Related Work:
This document is part of the OASIS Open Document Format for Office Applications (OpenDocument) Version 1.2 specification.

The OpenDocument v1.2 specification has these parts:
- OpenDocument v1.2 part 1: OpenDocument Schema
- OpenDocument v1.2 part 2 (this part): Recalculated Formula (OpenFormula) Format
- OpenDocument v1.2 part 3: Packages

Declared XML Namespaces:
None.

Abstract:
This document is part of the Open Document Format for Office Applications (OpenDocument) Version 1.2 specification.

It defines a formula language to be used in OpenDocument documents.

Status:
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1 Introduction

1.1 Introduction

This document is part of the Open Document Format for Office Applications (OpenDocument) Version 1.2 specification. It defines a formula language for OpenDocument documents, which is also called OpenFormula.

OpenFormula is a specification of an open format for exchanging recalculated formulas between office applications, in particular, formulas in spreadsheet documents. OpenFormula defines data types, syntax, and semantics for recalculated formulas, including predefined functions and operations.

Using OpenFormula allows document creators to change the office application they use, exchange formulas with others (who may use a different application), and access formulas far in the future, with confidence that the recalculated formulas in their documents will produce equivalent results if given equivalent inputs.

OpenFormula is intended to be a supporting document to the Open Document Format for Office Applications (OpenDocument) format, particularly for defining its attributes table:formula and text:formula. It can also be used in other circumstances where a simple, easy-to-read infix text notation is desired for exchanging recalculated formulas.

Terminology

All text is normative unless otherwise labeled.

Within the normative text of this specification, the terms "shall", "shall not", "should", "should not", "may" and "need not" are to be interpreted as described in Annex H of [ISO/IEC Directives].

1.2 Purpose

OpenFormula defines:

1. data types
2. syntax
3. semantics

for recalculated formulas.

OpenFormula also defines functions.

OpenFormula does not define:

1. a user interface
2. a general notation for mathematical expressions

Normative References


1.3 Non-Normative References


2 Expressions and Evaluators

2.1 Introduction

The OpenDocument specification defines conformance for formula expressions and evaluators. For evaluators, there are three groups of features that an evaluator may support. This chapter defines the basic requirements for the individual conformance targets.

2.2 OpenDocument Formula Expression

An OpenDocument formula expression shall adhere to the expression syntax defined in chapter 4. It may use subsets or supersets of OpenFormula.

2.3 Evaluators

2.3.1 OpenDocument Formula Evaluator

An OpenDocument Formula Evaluator is a program that can parse and recalculate OpenDocument formula expressions, and that meets the following additional requirements:

A) It may implement subsets or supersets of this specification.

B) It shall conform to one of: (C16) OpenDocument Formula Small Group Evaluator, (C17) OpenDocument Formula Medium Group Evaluator or (C18) OpenDocument Formula Large Group Evaluator

C) It may implement additional functions beyond those defined in this specification. It may further implement additional formula syntax, additional operations, additional optional parameters for functions, or may consider function parameters to be optional when they are required by this specification.

D) Applications should clearly document their extensions in their user documentation, both online and paper, in a manner so users would be likely to be aware when they are using a non-standard extension.

Note 1: An expression may reference a nonstandard function by name, or depend on implementation-defined behavior, or on semantics not guaranteed by this specification. An expression may reference a nonstandard function by name, or depend on implementation-defined behavior, or on semantics not guaranteed by this specification. Reference to or dependence upon functions or behavior not defined by this standard may impair the interoperability of the resulting expression(s).

Note 2: This specification defines formulas in terms of a canonical text representation used for exchange. If formulas are contained in XML attributes some characters shall be escaped as required by the XML specification (e.g., the character & shall be escaped in XML attributes using notations such as &amp;). All string and character literals references by this specification are in the value space defined by [UNICODE] thus, “A” is U+0041, “Z” is U+005A, and the range of characters “A-Z” is the range U+0041 through U+005A inclusive.
2.3.2 OpenDocument Formula Small Group Evaluator

An OpenDocument Formula Small Group Evaluator is an OpenDocument Formula Evaluator that meets the following additional requirements:

A) It shall implement at least the limits defined in the "Basic Limits" section.

B) It shall implement the syntax defined in these sections on syntax: Criteria; Basic Expressions; Constant Numbers; Constant Strings; Operators; Functions and Function Parameters; Nonstandard Function Names; References; Simple Named Expressions; Errors; Whitespace.

C) It shall implement all implicit conversions for the types it implements, at least Text, Conversion to Number, Reference, Conversion to Logical, and Error.

D) It shall implement the following operators (which are all the operators except reference union (~)):

E) It shall implement at least the following functions as defined in this specification: ABS 8.16.2; ACOS 8.16.3 ; AND 8.15.2 ; ASIN 8.16.7 ; ATAN 8.16.9 ; ATAN2 8.16.10 ; AVERAGE 8.18.3 ; AVERAGEIF 8.18.5 ; CHOOSE 8.14.3 ; COUNT 8.13.4 ; COUNTA 8.13.6 ; COUNTBLANK 8.13.8 ; COUNTIF 8.13.9 ; DATE 8.10.2 ; DAVERAGE 8.9.2 ; DAY 8.10.5 ; DCOUNT 8.9.3 ; DCOUNTA 8.9.4 ; DDB 8.12.15 ; DEGREES 8.16.25 ; DGET 8.9.5 ; DMAX 8.9.6 ;DMIN 8.9.7 ; DPRODUCT 8.9.8 ; DSTDEV 8.9.9 ; DSTDEVP 8.9.10 ; DSUM 8.9.11 ; DVAR 8.9.12 ; DVARP 8.9.13 ; EVEN 8.16.30 ; EXACT 8.20.8 ; EXP 8.16.31 ; FACT 8.16.32 ; FALSE 8.15.3 ; FIND 8.20.9 ; FV 8.12.21 ; HLOOKUP 8.14.5 ; HOUR 8.10.10 ; IF 8.15.4 ; INDEX 8.14.6 ; INT 8.17.3 ; IRR 8.12.25 ; ISBLANK 8.13.14 ; ISERROR 8.13.15 ; ISLOGICAL 8.13.19 ; ISNA 8.13.20 ; ISNONTEXT 8.13.21 ; ISNUMBER 8.13.22 ; ISTEXT 8.13.25 ; LEFT 8.20.15 ; LEN 8.20.13 ; LN 8.16.39 ; LOG 8.16.40 ; LOG10 8.16.41 ; LOWER 8.20.14 ; MATCH 8.14.9 ; MAX 8.18.45 ; MID 8.20.15 ; MIN 8.18.48 ; MINUTE 8.10.12 ; MOD 8.16.42 ; MONTH 8.10.13 ; N 8.13.26 ; NA 8.13.27 ; NOT 8.15.7 ; NOW 8.10.15 ; NPER 8.12.30 ; NPV 8.12.31 ; ODD 8.16.44 ; OR 8.15.8 ; PI 8.16.45 ; PMT 8.12.37 ; POWER 8.16.46 ; PRODUCT 8.16.47 ; PROPER 8.20.16 ; PV 8.12.42 ; RADIANS 8.16.49 ; RATE 8.12.43 ; REPLACE 8.20.17 ; REPT 8.20.18 ; RIGHT 8.20.19 ; ROUND 8.17.6 ; ROWS 8.13.30 ; SECOND 8.10.16 ; SIN 8.16.55 ; SLN 8.12.46 ; SQRT 8.16.58 ; STDEV 8.18.72 ; STDEVP 8.18.74 ; SUBSTITUTE 8.20.21 ; SUM 8.16.61 ; SUMIF 8.16.62 ; SYD 8.12.47 ; T 8.20.22 ; TAN 8.16.49 ; TIME 8.10.17 ; TODAY 8.10.19 ; TRIM 8.20.24 ; TRUE 8.15.9 ; TRUNC 8.17.9 ; UPPER 8.20.27 ; VALUE 8.13.34 ; VAR 8.18.82 ; VARP 8.18.84 ; VLOOKUP 8.14.12 ; WEEKDAY 8.10.20 ; YEAR 8.10.23

F) It need not evaluate references that contain more than one area.

G) It need not implement inline arrays, complex numbers, and the reference union operator.

H) For expressions embedded in an OpenDocument document, it shall consider the values of the following host defined properties: HOST CASE SENSITIVE, HOST PRECISION AS SHOWN, HOST SEARCH CRITERIA MUST APPLY TO WHOLE CELL, HOST AUTOMATIC FIND LABELS, HOST USE REGULAR EXPRESSIONS, HOST USE WILDCARDS, HOST NULL YEAR, HOST NULL DATE.

I) It shall support international characters for named expression identifiers.

J) Note: This specification does not mandate a user interface for international characters, so a resource-constrained application may choose to not show the traditional glyph (e.g., it may show the [UNICODE] numeric code instead).
2.3.3 OpenDocument Formula Medium Group Evaluator

An **OpenDocument Formula Medium Group Evaluator** is an OpenDocument Small Group Formula Evaluator that meets the following additional requirements:

A) It shall implement the following functions as defined in this specification: ACCRINT 8.12.2; ACCRINTM 8.12.3; ACOSH 8.16.4; ACOT 8.16.5; ACOTH 8.16.6; ADDRESS 8.14.2; ASINH 8.16.8; ATANH 8.16.11; AVEDEV 8.18.2; BESSELI 8.16.12; BESSELY 8.16.13; BETADIST 8.18.7; BETAINV 8.18.8; BINOMDIST 8.18.10; CEILING 8.17.2; CHAR 8.20.3; CLEAN 8.20.4; CODE 8.20.5; COLUMN 8.13.4; COMBIN 8.16.16; CONCATENATE 8.20.6; CONFIDENCE 8.16.16; CONVERT 8.16.18; CORREL 8.18.17; COSH 8.16.20; COT 8.16.21; COTH 8.16.22; COUPDAYBS 8.12.6; COUPDAYS 8.12.7; COUPDAYSNC 8.12.8; COUPNCD 8.12.9; COUPNUM 8.12.10; COUPPCD 8.12.11; COVAR 8.18.18; CRITBINOM 8.18.19; CUMIPMT 8.12.12; CUMPRINC 8.12.13; DATEVALUE 8.10.4; DAYS360 8.10.7; DB 8.12.14; DEVSQ 8.18.20; DISC 8.12.16; DOLLARDE 8.12.17; DOLLARFR 8.12.18; DURATION 8.12.19; EFFECT 8.12.20; EOMONTH 8.10.9; ERF 8.16.27; ERFC 8.16.28; EXPONDIST 8.18.21; FISHER 8.18.26; FISHERINV 8.18.27; FIXED 8.20.10; FLOOR 8.17.4; FORECAST 8.18.28; FTEST 8.18.30; GAMMA 8.18.31; GAMMAINV 8.18.32; GAMMALN 8.16.35; GCD 8.16.36; GEOMEAN 8.18.34; HARMEAN 8.18.36; HYPGEOMDIST 8.18.37; INTERCEPT 8.18.38; INTRATE 8.12.23; ISEVEN 8.13.17; ISODD 8.13.23; ISOWEEKNUM 8.10.11; KURT 8.18.39; LARGE 8.18.40; LCM 8.16.38; LEGACY.CHIDIST 8.18.11; LEGACY.CHIINV 8.18.13; LEGACY.CHITEST 8.18.15; LEGACY.FDIST 8.18.23; LEGACY.FINV 8.18.25; LEGACY.NORMSDIST 8.18.54; LEGACY.NORMSINV 8.18.55; LEGACY.TDIST 8.18.77; LINDEX 8.18.41; LOGEST 8.18.42; LOGINV 8.18.43; LOGNORMDIST 8.18.44; LOOKUP 8.14.8; MDURATION 8.12.27; MEDIAN 8.18.47; MINVERSE 8.5.3; MIRR 8.12.28; MMULT 8.5.4; MODE 8.18.50; MROUND 8.17.5; MULTINOMIAL 8.16.43; NEGINV 8.18.51; NETWORKDAYS 8.10.14; NOMINAL 8.12.29; ODDPFRCIE 8.12.32; ODDFYIELD 8.12.33; ODDPRICE 8.12.34; ODDLYIELD 8.12.35; OFFSET 8.14.11; PEARSON 8.18.56; PERCENTILE 8.18.57; PERCENTRANK 8.18.58; PERMUT 8.18.59; POISSON 8.18.62; PRICE 8.12.39; PRICMAT 8.12.41; PROB 8.18.63; QUARTILE 8.18.64; QUOTIENT 8.16.48; RAND 8.16.50; RANDBETWEEN 8.16.51; RANK 8.18.65; RECEIVED 8.12.44; ROMAN 8.19.17; ROUND 8.17.7; ROUNDUP 8.17.8; ROW 8.13.29; RSQ 8.18.66; SERIESUM 8.16.53; SIGN 8.16.54; SINH 8.16.56; SKEW 8.18.67; SKEWP 8.18.68; SLOPE 8.18.69; SMALL 8.18.70; SQRTP 8.16.59; STANDARDIZE 8.18.71; STDEVA 8.18.73; STDEVPA 8.18.75; STEYX 8.18.76; SUBTOTAL 8.16.60; SUMPRODUCT 8.16.64; SUMSQ 8.16.65; SUMX2MY2 8.16.66; SUMX2PY2 8.16.67; SUMXY 8.16.68; TANH 8.16.70; TBILLEDG 8.12.48; TBILLPRICE 8.12.49; TBILLYIELD 8.12.50; TIME 8.10.18; TINV 8.18.78; TRANSPOSE 8.5.6; TREND 8.18.79; TRIMMEAN 8.18.80; TTEST 8.18.81; TYPE 8.13.33; VARA 8.18.83; VDB 8.12.51; WEEKNUM 8.10.21; WEIBULL 8.18.86; WORKDAY 8.10.22; XIRR 8.12.52; XOR 8.12.53; YEARFRAC 8.10.24; YIELD 8.12.54; YIELDDISC 8.12.55; YIELDMAT 8.12.56; ZTEST 8.18.87

B) It shall implement the Infix Operator Reference Union ("-"") 8.4.13

C) It shall evaluate references with more than one area.

2.3.4 OpenDocument Formula Large Group Evaluator

An **OpenDocument Formula Large Group Evaluator** is an OpenDocument Medium Group Formula Evaluator that meets the following additional requirements:

A) It shall implement the syntax defined in these sections on syntax: Inline Arrays; Automatic Intersection; External Named Expressions.

B) It shall implement the complex number type as discussed in the section on Complex Number, array formulas, and Sheet-local Named Expressions.

It shall implement the following functions as defined in this specification: AMORLINC 8.12.5; ARABIC 8.19.2; AREAS 8.13.2; ASC 8.20.2; AVERAGEA 8.18.4; AVERAGEIFS 8.18.6; BASE
differences from OpenFormula and some existing applications are:
In practice, for nearly all documents the differences are irrelevant. The primary variances and
different than the user interface of some implementations.
In a few cases a specific approach is required (e.g., string indexes begin at one), which may be
Applications
Behavioral Changes)
2.4 Variances (Implementation-defined, Unspecified, and Behavioral Changes)

Applications should document all implementation-defined and variances from this standard in a
manner that the application users can obtain the information (e.g., in the application help for the
relevant function).

In a few cases a specific approach is required (e.g., string indexes begin at one), which may be
different than the user interface of some implementations.

In practice, for nearly all documents the differences are irrelevant. The primary variances and
differences from OpenFormula and some existing applications are:

- Some conversions between types are not required to be automatic. In particular, applications
  may, but need not, perform automatic conversion of text in a cell when it is to be used as a
  number (see Auto Text to Number).

Note: The following functions are documented by this specification, but not included even in the
Large group: CELL 8.13.3; DOLLAR 8.20.7
Note: Interoperability is improved by the use of the DATE and TIME functions or the textual ISO-8601 date representation because dates in that format do not rely upon epoch or locale-specific settings.

There need not be a distinguishable Logical type. Applications may have a Logical type distinct from Number (see Distinct Logical), but Logical values may also be represented by the Number type using the values 1 (True) and 0 (False). This means that functions that take number sequences (such as SUM) may or may not include true and false values in the sequence.

- Applications vary on the set of Errors they support. In this specification. The only distinguished Error is #N/A; all other errors are simply errors, allowing applications to choose the Error set that best meets their needs.

- In this specification, string index positions start from 1. Users of applications with string index positions starting from 0 shall add and subtract 1 on import/export of this format, as appropriate.

- Database criteria match patterns (such as the pattern matching language for text) have historically varied: Some support glob syntax (e.g., a*b is a, followed by 0 or more characters, followed by b), while others support traditional regular expression syntax (e.g., a*b is zero or more a’s, followed by b). This specification supports both pattern languages.

Note: Interoperability is improved by the use of the DATE and TIME functions or the textual [ISO8601] date representation because dates in that format do not rely upon epoch or locale-specific settings.

In an OpenDocument file, calculation settings impact formula recalculation, which can be the same or different from a particular application's defaults. These include whether or not text comparisons are case-sensitive, or if search criteria shall apply to the whole cell.
3 Formula Processing Model

3.1 General

This section describes the basic formula processing model: how expressions are calculated, when recalculation occurs, and limits on formulas.

3.2 Expression Evaluation

3.2.1 General

OpenFormula defines rules for the evaluation of expressions as well as the functions and operators that appear in expressions.

3.2.2 Expression Calculation

Expressions in OpenFormula shall be evaluated by application of the following rules:

1) If an expression consists of a constant Number (7.2), a constant String (7.3), a Reference (7.8), constant Error (per section 5.12), the value of that type is returned.

2) If an expression consists of one or more operations, apply the operators in order of precedence and associativity as defined by Table 1 in 7.4 (Operators). Precedence of operators may be altered by the use of "( (LEFT PARENTHESES, U+0028) and ") (RIGHT PARENTHESES, U+0029) to group operators. Evaluate the operator as described in Operator and Function Evaluation, 3.2.3.

3) If an expression consists of a function call (7.5, 7.7), evaluate the function as described in Operator and Function Evaluation, 3.2.3.

4) If an expression consists of a named expression (7.11), the result of evaluating the named expression is returned.

5) If an expression consists of a QuotedLabel (7.10), AutomaticIntersection (7.10.6), or Array (7.15), its value is returned. Expression Syntax 5

Once evaluation has completed:

1) If the result is a Reference and a single non-reference value is needed, it is converted to the referenced value, using the rules of Non-Scalar Evaluation, 3.3, 1.2.

2) If the result an Array, for the display area, apply the rules of Non-Scalar Evaluation, 3.3, 1.1.

3.2.3 Operator and Function Evaluation

Operators and functions in OpenFormula shall be evaluated according to their definitions by applying the following rules:

1) The value of all expression arguments are computed. Exceptions to computation of all arguments are noted in a function's specification.
Note: The practice of computing all argument expressions is known as "eager" evaluation. The IF function is an example of a function that does not require computation of all arguments.

2) If an argument expression evaluates to Error, calculation of the operator or function may short-circuit and return the Error if the function does not suppress error propagation as noted in the function's specification.

3) If an operator or function is passed a value of incorrect type, call the appropriate implicit conversion function to convert the value to the correct type. If conversion is not possible, generate an Error.

4) The function or operation is called with its argument expressions' results, and the result of the function or operation is the evaluation of the expression.

3.3 Non-Scalar Evaluation (aka 'Array expressions')

Conceptually, formulas are recalculated from the "outside-in". Any formula is an expression that produces a result. An expression is calculated as follows:

1. If an expression is a constant number or string, that constant is returned

2. If it is a reference, the reference is returned. If a reference is to be displayed, the value of the reference is displayed, not the reference itself.

3. Otherwise, it is one or more operations or functions; in the case of operations, the highest-precedence operation not processed is processed first.

a) The values of all argument expressions are computed, that is, formulas are normally "eagerly" evaluated. Exceptions to eager evaluation are noted in the function or operation's specification; in particular, the IF() function does not calculate the "else" parameter if the condition is true, and does not calculate the "then" parameter if the condition is false. The CHOOSE() function does not calculate parameters other than the chosen. Function parameters shall act as if they had been computed in left-to-right order. Operators should act as if they had been computed in the order of precedence and associativity (so they are computed left-to-right for +, *, and so on, but right-to-left for the exponentiation operator ^).

b) If any of the arguments of the function/operation are not of the correct type, the appropriate implicit conversion function is called to convert it to the correct type for the operator or function.

c) The operation or function is then called with the resulting values of its arguments.

The above model only describes how recalculation appears to the end-user. Applications may, and typically do, optimize this process as long as the final results produce the same answer. For example, applications may parse a formula and translate it into some intermediate form (such as byte-code), which immediately descends to the "innermost" computation that needs to be calculated and then works out to the final result.

When a formula is computed, it is notionally provided a "context" as input. The context may include formula variables (including named ranges, document variables, fields, and so on), and/or additional function definitions that the formula can call. A formula may also be provided as input an ordered list of zero or more parameters (though the syntax for parameters is not given in this version of the specification). In an OpenDocument formula, this context also includes calculation settings (such as whether or not text comparisons are case-sensitive).

A formula may include calls to functions, which are normally provided the same context but with their own set of ordered parameters.
Any formula computes a single result, though that single result may actually be a set of values.

### 3.4 Non-Scalar Evaluation (aka 'Array expressions')

Non-scalar values passed as arguments to functions are evaluated by intersection or iteration.

1) Evaluation as an implicit intersection of the argument with the expression's evaluation position.

   1.1) Inline Arrays
   
   Element (0;0) of the array is used in place of the array.

   **Note 1:**
   
   - `=ABS({-3;-4})` => ABS(-3)  // row vector
   - `=ABS({-3|-4})` => ABS(-3)  // column vector
   - `=ABS({-3|-4|-6;-8})` => ABS(-3)  // matrix
   - `{1;2;3|4;5;6}` => 1  // simple display

1.2) References

   1.2.1) If the target reference is a row-vector (Nx1) use the value at the intersection of the evaluation position's column and the reference's row.

   **Note 2:**
   
   - in cell B2 : `=ABS(A1:C1)` => ABS(B1)
   - If there is no intersection the result is #VALUE!

   **Note 3:** in cell D4 : `=ABS(A1:C1)` => #VALUE!

   1.2.2) If the target reference is a column-vector (1xM) the value at the intersection of the evaluation position's row and the reference's column.

   **Note 4:**
   
   - in cell D4 : `=ABS(A1:A3)` => #VALUE!

2) Matrix evaluation.

If an expression is being evaluated in a cell flagged as a being part of a 'Matrix' (OpenDocument 8.1.3 `table:number-matrix-columns-spanned`):

2.1) The portion of a non-scalar result to be displayed may not be co-extensive with a specified display area. The portion of the non-scalar result to be displayed is determined by:

   2.1.1) If the position to be displayed exists in the result, display that position.

   2.1.2) If the non-scalar result is 1 column wide, subsequent columns in the display area display the value in the first column. This applies to:
   - scalars '3'
   - singletons '{3}'
   - column vectors '{1|2|3}'

   2.1.3) If the non-scalar result is 1 row high, subsequent rows in the display area use the value of the first row. This applies to:
   - scalars '3'
   - singletons '{3}'
   - row vectors '{1;2;3}'

   2.1.4) If none of the other rules apply #N/A
2.2) Calculations with non-scalar inputs are a generalization of (2.1).

When evaluating a formula in 'matrix' mode, and a non-scalar value is passed to a
function argument that expects a scalar, the function is evaluated multiple times,
iterating over the non-scalar input(s) and putting the function result into a matrix at the
position corresponding to the input. Unary/Binary operators, other than range and
union, follow the rules for scalar functions when passed non-scalar values.

Inline arrays and references are interchangeable.

2.2.1) Functions returning arrays are not eligible for implicit iteration. When evaluated in
'matrix' mode the {0;0}th element is used.

2.2.2) The result matrix is rectangular, sized with the maximum number of rows and
columns from all non-scalar arguments.

2.2.3) The result matrix is populated by extracting the corresponding value from each of
the non-scalar arguments based on the following rules, and evaluating the function
with that set of arguments.

2.2.3.1) If the argument data is a singleton array or a scalar the value is repeated
for each evaluation.

2.2.3.2) If the argument data is 1 column wide the value in the corresponding row
is used to evaluate all columns in the result matrix.
2.2.3.3) If the argument data is 1 row height the value in the corresponding column is used to evaluate all rows in the result matrix.

Note 11:
= {1;2} + {10;20|30;40} => {11;22|31;42}

2.2.3.4) If one argument data is 1 column wide and another argument data is 1 row height the value of the corresponding row respectively column is used to evaluate all elements in the result matrix.

Note 12:
={1;2} + {10|20} => {11;12|21;22}

2.2.3.5) If an argument is a 2d matrix the argument value in the position corresponding to the current output position is used if it is within range of the supplied argument, otherwise #N/A is used in the calculation.

Note 13:
=MID("abcd";{1;2};{1;2;3}) => {"a";"bc";#VALUE!}

3.5 Host-Defined Behaviors

A Formula Evaluator operates in an execution environment (a "host"). The behavior of the Formula Evaluator is parametrized by host-defined properties and functions.

The following properties are host-defined:

1) HOST-CASE-SENSITIVE: if true, text comparisons are case-sensitive. This influences the operators =, <>, <=, =>, and >=, as well as database query functions that use them. Note that the EXACT function is always case-sensitive, regardless of this calculation setting.

2) HOST-PRECISION-AS-SHOWN: If true, calculations are performed using rounded values of those displayed; otherwise, calculations are performed using the precision of the underlying numeric representation. Note: This does not impose a particular numeric model. Since implementations may use binary representations, this rounding may be inexact for decimal value.

3) HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL If true, the specified search criteria shall apply to the entire cell contents if it is a text match using = or <>; if not, only the initial text needs to match.

4) HOST-AUTOMATIC-FIND-LABELS: if true, row and column labels are automatically found.

5) HOST-USE-REGULAR-EXPRESSIONS: If true, regular expressions are used for character string comparisons and when searching.

6) HOST-USE-WILDCARDS: If true, wildcards question mark '?' and asterisk '*' are used for character string comparisons and when searching. Wildcards may be escaped with a tilde '~' character.

7) HOST-NULL-YEAR: This defines how to convert a two-digit year into a four-digit year. All two-digit year values are interpreted as a year that equals or follows this year.

8) HOST-NULL-DATE: Defines the beginning of the epoch; a numeric date of 0 equals this date.
9) **HOST-LOCALE**: The locale to be used for locale-dependent operations, such as conversion of text to dates, or text to numbers.

10) **HOST-ITERATION-STATUS**: If enabled, iterative calculations of cyclic references are performed.

11) **HOST-ITERATION-MAXIMUM-DIFFERENCE**: If iterative calculations of cyclic references are enabled, the maximum absolute difference between calculation steps that all involved formula cells must yield for the iteration to end and yield a result.

12) **HOST-ITERATION-STEPS**: If iterative calculations of cyclic references are enabled, the maximum number of steps iterations are performed if the results are not within HOST-ITERATION-MAXIMUM-DIFFERENCE.

The function HOST-REFERENCE-RESOLVER(Reference) is implementation defined. This function takes as input a Unicode string containing a Reference according to section 4.8 and returns a resolved value.

### 3.6 When recalculation occurs

Implementations of OpenFormula typically recalculate formulas when its information is needed. Typical implementations will note what values a formula depends on, and when those dependent values are changed and the formula’s results are displayed, it will re-execute the formulas that depend on them to produce the new results (choosing the formulas in the right order based on their dependencies). Implementations may recalculate when a value changes (this is termed **automatic recalculation**) or on user command (this is termed **manual recalculation**).

Some functions’ dependencies are difficult to determine and/or should be recalculated more frequently. These include functions that return today’s date or time, random number generator functions (such as RAND 8.16.50), or ones that indirectly determine the cells to act on. Many implementations **always** recalculate formulas including such functions whenever a recalculation occurs. Functions that are **always** recalculated whenever a recalculation occurs are termed **volatile** functions. Functions that are often volatile functions include CELL 8.13.3, HYPERLINK 8.11.3, INDIRECT 8.14.7, INFO 8.13.13, NOW 8.10.15, OFFSET 8.14.11, RAND 8.16.50 and TODAY 8.10.19. Functions that depend on the cell position of the formula they are contained in or the position of a cell they reference need to be recalculated whenever that cell is moved, such functions are COLUMN 8.13.4, ROW 8.13.29 and SHEET 8.13.31. In addition, formulas may indicate that they should **always** be recalculated during a recalculation process by including a forced recalculation marker, as described in the syntax below.

### 3.7 Numerical Models

This specification does not, by itself, specify a numerical implementation model, though it does imply some minimal levels of accuracy for most functions. For example, an application cannot say that it implements the infix operator “/” as specified in this document if it implements integer-only arithmetic.

In practice, applications tend to use at least one IEEE 754-1985 binary floating-point representation, using at least the 64-bit representation and possibly larger widths for intermediate results. When IEEE 754 representations are used, results such as Inf (infinity) and Nan (not a number) are considered an Error value. Applications may use IEEE 854-1997 (which covers decimal arithmetic). In general, applications are encouraged to use appropriate standards for their numerical models. This means that applications will often not produce “exact” results, but only approximate results for a large number of places.

**Basic Limits**

Evaluators which claim to support “basic limits” shall support at least the following limits:
1. formulas up to at least 1024 characters long, as measured when in OpenDocument interchange format not counting the square brackets around cell addresses, or the "." in a cell address when the sheet name is omitted.

2. at least 30 parameters per function when the function prototype permits a list of parameters.

3. permit strings of ASCII characters of up to 32,767 \(({2^{15}}-1)\) characters.

4. support at least 7 nesting levels of functions.
4 Types

4.1 General

All values defined by OpenFormula have a type. OpenFormula defines Text, Number, Complex Number, Logical, Error, Reference, ReferenceList and Array types.

4.2 Text (String)

A Text value (also called a string value) is a Character string per [CharModel] sequence of zero or more characters.

Evaluators should accept UNICODE strings, but shall accept strings of ASCII (Unicode U+0020 through U+007F, inclusive) characters.

A text value of length zero is termed the empty string.

Index positions in a text value begin at 1.

Whether or not Unicode Normalization [UTR15] is performed on formulas, formula results or user inputs is implementation-defined. Some functions defined in this Part are labeled as “normalization-sensitive”, meaning that the results of the formula evaluation may differ depending on whether normalization occurs, and which normalization form is used. Mixing operands of different normalization forms in the same calculation is undefined.

4.3 Number

4.3.1 General

A number is a numeric value.

Numbers shall be able to represent fractional values (they shall not be limited to only integers).

Evaluators may implement Number with an arbitrary fixed or with a variable bit length. A cell with a constant numeric value has the Number type.

Note: Many evaluators implement numbers as 64-bit IEEE floating point values and use the CPU’s floating-point instructions where available (so intermediate values may be represented using more than 64 bits).

Implementations typically support many subtypes of Number, including Date, Time, DateTime, Percentage, fixed-point arithmetic, and arithmetic supporting arbitrarily long integers, and determine the display format from this. All such Number subtypes shall yield True for the ISNUMBER 8.13.22 function. This specification does not require that specific subtypes be distinguishable from each other, or that the subtype be tracked, but in practice most implementations do such tracking because requiring users to manually format every cell appropriately becomes tedious very quickly. Automatically determining the most likely subtype is especially important for a good user interface when generating OpenDocument format, since some subtypes (such as date, time, and currency) are stored in a different manner depending on their subtype. Thus, this specification identifies some common subtypes and identifies those subtypes where relevant in some function definitions, as an aid to implementing good user interfaces. Many applications vary in the subtype produced when combining subtypes (e.g., what is the result when percentages are multiplied together), so unless otherwise noted these are unspecified. Typical implementations try to heuristically determine the
"right" format for a cell when a formula is first created, based on the operations in the formula. Users can then override this format, so as a result the heuristics are not important for data exchange (and thus outside the scope of this specification).

All Number subtypes shall yield True for the ISNUMBER function.

**Note:** This specification does not require that specific subtypes be distinguishable from each other, or that the subtype be tracked, but in practice most evaluators do such tracking. Automatically determining the most likely subtype is important for a good user interface and when generating OpenDocument format, since some subtypes (such as date, time, and currency) are stored in a different manner depending on their subtype. Typical implementations try to heuristically determine the "right" format for a cell when a formula is first created, based on the operations in the formula. Expression authors can then override this display format, so as a result the heuristics are not important for data exchange (and thus outside the scope of this specification).

### 4.3.2 Time

Time is a subtype of Number. 

Time is represented as a fraction of a day.

### 4.3.3 Date

Date is a subtype of Number. 

Date is represented by an integer value. 

A serial date is the expression of a date as the number of days elapsed from a start date called the epoch.

Evaluators shall support all dates from 1904-01-01 through 9999-12-31 (inclusive) in calculations, should support dates from 1899-12-30 through 9999-12-31 (inclusive) and may support a wider date range.

**Note 1:** Using expressions that assume serial numbers are based on a particular epoch may cause interoperability issues.

Evaluators shall support positive serial numbers. Evaluators may support negative serial numbers to represent dates before an epoch.

**Note 2:** It is implementation-defined if the year 1900 is treated as a leap year.

**Note 3:** Evaluators that treat 1900 as a non-leap year can use the epoch date 1899-12-30 to compensate for serial numbers that originate from evaluators that treat 1900 as a leap year and use 1899-12-31 as an epoch date.

### 4.3.4 DateTime

DateTime is a subtype of Number. It is a Date plus Time.

### 4.3.5 Percentage

A percentage is a subtype of Number that may be displayed by multiplying the number by 100 and adding the sign "%" or with other formatting depending upon the number format assigned to the cell where it appears.
4.3.6 Currency

A currency is a subtype of Number that may appear with or without a currency symbol or with other formatting depending upon the number format assigned to the cell where it appears.

4.3.7 Logical (Number)

A Logical value is a subtype of Number where TRUE() returns 1 and FALSE() returns 0.

The implicit conversion operator “Convert to Logical” 8.3.12, when a Number is passed as a condition, 0 is considered False and all other numeric values are considered True.

Note: Logical values can be a distinct type from Number. 4.5

4.4 Complex Number

A complex number (sometimes also called an imaginary number) is a pair of real numbers including a real part and an imaginary part. In mathematics, complex numbers are often written as $x + iy$, where $x$ (the real part) and $y$ (the imaginary part) are real numbers and $i$ is $\sqrt{-1}$. A complex number can also be written as $re^{i\theta} = r\cos(\theta) + ir\sin(\theta)$, where $r$ is the modulus of the complex number (a real number) and $\theta$ is the argument or phase (a real number representing an angle in radians).

A complex number may, but need not be, represented as a Number or Text. The results of the functions ISNUMBER() and ISTEXT() are implementation-defined when applied to a complex number.

Functions and operators that accept complex numbers shall accept Text values as complex numbers (8.3.10 Conversion to Complex Number, as well as Numbers that are not complex numbers.

Note 1: IMSUM("3i",4) will produce the same result as COMPLEX(4;3).

Note 2: Expression authors should be aware that use of functions that are not defined by OpenFormula as accepting complex numbers as input may impair interoperability.

Equality can be tested using IMSUB to compute the difference, use IMABS to find the absolute difference, and then ensure the absolute difference is smaller than or equal to some nonnegative value (for exact equality, compare for equality with 0).

4.5 Logical (Boolean)

A Logical value (also called a Boolean value) is a value with one of two values: TRUE() and FALSE().

Note: Logical values can be represented as a subtype of Number. 4.3.7

4.6 Error

An Error is one of a set of possible error values. Implementations may have many different error values, but one error value in particular is distinct: #N/A, the result of the NA() function. Users may
choose to enter some data values as #N/A, so that this error value propagates to any other formula that uses it, and may test for this using the function ISNA().

Functions and operators that receive one or more error values as an input shall produce one of those input error values as their result, except when the formula or operator is specifically defined to do otherwise.

In an OpenDocument document, if an error value is the result of a cell computation it shall be stored as if it was a string. That is, the office:value-type of an error value is string; if the computed value is stored, it is stored in the attribute office:string-value.

Note: This does not change an Error into a string type (since the Error will be restored on recalculation); this enables applications which cannot recalculate values to display the error information.

4.7 Empty Cell

An empty cell is neither zero nor the empty string, and an empty cell can be distinguished from cells containing values (including zero and the empty string). An empty cell is not the same as an Error, in particular, it is distinguishable from the Error #N/A (not available).

4.8 Reference

A cell strip consists of cell positions in the same row and in one or more contiguous columns.

A cell rectangle consists of cell positions in the same cell strips of one or more contiguous rows.

A cell cuboid consists of cell positions in the same cell rectangles of one or more contiguous sheets.

A reference is the smallest cuboid that (1) contains specifically-identified cell positions and/or specifically-identified complete columns/rows such that (2) removal of any cell positions either violates condition (1) or does not leave a cuboid.

Cell positions in a cell cuboid/rectangle/strip can resolve to empty cells (section 3.7).

The definitions of specific operations and functions that allow references as operands and parameters stipulate any particular limitations there are on forms of references and how empty cells, when permitted, are interpreted.

4.9 ReferenceList

A reference list contains 1 or more references, in order. A reference list can be passed as an argument to functions where passing one reference results in an identical computation as an arbitrary sequence of single references occupying the identical cell range.


A reference list cannot be converted to an array.


Passing a reference list where a function does not expect one shall generate an Error. Passing a reference list in array iteration context to a function expecting a scalar value shall generate an Error.
4.10 Array

An array is a set of rows each with the same number of columns that contain one or more values. There is a maximum of one value per intersection of row and column. The intersection of a row and column may contain no value.

4.11 Pseudotypes

4.11.1 General

Many functions require a type or a set of types with special properties, and/or process them specially. For example, a "Database" requires headers that are the field names. These specialized types are called pseudotypes.

4.11.2 Scalar

A Scalar value is a value that has a single value. A reference to more than one cell is not a scalar (by itself), and shall be converted to one as described below. An array with more than one element is not a scalar. The types Number (including a complex number), Logical, and Text are scalars.

4.11.3 DateParam

A DateParam is a value that is either a Number (interpreted as a serial number; 4.3.3) or Text; text is automatically converted to a date value. 8.3.15

4.11.4 TimeParam

A TimeParam is a value that is either a Number (interpreted as a serial number; 4.3.2) or Text; text is automatically converted to a time value (fraction of a day). 8.3.16

4.11.5 Integer

An integer is a subtype of Number that has no fractional value. An integer X is equal to INT(X). Division of one integer by another integer may produce a non-integer.

4.11.6 TextOrNumber

TextOrNumber is a value that is either a Number or Text.

4.11.7 Basis

4.11.7.1 General

A basis is a subtype of Integer that specifies the day-count convention to be used in a calculation. This standard defines five day-count conventions, corresponding to widely used current and historical accounting conventions. Each of these five bases defines two things:

1. How to calculate the number of days between two dates, date1 and date2.
2. How to calculate the number of days in each year between two dates, date1 and date2.
Historically day-count bases used the naming convention x/y, which indicated that the convention assumed x days per month and y days per year. These names are given for reference purposes.

<table>
<thead>
<tr>
<th>Date Basis</th>
<th>Historical Name</th>
<th>Day Count</th>
<th>Days in Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>US (NASD) 30/360</td>
<td>Procedure A, 4.11.7.3</td>
<td>Procedure D, 4.11.7.6</td>
</tr>
<tr>
<td>1</td>
<td>Actual/Actual</td>
<td>Procedure B, 4.11.7.4</td>
<td>Procedure E, 4.11.7.7</td>
</tr>
<tr>
<td>2</td>
<td>Actual/360</td>
<td>Procedure B, 4.11.7.4</td>
<td>Procedure D, 4.11.7.6</td>
</tr>
<tr>
<td>3</td>
<td>Actual/365</td>
<td>Procedure B, 4.11.7.4</td>
<td>Procedure F, 4.11.7.8</td>
</tr>
<tr>
<td>4</td>
<td>European 30/360</td>
<td>Procedure C, 4.11.7.5</td>
<td>Procedure D, 4.11.7.6</td>
</tr>
</tbody>
</table>

### 4.11.7.2 Procedural Notation

The day-count procedures are expressed using notations defined as:

- \( \text{day}(\text{date}) \) returns the day of the month for the given date value, an integer from 1 to 31
- \( \text{month}(\text{date}) \) returns the month of a given date value, an integer from 1-12
- \( \text{year}(\text{date}) \) returns the year of the given date value
- \( \text{truncate}(\text{date}) \) truncates any fractional (hours, minutes, seconds) of a date value and returns the whole date portion.
- \( \text{Binary comparison operators } \text{date1}>\text{date2} \) and \( \text{date1} == \text{date2} \)
- \( \text{is-leap-year}(\text{year}) \) returns true if year is a leap year, otherwise false.

**Note:** Some of the day count procedures use intermediate results that contain counter-factual dates, such as February 30th. This is not an error. The above functions work on such dates as well, e.g., \( \text{day}(\text{February 30th}) = 30 \).

### 4.11.7.3 Procedure A

1. \( \text{truncate}(\text{date1}), \text{truncate}(\text{date2}) \)
2. If \( \text{date1} == \text{date2} \) return 0
3. If \( \text{date1}>\text{date2} \), then swap the values of \( \text{date1} \) and \( \text{date2} \).
4. If \( \text{day}(\text{date1}) == 31 \) then subtract 1 day from \( \text{date1} \)
5. If \( \text{day}(\text{date1}) == 30 \) and \( \text{day}(\text{date2}) == 31 \) then subtract 1 day from \( \text{date2} \)
6. If both \( \text{date1} \) and \( \text{date2} \) are the last day of February, change \( \text{date2} \) to the 30th of the month.
7. If \( \text{date1} \) is the last day of February, change it to the 30th of the month.
8. Return \( (\text{year}(\text{date2})*360 + \text{month}(\text{date2})*30 + \text{day}(\text{date2})) - (\text{year}(\text{date1})*360 + \text{month}(\text{date1})*30 + \text{day}(\text{date1})) \).

### 4.11.7.4 Procedure B

1. \( \text{truncate}(\text{date1}), \text{truncate}(\text{date2}) \)
2. If \( \text{date1}>\text{date2} \), then swap the values of \( \text{date1} \) and \( \text{date2} \).
3. Return the actual numbers of days between date1 and date2, inclusive of date1, but not inclusive of date2.

### 4.11.7.5 Procedure C

1. `truncate(date1), truncate(date2)`
2. `If date1==date2 return 0`
3. `If date1> date2, then swap the values of date1 and date2.`
4. `If day(date1)==31 then subtract 1 from date1`
5. `If day(date2)==31 then subtract 1 from date 2`
6. `Return (year(date2)*360 + month(date2)*30 + day(date2)) - (year(date1)*360 + month(date1)*30 + day(date1)).`

### 4.11.7.6 Procedure D

1. `Return 360`

### 4.11.7.7 Procedure E

1. Evaluate A: `year(date1) != year(date2)`
2. Evaluate B: `year(date2)!=year(date1)+1`
3. Evaluate C: `month(date1) < month(date2)`
4. Evaluate D: `month(date1) == month(date2)`
5. Evaluate E: `day(date1) < day(date2)`
6. Evaluate F: `(A and B) or (A and C) or (A and D and E)`
7. If F is true then return the average of the number of days in each year between date1 and date2, inclusive.
8. Otherwise, if A and is-leap-year(year(date1)) then return 366
9. Otherwise, if a February 29 occurs between date1 and date2 then return 366
10. Otherwise, if date2 is a February 29, then return 366
11. Otherwise return 365

### 4.11.7.8 Procedure F

1. `Return 365`

---

A basis is a subtype of Integer (and thus of Number) that indicates the calendar system conventions to be used. If basis is omitted from a financial function, the default is basis 0.

Basis values are defined as follows (where x/y indicates x days per month and y days per year):

- Basis 0 or omitted (30/360): Truncates date values and swaps them if date1 is after date2. If the dates are equal, the difference of days is 0. Assumes that each month has 30 days and the total number of days in the year is 360 by making the following adjustments:
  - If both day-of-months are 31, they are changed to 30
Otherwise, if date1’s day-of-month is 31, it is changed to 30

Otherwise, if date1’s day of month is 30 and date2’s day of month is 31, date2’s day of month is changed to 30 (note that date2’s day of month will stay 31 if date1’s day < 30)

Otherwise, if both dates are the last day of February in their respective years, both day of month is changed to 30

Otherwise, if date1 is the last day of February, its day of month is changed to 30

Then computes the difference as
\[(date2.\text{year} \times 360 + date2.\text{month} \times 30 + date2.\text{day}) - (date1.\text{year} \times 360 + date1.\text{month} \times 30 + date1.\text{day})\]

- **Basis 1 (Actual/actual):** Truncates date values and swaps them if date1 is after date2. If the dates are equal, the difference in days is 0. If date1 and date2 not “less than or equal to a year apart” (as defined below), then the days in the years between the dates is the average number of days in the years between date1 and date2, inclusive. Otherwise, the days in the years between the dates is 365, except for these cases (where it is 366): the dates are in the same year and it is a leap year, a February 29 occurs between the two dates, or date2 is February 29.

To determine if date1 and date2 are “less than or equal to a year apart” for purposes of this algorithm, one of these conditions must be true:

- The two dates have the same year
- Date2’s year is exactly one more than date1’s year, and ((date1.month > date2.month) or ((date1.month == date2.month) and (date1.day >= date2.day)))

- **Basis 2 (Actual/360):** Truncates date values and swaps them if date1 is after date2. If the dates are equal, the difference in days is 0. Computes the actual difference in days, and presumes there are always 360 days per year.

- **Basis 3 (Actual/365):** Truncates date values and swaps them if date1 is after date2. If the dates are equal, the difference in days is 0. Computes the actual difference in days, and presumes there are always 365 days per year.

- **Basis 4 (30/360):** Truncates date values and swaps them if date1 is after date2. If the dates are equal, the difference in days is 0. Assumes that each month has 30 days and the total number of days in the year is 360; any day-of-month (in date1, date2, or both) with a value of 31 is changed to 30. February dates are never changed, because there is no February 31.

Then computes the difference as
\[(date2.\text{year} \times 360 + date2.\text{month} \times 30 + date2.\text{day}) - (date1.\text{year} \times 360 + date1.\text{month} \times 30 + date1.\text{day})\]

**Criterion**

A **criterion** is a single cell Reference, Number or Text. It is used in comparisons with cell contents.

A reference to an empty cell is interpreted as the numeric value 0.

A matching expression can be:

- A Number or Logical value. A matching cell content equals the Number or Logical value.

- A value beginning with a comparator (<, <=, =, >, >=, <>). 8.4.9

For =, if the value is empty it matches empty cells. 4.7
For <>, if the value is empty it matches non-empty cells.

For <>, if the value is not empty it matches any cell content except the value, including empty cells.

**Note:** ":0" does not match empty cells.

For = and <>, if the value is not empty and can not be interpreted as a Number type or one of its subtypes and the host-defined property HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL calculation setting "search-criteria-must-apply-to-whole-cell" is true, comparison is against the entire cell contents, if false, comparison is against any subpart of the field that matches the criteria. For = and <>, if the value is not empty and can not be interpreted as a Number type or one of its subtypes 3.5 applies.

- Other Text value. If the host-defined property HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL calculation setting "search-criteria-must-apply-to-whole-cell" is true, the comparison is against the entire cell contents, if false, comparison is against any subpart of the field that matches the criteria.

### 4.11.8 Database

A **database** is a rectangular organized set of data. Any database has a set of one or more fields that determine the structure of the database. A database has a set of zero or more records with data, and each record contains data for every field (though that field may be empty).

Evaluators shall support the use of ranges as databases if they support any database functions. The first row of a range is interpreted as a set of field names.

**Note:** Field names of type Text and unique without regard to case enhance the interoperability of data. It is also a common expectation that rows following the first row of data are data records that correspond to field names in the first row.

A single cell containing text can be used as a database; if it is, it is a database with a single field and no data records.

Evaluators supporting databases and named ranges shall support the use of named ranges as a range, and the use of a Text value as a database (which, if it matches the name of a named range, will be considered the named range).

**Note:** It is considered good practice to define a named range for a database because it eases maintenance (the range can be changed for all functions by changing just one definition). However, the use of named ranges for a database is not required by this specification.

### 4.11.9 Field

A **field** is a value that selects a field in a database; it is also called a **field selector**. If the field selector is Text, it selects the field in the database with the same name.

Evaluators should match the database field name case insensitive.

If a field selector is a Number, it is a positive integer and used to select the fields. Fields are numbered from left to right beginning with the number 1.

All functions that accept a field parameter shall, when evaluated, return an Error if the selected field does not exist.
4.11.10 Criteria

A criteria is a rectangular set of values, with at least one column and two rows, that selects matching records from a database. The first row lists fields against which expressions will be matched. 4.11.9 Rows after the first row contain fields with expressions for matching against database records.

For a record to be selected from a database, all of the expressions in a row of criteria shall match. A reference to an empty cell is interpreted as the numeric value 0.

- Expressions are matched as per 4.11.7.8 Criterion.

4.11.11 Sequences (NumberSequence, NumberSequenceList, DateSequence, LogicalSequence, and ComplexSequence)

Some functions accept a sequence, i.e., a value that is to be treated as a sequential series of values. The following are sequences: NumberSequence, NumberSequenceList, DateSequence, LogicalSequence, and ComplexSequence.

When evaluating a function that accepts a sequence, the evaluator shall follow the rules for that sequence as defined in section 8.35.3. When processing a ReferenceList, the references are processed in order (first, second if any, and so on). In a cuboid, the first sheet is first processed, followed by later sheets (if any) in order. Inside a sheet, it is implementation-defined as to whether the values are processed row-at-a-time or column-at-a-time, but it must be one of these two processing orders. If processing row-at-a-time, the sequence must be produced by processing each row in turn, from smallest to largest column value (e.g., A1, B1, C1). If processing column-at-a-time, the sequence must be produced by processing each column at a time, from the smallest to the largest row value (e.g., A1, A2, A3).

4.11.12 Any

*Any represents a value of any type defined in this standard, including Error values.*
5 Expression Syntax
7 General

The OpenFormula syntax is defined using the BNF notation of the XML specification, chapter 6 [XML1.0]. Each syntax rule is defined using "::=".

Note: Formulas are typically embedded inside an XML document. When this occurs, characters (such as "<", ",", """, and "&") shall be escaped, as described in section 2.4 of the XML specification [XML1.0]. In particular, the less-than symbol "<" is typically represented as "&lt;", the double-quote symbol as "&quot;", and the ampersand symbol as "&amp;" (alternatively, a numeric character reference can be used).

7.1 Basic Expressions

Formulas may start with a '=' (EQUALS SIGN, U+003D), which if present may be followed by a "forced recalculate" marker '=' (EQUALS SIGN, U+003D), followed by an expression. If the second '=' (EQUALS SIGN, U+003D) is present, this formula is a "forced recalculation" formula. If a formula is marked as a "forced recalculation" formula, then it should be recalculated whenever one of its predecessors it depends on changes.

Expressed in BNF grammar, a formula is specified:

Formula ::= Intro? Expression
Intro ::= '=' ForceRecalc?
ForceRecalc ::= '='

The primary component of a formula is an Expression. Formulas are composed of Expression s, which may in turn be composed from other Expression s.

Expression ::=_whitespace* ( Number | String | Array | PrefixOp Expression | Expression PostfixOp | Expression InfixOp Expression | ' (' Expression ') ' | FunctionName Whitespace* '(' ParameterList ')' | Reference | QuotedLabel | AutomaticIntersection | NamedExpression | Error ) Whitespace*
SingleQuoted ::= "'" ([^'] | "'"*)+ "'"
### 7.2 Constant Numbers

Constant numbers are written using '.' (FULL STOP, U+002E) dot as the decimal separator. Optional "E" or "e" denotes scientific notation. Syntactically, negative numbers are positive numbers with a prefix "-" (HYPHEN-MINUS, U+002D) operator. A constant number is of type `Number`.

```
Number ::= StandardNumber |
StandardNumber ::= [0-9]+ ('.' [0-9]+)? ([eE] [-+]? [0-9]+)?
```

Evaluators should be able to read the `Number` format, which accepts a decimal fraction that starts with decimal point '.' (FULL STOP, U+002E), without a leading zero. Evaluators shall write numbers only using the `StandardNumber` format, which requires a leading digit, and shall not write numbers with a leading '.' (FULL STOP, U+002E).

### 7.3 Constant Strings

Constant strings are surrounded by double-quote characters (QUOTATION MARK, U+0022); a literal double-quote character "" (QUOTATION MARK, U+0022) as string content is escaped by duplicating it. When a formula is stored in an XML attribute, XML escaping rules apply: thus inside an XML attribute double-quote characters shall be escaped (e.g., as "") and carriage return characters in a String (e.g., as \\n
```
String ::= '"' ([^"#x00] | '\"')* '"'
```

### 7.4 Operators

Operators are functions with one or more parameters.

```
PrefixOp ::= '+' | '-'
PostfixOp ::= '%'
ArithmeticOp ::= '+' | '-' | '*' | '/' | '^'
ComparisonOp ::= '=' | '<>' | '<' | '>' | '<=' | '>='
StringOp ::= '=' | '<>' | '<' | '>' | '<=' | '>='
IntersectionOp ::= '!'
ReferenceConcatenationOp ::= '~'
RangeOp ::= ':'
```

There are three predefined reference operators: reference intersection, reference concatenation, and range. The result of these operators may be a 3 dimensional range, with front-upper-left and back-lower-right corners, or even a list of such ranges in the case of cell concatenation.

```
IntersectionOp ::= '!
ReferenceConcatenationOp ::= '~'
RangeOp ::= ':'
```

Table 1 - Operators defines the associativity and precedence of operators, from highest to lowest precedence.
### Table 1 - Operators

<table>
<thead>
<tr>
<th>Associativity</th>
<th>Operator(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>left</td>
<td><code>:</code></td>
<td>Range.</td>
</tr>
<tr>
<td>left</td>
<td><code>!</code></td>
<td>Reference intersection ([A1..C4]![B1..B5] is [B1..B4]). Displayed as the space character in some implementations.</td>
</tr>
<tr>
<td>left</td>
<td><code>~</code></td>
<td>Reference union. Displayed as the function parameter separator in some implementations.</td>
</tr>
<tr>
<td>right</td>
<td><code>+-</code></td>
<td>Prefix unary operators, e.g., -5 or [-A1]. Note that these have a different precedence than add and subtract.</td>
</tr>
<tr>
<td>left</td>
<td><code>%</code></td>
<td>Postfix unary operator % (divide by 100). Note that this is legal with expressions (e.g., [B1]%).</td>
</tr>
<tr>
<td>left</td>
<td><code>^</code></td>
<td>Power (2^3 is 8).</td>
</tr>
<tr>
<td>left</td>
<td><code>*/</code></td>
<td>Multiply, divide.</td>
</tr>
<tr>
<td>left</td>
<td><code>+-</code></td>
<td>Binary operations add, subtract. Note that unary (prefix) + and - have a different precedence.</td>
</tr>
<tr>
<td>left</td>
<td><code>&amp;</code></td>
<td>Binary operation string concatenation. Note that unary (prefix) + and - has a different precedence. Note that &quot;&amp;&quot; shall be escaped when included in an XML document.</td>
</tr>
<tr>
<td>left</td>
<td><code>=,&lt;,&gt;,&lt;=,&gt;=</code></td>
<td>Comparison operators equal to, not equal to, less than, less than or equal to, greater than, greater than or equal to</td>
</tr>
</tbody>
</table>

**Note 1:** Prefix "-" has a higher precedence than "^", that "^" is left-associative, and that reference intersection has a higher precedence than reference union.

**Note 2:** Prefix "+" and "-" are defined to be right-associative. However, note that typical applications which implement at most the operators defined in this specification (as specified) may implement them as left-associative, because the calculated results will be identical.

**Note 3:** Precedence can be overridden by using parentheses, so "=2+3*4" computes to 14 but "=(2+3)*4" computes 20. Implementations should retain "unnecessary" parentheses and white space, since these are added by people to improve readability.

### 7.5 Functions and Function Parameters

<table>
<thead>
<tr>
<th>Associativity</th>
<th>Operator(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>left</td>
<td><code>:</code></td>
<td>Range.</td>
</tr>
<tr>
<td>left</td>
<td><code>!</code></td>
<td>Reference intersection ([A1..C4]![B1..B5] is [B1..B4]). Displayed as the space character in some implementations.</td>
</tr>
<tr>
<td>left</td>
<td><code>~</code></td>
<td>Reference union. Displayed as the function parameter separator in some implementations.</td>
</tr>
<tr>
<td>right</td>
<td><code>+-</code></td>
<td>Prefix unary operators, e.g., -5 or [-A1]. Note that these have a different precedence than add and subtract.</td>
</tr>
<tr>
<td>left</td>
<td>left</td>
<td>left</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>%</td>
<td>^</td>
<td>*</td>
</tr>
</tbody>
</table>

Postfix unary operator `%` (divide-by-100). Note that this is legal with expressions (e.g., `[B1]`%), it can be duplicated (1%%), and it does not change the meaning of other operations such as `+/–`.  

Power (`2^3` is 8).  

Multiply, divide.  

Binary operations add, subtract. Note that unary (prefix) `+` and `–` have a different precedence.  

Binary operation string concatenation. Note that unary (prefix) `+` and `–` have a different precedence. Note that `&` shall be escaped when included in an XML document.  

Comparison operators equal to, not equal to, less than, less than or equal to, greater than, greater than or equal to.  

Note: Prefix `–` has a higher precedence than `^`, that `^` is left-associative, and that reference intersection has a higher precedence than reference union.  

Note: Prefix `+`, and `–` are defined to be right associative. However, note that typical applications which implement at most the operators defined in this specification (as specified) may implement them as left-associative, because the calculated results will be identical.  

Note: Precedence can be overridden by using parentheses, so `=2+3*4` computes to 14 but `=(2+3)*4` computes 20. Implementations should retain “unnecessary” parentheses and white-space, since these are added by people to improve readability.  

### 7.6 Functions and Function Parameters

Functions are called by name, followed by parentheses surrounding a list of parameters. Parameters are separated using the semicolon `;` (SEMICOLON, U+003B) character:  

```
FunctionName ::= LetterXML (LetterXML | DigitXML | Identifier)*  
Identifier ::= LetterXML (LetterXML | DigitXML |  
               '_ ' | '. ' | CombiningCharXML)*  
```

Where `LetterXML`, `DigitXML`, and `CombiningCharXML` are `Letter`, `Digit`, and `CombiningChar` as they are defined in [XML1.0].

Function names are case-insensitive.

Function calls shall be given a parameter list, though it may be empty. An empty list of parameters is considered a call with 0 parameters, not a call with one parameter that happens to be empty. TRUE() is syntactically a function call with 0 parameters. It is syntactically legitimate to provide empty parameters, though functions may not accept empty parameters unless otherwise noted:

```
ParameterList ::= /* empty */ |  
  Parameter (Separator EmptyOrParameter )* |  
  Separator EmptyOrParameter /* First param empty */ |  
  (Separator EmptyOrParameter )*  
EmptyOrParameter ::= /* empty */ Whitespace* | Parameter  
Parameter ::= Expression  
Separator ::= ';'
```
### 7.7 Nonstandard Function Names

When writing a document using function(s) not defined in this specification, an evaluator shall include a prefix in such function names to identify the original definer of the function's semantics. When the origin of a function cannot be determined, producers may omit a prefix. Producers may use the prefix to differentiate between different definition types. Evaluators that do not support a function should compute its result as some Error value other than `NA()`. ould include a prefix in such function names to identify the original definer of the function's semantics.

**Note:** Examples of implementation-defined functions include extension functions included with an implementation, user-defined functions written by users, and 3rd party functions distributed in libraries.

The prefix should begin with a domain name owned by the definer, in reverse order, and should be in uppercase letters (where lower/uppercase letters apply). This prefix should be the shortest prefix sufficient to identify the application company/project, followed by a period, optionally followed by version information or more specific product identification and a period, followed by the original function name itself. The version information should be included if an application substantially changes the semantics of a function (as viewed by users of that function) and one of those later versions of the function is intended. Evaluators may implement functions originally defined by another evaluator, and thus may read and/or write function names that use another evaluator's prefix.

**Note:** Examples of such names include `COM.MICROSOFT.CUBEMEMBER`, `ORG.OPENOFFICE.STYLE`, `ORG.GNUMERIC.RANDRAYLEIGH`, and `COM.LOTUS.V98.FOO`.

Evaluators should avoid defining evaluator-unique functions beginning with a top-level domain name followed by a period. Evaluators should avoid defining application functions beginning with "NET.", "COM.", "ORG.", or a country code followed by a period.

Evaluators that do not support a function should compute its result as some Error value other than `NA()`.

### 7.8 References

References refer to a specific cell or set of cells. The syntax for a constant reference:

```plaintext
Reference ::= ['[ (Source? RangeAddress) | ReferenceErrorSource? RangeAddress ]'

RangeAddress ::= SheetLocatorOrEmpty '.' Column Row (':'. Column Row )? | SheetLocatorOrEmpty '.' Column ':' Column | SheetLocatorOrEmpty '.' Row ':' Row | SheetLocator '.' Column Row ':' SheetLocator '.' Column Row | SheetLocator '.' Column ':' SheetLocator '.' Column | SheetLocator '.' Row ':' SheetLocator '.' Row

SheetLocatorOrEmpty ::= SheetLocator | /* empty */

SheetName ::= QuotedSheetName | '$' [^\]\#$. #$']+

QuotedSheetName ::= '$'? SingleQuoted | Error

SubtableCell ::= ( Column Row ) | QuotedSheetName

ReferenceError ::= '#REF!

Column ::= '$' [A-Z]+

Row ::= '$' [1-9] [0-9]*
```
References always begin with '[' (LEFT SQUARE BRACKET, U+005B); this disambiguates cell addresses from function names and named expressions. SheetNames include single-quote“’” (APOSTROPHES, U+0027) characters by doubling them and having the entire name surrounded by single-quotes. Column labels shall be in uppercase. The syntax supports whole-row and whole-column references. A reference is of type Reference.

A ReferenceError provides information that a formula evaluates to an Error because of a particular reference having been invalidated by actions that occurred after the formula was validly created.

Columns are named by a sequence of one or more uppercase letters A-Z (U+0041 through U+005A). Columns are named A, B, C, ... X, Y, Z, AA, AB, AC, ... AY, AZ, BA, BB, BC, ... ZX, ZY, ZZ, AAA, AAB, AAC, AAZ, ABA, ABB, and so on.

If a RangeAddress does not contain a Column element or does not contain a Row element, it specifies a cell rectangle (4.8 Reference). If it contains Row elements, the cell rectangle starts on the first column and ends on the last column the evaluator supports. If it contains Column elements, the cell rectangle starts on the first row and ends on the last row the evaluator supports.

If in a RangeAddress the first part (left of ':' colon) contains a SheetLocator and the second part (right of ':' colon) does not contain a SheetLocator, the second part inherits the SheetLocator from the first part.

If a RangeAddress contains two different SheetLocators, it specifies a cell cuboid (4.8 Reference).

If a RangeAddress contains no SheetLocator, the current sheet local to the position where the expression is evaluated is referred.

A reference with an explicit row or column value beyond the capabilities of an evaluator shall be computed as an Error, and not as a reference.

Note that references can include a single embedded “:” separator. Evaluators should use references with embedded “:” separators inside the [...] markers, instead of the general-purpose “:” operator, when saving files, and where there is a choice of cells to join, and evaluators should choose the leftmost pair.

The optional Source expresses that the reference is to sheets and/or cells in a different location (possibly in a same-document fragment) than that for the formula in which the reference occurs. The optional Source is also used for locating Named Expressions (section 5.11 Source location’s IRI is described in [RFC3987]. Internationalized Resource Identifiers (IRIs), based on [RFC3986], Uniform Resource Identifier (URI): General Syntax. Evaluators should support absolute IRIs (URLs are IRIs too). Evaluators should support relative IRIs, which can be distinguished because they do not begin with [A-Za-z]+ “:”. Relative IRIs are formed according to section 6.5 of RFC3987, respectively section 4.2 of RFC3986. Evaluators should always use a “/” prefix when saving a relative IRI, since this is unambiguous. Evaluators should support the file scheme (file:// prefix).

The IRI portion of Source shall be an IRI reference [RFC3987] conforming to the general syntax IRI-reference rule (section 2.2 of [RFC3987]) after each pair of consecutive single-quote characters (APOSTROPE, U+0027) is replaced by one single single-quote character.

Note: The escaping of single-quotes as paired single-quotes is because the IRI is enclosed in single quote characters of the Source.

Resolution of the [RFC3987] IRI reference is host-defined behavior. 3.5

Evaluators may support a variety of IRI/URI/URL schemes (such as “http:”).
7.9 Reference List

A reference list is the result of the Infix Operator Reference Concatenation 8.4.13 'ـ', the syntax is:

\[
\text{ReferenceList ::= Reference (Whitespace* ReferenceConcatenationOp Whitespace* Reference)*}
\]

A reference list can be passed as an argument to functions expecting a reference parameter where passing one reference results in an identical computation as an arbitrary sequence of single references occupying the identical cell range. A reference list cannot be converted to an array.

7.10 Quoted Label

7.10.1 General

A quoted label is Text contained in a table as cell content, either literally or as a formula result.

\[
\text{QuotedLabel ::= SingleQuoted}
\]

A quoted label identifies a column or a row, depending on the label range in which its text appears.

7.10.2 Lookup of Defined Labels

For a QuotedLabel, first the cells defined in column label ranges (cell ranges of the \text{table:label-cell-range-address} attribute in the elements \text{<table:label-range>} with attribute \text{table:orientation} set to column) are searched for the string content of QuotedLabel (without the quotes). If found, the corresponding column's range of the data cell range of the \text{table:data-cell-range-address} attribute is taken as a reference. If not found, the cells defined in row label ranges (attribute \text{table:orientation} set to row) are searched and if found the corresponding row's range of the data cell range is taken. Label ranges of the current formula's sheet take precedence over label ranges of other sheets if a name occurs in both.

7.10.3 Automatic Lookup of Labels

For a QuotedLabel where no defined label is found, an automatic lookup is performed on the sheet where the formula cell resides, if that document setting is enabled (\text{HOST-AUTOMATIC-FIND-LABELS value true }).

Matches to the upper left of the formula cell are preferred over other matches, followed by matches with a smaller distance. The following algorithm is used:

Cells on the same sheet as the formula cell are examined \text{column-wise} from left to right whether they contain the text of QuotedLabel (without the quotes). If more than one cell match, the distance and direction from the formula cell's position is taken into account. The distance is calculated by

\[
\text{Distance= ColumnDifference*ColumnDifference+ RowDifference*Row Difference}
\]

using an idealized layout of quadratic cells. For the direction, during the run two independent match positions are remembered each time Distance is smaller than a previous Distance: \text{Match2} for positions right of and/or below the formula position (FormulaColumn < MatchColumn || FormulaRow < MatchRow), \text{Match1} for all others (not right of and not below). Match1 also holds the very first match, in case there is only one match or all matches are somewhere below or right of the formula cell. After having found the smallest distances the conditions are:

1. If Match1 has the smallest distance, that match is taken.
2. Else, Match2 (right and/or below) has the smallest or an equal distance:
   2.1 A match to the upper left (FormulaColumn >= Match1Column && FormulaRow >= Match1Row) takes precedence over matches to other directions.

2.2 Else, if there is no match to the upper left:
   2.2.1 If Match1 is somewhere right of the formula cell (FormulaColumn < Match1Column) it was the first match found in column-wise lookup.
       2.2.1.1 If Match2 is above the formula cell (FormulaRow >= Match2Row) it is to the upper right of the formula cell and either nearer than Match1 or Match1 is below. Match2 is taken.
       2.2.1.2 Else Match2 is below the formula cell and Match1 is taken.
   2.2.2 Else (Match1 not right of the formula cell => two matches below or below and right) the match with the smallest distance is taken.

If the resulting cell is below or above another cell containing Text a row label is assumed, else a column label is assumed.

|| **Note:** Use of automatically looked up column or row labels in expressions impairs interoperability.||

### 7.10.4 Implicit Intersection

For the reference resulting from a single QuotedLabel an implicit intersection is generated if the operator or function where it is used with expects a scalar value. The intersection is generated with the current formula's cell position, thus for a column label an intersection is generated with the formula cell's row, for a row label with the formula cell's column.

### 7.10.5 Automatic Range

When passed as a non-scalar argument (e.g. Array or NumberSequence) to a function, an automatically looked up column or row label (not defined label range) is converted to an automatic range reference that is adjusted each time the formula is interpreted. The range is generated from the column below a column label, or the row right of a row label, constructed by encompassing contiguous non-empty cells. An empty cell interrupts contiguousness, one empty cell directly below a column label cell or right of a row label cell is ignored, column or row label is converted to an automatic range reference that is adjusted each time the formula is interpreted. The range is generated from the corresponding column respectively row intersecting an area directly below respectively right of the label cell that is constructed by encompassing contiguous cells. A blank cell interrupts contiguousness, one blank cell directly below respectively right of the label cell is ignored.
Example:

### Table 2 - Automatic Range

<table>
<thead>
<tr>
<th>Row</th>
<th>Data</th>
<th>Expression</th>
<th>Result</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Label</td>
<td>=SUM('Label')</td>
<td>3</td>
<td>Empty cell in row 2 is skipped (two empty cells in row 2 and 3 would not and stop), empty cell in row 5 stops the automatic range.</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Row</th>
<th>Data</th>
<th>Expression</th>
<th>Result</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Label</td>
<td>=SUM('Label')</td>
<td>3</td>
<td>Blank cell in row 2 is skipped (two blank cells in row 2 and 3 would not and stop), blank cell in row 5 stops the automatic range.</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If any cell content is entered in row 5 the range is regenerated as follows:

### Table 3 - Automatic Range

<table>
<thead>
<tr>
<th>Row</th>
<th>Data</th>
<th>Expression</th>
<th>Result</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Label</td>
<td>=SUM('Label')</td>
<td>15</td>
<td>Empty cell in row 2 is skipped, empty cell in row 7 stops the automatic range.</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 7.10.6 Automatic Intersection

<table>
<thead>
<tr>
<th>Row</th>
<th>Data</th>
<th>Expression</th>
<th>Result</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Label</td>
<td>=SUM('Label')</td>
<td>15</td>
<td>Blank cell in row 2 is skipped, blank cell in row 7 stops the automatic range.</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 7.10.7 Automatic Intersection

An automatic intersection may be used to identify the intersection of two quoted labels. Note that this is different from the `IntersectionOp`, which takes two references instead of two labels:

\[
\text{AutomaticIntersection} ::= \text{QuotedLabel} \text{ Whitespace* '!!' Whitespace* QuotedLabel}
\]

In an automatic intersection, one of the labels identifies a row, the other a column; they may be in either order. Each `QuotedLabel` is looked up as defined above under "Lookup of Defined Lables" and "Automatic Lookup of Labels". If two data cell ranges are found, the intersection of the column's data cell range and the row's data cell range is generated. If the intersection result is not exactly one cell, an Error is generated.

### 7.11 Named Expressions

A `NamedExpression` references another expression, possibly in a completely different spreadsheet or any other document type that can be imported into a spreadsheet.

\[
\text{NamedExpression} ::= \text{SimpleNamedExpression} | \text{SheetLocalNamedExpression} | \text{ExternalNamedExpression}
\]

\[
\text{SimpleNamedExpression} ::= \text{Identifier} | '$$' (\text{Identifier} | \text{SingleQuoted})
\]

\[
\text{SheetLocalNamedExpression} ::= \text{QuotedSheetName} \text{.'} \text{SimpleNamedExpression}
\]

\[
\text{ExternalNamedExpression} ::= \text{Source} #\text{(SimpleNamedExpression | SheetLocalNamedExpression)}
\]

Evaluators supporting named expressions shall support Simple Named Expressions that are global to all the sheets in a (spreadsheet) document in the current document. This is a named expression without a `Source`, `QuotedSheetName`, or `SubtableCell`. The type of a named expression is the type of the value that the named expression returns.

Named expressions are case-consistent, meaning that matching is done case-insensitive and identifiers can not differ ONLY in their case. Evaluators should write identifiers with identical case in all locations.
Evaluators may support Sheet-local Named Expressions that are local (attached) to individual sheets. In that case, a non-empty \texttt{QuotedSheetName} can be used to reference a sheet-specific named expression. The most specific named expression for a given expression is used. If the \texttt{QuotedSheetName} is empty, the search for the named expression begins with the current sheet, then up through the container(s) of the sheet (the same is true if the \texttt{QuotedSheetName} rule fragment is not included at all). If there is a non-empty \texttt{QuotedSheetName}, search begins with that named sheet, then up through its container(s) for the given name.

\textbf{Note}: There is no syntax for referencing a named expression without first looking at the current sheet's named expressions; where this is a problem, a user can define a blank sheet and reference that sheet as the starting location for finding the named expression.

If a sheetname is not empty, it shall be quoted using ‘‘ (APOSTROPHE, U+0027). While both \texttt{Source} and \texttt{QuotedSheetName} can begin with the single-quote character ‘‘ (APOSTROPHE, U+0027), they are distinguished: after the closing single-quote character, a non-empty source shall have the ‘#’ (NUMBER SIGN, U+0023) character as the next non-whitespace; a non-empty sheetname shall be followed by the ‘.’ (FULL STOP, U+002E) character as the next non-whitespace.

Expressions should limit the names of their identifiers to only ([UNICODE]) letters, underscores, and digits, not including patterns that look like cell references or the words True or False.

\textbf{Note}: Some evaluators do not support the use of Unicode for identifiers.

\textbf{Identifier ::= ( LetterXML
(LetterXML | DigitXML | ‘_’ | CombiningCharXML)* )}
- ( [A-Za-z]+[0-9]+ )
- ([Tt][Rr][Uu][Ee]) - ([Ff][Aa][Ll][Ss][Ee])

\section{7.12 Constant Errors}

7.13 Constant Errors

7.14 Evaluators shall support the Error value \#N/A. Evaluators may support other Error values. Evaluators may allow entry of errors directly, parse them and recognize them as Errors. Functions shall propagate Errors unless stated otherwise.

Inline Error constants shall have the following syntax:

\texttt{Error ::= ‘#’ [A-Z0-9]+ (\[!\] | (‘/’ ([A-Z] | \([0-9]\) [!\])\)))

Specific Error values are indicated by an identifier.

Table 4 is a list of constant error names that are used by several existing implementations. Evaluators may implement other constant Error values.

\begin{table}[h]
\centering
\begin{tabular}{|l|l|}
\hline
\textbf{Name} & \textbf{Comments} \\
\hline
\#DIV/0! & Attempt to divide by zero, including division by an empty cell. ERROR.TYPE of 2 \\
\hline
\#NAME? & Unrecognized/deleted name. ERROR.TYPE of 5. \\
\hline
\end{tabular}
\caption{Possible Other Constant Error Values}
\end{table}
#N/A
Not available. ISNA() applied to this value will return True. Lookup functions which failed, and NA(), return this value. ERROR.TYPE of 7.

#NULL!
Intersection of ranges produced zero cells. ERROR.TYPE of 1.

#NUM!
Failed to meet domain constraints (e.g., input was too large or too small). ERROR.TYPE of 6.

#REF!
Reference to invalid cell (e.g., beyond the application's abilities). ERROR.TYPE of 4.

#VALUE!
Parameter is wrong type. ERROR.TYPE of 3.

An unknown constant Error value shall be mapped into an Error value supported by the evaluator when read (e.g., the application's equivalent of #NAME?), though an evaluator may warn the user if this has or will take place. It is desirable to preserve the original specific Error name when writing an Error constant back out, where possible, but evaluators may write a different Error value for a formula than they did when reading it for Errors other than #N/A. Whitespace shall not be included in an Error name.

Evaluators should use a human-comprehensible name, not a numeric id, for constant Error values they write.

### 7.15 Inline Arrays

Inline arrays are enclosed with curly braces. Inside, they contain one or more rows, with each row separated by a row separator:

\[
\text{Array} ::= \{' \text{MatrixRow} \ (\text{RowSeparator} \ \text{MatrixRow} \ )* \}'
\]

\[
\text{MatrixRow} ::= \text{Expression} \ (\';\ \text{Expression} \ )* \\
\text{RowSeparator} ::= '\'
\]

Evaluators that support inline arrays shall accept a matrix with one or more rows, each with one or more columns, with the same number of columns in each row, with constant values for each expression. Evaluators that do not support inline arrays, or cannot support a particular use permitted by this syntax, should compute an Error value for such arrays. An inline array is of type Array.

**Note:** Expression authors should be aware that use of Expression other than constant Number or constant String may impair interoperability.

### 7.16 Whitespace

\[
\text{Whitespace} ::= \#x20 \ | \ \#x09 \ | \ \#x0a \ | \ \#x0d
\]

For calculation purposes, whitespace is ignored unless it is inside the contents of string constants or text surrounded by single quotes. Evaluators shall ignore any whitespace characters before and/or after any operators, constant numbers, constant strings, constant errors, inline arrays, parentheses used for controlling precedence, and the closing parenthesis of a function call. Whitespace shall be ignored following the initial equal sign(s). Whitespace shall be ignored just before a function name, but whitespace shall not separate a function name from its initial opening parentheses. Whitespace shall not be used in the interior of a terminating grammar rule (a rule that references no other rule other than character sets, internally or externally-defined), unless specifically permitted by the terminating grammar rule, since these rules define the lexical properties of a component. Evaluators shall not write formulas with whitespace embedded in any unquoted identifier, constant Number, or constant Error. Evaluators shall treat SPACE (U+0020), CHARACTER TABULATION (U+0009), LINE FEED (U+000A), and CARRIAGE RETURN (U+000D) as whitespace characters.
An embedded line break shall be represented by a single LINE FEED character (U+000A), not by a carriage return-linefeed pair. When embedded in an XML attribute the linefeed character is represented as 
"&#x0A;".

Evaluators should retain whitespace entered by the original formula creator and use it when saving or presenting the formula, and should not add additional whitespace unless directed to do so during the process of editing a formula.
8 Standard Operators and Functions

8.1 General

OpenFormula defines commonly used operators and functions.

Function names ignore case. Evaluators should write function names in all uppercase letters when writing OpenFormula formulas.

Unless otherwise noted, if any value being provided is an Error, the result is an Error; if more than one Error is provided, one of them is returned (evaluators should return the leftmost Error result).

8.2 Common Template for Functions and Operators

For every function or operator, the following are defined in this specification:

- **Name**: The function/operator name.
- **Summary**: One sentence briefly describing the function or operator.
- **Syntax**:
  - Parameter names are shown in order, with each parameter prefixed by the type or pseudo-type of that parameter. If the type has multiple names separated by "|", then any of those types are permitted.
  - A { ... } indicates a list of zero or more parameters, separated by the function parameter separator character.
  - A { ... } followed by a superscripted + indicates a list of one or more parameters, separated by the function parameter separator character.
  - Components surrounded by [ ... ] are optional. Optional components may be omitted.
  - An optional parameter followed by the = symbol has the default value given after the equal sign.
  - Parameters are separated with a semicolon (";"), as per the OpenFormula syntax.

When a function is given a value of a different type, the parameters are first converted using the implicit conversion rules before the function operates on its parameters.

Evaluators may extend functions by permitting fewer or additional parameters, which documents may use. Extended functions may result in a lack of interoperability.

- **Returns**: Return type (e.g., Number, Text, Logical, Reference).
- **Constraints**: A description of constraints, in addition to the constraints imposed by the parameter types. If there are no additional constraints beyond those imposed by the parameter types, this is "None". If a constraint is not met, the function/operator shall return an Error unless otherwise noted.
- **Semantics**: This text describes what the function/operator does.

If a parameter is a pseudotype, but the provided value fails to meet the requirements for that type, the behavior is implementation-defined.
Note: Functions and operators are defined by mathematical formulas or by an OpenFormula formula. Formulas define the correct result, and not the algorithm for calculation. Since computing systems have limited precision and range of numbers, some functions cannot or should not be naively implemented as their formulas suggest. This specification defines the mathematically correct answer, and allows implementors to choose the best algorithm that will meet that definition.

- Comment: Explanatory comment.
- See also A list of related operators and functions.

The implicit conversion operators omit many of these items, e.g., the syntax (since there is none).

### 8.3 Implicit Conversion Operators

#### 8.3.1 General

Any given function or operand takes 0 or more parameters, and each of those parameters has an expected type. The expected type can be one of the base types, identified above. It can also be of some conversion type that controls conversion, e.g., Any means that no conversion is done (it can be of any type); NumberSequence causes a conversion to an ordered sequence of zero or more numbers. If the passed-in type does not match the expected type, an attempt is made to automatically convert the value to the expected type. An Error is returned if the type cannot be converted (this can never happen if the expected type is Any). Unless otherwise noted, any conversion operation applied to a value of type Error returns the same value.

#### 8.3.2 Conversion to Scalar

To convert to a scalar, if the value is of type:

- Number, Logical, or Text, return the value.
- reference to a single cell: obtain the value of the referenced cell, and return that value.
- reference to more than one cell: do an implied intersection, 8.3.3, to determine which single cell to use, then handle as a reference to a single cell.

#### 8.3.3 Implied intersection

In some cases a reference to a single cell is needed, but a reference to multiple cells is provided. In this case an "implied intersection" is performed. To perform an implied intersection:

- Compute the union of cells contained in the current row and current column of the formula being computed.
- Intersect this with the provided reference to multiple cells
- If a single cell is referenced; return it; otherwise, return an Error.

#### 8.3.4 Force to array context (ForceArray)

A ForceArray attribute forces calculation of the argument's expression into non-scalar array mode. This means that no implied intersection is performed, instead where a reference to a single cell is expected and multiple cells are provided, iteration over the multiple cells is performed and results are stored in an array that is passed on.
See also Non-Scalar Evaluation 3.3

8.3.5 Conversion to Number

If the expected type is Number, then if value is of type:

- Number, return it.
- Logical, return 0 if FALSE, 1 if TRUE.
- Text: The specific conversion is implementation-defined; an evaluator may return 0, an Error value, or the results of its attempt to convert the Text value to a Number (and fall back to 0 or Error if it fails to do so). Evaluators may apply VALUE() or some other function to do this conversion, should they choose to do so. Conversion depends on the actual locale the application runs in, especially if group or decimal separators are involved.
- Reference: If the reference covers more than one cell, do an implied intersection to determine which cell to use. Then obtain the value of the single cell and perform the rules as above. If the calculation setting “precision-as-shown” is true, then convert the number to the closest possible representation of the displayed number. If the cell is empty (blank), use 0 (zero) as the value. Evaluators may choose to convert references to Text in a different manner than they handle converting embedded Text to a Number.

8.3.6 Conversion to Integer

If the expected type is Integer for a function or operator, apply the “Conversion to Number” operation. Then, if the result is a Number but not an integer, apply the specific conversion from Number to integer specified by that particular function/operator. If the function or operator does not specify any particular conversion operation, then the conversion from a non-integer Number into an integer is implementation-defined.

Many different conversions from a non-integer number into an integer are possible. The conversion direction may be towards negative infinity, towards positive infinity, towards zero, away from zero, towards the nearest even number, or towards the nearest odd number. A conversion can select the nearest integer, the nearest even or odd integer, or the “next” integer in the given direction if it is not already an integer. If a conversion selects the nearest integer, a direction is still needed (for when a value is halfway between two integers). In this specification, this conversion is referred to as “rounding” or “truncation”; these terms by themselves do not specify any specific operation.

If a function specifies its rounding operation using a series of capital letters, the function defined in this specification for that function is used to do the conversion to integer. Common such functions are:

- INT, which if given non-integer rounds down to the next integer towards negative infinity, regardless of whether or not it is the closest integer.
- ROUND, which if given non-integer rounds to the nearest integer. If the input number is halfway between integers, it rounds away from zero.
- TRUNC, which if given non-integer rounds towards zero, regardless of whether or not that integer is the closest integer.

8.3.7 Conversion to NumberSequence

If the expected type is NumberSequence, then if value is of type:

- Number, Text, or Logical, handle as Conversion to Number 8.3.5 (creating a sequence of length 1).
● reference, create a sequence of numbers from the values of the referenced cells that only includes the values of type Number or Error. Thus, Empty cells and Text that could be converted into a value is not included in a number sequence. If the Logical type is a distinguished type from the Number type, it should not be included in the sequence of numbers; if the Logical type is not a distinguished type, then such values will (of course) be included in the number sequence.

8.3.8 Conversion to NumberSequenceList

Identical to Conversion to NumberSequence 8.3.7, with the addition that instead of a Reference also a ReferenceList is accepted as argument. Each Reference in the list is converted to a NumberSequence in the order of occurrence.

8.3.9 Conversion to DateSequence

Identical to Conversion to NumberSequence 8.3.7 except that each element in the list represents a serial date value of subtype Date.

8.3.10 Conversion to Complex Number

An evaluator may accept complex numbers as Text, Number, or a different distinguishable type. If the value is:

● Number that is not complex, use the Number with 0 as the imaginary part.
● Text, attempt to convert to complex number using VALUE(). If it is a number that is not complex, use it. If the text matches one of these patterns, accept it:

  ([+-]?Number [+-]?Number[ij]
  
  [+-]?Number[ij]

● Logical, convert to Number and then handle as Number.
● reference: Convert to Scalar, then use the rules above. If the reference is to an empty cell, consider it equal to 0.

8.3.11 Conversion to ComplexSequence

If the expected type is ComplexSequence, then if value is of type:

● Number, Text, or Logical, handle as Conversion to Complex Number (creating a sequence of length 1).

● Reference, create a sequence of complex numbers from the values of the referenced cells that only includes the values of type Number, Text, and Error. Empty cells are not included in a complex number sequence. If the Logical type is a distinguished type from the Number type, it should not be included in the sequence of numbers; if the Logical type is not a distinguished type, then such values will (of course) be included in the number sequence.

8.3.12 Conversion to Logical

If the expected type is Logical, then if value is of type:
● Number, return TRUE() for nonzero and FALSE() for 0.

● Text: The specific conversion is implementation-defined; an evaluator may return False, an Error value, or the results of its attempt to convert the Text value (ignoring case) to a Logical value (and fall back to False or Error if it fails to do so). Conversion depends on the actual locale the evaluator runs in.

● Logical, return it.

● Reference, convert to scalar and then perform as above. If the reference is to an empty cell, consider it FALSE().

8.3.13 Conversion to LogicalSequence

If the expected type is LogicalSequence, then if value is of type:

● Number or Logical, handle as Conversion to Logical (creating a sequence of length 1).

● Reference, create a sequence of logical values from the values of the referenced cells that only includes the values of type Logical and Error. If the Logical type is not a distinguished type, then include values of type Number, converting each to a Logical value as described in Conversion to Logical. Empty cells are not included in a LogicalSequence.

8.3.14 Conversion to Text

If the expected type is Text, then if value is of type:

● Number, transform into Text (with no whitespace).

● Text, return it.

● Logical, return "TRUE" if it is TRUE and "FALSE" if it is false.

● Reference: perform conversion to scalar. If the referenced cell is empty, treat as an empty string (a text value with length 0). Then perform as above.

8.3.15 Conversion to DateParam

If the expected type is the pseudotype DateParam, then if value is of type:

● Number, return it.

● Text, pass to DATEVALUE, and if non-Error, return it. If DATEVALUE would return an Error, an evaluator may attempt to convert to a Number in other ways (such as by calling VALUE); this is implementation-defined. If the evaluator cannot convert to Number, it returns an Error.

● Logical, the result is implementation-defined, either a Number or Error

● Reference: perform conversion to scalar, then perform as above. If the cell is empty, return 0.

8.3.16 Conversion to TimeParam

If the expected type is the pseudotype TimeParam, then if value is of type:

● Number, return it.
8.4 Standard Operators

8.4.1 General

The functions defined under standard operators differ from other functions only by on the basis of their frequency of use. That frequency of use has lead to the colloquial terminology, standard operators.

8.4.2 Infix Operator "+"

Summary: Add two numbers.
Syntax: Number Left + Number Right
Returns: Number
Constraints: None
Semantics: Adds numbers together.
See also Infix Operator "-" 8.4.3, Prefix Operator "+" 8.4.15

8.4.3 Infix Operator "-"

Summary: Subtract the second number from the first.
Syntax: Number Left - Number Right
Returns: Number
Constraints: None
Semantics: Subtracts one number from another number.
See also Infix Operator "+" 8.4.2, Prefix Operator "-" 8.4.16

8.4.4 Infix Operator "*"

Summary: Multiply two numbers.
Syntax: Number Left * Number Right
Returns: Number
Constraints: None
Semantics: Multiplies numbers together.
See also Infix Operator "+" 8.4.2, Infix Operator "/" 8.4.5
8.4.5 Infix Operator "/"

Summary: Divide the second number into the first.
Syntax: Number Left / Number Right
Returns: Number
Constraints: None
Semantics: Divides numbers. Dividing by zero returns an Error.
See also Infix Operator "/" 8.4.3, Infix Operator "*" 8.4.4

8.4.6 Infix Operator "^"

Summary: Exponentiation (Power).
Syntax: Number Left ^ Number Right
Returns: Number
Constraints: NOT(AND(Left=0; Right=0)); Evaluators may evaluate expressions where OR(Left != 0; Right != 0) evaluates to a non-Error value.
Semantics: Returns POWER(Left, Right).
See also Infix Operator "^" 8.4.4, POWER 8.16.46

8.4.7 Infix Operator "/="

Summary: Report if two values are equal
Syntax: Scalar Left = Scalar Right
Returns: Logical
Constraints: None
Semantics: Returns TRUE if two values are equal. If the values differ in type, return FALSE. If the values are both Number, return TRUE if they are considered equal, else return FALSE. If they are both Text, return TRUE if the two values match, else return FALSE. For Text values, if the calculation setting HOST-CASE-SENSITIVE is false, text is compared but characters differencing only in case are considered equal. If they are both Logicals, return TRUE if they are identical, else return FALSE. Error values cannot be compared to a constant Error value to determine if that is the same Error value.

Evaluators may approximate and test equality of two numeric values with an accuracy of the magnitude of the given values scaled by the number of available bits in the mantissa, ignoring some least significant bits and thus providing compensation for not exactly representable values.

The result of "1=TRUE()" is FALSE for evaluators that implement a distinct Logical type and TRUE if they don't.

See also Infix Operator "/=", Infix Operator "<>" 8.4.8

8.4.8 Infix Operator "<>"

Summary: Report if two values are not equal
**Syntax**: Any Left <> Any Right

**Returns**: Logical

**Constraints**: None

**Semantics**: Returns NOT(Left = Right) if Left and Right are not Error. For Text values, if the calculation setting HOST-CASE-SENSITIVE is false, text is compared but characters differing only in case are considered equal.

If either Left and Right are an Error, the result is an Error; this operator cannot be used to determine if two Errors are the same kind of Error.

**Note**: In some user interfaces the infix operator "<>" is displayed (or accepted) as "!=" or "≠".

**See also** Infix Operator "=" 8.4.7

### 8.4.9 Infix Operator Ordered Comparison ("<", "<="", ",">", ",">=")

**Summary**: Report if two values have the given order

**Syntax**: Scalar Left op Scalar Right

where op is one of: ",">", ",">="

**Returns**: Logical

**Constraints**: None

**Semantics**: Returns TRUE if the two values are less than, less than or equal, greater than, or greater than or equal (respectively). If both Left and Right are Numbers, compare them as numbers. If both Left and Right are Text, compare them as text; if the calculation setting HOST-CASE-SENSITIVE is false, text is compared but characters are compared ignoring case. If the values are both Logical, convert both to Number and then compare as Number.

These functions return one of True, False, or an Error if Left and Right have different types, but it is implementation-defined which of these results will be returned when the types differ.

**See also** Infix Operator "<>" 8.4.8, Infix Operator "=" 8.4.7

### 8.4.10 Infix Operator "&"

**Summary**: Concatenate two strings.

**Syntax**: Text Left & Text Right

**Returns**: Text

**Constraints**: None

**Semantics**: Concatenates two text (string) values.

**Note**: The infix operator "&" is equivalent to CONCATENATE(Left,Right).

**See also** Infix Operator "+" 8.4.2, CONCATENATE 8.20.6

### 8.4.11 Infix Operator Reference Range ("":")

**Summary**: Computes an inclusive range given two references

**Syntax**: Reference Left : Reference Right
Returns: Reference

Constraints: None

Semantics: Takes two references and computes the range, that is, a reference to the smallest 3-
dimensional cube of cells that include both Left and Right including the cells on sheets positioned
between Left and Right. Left and Right need not be a single cell. For an expression such as
[B4..B5];[C5] the resulting range is B4:C5. In case Left and/or Right involve a reference list (result
of operator reference union), the range is computed and extended for each element of the list(s).

Note: For example, (a,b,c,d denoting one reference each)
(a~b);(c~d) computes a:b:c:d
determining the outermost front-top-left and rear-bottom-right corners.

Left and Right may also be defined names or the result of a function returning a reference, such as
INDIRECT.

See also Infix Operator Reference Union 8.4.13, Infix Operator Reference Intersection 8.4.12,
INDIRECT 8.14.7

8.4.12 Infix Operator Reference Intersection ("!")

Summary: Compute the intersection of two references

Syntax: Reference Left ! Reference Right

Returns: Reference

Constraints: None

Semantics: Takes two references and computes the intersection - a reference to the intersection of
cells in both Left and Right. If there are no cells in common, returns an Error.

If Left or Right are not of type Reference or ReferenceList, an Error shall be returned.

If Left and/or Right are reference lists (result of infix operator reference concatenation), the
intersection is computed for each combination of Left and Right, producing a reference list of
intersections.

Note 1: For example (a,b,c,d denoting one reference each):
(a~b)!(c~d) will compute (a!c)~(a!d)~(b!c)~(b!d)

If for a resulting intersection there are no cells in common, the element is ignored and omitted from
the result list. If for all intersections there are no cells in common and the result list is empty, Error
#NULL! is returned.

Note 2: Intersection is notated as "!" in OpenFormula format, but as a space character in some user
interfaces.

See also Infix Operator Reference Union 8.4.13

8.4.13 Infix Operator Reference Concatenation ("~") (aka Union)

Summary: Concatenate two references

Syntax: Reference Left ~ Reference Right

Returns: ReferenceList

Constraints: None
**Semantics:** Takes two references and computes the "cell union", which is a concatenation of the reference Left followed by the reference Right. This is not the same as a union in set theory; duplicate references to cells are not removed. The resulting reference will have the number of areas, as reported by AREAS, as AREAS(Left)+AREAS(Right).

**Note:** Concatenation is notated as "~" in OpenFormula format, but as a comma or "+" in some user interfaces.

If Left or Right are not of type Reference or ReferenceList, an Error shall be returned.

**Test Cases:**

See also Infix Operator Reference Range 8.4.11, Infix Operator Reference Intersection 8.4.12

### 8.4.14 Postfix Operator "%"

**Summary:** Divide the operand by 100

**Syntax:** Number Left %

**Returns:** Number

**Constraints:** None

**Semantics:** Computes Left / 100.

See also Prefix Operator "-" 8.4.16, Prefix Operator "+" 8.4.15

### 8.4.15 Prefix Operator "+"

**Summary:** No operation; returns its one argument.

**Syntax:** + Any Right

**Returns:** Any

**Constraints:** None

**Semantics:** Returns the value given to it. Note that this does not convert a value to the Number type. In fact, it does no conversion at all of a Number, Logical, or Text value - it returns the same Number, Logical, or Text value (respectively). The "+" applied to a reference may return the reference, or an Error.

See also Infix Operator "+" 8.4.2

### 8.4.16 Prefix Operator "-"

**Summary:** Negate its one argument.

**Syntax:** - Number Right

**Returns:** Number

**Constraints:** None

**Semantics:** Computes 0 - Right.

See also Infix Operator "-" 8.4.3
8.5 Matrix Functions

8.5.1 General

Matrix functions operate on matrices.

A matrix with $M$ rows and $N$ columns and $N$ rows is defined by

\[
A_{M \times N} = \begin{pmatrix}
a_{11} & a_{21} & \cdots & a_{N1} \\
a_{12} & a_{22} & \cdots & a_{N2} \\
\vdots & \vdots & \ddots & \vdots \\
a_{1M} & a_{2M} & \cdots & a_{MN}
\end{pmatrix}
\]

The dimension subscript may be omitted, if the context allows it, i.e. $A_{M \times N} = A$. Matrices are represented by upper case letters. The elements of a matrix are denoted by the corresponding lower case letter and subscripts, which defines the row and column.

Square matrices have the same amount of columns and rows, i.e. $M = N$.

8.5.2 MDETERM

Summary: Calculates the determinant of a matrix.

Syntax: MDETERM( ForceArray Array matrix )

Returns: Number

Constraints: Only square matrices are allowed.

Semantics: Returns the determinant of the matrix. The determinant is defined by

\[
\det(A_{N \times N}) = \sum_P \text{sgn}(P) \prod_{i=1}^{N} a_{ip}
\]

where $P$ denotes a permutation of the numbers 1, 2, ..., $n$ and $\text{sgn}(P)$ is the sign of the permutation, which is +1 for an even amount of permutations (i.e., permutations that can be written as the composition of an even number of transpositions), -1 otherwise. A transposition on 1, ..., $n$ is a permutation of 1, ..., $n$ with exactly $(n-2)$ numbers fixed and +1 for an odd amount.

Matrices with a non-zero determinant are invertible.

See also MINVERSE 8.5.3

8.5.3 MINVERSE

Summary: Returns the inverse of a matrix.

Syntax: MINVERSE( ForceArray Array matrix )

Returns: Array

Constraints: Only square matrices are allowed.
Semantics: Calculates the inverse $A^{-1}$ of matrix $A$. The matrix $A$ multiplied with its inverse $A^{-1}$ results in the unity matrix of the same dimension as $A$:

$A_{N \times N} A_{N \times N}^{-1} = A_{N \times N}^{-1} A_{N \times N} = 1_{N \times N}$

Invertible matrices have a non-zero determinant. If the matrix is not invertible, this function should return an Error value.

See also MDETERM 8.5.2

### 8.5.4 MMULT

**Summary:** Multiplies the matrices $A$ and $B$.

**Syntax:** MMULT( ForceArray Array A ; ForceArray Array B )

**Returns:** Array

**Constraints:** COLUMNS(A)=ROWS(B)

**Semantics:** Returns the matrix product of the two matrices. The elements $c_{mn}$ of the resulting matrix $C_{M \times N} = A_{M \times K} B_{K \times N}$, are defined by:

$$c_{mn} = \sum_{k=1}^{K} a_{mk} b_{kn}$$

### 8.5.5 MUNIT

**Summary:** Creates a unit matrix of a specified dimension $N$.

**Syntax:** MUNIT( Integer N )

**Returns:** Array

**Constraints:** The dimension has to be greater than zero.

**Semantics:** Creates the unit matrix (identity matrix) of dimension $N$.

$$1_{N \times N} = \begin{bmatrix} 1 & 0 & \ldots & 0 \\ 0 & 1 & \ldots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \ldots & 1 \end{bmatrix}$$

### 8.5.6 TRANSPOSE

**Summary:** Returns the transpose of a matrix.

**Syntax:** TRANSPOSE( Array A )

**Returns:** Array

**Constraints:** None
Semantics: Returns the transpose $A^T$ of a matrix $A$, i.e. rows and columns of the matrix are exchanged.

\[ A^T_{M \times N} = \begin{pmatrix} a_{11} & a_{21} & \cdots & a_{M1} \\ a_{12} & a_{22} & \cdots & a_{M2} \\ \vdots & \vdots & \ddots & \vdots \\ a_{1N} & a_{2N} & \cdots & a_{MN} \end{pmatrix}_{N \times M} \]

8.6 Bit operation functions

8.6.1 General

Evaluators shall support unsigned integer values and results of at least 48 bits (values from 0 to $2^{48} - 1$ inclusive). Operations that receive or result in a value that cannot be represented within 48 bits are implementation-defined.

8.6.2 BITAND

Summary: Returns bitwise "and" of its parameters

Syntax: BITAND( Integer X ; Integer Y )

Returns: Number

Constraints: $X \geq 0$, $Y \geq 0$

Semantics: Returns bitwise "and" of its parameters. In the result, each bit position is 1 if and only if all parameters' bits at that position are also 1; else it is 0.

See also BITOR 8.6.4, BITXOR 8.6.6, AND 8.15.2

8.6.3 BITLSHIFT

Summary: Returns left shift of value $x$ by $n$ bits ("<<")

Syntax: BITLSHIFT( Integer x ; Integer n )

Returns: Number

Constraints: $x \geq 0$

Semantics: Returns left shift of value $x$ by $n$ bit positions:

- If $n<0$, return BITRSHIFT($x$,-$n$)
- if $n=0$, return $x$
- if $n>0$, return $x \times 2^n$

See also BITAND 8.6.2, BITXOR 8.6.6, BITRSHIFT 8.6.5

8.6.4 BITOR

Summary: Returns bitwise “or” of its parameters
Syntax: BITOR( Integer X ; Integer Y )

Returns: Number

Constraints: X ≥ 0, Y ≥ 0

Semantics: Returns bitwise “or” of its parameters. In the result, each bit position is 1 if any of its parameters' bits at that position are also 1; else it is 0.

See also BITAND 8.6.2, BITXOR 8.6.6, AND 8.15.2

8.6.5 BITRSHIFT

Summary: Returns right shift of value x by n bits (“>>”)

Syntax: BITRSHIFT( Integer x ; Integer n )

Returns: Number

Constraints: x ≥ 0

Semantics: Returns right shift of value x by n bit positions:

● If n<0, return BITLSHIFT(x,-n)
● if n=0, return x
● if n>0, return INT(x/2^n)

See also BITAND 8.6.2, BITXOR 8.6.6, BITLSHIFT 8.6.3

8.6.6 BITXOR

Summary: Returns bitwise “exclusive or” of its parameters

Syntax: BITXOR( Integer X ; Integer Y )

Returns: Number

Constraints: X ≥ 0, Y ≥ 0

Semantics: Returns bitwise “exclusive or” (xor) of its parameters. In the result, each bit position is 1 if one or the other parameters' bits at that position are 1; else it is 0.

See also BITAND 8.6.2, BITOR 8.6.4, OR 8.15.8

8.7 Byte-position text functions

8.7.1 General

Byte-position text functions are like their equivalent ordinary text functions, but manipulate byte positions rather than a count of the number of characters. Byte positions are integers that may depend on the specific text representation used by the implementation. Byte positions are by definition implementation-dependent and reliance upon them reduces interoperability.

The pseudotypes ByteLength and BytePosition are Integers, but their exact meanings and values are not further defined by this specification.
### 8.7.2 FINDB

**Summary:** Returns the starting position of a given text, using byte positions.

**Syntax:** `FINDB( Text Search ; Text T [ ; BytePosition Start ] )`

**Returns:** BytePosition

**Semantics:** The same as FIND, but using byte positions.

**See also** FIND 8.20.9, LEFTB 8.7.3, RIGHTB 8.7.7

### 8.7.3 LEFTB

**Summary:** Returns a selected number of text characters from the left, using a byte position.

**Syntax:** `LEFTB( Text T [ ; ByteLength Length ] )`

**Returns:** Text

**Semantics:** As LEFT, but using a byte position.

**See also** LEFT 8.20.12, RIGHT 8.20.19, RIGHTB 8.7.7

### 8.7.4 LENB

**Summary:** Returns the length of given text in units compatible with byte positions

**Syntax:** `LENB( Text T )`

**Returns:** ByteLength

**Constraints:** None.

**Semantics:** As LEN, but compatible with byte position values.

**See also** LEN 8.20.13, LEFTB 8.7.3, RIGHTB 8.7.7

### 8.7.5 MIDB

**Summary:** Returns extracted text, given an original text, starting position using a byte position, and length.

**Syntax:** `MIDB( Text T ; BytePosition Start ; ByteLength Length )`

**Returns:** Text

**Constraints:** Length >= 0.

**Semantics:** As MID, but using byte positions.

**See also** MID 8.20.15, LEFTB 8.7.3, RIGHTB 8.7.7, REPLACEB 8.7.6

### 8.7.6 REPLACEB

**Summary:** Returns text where an old text is replaced with a new text, using byte positions.

**Syntax:** `REPLACEB( Text T ; BytePosition Start ; ByteLength Len ; Text New )`

**Returns:** Text
Semantics: As REPLACE, but using byte positions.

See also REPLACE 8.20.17, LEFTB 8.7.3, RIGHTB 8.7.7, MIDB 8.7.5, SUBSTITUTE 8.20.21

8.7.7 RIGHTB

Summary: Returns a selected number of text characters from the right, using byte position.

Syntax: RIGHTB( Text T [ ; ByteLength Length ] )

Returns: Text

Semantics: As RIGHT, but using byte positions.

See also RIGHT 8.20.19, LEFTB 8.7.3

8.7.8 SEARCHB

Summary: Returns the starting position of a given text, using byte positions.

Syntax: SEARCHB( Text Search ; Text T [ ; BytePosition Start ] )

Returns: BytePosition

Semantics: As SEARCH, but using byte positions.

See also SEARCH 8.20.20, EXACT 8.20.8, FIND 8.20.9, FINDB 8.7.2

8.8 Complex Number Functions

8.8.1 General

Functions for complex numbers.

8.8.2 COMPLEX

Summary: Creates a complex number from a given real coefficient and imaginary coefficient.

Syntax: COMPLEX( Number Real ; Number Imaginary [ ; Text Suffix ] )

Returns: Complex

Constraints: None

Semantics: Constructs a complex number by the given coefficients. The third parameter Suffix is optional, and should be either “i” or “j”. Upper case “I” or “J” are not accepted for the suffix parameter.

8.8.3 IMABS

Summary: Returns the absolute value of a complex number

Syntax: IMABS( Complex X )

Returns: Number

Constraints: None
Semantics: If \( X = a + bi \) or \( X = a + bj \), the absolute value is \( \sqrt{a^2 + b^2} \); if \( N = r(\cos \varphi + \sin \varphi) \), the absolute value is \( r \).

See also IMARGUMENT 8.8.5

### 8.8.4 IMAGINARY

**Summary:** Returns the imaginary coefficient of a complex number

**Syntax:** IMAGINARY( Complex X )

**Returns:** Number

**Constraints:** None

**Semantics:** If \( X = a + bi \) or \( X = a + bj \), then the imaginary coefficient is \( b \).

See also IMREAL 8.8.19

### 8.8.5 IMARGUMENT

**Summary:** Returns the complex argument of a complex number

**Syntax:** IMARGUMENT( Complex X )

**Returns:** Number

**Constraints:** None

**Semantics:** If \( X = a + bi = r(\cos \varphi + \sin \varphi) \), \( a \) or \( b \) is not 0 and \(-\pi < \varphi \leq \pi \), then the complex argument is \( \varphi \). \( \varphi \) is expressed by radians. If \( X = 0 \), then IMARGUMENT(X) is implementation-defined and either 0 or an error.

See also IMABS 8.8.3

### 8.8.6 IMCONJUGATE

**Summary:** Returns the complex conjugate of a complex number

**Syntax:** IMCONJUGATE( Complex X )

**Returns:** Complex

**Constraints:** None

**Semantics:** If \( X = a + bi \), then the complex conjugate is \( a - bi \).

### 8.8.7 IMCOS

**Summary:** Returns the cosine of a complex number

**Syntax:** IMCOS( Complex X )

**Returns:** Complex

**Constraints:** None

**Semantics:** If \( X = a + bi \), then \( \cos(X) = \cos(a)\cosh(b) - \sin(a)\sinh(b)i \).

See also IMSIN 8.8.20
### 8.8.8 IMCOSH

**Summary:** Returns the hyperbolic cosine of a complex number.

**Syntax:** IMCOSH(Complex N)

**Returns:** Complex

**Constraints:** None

**Semantics:** If N=a+bi, then \( \cosh(N) = \cosh(a) \cos(b) + \sinh(a) \sin(b)i \). 

### 8.8.9 IMCOT

**Summary:** Returns the cotangent of a complex number.

**Syntax:** IMCOT(Complex N)

**Returns:** Complex

**Constraints:** None

**Semantics:** Equivalent to the following (except N is computed only once):

\[
\text{IMDIV}(\text{IMCOS}(N);\text{IMSIN}(N))
\]

See also IMTAN 8.8.20

### 8.8.10 IMCSC

**Summary:** Returns the cosecant of a complex number.

**Syntax:** IMCSC(Complex N)

**Returns:** Complex

**Constraints:** None

**Semantics:** Equivalent to the following:

\[
\text{IMDIV}(1;\text{IMSIN}(N))
\]

See also IMSIN 8.8.20

### 8.8.11 IMCSCH

**Summary:** Returns the hyperbolic cosecant of a complex number.

**Syntax:** IMCSCH(Complex N)

**Returns:** Number

**Constraints:** None

**Semantics:** Computes the hyperbolic cosecant. This is equivalent to:

\[
\text{IMDIV}(1;\text{IMSINH}(N))
\]

See also IMSIN, CSCH
8.8.12 IMDIV

Summary: Divides the second number into the first.

Syntax: IMDIV( Complex X ; Complex Y )

Returns: Complex

Constraints: None

Semantics: Given X=a+bi and Y=c+di, return the quotient

\[
\frac{(ac+bd)+(bc-ad)i}{(c^2+d^2)}
\]

Division by zero returns an Error.

See also IMDIV 8.8.12

8.8.13 IMEXP

Summary: Returns the exponent of e and a complex number.

Syntax: IMEXP( Complex X )

Returns: Complex

Constraints: None

Semantics: If X=a+bi, the result is e^a(\cos b + i \sin b).

See also IMLN 8.8.14

8.8.14 IMLN

Summary: Returns the natural logarithm of a complex number.

Syntax: IMLN( Complex X )

Returns: Complex

Constraints: X \neq 0

Semantics: COMPLEX(LN(IMABS(X)); IMARGUMENT(X)) if X=r(cos \phi + isin \phi), \phi is expressed by radians, then the natural logarithm is returned.

See also IMEXP 8.8.13, IMLOG10 8.8.15

8.8.15 IMLOG10

Summary: Returns the common logarithm of a complex number.

Syntax: IMLOG10( Complex X )

Returns: Complex

Constraints: X \neq 0

Semantics: IMLOG10(X) is IMDIV(IMLN(X);COMPLEX(LN(10);0)) if X=r(cos \phi + isin \phi), \phi is expressed by radians, then the common logarithm is returned.
See also IMLN 8.8.14, IMPOWER 8.8.17

8.8.16 IMLOG2

Summary: Returns the binary logarithm of a complex number.
Syntax: IMLOG2( Complex X )
Returns: Complex
Constraints: \( X \neq 0 \)

Semantics: \( IMLOG2(X) = IMDIV(IMLN(X); COMPLEX(LN(2);0)) \)
if \( X = r(\cos \varphi + isin \varphi) \), \( \varphi \) is expressed by radians, then the binary logarithm is returned.

See also IMLN 8.8.14, IMPOWER 8.8.17

8.8.17 IMPOWER

Summary: Returns the complex number \( X \) raised to the \( Y \)th power of \( N \) and a complex number.
Syntax: IMPOWER( Complex X ; Complex Y ) or IMPOWER( Complex X ; Number Y )
Returns: Complex
Constraints: \( X \neq 0 \)

Semantics: \( IMPOWER(X;Y) = IMEXP(IMPRODUCT(Y; IMLN(X))) \)
if \( X = a+bi = r(\cos \varphi + isin \varphi) \), the result is...

An evaluator implementing this function shall permit any Number \( Y \) but may also allow any Complex \( Y \).

See also IMEXP 8.8.13

See also IMEXP 8.8.13

8.8.18 IMPRODUCT

Summary: Returns the product of complex numbers.
Syntax: IMPRODUCT( { ComplexSequence N })+
Returns: Complex
Constraints: None

Semantics: Multiply the complex numbers together. Given two complex numbers \( X = a+bi \) and \( Y = c+di \), the product \( X*Y = (ac-bd) + (ad+bc)i \)

See also IMDIV 8.8.12

8.8.19 IMREAL

Summary: Returns the real coefficient of a complex number
Syntax: IMREAL( Complex N )
Returns: Number
8.8.20 IMSIN

**Summary:** Returns the sine of a complex number

**Syntax:** IMSIN( Complex N )

**Returns:** Complex

**Constraints:** None

**Semantics:** If N=a+bi, then sin(N)=sin(a)cosh(b)+cos(a)sinh(b)i.

See also IMCOS 8.8.7

8.8.21 IMSINH

**Summary:** Returns the hyperbolic sine of a complex number

**Syntax:** IMSINH( Complex N )

**Returns:** Complex

**Constraints:** None

**Semantics:** If N=a+bi, then sinh(N)=sinh(a)cos(b)+cosh(a)sin(b)i.

See also IMCOS 8.8.7

8.8.22 IMSEC

**Summary:** Returns the secant of a complex number

**Syntax:** IMSEC(Complex N)

**Returns:** Complex

**Constraints:** None

**Semantics:** Equivalent to the following:

IMDIV(1;IMCOS(N))

See also IMCOS 8.8.7

8.8.23 IMSECH

**Summary:** Returns the hyperbolic secant of a complex number

**Syntax:** IMSECH( Complex N )

**Returns:** Number

**Constraints:** None

**Semantics:** Computes the hyperbolic secant. This is equivalent to:

IMDIV(1;IMCOSH(N))
See also IMCOSH, SECH

### 8.8.24 IMSQRT

**Summary:** Returns the square root of a complex number

**Syntax:** IMSQRT( Complex N )

**Returns:** Complex

**Constraints:** None

**Semantics:** If \( N=0+0i \), then IMSQRT(N)=0. Otherwise IMSQRT(N) is \( \sqrt{\text{IMABS}(N)} \ast \sin(\text{IMARGUMENT}(N)/2) + \sqrt{\text{IMABS}(N)} \ast \cos(\text{IMARGUMENT}(N)/2)i \). If \( \phi \) is expressed by radians, then the square root of N is returned.

See also IMPOWER 8.8.17

### 8.8.25 IMSUB

**Summary:** Subtracts the second complex number from the first.

**Syntax:** IMSUB( Complex X ; Complex Y )

**Returns:** Complex

**Constraints:** None

**Semantics:** Subtract complex number Y from X.

See also IMSUM 8.8.26

### 8.8.26 IMSUM

**Summary:** Sums (add) a set of complex numbers, including all numbers in ranges

**Syntax:** IMSUM( { ComplexSequence N }+ )

**Returns:** Complex Number

**Constraints:** None

**Semantics:** Adds complex numbers together. Text that cannot be converted to a complex number is ignored.

It is implementation-defined what happens if this function is given zero parameters; an evaluator may either produce an Error or the Number 0 if it is given zero parameters.

See also IMSUB 8.8.25

### 8.8.27 IMTAN

**Summary:** Returns the tangent of a complex number

**Syntax:** IMTAN(Complex N)

**Returns:** Complex

**Constraints:** None
Semantics: Equivalent to the following (except N is computed only once):

$$\text{IMDIV}(\text{IMSIN}(N); \text{IMCOS}(N))$$

See also IMSIN, IMCOS, IMCOT 8.8.25

8.9 Database Functions

8.9.1 General

Database functions use the variables, Database 4.11.8, Field 4.11.9, and Criteria 4.11.10.

The results of database functions may change when the values of the HOST-USE-REGULAR-EXPRESSIONS or HOST-USE-WILDCARDS or HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL properties change. 3.5

8.9.2 DAVERAGE

Summary: Finds the average of values in a given field from the records (rows) in a database that match a search criteria.

Syntax: $\text{DAVERAGE}( \text{Database} \; D \;; \; \text{Field} \; F \;; \; \text{Criteria} \; C )$

Returns: Number

Constraints: None

Semantics: Perform AVERAGE on data records in database D field F that match criteria C.

See also AVERAGE 8.18.3, COUNT 8.13.6, DSUM 8.9.11, DCOUNT 8.9.3, SUM 8.16.61

8.9.3 DCOUNT

Summary: Counts the number of records (rows) in a database that match a search criteria and contain numerical values.

Syntax: $\text{DCOUNT}( \text{Database} \; D \;; \; \text{Field} \; F \;; \; \text{Criteria} \; C )$

Returns: Number

Constraints: None

Semantics: Perform COUNT on data records in database D field F that match criteria C.

See also COUNT 8.13.6, COUNTA 8.13.7, DCOUNTA 8.9.4, DSUM 8.9.11

8.9.4 DCOUNTA

Summary: Counts the number of records (rows) in a database that match a search criteria and contain values (as COUNTA).

Syntax: $\text{DCOUNTA}( \text{Database} \; D \;; \; \text{Field} \; F \;; \; \text{Criteria} \; C )$

Returns: Number

Constraints: None

Semantics: Perform COUNTA on data records in database D field F that match criteria C.
See also COUNT 8.13.6, COUNTA 8.13.7, DCOUNT 8.9.3, DSUM 8.9.11

8.9.5 DGET

Summary: Gets the single value in the field from the single record (row) in a database that matches a search criteria.

Syntax: DGET( Database D ; Field F ; Criteria C )

Returns: Number

Constraints: None

Semantics: Extracts the value in field F of the one data record in database D that matches criteria C. If no records match, or more than one matches, it returns an Error.

See also DMAX 8.9.6, DMIN 8.9.7, DSUM 8.9.11

8.9.6 DMAX

Summary: Finds the maximum value in a given field from the records (rows) in a database that match a search criteria.

Syntax: DMAX( Database D ; Field F ; Criteria C )

Returns: Number

Constraints: None

Semantics: Perform MAX on only the data records in database D field F that match criteria C.

See also MAX 8.18.45, DMIN 8.9.7, MIN 8.18.48

8.9.7 DMIN

Summary: Finds the minimum value in a given field from the records (rows) in a database that match a search criteria.

Syntax: DMIN( Database D ; Field F ; Criteria C )

Returns: Number

Constraints: None

Semantics: Perform MIN on only the data records in database D field F that match criteria C.

See also MIN 8.18.48, DMAX 8.9.6, MAX 8.18.45

8.9.8 DPRODUCT

Summary: Finds the product of values in a given field from the records (rows) in a database that match a search criteria.

Syntax: DPRODUCT( Database D ; Field F ; Criteria C )

Returns: Number

Constraints: None

Semantics: Multiply together only the data records in database D field F that match criteria C.
See also SUM 8.16.61, DSUM 8.9.11

8.9.9 DSTDEV

Summary: Finds the sample standard deviation in a given field from the records (rows) in a database that match a search criteria.

Syntax: DSTDEV( Database D ; Field F ; Criteria C )

Returns: Number

Constraints: None

Semantics: Perform STDEV on only the data records in database D field F that match criteria C.

See also STDEV 8.18.72, DSTDEVP 8.9.10

8.9.10 DSTDEVP

Summary: Finds the population standard deviation in a given field from the records (rows) in a database that match a search criteria.

Syntax: DSTDEVP( Database D ; Field F ; Criteria C )

Returns: Number

Constraints: None

Semantics: Perform STDEVP on only the data records in database D field F that match criteria C.

See also STDEVP 8.18.74, DSTDEV 8.9.9

8.9.11 DSUM

Summary: Finds the sum of values in a given field from the records (rows) in a database that match a search criteria.

Syntax: DSUM( Database D ; Field F ; Criteria C )

Returns: Number

Constraints: None

Semantics: Perform SUM on only the data records in database D field F that match criteria C.

See also SUM 8.16.61, DMIN 8.9.7, DMAX 8.9.6

8.9.12 DVAR

Summary: Finds the sample variance in a given field from the records (rows) in a database that match a search criteria.

Syntax: DVAR( Database D ; Field F ; Criteria C )

Returns: Number

Constraints: None

Semantics: Perform VAR on only the data records in database D field F that match criteria C.
See also VAR 8.18.82, DVARP 8.9.13

8.9.13 DVARP

Summary: Finds the population variance in a given field from the records (rows) in a database that match a search criteria.

Syntax: DVARP( Database D ; Field F ; Criteria C )

Returns: Number

Constraints: None

Semantics: Perform VARP on only the data records in database D field F that match criteria C.

See also VARP 8.18.84, DVAR 8.9.12

8.10 Date and Time Functions

8.10.1 General

8.10.2 DATE

Summary: Constructs a date from year, month, and day of month.

Syntax: DATE( Integer Year ; Integer Month ; Integer Day )

Returns: Date

Constraints: 1904 <= Year <= 9956; 1 <= Month <= 12; 1 <= Day <= 31; Evaluators may evaluate expressions that do no meet this constraint.

Semantics: This computes the date’s serial number given Year, Month, and Day of the Gregorian calendar. Fractional values are truncated. Month > 12 and Day > days of Month will roll over the date, computing the result by adding months and days as necessary. The value of the serial number depends on the current epoch.

See also TIME 8.10.17, DATEVALUE 8.10.4

8.10.3 DATEDIF

Summary: Returns the difference in years, months, or days of two date numbers.

Syntax: DATEDIF( DateParam StartDate ; DateParam EndDate ; Text Format )

Returns: Number

Constraints: None

Semantics: Compute difference of StartDate and EndDate, in the units given by Format.

The Format is a code from the following table, entered as text, that specifies the format you want the result of DATEDIF to have.

<table>
<thead>
<tr>
<th>format</th>
<th>Returns the number of</th>
</tr>
</thead>
</table>

Table 5 - DATEDIF
y | Years
---|---
m | Months. If there is not a complete month between the dates, 0 will be returned.
d | Days
md | Days, ignoring months and years
ym | Months, ignoring years
yd | Days, ignoring years

See also DAYS360 8.10.7, DAYS 8.10.6, Infix Operator ".-" 8.4.3

8.10.4 DATEVALUE

Summary: Returns the date serial number from given text.

Syntax: DATEVALUE( Text D )

Returns: Date

Constraints: None

Semantics: This computes the serial number of the text string \( D \), using the current locale. This function shall accept ISO date format (YYYY-MM-DD), which is locale-independent. It is semantically equal VALUE(Date) if Date has a date format, since text matching a date format is automatically converted to a serial number when used as a Number. If the text of \( D \) has a combined date and time format, e.g. YYYY-MM-DD HH:MM:SS, the integer part of the date serial number is returned. If the text of Date does not have a date or time format, an evaluator may return an Error. See VALUE for more information on date formats. The value of the serial number depends on the current epoch.

See also TIME 8.10.17, DATE 8.10.2, TIMEVALUE 8.10.18, VALUE 8.13.34

8.10.5 DAY

Summary: Returns the day from a date.

Syntax: DAY( DateParam Date )

Returns: Number

Constraints: None

Semantics: Returns the day portion of a date.

See also MONTH 8.10.13, YEAR 8.10.23

8.10.6 DAYS

Summary: Returns the number of days between two dates

Syntax: DAYS( DateParam EndDate ; DateParam StartDate )

Returns: Number

Constraints: None
Semantics: Returns the number of days between two dates. If StartDate and EndDate are Numbers, this is EndDate – StartDate. If they are both Text, this is DATEVALUE(StartDate) – DATEVALUE(EndDate).

See also DATEDIF 8.10.3, DAYS360 8.10.7, MONTH 8.10.13, YEAR 8.10.23, Infix Operator “-” 8.4.3

8.10.7 DAYS360

Summary: Returns the number of days between two dates using the 360-day year

Syntax: DAYS360( DateParam StartDate ; DateParam EndDate [ ; Integer Method = 0 ] )

Returns: Number

Constraints: $0 \leq Method \leq 1$

Semantics: Returns the number of days between two dates, using the 360-day year system (12 30-month days). In this system, February always has 30 days and there are no leap years.

If method is 0, it uses the National Association of Securities Dealers (NASD) method, also known as the U.S. method. If the method is 1, the European method is used.

The US/NASD Method (30US/360):

1. Truncate date values, set sign=1.
2. If StartDate's day-of-month is 31, it is changed to 30.
3. Otherwise, if StartDate's day-of-month is the last day of February, it is changed to 30.
4. If EndDate's day-of-month is 31 and StartDate's day-of-month is 30 (after having applied a change for #2 or #3, if necessary), EndDate's day-of-month is changed to 30.

Note 1: This calculation is slightly different from Basis 0 (4.11.7 Basis). Dates are never swapped.

The European Method (30E/360):

1. Truncate date values, set sign=1.
2. If StartDate is after EndDate then swap dates and set sign=-1.
3. If StartDate's day-of-month is 31, it is changed to 30.
4. If EndDate's day-of-month is 31, it is changed to 30.

Note 2: Days in February are never changed.

Note 3: This calculation is identical to Basis 4 (4.11.7 Basis)

For both methods the value then returned is

\[ \text{sign} \times ((\text{EndDate.year} \times 360 + \text{EndDate.month} \times 30 + \text{EndDate.day}) - (\text{StartDate.year} \times 360 + \text{StartDate.month} \times 30 + \text{StartDate.day})) \]

See also DAYS 8.10.6, DATEDIF 8.10.3

8.10.8 EDATE

Summary: Returns the serial number of a given date when MonthAdd months is added

Syntax: EDATE( DateParam StartDate ; Number MonthAdd )
Returns: Number

Constraints: None

Semantics: First truncate StartDate and MonthAdd, then add MonthAdd number of months. MonthAdd can be positive, negative, or 0; if zero, the number representing StartDate (in the current epoch) is returned.

If after adding the given number of months, the day of month in the new month is larger than the number of days in the given month, the day of month is adjusted to the last day of the new month. Then the serial number of that date is returned.

See also DAYS 8.10.6, DATEDIF 8.10.3, EOMONTH 8.10.9

8.10.9 EOMONTH

Summary: Returns the serial number of the end of a month, given date plus MonthAdd months

Syntax: EOMONTH( DateParam StartDate ; Integer MonthAdd )

Returns: Number

Constraints: None

Semantics: First truncate StartDate and MonthAdd, then add MonthAdd number of months. MonthAdd can be positive, negative, or 0. Then return the serial number representing the end of that month. Due to the semantics of this function, the value of DAY(StartDate) is irrelevant.

See also EDATE 8.10.8

8.10.10 HOUR

Summary: Extracts the hour (0 through 23) from a time.

Syntax: HOUR( TimeParam T )

Returns: Number

Constraints: None

Semantics: Extract from T the hour value, 0 through 23, as per a 24-hour clock. This is equal to:

DayFraction=(T-INT(T))
Hour=INT(DayFraction*24)

See also MONTH 8.10.13, DAY 8.10.5, MINUTE 8.10.12, SECOND 8.10.16

8.10.11 ISOWEEKNUM

Summary: Determines the ISO week number of the year for a given date.

Syntax: ISOWEEKNUM( DateParam Date [; Integer Mode = 2] )

Returns: Number

Constraints: None

Semantics: Returns the ordinal number of the ISO8601 calendar week in the year for the given date. ISO 8601 defines the calendar week as a time interval of seven calendar days starting with a Monday, and the first calendar week of a year as the one that includes the first Thursday of that year.
Yearnumber of the ISO 8601 week in the year for the given date. Note that this is not the
"conventional" week number used by some applications (for that, see WEEKNUM). In this system,
week number 1 of any year is the week that contains January 4, because (1) Monday is considered
the first day of the week, and (2) a week that lies partly in one year and partly in another is assigned
a number in the year in which most of its days lie.

Mode determines the starting day of the week:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Week starts on</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sunday</td>
</tr>
<tr>
<td>2</td>
<td>Monday</td>
</tr>
</tbody>
</table>

See also DAY 8.10.5, MONTH 8.10.13, YEAR 8.10.23, WEEKDAY 8.10.20, WEEKNUM 8.10.21

8.10.12 MINUTE

Summary: Extracts the minute (0 through 59) from a time.

Syntax: MINUTE( TimeParam T )

Returns: Number

Constraints: None

Semantics: Extract from T the minute value, 0 through 59, as per a clock. This is equal to:
DayFraction=(T-INT(T))
HourFraction=(DayFraction*24-INT(DayFraction*24))
Minute=INT(HourFraction*60)

See also MONTH 8.10.13, DAY 8.10.5, HOUR 8.10.10, SECOND 8.10.16

8.10.13 MONTH

Summary: Extracts the month from a date.

Syntax: MONTH( DateParam Date )

Returns: Number

Constraints: None

Semantics: Takes a date and returns the month portion.

See also YEAR 8.10.23, DAY 8.10.5

8.10.14 NETWORKDAYS

Summary: Returns the whole number of work days between two dates.

Syntax: NETWORKDAYS( DateParam Date1 ; DateParam Date2 [ ; [ DateSequence holidays ] [ ; LogicalSequence workdays ] ] )

Returns: Number
Constraints: None

Semantics: Returns the whole number of work days between two dates, ignoring weekends.

Work days are defined as non-weekend, non-holiday days. By default, weekends are Saturdays and Sundays and there are no holidays.

The optional 3rd parameter Holidays can be used to specify a list of dates to be treated as holidays. Note that this parameter can be omitted as an empty parameter (two consecutive ;; semicolons) to be able to pass the set of Workdays without Holidays.

The optional 4th parameter Workdays can be used to specify a different definition for the standard work week by passing in a list of numbers which define which days of the week are workdays (indicated by 0) or not (indicated by non-zero) in order Sunday, Monday,..., Saturday. So, the default definition of the work week excludes Saturday and Sunday and is: {1;0;0;0;0;0;1}. To define the work Logical values which define which days of the week are workdays. So, the default definition of the work week excludes Saturday and Sunday and is: {1;0;0;0;0;0;1}. To define the work week as excluding Friday and Saturday, the third parameter would be: {0;0;0;0;0;1;1}.

8.10.15 NOW

Summary: Returns the serial number of the current date and time.

Syntax: NOW()

Returns: DateTime

Constraints: None

Semantics: This returns the current day and time serial number, using the current locale. If you want only the serial number of the current day, use TODAY 8.10.19.

See also DATE 8.10.2, TIME 8.10.17, TODAY 8.10.19

8.10.16 SECOND

Summary: Extracts the second (the integer 0 through 59) from a time. This function presumes that leap seconds never exist.

Syntax: SECOND(TimeParam T)

Returns: Number

Constraints: None

Semantics: Extract from T the second value, 0 through 59, as per a clock. Note that this returns an integer, without a fractional part. Note also that this rounds to the nearest second, instead of returning the integer part of the seconds. This is equal to:

DayFraction=(T-INT(T))
HourFraction=(DayFraction*24-INT(DayFraction*24))
MinuteFraction=(HourFraction*60-INT(HourFraction*60))
Second=ROUND(MinuteFraction*60)

See also MONTH 8.10.13, DAY 8.10.5, HOUR 8.10.10, MINUTE 8.10.12
8.10.17 TIME

Summary: Constructs a time value from hours, minutes, and seconds.

Syntax: TIME( Number hours ; Number minutes ; Number seconds )

Returns: Time

Constraints: None. Evaluators may first perform INT() on the hour, minute, and second before doing the calculation.

Semantics: Returns the fraction of the day consumed by the given time, i.e.:

\[((\text{hours} \times 60 \times 60) + (\text{minutes} \times 60) + \text{seconds}) / (24 \times 60 \times 60)\]

Time is a subtype of number, where a time value of 1 = 1 day = 24 hours.

Hours, minutes, and seconds may be any arbitrary numbers (they shall not be limited to the ranges 0..24, 0..59, or 0..60 respectively).

See also DATE 8.10.2

8.10.18 TIMEVALUE

Summary: Returns a time serial number from given text.

Syntax: TIMEVALUE( Text T )

Returns: Time

Constraints: None

Semantics: This computes the serial number of the text string T, which is a time, using the current locale. This function shall accept ISO time format (HH:MM:SS), which is locale-independent. If the text of T has a combined date and time format, e.g. YYYY-MM-DD HH:MM:SS, the fractional part of the date serial number is returned. If the text of T does not have a time format, an evaluator may attempt to convert the number another way (e.g., using VALUE), or it may return an Error (this is implementation-dependent).

See also TIME 8.10.17, DATE 8.10.2, DATEVALUE 8.10.4, VALUE 8.13.34

8.10.19 TODAY

Summary: Returns the serial number of today.

Syntax: TODAY()

Returns: Date

Constraints: None

Semantics: This returns the current day's serial number, using current locale. This only returns the date, not the datetime value. For the specific time of day as well, use NOW 8.10.15.

See also TIME 8.10.17, NOW 8.10.15

8.10.20 WEEKDAY

Summary: Extracts the day of the week from a date; if text, uses current locale to convert to a date.

Syntax: WEEKDAY( DateParam Date [ ; Integer Type = 1 ] )
Returns: Number

Constraints: None

Semantics: Returns the day of the week from a date, as a number from 0 through 7. The exact meaning depends on the value of Type:

1. When Type is 1, Sunday is the first day of the week, with value 1; Saturday has value 7.
2. When Type is 2, Monday is the first day of the week, with value 1; Sunday has value 7.
3. When Type is 3, Monday is the first day of the week, with value 0; Sunday has value 6.

<table>
<thead>
<tr>
<th>Day of Week</th>
<th>Type=1 Result</th>
<th>Type=2 Result</th>
<th>Type=3 Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunday</td>
<td>1</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Monday</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Tuesday</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Wednesday</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Thursday</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Friday</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Saturday</td>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

See also DAY 8.10.5, MONTH 8.10.13, YEAR 8.10.23

8.10.21 WEEKNUM

Summary: Determines the week number of the year for a given date.

Syntax: WEEKNUM( DateParam Date [ ; Number Mode = 1 ] )

Returns: Number

Constraints: 1 ≤ Mode ≤ 2, or 11 ≤ Mode ≤ 17, or Mode = 21, or Mode = 150

Semantics: Returns the number of the week in the year for the given date.

For Mode={1, 2, 11, 12, ..., 17} the week containing January 1 is the first week of the year, and is numbered week 1. The week starts on {Sunday, Monday, Monday, Tuesday, ..., Sunday}.

Mode 21 or 150 are both [ISO8601], the week starts on Monday and the week containing the first Thursday of the year is the first week of the year, and is numbered week 1.

See also DAY 8.10.5, MONTH 8.10.13, YEAR 8.10.23, WEEKDAY 8.10.20, ISOWEEKNUM 8.10.11

8.10.22 WORKDAY

Summary: Returns the date serial number which is a specified number of work days before or after an input date.

Syntax: WORKDAY( DateParam Date ; Number Offset [ ; [ DateSequence Holidays ] [ ; LogicalSequence Workdays ] ] )

Returns: DateTime
**Constraints:** None

**Semantics:** Returns the date serial number for the day that is offset from the input Date parameter by the number of work days specified in the Offset parameter. If Offset is negative, the offset will return a date prior to Date. If Offset is positive, a date later Date is returned. If Offset is zero, then Date is returned.

Work days are defined as non-weekend, non-holiday days. By default, weekends are Saturdays and Sundays and there are no holidays.

The optional 3rd parameter Holidays can be used to specify a list of dates to be treated as holidays. Note that this parameter can be omitted as an empty parameter (two consecutive ;; semicolons) to be able to pass the set of Workdays without Holidays.

The optional 4th parameter Workdays can be used to specify a different definition for the standard work week by passing in a list of numbers which define which days of the week are workdays (indicated by 0) or not (indicated by non-zero) in order Sunday, Monday,..., Saturday. If all seven numbers in Workdays are non-zero and Offset is also non-zero, WORKDAY returns an error Logical values which define which days of the week are workdays.

**Note:** The default definition of the work week that excludes Saturday and Sunday and is: {1;0;0;0;0;0;1}. To define the workweek as excluding Friday and Saturday, the third parameter would be: {0;0;0;0;1;1}.

8.10.23 YEAR

**Summary:** Extracts the year from a date given in the current locale of the evaluator.

**Syntax:** YEAR( DateParam D )

**Returns:** Number

**Constraints:** None

**Semantics:** Parses a date-formatted string in the current locale's format and returns the year portion.

If a year is given as a two-digit number, as in "05-21-15", then the year returned is either 1915 or 2015, depending upon the break point in the calculation context. In an OpenDocument document, this break point is determined by HOST-NULL-YEAR.

Evaluators shall support extracting the year from a date beginning in 1900. Three-digit year numbers precede adoption of the Gregorian calendar, and may return either an Error or the year number. Four-digit year numbers preceding 1582 (inception of the Gregorian Calendar) may return either an Error or the year number. Four-digit year numbers following 1582 should return the year number.

**See also** MONTH 8.10.13, DAY 8.10.5, VALUE 8.13.34

8.10.24 YEARFRAC

**Summary:** Extracts the number of years (including fractional part) between two dates

**Syntax:** YEARFRAC( DateParam StartDate ; DateParam EndDate [ ; Basis Basis = 0 ] )

**Returns:** Number

**Constraints:** None
Semantics: Computes the fraction of the number of years between a StartDate and EndDate.
Basis is the system for determining how many days are in a month or year.

Basis indicates the day-count convention to use in the calculation. Note: The Basis default is not the actual number of days in a month or year. 4.11.7

See also DATEDIF 8.10.3

8.11 External Access Functions

8.11.1 General

OpenFormula defines two functions, DDE and HYPERLINK, for accessing external data.

8.11.2 DDE

Summary: Returns data from a DDE request
Syntax: DDE( Text server ; Text topic ; Text item [ ; Integer Mode = 0 ] )
Returns: Number|Text
Constraints: None

Semantics: Performs a DDE request and returns its result. The request invokes the service server on the topic named as topic, requesting that it reply with the information on item.

Evaluators may choose to not perform this function on every recalculation, but instead cache an answer and require a separate action to re-perform these requests. Evaluators shall perform this request on initial load when their security policies permit it.

Mode is an optional parameter that determines how the results are returned:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 or missing</td>
<td>Data converted to number using VALUE in the number style's locale of the default table cell style</td>
</tr>
<tr>
<td>1</td>
<td>Data converted to number using VALUE in the English-US (en_US) locale</td>
</tr>
<tr>
<td>2</td>
<td>Data retrieved as text (not converted to number)</td>
</tr>
</tbody>
</table>

Table 8 - DDE

In an OpenDocument spreadsheet document the default table cell style is specified with table:default-cell-style-name. Its number:number-style specified by style:data-style-name specifies the locale to use in the conversion.

The DDE function is non-portable because it depends on availability of external programs (server parameter) and their interpretation of the topic and item parameters.

8.11.3 HYPERLINK

Summary: Creation of a hyperlink involving an evaluated expression
Returns a Text or Number result and adds a string to the IRI part of a hyperlink cell.

Syntax: HYPERLINK( Text IRI [ ; Text|Number FunctionResult ] )
Returns: Text or Number

Constraints: None

Semantics: The default for the second argument is the value of the first argument. The second argument value is returned. IRI parameter specifies the link target added to the hyperlink cell, while the FunctionResult parameter is shown as part of the formula result in the cell. If FunctionResult is omitted, the IRI will be used for both the IRI and the cell result. If FunctionResult is Text, a Text result is returned. If FunctionResult is Number, a Number result is returned.

In addition, hosting environments may interpret expressions containing HYPERLINK function calls as calling for an implementation-dependent creation of a hypertext link based on the expression containing the HYPERLINK function calls. If a formula contains a HYPERLINK function, the cell becomes a "hyperlink cell". Clicking on this cell will execute the contained hyperlink. Therefore it is irrelevant if the HYPERLINK function is really evaluated (it may i.e. be located in a non-executed part of an IF function) – the cell will always be a hyperlink cell, even if the formula evaluates to a number or a Boolean value. The only exception to this rule is if an Error code would be part of the IRI. In this case no hyperlink cell will be created.

In a hyperlink cell, all other functions affect both the current IRI and the cell text. Therefore the formula has to be evaluated twice. In the first run using the IRI part of all hyperlink functions, and in the second run using the FunctionResult part.

8.12 Financial Functions

8.12.1 General

The financial functions are defined for use in financial calculations.

An annuity is a recurring series of payments. A "simple annuity" is one where equal payments are made at equal intervals, and the compounding of interest occurs at those same intervals. The time between payments is called the "payment interval". Where payments are made at the end of the payment interval, it is called an "ordinary annuity". Where payments are made at the beginning of the payment interval, it is called an "annuity due". Periods are numbered starting at 1.

Financial functions defined in this standard use a cash flow sign convention where outgoing cash flows are negative and incoming cash flows are positive.

8.12.2 ACCRINT

Summary: Calculates the accrued interest for securities with periodic interest payments.

Syntax: ACCRINT( DateParam issue ; DateParam first ; DateParam settlement ; Number coupon ; Number par ; Integer frequency [ ; Basis basis = 0 [ ; Logical calc_method = TRUE() ] ] )

Returns: Currency

Constraints: issue < first < settlement ; coupon > 0; par > 0

frequency is one of the following values:

<table>
<thead>
<tr>
<th>frequency</th>
<th>Frequency of coupon payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Annual</td>
</tr>
<tr>
<td>2</td>
<td>Semiannual</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>frequency</th>
<th>Frequency of coupon payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Quarterly</td>
</tr>
<tr>
<td>12</td>
<td>Monthly</td>
</tr>
</tbody>
</table>

**Semantics:** Calculates the accrued interest for securities with periodic interest payments. ACCRINT supports short, standard, and long coupon periods.

If calc_method is TRUE (the default) then ACCRINT returns the sum of the accrued interest in each coupon period from issue date until settlement date. If calc_method is FALSE then ACCRINT returns the sum of the accrued interest in each coupon period from first date until settlement date. For each coupon period, the interest is \( \text{par} \times \text{coupon} \times \text{YEARFRAC} \) (start-of-period; end-of-period; basis).

- **issue** The security's issue or dated date.
- **first** The security's first interest date.
- **settlement** The security's settlement date.
- **coupon** The security's annual coupon rate.
- **par** The security's par value, that is, the principal to be paid at maturity.
- **frequency** The number of coupon payments per year.
- **basis** Basis indicates the day-count convention to use in the calculation. The type of day-count basis to use; see section 4.11.7.
- **calc_method** A logical value that specifies how to treat the case where settlement>first.

**See also** ACCRINTM 8.12.3

### 8.12.3 ACCRINTM

**Summary:** Calculates the accrued interest for securities that pay at maturity.

**Syntax:**

\[
\text{ACCRINTM}( \text{DateParam} \text{ issue} ; \text{DateParam} \text{ settlement} ; \text{Number} \text{ coupon} ; \text{Number} \text{ par} [ ; \text{Basis} \text{ basis} = 0 ] )
\]

**Returns:** Currency

**Constraints:** \( \text{coupon} > 0; \text{par} > 0 \)

**Semantics:** Calculates the accrued interest for securities that pay at maturity.

- **issue** The security's issue or dated date.
- **settlement** The security's maturity date.
- **coupon** The security's annual coupon rate.
- **par** The security's par value, that is, the principal to be paid at maturity.
- **basis** Basis indicates the day-count convention to use in the calculation. The type of day-count basis to use; see section 4.11.7.

**See also** ACCRINT 8.12.2

### 8.12.4 AMORDEGRC

**Summary:** Calculates the amortization value for the French accounting system using degressive depreciation.

**Syntax:**

\[
\text{AMORDEGRC}( \text{Number} \text{ cost} ; \text{DateParam} \text{ purchaseDate} ; \text{DateParam} \text{ firstPeriodEndDate} ; \text{Number} \text{ salvage} ; \text{Integer} \text{ period} ; \text{Number} \text{ rate} [ ; \text{Basis} \text{ basis} = 0 ] )
\]

**Returns:** Currency

**Constraints:** \( \text{cost} > 0; \text{purchaseDate} <= \text{firstPeriodEndDate}; \text{salvage} >= 0; \text{period} >= 0; \text{rate} > 0 \)
**Semantics:** Calculates the amortization value for the French accounting system using degressive depreciation.

- **cost** The value of the asset at the date of acquisition.
- **purchaseDate** The date of acquisition.
- **firstPeriodEndDate** The end date of the first depreciation period.
- **salvage** The value of the asset at the end of the depreciation life time.
- **period** The period of interest.
- **rate** The rate of depreciation.
- **basis** The type of day-count basis to use; see section 4.11.7

The asset life time is the inverse of the rate, $\frac{1}{\text{rate}}$. The depreciation factor is denoted by $\text{factor}$.

**Table 10—AMORDEGRC**

<table>
<thead>
<tr>
<th>Asset life time ((1/\text{rate}))</th>
<th>Depreciation factor ((\text{factor}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>4.0</td>
</tr>
<tr>
<td>1.5</td>
<td>4.5</td>
</tr>
<tr>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

The depreciation allowance for the period is denoted by $\text{factor}$ and takes the following values:

**See also** AMORLINC 8.12.5, DB 8.12.14, DDB 8.12.15, YEARFRAC 8.10.24

### 8.12.5 AMORLINC

**Summary:** Calculates the amortization value for the French accounting system using linear depreciation (l'amortissement linéaire comptable).

**Syntax:**

```plaintext
AMORLINC( Number cost ; DateParam purchaseDate ; DateParam firstPeriodEndDate ; Number salvage ; Integer period ; Number rate [ ; Basis basis = 0 ] )
```

**Returns:** Currency

**Constraints:**

- $\text{cost} > 0$; $\text{purchaseDate} \leq \text{firstPeriodEndDate}$; $\text{salvage} \geq 0$; $\text{period} \geq 0$; $\text{rate} > 0$

**Semantics:** Calculates the amortization value for the French accounting system using linear depreciation.

- **cost** The value of the asset at the date of acquisition.
- **purchaseDate** The date of acquisition.
- **firstPeriodEndDate** The end date of the first depreciation period.
salvage
The value of the asset at the end of the depreciation life time.
period
Which period the depreciation should be calculated for.
rate
The rate of depreciation.
basis
Basis indicates the day-count convention to use in the calculation. Indicates the day-count basis to use; see section 4.11.7

When period = 0:

\[ \text{AMORLINC} = \text{cost} \cdot \text{rate} \cdot \text{YEARFRAC} \left( \text{purchaseDate}, \text{firstPeriodEndDate}, \text{basis} \right) \]

For full periods, where period > 0, the depreciation is \( \text{cost} \cdot \text{rate} \)

\[ t = \frac{\text{cost} - \text{salvage}}{\text{cost} \cdot \text{rate}} \]

For the last period, possibly a partial period, the depreciation = cost-salvage-accumulated-depreciation, where accumulated-depreciation is the sum of the depreciation in period 0 plus any full period depreciations.

\[ \text{AMORLINC} = \text{cost} \cdot \text{rate} \]

When period > depreciated life of the asset, i.e., when period > (cost-salvage)/(cost*rate) then the depreciation is 0.

\[ \text{AMORLINC} = 0 \]

Note: The behavior of this function is implementation-defined in cases where purchaseDate = firstPeriodEndDate.

See also AMORDEGRC 8.12.4, DB 8.12.14, DDB 8.12.15, YEARFRAC 8.10.24

### 8.12.6 COUPDAYBS

**Summary:** Calculates the number of days between the beginning of the coupon period that contains the settlement date and the settlement date.

**Syntax:** COUPDAYBS( DateParam settlement ; DateParam maturity ; Integer frequency [ ; Basis basis = 0 ] )

**Returns:** Number

**Constraints:** settlement < maturity

**frequency** is one of the following values:

<table>
<thead>
<tr>
<th>frequency</th>
<th>Frequency of coupon payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Annual</td>
</tr>
<tr>
<td>2</td>
<td>Semiannual</td>
</tr>
<tr>
<td>4</td>
<td>Quarterly</td>
</tr>
</tbody>
</table>

**Semantics:** Calculate the number of days from the beginning of the coupon period to the settlement date.
settlement       The settlement date.
maturity         The maturity date.
frequency        The number of coupon payments per year.
basis            Basis indicates the day-count convention to use in the calculation. The type of day-count basis; see section 4.11.7

See also COUPDAYS 8.12.7, COUPDAYSNC 8.12.8, COUPNC 8.12.8, COUPNUM 8.12.10, COUPPCD 8.12.11

8.12.7 COUPDAYS

Summary: Calculates the number of days in a coupon period that contains the settlement date.

Syntax: COUPDAYS( DateParam settlement ; DateParam maturity ; Integer frequency [ ; Basis basis = 0 ] )

Returns: Number

Constraints: settlement < maturity

frequency is one of the following values:

<table>
<thead>
<tr>
<th>frequency</th>
<th>Frequency of coupon payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Annual</td>
</tr>
<tr>
<td>2</td>
<td>Semiannual</td>
</tr>
<tr>
<td>4</td>
<td>Quarterly</td>
</tr>
</tbody>
</table>

Semantics: Calculates the number of days in the coupon period containing the settlement date.

See also COUPDAYBS 8.12.6, COUPDAYSNC 8.12.8, COUPNC 8.12.8, COUPNUM 8.12.10, COUPPCD 8.12.11

8.12.8 COUPDAYSNC

Summary: Calculates the number of days between a settlement date and the next coupon date.

Syntax: COUPDAYSNC( DateParam settlement ; DateParam maturity ; Integer frequency [ ; Basis basis = 0 ] )

Returns: Number

Constraints: settlement < maturity

frequency is one of the following values:
### Table 13 - COUPDAYSNC

<table>
<thead>
<tr>
<th>frequency</th>
<th>Frequency of coupon payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Annual</td>
</tr>
<tr>
<td>2</td>
<td>Semiannual</td>
</tr>
<tr>
<td>4</td>
<td>Quarterly</td>
</tr>
</tbody>
</table>

**Semantics:** Calculates the number of days between the settlement date and the next coupon date.

- **settlement**: The settlement date.
- **maturity**: The maturity date.
- **frequency**: The number of coupon payments per year.
- **basis**: Basis indicates the day-count convention to use in the calculation. The type of day-count basis; see section 4.11.7

**See also** COUPDAYBS 8.12.6, COUPDAYS 8.12.7, COUPNCD 8.12.8, COUPNUM 8.12.10, COUPPCD 8.12.11

### 8.12.9 COUPNCD

**Summary:** Calculates the next coupon date following a settlement.

**Syntax:** COUPNCD( DateParam settlement ; DateParam maturity ; Integer frequency [ ; Basis basis = 0 ] )

**Returns:** Date

**Constraints:** settlement < maturity

**frequency** is the number of coupon payments per year. **frequency** is one of the following values:

### Table 14 - COUPNCD

<table>
<thead>
<tr>
<th>frequency</th>
<th>Frequency of coupon payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Annual</td>
</tr>
<tr>
<td>2</td>
<td>Semiannual</td>
</tr>
<tr>
<td>4</td>
<td>Quarterly</td>
</tr>
</tbody>
</table>

**Semantics:** Calculates the next coupon date after the settlement date based on the maturity (expiration) date of the asset, the frequency of coupon payments and the day-count basis.

**Basis** indicates the day-count convention to use in the calculation, 4.11.7

### 8.12.10 COUPNUM

**Summary:** Calculates the number of outstanding coupons between settlement and maturity dates.

**Syntax:** COUPNUM( DateParam settlement ; DateParam maturity ; Integer frequency [ ; Basis basis = 0 ] )

**Returns:** Number
Constraints: frequency is the number of coupon payments per year. frequency is one of the following values:

<table>
<thead>
<tr>
<th>frequency</th>
<th>Frequency of coupon payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Annual</td>
</tr>
<tr>
<td>2</td>
<td>Semiannual</td>
</tr>
<tr>
<td>4</td>
<td>Quarterly</td>
</tr>
</tbody>
</table>

Semantics: Calculates the number of coupons in the interval between the *settlement* and the *maturity* (expiration) date of the asset, the *frequency* of coupon payments and the day-count *basis*.

Basis indicates the day-count convention to use in the calculation. See also COUPDAYBS 8.12.6, COUPDAYS 8.12.7, COUPDAYSNC 8.12.8, COUPNCD 8.12.8, COUPPCD 4.11.7.

See also COUPDAYBS 8.12.6, COUPDAYS 8.12.7, COUPDAYSNC 8.12.8, COUPNCD 8.12.8, COUPPCD 8.12.11

### 8.12.11 COUPPCD

Summary: Calculates the next coupon date prior a settlement.

Syntax: COUPPCD( *DateParam* settlement ; *DateParam* maturity ; *Integer* frequency [ ; *Basis* basis = 0 ] )

Returns: Date

Constraints: *settlement* < *maturity*

frequency is the number of coupon payments per year. frequency is one of the following values:

<table>
<thead>
<tr>
<th>frequency</th>
<th>Frequency of coupon payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Annual</td>
</tr>
<tr>
<td>2</td>
<td>Semiannual</td>
</tr>
<tr>
<td>4</td>
<td>Quarterly</td>
</tr>
</tbody>
</table>

Semantics: Calculates the next coupon date prior to the *settlement* date based on the *maturity* (expiration) date of the asset, the *frequency* of coupon payments and the day-count *basis*.

Basis indicates the day-count convention to use in the calculation. See also COUPDAYBS 8.12.6, COUPDAYS 8.12.7, COUPDAYSNC 8.12.8, COUPNCD 8.12.8, COUPPCD 4.11.7.

See also COUPDAYBS 8.12.6, COUPDAYS 8.12.7, COUPDAYSNC 8.12.8, COUPNCD 8.12.8, COUPPCD 8.12.10

### 8.12.12 CUMIPMT

Summary: Calculates a cumulative interest payment.
**Syntax:** CUMIPMT( Number rate ; Number periods ; Number value ; Integer start ; Integer end ; Integer type )

**Returns:** Currency

**Constraints:** rate > 0; value > 0; 1 <= start <= end <= periods

Type is one of the following values:

<table>
<thead>
<tr>
<th>type</th>
<th>Maturity date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>due at the end</td>
</tr>
<tr>
<td>1</td>
<td>due at the beginning</td>
</tr>
</tbody>
</table>

**Semantics:** Calculates the cumulative interest payment.

rate The interest rate per period.

periods The number of periods.

value The current value of the loan.

start The starting period.

end The end period.

type The maturity date, the beginning or the end of a period.

\[
CUMIPMT = \sum_{p=\text{start}}^{\text{end}} IPMT(rate, p, period, value, 0, type)
\]

See also IPMT 8.12.24, CUMPRINC 8.12.13

8.12.13 CUMPRINC

**Summary:** Calculates a cumulative principal payment.

**Syntax:** CUMPRINC( Number rate ; Number periods ; Number value ; Integer start ; Integer end ; Integer type )

**Returns:** Currency

**Constraints:** type is one of the following values:

<table>
<thead>
<tr>
<th>type</th>
<th>Maturity date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>due at the end</td>
</tr>
<tr>
<td>1</td>
<td>due at the beginning</td>
</tr>
</tbody>
</table>

**Semantics:** Calculates the cumulative principal payment.

rate The interest rate per period.

periods The number of periods.

value The current value of the loan.

start The starting period.

end The end period.

type The maturity date, the beginning or the end of a period.
\[ CUMPRINC = \sum_{p=start}^{end} PPMT(rate, p, periods, value, 0, type) \]

See also PPMT 8.12.38, CUMIPMT 8.12.12

8.12.14 DB

Summary: Compute the depreciation allowance of an asset.

Syntax: DB( Number cost ; Number salvage ; Integer lifeTime ; Number period [ ; Number month = 12 ] )

Returns: Currency

Constraints: cost > 0, salvage >= 0, lifetime > 0; period > 0; 0 < month < 13

Semantics: Calculate the depreciation allowance of an asset with an initial value of cost, an expected useful lifeTime, and a final salvage value at a specified period of time, using the fixed-declining balance method. The parameters are:

- **cost**: the total amount paid for the asset.
- **salvage**: the salvage value at the end of the lifeTime.
- **lifeTime**: the number of periods that the depreciation will occur over. A positive integer.
- **period**: the time period for which you want to find the depreciation allowance, in the same units as lifeTime.
- **month**: (optional) the number of months in the first year of depreciation, assumed to be 12, if not specified. If a value is specified for month, lifeTime and period are assumed to be measured in years.

The rate is calculated as follows:

\[ rate = 1 - \left( \frac{salvage}{cost} \right)^{\frac{1}{lifeTime}} \]

and is rounded to 3 decimals.

For the first period the residual value is

\[ value_1 = cost \left( 1 - \frac{month}{12} \cdot rate \right) \]

For all periods, where period <= lifeTime, the residual value is calculated by

\[ value_{period} = value_{period-1} \cdot (1 - rate) \]

If month was specified, the residual value for the period after lifeTime becomes

\[ value_{lifeTime+1} = value_{lifeTime} \cdot \left( 1 - \left( 1 - \frac{month}{12} \right) \cdot rate \right) \]

The depreciation allowance for the first period is

\[ DB_1 = cost - value_1 \]
For all other periods the allowance is calculated by

\[ DB_{\text{period}} = value_{\text{period}} - value_{\text{period}-1} \]

For all periods, where \( \text{period} > \text{lifeTime} + 1 - \text{INT(month/12)} \), the depreciation allowance is zero.

See also DDB 8.12.15, SLN 8.12.46

### 8.12.15 DDB

**Summary:** Compute the amount of depreciation at a given period of time.

**Syntax:** DDB( Number cost ; Number salvage ; Number lifeTime ; Number period [ ; Number declinationFactor = 2 ] )

**Returns:** Currency

**Constraints:** cost \( \geq 0 \), salvage \( \geq 0 \), salvage \( \leq \) cost, 1 \( \leq \) period \( \leq \) lifeTime, declinationFactor > 0

**Semantics:** Compute the amount of depreciation of an asset at a given period of time. The parameters are:

- `cost`: the total amount paid for the asset.
- `salvage`: the salvage value at the end of the LifeTime
- `lifeTime`: the number of periods that the depreciation will occur over.
- `period`: the period for which a depreciation value is specified.
- `declinationFactor`: the method of calculating depreciation, the rate at which the balance declines. Defaults to 2. If 2, double-declining balance is used.

To calculate depreciation, DDB uses a fixed rate. When `declinationFactor` = 2 this is the double-declining-balance method (because it is double the straight-line rate that would depreciate the asset to zero). The rate is given by:

\[ \text{rate} = \frac{\text{declinationFactor}}{\text{lifeTime}} \]

The depreciation each period is calculated as

\[ \text{depreciation\_of\_period} = \text{MIN}( \text{book\_value\_at\_start\_of\_period} \times \text{rate}; \text{book\_value\_at\_start\_of\_period} - \text{salvage} ) \]

Thus the asset depreciates at rate until the book value is `salvage` value.

\[ \text{BookValue\_At\_Start\_Of\_Period}_p = \text{cost} - \sum_{i=1}^{n-1} \text{Depreciation\_Of\_Period}_i \]

To allow also non-integer `period` values this algorithm may be used:
\[
rate = \frac{\text{declinationFactor}}{\text{lifeTime}}
\]

if \( rate \geq 1 \) then

\[
\{ \\
\quad rate = 1 \\
\quad \text{if period} = 1 \text{ then} \\
\quad \quad oldValue = cost \\
\quad \text{else} \\
\quad \quad oldValue = 0 \\
\quad \text{endif} \\
\}
\]

else

\[
\{ \\
\quad oldValue = cost \cdot (1 - rate)^{period - 1} \\
\}
\]
endif

\[
\text{newValue} = cost \cdot (1 - rate)^{period}
\]

if \( \text{newValue} \neq \text{salvage} \) then

\[
\text{DDB} = oldValue - \text{salvage}
\]
else

\[
\text{DDB} = oldValue - \text{newValue}
\]
endif

if \( \text{DDB} \neq 0 \) then

\[
\text{DDB} = 0
\]
endif

If period is an integer number, the relation between DDB and VDB is:

\[
\text{DDB}( \text{cost} ; \text{salvage} ; \text{lifeTime} ; \text{period} ; \text{declinationFactor} )
\]
equal

\[
\text{VDB}( \text{cost} ; \text{salvage} ; \text{lifeTime} ; \text{period - 1} ; \text{period} ; \text{declinationFactor} ; \text{TRUE}() )
\]

See also SLN 8.12.46, VDB 8.12.51

8.12.16 DISC

Summary: Returns the discount rate of a security.

Syntax: DISC( DateParam settlement ; DateParam maturity ; Number price ; Number redemption [ ; Basis basis = 0 ] )

Returns: Percentage

Constraints: \( \text{settlement} < \text{maturity} \)

Semantics: Calculates the discount rate of a security.

settlement The settlement date of the security.
maturity The maturity date.
price The price of the security.
redemption The redemption value of the security.
basis Basis indicates the day-count convention to use in the calculation. The day-count basis; see section 4.11.7
\[
\text{DISC} = \frac{\text{redemption} - \text{price}}{\text{redemption}} \times \text{YEARFRAC}(\text{settlement}, \text{maturity}, \text{basis})
\]

See also YEARFRAC 8.10.24

**8.12.17 DOLLARDE**

**Summary:** Converts a fractional dollar representation into a decimal representation.

**Syntax:** DOLLARDE( Number fractional ; Integer denominator )

**Returns:** Number

**Constraints:** denominator > 0

**Semantics:** Converts a fractional dollar representation into a decimal representation.

\[
\text{DOLLARDE} = \text{TRUNC} (\text{fractional}) + \frac{\text{fractional} - \text{TRUNC} (\text{fractional})}{\text{denominator}}
\]

See also DOLLARFR 8.12.18, TRUNC 8.17.9

**8.12.18 DOLLARFR**

**Summary:** Converts a decimal dollar representation into a fractional representation.

**Syntax:** DOLLARFR( Number decimal ; Integer denominator )

**Returns:** Number

**Constraints:** denominator > 0

**Semantics:** Converts a decimal dollar representation into a fractional representation.

\[
\text{DOLLARFR} = \text{TRUNC} (\text{decimal}) + \text{decimal} - \text{TRUNC} (\text{decimal}) \cdot \text{denominator}
\]

See also DOLLARFR 8.12.17, TRUNC 8.17.9

**8.12.19 DURATION**

**Summary:** Returns the Macaulay duration of a fixed interest security in years

**Syntax:** DURATION( Date Settlement ; Date Maturity ; Number Coupon ; Number Yield ; Number Frequency [ ; Basis Basis = 0 ] )

**Returns:** Number

**Constraints:** Yield >= 0, Coupon >= 0, Settlement <= Maturity; Frequency = 1, 2, 4

**Semantics:** Computes the Macaulay duration, given:
Settlement the date of purchase of the security

Maturity the date when the security matures

- **Maturity** the date when the security matures

- **Coupon** the annual nominal rate of interest

Yield the annual yield of the security

Frequency number of interest payments per year

**Basis** Basis indicates the day-count convention to use in the calculation. Date calculation basis; see section 4.11.7

See also MDURATION 8.12.27

### 8.12.20 EFFECT

**Summary:** Returns the net annual interest rate for a nominal interest rate.

**Syntax:** EFFECT( Number rate ; Integer payments )

**Returns:** Number

**Constraints:** rate &ge; 0; payments &gt; 0

**Semantics:** Nominal interest refers to the amount of interest due at the end of a calculation period. Effective interest increases with the number of payments made. In other words, interest is often paid in installments (for example, monthly or quarterly) before the end of the calculation period.

\[
EFFECT = \left( 1 + \frac{rate}{payments} \right)^{payments} - 1
\]

See also NOMINAL 8.12.29

### 8.12.21 FV

**Summary:** Compute the future value (FV) of an investment.

**Syntax:** FV( Number Rate ; Number Nper ; Number Payment [ ; [ Number Pv = 0 ] [ ; Number PayType = 0 ] ] )

**Returns:** Currency

**Constraints:** None.

**Semantics:** Computes the future value of an investment. The parameters are:

- **Rate:** the interest rate per period.
- **Nper:** the total number of payment periods.
- **Payment:** the payment made in each period.
- **Pv:** the present value; default is 0.
- **PayType:** the type of payment, defaults to 0. It is 0 if payments are due at the end of the period; 1 if they are due at the beginning of the period.
See PV 8.12.42 for the equation this solves.

See also PV 8.12.42, NPER 8.12.30, PMT 8.12.37, RATE 8.12.43

### 8.12.22 FVSCHEDULE

**Summary:** Returns the accumulated value given starting capital and a series of interest rates.

**Syntax:** FVSCHEDULE( `Number Principal ; NumberSequence Schedule` )

**Returns:** Currency

**Constraints:** None.

**Semantics:** Returns the accumulated value given starting capital and a series of interest rates, as follows:

\[
Principle \cdot \prod_{i=1}^{N} \left(1 + Schedule[i]\right)
\]

See also PV 8.12.42, NPER 8.12.30, PMT 8.12.37, RATE 8.12.43

### 8.12.23 INTRATE

**Summary:** Computes the interest rate of a fully vested security.

**Syntax:** INTRATE( `Date Settlement ; Date Maturity ; Number Investment ; Number Redemption ; Basis Basis = 0` )

**Returns:** Number

**Constraints:** Settlement < Maturity

**Semantics:** Calculates the annual interest rate that results when an item is purchased at the investment price and sold at the redemption price. No interest is paid on the investment. The parameters are:

- **Settlement:** the date of purchase of the security.
- **Maturity:** the date on which the security is sold.
- **Investment:** the purchase price.
- **Redemption:** the selling price.

**Basis** indicates the day-count convention to use in the calculation. 4.11.7-optional indicates the day-count basis to use; see section 4.11.7.

The return value for this function is:

\[
INTRATE = \frac{Redemption - Investment}{Investment \cdot YEARFRAC(Settlement ; Maturity ; Basis)}
\]

See also RECEIVED 8.12.44, YEARFRAC 8.10.24

### 8.12.24 IPMT

**Summary:** Returns the amount of an annuity payment going towards interest.
**Syntax:** IPMT( *Number Rate* ; *Number Period* ; *Number Nper* ; *Number PV* [ ; *Number FV* = 0 [ ; *Number Type* = 0 ] ] )

**Returns:** Currency

**Constraints:** None.

**Semantics:** Computes the interest portion of an amortized payment for a constant interest rate and regular payments. The interest payment is the interest rate multiplied by the balance at the beginning of the period. The parameters are:

- **Rate:** The periodic interest rate.
- **Period:** The period for which the interest payment is computed.
- **Nper:** The total number of periods for which the payments are made.
- **PV:** The present value (e.g., the initial loan amount).
- **FV:** The future value (optional) at the end of the periods. Zero if omitted.
- **Type:** The due date for the payments (optional). Zero if omitted. If type is 1, then payments are made at the beginning of each period. If type is 0, then payments are made at the end of each period.

**See also** PPMT 8.12.38, PMT 8.12.37

### 8.12.25 IRR

**Summary:** Compute the internal rate of return for a series of cash flows.

**Syntax:** IRR( *NumberSequence Values* [ ; *Number Guess* = 0.1 ] )

**Returns:** Percentage

**Constraints:** None.

**Semantics:** Compute the internal rate of return for a series of cash flows.

If provided, *Guess* is an estimate of the interest rate to start the iterative computation. If omitted, the value 0.1 (10%) is assumed.

The result of IRR is the rate at which the NPV() function will return zero with the given values.

There is no closed form for IRR. Evaluators may return an approximate solution using an iterative method, in which case the *Guess* parameter may be used to initialize the iteration. If the evaluator is unable to converge on a solution given a particular *Guess*, it may return an Error.

**See also** NPV 8.12.31, RATE 8.12.43

### 8.12.26 ISPMT

**Summary:** Compute the interest payment of an amortized loan for a given period.

**Syntax:** ISPMT( *Number Rate* ; *Number Period* ; *Number Nper* ; *Number Pv* )

**Returns:** Currency

**Constraints:** None.

**Semantics:** Computes the interest payment of an amortized loan for a given period. The parameters are:
● Rate: the interest rate per period.
● Period: the period for which the interest is computed
● Nper: the total number of payment periods.
● Pv: the amount of the investment

See also PV 8.12.42, FV 8.12.21, NPER 8.12.30, PMT 8.12.37, RATE 8.12.43

8.12.27 MDURATION

Summary: Returns the modified Macaulay duration of a fixed interest security in years

Syntax: MDURATION( Date Settlement ; Date Maturity ; Number Coupon ; Number Yield ; Number Frequency ; Basis Basis = 0 )

Returns: Number

Constraints: Yield >= 0, Coupon >= 0, Settlement <= Maturity; Frequency = 1, 2, 4

Semantics: Computes the modified Macaulay duration, given:

● Settlement the date of purchase of the security
● Maturity the date when the security matures
● Coupon the annual nominal rate of interest
● Yield the annual yield of the security
● Frequency number of interest payments per year
● Basis Basis indicates the day-count convention to use in the calculation. Date calculation basis; see section 4.11.7

The modified duration is computed as follows:

\[
duration = DURATION ( \text{Settlement} , \text{Maturity} , \text{Coupon} , \text{Yield} , \text{Frequency} , \text{Basis} )
\]

\[
MDURATION = \frac{duration}{1 + \left( \frac{\text{Yield}}{\text{Frequency}} \right)}
\]

See also DURATION 8.12.19

8.12.28 MIRR

Summary: Returns the modified internal rate of return (IRR) of a series of periodic investments

Syntax: MIRR( Array Values ; Number Investment ; Number ReinvestRate )

Returns: Percentage

Constraints: Values shall contain at least one positive value and at least one negative value.

Semantics: Values is a series of periodic income (positive values) and payments (negative values) at regular intervals (Text and Empty cells are ignored). Investment is the rate of interest of the payments (negative values); ReinvestRate is the rate of interest of the reinvestment (positive values).
Computes the modified internal rate of return, which is:

\[
\frac{\left(-\text{NPV}(\text{ReinvestRate, Values} > 0)*\left(1 + \text{ReinvestRate}\right)^n\right)}{\text{NPV}(\text{Investment, Values} < 0)*\left(1 + \text{Investment}\right)}\left(\frac{1}{n-1}\right) - 1
\]

where \(N\) is the number of incomes and payments in Values (total).

See also IRR 8.12.25

8.12.29 NOMINAL

Summary: Compute the annual nominal interest rate.

Syntax: NOMINAL( Number EffectiveRate ; Integer CompoundingPeriods )

Returns: Number

Constraints: EffectiveRate > 0, CompoundingPeriods > 0

Semantics: Returns the annual nominal interest rate based on the effective rate and the number of compounding periods in one year. The parameters are:

- EffectiveRate: effective rate
- CompoundingPeriods: the compounding periods per year

Suppose that \(P\) is the present value, \(m\) is the compounding periods per year, the future value after one year is

\[
P\left(1 + \frac{\text{NOMINAL}}{m}\right)^m
\]

The mapping between nominal rate and effective rate is

\[
\text{EFFECT} = \left(1 + \frac{\text{NOMINAL}}{m}\right)^m - 1
\]

See also EFFECT 8.12.20

8.12.30 NPER

Summary: Compute the number of payment periods for an investment.

Syntax: NPER( Number Rate ; Number Payment ; Number Pv [ ; [ Number Fv ] [ ; Number PayType ] ] )

Returns: Number

Constraints: None.

Semantics: Computes the number of payment periods for an investment. The parameters are:

- Rate: the constant interest rate.
- Payment: the payment made in each period.
- Pv: the present value of the investment.
- Fv: the future value; default is 0.
● PayType: the type of payment, defaults to 0. It is 0 if payments are due at the end of the period; 1 if they are due at the beginning of the period.

If Rate is 0, then NPER solves this equation:

\[ PV = -Fv - (Payment \times NPER) \]

If Rate is non-zero, then NPER solves this equation:

\[ 0 = PV \times (1 + Rate)^{NPER} + \frac{Payment \times (1 + Rate \times PaymentType) \times ((1 + Rate)^{NPER} - 1)}{Rate} + Fv \]

Evaluators claiming to support the "Medium" or "Large" set shall support negative rates; evaluators only claiming to support the "Small" set need not.

See also FV 8.12.21, RATE 8.12.43, PMT 8.12.37, PV 8.12.42

8.12.31 NPV

Summary: Compute the net present value (NPV) for a series of periodic cash flows.

Syntax: NPV( Number Rate ; { NumberSequenceList Value } )

Returns: Currency

Constraints: None.

Semantics: Computes the net present value for a series of periodic cash flows with the discount rate Rate. Values should be positive if they are received as income, and negative if the amounts are paid as outgo. Because the result is affected by the order of values, evaluators shall evaluate arguments in the order given and range reference and array arguments row-wise starting from top left.

If n is the number of values in the Values, the formula for NPV is:

\[ NPV = \sum_{i=1}^{N} \frac{Values_i}{(1 + Rate)^i} \]


8.12.32 ODDFPRICE

Summary: Compute the value of a security per 100 currency units of face value. The security has an irregular first interest date.

Syntax: ODDFPRICE( DateParam Settlement ; DateParam Maturity ; DateParam Issue ; DateParam First ; Number Rate ; Number Yield ; Number Redemption ; Number Frequency [ ; Basis Basis = 0 ] )

Returns: Number

Constraints: Rate, Yield, and Redemption should be greater than 0.

Semantics: The parameters are

● Settlement: the settlement/purchase date of the security

● Maturity: the maturity/expire date of the security
8.12.34 ODDLPRICE

Summary: Compute the value of a security per 100 currency units of face value. The security has an irregular last interest date.

Syntax: ODDLPRICE( DateParam Settlement ; DateParam Maturity ; DateParam Issue ; DateParam First ; Number Rate ; Number Price ; Number Redemption ; Number Frequency [ ; Basis Basis = 0 ] )

Returns: Number

Constraints: Rate, Price, and Redemption should be greater than 0. Maturity > First > Settlement > Issue.

Semantics: The parameters are

- Settlement: the settlement/purchase date of the security
- Maturity: the maturity/expire date of the security
- Issue: the issue date of the security
- First: the first coupon date of the security
- Rate: the interest rate of the security
- Price: the price of the security
- Redemption: the redemption value per 100 currency units face value
- Frequency: the number of interest payments per year. 1=annual; 2=semiannual; 3=half-yearly; 4=quarterly.
- Basis: indicates the day-count convention to use in the calculation. 4.11.7-the type which indicates how the year is to be calculated by days; see section 4.11.7.

See also ODDLPRICE 8.12.35, ODDFYIELD 8.12.33

8.12.33 ODDFYIELD

Summary: Compute the yield of a security per 100 currency units of face value. The security has an irregular first interest date.

Syntax: ODDFYIELD( DateParam Settlement ; DateParam Maturity ; DateParam Issue ; DateParam First ; Number Rate ; Number Price ; Number Redemption ; Number Frequency [ ; Basis Basis = 0 ] )

Returns: Number

Constraints: Rate, Price, and Redemption should be greater than 0. Maturity > First > Settlement > Issue.

Semantics: The parameters are

- Settlement: the settlement/purchase date of the security
- Maturity: the maturity/expire date of the security
- Issue: the issue date of the security
- First: the first coupon date of the security
- Rate: the interest rate of the security
- Price: the price of the security
- Redemption: the redemption value per 100 currency units face value
- Frequency: the number of interest payments per year. 1=annual; 2=semiannual; 3=half-yearly; 4=quarterly.
- Basis: indicates the day-count convention to use in the calculation. 4.11.7-the type which indicates how the year is to be calculated by days; see section 4.11.7.

See also ODDLYIELD 8.12.35, ODDFPRICE 8.12.32
**Syntax:** ODDLPRICE( DateParam Settlement ; DateParam Maturity ; DateParam Last ; Number Rate ; Number AnnualYield ; Number Redemption ; Number Frequency [ ; Basis Basis = 0 ] )

**Returns:** Number

**Constraints:** Rate, AnnualYield, and Redemption should be greater than 0. The Maturity date should be greater than the Settlement date, and the Settlement should be greater than the last interest date.

**Semantics:** The parameters are

- Settlement: the settlement/purchase date of the security
- Maturity: the maturity/expire date of the security
- Last: the last interest date of the security
- Rate: the interest rate of the security
- AnnualYield: the annual yield of the security
- Redemption: the redemption value per 100 currency units face value
- Frequency: the number of interest payments per year. 1=annual; 2=semiannual/half-yearly; 4=quarterly
- Basis: indicates the day-count convention to use in the calculation, the type which indicates how the year is to be calculated by days; see section 4.11.7.

**See also** ODDFPRICE 8.12.32

### 8.12.35 ODDLYIELD

**Summary:** Compute the yield of a security which has an irregular last interest date.

**Syntax:** ODDLYIELD( DateParam Settlement ; DateParam Maturity ; DateParam Last ; Number Rate ; Number Price ; Number Redemption ; Number Frequency [ ; Basis Basis = 0 ] )

**Returns:** Number

**Constraints:** Rate, Price, and Redemption should be greater than 0.

**Semantics:** The parameters are

- Settlement: the settlement/purchase date of the security
- Maturity: the maturity/expire date of the security
- Last: the last interest date of the security
- Rate: the interest rate of the security
- Price: the price of the security
- Redemption: the redemption value per 100 currency units face value
- Frequency: the number of interest payments per year. 1=annual; 2=semiannual/half-yearly; 4=quarterly.
- Basis: indicates the day-count convention to use in the calculation, the type which indicates how the year is to be calculated by days; see section 4.11.7.

**See also** ODDLPRICE 8.12.34 , ODDFYIELD 8.12.33
8.12.36 PDURATION

Summary: Returns the number of periods required by an investment to realize a specified value.

Syntax: PDURATION( Number rate ; Number currentValue ; Number specifiedValue )

Returns: Number

Constraints: rate > 0; currentValue > 0; specifiedValue > 0

Semantics: Calculates the number of periods for attaining a certain value specifiedValue, starting from currentValue and using the interest rate rate.

- rate: The interest rate per period.
- currentValue: The current value of the investment.
- specifiedValue: The value, that should be reached.

\[
PDURATION = \frac{\log(specifiedValue) - \log(currentValue)}{\log(rate + 1)}
\]

See also DURATION 8.12.19

8.12.37 PMT

Summary: Compute the payment made each period for an investment.

Syntax: PMT( Number Rate ; Integer Nper ; Number Pv [ ; [ Number Fv = 0 ] [ ; Number PayType = 0 ] ] )

Returns: Currency

Constraints: Nper > 0

Semantics: Computes the payment made each period for an investment. The parameters are:

- Rate: the interest rate per period.
- Nper: the total number of payment periods.
- Pv: the present value of the investment.
- Fv: the future value of the investment; default is 0.
- PayType: the type of payment, defaults to 0. It is 0 if payments are due at the end of the period; 1 if they are due at the beginning of the period. With PayType=1 the first payment is made on the same day the loan is taken out.

If Rate is 0, the following equation is solved:

\[
Pv = -Fv - (PMT \cdot Nper)
\]

If Rate is nonzero, then PMT solves this equation:

\[
0 = Pv \cdot (1 + Rate)^{Nper} + \frac{PMT \cdot (1 + Rate \cdot PayType) \cdot ((1 + Rate)^{Nper} - 1)}{Rate} + Fv
\]

See also FV 8.12.21, NPER 8.12.30, PV 8.12.42, RATE 8.12.43
8.12.38 PPMT

**Summary:** Calculate the payment for a given period on the principal for an investment at a given interest rate and constant payments.

**Syntax:** `PPMT(Number Rate ; Integer Period ; Integer nPer ; Number Present [ ; Number Future = 0 ] [ ; Number Type = 0 ] )`

**Returns:** `Number`

**Constraints:** Rate and Present should be greater than 0. 0<Period <nPer.

**Semantics:** The parameters are

- Rate: the interest rate
- Period: the given period that the payment returned is for
- nPer: the total number of periods
- Present: the present value
- Future: optional, the future value specified after nPer periods. The default value is 0.
- Type: optional, 0 or 1, respectively for payment at the end or at the beginning of a period. The default value is 0.

See also PMT 8.12.37

8.12.39 PRICE

**Summary:** Calculates a quoted price for an interest paying security, per 100 currency units of face value.

**Syntax:** `PRICE(DateParam Settlement ; DateParam Maturity ; Number Rate ; Number AnnualYield ; Number Redemption ; Number Frequency [ ; Basis Basis = 0 ] )`

**Returns:** `Number`

**Constraints:** Rate, AnnualYield, and Redemption should be greater than 0; Frequency = 1, 2 or 4.

**Semantics:** If A is the number of days from the Settlement date to next coupon date, B is the number of days of the coupon period that the Settlement is in, C is the number of coupons between Settlement date and Redemption date, D is the number of days from beginning of coupon period to Settlement date, then PRICE is calculated as

\[
PRICE = \frac{Redemption \times YIELD^{C-\frac{A}{B}}}{(1+YIELD^{\frac{D}{B}})} + \sum_{k=1}^{C} \frac{100 \times Rate \times Freqency^{k-\frac{A}{B}} - 100 \times Rate \times Freqency^{k-\frac{A}{B}} \times D}{B}
\]

The parameters are

- Settlement: the settlement/purchase date of the security
- Maturity: the maturity/expire date of the security
- Rate: the interest rate of the security
• AnnualYield: a measure of the annual yield of a security (compounded at each interest payment)
• Redemption: the redemption value per 100 currency units face value
• Frequency: the number of interest payments per year. 1=annual; 2=semiannual/half-yearly; 4=quarterly.
• Basis: indicates the day-count convention to use in the calculation, see section 4.11.7.

See also PRICEDISC 8.12.40, PRICEMAT 8.12.41

8.12.40 PRICEDISC

Summary: Calculate the price of a security with a discount per 100 currency units of face value.

Syntax: PRICEDISC( DateParam Settlement ; DateParam Maturity ; Number Discount ; Number Redemption [ ; Basis Basis = 0 ] )

Returns: Number

Constraints: Discount and Redemption should be greater than 0.

Semantics: The parameters are
• Settlement: the settlement/purchase date of the security
• Maturity: the maturity/expire date of the security
• Discount: the discount rate of the security
• Redemption: the redemption value per 100 currency units face value
• Basis: indicates the day-count convention to use in the calculation, see section 4.11.7.

See also PRICE 8.12.39, PRICEMAT 8.12.41, YIELDDISC 8.12.55

8.12.41 PRICEMAT

Summary: Calculate the price per 100 currency units of face value of the security that pays interest on the maturity date.

Syntax: PRICEMAT( DateParam Settlement ; DateParam Maturity ; DateParam Issue ; Number Rate ; Number AnnualYield [ ; Basis Basis = 0 ] )

Returns: Number

Constraints: Settlement < Maturity, Rate >= 0, AnnualYield >= 0

Semantics: The parameters are
• Settlement: the settlement/purchase date of the security
• Maturity: the maturity/expire date of the security
• Issue: the issue date of the security
• Rate: the interest rate of the security
• AnnualYield: the annual yield of the security
If both, *Rate* and *AnnualYield*, are 0, the return value is 100.

**See also** PRICEDISC 8.12.40, PRICEMAT 8.12.41

### 8.12.42 PV

**Summary:** Compute the present value (PV) of an investment.

**Syntax:** `PV( Number Rate ; Number Nper ; Number Payment [ ; [ Number Fv = 0 ] [ ; Number PayType = 0 ] ] )`

**Returns:** Currency

**Constraints:** None.

**Semantics:** Computes the present value of an investment. The parameters are:

- **Rate:** the interest rate per period.
- **Nper:** the total number of payment periods.
- **Payment:** the payment made in each period.
- **Fv:** the future value; default is 0.
- **PayType:** the type of payment, defaults to 0. It is 0 if payments are due at the end of the period; 1 if they are due at the beginning of the period.

If *Rate* is 0, then:

\[
PV = - Fv - (Payment \times Nper)
\]

If *Rate* is nonzero, then PV solves this equation:

\[
0 = PV \times (1 + Rate)^{Nper} + \frac{Payment \times (1 + Rate \times PayType) \times ((1 + Rate)^{Nper} - 1)}{Rate} + Fv
\]

**See also** FV 8.12.21, NPER 8.12.30, PMT 8.12.37, RATE 8.12.43

### 8.12.43 RATE

**Summary:** Compute the interest rate per period of an investment.

**Syntax:** `RATE( Number Nper ; Number Payment ; Number Pv [ ; [ Number Fv = 0 ] [ ; [ Number PayType = 0 ] [ ; Number Guess = 0.1 ] ] ] )`

**Returns:** Percentage

**Constraints:** If *Nper* is 0 or less than 0, the result is an Error.

**Semantics:** Computes the interest rate of an investment. The parameters are:

- **Nper:** the total number of payment periods.
- **Payment:** the payment made in each period.
- **Pv:** the present value of the investment.
- Fv: the future value; default is 0.
- PayType: the type of payment, defaults to 0. It is 0 if payments are due at the end of the period; 1 if they are due at the beginning of the period.
- Guess: An estimate of the interest rate to start the iterative computation. If omitted, 0.1 (10%) is assumed.

Rate solves this equation:

\[
0 = Fv + Pv \cdot (1 + Rate)^{Nper} + \frac{Payment \cdot (1 + Rate \cdot PayType) \cdot (1 + Rate)^{Nper} - 1}{Rate}
\]

See also: FV 8.12.21, NPER 8.12.30, PMT 8.12.37, PV 8.12.42

8.12.44 RECEIVED

Summary: Calculates the amount received at maturity for a zero coupon bond.

Syntax: RECEIVED( DateParam Settlement ; DateParam Maturity ; Number Investment ; Number Discount [ ; Basis Basis = 0 ] )

Returns: Number

Constraints: Investment and Discount should be greater than 0.

Semantics:
The parameters are
- Settlement: the settlement/purchase date of the security
- Maturity: the maturity/expire date of the security
- Investment: the amount of investment in the security
- Discount: the discount rate of the security
- Basis: indicates the day-count convention to use in the calculation; the day-count basis used in this calculation; see section 4.11.7

The return value is:

\[
RECEIVED = \frac{Investment}{1 - Discount \cdot YEARFRAC( Settlemen \ ; \ Maturity \ ; \ Basis )}
\]

See also: YEARFRAC 8.10.24

8.12.45 RRI

Summary: Returns an equivalent interest rate when an investment increases in value.

Syntax: RRI( Number N ; Number Pv ; Number Fv )

Returns: Percentage

Constraints: N > 0
Semantics: Returns the interest rate given $N$ (the number of periods), $Pv$ (present value), and $Fv$ (future value), calculated as follows:

$$\left( \frac{Fv}{Pv} \right)^{\frac{1}{N}} - 1$$

See also FV 8.12.21, NPER 8.12.30, PMT 8.12.37, PV 8.12.42, RATE 8.12.43

8.12.46 SLN

Summary: Compute the amount of depreciation at a given period of time using the straight-line depreciation method.

Syntax: DDB( Number Cost ; Number Salvage ; Number LifeTime )

Returns: Currency

Constraints: None.

Semantics: Compute the amount of depreciation of an asset at a given period of time using straight-line depreciation. The parameters are:

- Cost: the total amount paid for the asset.
- Salvage: the salvage value at the end of the LifeTime (often 0)
- LifeTime: the number of periods that the depreciation will occur over. A positive integer.

For alternative methods to compute depreciation, see DDB 8.12.15.

See also DDB 8.12.15

8.12.47 SYD

Summary: Compute the amount of depreciation at a given period of time using the Sum-of-the-Years'-Digits method.

Syntax: SYD( Number Cost ; Number Salvage ; Number LifeTime ; Number Period )

Returns: Currency

Constraints: None.

Semantics: Compute the amount of depreciation of an asset at a given period of time using the Sum-of-the-Years'-Digits method. The parameters are:

- Cost: the total amount paid for the asset.
- Salvage: the salvage value at the end of the LifeTime (often 0)
- LifeTime: the number of periods that the depreciation will occur over. A positive integer.
- Period: the period for which the depreciation value is specified.

$$SYD=\frac{(Cost-Salvage)\cdot(LifeTime+1-Period)\cdot2}{(LifeTime+1)\cdotLifeTime}$$

For other methods of computing depreciation, see DDB 8.12.15.

See also SLN 8.12.46, DDB 8.12.15
8.12.48 TBILLEQ

Summary: Compute the bond-equivalent yield for a treasury bill.

Syntax: TBILLEQ( DateParam Settlement ; DateParam Maturity ; Number Discount )

Returns: Number

Constraints: The maturity date should be less than one year beyond settlement date. Discount is any positive value.

Semantics: The parameters are defined as,
- Settlement: the settlement/purchase date of the treasury bill
- Maturity: the maturity/expire date of the treasury bill
- Discount: the discount rate of the treasury bill

TBILLEQ is calculated as

\[ TBILLEQ = \frac{365 \cdot rate}{360 - (rate \cdot DSM)} \]

where DSM is the number of days between settlement and maturity computed according to the 360 days per year basis (basis 2, 4.11.7)

See also TBILLPRICE 8.12.49, TBILLYIELD 8.12.50

8.12.49 TBILLPRICE

Summary: Compute the price per 100 face value for a treasury bill.

Syntax: TBILLPRICE( DateParam Settlement ; DateParam Maturity ; Number Discount )

Returns: Number

Constraints: The maturity date should be less than one year beyond settlement. Discount is any positive value.

Semantics: The parameters are:
- Settlement: the settlement/purchase date of the treasury bill
- Maturity: the maturity/expire date of the treasury bill
- Discount: the discount rate of the treasury bill

See also TBILLEQ 8.12.48, TBILLYIELD 8.12.50

8.12.50 TBILLYIELD

Summary: Compute the yield for a treasury bill.

Syntax: TBILLYIELD( DateParam Settlement ; DateParam Maturity ; Number Price )

Returns: Number

Constraints: The maturity date should be less than one year beyond settlement. Price is any positive value.

Semantics: The parameters are:
● Settlement: the settlement/purchase date of the treasury bill
● Maturity: the maturity/expire date of the treasury bill
● Price: the price of the treasury bill per 100 face value

See also TBILLEQ 8.12.48, TBILLPRICE 8.12.49

8.12.51 VDB

Summary: Calculates the depreciation allowance of an asset with an initial value, an expected useful life, and a final value of salvage for a period specified, using the variable-rate declining balance method.

Syntax: VDB( Number cost ; Number salvage ; Number lifeTime ; Number startPeriod ; Number endPeriod [ ; Number depreciationFactor = 2 [ ; Logical noSwitch = FALSE() ] ] )

Returns: Number

Constraints: salvage < cost, lifeTime > 0, 0 ≤ startPeriod ≤ lifeTime, startPeriod ≤ endPeriod ≤ lifeTime, depreciationFactor ≥ 0

Semantics: cost is the amount paid for the asset. cost can be any value greater than salvage.

salvage is the value of the asset at the end of its life. salvage can be any value.

lifeTime is the number of periods the asset takes to depreciate to its salvage value. lifeTime can be any value greater than 0.

startPeriod is the point in the asset's life when you want to begin calculating depreciation. startPeriod can be any value greater than or equal to 0, but cannot be greater than lifeTime.

endPeriod is the point in the asset's life when you want to stop calculating depreciation. end-Period can be any value greater than startPeriod.

startPeriod and endPeriod correspond to the asset's life, relative to the fiscal period. For example, if you want to find the first year's depreciation of an asset purchased at the beginning of the second quarter of a fiscal year, start-period would be 0 and end-period would be 0.75 (1 minus 0.25 of a year).

VDB allows for the use of an initialPeriod option to calculate depreciation for the period the asset is placed in service. VDB uses the fractional part of startPeriod and endPeriod to determine the initialPeriod option. If both startPeriod and endPeriod have fractional parts, then VDB uses the fractional part of startPeriod.

depreciationFactor is an optional argument that specifies the percentage of straight-line depreciation you want to use as the depreciation rate. If you omit this argument, VDB uses 2, which is the double-declining balance rate. depreciation-factor can be any value greater than or equal to 0; commonly used rates are 1.25, 1.50, 1.75, and 2.

noSwitch is an optional argument that you include if you do not want VDB to switch to straight-line depreciation for the remaining useful life. Normally, declining-balance switches to such a straight-line calculation when it is greater than the declining-balance calculation.

If noSwitch is FALSE() or omitted, VDB automatically switches to straight-line depreciation when that is greater than declining-balance depreciation. If noSwitch is TRUE(), VDB never switches to straight-line depreciation.

See also DDB 8.12.15, SLN 8.12.46
8.12.52 XIRR

Summary: Compute the internal rate of return for a non-periodic series of cash flows.

Syntax: XIRR( NumberSequence Values ; DateSequence Dates [ ; Number Guess = 0.1 ] )

Returns: Number

Constraints: The size of Values and Dates are equal. Values contains at least one positive and one negative cash flow.

Semantics: Compute the internal rate of return for a series of cash flows which is not necessarily periodic. The parameters are

- Values: a series of cash flows. The first cash-flow amount is a negative number that represents the investment. The later cash flows are discounted based on the annual discount rate and the timing of the flow. The series of cash flow should contain at least one positive and one negative value.
- Dates: a series of dates that corresponds to values. The first date indicates the start of the cash flows. The range of Values and Dates shall be the same size.
- Guess: If provided, Guess is an estimate of the interest rate to start the iterative computation. If omitted, the value 0.1 (10%) is assumed. The result of XIRR is the rate at which the XNPV() function will return zero with the given cash flows. There is no closed form for XIRR. Implementations may return an approximate solution using an iterative method, in which case the Guess parameter may be used to initialize the iteration. If the implementation is unable to converge on a solution given a particular Guess, it may return an error.

See also IRR 8.12.25

8.12.53 XNPV

Summary: Compute the net present value of a series of cash flows.

Syntax: XNPV( Number Rate ; Reference|Array Values ; Reference| Array Dates )

Returns: Number

Constraints:

Number of elements in Values equals number of elements in Dates.

All elements of Values are of type Number.

All elements of Dates are of type Number.

All elements of Dates >= Dates[1]

Semantics: Compute the net present value for a series of cash flows which is not necessarily periodic. The parameters are

- Rate: discount rate. The value should be greater than -1.
- Values: a series of cash flows. The first cash-flow amount is a negative number that represents the investment. The later cash flows are discounted based on the annual discount rate and the timing of the flow. The series of cash flow should contain at least one positive and one negative value.
Dates: a series of dates that corresponds to values. The first date indicates the start of the cash flows. If the dimensions of the Values and Dates arrays differ, evaluators shall match value and date pairs row-wise starting from top left.

With N being the number of elements in Values and Dates each, the formula is:

\[
XNPV = \sum_{i=1}^{N} \frac{Values_i}{(1+Rate)^{(Dates_i-Dates_1)/365}}
\]

See also NPV 8.12.31

8.12.54 YIELD

Summary: Calculate the yield of a bond.

Syntax: YIELD( DateParam Settlement ; DateParam Maturity ; Number Rate ; Number Price ; Number Redemption ; Number Frequency [ ; Basis Basis = 0 ] )

Returns: Number

Constraints: Rate, Price, and Redemption should be greater than 0.

Semantics: The parameters are

- Settlement: the settlement/purchase date of the bond
- Maturity: the maturity/expire date of the bond
- Rate: the interest rate of the bond
- Price: the price of the bond per 100 currency units face value
- Redemption: the redemption value of the bond per 100 currency units face value
- Frequency: the number of interest payments per year. 1=annual; 2=semiannual; 4=quarterly
- Basis: indicates the day-count convention to use in the calculation, see section 4.11.7.

See also PRICE 8.12.39, YIELDDISC 8.12.55, YIELDMAT 8.12.56

8.12.55 YIELDDISC

Summary: Calculate the yield of a discounted security per 100 currency units of face value.

Syntax: YIELDDISC( DateParam Settlement ; DateParam Maturity ; Number Price ; Number Redemption [ ; Basis Basis = 0 ] )

Returns: Number

Constraints: Price and Redemption should be greater than 0.

Semantics: The parameters are

- Settlement: the settlement/purchase date of the security
- Maturity: the maturity/expire date of the security
- Price: the price of the security per 100 currency units face value
- Redemption: the redemption value of the security per 100 currency units face value
- Basis: indicates the day-count convention to use in the calculation, see section 4.11.7.
Redemption: the redemption value per 100 currency units face value

Basis: indicates the day-count convention to use in the calculation, the day-count basis for this calculation; see section 4.11.7

The return value is

\[
YIELDDISC = \frac{\text{Redemption}}{\text{Price}} - 1 \quad \text{YEARFRAC}(\text{Settlement}; \text{Maturity}; \text{Basis})
\]

See also PRICEDISC 8.12.40, YEARFRAC 8.10.24

8.12.56 YIELDMAT

Summary: Calculate the yield of the security that pays interest on the maturity date.

Syntax: YIELDMAT( DateParam Settlement ; DateParam Maturity ; DateParam Issue ; Number Rate ; Number Price [ ; Basis Basis = 0 ] )

Returns: Number

Constraints: Rate and Price should be greater than 0.

Semantics: The parameters are

- Settlement: the settlement/purchase date of the security
- Maturity: the maturity/expire date of the security
- Issue: the issue date of the security
- Rate: the interest rate of the security
- Price: the price of the security per 100 currency units face value

Basis: indicates the day-count convention to use in the calculation, the type which indicates how the year is to be calculated by days; see section 4.11.7

See also PRICE 8.12.39, YIELD 8.12.54, YIELDDISC 8.12.55

8.13 Information Functions

8.13.1 General

Information functions provide information about a data value, the spreadsheet, or underlying environment, including special functions for converting between data types.

8.13.2 AREAS

Summary: Returns the number of areas in a given reference

Syntax: AREAS( ReferenceList R )

Returns: Number

Constraints: None
**Semantics:** Returns the number of areas in the reference list.

**See also** Infix Operator Reference Concatenation 8.4.13, INDEX 8.14.6

### 8.13.3 CELL

**Summary:** Returns information about position, formatting or contents in a reference.

**Syntax:** CELL( Text Info_Type [ ; Reference R ] )

**Returns:** Information about position, formatting properties or content

**Constraints:** None

**Semantics:** The parameters are

- *Info_Type*: the text string which specifies the type of information. Please refer to the following table.

<table>
<thead>
<tr>
<th>Info_Type</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>COL</td>
<td>Returns the column number of the cell.</td>
</tr>
<tr>
<td>ROW</td>
<td>Returns the row number of the cell.</td>
</tr>
<tr>
<td>SHEET</td>
<td>Returns the sheet number of the cell.</td>
</tr>
<tr>
<td>ADDRESS</td>
<td>Returns the absolute address of the cell. The sheet name is included if given in the reference. For an external reference a <em>Source</em> as specified in the syntax rules for References 7.8 is included.</td>
</tr>
<tr>
<td>FILENAME</td>
<td>Returns the file name of the file that contains the cell as an IRI. If the file is newly created and has not yet been saved, the file name is empty text &quot;&quot;.</td>
</tr>
<tr>
<td>CONTENTS</td>
<td>Returns the contents of the cell, without formatting properties.</td>
</tr>
<tr>
<td>COLOR</td>
<td>Returns 1 if color formatting is set for negative value in this cell; otherwise returns 0</td>
</tr>
</tbody>
</table>
| FORMAT | Returns a text string which shows the number format of the cell.  
|        | ,(comma) = number with thousands separator  
|        | F = number without thousands separator  
|        | C = currency format  
|        | S = exponential representation  
|        | P = percentage  
|        | To indicate the number of decimal places after the decimal separator, a number is given right after the above characters.  
|        | D1 = MMM-D-YY, MM-D-YY and similar formats  
|        | D2 = DD-MM  
|        | D3 = MM-YY  
|        | D4 = DD-MM-YYYY HH:MM:SS  
|        | D5 = MM-DD  
|        | D6 = HH:MM:SS AM/PM  
|        | D7 = HH:MM AM/PM  
|        | D8 = HH:MM:SS  
|        | D9 = HH:MM  
|        | G = All other formats  
|        | - (Minus) at the end = negative numbers in the cell have color setting  
|        | () (brackets) at the end = this cell has the format settings with parentheses for positive or all values |
| TYPE | Returns the text value corresponding to the type of content in the cell:  
|      | "b" : blank or empty cell content  
|      | "l" : label or text cell content  
|      | "v" : number value cell content |
| WIDTH | Returns the column width of the cell.  
|       | The unit is the width of one zero (0) character in default font size. |
| PROTECT | Returns the protection status of the cell:  
|        | 1 = cell is protected  
|        | 0 = cell is unprotected |
| PARENTHESES | Returns 1 if the cell has the format settings with parentheses for positive or all values, otherwise returns 0 |
| PREFIX | Returns single character text strings corresponding to the alignment of the cell. |
8.13.4 COLUMN

Summary: Returns the column number(s) of a reference

Syntax: COLUMN([ Reference R ])

Returns: Number

Constraints: AREAS(R) = 1

Semantics: Returns the column number of a reference, where “A” is 1, “B” is 2, and so on. If no parameter is given, the current cell is used. If a reference has multiple columns, an array of numbers is returned with all of the columns in the reference.

See also ROW 8.13.29, SHEET 8.13.31

8.13.5 COLUMNS

Summary: Returns the number of columns in a given range

Syntax: COLUMNS( Reference|Array R )

Returns: Number

Constraints: None

Semantics: Returns the number of columns in the range or array specified. The result is not dependent on the cell content in the range.

See also ROWS 8.13.30

8.13.6 COUNT

Summary: Count the number of Numbers provided

Syntax: COUNT( { NumberSequenceList N }+ )

Returns: Number

Constraints: One or more parameters.

Semantics: Counts the numbers in the list of NumberSequences provided. Only numbers in references are counted; all other types are ignored. Errors are not propagated. It is implementation-defined what happens if 0 parameters are passed, but it should be an Error or 0.

See also COUNTA 8.13.7
8.13.7 COUNTA

Summary: Count the number of non-empty values

Syntax: COUNTA( { Any A } )

Returns: Number

Constraints: None.

Semantics: Counts the number of non-blank values in the list of Any sequences provided. A value is non-blank if it contains any content of any type, including an Error. In a reference, every cell that is not empty is included in the count. An empty string value (""") is not considered blank. Errors contained in a range are considered a non-blank value for purposes of the count; errors do not propagate. Constant expressions or formulas are allowed; these are evaluated and if they produce an Error value the Error value is counted as one non-blank value (and not propagated as an Error). It is implementation-defined what happens if 0 parameters are passed, but it should be an Error or 0. Any A may be a ReferenceList.

See also COUNT 8.13.6, ISBLANK 8.13.14

8.13.8 COUNTBLANK

Summary: Count the number of blank values

Syntax: COUNTBLANK( ReferenceList R )

Returns: Number

Constraints: None.

Semantics: Counts the number of blank cells in the Reference provided. A cell is blank if the cell is empty for purposes of COUNTBLANK. If ISBLANK(R) is true, then it is blank. A cell with numeric value zero ('0') is not blank. It is implementation-defined whether or not a cell returning the empty string ('"") is considered blank; because of this, there is a (potential) subtle difference between COUNTBLANK and ISBLANK.

Evaluators shall support one Reference as a parameter and may support a ReferenceList as a parameter.

See also COUNT 8.13.6, COUNTA 8.13.7, COUNTIF 8.13.9, ISBLANK 8.13.14

8.13.9 COUNTIF

Summary: Count the number of cells in a range that meet a criteria.

Syntax: COUNTIF( ReferenceList R ; Criterion C )

Returns: Number

Constraints: Does not accept constant values as the reference parameter.

Semantics: Counts the number of cells in the reference range R that meet the Criterion C (4.11.7.8).

The values returned may vary depending upon the HOST-USE-REGULAR-EXPRESSIONS or HOST-USE-WILDCARDS or HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL properties. 3.5
See also COUNT 8.13.6, COUNTA 8.13.7, COUNTBLANK 8.13.8, COUNTIFS 8.13.10, SUMIF 8.16.62, Infix Operator "=" 8.4.7, Infix Operator "<>" 8.4.8, Infix Operator Ordered Comparison ("<", "<=", ">", ">=") 8.4.9

8.13.10 COUNTIFS

Summary: Count the number of cells that meet multiple criteria in multiple ranges.

Syntax: COUNTIFS( Reference R1 ; Criterion C1 [ ; Reference R2 ; Criterion C2 ]... )

Returns: Number

Constraints: Does not accept constant values as the reference parameter.

Semantics: Counts the number of cells that meet the Criterion C1 in the reference range R1 and the Criterion C2 in the reference range R2, and so on (4.11.7.8). All reference ranges shall have the same dimension and size, else an Error is returned. A logical AND is applied between each array result of each selection; an entry is counted only if the same position in each array is the result of a Criterion match.

The values returned may vary depending upon the HOST-USE-REGULAR-EXPRESSIONS or HOST-USE-WILDCARDS or HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL properties. 3.5

See also AVERAGEIFS 8.18.6, COUNT 8.13.6, COUNTA 8.13.7, COUNTBLANK 8.13.8, COUNTIF 8.13.9, SUMIF 8.16.62, SUMIFSCOUNT 8.13.6, COUNTA 8.13.7, COUNTBLANK 8.13.8, COUNTIFS 8.13.9, SUMIFS 8.16.63, Infix Operator "=" 8.4.7, Infix Operator "<>" 8.4.8, Infix Operator Ordered Comparison ("<", "="", ">", ">=") 8.4.9

8.13.11 ERROR.TYPE

Summary: Returns Number representing the specific Error type.

Syntax: ERROR.TYPE( Error E )

Returns: Number

Constraints: None.

Semantics: Returns a number representing what kind of Error has occurred. Note that unlike most functions, this function does not propagate Error values. Receiving a non-Error value returns an Error. In particular, ERROR.TYPE(NA()) returns 7, and ERROR.TYPE applied to a non-Error returns an Error.

See also NA 8.13.27

8.13.12 FORMULA

Summary: Returns formula at given reference as text

Syntax: FORMULA( Reference X )

Returns: String

Constraints: Reference X shall contain a formula

Semantics: Returns the formula in reference X as a string. The specific syntax of this returned string is implementation-defined. This function is intended to aid debugging by simplifying display of formulas in other cells. Error results of the referred formula cell are not propagated.
See also ISFORMULA 8.13.18

8.13.13 INFO

Summary: Returns information about the environment

Syntax: INFO( Text Category )

Returns: Any (see below)

Constraints: Category shall be valid

Semantics: Returns information about the environment in the given category.

Evaluators shall support at least the following categories:

<table>
<thead>
<tr>
<th>Category</th>
<th>Meaning</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;directory&quot;</td>
<td>Current directory. This shall be formatted so file names can be appended to the result (e.g., on POSIX and Windows systems it shall end with the separator &quot;/&quot; or &quot;&quot; respectively).</td>
<td>Text</td>
</tr>
<tr>
<td>&quot;memavail&quot;</td>
<td>Amount of memory “available”, in bytes. On many modern (virtual memory) systems this value is not really available, but a system should return 0 if it is known that there is no more memory available, and greater than 0 otherwise.</td>
<td>Number</td>
</tr>
<tr>
<td>&quot;memused&quot;</td>
<td>Amount of memory used, in bytes, by the data</td>
<td>Number</td>
</tr>
<tr>
<td>&quot;numfile&quot;</td>
<td>Number of active worksheets in files</td>
<td>Number</td>
</tr>
<tr>
<td>&quot;osversion&quot;</td>
<td>Operating system version</td>
<td>Text</td>
</tr>
<tr>
<td>&quot;origin&quot;</td>
<td>The top leftmost visible cell's absolute reference prefixed with &quot;$A:$. In locales where cells are ordered right-to-left, the top rightmost visible cell is used instead.</td>
<td>Text</td>
</tr>
<tr>
<td>&quot;recalc&quot;</td>
<td>Current recalculation mode. If the locale is English, this is either &quot;Automatic&quot; or &quot;Manual&quot; (the exact text depends on the locale)</td>
<td>Text</td>
</tr>
<tr>
<td>&quot;release&quot;</td>
<td>The version of the implementation.</td>
<td>Text</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>The type of the operating system.</td>
<td>Text</td>
</tr>
<tr>
<td>&quot;totmem&quot;</td>
<td>Total memory available in bytes, including the memory already used.</td>
<td>Number</td>
</tr>
</tbody>
</table>

Evaluators may support other categories.

See also CELL 8.13.3
8.13.14 ISBLANK

Summary: Return TRUE if the referenced cell is blank, else return FALSE

Syntax: ISBLANK( Scalar X )

Returns: Logical

Constraints: None

Semantics: If X is of type Number, Text, or Logical, return FALSE. If X is a reference to a cell, examine the cell; if it is blank (has no value), return TRUE, but if it has a value, return FALSE. A cell with the empty string is not considered blank.

See also ISNUMBER 8.13.22, ISTEXT 8.13.25

8.13.15 ISERR

Summary: Return True if the parameter has type Error and is not NA, else return False.

Syntax: ISERR( Scalar X )

Returns: Logical

Constraints: None

Semantics: If X is of type Error, and ISNA(X) is not true, returns TRUE. Otherwise it returns FALSE. Note that this function returns False if given NA(); if this is not desired, use ISERROR 8.13.16. Note that this function does not propagate Error values.

ISERR(X) is the same as:

IF(ISNA(X),FALSE(),ISERROR(X))

See also ERROR.TYPE 8.13.11, ISERROR 8.13.16, ISNUMBER 8.13.22, ISTEXT 8.13.25, NA 8.13.27

8.13.16 ISERROR

Summary: Return TRUE if the parameter has type Error, else return FALSE

Syntax: ISERROR( Scalar X )

Returns: Logical

Constraints: None

Semantics: If X is of type Error, returns TRUE, else returns FALSE. Note that this function returns True if given NA(); if this is not desired, use ISERR 8.13.15. Note that this function does not propagate Error values.

See also ERROR.TYPE 8.13.11, ISERR 8.13.15, ISNA 8.13.20, ISNUMBER 8.13.22, ISTEXT 8.13.25, NA 8.13.27

8.13.17 ISEVEN

Summary: Return TRUE if the value is even, else return FALSE

Syntax: ISEVEN( Number X )

Returns: Logical
Constraints: None

Semantics: First, compute $X_1 = \text{TRUNC}(X)$. Then, if $X_1$ is even (a division by 2 has a remainder of 0), return True, else return False. The result is implementation-defined if given a Logical value; an evaluator may return either an Error or the result of converting the Logical value to a Number (per Conversion to Number 8.3.5).

See also ISODD 8.13.23

8.13.18 ISFORMULA

Summary: Return TRUE if the reference refers to a formula, else return FALSE

Syntax: ISFORMULA( Reference $X$ )

Returns: Logical

Constraints: None

Semantics: If $X$ refers to a cell whose value is computed by a formula, return TRUE(), else return FALSE(). A formula itself may compute a constant; in that case it will still return TRUE() since it is still a formula. Passing a non-reference, or a reference to more than one cell, is implementation-defined.

See also ISTEIX 8.13.25, ISNUMBER 8.13.22

8.13.19 ISLOGICAL

Summary: Return TRUE if the parameter has type Logical, else return FALSE

Syntax: ISLOGICAL( Scalar $X$ )

Returns: Logical

Constraints: None

Semantics: If $X$ is of type Logical, returns TRUE, else FALSE. Evaluators that do not have a distinct Logical type will return the same value ISNUMBER($X$) would return.

See also ISTEIX 8.13.25, ISNUMBER 8.13.22

8.13.20 ISNA

Summary: Return True if the parameter is of type NA, else return False.

Syntax: ISERR( Scalar $X$ )

Returns: Logical

Constraints: None

Semantics: If $X$ is NA, return True, else return False. Note that if $X$ is a reference, the value being referenced is considered. This function does not propagate Error values.

See also ERROR.TYPE 8.13.11, ISERROR 8.13.16, ISERR 8.13.15, ISNUMBER 8.13.22, ISTEIX 8.13.25, NA 8.13.27

8.13.21 ISNONTEXT

Summary: Return TRUE if the parameter does not have type Text, else return FALSE
Syntax: ISNONTEXT( Scalar X )

Returns: Logical

Constraints: None

Semantics: If X is of type Text, ISNONTEXT returns FALSE, else TRUE. If X is a reference, it examines what X references. References to empty cells are not considered text, so for reference to an empty cell ISNONTEXT will return TRUE, returns FALSE, else TRUE. If X is a reference, examines what X references. References to empty cells are NOT considered Text, so a reference to an empty cell will return TRUE.

ISONONTEXT(X) is equivalent to NOT(ISTEXT(X))

See also ISNUMBER 8.13.22, ISLOGICAL 8.13.19, ISTEXT 8.13.25

8.13.22 ISNUMBER

Summary: Return TRUE if the parameter has type Number, else return FALSE

Syntax: ISNUMBER( Scalar X )

Returns: Logical

Constraints: None

Semantics: If X is of type Number, returns TRUE, else FALSE. Evaluators may not have a distinguished Logical type; in such evaluators, ISNUMBER(TRUE()) is TRUE.

See also ISTEXT 8.13.25, ISLOGICAL 8.13.19

8.13.23 ISODD

Summary: Return TRUE if the value is even, else return FALSE

Syntax: ISODD( Number X )

Returns: Logical

Constraints: None

Semantics: First, compute X1=TRUNC(X). Then, if X1 is odd (a division by 2 has a remainder of 1), return True, else return False. The result is implementation-defined if given a Logical value; an evaluator may return either an Error or the result of converting the Logical value to a Number (per Conversion to Number 8.3.5 ).

See also ISEVEN 8.13.17

8.13.24 ISREF

Summary: Return True if the parameter is of type reference, else return False.

Syntax: ISREF( Any X )

Returns: Logical

Constraints: None

Semantics: If X is of type Reference or ReferenceList, return True, else return False. Note that unlike nearly all other functions, when given a reference this function does not then examine the
value being referenced. Some functions and operators return references, and thus ISREF will return True when given their results. \(X\) may be a ReferenceList, in which case ISREF returns True.

See also ISNUMBER 8.13.22, ISTEXT 8.13.25

8.13.25 ISTEXT

Summary: Return TRUE if the parameter has type Text, else return FALSE. If \(X\) is a reference, examines what \(X\) references. References to empty cells are NOT considered Text, so a reference to a empty cell will return FALSE. Empty Cell 4.7

ISTEXT(\(X\)) is equivalent to NOT(ISNONTEXT(\(X\))).

Syntax:  
STEXT( Scalar \(X\) )

Returns: Logical

Constraints: None

Semantics: If \(X\) is of type Text, returns TRUE, else FALSE. References to empty cells are NOT considered Text. If \(X\) is a reference, examines what \(X\) references. References to empty cells are NOT considered Text, so a reference to a empty cell will return FALSE. Empty Cell 4.7 blank cells are NOT considered Text.

See also ISNONTEXT 8.13.21, ISNUMBER 8.13.22, ISLOGICAL 8.13.19

8.13.26 N

Summary: Return the number of a value.

Syntax: N( Any \(X\) )

Returns: Number Text

Constraints: None

Semantics: If \(X\) is a Reference, it is first dereferenced to a scalar. Then its type is examined. If it is of type Number, it is returned. If it is of type Logical, 1 is returned if TRUE else 0 is returned. It is implementation-defined what happens if it is provided a Text value.

See also T 8.20.22, VALUE 8.13.34

8.13.27 NA

Summary: Return the constant Error value #N/A.

Syntax: NA()

Returns: Error

Constraints: Shall have 0 parameters

Semantics: This function takes no arguments and returns the Error NA.

See also ERROR.TYPE 8.13.11, ISERROR 8.13.16

8.13.28 NUMBERVALUE

Summary: Convert text to number, in a locale-independent way
Syntax: NUMBERVALUE( Text X [ ; Text DecimalSeparator [ ; Text GroupSeparator ] ] )

Returns: Number

Constraints: LEN(DecimalSeparator) = 1, DecimalSeparator shall not appear in GroupSeparator

Semantics: Converts given Text value X into Number. If X is a Reference, it is first dereferenced.

X is transformed according to the following rules:

1) Starting from the beginning, remove all occurrences of the group separator before any decimal separator.
2) Starting from the beginning, replace the first occurrence in the text of the decimal separator character with the FULL STOP (U+002E) character.
3) Remove all whitespace characters (7.16).
4) If the first character of the resulting string is a period FULL STOP (U+002E) then prepend a zero.
5) If the string ends in one or more instances of PERCENT SIGN (U+0025), remove the percent sign(s).

If the resulting string is a valid xsd:float, then return the number corresponding to that string, according to the definition provided in XML Schema, Part 2, Section 3.2.4. If percent signs were removed in step 5, divide the value of the returned number by 100 for each percent sign removed.

If the string is not a valid xsd:float then return an error.

DecimalSeparator defines the character used as the decimal separator, for example "." (period) or "," (comma). If this parameter is not given, only integer numbers are parsed.

GroupSeparator defines the character(s) used as grouping separator, for example "," (comma) or "." (period). If this parameter is not given, only integer or decimal numbers containing the DecimalSeparator are parsed. If this parameter is given, all characters contained are ignored in T if each is surrounded by a digit on each side. If GroupSeparator contains "," U+0020 (SPACE), U+0020 and U+00A0 (NO-BREAK SPACE) shall be equally treated.

If the supplied text X cannot be converted into a Number, an Error is returned.

Regardless of the current locale, the evaluator shall accept text representations that match this regular expression when DecimalSeparator is "," (a period) and GroupSeparator is "," (a comma):

```
```

If, for example, DecimalSeparator is "," (a comma) and GroupSeparator is "," (a period), use the expression above but swapping the comma for the period (so "," is ignored).

See also N 8.13.26, T 8.20.22, DATEVALUE 8.10.4, TIMEVALUE 8.10.18, VALUE 8.13.34

8.13.29 ROW

Summary: Returns the row number(s) of a reference

Syntax: ROW( [ Reference R ] )

Returns: Number

Constraints: AREAS(R) = 1
Semantics: Returns the row number of a reference. If no parameter is given, the current cell is used. If a reference has multiple rows, an array of numbers is returned with all of the rows in the reference.

See also COLUMN 8.13.4, SHEET 8.13.31

8.13.30 ROWS

Summary: Returns the number of rows in a given range

Syntax: ROWS( Reference|Array R )

Returns: Number

Constraints: None

Semantics: Returns the number of rows in the range or array specified. The result is not dependent on the cell content in the range.

See also COLUMNS 8.13.5

8.13.31 SHEET

Summary: Returns the sheet number of the reference or the string representing a sheet name.

Syntax: SHEET( [ Text|Reference R ] )

Returns: Number >= 1

Constraints: R shall not contain a Source Location (7.8 References)

Semantics: Returns the 1 based sheet number of the given reference or sheet name.

Hidden sheets are not excluded from the sheet count.

If no parameter is given, the result is the sheet number of the sheet containing the formula.
If a Reference is given it is not dereferenced.
If the reference encompasses more than one sheet, the result is the number of the first sheet in the range.
If a reference does not contain a sheet reference, the result is the sheet number of the sheet containing the formula.

If the function is not evaluated within a table cell, an error is returned.

See also COLUMN 8.13.4, ROW 8.13.29, SHEETS 8.13.32

8.13.32 SHEETS

Summary: Returns the number of sheets in a reference or current document

Syntax: SHEETS( [ Reference R ] )

Returns: Number >= 1

Constraints: R shall not contain a Source Location (7.8 References)

Semantics: Returns the number of sheets in the given reference.
If no parameter is given, the number of sheets in the document is returned.
Hidden sheets are not excluded from the sheet count.

**See also** COLUMNS 8.13.5, ROWS 8.13.30, SHEET 8.13.31

### 8.13.33 TYPE

**Summary:** Returns a number indicating the type of the provided value.

**Syntax:** `TYPE( Any value )`

**Returns:** Number

**Constraints:** None

**Semantics:** Returns a number indicating the type of the value given:

<table>
<thead>
<tr>
<th>Value’s Type</th>
<th>TYPE Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>1</td>
</tr>
<tr>
<td>Text</td>
<td>2</td>
</tr>
<tr>
<td>Logical</td>
<td>4</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
</tr>
<tr>
<td>Array</td>
<td>64</td>
</tr>
</tbody>
</table>

If a Reference is provided, the reference is first dereferenced, and any formulas are evaluated.

**Note:** Reliance on the return of 4 for `TYPE()` will impair the interoperability of a document containing an expression that relies on that value.

**See also** ERROR.TYPE 8.13.11

### 8.13.34 VALUE

**Summary:** Convert text to number

**Syntax:** `VALUE( Text X )`

**Returns:** Number

**Constraints:** None

**Semantics:** Converts given text value X into Number. If X is a Reference, it is first dereferenced. VALUE is only specified if it is given a Text value or a Reference to a single cell containing a Text value; it is implementation-defined what happens if VALUE is given neither a Text value nor a Reference to a Text value. If the Text has a date, time, or datetime format, it is converted into a serial Number. In many cases the conversion of a date or datetime format is locale-dependent.

If the supplied text X cannot be converted into a Number, an Error is returned.

Regardless of the current locale, an evaluator shall accept numbers matching this regular expression (which does not include a decimal point character) and convert it into a Number. If the value ends in %, it shall divide the number by 100:

\[ [+-]? [0-9]+([eE][+-]?[0-9]+)? %? \]
VALUE shall accept text representations of numbers in the current locale. In the en_US locale, an evaluator shall accept decimal numbers matching this regular expression and convert it into a Number (the leading "$" is ignored; commas are ignored if they match the rule of a thousands separator; if the value ends in %, it shall divide the number by 100):

```
[+-]?\.?\$(\[0-9\]+,\[0-9\]\{3\})+\?\([.][0-9]+\)?\((([eE][+-][0-9]+)|%)\)?
```

Evaluators shall accept accept fractional values matching the regular expression:

```
[+-]? \[0-9\]+ \ [0-9]+/[1-9]\[0-9\]?
```

A leading minus sign is considered identifying a negative number for the entire value. There is a space between the integer and the fractional portion; values between 0 and 1 can be represented by using 0 for the integer part.

Evaluators shall support time values in at least the HH:MM and HH:MM:SS formats, where HH is a 1-2 digit value from 0 to 23, MM is a 1-2 digit value from 0 to 59, and SS is a 1-2 digit value from 0 to 59. The hour may be one or two digits when it is less than 10. VALUE converts time values into Numbers ranging from 0 to 1, which is percentage of day that has elapsed by that time. Thus, VALUE("2:00") is the same as 2/24. Evaluators should accept times with fractional seconds as well when expressed in the form HH:MM:SS.ssss...

Evaluators shall accept textual dates in [ISO8601]ISO 8601 format (YYYY-MM-DD), converting them into serial numbers based on the current epoch. Evaluators shall, when running in the en_US locale, accept the format MM/DD/YYYY .

In addition, in locale en_US, evaluators shall support the following formats (where YYYY is a 4-digit year, YY a 2-digit year, MM a numerical month, DD a numerical day, mmm a 3-character abbreviated alphabetical name, and mmmmm a full name):

<table>
<thead>
<tr>
<th>Format</th>
<th>Example</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM/DD/YYY</td>
<td>5/21/2006</td>
<td>LOCALE-DEPENDENT; Long year format with slashes.</td>
</tr>
<tr>
<td>MM/DD/YY</td>
<td>5/21/06</td>
<td>LOCALE-DEPENDENT; Short year format with slashes</td>
</tr>
<tr>
<td>MM-DD-YYYY</td>
<td>5-21-2006</td>
<td>LOCALE-DEPENDENT; Long year format with dashes</td>
</tr>
<tr>
<td>mmm DD, YYYY</td>
<td>Oct 29, 2006</td>
<td>LOCALE-DEPENDENT; Short alphabetic month day, year. Note: mmm depends on the locale’s language.</td>
</tr>
<tr>
<td>DD mmm YYYY</td>
<td>29 Oct 2006</td>
<td>LOCALE-DEPENDENT; Short alphabetic day month year</td>
</tr>
<tr>
<td>mmmmmm DD, YYYY</td>
<td>October 29, 2006</td>
<td>LOCALE-DEPENDENT; Long alphabetic month, year</td>
</tr>
<tr>
<td>DD mmmmmm YYYY</td>
<td>29 October 2006</td>
<td>LOCALE-DEPENDENT; Long alphabetic day month year</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Format</th>
<th>Example</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM/DD/YYY</td>
<td>5/21/2006</td>
<td>LOCALE-DEPENDENT; Long year format with slashes.</td>
</tr>
<tr>
<td>Date Format</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>MM/CC/YY</strong></td>
<td>LOCALE-DEPENDENT: Short year format with slashes</td>
<td></td>
</tr>
<tr>
<td><strong>MM-DD-YYYY</strong></td>
<td>LOCALE-DEPENDENT: Long year format with dashes (short year may be supported, but it may also be used for years less than 100)</td>
<td></td>
</tr>
<tr>
<td><strong>mmm-DD, YYYY</strong></td>
<td>LOCALE-DEPENDENT: Short alphabetic month day, year. Note: mmm depends on the locale's language.</td>
<td></td>
</tr>
<tr>
<td><strong>DD-mmm, YYYY</strong></td>
<td>LOCALE-DEPENDENT: Short alphabetic day month year</td>
<td></td>
</tr>
<tr>
<td><strong>mmmmm-DD, YYYY</strong></td>
<td>LOCALE-DEPENDENT: Long alphabetic month day, year</td>
<td></td>
</tr>
<tr>
<td><strong>DD-mmmmm, YYYY</strong></td>
<td>LOCALE-DEPENDENT: Long alphabetic day month year</td>
<td></td>
</tr>
</tbody>
</table>

Evaluators should support other locales. Many conversions will vary by locale, including the decimal point (comma or period), names of months, date formats (MM/DD vs. DD/MM), and so on. Dates in particular vary by locale.

Evaluators shall support the datetime format, which is a date followed by a time, using either the space character or the literal “T” character as the separator (the “T” is from ISO 8601). Evaluators shall support at least the ISO date format in a datetime format; they may support other date formats in a datetime format as well. Formats such as “YYYY-MM-DD HH:MM” and “YYYY-MM-DDTHH:MM:SS” (where “T” is the literal character T) shall be accepted. The result of accepting a datetime format shall be a representation of that specific time (without removing either the date or the time of day, unlike DATEVALUE or TIMEVALUE).

Evaluators may accept other formats that will convert to numbers, and those conversions may be locale-dependent, as long as they do not conflict with the above. Where no conversion is determined, an Error is returned.

See also N 8.13.26, T 8.20.22, DATEVALUE 8.10.4, TIMEVALUE 8.10.18, NUMBERVALUE 8.13.28

8.14 Lookup Functions

8.14.1 General

These functions look up information. Note that IF() can be considered a trivial lookup function, but it is listed as a logical function instead.

8.14.2 ADDRESS

Summary: Returns a cell address (reference) as text

Syntax: ADDRESS( Integer Row ; Integer Column [ ; Integer Abs = 14 [ ; Logical A1 = TRUE() [ ; Text Sheet ] ] ] )

Returns: Text

Constraints: Row >= 1, Column >= 1, 1 <= Abs <= 4; A1 = TRUE(). Evaluators may evaluate expressions that do not meet the constraint A1 = TRUE().

Semantics: Returns a cell address (reference) as text. The text does not include the surrounding [...] of a reference. If a Sheet name is given, the sheet name in the text returned is followed by a “.”
and the column/row reference if \( A1 \) is TRUE, or a "!" and the column/row reference if \( A1 \) is FALSE; otherwise no ",." respectively "!" is included. Columns are identified using uppercase letters. The value of \( \text{Abs} \) determines if the column and/or row is absolute or relative. The value of \( A1 \) determines if \( A1 \) reference style or \( R1C1 \) reference style is used.

<table>
<thead>
<tr>
<th>( \text{Abs} )</th>
<th>( \text{Meaning} )</th>
<th>( A1 = \text{TRUE()} )</th>
<th>( A1 = \text{FALSE()} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>fully absolute</td>
<td>$A$1</td>
<td>( R1C1 )</td>
</tr>
<tr>
<td>2</td>
<td>row absolute, column relative</td>
<td>( A$1 )</td>
<td>( R1C[1] )</td>
</tr>
<tr>
<td>3</td>
<td>row relative, column absolute</td>
<td>$A1 )</td>
<td>( R[1]C1 )</td>
</tr>
<tr>
<td>4</td>
<td>fully relative</td>
<td>( A1 )</td>
<td>( R[1]C[1] )</td>
</tr>
</tbody>
</table>

Table 23 - ADDRESS

Note that the INDIRECT function accepts this format.

**See also** INDIRECT 8.14.7

### 8.14.3 CHOOSE

**Summary:** Uses an index to return a value from a list of values.

**Syntax:** \( \text{CHOOSE}( \text{Integer Index} ; \{ \text{Any Value} \}^* ) \)

**Returns:** Any

**Constraints:** Returns an Error if Index < 1 or if there is no corresponding value in the list of Values.

**Semantics:** Uses Index to determine which value, from a list of values, to return. If Index is 1, CHOOSE returns the first Value; if Index is 2, CHOOSE returns the second value, and so on. Note that the Values may be formula expressions. Expression paths of parameters other than the one chosen are not calculated or evaluated for side effects.

**See also** IF 8.15.4

### 8.14.4 GETPIVOTDATA

**Summary:** Return a value from a data pilot table.

**Syntax:** \( \text{GETPIVOTDATA}( \text{Text DataField} ; \text{Reference Table} \{ ; \text{Text Field} ; \text{Scalar Member} \}^* ) \)

**Note:** This function knows two different syntaxes. This version of the syntax is distinguished by the second parameter Table being a Reference.

**Returns:** Any

**Semantics:** Returns a single result from the calculation of a data pilot table.

The data pilot table is selected by Table, which is a reference to a cell or cell range that’s within a data pilot table or contains a data pilot table. If the cell range contains several data pilot tables, the last one in the order of <table: data-pilot-table> elements in the file is used.

DataField selects one of the data pilot table’s data fields. It can be the name of the source column, or the given name of the data field (such as “Sum of Sales”).

If no Field/Member pairs are given, the grand total is returned. Otherwise, each pair adds a constraint that the result shall satisfy. Field is the name of a field from the data pilot table. Member
is the name of a member (item) from that field. If a member is a number, Member can alternatively be its numerical value.

If the data pilot table contains only a single result value that fulfills all of the constraints, or a subtotal result that summarizes all matching values, that result is returned. If there is no matching result, or several ones without a subtotal for them, an Error is returned. These conditions apply to results that are included in the data pilot table. If the source data contains entries that are hidden by settings of the data pilot table, they are ignored. The order of the Field/Member pairs is not significant. Field and member names are case-insensitive.

If no constraint for a page field is given, the field's selected value is implicitly used. If a constraint for a page field is given, it shall match the field's selected value, or an Error is returned.

Subtotal values from the data pilot table are only used if they use the function "auto" (except when specified in the constraint, see below).

Alternative syntax: GETPIVOTDATA( Reference Table ; Text Constraints )

For compatibility, a second syntax is allowed. Table has the same meaning as above. This version of the syntax is distinguished by the first parameter Table being a Reference.

Constraints is a space-separated list. Entries can be quoted (single quotes). One of the entries can be the data field name. The data field name can be left out if the data pilot table contains only one data field, otherwise it shall be present. Each of the other entries specifies a constraint in the form Field[Member] (with literal characters [ and ]), or only Member if the member name is unique within all fields that are used in the data pilot table. A function name can be added in the form Field[Member;Function], which will cause the constraint to match only subtotal values which use that function. The possible function names are the same as in the <table:data-pilot-subtotal> element, case-insensitive.

8.14.5 HLOOKUP

Summary: Look for a matching value in the first row of the given table, and return the value of the indicated row.

Syntax: HLOOKUP( Any Lookup ; Reference|Array DataSource ; Integer Row [ ; Logical RangeLookup = TRUE() ] )

Returns: Any

Constraints: Row >= 1; Search portion of DataSource shall not include Logical values. Evaluators may evaluate expressions that do not meet the constraint that the searched portion of a DataSource not include Logical values.

Semantics:

If RangeLookup is omitted or TRUE or not 0, the first row of DataSource is assumed to be sorted in ascending order, with smaller numbers before larger ones, smaller text values before larger ones (e.g., "A" before "B", and "B" before "BA"), and False before True. If the types are mixed, Numbers are sorted before Text, and Text before Logicals; evaluators without a separate Logical type may include a Logical as a Number. The lookup will try to match an entry of value Lookup. If none is found the largest entry less than Lookup is taken as a match. From a sequence of identical values <= Lookup the last entry is taken. If there is no data less than or equal to Lookup, the #N/A Error is returned. If Lookup is of type Text and the value found is of type Number, the #N/A Error is returned. If DataSource is not sorted, the result is undetermined and implementation-dependent. In most cases it will be arbitrary and just plain wrong due to binary search algorithms.

If RangeLookup is FALSE or 0, DataSource does not need to be sorted and an exact match is searched. Each value in the first row of DataSource is examined in order (starting at the left) until its value matches Lookup.
Both methods, if there is a match, return the corresponding value in row Row, relative to the DataSource, where the topmost row in DataSource is 1.

The values returned may vary depending upon the HOST-USE-REGULAR-EXPRESSIONS or HOST-USE-WILDCARDS or HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL properties. 3.5


8.14.6 INDEX

Summary: Returns a value using a row and column index value (and optionally an area index).

Syntax: INDEX( ReferenceList|Array DataSource ; [ Integer Row ] ; [ Integer Column ] ; Integer AreaNumber = 1 )

Returns: Any

Constraints: Row >= 0, Column >= 0,
1 <= AreaNumber <= number of references in DataSource if that is a ReferenceList, else AreaNumber = 1

Semantics:

Given a DataSource, returns the value at the given Row and Column (starting numbering at 1, relative to the top left of the DataSource) of the given area AreaNumber. If AreaNumber is not given, it defaults to 1 (the first and possibly only area). This function is essentially a two-dimensional version of CHOOSE, which does not accept range parameters.

If Row is omitted or an empty parameter (two consecutive ;; semicolons) or 0, an entire column of the given area AreaNumber in DataSource is returned. If Column is omitted or an empty parameter (two consecutive ;; semicolons) or 0, an entire row of the given area AreaNumber in DataSource is returned. If both, Row and Column, are omitted or empty or 0, the entire given area AreaNumber is returned.

If DataSource is a one-dimensional column vector, Column is optional or can be omitted as an empty parameter (two consecutive ;; semicolons). If DataSource is a one-dimensional row vector, Row is optional, which effectively makes Row act as the column offset into the vector, or can be omitted as an empty parameter (two consecutive ;; semicolons).

If Row or Column have a value greater than the dimension of the corresponding given area AreaNumber, an Error is returned.

See also AREAS 8.13.2, CHOOSE 8.14.3

8.14.7 INDIRECT

Summary: Return a reference given a string representation of a reference

Syntax: INDIRECT( Text Ref [ ; Logical A1 = TRUE() ] )

Returns: Reference

Constraints: Ref is valid reference

Semantics: Given text for a reference (such as “A3”), returns a reference. If A1 is False, it is interpreted as an R1C1 reference style. For interoperability, if the Ref text includes a sheet name, evaluators should be able to parse both, the “.” dot and the “!” exclamation mark, as the sheet name separator. If evaluators support the A1=FALSE() case of the ADDRESS 8.14.2 function and include the “!” exclamation mark as the sheet name separator, evaluators shall correctly parse that in the
A1=FALSE() case of this INDIRECT function. Evaluators shall correctly parse the "." dot as the sheet name separator in the A1=TRUE() case.

See also ADDRESS 8.14.2

8.14.8 LOOKUP

Summary: Look for criterion in an already-sorted array, and return a corresponding result

Syntax: LOOKUP( Any Find ; ForceArray Reference|Array Searched [ ; ForceArray Reference|Array Results ] )

Returns: Any

Constraints: The searched portion of Searched shall be sorted in ascending order; if provided, Results shall have the same length as Searched. The searched portion of Searched shall not include Logical values. Evaluators may evaluate expressions that do not meet the constraint that the searched portion of a Searched not include Logical values.

Semantics: This function searches for Find in a row or column of the previously-sorted array Searched and returns a corresponding value. The match is the largest value in the row/column of Searched that is less than or equal to Find (so an exact match is always preferred over inexact ones). From a sequence of identical values <= Find the last entry is taken. If Find is smaller than the smallest value in the first row or column (depending on the array dimensions), LOOKUP returns the #N/A Error. If Find is of type Text and the value found is of type Number, the #N/A Error is returned.

The searched portion of Searched shall be sorted in ascending order, and so that values of type Number precede values of type Text if both types are included (e.g., -2, 0, 2, “A”, “B”).

There are two major uses for this function; the 3-parameter version (vector) and the 2-parameter version (non-vector array).

Note: Interoperability is improved by use of HLOOKUP or VLOOKUP in expressions over LOOKUP.

When given two parameters, Searched is first examined:

- If Searched is square or is taller than it is wide (more rows than columns), LOOKUP searches in the first column (similar to VLOOKUP), and returns the corresponding value in the last column.
- If Searched covers an area that is wider than it is tall (more columns than rows), LOOKUP searches in the first row (similar to HLOOKUP), and returns the corresponding value in the last row.

When given 3 parameters, Results shall be a vector (either a row or a column) or an Error is raised. The function determines the index of the match in the first column respectively row of Searched, and returns the value in Results with the same index.

Searched is first examined:

- If Searched is square or is taller than it is wide (more rows than columns), LOOKUP searches in the first column (similar to VLOOKUP).
- If Searched covers an area that is wider than it is tall (more columns than rows), LOOKUP searches in the first row (similar to HLOOKUP).

The lengths of the search vector and the result vector do not need to be identical. When the match position falls outside the length of the result vector, an Error is returned if the result vector is given as an array object. If it is a cell range, it gets automatically extended to the length of the searched vector, but in the direction of the result vector. If just a single cell reference was passed, a column vector is generated. If the cell range cannot be extended due to the sheet's size limit, then the #N/A Error is returned.
The values returned may vary depending upon the HOST-USE-REGULAR-EXPRESSIONS or HOST-USE-WILDCARDS or HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL properties. 3.5


8.14.9 MATCH

Summary: Finds a Search item in a sequence, and returns its position (starting from 1).

Syntax: MATCH( Scalar Search ; Reference|Array SearchRegion [ ; Integer MatchType = 1 ] )

Returns: Any

Constraints: -1 <= MatchType <= 1; The searched portion of SearchRegion shall not include Logical values. Evaluators may evaluate expressions that do not meet the constraint that the searched portion of a SearchRegion not include Logical values.

SearchRegion shall be a vector (a single row or column)

Semantics:

● MatchType = -1 finds the smallest value that is greater than or equal to Search in a SearchRegion where values are sorted in descending order. From a sequence of identical values >= Search the last value is taken. If no value >= Search exists, the #N/A Error is returned. If Search is of type Number and the value found is of type Text, the #N/A Error is returned.

● MatchType = 0 finds the first value that is equal to Search. Values in SearchRegion do not need to be sorted. If no value equal to Search exists, the #N/A Error is returned.

● MatchType = 1 or omitted finds the largest value that is less than or equal to Search in a SearchRegion where values are sorted in ascending order. From a sequence of identical values <= Search the last value is taken. If no value <= Search exists, the #N/A Error is returned. If Search is of type Text and the value found is of type Number, the #N/A Error is returned.

If a match is found, MATCH returns the relative position (starting from 1). For Text the comparison is case-insensitive. MatchType determines the type of search; if MatchType is 0, the SearchRegion shall be considered unsorted, and the first match is returned. If MatchType is 1, the SearchRegion may be assumed to be sorted in ascending order, with smaller Numbers before larger ones, smaller Text values before larger ones (e.g., "A" before "B", and "B" before "BA"), and False before True. If the types are mixed, Numbers are sorted before Text, and Text before Logicals; evaluators without a separate Logical type may include a Logical as a Number. If MatchType is -1, then SearchRegion may be assumed to be sorted in descending order (the opposite of the above). If MatchType is 1 or -1, evaluators may use binary search or other techniques so that they do not need to examine every value in linear order. MatchType defaults to 1.

The values returned may vary depending upon the HOST-USE-REGULAR-EXPRESSIONS or HOST-USE-WILDCARDS or HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL properties. 3.5


8.14.10 MULTIPLE.OPERATIONS

Summary: Executes a formula expression while substituting a row reference and a column reference.

Syntax: MULTIPLE.OPERATIONS( Reference FormulaCell ; Reference RowCell ; Reference RowReplacement [ ; Reference ColumnCell ; Reference ColumnReplacement ] )
Returns: Any

Semantics:

- **FormulaCell** reference to the cell that contains the formula expression to calculate.
- **RowCell** reference that is to be replaced by **RowReplacement**.
- **RowReplacement** reference that replaces **RowCell**.
- **ColumnCell** reference that is to be replaced by **ColumnReplacement**.
- **ColumnReplacement** reference that replaces **ColumnCell**.

**MULTIPLE.OPERATIONS** executes the formula expression pointed to by **FormulaCell** and all formula expressions it depends on while replacing all references to **RowCell** with references to **RowReplacement** respectively all references to **ColumnCell** with references to **ColumnReplacement**.

If calls to **MULTIPLE.OPERATIONS** are encountered in dependencies, replacements of target cells shall occur in queued order, with each replacement using the result of the previous replacement.

Note: The function may be used to create tables of expressions that depend on two input parameters.

Example: **FormulaCell** is B5, **RowCell** is B3, **ColumnCell** is B2

### Table 24 - **MULTIPLE.OPERATIONS**

<table>
<thead>
<tr>
<th>row</th>
<th>col_B</th>
<th>col_C</th>
<th>col_D</th>
<th>col_E</th>
<th>col_F</th>
</tr>
</thead>
<tbody>
<tr>
<td>row_2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>=MULTIPLE.OPERATIONS($B$5:$B$3 ;$C3:$B$2;$D$2)</td>
<td>=MULTIPLE.OPERATIONS($B$5:$B$3 ;$C3:$B$2;$E$2)</td>
<td>=MULTIPLE.OPERATIONS($B$5:$B$3 ;$C3:$B$2;$F$2)</td>
</tr>
<tr>
<td>row_3</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>=MULTIPLE.OPERATIONS($B$5:$B$3 ;$C4:$B$2;$D$2)</td>
<td>=MULTIPLE.OPERATIONS($B$5:$B$3 ;$C4:$B$2;$E$2)</td>
<td>=MULTIPLE.OPERATIONS($B$5:$B$3 ;$C4:$B$2;$F$2)</td>
</tr>
<tr>
<td>row_4</td>
<td>=B2+B3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>=MULTIPLE.OPERATIONS($B$5:$B$3 ;$C5:$B$2;$D$2)</td>
<td>=MULTIPLE.OPERATIONS($B$5:$B$3 ;$C5:$B$2;$E$2)</td>
<td>=MULTIPLE.OPERATIONS($B$5:$B$3 ;$C5:$B$2;$F$2)</td>
</tr>
<tr>
<td>row_5</td>
<td>=B2*B3+B4</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>=MULTIPLE.OPERATIONS($B$5:$B$3 ;$C6:$B$2;$D$2)</td>
<td>=MULTIPLE.OPERATIONS($B$5:$B$3 ;$C6:$B$2;$E$2)</td>
<td>=MULTIPLE.OPERATIONS($B$5:$B$3 ;$C6:$B$2;$F$2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Result:

Table 25 - MULTIPLE.OPERATIONS

<table>
<thead>
<tr>
<th></th>
<th>col_B</th>
<th>col_C</th>
<th>col_D</th>
<th>col_E</th>
<th>col_F</th>
</tr>
</thead>
<tbody>
<tr>
<td>row_2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>row_3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>row_4</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>row_5</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>9</td>
<td>14</td>
<td>19</td>
<td></td>
</tr>
</tbody>
</table>

Note that although only cell B5 is passed as the FormulaCell parameter, also the references to B2 and B3 of the formula in cell B4 are replaced, because B5 depends on B4.

8.14.11 OFFSET

Summary: Modifies a reference's position and dimension.

Syntax: OFFSET( Reference reference ; Integer rowOffset ; Integer columnOffset [ ; [ Integer newHeight ] [ ; [ Integer newWidth ] ] ] )

Returns: Reference

Constraints: newWidth > 0; newHeight > 0
The modified reference shall be in a valid range, starting from column/row one to the maximum column/row.

Semantics: Shifts reference by rowOffset rows and by columnOffset columns. Optionally, the dimension can be set to newWidth and/or newHeight, if omitted the width/height of the original reference is taken. Note that newHeight may be empty (two consecutive semicolons ;;) followed by a given newWidth argument. Returns the modified reference.

See also COLUMN 8.13.4, COLUMNS 8.13.5, ROW 8.13.29, ROWS 8.13.30

8.14.12 VLOOKUP

Summary: Look for a matching value in the first column of the given table, and return the value of the indicated column.

Syntax: VLOOKUP( Any Lookup ; Reference|Array DataSource ; Integer Column [ ; Logical RangeLookup = TRUE() ] )

Returns: Any

Constraints: Column >= 1; The searched portion of DataSource shall not include Logical values. Evaluators may evaluate expressions that do not meet the constraint that the searched portion of a DataSource not include Logical values.

Semantics:

If RangeLookup is omitted or TRUE or not 0, the first column of DataSource is assumed to be sorted in ascending order, with smaller Numbers before larger ones, smaller Text values before larger ones (e.g., "A" before "B", and "B" before "BA"), and False before True. If the types are mixed, Numbers are sorted before Text, and Text before Logicals; evaluators without a separate Logical type may include a Logical as a Number. The lookup will try to match an entry of value
**Lookup**. From a sequence of identical values <= Lookup the last entry is taken. If none is found the largest entry less than Lookup is taken as a match. If there is no data less than or equal to Lookup, the #N/A Error is returned. If Lookup is of type Text and the value found is of type Number, the #N/A Error is returned. If DataSource is not sorted, the result is undetermined and implementation-dependent. In most cases it will be arbitrary and just plain wrong due to binary search algorithms.

If RangeLookup is FALSE or 0, DataSource does not need to be sorted and an exact match is searched. Each value in the first column of DataSource is examined in order (starting at the top) until its value matches Lookup. If no value matches, the #N/A Error is returned.

Both methods, if there is a match, return the corresponding value in column Column, relative to the DataSource, where the leftmost column in DataSource is 1.

The values returned may vary depending upon the HOST-USE-REGULAR-EXPRESSIONS or HOST-USE-WILDCARDS or HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL properties. 3.5


**8.15 Logical Functions**

**8.15.1 General**

The logical functions are the constants TRUE() and FALSE(), the functions that compute Logical values NOT(), AND(), and OR(), and the conditional function IF(). The OpenDocument specification mentions "logical operators"; these are another name for the logical functions.

Note that because of Error values, any logical function that accepts parameters can actually produce TRUE, FALSE, or an Error value, instead of TRUE or FALSE.

These are not bitwise operations, e.g., AND(12;10) produces TRUE(), not 8. See the bit operation functions for bitwise operations.

**8.15.2 AND**

Summary: Compute logical AND of all parameters.

Syntax: AND( { Logical|NumberSequenceList L }* )

Returns: Logical

Constraints: Shall have 1 or more parameters

Semantics: Computes the logical AND of the parameters. If all parameters are True, returns True; if any are False, returns False. When given one parameter, this has the effect of converting that one parameter into a Logical value. When given zero parameters, evaluators may return a Logical value or an Error.

Also in array context a logical AND of all arguments is computed, range or array parameters are not evaluated as a matrix and no array is returned. This behavior is consistent with functions like SUM. To compute a logical AND of arrays per element use the * operator in array context.

See also OR 8.15.8, IF 8.15.4

**8.15.3 FALSE**

Summary: Returns constant FALSE
Syntax: FALSE()

Returns: Logical

Constraints: Shall have 0 parameters

Semantics: Returns logical constant FALSE. This may be a Number or a distinct type.

See also TRUE 8.15.9, IF 8.15.4

8.15.4 IF

Summary: Return one of two values, depending on a condition

Syntax: IF( Logical Condition [ ; [ Any IfTrue ] [ ; [ Any IfFalse ] ] ] )

Returns: Any

Constraints: None.

Semantics: Computes Condition. If it is TRUE, it returns IfTrue, else it returns IfFalse. If there is only 1 parameter, IfTrue is considered to be TRUE(). If there are less than 3 parameters, IfFalse is considered to be FALSE(). Thus the 1 parameter version converts Condition into a Logical value. If there are 2 or 3 parameters but the second parameter is null (two consecutive ;; semicolons), IfFalse is considered to be 0. If there are 3 parameters but the third parameter is null, IfFalse is considered to be 0. This function only evaluates IfTrue, or IfFalse, and never both; that is to say, it short-circuits.

See also AND 8.15.2, OR 8.15.8

8.15.5 IFERROR

Summary: Return X unless it is an Error, in which case return an alternative value

Syntax: IFERROR( Any X ; Any Alternative )

Returns: Any

Constraints: None.

Semantics: Computes X. If ISERROR(X) is true, return Alternative, else return X. Thus this is semantically equivalent to IF(ISERROR(X); Alternative; X), except that X is only computed once. If X or Alternative is a cell reference to an empty cell, it is treated as the empty string “”.

Note: This is semantically equivalent to IF(ISERROR(X); Alternative; X), except that X is only computed once.

See also IF 8.15.4, ISERROR 8.13.16

See also IFNA 8.15.2

8.15.6 IFNA

Summary: Return X unless it is an NA, in which case return an alternative value

Syntax: IFNA( Any X ; Any Alternative )

Returns: Any

Constraints: None.
**Semantics**: Computes X. If ISNA(X) is true, return Alternative, else return X. Thus this is semantically equivalent to IF(ISNA(X); Alternative; X), except that X is only computed once. If X or Alternative is a cell reference to an empty cell, it is treated as the empty string “”.

**Note**: This is semantically equivalent to IF(ISNA(X); Alternative; X), except that X is only computed once.

**See also** IF 8.15.4, ISNA 8.13.20

**See also** IF 8.15.2

### 8.15.7 NOT

**Summary**: Compute logical NOT

**Syntax**: NOT( Logical L )

**Returns**: Logical

**Constraints**: Shall have 1 parameter

**Semantics**: Computes the logical NOT. If given TRUE, returns FALSE; if given FALSE, returns TRUE.

**See also** AND 8.15.2, IF 8.15.4

### 8.15.8 OR

**Summary**: Compute logical OR of all parameters.

**Syntax**: OR( { Logical|NumberSequenceList L } + )

**Returns**: Logical

**Constraints**: Shall have 1 or more parameters

**Semantics**: Computes the logical OR of the parameters. If all parameters are False, it shall return False; if any are True, it shall returns True. When given one parameter, this has the effect of converting that one parameter into a Logical value. When given zero parameters, evaluators may return a Logical value or an Error.

Also in array context a logical OR of all arguments is computed, range or array parameters are not evaluated as a matrix and no array is returned. This behavior is consistent with functions like SUM. To compute a logical OR of arrays per element use the + operator in array context.

**See also** AND 8.15.2, IF 8.15.4

### 8.15.9 TRUE

**Summary**: Returns constant TRUE

**Syntax**: TRUE()

**Returns**: Logical

**Constraints**: Shall have 0 parameters

**Semantics**: Returns logical constant TRUE. The result of this function may or may not be equal to 1 when compared using “=” . It always has the value of 1 if used in a context requiring Number (because of the automatic conversions), so if ISNUMBER(TRUE()), then it shall have the value 1.
8.15.10 XOR

Summary: Compute a logical XOR of all parameters.

Syntax: XOR( { Logical L } )

Returns: Logical

Constraints: Shall have 1 or more parameters.

Semantics: Computes the logical XOR of the parameters such that the result is an addition modulo 2. If an even number of parameters is True it returns False, if an odd number of parameters is True it returns True. When given one parameter, this has the effect of converting that one parameter into a Logical value.

See also AND 8.15.2, OR 8.15.8

8.16 Mathematical Functions

8.16.1 General

This section describes functions for various mathematical functions, including trigonometric functions like SIN 8.16.55). Note that the constraint text presumes that a value of type Number is a real number (no imaginary component). Unless noted otherwise, all angle measurements are in radians.

8.16.2 ABS

Summary: Return the absolute (nonnegative) value.

Syntax: ABS( Number N )

Returns: Number

Constraints: None

Semantics: If N < 0, returns -N, otherwise returns N.

See also Prefix Operator “-” 8.4.16

8.16.3 ACOS

Summary: Returns the principal value of the arc cosine of a number. The angle is returned in radians.

Syntax: ACOS( Number N )

Returns: Number

Constraints: -1.0 <= N <= 1.0.

Semantics: Computes the arc cosine of a number, in radians.

\[
\text{acos}(N) = \frac{\pi}{2} - \left( N + \frac{1}{2 \cdot 3} N^3 + \frac{1 \cdot 3}{2 \cdot 4 \cdot 5} N^5 + \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6 \cdot 7} N^7 + \ldots \right)
\]
Returns a principal value $0 \leq \text{result} \leq \pi$.

**See also** COS 8.16.19, RADIANS 8.16.49, DEGREES 8.16.25

### 8.16.4 ACOSH

**Summary:** Return the principal value of the inverse hyperbolic cosine

**Syntax:** ACOSH( *Number* N )

**Returns:** Number

**Constraints:** $N \geq 1$

**Semantics:** Computes the principal value of the inverse hyperbolic cosine.

\[
\text{acosh}(N) = \ln(N + \sqrt{N^2 - 1})
\]

**See also** COSH 8.16.20, ASINH 8.16.8

### 8.16.5 ACOT

**Summary:** Return the principal value of the arc cotangent of a number. The angle is returned in radians.

**Syntax:** ACOT( *Number* N )

**Returns:** Number

**Semantics:** Computes the arc cotangent of a number, in radians.

Returns a principal value $0 < \text{result} < \pi$.

**See also** COT 8.16.21, ATAN 8.16.9, TAN 8.16.69, RADIANS 8.16.49, DEGREES 8.16.25

### 8.16.6 ACOTH

**Summary:** Return the hyperbolic arc cotangent

**Syntax:** ACOTH( *Number* N )

**Returns:** Number

**Constraints:** $\text{ABS}(N) > 1$

**Semantics:** Computes the hyperbolic arc cotangent. The hyperbolic arc cotangent is an analog of the ordinary (circular) arc cotangent.

\[
\text{acoth}(N) = \frac{1}{2} \ln\left(\frac{x+1}{x-1}\right)
\]

**See also** COSH 8.16.20, ASINH 8.16.8

### 8.16.7 ASIN

**Summary:** Return the principal value of the arc sine of a number. The angle is returned in radians.

**Syntax:** ASIN( *Number* N )
Returns: Number

Constraints: $-1 \leq N \leq 1$.

Semantics: Computes the arc sine of a number, in radians.

$$\text{asin}(N) = N + \frac{1}{2 \cdot 3} N^3 + \frac{1}{2 \cdot 4 \cdot 5} N^5 + \frac{1}{2 \cdot 4 \cdot 6 \cdot 7} N^7 + \ldots$$

Returns a principal value $-\pi/2 \leq \text{result} \leq \pi/2$.

See also SIN 8.16.55, RADIANS 8.16.49, DEGREES 8.16.25

### 8.16.8 ASINH

Summary: Return the principal value of the inverse hyperbolic sine

Syntax: ASINH( Number $N$ )

Returns: Number

Constraints: None

Semantics: Computes the principal value of the inverse hyperbolic sine.

$$\text{asinh}(N) = \ln(N + \sqrt{N^2 + 1})$$

See also SINH 8.16.56, ACOSH 8.16.4

### 8.16.9 ATAN

Summary: Return the principal value of the arc tangent of a number. The angle is returned in radians.

Syntax: ATAN( Number $N$ )

Returns: Number

Semantics: Computes the arc tangent of a number, in radians.

Returns a principal value $-\pi/2 < \text{result} < \pi/2$.

See also ATAN2 8.16.10, TAN 8.16.69, RADIANS 8.16.49, DEGREES 8.16.25

### 8.16.10 ATAN2

Summary: Returns the principal value of the arc tangent given a coordinate of two numbers. The angle is returned in radians.

Syntax: ATAN2( Number $x$ ; Number $y$ )

Returns: Number

Constraints: $x \neq 0$ or $y \neq 0$

Semantics: Computes the arc tangent of two numbers (the $x$ and $y$ coordinates of a point), in radians. This is similar to ATAN($y/x$), but the signs of the two numbers are taken into account so that the result covers the full range from $-\pi$ to $+\pi$. ATAN2(0;0) is implementation-defined, evaluators may return 0 or an Error.
Returns a principal value -PI < result ≤ PI.

See also ATAN 8.16.9, TAN 8.16.69, RADIANS 8.16.49, DEGREES 8.16.25

8.16.11 ATANH

Summary: Return the principal value of the inverse hyperbolic tangent

Syntax: ATANH( Number N )

Returns: Number

Constraints: -1 < N < 1

Semantics: Computes the principal value of the inverse hyperbolic tangent.

\[
\text{atanh}(N) = \frac{1}{2} \ln\left(\frac{1 + N}{1 - N}\right)
\]

See also COSH 8.16.20, SINH 8.16.56, ASINH 8.16.8, ACOSH 8.16.4, ATAN 8.16.9, ATAN2 8.16.10, FISHER 8.18.26

8.16.12 BESSELI

Summary: Returns the modified Bessel function of integer order In(x).

Syntax: BESSELI( Integer X ; Number N )

Returns: Number

Constraints: N >= 0, INT(N)=N; Evaluators may evaluate expressions where N >= 0 returns a non-error value.

Semantics: Computes the modified Bessel function of integer order In(x). N is also known as the order.

See also BESSELJ 8.16.13, BESSELK 8.16.14, BESSELY 8.16.15

8.16.13 BESSELJ

Summary: Returns the Bessel function of integer order Jn(x) (cylinder function)

Syntax: BESSELJ( Integer X ; Number N )

Returns: Number

Constraints: N >= 0, INT(N)=N; Evaluators may evaluate expressions where N >= 0 returns a non-error value.

Semantics: Computes the Bessel function of integer order Jn(x). N is also known as the order.

See also BESSELI 8.16.12, BESSELK 8.16.14, BESSELY 8.16.15

8.16.14 BESSELK

Summary: Returns the modified Bessel function of integer order Kn(x).

Syntax: BESSELK( Integer X ; Number N )
Returns: Number

Constraints: \( N \geq 0, \text{INT}(N)=N; \) Evaluators may evaluate expressions where \( N \geq 0 \) returns a non-error value.

Semantics: Computes the Bessel function of integer order \( K_n(x) \). \( N \) is also known as the order.

See also BESSELI 8.16.12, BESSELJ 8.16.13, BESSELY 8.16.15

8.16.15 BESSELY

Summary: Returns the Bessel function of integer order \( Y_n(x) \), also known as the Neumann function.

Syntax: BESSELY( Integer \( X \); Number \( N \) )

Returns: Number

Constraints: \( N \geq 0, \text{INT}(N)=N; \) Evaluators may evaluate expressions where \( N \geq 0 \) returns a non-error value.

Semantics: Computes Bessel function of integer order \( Y_n(x) \), also known as the Neumann function. \( N \) is also known as the order.

See also BESSELI 8.16.12, BESSELJ 8.16.13, BESSELYK 8.16.14

8.16.16 COMBIN

Summary: Returns the number of different \( R \)-length sets that can be selected from \( N \) items.

Syntax: COMBIN( Integer \( N \); Integer \( R \) )

Returns: Number

Constraints: \( N \geq 0, R \geq 0, R \leq N \)

Semantics: COMBIN returns the binomial coefficient, which is the number of different \( R \)-length sets that can be selected from \( N \) items. Since they are sets, order in the sets is not relevant. The parameters are truncated (using INT) before use. For example, if a jar contains five marbles, each one a distinct color, the number of different three-marble groups \( \text{COMBIN}(5;3) = 10 \). The result is

\[
\binom{N}{R} = \frac{\text{PERMUT}(N;R)}{R!} = \frac{N!}{R!(N-R)!}
\]

Note that if order is important, use PERMUT instead.

See also PERMUT 8.18.59

8.16.17 COMBINA

Summary: Returns the number of combinations with repetitions.

Syntax: COMBINA( Integer \( N \); Integer \( M \) )

Returns: Number

Constraints: \( N \geq 0, M \geq 0, N \geq M; \) Evaluators may evaluate expressions where \( N \geq 0, M \geq 0 \) returns a non-error value.
**Semantics:** Returns the number of possible combinations of $M$ objects out of $N$ possible ones, with repetitions allowed. Actual arguments that are not integers are truncated (using INT) before use. The result is

$$\binom{N + M - 1}{N - 1}$$

See also COMBIN 8.16.16

### 8.16.18 CONVERT

**Summary:** Returns a number converted from one unit system into another

**Syntax:** CONVERT( Number N ; Text From ; Text Into )

**Returns:** Number

**Constraints:** From and Into shall be legal units, and shall be in the same unit group.

**Semantics:** Returns the number converted from the unit identified by From into the unit identified by Into. A unit is a unit symbol, optionally preceded by a unit prefix (either a decimal prefix or a binary prefix). Units (including both the unit symbol and the optional unit prefix) are case-sensitive.

Evaluators claiming to implement this function shall support at least the following unit symbols (with conversions between them and other units in the same group):

<table>
<thead>
<tr>
<th>Unit group</th>
<th>Unit symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area</strong></td>
<td>&quot;uk_acre&quot;</td>
<td>International acre (using international feet), exactly 4046.8564224 m²; normally not used for U.S. land areas</td>
</tr>
<tr>
<td></td>
<td>&quot;us_acre&quot;</td>
<td>U.S. survey/statute acre (using U.S. survey/statute feet), exactly 4046+13525426/15499969 m²</td>
</tr>
<tr>
<td></td>
<td>&quot;ang2&quot; or &quot;ang^2&quot;</td>
<td>Square angstrom (an Angstrom is exactly $10^{-10}$ m)</td>
</tr>
<tr>
<td></td>
<td>&quot;ar&quot;</td>
<td>are, 100 m² (not abbreviated as &quot;a&quot;)</td>
</tr>
<tr>
<td></td>
<td>&quot;ft2&quot; or &quot;ft^2&quot;</td>
<td>Square international feet (1 foot is exactly 0.3048 m)</td>
</tr>
<tr>
<td></td>
<td>&quot;ha&quot;</td>
<td>hectare, 10 000 m²</td>
</tr>
<tr>
<td></td>
<td>&quot;in2&quot; or &quot;in^2&quot;</td>
<td>Square international inches (1 inch is exactly 2.54 cm)</td>
</tr>
<tr>
<td></td>
<td>&quot;ly2&quot; or &quot;ly^2&quot;</td>
<td>Square light-year (where year=365.25 days)</td>
</tr>
<tr>
<td></td>
<td>&quot;m2&quot; or &quot;m^2&quot;</td>
<td>Square meters</td>
</tr>
<tr>
<td></td>
<td>&quot;Morgen&quot;</td>
<td>Morgen, 2500 m²</td>
</tr>
<tr>
<td></td>
<td>&quot;mi2&quot; or &quot;mi^2&quot;</td>
<td>Square international miles</td>
</tr>
<tr>
<td></td>
<td>&quot;Nm2&quot; or &quot;Nm^2&quot;</td>
<td>Square nautical miles (1 nautical mile is 1852 m)</td>
</tr>
<tr>
<td></td>
<td>&quot;Pica2&quot; or</td>
<td>Square Pica Point (one Pica point is 1/72 inch)</td>
</tr>
<tr>
<td>Unit group</td>
<td>Unit symbol</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Distance (Length)</strong></td>
<td>&quot;Pica^2&quot;</td>
<td>Square Pica (one Pica is 1/6 inch)</td>
</tr>
<tr>
<td></td>
<td>&quot;picapt2&quot; or &quot;picapt^2&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&quot;pica^2&quot; or &quot;pica^2&quot;</td>
<td>Square international yards (1 yard is 0.9144 m)</td>
</tr>
<tr>
<td></td>
<td>&quot;yd2&quot; or &quot;yd^2&quot;</td>
<td></td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>&quot;BTU&quot; (&quot;btu&quot;)</td>
<td>International Table British Thermal Unit</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit group</th>
<th>Unit symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distance (Length)</strong></td>
<td>&quot;ang&quot; *</td>
<td>Angstrom, exactly $10^{-10}$ m</td>
</tr>
<tr>
<td></td>
<td>&quot;ell&quot;</td>
<td>Ell, exactly 45 international inches</td>
</tr>
<tr>
<td></td>
<td>&quot;ft&quot;</td>
<td>International Foot, exactly 0.3048 m and also exactly 12 international inches.</td>
</tr>
<tr>
<td></td>
<td>&quot;in&quot;</td>
<td>International Inch, exactly 2.54 cm.</td>
</tr>
<tr>
<td></td>
<td>&quot;ly&quot; *</td>
<td>Light-year, $(299792458 \text{ m/s}) (3600 \text{ s/hr}) (24 \text{ hr/day}) (365.25 \text{ day})$</td>
</tr>
<tr>
<td></td>
<td>&quot;m&quot; *</td>
<td>Meter</td>
</tr>
<tr>
<td></td>
<td>&quot;mi&quot;</td>
<td>International Mile, exactly 1609.344 m and exactly 5280 international feet. This is not a U.S. survey/statute mile (see &quot;smi&quot;) nor a nautical mile (see &quot;Nmi&quot;), but this is the mile normally used in the U.S. customary system</td>
</tr>
<tr>
<td></td>
<td>&quot;Nmi&quot;</td>
<td>International nautical mile, exactly 1852 m. Note that this is not the obsolete U.S. nautical mile nor the Admiralty mile.</td>
</tr>
<tr>
<td></td>
<td>&quot;parsec&quot; or &quot;pc&quot;</td>
<td>Distance from sun to a point having heliocentric parallax of one second (used for stellar distance), $\text{AU}/\tan(1/3600 \text{ degree})$ where an AU is exactly 149,597,870.691 kilometers. *</td>
</tr>
<tr>
<td></td>
<td>&quot;Pica&quot; or &quot;picapt&quot;</td>
<td>Pica (1/72 inch)</td>
</tr>
<tr>
<td></td>
<td>&quot;pica&quot;</td>
<td>Pica (1/6 inch)</td>
</tr>
<tr>
<td></td>
<td>&quot;survey_mi&quot;</td>
<td>U.S. survey &quot;mile&quot; aka U.S. statute mile, exactly $6336000/3937 \text{ m};$ used in some U.S. maps. This is not the mile (see &quot;mi&quot;) normally used in the U.S.</td>
</tr>
<tr>
<td></td>
<td>&quot;yd&quot;</td>
<td>International yard, exactly 0.9144 m and exactly 3 international feet.</td>
</tr>
<tr>
<td>Unit group</td>
<td>Unit symbol</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>&quot;c&quot; *</td>
<td></td>
<td>Thermodynamic calorie, 4.184 J. This is not a dietary Calorie (kilocalorie). For high accuracy, use Joule, due to the many conflicting definitions of calorie.</td>
</tr>
<tr>
<td>&quot;cal&quot; *</td>
<td></td>
<td>International Table (IT) calorie, 4.1868 J. This is not a dietary Calorie (kilocalorie). For high accuracy, use Joule, due to the many conflicting definitions of calorie.</td>
</tr>
<tr>
<td>&quot;e&quot; *</td>
<td></td>
<td>Erg</td>
</tr>
<tr>
<td>&quot;eV&quot; (&quot;ev&quot;) *</td>
<td></td>
<td>Electron volt (eV preferred)</td>
</tr>
<tr>
<td>&quot;flb&quot;</td>
<td></td>
<td>Foot-pound (international foot, avoirdupois pound)</td>
</tr>
<tr>
<td>&quot;HPh&quot; (&quot;hh&quot;)</td>
<td></td>
<td>Horsepower-hour (HPh preferred)</td>
</tr>
<tr>
<td>&quot;J&quot; *</td>
<td></td>
<td>Joule</td>
</tr>
<tr>
<td>&quot;Wh&quot; (&quot;wh&quot;) *</td>
<td></td>
<td>Watt-hour</td>
</tr>
<tr>
<td>&quot;dyn&quot; (&quot;dy&quot;) *</td>
<td></td>
<td>Dyne</td>
</tr>
<tr>
<td>&quot;N&quot; *</td>
<td></td>
<td>Newton</td>
</tr>
<tr>
<td>&quot;lbf&quot;</td>
<td></td>
<td>Pound force (see &quot;lbm&quot; for pound mass)</td>
</tr>
<tr>
<td>&quot;pond&quot; *</td>
<td></td>
<td>Pond, gravitational force on a mass of one gram, 9.80665E-3 N.</td>
</tr>
<tr>
<td>&quot;bit&quot; * †</td>
<td></td>
<td>bit</td>
</tr>
<tr>
<td>&quot;byte&quot; * †</td>
<td></td>
<td>byte = 8 bits</td>
</tr>
<tr>
<td>&quot;ga&quot; *</td>
<td></td>
<td>Gauss</td>
</tr>
<tr>
<td>&quot;T&quot; *</td>
<td></td>
<td>Tesla</td>
</tr>
<tr>
<td>&quot;g&quot; *</td>
<td></td>
<td>Gram</td>
</tr>
<tr>
<td>&quot;grain&quot;</td>
<td></td>
<td>Grain, 1/7000 international pound mass (avoirdupois) (U.S. usage).</td>
</tr>
<tr>
<td>&quot;cwt&quot; (&quot;shweight&quot;)</td>
<td></td>
<td>U.S. (short) hundredweight, 100 lbm</td>
</tr>
<tr>
<td>&quot;uk_cwt&quot; or &quot;lcwt&quot; (&quot;hweight&quot;)</td>
<td></td>
<td>Imperial hundredweight, aka long hundredweight; 112 lbm</td>
</tr>
<tr>
<td>Unit group</td>
<td>Unit symbol</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td></td>
<td>&quot;lbm&quot;</td>
<td>International pound mass (avoirdupois), exactly 453.59237 g (see &quot;lbf&quot; for pound force)</td>
</tr>
<tr>
<td></td>
<td>&quot;stone&quot;</td>
<td>14 international pound mass (avoirdupois)</td>
</tr>
<tr>
<td></td>
<td>&quot;ton&quot;</td>
<td>2000 international pound mass (avoirdupois) (U.S. usage). Note that there are many other measures also called &quot;ton&quot;, in particular, this is not a metric ton (tonne).</td>
</tr>
<tr>
<td></td>
<td>&quot;ozm&quot;</td>
<td>Ounce mass (avoirdupois), exactly 1/16 of an international pound mass (avoirdupois) (see &quot;oz&quot; for fluid ounce)</td>
</tr>
<tr>
<td></td>
<td>&quot;sg&quot;</td>
<td>Slug; 32.174 international pound mass (avoirdupois)</td>
</tr>
<tr>
<td></td>
<td>&quot;u&quot;*</td>
<td>U (atomic mass unit)</td>
</tr>
<tr>
<td></td>
<td>&quot;uk_ton&quot; or &quot;LTON&quot; (&quot;brton&quot;)</td>
<td>Imperial ton, aka &quot;long ton&quot;, &quot;deadweight ton&quot;, or &quot;weight ton&quot;. 2240 lbm.</td>
</tr>
</tbody>
</table>

**Power**

|            | "HP" ("h") | Mechanical horsepower aka Imperial horsepower. 550 foot-pounds per second. The unit "h" is deprecated and should be replaced with "HP". |
|            | "PS"       | Pferdestärke (German "horse strength", close but not identical to "HP"), the amount of power to lift a mass of 75 kilograms in one second against the earth gravitation between a distance of one meter, approximately 735.49875 W. |
|            | "W" ("w")* | Watt |

**Pressure**

|            | "atm" ("at")* | Atmosphere |
|            | "mmHg"*       | mm of Mercury |
|            | "Pa"*         | Pascal; Pa preferred, as it is the standard abbreviation. Note that "P" or "p" may not be accepted. |
|            | "psi"         | Pounds per square inch, using avoirdupois pounds and international inches. |
|            | "Torr"        | Torr, exactly 101325/760 Pa (this is close but not equal to mmHg) |

**Speed**

<p>|            | &quot;admkn&quot;      | Admiralty knot, exactly 6080 international feet/hour. |
|            | &quot;kn&quot;         | Knot, exactly one Nautical mile per hour or exactly 1852/3600 m/s. Note that this is not an Admiralty knot (&quot;admkn&quot;). |</p>
<table>
<thead>
<tr>
<th>Unit group</th>
<th>Unit symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;m/h&quot; or &quot;m/hr&quot;</td>
<td>Meters per hour</td>
<td></td>
</tr>
<tr>
<td>&quot;m/s&quot; or &quot;m/sec&quot;</td>
<td>Meters per second</td>
<td></td>
</tr>
<tr>
<td>&quot;mph&quot;</td>
<td>Miles per hour (international miles)</td>
<td></td>
</tr>
<tr>
<td>&quot;C&quot; (&quot;cel&quot;)</td>
<td>degrees Celsius</td>
<td></td>
</tr>
<tr>
<td>&quot;F&quot; (&quot;fah&quot;)</td>
<td>degrees Fahrenheit</td>
<td></td>
</tr>
<tr>
<td>&quot;K&quot; (&quot;kel&quot;)</td>
<td>Kelvin</td>
<td></td>
</tr>
<tr>
<td>&quot;Rank&quot;</td>
<td>degrees Rankine</td>
<td></td>
</tr>
<tr>
<td>&quot;Reau&quot;</td>
<td>degrees Réaumur; °C = °Ré · 5/4.</td>
<td></td>
</tr>
<tr>
<td>&quot;day&quot; or &quot;d&quot;</td>
<td>Day (exactly 24 hours)</td>
<td></td>
</tr>
<tr>
<td>&quot;hr&quot;</td>
<td>Hour (exactly 60 minutes)</td>
<td></td>
</tr>
<tr>
<td>&quot;mn&quot; or &quot;min&quot;</td>
<td>Minute (exactly 60 seconds)</td>
<td></td>
</tr>
<tr>
<td>&quot;sec&quot; or &quot;s&quot;</td>
<td>Second (&quot;s&quot; is the official abbreviation of this SI base unit, while &quot;sec&quot; is its traditional abbreviation in the CONVERT function)</td>
<td></td>
</tr>
<tr>
<td>&quot;yr&quot;</td>
<td>Year (exactly 365.25 days, for purposes of this function)</td>
<td></td>
</tr>
<tr>
<td>&quot;ang3&quot; or &quot;ang^3&quot;</td>
<td>Cubic angstrom</td>
<td></td>
</tr>
<tr>
<td>&quot;barrel&quot;</td>
<td>U.S. oil barrel, exactly 42 U.S. customary gallons (liquid). Note that many other units are also called barrels (e.g., a beer barrel in the U.K. is 36 imperial gallons)</td>
<td></td>
</tr>
<tr>
<td>&quot;bushel&quot;</td>
<td>U.S. bushel (not Imperial bushel), interpreted as volume</td>
<td></td>
</tr>
<tr>
<td>&quot;cup.&quot;</td>
<td>Cup (U.S. customary liquid measure)</td>
<td></td>
</tr>
<tr>
<td>&quot;ft3&quot; or &quot;ft^3&quot;</td>
<td>Cubic international feet</td>
<td></td>
</tr>
<tr>
<td>&quot;gal&quot;</td>
<td>Gallon (U.S. customary liquid measure), 3.785411784 liters</td>
<td></td>
</tr>
<tr>
<td>&quot;GRT&quot; (&quot;regton&quot;)</td>
<td>Gross Registered Ton, 100 cubic (international) feet</td>
<td></td>
</tr>
<tr>
<td>&quot;in3&quot; or &quot;in^3&quot;</td>
<td>Cubic international inch</td>
<td></td>
</tr>
<tr>
<td>&quot;l&quot; or &quot;L&quot; (&quot;lt&quot;)</td>
<td>Liter</td>
<td></td>
</tr>
<tr>
<td>Unit group</td>
<td>Unit symbol</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>&quot;ly^3&quot; or &quot;ly^3&quot;</td>
<td>Cubic light-year</td>
<td></td>
</tr>
<tr>
<td>&quot;m^3&quot; or &quot;m^3&quot;</td>
<td>Cubic meter</td>
<td></td>
</tr>
<tr>
<td>&quot;mi^3&quot; or &quot;mi^3&quot;</td>
<td>Cubic international mile</td>
<td></td>
</tr>
<tr>
<td>&quot;mT&quot; or &quot;mTON&quot;</td>
<td>Measurement ton aka “freight ton”, 40 cubic feet</td>
<td></td>
</tr>
<tr>
<td>&quot;Nmi^3&quot; or &quot;Nmi^3&quot;</td>
<td>Cubic nautical mile</td>
<td></td>
</tr>
<tr>
<td>&quot;oz&quot;</td>
<td>Fluid ounce (U.S. customary liquid measure; see “ozm” for ounce mass)</td>
<td></td>
</tr>
<tr>
<td>&quot;Pica^3&quot; or &quot;Pica^3&quot;</td>
<td>Cubic Pica Point (one Pica point is 1/72 inch)</td>
<td></td>
</tr>
<tr>
<td>&quot;picapt^3&quot; or &quot;picapt^3&quot;</td>
<td>Cubic Pica (one Pica is 1/6 inch)</td>
<td></td>
</tr>
<tr>
<td>&quot;pt&quot; or &quot;us_pt&quot;</td>
<td>U.S. Pint (liquid measure)</td>
<td></td>
</tr>
<tr>
<td>&quot;qt&quot;</td>
<td>Quart (U.S. customary liquid measure). This is 0.946352946 liters, and thus not the same as the U.S. dry quart (1.101220 liters), nor is this the same as the Imperial quart (as used in the U.K. and Canada, which is 1.1365225 liters exactly)</td>
<td></td>
</tr>
<tr>
<td>&quot;tbs&quot;</td>
<td>Tablespoon (U.S. customary, traditional meaning). This shall be 0.5 U.S. fluid ounce, not 15mL (common in U.S.) or 20mL (common in Australia).</td>
<td></td>
</tr>
<tr>
<td>&quot;tsp&quot;</td>
<td>Teaspoon (U.S. customary, traditional meaning), 1/6 fluid ounce in U.S. customary measure. This is not the 1/8 Imperial fl. oz. per Imperial units nor the modern teaspoon of 5 mL currently used in the U.S.; see &quot;tspm&quot;</td>
<td></td>
</tr>
<tr>
<td>&quot;tspm&quot;</td>
<td>Modern teaspoon, 5mL</td>
<td></td>
</tr>
<tr>
<td>&quot;uk_gal&quot;</td>
<td>U.K. / Imperial gallon, 4.54609 liters.</td>
<td></td>
</tr>
<tr>
<td>&quot;uk_pt&quot;</td>
<td>U.K. / Imperial pint, 1/8 of a UK gallon.</td>
<td></td>
</tr>
<tr>
<td>&quot;uk_qt&quot;</td>
<td>U.K. / Imperial quart, 1/4 of a UK gallon.</td>
<td></td>
</tr>
<tr>
<td>&quot;yd^3&quot; or &quot;yd^3&quot;</td>
<td>Cubic international yard</td>
<td></td>
</tr>
</tbody>
</table>

If a conversion factor (as listed above) is not exact, an implementation may use a more accurate conversion factor instead.

Implementation-defined unit names should contain a ‘FULL STOP’ (U+002E) character.
<table>
<thead>
<tr>
<th>Unit-group</th>
<th>Unit-symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area</strong></td>
<td>&quot;uk_acre&quot;</td>
<td>International acre (using international feet), exactly 4046.8564224 m², normally not used for U.S. land areas</td>
</tr>
<tr>
<td></td>
<td>&quot;us_acre&quot;</td>
<td>U.S. survey/statute acre (using U.S. survey/statute feet), exactly 4046.8524426/15499969 m²</td>
</tr>
<tr>
<td></td>
<td>&quot;ang2&quot; or &quot;ang^2&quot;</td>
<td>Square angstrom (an Angstrom is exactly 10⁻¹⁰ m)</td>
</tr>
<tr>
<td></td>
<td>&quot;ar&quot; or &quot;a&quot;</td>
<td>are, 100 m² (not abbreviated as &quot;a&quot;)</td>
</tr>
<tr>
<td></td>
<td>&quot;ft2&quot; or &quot;ft^2&quot;</td>
<td>Square international feet (1 foot is exactly 0.3048 m)</td>
</tr>
<tr>
<td></td>
<td>&quot;ha&quot;</td>
<td>hectare, 10.000 m²</td>
</tr>
<tr>
<td></td>
<td>&quot;in2&quot; or &quot;in^2&quot;</td>
<td>Square international inches (1-inch is exactly 2.54 cm)</td>
</tr>
<tr>
<td></td>
<td>&quot;ly&quot; or &quot;ly2&quot;</td>
<td>Square light-year (where year=365.25 days)</td>
</tr>
<tr>
<td></td>
<td>&quot;m2&quot; or &quot;m^2&quot;</td>
<td>Square meters</td>
</tr>
<tr>
<td></td>
<td>&quot;Morgen&quot;</td>
<td>Morgen, 2500 m²</td>
</tr>
<tr>
<td></td>
<td>&quot;mi2&quot; or &quot;mi^2&quot;</td>
<td>Square international miles</td>
</tr>
<tr>
<td></td>
<td>&quot;Nmi2&quot; or &quot;Nmi^2&quot;</td>
<td>Square nautical miles (1 nautical mile is 1852 m)</td>
</tr>
<tr>
<td></td>
<td>&quot;Pica2&quot; or &quot;Pica^2&quot;</td>
<td>Square Pica (one Pica is 1/72 in.)</td>
</tr>
<tr>
<td></td>
<td>&quot;yd2&quot; or &quot;yd^2&quot;</td>
<td>Square international yards (1 yard is 0.9144 m)</td>
</tr>
<tr>
<td><strong>Distance</strong></td>
<td>&quot;ang&quot;</td>
<td>Angstrom, exactly 10⁻¹⁰ m</td>
</tr>
<tr>
<td><strong>(Length)</strong></td>
<td>&quot;ell&quot;</td>
<td>Ell, exactly 45 international inches</td>
</tr>
<tr>
<td></td>
<td>&quot;ft&quot;</td>
<td>International Foot, exactly 0.3048 m and also exactly 12 international inches</td>
</tr>
<tr>
<td></td>
<td>&quot;in&quot;</td>
<td>International Inch, exactly 2.54 cm</td>
</tr>
<tr>
<td></td>
<td>&quot;ly&quot; *</td>
<td>Light-year, the distance light travels in a vacuum, in a Julian-year of 365.25 days</td>
</tr>
<tr>
<td></td>
<td>&quot;m&quot; *</td>
<td>Meter</td>
</tr>
<tr>
<td></td>
<td>&quot;mi&quot;</td>
<td>International Mile, exactly 1609.344 m and exactly 5280 international feet. This is not a U.S. survey/statute mile (see &quot;smi&quot;) nor a nautical mile (see &quot;Nmi&quot;), but this is the mile normally used in the U.S. customary system</td>
</tr>
<tr>
<td></td>
<td>&quot;Nmi&quot;</td>
<td>International nautical mile, exactly 1852 m. Note that this is not the obsolete U.S. nautical mile nor the Admiralty mile.</td>
</tr>
<tr>
<td>Unit-group</td>
<td>Unit-symbol</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>&quot;parsec&quot; or &quot;pc&quot;</td>
<td>*</td>
<td>Distance from sun to a point having heliocentric parallax of one-second (used for stellar distance)*</td>
</tr>
<tr>
<td>&quot;pica&quot;</td>
<td>Pica (1/72 in.)</td>
<td></td>
</tr>
<tr>
<td>&quot;survey_mi&quot;</td>
<td>U.S. survey mile, aka U.S. statute mile, exactly 6336000/3937 m; used in some U.S. maps. This is not the mile (see &quot;mi&quot;) normally used in the U.S.</td>
<td></td>
</tr>
<tr>
<td>&quot;yd&quot;</td>
<td>International yard, exactly 0.9144 m and exactly 3 international feet.</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>&quot;BTU&quot; (&quot;btu&quot;)</td>
<td>International Table British Thermal Unit</td>
</tr>
<tr>
<td></td>
<td>&quot;e&quot; *</td>
<td>Thermodynamic calorie, 4.184 J. This is not a dietary Calorie (kilocalorie). For high accuracy, use Joule, due to the many conflicting definitions of calorie.</td>
</tr>
<tr>
<td></td>
<td>&quot;cal&quot; *</td>
<td>International Table (IT) calorie, 4.1868 J. This is not a dietary Calorie (kilocalorie). For high accuracy, use Joule, due to the many conflicting definitions of calorie.</td>
</tr>
<tr>
<td></td>
<td>&quot;eV&quot; (&quot;ev&quot;). *</td>
<td>Electron volt (eV-preferred)</td>
</tr>
<tr>
<td></td>
<td>&quot;flb&quot;</td>
<td>Foot-pound (international foot, avoirdupois pound)</td>
</tr>
<tr>
<td></td>
<td>&quot;HPh&quot; (&quot;hh&quot;).</td>
<td>Horsepower-hour (HPh-preferred)</td>
</tr>
<tr>
<td></td>
<td>&quot;J&quot; *</td>
<td>Joule</td>
</tr>
<tr>
<td></td>
<td>&quot;Wh&quot; (&quot;wh&quot;). *</td>
<td>Watt-hour</td>
</tr>
<tr>
<td>Force-(Weight)</td>
<td>&quot;dyn&quot; (&quot;dy&quot;) *</td>
<td>Dyne</td>
</tr>
<tr>
<td></td>
<td>&quot;N&quot; *</td>
<td>Newton</td>
</tr>
<tr>
<td></td>
<td>&quot;lbf&quot;</td>
<td>Pound force (see &quot;lbm&quot; for pound mass)</td>
</tr>
<tr>
<td></td>
<td>&quot;pond&quot; *</td>
<td>Pond, gravitational force on a mass of one gram</td>
</tr>
<tr>
<td>Information</td>
<td>&quot;bit&quot; *†</td>
<td>bit</td>
</tr>
<tr>
<td></td>
<td>&quot;byte&quot; *†</td>
<td>byte = 8 bits</td>
</tr>
<tr>
<td>Magnetic-Flux-Density</td>
<td>&quot;gauss&quot;</td>
<td>Gauss</td>
</tr>
<tr>
<td></td>
<td>&quot;T&quot; *</td>
<td>Tesla</td>
</tr>
<tr>
<td>Unit-group</td>
<td>Unit-symbol</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Mass</td>
<td>&quot;g&quot;*</td>
<td>Gram</td>
</tr>
<tr>
<td></td>
<td>&quot;grain&quot;</td>
<td>Grain, 1/7000 international pound mass (avoirdupois) (U.S. usage).</td>
</tr>
<tr>
<td></td>
<td>&quot;cwt&quot; (&quot;shweight&quot;)</td>
<td>U.S. (short) hundredweight, 100 lbm</td>
</tr>
<tr>
<td></td>
<td>&quot;uk_cwt&quot; or &quot;lcwt&quot; (&quot;hweight&quot;)</td>
<td>Imperial hundredweight, aka long hundredweight, 112 lbm</td>
</tr>
<tr>
<td></td>
<td>&quot;lbn&quot;</td>
<td>International pound mass (avoirdupois), exactly 453.59237 g (see &quot;lbf&quot; for pound force)</td>
</tr>
<tr>
<td></td>
<td>&quot;stone&quot;</td>
<td>14 international pound mass (avoirdupois)</td>
</tr>
<tr>
<td></td>
<td>&quot;ton&quot;</td>
<td>2000 international pound mass (avoirdupois) (U.S. usage). Note that there are many other measures also called &quot;ton&quot;; in particular, this is not a metric ton (tonne).</td>
</tr>
<tr>
<td></td>
<td>&quot;ozm&quot;</td>
<td>Ounce mass (avoirdupois), exactly 1/16 of an international pound mass (avoirdupois) (see &quot;oz&quot; for fluid ounce)</td>
</tr>
<tr>
<td></td>
<td>&quot;sg&quot;</td>
<td>Slug; 32.174 international pound mass (avoirdupois)</td>
</tr>
<tr>
<td></td>
<td>&quot;u&quot;*</td>
<td>U (atomic mass unit)</td>
</tr>
<tr>
<td></td>
<td>&quot;uk_ton&quot; or &quot;LTON&quot; (&quot;brton&quot;)</td>
<td>Imperial ton, aka &quot;long ton&quot;, &quot;deadweight ton&quot;, or &quot;weight ton&quot;; 2240 lbm.</td>
</tr>
<tr>
<td>Power</td>
<td>&quot;HP&quot; (&quot;h&quot;)</td>
<td>Horsepower. The unit &quot;h&quot; is deprecated and should be replaced with &quot;HP&quot;.</td>
</tr>
<tr>
<td></td>
<td>&quot;PS&quot;</td>
<td>Pferdestärke (German &quot;horse-strength&quot;, close but not identical to &quot;HP&quot;)</td>
</tr>
<tr>
<td></td>
<td>&quot;W&quot; (&quot;w&quot;)*</td>
<td>Watt</td>
</tr>
<tr>
<td>Pressure</td>
<td>&quot;atm&quot; (&quot;at&quot;)*</td>
<td>Atmosphere</td>
</tr>
<tr>
<td></td>
<td>&quot;mmHg&quot;*</td>
<td>mm of Mercury</td>
</tr>
<tr>
<td></td>
<td>&quot;Pa&quot;*</td>
<td>Pascal; Pa preferred, as it is the standard abbreviation. Note that &quot;P&quot; or &quot;p&quot; may not be accepted.</td>
</tr>
<tr>
<td></td>
<td>&quot;psi&quot;</td>
<td>Pounds per square inch, using avoirdupois pounds and international inches.</td>
</tr>
<tr>
<td></td>
<td>&quot;Torr&quot;</td>
<td>Torr, exactly 101325/760 Pa (this is close but not equal).</td>
</tr>
<tr>
<td>Unit group</td>
<td>Unit symbol</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Speed</td>
<td>&quot;admkn&quot;</td>
<td>Admiralty knot, exactly 6080 international feet/hour.</td>
</tr>
<tr>
<td></td>
<td>&quot;kn&quot;</td>
<td>Knot, exactly one Nautical mile per hour or exactly 1852/3600 m/s. Note that this is not an Admiralty knot (&quot;admkn&quot;).</td>
</tr>
<tr>
<td></td>
<td>&quot;m/h&quot; or &quot;m/hr&quot;</td>
<td>Meters per-hour</td>
</tr>
<tr>
<td></td>
<td>&quot;m/s&quot; or &quot;m/sec&quot;</td>
<td>Meters per-second</td>
</tr>
<tr>
<td></td>
<td>&quot;mph&quot;</td>
<td>Miles per-hour (international miles)</td>
</tr>
<tr>
<td>Temperature</td>
<td>&quot;°C&quot; (&quot;cel&quot;)</td>
<td>degrees Celsius</td>
</tr>
<tr>
<td></td>
<td>&quot;°F&quot; (&quot;fah&quot;)</td>
<td>degrees Fahrenheit</td>
</tr>
<tr>
<td></td>
<td>&quot;°K&quot; (&quot;kel&quot;)</td>
<td>Kelvin</td>
</tr>
<tr>
<td></td>
<td>&quot;°Rank&quot;</td>
<td>degrees Rankine</td>
</tr>
<tr>
<td></td>
<td>&quot;°Reau&quot;</td>
<td>degrees Réaumur; °C = °Ré · 5/4.</td>
</tr>
<tr>
<td>Time</td>
<td>&quot;day&quot; or &quot;d&quot;</td>
<td>Day (exactly 24 hours)</td>
</tr>
<tr>
<td></td>
<td>&quot;hr&quot;</td>
<td>Hour (exactly 60 minutes)</td>
</tr>
<tr>
<td></td>
<td>&quot;mn&quot; or &quot;min&quot;</td>
<td>Minute (exactly 60 seconds)</td>
</tr>
<tr>
<td></td>
<td>&quot;sec&quot; or &quot;s&quot;</td>
<td>Second (&quot;s&quot; is the official abbreviation of this SI base unit, while &quot;sec&quot; is its traditional abbreviation in the CONVERT function)</td>
</tr>
<tr>
<td></td>
<td>&quot;yr&quot;</td>
<td>Year (exactly 365.25 days, for purposes of this function)</td>
</tr>
<tr>
<td>Volume</td>
<td>&quot;ang3&quot; or &quot;ang^3&quot;</td>
<td>Cubic angstrom</td>
</tr>
<tr>
<td></td>
<td>&quot;barrel&quot;</td>
<td>U.S. oil barrel, exactly 42 U.S. customary gallons (liquid). Note that many other units are also called barrels (e.g., a beer barrel in the U.K. is 36 Imperial gallons)</td>
</tr>
<tr>
<td></td>
<td>&quot;bushel&quot;</td>
<td>U.S. bushel (not Imperial bushel), interpreted as volume</td>
</tr>
<tr>
<td></td>
<td>&quot;cup&quot;</td>
<td>Cup (U.S. customary liquid measure)</td>
</tr>
<tr>
<td></td>
<td>&quot;ft3&quot; or &quot;ft^3&quot;</td>
<td>Cubic international feet</td>
</tr>
<tr>
<td>Unit-group</td>
<td>Unit-symbol</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>----------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>&quot;gal&quot;</td>
<td></td>
<td>Gallon (U.S. customary liquid measure)</td>
</tr>
<tr>
<td>&quot;GRT&quot; (&quot;regton&quot;)</td>
<td></td>
<td>Gross Registered Ton, 100 cubic (international) feet</td>
</tr>
<tr>
<td>&quot;in³&quot; or &quot;in^3&quot;</td>
<td></td>
<td>Cubic international-inch</td>
</tr>
<tr>
<td>&quot;L&quot; or &quot;L&quot; (&quot;lt&quot;)</td>
<td></td>
<td>Liter</td>
</tr>
<tr>
<td>&quot;ly³&quot; or &quot;ly^3&quot;</td>
<td></td>
<td>Cubic-light-year</td>
</tr>
<tr>
<td>&quot;m³&quot; or &quot;m^3&quot; *</td>
<td></td>
<td>Cubic-meter</td>
</tr>
<tr>
<td>&quot;mi³&quot; or &quot;mi^3&quot;</td>
<td></td>
<td>Cubic-international-mile</td>
</tr>
<tr>
<td>&quot;MTON&quot;</td>
<td></td>
<td>Measurement-ton aka &quot;freight ton&quot;, 40 cubic feet</td>
</tr>
<tr>
<td>&quot;Nmi³&quot; or &quot;Nmi^3&quot;</td>
<td></td>
<td>Cubic nautical-mile</td>
</tr>
<tr>
<td>&quot;oz&quot;</td>
<td></td>
<td>Fluid-ounce (U.S. customary liquid measure; see &quot;ozm&quot; for ounce mass)</td>
</tr>
<tr>
<td>&quot;Pica³&quot; or &quot;Pica^3&quot;</td>
<td></td>
<td>Cubic-Pica</td>
</tr>
<tr>
<td>&quot;pt&quot; or &quot;us_pt&quot;</td>
<td></td>
<td>U.S. Pint (liquid measure)</td>
</tr>
<tr>
<td>&quot;qt&quot;</td>
<td></td>
<td>Quart (U.S. customary liquid measure). This is 0.946352946 liters, and thus not the same as the U.S. dry quart (1.101220 liters), nor is this the same as the Imperial quart (as used in the U.K. and Canada, which is 1.1365225 liters exactly)</td>
</tr>
<tr>
<td>&quot;tbs&quot;</td>
<td></td>
<td>Tablespoon (U.S. customary, traditional meaning). This shall be 0.5 U.S. fluid ounce, not 15mL (common in U.S.) or 20mL (common in Australia).</td>
</tr>
<tr>
<td>&quot;tsp&quot;</td>
<td></td>
<td>Teaspoon (U.S. customary, traditional meaning). 1/6 fluid-ounce in U.S. customary measure. This is not the 1/8 Imperial fl. oz. per Imperial units nor the modern teaspoon of 5 mL currently used in the U.S.; see &quot;tspm&quot;</td>
</tr>
<tr>
<td>&quot;tspm&quot;</td>
<td></td>
<td>Modern teaspoon, 5mL</td>
</tr>
<tr>
<td>&quot;uk_gal&quot;</td>
<td></td>
<td>U.K. / Imperial-gallon</td>
</tr>
<tr>
<td>&quot;uk_pt&quot;</td>
<td></td>
<td>U.K. / Imperial-pint</td>
</tr>
<tr>
<td>&quot;uk_qt&quot;</td>
<td></td>
<td>U.K. / Imperial-quart</td>
</tr>
<tr>
<td>&quot;yd³&quot; or &quot;yd^3&quot;</td>
<td></td>
<td>Cubic-international-yard</td>
</tr>
</tbody>
</table>

Evaluators shall support decimal prefixes for unit symbols marked with * and binary prefixes for unit symbols marked with †. Evaluators should not support prefixes for other unit symbols.
The unit symbols in parentheses are deprecated unit symbols; evaluators shall support these unit symbols.

Evaluators should use internationally-standardized unit name abbreviations for such additions where possible. Evaluators may support the obsolete symbols "p" and "P" as unit names for Pascals.

For purposes of this function, a year is exactly 365.25 days long.

Evaluators claiming to support this function shall permit the following unit decimal prefixes to be prepended to any unit symbol marked with "*" in the unit table cell above. Adding a unit prefix indicates multiplication of the (scalar) unit by the given prefix value; for example km indicates kilometres, and km2 or km^2 indicate square kilometres.
<table>
<thead>
<tr>
<th>Unit Prefix</th>
<th>Description</th>
<th>Prefix Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;y&quot;</td>
<td>yotta</td>
<td>1E+24</td>
</tr>
<tr>
<td>&quot;z&quot;</td>
<td>zetta</td>
<td>1E+21</td>
</tr>
<tr>
<td>&quot;E&quot;</td>
<td>exa</td>
<td>1E+18</td>
</tr>
<tr>
<td>&quot;P&quot;</td>
<td>peta</td>
<td>1E+15</td>
</tr>
<tr>
<td>&quot;T&quot;</td>
<td>tera</td>
<td>1E+12</td>
</tr>
<tr>
<td>&quot;G&quot;</td>
<td>giga</td>
<td>1E+09</td>
</tr>
<tr>
<td>&quot;M&quot;</td>
<td>mega</td>
<td>1E+06</td>
</tr>
<tr>
<td>&quot;k&quot;</td>
<td>kilo</td>
<td>1E+03</td>
</tr>
<tr>
<td>&quot;h&quot;</td>
<td>hecto</td>
<td>1E+02</td>
</tr>
<tr>
<td>&quot;da&quot; or &quot;e&quot;</td>
<td>deka (</td>
<td>1E+01</td>
</tr>
<tr>
<td></td>
<td>Note: “e” is not a standard SI prefix</td>
<td></td>
</tr>
<tr>
<td>&quot;d&quot;</td>
<td>deci</td>
<td>1E-01</td>
</tr>
<tr>
<td>&quot;c&quot;</td>
<td>centi</td>
<td>1E-02</td>
</tr>
<tr>
<td>&quot;m&quot;</td>
<td>milli</td>
<td>1E-03</td>
</tr>
<tr>
<td>&quot;µ&quot;</td>
<td>micro</td>
<td>1E-06</td>
</tr>
<tr>
<td></td>
<td>Note: this is “µ”, not the standard SI µ</td>
<td></td>
</tr>
<tr>
<td>&quot;n&quot;</td>
<td>nano</td>
<td>1E-09</td>
</tr>
<tr>
<td>&quot;p&quot;</td>
<td>pico</td>
<td>1E-12</td>
</tr>
<tr>
<td>&quot;f&quot;</td>
<td>femto</td>
<td>1E-15</td>
</tr>
<tr>
<td>&quot;a&quot;</td>
<td>atto</td>
<td>1E-18</td>
</tr>
<tr>
<td>&quot;z&quot;</td>
<td>zepto</td>
<td>1E-21</td>
</tr>
<tr>
<td>&quot;y&quot;</td>
<td>yocto</td>
<td>1E-24</td>
</tr>
<tr>
<td>Unit-Prefix</td>
<td>Description</td>
<td>Prefix-Value</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td>&quot;Y&quot;</td>
<td>yotta</td>
<td>1E+24</td>
</tr>
<tr>
<td>&quot;Z&quot;</td>
<td>zetta</td>
<td>1E+21</td>
</tr>
<tr>
<td>&quot;E&quot;</td>
<td>exa</td>
<td>1E+18</td>
</tr>
<tr>
<td>&quot;P&quot;</td>
<td>peta</td>
<td>1E+15</td>
</tr>
<tr>
<td>&quot;T&quot;</td>
<td>tera</td>
<td>1E+12</td>
</tr>
<tr>
<td>&quot;G&quot;</td>
<td>giga</td>
<td>1E+09</td>
</tr>
<tr>
<td>&quot;M&quot;</td>
<td>mega</td>
<td>1E+06</td>
</tr>
<tr>
<td>&quot;k&quot;</td>
<td>kilo</td>
<td>1E+03</td>
</tr>
<tr>
<td>&quot;h&quot;</td>
<td>hecto</td>
<td>1E+02</td>
</tr>
<tr>
<td>&quot;da&quot; or &quot;e&quot;</td>
<td>deka (note: &quot;e&quot; is not a standard SI prefix)</td>
<td>1E+01</td>
</tr>
<tr>
<td>&quot;d&quot;</td>
<td>deci</td>
<td>1E-01</td>
</tr>
<tr>
<td>&quot;c&quot;</td>
<td>centi</td>
<td>1E-02</td>
</tr>
<tr>
<td>&quot;m&quot;</td>
<td>milli</td>
<td>1E-03</td>
</tr>
<tr>
<td>&quot;u&quot;</td>
<td>micro (note: this is &quot;u&quot;, not the standard SI µ)</td>
<td>1E-06</td>
</tr>
<tr>
<td>&quot;n&quot;</td>
<td>nano</td>
<td>1E-09</td>
</tr>
<tr>
<td>&quot;p&quot;</td>
<td>pico</td>
<td>1E-12</td>
</tr>
<tr>
<td>&quot;f&quot;</td>
<td>femto</td>
<td>1E-15</td>
</tr>
<tr>
<td>&quot;a&quot;</td>
<td>atto</td>
<td>1E-18</td>
</tr>
<tr>
<td>&quot;z&quot;</td>
<td>zepto</td>
<td>1E-21</td>
</tr>
<tr>
<td>&quot;y&quot;</td>
<td>yocto</td>
<td>1E-24</td>
</tr>
</tbody>
</table>

The prefix "e" for 10⁻¹ is nonstandard and included for backward compatibility with legacy applications and documents.

The unit names marked with † in the unit symbol table above (see the Information group) shall also support the following binary prefixes per IEC 60027-2:
### Table 28 - Binary prefixes for use in CONVERT

<table>
<thead>
<tr>
<th>Binary Unit Prefix</th>
<th>Description</th>
<th>Prefix Value</th>
<th>Derived from</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Yi&quot;</td>
<td>yobi</td>
<td>$2^{80} = 1 208 925 819 614 629 174 706 176$</td>
<td>yotta</td>
</tr>
<tr>
<td>&quot;Zi&quot;</td>
<td>zebi</td>
<td>$2^{70} = 1 180 591 620 717 411 303 424$</td>
<td>zetta</td>
</tr>
<tr>
<td>&quot;Ei&quot;</td>
<td>exbi</td>
<td>$2^{60} = 1 152 921 504 606 846 976$</td>
<td>exa</td>
</tr>
<tr>
<td>&quot;Pi&quot;</td>
<td>pebi</td>
<td>$2^{50} = 1 125 899 906 842 624$</td>
<td>peta</td>
</tr>
<tr>
<td>&quot;Ti&quot;</td>
<td>tebi</td>
<td>$2^{40} = 1 099 511 627 776$</td>
<td>terra</td>
</tr>
<tr>
<td>&quot;Gi&quot;</td>
<td>gibi</td>
<td>$2^{30} = 1 073 741 824$</td>
<td>giga</td>
</tr>
<tr>
<td>&quot;Mi&quot;</td>
<td>mebi</td>
<td>$2^{20} = 1 048 576$</td>
<td>mega</td>
</tr>
</tbody>
</table>
| "K"
| ki
| b
| ^{10} = 1024 | kilo |

<table>
<thead>
<tr>
<th>Binary Unit Prefix</th>
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<th>Prefix Value</th>
<th>Derived from</th>
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</thead>
<tbody>
<tr>
<td>&quot;Yi&quot;</td>
<td>yebi</td>
<td>$2^{80} = 1 208 925 819 614 629 174 706 176$</td>
<td>yetta</td>
</tr>
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<td>&quot;Zi&quot;</td>
<td>zebi</td>
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<tr>
<td>&quot;Ei&quot;</td>
<td>exbi</td>
<td>$2^{60} = 1 152 921 504 606 846 976$</td>
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<td>&quot;Pi&quot;</td>
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<tr>
<td>&quot;Gi&quot;</td>
<td>gibi</td>
<td>$2^{30} = 1 073 741 824$</td>
<td>giga</td>
</tr>
<tr>
<td>&quot;Mi&quot;</td>
<td>mebi</td>
<td>$2^{20} = 1 048 576$</td>
<td>mega</td>
</tr>
</tbody>
</table>
| "K"
| ki
| ^{10} = 1024 | kilo |

In the case where there is a naming conflict (a unit name with a prefix is the same as an unprefixed name), the unprefixed name shall take precedence.

Evaluators may implement this conversion by first converting to some SI unit (e.g., meter and kilogram), and then convert again to the final unit.

See also EUROCONVERT 8.16.29

### 8.16.19 COS

**Summary:** Return the cosine of an angle specified in radians.

**Syntax:** COS( Number N )

**Returns:** Number

**Constraints:** None

**Semantics:** Computes the cosine of an angle specified in radians.
\[
\cos N = 1 - \frac{N^2}{2!} + \frac{N^4}{4!} - \frac{N^6}{6!} + \ldots
\]

See also ACOS 8.16.3, RADIANS 8.16.49, DEGREES 8.16.25

### 8.16.20 COSH

**Summary:** Return the hyperbolic cosine of the given hyperbolic angle

**Syntax:** `COSH(Number N )`

**Returns:** Number

**Constraints:** None

**Semantics:** Computes the hyperbolic cosine of a hyperbolic angle. The hyperbolic cosine is an analog of the ordinary (circular) cosine. The points \((\cosh t, \sinh t)\) define the right half of the equilateral hyperbola, just as the points \((\cos t, \sin t)\) define the points of a circle.

\[
\cosh(N) = \frac{e^N + e^{-N}}{2}
\]

See also ACOSH 8.16.4, SINH 8.16.56, TANH 8.16.70

### 8.16.21 COT

**Summary:** Return the cotangent of an angle specified in radians

**Syntax:** `COT(Number N )`

**Returns:** Number

**Constraints:** None

**Semantics:** Computes the cotangent of an angle specified in radians.

\[
\cot(x) = \frac{1}{\tan(x)}
\]

See also ACOT 8.16.5, TAN 8.16.69, RADIANS 8.16.49, DEGREES 8.16.25, SIN 8.16.55, COS 8.16.19

### 8.16.22 COTH

**Summary:** Return the hyperbolic cotangent of the given hyperbolic angle

**Syntax:** `COTH(Number N )`

**Returns:** Number

**Constraints:** N<>0

**Semantics:** Computes the hyperbolic cotangent of a hyperbolic angle. The hyperbolic cotangent is an analog of the ordinary (circular) cotangent.

\[
\coth(N) = \frac{1}{\tanh(N)} = \frac{\cosh(N)}{\sinh(N)} = \frac{e^N + e^{-N}}{e^N - e^{-N}}
\]

See also ACOSH 8.16.4, SINH 8.16.56, TANH 8.16.70
8.16.23 CSC

Summary: Return the cosecant of an angle specified in radians.
Syntax: CSC( Number N )
Returns: Number
Constraints: None
Semantics: Computes the cosecant cosine of an angle specified in radians. Equivalent to:
\[ 1/\sin(N) \]
See also SIN 8.16.55

8.16.24 CSCH

Summary: Return the hyperbolic cosecant of the given angle specified in radians
Syntax: CSCH( Number N )
Returns: Number
Constraints: None
Semantics: Computes the hyperbolic cosecant of a hyperbolic angle. This is equivalent to:
\[ 1/\sinh(N) \]
See also SINH 8.16.56, CSCH

8.16.25 DEGREES

Summary: Convert radians to degrees.
Syntax: DEGREES( Number N )
Returns: Number
Constraints: None
Semantics: Converts a number in radians into a number in degrees. DEGREES(N) is equal to
\[ N \times 180/\pi \]
See also RADIANS 8.16.49, PI 8.16.45

8.16.26 DELTA

Summary: Report if two numbers are equal, returns 1 if they are equal.
Syntax: DELTA( Number X [ ; Number Y = 0 ] )
Returns: Number
Constraints: None
Semantics: If X and Y are equal, return 1, else 0. Y is set to 0 if omitted.
See also Infix operator “=“ 8.4.7
**8.16.27 ERF**

**Summary:** Calculates the error function.

**Syntax:** `ERF( Number z0 [ ; Number z1 ] )`

**Returns:** Number

**Constraints:** None

**Semantics:** With a single argument, returns the error function of $z0$:

$$ERF(z0) = \frac{2}{\sqrt{\pi}} \int_0^{z0} e^{-t^2} dt$$

With two arguments, returns

$$ERF(z0 ; z1) = \frac{2}{\sqrt{\pi}} \int_{z0}^{z1} e^{-t^2} dt$$

**See also** ERFC 8.16.28

---

**8.16.28 ERFC**

**Summary:** Calculates the complementary error function.

**Syntax:** `ERFC( Number z )`

**Returns:** Number

**Constraints:** None

**Semantics:** returns the complementary error function of $z$: $ERFC(z) = 1 – ERF(z)$

**See also** ERF 8.16.27

---

**8.16.29 EUROCONVERT**

**Summary:** Converts a Number, representing a value in one European currency, to an equivalent value in another European currency, according to the fixed conversion rates defined by the Council of the European Union.

**Syntax:** `EUROCONVERT( Number N ; Text From ; Text To [ ; Logical FullPrecision = FALSE() [ ; Integer TriangulationPrecision ] ] )`

**Returns:** Currency

**Constraints:** From and To shall be known to the evaluator. TriangulationPrecision shall be $\geq 3$, if not omitted.

If an evaluator does not support the parameters FullPrecision and TriangulationPrecision, FullPrecision should be assumed to be false.

**Semantics:** Returns the given money value of a conversion from From currency into To currency. Both From and To shall be the official [ISO4217] abbreviation for the given currency; note that these are in upper case, but the function accepts lower case or mixed case as well. If From and To are equal currencies, the value $N$ is returned, no precision or triangulation is applied.
The function shall use the rates of exchange as set by the European Commission, as follows:

### Table 29 - EUROCONVERT

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Rate</th>
<th>Currency</th>
<th>Decimals</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;ATS&quot;</td>
<td>13.7603</td>
<td>Austrian Schilling</td>
<td>2</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;BEF&quot;</td>
<td>40.3399</td>
<td>Belgian Franc</td>
<td>0</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;DEM&quot;</td>
<td>1.95583</td>
<td>German Mark</td>
<td>2</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;ESP&quot;</td>
<td>166.386</td>
<td>Spanish Peseta</td>
<td>0</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;FIM&quot;</td>
<td>5.94573</td>
<td>Finnish Markka</td>
<td>2</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;FRF&quot;</td>
<td>6.55957</td>
<td>French Franc</td>
<td>2</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;IEP&quot;</td>
<td>0.787564</td>
<td>Irish Pound</td>
<td>2</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;ITL&quot;</td>
<td>1936.27</td>
<td>Italian Lira</td>
<td>0</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;LUF&quot;</td>
<td>40.3399</td>
<td>Luxembourg Franc</td>
<td>0</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;NLG&quot;</td>
<td>2.20371</td>
<td>Dutch Guilder</td>
<td>2</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;PTE&quot;</td>
<td>200.482</td>
<td>Portuguese Escudo</td>
<td>2</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;GRD&quot;</td>
<td>340.750</td>
<td>Greek Drachma</td>
<td>2</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;SIT&quot;</td>
<td>239.640</td>
<td>Slovenian Tolar</td>
<td>2</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;MTL&quot;</td>
<td>0.429300</td>
<td>Maltese Lira</td>
<td>2</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;CYP&quot;</td>
<td>0.585274</td>
<td>Cypriot Pound</td>
<td>2</td>
</tr>
<tr>
<td>&quot;EUR&quot;</td>
<td>&quot;SKK&quot;</td>
<td>30.1260</td>
<td>Slovak Koruna</td>
<td>2</td>
</tr>
</tbody>
</table>

As new member countries adopt the Euro, new conversion rates will become active and evaluators may add them using the respective [ISO4217](http://www.iso.org/iso/iso4217) codes and fixed rates as defined by the European Council, on the basis of a European Commission proposal.

**Note:**
The European Commission’s Euro entry page is [http://ec.europa.eu/euro/](http://ec.europa.eu/euro/)

If `FullPrecision` is omitted or False, the result is rounded according to the decimals of the *To* currency. If `FullPrecision` is True the result is not rounded.

If `TriangulationPrecision` is given and >=3, the intermediate result of a triangular conversion (currency1,EUR,currency2) is rounded to that precision. If `TriangulationPrecision` is omitted, the intermediate result is not rounded. Also if To currency is “EUR”, `TriangulationPrecision` precision is used as if triangulation was needed and conversion from EUR to EUR was applied.

**See also** CONVERT
8.16.30 EVEN

Summary: Rounds a number up to the nearest even integer. Rounding is away from zero.

Syntax: EVEN( Number N )

Returns: Number

Constraints: None

Semantics: Returns the even integer whose sign is the same as N's and whose absolute value is greater than or equal to the absolute value of N.

See also ODD 8.16.44

8.16.31 EXP

Summary: Returns e raised by the given number.

Syntax: EXP( Number X )

Returns: Number

Constraints: None

Semantics: Computes

\[ e^x = 1 + \frac{X}{1!} + \frac{X^2}{2!} + \frac{X^3}{3!} + \frac{X^n}{n!} + ... \]

See also LOG 8.16.40, LN 8.16.39

8.16.32 FACT

Summary: Return factorial (!). 

Syntax: FACT( Integer F )

Returns: Number

Constraints: F >= 0

Semantics: Return the factorial

\[ F! = F \cdot (F-1) \cdot (F-2) \cdot ... \cdot 1 \]

F(0)=F(1)=1.

See also Infix Operator "*** 8.4.4, GAMMA 8.16.34

8.16.33 FACTDOUBLE

Summary: Returns double factorial (!!!).

Syntax: FACTDOUBLE( Integer F )

Returns: Number

Constraints: F >= 0
Semantics: Return

\[ F! = F \cdot (F - 2) \cdot (F - 4) \cdots 1 \]

Double factorial is computed by multiplying every other number in the 1..N range, with N always being included.

See also Infix Operator "*** 8.4.4, GAMMA 8.16.34, FACT 8.16.32

8.16.34 GAMMA

Summary: Return gamma function value.

Syntax: GAMMA( Number N )

Returns: Number

Constraints: N<>0 and N not a negative integer.

Semantics: Return

\[ \Gamma(N) = \int_{0}^{\infty} t^{N-1} e^{-t} dt \]

with \( \Gamma(N+1) = N \cdot \Gamma(N) \). Note that for non-negative integers \( N, \Gamma(N+1) = N! = FACT(N) \). Note that GAMMA can accept non-integers.

See also FACT 8.16.32

8.16.35 GAMMALN

Summary: Returns the natural logarithm of the GAMMA function.

Syntax: GAMMALN( Number X )

Returns: Number

Constraints: For each \( X, X > 0 \)

Semantics: Returns the same value as =LN(GAMMA(X))

See also GAMMA 8.16.34, FACT 8.16.32

8.16.36 GCD

Summary: Returns the greatest common divisor (GCD)

Syntax: GCD( { NumberSequenceList X }+ )

Returns: Number

Constraints: For all a in X: INT(a) >= 0 and for at least one a in X: INT(a)>0

Semantics: Return the largest integer \( N \) such that for every \( a \) in X: INT(a) is a multiple of \( N \).

Note: If for all a in X: INT(a)=0 the return value is implementation-defined but is either an Error or 0.

See also LCM 8.16.38
8.16.37 GESTEP

Summary: Returns 1 if a number is greater than or equal to another number, else returns 0.

Syntax: GESTEP( Number X [ ; Number Step = 0 ] )

Returns: Number

Semantics: Number X is tested against number Step. If greater or equal 1 is returned, else 0. The second parameter is assumed 0 if omitted. If one of the parameters is not a Number, the function results in an Error.

See also

8.16.38 LCM

Summary: Returns the least common multiplier

Syntax: LCM( { NumberSequenceList X }+ )

Returns: Number

Constraints: For all in X: INT(X)=X, X >= 0

Semantics: Return the smallest integer that is the multiple of the given values. Each value has INT applied to it first. Note that if given two numbers, ABS(a*b)=LCM(a;b)*GCD(a;b).

See also GCD 8.16.36

8.16.39 LN

Summary: Return the natural logarithm of a number.

Syntax: LN( Number X )

Returns: Number

Constraints: X>0

Semantics: Computes the natural logarithm (base e) of the given number.

\[ \ln x = 2 \left[ \frac{x-1}{x+1} + \frac{1}{3} \left( \frac{x-1}{x+1} \right)^3 + \frac{1}{5} \left( \frac{x-1}{x+1} \right)^5 + \ldots \right] \]

See also LOG 8.16.40, LOG10 8.16.41, POWER 8.16.46, EXP 8.16.31

8.16.40 LOG

Summary: Return the logarithm of a number in a specified base.

Syntax: LOG( Number N [ ; Number Base = 10 ] )

Returns: Number

Constraints: N > 0

Semantics: Computes the logarithm of a number in the specified base. Note that if the base is not specified, the logarithm base 10 is returned.

See also LOG10 8.16.41, LN 8.16.39, POWER 8.16.46, EXP 8.16.31
8.16.41 LOG10

**Summary**: Return the base 10 logarithm of a number.

**Syntax**: LOG10( Number N )

**Returns**: Number

**Constraints**: N > 0

**Semantics**: Computes the base 10 logarithm of a number.

**See also** LOG 8.16.40, LN 8.16.39, POWER 8.16.46, EXP 8.16.31

8.16.42 MOD

**Summary**: Return the remainder when one number is divided by another number.

**Syntax**: MOD( Number a ; Number b )

**Returns**: Number

**Constraints**: b != 0

**Semantics**: Computes the remainder of a/b. The remainder has the same sign as b.

**See also** Infix Operator "/" 8.4.5, QUOTIENT 8.16.48

8.16.43 MULTINOMIAL

**Summary**: Returns the multinomial for the given values.

**Syntax**: MULTINOMIAL( { NumberSequence A } )

**Returns**: Number

**Constraints**: None

**Semantics**: Returns the multinomial of the sequence A = (a1, a2, ..., an). Multinomial is defined as FACT(a1+a2+...+an) / (FACT(a1)*FACT(a2)*...*FACT(an))

**See also** FACT 8.16.32

8.16.44 ODD

**Summary**: Rounds a number up to the nearest odd integer, where "up" means "away from 0".

**Syntax**: ODD( Number N )

**Returns**: Number

**Constraints**: None

**Semantics**: Returns the odd integer whose sign is the same as N's and whose absolute value is greater than or equal to the absolute value of N. In other words, any "rounding" is away from zero. By definition, ODD(0) is 1.

**See also** EVEN 8.16.30
8.16.45 PI

Summary: Return the approximate value of Pi.

Syntax: PI()

Returns: Number

Constraints: None.

Semantics: This function takes no arguments and returns the (approximate) value of pi. Evaluators should use the closest possible numerical representation that is possible in their representation of numbers.

See also SIN 8.16.55, COS 8.16.19

8.16.46 POWER

Summary: Return the value of one number raised to the power of another number.

Syntax: POWER( Number a ; Number b )

Returns: Number

Constraints: None

Semantics: Computes a raised to the power b.

• POWER(0,0) is implementation-defined, but shall be one of 0,1, or an Error.
• POWER(0,b), where b < 0, shall return an Error.
• POWER(a,b), where a<=0 and INT(b)!=b, is implementation-defined.

See also LOG 8.16.40, LOG10 8.16.41, LN 8.16.39, EXP 8.16.31

8.16.47 PRODUCT

Summary: Multiply the set of numbers, including all numbers inside ranges

Syntax: PRODUCT( { NumberSequence N }+ )

Returns: Number

Constraints: None

Semantics: Returns the product of the Numbers (and only the Numbers, i.e., not Text inside ranges). This is equivalent to SUM except that it uses the * operator instead of +.

See also SUM 8.16.61

8.16.48 QUOTIENT

Summary: Return the integer portion of a division.

Syntax: QUOTIENT( Number A ; Number B )

Returns: Number

Constraints: B <> 0
**Semantics:** Return the integer portion of a division.

**See also** MOD 8.16.42

### 8.16.49 RADIANS

**Summary:** Convert degrees to radians.

**Syntax:** RADIANS( *Number N* )

**Returns:** Number

**Constraints:** None

**Semantics:** Converts a number in degrees into a number in radians. RADIANS(N) is equal to N*PI()/180.

**See also** DEGREES 8.16.25, PI 8.16.45

### 8.16.50 RAND

**Summary:** Return a random number between 0 (inclusive) and 1 (exclusive).

**Syntax:** RAND()

**Returns:** Number

**Semantics:** This function takes no arguments and returns a random number between 0 (inclusive) and 1 (exclusive). Note that unlike most functions, this function will typically return different values when called each time with the same (empty set of) parameters.

**See also** RANDBETWEEN 8.16.51

### 8.16.51 RANDBETWEEN

**Summary:** Return a random integer number between A and B.

**Syntax:** RANDBETWEEN( *Integer A* ; *Integer B* )

**Returns:** Integer

**Constraints:** A <= B

**Semantics:** The function returns a random integer number between A and B inclusive. Note that unlike most functions, this function will often return different values when called each time with the same parameters.

**See also** RAND 8.16.50

### 8.16.52 SEC

**Summary:** Return the secant of an angle specified in radians.

**Syntax:** SEC( *Number N* )

**Returns:** Number

**Constraints:** None

**Semantics:** Computes the secant cosine of an angle specified in radians. Equivalent to:
1/COS(N)

See also SIN 8.16.55

8.16.53 SERIESSUM

Summary: Returns the sum of a power series.

Syntax: SERIESSUM( Number X ; Number N ; Number M ; Array Coefficients )

- X: the independent variable of the power series.
- N: the initial power to which X is to be raised.
- M: the increment by which to increase N for each term in the series.
- Coefficients: a set of coefficients by which each successive power of the variable X is multiplied.

Returns: Number

Constraints:

All elements of Coefficients are of type Number.
X <> 0 if any of the exponents, which are generated from N and M, are negative.

Semantics: Returns a sum of powers of the number X.

With C being the number of coefficients the function is computed as:

\[
SERIESSUM = \sum_{i=1}^{C} \text{Coefficient}_i \cdot X^{N+(i-1)M}
\]

If X=0 and all of the exponents are non-negative then \(0^0\) shall be set to 1 and \(0^{\text{exponent} > 0}\) shall be set to 0.

8.16.54 SIGN

Summary: Return the sign of a number

Syntax: SIGN( Number N )

Returns: Number

Constraints: None

Semantics: If N < 0, returns -1; if N > 0, returns +1; if N == 0, returns 0.

See also ABS 8.16.2

8.16.55 SIN

Summary: Return the sine of an angle specified in radians

Syntax: SIN( Number N )

Returns: Number

Constraints: None
**Semantics:** Computes the sine of an angle specified in radians.

\[
\sin(N) = N - \frac{N^3}{3!} + \frac{N^5}{5!} - \frac{N^7}{7!} + \ldots
\]

See also ASIN 8.16.7, RADIANS 8.16.49, DEGREES 8.16.25

**8.16.56 SINH**

**Summary:** Return the hyperbolic sine of the given hyperbolic angle

**Syntax:** SINH( Number N )

**Returns:** Number

**Constraints:** None

**Semantics:** Computes the hyperbolic sine of a hyperbolic angle. The hyperbolic sine is an analog of the ordinary (circular) sine. The points \((\cosh t, \sinh t)\) define the right half of the equilateral hyperbola, just as the points \((\cos t, \sin t)\) define the points of a circle.

\[
\sinh(N) = \frac{e^N - e^{-N}}{2}
\]

See also ASINH 8.16.8, COSH 8.16.20, TANH 8.16.70

**8.16.57 SECH**

**Summary:** Return the hyperbolic secant of the given angle specified in radians

**Syntax:** SECH( Number N )

**Returns:** Number

**Constraints:** None

**Semantics:** Computes the hyperbolic secant of a hyperbolic angle. This is equivalent to:

\[
\frac{1}{\cosh(N)}
\]

See also SINH 8.16.56, CSCH

**8.16.58 SQRT**

**Summary:** Return the square root of a number

**Syntax:** SQRT( Number N )

**Returns:** Number

**Constraints:** \(N \geq 0\)

**Semantics:** Returns the square root of a non-negative number. This function shall produce an Error if given a negative number; for producing complex numbers, see IMSQRT.

See also POWER 8.16.46, IMSQRT 8.8.24, SQRTPI 8.16.59
8.16.59 SQRTPi

Summary: Return the square root of a number multiplied by pi.

Syntax: SQRTPi( Number N )

Returns: Number

Constraints: N>=0

Semantics: Returns the square root of a non-negative number after it was first multiplied by PI, that is, SQR(T(N*PI())). This function shall produce an Error if given a negative number; for producing complex numbers, see IMSQRT.

See also POWER 8.16.46, SQRT 8.16.58, PI 8.16.45, IMSQRT 8.8.24

8.16.60 SUBTOTAL

Summary: Evaluates a function on a range.

Syntax: SUBTOTAL( Integer function ; NumberSequence sequence )

Returns: Number

Constraints: None

Semantics: Computes a given function on a number sequence. Function is denoted by the first parameter: The difference from standard functions is that all members of the sequence are excluded which:

● include a call to SUBTOTAL in their formula

● are in a row that is hidden by a table:visibility="filter" attribute of the <table:table-row> element.

● are in a row that is hidden by a table:visibility="collapse" attribute of the <table:table-row> element if the function ID is one of 101...111.

<table>
<thead>
<tr>
<th>Function</th>
<th>Exclude hidden by filter</th>
<th>Exclude hidden by filter or collapsed</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVERAGE</td>
<td>1</td>
<td>101</td>
</tr>
<tr>
<td>COUNT</td>
<td>2</td>
<td>102</td>
</tr>
<tr>
<td>COUNTA</td>
<td>3</td>
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</tr>
<tr>
<td>MAX</td>
<td>4</td>
<td>104</td>
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<tr>
<td>MIN</td>
<td>5</td>
<td>105</td>
</tr>
<tr>
<td>PRODUCT</td>
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<td>106</td>
</tr>
<tr>
<td>STDEV</td>
<td>7</td>
<td>107</td>
</tr>
<tr>
<td>STDEVP</td>
<td>8</td>
<td>108</td>
</tr>
<tr>
<td>SUM</td>
<td>9</td>
<td>109</td>
</tr>
<tr>
<td>VAR</td>
<td>10</td>
<td>110</td>
</tr>
</tbody>
</table>
See also SUM 8.16.61, AVERAGE 8.18.3

8.16.61 SUM

Summary: Sum (add) the set of numbers, including all numbers in ranges

Syntax: SUM( { NumberSequenceList }+ )

Returns: Number

Constraints: N !={} ; Evaluators may evaluate expressions that do not meet this constraint.

Semantics: Adds Numbers (and only Numbers) together (see the text on conversions).

See also AVERAGE 8.18.3

8.16.62 SUMIF

Summary: Sum the values of cells in a range that meet a criteria.

Syntax: SUMIF( ReferenceList|Reference R ; Criterion C [ ; Reference S ] )

Returns: Number

Constraints: Does not accept constant values as the range parameter.

Semantics: Sums the values of type Number in the range R or S that meet the Criterion C (4.11.7.8).

If S is not given, R may be a reference list. If S is given, R shall not be a reference list with more than 1 references and an Error be generated if it was.

If the optional range S is included, then the values of S starting from the top left cell and matching the geometry of R (same number of rows and columns) are summed if the corresponding value in R meets the Criterion. The actual range S is not considered. If the resulting range exceeds the sheet bounds, column numbers larger than the maximum column and row numbers larger than the maximum row are silently ignored, no Error is generated for this case.

The values returned may vary depending upon the HOST-USE-REGULAR-EXPRESSIONS or HOST-USE-WILDCARDS or HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL properties. 3.5

See also COUNTIF 8.13.9, SUM 8.16.61, Infix Operator "=" 8.4.7, Infix Operator "<>" 8.4.8, Infix Operator Ordered Comparison ("<", "=" , ">", ">=") 8.4.9

8.16.63 SUMIFS

Summary: Sum the values of cells in a range that meet multiple criteria in multiple ranges.

Syntax: SUMIFS( Reference R ; Reference R1 ; Criterion C1 [ ; Reference R2 ; Criterion Any C2 ]... )

Returns: Number

Constraints: Does not accept constant values as the reference parameter.

Semantics: Sums the value of cells in range R that meet the Criterion C1 in the reference range R1 and the Criterion C2 in the reference range R2, and so on (4.11.7.8). All reference ranges shall have
the same dimension and size, else an Error is returned. A logical AND is applied between each array result of each selection; an entry is counted only if the same position in each array is the result of a criteria match.

The values returned may vary depending upon the HOST-USE-REGULAR-EXPRESSIONS or HOST-USE-WILDCARDS or HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL properties. 3.5

See also AVERAGEIFS 8.18.6, COUNTIFS 8.13.10, SUMIF 8.16.62, Infix Operator "=" 8.4.7, Infix Operator "<>" 8.4.8, Infix Operator Ordered Comparison ("<", "<=", ",", ",>=") 8.4.9

8.16.64 SUMPRODUCT

Summary: Returns the sum of the products of the matrix elements.

Syntax: SUMPRODUCT( { ForceArray Array A } )

Returns: Number

Constraints: All matrices shall have the same dimensions.

Semantics: Multiplies the corresponding elements of all matrices and returns the sum of them.

\[ \text{SUMPRODUCT} (A_1, A_2, \ldots, A_K) = \sum_{m=1}^{M} \sum_{n=1}^{N} \prod_{k=1}^{K} a_{km,n} \]

where \( a_{km,n} \) denotes an element of the matrix \( A_K \).

8.16.65 SUMSQ

Summary: Sum (add) the set of squares of numbers, including all numbers in ranges

Syntax: SUMSQ( { NumberSequence N } )

Returns: Number

Constraints: \( N \neq \{ \} \); Evaluators may evaluate expressions that do not meet this constraint.

Semantics: Adds squares of Numbers (and only Numbers) together. See the text on conversions.

8.16.66 SUMX2MY2

Summary: Returns the sum of the difference between the squares of the matrices \( A \) and \( B \).

Syntax: SUMX2MY2( ForceArray Array A ; ForceArray Array B )

Returns: Number

Constraints: Both matrices shall have the same dimensions.

Semantics: Sums up the differences of the corresponding elements squares for two matrices.

\[ \text{SUMX2MY2} (A, B) = \sum_{m=1}^{M} \sum_{n=1}^{N} (a_{mn}^2 - b_{mn}^2) \]
8.16.67 SUMX2PY2

Summary: Returns the total sum of the squares of the matrices A and B.

Syntax: SUMX2PY2( ForceArray Array A ; ForceArray Array B )

Returns: Number

Constraints: Both matrices shall have the same dimensions.

Semantics: Sums up the squares of each element of the two matrices.

\[
SUMX2PY2 ( A , B ) = \sum_{m=1}^{M} \sum_{n=1}^{N} ( a_{mn}^2 + b_{mn}^2 )
\]

8.16.68 SUMXMY2

Summary: Returns the sum of the squares of the differences between matrix A and B.

Syntax: SUMXMY2( ForceArray Array A ; ForceArray Array B )

Returns: Number

Constraints: Both matrices shall have the same dimensions.

Semantics: Sums up the squares of the differences of the corresponding elements for two matrices.

\[
SUMXMY2 ( A , B ) = \sum_{m=1}^{M} \sum_{n=1}^{N} ( a_{mn} - b_{mn} )^2
\]

8.16.69 TAN

Summary: Return the tangent of an angle specified in radians

Syntax: TAN( Number N )

Returns: Number

Constraints: None

Semantics: Computes the tangent of an angle specified in radians.

\[ TAN(x) = \frac{SIN(x)}{COS(x)} \]

See also ATAN 8.16.9, ATAN2 8.16.10, RADIANS 8.16.49, DEGREES 8.16.25, SIN 8.16.55, COS 8.16.19, COT 8.16.21

8.16.70 TANH

Summary: Return the hyperbolic tangent of the given hyperbolic angle

Syntax: TANH( Number N )

Returns: Number

Constraints: None
Semantics: Computes the hyperbolic tangent of a hyperbolic angle. The hyperbolic tangent is an analog of the ordinary (circular) tangent. The points \((\cosh t, \sinh t)\) define the right half of the equilateral hyperbola, just as the points \((\cos t, \sin t)\) define the points of a circle.

\[
\tanh(N) = \frac{\sinh(N)}{\cosh(N)} = \frac{e^N - e^{-N}}{e^N + e^{-N}}
\]

See also ATANH 8.16.11, SINH 8.16.56, COSH 8.16.20, FISHERINV 8.18.27

8.17 Rounding Functions

8.17.1 General

Rounding functions convert an arbitrary Number into an Integer.

8.17.2 CEILING

Summary: Round a number \(N\) up to the nearest multiple of the second parameter, \(\text{significance}\).

Syntax: \(\text{CEILING}(\ Number\ N\ [\ ;\ [\ Number\ \text{significance}]\ [\ ;\ Number\ \text{mode}]])\)

Returns: Number

Constraints: Both \(N\) and \(\text{significance}\) shall be numeric and have the same sign if not 0.

Semantics: Rounds a number up to a multiple of the second number. If \(\text{significance}\) is omitted or an empty parameter (two consecutive ;; semicolons) it is assumed to be -1 if \(N\) is negative and +1 if \(N\) is non-negative, making the function act like the normal mathematical ceiling function if \(\text{mode}\) is not given or zero. If \(\text{mode}\) is given and not equal to zero, the absolute value of \(N\) is rounded away from zero to a multiple of the absolute value of \(\text{significance}\) and then the sign applied. Mount of \(N\) is rounded away from zero to a multiple of \(\text{significance}\) and then the sign applied. If \(\text{mode}\) is omitted or zero, rounding is toward positive infinity; the number is rounded to the smallest multiple of significance that is equal-to or greater than \(N\). If any of the two parameters \(N\) or \(\text{significance}\) is zero, the result is zero.

Note: Many application user interfaces have a CEILING function with only two parameters, and somewhat different semantics than given here (e.g., they operate as if there was a non-zero mode value). These CEILING functions are inconsistent with the standard mathematical definition of CEILING.

See also FLOOR 8.17.4, INT 8.17.3

8.17.3 INT

Summary: Rounds a number down to the nearest integer.

Syntax: \(\text{INT}(\ Number\ N)\)

Returns: Number

Constraints: None

Semantics: Returns the nearest integer whose value is less than or equal to \(N\). Rounding is towards negative infinity.
See also ROUND 8.17.6, TRUNC 8.17.9

### 8.17.4 FLOOR

**Summary:** Round a number \( N \) **down** to the nearest multiple of the second parameter, *significance*.

**Syntax:** FLOOR( *Number N* [ ; [ *Number significance* ] [ ; *Number mode* ] ] )

**Returns:** Number

**Constraints:** Both \( N \) and *significance* shall be numeric and have the same sign.

**Semantics:** Rounds a number down to a multiple of the second number. If *significance* is omitted or an empty parameter (two consecutive ;; semicolons) it is assumed to be -1 if \( N \) is negative and +1 if \( N \) is non-negative, making the function act like the normal mathematical floor function if *mode* is not given or zero. If *mode* is given and not equal to zero, the absolute value of \( N \) is rounded away from zero to a multiple of the absolute value of *significance* and then the sign applied. Mount of \( N \) is rounded toward zero to a multiple of *significance* and then the sign applied. Otherwise, it rounds toward negative infinity, and the result is the largest multiple of *significance* that is less than or equal to \( N \). If any of the two parameters \( N \) or *significance* is zero, the result is zero.

**Note:** Many application user interfaces have a FLOOR function with only two parameters, and somewhat different semantics than given here (e.g., they operate as if there was a non-zero mode value). These FLOOR functions are inconsistent with the standard mathematical definition of FLOOR.

See also CEILING 8.17.2, INT 8.17.3

### 8.17.5 MROUND

**Summary:** Rounds the number to given multiple.

**Syntax:** MROUND( *Number a* ; *Number b* )

**Returns:** Number

**Constraints:** None

**Semantics:** Returns the number \( X \), for which the following holds: \( X/b=\text{INT}(X/b) \) (\( b \) divides \( X \)), and for any other \( Y \) with the same property, \( \text{ABS}(Y-a)\geq\text{ABS}(X-a) \). In case that two such \( X \) exist, the greater one is the result. In less formal language, this function rounds the number \( a \) to multiples of \( b \).

See also ROUND 8.17.6

### 8.17.6 ROUND

**Summary:** Rounds the value \( X \) to the nearest multiple of the power of 10 specified by *Digits*.

**Syntax:** ROUND( *Number X* [ ; *Number Digits* = 0 ] )

**Returns:** Number

**Constraints:** None

**Semantics:** Round number \( X \) to the precision specified by *Digits*. The number \( X \) is rounded to the nearest power of 10 given by \( 10^{-\text{Digits}} \). If *Digits* is zero, or absent, round to the nearest decimal integer. If *Digits* is non-negative, round to the specified number of decimal places. If *Digits* is negative, round to the left of the decimal point by -*Digits* places. If \( X \) is halfway between the two
nearest values, the result shall round away from zero. Note that if X is a Number, and Digits <= 0, the results will always be an integer (without a fractional component).

See also TRUNC 8.17.9, INT 8.17.3

8.17.7 ROUNDDOWN

Summary: Rounds the value X towards zero to the number of digits specified by Digits

Syntax: ROUNDDOWN( Number X ; Integer Digits = 0 )

Returns: Number

Constraints: None

Semantics: Round X towards zero, to the precision specified by Digits. The number returned is a multiple of 10^{-Digits}. If Digits is zero, or absent, round to the largest decimal integer whose absolute value is smaller or equal to the absolute value of X. If Digits is positive, round towards zero to the specified number of decimal places. If Digits is negative, round towards zero to the left of the decimal point by -Digits places.

See also TRUNC 8.17.9, INT 8.17.3, ROUND 8.17.6, ROUNDDOWN 8.17.7

8.17.8 ROUNDUP

Summary: Rounds the value X away from zero to the number of digits specified by Digits

Syntax: ROUNDUP( Number X ; Integer Digits = 0 )

Returns: Number

Constraints: None

Semantics: Round X away from zero, to the precision specified by Digits. The number returned is a multiple of 10^{-Digits}. If Digits is zero, or absent, round to the smallest decimal integer whose absolute value is larger or equal to the absolute value of X. If Digits is positive, round away from zero to the specified number of decimal places. If Digits is negative, round away from zero to the left of the decimal point by -Digits places.

See also TRUNC 8.17.9, INT 8.17.3, ROUND 8.17.6, ROUNDDOWN 8.17.7

8.17.9 TRUNC

Summary: Truncate a number to a specified number of digits.

Syntax: TRUNC( Number a ; IntegerNumber b )

Returns: Number

Constraints: None

Semantics: Truncate number a to the number of digits specified by b. If b is zero, or absent, truncate to a decimal integer. If b is positive, truncate to the specified number of decimal places. If b is negative, truncate to the left of the decimal point. If b is not an integer, it is truncated.

See also ROUND 8.17.6, INT 8.17.3
8.18 Statistical Functions

8.18.1 General

The following are statistical functions (functions that report information on a set of numbers). Some functions that could also be considered statistical functions, such as SUM, are listed elsewhere.

8.18.2 AVEDEV

Summary: Calculates the average of the absolute deviations of the values in list.
Syntax: AVEDEV( { NumberSequenceList N } )
Returns: Number
Constraints: None.
Semantics:
\[
\frac{1}{n} \sum_{i=1}^{n} |x_i - \bar{x}|
\]
See also SUM, AVERAGE

8.18.3 AVERAGE

Summary: Average the set of numbers
Syntax: AVERAGE( { NumberSequence N } )
Returns: Number
Constraints: At least one Number included. Returns an Error if no Numbers provided.
Semantics: Computes SUM(List) / COUNT(List).
See also SUM 8.16.61, COUNT 8.13.6

8.18.4 AVERAGEA

Summary: Average values, including values of type Text and Logical.
Syntax: AVERAGEA( { Any N } )
Returns: Number
Constraints: At least one value included. Returns an Error if no value provided.
Semantics: A variant of the AVERAGE function that includes values of type Text and Logical. Text values are treated as number 0. Logical True is treated as 1 and False is treated as 0. Empty cells are not included. Any N may be of type ReferenceList.
See also AVERAGE 8.18.3

8.18.5 AVERAGEIF

Summary: Average the values of cells in a range that meet a criteria.
Syntax: \texttt{AVERAGEIF( Reference R ; Criterion C [ ; Reference A ] )}

Returns: Number

Constraints: Does not accept constant values as reference parameters.

Semantics: If reference \texttt{A} is omitted, averages the values of cells in the reference range \texttt{R} that meet the Criterion \texttt{C} (4.11.7.8). If reference \texttt{A} is given, averages the values of cells of a range that is constructed using the top left cell of reference \texttt{A} and applying the dimensions, shape and size, of reference \texttt{R}. If no cell in range \texttt{R} matches the Criterion \texttt{C}, an Error is returned. If no Numbers are in the range to be averaged, an Error is returned.

The values returned may vary depending upon the HOST-USE-REGULAR-EXPRESSIONS or HOST-USE-WILDCARDS or HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL properties. 3.5

See also AVERAGEIFS 8.18.6, COUNTIF 8.13.9, SUMIF 8.16.62, Infix Operator "=" 8.4.7, Infix Operator "<>" 8.4.8, Infix Operator Ordered Comparison ("<", "<="", ">", ">=") 8.4.9

\textbf{8.18.6 AVERAGEIFS}

Summary: Average the values of cells that meet multiple criteria in multiple ranges.

Syntax: \texttt{AVERAGEIFS( Reference A ; Reference R1 ; Criterion C1 [ ; Reference R2 ; Criterion C2 ]... )}

Returns: Number

Constraints: Does not accept constant values as reference parameters.

Semantics: Averages the values of cells in the reference range \texttt{A} that meet the Criterion \texttt{C1} in the reference range \texttt{R1} and the Criterion \texttt{C2} in the reference range \texttt{R2}, and so on (4.11.7.8). All reference ranges shall have the same dimension and size, else an Error is returned. A logical AND is applied between each array result of each selection; a cell of reference range \texttt{A} is evaluated only if the same position in each array is the result of a Criterion match. If no numbers are in the result set to be averaged, an Error is returned.

The values returned may vary depending upon the HOST-USE-REGULAR-EXPRESSIONS or HOST-USE-WILDCARDS or HOST-SEARCH-CRITERIA-MUST-APPLY-TO-WHOLE-CELL properties. 3.5

See also AVERAGEIF 8.18.5, COUNTIFS 8.13.10, SUMIFS 8.16.63, Infix Operator "=" 8.4.7, Infix Operator "<>" 8.4.8, Infix Operator Ordered Comparison ("<", "<="", ">", ">=") 8.4.9

\textbf{8.18.7 BETADIST}

Summary: returns the value of the probability density function or the cumulative distribution function for the beta distribution.

Syntax: \texttt{BETADIST( Number x ; Number \alpha ; Number \beta [ ; Number a = 0 [ ; Number b = 1 [ ; Logical Cumulative = TRUE() ] ] ] )}

Returns: Number

Constraints: \( \alpha > 0, \beta > 0, \ a < b, \)
If \( \alpha < 1, \) then the density function has a pole at \( x = a. \)
If \( \beta < 1, \) then the density function has a pole at \( x = b. \)
In both cases, if \( x=a \) respectively \( x=b \) and Cumulative=FALSE(), an Error is returned.

Semantics: If Cumulative is FALSE(), BETADIST returns 0 if \( x < a \) or \( x > b \) and the value
\[ \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} \left( \frac{x-a}{b-a} \right)^{\alpha-1} \left( \frac{1-x-a}{b-a} \right)^{\beta-1} \frac{1}{b-a} \]

otherwise.

If Cumulative is TRUE(), BETADIST returns 0 if \( x < a \), 1 if \( x > b \), and the value

\[ \int_a^x \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} \left( \frac{t-a}{b-a} \right)^{\alpha-1} \left( \frac{1-t-a}{b-a} \right)^{\beta-1} \frac{1}{b-a} dt \]

otherwise.

**Note:** With substitution

\[ z = \frac{t-a}{b-a} \]

the term can be written as

\[ \int_0^{x-a/b} \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} \cdot z^{\alpha-1}(1-z)^{\beta-1} \, dz \]

See also BETAINV 8.18.8

### 8.18.8 BETAINV

**Summary:** returns the inverse of \( \text{BETADIST}(x; \alpha; \beta; a; b; \text{TRUE}) \).

**Syntax:** \( \text{BETAINV}( \text{Number } p ; \text{Number } \alpha ; \text{Number } \beta [ ; \text{Number } a = 0 [ ; \text{Number } b = 1 ] ] ) \)

**Returns:** Number

**Constraints:** \( 0 \leq p \leq 1 \), \( \alpha > 0 \), \( \beta > 0 \), \( a < b \)

**Semantics:** BETAINV returns the unique number \( x \) in the closed interval from \( a \) to \( b \) such that \( \text{BETADIST}(x; \alpha; \beta; a; b) = p \).

See also BETADIST 8.18.7

### 8.18.9 BINOM.DIST.RANGE

**Summary:** Returns the probability of a trial result using binomial distribution.

**Syntax:** \( \text{BINOM.DIST.RANGE}( \text{Integer } N ; \text{Number } P ; \text{Integer } S [ ; \text{Integer } S2 ] ) \)

**Returns:** Number

**Constraints:** \( 0 \leq P \leq 1 \), \( 0 \leq S \leq S2 \leq N \)

**Semantics:** Let \( N \) be a total number of independent trials, and \( P \) be a probability of success for each trial. This function returns the probability that the number of successful trials shall be exactly \( S \). If the optional parameter \( S2 \) is provided, this function returns the probability that the number of successful trials shall lie between \( S \) and \( S2 \) inclusive.

This function is computed as follows:

If \( S2 \) is not given, let \( S2:=S \). Then the function returns the value of
\[ \sum_{k=S}^{N} \binom{N}{k} P^k (1-P)^{N-k} \]

See also BINOMDIST 8.18.10

Note: This describes how the function works in OOO. KSpread has a similar function, called BINO, which takes the arguments in a different order, and doesn't have the 4th argument. Gnumeric doesn't have this function. Excel doesn't have this function.

### 8.18.10 BINOMDIST

**Summary:** Returns the binomial distribution.

**Syntax:**  
\[
\text{BINOMDIST}( \text{Integer } S ; \text{ Integer } N ; \text{ Number } P ; \text{ Logical } \text{Cumulative } )
\]

**Returns:** Number

**Constraints:** 0 <= P <= 1; 0 <= S <= N

**Semantics:** If Cumulative is FALSE(), this function returns the same result as BINOM.DIST.RANGE(N;P;S). If Cumulative is TRUE(), it is equivalent to calling BINOM.DIST.RANGE(N;P;0;S).

See also BINOM.DIST.RANGE 8.18.9

### 8.18.11 LEGACY.CHIDIST

**Summary:** returns the right-tail probability for the $\chi^2$-distribution.

**Syntax:**  
\[
\text{LEGACY.CHIDIST}( \text{Number } x ; \text{ Number } \text{DegreesOfFreedom } )
\]

**Returns:** Number

**Constraints:** DegreesOfFreedom is a positive integer.

**Semantics:** In the following $n$ is DegreesOfFreedom. LEGACY.CHIDIST returns 1 for $x \leq 0$ and the value

\[
\int_{x}^{\infty} \frac{n^{n/2-1}}{2^{n/2}} e^{-t/2} \frac{t^{n/2-1}}{\Gamma(n/2)}
\]

for $x > 0$.

See also CHISQDIST 8.18.12, LEGACY.CHITEST 8.18.15

### 8.18.12 CHISQDIST

**Summary:** returns the value of the probability density function or the cumulative distribution function for the $\chi^2$-distribution.

**Syntax:**  
\[
\text{CHISQDIST}( \text{Number } x ; \text{ Number } \text{DegreesOfFreedom } [; \text{ Logical } \text{Cumulative } = \text{TRUE}()] )
\]

**Returns:** Number

**Constraints:** DegreesOfFreedom is a positive integer.
Semantics: In the following n is DegreesOfFreedom.

If Cumulative is FALSE(), CHISQDIST returns 0 for $x \leq 0$ and the value
\[
\frac{\frac{n}{2}^{n-1}}{\Gamma \left( \frac{n}{2} \right)} \frac{x^{\frac{n}{2}-1}}{2^\frac{n}{2}} e^{-\frac{x}{2}}
\]
for $x > 0$.

If Cumulative is TRUE(), CHISQDIST returns 0 for $x \leq 0$ and the value
\[
\int_0^x \frac{t^{\frac{n}{2}-1}}{2^\frac{n}{2}} e^{-\frac{t}{2}} dt
\]
\[
\frac{\frac{n}{2}^{n-1}}{\Gamma \left( \frac{n}{2} \right)}
\]
for $x > 0$.

See also LEGACY.CHIDIST 8.18.11

8.18.13 LEGACY.CHIINV

Summary: returns the inverse of LEGACY.CHIDIST(x; DegreesOfFreedom).

Syntax: LEGACY.CHIINV( Number p ; Number DegreesOfFreedom )

Returns: Number

Constraints: DegreesOfFreedom is a positive integer and $0 < p \leq 1$.

Semantics: LEGACY.CHIINV returns the unique number $x$ such that LEGACY.CHIDIST($x$; DegreesOfFreedom) = p.

See also LEGACY.CHIDIST 8.18.11

8.18.14 CHISQINV

Summary: returns the inverse of CHISQDIST(x; DegreesOfFreedom; TRUE()).

Syntax: CHISQINV( Number p ; Number DegreesOfFreedom )

Returns: Number

Constraints: DegreesOfFreedom is a positive integer and $0 \leq p < 1$.

Semantics: CHISQINV returns the unique number $x \geq 0$ such that CHISQDIST($x$; DegreesOfFreedom;TRUE()) = p.

See also CHISQDIST 8.18.12

8.18.15 LEGACY.CHITEST

Summary: Returns some Chi square goodness-for-fit test.
**Syntax:** LEGACY.CHITEST( *ForceArray Array A* ; *ForceArray Array E*)

**Returns:** Number

**Constraints:**
ROWS(A) == ROWS(E)
COLUMNS(A) == COLUMNS(E)
COLUMNS(A) * ROWS(A) > 1

**Semantics:**
For an empty element or an element of type Text or Boolean in A the element at the corresponding position of E is ignored, and vice versa.

- **A** actual observation data.
- **E** expected values.

First a Chi square statistic is calculated:

\[
\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(A_{ij} - E_{ij})^2}{E_{ij}}
\]

with

- \( r \) = number of rows
- \( c \) = number of columns
- \( A_{ij} \) = element of actual data
- \( E_{ij} \) = element of expected values

Then LEGACY.CHIDIST is called with the Chi-square value and a degree of freedom (df):

- if \( r > 1 \) and \( c > 1 \)
  \[
df = (r - 1) \cdot (c - 1)
\]
- else
  \[
df = r \cdot c - 1
\]

**See also** LEGACY.CHIDIST 8.18.11

### 8.18.16 CONFIDENCE

**Summary:** Returns the confidence interval for a population mean.

**Syntax:** CONFIDENCE( *Number alpha* ; *Number stddev* ; *Number size*)

**Returns:** Number

**Constraints:** 0 < alpha < 1; stddev > 0, size >= 1

**Semantics:** Calling this function is equivalent to calling NORMINV(1 - alpha / 2; 0; 1) * stddev / SQRT (size)
8.18.17 CORREL

Summary: Calculates the correlation coefficient of values in N1 and N2.

Syntax: CORREL( ForceArray Array N1 ; ForceArray Array N2 )

Returns: Number

Constraints: COLUMNS(N1) = COLUMNS(N2), ROWS(N1) = ROWS(N2), both sequences shall contain at least one number at corresponding positions each.

Semantics: Has the same value as COVAR(N1;N2)/STDEVP(N1)*(STDEVP(N2)). The CORREL function actually is identical to the PEARSON function.

For an empty element or an element of type Text or Boolean in N1 the element at the corresponding position of N2 is ignored, and vice versa.

See also PEARSON 8.18.56

8.18.18 COVAR

Summary: Calculates covariance of two cell ranges.

Syntax: COVAR( ForceArray Array n1 ; ForceArray Array n2 )

Returns: Number

Constraints: COLUMNS(n1) = COLUMNS(n2), ROWS(n1) = ROWS(n2), both sequences shall contain at least one number at corresponding positions each.

Semantics: returns

\[ \sum_{a \in n1, b \in n2} (a - \overline{n1})(b - \overline{n2}) \]

where \( \overline{n1} \) is the result of calling AVERAGE(n1), and \( \overline{n2} \) is the result of calling AVERAGE(n2).

For an empty element or an element of type Text or Boolean in n1 the element at the corresponding position of n2 is ignored, and vice versa.

8.18.19 CRITBINOM

Summary: Returns the smallest value for which the cumulative binomial distribution is greater than or equal to a criterion value.

Syntax: CRITBINOM( Number Trials ; Number SP ; Number Alpha )

Returns: Number

Constraints: Trials >=0, 0 <= SP <= 1, Alpha >= 1

Semantics:
Trials is the total number of trials.
SP is the probability of success for one trial.
Alpha is the threshold probability to be reached or exceeded.

8.18.20 DEVSQ

Summary: Calculates sum of squares of deviations.
**Syntax:** \( \text{DEVSQ}( \{ \text{NumberSequence} \ n \}^{\ast} ) \)

**Returns:** Number

**Semantics:** returns
\[
\sum_{x \in n} (x-a)^2
\]

where \( a \) is the result of calling AVERAGE(\( n \)).

### 8.18.21 EXPONDIST

**Summary:** returns the value of the probability density function or the cumulative distribution function for the exponential distribution.

**Syntax:** \( \text{EXPONDIST}( \\text{Number} \ x ; \ \text{Number} \ \lambda ; [ ; \ \text{Logical} \ \text{Cumulative} = \text{TRUE}()] \) \)

**Returns:** Number

**Constraints:** \( \lambda > 0 \)

**Semantics:** If Cumulative is FALSE(), EXPONDIST returns 0 if \( x < 0 \) and the value
\[
\lambda e^{-\lambda x}
\]

otherwise.

If Cumulative is TRUE(), EXPONDIST returns 0 if \( x < 0 \) and the value
\[
\int_{0}^{x} \lambda e^{-\lambda t} dt = 1 - e^{-\lambda x}
\]

otherwise.

### 8.18.22 FDIST

**Summary:** returns the value of the probability density function or the cumulative distribution function for the F-distribution.

**Syntax:** \( \text{FDIST}( \\text{Number} \ x ; \ \text{Number} \ r_1 ; \ \text{Number} \ r_2 [ ; \ \text{Logical} \ \text{Cumulative} = \text{TRUE}()] \) \)

**Returns:** Number

**Constraints:** \( r_1 \) and \( r_2 \) are positive integers

**Semantics:**

\( r_1 \) is the degrees of freedom in the numerator of the F distribution.
\( r_2 \) is the degrees of freedom in the denominator of the F distribution.

If Cumulative is FALSE(), FDIST returns 0 if \( x < 0 \), an Error if the numerator degrees of freedom \( r_1 = 1 \) and \( x = 0 \), and the value
\[ \frac{\Gamma\left( \frac{r_1 + r_2}{2} \right)}{\Gamma\left( \frac{r_1}{2} \right) \Gamma\left( \frac{r_2}{2} \right)} \frac{r_1^{\frac{r_1}{2}}}{r_2^{\frac{r_2}{2}}} x^{\frac{r_1}{2} - 1} \cdot \frac{r_1}{r_2} \left( 1 + \frac{r_1}{r_2} x \right)^{-\frac{r_1 + r_2}{2}} \]

otherwise.

If the numerator degrees of freedom \( r_1 = 1 \), then the density function has a pole at \( x=0 \), the subterm \( x^{\frac{r_1}{2} - 1} \) is not defined.

If Cumulative is TRUE(), FDIST returns 0 if \( x < 0 \) and the value

\[ \frac{\Gamma\left( \frac{r_1 + r_2}{2} \right)}{\Gamma\left( \frac{r_1}{2} \right) \Gamma\left( \frac{r_2}{2} \right)} \frac{r_1^{\frac{r_1}{2}}}{r_2^{\frac{r_2}{2}}} \int_0^x t^{\frac{r_1}{2} - 1} \left( 1 + \frac{r_1}{r_2} t \right)^{-\frac{r_1 + r_2}{2}} dt \]

otherwise.

See also LEGACY.FDIST 8.18.23

8.18.23 LEGACY.FDIST

Summary: returns the area of the right tail of the probability density function for the F-distribution.

Syntax: LEGACY.FDIST( Number x ; Number r1 ; Number r2 )

Returns: Number

Constraints: \( r_1 \) and \( r_2 \) are positive integers

Semantics:

LEGACY.FDIST returns Error if \( x < 0 \) and the value

\[ \frac{\Gamma\left( \frac{r_1 + r_2}{2} \right)}{\Gamma\left( \frac{r_1}{2} \right) \Gamma\left( \frac{r_2}{2} \right)} \frac{r_1^{\frac{r_1}{2}}}{r_2^{\frac{r_2}{2}}} \int_x^\infty t^{\frac{r_1}{2} - 1} \left( 1 + \frac{r_1}{r_2} t \right)^{-\frac{r_1 + r_2}{2}} dt \]

otherwise.

Note that the latter is \((1 - FDIST(x; r_1; r_2; TRUE()))\).

See also FDIST 8.18.22
8.18.24 FINV

Summary: returns the inverse of FDIST(x;r;1;r2;TRUE()).

Syntax: FINV( Number p ; Number r1 ; Number r2 )

Returns: Number

Constraints: 0 ≤ p < 1 , r1 and r2 are positive integers

Semantics: FINV returns the unique non-negative number x such that FDIST(x;r1;r2) = p.

See also FDIST 8.18.22, LEGACY.FDIST 8.18.23, LEGACY.FINV 8.18.25

8.18.25 LEGACY.FINV

Summary: returns the inverse of LEGACY.FDIST(x;r1;r2).

Syntax: LEGACY.FINV( Number p ; Number r1 ; Number r2 )

Returns: Number

Constraints: 0 < p ≤ 1 , r1 and r2 are positive integers

Semantics: LEGACY.FINV returns the unique non-negative number x such that LEGACY.FDIST(x;r1;r2) = p.

See also FDIST 8.18.22, LEGACY.FDIST 8.18.23, FINV 8.18.24

8.18.26 FISHER

Summary: returns the Fisher transformation.

Syntax: FISHER( Number r )

Returns: Number

Constraints: -1 < r < 1

Semantics: Returns the Fisher transformation with a sample correlation r. This function computes

\[
\frac{1}{2} \ln \left( \frac{1+r}{1-r} \right)
\]

where \( \ln \) is the natural logarithm function.

FISHER is a synonym for ATANH.

See also ATANH 8.16.11

8.18.27 FISHERINV

Summary: returns the inverse Fisher transformation.

Syntax: FISHERINV( Number r )

Returns: Number

Constraints: none
Semantics: Returns the inverse Fisher transformation. This function computes
\[
\frac{e^{2r} - 1}{e^{2r} + 1}
\]

FISHERINV is a synonym for TANH.

See also TANH 8.16.70

8.18.28 FORECAST

Summary: Extrapolates future values based on existing x and y values.

Syntax: FORECAST( Number Value ; ForceArray Array Data_Y ; ForceArray Array Data_X )

Returns: Number

Constraints: COLUMNS(Data_Y) = COLUMNS(Data_X), ROWS(Data_Y) = ROWS(Data_X)

Semantics:
Value is the x-value, for which the y-value on the linear regression is to be returned.
Data_Y is the array or range of known y-values.
Data_X is the array or range of known x-values.

For an empty element or an element of type Text or Boolean in Data_Y the element at the corresponding position of Data_X is ignored, and vice versa.

8.18.29 FREQUENCY

Summary: Categorizes values into intervals and counts the number of values in each interval.

Syntax: FREQUENCY( NumberSequenceList data ; NumberSequenceList bins )

Returns: Array

Constraints: Values in bins shall be sorted in ascending order and bins shall be a column vector. Evaluators may accept unsorted values in bins.

Semantics: Counts the number of values for each interval given by the border values in bins. The values in bins determine the upper boundaries of the intervals. The intervals include the upper boundaries. The returned array is a column vector and has one more element than bins; the last element represents the number of all elements greater than the last value in bins. If bins is empty, all values in data are counted. The values in the result array are ordered matching the original order of bins. If the values in bins are not sorted in ascending order, they are sorted internally to form category intervals and the counts of data values are "unsorted" to the original order of bins. If data is empty, the value of all elements in the returned array is 0.

data The data, that should be categorized and counted according to the given intervals.
bins The upper boundaries determining the intervals the values in data should be grouped by.

8.18.30 FTEST

Summary: Calculates the probability of an F-test.

Syntax: FTEST( ForceArray NumberSequence Data_1 ; ForceArray NumberSequence Data_2 )

Returns: Number
Constraints: Data_1 and Data_2 shall both contain at least 2 numbers and shall both have nonzero variances.

Semantics: Calculates the two-tailed probability that, based on two samples from two normal distributions, these normal distributions have different variances.

Suppose the first sample has size n1 and sample variance s1^2 and the second sample has size n2 and sample variance s2^2. If s1^2>s^2 FDIST returns twice the area of the right tail of the F-distribution with degrees of freedom n1-1,n2-1 beyond s^1/s^2. If s1^2<s^2 FDIST returns twice the area of the left tail of the F-distribution with degrees of freedom n1-1,n2-1 below s^1/s^2.

See also TTEST 8.18.81

8.18.31 GAMMADIST

Summary: returns the value of the probability density function or the cumulative distribution function for the Gamma distribution.

Syntax: GAMMADIST( Number x ; Number α ; Number β [ ; Logical Cumulative = TRUE() ] )

Returns: Number

Constraints: α > 0, β > 0

Semantics: If Cumulative is FALSE(), GAMMADIST returns 0 if x < 0 and the value

\[ \frac{1}{\beta^{\alpha} \cdot \Gamma(\alpha)} \cdot x^{\alpha-1} \cdot e^{-\frac{x}{\beta}} \]

otherwise.

If Cumulative is TRUE(), GAMMADIST returns 0 if x < 0 and the value

\[ \int_{0}^{x} \frac{1}{\beta^{\alpha} \cdot \Gamma(\alpha)} \cdot t^{\alpha-1} \cdot e^{-\frac{t}{\beta}} dt \]

otherwise.

See also GAMMAINV 8.18.32

8.18.32 GAMMAINV

Summary: returns the inverse of GAMMADIST(x;α;β;TRUE()).

Syntax: GAMMAINV( Number p ; Number α ; Number β )

Returns: Number

Constraints: 0 ≤ p < 1, α > 0, β > 0

Semantics: GAMMAINV returns the unique number x ≥ 0 such that GAMMAINV(x;α;β) = p.

See also GAMMADIST 8.18.31

8.18.33 GAUSS

Summary: Returns 0.5 less than the standard normal cumulative distribution
Syntax: GAUSS( Number x )

Returns: Number

Semantics: Returns NORMDIST(x;0;1;TRUE())-0.5

See also NORMDIST 8.18.52

8.18.34 GEOMEAN

Summary: returns the geometric mean of a sequence

Syntax: GEOMEAN( { NumberSequenceList N } )

Returns: Number

Semantics: Returns the geometric mean of a given sequence. That means

\[ \left( \prod_{a \in N} a \right)^{1/n} \]

where \( n \) is a result of calling COUNT(N).

8.18.35 GROWTH

Summary: Returns predicted values based on an exponential regression. Calculates a sequence of values based on a least squares exponential fit to known value pairs.

Syntax: GROWTH( Array knownY [ ; [ Array knownX ] [ ; [ Array newX ] [ ; Logical ConstNumberSequence knownY [ ; [ NumberSequence knownX ] [ ; [ NumberSequence newX ] [ ; Logical allowConstant = TRUE() ] ] ] ] ] ] )

Returns: Array

Constraints:

- \((\text{COLUMNS}(\text{knownY}) = \text{COLUMNS}(\text{knownX}) \text{ and } \text{ROWS}(\text{knownY}) = \text{ROWS}(\text{knownX})) \text{ or } (\text{COLUMNS}(\text{knownY}) = 1 \text{ and } \text{ROWS}(\text{knownY}) = \text{ROWS}(\text{knownX}) \text{ and } \text{COLUMNS}(\text{knownX}) = \text{COLUMNS}(\text{newX})) \text{ or } (\text{COLUMNS}(\text{knownY}) = 1 \text{ and } \text{ROWS}(\text{knownY}) = \text{ROWS}(\text{newX}) \text{ and } \text{COUNT}(\text{knownY}) = \text{COUNT}(\text{knownX}) \text{ and } \text{COUNT}(\text{knownY}), \text{COUNT}(\text{knownX}) > 1)\)

Semantics:

- \( \text{knownY} \): The set of known y-values to be used to determine the regression equation
- \( \text{knownX} \): The set of known x-values to be used to determine the regression equation. If omitted or an empty parameter, it is set to the sequence 1,2,3,...,k where \( k = \text{ROWS}(\text{knownY}) \cdot \text{COLUMNS}(\text{knownY}) \)
- \( \text{newX} \): The set of x-values for which predicted \( \hat{y} \)-values are to be calculated. If omitted or an empty parameter, it is set to \( \text{knownX} \).
- \( \text{Const} \): If set to FALSE(), the model constant \( a \) is equal to 0.
- \( \text{LOGEST}(\text{knownY}; \text{knownX}; \text{Const}; \text{FALSE()}) \) either returns an error or an array with 1 row and \( n+1 \) columns. If it returns an error then so does GROWTH. If it returns an array, we call the entries in that array \( b_0, b_1, \ldots, b_n, a \).
- Let \( z_{ij} \) denote the entry in the \( i \)th row and \( j \)th column of \( \text{newX} \).
If $\text{COLUMNS}(\text{knownY}) = \text{COLUMNS}(\text{knownX})$ and $\text{ROWS}(\text{knownY}) = \text{ROWS}(\text{knownX})$, then GROWTH returns an array with $\text{ROWS}(\text{newX})$ rows and $\text{COLUMNS}(\text{newX})$ column, such that the entry in its $i$th row and $j$th column is $a \times b_i^{z_{ij}}$.

Otherwise, if $\text{COLUMNS}(\text{knownY}) = 1$ and $\text{ROWS}(\text{knownY}) = \text{ROWS}(\text{knownX})$ and $\text{COLUMNS}(\text{knownX}) = \text{COLUMNS}(\text{newX})$, then GROWTH returns an array with $\text{ROWS}(\text{newX})$ rows and 1 column, such that the entry in the $i$th row is $a \times \prod_{j=1}^{n} b_j^{z_{ij}}$.

Otherwise, if $\text{COLUMNS}(\text{knownY}) = \text{COLUMNS}(\text{knownX})$ and $\text{ROWS}(\text{knownY}) = 1$ and $\text{ROWS}(\text{knownX}) = \text{ROWS}(\text{newX})$, then GROWTH returns an array with 1 row and $\text{COLUMNS}(\text{newX})$ columns, such that the entry in the $j$th column is $a \times \prod_{i=1}^{n} b_i^{z_{ij}}$.

Semantics: Calculates a sequence of values based on an exponential least squares fit of known value-pairs.

If $\text{knownX}$ is omitted or an empty parameter (two consecutive ;; semicolons), it is set to the sequence of $\text{knownY}$, where $\text{knownX}$.

If $\text{newX}$ is omitted or an empty parameter (two consecutive ;; semicolons), it is set to be equal to $\text{knownX}$.

If $\text{allowConstant}$ is TRUE, the fit is to the function $a \times \prod_{j=1}^{n} b_j^{z_{ij}}$, where $b$ and $m$ are constants determined in the fit. If $\text{allowConstant}$ is FALSE, the fit is to the function $a \times \prod_{i=1}^{n} b_i^{z_{ij}}$, i.e. when $\text{allowConstant}$ is FALSE, the constant $b$ is set to 1. The default is TRUE.

See also TREND 8.18.79

8.18.36 HARMEAN

Summary: returns the harmonic mean of a sequence

Syntax: HARMEAN( { NumberSequenceList N } )

Returns: Number

Semantics: Returns the harmonic mean of a given sequence. That means

$$\frac{1}{\sum_{i=1}^{n} \frac{1}{a_i}}$$

where $a_1, a_2, \ldots, a_n$ are the numbers of the sequence $N$ and $n$ is a result of calling COUNT($N$).

8.18.37 HYPGEOMDIST

Summary: The hypergeometric distribution returns the number of successes in a sequence of $n$ draws from a finite population without replacement.

Syntax: HYPGEOMDIST( Integer $x$ ; Integer $n$ ; Integer $M$ ; Integer $N$ [ ; Logical Cumulative = FALSE()] )
Returns: Number

Constraints: $0 \leq x \leq n \leq N$, $0 \leq M \leq N$

Semantics:

$x$ is the number of successes in $n$ trials

$n$ is the number of trials

$M$ is the number of successes in the population

$N$ is the total population

$cumulative$ is a Logical parameter. If $cumulative$ is FALSE(), return the probability of exactly $x$ successes. If $cumulative$ is TRUE(), return the probability of at most $x$ successes. If omitted, FALSE() is assumed.

If Cumulative is FALSE(), HYPGEOMDIST returns

$$\binom{M}{x} \binom{N-M}{n-x} \frac{N}{n}$$

If Cumulative is TRUE(), HYPGEOMDIST returns

$$\sum_{i=0}^{x} \binom{M}{i} \binom{N-M}{n-i} \frac{N}{n}$$

Note:

$$\binom{x}{y} = 0 \text{ for } y > x$$

8.18.38 INTERCEPT

Summary: Returns the y-intercept of the linear regression line for the given data.

Syntax: INTERCEPT( ForceArray Array Data_Y ; ForceArray Array Data_X )

Returns: Number

Constraints: $\text{COLUMNS(Data_X)} = \text{COLUMNS(Data_Y)}$, \text{ROWS(Data_X)} = \text{ROWS(Data_Y)}

Semantics:

INTERCEPT returns the intercept (a) calculated as described in 5.18.41 for the function call LINEST(DATA_Y,DATA_X,FALSE()).

For an empty element or an element of type Text or Boolean in Data_Y the element at the corresponding position of Data_X is ignored, and vice versa.

8.18.39 KURT

Summary: Return the kurtosis (“peakedness”) of a data set.
Syntax: KURT( { NumberSequenceList } )

Returns: Number

Constraints: #Numbers>=4, STDEV(X) <> 0

Semantics:
Kurtosis characterizes the relative peakedness or flatness of a distribution compared with the normal distribution. Positive kurtosis indicates a relatively peaked distribution (compared to the normal distribution), while negative kurtosis indicates a relatively flat distribution.

\[
kurtosis = \frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum_{i=1}^{n} \left( \frac{x_i - \bar{x}}{s} \right)^4 - \frac{3(n-1)^2}{(n-2)(n-3)}
\]

where s is the sample standard deviation, and n is the number of numbers.

8.18.40 LARGE

Summary: Finds the nth largest value in a list.

Syntax: LARGE( NumberSequenceList; Number|Array N )

Returns: Number or Array

Constraints: ROUNDUP(N;0)=N. If the resulting N is <1 or larger than the size of List, Error is returned

Semantics: If N is an array of numbers, an array of largest values is returned.

See also SMALL 8.18.70, ROUNDUP 8.17.8

8.18.41 LINEST

Summary: Returns the parameters of the (simple or multiple) linear regression equation for the given data and, optionally, statistics on this regression linear trend best fitting the given data. This function shall be entered as an array formula.

Syntax: LINEST( Array knownY [ ; [ Array knownX ] [ ; Logical Const = TRUE() [ ; Logical Stats = FALSE() ] ] ] )

Returns: Array

Constraints: (COLUMNS(knownY) = COLUMNS(knownX) and ROWS(knownY) = ROWS(knownX)) or (COLUMNS(knownY) = 1 and ROWS(knownY) = ROWS(knownX)) or (COLUMNS(knownY) = COLUMNS(knownX) and ROWS(knownY) = 1)COLUMNS(knownY) = COLUMNS(knownX), ROWS(knownY) = ROWS(knownX), COUNT(knownY) = COUNT(knownX)

Semantics:

knownY: The set of y-values for the equation, either one single column or one single row

knownX: The set of x-values for the equation. If omitted or an empty parameter, it is set to the sequence 1,2,…,k, where \( k = \text{ROWS}(\text{knownY}) \cdot \text{COLUMNS}(\text{knownY}) \), a single column or single row matching knownY. If omitted or an empty parameter (two consecutive ;s, semicolons), it is set to the sequence \( \ldots \), where \( \ldots \). If one single value, it is applied to all.
**Const**: If set to FALSE(), the model constant \(a\) is equal to 0 and the line goes through the zero point.

**Stats**: If FALSE(), only the regression coefficient is to be calculated. If set to TRUE(), the result will include other statistical data, returned as an array, as shown in the table:

If any of the entries in knownY and knownX do not convert to Number, LINEST returns an error.

The result created by LINEST if STATS is TRUE() is given in Table 30 - LINEST. If STATS is FALSE() it is just the first row of Table 30 - LINEST. The empty cells in this table are returned as empty or as containing an error.

If COLUMNS(knownY) = COLUMNS(knownX) and ROWS(knownY) = ROWS(knownX) then \(n=1\), \(k=\text{ROWS(knownY)} \cdot \text{COLUMNS(knownY)}\), the entries of knownX in column major order are denoted with \(x_1, x_2, \ldots, x_n\) and the entries of knownY in column major order are denoted with \(y_1, y_2, \ldots, y_k\).

Otherwise but if COLUMNS(knownY) = 1, then \(n=\text{COLUMNS(knownX)}\), \(k=\text{ROWS(knownY)}\), the entry in the \(j\)th column and \(i\)th row of knownX is denoted \(x_{ij}\) and the entry in the \(i\)th row of knownY is denoted \(y_i\).

Otherwise but if ROWS(knownY) = 1, then \(n=\text{ROWS(knownX)}\), \(k=\text{COLUMNS(knownY)}\), the entry in the \(j\)th column and \(i\)th row of knownX is denoted \(x_{ji}\) and the entry in the \(j\)th column of knownY is denoted \(y_j\).

If Const is TRUE() and \(k \leq n+1\) LINEST returns an error. Similarly, if Const is FALSE() and \(k \leq n\) LINEST returns an error.

We denote \(\bar{x}_i = \frac{1}{k} \sum_{j=1}^{k} x_{ij}\) and \(\bar{y} = \frac{1}{k} \sum_{j=1}^{k} y_j\), and define the following matrices:

\[
Y = \begin{pmatrix} y_1 \\ \vdots \\ y_k \end{pmatrix} \quad \text{and} \quad X = \begin{pmatrix} 1 & x_{11} & \cdots & x_{1n} \\ 1 & x_{12} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & x_{k1} & \cdots & x_{kn} \end{pmatrix} \quad \text{for Const being TRUE()}, \quad \text{and} \quad X = \begin{pmatrix} x_{11} & \cdots & x_{1n} \\ x_{12} & \cdots & x_{2n} \\ \vdots & \ddots & \vdots \\ x_{k1} & \cdots & x_{kn} \end{pmatrix} \quad \text{for Const being FALSE().}
Let \( X^T \) denote the transpose of \( X \), see 6.5.6 TRANSPOSE. Then the matrix product \( X^T \cdot X \) is a square matrix. If \( X^T \cdot X \) is not invertible, then LINEST shall either return an error or calculate a result as described below.

If \( X^T \cdot X \) is invertible, then \( (X^T \cdot X)^{-1} \cdot X^T \cdot Y \) is a matrix \( B \) with a single column. If Const is TRUE(), the entries of \( B \) are denoted \( B = \begin{pmatrix} a \\ b_1 \\ \vdots \\ b_n \end{pmatrix} \); if Const is FALSE(), the entries of \( B \) are denoted \( B = \begin{pmatrix} b_1 \\ \vdots \\ b_n \end{pmatrix} \) and \( a = 0 \).

These \( a, b_1, \ldots, b_n \) are the values returned by LINEST in the first row of its result array in the order given in Table 30 - LINEST.

The statistics in the 2nd to 5th rows of Table 30 - LINEST are as follows:

If Const is TRUE:

\[
\begin{align*}
\text{df} &= k - n - 1 \\
SS_{\text{resid}} &= \sum_{j=1}^{k} \left( (a + \sum_{i=1}^{n} b_j x_{ij} - y_i)^2 \right) \\
SS_{\text{reg}} &= \sum_{j=1}^{k} \left( (a + \sum_{i=1}^{n} b_j x_{ij} - \bar{y})^2 \right) \\
s_a &= s_e \sqrt{d_1} \\
s_{b_i} &= s_e \sqrt{d_{i+1}} \quad \text{where } d_i \text{ is the element in the } i\text{th row and } i\text{th column of} \\
(X^T \cdot X)^{-1}
\end{align*}
\]

\[
R^2 = \frac{SS_{\text{reg}}}{SS_{\text{resid}}/df} \quad \text{and} \quad F = \frac{SS_{\text{reg}}/n}{SS_{\text{resid}}/df}.
\]

If Const is FALSE:

\[
\begin{align*}
\text{df} &= k - n \\
SS_{\text{resid}} &= \sum_{j=1}^{k} \left( \sum_{i=1}^{n} b_j x_{ij} - y_i \right)^2 \\
SS_{\text{reg}} &= \sum_{j=1}^{k} \left( \sum_{i=1}^{n} b_j x_{ij} \right)^2 \\
s_{b_i} &= s_e \sqrt{d_i} \quad \text{where } d_i \text{ is the element in the } i\text{th row and } i\text{th column of} \\
(X^T \cdot X)^{-1}
\end{align*}
\]

\[
R^2 = \frac{SS_{\text{reg}}}{SS_{\text{resid}}/df} \quad \text{and} \quad F = \frac{SS_{\text{reg}}/n}{SS_{\text{resid}}/df}.
\]

In this case, \( s_a \) is undefined and is returned as either 0, blank or an error.

If \( X^T \cdot X \) is not invertible, then the columns of \( X \) are linearly dependent. In this case an evaluator shall return an error or select any maximal linearly independent subset of these columns that if Const is TRUE() includes the first column and perform the above calculations with that subset. In the latter case the coefficients \( b_i \) of omitted columns are returned as 0.

### Table 31 - LINEST

| slope \((b_n)\) | slope \((b_{n-1})\) | ... | slope \((b_2)\) | intercept \((a)\) |
Every linear equation can be written using the form:

\[ y = ax + b \]

where \( y \) is the dependent y-value

\( a \) is the intercept (or constant) that represents the point at which the line crosses the y-axis.

\( b \) is the slope coefficient that corresponds to each x-value

\( a \) or the INTERCEPT is calculated using this formula:

\[ \text{INTERCEPT} = y - bx \]

\( b \) or the SLOPE is calculated using this formula:

\[ \text{SLOPE} = \frac{\text{sum}(x) \times \text{sum}(y) - \text{sum}(xy)}{\text{sum}(x^2) - \text{(\text{sum}(x))^2}} \]

Standard Error of the Y value is calculated using this formula:

\[ \text{Standard Error of the Y value} = \sqrt{\frac{\text{SS resid}}{\text{df}}} \]

SS resid = Residual sum-of-squares

F Statistics

\[ F = \frac{\text{SS reg}}{\text{df}} \]

\( \sigma_a \) Standard error for the intercept (a)

\( \sigma_b \) Standard error for the y-values

\( \sigma_b \) Standard error for the slope (b)

\( \sigma_b \) Standard error for the slope (b)
The RSQ Value ($r^2$) is calculated using the following formula:

The Regression Sum of squares is calculated as follows:

The Residual sum of squares is calculated using this formula:
The degrees of freedom (df) is calculated with this formula:

The F-Statistics is calculated as follows:

For \( \text{const} = \text{FALSE()} \) the Calculations for the \text{INTERCEPT}, the \text{SLOPE} and the other statistics are based on the following formulas:

a or the \text{INTERCEPT} is zero by definition:

b or the \text{SLOPE} is calculated using this formula:

Standard Error of the Y value is calculated using this formula:

Standard Error of the Slope (a) value is calculated using this formula:

Standard Error of the Intercept (b) value is calculated using this formula:
The RSQ Value \( (r^2) \) is calculated using the following formula:

The Regression Sum of squares is calculated as follows:

The Residual sum of squares is calculated using this formula:

The degrees of freedom \( (df) \) is calculated with this formula:

The F Statistics is calculated as follows:

### 8.18.42 LOGEST

**Summary:** Returns the parameters of an exponential regression equation for the given data obtained by linearizing this intrinsically linear response function and returns, optionally, statistics on.
this regression array of values for an exponential curve that best fits your data. This function shall be entered as an array formula.

**Syntax:** \( \text{LOGEST( } \text{Array knownY } [ ; \text{ Array knownX } ] [ ; \text{ Logical Const } = \text{ TRUE() } ] [ ; \text{ Logical Stats } = \text{ FALSE() } ] ) \)

**Returns:** Array

**Constraints:** \( (\text{COLUMNS(knownY)} = \text{COLUMNS(knownX)} \text{ and ROWS(knownY)} = \text{ROWS(knownX)}) \text{ or (COLUMNS(knownY)} = 1 \text{ and ROWS(knownY)} = \text{ROWS(knownX)}) \text{ or (COLUMNS(knownY)} = \text{COLUMNS(knownX)} \text{ and ROWS(knownY)} = 1)\text{COLUMNS(knownY)} = \text{COLUMNS(knownX)}, \text{ROWS(knownY)} = \text{ROWS(knownX)}, \text{COUNT(knownY)} = \text{COUNT(knownX)} \)

**Semantics:**

- **knownY:** The set of y-values for the equation, either one single column or one single row
- **knownX:** The set of x-values for the equation. If omitted or an empty parameter, it is set to the sequence 1,2,3,…, \( k \) where \( k = \text{ROWS(knownY)} \cdot \text{COLUMNS(knownY)} \), a single column or single row matching knownY. If omitted or an empty parameter (two consecutive ;; semicolons), it is set to the sequence \( \text{Object 420} \), where \( \text{Object 421} \). If one single value, it is applied to all.
- **Const:** If set to \text{FALSE()}, the model constant \( b \) is equal to 0 \text{FALSE()} to specify whether the constant \( b \) is equal to 1.
- **Stats:** If \text{FALSE()}, only the regression coefficient is to be calculated. If set to \text{TRUE()}, the result will include other statistical data \text{TRUE()} to specify to return additional regression statistics.

If any of the entries in \text{knownY} and \text{knownX} do not convert to Number or if any of the entries in \text{knownY} is negative, \text{LOGEST} returns an error. Every exponential equation can be written using the form \( y = e^{ax} \text{ or } y = s^{bx} \text{ if there are multiple x-values.} 

The result created by \text{LOGEST} if \text{STATS} is \text{TRUE()} is given in Table 32 - \text{LOGEST}. If \text{STATS} is \text{FALSE()} it is just the first row of Table 32 - \text{LOGEST}. The empty cells in this table are returned as empty or as containing an error.

<table>
<thead>
<tr>
<th>( e^b )</th>
<th>( e^{b-1} )</th>
<th>( \ldots )</th>
<th>( e^1 )</th>
<th>( e^{a} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( s_{b-1} )</td>
<td>( s_{b-1} )</td>
<td>( \ldots )</td>
<td>( s_{b-1} )</td>
<td>( s_{a} )</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>( s_e )</td>
<td>( \ldots )</td>
<td>( s_e )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>( F )</td>
<td>( df )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( SS_{reg} )</td>
<td>( SS_{resid} )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If \text{COLUMNS(knownY)} = \text{COLUMNS(knownX)} and \text{ROWS(knownY)} = \text{ROWS(knownX)} then \( n = 1 \). If \( k = \text{ROWS(knownY)} \cdot \text{COLUMNS(knownY)} \), the entries of \text{knownX} in column major order are denoted with \( x_{11}, x_{2n}, \ldots, x_{1n} \) and the entries of \text{knownY} in column major order are denoted with \( y_{1}, y_{2}, \ldots, y_{k} \).
Otherwise but if \( \text{COLUMNS}(\text{knownY}) = 1 \), then 
\[
 n = \text{COLUMNS}(\text{knownX}) \quad \text{and the entry in the } j\text{th column and } i\text{th row of } \text{knownX} \text{ is denoted } x_{ij} \text{ and the entry in the } i\text{th row of } \text{knownY} \text{ is denoted } y_i .
\]

Otherwise but if \( \text{ROWS}(\text{knownY}) = 1 \), then 
\[
 n = \text{ROWS}(\text{knownX}) \quad k = \text{COLUMNS}(\text{knownY}) \quad \text{and the entry in the } j\text{th column and } i\text{th row of } \text{knownX} \text{ is denoted } x_{ji} \text{ and the entry in the } j\text{th column of } \text{knownY} \text{ is denoted } y_j .
\]

If Const is TRUE() and \( k \leq n + 1 \), LOGEST returns an error. Similarly, if Const is FALSE() and \( k \leq n \), LOGEST returns an error.

We denote 
\[
 x_i = \frac{1}{k} \sum_{j=1}^{k} x_{ij} \quad \text{and} \quad \ln(y) = \frac{1}{k} \sum_{j=1}^{k} \ln(y_j)
\]

and define the following matrices:

\[
 Y = \begin{bmatrix}
 \ln(y_1) \\
 \vdots \\
 \ln(y_k)
\end{bmatrix} \quad \text{and} \quad X = \begin{bmatrix}
 1 & x_{11} & \ldots & x_{1n} \\
 1 & x_{12} & \ldots & x_{2n} \\
 \vdots & \vdots & \ddots & \vdots \\
 1 & x_{k1} & \ldots & x_{kn}
\end{bmatrix}
\]

for Const being TRUE(), and

\[
 X = \begin{bmatrix}
 1 & x_{11} & \ldots & x_{1n} \\
 1 & x_{12} & \ldots & x_{2n} \\
 \vdots & \vdots & \ddots & \vdots \\
 1 & x_{k1} & \ldots & x_{kn}
\end{bmatrix}
\]

for Const being FALSE().

Let \( X^T \) denote the transpose of \( X \), see 6.5.6 TRANSPOSE. Then the matrix product \( X^T \cdot X \) is a square matrix. If \( X^T \cdot X \) is not invertible, then LOGEST shall either return an error or calculate a result as described below.

If \( X^T \cdot X \) is invertible, then \( (X^T \cdot X)^{-1} \cdot X^T \cdot Y \) is a matrix \( B \) with a single column. If Const is

TRUE(), the entries of \( B \) are denoted
\[
 B = \begin{bmatrix}
 a \\
 b_1 \\
 \vdots \\
 b_n
\end{bmatrix}
\]

and \( a = 0 \).

If Const is FALSE(), the entries of \( B \) are denoted
\[
 B = \begin{bmatrix}
 b_1 \\
 \vdots \\
 b_n
\end{bmatrix}
\]

Then \( e^a \), \( e^{b_1} \), \ldots, \( e^{b_n} \) are the values returned by LOGEST in the first row of its result array in the order given in Table 1 - Operators.

The statistics in the 2nd to 5th rows of Table 1 - Operators are as follows:

If Const is TRUE():

\[
 df = k - n - 1 \quad \text{and} \quad s_a = s_e \sqrt{d_1}
\]

\[
 SS_{\text{resid}} = \sum_{j=1}^{k} \sum_{i=1}^{n} (a + \sum_{j=1}^{n} b_j x_{ij}) - \ln(y_i) \quad SS_{\text{reg}} = \sum_{j=1}^{k} \sum_{i=1}^{n} (a + \sum_{j=1}^{n} b_j x_{ij}) - \ln(y) \quad s_e = \sqrt{d_1}
\]
\[ s_b = s_e \sqrt{d_{i+1}} \quad \text{where} \quad d_{i} \quad \text{is the element in the } i \text{th row and } i \text{th column of} \quad (X^T \cdot X)^{-1} \quad s_e = \sqrt{SS_{\text{resid}} / df} \]

\[ R^2 = \frac{SS_{\text{reg}}}{\sum_{j=1}^{k} (\ln(y_j) - \ln(y))^2} \quad \text{and} \quad F = \frac{SS_{\text{reg}} / n}{SS_{\text{resid}} / df} \]

If \( Const \) is FALSE:

\[ df = k - n \quad SS_{\text{resid}} = \sum_{j=1}^{k} \left( \left( \sum_{i=1}^{n} b_j x_{ij} \right) - \ln(y_j) \right)^2 \quad SS_{\text{reg}} = \sum_{j=1}^{k} \left( \sum_{i=1}^{n} b_j x_{ij} \right)^2 \quad s_e = \sqrt{SS_{\text{resid}} / df} \quad s_e = \sqrt{SS_{\text{resid}} / df} \]

\[ d_{i} \quad \text{is the element in the } i \text{th row and } i \text{th column of} \quad (X^T \cdot X)^{-1} \quad s_b = s_e \sqrt{d_{i}} \]

\[ F = \frac{SS_{\text{reg}} / n}{SS_{\text{resid}} / df} \quad \text{In this case} \quad s_a \quad \text{is undefined and is returned as either 0, blank or an error.} \]

If \( X^T \cdot X \) is not invertible, then the columns of \( X \) are linearly dependent. In this case an evaluator
shall return an error or select any maximal linearly independent subset of these columns that if
\( Const \) is TRUE() includes the first column and perform the above calculations with that subset. In
the latter case the coefficients \( e^b \) of omitted columns are returned as 1.

\( y \) is the dependent y-value

The b-values are bases corresponding to each exponent x-value

a is a constant value:

The Functions used to calculate the LOGEST values are the same as for the LINEST function. You
have just to make the Y-Values the natural logarithmic of the given ones ( \( C=Y \) and the New Y=ln
(\( C \))). The result for the 'a' and 'b' values has to be calculated by applying the EXP() function to the
values:

LOGEST with Stats parameter set to TRUE() returns additional statistical data in an array. They are
at the positions shown in the table : |  

<table>
<thead>
<tr>
<th>Table 33 – LOGEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>slope (b_n)</td>
</tr>
<tr>
<td>\sigma_a \text{ Standard error for the slope (b_n)}</td>
</tr>
<tr>
<td>\sigma_a \text{ Standard error for the y-Values }</td>
</tr>
<tr>
<td>degrees of freedom (df)</td>
</tr>
<tr>
<td>SS_{\text{reg}} \text{ Regression sum of squares}</td>
</tr>
</tbody>
</table>
8.18.43 LOGINV

Summary: returns the inverse of LOGNORMDIST(x;Mean;StandardDeviation,TRUE()).

Syntax: LOGINV( Number p [ ; Number Mean = 0 [ ; Number StandardDeviation = 1 ] ] )

Returns: Number

Constraints: StandardDeviation > 0 and 0 < p < 1.

Semantics: LOGINV returns the unique number x such that LOGNORMDIST(x;Mean;StandardDeviation;TRUE()) = p.

See also LOGNORMDIST 8.18.44

8.18.44 LOGNORMDIST

Summary: returns the value of the probability density function or the cumulative distribution function for the lognormal distribution with the mean and standard deviation given.

Syntax: LOGNORMDIST( Number x [ ; Number m = 0 [ ; Number s = 1 [ ; Logical Cumulative = TRUE() ] ] ] )

Returns: Number

Constraints: σ > 0; x > 0 if Cumulative is FALSE()

Semantics: If Cumulative is FALSE(), LOGNORMDIST returns the value

$$e^{\frac{1}{2}\left(\frac{\ln(x)-\mu}{\sigma}\right)^2} \times \sqrt{\frac{2\pi}{2\sigma}}$$

If Cumulative is TRUE(), LOGNORMDIST returns the value

$$\int_0^x e^{\frac{1}{2}\left(\frac{\ln(t)-\mu}{\sigma}\right)^2} \times \frac{1}{t\sqrt{\frac{2\pi}{2\sigma}}} \, dt$$

if X > 0 and 0 otherwise.

8.18.45 MAX

Summary: Return the maximum from a set of numbers.

Syntax: MAX( { NumberSequenceList N }^+ )

Returns: Number

Constraints: None.

Semantics: Returns the value of the maximum number in the list passed in. Non-numbers are ignored. Note that if Logical types are a distinct type, they are not included. What happens when MAX is provided 0 parameters is implementation-defined, but MAX with no parameters should return 0.

See also MAXA 8.18.46, MIN 8.18.48
8.18.46 MAXA

Summary: Return the maximum from a set of values, including values of type Text and Logical.

Syntax: MAXA( { Any N }* )

Returns: Number

Constraints: None.

Semantics: A variation of the MAX function that includes values of type Text and Logical. Text values are treated as number 0. Logical True is treated as 1, and False is treated as 0. Empty cells are not included. What happens when MAXA is provided 0 parameters is implementation-defined. Any N may be of type ReferenceList.

See also MAX 8.18.45, MIN 8.18.48, MINA 8.18.49

8.18.47 MEDIAN

Summary: Returns the median (middle) value in the list.

Syntax: MEDIAN( { NumberSequenceList X}+ )

Returns: Number

Semantics:

MEDIAN logically ranks the numbers (lowest to highest). If given an odd number of values, MEDIAN returns the middle value. If given an even number of values, MEDIAN returns the arithmetic average of the two middle values.

\[
\hat{x} = \begin{cases} 
\frac{x_{(n+1)/2}}{2} & \text{for } n = \text{odd} \\
\frac{1}{2} \left( x_{\left\lfloor \frac{n}{2} \right\rfloor} + x_{\left\lfloor \frac{n}{2} \right\rfloor + 1} \right) & \text{for } n = \text{even} 
\end{cases}
\]

8.18.48 MIN

Summary: Return the minimum from a set of numbers.

Syntax: MIN( { NumberSequenceList N }* )

Returns: Number

Constraints: None.

Semantics: Returns the value of the minimum number in the list passed in. Returns zero if no numbers are provided in the list. What happens when MIN is provided 0 parameters is implementation-defined, but MIN() with no parameters should return 0.
See also MAX 8.18.45, MINA 8.18.49

8.18.49 MINA

Summary: Return the minimum from a set of values, including values of type Text and Logical.

Syntax: MINA( { Any N }+ )

Returns: Number

Constraints: None.

Semantics: A variation of the MIN function that includes values of type Text and Logical. Text values are treated as number 0. Logical True is treated as 1, and False is treated as 0. Empty cells are not included. What happens when MINA is provided 0 parameters is implementation-defined. Any N may be of type ReferenceList.

See also MIN 8.18.48, MAXA 8.18.46

8.18.50 MODE

Summary: Returns the most common value in a data set.

Syntax: MODE( { ForceArray NumberSequence N }+ )

Semantics: Returns the most common value in a data set. If there are more than one values with the same largest frequency, returns the smallest value. If the number sequence does no contain at least two equal values, the MODE is not defined as no most common value can be found. Therefore an Error message has to be shown.

8.18.51 NEGBINOMDIST

Summary: Returns the negative binomial distribution.

Syntax: NEGBINOMDIST( Integer x ; Integer r ; Number p )

● x The number of failures.
● r The threshold number of successes.
● p The probability of a success.

Returns: Number

Constraints:
● If (x + r - 1) <= 0 NEGBINOMDIST returns an Error.
● If p < 0 or p > 1 NEGBINOMDIST returns an Error.

Semantics:
NEGBINOMDIST returns the probability that there will be x failures before the r-th success, when the constant probability of a success is p.

Note: This function is similar to the binomial distribution, except that the number of successes is fixed, and the number of trials is variable. Like the binomial, trials are assumed to be independent.
\[ P_{r,p}(x) = \binom{x+r-1}{r-1} p^r (1-p)^x \]

\( \binom{x+r-1}{r-1} \) is a binomial coefficient

### 8.18.52 NORMDIST

**Summary:** returns the value of the probability density function or the cumulative distribution function for the normal distribution with the mean and standard deviation given.

**Syntax:**

\[
\text{NORMDIST}( \text{Number } x ; \text{Number Mean} ; \text{Number StandardDeviation} [ ; \text{Logical Cumulative} = \text{TRUE}()] )
\]

**Returns:** Number

**Constraints:** StandardDeviation > 0.

**Semantics:** In the following \( \mu \) is Mean and \( \sigma \) is StandardDeviation.

If Cumulative is FALSE(), NORMDIST returns the value

\[
e^{-\frac{1}{2} \left( \frac{x-\mu}{\sigma} \right)^2} \frac{1}{\sqrt{2\pi \sigma}}
\]

If Cumulative is TRUE(), NORMDIST returns the value

\[
\int_{-\infty}^{x} e^{-\frac{1}{2} \left( \frac{t-\mu}{\sigma} \right)^2} \frac{1}{\sqrt{2\pi \sigma}} dt
\]

**See also** LEGACY.NORMSDIST 8.18.54

### 8.18.53 NORMINV

**Summary:** returns the inverse of NORMDIST(x;Mean;StandardDeviation,TRUE()).

**Syntax:**

\[
\text{NORMINV}( \text{Number } p ; \text{Number Mean} ; \text{Number StandardDeviation} )
\]

**Returns:** Number

**Constraints:** StandardDeviation > 0 and 0 < p < 1.

**Semantics:** NORMINV returns the unique number x such that NORMDIST(x;Mean;StandardDeviation;TRUE()) = p.

**See also** NORMDIST 8.18.52

### 8.18.54 LEGACY.NORMSDIST

**Summary:** returns the value of the cumulative distribution function for the standard normal distribution.

**Syntax:**

\[
\text{LEGACY.NORMSDIST}( \text{Number } x )
\]
Returns: Number

Constraints: None

Semantics: LEGACY.NORMSDIST returns the value

$$\int_{-\infty}^{x} e^{-\frac{1}{2}t^2} dt$$

This is exactly NORMDIST(x;0;1;TRUE()).

See also NORMDIST 8.18.52, LEGACY.NORMSINV 8.18.55

8.18.55 LEGACY.NORMSINV

Summary: returns the inverse of LEGACY.NORMSDIST(x).

Syntax: LEGACY.NORMSINV( Number p )

Returns: Number

Constraints: 0 < p < 1.

Semantics: LEGACY.NORMSINV returns NORMINV (p).

See also NORMINV 8.18.53, LEGACY.NORMSDIST 8.18.54

8.18.56 PEARSON

Summary: PEARSON returns the Pearson correlation coefficient of two data sets

Syntax: PEARSON( ForceArray Array independent_Values ; ForceArray Array dependent_Values )

Returns: Number

Constraints: COLUMNS(independent_Values) = COLUMNS(dependent_Values),
ROWS(independent_Values) = ROWS(dependent_Values), both sequences shall contain at least
one number at corresponding positions each.

Semantics:

independent_Values represents the array of the first data set. (X-Values)
dependent_Values represents the array of the second data set. (Y-Values)

$$r = \frac{\sum_{i=1}^{N} (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{N} (x_i - \bar{x})^2 \sum_{i=1}^{N} (y_i - \bar{y})^2}}$$

$$\bar{x}, \bar{y} \text{ are the averages of the given x, y data}$$

For an empty element or an element of type Text or Boolean in independent_Values the element at
the corresponding position of dependent_Values is ignored, and vice versa.
**8.18.57 PERCENTILE**

**Summary:** Calculates the x-th sample percentile among the values in range.

**Syntax:** PERCENTILE( NumberSequenceList Data ; Number x )

**Returns:** Number

**Constraints:**
- COUNT(Data) > 0
- 0 <= x <= 1

**Semantics:**
- **Data** The array or range of values to get the percentile from.
- **x** The percentile value between 0 and 1, inclusive. If x is not a multiple of \( \frac{1}{n-1} \), PERCENTILE interpolates to obtain the value between two data points.

Returns the x-th sample percentile of data values in Data. A percentile returns the scale value for a data series which goes from the smallest (Alpha=0) to the largest value (Alpha=1) of a data series. For Alpha = 25%, the percentile means the first quartile; Alpha = 50% is the MEDIAN.

<table>
<thead>
<tr>
<th>Step 1:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sort the list of numbers given by array Data.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculate the ranking ([1, \ldots, n]), split into integer and decimal part</td>
</tr>
</tbody>
</table>

\[
r = 1 + x \cdot (n - 1) = I + D
\]

with
- \(x\) = the percentile you want to find
- \(n\) = the count of values
- \(I\) = the integer part of the ranking = \(\lfloor r \rfloor\)
- \(D\) = the decimal part of the ranking = \(r - \lfloor r \rfloor\)

<table>
<thead>
<tr>
<th>Step 3:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpolate between the necessary two numbers</td>
</tr>
</tbody>
</table>

\[
PERCENTILE = Y_I + D \cdot (Y_{I+1} - Y_I)
\]

with \(Y_I\) being the data point ranked at position \(I\)

**See also** MAX 8.18.45, MEDIAN 8.18.47, MIN 8.18.48, PERCENTRANK 8.18.58, QUARTILE 8.18.64, RANK 8.18.65

**8.18.58 PERCENTRANK**

**Summary:** Returns the percentage rank of a value in a sample.
Syntax: PERCENTRANK( NumberSequenceList Data ; Number X [ ; Integer Significance = 3 ] )

Returns: Number

Constraints:
- COUNT(Data) > 0
- MIN(Data) <= X <= MAX(Data)
- INT(Significance) = Significance; Significance >= 1

Semantics:
- Data is the array or range of data with numeric values.
- X is the value whose rank is to be determined.
- Significance is an optional value that identifies the number of significant digits for the returned percentage value. If omitted, a value of 3 is used (0.xxx).

Returns the rank of a value in a data set Data as a percentage of the data set, a value between 0 and 1, inclusive. This function can be used to evaluate the relative standing of a value within a data set.

For COUNT(Data) > 1, PERCENTRANK returns \( r / (\text{COUNT(Data)} - 1) \), where \( r \) is the rank of \( X \) in Data. The rank of the lowest number in Data is 0, and of the next lowest number 1, and so on. If \( X \) is not in Data, it is assigned a fractional rank proportionately between the rank of the numbers on either side. Specifically, if \( X \) lies between \( Y \) and \( Z=Y+1 \) (\( Y < X < Z \)) with \( Y \) being the largest number smaller than \( X \) and \( Z \) the smallest number larger than \( X \), and where \( Y \) has rank \( r_y \), the rank of \( X \) is calculated as

\[
rx = r_y \frac{X-Y}{Z-Y}
\]

In the special case where \( \text{COUNT(Data)} == 1 \), the only valid value for \( X \) is the single value in Data, in which case PERCENTRANK returns 1.

See also PERCENTILE 8.18.57, RANK 8.18.65

8.18.59 PERMUT

Summary: returns the number of permutations of \( k \) objects taken from \( n \) objects.

Syntax: PERMUT( Integer n ; Integer k )

Returns: Number

Constraints: \( n >= 0 \); \( k >= 0 \); \( n >= k \)

Semantics: PERMUT returns

\[
\binom{n}{k} \frac{|k|!}{|k|!}
\]

respectively

\[
\frac{n!}{(n-k)!}
\]
**8.18.60 PERMUTATION**

**Summary:** Returns the number of permutations for a given number of objects (repetition allowed).

**Syntax:** PERMUTATIONA( Integer Total ; Integer Chosen )

**Returns:** Number

**Constraints:** Total >= 0, Chosen >= 0

**Semantics:** Given Total number of objects, return the number of permutations containing Chosen number of objects, with repetition permitted. The result is 1 if Total = 0 and Chosen = 0, otherwise the result is

\[ \text{PERMUTATIONA} = \text{Total}^{\text{Chosen}} \]

**8.18.61 PHI**

**Summary:** Returns the values of the density function for a standard normal distribution.

**Syntax:** PHI( Number N )

**Returns:** Number

**Semantics:** PHI(N) is a synonym for NORMDIST(N,0,1,FALSE()).

**8.18.62 POISSON**

**Summary:** returns the probability or the cumulative distribution function for the Poisson distribution

**Syntax:** POISSON( Integer x ; Number \( \lambda \) [ ; Logical Cumulative = TRUE() ] )

**Returns:** Number

**Constraints:** \( \lambda > 0 \), \( x >= 0 \)

**Semantics:** If Cumulative is FALSE(), POISSON returns the value

\[ e^{-\lambda} \frac{\lambda^{|x|}}{|x|!} \]

If Cumulative is TRUE(), POISSON returns the value

\[ \sum_{k=0}^{k=|x|} \frac{e^{-\lambda} \lambda^k}{k!} \]

**8.18.63 PROB**

**Summary:** Returns the probability that a discrete random variable lies between two limits.

**Syntax:** PROB( ForceArray Array Data ; ForceArray Array Probability ; Number Start [ ; Number End ] )

**Returns:** Number

**Constraints:**
- The sum of the probabilities in Probability shall equal 1.
All values in Probability shall be > 0 and <= 1.

COUNT(Data) = COUNT(Probability)

Semantics:

- **Data** is the array or range of data in the sample (the Number values in this array or range are referred to below as \(d_1, d_2, \ldots, d_n\)).

- **Probability** is the array or range of the corresponding probabilities (the Number values in this array or range are referred to below as \(p_1, p_2, \ldots, p_n\)).

- **Start** is the start value (lower bound) of the interval whose probabilities are to be summed.

- **End** (optional) is the end value (upper bound) of the interval whose probabilities are to be summed. If omitted, \(End = Start\) is used.

\[a \leq x \leq b\] Suppose that \(I(x, a, b)\) denotes the indicator function that is 1 if and 0 otherwise. Then PROB returns

\[
\sum_{i=1}^{n} (I(d_i, Start, End) \times p_i)
\]

i.e. the sum of all probabilities \(p_i\) whose corresponding data value \(d_i\) satisfies \(Start \leq d_i \leq End\).

Note that if \(End < Start\) then PROB returns 0 since in this case \(I(d_i, Start, End) = 0\) for all \(i\).

See also

8.18.64 QUARTILE

Summary: Returns a quartile of a set of data points.

Syntax: QUARTILE( NumberSequence Data ; Integer Quart )

Returns: Number

Constraints:

- COUNT(Data) > 0
- 0 <= Quart <= 4

Semantics:

- **Data** The cell range or data array of numeric values.

- **Quart** The number of the quartile to return.

  If Quart = 0, the minimum value is returned, which is equivalent to the MIN() function.

  If Quart = 1, the value of the 25th percentile is returned.

  If Quart = 2, the value of the 50th percentile is returned, which is equivalent to the MEDIAN() function.

  If Quart = 3, the value of the 75th percentile is returned.

  If Quart = 4, the maximum value is returned, which is equivalent to the MAX() function.
Based on the statistical rank of the data points in Data, QUARTILE returns the percentile value indicated by Quart. The percentile is calculated as Quart divided by 4. An algorithm to calculate the percentile for a set of data points is given in the definition of PERCENTILE.

See also MAX 8.18.45, MEDIAN 8.18.47, MIN 8.18.48, PERCENTILE 8.18.57, PERCENTRANK 8.18.58, RANK 8.18.65

8.18.65 RANK

Summary: Returns the rank of a number in a list of numbers.

Syntax: RANK( Number Value ; NumberSequenceList Data [ ; Number Order = 0 ] )

Returns: Number

Constraints: Value shall exist in Data.

Semantics: The RANK function returns the rank of a value within a list.

- **Value** the number for which to determine the rank.
- **Data** numbers used to determine the ranking.
- **Order** specifies how to rank the numbers:
  - If 0 or omitted, Data is ranked in descending order.
  - If not 0, Data is ranked in ascending order.

If a number in Data occurs more than once it is given the same rank, but increments the rank for subsequent different numbers. If Value does not exist in Data an Error is returned.

8.18.66 RSQ

Summary: Returns the square of the Pearson product moment correlation coefficient through data points in known_y's and known_x's.

Syntax: RSQ( ForceArray Array arrayY ; ForceArray Array arrayX )

Returns: Number

Constraints:

The arguments shall be either numbers or names, arrays, or references that contain numbers.

If an array or reference argument contains Text, Logical values, or empty cells, those values are ignored; however, cells with the value zero are included.

If "arrayY" and "arrayX" are empty or have a different number of data points, then #N/A is returned.

COLUMNS(arrayY) = COLUMNS(arrayX), ROWS(arrayY) = ROWS(arrayX)

Semantics: The r-squared value can be interpreted as the proportion of the variance in y attributable to the variance in x.
\[ r^2 = \frac{\sum_{i=1}^{N} (y_i - \bar{y})^2 - \sum_{i=1}^{N} (y_i - y_{calc})^2}{\sum_{i=1}^{N} (y_i - \bar{y})^2} \]

and

\[ y_{calc} = a + bx \]

where

\[ a = \frac{\sum_{i=1}^{N} (x_i^2) - \left( \sum_{i=1}^{N} x_i \right)^2}{N \left( \sum_{i=1}^{N} x_i^2 \right) - \left( \sum_{i=1}^{N} x_i \right)^2} \]

\[ b = \frac{\sum_{i=1}^{N} (x_i y_i) - \left( \sum_{i=1}^{N} x_i \right) \left( \sum_{i=1}^{N} y_i \right)}{N \left( \sum_{i=1}^{N} x_i^2 \right) - \left( \sum_{i=1}^{N} x_i \right)^2} \]

The result of the RSQ function is the same as PEARSON * PEARSON.

For an empty element or an element of type Text or Boolean in arrayY the element at the corresponding position of arrayX is ignored, and vice versa.

See also PEARSON 8.18.56

8.18.67 SKEW

Summary: Estimates the skewness of a distribution using a sample set of numbers.

Syntax: SKEW( \{ NumberSequenceList sample \} )

Returns: Number

Constraints: The sequence shall contain three numbers at least.

Semantics: Estimates the skewness of a distribution using a sample set of numbers.

Given the expectation value \( \bar{x} \) and the standard deviation estimate \( s \), the skewness becomes

\[ v = \frac{N}{(N-1)(N-2)} \sum_{i=1}^{N} \left( \frac{x_i - \bar{x}}{s} \right)^3 \]

See also SKEWP 8.18.68

8.18.68 SKEWP

Summary: Calculates the skewness of a distribution using the population of a random variable.

Syntax: SKEWP( \{ NumberSequence population \} )
Returns: Number

Constraints: The sequence shall contain three numbers at least.

Semantics: Calculates the skewness of a distribution using the population, i.e. the possible outcomes, of a random variable.

Given the expectation value \( \bar{x} \) and the standard deviation \( \sigma \), the skewness becomes

\[
v = \frac{1}{N} \sum_{i=1}^{N} \left( \frac{x_i - \bar{x}}{\sigma} \right)^3
\]

See also SKEW 8.18.67

8.18.69 SLOPE

Summary: Calculates the slope of the linear regression line.

Syntax: SLOPE( ForceArray y ; ForceArray x )

Returns: Number

Constraints: COLUMNS(y) = COLUMNS(x), ROWS(y) = ROWS(x), both sequences shall contain at least one number at corresponding positions each.

Semantics: Calculates the slope of the linear regression line.

\[
a = \frac{\sum_{i=1}^{N} (x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{N} (x_i - \bar{x})^2}
\]

For an empty element or an element of type Text or Boolean in y the element at the corresponding position of x is ignored, and vice versa.

See also INTERCEPT 8.18.38, STEYX 8.18.76

8.18.70 SMALL

Summary: Finds the nth smallest value in a list.

Syntax: SMALL( NumberSequenceList List ; Integer|Array N )

Returns: Number or Array

Constraints: ROUNDDOWN(N;0)=N, effectively being INT(N)=N for positive numbers. If the resulting N is <1 or larger than the size of List, Error is returned.

Semantics: If N is an array of numbers, an array of smallest values is returned.

See also LARGE 8.18.40, ROUNDDOWN 8.17.7

8.18.71 STANDARDIZE

Summary: Calculates a normalized value of a random variable.

Syntax: STANDARDIZE( Number value ; Number mean ; Number sigma )
Returns: Number

Constraints: \( \sigma > 0 \)

Semantics: Calculates a normalized value of a random variable.

\[
\text{STANDARDIZE} = \frac{(\text{value} - \text{mean})}{\sigma}
\]

See also GAUSS 8.18.33

8.18.72 STDEV

Summary: Compute the sample standard deviation of a set of numbers.

Syntax: STDEV( \{ NumberSequenceList N \} )

Returns: Number

Constraints: At least two numbers shall be included. Returns an Error if less than two Numbers are provided.

Semantics: Computes the sample standard deviation \( s \), where

\[
s^2 = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2
\]

with

\[
\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i
\]

Note that \( s \) is not the same as the standard deviation of the set, \( \sigma \), which uses \( n \) rather than \( n - 1 \).

See also STDEVP 8.18.74, AVERAGE 8.18.3

8.18.73 STDEVA

Summary: Calculate the standard deviation using a sample set of values, including values of type Text and Logical.

Syntax: STDEVA( \{ Any sample \} )

Returns: Number

Constraints: COUNTA(sample) > 1.

Semantics: Unlike the STDEV function, includes values of type Text and Logical. Text values are treated as number 0. Logical True is treated as 1, and False is treated as 0. Empty cells are not included.

The handling of string constants as parameters is implementation-defined. Either, string constants are converted to numbers, if possible and otherwise, they are treated as zero, or string constants are always treated as zero.

Suppose the resulting sequence of values is \( x_1, x_2, \ldots, x_n \). Then let
STDEVA returns

\[ s = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2} \]

See also STDEV 8.18.72

8.18.74 STDEVP

Summary: Calculates the standard deviation using the population of a random variable, including values of type Text and Logical.

Syntax: STDEVP( { NumberSequence N }+ )

Returns: Number

Constraints: None.

Semantics: Computes the standard deviation of the set \( \sigma \), where

\[ \sigma^2 = \frac{1}{n} \sum_{i=1}^{n} (x_i - \bar{x})^2 \]

Note that \( \sigma \) is not the same as the sample standard deviation, \( s \), which uses \( n - 1 \) rather than \( n \).

See also STDEV 8.18.72, AVERAGE 8.18.3

8.18.75 STDEVPA

Summary: Calculates the standard deviation using the population of a random variable, including values of type Text and Logical.

Syntax: STDEVPA( { Any sample }+ )

Returns: Number

Constraints: None.

Semantics: Unlike the STDEV function, includes values of type Text and Logical. Text values are treated as number 0. Logical True is treated as 1, and False is treated as 0. Empty cells are not included.

Given the expectation value \( \bar{x} \) the standard deviation becomes

\[ \sigma^2 = \frac{1}{n} \sum_{i=1}^{n} (x_i - \bar{x})^2 \]

In the sequence, only Numbers and Logical types are considered; cells with Text are converted to 0; other types are ignored. If Logical types are a distinct type, they are still included, with True considered 1 and False considered 0. Any sample may be of type ReferenceList.

The handling of string constants as parameters is implementation-defined. Either, string constants are converted to numbers, if possible and otherwise, they are treated as zero, or string constants are always treated as zero.
See also STDEVP 8.18.74

8.18.76 STEYX

Summary: Calculates the standard error of the predicted y value for each x in the regression.

Syntax: STEYX( ForceArray Array measuredY ; ForceArray Array X )

Returns: Number

Constraints: COLUMNS(measuredY) = COLUMNS(X), ROWS(measuredY) = ROWS(X), both sequences shall contain at least three numbers at corresponding positions each.

Semantics: Calculates the standard error of the predicted y value for each x in the regression.

\[
STEYX = \sqrt{\frac{1}{n(n-2)} \left( \frac{n \sum x_i y_i^2 - \left( \sum x_i \sum y_i \right)^2}{n \sum x_i^2 - \left( \sum x_i \right)^2} \right) - \left( \frac{n \sum x_i y_i - \sum x_i \sum y_i}{n} \right)^2}
\]

For an empty element or an element of type Text or Boolean in measuredY the element at the corresponding position of X is ignored, and vice versa.

See also INTERCEPT 8.18.38, SLOPE 8.18.69

8.18.77 LEGACY.TDIST

Summary: Returns the area to the tail or tails of the probability density function of the t-distribution.

Syntax: LEGACY.TDIST( Number x ; Integer df ; Integer tails)

Returns: Number

Constraints: x≥0, df ≥ 1, tails = 1 or 2

Semantics: Then LEGACY.TDIST returns

\[
tails \int_{x}^{\infty} f(t) dt
\]

where

\[
f(t) = \frac{\Gamma\left(\frac{df+1}{2}\right)}{\sqrt{\pi} df \, \Gamma\left(\frac{df}{2}\right)} \left(1 + \frac{t^2}{df}\right)^{-\frac{(df+1)}{2}}
\]

Note that df denotes the degrees of freedom of the t-distribution and Γ is the Gamma function.

See also BETADIST 8.18.7, BINOMDIST 8.18.10, CHISQDIST 8.18.12, EXPONDIST 8.18.21, FDIST 8.18.22, GAMMADIST 8.18.31, GAUSS 8.18.33, HYPGEOMDIST 8.18.37, LOGNORMDIST 8.18.44, NEGBINOMDIST 8.18.51, NORMDIST 8.18.52, POISSON 8.18.62, WEIBULL 8.18.86
**8.18.78 TINV**

**Summary:** Calculates the inverse of the two-tailed t-distribution.

**Syntax:** TINV( Number probability ; Integer degreeOfFreedom )

**Returns:** Number

**Constraints:** 0 < probability <= 1, degreeOfFreedom >= 1

**Semantics:** Calculates the inverse of the two-tailed t-distribution.

**See also** LEGACY.TDIST 8.18.77

---

**8.18.79 TREND**

**Summary:** Returns predicted values based on a simple or multiple linear regression

**Calculates a sequence of values based on a linear regression of known value pairs.**

**Syntax:** TREND( Array knownY [ ; [ Array knownX ] [ ; Array newX ] [ ; Logical Const ] NumberSequence knownY [ ; NumberSequence knownX ] [ ; NumberSequence newX ] [ ; Logical allowOffset = TRUE() ] ] )

**Returns:** Array

**Constraints:** (COLUMNS(knownY) = COLUMNS(knownX) and ROWS(knownY) = ROWS(knownX)) or (COLUMNS(knownY) = 1 and ROWS(knownY) = ROWS(knownX) and COLUMNS(knownX) = COLUMNS(newX)) or (COLUMNS(knownY) = COLUMNS(knownX) and ROWS(knownY) = 1 and ROWS(knownX) = ROWS(newX) COUNT(knownY) = COUNT(knownX), COLUMNS(knownY) = COLUMNS(knownX), ROWS(knownY) = ROWS(knownX))

**Semantics:** Calculates a sequence of values based on a linear regression of known value pairs.

- knownY: The set of known y-values to be used to determine the regression equation
- knownX: The set of known x-values to be used to determine the regression equation. If omitted or an empty parameter, it is set to the sequence 1,2,3,...,k, where k = ROWS(knownY)⋅COLUMNS(knownY). If an empty parameter, it is set to knownX.
- newX: The set of x-values for which predicted $\hat{y}$-values are to be calculated. If omitted or an empty parameter, it is set to knownX.
- Const: If set to FALSE(), the model constant a is equal to 0.
- LINEST(knownY; knownX; Const; FALSE()) either returns an error an array with 1 row and n+1 columns. If it returns an error then so does TREND. If it returns an array, we call the entries in that array $b_n, b_{n-1}, \ldots, b_1, a$.
- Let $z_{ij}$ denote the entry in the i-th row and j-th column of newX.

If COLUMNS(knownY) = COLUMNS(knownX) and ROWS(knownY) = ROWS(knownX), then TREND returns an array with ROWS(newX) rows and COLUMNS(newX) column, such that the entry in its i-th row and j-th column is $a + b_j \cdot z_{ij}$.
Otherwise, if \( \text{COLUMNS}(\text{knownY}) = 1 \) and \( \text{ROWS}(\text{knownY}) = \text{ROWS}(\text{knownX}) \) and \( \text{COLUMNS}(\text{knownX}) = \text{COLUMNS}(\text{newX}) \), then \( \text{TREND} \) returns an array with \( \text{ROWS}(\text{newX}) \) rows and 1 column, such that the entry in the \( i \)th row is

\[
a + \sum_{j=1}^{n} b_j z_{ij}
\]

Otherwise, if \( \text{COLUMNS}(\text{knownY}) = \text{COLUMNS}(\text{knownX}) \) and \( \text{ROWS}(\text{knownY}) = 1 \) and \( \text{ROWS}(\text{knownX}) = \text{ROWS}(\text{newX}) \), then \( \text{TREND} \) returns an array with 1 row and \( \text{COLUMNS}(\text{newX}) \) columns, such that the entry in the \( j \)th column is

\[
a + \sum_{i=1}^{n} b_i z_{ij}
\]

If \( \text{knownX} \) is omitted or an empty parameter (two consecutive \( ; ; \) semicolons), it is set to the sequence

\[ \text{Object 424} \]

where

\[ \text{Object 433} \]

If \( \text{newX} \) is omitted or an empty parameter (two consecutive \( ; ; \) semicolons), it is set to be equal to \( \text{knownX} \).

If \( \text{allowOffset} \) is TRUE:


If \( \text{allowOffset} \) is FALSE:

See also \( \text{INTERCEPT} \) 8.18.38, \( \text{SLOPE} \) 8.18.69, \( \text{STEYX} \) 8.18.76

### 8.18.80 TRIMMEAN

**Summary:** Returns the mean of a data set, ignoring a proportion of high and low values.

**Syntax:** \( \text{TRIMMEAN} \left( \text{NumberSequenceList dataSet} ; \text{Number cutOffFraction} \right) \)

**Returns:** Number

**Constraints:** \( 0 \leq \text{cutOffFraction} < 1 \)

**Semantics:** Returns the mean of a data set, ignoring a proportion of high and low values.

Let \( n \) denote the number of elements in the data set and let

\[ \text{sortedDataSet}_1, \text{sortedDataSet}_2, \text{sortedDataSet}_3, \ldots, \text{sortedDataSet}_n \]

be the values in the data set sorted in ascending order. Moreover let

\[ \text{cutOff} = \text{INT} \left( \frac{n \cdot \text{cutOffFraction}}{2} \right) \]

Then \( \text{TRIMMEAN} \) returns the value

\[
\frac{1}{n - 2 \cdot \text{cutOff}} \sum_{i=\text{cutOff}+1}^{n-\text{cutOff}} \text{sortedDataSet}_i
\]

See also \( \text{AVERAGE} \) 8.18.3, \( \text{GEOMEAN} \) 8.18.34, \( \text{HARMEAN} \) 8.18.36

### 8.18.81 TTEST

**Summary:** Calculates the p-value of a 2-sample t-test.

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**Syntax:** TTEST( ForceArray Array X ; ForceArray Array Y ; Integer tails ; Integer type )

**Returns:** Number

**Constraints:** COUNT(X)>1, COUNT(Y)>1, tails = 1 or 2, type = 1, 2, or 3, (COUNT(X)=COUNT(Y) or type ≠1)

COLUMNS(X) = COLUMNS(Y), ROWS(X) = ROWS(Y)

**Semantics:** Let \( X_1, X_2, \ldots, X_n \) be the numbers in the sequence \( X \) and \( Y_1, Y_2, \ldots, Y_m \) be the numbers in the sequence \( Y \). Then

\[
X = \frac{1}{n} \sum_{i=1}^{n} X_i
\]

and

\[
Y = \frac{1}{m} \sum_{i=1}^{m} Y_i
\]

Moreover let

\[
s_X^2 = \frac{1}{n-1} \sum_{i=1}^{n} (X_i - \bar{X})^2
\]

\[
s_Y^2 = \frac{1}{m-1} \sum_{i=1}^{m} (Y_i - \bar{Y})^2
\]

and

\[
f(x, df) = \frac{\left(\frac{df+1}{2}\right)}{\sqrt{\pi df} \Gamma\left(\frac{df}{2}\right)} \left[1 + \frac{x^2}{2}\right]^{\frac{df+1}{2}}
\]

where \( \Gamma \) is the Gamma function.

1. If type = 1, TTEST calculates the p-value for a paired-sample comparison of means test. Note that in this case due to the above constraints \( n=m \). With

\[
s_{X-Y}^2 = \frac{1}{n-1} \sum_{i=1}^{n} ((X_i - Y_i) - (X - Y))^2
\]

and

\[
t = \frac{X - Y}{\sqrt{s_{X-Y}^2 \sqrt{n}}}
\]

TTEST returns

\[
tails \cdot \int_{t}^{\infty} f(x, n-1) \, dx
\]

2. If type = 2, TTEST calculates the p-value of a comparison of means for independent samples from populations with equal variance. With
\[ s_p^2 = \frac{(n-1)s_x^2 + (m-1)s_y^2}{n+m-2} \]

and

\[ t = \left| \frac{\bar{X} - \bar{Y}}{s_p \sqrt{\frac{1}{n} + \frac{1}{m}}} \right| \]

TTEST returns

\[ \text{tails} \cdot \int_t^\infty f(x, n+m-2) \, dx \]

(3) If type = 3, TTEST calculates the p-value of a comparison of means for independent samples from populations with not necessarily equal variances. With

\[ t = \left| \frac{\bar{X} - \bar{Y}}{\sqrt{\frac{s_x^2}{n} + \frac{s_y^2}{m}}} \right| \]

and

\[ v = \frac{\left( \frac{s_x^2}{n} + \frac{s_y^2}{m} \right)^2}{\frac{\left( \frac{s_x^2}{n} \right)^2}{n-1} + \frac{\left( \frac{s_y^2}{m} \right)^2}{m-1}} \]

TTEST returns

\[ \text{tails} \cdot \int_t^\infty f(x, v) \, dx \]

For an empty element or an element of type Text or Boolean in \( X \) the element at the corresponding position of \( Y \) is ignored, and vice versa.

See also FTEST 8.18.30, LEGACY.TDIST 8.18.77, ZTEST 8.18.87

8.18.82 \textbf{VAR}

Summary: Compute the sample variance of a set of numbers.

Syntax: \textsc{VAR} ( \{ \text{NumberSequence N} \} + )

Returns: Number

Constraints: At least two numbers shall be included. Returns an Error if less than two Numbers are provided.

Semantics: Computes the sample variance \( s^2 \), where

\[ s^2 = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2 = \frac{1}{n-1} \left( \sum_{i=1}^{n} x_i^2 - n \bar{x}^2 \right) \]
Note that $s^2$ is not the same as the variance of the set, $\sigma^2$, which uses $n$ rather than $n - 1$.

**See also** VARP 8.18.84, STDEV 8.18.72, AVERAGE 8.18.3

### 8.18.83 VARA

**Summary:** Estimates the variance using a sample set of values, including values of type Text and Logical.

**Syntax:** VARA( { Any sample }+)

**Returns:** Number

**Constraints:** The sequence shall contain two numbers at least.

**Semantics:** Unlike the VAR function, includes values of type Text and Logical. Text values are treated as number 0. Logical True is treated as 1, and False is treated as 0. Empty cells are not included.

Given the expectation value $\bar{x}$ the estimated variance becomes

$$s^2 = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2 = \frac{1}{n-1} \left( \sum_{i=1}^{n} x_i^2 - n \bar{x}^2 \right)$$

In the sequence, only Numbers and Logical types are considered; cells with Text are converted to 0; other types are ignored. If Logical types are a distinct type, they are still included, with True considered 1 and False considered 0. Any sample may be of type ReferenceList.

The handling of string constants as parameters is implementation-defined. Either, string constants are converted to numbers, if possible and otherwise, they are treated as zero, or string constants are always treated as zero.

**See also** VAR 8.18.82

### 8.18.84 VARP

**Summary:** Compute the variance of the set for a set of numbers.

**Syntax:** VARP( { NumberSequence N }+)

**Returns:** Number

**Constraints:** COUNT(N)\(\geq 1\)

**Semantics:** Computes the variance of the set $\sigma^2$, where

$$\sigma^2 = \frac{1}{n} \sum_{i=1}^{n} (x_i - \bar{x})^2 = \frac{1}{n} \left( \sum_{i=1}^{n} x_i^2 - n \bar{x}^2 \right)$$

Note that $\sigma^2$ is not the same as the sample variance, $s^2$, which uses $n - 1$ rather than $n$.

If only one number is provided, returns 0.

**See also** VAR 8.18.82, STDEVP 8.18.74, AVERAGE 8.18.3
8.18.85 VARPA

Summary: Calculates the variance using the population of the distribution, including values of type Text and Logical.

Syntax: VARPA( Any sample )

Returns: Number

Constraints: None

Semantics: Unlike the VARP function, includes values of type Text and Logical. Text values are treated as number 0. Logical True is treated as 1, and False is treated as 0. Empty cells are not included.

Given the expectation value $\bar{x}$, the variance becomes

$$\sigma^2 = \frac{1}{n} \sum_{i=1}^{n} (x_i - \bar{x})^2 = \frac{1}{n} \left( \sum_{i=1}^{n} x_i^2 - n \bar{x}^2 \right)$$

In the sequence, only Numbers and Logical types are considered; cells with Text are converted to 0; other types are ignored. If Logical types are a distinct type, they are still included, with True considered 1 and False considered 0. Any sample may be of type ReferenceList.

The handling of string constants as parameters is implementation-defined. Either, string constants are converted to numbers, if possible and otherwise, they are treated as zero, or string constants are always treated as zero.

See also VARP 8.18.84

8.18.86 WEIBULL

Summary: Calculates the Weibull distribution.

Syntax: WEIBULL( Number value ; Number alpha ; Number beta ; Logical cumulative )

Returns: Number

Constraints: value $\geq 0$; shape $> 0$; scale $> 0$

Semantics: Calculates the Weibull distribution at the position value.

If cumulative is false, the probability density function is calculated:

$$f(x) = \frac{\text{shape}}{\text{scale}} \left( \frac{\text{value}}{\text{scale}} \right)^{\text{shape}-1} e^{-\left( \frac{\text{value}}{\text{scale}} \right)^{\text{shape}}}$$

If cumulative is true, the cumulative distribution function is calculated:

$$F(x) = 1 - e^{-\left( \frac{\text{value}}{\text{scale}} \right)^{\text{shape}}}$$

See also BETADIST 8.18.7, BINOMDIST 8.18.10, CHISQDIST 8.18.12, EXPONDIST 8.18.21, FDIST 8.18.22, GAMMADIST 8.18.31, GAUSS 8.18.33, HYPGEOMDIST 8.18.37, LOGNORMDIST 8.18.44, NEGBINOMDIST 8.18.51, NORMDIST 8.18.52, POISSON 8.18.62, LEGACY.TDIST 8.18.77
8.18.87 ZTEST

Summary: Calculates the probability of observing a sample mean as large or larger than the mean of the given sample for samples drawn from a normal distribution.

Syntax: ZTEST( NumberSequenceList sample ; Number mean [ ; Number sigma ] )

Returns: Number

Constraints: The sequence sample shall contain at least two numbers.

Semantics: Calculates the probability of observing a sample mean as large or larger than the mean of the given sample for samples drawn from a normal distribution with the given mean mean and the given standard deviation sigma. If sigma is omitted, it is estimated from sample, using STDEV. With sample being the mean of sample and

\[ z = \frac{\text{sample} - \text{mean}}{\text{sigma}} \sqrt{n} \]

ZTEST returns

\[ P\{Z \leq z\} = \frac{1}{\sqrt{2 \pi}} \int_{-\infty}^{z} e^{-\frac{x^2}{2}} dx \]

See also FTEST 8.18.30, TTEST 8.18.81

8.19 Number Representation Conversion Functions

8.19.1 General

These functions convert between different representations of numbers, such as between different bases and Roman numerals.

The base conversion functions xxx2BIN (such as DEC2BIN), xxx2OCT, and xxx2HEX functions return Text, while the xxx2DEC functions return Number. All of the xxx2yyy functions accept either Text or Number, though a Number is interpreted as the digits when printed in base 10. These are intended to support relatively small numbers, and have a somewhat convoluted interface and semantics, as described in their specifications. General base conversion capabilities are provided by BASE and DECIMAL.

As an argument for the HEX2xxx functions, a hexadecimal number is any string consisting solely of the characters "0","1" to "9", "a" to "f" and "A" to "F". The hexadecimal output of an xxx2HEX function shall be a string consisting solely of the characters "0","1" to "9" (U+0030 through U+0039), "a" to "f" (U+0061 through U+0066) and "A" to "F" (U+0041 through U+0046), and should be a string consisting solely of the characters "0","1" to "9" and "A" to "F". In both cases, the 40th bit (from the right) is considered a sign bit.

8.19.2 ARABIC

Summary: Convert Roman numerals to Number.

Syntax: ARABIC( Text X )

Returns: Number

Constraints: X shall contain Roman numerals, or an empty string.
**Semantics:** Converts the Roman numeral to Number. This is the reverse of ROMAN; see ROMAN for the values of individual Roman numeral symbols. A Roman symbol to the left of a larger symbol (directly or indirectly) reduces the final value by the symbol amount, otherwise, it increases the final amount by the symbol's amount. Case is ignored.

The characters accepted are U+004D "M", U+0044 "D", U+0043 "C", U+004C "L", U+0058 "X", U+0056 "V", U+0049 "I", U+006D "m", U+0064 "d", U+0063 "c", U+006C "l", U+0078 "x", U+0076 "v", U+0069 "i".

The following identity shall hold: ARABIC(ROMAN(x; any)) = x, when ROMAN(x; any) is not an Error.

If X is an empty string, 0 is returned.

**See also** Infix Operator "&" 8.4.10, ROMAN 8.19.17

### 8.19.3 BASE

**Summary:** Converts a number into a text representation with the given base.

**Syntax:** BASE( Integer X ; Integer Radix [ ; Integer MinimumLength ] )

**Returns:** Text

**Constraints:** X ≥ 0, 2 ≤ Radix ≤ 36, MinimumLength ≥ 0

**Semantics:** Converts number X into text that represents the value of X in base Radix. The symbols 0-9 (U+0030 through U+0039), then upper case A-Z (U+0041 through U+005A) are used as digits. Thus, BASE(45745;36) returns “ZAP”.

If MinimumLength is not supplied, the generated text uses the smallest number of characters (i.e., it does not add leading 0s). If MinimumLength is supplied, and the resulting text would normally be smaller than MinimumLength, leading 0s are added to produce text exactly MinimumLength characters long. If the text is longer than the MinimumLength argument, the MinimumLength parameter is ignored.

**See also** DECIMAL 8.19.10

### 8.19.4 BIN2DEC

**Summary:** Converts a binary (base 2) number (up to 10 digits) to its decimal equivalent

**Syntax:** BIN2DEC( TextOrNumber X )

**Returns:** Number

**Constraints:** X shall contain only binary digits (no space or other characters), and shall contain at least one binary digit. When considered as a Number, INT(X)=X. Evaluators may evaluate expressions where the digits in X are only 0 or 1, no more than 10 digits.

**Semantics:** Converts given binary number into decimal equivalent, with the topmost 10th digit being the sign bit (using a two's complement representation). If given Text, the text is considered a binary number representation. If given a Number, the digits of the number when printed as base 10 are considered the digits of the equivalently-represented binary number. It is implementation-defined what happens if given a Logical value; an evaluator may produce an Error, or it may convert the Logical to Number (per “Convert to Number”) and then process as a Number.

If any digits are 2 through 9, an evaluator shall return an Error. It is implementation-defined what happens if an evaluator is given an empty string; evaluators may return an Error or 0 in such cases.
8.19.5 BIN2HEX

Summary: Converts a binary (base 2) number (10th bit is sign) to its hexadecimal equivalent

Syntax: BIN2HEX( TextOrNumber X [ ; Number Digits ] )

Returns: Text

Constraints: X shall contain only binary digits (no space or other characters), and shall contain at least one binary digit. When considered as a Number, INT(X)=X. Evaluators may evaluate expressions where the digits in X are only 0 or 1, no more than 10 digits.

Semantics: Converts given binary number into hexadecimal (base 16) equivalent. For input value X, the topmost 10th digit is considered the sign bit (using a two's complement representation). If given Text, the text is considered a binary number representation. If given a Number, the digits of the number when printed as base 10 are considered the digits of the equivalently-represented binary number. It is implementation-defined what happens if given a Logical value; an evaluator may produce an Error, or it may convert the Logical to Number (per “Convert to Number”) and then process as a Number.

If any digits in X are 2 through 9, an evaluator shall return an Error. It is implementation-defined what happens if an evaluator is given an empty string; evaluators may return an Error or 0 in such cases.

The resulting value is a hexadecimal value, up to 10 hexadecimal digits, with the topmost bit (40th bit) being the sign bit and in two's complement form. The digits A through F are in uppercase. If the input has its 10th bit on, the Digits argument is ignored; otherwise, the Digits indicates the number of digits in the output, with leading 0 digits added as necessary to bring it up to that number of digits. If there are more digits required than the Digits parameter specifies, the results are implementation-defined.

8.19.6 BIN2OCT

Summary: Converts a binary (base 2) number (10th bit is sign) to its octal (base 8) equivalent

Syntax: BIN2OCT( TextOrNumber X [ ; Number Digits ] )

Returns: Text

Constraints: X shall contain only binary digits (no space or other characters), and shall contain at least one binary digit. When considered as a Number, INT(X)=X. Evaluators may evaluate expressions where the digits in X are only 0 or 1, no more than 10 digits.

Semantics: Converts given binary number into octal (base 8) equivalent. For input value X, the topmost 10th digit is considered the sign bit (using a two's complement representation). If given Text, the text is considered a binary number representation. If given a Number, the digits of the number when printed as base 10 are considered the digits of the equivalently-represented binary number. It is implementation-defined what happens if given a Logical value; an evaluator may produce an Error, or it may convert the Logical to Number (per “Convert to Number”) and then process as a Number.

If any digits in X are 2 through 9, an evaluator shall return an Error. It is implementation-defined what happens if an evaluator is given an empty string; evaluators may return an Error or 0 in such cases.

The resulting value is an octal value, up to 10 octal digits, with the topmost bit (30th bit) being the sign bit and in two's complement form. If the input has its 10th bit on, the Digits argument is ignored; otherwise, the Digits indicates the number of digits in the output, with leading 0 digits added as necessary to bring it up to that number of digits. If there are more digits than specified by the Digits parameter, its results are implementation-defined.
8.19.7 DEC2BIN

Summary: Converts a decimal number to base 2 (whose 10th bit is sign)

Syntax: DEC2BIN( TextOrNumber X [ ; Number Digits ] )

Returns: Text

Constraints: X shall contain only decimal digits (no space or other characters), and shall contain at least one decimal digit. When considered as a Number, INT(X)=X. Evaluators may evaluate expressions where -512 <= X <= 511.

Semantics: Converts given number into binary (base 2) equivalent. If given Text, the text is considered a decimal number representation, and may have a leading minus sign. It is implementation-defined what happens if given a Logical value; an evaluator may produce an Error, or it may convert the Logical to Number (per "Convert to Number") and then process as a Number.

The resulting value is a binary value, up to 10 digits, with the topmost bit (10th bit) being the sign bit and in two's complement form. If the input is negative, the Digits argument is ignored; otherwise, the Digits indicates the number of digits in the output, with leading 0 digits added as necessary to bring it up to that number of digits. If there are more digits than specified by the Digits parameter, the results are implementation-defined.

8.19.8 DEC2HEX

Summary: Converts a decimal number to base 16 (whose 40th bit is sign)

Syntax: DEC2HEX( TextOrNumber X [ ; Number Digits ] )

Returns: Text

Constraints: X shall contain only decimal digits (no space or other characters), and shall contain at least one decimal digit. When considered as a Number, INT(X)=X. Evaluators may evaluate expressions where -2^39 <= X <= 2^39-1.

Semantics: Converts given number into hexadecimal (base 16) equivalent. If given Text, the text is considered a decimal number representation, and may have a leading minus sign. It is implementation-defined what happens if given a Logical value; an evaluator may produce an Error, or it may convert the Logical to Number (per "Convert to Number") and then process as a Number.

The resulting value is a hexadecimal value, up to 10 digits, with the topmost bit (40th bit) being the sign bit and in two's complement form. If the input is negative, the Digits argument is ignored; otherwise, the Digits indicates the number of digits in the output, with leading 0 digits added as necessary to bring it up to that number of digits. If there are more digits than specified by the Digits parameter, the results are implementation-defined.

8.19.9 DEC2OCT

Summary: Converts a decimal number to base 8 (whose 30th bit is sign)

Syntax: DEC2OCT( TextOrNumber X [ ; Number Digits ] )

Returns: Text

Constraints: X shall contain only decimal digits (no space or other characters), and shall contain at least one decimal digit. When considered as a Number, INT(X)=X. Evaluators may evaluate expressions where -2^29 <= X <= 2^29-1.

Semantics: Converts given number into octal (base 8) equivalent. If given Text, the text is considered a decimal number representation, and may have a leading minus sign. It is
implementation-defined what happens if given a Logical value; an evaluator may produce an Error, or it may convert the Logical to Number (per "Convert to Number") and then process as a Number.

The resulting value is a octal value, up to 10 digits, with the topmost bit (30th bit) being the sign bit and in two's complement form. If the input is negative, the Digits argument is ignored; otherwise, the Digits indicates the number of digits in the output, with leading 0 digits added as necessary to bring it up to that number of digits. If there are more digits than specified by the Digits parameter, the results are implementation-defined.

See also OCT2DEC

8.19.10 DECIMAL

Summary: Converts text representing a number in a given base into a base 10 number.

Syntax: DECIMAL( Text X ; Integer Radix )

Returns: Number

Constraints: 2 ≤ Radix ≤ 36

Semantics: Converts text X in base Radix to a Number. Uppercase letters (U+0041 through U+005A) and lowercase letters (U+0061 through U+007A) are both accepted as equivalent if Radix > 10. Thus, DECIMAL("zap",36) and DECIMAL("ZAP",36) both compute 45745.

An Error is returned if X has characters that do not belong in base Radix. However, leading spaces and tabs in X are always ignored. If Radix is 16, a leading regular expression "0?[Xx]" is ignored, as is a trailing letter H or h. If Radix is 2, the letter b or B at the end is ignored (if present).

See also BASE 8.19.3

8.19.11 HEX2BIN

Summary: Converts a hexadecimal number (40th bit is sign) to base 2 (whose 10th bit is sign)

Syntax: HEX2BIN( TextOrNumber X [ ; Number Digits ] )

Returns: Text

Constraints: X shall contain only hexadecimal digits (no space or other characters), and shall contain at least one hexadecimal digit. When considered as a Number, INT(X)=X. Evaluators may evaluate expressions where X is considered in base 10, -512 <= X <= 511.

Semantics: Converts given hexadecimal number into binary (base 2) equivalent. If given Text, the text is considered a hexadecimal number representation; if its 40th bit is 1, it is considered a negative number. It is implementation-defined what happens if given a Logical value; an evaluator may produce an Error, or it may convert the Logical to Number (per "Convert to Number") and then process as a Number.

The resulting value is a binary value, up to 10 digits, with the topmost bit (10th bit) being the sign bit and in two's complement form. If the input is negative (40th bit is 1), the Digits argument is ignored; otherwise, the Digits indicates the number of digits in the output, with leading 0 digits added as necessary to bring it up to that number of digits. If there are more digits than specified by the Digits parameter, the results are implementation-defined.

8.19.12 HEX2DEC

Summary: Converts a hexadecimal number (40th bit is sign) to decimal
Syntax: HEX2DEC( TextOrNumber X )

Returns: Number

Constraints: X shall contain only hexadecimal digits (no space or other characters), and shall contain at least one hexadecimal digit. When considered as a Number, INT(X)=X. Evaluators may evaluate expressions where X shall have 1 though 10 (inclusive) hexadecimal digits.

Semantics: Converts given hexadecimal number into decimal equivalent. If given Text, the text is considered a hexadecimal number representation. If X's 40th bit is 1, it is considered a negative number. It is implementation-defined what happens if given a Logical value; an evaluator may produce an Error, or it may convert the Logical to Number (per "Convert to Number") and then process as a Number.

The resulting value is a decimal number.

8.19.13 HEX2OCT

Summary: Converts a hexadecimal number (40th bit is sign) to base 8 (whose 30th bit is sign)

Syntax: HEX2OCT( TextOrNumber X [ ; Number Digits ] )

Returns: Text

Constraints: X shall contain hexadecimal digits (no spaces or other characters), and shall contain at least one hexadecimal digit. When considered as Number, INT(X)=X. Evaluators may evaluate expressions where X has 1 to 10 (inclusive) hexadecimal digits, base 10 value of X is -2^{29} < X < 2^{29}-1.

Semantics: Converts given hexadecimal number into octal (base 8) equivalent. If given Text, the text is considered a hexadecimal number representation; if its 40th bit is 1, it is considered a negative number. It is implementation-defined what happens if given a Logical value; an evaluator may produce an Error, or it may convert the Logical to Number (per "Convert to Number") and then process as a Number.

The resulting value is an octal value, up to 10 digits, with the topmost bit (10th bit) being the sign bit and in two's complement form. If the input is negative (40th bit is 1), the Digits argument is ignored; otherwise, the Digits indicates the number of digits in the output, with leading 0 digits added as necessary to bring it up to that number of digits. If there are more digits than specified by the Digits parameter, the results are implementation-defined.

8.19.14 OCT2BIN

Summary: Converts an octal number (30th bit is sign) to base 2 (whose 10th bit is sign)

Syntax: OCT2BIN( TextOrNumber X [ ; Number Digits ] )

Returns: Text

Constraints: X shall contain only octal digits (no space or other characters), and shall contain at least one octal digit. When considered as a Number, INT(X)=X. Evaluators may evaluate expressions where X is considered in base 10, -512 <= X <= 511.

Semantics: Converts given octal (base 8) number into binary (base 2) equivalent. If given Text, the text is considered an octal number representation; if its 30th bit is 1, it is considered a negative number. It is implementation-defined what happens if given a Logical value; an evaluator may produce an Error, or it may convert the Logical to Number (per "Convert to Number") and then process as a Number.
The resulting value is a binary value, up to 10 digits, with the topmost bit (10th bit) being the sign bit and in two's complement form. If the input is negative (30th bit is 1), the Digits argument is ignored; otherwise, the Digits indicates the number of digits in the output, with leading 0 digits added as necessary to bring it up to that number of digits. If there are more digits than specified by the Digits parameter, the results are implementation-defined.

8.19.15 OCT2DEC

Syntax: OCT2DEC( TextOrNumber X )

Summary: Converts an octal number (30th bit is sign) to decimal

Returns: Number

Constraints: X shall contain only octal digits (no space or other characters), and shall contain at least one octal digit. When considered as a Number, INT(X)=X. Evaluators may evaluate expressions where X shall have 1 through 10 (inclusive) octal digits.

Semantics: Converts given octal number into decimal equivalent. If given Text, the text is considered a octal number representation. If X's 30th bit is 1, it is considered a negative number. It is implementation-defined what happens if given a Logical value; an evaluator may produce an Error, or it may convert the Logical to Number (per "Convert to Number") and then process as a Number.

The resulting value is a decimal number.

8.19.16 OCT2HEX

Summary: Converts an octal number (30th bit is sign) to hexadecimal (whose 40th bit is sign)

Syntax: OCT2HEX( TextOrNumber X [ ; Number Digits ] )

Returns: Text

Constraints: X shall contain only octal digits (no space or other characters), and shall contain at least one octal digit. When considered as a Number, INT(X)=X. Evaluators may evaluate expressions where X shall have 1 to 10 (inclusive) octal digits.

Semantics: Converts given octal (base 8) number into hexadecimal (base 16) equivalent. If given Text, the text is considered an octal number representation; if its 30th bit is 1, it is considered a negative number. It is implementation-defined what happens if given a Logical value; an evaluator may produce an Error, or it may convert the Logical to Number (per "Convert to Number") and then process as a Number.

The resulting value is a hexadecimal value, up to 10 digits, with the topmost bit (40th bit) being the sign bit and in two’s complement form. If the input is negative (30th bit is 1), the Digits argument is ignored; otherwise, the Digits indicates the number of digits in the output, with leading 0 digits added as necessary to bring it up to that number of digits. If there are more digits than specified by the Digits parameter, the results are implementation-defined.

8.19.17 ROMAN

Summary: Convert to Roman numerals

Syntax: ROMAN( Integer N [ ; Integer Format = 0 ] )

Returns: Text

Constraints: N>=0, N<4000, 0 <= Format <= 4, ISLOGICAL(1) or NOT(ISLOGICAL(Format))
**Semantics:** Return the Roman numeral representation of N. “Format” specifies the level of conciseness, and defaults to 0, the classic representation, with larger numbers requiring increasing conciseness.

To support legacy documents, evaluators with Logical types that are distinct from Number may accept the format parameter as a scalar, and accept TRUE() specifying format 0, and FALSE() specifying format 4.

The following identity shall hold: \( \text{ARABIC(ROMAN(x; any)) = x, when ROMAN(x; any) is not an Error.} \)

If N is 0, an empty string is returned.

Table 34 - ROMAN lists the values of individual roman numerals; roman numerals that precede (directly or indirectly) a larger-valued roman number subtract their value from the final value.

<table>
<thead>
<tr>
<th>Roman Numeral</th>
<th>Value</th>
<th>Unicode Code Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1</td>
<td>U+0049</td>
</tr>
<tr>
<td>V</td>
<td>5</td>
<td>U+0056</td>
</tr>
<tr>
<td>X</td>
<td>10</td>
<td>U+0058</td>
</tr>
<tr>
<td>L</td>
<td>50</td>
<td>U+004C</td>
</tr>
<tr>
<td>C</td>
<td>100</td>
<td>U+0043</td>
</tr>
<tr>
<td>D</td>
<td>500</td>
<td>U+0044</td>
</tr>
<tr>
<td>M</td>
<td>1000</td>
<td>U+004D</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Roman Numeral</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>V</td>
<td>5</td>
</tr>
<tr>
<td>X</td>
<td>10</td>
</tr>
<tr>
<td>L</td>
<td>50</td>
</tr>
<tr>
<td>C</td>
<td>100</td>
</tr>
<tr>
<td>D</td>
<td>500</td>
</tr>
<tr>
<td>M</td>
<td>1000</td>
</tr>
</tbody>
</table>

Evaluators that accept 0 as a value of N should return the string “0”. Evaluators that accept negative values of N should include a negative sign (“-“) as the first character.

The Format levels are:
### Table 35 - ROMAN

<table>
<thead>
<tr>
<th>Format</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 or omitted (or TRUE)</td>
<td>Only subtract powers of 10, not L or V, and only if the next number is not more than 10 times greater. A number following the larger one shall be smaller than the subtracted number. Also known as classic.</td>
</tr>
<tr>
<td>1</td>
<td>Powers of 10, and L and V may be subtracted, only if the next number is not more than 10 times greater. A number following the larger one shall be smaller than the subtracted number.</td>
</tr>
<tr>
<td>2</td>
<td>Powers of 10 and L, but not V, may be subtracted, also if the next number is more than 10 times greater. A number following the larger one shall be smaller than the subtracted number.</td>
</tr>
<tr>
<td>3</td>
<td>Powers of 10, and L and V may be subtracted, also if the next number is more than 10 times greater. A number following the larger one shall be smaller than the subtracted number.</td>
</tr>
<tr>
<td>4 (or FALSE)</td>
<td>Produce the fewest Roman digits possible. Also known as simplified.</td>
</tr>
</tbody>
</table>

See also Infix Operator "&" 8.4.10, ARABIC 8.19.2

### 8.20 Text Functions

#### 8.20.1 General

#### 8.20.2 ASC

**Summary:** Converts full-width to half-width ASCII and katakana characters.

**Syntax:** ASC( Text T )

**Returns:** Text

**Constraints:** None

**Semantics:** Conversion is done for full-width ASCII and [UNICODE] katakana characters, some characters are converted in a special way, see table below. Other characters are copied from T to the result. This is the complementary function to JIS.

The percent sign % in the conversion table below denotes the modulo operation. A followed by means that a character is converted to two consecutive characters.

<table>
<thead>
<tr>
<th>From Unicode Character (c)</th>
<th>To Unicode Character</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>U+30a1 ≤ c ≤ U+30aa if c%2==0</td>
<td>(c - 0x30a2) / 2 + 0xff71</td>
<td>katakana a-o</td>
</tr>
<tr>
<td>From Unicode Character (c)</td>
<td>To Unicode Character</td>
<td>Comment</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------------</td>
<td>---------</td>
</tr>
<tr>
<td>U+30a1 &lt;= c &lt;= U+30aa</td>
<td>(c - 0x30a1) / 2 + 0xff67</td>
<td>katakana small a-o</td>
</tr>
<tr>
<td>if c%2==1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U+30ab &lt;= c &lt;= U+30c2</td>
<td>(c - 0x30ab) / 2 + 0xff76</td>
<td>katakana ka-chi</td>
</tr>
<tr>
<td>if c%2==1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U+30ab &lt;= c &lt;= U+30c2</td>
<td>(c - 0x30ac) / 2 + 0xff9e</td>
<td>katakana ga-dhi</td>
</tr>
<tr>
<td>if c%2==0</td>
<td>followed by 0xff9e</td>
<td></td>
</tr>
<tr>
<td>U+30c3</td>
<td>0xff6f</td>
<td>katakana small tsu</td>
</tr>
<tr>
<td>U+30c4 &lt;= c &lt;= U+30c9</td>
<td>(c - 0x30c4) / 2 + 0xff82</td>
<td>katakana tsu-to</td>
</tr>
<tr>
<td>if c%2==0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U+30c4 &lt;= c &lt;= U+30c9</td>
<td>(c - 0x30c5) / 2 + 0xff82</td>
<td>katakana du-do</td>
</tr>
<tr>
<td>if c%2==1</td>
<td>followed by 0xff9e</td>
<td></td>
</tr>
<tr>
<td>U+30ca &lt;= c &lt;= U+30ce</td>
<td>c - 0x30ca + 0xff85</td>
<td>katakana na-no</td>
</tr>
<tr>
<td>U+30cf &lt;= c &lt;= U+30dd</td>
<td>(c - 0x30cf) / 3 + 0xff8a</td>
<td>katakana ha-ho</td>
</tr>
<tr>
<td>if c%3==0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U+30cf &lt;= c &lt;= U+30dd</td>
<td>(c - 0x30d0) / 3 + 0xff8a</td>
<td>katakana ba-bo</td>
</tr>
<tr>
<td>if c%3==1</td>
<td>followed by 0xff9e</td>
<td></td>
</tr>
<tr>
<td>U+30cf &lt;= c &lt;= U+30dd</td>
<td>(c - 0x30d1) / 3 + 0xff8a</td>
<td>katakana pa-po</td>
</tr>
<tr>
<td>if c%3==2</td>
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<td>c - 0x30de + 0xff8f</td>
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<td>(c - 0x30e4) / 2 + 0xff94</td>
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<td>(c - 0x30e3) / 2 + 0xffc</td>
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| U+309c                    | U+ff9f              | KATAKAN...
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<th>To-Unicode-Character</th>
<th>Comment</th>
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<td>U+30ef &lt;= c &lt;= U+30dd if c%3==0</td>
<td>(c−0x30ef)/3 + 0xff8a</td>
<td>katakana-ha-he</td>
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<tr>
<td>U+30ef &lt;= c &lt;= U+30dd if c%3==1</td>
<td>(c−0x30d0)/3 + 0xff8a followed by 0xff9e</td>
<td>katakana-ba-bo</td>
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<tr>
<td>U+30ef &lt;= c &lt;= U+30dd if c%3==2</td>
<td>(c−0x30d1)/3 + 0xff8a followed by 0xff9f</td>
<td>katakana-pa-po</td>
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<tr>
<td>U+30de &lt;= c &lt;= U+30e2</td>
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<tr>
<td>U+30e3 &lt;= c &lt;= U+30e8 if c%2==0</td>
<td>(c−0x30e4)/2 + 0xff94</td>
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| U+30fc | U+ff70 | KATAKANA-HIRAGANA-
### 8.20.3 CHAR

**Summary:** Return character represented by the given numeric value

**Syntax:** CHAR( Number N )

**Returns:** Text

**Constraints:** N <= 127; Evaluators may evaluate expressions where N >= 1, N <= 255.

**Semantics:**

Returns character represented by the given numeric value.

Evaluators should return an Error if N > 255.

Evaluators should implement CHAR such that CODE(CHAR(N)) returns N for any 1 <= N <= 255.

**Note 1:** Beyond 127, some evaluators return a character from a system-specific code page, while others return the [UNICODE] character. Most evaluators do not allow values greater than 255.

**Note 2:** Where interoperability is a concern, expressions should use the UNICHAR function.

**See also** CODE 8.20.5, UNICHAR 8.20.25, UNICODE 8.20.26

### 8.20.4 CLEAN

**Summary:** Remove all non-printable characters from the string and return the result.

**Syntax:** CLEAN( Text T )

**Returns:** Text

**Semantics:**

Removes all non-printable characters from the string T and returns the resulting string. Evaluators should remove each particular character from the string, if and only if the character belongs to [UNICODE] class Cc (Other - Control), or to Unicode class Cn (Other - Not Assigned). The resulting string shall contain all printable characters from the original string, in the same order. The space character is considered a printable character.
8.20.5 CODE

**Summary:** Return numeric value corresponding to the first character of the text value.

**Syntax:** CODE( Text T )

**Returns:** Number

**Constraints:** code point <= 127 (ASCII); Evaluators may evaluate expressions where Length(T) > 0.

**Semantics:**
Returns a numeric value which represents the first letter of the given text T.

Behavior for code points >= 128 is implementation-defined. Evaluators may use the underlying system's code page. Evaluators should implement CODE such that CODE(CHAR(N)) returns N for 1 <= N <= 255.

**Note:** Where interoperability is a concern, expressions should use the UNICODE function. 8.20.26

**See also** CHAR 8.20.3, UNICHAR 8.20.25, UNICODE 8.20.26

8.20.6 CONCATENATE

**Summary:** Concatenate the text strings

**Syntax:** CONCATENATE( { Text T } )

**Returns:** Text

**Constraints:** None

**Semantics:** Concatenate each text value, in order, into a single text result.

**See also** Infix Operator "&" 8.4.10

8.20.7 DOLLAR

**Summary:** Convert the parameters to Text formatted as currency.

**Syntax:** DOLLAR( Number N [ ; Integer D ] )

**Returns:** Text

**Constraints:** None

**Semantics:** Returns the value formatted as a currency, using locale-specific data. D is the number of decimal places used in the result string, a negative D rounds number N. If D is omitted, locale information may be used to determine the currency's decimal places, or a value of 2 shall be assumed.

8.20.8 EXACT

**Summary:** Report if two text values are equal using a case-sensitive comparison.

**Syntax:** EXACT( Text t1 ; Text t2 )

**Returns:** Logical

**Constraints:** None
**Semantics:** Converts both sides to Text, and then returns TRUE if the two text values are equal, including case, otherwise it returns FALSE.

**See also** FIND 8.20.9, SEARCH 8.20.20, Infix Operator "<>" 8.4.8, Infix Operator "=" 8.4.7

### 8.20.9 FIND

**Summary:** Return the starting position of a given text.

**Syntax:** FIND( Text Search ; Text T [ ; Integer Start = 1 ] )

**Returns:** Number

**Constraints:** Start >= 1

**Semantics:** Returns the character position where Search is first found in T, when the search is started from character position `Start`. The match is case-sensitive, and no wildcards or other instructions are considered in Search. Returns an Error if text not found.

**See also** EXACT 8.20.8, SEARCH 8.20.20

### 8.20.10 FIXED

**Summary:** Round the number to a specified number of decimals and format the result as a text.

**Syntax:** FIXED( Number N [ ; Integer D = 2 [ ; Logical OmitSeparators = FALSE() ] ] )

**Returns:** Text

**Constraints:** None

**Semantics:** Rounds value N to D decimal places (after the decimal point) and returns the result formatted as text, using locale-specific settings. If D is negative, the number is rounded to ABS(D) places to the left from the decimal point. If the optional parameter `OmitSeparators` is True, then group separators are omitted from the resulting string. Group separators are included in the absence of this parameter. If D is a fraction, it is rounded towards 0 as an integer (ignoring what is the closest integer).

### 8.20.11 JIS

**Summary:** Converts half-width to full-width ASCII and katakana characters.

**Syntax:** JIS( Text T )

**Returns:** Text

**Constraints:** None

**Semantics:** Conversion is done for half-width ASCII and [UNICODE] katakana characters, some characters are converted in a special way, see table below. Other characters are copied from T to the result. This is the complementary function to ASC.

A **followed by** means that there are two consecutive characters to convert from.

<table>
<thead>
<tr>
<th>From Unicode Character (c)</th>
<th>To Unicode Character</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>U+0022</td>
<td>0x201d</td>
<td>QUOTATION MARK =&gt; RIGHT</td>
</tr>
<tr>
<td>From Unicode Character (c)</td>
<td>To Unicode Character</td>
<td>Comment</td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------------------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DOUBLE QUOTATION MARK This is an exception to the ASCII range that follows below.</td>
</tr>
<tr>
<td>U+005c</td>
<td>0xffe5</td>
<td>REVERSE SOLIDUS &quot;&quot; =&gt; FULLWIDTH YEN SIGN (code-page 932 legacy, for details see ASC function) This is an exception to the ASCII range that follows below.</td>
</tr>
<tr>
<td>U+0060</td>
<td>0x2018</td>
<td>GRAVE ACCENT =&gt; LEFT SINGLE QUOTATION MARK This is an exception to the ASCII range that follows below.</td>
</tr>
<tr>
<td>U+0027</td>
<td>0x2019</td>
<td>APOSTROPHE =&gt; RIGHT SINGLE QUOTATION MARK This is an exception to the ASCII range that follows below.</td>
</tr>
<tr>
<td>U+0021 &lt;= c &lt;= U+007e</td>
<td>c - 0x0021 + 0xff01</td>
<td>ASCII characters</td>
</tr>
<tr>
<td>U+ff66</td>
<td>0x30f2</td>
<td>katakana wo</td>
</tr>
<tr>
<td>U+ff67 &lt;= c &lt;= U+ff6b</td>
<td>(c - 0xff67) * 2 + 0x30a1</td>
<td>katakana small a-o</td>
</tr>
<tr>
<td>U+ff6c &lt;= c &lt;= U+ff6e</td>
<td>(c - 0xff6c) * 2 + 0x30e3</td>
<td>katakana small ya-yo</td>
</tr>
<tr>
<td>U+ff6f</td>
<td>0x30c3</td>
<td>katakana small tsu</td>
</tr>
<tr>
<td>U+ff71 &lt;= c &lt;= U+ff75</td>
<td>(c - 0xff71) * 2 + 0x30a2</td>
<td>katakana a-o</td>
</tr>
<tr>
<td>U+ff76 &lt;= c &lt;= U+ff81</td>
<td>(c - 0xff76) * 2 + 0x30ac</td>
<td>katakana ga-dsu</td>
</tr>
<tr>
<td>not followed by U+ff9e</td>
<td>(c - 0xff76) * 2 + 0x30ab</td>
<td>katakana ka-chi</td>
</tr>
<tr>
<td>U+ff82 &lt;= c &lt;= U+ff84</td>
<td>(c - 0xff82) * 2 + 0x30c5</td>
<td>katakana du-do</td>
</tr>
<tr>
<td>not followed by U+ff9e</td>
<td>(c - 0xff82) * 2 + 0x30c4</td>
<td>katakana tsu-to</td>
</tr>
<tr>
<td>U+ff85</td>
<td>c - 0xff85 + 0x30ca</td>
<td>katakana na-no</td>
</tr>
<tr>
<td>U+ff8a &lt;= c &lt;= U+ff8e</td>
<td>(c - 0xff8a) * 3 + 0x30d0</td>
<td>katakana ba-bo</td>
</tr>
<tr>
<td>not followed by U+ff9e</td>
<td>(c - 0xff8a) * 3 + 0x30d1</td>
<td>katakana pa-po</td>
</tr>
<tr>
<td>U+ff8a &lt;= c &lt;= U+ff8e</td>
<td>(c - 0xff8a) * 3 + 0x30cf</td>
<td>katakana ha-ho</td>
</tr>
<tr>
<td>From Unicode Character (c)</td>
<td>To Unicode Character</td>
<td>Comment</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------------</td>
<td>---------</td>
</tr>
<tr>
<td>U+ff8f &lt;= c &lt;= U+ff93</td>
<td>c - 0xff8f + 0x30de</td>
<td>katakana ma-mo</td>
</tr>
<tr>
<td>U+ff94 &lt;= c &lt;= U+ff96</td>
<td>(c - 0xff94) * 2 + 0x30e4</td>
<td>katakana ya-yo</td>
</tr>
<tr>
<td>U+ff97 &lt;= c &lt;= U+ff9b</td>
<td>c - 0xff97 + 0x30e9</td>
<td>katakana ra-ro</td>
</tr>
<tr>
<td>U+ff9c</td>
<td>U+30ef</td>
<td>katakana wa</td>
</tr>
<tr>
<td>U+ff9d</td>
<td>U+30f3</td>
<td>katakana nn</td>
</tr>
<tr>
<td>U+ff9e</td>
<td>U+309b</td>
<td>HALFWIDTH KATAKANA VOICED SOUND MARK =&gt; FULLWIDTH</td>
</tr>
<tr>
<td>U+ff9f</td>
<td>U+309c</td>
<td>HALFWIDTH KATAKANA SEMI-VOICED SOUND MARK =&gt; FULLWIDTH</td>
</tr>
<tr>
<td>U+ff70</td>
<td>U+30fc</td>
<td>HALFWIDTH KATAKANA-HIRAGANA PROLONGED SOUND MARK =&gt; FULLWIDTH</td>
</tr>
<tr>
<td>U+ff61</td>
<td>U+3002</td>
<td>HALFWIDTH IDEOGRAPHIC FULL STOP =&gt; FULLWIDTH</td>
</tr>
<tr>
<td>U+ff62</td>
<td>U+300c</td>
<td>HALFWIDTH LEFT CORNER BRACKET =&gt; FULLWIDTH</td>
</tr>
<tr>
<td>U+ff63</td>
<td>U+300d</td>
<td>HALFWIDTH RIGHT CORNER BRACKET =&gt; FULLWIDTH</td>
</tr>
<tr>
<td>U+ff64</td>
<td>U+3001</td>
<td>HALFWIDTH IDEOGRAPHIC COMMA =&gt; FULLWIDTH</td>
</tr>
<tr>
<td>U+ff65</td>
<td>U+30fb</td>
<td>HALFWIDTH KATAKANA MIDDLE DOT =&gt; FULLWIDTH</td>
</tr>
</tbody>
</table>

**Note 1:** For references regarding halfwidth and fullwidth characters see [UAX11] and the Halfwidth and Fullwidth Code Chart of [UNICODE].

**Note 2:** For information about the mapping of JIS X 0201 and JIS X 0208 to Unicode characters see [JISX0201] and [JISX0208].

**See also** ASC 8.20.2

### 8.20.12 LEFT

**Summary:** Return a selected number of text characters from the left.

**Syntax:** `LEFT( Text T [ ; Integer Length ] )`

**Returns:** Text

**Constraints:** Length >= 0
**Semantics:** Returns the INT(Length) number of characters of text T, starting from the left. If Length is omitted, it defaults to 1; otherwise, it computes Length=INT(Length). If T has fewer than Length characters, it returns T. This means that if T is an empty string (which has length 0) or the parameter Length is 0, LEFT() will always return an empty string. Note that if Length<0, an Error is returned. This function shall return the same string as MID(T; 1; Length).

*The results of this function may be normalization-sensitive. 4.2*

**See also** LEN 8.20.13, MID 8.20.15, RIGHT 8.20.19

### 8.20.13 LEN

**Summary:** Return the length, in characters, of given text

**Syntax:** LEN( Text T )

**Returns:** Integer

**Constraints:** None.

**Semantics:** Computes number of characters (not the number of bytes) in T. If T is of type Number, it is automatically converted to Text, including a fractional part and decimal separator if necessary.

*The results of this function may be normalization-sensitive. 4.2*

**See also** TEXT 8.20.23, ISTEMPT 8.13.25, LEFT 8.20.12, MID 8.20.15, RIGHT 8.20.19

### 8.20.14 LOWER

**Summary:** Return input string, but with all uppercase letters converted to lowercase letters.

**Syntax:** LOWER( Text T )

**Returns:** Text

**Constraints:** None

**Semantics:** Return input string, but with all uppercase letters converted to lowercase letters, as defined by sections 3.13 Default Case Algorithms, 4.2 Case-Normative and 5.18 Case Mappings of [UNICODE]. As with most functions, it is side-effect free (it does not modify the source values). All Evaluators shall convert A-Z to a-z.

**Note:** As this function can be locale aware, results may be unexpected in certain cases. For example in a Turkish locale an upper case "I without dot" (LATIN CAPITAL LETTER I, U+0049) is converted to a lower case "i without dot" (LATIN SMALL LETTER DOTLESS I, U+0131).

**See also** UPPER 8.20.27, PROPER 8.20.16

### 8.20.15 MID

**Summary:** Returns extracted text, given an original text, starting position, and length.

**Syntax:** MID( Text T ; Integer Start ; Integer Length )

**Returns:** Text

**Constraints:** Start >= 1, Length >= 0.

**Semantics:** Returns the characters from T, starting at character position Start, for up to Length characters. For the integer conversions, Start=INT(Start), and Length=INT(Length). If there are less
than Length characters starting at start, it returns as many characters as it can beginning with Start. In particular, if Start > LEN(T), it returns the empty string (""). If Start < 0, it returns an Error. If Start >=0, and Length=0, it returns the empty string. Note that MID(T;1;Length) produces the same results as LEFT(T;Length).

The results of this function may be normalization-sensitive. 4.2

See also LEFT 8.20.12, LEN 8.20.13, RIGHT 8.20.19, REPLACE 8.20.17, SUBSTITUTE 8.20.21

8.20.16 PROPER

Summary: Return the input string with the first letter of each word converted to an uppercase letter and the rest of the letters in the word converted to lowercase.

Syntax: PROPER( Text T )

Returns: Text

Constraints: None

Semantics: Return input string, but modified as follows:

- If the first character is a letter, it is converted to its uppercase equivalent; otherwise, the original character is returned
- If a letter is preceded by a non-letter, it is converted to its uppercase equivalent
- If a letter is preceded by a letter, it is converted to its lowercase equivalent.

Evaluators shall implement this for at least the Latin letters A-Z and a-z.

As with most functions, it is side-effect free, that is, it does not modify the source values.

See also LOWER 8.20.14, UPPER 8.20.27

8.20.17 REPLACE

Summary: Returns text where an old text is substituted with a new text.

Syntax: REPLACE( Text T ; Number Start ; Number Count ; Text New )

Returns: Text

Constraints: Start >= 1.

Semantics: Returns text T, but remove the characters starting at character position Start for Count characters, and instead replace them with New. Character positions defined by Start begin at 1 (for the leftmost character). If Count=0, the text New is inserted before character position Start, and all the text before and after Start is retained. If Start > length of text T (TLen) then Start is set to TLen. If Count > TLen - Start then Count is set to TLen - Start.

REPLACE(T;Start;Len;New) is the same as LEFT(T;Start-1) & New & MID(T; Start+Len; LEN(T)))

See also LEFT 8.20.12, LEN 8.20.13, MID 8.20.15, RIGHT 8.20.19, SUBSTITUTE 8.20.21

8.20.18 REPT

Summary: Return text repeated Count times.

Syntax: T( Text T ; Integer Count )
Returns: Text

Constraints: Count >= 0

Semantics: Returns text $T$ repeated $Count$ number of times; if $Count$ is zero, an empty string is returned. If $Count < 0$, the result is Error.

See also LEFT 8.20.12, MID 8.20.15, RIGHT 8.20.19, SUBSTITUTE 8.20.21

8.20.19 RIGHT

Summary: Return a selected number of text characters from the right.

Syntax: RIGHT( Text $T$ [ ; Integer Length ] )

Returns: Text

Constraints: Length >= 0

Semantics: Returns the $Length$ number of characters of text $T$, starting from the right. If $Length$ is omitted, it defaults to 1; otherwise, it computes $Length=\text{INT}(Length)$. If $T$ has fewer than $Length$ characters, it returns $T$ (unchanged). This means that if $T$ is an empty string (which has length 0) or the parameter $Length$ is 0, RIGHT() will always return an empty string. Note that if $Length<0$, an Error is returned.

The results of this function may be normalization-sensitive. 4.2

See also LEFT 8.20.12, LEN 8.20.13, MID 8.20.15

8.20.20 SEARCH

Summary: Return the starting position of a given text.

Syntax: SEARCH( Text Search ; Text $T$ [ ; Integer Start = 1 ] )

Returns: Integer

Constraints: Start >= 1

Semantics: Returns the character position where Search is first found in $T$, when the search is started from character position Start. The match is not case-sensitive. Start is 1 if omitted. Returns an Error if text not found.

The values returned may vary depending upon the HOST-USE-REGULAR-EXPRESSIONS or HOST-USE-WILDCARDS properties. 3.5

See also EXACT 8.20.8, FIND 8.20.9

8.20.21 SUBSTITUTE

Summary: Returns text where an old text is substituted with a new text.

Syntax: SUBSTITUTE( Text $T$ ; Text Old ; Text New [ ; Integer Which ] )

Returns: Text

Constraints: Which >= 1 (when provided)

Semantics: Returns text $T$, but with text $Old$ replaced by text $New$ (when searching from the left). If $Which$ is omitted, every occurrence of $Old$ is replaced with $New$; if $Which$ is provided, only that occurrence of $Old$ is replaced by $New$ (starting the count from 1). If there is no match, or if $Old$ has
length 0, the value of \( T \) is returned. Note that \( \text{Old} \) and \( \text{New} \) may have different lengths. If \( \text{Which} \) is present and \( \text{Which} < 1 \), returns Error.

**See also** LEFT 8.20.12, LEN 8.20.13, MID 8.20.15, REPLACE 8.20.17, RIGHT 8.20.19

### 8.20.22 \( T \)

**Summary:** Return the text (if Text), else return 0-length Text value

**Syntax:** \( T( \text{Any} X ) \)

**Returns:** Text

**Constraints:** None

**Semantics:** The type of (a dereferenced) \( X \) is examined; if it is of type Text, it is returned, else an empty string (Text value of zero length) is returned. This is not a type-conversion function; \( T(5) \) produces an empty string, not "5".

**See also** N 8.13.26

### 8.20.23 TEXT

**Summary:** Return the value converted to a text.

**Syntax:** \( \text{TEXT}( \text{Scalar X ; Text FormatCode} ) \)

**Returns:** Text

**Constraints:** The \( \text{FormatCode} \) is a sequence of characters with an implementation-defined meaning.

**Semantics:** Converts the value \( X \) to a Text according to the rules of a number format code passed as \( \text{FormatCode} \) and returns it.

**See also** N 8.13.26, T 8.20.22

### 8.20.24 TRIM

**Summary:** Remove leading and trailing spaces, and replace all internal multiple spaces with a single space.

**Syntax:** \( \text{TRIM}( \text{Text T} ) \)

**Returns:** Text

**Constraints:** None.

**Semantics:** Takes \( T \) and removes all leading and trailing space. Any other sequence of 2 or more spaces is replaced with a single space.

A space is one or more, HORIZONTAL TABULATION (U+0009), LINE FEED (U+000A), CARRIAGE RETURN (U+000D) or SPACE (U+0020) characters.

**See also** LEFT 8.20.12, RIGHT 8.20.19

### 8.20.25 UNICHAR

**Summary:** Return the character represented by the given numeric value according to the [UNICODE] Standard.
**Syntax:** UNICHAR( Integer N )

**Returns:** Text

**Constraints:** N >= 0, N <= 1114111 (U+10FFFF)

**Semantics:** Returns the character having the given numeric value as [UNICODE] code point. Evaluators shall support values between 1 and 0xFFFF. Evaluators should allow N to be any [UNICODE] code point of type Graphic, Format or Control. Evaluators should implement UNICHAR such that UNICODE(UNICHAR(N)) returns N for any [UNICODE] code point N of type Graphic, Format or Control represented by the given numeric value. Evaluators shall support values between 1 and 0xFFFF, which is the maximum possible value in UCS-2 encoding using two octets. Evaluators should allow N to be any legal character value in [UNICODE] assuming UCS-4 encoding. Evaluators should implement UNICHAR such that UNICODE(UNICHAR(N)) returns N for any N >= 0 and N <= 1114111.

**Note:** Depending on the evaluator's encoding the string returned may be actually longer than expected, for example in UTF-8 or UTF-16 encodings.

**See also** UNICODE 8.20.26

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**8.20.26 UNICODE**

**Summary:** Return the [UNICODE] code point corresponding to the first character of the text value.

**Syntax:** UNICODE( Text T )

**Returns:** Number

**Constraints:** Length(T) > 0.

**Semantics:** Returns the numeric value of the [UNICODE] code point of the first character of the given text T.

**The results of this function may be normalization-sensitive. 4.2**

**See also** UNICHAR 8.20.25

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**8.20.27 UPPER**

**Summary:** Return input string, but with all lowercase letters converted to uppercase letters.

**Syntax:** UPPER( Text T )

**Returns:** Text

**Constraints:** None

**Semantics:** Return input string, but with all lowercase letters converted to uppercase letters, as defined by sections 3.13 Default Case Algorithms, 4.2 Case-Normative and 5.18 Case Mappings of [UNICODE]. As with most functions, it is side-effect free (it does not modify the source values). All Evaluators shall convert a-z to A-Z.

**Note:** As this function can be locale aware, results may be unexpected in certain cases, for example in a Turkish locale a lower case "i with dot" (LATIN SMALL LETTER I) U+0069 is converted to an upper case "i with dot" (LATIN CAPITAL LETTER I WITH DOT ABOVE, U+0130).

**See also** LOWER 8.20.14, PROPER 8.20.16
9 Other Capabilities

9.1 General

Evaluators may implement additional abilities that are not a matter of which function they support. The following sections describe some specific additional capabilities; evaluators may implement them, and documents may require them (though such documents may not be correctly recalculated on applications which do not implement them). Documents that depend on these other capabilities can still be considered “portable documents”, but only if these additional capabilities are clearly noted (since not applications implement these additional capabilities).

9.2 Inline constant arrays

Evaluators claiming to implement “Inline constant arrays” shall support inline arrays with one matrix, with one or more rows, and one or more columns. Such evaluators shall support these 2-dimensional arrays as long as the number of expressions in each row is identical; evaluators may but need not support arrays with a different number of expressions in each row. They shall support at least the following syntactic rules in the Expression values for the inline array:

- Number, optionally preceded with the prefix "-" operator (for negative numbers)
- Text
- Logical constants TRUE() and FALSE()
- Error

9.3 Inline non-constant arrays

Evaluators claiming to implement “Inline non-constant arrays” shall support the full Expression syntax in each component of an array (and not just constants).

9.4 Year 1583

Evaluators claiming to implement “Year 1583” can correctly calculate dates correctly starting from the January 1 of the (ISO) year 1583. This means that the evaluator correctly determines that 1900 was not a leap year, and can handle year values for dates back to at least 1583.

These calculations use the ISO (proleptic Gregorian) calendar, that is, the calculations use the usual rules for the ISO (Gregorian) calendar, regardless of locale. This calendar began official use in some locales in 1582, but other locales used other calendars (such as the Julian calendar) and switched to the Gregorian calendar at different times in history, if they switched at all. Evaluators may choose to support years even earlier than this; such evaluators should use a proleptic Gregorian system (continuing the years backwards as if the calendar existed in those years). Note that not all people used, or currently use, the ISO (Gregorian) calendar.

Correct date calculations in this calendar system require that leap years be handled correctly. In this calendar system, leap years include 29 days in February (which otherwise has 28 days), for 366 total days in a leap year. In general, all years evenly divisible by 4 are leap years. However, years that are divisible by 100 shall also be divisible by 400 to be a leap year; otherwise, they are common (non-leap) years.
10 Non-portable Features

10.1 General

Expressions may depend upon features that are not implemented by all evaluators. This section identifies and defines some features not commonly implemented to enable expressions to indicate their reliance on these features.

10.2 Distinct Logical

An evaluator may have the “Distinct Logical” feature, which means that its Logical type is a distinct type from both Number and Text, and that certain other properties or queries hold true as well. Some legacy documents depend on the “distinct logical” feature. An evaluator that has the “distinct logical” feature as described in this specification shall have the following properties:

- ISNUMBER() applied to a Logical value (constant or calculated) will return False, and ISLOGICAL() applied to a Number will be False, either directly or via a reference
- TRUE() will not be equal to 1, and FALSE() will not be equal to 0, when they are compared using “=”
- In a NumberSequence (such as when using SUM), Logical values are skipped when inside a range, but are included and automatically converted to a Number if provided as the NumberSequence itself

10.3 Auto Text to Number

An evaluator may have the “Auto Text to Number” feature, which means that the “Convert to Number” function, when receiving a Text value or a Reference to a Text value, converts the Text into a Number, typically through calling the VALUE() function. This feature can be convenient if files never change locale, but in today’s international environment, this feature can easily lead to data files that look correct but give subtly wrong answers, especially when shared with users who use a different locale. This can be a problem even when the documents never leave a small geographical area, since users may choose a locale they are familiar with that is different that the one expected by the document sender.