Antonio Loaiza

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ABOUT ME

Summary

Mechanical and Aerospace Engineer with 5 years of experience in robotics, UAV development, and CNC manufacturing. Skilled in drone assembly, avionics integration, and precision fabrication of aerospace components. Proficient in programming rotary actuators and advancing structural and thermal design through materials science and mechanical research.

Degree: Bachelors in Bioengineering: Biosystems
GPA: 3.5
Specialization: Stem Cells, Human Embryoid Bodies, Prosthetics, and Robotics

Degree: Masters in Mechanical & Aerospace Engineering
GPA: 3.77
Specialization: UAVs, fluid dynamics, propulsion, heat transfer, robotics and CNC Machining

Contents

ROVER MANUFACTURING RESEARCHER: UC IRVINE

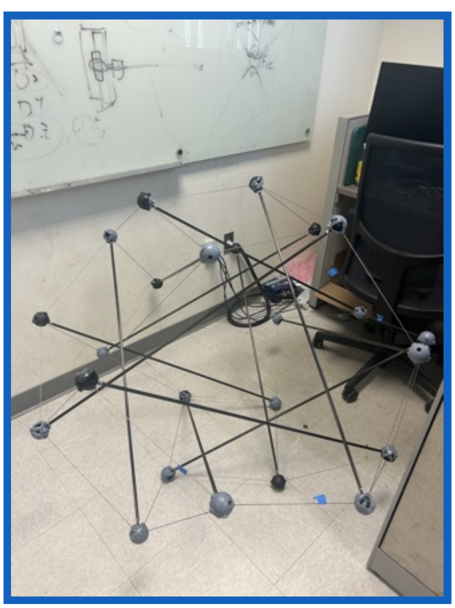
1.1 PROJECT DESCRIPTION

Tensegrity refers to a structure that maintains stability through tensional forces (Fuller, 1982). The idea behind the tensegrity rover comes from research on post-buckling behavior of an octahedron tensegrity structure (Rimoli, 2018, pp. 146-157). Our concept improves current rover maneuvering technologies by introducing a state-of-the-art design using a cable-pulley system integrated into a truncated-octahedron tensegrity structure. This approach leverages the collapsible nature of tensegrity for actuated locomotion, while simultaneously providing an impact-absorbing frame. For my Master's project, I led a group of five undergraduate students to manufacture the tensegrity rover under the supervision of Kevin Garanger (our lab post-doc). The rover consists of the assembled tensegrity structure, along with the following components:

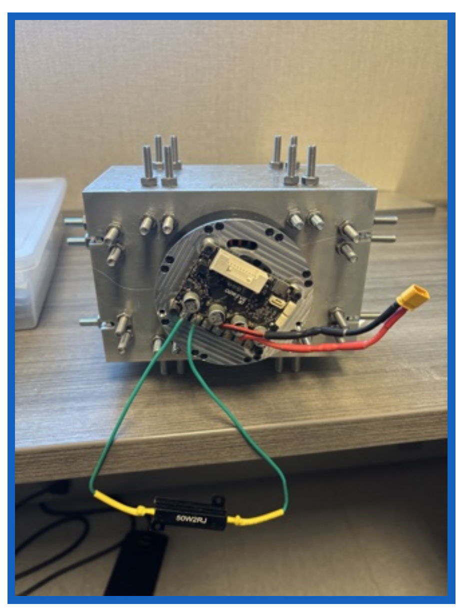
- Motor driver adapter
- Electronics box enclosure
- Collapsible rover structure
- Spool used to spindle the wires of the structure
- Two versions of nodes with dowels

The rover manufacturing project consists of the following documents:

- Motor driver dimensions and purpose
- Electronics box enclosure dimensions and purpose
- Collapsible rover purpose
- Spool system dimensions and purpose
- Protocol for making two sets of nodes



Tensegrity Structure

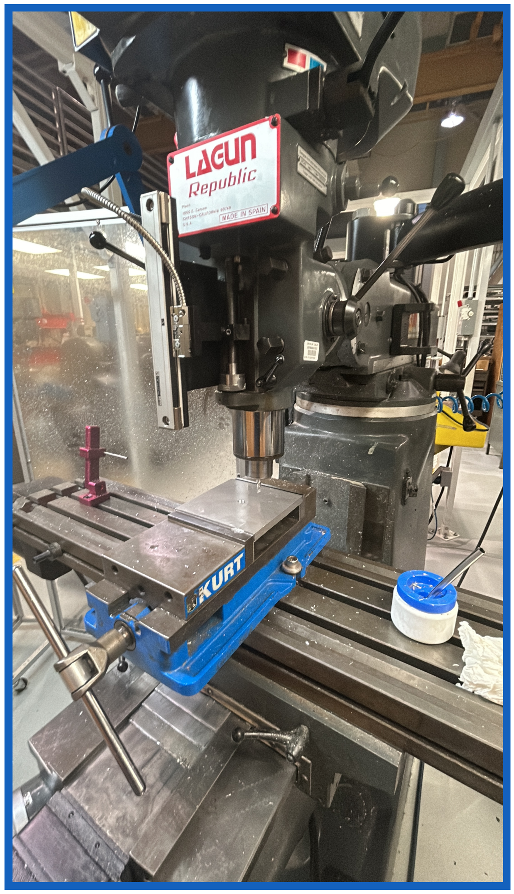


Electronics Enclosure

1.2 METHODS/SKILLS

- SolidWorks parts, assembly, and drawings
- Lathe Machining
- CNC and Bridgeport Milling Machining
- Plasma Laser Cutter
- Python Code for CAN-Bus Communication
- Abaqus structural simulations

Lathe Milling Machine



Bridgeport Milling Machine

Plasma Laser Cutter

1.3 RESULTS

- CAD designed and CNC machined a lightweight motor driver mount for a rotary motor, reducing the weight by a third.
- Designed and trained undergraduate students to CNC machine aluminum nodes, dowels, rods, and pulley components for a collapsible rover.
- Documented manufacturing rover components with GD&T protocols, recording dimensional accuracy of mechanical stacking alignment within ± 0.2 mm tolerances.
- Built a collapsible tensegrity rover capable of absorbing 17% compression strain and programmed its rotary motor with CAN Bus, enabling 9× faster data speed and real-time actuation.
- Developed a detailed protocol for manufacturing collapsible rover parts, allowing future graduate and undergraduate students to design and make their own components.

1.4 MOTOR DRIVER ADAPTER

Component Description:

The collapsible rover relies on a central rotary motor that serves to pull the wires and compress the robot's structure. Upon releasing the pulled cables, the sudden expansion created by the tension allows the robot to move back and forth.

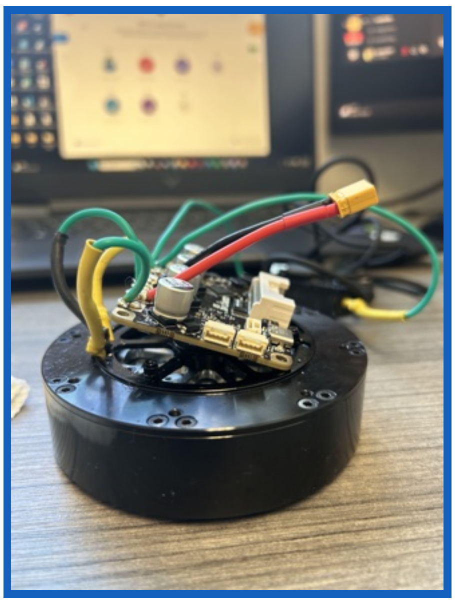
Problem Encountered:

A challenge encountered when working with the rotary motor was that the motor driver on the actuator relied on buggy software to control the motor. Our goal was to control the rotary actuator via CAN-Bus communication written with Python code. When adapting the new motor driver, our driver was not suitable for the current motor casing.

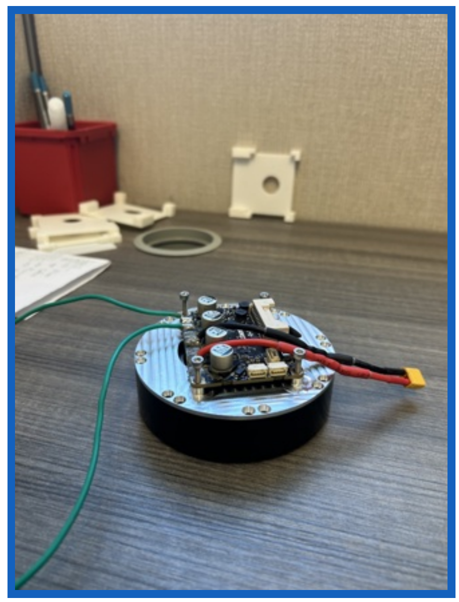
Solution:

The solution to improve the motor was to replace the motor driver. To mount the new motor driver on the rotary actuator, I designed a new casing for the motor using CAD and manufactured it with CNC and milling machines.

(a) Before

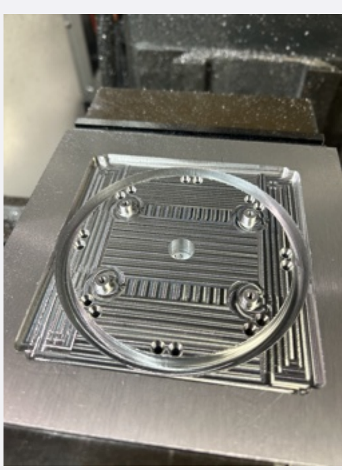
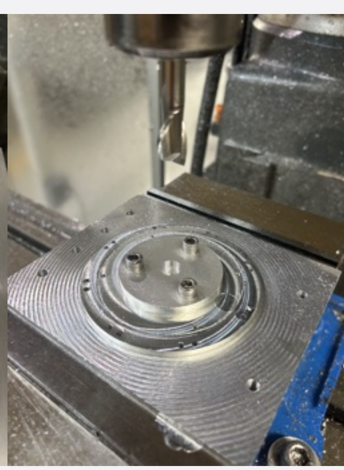


(b) After

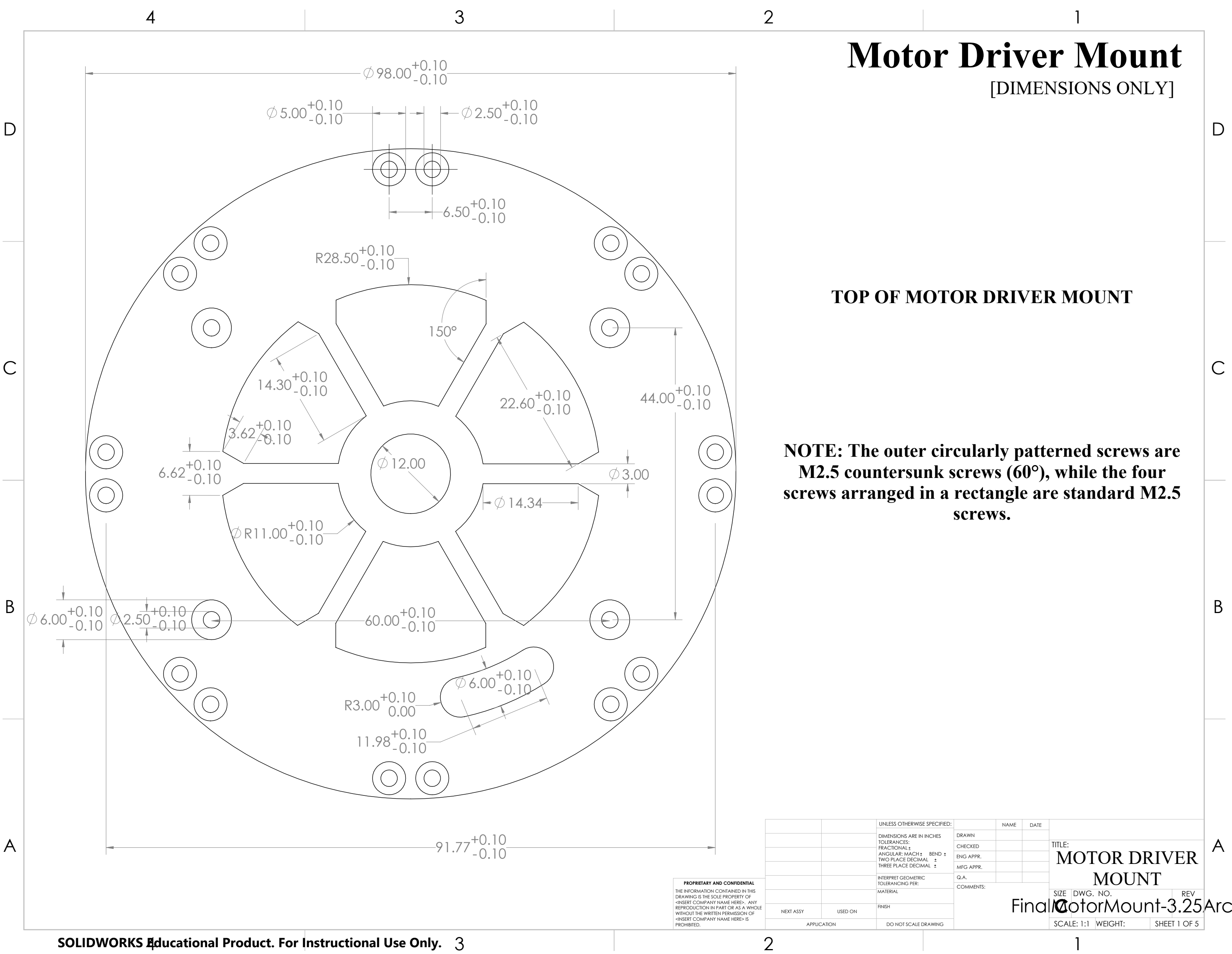


(a,b) Before & After: Manufacturing Motor Driver Adapter for Rotary Actuator

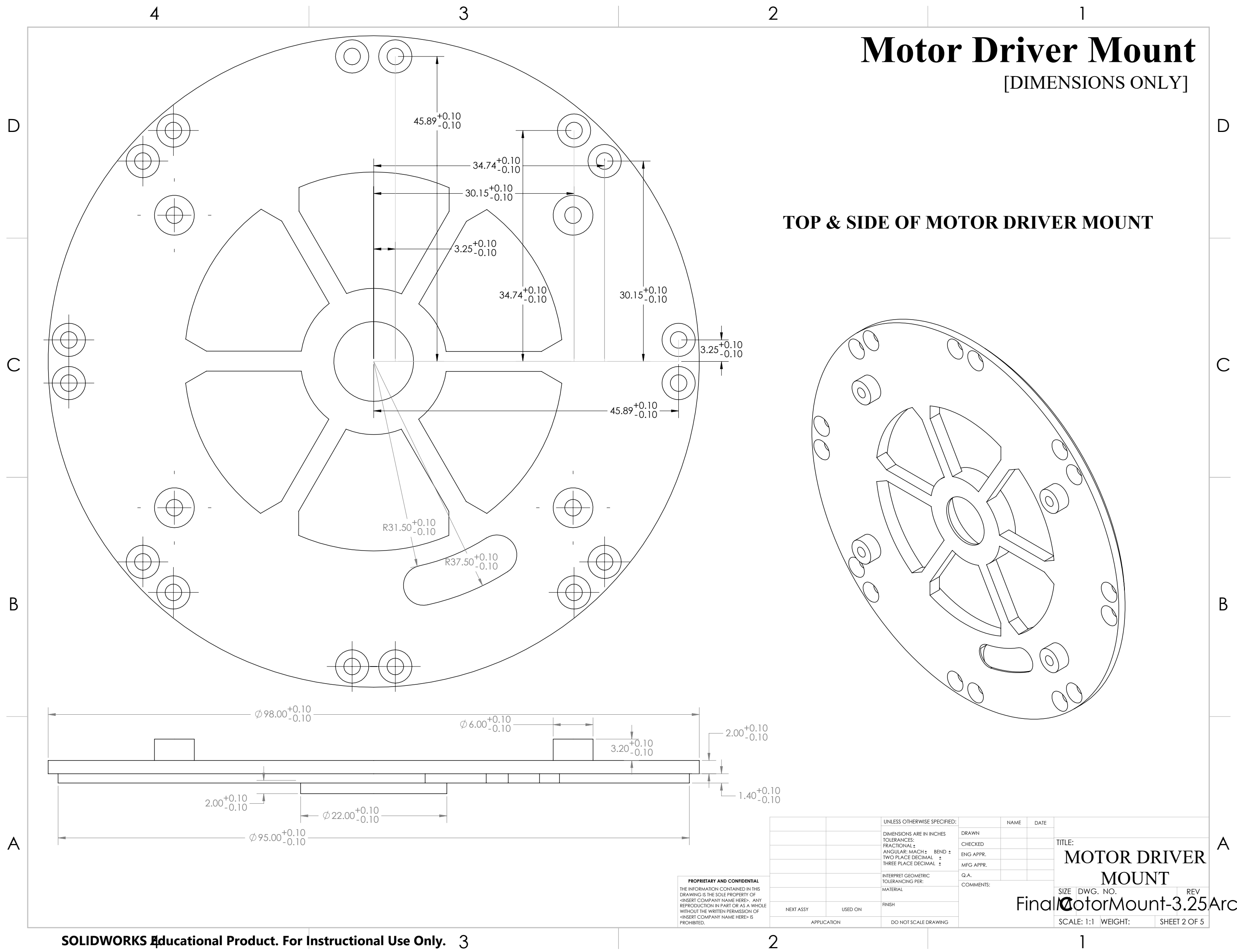
Progress

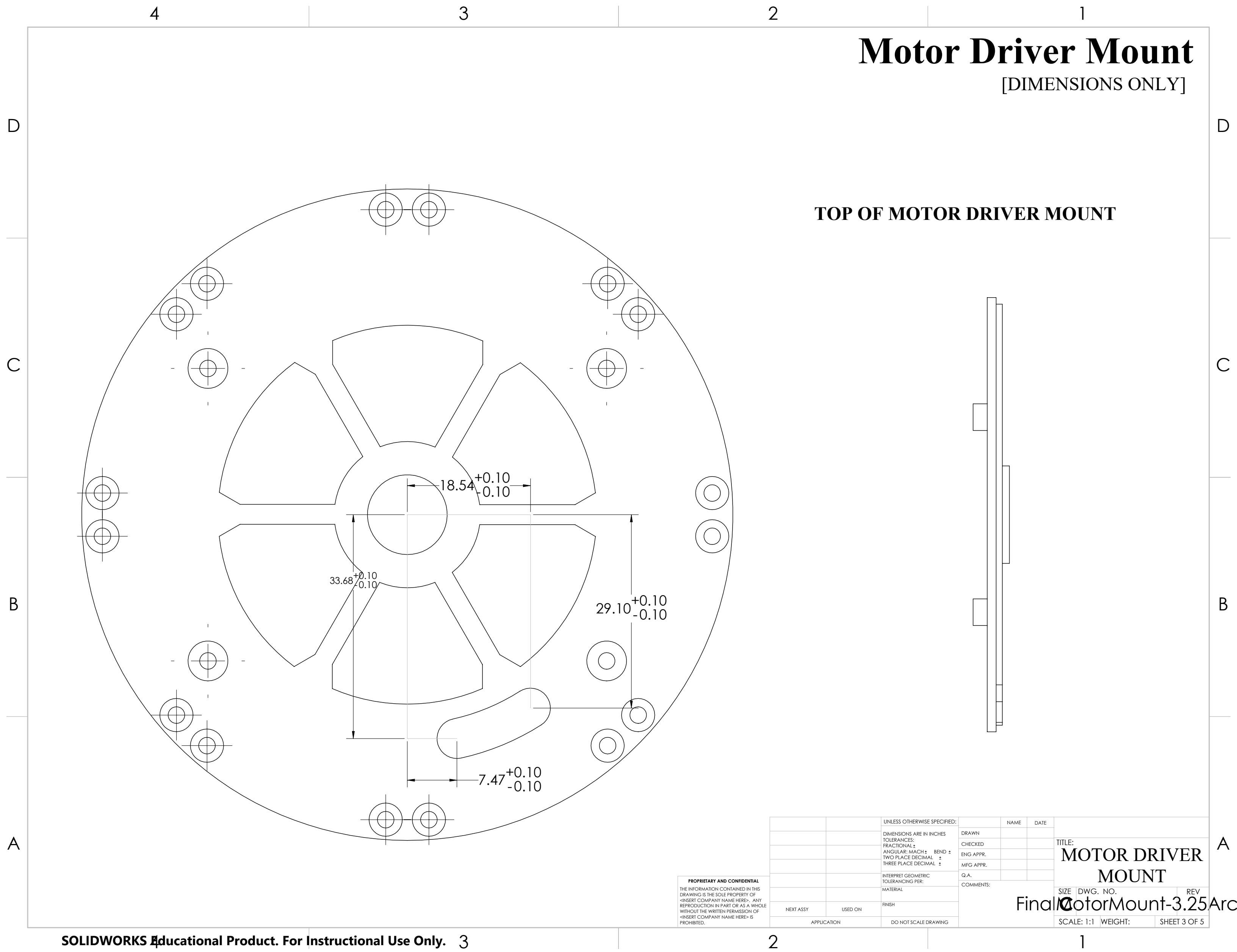
Motor Driver Adapter Dimensions (Page 1 of 4)



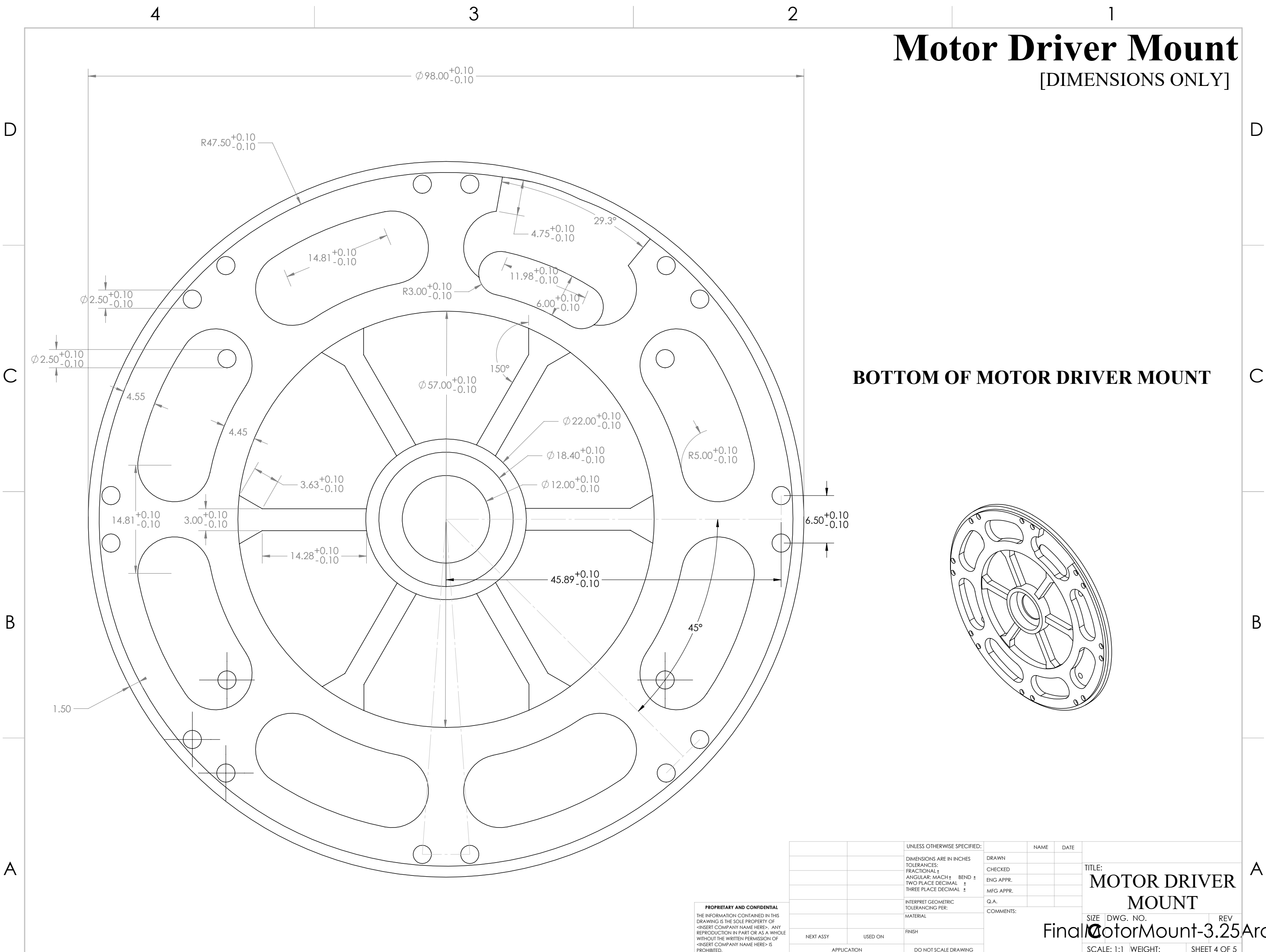
Motor Driver Adapter Dimensions (Page 2 of 4)



Motor Driver Adapter Dimensions (Page 3 of 4)



Motor Driver Adapter Dimensions (Page 4 of 4)



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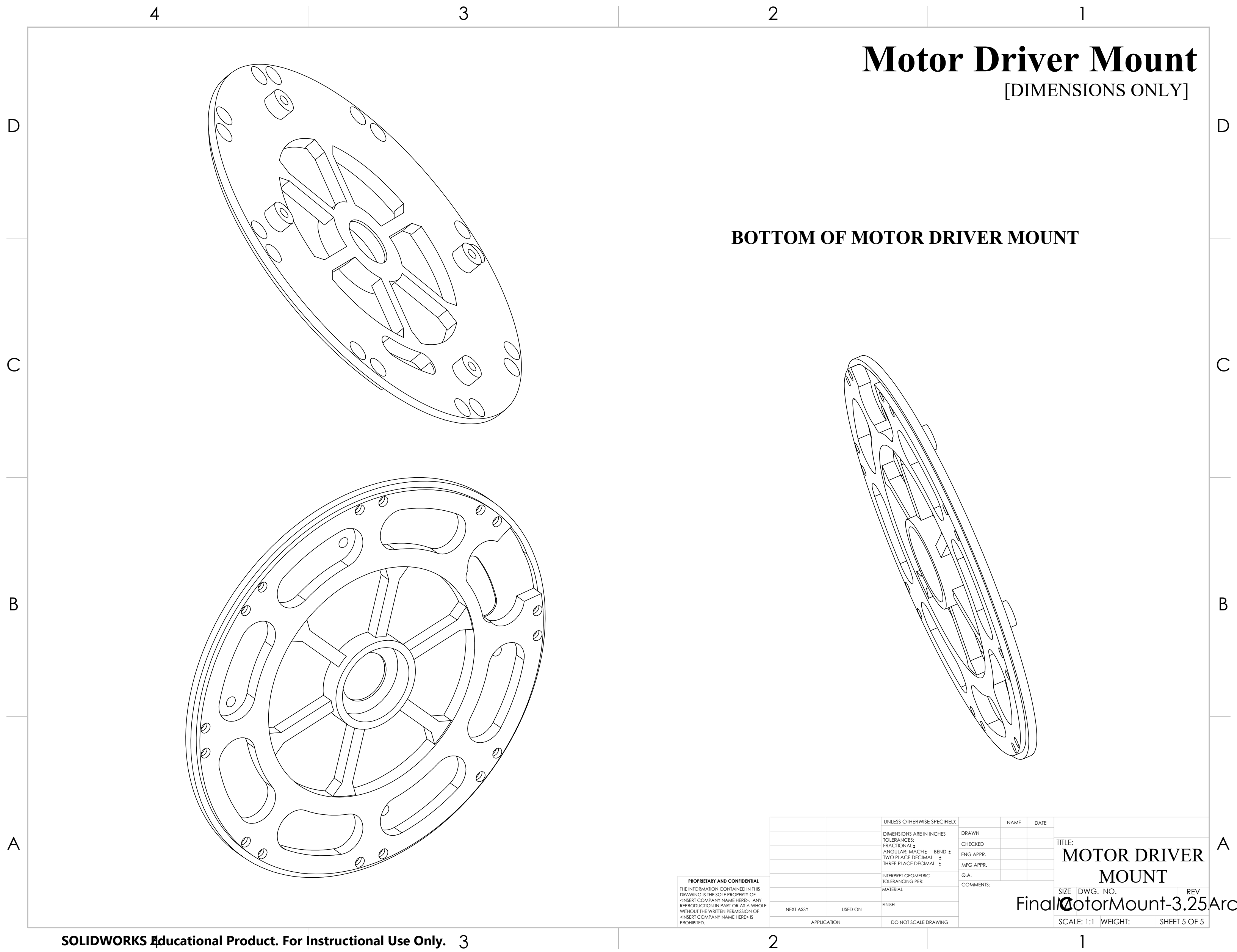
Motor Driver Adapter Dimensions (Page 5 of 5)

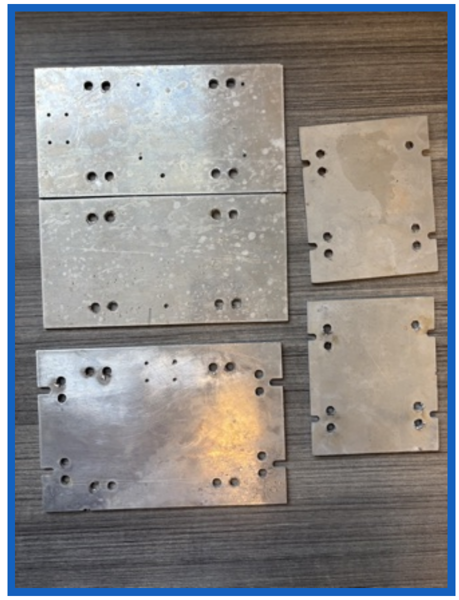


1.5 ELECTRONICS ENCLOSURE

Component Description:

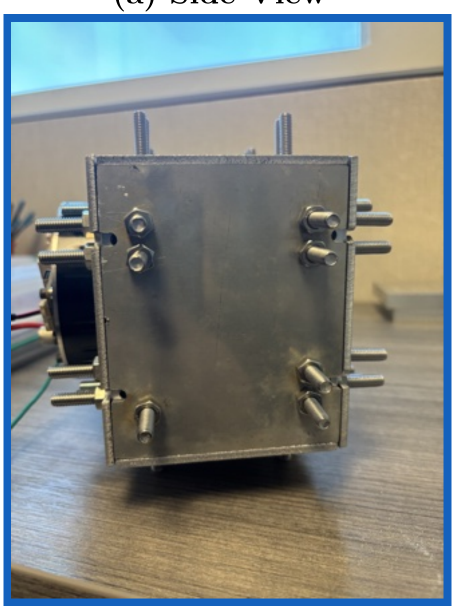
For this part of the project, I collaborated with an undergraduate student to manufacture and assemble the electronics box. Under my supervision, a team of undergraduate students designed the faces of the electronics box. Next, I fabricated the electronics box enclosure using a 1/8" aluminum sheet metal by cutting out the box faces with a plasma cutter. Then, I made a waste brick to mount the plates of the box on the milling machine and drill M2.5 and M3 screw holes. Along with this, I trained an undergraduate student (Sharon) to use a milling machine to produce aluminum bridges that joined the aluminum faces of the electronics box together. The figures below show the plasma cutter carving the electronics box faces, the electronics box assembly, and the integration of the motor driver adapter with the rotary actuator.

Plasma Cutting Box

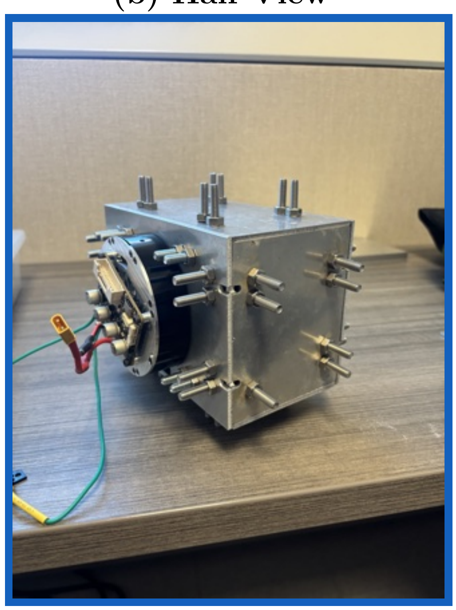


Electronics Box Sides

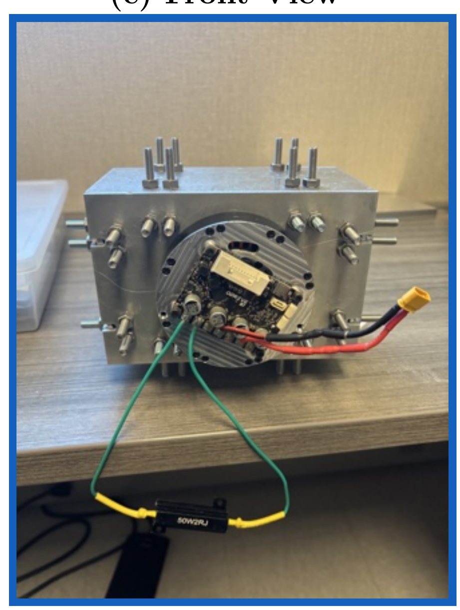
(a) Side View



(b) Half View

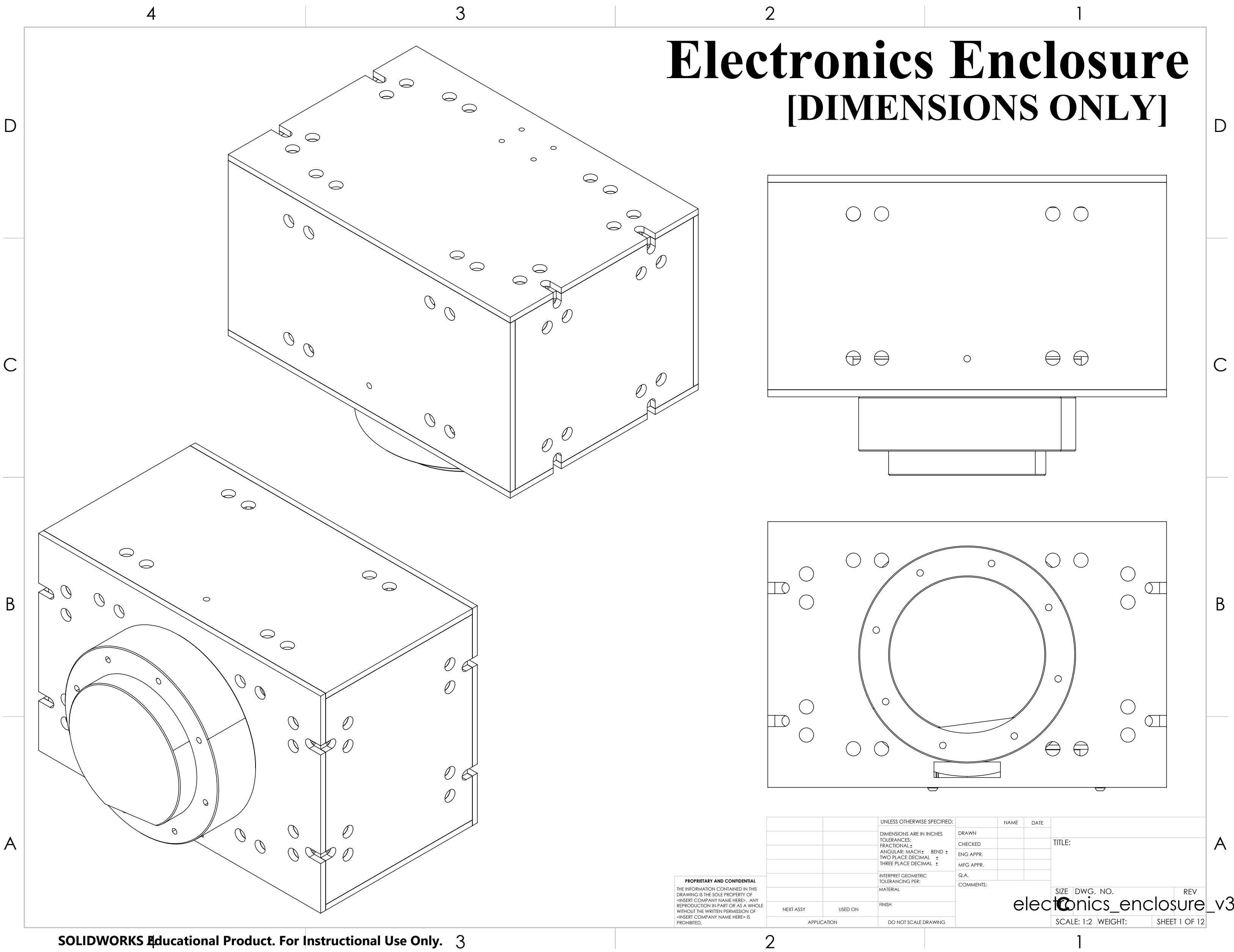


(c) Front View



(a-c) Side, Half, and Front View of the Electronics Box Enclosure with Rotary Actuator

Electronics Enclosure Dimensions (Page 1 of 12)



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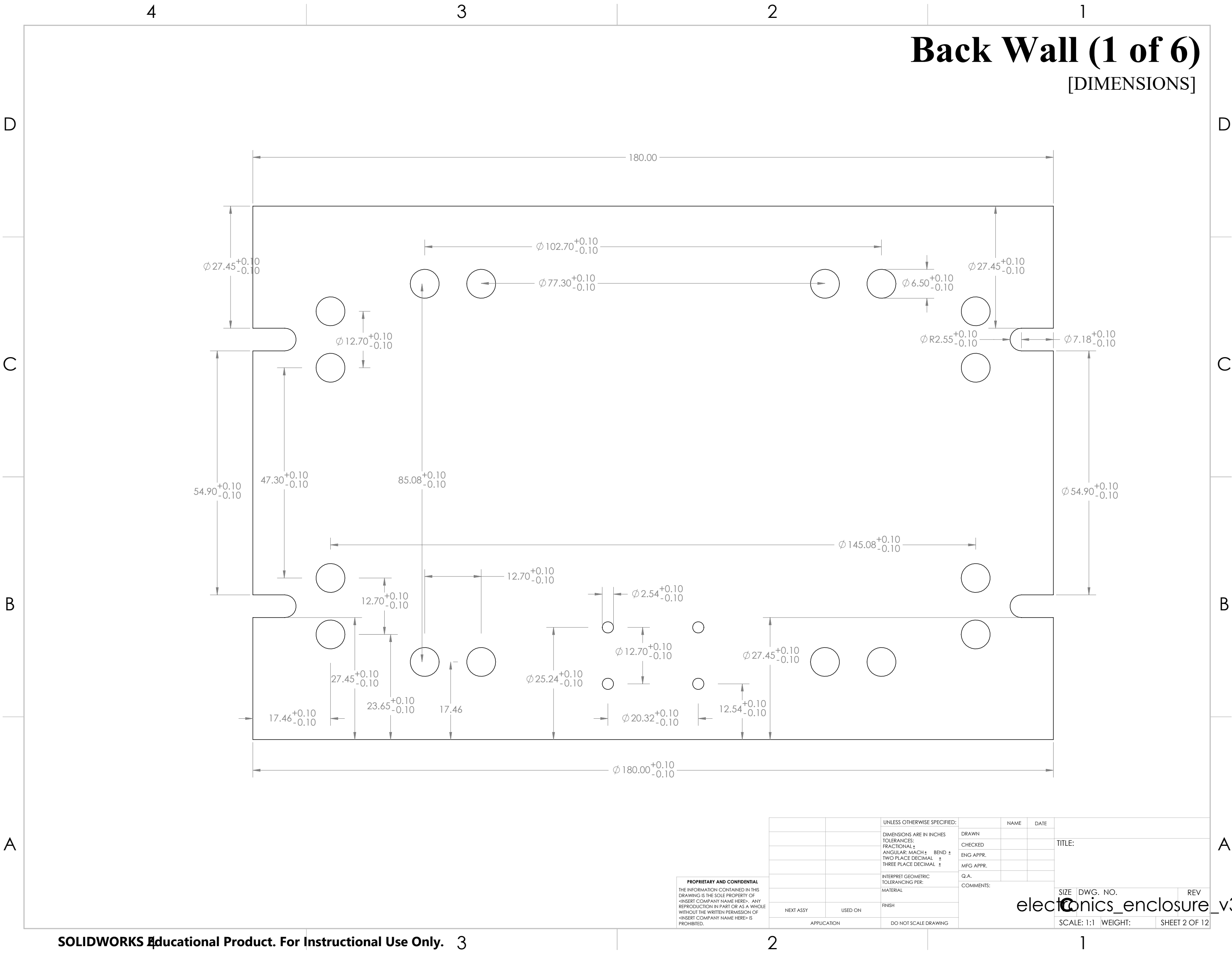
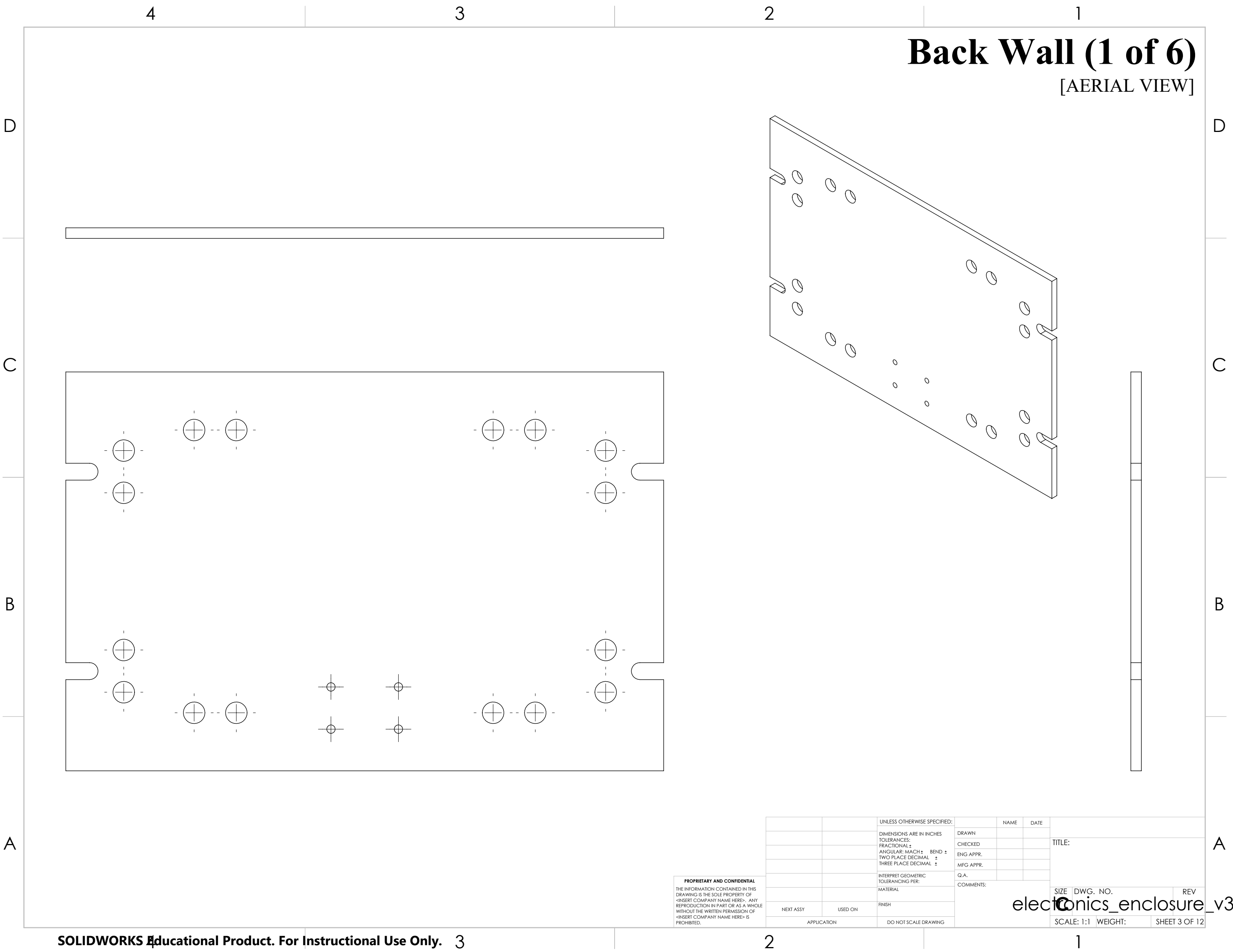


Electronics Enclosure Dimensions (Page 3 of 12)



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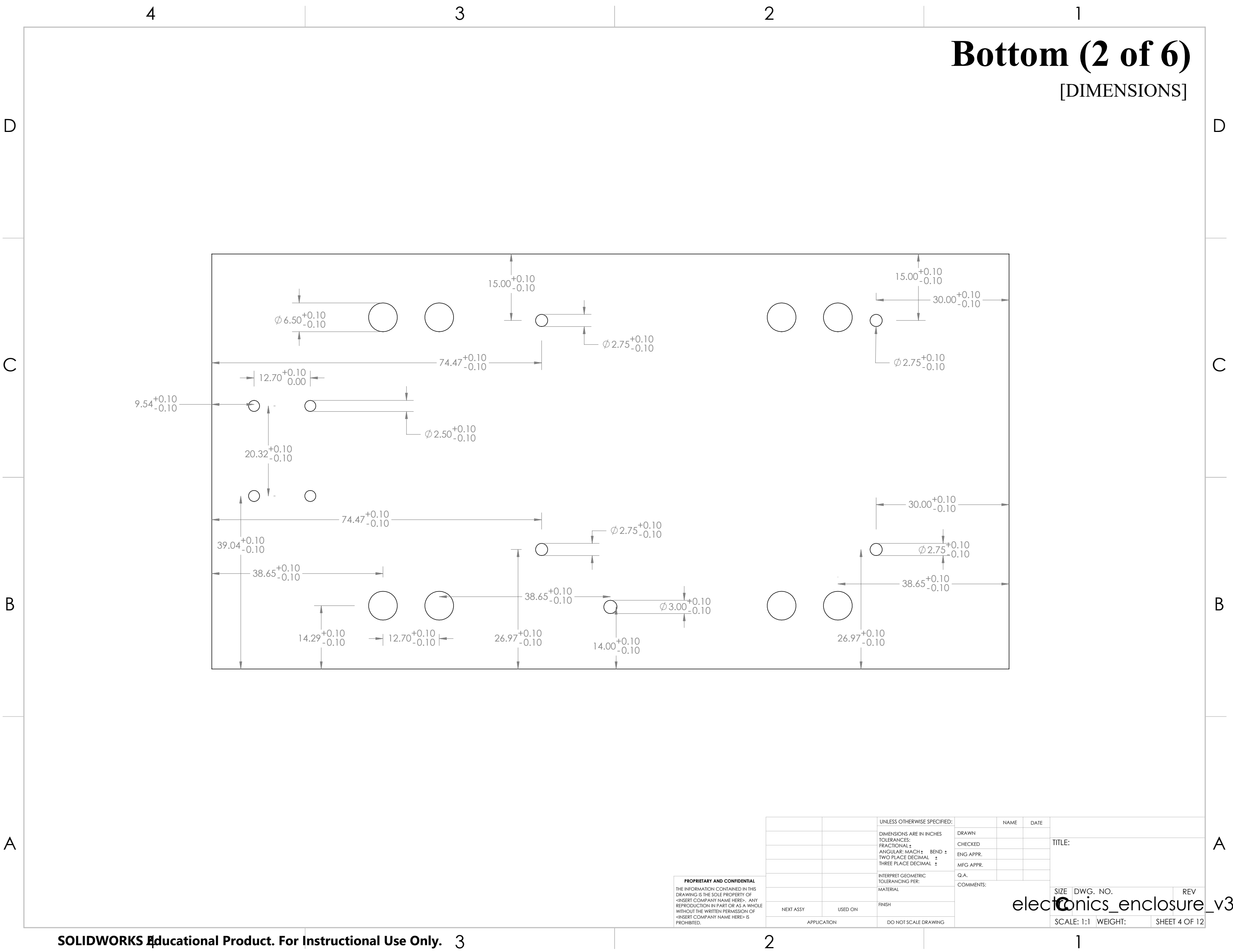

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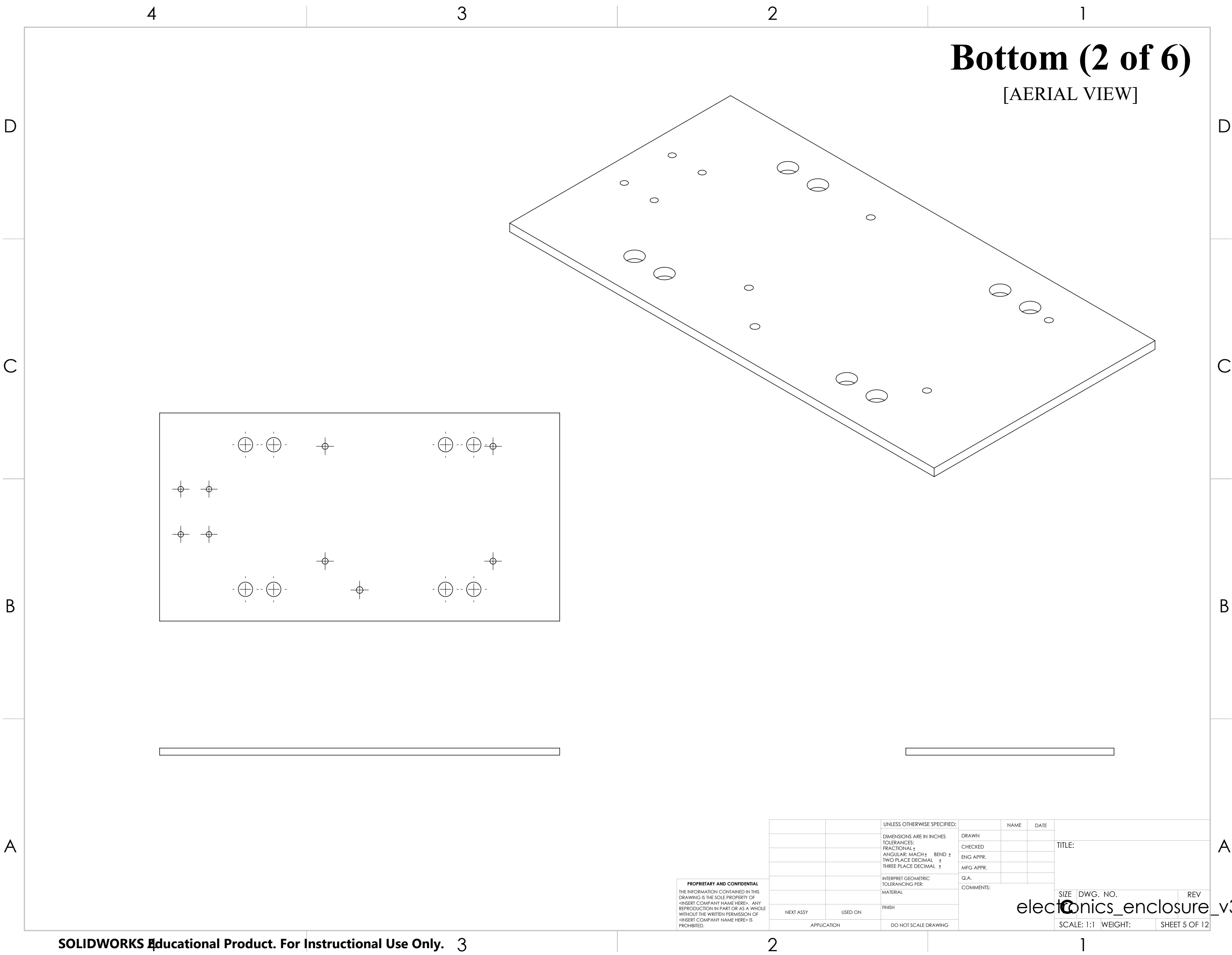

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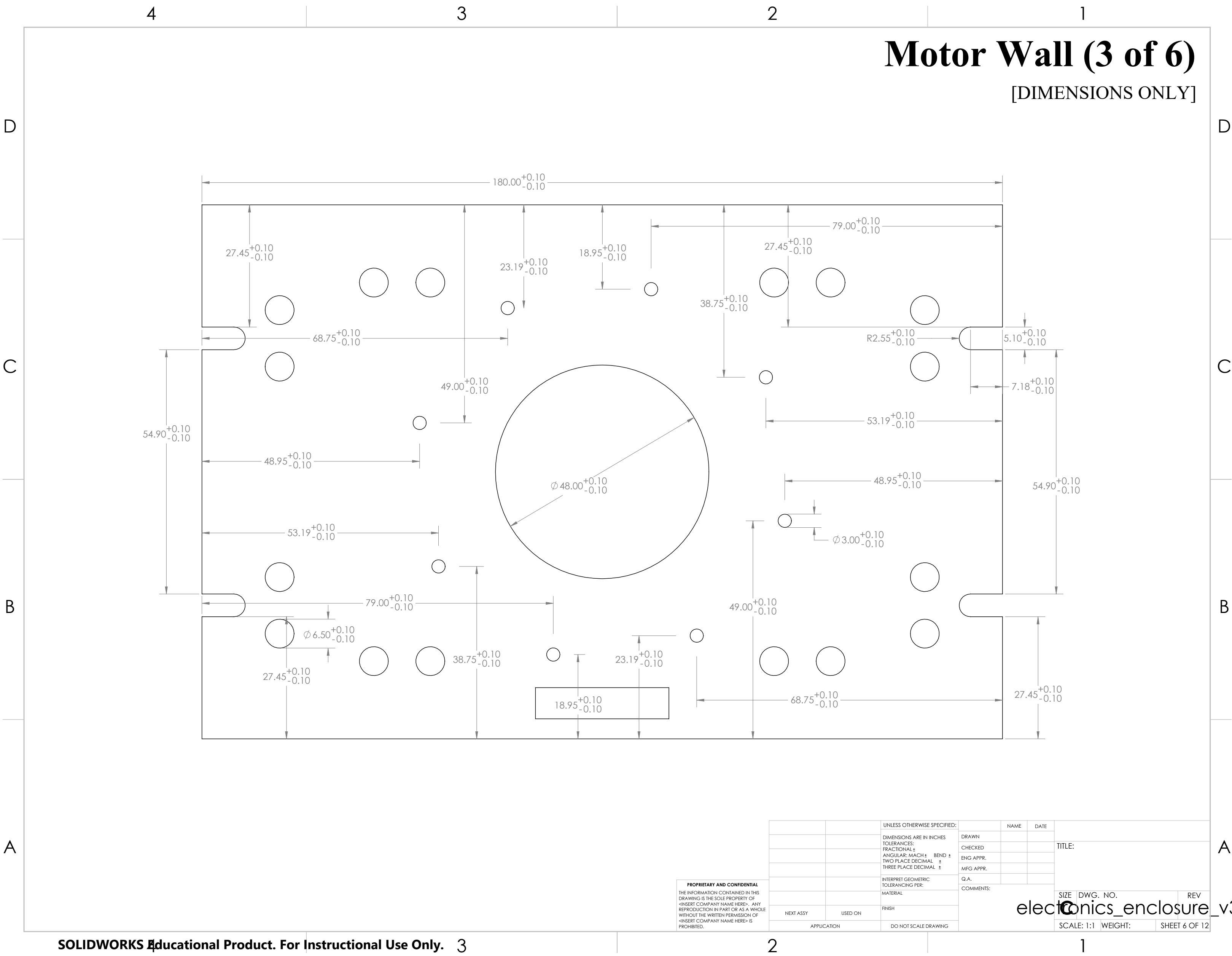
Electronics Enclosure Dimensions (Page 6 of 12)



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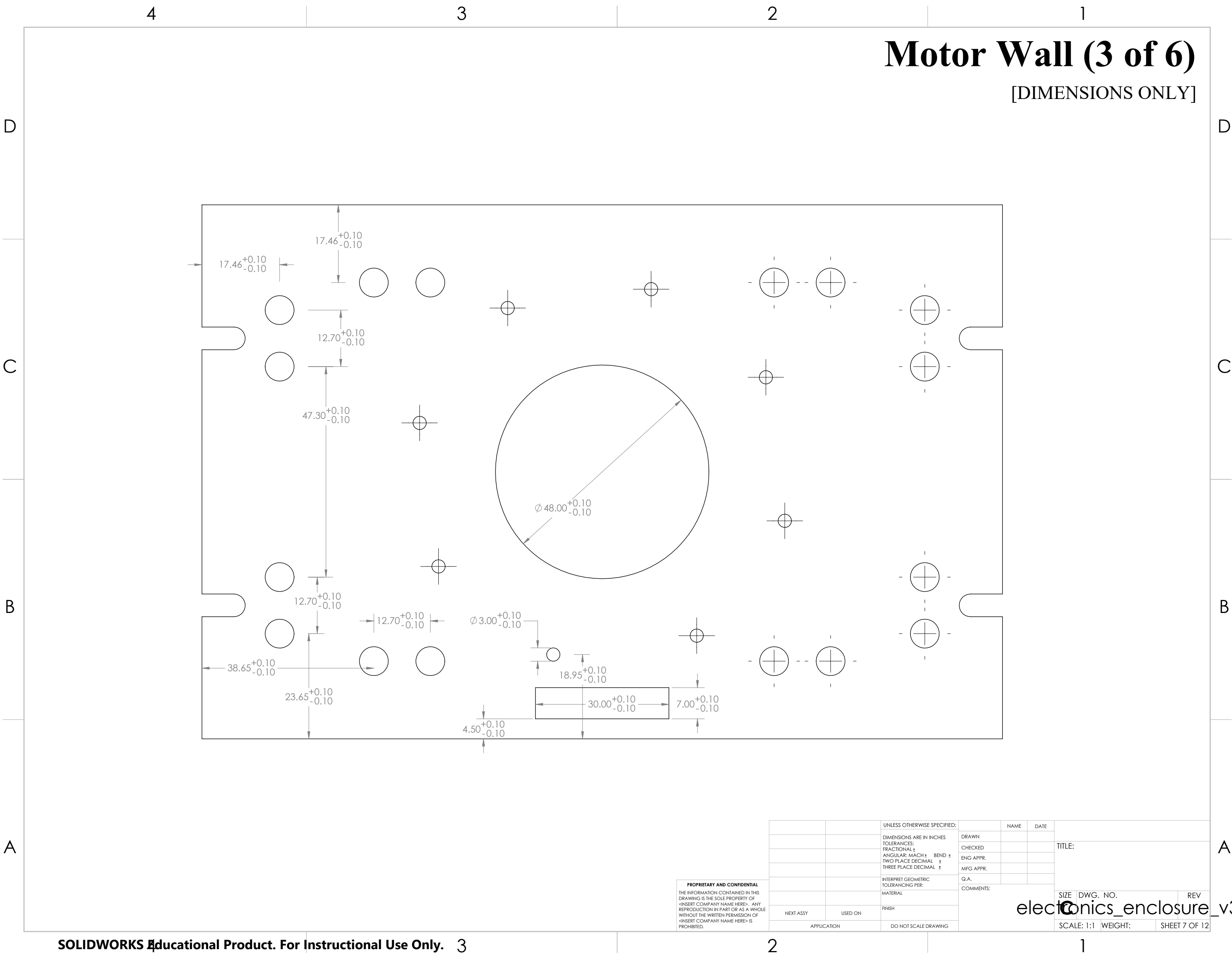
Electronics Enclosure Dimensions (Page 7 of 12)



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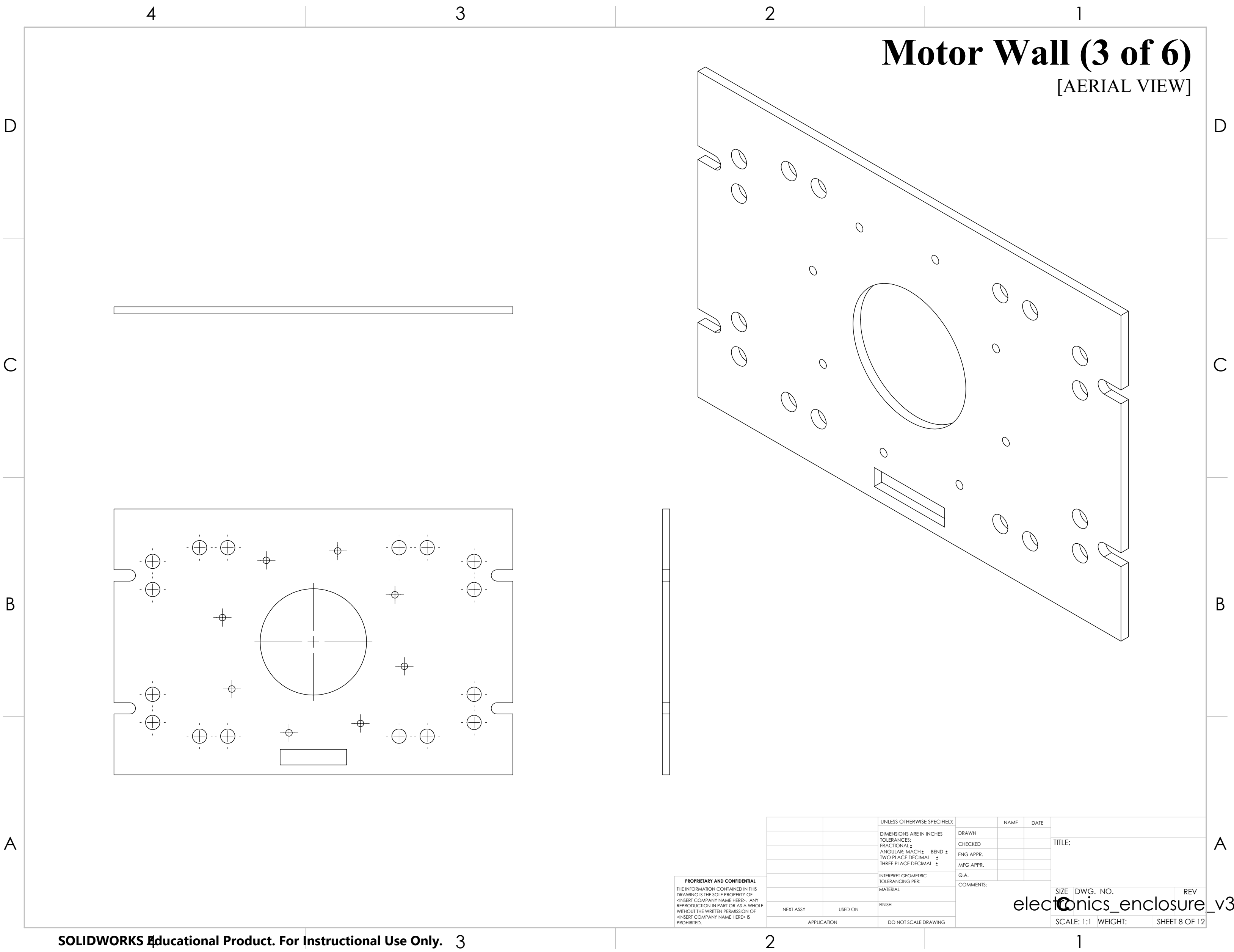
Electronics Enclosure Dimensions (Page 8 of 12)



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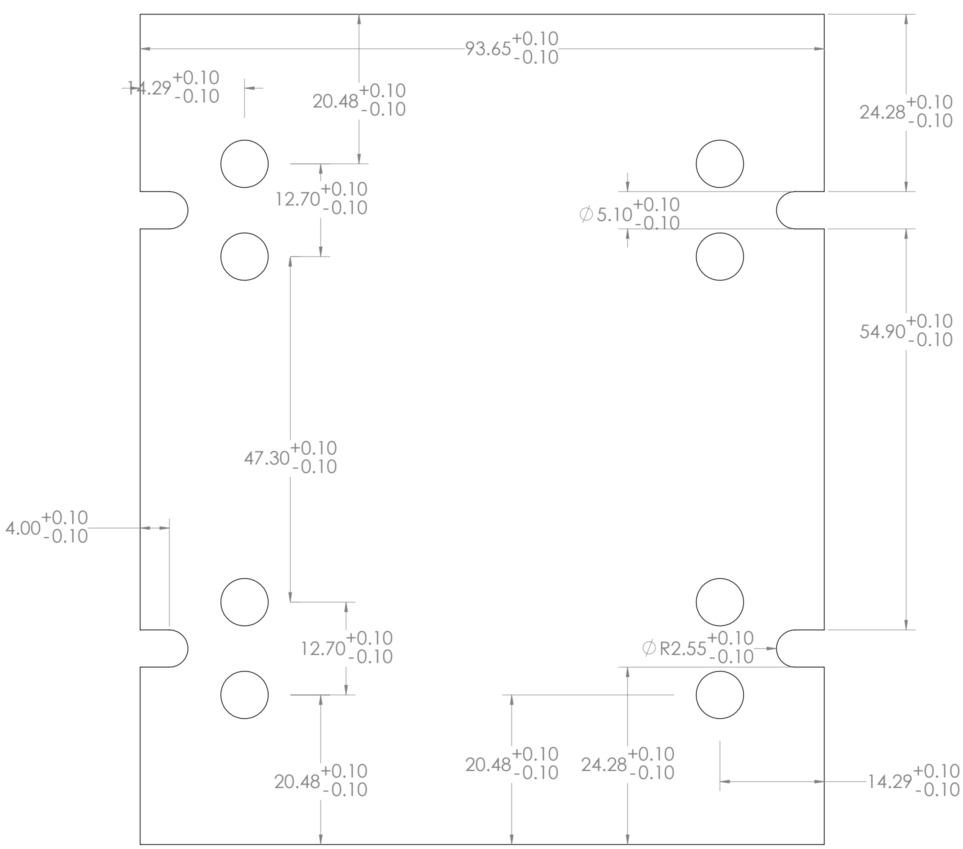
Electronics Enclosure Dimensions (Page 9 of 12)

4 3 2 1

Side Panels (4 and 5 of 6)

[DIMENSIONS]



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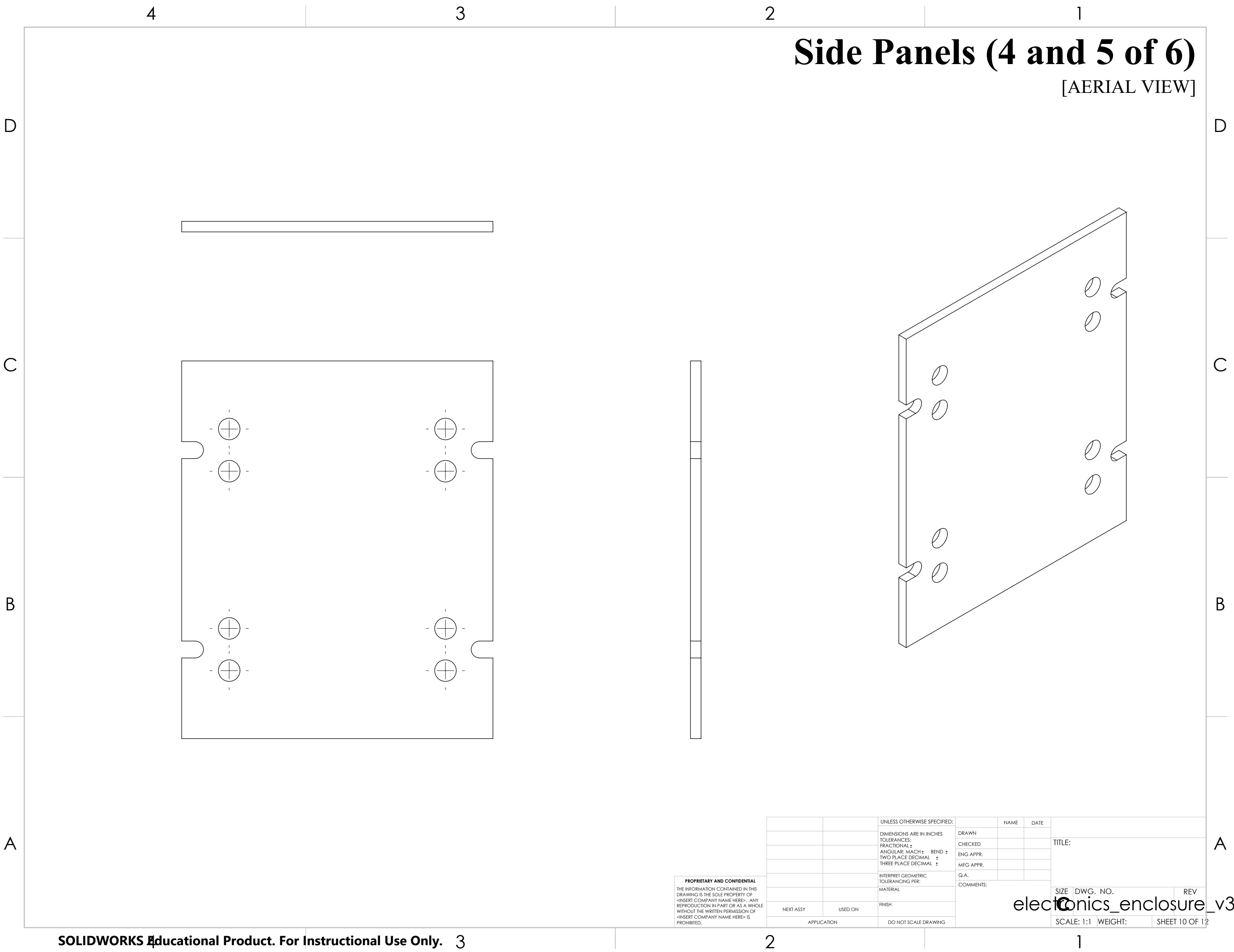
Electronics Enclosure Dimensions (Page 10 of 12)



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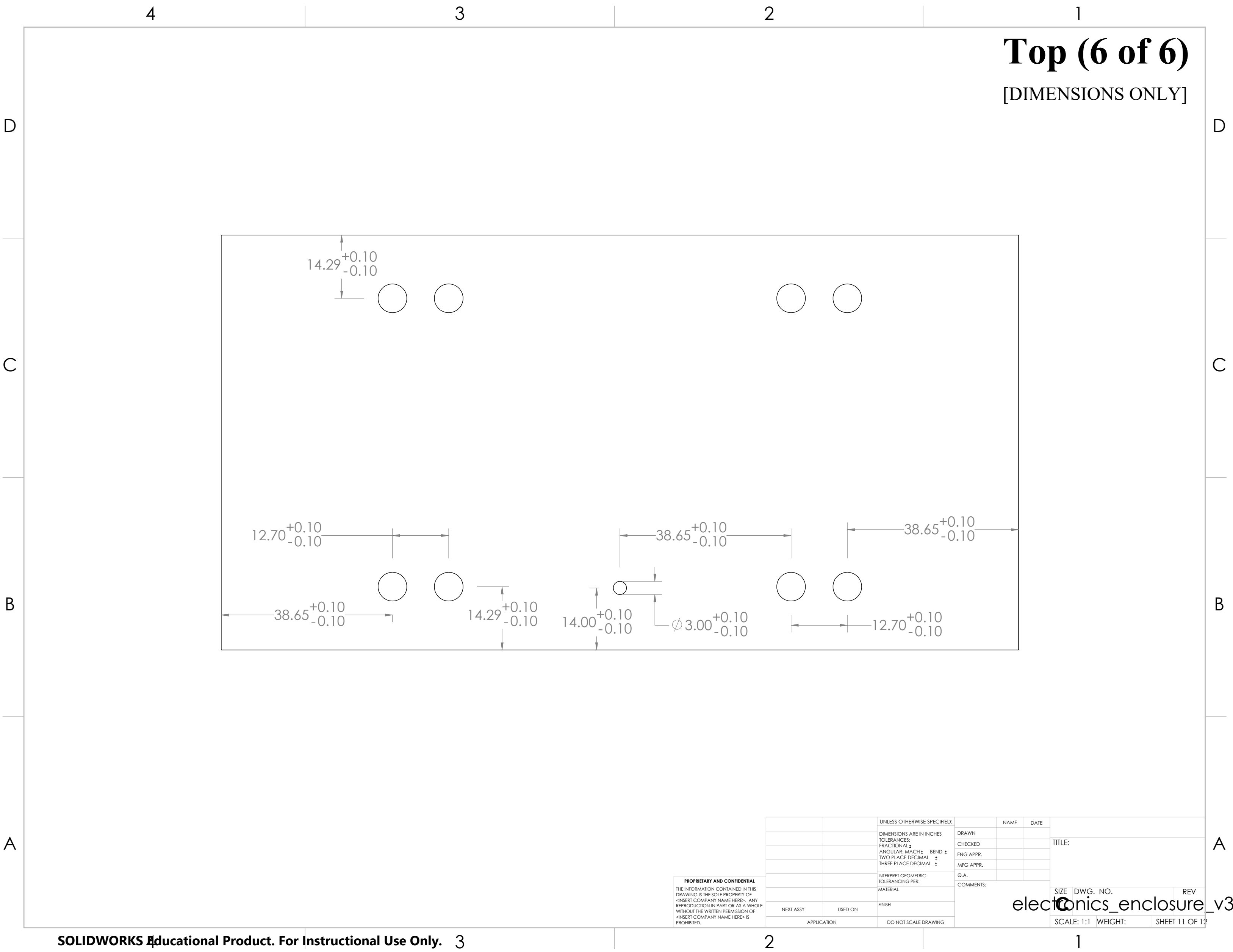
Electronics Enclosure Dimensions (Page 11 of 12)



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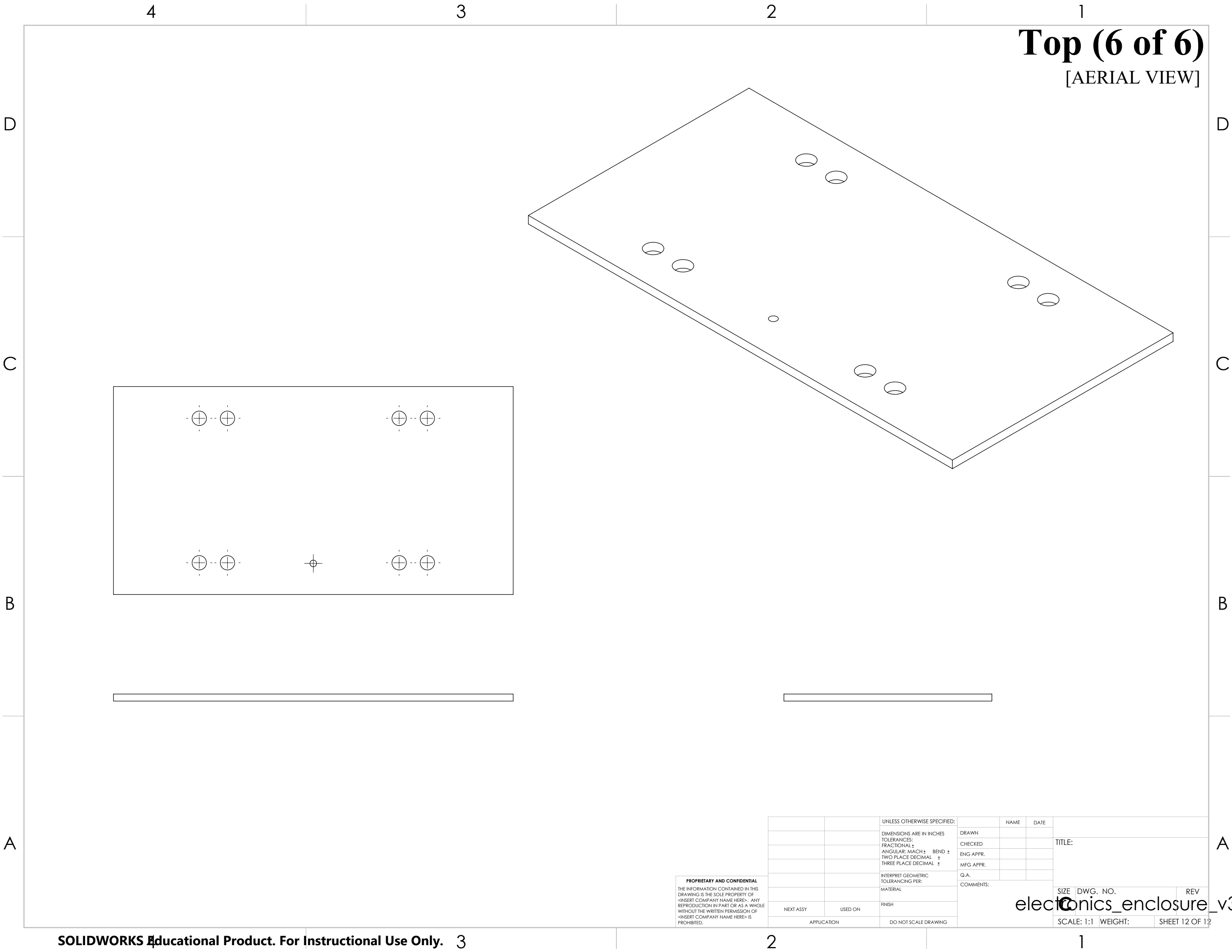

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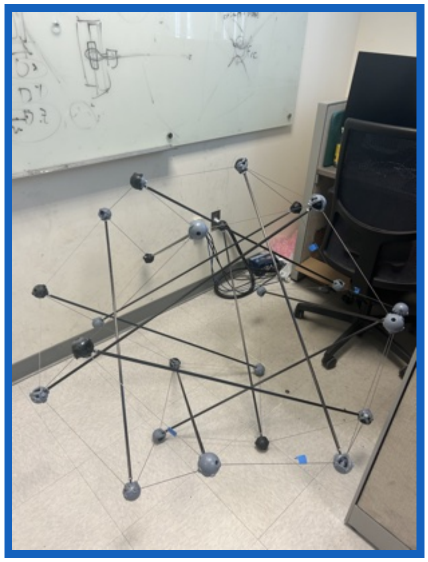
1.6 COLLAPSIBLE ROVER STRUCTURE

Component Description:

The figure below displays the structure of our rover. I led and supervised a team of undergraduate students in creating a CAD model and assembling a collapsible tensegrity rover. The rover features CAD-designed block nodes, aluminum rods, steel cables, and over 3,000 individual components. We bought the aluminum rods and steel cables online and cut them to size in the workshop. The structure supported the weight of the electronics enclosure, motor, two node variations, and the large spool, while also accommodating the deformation required for locomotion.



Collapsible Tensegrity Rover Structure

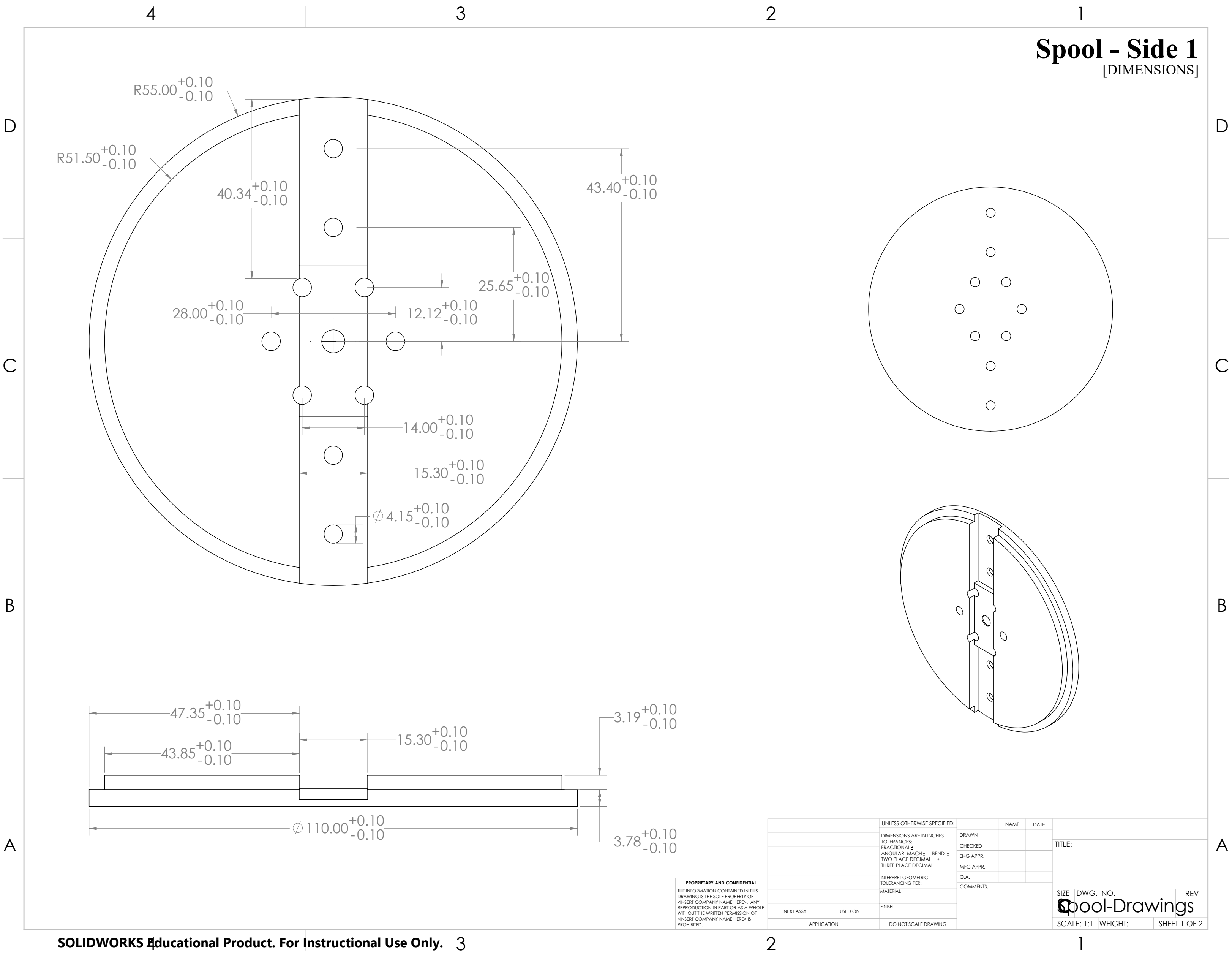
1.7 SPOOL SYSTEM

Component Description:

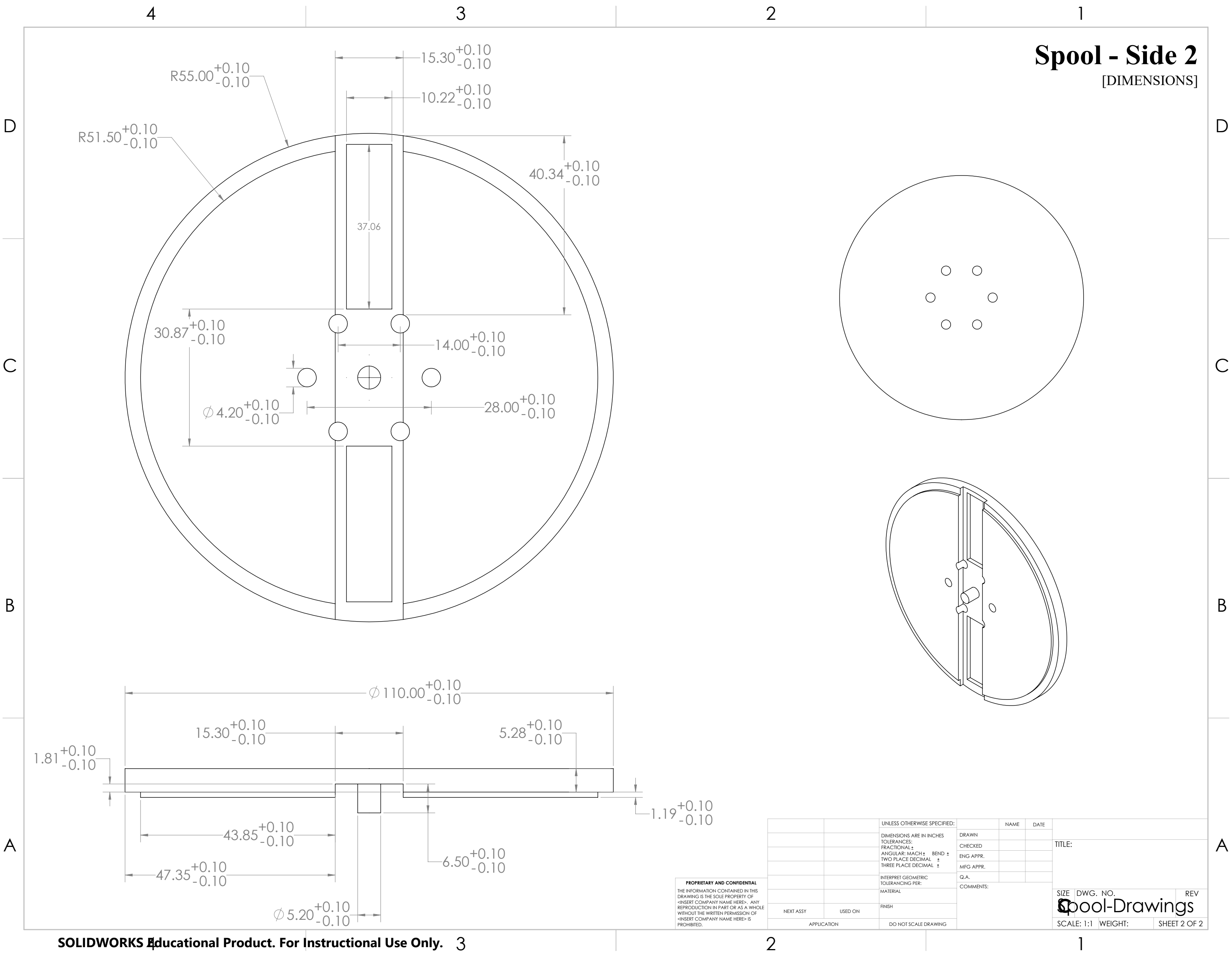
The spool is a critical component of the tensegrity rover, serving as a pulley mechanism while guiding the wires through the structure's nodes. I manufactured the spool by designing it in CAD and machining it with a CNC. The dimensions of the spool are detailed in the following pages. This spool is mounted in a linear gear train manner to the rotary actuator, generating movement with the motor.

CNC Machined Spool

Spool Dimensions (Page 1 of 2)



Spool Dimensions (Page 2 of 2)



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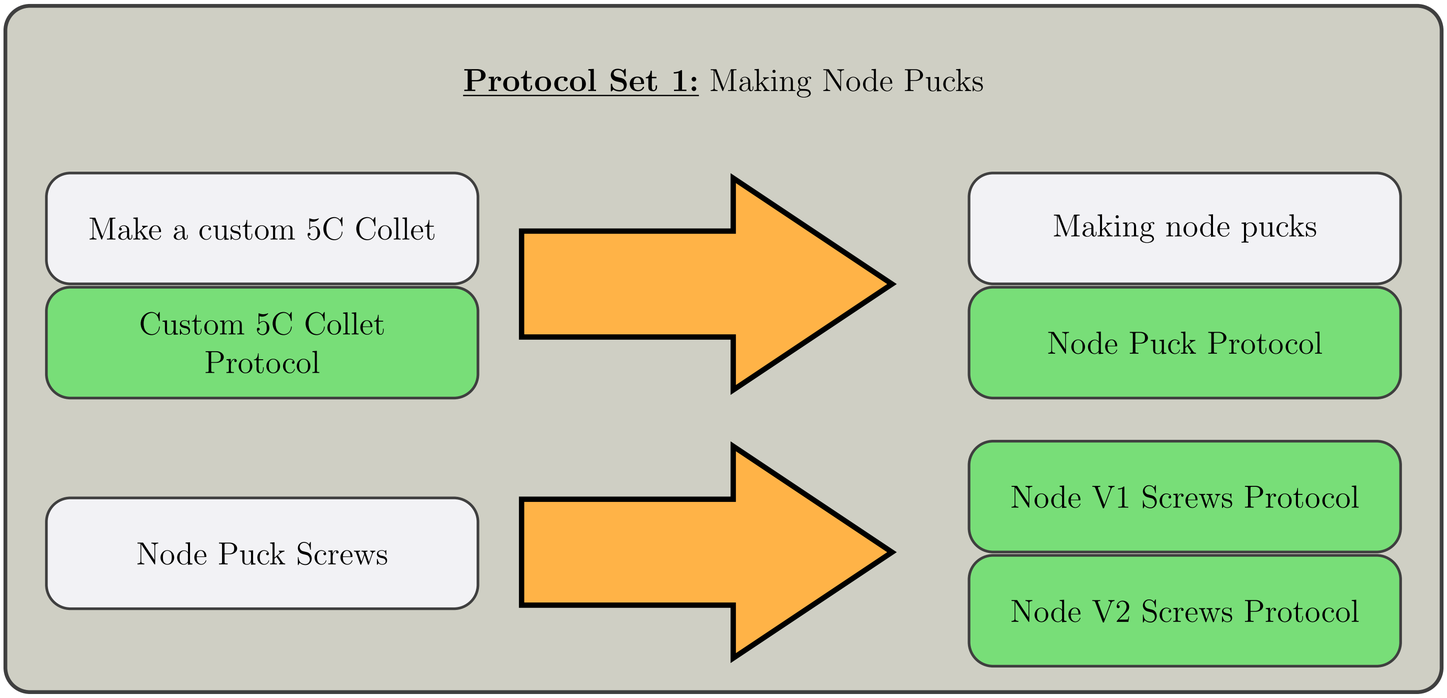
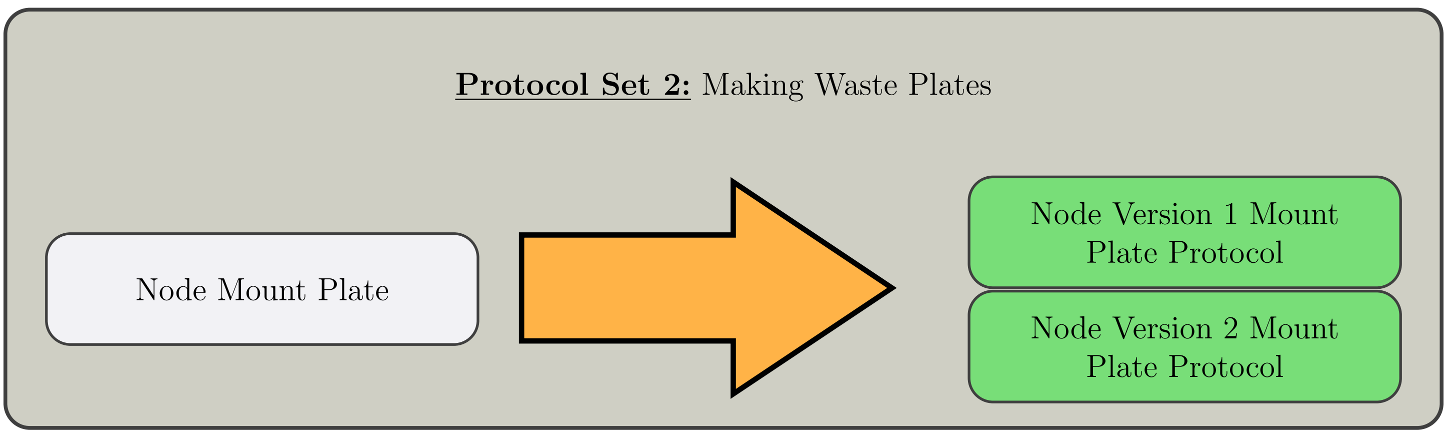
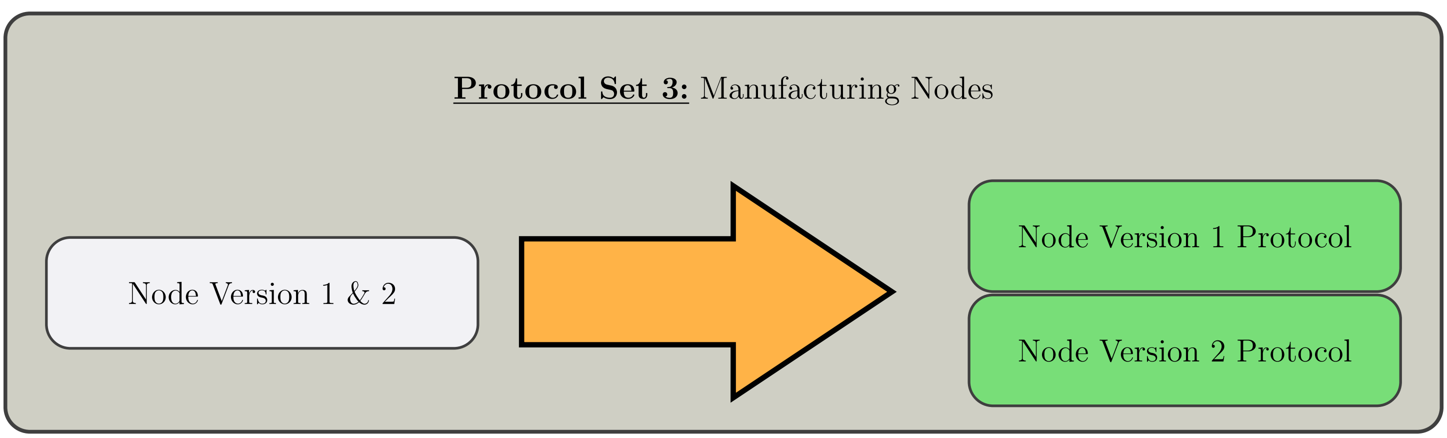
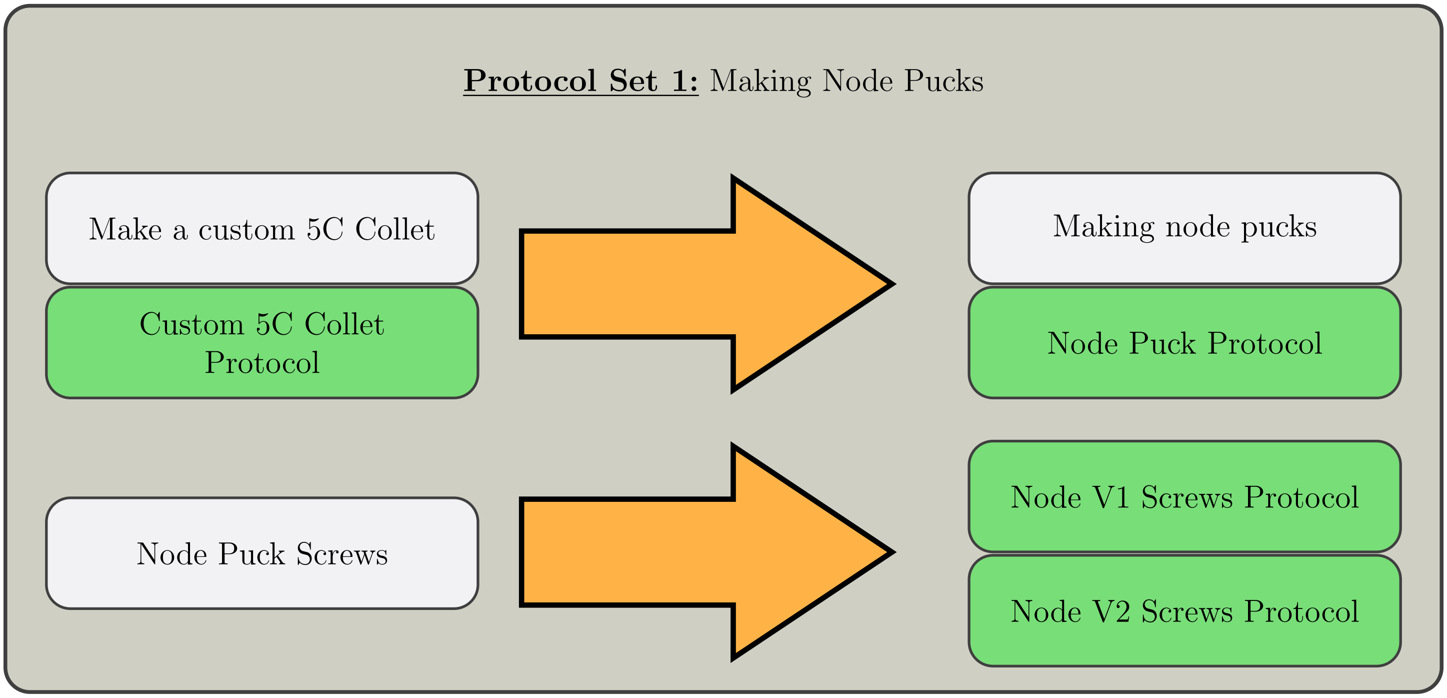
1.8 NODE PROTOCOLS & SETUP

3 Sets of Protocols for Manufacturing Nodes







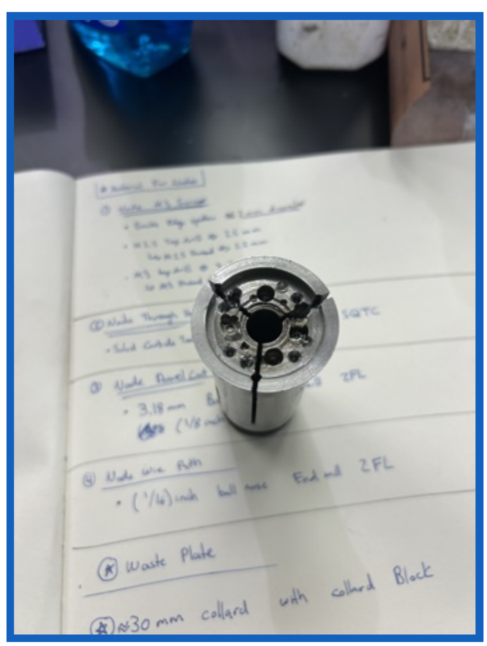


Component Description:

The purpose behind making a custom 5C collet mount and node pucks is to achieve the desired node designs. The custom 5C collet enabled us to mount the nodes on the lathe for surface finishing and provided a way to drill and tap screw holes on the milling machine. Additional information on the tools used can be found in the CAD drawings and protocols. I created three distinct protocols for creating the custom 5C collet and the nodes with screws. The protocols are called "Custom 5C Collet", "Node Pucks", and "Node V1 Screws & Node V2 Screws". Together, the protocols divide into four primary steps for manufacturing the nodes:

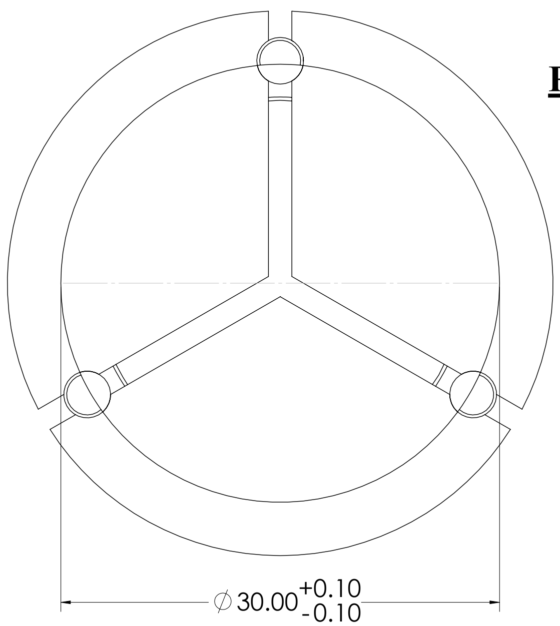
1. Making a custom 5C collet
   (a) First, I designed a custom 5C collet to securely mount the nodes. This custom 5C collet provides a mechanism for securing the nodes on the lathe and milling machine. Images of the 5C collet and the 5C block mechanism are displayed below. The custom 5C collet protocol provides a detailed procedure for creating your own 5C collet for mounting node pucks.

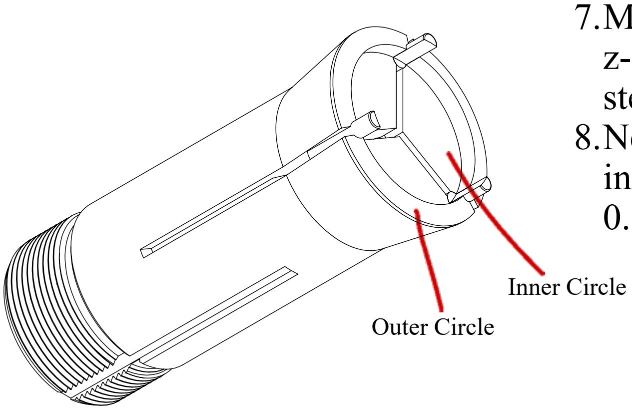
5C Block Setup



Custom 5C Collet

Custom 5C Collet Protocol & Dimensions (Page 1 of 2)





Custom 5C Collet

[PROTOCOL]

PART A:

1. Get a Machine-Your-Own 5C Collet[3209A12] and mount it on the Lathe.
2. First, mount a chuck and a small centre on the tailstock. Move the tailstock across the z-axis, so that your small centre drill is a few millimeters away from, your 5C collet.
3. Set the RPM to 1200, and turn on the lathe.
4. Extend the centre drill on the tailstock, so that you touch the center of face of the collet. Keep extending the tailstock, until your centre drill does a small center hole.
5. Switch and mount a 1/8" drill on the tailstock. Extend the tailstock across the z-axis so that 1/8" drill so that you begin to drill the collet. Drill down about 1 millimeter.
6. Switch and mount a 1/8" endmill on the tailstock. Extend the tailstock across the z-axis so that 1/8" drill so that you begin to drill the collet. Drill down about 1 millimeter.
7. Mount a boring bar on the turret, and move the turret across the z-axis so that you internally tune the cuts previously done in steps 5 and 6.
8. Next, move the x-axis 15mm so that the boring bar creates and inner cirlce of 30mm in diameter with a tolerance of +/- 0.1mm.

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TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL Hardened Steel
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COMMENTS:

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SIZE C | DWG. NO. 5C Collet | REV
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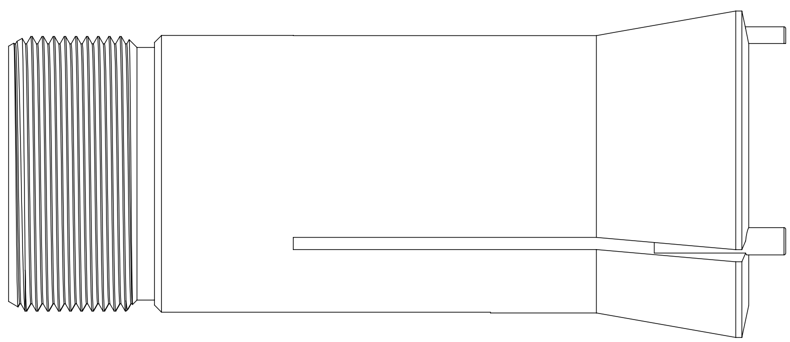
Custom 5C Collet Protocol & Dimensions (Page 2 of 2)

Custom 5C Collet

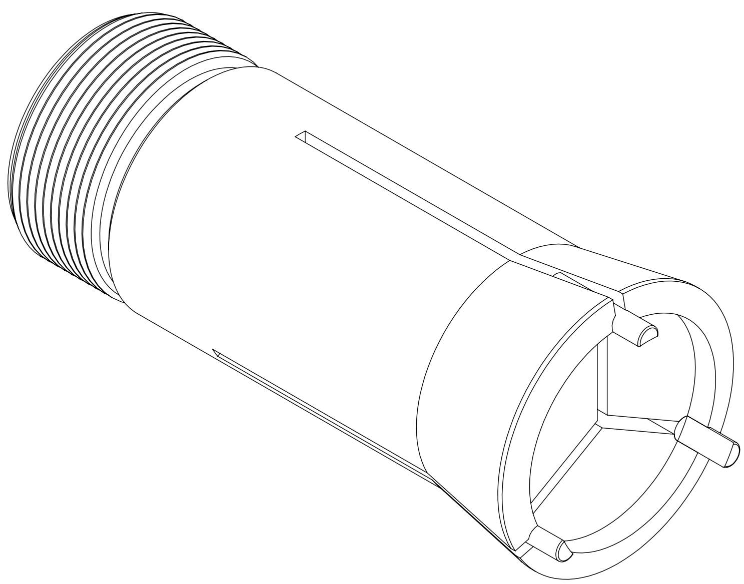
[PROTOCOL]



PART B:

1. Repeat steps 5-8 in Part A, until you have created an inner circle that is a cut pocket made on the collet 2mm(+/- 0.2mm of tolerance) in depth and 30mm +/- 0.1m in depth, when compared to the outer circle.

NOTE: You will need to drill more than 2mm in depth to achieve this. However, do not exceed 1mm cuts at a time.



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TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL Hardened Steel

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COMMENTS:

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SIZE C | DWG. NO. 5C Collet | REV

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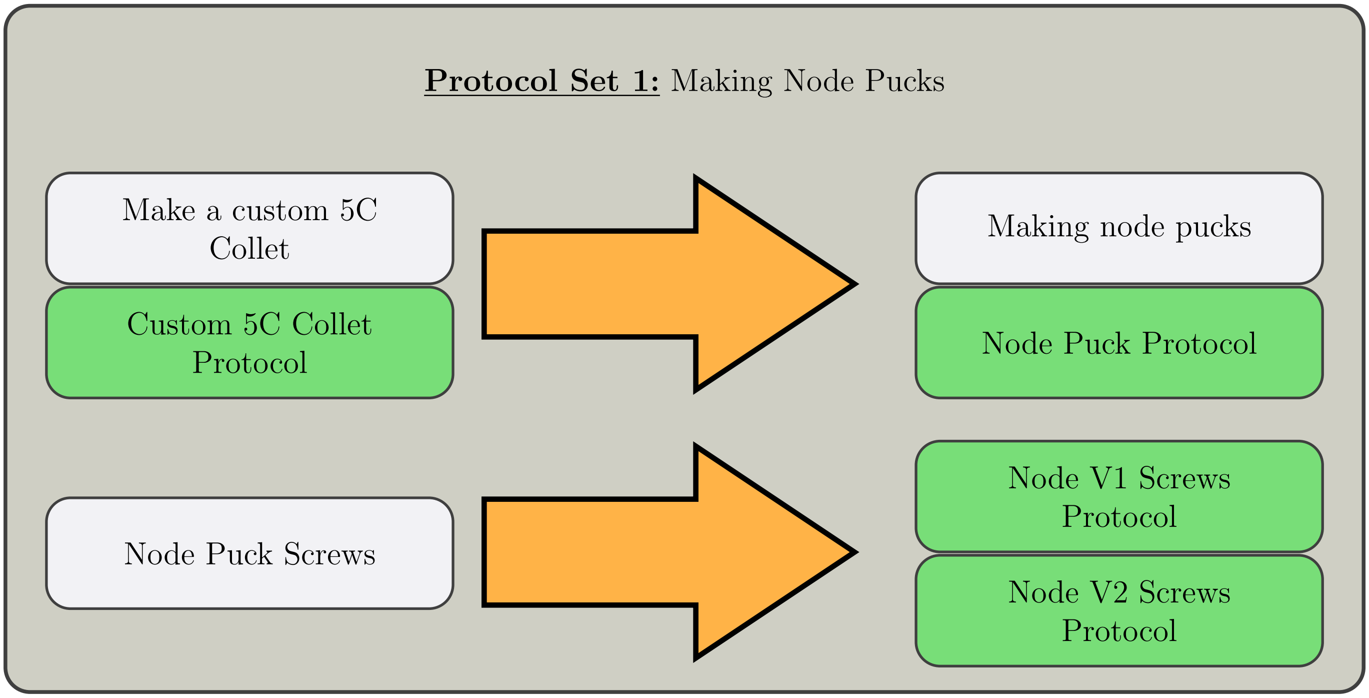


2. Cutting node pucks from an aluminum rod
   (a) I devised a method of making node pucks from an aluminum rod. First, I would cut the aluminum rod into 30mm diameter by 5mm tall rough-ended node pucks. Images of the aluminum rod being cut on the lathe and the faces of the nodes are displayed below. Similarly, the node puck protocol specifies how aluminum nodes are manufactured into node pucks.
3. Mounting node pucks with 5C collet onto the lathe
   (a) Next, I mounted the rough-ended node puck with the 5C collet onto the lathe. For this step, the purpose was to face the roughened side of the node pucks. The node puck protocol provides additional details about this procedure, and an image of the resulting node pucks is shown below.

Aluminum Rod on Lathe

Node Pucks

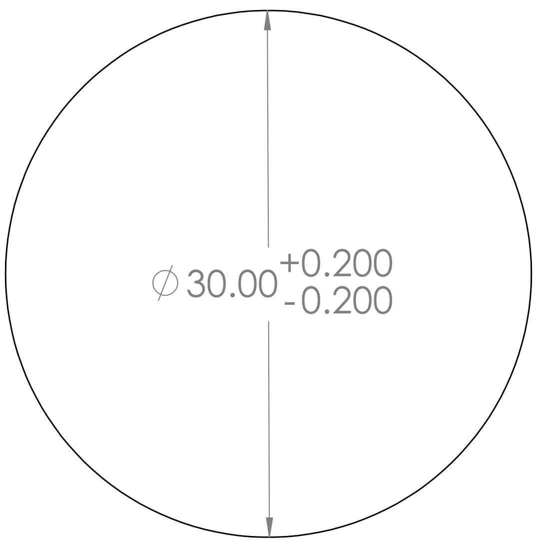
Facing Node Pucks

2 1

[Part A. Reducing Diameter of Rod]

Node Pucks
[PROTOCOL]

B



1. Get a 1-1/4" aluminum rod, and mount it on the Lathe. Let only around 25mm of the rod stick out to cut, for safety purposes.
2. Mount a turning tool on the lathe turret, set the spindle speed to 1200RPM, and turn on the lathe.
3. Cut off around 1mm of the rod face by moving the x-axis in order to smoothen out the circular face of aluminum rod. Then, set your z-axis to zero right after making the cut.
4. With the lathe still on and the turning tool mounted, touch the curved surface of the aluminum rod and set the x-axis to zero.
5. Now, carefully move your right cut tool to zero-zero.
6. With the same cutter, cut along the length of the rod to reduce the diameter to 30mm +/- 0.2mm tolerance. When doing the turning cuts on the rod, take away less than 1mm at a time, until your rod measures the 30mm in diameter. (NOTE: Do only a length of 20 mm to avoid contact with the actual lathe machine).
7. Once your rod is around 30mm in diamter, turn off the lathe machine, and move cutting right cut tool away.

B

A

UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN			
	CHECKED			TITLE:
	ENG APPR.			Node Puck
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL	COMMENTS:			SIZE A DWG. NO. Node-Puck REV
FINISH				
DO NOT SCALE DRAWING				SCALE: 2:1 WEIGHT: SHEET 1 OF 3

NEXT ASSY	USED ON
APPLICATION	

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A

2 1

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Node Puck Protocol & Dimensions (Page 2 of 3)

[Part B. Cutting the Pucks]

Node Pucks
[PROTOCOL]

1. Make sure the rod you cut from part A is 30mm +/- 0.2mm in diameter.
2. Mount a parting tool, and touch the circular face of the rod and zero the z-axis.
3. Move the parting tool way from the rod, set the lathe to 640RPM and turn on the machine.
4. "Move the node 5.5 mm + parting tool thickness to the left along the Z-axis (NOTE: with the x-axis keep a distance from the rod to avoid contact).
5. Then, slowly move the x-axis to part the rod. The node should be 5.5mm +/- 0.5mm in thickness. One of the sides of the node will have a rough finish. (NOTE: the slow cut should have spiral chips when chop cutting)
6. You'll do steps 2-5 twice, before you need to pull out the rod another 25mm to produce more nodes. (NOTE: Never have more than 25mm of the rod come out of the lathe).
7. Repeat All of Part A and Part B steps 1-6 to make enough nodes (with a rough and smooth side). The rough Side will later be cleaned while the puck is on a custom 5C collet.
8. Once you have enough half-finished nodes, turn off the machine and dismount the aluminum rod.

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN			TITLE:
			CHECKED			Node Puck
			ENG APPR.			
			MFG APPR.			
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
		MATERIAL	COMMENTS:			SIZE A DWG. NO. Node-Puck REV
NEXT ASSY	USED ON	FINISH				
APPLICATION		DO NOT SCALE DRAWING				SCALE: 2:1 WEIGHT: SHEET 2 OF 3

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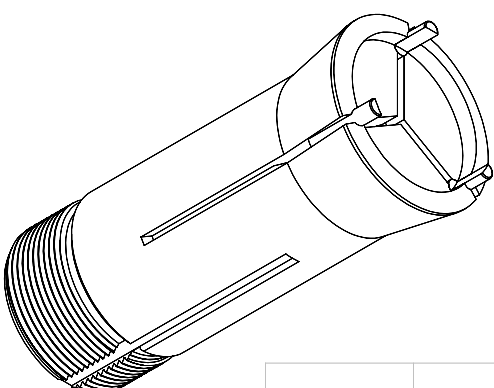
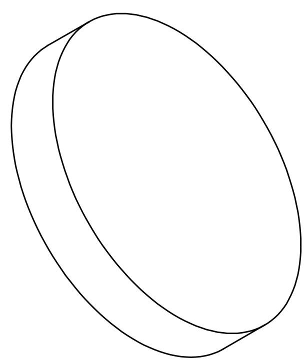
Node Puck Protocol & Dimensions (Page 3 of 3)

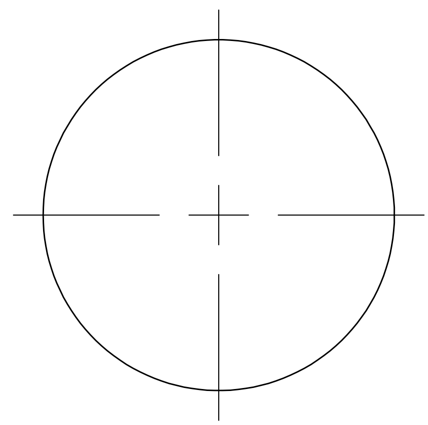
[Part C. Smoothing Rough Face of the Node]

Node Pucks
[PROTOCOL]

1. Finish the CUSTOM 5C COLLET DRAWING
2. With the Lathe off, mount the unfinished node on the 5C custom collet and in the Lathe, with the rough surface facing outward. (NOTE: The custom 5C collet should have a 30mm +/- 0.1mm diameter cut, with a depth of 2mm +/- 0.1mm, and the node should perfectly fit in that pocket)
3. Turn on the Lathe and set the spindle speed to 1200 RPM. Mount a turning cut tool, and move the z-axis to touch the rough face of the node(5.5 mm +/- 0.5mm), zero out the Z-axis, and move away.
4. Slice the node's rough surface to reduce thickness with the z-axis, so that the node is 5mm +/- 0.1mm. (NOTE: It is important to measure the node thickness after each slice, and a maximum 0.2mm at a time until the node has a thickness of 5mm).







UNLESS OTHERWISE SPECIFIED:	NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	
	CHECKED	
	ENG APPR.	
	MFG APPR.	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	
MATERIAL	COMMENTS:	
FINISH		
DO NOT SCALE DRAWING		

NEXT ASSY | USED ON
APPLICATION

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TITLE: Node Puck

SIZE: A | DWG. NO.: Node-Puck | REV

SCALE: 2:1 | WEIGHT: | SHEET 3 OF 3

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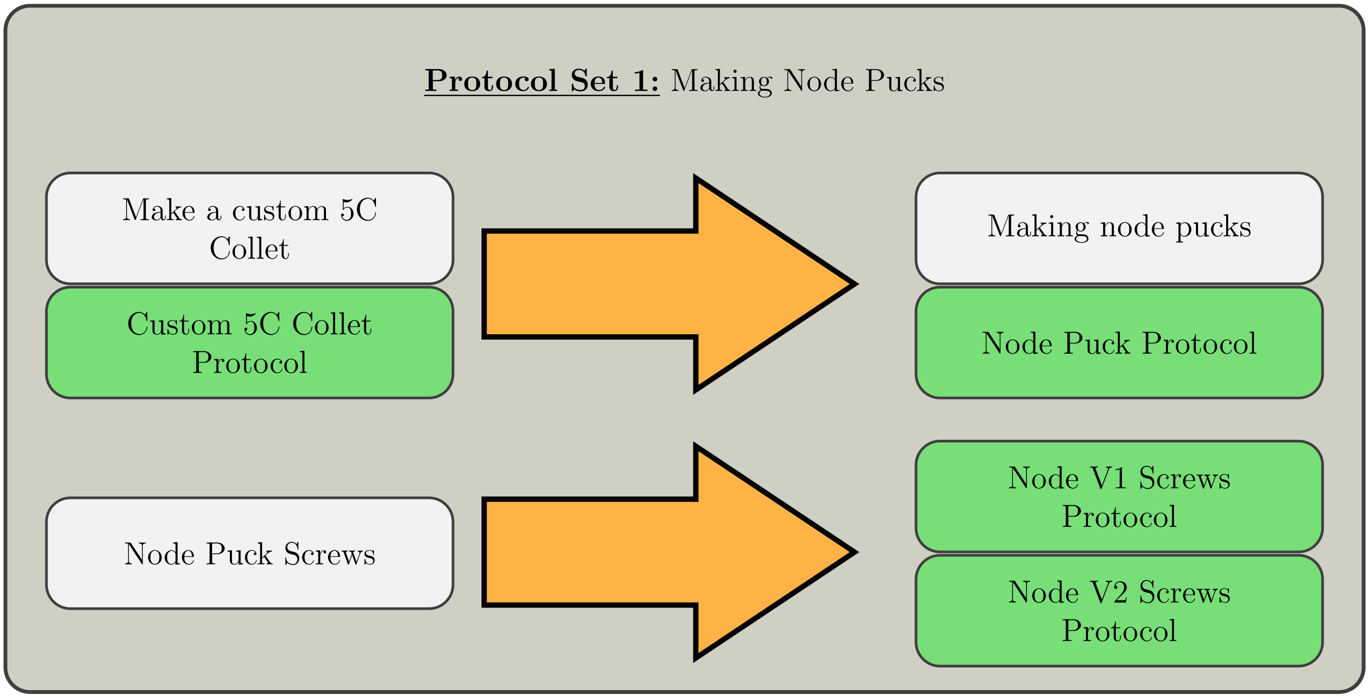
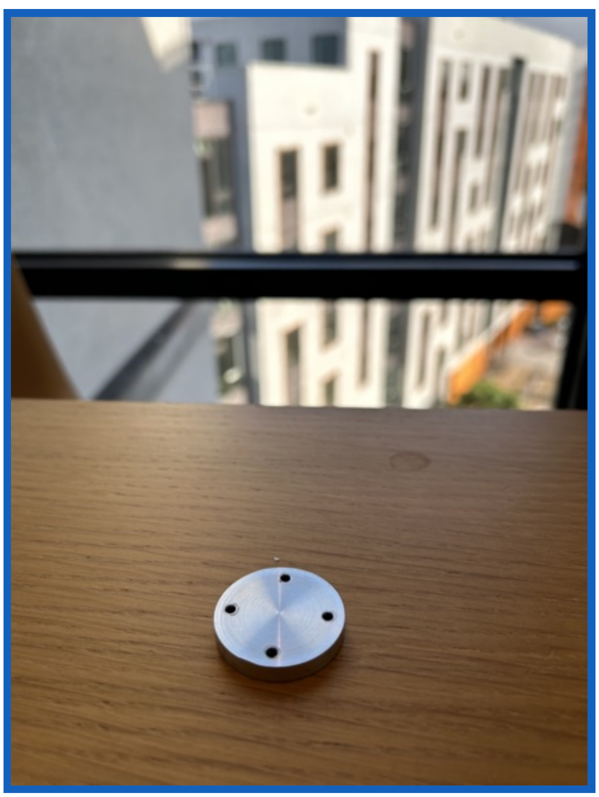


4. Tap Drilling node pucks with 5C block on the milling machine
   (a) Finally, I secured the node pucks and a custom 5C block on the milling machine to drill and tap screw holes on the node pucks. Later, this allowed me to secure the node puck onto a plate for carving its features. The detailed procedure for drilling screw holes on the nodes is described below. Similarly, the images below display the two versions of the node screws.



Node Version 1 Screws

Node Version 2 Screws

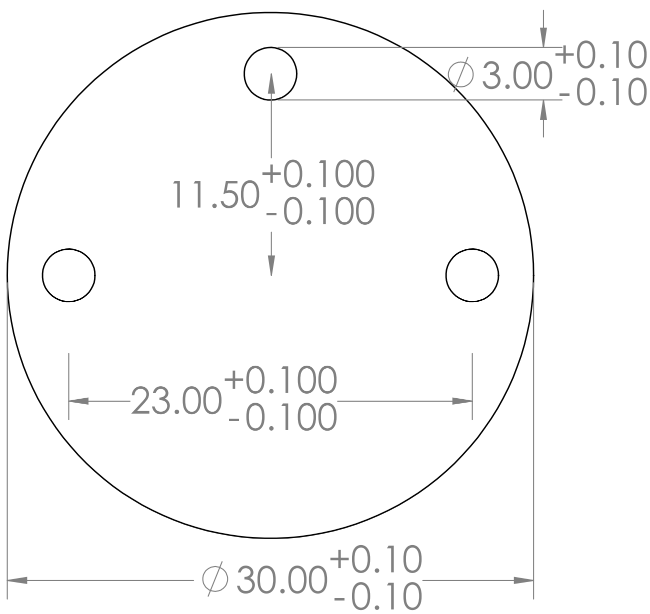
2 1

B

Node V1 Screws

[Protocol]

Part A: Mounting Pucks on Mill



1. Once you finished making node pucks, mount the node into the custom 5C collet and 5C block using a 5C ring. Tighten the puck on the collet, so that the node does not move upon drilling.
2. Set the 5C mechanism with the node on the Mill, and face the node upwards. Put a stopper, so that every time you move the 5C block it has the same location.
3. Mount an edge finder on the mill, turn on the mill, and set the machine to 1100RPM.
4. Touch off the edges of the 5C block so that the node is centered on the machine, and zero out the x-axis and y-axis at the center of the node. Turn off the machine.
5. Mount a small centre drill on a chuck, turn on the machine and set it to 1400RPM. Carve out a small dent where you will be drilling screw holes.
6. Turn off the machine. Mount the drill bit necessary for the screw holes. (NOTE: For clearance holes, drill through the node with a 1/8" drill bit. For threaded holes use a #40 drill.

A

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NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE: Node V1 Screws

SIZE A DWG. NO. NodeV1-Screws REV

SCALE: 2:1 WEIGHT: SHEET 1 OF 2

2 1

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Node Version 1 Screws Protocol & Dimensions (Page 2 of 2)

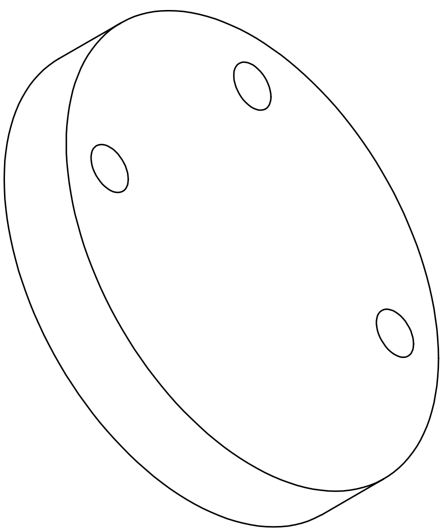
2 1

B

Node V1 Screws

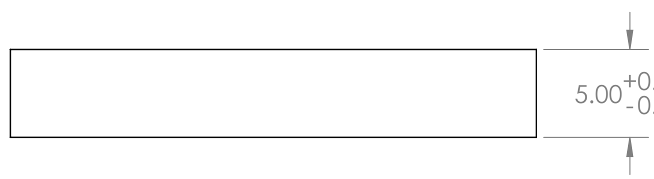
[Protocol]

Part B: Drilling Screws



1. Turn on the mill again, and drill through the all screw holes (5mm depth + 0.4mm tolerance) one-by-one.
2. Turn off the mill. For the screw holes that are threaded, move the mill to the hole positions, and use a tap (3mm) and die to thread the holes. Use thread cutting oil for each threaded hole. This finishes the node screws.
3. Unmount the 5C mechanism, take out the node and place a new puck. Set the 5C mechanism on the mill. (NOTE: Mounting the 5C mechanism with the puck should preserve your zero-zero.
4. Repeat Part A and Part B of the protocol, until you drilled screws on all your pucks.

B



A

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN			TITLE:
			CHECKED			Node V1 Screws
			ENG APPR.			
			MFG APPR.			
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
		MATERIAL	COMMENTS:			SIZE A DWG. NO. NodeV1-Screws REV
NEXT ASSY	USED ON	FINISH				
APPLICATION		DO NOT SCALE DRAWING				SCALE: 2:1 WEIGHT: SHEET 2 OF 2

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A

2 1

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Node Version 2 Screws Protocol & Dimensions (Page 1 of 2)

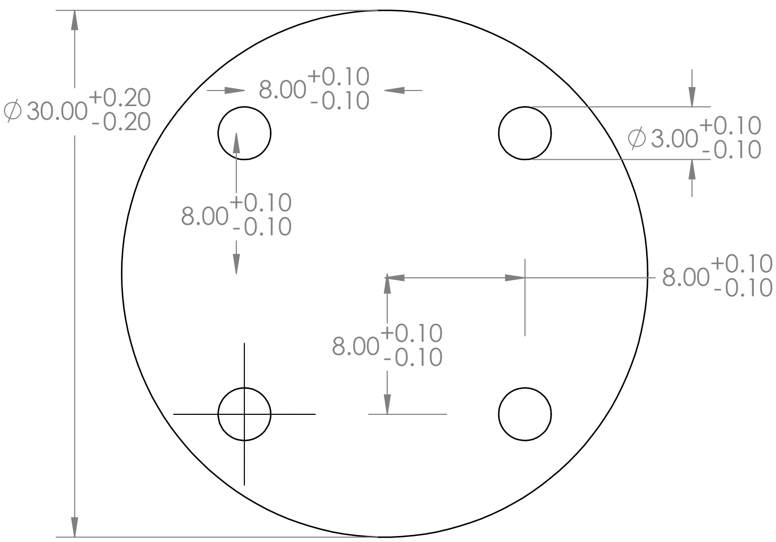
2 1

B

Node V2 Screws

[Protocol]

Part A: Mounting Pucks on Mill



1. Once you finished making node pucks, mount the node into the custom 5C collet and 5C block using a 5C ring. Tighten the puck on the collet, so that the node does not move upon drilling.
2. Set the 5C mechanism with the node on the Mill, and face the node upwards. Put a stopper, so that every time you move the 5C block it has the same location.
3. Mount an edge finder on the mill, turn on the mill, and set the machine to 1100RPM.
4. Touch off the edges of the 5C block so that the node is centered on the machine, and zero out the x-axis and y-axis at the center of the node. Turn off the machine.
5. Mount a small centre drill on a chuck, turn on the machine and set it to 1400RPM. Carve out a small dent where you will be drilling screw holes.
6. Turn off the machine. Mount the drill bit necessary for the screw holes. (NOTE: For clearance holes, drill through the node with a 1/8" drill bit. For threaded holes use a #40 drill.

B

A

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

Node-V2 Screw/Clearance

SIZE A DWG. NO. REV

NodeV2_Screw-Clearance

SCALE: 2:1 WEIGHT: SHEET 1 OF 2

NEXT ASSY | USED ON

APPLICATION

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A

2 1

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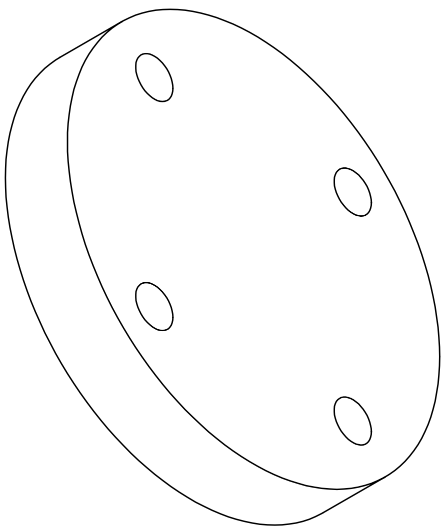
Node Version 2 Screws Protocol & Dimensions (Page 2 of 2)

2 1

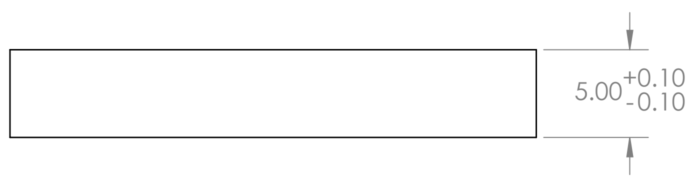
Node V2 Screws

[Protocol]

Part B: Drilling Screws



1. Turn on the mill again, and drill through the all screw holes (5mm depth + 0.4mm tolerance) one-by-one.
2. Turn off the mill. For the screw holes that are threaded, move the mill to the hole positions, and use a tap (3mm) and die to thread the holes. Use thread cutting oil for each threaded hole. This finishes the node screws.
3. Unmount the 5C mechanism, take out the node and place a new puck. Set the 5C mechanism on the mill. (NOTE: Mounting the 5C mechanism with the puck should preserve your zero-zero.
4. Repeat Part A and Part B of the protocol, until you drilled screws on all your pucks.



B B

A A

		UNLESS OTHERWISE SPECIFIED:	
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	
		INTERPRET GEOMETRIC TOLERANCING PER:	
		MATERIAL	
NEXT ASSY	USED ON	FINISH	
APPLICATION		DO NOT SCALE DRAWING	

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:

SIZE A | DWG. NO. NodeV2_Screw-Clearance | REV

SCALE: 2:1 | WEIGHT: | SHEET 2 OF 2

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2 1

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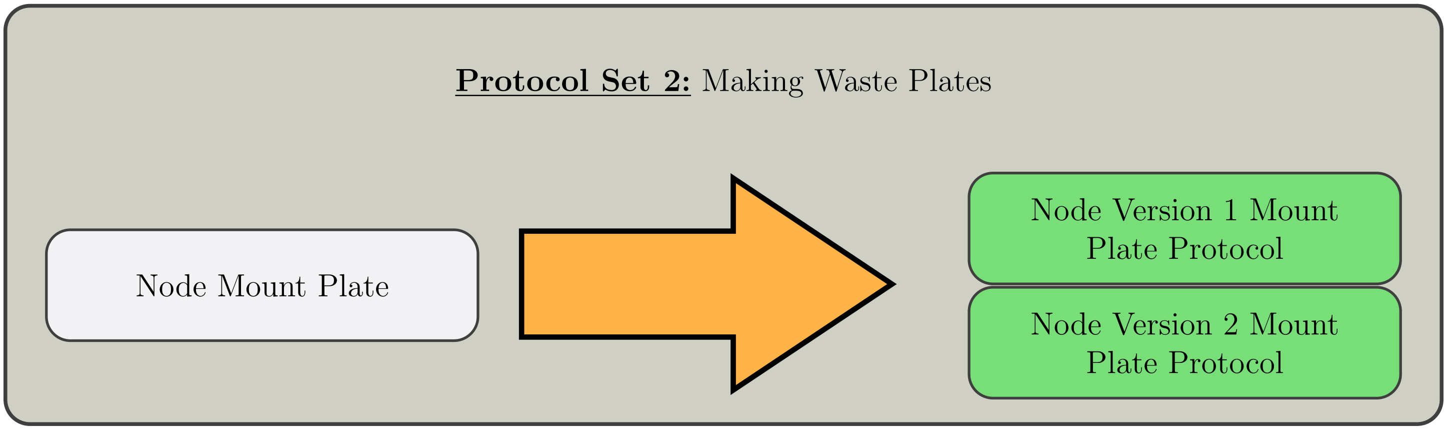
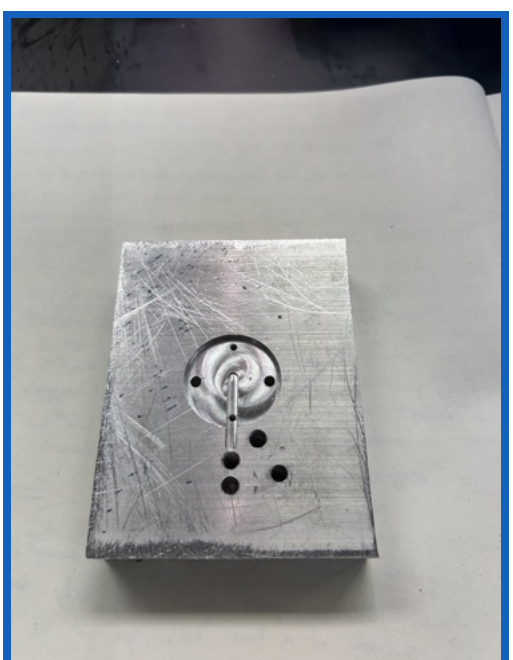


Component Description:

The purpose behind the node mount plate is to secure the nodes manufactured on the milling machine. As a result, I was able to machine distinct features onto their faces. The features used in both versions of the nodes include: wire paths, dowel pockets, and ball and shank pockets. The protocols for fabricating the nodes specify these features. In the protocol for making the node mounting plates, we first face off all the sides of the plate for symmetric mounting. Next, we drill a 2mm deep pocket with the same diameter as the node to mount our nodes into those pockets. Finally, we drill holes in the mount plate to secure the nodes. The threading on the mounting plates is M2.5, while the threading of the nodes is M3. As a result, the screw holes on the nodes serve as clearance holes, while the screws on the waste plate are for M2.5 screws. There were two different protocols made for the node mount plate, one for manufacturing node version 1 and another for node version 2. The difference between the node version 1 plate protocol and the node version 2 plate protocol is the orientation of the screws. The distance from the screw holes to the center of the node puck is in the corresponding protocol guides. On the other hand, the orientation for both node versions are the following:

- For the node version 1 mount plate, the orientation of the screws are at: $0°, 90°, 180°$, and $270°$
- For the node version 2 mount plate, the orientation of the screws are at: $45°, 135°, 225°$, and $315°$

The following pages provide a step-by-step guide for fabricating node mount plates for both Version 1 and Version 2. Also, below are some images of how these node mount plates look.



Mount Plate Version 1

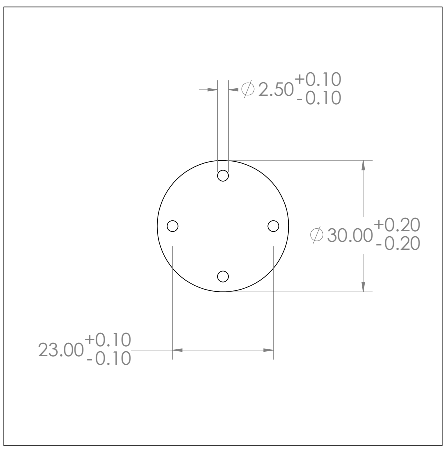
Mount Plate Version 2

Mount Plate Version 1 Protocol & Dimensions (Page 1 of 3)

Node V1 Plate

[PROTOCOL]

PART A: Leveling out all surface on the Node Plate



1. Get an aluminum block (larger than your node puck and as flat as possible on all surfaces). Mount the block on the milling machine. (NOTE: You will repeat Part A for every surface of the aluminum block)
2. Secure a chuck and 1/2" end mill on the mill.
3. Move around your x and y-axis, and bring down the z-axis so that the end mill touches flat with the block's surface and secure the z-axis.
4. Turn on the milling machine and set it to 1400 RPM. Move the x and y-axis off the part, and bring down your z-axis around 2mm.
5. Move around the x and y-axis (without touching the block), so that you are able to cut a corner.
6. Now, by only moving the x-axis or y-axis, do a row or column cut across the enitre surface of the block. (NOTE: you want to do the same row back and forth off the opposite sides of the plate to get a clean cut)
7. Move the x,y-axis perpendicular to start another row or column. Repeat step 5.
8. Do step 4 and 5 to finish leveling out the plate.
9. Move the cutter off the plate and turn off the machine.
10. Flip the node plate on the mill machine, and repeat steps 3-10 until all sides of the node plate has been cleaned.
11. Move the cutter away from the plate and turn off the mill.

UNLESS OTHERWISE SPECIFIED:		NAME	DATE		
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN			TITLE:	
	CHECKED			Node V1 Plate	
	ENG APPR.				
	MFG APPR.				
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.				
MATERIAL	COMMENTS:			SIZE DWG. NO. C WastePlateV1	REV
FINISH				SCALE: 2:1 WEIGHT:	SHEET 1 OF 3
DO NOT SCALE DRAWING					

NEXT ASSY	USED ON
APPLICATION	

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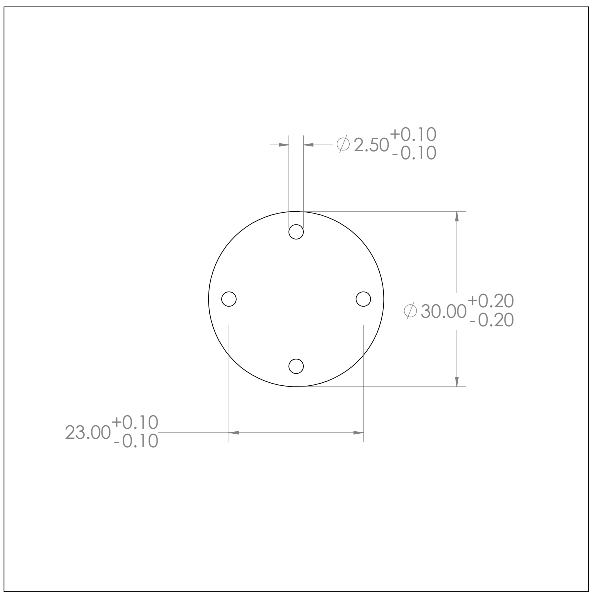
Mount Plate Version 1 Protocol & Dimensions (Page 2 of 3)

Node V1 Waste Plate

[PROTOCOL]

PART B: Carving Out Node Pocket



1. After finishing Part A, mount a 1/8" end mill to the chuck.
2. Move the x,y-axis so that you eye-ball being at the center of the plate (without touching plate with the z-axis).
3. Bring down the z-axis so that the cutter touches the plate. Turn on the mill and set it to 1600 RPM.
4. Set the x and y-axis to zero, and bring down the z-axis 0.5mm.
5. Carve out a circle shape of 30mm (+/- 0.2mm tolerance), so that it becomes a node pocket.
6. Repeat steps 4 and 5, until you have a 2mm (+/- 0.1mm tolerance) deep pocket for the nodes.
7. Turn off the machine.

UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
	CHECKED		
	ENG APPR.		
	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

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TITLE: **Node V1 Plate**

SIZE C | DWG. NO. WastePlateV1 | REV

SCALE: 2:1 | WEIGHT: | SHEET 2 OF 3

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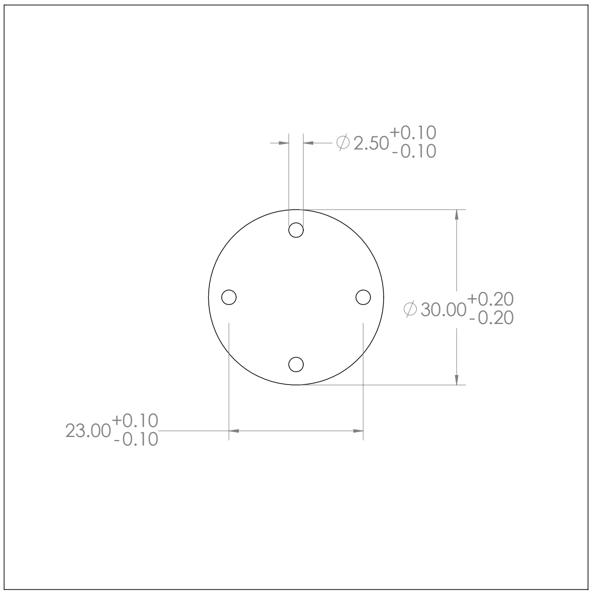
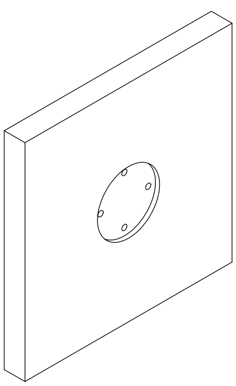
Node V1 Plate

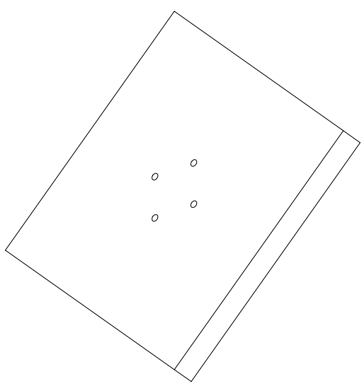
[PROTOCOL]

PART C: Threading the Screws on the Plate



1. Mount a small centre drill on a chuck, turn on the machine and set it to 1400RPM. Carve out a small dent where you will be drilling holes.
2. Turn off the machine. Mount a # 50 drill bit.
3. Turn on the mill, and move the dill bit to the screw positions and drill through the holes (5mm depth +0.4 mm tolerance) one-by-one.
4. Turn off the mill. Move the mill to the hole positions, and use a tap (2-56) and die to thread holes. Use thread cutting oil for each threaded hole.
5. This finishes threading the screw holes on the plate.





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NEXT ASSY | USED ON | APPLICATION | DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE: **Node V1 Plate**

SIZE C | DWG. NO. WastePlateV1 | REV

SCALE: 2:1 | WEIGHT: | SHEET 3 OF 3

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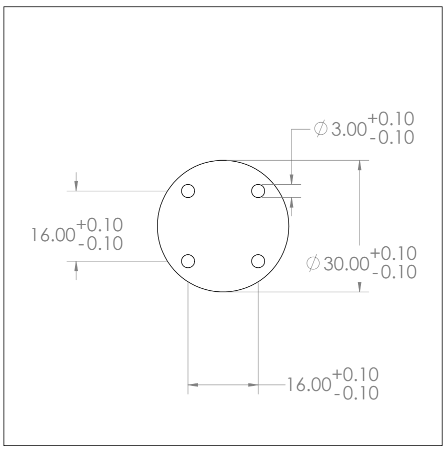
Node V2 Plate

[PROTOCOL]

PART A: Leveling out all surface on the Node Plate



1. Get an aluminum block (larger than your node puck and as flat as possible on all surfaces). Mount the block on the milling machine. (NOTE: You will repeat Part A for every surface of the aluminum block)
2. Secure a chuck and 1/2" end mill on the mill.
3. Move around your x and y-axis, and bring down the z-axis so that the end mill touches flat with the block's surface and secure the z-axis.
4. Turn on the milling machine and set it to 1400 RPM. Move the x and y-axis off the part, and bring down your z-axis around 2mm.
5. Move around the x and y-axis (without touching the block), so that you are able to cut a corner.
6. Now, by only moving the x-axis or y-axis, do a row or column cut across the enitre surface of the block. (NOTE: you want to do the same row back and forth off the opposite sides of the plate to get a clean cut)
7. Move the x,y-axis perpendicular to start another row or column. Repeat step 5.
8. Do step 4 and 5 to finish leveling out the plate.
9. Move the cutter off the plate and turn off the machine.
10. Flip the node plate on the mill machine, and repeat steps 3-10 until all sides of the node plate has been cleaned.
11. Move the cutter away from the plate and turn off the mill.

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TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE: Node V2 Plate

SIZE C DWG. NO. WastePlateV2 REV

SCALE: 2:1 WEIGHT: SHEET 1 OF 3

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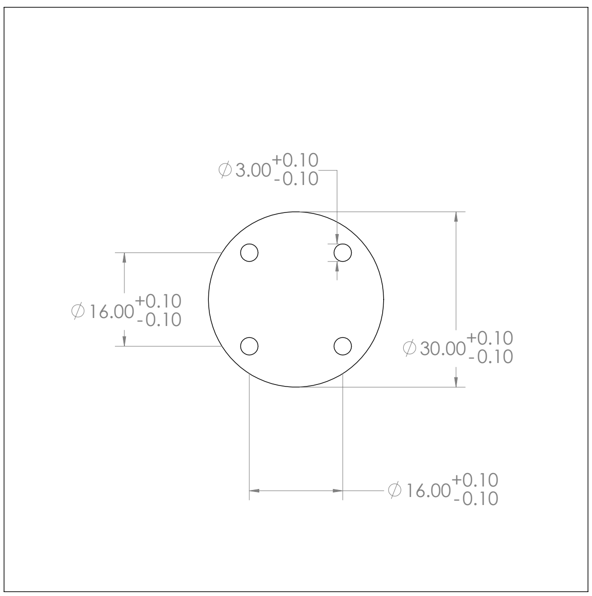
4 3 2 1

D

Node V2 Plate

[PROTOCOL]

PART B: Carving Out Node Pocket



C

1. After finishing Part A, mount a 1/8" end mill to the chuck.
2. Move the x,y-axis so that you eye-ball being at the center of the plate (without touching plate with the z-axis).
3. Bring down the z-axis so that the cutter touches the plate. Turn on the mill and set it to 1600 RPM.
4. Set the x and y-axis to zero, and bring down the z-axis 0.5mm.
5. Carve out a circle shape of 30mm (+/- 0.2mm tolerance), so that it becomes a node pocket.
6. Repeat steps 4 and 5, until you have a 2mm (+/- 0.1mm tolerance) deep pocket for the nodes.
7. Turn off the machine.

B

A

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TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

NAME DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:

TITLE:
Node V2 Plate

SIZE C DWG. NO. WastePlateV2 REV
SCALE: 2:1 WEIGHT: SHEET 2 OF 3

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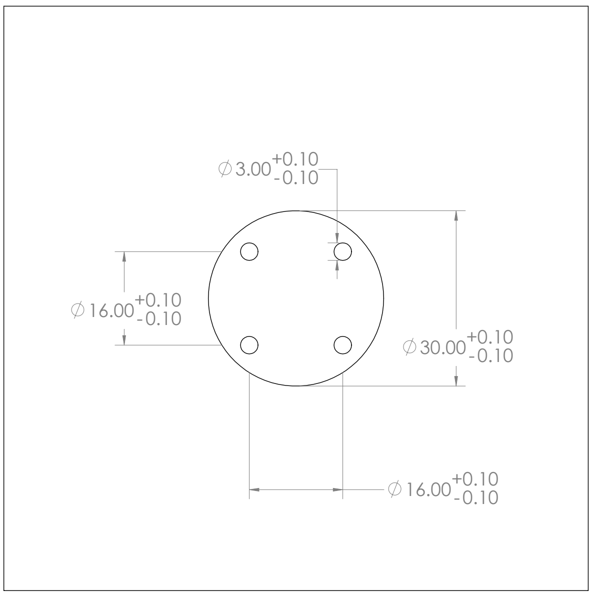
4 3 2 1

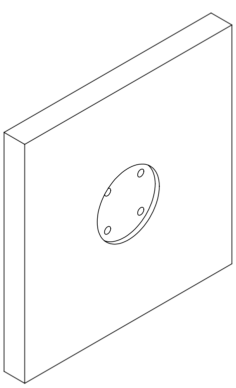
Node V2 Plate

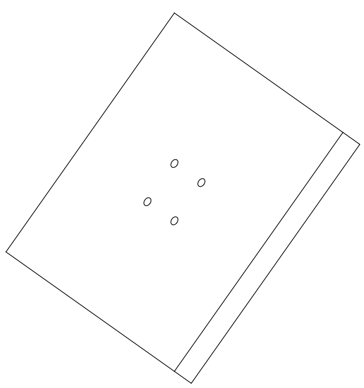
[PROTOCOL]

PART C: Threading the Screws on the Plate



1. Mount a small centre drill on a chuck, turn on the machine and set it to 1400RPM. Carve out a small dent where you will be drilling holes.
2. Turn off the machine. Mount a # 50 drill bit.
3. Turn on the mill, and move the dill bit to the screw positions and drill through the holes (5mm depth +0.4 mm tolerance) one-by-one.
4. Turn off the mill. Move the mill to the hole positions, and use a tap (2-56) and die to thread holes. Use thread cutting oil for each threaded hole.
5. This finishes threading the screw holes on the plate.





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TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
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CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

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TITLE: Node V2 Plate

SIZE C | DWG. NO. WastePlateV2 | REV

SCALE: 2:1 | WEIGHT: | SHEET 3 OF 3

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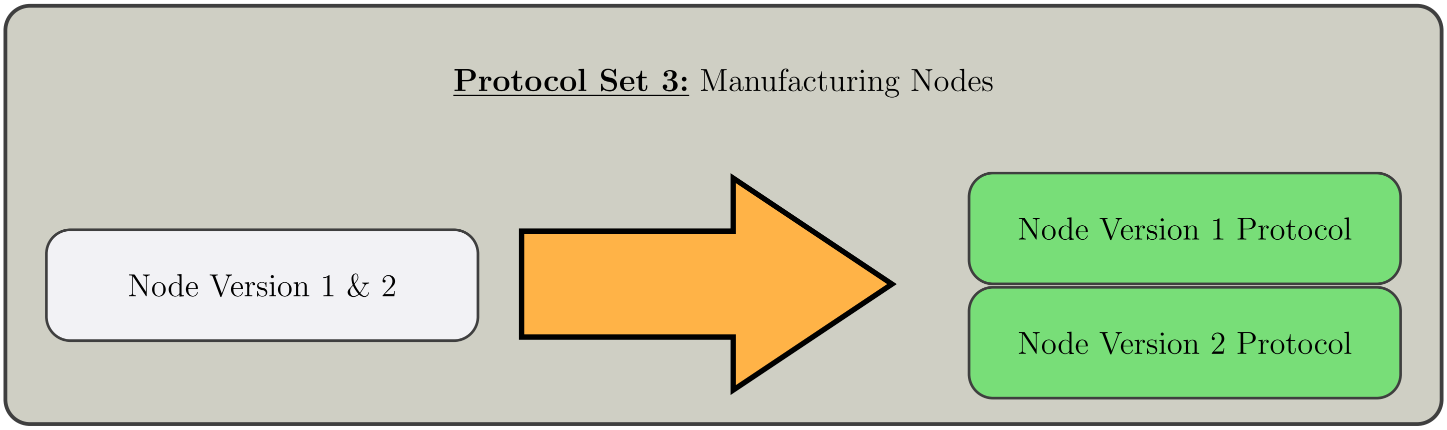
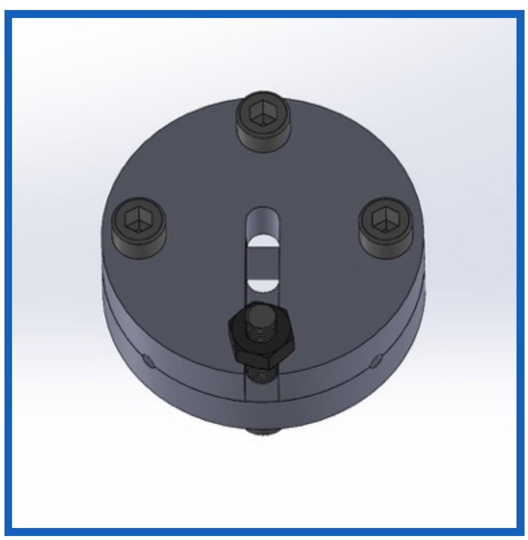


Component Description Node Version 1:

Node version 1 includes a dowel with a through-cut that serves as a pulley system, allowing the wires of the tensegrity rover to actuate the faces. Additionally, Version 1 features two wire paths that enable the smaller wire to form a pulley system at a different node angle. With all the features combined on the node, the design allows for three separate wire systems to move with the node. One method uses the dowel, while the other two use the cut-out wire paths. The 3x10 mm aluminum dowels depicted in the CAD 2D drawings were purchased online, as machining components of such small dimensions on a lathe presents significant challenges. The figures below demonstrate what node version 1 looks like after being manufactured in the machine shop, the assembly of node version 1, and the small dowel. To assemble a node version 1 mechanical system, you need the following:

- Two nodes facing each other at a 180° angle rotation
- A 3mm x 10mm dowel
- M3 Screws and Nuts

Node Version 1



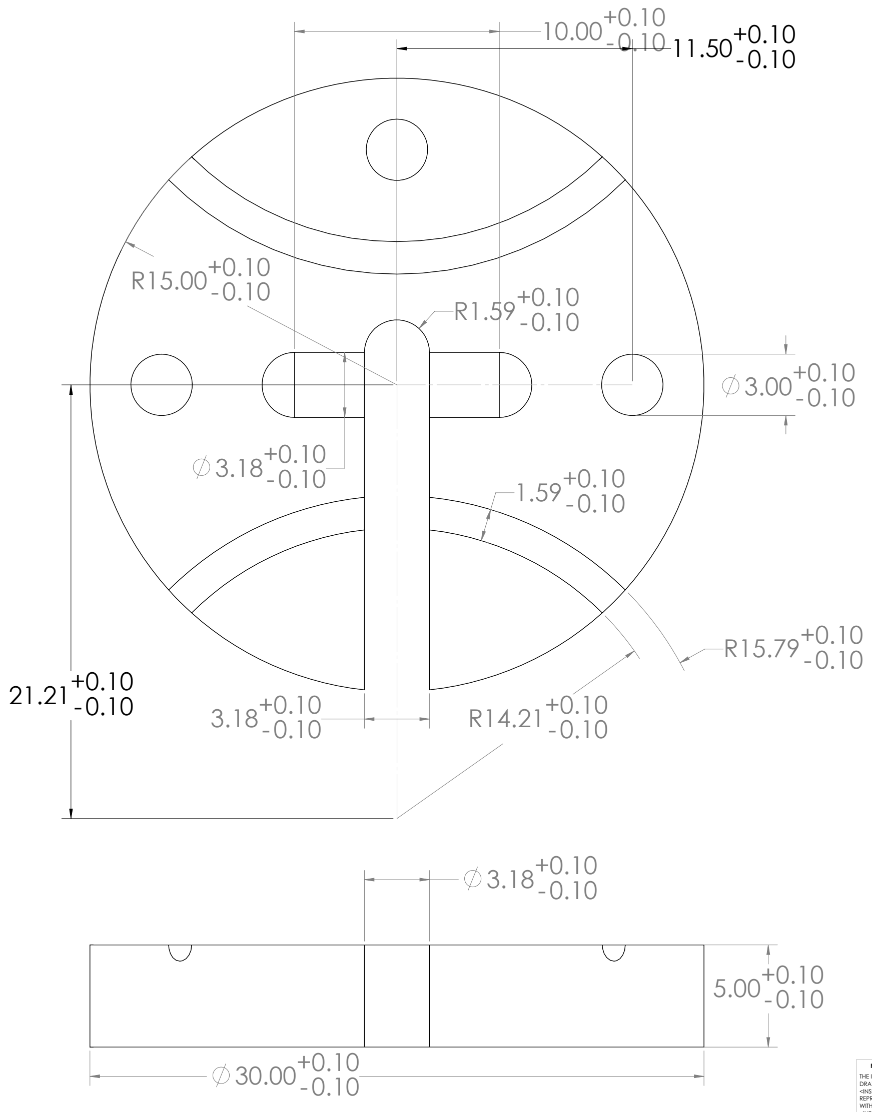
Node Version 1 Assembly

Node Version 1 Dowel

Node/Dowel Version 1 Protocol & Dimensions (Page 1 of 4)

Node V1

[PROTOCOL]

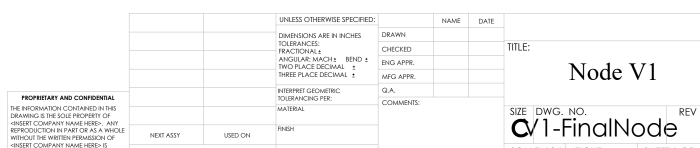


Part A: Mounting the Nodes on Mill

1. To do this protocol, you must first complete drilling screw holes onto the node, and finshed making a node mount waste plate.
2. Secure the nodes onto the node mount waste plate with M2.5 Screws. (NOTE: The waste plaste thread is M2.5 thread, while the the threading on the node is for an M3)
3. Zero out the x and y-axis on the milling machine so that the zero-zero origin is at the center of the node.

Part B: Making Wire Path

1. Mount a chuck and a 1/16" ball nose end mill on the lathe.
2. For Part B, even though your zero-zero is at the center of the nodes, the circular wire cuts have the y-axis orgin +/- 21.21mm from the center of the node.
3. Set the z-axis at zero by touching the top of the node.
4. Move the y-axis with your 1/16" ball nose end mill +21.21mm (should be away from center of node).
5. Turn on the milling machine and set it to 1600 RPM.
6. Bring down the z-axis to negative 1/16" so that it can have a depth cut with the same diameter as the cutter.
7. Do a circular radius pattern cut of 15mm +/- 0.1mm to carve out the wire path.
8. Turn off the mill, and move the y-axis to -21.21mm.
9. Repeat steps 5-7 to do the bottom wire path.
10. Turn off the milling machine.



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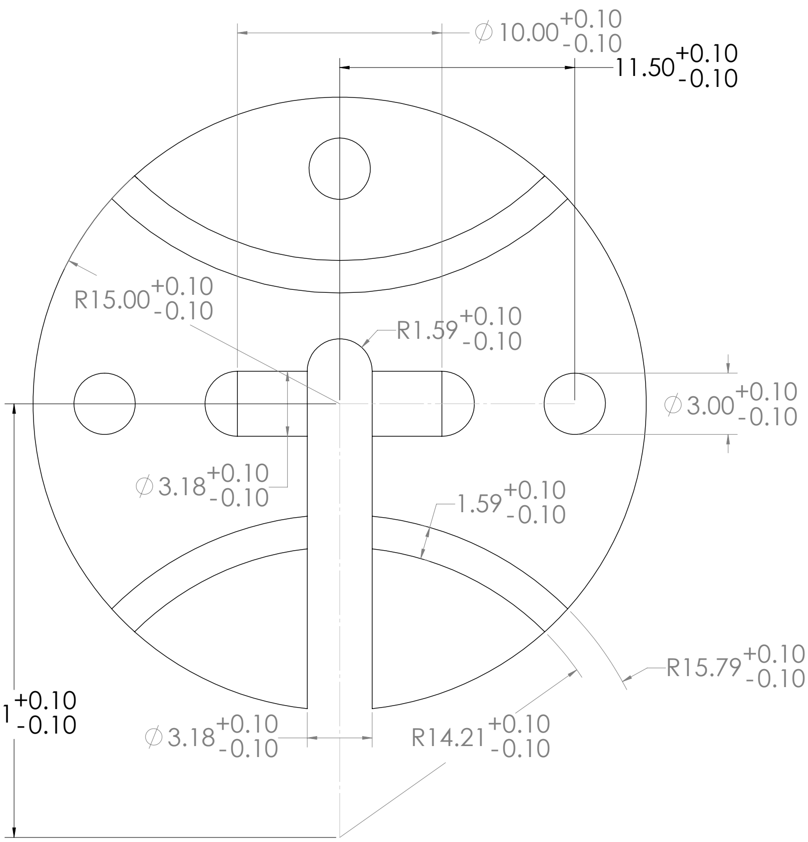
Node/Dowel Version 1 Protocol & Dimensions (Page 2 of 4)

Node V1

[PROTOCOL]



Part C: Dowel Cuts

1. Mount a centre drill on the chuck, and move the mill to zero-zero at the middle of the node.
2. Turn on the mill, set it to 1400 RPM and slightly dent the center of the node by bringing down the z-axis.
3. Turn off the machine and mount 1/8" ball nose end mill on the chuck.
4. Turn on the machine and set it to 1600 RPM.
5. Cut out the dowel pocket, by bring down the z-axis 0.5mm at a time, and moving the x-axis 5mm to the left and to the right (not including the radius of the cutter).
6. Repeat step 4, until your dowel pocket is 1.59mm in depth.
7. Turn off the machine.

Part D: Through Cut

1. NOTE: This cut will start at (x,y) = (0mm,1.59mm)
2. Mount a 1/8" end mill on the chuck, and move your cutter to the start position.
3. You will cut down through the node (5mm thickness). The path the cut we will follow is from (x=0mm, y=1.59mm) to (x=0mm, y= -16mm). Do the path back and forth to get clean cuts.
4. Cut the z-axis less than 1mm at a time. Repeat all of Part D until you have completly cut thorugh the node.

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NEXT ASSY | USED ON | APPLICATION

NAME DATE DRAWN CHECKED ENG APPR. MFG APPR. Q.A. COMMENTS:

TITLE: Node V1

SIZE C DWG. NO. V1-FinalNode REV

SCALE: 5:1 WEIGHT: SHEET 2 OF 4

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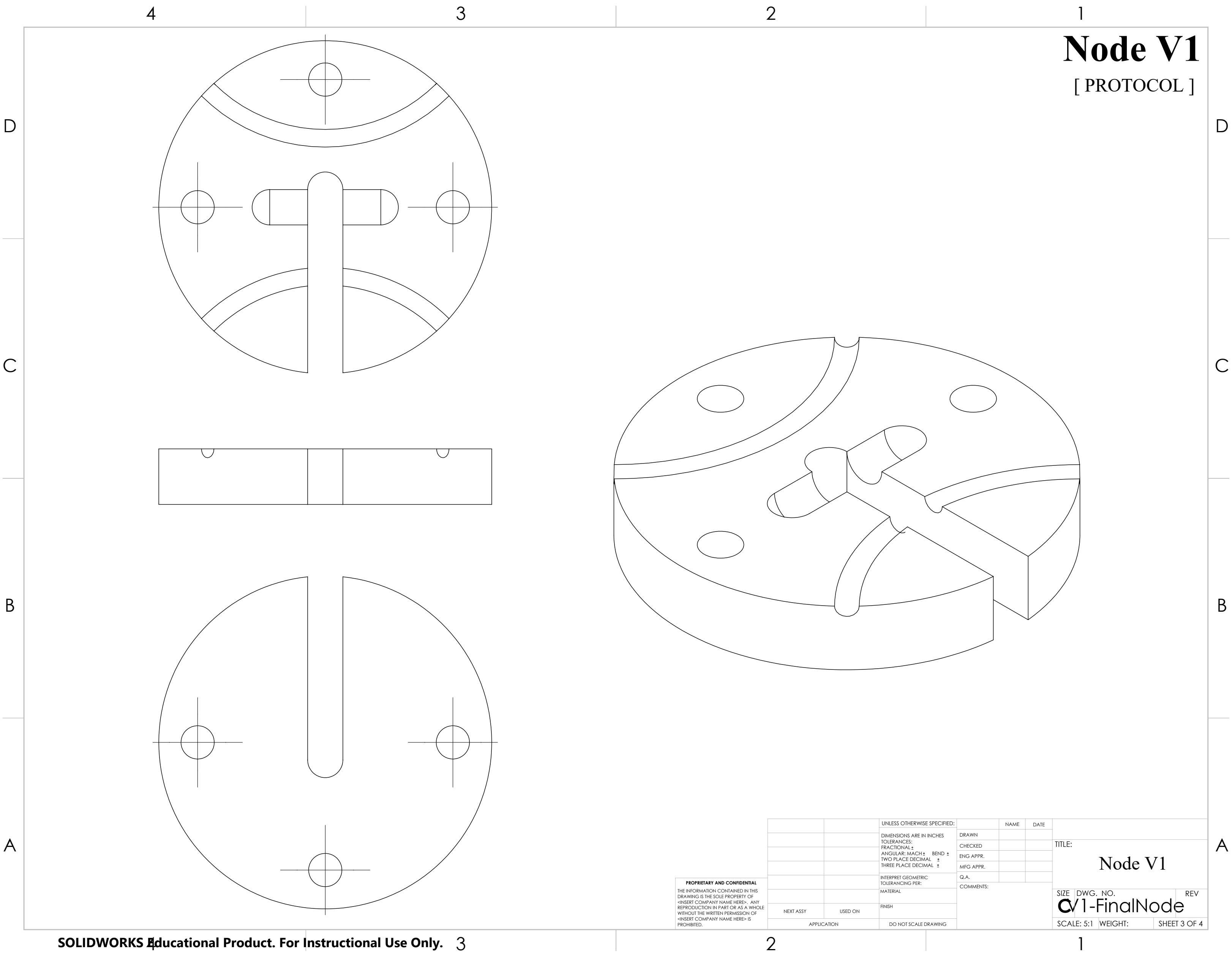
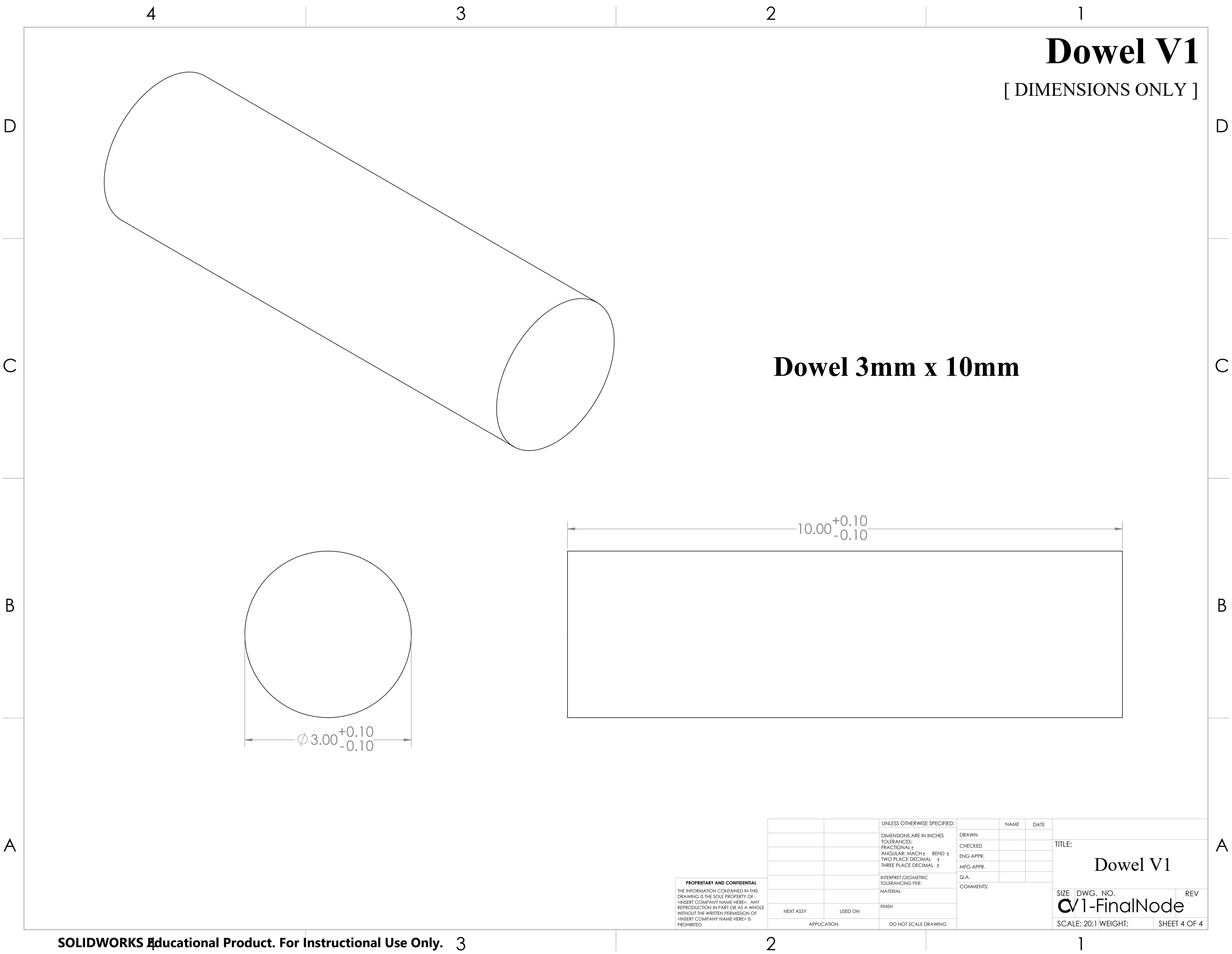
Node/Dowel Version 1 Protocol & Dimensions (Page 3 of 4)



Node/Dowel Version 1 Protocol & Dimensions (Page 4 of 4)



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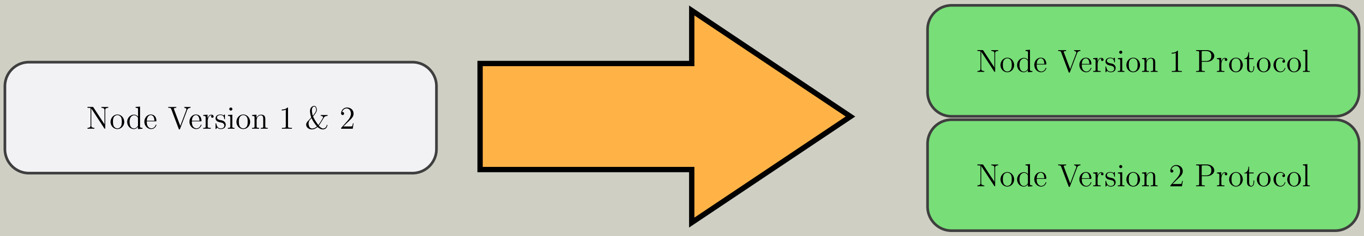
Protocol Set 3: Manufacturing Nodes

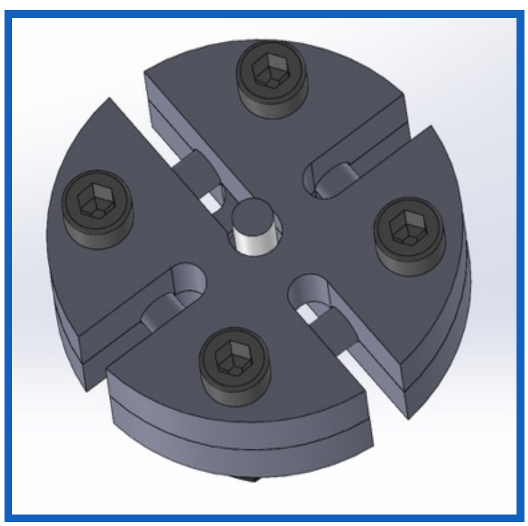


Component Description Node Version 2:

Node version 2 is composed of 4 dowels through-cuts that serve as individual pulley systems. Node version 2 moves around and turns the faces of the nodes, providing movement to the tensegrity structure. The tools used to make the features on the nodes were the following: 1/8" end mill, 1/8" ball nose end mill, and 15/64" ball end mill.

First, the 1/8" end mill has through cuts on the nodes, which allows the wires to go around the node dowels. Next, the 1/8" ball nose end mill carved the dowel pockets. By combining the through cuts and dowel pockets, our system forms a pull system that moves the tensegrity structure. Finally, a 15/64" ball end mill created a pocket for the ball-and-shank mechanism, which was directly actuated by the motor and the attached spool system. Node V2 incorporates four pulley systems and a ball-and-shank mechanism that together generate locomotion on the faces of the tensegrity rover. The figures below demonstrate the node version 2 manufactured at the machine shop, along with the assembly of node version 2 with a small 3mm x 6mm. Due to the complexity of manufacturing such a small dowel, we ordered the 3mm x 6mm dowels.

Node Version 2



Node Version 2 Assembly

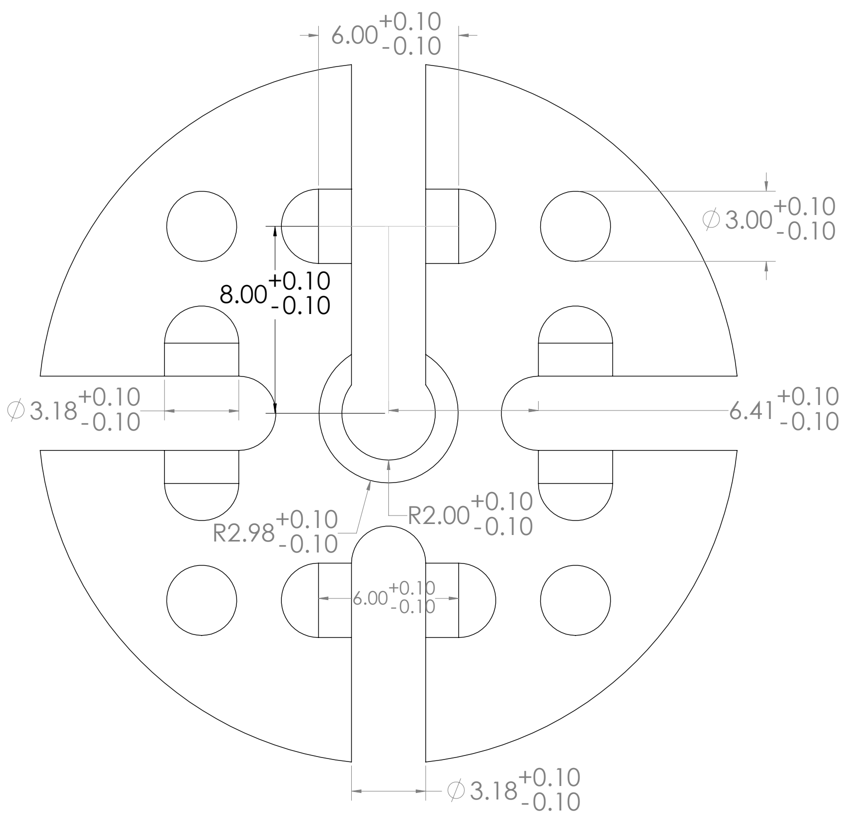
Node Version 2 Dowel

Node/Dowel Version 2 Protocol & Dimensions (Page 1 of 5)

4 3 2 1

NODE V2

[PROTOCOL]



Part A: Mounting the Nodes on Mill

1. To do this protocol, you must first complete drilling screw holes onto the node, and finshed making a node mount waste plate.
2. Secure the nodes onto the node mount waste plate with M2.5 Screws. (NOTE: The waste plaste thread is M2.5 thread, while the the threading on the node is for an M3)
3. Zero out the x and y-axis on the milling machine so that the zero-zero origin is at the center of the node.

Part B: Center Ball and Shank

1. Mount a centre drill on the chuck, and move the mill to zero-zero at the middle of the node.
2. Turn on the mill, set it to 1400 RPM and slightly dent the center of the node by bringing down the z-axis.
3. Turn off the machine and mount 15/64" ball nose end mill on the chuck.
4. Turn on the machine and set it to 1600 RPM.
5. Bring down the z-axis to z = - 3mm. This creates the ball shank pocket.
6. Turn off the machine.

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ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
NEXT ASSY | USED ON
APPLICATION | DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:
NODE V2
SIZE C DWG. NO. V2-TopNode REV
SCALE: 2:1 WEIGHT: SHEET 1 OF 5

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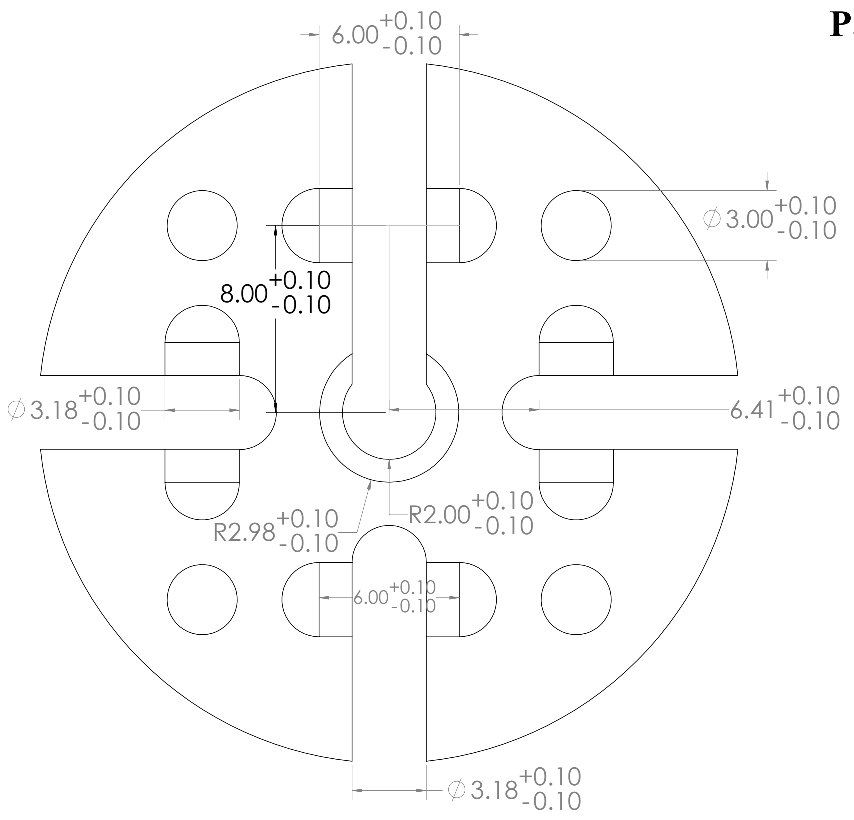
4 3 2 1

Node/Dowel Version 2 Protocol & Dimensions (Page 2 of 5)

NODE V2

[PROTOCOL]



Part C: Dowel Cuts

NOTE: The dowel cut will be done 4 times at different starting points:

- Dowel 1: (x,y) = (0, 8)mm
- Dowel 2: (x,y) =(8, 0)mm
- Dowel 3 :(x,y) =(0, -8)mm
- Dowel 4 :(x,y) =(-8, 0)mm

With respective dowel cut movements:

- Dowel 1: From (-3,8)mm to (3,8)mm
- Dowel 2: From (8,3)mm to (8,-3)mm
- Dowel 3: From (-3,-8)mm to (3,-8)mm
- Dowel 4: From (-8,-3)mm to (-8,3)mm

1. Mount a centre drill on the chuck, and move to the starting point to Dowel 1 position.
2. Turn on the mill, set it to 1400 RPM and slightly dent the the dowel starting point.
3. Turn off the machine and mount 1/8" ball nose end mill on the chuck.
4. Turn on the machine and set it to 1600 RPM.
5. Cut out the dowel pocket witht eh respective dowel cut movements, by bringing down the z-axis by no more than 0.5mm at a time.
6. Repeat step 5, until your dowel pocket is 1.58mm in depth.
7. Repeat all of Part C for Dowel Cut 2, 3, and 4.
8. Turn off the machine.

TITLE: NODE V2

SIZE C DWG. NO. V2-TopNode REV

SCALE: 2:1 WEIGHT: SHEET 2 OF 5

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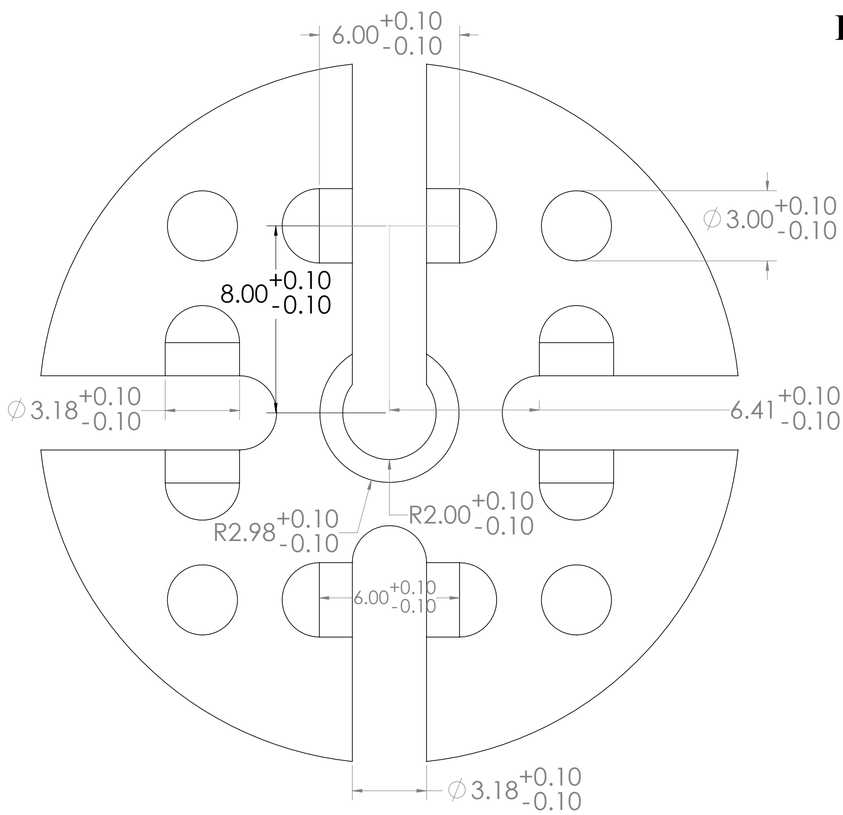
Node/Dowel Version 2 Protocol & Dimensions (Page 3 of 5)

NODE V2

[PROTOCOL]



Part D: Through cuts

NOTE: The dowel cut will be done 4 times at different starting points:

- Through-cut 1: (x,y) = (0, 0)mm
- Through-cut 2: (x,y) =(6.41, 0)mm
- Through-cut 3 :(x,y) =(0, -6.41)mm
- Through-cut 4 :(x,y) =(-6.41, 0)mm

With respective through cut movements:

- Through-cut 1: From (0, 0)mm to (0,16)mm
- Through-cut 2: From (6.41, 0)mm to (16,0)mm
- Through-cut 3: From (0, -6.41)mm to (0,-16)mm
- Through-cut 4: From (-6.41, 0)mm to (-16,0)mm

1. Mount a centre drill on the chuck, and move to the starting point to through-cut 1 position.
2. Turn on the mill, set it to 1400 RPM and slightly dent the the throuch-cut starting point.
3. Turn off the machine and mount 1/8" end mill on the chuck.
4. Turn on the machine and set it to 1600 RPM.
5. Follow the through-cut path movement back and forth across the 5 mm thick node, lowering the Z-axis by no more than 0.5–1.0 mm at a time and repeating the full path until the cut is complete.
6. Repeat step 5, until you have cut through the node.
7. Repeat all of Part D for Through cut 2, 3, and 4.
8. Turn off the machine.

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DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN			TITLE: NODE V2
	CHECKED			
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL	COMMENTS:			SIZE C, DWG. NO. V2-TopNode, REV
FINISH				
DO NOT SCALE DRAWING				SCALE: 2:1 WEIGHT: SHEET 3 OF 5

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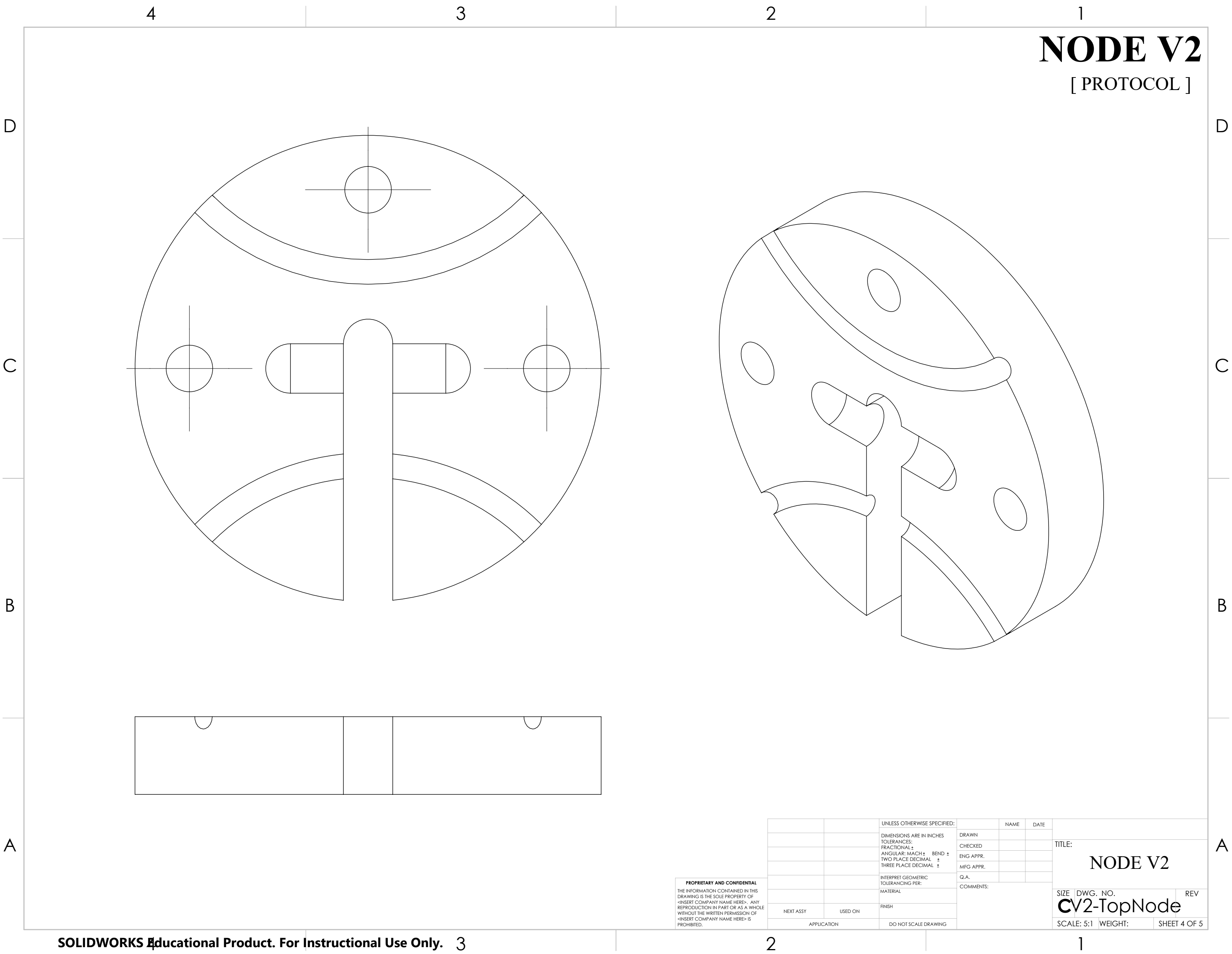
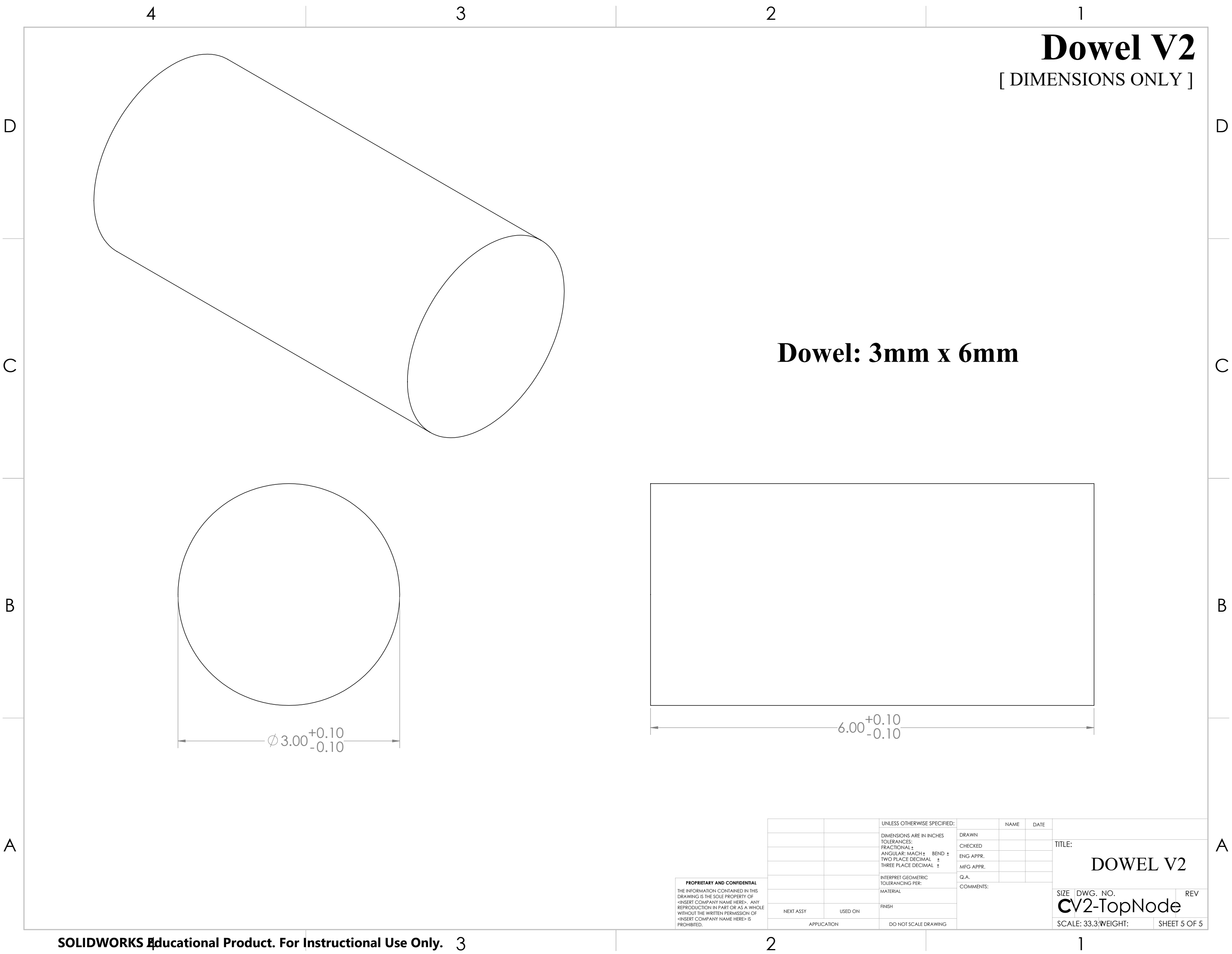
Node/Dowel Version 2 Protocol & Dimensions (Page 4 of 5)

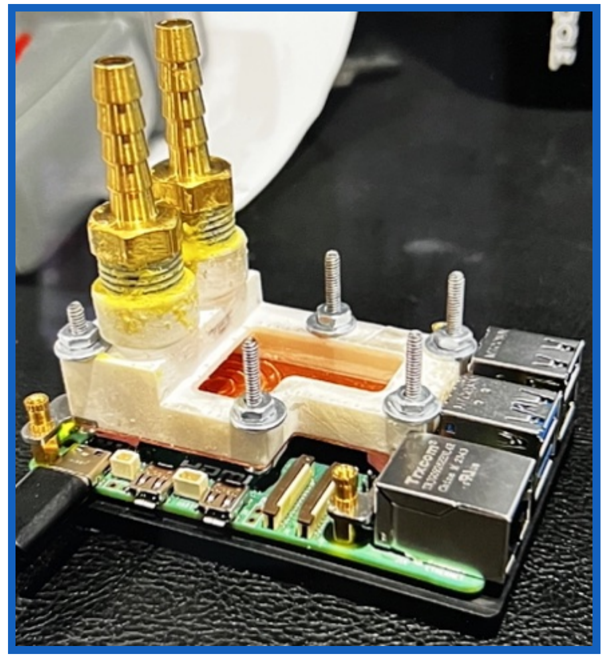


Node/Dowel Version 2 Protocol & Dimensions (Page 5 of 5)



CNC MACHINIST FOR HEAT TRANSFER: UC IRVINE

Project Description: I collaborated with a fellow graduate student on his MS project, which focused on designing a two-phase flow cooling system for a Raspberry Pi computer. My contributions became important when he was unable to achieve the desired results with 3D copper printing, and outsourcing proved too expensive. As a result, he asked me to CNC machine a copper cold plate for his two-phase cooling system. The images show the 3D-printed copper cold plate, the copper cold plate I CNC-machined, and the final assembled setup.



Copper Cold Plate Final Setup

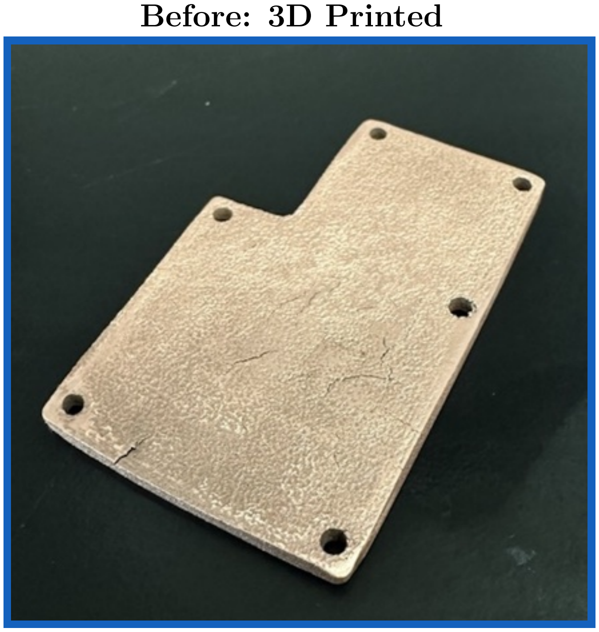
Methods & Skills:

- SolidWorks Parts, Assembly and 2D Drawings
- Bridgeport Machining
- CNC Machining

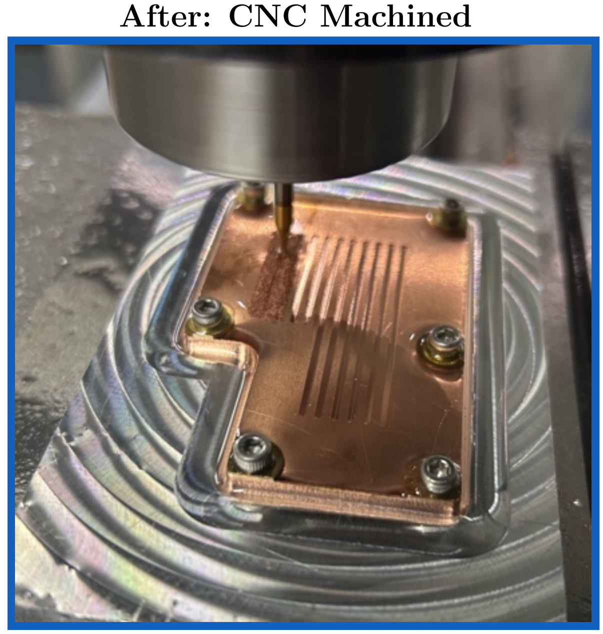
Results:

- Improved the heat transfer of the computer system by reducing the temperatures by 35% (from 85° to 55°) compared to prior designs.
- Automated the CNC milling procedure to manufacture copper cold plates by customizing the G-codes to reduce production time by 40% (from 10 to 6 hours) for mass production.
- Cut the cost of fabrication by 75%, lowering the price of producing copper cold plates from $20 (outsourced) to $4 (in-house CNC milling).

Before: 3D Printed

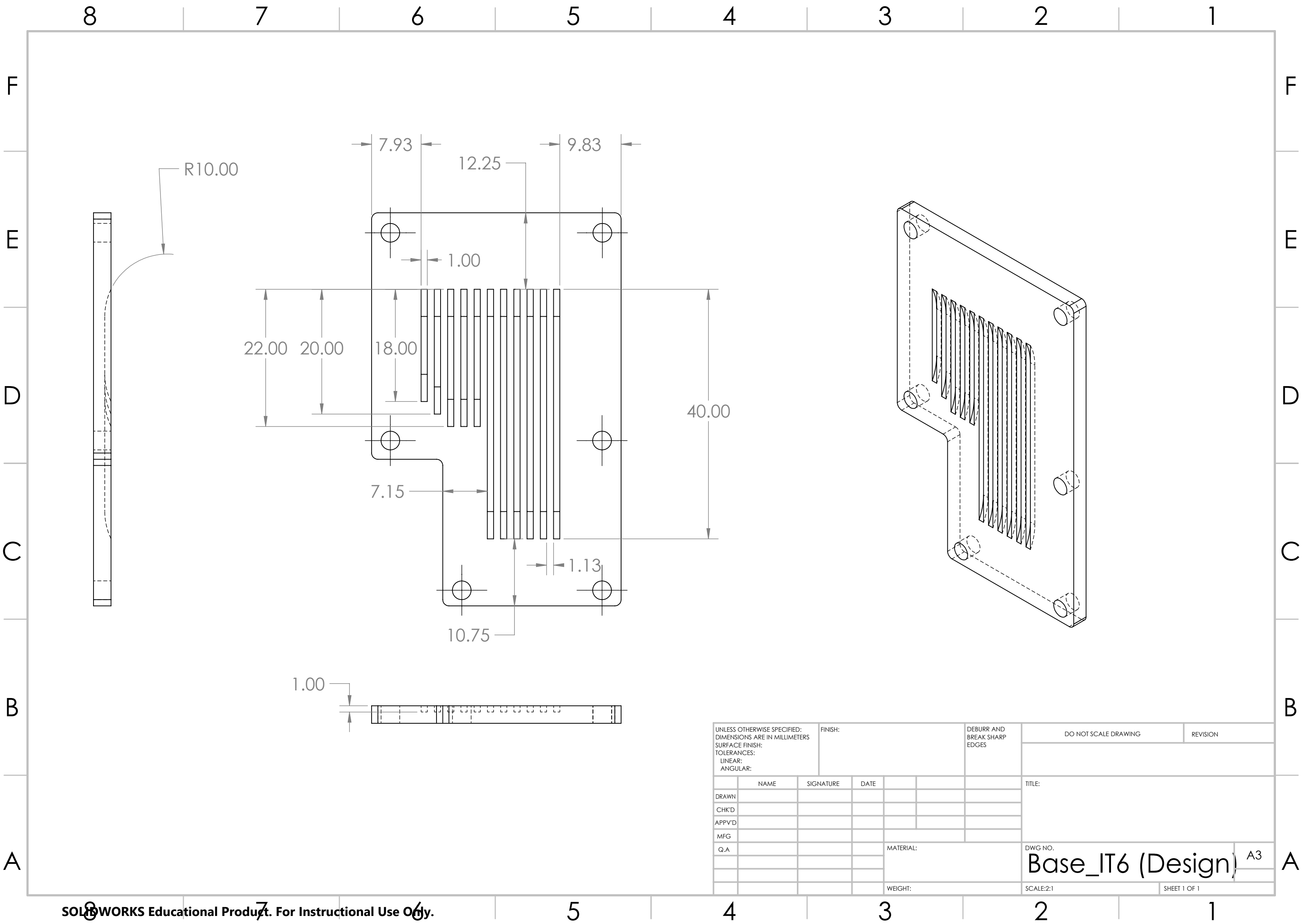


After: CNC Machined

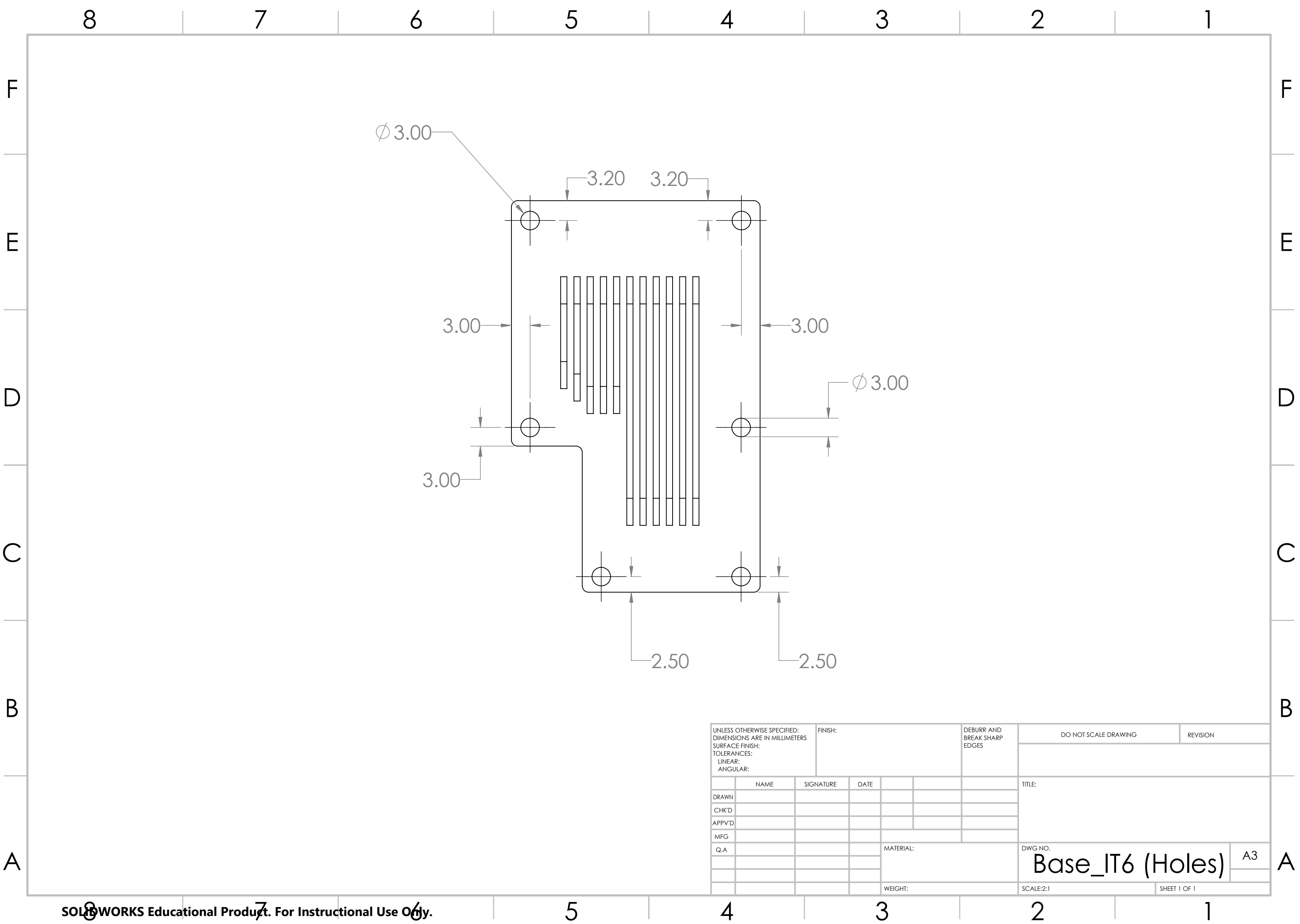


Before & After Copper Cold Plate: 3D Printing vs CNC Machining

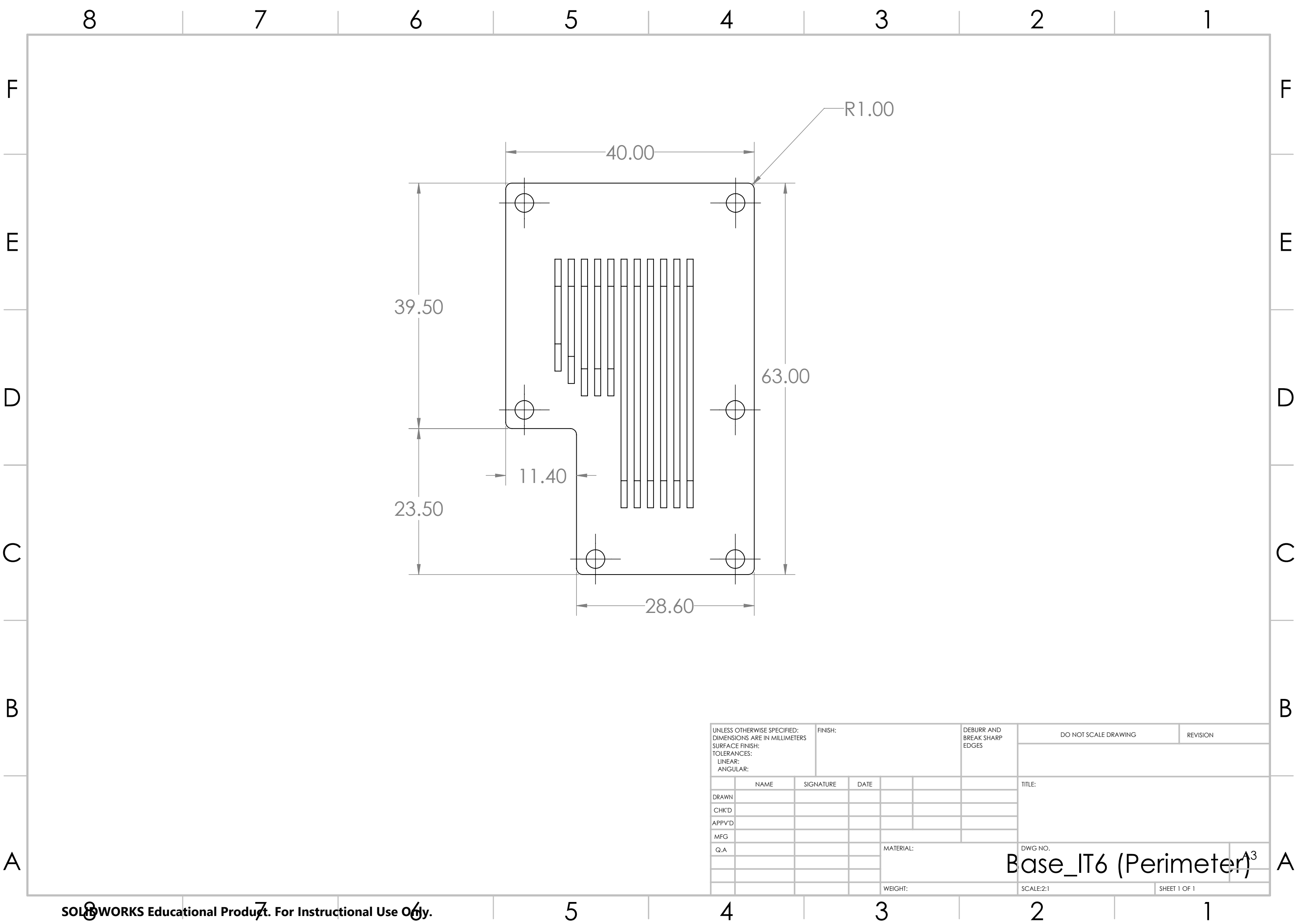
Copper Cold Plate Dimensions (Page 1 of 3)



Copper Cold Plate Dimensions (Page 2 of 3)

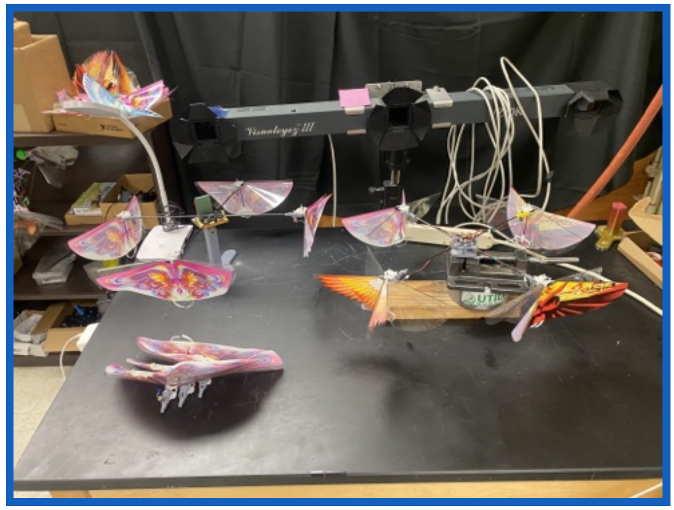


Copper Cold Plate Dimensions (Page 3 of 3)



FLAPPING-WING UNMANNED AERIAL VEHICLE: UC IRVINE

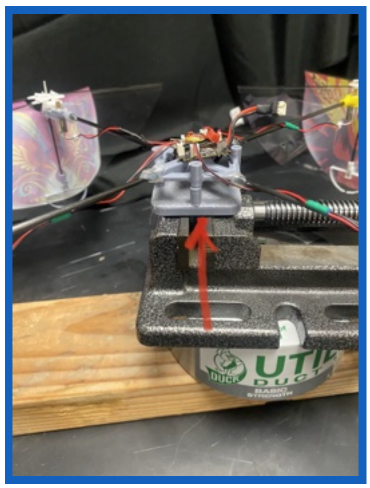
Project Description: The purpose of the "Alpha" Quad-flapper is to implement nature's evolutionary adaptations in current Unmanned Aerial Vehicles (UAV) technologies. The "Alpha" quad-flapper uses the flapping wing mechanism used in hummingbirds to enhance applications of lift and thrust in UAVs. Initially, the structure of the Flapping-wing Micro Air Vehicle (FWMAV) was 3D printed using CAD software and assembled using plastic wings. The flight controller was programmed to regulate power and control thrust for the drone's four motors. After manufacturing the drone, the UAV was placed under the wind tunnel to examine the effectiveness of the motor's power-thrust ratio and lift distribution on the four flapping wings.



Multiple Quad-flappers Assembled

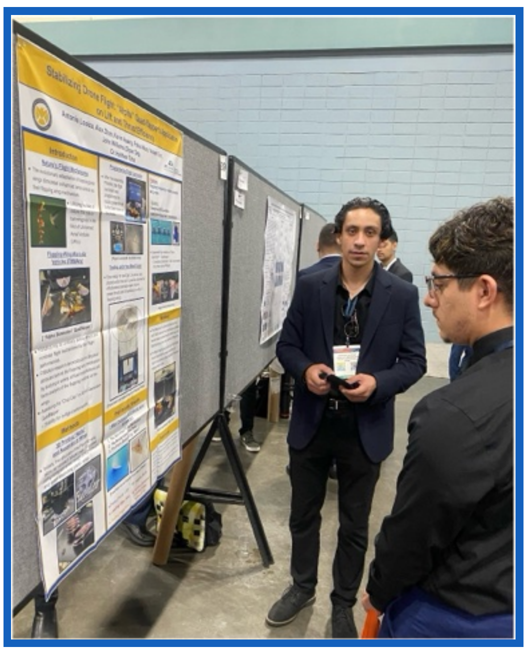
Methods & Skills:

- SolidWorks Parts, Assembly and 2D Drawings
- 3D printing with PLA
- Programming Betaflight with C++ code



Drone Body

Drone Wings



Presentation at SACNAS in San Juan, Puerto Rico

Results:

- Designed and assembled a UAV using DFMA principles, reducing production costs by 75% compared to conventional drones.
- Engineered a bio-inspired flapping-wing drone, mimicking hummingbird flight and boosting thrust-to-power ratio by 2.5x over similar-sized drones.
- Programmed the drone's flight controller, and designed a vibration-damping ESC mount — increasing the peak frequency by 40% and enhancing flight stability.
- Awarded best poster presentation (out of approximately 1000 participants), for the Quad-flapper drone project at the 2022 National Diversity in STEM conference in San Juan, Puerto Rico.

References

1. Fuller, R.B. (1982). Synergetics: Explorations in the Geometry of Thinking. New York: Macmillan Pub. Co.

2. Rimoli, Julian J. "A reduced-order model for the dynamic and post-buckling behavior of Tensegrity Structures." Mechanics of Materials, vol. 116, Jan. 2017, PP. 146-157, https://doi.org/10.1016/j.mechmat.2017.01.009