Vectors, Scripts, and Plots in Matlab

- This section introduces fundamental features and capabilities of MATLAB as related to numerical methods.
- These range from vector and matrix operations to plotting functions and sets of data.
- We will discuss several MATLAB built-in functions (commands) and their applications, as well as preparing user-defined functions to perform specific tasks.

Built-In Functions

in the command window type

```
>> sin(pi/2)
>> exp(2)
```

```
>> sqrt(5)
```

Note: In Matlab anything that comes in a line after a % is a comment.

Vectors

- In Matlab, the basic objects are matrices, i.e. arrays of numbers. Vectors can be thought of as special matrices.
- A row vector is recorded as a $1 \times n$ matrix and a column vector is recorded as a $m \times 1$ matrix.

To enter a row vector in Matlab, type the following in the command window:

```
>>   v = [1 2 3 4]
```

Note: Commas may be used instead of spaces between elements.

For column vectors, the elements must be separated by semicolons.

```
>> w = [1 ; 2; 3; 4]
```

Note: Arrays of numbers with equal spacing can be created more effectively. For example, a row vector whose first element is 2, its last element is 17, with a spacing of 3 is created as

```
>> v = [2:3:17] or >> v = 2:3:17
```

To create a column vector with the same properties:

```
>> w = [2:3:17]'
```

Any component of a vector can be easily retrieved.

```
>> v(4)
```

Option 2: `linspace`

Another way to create vectors with equally spaced elements is by using the `linspace` command.

6 equally-spaced points between 1 and 10

```
>> x = linspace(1,10,6)
```

Note: The default value for the number of points is 100.

Matrices

A matrix can be created by using brackets enclosing all of its elements, rows separated by a semicolon.

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

An entry can be accessed by using the row and column number of the location of that entry.

```
>> A (2,1)
```

An entire row or column of a matrix is accessed by using a colon.

2nd row of A

```
>> A(2,:)
```

3rd column of A

```
>> A(:,3)
```

To replace an entire column of matrix A by a given vector v, we proceed as follows.

```
>> v = [1;0];
>> A_new = A; % Pre-allocate
              % the new matrix
>> A_new(:,2) = v % Replace the
                  % 2nd column with v
```

Now try:

```
>> B_new = [A v]
```

Next, try the commands:

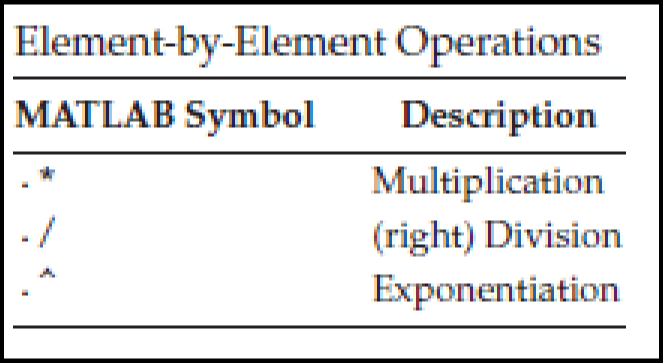
```
>> zeros(5)
>> zeros(5,2)
>> ones(3)
>> ones(3,2)
```

Now, explore the commands:
`length` and `size`

Element-by-Element Operations

Suppose we want to raise each element of a vector to power of 2.

```
>> x = linspace(0,10,6)
>> x.^2
```



Element-by-Element Operations

MATLAB Symbol	Description
.*	Multiplication
./	(right) Division
.^	Exponentiation

Plots

Plotting a vector of values versus another vector of values is done by using the `plot` command.

```
>> x = linspace(1,10,20);
>> y = x.^2;
>> plot(x,y,'*')
```

Check: `>> help plot` and `help hold`

Script Files

- A script file comprises a list of commands as if they were typed at the command line.
- Script files can be created in the MATLAB Editor, and saved as an M file.
- When the script file is executed (run), MATLAB executes the commands.
- Next, create a mfile with

```
x = linspace(0,1)
x2 = x .^2;
x3 = x .^3;
x4 = x .^4;
plot (x,x,'k ',x,x2 ,'b ',...
    x,x3,'g', x,x4 ,'r')
```

To increase happiness, write a well-commented script program that graphs the functions $\sin x, \sin 2x, \sin 3x$, and $\sin 4x$ on the interval $0, 2\pi$ on **one plot**. (π is pi in Matlab.) Use a sufficiently small step size to make all the graphs smooth.

Matlab functions

- The function can be a simple single mathematical expression or a complicated and involved series of calculations.

Generic structure of a matlab function

```
function [output variables] = FunctionName(input variables)
% Comments

Expressions/statements

Calculation of all output variables

end
```

* The first executable line in a function file must be the function definition line.

```
function [output arguments] = function_name(input arg.)
function y = myfunc (x)
% Computes the function
%             2x^2 -3x +1
% Input : x -- a number or vector;
% for a vector the computation
% is elementwise
% Output : y -- a number
% or vector of the
% same size as x
y = 2*x.^2 - 3*x + 1;
end
```

- Whenever you write code, it is a good practice to add comments that describe the code.
- Comments allow others to understand your code, and can refresh your memory when you return to it later.
- Add comments using the percent (%) symbol.

To increase happiness, let’s write a function (name it FtoC) that converts temperature in degrees F to temperature in degrees C.
(Hint: C=5*(F-32)/9;)

Now try: Write a function to calculates the area and the circumference of a circle of a given radius.

Remark:

- If there are more than one, the input arguments are separated with commas.
- The function body contains the computer code that actually performs the computations.
- The code can use all MATLAB programming features.
- This includes calculations, assignments, any built-in or user-defined functions, flow control (conditional statements and loops), comments, blank lines.

In general, the best way to use a function is to capture the result it returns and then use or print this result.

Anonymous function

- An anonymous function offers a way to create a function for simple expressions with or without creating an M file.
- Anonymous functions can only contain one expression and cannot return more than one output variable.
- They can either be created in the Command Window or as a script.

```
My_function = @(arguments)(expression)
```

Let's create a function to evaluate

$$\alpha = \sqrt{(1 + e^{(-bx/2)})}$$

```
>> alpha = @(b,x)(sqrt(1+exp(-b*x/2)))
>> alpha(1,2)
```

HW: Read about `inline` function.

Program Flow Control

Program flow can be controlled with the following three commands:
`for`, `if`, and `while`.

`for` Loop

A `for/end` loop repeats a statement, or a group of statements, a specific number of times. Its generic form is

```
for i = first:increment:last,
    statements...
end
```

1. The index `i` assumes its first value
2. all statements in the subsequent lines are executed with `i = first`, then the program goes back to the `for` command

3. `i` assumes the value
   `i = first + increment` and the process continues until the very last run corresponding to `i = last`.

Ex. Write a script to generate a 5×5 matrix A with diagonal entries all equal to 1, and super diagonal entries all equal to 2, while all other entries are zero.

`if` Command

The most general form of the `if` command is
Its generic form is

```
if condition 1
    set of expressions 1
else if condition 2
    set of expressions 2
else
    set of expressions 3
end
```

The simplest form of a conditional statement is the `if/end` structure. For example

```
x = 3;
my_func = @(x)(x^2+5*x-6);
if my_func(x) ~=0
    disp('x is not a root')
end
```

The `if/else/end` structure
allows for choosing one group of expressions from two groups.

```
x = 1;
my_func = @(x)(x^2+5*x-6);
if my_func(x) ~=0
    disp('x is not a root')
else
    disp('x is a root :)')
end
```

`while` Loop

A `while/end` loop repeats a statement, or a group of statements, until a specific condition is met.
Its generic form is:

```
while condition
    statements
end
```

Ex. Write a script to generate a 5×5 matrix A with diagonal entries all equal to 1, and super–diagonal entries all equal to -3, while all other entries are zero, this time with the aid of the while loop.

To increase the happiness, write a script file that employs any combination of the flow control commands to generate

$$\begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 2 & 0 & -1 \\ -7 & 0 & 3 & 0 \\ 0 & -7 & 0 & 4 \end{bmatrix}$$

Reference