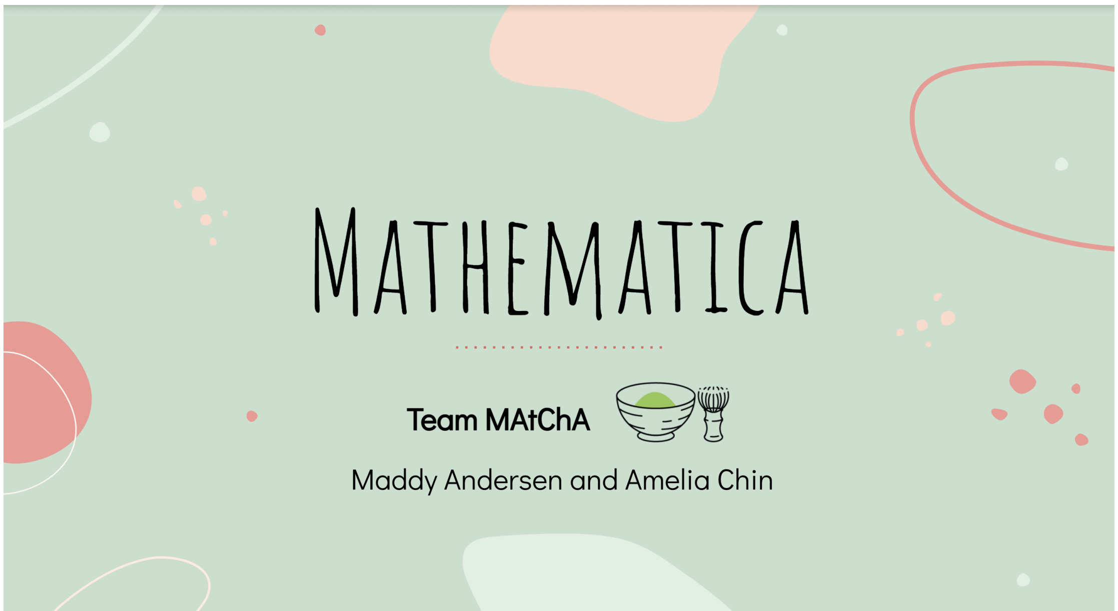
P2: TEDxSoftDevVIII — Mathematica

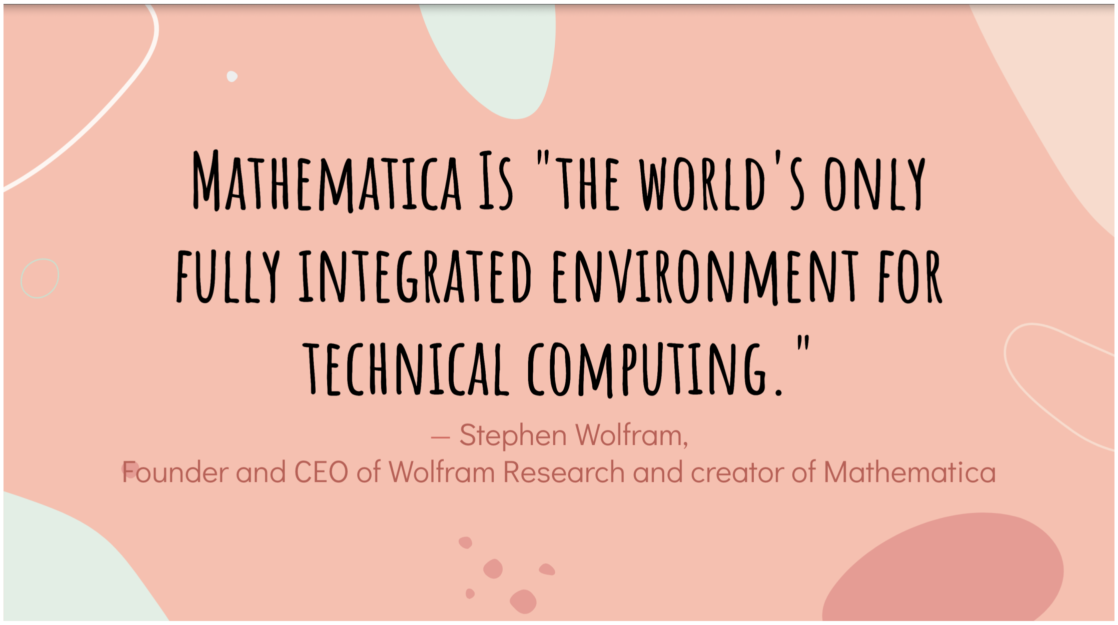
Team MAtChA: Maddy Andersen and Amelia Chin



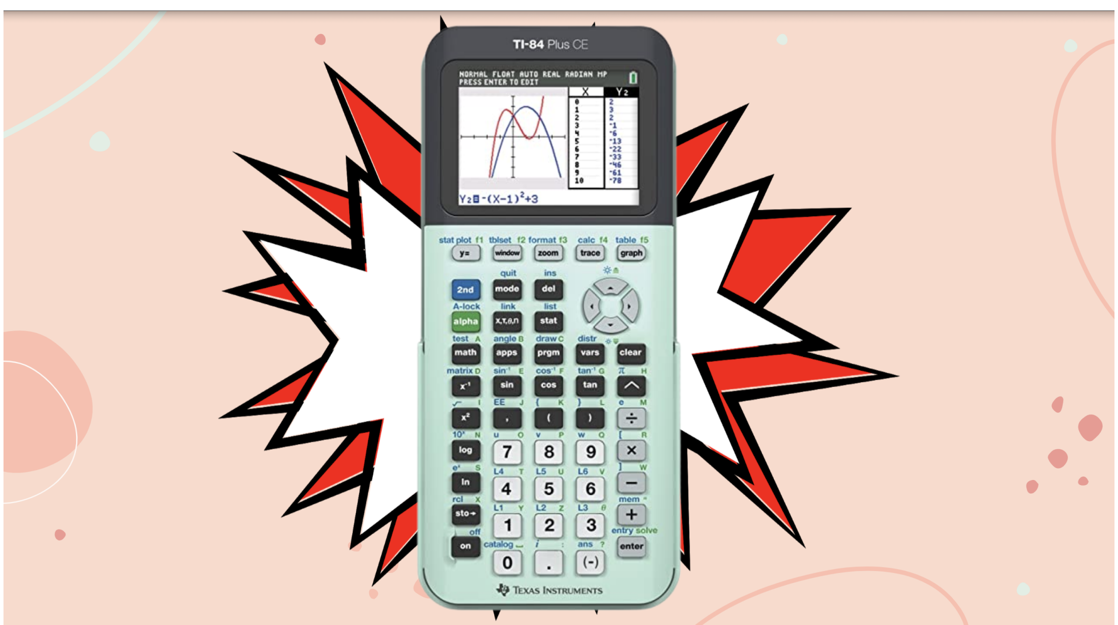
It’s 2 am. You have a problem set due at 8 am that you are nowhere near done with.

The problem requires you to visualize a 3D graph. You try your Ti-84 Plus, but it only graphs in 2D. Then you try Desmos, but it lets you down too. What do you do?

Introducing Mathematica, AKA fast acting math relief! While Mathematica will solve your homework problems, what exactly is Mathematica?



Stephen Wolfram, the creator of Mathematica, describes it as “the world’s only fully integrated environment for technical computing,” but what does that mean?



In the simplest terms, Mathematica is a graphing calculator on steroids. It is a platform that allows users to work with and visualize data from many fields, including math, science and technology, society and culture, and everyday life. Mathematica is used professionally in a variety of fields, but even as a high school or college student, Mathematica can still be a useful tool. You can use it to solve math equations at 2 am, or you can also use it to enhance data visualization in research papers and projects.

While math and science papers may come to mind first, one student used Mathematica in an architecture paper to visualize components of a landmark building in Italy. The student eventually used their

Mathematica calculations to 3D print the structure.

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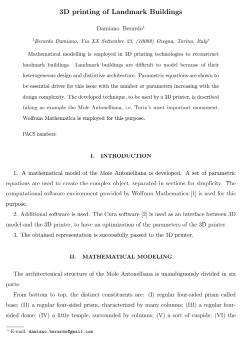

3D printing of Landmark Buildings

Damiano Berardo[1]

[1]*Berardo Damiano, Via XX Settembre 23, (10080) Ozegna, Torino, Italy**

Mathematical modelling is employed in 3D printing technologies to reconstruct landmark buildings. Landmark buildings are difficult to model because of their heterogeneous design and distintive architecture. Parametric equations are shown to be essential driver for this issue with the number or parameters increasing with the design complexity. The developed technique, to be used by a 3D printer, is described taking as example the Mole Antonelliana, i.e. Turin's most important monument. Wolfram Mathematica is employed for this purpose.

PACS numbers:

I. INTRODUCTION

1. A mathematical model of the Mole Antonelliana is developed. A set of parametric equations are used to create the complex object, separated in sections for simplicity. The computational software environment provided by Wolfram Mathematica [1] is used for this purpose.

2. Additional software is used. The Cura software [2] is used as an interface between 3D model and the 3D printer, to have an optimization of the parameters of the 3D printer.

3. The obtained representation is successfully passed to the 3D printer.

II. MATHEMATICAL MODELING

The architectonical structure of the Mole Antonelliana is unambiguously divided in six parts.

From bottom to top, the distinct constituents are: (I) regular four-sided prism called base; (II) a regular four-sided prism, characterized by many columns; (III) a regular four-sided dome; (IV) a little temple, surrounded by columns; (V) a sort of cuspide; (VI) the

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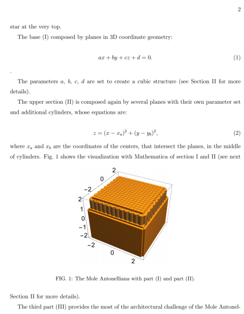

2

star at the very top.

The base (I) composed by planes in 3D coordinate geometry:

$$ax + by + cz + d = 0. \quad (1)$$

The parameters a, b, c, d are set to create a cubic structure (see Section II for more details).

The upper section (II) is composed again by several planes with their own parameter set and additional cylinders, whose equations are:

$$z = (x - x_a)^2 + (y - y_b)^2, \quad (2)$$

where x_a and x_b are the coordinates of the centers, that intersect the planes, in the middle of cylinders. Fig. 1 shows the visualization with Mathematica of section I and II (see next

FIG. 1: The Mole Antonelliana with part (I) and part (II).

Section II for more details).

The third part (III) provides the most of the architectural challenge of the Mole Antonel-

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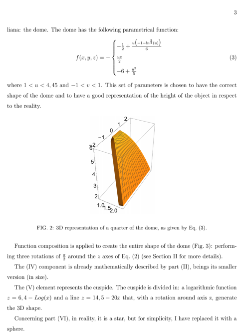

3

liana: the dome. The dome has the following parametrical function:

$$f(x,y,z) = -\begin{cases} -\frac{1}{2} + \frac{u\left(-1-\log^{0.75}(u)\right)}{6} \\ \frac{uv}{2} \\ -6+\frac{u^2}{5} \end{cases} \quad (3)$$

where $1 < u < 4.45$ and $-1 < v < 1$. This set of parameters is chosen to have the correct shape of the dome and to have a good representation of the height of the object in respect to the reality.

FIG. 2: 3D representation of a quarter of the dome, as given by Eq. (3).

Function composition is applied to create the entire shape of the dome (Fig. 3): performing three rotations of $\frac{\pi}{2}$ around the z axes of Eq. (2) (see Section II for more details).

The (IV) component is already mathematically described by part (II), beings its smaller version (in size).

The (V) element represents the cuspide. The cuspide is divided in: a logarithmic function $z = 6.4 - Log(x)$ and a line $z = 14.5 - 20x$ that, with a rotation around axis z, generate the 3D shape.

Concerning part (VI), in reality, it is a star, but for simplicity, I have replaced it with a sphere.

The result is shown in Fig. 4.

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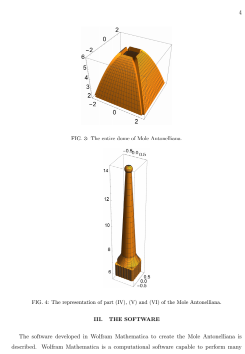

4

FIG. 3: The entire dome of Mole Antonelliana.

FIG. 4: The representation of part (IV), (V) and (VI) of the Mole Antonelliana.

III. THE SOFTWARE

The software developed in Wolfram Mathematica to create the Mole Antonelliana is described. Wolfram Mathematica is a computational software capable to perform many

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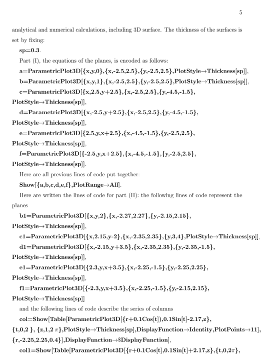

5

analytical and numerical calculations, including 3D surface. The thickness of the surfaces is set by fixing:

```
sp=0.3.
```

Part (I), the equations of the planes, is encoded as follows:

```
a=ParametricPlot3D[{x,y,0},{x,-2.5,2.5},{y,-2.5,2.5},PlotStyle→Thickness[sp]],
b=ParametricPlot3D[{x,y,1},{x,-2.5,2.5},{y,-2.5,2.5},PlotStyle→Thickness[sp]],
c=ParametricPlot3D[{x,2.5,y+2.5},{x,-2.5,2.5},{y,-4.5,-1.5},
PlotStyle→Thickness[sp]],
d=ParametricPlot3D[{x,-2.5,y+2.5},{x,-2.5,2.5},{y,-4.5,-1.5},
PlotStyle→Thickness[sp]],
e=ParametricPlot3D[{2.5,y,x+2.5},{x,-4.5,-1.5},{y,-2.5,2.5},
PlotStyle→Thickness[sp]],
f=ParametricPlot3D[{-2.5,y,x+2.5},{x,-4.5,-1.5},{y,-2.5,2.5},
PlotStyle→Thickness[sp]].
```

Here are all previous lines of code put together:

```
Show[{a,b,c,d,e,f},PlotRange→All].
```

Here are written the lines of code for part (II): the following lines of code represent the planes

```
b1=ParametricPlot3D[{x,y,2},{x,-2.27,2.27},{y,-2.15,2.15},
PlotStyle→Thickness[sp]],
c1=ParametricPlot3D[{x,2.15,y-2},{x,-2.35,2.35},{y,3,4},PlotStyle→Thickness[sp]],
d1=ParametricPlot3D[{x,-2.15,y+3.5},{x,-2.35,2.35},{y,-2.35,-1.5},
PlotStyle→Thickness[sp]],
e1=ParametricPlot3D[{2.3,y,x+3.5},{x,-2.25,-1.5},{y,-2.25,2.25},
PlotStyle→Thickness[sp]],
f1=ParametricPlot3D[{-2.3,y,x+3.5},{x,-2.25,-1.5},{y,-2.15,2.15},
PlotStyle→Thickness[sp]]
```

and the following lines of code describe the series of columns

```
col=Show[Table[ParametricPlot3D[{r+0.1Cos[t]),0.1Sin[t]-2.17,z},
{t,0,2 }, {z,1,2 π},PlotStyle→Thickness[sp],DisplayFunction→Identity,PlotPoints→11],
{r,-2.25,2.25,0.4}],DisplayFunction→$DisplayFunction],
col1=Show[Table[ParametricPlot3D[{r+0.1Cos[t],0.1Sin[t]+2.17,z},{t,0,2π},
```

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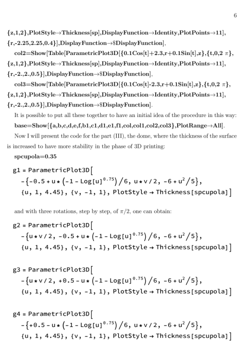

6

```
{z,1,2},PlotStyle→Thickness[sp],DisplayFunction→Identity,PlotPoints→11],
{r,-2.25,2.25,0.4}],DisplayFunction→$DisplayFunction],
col2=Show[Table[ParametricPlot3D[{0.1Cos[t]+2.3,r+0.1Sin[t],z},{t,0,2 π},
{z,1,2},PlotStyle→Thickness[sp],DisplayFunction→Identity,PlotPoints→11],
{r,-2.,2.,0.5}],DisplayFunction→$DisplayFunction],
col3=Show[Table[ParametricPlot3D[{0.1Cos[t]-2.3,r+0.1Sin[t],z},{t,0,2 π},
{z,1,2},PlotStyle→Thickness[sp],DisplayFunction→Identity,PlotPoints→11],
{r,-2.,2.,0.5}],DisplayFunction→$DisplayFunction].
```

It is possible to put all these together to have an initial idea of the procedure in this way:

```
base=Show[{a,b,c,d,e,f,b1,c1,d1,e1,f1,col,col1,col2,col3},PlotRange→All].
```

Now I will present the code for the part (III), the dome, where the thickness of the surface is increased to have more stability in the phase of 3D printing:

```
spcupola=0.35

g1 = ParametricPlot3D[
  -{-0.5 + u * (-1 - Log[u]^0.75) / 6, u * v / 2, -6 + u^2 / 5},
  {u, 1, 4.45}, {v, -1, 1}, PlotStyle → Thickness[spcupola]]
```

and with three rotations, step by step, of $\pi/2$, one can obtain:

```
g2 = ParametricPlot3D[
  -{u * v / 2, -0.5 + u * (-1 - Log[u]^0.75) / 6, -6 + u^2 / 5},
  {u, 1, 4.45}, {v, -1, 1}, PlotStyle → Thickness[spcupola]]

g3 = ParametricPlot3D[
  -{u * v / 2, +0.5 - u * (-1 - Log[u]^0.75) / 6, -6 + u^2 / 5},
  {u, 1, 4.45}, {v, -1, 1}, PlotStyle → Thickness[spcupola]]

g4 = ParametricPlot3D[
  -{+0.5 - u * (-1 - Log[u]^0.75) / 6, u * v / 2, -6 + u^2 / 5},
  {u, 1, 4.45}, {v, -1, 1}, PlotStyle → Thickness[spcupola]]

G=Show[{g1,g2,g3,g4},PlotRange→All]
```

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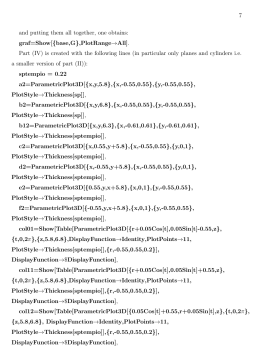

7

and putting them all together, one obtains:

```
graf=Show[{base,G},PlotRange→All].
```

Part (IV) is created with the following lines (in particular only planes and cylinders i.e. a smaller version of part (II)):

```
sptempio = 0.22
a2=ParametricPlot3D[{x,y,5.8},{x,-0.55,0.55},{y,-0.55,0.55},
PlotStyle→Thickness[sp]],
b2=ParametricPlot3D[{x,y,6.8},{x,-0.55,0.55},{y,-0.55,0.55},
PlotStyle→Thickness[sp]],
b12=ParametricPlot3D[{x,y,6.3},{x,-0.61,0.61},{y,-0.61,0.61},
PlotStyle→Thickness[sptempio]],
c2=ParametricPlot3D[{x,0.55,y+5.8},{x,-0.55,0.55},{y,0,1},
PlotStyle→Thickness[sptempio]],
d2=ParametricPlot3D[{x,-0.55,y+5.8},{x,-0.55,0.55},{y,0,1},
PlotStyle→Thickness[sptempio]],
e2=ParametricPlot3D[{0.55,y,x+5.8},{x,0,1},{y,-0.55,0.55},
PlotStyle→Thickness[sptempio]],
f2=ParametricPlot3D[{-0.55,y,x+5.8},{x,0,1},{y,-0.55,0.55},
PlotStyle→Thickness[sptempio]],
col01=Show[Table[ParametricPlot3D[{r+0.05Cos[t],0.05Sin[t]-0.55,z},
{t,0,2π},{z,5.8,6.8},DisplayFunction→Identity,PlotPoints→11,
PlotStyle→Thickness[sptempio]],{r,-0.55,0.55,0.2}],
DisplayFunction→$DisplayFunction],
col11=Show[Table[ParametricPlot3D[{r+0.05Cos[t],0.05Sin[t]+0.55,z},
{t,0,2π},{z,5.8,6.8},DisplayFunction→Identity,PlotPoints→11,
PlotStyle→Thickness[sptempio]],{r,-0.55,0.55,0.2}],
DisplayFunction→$DisplayFunction],
col12=Show[Table[ParametricPlot3D[{0.05Cos[t]+0.55,r+0.05Sin[t],z},{t,0,2π},
{z,5.8,6.8}, DisplayFunction→Identity,PlotPoints→11,
PlotStyle→Thickness[sptempio]],{r,-0.55,0.55,0.2}],
DisplayFunction→$DisplayFunction],
col13=Show[Table[ParametricPlot3D[{0.05Cos[t]-0.55,r+0.05Sin[t],z},{t,0,2π},
```

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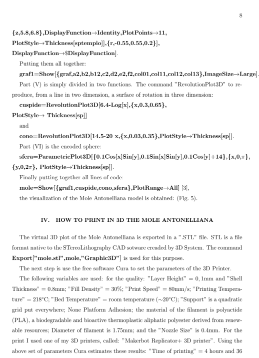

8

```
{z,5.8,6.8},DisplayFunction→Identity,PlotPoints→11,
PlotStyle→Thickness[sptempio]],{r,-0.55,0.55,0.2}],
DisplayFunction→$DisplayFunction].
```

Putting them all together:

```
graf1=Show[{graf,a2,b2,b12,c2,d2,e2,f2,col01,col11,col12,col13},ImageSize→Large].
```

Part (V) is simply divided in two functions. The command "RevolutionPlot3D" to reproduce, from a line in two dimension, a surface of rotation in three dimension:

```
cuspide=RevolutionPlot3D[6.4-Log[x],{x,0.3,0.65},
PlotStyle→ Thickness[sp]]
```

and

```
cono=RevolutionPlot3D[14.5-20 x,{x,0.03,0.35},PlotStyle→Thickness[sp]].
```

Part (VI) is the encoded sphere:

```
sfera=ParametricPlot3D[{0.1Cos[x]Sin[y],0.1Sin[x]Sin[y],0.1Cos[y]+14},{x,0,π},
{y,0,2π}, PlotStyle→Thickness[sp]].
```

Finally putting together all lines of code:

```
mole=Show[{graf1,cuspide,cono,sfera},PlotRange→All] [3],
```

the visualization of the Mole Antonelliana model is obtained: (Fig. 5).

IV. HOW TO PRINT IN 3D THE MOLE ANTONELLIANA

The virtual 3D plot of the Mole Antonelliana is exported in a ".STL" file. STL is a file format native to the STereoLithography CAD sotware creaded by 3D System. The command **Export[''mole.stl'',mole,''Graphic3D'']** is used for this purpose.

The next step is use the free software Cura to set the parameters of the 3D Printer.

The following variables are used: for the quality: "Layer Height" = 0, 1mm and "Shell Thickness" = 0.8mm; "Fill Density" = 30%; "Print Speed" = 80mm/s; "Printing Temperature" = 218°C; "Bed Temperature" = room temperature (∼20°C); "Support" is a quadratic grid put everywhere; None Platform Adhesion; the material of the filament is polyactide (PLA), a biodegradable and bioactive thermoplastic aliphatic polyester derived from renewable resources; Diameter of filament is 1.75mm; and the "Nozzle Size" is 0.4mm. For the print I used one of my 3D printers, called: "Makerbot Replicator+ 3D printer". Using the above set of parameters Cura estimates these results: "Time of printing" = 4 hours and 36

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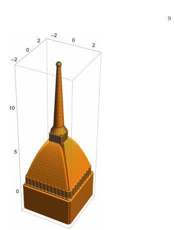

9

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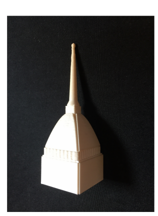

10

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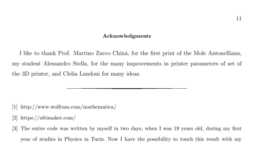

11

Acknowledgments

I like to thank Prof. Martino Zucco Chinà, for the first print of the Mole Antonelliana, my student Alessandro Stella, for the many improvements in printer parameters of set of the 3D printer, and Clelia Landoni for many ideas.

[1] http://www.wolfram.com/mathematica/

[2] https://ultimaker.com/

[3] The entire code was written by myself in two days, when I was 19 years old, during my first year of studies in Physics in Turin. Now I have the possibility to touch this result with my hands.

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FIG. 5: The Mole Antonelliana created in Mathematica.

minutes; 9.51 meters of filament is used; and a mass of 28gr.

The result of the print is showed in Fig. 6. The 3D model of the Mole Antonellina has a mass of 28gr, a length of the quadratic base is 4cm on the side and the height is 16cm. The real Mole Antonelliana's height is 168m, so the print is scaled down by about 1:1000.

V. CONCLUSIONS

3D printing of landmarks buildings is shown through the example of the Mole Antonelliana. No predefined modeling software is used. A new mathematical modelling algorithm is developed. The model is characterized by a parametric description. Parametric functions are selected to describe the complex architectural unit. Computing software is used to interface the developed 3D model to the 3D printer.

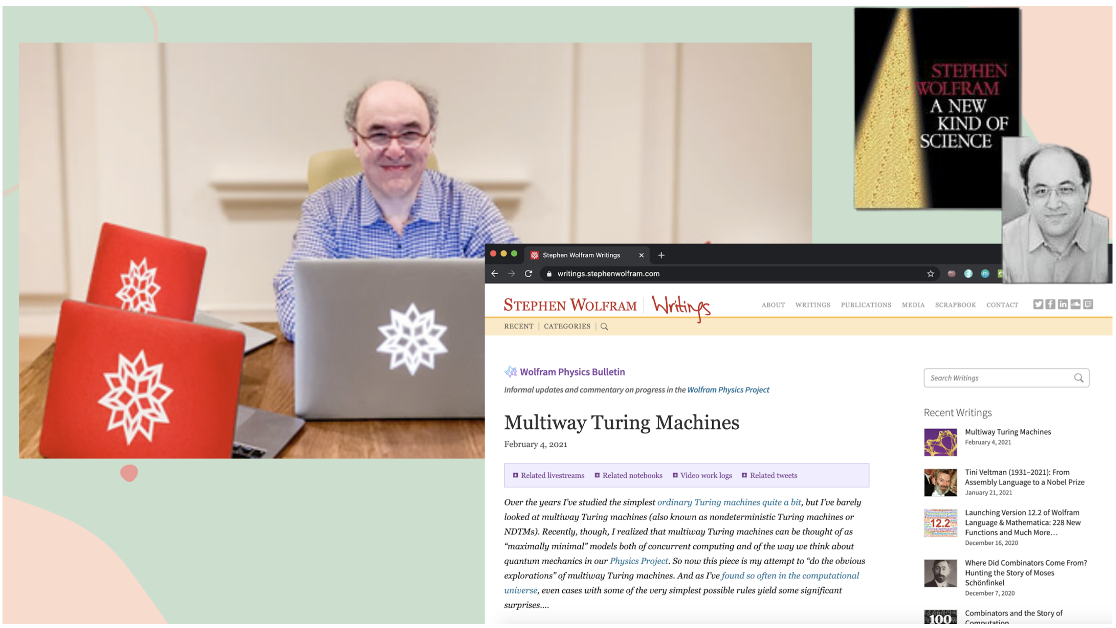
FIG. 6: The Mole Antonelliana printed in 3D, with white filament.

The model of Turin's monuments results proportional to the real one and well shape. On the top of the monument a sphere has been modelled instead of a star, showing a genuine product. The resulting model is not perfect in details. On the one hand, architectural complexities can be refined increasing the number of model parameters. On the other hand, details can't be too small, because they'd be omitted by the resolution of the 3D printer.

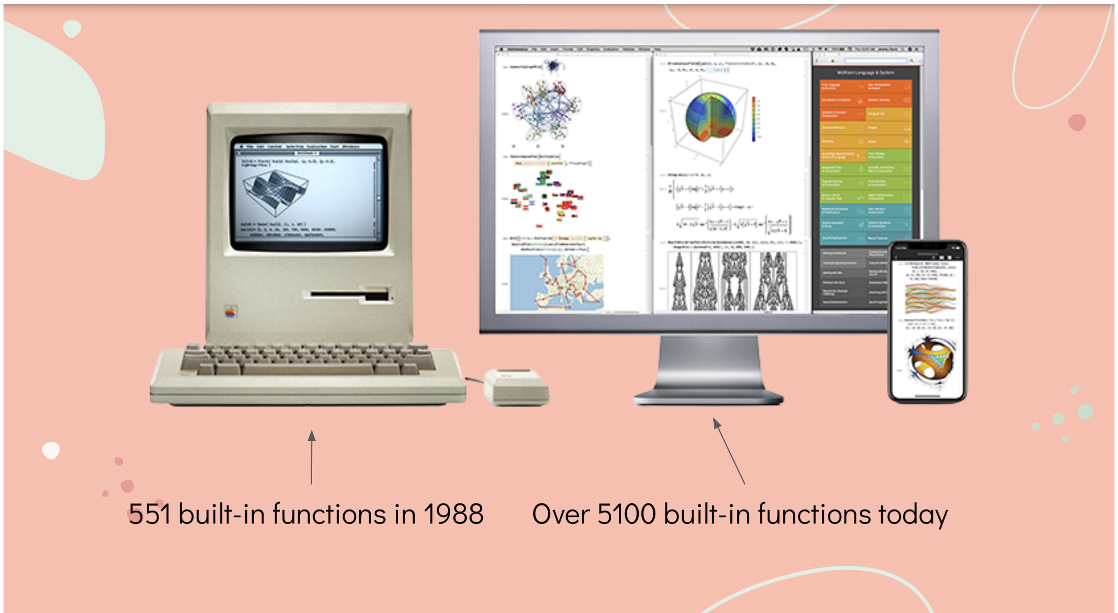
Most importantly, it's possible create from pure equations many complex objects.

If you want to download this paper, follow this link: https://www.academia.edu/38008422/3D_printing _of _Landmark _Buildings

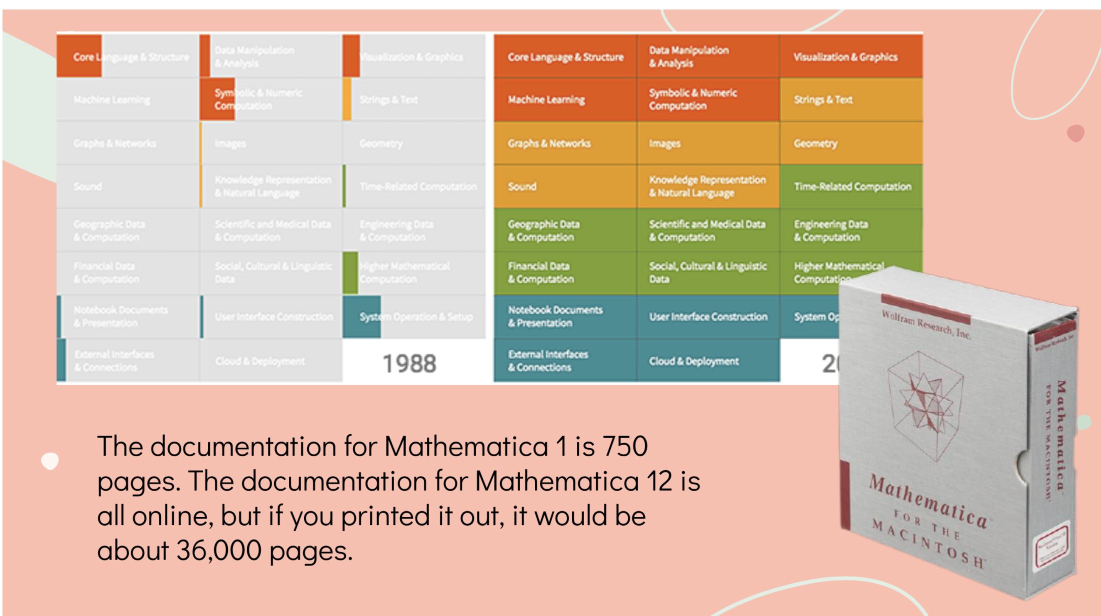
Just to summarize, Mathematica is used to visualize all sorts of data for a variety of purposes and classes.



Mathematica was created in 1988 by Stephen Wolfram, a famous British computer scientist, physicist, and businessman. Since then, there have been 11 subsequent versions. (We're on version 12 now.) Wolfram also writes often about his work on his blog, which will be linked at the end of this presentation. He's also written several books, including "A New Kind of Science," a 1200 page long book about computing and his work.



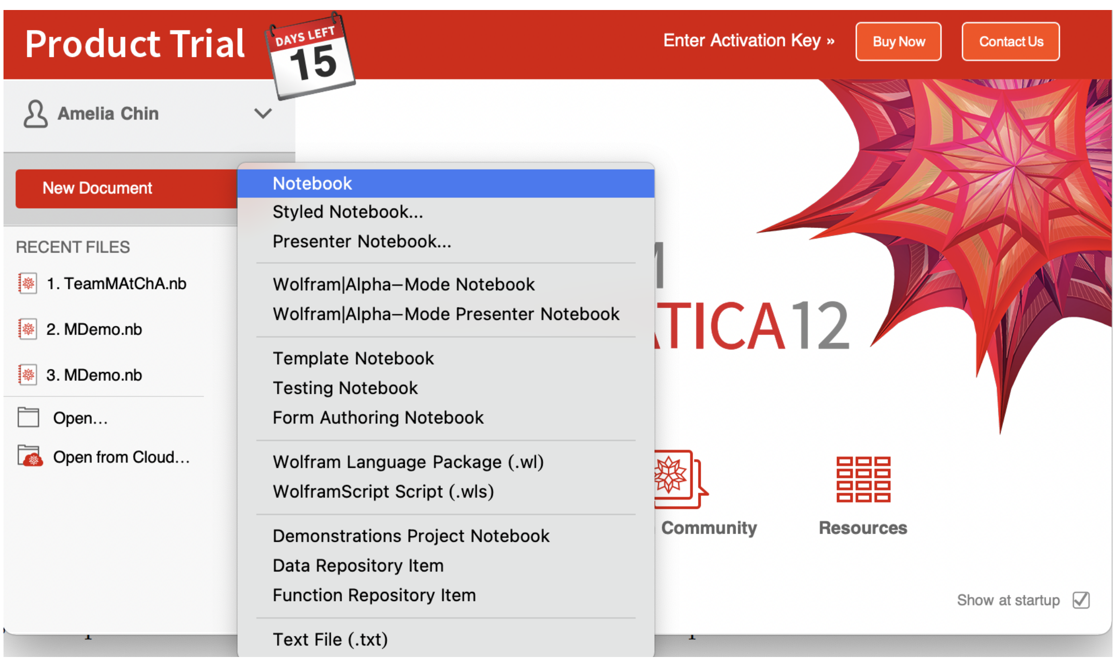
This is a cool side-by-side comparison of Mathematica 1 and Mathematica 12. Obviously there have been changes made since version 1 launched over 30 years ago: version 1 only had 551 built-in functions, while version 12 has over 5100. However, the general format and language used in Mathematica have remained the same, and code written for version 1 runs in version 12. Wolfram has even said that he occasionally runs his own original code to see if it still works.



This is a side-by-side comparison of how Mathematica's capabilities and coverage in various fields have expanded since its 1988 launch. For example, Mathematica 1 could not handle geometry problems, but Mathematica 12 handles them just as well as any other subject.

As a fun fact, The National Museum of Math (MoMath) in NYC uses Mathematica's tools to create their many logos. You can even create your own version of their logo at an exhibit powered by Mathematica.

While we've shown you large-scale uses of Mathematica in the architectural paper and at MoMath, we're now going to show you more about how Mathematica works and what else you can do with it in the Mathematica Desktop app.

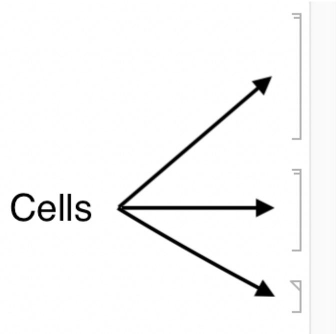


Start at Mathematica Desktop home, click down arrow to view options.

When you create a new document, there are many options: Notebook, Styled Notebook, Presenter

Notebook, etc. We'll be talking about the most basic Notebook. A notebook is what you call a Mathematica document.

Choose Notebook option to create a new notebook.



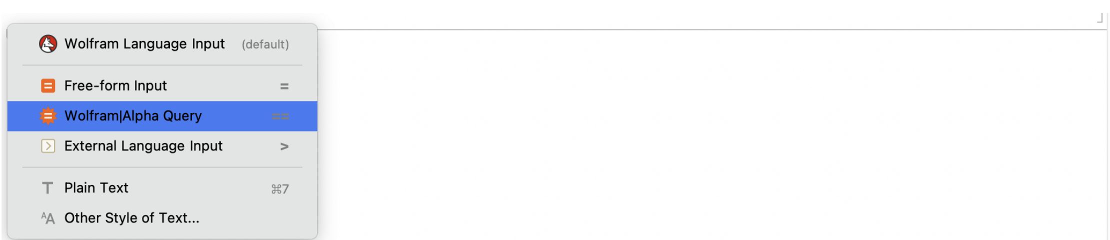
Notebooks are organized into cells, designated by the square brackets on the right.

To create a new cell, hover between or under existing cells. A horizontal bar with a "+" sign should appear.

There are many options for how you can input the content of a cell. The "+" sign allows you to determine which one you want: as a Wolfram Language Input, Free-form input, Wolfram|Alpha Query, External Language Input, Plain Text, or Other Style of Text. While in all of these cells, you would input content, only some return outputs.

We are going to explore each of these cell options in depth right now. The first three types will give us an output when we enter an input. Regardless of what type of input you choose, just to summarize, the input is within a cell within a notebook.

We're going to start with a Wolfram|Alpha Query cell.



For a Wolfram|Alpha Query, the input can be in your natural language, which is without special formatting or syntax. As you'll see in a second, it returns results stylized like the Wolfram|Alpha website (if you've ever used that).

First, going back to 2am, we can find the derivative of 3x^3+4x^2. Once the input is typed in, press Shift and Enter simultaneously to compute.

In[1]:= **derivative of 3x^3+4x^2**

Derivative:

Use the power rule | Hide steps

$$\frac{d}{dx}(3x^3 + 4x^2) = x(9x + 8)$$

Possible intermediate steps:

Possible derivation:

$$\frac{d}{dx}(3x^3 + 4x^2)$$

Differentiate the sum term by term and factor out constants:

$$= 4\left(\frac{d}{dx}(x^2)\right) + 3\left(\frac{d}{dx}(x^3)\right)$$

Use the power rule, $\frac{d}{dx}(x^n) = n x^{n-1}$, where $n = 2$.

$\frac{d}{dx}(x^2) = 2x$:

$$= 3\left(\frac{d}{dx}(x^3)\right) + 4\,\boxed{2x}$$

Simplify the expression:

$$= 8x + 3\left(\frac{d}{dx}(x^3)\right)$$

Use the power rule, $\frac{d}{dx}(x^n) = n x^{n-1}$, where $n = 3$.

$\frac{d}{dx}(x^3) = 3x^2$:

$$= 8x + 3\,\boxed{3x^2}$$

Simplify the expression:

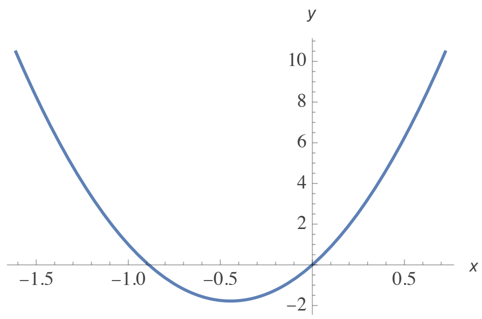
$$= 8x + 9x^2$$

Simplify the expression:

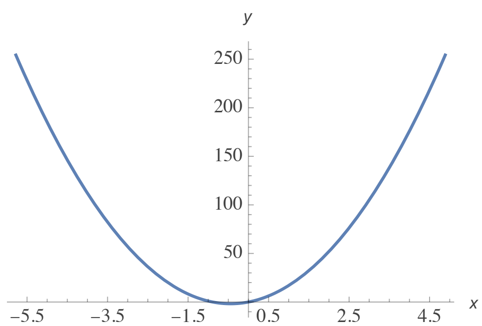
Answer:

$$= x(8 + 9x)$$

Plots:



min max



min max

Geometric figure: Properties

parabola

Alternate form:

$$\frac{1}{9}(9x+4)^2-\frac{16}{9}$$

Expanded forms:

$$\{9x^2+8x, \text{MInput}\to\text{Hold}[\text{expand} \quad x(9x+8)], \text{MOutput}\to 9x^2+8x\}$$

Roots : Approximate forms Step-by-step solution

$$x=-\frac{8}{9}$$

$$x=0$$

Polynomial discriminant :

Show class number

$$\Delta = 64$$

Properties as a real function:

Approximate forms

Domain:

$\mathbb{R}$ (all real numbers)

Range:

$$\{y \in \mathbb{R} : y \geq -\frac{16}{9}\}$$

R is the set of real numbers »

Indefinite integral:

Step –by –step solution

$$\int x\,(8 + 9\,x)\,dx = 3\,x^3 + 4\,x^2 + \text{constant}$$

Global minimum:

Approximate form | Step –by –step solution

$$\min\{x\,(9\,x + 8)\} = -\frac{16}{9} \text{ at } x = -\frac{4}{9}$$

Definite integral:

More digits

$$\int_{-\frac{8}{9}}^{0} x\,(8 + 9\,x)\,dx = -\frac{256}{243} \approx -1.0535$$

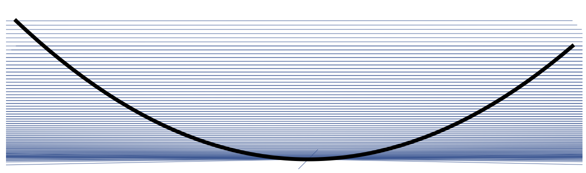
Definite integral area below the axis between the smallest and largest real roots:

More digits

$$\int_{-\frac{8}{9}}^{0} x\,(8 + 9\,x)\,\theta(-x\,(8 + 9\,x))\,dx = -\frac{256}{243} \approx -1.0535$$

$\theta(x)$ is the Heaviside step function »

Differential geometric curves:



— $x(9x+8)$ — normals

Horizontal plot range:

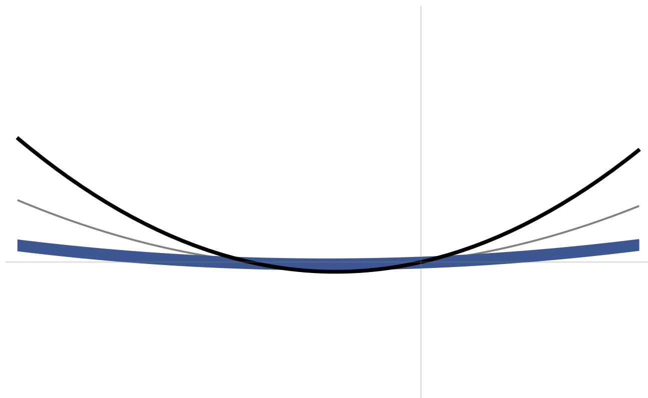
x_{min} x_{max} symmetric

+ More controls

Differential equation solution curve families:

embedding function $c_2 x^2 + c_1 x + c_0$

embedding ODE $y^{(3)}(x) = 0$



— original function $9x^2 + 8x$

— c_j-values function $\frac{9x^2}{2} + 4x$

— c_1-family $c_1 + \frac{9x^2}{2} + 4x$

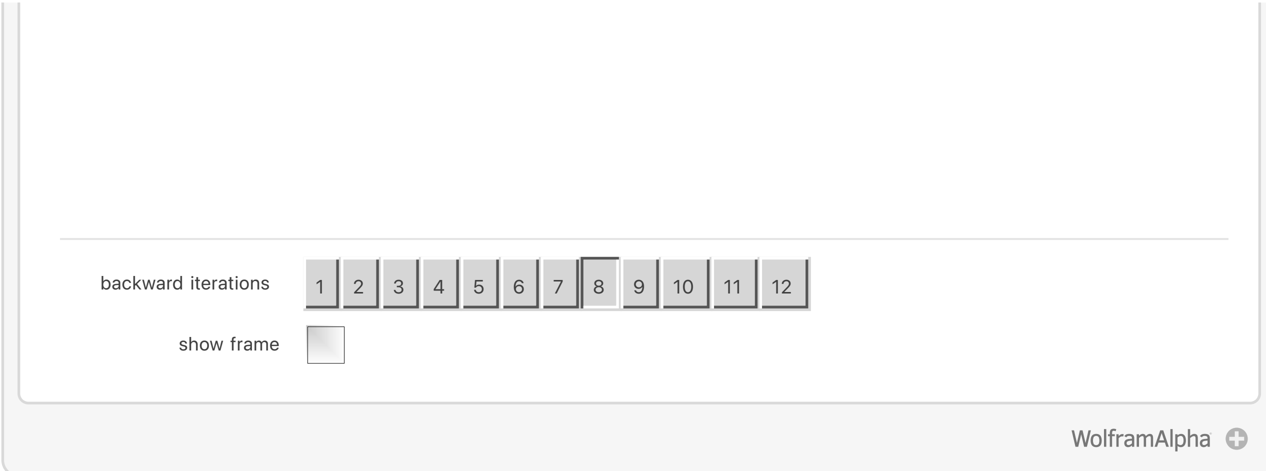
Horizontal plot range

x_{min} x_{max}

show axes show ticks

+ More controls

Inverse iterations:



This returns the derivative, a step-by-step solution, graphs, and alternate forms, among other things.

The Wolfram|Alpha Query also has a few fun features. One of them is creating curves of popular characters, such as Elmo.

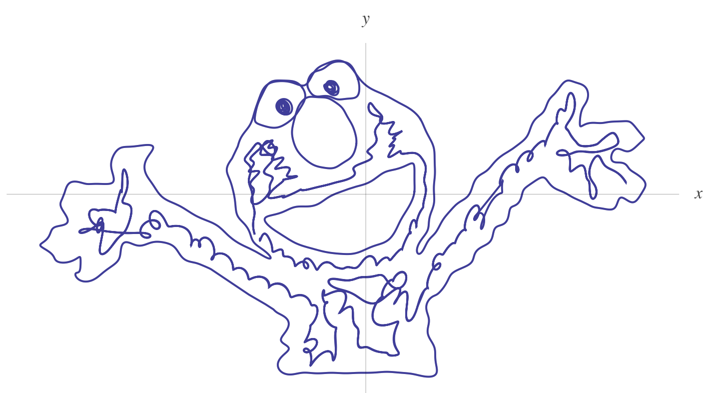
In[2]:= **elmo curve**

Input interpretation:

Elmo-like curve (popular curve)

Plot:

Hide axes Show ticks



t

(plotted for t from 0 to 32π)

Associated fictional character:

Elmo

Equations:

Parametric equations:

$$x(t) = \left(\left(-\frac{13}{22}\sin\left(\frac{350}{233} - 118\,t\right) - \frac{14}{19}\sin\left(\frac{17}{13} - 113\,t\right) - \frac{38}{61}\sin\left(\frac{23}{17} - 112\,t\right) - \frac{123}{46}\sin\left(\frac{31}{20} - 108\,t\right) - \frac{3}{37}\sin\left(\frac{2}{13}\right.\right.\right.$$

$$y(t) = \left(\left(-\frac{48}{31}\sin\left(\frac{50}{33} - 121\,t\right) - \frac{11}{18}\sin\left(\frac{37}{24} - 119\,t\right) - \frac{1}{33}\sin\left(\frac{34}{25} - 117\,t\right) - \frac{47}{23}\sin\left(\frac{25}{16} - 115\,t\right) - \frac{21}{29}\sin\left(\frac{49}{32} - 1\right.\right.\right.$$

$\theta(x)$ is the Heaviside step function »

$\mathrm{sgn}(x)$ is the sign of x »

Property:

fictional character curves

WolframAlpha

This returns a very cute graph, as well as the equation that produces it.

If you want to learn about a particular topic, such as the Perseverance rover that recently landed on Mars, you can use a Wolfram|Alpha Query.

In[4]:= **Perseverance rover**

Input interpretation:

Perseverance Rover (deep space probe)

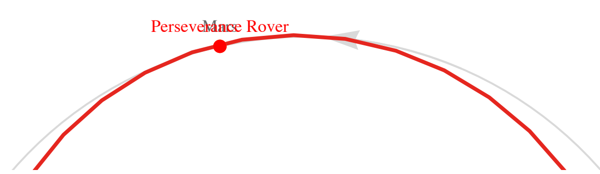
Rover properties: Show metric More

target	Mars
dry mass	2260 lb
launch mass	2260 lb
length	9.8 ft
width	8.9 ft
height	7.2 ft
number of wheels	6 wheels
heliocentric velocity	51 057 mph
power source	radioisotope thermoelectric generator
distance from Sun	149.5 million mi 1.608 au
distance from Earth	157.3 million mi 1.692 au

Mission properties: More

launch date	7:50 am EDT | Thursday, July 30, 2020 (1 year ago)
arrival date	Mars | 3:56 pm EST | Thursday, February 18, 2021
impact type	landing
operator country	United States

Current probe position : Hide arrows



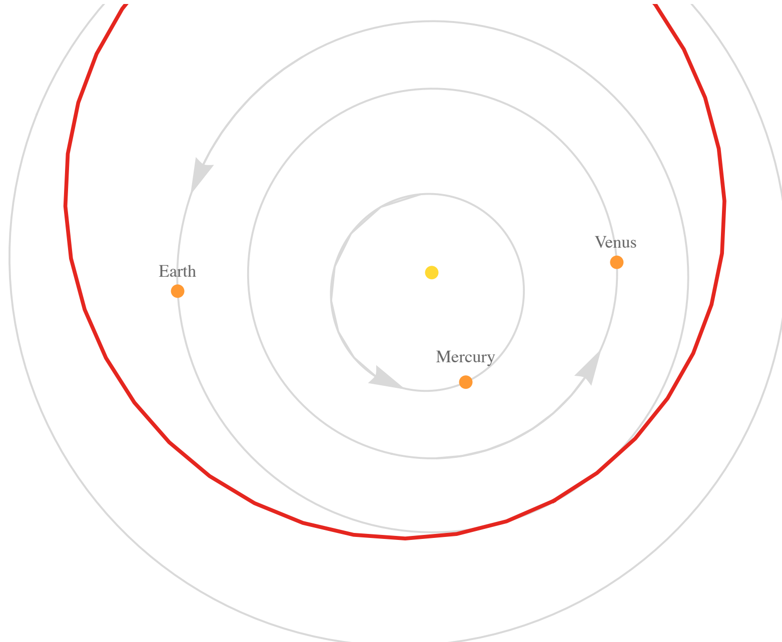
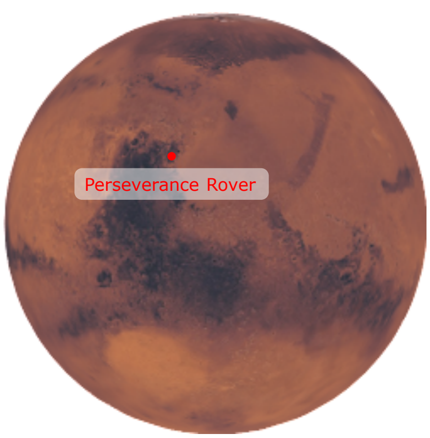


Image:

Surface location:

Show DMS | Cylindrical projection



(Mars, centered at 90° E longitude)

18° 26' 38" North	77° 27' 3" East

Equatorial location:

Show decimal

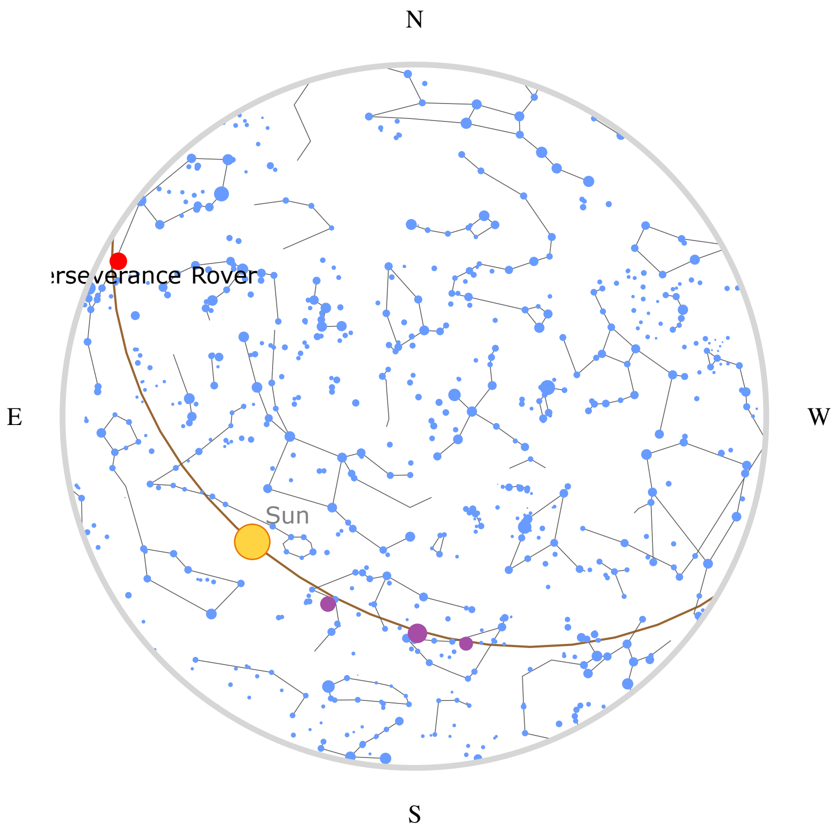
right ascension	$4^h\ 41^m\ 17.3^s$

declination	23° 41' 59.7"

✚ Units

Current sky position from New York City, New York:

Show mesh | Zoom | Show decimal



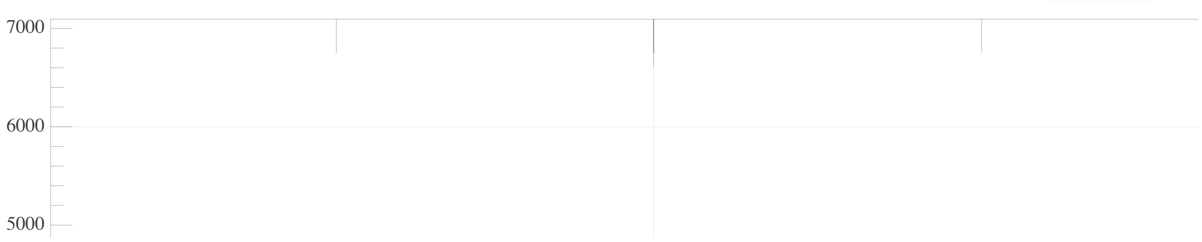
altitude	4° 30.911'
azimuth	62° 21.54' (ENE)
constellation	Taurus

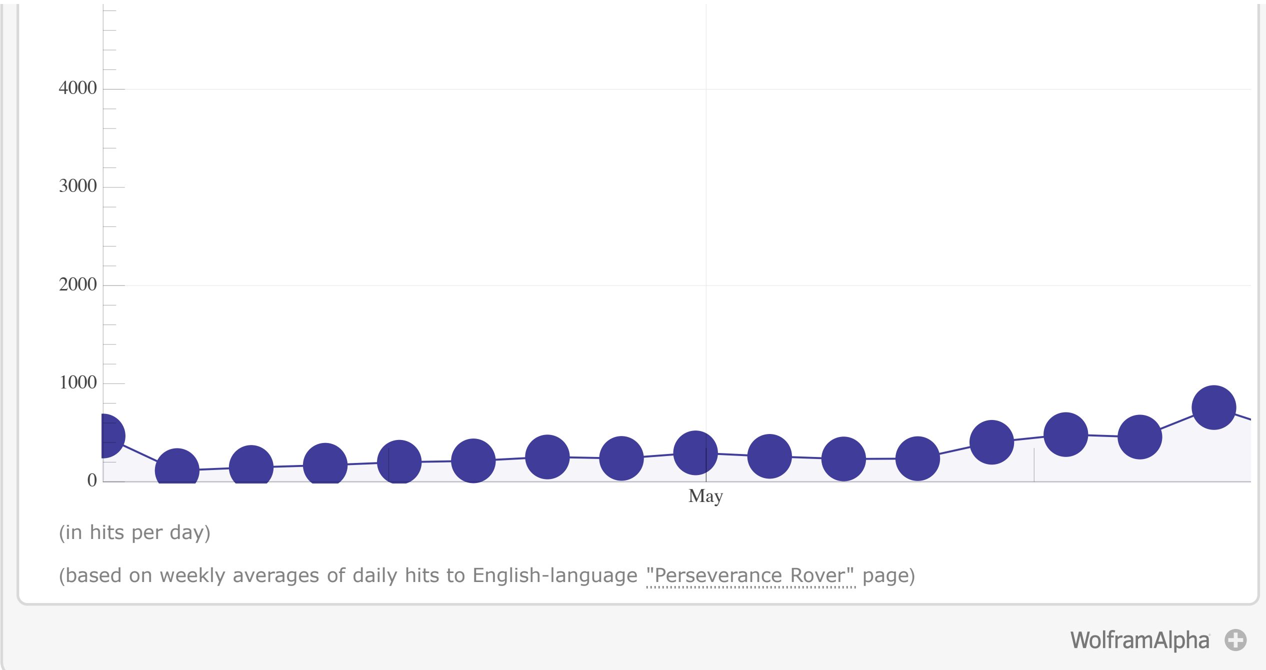
Wikipedia summary:

Perseverance, nicknamed *Percy*, is a car–sized rover designed to explore the Jezero crater on Mars as part of NASA's Mars 2020 mission. It was manufactured by the Jet Propulsion Laboratory and was launched on 30 July 2020, at 7 a.m. EDT (11 UTC), and is expected to land on Mars on 18 February 2021.

Wikipedia page hits history:

Log scale

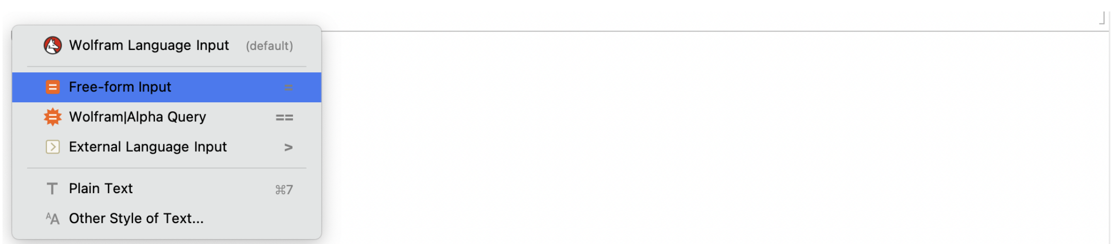




As you can see, a Wolfram|Alpha Query is similar to a Google search. Unlike with a Google search, however, you don’t have to jump around to multiple websites to compile your information. Wolfram|Alpha compiles it for you into an easily readable table.

To produce the outputs of your queries, Mathematica uses the Wolfram Knowledgebase. The Knowledgebase has been developed and fact-checked over the last three decades, with all data coming from primary sources. Fun fact: Alexa and Siri access the Knowledgebase to answer your random questions!

The next input type we will be exploring is the free-form cell.

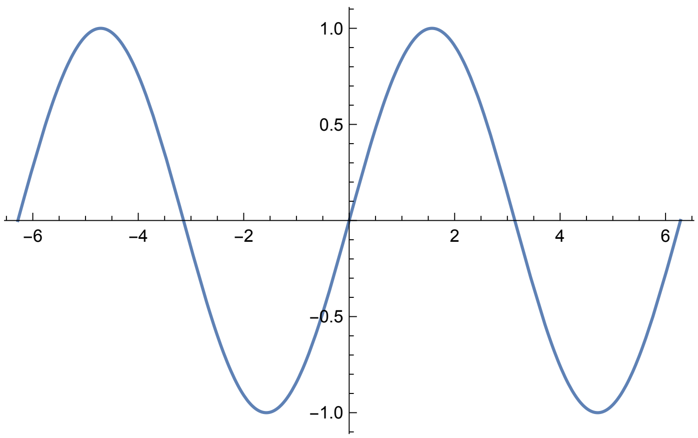


As in the Wolfram|Alpha Query, the input is in natural language. A free-form cell will either return relevant information or convert your input into Wolfram Language syntax for further use. For example, if you wanted to plot sin x but didn’t know the Mathematica syntax, you can use a free-form cell.

In[6]:=

```
plot sin x
Plot[Sin[x], {x, -2 * Pi, 2 * Pi}]
```

Out[6]=



As you can see, the output shows both the graph and “plot sin x” in the Wolfram Language syntax.

If you’re feeling lonely in quarantine, you can speak to a free-form cell like a friend.

In[7]:=

```
hello »
↳ Response
  TextCell["Hello, human."]
```

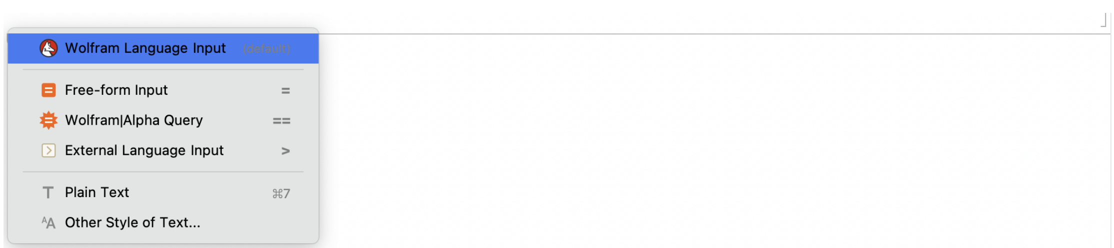
Out[7]= `Hello, human.`

In[12]:=

```
tell me a joke
↳ Result
  TextCell[
   "Starbuck worried Captain Ahab's pursuit of Möbius Dick was a one-sided fight."]
```

Out[12]= `Starbuck worried Captain Ahab's pursuit of Möbius Dick was a one-sided fight.`

We will now be going into more depth about the Wolfram Language.

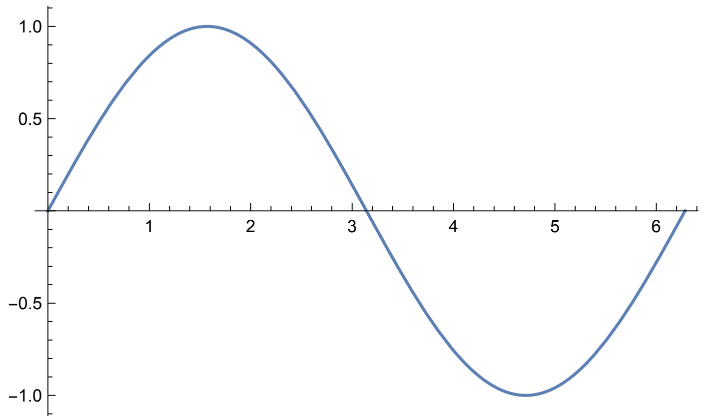


The Wolfram Language is built to be easily readable by both machines and humans. As you’ll see in the following examples, the code is understandable without knowing much of the syntax.

We’ll start by plotting sin x again, but this time we know the syntax.

In[13]:=
```
Plot[Sin[x], {x, 0, 2 Pi}]
```

Out[13]=

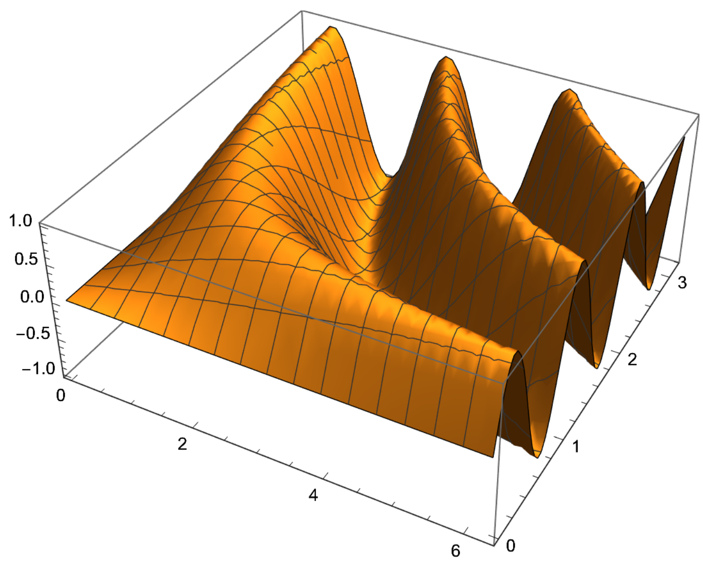


Notice how Mathematica uses capital letters for their built-in functions and constants, including Pi and Sin. This allows you to easily define your own using lowercase letters.

As we discussed earlier, Mathematica is great for 3D rendering. Let’s make this sine graph 3D!

In[14]:=
```
Plot3D[Sin[x y], {x, 0, 2 Pi}, {y, 0, Pi}]
```

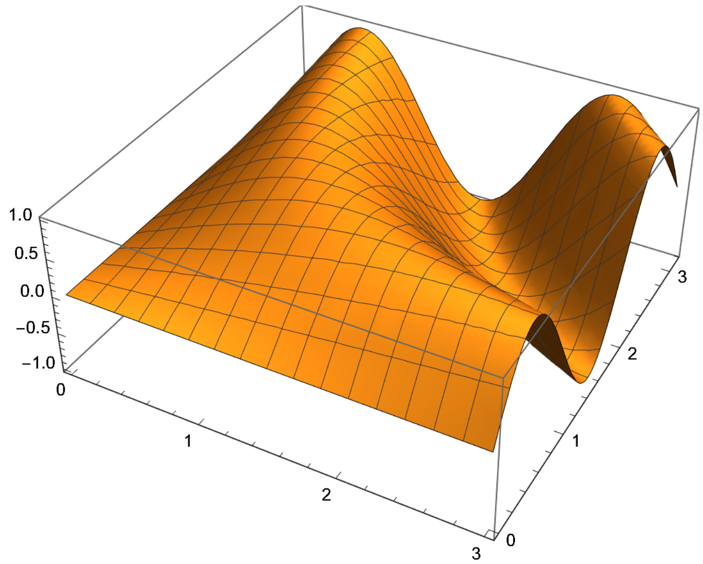
Out[14]=



You can easily manipulate this graph to view it from different angles. If we change one of these values, the graph will respond accordingly.

In[15]:=
```
Plot3D[Sin[x y], {x, 0, 3}, {y, 0, Pi}]
```

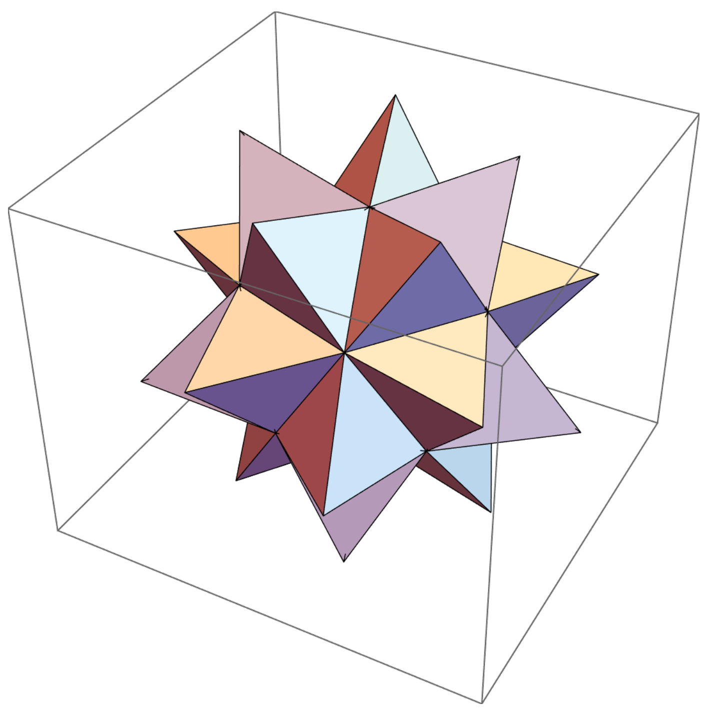
Out[15]=



Aside from graphs, we can also visualize shapes.

In[16]:=
```
PolyhedronData["MathematicaPolyhedron"]
```

Out[16]=



This is the Wolfram logo in 3D.

If you're done with your math homework and it's time for Art Appreciation, don't close Mathematica!

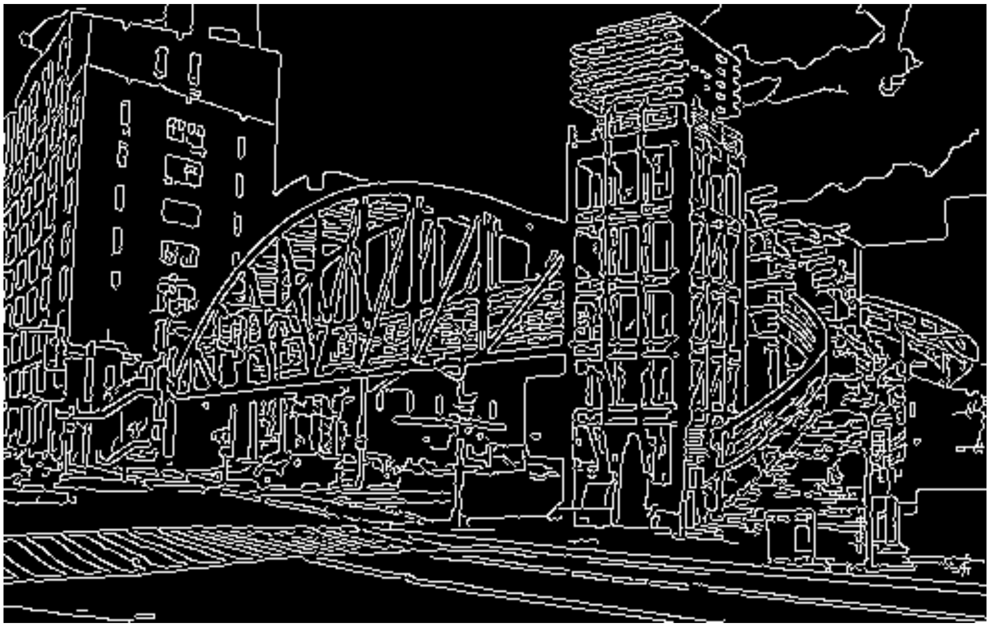
In[22]:=
```
EntityValue[
 RandomSample[Vincent van Gogh PERSON ["NotableArtworks"], 15], "Image"]
```

Out[22]= {, , , , , , , , , , , , , , }

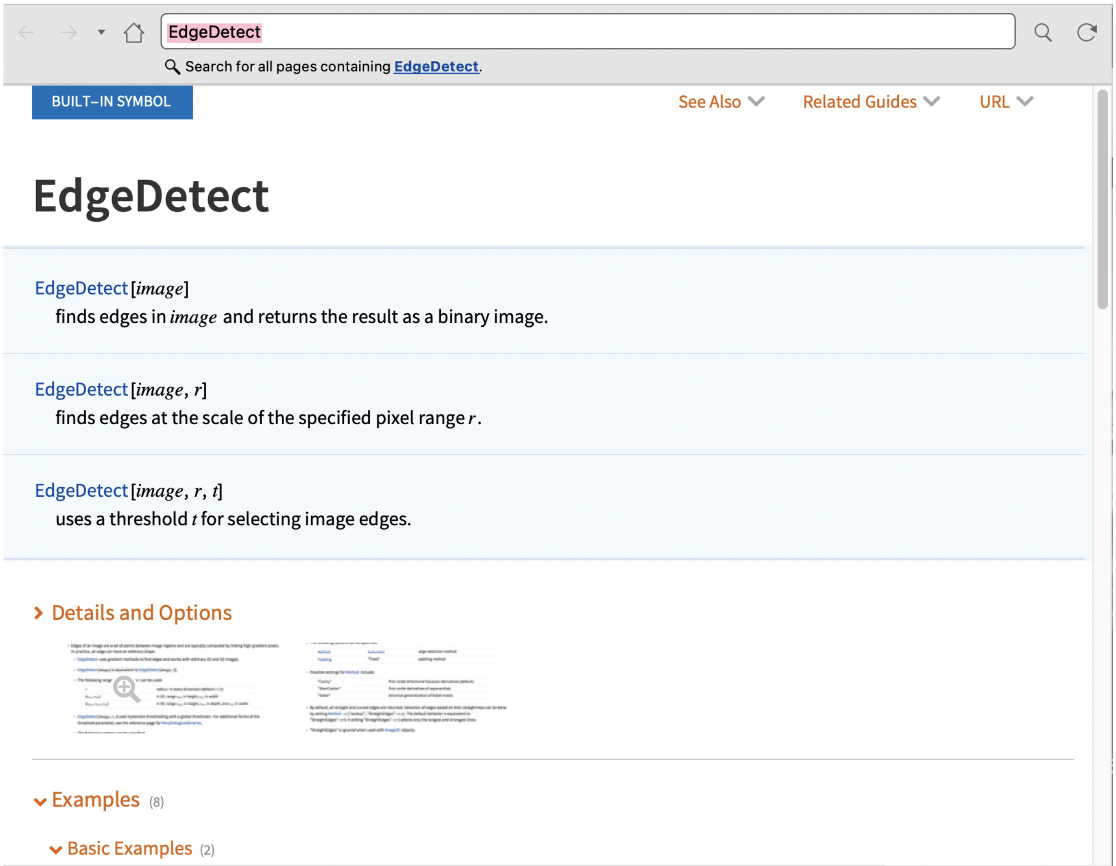
This returns 15 random paintings from van Gogh’s notable artworks as images.

Aside from taking in text and numbers as inputs, Mathematica can also take in photos.

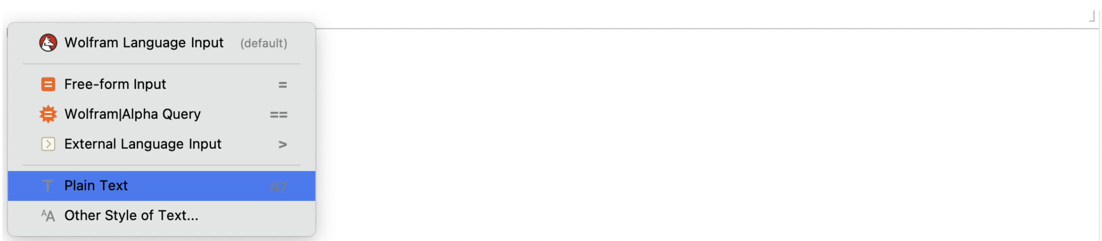
In[23]:= `EdgeDetect[`  `]`

Out[23]= 

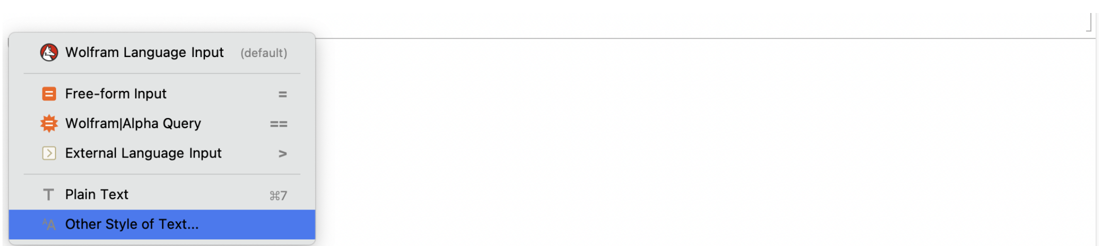
While the Wolfram Language is pretty intuitive as you've seen, if you're ever confused about or wondering what else you could do with a specific function, there is a "i" button with information from the Wolfram Language Documentation Guide.



It can be helpful to add captions, comments, or text to supplement your data when creating research papers. You can do so with the plain text input.



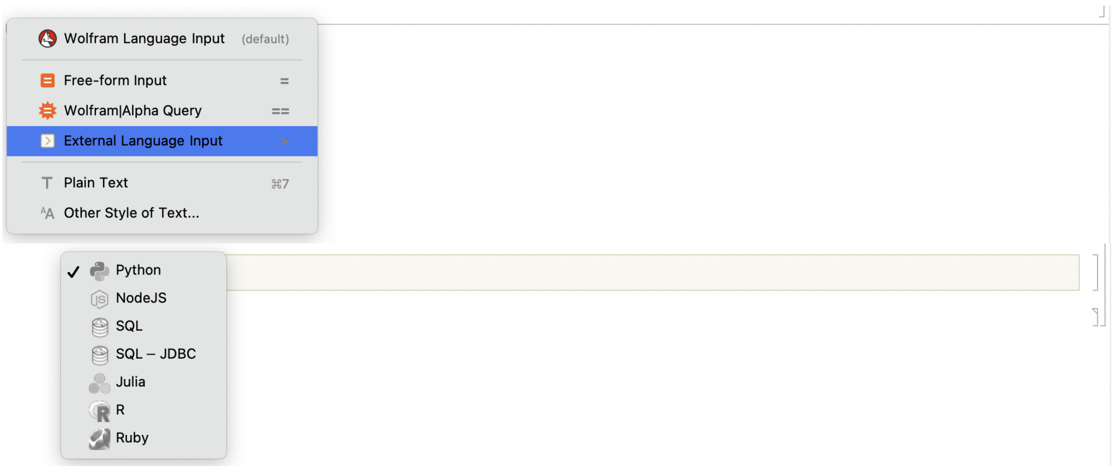
There is also the option to input in another style of text.

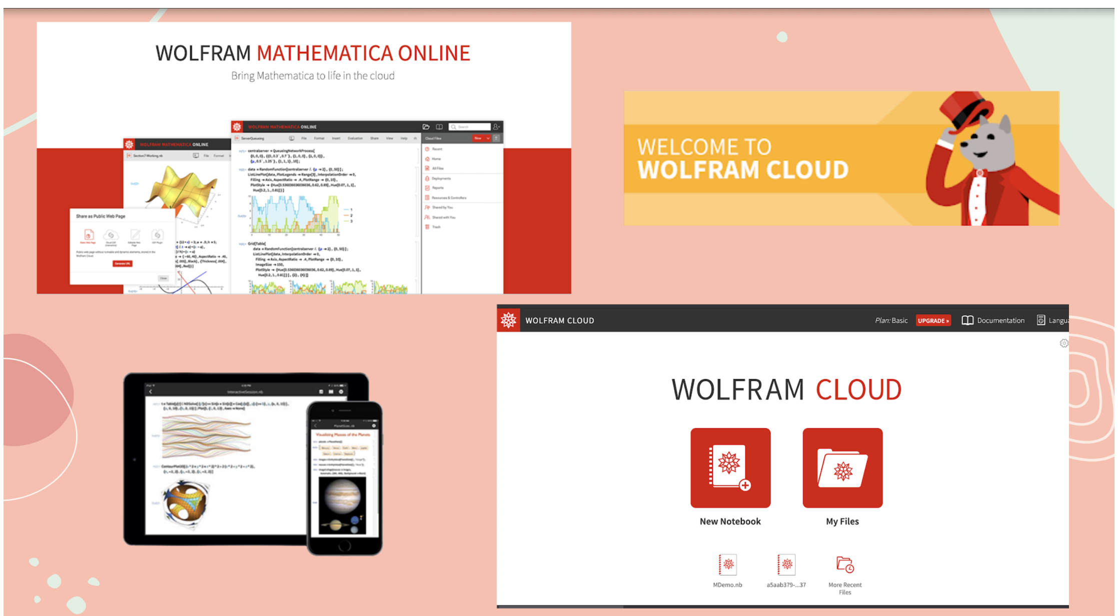


For example, you can type in Code, which would appear in a block, or headings like Title, Subtitle, Chapter, and Section to organize your notebook.

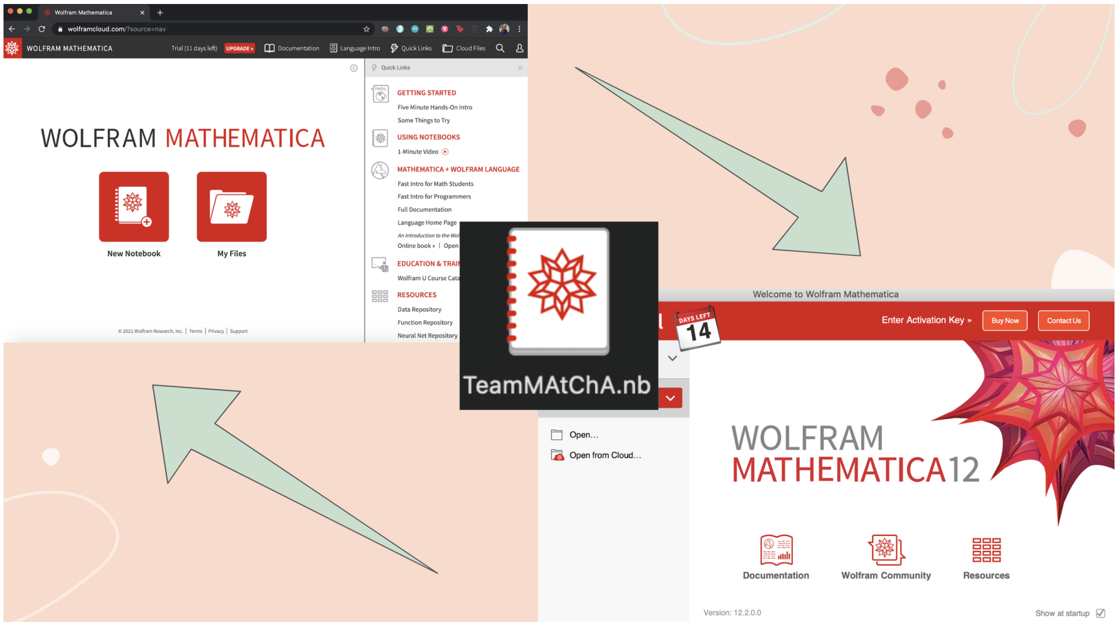
```
This is code!
```

We will not be exploring this today, but you can also use other programming languages within the Notebook, such as Python and SQL.

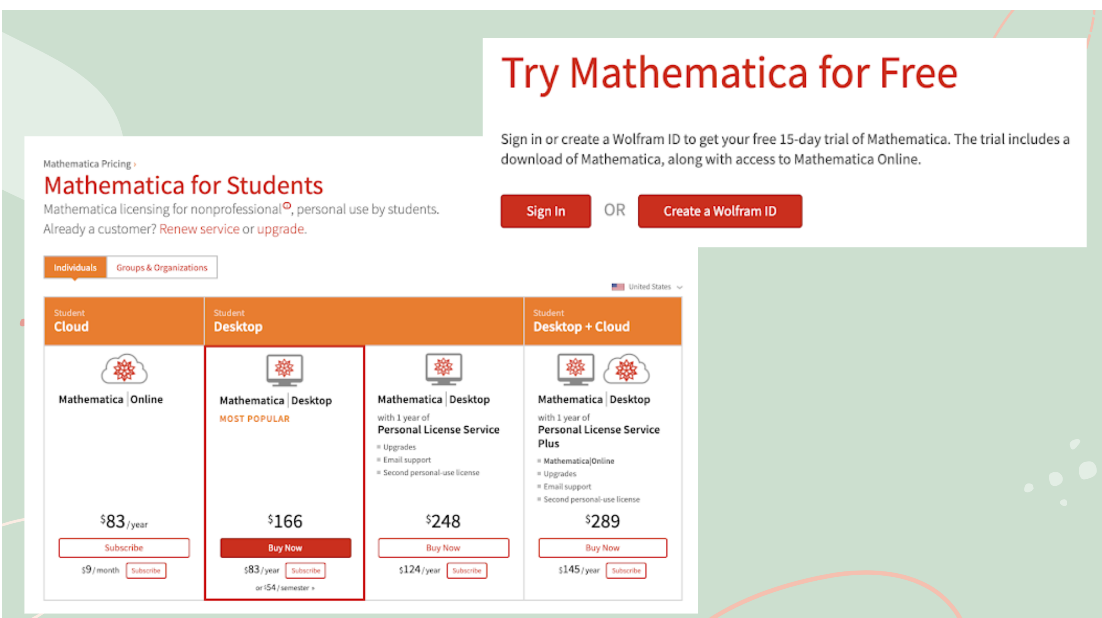




There is also a browser version of Mathematica, as well as mobile versions for your phone and tablet.



If you were wondering how the browser and desktop versions interact, we ran a few tests while researching. We found that if you make a notebook in Mathematica Desktop, you can upload it and edit it in Mathematica Browser. However, to view and edit the updated notebook in Mathematica Desktop, you have to download the updated version from Mathematica Browser first. This isn't very convenient, so we recommend sticking with one version.



You can get Mathematica from the Wolfram website, either the browser version, the desktop version, or both. It is expensive, but Wolfram offers a 15-day trial, and most colleges have a license and offer it to students for free. Unfortunately, Stuyvesant does not provide students with Mathematica, but look forward to having access in college!

That’s all for our presentation, but you can learn more by scanning this QR code. We’ve compiled a list of our favorite Mathematica resources.
If you can’t scan, here is the link: https://docs.google.com/document/d/117NpIvG83wZw-K5KAp_uVJEl-lx9Cp8aRrTaYcvSWouE/edit?usp=sharing.