



ME 444

MATLAB® FOR ENGINEERS

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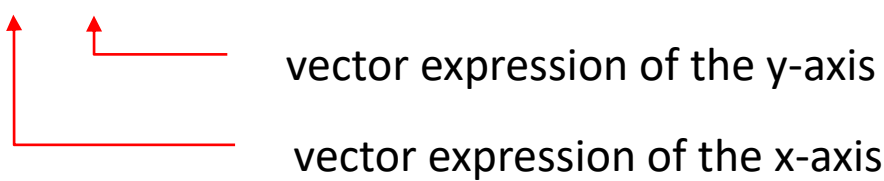
Tuesday: 13.30- 15:00

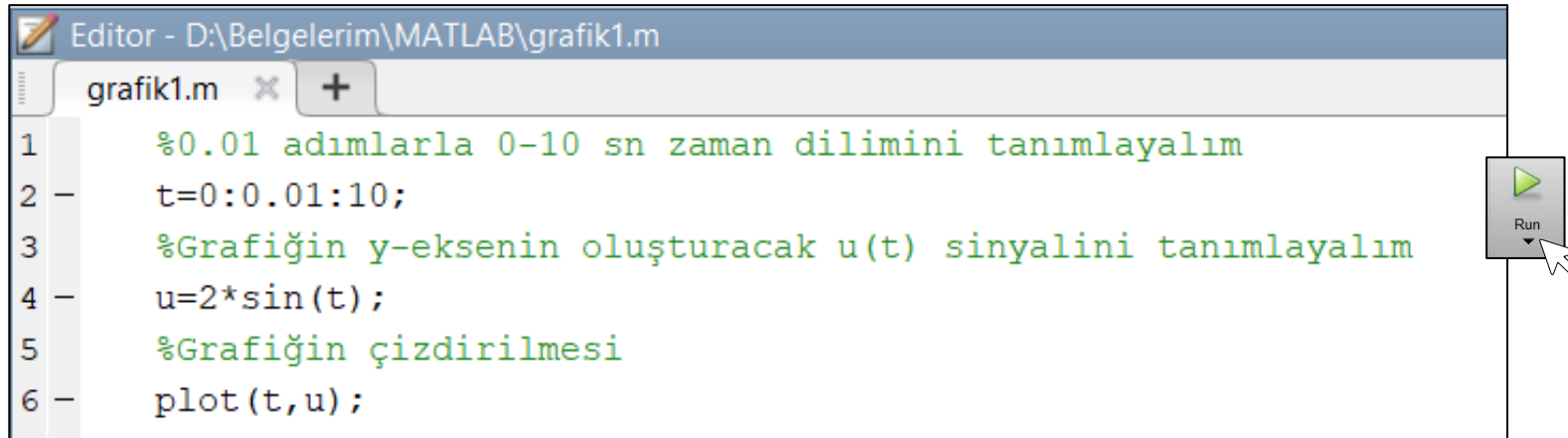
Friday : 10.00- 11.30

CHAPTER 8

GRAPHIC OPERATIONS

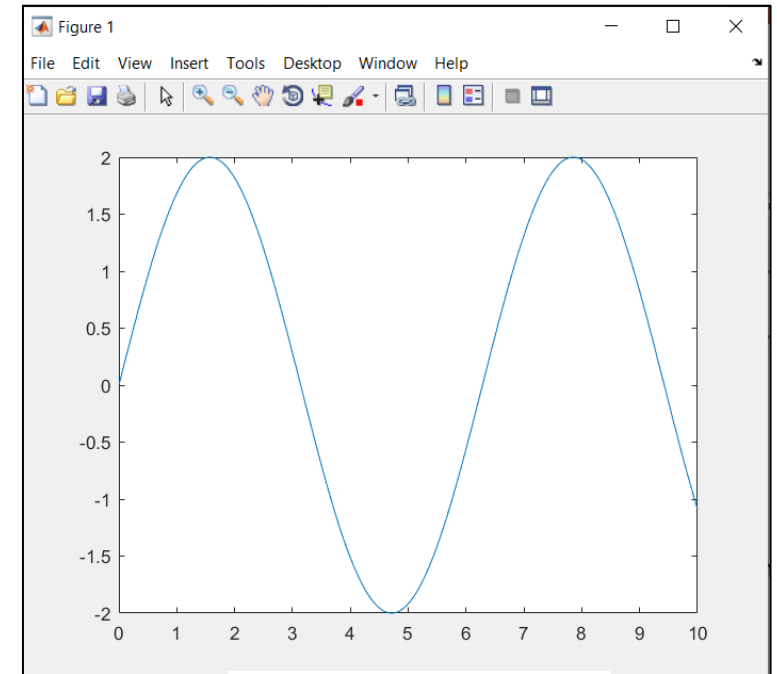
Graphic Operations in MATLAB – plot Command

- It is used in two-dimensional graphic drawing.
- `plot ( x, y )`
 - 
- Example: Plot the signal $u(t)=2\sin(\omega t)$ in 0.01 steps for a time frame of 0 to 10 sec? Note: $\omega=1$



```
1 %0.01 adımlarla 0-10 sn zaman dilimini tanımlayalım
2 t=0:0.01:10;
3 %Grafiğin y-eksenin oluşturacak u(t) sinyalinin tanımlayalım
4 u=2*sin(t);
5 %Grafiğin çizdirilmesi
6 plot(t,u);
```

Editor Window



Graphic Window

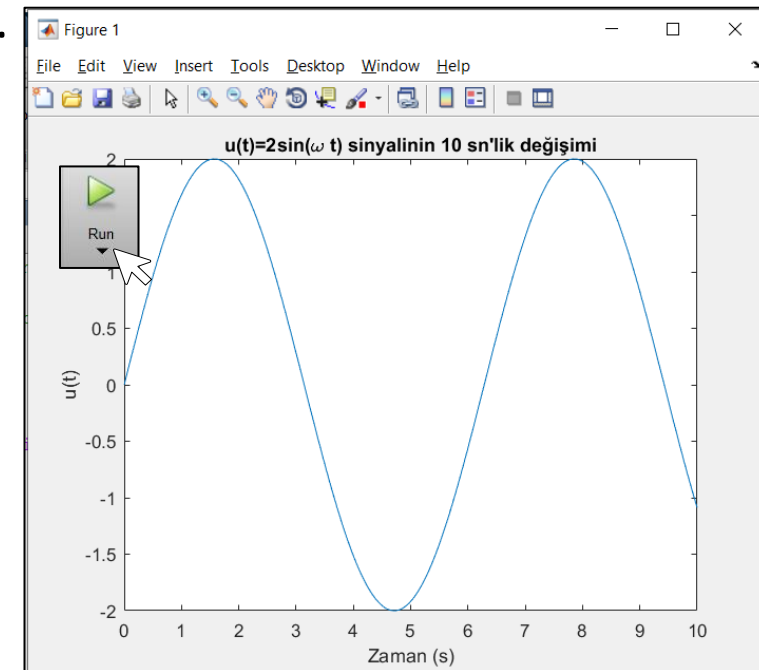
Graphic Operations in MATLAB – plot Command/Naming the Chart

- In order for the drawn graphics to be more understandable, titles and axes should also be named. We perform these operations with the following commands:
- `title ('Chart title')`
- `xlabel ('label of x-axis')`
- `ylabel ('label of the y-axis')`
- Example: Let's redraw the graphic in the previous example.

```
Editor - D:\Belgelerim\MATLAB\grafik1.m
grafik1.m x +
1 %0.01 adımlarla 0-10 sn zaman dilimini tanımlayalım
2 t=0:0.01:10;
3 %Grafığın y-eksenin oluşturacak u(t) sinyalinin tanımlayalım
4 u=2*sin(t);
5 %Grafığın çizdirilmesi
6 plot(t,u);
7 %Grafığın isimlendirilmesi
8 title('u(t)=2sin(\omega t) sinyalinin 10 sn''lik değişimi');
9 %Eksenlerin isimlendirilmesi
10 xlabel('Zaman (s)');
11 ylabel('u(t)');
```

Editor Window

Graphic Window



Graphic Operations in MATLAB – plot Command/Naming the Chart/ Sizing Graphic Names and Labels

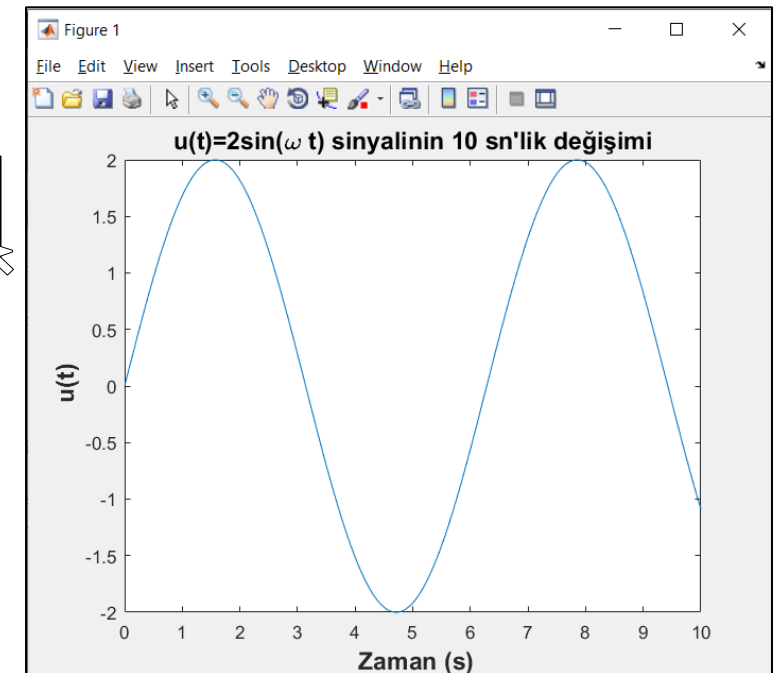
- In some cases, we may want the names of the charts or the axis labels to be written in bold or in different sizes (font). In these cases, the size setting of the text should be changed.
- `fontsize('desired_font')`
- Example: Let's redraw the graphic in the previous example.

Graphic Window

```
Editor - D:\Belgelerim\MATLAB\grafik1.m
grafik1.m x +
1 %0.01 adımlarla 0-10 sn zaman dilimini tanımlayalım
2 t=0:0.01:10;
3 %Grafığın y-eksenin oluşturacak u(t) sinyalini tanımlayalım
4 u=2*sin(t);
5 %Grafığın çizdirilmesi
6 plot(t,u);
7 %Grafığın isimlendirilmesi
8 title('u(t)=2sin(\omega t) sinyalinin 10 sn''lik değişimi','fontsize',[14]);
9 %Eksenlerin isimlendirilmesi ve büyüklük ayarı
10 xlabel('\bf Zaman (s)','fontsize',[14]);
11 ylabel('\bf u(t)','fontsize',[14]);
```

`\bf` : bold face

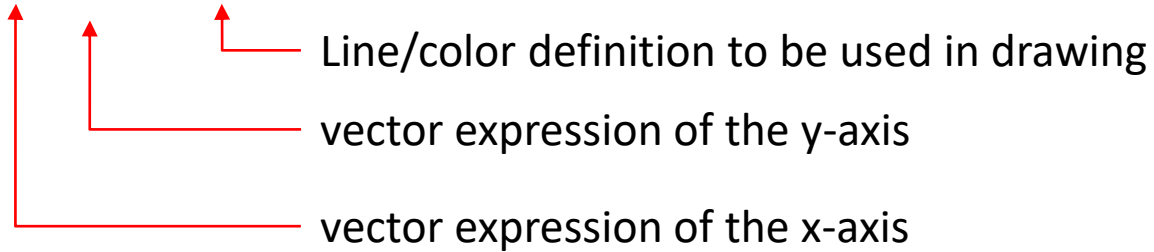
Editor Window



Graphic Operations in MATLAB – plot Command/ Changing Graphic Line-marking and Color Styles

- Graphs drawn with the plot command are drawn with straight lines.

- `plot(x,y,'c')`

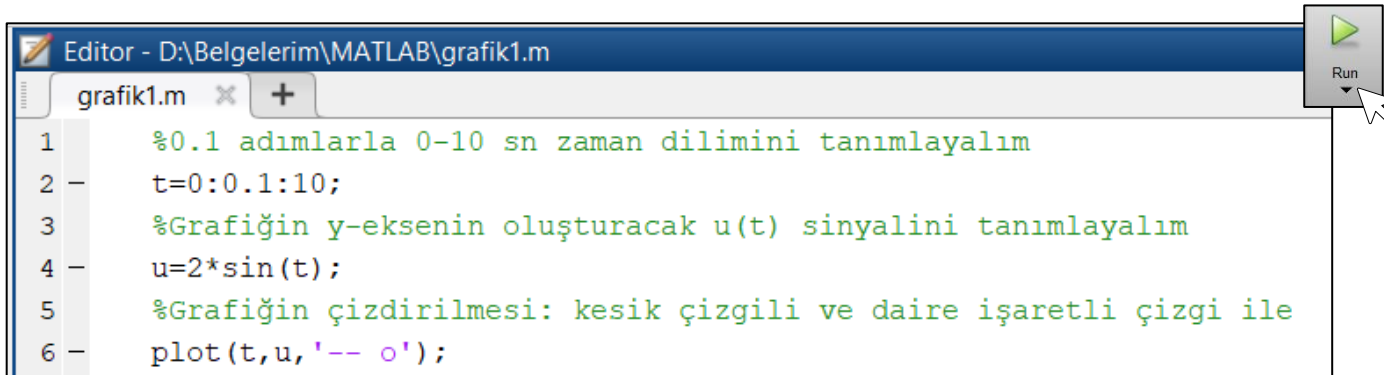


Graphic Operations in MATLAB – plot Command/ Changing Graphic Line-marking and Color Styles

Color	Marker type	Line type
y: yellow	. : dot	- : solid line
m: magenta	o : round	: : dotted-line
b: blue	x : x mark	-. : dash-dot line
r: red	+ : plus mark	-- : dashed line
g: green	* : star mark	
w: white	s : square	
k: black	d : diamond	
	v : triangle (downward)	
	^ : triangle (upward)	
	< : triangle (leftward)	
	> : triangle (righthward)	
	p : pentagram	

Graphic Operations in MATLAB – plot Command/Naming the Chart/ Sizing Graphic Names and Labels

- Let's change the line style of the chart in the previous example.

The image shows the MATLAB Editor window with a file named 'grafik1.m'. The code inside the editor is as follows:

```
1 %0.1 adımlarla 0-10 sn zaman dilimini tanımlayalım
2 t=0:0.1:10;
3 %Grafiğin y-eksenin oluşturacak u(t) sinyalinı tanımlayalım
4 u=2*sin(t);
5 %Grafiğin çizdirilmesi: kesik çizgili ve daire işaretli çizgi ile
6 plot(t,u,'-- o');
```

A mouse cursor is pointing at the 'Run' button in the top right corner of the editor window.

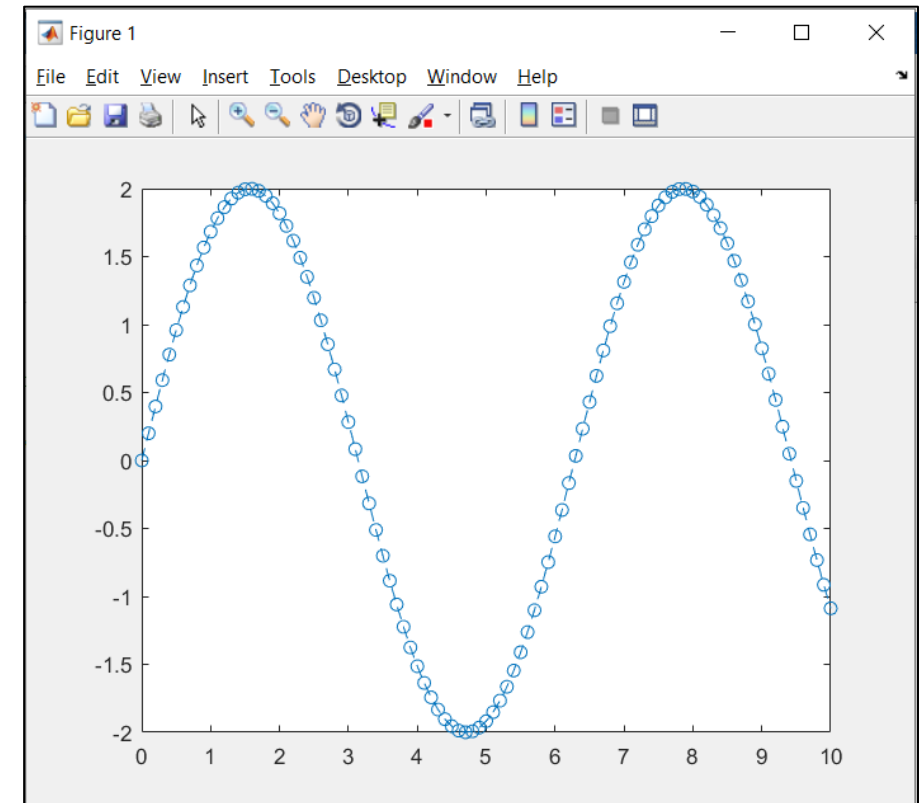
Editor - D:\Belgelerim\MATLAB\grafik1.m

grafik1.m x +

1 %0.1 adımlarla 0-10 sn zaman dilimini tanımlayalım
2 t=0:0.1:10;
3 %Grafiğin y-eksenin oluşturacak u(t) sinyalinı tanımlayalım
4 u=2*sin(t);
5 %Grafiğin çizdirilmesi: kesik çizgili ve daire işaretli çizgi ile
6 plot(t,u,'-- o');

Run

Editor Window



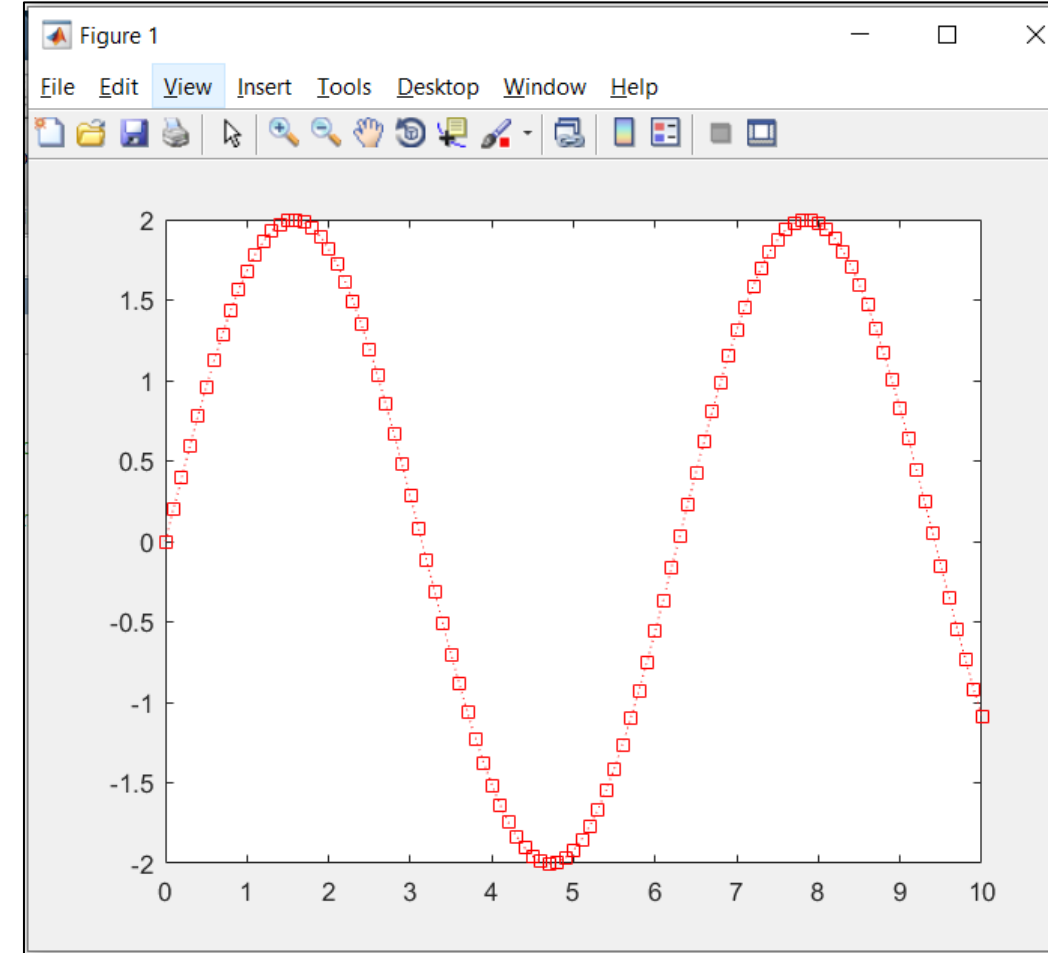
Graphic Window

Graphic Operations in MATLAB – plot Command/Naming the Chart/ Sizing Graphic Names and Labels

- Let's change the line style of the chart in the previous example.

```
Editor - D:\Belgelerim\MATLAB\grafik1.m
grafik1.m x +
1 %0.1 adımlarla 0-10 sn zaman dilimini tanımlayalım
2 t=0:0.1:10;
3 %Grafiğin y-eksenin oluşturacak u(t) sinyalinin tanımlayalım
4 u=2*sin(t);
5 %Grafiğin çizdirilmesi: iki noktalı, kare işaretli ve kırmızı renkli çizgi ile
6 plot(t,u,': s r');
```

Editor Window

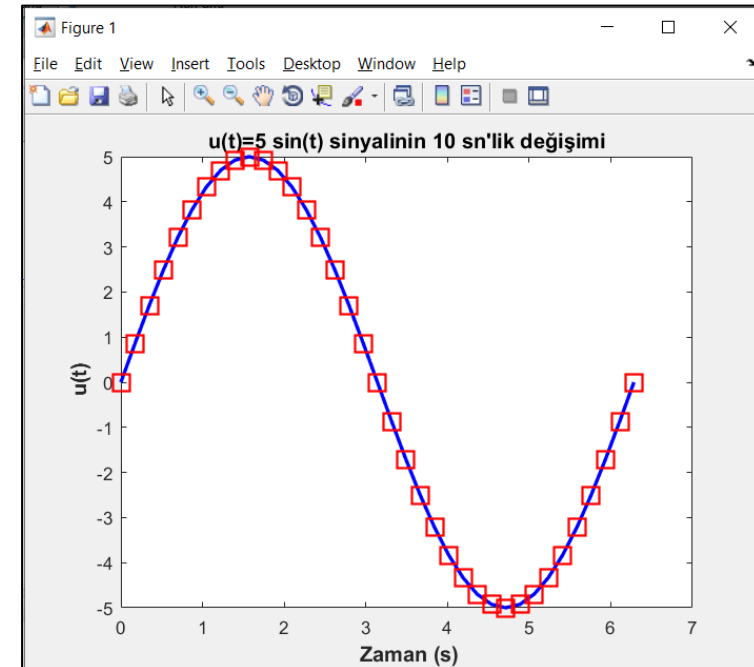


Graphic Window

Graphic Operations in MATLAB – plot Command

- `plot (x, y, 'LineStyle', '--', ...
 'Color', 'r', ...
 'LineWidth', 2 , ...
 'Marker', 's' , ...
 'MarkerEdgeColor', 'b', ...
 'MarkerFaceColor', 'g', ...
 'MarkerSize', 10)`

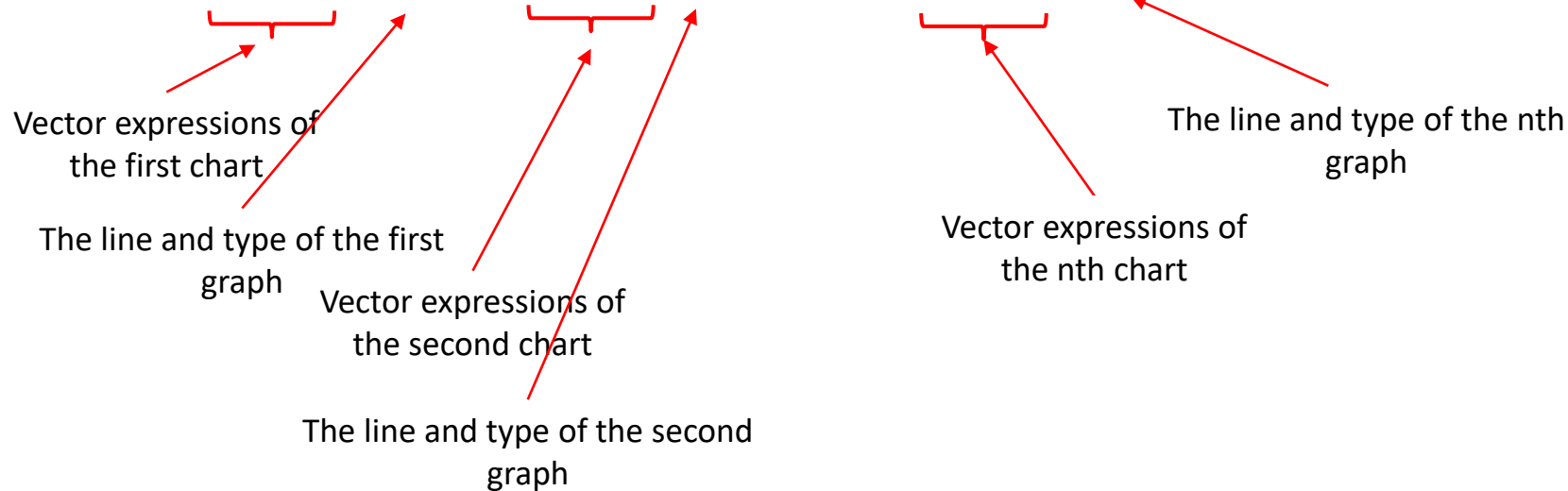
```
Editor - D:\Belgelerim\MATLAB\grafik1.m
grafik1.m x +
1 - t=0:pi/18:2*pi;
2 - u=5*sin(t);
3   %Grafiğin çizdirilmesi
4 - plot(t,u,'- b s','linewidth',2,'MarkerEdgeColor','r','MarkerSize',12);
5   %Grafiğin isimlendirilmesi
6 - title('u(t)=5 sin(t) sinyalinin 10 sn'lik değişimi','fontsize',[12]);
7   %Eksenlerin isimlendirilmesi ve büyüklük ayarı
8 - xlabel('\bf Zaman (s)','fontsize',[12]);
9 - ylabel('\bf u(t)','fontsize',[12]);
```



Graphic Operations in MATLAB – plot Command/ Drawing Multiple Charts in a Single Figure

- If it is desired to draw more than one graphic with different features in a single figure,

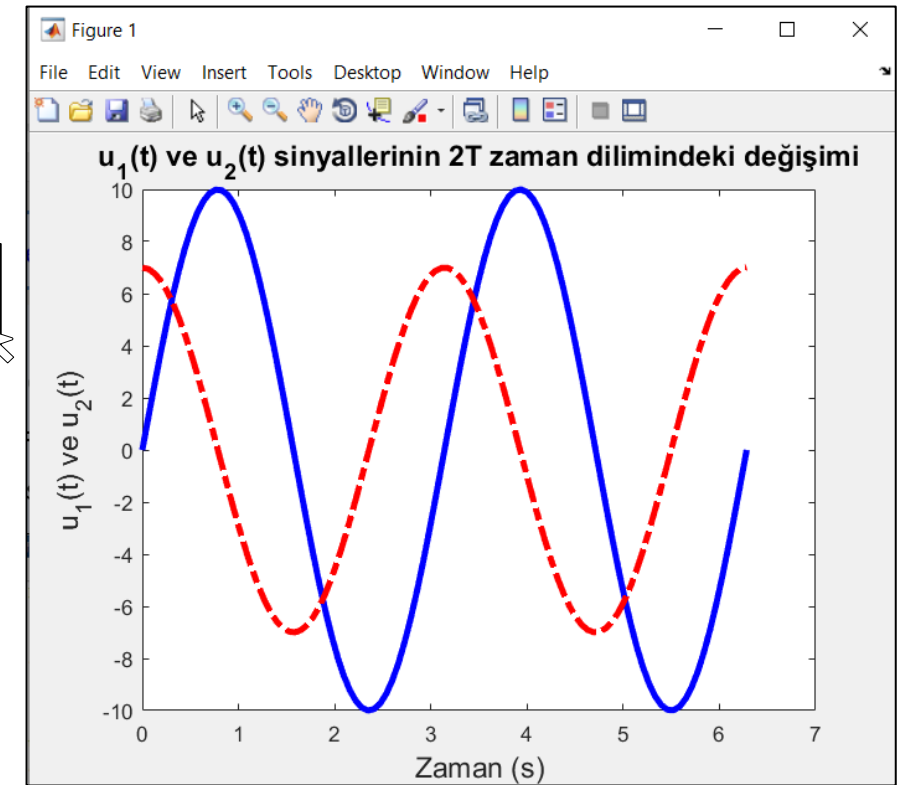
- `plot ( x1,y1,'c1', x2,y2,'c2',..., xn,yn,'cn', )`



Graphic Operations in MATLAB – plot Command/ Drawing Multiple Charts in a Single Figure

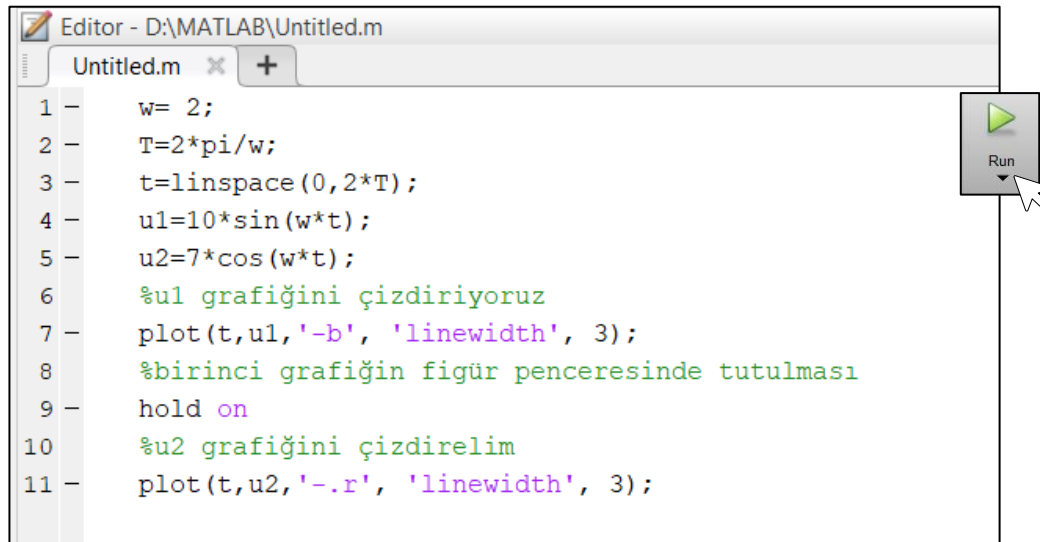
- Example: Compare the signals given below on a single chart.
 - Define two different signals as $u_1(t) = 10\sin(\omega t)$ and $u_2(t) = 7\cos(\omega t)$. $\omega = 2 \text{ rad/sn}$
 - Compare the 2-period changes of the given signals.

```
Editor - D:\Belgelerim\MATLAB\grafik2.m
grafik2.m
1 % Grafik çiziminde kullanılacak u1(t) ve u2(t) sinyallerinin 2*T'ye göre tanımlanması
2 w = 2;
3 T = 2*pi/w;
4 t = linspace(0,2*T);
5 u1 = 10*sin(w*t);
6 u2 = 7*cos(w*t);
7
8 % Grafik çiziminin tek plot komutu ile gerçekleştirilmesi
9 plot(t,u1,'-b',t,u2, '-.r', 'linewidth',3)
10
11 % Grafik üzerinde eksen açıklamalarının yapılması |
12 xlabel ('Zaman (s)','fontsize',14)
13 ylabel('u_1(t) ve u_2(t)','fontsize',14)
14 title('u_1(t) ve u_2(t) sinyallerinin 2T zaman dilimindeki değişimi','fontsize',14)
```

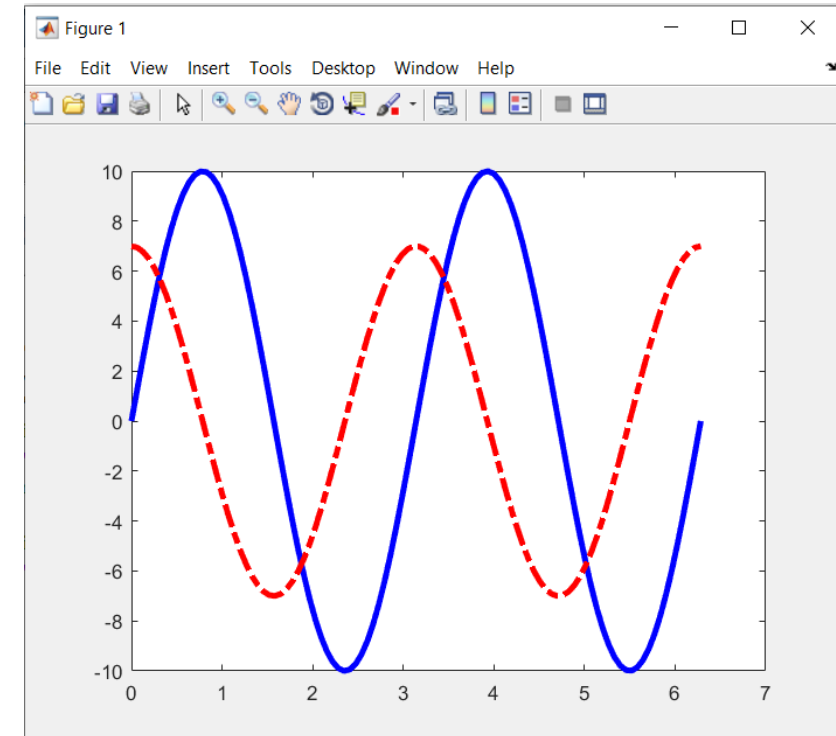


Graphic Operations in MATLAB – plot Command

- In the previous examples, we used the plot command to plot multiple graph grasses on the same figure with a single line of code.
- You can also perform this operation with the `hold on` / `hold off` commands.
- Example: Let's plot the signals given by the curves $u_1(t)=10\sin(\omega t)$ and $u_2(t)=7\cos(\omega t)$ in a single figure ($\omega=2$ rad/sec and compare the 2-period changes of the signals).



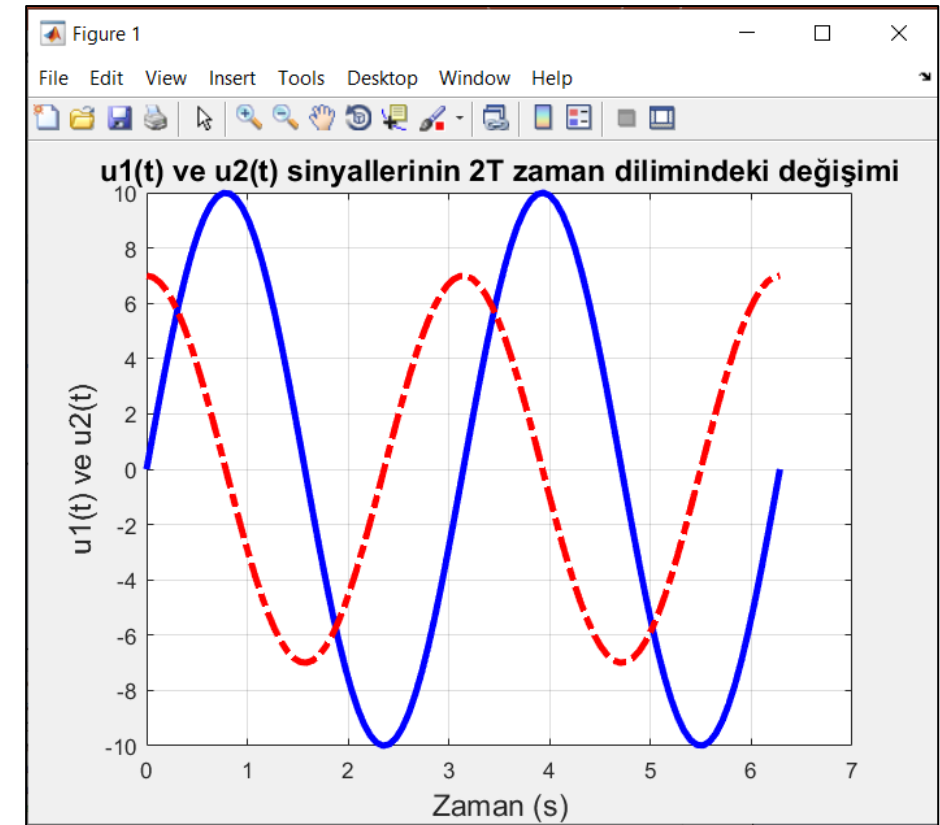
```
Editor - D:\MATLAB\Untitled.m
Untitled.m
1 - w= 2;
2 - T=2*pi/w;
3 - t=linspace(0,2*T);
4 - u1=10*sin(w*t);
5 - u2=7*cos(w*t);
6 - %u1 grafiğini çizdiriyoruz
7 - plot(t,u1,'-b', 'linewidth', 3);
8 - %birinci grafiğin figür penceresinde tutulması
9 - hold on
10 - %u2 grafiğini çizdirelim
11 - plot(t,u2,'-.r', 'linewidth', 3);
```



Graphic Operations in MATLAB –plot Command/ Horizontal-vertical partitioning the graph with the grid command

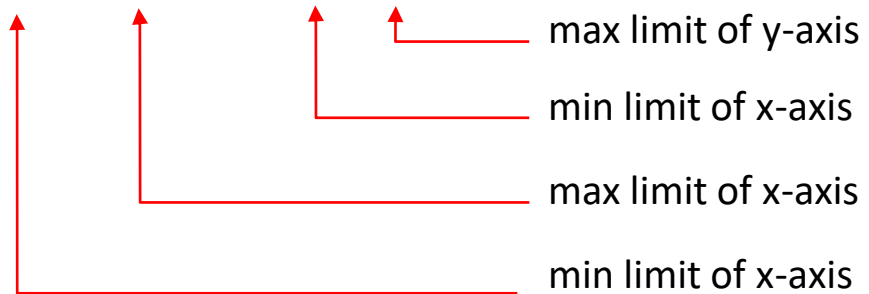
- grid command creates sections with horizontal and vertical lines for easier reading of graphics.
- grid on Adds grids
- grid off Removes grids

```
Editor - D:\MATLAB\Untitled.m
Untitled.m x +
1 - w= 2;
2 - T=2*pi/w;
3 - t=linspace(0,2*T);
4 - u1=10*sin(w*t);
5 - u2=7*cos(w*t);
6 - %u1 grafiğini çizdiriyoruz
7 - plot(t,u1,'-b', 'linewidth', 3);
8 - %birinci grafiğin figür penceresinde tutulması
9 - hold on
10 - %u2 grafiğini çizdirelim
11 - plot(t,u2,'-.r', 'linewidth', 3);
12 - %eksen açıklamalarının eklenmesi
13 - xlabel('Zaman (s)','fontsize',14);
14 - ylabel('u1(t) ve u2(t)','fontsize',14);
15 - title('u1(t) ve u2(t) sinyallerinin 2T zaman dilimindeki değişimi','fontsize',14);
16 - %grid on komutu ile ızgara eklenmesi
17 - grid on;
```



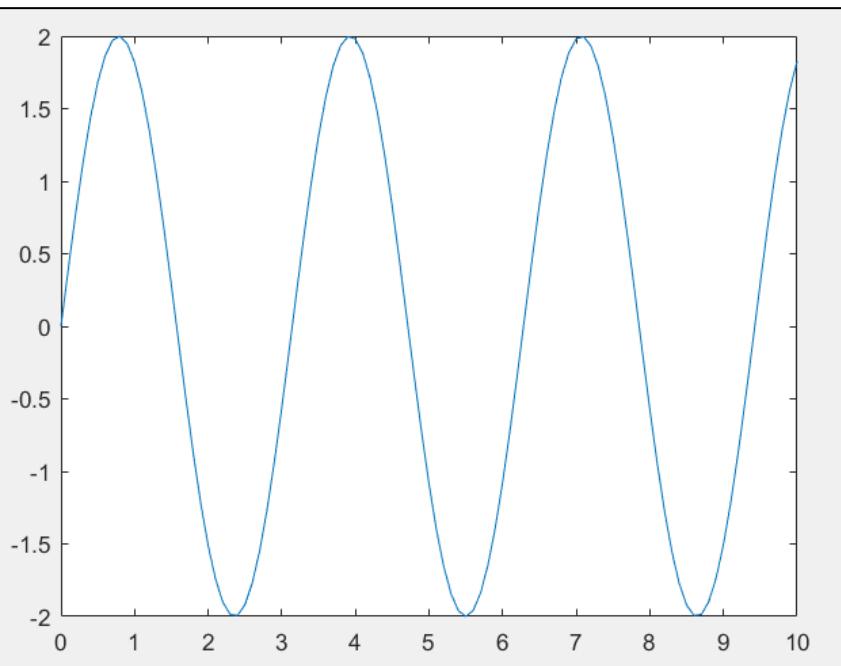
Graphic Operations in MATLAB – plot Command/ Scaling with the axis command

- `axis` command It determines the scaling of the axes of the chart, that is, the maximum-minimum values of the axes.
- `axis([xmin xmax ymin ymax])`



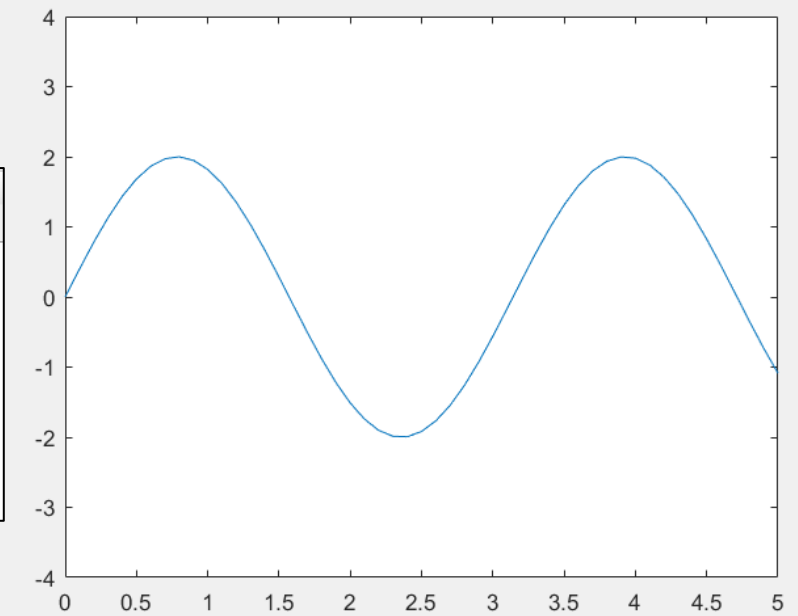
Graphic Operations in MATLAB – plot Command/ Scaling with the axis command

- Example: Plot the graph $x(t)=2\sin(\omega t)$ in 0.1 steps between 0 and 10 sec. Then scale the x-axis of the graph between 0 and 5 sec, and the y-axis between -4 and 4. ($\omega=2$)



Before scaling

```
Editor - D:\MATLAB\Untitled.m
Untitled.m  x  +
- t=0:0.1:10;
- w=2;
- u=2*sin(w*t);
- %u grafiğini çizdiriyoruz
- plot(t,u);
- %grafiğin eksenlerinin yeniden ölçeklendirilmesi
- axis([0 5 -4 4]);
```



After scaling

Graphic Operations in MATLAB – `fplot` Command

- This command draws the graph of a function according to defined limit values (between x_1 and x_2).
- `fplot ('function', [x1 x2])`

Function to be
graphed

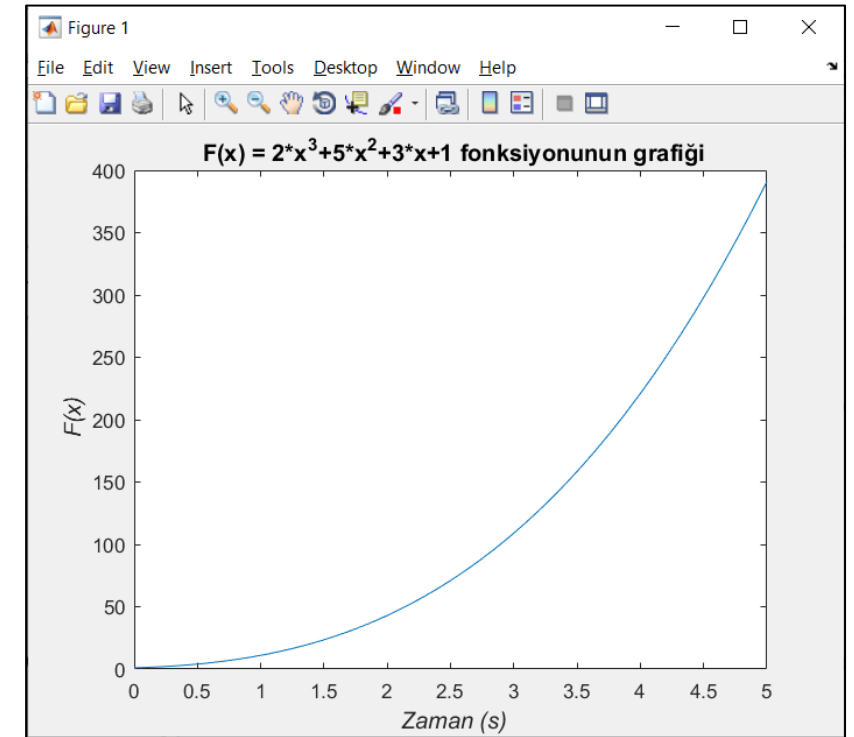
first limit value on
 x -axis

last limit value on
 x -axis

Ex: Let's write a script that draws the variation of function

$F(x) = 2x^3 + 5x^2 + 3x + 1$ in the range of 0-5 m.

```
Editor - D:\Belgelerim\MATLAB\grafik3.m
grafik3.m x +
1 - fplot('2*x^3+5*x^2+3*x+1',[0 5])
2
3 - xlabel('\it Zaman (s)','fontsize',12)
4 - ylabel('\it F(x)','fontsize',12)
5 - title('\bf F(x) = 2*x^3+5*x^2+3*x+1 fonksiyonunun grafiği','fontsize',12)
```



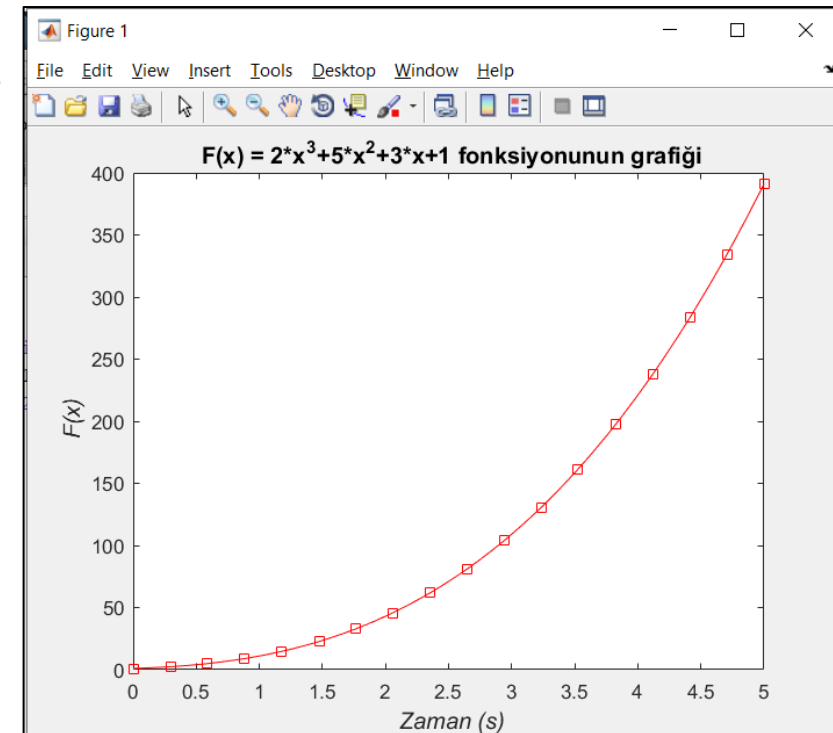
Graphic Operations in MATLAB – fplot Command

- Line type and color can also be changed in the fplot command.
- It can also be defined in a tolerance to the number of points (sample) to be displayed on the graph between x_1 and x_2
- `fplot ('function', [x1 x2], tolerance, 'tcm')`
 - Tolerance value* (points to tolerance)
 - Type of line* (points to 't')
 - Color of the line* (points to 'c')
 - Type of marker* (points to 'm')

Ex: Let's draw the previous example with straight lines, red color and square markings.

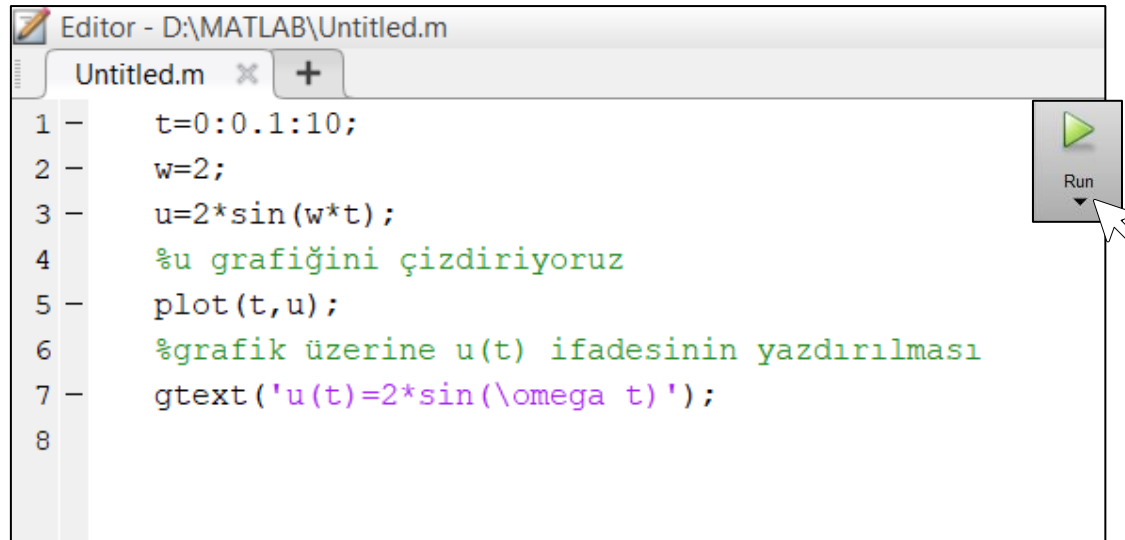
```

Editor - D:\Belgelerim\MATLAB\grafik3.m
grafik3.m
1 - fplot('2*x^3+5*x^2+3*x+1',[0 5],1,'-rs')
2
3 - xlabel('\it Zaman (s)','fontsize',12)
4 - ylabel('\it F(x)','fontsize',12)
5 - title('\bf F(x) = 2*x^3+5*x^2+3*x+1 fonksiyonunun grafiği','fontsize',12)
  
```

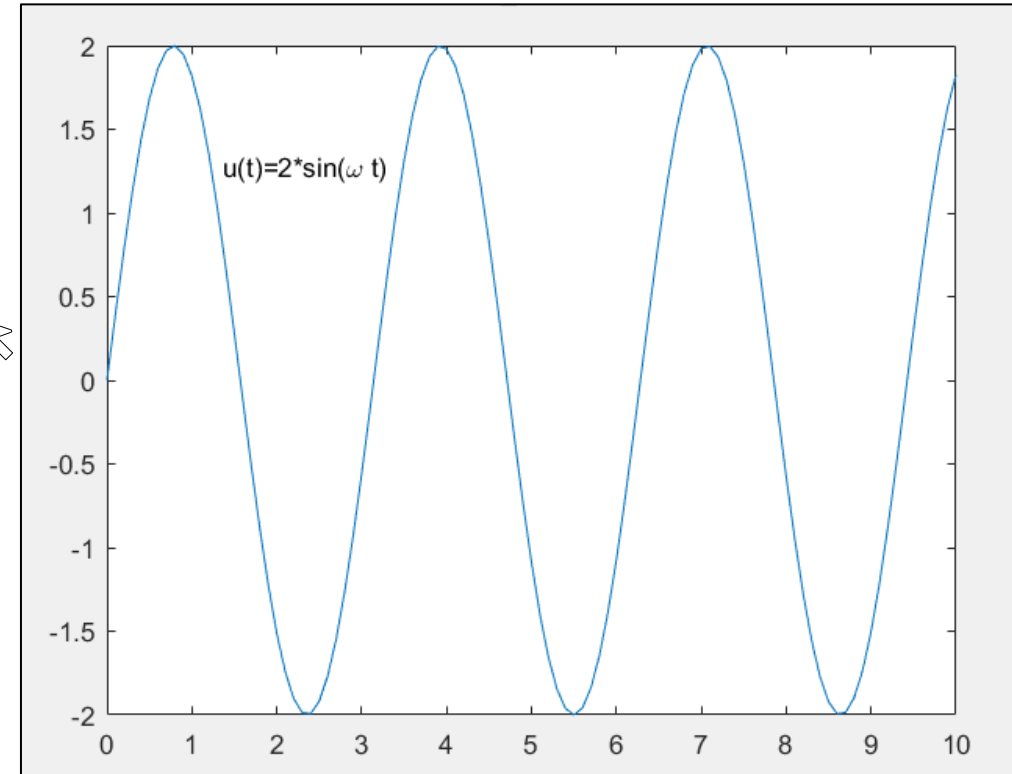


Graphic Operations in MATLAB – Editing the Graphics

- `gtext('description text')` : It allows to write a description on the graphics window. It can also be defined in a tolerance to the number of points (sample) to be displayed on the graph between x_1 and x_2



```
Editor - D:\MATLAB\Untitled.m
Untitled.m x +
1 - t=0:0.1:10;
2 - w=2;
3 - u=2*sin(w*t);
4 - %u grafiğini çizdiriyoruz
5 - plot(t,u);
6 - %grafik üzerine u(t) ifadesinin yazdırılması
7 - gtext('u(t)=2*sin(\omega t)');
8
```



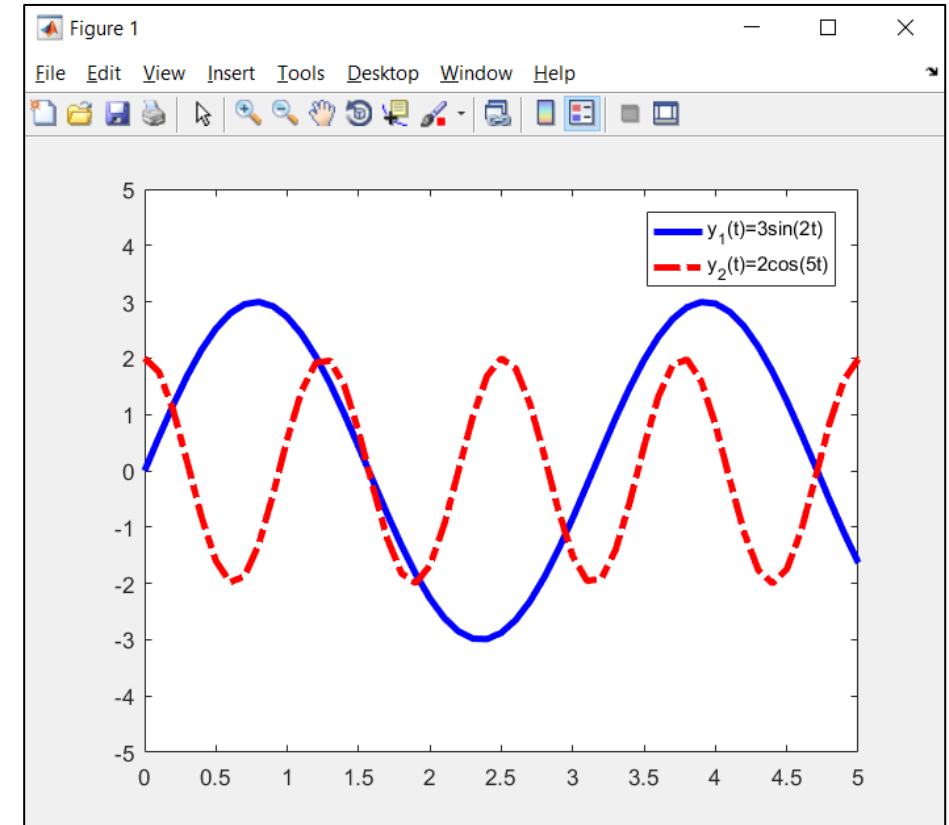
Graphic Operations in MATLAB – Editing the Graphics

- **legend:** It opens a box according to the position defined on the graphics window and displays the drawing shape and color used in the related graphics according to the drawing order and provides a description (indicator) to be written.
- `legend('description1', 'description2')`
For the 1st graph  For the 2nd graph 

Graphic Operations in MATLAB – Editing the Graphics

- Example: Have the graphs $y_1=3\sin(2t)$ and $y_2=2\cos(5t)$ drawn on the same figure between 0 and 10 with 0.1 steps and annotate the graph with the legend command.

```
Untitled.m x +
1 - t=0:0.1:10;
2
3 - y1=3*sin(2*t);
4 - y2=2*cos(5*t);
5 %Grafikleri çizdiriyoruz
6 - plot(t,y1,'-b',t,y2,'-.r','linewidth',3);
7 - axis([0 5 -5 5]);
8 %legend komutu ile grafiklerin açıklamalarını ekleyelim
9 - legend('y_1(t)=3sin(2t)', 'y_2(t)=2cos(5t)');
```



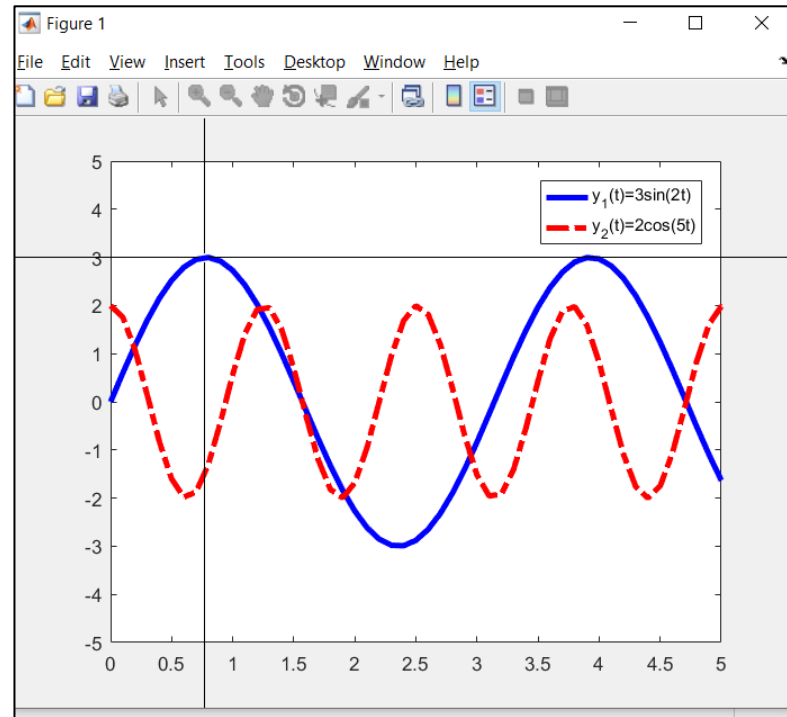
Graphic Operations in MATLAB – Editing the Graphics

- **ginput**: It provides to obtain the coordinates (values) of the point or points specified on the graph by means of the mouse numerically in the command window.
- **ginput**(**n**) n: Number of points to mark on the chart

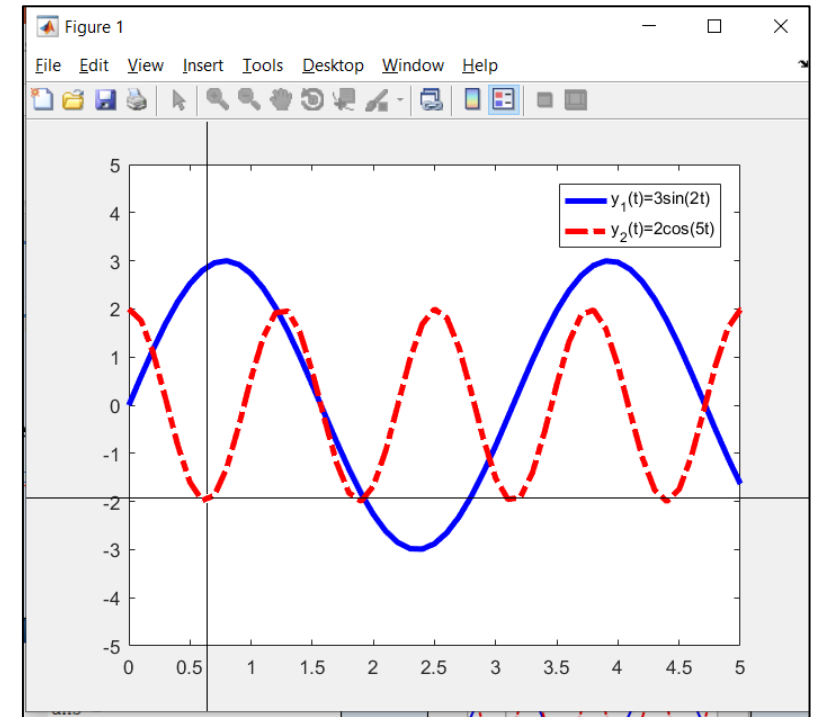
```
Command Window
>> ginput(2)

ans =

    0.7781    2.9089
    0.6123   -1.9743
```



Selected 1st point

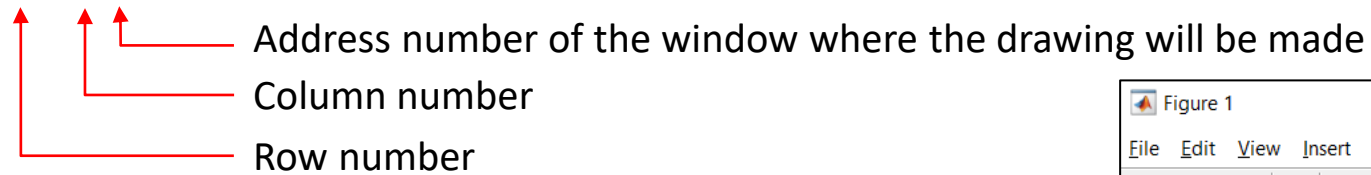


Selected 2nd point

Graphic Operations in MATLAB – Splitting the figure window with the subplot command

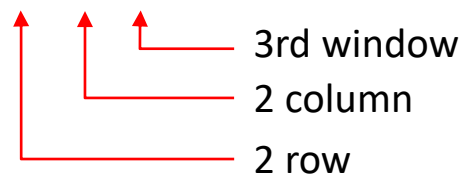
- It provides the addressing of the window where the drawing will be made by dividing the figure window as many times as desired.

- `subplot(m,n,p)`

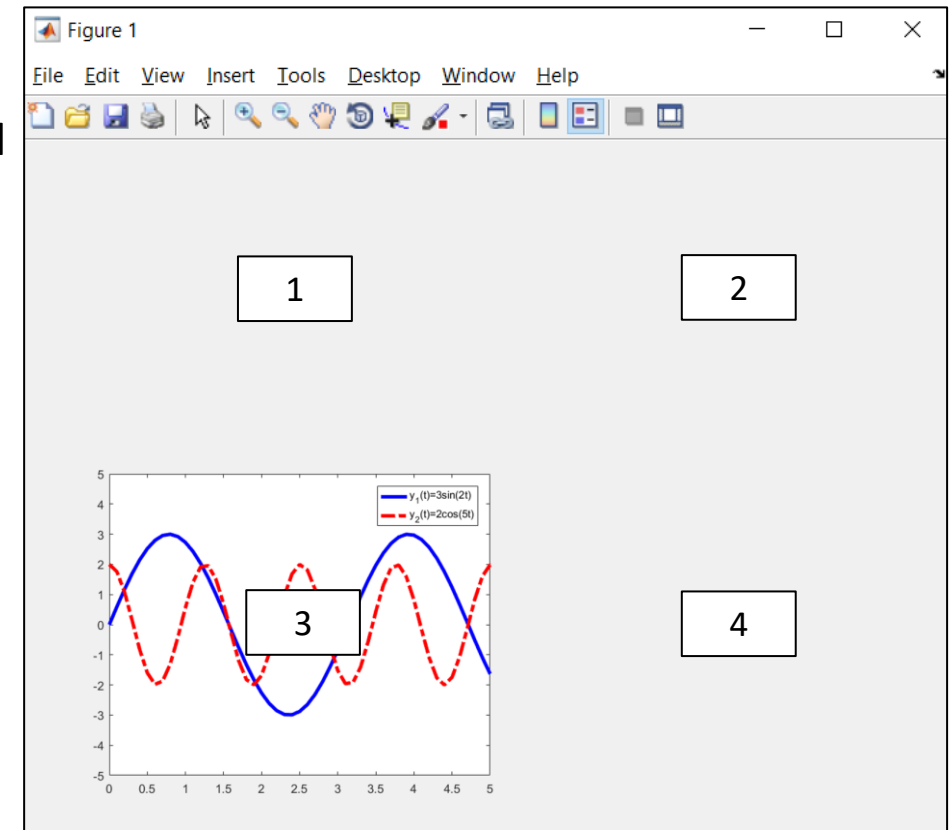


- The address of the window where the drawing will be made is found from the resulting matrix by numbering line by line, starting from the window in the first row-first column.

- `subplot(2,2,3)`



With the subplot command, the figure window is divided into $m \times n$ windows.

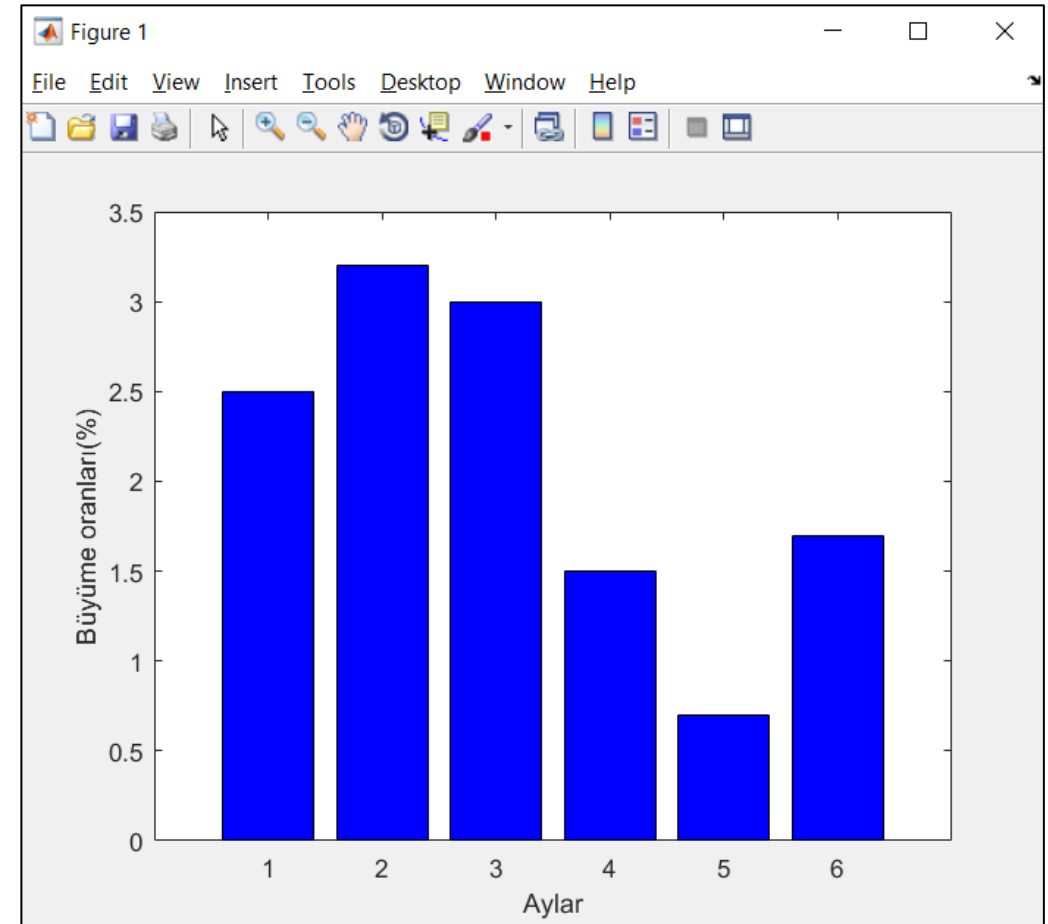


Graphic Operations in MATLAB – Custom Charts – Bar Charts

- `bar(x,y)`

Values on y-axis
Values on x-axis

```
Editor - D:\MATLAB\Untitled2.m
Untitled2.m
1 %zaman aralığı- x eksenini
2 ay=1:6;
3 %Aylara göre büyüme oranları (%)
4 buyume=[2.5 3.2 3 1.5 0.7 1.7];
5 %mavi dolgu rengine sahip bir grafik çizdirelim
6 bar(ay,buyume,'b');
7 xlabel('Aylar');
8 ylabel('Büyüme oranları(%)');
```

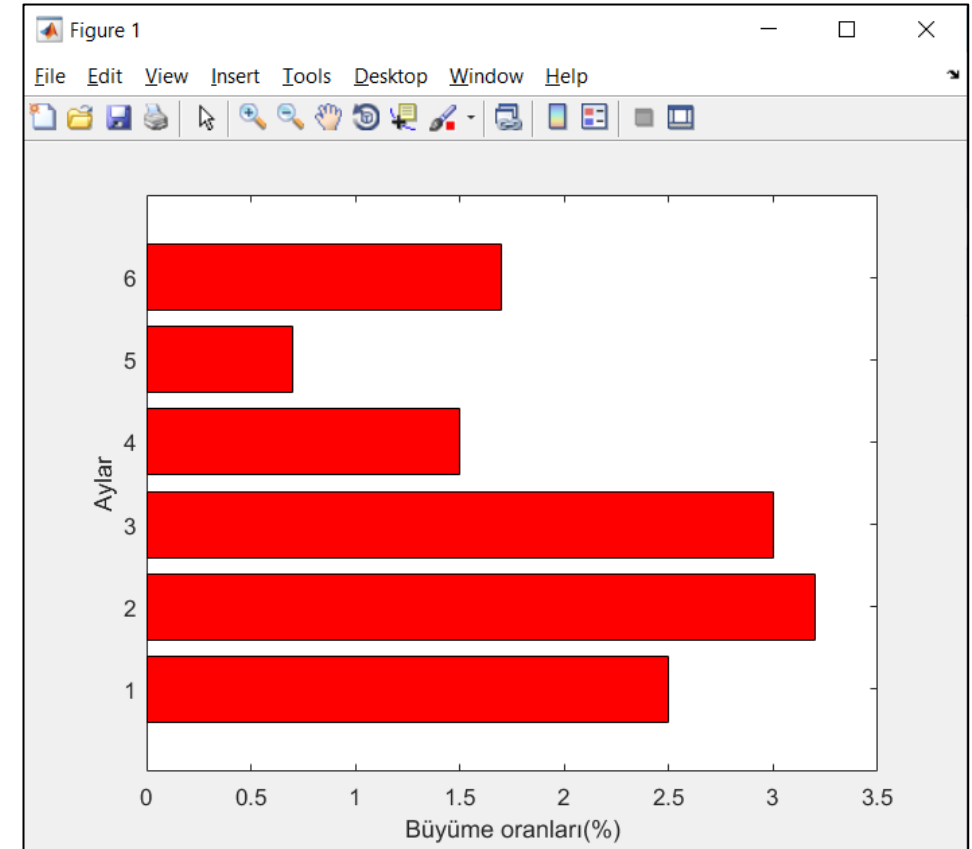


Graphic Operations in MATLAB – Custom Charts – Horizontal Bar Charts

- `barh(x,y)`

Values on y-axis
Values on x-axis

```
Editor - D:\MATLAB\Untitled2.m
Untitled2.m
1 %zaman aralığı- x eksenini
2 ay=1:6;
3 %Aylara göre büyüme oranları (%)
4 buyume=[2.5 3.2 3 1.5 0.7 1.7];
5 %kırmızı dolgu rengine sahip bir grafik çizdirelim
6 barh(ay,buyume,'r');
7 xlabel('Büyüme oranları(%)');
8 ylabel('Aylar');
```



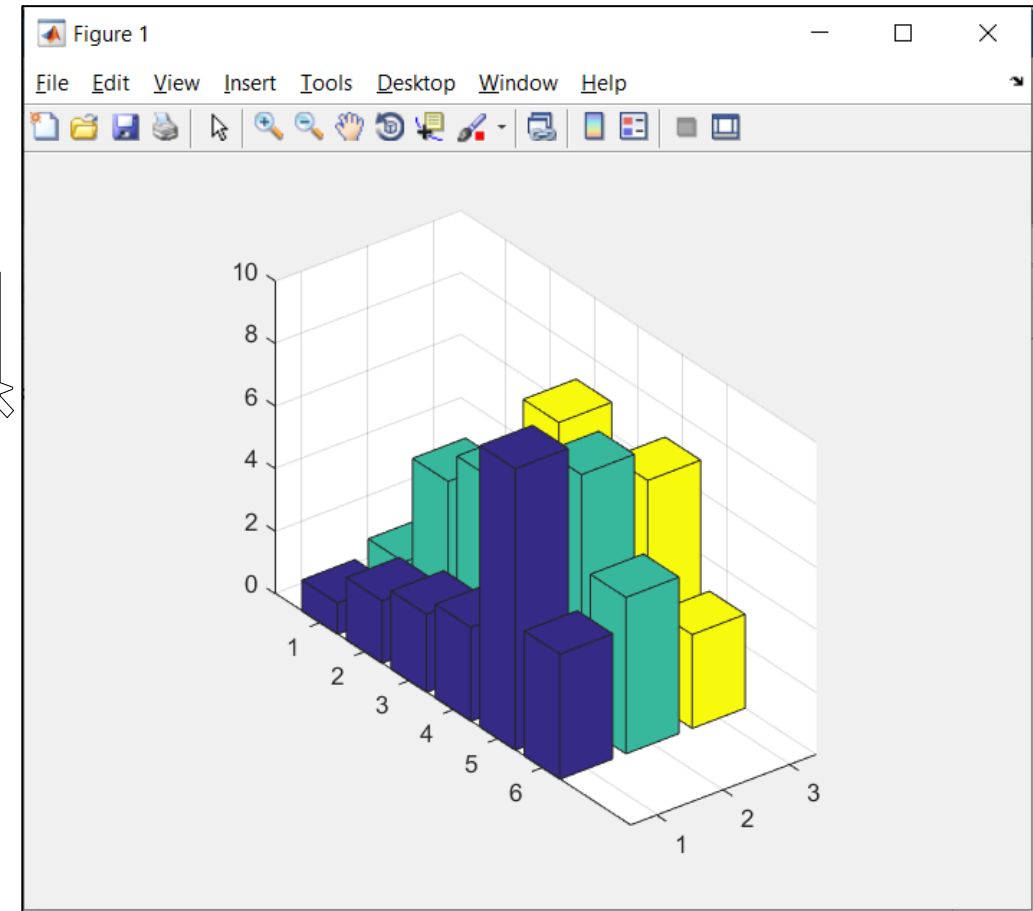
Graphic Operations in MATLAB – Custom Charts – 3D Bar Charts

- `bar3(A)`



Vector having x, y and z-coordinates

```
Editor - D:\MATLAB\Untitled2.m
Untitled2.m x +
1 %3 boyutlu grafiği çizdirilecek matrisin tanımlanması
2 A=[1 1.5 3; 2 5 4; 2.5 6 7; 3 4 5; 9 8 7; 4 5 3];
3 %3 boyutlu grafik çizimi
4 bar3(A)
```

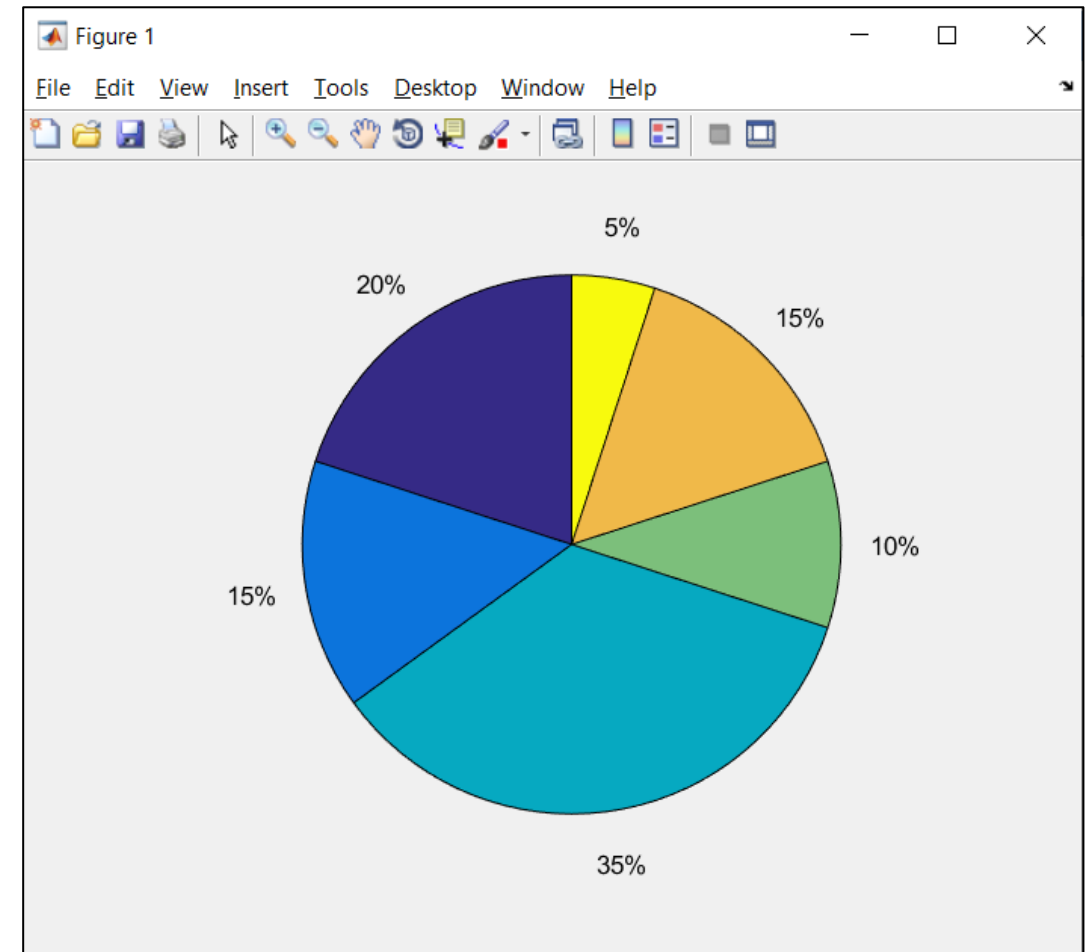


Graphic Operations in MATLAB – Custom Charts – Pie Charts

- `pie(A)`

Matrix with percentage of each slice in a pie chart

```
Editor - D:\MATLAB\Untitled2.m
Untitled2.m x +
1 %pasta grafikteki değerlerin tanımlanması
2 - A=[20 15 35 10 15 5];
3 %pasta grafik çizimi
4 - pie(A)
```



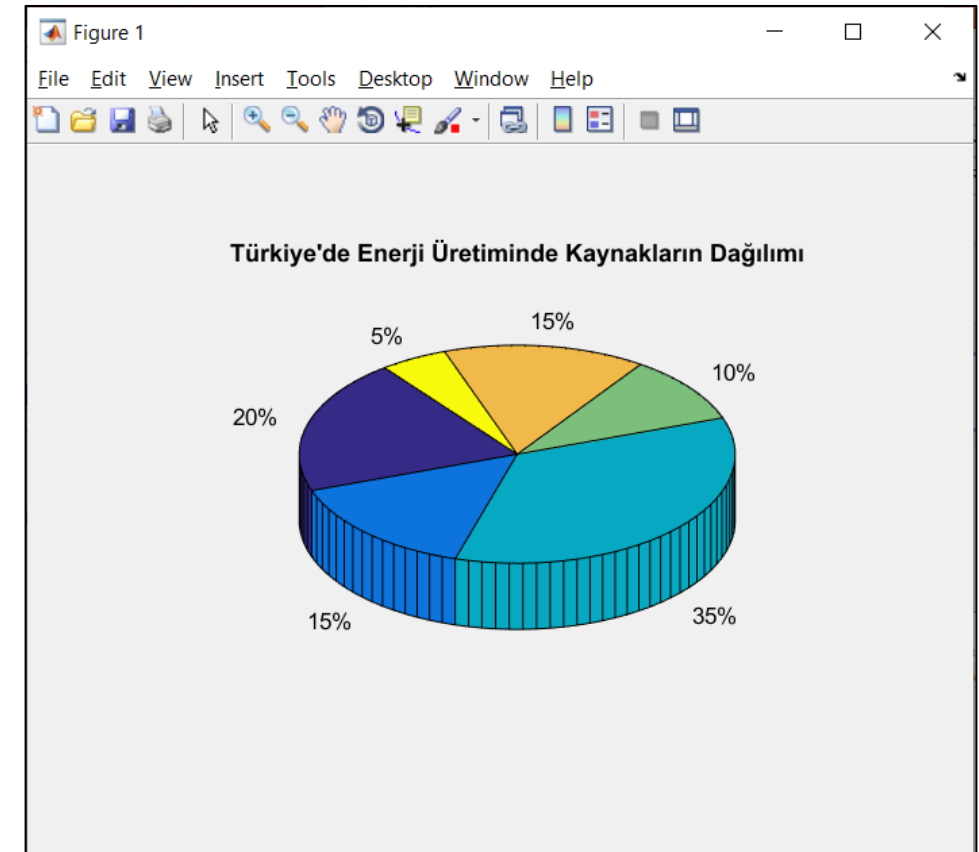
Graphic Operations in MATLAB – Custom Charts – 3D Pie Charts

- `pie3(A)`



Matrix with percentage of each slice in a pie chart

```
Editor - D:\MATLAB\Untitled2.m
Untitled2.m
1 %pasta grafikteki değerlerin tanımlanması
2 A=[20 15 35 10 15 5];
3 %pasta grafik çizimi
4 pie3(A)
5 %Grafığe bir başlık ekleyelim
6 title('Türkiye'de Enerji Üretiminde Kaynakların Dağılımı');
```



Graphic Operations in MATLAB – Adding Symbols to Charts

Krakter	Sembol	Krakter	Sembol	Krakter	Symbol
\alpha	α	\upsilon	υ	\sim	$\sim$
\beta	β	\phi	ϕ	\leq	$\leq$
\gamma	γ	\chi	χ	\infty	∞
\delta	δ	\psi	ψ	\clubsuit	$\clubsuit$
\epsilon	ϵ	\omega	ω	\diamondsuit	$\diamondsuit$
\zeta	ζ	\Gamma	Γ	\heartsuit	$\heartsuit$
\eta	η	\Delta	Δ	\spadesuit	$\spadesuit$
\theta	θ	\Theta	Θ	\leftrightharpoonup	$\leftrightarrow$
\vartheta	ϑ	\Lambda	Λ	\leftarrow	$\leftarrow$
\iota	ι	\Xi	Ξ	\uparrow	$\uparrow$

\kappa	κ	\Pi	Π	\rightarrow	$\rightarrow$
\lambda	λ	\Sigma	Σ	\downarrow	$\downarrow$
\mu	μ	\Upsilon	Υ	\circ	$\circ$
\nu	ν	\Phi	Φ	\pm	$\pm$
\xi	ξ	\Psi	Ψ	\geq	$\geq$
\pi	π	\Omega	Ω	\propto	$\propto$
\rho	ρ	\forall	$\forall$	\partial	∂
\sigma	σ	\exists	$\exists$	\bullet	$\bullet$
\varsigma	ς	\ni	$\ni$	\div	$\div$
\tau	τ	\equiv	$\equiv$	\neq	$\neq$

\equiv	$\equiv$	\approx	$\approx$	\aleph	$\aleph$
\Im	$\Im$	\Re	$\Re$	\wp	$\wp$
\otimes	$\otimes$	\oplus	$\oplus$	\oslash	$\oslash$
\cap	$\cap$	\cup	$\cup$	\supseteq	$\supseteq$
\supset	$\supset$	\subseteq	$\subseteq$	\subset	$\subset$
\int	$\int$	\in	$\in$	\circ	$\circ$
\rfloor	$\rfloor$	\lceil	$\lceil$	\nabla	∇
\lfloor	$\lfloor$	\cdot	$\cdot$	\ldots	$\ldots$
\perp	$\perp$	\neg	$\neg$	\prime	$\prime$
\wedge	$\wedge$	\times	$\times$	\emptyset	$\emptyset$
\rceil	$\rceil$	\surd	$\surd$	\mid	$\mid$
\vee	$\vee$	\varpi	ϖ	\copyright	$\copyright$
\langle	$\langle$	\rangle	$\rangle$		

Next week

Chapter 9

Numerical Analysis in MATLAB