Beyond the Mouse – A Short Course on Programming

5. Matlab IO: Getting data in and out of Matlab

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YOU'LL NEVER FIND A PROGRAMMING LANGUAGE THAT FREES YOU FROM THE BURDEN OF CLARIFYING YOUR IDEAS.
BUT I KNOW WHAT I MEAN!

"The Uncomfortable Truths Well",
http://xkcd.com/568 (April 13, 2009)

Outline

1. File access
2. Plotting Data
3. Annotating Plots
4. Many Data - one Figure
5. Saving your Figure
6. Misc
7. Examples

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1. File access
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File access 1: Excel-data

`xlsread`

- `[num, txt, raw] =` **xlsread** `('myfile.xls', 'sheet23');` attempts to read sheet 23 (first sheet if parameter omitted)
- `num` – a matrix that contains all numeric data
- `txt` – a cell array that contains all text data
- `raw` – cell array with columns `xlsread` could not interpret

File access 1: Excel-data

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- `raw` – cell array with columns `xlsread` could not interpret

`xlswrite`

- `[status, msg] =` **xlswrite** `('myfile.xls', M, 'sheet42');` attempts to write matrix `M` to sheet 42 of myfile.xls
- `status` – `1` on success, `0` on error
- `msg` – error message object with fields `message` and `identifier`

File access 1: Excel-data

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xlswrite

- `[status, msg] =` **xlswrite** `('myfile.xls', M, 'sheet42');` attempts to write matrix `M` to sheet 42 of myfile.xls
- `status` – `1` on success, `0` on error
- `msg` – error message object with fields `message` and `identifier`

See Also:

`dlmread, dlmwrite, csvread, csvwrite`

File access 1.5: Opening and closing files

fopen

- `fid =` **fopen**`('filename', mode);`
  Open a file, **do not discard fid!**
- `mode` is:
  - `'r'` – read (default)
  - `'w'` – write (overwrite if file exists)
  - `'a'` – append (append if file exists)

Wherever **fid** is used in the following, these functions must be used!

File access 1.5: Opening and closing files

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`fclose`

- `fid =` **fclose** `(fid);`
  close file with identifier `fid`

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File access 1.5: Opening and closing files

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  close file with identifier `fid`

Wherever **fid** is used in the following, these functions must be used!

File access 2: Text Files 1/3

textread

- `[A, B, C, ...] =` **textread** `('filename', 'format', N);` reads data from file 'filename' to **multiple outputs** A,B,C,... using specified `format` until **entire** file is read, or `N` times.

File access 2: Text Files 1/3

textread

- `[A, B, C, ...] =` **textread**`('filename', 'format', N);`
  reads data from file 'filename' to **multiple outputs** A,B,C,... using specified `format` until **entire** file is read, or `N` times.

textscan

- `C =` **textscan**`(fid, 'format', N);`
  reads data from file `fid` **OR** a string to cell array `C` using specified `format` until **entire** file is read, or `N` times (resume from where left by calling textscan again later).

File access 2: Text Files 1/3

`textread`

- `[A, B, C, ...] =` **textread**`('filename', 'format', N);`
  reads data from file 'filename' to **multiple outputs** A,B,C,... using specified `format` until **entire** file is read, or `N` times.

`textscan`

- `C =` **textscan**`(fid, 'format', N);`
  reads data from file `fid` **OR** a string to cell array `C` using specified `format` until **entire** file is read, or `N` times (resume from where left by calling textscan again later).

Use `textscan` if you want . . .

- to read large files (better performance than textread)
- **one** cell array as opposed to many outputs
- read from any point in the file (use `fseek` on `fid` first)
- more options and choices in data conversion (see doc)

File access 2: Text Files 2/3

`fprintf`

- `count =` **fprintf**`(fid, 'format', A, ...);`
  formats data in matrix `A` (and additional arguments) according to format string and writes to the file associated with `fid`
- `count` – number of bytes written

File access 2: Text Files 2/3

`fprintf`

- `count =` **fprintf**`(fid, 'format', A, ...);`
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File access 2: Text Files 2/3

`fprintf`

- `count = `**fprintf**`(fid, 'format', A, ...);` formats data in matrix `A` (and additional arguments) according to format string and writes to the file associated with `fid`
- `count` – number of bytes written

See also

- `dlmwrite`: Write matrix to ASCII delimited file
- `csvwrite`: Write matrix to comma-separated value file

File access 2: Text Files 3/3

fprintf example

```
clear all, clc, close all;

% create data here
x = 1:10
y = rand(1,10)

% open a file in write mode
fout = fopen('random_numbers.txt', 'w');

% write our data:
%   x is first column,
%   y is second column
fprintf(fout, '%d\t%f\n', [x; y])

% don't forget to close the file!
fclose(fout)
```

File access 2: Text Files 3/3

fprintf example

```
clear all, clc, close all;

% create data here
x = 1:10
y = rand(1,10)

% open a file in write mode
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fprintf(fout, '%d\t%f\n', [x; y])

% don't forget to close the file!
fclose(fout)
```

output

```
1  0.706046
2  0.031833
3  0.276923
4  0.046171
5  0.097132
6  0.823458
7  0.694829
8  0.317099
9  0.950222
10 0.034446
```

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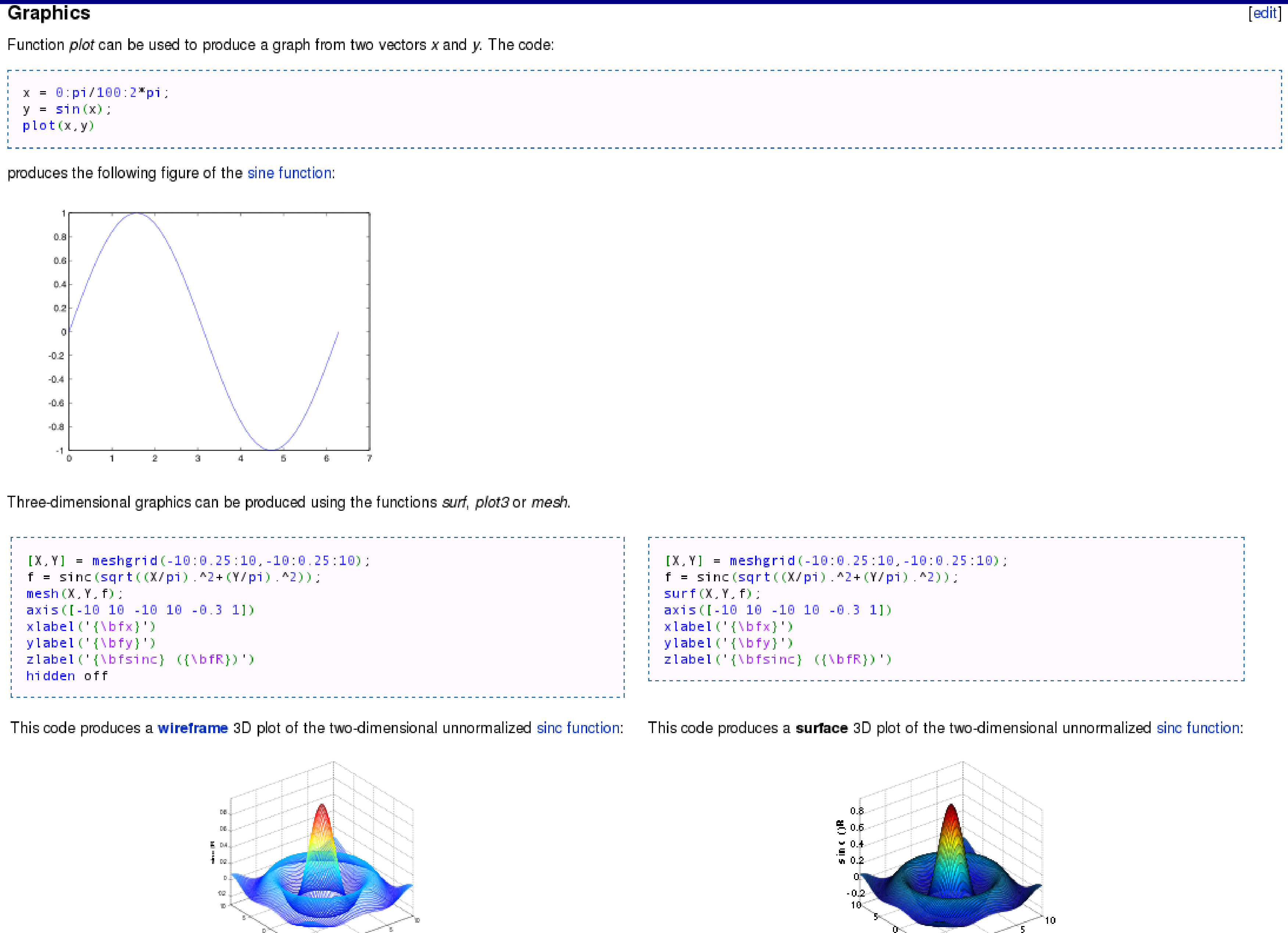
plot



Graphics

[edit]

Function *plot* can be used to produce a graph from two vectors *x* and *y*. The code:

```
x = 0:pi/100:2*pi;
y = sin(x);
plot(x,y)
```

produces the following figure of the sine function:

Three-dimensional graphics can be produced using the functions *surf*, *plot3* or *mesh*.

```
[X,Y] = meshgrid(-10:0.25:10,-10:0.25:10);
f = sinc(sqrt((X/pi).^2+(Y/pi).^2));
mesh(X,Y,f);
axis([-10 10 -10 10 -0.3 1])
xlabel('{\bfx}')
ylabel('{\bfy}')
zlabel('{\bfsinc} ({\bfR})')
hidden off
```

This code produces a **wireframe** 3D plot of the two-dimensional unnormalized sinc function:

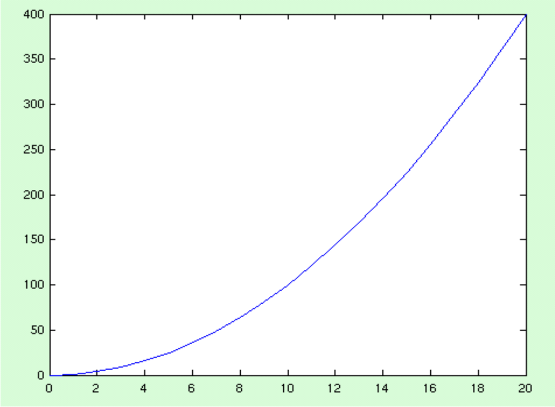
```
[X,Y] = meshgrid(-10:0.25:10,-10:0.25:10);
f = sinc(sqrt((X/pi).^2+(Y/pi).^2));
surf(X,Y,f);
axis([-10 10 -10 10 -0.3 1])
xlabel('{\bfx}')
ylabel('{\bfy}')
zlabel('{\bfsinc} ({\bfR})')
```

This code produces a **surface** 3D plot of the two-dimensional unnormalized sinc function:

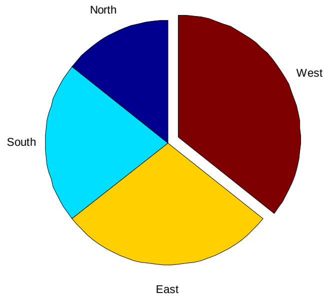
2D plotting

1. Define x-vector
2. Define y-vector
3. plot(x,y)

```
>> x = 1:20;
>> y = x^2;
>> plot(x, y)
```



plot just gives a normal x-y graph with linear axes.

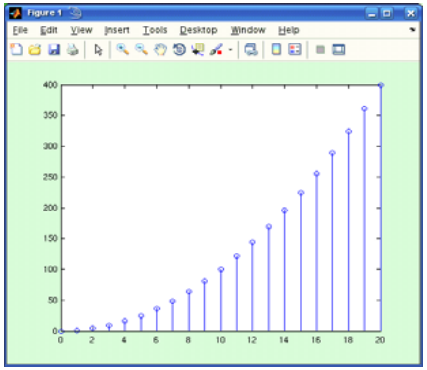


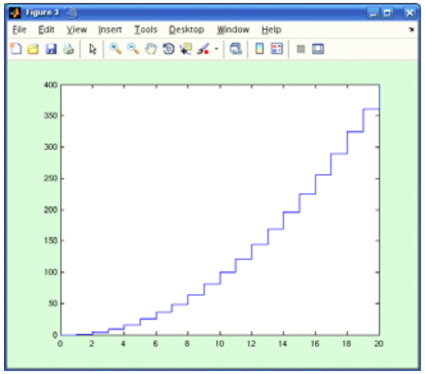
There are other 2D plotting commands, e.g:

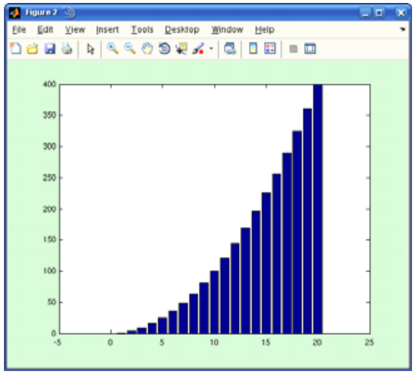
semilogy, semilogx, loglog

stem, stairs, bar

pie, hist

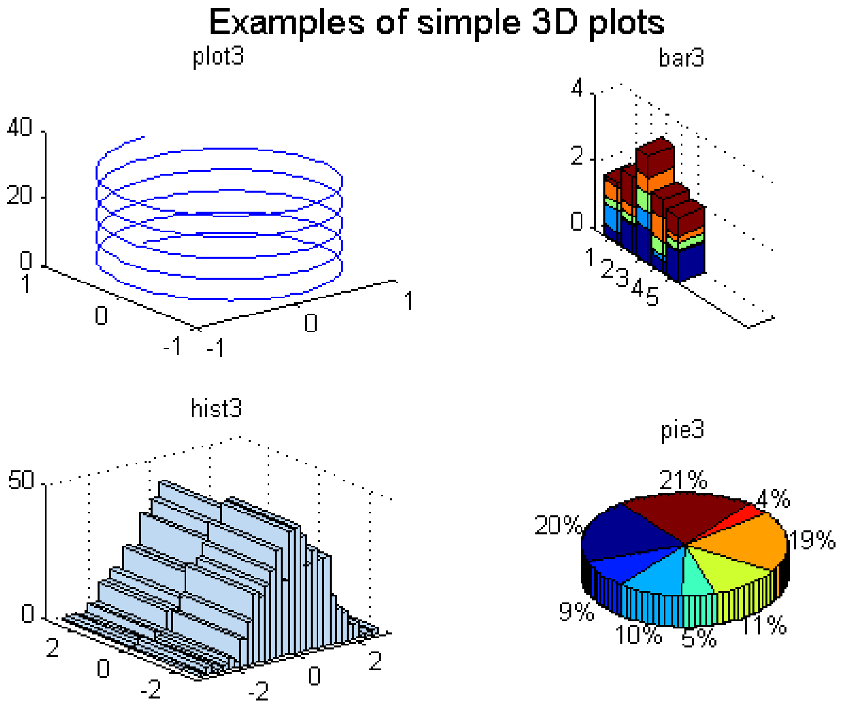






3D plotting

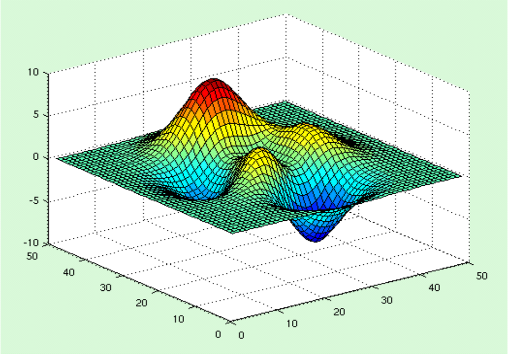
1. Define x-vector
2. Define y-vector
3. Define z-vector
4. plot3(x,y,z)

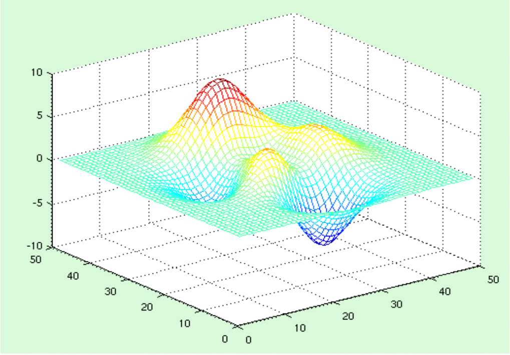


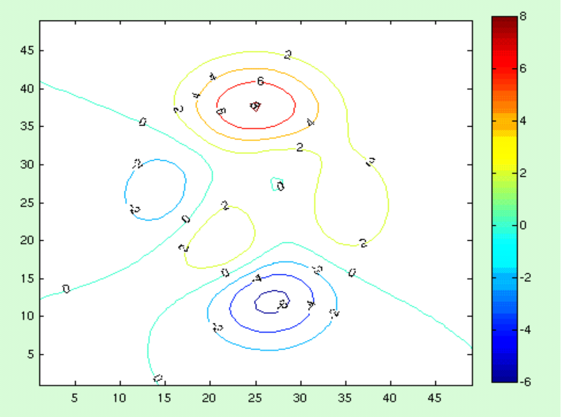
There are other 3D plotting commands, e.g:

surf, mesh, contour

pie3, bar3, hist3





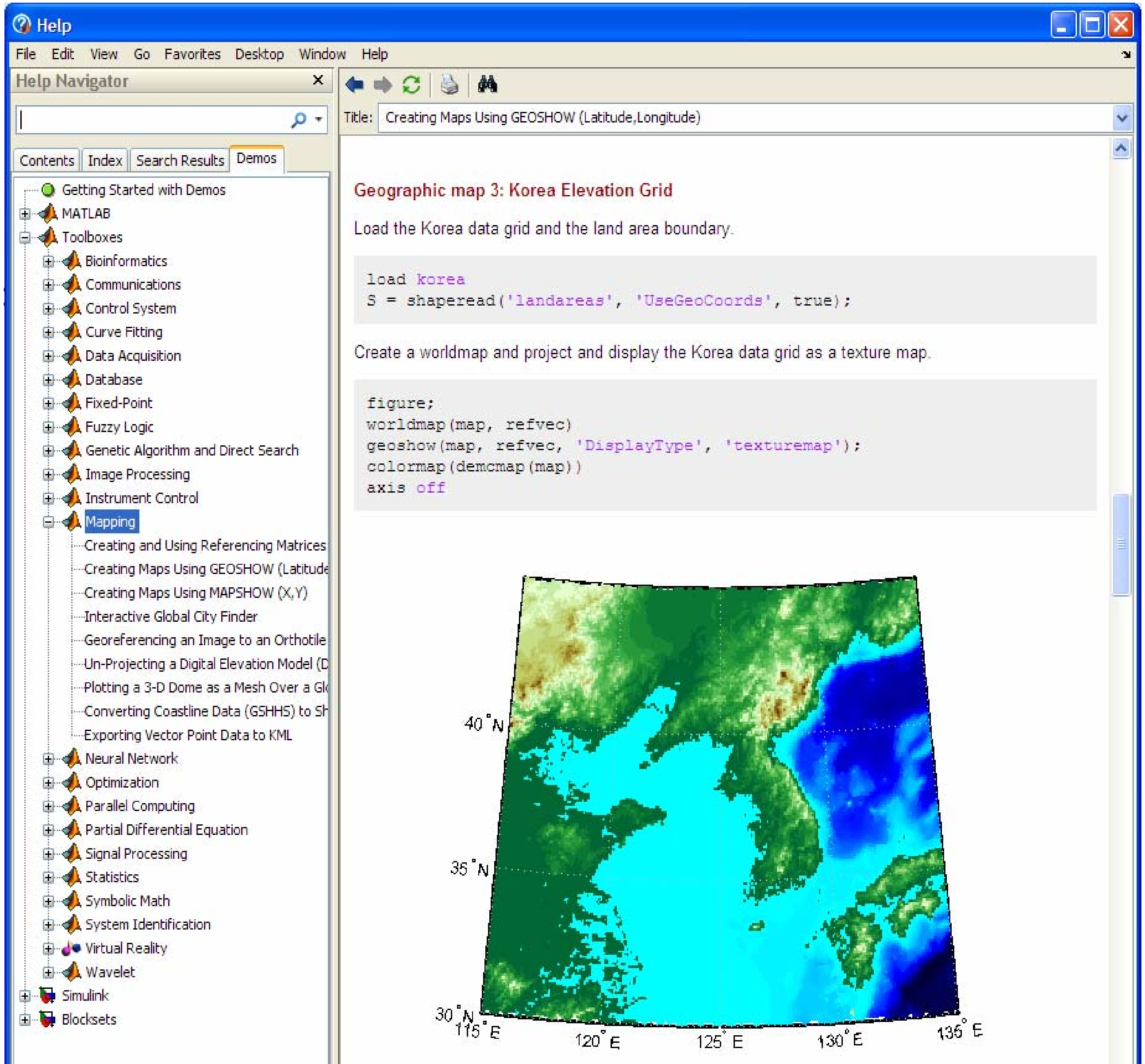


Plotting maps: the Mapping Toolbox

>> help map
>> mapdemos

Can write KML (GoogleEarth):
>> help kmlwrite

Alternative to GMT


Help
File Edit View Go Favorites Desktop Window Help
Help Navigator
Contents
Index
Search Results
Demos
Getting Started with Demos
MATLAB
Toolboxes
Bioinformatics
Communications
Control System
Curve Fitting
Data Acquisition
Database
Fixed-Point
Fuzzy Logic
Genetic Algorithm and Direct Search
Image Processing
Instrument Control
Mapping
Creating and Using Referencing Matrices
Creating Maps Using GEOSHOW (Latitude
Creating Maps Using MAPSHOW (X,Y)
Interactive Global City Finder
Georeferencing an Image to an Orthotile
Un-Projecting a Digital Elevation Model (D
Plotting a 3-D Dome as a Mesh Over a Gl
Converting Coastline Data (GSHHS) to Sh
Exporting Vector Point Data to KML
Neural Network
Optimization
Parallel Computing
Partial Differential Equation
Signal Processing
Statistics
Symbolic Math
System Identification
Virtual Reality
Wavelet
Simulink
Blocksets
Title:
40°N
35°N
30°N
115°E
120°E
125°E
130°E
135°E

Title: Creating Maps Using GEOSHOW (Latitude,Longitude)

Geographic map 3: Korea Elevation Grid

Load the Korea data grid and the land area boundary.

```
load korea
S = shaperead('landareas', 'UseGeoCoords', true);
```

Create a worldmap and project and display the Korea data grid as a texture map.

```
figure;
worldmap(map, refvec)
geoshow(map, refvec, 'DisplayType', 'texturemap');
colormap(demcmap(map))
axis off
```

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Changing the line style: plot(x,y,s)

By default, plot(x,y) uses a blue line to connect data points

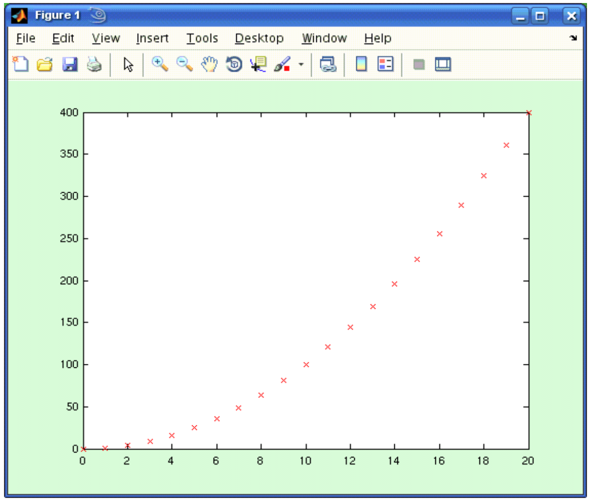
>> help plot

```
Various line types, plot symbols and colors may be obtained with
    PLOT(X,Y,S) where S is a character string made from one element
    from any or all the following 3 columns:

           b     blue          .     point              -     solid
           g     green         o     circle             :     dotted
           r     red           x     x-mark             -.    dashdot
           c     cyan          +     plus               --    dashed
           m     magenta       *     star             (none)  no line
           y     yellow        s     square
           k     black         d     diamond
           w     white         v     triangle (down)
                               ^     triangle (up)
                               <     triangle (left)
                               >     triangle (right)
                               p     pentagram
                               h     hexagram
```

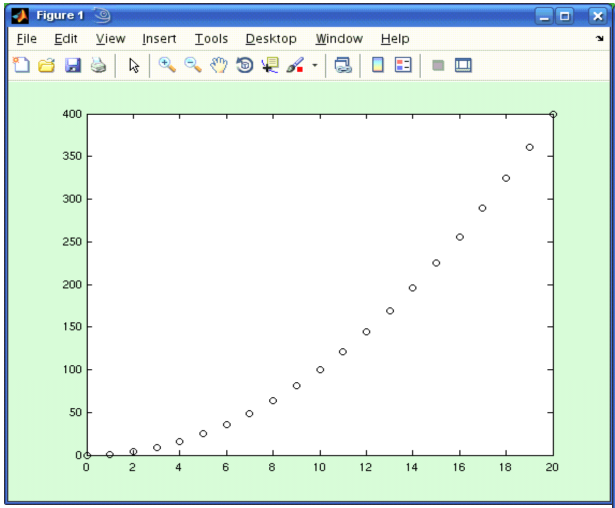
plot(x,y,s)

plot(x,y,'rx')



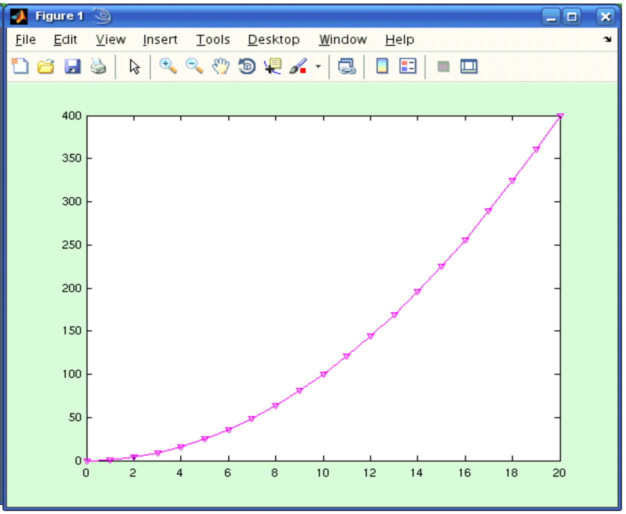
red crosses

plot(x,y,'bo')



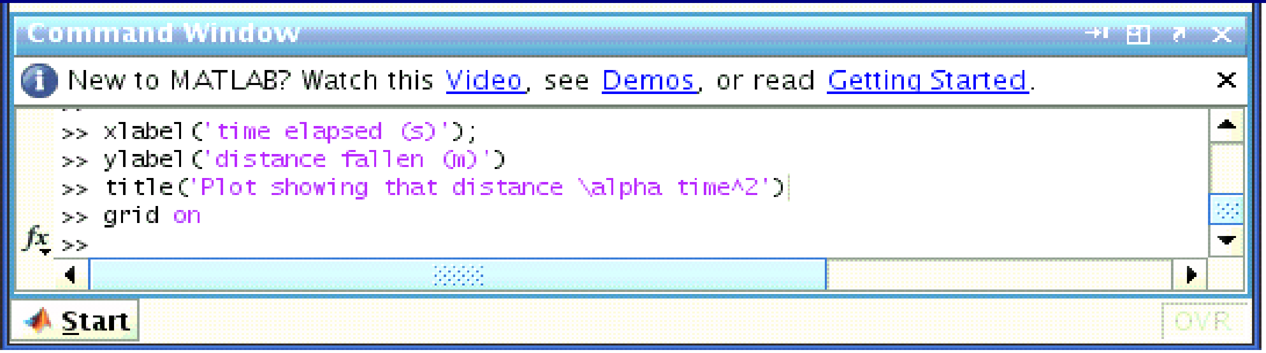
black circles

plot(x, y, 'mv-')



magenta triangles + line

Labelling axes

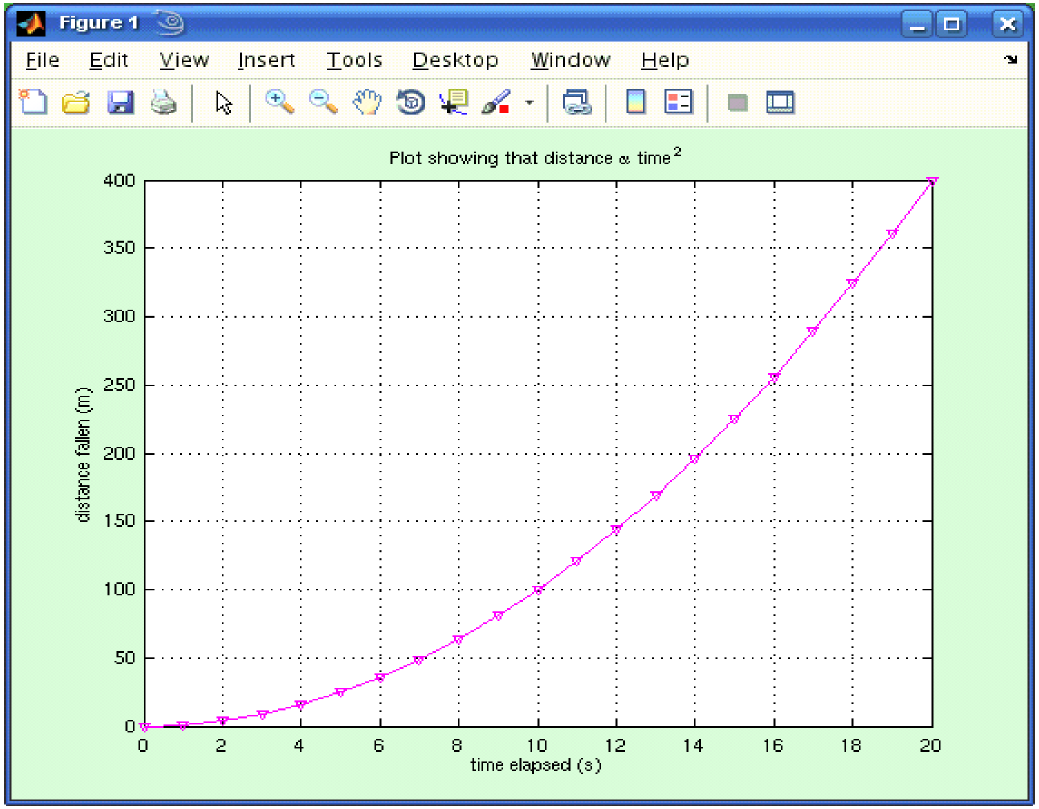


New to MATLAB? Watch this Video, see Demos, or read Getting Started.

```
>> xlabel('time elapsed (s)');
>> ylabel('distance fallen (m)')
>> title('Plot showing that distance \alpha time^2')
>> grid on
>>
```

xlabel
ylabel
title
grid on

Superscripts: ‘time^2’ => time^2
Subscripts: ‘SO_2’ => SO_2
Greek characters: \alpha => α



Adding text

To add text at the position xpos, ypos to the current axes use:

```
>> text(xpos, ypos, ‘some_string’);
```

Remember you can use sprintf.

```
>> text(2.3, 5.1, sprintf(‘station %s’,station{stationNum}) );
```

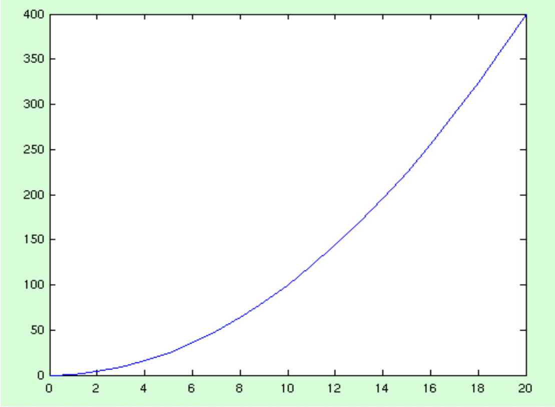
Changing the data range shown

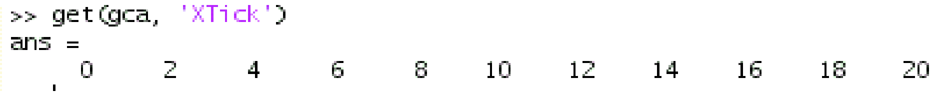
Default: show all the data.

To override use:

```
>> set(gca, ‘XLim’, [xmin xmax]); % x-axis only
>> set(gca, ‘YLim’, [ymin ymax]); % y-axis only
>> set(gca, ‘XLim’, [xmin xmax], ‘YLim’, [ymin ymax]); % both axes
```

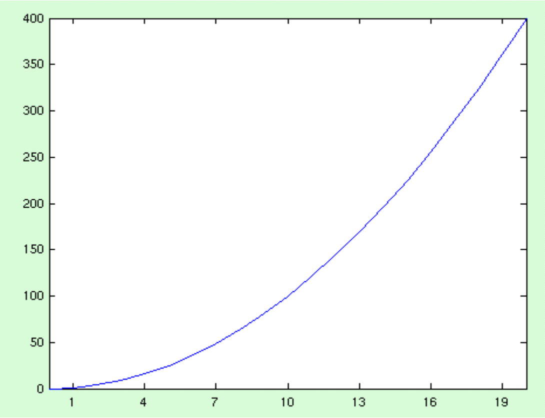
Changing the tick positions/labels



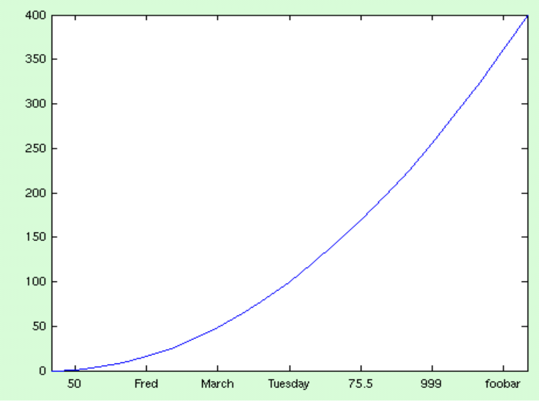


```
>> get(gca, 'XTick')
ans =
      0     2     4     6     8    10    12    14    16    18    20
```

set(gca, 'XTick', 1:3:22)



set(gca, 'XTickLabel', {50, 'Fred', 'March', 'Tuesday', 75.5, 999, 'foobar'})



Plotting against date/time: datenum & datetick

datenum() returns the day number (and fractional day number) in the calendar starting 1st January in the year 0 AD.

Excel dates and times are similar except Excel uses the origin 1st January 1900. But you normally ask Excel to format those cells with a particular date/time format, so you don’t see the raw numbers. In MATLAB, datenum gives those raw numbers.

To convert from Excel day-numbers to MATLAB datenum format:

```
	mtime = etime + datenum(1900, 1, 1);
```

Call it like:

```
datenum(YYYY, MM, DD)
datenum(YYYY, MM, DD, hh, mi, ss)
datenum(‘2009/04/29 18:27:00’)
```

Remember to use vectorisation:

```
	redoubtEventTimes = {‘2009/03/22 22:38’; ‘2009/03/23 04:11’; ‘2009/03/23 06:23’}
	dnum = datenum(redoubtEventTimes); % result is a 3 x 1 vector of datenums.
	datetick(‘x’); % can give unexpected results, ask for help.
```

datestr

I often use dates in plot labels, or in file paths/names.

datestr(array, dateform) is used to generate a human-readable string from an array of dates/times in datenum format.

```
>> lectureTime = datenum(2009, 4, 29, 12, 30, 0)
733890.5208
>> datestr(lectureTime, 30)
20090427T123000
>> datestr(lectureTime, 31)
2009-04-29 12:30:00
>> datestr(lectureTime, ‘mm/dd/yyyy’)
04/29/2009
>> xlabel( sprintf(‘This plot was generated at %s’, datestr(now, 31) ) );
```

An aside – making dates work for you:

YYYYMMDD, not MMYYDD (U.S.) or DDMMYY (Europe).

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MATLAB Graphics Object Hierarchy

- Screen
    - Figure1
        - Axes1 (xlabel, ylabel, title, tick marks, tick labels)
            - Graph1 (linestyle, legendlabel)
            - Graph2
            - …
        - Axes2
            - Graph1
            - …
    - Figure2
        - Axes1
            - Graph1
            - Graph2
        - Axes2
            - Graph1
    - …

figure axes plot

figure

To create a new figure with no axes:

```
>> figure;
```

To highlight a figure that is already displayed (if it doesn’t already exist, it will be created):

```
>> figure(2)
```

To get all the properties associated with a figure:

```
>> get(figure(2))
```

To get a particular property associated with a figure:

```
>> get(figure(1), ‘Position’)
[420   528   560   420]
```

To modify a particular property associated with a figure:

```
>> set(figure(1), ‘Position’, [100 100 560 420])
```

This particular example will just move where figure(1) is plotted on the screen.

To get a ‘handle’ for the current active figure window use **gcf**.

```
>> get(gcf, ‘Position’)
```

Will return the screen position of the current active figure window.

axes

New figures are created without a set of axes.

To get a ‘handle’ for the current active set of axes use **gca** (get current axes).
Example: get a list of all properties associated with current axes
>> get(gca)

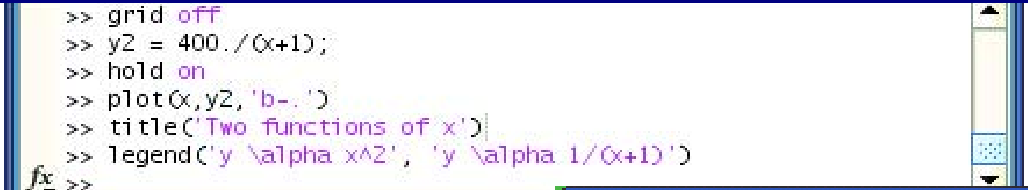
>> get(gca, ‘position’)
This will return the screen position of the current active figure window, which by default is:
[0.13 0.11 0.775 0.815]
Format here is [xorigin yorigin xwidth yheight] in fractions of the figure window width.

To modify the position of the current axes within a figure:
>> set(gca, ‘position’, [0.2 0.3 0.6 0.4])
The axes would start 20% of the way across the screen, 30% of the way up,
and be 60% the screen width, and 40% the screen height.

An alternative syntax is just to call the axes command:

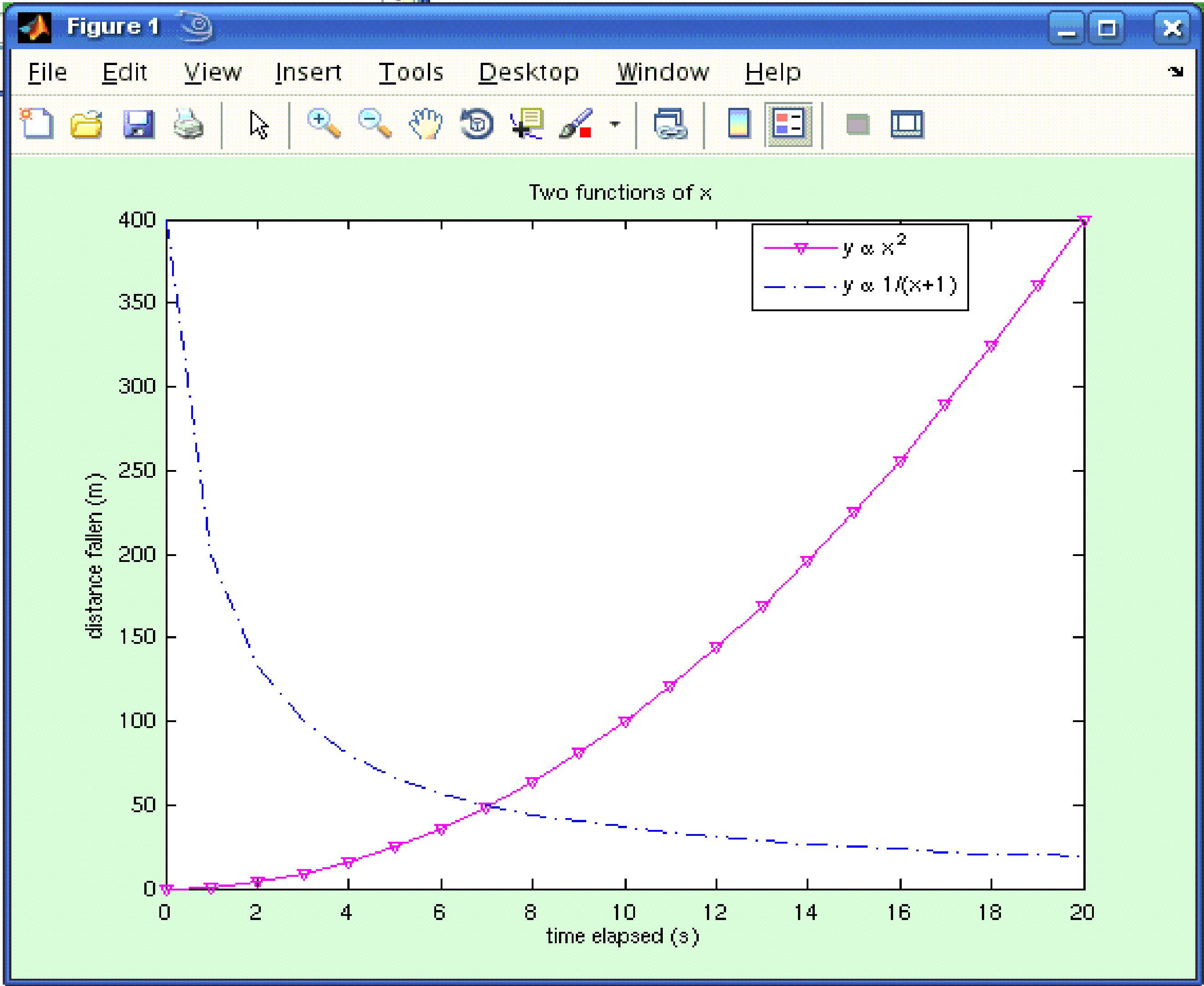
>> axes(‘position’, [0.2 0.3 0.6 0.4]);
Either will create a figure if none already exists. Or modify the current set of axes on the current figure.

Multiple plots on a figure 1: hold on



```
>> grid off
>> y2 = 400./(x+1);
>> hold on
>> plot(x,y2,'b-.')
>> title('Two functions of x')
>> legend('y \alpha x^2', 'y \alpha 1/(x+1)')
>>
```

hold on “holds on” to graphs already in the current axes.
Normally they would be erased



hold on

plot(x,y,'-.')

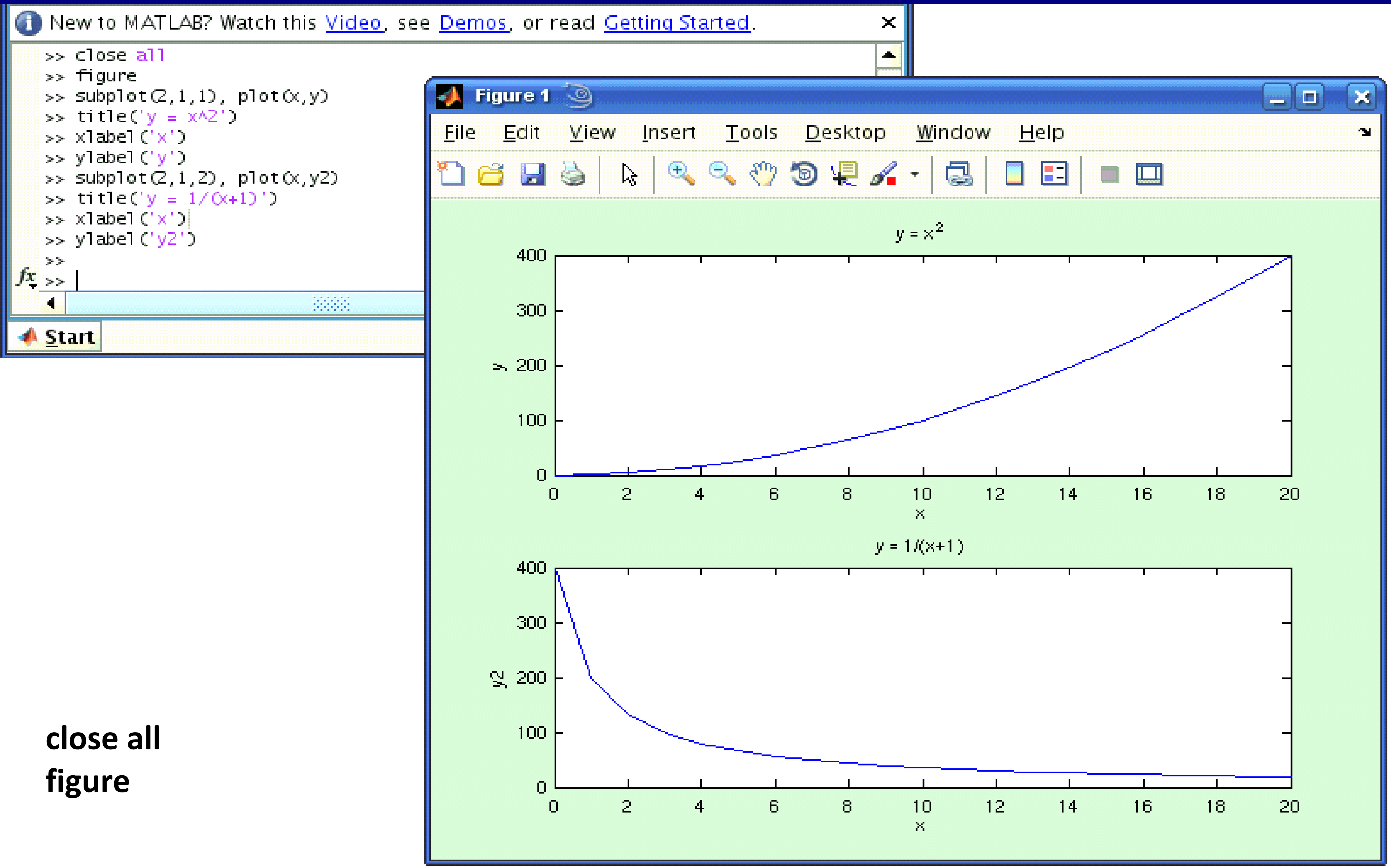
title

legend

hold off

If your graphs have very different scales, and you have just two, try **plotyy**

Multiple plots on a figure 2: subplot



New to MATLAB? Watch this Video, see Demos, or read Getting Started.

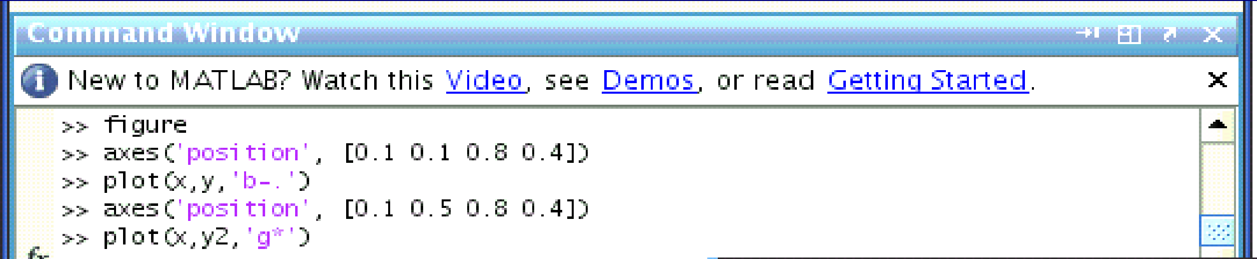
```
>> close all
>> figure
>> subplot(2,1,1), plot(x,y)
>> title('y = x^2')
>> xlabel('x')
>> ylabel('y')
>> subplot(2,1,2), plot(x,y2)
>> title('y = 1/(x+1)')
>> xlabel('x')
>> ylabel('y2')
>>
>> |
```

close all

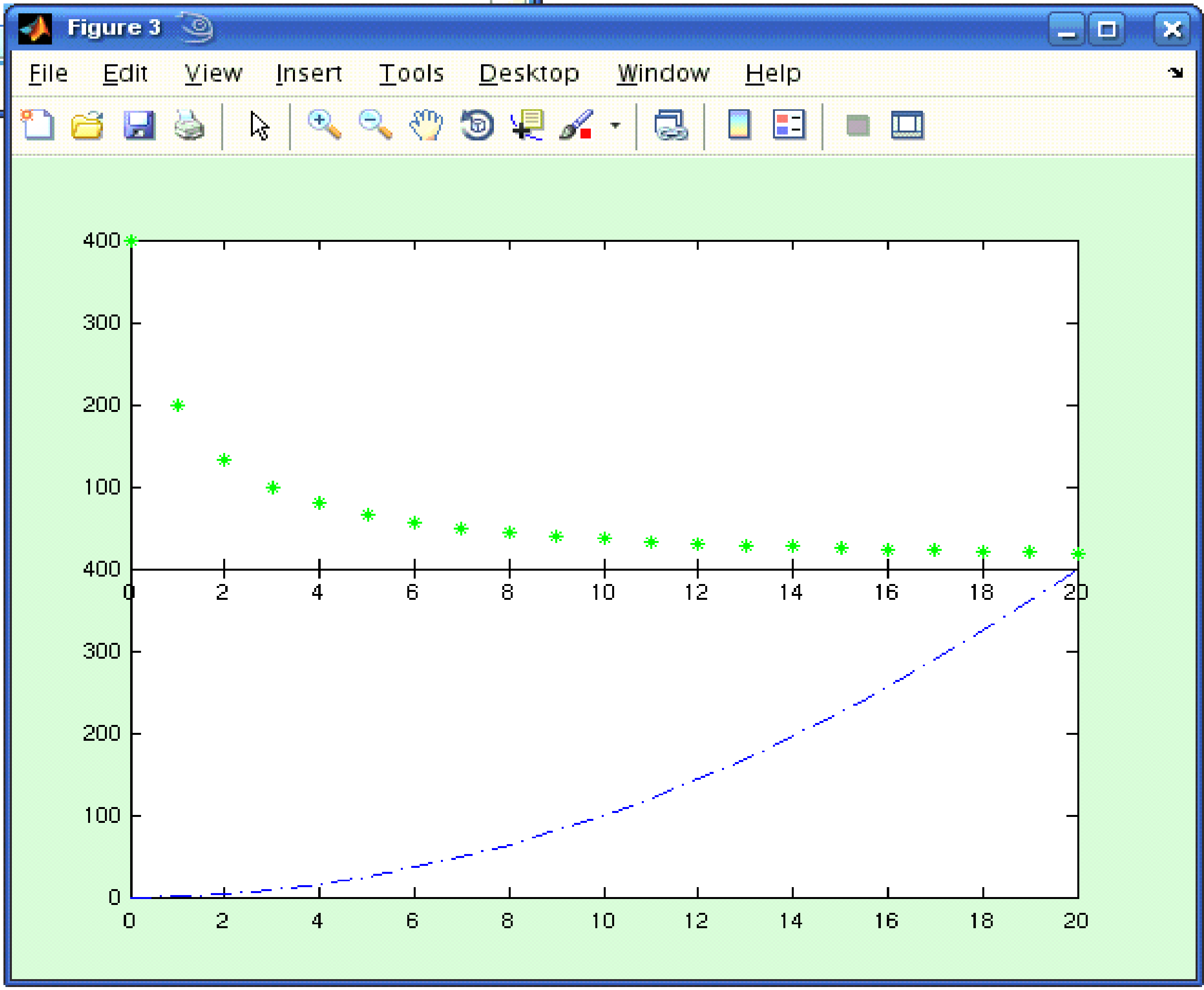
figure

subplot(M, N, plotnum) - an M x N array of plot axes

Multiple plots on a figure 3: axes(‘position’, […])


Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
Start

```
>> figure
>> axes('position', [0.1 0.1 0.8 0.4])
>> plot(x,y,'b-.')
>> axes('position', [0.1 0.5 0.8 0.4])
>> plot(x,y2,'g*')
>>
```



axes(‘position’, [xorigin yorigin xwidth yheight]); – for finer control than subplot

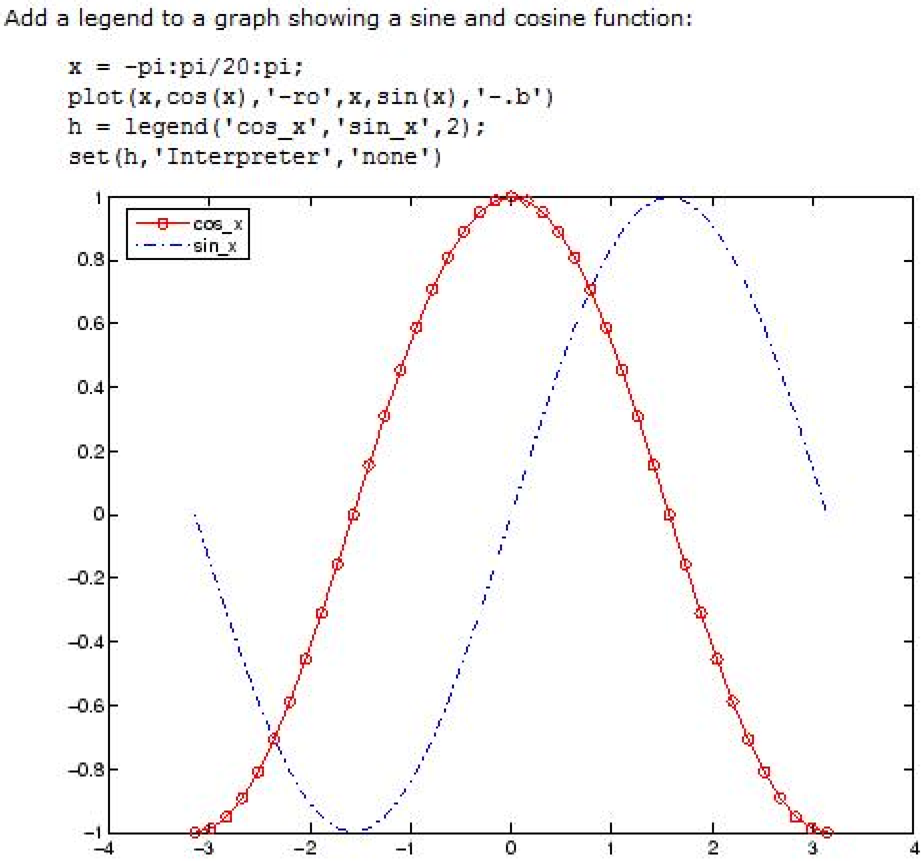
set(gca, 'XTickLabel', {}) - remove x tick labels

Multiple plots on a figure 4: long form of plot command

plot(x1, y1, x2, y2, …, xn, yn)
% a way of plotting multiple graphs without using **hold on**

plot(x1, y1, s1, x2, y2, s2, …, xn, yn, sn)
% as above, but override the default lin styles.

You can then use **legend** to create a key for the different graphs in your figure.



Add a legend to a graph showing a sine and cosine function:

```
x = -pi:pi/20:pi;
plot(x,cos(x),'-ro',x,sin(x),'-.b')
h = legend('cos_x','sin_x',2);
set(h,'Interpreter','none')
```

Outline

1. File access
2. Plotting Data
3. Annotating Plots
4. Many Data - one Figure
5. Saving your Figure
6. Misc
7. Examples

Writing an image file - print

print -f1 -dpng myplotfilename.png - script form

print('-f1', '-dpng', '-r200', 'myplotfilename.png') - functional form

-r200 means print with resolution 200 dots per inch (use lower number for small plot)

-f2 means print figure 2

Devices include:

ps, psc, ps2, psc2	- Postscript (c = colour, 2 = level 2)
eps, epsc, eps2, eps2	- Encapsulated Postscript (c = colour, 2 = level 2)
ill	- Adobe Illustrator format
jpeg90	- JPEG with quality 90 (can be 01 to 99)
tiff	- TIFF
png	- PNG

Can also capture a figure window with:
>> print –dmeta
on a Windows system, and paste it into your document. It does the same thing as ALT-PRT SC.

Writing an image file - print

Example:

You have (numberOfPlots) figures and you want to save all of them as level-2 color encapsulated postscript files with names like myplot1.eps, myplot2.eps:

```
for plotNum = 1 : numberOfPlots
        print('-depsc2', sprintf('-f%d',plotNum), '-r70',
sprintf('myplot%d.eps',plotNum) );
end
```

For plotNum = 2, the print line would evaluate to:

```
        print('-depsc2', '-f2', '-r70', 'myplot2.eps')
```

Saving your Figure (2): `saveas`

`saveas`

- **saveas**`(h, 'filename.ext');`
  saveas`(h, 'filename', 'format');`
- saves figure with the handle `h` to file `filename`.
- file format is either handled by the extention `ext` or the specified `format`:

`ai`	Adobe Illustrator	`bmp`	Windows bitmap
`emf`	Enhanced metafile	`eps`	EPS Level 1
`fig`	Matlab figure	`jpg`	JPEG
`m`	Matlab M-file	`pbm`	Portable bitmap
`pcx`	Paintbrush 24-bit	`pdf`	Portable Document Format
`pgm`	Portable Graymap	`png`	Portable Network Graphics
`ppm`	Portable Pixmap	`tif`	TIFF image, compressed