

Pet Cleanup Project

Technical Design Review

Group C

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Technical Design Review

1. Prototype Design

Based on user needs defined in the Problem Definition Review [1], the group designed and fabricated a prototype (Appendix A, Figure A1) described in the Conceptual Design Review [2]. This prototype features unique biomimetic bristles (Appendix A, Figure A2) modeled after the papillae found on cat tongues and a hinge that allows the brush to better conform to a pet's body. Construction of the prototype is discussed in the Detailed Design Review [3].

2. Verification Results

After constructing a functioning prototype of the pet brush, the group conducted tests to determine its efficacy. Based on user needs established in the Problem Definition Review [1], a testing scorecard was included with the Conceptual Design Review [2]. Final scores are presented in Appendix B. Based on the tests defined there, the group conducted initial testing with several pets. The results of the first tests were presented in the Preliminary Verification presentation [4].

Tests were conducted as prescribed by the CDR [2]. After brushing a pet for some time, the time it took to clean out the brush was measured. For many brushes, this can be frustrating due to the tendency of pet hair to become entangled or trapped in the brush. It was found that this brush design is not as susceptible to tangles and hair is readily removable. As such, a score of 5 was assigned in this category.

The brush's mass contributes to its ease of use - a heavy brush will not be as easy or comfortable for a pet. In part because of the initial intention to use steel bolts to fasten the brush's hinge together, this was initially a concern. With the zip-tie based hinge, however, it is comfortable to use and its mass is well below the target set. The zip ties add a negligible amount of mass. As such, mass was estimated using CAD models at 0.21 lbs (95 grams) [5]. As such, one point was assigned in this category. Due to challenges sourcing appropriate springs, springs were not included on the final prototype. The friction between the hinge components is adequate to hold the brush in a fixed position during brushing and the zip ties' elasticity can offer some force returning the brush to a neutral position. Despite this, the brush performed well even without springs, and based on the observed challenges, the addition of springs may not improve its performance.

The brush's material cost is minimal thanks to its 3D-printed construction. Based on the cost of ABS plastic (around \$0.65 per cubic inch) [6], the overall material cost of the brush if made of solid ABS would be \$3.19. This cost does not include manufacturing, waste, packaging, or labor. This cost is below the \$10 target set, meaning the design receives one point in that category.

The force to break one bristle was set as a metric as survey respondents expressed that product reliability was an important factor for them [1]. Due to technical limitations, force measurement could not be performed as initially planned in the CDR [2]. With the time available, there was not a way to easily apply and measure force in such a specific way to test the bristle's breakage force. In handling the brush normally, no bristles were damaged.

The amount of brush strokes to adequately clean the pet was found to be 5. A lower amount of brush strokes was important to minimize the amount of time it took to clean the pet. Efficiency was important to the user's needs as data from the surveys showed that pet cleanup often took too much time [1]. The brush was both tested on long and short haired cats. For short-haired cats, the average amount of strokes necessary to brush the pet was 5. The longer haired cats took about 8 strokes to brush because of the larger volume of hair. The amount of strokes is dependent on the type of pet hair; therefore, an average score of 4 on the testing score card was assigned. This testing showed that further refinement of the bristle geometry may be necessary to commercialize such a product. Elongating the bristles slightly may help it deal with longer fur (which may stack further from the skin) more effectively.

In any pet product, the pet can be a very important decision maker. It is very important that a brush be comfortable for the pet being brushed as well as for the user. As such, the pet's opinion was subjectively evaluated. If the pet appeared to be uncomfortable or under duress, fewer points would be awarded. If the pet was comfortable or enjoying the brushing, more points would be awarded. The first bristle prototype (Appendix A, Figure A3) was not tested with pets, as its bristles were quite sharp. The second prototype (Appendix A, Figure A2) fixed this issue, and testing started with two cats, who both enjoyed the brushing (Appendix A, Figure A4). As such, it was scored at a 7/10 for preliminary testing [4]. After this, additional testing was conducted with other pets. In this testing, an 8/10 was assigned. Overall, the average of 7.5 is used for scoring.

From these data, a final score of 18 is assigned. This score is lower than the preliminary score as the brush does not perform as well with long-haired cats. This score indicates that before commercialization is possible, additional work must be done to refine the geometry of the bristles. This could include testing with more varied pets (such as different species with different types of hair) and additional design towards aspects such as ergonomics for the user.

References

- [1] L. Barone, M. Faizul, D. Haikal, & R. Rutiser Sundar, “Pet cleanup project problem definition review,”
<https://github.com/rutisersundar1/ENGR1182GroupC/blob/main/Technical%20Documentation/Problem%20Definition%20Review.pdf> (accessed Apr. 20, 2022)
- [2] L. Barone, M. Faizul, D. Haikal, & R. Rutiser Sundar, “Pet brush project conceptual design review,”
<https://github.com/rutisersundar1/ENGR1182GroupC/blob/main/Technical%20Documentation/Conceptual%20Design%20Review.pdf> (accessed Apr. 20, 2022)
- [3] L. Barone, M. Faizul, D. Haikal, & R. Rutiser Sundar, “Pet brush project detailed design review,”
<https://github.com/rutisersundar1/ENGR1182GroupC/blob/main/Technical%20Documentation/Detailed%20Design%20Review.pdf> (accessed Apr. 20, 2022)
- [4] L. Barone, M. Faizul, D. Haikal, & R. Rutiser Sundar, “Preliminary verification presentation,”
<https://github.com/rutisersundar1/ENGR1182GroupC/blob/main/Presentations/P2.2%20Preliminary%20Verification.pdf> (accessed Apr. 20, 2022)
- [5] L. Barone, M. Faizul, D. Haikal, & R. Rutiser Sundar, “Pet brush project SOLIDWORKS models,”
<https://github.com/rutisersundar1/ENGR1182GroupC/tree/main/SOLIDWORKS%20Models> (accessed Apr. 20, 2022)
- [6] ToyBuilder Labs, “Material cost for printing,”
<https://www.toybuilderlabs.com/blogs/news/13055597-material-cost-for-printing> (accessed Apr. 20, 2022)

Appendix A: Images

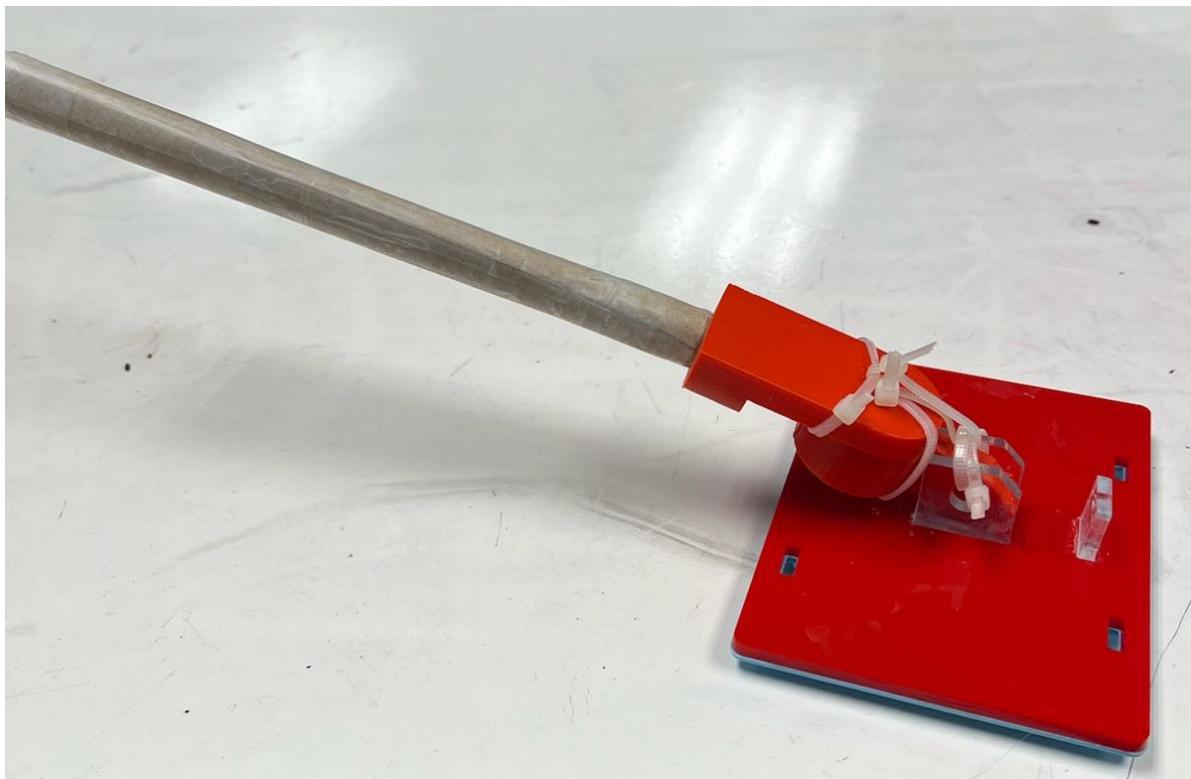


Figure A1: Final Prototype



Figure A2: Final Bristles



Figure A3: First Bristle Prototype

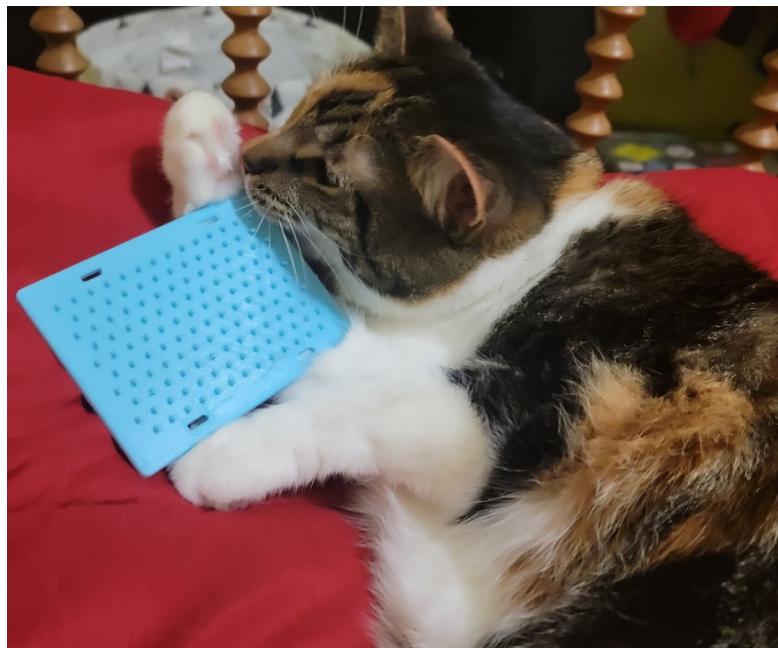
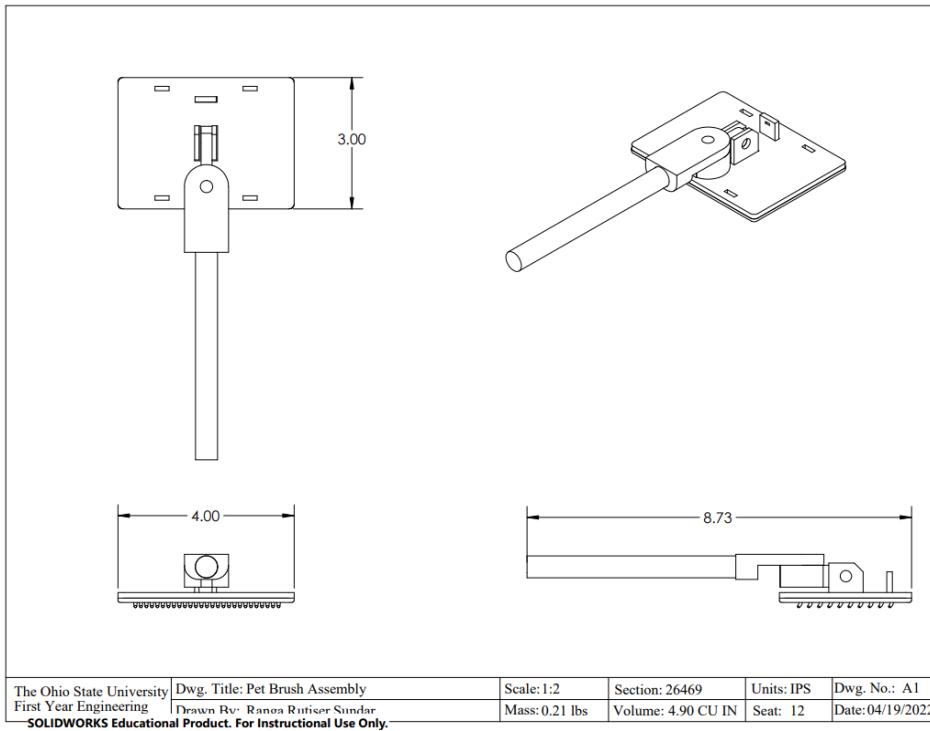
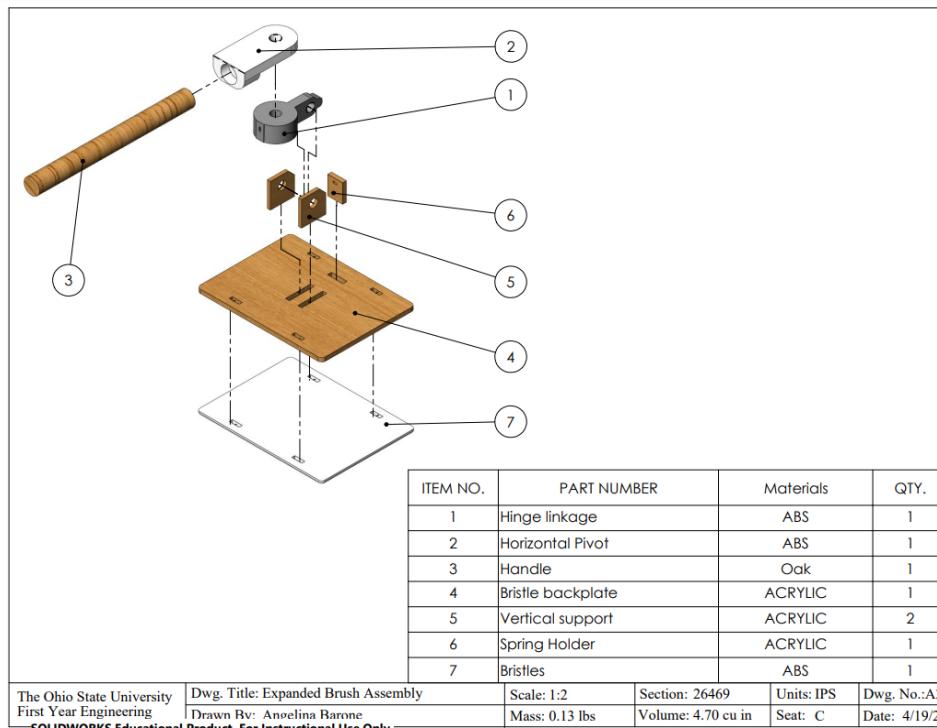


Figure A4: Confused user during testing

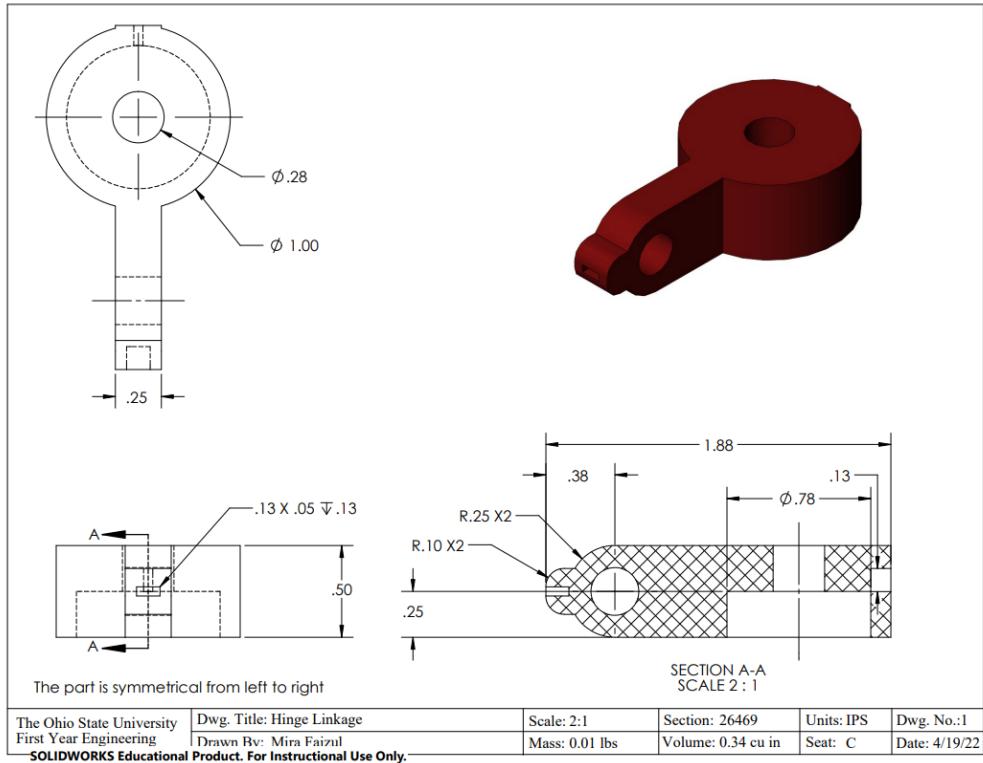
Appendix B: Working Drawing Packet



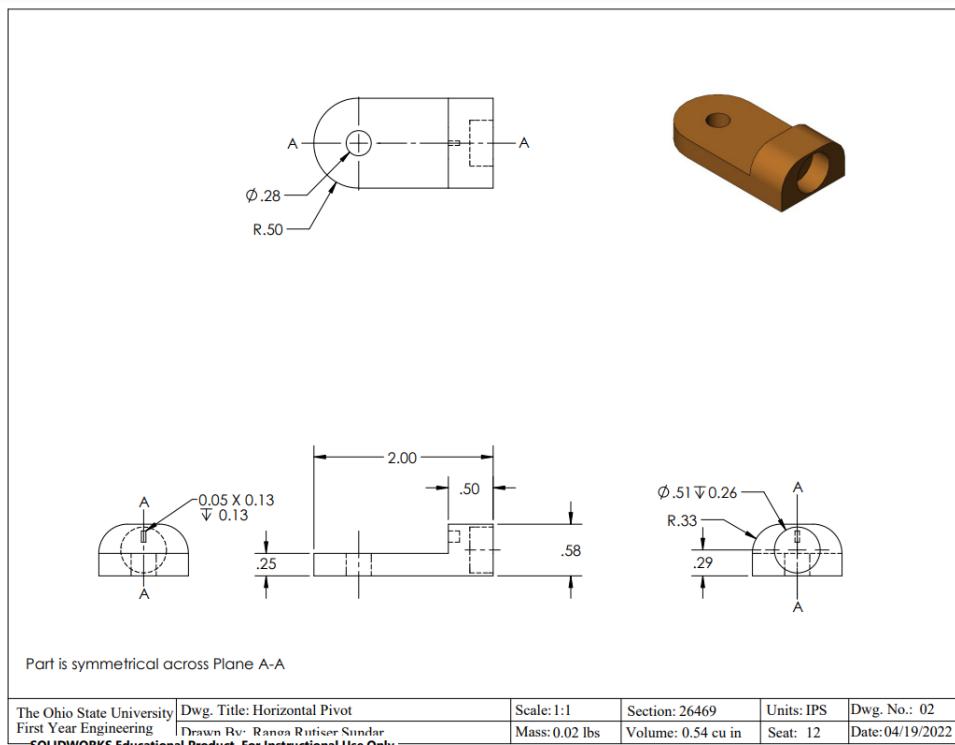
Drawing A1: Pet Brush Assembly



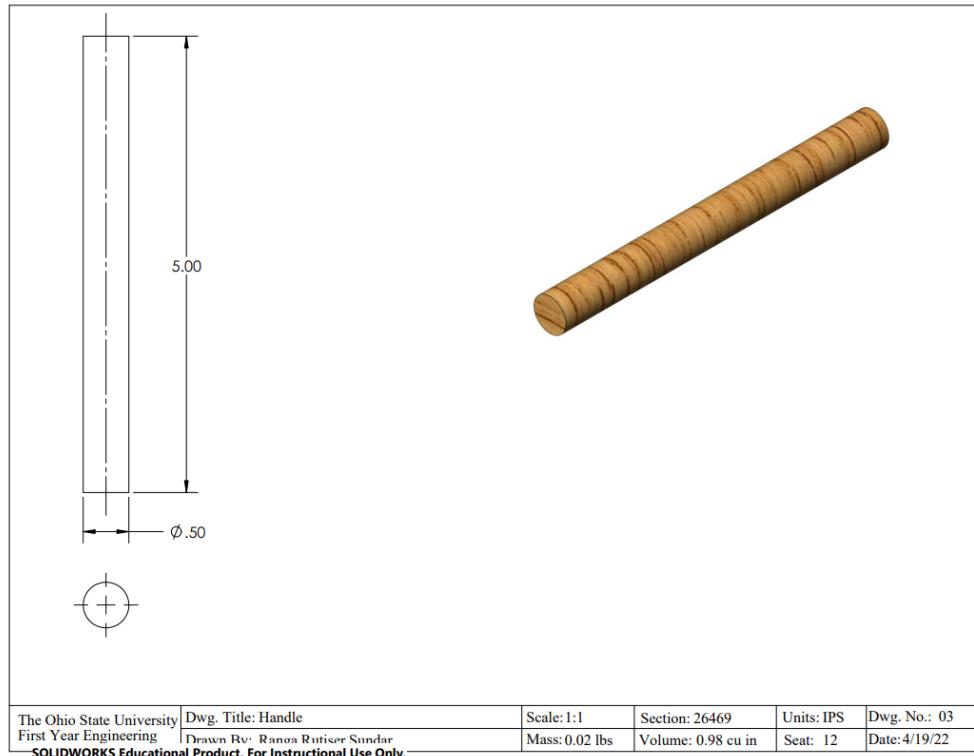
Drawing A2: Exploded Brush Assembly



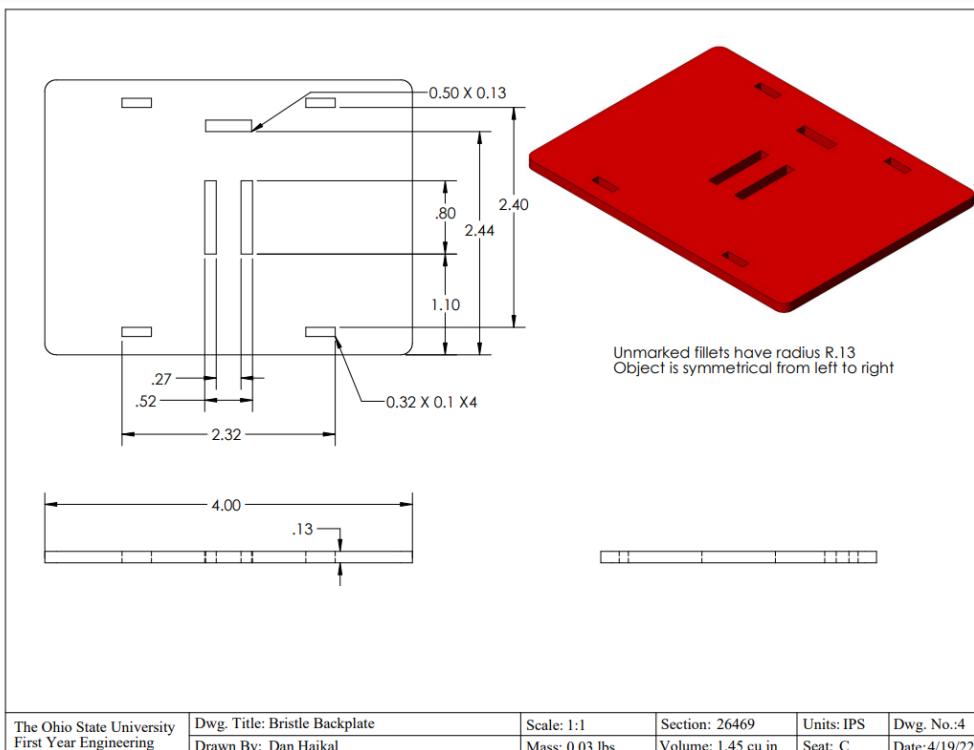
Drawing 1: Hinge Linkage



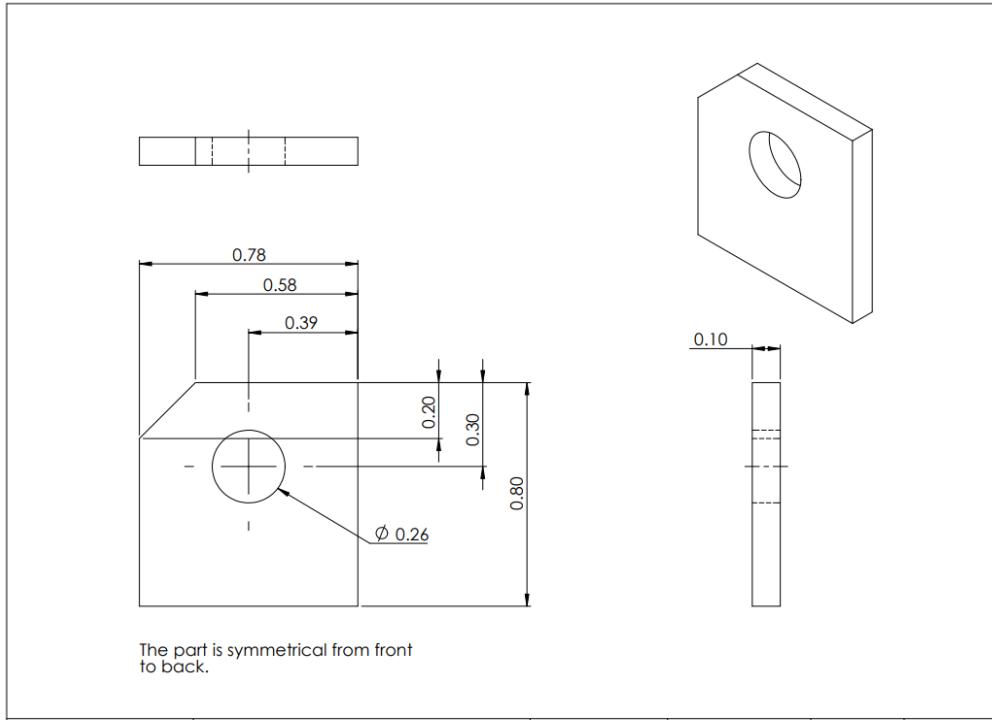
Drawing 2: Horizontal Pivot



Drawing 3: Handle

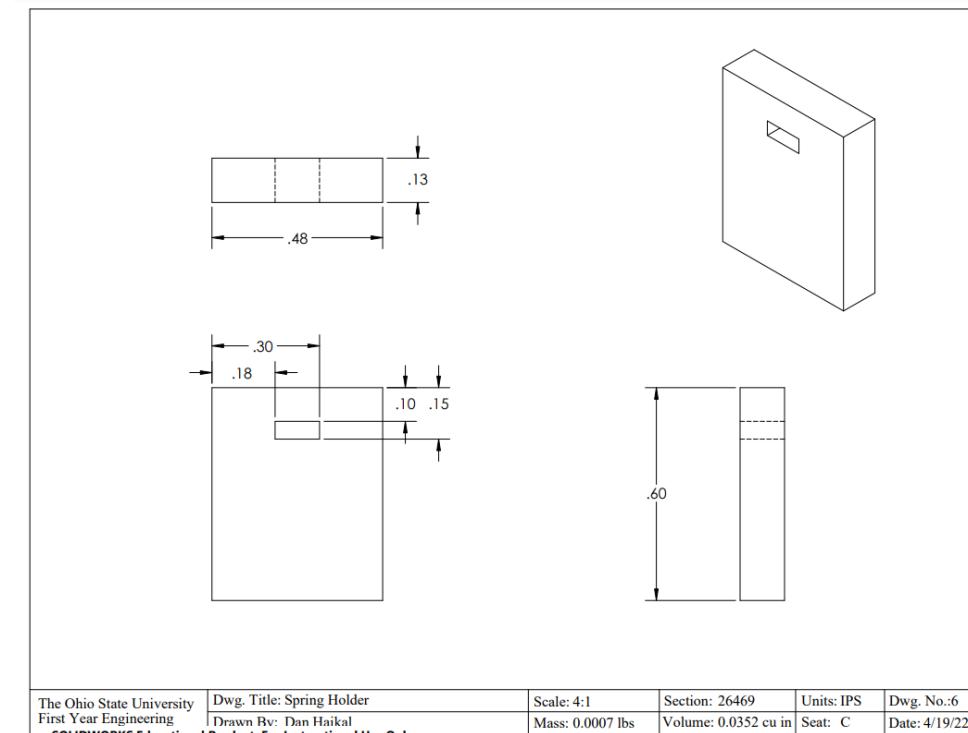


Drawing 4: Bristle Backplate



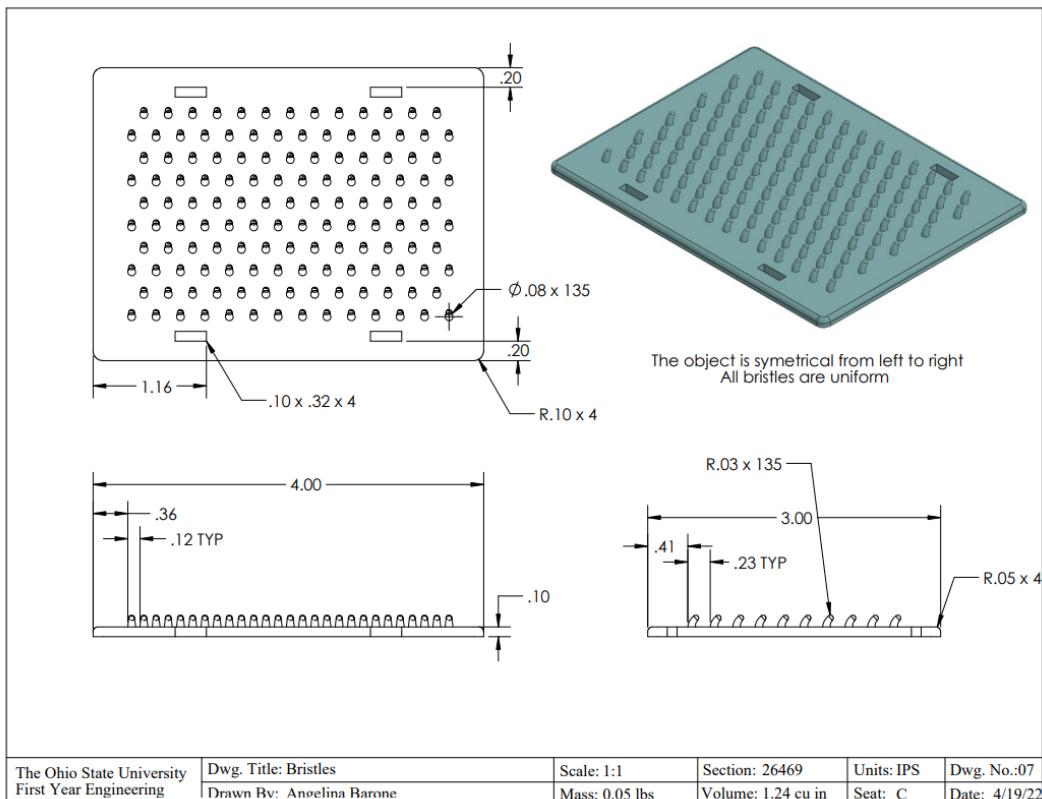
The Ohio State University First Year Engineering	Dwg. Title: Vertical Support Drawn By: Mira Faizul SOLIDWORKS Educational Product. For Instructional Use Only.	Scale: 3:1 Mass: 0.0011 lbs	Section: 26469 Volume: 0.0551 cu in	Units: IPS Seat: C	Dwg. No.:5 Date: 4/19/22
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Drawing 5: Vertical Support



The Ohio State University First Year Engineering	Dwg. Title: Spring Holder Drawn By: Dan Haikal SOLIDWORKS Educational Product. For Instructional Use Only.	Scale: 4:1 Mass: 0.0007 lbs	Section: 26469 Volume: 0.0352 cu in	Units: IPS Seat: C	Dwg. No.:6 Date: 4/19/22
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Drawing 6: Spring Holder



Drawing 7: Bristles

Appendix C: Final Testing Scorecard

Table A1: Final Scorecard

Requirement	Range	Score Rubric (Total Score: 18/28)									Final Score
		8	7	6	5	4	3	2	1	0	
Time to clean hair out of brush (5 pts)	0 - 120 seconds				≤80 s	≤90 s	≤100 s	≤110 s	≤120 s	>120 s	5
Total brush mass (1pt)	0 - 500 g								<250 g	>250 g	1
Brush material cost (1pt)	\$0-20								< \$10	> \$10	1
Force to break one bristle (3pts)	0-3 lbs of force						≥ 3 lbs	≥ 2 lbs	≥ 1 lb	< 1 lb	3
Brush strokes to adequately clean pet (8pts)	1-10	1	2	3	4	5	6	7	8	≥ 9	4
Pet opinion (7pts)	1-10		10	9	8	7	6	5	4	<3	4

Appendix D: Group Responsibilities

FD1: Prototype Working Drawings Packet				
Project Manager for Assignment		Ranga Rutiser Sundar		
Deputy Manager for Assignment		Angelina Barone		
Drafted Assignment	All group members	Revised Assignment	All group members	
Reviewed Assignment	Ranga Rutiser Sundar	Proofread Assignment	All group members	
Created Figures	All group members	Created Tables	N/A	
Other Contributions				
N/A				
Problems Overcome				
The group created a working drawings packet for the prototype.				

FD2: Final Verification Testing				
Project Manager for Assignment		Mira Faizul		
Deputy Manager for Assignment		Dan Haikal		
Drafted Assignment	All group members	Revised Assignment	All group members	
Reviewed Assignment	All group members	Proofread Assignment	All group members	
Created Figures	Angelina Barone	Created Tables	Ranga Rutiser Sundar	
Other Contributions				
N/A				
Problems Overcome				
The group presented the results of the verification conducted.				