Maths and Richard Serra's torqued ellipse in the Guggenheim at Bilbao

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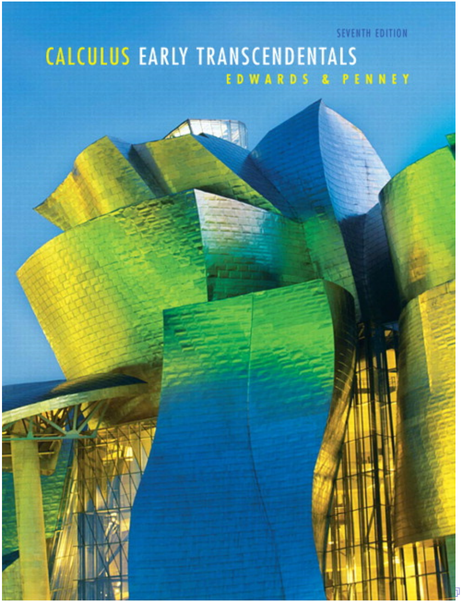
These slides and the sage-cocalc worksheet are on my homepage `http://pub.math.leidenuniv.nl/~edixhovensj/`, onder ‘talks. . . ’.

The Guggenheim museum in Bilbao

A calculus book



Richard Serra's "torqued ellipse"

How is this surface made?

Let us watch Serra's explanation in
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Each line in the contour gives a plane through our eye. Such a plane is tangent to both ellipses. The lines of intersection of such a plane with the planes containing the ellipses are tangent to the ellipses.

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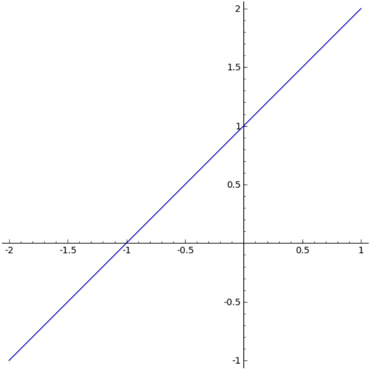
He rolls a plane around the 2 ellipses, or he rolls his wheel over a sheet of lead. Or think of his wheel with glue on it that rolls on a sheet of paper.

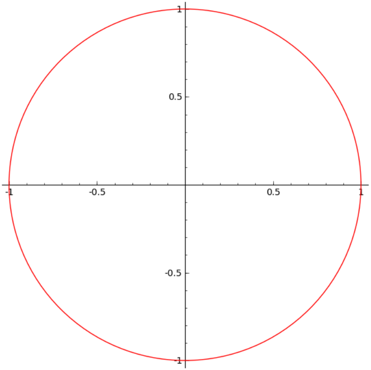
An equation for the surface?

First we practice in dimension 2.
Back to Nicolas d'Oresme (14th century). A plane curve of degree 1.



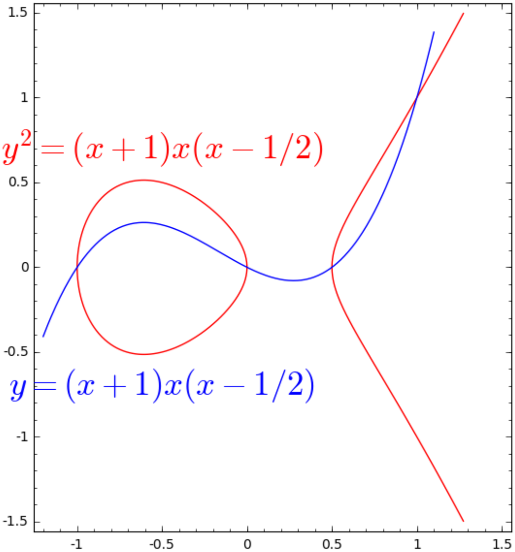
The line given by the equation $y = x + 1$.

A plane curve of degree 2



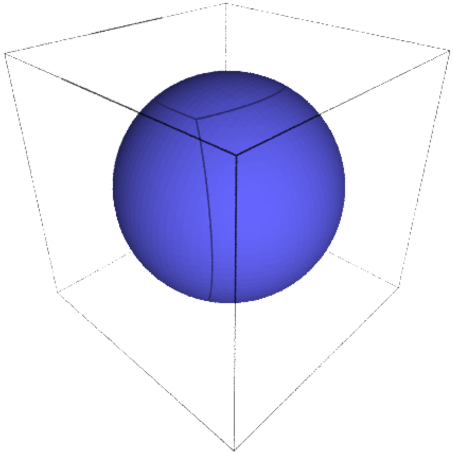
The circle given by the equation $x^2 + y^2 = 1$.

A plane curve of degree 3



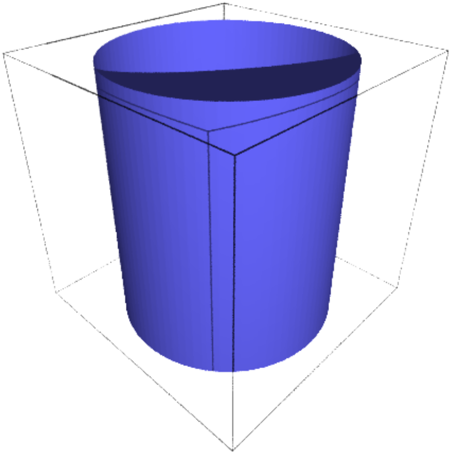
The sphere

The equation of the sphere is $x^2 + y^2 + z^2 = 1$.

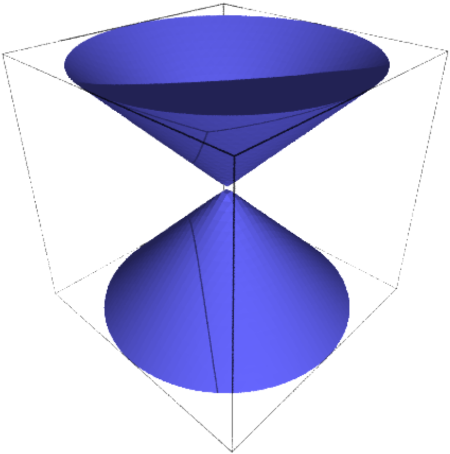


The cylinder

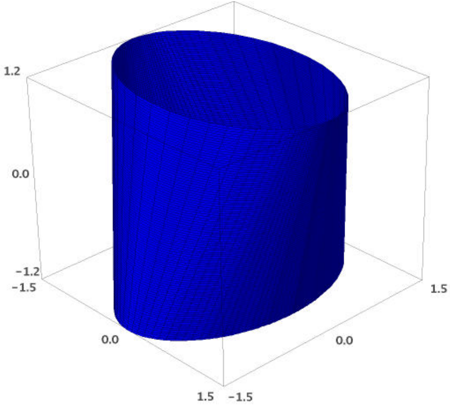
The equation of the cylinder is $x^2 + y^2 = 1$.



The cone



A parametrisation of the surface



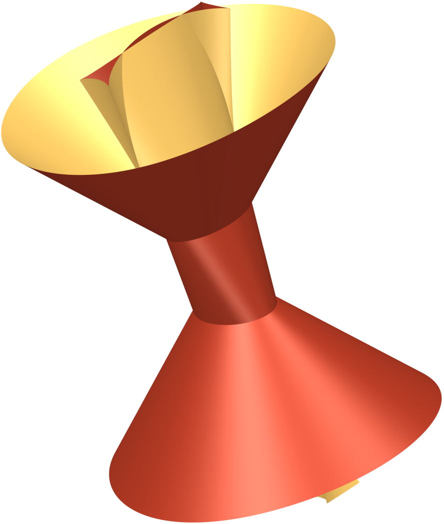
Figures and computations done by sage (`https://cocalc.com`).

The equation of the surface

$$
\begin{aligned}
&16384x^8 + 81920x^6y^2 + 135168x^4y^4 + 81920x^2y^6 + 16384y^8 \\
&- 6144x^6z^2 - 76800x^4y^2z^2 - 76800x^2y^4z^2 - 6144y^6z^2 \\
&- 3776x^4z^4 + 24832x^2y^2z^4 - 3776y^4z^4 - 336x^2z^6 - 336y^2z^6 + 9z^8 \\
&+ 45056x^6z + 30720x^4y^2z - 30720x^2y^4z - 45056y^6z - 20736x^4z^3 \\
&+ 20736y^4z^3 - 5472x^2z^5 + 5472y^2z^5 - 6144x^6 - 76800x^4y^2 \\
&- 76800x^2y^4 - 6144y^6 + 40832x^4z^2 + 77312x^2y^2z^2 + 40832y^4z^2 \\
&- 16560x^2z^4 - 16560y^2z^4 - 612z^6 - 20736x^4z + 20736y^4z \\
&+ 20160x^2z^3 - 20160y^2z^3 - 3776x^4 + 24832x^2y^2 \\
&- 3776y^4 - 16560x^2z^2 - 16560y^2z^2 + 10422z^4 - 5472x^2z \\
&+ 5472y^2z - 336x^2 - 336y^2 - 612z^2 + 9 = 0
\end{aligned}
$$

Thanks to Joan-Carles Lario (UPC Barcelona).

Surfer plot of the equation



The origin of the ‘other half’

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For each point of the bottom ellipse there are 2 points of the upper ellipse where the tangent lines are parallel to that to the bottom ellipse.

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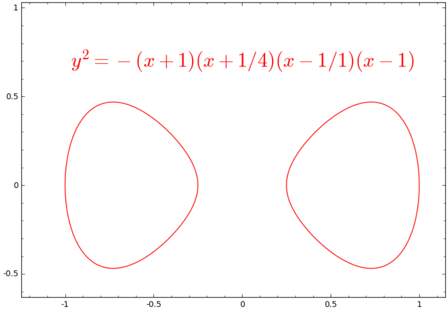
The set of all these lines on the surface is parametrised by a curve of the form:



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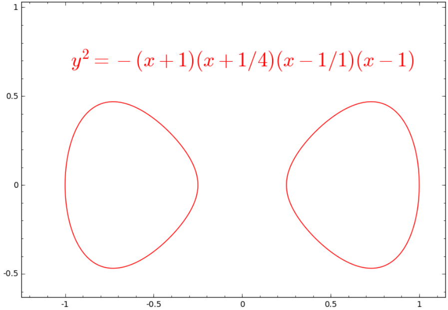
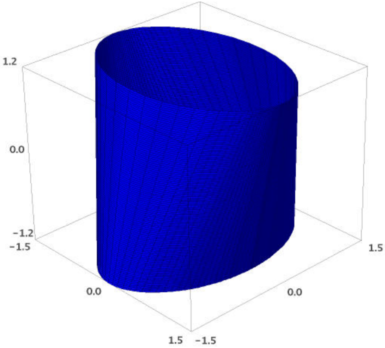
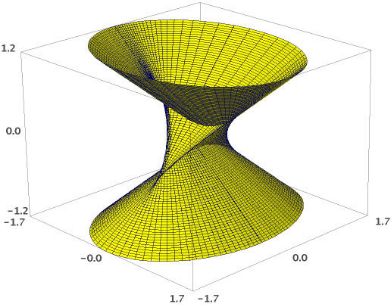


Process: let Serra’s wheel roll, 1 wheel on top of the paper, and the other wheel below it.

The siamese twins, apart





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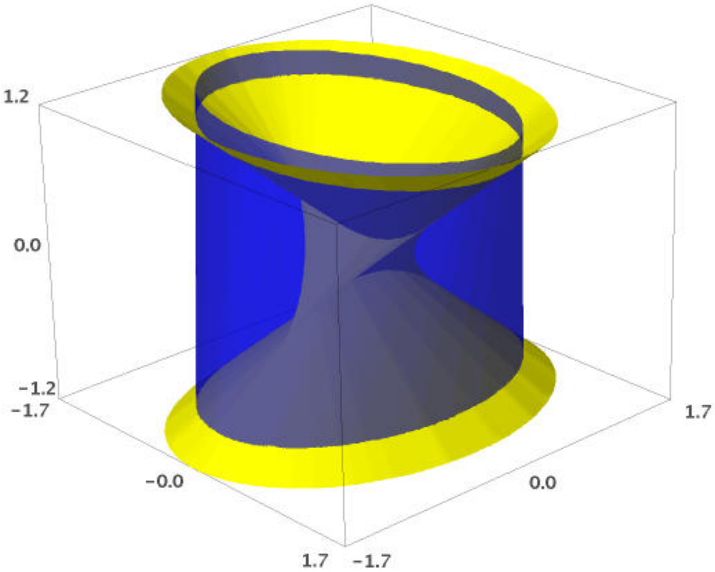
The siamese twin



3D-printing, Imaginary

Oliver Labs is a mathematician in Mainz, with interest in computer science and design.

He has converted the sage output to input for a 3d-printer, such that I have been able to have the siamese twin printed by Shapeways.

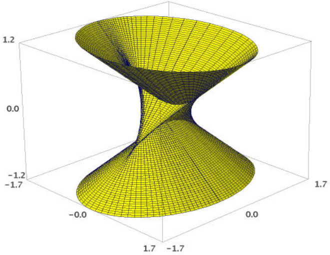
Go and look here!
`http://www.oliverlabs.net/`
`http://www.shapeways.com/art/mathematical-art?li=nav`

Another beautiful place: `https://imaginary.org`. Part of this exhibition is now permanently in the Boerhaave museum in Leiden.

The surfer programme:
`https://imaginary.org/program/surfer`

A project?

Would anyone be interested in realising the new part, as big as the old part in the Guggenheim? Say, with steel rods for the lines, and wires for the surface. Thanks to Mats Beentjes's bachelor thesis I know exactly where to place them in the most esthetical way.



Thank you for your attention!