

Symbolische Programmierung

Wolfram Mathematica, sympy, ...

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Disclaimer

- Ich bin kein Mathematica-Profi
- Ich bin kein sympy-Profi
- Ich laber möglicherweise Müll

Installation

Mathematica:

- 72 Lizenzen für Mathematica 13.1 verfügbar
- Verbindung zum Lizenzserver erforderlich
- Mehr Infos (nur aus dem Uni-Netz erreichbar):
<https://www.rrz.uni-hamburg.de/services/software/software-thematisch/software-alpha/mathematica.html>

SymPy:

- `pip install sympy`
- Für die volle Fake Mathematica Experience:
 - `pip install jupyterlab`

Symbolische vs. Numerische Programmierung

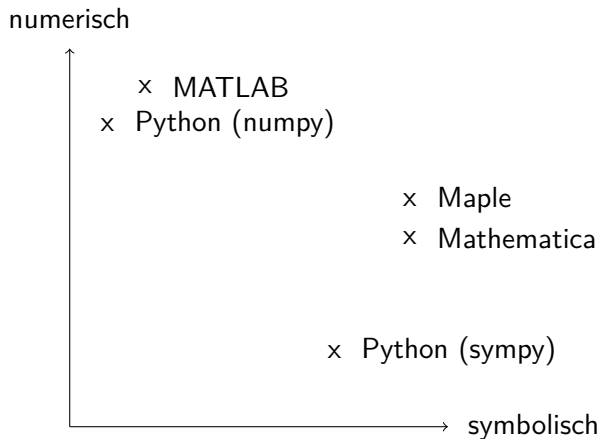
Wir wollen:

- Gleichungen umstellen, lösen, vereinfachen
- Ableitungen, Stammfunktionen bestimmen
- Eigenwerte, Gleichungssysteme
- ...

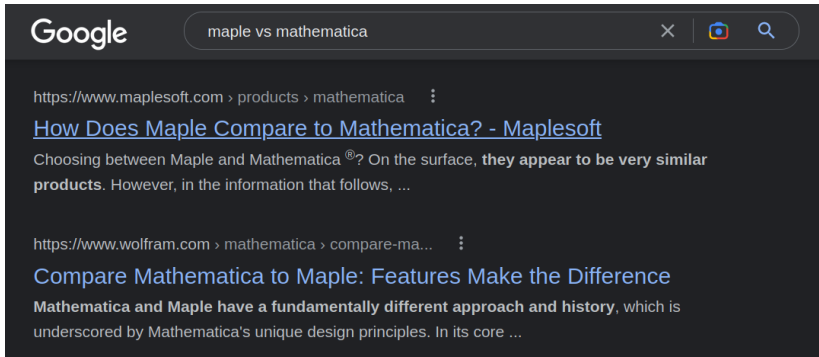
Analytische Mathematik \leftrightarrow Numerische Mathematik

Symbolische Programmierung \leftrightarrow Numerische Programmierung

Programmiersprachen



Programmiersprachen



Google

maple vs mathematica

https://www.maplesoft.com › products › mathematica

[How Does Maple Compare to Mathematica? - Maplesoft](#)

Choosing between Maple and Mathematica[®]? On the surface, **they appear to be very similar products**. However, in the information that follows, ...

https://www.wolfram.com › mathematica › compare-ma...

[Compare Mathematica to Maple: Features Make the Difference](#)

Mathematica and Maple have a fundamentally different approach and history, which is underscored by Mathematica's unique design principles. In its core ...

Programmiersprachen

Mathematica

- Kostet Geld
- Neue Programmiersprache
- + Elegantere Syntax
- + Mehr und ausgereifere Features

sympy

- + Gratis
- + Vertraute Syntax
- Etwas clunky
- Etwas basic

Beispiele (Python)

```
>>> import numpy as np
```

```
>>> np.sqrt(2)
1.4142135623730951
```

```
>>> np.sqrt(2)**2
2.0000000000000004
```

```
>>> import sympy as sp
```

```
>>> sp.sqrt(2)
sqrt(2)
```

```
>>> sp.N(sp.sqrt(2))
1.41421356237310
```

```
>>> sp.sqrt(2)**2
2
```


Beispiele (Python)

:(

```
>>> import sympy as sp

>>> a,b = sp.symbols("a b")

>>> 5*a + 4*b - 2*a
3*a + 4*b

>>> sp.expand((a + b)**2)
a**2 + 2*a*b + b**2
```

Beispiele (Python)

Berechne $\int_0^1 x + x^2 dx$.

```
>>> import numpy as np

>>> def f(x):
...     return x + x**2

>>> xs = np.linspace(0, 1,
    ↪ num=100)

>>> np.trapz(f(xs), x=xs)
0.8333503384008434
```

```
>>> import sympy as sp

>>> x = sp.symbols("x")

>>> f = x + x**2

>>> sp.integrate(f)
x**3/3 + x**2/2

>>> sp.integrate(f, (x,0,1))
5/6

>>> 5/6
0.8333333333333334
```

Beispiele (Python)

Berechne $\int_5^{10} \frac{x}{\sqrt{x^4 + 10x^2 - 96x - 72}} dx$.

```
>>> import numpy as np

>>> def f(x):
...     return x /
    ↪ np.sqrt(x**4 +
    ↪ 10*x**2 - 96*x - 72)

>>> xs = np.linspace(5,
    ↪ 10, num=100)

>>> np.trapz(f(xs), x=xs)
0.7579090249485106
```

```
>>> import sympy as sp
>>> x = sp.symbols("x")

f = x / sp.sqrt(x**4 +
    ↪ 10*x**2 - 96*x - 72)

>>> sp.integrate(f)
Integral(x/sqrt(x**4 +
    ↪ 10*x**2 - 96*x - 72),
    ↪ x)

>>> sp.N(sp.integrate(f,
    ↪ (x,5,10)))
0.757876976057575
```

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

Wolfram|Alpha



$((\text{distance from earth to moon}) / (\text{length of an elephant})) * (\text{mass of an elephant})$



NATURAL LANGUAGE

MATH INPUT

EXTENDED KEYBOARD

EXAMPLES

UPLOAD

RANDOM

Assuming African bush elephant | Use [elephants](#) instead

Assuming length | Use [head and body length](#) instead

Input interpretation

Moon distance from Earth

African bush elephant length

African bush elephant weight

Result

Show non-metric

Show details

$(9 \times 10^{10}$ to $5.3 \times 10^{11})$ kg (kilograms)

Unit conversions

$\approx (1.9 \times 10^{11}$ to $1.2 \times 10^{12})$ lb (pounds)

Wolfram|Alpha

```
In[4]= WolframAlpha["((distance from earth to moon) / (length of an elephant)) * (mass of an elephant)"]
```

Assuming African bush elephant | Use **elephants** instead
Assuming length | Use **head and body length** instead

Input interpretation: +

Moon distance from Earth

African bush elephant weight

African bush elephant length

Out[4]=

Result:

$(9 \times 10^{10}$ to $5.3 \times 10^{11})$ kg (kilograms)

Show non-metric

Show details +

Unit conversions: +

$\approx (1.9 \times 10^{11}$ to $1.2 \times 10^{12})$ lb (pounds)

$\approx (9 \times 10^{13}$ to $5.5 \times 10^{14})$ grams

$\approx (9 \times 10^7$ to $5.5 \times 10^8)$ t (metric tons)

WolframAlpha +



Wolfram|Alpha

```
In[12]:= Integrate[x2, x]
```

```
Out[12]=  $\frac{x^3}{3}$ 
```

Wolfram|Alpha



integral x^2 dx



NATURAL LANGUAGE



MATH INPUT



EXTENDED KEYBOARD



EXAMPLES



UPLOAD



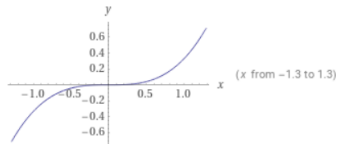
RANDOM

Indefinite integral

 Step-by-step solution

$$\int x^2 dx = \frac{x^3}{3} + \text{constant}$$

Plot of the integral



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Wolfram|Alpha



$$\int x^2 dx$$



NATURAL LANGUAGE



MATH INPUT

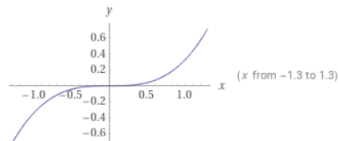
★ √ ∂f (::) √v aω | ...

Indefinite integral

 Step-by-step solution

$$\int x^2 dx = \frac{x^3}{3} + \text{constant}$$

Plot of the integral



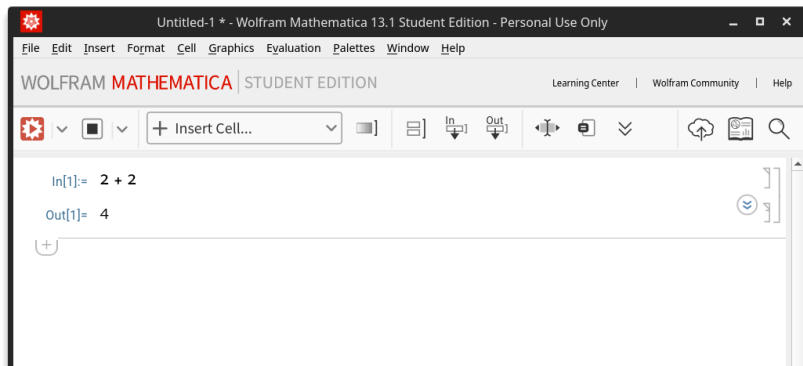
POWERED BY THE WOLFRAM LANGUAGE

Mathematica

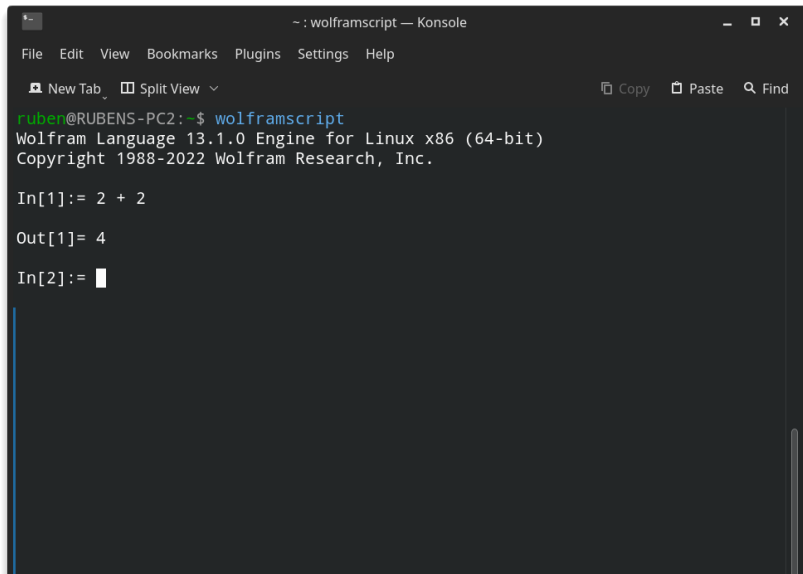
- Interface für die Wolfram Language
- Kernel und GUI (vgl. Jupyter Notebook)
- Interaktion über Notebook
- Ein- und Ausgaben sind strukturiert in Cells

Eine erste Rechnung

- Im Hauptbildschirm: *New Document* → *Notebook*
- Tippe „2+2“ und bestätige mit Shift + Enter



Alternativ: Über die Konsole



```
~ : wolframscript — Konsole
File Edit View Bookmarks Plugins Settings Help
New Tab Split View Copy Paste Find
ruben@RUBENS-PC2:~$ wolframscript
Wolfram Language 13.1.0 Engine for Linux x86 (64-bit)
Copyright 1988-2022 Wolfram Research, Inc.

In[1]:= 2 + 2
Out[1]= 4
In[2]:=
```

Intermission

sympy

- `https://www.sympy.org/en/features.html`
- `https://jupyter.org/`
- `jupyter-lab`

Übung

Betrachte die Funktionenfolge

$$f_n(x) = \cos\left(\frac{\pi x^{(2n+1)}}{2(3n-7)}\right).$$

Finde $n \in \{1, \dots, 25\} \subset \mathbb{N}$ so, dass die betragsmäßig kleinste Nullstelle von $f_n(x)$ bei $x = 2$ liegt

(also $f_n(2) = 0$ und $f_n(x) \neq 0$ für alle $x \in (-2, 2) \subset \mathbb{R}$).