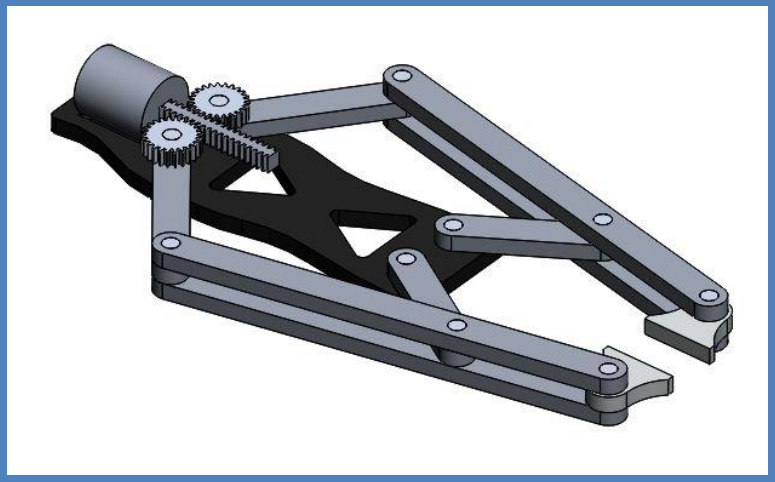
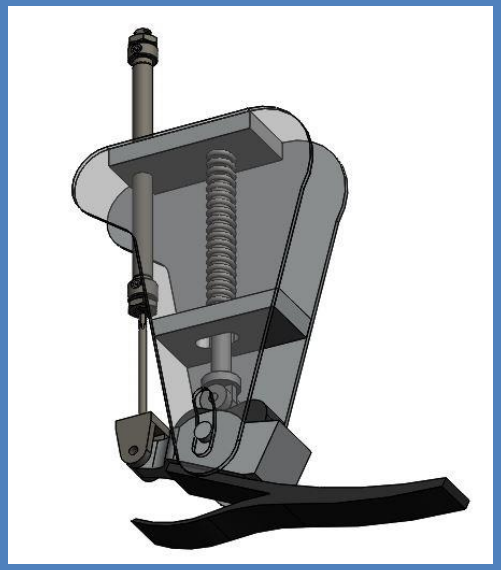




DESIGN PROJECT 1: 4-BAR LINKAGE AND CAM STRUCTURES

Christina Segar

ENGR3330 Mechanical Design Olin College of Engineering Oct. 8, 2018

Grade:	_____\ 100
Exec Summary:	_____\2
Preliminary Design:	_____\10
FBDs:	_____\10
CAD Models:	_____\20
FEA/FOS:	_____\10
Optimize Parts:	_____\15
Manufacture DWGs:	_____\20
Assembly DWGS:	_____\10
BOM:	_____\3

Executive Summary:

Overall, I sought to create two assemblies to demonstrate a four-bar system and a cam system within real-use context. This process began with basic research into existing mechanisms that use each of these mechanical systems. I searched within the field of assistive technology because I find this to be an interesting space where a lot can be done to help improve the lives of individuals. Specifically, I looked into end-of-limb articulation because I want to learn more about mechanical actuation for more fluid movement of prosthetic hands and feet.

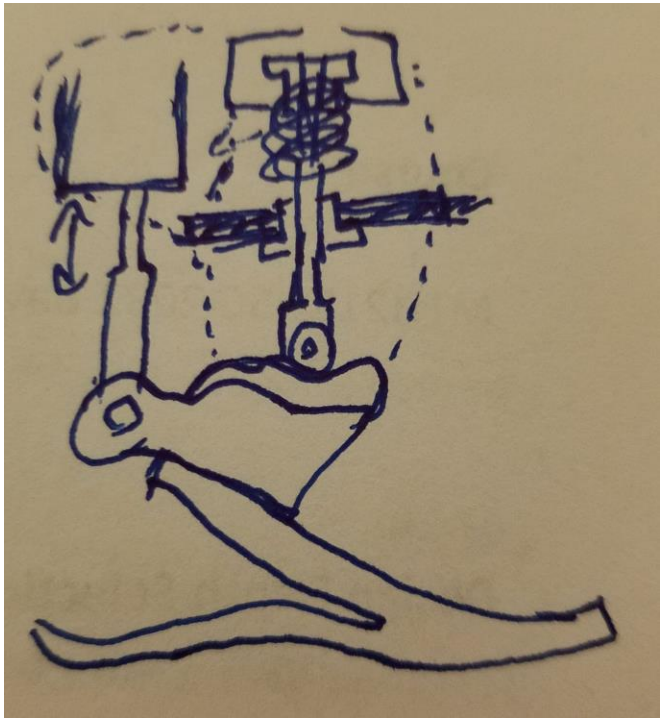
Once I found designs that utilized these mechanical systems, I sketched out a simplified version of each one that would include the key components without adding too much complexity beyond the systems in focus. For the four-bar assembly, I started with geometric modeling to determine the desired linkage lengths to get the motion I was looking to achieve. Once I had a basic model, I also ran motion analysis to check if the linkages would move in the way I had expected. The cam assembly was more complicated in part because it was more difficult to find a cam being used in the assistive-tech space, but also in part because I restricted myself by looking for a specific area of design. The motion beyond the cam, which acts as a force dampener, is more complex than I had originally thought, so a lot of the modeling required making changes to many parts at once. Much of the geometry on this piece was more organic, so constraining important dimensions and positions was a challenge.

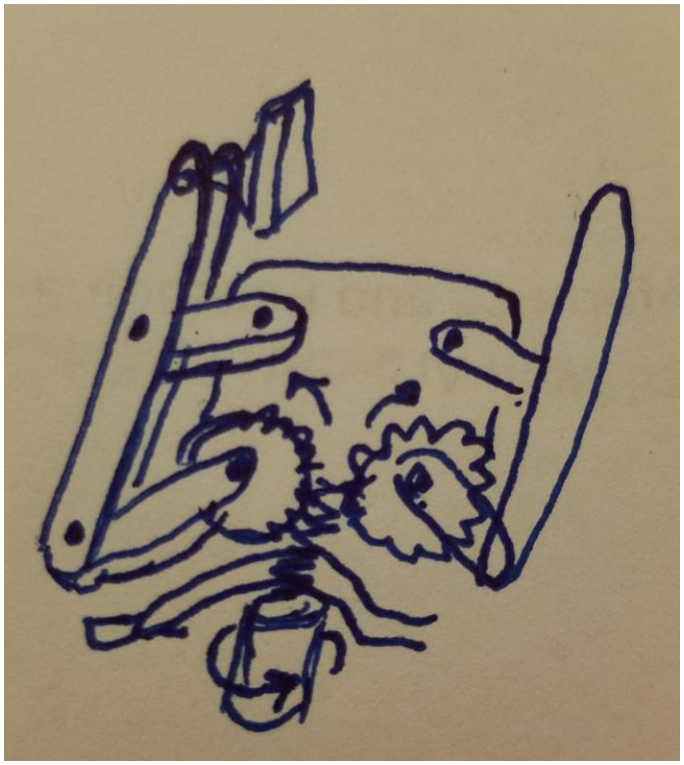
If more work were to be done on these assemblies, I'd recommend adding constraint complexity to both assemblies. By this I mean creating a more rigid mount for the motor on the four-bar assembly so that the worm gear can align with the spur gears properly. On the four-bar assembly this would mean mounting the top of the piston so that all motion is transferred to the ankle piece. Additionally, the cam follower should have housings between the shaft and each of the mounting blocks it runs through.

Preliminary Design Sketch and Product Description:

The Actuated Foot

The actuated foot is designed off of an under-actuated foot mechanism that allows impact from the ground to be absorbed through the cam follower and attached spring. It includes a pneumatic actuation that drives the rod upwards, pushing the toe of the foot (the curvy shape at the bottom of the sketch) down towards the ground. The flexible foot material along with the spring is then able to absorb the force of the foot against the ground. The cam has a variable path that allows the follower to constrict more at different foot angles depending on where more shock needs to be absorbed and where there needs to be a push-back force.

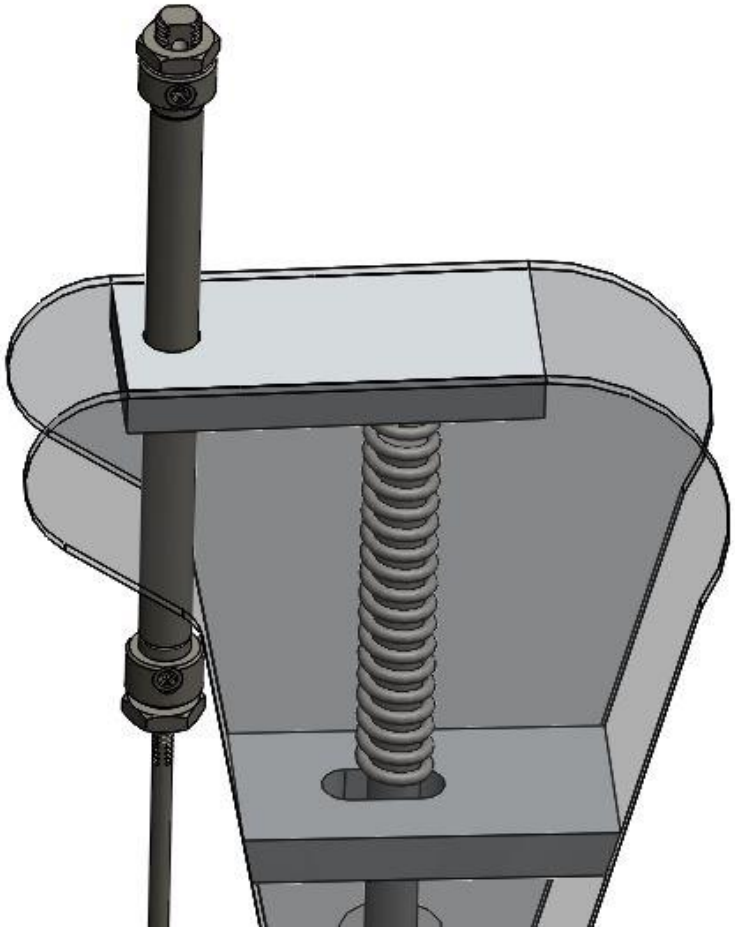




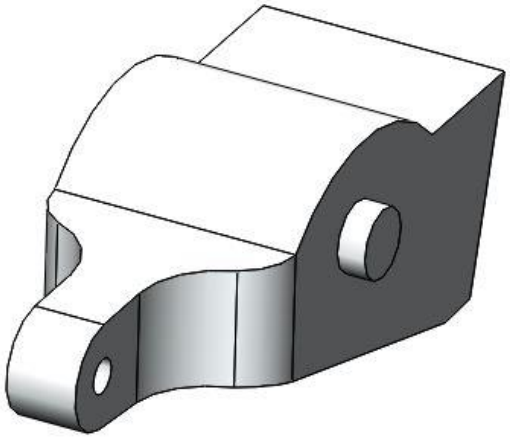
The Claw Grabber

The claw grabber is inspired by a reach assist mechanism that allows people to reach objects that are difficult to grasp. It is simply actuated by a driven worm gear that turns both gears simultaneously to move the linkages and open or close the claws. In the diagram above, the left side claw has more details drawn in to show how the linkages sandwich each other and hold the rubber gripping piece at the front of the claws. The motion on this can be simulated to see what kind of movement profile the claw will achieve, and this can be modified to get the desired grabbing motion.

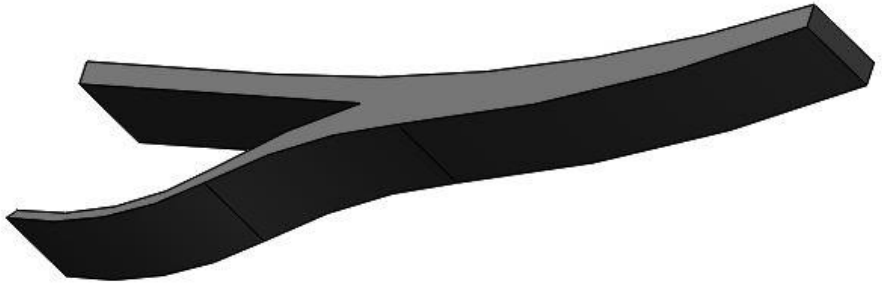
CAD Models (annotated summary of major parts):



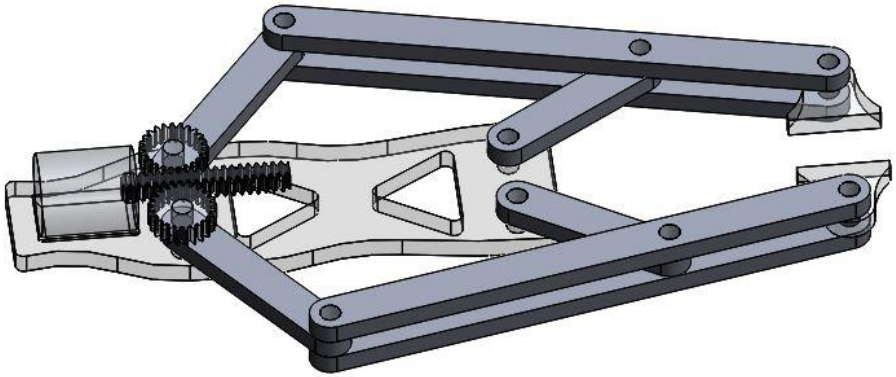
The Actuated Foot assembly is composed of two side plates sandwiching spacer blocks for the piston and cam follower assemblies. The piston is constrained by the top block which is welded to the side pieces. The cam follower sits within a slot in the middle block and follows the path of the cam which is fixed to the top of the ankle joint. The cam follower is also encased by a spring that runs between the middle and top blocks.



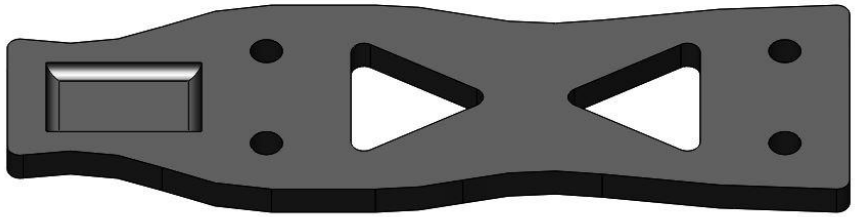
The Ankle Joint is tapered on one end where it connects to the clevis joint of the piston. The round extrusion on the side allows it to rotate along the rounded slot in the wall of the side plate. This constrains the motion without restricting it.



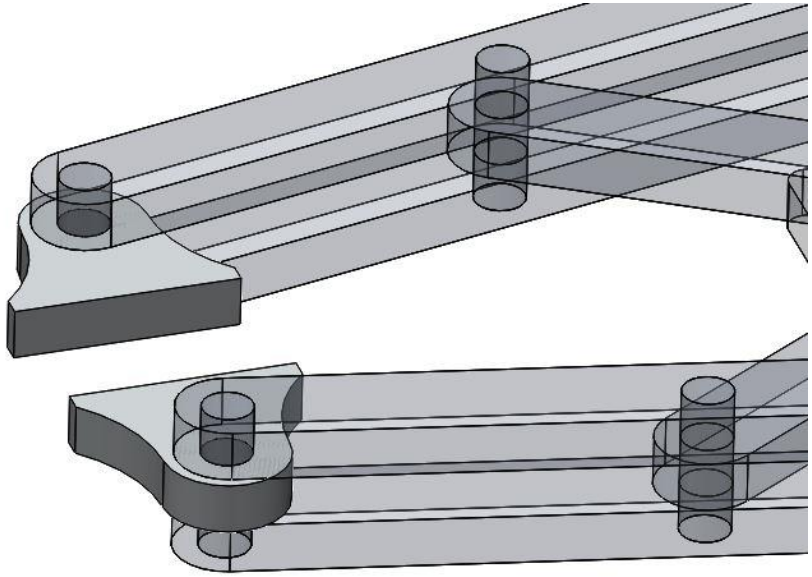
The Molded Foot is made of strong rubber that flexes but maintains its shape. This piece is fixed to the bottom of the ankle joint and it contact the ground upon impact. The foot moves with the ankle joint, which is controlled by the pneumatic piston.



The Grabber Linkages are the four-bar linkage structure that allows the claw to grasp objects with a fluid motion. The driving linkage on each side is fixed with a gear to translate motion while the other driven linkage is free to rotate at the point it is fixed to the base structure. The linkages are held together by pins with retaining rings on either end (see BOM for specific part list).



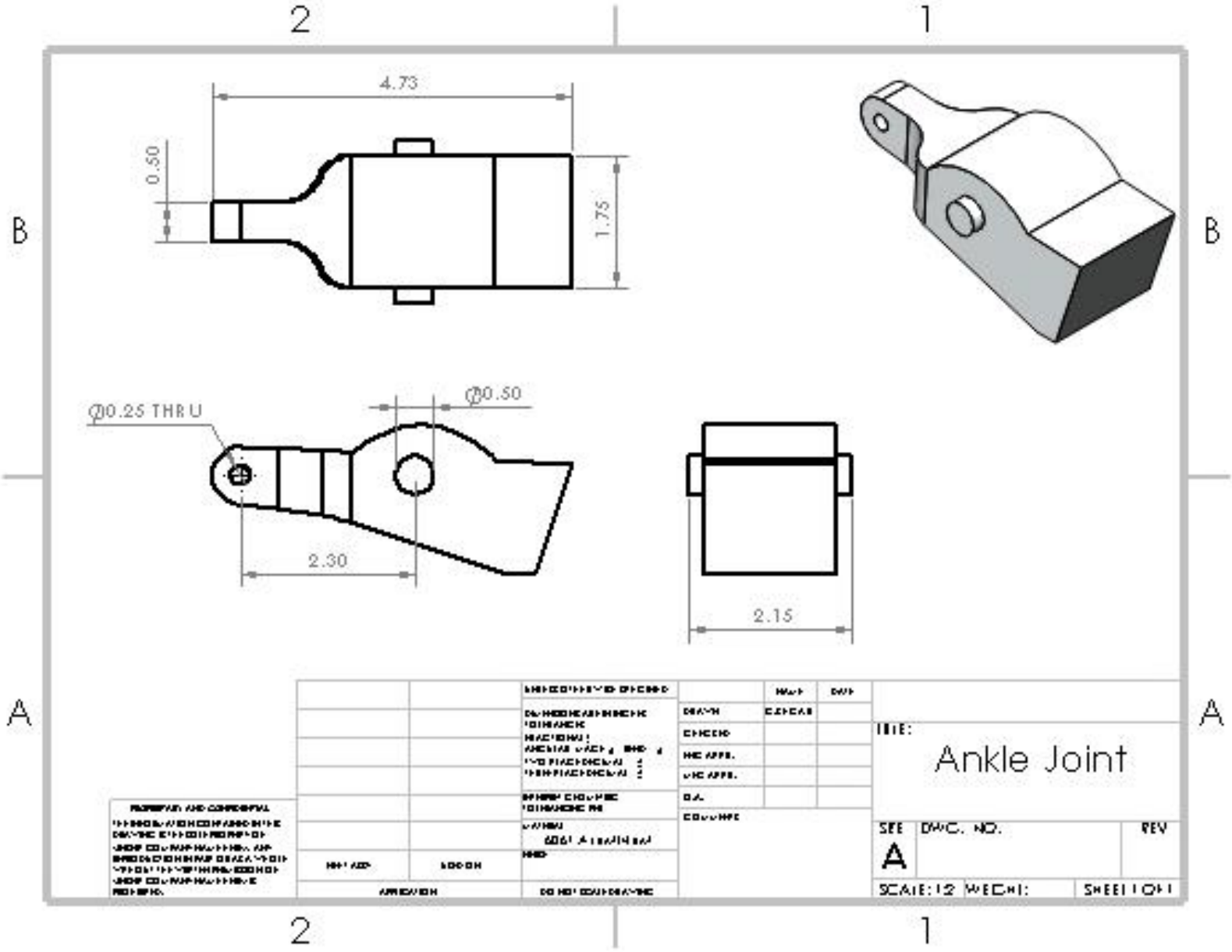
The Base Plate is the connection point for the linkages, acting as the "fourth bar" in the four-bar linkage system. It includes a pocket bored out for the motor to sit in as well as lightening holes that add an aesthetic element to the base design.



The Rubber Grips are able to pivot so that they can meet different sized objects at their contact surface. They are made of a soft rubber material that conforms to objects instead of pushing up against them, allowing the grippers to manage objects with more difficult shapes.

Manufacturing Detailed Drawings:

On the following pages are the detailed part drawings for both the Actuated Foot and Claw Grabber assemblies, respectively. Each drawing address overall dimensions as well as key dimensions that will affect other parts.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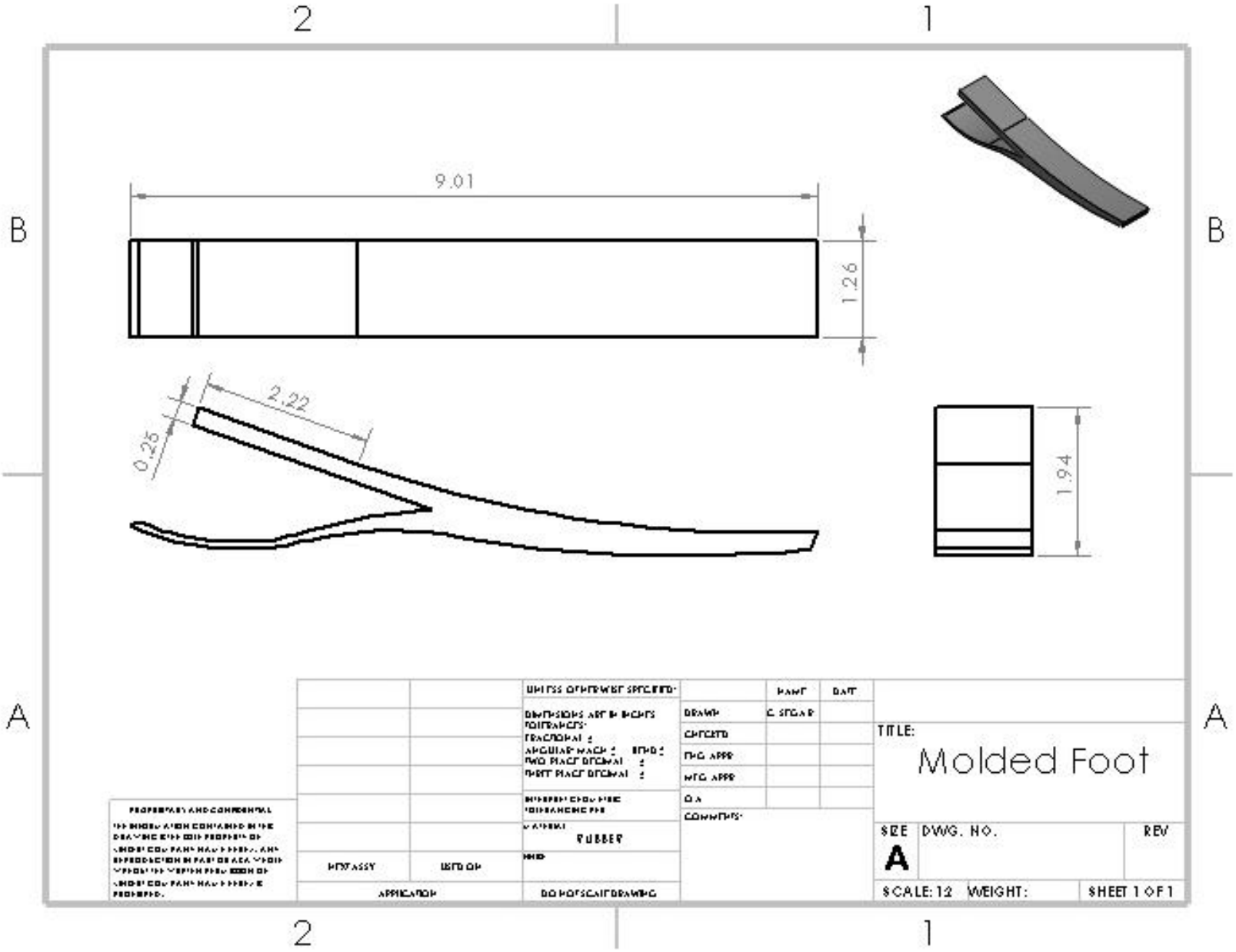
SHEET 1 OF 1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MFG APPR.
Q.A.
COMMENTS:
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REV
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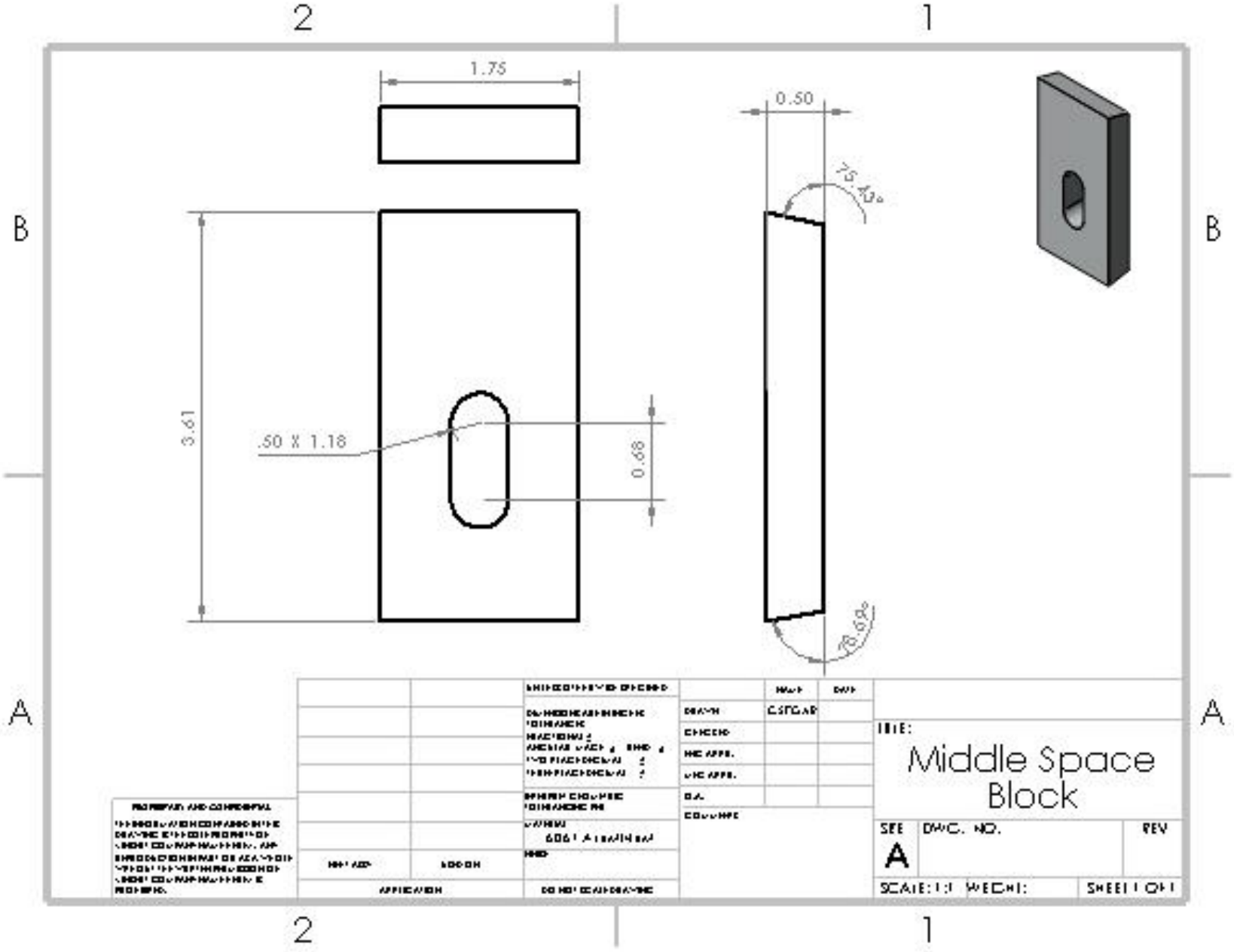
WEIGHT:
SHEET 1 OF 1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.50 X 1.18
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78.69°
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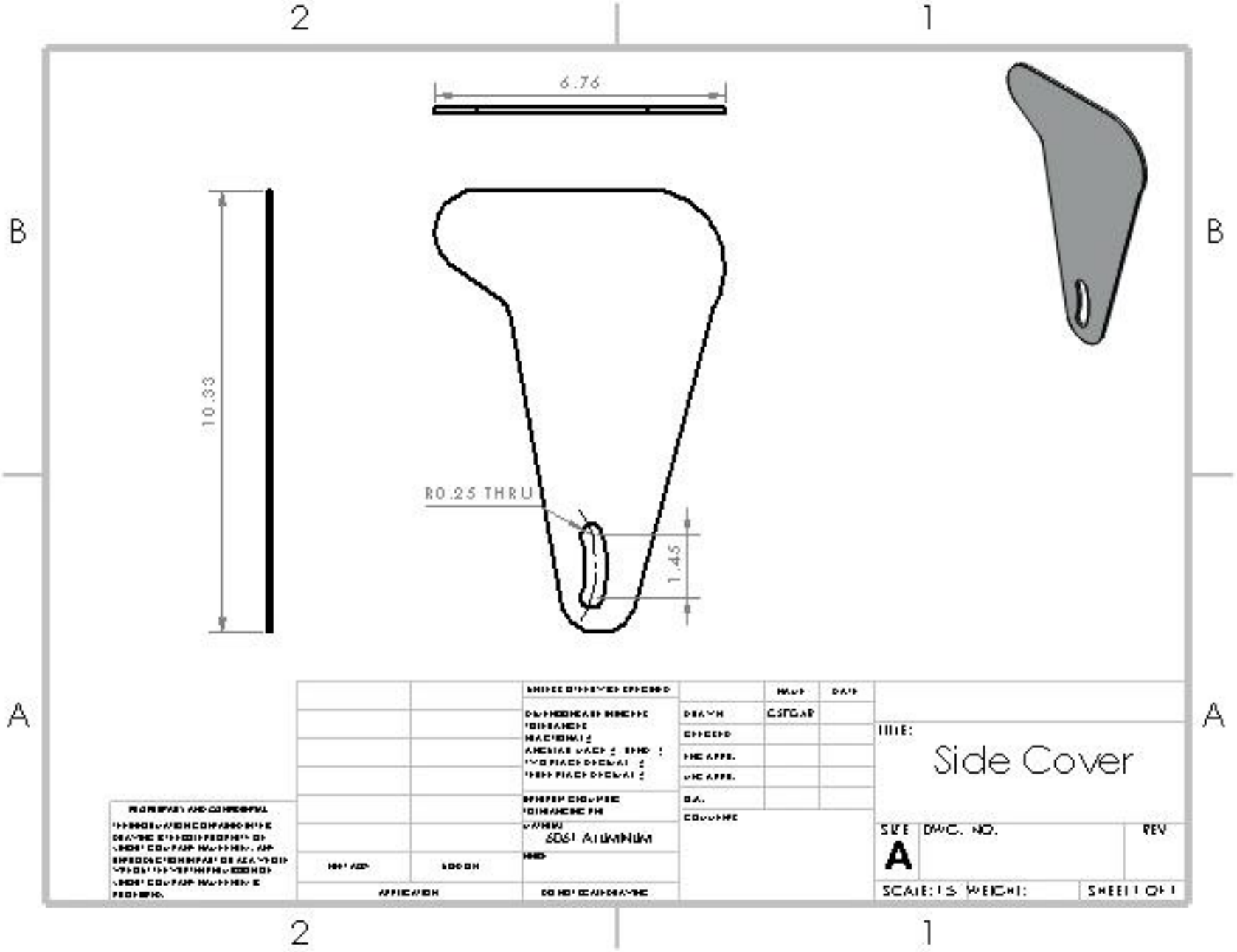
SHEET 1 OF 1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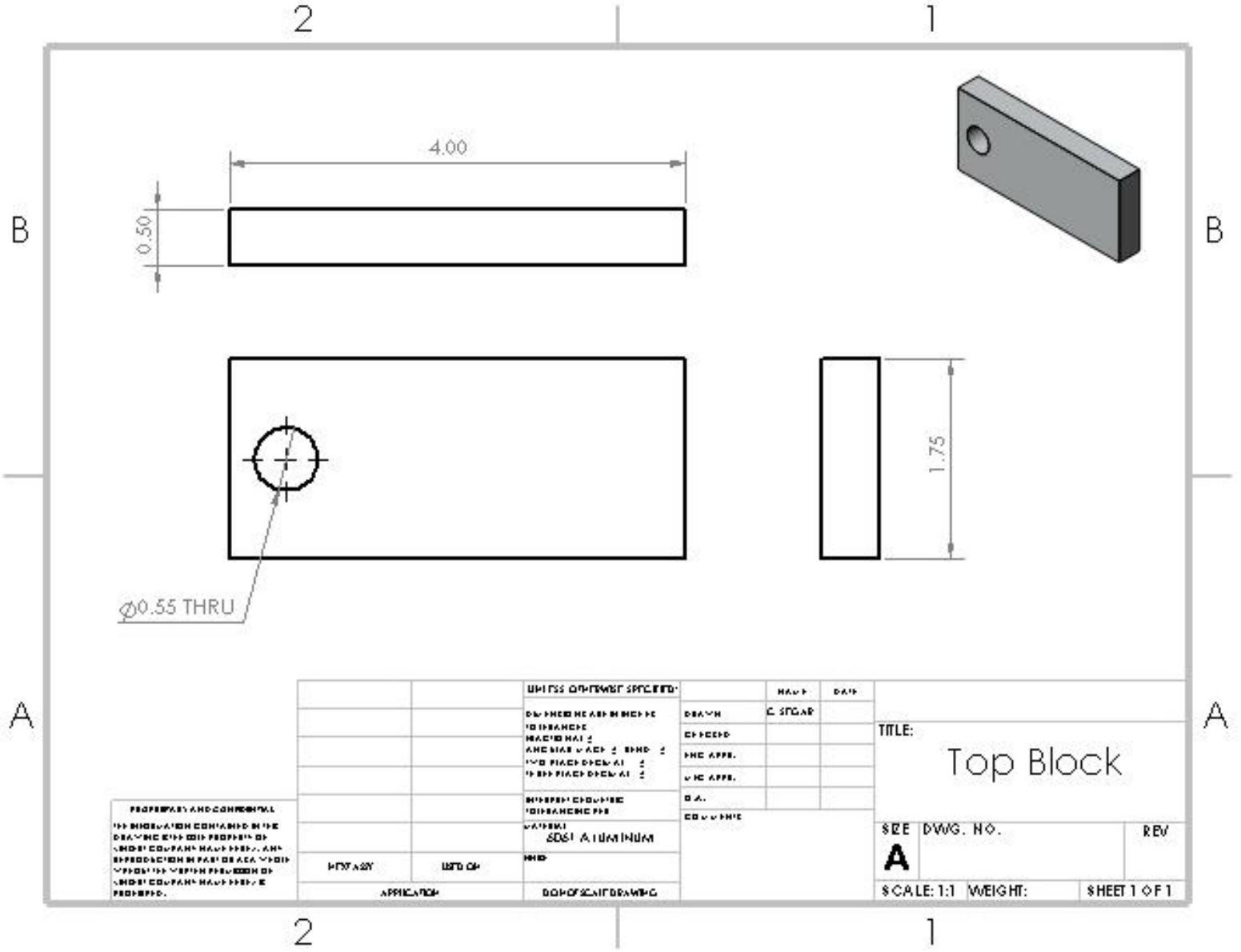
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ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
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6061 ALUMINUM
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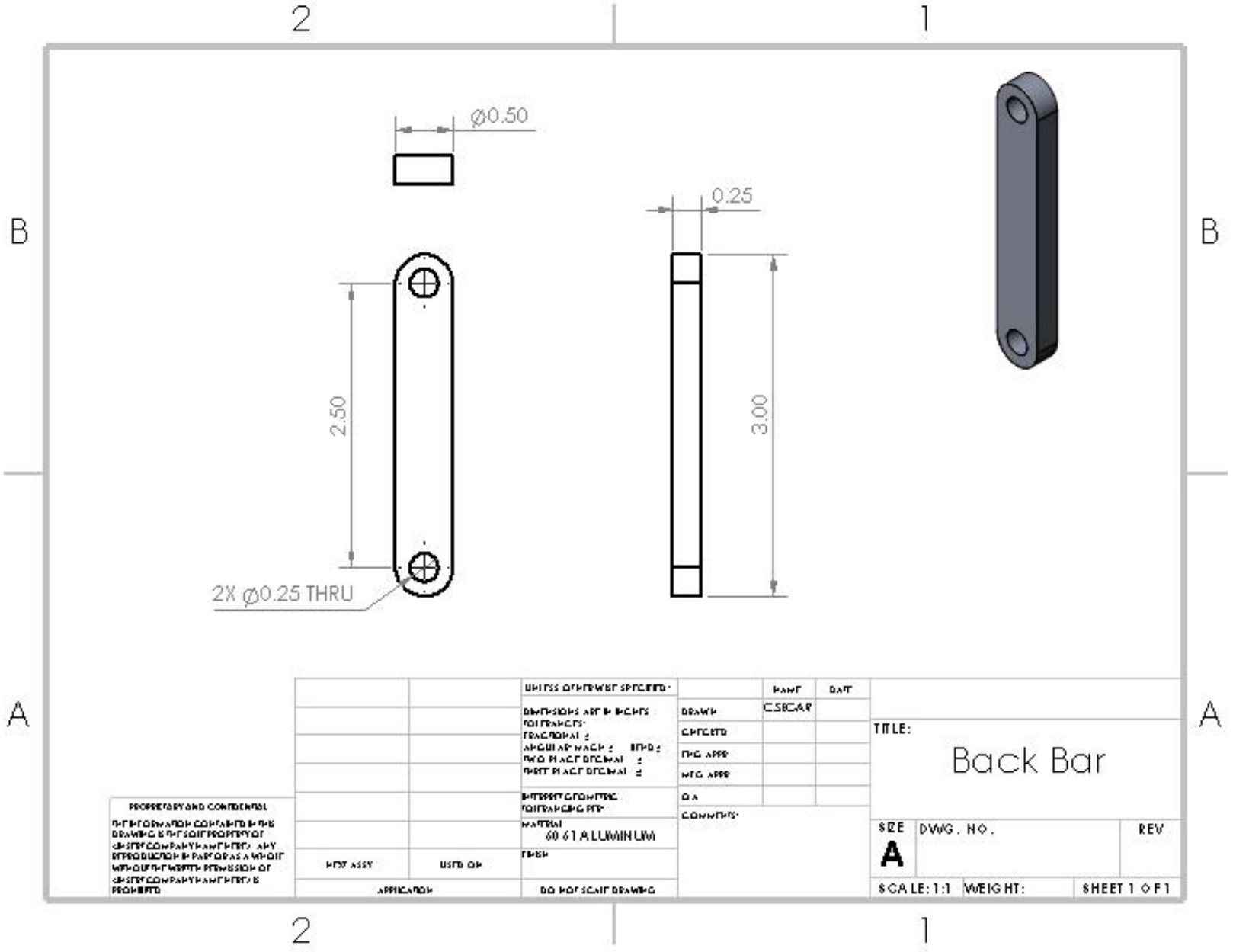
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ENG APPR
MFG APPR
Q.A
COMMENTS:
MATERIAL
6061 ALUMINUM
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APPLICATION
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REV
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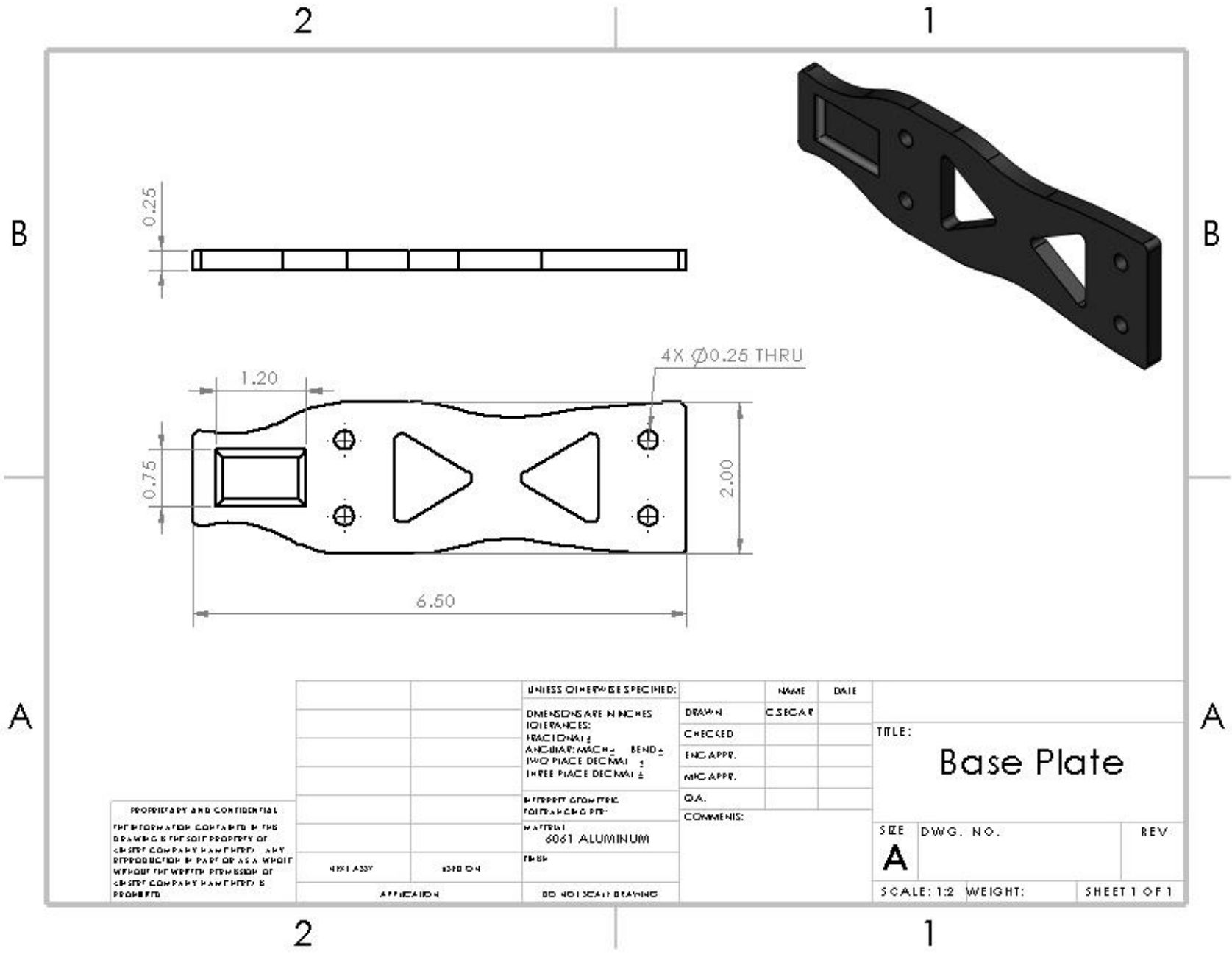
WEIGHT:
SHEET 1 OF 1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COMMENTS:
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FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
6061 ALUMINUM
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THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
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REV
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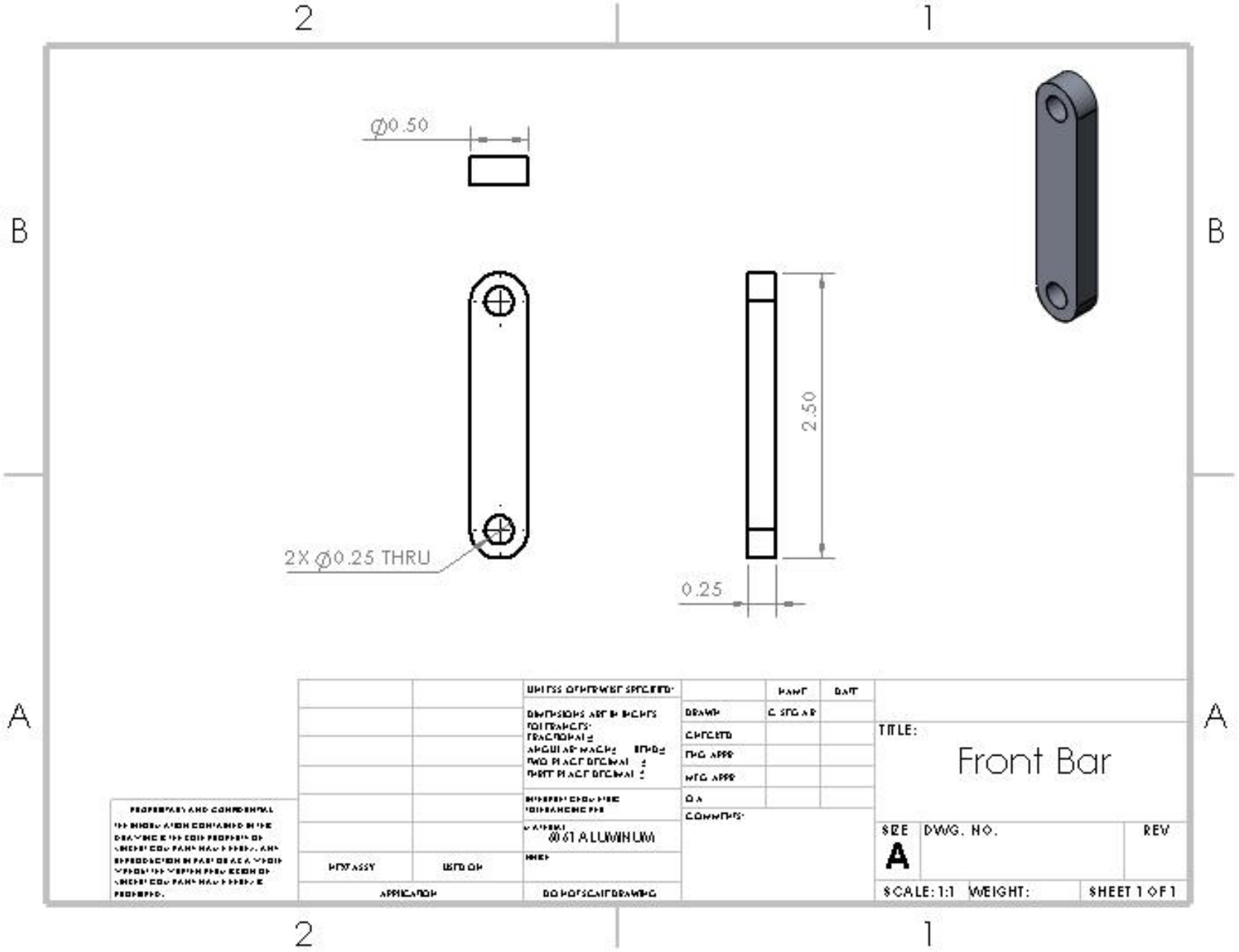
WEIGHT:
SHEET 1 OF 1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MFG APPR
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COMMENTS:
MATERIAL
6061 ALUMINUM
NEXT ASSY
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APPLICATION
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Front Bar
SIZE
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DWG. NO.
REV
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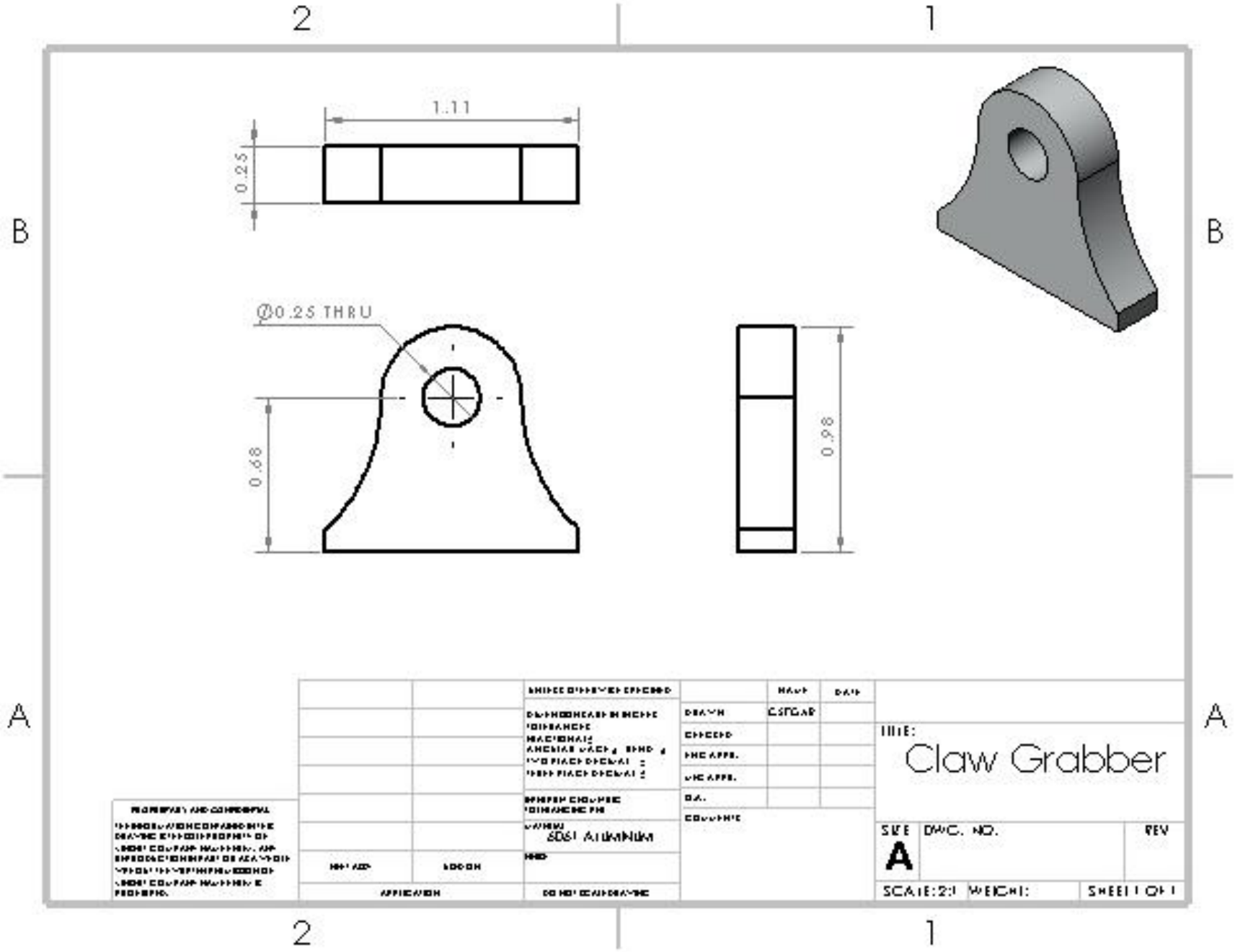
WEIGHT:
SHEET 1 OF 1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6061 Aluminum
Claw Grabber
SIZE
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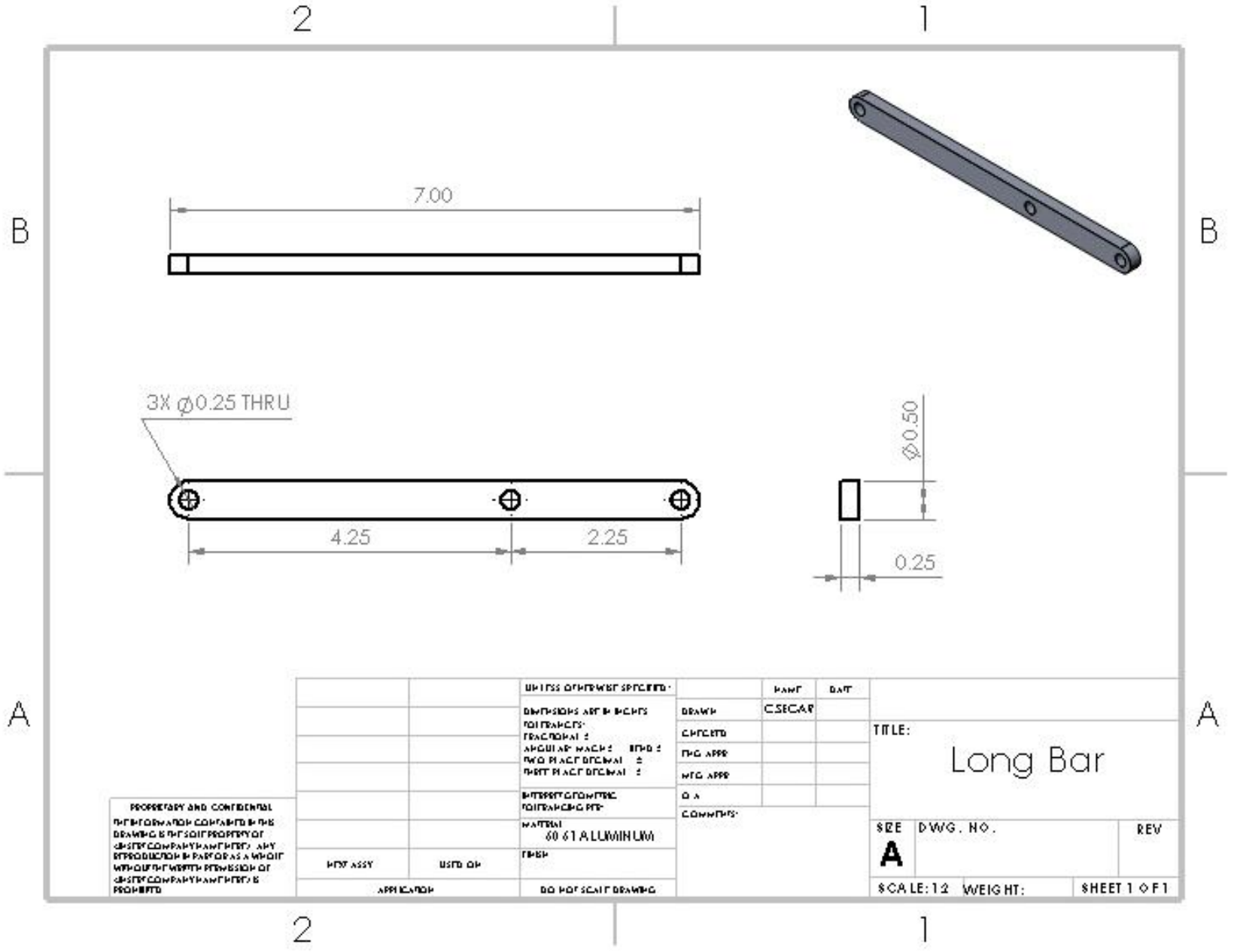
SHEET 1 OF 1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COMMENTS:
TITLE:
Long Bar
SIZE
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DWG. NO.
REV
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
MATERIAL
6061 ALUMINUM
FINISH
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APPLICATION
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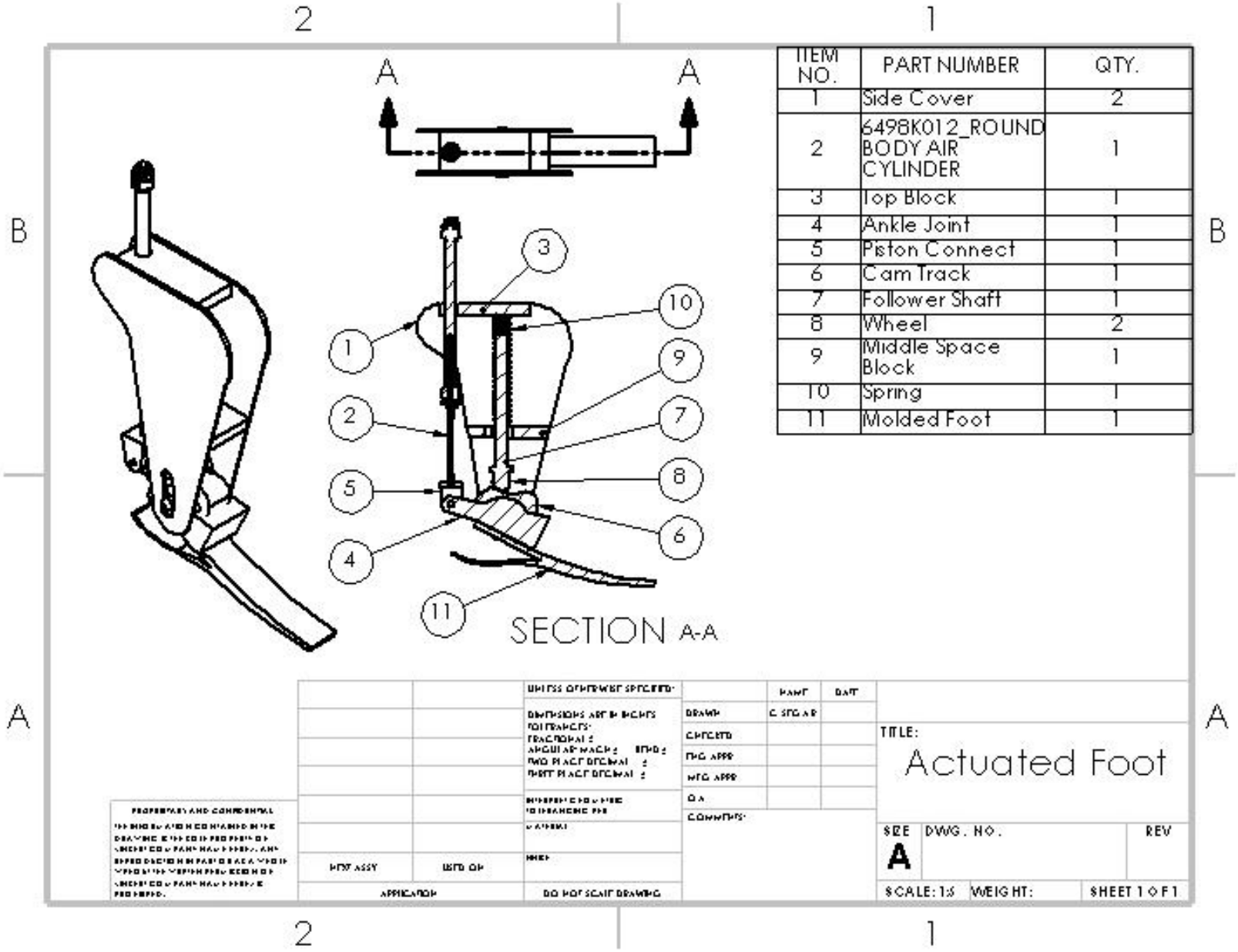
Complete Assembly Drawings:

The following pages include the assembly drawings for both the cam structure "Actuated Foot" and the four-bar linkage structure "Claw Grabber". The Parts are listed in a preliminary BOM. For a full and detailed purchase list, see the final page of this report.


2
1
A
A
B
B
A
A
3
10
1
9
2
7
5
8
6
4
11
SECTION A-A
ITEM NO.
PART NUMBER
QTY.
1 Side Cover 2
2 6498K012_ROUND BODY AIR CYLINDER 1
3 Top Block 1
4 Ankle Joint 1
5 Piston Connect 1
6 Cam Track 1
7 Follower Shaft 1
8 Wheel 2
9 Middle Space Block 1
10 Spring 1
11 Molded Foot 1
UNLESS OTHERWISE SPECIFIED:
DRAWN
CHECKED
ENG APPR
MFG APPR
Q.A
COMMENTS:
NAME
DATE
C. STOLAR
TITLE:
Actuated Foot
SIZE
A
DWG. NO.
REV
SCALE: 1:5
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
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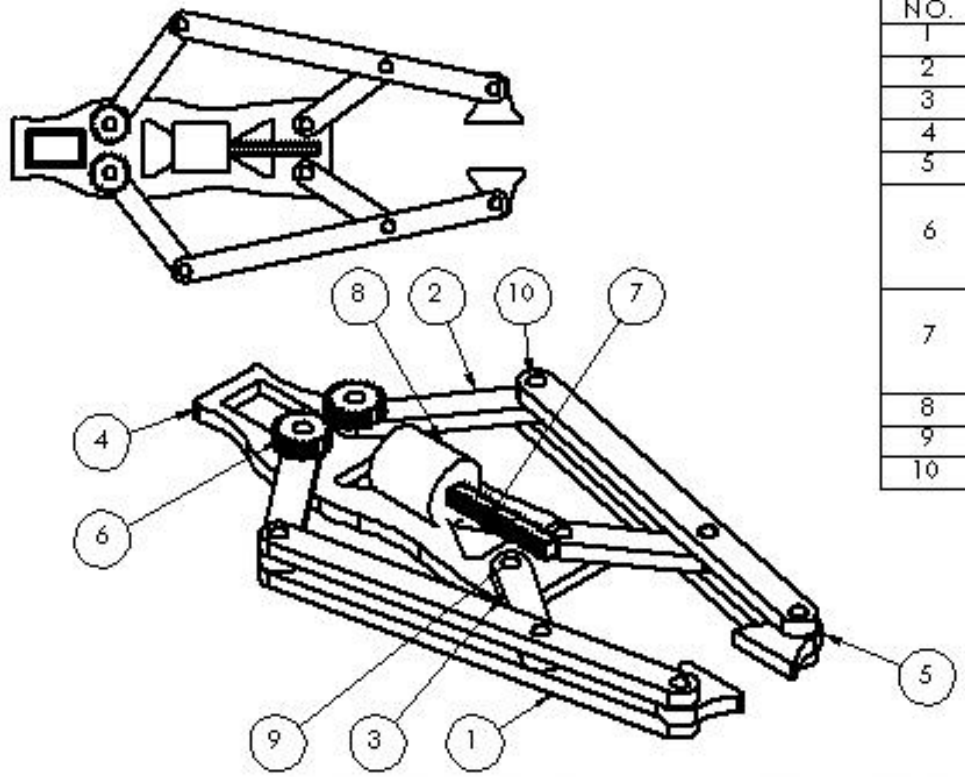
DO NOT SCALE DRAWING



ITEM NO.	PART NUMBER	QTY.
1	Long Bar	4
2	Back Bar	2
3	Front Bar	2
4	Base Plate	1
5	Claw Grabber	2
6	Inch - Spur gear 32DP 24T 20PA 0.25FW --- S24N3.0H2.0L0.25N	2
7	Inch - Rack-spur - rectangular 32DP 20PA .25FW .2PH 2L---SAII	1
8	Rack Drive	1
9	Pin_0.5IN	2
10	Pin_0.75IN	8

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	C. SEGAR	
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			COMMENTS:		
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TITLE:

Claw Grabber

SIZE	DWG. NO.	REV
A		

SCALE: 1:5 WEIGHT: SHEET 1 OF 1

Bill of Materials:

As follows is the BOM for both assemblies. Note prices are listed only for purchased parts, while stock parts are noted as material stock type.

Item	Assembly	Description	Quantity	Source	Price Per	Total Price	P/N	Link
1	Claw Grabber	Long Bar	4	Aluminum Sheet Stock				
2		Back Bar	2	Aluminum Sheet Stock				
3		Front Bar	2	Aluminum Sheet Stock				
4		Base Plate	1	Aluminum Stock				
5		Claw Grabber	2	Aluminum Stock				
6		24T 32DP Spur Gear	2	McMaster-Carr	20.1	40.2	7880K31	https://www.mcmaster.com/7880k31
7		32DP Rack Spur	1	McMaster-Carr	54.58	54.58	2932N2	https://www.mcmaster.com/2932n2
8		Rack Drive Motor	1	McMaster-Carr	62.74	62.74	6409K11	https://www.mcmaster.com/6409k11
9		0.5IN, 0.25OD Pin	2	McMaster-Carr	6.24	12.48	93890A116	https://www.mcmaster.com/93890a116
10		0.75IN, 0.25OD Pin	8	McMaster-Carr	6.76	54.08	93890A118	https://www.mcmaster.com/93890a118
11	Actuated Foot	Side Cover	2	Aluminum Sheet Stock				
12		Pneumatic Cylinder	1	McMaster-Carr	43.96	43.96	6498K012	https://www.mcmaster.com/6498k012
13		Top Block	1	Aluminum Stock				
14		Ankle Joint	1	Aluminum Stock				
15		Piston Connect Clevis	1	McMaster-Carr	6.9	6.9	6071K11	https://www.mcmaster.com/6071k11
16		Cam Track	1	Rubber Stock				
17		Follower Shaft	1	Pro-Hawk	Request Quote (Custom)			http://www.directindustry.com/prod/pro-hawk/product-26292-62199.html
18		Follower Wheel	2	with Follower Shaft				
19		Middle Space Block	1	Aluminum Stock				
20		Spring	1	McMaster-Carr	12.99 (Pack of 6)	12.99	9657K321	https://www.mcmaster.com/9657k321
21		Molded Foot	1	Rubber Stock				
Total Purchase: 287.93								