

Visualizing Mathematics with 3D Printing:

Part 1:

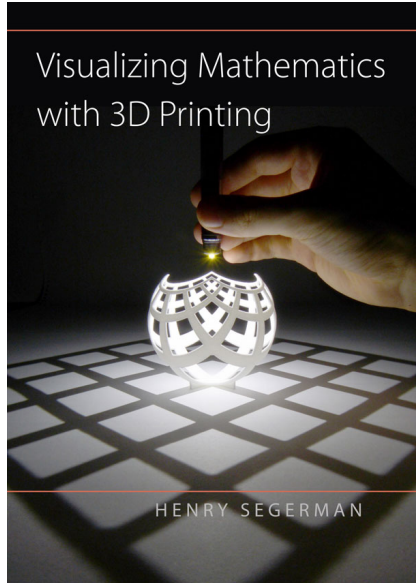
3D printing in education

Part 2:

Augmenting a Traditional
Book with New Media

Henry Segerman

Department of Mathematics
Oklahoma State University



Part 1:

3D printing in education



Two main uses

1. Teacher makes manipulatives and visualizations
 - ▶ E.g. quadric surfaces.

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 - ▶ Buy own.
 - Requires money, space, maintenance... but fast(ish) turnaround time.
 - ▶ Use an online service (e.g. [Shapeways.com](https://shapeways.com)).
 - No startup cost but more expensive per print, higher quality, more design freedom.

Why have students learn 3D printing?

- ▶ Highly motivating - students get to take home something they made with their mind.
- ▶ Consolidates students' math skills - use on real world problems.
- ▶ 3D printing is perfect for project work, difficult to do in math otherwise.
- ▶ Students self-correct errors: they see that their solution doesn't work. (Compare with exams - incorrect answer "doesn't matter" and they don't find out until next week.)
- ▶ 3D technology is likely to be highly relevant for future careers.

"The more math you know, the more stuff you can make"

- George Hart

MoMath - Mathenaeum



MoMath - Mathenaeum



Use in High School - UK Department of Education report

3D printers in schools: uses in the curriculum

Enriching the teaching of STEM and design subjects

October 2013

Use in High School - UK Department of Education report

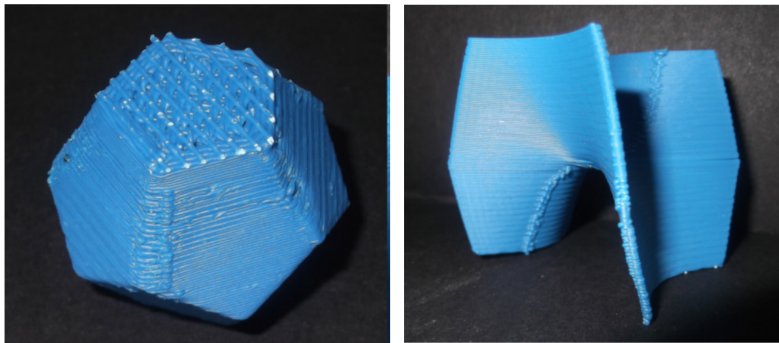


Figure 8 - At Watford Grammar School for Boys the printer was used to demonstrate a 3D graph for various algebraic equations as well as producing examples of regular shapes (Dodecahedron).

Use in High School - UK Department of Education report



Figure 10 - The Kings School, Peterborough made a set of cones and part cones for a mathematics investigation into areas and volumes.



Figure 11 - At Highworth Grammar School for Girls, a set of laminae were made to support the teaching of centres of mass in mechanics instruction.

Use in High School - UK Department of Education report

Excerpts

- ▶ “Equipping pupils to understand the application and potential of this new type of technology will be important to helping prepare them for a world in which similar technologies will be increasingly commonplace, particularly in STEM contexts.”
- ▶ “The 3D printer is ideally suited to project work, where learning arises naturally as part of an investigation or construction project.”
- ▶ “...the printers had a highly motivational effect on pupils and most schools reported a greater interest in STEM subjects.”

MATH 297: Current Knot Theory Research and 3D Printing Policy and Syllabus

Instructor: Laura Taalman, Professor in the Department of Mathematics and Statistics
Email: taalmana@jmu.edu
Website: educ.jmu.edu/~taalmana
Class site: www.geekhaus.com/3space
Meetings: Wednesdays 2:30pm-4:30pm in the JMU 3-SPACE classroom (Burruss 349)
Textbook: The internet!

<http://geekhaus.com/3space>

Use in College - Laura Taalman, JMU

Course Objectives

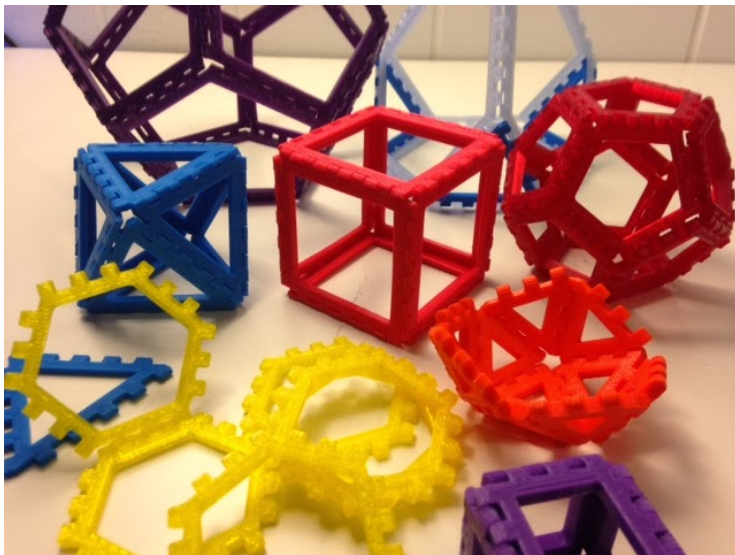
1. Study current accessible research in knot theory and attempt to come up with new results and/or generate and examine examples that support the current literature.
2. Use 3D printers to produce actual physical models of the knots and related objects that are in the papers you are reading. You may have to learn Mathematica, Maple, MATLAB, OpenSCAD, TopMod, or other programs to help you create the models.
3. Learn how communicate mathematics through written papers, blog posts, and presentations using LaTeX, Beamer, WordPress, Blogger, and other typesetting and presentation software.
4. Complete applications for REU programs and other future research projects.
5. Present your work as a talk and as a poster at the MD/DC/VA MAA spring that will be held at JMU this spring on April 25-26.
6. Create and print a final project that will be housed in the front foyer display case in the Department of Mathematics and Statistics in Roop Hall.

<http://geekhaus.com/3space>

Use in College - Laura Taalman, JMU



More from Laura Taalman



More from Laura Taalman



More from Laura Taalman

Day 365!!! Last day of the print-every-day-for-a-year project!

I think the first thing that needs saying here is that a year is a very long time. There are a lot of days in a year. After about 60 or 70 days I remember thinking that we were probably halfway through this year-long blog thing and then being shocked at just how many days there are in a year. Damn.

But it is over, we have finished the year and so we get a TROPHY. Since our 3D-printing journey began with the desire to print knots, our trophy is a tiny 3D-printer (model from RichRap's very cleverly designed [Advent Makerbot Replicator 2](#)), which is printing an even tinier knot (model dating back all the way to the beginning of this journey, on [Day 9](#)):



HACKTASTIC

PolyBowls – From zero to OpenSCAD in 6 minutes

👤 mathgrrl 📅 August 28, 2015 💬 0 Comments

The following collection of bowls and pen holders we all generated from the same simple OpenSCAD code:



ABOUT HACKTASTIC

This is a blog about design, math, and failure by [@mathgrrl](#).

MATHGRRL DESIGNS

Customize and download hundreds of 3D models at the [mathgrrl](#) page on Thingiverse.

WISDOM COLLECTORS

New to 3D design? Me too. These [Wisdom Collectors](#) gather notes and resources for getting started with three.js, Maya, OpenSCAD, and the math of meshes.

<http://mathgrrl.com/hacktastic/>

Use in College - Chris Hanusa, Queens College, CUNY



Math with Mathematica

Welcome to Math 213, Math with Mathematica, this Spring 2015!

Virtual Art Gallery



Course Information

- [Course Syllabus](#)
- [Course Calendar](#)
- [Course Content](#), including a list of topics covered, in-class tutorials, and homework assignments.
- Information about the [Course Projects](#).
- Information about [Mathematica Access](#) (On MyQC; login required)
- A link to [Google Classroom](#)

Key Dates: (subject to change)

- **First Day of Class:** Wednesday, January 28
- **Quiz 1:** Wednesday, February 11
- **Project 1 Due:** Wednesday, March 4
- **Quiz 2:** Monday, March 9
- **Project 2 Due:** Wednesday, April 1
- **Project 3 Due:** Wednesday, May 13
- **Last Day of Class:** Wednesday, May 13
- **Project Presentations:** Wednesday, May 13 and Final Exam Day, Monday, May 18 from 8:30–10:30

<http://qc.edu/~chanusa/courses/213/15/index.html>

Use in College - Chris Hanusa, Queens College, CUNY



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<http://qc.edu/~chanusa/courses/213/15/index.html>

Use in College - Dave Bachman, Pitzer College



More from Dave Bachman



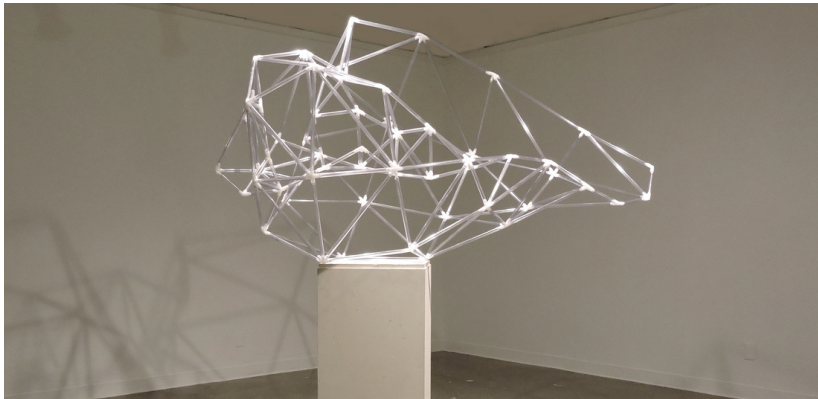
<http://davidbachman.org>

More from Dave Bachman



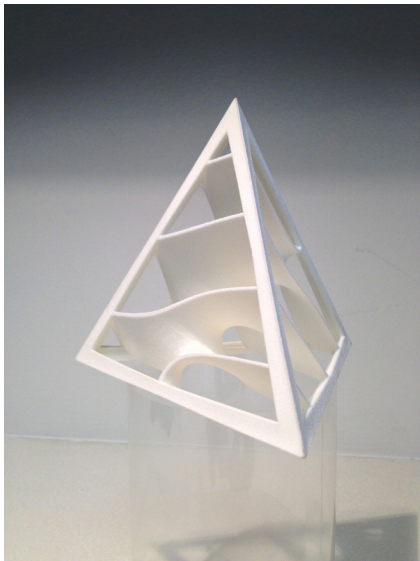
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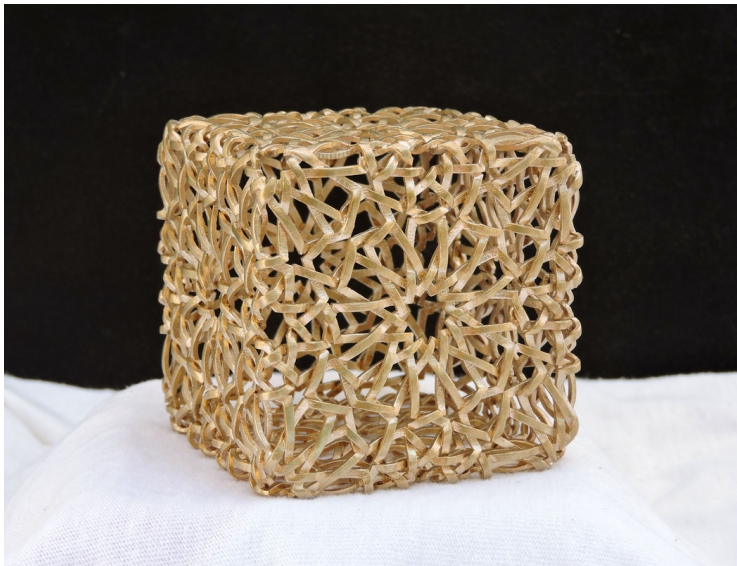
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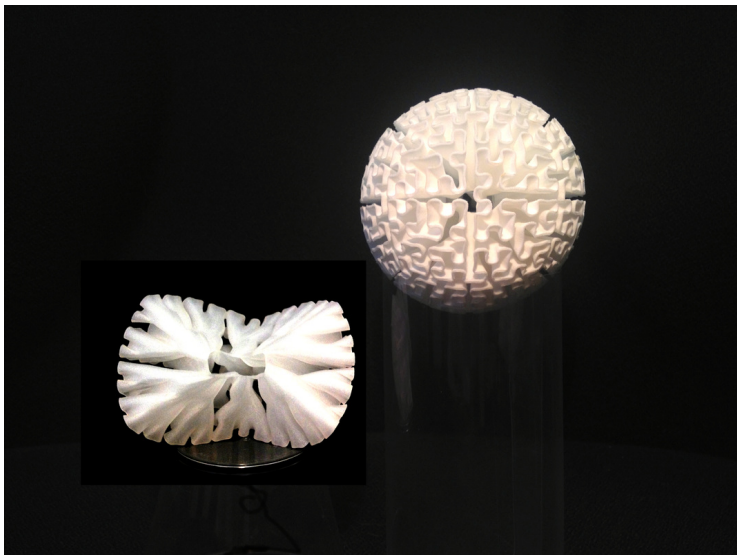
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(Joint with Robert Fathauer and me.)

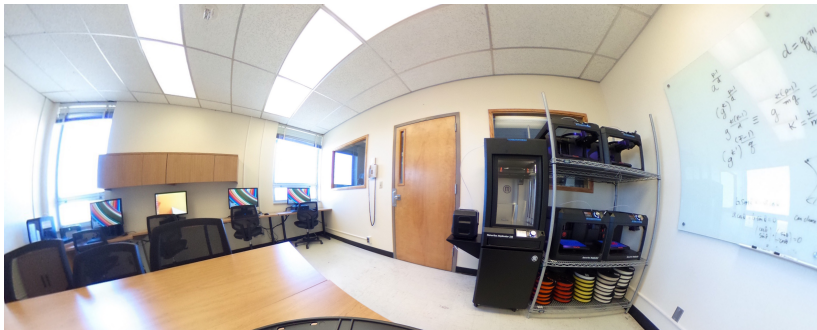
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Use in College - me

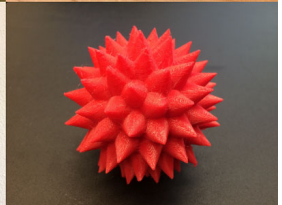
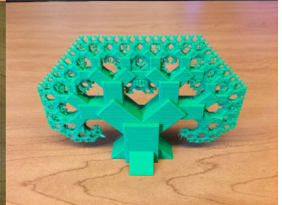
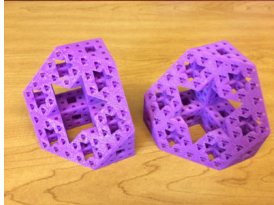
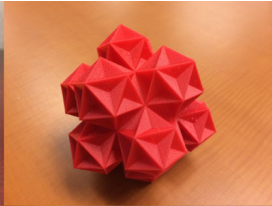
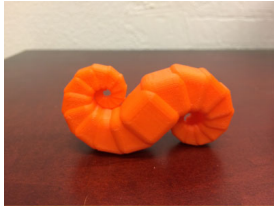
Math 4423: Geometry and Algorithms in Three-dimensional Modeling

Course Objectives: There are two goals of this course.

- Students will learn some of the mathematical underpinnings behind the ways in which three-dimensional content is represented, generated and modified using computers.
- Students will apply their knowledge of these topics: they will learn how to use the CAD (Computer-Aided Design) program Rhinoceros, including automation with the programming language Python, and Makerbot 3D printers. They will use all of these to design and 3D print models at the 3D printing lab in the Department of Mathematics. Models will illustrate mathematical concepts, and/or be drawn from students' other academic interests. Students will write reports describing the mathematics, design choices, and other relevant details behind their models.

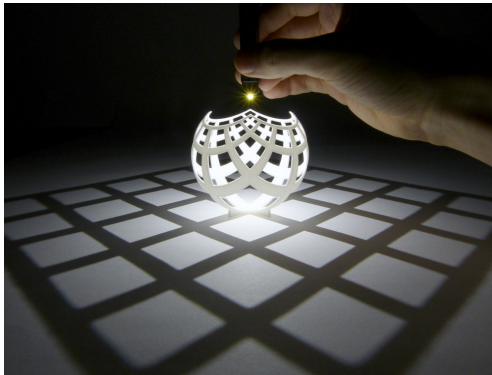


Use in College - me



Part 2:

Augmenting a Traditional Book with New Media



What is the idea of the book?

- ▶ Popular mathematics book

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Visualizing Mathematics with 3D Printing [Chapters](#) [Pre-order Now!](#)


Visualizing Mathematics with 3D Printing

Henry Segerman


*This is the companion website for an upcoming popular mathematics book.
Click around to explore figures from the book!*

[Read more...](#)


1. Symmetry




2. Polyhedra




3. Four-dimensional space




4. Tilings and curvature




5. Knots



6. Surfaces



7. Menagerie



[CONTACT](#) [ABOUT](#)

© Henry Segerman

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 - ▶ Rotate a virtual model on screen
 - ▶ Order a print online
 - ▶ Download the file to 3D print themselves

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
2. Polyhedra




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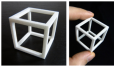
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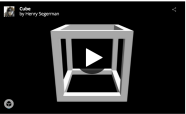
price


1.10

read

A cube, 3D printed in nylon plastic.

Cube by Henry Segerman





Cube

BUY NOW

3D printed in Nylon...

Designed by Henry...

\$11.00

on

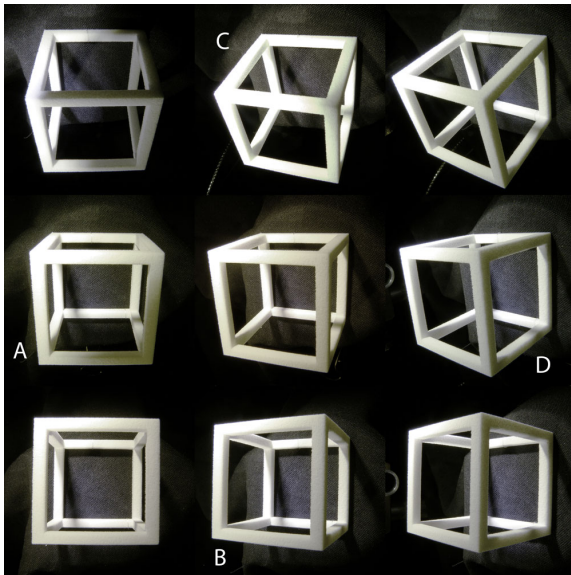
Shapeways

shapeways®

Thingiverse
<http://www.thingiverse.com/thing/1301788>

Figure files
cube.stl - 1029kb
cube.dxf - 1029kb

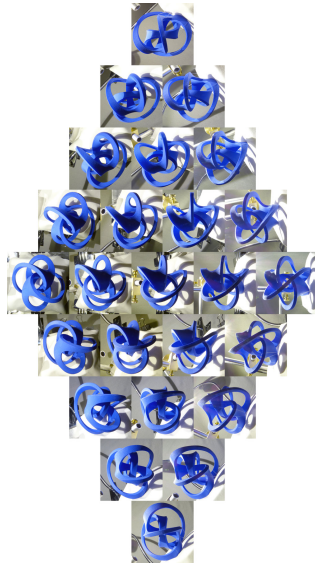
Symmetry



Symmetry

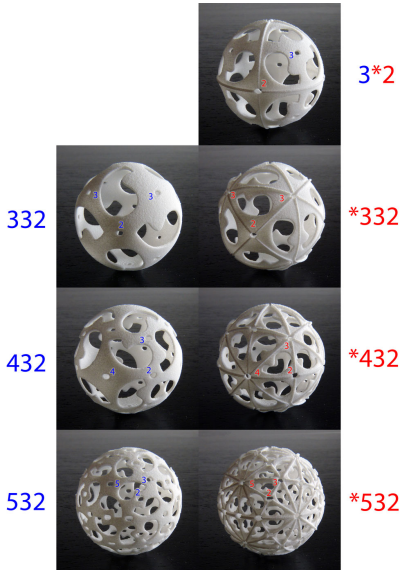


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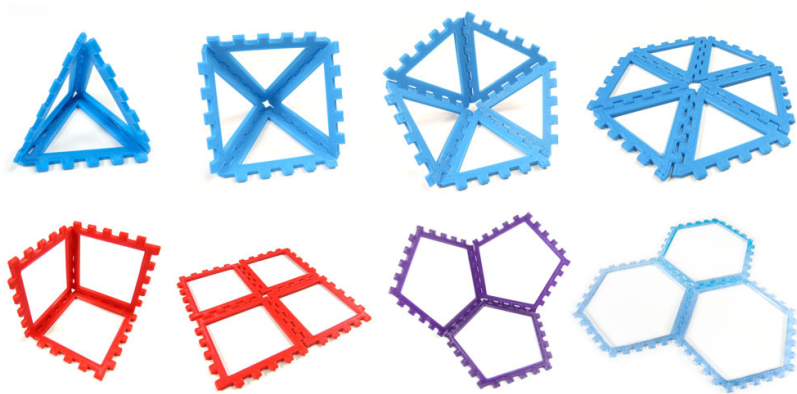


Soliton, by Bathsheba Grossman

Symmetry

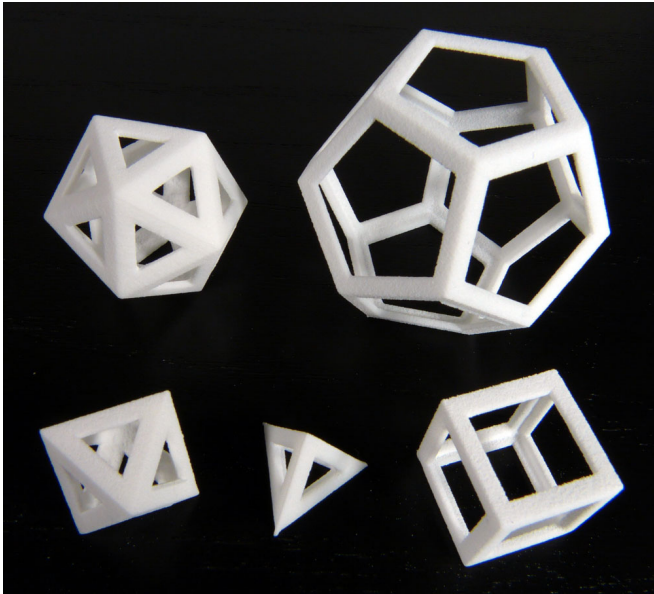


Polyhedra

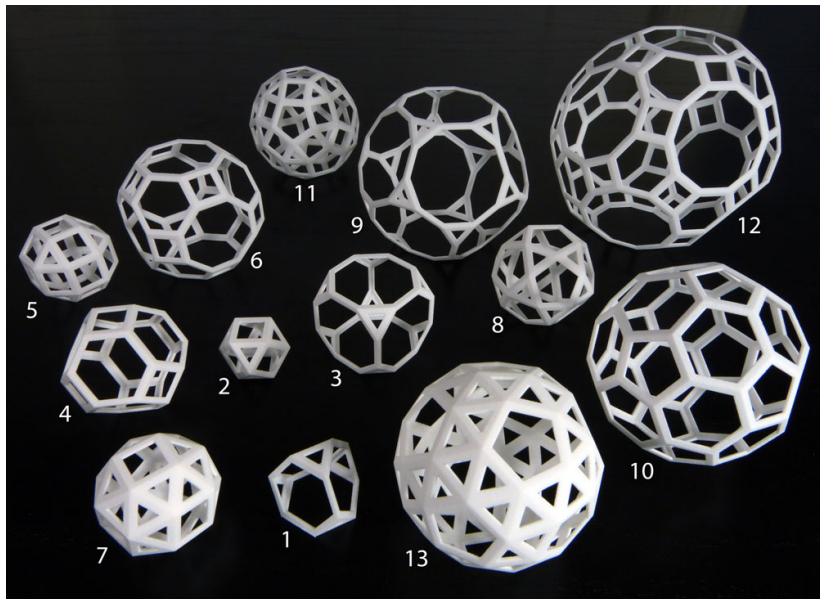


Snap tiles by Laura Taalman

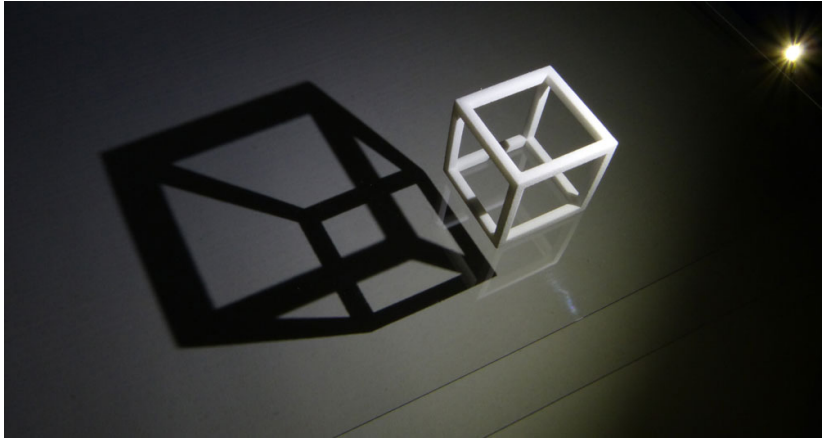
Polyhedra



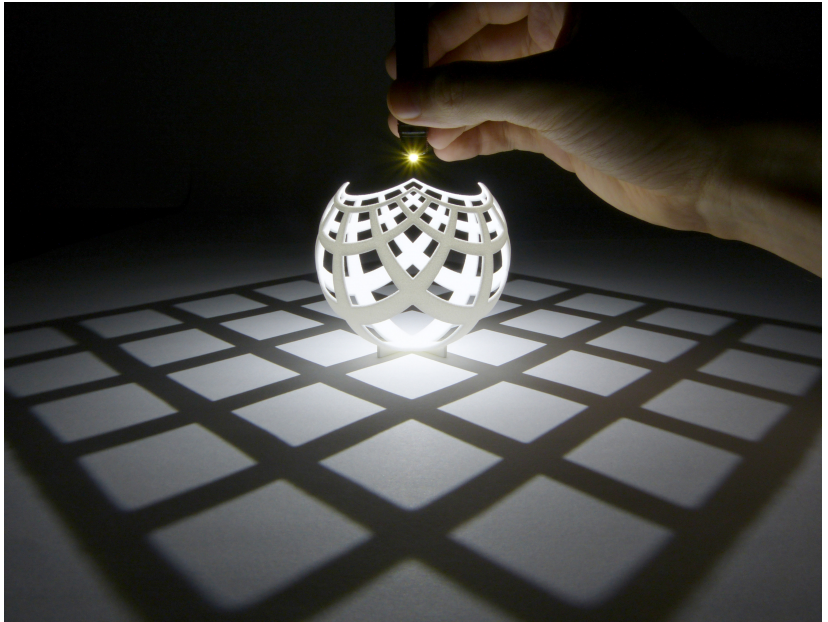
Polyhedra



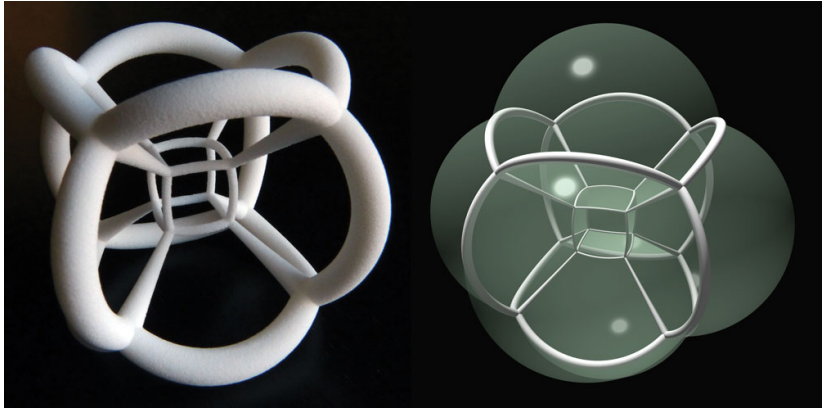
The fourth dimension



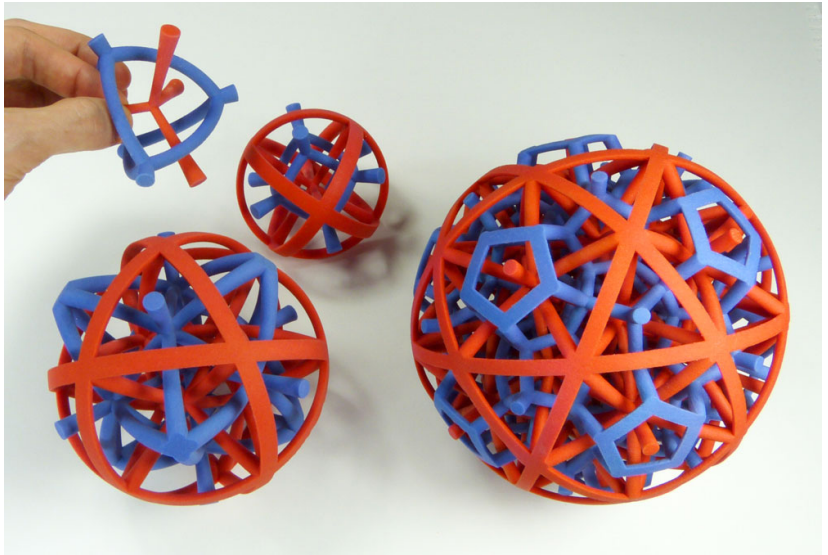
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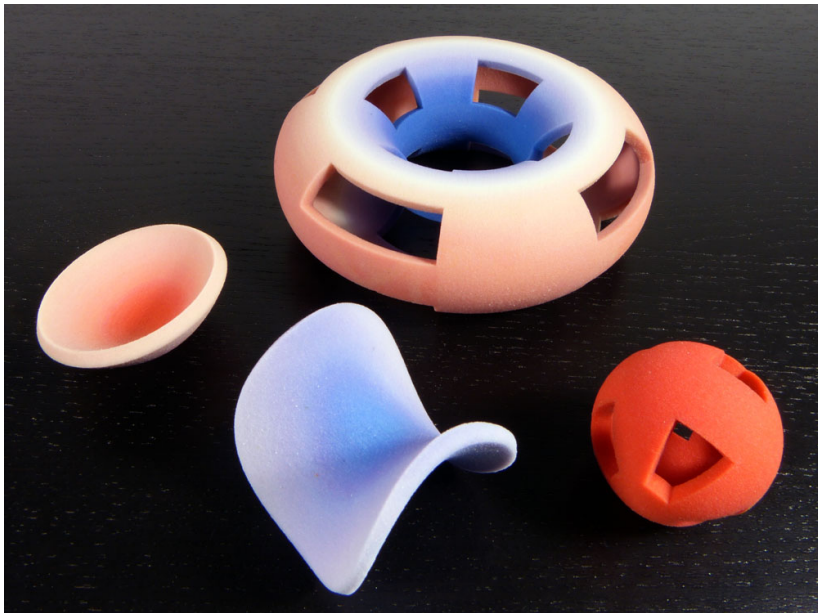
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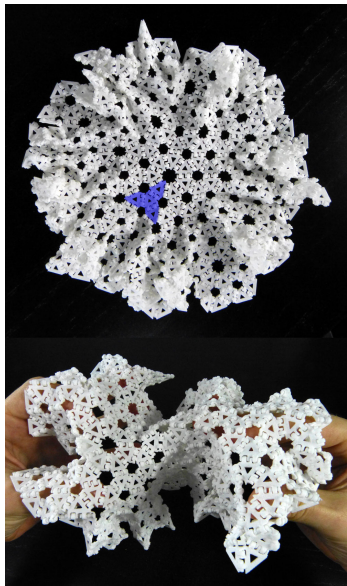
The fourth dimension



Tilings and curvature



Tilings and curvature



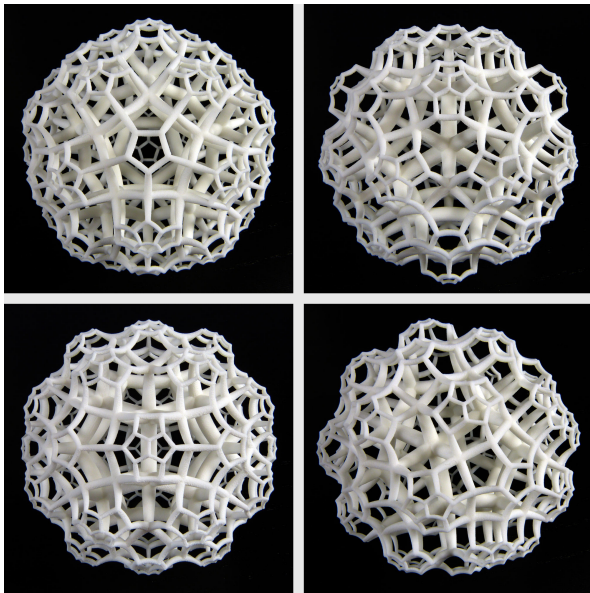
Joint work with Geoffrey Irving

Tilings and curvature



Joint work with Saul Schleimer

Tilings and curvature



Knots and surfaces

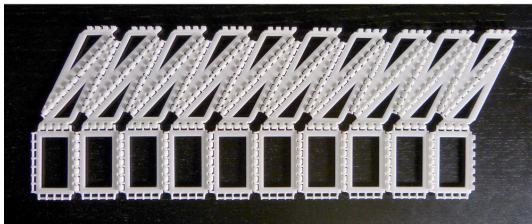
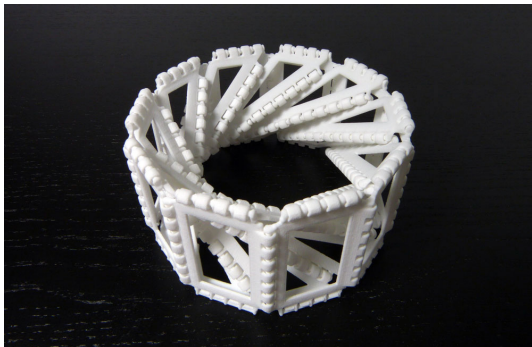


Joint work with Keenan Crane

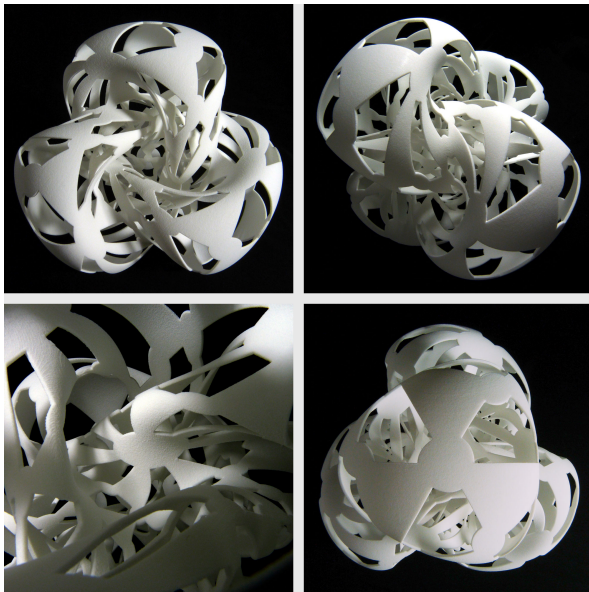
Knots and surfaces



Knots and surfaces

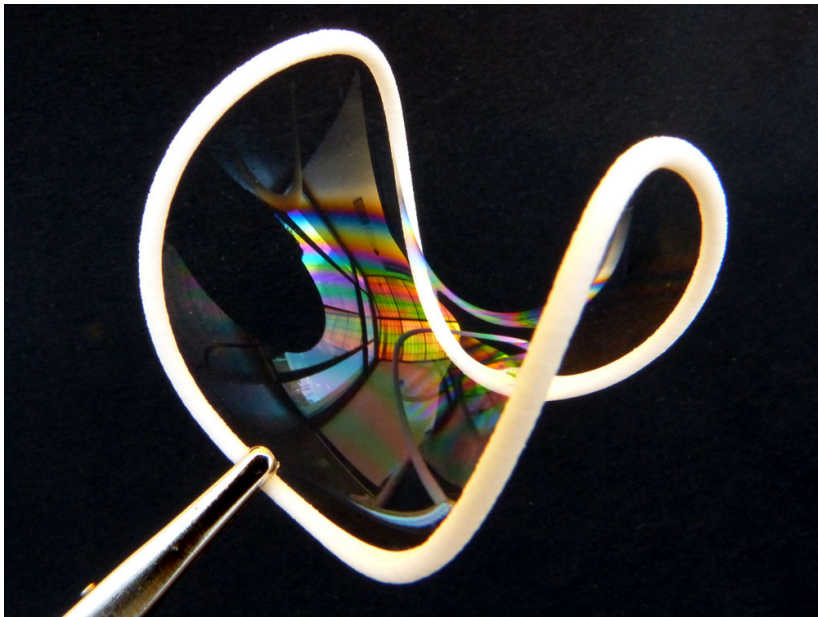


Knots and surfaces



Joint work with Saul Schleimer

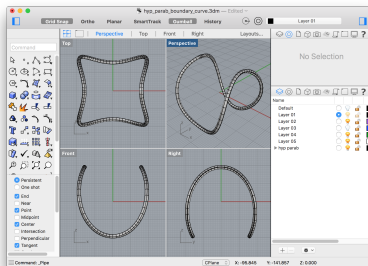
Knots and surfaces



Tools for designing and printing the 3D models

Rhinoceros (rhino3d.com)

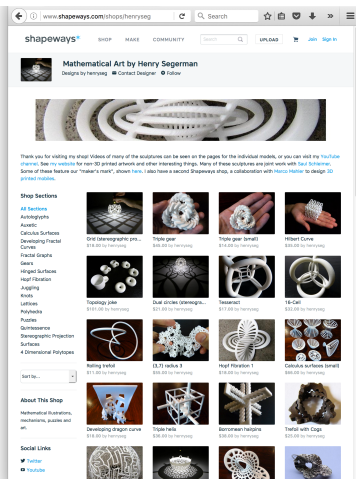
- ▶ Commercial CAD software
- ▶ Happens to be very good for mathematical models
- ▶ “Ruler and compass” constructions
- ▶ Python scripting interface
- ▶ Mac and Windows



Tools for designing and printing the 3D models

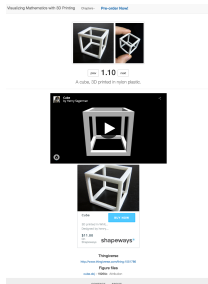
Shapeways (shapeways.com)

- ▶ Online 3D printing service
- ▶ High quality
- ▶ Good service
- ▶ Relatively inexpensive



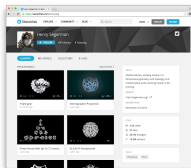
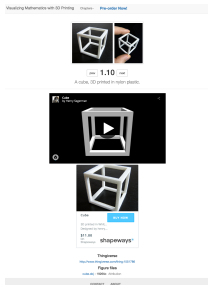
Making the models available online

- The book's sister website: 3dprintmath.com



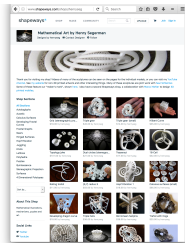
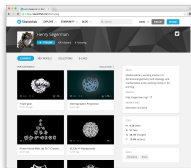
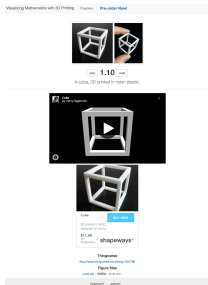
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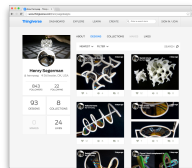
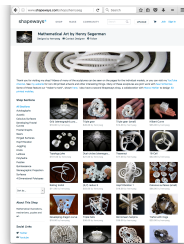
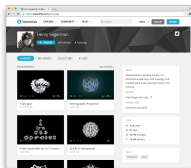
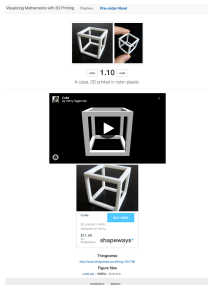
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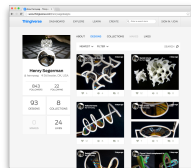
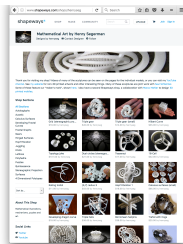
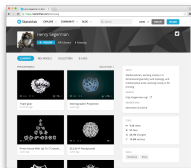
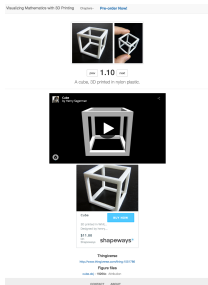
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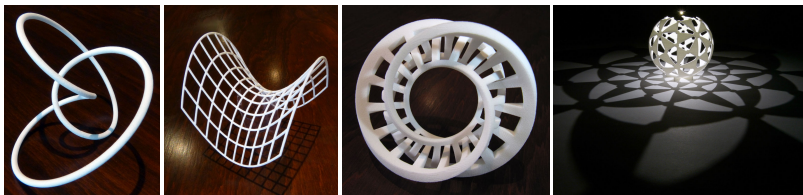
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Why open source?

Thanks!



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