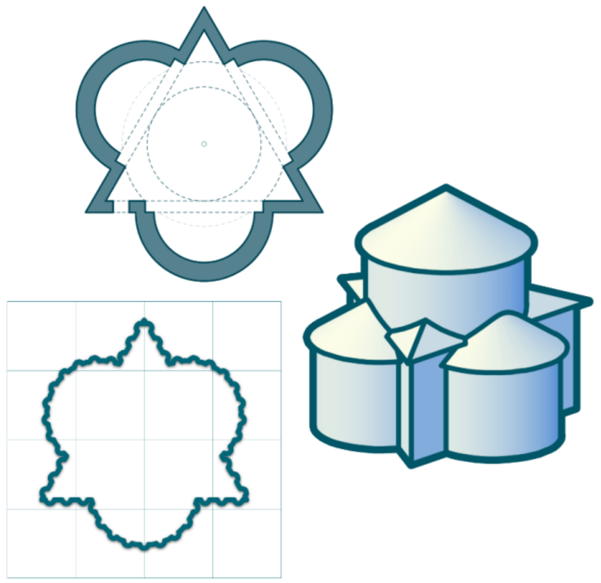
Digital Representation

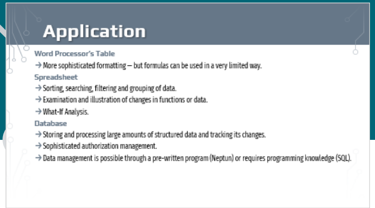
BMEEPAGA205

❯ Plotting Functions

❯ Data Management, Visualization

lecturer: László Strommer PhD





Application

Word Processor's Table

→ More sophisticated formatting – but formulas can be used in a very limited way.

Spreadsheet

→ Sorting, searching, filtering and grouping of data.

→ Examination and illustration of changes in functions or data.

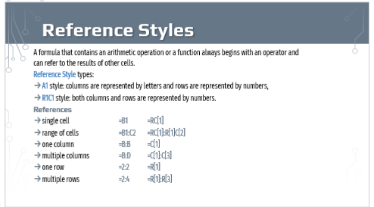
→ What-If Analysis.

Database

→ Storing and processing large amounts of structured data and tracking its changes.

→ Sophisticated authorization management.

→ Data management is possible through a pre-written program (Neptun) or requires programming knowledge (SQL).



Reference Styles

A formula that contains an arithmetic operation or a function always begins with an operator and can refer to the results of other cells.

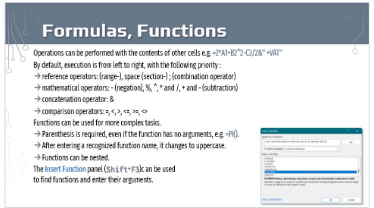
Reference Style types:

→ A1 style: columns are represented by letters and rows are represented by numbers,

→ R1C1 style: both columns and rows are represented by numbers.

References

→ single cell	=B1	=RC[1]
→ range of cells	=B1:C2	=RC[1]:R[1]C[2]
→ one column	=B:B	=C[1]
→ multiple columns	=B:D	=C[1]:C[3]
→ one row	=2:2	=R[1]
→ multiple rows	=2:4	=R[1]:R[3]



Formulas, Functions

Operations can be performed with the contents of other cells e.g. =2*A1+B2^2-C3/2&" +VAT"

By default, execution is from left to right, with the following priority :

→ reference operators: (range-), space (section-) ; (combination operator)

→ mathematical operators: - (negation), %, ^, * and /, + and - (subtraction)

→ concatenation operator: &

→ comparison operators: =, <, >, <=, >=, <>

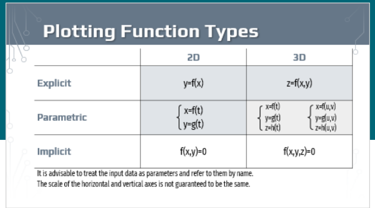
Functions can be used for more complex tasks.

→ Parenthesis is required, even if the function has no arguments, e.g. =PI().

→ After entering a recognized function name, it changes to uppercase.

→ Functions can be nested.

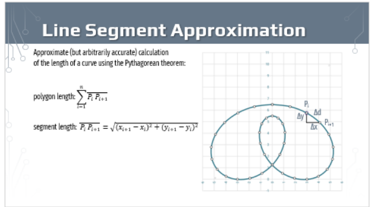
The Insert Function panel (`Shift+F3`)c an be used to find functions and enter their arguments.



Plotting Function Types

	2D	3D
Explicit	y=f(x)	z=f(x,y)
Parametric	$\begin{cases} x=f(t) \\ y=g(t) \end{cases}$	$\begin{cases} x=f(t) \\ y=g(t) \\ z=h(t) \end{cases}$ $\begin{cases} x=f(u,v) \\ y=g(u,v) \\ z=h(u,v) \end{cases}$
Implicit	f(x,y)=0	f(x,y,z)=0

It is advisable to treat the input data as parameters and refer to them by name.
The scale of the horizontal and vertical axes is not guaranteed to be the same.

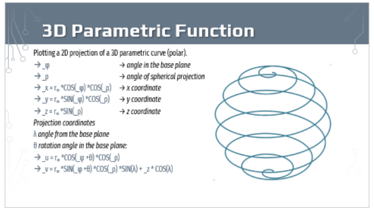


Line Segment Approximation

Approximate (but arbitrarily accurate) calculation of the length of a curve using the Pythagorean theorem:

polygon length: $\sum_{i=1}^{n} \overline{P_i P_{i+1}}$

segment length: $\overline{P_i P_{i+1}} = \sqrt{(x_{i+1} - x_i)^2 + (y_{i+1} - y_i)^2}$



3D Parametric Function

Plotting a 2D projection of a 3D parametric curve (polar).

→ _φ → *angle in the base plane*

→ _ρ → *angle of spherical projection*

→ _x = r₀ *COS(_φ) *COS(_ρ) → *x coordinate*

→ _y = r₀ *SIN(_φ) *COS(_ρ) → *y coordinate*

→ _z = r₀ *SIN(_ρ) → *z coordinate*

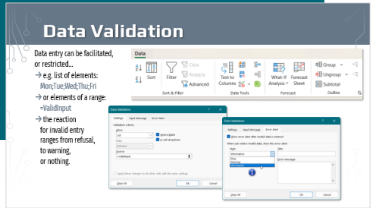
Projection coordinates

λ *angle from the base plane*

θ *rotation angle in the base plane:*

→ _u = r₀ *COS(_φ +θ) *COS(_ρ)

→ _v = r₀ *SIN(_φ +θ) *COS(_ρ) *SIN(λ) + _z * COS(λ)



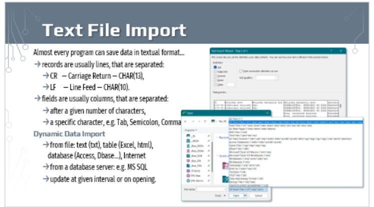
Data Validation

Data entry can be facilitated, or restricted…

→ e.g. list of elements: Mon;Tue;Wed;Thu;Fri

→ or elements of a range: =ValidInput

→ the reaction for invalid entry ranges from refusal, to warning, or nothing.



Text File Import

Almost every program can save data in textual format…

→ records are usually lines, that are separated:

→ CR – Carriage Return – CHAR(13),

→ LF – Line Feed – CHAR(10).

→ fields are usually columns, that are separated:

→ after a given number of characters,

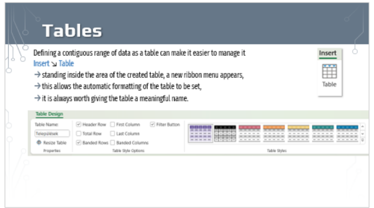
→ a specific character, e.g. Tab, Semicolon, Comma

Dynamic Data Import

→ from file: text (txt), table (Excel, html), database (Access, Dbase…), Internet

→ from a database server: e.g. MS SQL

→ update at given interval or on opening.



Tables

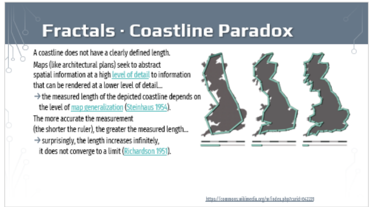
Defining a contiguous range of data as a table can make it easier to manage it

Insert ↘ Table

→ standing inside the area of the created table, a new ribbon menu appears,

→ this allows the automatic formatting of the table to be set,

→ it is always worth giving the table a meaningful name.



Fractals · Coastline Paradox

A coastline does not have a clearly defined length.

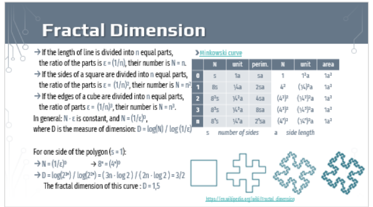
Maps (like architectural plans) seek to abstract spatial information at a high level of detail to information that can be rendered at a lower level of detail…

→ the measured length of the depicted coastline depends on the level of map generalization (Steinhaus 1954).

The more accurate the measurement (the shorter the ruler), the greater the measured length…

→ surprisingly, the length increases infinitely, it does not converge to a limit (Richardson 1951).

https://commons.wikimedia.org/w/index.php?curid=042721



Fractal Dimension

→ If the length of line is divided into n equal parts, the ratio of the parts is ε = (1/n), their number is N = n.

→ If the sides of a square are divided into n equal parts, the ratio of the parts is ε = (1/n)², their number is N = n².

→ If the edges of a cube are divided into n equal parts, the ratio of parts ε = (1/n)³, their number is N = n³.

In general: N · ε is constant, and N = (1/ε)ᴰ, where D is the measure of dimension: D = log(N) / log (1/ε)

❯ Minkowski curve

	N	unit	perim.	N	unit	area
0	s	1a	sa	1	1^2a	$1a^2$
1	8s	¼a	2sa	4^2	$(¼)^2a$	$1a^2$
2	8^2s	$¼^2a$	4sa	$(4^2)^2$	$(¼^2)^2a$	$1a^2$
3	8^3s	$¼^3a$	8sa	$(4^3)^2$	$(¼^3)^2a$	$1a^2$
n	8^ns	$¼^na$	2^nsa	$(4^n)^2$	$(¼^n)^2a$	$1a^2$

s *number of sides* a *side length*

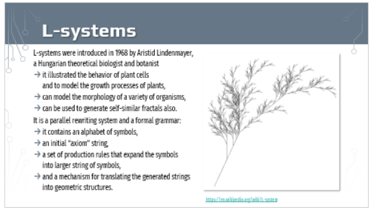
For one side of the polygon (s = 1):

→ $N = (1/\varepsilon)^D$ → $8^n = (4^n)^D$

→ $D = \log(2^{3n}) / \log(2^{2n}) = (3n \cdot \log 2) / (2n \cdot \log 2) = 3/2$

The fractal dimension of this curve : D = 1,5

https://en.wikipedia.org/wiki/Fractal_dimension



L-systems

L-systems were introduced in 1968 by Aristid Lindenmayer, a Hungarian theoretical biologist and botanist

→ it illustrated the behavior of plant cells and to model the growth processes of plants,

→ can model the morphology of a variety of organisms,

→ can be used to generate self-similar fractals also.

It is a parallel rewriting system and a formal grammar:

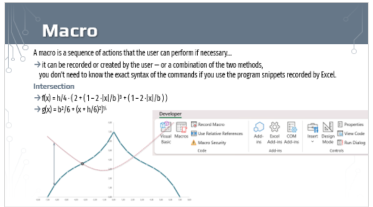
→ it contains an alphabet of symbols,

→ an initial "axiom" string,

→ a set of production rules that expand the symbols into larger string of symbols,

→ and a mechanism for translating the generated strings into geometric structures.

https://en.wikipedia.org/wiki/L-system



Macro

A macro is a sequence of actions that the user can perform if necessary…

→ it can be recorded or created by the user – or a combination of the two methods, you don't need to know the exact syntax of the commands if you use the program snippets recorded by Excel.

Intersection

→ f(x) = h/4 · (2 + (1 – 2 ·|x| /b)³ + (1 – 2 ·|x| /b))

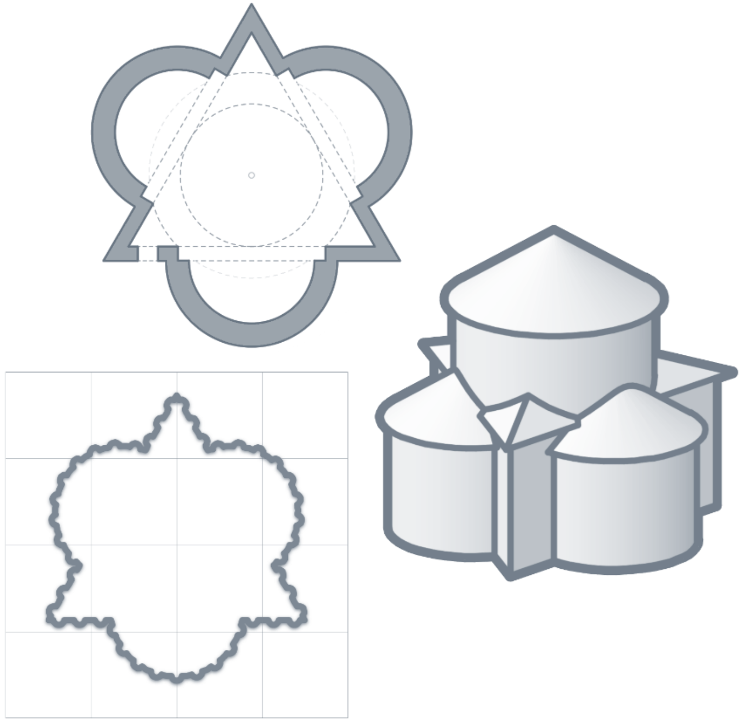
→ g(x) = b²/6 + (x + h/6)²)½

Spreadsheet ❯ Basics

Digital Representation

BMEEPAGA205

László Strommer PhD.



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Excel workbook

In Excel...

→ If the operating system is set to Hungarian, then the decimal symbol is comma, and the list separator is semicolon.

→ The names of the functions and their options change with the language, but the saved file can be used in all languages

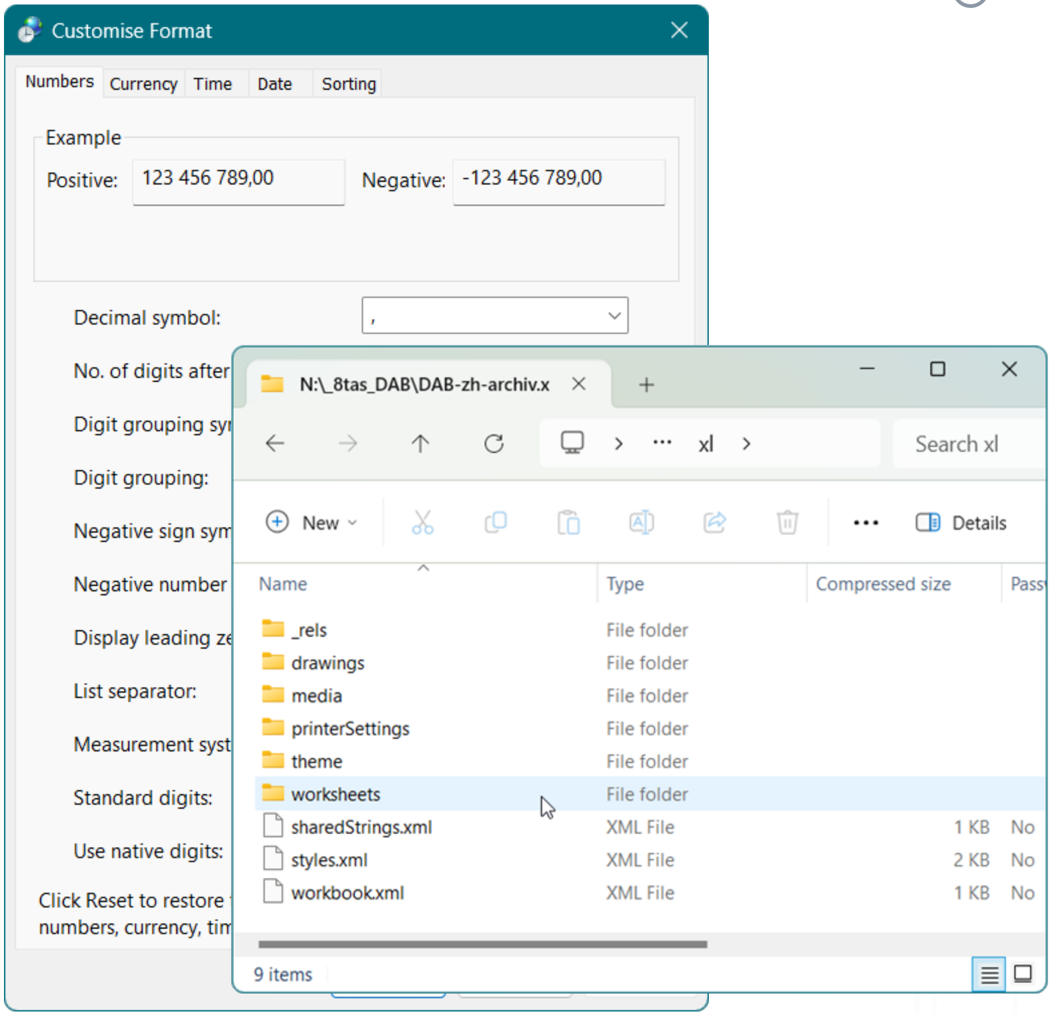
→ Former xls/xlm format...

  → 256 columns, 65 536 rows

→ Current xlsx/xlsm format...

  → 16 384 columns, 1 048 576 rows (compatibility!)

  → It's basically a compressed file that contains the worksheets (SheetN), and the drawings and images used in them.



Customise Format

Example

Positive: 123 456 789,00

Negative: -123 456 789,00

Decimal symbol: ,

No. of digits after

Digit grouping sy

Digit grouping:

Negative sign sym

Negative number

Display leading ze

List separator:

Measurement syst

Standard digits:

Use native digits:

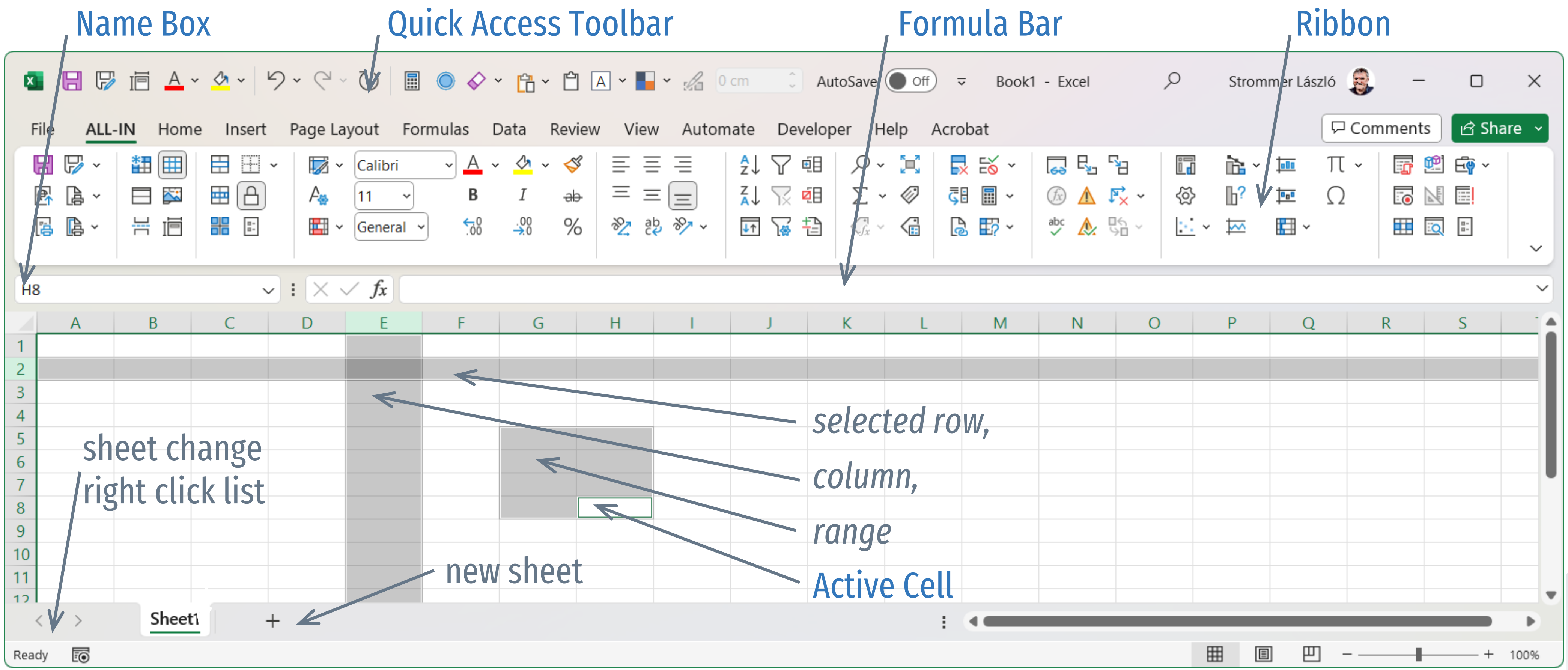
Click Reset to restore
numbers, currency, tim

N:_8tas_DAB\DAB-zh-archiv.x

Name	Type	Compressed size	Pass
_rels	File folder		
drawings	File folder		
media	File folder		
printerSettings	File folder		
theme	File folder		
worksheets	File folder		
sharedStrings.xml	XML File	1 KB	No
styles.xml	XML File	2 KB	No
workbook.xml	XML File	1 KB	No

9 items

Program window



Name Box

Quick Access Toolbar

Formula Bar

Ribbon

selected row,

column,

range

Active Cell

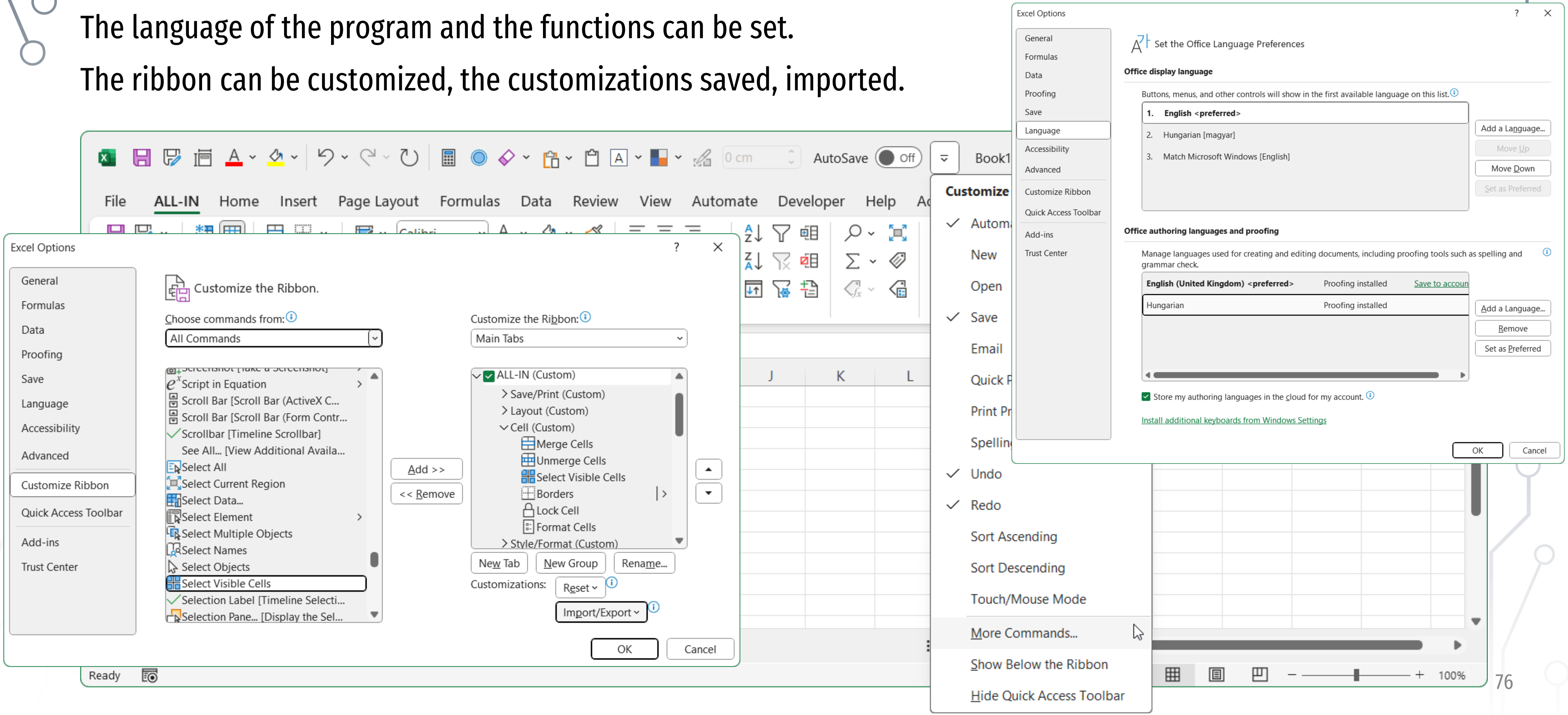
sheet change right click list

new sheet

Customization

The language of the program and the functions can be set.

The ribbon can be customized, the customizations saved, imported.



Excel Options

Customize the Ribbon.

Choose commands from: All Commands

Customize the Ribbon: Main Tabs

Customizations: Reset ˅ Import/Export ˅

Excel Options

Set the Office Language Preferences

Office display language

Buttons, menus, and other controls will show in the first available language on this list.

1. **English <preferred>**
2. Hungarian [magyar]
3. Match Microsoft Windows [English]

Office authoring languages and proofing

Manage languages used for creating and editing documents, including proofing tools such as spelling and grammar check.

English (United Kingdom) <preferred>	Proofing installed	Save to accoun
Hungarian	Proofing installed	

☑ Store my authoring languages in the cloud for my account.

Install additional keyboards from Windows Settings

Content · Behavior

Static content

→ Text-constant (max. 32 767 character), e.g. Income

→ Constant (max. 15 digits), pl. 1234, 1,23, 2005.10.24

→ Formula containing action(s) and function(s), e.g. =2^8 or =PI()

Changing content

→ a formula whose result depends...

  → from the contents of another cell, e.g. =A1+1,

  → or from another variable, e.g. from the current date: =TODAY().

Dynamic content

→ a formula whose content spills into neighboring cells,
and if this is not successful (e.g. because the cell is not empty), displays an error message (#SPILL!)

Content · Type

The content of a cell — either static or not — can be one of the following types.

Numerical value

→ Right-aligned in in an unformatted cell — by default it cannot extend into another cell (###, if it doesn't fit).

Logical value

→ TRUE or FALSE (~ 1 v. 0).

→ Centered in an unformatted cell — by default it cannot extend into another cell (###, if it doesn't fit).

Error message

→ Normally only if the formula in the cell results in an error.

Text

→ All content that is not one of the above is stored as text.

→ Left-aligned in an unformatted cell and may extend to the adjacent cell if it is empty (if not, it may be truncated).

Cell Format

Format Cells

→ Alignment:

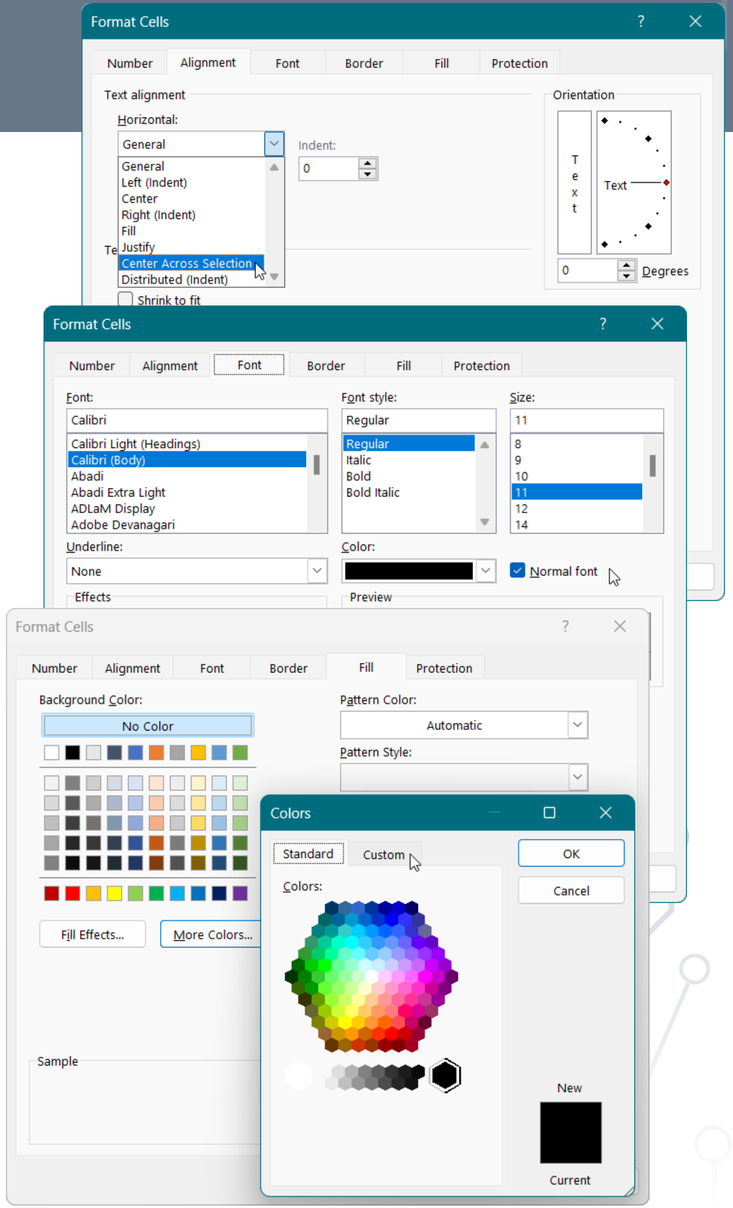
horizontal and vertical text alignment (e.g. to the center of selected cells),
text orientation, wrap text (line break: `Alt+Enter`),
shrink text to fit, merge cells (preferably: center across selection),

→ Font: font style, size, color (superscript, subscript),
the Normal style and the theme's default styles can also be set.

→ Border/Fill/Pattern:
border color, line type, thickness, or background color and pattern
can be specified for the selected cell or range of cells.

→ Cell Styles and Templates can be used.

→ There is no style hierarchy and inheritance, but it is possible to control
which formatting options the style applies to (e.g. only number format).



Format Cells

Horizontal: General

Indent: 0

Orientation: 0 Degrees

□ Shrink to fit

Format Cells

Font: Calibri

Font style: Regular

Size: 11

Underline: None

☑ Normal font

Format Cells

Background Color: No Color

Pattern Color: Automatic

Colors

Number Format

Format Cells ❯ Number

→ General:

format deemed appropriate by the program

→ Number:

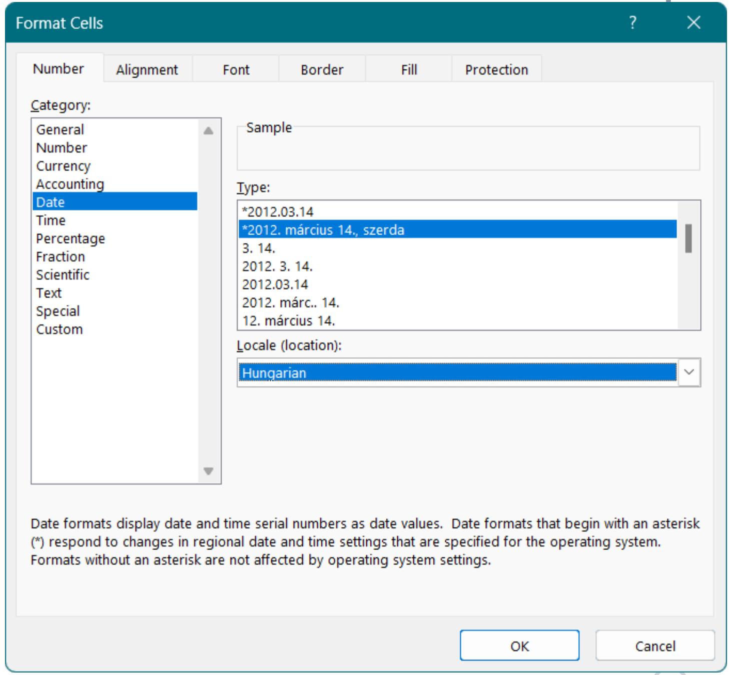
displaying the number with a given precision,
with selectable thousand separator (12 345)

→ Date/Time:

the integer part of the number represents the day (1 = 1900-01-01),
the fractional part represents the time (e.g. 0.5 = 12:00:00)

→ Custom:

unique format, e.g. with value-dependent formatting



Category:
General
Number
Currency
Accounting
Date
Time
Percentage
Fraction
Scientific
Text
Special
Custom

Type:
*2012.03.14
*2012. március 14., szerda
3. 14.
2012. 3. 14.
2012.03.14
2012. márc.. 14.
12. március 14.

Locale (location):
Hungarian

Date formats display date and time serial numbers as date values. Date formats that begin with an asterisk (*) respond to changes in regional date and time settings that are specified for the operating system. Formats without an asterisk are not affected by operating system settings.

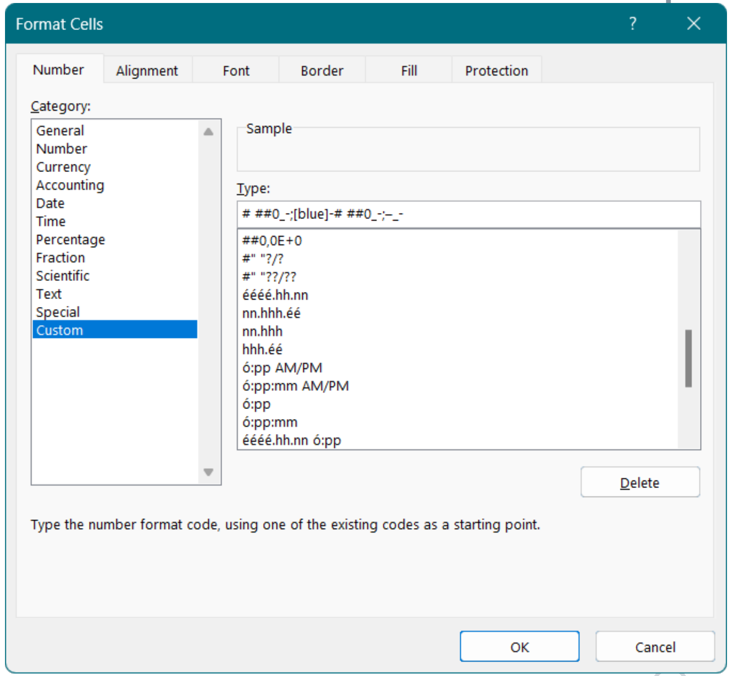
Custom Number Format

Format Cells ❯ Number ❯ Custom:

→ unique display format code with maximum four sections

- → by default, its sign-dependent: "+","–","0","text"
- → conditions (limits) can be specified, e.g. [<2]
- → basic colors can be specified, e.g. [Blue]
- → text that can be added, e.g. the unit of measure, e.g. # ###.0" m^2"
- → # → display only non-zero digits (e.g. 0.06 v. 0.15 & 0,# → 0,1)
- → 0 → always display the given digit (pl. 630 & 00-00 → 06-30)
- → % → show the value multiplied by 100 (0.123 & 0% → 12%)
- → Space → displays the number divided by 1000 (12345 & 0,0 " t." → 12,3 t.)
- → *The display accuracy of the number normally does not affect the further calculation.*

→ *Decimal sign ("." or ",") and list separator ("","" or ";") according to Windows settings.*



Type:

```
# ##0_-;[blue]-# ##0_-;–_-
```

```
##0,0E+0
#" "?/?
#" "??/??
éééé.hh.nn
nn.hhh.éé
nn.hhh
hhh.éé
ó:pp AM/PM
ó:pp:mm AM/PM
ó:pp
ó:pp:mm
éééé.hh.nn ó:pp
```

Type the number format code, using one of the existing codes as a starting point.

Text Formatting

Spreadsheets are not suitable for managing and formatting long texts...

→ formatting options are narrower, their execution is more difficult,

→ there is a limit for length of the of text in cells (insert a text box instead),

→ text transfer between cells is cumbersome.

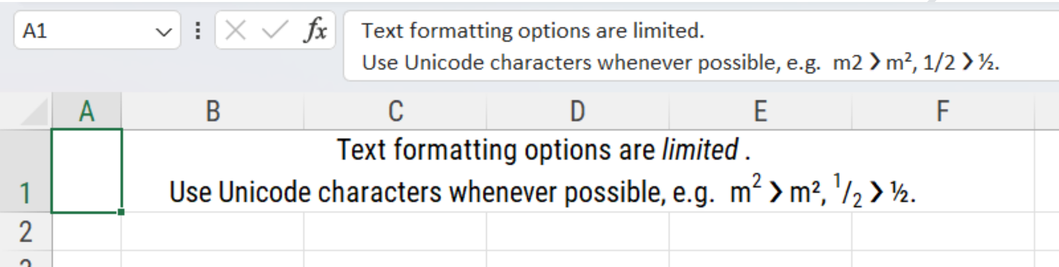
It is possible, to display the result of a calculation or a content that depends on a certain condition.

→ Character-level formatting is available only for static text, and formatting is visible only on the final result.

→ Styles are interpreted at the cell level, but do not necessarily cover all aspects (e.g. number only).

→ Alignment: within the cell (either single or merged), centered across the selection.

→ Line break within a cell: `Alt`+`Enter`.



Text formatting options are limited.
Use Unicode characters whenever possible, e.g. m2 ❯ m², 1/2 ❯ ½.

Text formatting options are *limited* .
Use Unicode characters whenever possible, e.g. m^2 ❯ m², $^1/_2$ ❯ ½.

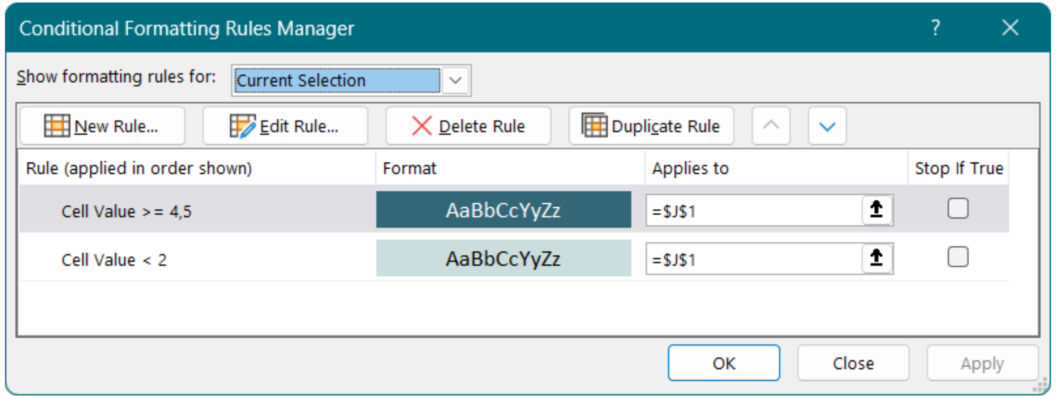
Variable Format / Content

Formatting based on a cell's own result

→ Conditional Formatting

value-dependent settings of font, font style, cell border, fill color and pattern

→ Custom number format



Show formatting rules for: Current Selection

Rule (applied in order shown)	Format	Applies to	Stop If True
Cell Value >= 4,5	AaBbCcYyZz	=$J$1	□
Cell Value < 2	AaBbCcYyZz	=$J$1	□

Content depending on the value of another cell

→ Content varies depending on a given condition:

=IF(TestAvg >= 4,5, "Excellent!"; IF(TestAvg < 2, "Failed„, "Okay"))

→ Combining calculation results or other data

="still "&TEXT(Deadline - Date;"0")&„to go"

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A formula that contains an arithmetic operation or a function always begins with an operator and can refer to the results of other cells.

Reference Style types:

→ A1 style: columns are represented by letters and rows are represented by numbers,

→ R1C1 style: both columns and rows are represented by numbers.

References

→ single cell	=B1	=RC[1]
→ range of cells	=B1:C2	=RC[1]:R[1]C[2]
→ one column	=B:B	=C[1]
→ multiple columns	=B:D	=C[1]:C[3]
→ one row	=2:2	=R[1]
→ multiple rows	=2:4	=R[1]:R[3]

Reference Types

Relative Reference

→ the reference is relative to the location of the cell, e.g. A2 |RC[-1]

Absolute Reference

→ the reference maintains the original cell reference, e.g. $C$2 |R2C3

Mixed Reference

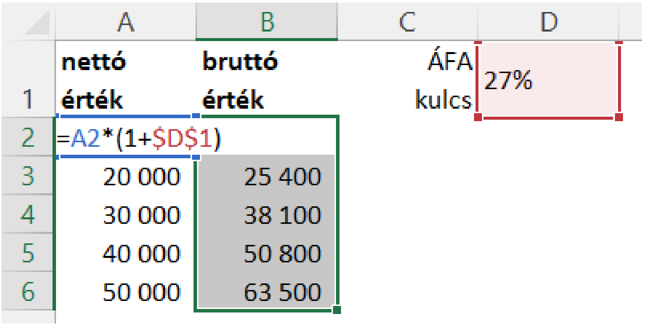
→ the reference is partially absolute and partially relative, e.g. B$1*$A2

Dynamic Reference

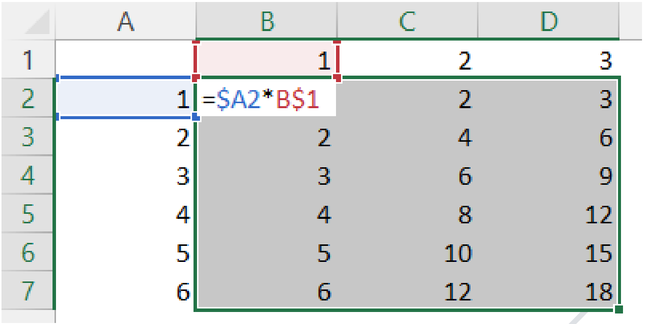
→ refers to a dynamic domain, e.g. A1#

Indirect Reference*

→ the referenced cell is formally the cell that contains the formula (RC), determining the cell or range to be considered in relation to it, e.g. =OFFSET(RC, -1, 0)



	A	B	C	D
1	nettó érték	bruttó érték	ÁFA kulcs	27%
2	=A2*(1+$D$1)			
3	20 000	25 400		
4	30 000	38 100		
5	40 000	50 800		
6	50 000	63 500		



	A	B	C	D
1		1	2	3
2	1	=$A2*B$1	2	3
3	2	2	4	6
4	3	3	6	9
5	4	4	8	12
6	5	5	10	15
7	6	6	12	18

** Recommended e.g. to ensure that the formulas always refer to the cell above them even if new lines are inserted.*

Reference · Using Names

To make formulas easier to understand, names can be used as references also.

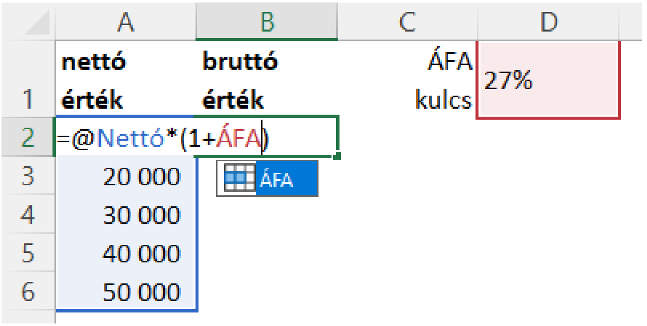
→ By default, we simply select the cell or range, then we write the desired name in the Name Box (+`Enter`).

→ Using the Name Manager (`Ctrl`+`F3`) gives greater control e.g. in case of dynamic range, or page-specific name.

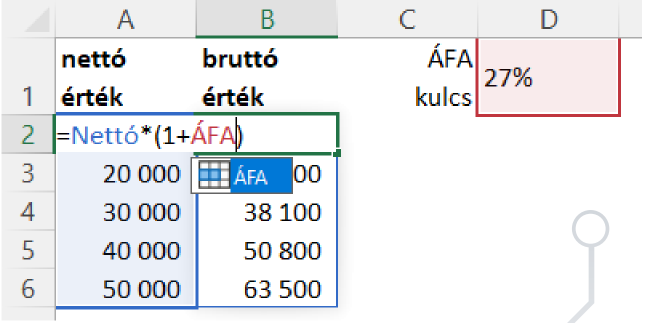
→ Name of a cell (e.g. C1 → ÁFA) behaves as absolute reference, e.g. =ÁFA.

→ Name of a named range (e.g. A2:A6 → Nettó)

- → behaves as absolute reference for summary functions, e.g. =SUM(Nettó),
- → for other operations
  in earlier versions, it behaves as a mixed reference, e.g. =2*Nettó,
  in newer versions, the same behavior requires an @ sign, e.g. =2*@Nettó,
  without an @, a dynamic formula spills the range (B2:B6).



	A	B	C	D
1	nettó érték	bruttó érték	ÁFA kulcs	27%
2	=@Nettó*(1+ÁFA)			
3	20 000			
4	30 000			
5	40 000			
6	50 000			



	A	B	C	D
1	nettó érték	bruttó érték	ÁFA kulcs	27%
2	=Nettó*(1+ÁFA)			
3	20 000	00		
4	30 000	38 100		
5	40 000	50 800		
6	50 000	63 500		

→ Intersections of named rows and columns can be referred with names separated by spaces, e.g. =January Income.

Reference · Dynamic Ranges

When using dynamic formulas, the referenced range determines how much space the result requires (if it doesn't fit: #SPILL!).

→ In case of a dynamic row (B1: =SEQUENCE(1,3)) and column (A2: =SEQUENCE(6,1)), it is enough to enter the formula in a single cell (B2: =A2# *B1#), it automatically populates the entire range.

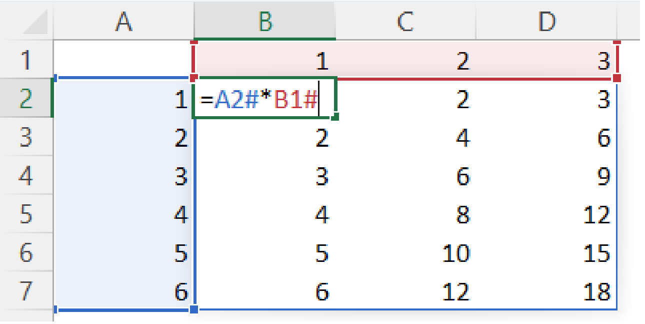
→ Using the Name Manager (Ctrl+F3) dynamic ranges can be named (=Sheet!$A$2# → _Szorzó | =Lap!$B$1# → _Szorzandó) – then it is enough to refer to these names in dynamic formulas (B2: =_Szorzó*_Szorzandó) (Multiplier and Multiplicand).

→ It is worth noting that the same formula works even if the row and column names point to a non-dynamic range (=Lap!$A$2:$A$7 → _Szorzó | =Lap!$B$1:$D$1 → _Szorzandó).

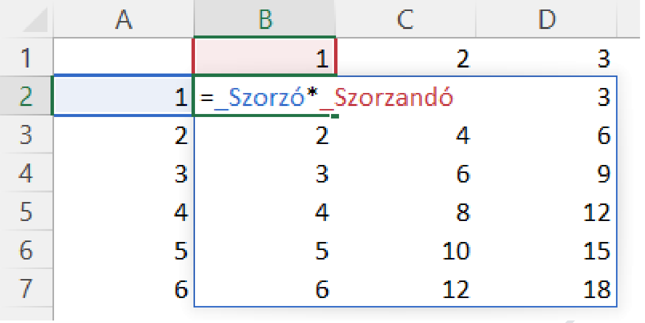
In this case, changing the formula does not change the area of the resulting range – the workaround is to change the number of rows also.

Formulas

Name Manager



	A	B	C	D
1		1	2	3
2	1	=A2#*B1#	2	3
3	2	2	4	6
4	3	3	6	9
5	4	4	8	12
6	5	5	10	15
7	6	6	12	18



	A	B	C	D
1		1	2	3
2	1	=_Szorzó*_Szorzandó		3
3	2	2	4	6
4	3	3	6	9
5	4	4	8	12
6	5	5	10	15
7	6	6	12	18

Reference · Tables

Data tables may be easier to use if they are defined as tables.

→ Definition (standing inside the range): Insert↘ Table

→ each column in the table must have a unique Header Row,
if this is not the case, it will be created or modified automatically.

→ Using the Table Design ribbon menu:

→ the Table Name can be modified,

→ the Filter Button can be activated,

→ the table can be formatted automatically
Banded/First/Last Row/Column.

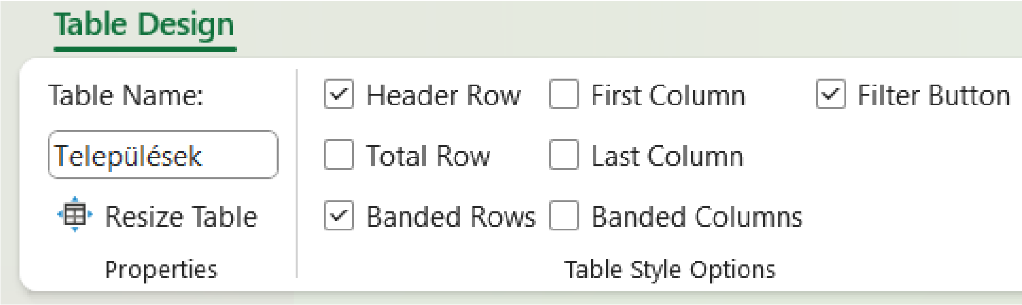


Table Design

Table Name:
Települések
Resize Table
Properties

☑ Header Row ☐ First Column ☑ Filter Button
☐ Total Row ☐ Last Column
☑ Banded Rows ☐ Banded Columns
Table Style Options

→ In the table, formulas automatically populate the entire column and usually refer to the column header
=[@Column1]

→ Formulas outside the table insert the table name before the column header
=Table1[@Column1]

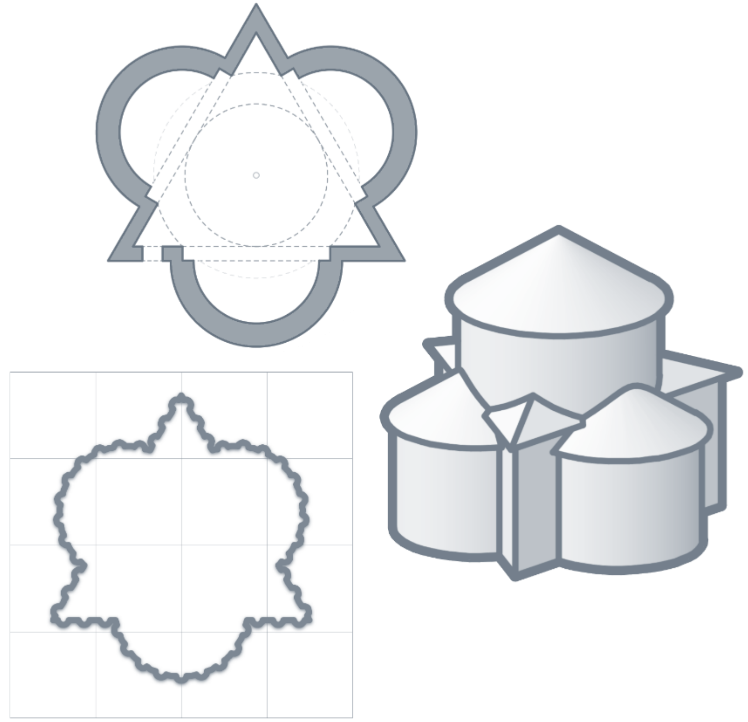
Spreadsheet

❯ Functions

Digital Representation

BMEEPAGA205

László Strommer PhD.



Formulas, Functions

Operations can be performed with the contents of other cells e.g. =2*A1+B2^2-C3/2&" +VAT"

By default, execution is from left to right, with the following priority :

→ reference operators: (range-), space (section-) ; (combination operator)

→ mathematical operators: - (negation), %, ^, * and /, + and - (subtraction)

→ concatenation operator: &

→ comparison operators: =, <, >, <=, >=, <>

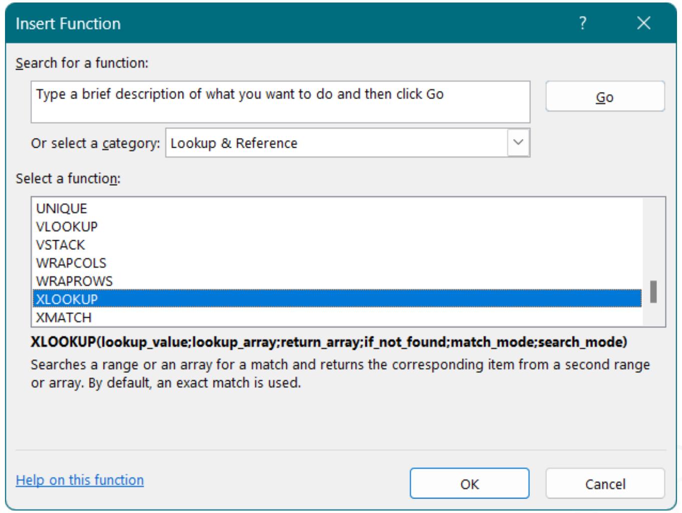
Functions can be used for more complex tasks.

→ Parenthesis is required, even if the function has no arguments, e.g. =PI().

→ After entering a recognized function name, it changes to uppercase.

→ Functions can be nested.

The Insert Function panel (Shift+F3)c an be used to find functions and enter their arguments.



Search for a function:

Type a brief description of what you want to do and then click Go

Or select a category: Lookup & Reference

Select a function:

UNIQUE
VLOOKUP
VSTACK
WRAPCOLS
WRAPROWS
XLOOKUP
XMATCH

XLOOKUP(lookup_value;lookup_array;return_array;if_not_found;match_mode;search_mode)

Searches a range or an array for a match and returns the corresponding item from a second range or array. By default, an exact match is used.

Inserting Functions, Arguments

When inserting a function…

→ first the category, then the function can be selected,

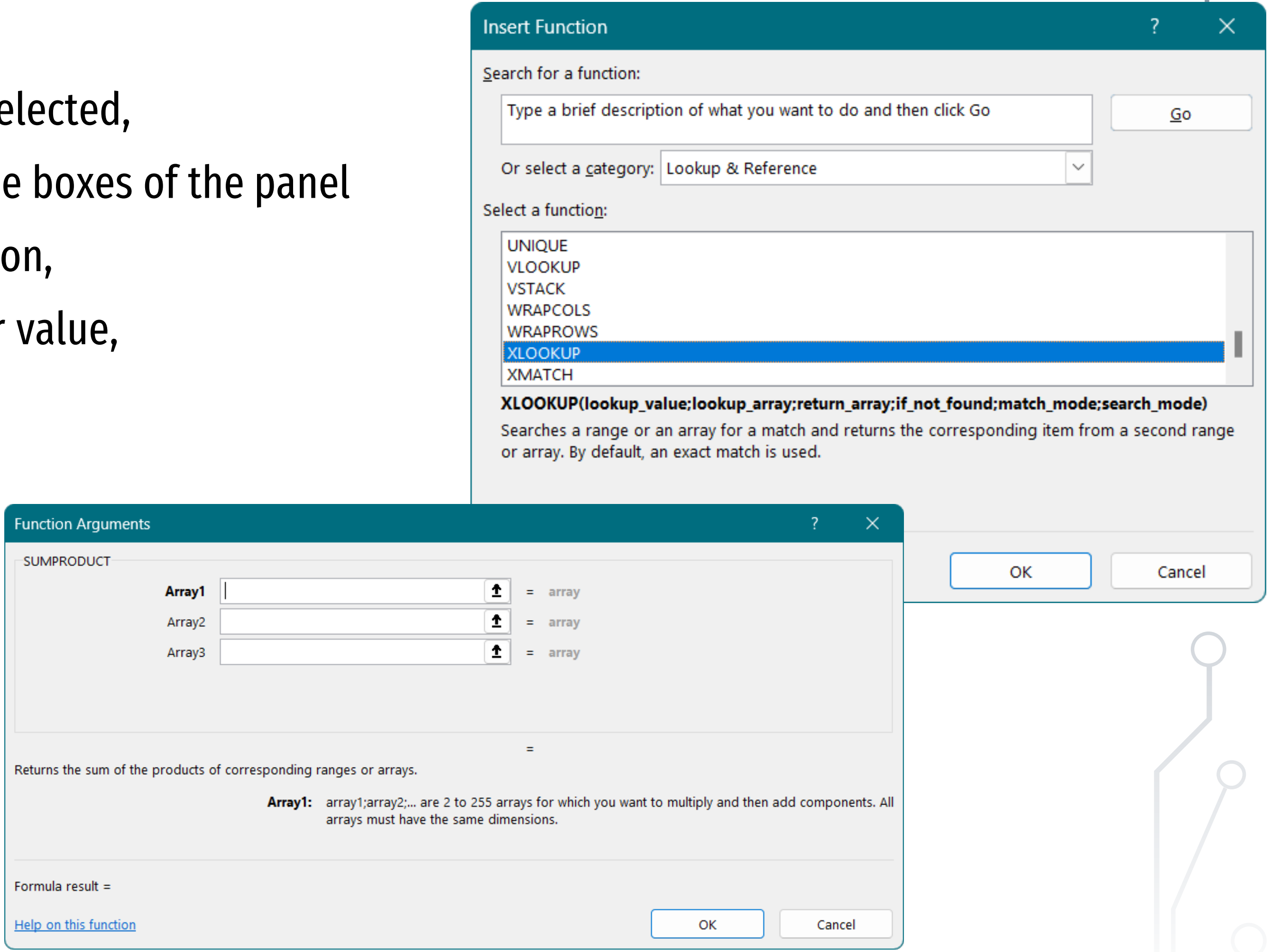
→ the parameters can be given (or shown) in the boxes of the panel

→ the type of arguments depends on the function,

  → can be number, text, logical value or error value,

  → can be a reference,

  → can be another formula, or function.



Insert Function

Search for a function:

Type a brief description of what you want to do and then click Go

Or select a category: Lookup & Reference

Select a function:

- UNIQUE
- VLOOKUP
- VSTACK
- WRAPCOLS
- WRAPROWS
- XLOOKUP
- XMATCH

XLOOKUP(lookup_value;lookup_array;return_array;if_not_found;match_mode;search_mode)

Searches a range or an array for a match and returns the corresponding item from a second range or array. By default, an exact match is used.

Function Arguments

SUMPRODUCT

Array1 = array

Array2 = array

Array3 = array

=

Returns the sum of the products of corresponding ranges or arrays.

Array1: array1;array2;... are 2 to 255 arrays for which you want to multiply and then add components. All arrays must have the same dimensions.

Formula result =

Help on this function

Text Manipulation

→ VALUE(...)	• converts text that can be interpreted as a number into a number
→ TEXT(...,"0%")	• converts a number into text in the specified number format
→ LEFT(..., n) / RIGHT(..., n)	• returns the first/last n characters of text
→ MID(..., i, n)	• returns n characters taken from the i-th position of the text
→ FIND(..., ..., i)	• returns the starting position of a string in a text (starting from i)
→ LEN(...)	• returns the number of characters in a text
→ TRIM(...) / CLEAN(...)	• removal of unnecessary spaces/characters
→ SUBSTITUTE(...)	• replace a given string in a text
→ UPPER(...) / LOWER(...)	• converts text to upper/lower case
→ PROPER(...)	• converts text into a proper format (begins all words with a capital letter)

Mathematics & Logics

→ SUMPRODUCT(a, b, ...) • multiplies the corresponding elements of ranges of the same dimension, and returns the sum of the results (other operations can be used also)

→ IF(test, iftrue, iffalse) • returns one or another value depending on the evaluation of a comparison

→ IFS(test1, iftrue1, ...) • returns the value that corresponds to the first TRUE condition

→ IFERROR(..., "?!") • returns an alternative result if the formula would result in an error

→ IFNA(..., "?!") • returns an alternative result if the formula would result in an #NA (Not found) error

→ NOT(...) • returns the opposite of a logical value (from false to true and vice versa)

→ OR(..., ...) • true if at least one of the conditions is true

→ AND(..., ...) • true if all conditions are true

→ RADIANS(...) / DEGREES (...) • conversion between degrees and radians

→ SIN(...) / COS(...) / TAN(...) • returns the sine / cosine / tangent of an angle in radians

→ ABS(...) / INT(...) / PI(...) • absolute value of a number / integer part of a number / the value of pi

Statistcs

→ AVERAGE(...)	• average value in the argument
→ AVERAGEIFS(...)	• average of cells matching given criteria
→ MIN(...) / MAX(...)	• minimum, maximum of a set of values in the argument
→ MINIFS(...) / MAXIFS(...)	• minimum and maximum of cells that meet the criteria
→ SUM(...)	• sum of arguments (cells)
→ SUMIFS(...)	• sum of cells matching given criteria
→ COUNT(...)	• number of cells containing numbers in the argument
→ COUNTA(...)	• number of values (non-empty cells) in the argument
→ COUNTBLANK(...)	• number of empty cells in the argument
→ COUNTIFS(...)	• number of cells matching given criteria
→ GEOMEAN(...)	• geometric mean of arguments
→ MEDIAN(...)	• median value of arguments
→ LARGE(..., n) / SMALL(..., n)	• the n-th smallest/largest number

Lookup & Reference

→ XLOOKUP(...) • searches a range for a match, returns the corresponding item from another range

→ MATCH(...) • searches for a specified item in a range, and returns its relative position

→ XMATCH(...) • searches for a specified item in a range, and returns its relative position

→ INDEX(..., R, C) • returns the element in a specified row (and column) of a given range

→ OFFSET(..., R, C) • returns a reference to a range (a single cell or a range with a given size) that is a specified number of rows and columns from a cell or range of cells

→ ADDRESS(R, C) • returns the address of a cell specified by row and column numbers

→ INDIRECT(...) • returns the reference specified by a text string

Dynamic Functions & Info

→ UNIQUE(...) • returns a list of unique values in a list or range

→ FILTER(...) • allows filtering a range of data based on the specified criteria

→ SORT(...) • returns the contents of a range arranged in order

→ SORTBY(...) • sorts the contents of a range based on the values in a corresponding range

→ TRANSPOSE(...) • returns the the transpose of range

→ SEQUENCE(...) • generate a list of sequential numbers in an array

Displaying information about the file name and location, and/or the date and time of the printing can be useful, e.g. during retrieval and change tracking:

→ CELL("filename")

→ TODAY(), or NOW()

Plotting Function Types

	2D	3D
Explicit	$y=f(x)$	$z=f(x,y)$
Parametric	$\begin{cases} x=f(t) \\ y=g(t) \end{cases}$	$\begin{cases} x=f(t) \\ y=g(t) \\ z=h(t) \end{cases}$ $\begin{cases} x=f(u,v) \\ y=g(u,v) \\ z=h(u,v) \end{cases}$
Implicit	$f(x,y)=0$	$f(x,y,z)=0$

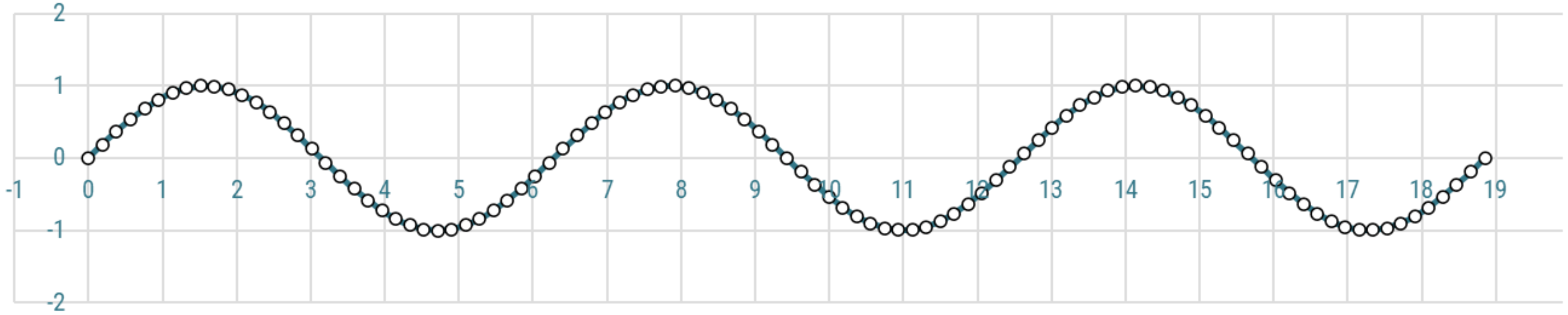
It is advisable to treat the input data as parameters and refer to them by name.

The scale of the horizontal and vertical axes is not guaranteed to be the same.

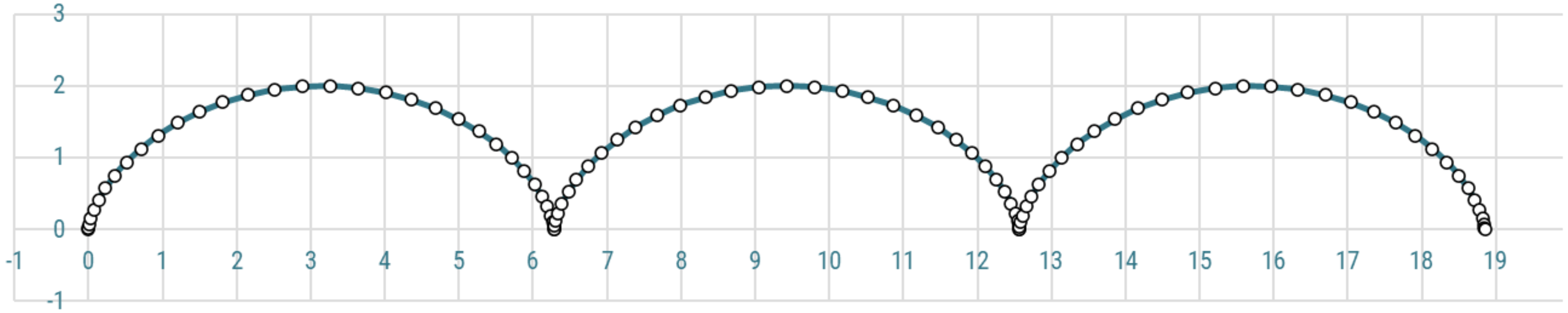
Plotting 2D Functions

The curve can be approximated with its chords – the sections connecting the dividing points. (a = b = 1).

Explicit → e.g. _x =_i/n * w * 2*PI() → _y = a* SIN(_x)



Parametric → e.g. _φ =_i/n * w * 2*PI() → _x = a*_φ – b* SIN(_φ) /// _y = a – b* COS(_φ)



Division Algorithm

Algorithm for setting up the division points of the function (distribution density → accuracy).

n number of divisions (sections) → a positive integer

s symmetry multiplier → $s = 2^a$ for symmetry number a (s = 1 when dividing the entire range)

_i node identifier → the SEQUENCE(...) function can be used for dynamic operation:

→ number of rows specifies the number of division points → typically s*n+1,

→ the number of rows is typically 1, so it can even be omitted,

→ starting value → typically 0 or −s*n/2,

→ step value is typically 1, so it can even be omitted.

_i/s/n a series of normalized ratios indicating the position of each division point within the range:

→ an explicit function is typically divided in the x direction, e.g. _x =_i/n *w*2*PI(),

→ in the case of a parametric function, the independent variable is divided, e.g. _φ =_i/n *w*2*PI().

2D Chart

Steps for plotting the function:

→ it is advisable to select the range first,

→ Insert ↘ Chart,

→ chart type → usually XY Scatter,

→ subtype → usually with straight lines,

→ function name → usually the cell above the y values,

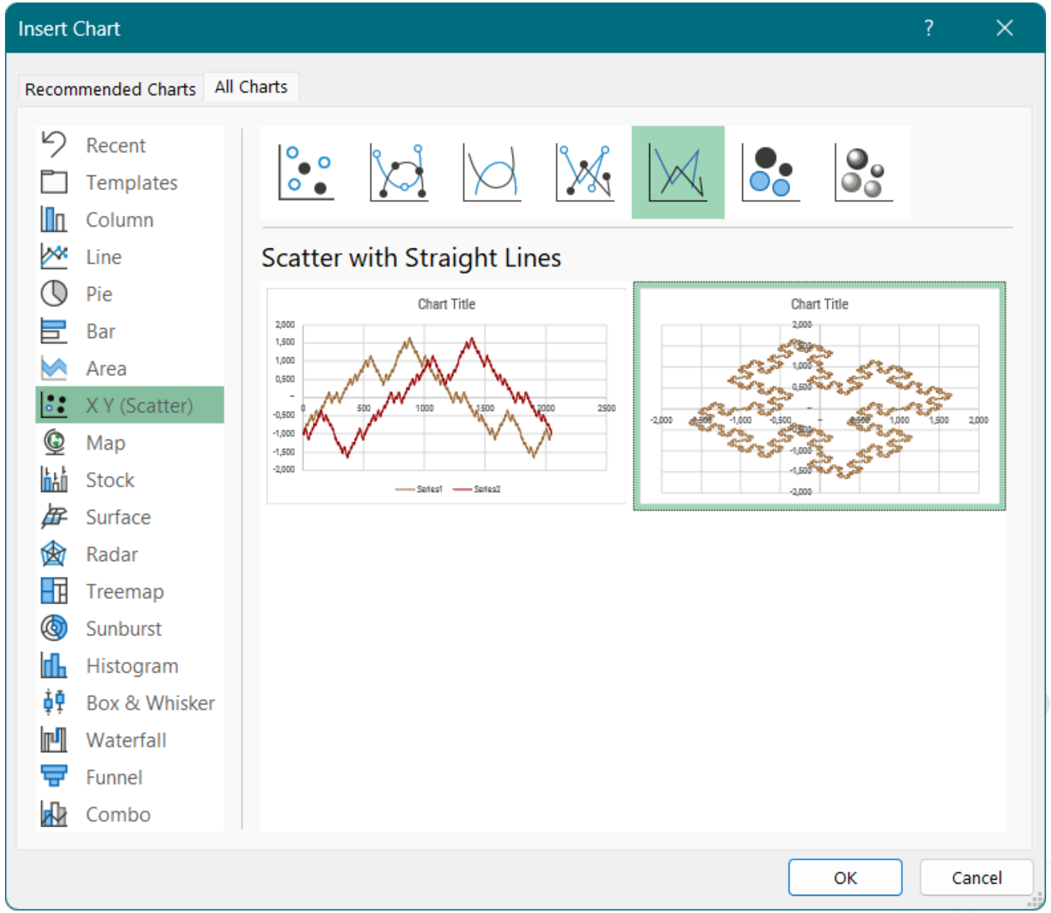
→ additional data lines can be added,

→ other parameters can be specified (e.g. chart title),

→ the axes can be set up (min., max., step),

→ the size (and aspect ratio) can be set,

→ formatting can be customized.



Insert Chart

All Charts: X Y (Scatter)

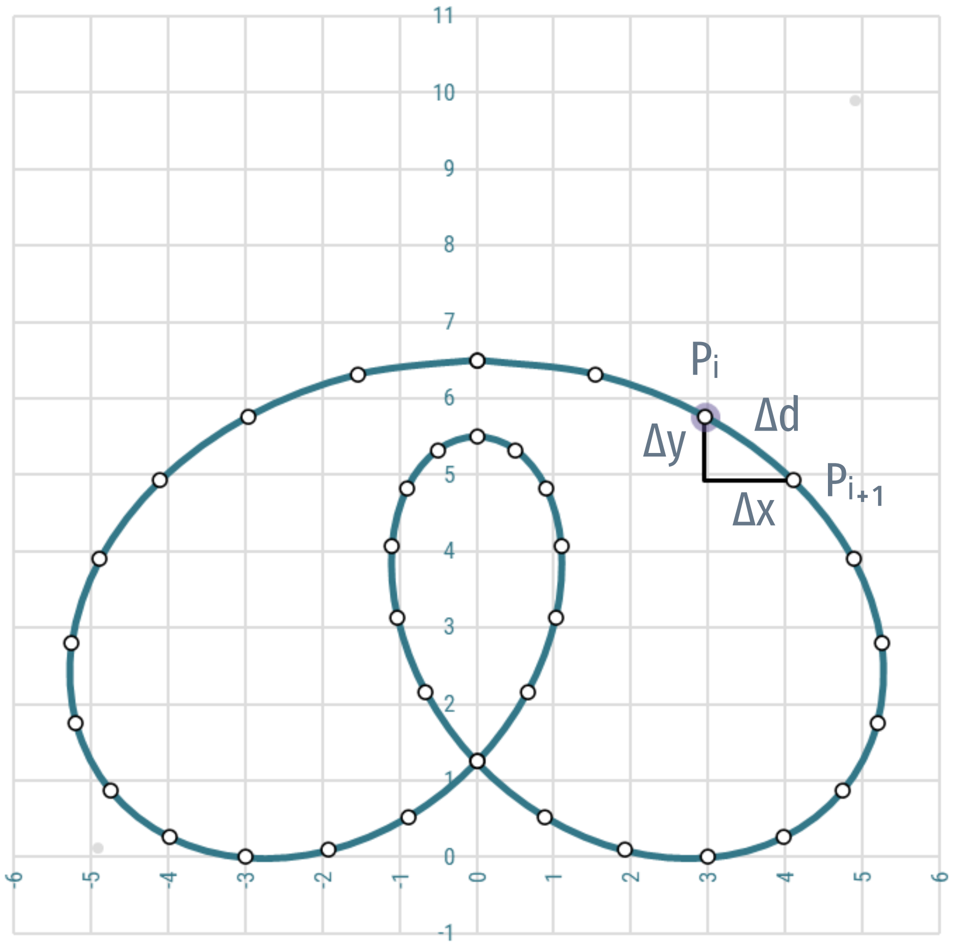
Scatter with Straight Lines

Line Segment Approximation

Approximate (but arbitrarily accurate) calculation of the length of a curve using the Pythagorean theorem:

polygon length: $\sum_{i=1}^{n} \overline{P_i\, P_{i+1}}$

segment length: $\overline{P_i\, P_{i+1}} = \sqrt{(x_{i+1} - x_i)^2 + (y_{i+1} - y_i)^2}$



Numerical Integral

Approximation of the area under a curve by elementary area units:

→ s·n+1 division points → s·n area units

→ $A = \Sigma A_i$

Typical methods

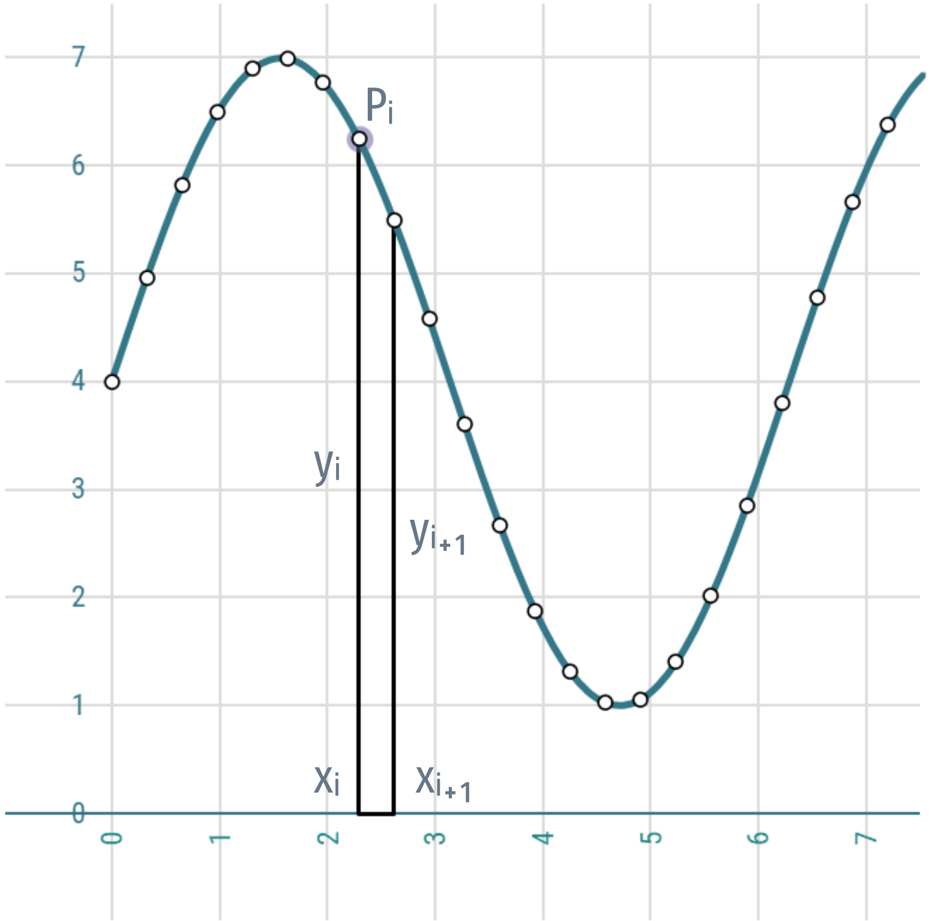
→ Simpson's parabola formula

→ rectangle formula

$A_i = (x_i - x_{i+1}) \cdot (y_i - y_{i+1})$

→ trapezoid formula

$A_i = (x_i - x_{i+1}) \cdot \frac{1}{2}(y_i + y_{i+1})$



Heron’s Formula

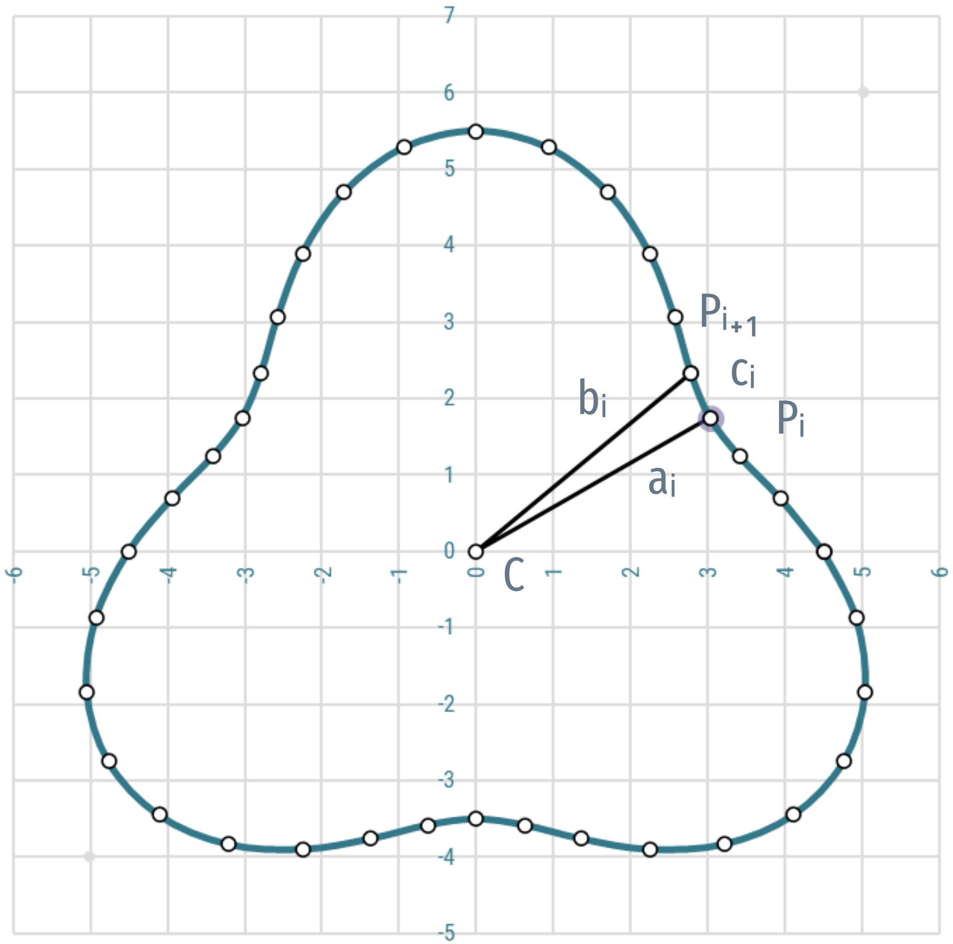
If there is a point within the closed curve
that can be connected to all contour points
without intersecting the curve itself,
then the area can be approximated
using Heron's formula.

Approximation of the enclosed area by triangles:

→ $s \cdot n+1$ division points → $s \cdot n$ triangles

→ $A = \Sigma A_i$

→ $A_i = \frac{1}{4} \left[(a_i+b_i+c_i) \cdot (-a_i+b_i+c_i) \cdot (a_i-b_i+c_i) \cdot (a_i+b_i-c_i)\right]^{\frac{1}{2}}$.



https://mathworld.wolfram.com/HeronsFormula.html

Next Point

The coordinates of the next point (after the current one) are needed to calculate the length of the curve and the area under or enclosed by the curve...

→ the formula can refer to next row,

→ a more flexible solution is to handle this dynamically, either as a range of cells or as a definition, e.g.

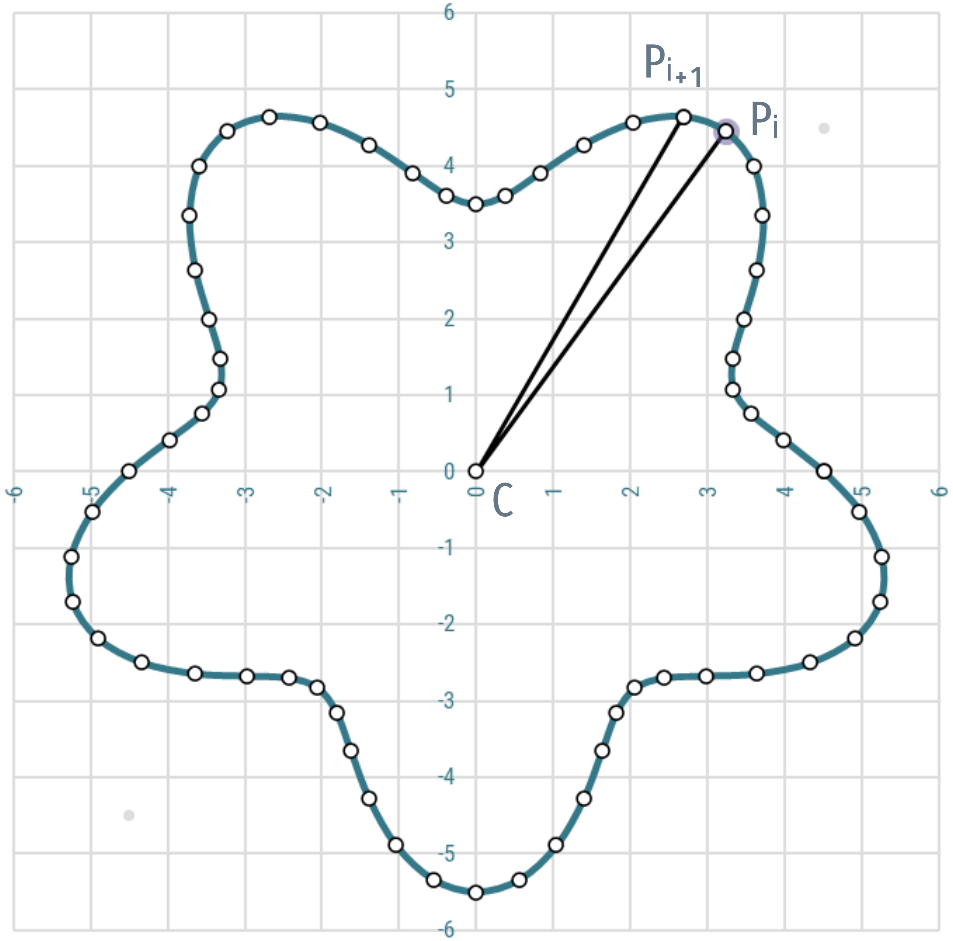
  → _x$_{i+1}$ = OFFSET(_x, 1, 0, ROWS(_x)-1)

  → _y$_{i+1}$ = OFFSET(_y, 1, 0, ROWS(_y)-1)

  → it is important to handle the last missing row, e.g.
  Δls = IFERROR(SQRT((_x$_{i+1}$-_x)^2 + (_y$_{i+1}$-_y)^2); "·")

  → it can be a range of cell,

  → or it can be a transcendent range defined with the Name Manager



Goal Seek, Solver

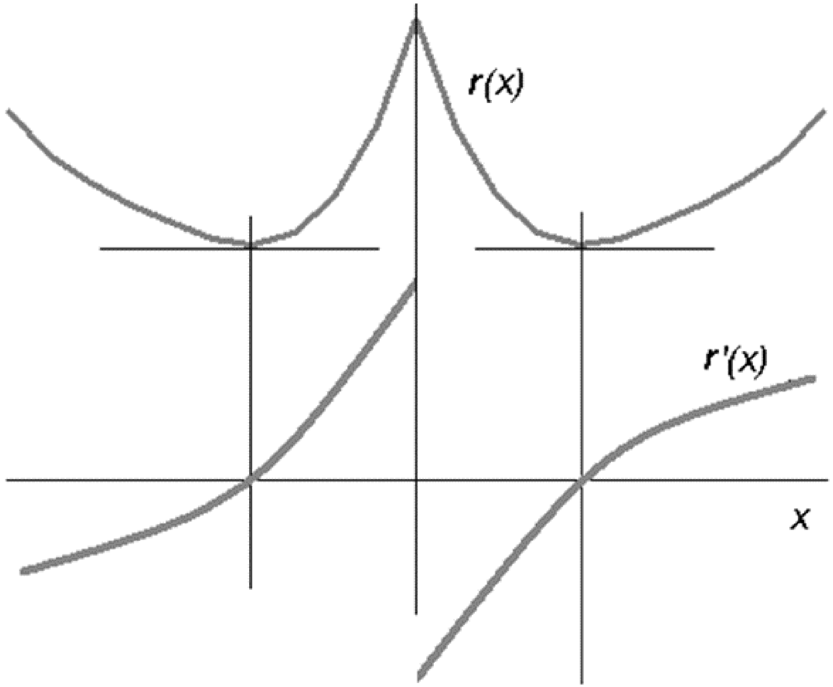
The Goal Seek can be used when the desired optimal result is known, but the corresponding input value needs to be found.

Solver is an add-in program that can be used to find the optimal, maximum, or minimum value of a cell by changing the value of another cell or more cells.

Target value → intersection of functions.

Minimum or maximum → extreme value of a function
→ where the derivative function changes sign.

Both methods find a local solution, which can thus depend on the initial value.



Spreadsheet

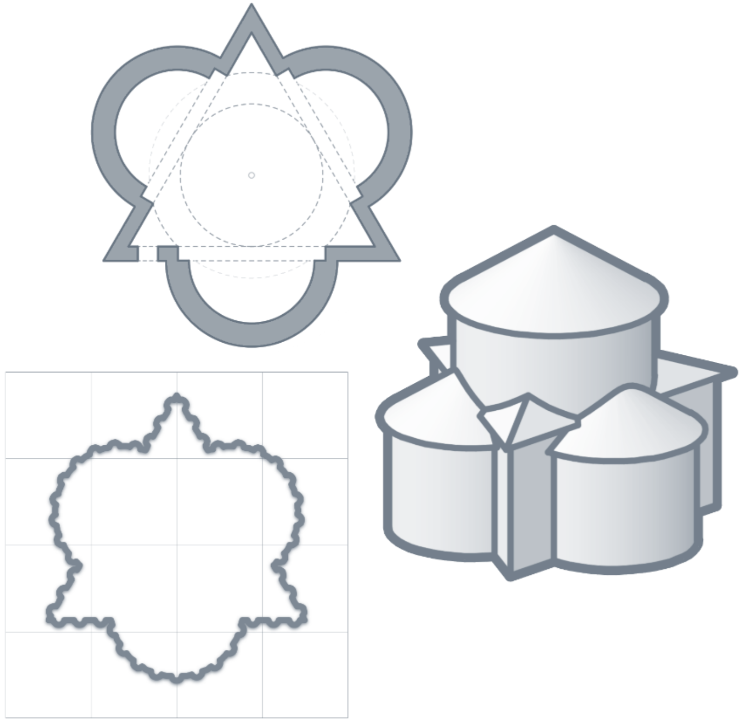
› Functions

› Data

Digital Representation

BMEEPAGA205

László Strommer PhD.



3D Parametric Function

Plotting a 2D projection of a 3D parametric curve (polar).

→ _φ	→ *angle in the base plane*
→ _ρ	→ *angle of spherical projection*
→ $\_x = r_o * \cos(\_\varphi) * \cos(\_\rho)$	→ *x coordinate*
→ $\_y = r_o * \sin(\_\varphi) * \cos(\_\rho)$	→ *y coordinate*
→ $\_z = r_o * \sin(\_\rho)$	→ *z coordinate*

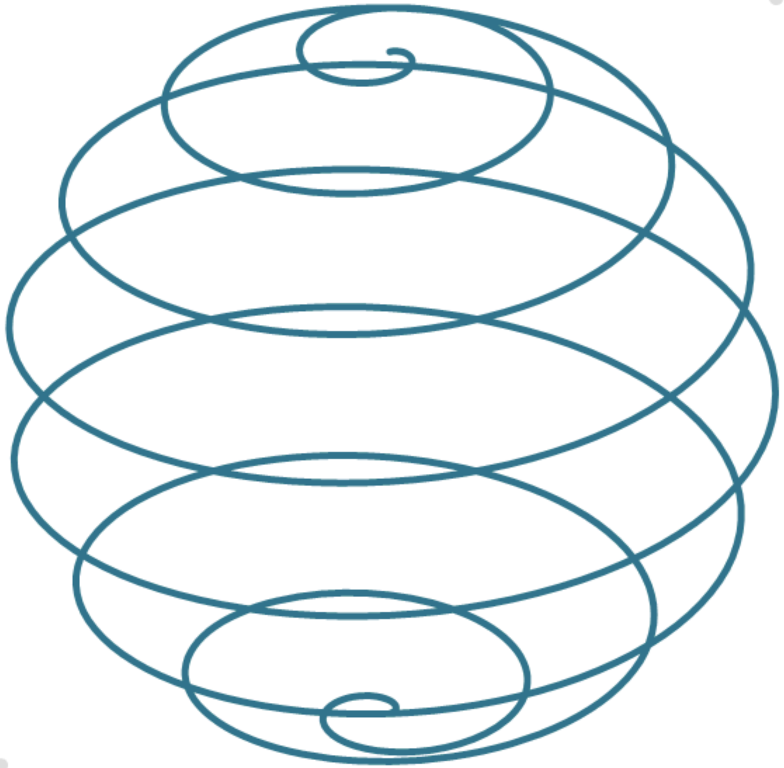
Projection coordinates

λ *angle from the base plane*

θ *rotation angle in the base plane:*

→ $\_u = r_o * \cos(\_\varphi + \theta) * \cos(\_\rho)$

→ $\_v = r_o * \sin(\_\varphi + \theta) * \cos(\_\rho) * \sin(\lambda) + \_z * \cos(\lambda)$



2D Parametric Function

Sometimes it makes sense to use multiple parameters.

→ n = 6 → *6 sections per quarter*

→ s = 4 → *4 quarter*

→ w = 4 → *4 rounds*

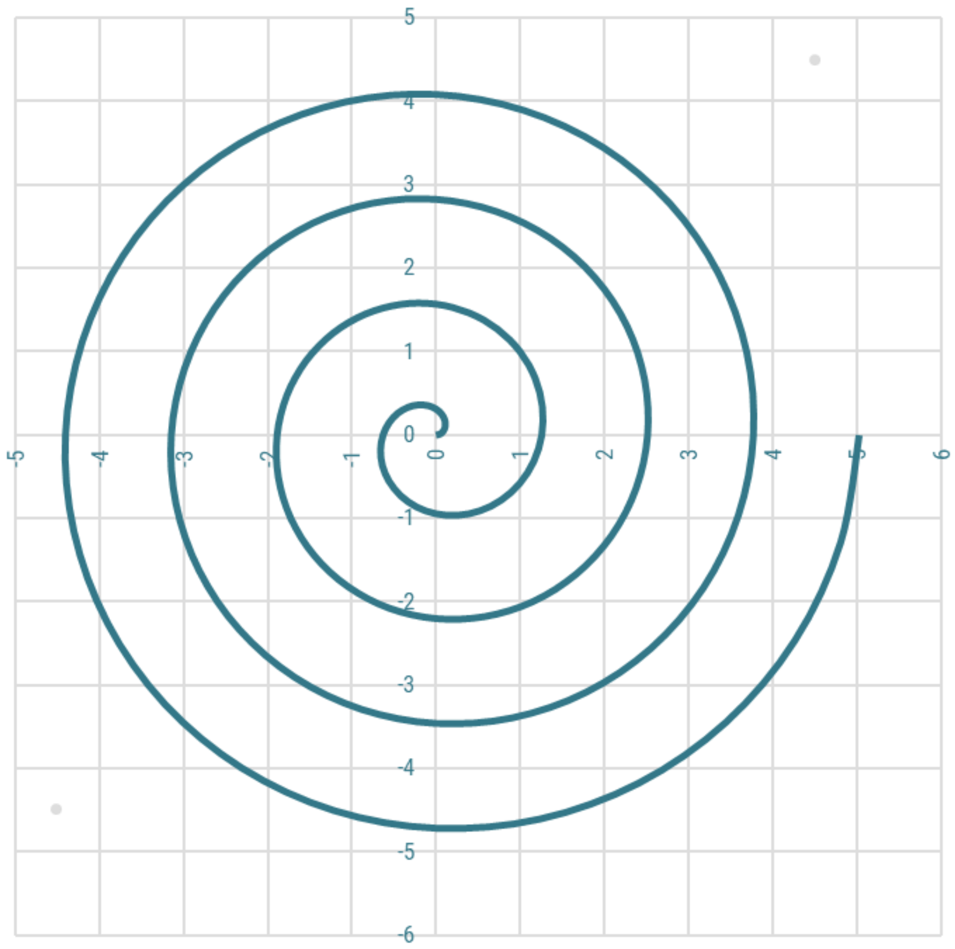
→ _i = SEQUENCE(w*s*n+1; ; 0)

→ _φ = _i/s/n *2*PI() → *central angle*

→ _r = 1/5*_φ → *current radius*

→ _x =_r * COS(_φ) → *x coordinate*

→ _y =_r * SIN(_φ) → *y coordinate*



Freeform Curves

Computer-aided design requires the ability to handle free-form curves and surfaces…

→ interactive design → relatively easy modifiability

→ application of grip-points

→ better if the handle points only have a local effect

→ continuity…

0: common endpoint

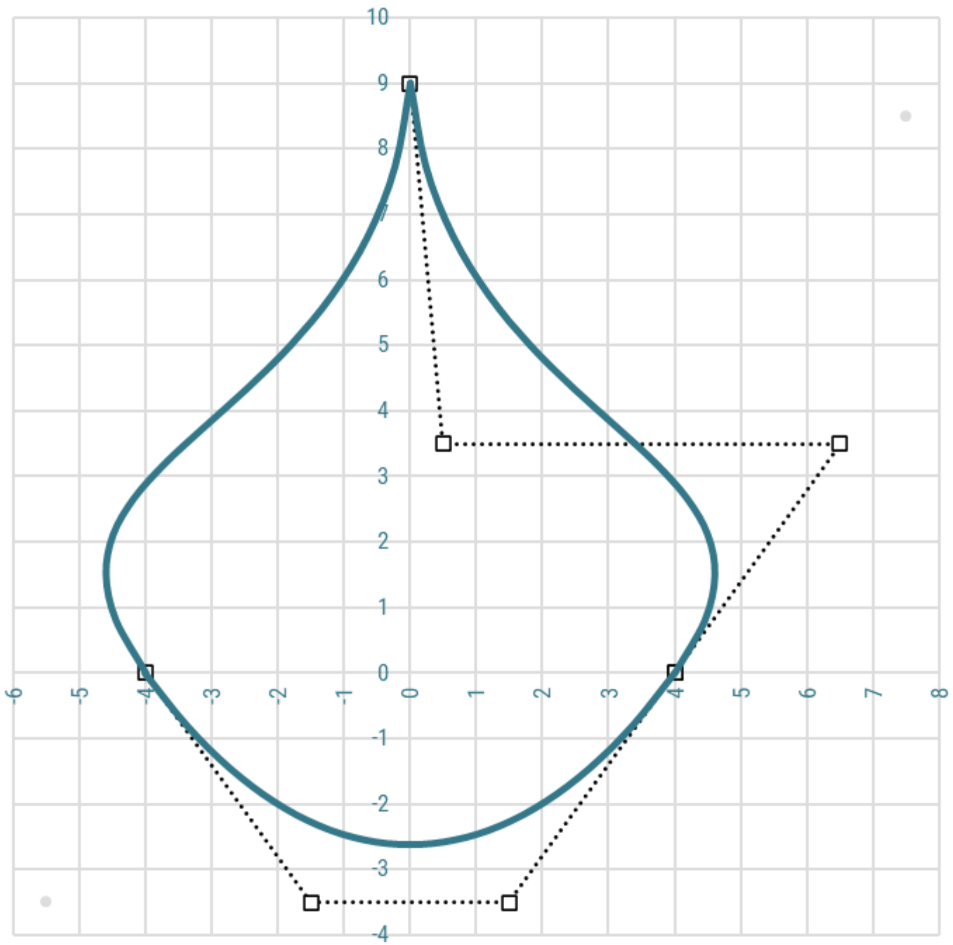
1: common tangent

2: equal curvature

Spline

Bézier curve

B-spline



https://mathworld.wolfram.com/BezierCurve.html

3D Parametric Function

Plotting a 2D projection of a 3D parametric curve (Cartesian).

→ n = 2 → _i = SEQUENCE((n+1)^3; ; 0) /// 0 →26

Ordinal numbers of spatial points in the ternary number system:

→ _p = SEQUENCE(1; 3; 0)

  → _pN = MOD(INT(_i / (n+1)^@_p); n+1)

Coordinates of spatial points (for even n*):*

→ _x = IF(ISEVEN(_p1+_p2); (_p0/n); 1-(_p0/n))

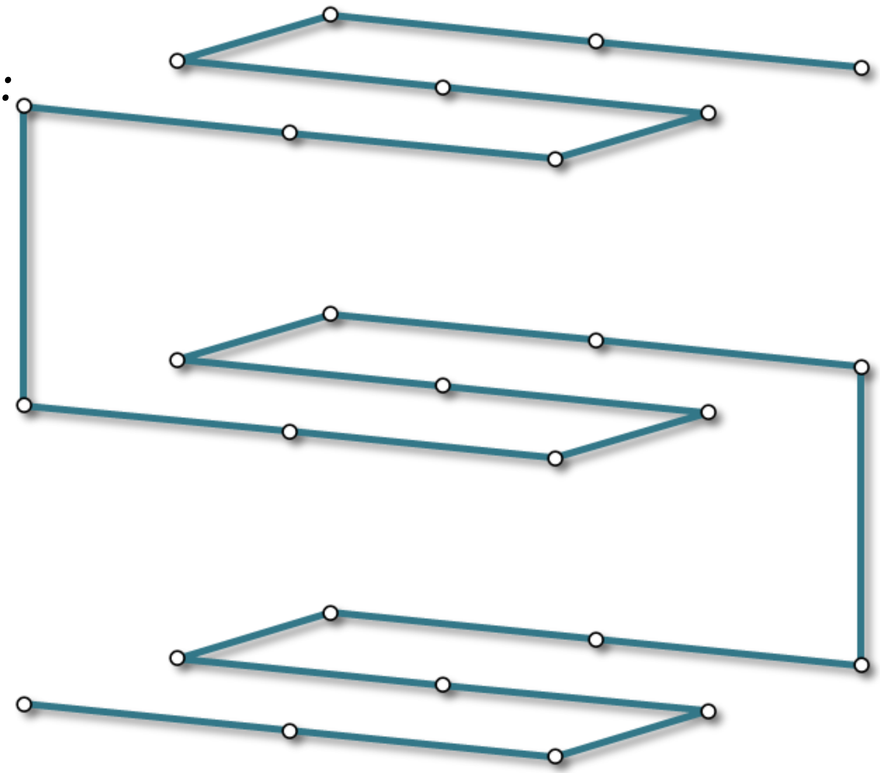
→ _y = IF(ISEVEN(_p2+0); (_p1/n); 1-(_p1/n))

→ _z = _p2/n

Projection coordinates assuming λ *angle from the base plane and* θ *rotation in the base plane:*

→ _u =_x *SIN(-θ) +_y *COS(-θ)

→ _v =_x *-COS(-θ)*SIN(λ) + _y * SIN(-θ)*SIN(λ) +_z * COS(λ)



RGB Color Space

Plotting a 2D projection of a 3D parametric curve (Cartesian).

→ n = 3 | 5 | 15 → _i = SEQUENCE((n+1)^3; ; 0)

Ordinal numbers of points in the ternary number system :

→ _p = SEQUENCE(1; 3; 0)

→ _pN = MOD(INT(_i / (n+1)^@_p); n+1)

Coordinates of spatial points (for odd n*):*

→ _x = IF(ISEVEN(_p1+0); (_p0/n); 1-(_p0/n))

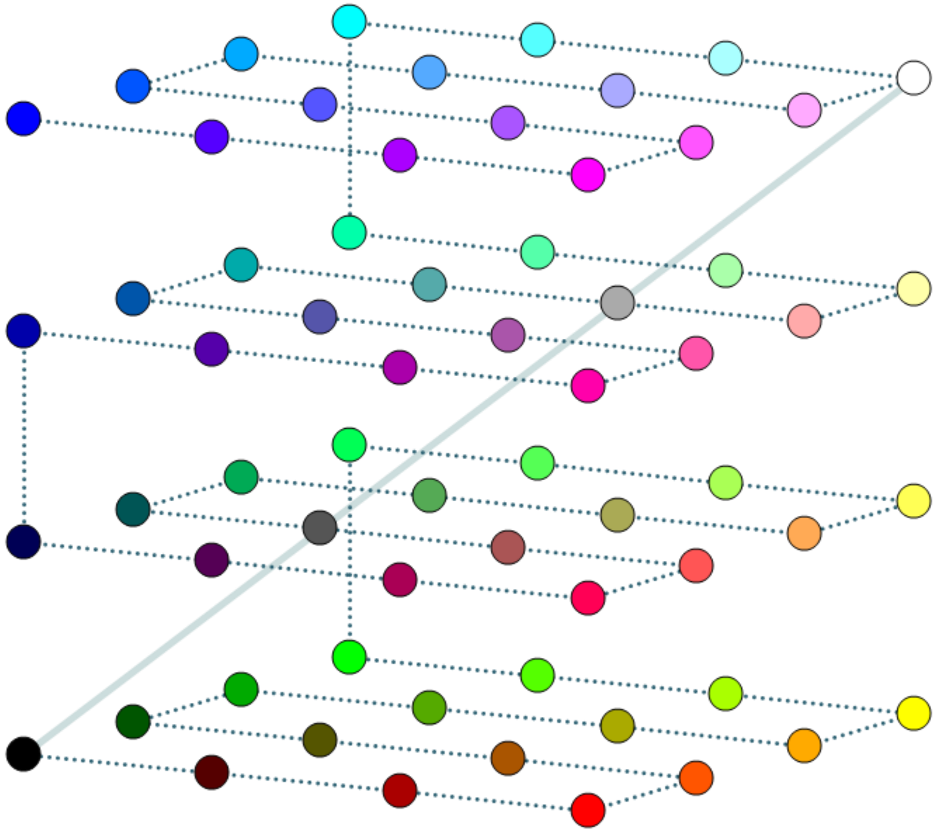
→ _y = IF(ISEVEN(_p2+0); (_p1/n); 1-(_p1/n))

→ _z = _p2/n

Projection coordinates assuming λ *angle from the base plane and* θ *rotation in the base plane:*

→ _u =_x *SIN(-θ) +_y *COS(-θ)

→ _v =_x *-COS(-θ)*SIN(λ) + _y * SIN(-θ)*SIN(λ) +_z * COS(λ)



3D Surface Representation

Plotting a 3D Surface:

→ in case of z=f(x,y) explicit form,

→ only over a rectangular base.

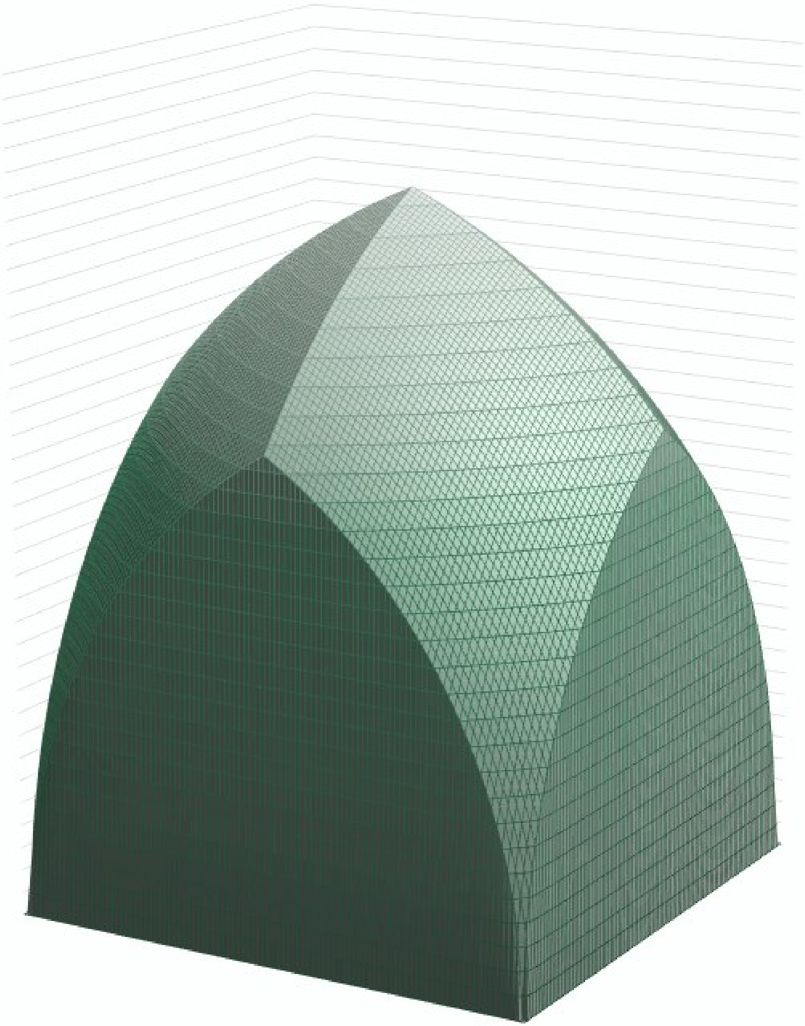
→ The z value corresponding to each division point is displayed – the representation is correct if the division in the x and y directions is even.

→ The ratio of the base and height may be distorted.

→ Each floor plan point can have only one z value:

→ a full sphere cannot be represented,

→ vertical surfaces cannot be represented, they can only be approximated.



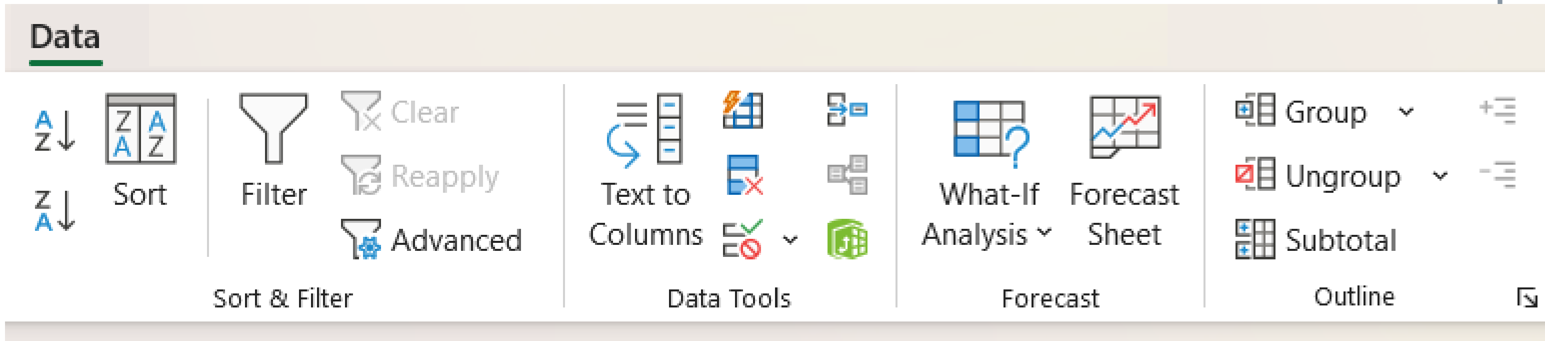
Data Validation

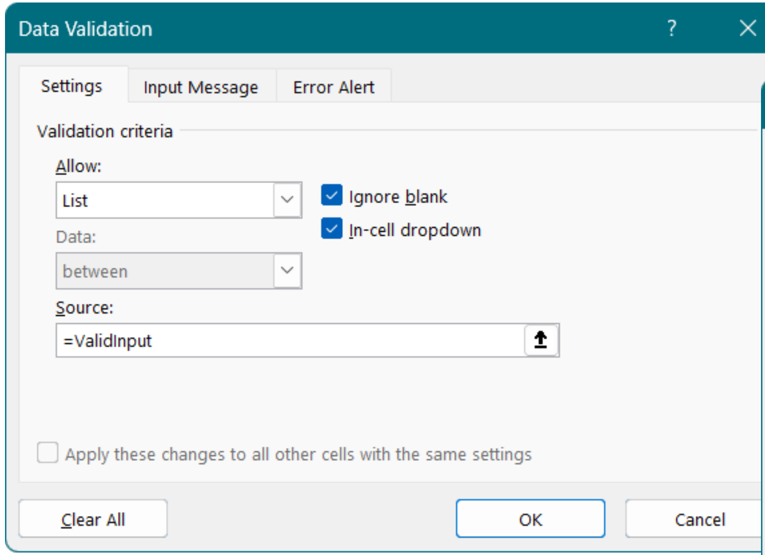
Data entry can be facilitated, or restricted…

→ e.g. list of elements:
Mon;Tue;Wed;Thu;Fri

→ or elements of a range:
=ValidInput

→ the reaction
for invalid entry
ranges from refusal,
to warning,
or nothing.





Validation criteria

Allow: List

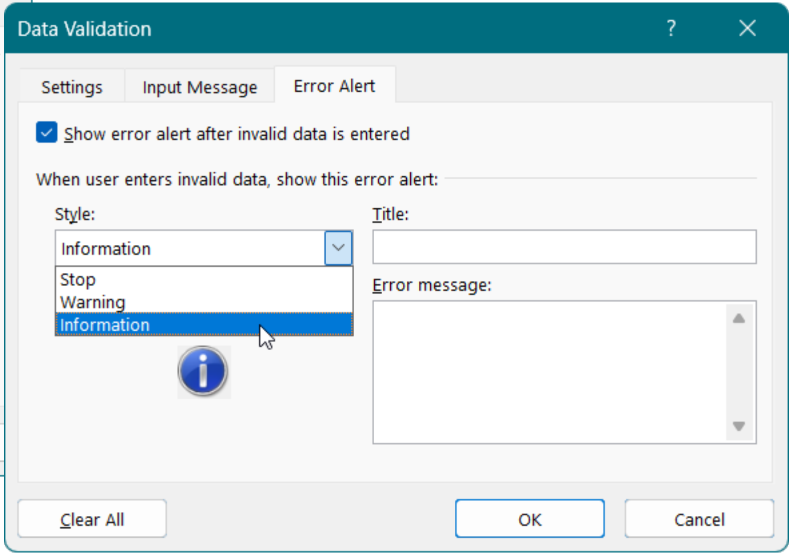
☑ Ignore blank

☑ In-cell dropdown

Data: between

Source: =ValidInput

☐ Apply these changes to all other cells with the same settings



☑ Show error alert after invalid data is entered

When user enters invalid data, show this error alert:

Style: Information
- Stop
- Warning
- Information

Title:

Error message:

Data Entry Assistance

→ Define the input column as a dynamic range:

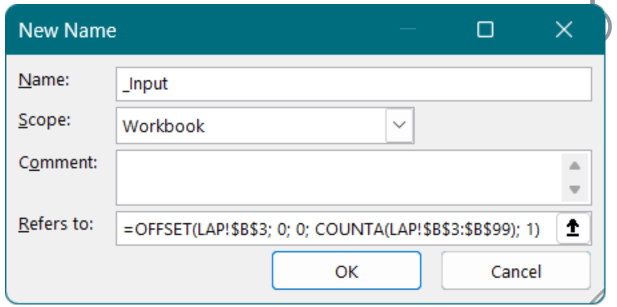
_Input→ =OFFSET(LAP!$B$3; 0; 0; COUNTA(LAP!$B$3:$B$99); 1)

→ List of unique items based on the input:

D3 =SORT(UNIQUE(_Input)

previously:

=IFNA(INDEX(Lista1; MATCH(0;INDEX(COUNTIFS(D$2:D2;Lista1);0;0);0));"·")



Name: _Input

Scope: Workbook

Comment:

Refers to: =OFFSET(LAP!$B$3; 0; 0; COUNTA(LAP!$B$3:$B$99); 1)

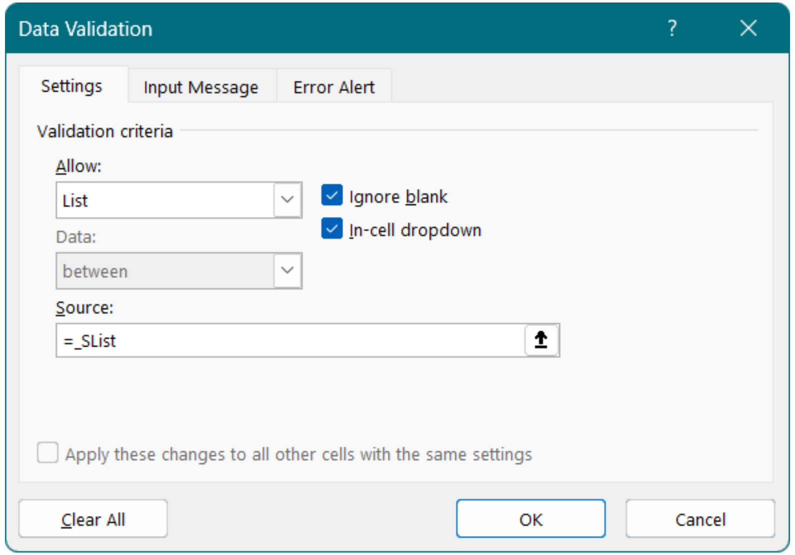
→ Define the dynamic unique list:

_SList→ = LAP!$D$3#

→ Validate input data:

Allow: List

Source =_SList



Validation criteria

Allow: List

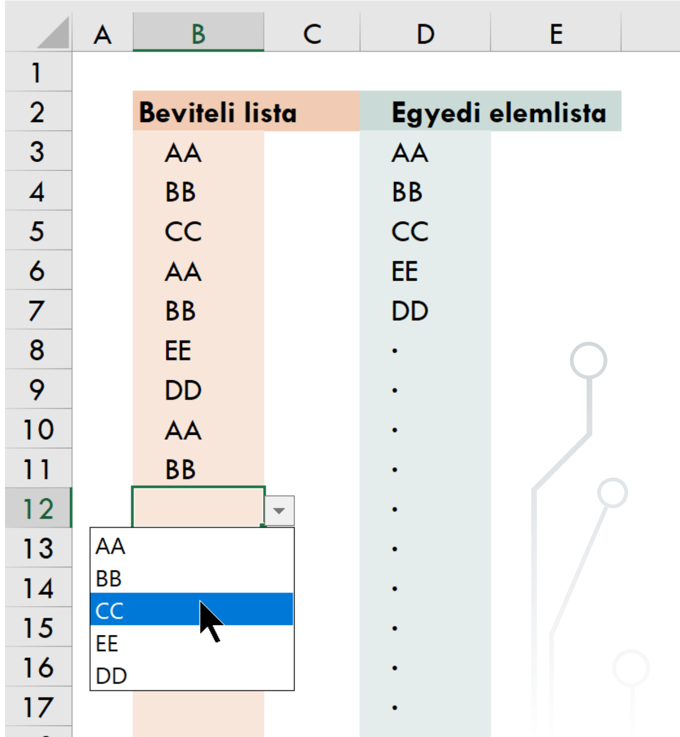
☑ Ignore blank

☑ In-cell dropdown

Data: between

Source: =_SList

☐ Apply these changes to all other cells with the same settings



	A	B	C	D	E
1					
2		**Beviteli lista**		**Egyedi elemlista**	
3		AA		AA	
4		BB		BB	
5		CC		CC	
6		AA		EE	
7		BB		DD	
8		EE		·	
9		DD		·	
10		AA		·	
11		BB		·	
12				·	
13				·	
14				·	
15				·	
16				·	
17				·	

Perspicuity

→ Freeze headers or split screen:

View ↘ Freeze Panes, or View ↘ Split.

→ Freeze headers in print:

Page Layout ↘ Print Titles.

→ Highlighting important elements:

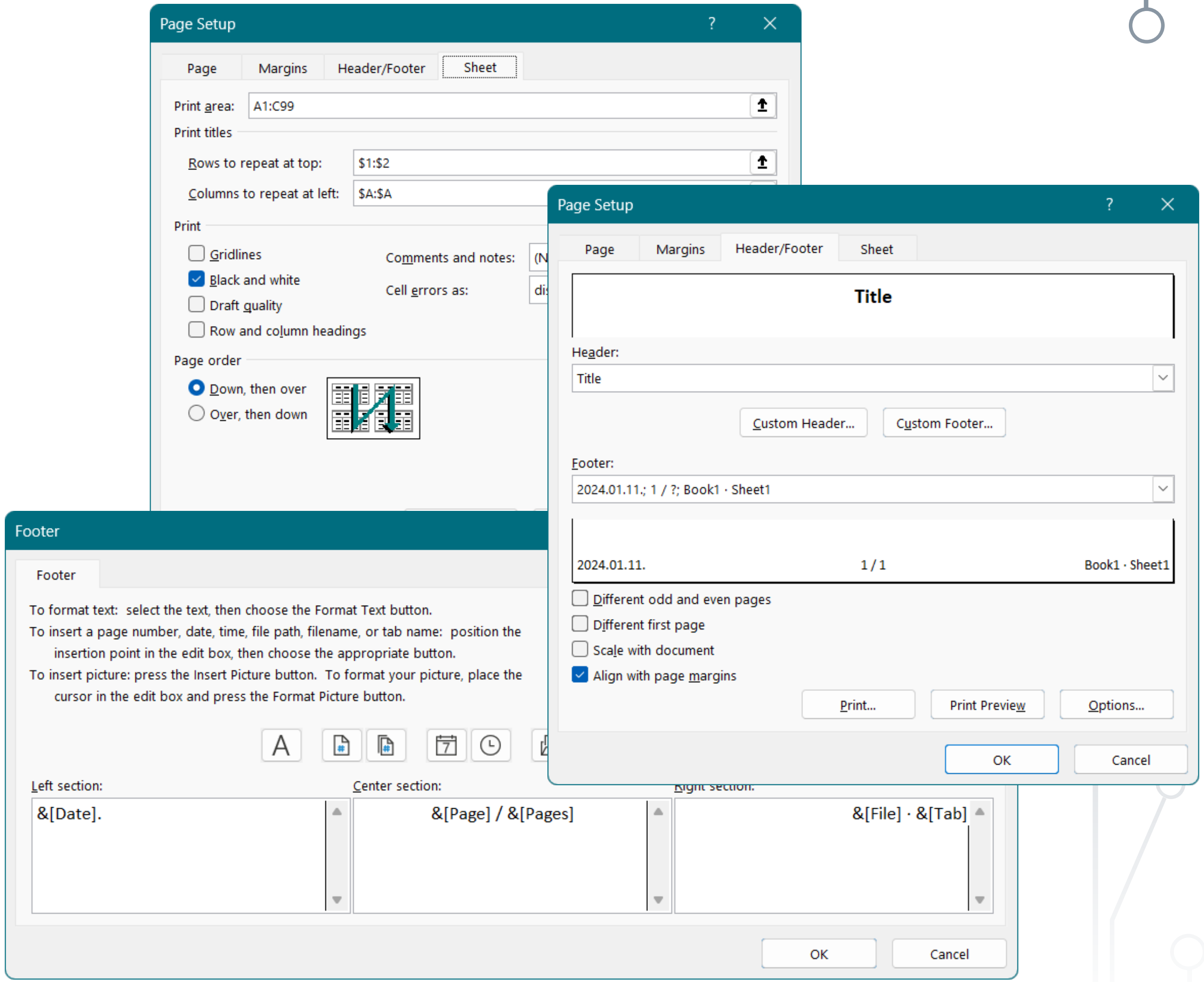
Format Cells/ Fill

In print it can be set to appear in black and white, without background color.

→ Outline and group if necessary:

Data ↘ Outline.

→ Page number, title, file name, date, time…



Print area: A1:C99

Print titles

Rows to repeat at top: $1:$2

Columns to repeat at left: $A:$A

Print

□ Gridlines
☑ Black and white
□ Draft quality
□ Row and column headings

Comments and notes: (N

Cell errors as: di

Page order

● Down, then over
○ Over, then down

Title

Header: Title

Custom Header... Custom Footer...

Footer: 2024.01.11.; 1 / ?; Book1 · Sheet1

2024.01.11. 1 / 1 Book1 · Sheet1

□ Different odd and even pages
□ Different first page
□ Scale with document
☑ Align with page margins

Print... Print Preview Options...

To format text: select the text, then choose the Format Text button.

To insert a page number, date, time, file path, filename, or tab name: position the insertion point in the edit box, then choose the appropriate button.

To insert picture: press the Insert Picture button. To format your picture, place the cursor in the edit box and press the Format Picture button.

Left section: &[Date].

Center section: &[Page] / &[Pages]

Right section: &[File] · &[Tab]

Text File Import

Almost every program can save data in textual format…

→ records are usually lines, that are separated:

→ CR – Carriage Return – CHAR(13),

→ LF – Line Feed – CHAR(10).

→ fields are usually columns, that are separated:

→ after a given number of characters,

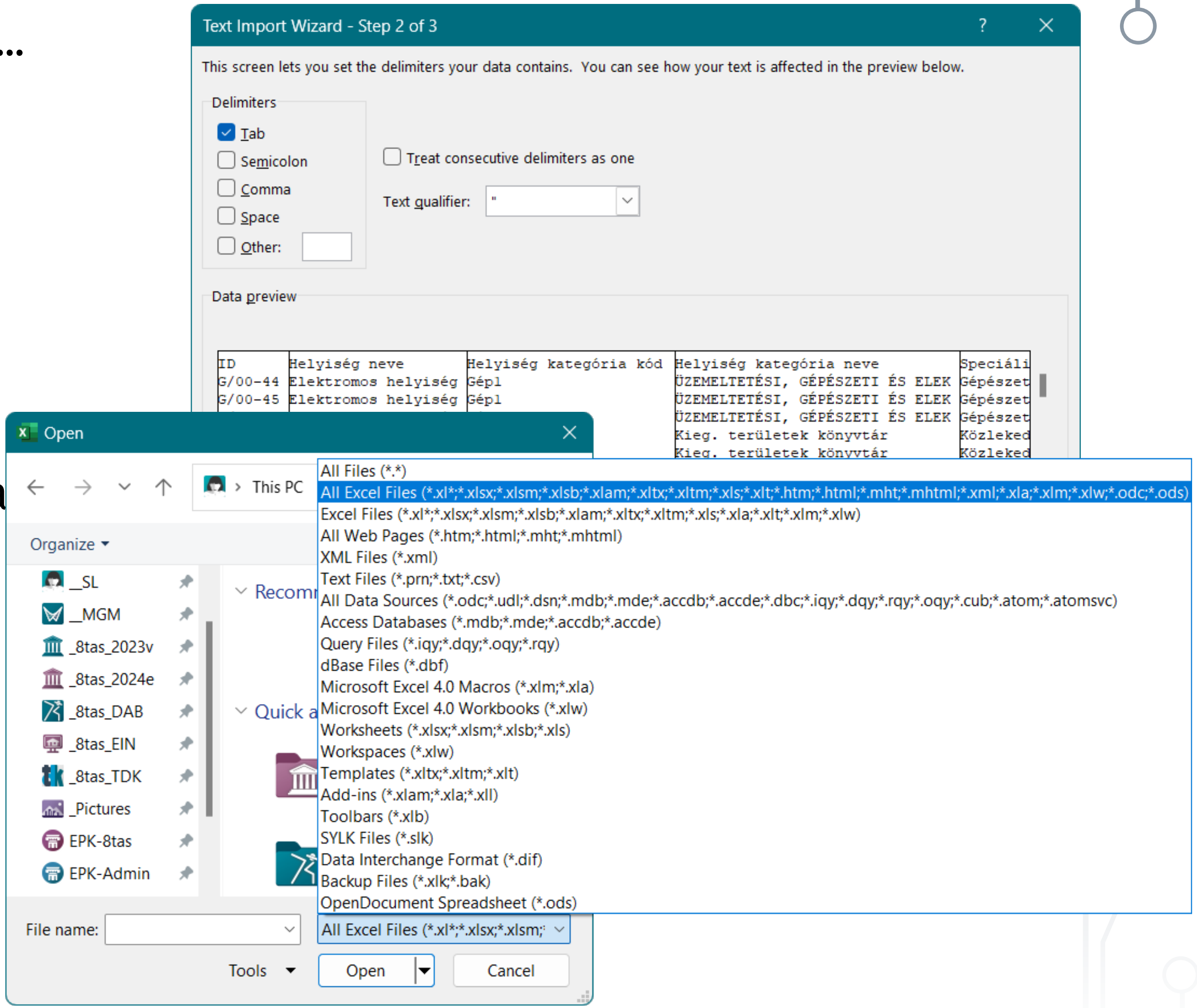
→ a specific character, e.g. Tab, Semicolon, Comma

Dynamic Data Import

→ from file: text (txt), table (Excel, html), database (Access, Dbase…), Internet

→ from a database server: e.g. MS SQL

→ update at given interval or on opening.



Text Import Wizard - Step 2 of 3

This screen lets you set the delimiters your data contains. You can see how your text is affected in the preview below.

Delimiters

☑ Tab
☐ Semicolon
☐ Comma
☐ Space
☐ Other:

☐ Treat consecutive delimiters as one

Text qualifier: "

Data preview

ID	Helyiség neve	Helyiség kategória kód	Helyiség kategória neve	Speciáli
G/00-44	Elektromos helyiség	Gépl	ÜZEMELTETÉSI, GÉPÉSZETI ÉS ELEK	Gépészet
G/00-45	Elektromos helyiség	Gépl	ÜZEMELTETÉSI, GÉPÉSZETI ÉS ELEK	Gépészet
			ÜZEMELTETÉSI, GÉPÉSZETI ÉS ELEK	Gépészet
			Kieg. területek könyvtár	Közleked
			Kieg. területek könyvtár	Közleked

Open

File name:

All Excel Files (*.xl*;*.xlsx;*.xlsm;

?
This PC
Organize ▾
_SL
_MGM
_8tas_2023v
_8tas_2024e
_8tas_DAB
_8tas_EIN
_8tas_TDK
_Pictures
EPK-8tas
EPK-Admin
Recomm
Quick a
All Files (*.*)
All Excel Files (*.xl*;*.xlsx;*.xlsm;*.xlsb;*.xlam;*.xltx;*.xltm;*.xls;*.xlt;*.htm;*.html;*.mht;*.mhtml;*.xml;*.xla;*.xlm;*.xlw;*.odc;*.ods)
Excel Files (*.xl*;*.xlsx;*.xlsm;*.xlsb;*.xlam;*.xltx;*.xltm;*.xls;*.xla;*.xlt;*.xlm;*.xlw)
All Web Pages (*.htm;*.html;*.mht;*.mhtml)
XML Files (*.xml)
Text Files (*.prn;*.txt;*.csv)
All Data Sources (*.odc;*.udl;*.dsn;*.mdb;*.mde;*.accdb;*.accde;*.dbc;*.iqy;*.dqy;*.rqy;*.oqy;*.cub;*.atom;*.atomsvc)
Access Databases (*.mdb;*.mde;*.accdb;*.accde)
Query Files (*.iqy;*.dqy;*.oqy;*.rqy)
dBase Files (*.dbf)
Microsoft Excel 4.0 Macros (*.xlm;*.xla)
Microsoft Excel 4.0 Workbooks (*.xlw)
Worksheets (*.xlsx;*.xlsm;*.xlsb;*.xls)
Workspaces (*.xlw)
Templates (*.xltx;*.xltm;*.xlt)
Add-ins (*.xlam;*.xla;*.xll)
Toolbars (*.xlb)
SYLK Files (*.slk)
Data Interchange Format (*.dif)
Backup Files (*.xlk;*.bak)
OpenDocument Spreadsheet (*.ods)
Tools ▾
Open
Cancel

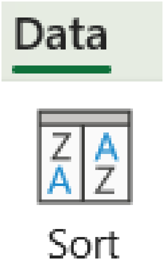
Sort

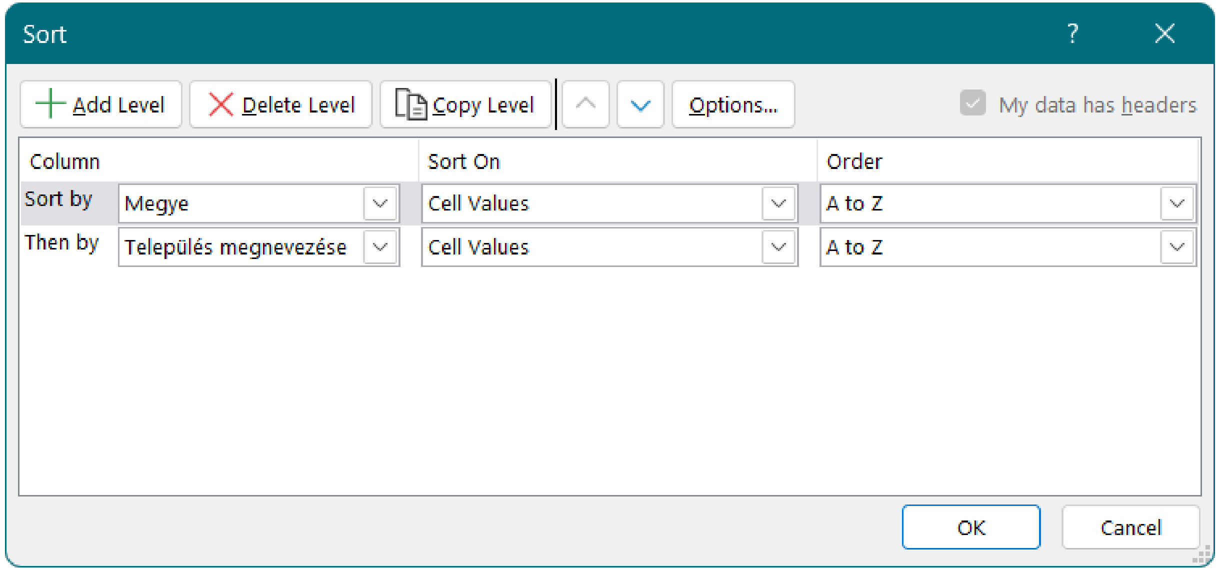
Sorting of data according to several (ranked) aspects Data ↘ Sort ...

→ the data table should not contain merged cells,

→ each column should have a title,

→ the area should not contain empty rows and columns should be continuous (selectable by Ctrl+A).

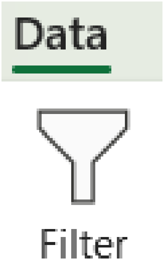




☑ My data has headers

	Column	Sort On	Order
Sort by	Megye	Cell Values	A to Z
Then by	Település megnevezése	Cell Values	A to Z

Filter

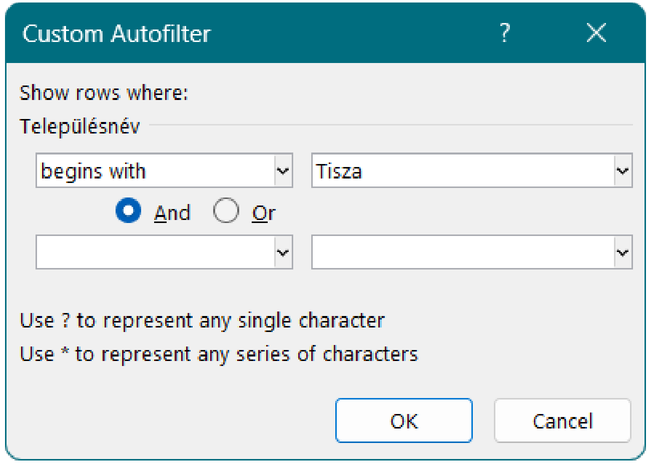


Data filtering Data ↘ Filter ...

→ the (contiguous) range below selected cells can be filtered,

→ the filters can be combined

e.g. show the settlements whose name begins with “Tisza”, and whose population is ≥10k, and <50k.



Custom Autofilter

Show rows where:

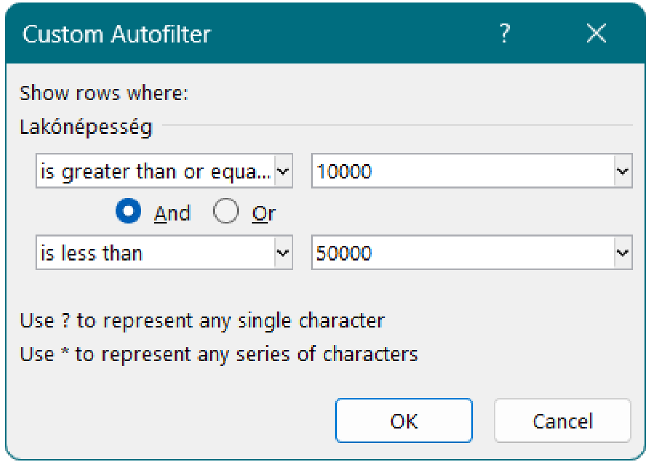
Településnév

begins with | Tisza

● And ○ Or

Use ? to represent any single character

Use * to represent any series of characters



Custom Autofilter

Show rows where:

Lakónépesség

is greater than or equa... | 10000

● And ○ Or

is less than | 50000

Use ? to represent any single character

Use * to represent any series of characters

Data Management

A spreadsheet is not a database, it is not suitable for the secure storage of large amounts of data ...

→ the table size is a strong limit – it cannot store e.g. the data of all BME students,

→ difficult (can only be solved by password protection of the page) to control (authorize) the modification of sensitive data,

→ it is practically impossible to log the changes.

It is suitable – especially for smaller amounts of data...

→ for quick sorting of data,

→ to filter out data sets that meet given conditions,

→ to produce derived data,

→ to create charts.

Formats

List

→ in the first row the headers specifiy (identify) the categories – there can only be one such row

→ in the other rows (records) the items of a given column (fields) belong to that category (e.g. Neptun code), and must be of the same type (text, number, date),

→ and there can be no blank rows and columns.

Form

→ details of a given record in tabular form (field name and <value>)

Summary Table

→ can contain sums, numbers, averages...

Field & Record

Data Field

→contains numerical or textual data

Data Record

→different types of data fields belonging to an object

	Field 01	Field 02	Field 02	Field 02
Record 01	Asimov, Isaac	Alapítvány	Foundation	1951.
Record 02	Herbert, Frank	Dűne	Dune	1965.
Record 03	Pohl, Frederik	Az átjáró	Gateway	1977.
Record 03	Zsoldos Péter	Ellenpont		

Relation

A relation is a table ...

Rows

→ logically related data,

→ their order is indifferent (if not, then it is not a relation),

→ no two can be exactly alike.

Columns

→ data of the same type (attributes),

→ columns have a unique name (field name),

→ should not contain a value that can be derived from another attribute of same row.

Primary Key

A row of the relation is clearly identified...

→ a group of attributes that identify only one row (unambiguity),

→ no subset of attributes in the key constitutes a key

→ the value of the attributes in the key cannot be undefined (NULL).

ID	Room Name
EG_00_44	Electrical room
EG_00_45	Electrical room
EG_00_48	Electrical room
EK_00_01	Ante-room
EK_00_02	Library entrance

Consultation

Teacher	Date	Student
ML	2008.10.01	Hallgató Bálint
LP	2008.10.08	Építész Gábor
LP	2008.10.08	Ábris János
FT	2008.10.03	

Redundancy

Storing a fact multiple times, or storing data that can be derived from other data, should be avoided...

→ if the category of a room changes, several fields in the record must be changed,

→ for a new room, the name of the room category must be found out from the previous lines of the given category,

→ by deleting a room, its category may also disappear, the category code-name association can be lost.

A duplicate is not necessarily a redundancy...

→ e.g. LP|2007.10.08.

Consultation

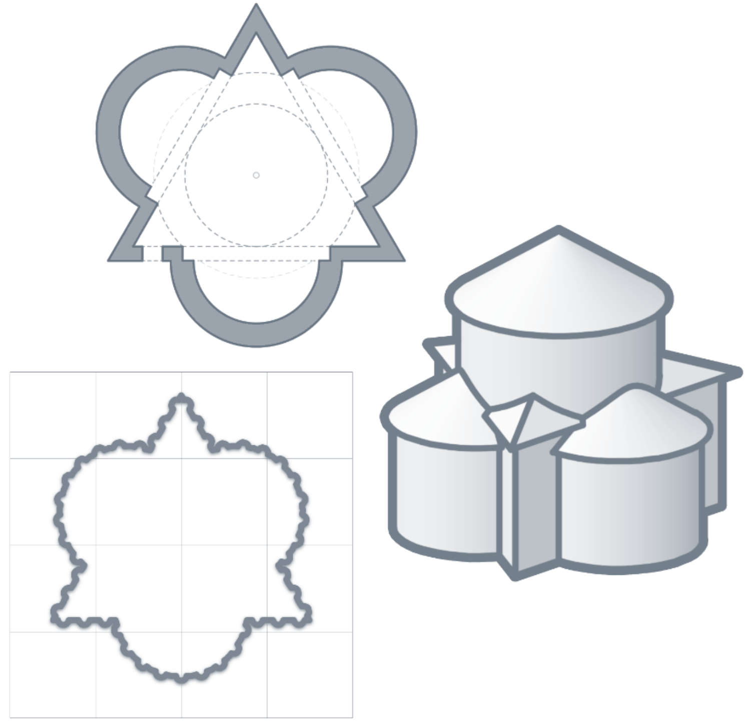
Teacher	Date	Student
ML	2008.10.01.	Hallgató Bálint
LP	2008.10.08.	Építész Gábor
LP	2008.10.08.	Ábris János
FT	2008.10.03.	

Spreadsheet ❯ Data Tables

Digital Representation

BMEEPAGA205

László Strommer PhD.



Tables

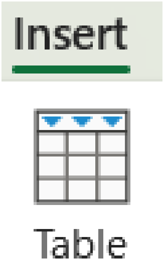
Defining a contiguous range of data as a table can make it easier to manage it

Insert ↘ Table

→ standing inside the area of the created table, a new ribbon menu appears,

→ this allows the automatic formatting of the table to be set,

→ it is always worth giving the table a meaningful name.



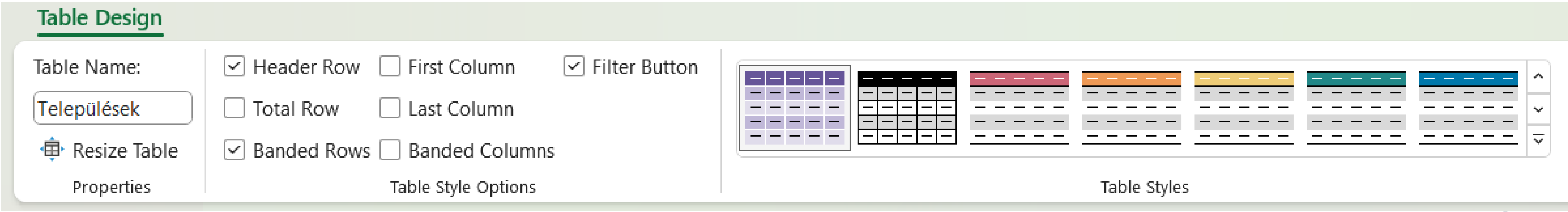


Table Design

Table Name: Települések

Resize Table

Properties

☑ Header Row □ First Column ☑ Filter Button

□ Total Row □ Last Column

☑ Banded Rows □ Banded Columns

Table Style Options

Table Styles

Data management · Aggregation

You can query the range's sum or product (SUM() |PRODUCT()),
count the number of cells that are numbers, blanks, or not blanks (COUNT() |COUNTBLANKS() |COUNTA()),
calculate their average, median, minimum or maximum (AVERAGE() |MEDIAN() |MIN()|MAX()),
search for the k-th largest or smallest value (LARGE(), SMALL()),
query other statistical characteristics (e.g. geometric mean, mode, standard deviation, variance),
and calculate the sum of the product of corresponding ranges (e.g. for weighted average) (SUMPRODUCT()).

The logic of the aggregation is sometimes obvious – but there are more complicated indicators also...

→ number of settlements (→number of records) =COUNTA(Settlements[Name]),

→ number of apartments (→sum of an entire column) =SUM(Settlements[Apartments]),

→ average population of settlements =AVERAGE(Settlements[Population]),

→ residents live in a settlement with this number of inhabitants on average (→ weighted average):
=SUMPRODUCT(Settlements[Population]; Settlements[Population]) / SUM(Settlements[Population])

Conditional Aggregation

A search table can be generated by collecting the unique values of a given column of the data table (UNIQUE()), sorting them (SORT()) and, if necessary, transposing them horizontally (TRANSPOSE()):

=TRANSPOSE(SORT(UNIQUE(Settlements[Region])))

The resulting dynamic range should be given a characteristic name(e.g. _RegionList).

The summary table can be uploaded with the calculated data...

→ Count the records that match one or more criteria (COUNTIFS())

→ number of settlements =COUNTIFS(Settlements[Region]; _RegionList)

→ Summarize a field of records that match one or more criteria (SUMIFS())

→ number of inhabitants =SUMIFS(Settlements[Population]; Settlements[Region]; _RegionList)

→ Similarly, the minimum, maximum, and average can also be queried (e.g. AVERAGEIFS ())

→ average population of settlements =AVERAGEIFS(Settlements[Population]; Settlements[Region]; _RegionList)

Classification

Search functions can be used to classify elements according to a given property...

→ first, a classification table with the limits must be created ▶

→ based on this table, the original table can be supplemented with a new column :

→ search vertically or horizontally (XLOOKUP()):

=XLOOKUP([@Population]; limit; size; ;-1)

→ in previous versions (INDEX() / XMATCH()):

=INDEX(size; MATCH([@ Population]; limit;   ))

→ the task can be solved with nested IF() functions, or the IFS() function.

size	limit
tiny	0
small	1000
medium	5000
big	25000
mega	75000

The purpose of the classification is obviously to prepare the table for a conditional aggregation...

→ number of settlements in each category =COUNTIFS(Settlements[Size]; size)

→ number of inhabitants in each category =SUMIFS(Settlements[Population]; Settlements[Size]; size)

Pivot Table

The pivot table can be used to analyze the data table (Insert ↘ Pivot Table)

→ it can show different aspects horizontally and vertically (+hierarchically),

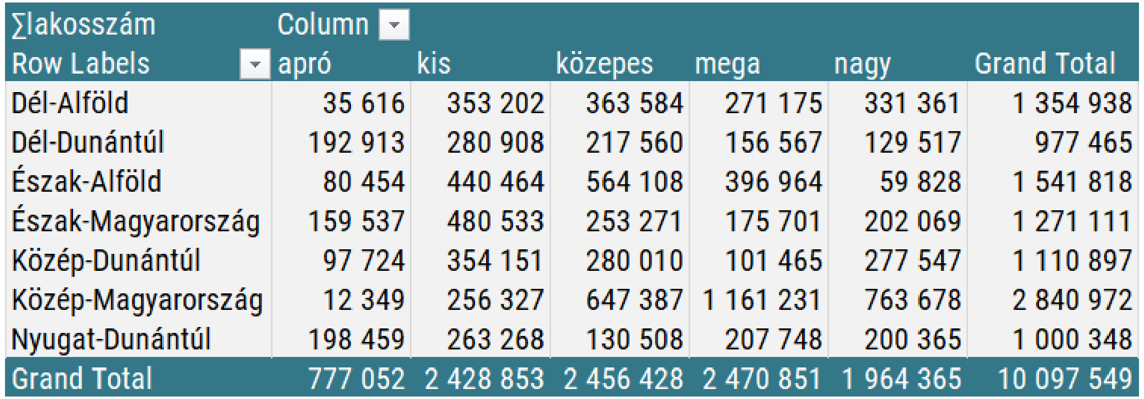
→ the connection to datasheet can be refreshed.

The data analysis can usually be solved with aggregator functions also…

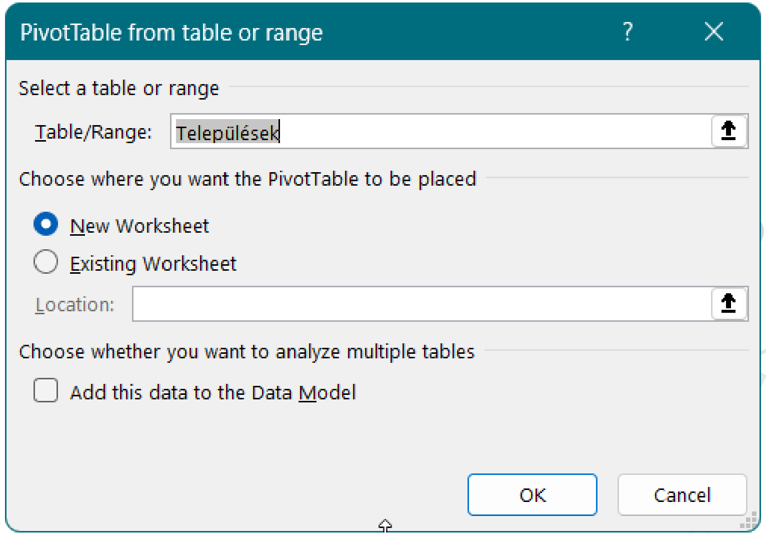
→ =SUMIFS(Settlements[Population]; Settlements[Region]; _RegionList; Settlements[Size]; size)

→ the pivot table can be altered and rearranged more quickly,

→ the pivot table can be more freely formatted and shaped (e.g. order), its aspects can be customized (e.g. combining types)



∑lakosszám	Column ▾					
Row Labels ▾	apró	kis	közepes	mega	nagy	Grand Total
Dél-Alföld	35 616	353 202	363 584	271 175	331 361	1 354 938
Dél-Dunántúl	192 913	280 908	217 560	156 567	129 517	977 465
Észak-Alföld	80 454	440 464	564 108	396 964	59 828	1 541 818
Észak-Magyarország	159 537	480 533	253 271	175 701	202 069	1 271 111
Közép-Dunántúl	97 724	354 151	280 010	101 465	277 547	1 110 897
Közép-Magyarország	12 349	256 327	647 387	1 161 231	763 678	2 840 972
Nyugat-Dunántúl	198 459	263 268	130 508	207 748	200 365	1 000 348
Grand Total	777 052	2 428 853	2 456 428	2 470 851	1 964 365	10 097 549



PivotTable from table or range

Select a table or range

Table/Range: Települések

Choose where you want the PivotTable to be placed

● New Worksheet

○ Existing Worksheet

Location:

Choose whether you want to analyze multiple tables

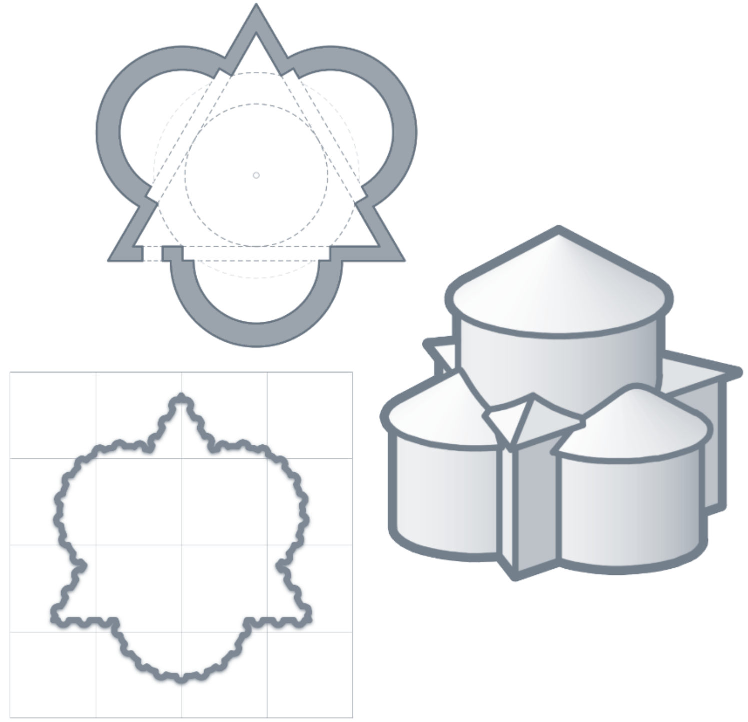
□ Add this data to the Data Model

Spreadsheet
❯ Fractals

Digital Representation

BMEEPAGA205

László Strommer PhD.



Fractals · Coastline Paradox

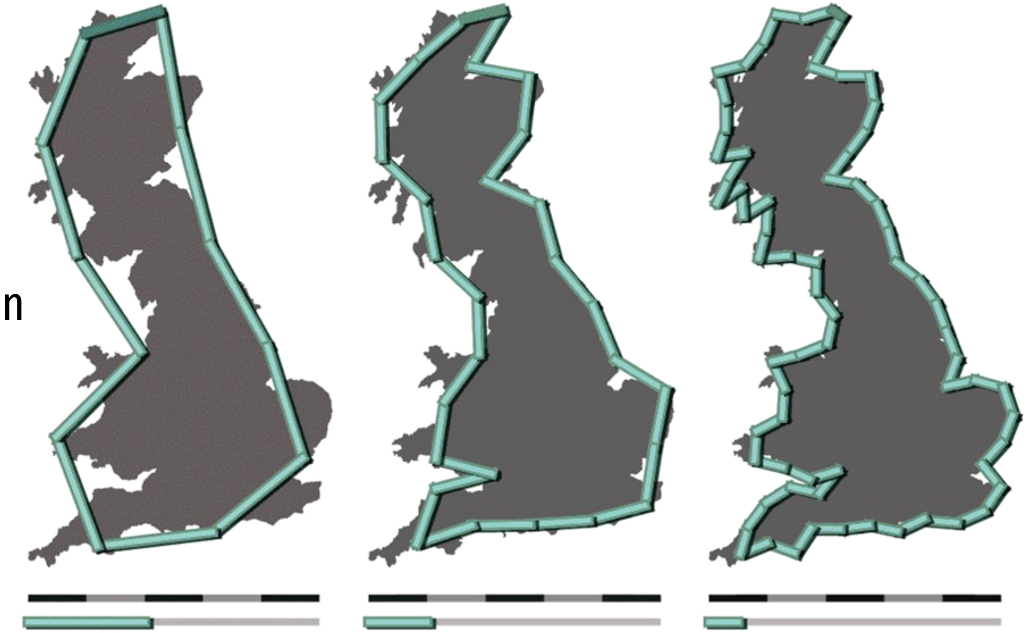
A coastline does not have a clearly defined length.

Maps (like architectural plans) seek to abstract spatial information at a high level of detail to information that can be rendered at a lower level of detail…

→ the measured length of the depicted coastline depends on the level of map generalization (Steinhaus 1954).

The more accurate the measurement (the shorter the ruler), the greater the measured length…

→ surprisingly, the length increases infinitely, it does not converge to a limit (Richardson 1951).



https://commons.wikimedia.org/w/index.php?curid=642221

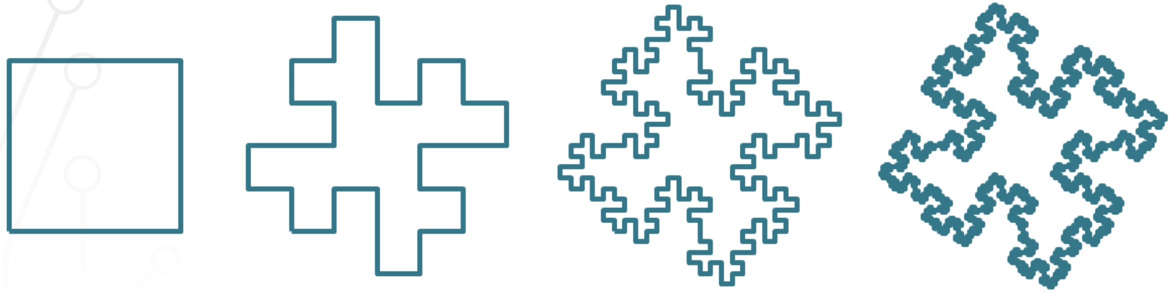
Deterministic Fractals

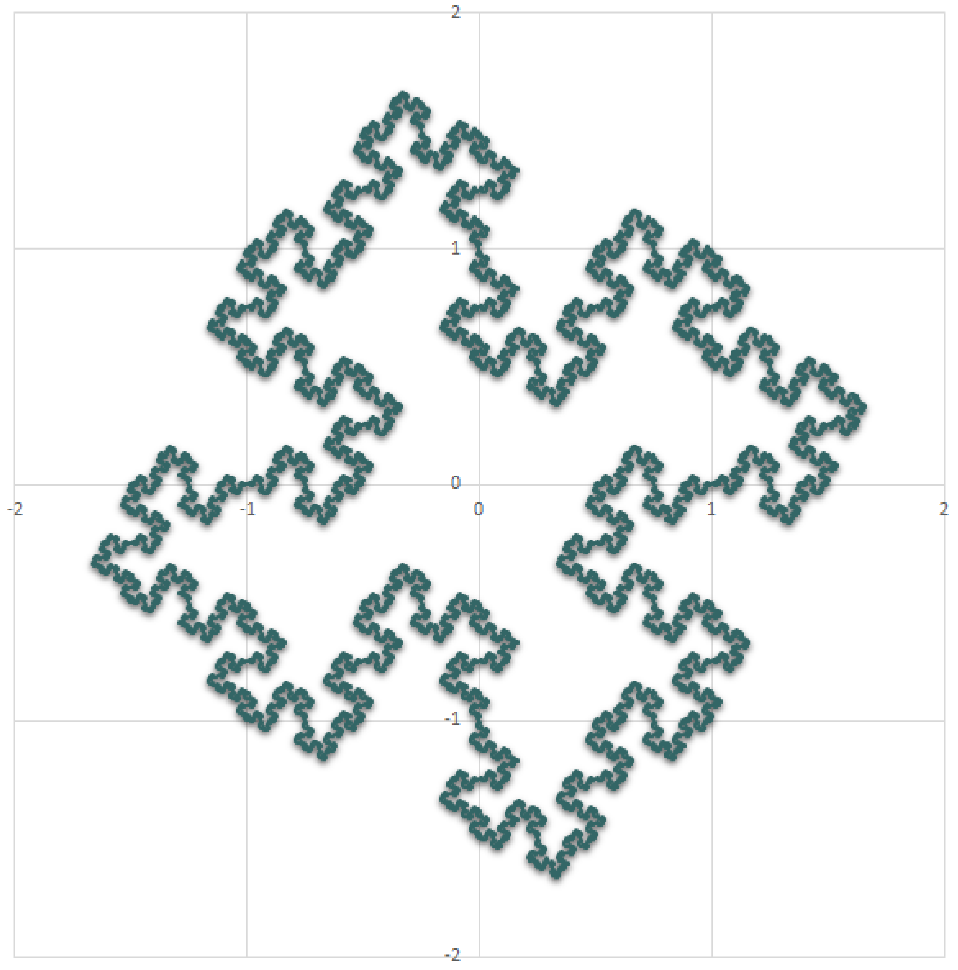
› Minkowski curve

	N	unit	perim.	N	unit	area
0	s	1a	sa	1	1^2a	$1a^2$
1	8s	¼a	2sa	4^2	$(¼)^2$a	$1a^2$
2	8^2s	$¼^2$a	4sa	$(4^2)^2$	$(¼^2)^2$a	$1a^2$
3	8^3s	$¼^3$a	8sa	$(4^3)^2$	$(¼^3)^2$a	$1a^2$
n	8^ns	$¼^n$a	2^nsa	$(4^n)^2$	$(¼^n)^2$a	$1a^2$

s *number of sides* a *side length*

→ *After infinite iterations, the curve has an infinite perimeter.*





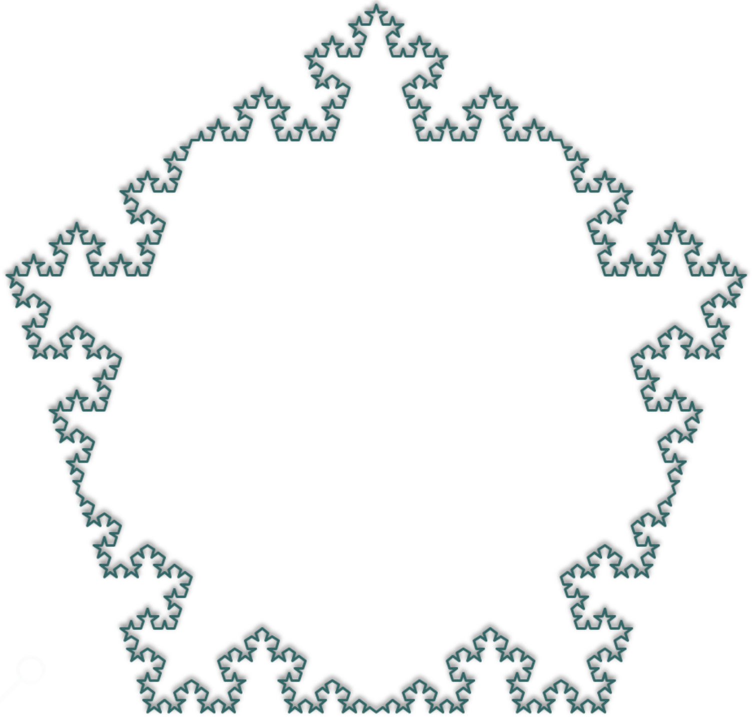
https://en.wikipedia.org/wiki/Koch_snowflake

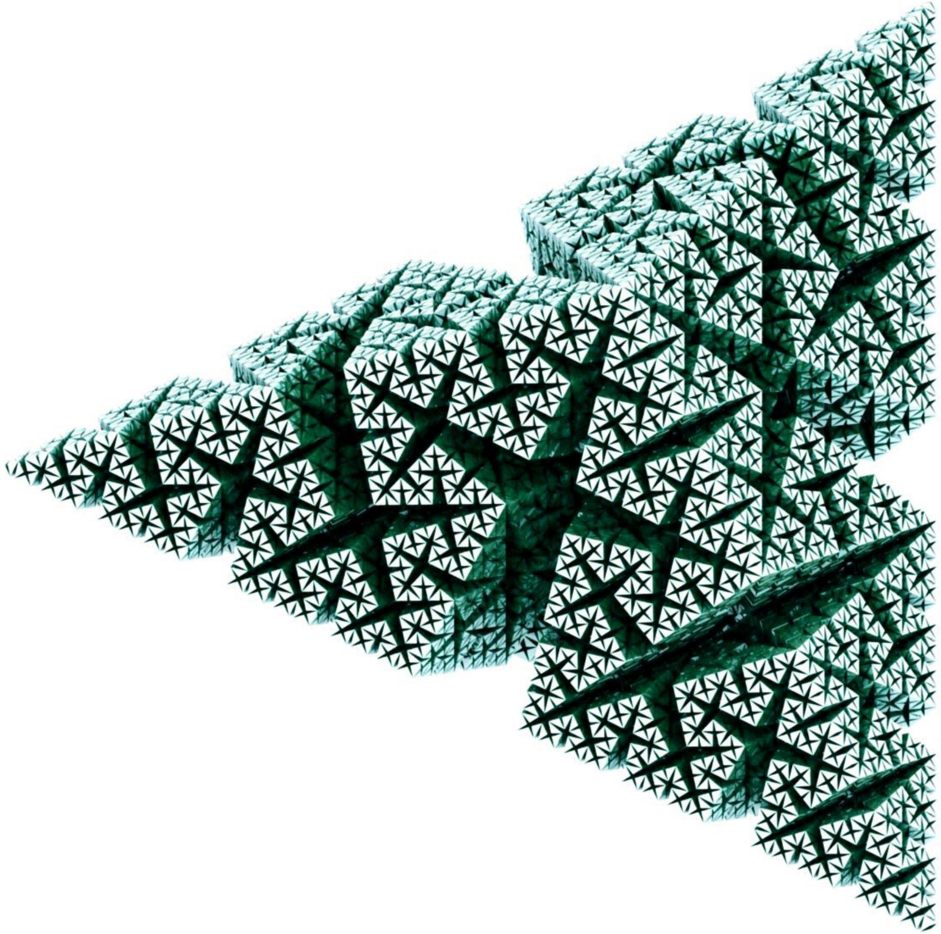
Deterministic Fractals 2D / 3D

After infinite number of iterations any Koch curve variant encloses a finite area but has an infinite perimeter.

→ The same logic can be extended to 3D objects also.

→ Deterministic fractals follow a strict rewriting rule.





https://en.wikipedia.org/wiki/Koch_snowflake

Random Fractals

Natural forms can be more closely approximated
if chance also plays a role in the generation of the shape.

Slope

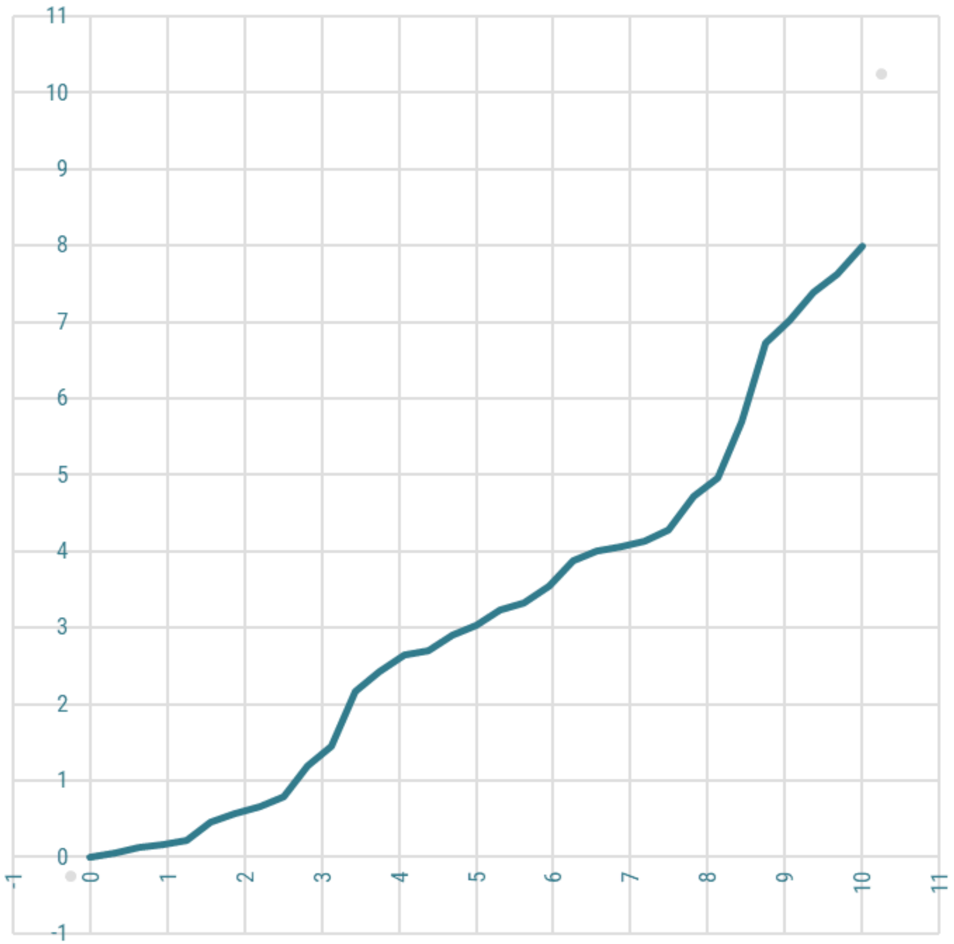
→ the two endpoints are given,

→ the midpoint of the segment
can be moved up or down
with a random distance between limits
proportional to the height difference,

→ the process can be repeated
with each newly created segment,
for any number of generations.

→ n = 2^g

g →	0	1	2	3	4
n →	1	2	4	8	16
	0	00	000	0000	00000
	1	01	001	0001	00001
		10	010	0010	00010
			011	0011	00011
			100	0100	00100
				0101	00101
				0110	00110
				0111	00111
				1000	01000
					01001
					01010
					01011
					01100
					01101
					01110
					01111
					10000



Fractal Dimension

→ If the length of line is divided into n equal parts, the ratio of the parts is $\varepsilon = (1/n)$, their number is $N = n$.

→ If the sides of a square are divided into n equal parts, the ratio of the parts is $\varepsilon = (1/n)^2$, their number is $N = n^2$.

→ If the edges of a cube are divided into n equal parts, the ratio of parts $\varepsilon = (1/n)^3$, their number is $N = n^3$.

In general: $N \cdot \varepsilon$ is constant, and $N = (1/\varepsilon)^D$,

where D is the measure of dimension: $D = \log(N) / \log(1/\varepsilon)$

› Minkowski curve

	N	unit	perim.	N	unit	area
0	s	$1a$	sa	1	1^2a	$1a^2$
1	$8s$	$\frac{1}{4}a$	$2sa$	4^2	$(\frac{1}{4})^2a$	$1a^2$
2	8^2s	$\frac{1}{4^2}a$	$4sa$	$(4^2)^2$	$(\frac{1}{4^2})^2a$	$1a^2$
3	8^3s	$\frac{1}{4^3}a$	$8sa$	$(4^3)^2$	$(\frac{1}{4^3})^2a$	$1a^2$
n	8^ns	$\frac{1}{4^n}a$	2^nsa	$(4^n)^2$	$(\frac{1}{4^n})^2a$	$1a^2$

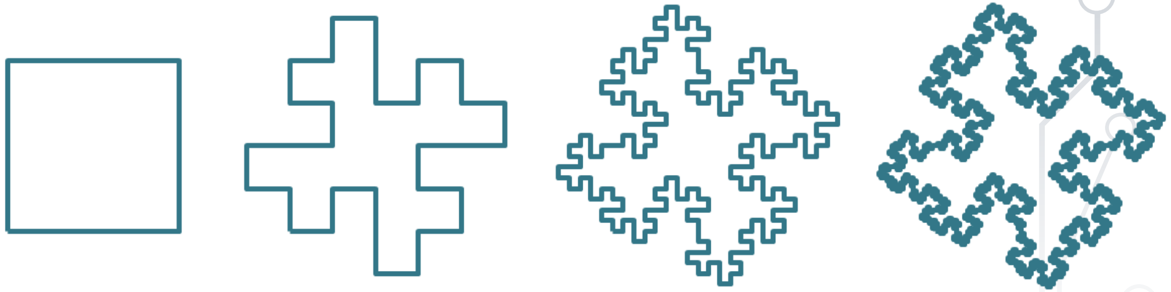
s *number of sides* a *side length*

For one side of the polygon ($s = 1$):

→ $N = (1/\varepsilon)^D$ → $8^n = (4^n)^D$

→ $D = \log(2^{3n}) / \log(2^{2n}) = (3n \cdot \log 2) / (2n \cdot \log 2) = 3/2$

The fractal dimension of this curve : $D = 1{,}5$



https://en.wikipedia.org/wiki/Fractal_dimension

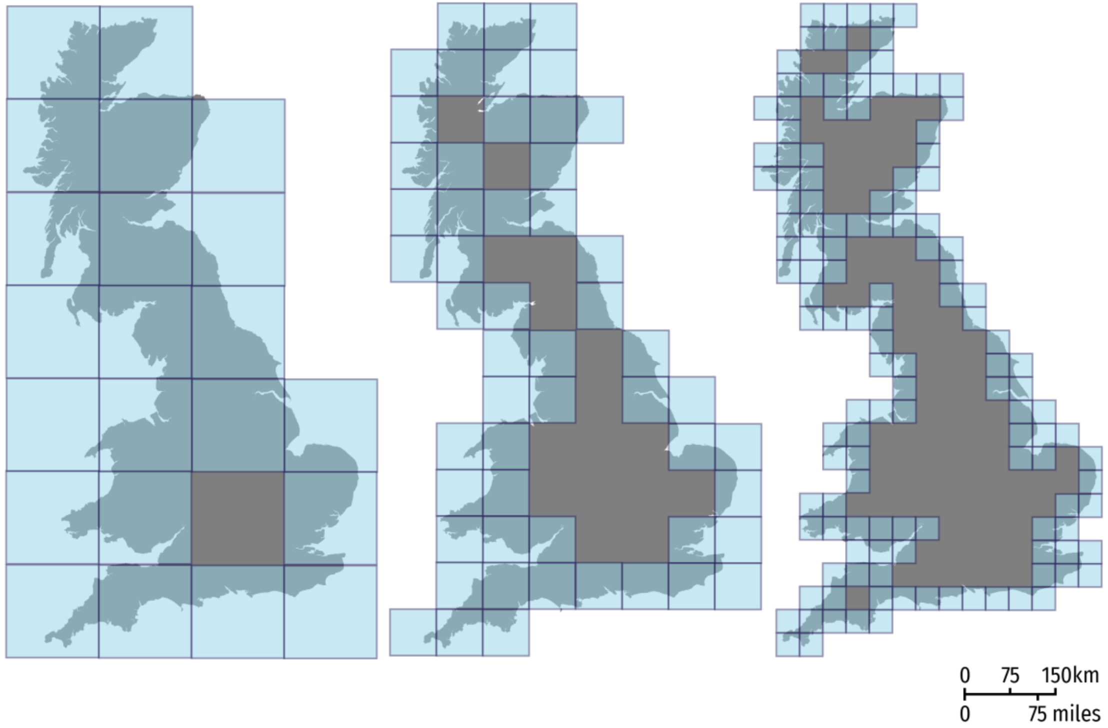
Box-Counting Dimension

Box-counting is a way of determining the fractal dimension.

→ Place the fractal over a regular grid and count the number of boxes that are required to cover it.

→ The box-counting dimension is calculated by observing how this number changes as the grid gets finer and finer.

→ $D = \lim (\log(N) / \log (1/\varepsilon)) \quad | \varepsilon \to 0$



Even if this limit does not exist, one may still take the limit superior and limit inferior, which define the upper and lower box dimensions.

https://en.wikipedia.org/wiki/Minkowski–Bouligand_dimension

L-systems

L-systems were introduced in 1968 by Aristid Lindenmayer, a Hungarian theoretical biologist and botanist

→ it illustrated the behavior of plant cells and to model the growth processes of plants,

→ can model the morphology of a variety of organisms,

→ can be used to generate self-similar fractals also.

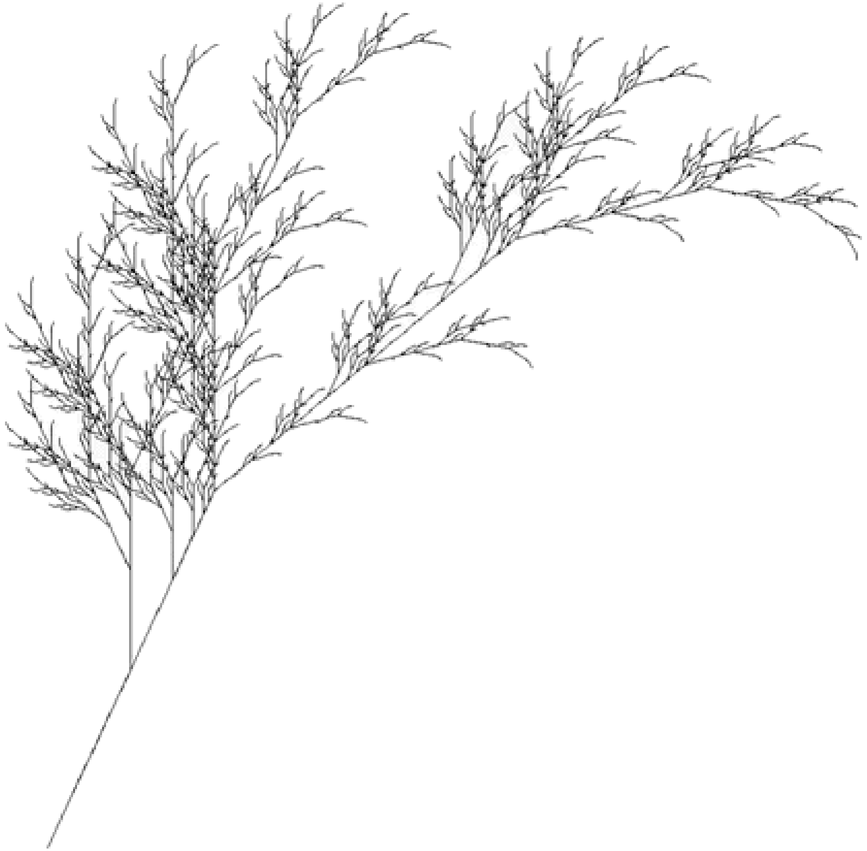
It is a parallel rewriting system and a formal grammar:

→ it contains an alphabet of symbols,

→ an initial “axiom” string,

→ a set of production rules that expand the symbols into larger string of symbols,

→ and a mechanism for translating the generated strings into geometric structures.



https://en.wikipedia.org/wiki/L-system

L-systems

Rewriting is a technique for defining complex objects by successively replacing parts of an initial object using a set of production rules.

L-systems employ all possible rules in every iteration – formal grammars applie only one rule per iteration.

Growth of Algae – ({a,b}, a, {a→b, b→ab})

→ a, b, ab, bab, abbab, bababbab, abbabbababbab

→ lengths of the words → Fibonacci sequence

Koch curve – ({f,+,–}, f+f+f, {f→f-f+f-f})

Symbols of the alphabet are represented graphically using the turtle graphics interpretation of strings:

f = *draw forward* | + = *turn left 120°* | – = *turn right 60°*.

The Algorithmic Beauty of Plants · Prusinkiewicz & Lindenmayer

DOL – deterministic context-free L-system

→ there is exactly one production for each symbol,

→ each production rule refers only to a symbol itself.

Stochastic system

→ there are more production rules for a symbol, with their specific probabilities.

Context sensitive system

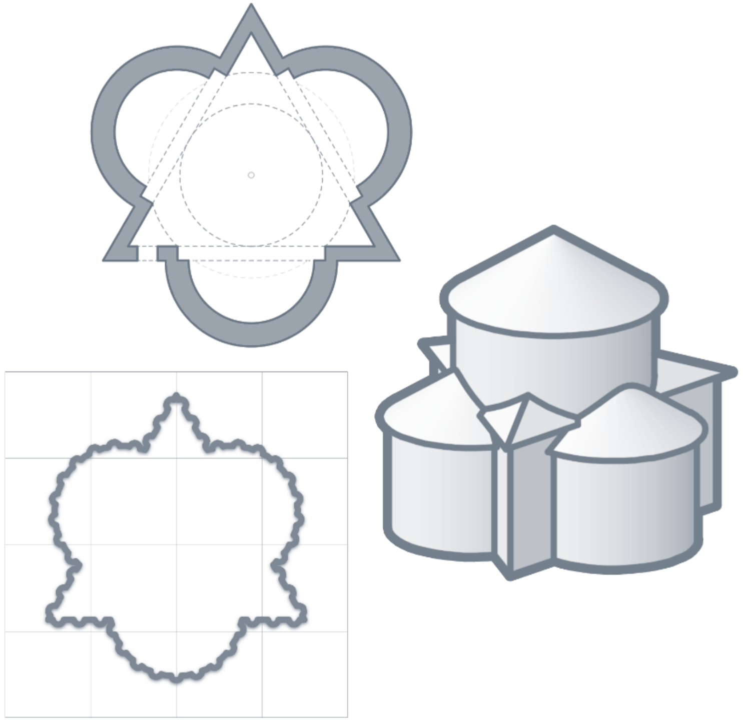
→ the production rule looks not only at the symbol it modifyes, but at its neighbours also.

Parametric system

→ a parameter list is associated with each symbol, that can be used by the drawing functions, and by the production rules also (e.g. age parameter)

https://encyclopediaofmath.org

Spreadsheet ❯ VBA, macro



Digital Representation

BMEEPAGA205

László Strommer PhD.

Macro

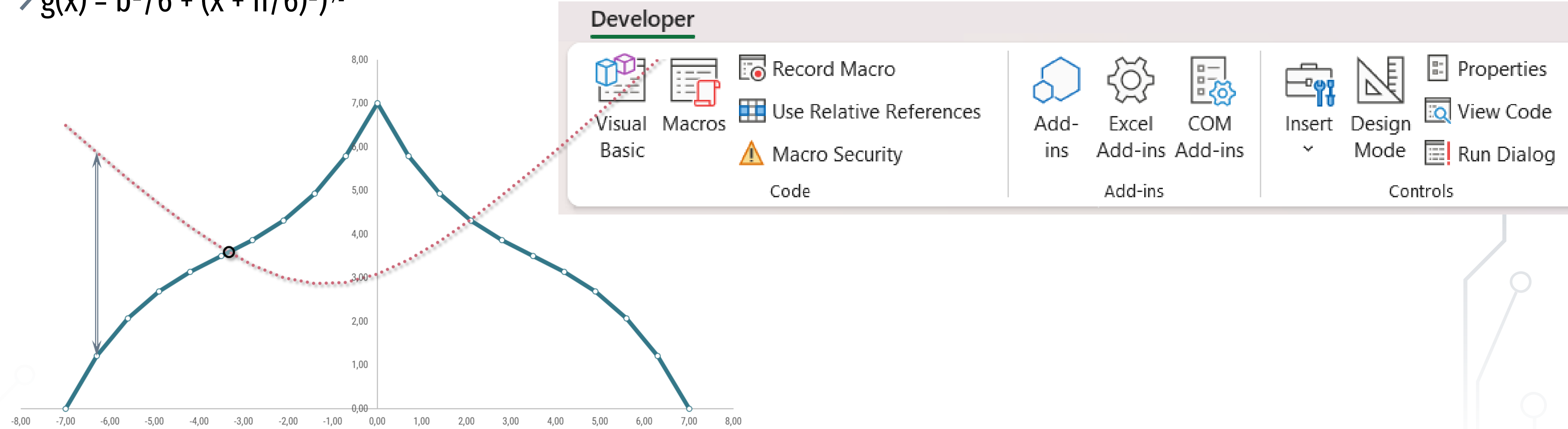
A macro is a sequence of actions that the user can perform if necessary...

→ it can be recorded or created by the user – or a combination of the two methods,
you don't need to know the exact syntax of the commands if you use the program snippets recorded by Excel.

Intersection

→ $f(x) = h/4 \cdot (2 + (1 - 2 \cdot |x| / b)^3 + (1 - 2 \cdot |x| / b))$

→ $g(x) = b^2/6 + (x + h/6)^2)^{½}$



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