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GEORGE MASON UNIVERSITY

AN INTRODUCTION TO 3D PRINTING IN THE STEM CLASSROOM

BASED ON WORK FUNDED BY 4VA

DOCTOR IN GAZA 3D PRINTS $5 STETHOSCOPE WITH BETTER AUDIO QUALITY THAN STANDARD $150 VERSION

SUBLIME

WHAT IS THE BIG DEAL ABOUT 3D PRINTING?

ENABLE VOLUNTEERS PRINT PROSTHETIC HANDS FOR CHILDREN

SUBLIME

WHAT IS THE BIG DEAL ABOUT 3D PRINTING?

3D-Printed Guns Are Only Getting Better, and Scarier

Adam Clark Estes
Filed to: GUNS 1/06/15 1:15pm

3D-Printed Guns Are O and Scarier

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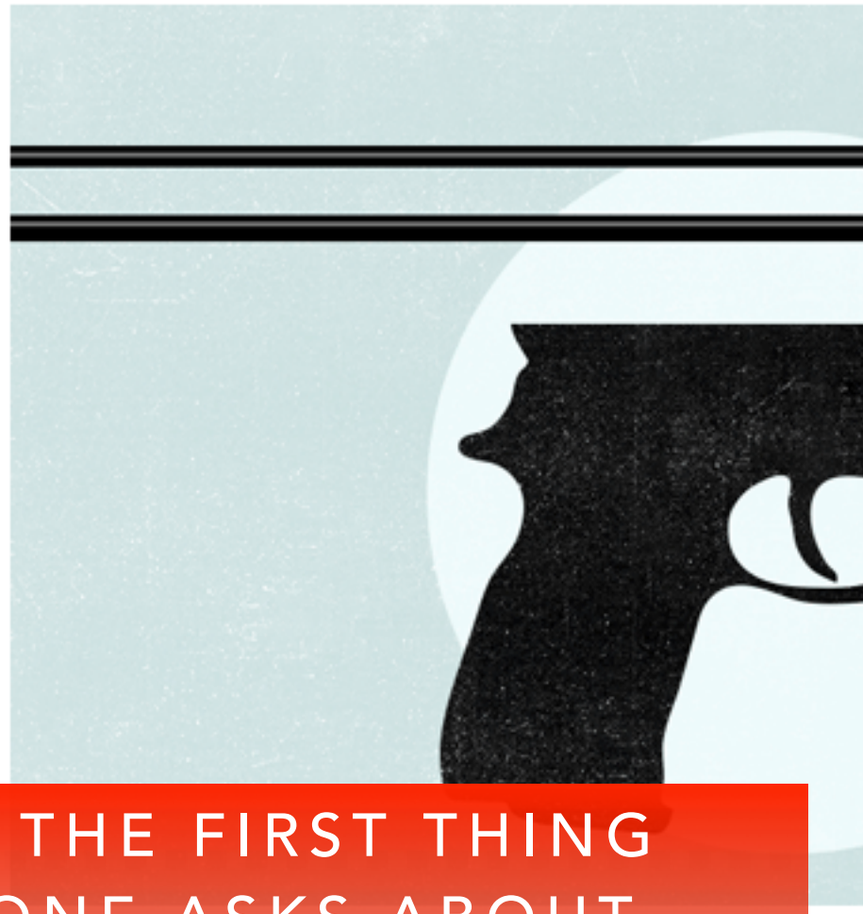

THIS IS THE FIRST THING EVERYONE ASKS ABOUT

UNSAVORY

WHAT IS THE BIG DEAL ABOUT 3D PRINTING?

Technology

3D-printed TSA master keys put travellers' luggage at risk

Lockpickers took advantage of US Transportation Security Administration breach in which photos of its 'approved' locks were posted online

A TSA of
baggage loc

Technolo

3D-p
trave

UNSAVORY

WHAT IS THE BIG DEAL ABOUT 3D PRINTING?

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travellers' luggage at ris

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Lockpickers took advantage of US Transportatio

3D PRINTED SUGAR CUBES, CHOCOLATES, MARZIPAN, AND OTHER FOODS ARE ALL A REALITY

RIDICULOUS

WHAT IS THE BIG DEAL ABOUT 3D PRINTING?

"THINGS MADE WITH 3D-PRINTERS TEND TO FALL INTO TWO BROAD CATEGORIES: ONE IS SILLY BORDERING ON USELESS—INCREDIBLY DETAILED CHESS PIECES, A MUG THAT LOOKS SURPRISED, A MASK THAT LOOKS LIKE TOM HANKS, WHAT HAVE YOU. THE OTHER IS LIVE-SAVING BORDERING ON FROM THE FUTURE, LIKE THE IDEA THAT WE MIGHT SOON HAVE 3D-PRINTED ORGANS."
OLGA KAZHAN, THE ATLANTIC

RIDICULOUS (I ADMIT IT, I MADE ONE OF THESE)

WHAT IS THE BIG DEAL ABOUT 3D PRINTING?

THE PROCESS OF MODELING IS ESSENTIALLY THE SAME WHETHER IT IS THE DESCRIPTION OF A HUMAN ORGAN, AN IPHONE CASE, OR A TOOTHPASTE SQUEEZER, AND WHETHER THE PRINTER IS AN $800 PRINTER OR A MILLION DOLLAR PRINTER

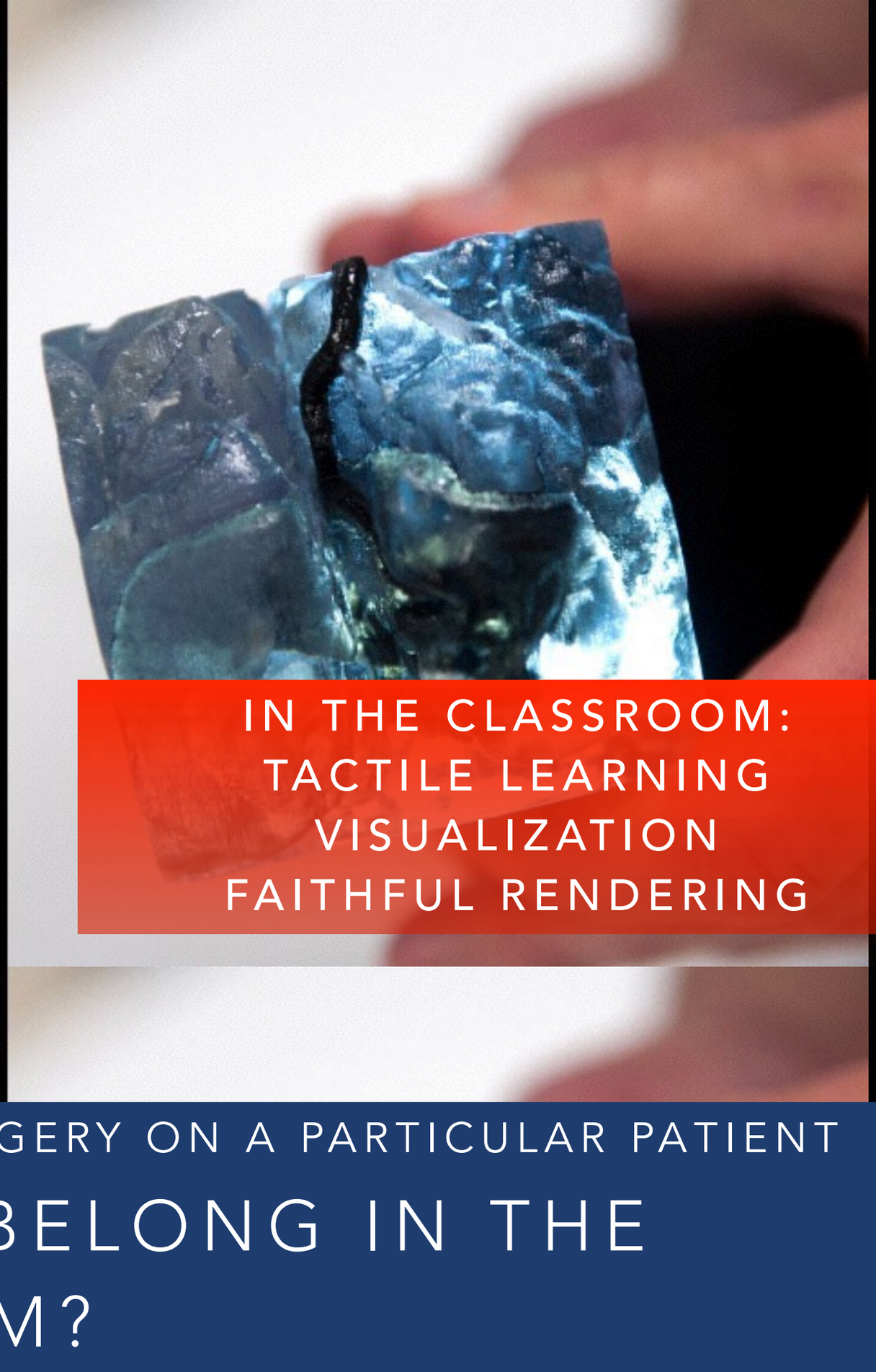
RIDICULOUS (I ADMIT IT, I MADE ONE OF THESE)

WHAT IS THE BIG DEAL ABOUT 3D PRINTING?

IN THE CLASSROOM:
TACTILE LEARNING
VISUALIZATION
FAITHFUL RENDERING

LEARNING TO DISSECT A FROG

DOES PRINTING BELONG IN THE STEM CLASSROOM?



IN THE CLASSROOM:
TACTILE LEARNING
VISUALIZATION
FAITHFUL RENDERING

LEARNING TO PERFORM SURGERY ON A PARTICULAR PATIENT

DOES PRINTING BELONG IN THE STEM CLASSROOM?

IN THE CLASSROOM:
TACTILE LEARNING
VISUALIZATION
FAITHFUL RENDERING

LEARNING TO VISUALIZE AN ABSTRACT CONCEPT

DOES PRINTING BELONG IN THE STEM CLASSROOM?

IN THE CLASSROOM:
TACTILE LEARNING
VISUALIZATION
FAITHFUL RENDERING

LEARNING BY CREATING

DOES PRINTING BELONG IN THE STEM CLASSROOM?

IN THE CLASSROOM:
TACTILE LEARNING
VISUALIZATION
FAITHFUL RENDERING

3D ARCHIVING OF RESEARCH

DOES PRINTING BELONG IN THE STEM CLASSROOM?

FUSED DEPOSITION MODELING

HOW DOES A 3D PRINTER WORK?

MOST 3D HOME OR OFFICE PRINTERS WORK BY EXTRUDING MANY THIN LAYERS OF HOT PLASTIC ON TOP OF EACH OTHER.

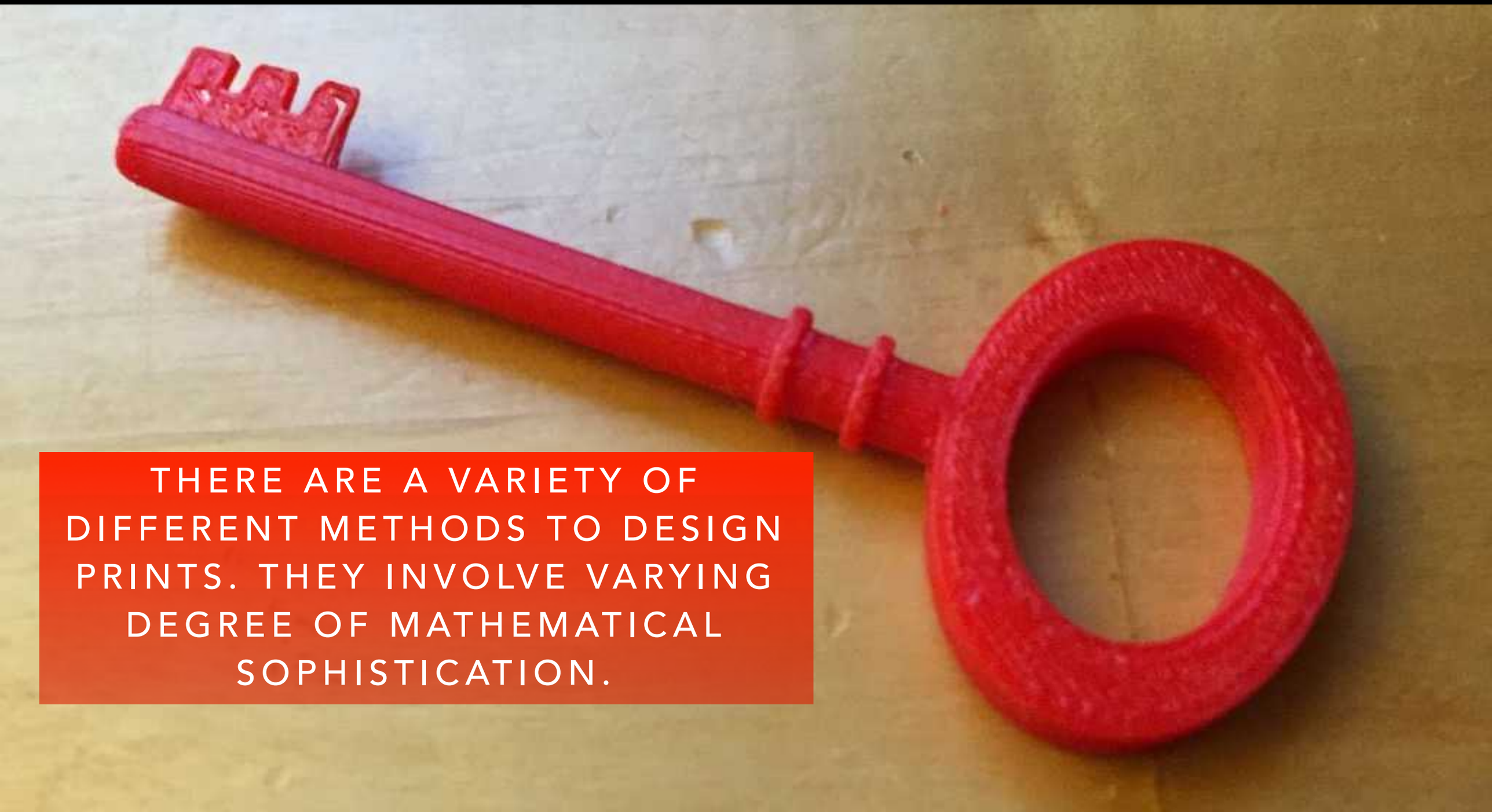
OTHER TECHNOLOGIES

HOW DOES A 3D PRINTER WORK?

OTHER TECHNOLOGIES ALSO EXIST, SUCH AS THIS, INSPIRED BY TERMINATOR 2

DESIGN

THE KEY TO CREATING A 3D MODEL



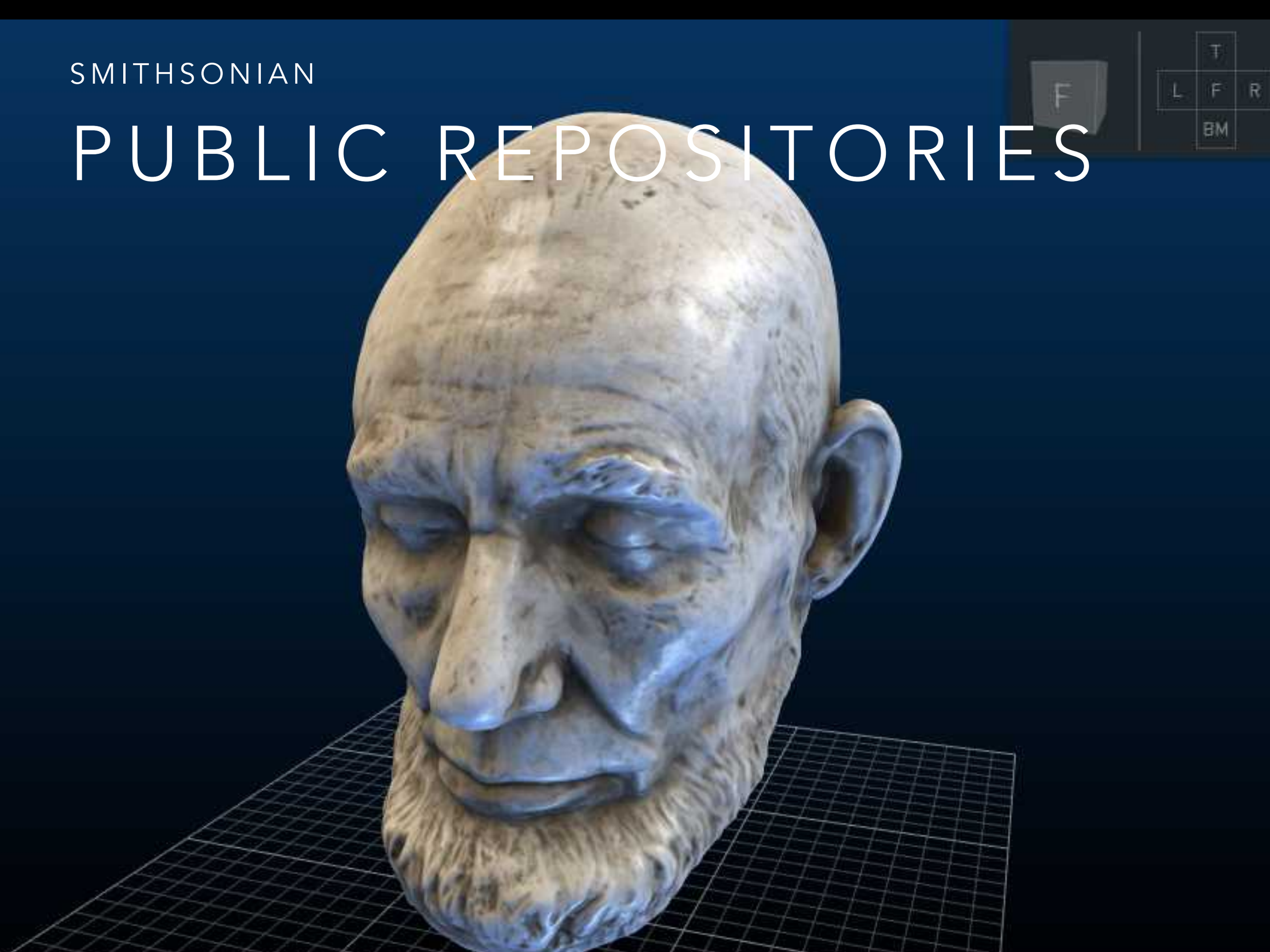
THERE ARE A VARIETY OF DIFFERENT METHODS TO DESIGN PRINTS. THEY INVOLVE VARYING DEGREE OF MATHEMATICAL SOPHISTICATION.

THINGIVERSE

PUBLIC REPOSITORIES

SMITHSONIAN

PUBLIC REPOSITORIES



MAJOR MUSEUMS (BRITISH, LOUVRE, NY METROPOLITAN, ...)

PUBLIC REPOSITORIES

DESIGN SOFTWARE

SCANNING

DESIGN SOFTWARE

SCANNING

LASER / PHOTOGRAMMETRY TO CREATE A MODEL:

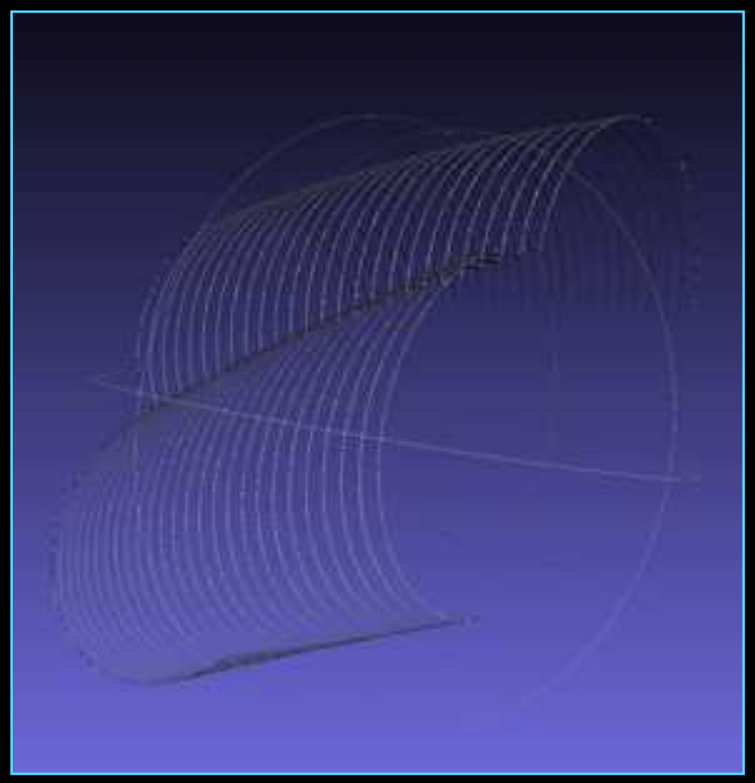
LASER SCANNER/CAMERA FINDS A SET OF POINTS ON THE OBJECT.

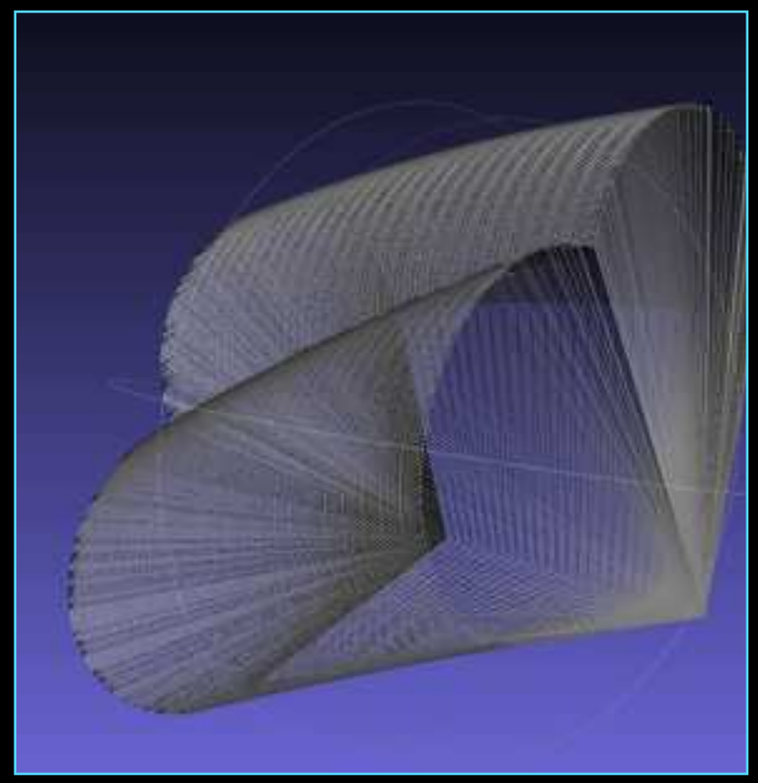
ERRORS AND HAVE TO BE CORRECTED.

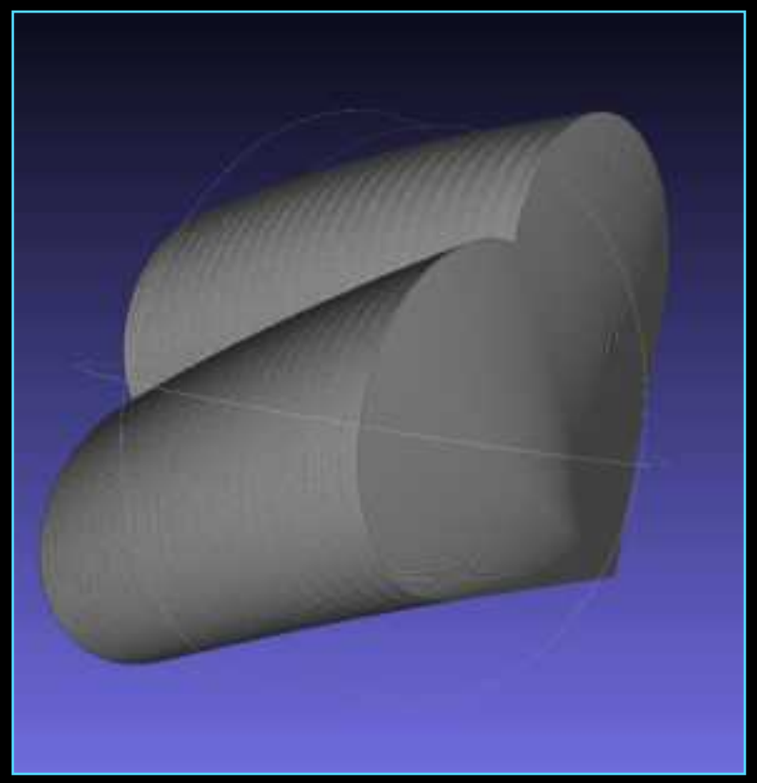
POINTS ARE CONVERTED INTO A SOLID OBJECT: MESHING

DESIGN SOFTWARE

MESHING







DESCRIBING THE OBJECT AS A POLYHEDRON WITH BOUNDING VERTICES (7852), EDGES, AND FACES (15700).

DESIGN SOFTWARE

IPHONE APP

123D SCULPT USES THE IPHONE TO DESIGN 3D OBJECTS WITH VERY LITTLE KNOWLEDGE. THIS PRINT WAS DESIGNED BY A THIRD GRADER.

DESIGN SOFTWARE

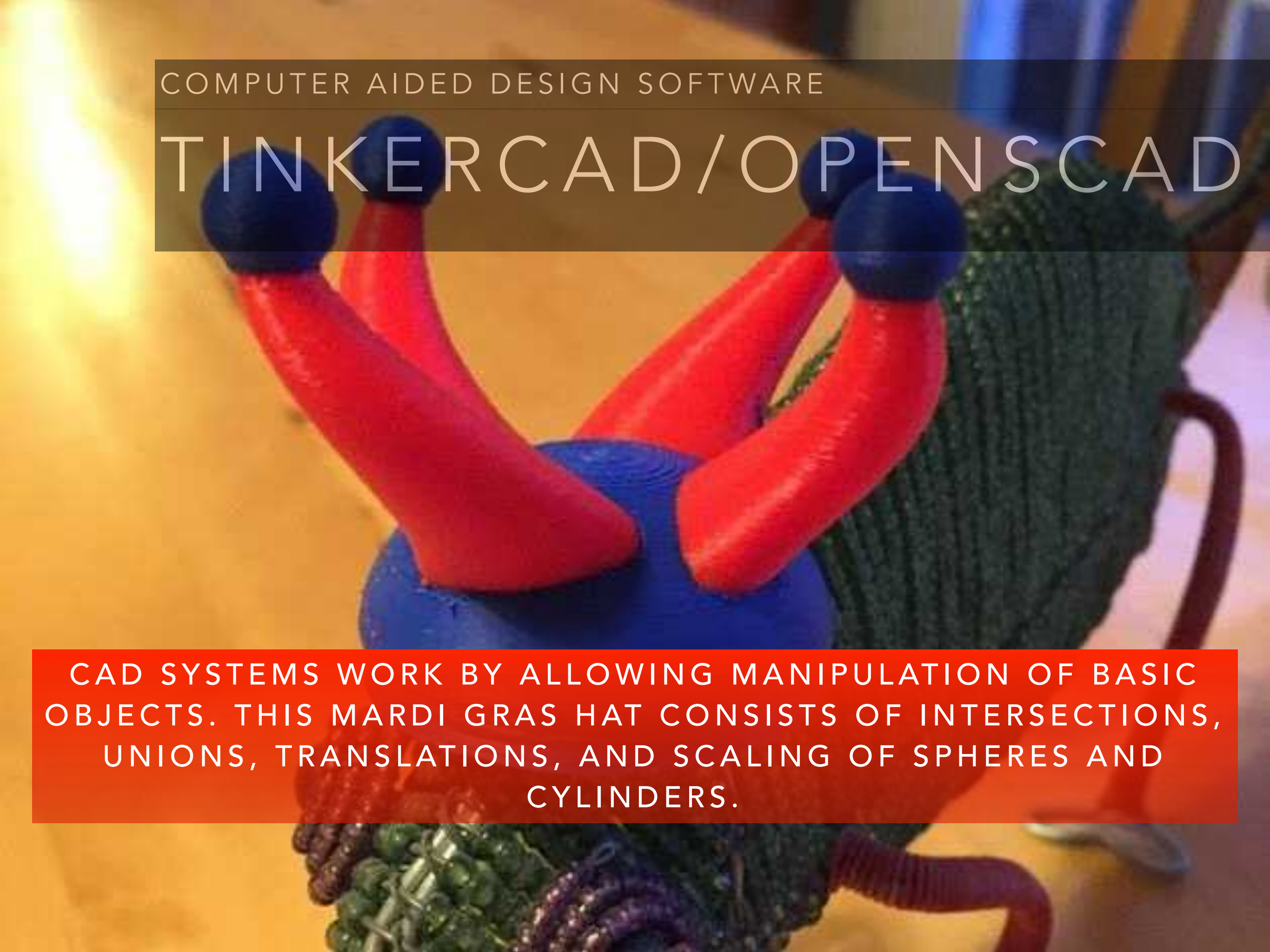
IPHONE APP

THIS PRINT WAS DESIGNED BY A SIXTH GRADER.

THE DOWNSIDE OF THIS METHOD: THE MODELER HAS LIMITED CONTROL OVER THE EXACT SPECIFICATIONS OF THE MODEL.

COMPUTER AIDED DESIGN SOFTWARE

TINKERCAD/OPENSCAD



CAD SYSTEMS WORK BY ALLOWING MANIPULATION OF BASIC OBJECTS. THIS MARDI GRAS HAT CONSISTS OF INTERSECTIONS, UNIONS, TRANSLATIONS, AND SCALING OF SPHERES AND CYLINDERS.

COMPUTER AIDED DESIGN SOFTWARE

TINKERCAD/OPENSCAD

PRINTS DESIGNED IN TINKERCAD BY MIDDLE SCHOOL GIRLS AT A 2015 GMU STEM SUMMER CAMP

FOCUS in STEM
STEM Accelerator Program
College of Science

F.O.C.U.S.

THE BUSINESS WOMEN'S GIVING CIRCLE
at the Community Foundation for Northern Virginia

“Learning STEM by Doing”-FOCUS 2015
75 participants, 20 counselors

COMPUTER AIDED DESIGN SOFTWARE

OPENSCAD

THIS HEART IS MADE USING A SQUARE AND TWO CIRCLES:

```
SQUARE(20);
TRANSLATE([10,20,0]) CIRCLE(10);
TRANSLATE([20,10,0]) CIRCLE(10);
```

COMPUTER AIDED DESIGN SOFTWARE

OPENSCAD

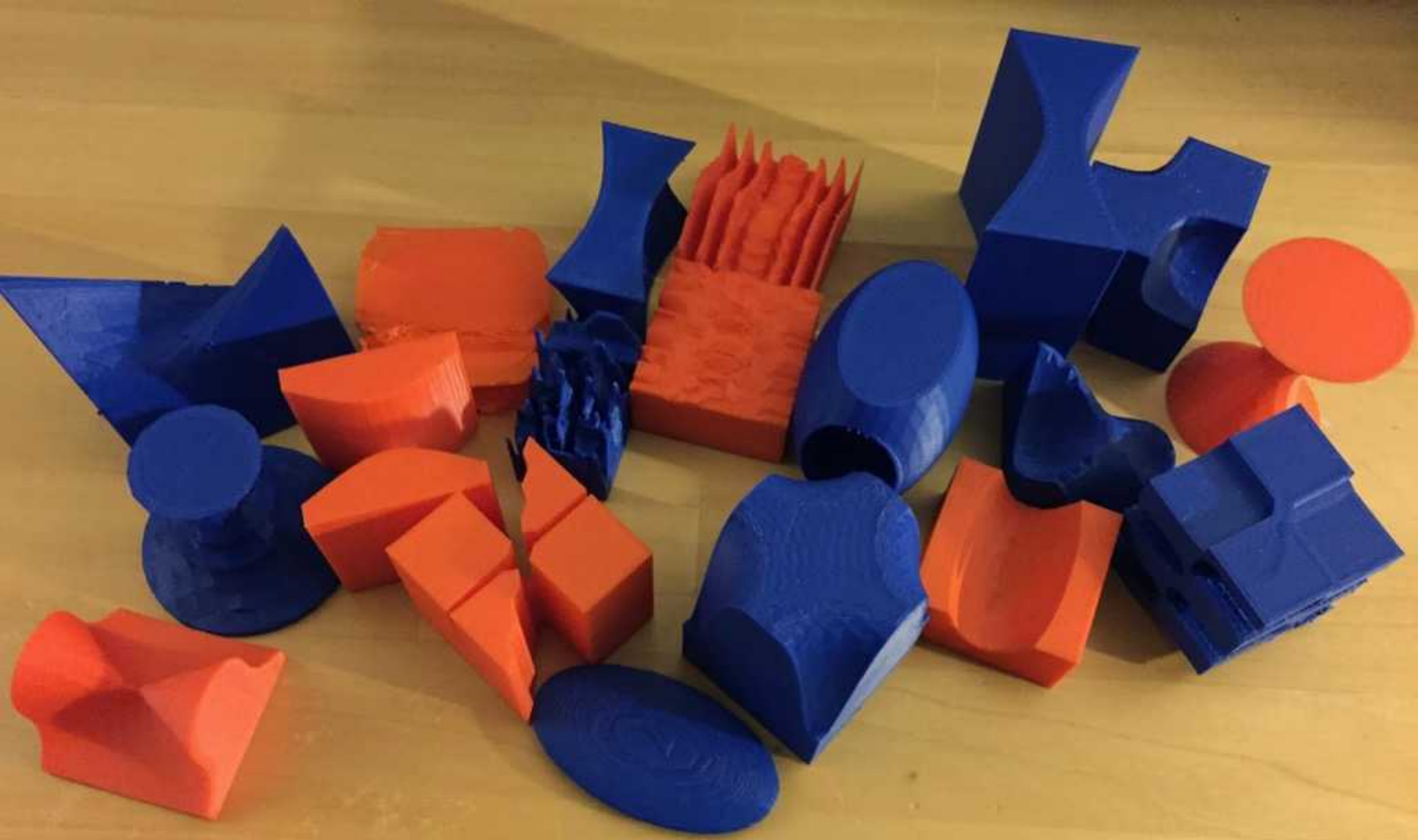
THIS SHAMROCK IS MADE BY COMBINING FOUR HEARTS:

```
HEART();
ROTATE([0,0,90]) HEART();
ROTATE([0,0,180]) HEART();
ROTATE([0,0,270]) HEART();
```

MATHEMATICAL SOFTWARE

MATHEMATICA

MATHEMATICA IS SPECIALLY DESIGNED FOR MATHEMATICAL MODELING. THIS ALLOWS FOR OBJECTS THAT COULD NOT EASILY BE MADE IN A CAD SYSTEM.



THESE PRINTS ARE CREATED IN MATHEMATICA
BY MULTIVARIABLE CALCULUS STUDENTS

MATHEMATICAL SOFTWARE

MATHEMATICA

MY GOAL IS TO BRING TO LIFE WHAT MATHEMATICIANS SEE IN THE MIND'S EYE

A CLASSIC CALCULUS QUESTION IS TO CALCULATE THE VOLUME OF A SPHERE WITH A CONE DRILLED OUT. IT IS HARD TO VISUALIZE, BUT HERE IT IS!

Mathematical saddle

Mathematical saddle: level sets

Ellipsoid

Ellipsoid: Different types of level sets

Monkey saddle: room for a monkey’s tail

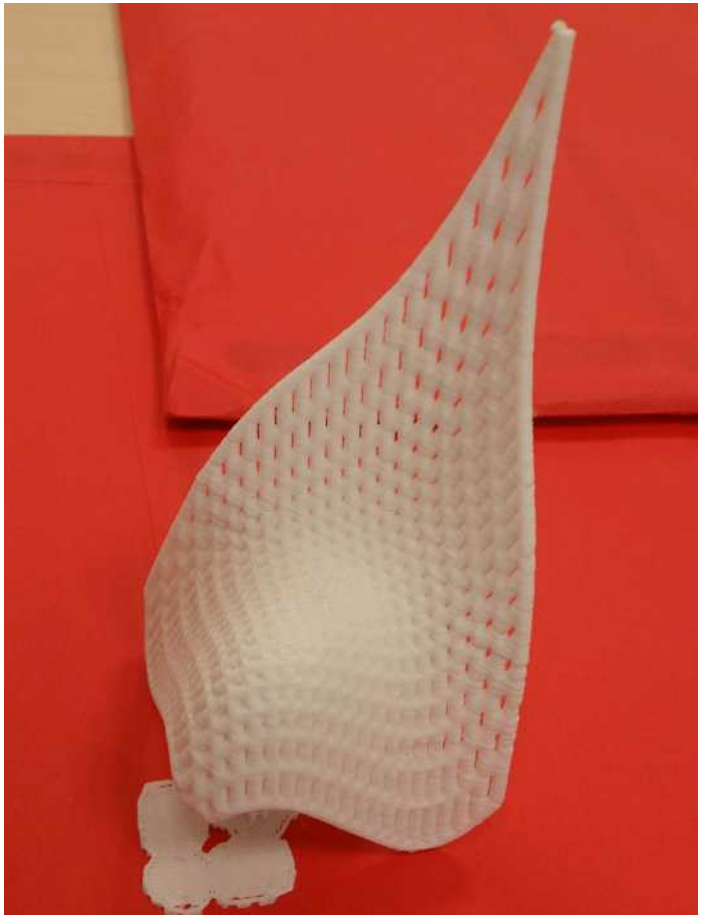
TORUS: ILLUSTRATION OF A MATHEMATICAL THEORY CALLED MORSE THEORY

A TRIANGULAR TORUS WITH TEN TWISTS AS IT WRAPS FOUR TIMES.

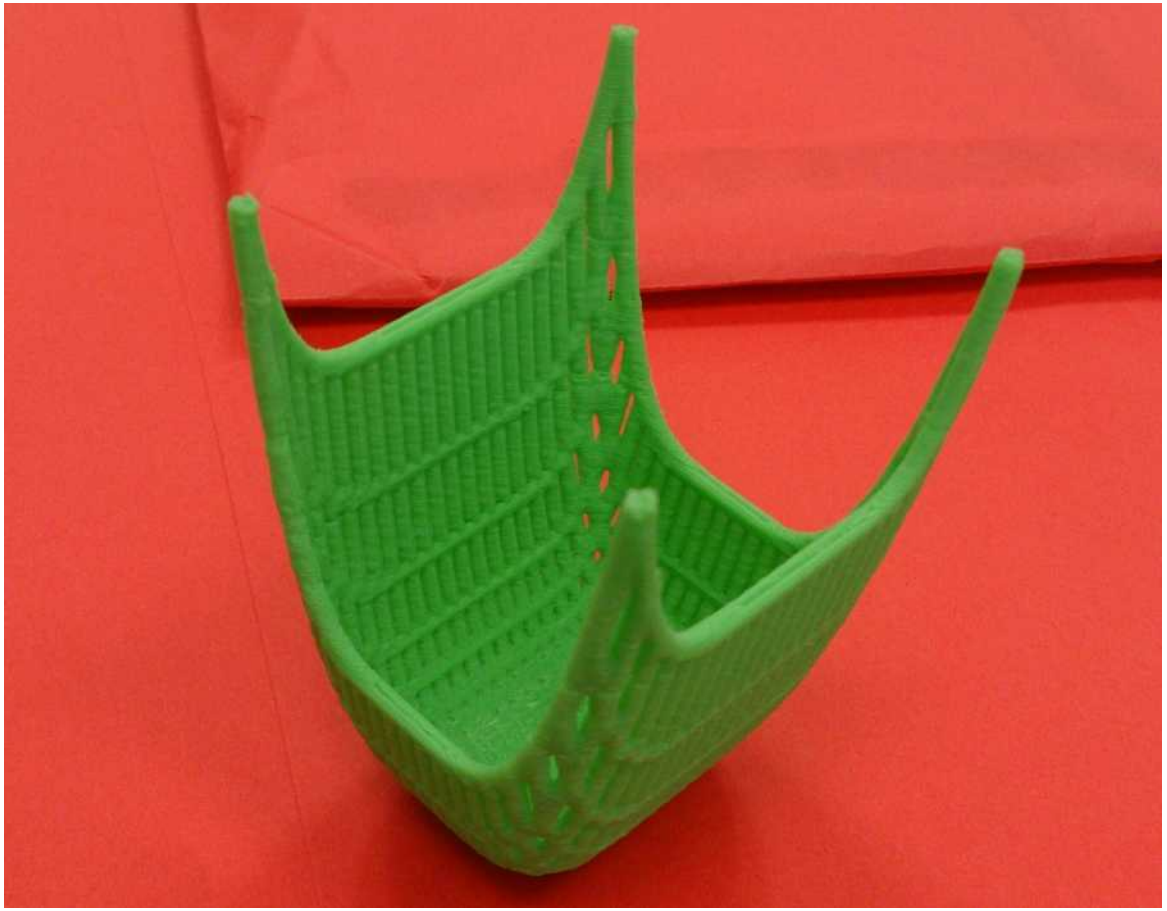

TWO MOBIUS STRIPS AT RIGHT ANGLES AT EVERY INTERSECTION POINT

FROM MY OWN RESEARCH:
MATERIALS SCIENCE MICROSTRUCTURES

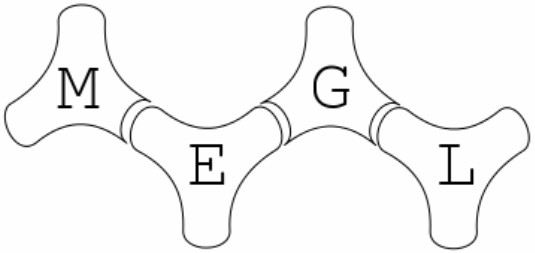
3D printing experiments in Calculus I



3D printing experiments in Calculus I



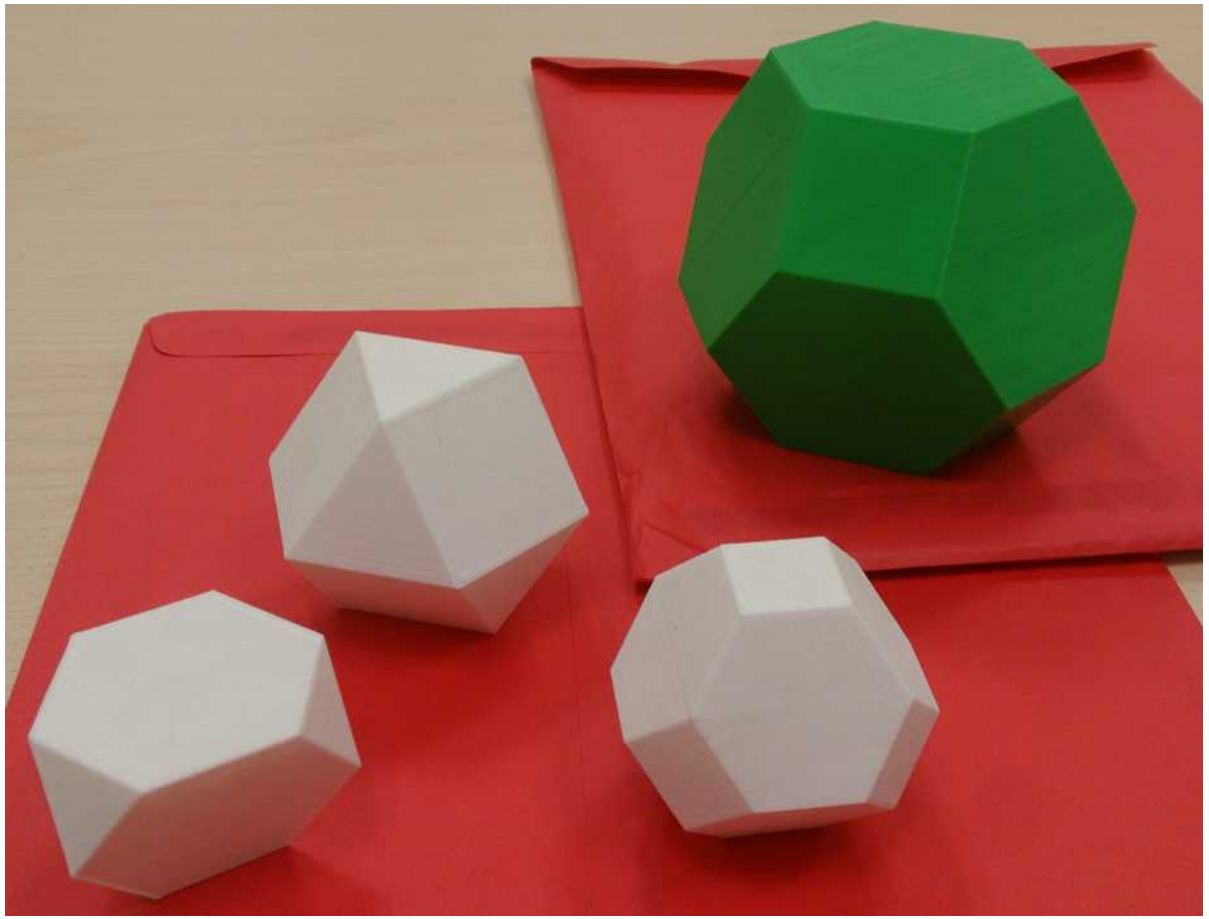
Mason Experimental Geometry Lab



Mason Experimental Geometry Lab

http://meglab.wikidot.com/visualization

Mason Experimental Geometry Lab



STILL LOOK IMPOSSIBLE?
HERE'S A STEP BY STEP GUIDE