

## 2D Graphics

One of Matlab's most powerful features is the ability to create graphic plots. There are so many methods of generating graphics in Matlab.

### 1. X-Y Plots

A Cartesian or  $x,y$  plot is based on plotting the  $x,y$  data pairs from the specified vectors. Clearly, **the vectors  $x$  and  $y$  must have the same number of elements**. Given a vector  $x$  of  $x$ -coordinates  $x_1$  through  $x_n$  and a vector  $y$  of  $y$ -coordinates  $y_1$  through  $y_n$ , `plot(x,y)` graphs the points  $(x_1,y_1)$  through  $(x_n,y_n)$ .

For example, to plot the two dimensions corresponding to  $(0,0)$ ,  $(1,1)$ ,  $(4,2)$ ,  $(5,-1)$  and  $(0,0)$  points .

```
x=[0 1 4 5 0]; y=[0 1 2 -1 0];
```

```
plot(x,y)
```

The command `plot(x,y)` opens a graphics window and draws an  $x-y$  plot of the elements of  $x$  versus the elements of  $y$ .

To plot the graph of  $y=x^3$  on the interval  $[-2,2]$ , first define a row vector whose components range from  $-2$  to  $2$  in increments of  $.05$ . Then define a vector  $y$ ; of the same size as  $x$  whose components are the cubes of the components of  $x$ . Finally use the `plot` function to display the graph.

```
x=-2:.05:2; y=x.^3;
```

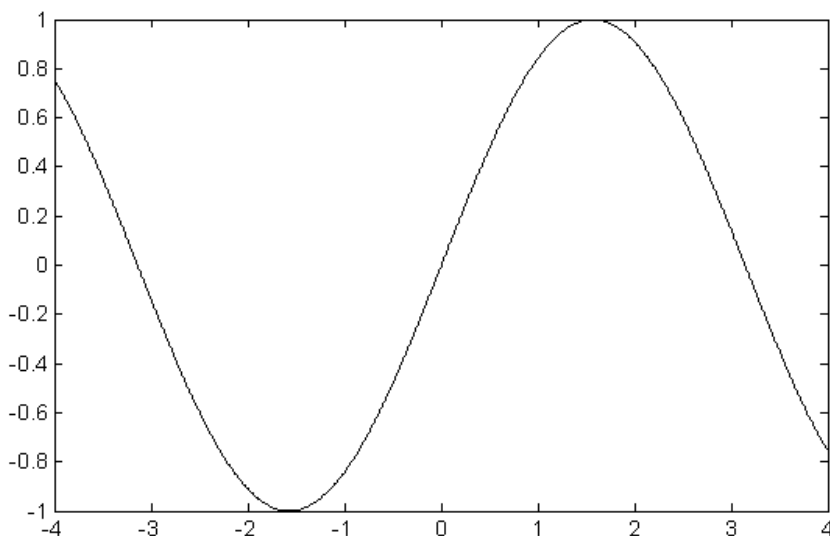
```
plot(x,y)
```

You can, also for example, draw the graph of the sine function over the interval  $-4$  to  $4$  with the following commands:

```
x = -4:.01:4; y = sin(x);
```

```
plot(x,y)
```

The resulting plot is shown in figure 1.

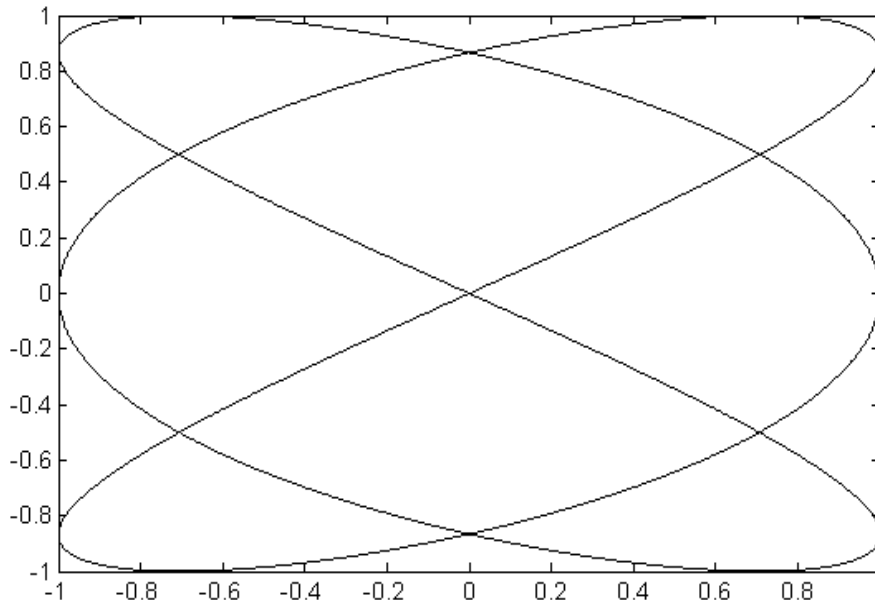


**Figure 1. Plotting sine over the interval -4 to 4**

Plots of parametrically defined curves can also be made. Try, for example,

```
t=0:.001:2*pi;  
x=cos(3*t);  
y=sin(2*t);  
plot(x,y)
```

The resulting plot is shown in figure 2.



**Figure 2. Plotting parametrically curves**

## **2. Grid**

A dotted grid may be added to the plot by:

```
grid on
```

This grid can be removed using grid off.

```
grid off
```

## **3. Controlling Axes**

Once a plot has been created in the graphics window you may wish to change the range of  $x$  and  $y$  values, this can be done by using the command “axis” as follows:

```
x =0:.01:1;  
y =sin(3*pi*x);  
plot(x,y)  
axis([-0.5 1.5 -1.2 1.2])
```

The axis command has four parameters, the first two are the minimum and maximum values of  $x$  to use on the axis and the last two are the minimum and maximum values of  $y$ .

## 4. Plotting Line Style

Matlab connects a line between the data pairs described by the vectors. You may wish to present data points and different type of connecting lines between these points. Data points can be described by a variety of characters such as ( . , + , \* , o and x ).

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>Character color</b>	<b>Character symbol</b>	<b>character line style</b>
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,'k+')` plots a black 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(x,y,'y-',x,y,'go')` plots the data twice, with a solid yellow line interpolating green circles at the data points.

## 5. Annotation

The last step before printing or saving a plot is usually to put a title and label the axes. You can put labels, titles, and text on a plot by using the commands:

`xlabel('text')`

`ylabel('text')`

`zlabel('text')`

`title('text')`

`text(x,y,'text')` places text at position x,y

`gtext('text')` use mouse to place text

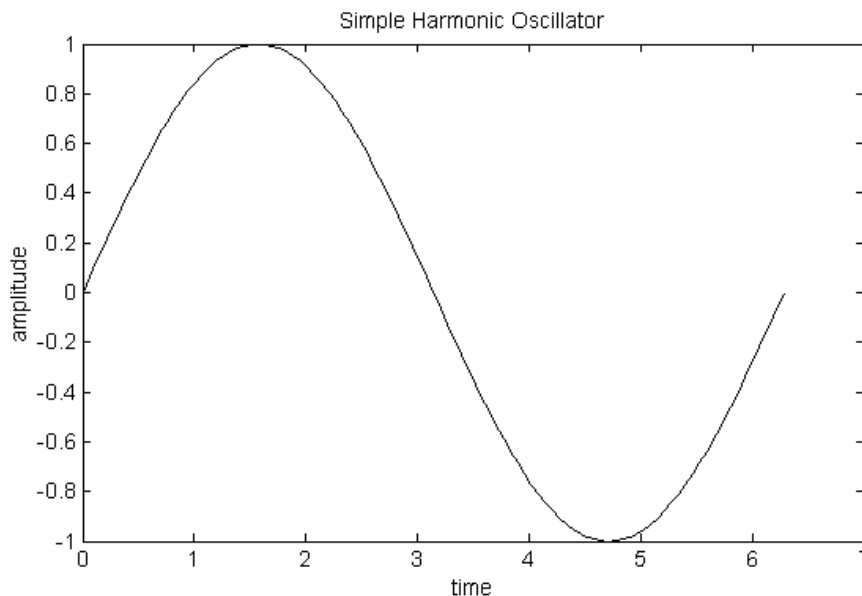
For example the graphs can be given titles, axes labeled, and text placed within the graph with the following commands;

```
t = 0:0.02*pi:2*pi;
```

```
plot(t,sin(t))
```

```
xlabel('time');ylabel('amplitude');title('Simple Harmonic Oscillator')
```

The resulting plot is shown in figure 3.



**Figure 3. Using annotation in plot**

## **6. Multi-plots**

There are two ways to make multiple plots on a single graph are illustrated by.

### **6.1 Multiple Data Vectors Plots**

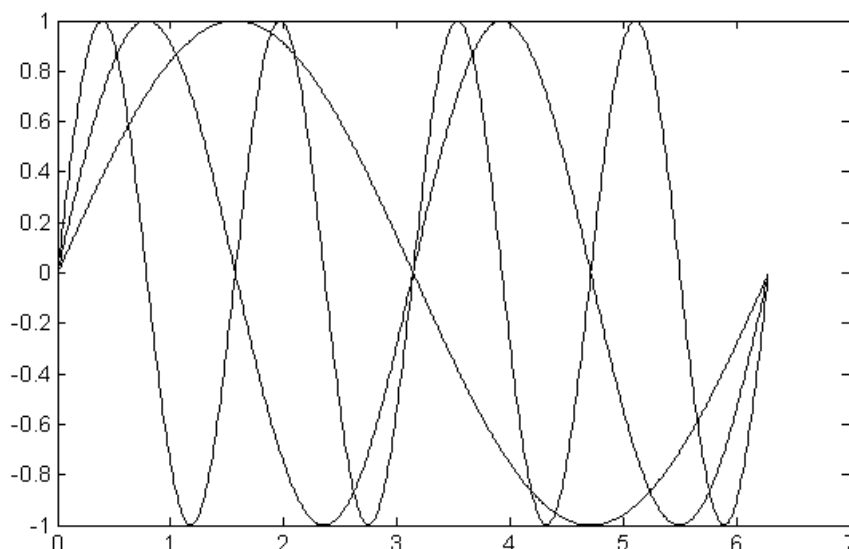
You can create multiple graphs by using multiple data vectors, for example:

```
x=0:.01:2*pi;
```

```
y1=sin(x);y2=sin(2*x);y3=sin(4*x);
```

```
plot(x,y1,x,y2,x,y3)
```

The re resulting plot is shown in figure 4.



**Figure 4. Multiple plots of sine vectors**

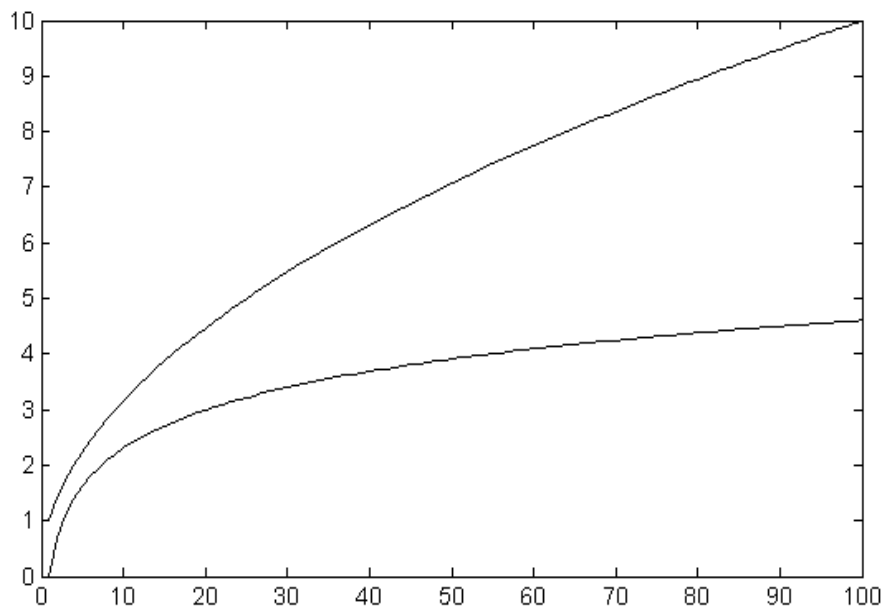
## **6.2 Multiple Plots with Hold**

Another way is with hold on. The command "hold on" holds the old graph when the new one is plotted. The axes may, however, become rescaled. "hold on" holds the current picture; "hold off" releases it (but does not clear the window).

Here is an example. Suppose we want to compare the log function with the square root function graphically. We can put them on the same plot. By default, both plots will appear in blue, so we will not know which log. We could make them different colors using options. Here is the final answer,

```
x=1:100;  
y=log(x);  
z=sqrt(x);  
plot(x,y,'r'); % plot log in red  
hold on;  
plot(x,z,'b'); % plot sqrt in blue  
hold off;
```

The resulting plot is shown in figure 5.



**Figure 5. Multiple plots with hold**

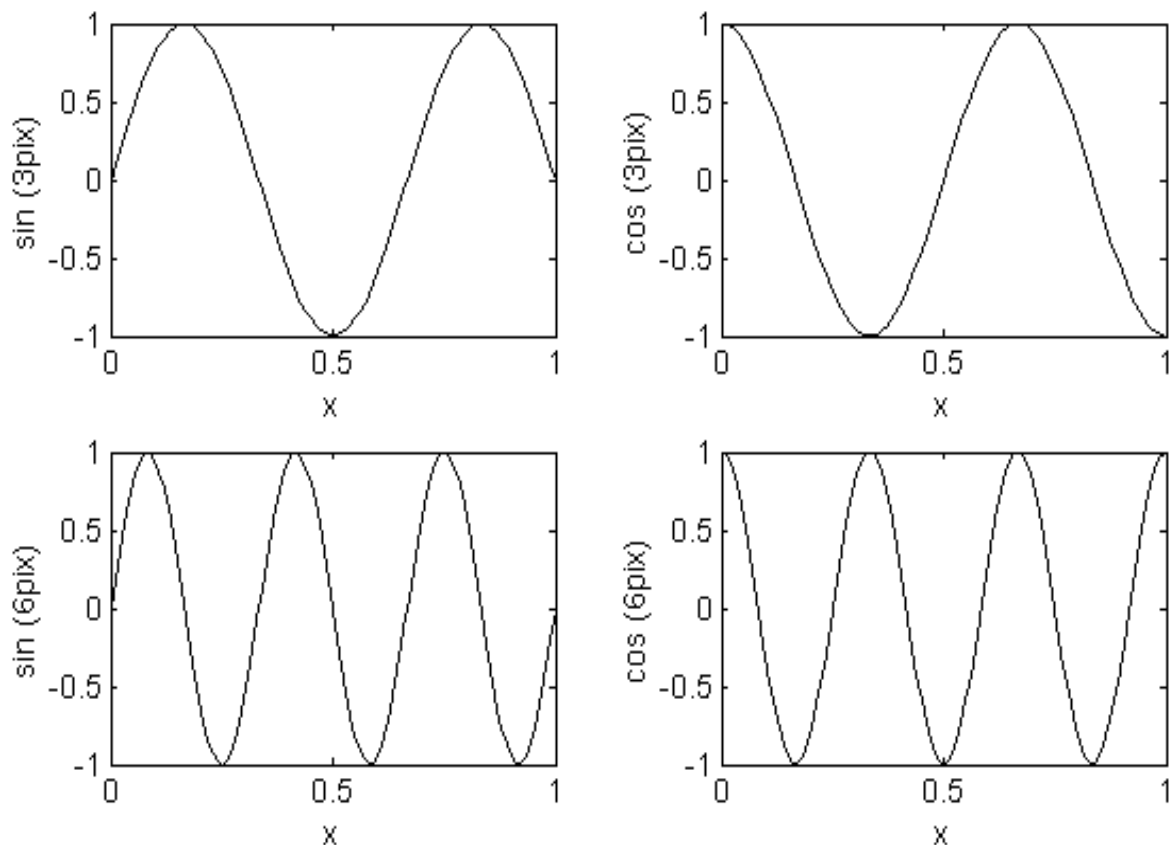
The "hold" command will remain active until you turn it off with the command 'hold off'.

## 7. Subplot

The graphics window may be split into an  $m$  by  $n$  array of smaller windows into which we may plot one or more graphs. The windows are numbered 1 to  $m$  by  $n$  row-wise, starting from the top left. All of plot properties such as hold and grid work on the current subplot individually.

```
x=0:.01:1;  
subplot(221), plot(x,sin(3*pi*x))  
xlabel('x'),ylabel('sin (3pix)')  
subplot(222), plot(x,cos(3*pi*x))  
xlabel('x'),ylabel('cos (3pix)')  
subplot(223), plot(x,sin(6*pi*x))  
xlabel('x'),ylabel('sin (6pix)')  
subplot(224), plot(x,cos(6*pi*x))  
xlabel('x'),ylabel('cos (6pix)')
```

The resulting plot is shown in figure 6.



**Figure 7. Using subplot**

Subplot(221) (or subplot(2,2,1)) specifies that the window should be split into a 2 by 2 array and we select the first sub-window.

### **Exercise 1:**

The laminar velocity profile in a pipe, can be given in equation  $V_x = V_{\max}(1 - (2*r/di)^2)$

Plot the velocity profile in a pipe? If you know that:s

r= distance from pipe center

di: Inner diameter of pipe (di=0.2 m)

$V_{\max}$ : maximum velocity in pipe ( $V_{\max}=2$  m)

#### Solution

Write the following code

```
di=.2; Vmax=2
```

```
r=-.1:.001:.1
```

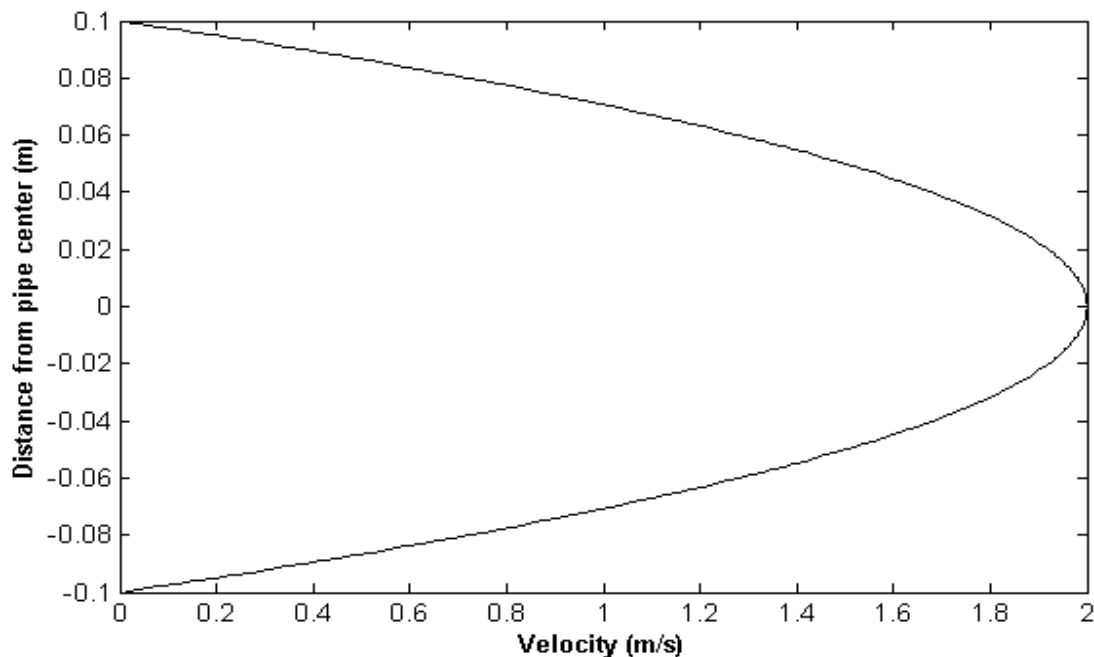
```
Vx=Vmax*(1-((2*r)/di).^2)
```

```
plot(Vx,r)
```

```
xlabel('Velocity (m/s)')
```

```
ylabel('Distance from pipe center (m)')
```

The result will be the figure.



### **Exercise 2:**

Plot k as a function of temperature from 373 to 600 k (use 50 point of Temperature).

If you know:

$$K = A \exp(B - (C/T) - \ln(D*T) - E*T + F*T^2)$$

Where

$$A = 3.33, B = 13.148, C = 5639.5, D = 1.077, E = 5.44 \times 10^{-4}, F = 1.125 \times 10^{-7}$$

#### Solution:

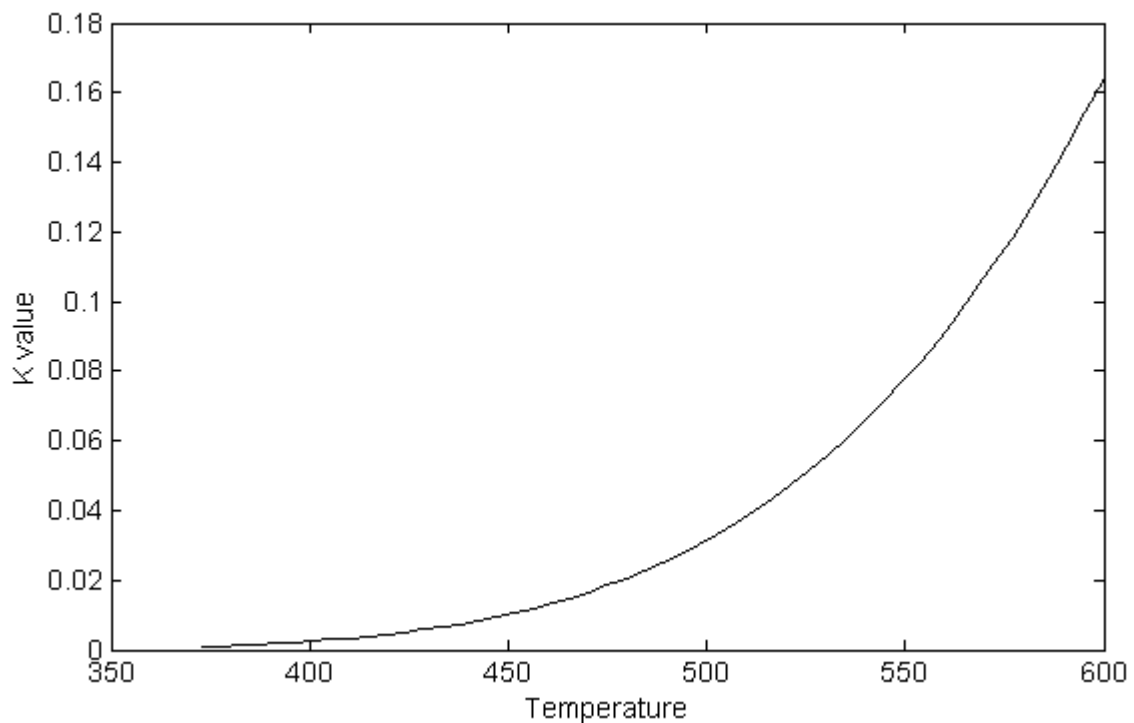
Write the following code

```

A=3.33;
B=13.148;
C=5639.5;
D=1.077;
E=5.44e-4;
F=1.125e-7;
Ts=(600-373)/49;%Ts means temperature increment
T=373:Ts:600
K=A*exp(B-(C./T)-log(D*T)-E*T+F*T.^2)
plot(T,K)
xlabel('Temperature')
ylabel('K value')

```

The result will be the figure.



### **Exercise 3:**

Plot Txy diagram for ethanol/water system. Knowing that the vapor pressures for three components are calculated by:

**Ethanol**      $P^{\circ}_e = \exp(18.5242 - 3578.91 / (T - 50.5))$

**Water**         $P^{\circ}_w = \exp(18.3036 - 3816.44 / (T - 46.13))$

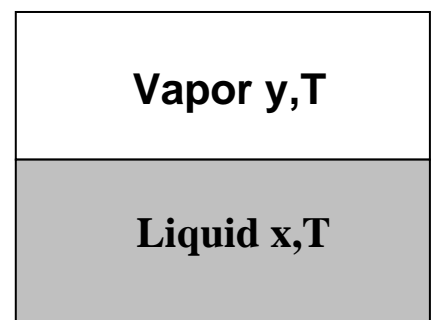
Where

$$K_i = P^{\circ}_i / P_t$$

$$P_t = 760$$

$$y_i = K_i \times x_i$$

At Bubble point  $\sum y_i = \sum K_i \times x_i = 1$





Solution:

**Xe=0:.1:1;**

**Xw=1-Xe;**

**for m=1:11**

**for T=273.15:.01:450;**

**Pe=exp(18.5242-3578.91/(T-50.5)); % Vapor pressure of Ethanol**

**Pw=exp(18.3036-3816.44/(T-46.13)); % Vapor pressure of Water**

**Ke=Pe/760; % Ethanol**

**Kw=Pw/760; % Water**

**sum=Ke\*Xe(m)+Kw\*Xw(m);**

**if sum>1**

**break**

**end**

**end**

**Temp(m)=T;**

**ye(m)=Ke\*Xe(m);**

**end**

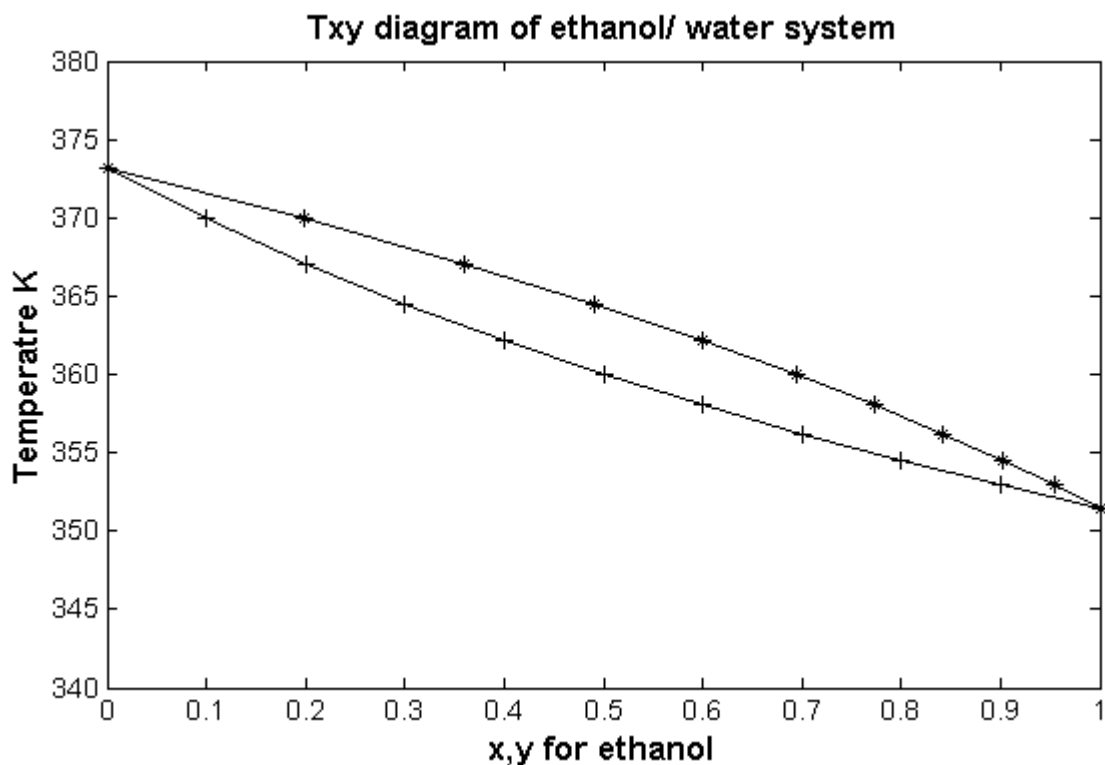
**plot(Xe,Temp,'k-+',ye,Temp,'k-\*')**

**axis ([0 1 340 380])**

**xlabel('x,y for ethanol')**

**ylabel('Temperatre K')**

**title('Txy diagram of ethanol/ water system')**



## Practice Problems

1) The heat capacity for a mixture of ethanol and water is given as follows:

$$Cp_m = x Cp_E(T) + (1-x) Cp_w(T)$$

where  $x$  is the mole fraction of ethanol. The pure component heat capacities can be computed using the following correlation:

$$Cp(T) = a + bT + cT^2 + dT^3$$

where  $T$  in degree Kelvin and  $Cp$  in J/(mole K)

Draw a plot for  $Cp_E$ ,  $Cp_w$  and  $Cp_m$  covering mole fraction range of 0-1 for  $T=100$  degree Kelvin. Knowing that:

Ethanol:  $a = -3.25137e+2$   $b = 4.13787e+0$   $c = -1.40307e-2$   $d = 1.70354e-5$

Water:  $a = 1.82964e+1$   $b = 4.72118e-1$   $c = -1.33878e-3$   $d = 1.31424e-6$

2) Plot the log of the values from 1 to 100.

3) Plot the parametric curve  $x = t \cos(t)$ ,  $y = t \sin(t)$  for  $0 < t < 10$ .

4) Plot the cubic curve  $y = x^3$ . Label the axis and put a title "a cubic curve" on the top of the graph.

5) Plot  $y=(x^3+x+1)/x$ , for  $-4 < x < 4$  and  $-10 < y < 10$ .

6) Plot  $y=\ln(x+1)$  and  $y=1-x^2$  on the same window for  $-2 < x < 6$  and  $-4 < y < 4$ .

7) Plot  $\cos(x^2 + 1)$  on  $[-2\pi, 2\pi]$ .