EP145 Introduction to Engineering

Topic 4

Use of Spreadsheets, GNUplot and Octave

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Introduction

In this chapter, we will discuss the basic use of:

1. **Electronic Spreadsheets**
2. **GNUplot**
3. **GNU Octave**

1. Electronic Spreadsheets

- A spreadsheet is the computer equivalent of a paper ledger sheet.
- It consists of a grid made from columns and rows. It is an environment that can make number manipulation easy and somewhat painless.

	paper ledger	
	car loan	$12,000
	interest	9.6%
	# of payments	60
	monthly payment	$252.61

	A	B	C
1		computer ledger	
2			
3		car loan	$12,000.00
4		interest	9.60%
5		# of payments	60
6			
7		Monthly Pmt.	$252.61

- Electronic spreadsheets can be used to solve an engineering problem.

Arithmetic Operators in Excel

+	Addition	2 + 3 = 5
–	Subtraction	2 – 3 = – 1
*	Multiplication	2 * 3 = 6
/	Right division	2 / 3 = 0.6666
^	Exponention (x^y)	2 ^ 3 = 8

Some Excel Functions

Function name

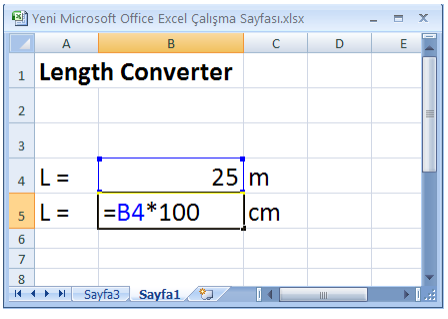
English	Turkish	Description	Example
`SUM(range)`	`TOPLA(aralık)`	sum of values	=SUM(A1:B5)
`AVERAGE(range)`	`ORTALAMA(aralık)`	mean of values	=AVERAGE(A1:B5)
`COUNT(range)`	`BAĞ_DEĞ_SAY(aralık)`	count values	=COUNT(F7:F11)
`MAX(range)`	`MAK(aralık)`	maximum value	=MAX(F7:F11)
`MIN(range)`	`MİN(aralık)`	minimum value	=MIN(F7:F11)
`STDEV(range)`	`STD_SAP(aralık)`	standard deviation	=STDEV(F7:F11)
`SIN()`	`SİN()`	sinus	=SIN(0.1)
`COS()`	`COS()`	cosinus	=COS(0.1)
`TAN()`	`TAN()`	tangent	=TAN(0.1)
`SQRT()`	`KARE_KÖK()`	square root	=SQRT(0.1)
`IF()`	`EĞER()`	if-else stucture	=IF(A1>10; ”yes”; “no”)

Note that

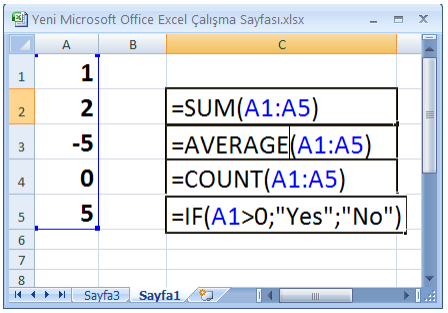
The argument of the trigonometric functions is in radian.

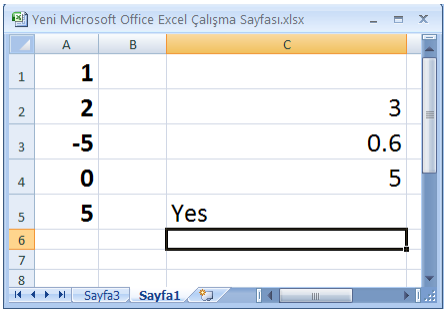
SIN(30) returns sinus of 30 radians!

EXAMPLE 1

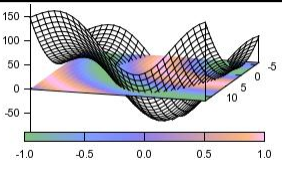


EXAMPLE 2



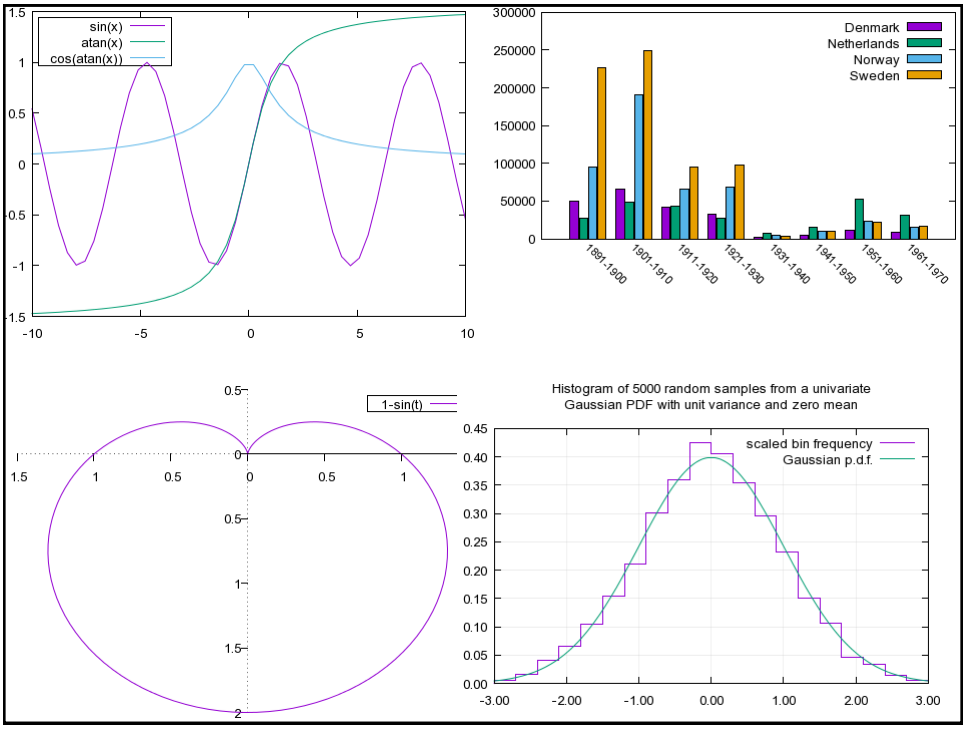


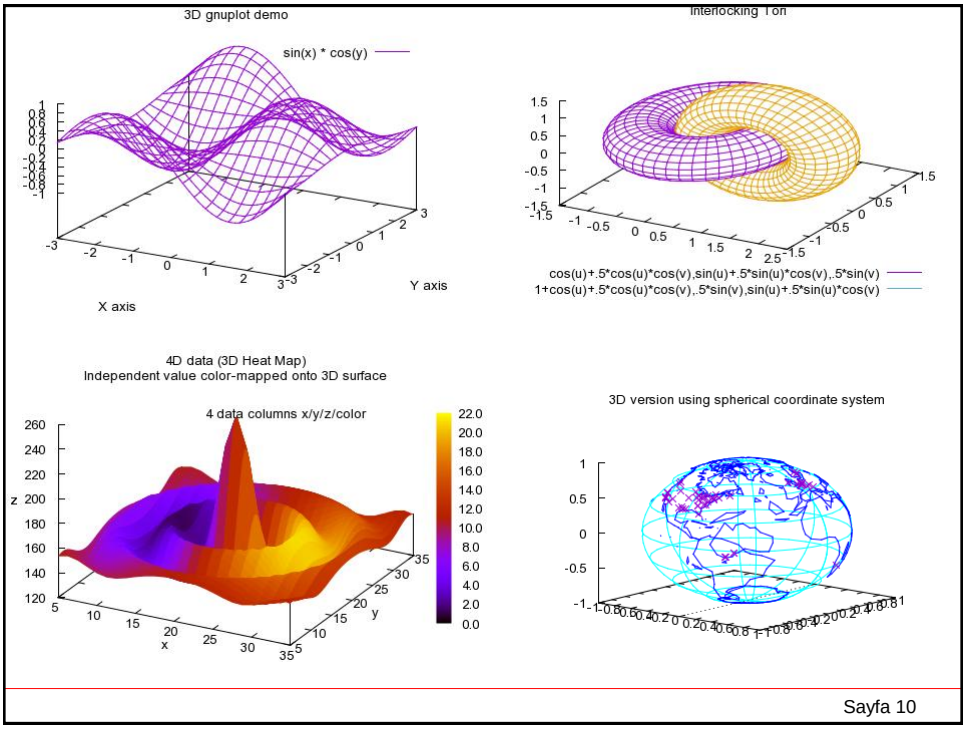
2. GNUplot



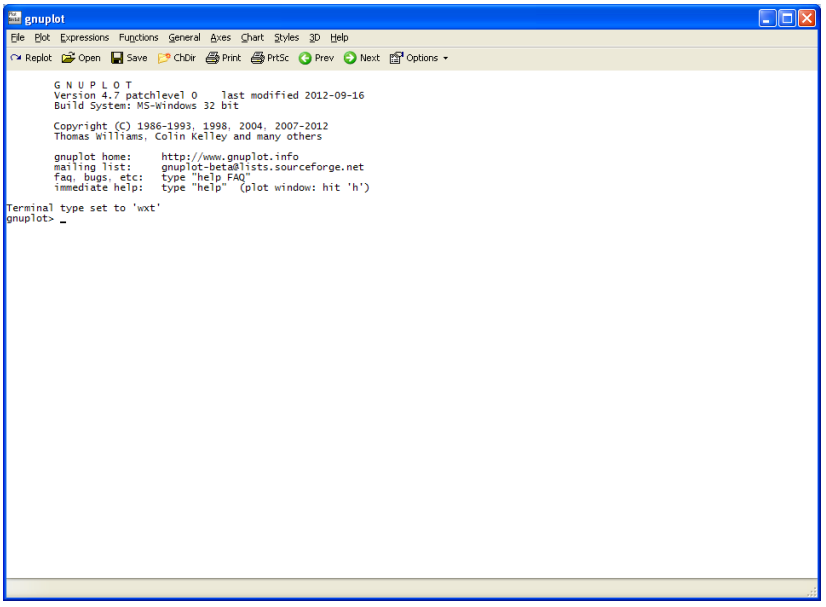
- Gnuplot is a portable command-line driven graphing utility for Linux, MS Windows and many other platforms.

- Gnuplot homepage: http://www.gnuplot.info
- Documentation: http://www.gnuplot.info/gnuplot_cvs.pdf
- Download: http://www.gnuplot.info/download.html
- Demos: http://gnuplot.sourceforge.net/demo

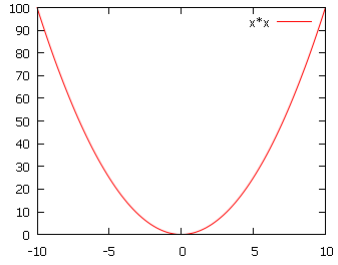

sin(x)
atan(x)
cos(atan(x))
Denmark
Netherlands
Norway
Sweden
1891-1900
1901-1910
1911-1920
1921-1930
1931-1940
1941-1950
1951-1960
1961-1970
1-sin(t)
Histogram of 5000 random samples from a univariate
Gaussian PDF with unit variance and zero mean
scaled bin frequency
Gaussian p.d.f.


3D gnuplot demo
sin(x) * cos(y)
X axis
Y axis
Interlocking Tori
cos(u)+.5*cos(u)*cos(v),sin(u)+.5*sin(u)*cos(v),.5*sin(v)
1+cos(u)+.5*cos(u)*cos(v),.5*sin(v),sin(u)+.5*sin(u)*cos(v)
4D data (3D Heat Map)
Independent value color-mapped onto 3D surface
4 data columns x/y/z/color
3D version using spherical coordinate system
Sayfa 10

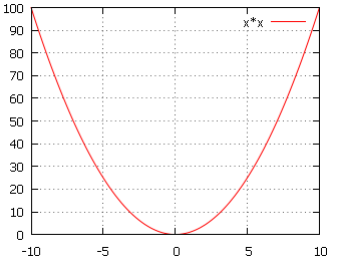
Running gnuplot:



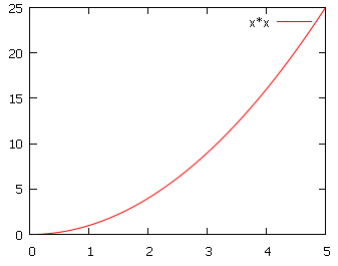

```
> plot x*x
```



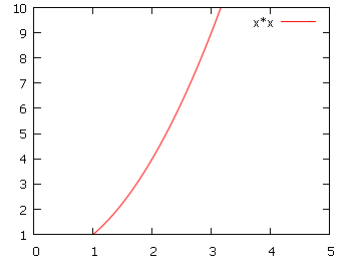

```
> set grid
> plot x*x
```



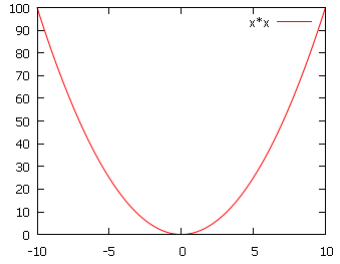

```
> plot [0:5] x*x
```




```
> plot [0:5] [1:10] x*x
```



```
> plot x*x lc 1
```



`lc` stands for line color

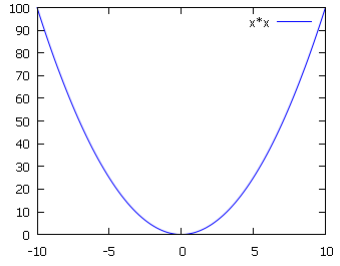
1 red

2 green

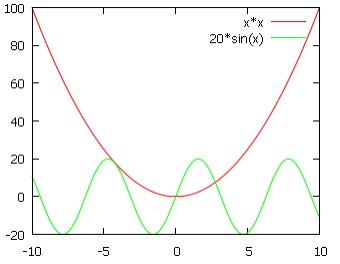
3 blue

etc.

```
> plot x*x lc 3
```




```
> plot x*x, 20*sin(x)
```



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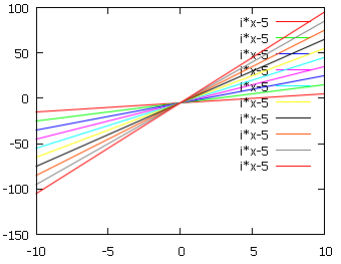
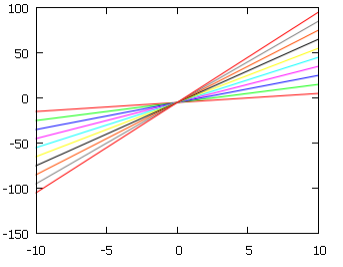
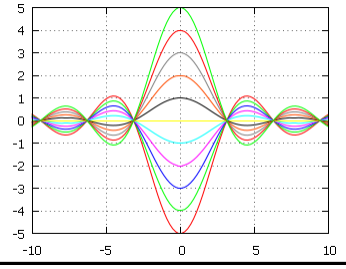
```
> plot for[i=1:10] i*x-5
```




```
> unset key
> plot for[i=1:10] i*x-5
```



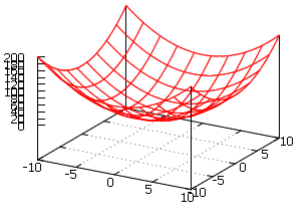
```
> set grid
> unset key
> plot for[i=-5:5] i*sin(x)/x
```



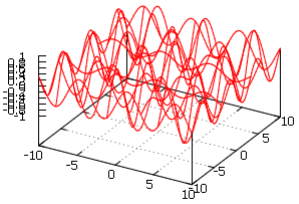
```
set key
unset key

set grid
unset grid
```

Sayfa 14

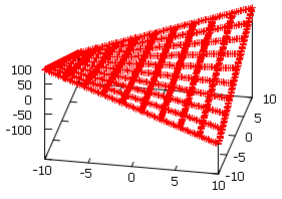
```
> splot x*x + y*y
```



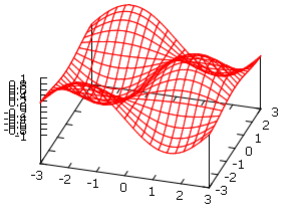
```
> splot sin(x)*sin(y)
```



```
> splot x*y with points
```



```
> set isosamples 21, 21
> splot [x=-3:3][y=-3:3]sin(x)*cos(y)
```



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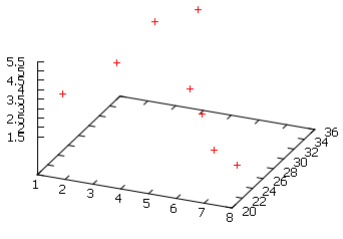
Consider you have the following data file saved in your Desktop as “data.txt”.

```
# X     Y      Z
  1     25     2.5
  2     30     3.1
  3     32     5.0
  4     35     5.1
  5     28     3.0
  6     25     2.7
  7     22     1.8
  8     21     1.5
```

```
> splot “data.txt” using 1:2:3
```



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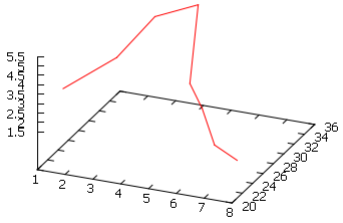
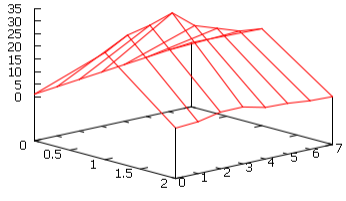
```
# X      Y       Z
  1     25      2.5
  2     30      3.1
  3     32      5.0
  4     35      5.1
  5     28      3.0
  6     25      2.7
  7     22      1.8
  8     21      1.5
```

```
> splot "data.txt" using 1:2:3 with lines
```



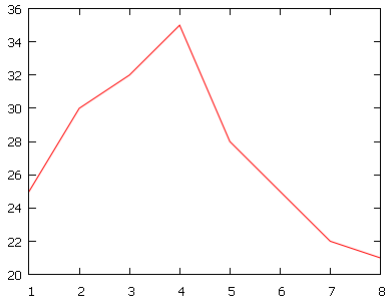

```
# X      Y       Z
  1     25      2.5
  2     30      3.1
  3     32      5.0
  4     35      5.1
  5     28      3.0
  6     25      2.7
  7     22      1.8
  8     21      1.5
```

```
> splot "data.txt" using 1:2:3 matrix with lines
```



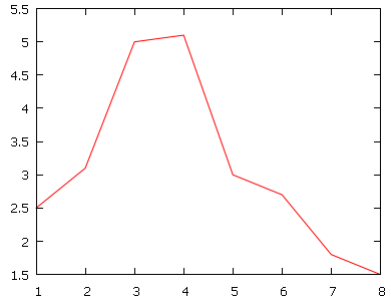
```
# X      Y       Z
  1     25      2.5
  2     30      3.1
  3     32      5.0
  4     35      5.1
  5     28      3.0
  6     25      2.7
  7     22      1.8
  8     21      1.5
```

```
> plot "data.txt" using 1:2 with lines
```

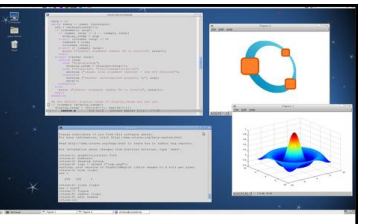



```
# X      Y       Z
  1     25      2.5
  2     30      3.1
  3     32      5.0
  4     35      5.1
  5     28      3.0
  6     25      2.7
  7     22      1.8
  8     21      1.5
```

```
> plot "data.txt" using 1:3 with lines
```



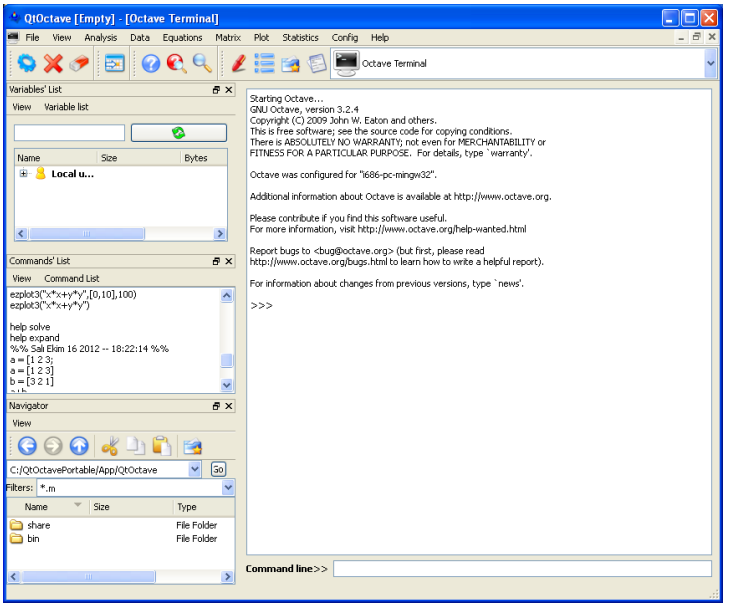
3. GNU Octave



- GNU Octave is a high-level interpreted language, primarily intended for numerical computations.
- It provides a convenient command line interface for solving linear and nonlinear problems numerically.

- Gnu octave homepage:
  http://www.gnu.org/software/octave
- Documentation:
  http://www.gnu.org/software/octave/octave.pdf
- Download:
  hhttp://www.gnu.org/software/octave/download.html

Qt Octave



Arithmetic Operators in Octave

`+`	Addition	2 + 3 = 5
`–`	Subtraction	2 – 3 = – 1
`*`	Multiplication	2 * 3 = 6
`/`	Right division	2 / 3 = 0.6666
`\`	Left division	2 \ 3 = 1.5
`^`	Exponention (x^y)	2 ^ 3 = 8
`.*`	Element-wise multiplication	(*we'll see later*)
`./`	Element-wise division	
`.^`	Element-wise exponention	

Some Octave Intrinsic Functions

Function	Description	Example
`abs(x)`	|x|	abs(-2) = 2
`sin(x)`	sine of x (*x is in radian*)	sin(1.5)
`cos(x)`	cosine of x	cos(1.5)
`tan(x)`	tangent of x	tan(1.5)
`sind(x)`	sine of x (*x is in degrees*)	sin(30)
`cosd(x)`	cosine of x	cos(30)
`tand(x)`	tangent of x	tan(30)
`asin(x)`	angle in radian from $\sin^{-1}(x)$	asin(0.5)
`acos(x)`	angle in radian from $\cos^{-1}(x)$	acos(0.5)
`atan(x)`	angle in radian from $\tan^{-1}(x)$	atan(0.5)
`sqrt(x)`	square root of x	sqrt(4) = 2
`log(x)`	ln(x)	log(2)
`log10(x)`	$\log_{10}(x)$	log10(2)
`exp(x)`	e^x	exp(-5)
`mod(x,y)`	x modulo y	mod(12,5) = 2

```
>> 3 + 1
ans = 4
```

```
>> sqrt(4)
ans = 2
```

```
>> pi
ans = 3.1416
```

```
>> x = 3 + 4i    % complex number
x = 3.0000 + 4.0000i
```


OneDim Arrays (Vectors)

- An array can be created in many ways:

```
>> x = [0  0.25  0.5  0.75  1]
x = 0    0.2500    0.5000    0.7500    1.0000
```

```
>> x = 0:0.25:1
x = 0    0.2500    0.5000    0.7500    1.0000
```

```
>> v = [1 2 3]  % row vector
v = 1   2   3
```

```
>> v = [1; 2; 3]  % column vector
v =
     1
     2
     3
```

```
>> v = [1 2 3]'  % transpose of a row vector
v =
     1
     2
     3
```


TwoDim Arrays (Matrices)

```
>> A = [1 1 1; 2 2 2]   % 2x3 matrix
A =  1     1     1
     2     2     2
```

```
>> A = [1 1 1
        2 2 2]
A =  1     1     1
     2     2     2
```

```
>> B = A'

B =  1     2
     1     2
     1     2
```

```
>> A = [1 2; 3 4]
A =
     1     2
     3     4

>> B = [4 5; 1 0]
B =
     4     5
     1     0

>> A*B
ans =
     6     5
    16    15

>> A+B
ans =

     5     7
     4     4
```



```
>> A = [1 2; 3 4]
A =
     1     2
     3     4

>> det(A)     % determinant of A
ans = -2


>> inv(A)     % matrix inverse of A
ans =
   -2.0000    1.0000
    1.5000   -0.5000
```

Array Functions

`n = length(x)` returns *number of elements of a vector*

```
>> x = [0  0.25  0.5  0.75 1];
>> length(x)
ans = 5
```


`sum(x)` *returns sum of the elements of vector x*

`prod(x)` *returns product of the elements of vector x*

```
>> x = [1  2  2.5  3  3.1];
>> sum(x)
ans = 11.6000
>> prod(x)
46.5000
```

`dot(x,y)` *returns dot product of two vectors x and y*

`cross(x,y)` *returns vector product of the elements of vector x and y*

```
>> a = [1 2 4];
>> b = [0 2 5];
>> dot(a,b)
ans = 24
>> cross(a,b)
ans =  2   -5    2
```

zeros(m,n) *returns a matrix of m rows and n columns that is filled with zeroes*

ones(m,n) *returns a matrix of m rows and n columns that is filled with ones*

rand(m,n) *returns a matrix of m rows and n columns that is filled with uniform random number between [0,1]*

eye(n) *creates an n x n identity (unit) matrix.*

```
>> P = zeros(2,3)
P =  0     0     0
     0     0     0
>> P = ones(2,3)
P =  1     1     1
     1     1     1
>> P = rand(2,3)
P = 0.9501    0.6068    0.8913
    0.2311    0.4860    0.7621
>> I = eye(2)
I =  1     0
     0     1
```


EXAMPLE 3

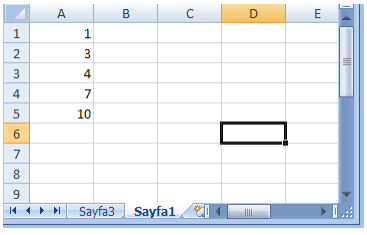
Solve the linear system

$$\begin{aligned} 2x + y &= 1 \\ -x + 2y + 2z &= 2 \\ y + 4z &= 3 \end{aligned}$$

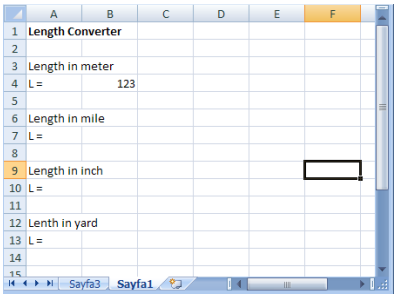
```
>> A = [2 1 0; -1 2 2; 0 1 4]; % Input 3 x 3 matrix
>> b = [1; 2; 3];              % Input column vector
>> x = A\b          % Solve A*x = b by left division

x =
    0.2500
    0.5000
    0.6250
```

Questions

1. The advantage of using a spreadsheet is:
   A) calculations can be done automatically
   B) changing data automatically updates calculations
   C) more flexibility
   D) to record, organize, and analyze data using formulas
   E) all of the above
2. In a spreadsheet, the intersection of a row and a column is called:
   A) data B) field C) cell D) equation E) address
3. For the spreadsheet given, write down the result of the following equations?
   a) =SUM(A1:A3)
   b) =SUM(A5:A3)
   c) =AVERAGE(A1:A5)
   d) =MAX(A1:A5)
   e) =MIN(A2:A4)
   f) =COUNT(A1:A4)
   g) =IF(A4<6; ”on”; ”off”)
   h) =SIN(A5)
   i) =(A1+A2)^2 + A3*A4
   i) =SQRT(A3)
   k) =STDEV(A1:A3)



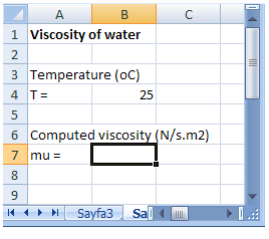
4. Consider one wants to prepare a spreadsheet to convert a length in meters (whose value is written in the cell B4) to miles, inches and yards. What must be the equations in the cell
   B7 to convert from m to mi
   B10 to convert from m to in
   B13 to convert from m to yd?



5. Viscosity is a measure of how easily a fluid flows. For example, water is "thin", having a lower viscosity, while honey is "thick", having a higher viscosity. The viscosity of water can be from the following correlation:

$$\mu = 2.414 \times 10^{\left(\frac{247.8}{T-140}\right)-5}$$

where T is the temperature in Kelvin and μ is the viscosity in N/s.m^2. Using Excel, write down the formula in cell B7 to evaluate the viscosity of the water for the given temperature in ^oC in cell B4.



6. Write down the GNUplot command to plot the function f(x) = sin(x)/x in the range [-10, 10].

7. Write down the GNUplot command to plot the set of functions $f_k(x)$ = k*cos(k*x) in the range [-pi, pi] for k = -4, -3, …, 3, 4

8. Write down the GNUplot command to plot the function f(x,y) = sin(x^3) + x*ln(y) in the x-range [-1,1] and y-range [1, 20].

9. Write down the GNUplot command to plot viscosity vs temperature graph of water in problem 5. Assume that temperature range is [0 ^oC,100 ^oC].

10. Gravitational force between two objects of masses m_1 and m_2 is given by:

$$F = G\frac{m_1 m_2}{r^2}$$

where r is the distance between the masses and G is the universal gravitational constant and has the value $G = 6.673 \times 10^{-11}$ N/(m.kg)^2. Assume that $m_1 = 6 \times 10^{24}$ kg (Earth) and $m_2 = 7.4 \times 10^{22}$ kg (Moon). Write down the GNUplot command to plot the graph of F vs r in the range r = [0, 384000 km].

10. Following data file named “wind.txt” contains measurement of the wind speed (km/h) as a function of time (pm) and temperature (^oC).
Write down the GNUplot command to plot
a) 3D matrix graph of wind speed vs time vs temperature.
b) 3D point graph of wind speed vs time vs temperature.
c) 2D graph of time vs wind speed
d) 2D graph of temperature vs wind speed

#time	temperature	wind_speed
1	25	2.5
2	30	3.1
3	32	5.0
4	35	5.1
5	28	3.0
6	25	2.7
7	22	1.8
8	21	1.5

11. Write down the following equations in Octave command line:

a) $K = ((1 - v^2/c^2)^{-1/2} - 1)mc^2$

b) $\psi = \frac{hk}{2\pi} + A\sin^2(x - \beta)$

c) $F = G\frac{m_1 m_2}{r^2}$

d) $\mu = 2.414 \times 10^{\left(\frac{247.8}{T-140}\right)-5}$

12. What is the output of the following Octave program?

```
>> h = 6.6e-34;
>> p = 2.2e-31;
>> lambda = h/p
```

13. What is the output of the following Octave program?

```
>> x = [1 2 3];
>> y = [3 2 1];
>> a = sum(x)
>> b = prod(y)
>> d = length(x)
>> e = exp(x)
>> dot(x, y) * x.^2
```


14. What is the output of the following Octave program?

```
>> A = [1 2; 4 5];
>> det(A)
>> inv(A)
>> det(inv(A'))
```

15. What is the output of the following Octave program?

```
>> a = [1 2 3];
>> b = [3 2 1];
>> log10(a)
>> a + b
>> 3*a
>> a.*b
>> a*b'
```

16. Solve the following system by using Octave:

```
  x +  y +  z = 6
 2x + 5y +  z = 15
-3x +  y + 5z = 14
```

References

1. P. Kosky et al., *Exploring Engineering*, 2nd Ed. Elsevier Inc. (2010)

2. S. Moaveni, *Engineering Fundamentals*, 4th Ed. Cengage Learning (2011)

3. http://www.gnuplot.info

4. http://t16web.lanl.gov/Kawano/gnuplot/datafile-e.html