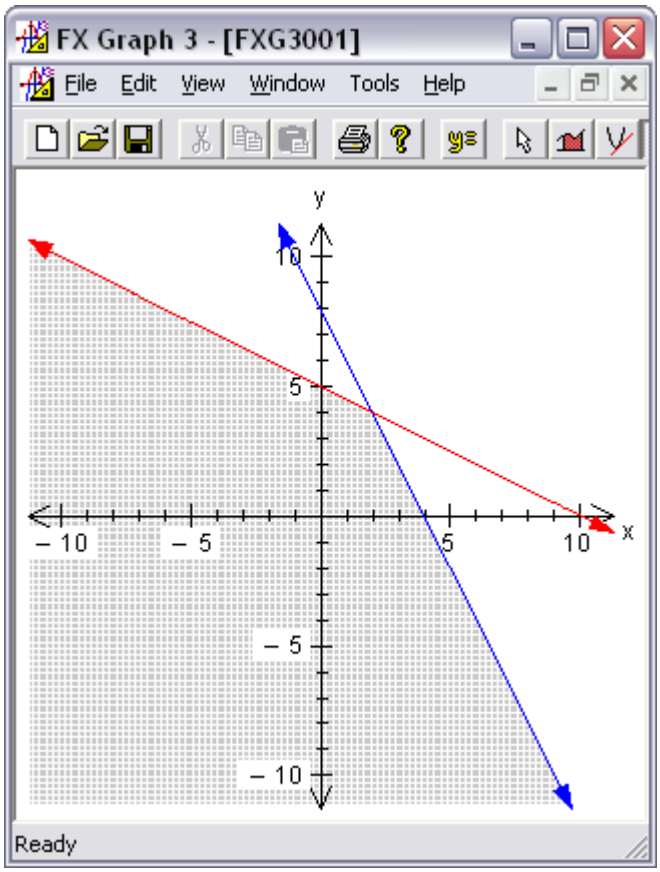
5.16.2.2 Solid Shading





Solid Shading

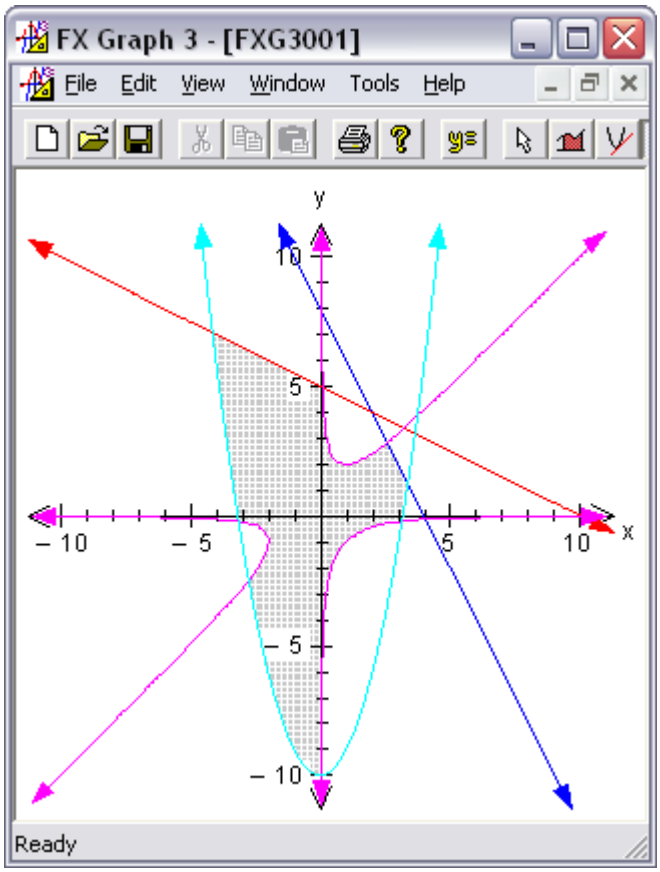
Solid shading is one block of solid color. Solid shading has the advantage of being faster to calculate and displays better on some devices. FX Graph uses solid shading when you have allowed it to and when the system of inequations is not too complicated for its systems.



Dotted shading

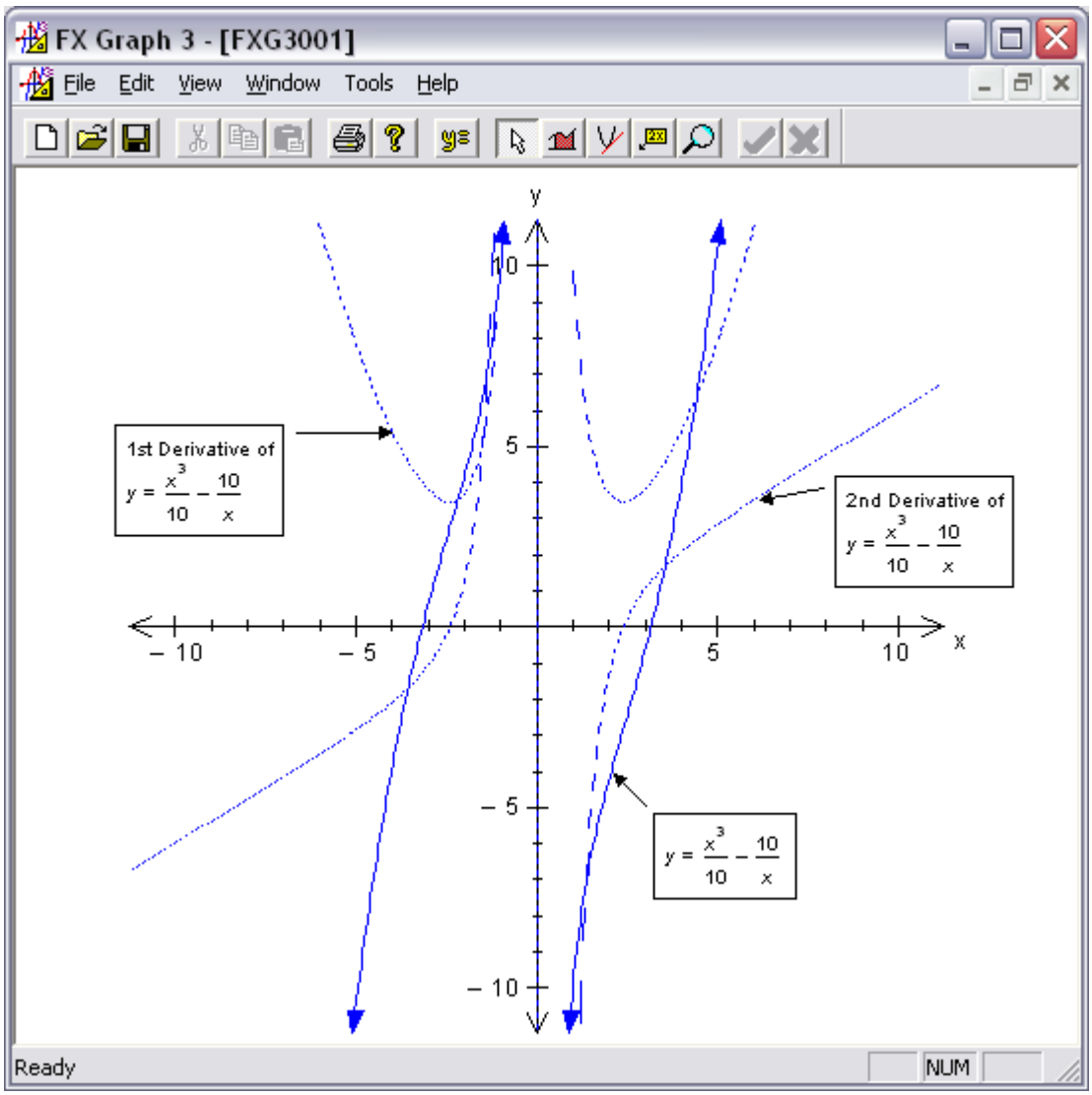
Uses an array of dots. FX Graph tests an array of coordinates and determines whether each point satisfies all inequations. Any points which satisfy all inequations are displayed. Dotted shading is a more robust approach - the complexity of the regions does not matter - but it is computationally intensive and does not display as well on some devices.

FX Graph will use dotted shading when the system of inequations is too complicated to solve. For example,



5.17 Derivative Curves

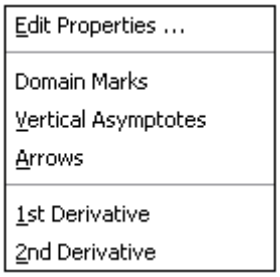
Cartesian functions can displayed with their first and second derivative curves.



To draw derivative curves for a function you have two options.

Right Click

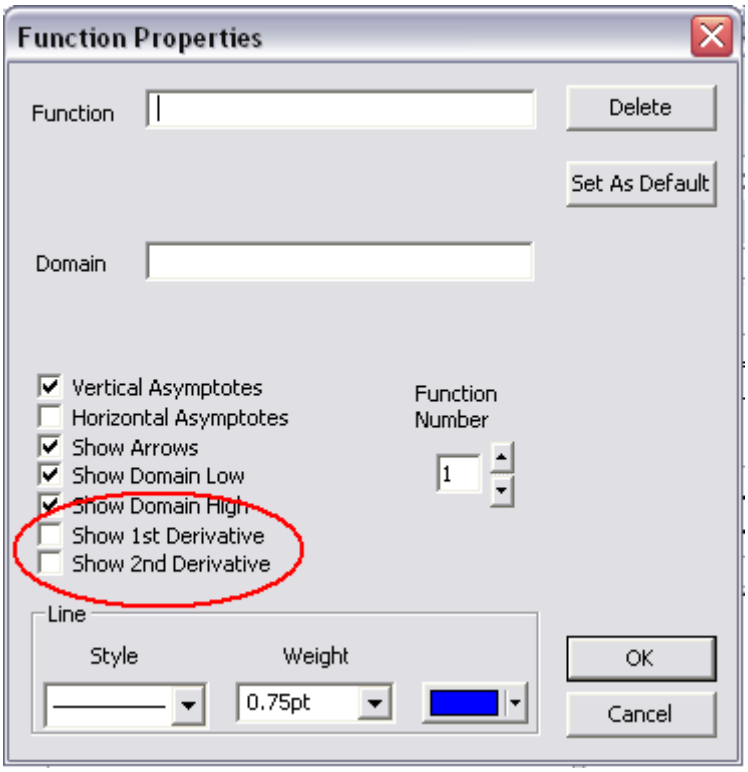
If you right click on an existing function you will see this mini-menu



You can select 1st and 2nd derivative curves on this mini menu.

Functions Screen

You can access the Functions Screen from the Quick Entry screen or by choosing Edit Properties on the mini-menu above.



5.18 Integrals

FX Graph can graph integrals for any Cartesian function.

5.18.1 Using Your Mouse to Create Integrals

5.18.1.1 Integral Mode

Before using your mouse to create an integral, you must first enter Integral Mode.

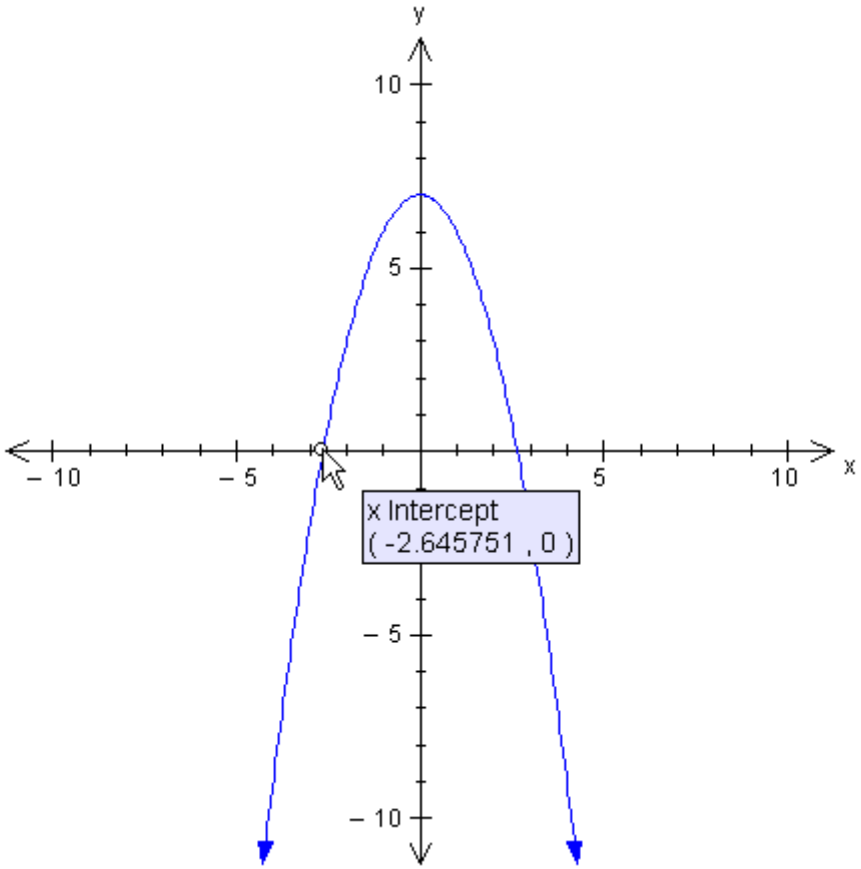
Push the button on FX Graph's toolbar. The cursor will change to to remind you that you are using Integral mode.

Integral mode is only available if you have entered a function that FX Graph can integrate.

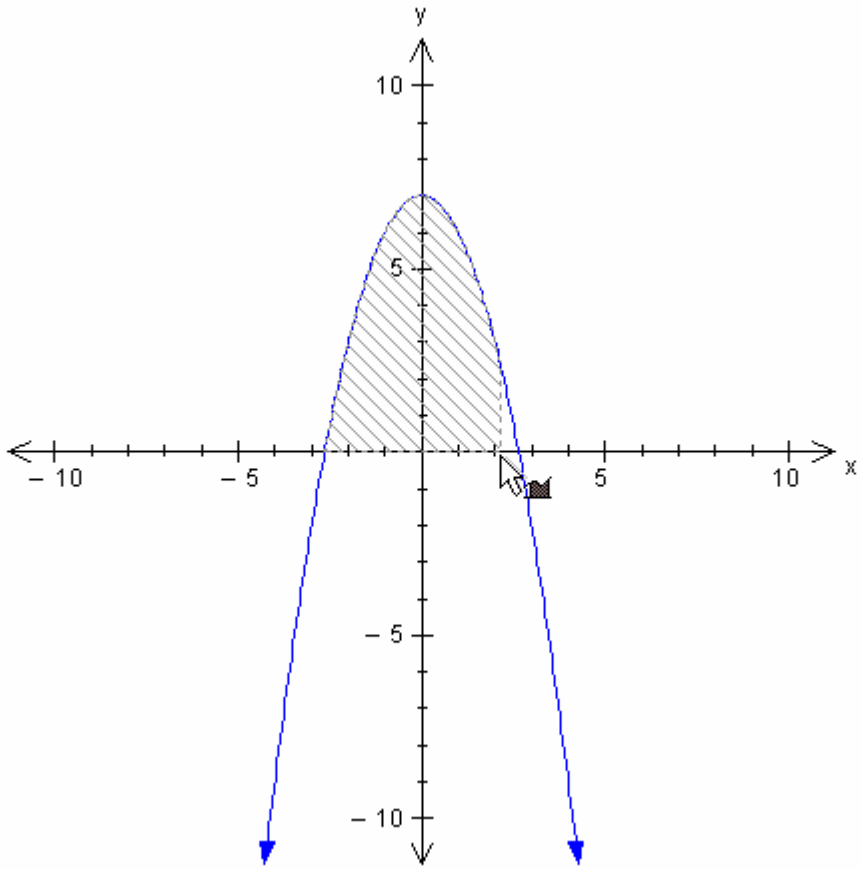
Once in Integral mode you can use the mouse to create integrals.

5.18.1.2 Integral Below One Curve

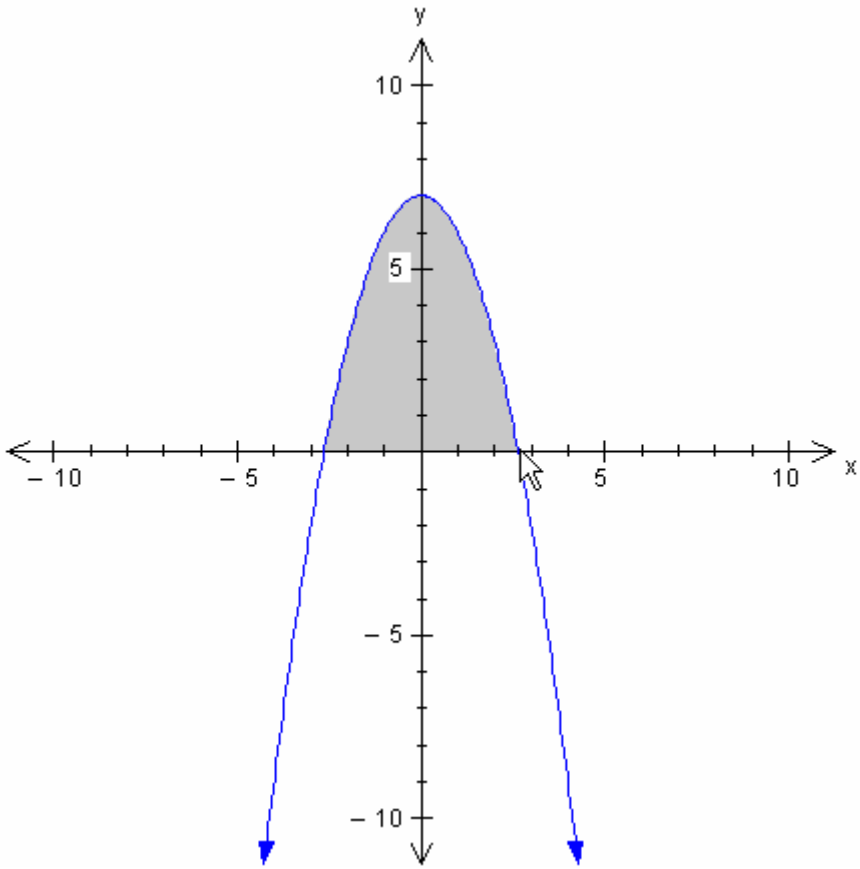
To sketch an integral below one curve, make sure you are in Integral mode. Move your mouse until the start point of your integral is shown. I have picked the x intercept but I could also have picked any point on the curve. The important thing is to wait until FX Graph gives you a message indicating it has found the function.



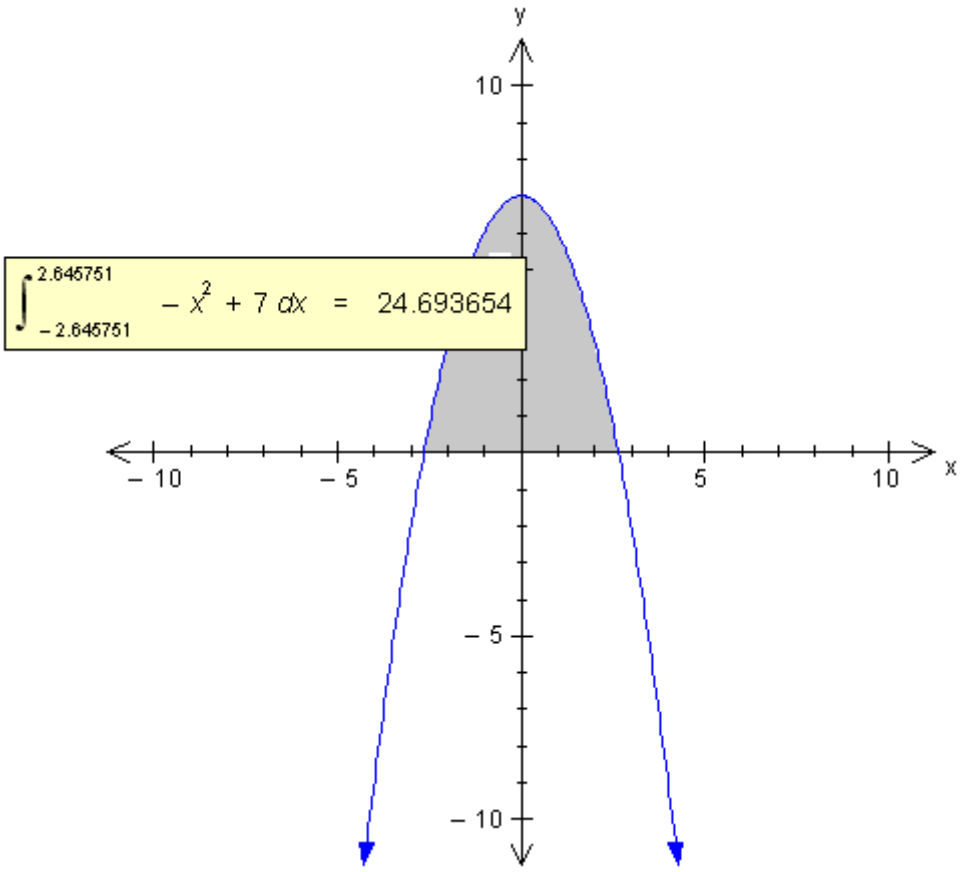
Click and hold the left mouse button, now move the mouse towards the end point of the integral. FX Graph will shade the integral as you go.



Release the mouse button when you have reached the end point of the integral and FX Graph will shade the integral for you.



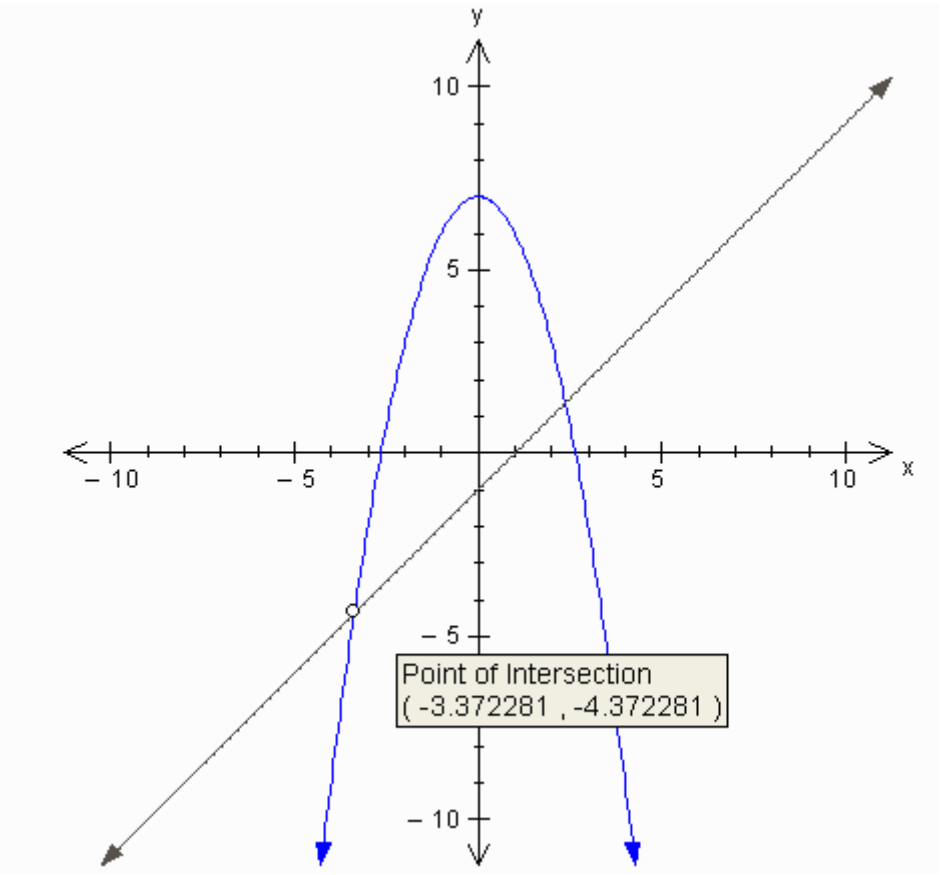
If you move the cursor over the integral and "hover", FX Graph will display the details of the integral.



5.18.1.3 Integral Between Two Curves

To create an integral between two curves **using the mouse**, your first click must be on an intersection between the two curves.

Move until the point of intersection has been found



If you start your integral now, the integral will be between the two curves.

I Don't Want My Integral to Start at the Intersection!

Then either create your integral with the mouse, starting at the intersection, and edit the start point later OR create the integral using the Tools menu.

5.18.1.4 Multiple Integrals

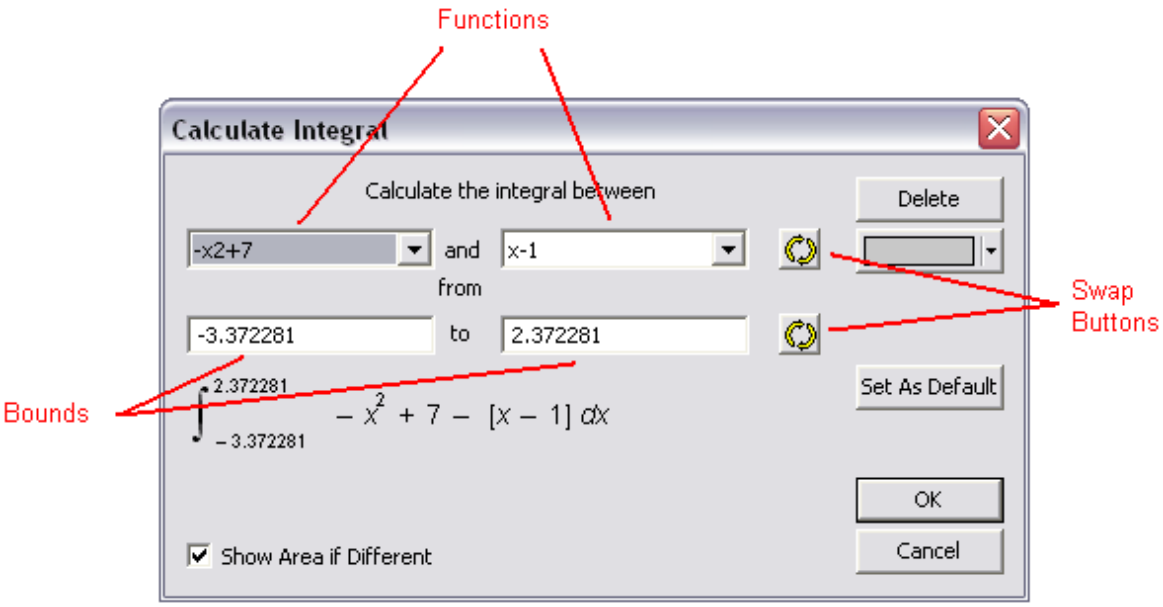
If you use the mouse to create an integral and then try to create a second integral, FX Graph will delete the first integral and replace it with the second. If you wish to create more than one integral, hold down the Ctrl key while creating the second integral.

5.18.1.5 Integral to y Axis

You cannot create an integral (or area) to the y axis using the mouse. You can either create it to the x axis using the mouse and edit the integral later or you can create the integral using the Tools menu.

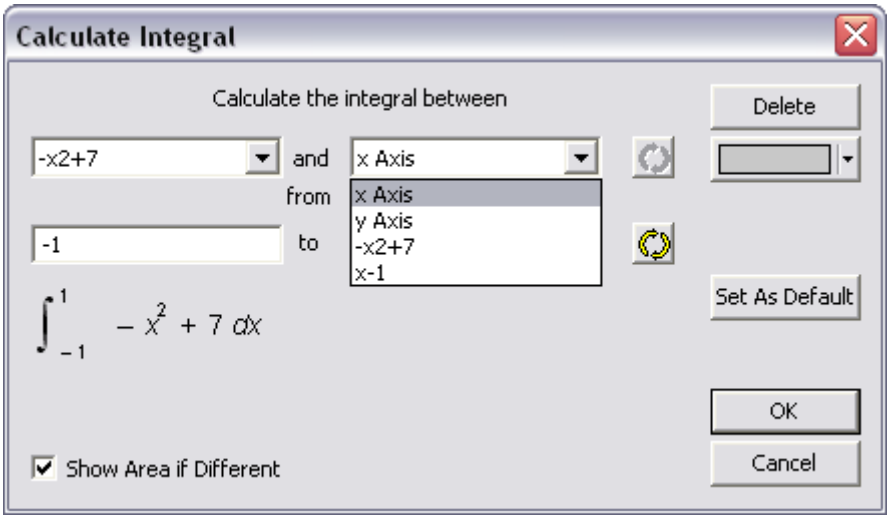
5.18.2 Editing Integrals

You can edit any integral by right clicking on it.

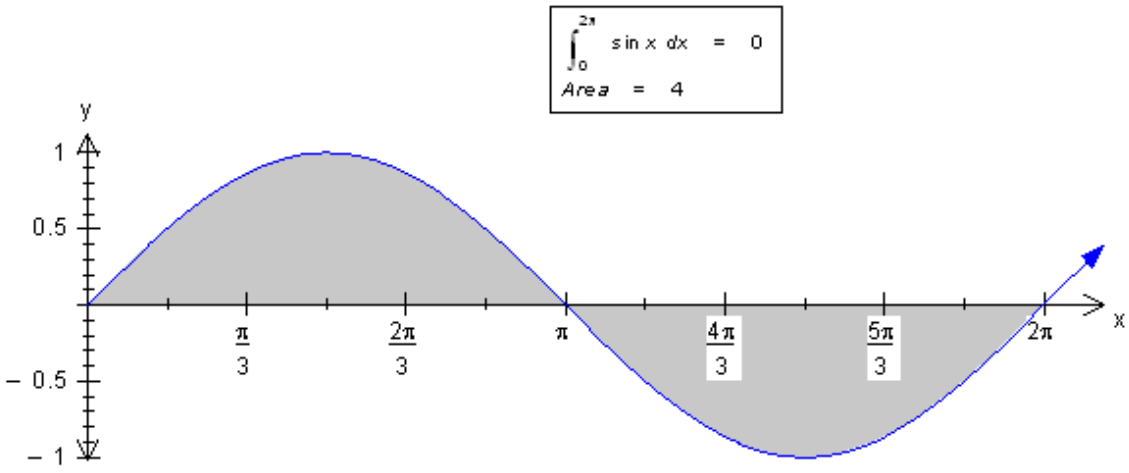


You can change the Functions that the integral is between and the Bounds of the Integral. The Swap buttons swap the two functions or bounds. Delete will delete the integral you are editing and you can change the colour of the shading.

The right hand Function is interesting as it allows you to find the integral between a function and the x axis or y axis. Just select from the list.



Show Area if Different allows for situations such as the integral of sin x from 0 to 2π. The integral is 0 but the area is 4. FX Graph can show this if you allow it.



5.18.3 Integral from Tools Menu

You can create an Integral directly, without the mouse, by choosing Integral from the Tools menu. When you do this you will see the same screen as when you edit an existing integral.

5.19 Tangent Lines

FX Graph can attach Tangent Lines to any Cartesian function.

5.19.1 Using Your Mouse to Create Tangent Lines

5.19.1.1 Tangent Line Mode

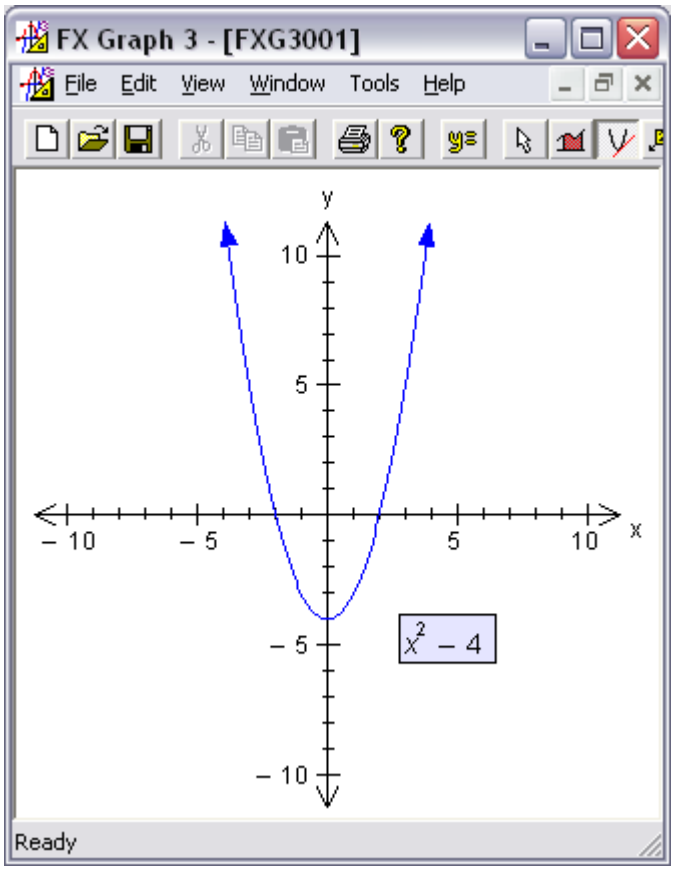
Before using your mouse to create a tangent, you must first enter Tangent Line Mode. Push the button on FX Graph's toolbar. The cursor will change to to remind you that you are using Tangent Line mode.

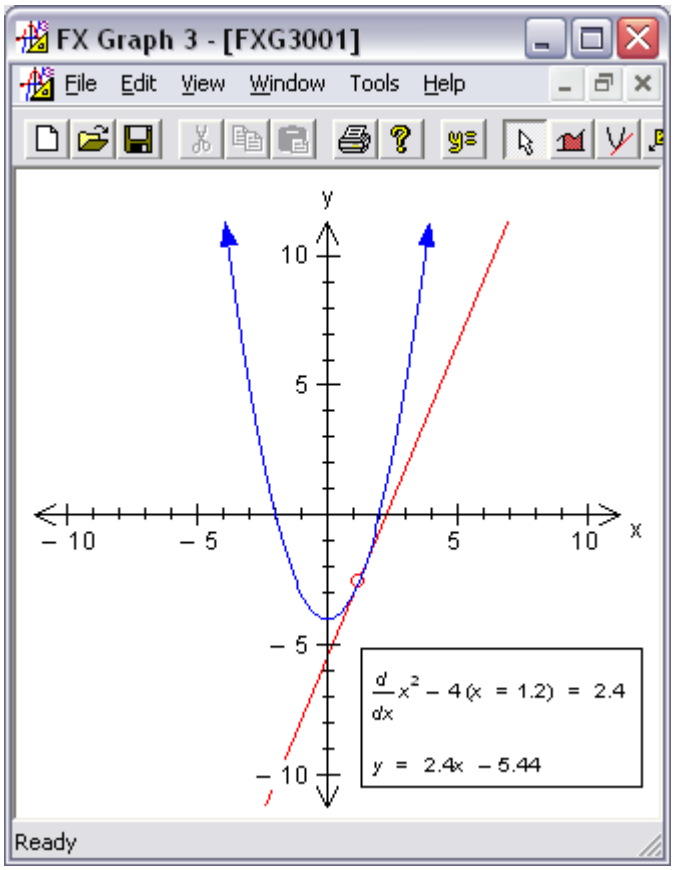
Tangent Line mode is only available if you have entered a function that FX Graph can attach a tangent line to.

Once in Tangent Line mode you can use the mouse to create tangent lines.

5.19.1.2 Tangent Line on a Curve

Attaching a tangent line to a function is easy. Just click on the curve you wish to attach the tangent line to. BEFORE you click, make sure that FX Graph has found the curve. You will know it has found the curve when it displays the curve's definition.

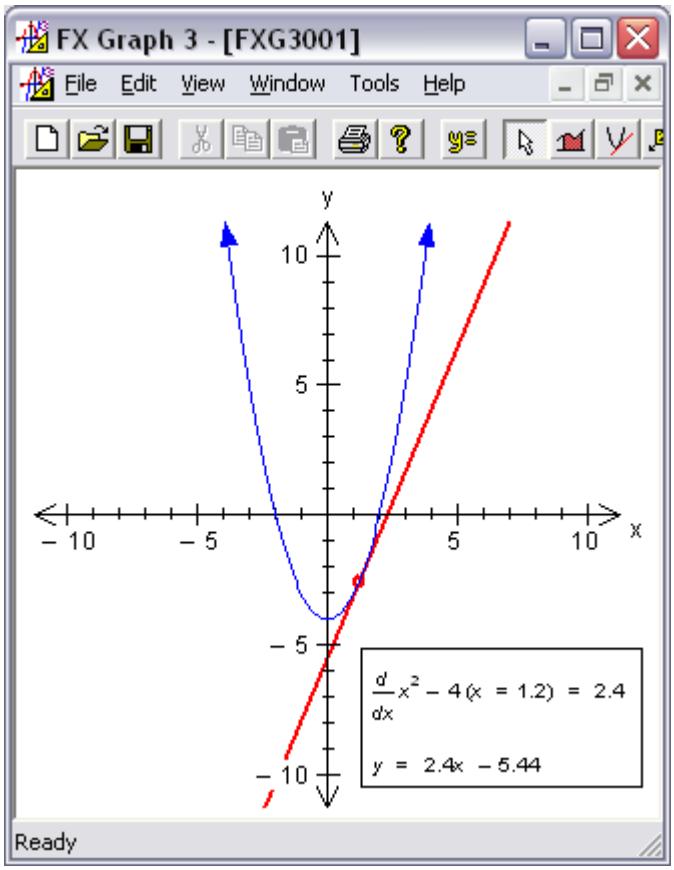




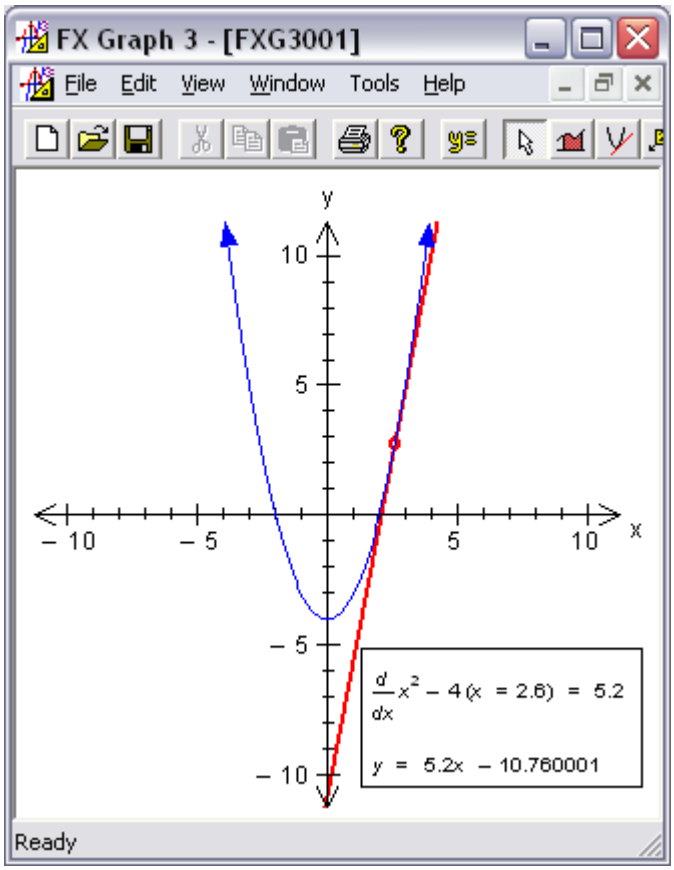
5.19.1.3 Moving a Tangent Line

You can move a tangent line on a curve by selecting it and using the left and right arrow keys to move it.

First, select the tangent line. You can do this when you are in select mode or tangent line mode. When the tangent line is selected, it will be drawn as a thicker line.



You can now press the left and right arrow keys to move the tangent line. The annotation will be updated automatically.

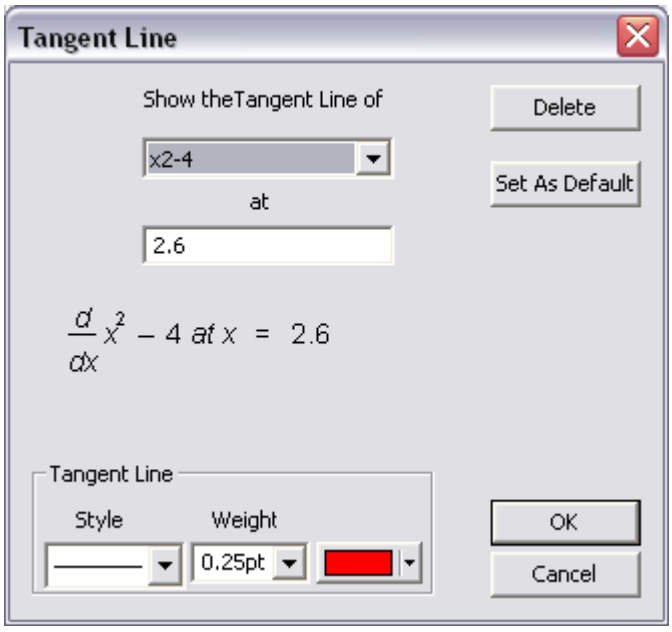


5.19.1.4 Multiple Tangent Lines

FX Graph will normally only allow one tangent line to be attached to a particular function. If you wish to attach more tangent lines to a function, hold down the Ctrl key as you click on the curve.

5.19.2 Editing a Tangent Line

You can edit a tangent line by right-clicking on it.



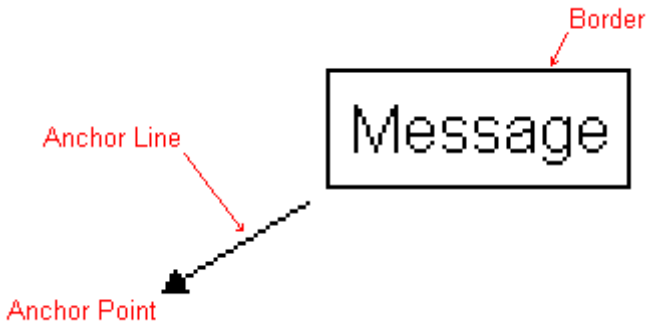
Here you can change the function, the location and the style and weight of a tangent line.

5.19.3 Tangent Lines From the Tools Menu

You can create an Tangent Line directly, without the mouse, by choosing Tangent Line from the Tools menu. When you do this you will see the same screen as when you edit an existing tangent line.

5.20 Annotations

Annotations are messages added to your graph. FX Graph annotations have the following features



The anchor line, anchor point and border are all optional.

5.20.1 Annotation Mode

Before using your mouse to create an annotation, you must first enter Annotation Mode. Push the button on FX Graph's toolbar. The cursor will change to  to remind you that you are using Annotation mode.

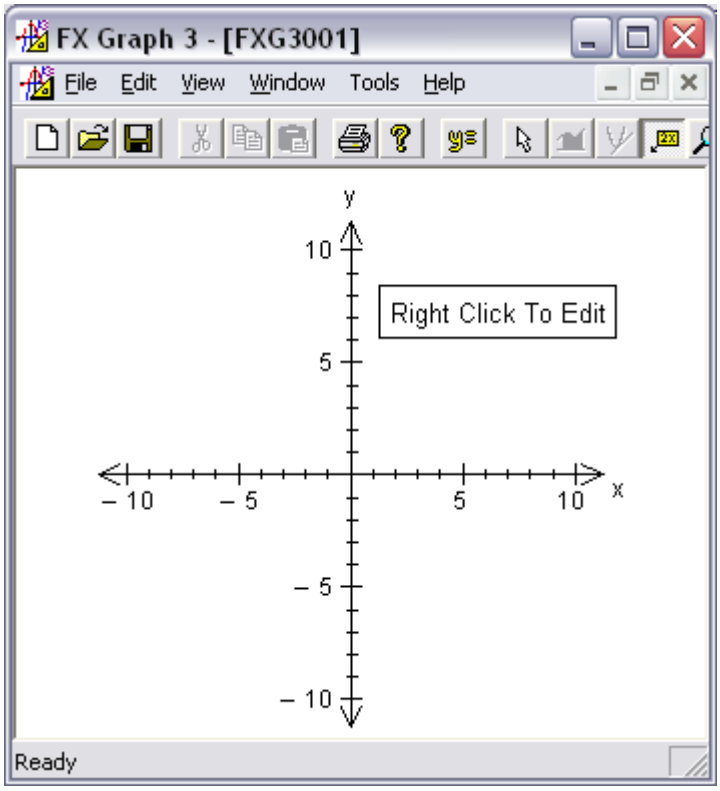
Once in Annotation mode you can use the mouse to create annotations.

5.20.2 Basic Annotations

You can add basic annotations anywhere on the screen.

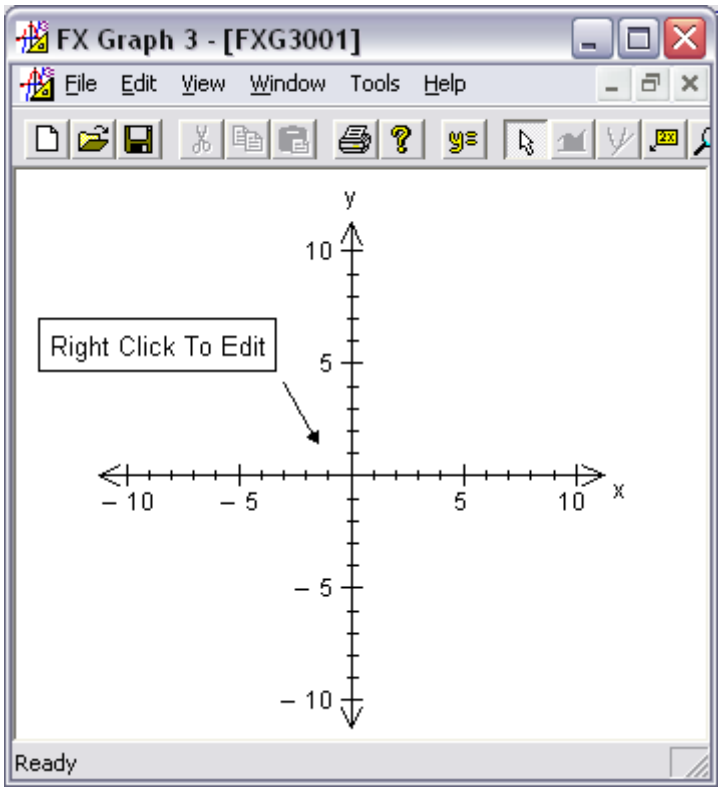
Annotation Without an Anchor

Just click on the screen and "blank" (it actually says "Right Click to Edit") annotation will appear.



Annotation With an Anchor

Sketch a line with the left mouse button clicked. FX Graph will create an annotation with an anchor.



5.20.3 Annotating Automatically

As you move around a graph, FX Graph will constantly give you small messages describing what is under the mouse. The messages may be the equation of the function, a point of interest, details of an integral or the location of an asymptote. If you left-click while one of these messages is on screen, FX Graph will create an annotation at the same location with the same information. This feature means that most annotations in FX Graph are created automatically!

Some of the annotations created this way will have their anchors locked to a point.

5.20.4 Moving Annotations

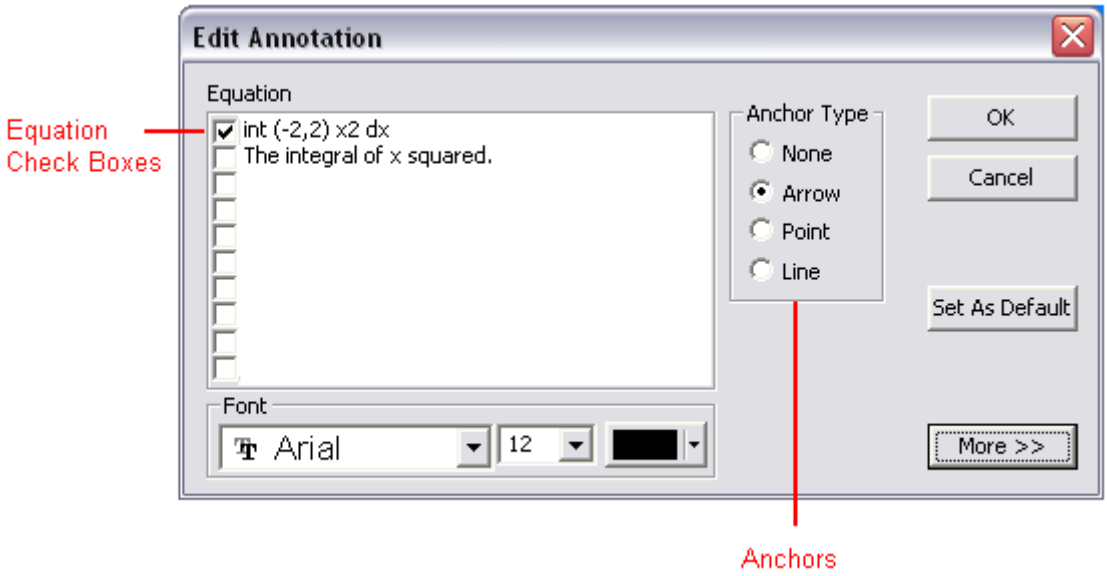
You can move annotations in Select Mode or Annotation mode

Left click on the annotation or the anchor and move them to their new location.

Note: The anchors of some automatically generated annotations are not movable as they locked onto a point on a function.

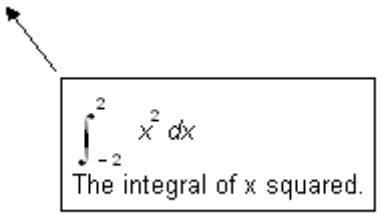
5.20.5 Editing Annotations

Right-click on the annotation to edit it.

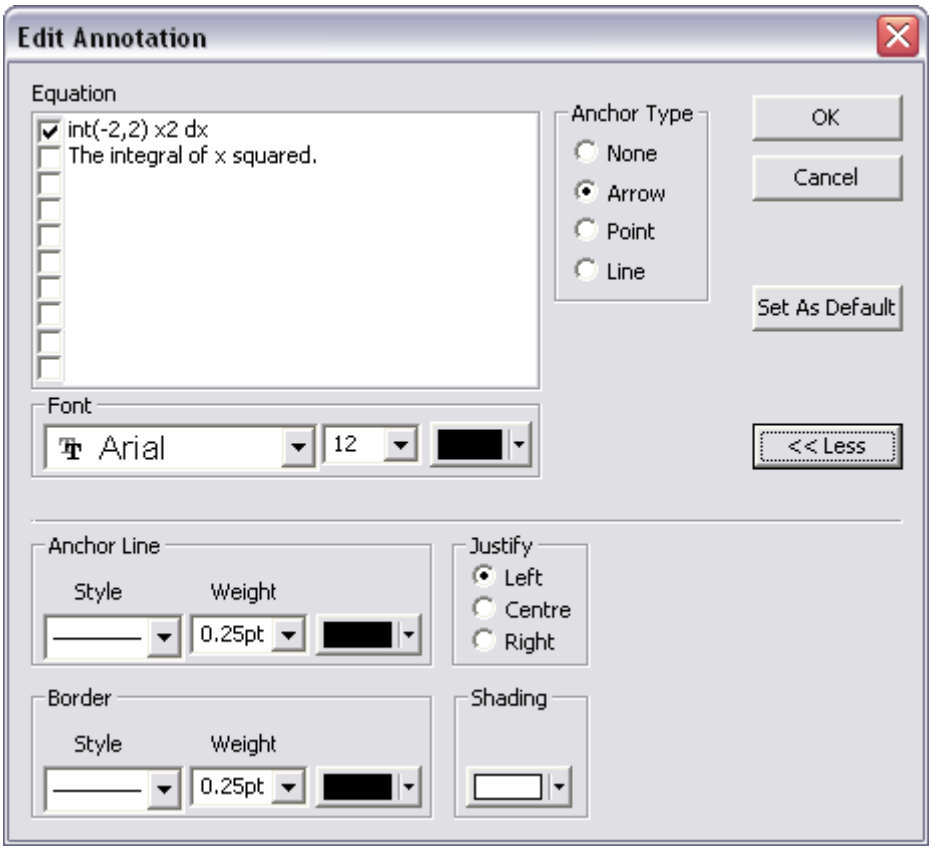


Anchors link the annotation to a point. You can turn off the anchor or have it show as an arrow, point or line.

You can have up to ten lines of information in your annotation and each line has an Equation Check Box next to it. This check box tells FX Graph how to interpret the information you have entered (or FX Graph has automatically generated for you). The first of our two lines is an equation so we have placed a tick in the box next to it to force FX Graph to display it that way. This annotation will appear as



The Edit Annotation screen also has a More>> button.



This lets you set the style of the anchor line, the border line and the shading in the rectangle. You can also set the justification style.

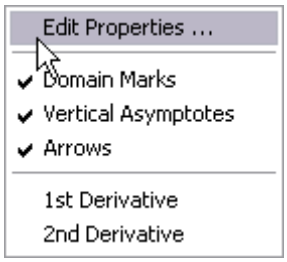
5.21 Greater Control

The Quick Entry screen allows you to construct graphs quickly and efficiently - but sometimes you will want more control. You can access these extra controls through the Quick Entry screen and right-clicking.

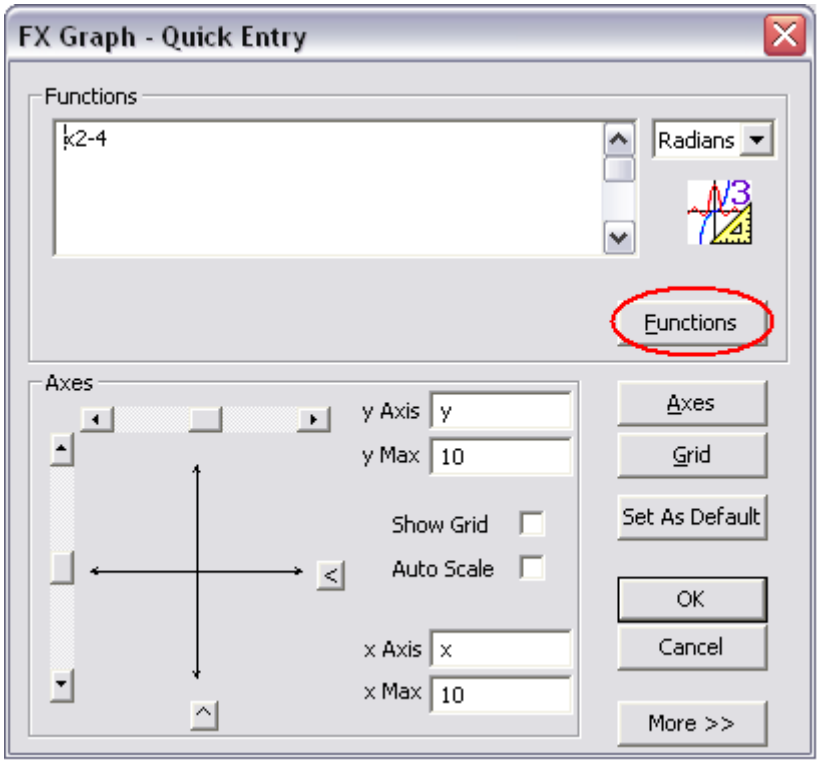
Functions	Push the Functions button on the Quick Entry screen or right click on the function you wish to edit and choose Edit Properties.
Axes	Push the Axes button on the Quick Entry screen or (optionally) right click on the axes in Select Mode
Grid	Push the Grid button on the Quick Entry screen

5.21.1 Functions

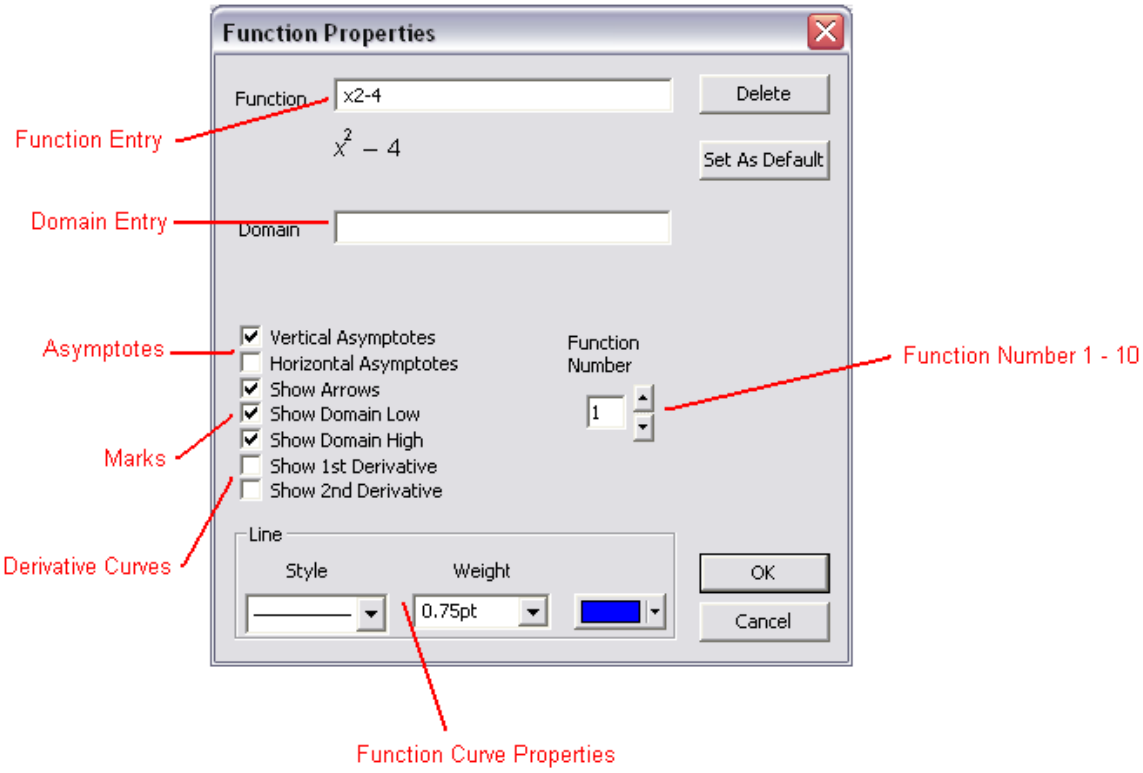
To access the Functions Screen, either right click on the function you wish to edit and choose Edit Properties



Or open the Quick Entry screen and push the Functions button



The Function Properties screen will open.



Function Entry

Enter functions in the function section in exactly the same manner as in the Quick Entry screen EXCEPT that the domain is now separated from the function for clarity.

Domain Entry

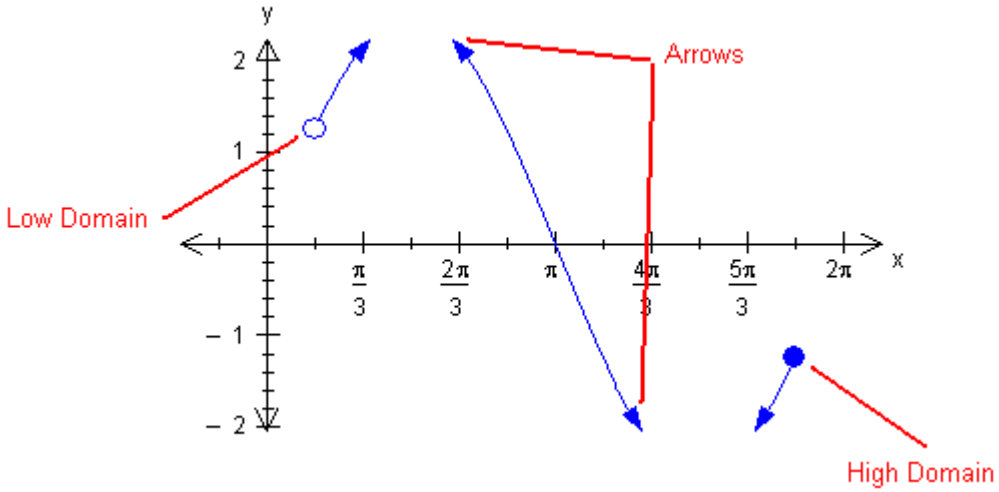
Domain entry using either the -2 <= x < 3 format or the [-2, 3) format.

Asymptotes

FX Graph calculates vertical asymptotes using both algebraic and numerical methods. Horizontal asymptotes are calculated numerically and are not quite as reliably detected as vertical asymptotes. These check boxes allow you to turn on display of these asymptotes.

Marks

FX Graph can draw domain marks and arrows on functions. FX Draw will draw an open circle for any < or > domain and a filled circle for any <= or >= domain. It can also draw arrowheads where ever the function leaves the plane. You can turn off these marks here.



Derivative Curves

FX Graph can draw the first and second derivative curve for any Cartesian function.

Function Curve Properties

Change the line style, weight and colour for the selected function.

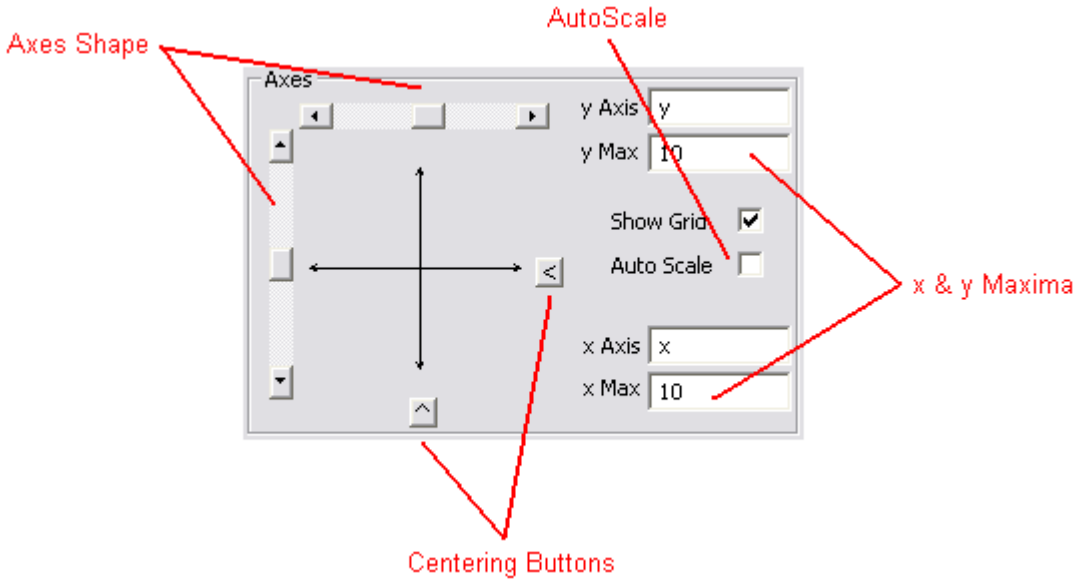
Function Number

Using the Quick Entry screen, you can edit all ten functions at once. The Function Properties screen only displays the properties for one function at a time. You can look at the other functions by changing the function number. The up and down arrows allow you to cycle through the numbers or you can type the function number directly in.

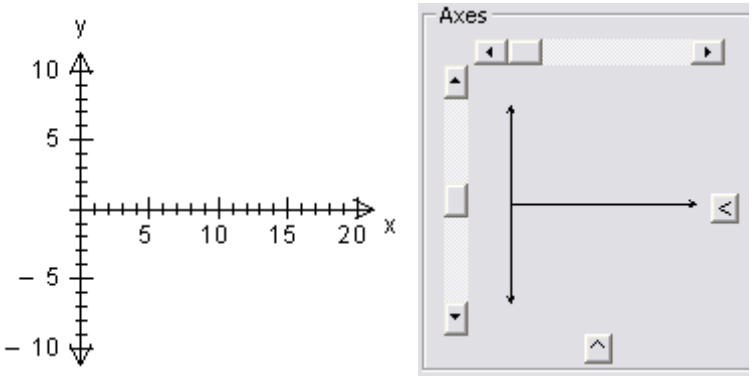
5.21.2 Axes

5.21.2.1 Setting Axes in the Quick Entry Screen

The quickest and easiest way to set axes is on the Quick Entry Screen.

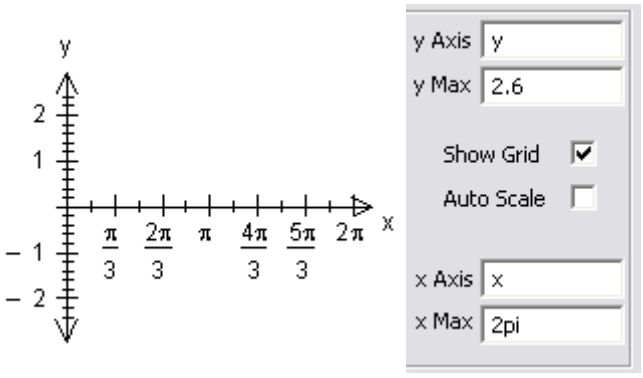


First - set the shape of the axes using the axes shape scroll bars. The centering buttons return the axis back to the middle. This makes it easy to get graphs such as



Second - set the x and y maxima - everything else is automatic

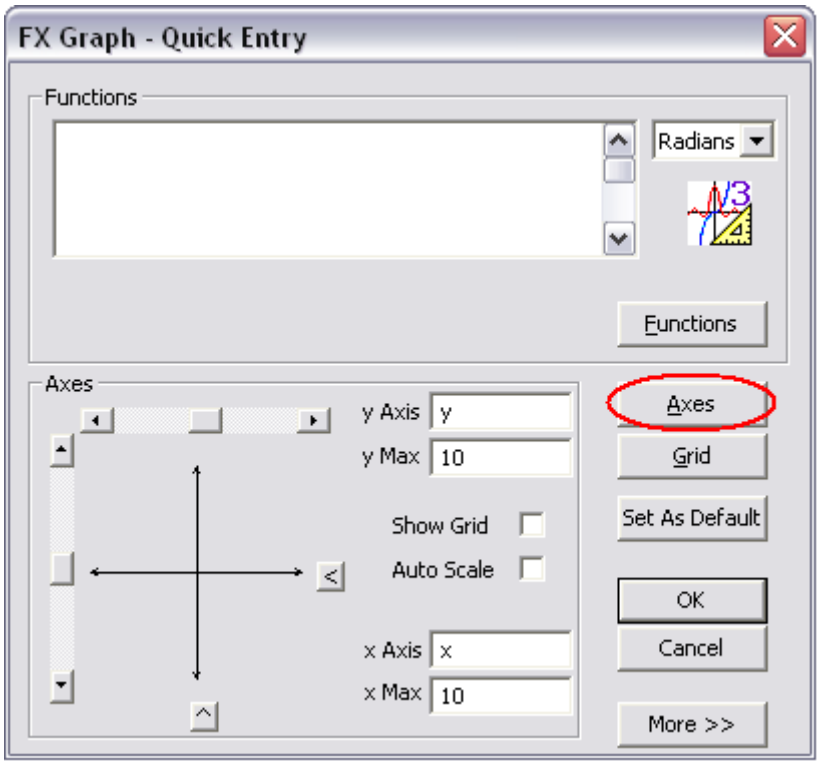
Note, setting an x maximum in terms of pi (eg 2pi) will force FX Graph to write the x axis scale in terms of pi.



Autoscale is discussed later in this section.

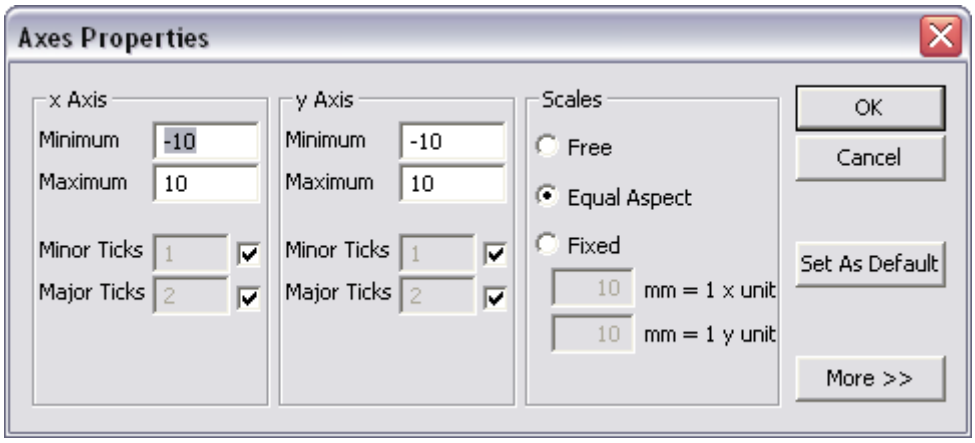
5.21.2.2 Axes Properties Screen

To access the Axes Properties Screen, open the Quick Entry Screen and push the Axes button

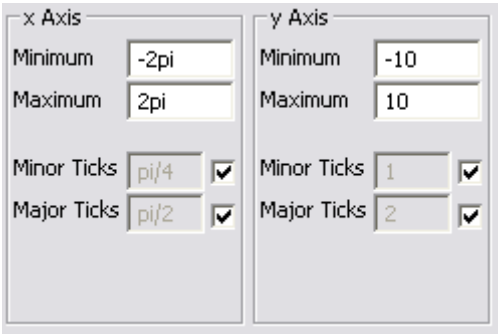


or (optionally) right click on the Axes when you are in Select mode. This option is controlled by the Tools/Preferences screen.

The Axes Properties screen will open.



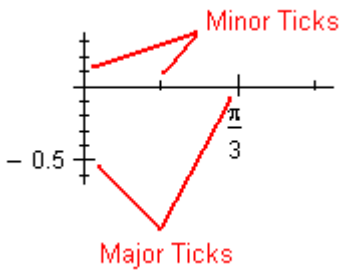
5.21.2.2.1 Axis Control



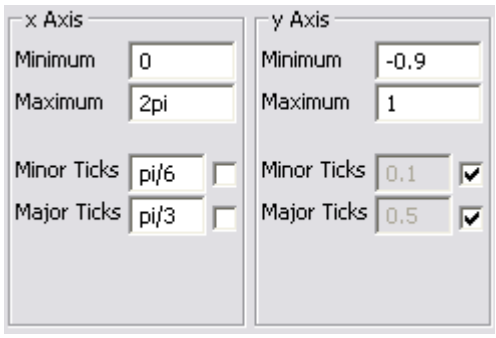
This part of the screen allows you to explicitly control the x & y Axes maximum and minimum. **Entering a maximum, minimum or tick in terms of pi forces FX Graph to mark that scale in terms of pi.**

You can also explicitly control the major and minor ticks for each axis.

Minor ticks - small axis marks and no numbers
Major ticks - large axis marks and numbers

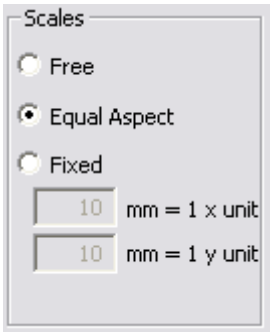


Before you can adjust the major and minor ticks, you must uncheck the box next to adjustments to ensure that FX Graph realises that you are taking responsibility for these settings.



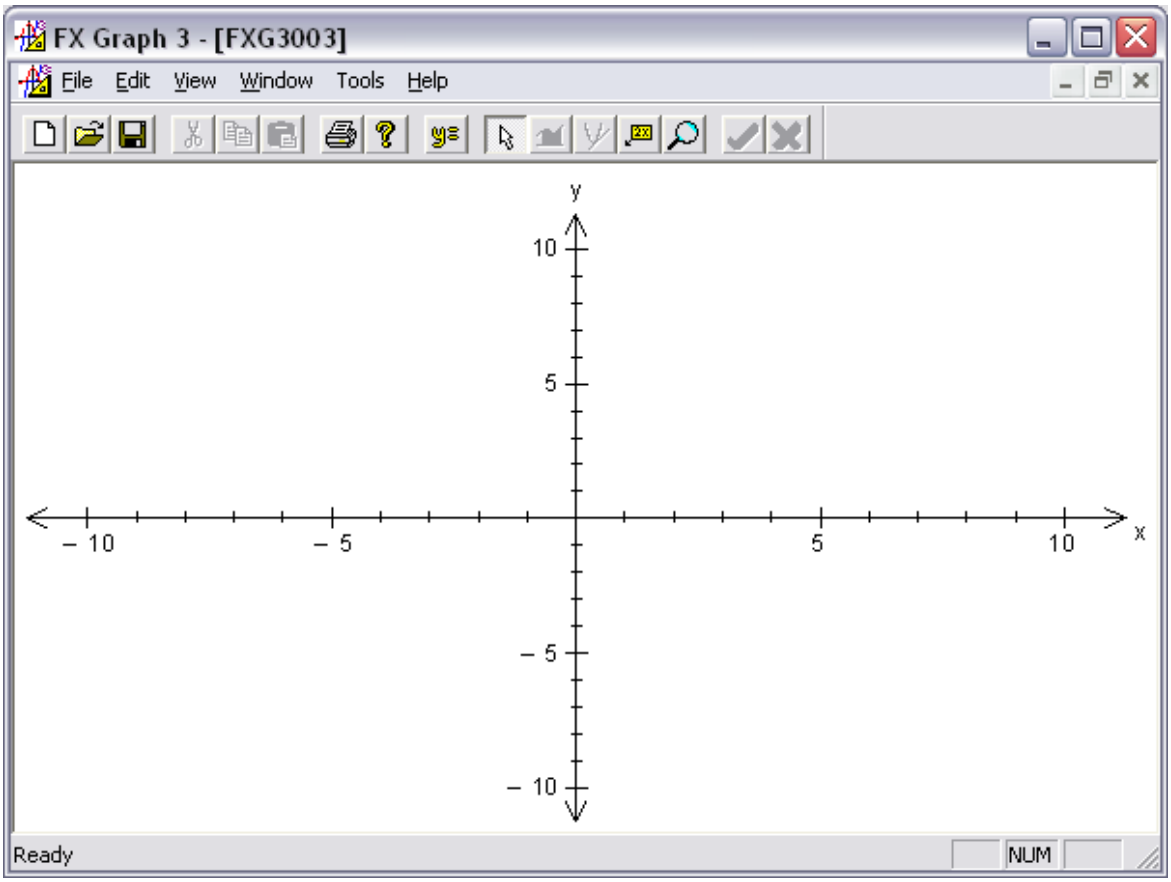
5.21.2.2.2 Scale Type

FX Graph can produce three different scale types.



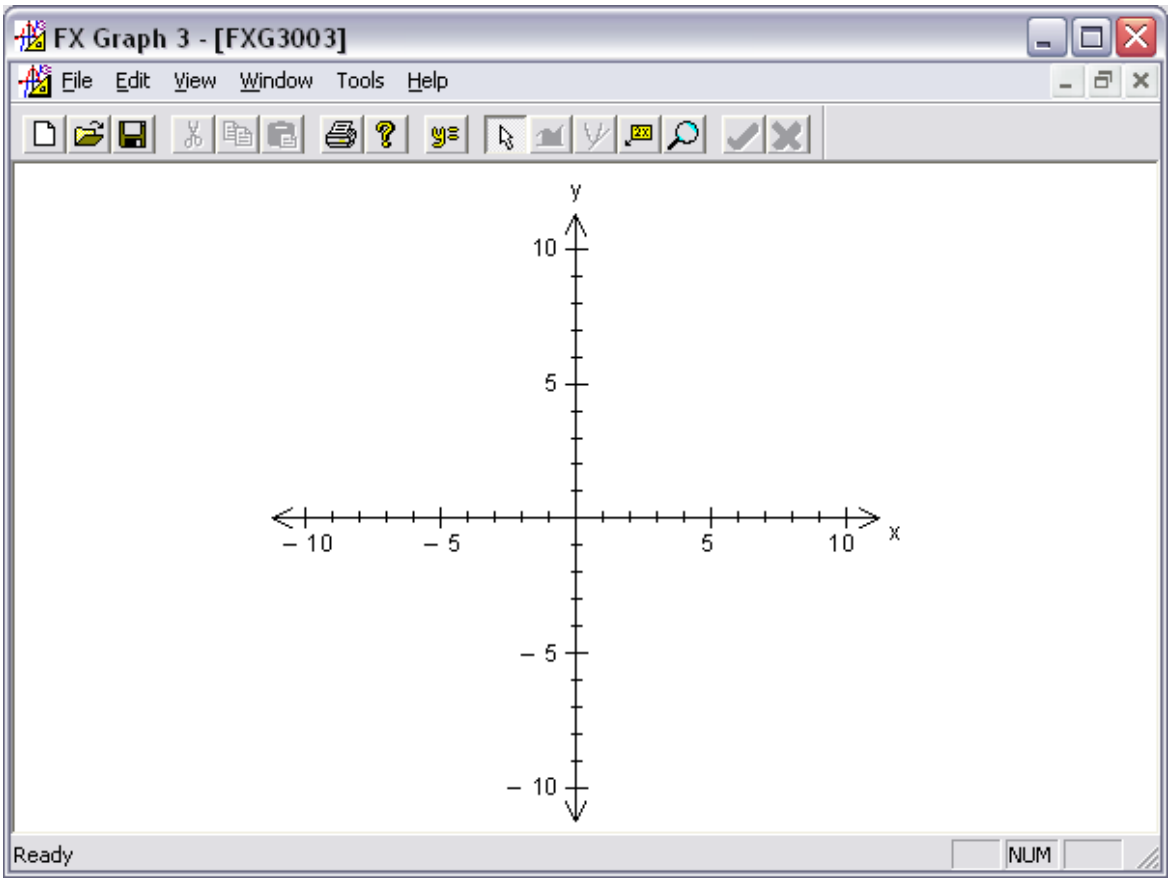
Free Scales

Free scales fill the available area using your maxima and minima. One unit on the x axis is very unlikely to be the same measurement as one unit on the y axis. For example, if we have a set of axes from -10 to 10 and draw them as free scales, the graph might look like this.



Equal Aspect

Equal aspect scales ensure that one unit on the x axis is the same measurement as one unit on the y axis. Using the same example, our graph might look like this.



Equal aspect scales are important for many graph types - especially polar. If you are not using equal aspect scales, many graphs just do not "look" right.

It is possible to get exact aspect scales to "fill the available rectangle". This is discussed in Tools / Preferences.

The equal aspect setting is ignored if your Cartesian function contains angle functions (eg sin, cos, tan) and you are not graphing in radians.

Fixed Scales

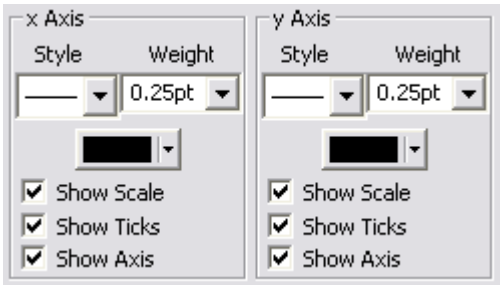
Fixed scales allow you to specify an exact number of millimetres per unit. This allows you to match existing graph paper for example.

Resizing

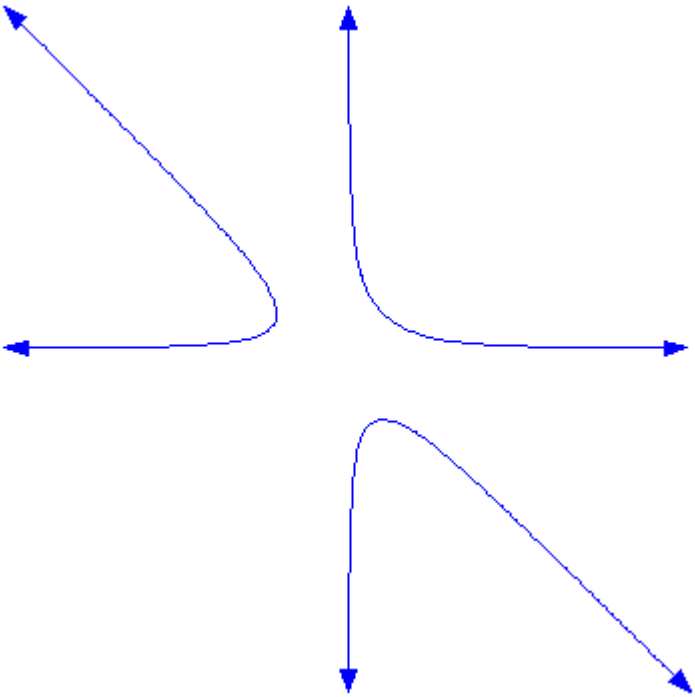
When you select Equal Aspect or Fixed Scales, FX Graph will produce a graph to your exact requirements. If you then place that graphic into another product (eg Word) and resize it, FX Graph has NO control over the output and your requirements will NO LONGER be met. It is much better to generate the exact graph you require inside FX Graph.

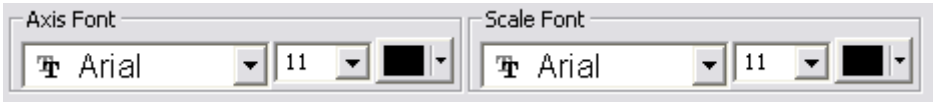
5.21.2.2.3 Axis Styles

You must push the More >> button to access these settings.



You can change the line type and colour for each axis. You can also turn OFF the scale, the ticks and the axis. This allows you to draw graphics without any axes if you wish.





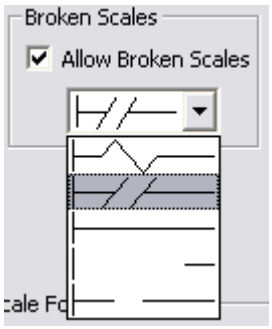
You can also change the fonts for the axis.

5.21.2.2.4 Break Types

You must push the More >> button to access these settings.

FX Graph will break scales if you allow it.

There are a number of different break styles available.



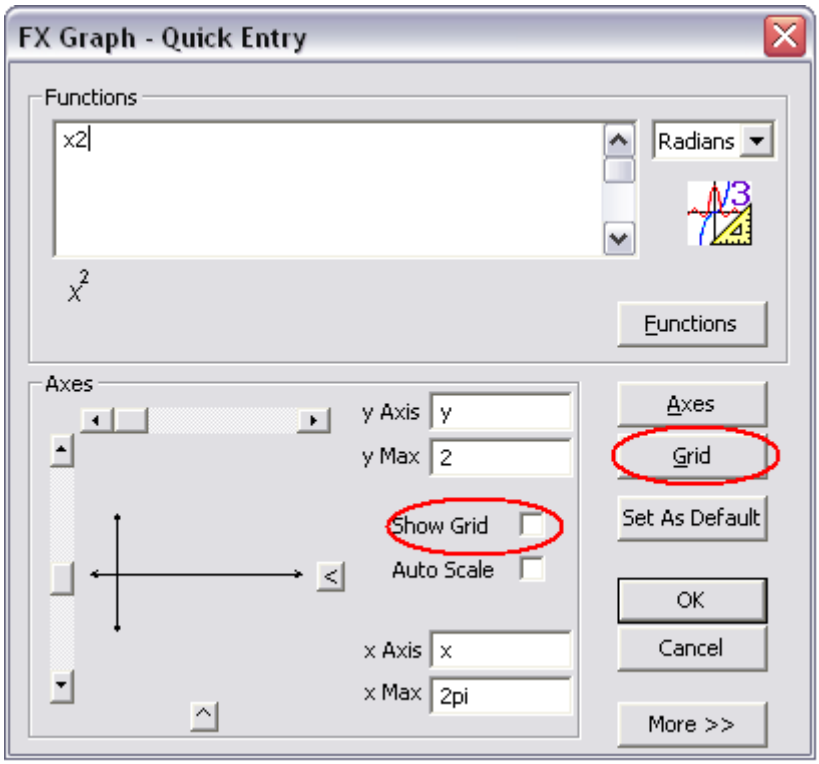
FX Graph will break the scale whenever the minimum value for an axis is greater than 0 or the maximum value is less than 0.

5.21.2.3 AutoScale

If the AutoScale box is checked on the Quick Entry screen, FX Graph will automatically detect any points of interest (local maxima and minima, x intercepts and intersections) from -500 to 500 and adjust the axes so that all of the points of interest are visible. Once you have selected Autoscaling, FX Graph takes full responsibility for the axes. **Please note that the autoscaling feature slows down the response time of FX Graph.**

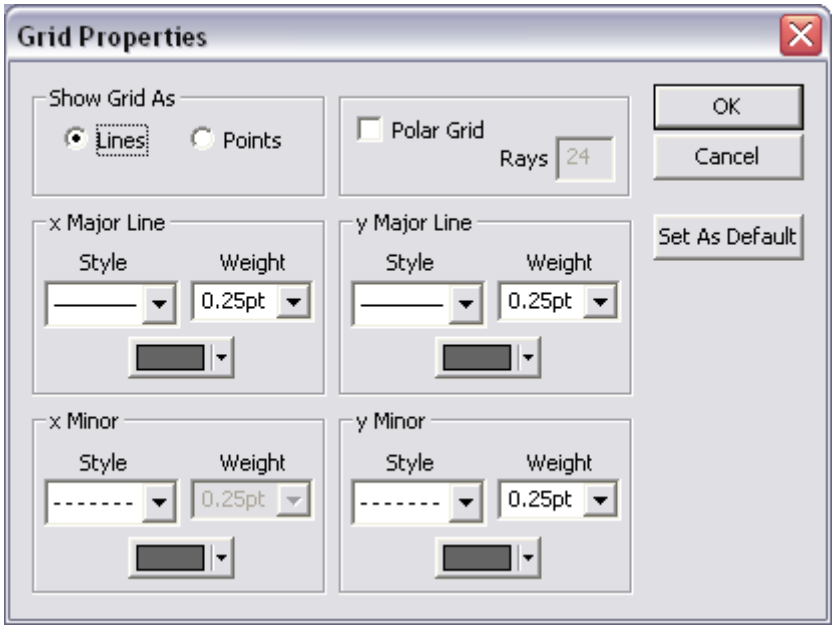
5.21.3 Grid

You can access the Grid Properties screen by pushing the Grid button on the Quick Entry screen

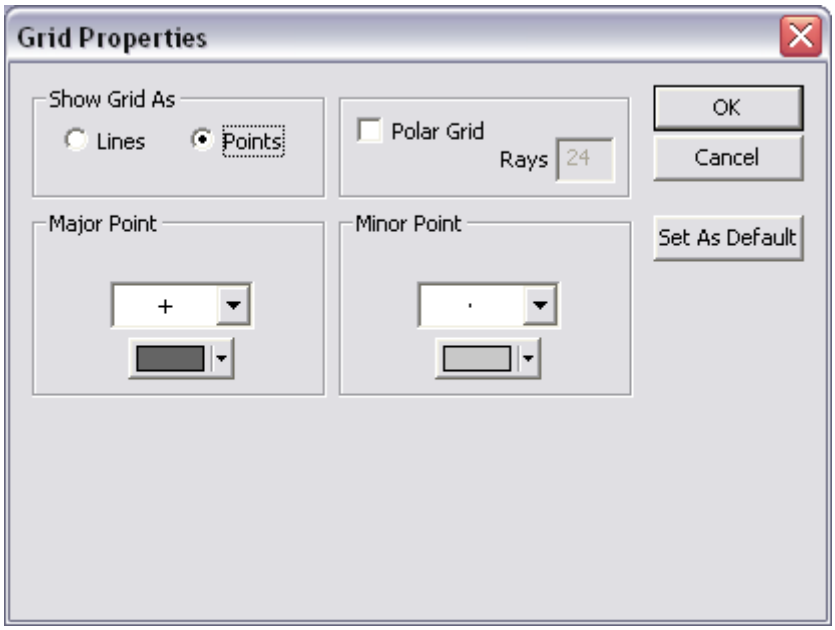


Note: No matter what changes you make to the Grid Properties, NOTHING will be shown unless you tick the Show Grid box on the Quick Entry screen.

The Grid Properties' layout depends if you have set the grid to show as lines or points.



Grid Lines Properties

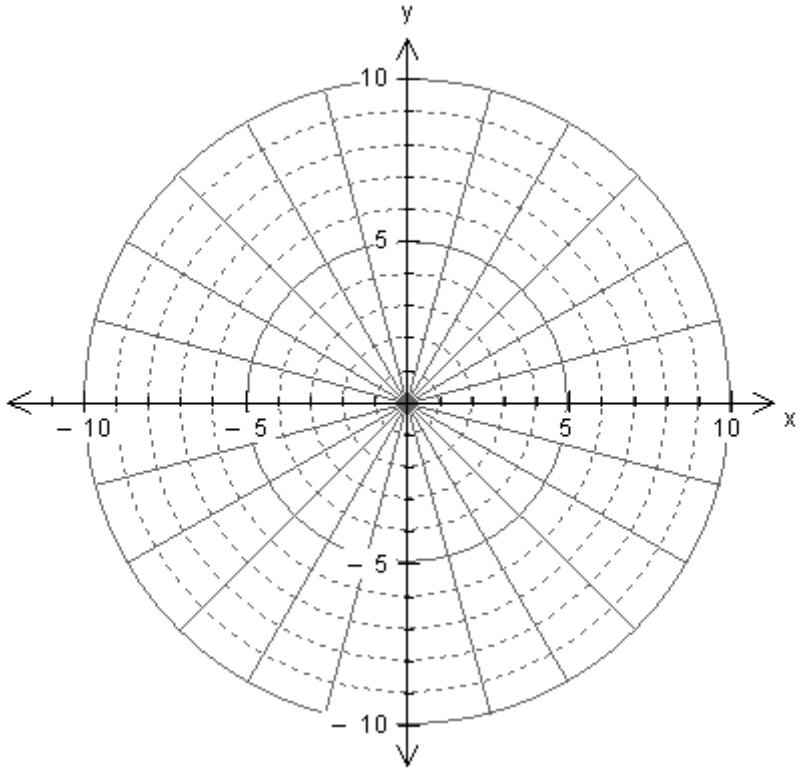


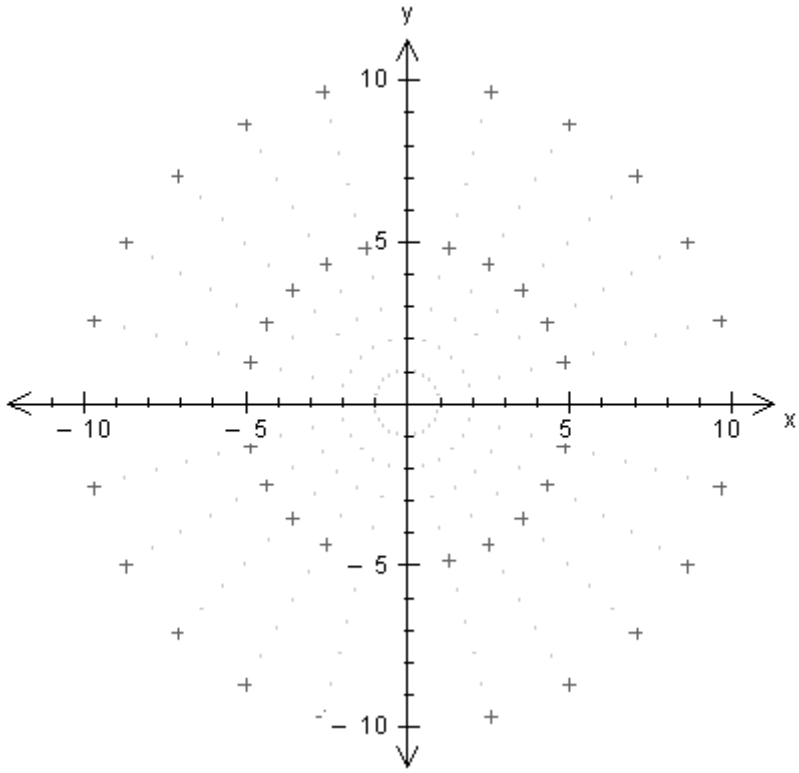
Grid Point Properties

Using the various sections you can change the style, weight and color of the lines and points.

Polar Grid

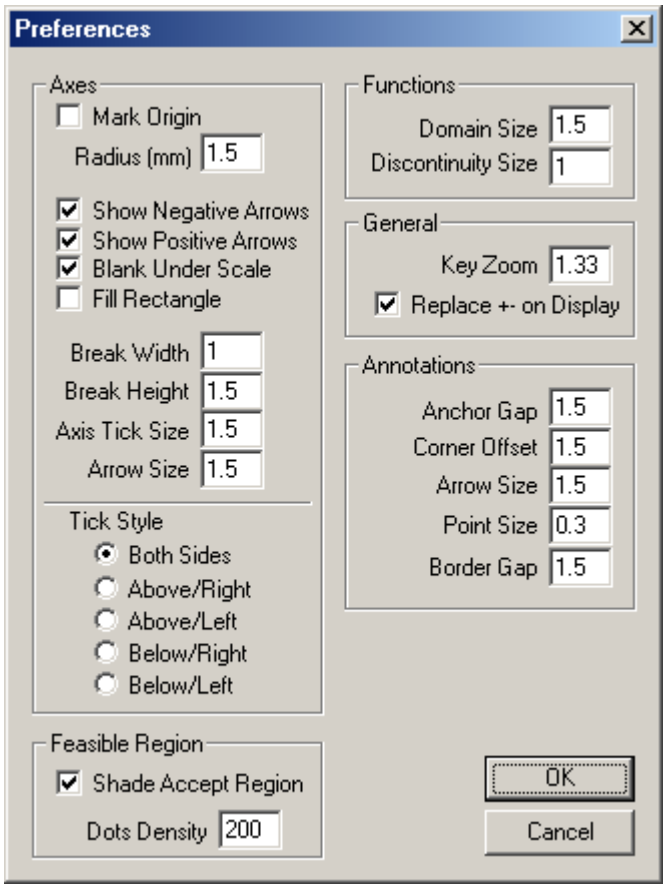
By checking the polar grid box, you can draw polar grids of lines or points. The number of rays determine how many radii emerge from the origin.





6 Preferences

Different locations around the world have different preferences - their graphs look different. FX Graph can support these differences and most differences are set in the Preferences page of the Tools menu.



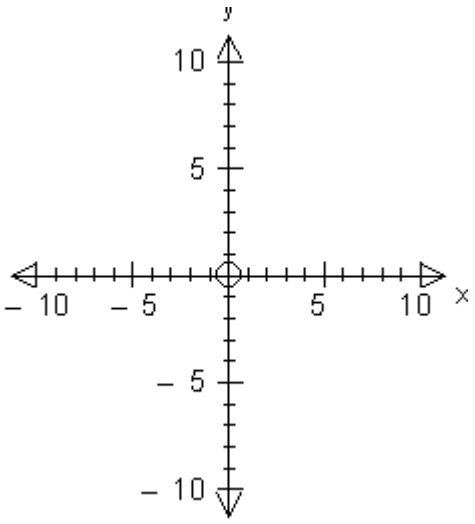
Preference settings are global - they will affect any open graph and any graph you create.

Note: Preference settings can be "locked" to prevent changes by students. More details can be found in FX Graph's installation notes.

6.1 Axes

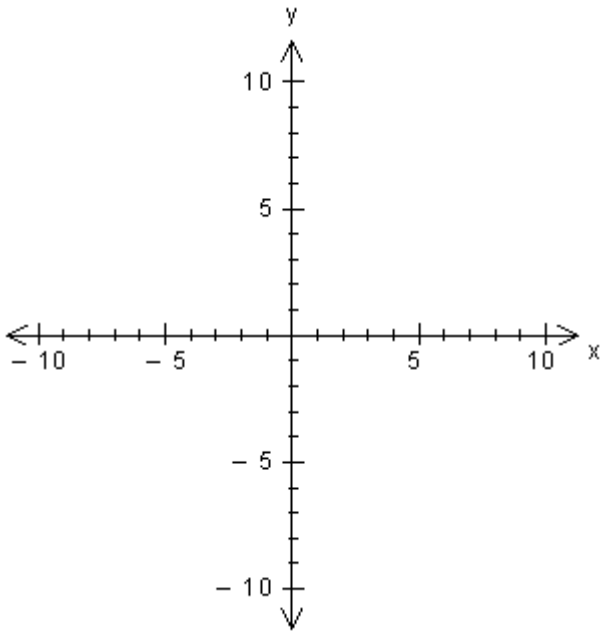
6.1.1 Mark Origin

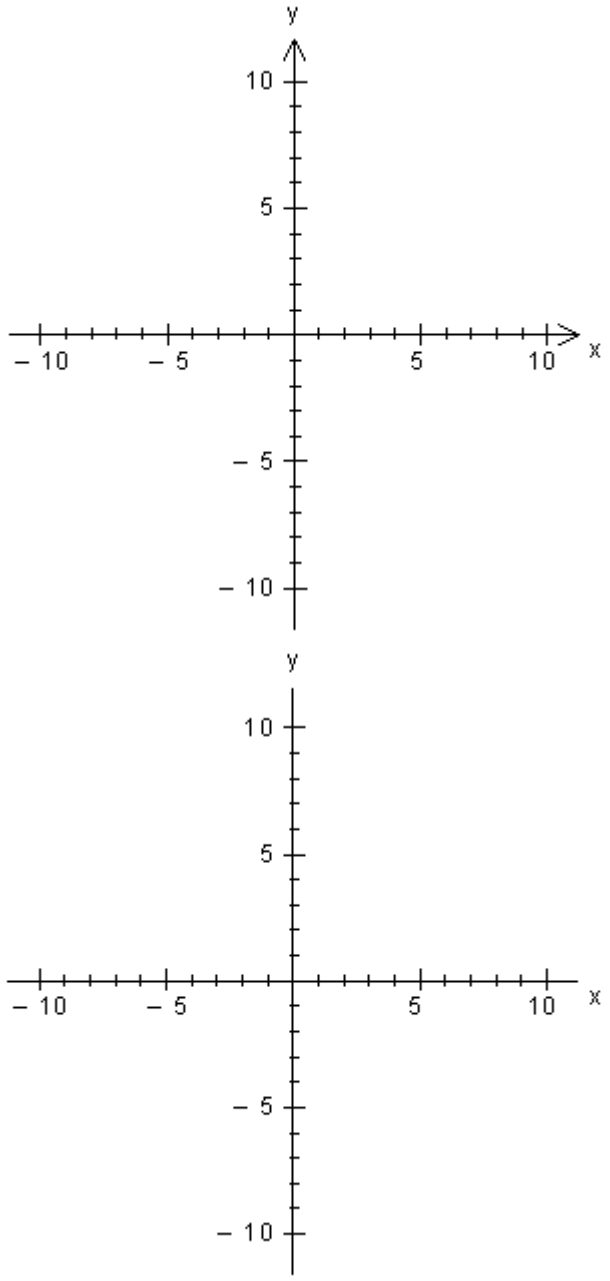
This option allows you to mark the origin of your set of axes with a small circle (the radius is set here).



6.1.2 Show Negative / Positive Arrows

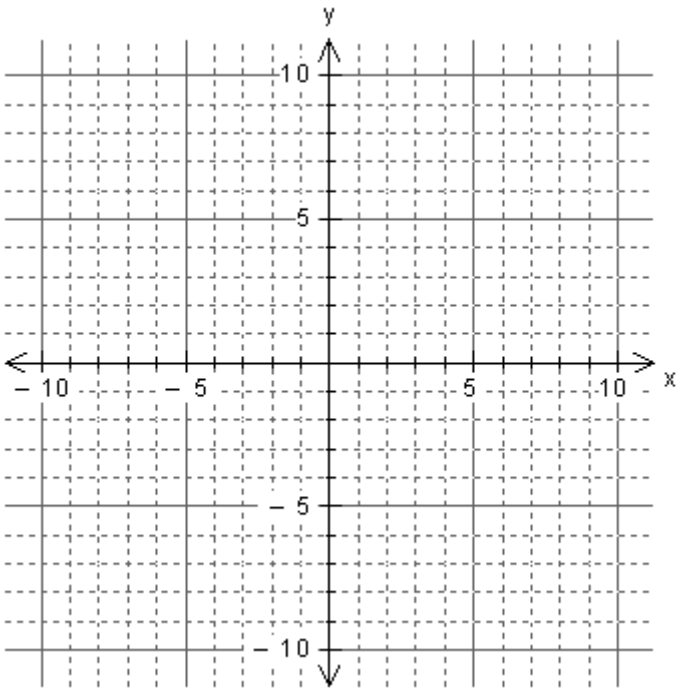
Different places in the world have different preferences for their axes. Some like arrow heads, some do not. Some like arrow heads only on the positive axes.

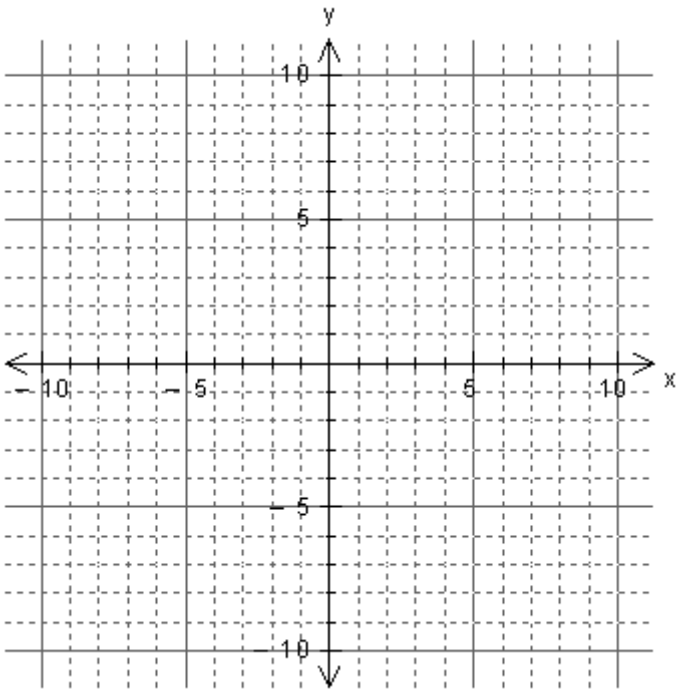




6.1.3 Blank Under Scale

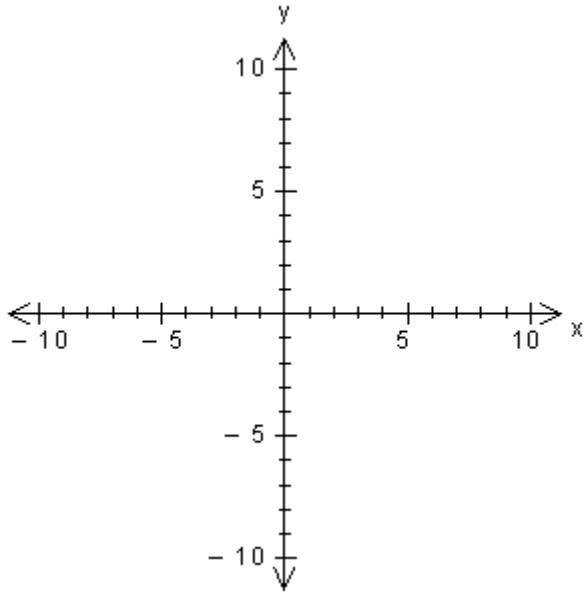
When you add a grid to a set of axes, the lines of the grid interfere with the scale. FX Graph will blank out an area of the grid before it writes the numbers of the scale and this prevents the grid making the scale hard to read. The blank under scale setting lets you turn off this feature. The two graphs below show you the result. The first graph has Blank Under Scale on, the second graph has it off.



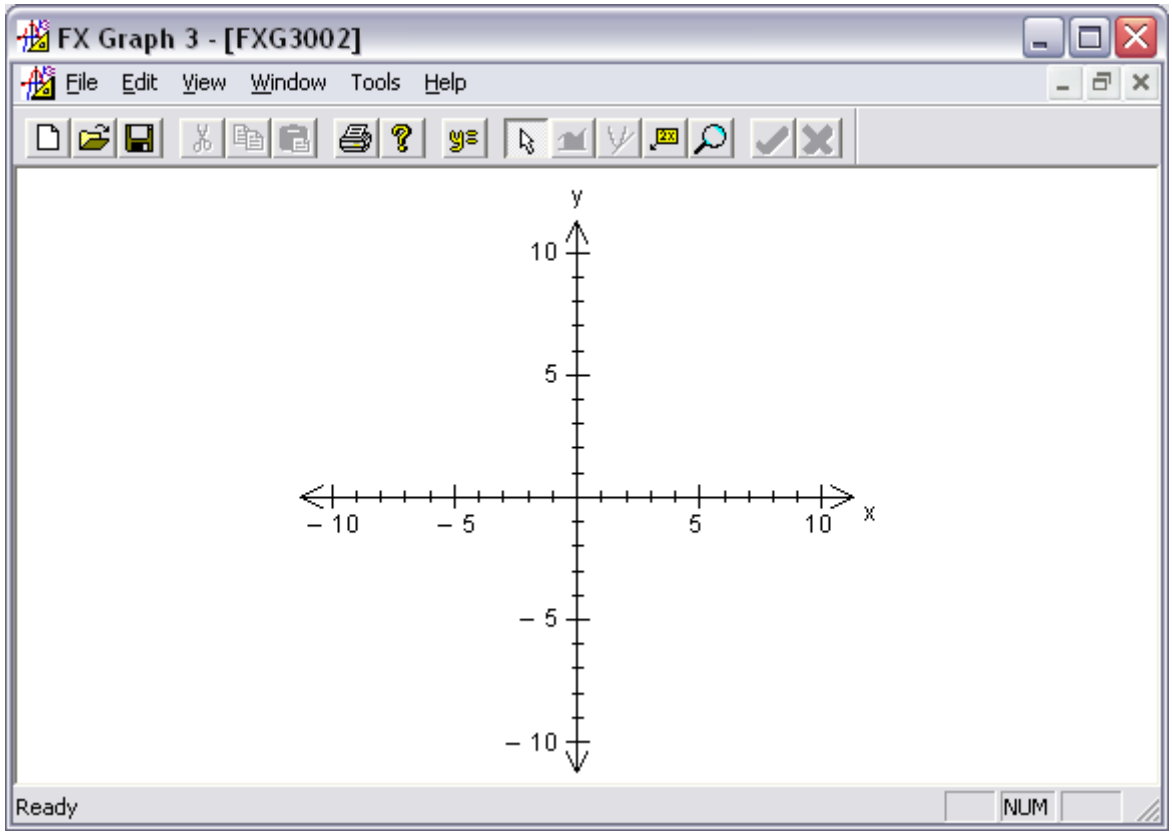


6.1.4 Fill Rectangle

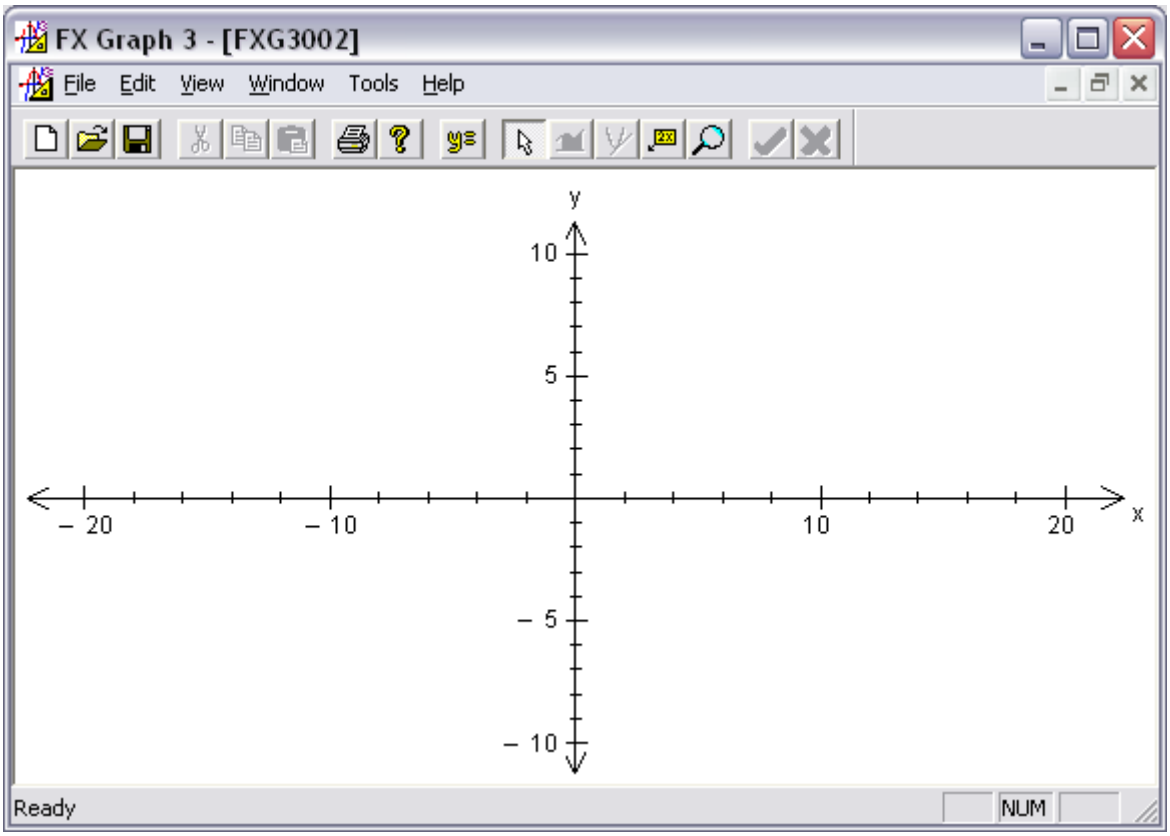
Fill Rectangle only has an effect if you have chosen Equal Aspect axes. Imagine that you have asked FX Graph to draw Equal Aspect axes and you want both the x and y axis to go from -10 to 10. This will produce a "square" set of axes.



If you are using this set of axes in a normal FX Graph window, FX Graph must add white space to each side of the graph to keep this square shape.

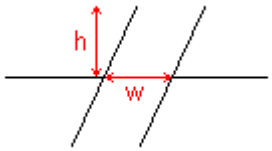


If you turn Fill Rectangle on, FX Graph will fill the sides with more of the axes - it uses your -10 to 10 settings as a MINIMUM requirement. The axes are still equal aspect but you do not have this wasted space at the side.



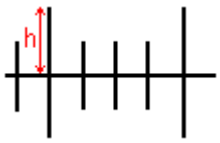
6.1.5 Break Width & Height

Break width (w) and height (h) are in millimetres and control how FX Graph draws break marks for broken scales. All break marks use these numbers in the drawing - not just the parallel line break mark shown here.



6.1.6 Axis Tick Size

Axis ticks are the marks on the scale. The Axis Tick Size (h on diagram) is measured in millimetres and is height above the x axis of a major tick. The minor tick is automatically half this size.

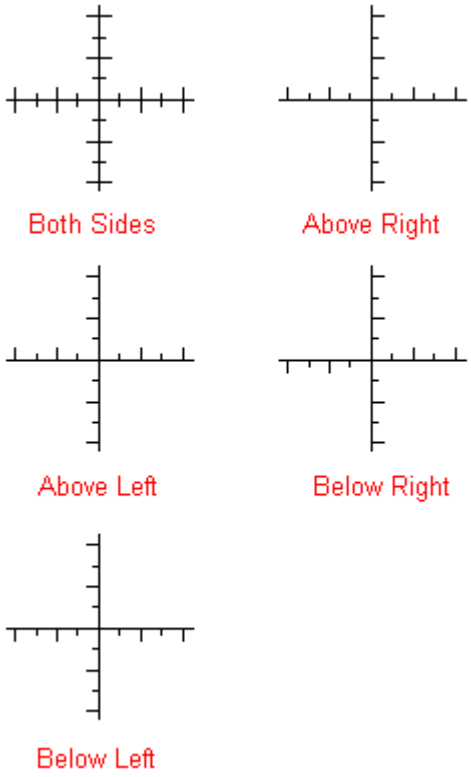


6.1.7 Arrow Size

Arrow Size (measured in millimetres) controls the size of the arrow heads at the ends of the axes.

6.1.8 Tick Style

This preference controls how the ticks are drawn on the axes. The various options are best shown in a diagram.

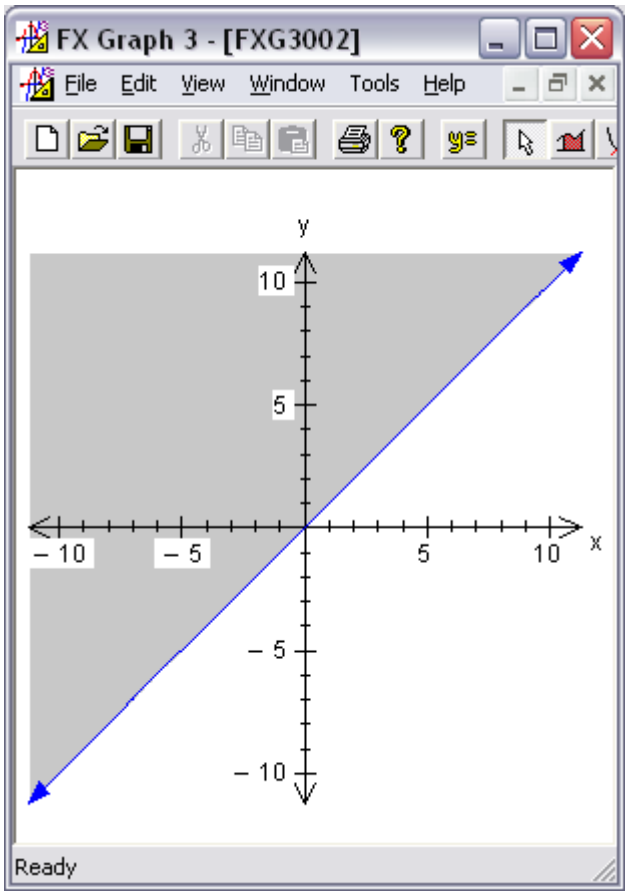


6.2 Feasible Region

6.2.1 Shade Accept Region

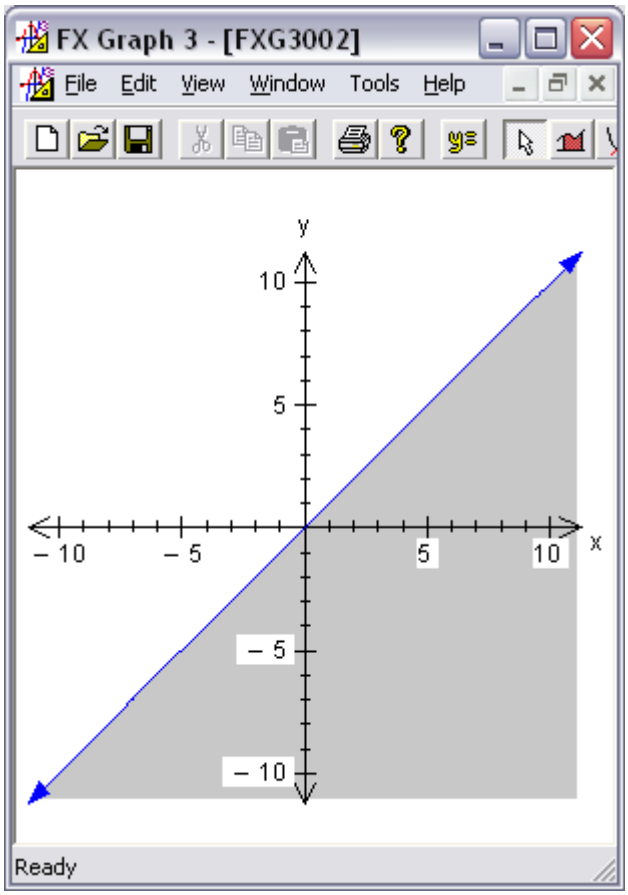
When shading the feasible region for an inequality, some locations shade the region that AGREES with or accepts the inequality.

y >= x



and some schools shade the region which disagrees with or does not accept the inequality

y >= x



If you tick Shade Accept region, y >= x will produce the first graph.

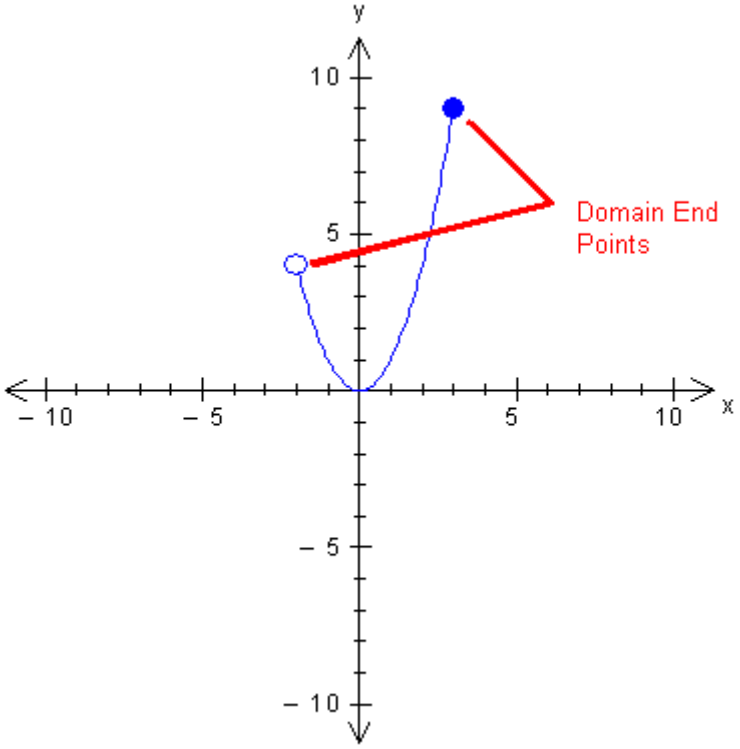
6.2.2 Dot Density

FX Graph will often shade feasible regions with an array of dots. The greater the number of dots, the more solid the shading - but the slower the calculations. A dot density of 200 (the default) will produce acceptable results on most computers but you can decrease the density on slower computers or increase it on faster computers.

6.3 Functions

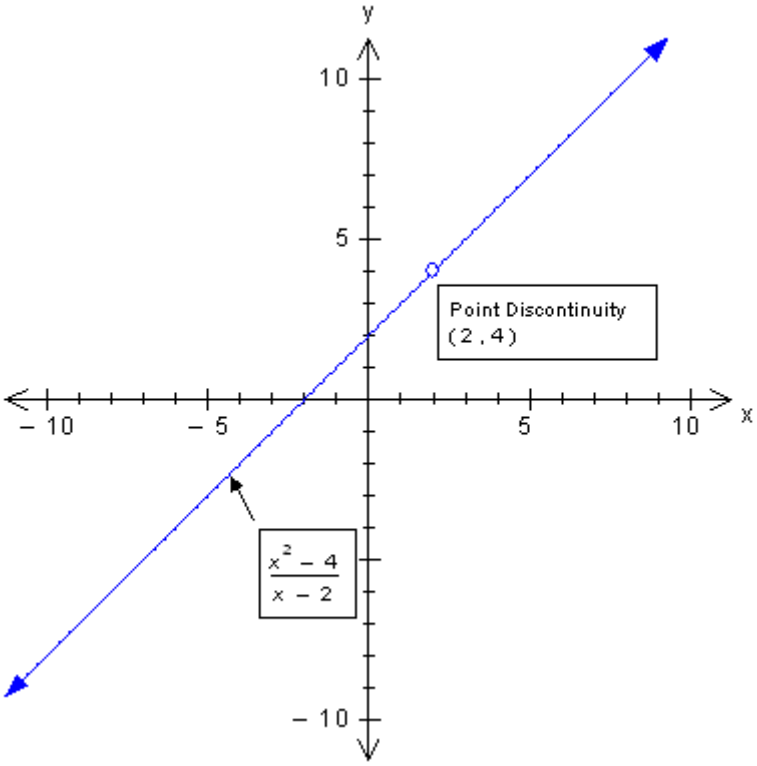
6.3.1 Domain Size

Sets the size of the domain end points. The size is the radius of the circles - in millimetres.



6.3.2 Discontinuity Size

Some functions have point discontinuities (see example below). FX Graph automatically finds these point discontinuities for rational functions and displays them with a small circle. This preference controls the radius of the circle (in millimetres).



6.4 General

6.4.1 Key Zoom Ratio

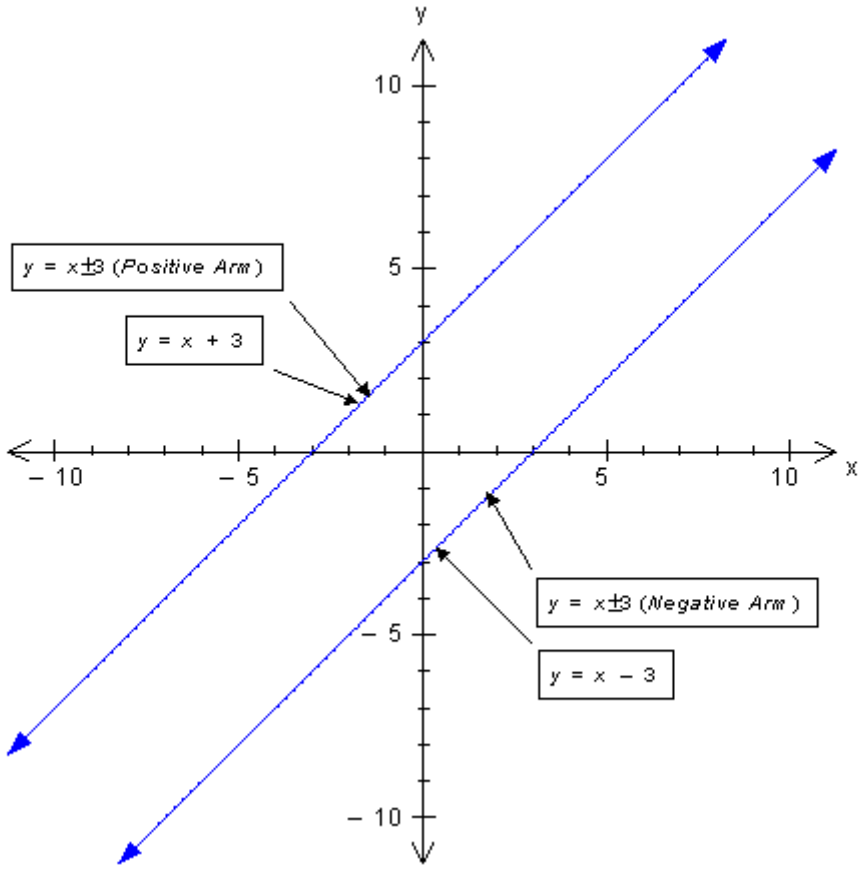
Pushing the Page Up and Page Down buttons will zoom the axes in FX Graph. This number determines the ratio that the scale is increased or decreased by.

For example, the default Key Zoom Ratio is 1.33333. If you axes have maxima of 10 and minima of -10, pushing the Page Up button will change the maxima to 13.33333 and the minima to -13.33333.

6.4.2 Replace +- on Display

FX Graph can accept +- (±) characters in equations.

For example, if you enter y = x+-3 you will see this graph.



The two parts of this function are each labelled with two annotations. The upper annotation retains the ± character with a positive or negative arm message. This is how FX Graph reports functions when Replace +- on Display is OFF. The lower annotation, where the ± character has been replaced by either + or - as appropriate, is how FX Graph reports these functions with Replace +- on Display ON.

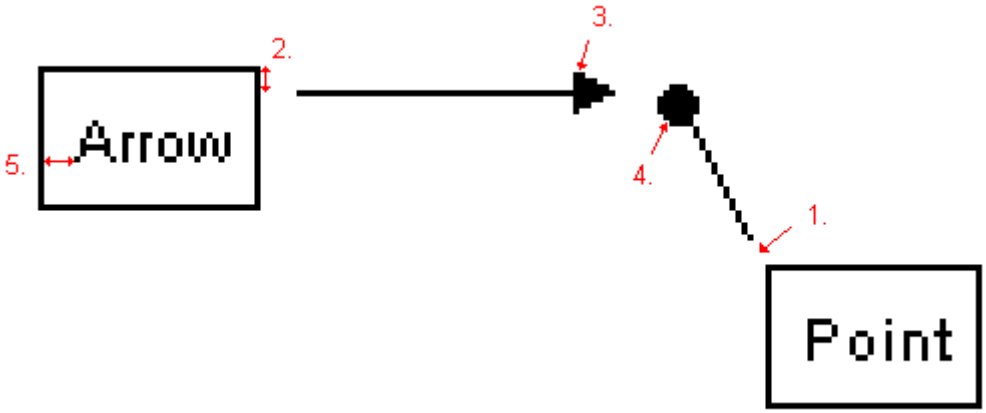
6.4.3 Right Click on Axes

Usually, right-clicking in the FX Graph screen will start the Quick Entry screen but if you right click on an axis, FX Graph will start the Axes properties screen. Some people dislike this behaviour and find it distracting. You can turn it off here.

6.5 Annotations

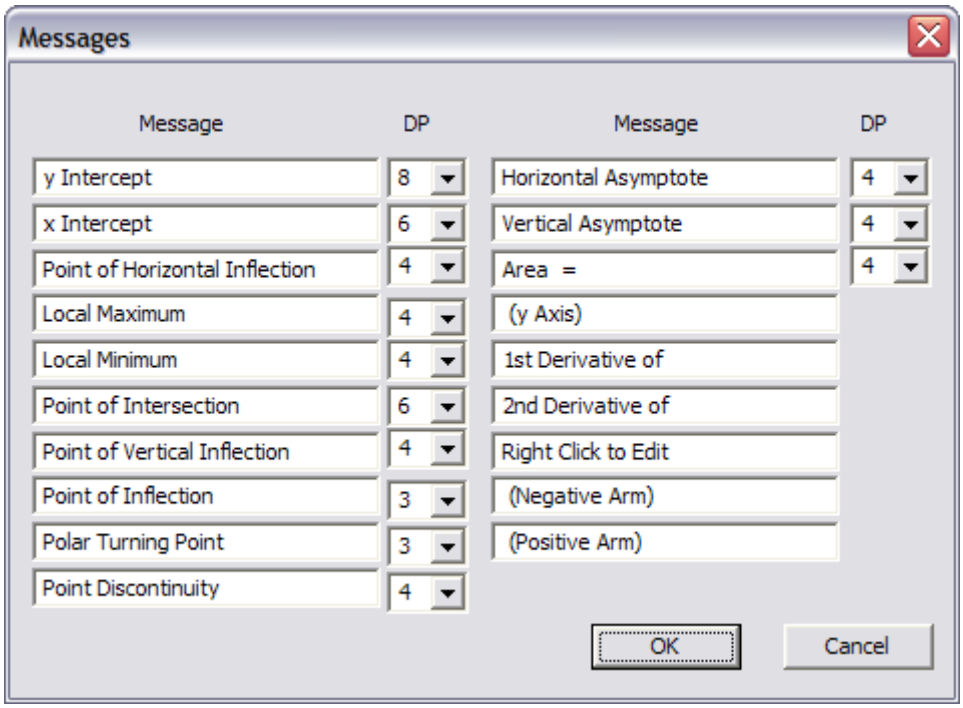
Annotations have a number of adjustments that can be edited here. There settings are:

1. Anchor Gap - the gap between the border and the beginning of the anchor line.
2. Corner Offset - As you move an annotation around, the anchor stays attached to a corner but this setting lets it float down the side of the border.
3. Arrow Size
4. Point Size
5. Border Gap - Between the border and the text.



7 Messages

FX Graph 3 displays many messages on screen - things like "Point of Intersection". By going to the Tools menu and choosing Messages, you can change the messages FX Graph provides.



You can also change the default number of decimal points that FX Graph uses when displaying the points. This is important because some routines (eg Point of Inflection) are not as accurate as others.

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