1. Arrays transpose operation

The transpose operation interchanges the rows by columns in a given array and vise versa. In mathematics, we denote this operation by the super script T. In MATLAB, the single quote (') symbol represents the transpose operation.

Example: Find $B = A^T$ if $A = \begin{bmatrix} -2 & 6 \\ -3 & 5 \end{bmatrix}$.

MATLAB session:

```
>> A=[-2 6;-3 5]
A =
    -2     6
    -3     5
>> B=A'
B =
    -2    -3
     6     5
```

You can create column vectors simply by entering there elements as a row vector. Then, take the transpose of the entered row vector or vise versa. For example, you can create the column vector c as follows:

```
>> c=[5 6 7]'
c=
     5
     6
     7
```

2. Arrays element by element operations

In these operations, the addition, subtraction, multiplication, division, and exponentiation will be performed on all elements of the array as shown in the following table:

Symbol	Operation	Form	Example
+	Scalar-array addition	A+B	[6 3]+2=[8 5]
-	Scalar-array subtraction	A-B	[6 3]-2=[4 1]
+	Array-array addition	A+B	[6 5]+[4 8]=[10 13]
-	Array-array subtraction	A-B	[6 5]-[4 8]=[2 -3]
.*	Array element by element multiplication	A.*B	[3 5].*[4 8]=[12 40]
./	Array element by element right division	A./B	[4 8]./[2 2]=[2 4]
.\	Array element by element left division	A.\B	[4 8].\[2 2]=[0.5 0.25]
.^	Array element by element exponentiation	A.^B	[3 2].^2=[9 4] [3 2].^[2 4]=[9 16] 2.^[3 2]=[8 4]

Example 1: Find the value of u and w from the following:

$$u = g - 2 \quad \text{and} \quad w = 2g - 1 \quad \text{if } g = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

MATLAB session:

```
>> g=[1:3;4:6;7:9];
>> u=g-2
u =
    -1     0     1
     2     3     4
     5     6     7
```

```
>> w=2*g-1
w =
     1     3     5
     7     9    11
    13    15    17
```

Example 2: The following table gives data for the distance traveled along five truck routes and the corresponding time required to traverse each route. Compute the average speed of each truck.

Distance (mile)	560	440	490	530	370
Time (hr)	10.3	8.2	9.1	10.1	7.5

MATLAB session:

```
>> d=[560 440 490 530 370];
>> t=[10.3 8.2 9.1 10.1 7.5];
>> speed=d./t
speed =
   54.3689   53.6585   53.8462   52.4752   49.3333
```

Example 3: The current passing through an electrical resistor having a voltage V across it is given by ohm's law: $i = V/R$, where R is the resistance. The power dissipated in the resistor is given by: $P = V^2/R$. Use the following data to compute (a) the current, (b) the power dissipated in each resistor.

R (ohm)	10^4	$2\text{x}10^4$	$3.5\text{x}10^4$	10^5	$2\text{x}10^5$
V (volt)	120	80	110	200	350

MATLAB session:

```
>> R=[1e4 2e4 3.5e4 1e5 2e5];
>> V=[120 80 110 200 350];
>> current=V./R
current =
    0.0120    0.0040    0.0031    0.0020    0.0018
>> power=V.^2./R
power =
    1.4400    0.3200    0.3457    0.4000    0.6125
```

Example 4: The radioactive element polonium has a half-life of 140 days. Starting with 10 grams of plutonium today, how much is left at the end of every week for 10 weeks. The amount remaining is given by: $amount\ remaining = initial\ \ amount(0.5)^{time\,/\,half\ life}$.

MATLAB session:

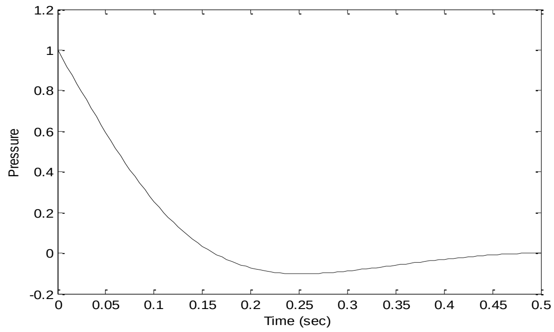
```
>> initial_amount=10;
>> half_life=140/7; % convert to weeks
>> time=[1:10];
>> amount_remaining=initial_amount*0.5.^(time/half_life)
amount_remaining =
    9.6594    9.3303    9.0125    8.7055    8.4090    8.1225    7.8458    7.5786    7.3204    7.0711
```

Example 5: The following equation describes the blood pressure in the aorta during the period following the closure of the heart's aortic valve. Plot the model for $0 \le t \le 0.5$ seconds.

$$P = e^{-8t}\sin\left(9.7t + \frac{\pi}{2}\right)$$

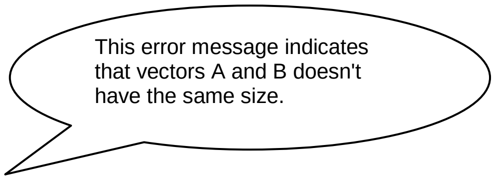
MATLAB session:

```
>> t=[0:0.005:0.5];
>> P=exp(-8*t).*sin(9.7*t+pi/2);
>> plot(t,P)
>> xlabel('Time (sec)')
>> ylabel('Pressure')
```



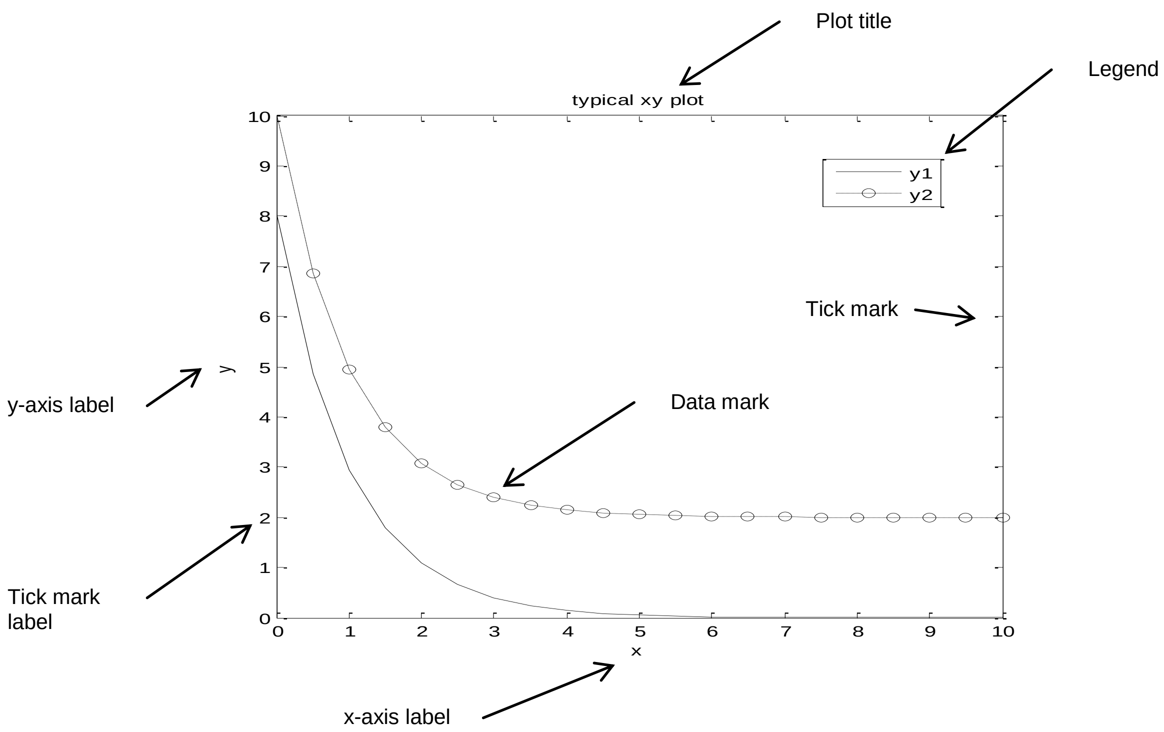
Array-array element by element operations require that the two arrays have identical size and shape. Otherwise MATLAB will display an error message indicating that the array doesn't have the same dimensions. For example:

```
>> A=[1:3]
A =
     1     2     3
>> B=[1:4]
B =
     1     2     3     4
>> A.*B
??? Error using ==> times
Matrix dimensions must agree.
```



3. XY plotting in MATLAB

MATLAB uses the plot command to plot curves into separate windows called *the figure window*. Figure windows have numbers like 1, 2, 3, etc. By default, MATLAB plots on figure window No.1 unless you change the figure number. The anatomy and nomenclature of a typical xy plot is shown below:



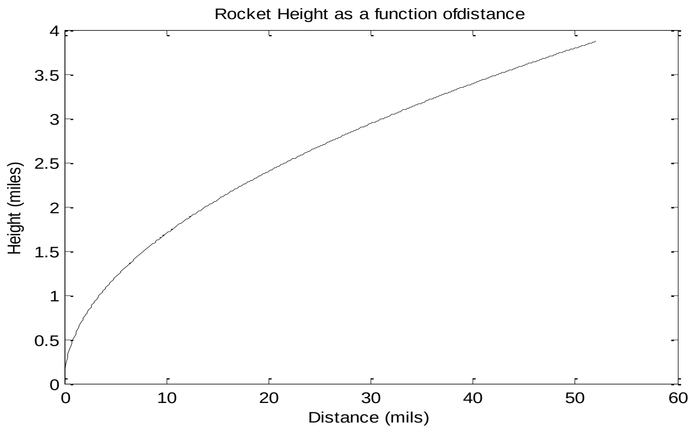
3.1 plot, label, and title commands

If x and y are vectors, then a single curve is plotted using the **plot(x,y)** command. The **xlabel** and **ylabel** commands put labels on the x-axis and y-axis respectively. The **title** command adds a title on the top of the plot area.

Example 1: Plot the function $y = 0.4\sqrt{1.8x}$ for $0 \le x \le 52$ where y represents the height of the rocket after launching (in miles) and x is the horizontal distance traveled (in miles).

MATLAB session:

```
>> x=[0:0.1:52];
>> y=0.4*sqrt(1.8*x);
>> plot(x,y)
>> xlabel('Distance (mils)')
>> ylabel('Height (miles)')
>> title('Rocket Height as a function of distance')
```



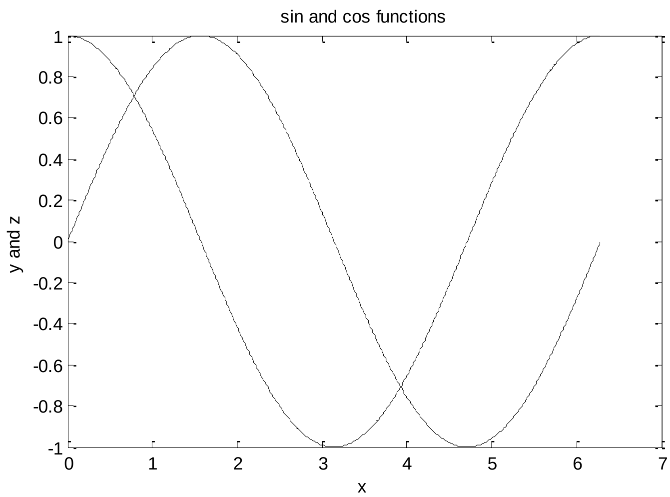
3.2 Data markers and line types

Suppose that you have two curves or data sets stored in the vectors x, y, u, and v. To plot x versus y and u versus v on the same plot, type **plot(x,y,u,v)**.

Example 2: Plot $y = \sin(x)$ and $z = \cos(x)$ for $0 \le x \le 2\pi$.

MATLAB session:

```
>> x=[0:0.1:2*pi];
>> y=sin(x);
>> z=cos(x);
>> plot(x,y,x,z)
>> xlabel('x')
>> ylabel('y and z')
>> title('sin and cos functions')
```



You can use the same fashion to plot more curves on the same plot:

`plot(x1,y1,x2,y2,x3,y3, …)`

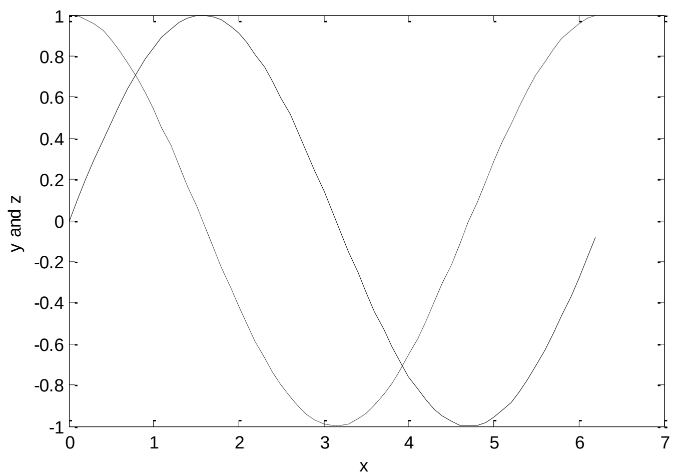
Note that both curves were plotted with a solid line. To distinguish between them, you can plot them with different data markers, line types, and colors. To do this, you should type the symbols shown below between single quotes after entering each data set.

Data marker		Line types		Color	
Dot (.)	`.`	Solid line	`-`	Black	`k`
Cross (x)	`X`	Dashed line	`--`	Blue	`b`
Plus sign (+)	`+`	Dash-dotted line	`-.`	Cyan	`c`
Square (□)	`s`	Dotted line	`:`	Magenta	`m`
Diamond (◊)	`d`			Red	`r`
Asterisk (*)	`*`			Yellow	`y`
Circle(o)	`o`				

Example 3: Plot the cos curve in the previous example as a dashed line.

<u>MATLAB session:</u>

```
>> x=[0:0.1:2*pi];
>> y=sin(x);
>> z=cos(x);
>> plot(x,y,x,z,'—')
>> xlabel('x')
>> ylabel('y and z')
```

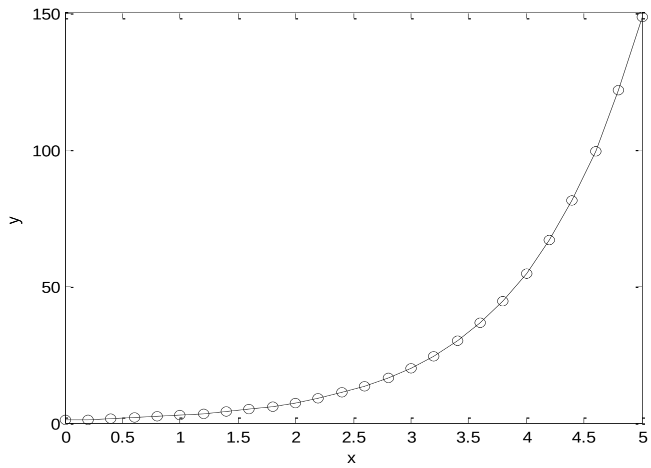


Example 4: Plot $y = e^x$ for $0 \le x \le 5$ using: circles as data markers, solid line, and black color.

<u>MATLAB session:</u>

```
>> x=[0:0.2:5];
>> y=exp(x);
>> plot(x,y,'o-k')
>> xlabel('x')
>> ylabel('y')
```

Use the **`ginput(n)`** command (n represent the figure No.) to get the value of x and y graphically for any point on the curve.



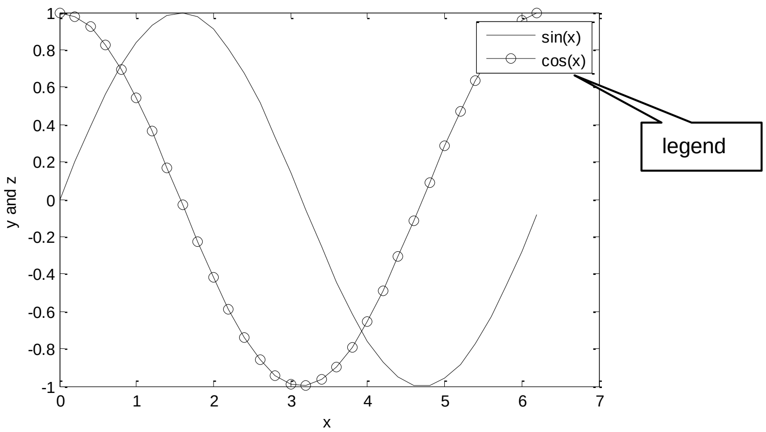
3.3 Labeling curves

If you use different data labels or markers and line types, then you must provide a legend. The basic form of this command is: **`legend('string1','string2',…)`** where string1 and string2 are text strings of your choice for labeling curve1, curve2, etc.

Example 5: Plot the sin and cos functions given an example 2. Decide how best to plot and label them to avoid confusion.

<u>MATLAB session:</u>

```
>> x=[0:0.2:2*pi];
>> y=sin(x);
>> z=cos(x);
>> plot(x,y,x,z,'o-k')
>> xlabel('x')
>> ylabel('y and z')
>> legend('sin(x)','cos(x)')
```



3.4 Obtaining the coordinates of a point

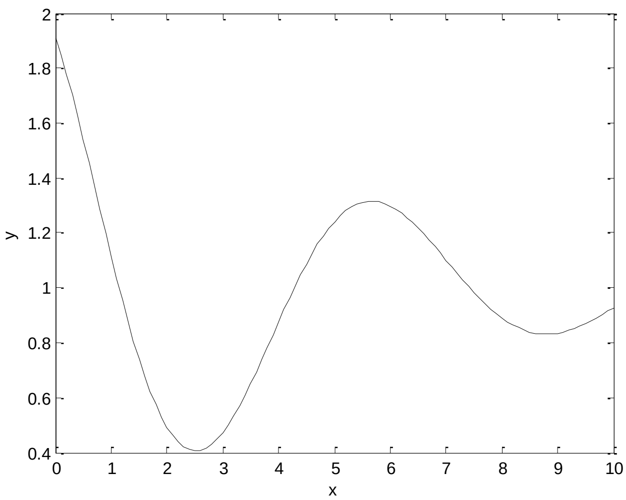
Some times it is useful or necessary to obtain the coordinates of a point on a curve graphically. The function `ginput` can be used for this purpose. Place it at the end of all the plot and the plot formatting statements, so that the plot will be in its final form. The command: `[x y]=ginput(n)` gets n points form the current plot and returns the x and y coordinates in the vectors x and y, which have a length n. To do this, position the cursor using a mouse and press the mouse button to get the coordinates on the plot.

Example 6: The function $y = 1 + e^{-0.2x}\sin(x+2)$ has two minimum points in the interval 0<x<10. Find the value of x and y at each minimum graphically.

<u>MATLAB session:</u>

```
>>clear
>>x=[0:0.1:10];
>>y=1+exp(-0.2*x).*sin(x+2);
>>plot(x,y)
>>xlabel('x')
>>ylabel('y')
>>[xm ym]=ginput(2)

xm =
       2.5461
       8.7903
ym =
      0.40702
       0.8327
```



PROBLEMS

1. Consider the following arrays

$$A = \begin{bmatrix} 1 & 4 & 2 \\ 2 & 4 & 100 \\ 7 & 9 & 7 \\ 3 & \pi & 42 \end{bmatrix} \qquad B = \ln(A)$$

Write MATLAB expressions to do the following:

a. Multiply the second column of B and the first column of A.

b. Evaluate the maximum value in the vector resulting from element by element multiplication of the second column of B with the first column of A.

c. Evaluate the sum of the first row of A divided element-by-element by the first three elements of the third column of B.

2. Write MATLAB assignment for each of the following functions, assuming that w, x, y, and z are vector quantities of equal length, and that c and d are scalars.

$$f = \frac{1}{\sqrt{\frac{2\pi c}{x}}} \qquad E = \frac{x + \frac{w}{y+z}}{x + \frac{w}{y-z}} \qquad A = \frac{e^{-c/(2x)}}{(\text{iny})\sqrt{dz}} \qquad S = \frac{x(2.15 + 0.35y)^{1.8}}{z(1-x)^{y}}$$

3. The mechanical work W done in using a force F to push a block through a distance D is W=FD. The following table gives data on the amount of force used to push a block through the given distance over five segments of a certain path. Use MATLAB to find (a) the work done on each segment of the path and (b) the total work done over the entire path.

	Path segment				
	1	2	3	4	5
Force (N)	400	550	700	500	600
Distance (m)	2	0.5	0.75	1.5	3

4. The potential energy stored in a spring is $kx^2/2$, where k is the spring constant and x is the compression in the spring. The force required to compress the spring is kx. The following table gives the data for five springs. Use MATLAB to find (a) the compression x in each spring and (b) the potential energy stored in each spring.

	Spring				
	1	2	3	4	5
Force (N)	11	7	8	10	9
Spring constant k (N/m)	1000	800	900	1200	700

5. Plot the following functions on the same plot for the period 0≤t≤10. Because they are similar, decide how best to plot and label them to avoid confusion.

$$x(t) = 10e^{-0.5t}\sin(3t+2)$$
$$y(t) = 7e^{-0.4t}\cos(5t-3)$$

6. The useful life of a machine depends on its operating temperature, as the following table shows. The functional description of the machine life is given by $y = 141860e^{-0.016T}$ where T is the machine temperature. Plot the function and the data on the same plot.

Temperature (°F)	100	120	140	160	180	200	220
Life (hrs)	28000	21000	15000	11000	8000	6000	4000

7. A water tank consists of a cylindrical part of radius r and height h, and a hemispherical top. The tank is to be constructed to hold 500 m^3 of liquid when filled. The surface area of the cylindrical part is 2πrh, and its volume is πr2h, The surface area of the hemispherical top is given by 2πr^2, and its volume is given by 2πr^3/3. The cost to construct the cylindrical part of the tank is $300 per square meter of surface area; the hemispherical part costs $400 per square meter. Plot the cost versus r from 2≤r≤10 meters, and determine graphically the radius that results in the least cost. Compute the corresponding height h.

8. A particular batch distillation unit is charged initially with 100 mol of a 60% mol benzene and 40% mol toluene mixture. Let L (mol) be the amount of liquid remaining in the still, and let x be the benzene mole fraction in the remaining liquid. It is found that:

$$L = 100\left(\frac{x}{0.6}\right)^{0.625}\left(\frac{1-x}{0.4}\right)^{-1.625}$$

Use a plot of L versus x to finds graphically what mole fraction of benzene will be when L=70 mol.