

Lecture 10: An overview of MATHEMATICA

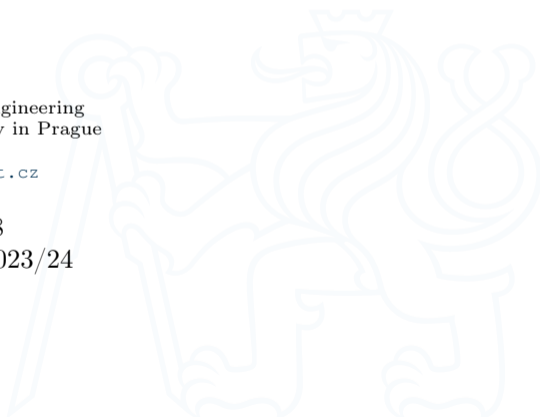
A8B17CAS

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November 28

Winter semester 2023/24





1. What is MATHEMATICA?
2. Launching and Termination
3. MATHEMATICA Environment
4. Scalars, Vectors, Matrices
5. Basic Math Operations





WOLFRAM MATHEMATICA is . . .

- ▶ A system for technical computing.
- ▶ A set of definitions and rules for manipulation/simplification of expressions.
- ▶ Philosophy: kernel & front end (notebook¹).
- ▶ Interpreted language (not compiled).
- ▶ Multi-licensed for CTU.
 - ▶ Available for students as well!

▶ with Wolfram ID: <https://ist.cvut.cz/nase-sluzby/mathematica/>

▶ [download.cvut.cz](https://ist.cvut.cz/nase-sluzby/mathematica/download)

¹https://en.wikipedia.org/wiki/Notebook_interface



WOLFRAM MATHEMATICA vs. MAPLE



- ▶ Heavily used in academics.
- ▶ Helps you to solve complex problems in seconds.
- ▶ Better for (symbolic) integration.
- ▶ ▶ Why is MATHEMATICA better.
- ▶ Other differences:
 - ▶ <https://www.geeksforgeeks.org/difference-between-maple-and-mathematica/>
 - ▶ <https://qr.ae/pvx030>
 - ▶ <https://www.reddit.com/r/Physics/comments/7gdx4g/comment/dqic7eq/?context=3>



- ▶ It has a wide range of special mathematical libraries.
- ▶ Better for ODE (ordinary differential equations), PDE (partial differential equations), and recurrence equations.
- ▶ ▶ Why is MAPLE better.



Historical Development of MATHEMATICA

- ▶ 1986-1988
 - ▶ Stephen Wolfram² works on a new algebraic system – SMP (a symbolic manipulation program)
- ▶ June 23, 1988
 - ▶ Mathematica 1.0 is launched.
- ▶ current version of Mathematica is 13.1 (November 2022)
- ▶ related references
 - ▶ History of the language in pictures
<https://www.wolfram.com/mathematica/scrapbook/>
 - ▶ Wolfram Language https://en.wikipedia.org/wiki/Wolfram_Language
 - ▶ Wiki https://en.wikipedia.org/wiki/Wolfram_Mathematica

²https://en.wikipedia.org/wiki/Stephen_Wolfram
<https://www.stephenwolfram.com/>

WOLFRAM MATHEMATICA (WM) logo



History of WM logo.



Figure 1. The Platonic Solids



Figure 2. Evolutions of the Platonic Solids

Da Vinci's stellated platonic solid.



► Related references:

► Platonic solids

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

► Spikey <https://mathworld.wolfram.com/Spikey.html>



Launching MATHEMATICA

- ▶ Desktop icon
- ▶ Command line:
 - ▶ math, wolfram or wolframscript

```

>wolframscript
Wolfram Language 12.0.0 Engine for Linux x86 (64-bit)
Copyright 1988-2019 Wolfram Research, Inc.

In[1]:= 5+3*2.1^2
Out[1]= 18.23

In[2]:= f1[x_]:=x^2;
In[3]:= Table[f1[n],{n,4}]
Out[3]= {1, 4, 9, 16}

In[4]:= f1/@{-1.1,3,Pi,4/5}
Out[4]= {1.21, 9, Pi , --}
          2 16
          25

In[5]:= Exit[]
>

```

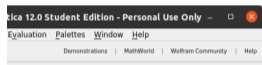
- ▶ A user can launch MATHEMATICA with optional parameters.
 - ▶ wolframscript -h (cmd help)
- ▶ System requirements³ for MATHEMATICA 13.1:
 - ▶ Windows 10+, Linux, macOS 10.14+
 - ▶ 4+ GB RAM
 - ▶ 19 GB of HDD
 - ▶ Any Intel or AMD x86-64 processor

³<https://www.wolfram.com/mathematica/system-requirements.html>

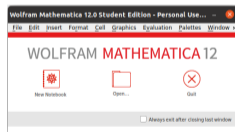


MATHEMATICA termination + termination of (long-running) computation

- ▶ Close notebook: Close button in the top right corner of the notebook window.



- ▶ Quit MATHEMATICA: “Quit” button in the welcome window.

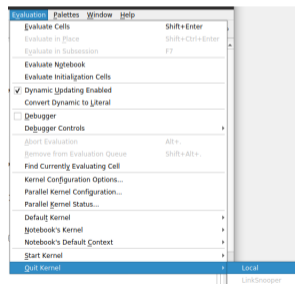


- ▶ Possibility to terminate MATHEMATICA in the command window.
- ▶ More advanced options (see documentation).

- ▶ When the computation runs too long



- ▶ ...quit MATHEMATICA kernel.





The MATHEMATICA's Notebook Environment

1. Input cell. (evaluate it by Shift + Enter)
2. Output cell(s).
3. Group of 1 input and output cell(s).

Notes:

- ▶ Input and Output cells are inner cells that are grouped in a group.
- ▶ (mouse-) double click on an inner cell closes all but this inner cell in the current group.

Untitled-2* - Wolfram Mathematica 12.0 Student Edition - Personal Use Only

File Edit Insert Format Cell Graphics Evaluation Palettes Window Help

WOLFRAM MATHEMATICA | STUDENT EDITION Demonstrations | MathWorld | Wolfram Community | Help

```
In[21]:= f1[x_, y_] := x^2 + y;
f2[{x_, y_}] := 2 x + 4 y;
f3[p_] := {p, p^2, 3 p, 4 p};
mat1 = Table[f1[n1, n2], {n1, 3}, {n2, 5}];
mat1 // MatrixForm
```

Out[24] MatrixForm-

$$\begin{pmatrix} 2 & 3 & 4 & 5 & 6 \\ 5 & 6 & 7 & 8 & 9 \\ 10 & 11 & 12 & 13 & 14 \end{pmatrix}$$

```
In[20]:= f2 /@ {{4, 5}, {1, 1}, {Pi, E}, {I, 3}}
```

Out[20] $\{28, 6, 4 e + 2 \pi, 12 + 2 i\}$

plot in complex plane total sort partition... more...

```
In[20]:= mat2 = Table[f3[p], {p, 2, 7}];
mat2
mat2 // MatrixForm
```

Out[30] $\{(2, 4, 6, 8), (3, 9, 9, 12), (4, 16, 12, 16), (5, 25, 15, 20), (6, 36, 18, 24), (7, 49, 21, 28)\}$

Out[31] MatrixForm-

$$\begin{pmatrix} 2 & 4 & 6 & 8 \\ 3 & 9 & 9 & 12 \\ 4 & 16 & 12 & 16 \\ 5 & 25 & 15 & 20 \\ 6 & 36 & 18 & 24 \\ 7 & 49 & 21 & 28 \end{pmatrix}$$

MATHEMATICA Online



▶ `https://www.wolfram.com/mathematica/online/`

- ▶ Runs in a web browser.
- ▶ Requires (CTU) login.
- ▶ Slower than regular MATHEMATICA.

The screenshot shows a web browser window with the URL `https://www.wolframcloud.com/env/8379a9f2-5bf8-4`. The page title is "WOLFRAM CLOUD" and the plan is "Basic". The interface includes a menu bar with options like "File", "Edit", "Format", "Insert", "Evaluation", "View", "Help", "Share", and "Publish".

The main content area displays a Mathematica notebook with the following code and output:

```

In[3]:= 100!
Out[3]= 93 326 215 443 944 152 681 699 238 856 266 700 490 715 968 264 381 621 468 592\
963 895 217 599 993 229 915 608 941 463 976 156 518 286 253 697 920 827 223\
758 251 185 210 916 864 000 000 000 000 000 000 000 000 000

```

```

In[4]:= Table[n^2, {n, 100}]
Out[4]= {1, 4, 9, 16, 25, 36, 49, 64, 81, 100, 121, 144, 169, 196, 225, 256, 289,
324, 361, 400, 441, 484, 529, 576, 625, 676, 729, 784, 841, 900, 961,
1024, 1089, 1156, 1225, 1296, 1369, 1444, 1521, 1600, 1681, 1764,
1849, 1936, 2025, 2116, 2209, 2304, 2401, 2500, 2601, 2704, 2809,
2916, 3025, 3136, 3249, 3364, 3481, 3600, 3721, 3844, 3969, 4096,
4225, 4356, 4489, 4624, 4761, 4900, 5041, 5184, 5329, 5476, 5625,
5776, 5929, 6084, 6241, 6400, 6561, 6724, 6889, 7056, 7225, 7396,
7569, 7744, 7921, 8100, 8281, 8464, 8649, 8836, 9025, 9216, 9409,
9604, 9801, 10000}

```

```

In[6]:= {t1, b1} = AbsoluteTiming[Total@Table[n^2, {n, 10000}]]; t1
Out[6]= 0.000539

```

On the right side of the interface, there is a "WELCOME TO WOLFRAM CLOUD" banner with a cartoon cat character. Below the banner, there are sections for "GETTING STARTED" (Five Minute Hands-On Intro, Some Things to Try), "USING NOTEBOOKS" (1-Minute Video), and "WOLFRAM LANGUAGE" (Fast Intro for Programmers, An Introduction to the Wolfram Language, Online book, Open Course).



Learning from online sources (Courses, Classes, Videos, ...)

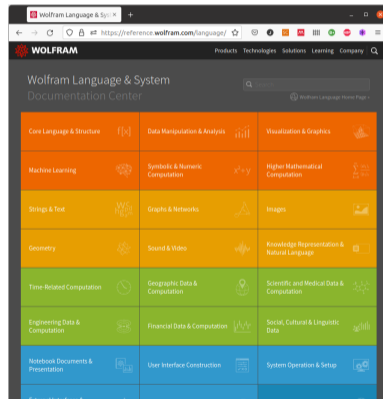
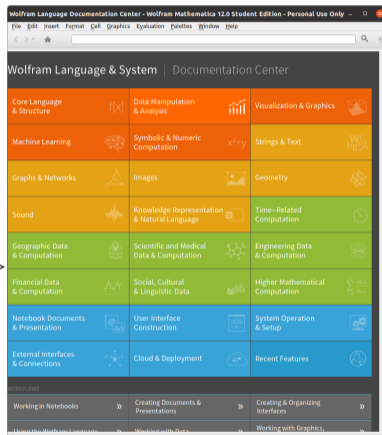
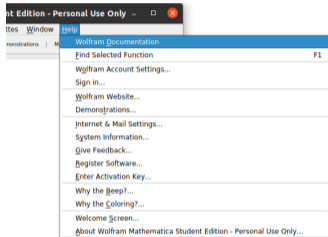
The screenshot shows the Wolfram website's navigation menu and the 'Learning & Support' section. The URL in the browser is <https://www.wolfram.com>. The navigation menu includes 'Products & Services', 'Technologies', 'Solutions', and 'Learning & Support'. The 'Learning & Support' section is expanded, showing three main categories: 'Learning', 'Need Help?', and 'Partners'. The 'Learning' category includes links for 'Wolfram Language Documentation', 'Fast Introduction for Programmers', 'Wolfram U', and 'Videos & Screencasts'. The 'Need Help?' category includes links for 'Support FAQ', 'Wolfram Community', and 'Contact Support'.

- ▶ A lot of video courses are available online at [https://www.wolfram.com/ Learning](https://www.wolfram.com/Learning) & *Support* section.
- ▶ <https://www.wolfram.com/language/fast-introduction-for-programmers/en/>
- ▶ <https://www.wolfram.com/wolfram-u/>



Documentation

<https://reference.wolfram.com/language/>





WOLFRAM language

WOLFRAM language is case-sensitive!

- ▶ As the core element of MATLAB is a matrix, the core element of MATHEMATICA is an *expression*.
 - ▶ Every expression consists of its head (e.g. `f`, `Set`, `Plus`, `Equal`,...) and arguments.
 - ▶ Examples: `f[1, 5, {5, 4}]`, `Set[a, 5^3]` (or `a=5^3`), `Plus[5, 3, 9]` (or `5+3+9`), `Equal[5-3, a + b]` (or `5-3 == a + b`).
- ▶ All built-in commands start with an *upper case* letter (e.g. `Sin[0.4]`).
- ▶ To pass arguments to functions, use *square brackets* (e.g. `BesselI[0, 2.0]`).
- ▶ For user-defined symbols/names use *lower case* starting letter (e.g. `myExpression=3+x^2-Log[y]`).
- ▶ Do not use underscore (“`_`”) in user-defined names (e.g. `my_expression` – invalid). “`_`” is a pattern that matches one arbitrary expression (e.g. `f1[x_] := Cos[x]^2`).
 - ▶ Letters and numbers are allowed; other symbols (colon “`:`”, hyphen “`-`” and others) are not.
- ▶ Beware of different syntax in MATLAB, e.g., `sin(x)` vs. `Sin[x]`, etc.



Variable Names

- ▶ Examples of valid symbols/names:

`a, aA, b, c, x1, x2, m12, test1, matrixA, fx, fX`

- ▶ Examples of invalid variable names:

`9var` (*starts with a number*)

`matrix_A` (*name cannot contain underscore*)

`Test-1` (*algebraic expression*)

- ▶ Examples of valid numbers in MATHEMATICA,

`3, -66, +0.0015, .015, 1*10^2, 1.6025 10^(-10),`

`05.1, Pi, E, I, Infinity, 2/3, 1.2, 1.2``20`



Workspace – Output Deletion

- ▶ To delete a cell:
 - ▶ Select the cell (left-click on it) and hit the Delete key on the keyboard. →
- ▶ To clean one (or more) variable(s):
 - ▶ `Clear[mySymbol1, myVariable2, myFunc3]`
or instead of `Clear` use `ClearAll` (removes also **Attributes** of the given objects).
 - ▶ Or unassign the given symbol:
`myVar = .`





Numerical objects in MATHEMATICA

► Types of numbers in MATHEMATICA:

Integer – arbitrary-length exact integer (*e.g.* 1000031).

Rational – *Integer/Integer* in lowest terms (*e.g.* 3/556).

Real – approximate real number with any specified precision (*e.g.* 12., -3.83`15).

Complex – complex number of the form *number + number I* (*e.g.* 83 + 0.500 I).

Get the type by `Head[number]`, *e.g.* `Head[123]`, `Head[123.00]`, `Head[3/6]`.

► Objects in MATHEMATICA can be grouped by a *List*, (*e.g.* {2, 3.05, 4/5, Pi^2, {2, {3}}, E^Pi}). Elements of lists can be other lists.

► Common numeric objects:

► scalar: a number (Integer, Rational, Real, or Complex).

► vector: a list of scalars (*e.g.* {5, 3.4, -6, -0.1 + 3 I}). 1D numeric object.

► matrix: a list of (row-) vectors (*e.g.* {{1, 2}, {3, 4}}). 2D numeric object.

► array (multidimensional matrices): A list of lower-dimensional (numerical) objects.

► Matrices (resp. lists of lists) can be complex, and can contain text/strings as well.



Matrix/List Creation

- ▶ Following techniques are available:
 - ▶ element-by-element entering (suitable for small matrices/lists only),
 - ▶ concatenation of parts to one object (*e.g.* row-vectors to one matrix) – make `List` of them,
 - ▶ by a formula for each element – use `Table[]` command,
 - ▶ generation by built-in functions (`ToeplitzMatrix[]`, `IdentityMatrix[]`, `DiagonalMatrix[]`, `Range[]`),
 - ▶ `Import` and `Export` from/to external files (`.mat`, `.txt`, `.xls`, ...).



Matrix Construction Element-by-element I.

- ▶ Test the following commands to construct matrices by element enumeration.

```

a1=a2=-1;
a1
a2
v1={-1,0,1};
v2={{-1},{0},{1}};
v1
v1//MatrixForm
v2//MatrixForm
matM1={{-1,0,1},{-2,0,2}};
matM2={{-1,-2},{0,0},{1,2}};
matM3={{-1,-2},{0,0}};
MatrixForm /@ {matM1,matM2,matM3}

```

- ▶ Suitable for small matrices only.

$$a_1 = a_2 = -1$$

$$\mathbf{v}_1 = \begin{bmatrix} -1 & 0 & 1 \end{bmatrix}$$

$$\mathbf{v}_2 = \begin{bmatrix} -1 \\ 0 \\ 1 \end{bmatrix}$$

$$\mathbf{M}_1 = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \end{bmatrix}$$

$$\mathbf{M}_2 = \begin{bmatrix} -1 & -2 \\ 0 & 0 \\ 1 & 2 \end{bmatrix}$$

$$\mathbf{M}_3 = \begin{bmatrix} -1 & -2 \\ 0 & 0 \end{bmatrix}$$



Notes on the syntax.

- ▶ The expression `f[expr1]` can be written in two other ways:
 - ▶ `expr1 // f` (postfix notation) and `f @ expr1` (prefix notation)
- ▶ The operator `/@` is the `Map` command.
`f /@ {1,2,5}` produces `{f[1], f[2], f[5]}`
It maps the symbol `f` on each element of the following expression.



Matrix Construction Element-by-element II.

- ▶ Construct the following matrices:
 - ▶ Matrix/list values are defined inside curly braces {},
 - ▶ colon “,” separates individual rows of a matrix.

$$\mathbf{A} = \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix} \quad \mathbf{B} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$



Matrix Construction Element-by-element II.

- ▶ Construct the following matrices:
 - ▶ Matrix/list values are defined inside curly braces {},
 - ▶ colon “,” separates individual rows of a matrix.

$$\mathbf{A} = \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix} \quad \mathbf{B} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

- ▶ User input:

```
matA = {{-1, 1}, {1, -2}};
```

```
matB = {{1, 2, 3}, {4, 5, 6}, {7, 8, 9}};
```



Matrix Construction Element-by-element II.

- ▶ Construct the following matrices:
 - ▶ Matrix/list values are defined inside curly braces {},
 - ▶ colon “,” separates individual rows of a matrix.

$$\mathbf{A} = \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix} \quad \mathbf{B} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

- ▶ User input:

```
matA = {{-1, 1}, {1, -2}};
```

```
matB = {{1, 2, 3}, {4, 5, 6}, {7, 8, 9}};
```

- ▶ ... and how does it see MATHEMATICA kernel:

```
matA//FullForm
```

```
FullForm[matB]
```

```
→ List[List[-1, 1], List[1, -2]]
```

```
→ List[List[1, 2, 3], List[4, 5, 6], List[7, 8, 9]]
```



Matrix Construction

- ▶ Semicolon placed at the end of a command suppresses the display of the output in the output cell.

```
a = 1
b = 5;
```

- ▶ When there is more than one command on the same line, a semicolon separates them.

```
a = 1; b = 5;
```

- ▶ To clear a symbol/variable, use `Clear` or `ClearAll` functions/commands. (`ClearAll` removes not only values but also attributes of the symbol)

```
Clear[a] OR a=.
```

- ▶ MATHEMATICA is not as strict as MATLAB in defining vectors as row or column vectors. *E.g.* the following matrix multiplication works:

```
mat={{1,-1},{2,2}};
v1={4,3}; v2={{4},{3}};
MatrixForm/@{ v1.mat, mat.v1, mat.v2}
```

...but the following does not work

```
v2 . mat;
```



Basic Math Operators I.

- ▶ Operator types:
 - ▶ arithmetic:
 - ▶ matrix,
 - ▶ vector,
 - ▶ relational,
 - ▶ logical and other (to be mentioned later ...).
- ▶ Other operations using MATHEMATICA functions:
 - ▶ `Conjugate`, `ConjugateTranspose`
 - ▶ `Sum`, `Total`, `Det` – determinant, `Sqrt` – square root,
 - ▶ and hundreds of other functions ...

<code>+</code> , <code>Plus</code>	addition
<code>-</code> , <code>Minus</code>	subtraction
<code>*</code> , <code>Times</code>	multiplication
<code>^</code> , <code>Power</code>	power
<code>Transpose</code>	transpose
<code>LinearSolve</code>	left matrix division

Notice the operator's precedence (to be discussed later).



Basic Math Operators II.

Type in the following commands:

▶ `a3 = -2/4;`

`a4 = -0.5;`

`a5 = -.50000000000000000000000000000000;`

▶ What is the difference between a_3 , a_4 and a_5 ? Evaluate function `Accuracy` for each variable/symbol.



Basic Math Operators II.

Type in the following commands:

▶ `a3 = -2/4;`

`a4 = -0.5;`

`a5 = -.50000000000000000000000000000000;`

▶ What is the difference between a_3 , a_4 and a_5 ? Evaluate function `Accuracy` for each variable/symbol.

`Accuracy[a3]`

`Accuracy[a4]`

`Accuracy[a5]`

→ Infinity

→ 16.2556

→ 29.



Basic Math Operators II.

Type in the following commands:

▶ `a3 = -2/4;`

`a4 = -0.5;`

`a5 = -.50000000000000000000000000000000;`

▶ What is the difference between a_3 , a_4 and a_5 ? Evaluate function `Accuracy` for each variable/symbol.

`Accuracy[a3]`

`Accuracy[a4]`

`Accuracy[a5]`

→ Infinity

→ 16.2556

→ 29.

▶ You can put it to one list to display it on one line:

`{Accuracy[a3], Accuracy[a4], Accuracy[a5]}`

→ {Infinity, 16.2556, 29.}



Basic Math Operators II.

- ▶ ...the previous expression can be written as:

Accuracy /@ {a3, a4, a5}

- ▶ Define list `myList={a3, a4, a5}`; and evaluate functions `Precision`, `Head`, `FullForm`, on each element of the list `myList`.



Basic Math Operators II.

- ▶ ...the previous expression can be written as:

```
Accuracy /@ {a3, a4, a5}
```

- ▶ Define list `myList={a3, a4, a5}`; and evaluate functions `Precision`, `Head`, `FullForm`, on each element of the list `myList`.

```
Precision /@ myList
```

```
Head /@ myList
```

```
FullForm /@ myList
```

- ▶ Beware the precedence of operators: Explain the difference between $a^2/a^3 \cdot a^4$ and $a^2/(a^3/a^4)$.
- ▶ *MATHEMATICA tries to maintain the precision of calculation as much as possible.*

```
{Sqrt[2], Sqrt[2]//N, Sqrt[2.], Tan[-1], N[Tan[-1], 9], 30!, N[30!]}
```

```
→ {√2, 1.41421, 1.41421, -Tan[1], -1.55740772,  
26525285981219105863630848000000, 2.65253*10^32}
```



Basic Math Functions I.

There are groups of functions in MATHEMATICA (similar to MATLAB): **Scalar** functions (e.g.: `Sin`, `Sqrt`, `Log`, `Factorial`), **Vector** functions (e.g.: `Total`, `Max`) and **Matrix** functions (e.g.: `Det`, `Trace`).

- ▶ Every symbol (variable/function) has its values/definitions and attributes.
 - ▶ Get help (values and definitions) on a specific symbol: `?symbName`, resp. more detailed help: `??symbName`:

```
x = 5 - 4; f2[x_] := x^2;
```

```
?x
```

```
?f2
```

```
?Sin
```

- ▶ Get attributes of a specific symbol: `Attributes[symbName]`:

```
Attributes[x]
```

```
Attributes[f2]
```

```
Attributes[Sin]
```



Basic Math Functions I.

- ▶ Symbol attribute `Listable` says MATHEMATICA to *automatically* distribute/`map` the symbol over *all elements* of the input list (recursively, at all levels) – it makes a symbol work as a scalar function (e.g. `Sin`).

```
v = {2, {2.3, -1/2}, 5, {{4 Pi, 10}, 3/8}};
```

```
h3[v]
```

```
h3 /@ v
```

```
SetAttributes[h3, Listable];
```

```
h3[v]
```

```
ClearAttributes[h3, Listable];
```

```
Sin[v]
```

- ▶ All “*scalar*” functions has attribute `Listable`.

```
Attributes /@ {Power, Sin, Cos, Plus, Times, Total, Max, Det, Trace}
```

- ▶ Example: the difference between matrix power and element-wise power.

```
matA = {{2, 3}, {1, -1}};
```

```
MatrixForm /@ {matA, matA . matA, MatrixPower[matA,2], matA^2, Power[matA,2]}
```



Basic Math Functions II.

- ▶ Using MATHEMATICA help, calculate the following expression: $a \sin^2(\alpha) + a \cos^2(\alpha) - a$
 - ▶ Use numerical values of your own choice. Additionally, functions `N` and `Simplify` may help too.
- ▶ Evaluate the following expression: $\log_{10}(a) + \log_{10}(b) - \log_{10}(ab)$
- ▶ Find the sum of all elements in individual rows of the following matrix:

$$T = \begin{bmatrix} \frac{1}{2} & \frac{1}{3} & \frac{1}{4} & \frac{1}{5} \\ 6 & 7 & 8 & 9 \\ 0.2 & 0.3 & 0.4 & 0.5 \end{bmatrix}.$$



Basic Math Functions II.

- ▶ Using MATHEMATICA help, calculate the following expression: $a \sin^2(\alpha) + a \cos^2(\alpha) - a$
 - ▶ Use numerical values of your own choice. Additionally, functions `N` and `Simplify` may help too.
`a=2; al=1; a Sin[al]^2 + a Cos[al]^2 - a //N`
- ▶ Evaluate the following expression: $\log_{10}(a) + \log_{10}(b) - \log_{10}(ab)$
`a = 3.1; b = 0.7; Log10[a] + Log10[b] - Log10[a b]`
- ▶ Find the sum of all elements in individual rows of the following matrix:

$$T = \begin{bmatrix} \frac{1}{2} & \frac{1}{3} & \frac{1}{4} & \frac{1}{5} \\ 6 & 7 & 8 & 9 \\ 0.2 & 0.3 & 0.4 & 0.5 \end{bmatrix}.$$

```
matT = {{1/2,1/3,1/4,1/5},{6,7,8,9},{0.2,0.3,0.4,0.5}};
Total /@ matT
```



Basic Math Functions II.

- ▶ Using MATHEMATICA help, calculate the following expression: $a \sin^2(\alpha) + a \cos^2(\alpha) - a$
 - ▶ Use numerical values of your own choice. Additionally, functions `N` and `Simplify` may help too.
`Clear[a, al]; a Sin[al]^2 + a Cos[al]^2 - a //Simplify`
- ▶ Evaluate the following expression: $\log_{10}(a) + \log_{10}(b) - \log_{10}(ab)$
`Clear[a, b]; Assuming[a>0 && b>0, Log10[a] + Log10[b] - Log10[a b] // Simplify]`
- ▶ Find the sum of all elements in individual rows of the following matrix:

$$T = \begin{bmatrix} \frac{1}{2} & \frac{1}{3} & \frac{1}{4} & \frac{1}{5} \\ \frac{2}{6} & \frac{3}{7} & \frac{4}{8} & \frac{5}{9} \\ 0.2 & 0.3 & 0.4 & 0.5 \end{bmatrix}.$$



Basic Math Functions III.

- ▶ Assume following vectors $\mathbf{u} = (1, 2, 3)$ and $\mathbf{v} = (3, 2, 1)$.

- ▶ Calculate:

$$\begin{array}{cc} \mathbf{u}\mathbf{v}^T & \mathbf{v}\mathbf{u}^T \\ \mathbf{v}^T\mathbf{u} & \mathbf{u}^T\mathbf{v} \end{array}$$

- ▶ Following functions are needed:

- ▶ `.` – matrix/vector multiplication,
- ▶ `Outer` – outer product.
- ▶ Note: Transpose will not help.

- ▶ What is the result of the operations mentioned above?



Basic Math Functions III.

- ▶ Assume following vectors $\mathbf{u} = (1, 2, 3)$ and $\mathbf{v} = (3, 2, 1)$.

- ▶ Calculate:

scalar $\mathbf{u}\mathbf{v}^T$ $\mathbf{v}\mathbf{u}^T$ scalar
matrix $\mathbf{v}^T\mathbf{u}$ $\mathbf{u}^T\mathbf{v}$ matrix

- ▶ Following functions are needed:

- ▶ `.` – matrix/vector multiplication,
- ▶ `Outer` – outer product.
- ▶ Note: Transpose will not help.

- ▶ What is the result of the operations mentioned above?

```

u = {1, 2, 3}; v = {3, 2, 1};
{u.v, v.u}
Outer[Times, v, u] // MatrixForm
Outer[Times, u, v] // MatrixForm

```

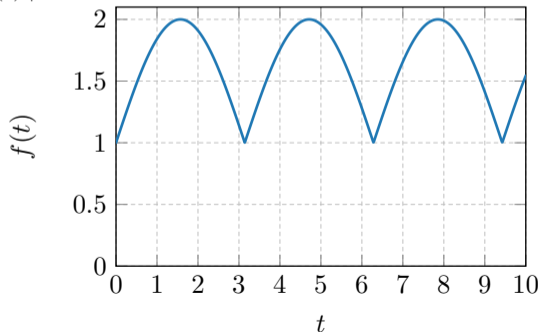
$$\begin{array}{cc}
 10 & 10 \\
 \left[\begin{array}{ccc} 3 & 6 & 9 \\ 2 & 4 & 6 \\ 1 & 2 & 3 \end{array} \right] & \left[\begin{array}{ccc} 3 & 2 & 1 \\ 6 & 4 & 2 \\ 9 & 6 & 3 \end{array} \right]
 \end{array}$$



Plot a Function

- ▶ Plot the following function in the interval $t \in (0, 10)$.
 - ▶ Use `Plot` command.
 - ▶ Do not define function $f(t)$ separately. Write the formula directly to the `Plot` command.

$$f(t) = |\sin(t)| + 1$$





Plot a Function

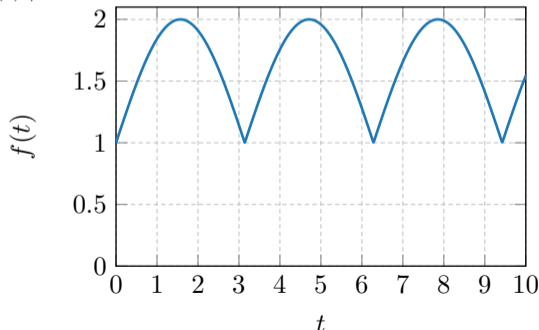
- ▶ Plot the following function in the interval $t \in (0, 10)$.
 - ▶ Use `Plot` command.
 - ▶ Do not define function $f(t)$ separately. Write the formula directly to the `Plot` command.

$$f(t) = |\sin(t)| + 1$$

```
Plot[Abs[Sin[t]]+1, {t, 0, 10}]
```

OR

```
Plot[Abs[Sin[x]]+1, {x, 0, 10},
  PlotRange->{{0, 10}, {0, 2.1}},
  GridLines->{Range[0, 10],
    Table[0.5 i, {i, 0, 5}]},
  AxesLabel->{"t", "f(t)"}]
```



Exercise



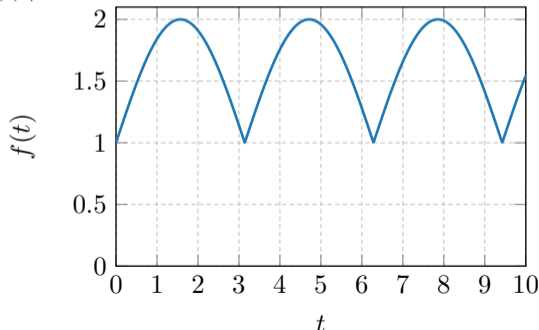
Plot a Function

- ▶ Plot the following function in the interval $t \in (0, 10)$.
 - ▶ Use `Plot` command.
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$$f(t) = |\sin(t)| + 1$$

...and the MATLAB-like approach in
MATHEMATICA

```
tVec = Subdivide[0, 10, 20];
fVals = Abs[Sin[tVec]]+1;
ListLinePlot[Transpose[{tVec,
  fVals}],
  PlotRange->{{0, 10}, {0, 2.1}},
  GridLines->{Range[0, 10],
    Table[0.5 i, {i, 0, 5}]},
  AxesLabel->{"t", "f(t)"}]
```



Questions?

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November 28

Winter semester 2023/24

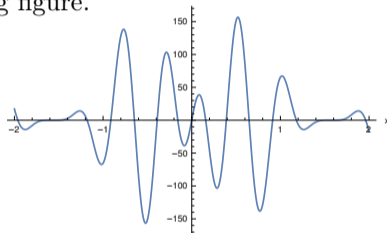
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Voluntary homework



- Compute fifth derivative of the expression/function $\sin^6(x) \cos^{10}(x)$, assign the results to a symbol `expr`, and plot the expression `expr` from -2 to 2 . (hint: use `D` command)

You should get the following figure.



- Define a matrix and compute the minimum of each row and each column. Use the following matrix.

$$\begin{bmatrix} 4 & -2 & 0 & 8 \\ 3 & -1 & 2 & 5 \\ -11 & 13 & 6 & 7 \end{bmatrix}$$

Hint: recall that a matrix is a list of rows: `{row1, row2, row3}`. Use `Total` command.