

Tetrus Project

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I. Initial Task

The initial problem was to take a tetrus, and cut it up into four symmetrical parts. The cuts were to be made along each arm, achieving an interlocking design that would resemble a Ying-Yang on the inner part of each arm. The goal was to create a puzzle that would be both fun to put together



and also aesthetically pleasing to the eye, as the final version would be manufactured in four colors and so the arms spinning together and coming together in the middle would create an attractive interplay of color and shape. The above figure is a preliminary example of what the goal was, although it underwent several changes throughout the process.



II. Design

I started out by creating a clay model, hoping to gain some insight into the line along which I would have to cut to create the model as desired. I started out by creating the four arms as seen at left, each in a

different color to simplify the distinction between each symmetric arm of the final model. The idea had been to mold the arms together into the tetrus shape and then cut them apart and bake them, verifying that they can be snapped together without coming apart.

However, there were inherent problems with the medium, limiting the helpfulness of the clay model. It was too pliable in its original state, resulting in arms that were all bent out of shape and in no way resembling the shape of a tetrus. As a result of this, I re-molded the shape and baked it, hoping to cut it apart once hardened.



Unfortunately, it turned out to be too hard to cut in its final state. In the end, though, modeling the tetrus in clay was not a total waste of time as it did help me approximate the cutting line along the arms of the tetrus, which helped with the decisions I had to make when modeling the shape of the cut on the computer.

The next step was to take a 3D representation of the tetrus in Maya and cut it up appropriately. I started out by simply trying to model a curve along similar lines to those



of the clay model. I quickly abandoned this idea, however, because the goal was to get four arms that were identical, and I was not certain enough of my ability to create a completely symmetrical curve. Wanting to find a logical curve along which to design my cutting plane, I decided to pick the

points at the middle of two adjacent arm “pits” and connect them, making the connection go through the middle of the arm at the midpoint between those two points. I then

extruded that curve into a NURBS surface, and rotated the middle hull 90 degrees and one of the edge hulls 180 degrees, resulting in a smooth curve that cut up the arm symmetrically.

Although this design was very aesthetically (and intellectually) pleasing, it yielded poor results—the arms did not snap or twist together sufficiently, and so the tetrus hung together only loosely when the arms were put together (see last picture on previous page).



The next thing I decided to try was to take a point on either side of a tetrus branch, on the outside of different sides of an arm “pit”, connecting them in the same manner as above, extruding a surface and rotating its hulls to -30, 90, and 210



respectively for the rightmost, middle and leftmost hulls. When manufactured, however, it became apparent that the arms could not fit together without being filed down heavily, and therefore had to be corrected as well. After filing down the arms enough to permit them to interlock with

relative ease, it became apparent how the curve needed to be modified.

The final version I manufactured ended up being a slight change of the previous curve, altering it to move across the inside of the arm in a monotonically increasing manner with reference to its y-coordinates as opposed to moving “up” and then “down”, resulting in arms that could not interlock well. The arms of the new design fit together

smoothly and would hopefully also preserve enough interlock to make sure that the tetrus would not fall apart when put together.

III. Problems

I encountered problems of two types: problems of design and problems with the tools I was using.

The design problems were somewhat predictable—parts I manufactured ended up either not quite having a snap or not being interlockable due to the curve dipping slightly too far on the inner arm, making any attempt to snap the arms into place unsuccessful. Other parts ended up being held together too loosely, and while they came together easily, they fell apart just as easily. At one point, I even attempted a design where the each arm was shaped like a wedge at the end, and came about, as it got closer to the top of the arm, into a V shape (see Figure 3).

Additionally, although I had wanted to create a perfectly mathematically logical curve and cutting plane, in the end I had to settle for tweaking the plane into place so that the resulting arms would look “correct” as opposed to having a perfect cutting plane.

The main problems, however, were the tools. It seems that there is not just one 3D modeling suite that I had access to that could do everything I needed to do. I had to design the cutting plane in Maya (mostly because I knew best how to use Maya—I am sure Lightwave has the same capabilities in terms of NURBS modeling as Maya, but I had never used it before and did not think it would be a wise use of my time to learn it thoroughly enough), export the tetrus and the cutting plane into Lightwave, cut the tetrus, and return it to Maya for further modification (cleaning up the geometry, etc). After that, I found out that Maya could not export to the STL file format, so I had to locate another piece of software to do that. It turned out that Rhinoceros had this capability (however, it did not have the capability to perform Boolean operations on polygon meshes).

Thus, a huge chunk of my time working on the project was spent coaxing the tools into doing what I needed them to do, finding the tools for the job and figuring out how to use them, as opposed to doing the actual work per se.

IV. Conclusions

Looking back at the project, I could have avoided a lot of needless work had I started out with a clear idea of the limitations of my tools, and which tools could provide which functions. Although I had thought I had a fair grasp of Maya, I learned, to my disappointment, that bugs which I had not before suspected will pop up in the worst places (its lack of ability to do Boolean operations properly, for example). It is not quite the Swiss Army knife of the 3D world that I had previously imagined it to be.

It turned out that my task was much more than just deciding how to cut up the arms of a 3D object—I had to adapt my tools, research new ones and learn how to use them at least enough to perform the actions I needed to perform. In the end, although the resulting tetrus puzzle is a fun distraction, the important part of the project is what I learned of working on a design project of this type, how to meet the engineering challenges involved, and how to not throw in the towel, but rather keep finding tools that will allow me to do exactly what I need.

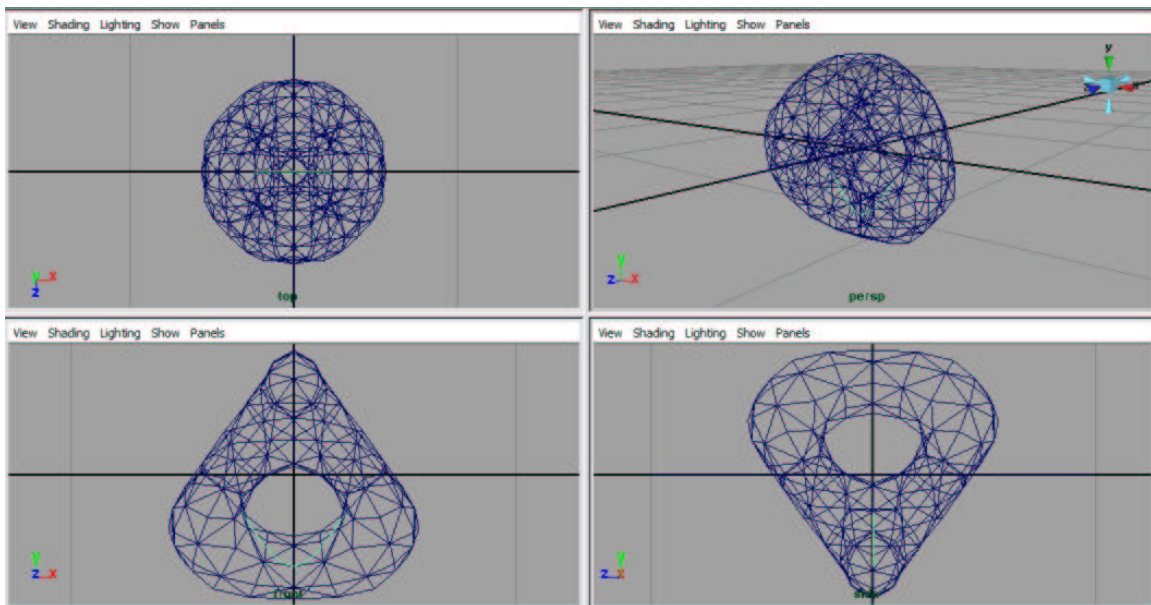


Figure 1: The curve along which I extruded the plane is highlighted in light blue.

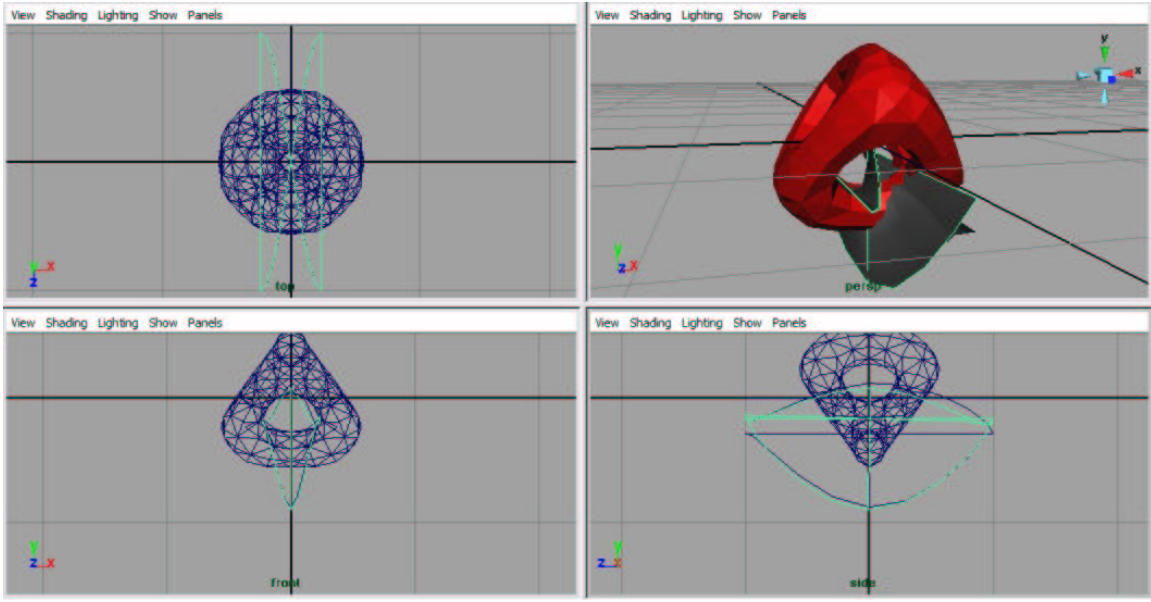


Figure 2: The initial cutting plane

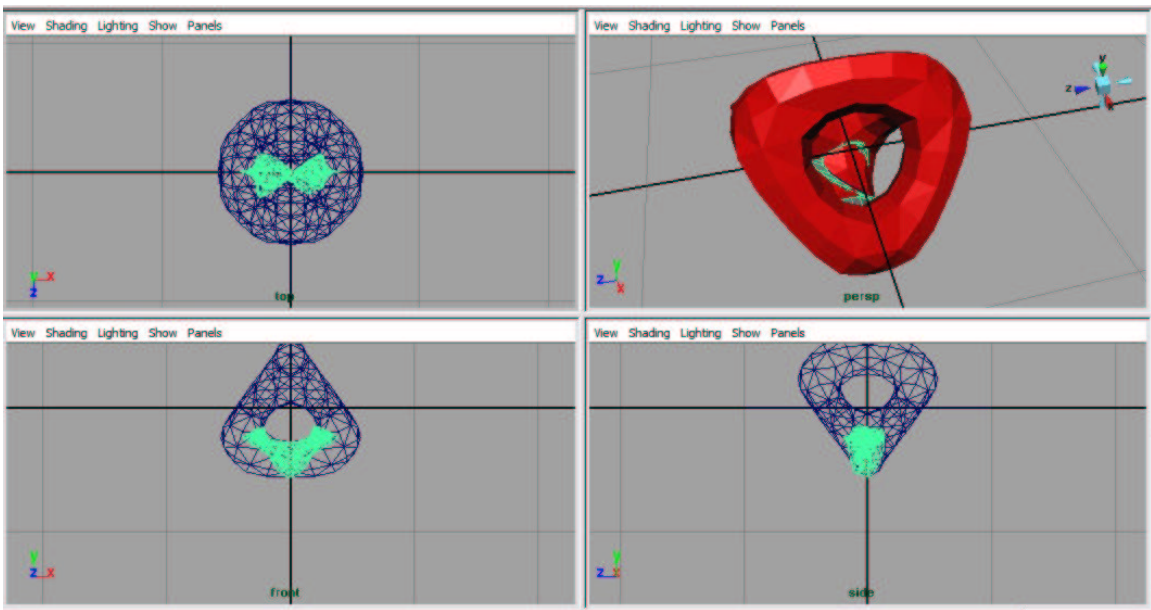


Figure 3: A failed wedge-shaped arm design

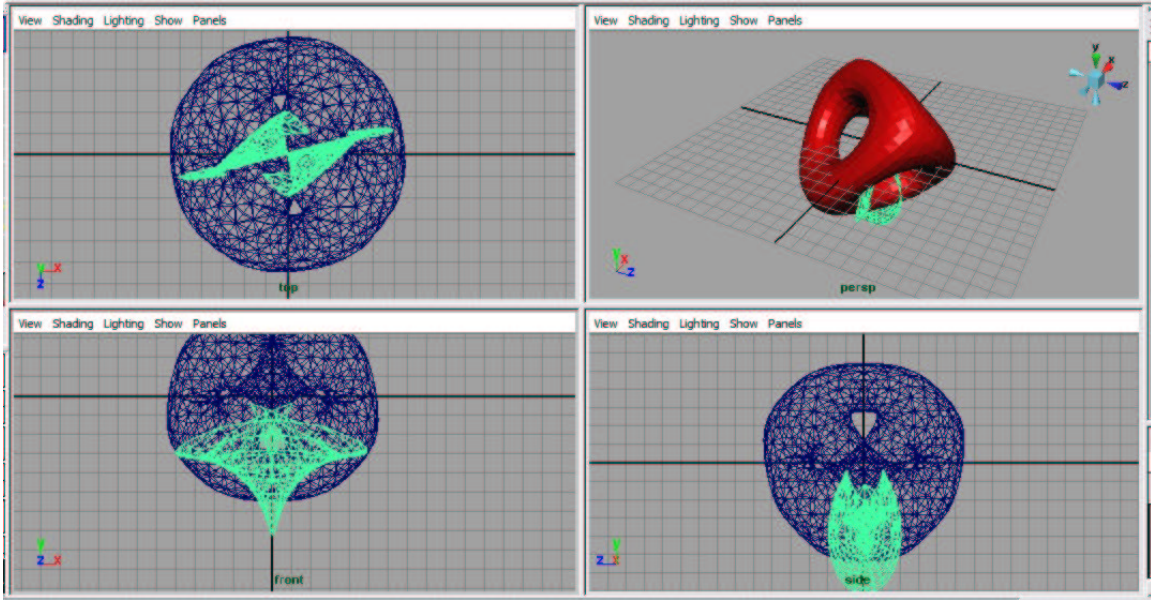


Figure 4: The final cutting plane.

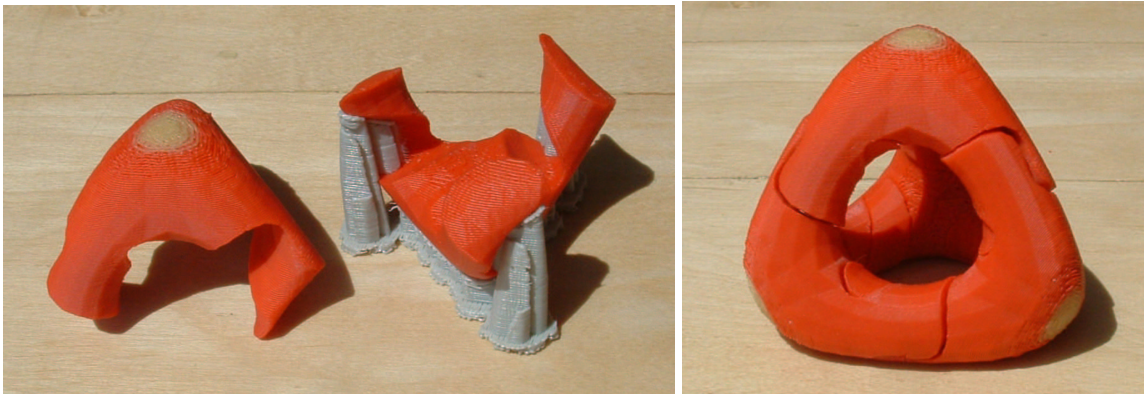


Figure 5: The final built model.