
Raazesh Sainudiin
IN ORDER TO UNDERSTAND THE UNIVERSE YOU MUST KNOW THE LANGUAGE IN WHICH IT IS WRITTEN AND THAT LANGUAGE IS MATHEMATICS

- GIUSEPPE GALILEI
GOAL IN THE CLASSROOM

We need our students to UNDERSTAND CONCEPTS CLEARLY, Not just follow formulaic recipes
THE PROBLEM

• We have a limited time to cover a comprehensive syllabus to a large number of students

• Mathematics is a difficult language!

WE NEED TO COMMUNICATE BEYOND TRADITIONAL READ/WRITE METHODS BY USING MORE VISUAL, TACTILE & KINAESTHETIC STRATEGIES
Example: Hyperbolic Paraboloid

Traditional Read/Write: Formula

\[ \frac{z}{c} = \frac{y^2}{b^2} - \frac{x^2}{a^2}. \]

Visual: Image
THE SOLUTION –
GOING A STEP FURTHER

What if students could:

• **SEE** More
• **FEEL** More
• **DO** More

with the aid of Custom 3D-printed learning aids?
WHAT IS 3D PRINTING?

3D printers make manufacturing digital, personal and affordable.

www.ebay.com
3D-PRINTED LEARNING AIDS

EXAMPLES OF CALCULUS SURFACES

Credit: Henry Segerman

youtube.com/watch?v=10KjAi5eA1Q
HOW TO PRINT CUSTOM 3D OBJECTS FOR TUTORIAL PROBLEMS: JUST 3 STEPS

MATHEMATICAL CONCEPT $\rightarrow$ COMPUTER MODEL $\rightarrow$ 3D PRINTED AID

(a) A hyperbolic paraboloid, showing slices through the surface in the $x$ and $y$ directions.
(b) A hyperbolic paraboloid, showing level curves.
HOW TO PRINT CUSTOM 3D OBJECTS FOR TUTORIAL PROBLEMS: JUST 3 STEPS

MATHEMATICAL CONCEPT → COMPUTER MODEL → 3D PRINTED AID

12 lines of MATHEMATICA Code

STL file for printing

```
1 f[u_, v_] := {u, v, u^2 - v^2};
2 scale = 40;
3 radius = 0.75;
4 numPoints = 24;
5 gridSteps = 16;
6 curvesU = Table[scale*f[u, i], {i, -1, 1, 2/gridSteps}];
7 curvesV = Table[scale*f[j, v], {j, -1, 1, 2/gridSteps}];
8 tubesU = ParametricPlot3D[curvesU, {u, -1, 1}, PlotStyle -> Tube[
    radius, PlotPoints -> numPoints], PlotRange -> All];
9 tubesV = ParametricPlot3D[curvesV, {v, -1, 1}, PlotStyle -> Tube[
    radius, PlotPoints -> numPoints], PlotRange -> All];
10 corners = Graphics3D[Table[Sphere[scale*f[i, j], radius], {i, -1, 1, 2}, {j, -1, 1, 2}, PlotPoints -> numPoints];
11 output = Show[tubesU, tubesV, corners]
12 Export["MathematicaParametricSurface.stl", output]
```
HOW TO PRINT CUSTOM 3D OBJECTS FOR TUTORIAL PROBLEMS: JUST 3 STEPS

MATHEMATICAL CONCEPT $\rightarrow$ COMPUTER MODEL $\rightarrow$ 3D PRINTED AID

Figure 9: The 3D printed object.
3D-PRINTED LEARNING AIDS
Scaling to suit classroom and tutorial style learning

Credit: Henry Segerman
youtube.com/watch?v=LBiiOEiD3Yk
MORE EMTH CONCEPTS THAT CAN BE AUGMENTED WITH LEARNING AIDS

- 2D & 3D Integration
- Volumes of Rotation
- Line & Contour Integrals
- Polar & Spherical Coordinates
- Transformation of random vectors
- Tangent Planes
- Linear Independence
FEASIBILITY

• Use online services

Average Tutorial:
6 Problems
3 Parallel Sessions
Will need 18 Objects
Cost for this example
72 USD
FEASIBILITY

• Buy a designated printer for the school
  • Cost effective in the long run
  • More applications for
    • Honours courses

• Marketing/Outreach
MEASURING EFFICACY

• Solicit Direct Feedback from
  • Students on their learning experience in the Course Survey
  • Tutors on Student Engagement

• Compare student performance in examinations with historical records (SDB)
CONCLUSION

For conceptual clarity, there’s nothing better than being able to see, feel and manipulate a mathematical object with one’s bare hands!
REFERENCES


Thank you