Integrated development system:

- Command Window
- Editor
- Command History
- Workspace Browser
- Profiler
- Current Directory Browser
- Shortcut-Bar
• Online-Help for all commands, functions etc.

• Command Window Help: `help [command]`

• Help-Browser: `helpwin [command]`
  `doc [command]`

• Search for `searchstring`: `lookfor searchstring`
MATLAB Basics

Variables

- Names for variables:
  - maximum of 63 characters
  - Letters, underscore "_" und digits
  - First character must be a letter
  - Distinguish small and capital letters

- Assign value to variable: \[ \text{variable}_1 = 25 \]

- Standard answering variable \texttt{ans}

- Variables are globally defined in Workspace
Types of Variables:

- **logical**: logical values 0 oder 1
- **char**: character (letters)
- **single**: floating point single precision 32 Bit
- **double**: floating point single precision 64 Bit
- **intX**: integer X = 8, 16, 32, 64
- **uintX**: unsigned integer X = 8, 16, 32, 64
- **struct**: array of C-like structures
- **cell**: array of indexed cells
- **map data**: fast key lookup data structure

- double (default) and char widely used

- Optimised storage with sparse in contrast to full
MATLAB Basics
Output, basic math operations and constants

• Comma or space after expression shows output, semi-colon omits output

• Operations: + Addition    - Subtraction
              * Multiplication  / Division
              ^ Power

• Constants:  pi    Pi
              eps  floating point accuracy
              inf Infinity
              NaN Not-a-Number

• Complexe numbers:  i, j    Imaginary Unit $\sqrt{-1}$
Vectors: Separation of elements by comma or space:

\[ \text{vektor} = [1 \ 2 \ 3] \]

Matrices: Separation of rows by semi-colon:

\[ \text{matrix} = [1 \ 2 \ 3 ; 5 \ 6 \ 7] \]

First element has index 1

Colon for row/column:

\[ \text{zeile}_1 = \text{matrix}(1,:) \]

Combining:

\[ \text{matrix} = [\text{vektor} ; 5 \ 6 \ 7] \]

Last element:

\[ \text{matrix}(:,\text{end}) \]
MATLAB Basics
Specific vectors und matrizes

- Elements with same step width: \( \text{fort} = (1:2:100) \)
- Number \( num \) of points between \( \text{start} \) und \( \text{stop} \):
  - Linear: \( \text{linspace(start,stop,num)} \)
  - Logarithmic: \( \text{logspace(start,stop,num)} \)
- Specific matrices (\( m \) rows, \( n \) columns):
  - Identity matrix: \( \text{eye(m)} \)
  - Matrix of ones: \( \text{ones(m,n)} \)
  - Matrix of zeros: \( \text{zeros(m,n)} \)
  - Random matrix: \( \text{rand(m,n)} \)
Numerous math & trigonometric functions

- `sqrt(x)` square root
- `exp(x)` exponential function
- `log(x)` natural Logarithm
- `log10(x)` logarithmu of 10
- `abs(x)` absolut
- `sign(x)` signum
- `real(x)` real part
- `imag(x)` imaginary part
- `angle(x)` angle of complex number
- `sin(x)` sine
- `cos(x)` cosine
- `tan(x)` tangens
- `rem(x, y)` rest after division $x/y$
- `round(x)` round
- `ceil(x)` round to ceil
- `floor(x)` round to floor
- `sum(v)` sum of vector elements
- `prod(v)` product of vector elements
- `min(v)` smalles vector element
- `max(v)` largest of vector element
- `mean(v)` arithmetic mean
- `atan(x)` arcus–tangens $\pm 90^\circ$
- `atan2(x, y)` arcus–tangens $\pm 180^\circ$
- `sinc(x)` sinc-function $\sin(\pi x)/(\pi x)$

Online–Help by `help elfun` and `help datafun`
• Lots of operations usable with vectors and matrices

• element-by-element operations with dot-operator “.\“.“

• Specific operations for vectors and matrices:

  
  \[
  \begin{array}{ll}
  .' & \text{transpose} \\
  ' & \text{conjugated trans.} \\
  \text{inv}(x) & \text{inversion} \\
  \end{array}
  \]

  
  \[
  \begin{array}{ll}
  \text{det}(x) & \text{determinant} \\
  \text{rank}(x) & \text{rank} \\
  \text{eig}(x) & \text{eigenvalue} \\
  \end{array}
  \]
• Structures for data of different types: scalars, matrices, strings, etc.

• Fields of structure contain values

\[ str = \text{struct}('name_1',value_1,'name_2',value_2,...) \]

• Access to field values with “.”-operator: \[ str.name \]

• Cell arrays: Multidimensional structure
MATLAB Basics
Administration of variables

- Dimension:
  - of a vector: \texttt{length(vektor)}
  - of a matrix: \texttt{size(matrix)}

- Anzeigen:
  - \texttt{who [variable]}: only variable names
  - \texttt{whos [variable]}: name, size, bytes and class

- Deletion:
  - of a variable: \texttt{clear variable}
  - of all variables: \texttt{clear, clear all}
Relational operators: $==$, $\sim=$, $<$, $\leq$, $>$, $\geq$,

- Test if variable $x$ exists: $\text{exist}(x)$

- Relational operators can be used with scalars, vectors and matrices

- Results: Zero (logical false) if operation is not true, otherwise One (logical true)

- Operator precedence:
  1. Mathematical expressions
  2. Relational operators from left to right
• Logical operators: ~ NOT, & AND, | OR, xor XOR

• Logical operators can be used with scalars, vectors and matrizes

• Results: Zero is logical false, all other values are logical true. Results are always 0 or 1.

• Operator precedence:
  1. Mathematical expressions
  2. NOT
  3. AND and OR from left to right
MATLAB Basics
Further operators und logical indexing

- “Shortcut“ operators: \( \&\& \) (AND) und \( \| \) (OR)
  Stops if result is fully determined: \( (1 \| \text{expression}) \)
  expression is not evaluated

- Any element nonzero: \( \text{any}(vektor) \)

- All elements nonzero: \( \text{all}(vektor) \)

- Indizes of nonzero elements: \( \text{find}(vektor) \)

- Logical indexing: \( a(a<0) = 1 \)
IF–statement

if logical expression
  statements
elseif logical expression
  statements
else
  statements
end

SWITCH–statement

switch expression(scalar or string)
  case value1
    statements
  case {value2 value3 ...}
    statements
  otherwise
    statements
end

• Separate statements and commands with ",", ",",";

• Nesting of if and switch possible
MATLAB Basics
Loop Control

- **FOR:**  
  \[
  \text{for } \text{variable} = \text{expression} \\
  \quad \text{statements} \\
  \text{end}
  \]

  \[
  \text{for } n = 1:1:10, \\
  \quad f = n^2, \\
  \text{end}
  \]

- **WHILE:**  
  \[
  \text{while } \text{expression} \\
  \quad \text{statements} \\
  \text{end}
  \]

  \[
  \text{while } w > 1, \\
  \quad w = w + 1; \\
  \text{end}
  \]

- **Loop:**  
  - Next iteration: \text{continue}
  - Termination: \text{break}
  - Termination: \text{return}
MATLAB Basics
MATLAB–Scripts

- M–File: Commands in ASCII–File with extension .m

- Comments: % Comment
  %{ ... %} Comment in several lines
  % Comments as cell-divider

- Continue command in next line: ...

- Show commands and comments: echo on

- Controlled paged output: more on

- Display contents of file: type file
MATLAB Basics
MATLAB–functions I

• Specific sort of M–files: – Input arguments
  – Output of values
  – Local variables

• Definition: function \[ var \] = functionname (par)

• Internal indicators: nargin, narginout

• Abort function with message: error('info')

• Nested functions possible

• Comments in functions: % Comment
• **Local variables** in function are deleted after function call

• **Static variables**: `persistent var`
Keep their value after function call

• **Global variables**: `global var`
Are to be defined as global in function **and** workspace and are available to all functions declaring it global

Delete with: `clear global`
MATLAB Basics
MATLAB–functions III

- **Inline Functions:**  \( f = \text{inline} \ (\text{funktion,}\ var) \)

- **Pseudo-Code:**  \( \text{pcode} \ (\text{funktion}) \)

- **Delete all functions:**  \( \text{clear functions} \)

- **Function Handle:**  \( f\_\text{handle} = \@\text{function} \)

  Information:  \( \text{functions}(f\_\text{handle}) \)

  Call with:  \( [y_1, \ldots, y_m] = \text{feval} \ (f\_\text{handle}, x_1, \ldots, x_n) \)