

Lattice Lamp

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ME227 S26



Interpretation of the Prompt

Prompt:

- Design an assembly using software tools like shape optimization, generative design, or latticing to improve strength to weight ratio and demonstrate functionality through physical prints without sacrificing performance.

Interpretation:

- Since generative design was new and interesting to me, I wanted to take advantage of it in an effective way to create something I've been meaning to make: a bedside mood lamp.

Objective:

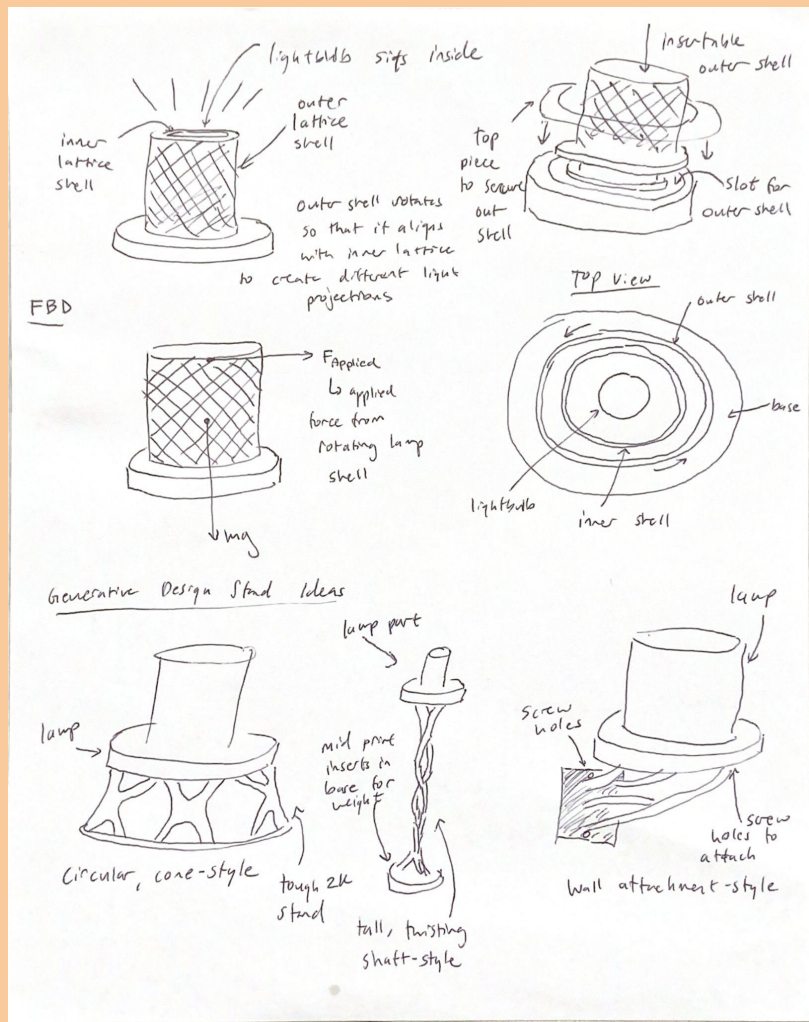
- Create a bedside mood lamp that utilizes latticing and generative design to improve strength to weight ratio and performance.
- The user is someone who needs light projected in a calming manner near their bedside.



Concept Sketches

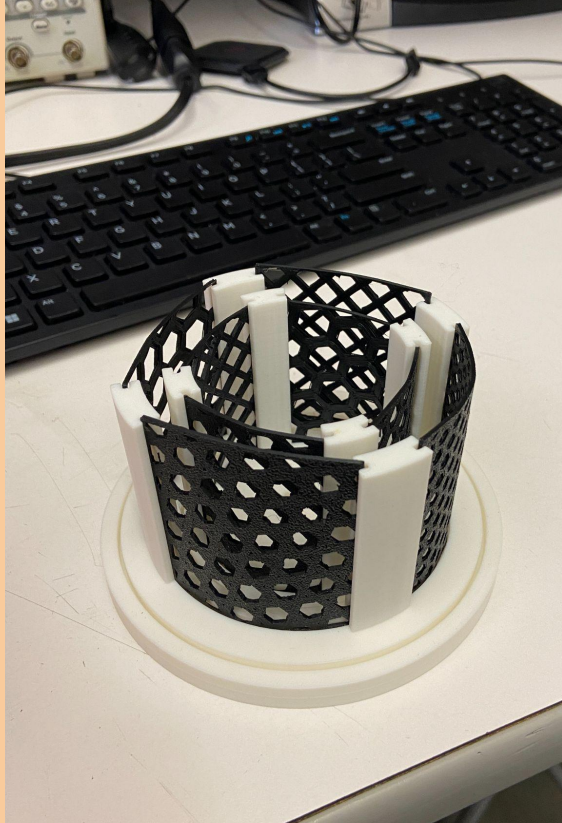
Sketch Contexts:

- Main design is a bedside lamp with rotating lattice shells that project the light in different patterns
- Lattices are used to improve performance of the light project from the lightbulb
- Generative design is used to improve weight-strength ratio of the stand used to support the lamp
- Main mechanism for rotating the shells of the lamp is to have a slot that the outer shell is inserted into and can slide around from force applied against PLA to PLA friction.
- Main forces are the weight of the lamp and finger/hand force applied by a user to rotate the outer shell of the lamp.
- Multiple generative design stands were sketched initially, but the wall attachment design was chosen due to having more meaningful constraint and load cases. This case would use command strips to attach to a wall.



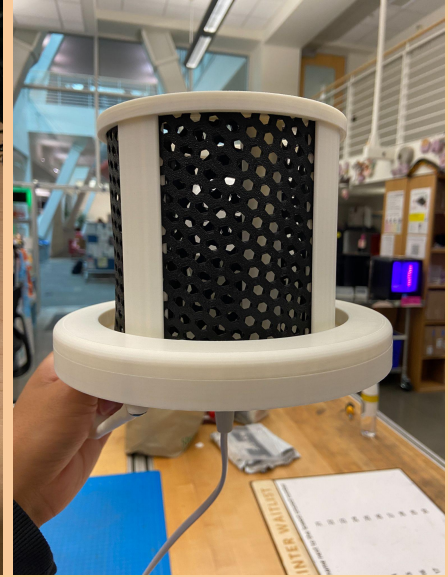
Prototypes and Test Prints

Lamp Test Print Prototype



To test the functionality of my rotating shell mechanism, I did a test print to test tolerances of the shell slot and the lattice panel slots. The print was done at 2x scaled down to save cost and time. From this, I found that my slot tolerances worked well, but the outer panels did not curve well, thus requiring a different solution.

Generative Design Test Print

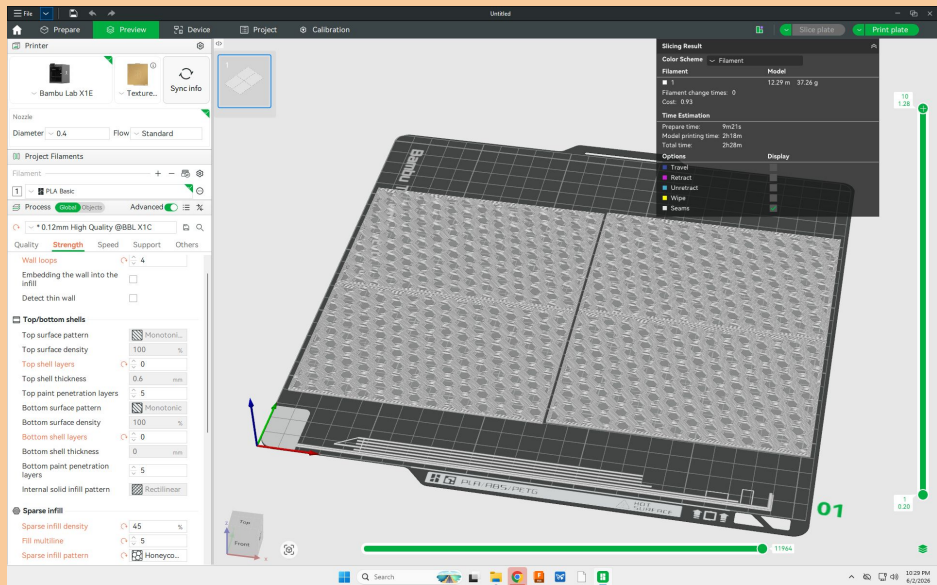


After discovering which generative design was most effective and worked the best with the rest of my assembly, I did a test print in PLA to see if it assembled well with the rest of my lamp. The PLA fixture was stronger than expected as it could support the weight of the lamp, confirming the strength of the design

Thermoforming Shell Panels

After my initial prototype test print, I discovered that the panels were hard to curve, so I considered using TPU instead of PLA. However, I discovered thermoforming online and decided to attempt this method to save costs.

Panel Slicer Settings



I used Bambu Studio to create the lattice with the following slicer settings:

- 4 wall loops, 0 top and bottom layers, 45% infill, 5 fill multiline, honeycomb sparse infill pattern

Heat Gun Thermoforming



- After printing, I used a heat gun to warm the panels to a deformable temperature
- Once deformable, I used a bottom to create a more uniform curve

Material Analysis

Lamp:

- Chosen material: **PLA**
- Reasoning:
 - Low cost - under \$3 prints were free at AMPS
 - Thermoplastic allowed for thermoforming of the shell panels
 - Faster printing time than resin and other thermoplastic materials
 - Lamp assembly comprised of many different parts



PLA allows for easy thermoforming



Both materials chose for cheaper costs as my class budget was running out

Stand:

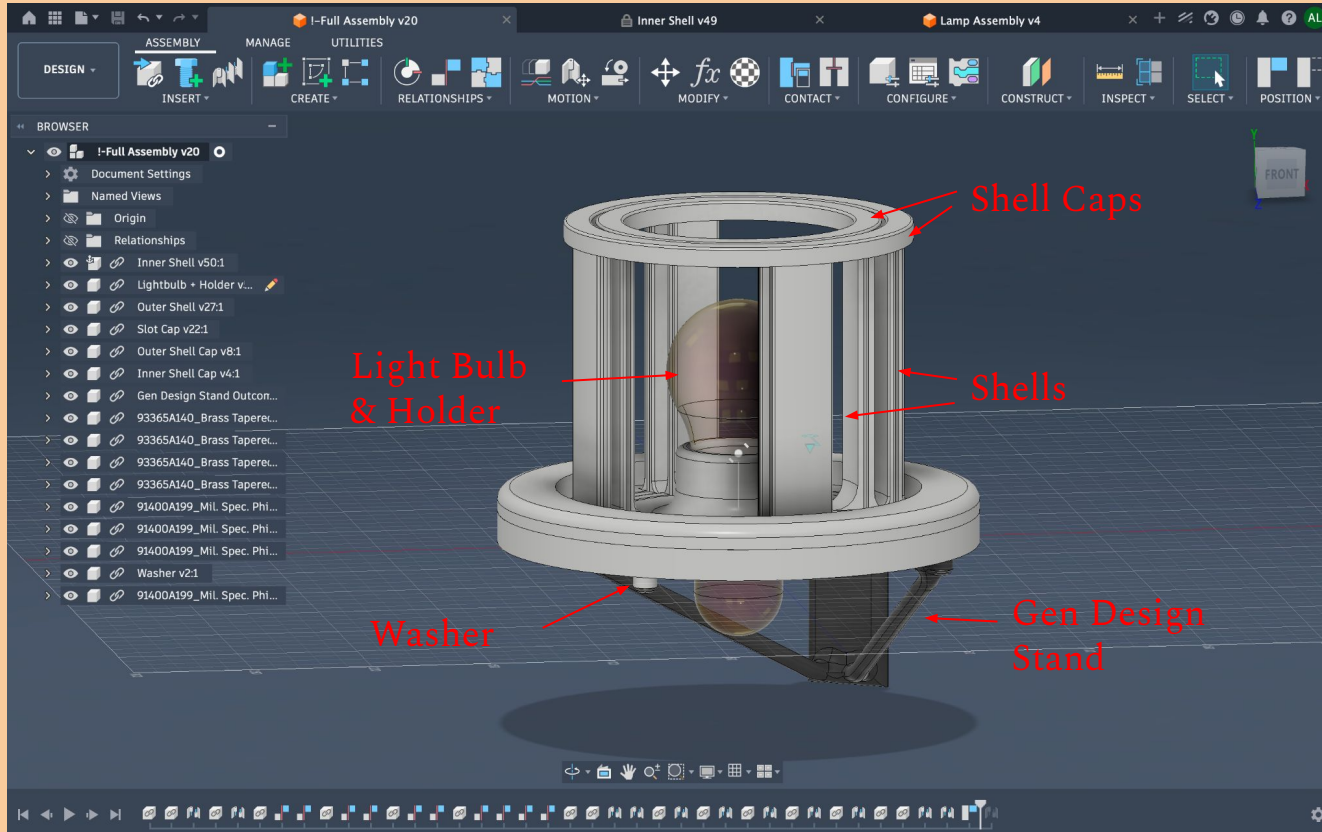
- Chosen material: **Tough 2000 Resin**
- Reasoning:
 - 2nd cheapest cost out of PRL resin materials (\$0.21/mL)
 - High stiffness, superior creep resistance
 - Best out of Tough Resin materials for load-bearing fixtures



Tough 2000 used in various load-bearing applications

CAD Screenshots

Full Assembly CAD

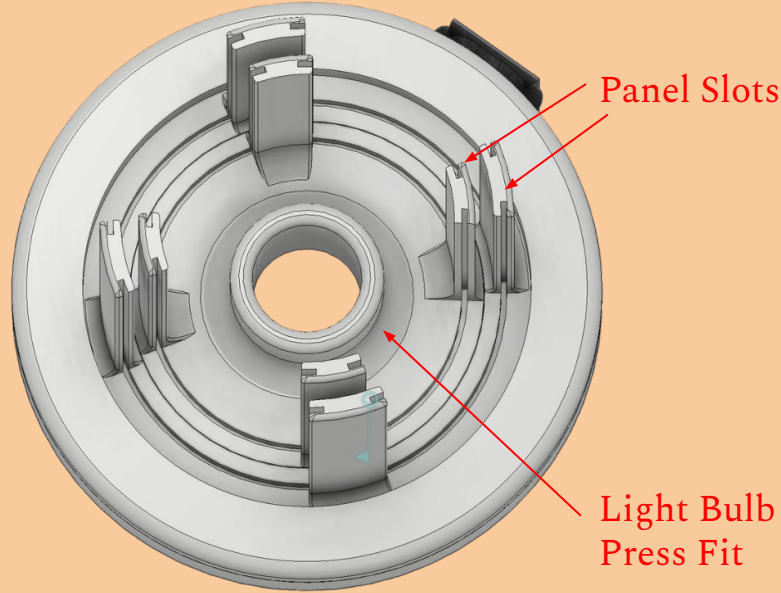


My full assembly CAD features:

- Inner and outer shells
- Inner and outer shell caps
- Generative design stand
- Modeled light bulb and holder based on caliper measurements
- Screws and heat set inserts
- Shell Cap
- Panels were left out due to latticing made in Bambu
- Washer for front screw
- Outer shell features a revolute joint

CAD Screenshots

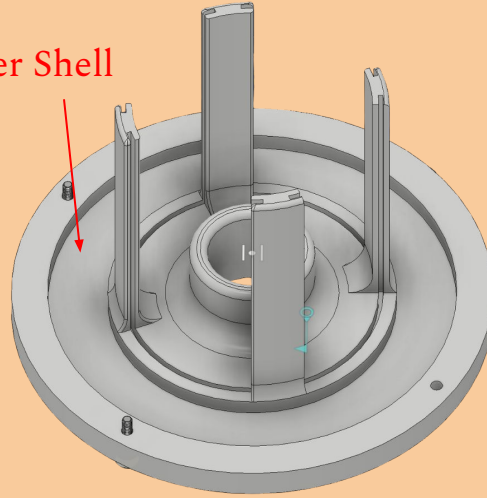
*Panel Slots &
Light Bulb Press Fit*



The inner and outer shells features friction fit slots for the lattice panels. Each shell has a top cap that is also friction fit to keep panels in place. The lightbulb in its holder is press fit within the center hole.

Shell Slot

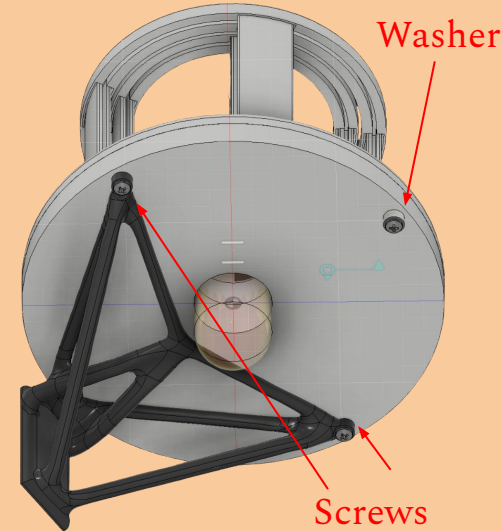
*Outer Shell
Slot*



The inner shell serves as the base with a slot to allow the outer shell to sit within and rotate. This is held together by a shell cap with heat set inserts for screws.

The bottom of the inner shell has holes for screws that allow the stand to be fixed to the lamp. The front hole features a washer to keep all screw lengths equal. The light bulb holder goes all the way through to allow the power cord to be connected.

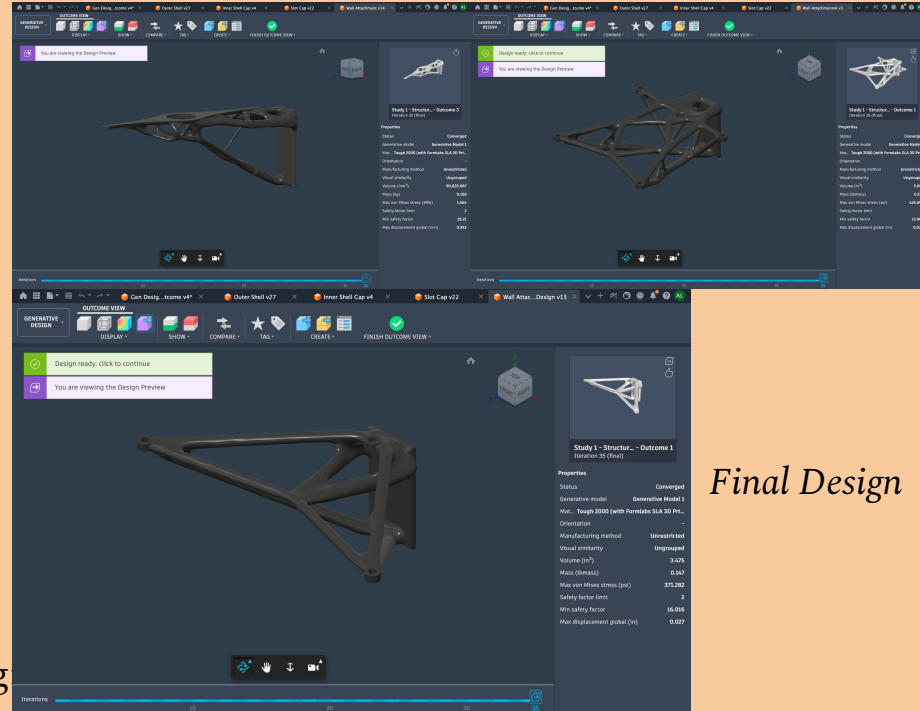
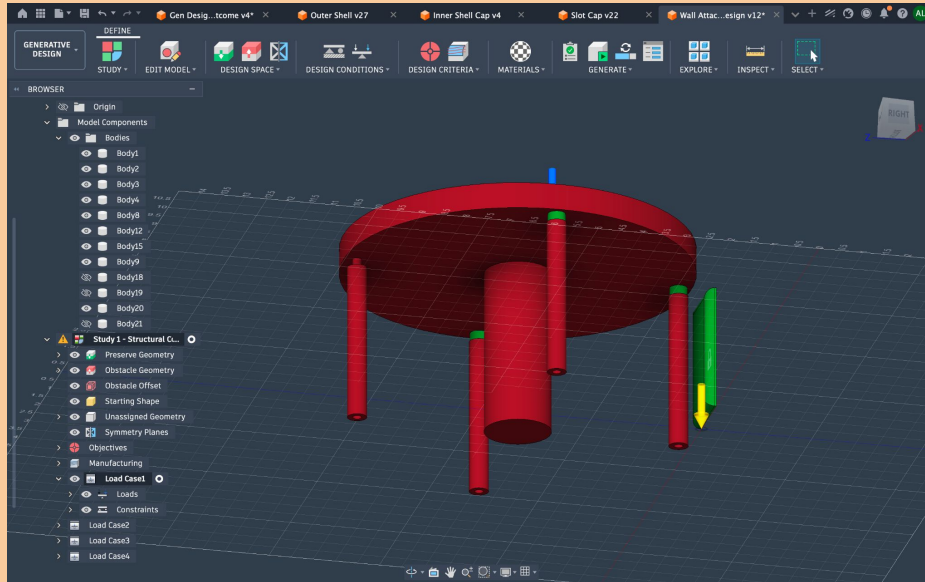
Stand Fixture



Generative Design Study

Generative Design Setup

Previous Iterations

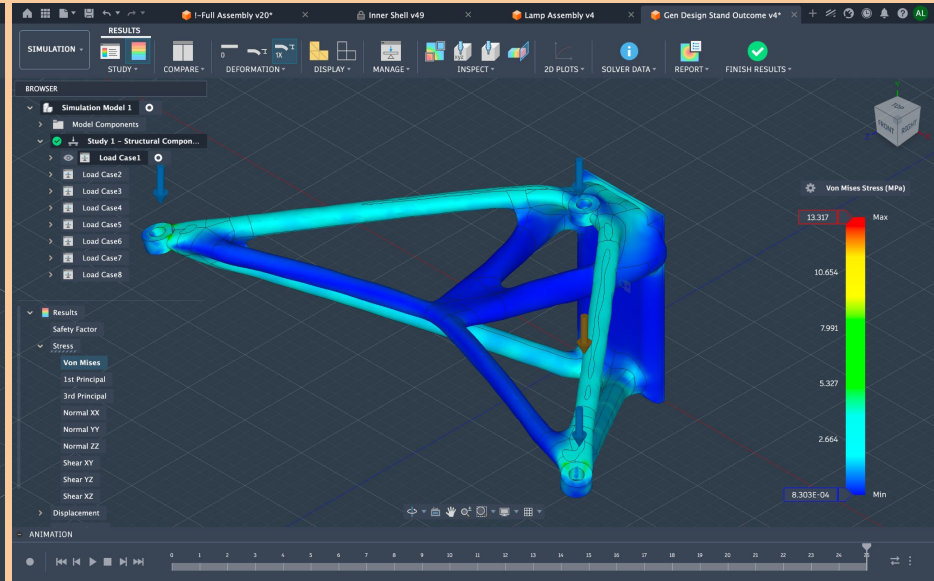
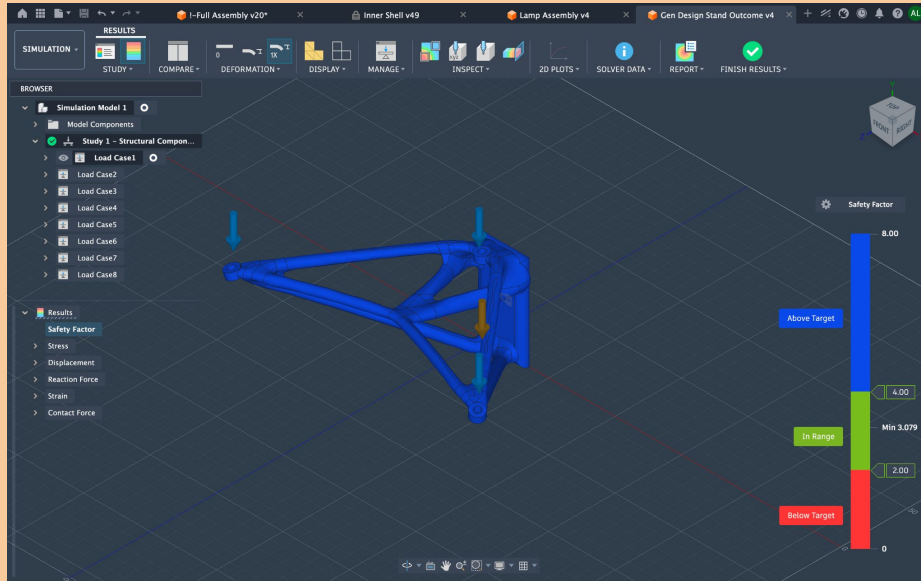


The final generative design setup featured the following

- **Preserve Regions:** 3 screw holes to attach to the lamp, 1 wall attachment base plate for command strips
- **Obstacle Regions:** Screwdriver & screw clearance, lamp bottom base, light bulb holder clearance

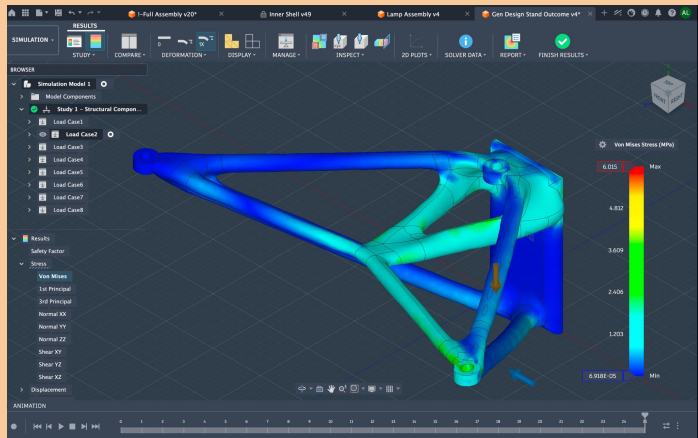
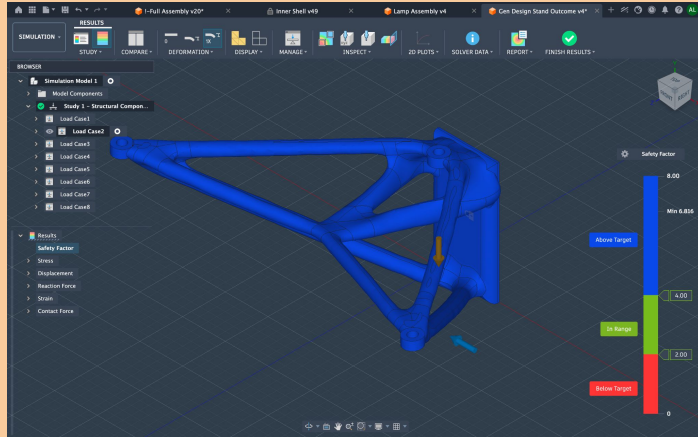
Multiple iterations of the stand were created, testing different preserve geometries. The final design was chosen based on cost, printability, and verified strength.

Simulation Results

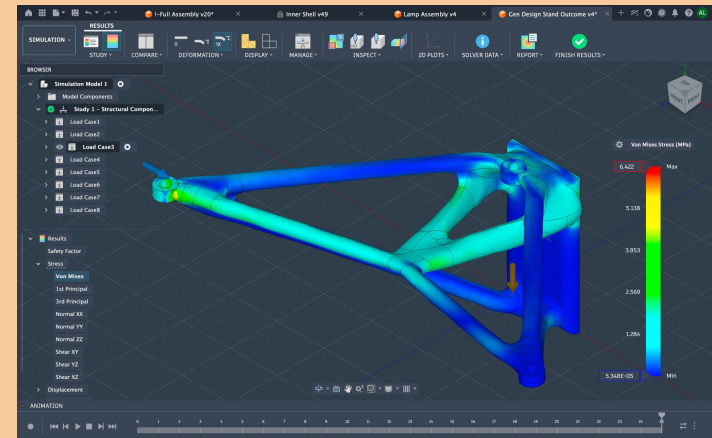
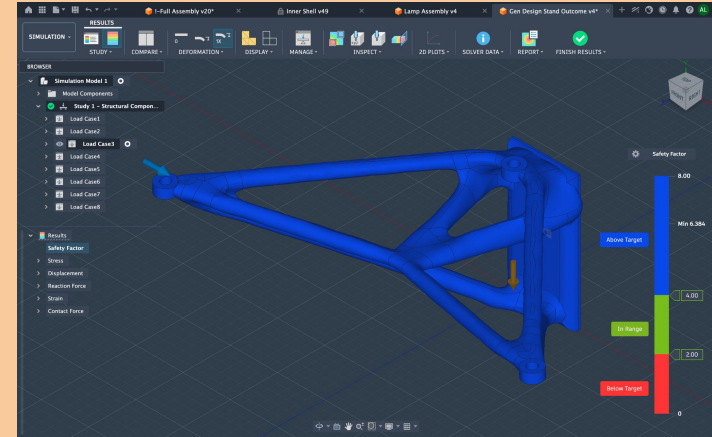


For my simulation and load cases, I tested the generative design stand that would be attached to a wall using two command strips. To define my loads, I based them off the stated weight that command strips can supports, which is 3lbs per strip, thus 6 lbs total. As a result, I made my load cases as 8 lbs to ensure that the command strips would fail before the stand fails. My main load case I wanted to verify was 8 lb force in the -Y direction, simulating if someone was pulling the lamp down or if the cord of the lamp was being pulled from the bottom. The simulation demonstrates a high safety factor, with evenly distributed stresses along the body of the stand, suggested that the generative design outcome was successful in supporting the load cases given.

Simulation Results

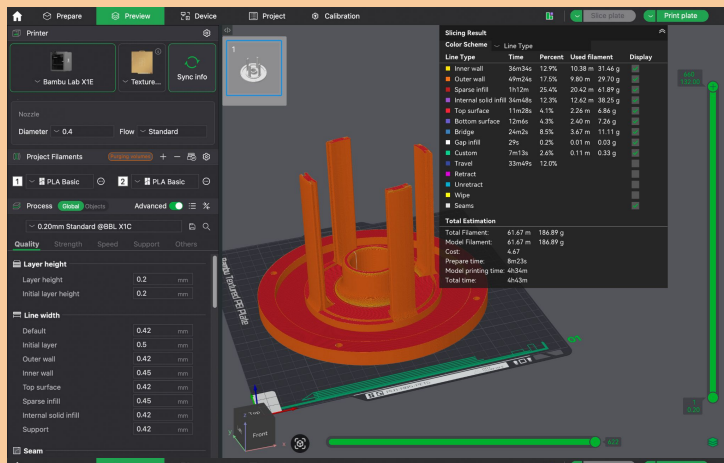


I also created load cases to simulate accidental applied forces in all different directions (+X, -X, +Z, -Z, +Y). This would be situations where someone ran into the lamp with their head or smacked the lamp from the side. Again, I used 8 lb force for my load cases to ensure the command strips would fail before the lamp stand would fail. All cases demonstrated safety factors above the minimum target of 2.

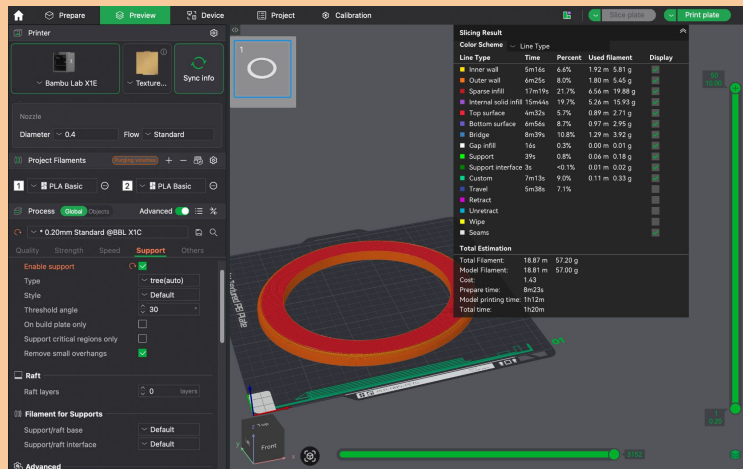


Slicer Screenshots

Inner
Shell
Print



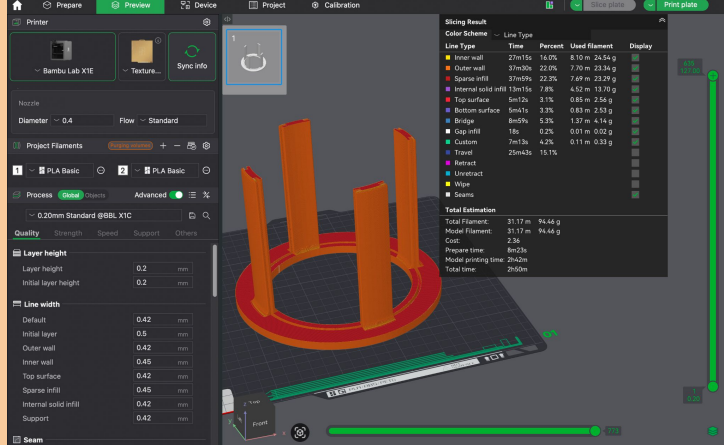
Slot
Cap
Print



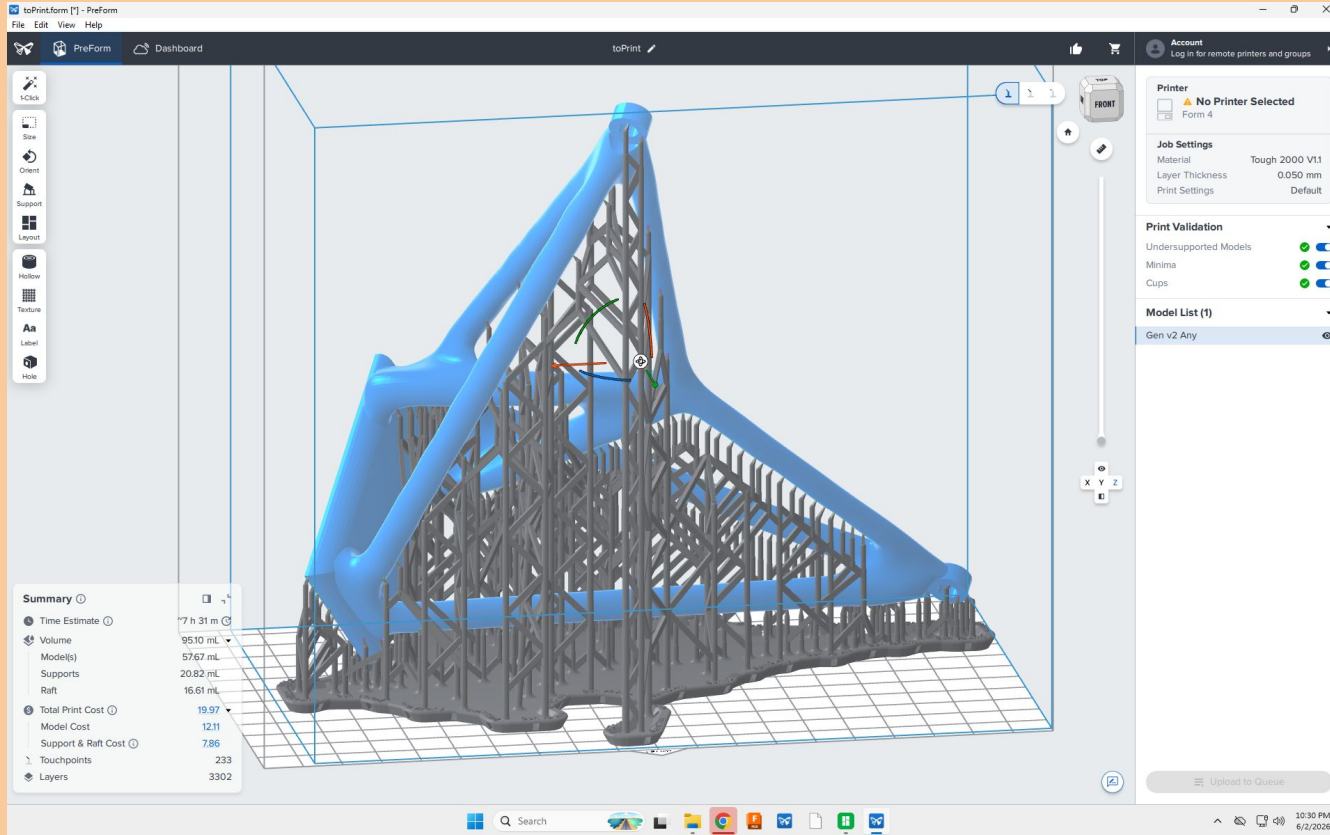
Bambu Slicer Settings:

- Used Bambu Lab X1E printer
- White PLA used for everything except lattice panels, which were black
- Default settings used for everything
- All PLA prints designs for minimal supports needed
- Only Inner Shell was over \$3, costing \$4.67 total for all PLA prints

Outer
Shell
Print



Slicer Screenshots



Formlabs Slicer Settings:

- Used Formlabs Form 4 with Tough 2000 resin
- Auto-orient used
- Auto supports enabled
- ~8h total print time
- ~0.5h post-processing time
- Cost of \$19.97
- Only the generative design stand was printed in resin, everything else was PLA

Lamp Assembly Process

1.

Light bulb holder press fit into inner shell



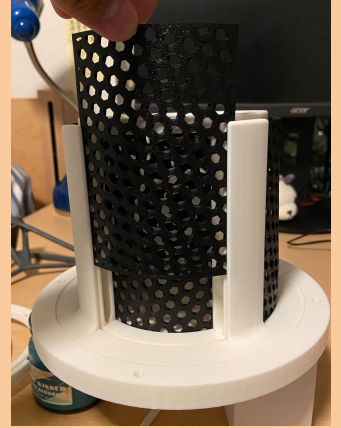
2.

Outer shell placed within inner shell slot



3.

Lattice panels slotted into outer and inner shells



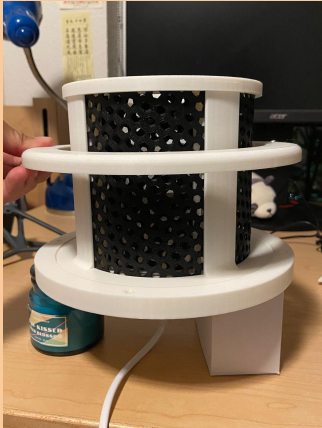
4.

Outer and inner shell caps placed on top



5.

Slot cap placed on top of outer shell



6.

Lamp screwed into stand using through hole screws fixed into heat set inserts in cap



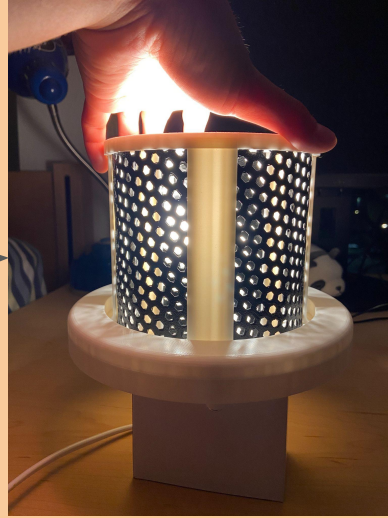
Performance Analysis

Results:

- Lamp features lattice panels that project light in unique manner
- Outer shell freely rotates within lamp to project light in different directions
- Generative design stands securely supports lamp on the wall with use of command strips
- Light bulb holder is securely press fit within lamp center

Future changes:

- Create interchangeable panel patterns to allow for different light projects
- Create another generative design stand that allow for resting on table top



Final Result

*Rotating
Lamp
CCW*

Reflection

Takeaways:

- Project was well-scoped, features an interesting way to use latticing while also taking advantage of generative design's capability to improve weight-strength ratio
- Generative design is a great tool, it can still create a viable outcome with minimal inputs as long as they're defined robustly
- Having a solid CAD model allow for things to run easier during production

Total Time & Budget

Time:

- Ideation/Sketching/CADing: ~ 20 hours
- Printing/Testing: ~ 20 hours
- Total: ~ 40 hours

Budget:

- PLA: \$4.67
- Tough 2000: \$19.97
- Screws & Heat Set Inserts: \$1.32
- Light Bulb & Holder: \$10 (from Amazon)
- Total: \$35.96 (\$25.96 from PTA)



Cumulative Budget

Project 1:

- PLA: \$0 (all prints under \$3)
- Magnets: \$0.75 (15 total)
- Key ring: \$0 (from personal inventory)
- Total: \$0.75

Project 2:

- \$139.17 / 3 team members = \$46.39

Project 3:

- PLA: \$4.67
- Tough 2000: \$19.97
- Screws & Heat Set Inserts: \$1.32
- Light Bulb & Holder: \$10 (from Amazon)
- Total: \$35.96 (\$25.96 from PTA)

Running Total from PTA: \$73.1

Although I was over class budget, I talked with other classmates under budget who were fortunately willing to cover the costs for me.

