# TMMF

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## Parte 4 – Funzioni con MatLab

## GRAPH OF z=f(x,y)

Consider a function of two real variables

$$f: A \subseteq R^2 \text{->} R$$

We want to depict its **graph** (or **plot**)

To the scope there exist **two different ways** in MatLab:

**1) PUNCTUAL DEFINITION**

**2) ANONYMOUS FUNCTION**

## 1) Graph with punctual definition

The steps are the following

a. **Define the interval of values that must be considered for the two independent variables. The interval must be defined as row vectors, x and y, having an high number of equally spaced elements. Thus the operator : or linspace can be used.**

b. **Define a grid on the plane (x,y) constituted by the set of couples having one element of the vector x and the second element taken form the vector y**

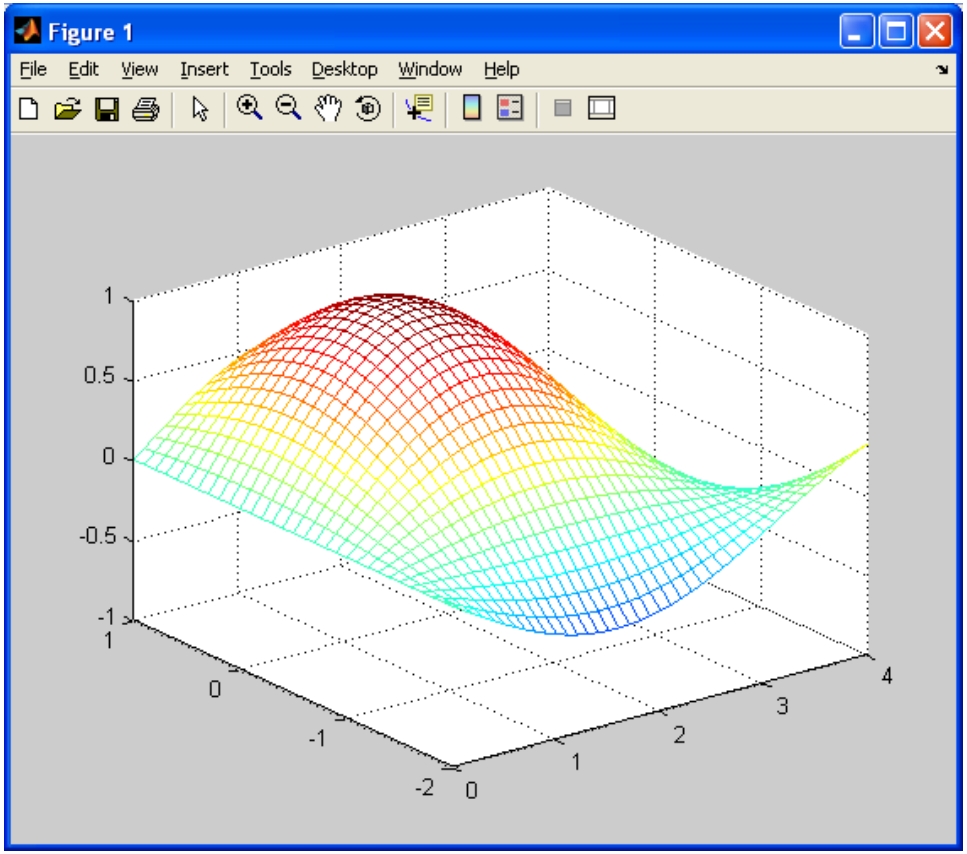
**the command [X Y]=meshgrid(x,y) creates matrices X and Y**

c. **Calculate the function z=f(X,Y) by applying f to the matrices X and Y. The punctual operators and the syntax of elementary functions must be considered. In such a way the value associated to each couple (x,y) is computed**

d. **Depict the graph of the function by using commands surf(X,Y,z) or mesh(X,Y,z) that plots the set of points (x,y,z) in $\square^3$**

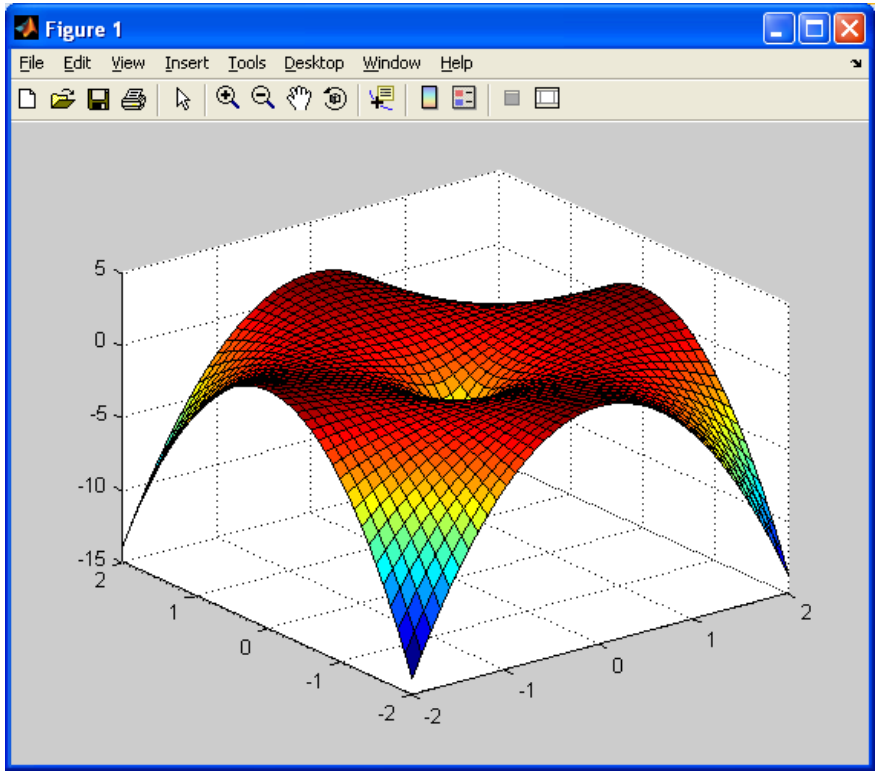
**EX** (1) $z = \sin(x) \cdot \cos(y)$

```
>> x=0:0.1:4;
>> y=-2:0.1:1;
>> [X Y]=meshgrid(x,y);
>> z=sin(X).*cos(Y);
>> mesh(X,Y,z)
```



**EX** (2) $z = \ln(x^2 + y^2) - x^2 y^2$

```
>> y=-2:0.1:2;
>> y=-2:0.1:2;
>> [X Y]=meshgrid(x,y);
>> z=log(X.^2+Y.^2)-(X.^2).*(Y.^2);
>> surf(X,Y,z)
```



## EX 14

**Plot the graphs of the following functions (punctual definition)**

(1) $z = \ln(x) \cdot \ln(y)$

consider $x \in [1,4]$ and $y \in [1,4]$ and use mesh

(2) $z = x^2 + y^2 - \cos(x) - \cos(y)$

consider $x \in [-1,1]$ and $y \in [-1,1]$ and use surf

## 1) Graph with anonymous function

The steps are the following

a. **Define the anonymous function by using the following expression:**

`z=@(x,y) law_of_xy`

**thus f(x,y) will be associated to z**

**Notice** **It is then possible to calculate the value of z at a given point (x0,y0) by using the command** `z(x0,y0)`

b. **Depict the plot by using one of the following commands:**

`ezsurf(z,[x_min x_max],[y_min y_max])` **or**

`ezmesh(z ,[x_min x_max],[y_min y_max]) )`

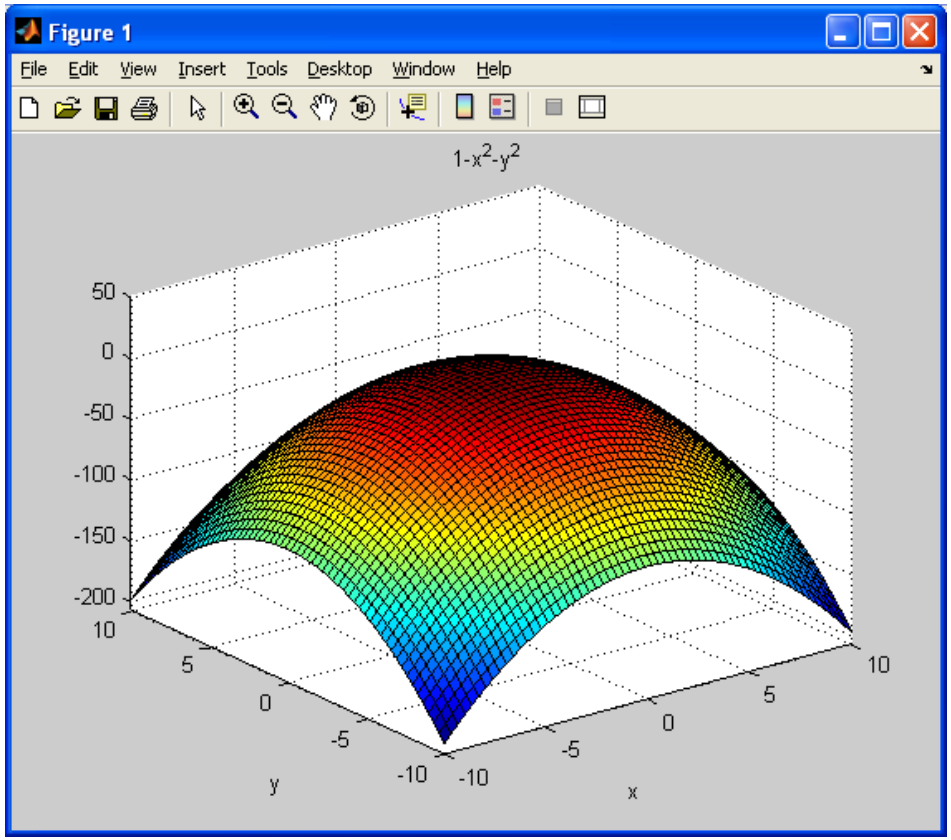
**and the graph will be represented for the independent variables belonging to the defined intervals**

## EX

(1) $z = 1 - x^2 - y^2$

```
>> z=@(x,y) 1-x.^2-y.^2;
>> ezsurf(z,[-10 10],[-10 10]);
```

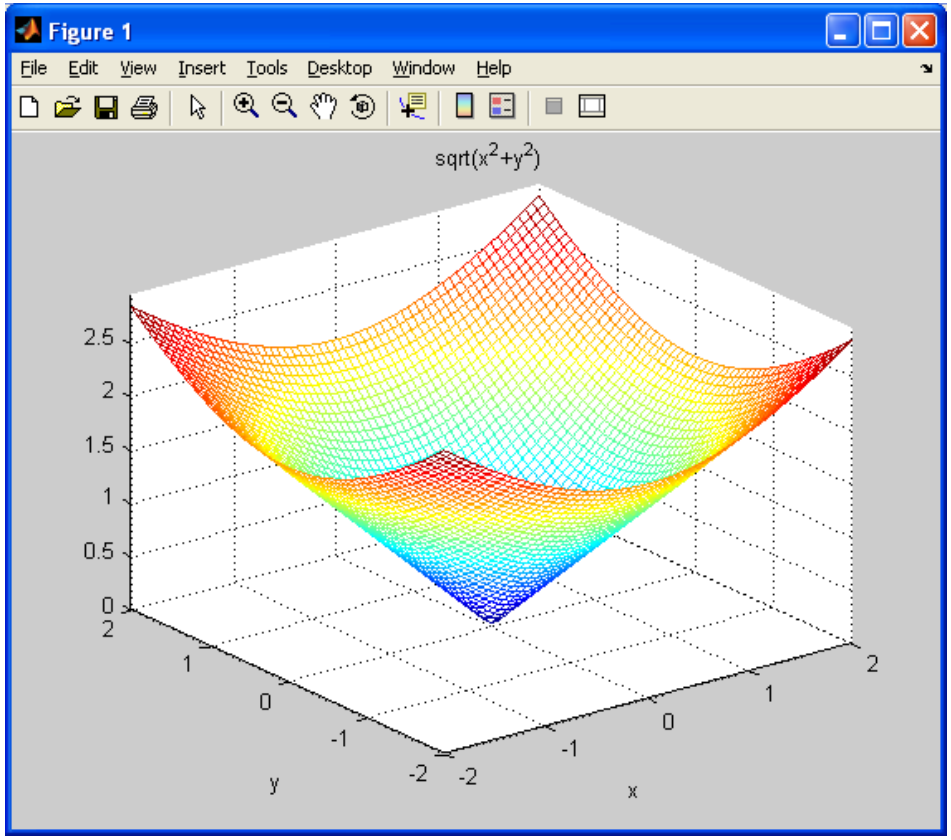
```
>> z(50,50)

ans =

      -4999
```



## EX

(2) $z = \sqrt{x^2 + y^2}$

```
>> z=@(x,y) sqrt(x.^2+y.^2);
>> ezmesh(z,[-2 2],[-2 2]);
```



## Visualisation options

Once the graph is obtained **the options related to the visualisation of the graph can be activated** and the tools of the graph-window can be used

- first **show plot tools** by activating View -> Palette, Browser, Editor
- click on the **surface** to modify its characteristic
- click on the **space** to modify the graph properties (such as title, labels, ticks and so on)

## EX 15

**Plot the graphs of the following functions (anonymous definition)**

(1) $z = \sqrt{|x|\,y^2} - |x|$ (use command ezsurf)

(2) $z = (xy)e^{x^2-y^2}$ (use command ezmesh)

Select a **suitable interval** for variables x and y

**Adjust the obtained graphs** by using the plot tools

# LEVEL CURVES

The level curves of function z=f(x,y) can be plotted with MatLab

## 1. Punctual definition

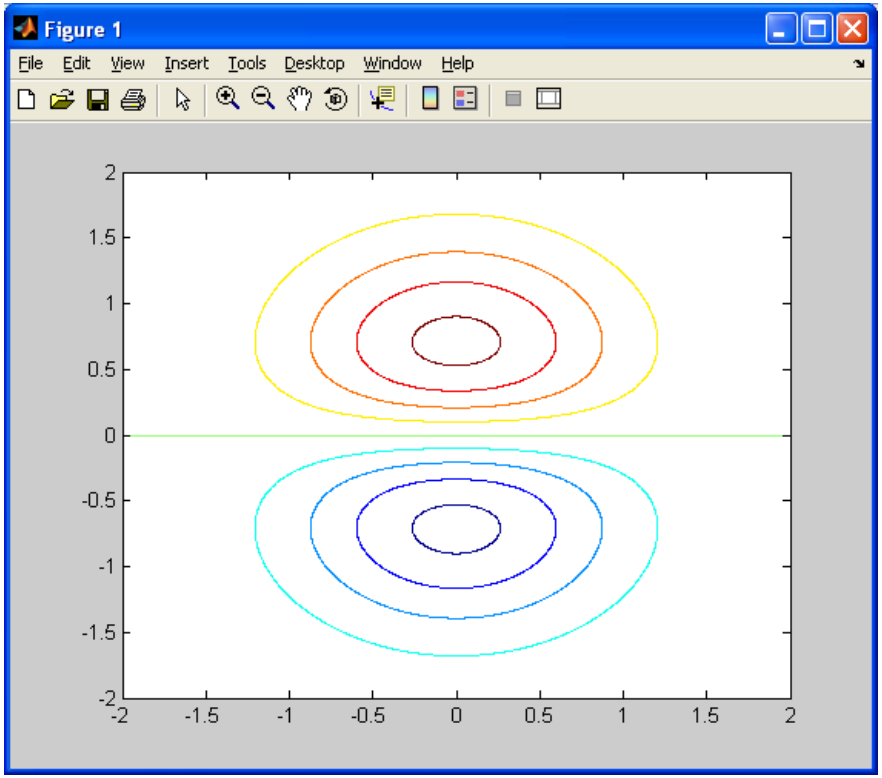
**Define the function by discretization and then use the command**

**contour(x,y,z) (or contourf(x,y,z)) to obtain the level curves**

## EX

$$(1) \quad z = ye^{-x^2-y^2}$$

```
>> x=linspace(-2,2,1000);
>> y=linspace(-2,2,1000);
>> [X Y]=meshgrid(x,y);
>> z=Y.*exp(-X.^2-Y.^2);
>> contour(x,y,z);
```



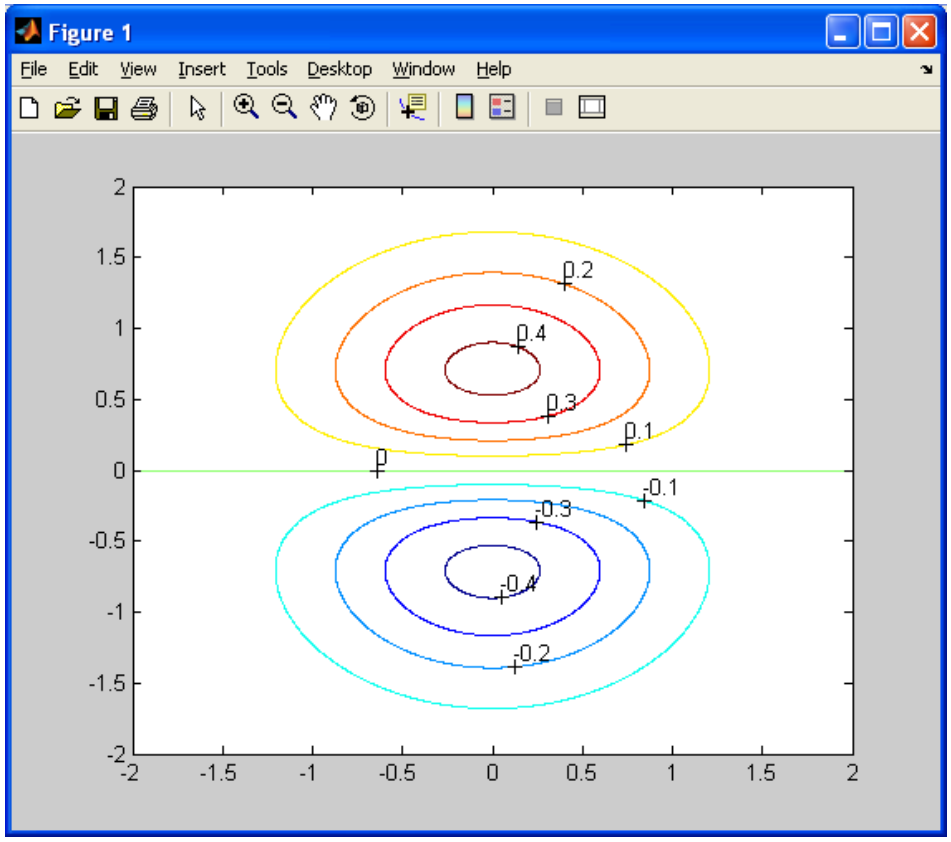
**Notice:** It is possible to add the z-value to each level curve

An output variable must be saved (for example c) while using the command contour:

**[c]=contour(x,y,z)**

With the instruction **clabel(c)** the z-value will be reported to each curve

```
>> [c]=contour(x,y,z);
>> clabel(c);
```



## EX 16

**Plot the level curves of the following functions (punctual definition); choose opportune intervals**

(1) $z = \dfrac{1}{x^2 + y^2 + 1}$ (use command contour)

(2) $z = |\sin(x) + \cos(y)|$ (use command contourf)

# LEVEL CURVES

## 2. Anonymous definition

Define the fuction as an anonymous function

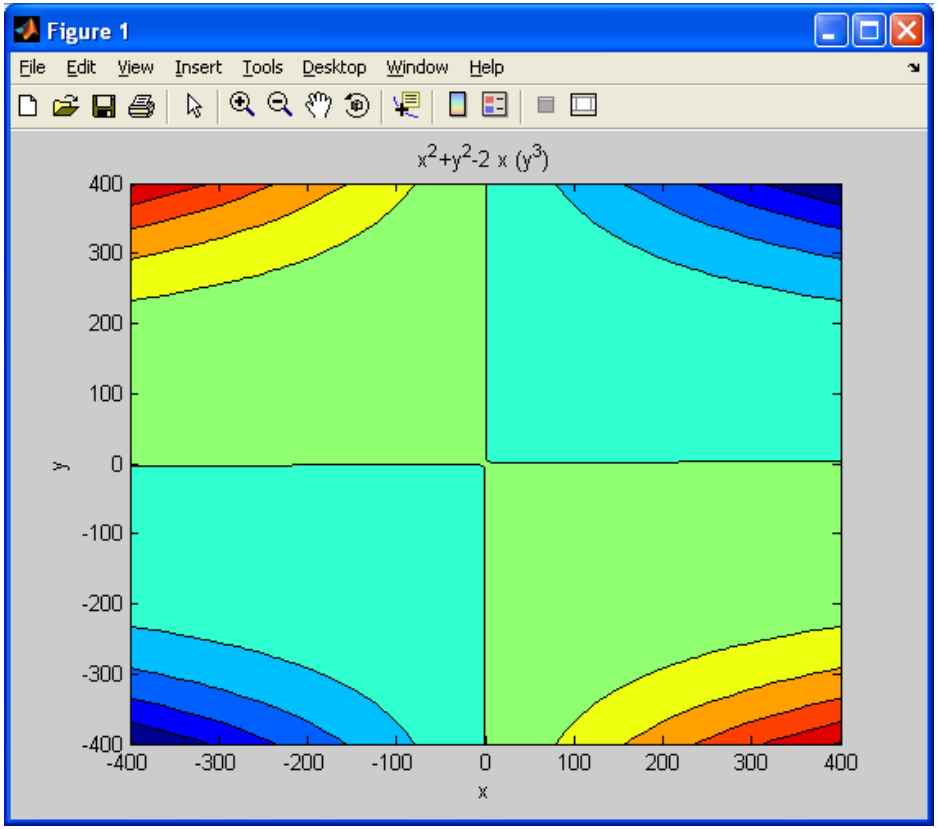
The command ezcontour(z,[x_min x_max],[y_min y_max])

(or ezcontourf(z,[x_min x_max],[y_min y_max])) must be used to plot the level curves

## EX

(2) $z = x^2 + y^2 - 2xy^3$

```
>> z=@(x,y) x.^2+y.^2-2*x.*(y.^3);
>> ezcontourf(z,[-400 400],[-400 400]);
```



## EX 17

Plot the level curves of the following functions by using the anonymous definition

$$(1)\quad z = \ln\left(\left|xy\right|\right) + \sqrt{x^2 + y^2}$$

$$(2)\quad z = x^2 + y^2 - 1$$

It is also possible to plot both the surface and the level curves in the 3D space

1. **Punctual definition**

   **Define the function and then use the commands surfc(x,y,z) (or meshc(x,y,z))**

2. **Anonymous definition**

   **Define the function and then use the commands**

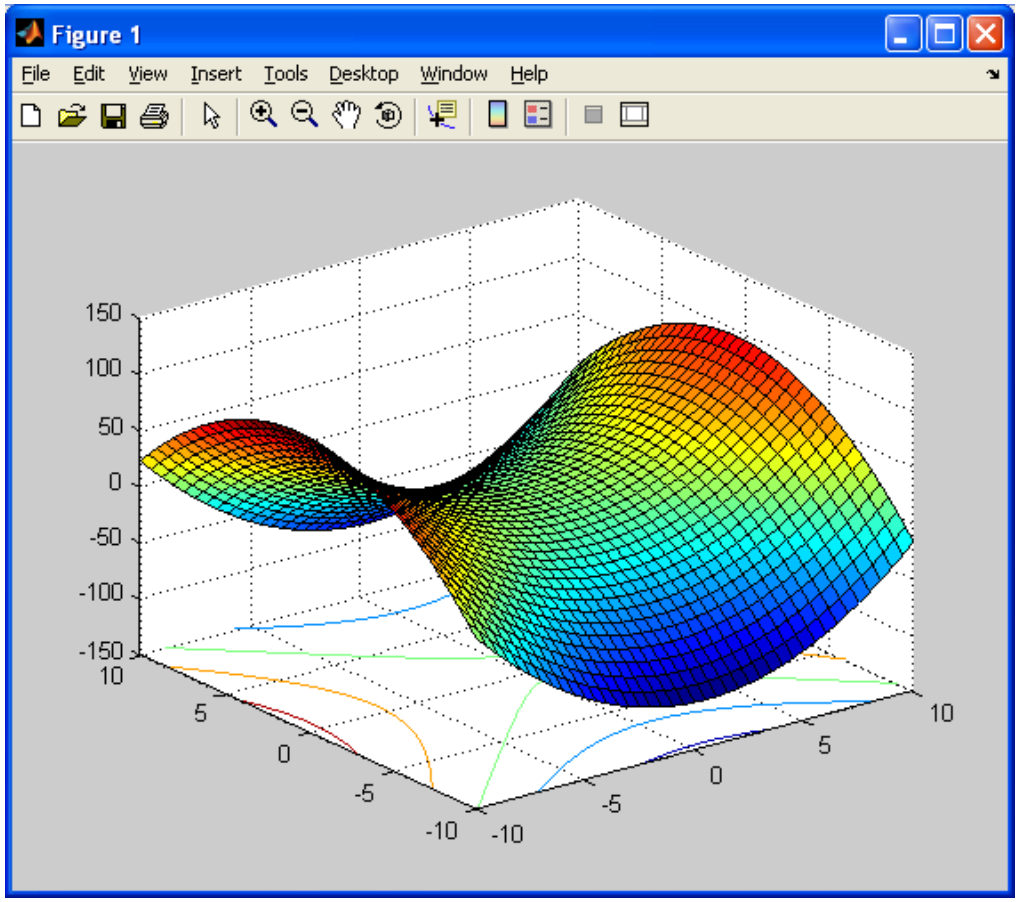
   **ezsurfc(z,[x_min x_max],[y_min y_max])**

   **(o ezmeshc(z,[x_min x_max],[y_min y_max]))**

## EX

(1) $z = x^2 - y^2 - x + 2 + y$

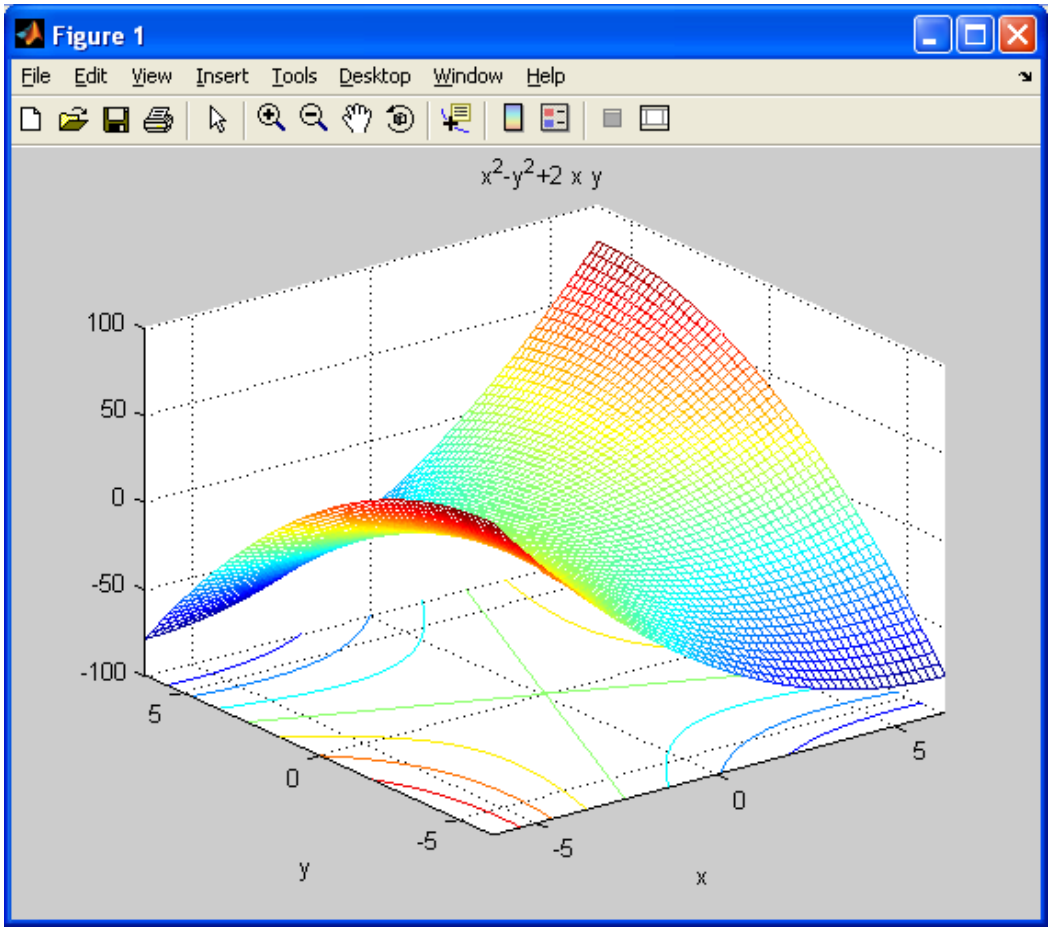
```
>> x=-10:0.5:10;
>> y=-10:0.5:10;
>> [X Y]=meshgrid(x,y);
>> z=X.^2-Y.^2-X+2+Y;
>> surfc(x,y,z);
```



## EX

(2) $z = x^2 - y^2 + 2xy$

```
>> z=@(x,y) x.^2-y.^2+2*x.*y;
>> ezmeshc(z);
```



## PLACE GRAPHS SIDE BY SIDE

It is also possible to plot two graphs side by side

Once a graph is obtained, by using the tool of the figure-window, it is possible to select the **new subplots** options


Then one of the plots can be selected: all the commands given in the command window will be applied to the selected plot. Change selection to apply command to a different plot

**Notice:** the command **axis square** can be used to obtain a square plot area

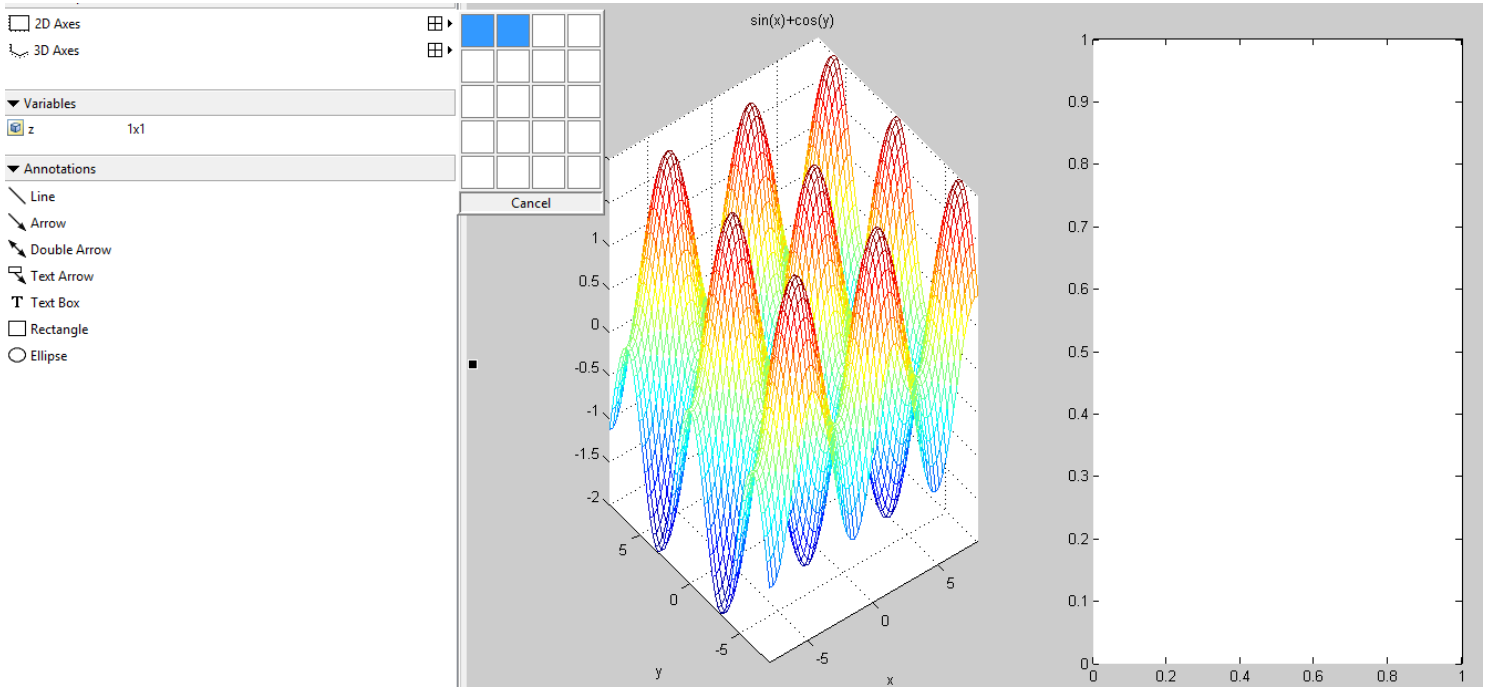
## EX

Plot the graph of the following function and put the level curves on the right hand side

$$z = \sin x + \cos y$$

1) Fristly plot the graph and then select a second subplot

```
>> z=@(x,y) sin(x)+cos(y);
>> ezmesh(z,[-8 8],[-8 8])
```



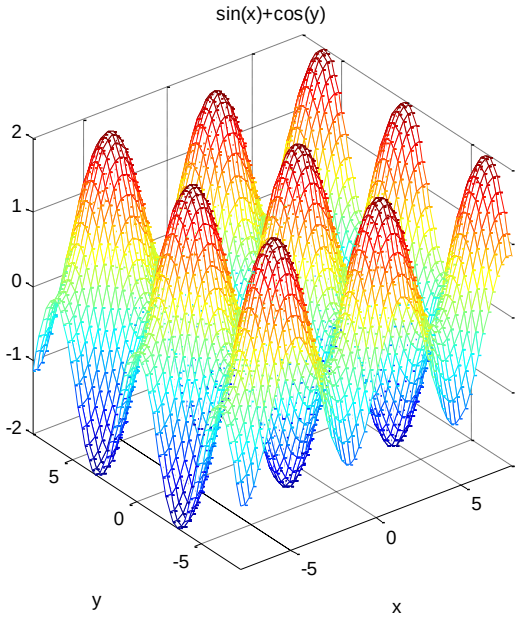
2) Select the second subplot and give instruction on the command window

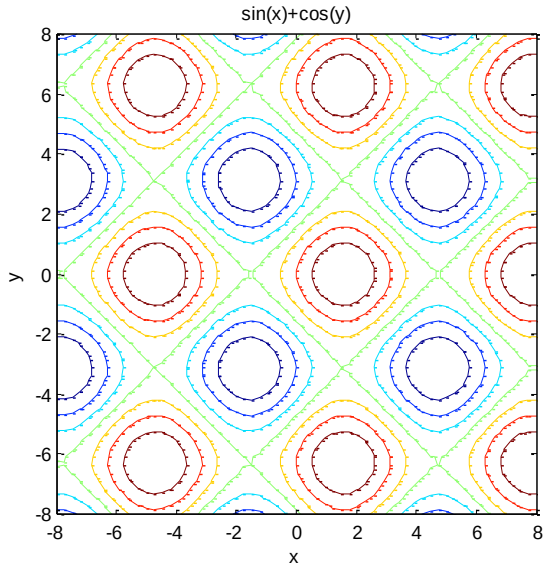
```
>> ezcontour(z,[-8 8],[-8 8])
```

Once obtained the second plot, select the first one and give command

```
>>axis square
```

And do the same with the second graph!




**Notice:** the figure **can be saved** in several formats, for instance jpg

## EX 17

Plot the graphs and the level curves (side by side) of the following functions

(1) $z = \sqrt{\left|x^2 - y^2\right|} + ye^{x^2+y^2}$ (use the anonymous definition)

(2) $z = x^2 + y^2 - xy$ (use the puntual definition)

## Homeworks

**1.9** Consider the following two functions

$$(1)\quad z = x^2 - y^2 - 5xy$$

$$(2)\quad z = \sqrt{x^2 + y^2 - 3}$$

- Calculate the value of z for x=12 and y=-2 for both functions
- Plot the graph of function (1) together with its level curves and then put on the right hand side the graph of function (2)
- Adjust the graph by using the plot tools and save the final figure in jpg format

**Notice that:** it is necessary to use the anonymous definition!

## Homeworks

**1.10** Consider the following function

$$z = \log|x^2 y|$$

- Plot the graph and then put the level curves on the right hand side by specifying the z values

**Notice that:** it is necessary to use the punctual definition!

# Homeworks

**1.11** Consider the following linear utility function

$$y = 0.5x_1 + 0.2x_2$$

- Plot the graph and then put the indifference curves on the right hand side

**Notice that:** (1) the indifference curves are the level curves; (2) being an economic function only not-negative values of x and y must be considered!

## Homeworks

**1.12** Consider the following CES production function

$$z = 2(3x^{-0.5} + 0.5y^{-0.5})^{-0.2}$$

- Plot the graph and then put the isoquants on the right hand side

**Notice that:** being an economic function only not-negative values of x and y must be considered!