

MATLAB

2D graphics

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Let's go back to when we first learned the graph of the function $y = f(x)$ on $a \leq x \leq b$.

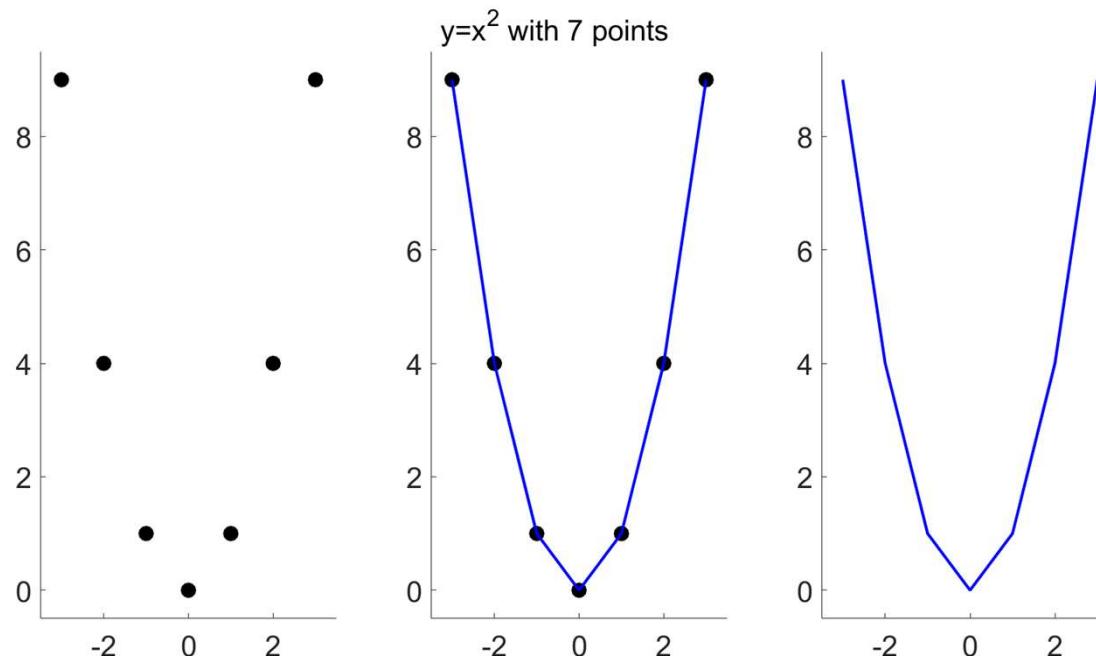
For example, we will draw the graph $y = x^2$ on $-3 \leq x \leq 3$.

We make a table

x	-3	-2	-1	0	1	2	3
y	9	4	1	0	1	4	9

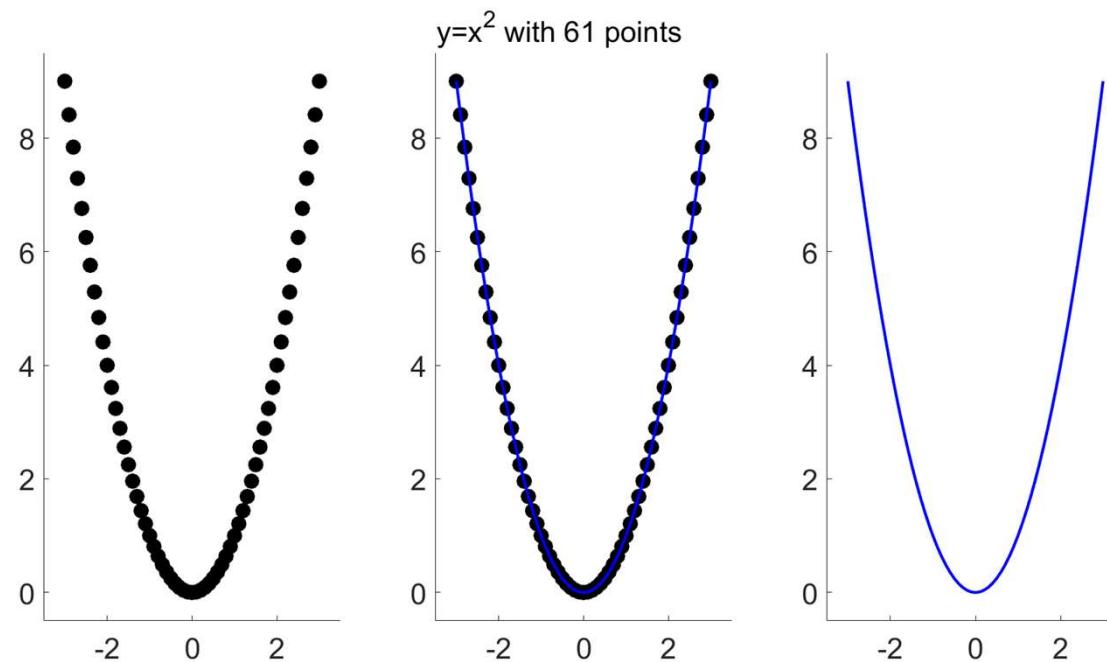
and dot the points on xy plain.

And then connect dots with lines.



The more points you use, the better the graph

x	-3	-2.9	-2.8	...	0	...	2.8	2.9	3
y	9	8.41	7.84	...	0	...	7.84	8.41	9



This is the basic idea of drawing a graph.

To draw the graph of the function $y = f(x)$ on $a \leq x \leq b$.

1. Make the domain points.

- There are 2 ways.

- 1) " $x = \text{linspace}(a, b, N)$ " : $a = x_1 < x_2 < \dots < x_{N-1} < x_N = b$ with evenly spaced.
- 2) " $x = "a:h:b"$ " : $a = x_1 < x_1 + h < \dots < x_{end} - h < x_{end} \leq b$

2. Compute the $y = f(x)$ on the domain points.

- see the next slide.

3. Connect the dots with lines.

- " $\text{scatter}(x, y)$ " : dot the points
- " $\text{plot}(x, y)$ " : connect the points with lines.

Compute the $y = f(x)$ on the domain points.

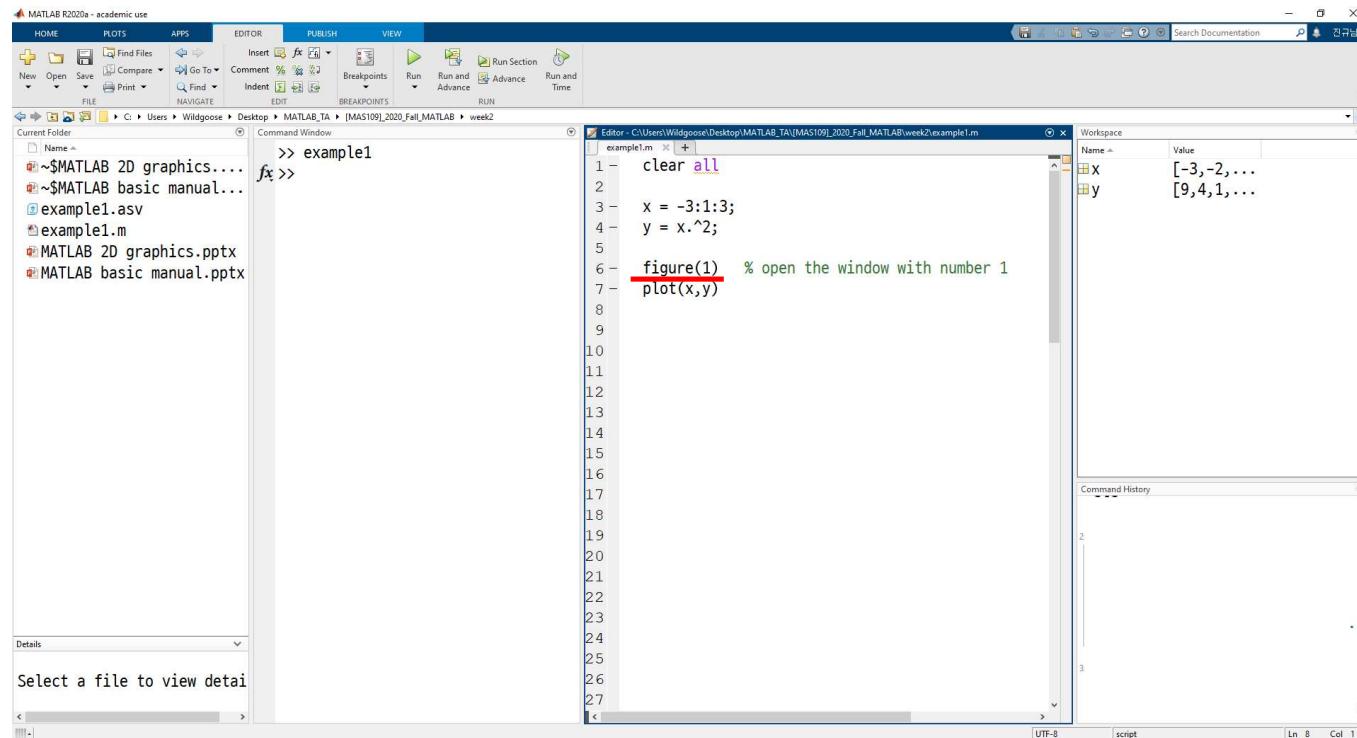
Here x is the **vector** which represents the domain points. (ex. $x = [-3, -2, -1, 0, 1, 2, 3]$)

Key idea for vector element-wise operation is just put **.** before the operation.

$y = f(x)$	MATLAB code	
x^d	$x.^d$	
a^x	$a.^x$	
e^x	$\exp(x)$	$e = \exp(1)$
$\log_e x$	$\log(x)$	
$\sin(x), \cos(x), \tan(x)$	$\sin(x), \cos(x), \tan(x)$	
$ x $	$\text{abs}(x)$	
\sqrt{x}	$\text{sqrt}(x)$ or $x.^{0.5}$	
$\frac{1}{x}$	$1./x$	
$\left \frac{x^2 - 2^x}{\log(x)} \right $	$\text{abs}(\text{(}x.^2 - 2.^x\text{) ./ log(x)})$	Example.

Now we have 2 vectors x, y . To see the graph, we will open the window.

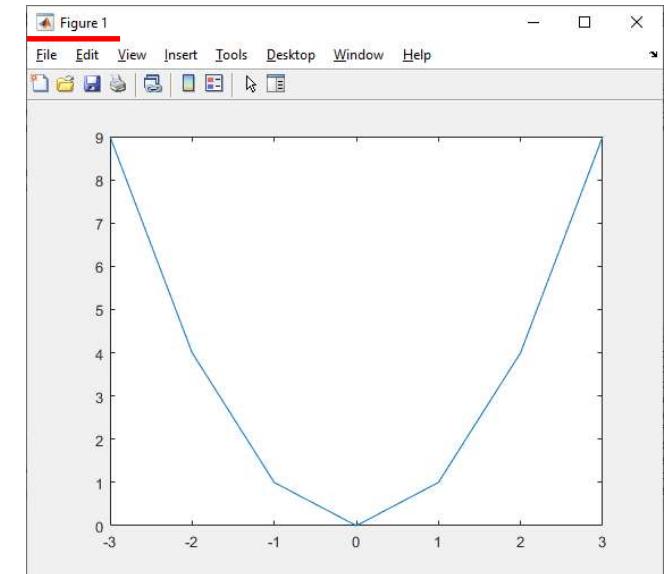
MATLAB command "figure()" make a black window.
Use "plot(x, y)" or "scatter(x, y)" to see the data in xy plain.



The screenshot shows the MATLAB R2020a interface. The top menu bar includes HOME, PLOTS, APPS, EDITOR, PUBLISH, and VIEW. The EDITOR tab is selected. The Current Folder browser shows files like 'MATLAB 2D graphics...', 'MATLAB basic manual...', 'example1.m', 'example1.asv', 'MATLAB 2D graphics.pptx', and 'MATLAB basic manual.pptx'. The Command Window displays the command `>> example1`. The Editor window shows the script file `example1.m` with the following code:

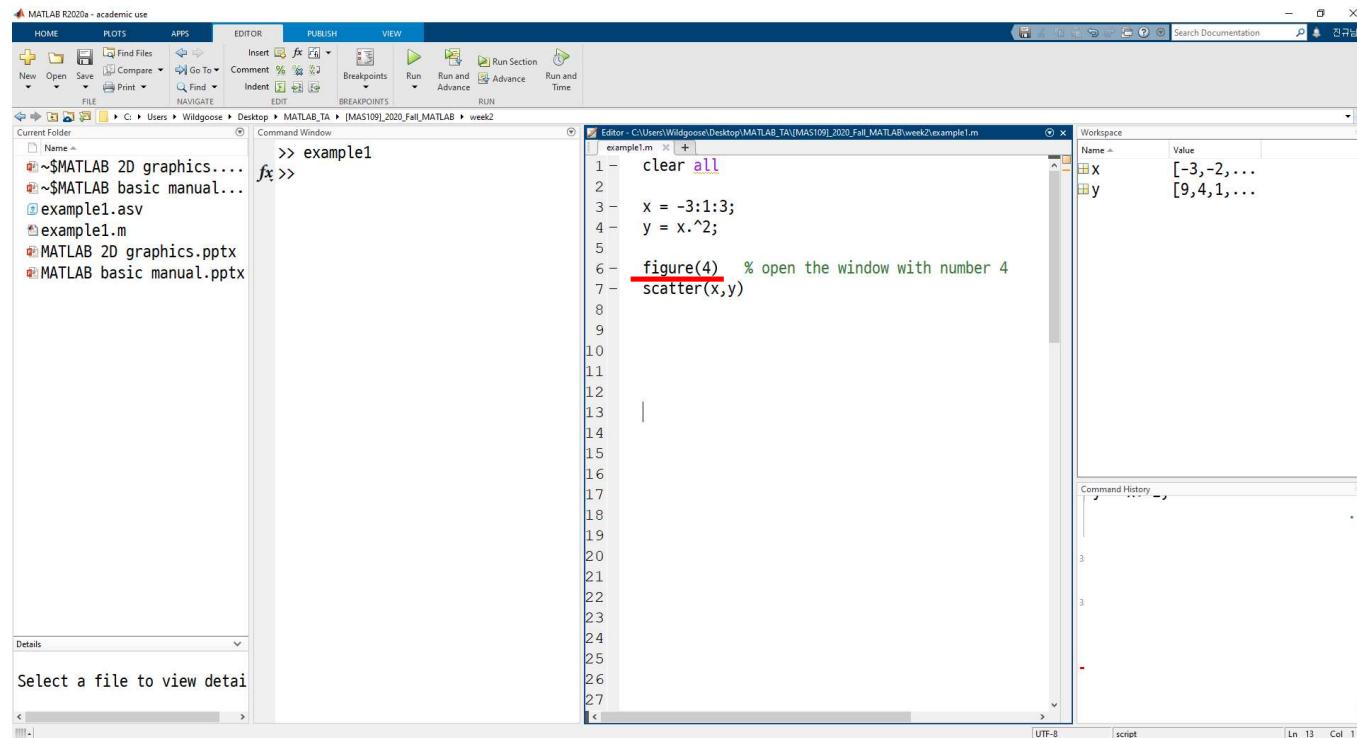
```
>> example1
fx >>
1 - clear all
2
3 - x = -3:1:3;
y = x.^2;
5
6 - figure(1) % open the window with number 1
7 - plot(x,y)
8
9
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24
25
26
27
```

The Workspace browser shows variables `x` and `y` defined. The Command History shows the command `plot(x,y)`.



Now we have 2 vectors x, y . To see the graph, we will open the window.

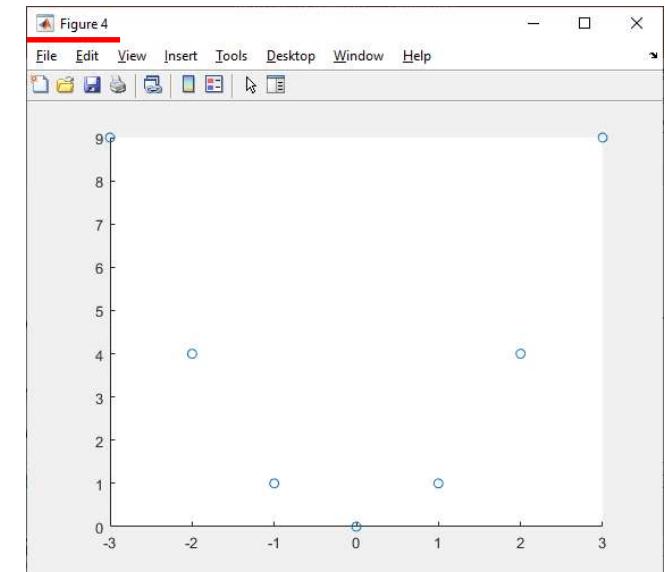
MATLAB command "figure()" make a black window.
Use "plot(x, y)" or "scatter(x, y)" to see the data in xy plain.



The screenshot shows the MATLAB R2020a interface. The Editor tab is active, displaying a script named 'example1.m' with the following code:

```
>> example1
fx >>
1 clear all
2
3 x = -3:1:3;
4 y = x.^2;
5
6 figure(4) % open the window with number 4
7 scatter(x,y)
```

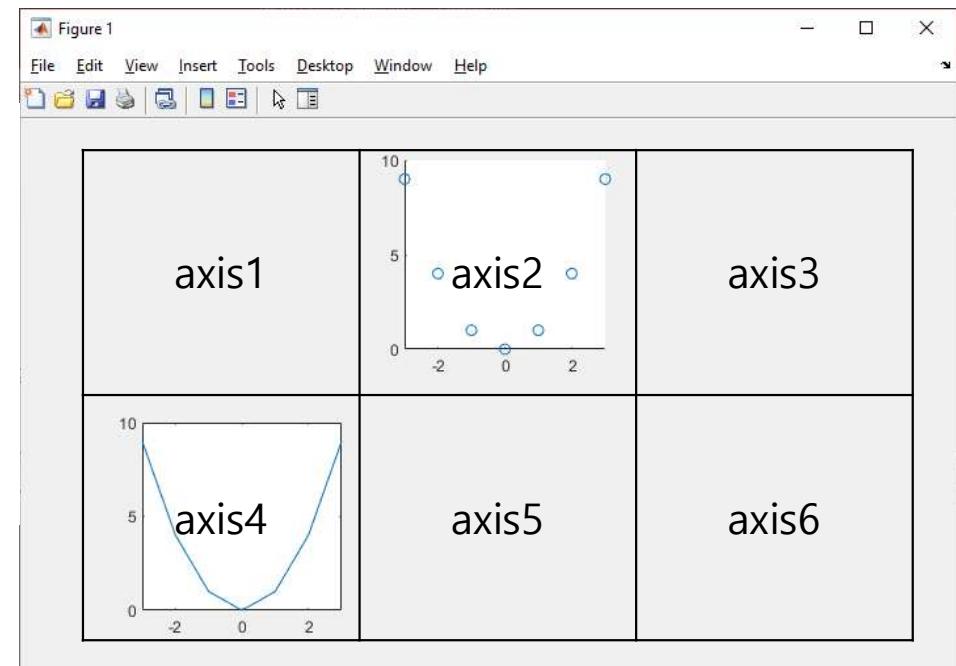
The Command Window shows the command 'fx' entered. The Workspace browser on the right shows variables x and y defined. The current folder browser shows various MATLAB files.



Display the several plots in same "figure" window.

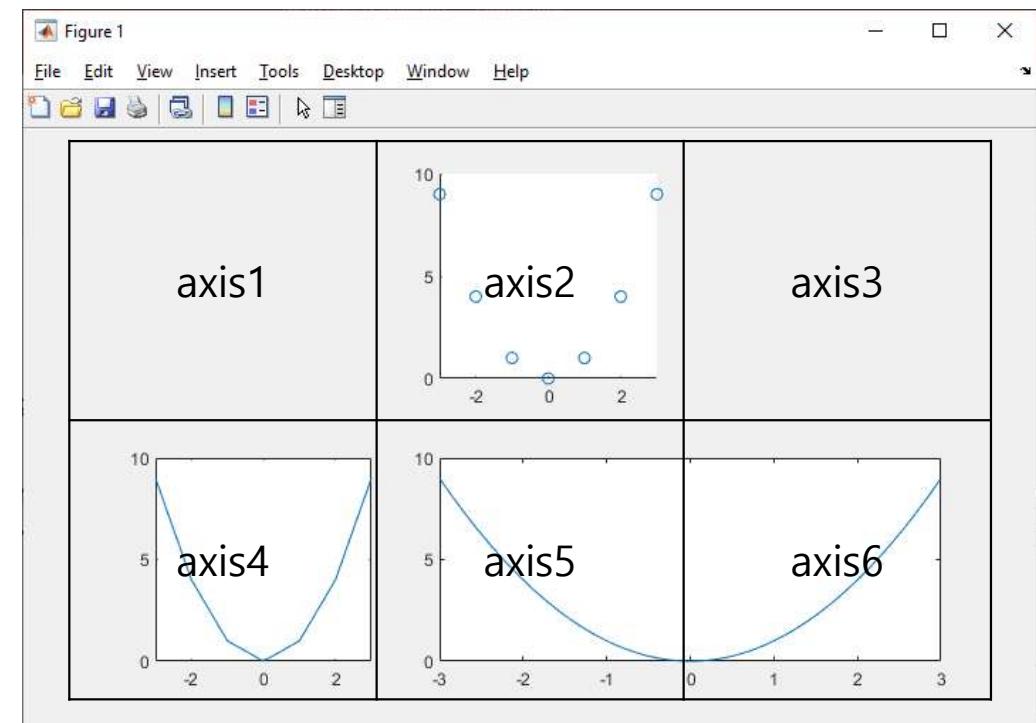
MATLAB command "subplot(m, n, k)" : divide the figure window into $m \times n$ regions and select the k^{th} region. So $1 \leq k \leq mn$. For example, consider "subplot(2,3, k)"

```
clear all  
  
x = -3:1:3;  
y = x.^2;  
  
figure(1) % open the window with number 1  
subplot(2,3,2),scatter(x,y)  
subplot(2,3,4),plot(x,y)
```



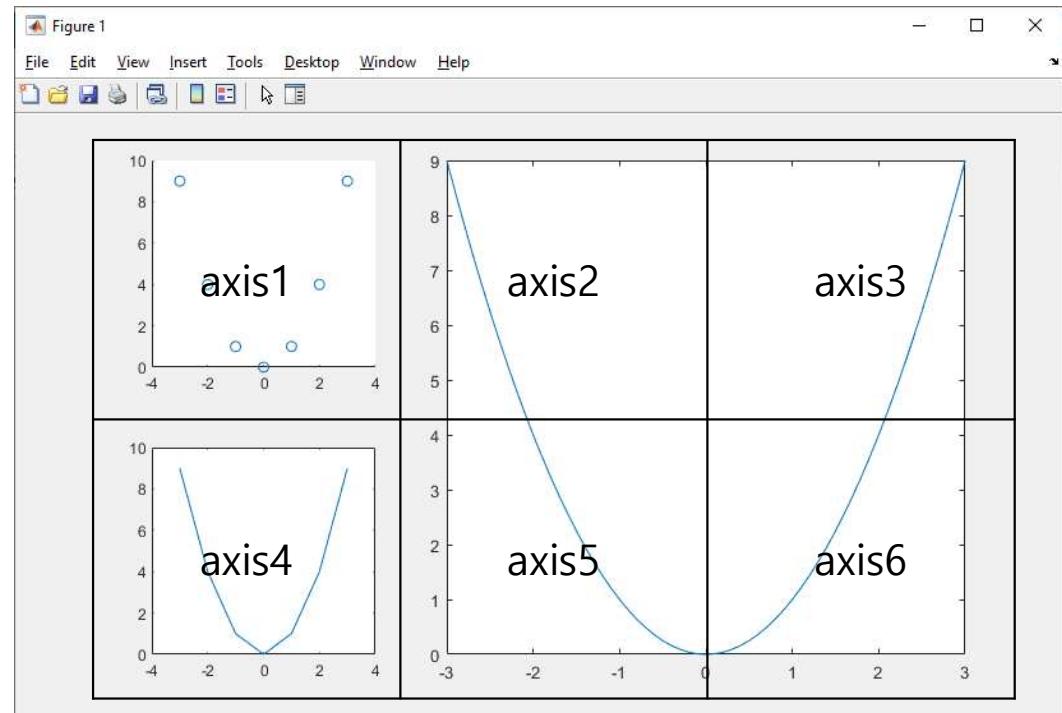
If you want to draw the graph in double size in 5, 6 axes simultaneously.
Then use the "subplot(2,3,[5,6])"

```
clear all  
  
x = -3:1:3;  
y = x.^2;  
  
figure(1) % open the window with number 1  
subplot(2,3,2),scatter(x,y)  
subplot(2,3,4),plot(x,y)  
  
x = -3:0.1:3;  
y = x.^2;  
subplot(2,3,[5,6]),plot(x,y)
```



Or you can draw in 2,3,5,6 axes simultaneously by use the "subplot(2,3,[2,3,5,6])"

```
clear all  
  
x = -3:1:3;  
y = x.^2;  
  
figure(1) % open the window with number 1  
subplot(2,3,1),scatter(x,y)  
subplot(2,3,4),plot(x,y)  
  
x = -3:0.1:3;  
y = x.^2;  
subplot(2,3,[2,3,5,6]),plot(x,y)
```

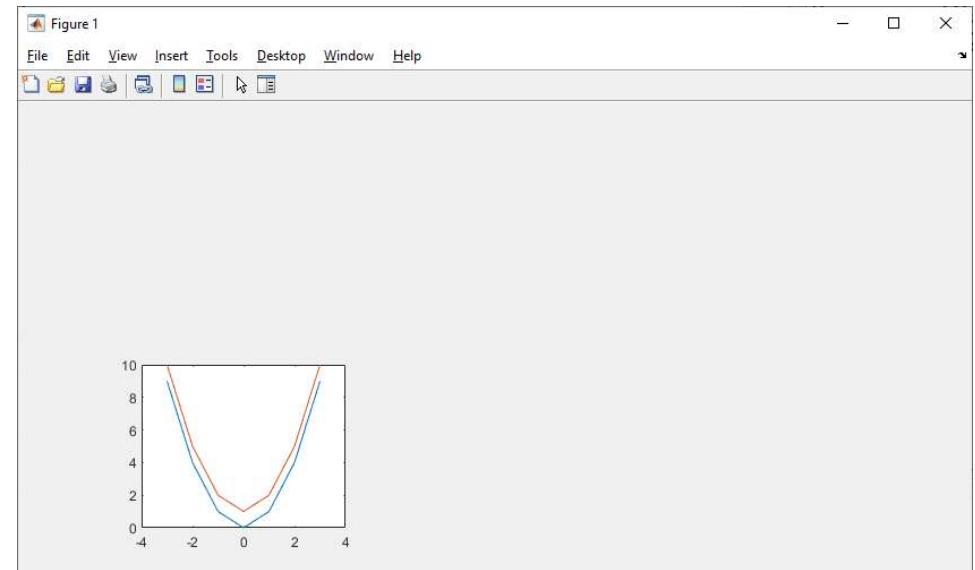


MATLAB can draw the multiple graph in same axis.
Use the MATLAB command "hold on" and "hold off".

"hold on" : hold current axis and overlap the graphs.

"hold off" : end of "hold on"

```
clear all  
  
x = -3:1:3;  
y = x.^2;  
z = x.^2 +1;  
figure(1) % open the window with number 1  
subplot(2,3,4),plot(x,y)  
hold on  
plot(x,z)  
hold off
```



MATLAB can draw the polar coordinate system.

Here is example. $r = \frac{\cos(\theta)}{2+\sin(\theta)}$ on $0 \leq \theta \leq 2\pi$

```
clear all  
  
theta = linspace(0,2*pi,200);  
r = cos(theta)./(2 + sin(theta));  
  
figure(1)  
polarplot(theta,r)
```

