**The FANtastic Four**

Group A – Final Project Portfolio

| **Members:** Muhammad Shao, Mark Luke, Ryan Bailey & Grant Nair | |
|---|---|
| **Class:** MECH 5680 (Tues/Thurs 11:10 AM – 12:30 PM) | **Professor:** Dr. Sandra Metzler |
| **Lab:** Wednesday 8:00 AM – 9:50 AM | **Date:** December 2nd, 2018 |

**Introduction:**

The project aims to model and simulate the "Chillout Desktop Fan." The group wanted to model a readily available, everyday object which we interact with on a daily basis. It is intriguing to understand the inner workings of such an object and understand the functionality of a simple object that one may not think to analyze. Also, a fan has a lot of dynamics at play, which gives the group a unique opportunity to push their boundaries through SolidWorks modeling and animation. Lastly, if time allows, the group would like to further extend this project into a fluid dynamics study and understand the flow of air through the modeled desk fan. In conclusion, this fan provides the group an opportunity to discover the intricacies of an everyday object, further develop their modeling abilities and further extend the model to a scientific study of fluid flow.

**Isometric Drawing View of Assembly:**

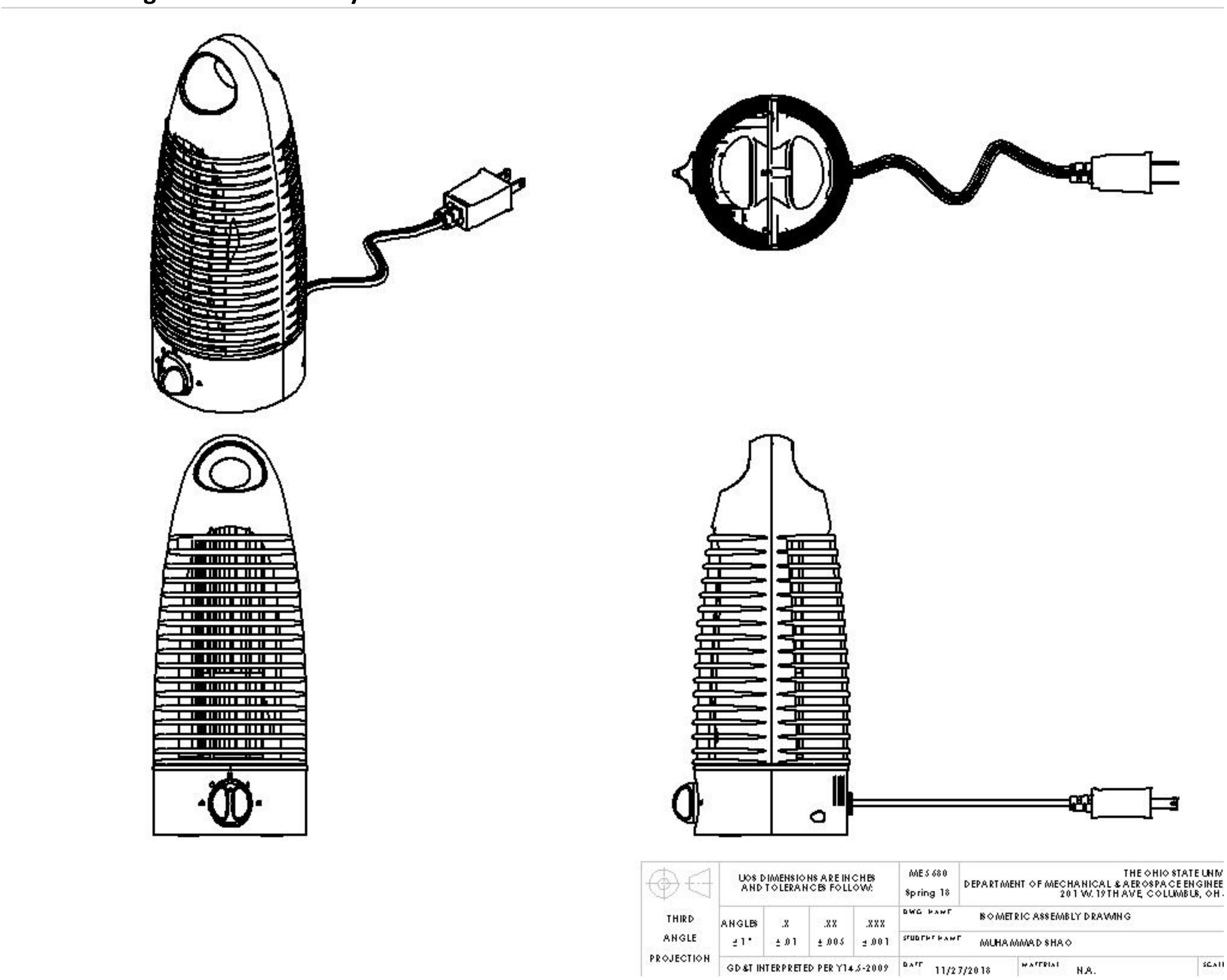



**Figure 1:** Isometric drawing view of entire assembly.

**Photo View 360° Rendering of Assembly:**

**Figure 2:** Render of modelled "Chillout Desktop Fan" full-assembly.

**Animation Links:**

| Motion Study: | Exploded View: | FEM Simulated Drop Test: |
|---|---|---|
| https://www.youtube.com/watch?v=lN3Clcl8gjg | https://www.youtube.com/watch?v=jCueYSfW0qQ | https://www.youtube.com/watch?v=EEcEyj5ALYI |

**Bill of Materials:**


**Figure 3:** Real-life exploded view with corresponding BOM balloons.

| Part Number | Description | Quantity |
|---|---|---|
| 1 | motor stator | 1 |
| 2 | motor control switch | 1 |
| 3 | motor winding housing | 1 |
| 4 | motor copper wiring | 1 |
| 5 | control knob | 1 |
| 6 | circular impeller | 1 |
| 7 | outer casing (front half) | 1 |
| 8 | outer casing (back half) | 1 |
| 9 | wire and plug | 1 |
| 10 | impeller bearing | 1 |
| 10 | rubber mounting feet | 4 |
| 11 | structural molded piece 1 (largest) | 1 |
| 12 | structural molded piece 2 | 1 |
| 13 | structural molded piece 3 | 1 |
| 14 | molded peice for motor mount | 1 |
| 15 | large motor bearing | 1 |
| 16 | small motor bearing | 1 |
| 17 | rotor and motor shaft | 1 |
| 18 | nut | 2 |
| 19 | O-ring | 1 |
| 20 | machine screw | 2 |
| 21 | longest screw | 2 |
| 22 | medium screw | 8 |
| 23 | shortest screw (flat) | 2 |
| 24 | shortest screw (point) | 2 |

**Table 1:** Bill of materials per “Real-Life” exploded view and balloon numbers.

| ITEM NO. | PART NUMBER | Real-Life Exploded View Baloon #s | QTY. |
|---|---|---|---|
| 1 | Outer Casing (Back) | 8 | 1 |
| 2 | Outer Casing (Front) | 7 | 1 |
| 3 | Motor Control Switch | 2 | 1 |
| 4 | Control Knob | 5 | 1 |
| 5 | Structural Molded Piece 3 | 13 | 1 |
| 6 | Structural Molded Piece 2 | 12 | 1 |
| 7 | Structural Molded Piece 1 | 11 | 1 |
| 8 | Motor Stator | 1 | 1 |
| 9 | Motor Winding Housing | 3 | 1 |
| 10 | Motor Copper Wiring | 4 | 1 |
| 11 | Plastic_Piece_DemonGuy | 14 | 1 |
| 12 | Molded Piece for Motor Mount | 16 | 1 |
| 13 | Small Motor Bearing | 15 | 1 |
| 14 | Rotor and Motor Shaft | 17 | 1 |
| 15 | Machine Screw | 20 | 2 |
| 16 | Nut | 18 | 2 |
| 17 | Impeller Bearing | 10 | 1 |
| 18 | Circular Impeller | 6 | 1 |
| 19 | O-Ring 3.75 IN | 19 | 1 |
| 20 | Long Screw | 21 | 2 |
| 21 | Short flat/point & medium screws | 22/23/24 | 11 |
| 22 | Plug | 9 | 1 |
| 23 | Power Cord | 9 | 1 |

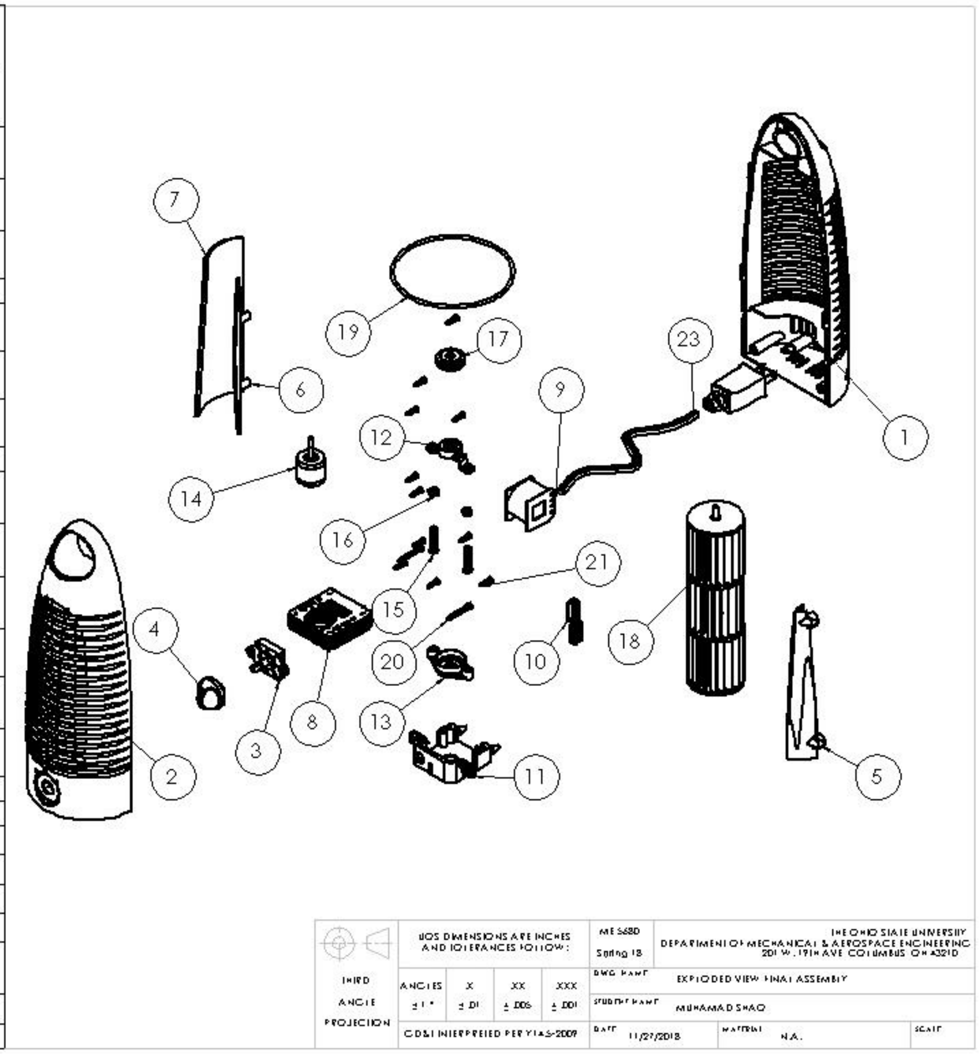



**Figure 4:** SolidWorks exploded view with balloons & BOM.

**Detailed Drawings:**
Below are figures for each detailed drawing. For clarity, the full-size drawings can be seen at the end of the report.

Muhammad Shao:

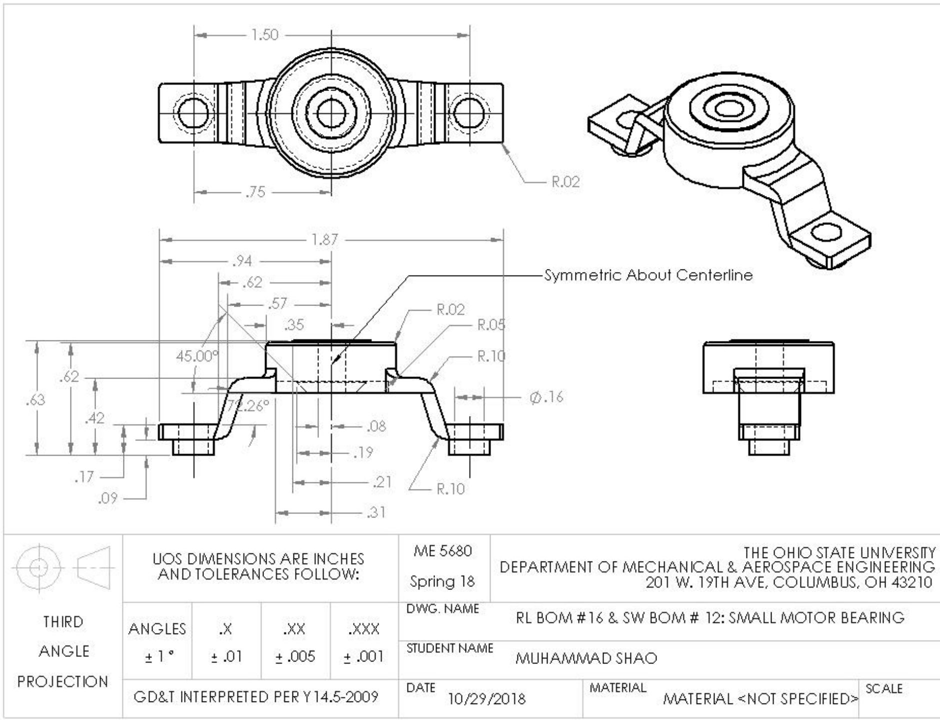



**Figure 5:** Detailed part drawing of “Small Motor Bearing” RL BOM # 16 & SW BOM # 12.

Mark Luke:

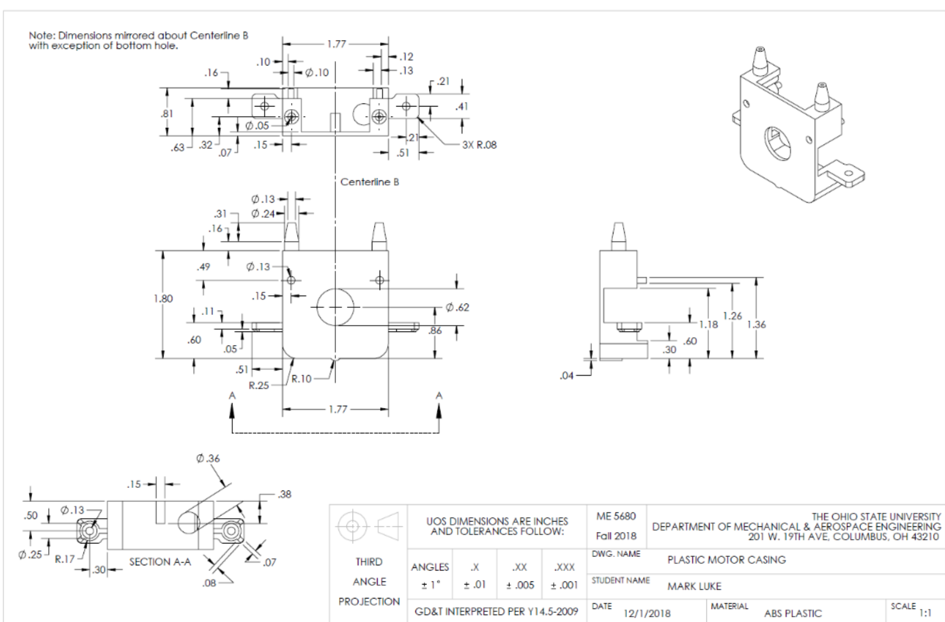



**Figure 6:** Detailed part drawing of the “Plastic Motor Casing” RL BOM # 14 & SW BOM # 11

Ryan Bailey:

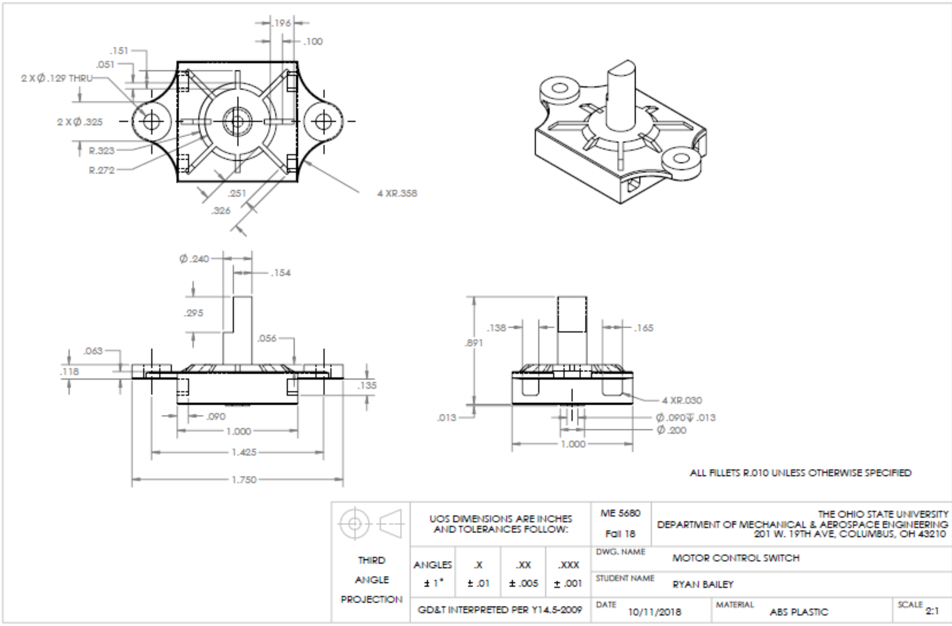



**Figure 7:** Detailed part drawing of the “Motor Control Switch” RL BOM # 2 & SW BOM # 3

Grant Nair:

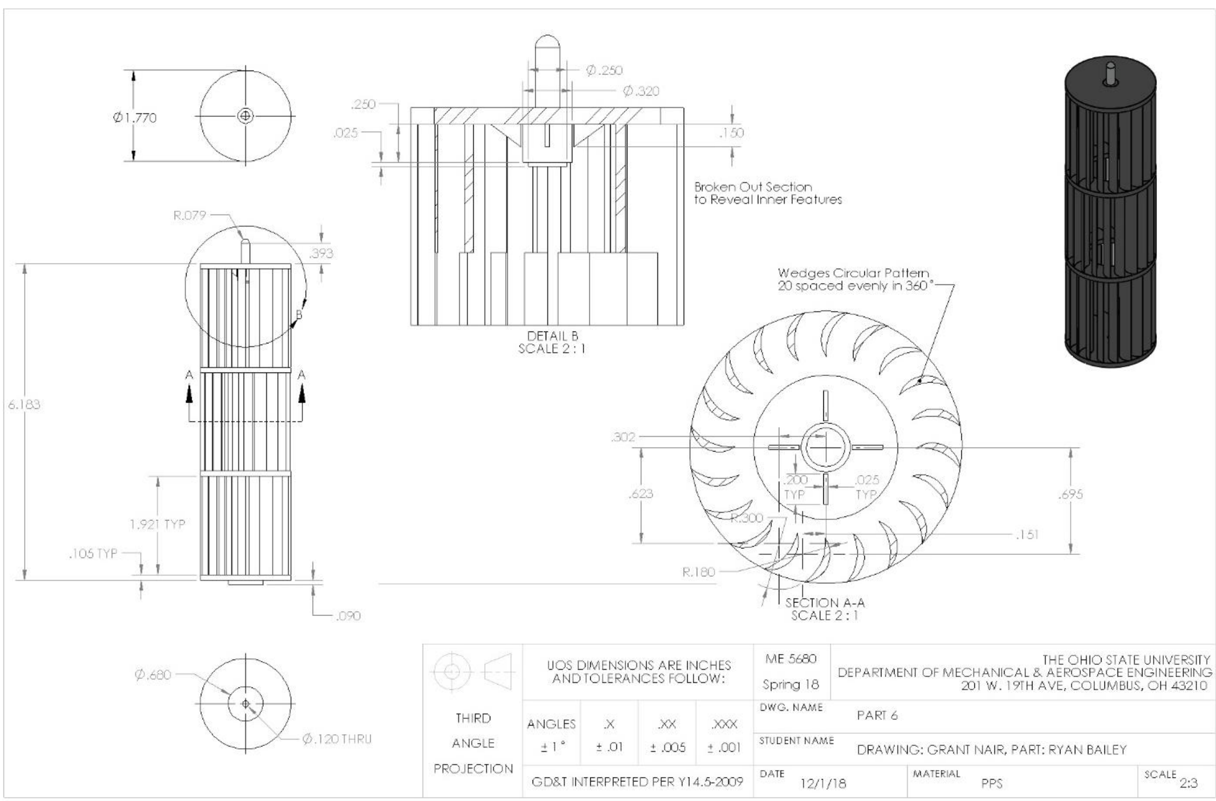
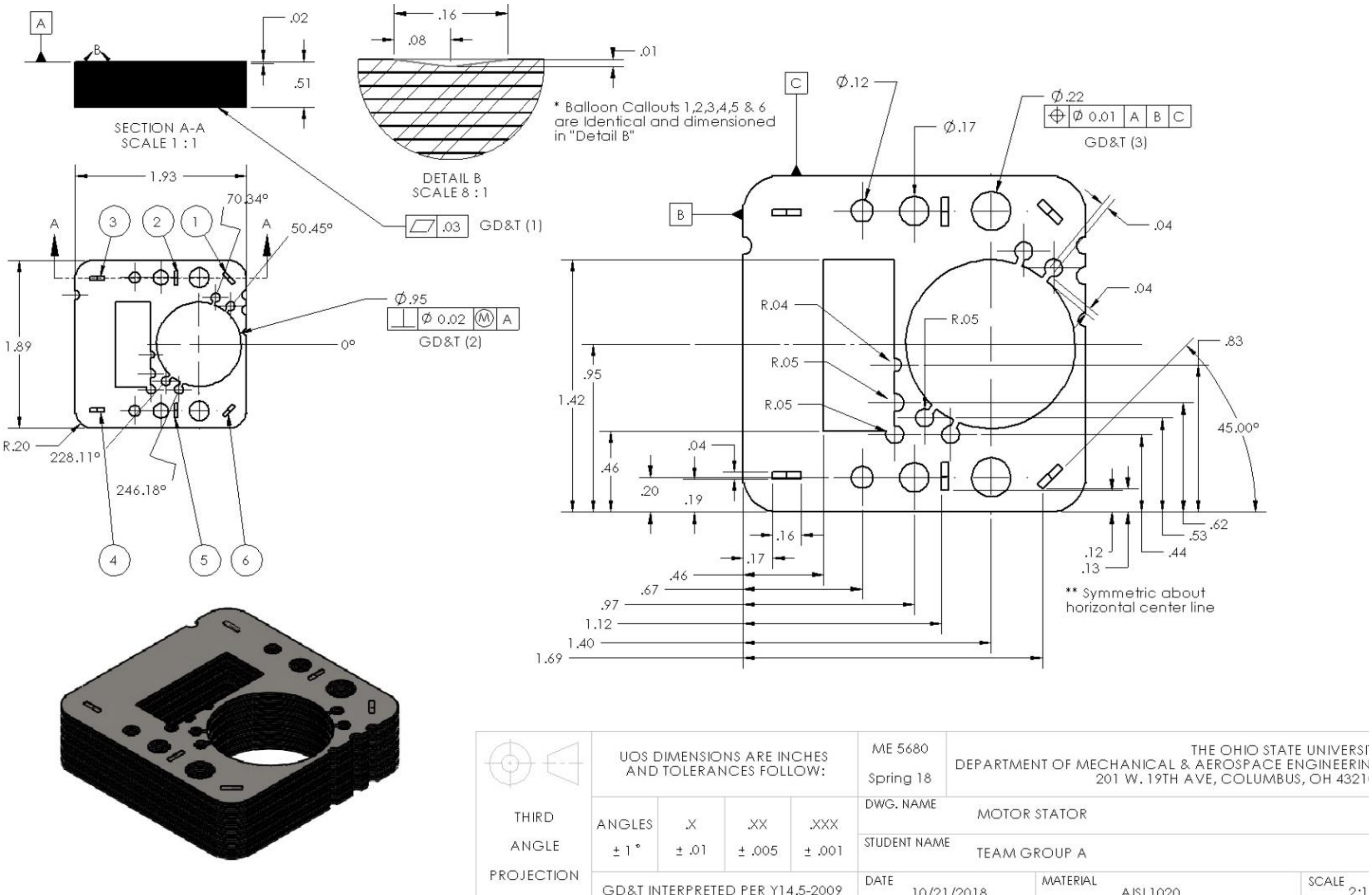



**Figure 8:** Detailed part drawing of the “Circular Impeller” RL BOM # 6 & SW BOM # 18

**GD&T Drawing:**

Justification of GD&T callouts:




| GD&T Callout | Justification |
|---|---|
| 1 | The bottom surface of the stator is called out for a flatness tolerance as many pieces mate to it, including the motor bearing as well as the plastic casing to hold the motor. The flatness tolerance helps align the holes for fastening the stator to the inside of the fan. |
| 2 | Perpendicularity of the largest hole for the rotor is called out to ensure that the rotor can fit inside the hole. The hole size at MMC minus the perpendicularity tolerance still allows for the rotor to fit inside the block |
| 3 | A position tolerance is applied to the holes where the bearing screws fasten around the stator. It is important that the holes are in the correct position to allow the screw to easily fit and fasten to the bearings. |

**Isometric Drawings of Complex Geometries:**

Muhammad Shao:

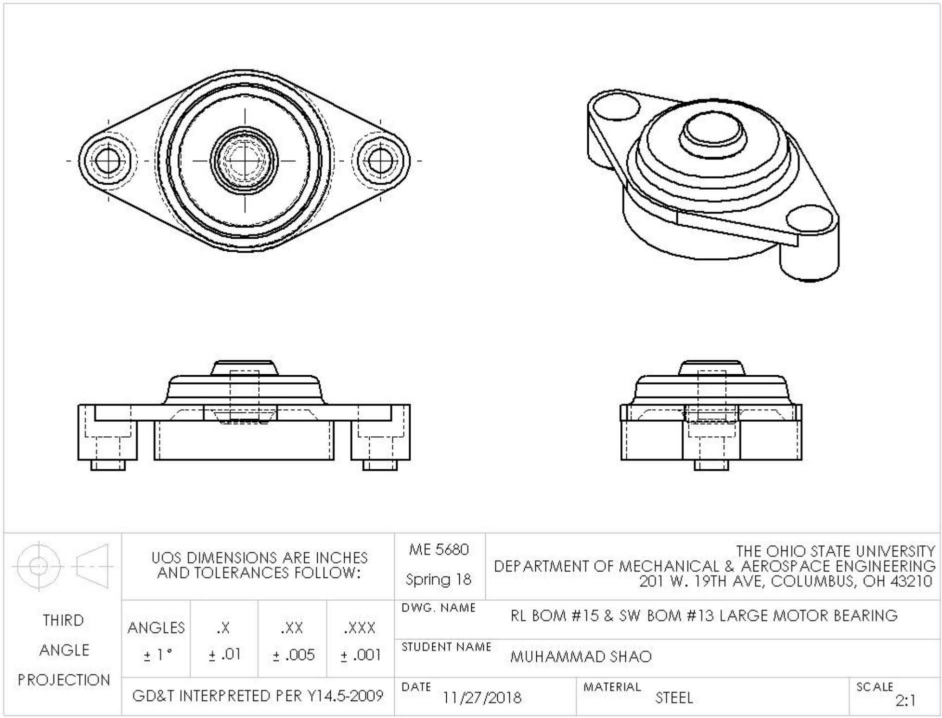



**Figure 9:** Iso. view of complex part: “Large Motor Bearing” RL BOM # 15 & SW BOM # 13.

Mark Luke:


**Figure 10:** Iso. View of “Large Injection Molded Internal Piece” RL BOM # 11 & SW BOM # 7.

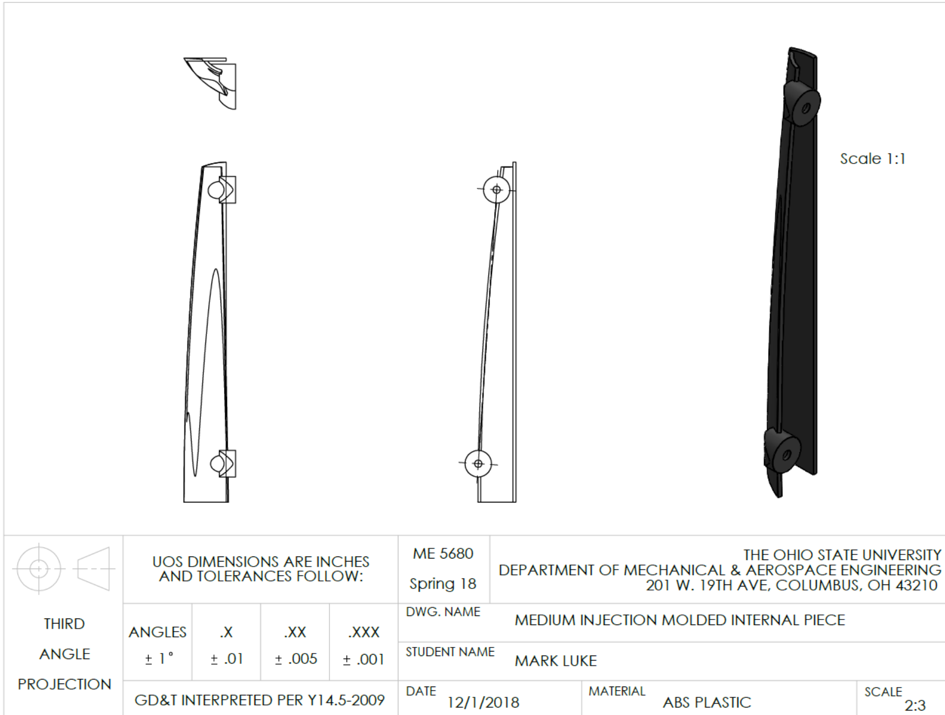



**Figure 11:** Iso. View of "Large Injection Molded Internal Piece" RL BOM # 12 & SW BOM # 5.

Ryan Bailey:

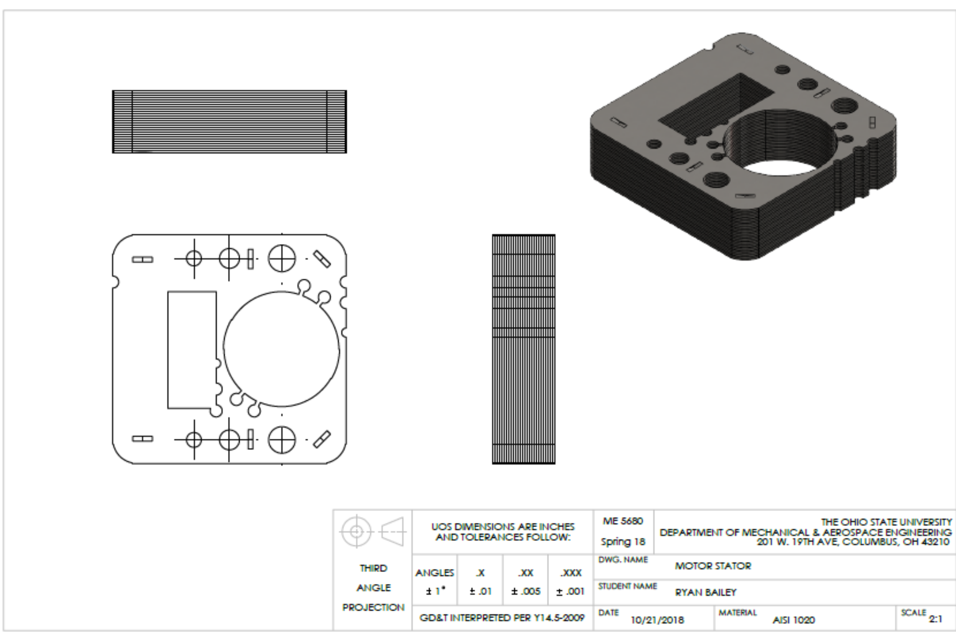



**Figure 12:** Iso. View of "Motor Stator" RL BOM # 1 & SW BOM # 8.

Grant Nair:

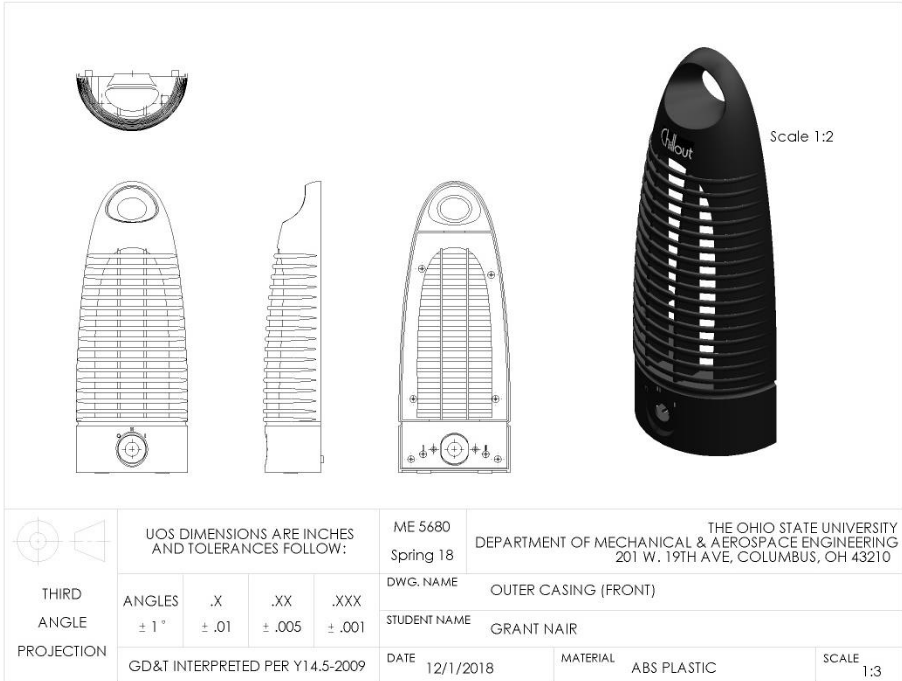



**Figure 13:** Iso. View of “Outer Casing (Front)” RL BOM # 7 & SW BOM # 2.

**Simulation:**

<u>Summary & Justification:</u>

Drop test simulation was chosen for the fan as it is likely to fall off someone's desk at home or an office. Several different impact locations were chosen to see the stress that develops after a fall of 1 meter from the ground. These locations were chosen as they each test different structural geometries of the casing and would likely be the areas to make impact with the ground. Below are the results after 100 microseconds of the casing impacting a rigid target (such as tile floor) on the top, ribs, and bottom.

<u>Analysis & Results:</u>

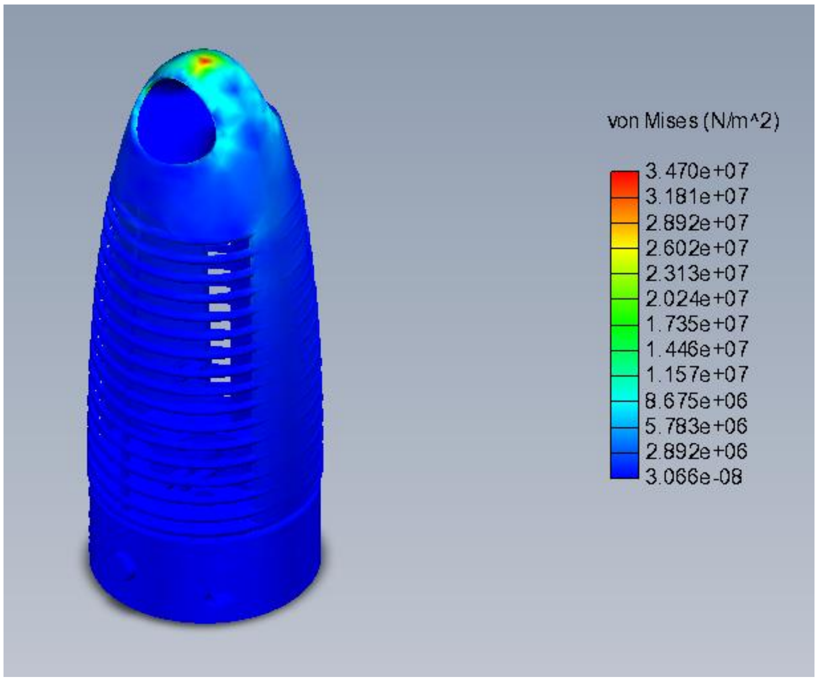



**Figure 14:** Drop test stress results for impact on top of casing.

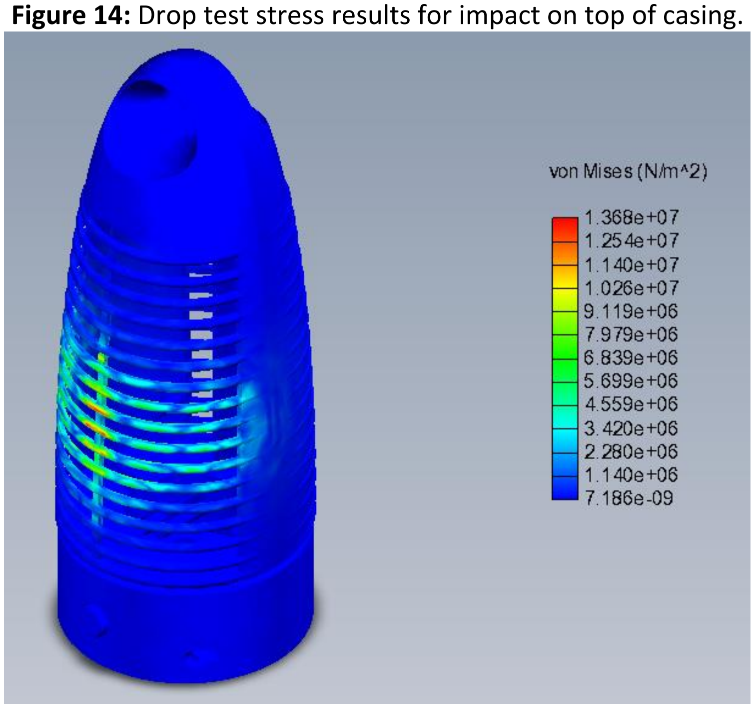



**Figure 15:** Drop test stress results for impact on ribs of casing.

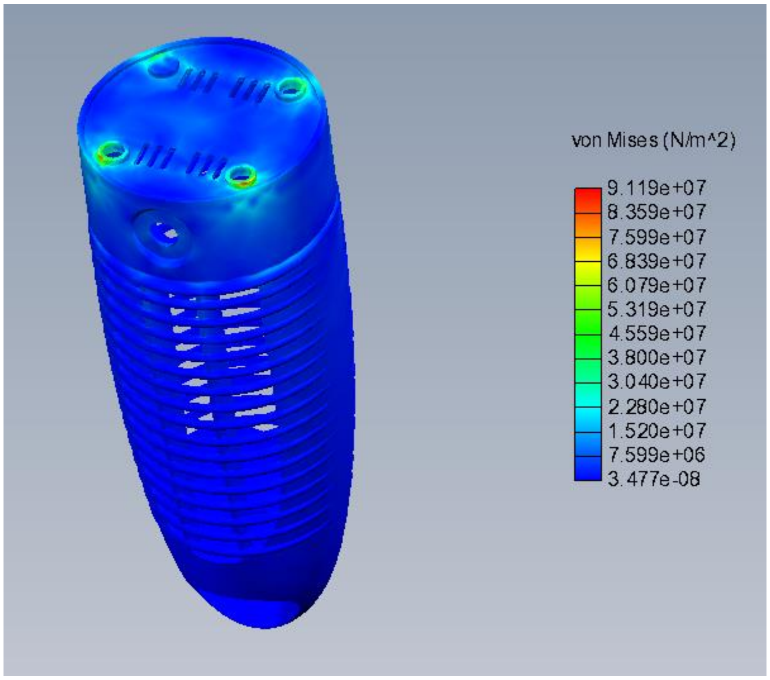



**Figure 16:** Drop test stress results for impact on bottom of casing.

From the plots above, all the stresses induced on the casing are on the order of $10^7$ Pa. The bottom feet that stick experienced the most stress of ab 91.2 MPa, and would break if they were ABS plastic (yield strength = 48.3 MPa). This result makes sense as the feet have the smallest cross section of the impact locations tested. However, these feet are actually made out of rubber, and would only deform if the casing landed on them. The top experiences the next highest stress of 34.7 MPa, which was a surprise as it was expected the ribs would have a higher stress due to the small cross section. Upon further review, the ribs impact point was not localized on just one rib, but over 2-3 ribs, which would reduce the highest stress values seen by this area. The top impact point was localized, creating larger stress values. This would only make the top elastically deform as it does not reach the yield strength of the material. Verification of the model for each impact location should occur through simple drop tests from a height of 1 meter. Multiple fans would be needed in case one breaks during this verification.

SolidWorks drop tests find stress values for a specific number of frames over certain time periods. To attempt to keep the model as consistent as possible, the same number of frames and total time period were used for each simulation. This could mean that the highest stress values were reached in a frame different than the ones shown above, and each impact location could reach max stress at a different time value. The max stress might not even be reached using the model impact time (100 microseconds), so longer impact times should be considered for a full drop test analysis. Each of the stress plots above is simply shown at 100 microseconds.

An animation of the rib drop test can be seen in the following link:
https://www.youtube.com/watch?v=EEcEyj5ALYI

**Difficulties:**

Some of the more challenging parts to model were the plastic pieces with odd contours, as many features of these could not be measured directly. One solution to modelling edge curves was to trace the curve on a piece of paper, measure the end to end distance and the max distance the curve strayed from a line drawn straight from end to end. This curve could then be modeled as an arc in SolidWorks. After two curves were made, a surface could be created with the help of guide lines and thickened to obtain an accurate part feature. A second solution includes modelling the top and bottom faces of the feature, and creating guide curves using the method mentioned before. The two faces could then be lofted for an accurate model.

While the team desired to perform a flow simulation with this model, considering the obvious use of a desk fan to produce flow, this proved to be far more complicated than expected. First, the lack of experience using Solidwork's Flow Simulation package, let alone any other flow analysis program, created a steep learning curve to execute this process. The team spent many hours on research and many attempts at producing a functioning simulation, and the team finally decided that this unique case of a fan is particularly tricky using this program, especially considering the team's understanding of the package. The flow simulation package of Solidworks provides shortcuts and assistance for fans/ turbines within the interior of bodies, and most importantly, for fans that experience or produce flow along the axis of rotation. As the impellor of this fan rotates perpendicular to the direction of flow, all of Solidwork's "Fan" tools built into the Flow Simulation package do not seem to be usable. Despite using "Rotating Regions", and assistance from Solidworks Flow Simulation textbooks, the team was not able to generate usable simulations beyond the 2D flow shown below, which doesn't appear to generate a propulsive flow only a blockage of flow.

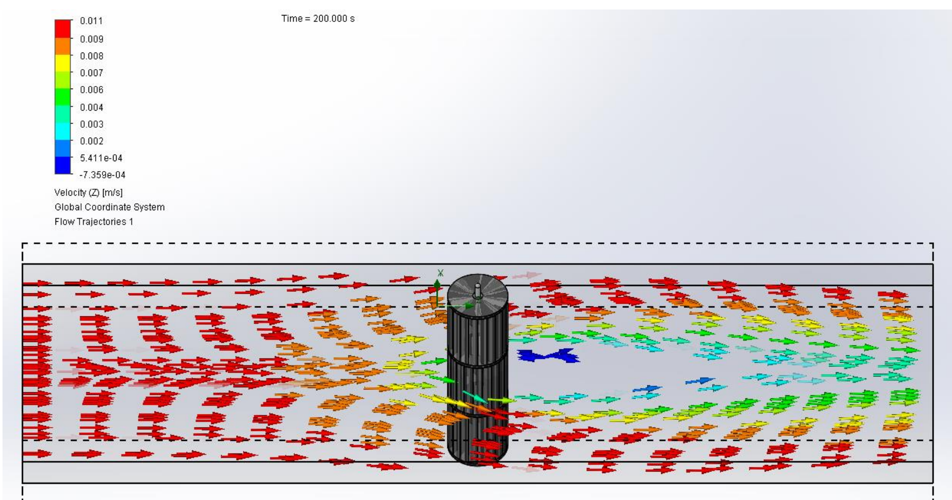
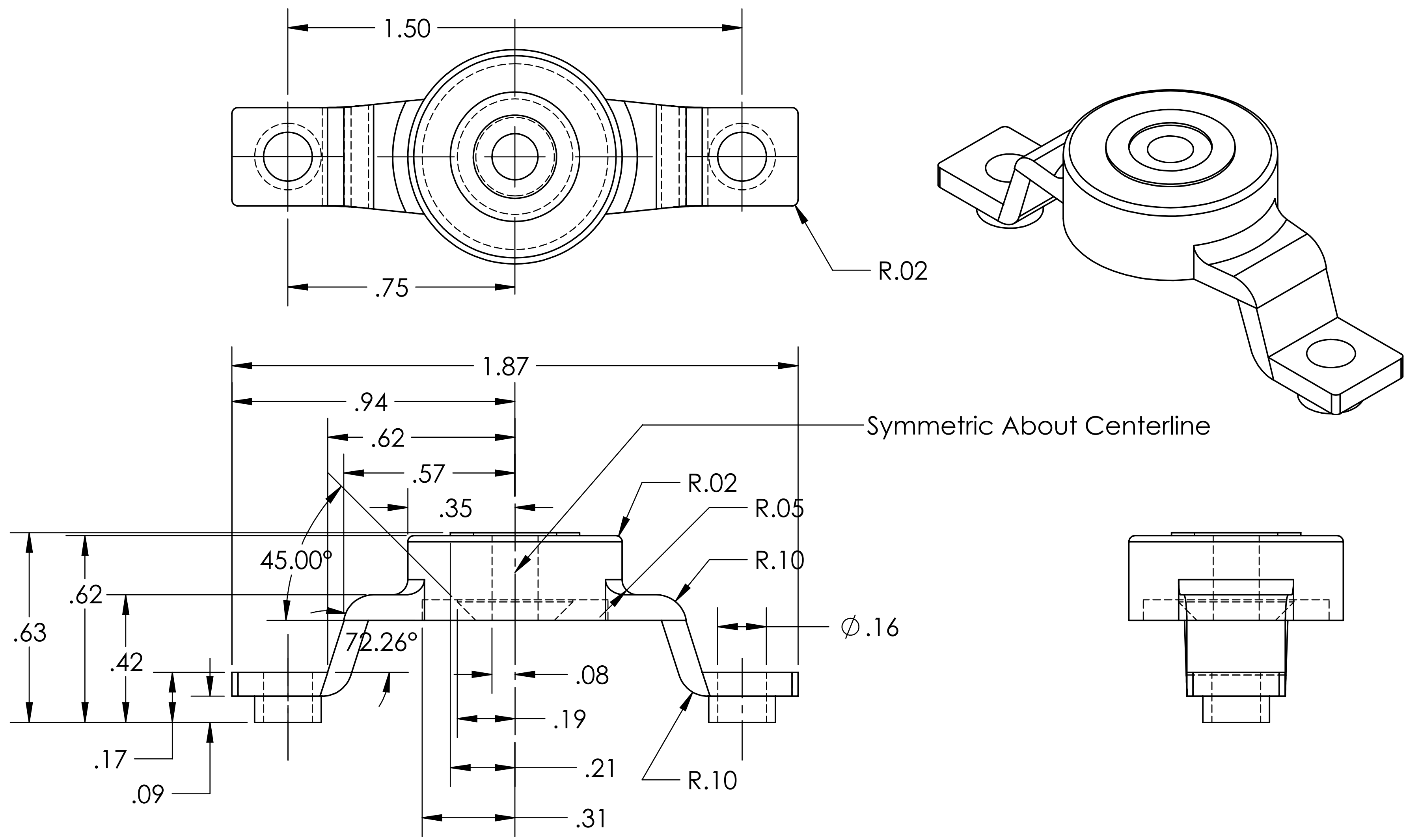



**Figure 17:** 2-D Flow Simulation with only Rotating Impeller Part and Initial Flow Velocity

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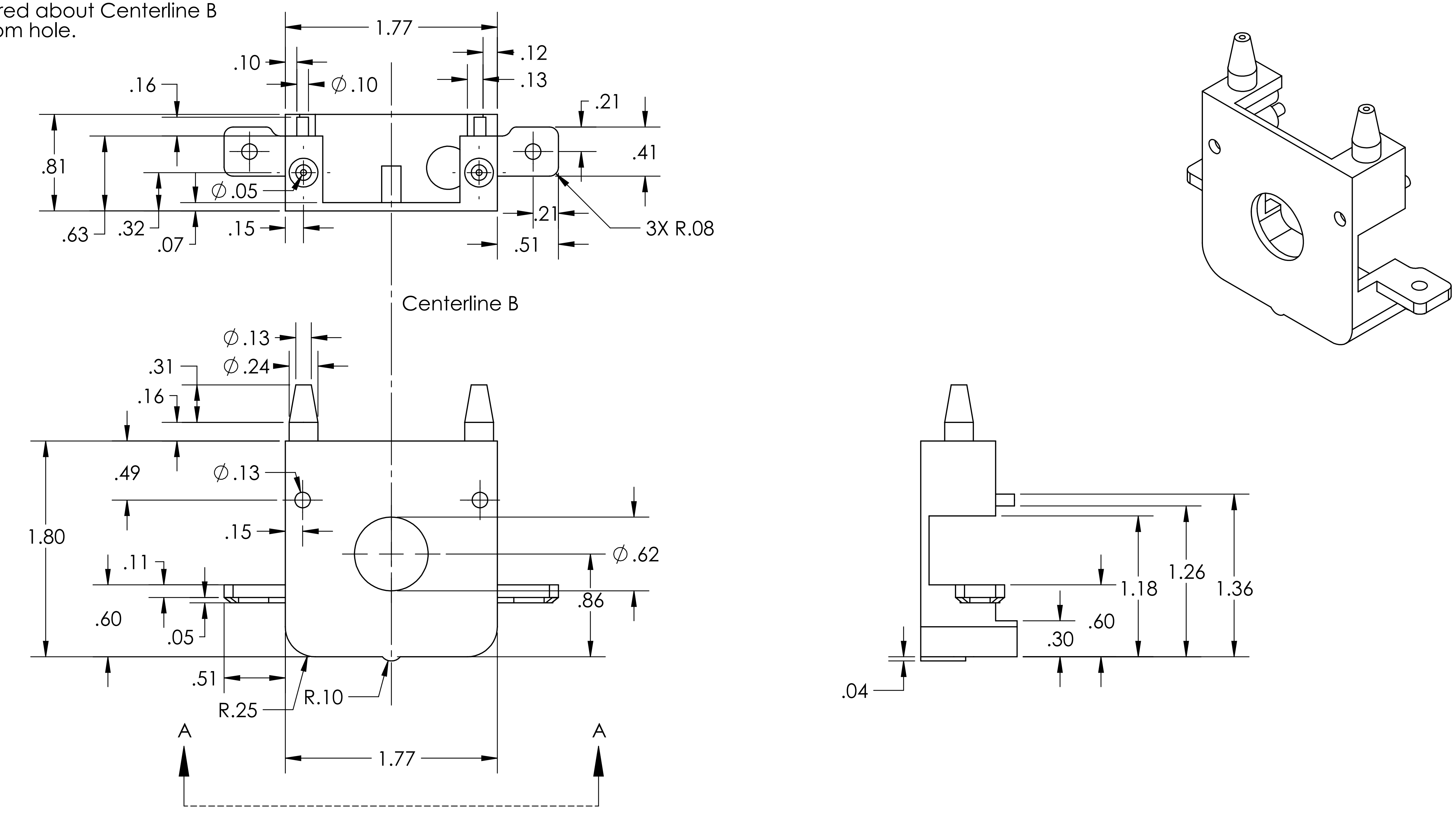
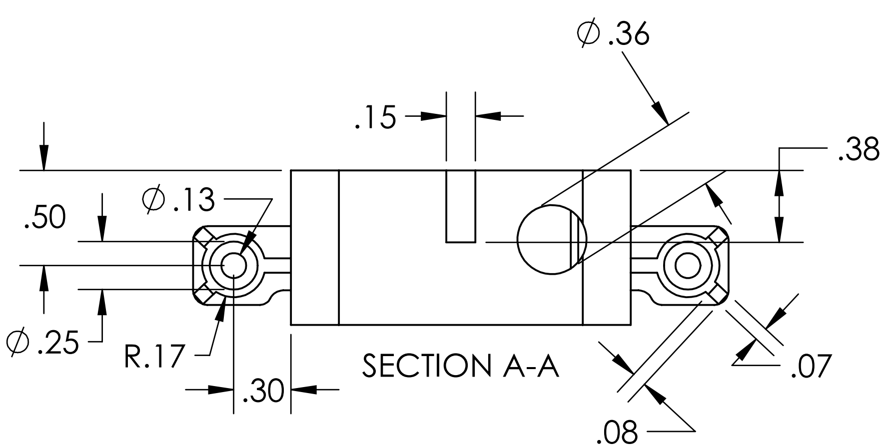
| | ANGLES<br>± 1° | .X<br>± .01 | .XX<br>± .005 | .XXX<br>± .001 | DWG. NAME | RL BOM #16 & SW BOM # 12: SMALL MOTOR BEARING |
| | | | | | STUDENT NAME | MUHAMMAD SHAO |
| | GD&T INTERPRETED PER Y14.5-2009 | | | | DATE 10/29/2018 | MATERIAL MATERIAL <NOT SPECIFIED> SCALE |

Note: Dimensions mirrored about Centerline B
with exception of bottom hole.

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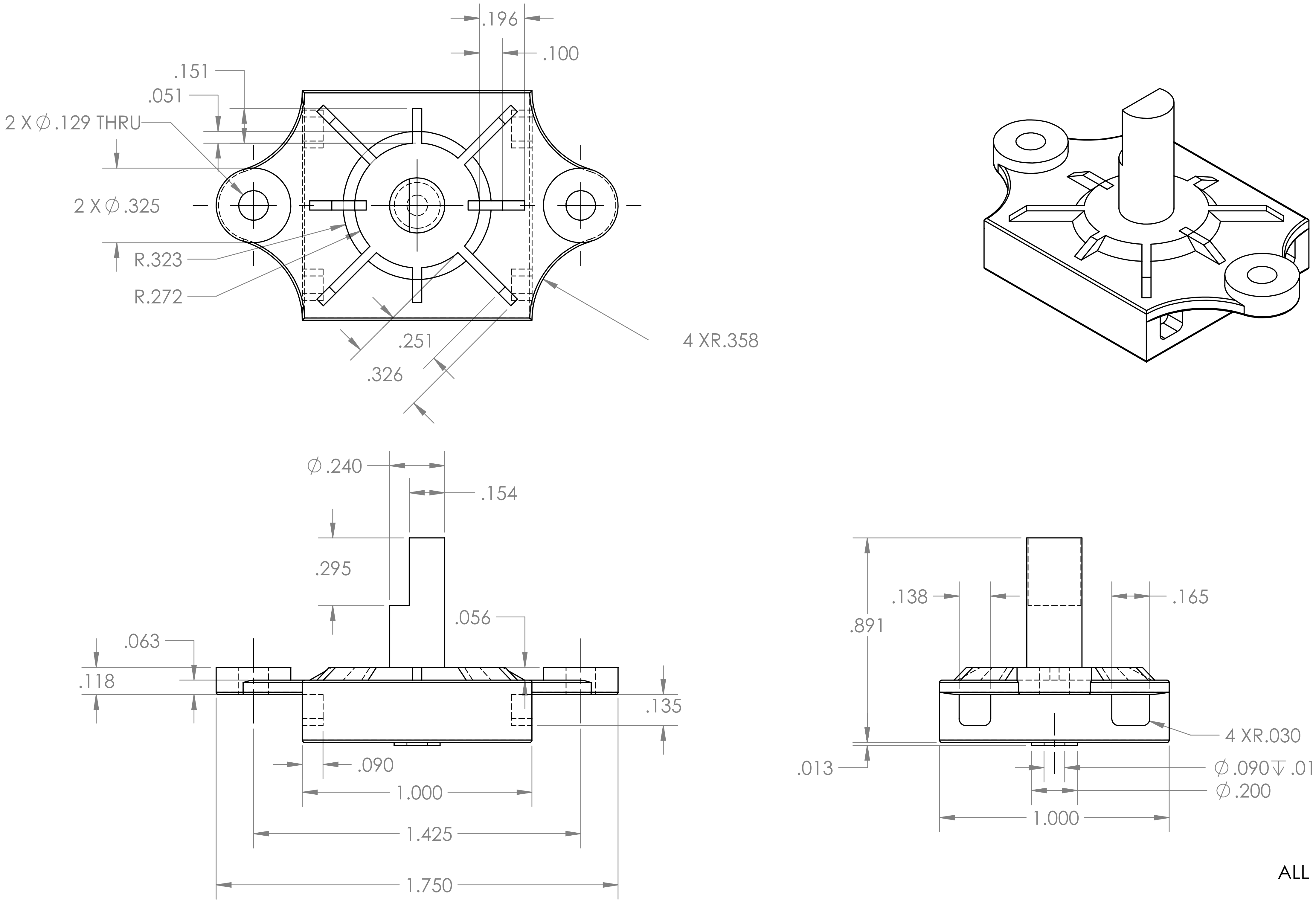
|---|---|---|---|---|---|---|
| | ANGLES ± 1° | .X ± .01 | .XX ± .005 | .XXX ± .001 | DWG. NAME | PLASTIC MOTOR CASING |
| | | | | | STUDENT NAME | MARK LUKE |
| | GD&T INTERPRETED PER Y14.5-2009 | | | | DATE 12/1/2018 | MATERIAL ABS PLASTIC — SCALE 1:1 |




ALL FILLETS R.010 UNLESS OTHERWISE SPECIFIED

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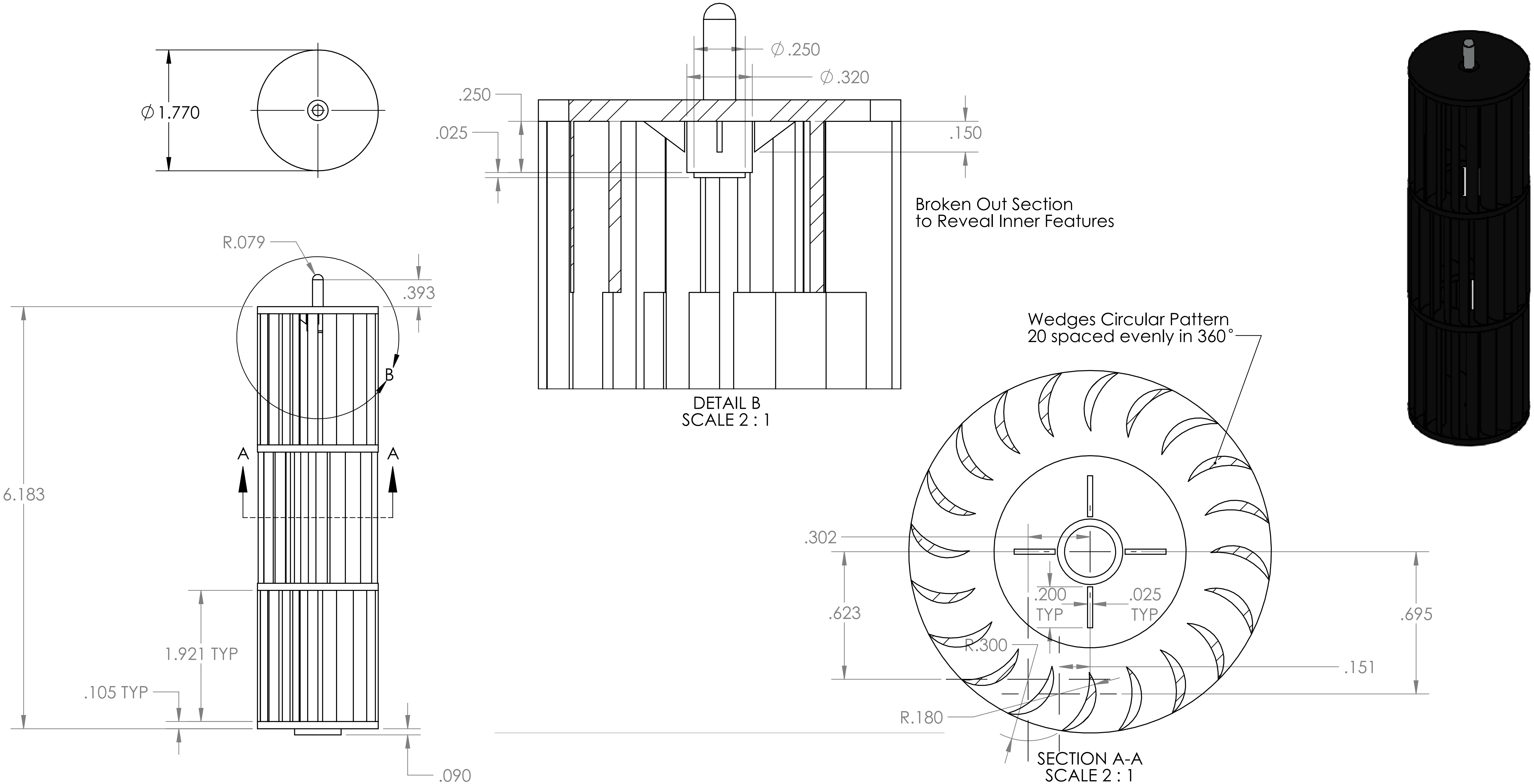
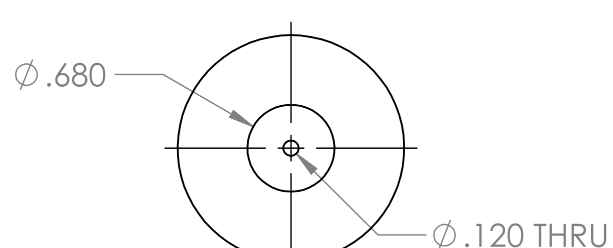
| | ANGLES ± 1° | .X ± .01 | .XX ± .005 | .XXX ± .001 | DWG. NAME | MOTOR CONTROL SWITCH |
| | | | | | STUDENT NAME | RYAN BAILEY |
| | GD&T INTERPRETED PER Y14.5-2009 | | | | DATE 10/11/2018 | MATERIAL ABS PLASTIC; SCALE 2:1 |

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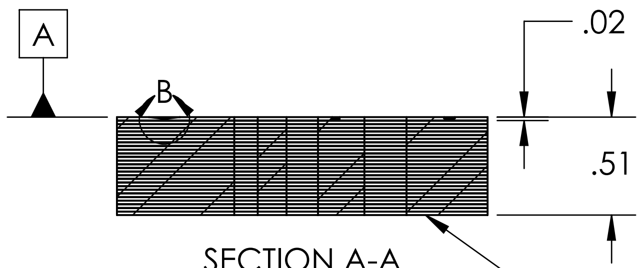
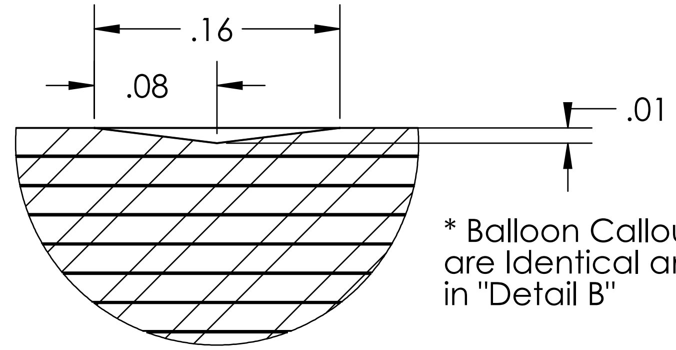
| | ANGLES ± 1° | .X ± .01 | .XX ± .005 | .XXX ± .001 | DWG. NAME | PART 6 | |
| | | | | | STUDENT NAME | DRAWING: GRANT NAIR, PART: RYAN BAILEY | |
| | GD&T INTERPRETED PER Y14.5-2009 | | | | DATE 12/1/18 | MATERIAL PPS | SCALE 2:3 |

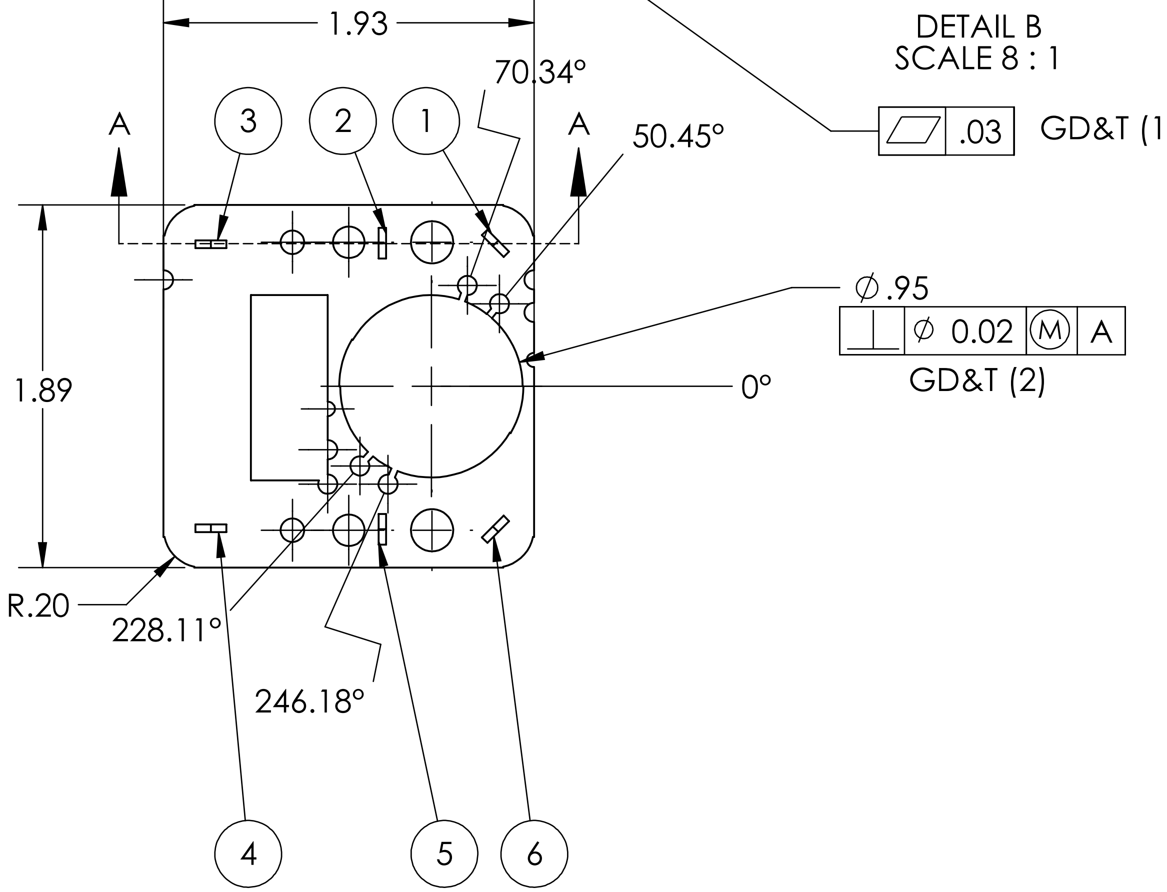


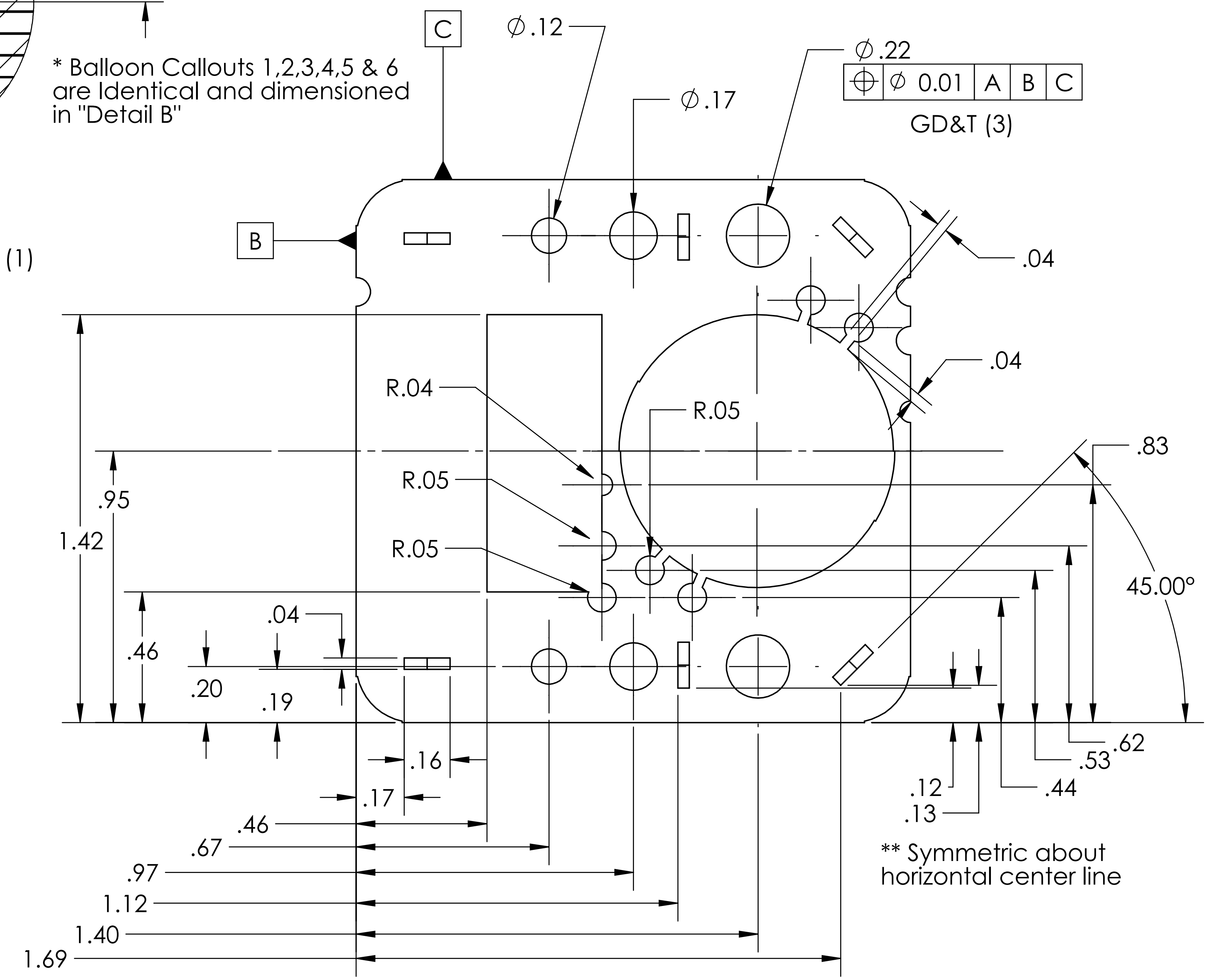

SECTION A-A
SCALE 1 : 1



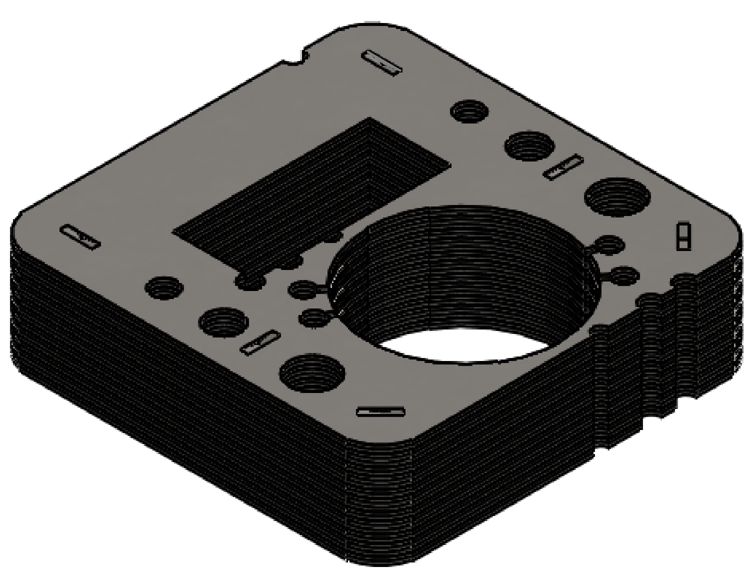

DETAIL B
SCALE 8 : 1

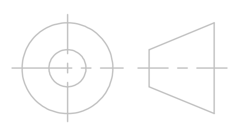
* Balloon Callouts 1,2,3,4,5 & 6 are Identical and dimensioned in "Detail B"




** Symmetric about horizontal center line





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| | ANGLES ± 1° | .X ± .01 | .XX ± .005 | .XXX ± .001 |
| | GD&T INTERPRETED PER Y14.5-2009 | | | |

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| DWG. NAME | MOTOR STATOR | | |
| STUDENT NAME | TEAM GROUP A | | |
| DATE 10/21/2018 | MATERIAL AISI 1020 | | SCALE 2:1 |