CUNY CareerPATH

3D Printing

New York City College of Technology

February 1, 2014

www.cuny.edu

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New York City College of Technology

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CareerPATH Program - Green Advanced Manufacturing Collaborative (GAMC)

Syllabus :: 3D Printing

Description:

Building on the foundations obtained in the prerequisite modeling course, students will further their modeling/computational skills to create water-tight designs and produce a number of types of 3D prints. Projects will provide students with experience in the use of a variety of tools, equipment, concepts, and emerging digitally-driven technologies, including parametric rule-based design, finishing and assembly techniques, and iterative design processes.

Objectives:

- To demonstrate the ability to prepare a solid model and send to a fabrication software for printing.
- To extract and finish a fdm or powder printer
- To bring professional projects into the class and work through to process of rapid prototyping.

Software:

- Rhinoceros 3D
- Grasshopper, Weaverbird, Ladybug
- Magics v18, Meshmixer
- ZPrint

Materials:

- zp 151 powder

Equipment:

- ZCorp 650 3d printer
- Makerbot Replicator 2 and 2X

Projects:

- ***Project 1*** :: Rapid Prototyping Foundations
- ***Project 2*** :: Geology Studies
- ***Project 2*** :: Bowl Studies
- ***Project 3*** :: Final Project

Deliverables:

- (1+) Geology Study Print
- (1+) Component Aggregation
- (2+) Bowl Studies
- (1+) Final Project

Assessment:

Through computer based/ fabrication projects and oral presentations, students will demonstrate their ability to:

1. Create digital parametric modeling projects of medium complexity.
2. Produce fabrication projects that utilize fundamental skills involving key set up, work flow, and assembly techniques, as well as best safety practices.
3. Produce fabricated tectonic material systems of their own design
4. Explain the uses of rapid prototyping and iterative design processes.

Attendance Policy

No absences accounting for more than 10% of class time are permitted during the course. For purposes of record, two latenesses are considered as one absence. Exceeding this limit will expose the student to failing at discretion of the instructor.

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CareerPATH Program - Green Advanced Manufacturing Collaborative (GAMC)

Grading:

Students successfully completing the course will receive a grade of pass or of pass with distinction. At the end of the course certificates will be given

Schedule:

February 1st 2014 –
9am – 3pm

Introduction and Overview:

Geology as a formal study
Develop a unit through simple surface manipulation. (Rhino)
Referencing Geometry into Grasshopper to create simple transformations. (GH)

Objectives:

Overview of Course
History of Rapid Prototyping
Machine Walk-Through
Working with Rhino to produce geometry ready for rapid prototyping.
Using Grasshopper to manipulate geometry
Exporting Geometry as an .STL

Output: **Volumetric Studies**

February 8st 2014 –
9am – 3pm

Formations:

Refining primitive
Sending primitive 3D print
Checking for Solid and Repairing
Exporting to .STL
Preparing the 3D printer for printing

1pm-3pm

Creating a Formation Array
Students will extract between 4-10 units for the next printing assignment.
Transformations using vector information (GH)
Reference geometry into Grasshopper to transform using weaverbird. (Optional)
Surface Aggregation Strategies (GH)
Extracting a 3d Print

Objectives:

Apply formation studies to design challenge.
Using Grasshopper to create a formal aggregation.
Demonstration of how to extract a 3d print.
Working with the FDM printers

Output: **Geometry Studies**

February 15th 2014 –
9am – 3pm

Fracturing:

Breaking Aggregations into printed assemblies with connectors.

Objectives:

Using Rhino to split, trim, boolean to develop parts of the original population (Rhino)
Using Grasshopper to create connections between units and assembly methods (GH)
Checking Mesh Models for Rapid Prototyping

Output: **Building Blocks**

February 22nd 2014 –

Pigment:

Color with Texture mapping:

9am – 3pm

Applying color and texture maps using photoshop with Rhino and Grasshopper
Using analysis tools in grasshopper to develop pigment colorations

Objectives:
Image mapping in Rhino (Rhino)
Referencing Photoshop into Grasshopper to produce mapping networks.(GH)
Exporting as a .VRML for Color Printing
Using ZPrint and ZEdit

Output: **Assembly with Color**

March 1st 2014 –
9am – 3pm

Repairing and Problem Solving Prints:
Using Rhino and Magics to Problem Solve Mesh models.
Creating casting molds with Magics

Objectives:
Magics Interface
Using the Repair tools in Rhino
Shrink Wrap and Mesh repair in Magics

March 8th 2014 –
9am – 3pm

Post Production:
Lecture on Post Production strategies
Experimenting with materials on 3d Prints
Spraying, coating, casting, interchangeable parts

Objectives:
Printing and extracting powder and FDM prints

March 15th 2014 –
9am – 3pm

Post Production:
Finishing Model and Refining

Objectives:
Finished Print Studies

Fabrication Resources:

Makerbot Industries	www.markertbot.com
Shapeways	www.shapeways.com
Forecast 3d printing	www.forecast.com

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CareerPATH Program - Green Advanced Manufacturing Collaborative (GAMC)

Course: 3D Printing
Assignment: Color Bowl
Description: Students, will design and develop full-color, texture-mapped 3D printed artifacts. The project is intended to synthesize the prior two projects, where form and color were examined, now utilizing the full range of the printer's color capabilities. Greater emphasis is placed in this project on the crafting of well-formed geometry, dealing with issues of mesh topology & repair, orientation optimization for ease of fabrication, machine tolerances and material limits, and print post-processing.

	Unsatisfactory [0-69%]	Average [70-79%]	Good [80- 89%]	Excellent [90-96%]	Exceptional [97-100%]
Proficiency with Rhino in producing 3D prints (cleanly modeled base unit & component aggregation, file organization & clarity, model exhibits understanding of 3D printing output requirements) - **20%**					
Proficiency with Grasshopper (organization & clarity of parametric definition, image texture maps correctly, labeled outputs & inputs, definition results in clean geometry) - **20%**					
Proficiency with ZPrint (build file correctly created, parts oriented properly [normal directions], texture maps reading correctly), **and if needed,** with Magics (efficiency of material use relative to part geometry, clean & printable resultant geometry) - **20%**					
Proficiency with 3D Printer (machine set-up & safety, machine cleanliness & maintenance procedures, part extracted from printer intact) - **20%**					
Proficiency with Post-Processing (part completely cleaned of all powder residue, part cleanly & evenly finished) - **20%**					
Totals					

Overall Total:
Feedback:

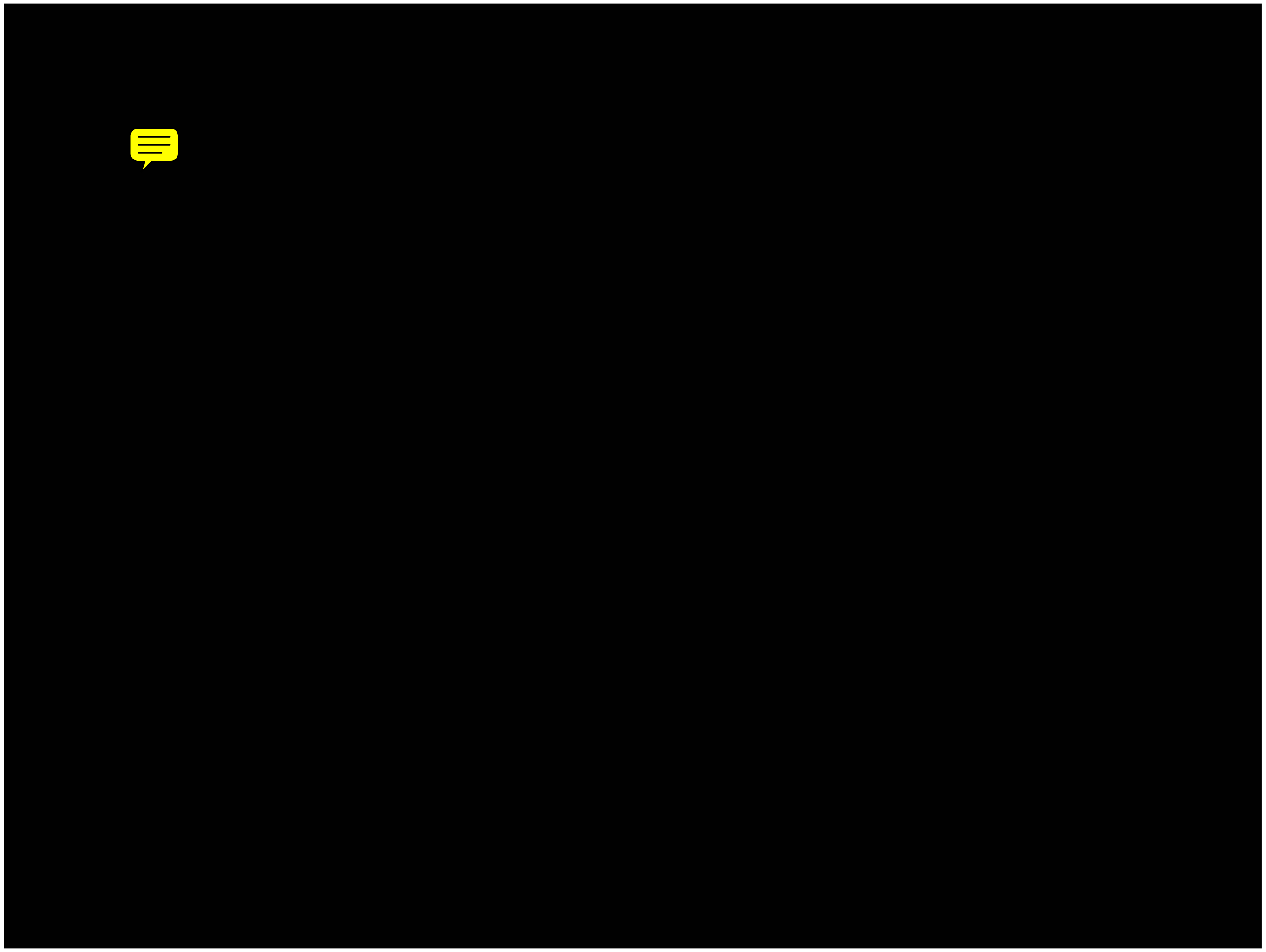
3D PRINTING METHODS

Type	Technologies	Materials
Extrusion	**Fused deposition modeling (FDM)**	Thermoplastics (e.g. PLA, ABS), HDPE, eutectic metals, edible materials, Rubber (Sugru), Modelling clay, Plasticine, RTV silicone, Porcelain, Metal clay (including Precious Metal Clay)
Wire	Electron Beam Freeform Fabrication(EBF)	Almost any metal alloy
Granular	Direct metal laser sintering (DMLS)	Almost any metal alloy
	Electron-beam melting(EBM)	Titanium alloys
	Selective laser melting(SLM)	Titanium alloys, Cobalt Chrome alloys, Stainless Steel, Aluminium
	Selective heat sintering(SHS)	Thermoplastic powder
	Selective laser sintering(SLS)	Thermoplastics, metal powders, ceramic powders
Powder bed and inkjet head 3D printing	**Plaster-based 3D printing (PP)**	Plaster
Laminated	Laminated object manufacturing (LOM)	Paper, metal foil, plastic film
Light polymerised	**Stereolithography (SLA)**	photopolymer
	Digital Light Processing(DLP)	photopolymer

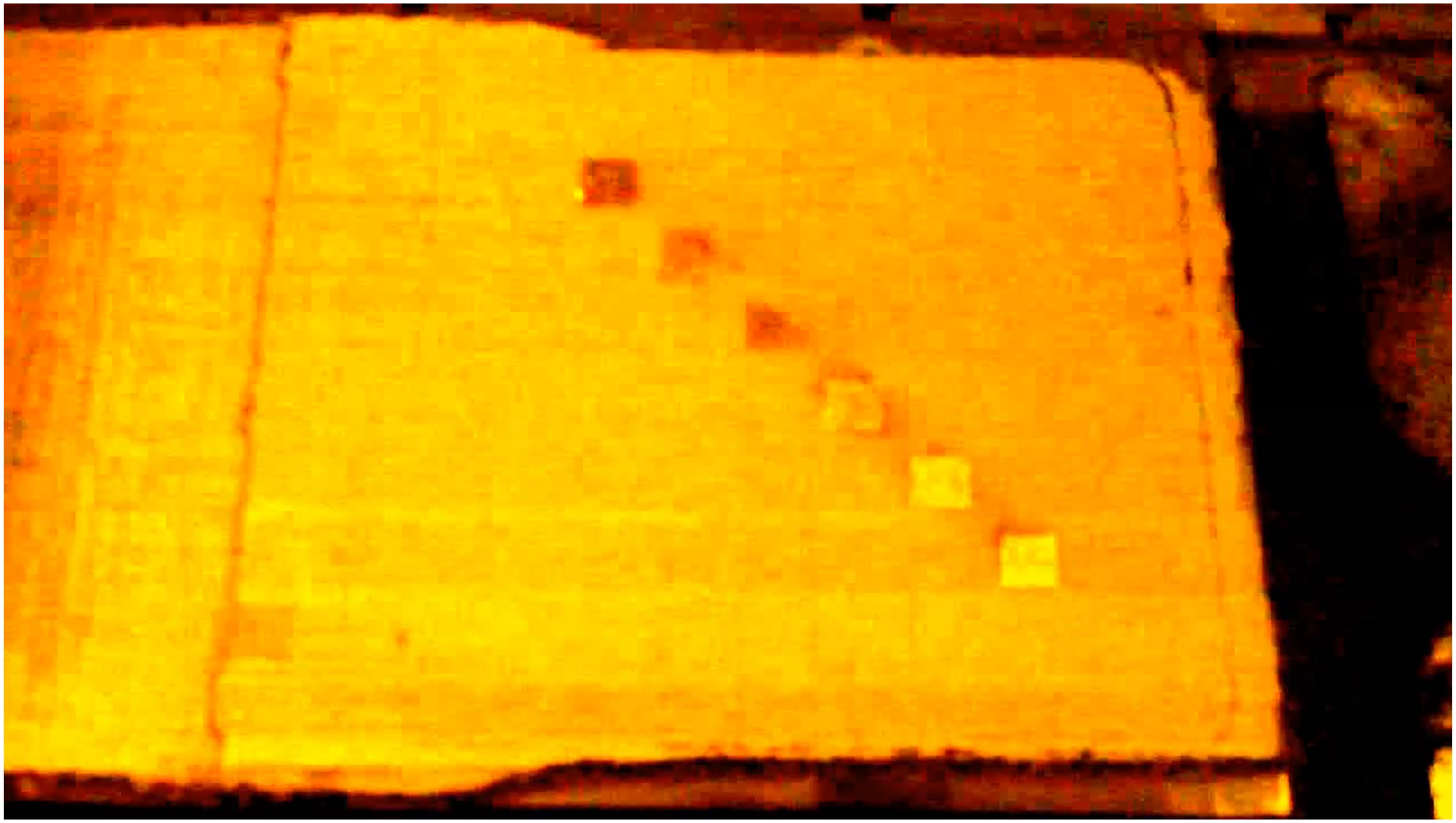
Fused deposition modeling (FDM)

Plaster-based 3D printing (PP)

Stereolithography (SLA)



Selective Laser Sintering (SLS)



Cement Polymer

It is a strong and rigid material that can be fiber reinforced, resulting in a 3D printed material stronger than standard concrete.

Wood

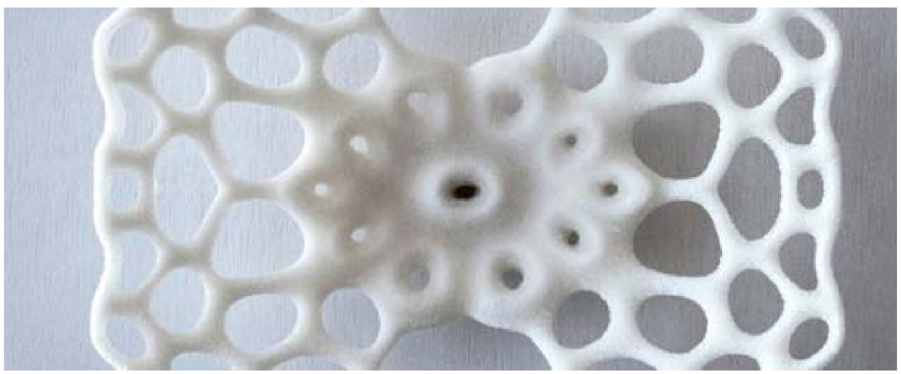
It is moderately strong and a rigid material with translucency. It can be fiber reinforced for added strength. A grain, similar to natural wood grain results from the additive layer manufacturing of the objects made with this material. The wood is made from recycled hard and soft woods.

Ronald Rael http://www.emergingobjects.com/

Paper

Prints are light gray and grainy. It demonstrates good printing strength and is very light weight. Paper for 3D printing can be produced from easily sourced waste material.

Salt



The material is strong, waterproof and translucent.

Ronald Rael http://www.emergingobjects.com/

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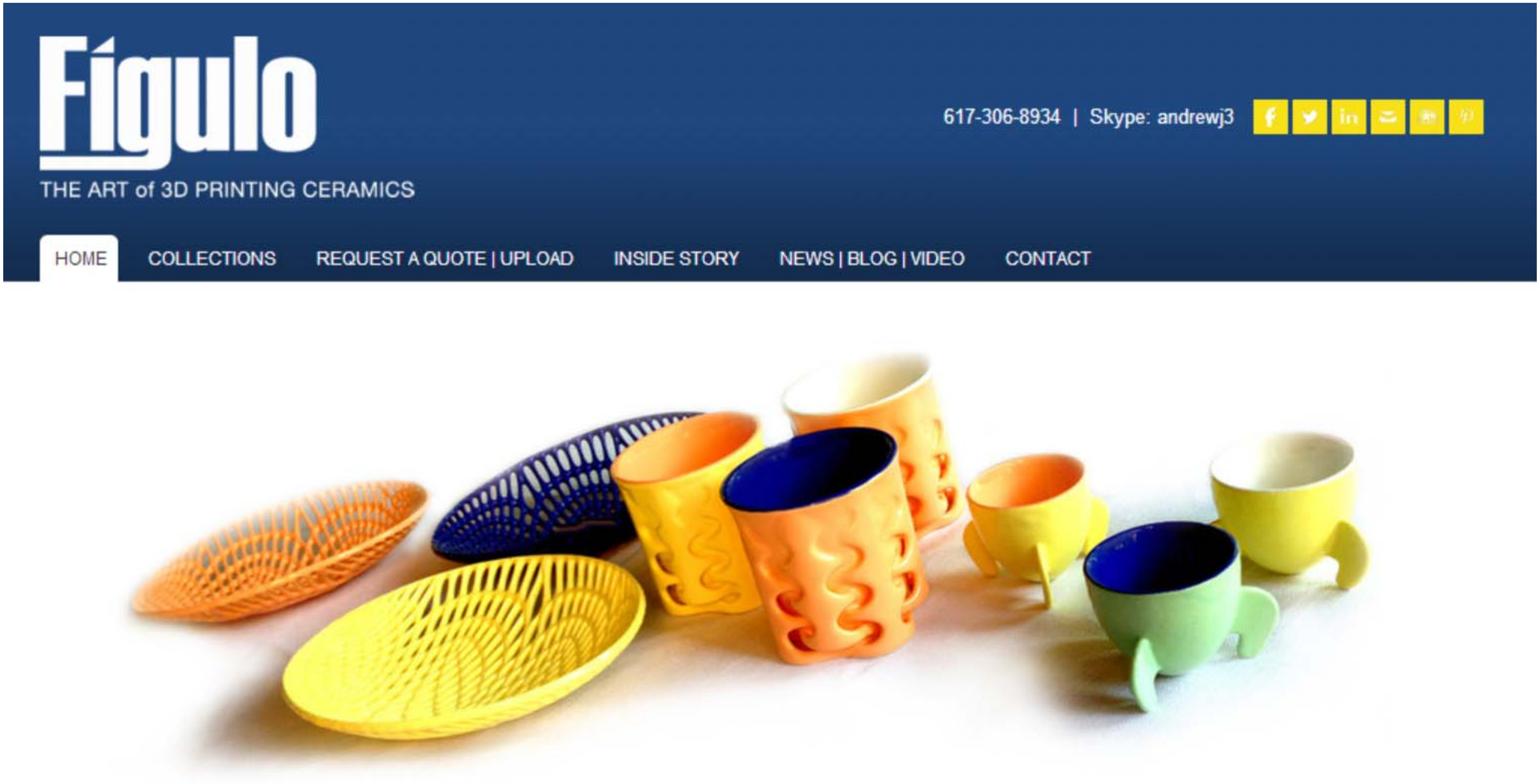

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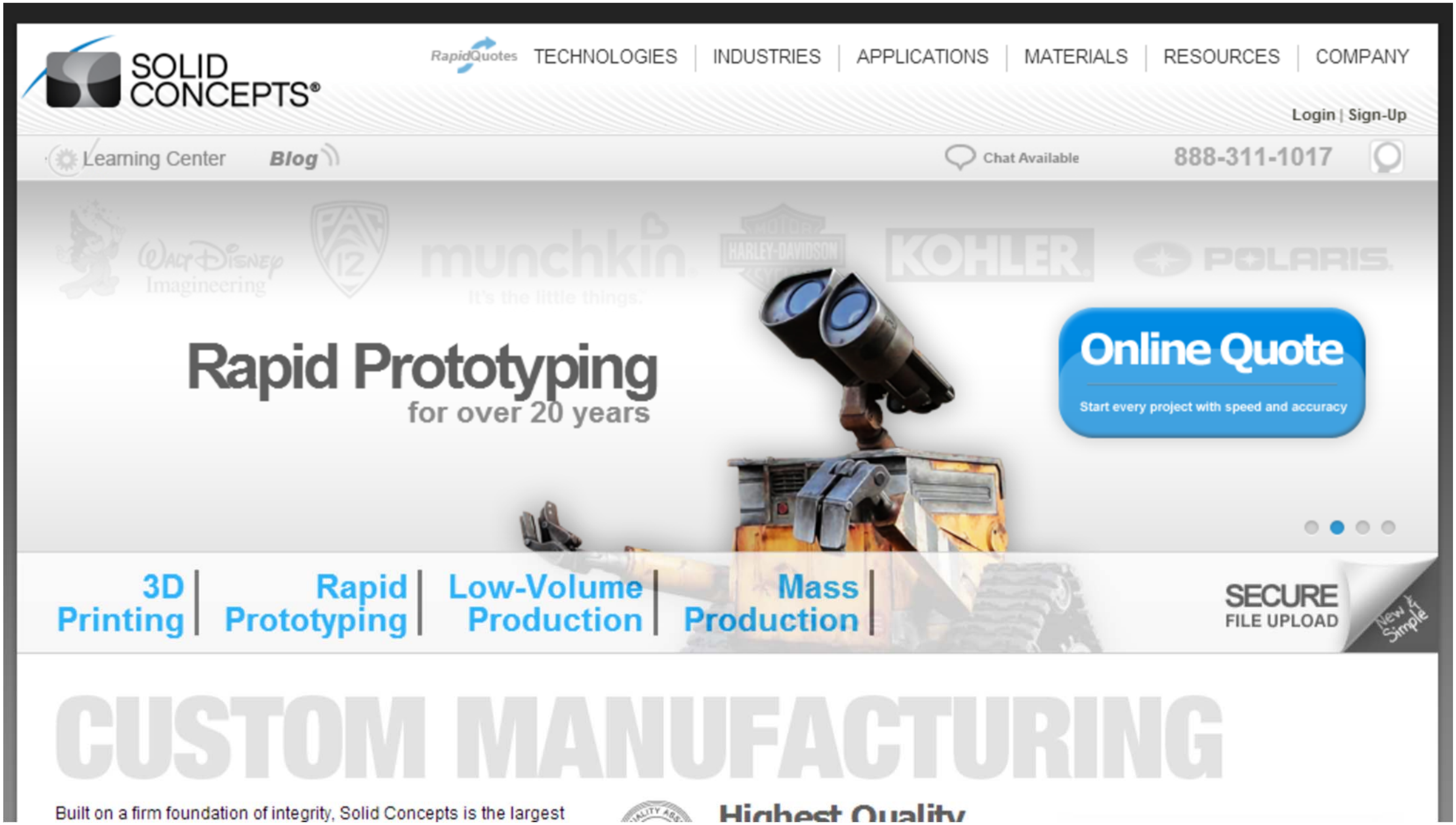
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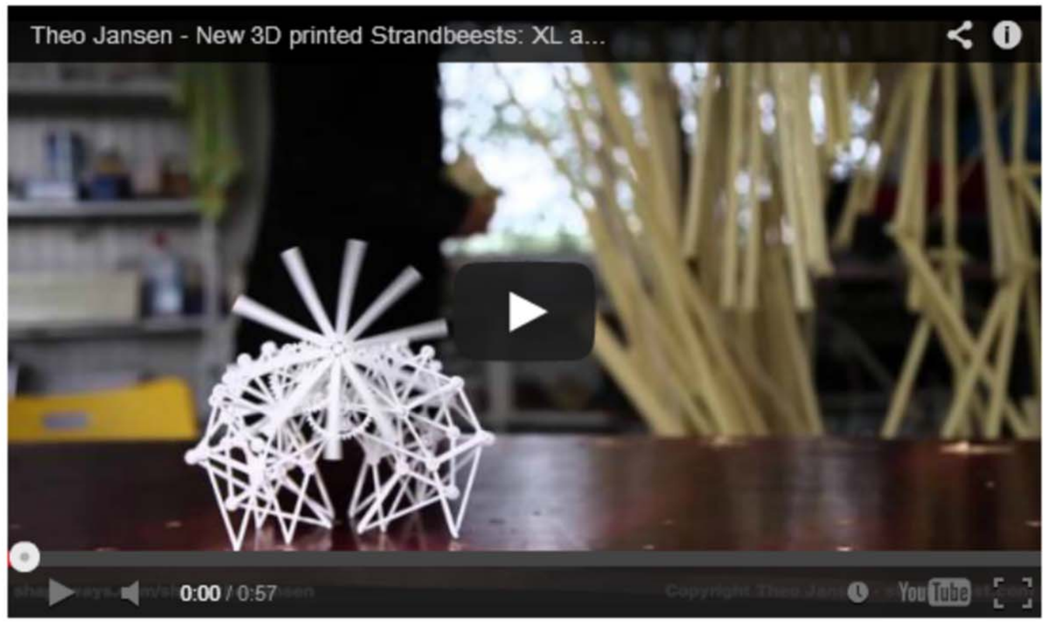
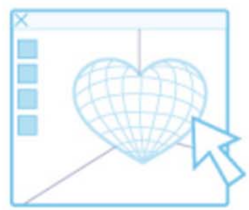
See Larva »

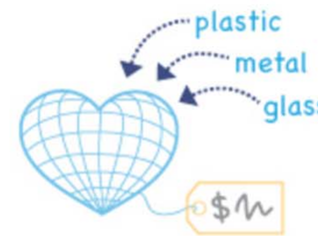


Idea!



Model your design.

Upload to Shapeways.



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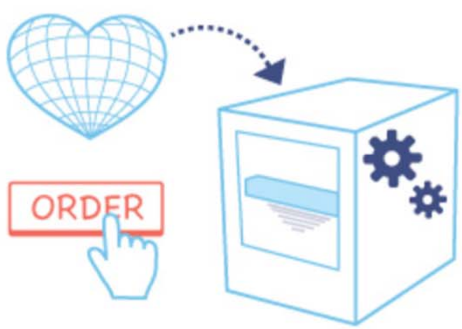

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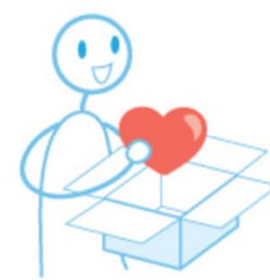
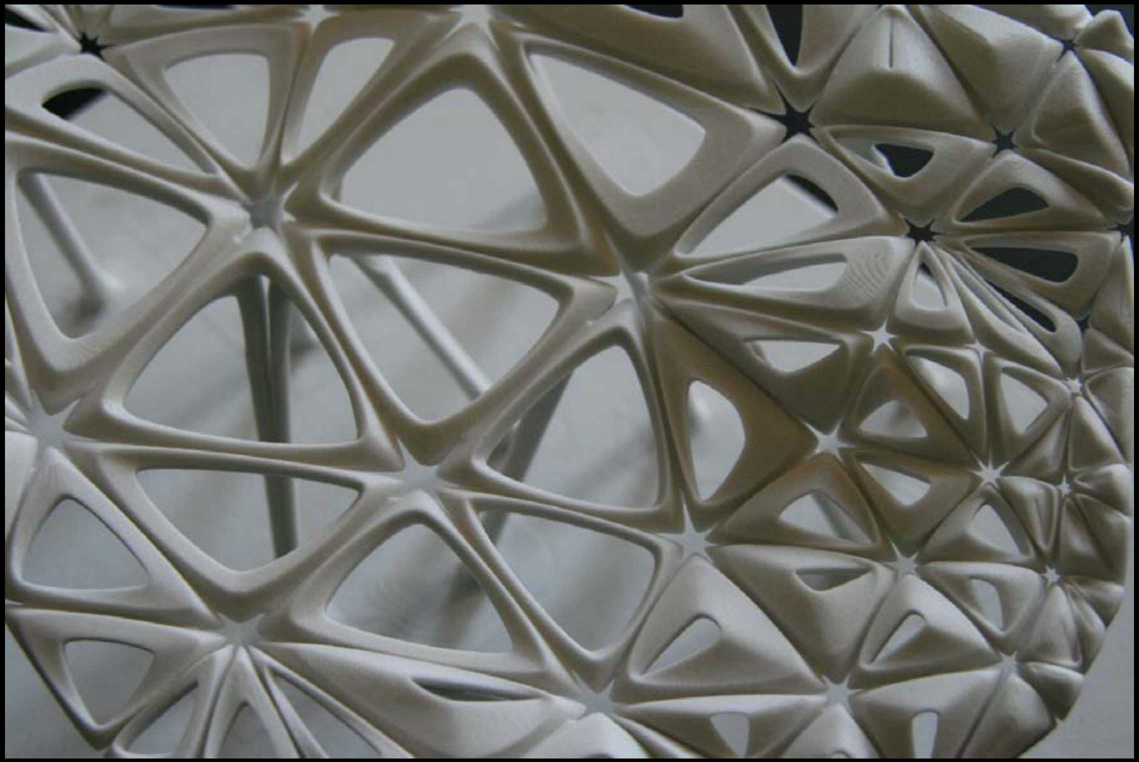
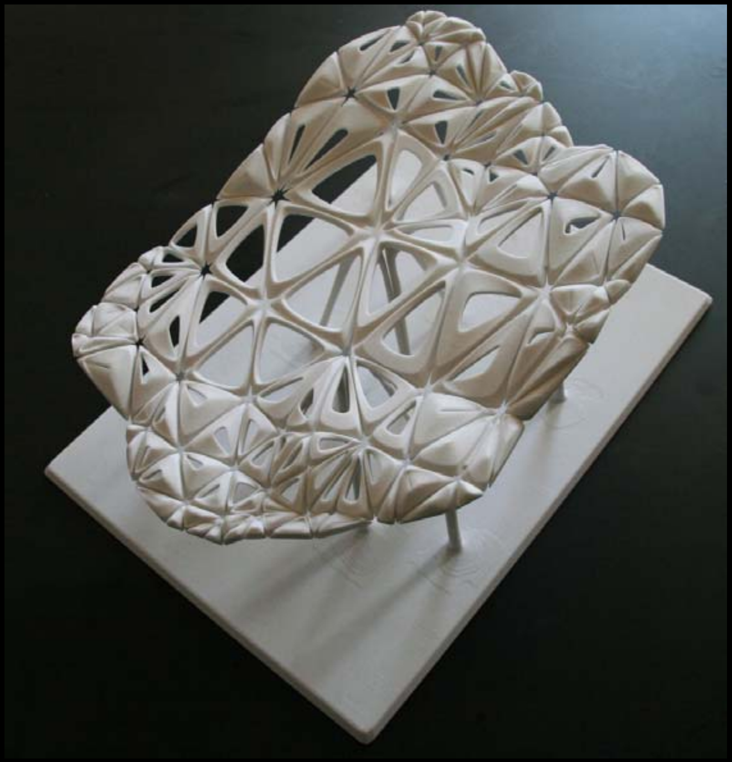
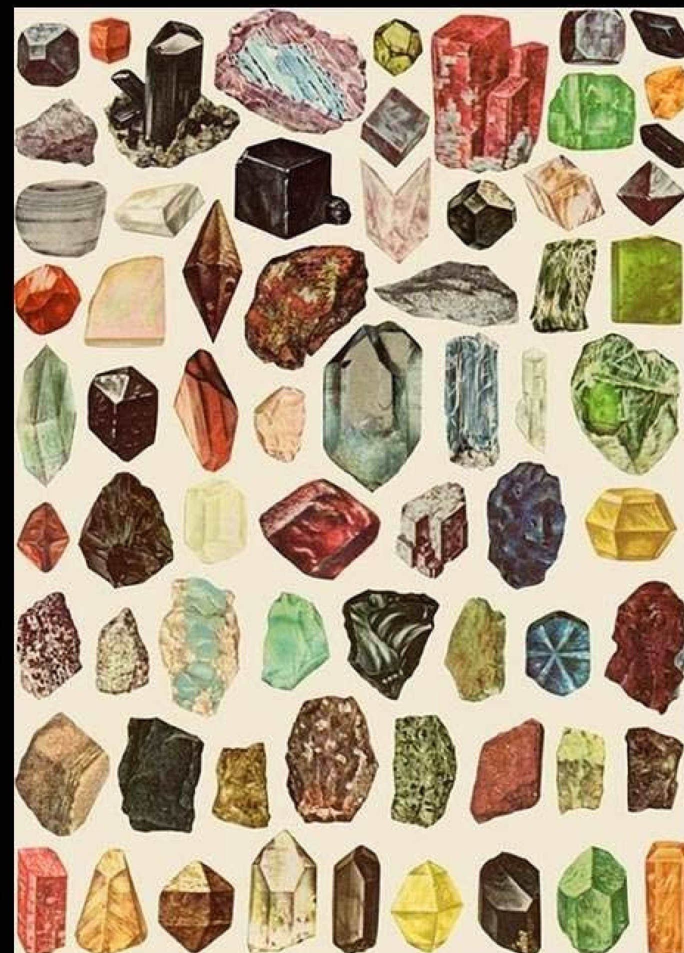


Your idea made real!

Neri Oxman www.materialecology.com/

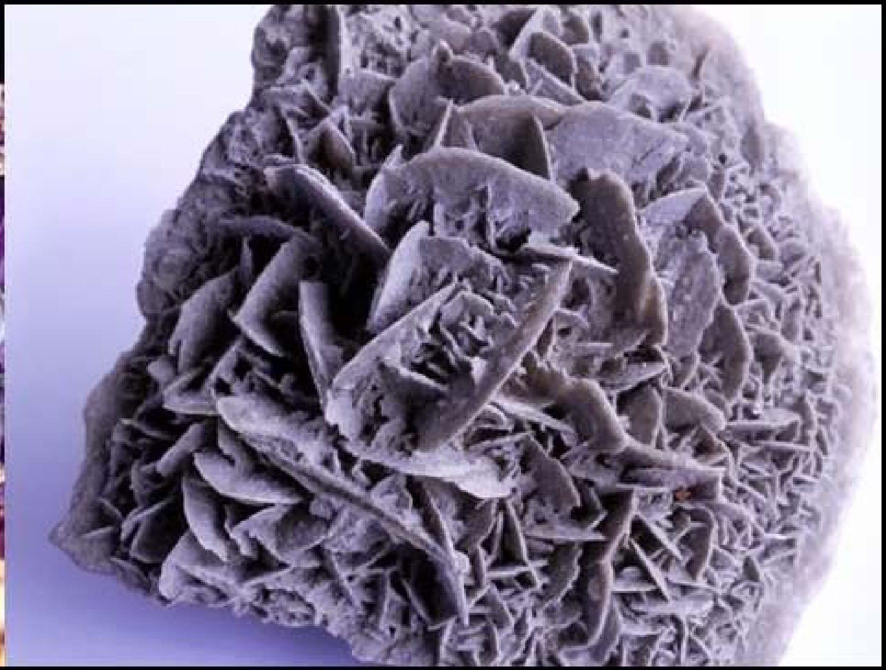


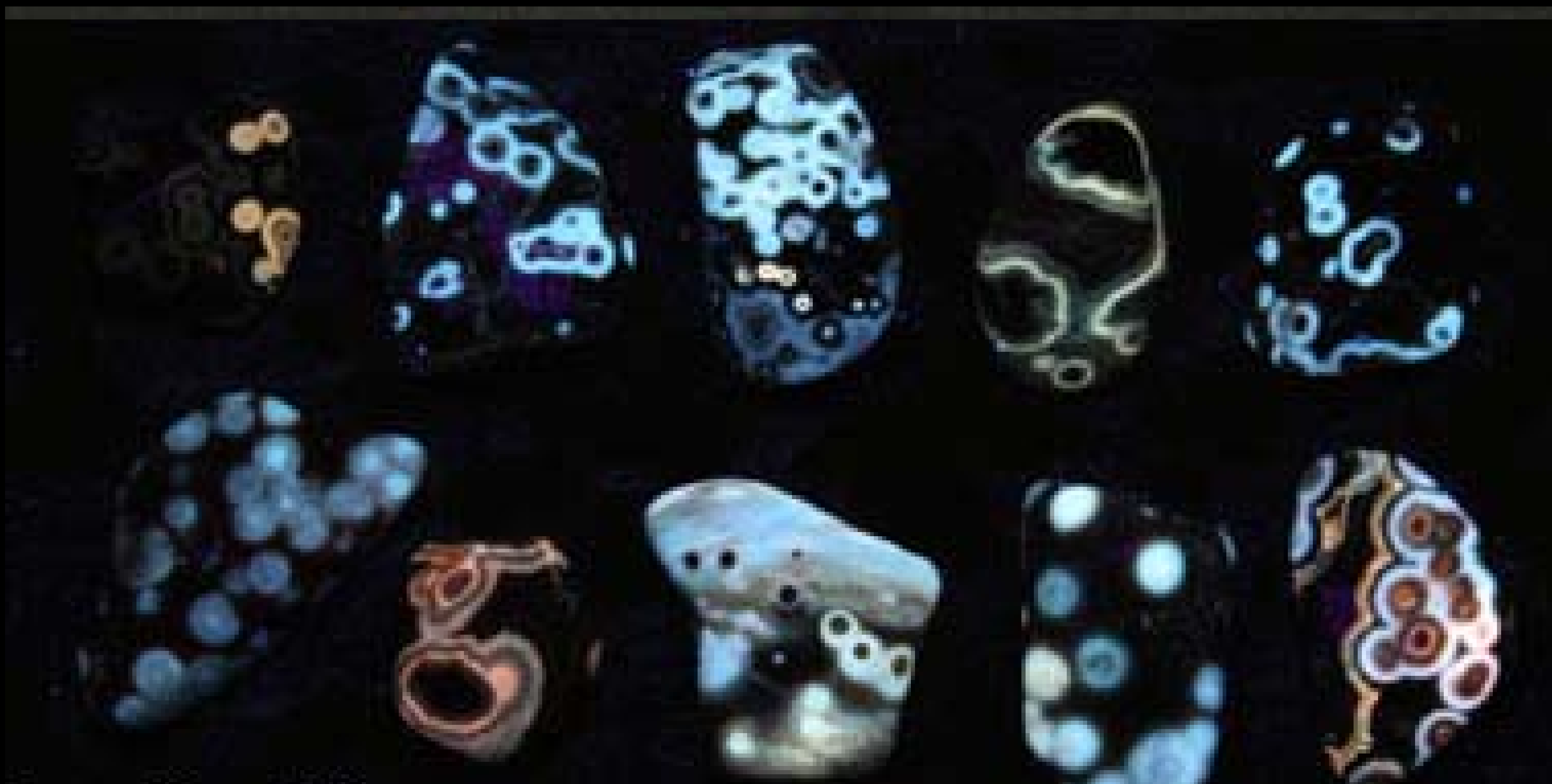


THE OBJECT

THE COMPOSITE

THE AGGRAGATION



THE PIGMENT






Parametric Design

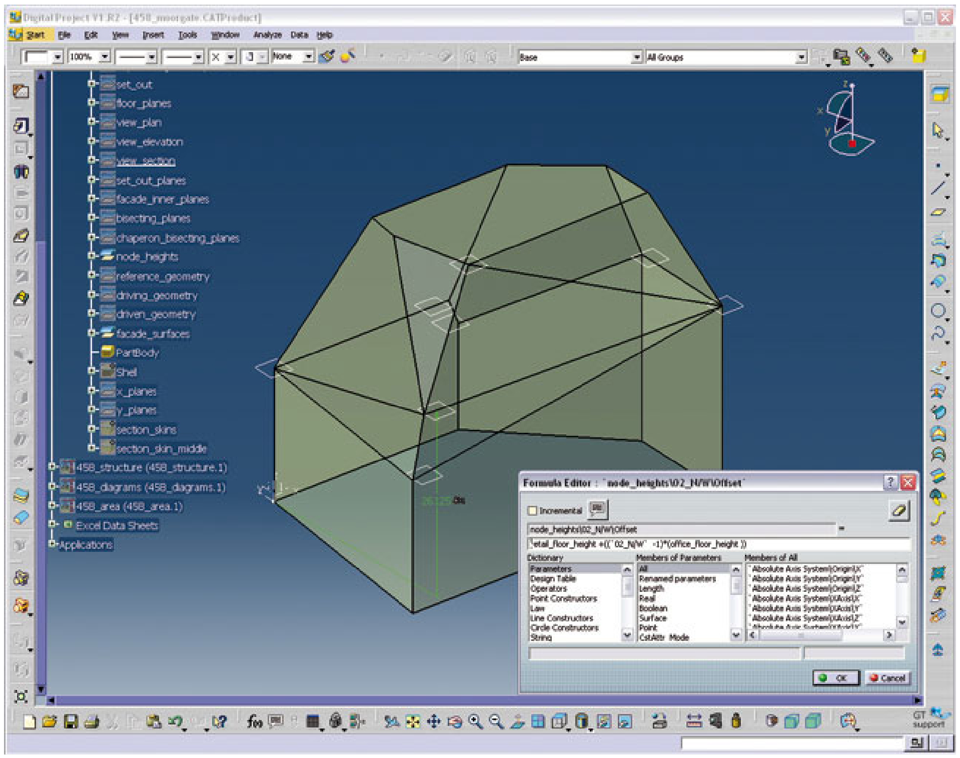
Parametric Thinking in a 3D Printing Oriented Workflow

Benjamin Hait + Hart Marlow

Grasshopper is a visual algorithim editor that enables a parametric design process.

Parametric Model

A model in which the parts change in a coordinated way defined by the various parameters and dependencies stated.



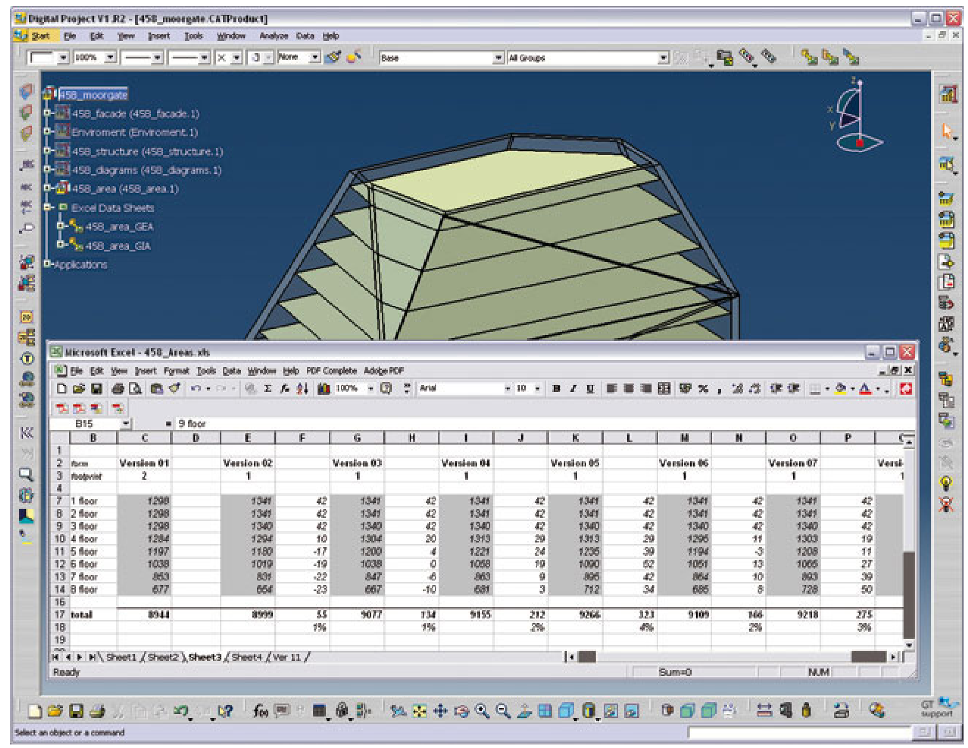
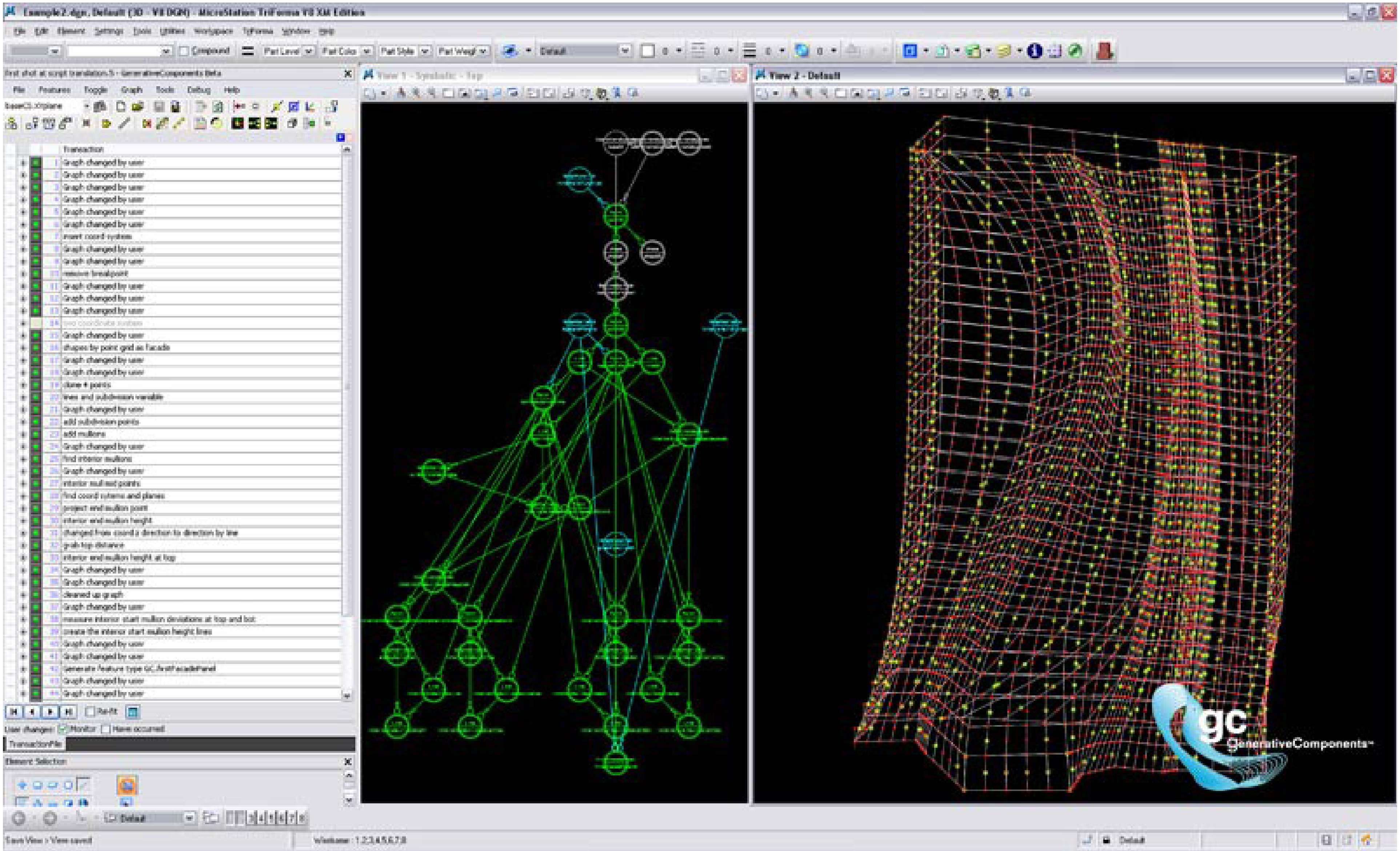


Image Courtesy: Gehry Technologies



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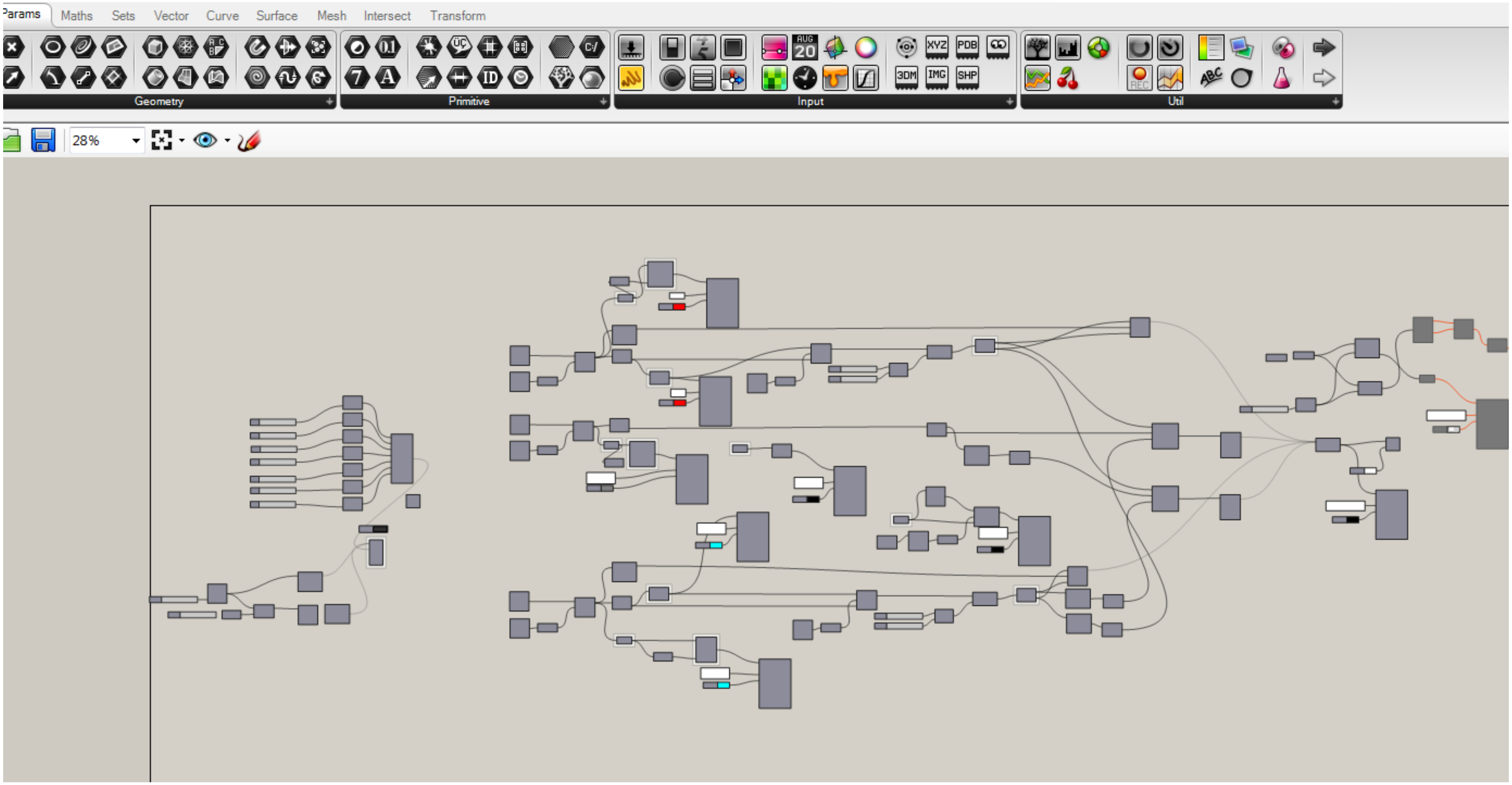
Params
Maths
Sets
Vector
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Transform
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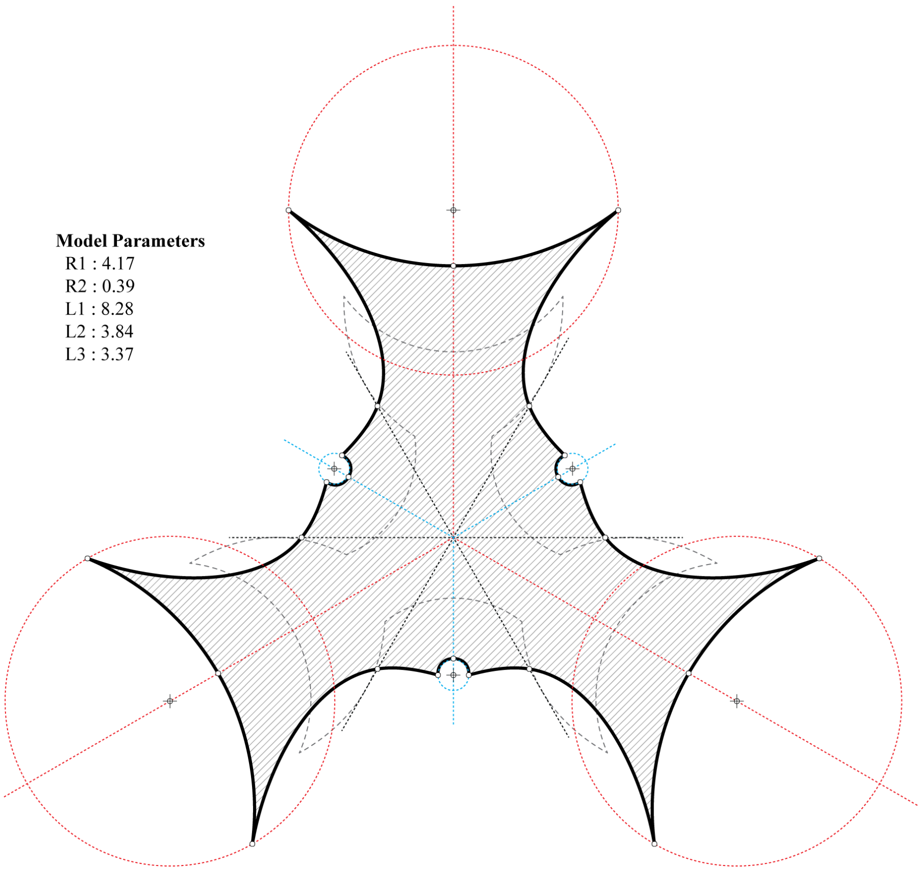
Primitive
Input
Util
28%

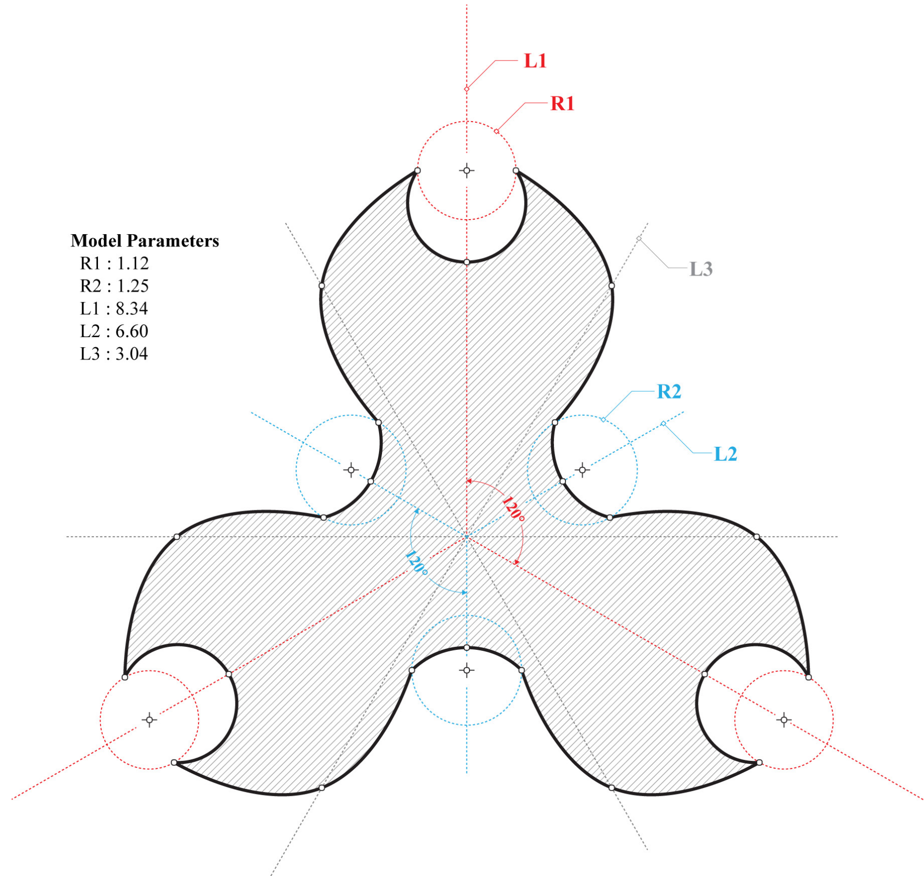
Parameter

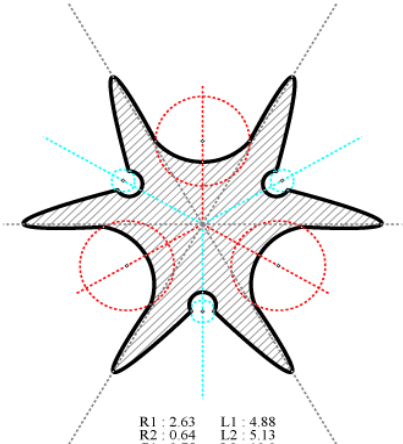
A parameter defines a system,
determining the limits and performance.

Model Parameters
R1 : 4.17
R2 : 0.39
L1 : 8.28
L2 : 3.84
L3 : 3.37

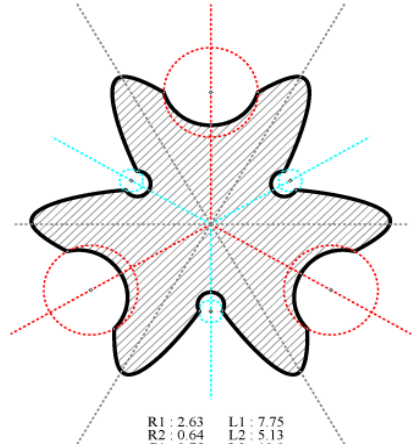


Model Parameters
R1 : 1.12
R2 : 1.25
L1 : 8.34
L2 : 6.60
L3 : 3.04

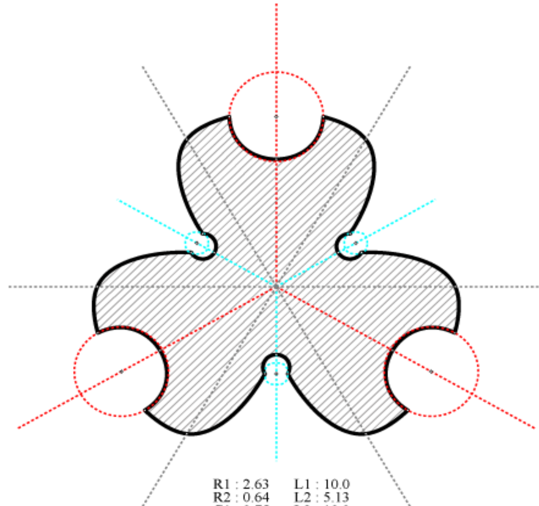




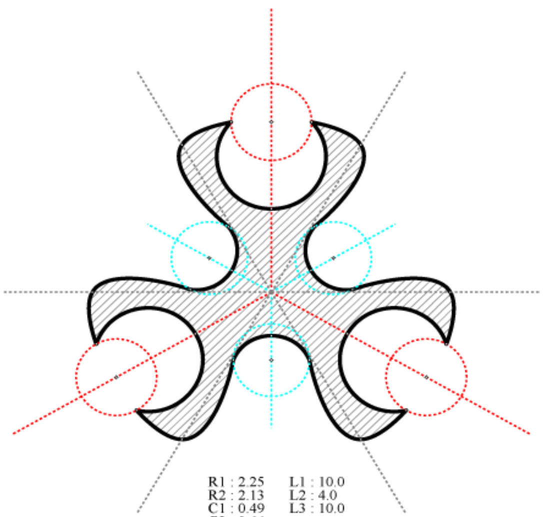
R1 : 2.63 L1 : 4.88
R2 : 0.64 L2 : 5.13
C1 : 0.75 L3 : 10.0
C2 : 0.78



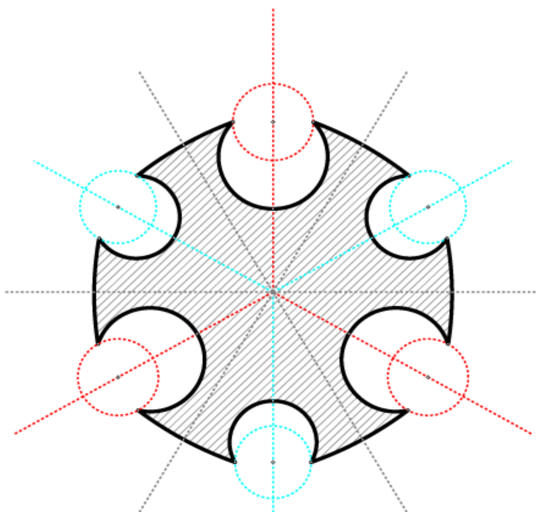
R1 : 2.63 L1 : 7.75
R2 : 0.64 L2 : 5.13
C1 : 0.75 L3 : 10.0
C2 : 0.78



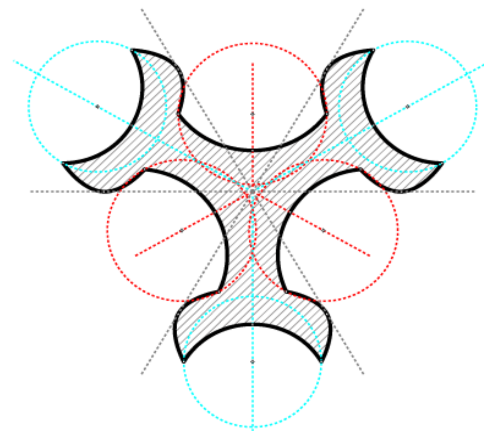
R1 : 2.63 L1 : 10.0
R2 : 0.64 L2 : 5.13
C1 : 0.75 L3 : 10.0
C2 : 0.78



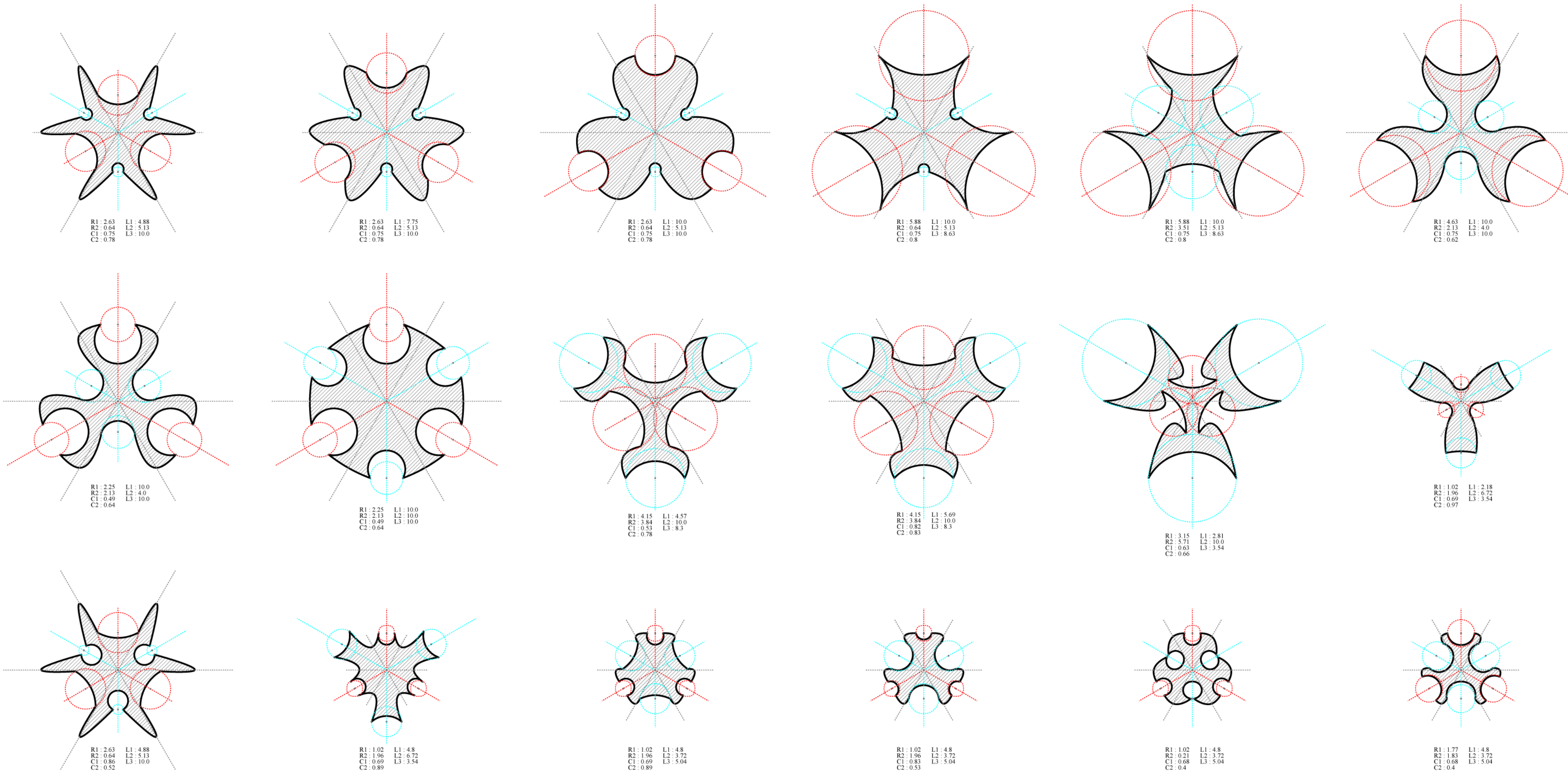
R1 : 2.25 L1 : 10.0
R2 : 2.13 L2 : 4.0
C1 : 0.49 L3 : 10.0
C2 : 0.64

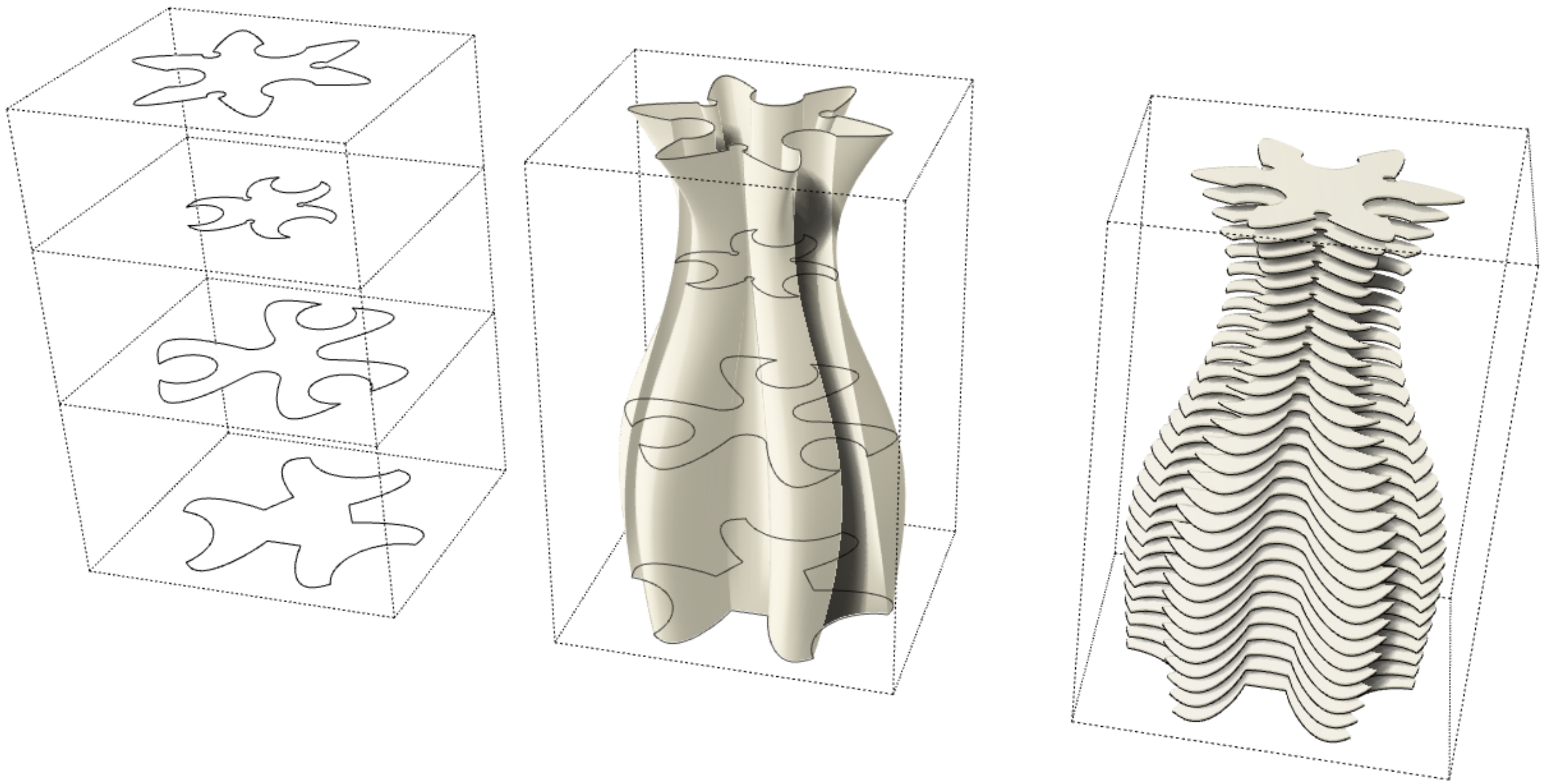


R1 : 2.25 L1 : 10.0
R2 : 2.13 L2 : 10.0
C1 : 0.49 L3 : 10.0
C2 : 0.64



R1 : 4.15 L1 : 4.57
R2 : 3.84 L2 : 10.0
C1 : 0.53 L3 : 8.3
C2 : 0.78


R1 : 2.63 L1 : 4.88
R2 : 0.64 L2 : 5.13
C1 : 0.75 L3 : 10.0
C2 : 0.78
R1 : 2.63 L1 : 7.75
R2 : 0.64 L2 : 5.13
C1 : 0.75 L3 : 10.0
C2 : 0.78
R1 : 2.63 L1 : 10.0
R2 : 0.64 L2 : 5.13
C1 : 0.75 L3 : 10.0
C2 : 0.78
R1 : 5.88 L1 : 10.0
R2 : 0.64 L2 : 5.13
C1 : 0.75 L3 : 8.63
C2 : 0.8
R1 : 5.88 L1 : 10.0
R2 : 3.51 L2 : 5.13
C1 : 0.75 L3 : 8.63
C2 : 0.8
R1 : 4.63 L1 : 10.0
R2 : 2.13 L2 : 4.0
C1 : 0.75 L3 : 10.0
C2 : 0.62
R1 : 2.25 L1 : 10.0
R2 : 2.13 L2 : 4.0
C1 : 0.49 L3 : 10.0
C2 : 0.64
R1 : 2.25 L1 : 10.0
R2 : 2.13 L2 : 10.0
C1 : 0.49 L3 : 10.0
C2 : 0.64
R1 : 4.15 L1 : 4.57
R2 : 3.84 L2 : 10.0
C1 : 0.53 L3 : 8.3
C2 : 0.78
R1 : 4.15 L1 : 5.69
R2 : 3.84 L2 : 10.0
C1 : 0.82 L3 : 8.3
C2 : 0.83
R1 : 3.15 L1 : 2.81
R2 : 5.71 L2 : 10.0
C1 : 0.63 L3 : 3.54
C2 : 0.66
R1 : 1.02 L1 : 2.18
R2 : 1.96 L2 : 6.72
C1 : 0.69 L3 : 3.54
C2 : 0.97
R1 : 2.63 L1 : 4.88
R2 : 0.64 L2 : 5.13
C1 : 0.86 L3 : 10.0
C2 : 0.52
R1 : 1.02 L1 : 4.8
R2 : 1.96 L2 : 6.72
C1 : 0.69 L3 : 3.54
C2 : 0.89
R1 : 1.02 L1 : 4.8
R2 : 1.96 L2 : 3.72
C1 : 0.69 L3 : 5.04
C2 : 0.89
R1 : 1.02 L1 : 4.8
R2 : 1.96 L2 : 3.72
C1 : 0.83 L3 : 5.04
C2 : 0.53
R1 : 1.02 L1 : 4.8
R2 : 0.21 L2 : 3.72
C1 : 0.68 L3 : 5.04
C2 : 0.4
R1 : 1.77 L1 : 4.8
R2 : 1.83 L2 : 3.72
C1 : 0.68 L3 : 5.04
C2 : 0.4



Essential Concepts

The **parameters** of a particular design are declared, not it's shape.

Because the process is **explicit**, it helps to have an idea about where you are going and how you might get there before beginning modeling.

The various inputs, processing, and results in this planning process is referred to as **algorithims**.

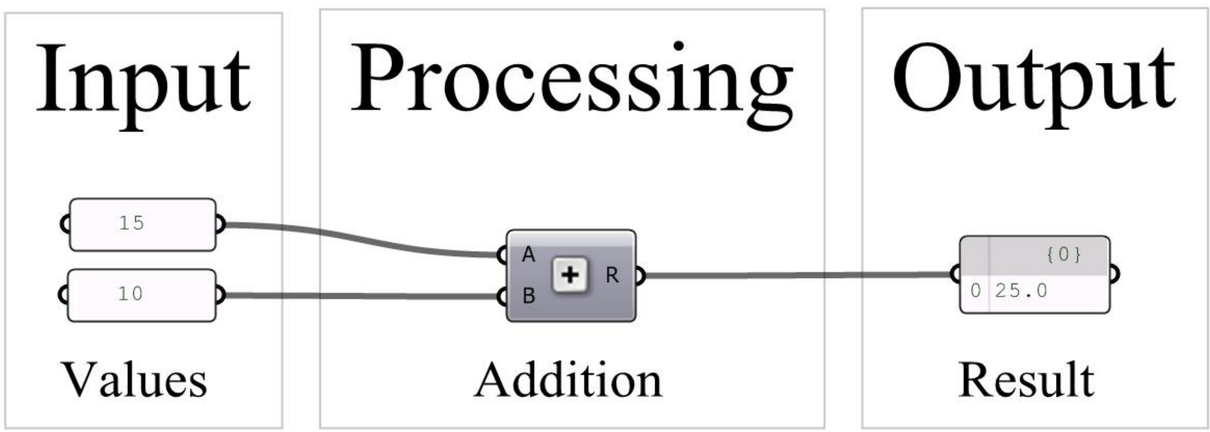
Algorithim

A set of rules, precisely defining a sequence of operations

Algorithmic Process

Three fundamental parts:

Input - Processing - Output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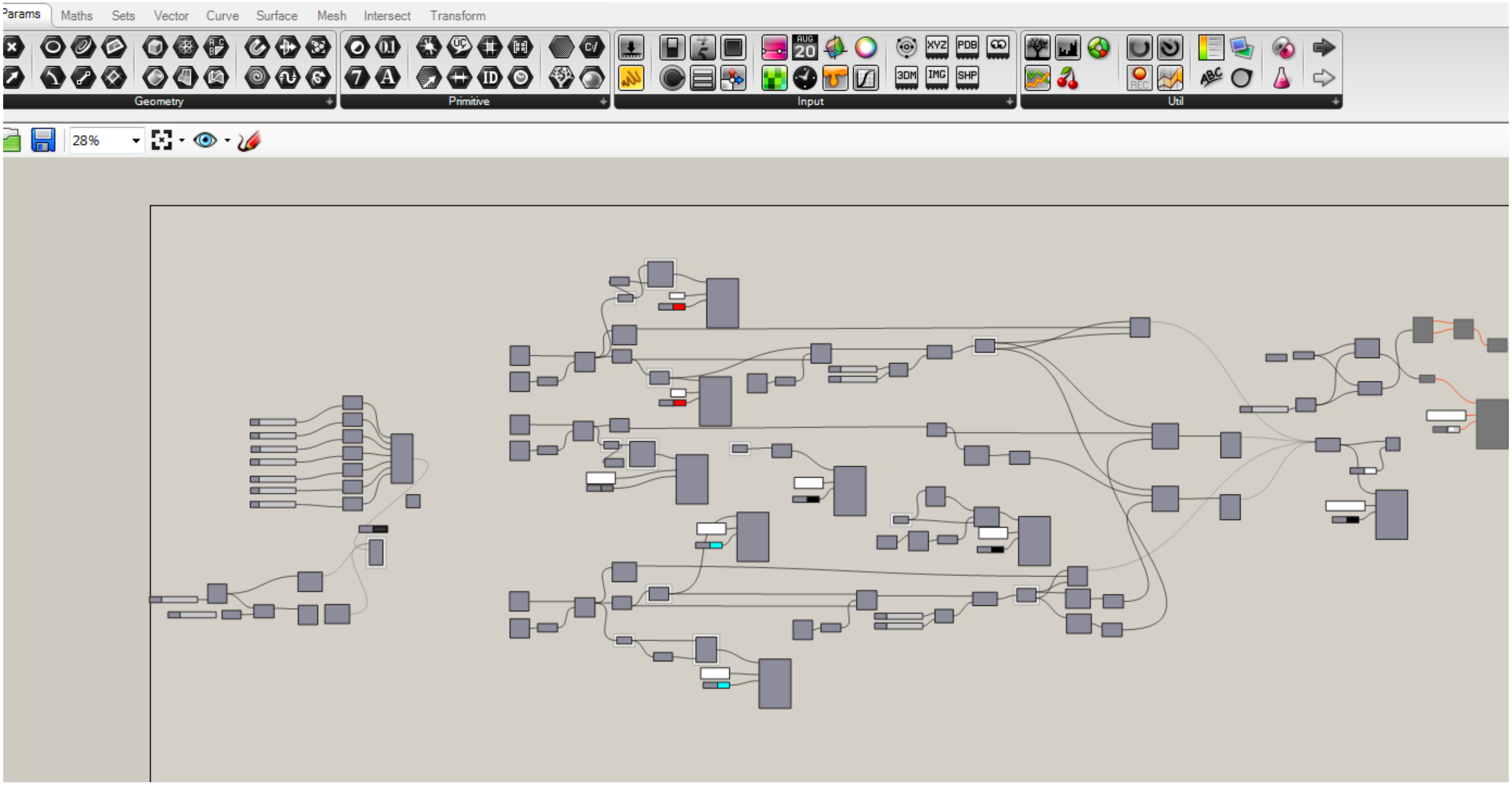
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Primitive
Input
Util
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Assignment 01: Geology Studies

Description:

Taking cues from the geology photography as seen in class, students will model faceted polygonal models. Students should produce a variety of 'types' - long, skinny / short, squat / round, smooth / jagged, pointy, etc. These models will then be printed on the MakerBot Replicator 2.

Students should also consider the optimal orientation for the models relative to the print bed. As FDM printing requires the inclusion of support material, possible orientations should be considered for their impact on material use and printing time.

Assessment:

Projects will be evaluated on the following criteria:

1. Minimum number of studies (3) produced
2. Studies demonstrate a variety of formal qualities.
3. Parts are oriented so as to reduce print time and material use as much as possible, unless arguments are presented otherwise (part finish quality on a particular face of the form study, etc.)
4. Geometry is manifold and print-ready.

Assignment 02: Component Aggregation

Description:

Students will design and develop aggregations using the most successful form study or studies from the previous assignment (Geology Primitive). These 'building blocks' will then be aggregated into an overall geometry with parameters such as translational distance, rotation, and scaling.

Greater emphasis is placed in this project on the use of parametric modeling via Grasshopper to control the effects produced by the final object. Students should produce a variety of studies using a single base geometry whose differences lie in the ways in which the parametric modeling affects the outcome.

Assessment:

Projects will be evaluated on the following criteria:

1. Minimum number of studies (3) produced
2. Grasshopper model outputs multiple closed meshes demonstrating the desired geometry manipulations that students intend.
3. Studies demonstrate a variety of formal qualities from both base geometry and the parametric operations that are applied to it (translation, rotation, scaling)
4. Texture mapped file is exported in the correct format for the ZPrint software.
5. Geometry is manifold and print-ready.

New York City College of Technology

The City University of New York

CareerPATH Program - Green Advanced Manufacturing Collaborative (GAMC)

Assignment 03: Color Bowls

Description:

Students will design and develop full-color, texture-mapped 3D printed artifacts. The project is intended to synthesize the prior two projects, where form and color were examined, now utilizing the full range of the printer's color capabilities.

Greater emphasis is placed in this project on the crafting of well-formed geometry, dealing with issues of mesh topology & repair, orientation optimization for ease of fabrication, machine tolerances and material limits, and print post-processing.

Assessment:

Projects will be evaluated on the following criteria:

1. Minimum number of studies (3) produced
2. Studies demonstrate a variety of formal and textural qualities from both geometry and texture mapping.
3. Texture mapped file is exported in the correct format for the ZPrint software.
4. Geometry is manifold and print-ready.