MATLAB Course
November-December 2006

Chapter 3: Graphics

Making plots

>> help plot

PLOT Linear plot.
PLOT(X,Y) plots vector Y versus vector X. If X or Y is a matrix, then the vector is plotted versus the rows or columns of the matrix, whichever line up. If X is a scalar and Y is a vector, length(Y) disconnected points are plotted.

PLOT(Y) plots the columns of Y versus their index.
If Y is complex, PLOT(Y) is equivalent to PLOT(real(Y),imag(Y)).
In all other uses of PLOT, the imaginary part is ignored.

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		
y	yellow	s	square		
k	black	d	diamond		
		v	triangle (down)		
		^	triangle (up)		
		<	triangle (left)		
		>	triangle (right)		
		p	pentagram		
		h	hexagram		

For example, PLOT(X,Y,'c+:') plots a cyan dotted line with a plus at each data point; PLOT(X,Y,'bd') plots blue diamond at each data point but does not draw any line.

PLOT(X1,Y1,S1,X2,Y2,S2,X3,Y3,S3,...) combines the plots defined by the (X,Y,S) triples, where the X's and Y's are vectors or matrices and the S's are strings.

For example, PLOT(X,Y,'y-',X,Y,'go') plots the data twice, with a solid yellow line interpolating green circles at the data points.

The PLOT command, if no color is specified, makes automatic use of the colors specified by the axes ColorOrder property. The default ColorOrder is listed in the table above for color systems where the default is blue for one line, and for multiple lines, to cycle through the first six colors in the table. For monochrome systems, PLOT cycles over the axes LineStyleOrder property.

PLOT returns a column vector of handles to LINE objects, one handle per line.

The X,Y pairs, or X,Y,S triples, can be followed by parameter/value pairs to specify additional properties of the lines.

See also SEMILOGX, SEMILOGY, LOGLOG, PLOTYY, GRID, CLF, CLC, TITLE, XLABEL, YLABEL, AXIS, AXES, HOLD, COLORDEF, LEGEND, SUBPLOT, STEM.

If you create a plot, you can find it in the figure window. Every new plot takes the place of the preceeding plot, unless you create a new figure window by:

>> figure

>> help figure
FIGURE Create figure window.
FIGURE, by itself, creates a new figure window, and returns its handle.

FIGURE(H) makes H the current figure, forces it to become visible, and raises it above all other figures on the screen. If Figure H does not exist, and H is an integer, a new figure is created with handle H.

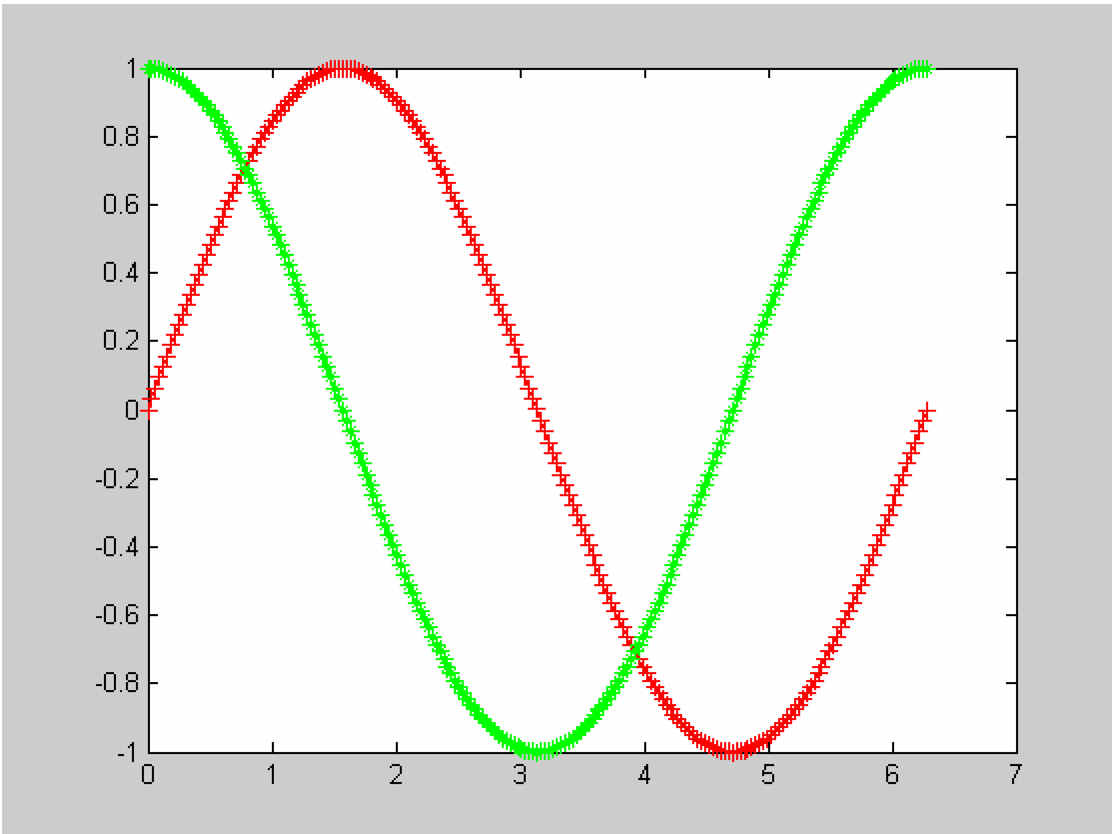
GCF returns the handle to the current figure.

Execute GET(H) to see a list of figure properties and their current values. Execute SET(H) to see a list of figure properties and their possible values.

See also subplot, axes, gcf, clf.

Example 1, a plot of two functions

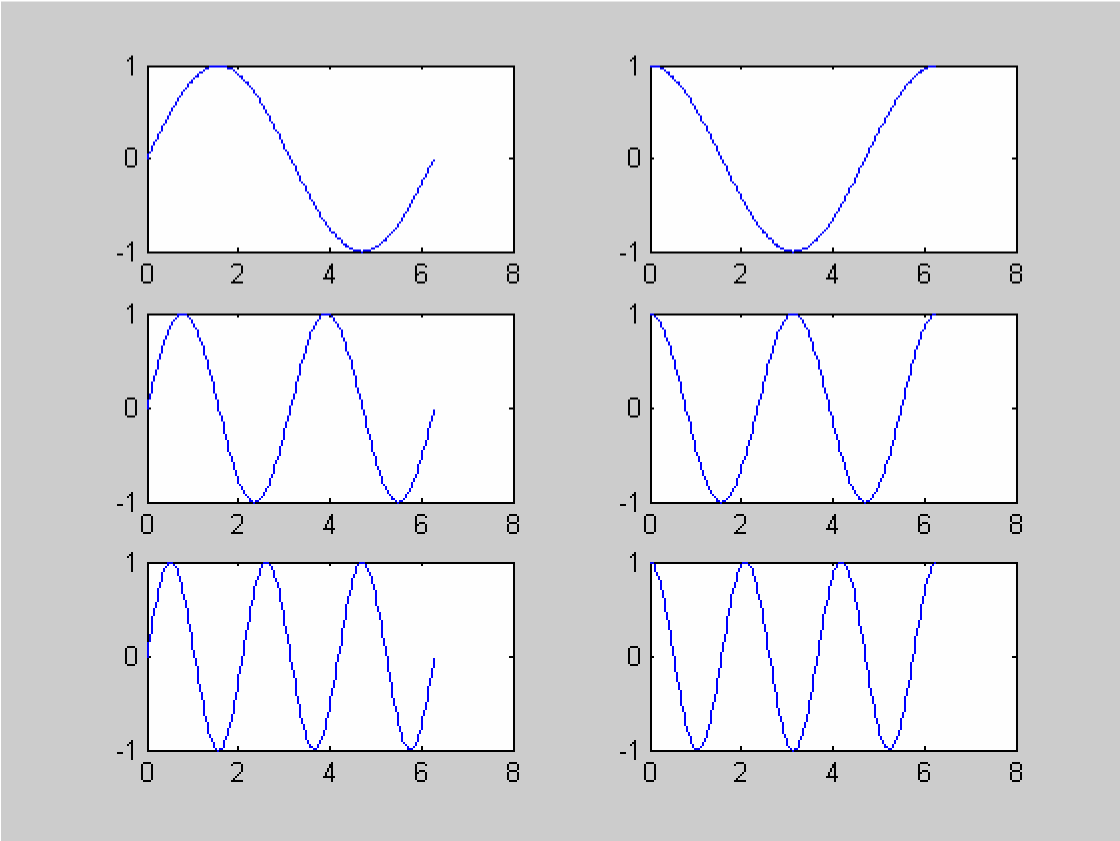
```
function example1
t = 0:pi/100:2*pi;
y1=sin(t);
y2=cos(t);
plot(t,y1,'r-+',t,y2,'g:*')
```



Example 2 making subplots

See help for: subplot

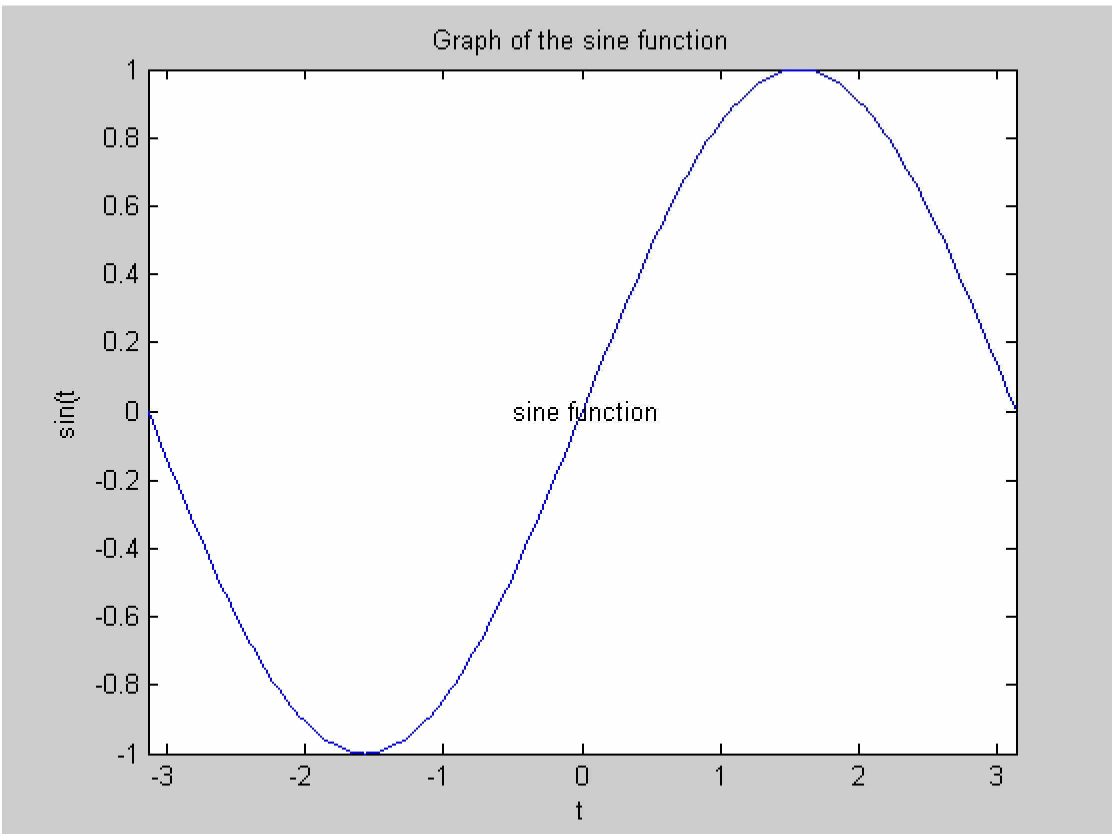
```
function example2
t = 0:pi/100:2*pi;
subplot(3,2,1);plot(t,sin(t));
subplot(3,2,2);plot(t,cos(t));
subplot(3,2,3);plot(t,sin(2*t));
subplot(3,2,4);plot(t,cos(2*t));
subplot(3,2,5);plot(t,sin(3*t));
subplot(3,2,6);plot(t,cos(3*t));
```



Example 3, axis, labels and titles

See help for: axis, xlabel, ylabel, title, text

```
function example3
t = -pi:pi/100:pi;
plot(t,sin(t));
axis([-pi pi -1 1])
xlabel('t')
ylabel('sin(t')
title('Graph of the sine function')
text(-.5,0,'sine function')
```



Example 4, three-dimensional plots

See help for: meshgrid, mesh

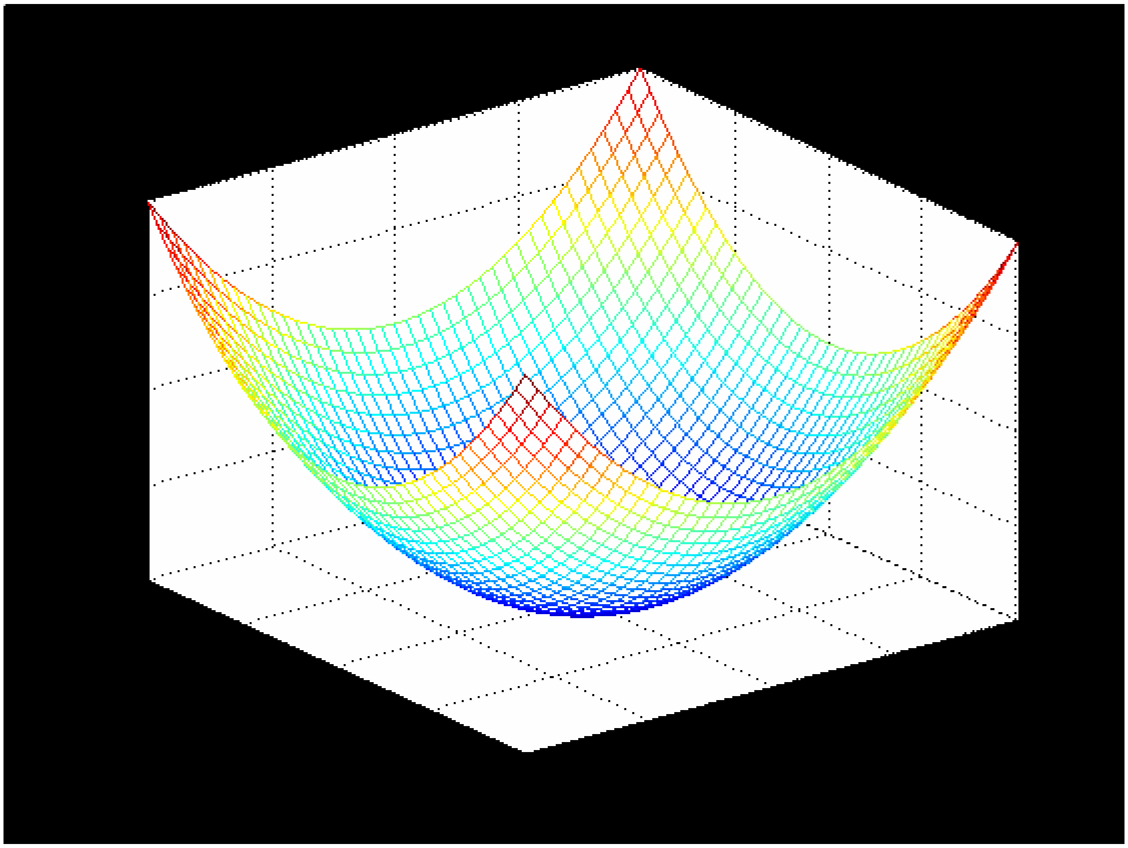
```
[X,Y]=meshgrid(-2:.5:2,-2:.5:2)

X =
  -2.0000  -1.5000  -1.0000  -0.5000        0   0.5000   1.0000   1.5000   2.0000
  -2.0000  -1.5000  -1.0000  -0.5000        0   0.5000   1.0000   1.5000   2.0000
  -2.0000  -1.5000  -1.0000  -0.5000        0   0.5000   1.0000   1.5000   2.0000
  -2.0000  -1.5000  -1.0000  -0.5000        0   0.5000   1.0000   1.5000   2.0000
  -2.0000  -1.5000  -1.0000  -0.5000        0   0.5000   1.0000   1.5000   2.0000
  -2.0000  -1.5000  -1.0000  -0.5000        0   0.5000   1.0000   1.5000   2.0000
  -2.0000  -1.5000  -1.0000  -0.5000        0   0.5000   1.0000   1.5000   2.0000
  -2.0000  -1.5000  -1.0000  -0.5000        0   0.5000   1.0000   1.5000   2.0000
  -2.0000  -1.5000  -1.0000  -0.5000        0   0.5000   1.0000   1.5000   2.0000


Y =
  -2.0000  -2.0000  -2.0000  -2.0000  -2.0000  -2.0000  -2.0000  -2.0000  -2.0000
  -1.5000  -1.5000  -1.5000  -1.5000  -1.5000  -1.5000  -1.5000  -1.5000  -1.5000
  -1.0000  -1.0000  -1.0000  -1.0000  -1.0000  -1.0000  -1.0000  -1.0000  -1.0000
  -0.5000  -0.5000  -0.5000  -0.5000  -0.5000  -0.5000  -0.5000  -0.5000  -0.5000
        0        0        0        0        0        0        0        0        0
   0.5000   0.5000   0.5000   0.5000   0.5000   0.5000   0.5000   0.5000   0.5000
   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000
   1.5000   1.5000   1.5000   1.5000   1.5000   1.5000   1.5000   1.5000   1.5000
   2.0000   2.0000   2.0000   2.0000   2.0000   2.0000   2.0000   2.0000   2.0000
```

- **Carry out the operations on these matrices element wise!!!!**
- **Compute function values for these matrices**

For instance:

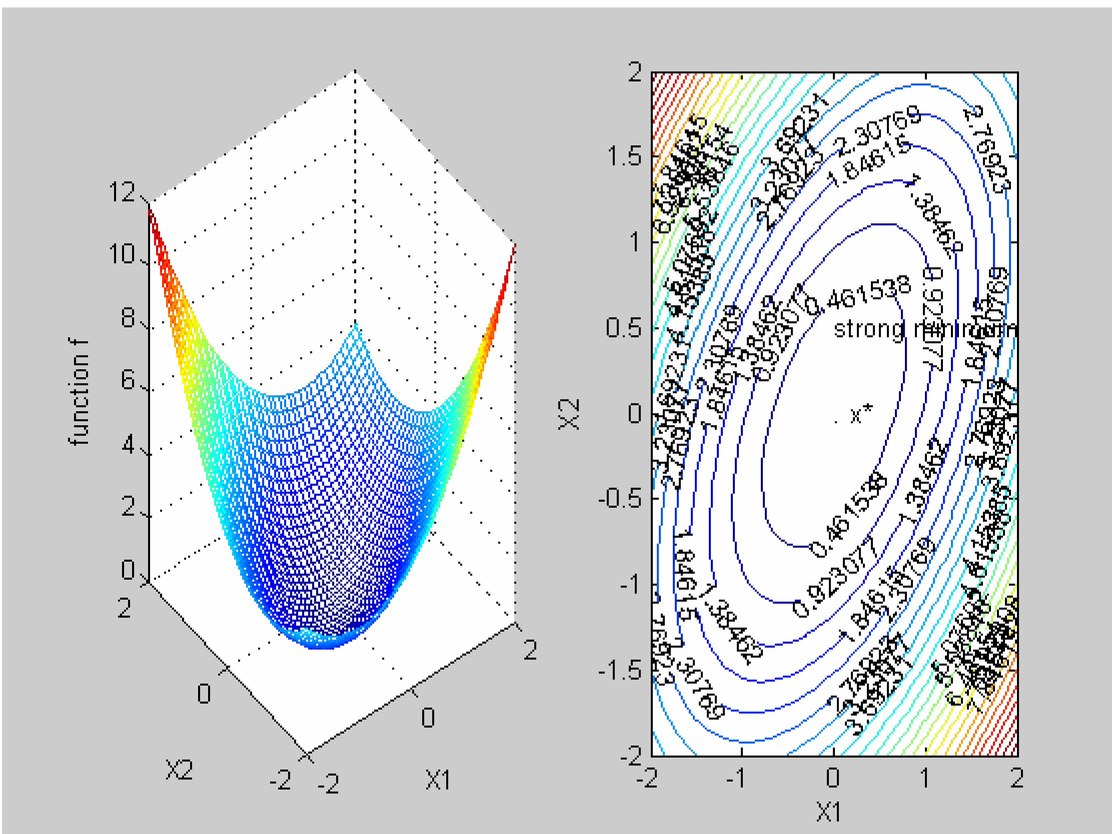
```
>> X.*Y

ans =
   4.0000   3.0000   2.0000   1.0000        0  -1.0000  -2.0000  -3.0000  -4.0000
   3.0000   2.2500   1.5000   0.7500        0  -0.7500  -1.5000  -2.2500  -3.0000
   2.0000   1.5000   1.0000   0.5000        0  -0.5000  -1.0000  -1.5000  -2.0000
   1.0000   0.7500   0.5000   0.2500        0  -0.2500  -0.5000  -0.7500  -1.0000
        0        0        0        0        0        0        0        0        0
  -1.0000  -0.7500  -0.5000  -0.2500        0   0.2500   0.5000   0.7500   1.0000
  -2.0000  -1.5000  -1.0000  -0.5000        0   0.5000   1.0000   1.5000   2.0000
  -3.0000  -2.2500  -1.5000  -0.7500        0   0.7500   1.5000   2.2500   3.0000
  -4.0000  -3.0000  -2.0000  -1.0000        0   1.0000   2.0000   3.0000   4.0000
```

```
function example4
[X,Y]=meshgrid(-10:.5:10);
f=X.^2+Y.^2;
mesh(X,Y,f)
```

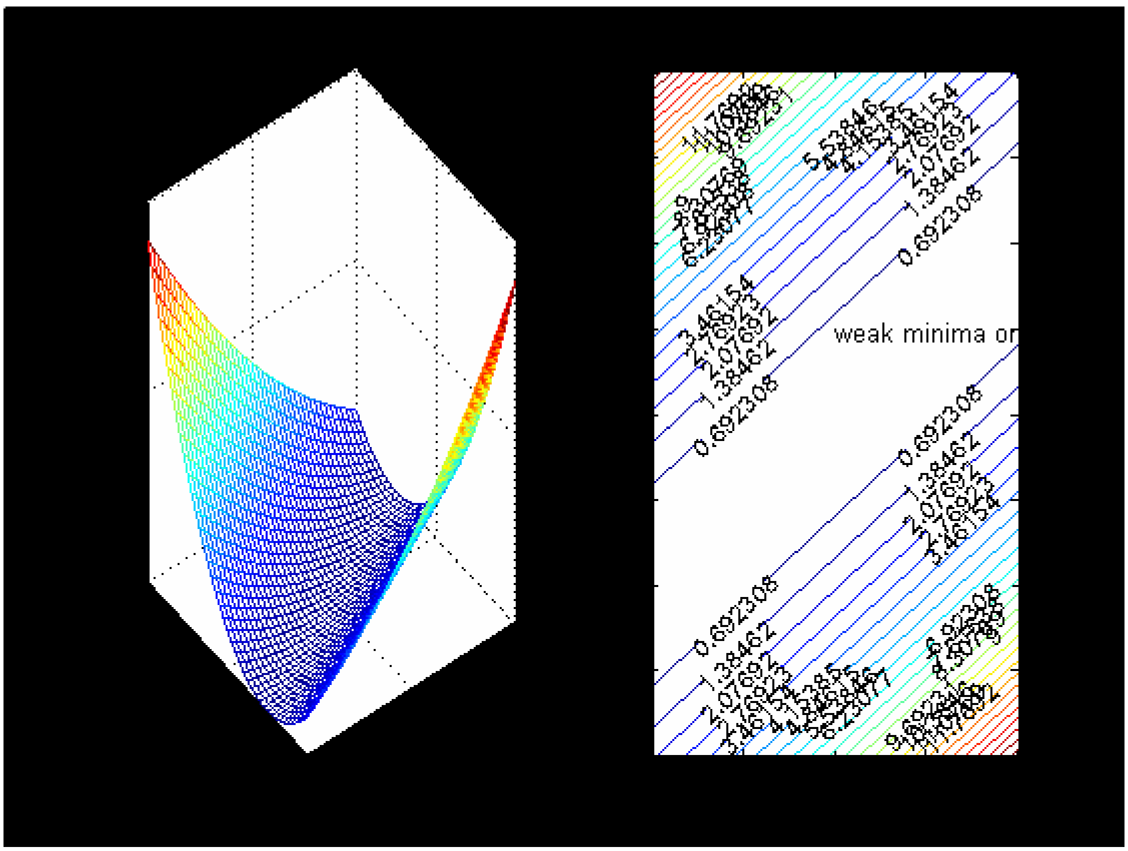


Example 5, contour plot

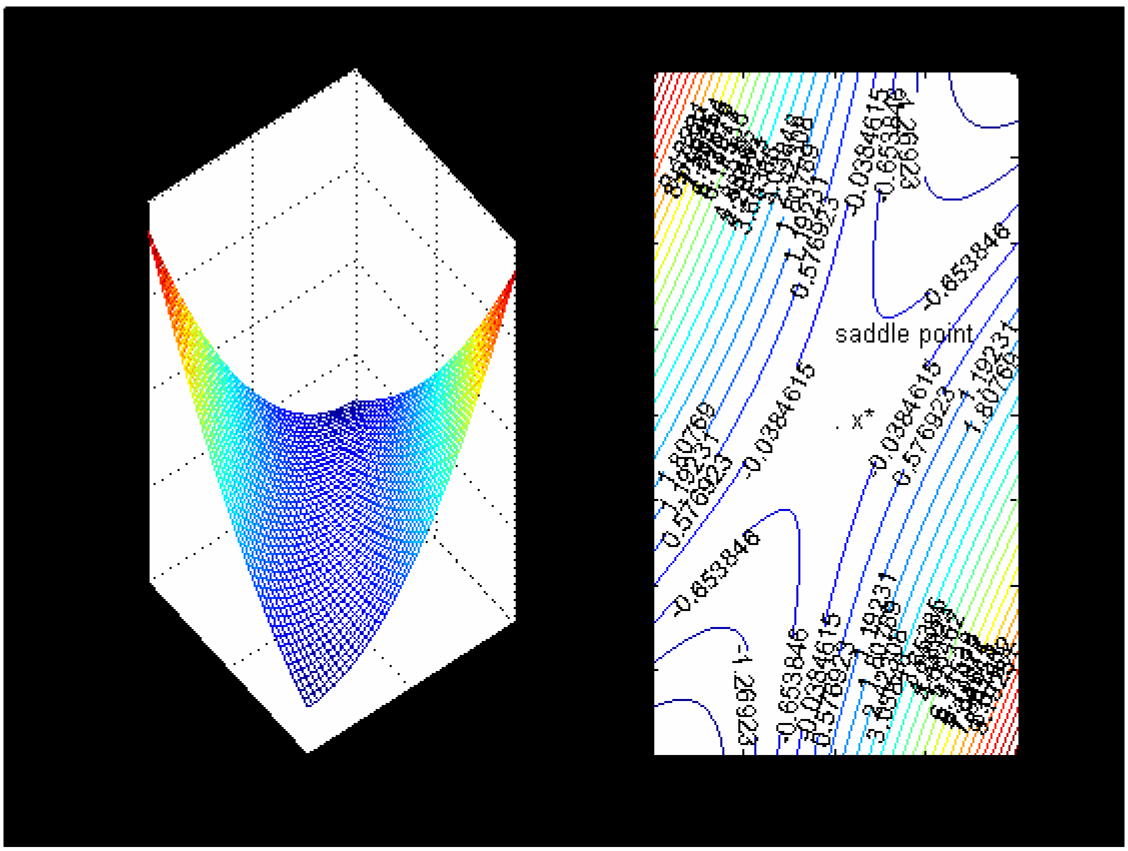
```
function example5
[X1,X2]=meshgrid(-2:.1:2,-2:.1:2);
%             first function
f=X1.^2-X1.*X2+X2.^2;
figure(1)
subplot(1,2,1);mesh(X1,X2,f)
Xlabel('X1')
Ylabel('X2')
Zlabel('function f')
subplot(1,2,2);[C,h]=contour(X1,X2,f,25);
clabel(C,h)
Xlabel('X1')
Ylabel('X2')
text(0,.5,'strong minimum')
text(0,0,'. x*')
```



```
%               second function
f=.5*X1.^2-2*X1.*X2+2*X2.^2;
figure(2)
subplot(1,2,1);mesh(X1,X2,f)
Xlabel('X1')
Ylabel('X2')
Zlabel('function f')
subplot(1,2,2);[C,h]=contour(X1,X2,f,25);
clabel(C,h)
Xlabel('X1')
Ylabel('X2')
text(0,.5,'weak minima on line')
```



```
%               third function
f=X1.^2-2*X1.*X2+.5*(X2.^2-1);
figure(3)
subplot(1,2,1);mesh(X1,X2,f)
Xlabel('X1')
Ylabel('X2')
Zlabel('function f')
subplot(1,2,2);[C,h]=contour(X1,X2,f,25);
clabel(C,h)
Xlabel('X1')
Ylabel('X2')
text(0,.5,'saddle point')
text(0,0,'. x*')
```



Exercises chapter 3

1: The density function of a univariate normal distribution is given as

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp[-\frac{(x-\mu)^2}{2\sigma^2}].$$

Make in one plot three pictures of the density function for $\sigma^2 = .5,\ 1.0,\ 2.0$ for $\mu = 0$. Add a title for the plot, add labels for the axes, and show text in the plot to denote the three pictures.

2: The density function of a multivariate normal distribution is given for p variables as

$$f(\mathbf{x}) = (2\pi)^{-p/2} \left|\mathbf{\Sigma}\right|^{-1/2} \exp[-\frac{1}{2}(\mathbf{x}-\boldsymbol{\mu})'\mathbf{\Sigma}^{-1}(\mathbf{x}-\boldsymbol{\mu})].$$

Assume p = 2 and the mean vector is equal to **0** and the variances of the variables are 1. Make in one figure several subplots corresponding to different correlations of the the two variables.
a: Add a title for the plots, add labels for the axes.
b: Show for each plot also the contours of the function values.
Note:

$$f(x_1, x_2) = (2\pi)^{-1} \left|\mathbf{\Sigma}\right|^{-1/2} \exp[-\frac{1}{2}(x_1\ x_2)\mathbf{\Sigma}^{-1}\begin{pmatrix} x_1 \\ x_2 \end{pmatrix}]$$

$$\mathbf{\Sigma} = \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \Rightarrow \mathbf{\Sigma}^{-1} = \frac{1}{1-\rho^2}\begin{pmatrix} 1 & -\rho \\ -\rho & 1 \end{pmatrix}$$

$$-\frac{1}{2}(x_1\ x_2)\mathbf{\Sigma}^{-1}\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = -\frac{1}{2(1-\rho^2)}(x_1\ x_2)\begin{pmatrix} 1 & -\rho \\ -\rho & 1 \end{pmatrix}\begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

$$= -\frac{1}{2(1-\rho^2)}\begin{pmatrix} x_1 - \rho x_2 & x_2 - \rho x_1 \end{pmatrix}\begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

$$= -\frac{1}{2(1-\rho^2)}(x_1^2 - 2\rho x_1 x_2 + x_2^2)$$

$$\boxed{f(x_1, x_2) = (2\pi)^{-1} \left|\mathbf{\Sigma}\right|^{-1/2} \exp[-\frac{1}{2(1-\rho^2)}(x_1^2 - 2\rho x_1 x_2 + x_2^2)]}$$