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Modul Plotting
Matlab & Octave

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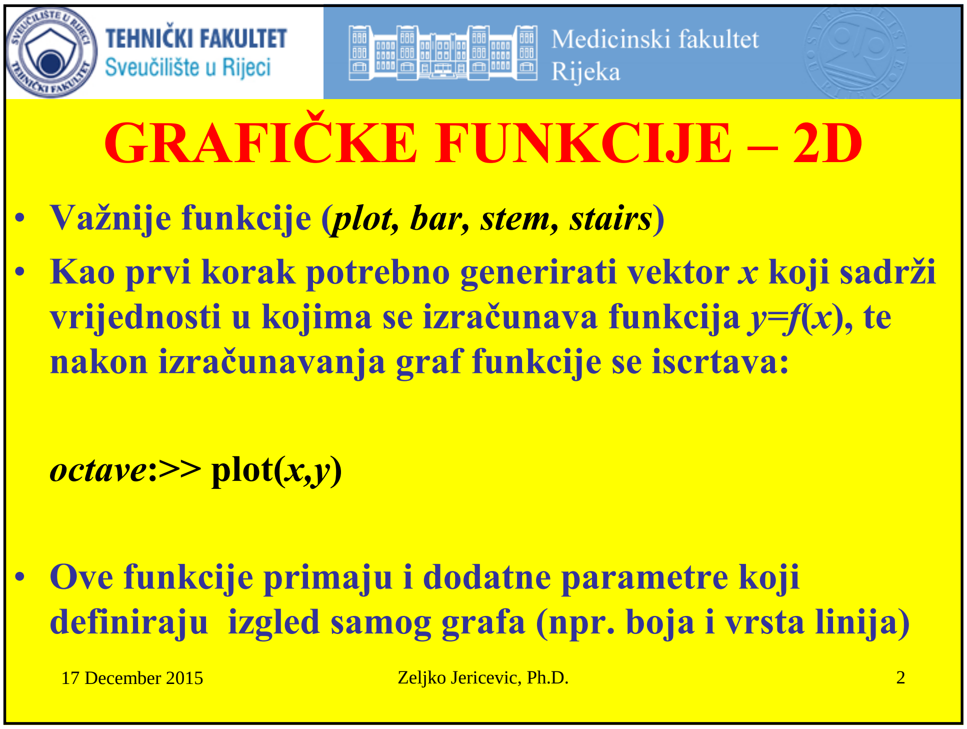

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GRAFIČKE FUNKCIJE – 2D

- Važnije funkcije (*plot, bar, stem, stairs*)
- Kao prvi korak potrebno generirati vektor *x* koji sadrži vrijednosti u kojima se izračunava funkcija *y*=*f*(*x*), te nakon izračunavanja graf funkcije se iscrtava:

octave:>> plot(*x*,*y*)

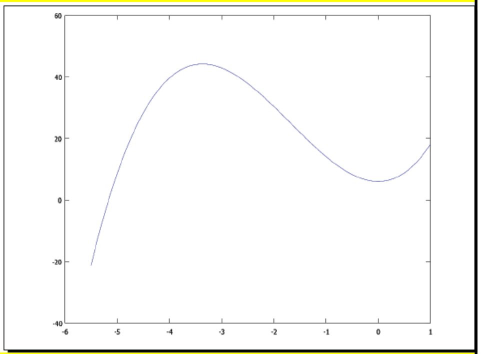
- Ove funkcije primaju i dodatne parametre koji definiraju izgled samog grafa (npr. boja i vrsta linija)

GRAFIČKE FUNKCIJE – 2D

- The first argument to function **plot** is *x*

$$f(x) = 2x^3 + 10.1x^2 + 6$$
$$x \in [-5.5;1]$$

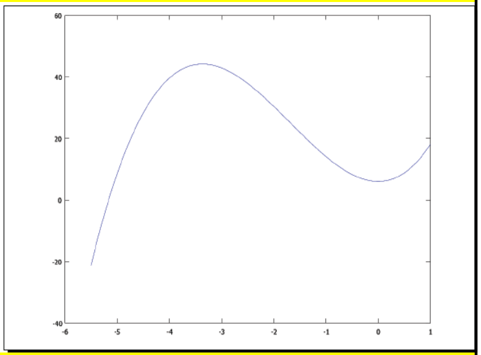
$$octave:>> p = [2 \quad 10.1 \quad 0 \quad 6];$$
$$octave:>> x = [-5.5:0.1:1];$$
$$octave:>> y = \mathrm{polyval}(p, x);$$
$$octave:>> plot(x, y)$$

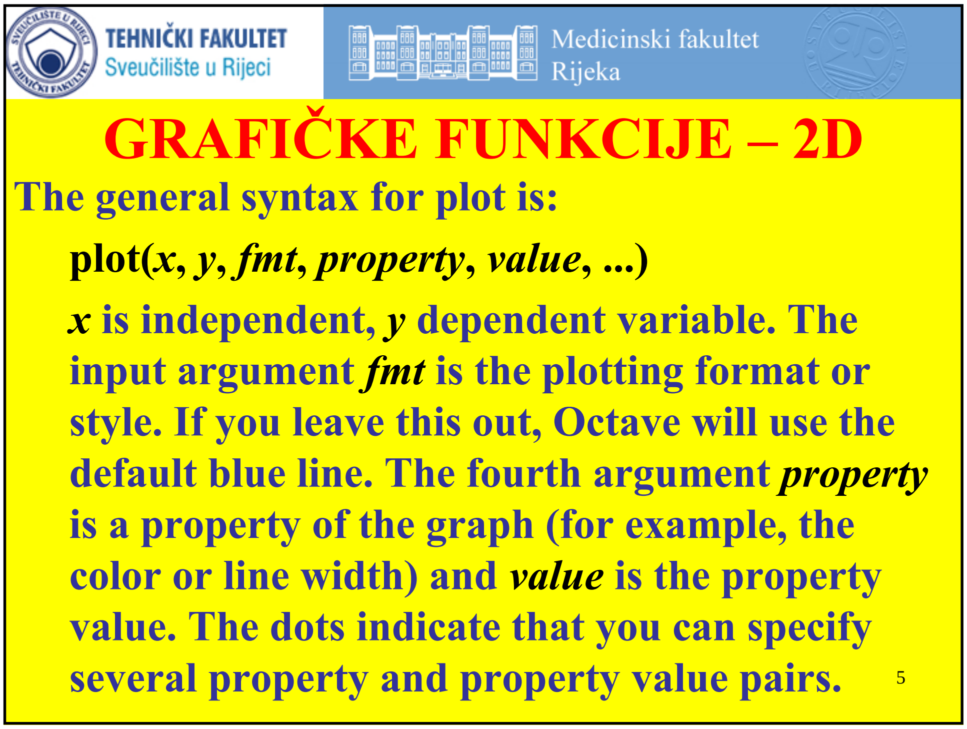


GRAFIČKE FUNKCIJE – 2D

Problems:

1. **The axes are not right, for example, the *x* axis starts from -6, not -5.5.**
2. **The graph and the window box lines are too thin.**
3. **The axes are not labelled.**
4. **The numbers on the axes are too small.**



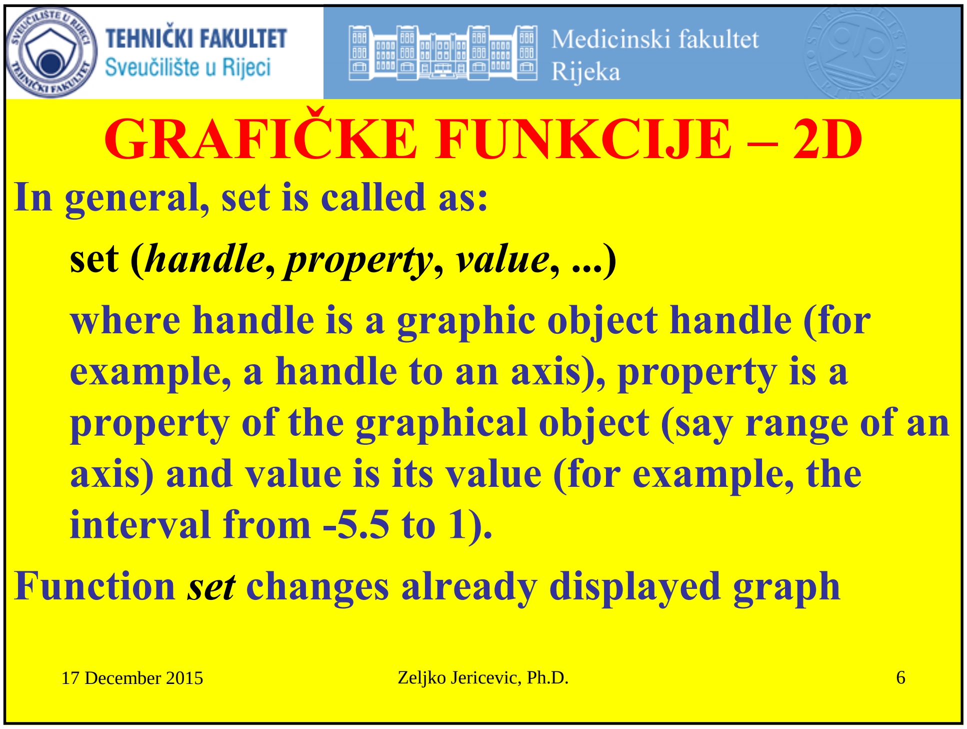


GRAFIČKE FUNKCIJE – 2D

The general syntax for plot is:

plot(*x*, *y*, *fmt*, *property*, *value*, ...)

x is independent, ***y*** dependent variable. The input argument ***fmt*** is the plotting format or style. If you leave this out, Octave will use the default blue line. The fourth argument ***property*** is a property of the graph (for example, the color or line width) and ***value*** is the property value. The dots indicate that you can specify several property and property value pairs.



GRAFIČKE FUNKCIJE – 2D

In general, set is called as:

set (*handle*, *property*, *value*, ...)

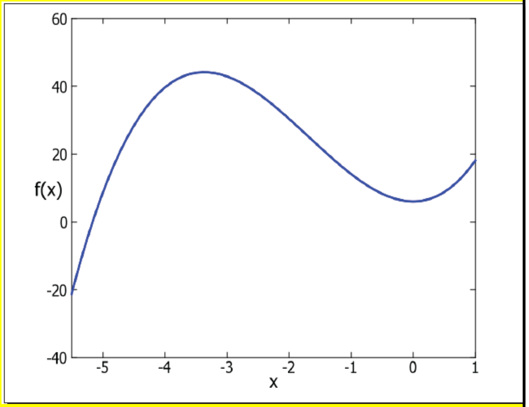
where handle is a graphic object handle (for example, a handle to an axis), property is a property of the graphical object (say range of an axis) and value is its value (for example, the interval from -5.5 to 1).

Function ***set*** changes already displayed graph

GRAFIČKE FUNKCIJE – 2D

Changing the default plot with the commands bellow:

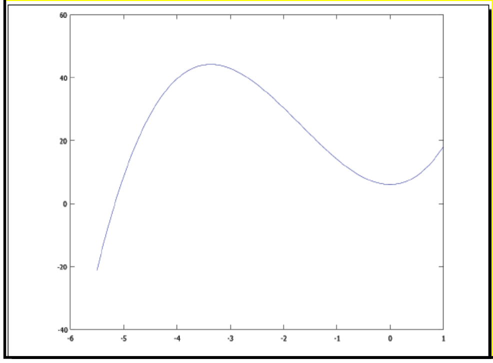
gca **function stands for "get current axis"**

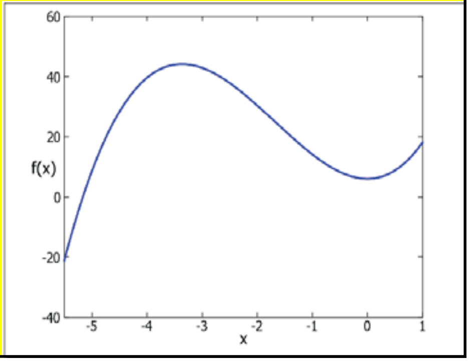


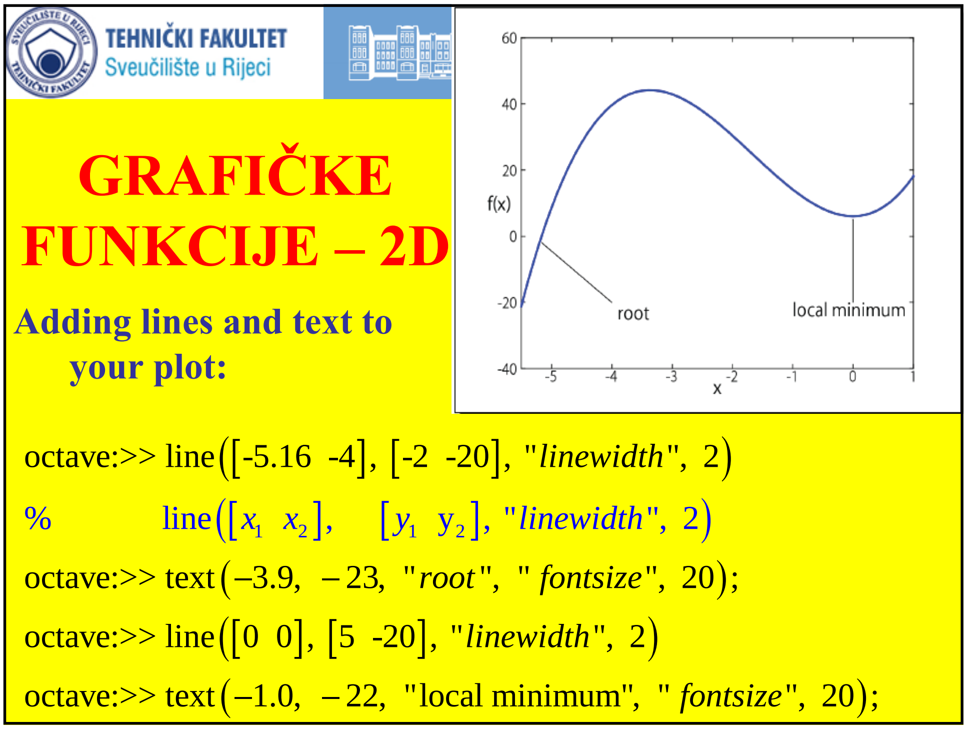
```
octave:>> plot(x, f, "linewidth", 5);
octave:>> set(gca, "x lim", [-5.5  1])
octave:>> set(gca, "linewidth", 2)
octave:>> set(gca, " fontsize", 25)
octave:>> set(gca, "xlabel", text("string", "x", " fontsize", 25))
octave:>> set(gca, "ylabel", text("string", " f (x)"," fontsize", 25))
```

GRAFIČKE FUNKCIJE – 2D

Plot with default plotting values (left) and after the changes (right)







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GRAFIČKE FUNKCIJE – 2D

Adding lines and text to your plot:

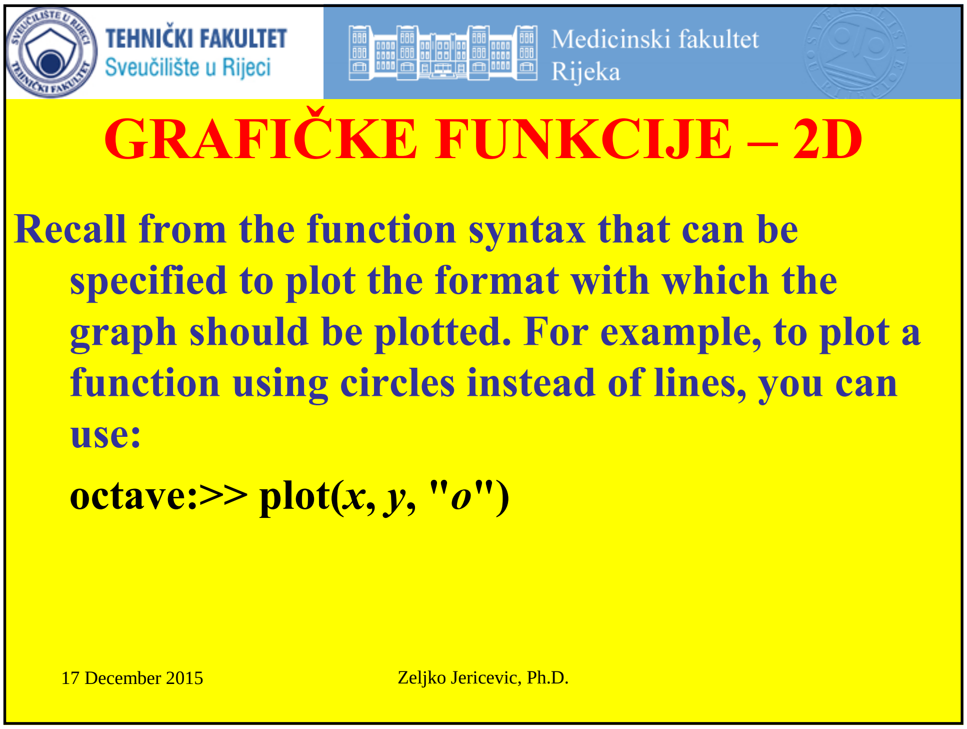
octave:>> line([-5.16 -4], [-2 -20], "*linewidth*", 2)

% line($[x_1 \;\; x_2]$, $[y_1 \;\; y_2]$, "*linewidth*", 2)

octave:>> text(–3.9, –23, "*root*", "*fontsize*", 20);

octave:>> line([0 0], [5 -20], "*linewidth*", 2)

octave:>> text(–1.0, –22, "local minimum", "*fontsize*", 20);



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GRAFIČKE FUNKCIJE – 2D

Recall from the function syntax that can be specified to plot the format with which the graph should be plotted. For example, to plot a function using circles instead of lines, you can use:

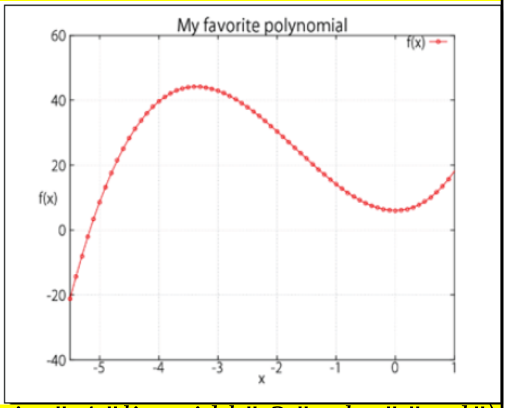
octave:>> plot(*x*, *y*, "*o*")

GRAFIČKE FUNKCIJE – 2D

The points may be too large or too small. The property markersize can help you to set the size of the points:

octave:>> plot(*x*, *y*, "*o*", "*markersize*", 4);

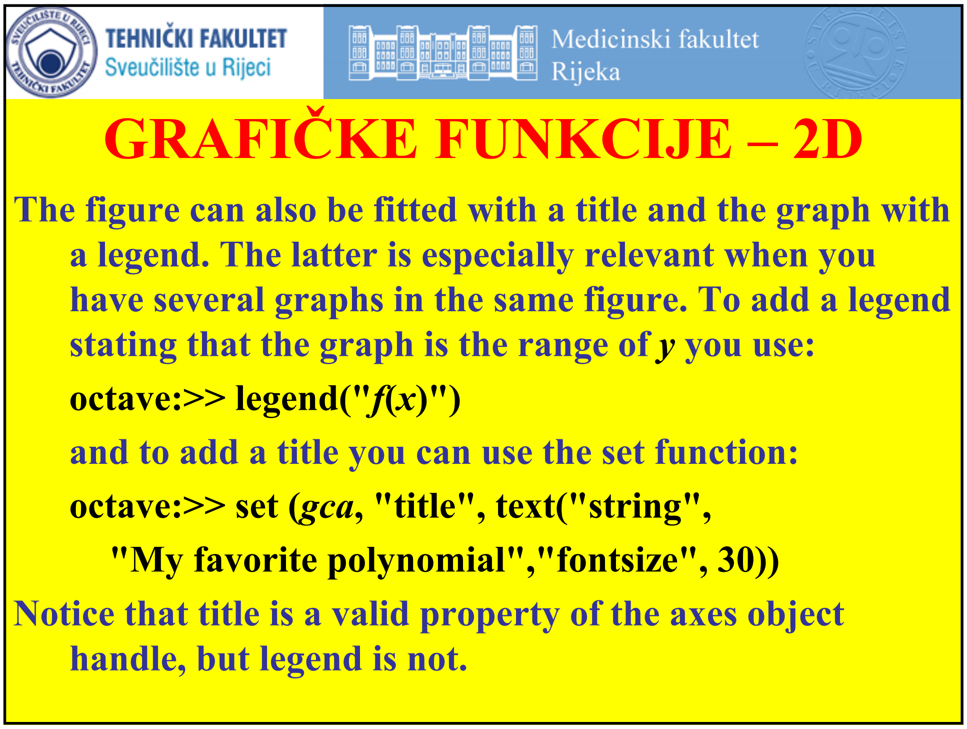
It is possible to experiment with the marker size value. Other point formats are *, +, x, ., and ^, which can be combined with - to connect the points with a line.



GRAFIČKE FUNKCIJE – 2D

Doing plot modifications all at once (graph is red now):

```
octave:>> plot(x, y,"o –","markersize",4,"linewidth",2,"color","red")
octave:>> set (gca,"xlim",[–5.5   1],"ylim",[–40   60],"linewidth",2,
" fontsize",25,"xlabel",text("string","x"," fontsize",25),"xlabel",
text("string"," f (x)"," fontsize",25))
```



GRAFIČKE FUNKCIJE – 2D

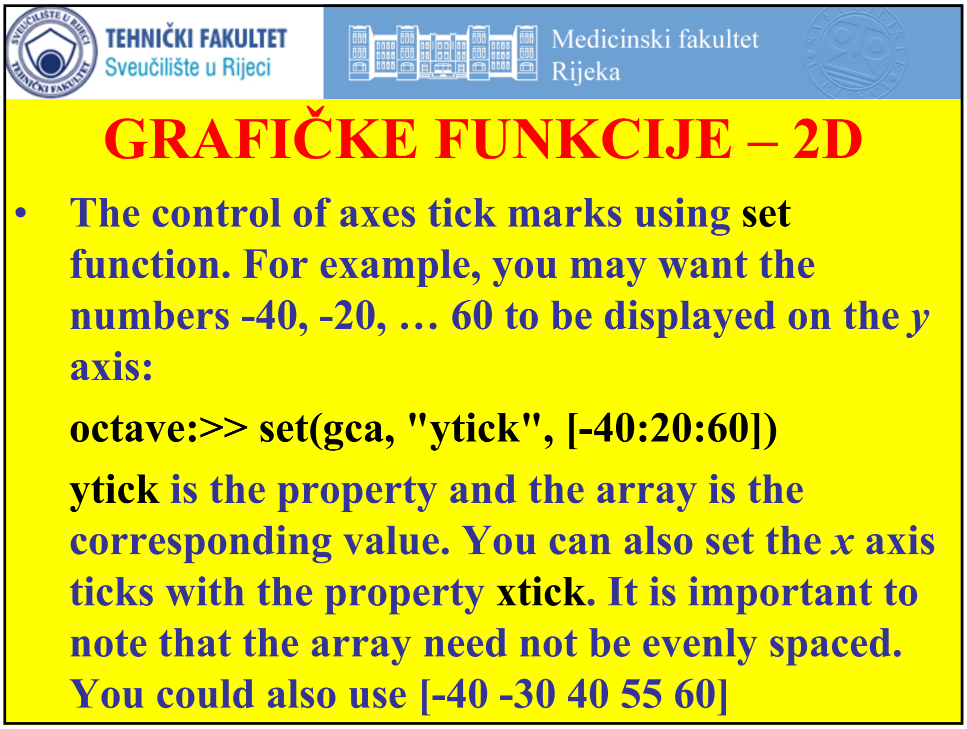
The figure can also be fitted with a title and the graph with a legend. The latter is especially relevant when you have several graphs in the same figure. To add a legend stating that the graph is the range of *y* you use:

```
octave:>> legend("f(x)")
```

and to add a title you can use the set function:

```
octave:>> set (gca, "title", text("string",
    "My favorite polynomial","fontsize", 30))
```

Notice that title is a valid property of the axes object handle, but legend is not.



GRAFIČKE FUNKCIJE – 2D

- The control of axes tick marks using **set** function. For example, you may want the numbers -40, -20, … 60 to be displayed on the *y* axis:

  ```
  octave:>> set(gca, "ytick", [-40:20:60])
  ```

  ytick is the property and the array is the corresponding value. You can also set the *x* axis ticks with the property **xtick**. It is important to note that the array need not be evenly spaced. You could also use [-40 -30 40 55 60]

GRAFIČKE FUNKCIJE – 2D

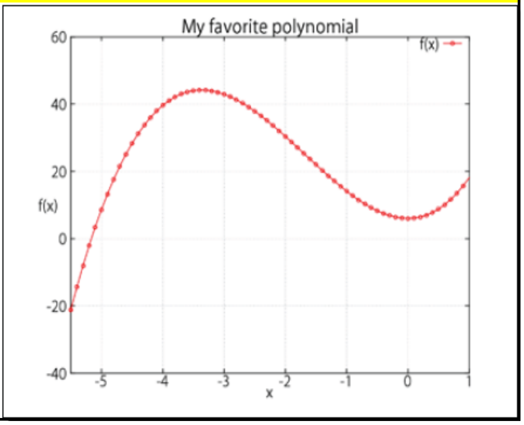
To turn on the grid, use:

octave:>> grid on

To turn the grid off again, simply type:

octave:>> grid off

The grid will connect the tick marks, so if you have unevenly spaced tick marks, the grid will also be unevenly spaced.



GRAFIČKE FUNKCIJE – 2D

The function **fplot** is used for plotting mathematical functions. This is different from plot that plots two data arrays against each other. To plot a *sine function* in the interval from 0 to 2π with fplot using 50 points use:

octave:>>fplot("*sin*", [0 2*pi], 50)

GRAFIČKE FUNKCIJE – 2D

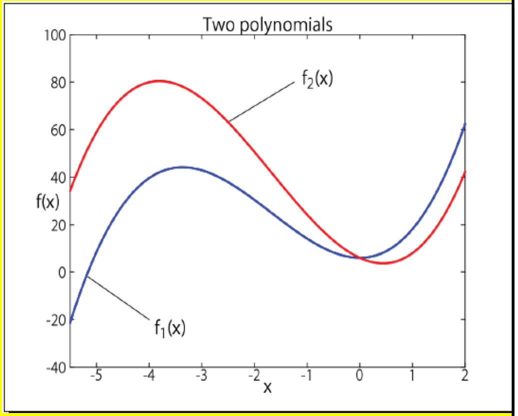
Just as it is possible to delete or clear variables from the workspace, the figures also can be deleted. The command:

```
octave:>> clf
```

will do so. The graphic window remains, but the content is deleted.

GRAFIČKE FUNKCIJE – 2D

Multiple graphs in the same figure:



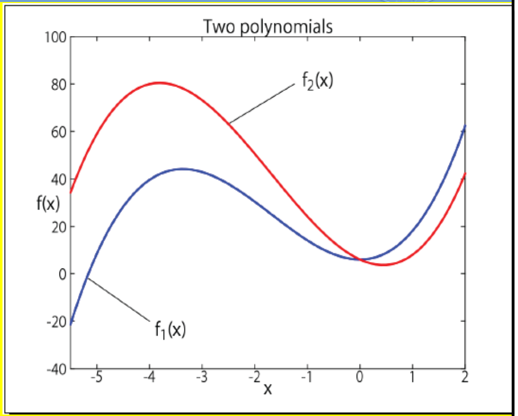
$$f_1(x) = 2x^3 + 10.1x^2 + 6$$

$$f_2(x) = 2x^3 + 10.1x^2 - 10.1x + 6$$

```
octave:>> x=[-5.5:0.1:2];  c1=[2   10.1   0   6];
octave:>> f1=polyval(c1,x);   f2=polyval(c2,x);
octave:>> plot (x, f1,"linewidth",5,x, f2,"linewidth",5,"color","red")
```

GRAFIČKE FUNKCIJE – 2D

Multiple graphs in the same figure (step by step):



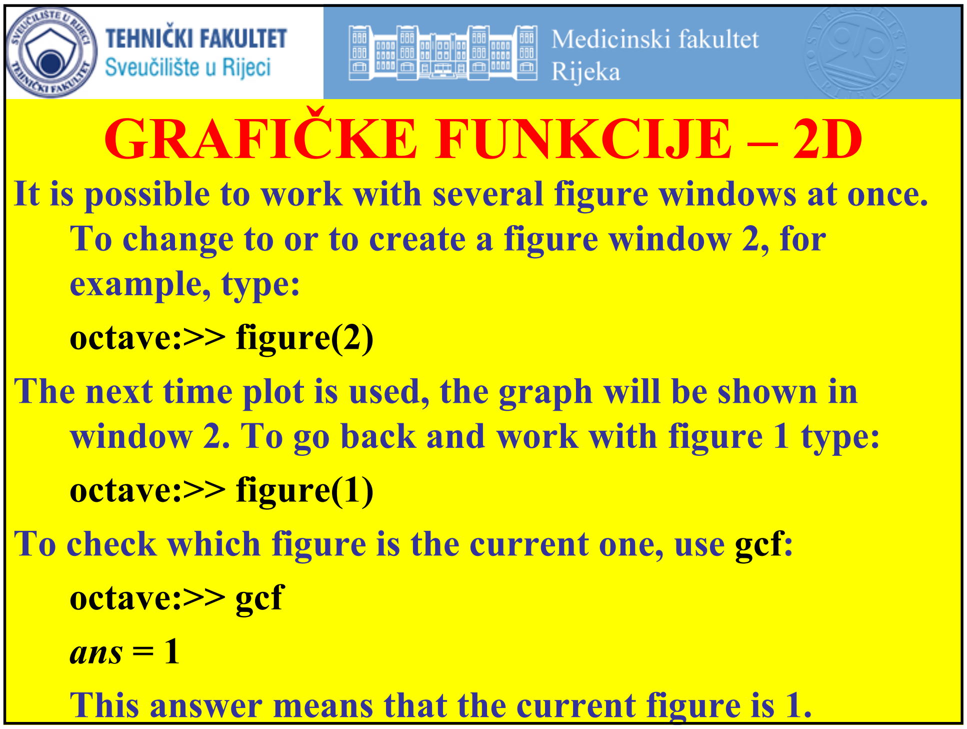
```
octave:>> plot (x, f1,"linewidth",5)
octave:>> hold on
octave:>> plot (x, f2,"linewidth",5,"color","red")
octave:>> hold off
```

GRAFIČKE FUNKCIJE – 2D

The subscripts are made with _ (underscore). An underscore indicates that the next character is a subscript. For example, in the previous figure :

```
octave:>> text(-3.9, -23, "f_1(x)")
```

If more than one character has to be a subscript, curly brackets around the characters are used, for example,"f_{123}(x)". For superscript, ^ (hat) is used instead of underscore. This feature, however, may not be supported by some plotting toolkit.



GRAFIČKE FUNKCIJE – 2D

It is possible to work with several figure windows at once. To change to or to create a figure window 2, for example, type:

```
octave:>> figure(2)
```

The next time plot is used, the graph will be shown in window 2. To go back and work with figure 1 type:

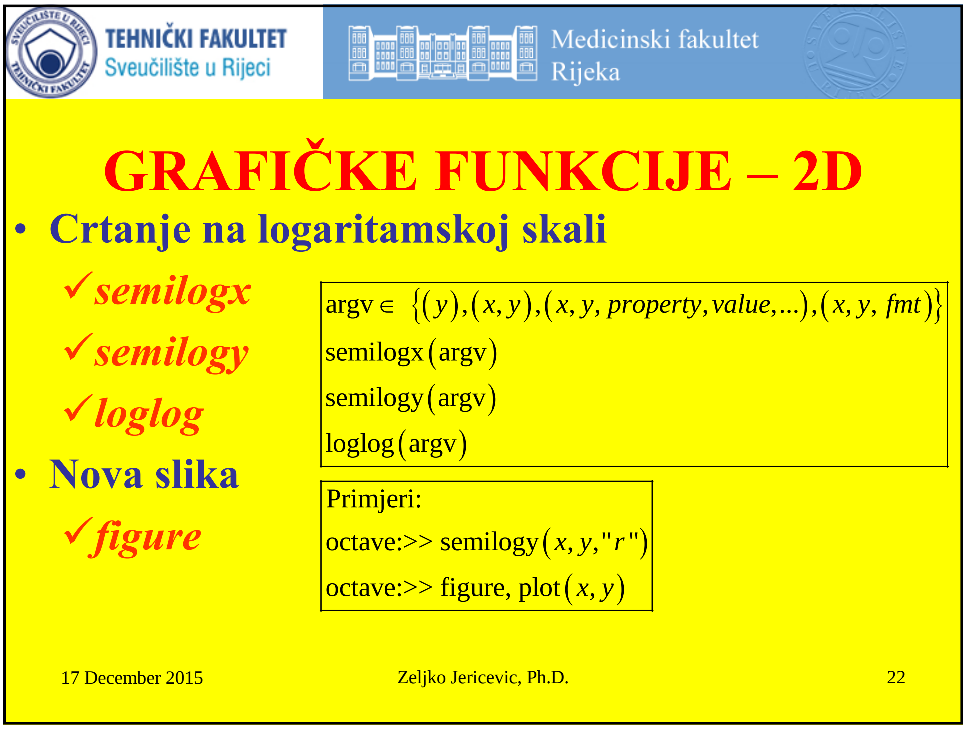
```
octave:>> figure(1)
```

To check which figure is the current one, use **gcf**:

```
octave:>> gcf
```

ans = 1

This answer means that the current figure is 1.



GRAFIČKE FUNKCIJE – 2D

- Crtanje na logaritamskoj skali
  - ✓*semilogx*
  - ✓*semilogy*
  - ✓*loglog*
- Nova slika
  - ✓*figure*

$\text{argv} \in \{(y),(x,y),(x,y,\textit{property},\textit{value},\ldots),(x,y,\textit{fmt})\}$

$\text{semilogx}(\text{argv})$

$\text{semilogy}(\text{argv})$

$\text{loglog}(\text{argv})$

Primjeri:

octave:>> semilogy$(x,y,"r")$

octave:>> figure, plot(x,y)

GRAFIČKE FUNKCIJE – 2D

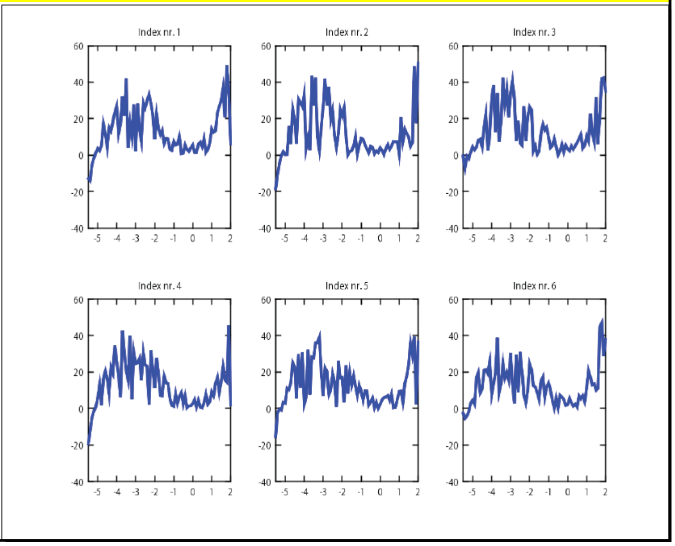
It is possible to have multiple subplots in the same window. For example, to start a figure window with dimensions 2 by 3, that is, with six plots, you use the command:

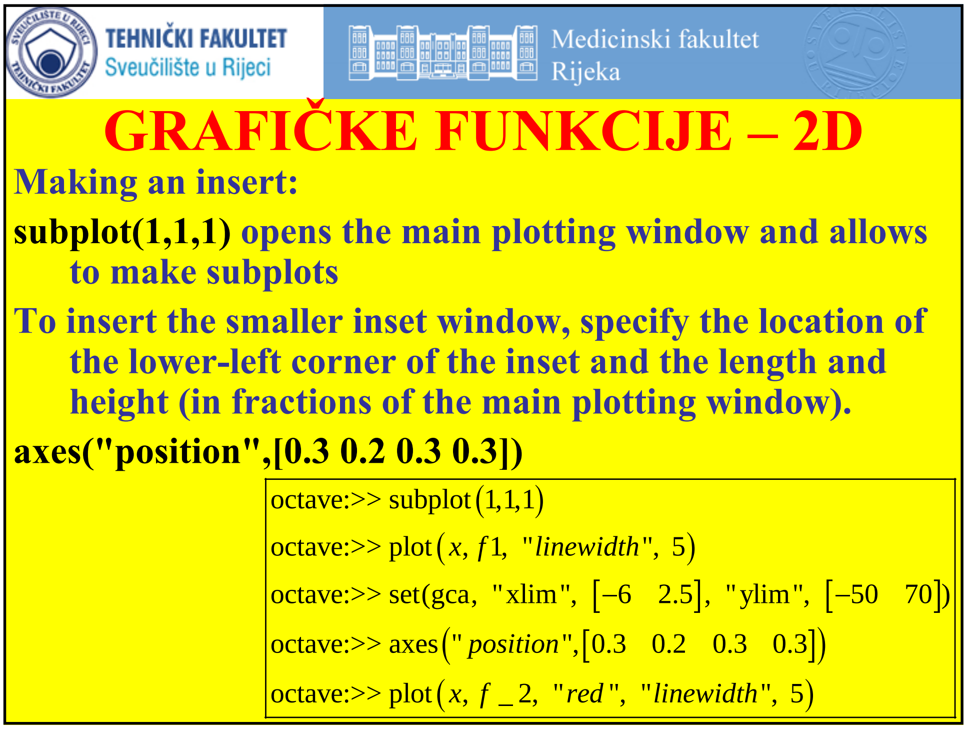
```
octave:>> subplot(2,3,1)
```

The first two arguments to subplot set the window dimensions, and the third tells Octave to plot in the subplot window with index 1. The indices run in a row-wise manner.

GRAFIČKE FUNKCIJE – 2D

The figure shows an example of a window with six subplots arranged on a 2 by 3 grid where each subplot is plotting something random.





GRAFIČKE FUNKCIJE – 2D

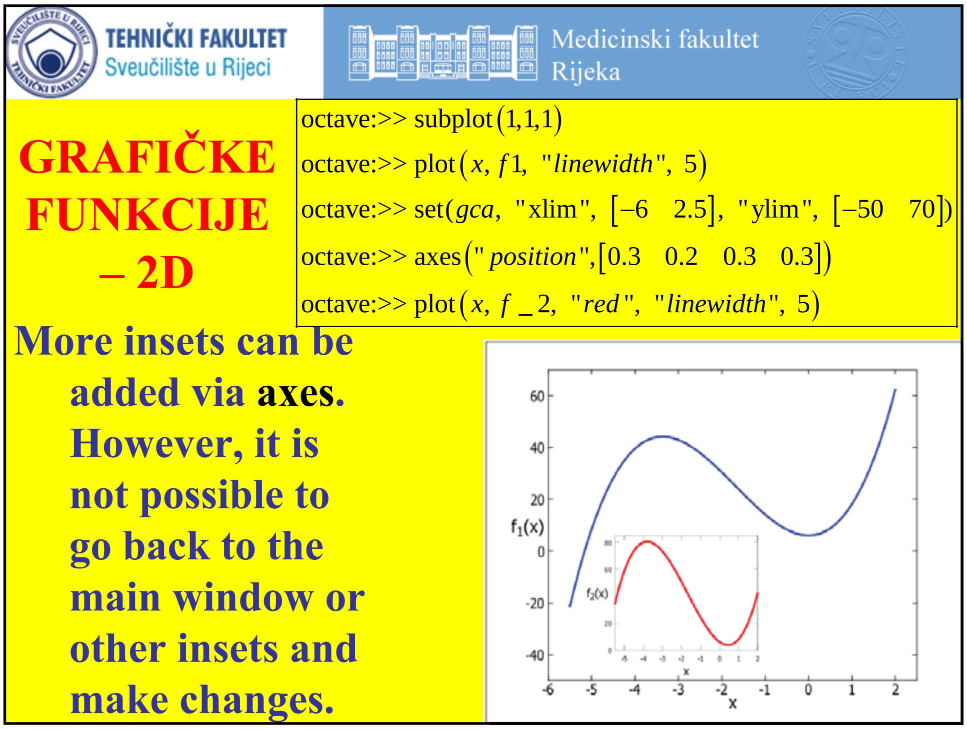
Making an insert:

subplot(1,1,1) opens the main plotting window and allows to make subplots

To insert the smaller inset window, specify the location of the lower-left corner of the inset and the length and height (in fractions of the main plotting window).

axes("position",[0.3 0.2 0.3 0.3])

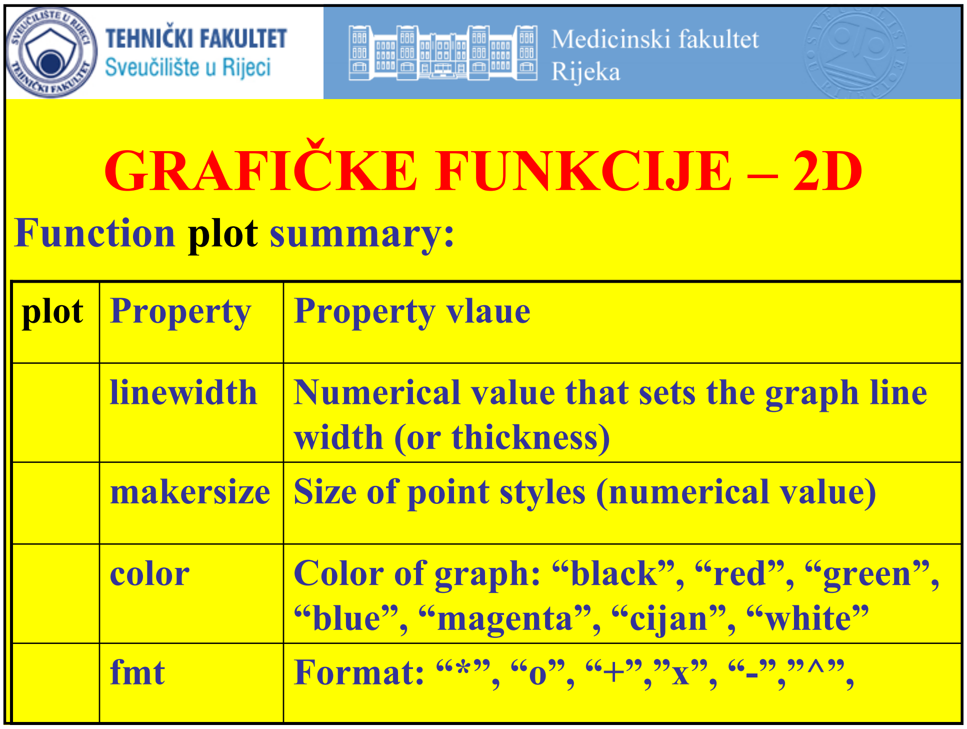
```
octave:>> subplot(1,1,1)
octave:>> plot(x, f1, "linewidth", 5)
octave:>> set(gca, "xlim", [-6   2.5], "ylim", [-50   70])
octave:>> axes("position",[0.3   0.2   0.3   0.3])
octave:>> plot(x, f_2, "red", "linewidth", 5)
```



GRAFIČKE FUNKCIJE – 2D

```
octave:>> subplot(1,1,1)
octave:>> plot(x, f1, "linewidth", 5)
octave:>> set(gca, "xlim", [-6   2.5], "ylim", [-50   70])
octave:>> axes("position",[0.3   0.2   0.3   0.3])
octave:>> plot(x, f_2, "red", "linewidth", 5)
```

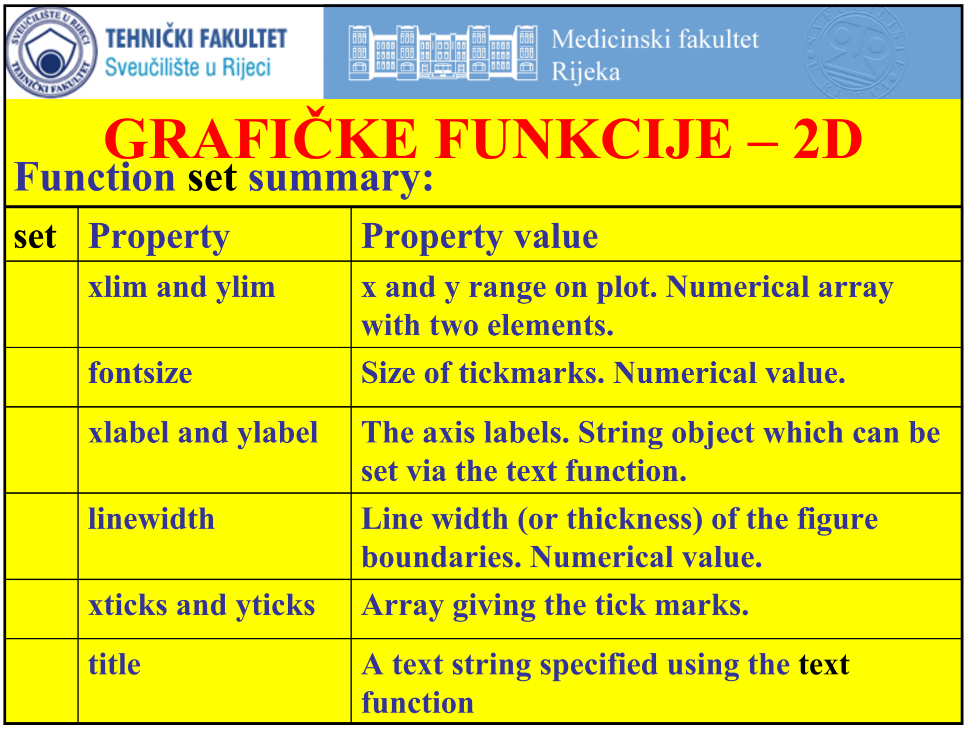
More insets can be added via **axes.** However, it is not possible to go back to the main window or other insets and make changes.



GRAFIČKE FUNKCIJE – 2D

Function **plot** summary:

plot	Property	Property vlaue
	linewidth	Numerical value that sets the graph line width (or thickness)
	makersize	Size of point styles (numerical value)
	color	Color of graph: “black”, “red”, “green”, “blue”, “magenta”, “cijan”, “white”
	fmt	Format: “*”, “o”, “+”,”x”, “-”,”^”,



GRAFIČKE FUNKCIJE – 2D

Function **set** summary:

set	Property	Property value
	xlim and ylim	x and y range on plot. Numerical array with two elements.
	fontsize	Size of tickmarks. Numerical value.
	xlabel and ylabel	The axis labels. String object which can be set via the text function.
	linewidth	Line width (or thickness) of the figure boundaries. Numerical value.
	xticks and yticks	Array giving the tick marks.
	title	A text string specified using the **text** function

GRAFIČKE FUNKCIJE – 2D

Saving the plot image:

You can save (or rather print) your plot to a file via the print function. For example:

```
octave:>> print("polynom.png", "-dpng");
```

will print the current window to the file "polynom.png" in png (Portable Network Graphics) format. Notice the -d before the format specification. This is an abbreviation for "device".

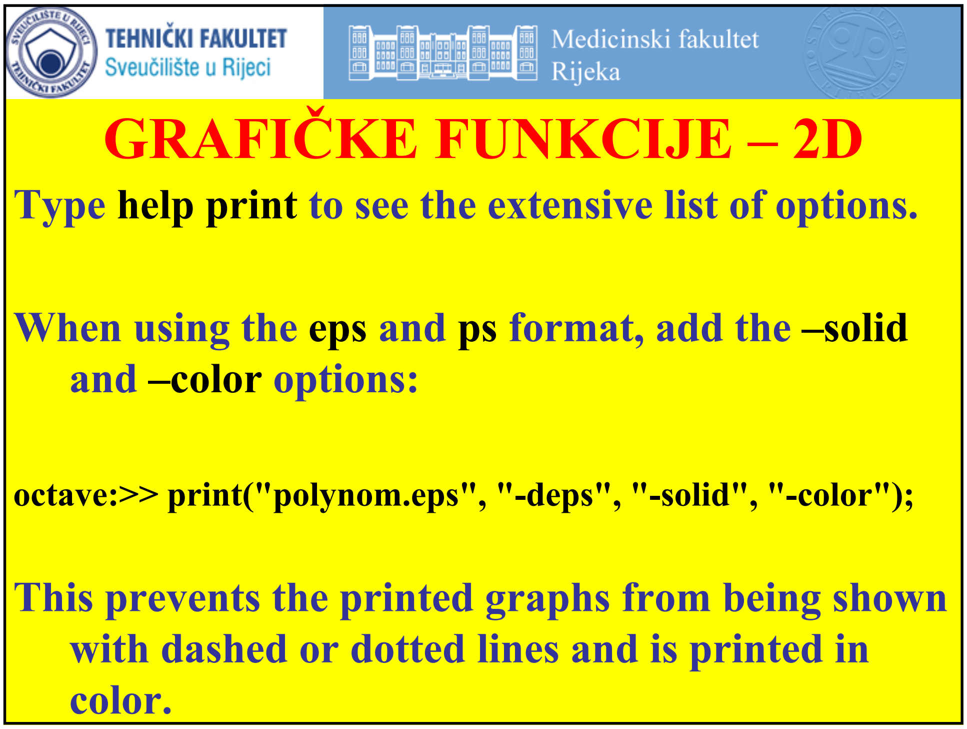
You can also use print in a non-functional form, for example, Command above could be replaced with:

```
octave:>> print polynom.png –dpng
```

GRAFIČKE FUNKCIJE – 2D

Print supports most of the common formats:

- eps Encapsulated PostScript (recommend).
- ps PostScript.
- pdf Portable Document Format.
- jpg/jpeg Joint Photographic Experts Group image.
- gif Graphics Interchange Format image.
- tex TeX picture (to be included in a TeX document).
- pslatex LaTex picture file for labels and PostScript for the graphics. This enables you to edit the labels later.
- png Portable Network Graphics image.



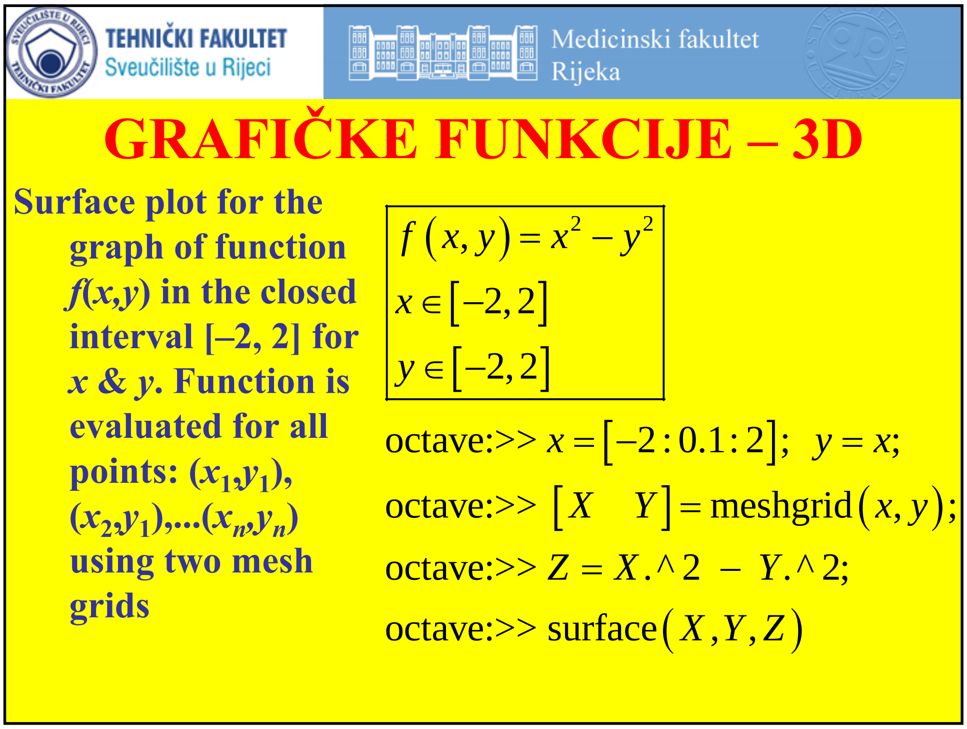
GRAFIČKE FUNKCIJE – 2D

Type **help print** to see the extensive list of options.

When using the **eps** and **ps** format, add the **–solid** and **–color** options:

```
octave:>> print("polynom.eps", "-deps", "-solid", "-color");
```

This prevents the printed graphs from being shown with dashed or dotted lines and is printed in color.



GRAFIČKE FUNKCIJE – 3D

Surface plot for the graph of function *f*(*x*,*y*) in the closed interval [–2, 2] for *x* & *y*. Function is evaluated for all points: (x_1,y_1), (x_2,y_1),...(x_n,y_n) using two mesh grids

$$\boxed{\begin{array}{l} f(x,y)=x^2-y^2 \\ x\in[-2,2] \\ y\in[-2,2] \end{array}}$$

octave:>> $x=[-2:0.1:2];\ \ y=x;$

octave:>> $[X\quad Y]=\text{meshgrid}(x,y);$

octave:>> $Z = X.\hat{}\,2\ -\ Y.\hat{}\,2;$

octave:>> $\text{surface}(X,Y,Z)$

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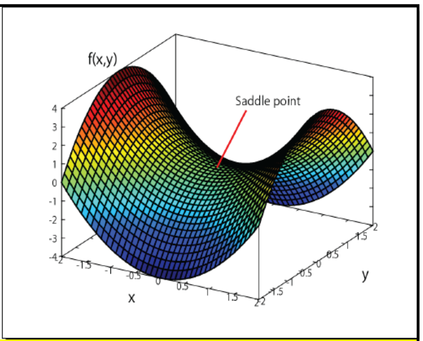
GRAFIČKE FUNKCIJE – 3D



$$\boxed{f\left(x,y\right)=x^2-y^2}$$

```
octave:>> surface(X,Y,Z,"linewidth",4)
octave:>> set(gca,"linewidth",2,"fontsize",20,"xlim",[−2 2])
octave:>> set(gca,"xlabel",text("string", "x","fontsize",30))
octave:>> set(gca,"ylabel",text("string", "y","fontsize",30))
octave:>> text(−3.2,1,3,"f (x, y)","fontsize",30)
octave:>> line([0 0],[0 1],[0 2],"linewidth",5,"color","red")
octave:>> text(−0.5,1.5,1.0,"Saddle point","fontsize",25)
```

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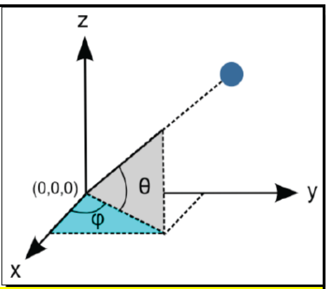


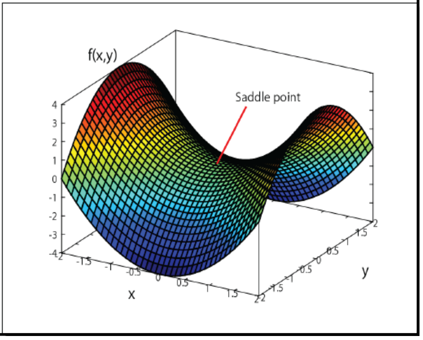
view function

Viewer change of position is done by the view function. The arguments to view are the azimuth and elevation angles *φ* and *θ*. (See the illustration on the right and up).

To set the view to (*φ*, *θ*)=(35,30), use:

```
octave:>> view(35,30)
```

(See on the right and down).

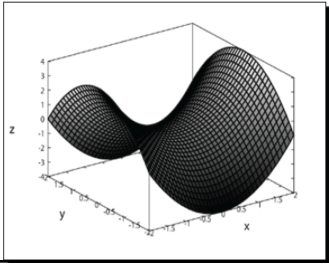


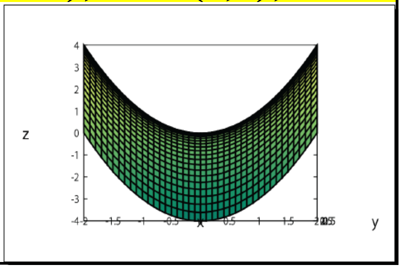
GRAFIČKE FUNKCIJE – 3D

colormap function

Changing the surface color is done by using colormap. (Two examples are shown bellow).

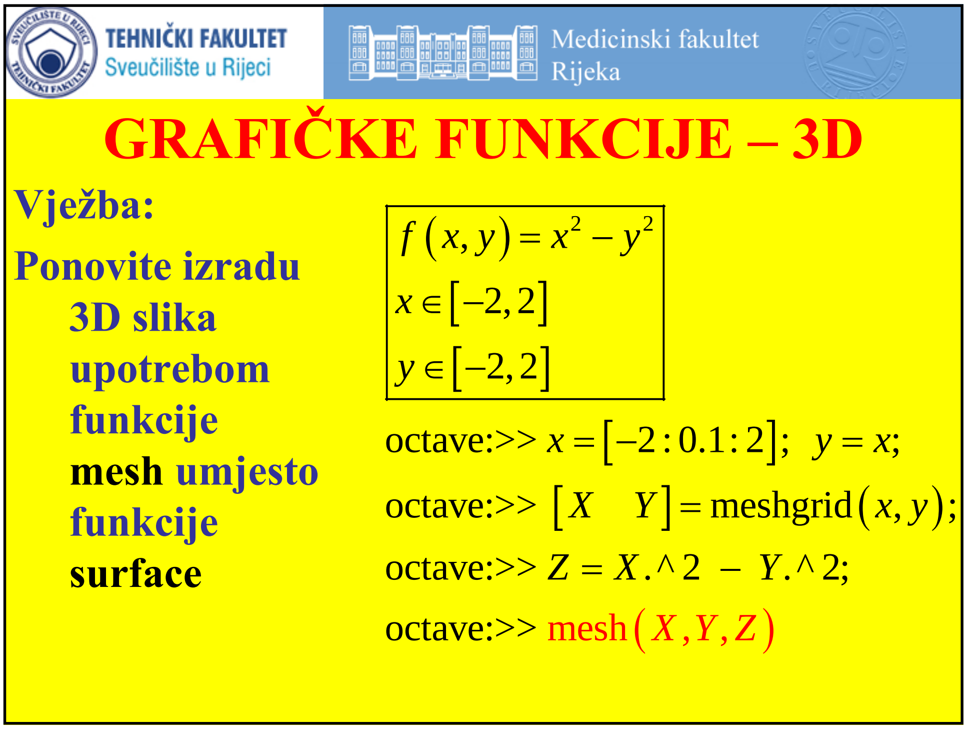
```
octave:>>colormap("gray"); view(-35, 30);
octave:>>colormap("summer"); view(0,0);
```





GRAFIČKE FUNKCIJE – 3D

Valid colormaps		
jet (default)	summer	copper
hsv	spring	gray
hot	autumn	bone
cool	winter	pink



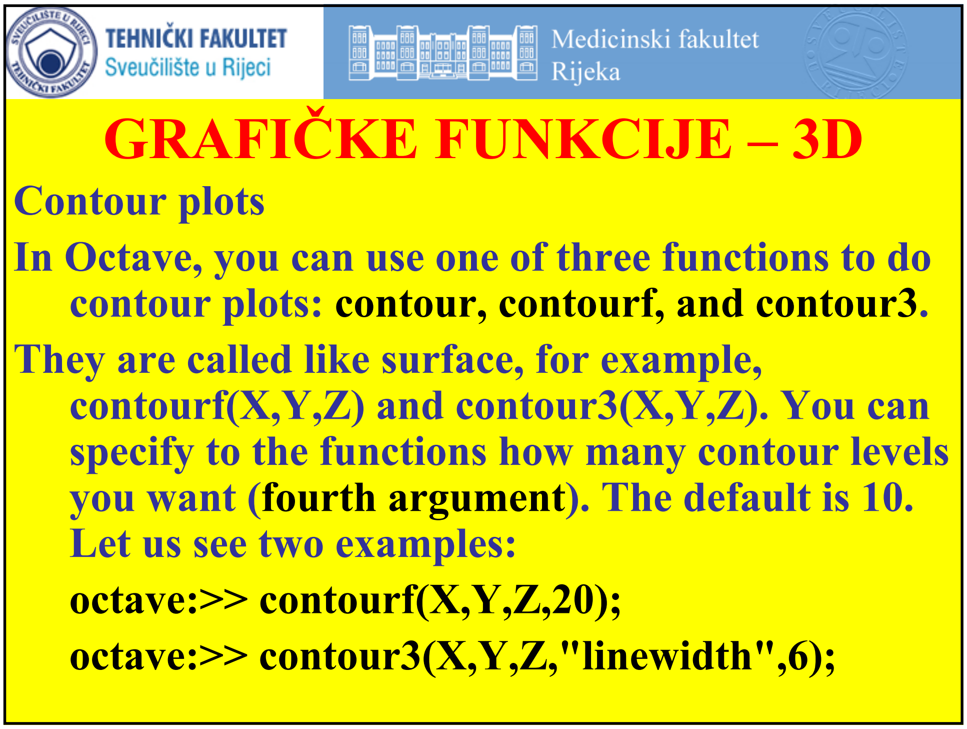
GRAFIČKE FUNKCIJE – 3D

Vježba:

Ponovite izradu 3D slika upotrebom funkcije **mesh** umjesto funkcije **surface**

$$\boxed{\begin{array}{l} f\left(x,y\right)=x^2-y^2 \\ x\in\left[-2,2\right] \\ y\in\left[-2,2\right] \end{array}}$$

```
octave:>> x = [−2 : 0.1 : 2];  y = x;
octave:>> [X   Y] = meshgrid(x, y);
octave:>> Z = X.^2  –  Y.^2;
octave:>> mesh(X,Y,Z)
```



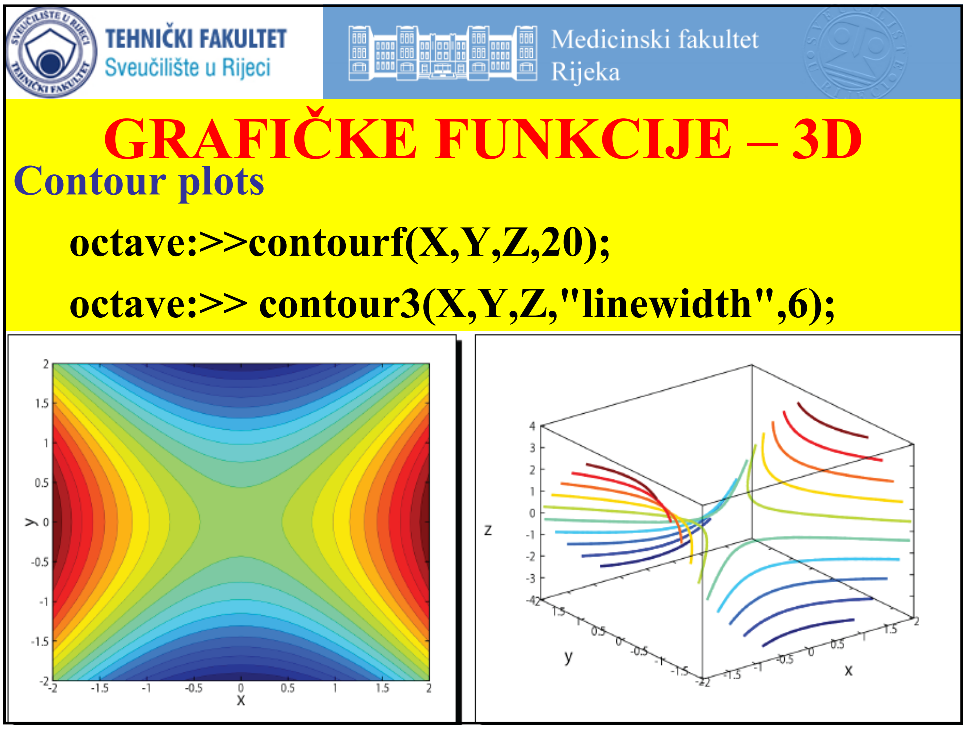
GRAFIČKE FUNKCIJE – 3D

Contour plots

In Octave, you can use one of three functions to do contour plots: **contour, contourf, and contour3**.

They are called like surface, for example, contourf(X,Y,Z) and contour3(X,Y,Z). You can specify to the functions how many contour levels you want (**fourth argument**). The default is 10. Let us see two examples:

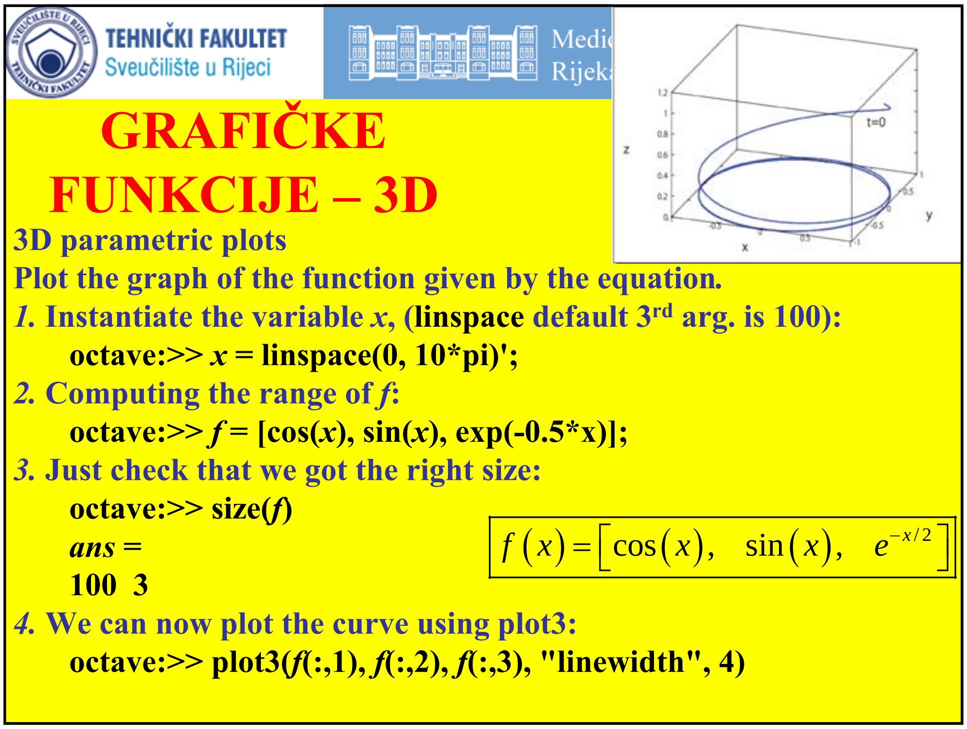
```
octave:>> contourf(X,Y,Z,20);
octave:>> contour3(X,Y,Z,"linewidth",6);
```



GRAFIČKE FUNKCIJE – 3D

Contour plots

```
octave:>>contourf(X,Y,Z,20);
octave:>> contour3(X,Y,Z,"linewidth",6);
```



GRAFIČKE FUNKCIJE – 3D

3D parametric plots

Plot the graph of the function given by the equation.

1. Instantiate the variable x, (linspace default 3rd arg. is 100):

```
octave:>> x = linspace(0, 10*pi)';
```

2. Computing the range of f:

```
octave:>> f = [cos(x), sin(x), exp(-0.5*x)];
```

3. Just check that we got the right size:

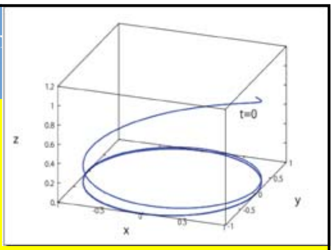
```
octave:>> size(f)
ans =
100  3
```

$$f(x) = \left[\cos(x),\quad \sin(x),\quad e^{-x/2}\right]$$

4. We can now plot the curve using plot3:

```
octave:>> plot3(f(:,1), f(:,2), f(:,3), "linewidth", 4)
```

GRAFIČKE FUNKCIJE – 3D



3D parametric plots

```
octave:>> plot3(f(:,1), f(:,2), f(:,3), "linewidth", 4)
```

5. To set the right properties, we can use:

```
octave:>> set(gca, "linewidth", 2, "fontsize", 20);
octave:>> set(gca, "xlabel", text("string", "x","fontsize", 30);
octave:>> set(gca, "ylabel", text("string", "y","fontsize", 30);
octave:>> set(gca, "zlabel", text("string", "z","fontsize", 30);
octave:>> set(gca, "zlim", [0 1.2])
octave:>> text(0.9, -0.25, 0.9, "t=0", "fontsize", 30)
octave:>> view(20,30)
```

$$f(x) = \left[\cos(x),\quad \sin(x),\quad e^{-x/2}\right]$$

The final figure is shown on the right and up.

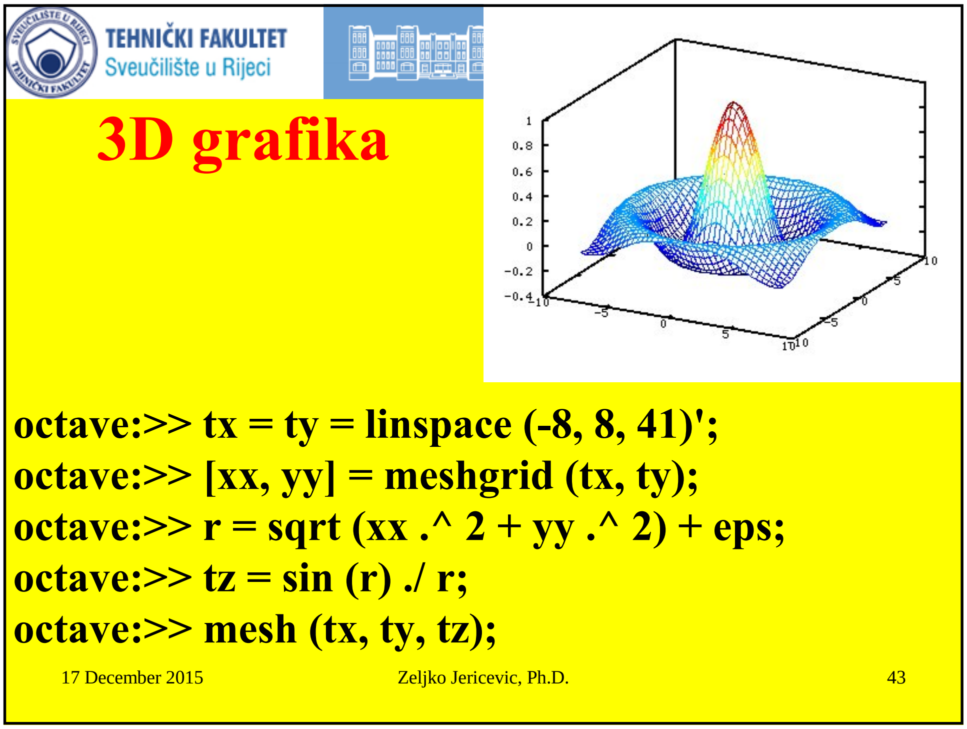
GRAFIČKE FUNKCIJE – 3D

- Slično kao u 2D slučaju korisnik mora sam kreirati vrijednosti nezavisnih varijabli u kojima će se funkcija izračunavati
- Funkcije za crtanje u 3D
  - ✓ *surf*
  - ✓ *mesh*
  - ✓ *contour*
  - ✓ *contoursurf*

$$\text{octave:>> } x1 = \text{linspace}(0,5,100)$$

$$\text{octave:>> } y1 = \text{linspace}(0,5,100)$$

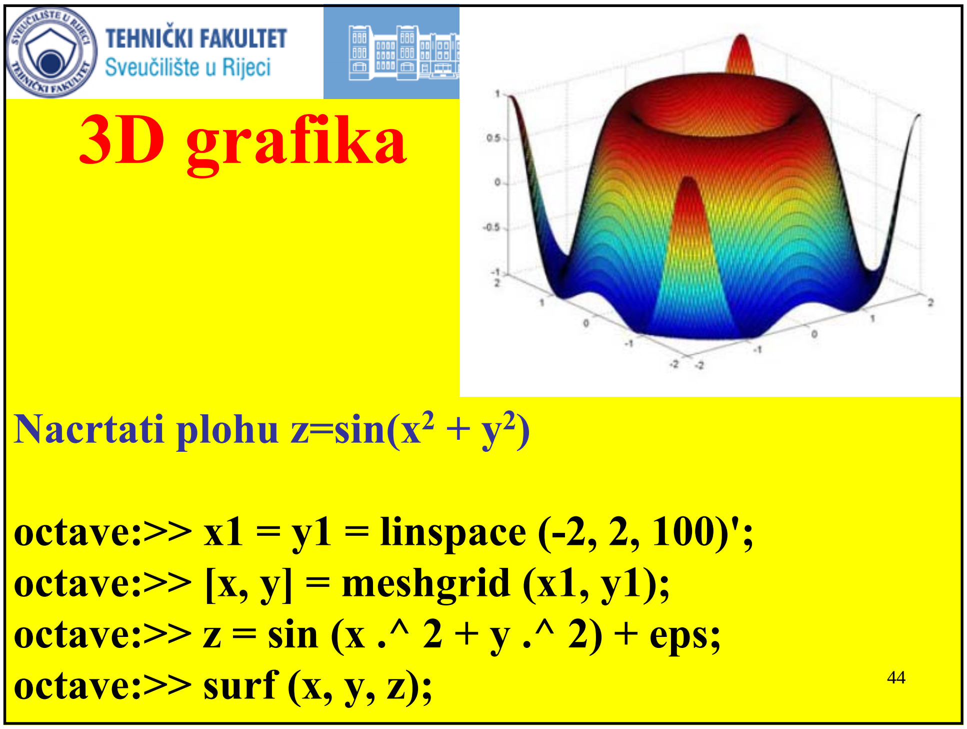
$$\text{octave:>> } [x, y] = \text{meshgrid}(x1, y1)$$



TEHNIČKI FAKULTET
Sveučilište u Rijeci

3D grafika

```
octave:>> tx = ty = linspace (-8, 8, 41)';
octave:>> [xx, yy] = meshgrid (tx, ty);
octave:>> r = sqrt (xx .^ 2 + yy .^ 2) + eps;
octave:>> tz = sin (r) ./ r;
octave:>> mesh (tx, ty, tz);
```



TEHNIČKI FAKULTET
Sveučilište u Rijeci

3D grafika

Nacrtati plohu $z=\sin(x^2 + y^2)$

```
octave:>> x1 = y1 = linspace (-2, 2, 100)';
octave:>> [x, y] = meshgrid (x1, y1);
octave:>> z = sin (x .^ 2 + y .^ 2) + eps;
octave:>> surf (x, y, z);
```