Topic 1

Basic MATLAB Tutorial

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1. Basic Commands

- **help command**  
  *get help for a command*

- **clear all**  
  *clears all the memory (workspace)*

- **clear x**  
  *removes variable x from the memory*

- **whos**  
  *lists all the variables (and details) on the workspace*
- Semicolon (;) at the end will suppress the output

- Command history: upper & lower arrows, also command name guess

- If you don’t use a variable name, your calculation is labelled and assigned by ans variable.
2. Data Types

- MATLAB data types are classes.

- Most commonly used types are
  - `double`
  - `char`
  - `logical`

- All of them are considered by MATLAB as arrays.

- Numerical objects belong to the class `double`
  (i.e. double precision array).

- A scalar is treated as a 1 1 array.
3. Variables

- Variable names, which must start with an English Letter.

- MATLAB is case sensitive: 
  `Food` and `food` are different variables

- There are several built-in constants and special variables:

  - `ans`: Default name for results
  - `eps`: Smallest number for which $1 + \text{eps} > 1$
  - `inf`: Infinity
  - `NaN`: Not a number
  - `i` or `j`: $\sqrt{-1}$
  - `pi`: $\pi$
>> eps
ans = 2.2204e-016

>> pi
ans = 3.1416

>> x = 3 + 4i  % complex number
x = 3.0000 + 4.0000i
### 4. Arrays and Matrices

Arrays can be constructed in several ways.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&gt;&gt; A = [5 -3 4 2]</code></td>
<td>Create a 1D array</td>
<td><code>A = 5 -3 4 2</code></td>
</tr>
<tr>
<td><code>&gt;&gt; A = [5, -3, 4, 2]</code></td>
<td>Create a 1D array</td>
<td><code>A = 5 -3 4 2</code></td>
</tr>
</tbody>
</table>
| `>> B = [1 2 3; 4 5 6; 7 8 9]` | Create a 3x3 matrix | `B =
1 2 3
4 5 6
7 8 9` |
| `>> B = [ 1 2 3
4 5 6
7 8 9 ]` | Create a 3x3 matrix | `B =
1 2 3
4 5 6
7 8 9` |
>> 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
5. Cells

- A cell array is a sequence of arbitrary objects

```matlab
>> c = {[1 2 3], 'Hello Everybody', 2 + 7i}
c =  
    [1x3 double]    'Hello Everybody'    [2.0000+ 7.0000i]

>> c{1} % first cell
ans = 1 2 3

>> c{1}(3) % third element of first cell
ans = 3
```
6. Strings (Character Arrays)

- String is a sequence of characters.

```
>> s1 = 'University '
>> s2 = 'of Gaziantep'
>> s3 = strcat(s1,s2)
>> s3
s3 = University of Gaziantep

>> s1(1:5)
ans = Unive

>> s2(8:12)
ans = antep
```
# 7. Some Intrinsic Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>abs(x)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sin(x)</td>
<td>sine of x</td>
<td>(x) is in radian</td>
</tr>
<tr>
<td>cos(x)</td>
<td>cosine of x</td>
<td></td>
</tr>
<tr>
<td>tan(x)</td>
<td>tangent of x</td>
<td></td>
</tr>
<tr>
<td>sind(x)</td>
<td>sine of x</td>
<td>(x) is in degrees</td>
</tr>
<tr>
<td>cosd(x)</td>
<td>cosine of x</td>
<td></td>
</tr>
<tr>
<td>tand(x)</td>
<td>tangent of x</td>
<td></td>
</tr>
<tr>
<td>asin(x)</td>
<td>angle in radian from (\sin^{-1}(x))</td>
<td></td>
</tr>
<tr>
<td>acos(x)</td>
<td>angle in radian from (\cos^{-1}(x))</td>
<td></td>
</tr>
<tr>
<td>atan(x)</td>
<td>angle in radian from (\tan^{-1}(x))</td>
<td></td>
</tr>
<tr>
<td>log(x)</td>
<td>(\ln(x))</td>
<td></td>
</tr>
<tr>
<td>log10(x)</td>
<td>(\log_{10}(x))</td>
<td></td>
</tr>
<tr>
<td>exp(x)</td>
<td>(e^{x})</td>
<td></td>
</tr>
<tr>
<td>mod(x, y)</td>
<td>x modulo y</td>
<td>(\text{mod}(12,5) = 2)</td>
</tr>
</tbody>
</table>
8. Input / Output

User input

```python
>> a = input('birinci sayi: ');
birinci sayi: 2
>> b = input('ikinci sayi: ');
ikiinci sayi: 3
>> c = a + b
 c = 5
```

```python
>> p = input('input an array: ');
input an array: [1 2 3]
>> p'
ans =

1
2
3
```
User output

- Normally MATLAB displays numerical results with about five digits, but this can be changed with the `format` command:

  ```matlab
  format long 16-digit display
  format short 5-digit display
  ```

  ```matlab
  >> pi % default format
  ans = 3.1416
  
  >> format long
  >> pi
  ans = 3.14159265358979
  
  >> format short
  >> pi
  ans = 3.1416
  ```
A simple way of printing values is to use `disp` function:

```
disp(value)
```

```> x = 10;
>> disp(x);
   10

>> y = [1 3 5 7];
>> disp(y)
   1     3     5     7

>> disp(y')
   1
   3
   5
   7

>> disp('University of Gaziantep')
University of Gaziantep```
To print formatted output, one can use `fprintf` function:

\[
\text{fprintf(} \text{format, list) \text{}}
\]

`format` contains formatting specifications

`list` is the list of items to be printed

Typical format specifiers are:

\[
\begin{align*}
\%w & \text{ Integer notation} \\
\%w.d & \text{ Floating point notation} \\
\%w.e & \text{ Exponential notation} \\
\\text{n} & \text{ Newline character (line break)}
\end{align*}
\]

where `w` is the width of the field and

`d` is the number of digits after the decimal point.
>> x = 123.456;
>> i = 1453;

>> fprintf('i = %d ve x = %f\n',i,x)
i = 1453 ve x = 123.456000

>> fprintf('i = %7d ve x = %10.2f\n',i,x)
i = 1453 ve x = 123.46
## 9. Arithmetic Operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Addition</td>
<td>$2 + 4 = 6$</td>
</tr>
<tr>
<td>–</td>
<td>Subtraction</td>
<td>$2 - 4 = -2$</td>
</tr>
<tr>
<td>*</td>
<td>Multiplication</td>
<td>$2 \times 4 = 8$</td>
</tr>
<tr>
<td>/</td>
<td>Right division</td>
<td>$2 / 4 = 0.5$</td>
</tr>
<tr>
<td>\</td>
<td>Left division (we’ll see later)</td>
<td>$2 \backslash 4 = 2$</td>
</tr>
<tr>
<td>^</td>
<td>Exponentiation (x^y)</td>
<td>$2 ^ 4 = 16$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>.*</td>
<td>Element-wise multiplication</td>
</tr>
<tr>
<td>./</td>
<td>Element-wise division</td>
</tr>
<tr>
<td>.^</td>
<td>Element-wise exponentation</td>
</tr>
</tbody>
</table>
>> 3 + 5  \% scalar addition
ans = 8

>> 3 ^ 5
ans = 243

>> 3 / 5
ans = 0.6000

>> 3 \ 5
ans = 1.6667
\begin{verbatim}
>> a = [1 2 3];
>> b = [-2 3 4];
>> a + b  \% vector addition
ans =
   -1    5    7

>> a * b'  \% dot product
ans = 16

>> a.*b  \% element-wise product
ans =
   -2    6   12
\end{verbatim}
>> A = [1 2 3; 4 5 6];
>> B = [7 8 9; 0 1 2];
>> A + B  % matrix addition

ans =
     8    10    12
     4     6     8

>> A * B'  % matrix product

ans =
     50     8
    122    17

>> A.*B  % element-wise product

ans =
     7    16    27
     0     5    12
Comparison Operators

- `<` Less than
- `<=` Less than or equal to
- `>` Greater than
- `>=` Greater than or equal to
- `==` Equal to
- `~=` Not equal to

Logical Operators

- `&` AND
- `|` OR
- `~` NOT
10. Conditional Statements

### If Statement

```plaintext
if condition
    block
end
```

**Executes the block of statements if the condition is true.**

### ElseIf Statement

```plaintext
if condition_1
    block_1
elseif condition_2
    block_2
... else
    block_n
end
```

**Executes the block_i of if the condition_i is true.**

**Otherwise block_n is executed.**

Note that the use of else statement is optional.
a = input('input a: ');
if mod(a,2)==1
    fprintf('%d is odd number\n',a)
else
    fprintf('%d is even number\n',a)
end

>> edit tekmi.m

>> tekmi
input a: 6
6 is even number
>>
% MATLAB script to calculate the 
% roots of f(x) = a x^2 + b x + c
a = input('Input a ');  
b = input('Input b ');  
c = input('Input c ');  
Delta = b*b - 4*a*c;

x1 = ( -b - sqrt(Delta) )/(2*a);  
x2 = ( -b + sqrt(Delta) )/(2*a);

if Delta < 0
    disp('Two imaginary roots:')
    x1, x2
elseif Delta > 0
    disp('Two real roots:')
    x1, x2
else
    disp('One real root:')
    x1
end

>> quadratic
Input a 1
Input b -2
Input c -8
Two real roots:
x1 = -2
x2 = 4

>> quadratic
Input a 1
Input b -4
Input c 4
One real root:
x1 = 2

>> quadratic
Input a 1
Input b 2
Input c 3
Two imaginary roots:
x1 = -1.0000 - 1.4142i
x2 = -1.0000 + 1.4142i

>> edit quadratic.m
11. Loops

while condition
    block
end

Executes the block of statements if the condition is true.

After execution of the block, condition is evaluated again. If it is still true, the block is executed again. The loop is repeated until the condition becomes false.

```matlab
>> edit loop1.m
k = 1;
while k<=6
    fprintf('%d %d
',k,k*k);
    k=k+1;
end

>> loop1
1  1
2  4
3  9
4 16
5 25
6 36
```
This is equivalent to:

```matlab
>> n = 1:5;
>> y = cos(n*pi/10);
>> y
```

```
y =
0.9511  0.8090  0.5878  0.3090  0.0000
```
```
>> x = 0:0.4:2;
>> for i = 1:length(x)
    fprintf('%4.1f %11.6e\n',x(i),log(x(i)))
end

Warning: Log of zero.
  0.0  -Inf
  0.4  -9.162907e-001
  0.8  -2.231436e-001
  1.2  1.823216e-001
  1.6  4.700036e-001
  2.0  6.931472e-001
```
Example: Write a program to find and list all integer (x,y) pairs satisfying the condition |x|+|y|<=3.

```matlab
>> edit pairs.m

for x = -3:3
    for y = -3:3
        if abs(x)+abs(y) <= 3
            fprintf('%d  %dn',x,y)
        end
    end
end

>> pairs
(-3  0)
(-2 -1)
(-2  0)
(-2  1)
(-1  -2)
...
```
**break and continue Statements**

Any loop can be exited by a **break** statement. The **continue** statement allows you to jump to the next iteration.

```matlab
for x = -5:5
    if x == 0
        break
    end
    fprintf('%f  %f
', x, 1/x)
end
```

```matlab
for x = -5:5
    if x == 0
        continue
    end
    fprintf('%f  %f
', x, 1/x)
end
```

>> kes
-5.000000  -0.200000
-4.000000  -0.250000
-3.000000  -0.333333
-2.000000  -0.500000
-1.000000  -1.000000

>> devam
-5.000000  -0.200000
-4.000000  -0.250000
-3.000000  -0.333333
-2.000000  -0.500000
-1.000000  -1.000000
1.000000   1.000000
2.000000   0.500000
3.000000   0.333333
...
References

