Introduction to MATLAB

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MATrix LABoratory
- http://www.mathworks.com
- Advantages of MATLAB
  - Ease of use
  - Platform independence
  - Predefined functions
  - Plotting
- Disadvantages of MATLAB
  - Can be slow
  - Expensive

MATLAB Desktop

MATLAB Basics
- A program can be input
  - command by command using the command line (lines starting with ">") on the MATLAB desktop
  - as a series of commands using a file (a special file called M-file)
- If a command is followed by a semicolon (;), result of the computation is not shown on the command window

MATLAB Basics: Getting Help
- help
  - help toolbox → e.g., help elfun
  - help command → e.g., help sin
- helpdesk, helpwin, "?” button
- lookfor
  - lookfor keyword → e.g., lookfor cotangent
- which
  - which name → e.g., which log
- demo

MATLAB Basics: Scratchpad

2 * 2
\[ \cot(3)\sqrt{\log(3)} + \cos(3)\sin(\log(3)) \]
\[ \cot(2.7)\sqrt{\log(2.7)} + \cos(2.7)\sin(\log(2.7)) \]
\[ \log(\sin(0.5) + \cos(0.5)^2) + \sqrt{\sin(0.5) + \cos(0.5)^2} - (\sin(0.5) + \cos(0.5)^2) \]
MATLAB Basics: Variables

- **Variable** is a name given to a reserved location in memory
  - `class_code = 111;`
  - `number_of_students = 65;`
  - `name = 'Bilkent University';`
  - `radius = 5;`
  - `area = pi * radius^2;`

MATLAB Basics: Variables

- Use meaningful names for variables
- MATLAB variable names
  - must begin with a letter
  - can contain any combination of letters, numbers and underscore (_)
  - must be unique in the first 31 characters
- MATLAB is case sensitive: “name”, “Name” and “NAME” are considered different variables
- Never use a variable with the same name as a MATLAB command
- Naming convention: use lowercase letters

MATLAB Basics: Arrays

- The fundamental unit of data is **array**

```
   column
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
```

```
   scalar value
1
```

```
   vector
-1 40 -3 11
```

```
   matrix
15 -2 3 21
-4 1 0 13
```

MATLAB Basics: Variables

- Initialization using assignment statements
  - `x = 5`
  - `y = x + 1`
  - `v = [ 1 2 3 4 ]`
  - `m = [ 1 2 3; 4 5 6 ]`
  - `n = [ 1 2 3; 4 5 ]`

```
   ?? Error
```

```
   ??? Error
```

MATLAB Basics: Variables

- Initialization using shortcut statements
  - colon operator → first:increment:last
  - `x = 1:2:10`
    - `x = 1 3 5 7 9`
  - `y = 0:0.1:0.5`
    - `y = 0 0.1 0.2 0.3 0.4 0.5`

MATLAB Basics: Variables

- Initialization using built-in functions
  - `zeros()`
    - `x = zeros(2)`
      - `x = [ 0 0 ; 0 0 ]`
  - `ones(), size(), length()`
    - `y = zeros(1,4)`
      - `y = [ 0 0 0 0 ]`

MATLAB Basics: Variables

- Initialization using keyboard input
  - `input()`
    - `value = input('Enter an input value: ')`
      - Enter an input value: 1.25
        - value = 1.2500
    - `name = input('What is your name: ', 's')`
      - What is your name: Selim
        - name = Selim

MATLAB Basics: Subarrays

- Array indices start from 1
  - `x = [-2 0 9 1 4];`
    - `x(2)`
      - ans = 0
    - `x(4)`
      - ans = 1
    - `x(8)`
      - ??? Error

MATLAB Basics: Subarrays

- `y = [ 1 2 3; 4 5 6 ];`
  - `y(1,2)`
    - ans = 2
  - `y(2,3)`
    - ans = 6
  - `y(2)`
    - ans = 4
      - (column major order)
        - (I don’t recommend you to use this form)
  - `y(2,1:2)`
    - ans = 4 5

MATLAB Basics: Subarrays

- `y = [ 1 2 3; 4 5 6 ];`
  - `y(1,:) = [ 4 -1 9 ]`
    - y =
      - 4 -1 9
      - 0 5 6
    - `y(:,2) = [ 3; 2 ]`
      - y =
        - 1 -5 3
        - 4 5 6
      - `y(2,1) = 0`
        - y(2,1) = 0
      - `y(:,2:end)`
        - y(:,2:end) =
          - 3 2

MATLAB Basics: Subarrays

- `x = [-2 0 9 1 4 ];`
  - `x(2) = 5`
    - x =
      - -2 5 9 1 4
  - `x(4) = x(1)`
    - x =
      - -2 5 9 1 4
  - `x(8) = -1`
    - x =
      - -2 5 9 -2 4
      - 0 0 -1
MATLAB Basics: Subarrays

- \( z = [ 1 \, 2 \, 3; \, 4 \, 5 \, 6; \, 7 \, 8 \, 9 ]; \)
- \( z(3,:) = 0 \)
- \( z(2,:) = [ 1 \, 5 ]; \)

\[
\begin{bmatrix}
1 & 2 & 3 \\
4 & 5 & 6 \\
0 & 0 & 0 \\
\end{bmatrix}
\]

\[
\begin{bmatrix}
-2 & 2 & 3 \\
-2 & 5 & 6 \\
-2 & 0 & 0 \\
\end{bmatrix}
\]

MATLAB Basics: Special Values

- \( \pi \): \( \pi \) value up to 15 significant digits
- \( i, j \): \( \sqrt{-1} \)
- \( \text{Inf} \): infinity (such as division by 0)
- \( \text{NaN} \): Not-a-Number (such as division of zero by zero)
- \( \text{clock} \): current date and time as a vector
- \( \text{date} \): current date as a string (e.g. 16-Feb-2004)
- \( \text{eps} \): epsilon
- \( \text{ans} \): default variable for answers

MATLAB Basics: Displaying Data

- Changing the data format
- \( \text{value} = 12.345678901234567 \)
- \( \text{format short} \) → 12.3457
- \( \text{long} \) → 12.34567890123457
- \( \text{short e} \) → 1.2346e+001
- \( \text{long e} \) → 1.234567890123457e+001
- \( \text{rat} \) → 1000/81
- \( \text{compact} \)
- \( \text{loose} \)

MATLAB Basics: Displaying Data

- The \( \text{disp( array) } \) function
- \( \text{disp('Hello');} \)
- \( \text{Hello} \)
- \( \text{disp(5);} \)
- \( 5 \)
- \( \text{disp( ['Bilkent ' 'University']);} \)
- \( \text{Bilkent University} \)
- \( \text{name = 'Selim'; disp( ['Hello ' name]);} \)
- \( \text{Hello Selim} \)

MATLAB Basics: Displaying Data

- The \( \text{num2str()} \) and \( \text{int2str()} \) functions
- \( \text{d = [ num2str(16) 'Feb-' num2str(2004)];} \)
- \( \text{disp(d);} \)
- \( 16-Feb-2004 \)
- \( x = 23.11; \)
- \( \text{disp( ['answer = ' num2str(x)]);} \)
- \( \text{answer = 23.11} \)
- \( \text{disp( ['answer = ' int2str(x)]);} \)
- \( \text{answer = 23} \)

MATLAB Basics: Displaying Data

- The \( \text{fprintf( format, data )} \) function
- \( \%d \) integer
- \( \%f \) floating point format
- \( \%e \) exponential format
- \( \\text{\ln} \) new line character
- \( \\text{\tt} \) tab character
MATLAB Basics: Displaying Data

- fprintf( 'Result is %d', 3 );
  Result is 3
- fprintf( 'Area of a circle with radius %d is %f', 3, pi*3^2 );
  Area of a circle with radius 3 is 28.274334
- x = 5;
- fprintf( 'x = %3d', x );
  x =   5
- x = pi;
- fprintf( 'x = %.2f', x );
  x = 3.14
- fprintf( 'x = %6.2f', x );
  x =   3.14
- fprintf( 'x = %d
  y = %d
', 3, 13 );
  x = 3
  y = 13

MATLAB Basics: Scalar Operations

- variable_name = expression;
  - addition   a + b   \rightarrow   a + b
  - subtraction a - b   \rightarrow   a - b
  - multiplication a * b   \rightarrow   a * b
  - division   a / b   \rightarrow   a / b
  - exponent   a^b   \rightarrow   a ^ b

MATLAB Basics: Scalar Operations

- x = 3 * 2 + 6 / 2
  - x = 9
- Processing order of operations is important
  - parenthesis (starting from the innermost)
  - exponentials (left to right)
  - multiplications and divisions (left to right)
  - additions and subtractions (left to right)
- x = 3 * 2 + 6 / 2
  - x = 9

MATLAB Basics: Built-in Functions

- result = function_name( input );
  - abs, sign
  - log, log10, log2
  - exp
  - sqrt
  - sin, cos, tan
  - asin, acos, atan
  - max, min
  - round, floor, ceil, fix
  - mod, rem
- help elfun

MATLAB Basics: Debugging

- Syntax errors
  - Check spelling and punctuation
- Run-time errors
  - Check input data
  - Can remove ";" or add "disp" statements
- Logical errors
  - Use shorter statements
  - Check typos
  - Check units
  - Ask your friends, TAs, instructor, parents, ...

MATLAB Basics: Useful Commands

- help command \rightarrow\ Online help
- lookfor keyword \rightarrow\ Lists related commands
- which \rightarrow\ Version and location info
- clear \rightarrow\ Clears the workspace
- clc \rightarrow\ Clears the command window
- diary filename \rightarrow\ Sends output to file
- diary on/off \rightarrow\ Turns diary on/off
- who, whos \rightarrow\ Lists content of the workspace
- more on/off \rightarrow\ Enables/disables paged output
- Ctrl+c \rightarrow\ Aborts operation
- \ldots\ \rightarrow\ Continuation
- % \rightarrow\ Comments