Lab 01 - Introduction to Matlab

1. Objective

Introducing students to the Matlab development environment.

2. Theoretical aspects

The following aspects shall be explained

2.1 Matlab Window

Main windows:

- Command line
- Editor
- Workspace

One can write commands directly at Command Line, or write a script file and run it. For one-liners, write them in command line. For longer programs, use a separate script (using a script is the recommended way).

2.2. Scalar-based operations

Define scalar variables:

```
a = 5
```

```
a = 5
```

```
b = 8.4
```

```
b = 8.4000
```

Ending command with a semicolon (;) suppresses the output in the command window. Operation is still executed. Using ; is recommended practice.

```
a = 7
```

```
a = 7
```

```
b = 5;
```

Do arithmetic operations with scalars (+ - * / ^):

```
c = a/b
```

```
c = 0.5952
```

```
d = a^2 + 7*b - 3;
```

Logical operations (comparisons etc):

```
a > b
```

```
ans = logical
   0
```

```
l = (c <= d)
```

```
l = logical
   1
```

Trigonometric functions and predefined constants (`pi`):

```
x = cos(2.5*pi)
```

```
x = 3.0616e-16
```

Other functions (exponential, logarithm, square root etc.):

```
y = exp(x) + log10(7.5/a) + sqrt(44)
```

```
y = 7.6632
```

2.3 Array-based operations (vectors / matrices)

Define arrays with [...]:

```
V = [1, 2, 3, 4, 5]                % V is a vector (values arranged in a row)
```

```
V = 1×5
     1     2     3     4     5
```

```
A = [1, 2, 3;  4, 5, 6; 7, 8, 9]   % A is a matrix. Each row ends with ;
```

```
A = 3×3
     1     2     3
     4     5     6
     7     8     9
```

Create matrices full of 0 or 1 with functions `zeros()` and `ones()`:

```
A = zeros(3,5);         % Make a matrix of size 3x5 full of zeros
B = ones(1, 1000);      % Make a vector of 1000 elements all equal to 1
C = 7*ones(1, 20000);   % Make a vector of 20000 elements equal to 7
```

Defining vectors via start:step:stop or `linspace()`:

```
D = 7 : 0.01 : 10;               % Make a vector going from 7 to 10 with steps of 0.1
E = linspace(10, 100, 50);  % Make a vector going from 10 to 100 in 50 equal steps
```

Array indexing, access to elements, modifying some values

Note: indexing starts at 1, not 0 like in C/Java/Python etc. First element of a vector is V(1)

```
A(2,3) = 55;
V(2) = 4;
i = 3;   V(i) = 56.789;
V2 = V(3:5)                 % Take from V only from 3rd element to 5th element
```

```
V2 = 1×3
   56.7890    4.0000    5.0000
```

```
V3 = V(3:end)               % Take from V only from 3rd element to the end
```

```
V3 = 1×3
   56.7890    4.0000    5.0000
```

Select rows or columns from a matrix:

```
A = [1,2,3;   4,5,6;   7,8,9];  % Let's make a matrix
Apartial = A(1,:)           % Take from A row 1 and columns all. Result is a row vector.
```

```
Apartial = 1×3
     1     2     3
```

```
Ap2      = A(:,2)           % Take from A rows all and column 2. Result is a column vector.
```

```
Ap2 = 3×1
     2
     5
     8
```

```
Asmall   = A(1:2, 1:2)      % Take from A rows 1 to 2, columns 1:2.
```

```
Asmall = 2×2
     1     2
     4     5
```

```
                            % Result is a 2x2 submatrix from upper-left corner of A.
```

Arithmetic operations with arrays:

```
A = [1, 2, 3];
B = [3, 3, 4];
C = [1, 1, 1;    2, 2, 2;    3, 3, 3]
```

```
C = 3×3
     1     1     1
     2     2     2
     3     3     3
```

```

D = A+B;    % sum of two vectors = a vector
E = A*C;    % 1x3 vector multiplied with 3x3 matrix
F = C*B'    % ' means "transposed". Multiply a 3x3 matrix with a 3x1 column vector
```

```
F = 3×1
    10
    20
    30
```

```
CC  = C*C;
CC2 = C^2;     % A^2 = A*A = matrix multiplication A with A
```

Broascasting:

```
V = A + 3;   % A is a vector, 3 is expanded to correct size, result is also a vector
```

Element-wise operations (.^):

```
Z = A.^2   % .^ means square operation is applied to each individual element
```

```
Z = 1×3
     1     4     9
```

```
Y = C.^2   % .^2 means every element is raised to power 2. The shape of Y is the same as of C.
```

```
Y = 3×3
     1     1     1
     4     4     4
     9     9     9
```

Logical operations (comparisons etc) with arrays

```
a = (A > 2);   % Each element is compared
```

Functions applied to arrays (trigonometric, mathematical functions, length/min/max/sum, etc)

```
A = 0:0.1:(4*pi);   % A vector going from 0 to 4pi
X = sin(A);         % X is a vector. sin() is applied to every element of A
Y = sqrt(A);
S = sum(A);         % sum of vector
minval = min(A)
```

```
minval = 0
```

```
maxval = max(A)
```

```
maxval = 12.5000
```

```
len  = size(A)      % Return size of A, i.e. [1, 126]     (1 row, 126 columns)
```

```
len = 1×2
     1   126
```

```
len1 = size(A,2)    % Return size of A along second dimension (126)
```

```
len1 = 126
```

Concatenation of arrays

```
A = [1,2,3];
B = [4,5,6];
C = [A, B]           % A is joined on the right side with B => C is [1,2,3,4,5,6]
```

```
C = 1×6
     1     2     3     4     5     6
```

```
D = [A; B]           % A is joined on the lower side with B => D is a matrix with two rows
```

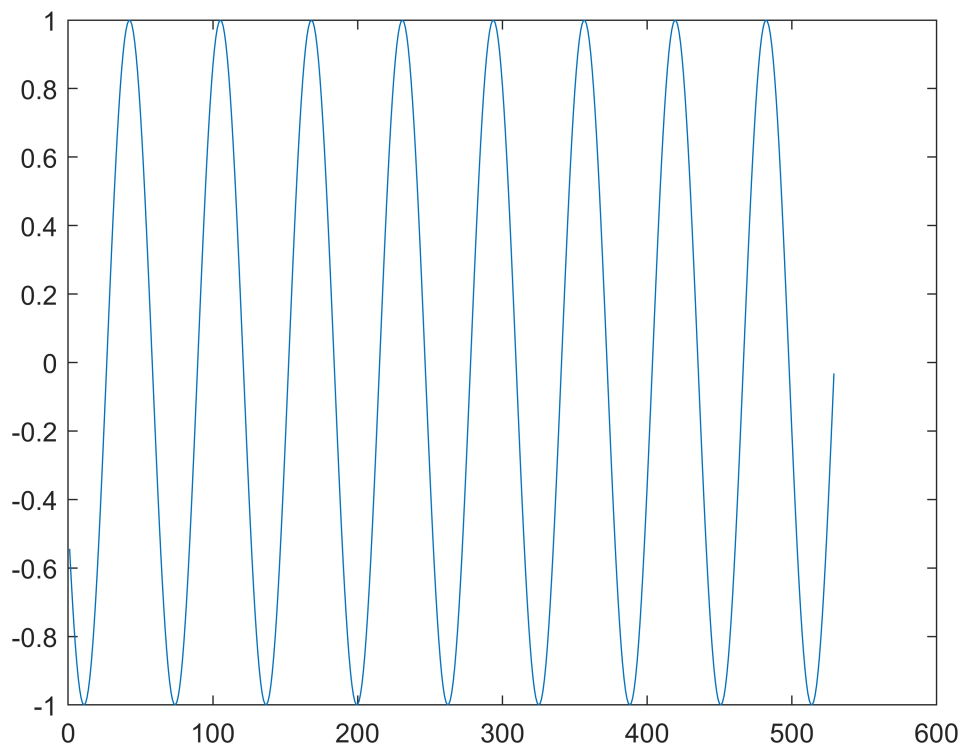
```
D = 2×3
     1     2     3
     4     5     6
```

```
E = [A, zeros(1,10)]  % E is A with 10 values of 0 appended at the end
```

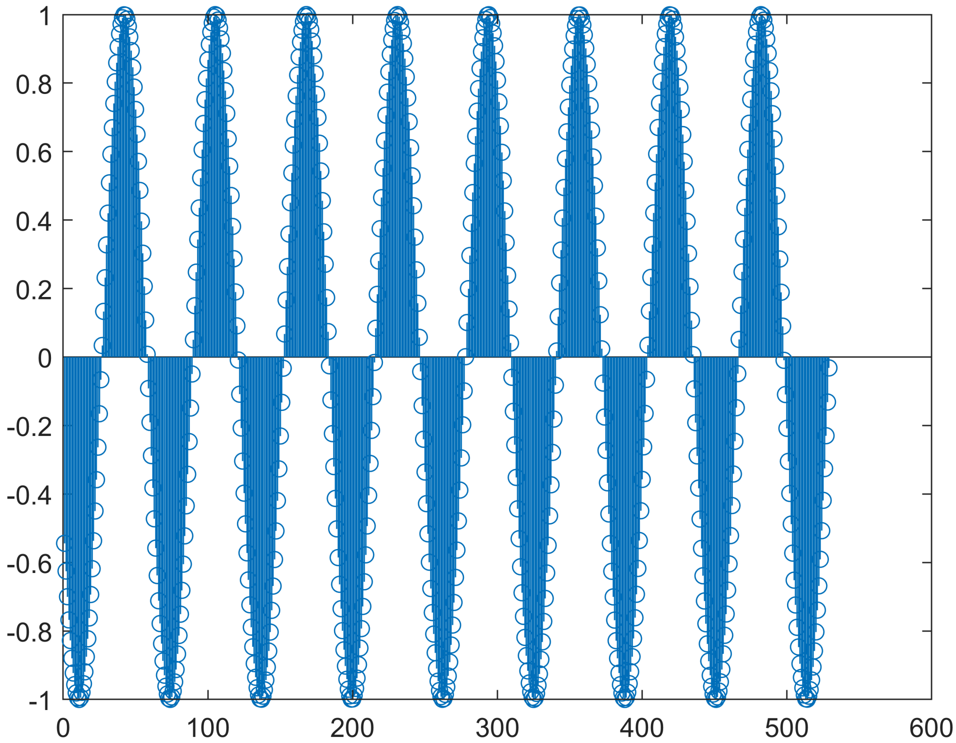
```
E = 1×13
     1     2     3     0     0     0     0     0     0     0     0     0     0
```

Graphical representation of a vectors with `plot()` and `stem()`:

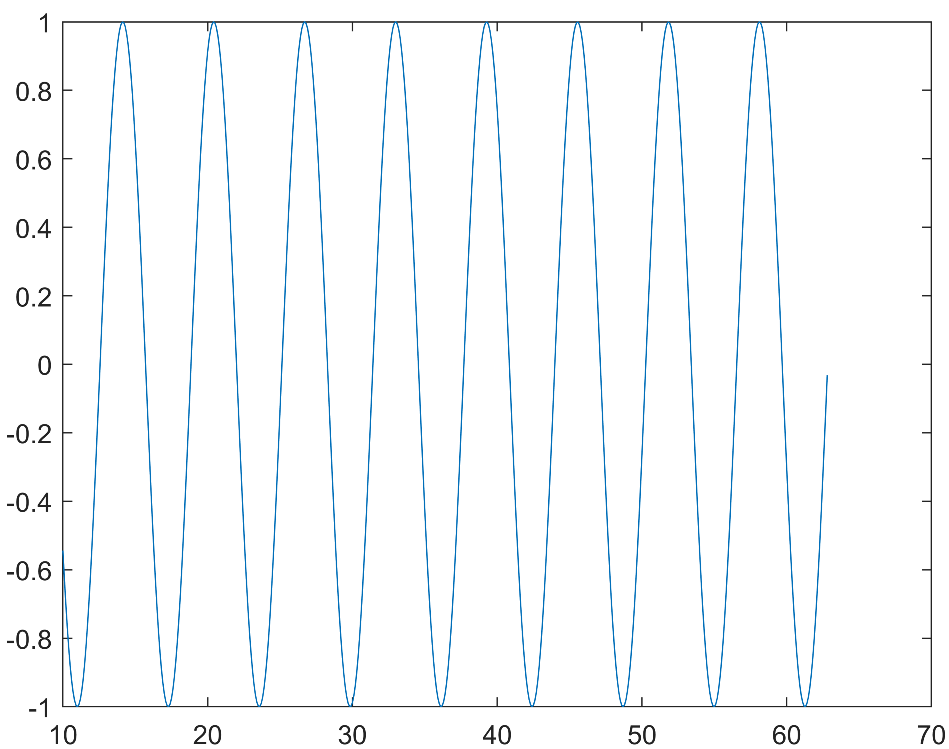
```
A = 10:0.1:(20*pi);   % A vector going from 0 to 4pi
X = sin(A);           % X is a vector. sin() is applied to every element of A
plot(X)       % Use plot() to display values like a continous function
```




```
stem(X)       % Use stem() to display values with vertical sticks, like a discrete signal
```




```
plot(A, X)    % Like plot(X), but puts values in A on the Ox axis
```



2.4 Keywords

If-then

```
a = sqrt(123)
```

```
a = 11.0905
```

```
if (a >= 10)
    b = 15;
end

a = sqrt(123)
```

```
a = 11.0905
```

```
if (a >= 10)
    b = 15;
    c = 66;
else
    c = 'ala bala portocala';   % c is a string
end
```

While:

```
a = 5;
i = 0
```

```
i = 0
```

```
while (a < 20)
    a = a + 0.2;
    i = i + 1;
end
fprintf('It took %d loops for a to exceed 20', i);
```

```
It took 76 loops for a to exceed 20
```

For:

```
for i = 1 : 10
    V(i) = i+1;
end

for i = 100:-1:7
    fprintf("%d",i);
end
```

```
10099989796959493929190898887868584838281807978777675747372717069686766656463626160595857565554535251504948474645444
```

3. Exercises

1. Define two variables $a = 5$ and $b = 0.3$ and compute $a + b$, $\frac{a}{b}$, a^b, $e^{a+ln(b)}$, $sin(a) + cos(b + \frac{\pi}{2})$

2. Define a vector A with 10 zeros, a matrix B of size 4×6 with all elements equal to 1, and a vector C with odd numbers from 1 la 21 (both included).

- Change the third element of A to 5
- Change element B(2,4) to 7
- Square all the elements of C, and save the result as a new vector D.
- Compute E = 4C - 50.
- Compare element-wise the vectors C and E. How many elements of C are larger than the corresponding elements from E? (use functions to calculate this, don't just count it yourselves)
- Apply sin() to all the elements of D

3. Define a vector t with 1000 elements uniformly spaced between 0 and 10. Compute and plot $\cos(2\pi ft)$, where f = 0.5.

4. Plot the signal $\sin(2\pi ft + \frac{\pi}{4})$, with f = 0.2, for a duration of 3 periods.

4. Final questions

1. TBD