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# Open Document Format for Office Applications (OpenDocument) Version 1.2

## Part 2: Recalculated Formula (OpenFormula) Format

### Candidate OASIS Standard 01

**10 May 2011**

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**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: Recalculated Formula \(OpenFormula\) Format \(this part\)](#)  
[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:**

This document was last revised or approved by the OASIS Open Document Format for Office Applications (OpenDocument) TC on the above date. The level of approval is also listed above. Check the "Latest Version" location noted above for possible later revisions of this document.

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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.

## 1.2 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].

## 1.3 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

## 1.4 Normative References

[CharModel] Martin J. Dürst, et. al., *Character Model for the World Wide Web 1.0: Fundamentals*, <http://www.w3.org/TR/2005/REC-charmod-20050215/>, W3C, 2005.

**[ISO/IEC Directives]** ISO/IEC Directives, Part 2 (Fifth Edition) *Rules for the structure and drafting of International Standards*, International Organization for Standardization and International Electrotechnical Commission, 2004.

**[ISO4217]** ISO 4217:2008 *Codes for the representation of currencies and funds*, International Organization for Standardization and International Electrotechnical Commission, 2008.

**[ISO8601]** ISO 8601:2004 *Data elements and interchange formats -- Information interchange -- Representation of dates and times*, International Organization for Standardization and International Electrotechnical Commission, 2004.

**[RFC3986]** T. Berners-Lee, R. Fielding, L. Masinter, *Uniform Resource Identifier (URI): Generic Syntax*, <http://www.ietf.org/rfc/rfc3986.txt>, IETF, 2005.

**[RFC3987]** M. Duerst, M. Suignard, *Internationalized Resource Identifiers (IRIs)*, <http://www.ietf.org/rfc/rfc3987.txt>, IETF, 2005.

**[UNICODE]** The Unicode Consortium. The Unicode Standard, Version 5.2.0, defined by: *The Unicode Standard, Version 5.2* (Mountain View, CA, The Unicode Consortium, 2009. ISBN 978-1-936213-00-9). (<http://www.unicode.org/versions/Unicode5.2.0/>).

**[UTR15]** Mark Davis, Martin Dürst, *Unicode Normalization Forms*, Unicode Technical Report #15, <http://www.unicode.org/reports/tr15/tr15-25.html>, 2005.

**[XML1.0]** Tim Bray, Jean Paoli, C. M. Sperberg-McQueen, Eve Maler, François Yergeau, *Extensible Markup Language (XML) 1.0 (Fourth Edition)*, <http://www.w3.org/TR/2006/REC-xml-20060816/>, W3C, 2006.

## 1.5 Non-Normative References

**[JISX0201]** The Unicode Consortium., *JIS X 0201 (1976) to Unicode 1.1 Table*, 1994, <http://www.unicode.org/Public/MAPPINGS/OBSOLETE/EASTASIA/JIS/JIS0201.TXT>.

**[JISX0208]** The Unicode Consortium., *JIS X 0208 (1990) to Unicode*, 1994, <http://www.unicode.org/Public/MAPPINGS/OBSOLETE/EASTASIA/JIS/JIS0208.TXT>.

**[UAX11]** Asmus Freytag, *East Asian Width*, Unicode Standard Annex #11, <http://www.unicode.org/reports/tr11/tr11-19.html>, 2009.

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## 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. 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 (~)): Infix Operator Ordered Comparison (" $<$ ", " $<=$ ", " $>$ ", " $>=$ "); Infix Operator " $&$ "; Infix Operator " $+$ "; Infix Operator " $-$ "; Infix Operator " $*$ "; Infix Operator " $/$ "; Infix Operator " $^$ "; Infix Operator " $=$ "; Infix Operator " $<>$ "; Postfix Operator " $%$ "; Prefix Operator " $+$ "; Prefix Operator " $-$ "; Infix Operator Reference Intersection (" $!$ "); Infix Operator Range (" $:$ ").
- E) It shall implement at least the following functions as defined in this specification: ABS 6.16.2 ; ACOS 6.16.3 ; AND 6.15.2 ; ASIN 6.16.7 ; ATAN 6.16.9 ; ATAN2 6.16.10 ; AVERAGE 6.18.3 ; AVERAGEIF 6.18.5 ; CHOOSE 6.14.3 ; COLUMNS 6.13.5 ; COS 6.16.19 ; COUNT 6.13.6 ; COUNTA 6.13.7 ; COUNTBLANK 6.13.8 ; COUNTIF 6.13.9 ; DATE 6.10.2 ; DAVERAGE 6.9.2 ; DAY 6.10.5 ; DCOUNT 6.9.3 ; DCOUNTA 6.9.4 ; DDB 6.12.14 ; DEGREES 6.16.25 ; DGET 6.9.5 ; DMAX 6.9.6 ; DMIN 6.9.7 ; DPRODUCT 6.9.8 ; DSTDEV 6.9.9 ; DSTDEVP 6.9.10 ; DSUM 6.9.11 ; DVAR 6.9.12 ; DVARP 6.9.13 ; EVEN 6.16.30 ; EXACT 6.20.8 ; EXP 6.16.31 ; FACT 6.16.32 ; FALSE 6.15.3 ; FIND 6.20.9 ; FV 6.12.20 ; HLOOKUP 6.14.5 ; HOUR 6.10.10 ; IF 6.15.4 ; INDEX 6.14.6 ; INT 6.17.2 ; IRR 6.12.24 ; ISBLANK 6.13.14 ; ISERR 6.13.15 ; ISERROR 6.13.16 ; ISLOGICAL 6.13.19 ; ISNA 6.13.20 ; ISNONTEXT 6.13.21 ; ISNUMBER 6.13.22 ; ISTEXT 6.13.25 ; LEFT 6.20.12 ; LEN 6.20.13 ; LN 6.16.39 ; LOG 6.16.40 ; LOG10 6.16.41 ; LOWER 6.20.14 ; MATCH 6.14.9 ; MAX 6.18.45 ; MID 6.20.15 ; MIN 6.18.48 ; MINUTE 6.10.12 ; MOD 6.16.42 ; MONTH 6.10.13 ; N 6.13.26 ; NA 6.13.27 ; NOT 6.15.7 ; NOW 6.10.15 ; NPER 6.12.29 ; NPV 6.12.30 ; ODD 6.16.44 ; OR 6.15.8 ; PI 6.16.45 ; PMT 6.12.36 ; POWER 6.16.46 ; PRODUCT 6.16.47 ; PROPER 6.20.16 ; PV 6.12.41 ; RADIANS 6.16.49 ; RATE 6.12.42 ; REPLACE 6.20.17 ; REPT 6.20.18 ; RIGHT 6.20.19 ; ROUND 6.17.5 ; ROWS 6.13.30 ; SECOND 6.10.16 ; SIN 6.16.55 ; SLN 6.12.45 ; SQRT 6.16.58 ; STDEV 6.18.72 ; STDEVP 6.18.74 ; SUBSTITUTE 6.20.21 ; SUM 6.16.61 ; SUMIF 6.16.62 ; SYD 6.12.46 ; T 6.20.22 ; TAN 6.16.69 ; TIME 6.10.17 ; TODAY 6.10.19 ; TRIM 6.20.24 ; TRUE 6.15.9 ; TRUNC 6.17.8 ; UPPER 6.20.27 ; VALUE 6.13.34 ; VAR 6.18.82 ; VARP 6.18.84 ; VLOOKUP 6.14.12 ; WEEKDAY 6.10.20 ; YEAR 6.10.23
- 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.
- 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 6.12.2 ; ACCRINTM 6.12.3 ; ACOSH 6.16.4 ; ACOT 6.16.5 ; ACOTH 6.16.6 ; ADDRESS 6.14.2 ; ASINH 6.16.8 ; ATANH 6.16.11 ; AVEDEV 6.18.2 ; BESSELI 6.16.12 ; BESSELJ 6.16.13 ; BESSELK 6.16.14 ; BESSELY 6.16.15 ; BETADIST 6.18.7 ; BETAINV 6.18.8 ; BINOMDIST 6.18.10 ; CEILING 6.17.1 ; CHAR 6.20.3 ; CLEAN 6.20.4 ; CODE 6.20.5 ; COLUMN 6.13.4 ; COMBIN 6.16.16 ; CONCATENATE 6.20.6 ; CONFIDENCE 6.18.16 ; CONVERT 6.16.18 ; CORREL 6.18.17 ; COSH 6.16.20 ; COT 6.16.21 ; COTH 6.16.22 ; COUPDAYBS 6.12.5 ; COUPDAYS 6.12.6 ; COUPDAYSNC 6.12.7 ; COUPNCD 6.12.7 ; COUPNUM 6.12.9 ; COUPPCD 6.12.10 ; COVAR 6.18.18 ; CRITBINOM 6.18.19 ; CUMIPMT 6.12.11 ; CUMPRINC 6.12.12 ; DATEVALUE 6.10.4 ; DAYS360 6.10.7 ; DB 6.12.13 ; DEVSQ 6.18.20 ; DISC 6.12.15 ; DOLLARDE 6.12.16 ;

DOLLARFR 6.12.17 ; DURATION 6.12.18 ; EFFECT 6.12.19 ; EOMONTH 6.10.9 ; ERF 6.16.27 ;  
 ERFC 6.16.28 ; EXPONDIS 6.18.21 ; FISHER 6.18.26 ; FISHERINV 6.18.27 ; FIXED 6.20.10 ;  
 FLOOR 6.17.3 ; FORECAST 6.18.28 ; FTEST 6.18.30 ; GAMMADIST 6.18.31 ; GAMMAINV  
 6.18.32 ; GAMMALN 6.16.35 ; GCD 6.16.36 ; GEOMEAN 6.18.34 ; HARMEAN 6.18.36 ;  
 HYPGEOMDIST 6.18.37 ; INTERCEPT 6.18.38 ; INTRATE 6.12.22 ; ISEVEN 6.13.17 ; ISODD  
 6.13.23 ; ISOWEEKNUM 6.10.11 ; KURT 6.18.39 ; LARGE 6.18.40 ; LCM 6.16.38 ;  
 LEGACY.CHIDIST 6.18.11 ; LEGACY.CHIINV 6.18.13 ; LEGACY.CHITEST 6.18.15 ;  
 LEGACY.FDIST 6.18.23 ; LEGACY.FINV 6.18.25 ; LEGACY.NORMSDIST 6.18.54 ;  
 LEGACY.NORMSINV 6.18.55 ; LEGACY.TDIST 6.18.77 ; LINEST 6.18.41 ; LOGEST 6.18.42 ;  
 LOGINV 6.18.43 ; LOGNORMDIST 6.18.44 ; LOOKUP 6.14.8 ; MDURATION 6.12.26 ; MEDIAN  
 6.18.47 ; MINVERSE 6.5.3 ; MIRR 6.12.27 ; MMULT 6.5.4 ; MODE 6.18.50 ; MROUND 6.17.4 ;  
 MULTINOMIAL 6.16.43 ; NEGBINOMDIST 6.18.51 ; NETWORKDAYS 6.10.14 ; NOMINAL  
 6.12.28 ; ODDFPRICE 6.12.31 ; ODDFYIELD 6.12.32 ; ODDLPRICE 6.12.33 ; ODDLYIELD  
 6.12.34 ; OFFSET 6.14.11 ; PEARSON 6.18.56 ; PERCENTILE 6.18.57 ; PERCENTRANK  
 6.18.58 ; PERMUT 6.18.59 ; POISSON 6.18.62 ; PRICE 6.12.38 ; PRICEMAT 6.12.40 ; PROB  
 6.18.63 ; QUARTILE 6.18.64 ; QUOTIENT 6.16.48 ; RAND 6.16.50 ; RANDBETWEEN 6.16.51 ;  
 RANK 6.18.65 ; RECEIVED 6.12.43 ; ROMAN 6.19.17 ; ROUNDDOWN 6.17.6 ; ROUNDUP  
 6.17.7 ; ROW 6.13.29 ; RSQ 6.18.66 ; SERIESSUM 6.16.53 ; SIGN 6.16.54 ; SINH 6.16.56 ;  
 SKEW 6.18.67 ; SKEWP 6.18.68 ; SLOPE 6.18.69 ; SMALL 6.18.70 ; SQRTPI 6.16.59 ;  
 STANDARDIZE 6.18.71 ; STDEVA 6.18.73 ; STDEVPA 6.18.75 ; STEYX 6.18.76 ; SUBTOTAL  
 6.16.60 ; SUMPRODUCT 6.16.64 ; SUMSQ 6.16.65 ; SUMX2MY2 6.16.66 ; SUMX2PY2 6.16.67 ;  
 SUMXMY2 6.16.68 ; TANH 6.16.70 ; TBILLEQ 6.12.47 ; TBILLPRICE 6.12.48 ; TBILLYIELD  
 6.12.49 ; TIMEVALUE 6.10.18 ; TINV 6.18.78 ; TRANSPOSE 6.5.6 ; TREND 6.18.79 ;  
 TRIMMEAN 6.18.80 ; TTEST 6.18.81 ; TYPE 6.13.33 ; VARA 6.18.83 ; VDB 6.12.50 ; WEEKNUM  
 6.10.21 ; WEIBULL 6.18.86 ; WORKDAY 6.10.22 ; XIRR 6.12.51 ; XNPV 6.12.52 ; YEARFRAC  
 6.10.24 ; YIELD 6.12.53 ; YIELDDISC 6.12.54 ; YIELDMAT 6.12.55 ; ZTEST 6.18.87

B) It shall implement the Infix Operator Reference Union ("~") 6.4.13

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 6.12.4 ;  
 ARABIC 6.19.2 ; AREAS 6.13.2 ; ASC 6.20.2 ; AVERAGEA 6.18.4 ; AVERAGEIFS 6.18.6 ; BASE  
 6.19.3 ; BIN2DEC 6.19.4 ; BIN2HEX 6.19.5 ; BIN2OCT 6.19.6 ; BINOM.DIST.RANGE 6.18.9 ;  
 BITAND 6.6.2 ; BITLSHIFT 6.6.3 ; BITOR 6.6.4 ; BITRSHIFT 6.6.5 ; BITXOR 6.6.6 ; CHISQDIST  
 6.18.12 ; CHISQINV 6.18.14 ; COMBINA 6.16.17 ; COMPLEX 6.8.2 ; COUNTIFS 6.13.10 ; CSC  
 6.16.23 ; 6.16.23CSCH 6.16.24 ; DATEDIF 6.10.3 ; DAYS 6.10.6 ; DDE 6.11.2 ; DEC2BIN 6.19.7 ;  
 DEC2HEX 6.19.8 ; DEC2OCT 6.19.9 ; DECIMAL 6.19.10 ; DELTA 6.16.26 ; EDATE 6.10.8 ;  
 ERROR.TYPE 6.13.11 ; EUROCONVERT 6.16.29 ; FACTDOUBLE 6.16.33 ; FDIST 6.18.22 ;  
 FINDB 6.7.2 ; FINV 6.18.24 ; FORMULA 6.13.12 ; FREQUENCY 6.18.29 ; FVSCHEDULE 6.12.21  
 ; GAMMA 6.16.34 ; GAUSS 6.18.33 ; GESTEP 6.16.37 ; GETPIVOTDATA 6.14.4 ; GROWTH  
 6.18.35 ; HEX2BIN 6.19.11 ; HEX2DEC 6.19.12 ; HEX2OCT 6.19.13 ; HYPERLINK 6.11.3 ;  
 IFERROR 6.15.5 ; IFNA 6.15.6 ; IMABS 6.8.3 ; IMAGINARY 6.8.4 ; IMARGUMENT 6.8.5 ;  
 IMCONJUGATE 6.8.6 ; IMCOS 6.8.7 ; IMCOT 6.8.9 ; IMCSC 6.8.10 ; IMCSC 6.8.11 ; IMDIV  
 6.8.12 ; IMEXP 6.8.13 ; IMLN 6.8.14 ; IMLOG10 6.8.15 ; IMLOG2 6.8.16 ; IMPOWER 6.8.17 ;  
 IMPRODUCT 6.8.18 ; IMREAL 6.8.19 ; IMSEC 6.8.22 ; IMSECH 6.8.23 ; IMSIN 6.8.20 ; IMSQRT  
 6.8.24 ; IMSUB 6.8.25 ; IMSUM 6.8.26 ; IMTAN 6.8.27 ; INDIRECT 6.14.7 ; INFO 6.13.13 ; IPMT



6.12.23 ; ISFORMULA 6.13.18 ; ISPMT 6.12.25 ; ISREF 6.13.24 ; JIS 6.20.11 ; LEFTB 6.7.3 ; LENB 6.7.4 ; MAXA 6.18.46 ; MDETERM 6.5.2 ; MULTIPLE.OPERATIONS 6.14.10 ; MUNIT 6.5.5 ; MIDB 6.7.5 ; MINA 6.18.49 ; NORMDIST 6.18.52 ; NORMINV 6.18.53 ; NUMBERVALUE 6.13.28 ; OCT2BIN 6.19.14 ; OCT2DEC 6.19.15 ; OCT2HEX 6.19.16 ; PDURATION 6.12.35 ; PERMUTATIONA 6.18.60 ; PHI 6.18.61 ; PPMT 6.12.37 ; PRICEDISC 6.12.39 ; REPLACEB 6.7.6 ; RIGHTB 6.7.7 ; RRI 6.12.44 ; SEARCH 6.20.20 ; SEARCHB 6.7.8 ; SEC 6.16.52 ; SECH 6.16.57 ; SHEET 6.13.31 ; SHEETS 6.13.32 ; SUMIFS 6.16.63 ; TEXT 6.20.23 ; UNICHAR 6.20.25 ; UNICODE 6.20.26 ; VARPA 6.18.85 ; XOR 6.15.10

**Note:** The following functions are documented by this specification, but not included even in the Large group: CELL 6.13.3 ; DOLLAR 6.20.7

## 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.

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).
- 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 but need 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 (5.3), a constant String (5.4), a Reference (5.8), 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 5.5 (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 (5.6, 5.7), evaluate the function as described in Operator and Function Evaluation, 3.2.3.
- 4) If an expression consists of a named expression (5.11), the result of evaluating the named expression is returned.
- 5) If an expression consists of a QuotedLabel (5.10), AutomaticIntersection (5.10.6), or Array (5.13), 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 is 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')

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 B2 : =ABS(A1:A3) => ABS(A2)

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 need 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

**Note 5:**

in matrix A1:B3 with ={1;2 3;4 5;6}	: cell B2 contains 4.	[Rule 2.1.1]
in matrix A1:B3 with ={1 3 5}	: cell B2 contains 3.	[Rule 2.1.1 for row, and Rule 2.1.2 column]
in matrix A1:B3 with ={2;4}	: cell B2 contains 4.	[Rule 2.1.3 for row, and Rule 2.1.1 column]
in matrix A1:C4 with ={1;2 3;4 5;6}	: cell C1,A4 contain #N/A.	[Rule 2.1.4]

**Note 6:** if a value is not requested it is not displayed

in matrix A1:B2 with ={1;2|3;4|5;6} : the value '6' is not displayed because B3 is not part of the display matrix.

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.

**Note 7:**

e.g. =SUM(INDIRECT({"A1";"A2"})) would produce the value in A1 when evaluated in array mode.

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

**Note 8:**

={1;2}+{3;4;5} => {4;6;#N/A}  
 ={1}+{1;2} => {2;3}

- 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.

**Note 9:**

= 1 + {1;2;3|4;5;6} => {2;3;4|5;6;7}  
 = {1} + {1;2;3|4;5;6} => {2;3;4|5;6;7}

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.

**Note 10:**

= {1|2} + {10;20|30;40}      => {11;21|32;42}

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!}

## 3.4 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 a subpart of the cell content needs to match the text.
- 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.

### 3.5 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 6.16.50), 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 6.13.3, HYPERLINK 6.11.3, INDIRECT 6.14.7, INFO 6.13.13, NOW 6.10.15, OFFSET 6.14.11, RAND 6.16.50 and TODAY 6.10.19. 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 6.13.4, ROW 6.13.29 and SHEET 6.13.31. 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.

### 3.6 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.

### 3.7 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].

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 a fixed or with a variable bit length. A cell with a constant numeric value has the Number type.

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 6.13.22 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.



### 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” 6.3.12, 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 (6.3.10 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.

**Note 1:** For example, SUM([.A1:.B2]) is identical to SUM([.A1]~[.B2]~[.A2]~[.B1]), but COLUMNS([.A1:.B2]), resulting in 2 columns, is not identical to COLUMNS([.A1]~[.B2]~[.A2]~[.B1]), where iterating over the reference list would result in 4 columns.

A reference list cannot be converted to an array.

**Note 2:** For example, in array context {ABS([.A1]~[.B2]~[.A2]~[.B1])} is an invalid expression, whereas {ABS([.A1:.B2])} is not.

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. 6.3.15

### 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). 6.3.16

### 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.

<b><i>Date Basis</i></b>	<b><i>Historical Name</i></b>	<b><i>Day Count</i></b>	<b><i>Days in Year</i></b>
0	US (NASD) 30/360	Procedure A, 4.11.7.3	Procedure D, 4.11.7.6

<i>Date Basis</i>	<i>Historical Name</i>	<i>Day Count</i>	<i>Days in Year</i>
1	Actual/Actual	Procedure B, 4.11.7.4	Procedure E, 4.11.7.7
2	Actual/360	Procedure B, 4.11.7.4	Procedure D, 4.11.7.6
3	Actual/365	Procedure B, 4.11.7.4	Procedure F, 4.11.7.8
4	European 30/360	Procedure C, 4.11.7.5	Procedure D, 4.11.7.6

### 4.11.7.2 Procedural Notation

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

- `day(date)` returns the day of the month for the given date value, an integer from 1 to 31
- `month(date)` returns the month of a given date value, an integer from 1-12
- `year(date)` returns the year of the given date value
- `truncate(date)` truncates any fractional (hours, minutes, seconds) of a date value and returns the whole date portion.
- Binary comparison operators `date1>date2` and `date1 == date2`
- `is-leap-year(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 30<sup>th</sup>. This is not an error. The above functions work on such dates as well, e.g., `day(February 30th) = 30`.

### 4.11.7.3 Procedure A

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 day from `date1`
5. If `day(date1)==30` and `day(date2)==31` then subtract 1 day from `date2`
6. If both `date1` and `date2` are the last day of February, change `date2` to the 30th of the month.
7. If `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. `truncate(date1)`, `truncate(date2)`
2. If `date1> date2`, then swap the values of `date1` and `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

### 4.11.8 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 (<, <=, =, >, >=, <>). 6.4.9

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 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 3.4 applies.

- Other Text value. If the host-defined property HOST-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.

## 4.11.9 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.

### 4.11.10 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.

### 4.11.11 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. 4.11.10 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 4.11.8 Criterion.

#### **4.11.12 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 6.3. 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).

#### **4.11.13 Any**

*Any* represents a value of any type defined in this standard, including Error values.



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## 5 Expression Syntax

### 5.1 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).

### 5.2 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 ::= "'" ([^'] | "'"")+ "'"
```

## 5.3 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 |  
        '.' [0-9]+ ([eE] [-+]? [0-9]+)?  
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).

## 5.4 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. A constant string is of type Text.

```
String ::= '"' ([^"#x00] | '"' )* '"'
```

## 5.5 Operators

Operators are functions with one or more parameters.

```
PrefixOp ::= '+' | '-'  
PostfixOp ::= '%'  
InfixOp ::= ArithmeticOp | ComparisonOp | StringOp | ReferenceOp  
ArithmeticOp ::= '+' | '-' | '*' | '/' | '^'  
ComparisonOp ::= '=' | '<>' | '<' | '>' | '<=' | '>='  
StringOp ::= '&'
```

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.

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

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

*Table 1 - Operators*

<b>Associativity</b>	<b>Operator(s)</b>	<b>Comments</b>
left	:	Range.
left	!	Reference intersection ([.A1:.C4]![.B1:.B5] is [.B1:.B4]). Displayed as the space character in some implementations.

left	~	Reference union. Displayed as the function parameter separator in some implementations.
right	+, -	Prefix unary operators, e.g., -5 or -.A1]. Note that these have a different precedence than add and subtract.
left	%	Postfix unary operator % (divide by 100). Note that this is legal with expressions (e.g., [B1]%).
left	^	Power (2 ^ 3 is 8).
left	*, /	Multiply, divide.
left	+, -	Binary operations add, subtract. Note that unary (prefix) + and - have a different precedence.
left	&	Binary operation string concatenation. Note that unary (prefix) + and - has a different precedence. Note that "&" shall be escaped when included in an XML document
left	=, <>, <, <=, >, >=	Comparison operators equal to, not equal to, less than, less than or equal to, greater than, greater than or equal to

**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.

## 5.6 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 |
                        ' _ ' | ' . ' | 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 need 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 ::= ';' ;

## 5.7 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().

**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.

**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().

## 5.8 References

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

```
Reference ::= '[' (Source? RangeAddress) | ReferenceError ']'
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 */
SheetLocator ::= SheetName ('.' SubtableCell)*
SheetName ::= QuotedSheetName | '$'? [^\\]\. #'$'+
QuotedSheetName ::= '$'? SingleQuoted
SubtableCell ::= ( Column Row ) | QuotedSheetName
ReferenceError ::= "#REF!"
Column ::= '$'? [A-Z]+
Row ::= '$'? [1-9] [0-9]*
Source ::= "" IRI "" "#"
CellAddress ::= SheetLocatorOrEmpty '.' Column Row /* Not used
directly */
```

References always begin with '[' (LEFT SQUARE BRACKET, U+005B); this disambiguates cell addresses from function names and named expressions. *SheetNames* include single-quote"" (APOSTROPHE, 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).

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 (APOSTROPHE, 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. 3.4

## 5.9 Reference List

A reference list is the result of the Infix Operator Reference Concatenation 6.4.13 '~', the syntax is:

```
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.

## 5.10 Quoted Label

### 5.10.1 General

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

`QuotedLabel ::= SingleQuoted`

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

## 5.10.2 Lookup of Defined Labels

For a `QuotedLabel`, first the cells defined in column label ranges (cell ranges of the `table:label-cell-range-address` attribute in the elements `<table:label-range>` with attribute `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 `table:data-cell-range-address` attribute is taken as a reference. If not found, the cells defined in row label ranges (attribute `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.

## 5.10.3 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 (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 **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  $Distance = ColumnDifference * ColumnDifference + RowDifference * RowDifference$  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: *Match2* for positions right of and/or below the formula position ( $FormulaColumn < MatchColumn \parallel FormulaRow < MatchRow$ ), *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 ( $FormulaColumn \geq Match1Column \ \&\& \ FormulaRow \geq Match1Row$ ) 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 ( $FormulaRow \geq Match2Row$ ) 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  $\Rightarrow$  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.

### 5.10.4 Implicit Intersection

For the reference resulting from a single `QuotedLabel` an implicit intersection is generated if the operator or function where it is used 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.

### 5.10.5 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.

*Example:*

*Table 2 - Automatic Range*

<b>Row</b>	<b>Data</b>	<b>Expression</b>	<b>Result</b>	<b>Comment</b>
<b>1</b>	Label	=SUM('Label')	3	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.
<b>2</b>				
<b>3</b>	1			
<b>4</b>	2			
<b>5</b>				
<b>6</b>	8			
<b>7</b>				
<b>8</b>	32			

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

*Table 3 - Automatic Range*

Row	Data	Expression	Result	Comment
1	Label	=SUM('Label')	15	Empty cell in row 2 is skipped, empty cell in row 7 stops the automatic range.
2				
3	1			
4	2			
5	4			
6	8			
7				
8	32			

### 5.10.6 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:

```
AutomaticIntersection ::= QuotedLabel 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.

## 5.11 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.

```
NamedExpression ::= SimpleNamedExpression |
                    SheetLocalNamedExpression | ExternalNamedExpression
SimpleNamedExpression ::= Identifier |
                        '$$' (Identifier | SingleQuoted)
SheetLocalNamedExpression ::=
                        QuotedSheetName '.' SimpleNamedExpression
ExternalNamedExpression ::=
                        Source (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 `QuotedSheetName` can be used to reference a sheet-specific named expression. The most specific named expression for a given expression is used. If the `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 `QuotedSheetName` rule fragment is not included at all). If there is a non-empty `QuotedSheetName`, search begins with that named sheet, then up through its container(s) for the given name.

**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 `Source` and `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.

```
Identifier ::= ( LetterXML
    (LetterXML | DigitXML | '_' | CombiningCharXML)* )
- ( [A-Za-z]+[0-9]+ )
- ([Tt][Rr][Uu][Ee]) - ([Ff][Aa][Ll][Ss][Ee])
```

## 5.12 Constant Errors

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:

```
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.

*Table 4 - Possible Other Constant Error Values*

Name	Comments
#DIV/0!	Attempt to divide by zero, including division by an empty cell. ERROR.TYPE of 2
#NAME?	Unrecognized/deleted name. ERROR.TYPE of 5.
#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.

## 5.13 Inline Arrays

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

```
Array ::= '{' MatrixRow ( RowSeparator MatrixRow ) * '}'
MatrixRow ::= Expression ( ';' Expression ) *
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.

## 5.14 Whitespace

```
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.

---

## 6 Standard Operators and Functions

### 6.1 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).

### 6.2 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).

## 6.3 Implicit Conversion Operators

### 6.3.1 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.

### 6.3.2 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, 6.3.3, to determine which single cell to use, then handle as a reference to a single cell.

### 6.3.3 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.

### 6.3.4 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

### 6.3.5 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.

### 6.3.6 Conversion to Integer

If the expected type is Integer for a function or operator, apply the “Conversion to Number” operation. 6.3.5 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.

### 6.3.7 Conversion to NumberSequence

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

- Number, Text, or Logical, handle as Conversion to Number 6.3.5 (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.

### 6.3.8 Conversion to NumberSequenceList

Identical to Conversion to NumberSequence 6.3.7 , 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.

### 6.3.9 Conversion to DateSequence

Identical to Conversion to NumberSequence 6.3.7 except that each element in the list represents a serial date value of subtype Date.

### 6.3.10 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.

### 6.3.11 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.

### 6.3.12 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().

### 6.3.13 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.

### 6.3.14 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.

### 6.3.15 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.

### 6.3.16 Conversion to TimeParam

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

- Number, return it.

- Text, pass to TIMEVALUE, and if non-Error, return it. If TIMEVALUE 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.

## 6.4 Standard Operators

### 6.4.1 General

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

### 6.4.2 Infix Operator "+"

**Summary:** Add two numbers.

**Syntax:** *Number Left + Number Right*

**Returns:** Number

**Constraints:** None

**Semantics:** Adds numbers together.

**See also** Infix Operator "-" 6.4.3, Prefix Operator "+" 6.4.15

### 6.4.3 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 "+" 6.4.2, Prefix Operator "-" 6.4.16

### 6.4.4 Infix Operator "\*"

**Summary:** Multiply two numbers.

**Syntax:** *Number Left \* Number Right*

**Returns:** Number

**Constraints:** None

**Semantics:** Multiplies numbers together.

**See also** Infix Operator "+" 6.4.2, Infix Operator "/" 6.4.5



### 6.4.5 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 "-" 6.4.3, Infix Operator "\*" 6.4.4

### 6.4.6 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 "\*" 6.4.4, POWER 6.16.46

### 6.4.7 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 "<>" 6.4.8

### 6.4.8 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 differencing 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 "=" 6.4.7

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

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

**Syntax:** *Scalar Left op Scalar Right*

where *op* is one of: "<", "<=", ">", or ">="

**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 "<>" 6.4.8, Infix Operator "=" 6.4.7

### 6.4.10 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 "+" 6.4.2, `CONCATENATE` 6.20.6

### 6.4.11 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 6.4.13, Infix Operator Reference Intersection 6.4.12, INDIRECT 6.14.7

## 6.4.12 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 6.4.13

## 6.4.13 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 6.4.11, Infix Operator Reference Intersection 6.4.12

## 6.4.14 Postfix Operator "%"

**Summary:** Divide the operand by 100

**Syntax:** *Number Left %*

**Returns:** Number

**Constraints:** None

**Semantics:** Computes Left / 100.

**See also** Prefix Operator "-" 6.4.16, Prefix Operator "+" 6.4.15

## 6.4.15 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 "+" 6.4.2

## 6.4.16 Prefix Operator "-"

**Summary:** Negate its one argument.

**Syntax:** *- Number Right*

**Returns:** Number

**Constraints:** None

**Semantics:** Computes 0 - Right.

**See also** Infix Operator "-" 6.4.3

## 6.5 Matrix Functions

### 6.5.1 General

Matrix functions operate on matrices.

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

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

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 number.

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

### 6.5.2 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

$$\det(A_{N \times N}) = \sum_P \operatorname{sgn}(P) \prod_{i=1}^N a_{ip_i}$$

where  $P$  denotes a permutation of the numbers 1, 2, ...,  $n$  and  $\operatorname{sgn}(P)$  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.

**See also** MINVERSE 6.5.3

### 6.5.3 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  $A$ :

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

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

**See also** MDETERM 6.5.2

## 6.5.4 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:

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

## 6.5.5 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*.

$$\mathbf{1}_{N \times N} = \begin{pmatrix} 1 & 0 & \dots & 0 \\ 0 & 1 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & 1 \end{pmatrix}$$

## 6.5.6 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.

$$A_{M \times N}^T = \begin{pmatrix} a_{11} & a_{21} & \dots & a_{M1} \\ a_{12} & a_{22} & \dots & a_{M2} \\ \vdots & \vdots & \ddots & \vdots \\ a_{1N} & a_{2N} & \dots & a_{MN} \end{pmatrix}_{N \times M}$$

## 6.6 Bit operation functions

### 6.6.1 General

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

### 6.6.2 BITAND

**Summary:** Returns bitwise “and” of its parameters

**Syntax:** BITAND( *Integer* X ; *Integer* Y )

**Returns:** Number

**Constraints:** X ≥ 0, Y ≥ 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 6.6.4, BITXOR 6.6.6, AND 6.15.2

### 6.6.3 BITLSHIFT

**Summary:** Returns left shift of value x by n bits (“<<”)

**Syntax:** BITLSHIFT( *Integer* x ; *Integer* n )

**Returns:** Number

**Constraints:** x ≥ 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\*2<sup>n</sup>

**See also** BITAND 6.6.2, BITXOR 6.6.6, BITRSHIFT 6.6.5

### 6.6.4 BITOR

**Summary:** Returns bitwise “or” of its parameters

**Syntax:** BITOR( *Integer* X ; *Integer* Y )

**Returns:** Number

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

**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 6.6.2, BITXOR 6.6.6, AND 6.15.2

## 6.6.5 BITRSHIFT

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

**Syntax:** BITRSHIFT( *Integer*  $x$  ; *Integer*  $n$  )

**Returns:** Number

**Constraints:**  $x \geq 0$

**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  $\text{INT}(x/2^n)$

**See also** BITAND 6.6.2, BITXOR 6.6.6, BITLSHIFT 6.6.3

## 6.6.6 BITXOR

**Summary:** Returns bitwise “exclusive or” of its parameters

**Syntax:** BITXOR( *Integer*  $X$  ; *Integer*  $Y$  )

**Returns:** Number

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

**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 6.6.2, BITOR 6.6.4, OR 6.15.8

## 6.7 Byte-position text functions

### 6.7.1 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.

### 6.7.2 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 6.20.9 , LEFTB 6.7.3 , RIGHTB 6.7.7

### 6.7.3 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 6.20.12, RIGHT 6.20.19, RIGHTB 6.7.7

### 6.7.4 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 6.20.13, LEFTB 6.7.3, RIGHTB 6.7.7

### 6.7.5 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 6.20.15, LEFTB 6.7.3, RIGHTB 6.7.7, REPLACEB 6.7.6

### 6.7.6 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 6.20.17, LEFTB 6.7.3, RIGHTB 6.7.7, MIDB 6.7.5, SUBSTITUTE 6.20.21

### 6.7.7 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 6.20.19, LEFTB 6.7.3

### 6.7.8 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 6.20.20, EXACT 6.20.8, FIND 6.20.9, FINDB 6.7.2

## 6.8 Complex Number Functions

### 6.8.1 General

Functions for complex numbers.

### 6.8.2 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.

### 6.8.3 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 =  $\sqrt{a^2+b^2}$  ; if  $N=r(\cos\phi + i\sin\phi)$ , the absolute value =  $r$ .

**See also** IMARGUMENT 6.8.5

### 6.8.4 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 6.8.19

### 6.8.5 IMARGUMENT

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

**Syntax:** IMARGUMENT( *Complex X* )

**Returns:** Number

**Constraints:** None

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

**See also** IMABS 6.8.3

### 6.8.6 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  $a-bi$ .

### 6.8.7 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 6.8.20

### 6.8.8 IMCOSH

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

**Syntax:** IMCOSH( *Complex N* )

**Returns:** Complex

**Constraints:** None

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

### 6.8.9 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 6.8.20

### 6.8.10 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 6.8.20

### 6.8.11 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** IMSINH, CSCH

### 6.8.12 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 6.8.12

### 6.8.13 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 6.8.14

### 6.8.14 IMLN

**Summary:** Returns the natural logarithm of a complex number.

**Syntax:** IMLN( *Complex X* )

**Returns:** Complex

**Constraints:**  $X \neq 0$

**Semantics:**  $\text{COMPLEX}(\text{LN}(\text{IMABS}(X)); \text{IMARGUMENT}(X))$ .

**See also** IMEXP 6.8.13 , IMLOG10 6.8.15

### 6.8.15 IMLOG10

**Summary:** Returns the common logarithm of a complex number.

**Syntax:** IMLOG10( *Complex X* )

**Returns:** Complex

**Constraints:**  $X \neq 0$

**Semantics:**  $\text{IMLOG10}(X)$  is  $\text{IMDIV}(\text{IMLN}(X); \text{COMPLEX}(\text{LN}(10); 0))$ .

**See also** IMLN 6.8.14 , IMPOWER 6.8.17

## 6.8.16 IMLOG2

**Summary:** Returns the binary logarithm of a complex number.

**Syntax:** IMLOG2( *Complex X* )

**Returns:** Complex

**Constraints:**  $X \neq 0$

**Semantics:** IMLOG2(X) is IMDIV(IMLN(X);COMPLEX(LN(2);0)) .

**See also** IMLN 6.8.14 , IMPOWER 6.8.17

## 6.8.17 IMPOWER

**Summary:** Returns the complex number X raised to the Yth power.

**Syntax:** IMPOWER( *Complex X* ; *Complex Y* ) or IMPOWER( *Complex X* ; Number Y)

**Returns:** Complex

**Constraints:**  $X \neq 0$

**Semantics:** IMPOWER(X;Y) is IMEXP(IMPRODUCT(Y; IMLN(X)))

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

**See also** IMEXP 6.8.13

## 6.8.18 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 6.8.12

## 6.8.19 IMREAL

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

**Syntax:** IMREAL( *Complex N* )

**Returns:** Number

**Constraints:** None

**Semantics:** If  $N=a+bi$  or  $N=a+bj$ , then the real coefficient is a.

**See also** IMAGINARY 6.8.4

### 6.8.20 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 6.8.7

### 6.8.21 IMSINH

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

**Syntax:** IMSINH( *Complex N* )

**Returns:** Complex

**Constraints:** None

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

### 6.8.22 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 6.8.7

### 6.8.23 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

### 6.8.24 IMSQRT

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

**Syntax:** IMSQRT( *Complex N* )

**Returns:** Complex

**Constraints:** None

**Semantics:** If  $N = 0+0i$ , then  $\text{IMSQRT}(N)=0$ . Otherwise  $\text{IMSQRT}(N)$  is  $\text{SQRT}(\text{IMABS}(N)) * \sin(\text{IMARGUMENT}(N)/2) + \text{SQRT}(\text{IMABS}(N)) * \cos(\text{IMARGUMENT}(N)/2)i$ .

**See also** IMPOWER 6.8.17

### 6.8.25 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 6.8.26

### 6.8.26 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 6.8.25

### 6.8.27 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 6.8.25

## 6.9 Database Functions

### 6.9.1 General

Database functions use the variables, Database 4.11.9, Field 4.11.10, and Criteria 4.11.11.

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. 3.4

### 6.9.2 DAVERAGE

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

**Syntax:** DAVERAGE( *Database D* ; *Field F* ; *Criteria C* )

**Returns:** Number

**Constraints:** None

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

**See also** AVERAGE 6.18.3, COUNT 6.13.6, DSUM 6.9.11, DCOUNT 6.9.3, SUM 6.16.61

### 6.9.3 DCOUNT

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

**Syntax:** DCOUNT( *Database D* ; *Field F* ; *Criteria C* )

**Returns:** Number

**Constraints:** None

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

**See also** COUNT 6.13.6, COUNTA 6.13.7, DCOUNTA 6.9.4, DSUM 6.9.11

### 6.9.4 DCOUNTA

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

**Syntax:** DCOUNTA( *Database D* ; *Field F* ; *Criteria C* )

**Returns:** Number

**Constraints:** None

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

**See also** COUNT 6.13.6, COUNTA 6.13.7, DCOUNT 6.9.3, DSUM 6.9.11

## 6.9.5 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 6.9.6, DMIN 6.9.7, DSUM 6.9.11

## 6.9.6 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 6.18.45, DMIN 6.9.7, MIN 6.18.48

## 6.9.7 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 6.18.48, DMAX 6.9.6, MAX 6.18.45

## 6.9.8 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 6.16.61, DSUM 6.9.11

### 6.9.9 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 6.18.72, DSTDEVP 6.9.10

### 6.9.10 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 6.18.74, DSTDEV 6.9.9

### 6.9.11 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 6.16.61, DMIN 6.9.7, DMAX 6.9.6

### 6.9.12 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 6.18.82, DVARP 6.9.13

### 6.9.13 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 6.18.84, DVAR 6.9.12

## 6.10 Date and Time Functions

### 6.10.1 General

### 6.10.2 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 not 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 6.10.17, DATEVALUE 6.10.4

### 6.10.3 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 5 - DATEDIF

<i>format</i>	<i>Returns the number of</i>
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 6.10.7, DAYS 6.10.6, Infix Operator “-” 6.4.3

## 6.10.4 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 6.10.17, DATE 6.10.2, TIMEVALUE 6.10.18, VALUE 6.13.34

## 6.10.5 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 6.10.13, YEAR 6.10.23

## 6.10.6 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 6.10.3, DAYS360 6.10.7, MONTH 6.10.13, YEAR 6.10.23, Infix Operator “-” 6.4.3

## 6.10.7 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 <= Method <= 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  
 $\text{sign} * ((\text{EndDate.year} * 360 + \text{EndDate.month} * 30 + \text{EndDate.day}) - (\text{StartDate.year} * 360 + \text{StartDate.month} * 30 + \text{StartDate.day}))$

**See also** DAYS 6.10.6, DATEDIF 6.10.3

## 6.10.8 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 6.10.6, DATEDIF 6.10.3, EOMONTH 6.10.9

## 6.10.9 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 6.10.8

## 6.10.10 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:

$\text{DayFraction} = (\text{T} - \text{INT}(\text{T}))$

$\text{Hour} = \text{INT}(\text{DayFraction} * 24)$

**See also** MONTH 6.10.13, DAY 6.10.5, MINUTE 6.10.12, SECOND 6.10.16

## 6.10.11 ISOWEEKNUM

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

**Syntax:** ISOWEEKNUM( *DateParam* *Date* )

**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.

**See also** DAY 6.10.5, MONTH 6.10.13, YEAR 6.10.23, WEEKDAY 6.10.20, WEEKNUM 6.10.21

## 6.10.12 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 6.10.13, DAY 6.10.5, HOUR 6.10.10, SECOND 6.10.16

## 6.10.13 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 6.10.23, DAY 6.10.5

## 6.10.14 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.

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

The optional 3<sup>rd</sup> 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 week as excluding Friday and Saturday, the third parameter would be: {0;0;0;0;0;1;1}.

## 6.10.15 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 6.10.19.

**See also** DATE 6.10.2, TIME 6.10.17, TODAY 6.10.19

## 6.10.16 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 6.10.13, DAY 6.10.5, HOUR 6.10.10, MINUTE 6.10.12

## 6.10.17 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 number (they shall not be limited to the ranges 0..24, 0..59, or 0..60 respectively).

**See also** DATE 6.10.2

## 6.10.18 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 6.10.17, DATE 6.10.2, DATEVALUE 6.10.4, VALUE 6.13.34

## 6.10.19 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 6.10.15.

**See also** TIME 6.10.17, NOW 6.10.15

## 6.10.20 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 6 - WEEKDAY

<i>Day of Week</i>	<i>Type=1 Result</i>	<i>Type=2 Result</i>	<i>Type=3 Result</i>
Sunday	1	7	6
Monday	2	1	0
Tuesday	3	2	1
Wednesday	4	3	2
Thursday	5	4	3
Friday	6	5	4
Saturday	7	6	5

See also DAY 6.10.5, MONTH 6.10.13, YEAR 6.10.23

## 6.10.21 WEEKNUM

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

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

**Returns:** Number

**Constraints:**  $1 \leq \text{Mode} \leq 2$ , or  $11 \leq \text{Mode} \leq 17$ , or  $\text{Mode} = 21$ , or  $\text{Mode} = 150$

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

For  $\text{Mode}=\{1, 2, 11, 12, \dots, 17\}$  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 6.10.5, MONTH 6.10.13, YEAR 6.10.23, WEEKDAY 6.10.20, ISOWEEKNUM 6.10.11

## 6.10.22 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 3<sup>rd</sup> 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.

**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;0;1;1}.

### 6.10.23 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 6.10.13, DAY 6.10.5, VALUE 6.13.34

### 6.10.24 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 indicates the day-count convention to use in the calculation. 4.11.7

**See also** DATEDIF 6.10.3

## 6.11 External Access Functions

### 6.11.1 General

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

### 6.11.2 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 7 - DDE

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

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.

### 6.11.3 HYPERLINK

**Summary:** Creation of a hyperlink involving an evaluated expression.

**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.

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.

## 6.12 Financial Functions

### 6.12.1 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.

### 6.12.2 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 8 - ACCRINT

<i>frequency</i>	<i>Frequency of coupon payments</i>
1	Annual
2	Semiannual
4	Quarterly
12	Monthly

**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  $\text{par} * \text{coupon} * \text{YEARFRAC}(\text{start-of-period}; \text{end-of-period}; \text{basis})$

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

See also ACCRINTM 6.12.3

### 6.12.3 ACCRINTM

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

**Syntax:** ACCRINT( *DateParam* issue ; *DateParam* settlement ; *Number* coupon ; *Number* par [ ; *Basis* basis = 0 ] )

**Returns:** Currency

**Constraints:** *coupon* > 0; *par* > 0

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

<i>issue</i>	The security's issue or dated date.
<i>settlement</i>	The security's maturity date.
<i>coupon</i>	The security's annual coupon rate.
<i>par</i>	The security's par value, that is, the principal to be paid at maturity.
<i>basis</i>	Basis indicates the day-count convention to use in the calculation. 4.11.7

See also ACCRINT 6.12.2

### 6.12.4 AMORLINC

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

**Syntax:** AMORLINC( *Number* cost ; *DateParam* purchaseDate ; *DateParam* firstPeriodEndDate ; *Number* salvage ; *Integer* period ; *Number* rate [ ; *Basis* basis = 0 ] )

**Returns:** Currency

**Constraints:** *cost* > 0; *purchaseDate* <= *firstPeriodEndDate*; *salvage* >= 0; *period* >= 0; *rate* > 0

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

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

When period = 0:

$$AMORLINC = cost \cdot rate \cdot YEARFRAC( purchaseDate, firstPeriodEndDate, basis )$$

For full periods, where period > 0, the depreciation is cost \* rate

$$t = \frac{cost - salvage}{cost \cdot rate}$$

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.

$$AMORLINC = cost \cdot rate$$

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

$$AMORLINC = 0$$

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

**See also** DB 6.12.13, DDB 6.12.14, YEARFRAC 6.10.24

## 6.12.5 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 9 - COUPDAYBS

<i>frequency</i>	<i>Frequency of coupon payments</i>
1	Annual
2	Semiannual
4	Quarterly

**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. 4.11.7

**See also** COUPDAYS 6.12.6 , COUPDAYSNC 6.12.7 , COUPNCD 6.12.7 , COUPNUM 6.12.9 , COUPPCD 6.12.10

## 6.12.6 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 10 - COUPDAYS

<i>frequency</i>	<i>Frequency of coupon payments</i>
1	Annual
2	Semiannual
4	Quarterly

**Semantics:** Calculates the number of days in the coupon period containing 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. 4.11.7

**See also** COUPDAYBS 6.12.5 , COUPDAYSNC 6.12.7 , COUPNCD 6.12.7 , COUPNUM 6.12.9 , COUPPCD 6.12.10

## 6.12.7 COUPDAYSNC

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

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

**Returns:** Number

**Constraints:** *settlement* < *maturity*

*frequency* is one of the following values:

Table 11 - COUPDAYSNC

<i>frequency</i>	<i>Frequency of coupon payments</i>
1	Annual
2	Semiannual
4	Quarterly

**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. 4.11.7

**See also** COUPDAYBS 6.12.5 , COUPDAYS 6.12.6 , COUPNCD 6.12.7 , COUPNUM 6.12.9 , COUPPCD 6.12.10

## 6.12.8 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 12 - COUPNCD

<i>frequency</i>	<i>Frequency of coupon payments</i>
1	Annual
2	Semiannual
4	Quarterly

**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

## 6.12.9 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 13 - COUPNUM

<i>frequency</i>	<i>Frequency of coupon payments</i>
1	Annual
2	Semiannual
4	Quarterly

**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. 4.11.7

**See also** COUPDAYBS 6.12.5, COUPDAYS 6.12.6, COUPDAYSNCF 6.12.7, COUPNCD 6.12.7, COUPPCD 6.12.10

## 6.12.10 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 14 - COUPPCD

<i>frequency</i>	<i>Frequency of coupon payments</i>
1	Annual
2	Semiannual
4	Quarterly

**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. 4.11.7

**See also** COUPDAYBS 6.12.5, COUPDAYS 6.12.6, COUPDAYSNCR 6.12.7, COUPNCD 6.12.7, COUPNUM 6.12.9

## 6.12.11 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 15 - CUMIPMT

<i>type</i>	<i>Maturity date</i>
0	due at the end
1	due at the beginning

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

<i>rate</i>	The interest rate per period.
<i>periods</i>	The number of periods.
<i>value</i>	The current value of the loan.
<i>start</i>	The starting period.
<i>end</i>	The end period.
<i>type</i>	The maturity date, the beginning or the end of a period.

$$CUMIPMT = \sum_{p=start}^{end} IPMT(rate, p, periods, value, 0, type)$$

See also IPMT 6.12.23, CUMPRINC 6.12.12

## 6.12.12 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 16 - CUMPRINC

<i>type</i>	<i>Maturity date</i>
0	due at the end
1	due at the beginning

**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 6.12.37 , CUMIPMT 6.12.11

## 6.12.13 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

$$DB_{period} = value_{period} - value_{period-1}$$

For all periods, where *period* > *lifeTime* + 1 – INT(*month*/12), the depreciation allowance is zero.

**See also** DDB 6.12.14, SLN 6.12.45

## 6.12.14 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 >= 0, salvage >= 0, salvage <= cost, 1 <= period <= 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:

$$rate = \frac{declinationFactor}{lifeTime}$$

The depreciation each period is calculated as

depreciation\_of\_period = MIN( book\_value\_at\_start\_of\_period \* rate; book\_value\_at\_start\_of\_period - salvage )

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

$$BookValueAtStartOfPeriod_p = cost - \sum_{i=1}^{p-1} DepreciationOfPeriod_i$$

To allow also non-integer *period* values this algorithm may be used:

```

rate = declinationFactor / lifeTime
if rate ≥ 1 then
{
  rate = 1
  if period = 1 then
    oldValue = cost
  else
    oldValue = 0
  endif
}
else
{
  oldValue = cost · (1 - rate)period - 1
}
endif
newValue = cost · (1 - rate)period
if newValue < salvage then
  DDB = oldValue - salvage
else
  DDB = oldValue - newValue
endif
if DDB < 0 then
  DDB = 0
endif

```

If period is an Integer number, the relation between DDB and VDB is:  
DDB( *cost* ; *salvage* ; *lifeTime* ; *period* ; *declinationFactor* )  
equals  
VDB( *cost* ; *salvage* ; *lifeTime* ; *period* - 1 ; *period* ; *declinationFactor* ; TRUE() )

See also SLN 6.12.45, VDB 6.12.50

## 6.12.15 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:** *settlement* < *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. 4.11.7

$$DISC = \frac{\frac{redemption - price}{redemption}}{YEARFRAC(settlement, maturity, basis)}$$

See also YEARFRAC 6.10.24

## 6.12.16 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.

<i>fractional</i>	Decimal fraction.
<i>denominator</i>	Denominator of the fraction.

$$DOLLARDE = TRUNC(fractional) + \frac{fractional - TRUNC(fractional)}{denominator}$$

See also DOLLARFR 6.12.17 , TRUNC 6.17.8

## 6.12.17 DOLLARFR

**Summary:** Converts a decimal dollar representation into a fractional representation.

**Syntax:** DOLLARFR( *Number* decimal ; *Integer* denominator )





## 6.12.20 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 6.12.41 for the equation this solves.

**See also** PV 6.12.41, NPER 6.12.29, PMT 6.12.36, RATE 6.12.42

## 6.12.21 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:

$$Principle \cdot \prod_{i=1}^N (1 + Schedule[i])$$

**See also** PV 6.12.41, NPER 6.12.29, PMT 6.12.36, RATE 6.12.42

## 6.12.22 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

The return value for this function is:

$$INTRATE = \frac{\frac{Redemption - Investment}{Investment}}{YEARFRAC( Settlement ; Maturity ; Basis )}$$

See also RECEIVED 6.12.43, YEARFRAC 6.10.24

### 6.12.23 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 6.12.37, PMT 6.12.36

### 6.12.24 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 6.12.30, RATE 6.12.42

## 6.12.25 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 6.12.41, FV 6.12.20, NPER 6.12.29, PMT 6.12.36, RATE 6.12.42

## 6.12.26 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  $\geq 0$ , Coupon  $\geq 0$ , Settlement  $\leq$  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. 4.11.7

The modified duration is computed as follows:

$duration = DURATION( Settlement , Maturity , Coupon , Yield , Frequency , Basis )$

$$MDURATION = \frac{duration}{1 + \left( \frac{Yield}{Frequency} \right)}$$

**See also** DURATION 6.12.18

## 6.12.27 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:

$$\left( \frac{-NPV(ReinvestRate, Values > 0) * (1 + ReinvestRate)^n}{NPV(Investment; Values < 0) * (1 + Investment)} \right)^{\left( \frac{1}{n-1} \right)} - 1$$

where N is the number of incomes and payments in Values (total).

**See also** IRR 6.12.24

## 6.12.28 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

$$P * \left( 1 + \frac{NOMINAL}{m} \right)^m$$

The mapping between nominal rate and effective rate is

$$EFFECT = \left( 1 + \frac{NOMINAL}{m} \right)^m - 1$$

See also EFFECT 6.12.19

## 6.12.29 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:

$$Pv = -Fv - (Payment * NPER)$$

If *Rate* is non-zero, then NPER solves this equation:

$$0 = Pv \cdot (1 + Rate)^{NPER} + \frac{Payment \cdot (1 + Rate \cdot PaymentType) \cdot ((1 + Rate)^{NPER} - 1)}{Rate} + Fv$$

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 6.12.20, RATE 6.12.42, PMT 6.12.36, PV 6.12.41

## 6.12.30 NPV

**Summary:** Compute the net present value (NPV) for a series of periodic cash flows.

**Syntax:** NPV( *Number Rate* ; { *NumberSequenceList Value* }<sup>+</sup> )

**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:

$$NPV = \sum_{i=1}^N \frac{Values_i}{(1 + Rate)^i}$$

**See also** FV 6.12.20, IRR 6.12.24, NPER 6.12.29, PMT 6.12.36, PV 6.12.41, XNPV 6.12.52

### 6.12.31 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
- Issue: the issue date of the security
- First: the first coupon date of the security
- Rate: the interest rate of the security
- Yield: 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; 4=quarterly.
- Basis indicates the day-count convention to use in the calculation. 4.11.7

**See also** ODDLPRICE 6.12.33 , ODDFYIELD 6.12.32

### 6.12.32 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; 4=quarterly.
- Basis: indicates the day-count convention to use in the calculation. 4.11.7

**See also** ODDLYIELD 6.12.34 , ODDFPRICE 6.12.31

### 6.12.33 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* 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; 4=quarterly
- Basis: indicates the day-count convention to use in the calculation. 4.11.7

**See also** ODDFPRICE 6.12.31

### 6.12.34 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; 4=quarterly.
- Basis: indicates the day-count convention to use in the calculation. 4.11.7

**See also** ODDLPRICE 6.12.33 , ODDFYIELD 6.12.32

### 6.12.35 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 6.12.18

### 6.12.36 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:

$$Pv = -Fv - (PMT * Nper)$$

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 6.12.20, NPER 6.12.29, PV 6.12.41, RATE 6.12.42

### 6.12.37 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 6.12.36

### 6.12.38 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* = 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

$$PRICE = \frac{Redemption}{\left(1 + \frac{Yield}{Frequency}\right)^{C-1+\frac{A}{B}}} + \sum_{k=1}^C \frac{\frac{100 * Rate}{Frequency}}{\left(1 + \frac{Yield}{Frequency}\right)^{k-1+\frac{A}{B}}} - 100 * \frac{Rate}{Frequency} * \frac{D}{B}$$

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; 4=quarterly.
- Basis: indicates the day-count convention to use in the calculation. 4.11.7

**See also** PRICEDISC 6.12.39, PRICEMAT 6.12.40

## 6.12.39 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. 4.11.7

**See also** PRICE 6.12.38, PRICEMAT 6.12.40, YIELDDISC 6.12.54

## 6.12.40 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
- Basis: indicates the day-count convention to use in the calculation. 4.11.7

If both, *Rate* and *AnnualYield*, are 0, the return value is 100.

**See also** PRICEDISC 6.12.39, PRICEMAT 6.12.40

## 6.12.41 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:

$$PV = -Fv - (Payment * Nper)$$

If *Rate* is nonzero, then PV solves this equation:

$$0 = PV \cdot (1 + Rate)^{Nper} + \frac{Payment \cdot (1 + Rate \cdot PayType) \cdot ((1 + Rate)^{Nper} - 1)}{Rate} + Fv$$

**See also** FV 6.12.20, NPER 6.12.29, PMT 6.12.36, RATE 6.12.42

## 6.12.42 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 6.12.20, NPER 6.12.29, PMT 6.12.36, PV 6.12.41

### 6.12.43 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. 4.11.7

The return value is:

$$RECEIVED = \frac{Investment}{1 - Discount \cdot YEARFRAC( Settlement ; Maturity ; Basis )}$$

See also YEARFRAC 6.10.24

## 6.12.44 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:

$$\left( \frac{Fv}{Pv} \right)^{(1/N)} - 1$$

**See also** FV 6.12.20, NPER 6.12.29, PMT 6.12.36, PV 6.12.41, RATE 6.12.42

## 6.12.45 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 6.12.14.

**See also** DDB 6.12.14

## 6.12.46 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.

$$SYD = \frac{(Cost - Salvage) \cdot (LifeTime + 1 - Period) \cdot 2}{(LifeTime + 1) \cdot LifeTime}$$

For other methods of computing depreciation, see DDB 6.12.14.

**See also** SLN 6.12.45, DDB 6.12.14

## 6.12.47 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 6.12.48, TBILLYIELD 6.12.49

## 6.12.48 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 6.12.47, TBILLYIELD 6.12.49

## 6.12.49 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 6.12.47, TBILLPRICE 6.12.48

## 6.12.50 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,  $0 \leq \text{startPeriod} \leq \text{lifeTime}$ ,  $\text{startPeriod} \leq \text{endPeriod} \leq \text{lifeTime}$ , depreciationFactor  $\geq 0$

**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. start-Period 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 6.12.14, SLN 6.12.45

### 6.12.51 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 6.12.24

### 6.12.52 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:

$$XNPV = \sum_{i=1}^N \frac{Values_i}{(1 + Rate)^{\frac{Dates_i - Dates_1}{365}}}$$

See also NPV 6.12.30

## 6.12.53 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. 4.11.7

See also PRICE 6.12.38, YIELDDISC 6.12.54, YIELDMAT 6.12.55

## 6.12.54 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 per 100 currency units face value
- Basis: indicates the day-count convention to use in the calculation. 4.11.7

The return value is

$$YIELDDISC = \frac{\frac{Redemption}{Price} - 1}{YEARFRAC(Settlement; Maturity; Basis)}$$

**See also** PRICEDISC 6.12.39, YEARFRAC 6.10.24

## 6.12.55 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. 4.11.7

**See also** PRICE 6.12.38, YIELD 6.12.53, YIELDDISC 6.12.54

## 6.13 Information Functions

### 6.13.1 General

Information functions provide information about a data value, the spreadsheet, or underlying environment, including special functions for converting between data types.

### 6.13.2 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 6.4.13, INDEX 6.14.6

### 6.13.3 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 17 - CELL

<i>Info_Type</i>	<i>Comment</i>
COL	Returns the column number of the cell.
ROW	Returns the row number of the cell.
SHEET	Returns the sheet number of the cell.
ADDRESS	Returns the absolute address of the cell. The sheet name is included if given in the reference. For an external reference a <i>Source</i> as specified in the syntax rules for <i>References</i> 5.8 is included.
FILENAME	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 "".
CONTENTS	Returns the contents of the cell, without formatting properties.
COLOR	Returns 1 if color formatting is set for negative value in this cell; otherwise returns 0
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. "'" (APOSTROPHE, U+0027) = left alignment "'" (QUOTATION MARK, U+0022) = right alignment ^(caret) = centered alignment \ (back slash) = filled alignment otherwise, returns empty string "".

- R : if R is a reference to a cell, it is the cell whose information will be returned; if R is a reference to a range, the top-left cell in the range is the selected one; if R is omitted, the current cell is used.

#### 6.13.4 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 6.13.29, SHEET 6.13.31

## 6.13.5 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 6.13.30

## 6.13.6 COUNT

**Summary:** Count the number of Numbers provided

**Syntax:** COUNT( { *NumberSequenceList N* }<sup>+</sup> )

**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 6.13.7

## 6.13.7 COUNTA

**Summary:** Count the number of non-empty values

**Syntax:** COUNTA( { *Any A* }<sup>+</sup> )

**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 6.13.6, ISBLANK 6.13.14

## 6.13.8 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 6.13.6, COUNTA 6.13.7, COUNTIF 6.13.9, ISBLANK 6.13.14

## 6.13.9 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* (4.11.8).

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. 3.4

**See also** COUNT 6.13.6, COUNTA 6.13.7, COUNTBLANK 6.13.8, COUNTIFS 6.13.10, SUMIF 6.16.62, Infix Operator "=" 6.4.7, Infix Operator "<>" 6.4.8, Infix Operator Ordered Comparison ("<", "<=", ">", ">=") 6.4.9

## 6.13.10 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 (4.11.8). 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. 3.4

**See also** AVERAGEIFS 6.18.6, COUNT 6.13.6, COUNTA 6.13.7, COUNTBLANK 6.13.8, COUNTIF 6.13.9, SUMIF 6.16.62, SUMIFS 6.16.63, Infix Operator "=" 6.4.7, Infix Operator "<>" 6.4.8, Infix Operator Ordered Comparison ("<", "<=", ">", ">=") 6.4.9

### 6.13.11 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 6.13.27

### 6.13.12 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 6.13.18

### 6.13.13 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 18 - INFO

<b>Category</b>	<b>Meaning</b>	<b>Type</b>
"directory"	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 "/" or "\" respectively).	Text
"memavail"	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	Number
"memused"	Amount of memory used, in bytes, by the data	Number
"numfile"	Number of active worksheets in files	Number
"osversion"	Operating system version	Text
"origin"	The top leftmost visible cell's absolute reference prefixed with "\$A:". In locales where cells are ordered right-to-left, the top rightmost visible cell is used instead.	Text
"recalc"	Current recalculation mode. If the locale is English, this is either "Automatic" or "Manual" (the exact text depends on the locale)	Text
"release"	The version of the implementation.	Text
"system"	The type of the operating system.	Text
"totmem"	Total memory available in bytes, including the memory already used.	Number

Evaluators may support other categories.

**See also** CELL 6.13.3

### 6.13.14 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 6.13.22, ISTEXT 6.13.25



### 6.13.15 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 6.13.16. 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 6.13.11, ISERROR 6.13.16, ISNUMBER 6.13.22, ISTEXT 6.13.25, NA 6.13.27

### 6.13.16 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 6.13.15. Note that this function does *not* propagate Error values.

**See also** ERROR.TYPE 6.13.11, ISERR 6.13.15, ISNA 6.13.20, ISNUMBER 6.13.22, ISTEXT 6.13.25, NA 6.13.27

### 6.13.17 ISEVEN

**Summary:** Return TRUE if the value is even, else return FALSE

**Syntax:** ISEVEN( *Number X* )

**Returns:** Logical

**Constraints:** None

**Semantics:** First, compute  $X1 = \text{TRUNC}(X)$ . Then, if X1 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 6.3.5 ).

**See also** ISODD 6.13.23

### 6.13.18 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** ISTE<sup>1</sup> 6.13.25, ISNUMBER 6.13.22

## 6.13.19 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** ISTE<sup>1</sup> 6.13.25, ISNUMBER 6.13.22

## 6.13.20 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 6.13.11, ISERROR 6.13.16, ISERR 6.13.15, ISNUMBER 6.13.22, ISTE<sup>1</sup> 6.13.25, NA 6.13.27

## 6.13.21 ISNONT<sup>1</sup>

**Summary:** Return TRUE if the parameter does *not* have type Text, else return FALSE

**Syntax:** ISNONT<sup>1</sup>( *Scalar* X )

**Returns:** Logical

**Constraints:** None

**Semantics:** If X is of type Text, ISNONT<sup>1</sup> 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 ISNONT<sup>1</sup> will return TRUE. Empty Cell 4.7

ISNONT<sup>1</sup>(X) is equivalent to NOT(ISTE<sup>1</sup>(X))

**See also** ISNUMBER 6.13.22, ISLOGICAL 6.13.19, ISTE<sup>1</sup> 6.13.25

### 6.13.22 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 need not have a distinguished Logical type; in such evaluators, ISNUMBER(TRUE()) is TRUE.

**See also** ISTEEXT 6.13.25, ISLOGICAL 6.13.19

### 6.13.23 ISODD

**Summary:** Return TRUE if the value is even, else return FALSE

**Syntax:** ISODD( *Number X* )

**Returns:** Logical

**Constraints:** None

**Semantics:** First, compute  $X1 = \text{TRUNC}(X)$ . 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 6.3.5 ).

**See also** ISEVEN 6.13.17

### 6.13.24 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 6.13.22, ISTEEXT 6.13.25

### 6.13.25 ISTEEXT

**Summary:** Return TRUE if the parameter has type Text, else return FALSE.

ISTEXT(X) is equivalent to NOT(ISNONTEXT(X)).

**Syntax:** ISTEEXT( *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

**See also** ISNONTEXT 6.13.21, ISNUMBER 6.13.22, ISLOGICAL 6.13.19

## 6.13.26 N

**Summary:** Return the number of a value.

**Syntax:** N( *Any X* )

**Returns:** Number

**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 6.20.22, VALUE 6.13.34

## 6.13.27 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 6.13.11, ISERROR 6.13.16

## 6.13.28 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 (5.14).

- 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.

**See also** N 6.13.26, T 6.20.22, DATEVALUE 6.10.4, TIMEVALUE 6.10.18, VALUE 6.13.34

### 6.13.29 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 6.13.4, SHEET 6.13.31

### 6.13.30 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 6.13.5

### 6.13.31 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 (5.8 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 6.13.4, ROW 6.13.29, SHEETS 6.13.32

## 6.13.32 SHEETS

**Summary:** Returns the number of sheets in a reference or current document

**Syntax:** SHEETS( [ *Reference* R ] )

**Returns:** Number  $\geq 1$

**Constraints:** R shall not contain a Source Location (5.8 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 6.13.5, ROWS 6.13.30, SHEET 6.13.31

## 6.13.33 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 19 - TYPE*

<i>Value's Type</i>	<i>TYPE Return</i>
Number	1
Text	2
Logical	4
Error	16
Array	64

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 6.13.11

### 6.13.34 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] 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 20 - VALUE

Format	Example	Comment
MM/DD/YYYY	5/21/2006	LOCALE-DEPENDENT; Long year format with slashes.

Y		
MM/DD/YY	5/21/06	LOCALE-DEPENDENT; Short year format with slashes
MM-DD-YYYY	5-21-2006	LOCALE-DEPENDENT; Long year format with dashes (short year may be supported, but it may also be used for years less than 100 .
mmm DD, YYYY	Oct 29, 2006	LOCALE-DEPENDENT; Short alphabetic month day, year. <b>Note:</b> mmm depends on the locale's language.
DD mmm YYYY	29 Oct 2006	LOCALE-DEPENDENT; Short alphabetic day month year
mmmmm DD, YYYY	October 29, 2006	LOCALE-DEPENDENT; Long alphabetic month day, year
DD mmmmm YYYY	29 October 2006	LOCALE-DEPENDENT; Long alphabetic day month year

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 6.13.26, T 6.20.22, DATEVALUE 6.10.4, TIMEVALUE 6.10.18, NUMBERTVALUE 6.13.28

## 6.14 Lookup Functions

### 6.14.1 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.

### 6.14.2 ADDRESS

**Summary:** Returns a cell address (reference) as text

**Syntax:** ADDRESS( *Integer* Row ; *Integer* Column [ ; *Integer* Abs = 1 [ ; *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 *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 21 - ADDRESS

<b>Abs</b>	<b>Meaning</b>	<b>A1 = TRUE()</b>	<b>A1 = FALSE()</b>
1	fully absolute	\$A\$1	R1C1
2	row absolute, column relative	A\$1	R1C[1]
3	row relative, column absolute	\$A1	R[1]C1
4	fully relative	A1	R[1]C[1]

Note that the INDIRECT function accepts this format.

**See also** INDIRECT 6.14.7

### 6.14.3 CHOOSE

**Summary:** Uses an index to return a value from a list of values.

**Syntax:** CHOOSE( *Integer Index* ; { *Any Value* }<sup>+</sup> )

**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 6.15.4

### 6.14.4 GETPIVOTDATA

**Summary:** Return a value from a data pilot table.

**Syntax:** GETPIVOTDATA( *Text DataField* ; *Reference Table* { ; *Text Field* ; *Scalar Member* }<sup>\*</sup> )

**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:function` attribute of the `<table:data-pilot-subtotal>` element, case-insensitive.

## 6.14.5 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  $\geq 1$ ; 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 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 Logical; 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  $\leq$  *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. 3.4

**See also** INDEX 6.14.6, MATCH 6.14.9, OFFSET 6.14.11, VLOOKUP 6.14.12

## 6.14.6 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 6.13.2, CHOOSE 6.14.3

## 6.14.7 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 6.14.2 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 6.14.2

## 6.14.8 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  $\leq$  *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. 3.4

**See also** HLOOKUP 6.14.5, INDEX 6.14.6, MATCH 6.14.9, OFFSET 6.14.11, VLOOKUP 6.14.12

## 6.14.9 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 Logical; 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. 3.4

**See also** HLOOKUP 6.14.5, OFFSET 6.14.11, VLOOKUP 6.14.12

## 6.14.10 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 22 - MULTIPLE.OPERATIONS

	col_B	col_C	col_D	col_E	col_F
row_2	1		1	2	3
row_3	1	1	=MULTIPLE.OPERATIONS(\$B\$5;\$B\$3;\$C3;\$B\$2;D\$2)	=MULTIPLE.OPERATIONS(\$B\$5;\$B\$3;\$C3;\$B\$2;E\$2)	=MULTIPLE.OPERATIONS(\$B\$5;\$B\$3;\$C3;\$B\$2;F\$2)
row_4	=B2+B3	2	=MULTIPLE.OPERATIONS(\$B\$5;\$B\$3;\$C4;\$B\$2;D\$2)	=MULTIPLE.OPERATIONS(\$B\$5;\$B\$3;\$C4;\$B\$2;E\$2)	=MULTIPLE.OPERATIONS(\$B\$5;\$B\$3;\$C4;\$B\$2;F\$2)
row_5	=B2*B3+B4	3	=MULTIPLE.OPERATIONS(\$B\$5;\$B\$3;\$C5;\$B\$2;D\$2)	=MULTIPLE.OPERATIONS(\$B\$5;\$B\$3;\$C5;\$B\$2;E\$2)	=MULTIPLE.OPERATIONS(\$B\$5;\$B\$3;\$C5;\$B\$2;F\$2)
		4	=MULTIPLE.OPERATIONS(\$B\$5;\$B\$3;\$C6;\$B\$2;D\$2)	=MULTIPLE.OPERATIONS(\$B\$5;\$B\$3;\$C6;\$B\$2;E\$2)	=MULTIPLE.OPERATIONS(\$B\$5;\$B\$3;\$C6;\$B\$2;F\$2)

Result:

Table 23 - MULTIPLE.OPERATIONS

	col_B	col_C	col_D	col_E	col_F
row_2	1		1	2	3
row_3	1	1	3	5	7
row_4	2	2	5	8	11
row_5	3	3	7	11	15
		4	9	14	19

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.

## 6.14.11 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 6.13.4, COLUMNS 6.13.5, ROW 6.13.29, ROWS 6.13.30

## 6.14.12 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  $\geq 1$ ; 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 Logical; 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  $\leq$  *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. 3.4

**See also** HLOOKUP 6.14.5, INDEX 6.14.6, MATCH 6.14.9, OFFSET 6.14.11

## 6.15 Logical Functions

### 6.15.1 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.



## 6.15.2 AND

**Summary:** Compute logical AND of all parameters.

**Syntax:** AND( { *Logical*|*NumberSequenceList* L }<sup>+</sup> )

**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 6.15.8, IF 6.15.4

## 6.15.3 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 6.15.9, IF 6.15.4

## 6.15.4 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 6.15.2, OR 6.15.8

## 6.15.5 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*.

**Note:** This is semantically equivalent to IF(ISERROR(*X*); *Alternative*; *X*), except that *X* is only computed once.

**See also** IF 6.15.4, ISERROR 6.13.16

### 6.15.6 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*.

**Note:** This is semantically equivalent to IF(ISNA(*X*); *Alternative*; *X*), except that *X* is only computed once.

**See also** IF 6.15.4, ISNA 6.13.20

### 6.15.7 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 6.15.2, IF 6.15.4

### 6.15.8 OR

**Summary:** Compute logical OR of all parameters.

**Syntax:** OR( { *Logical/NumberSequenceList L* }<sup>+</sup> )

**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 return 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 6.15.2, IF 6.15.4

## 6.15.9 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 but need 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.

**See also** FALSE 6.15.3, IF 6.15.4

## 6.15.10 XOR

**Summary:** Compute a logical XOR of all parameters.

**Syntax:** XOR( { *Logical L* }<sup>+</sup> )

**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 6.15.2, OR 6.15.8

# 6.16 Mathematical Functions

## 6.16.1 General

This section describes functions for various mathematical functions, including trigonometric functions like SIN 6.16.55). 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.

## 6.16.2 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 “-” 6.4.16

### 6.16.3 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:**  $-1.0 \leq N \leq 1.0$ .

**Semantics:** Computes the arc cosine of a number, in radians.

$$\operatorname{acos}(N) = \frac{\pi}{2} - \left[ N + \frac{1}{2 \cdot 3} N^3 + \frac{1 \cdot 3}{2 \cdot 4 \cdot 5} N^5 + \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6 \cdot 7} N^7 + \dots \right]$$

Returns a principal value  $0 \leq \text{result} \leq \text{PI}$ .

**See also** COS 6.16.19, RADIANS 6.16.49, DEGREES 6.16.25

### 6.16.4 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.

$$\operatorname{acosh}(N) = \ln(N + \sqrt{N^2 - 1})$$

**See also** COSH 6.16.20, ASINH 6.16.8

### 6.16.5 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  $0 < \text{result} < \text{PI}$ .

**See also** COT 6.16.21, ATAN 6.16.9, TAN 6.16.69, RADIANS 6.16.49, DEGREES 6.16.25

### 6.16.6 ACOTH

**Summary:** Return the hyperbolic arc cotangent

**Syntax:** ACOTH( *Number N* )

**Returns:** Number

**Constraints:** ABS(N) > 1

**Semantics:** Computes the hyperbolic arc cotangent. The hyperbolic arc cotangent is an analog of the ordinary (circular) arc cotangent.

$$\operatorname{acoth}(N) = \frac{1}{2} \ln\left(\frac{x+1}{x-1}\right)$$

**See also** COSH 6.16.20, ASINH 6.16.8

## 6.16.7 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 ≤ N ≤ 1.

**Semantics:** Computes the arc sine of a number, in radians.

$$\operatorname{asin}(N) = N + \frac{1}{2 \cdot 3} N^3 + \frac{1 \cdot 3}{2 \cdot 4 \cdot 5} N^5 + \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6 \cdot 7} N^7 + \dots$$

Returns a principal value  $-\pi/2 \leq \text{result} \leq \pi/2$ .

**See also** SIN 6.16.55, RADIANS 6.16.49, DEGREES 6.16.25

## 6.16.8 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.

$$\operatorname{asinh}(N) = \ln\left(N + \sqrt{N^2 + 1}\right)$$

**See also** SINH 6.16.56, ACOSH 6.16.4

## 6.16.9 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 6.16.10, TAN 6.16.69, RADIANS 6.16.49, DEGREES 6.16.25

## 6.16.10 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  $-\pi < \text{result} \leq \pi$ .

**See also** ATAN 6.16.9, TAN 6.16.69, RADIANS 6.16.49, DEGREES 6.16.25

## 6.16.11 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.

$$\operatorname{atanh}(N) = \frac{1}{2} \ln \left( \frac{1+N}{1-N} \right)$$

**See also** COSH 6.16.20, SINH 6.16.56, ASINH 6.16.8, ACOSH 6.16.4, ATAN 6.16.9, ATAN2 6.16.10, FISHER 6.18.26

## 6.16.12 BESSELI

**Summary:** Returns the modified Bessel function of integer order  $\ln(x)$ .

**Syntax:** BESSELI( *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 modified Bessel function of integer order  $\ln(x)$ . N is also known as the *order*.

**See also** BESSELJ 6.16.13, BESSELK 6.16.14, BESSELY 6.16.15

### 6.16.13 BESSELJ

**Summary:** Returns the Bessel function of integer order  $J_n(x)$  (cylinder function)

**Syntax:** BESSELJ( *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  $J_n(x)$ .  $N$  is also known as the *order*.

**See also** BESSELI 6.16.12, BESSELK 6.16.14, BESSELY 6.16.15

### 6.16.14 BESSELK

**Summary:** Returns the modified Bessel function of integer order  $K_n(x)$ .

**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 6.16.12, BESSELJ 6.16.13, BESSELY 6.16.15

### 6.16.15 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 6.16.12, BESSELJ 6.16.13, BESSELK 6.16.14

### 6.16.16 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 COMBIN(5;3) = 10. The result is

$$\binom{N}{R} = \frac{PERMUT}{R!} = \frac{N!}{R!(N-R)!}$$

Note that if order is important, use PERMUT instead.

**See also** PERMUT 6.18.59

## 6.16.17 COMBINA

**Summary:** Returns the number of combinations with repetitions.

**Syntax:** COMBINA( *Integer N* ; *Integer M* )

**Returns:** Number

**Constraints:** N >= 0, M >= 0, N >= M; Evaluators may evaluate expressions where N >= 0, M >= 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 6.16.16

## 6.16.18 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 24 - Unit names

Unit group	Unit symbol	Description
Area	"uk_acre"	International acre (using international feet), exactly 4046.8564224 m <sup>2</sup> ; normally <i>not</i> used for U.S. land areas
	"us_acre"	U.S. survey/statute acre (using U.S. survey/statute feet), exactly 4046+13525426/15499969 m <sup>2</sup>



<i>Unit group</i>	<i>Unit symbol</i>	<i>Description</i>
	"ang2" or "ang^2" *	Square angstrom (an Angstrom is exactly 10 <sup>-10</sup> m)
	"ar" *	are, 100 m <sup>2</sup> (not abbreviated as “a”)
	"ft2" or "ft^2"	Square international feet (1 foot is exactly 0.3048 m)
	"ha"	hectare, 10 000 m <sup>2</sup>
	"in2" or "in^2"	Square international inches (1 inch is exactly 2.54 cm)
	"ly2" or "ly^2"	Square light-year (where year=365.25 days)
	"m2" or "m^2" *	Square meters
	"Morgen"	Morgen, 2500 m <sup>2</sup>
	"mi2" or "mi^2"	Square international miles
	"Nmi2" or "Nmi^2"	Square nautical miles (1 nautical mile is 1852 m)
	"Pica2" or "Pica^2" "picapt2" or "picapt^2"	Square Pica Point (one Pica point is 1/72 inch)
	"pica2" or "pica^2"	Square Pica (one Pica is 1/6 inch)
	"yd2" or "yd^2"	Square international yards (1 yard is 0.9144 m)
<b>Distance (Length)</b>	"ang" *	Angstrom, exactly 10 <sup>-10</sup> m
	"ell"	Ell, exactly 45 international inches
	"ft"	International Foot, exactly 0.3048 m and also exactly 12 international inches.
	"in"	International Inch, exactly 2.54 cm.
	"ly" *	Light-year, (299792458 m/s) (3600 s/hr) (24 hr/day) (365.25 day)
	"m" *	Meter
	"mi"	International Mile, exactly 1609.344 m and exactly 5280 international feet. This is <i>not</i> a U.S. survey/statute mile (see “smi”) nor a nautical mile (see “Nmi”), but this <i>is</i> the mile normally used in the U.S. customary system
	"Nmi"	International nautical mile, exactly 1852 m. Note that

<b>Unit group</b>	<b>Unit symbol</b>	<b>Description</b>
		this is not the obsolete U.S. nautical mile nor the Admiralty mile.
	"parsec" or "pc" *	Distance from sun to a point having heliocentric parallax of one second (used for stellar distance), AU/tan(1/3600 degree) where an AU is exactly 149,597,870.691 kilometers. *
	"Pica" or "picapt"	Pica (1/72 inch)
	"pica"	Pica (1/6 inch)
	"survey_mi"	U.S. survey "mile, aka U.S. statute mile, exactly 6336000/3937 m; used in some U.S. maps. This is <i>not</i> the mile (see "mi") normally used in the U.S.
	"yd"	International yard, exactly 0.9144 m and exactly 3 international feet.
<b>Energy</b>	"BTU" ("btu")	International Table British Thermal Unit
	"c" *	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.
	"cal" *	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.
	"e" *	Erg
	"eV" ("ev") *	Electron volt (eV preferred)
	"flb"	Foot-pound (international foot, avoirdupois pound)
	"HPh" ("hh")	Horsepower-hour (HPh preferred)
	"J" *	Joule
	"Wh" ("wh") *	Watt-hour
<b>Force (Weight)</b>	"dyn" ("dy") *	Dyne
	"N" *	Newton
	"lbf"	Pound force (see "lbm" for pound mass)
	"pond" *	Pond, gravitational force on a mass of one gram, 9.80665E-3 N.

<b>Unit group</b>	<b>Unit symbol</b>	<b>Description</b>
<b>Information</b>	"bit" * †	bit
	"byte" * †	byte = 8 bits
<b>Magnetic Flux Density</b>	"ga" *	Gauss
	"T" *	Tesla
<b>Mass</b>	"g" *	Gram
	"grain"	Grain, 1/7000 international pound mass (avoirdupois) (U.S. usage).
	"cwt" ("shweight")	U.S. (short) hundredweight, 100 lbm
	"uk_cwt" or "lcwt" ("hweight")	Imperial hundredweight, aka long hundredweight; 112 lbm
	"lbm"	International pound mass (avoirdupois), exactly 453.59237 g (see "lbf" for pound force)
	"stone"	14 international pound mass (avoirdupois)
	"ton"	2000 international pound mass (avoirdupois) (U.S. usage). Note that there are many other measures also called "ton"; in particular, this is not a metric ton (tonne).
	"ozm"	Ounce mass (avoirdupois), exactly 1/16 of an international pound mass (avoirdupois) (see "oz" for fluid ounce)
	"sg"	Slug; 32.174 international pound mass (avoirdupois)
	"u" *	U (atomic mass unit)
	"uk_ton" or "LTON" ("brton")	Imperial ton, aka "long ton", "deadweight ton", or "weight ton". 2240 lbm.
<b>Power</b>	"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

<i>Unit group</i>	<i>Unit symbol</i>	<i>Description</i>
<b>Pressure</b>	"atm" ("at") *	Atmosphere
	"mmHg" *	mm of Mercury
	"Pa" *	Pascal; Pa preferred, as it is the standard abbreviation. Note that "P" or "p" need 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)
<b>Speed</b>	"admkn"	Admiralty knot, exactly 6080 international feet/hour.
	"kn"	Knot, exactly one Nautical mile per hour or exactly 1852/3600 m/s. Note that this is not an Admiralty knot ("admkn").
	"m/h" or "m/hr" *	Meters per hour
	"m/s" or "m/sec" *	Meters per second
	"mph"	Miles per hour (international miles)
<b>Temperature</b>	"C" ("cel")	degrees Celsius
	"F" ("fah")	degrees Fahrenheit
	"K" ("kel") *	Kelvin
	"Rank"	degrees Rankine
	"Reau"	degrees Réaumur; °C = °Ré · 5/4.
<b>Time</b>	"day" or "d"	Day (exactly 24 hours)
	"hr"	Hour (exactly 60 minutes)
	"mn" or "min"	Minute (exactly 60 seconds)
	"sec" or "s" *	Second ("s" is the official abbreviation of this SI base unit, while "sec" is its traditional abbreviation in the CONVERT function) *
	"yr"	Year (exactly 365.25 days, for purposes of this function)

<i>Unit group</i>	<i>Unit symbol</i>	<i>Description</i>
<b>Volume</b>	"ang <sup>3</sup> " or "ang <sup>3</sup> " *	Cubic angstrom
	"barrel"	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)
	"bushel"	U.S. bushel ( <i>not</i> Imperial bushel), interpreted as volume
	"cup"	Cup (U.S. customary liquid measure)
	"ft <sup>3</sup> " or "ft <sup>3</sup> "	Cubic international feet
	"gal"	Gallon (U.S. customary liquid measure), 3.785411784 liters.
	"GRT" ("regton")	Gross Registered Ton, 100 cubic (international) feet
	"in <sup>3</sup> " or "in <sup>3</sup> "	Cubic international inch
	"l" or "L" ("lt") *	Liter
	"ly <sup>3</sup> " or "ly <sup>3</sup> "	Cubic light-year
	"m <sup>3</sup> " or "m <sup>3</sup> " *	Cubic meter
	"mi <sup>3</sup> " or "mi <sup>3</sup> "	Cubic international mile
	"MTON"	Measurement ton aka "freight ton", 40 cubic feet
	"Nmi <sup>3</sup> " or "Nmi <sup>3</sup> "	Cubic nautical mile
	"oz"	Fluid ounce (U.S. customary liquid measure; see "ozm" for ounce mass)
	"Pica <sup>3</sup> " or "Pica <sup>3</sup> " "picapt <sup>3</sup> " or "picapt <sup>3</sup> "	Cubic Pica Point (one Pica point is 1/72 inch)
	"pica <sup>3</sup> " or "pica <sup>3</sup> "	Cubic Pica (one Pica is 1/6 inch)
	"pt" or "us_pt"	U.S. Pint (liquid measure)
	"qt"	Quart (U.S. customary liquid measure). This is 0.946352946 liters, and thus <i>not</i> the same as the U.S. dry quart (1.101220 liters), <i>nor</i> is this the same as the Imperial quart (as used in the U.K. and Canada, which is 1.1365225 liters exactly)

<b>Unit group</b>	<b>Unit symbol</b>	<b>Description</b>
	"tbs"	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).
	"tsp"	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 "tspm"
	"tspm"	Modern teaspoon, 5mL
	"uk_gal"	U.K. / Imperial gallon, 4.54609 liters.
	"uk_pt"	U.K. / Imperial pint, 1/8 of a UK gallon.
	"uk_qt"	U.K. / Imperial quart, 1/4 of a UK gallon.
	"yd3" or "yd^3"	Cubic international yard

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.

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 25 - Decimal Prefixes for use in CONVERT

<b>Unit Prefix</b>	<b>Description</b>	<b>Prefix Value</b>
"Y"	yotta	1E+24
"Z"	zetta	1E+21
"E"	exa	1E+18
"P"	peta	1E+15
"T"	tera	1E+12
"G"	giga	1E+09
"M"	mega	1E+06
"k"	kilo	1E+03
"h"	hecto	1E+02
"da" or "e"	deka ( <b>Note:</b> "e" is not a standard SI prefix	1E+01
"d"	deci	1E-01
"c"	centi	1E-02
"m"	milli	1E-03
"u"	micro <b>Note:</b> this is "u", not the standard SI $\mu$	1E-06
"n"	nano	1E-09
"p"	pico	1E-12
"f"	femto	1E-15
"a"	atto	1E-18
"z"	zepto	1E-21
"y"	yocto	1E-24

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 26 - Binary prefixes for use in CONVERT

<b>Binary Unit Prefix</b>	<b>Description</b>	<b>Prefix Value</b>	<b>Derived from</b>
"Yi"	yobi	2 <sup>80</sup> = 1 208 925 819 614 629 174 706 176	yotta
"Zi"	zebi	2 <sup>70</sup> = 1 180 591 620 717 411 303 424	zetta
"Ei"	exbi	2 <sup>60</sup> = 1 152 921 504 606 846 976	exa
"Pi"	pebi	2 <sup>50</sup> = 1 125 899 906 842 624	peta
"Ti"	tebi	2 <sup>40</sup> = 1 099 511 627 776	tera
"Gi"	gibi	2 <sup>30</sup> = 1 073 741 824	giga
"Mi"	mebi	2 <sup>20</sup> = 1 048 576	mega
"Ki"	kibi	2 <sup>10</sup> = 1024	kilo

In the case where there is a naming conflict (a unit name with a prefix is the same as an unprefix name), the unprefix 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 6.16.29

## 6.16.19 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.

$$\cos N = 1 - \frac{N^2}{2!} + \frac{N^4}{4!} - \frac{N^6}{6!} + \dots$$

**See also** ACOS 6.16.3, RADIANS 6.16.49, DEGREES 6.16.25

## 6.16.20 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 6.16.4, SINH 6.16.56, TANH 6.16.70

### 6.16.21 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.

$$\text{COT}(x) = 1 / \text{TAN}(x)$$

See also ACOT 6.16.5, TAN 6.16.69, RADIANS 6.16.49, DEGREES 6.16.25, SIN 6.16.55, COS 6.16.19

### 6.16.22 COTH

**Summary:** Return the hyperbolic cotangent of the given hyperbolic angle

**Syntax:** COTH( *Number N* )

**Returns:** Number

**Constraints:**  $N \neq 0$

**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 6.16.4, SINH 6.16.56, TANH 6.16.70

### 6.16.23 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:

$$1/\text{SIN}(N)$$

See also SIN 6.16.55

### 6.16.24 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:

$$1/\text{SINH}(N)$$

**See also** SINH 6.16.56, CSCH

### 6.16.25 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  $N \times 180/\text{PI}()$ .

**See also** RADIANS 6.16.49, PI 6.16.45

### 6.16.26 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 “=” 6.4.7

### 6.16.27 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  $z0$ :

$$\text{ERF}(Z0) = \frac{2}{\sqrt{\pi}} \int_0^{Z0} e^{-t^2} dt$$

With two arguments, returns

$$ERF(Z0; Z1) = \frac{2}{\sqrt{\pi}} \int_{Z0}^{Z1} e^{-t^2} dt$$

**See also** ERFC 6.16.28

## 6.16.28 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 6.16.27

## 6.16.29 EUROCONVERT

**Summary:** Converts a *Number N*, 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 >= 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 27 - EUROCONVERT

<i>From</i>	<i>To</i>	<i>Rate</i>	<i>Currency</i>	<i>Decimals</i>
"EUR"	"ATS"	13.7603	Austrian Schilling	2
"EUR"	"BEF"	40.3399	Belgian Franc	0
"EUR"	"DEM"	1.95583	German Mark	2
"EUR"	"ESP"	166.386	Spanish Peseta	0
"EUR"	"FIM"	5.94573	Finnish Markka	2

<i>From</i>	<i>To</i>	<i>Rate</i>	<i>Currency</i>	<i>Decimals</i>
"EUR"	"FRF"	6.55957	French Franc	2
"EUR"	"IEP"	0.787564	Irish Pound	2
"EUR"	"ITL"	1936.27	Italian Lira	0
"EUR"	"LUF"	40.3399	Luxembourg Franc	0
"EUR"	"NLG"	2.20371	Dutch Guilder	2
"EUR"	"PTE"	200.482	Portuguese Escudo	2
"EUR"	"GRD"	340.750	Greek Drachma	2
"EUR"	"SIT"	239.640	Slovenian Tolar	2
"EUR"	"MTL"	0.429300	Maltese Lira	2
"EUR"	"CYP"	0.585274	Cypriot Pound	2
"EUR"	"SKK"	30.1260	Slovak Koruna	2

As new member countries adopt the Euro, new conversion rates will become active and evaluators may add them using the respective [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/>  
The conversion rates and triangulation rules are available at  
[http://ec.europa.eu/economy\\_finance/euro/adoption/conversion/index\\_en.htm](http://ec.europa.eu/economy_finance/euro/adoption/conversion/index_en.htm) with links to the  
European Council Regulation legal documents at the <http://eur-lex.europa.eu/> European Union  
law database server.

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  $\geq 3$ , 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

## 6.16.30 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 6.16.44

### 6.16.31 EXP

**Summary:** Returns e raised by the given number.

**Syntax:** EXP( *Number* X )

**Returns:** Number

**Constraints:** None

**Semantics:** Computes

$$e^X = 1 + \frac{X}{1!} + \frac{X^2}{2!} + \frac{X^3}{3!} + \frac{X^n}{n!} + \dots$$

**See also** LOG 6.16.40, LN 6.16.39

### 6.16.32 FACT

**Summary:** Return factorial (!).

**Syntax:** FACT( *Integer* F )

**Returns:** Number

**Constraints:** F >= 0

**Semantics:** Return the factorial

$$F! = F \cdot (F-1) \cdot (F-2) \cdot \dots \cdot 1$$

F(0)=F(1)=1.

**See also** Infix Operator "\*" 6.4.4, GAMMA 6.16.34

### 6.16.33 FACTDOUBLE

**Summary:** Returns double factorial (!!).

**Syntax:** FACTDOUBLE( *Integer* F )

**Returns:** Number

**Constraints:** F >= 0

**Semantics:** Return

$$F! = F \cdot (F-2) \cdot (F-4) \cdot \dots \cdot 1$$

Double factorial is computed by multiplying every other number in the 1..N range, with N always being included.

**See also** Infix Operator "\*" 6.4.4, GAMMA 6.16.34, FACT 6.16.32

### 6.16.34 GAMMA

**Summary:** Return gamma function value.

**Syntax:** GAMMA( *Number* N )

**Returns:** Number

**Constraints:**  $N \neq 0$  and N not a negative integer.

**Semantics:** Return

$$\Gamma(N) = \int_0^{\infty} t^{N-1} e^{-t} dt$$

with  $\Gamma(N+1) = N * \Gamma(N)$ . Note that for non-negative integers N,  $\Gamma(N+1) = N! = \text{FACT}(N)$ . Note that GAMMA can accept non-integers.

**See also** FACT 6.16.32

### 6.16.35 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 6.16.34, FACT 6.16.32

### 6.16.36 GCD

**Summary:** Returns the greatest common divisor (GCD)

**Syntax:** GCD( { *NumberSequenceList* X }+ )

**Returns:** Number

**Constraints:** For all a in X:  $\text{INT}(a) \geq 0$  and for at least one a in X:  $\text{INT}(a) > 0$

**Semantics:** Return the largest integer N such that for every a in X:  $\text{INT}(a)$  is a multiple of N.

**Note:** If for all a in X:  $\text{INT}(a)=0$  the return value is implementation-defined but is either an Error or 0.

**See also** LCM 6.16.38

### 6.16.37 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**

### 6.16.38 LCM

**Summary:** Returns the least common multiplier

**Syntax:** LCM( { *NumberSequenceList* X }<sup>+</sup> )

**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 6.16.36

### 6.16.39 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.

$$\ln x = 2 \left[ \frac{x-1}{x+1} + \frac{1}{3} \left( \frac{x-1}{x+1} \right)^3 + \frac{1}{5} \left( \frac{x-1}{x+1} \right)^5 + \dots \right]$$

**See also** LOG 6.16.40, LOG10 6.16.41, POWER 6.16.46, EXP 6.16.31

### 6.16.40 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 6.16.41, LN 6.16.39, POWER 6.16.46, EXP 6.16.31

### 6.16.41 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 6.16.40, LN 6.16.39, POWER 6.16.46, EXP 6.16.31

### 6.16.42 MOD

**Summary:** Return the remainder when one number is divided by another number.

**Syntax:** MOD( *Number a* ; *Number b* )

**Returns:** Number

**Constraints:**  $b \neq 0$

**Semantics:** Computes the remainder of  $a/b$ . The remainder has the same sign as  $b$ .

**See also** Infix Operator "/" 6.4.5, QUOTIENT 6.16.48

### 6.16.43 MULTINOMIAL

**Summary:** Returns the multinomial for the given values.

**Syntax:** MULTINOMIAL( { *NumberSequence A* }<sup>+</sup> )

**Returns:** Number

**Constraints:** None

**Semantics:** Returns the multinomial of the sequence  $A = (a_1, a_2, \dots, a_n)$ . Multinomial is defined as  $\text{FACT}(a_1 + a_2 + \dots + a_n) / (\text{FACT}(a_1) * \text{FACT}(a_2) * \dots * \text{FACT}(a_n))$

**See also** FACT 6.16.32

### 6.16.44 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 6.16.30

### 6.16.45 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 6.16.55, COS 6.16.19

## 6.16.46 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  $a \leq 0$  and  $\text{INT}(b) \neq b$ , is implementation-defined.

**See also** LOG 6.16.40, LOG10 6.16.41, LN 6.16.39, EXP 6.16.31

## 6.16.47 PRODUCT

**Summary:** Multiply the set of numbers, including all numbers inside ranges

**Syntax:** PRODUCT( { *NumberSequence N* }<sup>+</sup> )

**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 6.16.61

## 6.16.48 QUOTIENT

**Summary:** Return the integer portion of a division.

**Syntax:** QUOTIENT( *Number A* ; *Number B* )

**Returns:** Number

**Constraints:**  $B \neq 0$

**Semantics:** Return the integer portion of a division.

**See also** MOD 6.16.42

## 6.16.49 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  $N \times \text{PI}() / 180$ .

**See also** DEGREES 6.16.25, PI 6.16.45

## 6.16.50 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 6.16.51

## 6.16.51 RANDBETWEEN

**Summary:** Return a random integer number between A and B.

**Syntax:** RANDBETWEEN( *Integer A* ; *Integer B* )

**Returns:** Integer

**Constraints:**  $A \leq B$

**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 6.16.50

## 6.16.52 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:

$$1/\text{COS}(N)$$

**See also** SIN 6.16.55

## 6.16.53 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.

$X \neq 0$  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:

$$SERIESSUM = \sum_{i=1}^C Coefficient_i \cdot X^{(N+(i-1)M)}$$

If  $X=0$  and all of the exponents are non-negative then  $0^0$  shall be set to 1 and  $0^{(exponent > 0)}$  shall be set to 0.

## 6.16.54 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 6.16.2

## 6.16.55 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.

$$\sin(N) = N - \frac{N^3}{3!} + \frac{N^5}{5!} - \frac{N^7}{7!} + \dots$$

**See also** ASIN 6.16.7, RADIANS 6.16.49, DEGREES 6.16.25

## 6.16.56 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 6.16.8, COSH 6.16.20, TANH 6.16.70

## 6.16.57 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:

$$1/\text{COSH}(N)$$

**See also** SINH 6.16.56, CSCH

## 6.16.58 SQRT

**Summary:** Return the square root of a number

**Syntax:** SQRT( *Number N* )

**Returns:** Number

**Constraints:** N>=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 6.16.46, IMSQRT 6.8.24, SQRTPI 6.16.59

## 6.16.59 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,  $\text{SQRT}(N \times \text{PI}())$ . This function shall produce an Error if given a negative number; for producing complex numbers, see IMSQRT.

**See also** POWER 6.16.46, SQRT 6.16.58, PI 6.16.45, IMSQRT 6.8.24

## 6.16.60 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.

Function	Exclude hidden by filter	Exclude hidden by filter or collapsed
AVERAGE	1	101
COUNT	2	102
COUNTA	3	103
MAX	4	104
MIN	5	105
PRODUCT	6	106
STDEV	7	107
STDEVP	8	108
SUM	9	109
VAR	10	110
VARP	11	111

**See also** SUM 6.16.61, AVERAGE 6.18.3

## 6.16.61 SUM

**Summary:** Sum (add) the set of numbers, including all numbers in ranges

**Syntax:** SUM( { *NumberSequenceList* N }<sup>+</sup> )

**Returns:** Number

**Constraints:**  $N \neq \{\}$ ; 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 6.18.3

## 6.16.62 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* (4.11.8).

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. 3.4

**See also** COUNTIF 6.13.9, SUM 6.16.61, Infix Operator "=" 6.4.7, Infix Operator "<>" 6.4.8, Infix Operator Ordered Comparison ("<", "<=", ">", ">=") 6.4.9

## 6.16.63 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 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 (4.11.8). 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. 3.4

**See also** AVERAGEIFS 6.18.6, COUNTIFS 6.13.10, SUMIF 6.16.62, Infix Operator "=" 6.4.7, Infix Operator "<>" 6.4.8, Infix Operator Ordered Comparison ("<", "<=", ">", ">=") 6.4.9

### 6.16.64 SUMPRODUCT

**Summary:** Returns the sum of the products of the matrix elements.

**Syntax:** SUMPRODUCT( { *ForceArray Array A* }<sup>+</sup> )

**Returns:** Number

**Constraints:** All matrices shall have the same dimensions.

**Semantics:** Multiplies the corresponding elements of all matrices and returns the sum of them.

$$SUMPRODUCT(A_1, A_2, \dots, A_K) = \sum_{m=1}^M \sum_{n=1}^N \left( \prod_{k=1}^K a_{k,mn} \right)$$

where  $a_{k,mn}$  denotes an element of the matrix  $A_K$ .

### 6.16.65 SUMSQ

**Summary:** Sum (add) the set of squares of numbers, including all numbers in ranges

**Syntax:** SUMSQ( { *NumberSequence N* }<sup>+</sup> )

**Returns:** Number

**Constraints:** N != {}; Evaluators may evaluate expressions that do not meet this constraint.

**Semantics:** Adds squares of Numbers (and only Numbers) together. See the text on conversions.

### 6.16.66 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.

$$SUMX2MY2(A, B) = \sum_{m=1}^M \sum_{n=1}^N (a_{mn}^2 - b_{mn}^2)$$

### 6.16.67 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.

$$SUMX2PY2(A, B) = \sum_{m=1}^M \sum_{n=1}^N (a_{mn}^2 + b_{mn}^2)$$

### 6.16.68 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.

$$SUMXMY2(A, B) = \sum_{m=1}^M \sum_{n=1}^N (a_{mn} - b_{mn})^2$$

### 6.16.69 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) = SIN(x) / COS(x)

**See also** ATAN 6.16.9, ATAN2 6.16.10, RADIANS 6.16.49, DEGREES 6.16.25, SIN 6.16.55, COS 6.16.19, COT 6.16.21

### 6.16.70 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 6.16.11, SINH 6.16.56, COSH 6.16.20, FISHERINV 6.18.27



## 6.17 Rounding Functions

### 6.17.1 CEILING

**Summary:** Round a number *N* **up** to the nearest multiple of the second parameter, *significance*.

**Syntax:** CEILING( *Number* *N* [ ; [ *Number* *significance* ] [ ; *Number* *mode* ] ] )

**Returns:** Number

**Constraints:** Both *N* and *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 *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 *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. If *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 *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 6.17.3, INT 6.17.2

### 6.17.2 INT

**Summary:** Rounds a number down to the nearest integer.

**Syntax:** 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 6.17.5, TRUNC 6.17.8

### 6.17.3 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. 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 6.17.1, INT 6.17.2

## 6.17.4 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 6.17.5

## 6.17.5 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  $-\text{Digits}$  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  $\text{Digits} \leq 0$ , the results will always be an integer (without a fractional component).

**See also** TRUNC 6.17.8, INT 6.17.2

## 6.17.6 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  $10^{-\text{Digits}}$ . 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 6.17.8, INT 6.17.2, ROUND 6.17.5, ROUNDUP 6.17.7

## 6.17.7 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  $10^{-\text{Digits}}$ . 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 6.17.8, INT 6.17.2, ROUND 6.17.5, ROUNDDOWN 6.17.6

## 6.17.8 TRUNC

**Summary:** Truncate a number to a specified number of digits.

**Syntax:** TRUNC( *Number* a ; *Integer* 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.

**See also** ROUND 6.17.5, INT 6.17.2

## 6.18 Statistical Functions

### 6.18.1 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.

### 6.18.2 AVEDEV

**Summary:** Calculates the average of the absolute deviations of the values in list.

**Syntax:** AVEDEV( { *NumberSequenceList* N }<sup>+</sup> )

**Returns:** Number

**Constraints:** None.

**Semantics:**

$$\frac{1}{n} \sum_{i=1}^n |x_i - \bar{x}|$$

**See also** SUM, AVERAGE

### 6.18.3 AVERAGE

**Summary:** Average the set of numbers

**Syntax:** AVERAGE( { *NumberSequence* N }<sup>+</sup> )

**Returns:** Number

**Constraints:** At least one Number included. Returns an Error if no Numbers provided.

**Semantics:** Computes SUM(*List*) / COUNT(*List*).

**See also** SUM 6.16.61, COUNT 6.13.6

### 6.18.4 AVERAGEA

**Summary:** Average values, including values of type Text and Logical.

**Syntax:** AVERAGEA( { *Any* N }<sup>+</sup> )

**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 6.18.3

### 6.18.5 AVERAGEIF

**Summary:** Average the values of cells in a range that meet a criteria.

**Syntax:** AVERAGEIF( *Reference* R ; *Criterion* C [ ; *Reference* A ] )

**Returns:** Number

**Constraints:** Does not accept constant values as reference parameters.

**Semantics:** If reference A is omitted, averages the values of cells in the reference range R that meet the Criterion C (4.11.8). If reference A is given, averages the values of cells of a range that is constructed using the top left cell of reference A and applying the dimensions, shape and size, of reference R. If no cell in range R matches the Criterion 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. 3.4

**See also** AVERAGEIFS 6.18.6, COUNTIF 6.13.9, SUMIF 6.16.62, Infix Operator "=" 6.4.7, Infix Operator "<>" 6.4.8, Infix Operator Ordered Comparison ("<", "<=", ">", ">=") 6.4.9

## 6.18.6 AVERAGEIFS

**Summary:** Average the values of cells that meet multiple criteria in multiple ranges.

**Syntax:** 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 *A* that meet the Criterion *C1* in the reference range *R1* and the Criterion *C2* in the reference range *R2*, and so on (4.11.8). 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 *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. 3.4

**See also** AVERAGEIF 6.18.5, COUNTIFS 6.13.10, SUMIFS 6.16.63, Infix Operator "=" 6.4.7, Infix Operator "<>" 6.4.8, Infix Operator Ordered Comparison ("<", "<=", ">", ">=") 6.4.9

## 6.18.7 BETADIST

**Summary:** returns the value of the probability density function or the cumulative distribution function for the beta distribution.

**Syntax:** BETADIST( *Number x* ; *Number α* ; *Number β* [ ; *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

$$\frac{\Gamma(\alpha + \beta)}{\Gamma(\alpha)\Gamma(\beta)} \cdot \left(\frac{x-a}{b-a}\right)^{\alpha-1} \cdot \left(1 - \frac{x-a}{b-a}\right)^{\beta-1} \cdot \frac{1}{b-a}$$

otherwise.

If Cumulative is TRUE(), BETADIST returns 0 if  $x < a$ , 1 if  $x > b$ , and the value

$$\int_a^x \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} \cdot \left(\frac{t-a}{b-a}\right)^{\alpha-1} \cdot \left(1-\frac{t-a}{b-a}\right)^{\beta-1} \cdot \frac{1}{b-a} dt$$

otherwise.

**Note:** With substitution

$$z \stackrel{\text{def}}{=} \frac{t-a}{b-a}$$

the term can be written as

$$\int_0^{\frac{x-a}{b-a}} \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} \cdot z^{\alpha-1} \cdot (1-z)^{\beta-1} dz$$

**See also** BETAINV 6.18.8

## 6.18.8 BETAINV

**Summary:** returns the inverse of BETADIST(x;α;β;a;b;TRUE()).

**Syntax:** BETAINV( *Number p* ; *Number α* ; *Number β* [ ; *Number a* = 0 [ ; *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 BETADIST(x;α;β;a;b) = p.

**See also** BETADIST 6.18.7

## 6.18.9 BINOM.DIST.RANGE

**Summary:** Returns the probability of a trial result using binomial distribution.

**Syntax:** BINOM.DIST.RANGE( *Integer N* ; *Number P* ; *Integer S* [ ; *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

$$\sum_{k=S}^{S2} \binom{N}{k} P^k (1-P)^{N-k}$$

**See also** BINOMDIST 6.18.10

### 6.18.10 BINOMDIST

**Summary:** Returns the binomial distribution.

**Syntax:** BINOMDIST( *Integer S* ; *Integer N* ; *Number P* ; *Logical Cumulative* )

**Returns:** Number

**Constraints:**  $0 \leq P \leq 1$ ;  $0 \leq S \leq N$

**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 6.18.9

### 6.18.11 LEGACY.CHIDIST

**Summary:** returns the right-tail probability for the  $\chi^2$ -distribution.

**Syntax:** LEGACY.CHIDIST( *Number x* ; *Number 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

$$\int_x^\infty \frac{t^{\frac{n}{2}-1} e^{-\frac{t}{2}}}{2^{\frac{n}{2}} \Gamma(n/2)} dt$$

for  $x > 0$ .

**See also** CHISQDIST 6.18.12, LEGACY.CHITEST 6.18.15

### 6.18.12 CHISQDIST

**Summary:** returns the value of the probability density function or the cumulative distribution function for the  $\chi^2$ -distribution.

**Syntax:** CHISQDIST( *Number x* ; *Number DegreesOfFreedom* [ ; *Logical Cumulative* = 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

$$\frac{x^{\frac{n}{2}-1} e^{-\frac{x}{2}}}{2^{\frac{n}{2}} \Gamma(n/2)}$$

for  $x > 0$ .

If Cumulative is TRUE(), CHISQDIST returns 0 for  $x \leq 0$  and the value

$$\int_0^x \frac{t^{\frac{n}{2}-1} e^{-\frac{t}{2}}}{2^{\frac{n}{2}} \Gamma(n/2)} dt$$

for  $x > 0$ .

**See also** LEGACY.CHIDIST 6.18.11

### 6.18.13 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 6.18.11

### 6.18.14 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 6.18.12

### 6.18.15 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<sub>ij</sub>* = element of actual data

*E<sub>ij</sub>* = 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  
 $df = r \cdot c - 1$

$LEGACY.CHITEST = LEGACY.CHIDIST(\chi^2; df)$

**See also** LEGACY.CHIDIST 6.18.11

## 6.18.16 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)

## 6.18.17 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 6.18.56

## 6.18.18 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

$$\sum_{a \in n1, b \in n2} (a - \overline{n1}) \cdot (b - \overline{n2})$$

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.

## 6.18.19 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.

## 6.18.20 DEVSQ

**Summary:** Calculates sum of squares of deviations.

**Syntax:** DEVSQ( { *NumberSequence n* }<sup>+</sup> )

**Returns:** Number

**Semantics:** returns

$$\sum_{x \in n} (x - a)^2$$

where *a* is the result of calling AVERAGE(*n*).

### 6.18.21 EXPONDIST

**Summary:** returns the value of the probability density function or the cumulative distribution function for the exponential distribution.

**Syntax:** EXPONDIST( *Number* x ; *Number*  $\lambda$  [ ; *Logical* Cumulative = 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.

### 6.18.22 FDIST

**Summary:** returns the value of the probability density function or the cumulative distribution function for the F-distribution.

**Syntax:** FDIST( *Number* x ; *Number*  $r_1$  ; *Number*  $r_2$  [ ; *Logical* Cumulative = 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

$$\frac{\Gamma\left(\frac{r_1+r_2}{2}\right)\left(\frac{r_1}{r_2}\right)^{\frac{r_1}{2}}}{\Gamma\left(\frac{r_1}{2}\right)\Gamma\left(\frac{r_2}{2}\right)} \cdot \frac{x^{\frac{r_1}{2}-1}}{\left(1+\frac{r_1}{r_2}x\right)^{\frac{r_1+r_2}{2}}}$$

otherwise.

If the numerator degrees of freedom  $r_1 = 1$ , then the density function has a pole at  $x=0$ , the

subterm  $x^{\frac{r_1}{2}-1} = 0^{-0.5}$  is not defined.

If Cumulative is TRUE(), FDIST returns 0 if  $x < 0$  and the value

$$\frac{\Gamma\left(\frac{r_1+r_2}{2}\right)\left(\frac{r_1}{r_2}\right)^{\frac{r_1}{2}}}{\Gamma\left(\frac{r_1}{2}\right)\Gamma\left(\frac{r_2}{2}\right)} \cdot \int_0^x \frac{t^{\frac{r_1}{2}-1}}{\left(1+\frac{r_1}{r_2}t\right)^{\frac{r_1+r_2}{2}}} dt$$

otherwise.

**See also** LEGACY.FDIST 6.18.23

### 6.18.23 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* r<sub>1</sub> ; *Number* r<sub>2</sub> )

**Returns:** Number

**Constraints:** r<sub>1</sub> and r<sub>2</sub> are positive integers

**Semantics:**

LEGACY.FDIST returns Error if x < 0 and the value

$$\frac{\Gamma\left(\frac{r_1+r_2}{2}\right)\left(\frac{r_1}{r_2}\right)^{\frac{r_1}{2}}}{\Gamma\left(\frac{r_1}{2}\right)\Gamma\left(\frac{r_2}{2}\right)} \cdot \int_x^\infty \frac{t^{\frac{r_1}{2}-1}}{\left(1+\frac{r_1}{r_2}t\right)^{\frac{r_1+r_2}{2}}} dt$$

otherwise.

Note that the latter is (1-FDIST(x; r<sub>1</sub>; r<sub>2</sub>;TRUE())).

**See also** FDIST 6.18.22

### 6.18.24 FINV

**Summary:** returns the inverse of FDIST(x;r<sub>1</sub>;r<sub>2</sub>;TRUE()).

**Syntax:** FINV( *Number* p ; *Number* r<sub>1</sub> ; *Number* r<sub>2</sub> )

**Returns:** Number

**Constraints:**  $0 \leq p < 1$  , r<sub>1</sub> and r<sub>2</sub> are positive integers

**Semantics:** FINV returns the unique non-negative number x such that FDIST(x;r<sub>1</sub>;r<sub>2</sub>) = p.

**See also** FDIST 6.18.22, LEGACY.FDIST 6.18.23, LEGACY.FINV 6.18.25

### 6.18.25 LEGACY.FINV

**Summary:** returns the inverse of LEGACY.FDIST(x;r<sub>1</sub>;r<sub>2</sub>).

**Syntax:** LEGACY.FINV( *Number* p ; *Number* r<sub>1</sub> ; *Number* r<sub>2</sub> )

**Returns:** Number

**Constraints:**  $0 < p \leq 1$ ,  $r_1$  and  $r_2$  are positive integers

**Semantics:** LEGACY.FINV returns the unique non-negative number  $x$  such that  $\text{LEGACY.FDIST}(x; r_1; r_2) = p$ .

**See also** FDIST 6.18.22, LEGACY.FDIST 6.18.23, FINV 6.18.24

## 6.18.26 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 6.16.11

## 6.18.27 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 6.16.70

## 6.18.28 FORECAST

**Summary:** Extrapolates future values based on existing  $x$  and  $y$  values.

**Syntax:** FORECAST( *Number*  $\text{Value}$  ; *ForceArray*  $\text{Array Data\_Y}$  ; *ForceArray*  $\text{Array Data\_X}$  )

**Returns:** Number

**Constraints:**  $\text{COLUMNS}(\text{Data\_Y}) = \text{COLUMNS}(\text{Data\_X})$ ,  $\text{ROWS}(\text{Data\_Y}) = \text{ROWS}(\text{Data\_X})$

**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.

## 6.18.29 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.

## 6.18.30 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  $n_1$  and sample variance  $s_1^2$  and the second sample has size  $n_2$  and sample variance  $s_2^2$ . If  $s_1^2 > s_2^2$  FDIST returns twice the area of the right tail of the F-distribution with degrees of freedom  $n_1-1, n_2-1$  beyond  $s_1^2/s_2^2$ . If  $s_1^2 < s_2^2$  FDIST returns twice the area of the left tail of the F-distribution with degrees of freedom  $n_1-1, n_2-1$  below  $s_1^2/s_2^2$ .

**See also** TTEST 6.18.81

## 6.18.31 GAMMADIST

**Summary:** returns the value of the probability density function or the cumulative distribution function for the Gamma distribution.

**Syntax:** GAMMADIST( *Number* x ; *Number*  $\alpha$  ; *Number*  $\beta$  [ ; *Logical* Cumulative = TRUE() ] )

**Returns:** Number

**Constraints:**  $\alpha > 0$ ,  $\beta > 0$

**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 6.18.32

### 6.18.32 GAMMAINV

**Summary:** returns the inverse of GAMMADIST( $x; \alpha; \beta; \text{TRUE}()$ ).

**Syntax:** GAMMAINV( *Number p* ; *Number  $\alpha$*  ; *Number  $\beta$*  )

**Returns:** Number

**Constraints:**  $0 \leq p < 1$  ,  $\alpha > 0$ ,  $\beta > 0$

**Semantics:** GAMMAINV returns the unique number  $x \geq 0$  such that GAMMADIST( $x; \alpha; \beta$ ) =  $p$ .

**See also** GAMMADIST 6.18.31

### 6.18.33 GAUSS

**Summary:** Returns 0.5 less than the standard normal cumulative distribution

**Syntax:** GAUSS( *Number x* )

**Returns:** Number

**Semantics:** Returns NORMDIST( $x; 0; 1; \text{TRUE}()$ )-0.5

**See also** NORMDIST 6.18.52

### 6.18.34 GEOMEAN

**Summary:** returns the geometric mean of a sequence

**Syntax:** GEOMEAN( { *NumberSequenceList N* }<sup>+</sup> )

**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( $N$ ).

### 6.18.35 GROWTH

**Summary:** Returns predicted values based on an exponential regression.

**Syntax:** GROWTH( Array knownY [ ; [ Array knownX ] [ ; [ Array newX ] [ ; Logical Const = 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( $newX$ ))

**Semantics:**

$knownY$ : 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  $1, 2, 3, \dots, k$ , where  $k = ROWS(knownY) \cdot COLUMNS(knownY)$ .

$newX$ : The set of x-values for which predicted  $y$ -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.

LOGEST( $knownY$ ;  $knownX$ ;  $Const$ ; 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  $b_n, b_{n-1}, \dots, b_1, a$ .

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 GROWTH 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  $a \times b_1^{z_{ij}}$ .

Otherwise, if COLUMNS( $knownY$ ) = 1 and ROWS( $knownY$ ) = ROWS( $knownX$ ) and COLUMNS( $knownX$ ) = COLUMNS( $newX$ ), then GROWTH returns an array with ROWS( $newX$ )

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 COLUMNS( $knownY$ ) = COLUMNS( $knownX$ ) and ROWS( $knownY$ ) = 1 and ROWS( $knownX$ ) = ROWS( $newX$ ), then GROWTH returns an array with 1 row and

COLUMNS( $newX$ ) columns, such that the entry in the  $j$ th column is  $a \times \prod_{i=1}^n b_i^{z_{ij}}$ .

**See also** TREND 6.18.79



### 6.18.36 HARMEAN

**Summary:** returns the harmonic mean of a sequence

**Syntax:** HARMEAN( { *NumberSequenceList* *N* }<sup>+</sup> )

**Returns:** Number

**Semantics:** Returns the harmonic mean of a given sequence. That means

$$\frac{n}{\sum_{i=1}^n \frac{1}{a_i}}$$

where  $a_1, a_2, \dots, a_n$  are the numbers of the sequence  $N$  and  $n$  is a result of calling COUNT( $N$ ).

### 6.18.37 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

$$\frac{\binom{M}{x} \binom{N-M}{n-x}}{\binom{N}{n}}$$

If Cumulative is TRUE(), HYPGEOMDIST returns

$$\sum_{i=0}^x \frac{\binom{M}{i} \binom{N-M}{n-i}}{\binom{N}{n}}$$

**Note:**

$$\binom{x}{y} = 0 \text{ for } y > x$$

## 6.18.38 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:** COLUMNS(Data\_X) = COLUMNS(Data\_Y), ROWS(Data\_X) = 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.

## 6.18.39 KURT

**Summary:** Return the kurtosis ("peakedness") of a data set.

**Syntax:** KURT( { *NumberSequenceList* X }<sup>+</sup> )

**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.

$$kurtosis = \left( \frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum_{i=1}^n \left( \frac{x_i - \bar{x}}{s} \right)^4 \right) - \frac{3(n-1)^2}{(n-2)(n-3)}$$

where s is the sample standard deviation, and n is the number of numbers.

## 6.18.40 LARGE

**Summary:** Finds the nth largest value in a list.

**Syntax:** LARGE( *NumberSequenceList* List ; *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 6.18.70, ROUNDUP 6.17.7

## 6.18.41 LINEST

**Summary:** Returns the parameters of the (simple or multiple) linear regression equation for the given data and, optionally, statistics on this regression.

**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)

**Semantics:**

*knownY*: The set of y-values for the equation

*knownX*: The set of x-values for the equation. If omitted or an empty parameter, it is set to the sequence  $1, 2, 3, \dots, k$ , where  $k = \text{ROWS}(\text{knownY}) \cdot \text{COLUMNS}(\text{knownY})$ .

*Const*: If set to FALSE(), the model constant *a* is equal to 0.

*Stats*: If FALSE(), only the regression coefficient is to be calculated. If set to TRUE(), the result will include other statistical data.

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 28 - LINEST. If STATS is FALSE() it is just the first row of Table 28 - LINEST. The empty cells in this table are returned as empty or as containing an error.

Table 28 - LINEST

$b_n$	$b_{n-1}$	...	$b_1$	$a$
$S_{b_n}$	$S_{b_{n-1}}$	...	$S_{b_1}$	$S_a$
$R^2$	$S_e$			
$F$	$df$			
$SS_{reg}$	$SS_{resid}$			

If COLUMNS(*knownY*) = COLUMNS(*knownX*) and ROWS(*knownY*) = ROWS(*knownX*) then  $n = 1$ ,  $k = \text{ROWS}(\text{knownY}) \cdot \text{COLUMNS}(\text{knownY})$ , the entries of *knownX* in column major order are denoted with  $x_{1n}, x_{2n}, \dots, x_{kn}$  and the entries of *knownY* in column major order are denoted with  $y_1, y_2, \dots, y_k$ .

Otherwise but if COLUMNS(*knownY*) = 1, then  $n = \text{COLUMNS}(\text{knownX})$ ,  $k = \text{ROWS}(\text{knownY})$ , 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  $n = ROWS(knownX)$ ,  $k = COLUMNS(knownY)$ , 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  $\bar{x}_i = \frac{1}{k} \cdot \sum_{j=1}^k x_{ij}$  and  $\bar{y} = \frac{1}{k} \cdot \sum_{j=1}^k y_j$ , and define the following matrices:

$$Y = \begin{pmatrix} y_1 \\ \vdots \\ y_k \end{pmatrix} \text{ and } X = \begin{pmatrix} 1 & x_{11} & \dots & x_{1n} \\ 1 & x_{12} & \dots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & x_{k1} & \dots & x_{kn} \end{pmatrix} \text{ for } Const \text{ being } TRUE(), \text{ and } X = \begin{pmatrix} x_{11} & \dots & x_{1n} \\ x_{12} & \dots & x_{2n} \\ \vdots & \ddots & \vdots \\ x_{k1} & \dots & x_{kn} \end{pmatrix} \text{ for } Const \text{ being } FALSE().$$

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

$$B = \begin{pmatrix} b_1 \\ \vdots \\ b_n \end{pmatrix} \text{ and } a = 0.$$

These  $a, b_1, \dots, b_n$  are the values returned by  $LINEST$  in the first row of its result array in the order given in Table 28 -  $LINEST$ .

The statistics in the 2<sup>nd</sup> to 5<sup>th</sup> rows of Table 28 -  $LINEST$  are as follows:

If  $Const$  is  $TRUE()$ :

$$df = k - n - 1, \quad SS_{resid} = \sum_{j=1}^k \left( \left( a + \sum_{i=1}^n b_i x_{ij} \right) - y_j \right)^2, \quad SS_{reg} = \sum_{j=1}^k \left( \left( a + \sum_{i=1}^n b_i x_{ij} \right) - \bar{y} \right)^2,$$

$$s_a = s_e \sqrt{d_1} \text{ and } s_{b_i} = s_e \sqrt{d_{i+1}} \text{ where } d_i \text{ is the element in the } i\text{th row and } i\text{th column of } (X^T \cdot X)^{-1},$$

$$s_e = \sqrt{\frac{SS_{resid}}{df}}, \quad R^2 = \frac{SS_{reg}}{\sum_{j=1}^k (y_j - \bar{y})^2} \text{ and } F = \frac{SS_{reg}/n}{SS_{resid}/df}.$$

If  $Const$  is  $FALSE()$ :

$$df = k - n, \quad SS_{resid} = \sum_{j=1}^k \left( \left( \sum_{i=1}^n b_j x_{ij} \right) - y_i \right)^2, \quad SS_{reg} = \sum_{j=1}^k \left( \sum_{i=1}^n b_j x_{ij} \right)^2, \quad s_{b_i} = s_e \sqrt{d_i} \quad \text{where } d_i \text{ is}$$

the element in the  $i$ th row and  $i$ th column of  $(X^T \cdot X)^{-1}$ ,  $s_e = \sqrt{\frac{SS_{resid}}{df}}$ ,  $R^2 = \frac{SS_{reg}}{\sum_{j=1}^k y_k^2}$  and

$$F = \frac{SS_{reg}/n}{SS_{resid}/df}. \quad \text{In this case } s_a \text{ is undefined and is returned as either 0, blank or an error.}$$

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  $b_i$  of omitted columns are returned as 0.

## 6.18.42 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.

**Syntax:** LOGEST( 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)

**Semantics:**

*knownY*: The set of y-values for the equation

*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  $k = \text{ROWS}(\text{knownY}) \cdot \text{COLUMNS}(\text{knownY})$ .

*Const*: If set to FALSE(), the model constant a is equal to 0.

*Stats*: If FALSE(), only the regression coefficient is to be calculated. If set to TRUE(), the result will include other statistical data.

If any of the entries in *knownY* and *knownX* do not convert to Number or if any of the entries in *knownY* is negative, LOGEST returns an error.

The result created by LOGEST if STATS is TRUE() is given in Table 29 - LOGEST. If STATS is FALSE() it is just the first row of Table 29 - LOGEST. The empty cells in this table are returned as empty or as containing an error.

Table 29 - LOGEST

$e^{b_n}$	$e^{b_{n-1}}$	...	$e^{b_1}$	$e^a$
$s_{b_n}$	$s_{b_{n-1}}$	...	$s_{b_1}$	$s_a$

$R^2$	$S_e$			
$F$	$df$			
$SS_{reg}$	$SS_{resid}$			

If  $COLUMNS(knownY) = COLUMNS(knownX)$  and  $ROWS(knownY) = ROWS(knownX)$  then  $n = 1$ ,  $k = ROWS(knownY) \cdot COLUMNS(knownY)$ , the entries of  $knownX$  in column major order are denoted with  $x_{1n}, x_{2n}, \dots, x_{kn}$  and the entries of  $knownY$  in column major order are denoted with  $y_1, y_2, \dots, y_k$ .

Otherwise but if  $COLUMNS(knownY) = 1$ , then  $n = COLUMNS(knownX)$ ,  $k = ROWS(knownY)$ , 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  $n = ROWS(knownX)$ ,  $k = COLUMNS(knownY)$ , 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  $k \leq n+1$  LOGEST returns an error. Similarly, if  $Const$  is  $FALSE()$  and  $k \leq n$  LOGEST returns an error.

We denote  $\bar{x}_i = \frac{1}{k} \cdot \sum_{j=1}^k x_{ij}$  and  $\overline{\ln(y)} = \frac{1}{k} \cdot \sum_{j=1}^k \ln(y_j)$ , and define the following matrices:

$$Y = \begin{pmatrix} \ln(y_1) \\ \vdots \\ \ln(y_k) \end{pmatrix} \text{ and } X = \begin{pmatrix} 1 & x_{11} & \dots & x_{1n} \\ 1 & x_{12} & \dots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & x_{k1} & \dots & x_{kn} \end{pmatrix} \text{ for } Const \text{ being } TRUE(), \text{ and } X = \begin{pmatrix} x_{11} & \dots & x_{1n} \\ x_{12} & \dots & x_{2n} \\ \vdots & \ddots & \vdots \\ x_{k1} & \dots & x_{kn} \end{pmatrix}$$

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  $B = \begin{pmatrix} a \\ b_1 \\ \vdots \\ b_n \end{pmatrix}$ ; if  $Const$  is  $FALSE()$ , the entries of  $B$  are denoted

$$B = \begin{pmatrix} b_1 \\ \vdots \\ b_n \end{pmatrix} \text{ and } a = 0.$$

Then  $e^a, e^{b_1}, \dots, e^{b_n}$  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 2<sup>nd</sup> to 5<sup>th</sup> rows of Table 1 - Operators are as follows:

If *Const* is TRUE():

$$df = k - n - 1, \quad SS_{resid} = \sum_{j=1}^k \left( \left( a + \sum_{i=1}^n b_j x_{ij} \right) - \ln(y_i) \right)^2, \quad SS_{reg} = \sum_{j=1}^k \left( \left( a + \sum_{i=1}^n b_j x_{ij} \right) - \overline{\ln(y)} \right)^2, \\ s_a = s_e \sqrt{d_1} \text{ and}$$

$$s_{b_i} = s_e \sqrt{d_{i+1}} \text{ where } d_i \text{ is the element in the } i\text{th row and } i\text{th column of } (X^T \cdot X)^{-1},$$

$$s_e = \sqrt{\frac{SS_{resid}}{df}}, \quad R^2 = \frac{SS_{reg}}{\sum_{j=1}^k (\ln(y_k) - \overline{\ln(y)})^2} \text{ and } F = \frac{SS_{reg}/n}{SS_{resid}/df}.$$

If *Const* is FALSE():

$$df = k - n, \quad SS_{resid} = \sum_{j=1}^k \left( \left( \sum_{i=1}^n b_j x_{ij} \right) - \ln(y_i) \right)^2, \quad SS_{reg} = \sum_{j=1}^k \left( \sum_{i=1}^n b_j x_{ij} \right)^2, \quad s_{b_i} = s_e \sqrt{d_i} \text{ where} \\ d_i \text{ is the element in the } i\text{th row and } i\text{th column of } (X^T \cdot X)^{-1}, \quad s_e = \sqrt{\frac{SS_{resid}}{df}}, \quad R^2 = \frac{SS_{reg}}{\sum_{j=1}^k \ln(y_k)^2}$$

and  $F = \frac{SS_{reg}/n}{SS_{resid}/df}$ . 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  $e^{b_i}$  of omitted columns are returned as 1.

### 6.18.43 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 6.18.44

### 6.18.44 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*  $\mu = 0$  [ ; *Number*  $\sigma = 1$  [ ; *Logical* Cumulative = TRUE() ] ] ] )

**Returns:** Number

**Constraints:**  $\sigma > 0$ ;  $x > 0$  if Cumulative is FALSE()

**Semantics:** If Cumulative is FALSE(), LOGNORMDIST returns the value

$$\frac{e^{-\frac{1}{2} \left( \frac{\ln(x) - \mu}{\sigma} \right)^2}}{x \sqrt{2\pi} \sigma}$$

If Cumulative is TRUE(), LOGNORMDIST returns the value

$$\int_0^x \frac{e^{-\frac{1}{2} \left( \frac{\ln(t) - \mu}{\sigma} \right)^2}}{t \sqrt{2\pi} \sigma} dt$$

if  $X > 0$  and 0 otherwise.

## 6.18.45 MAX

**Summary:** Return the maximum from a set of numbers.

**Syntax:** MAX( { *NumberSequenceList*  $N$  }<sup>+</sup> )

**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 6.18.46, MIN 6.18.48

## 6.18.46 MAXA

**Summary:** Return the maximum from a set of values, including values of type Text and Logical.

**Syntax:** MAXA( { *Any*  $N$  }<sup>+</sup> )

**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 6.18.45, MIN 6.18.48, MINA 6.18.49

## 6.18.47 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.

*n = is the count of the ranked numbersequence*

$$\tilde{x} = x_{\left(\frac{n+1}{2}\right)}$$

*for n = odd*

$$\tilde{x} = \frac{1}{2} \left( x_{\left(\frac{n}{2}\right)} + x_{\left(\frac{n}{2}+1\right)} \right)$$

*for n = even*

## 6.18.48 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 6.18.45, MINA 6.18.49

## 6.18.49 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 6.18.48, MAXA 6.18.46

## 6.18.50 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 not 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.

## 6.18.51 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  $(x + r - 1) \leq 0$  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.

$$P_{r,p}(x) = \binom{x+r-1}{r-1} p^r (1-p)^x$$

$$\binom{x+r-1}{r-1} \text{ is a binomial coefficient}$$

## 6.18.52 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:** NORMDIST( *Number* x ; *Number* Mean ; *Number* StandardDeviation [ ; *Logical* Cumulative = 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

$$\frac{e^{-\frac{1}{2} \cdot \left(\frac{x-\mu}{\sigma}\right)^2}}{\sqrt{2\pi} \sigma}$$

If Cumulative is TRUE(), NORMDIST returns the value

$$\int_{-\infty}^x \frac{e^{-\frac{1}{2} \cdot \left(\frac{t-\mu}{\sigma}\right)^2}}{\sqrt{2\pi} \sigma} dt$$

**See also** LEGACY.NORMSDIST 6.18.54

### 6.18.53 NORMINV

**Summary:** returns the inverse of NORMDIST(x;Mean;StandardDeviation,TRUE()).

**Syntax:** NORMINV( *Number p* ; *Number Mean* ; *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 6.18.52

### 6.18.54 LEGACY.NORMSDIST

**Summary:** returns the value of the cumulative distribution function for the standard normal distribution.

**Syntax:** LEGACY.NORMSDIST( *Number x* )

**Returns:** Number

**Constraints:** None

**Semantics:** LEGACY.NORMSDIST returns the value

$$\int_{-\infty}^x \frac{e^{-\frac{1}{2} \cdot t^2}}{\sqrt{2\pi}} dt$$

This is exactly NORMDIST(x;0;1;TRUE()).

**See also** NORMDIST 6.18.52, LEGACY.NORMSINV 6.18.55

### 6.18.55 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 6.18.53, LEGACY.NORMSDIST 6.18.54

## 6.18.56 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)

$$r = \frac{\sum_{i=1}^N (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^N (x_i - \bar{x})^2 \sum_{i=1}^N (y_i - \bar{y})^2}}$$

$\bar{x}, \bar{y}$  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.

## 6.18.57 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
- $0 \leq x \leq 1$

**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.

Step 1:

Sort the list of numbers given by array *Data* .

Step 2:

Calculate the ranking  $\{1, \dots, n\}$ , split into integer and decimal part

$$r = 1 + x \cdot (n - 1) = I + D$$

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 =  $r - \lfloor r \rfloor$

Step 3:

Interpolate between the necessary two numbers

$$PERCENTILE = Y_I + D \cdot (Y_{I+1} - Y_I)$$

with  $Y_I$  being the data point ranked at position  $I$

**See also** MAX 6.18.45, MEDIAN 6.18.47, MIN 6.18.48, PERCENTRANK 6.18.58, QUARTILE 6.18.64, RANK 6.18.65

## 6.18.58 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  $\text{COUNT}(\text{Data}) > 1$ , PERCENTRANK returns  $r / (\text{COUNT}(\text{Data}) - 1)$ , 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

$$r_x = r_y + \frac{X - Y}{Z - Y}$$

In the special case where  $\text{COUNT}(\text{Data}) == 1$ , the only valid value for  $X$  is the single value in *Data*, in which case PERCENTRANK returns 1.

**See also** PERCENTILE 6.18.57, RANK 6.18.65

## 6.18.59 PERMUT

**Summary:** returns the number of permutations of  $k$  objects taken from  $n$  objects.

**Syntax:** PERMUT( *Integer*  $n$  ; *Integer*  $k$  )

**Returns:** Number

**Constraints:**  $n \geq 0$ ;  $k \geq 0$ ;  $n \geq k$

**Semantics:** PERMUT returns

$$\left( \begin{matrix} n \\ k \end{matrix} \right) k!$$

respectively

$$\frac{n!}{(n-k)!}$$

## 6.18.60 PERMUTATIONA

**Summary:** Returns the number of permutations for a given number of objects (repetition allowed).

**Syntax:** PERMUTATIONA( *Integer*  $Total$  ; *Integer*  $Chosen$  )

**Returns:** Number

**Constraints:**  $Total \geq 0$ ,  $Chosen \geq 0$

**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

$$PERMUTATIONA = Total^{Chosen}$$

### 6.18.61 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()).

### 6.18.62 POISSON

**Summary:** returns the probability or the cumulative distribution function for the Poisson distribution

**Syntax:** POISSON( *Integer x* ; *Number λ* [ ; *Logical Cumulative* = TRUE() ] )

**Returns:** Number

**Constraints:**  $\lambda > 0$ ,  $x \geq 0$

**Semantics:** If Cumulative is FALSE(), POISSON returns the value

$$\frac{e^{-\lambda} \lambda^{[x]}}{[x]!}$$

If Cumulative is TRUE(), POISSON returns the value

$$\sum_{k=0}^{k=[x]} \frac{e^{-\lambda} \lambda^k}{k!}$$

### 6.18.63 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  $\leq 1$ .
- 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  $d_1, d_2, \dots, d_n$  ).
- *Probability* is the array or range of the corresponding probabilities ( the *Number* values in this array or range are referred to below as  $p_1, p_2, \dots, p_n$  ).
- *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**

## 6.18.64 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 6.18.45, MEDIAN 6.18.47, MIN 6.18.48, PERCENTILE 6.18.57, PERCENTRANK 6.18.58, RANK 6.18.65

## 6.18.65 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.

## 6.18.66 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.

$\text{COLUMNS}(\text{arrayY}) = \text{COLUMNS}(\text{arrayX}), \text{ROWS}(\text{arrayY}) = \text{ROWS}(\text{arrayX})$

**Semantics:** The r-squared value can be interpreted as the proportion of the variance in y attributable to the variance in x.

$$r^2 = \frac{\sum_{i=1}^N (y_i - \bar{y})^2 - \sum_{i=1}^N (y_i - y_{calc})^2}{\sum_{i=1}^N (y_i - \bar{y})^2}$$

$$y_{calc} = a + bx$$

and

$$a = \frac{\left( \sum_{i=1}^N (x_i^2) \right) \left( \sum_{i=1}^N (y_i) \right) - \left( \sum_{i=1}^N (x_i) \right) \left( \sum_{i=1}^N (x_i y_i) \right)}{N \left( \sum_{i=1}^N (x_i^2) \right) - \left( \sum_{i=1}^N (x_i) \right)^2}$$

$$b = \frac{N \left( \sum_{i=1}^N (x_i y_i) \right) - \left( \sum_{i=1}^N (x_i) \right) \left( \sum_{i=1}^N (y_i) \right)}{N \left( \sum_{i=1}^N (x_i^2) \right) - \left( \sum_{i=1}^N (x_i) \right)^2}$$

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 6.18.56

### 6.18.67 SKEW

**Summary:** Estimates the skewness of a distribution using a sample set of numbers.

**Syntax:** SKEW( { *NumberSequenceList* sample }<sup>+</sup> )

**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 6.18.68

### 6.18.68 SKEWP

**Summary:** Calculates the skewness of a distribution using the population of a random variable.

**Syntax:** SKEWP( { *NumberSequence* population }<sup>+</sup> )

**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 6.18.67

## 6.18.69 SLOPE

**Summary:** Calculates the slope of the linear regression line.

**Syntax:** SLOPE( *ForceArray* Array y ; *ForceArray* Array 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 6.18.38, STEYX 6.18.76

## 6.18.70 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 6.18.40, ROUNDDOWN 6.17.6

## 6.18.71 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.

$$STANDARDIZE = \frac{(value - mean)}{sigma}$$

**See also** GAUSS 6.18.33

## 6.18.72 STDEV

**Summary:** Compute the sample standard deviation of a set of numbers.

**Syntax:** STDEV( { *NumberSequenceList* N }<sup>+</sup> )

**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 6.18.74, AVERAGE 6.18.3

## 6.18.73 STDEVA

**Summary:** Calculate the standard deviation using a sample set of values, including values of type Text and Logical.

**Syntax:** STDEVA( { *Any sample* }<sup>+</sup> )

**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  $x_1, x_2, \dots, x_n$ . Then let

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

STDEVA returns

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2}$$

**See also** STDEV 6.18.72

### 6.18.74 STDEVP

**Summary:** Calculates the standard deviation using the population of a random variable, including values of type Text and Logical.

**Syntax:** STDEVP( { *NumberSequence* N }<sup>+</sup> )

**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 6.18.72, AVERAGE 6.18.3

### 6.18.75 STDEVPA

**Summary:** Calculates the standard deviation using the population of a random variable, including values of type Text and Logical.

**Syntax:** STDEVPA( { *Any sample* }<sup>+</sup> )

**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 6.18.74

## 6.18.76 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.

$$STEYX = \sqrt{\frac{1}{n(n-2)} \left( n \sum_n y_i^2 - \left( \sum_n y_i \right)^2 - \frac{\left( n \sum_n x_i y_i - \sum_n x_i \sum_n y_i \right)^2}{n \sum_n x^2 - \left( \sum_n x \right)^2} \right)}$$

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 6.18.38, SLOPE 6.18.69

## 6.18.77 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:**  $x \geq 0$ ,  $df \geq 1$ , tails = 1 or 2

**Semantics:** Then LEGACY.TDIST returns

$$tails \cdot \int_x^{\infty} f(t) dt$$

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  $\Gamma$  is the Gamma function.

**See also** BETADIST 6.18.7, BINOMDIST 6.18.10, CHISQDIST 6.18.12, EXPONDIST 6.18.21, FDIST 6.18.22, GAMMADIST 6.18.31, GAUSS 6.18.33, HYPGEOMDIST 6.18.37, LOGNORMDIST 6.18.44, NEGBINOMDIST 6.18.51, NORMDIST 6.18.52, POISSON 6.18.62, WEIBULL 6.18.86

## 6.18.78 TINV

**Summary:** Calculates the inverse of the two-tailed t-distribution.

**Syntax:** TINV( *Number probability* ; *Integer degreeOfFreedom* )

**Returns:** Number

**Constraints:**  $0 < \text{probability} \leq 1$ ,  $\text{degreeOfFreedom} \geq 1$

**Semantics:** Calculates the inverse of the two-tailed t-distribution.

**See also** LEGACY.TDIST 6.18.77

## 6.18.79 TREND

**Summary:** Returns predicted values based on a simple or multiple linear regression.

**Syntax:** TREND( *Array knownY* [ ; [ *Array knownX* ] [ ; [ *Array newX* ] [ ; *Logical Const* = 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*))

**Semantics:**

*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  $1, 2, 3, \dots, k$ , where  $k = \text{ROWS}(\text{knownY}) \cdot \text{COLUMNS}(\text{knownY})$ .

*newX*: The set of x-values for which predicted  $y$ -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 or 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  $b_n, b_{n-1}, \dots, b_1, a$ .

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*) columns, such that the entry in its  $i$ th row and  $j$ th column is  $a + b_1 \cdot z_{ij}$ .

Otherwise, if  $COLUMNS(knownY) = 1$  and  $ROWS(knownY) = ROWS(knownX)$  and  $COLUMNS(knownX) = COLUMNS(newX)$ , then TREND returns an array with  $ROWS(newX)$  rows

and 1 column, such that the entry in the  $i$ th row is  $a + \sum_{j=1}^n b_j \cdot z_{ij}$ .

Otherwise, if  $COLUMNS(knownY) = COLUMNS(knownX)$  and  $ROWS(knownY) = 1$  and  $ROWS(knownX) = ROWS(newX)$ , then TREND returns an array with 1 row and

$COLUMNS(newX)$  columns, such that the entry in the  $j$ th column is  $a + \sum_{i=1}^n b_i \cdot z_{ij}$ .

**See also** INTERCEPT 6.18.38, SLOPE 6.18.69, STEYX 6.18.76

## 6.18.80 TRIMMEAN

**Summary:** Returns the mean of a data set, ignoring a proportion of high and low values.

**Syntax:** TRIMMEAN( *NumberSequenceList* dataSet ; *Number* cutOffFraction )

**Returns:** Number

**Constraints:**  $0 \leq cutOffFraction < 1$

**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

$sortedDataSet_1, sortedDataSet_2, sortedDataSet_3, \dots, sortedDataSet_n$

be the values in the data set sorted in ascending order. Moreover let

$$cutOff = \text{INT} \left( \frac{n \cdot cutOffFraction}{2} \right)$$

Then TRIMMEAN returns the value

$$\frac{1}{n - 2 \cdot cutOff} \sum_{i=cutOff+1}^{n-cutOff} sortedDataSet_i$$

**See also** AVERAGE 6.18.3, GEOMEAN 6.18.34, HARMEAN 6.18.36

## 6.18.81 TTEST

**Summary:** Calculates the p-value of a 2-sample t-test.

**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  $X_1, X_2, \dots, X_n$  be the numbers in the sequence X and  $Y_1, Y_2, \dots, Y_m$  be the numbers in the sequence Y. Then



$$\bar{X} = \frac{1}{n} \sum_{i=1}^n X_i$$

and

$$\bar{Y} = \frac{1}{m} \sum_{i=1}^m Y_i$$

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

$$f(x, df) = \frac{\Gamma\left(\frac{df+1}{2}\right)}{\sqrt{\pi df} \Gamma\left(\frac{df}{2}\right)} \left(1 + \frac{x^2}{df}\right)^{-\frac{(df+1)}{2}}$$

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

$$s_{X-Y}^2 = \frac{1}{n-1} \sum_{i=1}^n ((X_i - Y_i) - (\bar{X} - \bar{Y}))^2$$

and

$$t = \left| \frac{\bar{X} - \bar{Y}}{\sqrt{s_{X-Y}^2}} \sqrt{n} \right|$$

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

$$t = \left| \frac{\bar{X} - \bar{Y}}{\sqrt{s_p^2 \left(\frac{1}{n} + \frac{1}{m}\right)}} \right|$$

TTEST returns

$$tails \cdot \int_t^{\infty} f(x, n+m-2) dx$$

- (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

$$tails \cdot \int_t^{\infty} f(x, v) dx$$

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 6.18.30, LEGACY.TDIST 6.18.77, ZTEST 6.18.87

## 6.18.82 VAR

**Summary:** Compute the sample variance of a set of numbers.

**Syntax:** VAR( { NumberSequence N }<sup>+</sup> )

**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

$$s^2 = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2 = \frac{1}{n-1} \left( \left( \sum_{i=1}^n x_i^2 \right) - n \bar{x}^2 \right)$$

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 6.18.84, STDEV 6.18.72, AVERAGE 6.18.3

## 6.18.83 VARA

**Summary:** Estimates the variance using a sample set of values, including values of type Text and Logical.

**Syntax:** VARA( { Any sample }<sup>+</sup> )

**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

$$s^2 = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2 = \frac{1}{n-1} \left( \left( \sum_{i=1}^n x_i^2 \right) - n \bar{x}^2 \right)$$

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 6.18.82

## 6.18.84 VARP

**Summary:** Compute the variance of the set for a set of numbers.

**Syntax:** VARP( { *NumberSequence* N }<sup>+</sup> )

**Returns:** Number

**Constraints:** COUNT(N)>=1

**Semantics:** Computes the variance of the set  $\sigma^2$ , where

$$\sigma^2 = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2 = \frac{1}{n} \left( \left( \sum_{i=1}^n x_i^2 \right) - n \bar{x}^2 \right)$$

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 6.18.82, STDEVP 6.18.74, AVERAGE 6.18.3

## 6.18.85 VARPA

**Summary:** Calculates the variance using the population of the distribution, including values of type Text and Logical.

**Syntax:** VARPA( { *Any sample* }<sup>+</sup> )

**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

$$\sigma^2 = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2 = \frac{1}{n} \left( \left( \sum_{i=1}^n x_i^2 \right) - n \bar{x}^2 \right)$$

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 6.18.84

## 6.18.86 WEIBULL

**Summary:** Calculates the Weibull distribution.

**Syntax:** WEIBULL( *Number* value ; *Number* alpha ; *Number* beta ; *Logical* cumulative )

**Returns:** Number

**Constraints:** *value* >= 0; *shape* > 0; *scale* > 0

**Semantics:** Calculates the Weibull distribution at the position *value*.

If *cumulative* is false, the probability density function is calculated:

$$\frac{shape}{scale} \left( \frac{value}{scale} \right)^{shape-1} e^{-\left( \frac{value}{scale} \right)^{shape}}$$

If *cumulative* is true, the cumulative distribution function is calculated:

$$1 - e^{-\left( \frac{value}{scale} \right)^{shape}}$$

**See also** BETADIST 6.18.7, BINOMDIST 6.18.10, CHISQDIST 6.18.12, EXPONDIST 6.18.21, FDIST 6.18.22, GAMMADIST 6.18.31, GAUSS 6.18.33, HYPGEOMDIST 6.18.37, LOGNORMDIST 6.18.44, NEGBINOMDIST 6.18.51, NORMDIST 6.18.52, POISSON 6.18.62, LEGACY.TDIST 6.18.77

## 6.18.87 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

$$z = \frac{\overline{sample} - mean}{sigma} \sqrt{n}$$

ZTEST returns

$$P(z \leq Z) = \frac{1}{\sqrt{2\pi}} \int_z^{\infty} e^{-\frac{x^2}{2}} dx$$

**See also** FTEST 6.18.30, TTEST 6.18.81

## 6.19 Number Representation Conversion Functions

### 6.19.1 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.

### 6.19.2 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 "&" 6.4.10, ROMAN 6.19.17

### 6.19.3 BASE

**Summary:** Converts a number into a text representation with the given base.

**Syntax:** BASE( *Integer* X ; *Integer* Radix [ ; *Integer* MinimumLength ] )

**Returns:** Text

**Constraints:**  $X \geq 0$ ,  $2 \leq \text{Radix} \leq 36$ ,  $\text{MinimumLength} \geq 0$

**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 6.19.10

### 6.19.4 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 10<sup>th</sup> 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.

### 6.19.5 BIN2HEX

**Summary:** Converts a binary (base 2) number (10<sup>th</sup> 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 10<sup>th</sup> 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 (40<sup>th</sup> bit) being the sign bit and in two's complement form. The digits A through F are in uppercase. If the input has its 10<sup>th</sup> 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.

### 6.19.6 BIN2OCT

**Summary:** Converts a binary (base 2) number (10<sup>th</sup> 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 10<sup>th</sup> 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 (30<sup>th</sup> bit) being the sign bit and in two's complement form. If the input has its 10<sup>th</sup> 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.

### 6.19.7 DEC2BIN

**Summary:** Converts a decimal number to base 2 (whose 10<sup>th</sup> 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,  $\text{INT}(X)=X$ . Evaluators may evaluate expressions where  $-512 \leq X \leq 511$ .

**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 (10<sup>th</sup> 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.

## 6.19.8 DEC2HEX

**Summary:** Converts a decimal number to base 16 (whose 40<sup>th</sup> 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,  $\text{INT}(X)=X$ . Evaluators may evaluate expressions where  $-2^{39} \leq X \leq 2^{39}-1$ .

**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 (40<sup>th</sup> 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.

## 6.19.9 DEC2OCT

**Summary:** Converts a decimal number to base 8 (whose 30<sup>th</sup> 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,  $\text{INT}(X)=X$ . Evaluators may evaluate expressions where  $-2^{29} \leq X \leq 2^{29}-1$ .

**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 (30<sup>th</sup> 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

## 6.19.10 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:**  $2 \leq \text{Radix} \leq 36$

**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 6.19.3

## 6.19.11 HEX2BIN

**Summary:** Converts a hexadecimal number (40<sup>th</sup> bit is sign) to base 2 (whose 10<sup>th</sup> 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,  $-512 \leq X \leq 511$ .

**Semantics:** Converts given hexadecimal number into binary (base 2) equivalent. If given *Text*, the text is considered a hexadecimal number representation; if its 40<sup>th</sup> 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 (10<sup>th</sup> bit) being the sign bit and in two's complement form. If the input is negative (40<sup>th</sup> 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.

## 6.19.12 HEX2DEC

**Summary:** Converts a hexadecimal number (40<sup>th</sup> 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,  $\text{INT}(X)=X$ . 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 40<sup>th</sup> 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.

### 6.19.13 HEX2OCT

**Summary:** Converts a hexadecimal number (40<sup>th</sup> bit is sign) to base 8 (whose 30<sup>th</sup> 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,  $\text{INT}(X)=X$ . 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 40<sup>th</sup> 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 (10<sup>th</sup> bit) being the sign bit and in two's complement form. If the input is negative (40<sup>th</sup> 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.

### 6.19.14 OCT2BIN

**Summary:** Converts an octal number (30<sup>th</sup> bit is sign) to base 2 (whose 10<sup>th</sup> 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,  $\text{INT}(X)=X$ . Evaluators may evaluate expressions where X is considered in base 10,  $-512 \leq X \leq 511$ .

**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 30<sup>th</sup> 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 (10<sup>th</sup> bit) being the sign bit and in two's complement form. If the input is negative (30<sup>th</sup> 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.

### 6.19.15 OCT2DEC

**Syntax:** OCT2DEC( *TextOrNumber* X )

**Summary:** Converts an octal number (30<sup>th</sup> 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 30<sup>th</sup> 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.

### 6.19.16 OCT2HEX

**Summary:** Converts an octal number (30<sup>th</sup> bit is sign) to hexadecimal (whose 40<sup>th</sup> 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 30<sup>th</sup> 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 (40<sup>th</sup> bit) being the sign bit and in two's complement form. If the input is negative (30<sup>th</sup> 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.

### 6.19.17 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: ARABIC(ROMAN(x; any)) = x, when ROMAN(x; any) is not an Error.

If N is 0, an empty string is returned.

Table 30 - 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 30 - ROMAN

<b>Roman Numeral</b>	<b>Value</b>	<b>Unicode Code Point</b>
I	1	U+0049
V	5	U+0056
X	10	U+0058
L	50	U+004C
C	100	U+0043
D	500	U+0044
M	1000	U+004D

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 31 - ROMAN

<b>Format</b>	<b>Meaning</b>
0 or omitted (or TRUE)	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 <i>classic</i> .
1	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.
2	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.

<b>Format</b>	<b>Meaning</b>
3	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.
4 (or FALSE)	Produce the fewest Roman digits possible. Also known as <i>simplified</i> .

See also Infix Operator "&" 6.4.10, ARABIC 6.19.2

## 6.20 Text Functions

### 6.20.1 General

### 6.20.2 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 32 - ASC

<b>From Unicode Character (c)</b>	<b>To Unicode Character</b>	<b>Comment</b>
U+30a1 <= c <= U+30aa if c%2==0	(c - 0x30a2) / 2 + 0xff71	katakana a-o
U+30a1 <= c <= U+30aa if c%2==1	(c - 0x30a1) / 2 + 0xff67	katakana small a-o
U+30ab <= c <= U+30c2 if c%2==1	(c - 0x30ab) / 2 + 0xff76	katakana ka-chi
U+30ab <= c <= U+30c2 if c%2==0	(c - 0x30ac) / 2 + 0xff76 followed by 0xff9e	katakana ga-dhi
U+30c3	0xff6f	katakana small tsu
U+30c4 <= c <= U+30c9 if c%2==0	(c - 0x30c4) / 2 + 0xff82	katakana tsu-to
U+30c4 <= c <= U+30c9 if c%2==1	(c - 0x30c5) / 2 + 0xff82 followed by 0xff9e	katakana du-do

<b><i>From Unicode Character (c)</i></b>	<b><i>To Unicode Character</i></b>	<b><i>Comment</i></b>
U+30ca <= c <= U+30ce	c - 0x30ca + 0xff85	katakana na-no
U+30cf <= c <= U+30dd if c%3==0	(c - 0x30cf) / 3 + 0xff8a	katakana ha-ho
U+30cf <= c <= U+30dd if c%3==1	(c - 0x30d0) / 3 + 0xff8a followed by 0xff9e	katakana ba-bo
U+30cf <= c <= U+30dd if c%3==2	(c - 0x30d1) / 3 + 0xff8a followed by 0xff9f	katakana pa-po
U+30de <= c <= U+30e2	c - 0x30de + 0xff8f	katakana ma-mo
U+30e3 <= c <= U+30e8 if c%2==0	(c - 0x30e4) / 2 + 0xff94)	katakana ya-yo
U+30e3 <= c <= U+30e8 if c%2==1	(c - 0x30e3) / 2 + 0xff6c	katakana small ya-yo
U+30e9 <= c <= U+30ed	c - 0x30e9 + 0xff97	katakana ra-ro
U+30ef	U+ff9c	katakana wa
U+30f2	U+ff66	katakana wo
U+30f3	U+ff9d	katakana nn
U+ff01 <= c <= U+ff5e	c - 0xff01 + 0x0021	ASCII characters
U+2015	U+ff70	HORIZONTAL BAR => HALFWIDTH KATAKANA- HIRAGANA PROLONGED SOUND MARK
U+2018	U+0060	LEFT SINGLE QUOTATION MARK => GRAVE ACCENT
U+2019	U+0027	RIGHT SINGLE QUOTATION MARK => APOSTROPHE
U+201d	U+0022	RIGHT DOUBLE QUOTATION MARK => QUOTATION MARK
U+3001	U+ff64	IDEOGRAPHIC COMMA
U+3002	U+ff61	IDEOGRAPHIC FULL STOP
U+300c	U+ff62	LEFT CORNER BRACKET
U+300d	U+ff63	RIGHT CORNER BRACKET
U+309b	U+ff9e	KATAKANA-HIRAGANA VOICED SOUND MARK
U+309c	U+ff9f	KATAKANA-HIRAGANA SEMI- VOICED SOUND MARK
U+30fb	U+ff65	KATAKANA MIDDLE DOT

<i>From Unicode Character (c)</i>	<i>To Unicode Character</i>	<i>Comment</i>
U+30fc	U+ff70	KATAKANA-HIRAGANA PROLONGED SOUND MARK
U+ffe5	U+005c	FULLWIDTH YEN SIGN => REVERSE SOLIDUS "\"
<b>Note 1:</b> The "\" (REVERSE SOLIDUS, U+005C) is a specialty that gets displayed as a Yen sign with some Japanese fonts, which is a legacy of code-page 932.		

**Note 2:** For references regarding halfwidth and fullwidth characters see [UAX11] and the Halfwidth and Fullwidth Code Chart of [UNICODE].

**Note 3:** For information about the mapping of JIS X 0201 and JIS X 0208 to Unicode characters see [JISX0201] and [JISX0208].

**See also** JIS 6.20.11

## 6.20.3 CHAR

**Summary:** Return character represented by the given numeric value

**Syntax:** CHAR( *Number N* )

**Returns:** Text

**Constraints:**  $N \leq 127$ ; Evaluators may evaluate expressions where  $N \geq 1$ ,  $N \leq 255$ .

**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  $1 \leq N \leq 255$ .

**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.  
6.20.25

**See also** CODE 6.20.5, UNICHAR 6.20.25, UNICODE 6.20.26

## 6.20.4 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.

## 6.20.5 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.  
6.20.26

**See also** CHAR 6.20.3, UNICHAR 6.20.25, UNICODE 6.20.26

## 6.20.6 CONCATENATE

**Summary:** Concatenate the text strings

**Syntax:** CONCATENATE( { *Text* *T* }<sup>+</sup> )

**Returns:** Text

**Constraints:** None

**Semantics:** Concatenate each text value, in order, into a single text result.

**See also** Infix Operator "&" 6.4.10

## 6.20.7 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.

## 6.20.8 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 6.20.9, SEARCH 6.20.20, Infix Operator "<>" 6.4.8, Infix Operator "=" 6.4.7

## 6.20.9 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 6.20.8, SEARCH 6.20.20

## 6.20.10 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).

## 6.20.11 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 33 - JIS

<b>From Unicode Character (c)</b>	<b>To Unicode Character</b>	<b>Comment</b>
U+0022	0x201d	QUOTATION MARK => RIGHT DOUBLE QUOTATION MARK This is an exception to the ASCII range that follows below.
U+005c	0xffe5	REVERSE SOLIDUS "\" => FULLWIDTH YEN SIGN (code-page 932 legacy, for details see ASC function) This is an exception to the ASCII range that follows below.
U+0060	0x2018	GRAVE ACCENT => LEFT SINGLE QUOTATION MARK This is an exception to the ASCII range that follows below.
U+0027	0x2019	APOSTROPHE => RIGHT SINGLE QUOTATION MARK This is an exception to the ASCII range that follows below.
U+0021 <= c <= U+007e	c - 0x0021 + 0xff01	ASCII characters
U+ff66	0x30f2	katakana wo
U+ff67 <= c <= U+ff6b	(c - 0xff67) * 2 + 0x30a1	katakana small a-o
U+ff6c <= c <= U+ff6e	(c - 0xff6c) * 2 + 0x30e3	katakana small ya-yo
U+ff6f	0x30c3	katakana small tsu
U+ff71 <= c <= U+ff75	(c - 0xff71) * 2 + 0x30a2	katakana a-o
U+ff76 <= c <= U+ff81 followed by U+ff9e	(c - 0xff76) * 2 + 0x30ac	katakana ga-dsu
U+ff76 <= c <= U+ff81 not followed by U+ff9e	(c - 0xff76) * 2 + 0x30ab	katakana ka-chi
U+ff82 <= c <= U+ff84 followed by U+ff9e	(c - 0xff82) * 2 + 0x30c5	katakana du-do
U+ff82 <= c <= U+ff84 not followed by U+ff9e	(c - 0xff82) * 2 + 0x30c4	katakana tsu-to
U+ff85 <= c <= U+ff89	c - 0xff85 + 0x30ca	katakana na-no
U+ff8a <= c <= U+ff8e followed by U+ff9e	(c - 0xff8a) * 3 + 0x30d0	katakana ba-bo
U+ff8a <= c <= U+ff8e followed by U+ff9f	(c - 0xff8a) * 3 + 0x30d1	katakana pa-po
U+ff8a <= c <= U+ff8e neither followed by U+ff9e nor	(c - 0xff8a) * 3 + 0x30cf	katakana ha-ho

<i>From Unicode Character (c)</i>	<i>To Unicode Character</i>	<i>Comment</i>
U+ff9f		
U+ff8f <= c <= U+ff93	c - 0xff8f + 0x30de	katakana ma-mo
U+ff94 <= c <= U+ff96	(c - 0xff94) * 2 + 0x30e4	katakana ya-yo
U+ff97 <= c <= U+ff9b	c - 0xff97 + 0x30e9	katakana ra-ro
U+ff9c	U+30ef	katakana wa
U+ff9d	U+30f3	katakana nn
U+ff9e	U+309b	HALFWIDTH KATAKANA VOICED SOUND MARK => FULLWIDTH
U+ff9f	U+309c	HALFWIDTH KATAKANA SEMI-VOICED SOUND MARK => FULLWIDTH
U+ff70	U+30fc	HALFWIDTH KATAKANA- HIRAGANA PROLONGED SOUND MARK => FULLWIDTH
U+ff61	U+3002	HALFWIDTH IDEOGRAPHIC FULL STOP => FULLWIDTH
U+ff62	U+300c	HALFWIDTH LEFT CORNER BRACKET => FULLWIDTH
U+ff63	U+300d	HALFWIDTH RIGHT CORNER BRACKET => FULLWIDTH
U+ff64	U+3001	HALFWIDTH IDEOGRAPHIC COMMA => FULLWIDTH
U+ff65	U+30fb	HALFWIDTH KATAKANA MIDDLE DOT => FULLWIDTH

**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 6.20.2

## 6.20.12 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 6.20.13, MID 6.20.15, RIGHT 6.20.19

## 6.20.13 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 6.20.23, ITEXT 6.13.25, LEFT 6.20.12, MID 6.20.15, RIGHT 6.20.19

## 6.20.14 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 6.20.27, PROPER 6.20.16

## 6.20.15 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 6.20.12, LEN 6.20.13, RIGHT 6.20.19, REPLACE 6.20.17, SUBSTITUTE 6.20.21

## 6.20.16 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 6.20.14, UPPER 6.20.27

## 6.20.17 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 6.20.12, LEN 6.20.13, MID 6.20.15, RIGHT 6.20.19, SUBSTITUTE 6.20.21

## 6.20.18 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 6.20.12, MID 6.20.15, RIGHT 6.20.19, SUBSTITUTE 6.20.21

## 6.20.19 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=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 6.20.12, LEN 6.20.13, MID 6.20.15

## 6.20.20 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. 3.4

**See also** EXACT 6.20.8, FIND 6.20.9

## 6.20.21 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 *Old* and *New* may have different lengths. If *Which* is present and *Which* < 1, returns Error.

**See also** LEFT 6.20.12, LEN 6.20.13, MID 6.20.15, REPLACE 6.20.17, RIGHT 6.20.19

## 6.20.22 T

**Summary:** Return the text (if Text), else return 0-length Text value

**Syntax:** T( *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 6.13.26

## 6.20.23 TEXT

**Summary:** Return the value converted to a text.

**Syntax:** TEXT( *Scalar X* ; *Text FormatCode* )

**Returns:** Text

**Constraints:** The *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 *FormatCode* and returns it.

**See also** N 6.13.26, T 6.20.22

## 6.20.24 TRIM

**Summary:** Remove leading and trailing spaces, and replace all internal multiple spaces with a single space.

**Syntax:** TRIM( *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 6.20.12, RIGHT 6.20.19

## 6.20.25 UNICHAR

**Summary:** Return the character represented by the given numeric value according to the [UNICODE] Standard.

**Syntax:** UNICHAR( *Integer N* )

**Returns:** Text

**Constraints:**  $N \geq 0$ ,  $N \leq 1114111$  (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.

**See also** UNICODE 6.20.26

## 6.20.26 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 6.20.25

## 6.20.27 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 6.20.14, PROPER 6.20.16



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## 7 Other Capabilities

### 7.1 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 need 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).

### 7.2 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

### 7.3 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).

### 7.4 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.

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## 8 Non-portable Features

### 8.1 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.

### 8.2 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

### 8.3