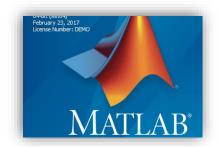
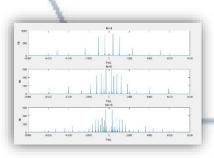
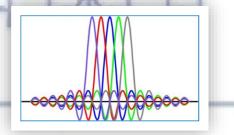
信号与系统实验

主讲人: 吴光 博士

Email: wug@sustech.edu.cn













Signals and Systems (Lab)

Lab 1: MATLAB Programming

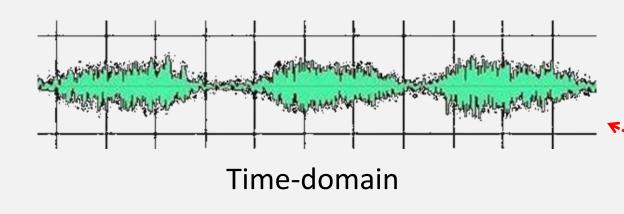
Dr. Wu Guang

wug@sustech.edu.cn

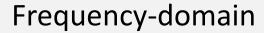
Electrical & Electronic Engineering Southern University of Science and Technology

Part 1: Introduction

Objective: Analysis in frequency-domain





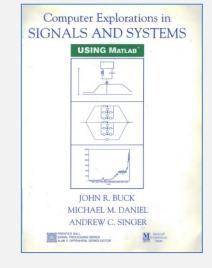




Labs in this course

5 Lab assignments+2 Projects

- Lab 1: MATLAB Programming (3 Weeks)
- Lab 2: Linear Time-Invariant Systems (2 Weeks)
- Lab 3: Fourier Series Representation of Periodic Signals (2 Weeks)
- Lab 4: The Continuous-Time Fourier Transform (2 Weeks)
- Lab 5: Coding Test & System, Transform, Convolution and Filter (1 Week)
- Project 1: Speech synthesis and perception with envelope cue (3 Weeks)
- Project 2: Motion detection via communication signals (3 Weeks)





Arrangements

5 lab assignments

- Two students work as a group;
- Two weeks per assignment;
- Evaluation: Lab Report
- Hard deadline: Please submit your report before the next lab session.

2 projects

- Four students work as a group;
- Three weeks per project;
- Evaluation: Project Report + Presentation;
- Hard deadline: please submit your report before the next project.

How to write your report?

Edit your report by word. Use the following format:

Write a short introduction to the lab assignment

Type down Question 1
Give you answer to Q1, add the figures if necessary

Type down Question 2
Give you answer to Q2, add the figures if necessary

Type down Question 3
Give you answer to Q3, add the figures if necessary

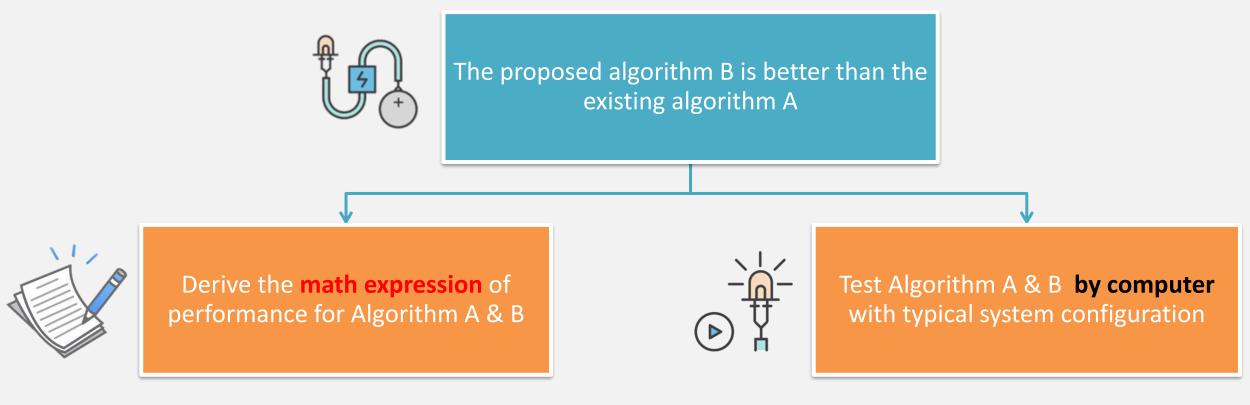
...

Fmail to wug@sustech.edu.cn

File name: (Lab Index)+(Student Name 1)+(Student Name 2)+ (Student No. 1)+ (Student No. 2)

Example: Lab1+张三+王伟+00001+00002

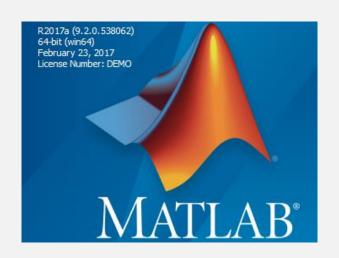
What's Simulation?

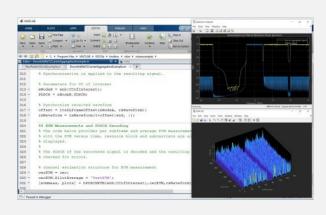


Solid math background is necessary

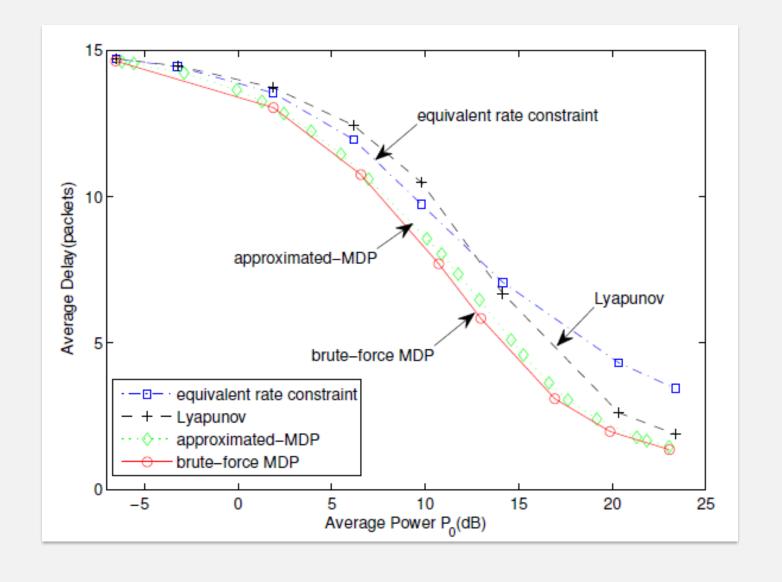
You need to write program

How to express your result?









Part 2: MATLAB Tutorial



What can you do with MATLAB?



Computational Biology

Analyze, visualize, and model biological data and systems



Control Systems

Design, test, and implement control systems



Data Science

Explore data; build machine learning models; do predictive analytics



Deep Learning

Data preparation, design, simulation, and deployment for deep neural networks



Embedded Systems

Design, code, and verify embedded systems



Enterprise and IT Systems

Use MATLAB with your IT systems



FPGA, ASIC, and SoC Development

Automate your workflow — from algorithm development to hardware design and verification



Image Processing and Computer Vision

Acquire, process, and analyze images and video for algorithm development and system design



Internet of Things

Connect embedded devices to the Internet and gain insight from your data



Machine Learning

Train models, tune parameters, and deploy to production or the edge

Mechatronics

Design, optimize, and verify mechatronic systems



Power Electronics Control Design

Design and implement digital control for motors, power converters, and battery systems



Predictive Maintenance

Develop and deploy condition monitoring and predictive maintenance software



Robotics

Convert your robotics ideas and concepts into autonomous systems that work seamlessly in real-world environments.



Signal Processing

Analyze signals and time-series data. Model, design, and simulate signal processing systems.

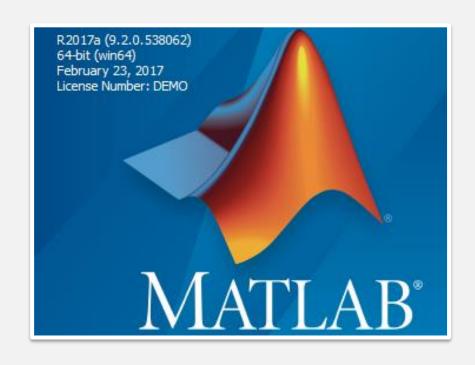


Test and Measurement

Acquire, analyze, and explore data and automate tests



MATLAB (MATrix LABoratory)



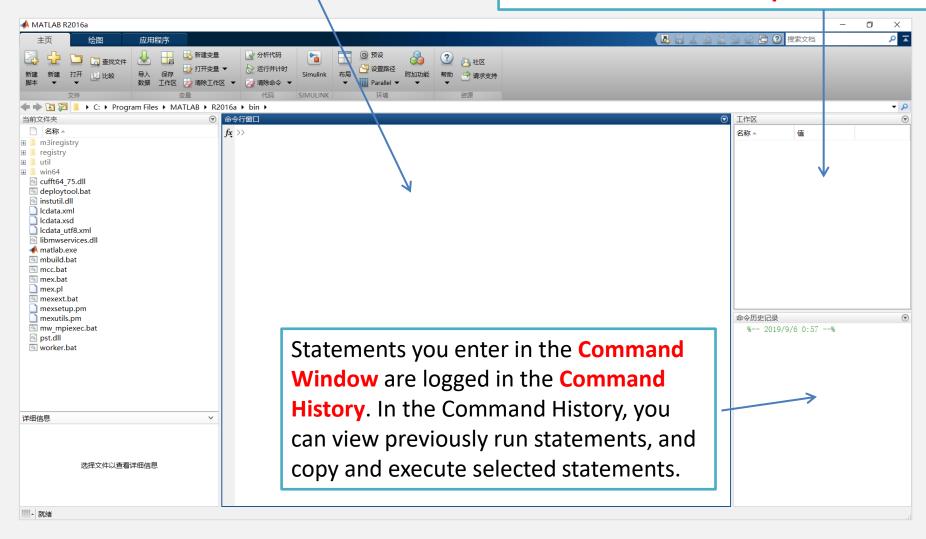




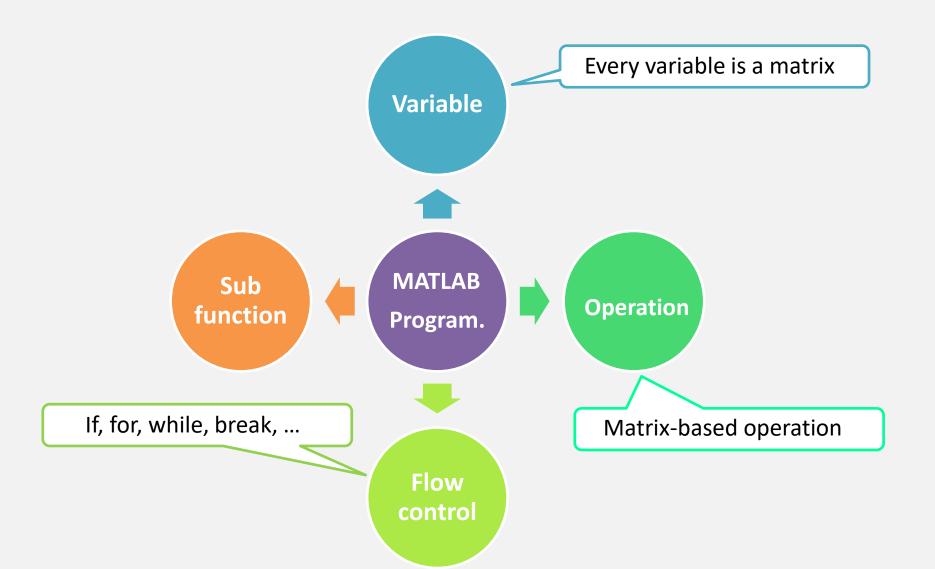


Type your MATLAB statement in Command Window, you can interact with MATLAB here.

All currently defined variables will be stored listed out in the **Workspace**.



Language Overview





How to Define Variables?

Example:

a=5

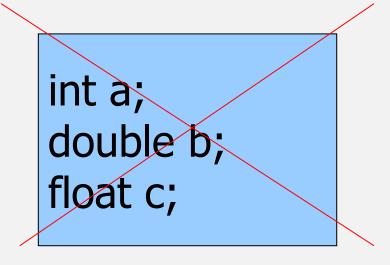
a='hello world'

a = 5.5

b=10+1i

a=a*b

a=a+b



No need to claim types.

- ① Latest value of variable will be stored in the workspace
- ② Semicolon (;) will stop the interaction with command window

Every Variable is a Matrix

```
• A vector x = [1 \ 2 \ 5 \ 1]
```

Row Vector

```
x = 1 \quad 2 \quad 5 \quad 1
```

• A matrix y = [1 2 3; 5 1 4; 3 2 -1]

Matrix

```
y =

1 2 3

5 1 4

3 2 -1
```

Transpose z = x' z = 12
5

Column Vector

Long Vector & Matrix

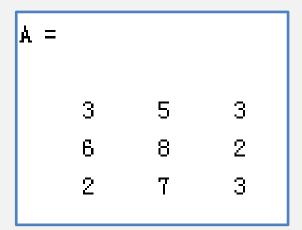
```
t =1:10
    t =
        1 2 3 4 5 6 7 8 9 10
k = 2:-0.5:-1
    k =
       2 1.5 1 0.5 0 -0.5 -1
B = [1:4; 5:8]
    B =
        1 2 3 4
```

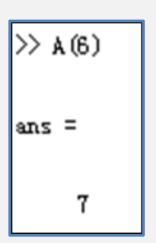
Generate vectors from functions

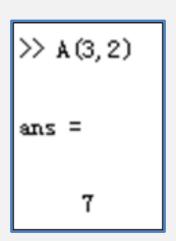
•	zeros(M,N)	MxN matrix of zeros	x = zeros(1,3)
			x =
	 		0 0 0
•	ones(M,N)	MxN matrix of ones	x = ones(1,3)
	 		X =
			1 1 1
•	rand(M,N)	MxN matrix of uniformly	x = rand(1,3)
		distributed random	x =
		numbers on (0,1)	0.9501 0.2311 0.6068

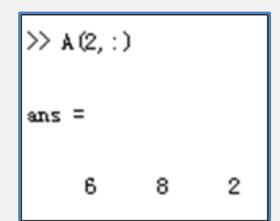
Matrix Index

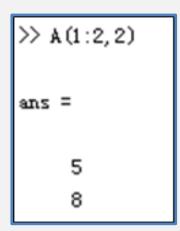
- The matrix indices begin from 1 (not 0 (as in C))
- The matrix indices must be positive integer











A(-2), A(0)

Error: ??? Subscript indices must either be real positive integers or logicals.

A(4,2)

Error: ??? Index exceeds matrix dimensions.

Concatenation of Matrices

```
x = [1 \ 2], y = [4 \ 5], z = [0 \ 0]
A = [x y]
   1 2 4 5
B = [x ; y]
```

C = [x y ; z]

Error using vertcat

Dimensions of matrices being concatenated are not consistent.

Operators (Arithmetic)

- + addition
- subtraction
- * multiplication
- / division
- ^ power
- ' complex conjugate transpose

Matrices Operations

Given A and B:

How about A^2 A/B 2*A A+1j*B (A+1j*B)'

Addition

Subtraction

Product

Transpose

Element-Wise Operators

```
In the previous example, please compare

A^2 v.s. A.^2

A*B v.s. A.*B

(A+1j*B)' v.s. (A+1j*B).'
```

- .* element-by-element multiplication
- ./ element-by-element division
- .^ element-by-element power
- .' transpose

$$x = A(1,:)$$

1 2 3

$$y = A(3, :)$$

3 8 -3

$$c = x . / y$$

C=

0.33 0.5 -3

$$d = x .^2$$

d=

4 9

$K = x^2$

Erorr:

??? Error using ==> mpower Matrix must be square.

 $B=x^*y$

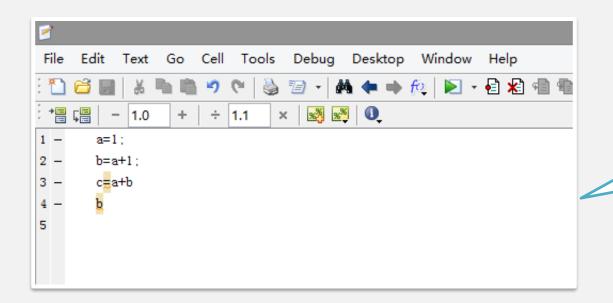
Erorr:

??? Error using ==> mtimes Inner matrix dimensions must agree.

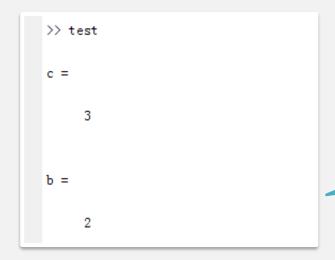
Useful Commands

- >> who
- >> whos
- >> clear
- >> clc
- >> dir
- >> help/doc

Write a Script



Instead of typing in the Command Window, you can write a script in Editor and save in a .m file, like test.m.

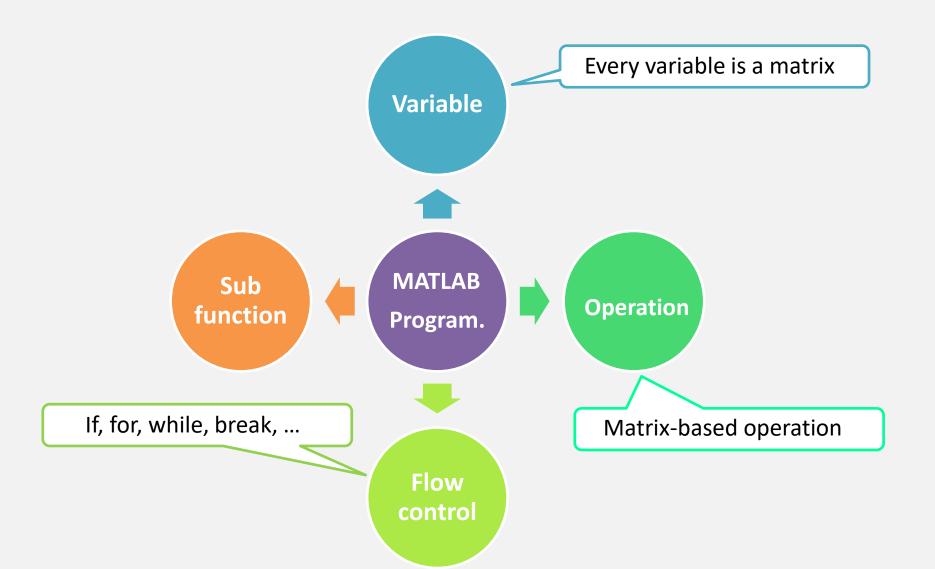


Then, you can run the .m file in **Command** Window. The command in the .m file will be executed one by one (like a batch file).



Run and Debug

Language Overview

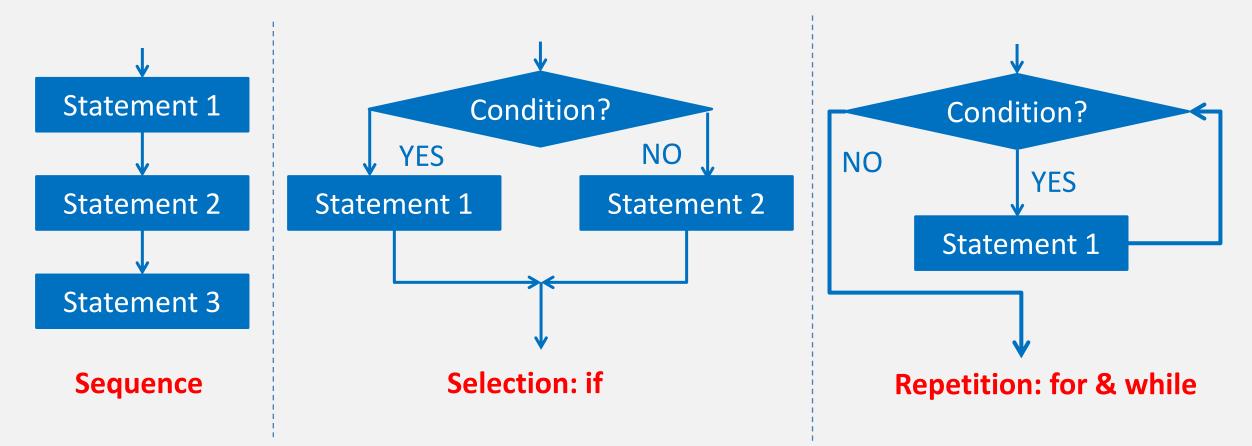




Flow Control

Similar to almost all programming language, MATLAB program has three basic structures:

Sequence, Selection and Repetition



```
if (Condition_1)
      MATLAB Commands
elseif (Condition 2)
      MATLAB Commands
elseif (Condition 3)
      MATLAB Commands
else
      MATLAB Commands
end
```

```
if ((a>3) & (b==5))
   Some MATLAB Commands;
end
if (a<3)
   Some MATLAB Commands;
elseif (b \sim = 5)
   Some MATLAB Commands;
end
if (a<3)
   Some MATLAB Commands;
else
   Some MATLAB Commands;
end
```



Exercise 1.1 Selector.m

Write a script to add '5' to a number if it is greater than '10', else add '10'.

Repetition -- For

for i=Index_Array

MATLAB Commands

end

```
for i=1:100
Some MATLAB Commands;
end
```

```
for j=1:3:200
Some MATLAB Commands;
end
```

```
for m=13:-0.2:-21
Some MATLAB Commands;
end
```

for k=[0.1 0.3 -13 12 7 -9.3] Some MATLAB Commands; end

Repetition --While

while (condition)

MATLAB Commands

end

while ((a>3) & (b==5))

Some MATLAB Commands;

end



Exercise 1.2 Accumulator.m

Write a script to output the sum of numbers from 1 to the number input.

Operators (Logical)

- 1. == Equal to
- 2. ~= Not equal to
- 3. < Strictly smaller
- 4. > Strictly greater
- 5. <= Smaller than or equal to
- 6. >= Greater than equal to
- 7. & And operator
- 8. Or operator
- 9. ~ Not operator

Writing User Defined Functions

- Functions are m-files which can be executed by specifying some inputs and supply some desired outputs.
- The code telling the MATLAB that an m-file is actually a function is

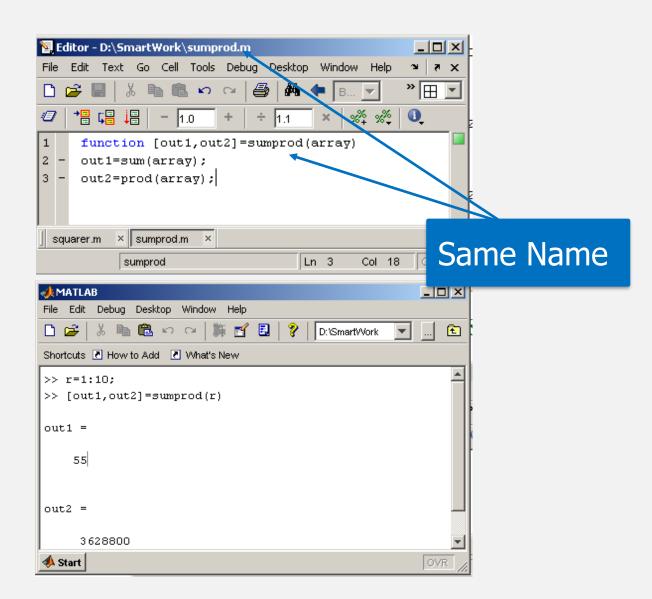
```
function out1=functionname(in1)
function out1=functionname(in1,in2,in3)
function [out1,out2]=functionname(in1,in2)
```

 You should write this command at the beginning of the m-file and you should save the m-file with a file name same as the function name

Writing User Defined Functions

 Another function which takes an input array and returns the sum and product of its elements as outputs

 The function sumprod(.) can be called from command window or an m-file as



Notes

- "%" is the neglect sign for MATLAB (equaivalent of "//" in C).

 Anything after it on the same line is neglected by MATLAB compiler.
- Sometimes slowing down the execution is done deliberately for observation purposes. You can use the command "pause" for this purpose

pause %wait until any key pause(3) %wait 3 seconds

Try to Avoid Loops

- Instead of loops, try to use matrix operators and bulit-in functions.
- Example: let a = [a1 a2 a3] and b=[b1 b2 b3], write a function to calculate

```
c=[a1+b1 a1+b2 a1+b3;
a2+b1 a2+b2 a2+b3;
a3+b1 a3+b2 a3+b3]
```

There are two solutions

```
function c = add1(a,b)
c = zeros(3,3);
for m=1:3
    for n=1:3
        c(m,n) = a(m) + b(n);
    end;
end;
```

```
function c = add2(a,b)
c = diag(a) * ones(3) + ones(3) * diag(b);
```

Test 1



IF (The input number N is an **even integer**)

IF (The input number N is an **odd integer**)

$$Sum=1+3+5+...+N;$$

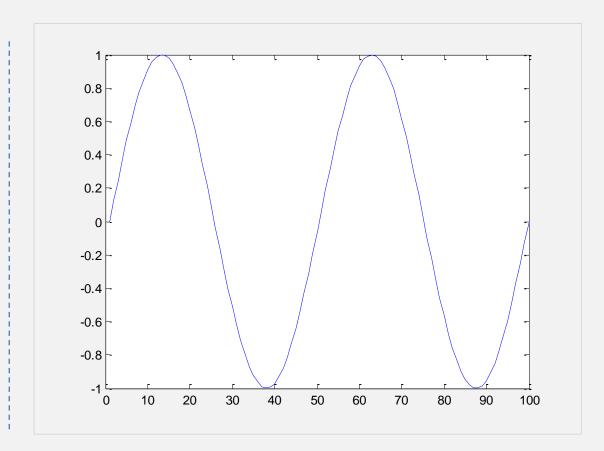
Basic task: Plot the signal sin(x) between $0 \le x \le 4\pi$

• Create an x-array of 100 samples between 0 and 4π .

Calculate sin(.) of the x-array

Plot the y-array

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



Plot the signal $e^{-x/3}\sin(x)$ between $0 \le x \le 4\pi$

• Create an x-array of 100 samples between 0 and 4π .

Calculate sin(.) of the x-array

Calculate e^{-x/3} of the x-array

$$>>y1=exp(-x/3);$$

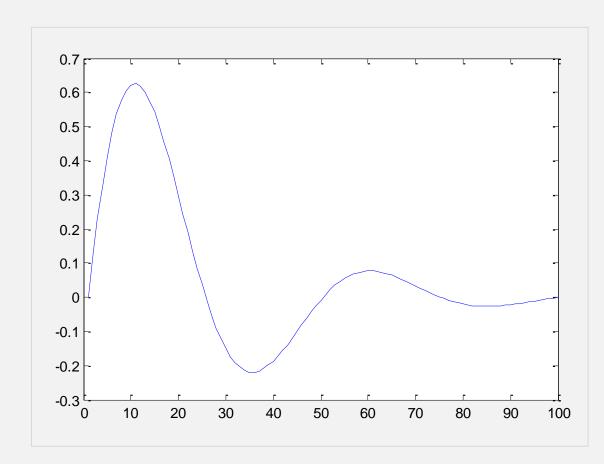
Multiply the arrays y and y1

Plot the signal $e^{-x/3}\sin(x)$ between $0 \le x \le 4\pi$

Multiply the arrays y and y1 correctly

Plot the y2-array

```
>>plot(y2)
>>plot(x,y2)
```



Plot and Stem

```
Example:

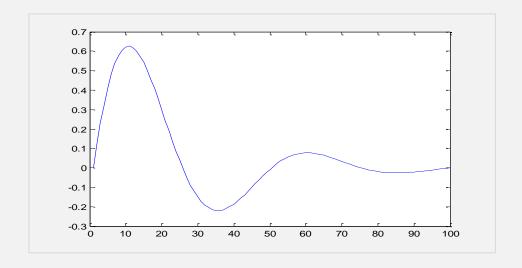
>>x=linspace(0,4*pi,100);

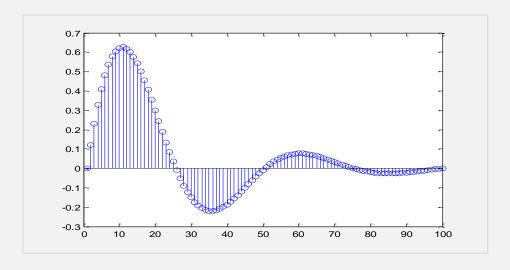
>>y=sin(x);

>>plot(y)

>>plot(x,y)
```

Example: >>stem(y) >>stem(x,y)



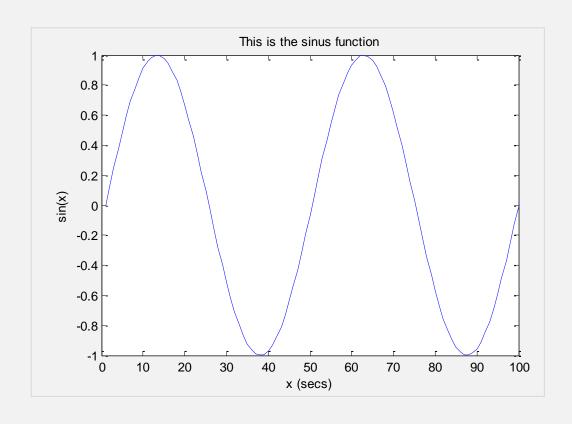


title, xlabel and ylabel

>>title('This is the sinus function')

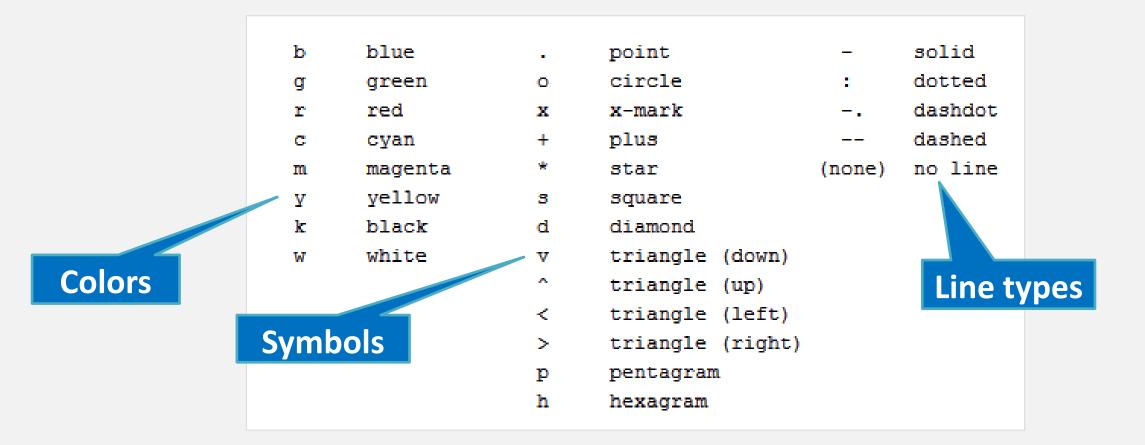
>>xlabel('x (secs)')

>>ylabel('sin(x)')



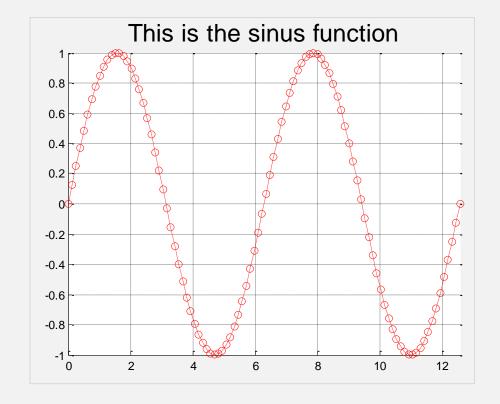
Line types, plot symbols and colors

Plot with various line types, plot symbols and colors



Example

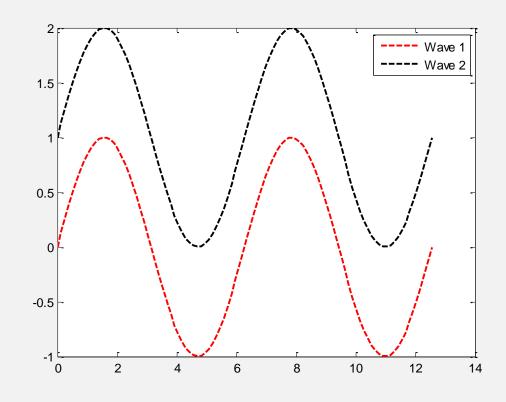
- >> plot(x, y, 'r--o')
- >> title('This is the sinus function','fontsize',20)
- >> grid on
- >> box off
- >> axis([0 4*pi ylim])





More plots in one panel

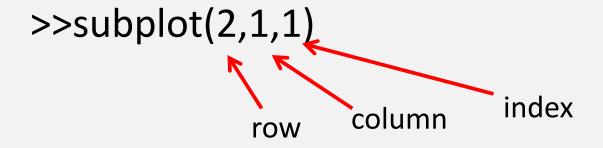
- >> figure(1)
- >> plot(x, y, 'r--', 'linewidth',2)
- >> hold on
- >> plot(x, y+1, 'k--', 'linewidth',2)
- >> legend('wave 1', 'wave 2')



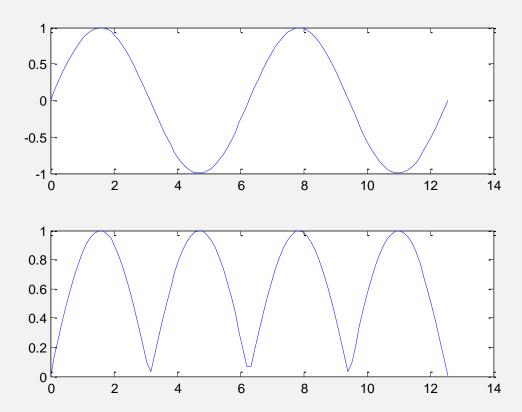


More figures

> Subplot



- >> figure(1)
- >> subplot(2,1,1),plot(x,y)
- >> subplot(2,1,2),plot(x,abs(y))



Some useful functions

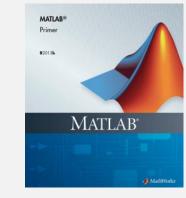
- **≻**length(.)
- >size(.)
- >abs(.)
- > sum(.)
- > mean(.)
- > std(.)
- > diff(.)

```
命令行窗口
  >> help mean
   mean Average or mean value.
      S = mean(X) is the mean value of the elements in X if X is a vector.
      For matrices, S is a row vector containing the mean value of each
      column.
      For N-D arrays, S is the mean value of the elements along the first
      array dimension whose size does not equal 1.
      mean (X, DIM) takes the mean along the dimension DIM of X.
      S = mean(..., TYPE) specifies the type in which the mean is performed,
      and the type of S. Available options are:
      'double'
                  - S has class double for any input X
       'native'
                  - S has the same class as X
      'default'
                - If X is floating point, that is double or single,
                     S has the same class as X. If X is not floating point,
                     S has class double.
      S = mean(..., MISSING) specifies how NaN (Not-A-Number) values are
      treated. The default is 'includenan':
```

To Start with MATLAB

 Work through the built-in tutorial in MATLAB: "Getting Started"

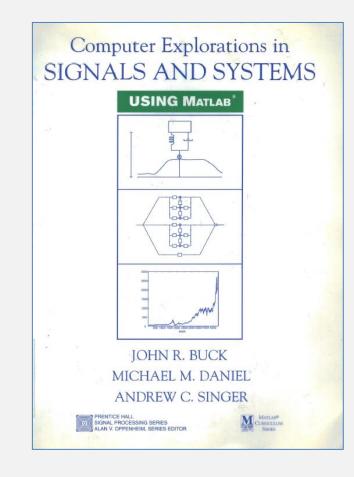
A short introduction: getstart.pdf



 A summary of university-authored MATLAB tutorials in <u>http://www.mathworks.com/academia/student_center/tutorials/launchpad.html</u>

Lab Assignments

- 1.4 & 1.5
- Submit your report.





Question ?

