



# PENGOLAHAN SINYAL DIGITAL

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# MATLAB

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# WHY MATLAB?

- Matrix Laboratory
- Created in late 1970's
- Intended for used in courses in matrix theory, linear algebra and numerical analysis
- Currently has grown into an interactive system and high level programming language for general scientific and technical computation

# WHY MATLAB? COMMON USES FOR MATLAB IN RESEARCH

- Data Acquisition
- Multi-platform, Multi Format data importing
- Analysis Tools (Existing, Custom)
- Statistics
- Graphing
- Modeling

# WHY MATLAB? DATA ACQUISITION

- A framework for bringing live, measured data into MATLAB using PC-compatible, plug-in data acquisition hardware

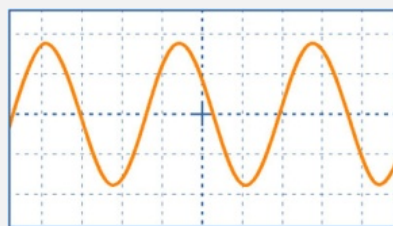




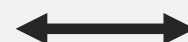
# WHY MATLAB? MULTI-PLATFORM, MULTI FORMAT DATA IMPORTING

- Data can be loaded into Matlab from almost any format and platform
- Binary data files (eg. REX, PLEXON etc.)
- Ascii Text (eg. Eyelink I, II)
- Analog/Digital Data files

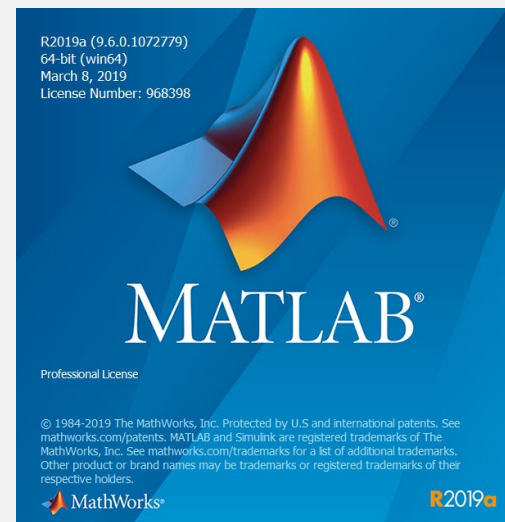
PC  
UNIX



100101010

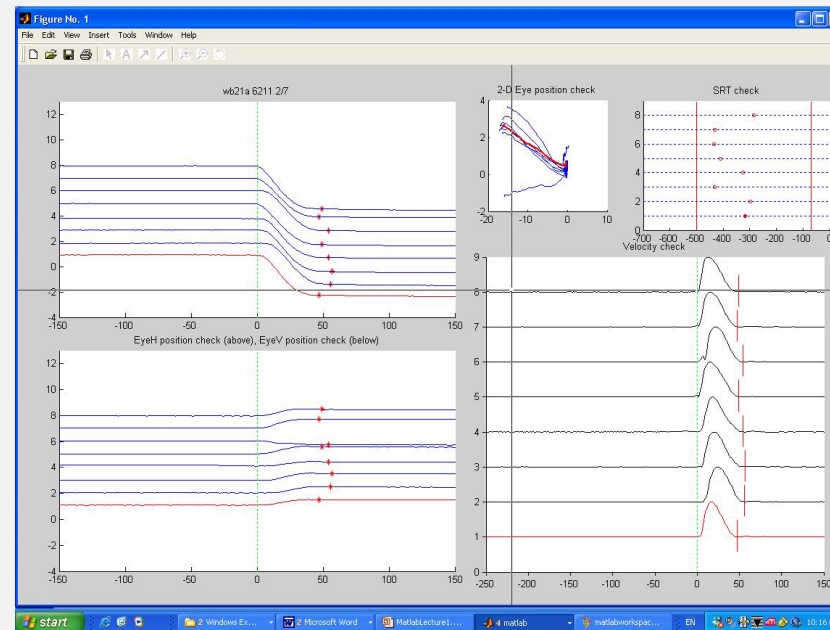


```
Subject 1 143
Subject 2 982
Subject 3 87 ...
```



# WHY MATLAB? ANALYSIS TOOLS

- A Considerable library of analysis tools exist for data analysis
- Provides a framework for the design, creation, and implementation of any custom analysis tool imaginable



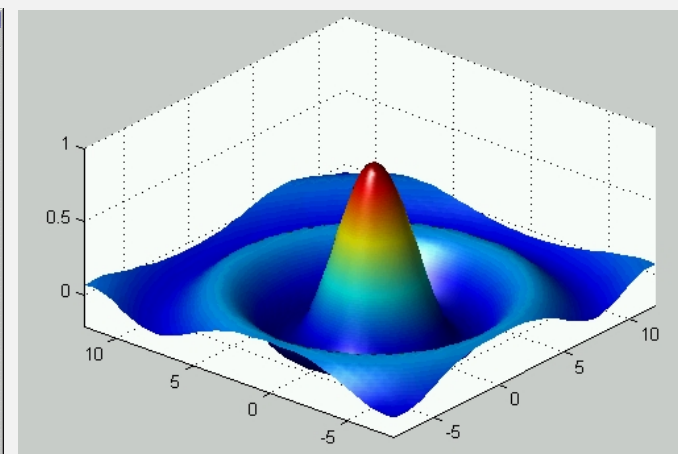
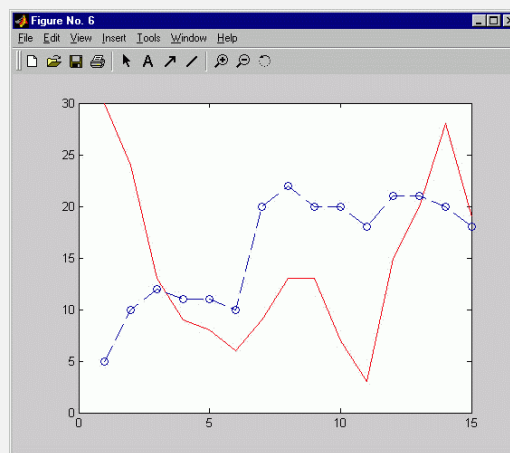
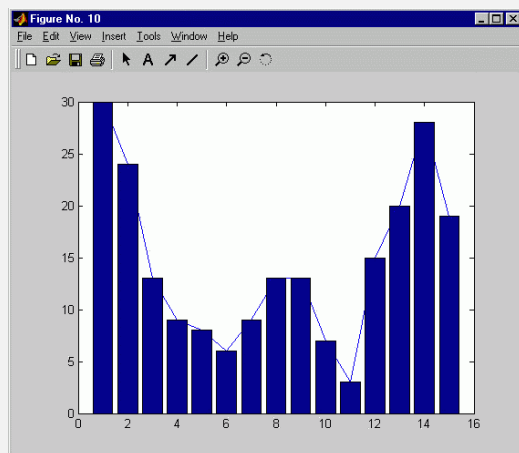
# WHY MATLAB? STATISTICAL ANALYSIS

- A considerable variety of statistical tests available including:
  - T-TEST
  - Mann-Whitney Test
  - Rank Sum Test
  - ANOVAs
  - Linear Regressions
  - Curve Fitting



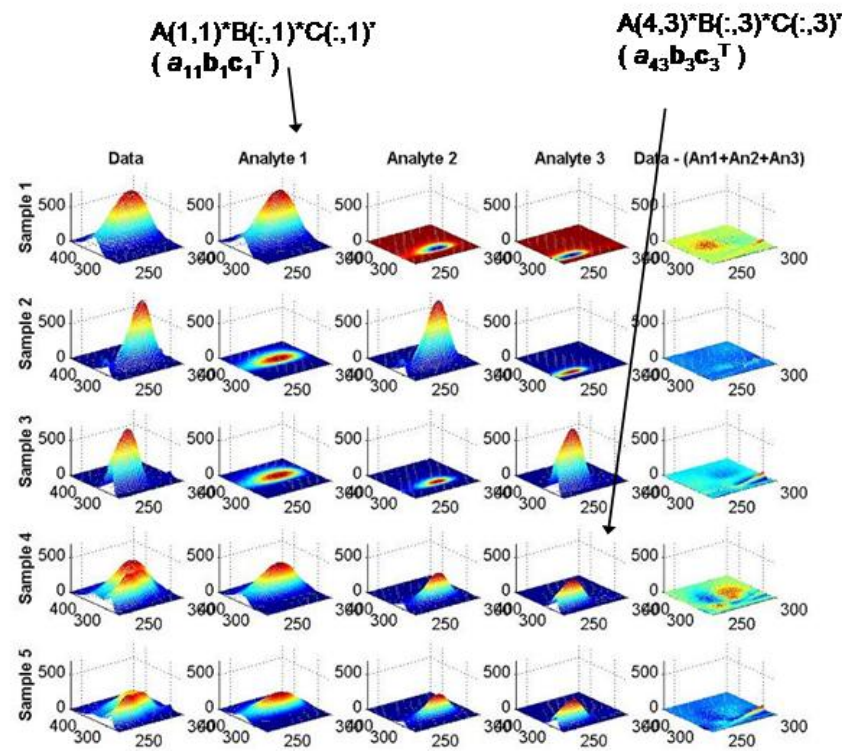
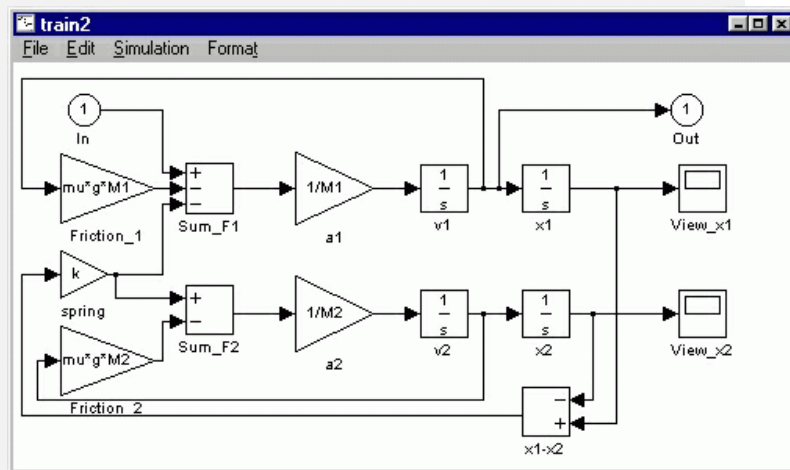
# WHY MATLAB? GRAPHING

- A Comprehensive array of plotting options available from 2 to 4 dimensions
- Full control of formatting, axes, and other visual representational elements



# WHY MATLAB? MODELING

- Models of complex dynamic system interactions can be designed to test experimental data





# MATLAB INTERFACE

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# NAVIGATING THE MATLAB DESKTOP

The screenshot displays the MATLAB R2019a desktop environment. The top menu bar includes tabs for HOME, PLOTS, APPS, EDITOR, PUBLISH, and VIEW. Below this is a toolbar with icons for various functions like New Script, Live Script, Find Files, Import Data, Save Workspace, Open Variable, Favorites, Run and Time, Simulink, Layout, Set Path, Add-Ons, Help, and Community. The main workspace is divided into three panes:

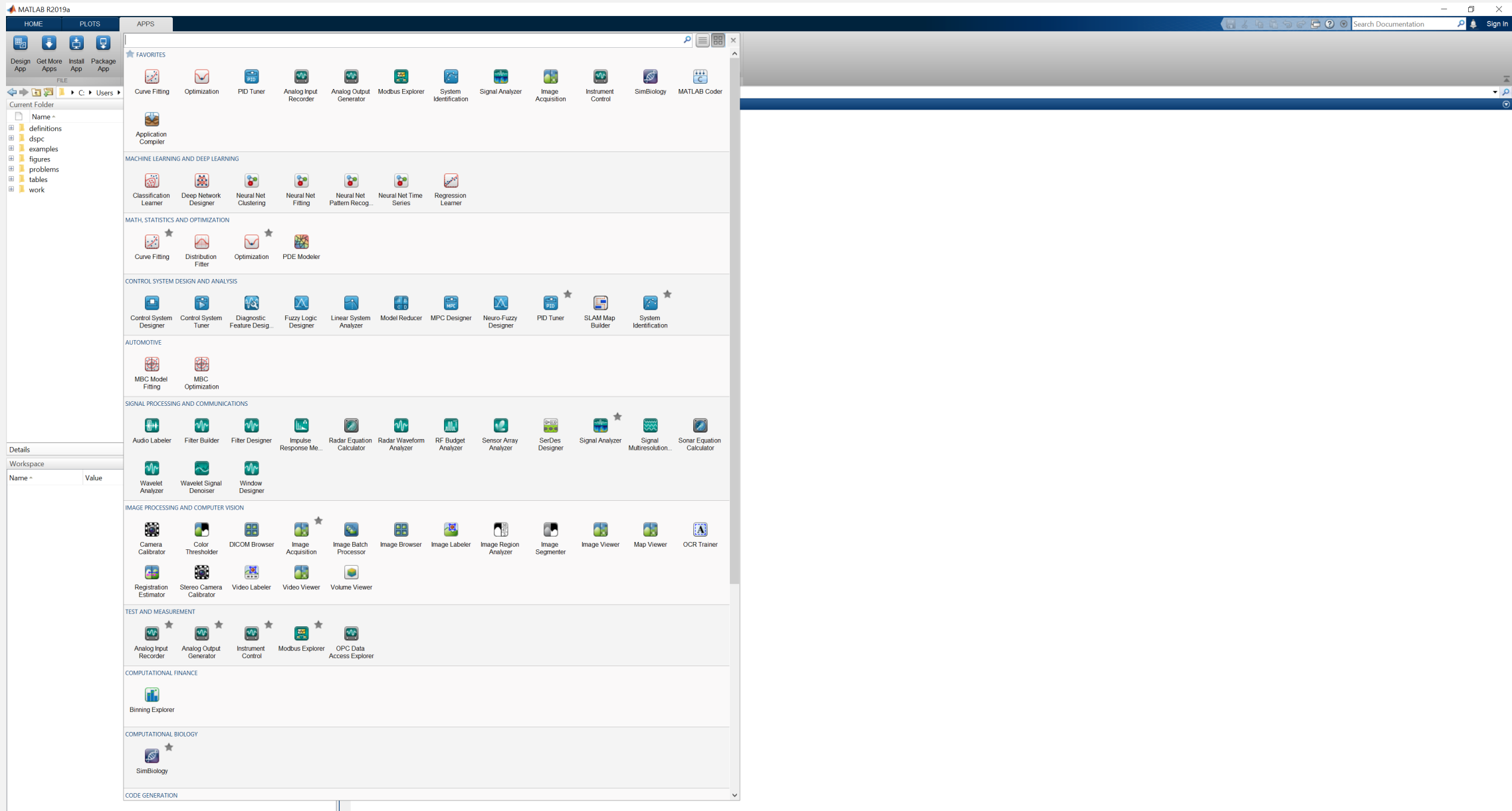
- Current Folder:** Shows a tree view of the current directory structure, including subfolders like definitions, dspc, examples, figures, problems, tables, and work.
- Workspace:** Displays a list of variables in the workspace, including 'a', 'ans', 'b', 'barstr', 'cbac', 'cbac\_Fc', 'cbac\_n', 'cbac\_N', 'cbac\_Vr', 'colors', 'drawstr', 'dv', 'Fc', 'Fc\_max', 'Fc\_min', 'fcolors', 'fs', 'fs\_max', 'fs\_min', 'fsize', 'g\_module', 'h\_fig', 'han', 'hc\_Fc', 'hc\_fs', 'hc\_n', 'hc\_N', 'hc\_type', 'hc\_view', 'hc\_Vr', 'hf\_1', 'hm\_save', and 'labels'.
- Editor:** Contains a script named 'install.m' with the following code:
 

```

31 dspc_net = pwd;
32 quit = 0;
33
34 % Set up location for DSP Companion
35
36 old_dspdir = which('g_dsp.m');
37 if (~isempty(old_dspdir))
38     old_dspdir = old_dspdir(1:end-13);
39 end
40 dspdir = userpath; % dspc destination folder
41 if isempty(dspdir)
42     dspdir = [matlabroot filesep 'dspc'];
43 else
44     if dspdir(end) == ';'
45         dspdir(end) = '';
46     end
47     dspdir = [dspdir filesep 'dspc'];
48 end
49
50 % Define paths
51
52 dspc = [dspdir filesep 'dspc'];
53 slide = [dspdir filesep 'slides'];
54 exam = [dspdir filesep 'examples'];
55 fig = [dspdir filesep 'figures'];
56 tab = [dspdir filesep 'tables'];
57 def = [dspdir filesep 'definitions'];
58 prob = [dspdir filesep 'problems'];
59 work = [dspdir filesep 'work'];
60 solutions = [dspdir filesep 'solutions'];
61 userload = prob;
62 usersave = prob;
63 userprint = prob;
64 menubar = 'none';
65 clear_window = 1;
      
```
- Command Window:** Shows the prompt 'fx >>'.

The status bar at the bottom indicates the current file is 'install.m' and the line/col is 19/11.

# COMMONLY USED TOOLBOXES



# EDITOR NAVIGATION

The screenshot displays the MATLAB R2019a environment with the Editor window open to a file named `install.m`. The interface includes a top toolbar with tabs for HOME, PLOTS, APPS, EDITOR, PUBLISH, and VIEW. The Editor window shows the following code:

```

31 dspc_net = pwd;
32 quit = 0;
33
34 % Set up location for DSP Companion
35
36 old_dspdir = which('g_dsp.m');
37 if (~isempty(old_dspdir))
38     old_dspdir = old_dspdir(1:end-13);
39 end
40 dspdir = userpath; % dspc destination folder
41 if isempty(dspdir)
42     dspdir = [matlabroot filesep 'dspc'];
43 else
44     if dspdir(end) == ';'
45         dspdir(end) = '';
46     end
47     dspdir = [dspdir filesep 'dspc'];
48 end
49
50 % Define paths
51
52 dspc      = [dspdir filesep 'dspc'];
53 slide     = [dspdir filesep 'slides'];
54 exam      = [dspdir filesep 'examples'];
55 fig       = [dspdir filesep 'figures'];
56 tab       = [dspdir filesep 'tables'];
57 def       = [dspdir filesep 'definitions'];
58 prob      = [dspdir filesep 'problems'];
59 work      = [dspdir filesep 'work'];
60 solutions = [dspdir filesep 'solutions'];
61 userload  = prob;
62 usersave  = prob;
63 userprint = prob;
64 menubar   = 'none';
65 clear_window = 1;
  
```

The Command Window at the bottom shows the prompt `>>`. The Workspace window on the left lists variables such as `a`, `ans`, `b`, `barstr`, `cback`, `fc`, `fs`, `g_module`, `h_fig`, `han`, `hc_fc`, `hc_fs`, `hc_n`, `hc_N`, `hc_type`, `hc_view`, `hc_Vr`, `hm_1`, `hm_save`, and `labels`.

DSP - Fisika UI



# PLOTTING NAVIGATION

The image displays the MATLAB R2019a interface, specifically the PLOTS menu. The menu is organized into several categories of plots, each with a corresponding icon. The categories include:

- Favorites:** A row of icons for frequently used plots.
- MATLAB LINE PLOTS:** Includes plot, Plot as multi..., Plot as multi..., plotly, semilogx, semilogy, loglog, area, errorbar, errorbar (hor...), plot3, and comet.
- MATLAB STEM AND STAIR PLOTS:** Includes stem, stairs, and stem3.
- MATLAB BAR PLOTS:** Includes bar, barh, bar3, bar3h, bar (stacked), barh (stacked), histogram, pareto, and plotmatrix.
- MATLAB SCATTER PLOTS:** Includes scatter, scatter3, spy, and plotmatrix.
- MATLAB GRAPH PLOTS:** Includes graph and digraph.
- MATLAB PIE CHARTS:** Includes pie and pie3.
- MATLAB HISTOGRAMS:** Includes histogram, histogram2, and rose.
- MATLAB POLAR PLOTS:** Includes polar, rose, and compass.
- MATLAB GEOGRAPHIC PLOTS:** Includes geoplots, geoscatter, and geobubble.
- MATLAB CONTOUR PLOTS:** Includes contour, contourf, and contour3.
- MATLAB IMAGE PLOTS:** Includes image, imagesc, and imagesz.

The interface also shows the Workspace pane on the left, listing variables and their values. The Command Window on the right is empty, and the MATLAB Documentation browser is visible at the bottom.

# SIMULINK NAVIGATION

New

Examples

Open...

Recent

Projects

From Source Control

Learn

Simulink Onramp

Search

All Templates

Q

My Templates

Learn More

Simulink

Blank Model

Blank Library

Blank Project

Folder to Project

Project from Git

Project from SVN

Code Generation

Digital Filter

Show more

Audio Toolbox

AUTOSAR Blockset

DSP System Toolbox

Embedded Coder

HDL Coder

Powertrain Blockset

SimEvents

Simscape

# APPLICATION DESIGNER

[Getting Started](#) | [Migrating GUIDE Apps to App Designer](#) | [Displaying Graphics in App Designer](#) | [Release Notes](#)

[Learn More](#)

[Open...](#)

## Recent Apps

No Recent Apps

### ▼ New

Blank App

2-Panel App with Auto-Reflow

3-Panel App with Auto-Reflow

### ▼ Examples: Getting Started

Interactive Tutorial

Respond to Numerical Input

Respond to User Selections

Use Instrumentation Controls

### ▼ Examples: Programming Tasks

Link Data to a Tree

Analyze an Image

Configure a Timer

Display Specialized Axes



# MATLAB OPERATION

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# NUMBERS

- MATLAB is a high-precision numerical engine and can handle all types of numbers, that is, integers, real numbers, complex numbers, among others, with relative ease.
- For example, the real number 1.23 is represented as simply 1.23 while the real number  $4.56 \times 10^7$  can be written as 4.56e7.
- The imaginary number  $\sqrt{-1}$  is denoted either by 1i or 1j, although in this book we will use the symbol 1j.
- Hence the complex number whose real part is 5 and whose imaginary part is 3 will be written as 5+1j\*3.
- Other constants preassigned by MATLAB are pi for  $\pi$ , inf for  $\infty$ , and NaN for not a number (for example, 0/0).
- These preassigned constants are very important and, to avoid confusion, should not be redefined by users.

# VARIABLES

- The basic variable is a matrix, or an array.
- MATLAB now supports multidimensional arrays
  - **Matrix:** A matrix is a two-dimensional set of numbers arranged in rows and columns. Numbers can be real- or complex-valued.
  - **Array:** This is another name for matrix. However, operations on arrays are treated differently from those on matrices. This difference is very important in implementation.



# WORKING WITH MATRICES

- Matlab works with essentially only one kind of object, a rectangular numerical matrix
- A matrix is a collection of numerical values that are organized into a specific configuration of rows and columns.
- The number of rows and columns can be any number

## Example

- 3 rows and 4 columns define a 3 x 4 matrix having 12 elements

# WORKING WITH MATRICES

- **Scalar:** This is a  $1 \times 1$  matrix or a single number that is denoted by the *variable* symbol, that is, lowercase italic typeface like

$$a = a_{11}$$

# WORKING WITH MATRICES

- **Column vector:** This is an  $(N \times 1)$  matrix or a vertical arrangement of numbers.
- It is denoted by the *vector* symbol, that is, lowercase bold typeface like

$$\mathbf{x} = [x_{i1}]_{i:1,\dots,N} = \begin{bmatrix} x_{11} \\ x_{21} \\ \vdots \\ x_{N1} \end{bmatrix}$$

- A typical vector in linear algebra is denoted by the column vector



# WORKING WITH MATRICES

- **Row vector:** This is a  $(1 \times M)$  matrix or a horizontal arrangement of numbers.
- It is also denoted by the vector symbol, that is,

$$\mathbf{y} = \left[ y_{1j} \right]_{j=1, \dots, M} = \left[ y_{11} \quad y_{12} \quad \cdots \quad y_{1M} \right]$$

- A one-dimensional discrete-time signal is typically represented by an array as a row vector.

# WORKING WITH MATRICES

- **General matrix:** This is the most general case of an  $(N \times M)$  matrix and is denoted by the matrix symbol, that is, uppercase bold typeface like

$$\mathbf{A} = [a_{ij}]_{i=1,\dots,N;j=1,\dots,M} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1M} \\ a_{21} & a_{22} & \cdots & a_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ a_{N1} & a_{N2} & \cdots & a_{NM} \end{bmatrix}$$

- This arrangement is typically used for two-dimensional discrete-time signals or images

# WORKING WITH MATRICES - EXAMPLE

```
c = 5.66
```

```
%c is a scalar or a 1 x 1 matrix
```

```
x = [ 3.5, 33.22, 24.5 ]
```

```
%x is a row vector or a 1 x 3 matrix
```

```
x1 = [2
```

```
5
```

```
3
```

```
-1]
```

```
%x1 is column vector or a 4 x 1 matrix
```

```
A = [ 1 2 4
```

```
2 -2 2
```

```
0 3 5
```

```
5 4 9 ]
```

```
%A is a 4 x 3 matrix
```

# WORKING WITH MATRICES - EXAMPLE

```

Command Window

>> c = 5.66           %c is a scalar or a 1 x 1 matrix
x = [ 3.5, 33.22, 24.5 ] %x is a row vector or a 1 x 3 matrix
x1 = [ 2
      5
      3
      -1]           %x1 is column vector or a 4 x 1 matrix
A = [ 1  2  4
      2 -2  2
      0  3  5
      5  4  9 ]     %A is a 4 x 3 matrix

c =
    5.6600

x =
    3.5000    33.2200    24.5000

x1 =
     2
     5
     3
    -1

A =
     1     2     4
     2    -2     2
     0     3     5
     5     4     9

fx >>

```

Name	Value
A	4x3 double
c	5.6600
x	[3.5000,33.22...
x1	[2;5;3;-1]

PLOTS		VARIABLE		VIEW		EDIT	
New from Selection		Open	Print	Rows	Columns	Insert	Delete
				1	1		
4x3 double							
	1	2	3	4	5	6	
1	1	2	4				
2	2	-2	2				
3	0	3	5				
4	5	4	9				
5							
6							
7							



# WORKING WITH MATRICES

- Spaces, commas, and semicolons are used to separate elements of a matrix
- Spaces or commas separate elements of a row  
[1 2 3 4] or [1,2,3,4]
- Semicolons separate columns  
[1,2,3,4;5,6,7,8;9,8,7,6] =  $\begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 8 & 7 & 6 \end{bmatrix}$

# OPERATORS

- MATLAB provides several arithmetic and logical operators, some of which follow.

= assignment

== equality

+ addition

- subtraction or minus

\* multiplication

.\* array multiplication

^ power

.^ array power

/ division

./ array division

<> relational operators

& logical AND

| logical OR

~ logical NOT

' transpose

.' array transpose

# IMPORTANT OPERATIONS ON MATRICES

- **Matrix addition and subtraction:** These are straightforward operations that are also used for array addition and subtraction. Care must be taken that the two matrix operands be *exactly* the same size.
- **Matrix conjugation:** This operation is meaningful only for complex valued matrices. It produces a matrix in which all imaginary parts are negated. It is denoted by  $\mathbf{A}^*$  in analysis and by `conj(A)` in MATLAB.

# IMPORTANT OPERATIONS ON MATRICES

- **Matrix transposition:** This is an operation in which every row (column) is turned into column (row). Let  $\mathbf{X}$  be an  $(N \times M)$  matrix. Then

$$\mathbf{X}' = [x_{ij}]; \quad j = 1, \dots, M, \quad i = 1, \dots, N$$

- is an  $(M \times N)$  matrix



# IMPORTANT OPERATIONS ON MATRICES

- **Multiplication by a scalar:** This is a simple straightforward operation in which each element of a matrix is scaled by a constant, that is

$$ab \Rightarrow a * b \quad (\text{scalar})$$

$$ax \Rightarrow a * x \quad (\text{vector or array})$$

$$a\mathbf{X} \Rightarrow a * \mathbf{X} \quad (\text{matrix})$$

- This operation is also valid for an array scaling by a constant

# IMPORTANT OPERATIONS ON MATRICES

- **Vector-vector multiplication:** In this operation, one has to be careful about matrix dimensions to avoid invalid results.
- The operation produces either a scalar or a matrix. Let  $\mathbf{x}$  be an  $(N \times 1)$  and  $\mathbf{y}$  be a  $(1 \times M)$  vectors.
- Then

$$\mathbf{x} * \mathbf{y} = \mathbf{x} \mathbf{y} \begin{bmatrix} x_1 \\ \vdots \\ x_N \end{bmatrix} \begin{bmatrix} y_1 & \cdots & y_M \end{bmatrix} = \begin{bmatrix} x_1 y_1 & \cdots & x_1 y_M \\ \vdots & \ddots & \vdots \\ x_N y_1 & \cdots & x_N y_M \end{bmatrix}$$

- produces a matrix.

# IMPORTANT OPERATIONS ON MATRICES

- **Matrix-vector multiplication:** If the matrix and the vector are compatible (i.e., the number of matrix-columns is equal to the vector-rows), then this operation produces a column vector:

$$y = A * x \Rightarrow \mathbf{y} = \mathbf{A}\mathbf{x} = \begin{bmatrix} a_{11} & \cdots & a_{1M} \\ \vdots & \ddots & \vdots \\ a_{N1} & \cdots & a_{NM} \end{bmatrix} \begin{bmatrix} x_1 \\ \vdots \\ x_M \end{bmatrix} = \begin{bmatrix} y_1 \\ \vdots \\ y_N \end{bmatrix}$$

# IMPORTANT OPERATIONS ON MATRICES

- **Matrix-matrix multiplication:** Finally, if two matrices are compatible, then their product is well-defined.
- The result is also a matrix with the number of rows equal to that of the first matrix and the number of columns equal to that of the second matrix.
- Note that the order in matrix multiplication is very important.



# ARRAY OPERATIONS

- These operations treat matrices as arrays.
- They are also known as *dot operations* because the arithmetic operators are prefixed by a dot (.), that is,  $.*$ ,  $./$ , or  $.^$ .

# ARRAY OPERATIONS

- **Array multiplication:** This is an element by element multiplication operation.
- For it to be a valid operation, both arrays must be the same size. Thus we have

$$x.*y \rightarrow \text{1D array}$$

$$X.*Y \rightarrow \text{2D array}$$

# ARRAY OPERATIONS

- **Array exponentiation:** In this operation, a scalar (real- or complexvalued) is raised to the power equal to every element in an array, that is,

$$a.^x \equiv \begin{bmatrix} a^{x_1} \\ a^{x_2} \\ \vdots \\ a^{x_N} \end{bmatrix}$$

# ARRAY OPERATIONS

- **Array transposition:** As explained, the operation  $A^T$  produces transposition of real- or complex-valued array  $A$ .



# INDEXING MATRICES

- A  $m \times n$  matrix is defined by the number of  $m$  rows and number of  $n$  columns
- An individual element of a matrix can be specified with the notation  $A(i,j)$  or  $A_{i,j}$  for the generalized element, or by  $A(4,1)=5$  for a specific element.

```
>> A = [1 2 4 5;6 3 8 2]
```

A is a 2 x 4 matrix

```
>> A(1,2)
```

```
Ans = 2
```

- The colon operator can be used to index a range of elements

```
>> A(2,1:3)
```

```
Ans = 6 3 8
```

# INDEXING MATRICES

- Specific elements of any matrix can be overwritten using the matrix index

Example:

$$A = \begin{bmatrix} 1 & 2 & 4 & 5 \\ 6 & 3 & 8 & 2 \end{bmatrix}$$

$$A(2,1) = 9$$

Ans

$$A = \begin{bmatrix} 1 & 2 & 4 & 5 \\ 9 & 3 & 8 & 2 \end{bmatrix}$$

# MATRIX SHORTCUTS

- The ones and zeros functions can be used to create any m x n matrices composed entirely of ones or zeros

## Example

```
a = ones(3,2)
```

```
a = [1 1  
     1 1  
     1 1]
```

```
b = zeros(1,5)
```

```
b = [0 0 0 0 0]
```

# CONTROL-FLOW

if-elseif-else structure

```
if condition1
    command1
elseif condition2
    command2
else
    command3
end
```

# CONTROL-FLOW

```
for..end loop
```

```
for index = values  
    program statements  
:  
end
```

# EXAMPLE

- Consider the following sum of sinusoidal functions

$$x(t) = \sin(2\pi t) + \frac{1}{3}\sin(6\pi t) + \frac{1}{5}\sin(10\pi t) = \sum_{k=1}^3 \frac{1}{k} \sin(2\pi kt), \quad 0 \leq t \leq 1$$

- Using MATLAB, we want to generate samples of  $x(t)$  at time instances 0:0.01:1.



# EXAMPLE

- **Approach 1** Here we will consider a typical C or Fortran approach, that is, we will use two for..end loops, one each on t and k.
- This is the most inefficient approach in MATLAB, but possible.

```
t = 0:0.01:1; N = length(t); xt = zeros(1,N);  
for n = 1:N  
    temp = 0;  
    for k = 1:3  
        temp = temp + (1/k)*sin(2*pi*k*t(n));  
    end  
    xt(n) = temp;  
end
```

# EXAMPLE

- **Approach 2** In this approach, we will compute each sinusoidal component in one step as a vector, using the time vector  $t = 0:0.01:1$  and then add all components using one for..end loop.

```
t = 0:0.01:1; xt = zeros(1,length(t));  
for k = 1:3  
    xt = xt + (1/k)*sin(2*pi*k*t);  
end
```

# SCRIPTS AND FUNCTIONS

- ***Scripts***

- implemented using a *script* file called an m-file (with an extension .m), which is only a text file that contains each line of the file as though you typed them at the command prompt.
- built-in editor, which also provides for context-sensitive colors and indents for making fewer mistakes and for easy reading.
- executed by typing the name of the script at the command prompt.
- script file must be in the current directory or in the directory of the path environment.

# SCRIPTS AND FUNCTIONS

- Example:
- General form of sinusoidal function is

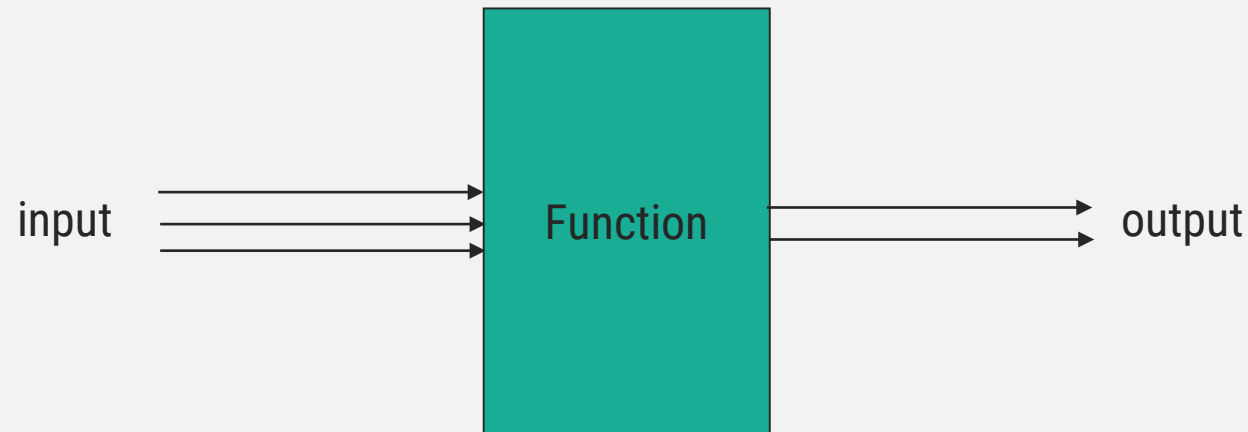
$$x(t) = \sum_{k=1}^K c_k \sin(2\pi kt)$$

- create a script file !  
% Script file to implement  
t = 0:0.01:1; k = 1:2:5; ck = 1./k;  
xt = ck \* sin(2\*pi\*k'\*t);

# SCRIPTS AND FUNCTIONS

- ***Functions***

- The second construct of creating a block of code is through subroutines.
- A major difference between script and function files is that the first executable line in a function file begins with the keyword `function` followed by an output-input variable declaration



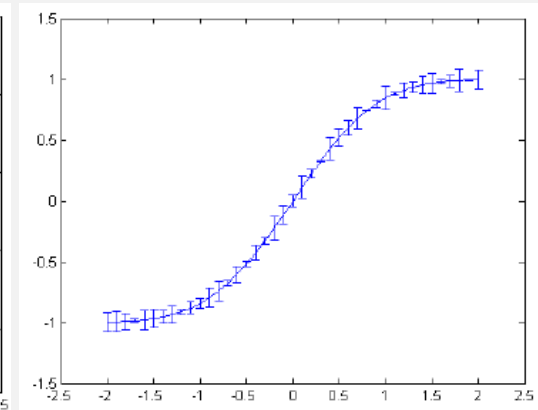
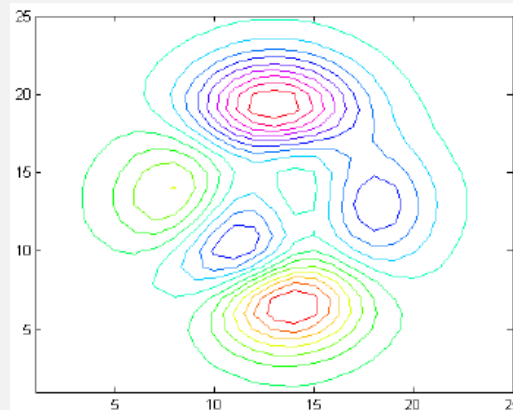
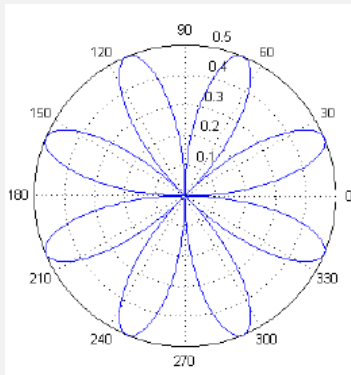
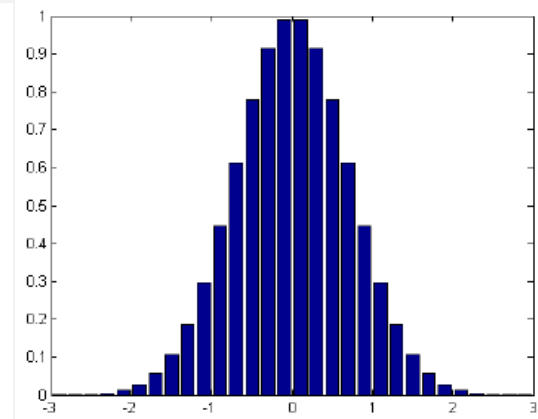
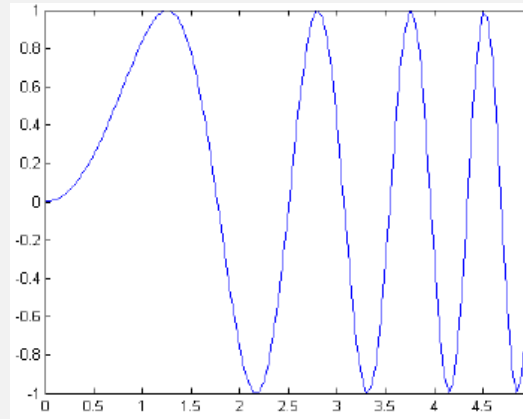
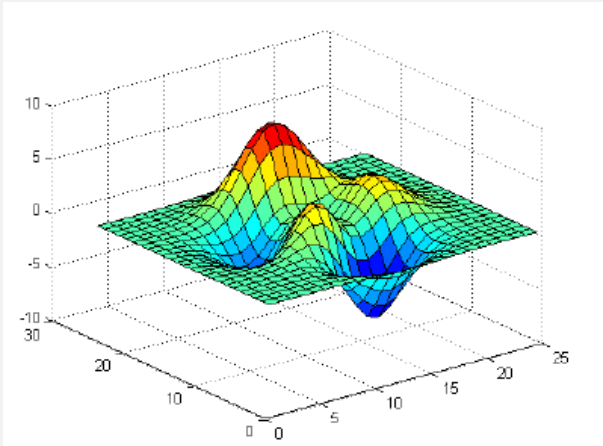
# SCRIPTS AND FUNCTIONS - EXAMPLE

```
function xt = sinsum(t,ck)
% Computes sum of sinusoidal terms of the form in (1.1)
% x = sinsum(t,ck)
%
K = length(ck); k = 1:K;
ck = ck(:)'; t = t(:)';
xt = ck * sin(2*pi*k'*t);
```



# PLOTTING

- Matlab has a powerful plotting engine that can generate a wide variety of plots.



# PLOTTING

- The basic plotting command is the `plot(t,x)` command, which generates a plot of x values versus t values in a separate figure window.
- The arrays t and x should be the same length and orientation.
- Optionally, some additional formatting keywords can also be provided in the plot function.
- The commands `xlabel` and `ylabel` are used to add text to the axis, and the command `title` is used to provide a title on the top of the graph.
- All aspects of a plot (style, size, color, etc.) can be changed by appropriate commands embedded in the program or directly through the GU

# PLOTTING EXAMPLE

```
% Plot of a simple sinusoidal wave  
% putting axis labels and title on the plot  
  
t = 0:0.01:2; % sample points from 0 to 2 in steps of 0.01  
x = sin(2*pi*t); % Evaluate sin(2 pi t)  
plot(t,x,'b'); % Create plot with blue line  
xlabel('t in sec'); ylabel('x(t)'); % Label axis  
title('Plot of sin(2\pi t)'); % Title plot
```

# PLOTTING EXAMPLE

- MATLAB provides an ability to display more than one graph in the same figure window.
- By means of the `hold on` command, several graphs can be plotted on the same set of axes.
- The `hold off` command stops the simultaneous plotting

```
plot(t,xt,'b'); hold on; % Create plot with blue line  
Hs = stem(n*0.05,xn,'b','filled'); % Stem-plot with handle Hs  
set(Hs,'markersize',4); hold off; % Change circle size
```

# PLOTTING EXAMPLE

- The `subplot` command, which displays several graphs in each individual set of axes arranged in a grid, using the parameters in the subplot command.

```
...  
subplot(2,1,1); % Two rows, one column, first plot  
plot(t,x,'b'); % Create plot with blue line  
...  
subplot(2,1,2); % Two rows, one column, second plot  
Hs = stem(n,x,'b','filled'); % Stem-plot with handle Hs  
...
```

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