1. MATLAB ENVIRONMENT

Characteristics

- Matrix oriented computing and graphical environment
- COMMAND window, FIGURE window, EDIT window
- Conversational and programming style, environment initialization
- Possibilities of data export and import, the use of toolboxes, simulation

1.1 Conversational Computational Mode

Notes to basic commands:

1. Command ended by a semicolon $\Longrightarrow$ store of a variable without its visualization
2. Return to previously written commands $\Longrightarrow$ up-arrow key
3. Help (help, help ⟨*command*⟩, lookfor ⟨*key*⟩, ...) and DOS commands (dir,...)
4. Visualization of variables (whos), delete of variables (clear ⟨*list*⟩)
5. The use of standard variables: pi, eps, i, j

```
%%% Example 1.1: Plot of a function f(x) for x=a,a+h,..,b
>>  a=0; b=20; h=0.1;
>>  x=a:h:b; f1=sin(x);
>>  plot(x,f1);
>>  xlabel('x'); ylabel('y'); title('SIN(X)');
```

1.2 Matrix and Vector Operations

Basics of the work with matrices:

1. The necessity of the use of correct dimensions of matrices and vectors
2. Selected operations (transposition, multiplication, inversion)

```
%%% Example 1.2: Solution of the set of linear equations A x = b
>>  A=[1 2 3; 4 5 6; 7 8 1];
>>  b=[6 15 16]';
>>  x=inv(A)*b
```

1.3 Programming Computational Mode

The style of work in EDIT and COMMAND window:

1. Opening of the EDIT window
2. Selection of commands - programming
3. Save of the final programme under a selected name
4. Start of the programme from the COMMAND window

```
%%% Example 1.3: Plot of a function f(x) for x=a,a+h,..,b
>>  sem1prog  % Programme call
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% SCRIPT SEM1PROG.M %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
  a=0; b=20; h=0.1;
  x=a:h:b; f2=abs(cos(x));
  plot(x,f2);
     xlabel('x'); ylabel('y'); title('ABS(COS(X))')
```

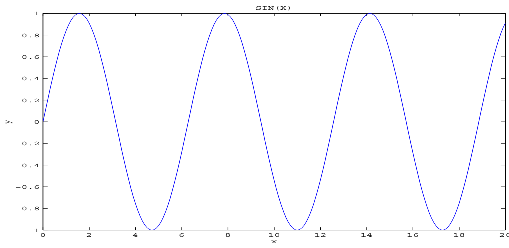
COMMANDS

PLOT
XLABEL
YLABEL
TITLE

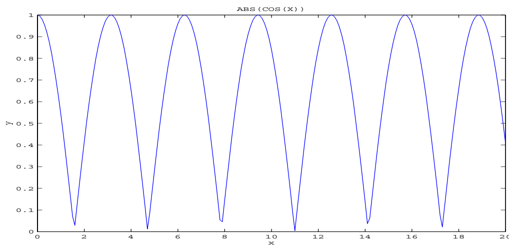
SIN
COS
ABS

INV

Solution of Examples



$$\mathbf{A} = \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 1 \end{pmatrix} \quad \mathbf{b} = \begin{pmatrix} 6 \\ 15 \\ 16 \end{pmatrix} \quad \mathbf{x} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$$



EXAMPLES 1

1.1 Evaluate and plot function f(x)=exp(x) for $x \in \langle a, b \rangle$ and step h (a=0, b=2, h=0.2)

1.2 Evaluate and plot function f(x)=log(x) for $x \in \langle a, b \rangle$ and step h (a=0.1, b=5, h=0.1)

1.3 Solve the system of equations A x = b pro A=[1 2; 3 3]; b=[5; 7];

2. BASIC OPERATIONS

Operators

- arithmetic: matrix: `+,-,*,/,^,'`
  vector: `,.*,./,.^,.'` (element-by-element operations)
- relational: `>,>=,==,=~,<,<=`
- logical: `&,|,~`

2.1 Assignment Commands

⟨*variable*⟩=⟨*expression*⟩

```
%%% Example 2.1: Operations with vectors
>>  v=[1 2 3 4];
>>  r1=v*v'
>>  r2=v.*v
>>  r3=v'*ones(1,4)
%%%
%%% Example 2.2: Relational expressions
>>  s1=3>5
>>  s2=3<5
%%% Example 2.3: Matrix operations
>>  A=[1 2; 3 4]
>>  b=[1 2]
>>  C=[A, b';[1 1 1]]
```

Solution

$$v = \begin{pmatrix}1 & 2 & 3 & 4\end{pmatrix}$$

$$r1 = 30$$

$$r2 = \begin{pmatrix}1 & 4 & 9 & 16\end{pmatrix}$$

$$r3 = \begin{pmatrix}1 & 1 & 1 & 1\\ 2 & 2 & 2 & 2\\ 3 & 3 & 3 & 3\\ 4 & 4 & 4 & 4\end{pmatrix}$$

$$s1 = 0, \quad s2 = 1$$

$$A = \begin{pmatrix}1 & 2\\ 3 & 4\end{pmatrix}, \quad b = \begin{pmatrix}1 & 2\end{pmatrix}$$

$$C = \begin{pmatrix}1 & 2 & 1\\ 3 & 4 & 2\\ 1 & 1 & 1\end{pmatrix}$$

2.2 Functions

Function categories:

1. Scalar: SIN, COS, EXP, LOG, ...
   $\Longrightarrow$ function is applied to each matrix element
2. Vector: SUM, MIN, MAX, MEAN, STD, ...
   $\Longrightarrow$ function is applied for each matrix column
3. Matrix: INV, DET
   $\Longrightarrow$ function is applied for the whole matrix

```
%%% Example 2.4: Functions
>>  A=[1 2;4 5];
>>  f1=sin(A)  % scalar function
>>  f2=sum(A)  % vector function
>>  f3=det(A)  % matrix function
%%%
%%% Example 2.5: Special functions
>>  z1=zeros(2,3)
>>  z2=ones(1,3)
>>  z3=rand(4,3)
>>  plot(z3);  title('PLOT OF MATRIX R=RAND(4,3)')
```

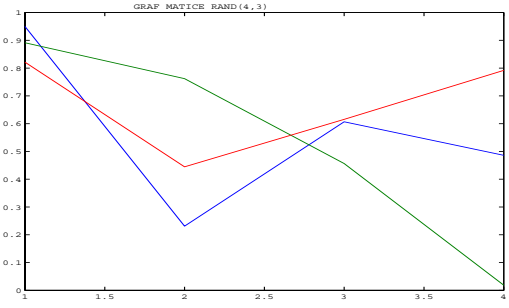
Solution

$$A = \begin{pmatrix}1 & 2\\ 4 & 5\end{pmatrix}$$

$$f1 = \begin{pmatrix}0.8415 & 0.9093\\ -0.7568 & -0.9589\end{pmatrix}$$

$$f2 = \begin{pmatrix}5 & 7\end{pmatrix}$$

$$f3 = -3$$



COMMANDS

EXP
SUM
MIN
MAX
DET
ONES
ZEROS
RAND

EXAMPLES 2

2.1 Define matrix A=[1 1.1 1.2;1.5 1.7 1.9; 2.1 2.4 2.7] and evaluate
- mean values of its rows and columns
- minimum and maximum values of the whole matrix
- determinant of the given matrix

2.2 Apply function HIST for the study of distribution of values v=RAND(1,N) assuming their number N=100, 500, 1000. Plot resulting random values by function PLOT (apply key ZOOM IN as well)

3. CONTROL COMMANDS

3.1 Loop Commands

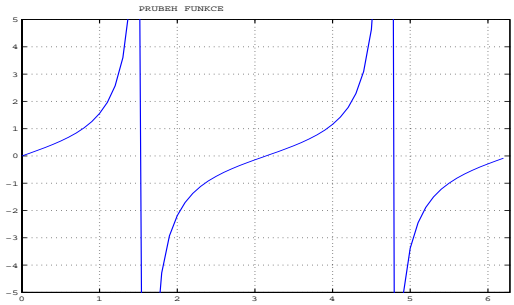
for $\langle variable \rangle = \langle expression \rangle$
    $\langle commands \rangle$
end

```
%%% Example 3.1: Evaluate the approximate value of integral of function
%%%   f(x)=sin(x) in limits a=0, b=20 for N=20 its parts
%%%   using rectangular rule:
%%%     Q ~ h*sum(f(x(i)) pro x(i)=a+(i-1)*h, i=1,2,...,N
%%%
    a=0; b=20; N=20; h=(b-a)/N;  % Definition of given values
    x=a:h:b; f=sin(x);           % Evaluation of function values
% Standard algorithm for the evaluation of the sum of given values
    S=0;
    for i=1:N;
       S=S+f(i);
    end;
    Q1=S*h
% Compressed algorithm for the evaluation of the sum of given values
    Q2=sum(f(1:N))*h
```

3.2 Decision Structures

if $\langle relational\_expression\_1 \rangle$
    $\langle commands\_1 \rangle$
elseif $\langle relational\_expression\_2 \rangle$
    $\langle commands\_2 \rangle$
else
    $\langle commands\_3 \rangle$
end

```
%%% Example 3.2: Plot of the given function in selected limits
%%%
    a=0; b=2*pi; h=0.1; x=a:h:b;
    k=menu('FUNCTION','Sin(x)','Cos(x)','Tan(x)');
    if k==1
      plot(x,sin(x))
    elseif k==2
      plot(x,cos(x))
    else
      plot(x,tan(x)); axis([0 2*pi -5 5]);
    end
    grid on
```



COMMANDS

FOR-END
IF-ELSEIF-ELSE-IF
MENU
FIGURE
AXIS
GRID

EXAMPLES 3

3.1 Evaluate approximate value of the integral of function $f(x)=sin(x)$ in limits $a=0$, $b=\pi$ for $N=20$, 40 and 60 its parts using the trapezoidal rule

3.2 Enlarge the algorithm resulting from the previous example by the MENU command for selection of variable N

4. SUBMATRICES

4.1 Submatrices

```
%%% Example 4.1: Basic matrix operations
>>  A=[1 2 3; 4 5 6; 7 8 9];
>>  B=A(2,:)
>>  C=A(:,[1 3])
>>  D=A(:,[3:-1:1])
```

4.2 Logical Operations

```
%%% Example 4.2: Logical matrix operations
>>  L=A(:,3)>8, A1=A(L,:)
>>  v=A(:)'
```

Solution

$$A = \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix}$$

$$B = \begin{pmatrix} 4 & 5 & 6 \end{pmatrix}$$

$$C = \begin{pmatrix} 1 & 3 \\ 4 & 6 \\ 7 & 9 \end{pmatrix} \qquad D = \begin{pmatrix} 3 & 2 & 1 \\ 6 & 5 & 4 \\ 9 & 8 & 7 \end{pmatrix}$$

$$L = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \qquad A1 = \begin{pmatrix} 7 & 8 & 9 \end{pmatrix}$$

$$v = \begin{pmatrix} 1 & 4 & 7 & 2 & 5 & 8 & 3 & 6 & 9 \end{pmatrix}$$

4.3 Function Subroutines

function [⟨*output_parameters*⟩]=⟨*name*⟩(⟨*input_parameters*⟩)
⟨*commands*⟩

Notes:

1. Formal parameters: matrices, vectors, strings
2. The number of real parameters can be smaller than that of formal parameters

```
%%% Example 4.3: Evaluate the approximate value of integral
%%%   of function f(x)=sin(x) in limits a=0, b=20 for
%%%   N=20 its parts using rectangular rule:
%%%     Q ~ h*sum(f(x(i)) pro x(i)=a+(i-1)*h, i=1,2,...,N
%%%
      a=0; b=20; N=20;
      Q=sem4prog(a,b,N)
```

COMMANDS

:
CLC
BREAK
FUNCTION

EXAMPLES 4

4.1 Define function subroutine for evaluation of minimum and maximum value of the given matrix and apply it for matrix **A** = [1 3 5; 2 4 6; 1 1 1]

4.2 Modify the given vector **x**=[1.1 1.4 1.9 2.1 1.3 1.7 1.8 5 1.5] by elimination of values that differ by more than the standard deviation from the mean value of the given sequence