Calcpad VM

Version 7.5 quick reference guide

ПРОЕКТСОФТ®
34-36 Peyo Yavorov blvd, Sofia 1164, Bulgaria
+359 2 423 4455
proektsoft.bg@gmail.com

How it works

1. **Enter** your formulas and text (in quotes) into the "**Code**" box on the left.
2. Press **F5** or click ▶ to **calculate**. The results will appear in the "**Output**" box on the right.
3. Click 🖨 to **print** or to **copy** the output, or **export** it to **Html**, **PDF** or **Word**.

The language

The Calcpad language includes the following elements (click an item to insert):

- Real numbers: digits **0** - **9** and decimal point "**.**";
- Complex numbers: **re** ± **im*i*** (e.g. **3** - **2*i***);
- Real vectors: [v_1; v_2; v_3; …; v_n];
- Real matrices: [M_{11}; M_{12}; … ; M_{1n} | M_{21}; M_{22}; … ; M_{2n} … | M_{m1}; M_{m2}; … ; M_{mn}];
- Variables:

  - all Unicode letters;

  - digits: **0** – **9**;

  - comma: “ , “;

  - special symbols: ′ , ″ , ‴ , ⁗ , ‾ , ø , Ø , ° , ∡ ;

  - superscripts: ^{0} , ^{1} , ^{2} , ^{3} , ^{4} , ^{5} , ^{6} , ^{7} , ^{8} , ^{9} , ^{n} , $^+$, $^-$;

  - subscripts: $_0$, $_1$, $_2$, $_3$, $_4$, $_5$, $_6$, $_7$, $_8$, $_9$, $_+$, $_-$, $_=$, $_($, $_)$;

  - “_“ (underscore) for subscript;

  Any variable name must start with a letter. Names are case sensitive.
- Constants: π, e, φ, γ, g, G, M_E, M_S, c, h, μ_0, ε_0, k_e, e, m_e, m_p, m_n, N_A, σ, k_B, R, F, γ_c, γ_s, γ_a, γ_g, γ_w

  Operators:

  “!” - factorial;

  “^” - exponent;

  “/” - division;

  “÷” - force division bar in inline mode and slash in pro mode (//);

  “\” - integer division;

  “⦼” - modulo (reminder, %%);

  “*” - multiplication;

  “-“ - minus;

  “+” - plus;

  “≡” - equal to (==);

  “≠” - not equal to (!=);

  “<” - less than;

  “>” - greater than;

  “≤” - less or equal (<=);

  “≥” - greater or equal (>=);

  “∧” - logical “AND” (&&);

  “∨” - logical “OR” (||);

  "∠" - phasor A∠φ (<<);

“⊕” - logical “XOR” (^^);

“=” - assignment;

- Custom functions type $f(x; y; z; ...)$;
- Built-in functions:

◦ Trigonometric:

sin(x)	- sine;
cos(x)	- cosine;
tan(x)	- tangent;
csc(x)	- cosecant;
sec(x)	- secant;
cot(x)	- cotangent;

◦ Hyperbolic:

sinh(x)	- hyperbolic sine;
cosh(x)	- hyperbolic cosine;
tanh(x)	- hyperbolic tangent;
csch(x)	- hyperbolic cosecant;
sech(x)	- hyperbolic secant;
coth(x)	- hyperbolic cotangent;

◦ Inverse trigonometric:

asin(x)	- inverse sine;
acos(x)	- inverse cosine;
atan(x)	- inverse tangent;
atan2$(x; y)$	- the angle whose tangent is the quotient of *y* and *x*;
acsc(x)	- inverse cosecant;
asec(x)	- inverse secant;
acot(x)	- inverse cotangent;

◦ Inverse hyperbolic:

asinh(x)	- inverse hyperbolic sine;
acosh(x)	- inverse hyperbolic cosine;
atanh(x)	- inverse hyperbolic tangent;
acsch(x)	- inverse hyperbolic cosecant;
asech(x)	- inverse hyperbolic secant;
acoth(x)	- inverse hyperbolic cotangent;

◦ Logarithmic, exponential and roots:

log(x)	- decimal logarithm;
ln(x)	- natural logarithm;
log_2(x)	- binary logarithm;
exp(x)	- exponential function;
sqr(x) or **sqrt**(x)	- square root;
cbrt(x)	- cubic root;
root$(x; n)$	- n-th root;

◦ Rounding:

round(x)	- round to the nearest integer;

floor(x) - round to the smaller integer (towards -∞);
ceiling(x) - round to the greater integer (towards +∞);
trunc(x) - round to the smaller integer (towards zero);

◦ Integer:

mod$(x;\ y)$ - the reminder of an integer division;
gcd$(x;\ y;\ z\ldots)$ - the greatest common divisor of several integers;
lcm$(x;\ y;\ z\ldots)$ - the least common multiple of several integers;

◦ Complex:

re(z) - the real part of a complex number;
im(z) - the imaginary part of a complex number;
abs(z) - absolute value/magnitude;
phase(z) - the phase of a complex number;
conj(z) - the conjugate of a complex number;

◦ Aggregate and interpolation:

min$(A;\ \vec{b};\ c\ldots)$ - minimum of multiple values;
max$(A;\ \vec{b};\ c\ldots)$ - maximum of multiple values;
sum$(A;\ \vec{b};\ c\ldots)$ - sum of multiple values;
sumsq$(A;\ \vec{b};\ c\ldots)$ - sum of squares
srss$(A;\ \vec{b};\ c\ldots)$ - square root of sum of squares;
average$(A;\ \vec{b};\ c\ldots)$ - average of multiple value;
product$(A;\ \vec{b};\ c\ldots)$ - product of multiple values;
mean$(A;\ \vec{b};\ c\ldots)$ - geometric mean;
take$(n;\ A;\ \vec{b};\ c\ldots)$ - returns the n-th element from the list;
line$(x;\ A;\ \vec{b};\ c\ldots)$ - linear interpolation;
spline$(x;\ A;\ \vec{b};\ c\ldots)$ - Hermite spline interpolation;

◦ Conditional and logical:

if(*cond*; *value-if-true*; *value-if-false*) - conditional evaluation;
switch(*cond1*; *value1*; *cond2*; *value2*; …; *default*) - selective evaluation;
not(x) - logical "NOT";
and$(A;\ \vec{b};\ c\ldots)$ - logical "AND";
or$(A;\ \vec{b};\ c\ldots)$ - logical "OR";
xor$(A;\ \vec{b};\ c\ldots)$ - logical "XOR";

◦ Other:

sign(x) - sign of a number;
random(x) - random number between 0 and x;
getunits(x) - gets the units of x without the value. Returns 1 if x is unitless;
setunits$(x;\ u)$ - sets the units u to x, where x can be scalar, vector or matrix;
clrunits(x) - clears the units from a scalar, vector or matrix x;
hp(x) - converts x to its high-performance (hp) equivalent type;
ishp(x) - checks if the type of x is a high-performance (hp) vector or matrix;

◦ Vector:

Creational:

vector(n) - creates an empty vector with length n;

vector_hp(n) - creates an empty high performance (hp) vector with length n;

range$(x_1; x_n; s)$ - creates a vector with values spanning from x_1 to x_n with step s;

range_hp $(x_1; x_n; s)$ - creates a high performance (hp) from a range of values as above;

Structural:

len$(\vec{v})$ - returns the length of the vector $\vec{v}$;

size$(\vec{v})$ - the actual size of the vector $\vec{v}$ (the index of the last non-zero element);

resize$(\vec{v}; n)$ - sets a new length n of the vector $\vec{v}$;

fill$(\vec{v}; x)$ - fills the vector $\vec{v}$ with value x;

join$(A; \vec{b}; c\ldots)$ - creates a vector by joining the arguments in the list – matrices, vectors and scalars;

slice$(\vec{v}; i_1; i_2)$ - returns the part of the vector $\vec{v}$ bounded by indexes i_1 and i_2 inclusive;

first$(\vec{v}; n)$ - the first n elements of the vector $\vec{v}$;

last$(\vec{v}; n)$ - the last n elements of the vector $\vec{v}$;

extract$(\vec{v}; \vec{i})$ - extracts those elements from $\vec{v}$ which indexes are contained in $\vec{i}$;

Data:

sort$(\vec{v})$ - sorts the vector $\vec{v}$ in ascending order;

rsort$(\vec{v})$ - sorts the vector $\vec{v}$ in descending order;

order$(\vec{v})$ - the indexes of $\vec{v}$, in ascending order by the elements of $\vec{v}$;

revorder$(\vec{v})$ - the indexes of $\vec{v}$, in descending order by the elements of $\vec{v}$;

reverse$(\vec{v})$ - vector containing the elements of $\vec{v}$ in reverse order;

count$(\vec{v}; x; i)$ - the number of elements of $\vec{v}$ equal to x with index ≥ i;

search$(\vec{v}; x; i)$ - the index of the first element in $\vec{v}$ with index ≥ i that is equal to x;

find$(\vec{v}; x; i)$ or

find_eq$(\vec{v}; x; i)$ - the indexes of all elements in $\vec{v}$, after the i-th, that are = x;

find_ne$(\vec{v}; x; i)$ - the indexes of all elements in $\vec{v}$, after the i-th , that are ≠ x;

find_lt$(\vec{v}; x; i)$ - the indexes of all elements in $\vec{v}$, after the i-th, that are < x;

find_le$(\vec{v}; x; i)$ - the indexes of all elements in $\vec{v}$, after the i-th, that are ≤ x;

find_gt$(\vec{v}; x; i)$ - the indexes of all elements in $\vec{v}$, after the i-th, that are > x;

find_ge$(\vec{v}; x; i)$ - the indexes of all elements in $\vec{v}$, after the i-th, that are ≥ x;

lookup$(\vec{a}; \vec{b}; x)$ or

lookup_eq$(\vec{a}; \vec{b}; x)$ - all elements of $\vec{a}$ for which the corresponding elements of $\vec{b}$ are = x;

lookup_ne$(\vec{a}; \vec{b}; x)$ - all elements of $\vec{a}$ for which the corresponding elements of $\vec{b}$ are ≠ x;

lookup_lt$(\vec{a}; \vec{b}; x)$ - all elements of $\vec{a}$ for which the corresponding elements of $\vec{b}$ are < x;

lookup_le$(\vec{a}; \vec{b}; x)$ - all elements of $\vec{a}$ for which the corresponding elements of $\vec{b}$ are ≤ x;

lookup_gt$(\vec{a}; \vec{b}; x)$ - all elements of $\vec{a}$ for which the corresponding elements of $\vec{b}$ are > x;

lookup_ge$(\vec{a}; \vec{b}; x)$ - all elements of $\vec{a}$ for which the corresponding elements of $\vec{b}$ are ≥ x;

Math:

norm_1($\vec{v}$) - L1 (Manhattan) norm of the vector $\vec{v}$;

norm($\vec{v}$) or **norm_2**($\vec{v}$) or

norm_e($\vec{v}$) - L2 (Euclidean) norm of the vector $\vec{v}$;

norm_p($\vec{v}$; p) - Lp norm of the vector $\vec{v}$;

norm_i($\vec{v}$) - L∞ (infinity) norm of the vector $\vec{v}$;

unit($\vec{v}$) - normalized form of the vector $\vec{v}$ (with L2 norm = 1);

dot($\vec{a}$; $\vec{b}$) - scalar product of two vectors $\vec{a}$ and $\vec{b}$;

cross($\vec{a}$; $\vec{b}$) - cross product of two vectors $\vec{a}$ and $\vec{b}$ (with length 2 or 3);

- Matrix:

Creational:

matrix(m; n) - creates an empty matrix with dimensions m×n;

identity(n) - creates an identity matrix with dimensions n×n;

diagonal(n; d) - creates an n×n diagonal matrix and fills the diagonal with value d;

column(m; c) - creates a column matrix with dimensions m×1, filled with value c;

utriang(n) - creates an upper triangular matrix with dimensions n×n;

ltriang(n) - creates a lower triangular matrix with dimensions n×n;

symmetric(n) - creates a symmetric matrix with dimensions n×n;

matrix_hp(m; n) - creates a high-performance matrix with dimensions m×n;

identity_hp(n) - creates a high-performance identity matrix with dimensions n×n;

diagonal_hp(n; d) - creates a high-performance n×n diagonal matrix filled with value d;

column_hp(m; c) - creates a high-performance m×1 column matrix filled with value c;

utriang_hp(n) - creates a high-performance n×n upper triangular matrix;

ltriang_hp(n) - creates a high-performance n×n lower triangular matrix;

symmetric_hp(n) - creates a high-performance symmetric matrix with dimensions n×n;

vec2diag($\vec{v}$) - creates a diagonal matrix from the elements of vector $\vec{v}$;

vec2row($\vec{v}$) - creates a row matrix from the elements of vector $\vec{v}$;

vec2col($\vec{v}$) - creates a column matrix from the elements of vector $\vec{v}$;

join_cols($\vec{c}_1$; $\vec{c}_2$; $\vec{c}_3$...) - creates a matrix by joining column vectors;

join_rows($\vec{r}_1$; $\vec{r}_2$; $\vec{r}_3$...) - creates a matrix by joining row vectors;

augment(A; B; C...) - creates a matrix by appending matrices A; B; C side by side;

stack(A; B; C...) - creates a matrix by stacking matrices A; B; C one below the other;

Structural:

n_rows(M) - number of rows in matrix M;

n_cols(M) - number of columns in matrix M;

resize(M; m; n) - sets new dimensions m and n for matrix M;

fill(M; x) - fills the matrix M with value x;

fill_row(M; i; x) - fills the i-th row of matrix M with value x;

fill_col(M; j; x) - fills the j-th column of matrix M with value x;

copy(A; B; i; j) - copies all elements from A to B, starting from indexes i and j of B;

add(A; B; i; j) - adds all elements from A to those of B, starting from indexes i and j of B;

row(M; i) - extracts the i-th row of matrix M as a vector;

col(M; j) - extracts the j-th column of matrix M as a vector;

extract_rows(M; $\vec{i}$) - extracts the rows from matrix M whose indexes are contained in vector $\vec{i}$;

extract_cols(M; $\vec{j}$) - extracts the columns from matrix M whose indexes are contained in vector $\vec{j}$;

diag2vec(M) - extracts the diagonal elements of matrix M to a vector;

submatrix(M; i_1; i_2; j_1; j_2) - extracts a submatrix of M, bounded between rows i_1 and i_2 and columns j_1 and j_2, incl.;

<u>Data</u>:

sort_cols(M; i) - sorts the columns of M based on the values in row i in ascending order;

rsort_cols(M; i) - sorts the columns of M based on the values in row i in descending order;

sort_rows(M; j) - sorts the rows of M based on the values in column j in ascending order;

rsort_rows(M; j) - sorts the rows of M based on the values in column j in descending order;

order_cols(M; i) - the indexes of the columns of M in ascending order by the values in row i;

revorder_cols(M; i) - the indexes of the columns of M in descending order by the values in row i;

order_rows(M; j) - the indexes of the rows of M in ascending order by the values in column j;

revorder_rows(M; j) - the indexes of the rows of M in descending order by the values in column j;

mcount(M; x) - number of occurrences of value x in matrix M;

msearch(M; x; i; j) - vector with the two indexes of the first occurrence of x in matrix M, starting from indexes i and j;

mfind(M; x) - the indexes of all elements in matrix M equal to x;

mfind_eq(M; x) - the indexes of all elements in matrix M equal to x;

mfind_ne(M; x) - the indexes of all elements in matrix M not equal to x;

mfind_lt(M; x) - the indexes of all elements in matrix M less than x;

mfind_le(M; x) - the indexes of all elements in matrix M less than or equal to x;

mfind_gt(M; x) - the indexes of all elements in matrix M greater than x;

mfind_ge(M; x) - the indexes of all elements in matrix M greater than or equal to x;

hlookup(M; x; i_1; i_2) - the values from row i_2 of M, for which the elements from row i_1 are equal to x;

hlookup_eq(M; x; i_1; i_2) - the values from row i_2 of M, for which the elements from row i_1 are equal to x;

hlookup_ne(M; x; i_1; i_2) - the values from row i_2 of M, for which the elements from row i_1 are not equal to x;

hlookup_lt(M; x; i_1; i_2) - the values from row i_2 of M, for which the elements from row i_1 are less than x;

hlookup_le(M; x; i_1; i_2) - the values from row i_2 of M, for which the elements from row i_1 are less than or equal to x;

hlookup_gt(M; x; i_1; i_2) - the values from row i_2 of M, for which the elements from row i_1 are greater than x;

hlookup_ge(M; x; i_1; i_2) - the values from row i_2 of M, for which the elements from row i_1 are greater than or equal to x;

vlookup(M; x; j_1; j_2) - the values from column j_2 of M, for which the elements from column j_1 are equal to x;

vlookup_eq(M; x; j_1; j_2) - the values from column j_2 of M, for which the elements from column j_1 are equal to x;

vlookup_ne(M; x; j_1; j_2) - the values from column j_2 of M, for which the elements from column j_1 are not equal to x;

vlookup_lt(M; x; j_1; j_2) - the values from column j_2 of M, for which the elements from column j_1 are less than x;

vlookup_le(M; x; j_1; j_2) - the values from column j_2 of M, for which the elements from column j_1 are less than or equal to x;

vlookup_gt(M; x; j_1; j_2) - the values from column j_2 of M, for which the elements from column j_1 are greater than x;

vlookup_ge(M; x; j_1; j_2) - the values from column j_2 of M, for which the elements from column j_1 are greater than or equal to x;

Math:

hprod(A; B) - Hadamard product of matrices A and B;

fprod(A; B) - Frobenius product of matrices A and B;

kprod(A; B) - Kronecker product of matrices A and B;

mnorm(M) or

mnorm_2(M) - L2 norm of matrix M;

mnorm_1(M) - L1 norm of matrix M;

mnorm_2(M) - Frobenius norm of matrix M;

mnorm_i(M) - L∞ norm of matrix M;

cond(M) or

cond_e(M) - condition number of M based on the Euclidean norm of the matrix;

cond_1(M) - condition number of M based on the L1 norm;

cond_2(M) - condition number of M based on the L2 norm;

cond_i(M) - condition number of M based on the L∞ norm;

det(M) - determinant of matrix M;

rank(M) - rank of matrix M;

trace(M) - trace of matrix M;

transp(M) - transpose of matrix M;

adj(M) - adjugate of matrix M;

cofactor(M) - cofactor matrix of M;

eigenvals(M; n_e) - the first n_e eigenvalues of matrix M (or all if omitted);

eigenvecs$(M; n_e)$ - the first n_e eigenvectors of matrix M (or all if omitted);

eigen$(M; n_e)$ - the first n_e eigenvalues and eigenvectors of M (or all if omitted);

cholesky(M) - Cholesky decomposition of a symmetric, positive-definite matrix M;

lu(M) - LU decomposition of matrix M;

qr(M) - QR decomposition of matrix M;

svd(M) - singular value decomposition of M;

inverse(M) - inverse of matrix M;

lsolve$(A; \vec{b})$ - solves the system of linear equations $A\vec{x} = \vec{b}$ using LDL^T decomposition for symmetric matrices, and LU for non-symmetric;

clsolve$(A; \vec{b})$ - solves the linear matrix equation $A\vec{x} = \vec{b}$ with symmetric, positive-definite coefficient matrix A using Cholesky decomposition;

slsolve$(A; \vec{b})$ - solves the linear matrix equation $A\vec{x} = \vec{b}$ with high-performance symmetric, positive-definite matrix A using preconditioned conjugate gradient (PCG) method;

msolve$(A; B)$ - solves the generalized matrix equation $AX = B$ using LDL^T decomposition for symmetric matrices, and LU for non-symmetric;

cmsolve$(A; B)$ - solves the generalized matrix equation $AX = B$ with symmetric, positive-definite coefficient matrix A using Cholesky decomposition;

smsolve$(A; B)$ - solves the generalized matrix equation $AX = B$ with high-performance symmetric, positive-definite matrix A using preconditioned conjugate gradient (PCG) method;

fft(M) - performs fast Fourier transform of row-major matrix M. It must have one row for real data and two rows for complex;

ift(M) - performs inverse Fourier transform of row-major matrix M. It must have one row for real data and two rows for complex;

Double interpolation:

take$(x; y; M)$ - returns the element of matrix M at indexes x and y;

line$(x; y; M)$ - double linear interpolation from the elements of matrix M based on the values of x and y;

spline$(x; y; M)$ - double Hermite spline interpolation from the elements of matrix M based on the values of x and y;

Tol - target tolerance for the iterative PCG solver.

Comments: **"Title"** or **'text'** in double or single quotes, respectively.

HTML, **CSS**, **JS** and **SVG** are allowed.

- Graphing and plotting:

$Plot{ $f(x)$ @ $x = a : b$ } - simple plot;

$Plot{ $x(t)$ | $y(t)$ @ $t = a : b$ } - parametric;

$Plot{ $f_1(x)$ & $f_2(x)$ & ... @ $x = a : b$ } - multiple;

$Plot{ $x_1(t)$ | $y_1(t)$ & $x_2(t)$ | $y_2(t)$ & ... @ $x = a : b$ } - multiple parametric;

$Map{ $f(x; y)$ @ $x = a : b$ & $y = c : d$ } - 2D color map of a 3D surface;

PlotHeight - height of plot area in pixels;
PlotWidth - width of plot area in pixels;
PlotSVG - draw plots in vector, SVG format (= 1) or raster, PNG (= 0);
PlotAdaptive - use adaptive mesh (= 1) for function plotting or uniform (= 0);
PlotStep - the size of the mesh for map plotting;
PlotPalette - the number of color palette to be used for surface plots (0-9);
PlotShadows - draw surface plots with shadows;
PlotSmooth - smooth gradient coloring (= 1) or isobands (= 0) for surface plots;
PlotLightDir - direction to light source (0-7) clockwise.

- Iterative and numerical methods:

$Root{$f(x) = const$ @ $x = a : b$} - root finding for $f(x) = const$;
$Root{$f(x)$ @ $x = a : b$} - root finding for $f(x) = 0$;
$Find{$f(x)$ @ $x = a : b$} - similar to above, but x is not required to be a precise solution;
$Sup{$f(x)$ @ $x = a : b$} - local maximum of a function;
$Inf{$f(x)$ @ $x = a : b$} - local minimum of a function;
$Area{$f(x)$ @ $x = a : b$} - adaptive Gauss-Lobatto numerical integration;
$Integral{$f(x)$ @ $x = a : b$} - Tanh-Sinh numerical integration;
$Slope{$f(x)$ @ $x = a$} - numerical differentiation by Richardson extrapolation;
$Derivative{$f(x)$ @ $x = a$} - numerical differentiation by complex step method;
$Sum{$f(x)$ @ $k = a : b$} - iterative sum;
$Product{$f(k)$ @ $k = a : b$} - iterative product;
$Repeat{$f(k)$ @ $k = a : b$} - iterative expression block with counter;
$While{*condition*; *expressions*} - iterative expression block with condition;
$Block{*expressions*} - multiline expression block;
$Inline{*expressions*} - inline expression block;

Precision - relative precision for numerical methods [10^{-2}; 10^{-16}] (default is 10^{-12}).

- Program flow control:

Simple:

```
#if condition
    your code goes here
#end if
```

Alternative:

```
#if condition
    your code goes here
#else
    some other code
#end if
```

Complete:

```
#if condition1
    your code goes here
#else if condition2
```

```
    your code goes here
#else
    some other code
#end if
```

You can add or omit as many "#else ifs" as needed. Only one "#else" is allowed.

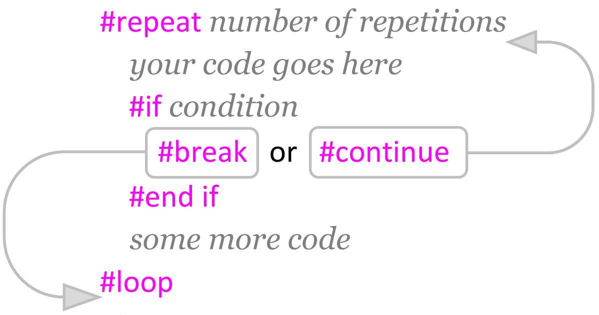
You can omit this too.

- Iteration blocks:

Simple:

```
#repeat number of repetitions
    your code goes here
#loop
```

With conditional break/continue:



```
#repeat number of repetitions
    your code goes here
    #if condition
        #break or #continue
    #end if
    some more code
#loop
```

With counter:

```
#for counter = start : end
    your code goes here
#loop
```

With condition:

```
#while condition
    your code goes here
#loop
```

- Modules and macros/string variables:

Modules:

`#include filename` - include external file (module);

`#local` - start local section (not to be included);

`#global` - start global section (to be included);

Inline string variable:

```
#def variable_name$ = content
```

Multiline string variable:

```
#def variable_name$
   content line 1
   content line 2
    ...
#end def
```

Inline macro:

```
#def macro_name$(param1$; param2$; ...) = content
```

Multiline macro:

```
#def macro_name$(param1$; param2$; ...)
```

```
    content line 1
    content line 2
    …
  #end def
```

- Import/Export of external data:
  Text/CSV files:
  #read *M* from *filename.txt*@R1C1:R2C2 TYPE=R SEP=',' - read matrix *M* from a text/CSV file;
  #write *M* to *filename.txt*@R1C1:R2C2 TYPE=N SEP=',' - write matrix *M* to a text/CSV file;
  #append *M* to *filename.txt*@R1C1:R2C2 TYPE=N SEP=',' - append matrix *M* to a text/CSV file;
  Excel files (xlsx and xlsm):
  #read *M* from *filename.xlsx*@Sheet1!A1:B2 TYPE=R - read matrix *M* from an Excel file;
  #write *M* to *filename.xlsx*@Sheet1!A1:B2 TYPE=N - write matrix *M* to an Excel file;
  #append *M* to *filename.xlsx*@Sheet1!A1:B2 TYPE=N - append matrix *M* to an Excel file;
  Sheet, range, TYPE and SEP can be omitted.
  For #read command, TYPE can be any of [R|D|C|S|U|L|V]. For hp matrices add _HP to the type.
  For #write and #append commands, TYPE can be Y or N.
- Output control:
  #hide - hide the report contents;
  #show - always show the contents (default);
  #pre - show the next contents only before calculations;
  #post - show the next contents only after calculations;
  #val - show only the result, without the equation;
  #equ - show complete equations and results (default);
  #noc - show only equations without results (no calculations);
  #nosub - do not substitute variables (no substitution);
  #novar - show equations only with substituted values (no variables);
  #varsub - show equations with variables and substituted values (default);
  #round *n* - rounds the output to *n* digits after the decimal point;
  #round default - restores rounding to the default settings;
  #format *FFFF* - specifies custom format string;
  #format default - restores the default formatting;
  #md on - enables markdown in comments;
  #md off - disables markdown in comments;
  #phasor - sets output format of complex numbers to polar phasor: A∠φ;
  #complex - sets output format of complex numbers to cartesian algebraic: a + ib.
- Breakpoints for step-by-step execution:
  #pause - calculates down to the current line and waits for the user to resume manually;
  #input - renders an input form to the current line and waits for user input.
  Each of the above commands is effective after the current line until the end of the report or another command that overwrites it.
- Units for trigonometric functions: #deg - degrees, #rad - radians, #gra - gradians;
- Separator for target units: |;
- Return angles with units: *ReturnAngleUnits* = 1;
- Dimensionless: %, ‰, ‱, pcm, ppm, ppb, ppt, ppq;

- Angle: °, ′, ″, deg, rad, grad, rev;
- Metric units (SI and compatible):

  Mass: g, hg, kg, t, kt, Mt, Gt, dg, cg, mg, µg, Da (or u);

  Length: m, km, dm, cm, mm, µm, nm, pm, AU, ly;

  Time: s, ms, µs, ns, ps, min, h, d, w, y;

  Frequency: Hz, kHz, MHz, GHz, THz, mHz, µHz, nHz, pHz, rpm;

  Speed: kmh;

  Electric current: A, kA, MA, GA, TA, mA, µA, nA, pA;

  Temperature: °C, Δ°C, K;

  Amount of substance: mol;

  Luminous intensity: cd;

  Area: a, daa, ha;

  Volume: L, daL, hL, dL, cL, mL, µL, nL, pL;

  Force: N, daN, hN, kN, MN, GN, TN, gf, kgf, tf, dyn;

  Moment: Nm, kNm;

  Pressure: Pa, daPa, hPa, kPa, MPa, GPa, TPa, dPa, cPa, mPa, µPa, nPa, pPa,
  bar, mbar, µbar, atm, at, Torr, mmHg;

  Viscosity: P, cP, St, cSt;

  Energy work: J, kJ, MJ, GJ, TJ, mJ, µJ, nJ, pJ,
  Wh, kWh, MWh, GWh, TWh, mWh, µWh, nWh, pWh,
  eV, keV, MeV, GeV, TeV, PeV, EeV, cal, kcal, erg;

  Power: W, kW, MW, GW, TW, mW, µW, nW, pW, hpM, ks,
  VA, kVA, MVA, GVA, TVA, mVA, µVA, nVA, pVA,
  VAR, kVAR, MVAR, GVAR, TVAR, mVAR, µVAR, nVAR, pVAR;

  Electric charge: C, kC, MC, GC, TC, mC, µC, nC, pC, Ah, mAh;

  Potential: V, kV, MV, GV, TV, mV, µV, nV, pV;

  Capacitance: F, kF, MF, GF, TF, mF, µF, nF, pF;

  Resistance: Ω, kΩ, MΩ, GΩ, TΩ, mΩ, µΩ, nΩ, pΩ;

  Conductance: S, kS, MS, GS, TS, mS, µS, nS, pS, ℧, k℧, M℧, G℧, T℧, m℧, µ℧, n℧, p℧;

  Magnetic flux: Wb , kWb, MWb, GWb, TWb, mWb, µWb, nWb, pWb;

  Magnetic flux density: T, kT, MT, GT, TT, mT, µT, nT, pT;

  Inductance: H, kH, MH, GH, TH, mH, µH, nH, pH;

  Luminous flux: lm;

  Illuminance: lx;

  Radioactivity: Bq, kBq, MBq, GBq, TBq, mBq, µBq, nBq, pBq, Ci, Rd;

  Absorbed dose: Gy, kGy, MGy, GGy, TGy, mGy, µGy, nGy, pGy;

  Equivalent dose: Sv, kSv, MSv, GSv, TSv, mSv, µSv, nSv, pSv;

  Catalytic activity: kat;
- Non-metric units (Imperial/US):

  Mass: gr, dr, oz, lb (or lbm, lb_m), kipm (or kip_m), st, qr,
  cwt (or cwt_UK, cwt_US), ton (or ton_UK, ton_US), slug;

  Length: th, in, ft, yd, ch, fur, mi, ftm (or ftm_UK, ftm_US),
  cable (or cable_UK, cable_US), nmi, li, rod, pole, perch, lea;

Speed: mph, knot;
Temperature: °F, Δ°F, °R;
Area: rood, ac;
Volume, fluid: fl_oz, gi, pt, qt, gal, bbl, or:
fl_oz_UK, gi_UK, pt_UK, qt_UK, gal_UK, bbl_UK,
fl_oz_US, gi_US, pt_US, qt_US, gal_US, bbl_US;
Volume, dry: (US) pt_dry, (US) qt_dry, (US) gal_dry, (US) bbl_dry,
pk (or pk_UK, pk_US), bu (or bu_UK, bu_US);
Force: ozf (or oz_f), lbf (or lb_f), kip (or kipf, kip_f), tonf (or ton_f), pdl;
Pressure: osi, osf psi, psf, ksi, ksf, tsi, tsf, inHg;
Energy/work: BTU, therm (or therm_UK, therm_US), quad;
Power: hp, hpE, hpS;

- Custom units - .Name = expression.
  Names can include currency symbols: €, £, ₤, ¥, ¢, ₽, ₹, ₩, ₪.