# Tutorial: Fundamentals

### Input and output

```
disp('Hello World')
```

```
Hello World
```

```
guess = input('Guess a number from 1 to 100')
```

```
guess = 1
```

### Cleaning up

Removes all varialbes form the workspace

```
clear all
```

Clears the contents of the command window

```
clc
```

Deletes all figures

```
close all
```

### Math operations

```
round(200*2.25/1.5) % Reounds to the nearest integer
```

```
ans = 300
```

### Array operations

Create an array of size 10, where elements are linear-spaced from 1 to 100

```
array = linspace(1, 100, 10)
```

```
array =
     1    12    23    34    45    56    67    78    89   100
```

Array indexing

```
array(1)
```

```
ans = 1
```

```
array(2:4)
```

```
ans =
    12    23    34
```

```
array(2:end)
```

```
ans =
    12    23    34    45    56    67    78    89   100
```

Start at 1, count by 2 and stop when the count reaches the end

```
array(1:2:end)
```

```
ans =
     1    23    45    67    89
```

```
 
```

Start at the last index, count by -2 and stop when the count reaches 1

```
array(end:-2:1)
```

```
ans =
   100    78    56    34    12
```

Select the first, fourth and fifth element of this array:

```
array([1 4 5])
```

```
ans =
     1    34    45
```

Transpose operator

```
array.'
```

```
ans =
     1
    12
    23
    34
    45
    56
    67
    78
    89
```

```
100
```

### Matrix operations

Create a matrix:

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

```
matrix =
     1     2     3
     4     5     6
     7     8     9
```

Get the first element

```
matrix(1, 1)
```

```
ans = 1
```

Extract a submatrix (rows 1 and 2 and columns 1, 2, 3)

```
matrix([1 2], [1 2 3])
```

```
ans =
     1     2     3
     4     5     6
```

Same result:

```
matrix(1:2, 1:3)
```

```
ans =
     1     2     3
     4     5     6
```

Get the third column

```
matrix(:, 3)
```

```
ans =
     3
     6
     9
```

Get all elements of the matrix as an array (arranged in column order)

```
matrix(:)
```

```
ans =
     1
```

```
4
7
2
5
8
3
6
9
```

Above expression is useful, when we compute the sum of all elements in a matrix:

```
sum(matrix(:))
```

```
ans = 45
```

Logical indexing

```
special_index = logical([1 0 0; 0 0 1; 0 0 0])
```

```
special_index = 3×3 logical array
   1   0   0
   0   0   1
   0   0   0
```

```
matrix(special_index)
```

```
ans =
     1
     6
```

Can also be used to assign values

```
matrix(special_index) = [1 6]
```

```
matrix =
     1     2     3
     4     5     6
     7     8     9
```

Linear indexing

```
H = hilb(4)
```

```
H =
    1.0000    0.5000    0.3333    0.2500
    0.5000    0.3333    0.2500    0.2000
    0.3333    0.2500    0.2000    0.1667
    0.2500    0.2000    0.1667    0.1429
```

```
H([2 11])
```

```
ans =
    0.5000    0.2000
```

Linear indexing is useful for extracting a set of pixel values from arbitrary locations e.g., (1,3), (2,4) and (4,3)

```
row_indices = [1 2 4];
column_indicies = [3 4 3];
M_of_H = size(H, 1);
% Computes: linear_indicies = M_of_H * (column_indicies-1) + row_indices
linear_indicies = sub2ind(size(H), row_indices, column_indicies)
```

```
linear_indicies =
     9    14    12
```

```
H(linear_indicies)
```

```
ans =
    0.3333    0.2000    0.1667
```

When a matrix has a large number of 0s, then use a sparse matrix:

```
A = [1 0 0; 0 3 4; 0 0 5]
```

```
A =
     1     0     0
     0     3     4
     0     0     5
```

```
sparse_A = sparse(A)
```

```
sparse_A =
   (1,1)        1
   (2,2)        3
   (2,3)        4
   (3,3)        5
```

```
original_A = full(sparse_A)
```

```
original_A =
     1     0     0
     0     3     4
     0     0     5
```

Important standard arrays:

```
zeros(2, 2)
```

```
ans =
     0     0
     0     0
```

```
ones(2, 2)
```

```
ans =
     1     1
     1     1
```

```
true(2, 2)
```

```
ans = 2×2 logical array
   1   1
   1   1
```

```
false(2, 2)
```

```
ans = 2×2 logical array
   0   0
   0   0
```

```
magic(4)
```

```
ans =
    16     2     3    13
     5    11    10     8
     9     7     6    12
     4    14    15     1
```

```
eye(4) % 4x4 Identity matrix
```

```
ans =
     1     0     0     0
     0     1     0     0
     0     0     1     0
     0     0     0     1
```

```
rand(2, 2) % uniformly distributed in the interval [0 1]
```

```
ans =
    0.0681    0.7898
    0.7452    0.0470
```

```
randn(2,2) % Gaussian distributed
```

```
ans =
    0.3030   -0.3789
   -0.7724    1.5691
```

### Cell arrays

Cell arrays is like  n-tuples. They provide a way to compine a mixed set of objects into a variable.

```
tuple = {1, 'Hello World', 1.3}
```

```
tuple = 1×3 cell array
    {[1]}    {'Hello World'}    {[1.3000]}
```

See the contents of a cell array:

```
celldisp(tuple)
```

```
tuple{1} =

     1


tuple{2} =

Hello World


tuple{3} =

    1.3000
```

Apply a function to each element of the cell array:

```
cellfun('length', tuple)
```

```
ans =
     1    11     1
```

### Structures

Create a struct

```
image_struct.name = 'Lena'
```

```
image_struct = struct with fields:
    name: 'Lena'
```

```
image_struct.image = imread('lena.jpg')
```

```
image_struct = struct with fields:
     name: 'Lena'
    image: [512×512 uint8]
```

Array of structs:

```
image_struct(2).name = 'Festia'
```

```
image_struct = 1×2 struct array with fields:
    name
    image
```

```
image_struct(2).image = imread('festia.jpg')
```

```
image_struct = 1×2 struct array with fields:
```

```
name
image
```

### Reading images

Get detailed information about an image:

```
K = imfinfo('lena.jpg')
```

```
K = struct with fields:
           Filename: '/home/omar/code/cvml/Lab1/lena.jpg'
        FileModDate: '25-Aug-2015 19:39:10'
           FileSize: 155707
             Format: 'jpg'
      FormatVersion: ''
              Width: 512
             Height: 512
           BitDepth: 8
          ColorType: 'grayscale'
    FormatSignature: ''
    NumberOfSamples: 1
       CodingMethod: 'Huffman'
      CodingProcess: 'Progressive'
            Comment: {}
```

Read an image into an array `f`. Note that semicolon is used to supress output

```
f = imread('lena.jpg');
```

Show the row and column dimensions of an image

```
size(f)
```

```
ans =
   512   512
```

Store the dimensions of a 2D image in variables

```
[M, N] = size(f);

M = size(f, 1); % Size of first dimension
N = size(f, 2); % Size of the second dimension
```

A single dimension is any dimension `d` for which `size(array, d)=1`

### Displaying images

Display an image

```
imshow(f)
```

Dynamic range (contrast/brightness) describes the measurement between maximum and minimum values in an image. If an image has low dynamic range, use follow function to scale up the range:

```
imshow(f, [ ])
```

If imshow() function is called again with another image MATLAB replaces the image in the figure window with the new image. To keep the first, we need to use the figure() function, which creates a new Figure window

```
figure()
```

Flip image vertically:

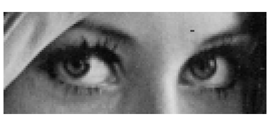
```
vflipped = f(end:-1:1, :);
imshow(vflipped)
```

Flip horizontally:

```
hflipped = f(:, end:-1:1);
imshow(hflipped)
```

Image cropping:

```
imshow(f(240:290, 230:360))
```



Subsampling (resizing) image:

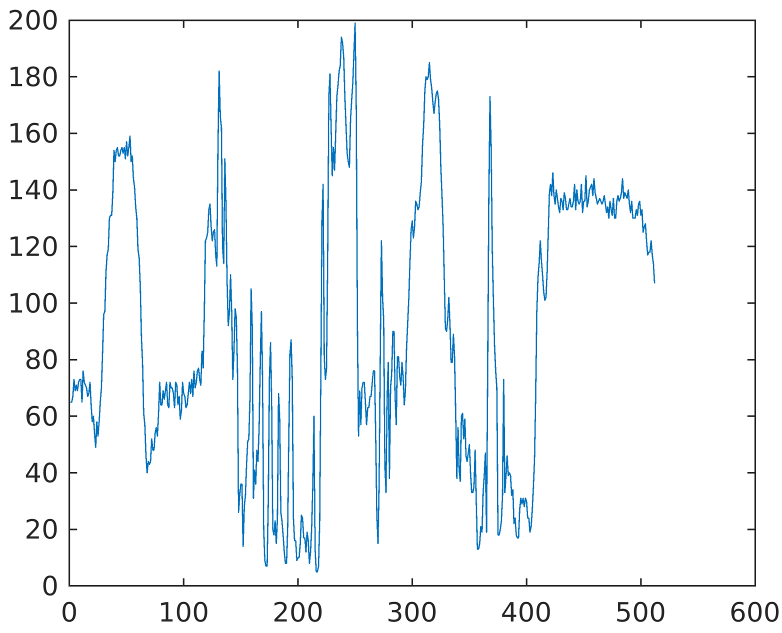
```
imshow(f(1:2:end, 1:2:end))
```

Plot a horizontal scan line through the middle of the image:

```
middle_row = round(size(f, 1) / 2)
```

```
middle_row = 256
```

```
plot(f(middle_row, :))
```



Mark the row that we have plotted:

```
temp = f; temp(middle_row, :) = 255; imshow(temp)
```

Image Tool is more interactive.

```
imtool(f)
```


### Saving images

Save image to current folder

```
imwrite(f, 'newname.jpg', 'quality', 100)
```