



Matlab Primer
(CSE)

Buchholz
Gatzhammer

Introduction to Matlab **(CSE)**

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Schedule of the next two days

Matlab Primer
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Thursday, October 18:

09:15 – 12:15 interactive lecture

12:15 – 13:15 lunch break

13:15 – 16:15 supervised individual work

Friday, October 19:

09:15 – 12:15 interactive lecture

12:15 – 13:15 lunch break

13:15 – 16:15 supervised individual work



What is MATLAB® and why do we use it?

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- **Matlab** is a technical computing environment for high-performance numerical computations and visualisation.
 - The name **Matlab** stands for *matrix laboratory*.
 - **Matlab** provides a high-level programming language and an interactive technical computing environment.
-
- Algorithm development
 - Data analysis and visualisation
 - Numerical computations
-
- <http://www.mathworks.com>
 - <http://www.octave.org/> (Free Software)



Courses in CSE using Matlab

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- Scientific Computing Lab
- Numerical Analysis

Industries using Matlab (selection)

- Aerospace
- Automotive
- Bio-chem, Pharmaceutical, Medical
- Communication
- Computers and Office Equipment
- Electronics
- Financial Services
- Semiconductors
- ...



Experience with programming languages

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- Matlab
- C/C++
- Java, C#
- Visual Basic
- Ada
- Pascal
- Fortran
- Mathematica, Maple
- Shell (Unix, dos)
- Perl
- others



Technical Preparations

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```
$ cd #change to your home directory
```

```
$ mkdir slides #directory for matlab intro slides
```

```
$ mkdir matlab #directory to store m-files
```

```
$ firefox & #Open a web browser
```

```
#Download this slides and the example files from the  
course web page
```



Outline Part I

Matlab Primer
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Accessing
MATLAB

Entering
matrices

Matrix
operations

Statements,
expressions,
variables

Mat. building
func.

M-files I

Control
constructs

Scalar func.

Graphics I

- 1 Accessing MATLAB
- 2 Entering matrices
- 3 Matrix operations, array operations
- 4 Statements, expressions, variables; saving a session
- 5 Matrix building functions
- 6 M-files I
- 7 Control constructs: For, while, if
- 8 Scalar functions
- 9 Graphics I



Accessing MATLAB

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Graphics I

```
$ matlab  
>> % do some work  
>> quit
```




Getting help

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Graphics I

Matlab documentation

<http://www.mathworks.com/access/helpdesk/help/techdoc/matlab.html>

Matlab Primer

<http://math.ucsd.edu/~driver/21d-s99/matlab-primer.html>

```
>> help  
>> help demo  
>> help lookfor  
>> help doc
```

command completion

TAB;

previous command

UP;

next command in the history

DOWN;



Entering matrices

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Graphics I

scalar

```
>> n = 8;  
>> n
```

vector

```
>> x = [1 2 3 4 5 6 7 8]
```

matrix

```
>> A = [1 2 3; 4 5 6; 7 8 9]
```

or

```
>> A = [  
1 2 3  
4 5 6  
7 8 9 ];
```



Entering matrices cont.

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Graphics I

```
>> a = [1 2]
>> b = [3 4]
>> B = [a;b]
>> B(1,1) = 5;
>> B
```

load from file

```
>> !echo "1 2 3">C.dat; echo "4 5 6">>C.dat;
echo "7 8 9">>C.dat
>> load('C.dat')
>> D = load('C.dat')
```



Matrix operations, array operations

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Graphics I

```
>> at = a'  
>> A^2  
>> A + B  
>> A * B  
>> A .* B  
>> A.^2  
>> n * A  
>> n + A  
  
>> F = [1 2; 3 4]  
>> c = [2; 2]
```

Exercise 1

Calculate the solution vector x of the the system $Fx = c$. Use the left division operator ' \backslash '. Verify your result.



Statements, expressions, variables; saving a session

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Graphics I

- An **expression** is a combination of values, functions, and variables, that are interpreted (evaluated) according to the rules of matlab.
- A **statement** is the minimal unit of structuring in matlab.
- All **variables** are created dynamically. There is no declaration or definition.

```
>> 1>2  
>> a*b  
>> ans  
>> c1 = c;  
>> ans
```



Statements, expressions, variables; saving a session cont.

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M-files I

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Graphics I

existing variables

```
>> i  
>> j  
>> eps  
>> pi
```

saving a session

```
>> save session1  
>> who  
>> whos  
>> clear  
>> who  
>> load session1  
>> whos  
>> !head session1.mat
```



Matrix building functions

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M-files I

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Graphics I

```
>> E = eye(3)
>> M = rand(3)
>> Z = zeros(3,2)
```

Exercise 2

Build a 6×3 -Matrix out of M, Z and $[1 \ 2 \ 3]'$!



M-files I

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Graphics I

- a sequence of commands can be stored in a script file
- files are called 'M-files' (extension of the files is '.m')
- two types of M-files: script files and function files
- store the M-files in the directory \sim /matlab.
- The script will be executed if you call it in the Matlab command line.

```
>> edit % start the matlab editor
```

Exercise 3

Write your solutions of the previous exercises in M-files and execute them!



Control constructs: For, while, if

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M-files I

**Control
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Graphics I

conditions

```
>> d = 3.7; e = rand(1);  
>> if (e ~= 0.0)  
f = d/e;  
end  
>> e ~= 0.0 % 1 -> true, 0 -> false  
  
>> if (e ~= 0.0)  
f = d/e;  
else  
f = 0;  
end
```



Control constructs: For, while, if cont.

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**Control
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Scalar func.

Graphics I

```
>> if (e < 0.5)
f = -1;
elseif (e > 0.5)
f = 1;
else
f = 0;
end
clear f;
```

loops

```
>> z = [];
for (k=1:10)
z = [z, rand];
end
z
clear z;
```



Control constructs: For, while, if cont.

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**Control
constructs**

Scalar func.

Graphics I

insertion: indent lines

```
z = [];  
for (k=1:10)  
    z = [z, rand];  
end  
z  
clear z;  
  
z = 9.7;  
n = 0.0;  
while (n+1 <= z)  
    n = n + 1;  
end  
n  
clear n z;
```



Control constructs: For, while, if cont.

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breaking loops

```
n = 10;
z = rand(1,n);
l = -1;
for (k=1:n)
    if (z(k)<0.5)
        l = k;
        break;
    end
end
l
clear n z l;
```

Exercise 4

Write an M-file that computes the factorial ($n!$) of a given integer number n !



Scalar functions

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Graphics I

```
>> pi_4 = atan(1.);  
>> sin(pi_4)  
>> exp(1.)
```

insertion: Colon notation

```
>> [1:5]  
>> [1:3:15]  
>> clear x;  
>> x = [1:3:15];  
>> z = rand(1,10);  
>> z2 = z(1:2:10)  
>> clear z z2;
```



Graphics I

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Graphics I

```
>> f = sin(0:0.1:2*pi);  
>> plot(f)  
>> clear f;  
>> z = 0:0.1:2*pi;  
>> f = sin(z);  
>> plot(z,f)  
>> clear f z;  
  
>> plot(sin(0:0.1:2*pi));  
>> hold on  
>> plot(cos(0:0.1:2*pi));  
>> hold off  
>> z = 0:0.1:2*pi;  
>> plot(z,sin(z),'r-',z,cos(z),'b--')  
>> clear z;
```



Graphics I cont.

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Graphics I

```
>> z = -2*pi:0.1:2*pi;  
>> title('Sine and Cosine');  
>> xlabel('angle');  
>> ylabel('value');  
>> legend('sine','cosine');  
>> grid on  
>> axis([-pi pi -1.5 1.5]);  
>> plot(z,sin(z),'r-',z,cos(z),'b--')  
>> clear z;
```

Exercise 5

Work though matlab graphics demo 2-D Plots, Line Plotting,
and Axes Properties!



Outline Part II

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Vector func.

Matrix func.

Mat. notation

Strings,
messages

M-files II

Measure time

Graphics II

- 10 Vector functions
- 11 Matrix functions
- 12 Sub-matrices and colon notation
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- 14 M-files II
- 15 Measuring the execution time: tic and toc
- 16 Graphics II



Vector functions

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Graphics II

```
>> clear all
>> x = [2 8 3 4 -5 -3 7 -1]
>> y = [3 8 2 1 4 11 8 1.2]
>> A = [6 2 3; 1 8 -9]
>> max(x)
>> z = max(x,y)
>> max(A)
>> max(A, [], 1)
>> max(A, [], 2)
>> [v, ii] = max(x', [], 1);
>> v
>> ii
>> x(ii)
>> max(A, 4)
```



Vector functions

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Graphics II

```
>> sum(x)
>> sum(A)
>> sum(A,1)
>> clear z v ii;
```

Exercise 6

Write an M-file that multiplies the elements in the rows of an 3×3 -matrix and stores the results in a new vector!



Matrix functions

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M-files II

Measure time

Graphics II

```
>> B = [x; y]
>> size(B)
>> max(size(B))
>> C = zeros(length(B));
>> whos
>> clear B,C;
>> B = [x(1:3); y(3:2:length(y)); A(2,:)]
>> eig(B)
>> [V,D] = eig(B);
>> V
>> D
>> det(B)
>> rank([x;y;x])
```

Exercise 7

Write an M-file that calculate the inverse of a 3×3 -matrix!
Verify your result!



Sub-matrices and colon notation

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M-files II

Measure time

Graphics II

```
>> B
>> B(1:2,2:3)
>> B(:,1)
>> B(2,:)
>> A
>> A2 = A(1:2,1:2);
>> A(1:2,1:2) = eye(2)
>> A(1:2,1:2) = A2(1:2,1:2);
>> C = [1 3; 2 4]
>> z = C(:)
>> n = B(3)
>> clear n A2 z
```



Text strings, error messages, input

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M-files II

Measure time

Graphics II

```
>> s = 'Hello World!'
>> s(1)
>> s(1:2:length(s))
>> s1 = s(1:6)
>> s2 = s(7:12)
>> s3 = [s1 s2]
>> s4 = [s1; s2]
>> s(1:12) = 'Hi everybody'
>> s = [s4 '!']
>> clear s s1 s2 s3 s4
```



Text strings, error messages, input cont.

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```
>> disp('Hello world!');  
>> disp('The value of pi is:'), disp(pi)  
>> val = input('Please enter a number:')  
>> error('Sorry, the value is out of range!')  
>>
```

Exercise 8

Write a M-file that counts the number of elements between two blanks resp. the begin and the end of a given string!



M-files II (function files)

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M-files II

Measure time

Graphics II

```
function a = square_area(e)
% SQUARE_AREA. Area of a square.
%   SQUARE_AREA(E) is the area of a square.
%   E is the length of a edge.

a = e*e;

% end of square_area

>> area = square_area(2.0)
>> help square_area
```



M-files II (function files) cont.

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M-files II

Measure time

Graphics II

```
function [vol,diag] = cube_info(e,d)
% CUBE_INFO. Volume and length of the diagonal of
% a cube.
%
% [VOLL,DIAG] = CUBE_INFO(E,D) produces the volume
% of a cube VOL and the length of diagonal of the
% cube. Where E is the length of a edge of a
% D-dimensional cube.

vol = e^d;
diag = e * sqrt(d);

% end of cube_info

>> [vol, diag] = cube_info(2.0,3)
>> vol = cube_info(2.0,3)
>> [vol, diag] = cube_info(1.5)
```




M-files II (function files) cont.

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Measure time

Graphics II

```
function [vol,diag] = cube_info(e,d)
% CUBE_INFO. Volume and length of the diagonal of
% a cube.
%
% [VOL,DIAG] = CUBE_INFO(E) produces the volume of
% a cube VOL and the length of diagonal of the cube.
% Where E is the length of a edge of the cube.
%
% [VOLL,DIAG] = CUBE_INFO(E,D) produces the volume
% of a cube VOL and the length of diagonal of the
% cube. Where E is the length of a edge of a
% D-dimensional cube.
...

```



M-files II (function files) cont.

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Matrix func.

Mat. notation

Strings,
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M-files II

Measure time

Graphics II

```
...
if (nargin < 2)
    d = 3;
end

vol = e^d;
diag = e * sqrt(d);

% end of cube_info

>> [vol, diag] = cube_info(1.5)

>> type cube_info
>> type tic
>> type rank
```



Measuring the execution time: tic and toc

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M-files II

Measure time

Graphics II

```
>> for n = 1:100;
    A = rand(n,n);
    b = rand(n,1);
    tic
    x = a\b;
    t(n) = toc;
>> end
>> plot(t)
>> clear n x b A t
```



Graphics II

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Measure time

Graphics II

```
close all
[X,Y] = meshgrid(-10:.2:10, -10:.2:10);
Z = sinsinc(0.0,X,Y);
surf(X,Y,Z);

function f = sinsinc (t,x,y)
r = sqrt(x.^2+y.^2) + eps;
f = cos(t)*sin(r)./r;
```

Exercise 9

Print the surface plot into an eps-file!



Graphics II cont.

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...

```
f1_handle = gcf;  
get(f1_handle);  
a1_handle = gca;  
get(a1_handle);  
get(a1_handle, 'XTick');
```

Exercise 10

Modify the ticks and the corresponding labels of the x-axis, using the command 'set'.



Graphics II cont.

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Measure time

Graphics II

```
n = 15;
inc = 2*pi/(n-1);
M=moviein(n);

for k=1:n
    t = inc*k;
    Z = sinsinc(t,X,Y);

    clf          %clear figure
    surf(X,Y,Z);
    axis([-10 10 -10 10 -1 1])

    colormap(copper)

    M(:,k) = getframe;
    pause
end
```



Graphics II cont.

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Measure time

Graphics II

```
>> movie(M)
>> movie2avi(M,'~/matlab/sinc.avi')
```

Exercise 11

Print the different figures to 'Portable Network Graphic (PNG)' files instead of creating the movie! Modify the name of the file according to the loop index.