FALL TERM PROJECT

BUMBLE BEES

GROUP #3

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8 DECEMBER 2023

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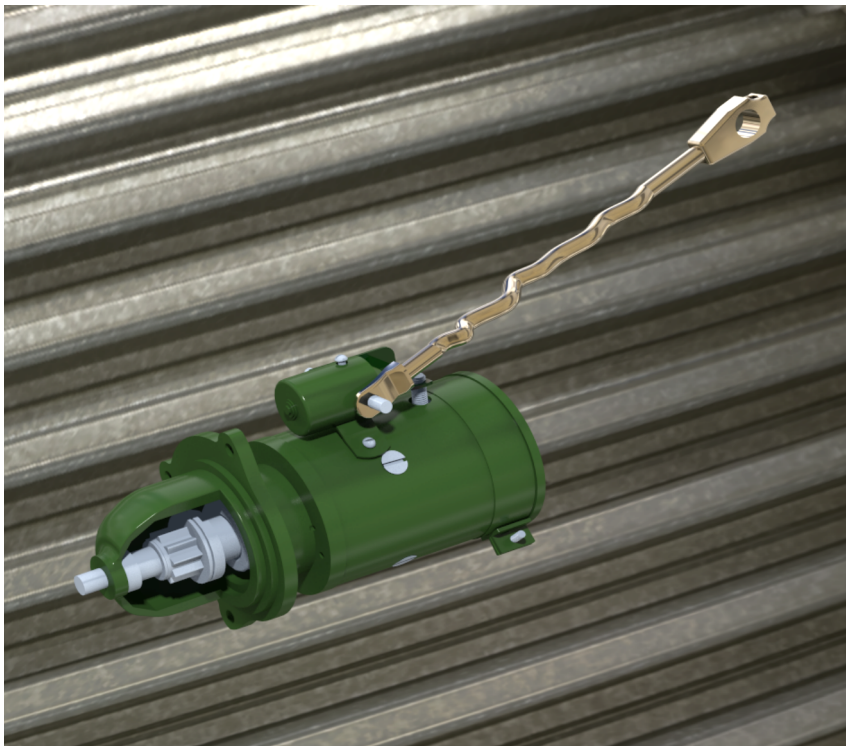
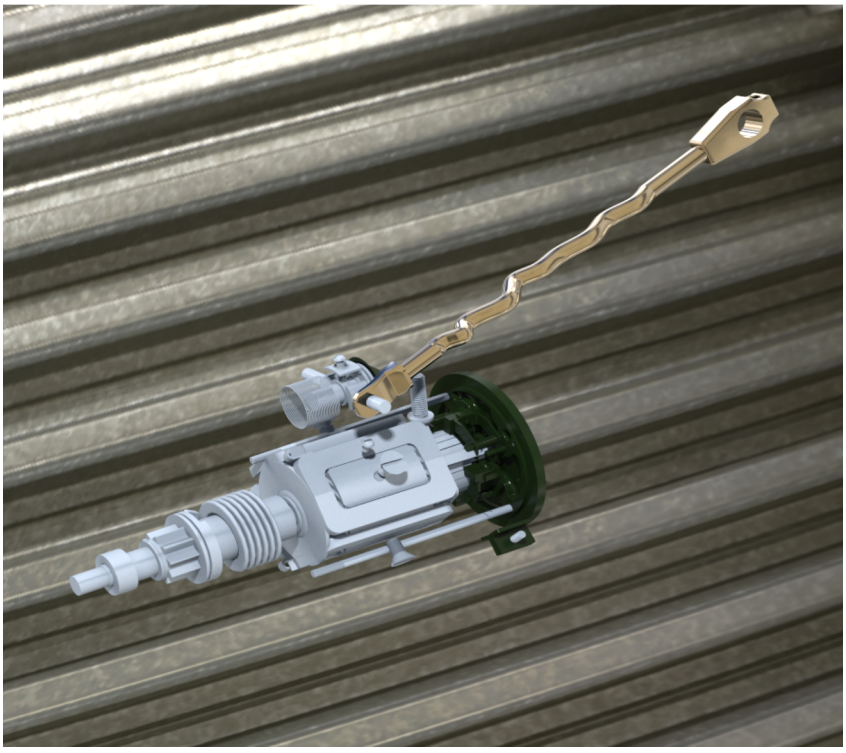
PROJECT IMAGE

CREO RENDERINGS





INTRODUCTION & HISTORY

Through careful deliberation, the team resolved to disassemble and render a Delco Remy starter, part number 11077424. Though finding information about the basic operations of the starter is painless to find, finding information about our specific part is difficult. No further information can be acquired from the manufacturer's website other than that the part is obsolete, and that it has a sister part, 11074425. Attempts were made to contact the manufacturer, but no further information could be provided. By close inspection of online sources and forums, it can be deduced that the 1945 John B tractor used this starter. It can be reasonably assumed that the part is old, from research collected and the thick layer of rust on the starter.

Before the advent of the starter, a common way to start an engine was the hand-crank method, as seen with the archetypal image of an aviator manually spinning his aircraft's propeller. This however, proved to be inconvenient and dangerous, as the behavior of the engine during start-up was quite unpredictable. A simple violent backfire of the engine could result in broken wrists, fingers, dislocated shoulders, and in the case of bigger engines, fatal injuries. A more convenient fashion to start an engine was necessary. In 1911, Charles Kettering of DELCO invented the electric starter, later used on 1912 Cadillacs. The rest of the industry would follow suit, eliminating the method of hand-cranking.

Coincidentally in 1910, Vincent Bendix almost went bankrupt after the failure of his company. He went back as a car dealer selling Cadillacs in Chicago, right as the electric starter was introduced. Bendix found the mechanism to be complicated and expensive, using a series of solenoids, springs and levers that engaged the starter. Instead, Bendix opted for a triple threaded shaft, where the pinion gear is forced down the shaft's grooves by inertia to mesh with the flywheel. When the engine begins to run under its own power, the high rotation causes the pinion gear to disengage from the flywheel through springs. Starters that did not use this mechanism had to have the gear be engaged and disengaged manually, usually with a pedal. His mechanism saw its first use on the 1914 Cadillac "Baby Grand."

APPLICATIONS

It is difficult to decipher the justification of a starter without first examining the engine as a whole. Thus, to realize the function of a starter, there underlies a necessary discussion of the internal combustion (IC) engine. In the common four-stroke engine system, there are four stages: Intake, Compression, Combustion, and Exhaust. In the intake stroke, the piston moves down inside the cylinder with the concurrent motion of the inlet valve's opening. This creates a vacuum that intakes

the necessary fuel air mixture for later combustion. In newer engines, the inlet valve is replaced by a fuel injection mechanism that injects fuel directly into the cylinder.

As the piston reaches the bottom of its stroke, the fuel intake closes and the piston enters its compression stage. The piston moves upward and compresses the fuel air mixture. As the piston reaches the top of the cylinder the second time, the spark plugs fire, forcing the compressed fuel air fixture to combustion. The force generated by the explosion sends the piston downward, which turns the crankshaft of the engine. As the shaft rotates, the piston rises up again, this time with the concurrent motion of the exhaust valve opening, forcing gasses out and into the exhaust manifold. The rotational action resumes and the piston moves down again, and the process repeats. In order to turn the initial stroke, a high torque mechanism must exist to provide the initial turning of the crankshaft. Thus is the purpose of the starter.

The principal methodology of the starter is to mesh a rotating starter pinion gear to the flywheel in the gearbox housing through extension, thus rotating the crankshaft and overcoming the initial resistance to commence the aforementioned process. Once the engine is running under its own power, the pinion gear is disengaged from the flywheel automatically to prevent backdrive, which is when the engine is driving the starter motor, which can damage both the starter and the engine. This mechanism is typically achieved through an overrunning clutch or a bendix drive, which employs a series of springs, collars, and rollers to disallow the pinion gear from rotating the rest of the starter motor as the engine begins to run under its own power.

PRODUCT CONSIDERATIONS

With limited knowledge of the specific part the project is applied to, sources of the general nature of starters and their history is relied upon. In general, the weight of the starter, its size, its power output, general material properties, service requirements, and positioning of parts are considered in designing a starter. Different engines may require different starters, as different engines may accommodate differing mounts, orientations, the engine's compression ratio, etc. Starters are typically heavy and made out of steel because if it was too light, it may not have enough structure to turn over the engine. The casing must be strong enough to withstand the high degrees of torque generated by a starter.

The product of this specific project largely mimics the initial form of starters in the early days, excluding the key ignition that largely came about in the 1940s. First, the initial powering of the motor must be considered. To do this, the battery must be connected to the starter motor via a switch. One problem this poses is that the starter motor demands heavy current from the battery, which means the ignition switch and the wires need to be unusually large and bulky.

To circumnavigate this, designers had to consider an external electrical relay, the most common being the solenoid. The power required to supply the starter is first sent through the solenoid by the battery. The solenoid, mounted on the rest of the motor casing (though an external heavy duty electrical relay could be used as an alternative), is an electromagnet that uses small current to energize, which moves a plunger that connects two copper terminals of a contactor switch. A separate connection exists between the battery and the starter motor. When the aforementioned contactor switch is completed, the battery sends electrical current to the starter motor.

A main point of concern is the activation of the pinion gear. One of the main drawbacks of the current configuration of our product is that the pinion gear rotates before it slips into place and mates completely with the flywheel. This method completely relies on the pinion gear being perfectly aligned to the flywheel's gear. Otherwise, the gears clash until both are in a perfect mesh. This leads to greater wear on the gears, requiring higher maintenance in the long run. Over the years, engineers have compensated for this condition by connecting the solenoid plunger to the pinion gear's horizontal movement through an actuating arm. This ensures that the pinion gear is completely meshed with the flywheel before the contactor switch is completed. However, this arm is not present in our current application, and may be a consideration for design change.

Another point of concern is the disengagement of the pinion gear from the flywheel. Normally, the Bendix arrangement allows the pinion to disengage automatically through inertia. As the engine begins to run under its own power, the pinion, meshed with the flywheel, rotates with higher speed and begins to move back into the bendix grooves. As the pinion is still meshed with the flywheel, it may cause a backdrive through the starter motor, which damages it. It also serves the disadvantage in that the pinion may disengage before the engine has the opportunity to start running. Engineers have accounted for this error by using an overrunning clutch, which is a series of springs and rollers that allows the pinion gear to freely roll independent of the starter motor shaft while keeping the pinion engaged.

CALCULATIONS

Part NO.	Part Name	Material	Mass (g)	Volume (cm^3)	CREO Calculated Weight (g)	CREO Calculated Volume (cm^3)
A5	Bolt	Copper	24.50	2.74	25.4	2.84
C1	End Frame	Steel	543.50	68.80	599.3	75.81
C2	Brushes	Copper	11.30	1.26	9.83	1.00
C3	Spring	Copper	2.70	0.30	0.93	0.1
C4	Brush Holder	Copper	7.60	0.85	15.01	1.68
B7	Coil	Steel	224.40	28.41	212	27.12
B9	Pinion	Steel	167.10	21.15	153	19.56
D1	Pole Piece	Iron	168.80	21.45	119.6	17.23
E3	Hoop	Steel	47.90	6.06	21.2	2.72
E1	Drive Housing	Steel	2142.70	271.23	2989	38.17

CONCLUSION

At the conception of the project, 10 parts were selected, at random, to be weighed and have their volumes measured. Once these parts were modeled in CREO, their approximate weights and volumes were calculated by the program, as recorded above. Positioned side by side, it is with much pleasure to say that the majority of the components had their estimated weights and volumes close to the actual measured values. There are a few exceptions, namely part E3. This part was a flexible hoop found in the Solenoid, and the discrepancy of the values could be a product of incorrect material estimation, or a difference in actual material volumes. By parts E1 and C3, divergence from the true values may also be explained by the sheer difficulty of accurately measuring a large, complex structure such as the drive housing, or a small, delicate part such as a spring. Due to the age of our reference part, weather variances may have also impacted the material. It must be noted, that for the majority of our components, a higher volume reflected higher weights for our respective parts, revealing our attention to accuracy to our measurements.

In addition to our consciousness of precision, we were also precise in our progression of the project. In the duration of our endeavor, we hit our deadlines

before or on time, and our communication never failed to deliver. Our schedule was structured in a relaxed way, which allowed ample time to focus on each task with detail, disallowed rushed products, all whilst providing adequate time to revise our submissions. Tasks were also satisfied by an even and practical division of labor. For example, parts that were heavily connected together were assigned to the same individual to ensure that the assembly meshed in a more comfortable manner. Given these circumstances, to the highest of our abilities, we were victorious in applying our newly found skills in CREO modeling to deliver a product that we believe to be a success.

BILL OF MATERIALS

Bill Of Materials					
Levels	**Part Number**	**Drawing Number**	**Quantity**	**Part Name**	**Material**
A	A0	1		**Solenoid Sub Assembly**	
	A1	2	2	Solenoid Windings	Copper
	A2	3	1	Plunger	Iron
	A3	4	2	Contact Disc	Copper
	A4	5	2	Spring	Steel
	A5	6	2	Field Bolts	Copper
	A6	7	1	Rubber Stopper	Rubber
	A7	8	1	Solenoid	Steel
	A8	9	1	Solenoid Lid	Steel
	A9	10	1	2 Holed Bracket	Steel
	A10	11	1	"L" Bracket	steel
	A11	12	1	Solenoid Bottom	steel
B	B0	13		**Drive Sub Assembly**	
	B2	15	1	Shaft	Steel
	B3	16	1	Commutator	Copper
	B5	18	1	Sleeve Washer	Steel
	B6	19	1	Driving Tail	Steel
	B7	20	1	Driving Head	Steel
	B8	21	1	Multithreaded Sleeve	Steel
	B9	22	1	Coil	Copper
	B10	23	2	Bendix Screw	Steel
	B11	24	1	Pinion	Steel
	B12	25	58	Armature Plate	Steel
	B13	26	1	Pinion Stop	Steel
	B14	27	1	Armature Winds Top	Steel & Copper
	B15	28	23	Armature Insulation Shell	Bakelite
	B16	29	1	Armature Winds Bottom	Steel & Copper
	B18	31	1	Armature Insulation Sheet Btm	Bakelite
	B17	30	2	Armature Insulation Ends	Bakelite
	B18	31	1	Armature Insulation Sheet Top	Bakelite
	B19	32	1	Inside Commutator I	Steel
	B20	51	1	Inside Commutator II	Steel
C	C0	52		**Brushes Sub Assembly**	
	C1	33	1	End Frame	Steel
	C2	34	4	Brush Holder	Copper
	C3	35	4	Spring	Steel
	C4	36	4	Brushes	Copper
	C5	37	4	Short Wires w/ Brackets	Copper
	C6	38	1	Long Wire w/ Brackets	Copper
	C7	54	1	Small Spring	Steel
D	D0	39		**Fields Sub Assembly**	
	D1	40	4	Pole Pieces	Iron
	D2	41	1	Right Field Coil	Copper/magnet Wire
	D3	42	1	Left Field Coil	Copper/Magnet Wire
	D4	43	2	Field Coil w/ Hole	Copper/Magnet Wire
E	E0	44		**Final Assembly**	
	E6	50	1	Connection Wire	Copper
	E5	45	4	Outer Bolt	Steel
	E4	46	2	Bracket	Steel
	E3	47	1	Hoop	Steel
	E2	48	1	Motor Housing	Steel
	E1	49	1	Drive Housing	Steel

Stock Parts			
Part Number	**Quantity**	**Part Name**	**Ordering Specifics**
SP1	2	Washer	16/27 mm
SP2	1	Washer Middle	OD= 25.2, ID= 14.5, 1.8 thick
SP3	3	Washers	9.7/17.5 mm x1 thick
SP4	2	Long Bolt	L=170.4mm, D=5.4mm, Thread L =23mm, Top- 9.5mm L & 4.6mm W
SP5	2	Washer(long bolt)	L=11.7mm, 7.2mm indise, 1.6mm W
SP6	2	Washer	Outside D=11.4mm, Inside D=6.5mm, W=1.7mm M6
SP7	2	Screw	Top D=7.1mm, W=2.5, D=3.6mm, H11.1mm
SP8	2	Washer	In=6.8mm, 4.1mm, W=1.0
SP9	4	Screw	Top D=0.89mm, H=3.6, D=4.6mm, L=9.6mm
SP10	2	Washer	OD=8.3mm, ID=4.9mm, W=1.1mm
SP11	1	Nut	L=9.5mm, W=3.0mm, D=3.5mm
SP12	4	Nut	L=15.7, W=3.9mm, D=8.0mm
SP13	5	Washer	Outside D=16.2mm, Inside D=9.6mm, W=1.6mm
SP14	4	Screw	L=15.0mm, Thread=12.68, D=3.28mm, Top D=6.22
SP15	1	Washer	Outside D= 5.95mm, W=0.8mm, ID=3.6mm
SP16	2	Winged Washer	Ouside D=17.5mm, Inside D=9.5mm, Wings- W=4.5mm, H=4.3mm
SP17	3	Rubber Washer	L=19.31mm, D=9.13mm, W=4.45
SP18	1	Washer	L=17.5mm, W=1.7mm, D=9.52mm
SP19	1	Washer	Outside D=17.4, Inside D=9.5mm, W=2.7mm
SP20	3	Rubber Washer	L=17.2mm, Inside D=9.5mm, W=2.7mm
SP21	2	Nut	L15.5mm, inside D=8.0mm, W=6.3mm
SP22	1	Washer	Inside D=20.6mm, Outside D=28.7mm, Thickness=1.5mm
SP23	2	Screw	L=11.3mm, TD=8.6mm, BD=4.6mm
SP24	2	Bolt	L=13.1mm, TD=9.3mm, BD=5.8mm
SP25	1	Bolt	TL=15.7mm, TL=4.5mm, H=22.4mm, BD=9.4mm
SP26	2	Washers	OD=10.0mm, ID=5.5mm, W=1.1mm
SP27	1	Screw in hoop	TD=8.5mm, BD=4.8mm, TH=3mm, H=28.2mm
SP28	1	Screw welded to field coils	TD=16.7mm BD=8.4mm TH=5mm H=40mm
SP29	1	Bolt for Wire	Top=11.8mm x 11.8mm, D=7.0mm, TD=3.7mm, L=40.0mm
SP30	4	Housing Screw	TD=17.5mm BD=9.5mm TH=9.5mm H=16.5mm
SP31	1	Nut(bolt-wire)	OD=13.5mm, ID=7.00mm, D=5.5mm

FINAL ASSEMBLY

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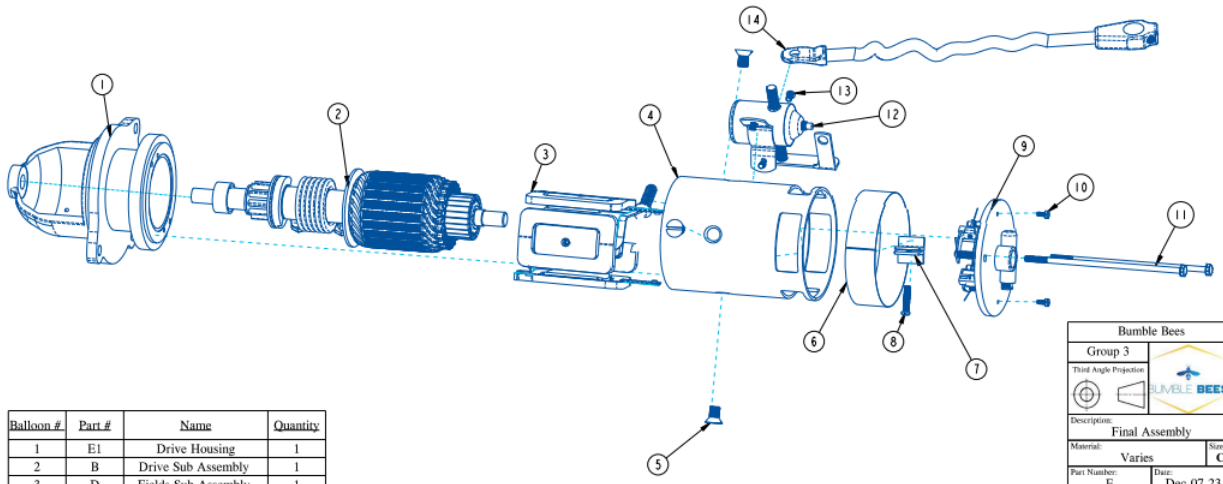

Balloon #	Part #	Name	Quantity
1	E1	Drive Housing	1
2	B	Drive Sub Assembly	1
3	D	Fields Sub Assembly	1
4	E2	Motor Housing	1
5	E5	Outer Bolt	4
6	E3	Hoop	1
7	E4	Bracket	2
8	SP27	Screw in hoop	1
9	C	Brushes Sub Assembly	1
10	SP7	Screw	2
11	SP4	Long Bolt	2
12	A	Solenoid Sub Assembly	1
13	SP23	Screw	1
14	E6	Connection Wire	1

Bumble Bees

Group 3

Third Angle Projection

Description: Final Assembly

Material: Varies

Size: C

Part Number: E

Date: Dec-07-23

Weight: 4535.92g

Modeled By: KP

Scale: 0.450

Drawn By: KP

Units: mm

Edited By:

Tolerance
1.0 ± 0.1
1.00 ± 0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified

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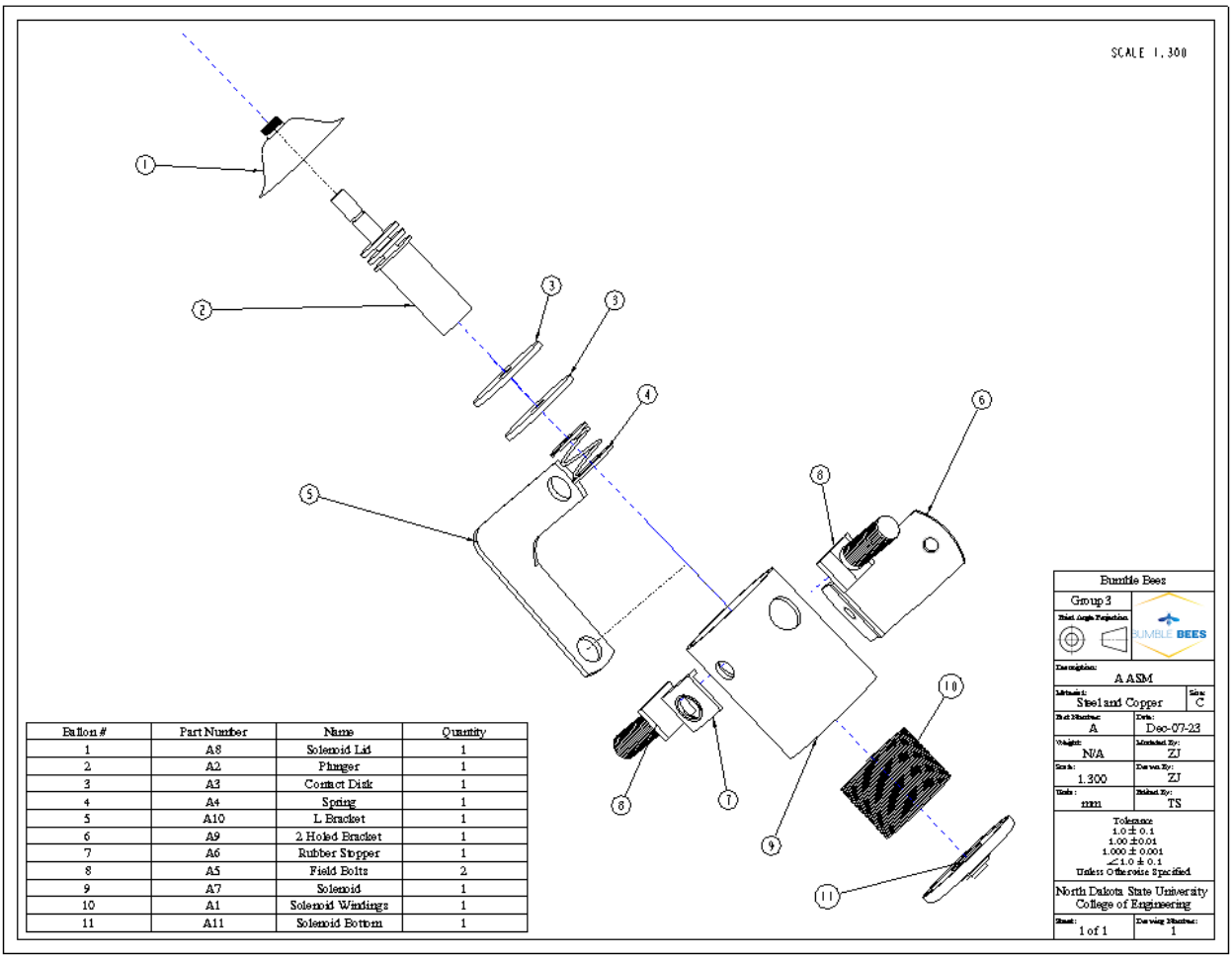
College of Engineering

Sheet: 1 of 1

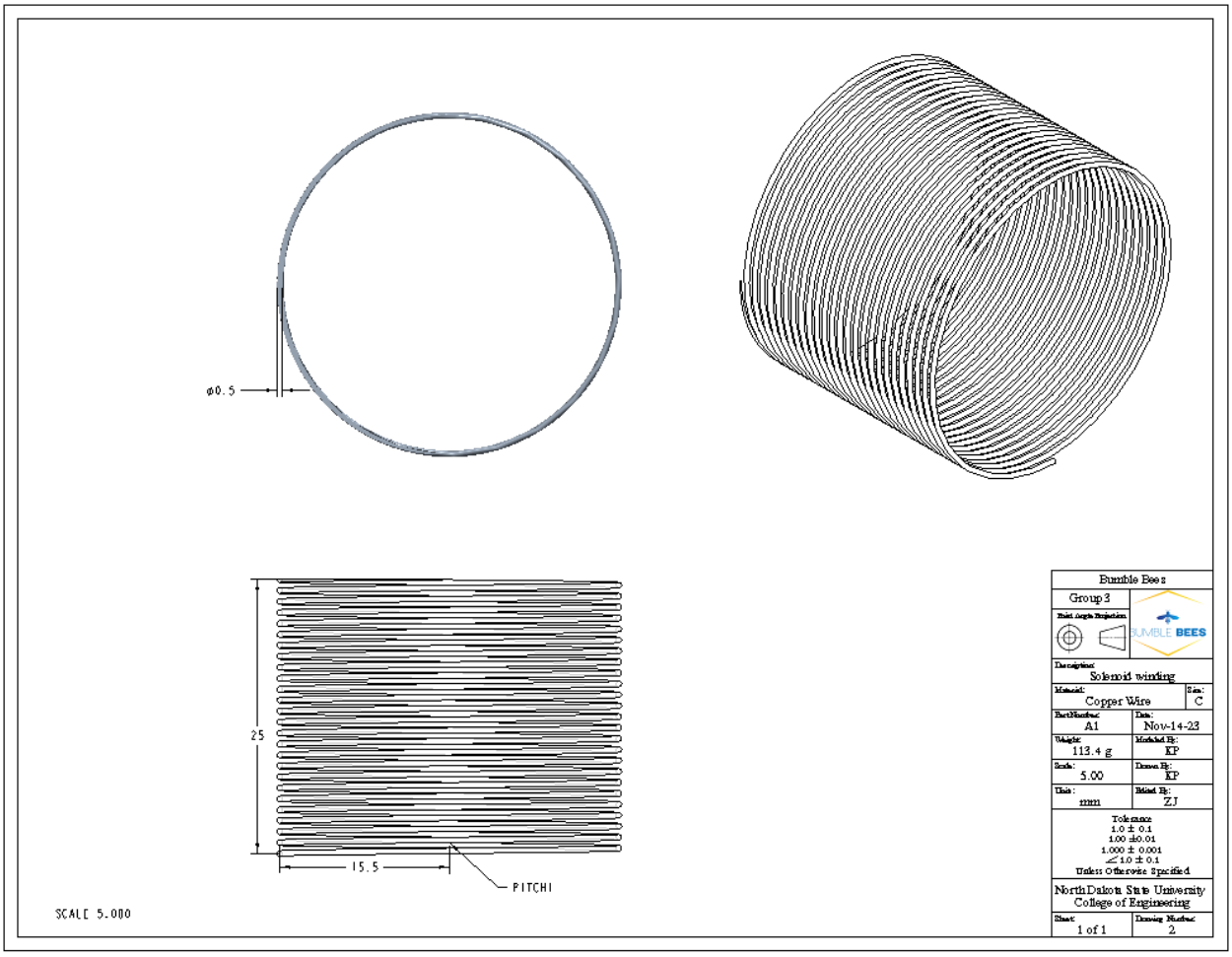
Drawing Number: 44

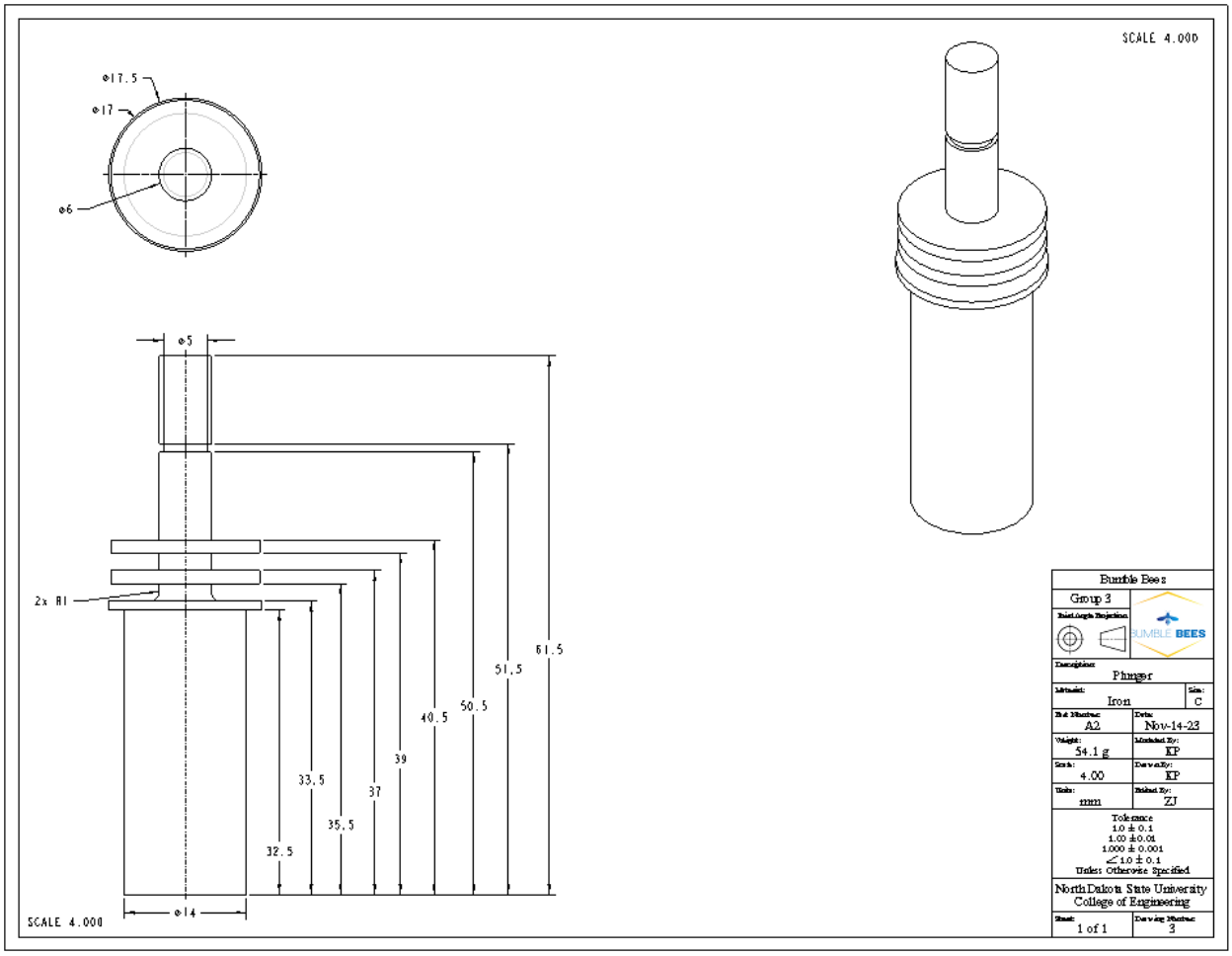
[A] SOLENOID SUBASSEMBLY



Ballon #	Part Number	Name	Quantity
1	A8	Solenoid Lid	1
2	A2	Plunger	1
3	A3	Contact Disk	1
4	A4	Spring	1
5	A10	L Bracket	1
6	A9	2 Holed Bracket	1
7	A6	Rubber Stopper	1
8	A5	Field Bolts	2
9	A7	Solenoid	1
10	A1	Solenoid Windings	1
11	A11	Solenoid Bottom	1

[A] ASSEMBLY DRAWINGS

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33.5
32.5
ø14
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Bumble Bees
Group 3
Third Angle Projection
BUMBLE BEES
Description:
Plunger
Material:
Iron
Size:
C
Part Number:
A2
Date:
Nov-14-23
Weight:
54.1 g
Modeled By:
KP
Scale:
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Drawn By:
KP
Units:
mm
Tested By:
ZJ
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College of Engineering
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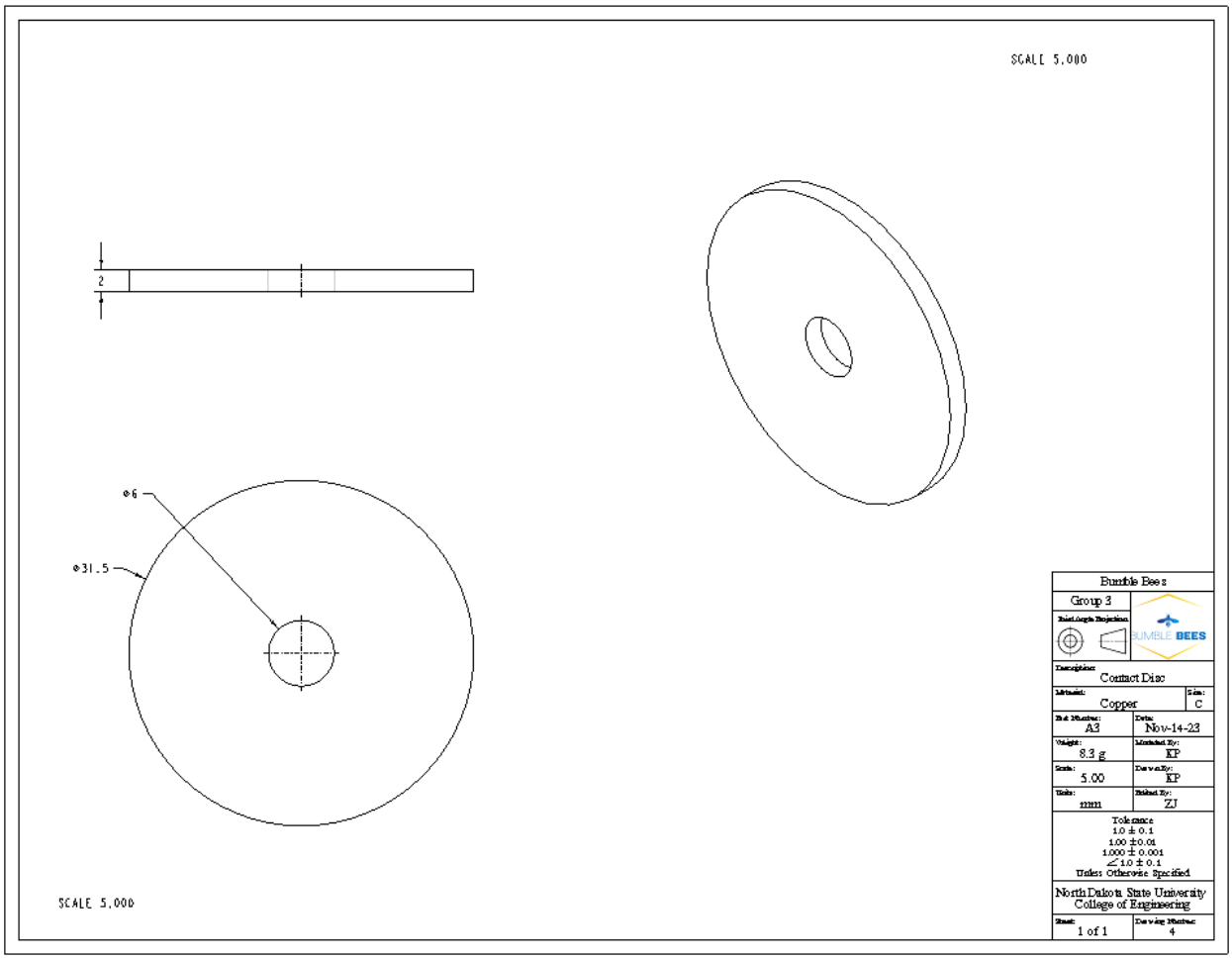
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ø6
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SCALE 5.000
Bumble Bees
Group 3
Third Angle Projection
BUMBLE BEES
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Contact Disc
Material:
Copper
Size:
C
Std Metric:
A3
Date:
Nov-14-23
Weight:
8.3 g
Modified By:
KP
Scale:
5.00
Drawn By:
KP
Units:
mm
Tested By:
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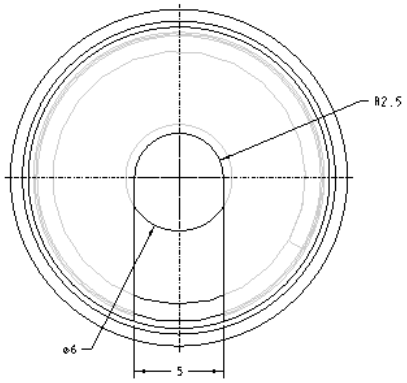

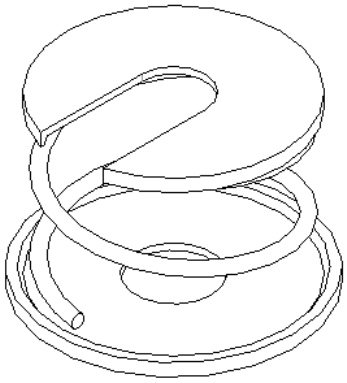

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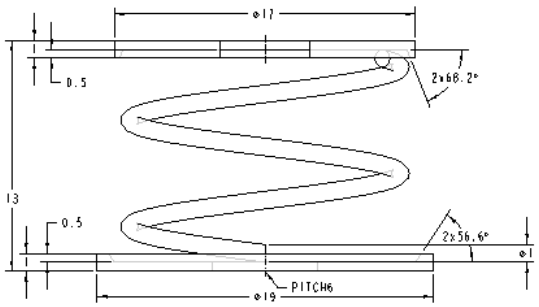

SCALE 8.000

Bumble Bees	
Group 3	
Third Angle Projection	BUMBLE BEES
Description:	Spring
Material:	Steel
Size:	C
Part Number:	A4
Date:	Nov-14-23
Weight:	5.2 g
Modeled By:	KP
Scale:	8.00
Drawn By:	KP
Units:	mm
Tested By:	ZJ
Tolerance 1.0 ± 0.1 1.00 ± 0.01 1.000 ± 0.001 ∠ 1.0 ± 0.1 Unless Otherwise Specified	
North Dakota State University College of Engineering	
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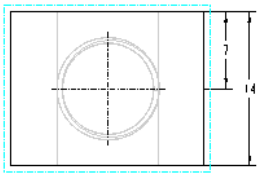

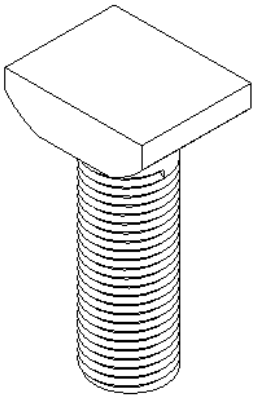

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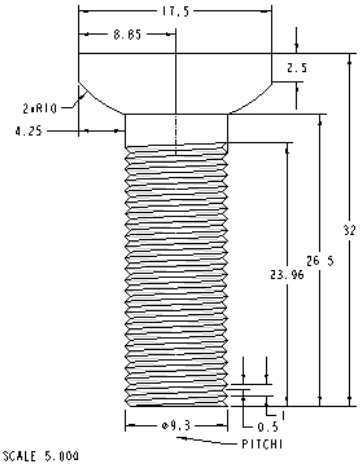

SCALE 5.000

Bumble Bees	
Group 3	
Third Angle Projection	BUMBLE BEES
Description: Field Bolt	
Material: Copper	Size: C
Part Number: A5	Date: Nov-14-23
Weight: 23.8 g	Checked By: KP
Scale: 5.00	Drawn By: KP
Units: mm	Tested By: ZJ
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North Dakota State University College of Engineering	
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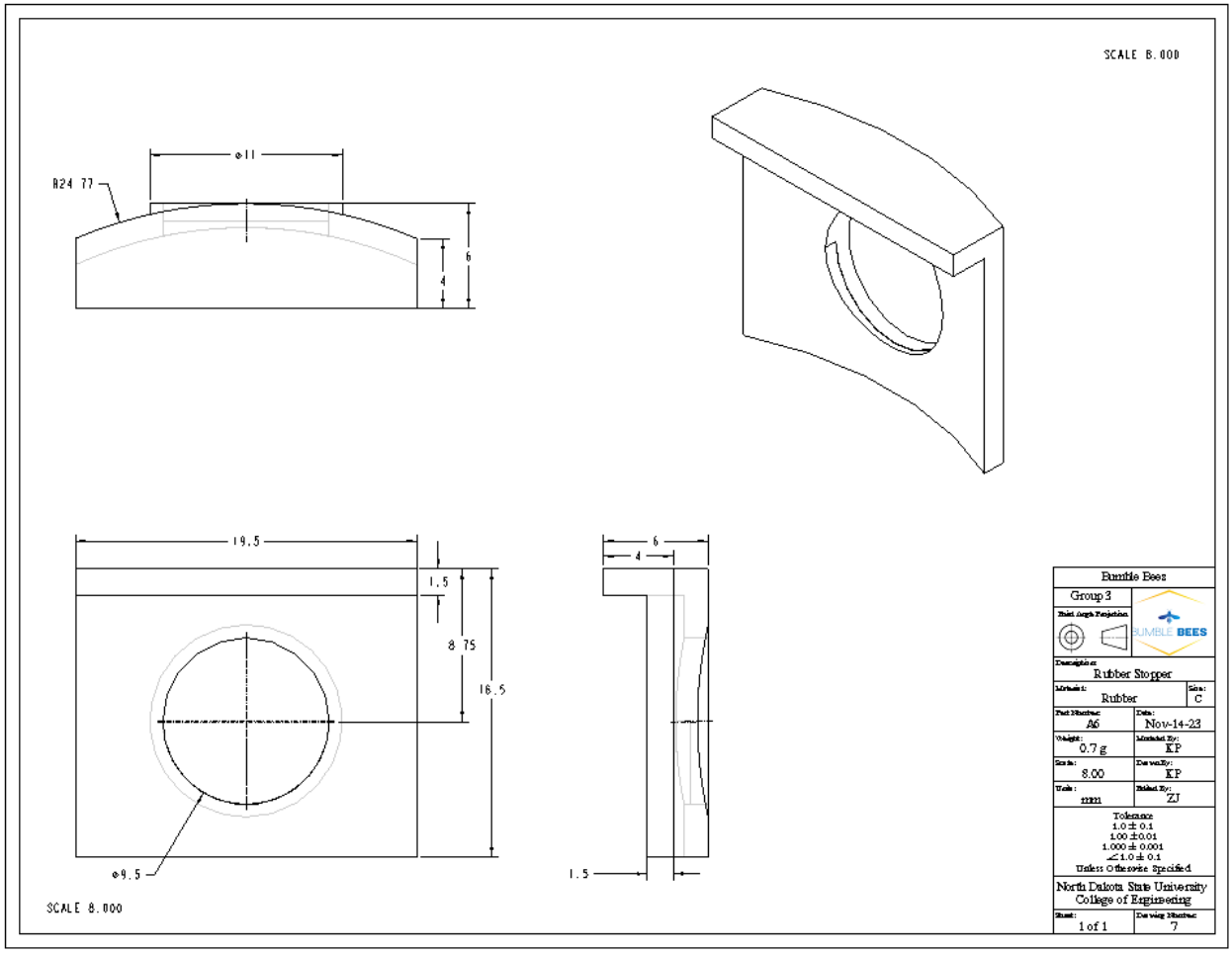
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4
1.5
SCALE 8.000
Bumble Bees
Group 3
Third Angle Projection
BUMBLE BEES
Description:
Rubber Stopper
Material:
Rubber
Size:
C
Part Number:
A6
Date:
Nov-14-23
Weight:
0.7 g
Modeled By:
KP
Scale:
8.00
Drawn By:
KP
Units:
mm
Tested By:
ZJ
Tolerance
1.0 ± 0.1
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North Dakota State University
College of Engineering
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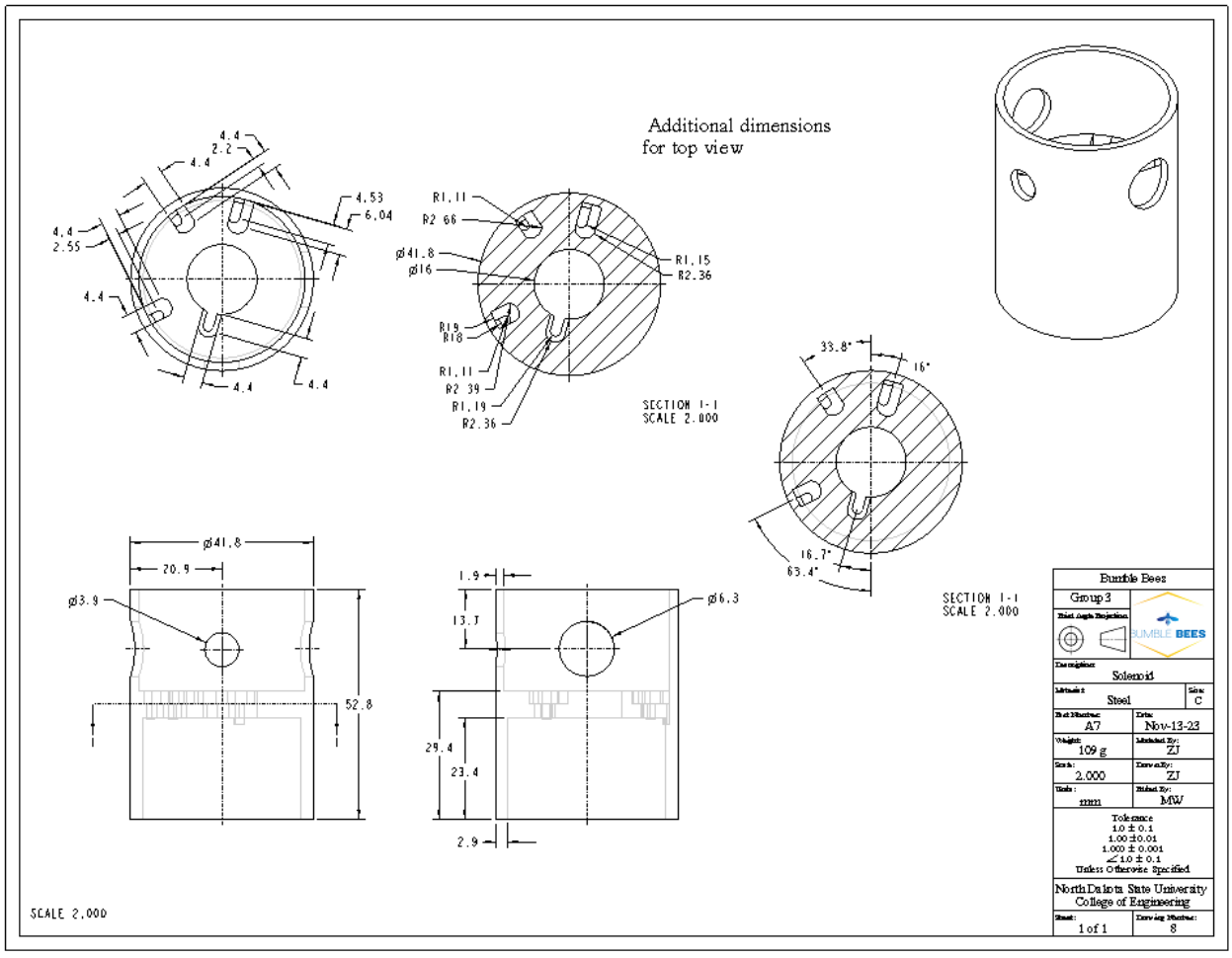
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R2.66
ø41.8
ø16
R1.15
R2.36
R19
R18
R1.11
R2.39
R1.19
R2.36
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16°
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63.4°
SECTION 1-1
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ø41.8
20.9
ø3.9
52.8
1.9
13.7
ø6.3
29.4
23.4
2.9
SCALE 2.000
Bumble Bees
Group 3
Third Angle Projection
BUMBLE BEES
Description:
Solenoid
Material:
Steel
Size:
C
Part Number:
A7
Date:
Nov-13-23
Weight:
109 g
Modified By:
ZJ
Scale:
2.000
Drawn By:
ZJ
Units:
mm
Model By:
MW
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
< 1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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1 of 1
Drawing Number:
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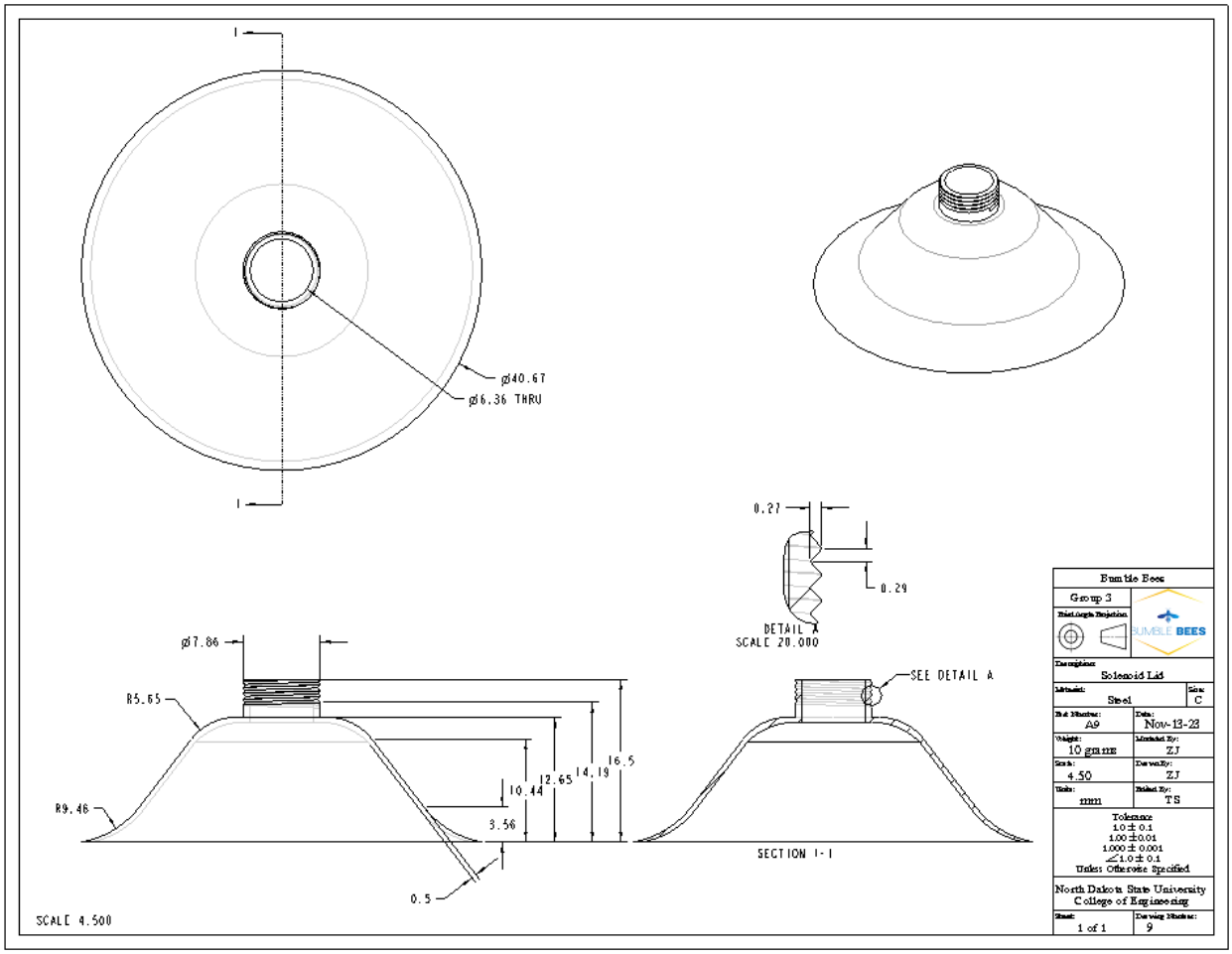
I
I
ø40.67
ø6.36 THRU
0.27
0.29
DETAIL A
SCALE 20.000
ø7.86
R5.65
R9.46
16.5
14.19
12.65
10.44
3.56
0.5
SEE DETAIL A
SECTION I-I
SCALE 4.500
Bumble Bees
Group 3
Solenoid Lid
Steel
C
A9
Nov-13-23
10 grams
ZJ
4.50
ZJ
mm
TS
Tolerance
1.0 ± 0.1
1.00 ± 0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
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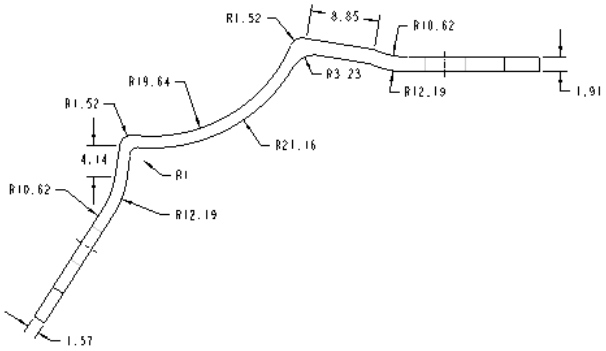
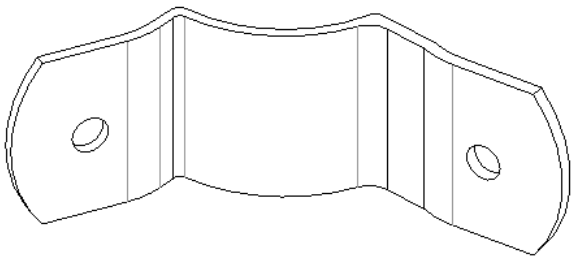
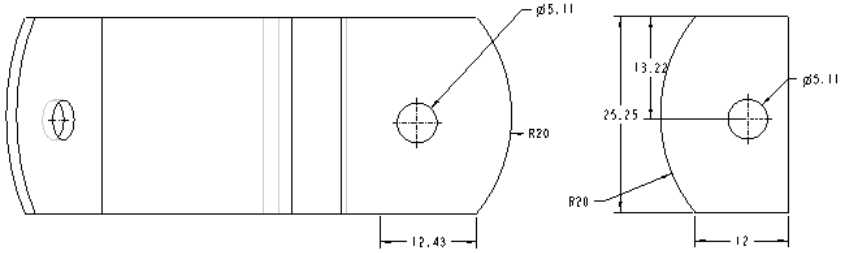
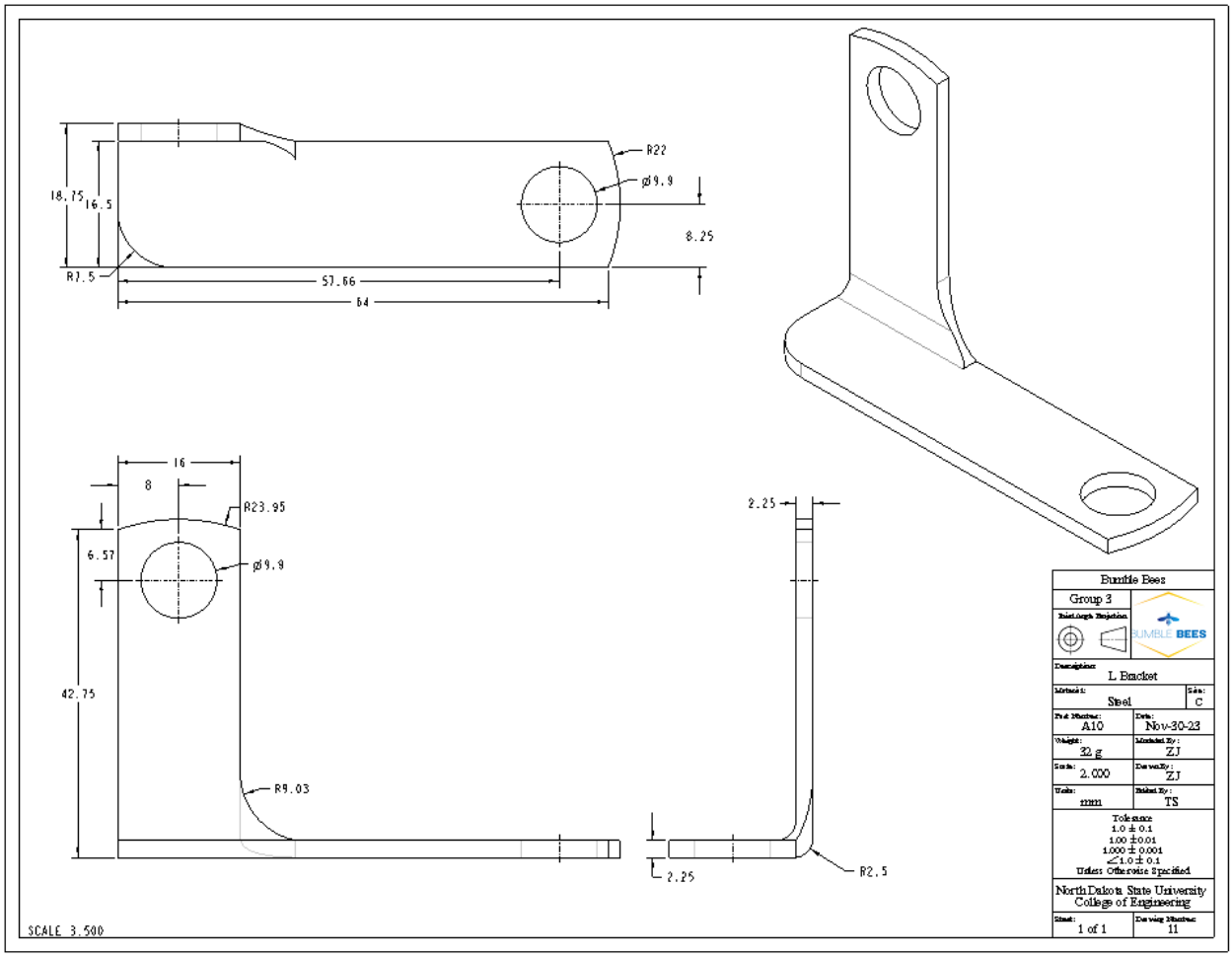






SCALE 3.500

Bumble Bees	
Group 3	
Part Name: 2 Holed Bracket	
Material: Steel	Size: C
Part Number: A9	Date: Dec-07-23
Weight: N/A	Modified By: ZJ
Scale: 3.500	Drawn By: ZJ
Units: mm	Edited By: TS
Tolerance 1.0 ± 0.1 1.00 ±0.01 1.000 ± 0.001 ∠1.0 ± 0.1 Unless Otherwise Specified	
North Dakota State University College of Engineering	
Sheet: 1 of 1	Drawing Number: 10


R22
ø9.9
18.75
16.5
8.25
R7.5
57.66
64
16
8
R23.95
6.57
ø9.9
42.75
R9.03
2.25
2.25
R2.5
SCALE 3.500
Bumble Bees
Group 3
L Bracket
Steel
C
A10
Nov-30-23
32 g
ZJ
2.000
ZJ
mm
TS
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
≤1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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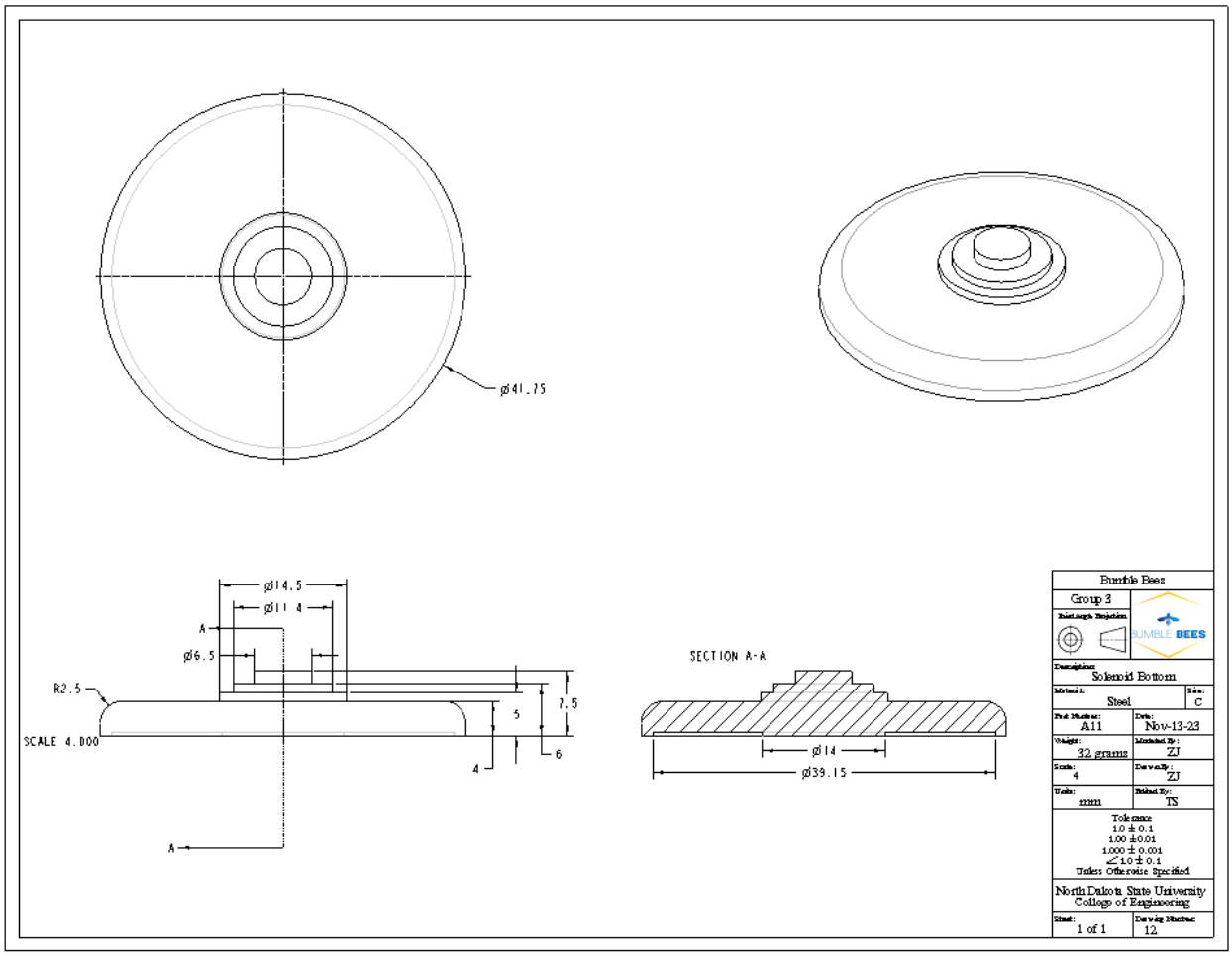
ø141.75
ø14.5
ø11.4
A
ø6.5
R2.5
SCALE 4.000
7.5
5
6
4
A
SECTION A-A
ø14
ø39.15
Bumble Bees
Group 3
Solenoid Bottom
Steel
C
A11
Nov-13-23
32 grams
ZJ
4
ZJ
mm
TS
Tolerance
1.0 ± 0.1
1.00 ± 0.01
1.000 ± 0.001
∠ 1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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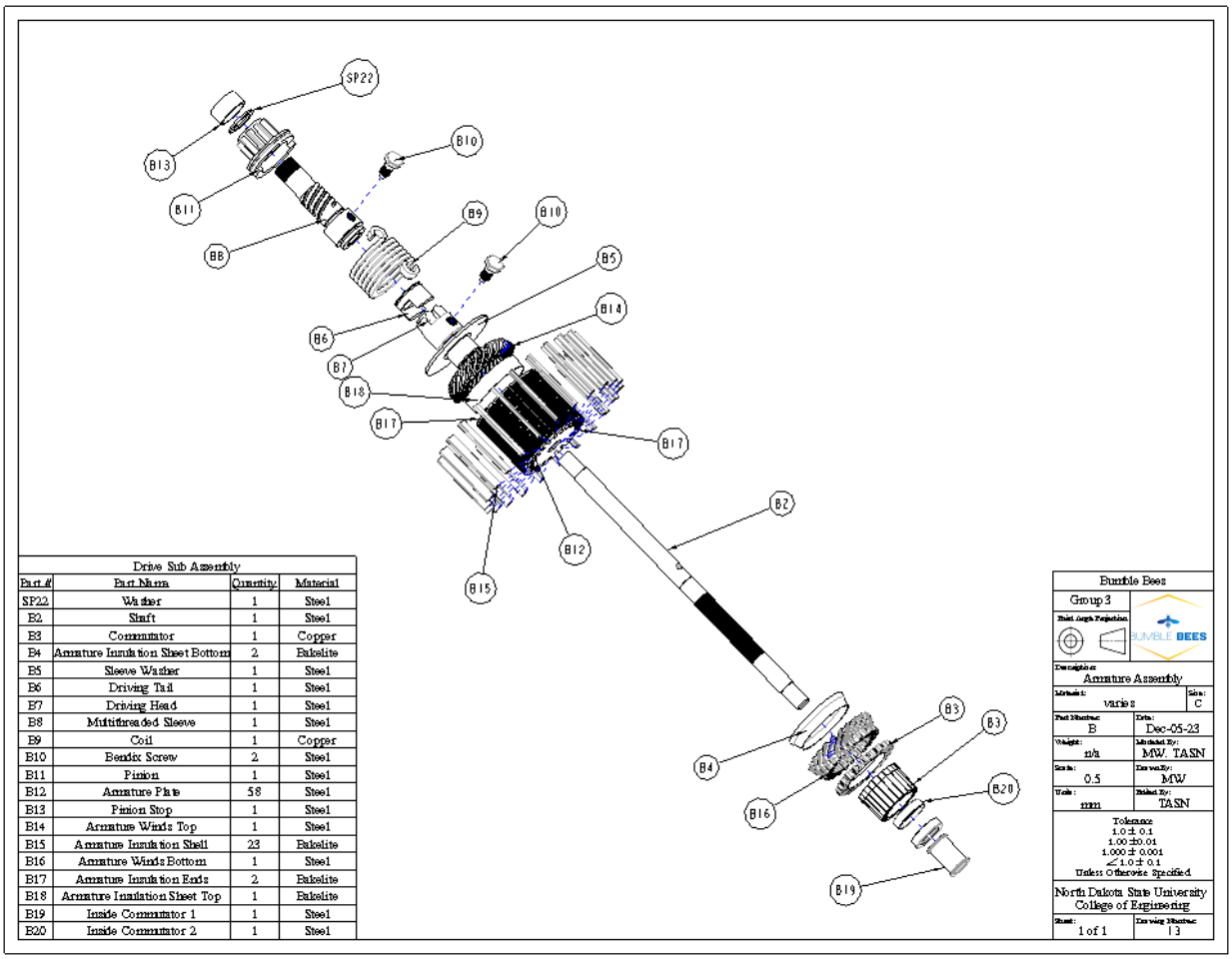
[B] DRIVE SUBASSEMBLY



Drive Sub Assembly			
Part #	Part Name	Quantity	Material
SP22	Washer	1	Steel
B2	Shaft	1	Steel
B3	Commutator	1	Copper
B4	Armature Insulation Sheet Bottom	2	Bakelite
B5	Sleeve Washer	1	Steel
B6	Driving Tail	1	Steel
B7	Driving Head	1	Steel
B8	Multithreaded Sleeve	1	Steel
B9	Coil	1	Copper
B10	Bendix Screw	2	Steel
B11	Pinion	1	Steel
B12	Armature Plate	58	Steel
B13	Pinion Stop	1	Steel
B14	Armature Winds Top	1	Steel
B15	Armature Insulation Shell	23	Bakelite
B16	Armature Winds Bottom	1	Steel
B17	Armature Insulation Ends	2	Bakelite
B18	Armature Insulation Sheet Top	1	Bakelite
B19	Inside Commutator 1	1	Steel
B20	Inside Commutator 2	1	Steel

Bumble Bees

Group 3

Third Angle Projection

BUMBLE BEES

Armature Assembly

Material: varies

Size: C

Part Number: B

Date: Dec-05-23

Weight: n/a

Modified By: MW, TASN

Scale: 0.5

Drawn By: MW

Units: mm

Tolerance
1.0 ± 0.1
1.00 ± 0.01
1.000 ± 0.001
∠ 1.0 ± 0.1
Unless Otherwise Specified

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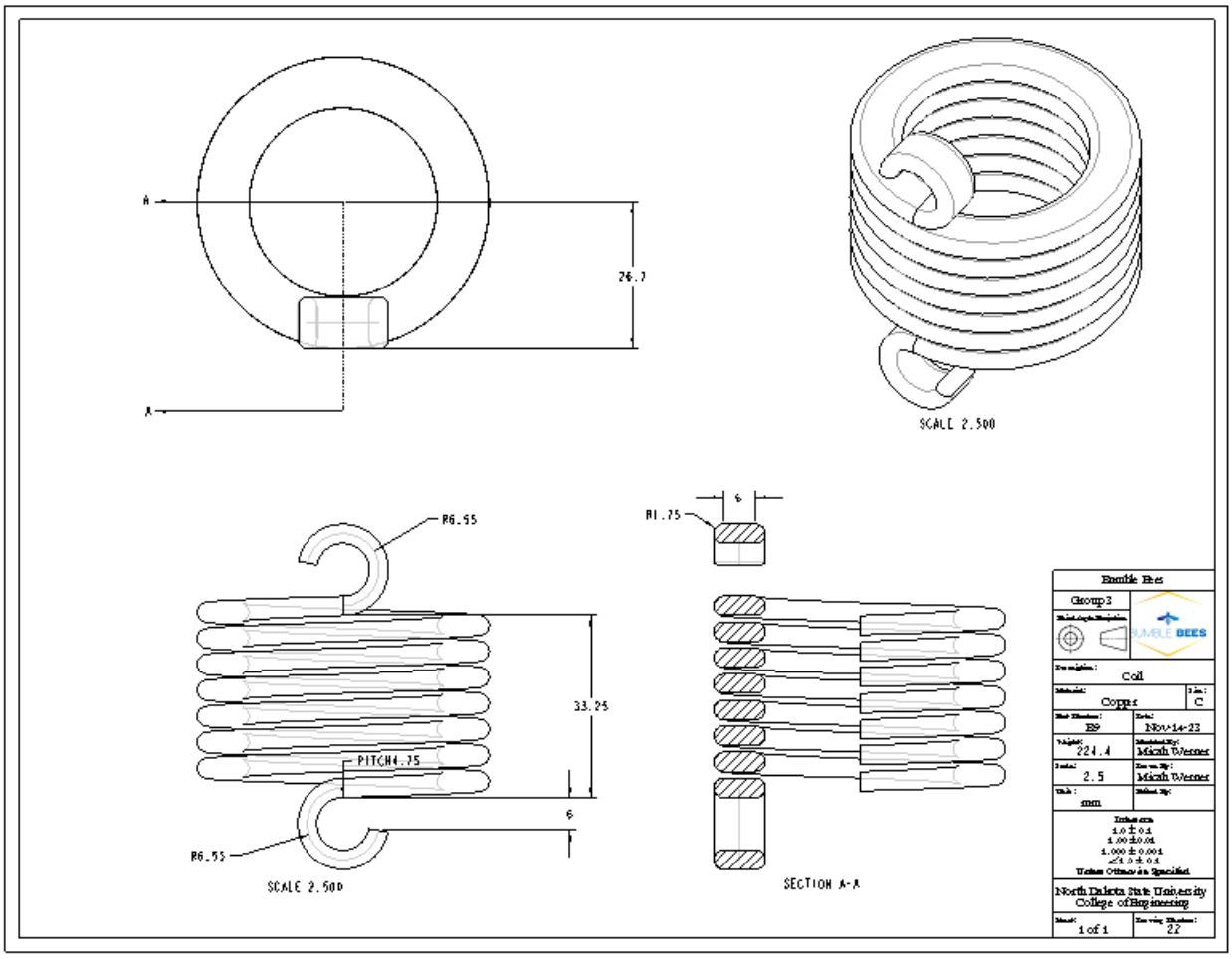
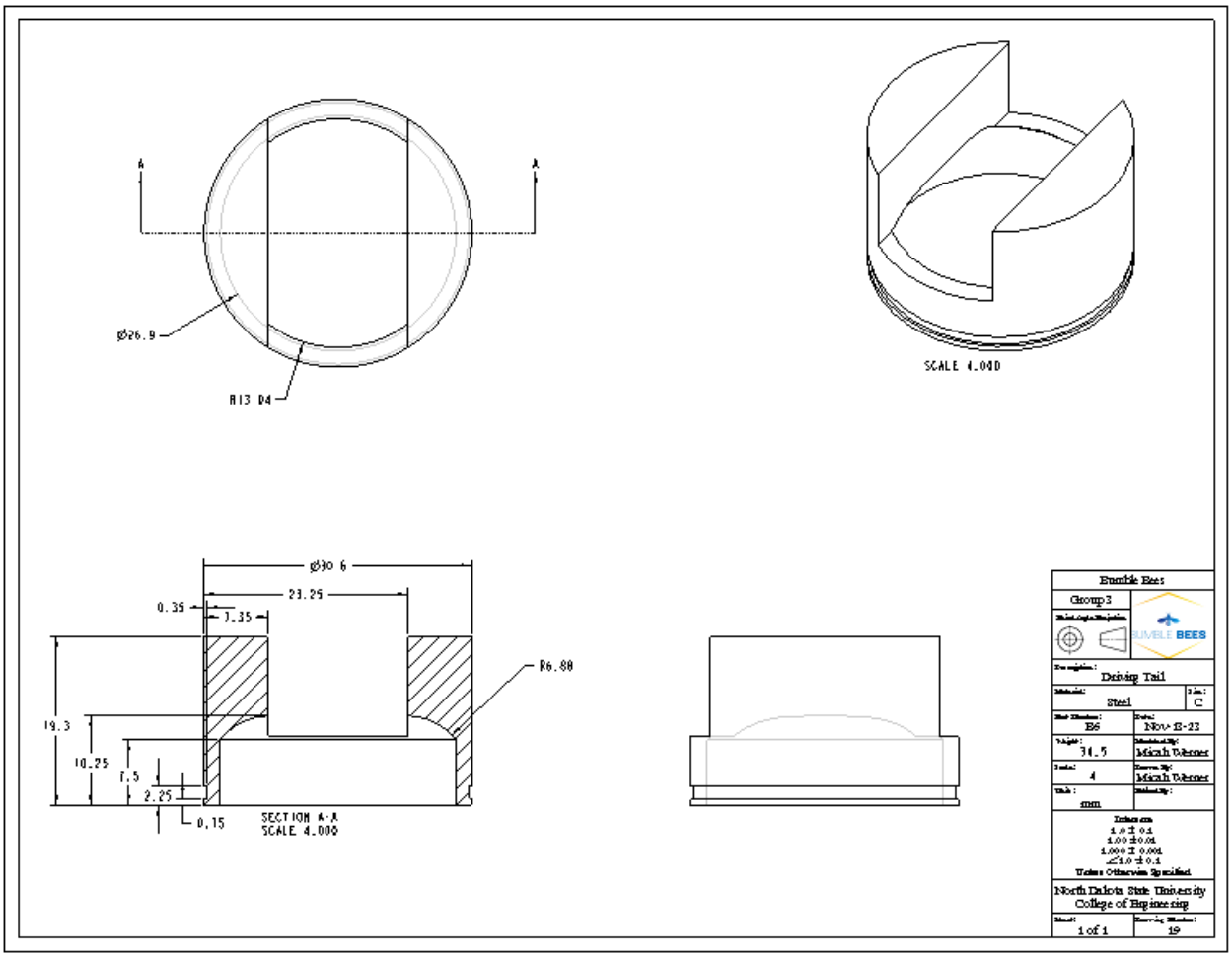
Drawing Number: 1 3

[B] ASSEMBLY DRAWINGS




A
A
Ø26.9
R13 D4
SCALE 4.000
Ø30.6
23.25
0.35
1.35
R6.80
19.3
10.25
7.5
2.25
0.15
SECTION A-A
SCALE 4.000
Bumble Bees
Group 3
BUMBLE BEES
Driving Tail
Steel
C
B6
Nov-13-23
31.5
Micah Werner
4
Micah Werner
mm
Unless Otherwise Specified
North Dakota State University
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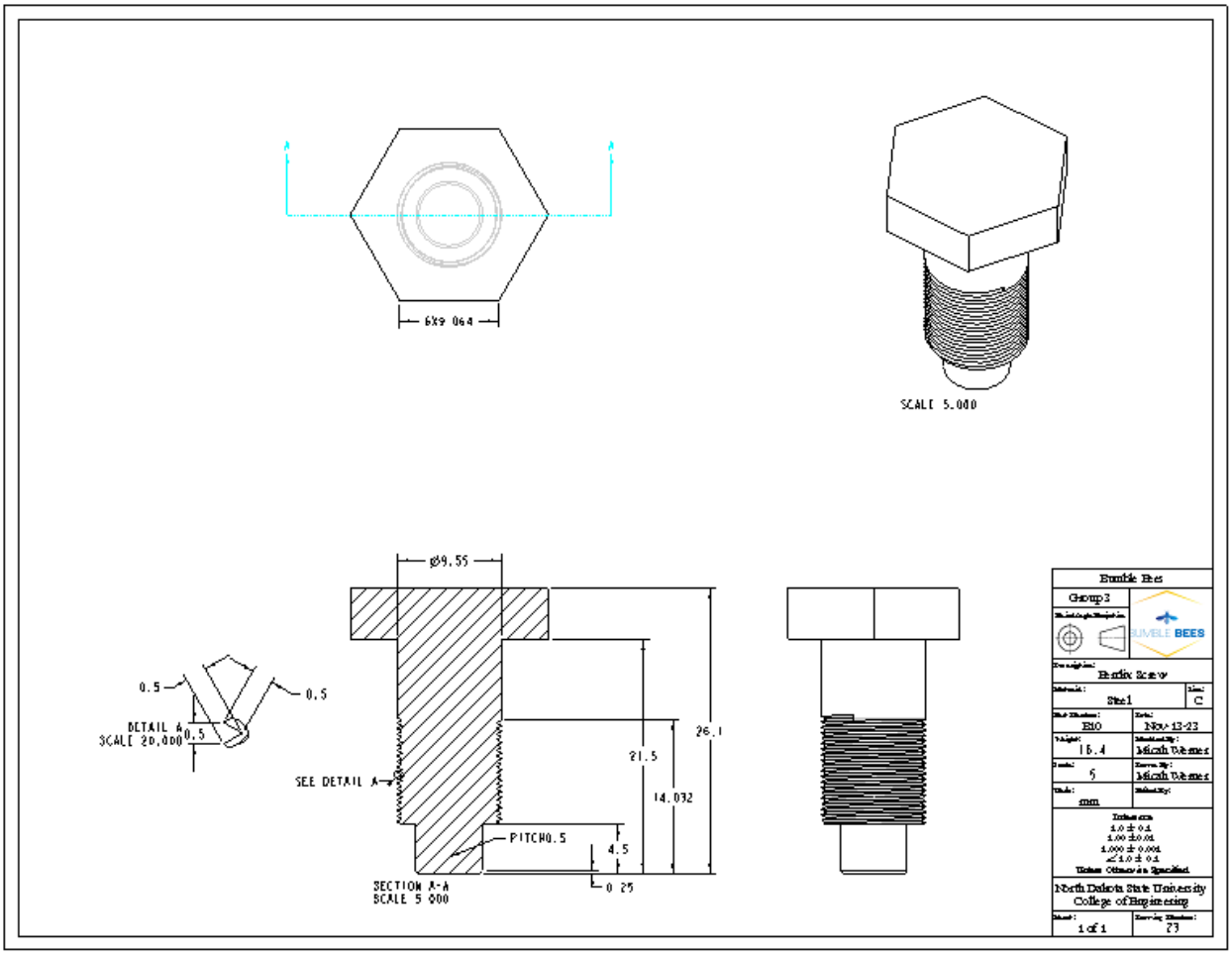
6X9 064
SCALE 5.000
ø9.55
0.5
0.5
DETAIL A
SCALE 20.000
0.5
SEE DETAIL A
26.1
21.5
14.032
PITCH0.5
4.5
0.25
SECTION A-A
SCALE 5.000
Bumble Bees
Group 3
BUMBLE BEES
Bumble Screw
Steel
C
EM0
Nov-13-23
16.4
Micah Weimer
5
Micah Weimer
mm
North Dakota State University
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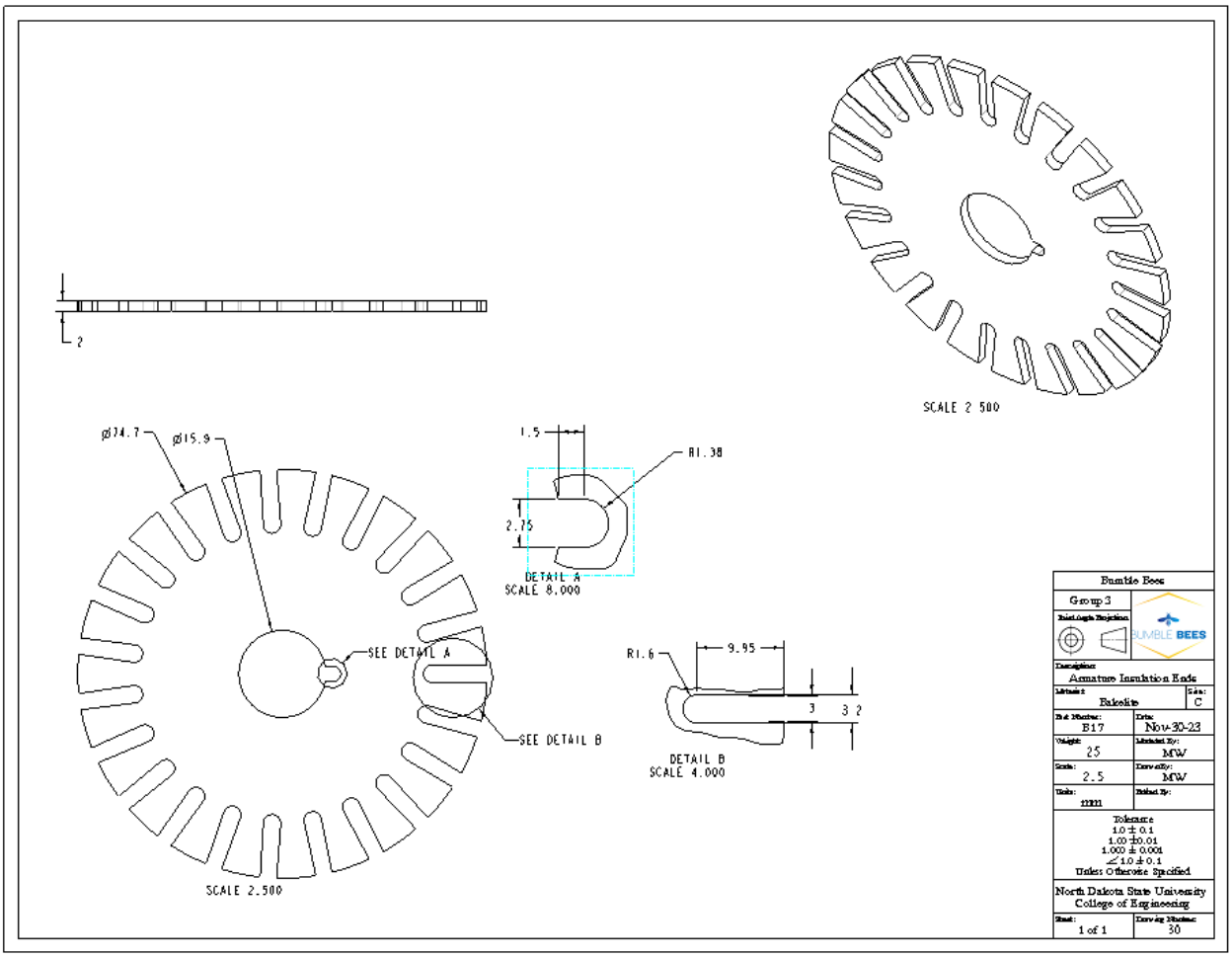
23


2
SCALE 2.500
ø24.7
ø15.9
SEE DETAIL A
SEE DETAIL B
SCALE 2.500
1.5
R1.38
2.75
DETAIL A
SCALE 8.000
R1.6
9.95
3
3.2
DETAIL B
SCALE 4.000
Bumble Bees
Group 3
BUMBLE BEES
Description:
Armature Insulation Ends
Material:
Bakelite
Size:
C
Dwg Number:
B17
Date:
Nov-30-23
Weight:
25
Modified By:
MW
Scale:
2.5
Drawn By:
MW
Units:
mm
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠ 1.0 ± 0.1
Unless Otherwise Specified
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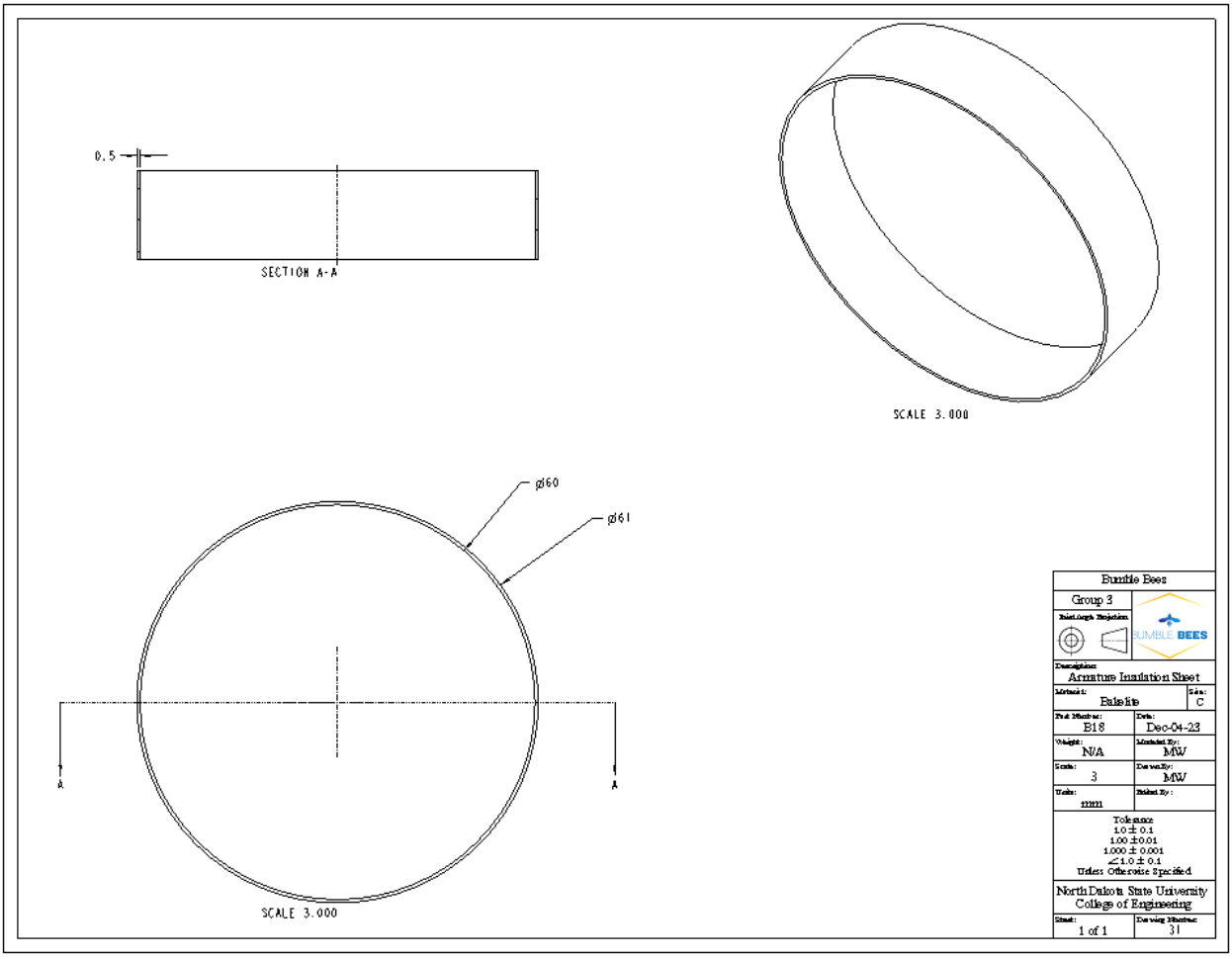
30


0.5
SECTION A-A
SCALE 3.000
ø60
ø61
A
A
SCALE 3.000
Bumble Bees
Group 3
BUMBLE BEES
Description:
Armature Insulation Sheet
Material:
Bakelite
Size:
C
Part Number:
B18
Date:
Dec-04-23
Weight:
N/A
Modeled By:
MW
Scale:
3
Drawn By:
MW
Units:
mm
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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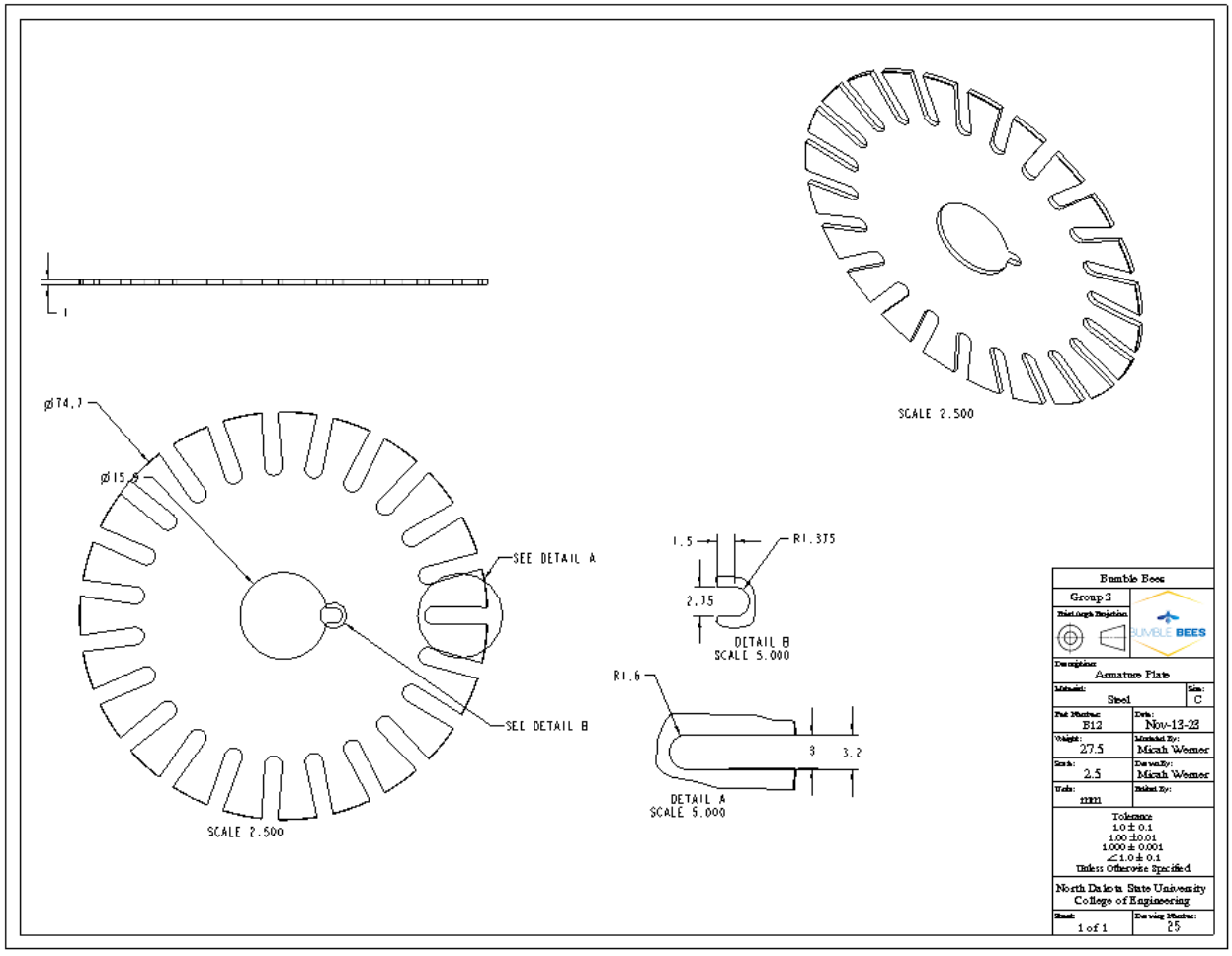
SCALE 2.500
Ø74.7
Ø15.8
SEE DETAIL A
SEE DETAIL B
SCALE 2.500
1.5
R1.375
2.75
DETAIL B
SCALE 5.000
R1.6
3
3.2
DETAIL A
SCALE 5.000
Bumble Bees
Group 3
BUMBLE BEES
Description:
Armature Plate
Material:
Steel
Size:
C
Part Number:
B12
Date:
Nov-13-23
Weight:
27.5
Modeled By:
Micah Weimer
Scale:
2.5
Drawn By:
Micah Weimer
Units:
mm
Tested By:
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
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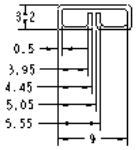
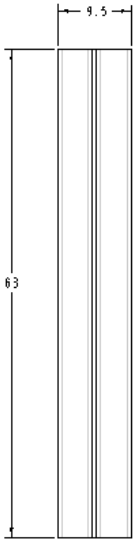
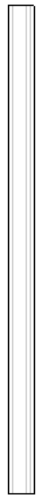
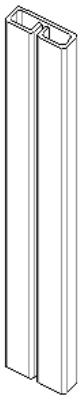


*All rounds are R0.5



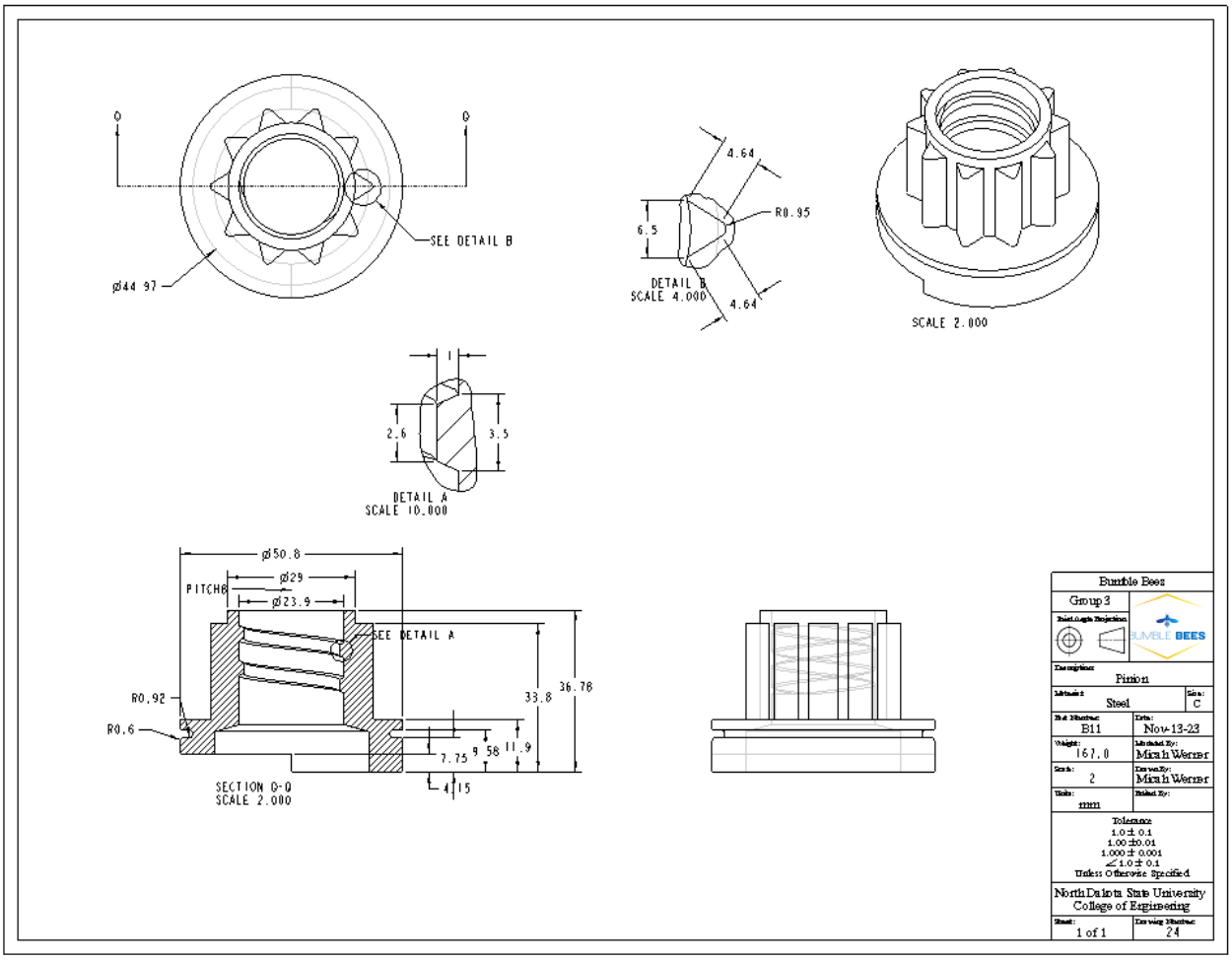
SCALE 3.500





SCALE 3.500

Bumble Bees	
Group 3	
Third Angle Projection	BUMBLE BEES
Description: Insulation Shell	
Material: Bakelite	Size: C
Dwg Number: B15	Date: Nov-30-23
Weight:	Checked By: MW
Scale: 3.5	Drawn By: MW
Units: mm	Tested By:
Tolerance 1.0 ± 0.1 1.00 ±0.01 1.000 ± 0.001 ∠ 1.0 ± 0.1 Unless Otherwise Specified	
North Dakota State University College of Engineering	
Sheet: 1 of 1	Drawing Number: 28


Q
Q
SEE DETAIL B
ø44.97
4.64
R0.95
6.5
DETAIL B
SCALE 4.000
4.64
SCALE 2.000
1
2.6
3.5
DETAIL A
SCALE 10.000
ø50.8
ø29
PITCH8
ø23.9
SEE DETAIL A
R0.92
R0.6
33.8
36.78
7.75
9.58
11.9
4.15
SECTION Q-Q
SCALE 2.000
Bumble Bees
Group 3
Third Angle Projection
BUMBLE BEES
Pinion
Steel
C
B11
Nov-13-23
167.0
Micah Werner
2
Micah Werner
mm
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠ 1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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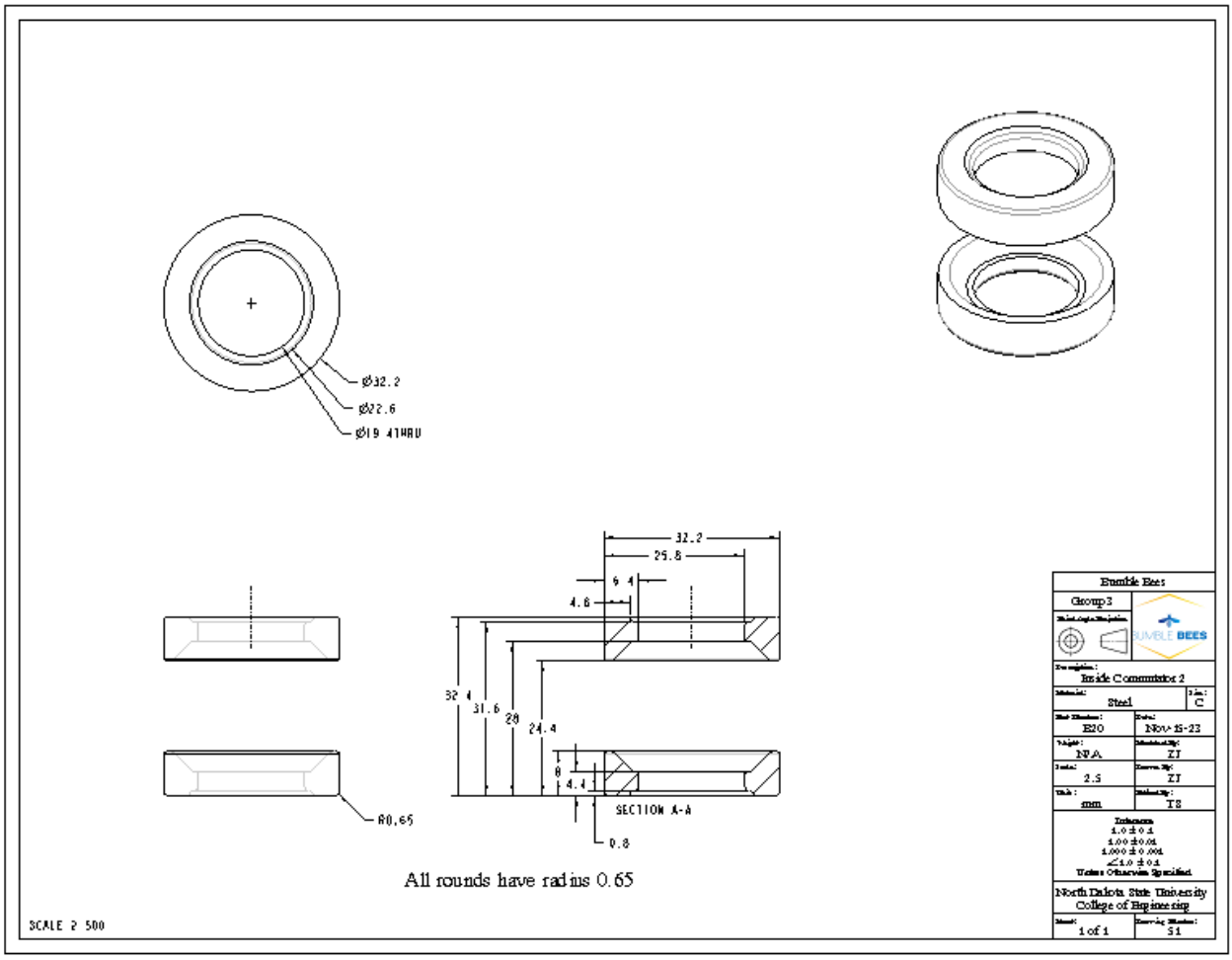
Ø32.2
Ø22.6
Ø19.41MAX
32.2
25.8
6.4
4.8
32.4
31.6
28
24.4
8
4.4
SECTION A-A
0.8
R0.65
All rounds have radius 0.65
SCALE 2.500
Bumble Bees
Group 3
Inside Commutator 2
Steel
C
E20
NOV-15-23
N/A
ZJ
2.5
ZJ
mm
TS
Tolerances
X.X ± 0.1
X.XX ± 0.01
X.XXX ± 0.005
∠X.X ± 0.1
Unless Otherwise Specified
North Dakota State University
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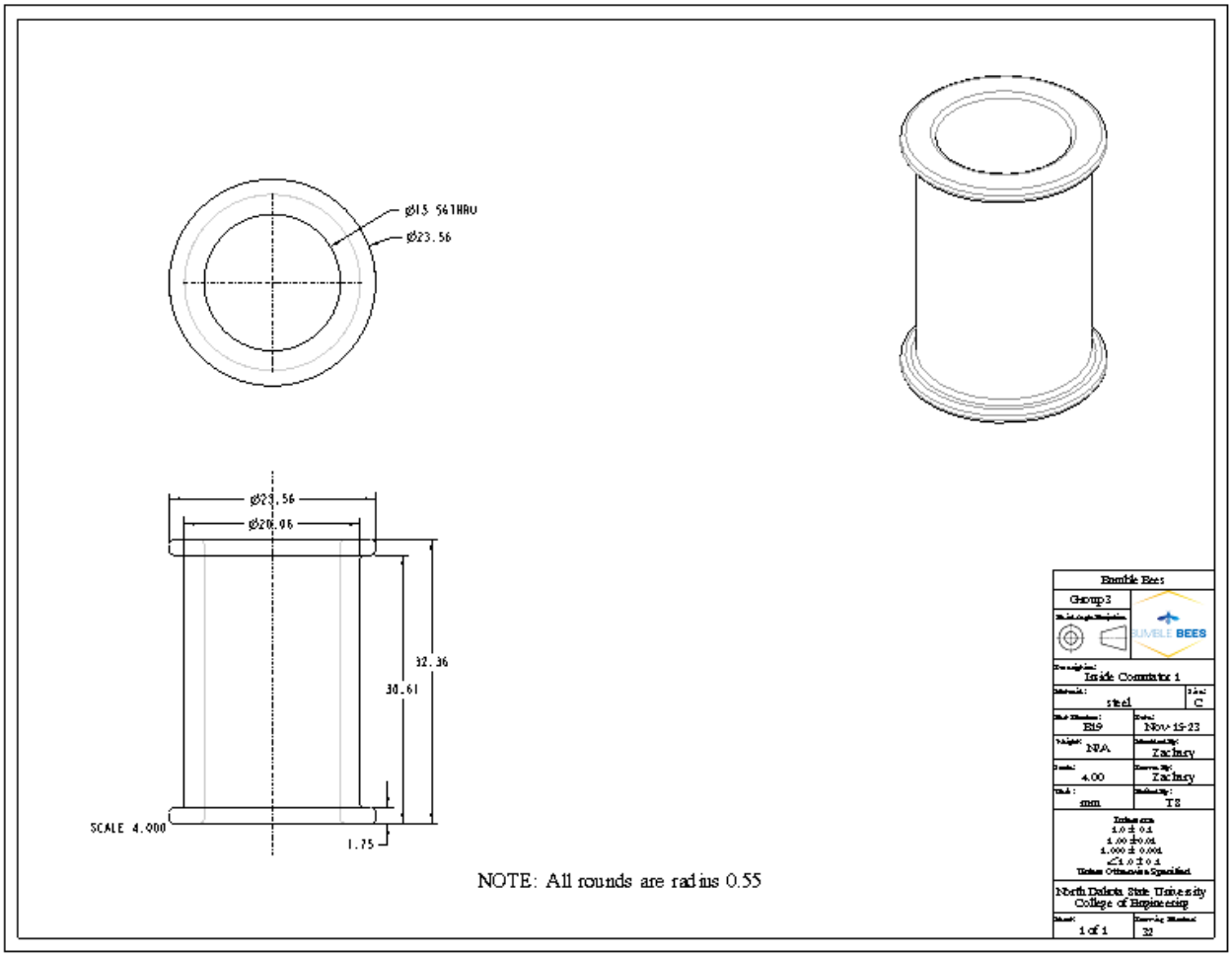
S1


Ø15.561THRU
Ø23.56
Ø23.56
Ø20.06
32.36
30.61
SCALE 4.000
1.75
NOTE: All rounds are radius 0.55
Bumble Bees
Group3
BUMBLE BEES
Inside Commutor 1
steel
C
EI9
Nov-15-23
N/A
Zachary
4.00
Zachary
mm
TS
North Dakota State University
College of Engineering
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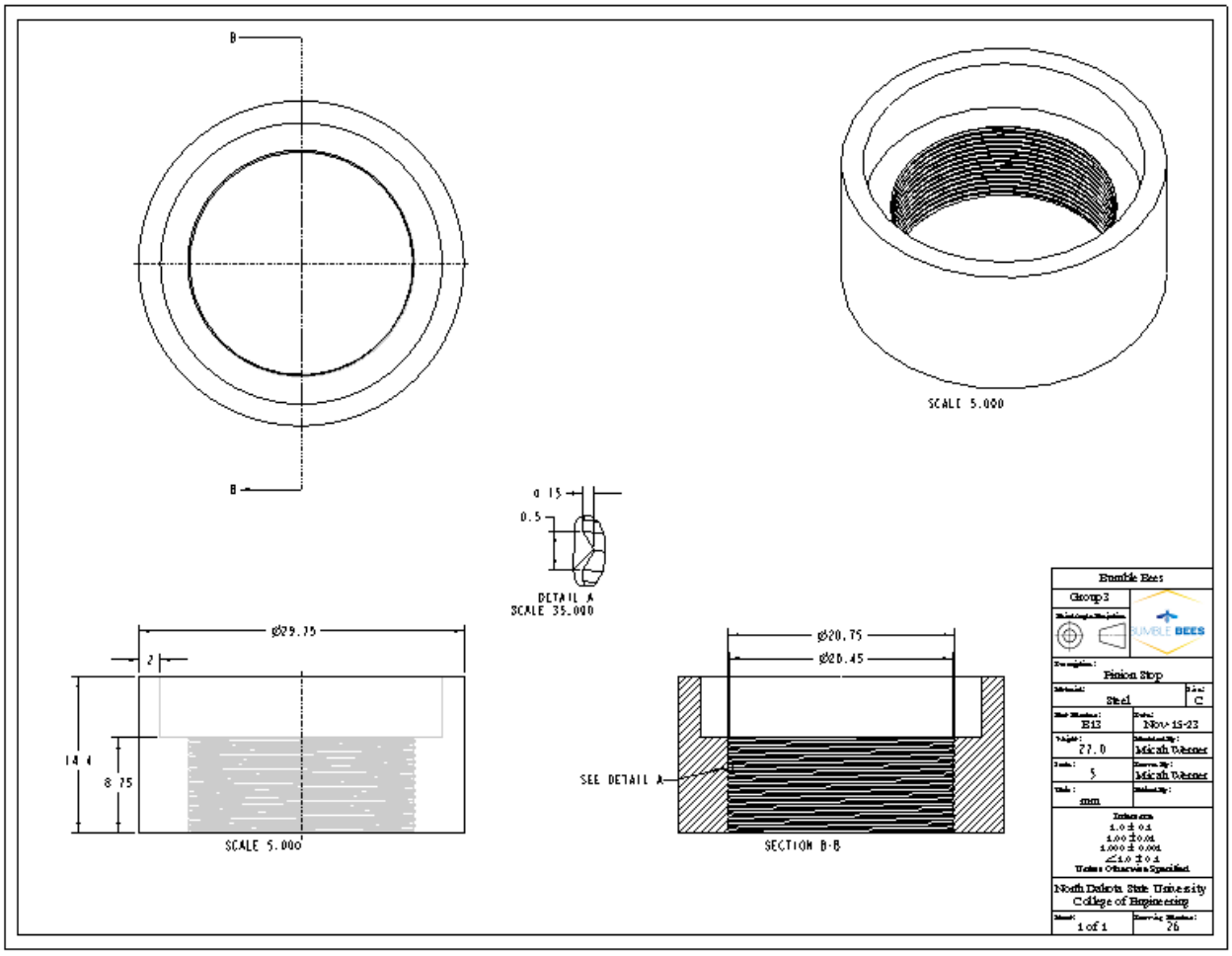
B
B
SCALE 5.000
0.15
0.5
DETAIL A
SCALE 35.000
Ø29.75
2
14.4
8.75
SCALE 5.000
Ø20.75
Ø20.45
SEE DETAIL A
SECTION B-B
Bumble Bees
Group 2
Pinion Stop
Steel
C
B13
Nov-15-23
27.0
Micah Weiner
5
Micah Weiner
mm
1.0 ± 0.1
1.00 ± 0.01
1.000 ± 0.001
≤4.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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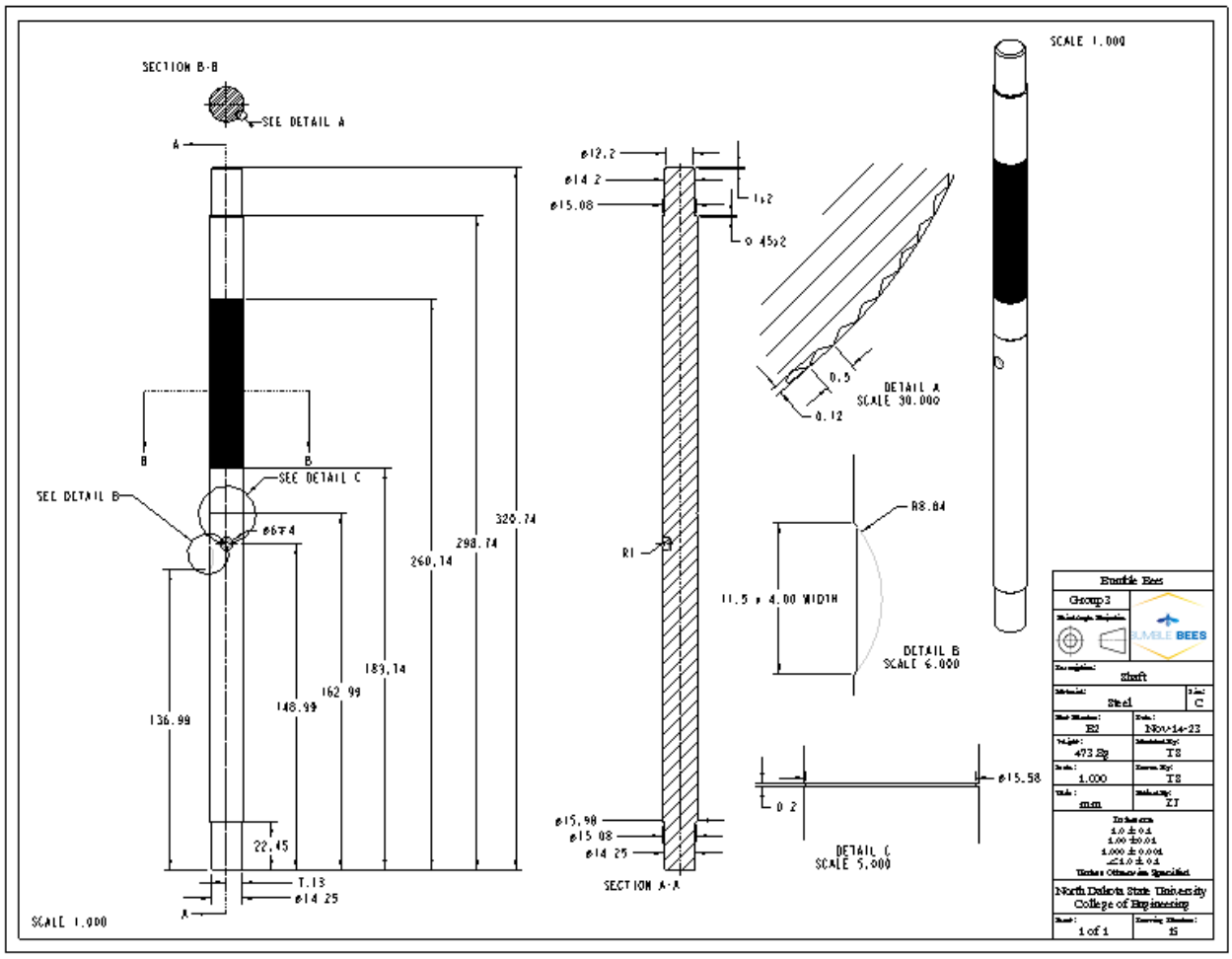
SECTION B-B
SEE DETAIL A
A
B
B
SEE DETAIL B
SEE DETAIL C
ø6.74
326.74
298.74
260.14
183.14
162.99
148.99
136.99
22.45
T.13
ø14.25
A
SCALE 1.000
ø12.2
ø14.2
ø15.08
1x2
0 45x2
0.5
0.12
DETAIL A
SCALE 30.000
R1
R8.84
11.5 x 4.00 WIDTH
DETAIL B
SCALE 6.000
ø15.58
0.2
DETAIL C
SCALE 5.000
ø15.98
ø15.08
ø14.25
SECTION A-A
SCALE 1.000
Bumble Bees
Group 3
BUMBLE BEES
Shaft
Steel
C
E2
NOV-14-23
473.8g
TS
1.000
TS
mm
ZT
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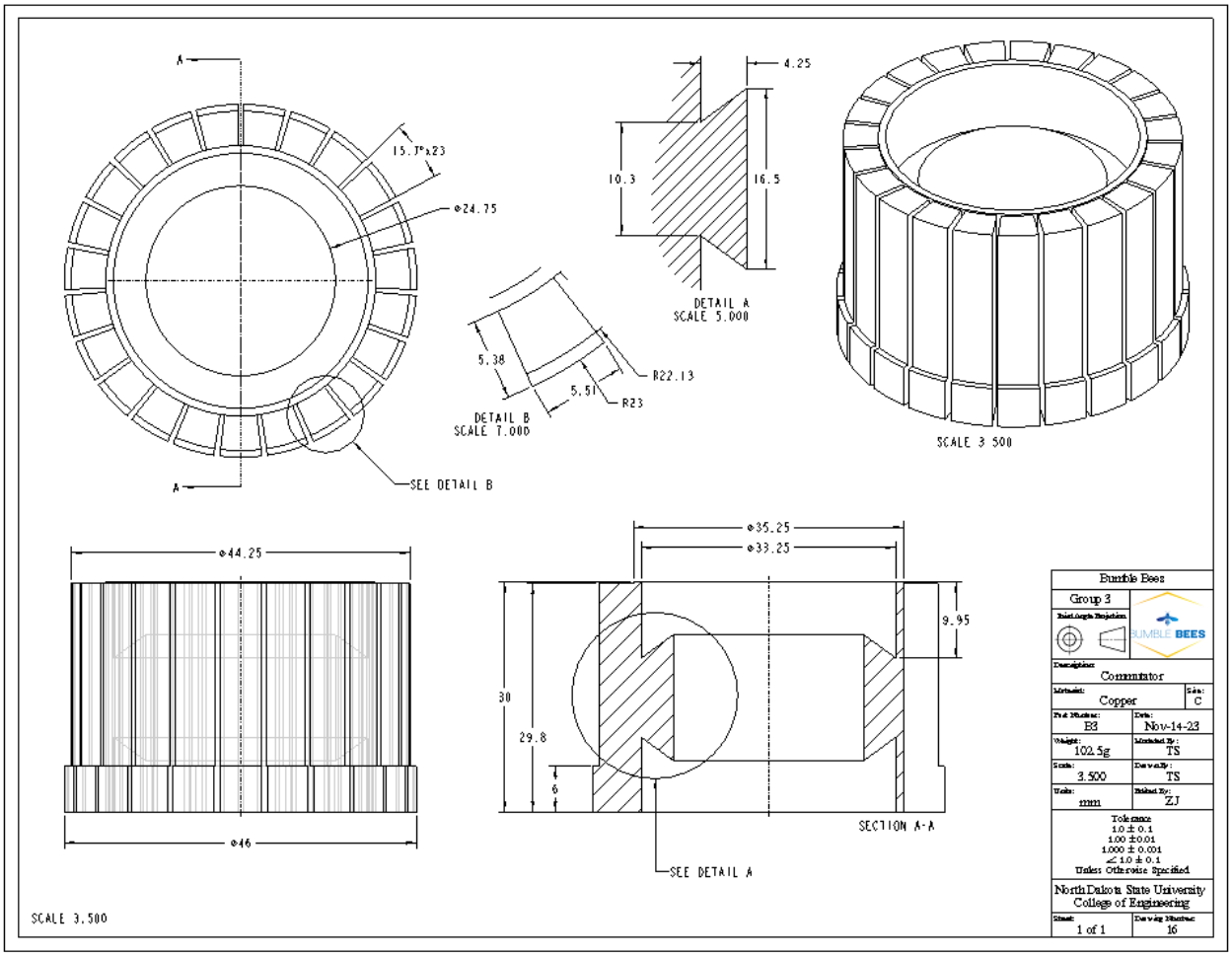
A
15.7°x23
ø24.75
A
SEE DETAIL B
4.25
10.3
16.5
DETAIL A
SCALE 5.000
5.38
R22.13
5.51
R23
DETAIL B
SCALE 7.000
SCALE 3.500
ø44.25
ø46
ø35.25
ø33.25
9.95
30
29.8
6
SECTION A-A
SEE DETAIL A
SCALE 3.500
Bumble Bees
Group 3
Description:
Commutator
Material:
Copper
Size:
C
Part Number:
B3
Date:
Nov-14-23
Weight:
102.5g
Modeled By:
TS
Scale:
3.500
Drawn By:
TS
Units:
mm
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
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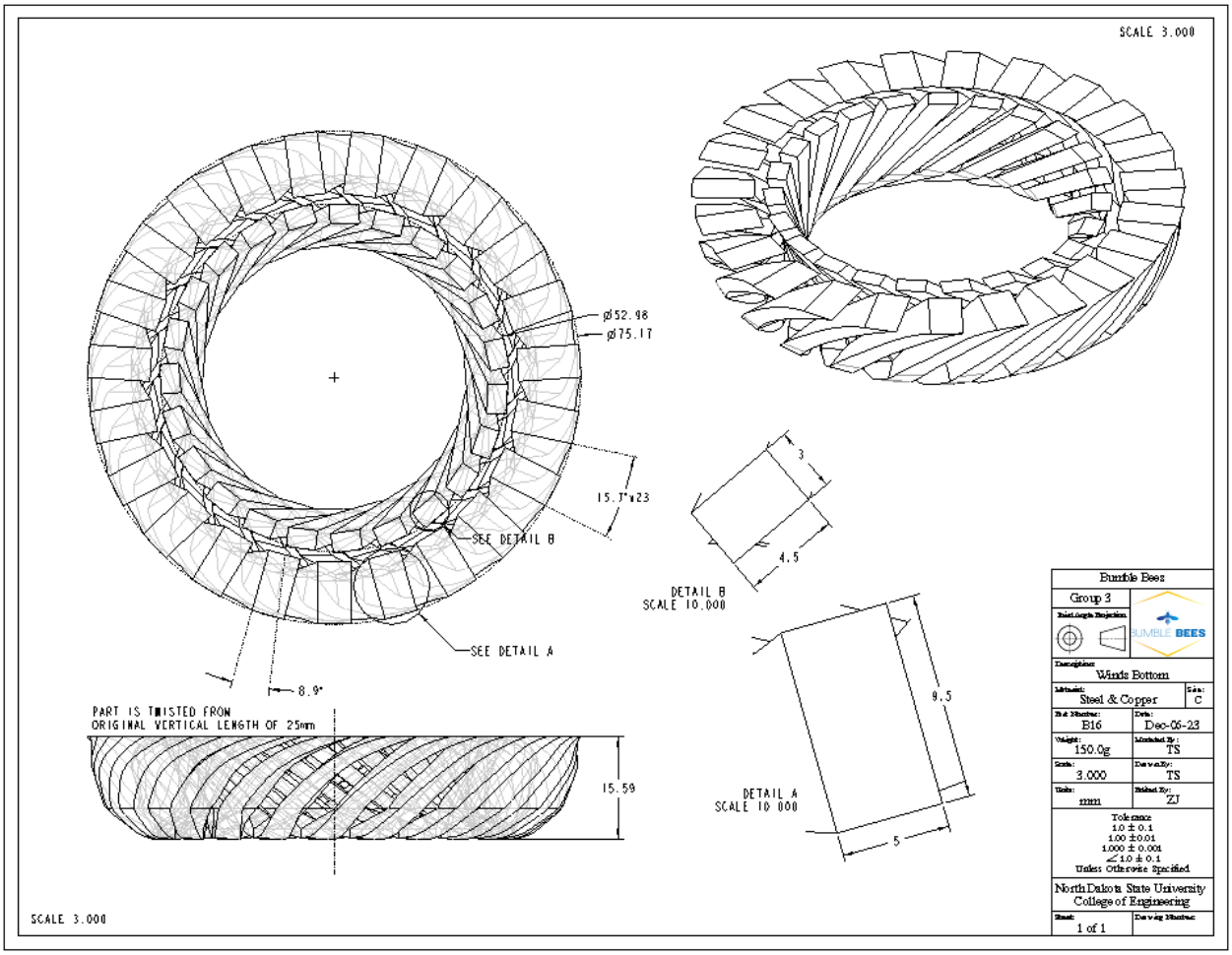
SCALE 3.000
ø52.98
ø75.17
15.7"x23
SEE DETAIL B
SEE DETAIL A
8.9°
PART IS TWISTED FROM
ORIGINAL VERTICAL LENGTH OF 25mm
15.59
SCALE 3.000
3
4.5
DETAIL B
SCALE 10.000
9.5
5
DETAIL A
SCALE 10.000
Bumble Bees
Group 3
Description:
Winds Bottom
Material:
Steel & Copper
Size:
C
Dwg Number:
B16
Date:
Dec-06-23
Weight:
150.0g
Modeled By:
TS
Scale:
3.000
Drawn By:
TS
Units:
mm
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠ 1.0 ± 0.1
Unless Otherwise Specified
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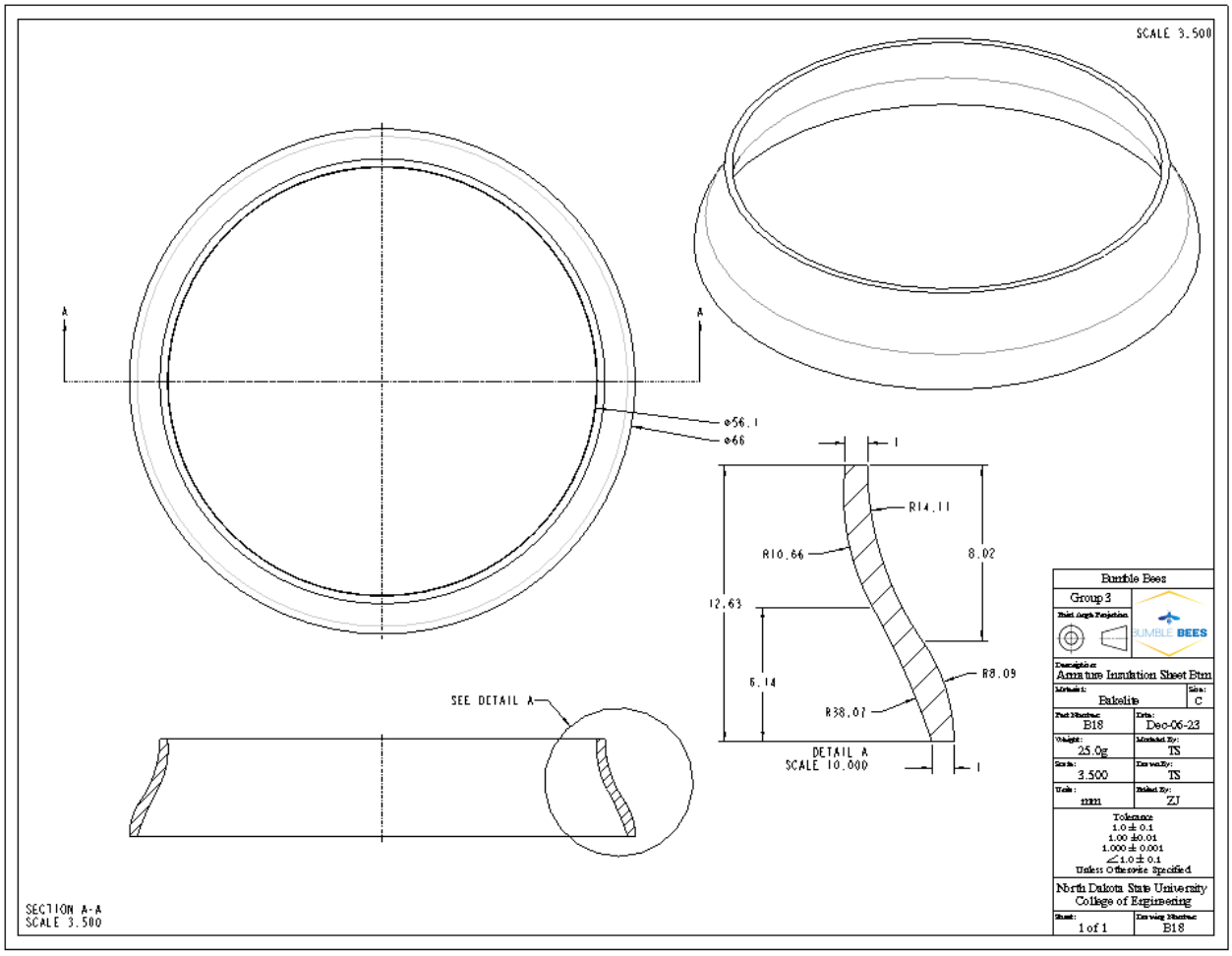
Drawing Number:


SCALE 3.500
A
A
ø56.1
ø66
1
R14.11
R10.66
8.02
12.63
6.14
R8.09
R38.07
1
SEE DETAIL A
DETAIL A
SCALE 10.000
SECTION A-A
SCALE 3.500
Bumble Bees
Group 3
BUMBLE BEES
Annulus Insulation Sheet Stm
Bakelite
C
B18
Dec-06-23
25.0g
TS
3.500
TS
mm
ZJ
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
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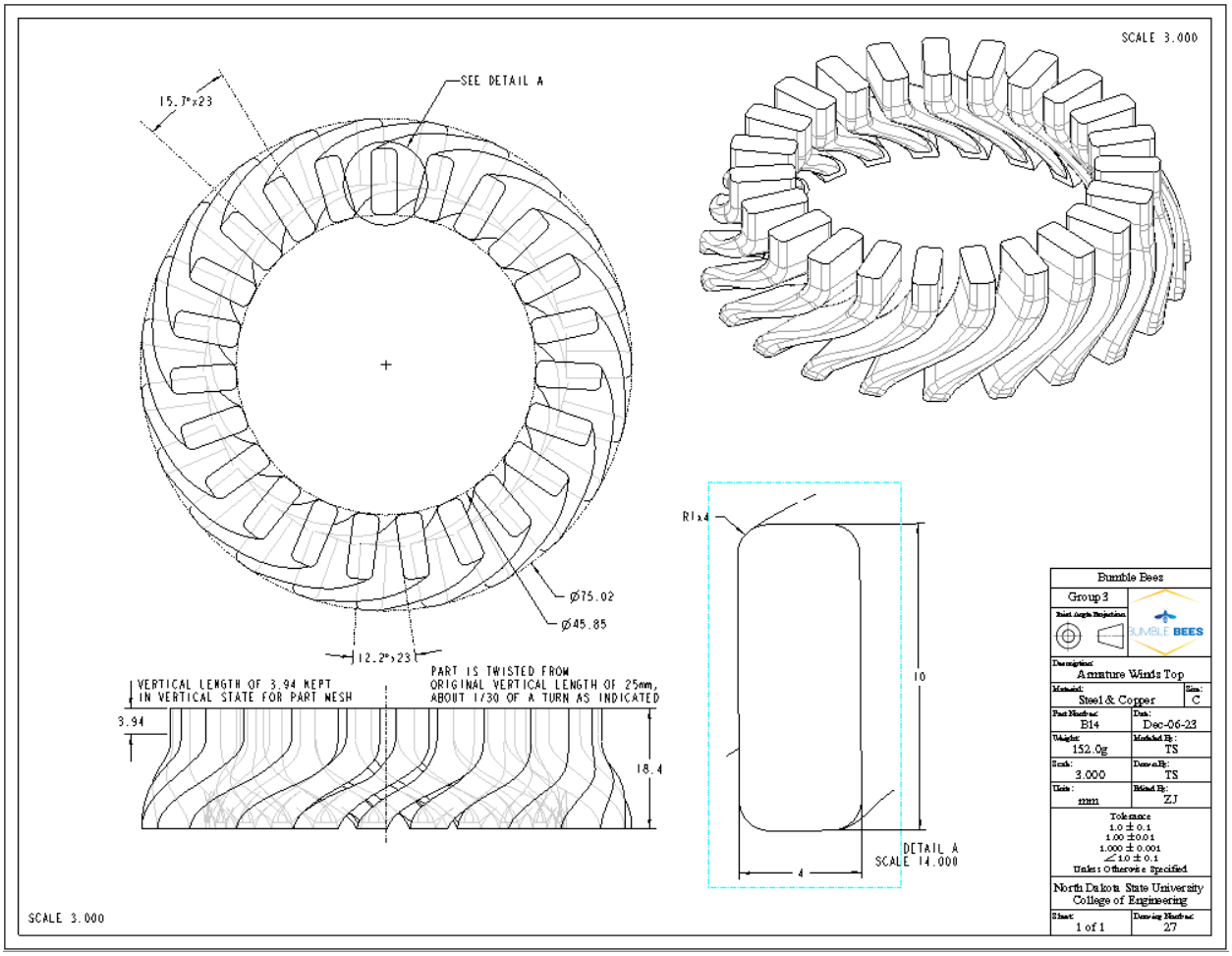
B18


SCALE 3.000
15.7°x23
SEE DETAIL A
Ø75.02
Ø45.85
12.2°x23
VERTICAL LENGTH OF 3.94 KEPT
IN VERTICAL STATE FOR PART MESH
PART IS TWISTED FROM
ORIGINAL VERTICAL LENGTH OF 25mm,
ABOUT 1/30 OF A TURN AS INDICATED
3.94
18.4
R1x4
10
4
DETAIL A
SCALE 14.000
SCALE 3.000
Bumble Bees
Group 3
Armature Winds Top
Steel & Copper
C
B14
Dec-06-23
152.0g
TS
3.000
TS
mm
ZJ
Tolerance
1.0 ± 0.1
1.00 ± 0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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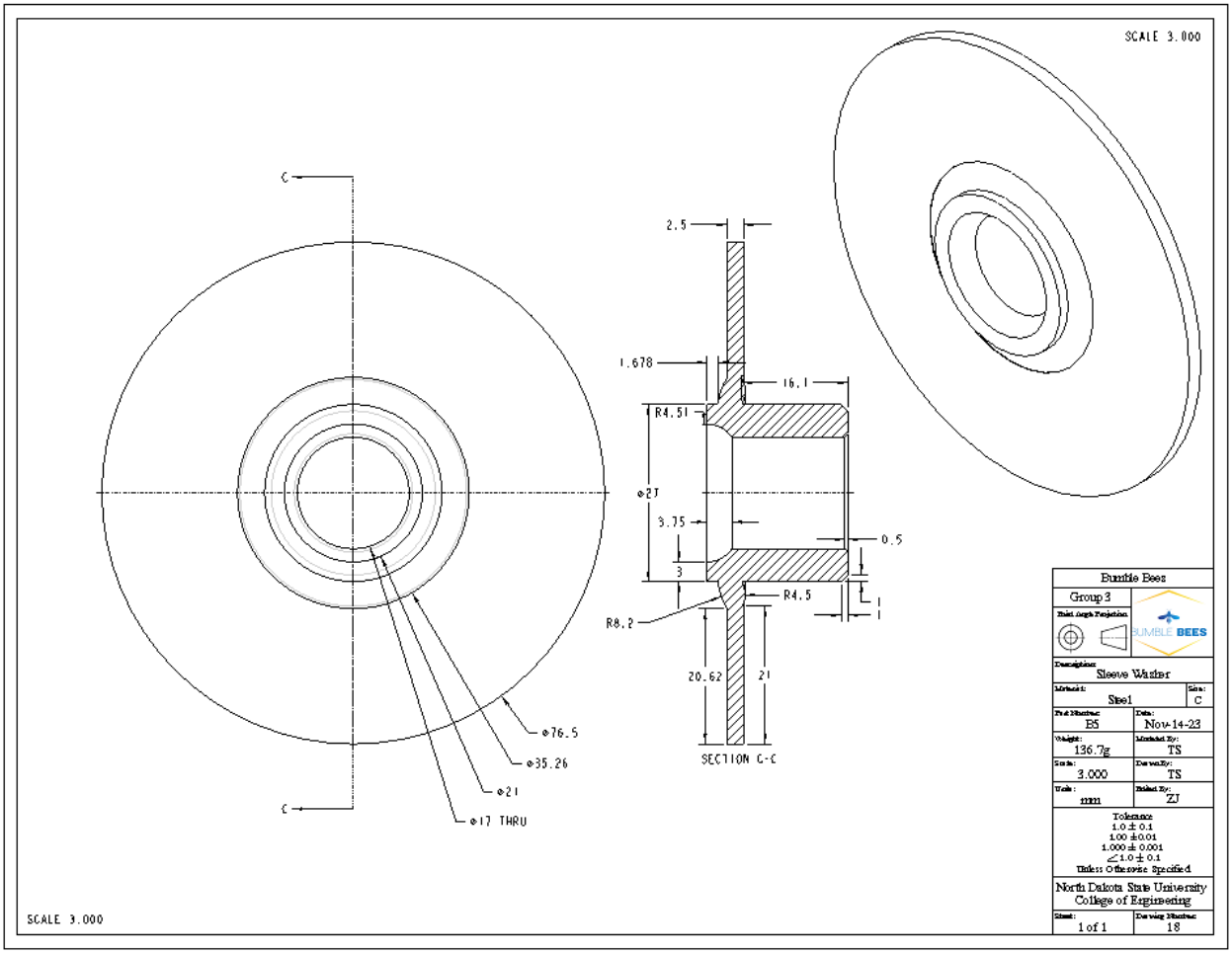
SCALE 3.000
C
C
ø76.5
ø35.26
ø21
ø17 THRU
2.5
1.678
16.1
R4.51
ø27
3.75
0.5
3
R4.5
1
1
R8.2
20.62
21
SECTION C-C
SCALE 3.000
Bumble Bees
Group 3
Sleeve Washer
Steel
C
BS
Nov-14-23
136.7g
TS
3.000
TS
mm
ZJ
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
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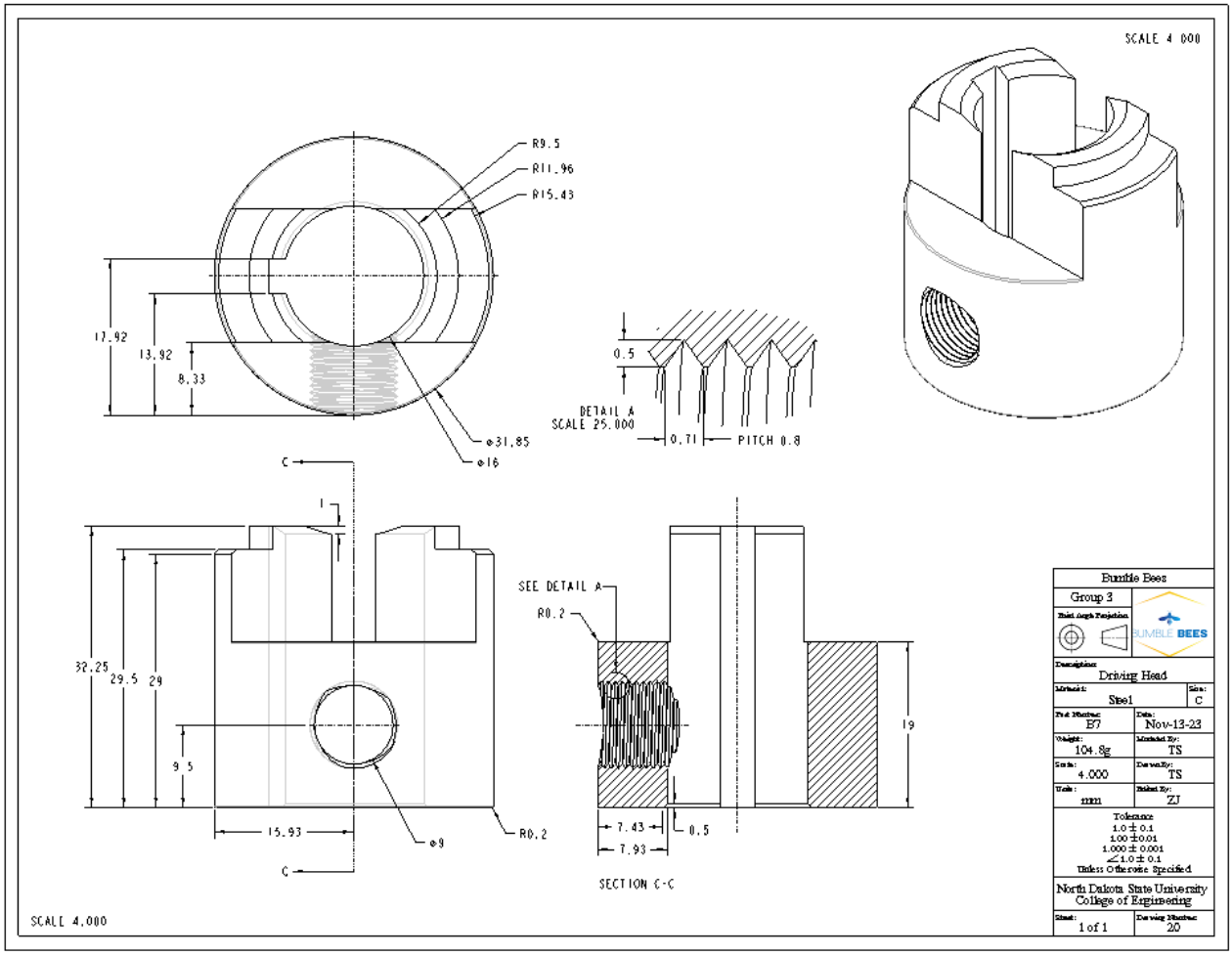
SCALE 4.000
R9.5
R11.96
R15.43
17.92
13.92
8.33
ø31.85
ø16
0.5
DETAIL A
SCALE 25.000
0.71
PITCH 0.8
C
1
32.25
29.5
29
9.5
15.93
ø9
R0.2
C
SEE DETAIL A
R0.2
19
7.43
7.93
0.5
SECTION C-C
SCALE 4.000
Bumble Bees
Group 3
Third Angle Projection
BUMBLE BEES
Description:
Driving Head
Material:
Steel
Size:
C
Part Number:
E7
Date:
Nov-13-23
Weight:
104.8g
Checked By:
TS
Scale:
4.000
Drawn By:
TS
Units:
mm
Tested By:
ZJ
Tolerance
1.0 ± 0.1
1.00 ± 0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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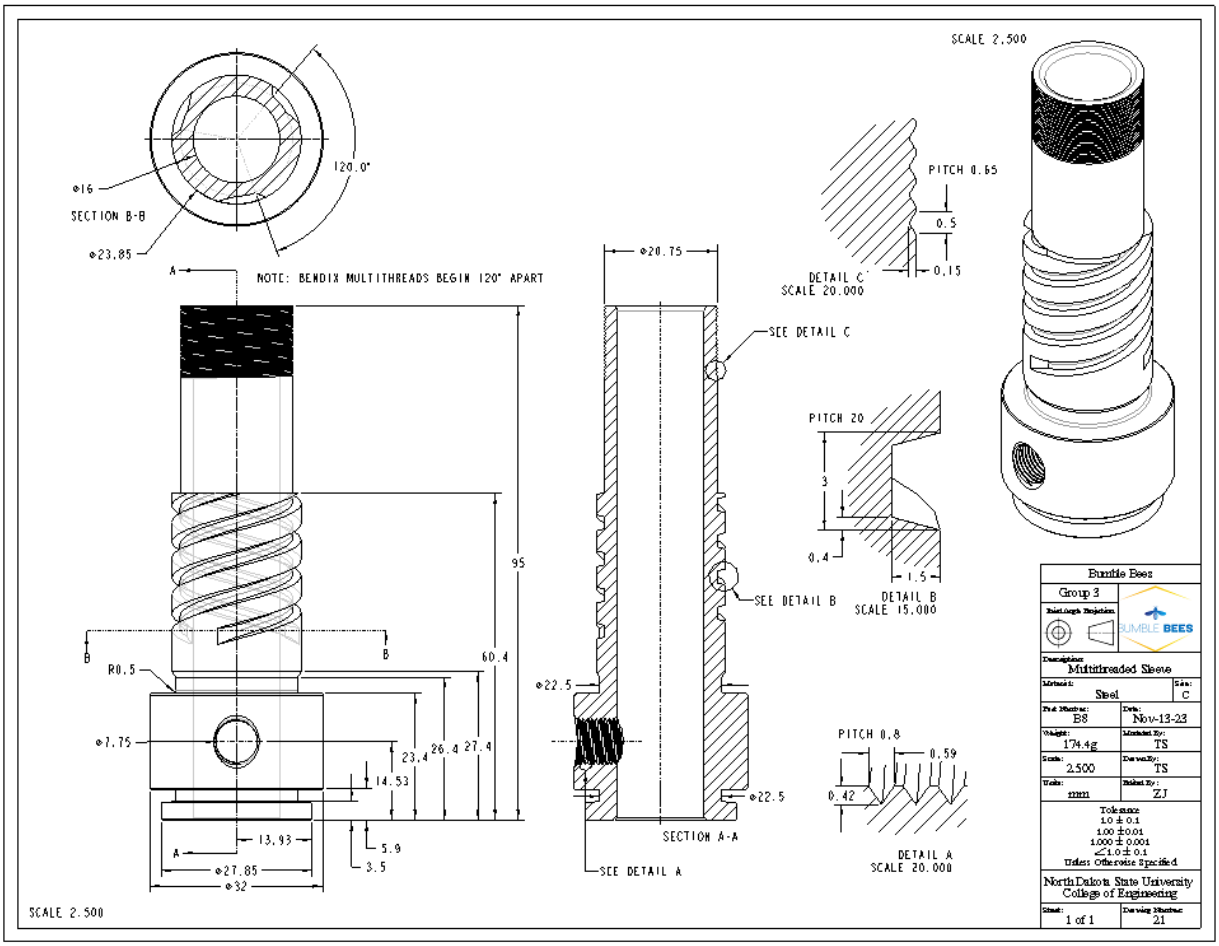
SCALE 2.500
120.0°
ø16
SECTION B-B
ø23.85
A
NOTE: BENDIX MULTITHREADS BEGIN 120° APART
95
60.4
B
B
R0.5
ø7.75
23.4
26.4
27.4
14.53
13.93
A
ø27.85
ø32
5.9
3.5
SCALE 2.500
ø20.75
SEE DETAIL C
SEE DETAIL B
ø22.5
ø22.5
SECTION A-A
SEE DETAIL A
PITCH 0.65
0.5
0.15
DETAIL C
SCALE 20.000
PITCH 20
3
0.4
1.5
DETAIL B
SCALE 15.000
PITCH 0.8
0.59
0.42
DETAIL A
SCALE 20.000
Bumble Bees
Group 3
BUMBLE BEES
Description:
Multithreaded Sleeve
Material:
Steel
Size:
C
First Machine:
B8
Date:
Nov-13-23
Weight:
174.4g
Modeled By:
TS
Scale:
2.500
Drawn By:
TS
Units:
mm
Tested By:
ZJ
Tolerance
1.0 ± 0.1
1.00 ± 0.01
1.000 ± 0.001
≤1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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Sheet:
1 of 1
Drawing Number:
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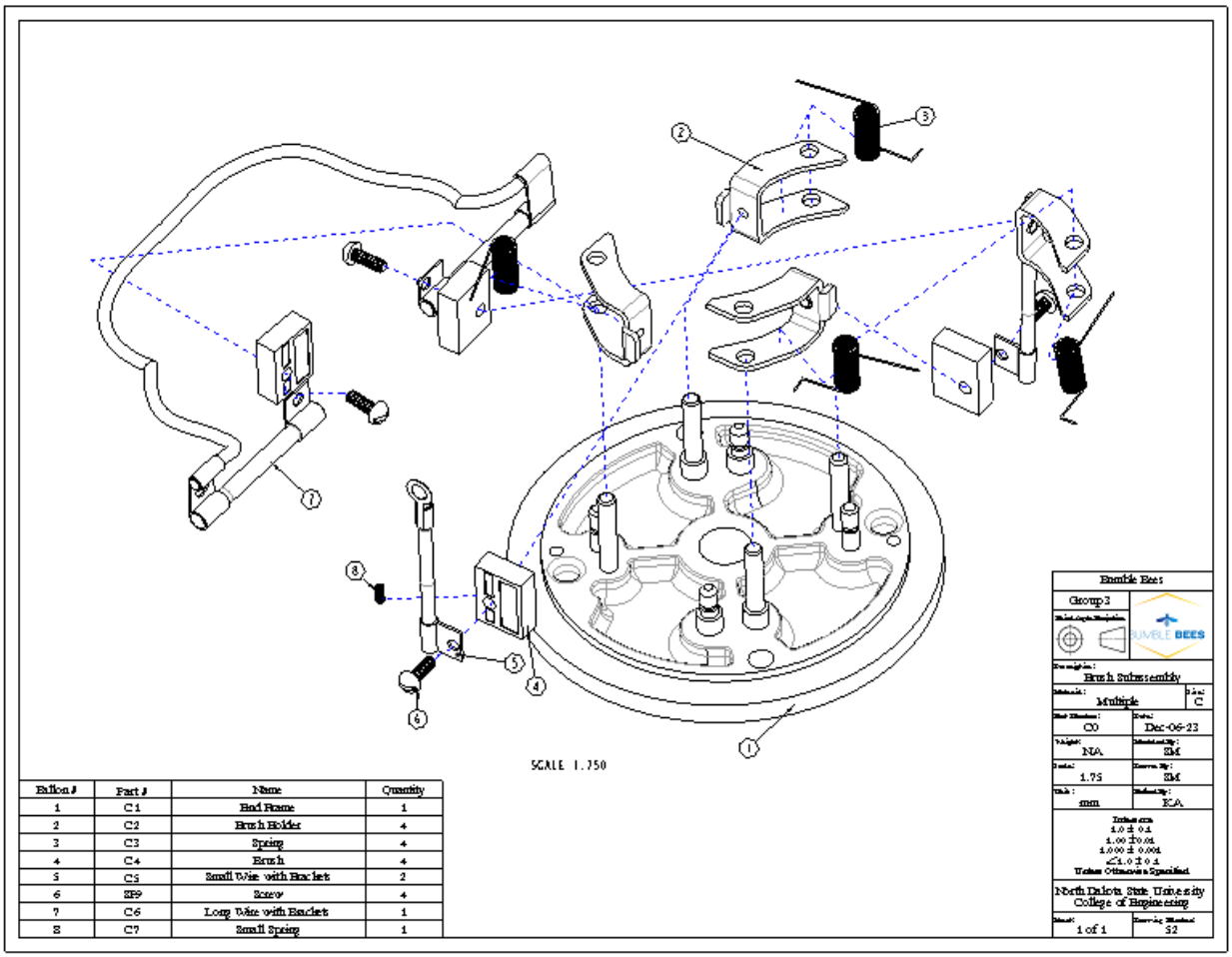
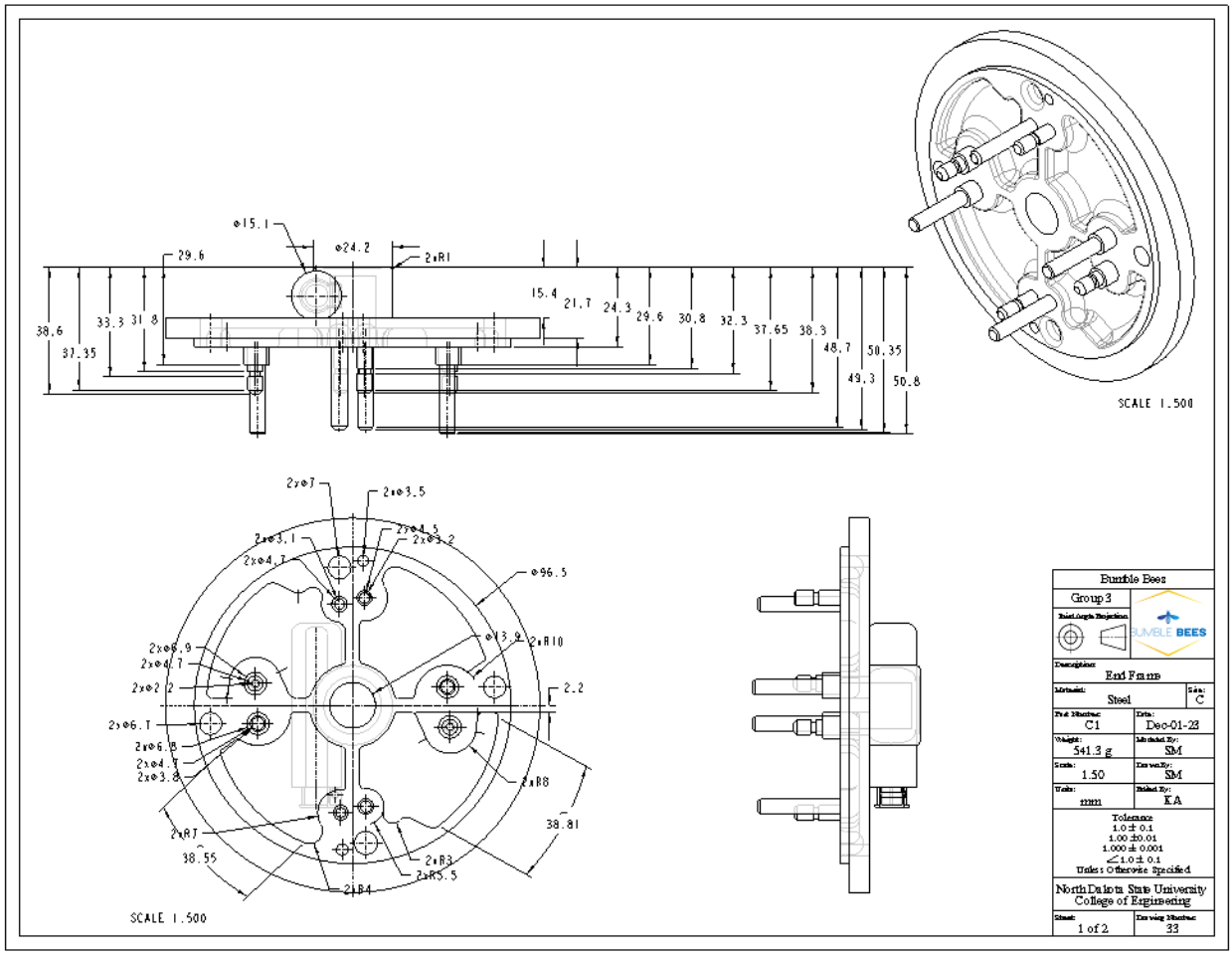
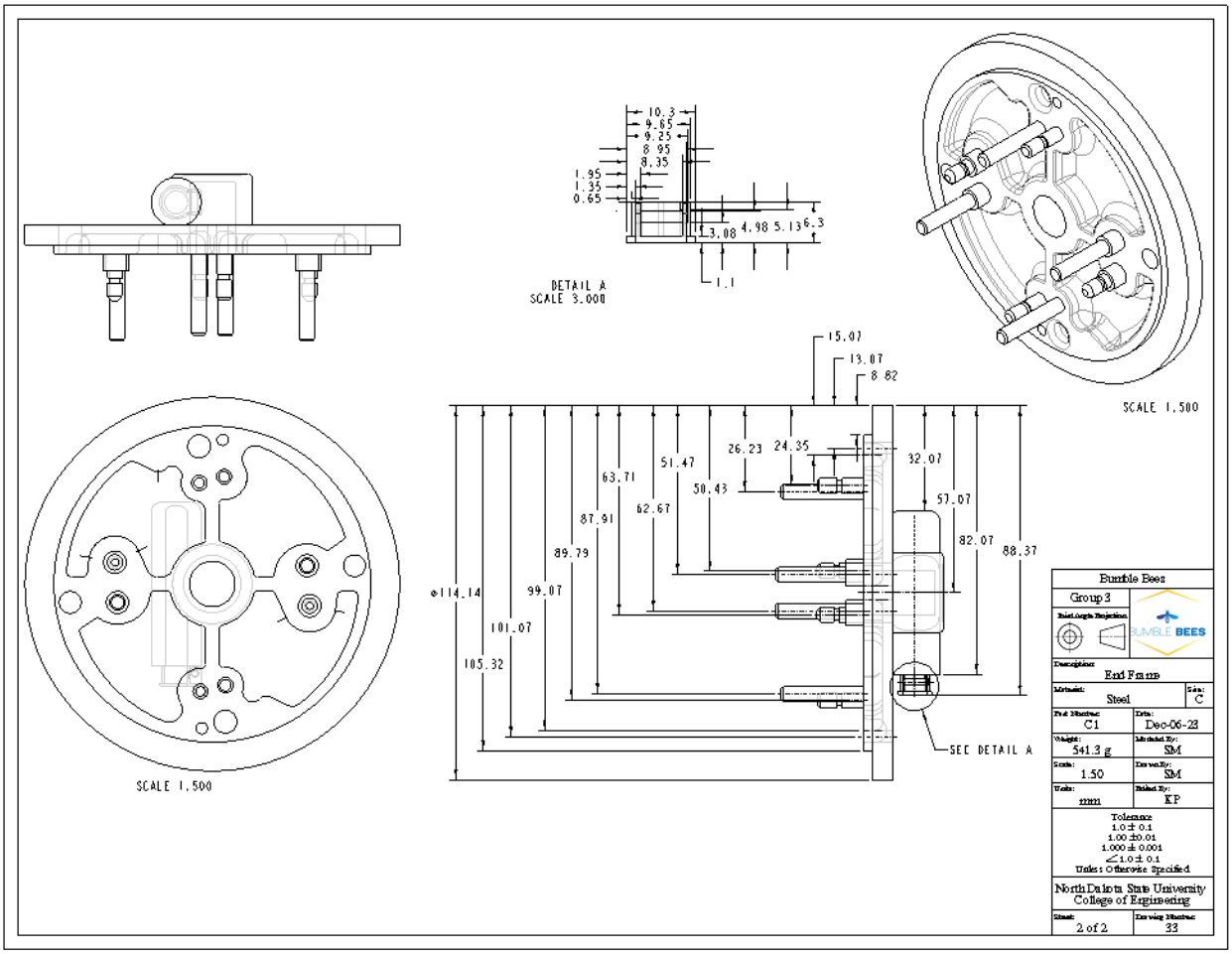
[C] BRUSHES SUBASSEMBLY



Balloon #	Part #	Name	Quantity
1	C1	End Frame	1
2	C2	Brush Holder	4
3	C3	Spring	4
4	C4	Brush	4
5	C5	Small Wire with Bracket	2
6	SP9	Screw	4
7	C6	Long Wire with Bracket	1
8	C7	Small Spring	1

[C] ASSEMBLY DRAWINGS




10.3
9.65
9.25
8.95
8.35
1.95
1.35
0.65
3.08
4.98
5.13
6.3
1.1
DETAIL A
SCALE 3.000
SCALE 1.500
15.07
13.07
8.82
26.23
24.35
32.07
51.47
50.43
63.71
62.67
57.07
87.91
82.07
88.37
89.79
99.07
ø114.14
101.07
105.32
SEE DETAIL A
SCALE 1.500
Bumble Bees
Group 3
BUMBLE BEES
End Frame
Steel
C
C1
Dec-06-23
541.3 g
SM
1.50
SM
mm
KP
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
College of Engineering
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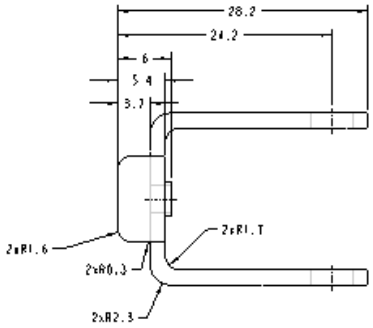
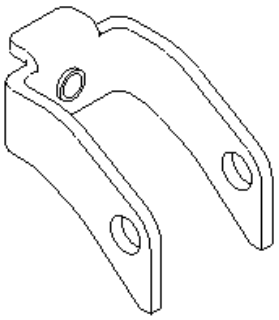
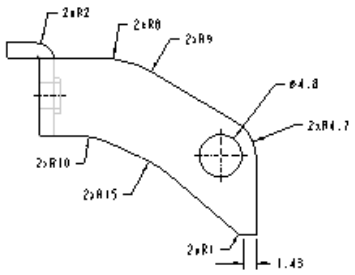
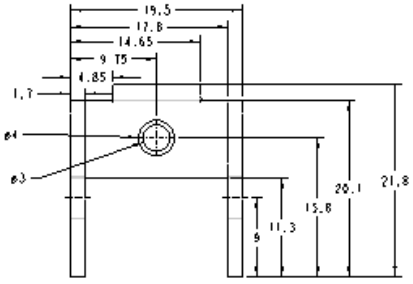




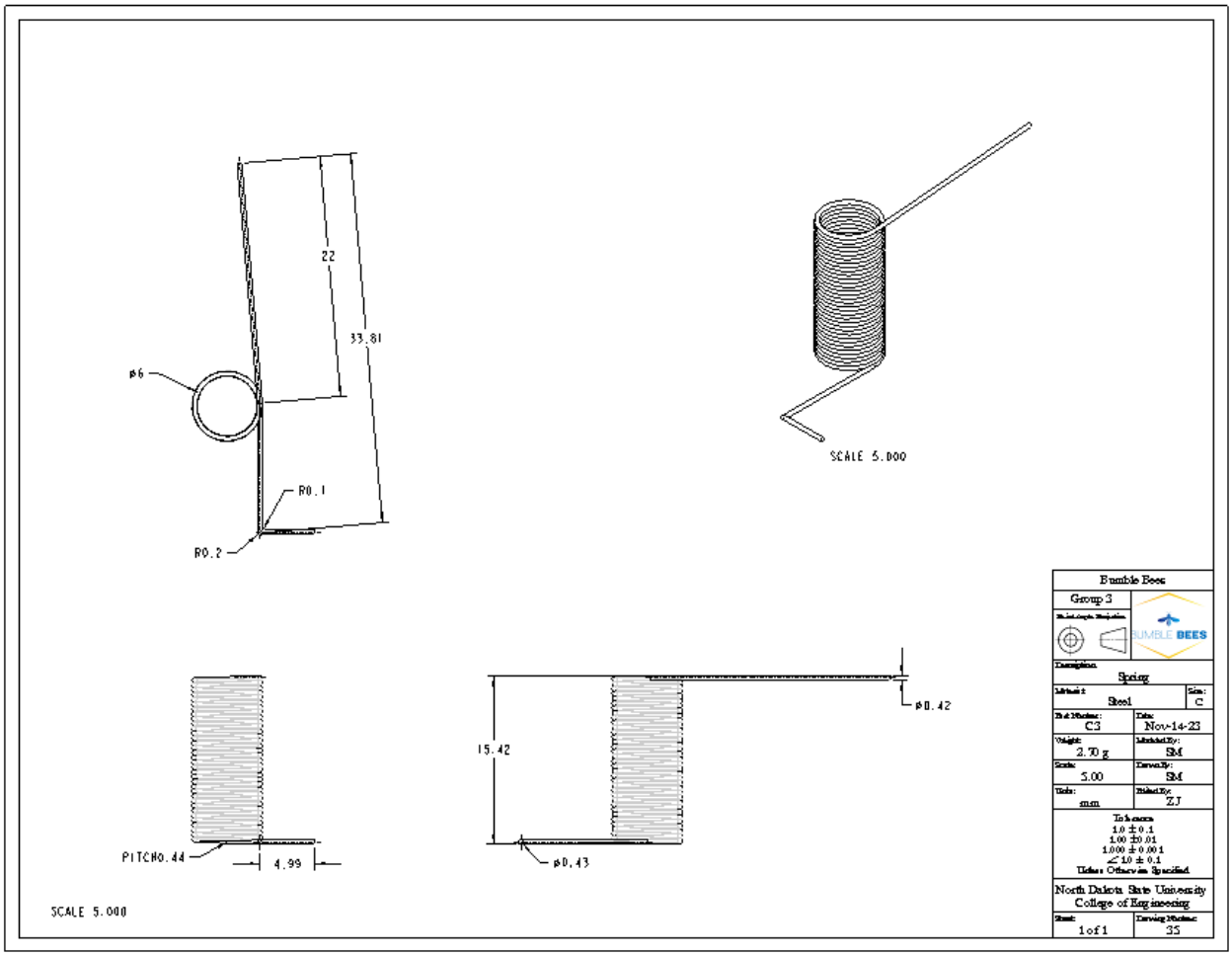
SCALE 4.000



SCALE 4.000



Bumble Bees	
Group 2	
Brush Holder	
Material: Copper	Size: C
Sheet Number: C2	Date: Nov-09-23
Weight: 7.5 g	Manufacturing: SM
Scale: 4.00	Drawn By: SM
Units: mm	Manufacturing: EA
Tolerances: 1.0 ± 0.1 1.00 ±0.01 1.000 ± 0.001 ≤1.0 ± 0.1 Unless Otherwise Specified	
North Dakota State University College of Engineering	
Sheet: 1 of 1	Drawing Number: 34


22
33.81
ø6
R0.1
R0.2
SCALE 5.000
PITCH0.44
4.99
15.42
ø0.42
ø0.43
SCALE 5.000
Bumble Bees
Group 3
Spring
Steel
C
C3
Nov-14-23
2.70 g
SM
5.00
SM
mm
ZJ
Tolerances
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠ 1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
College of Engineering
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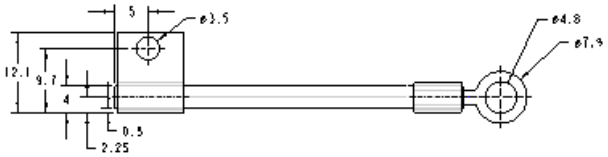
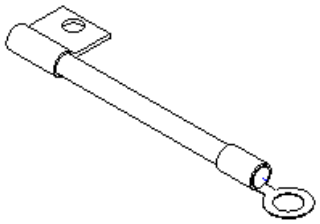
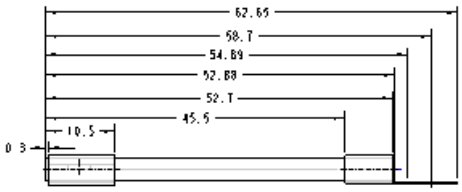
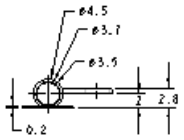




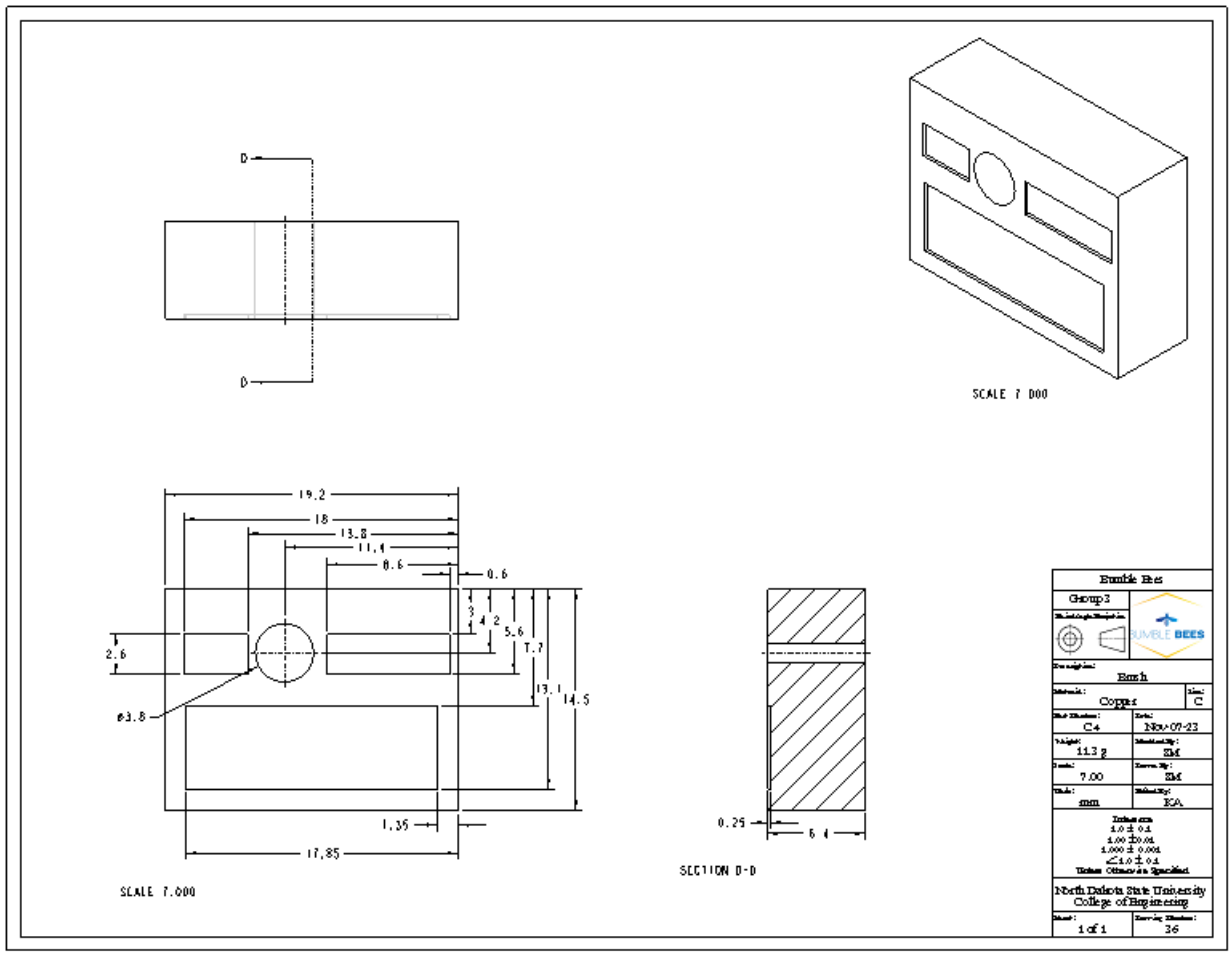
SCALE 3.000





SCALE 3.000

Bumble Bees	
Group 3	BUMBLE BEES
Short Wire & Bracket	
Material: Copper/Steel	Size: C
Part Number: CS	Date: Nov-11-23
Weight: 5.6 g	Submitted By: EM
Scale: 3.0	Drawn By: EM
Unit: mm	Checked By: KA
Tolerances: 1.0 ± 0.1 1.00 ± 0.01 1.000 ± 0.001 ∠1.0 ± 0.1 Unless Otherwise Specified	
North Dakota State University College of Engineering	
Sheet: 1 of 1	Drawing Number: 37


D
D
SCALE 7 000
19.2
18
13.8
11.4
8.6
0.6
3
4.2
5.6
7.7
13.1
14.5
2.6
ø3.8
1.35
17.85
SCALE 7.000
0.25
6.4
SECTION D-D
Bumble Bee
Group 3
BUMBLE BEES
Earth
Material:
Copper
Size:
C
DWG Number:
C4
Date:
Nov-07-23
Weight:
11.3 g
Modified By:
SM
Scale:
7.00
Drawn By:
SM
Units:
mm
Released By:
EA
Tolerances
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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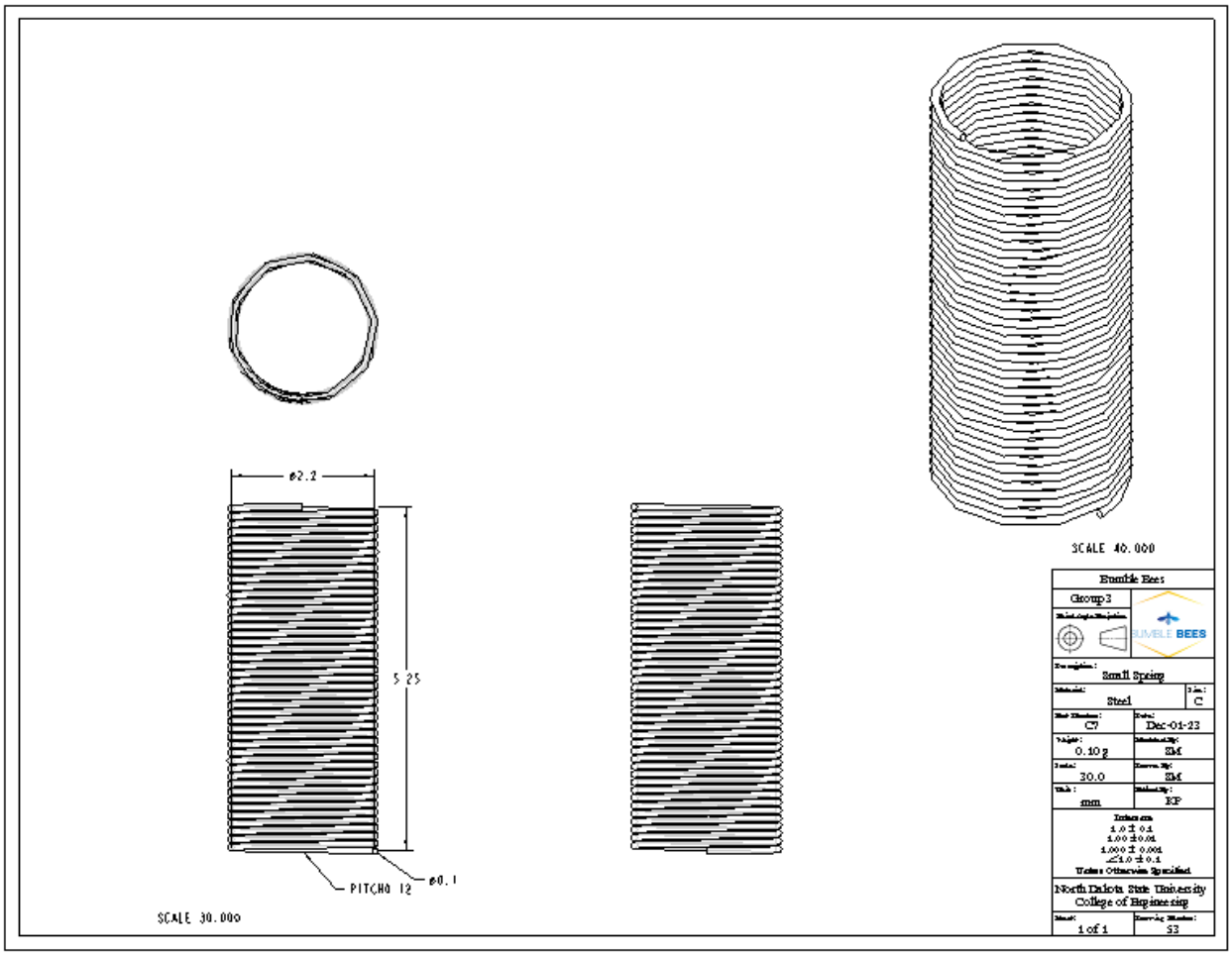
ø2.2
5.25
PITCH0.12
ø0.1
SCALE 30.000
SCALE 40.000
Bumble Bees
Group3
BUMBLE BEES
Small Spring
Steel
C
C7
Dec-01-23
0.10 g
SM
30.0
SM
mm
KP
Unless Otherwise Specified
North Dakota State University
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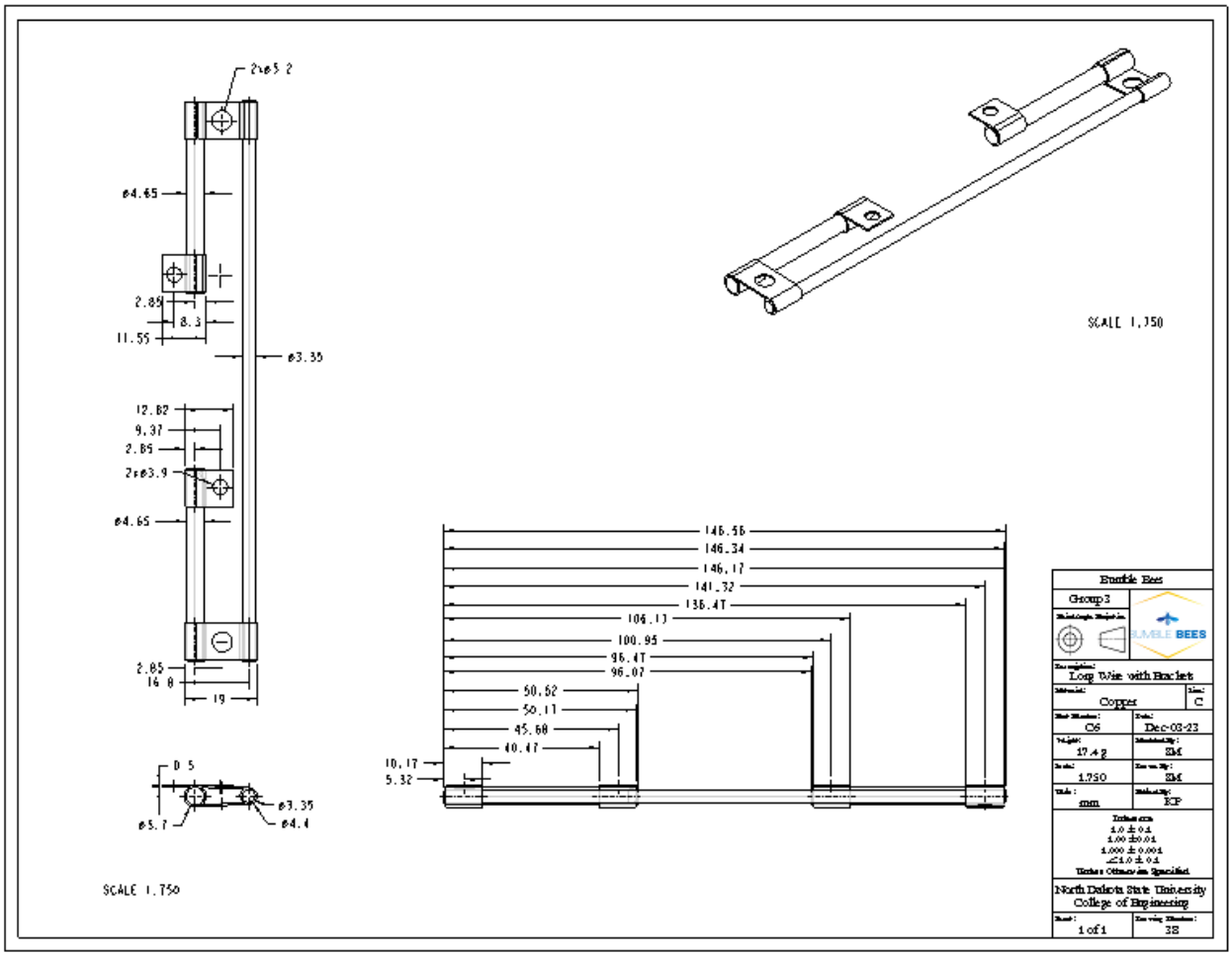
2xø5.2
ø4.65
2.85
8.3
11.55
ø3.35
12.82
9.37
2.85
2xø3.9
ø4.65
2.85
14.8
19
D 5
ø5.7
ø3.35
ø4.4
SCALE 1.750
146.56
146.34
146.17
141.32
136.47
106.13
100.95
96.47
96.07
50.62
50.17
45.68
40.47
10.17
5.32
SCALE 1.750
Bumble Bees
Group 3
BUMBLE BEES
Description:
Loop Wire with Bracket
Material:
Copper
Size:
C
Sheet Number:
06
Date:
Dec-08-23
Weight:
17.4 g
Manufacturing:
SM
Scale:
1.750
Drawn By:
SM
Units:
mm
Manufacturing:
ECP
Tolerances
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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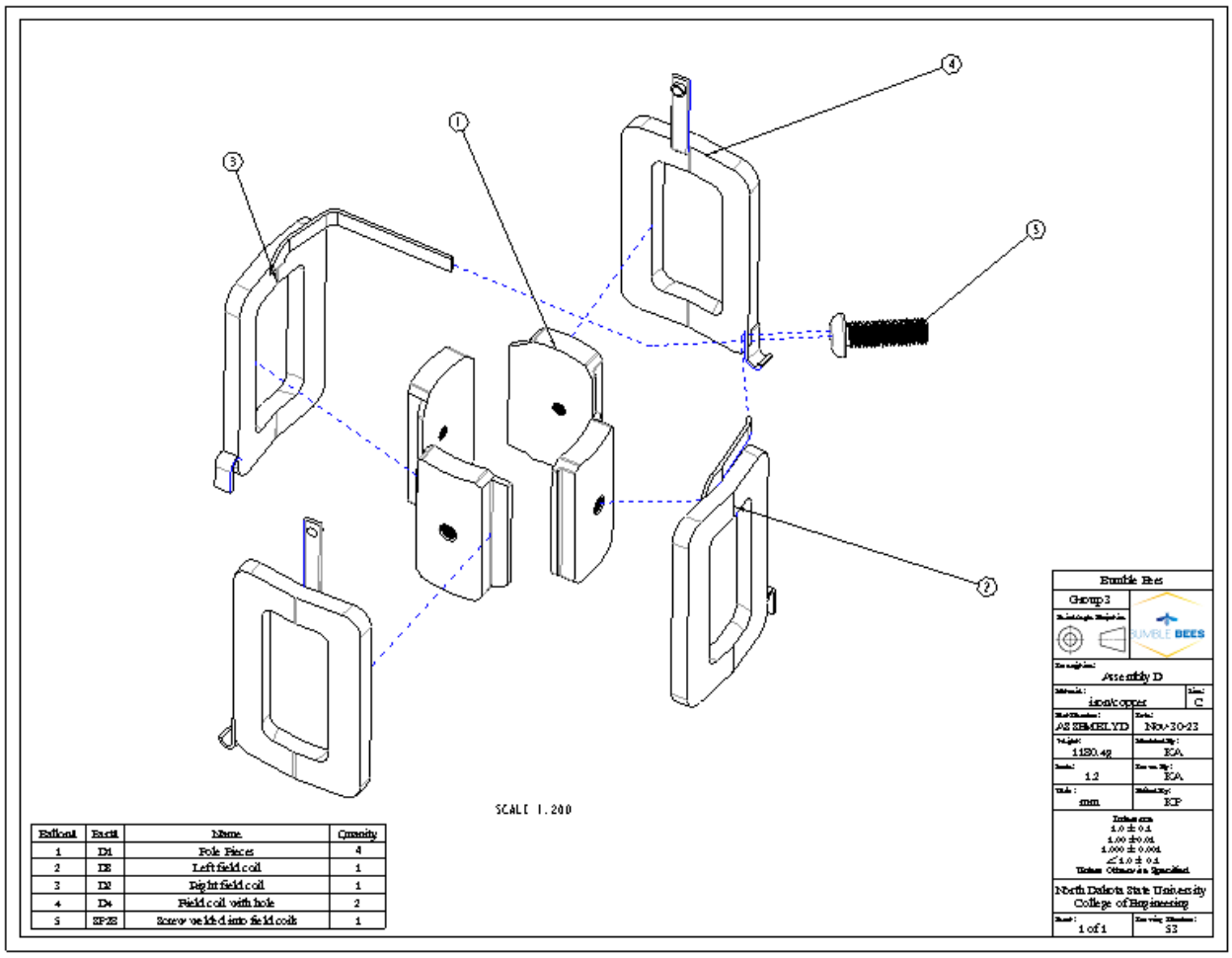
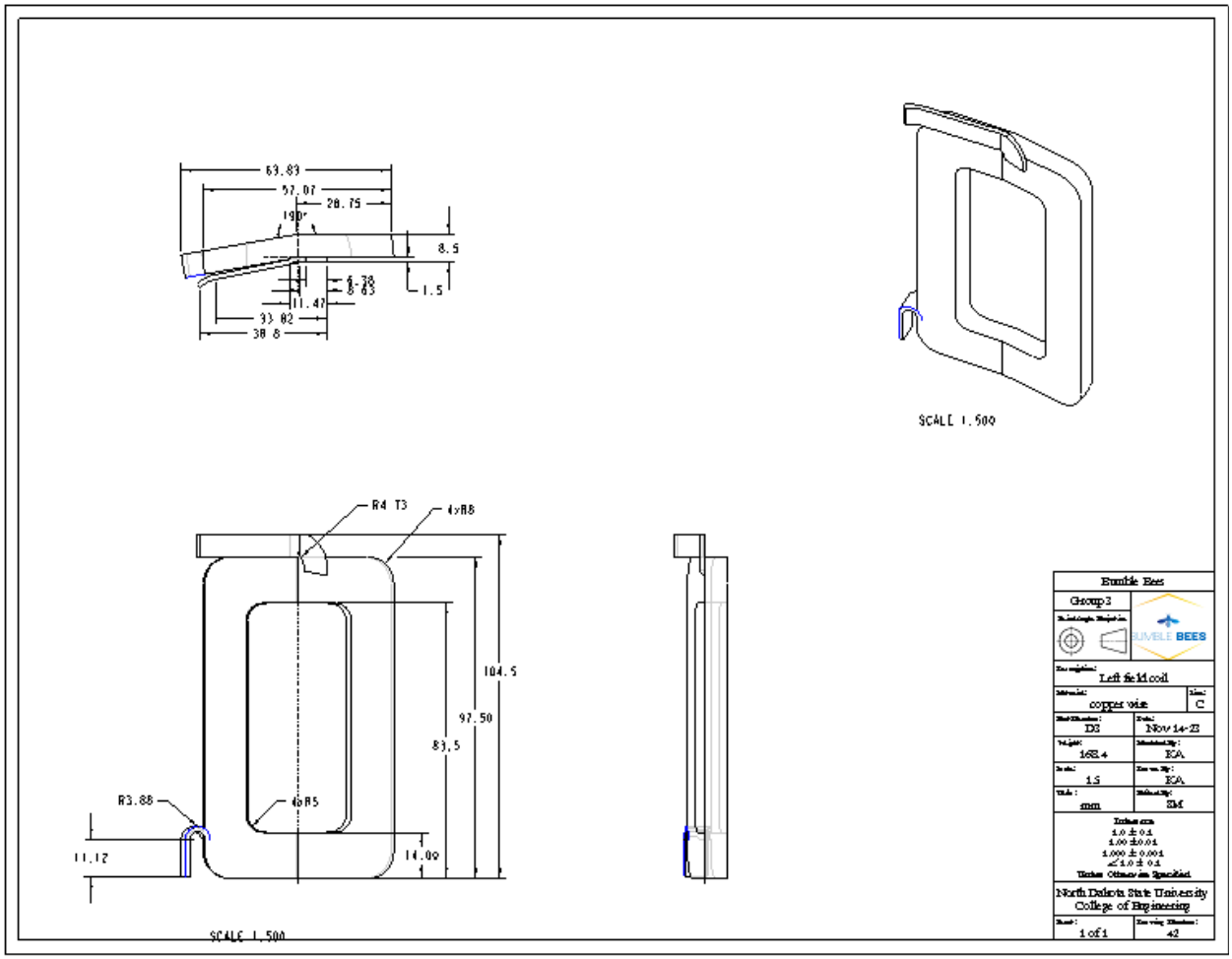
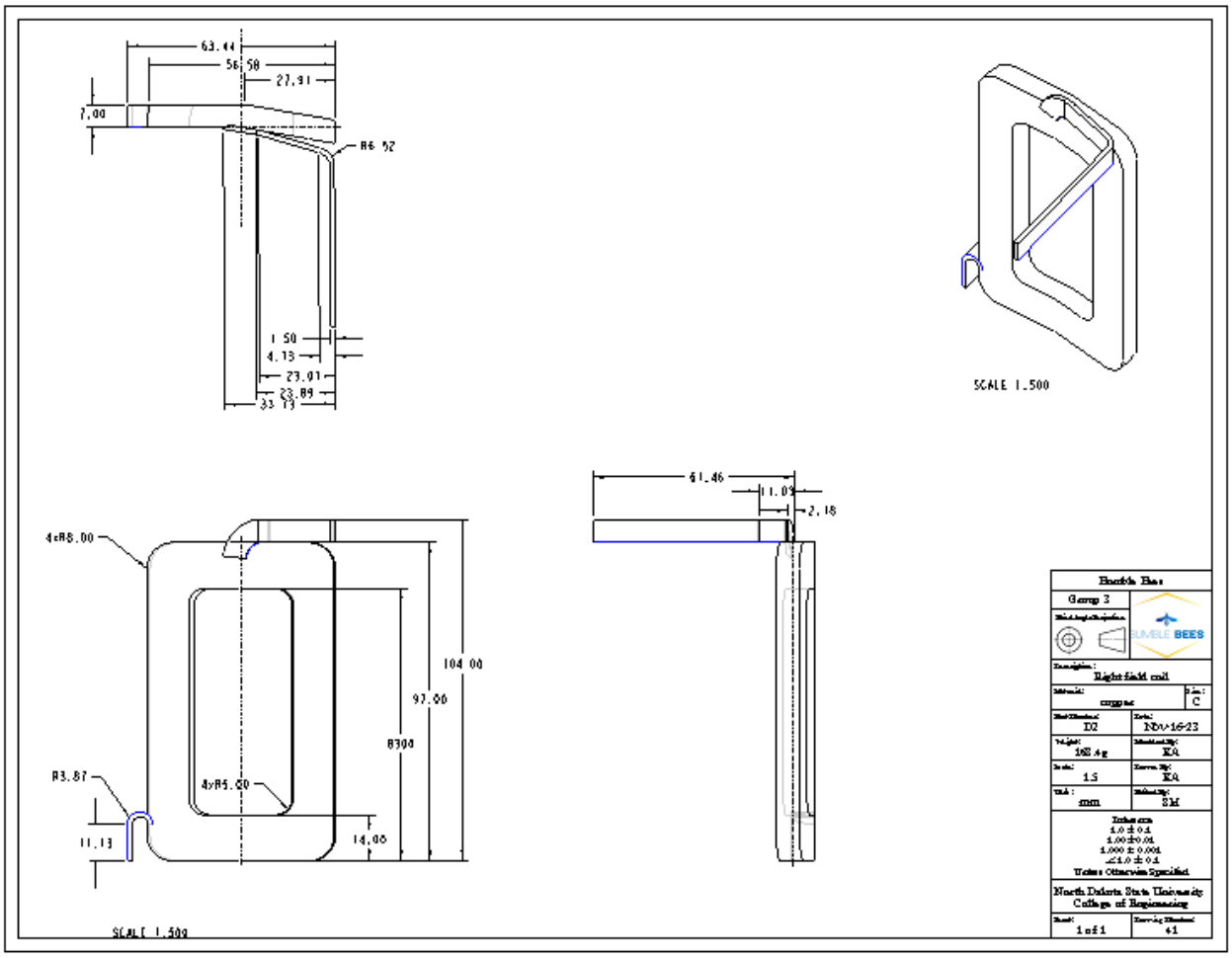
[D] FIELDS SUBASSEMBLY



BalloonI	PartN	Name	Quantity
1	D1	Pole Pieces	4
2	D5	Left field coil	1
3	D3	Right field coil	1
4	D4	Field coil with hole	2
5	SP25	Screw welded into field coils	1

[D] ASSEMBLY DRAWINGS




63.44
56.50
27.91
7.00
R6.52
1.50
4.13
23.91
23.89
33.73
SCALE 1.500
61.46
11.03
2.18
4xR8.00
104.00
97.00
83.00
R3.87
4xR5.00
11.13
14.06
SCALE 1.500
Electric Bee
Group 3
Right field unit
C
D2
NOV-16-23
163.4 g
EA
1.5
EA
mm
SW
Unless Otherwise Specified
North Dakota State University
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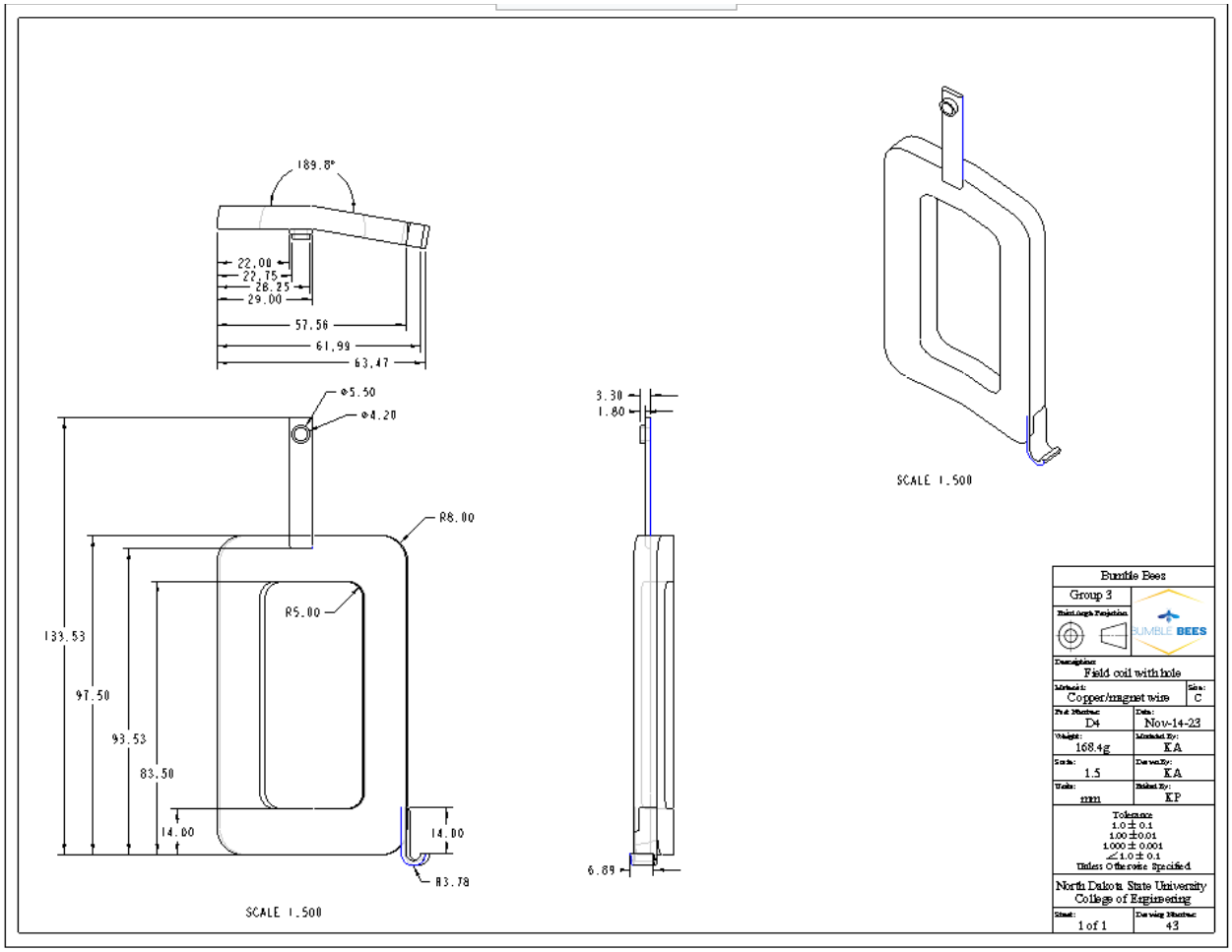
189.8°
22.00
22.75
28.25
29.00
57.58
61.99
63.47
Φ5.50
Φ4.20
R8.00
R5.00
133.53
97.50
93.53
83.50
14.00
14.00
R3.78
SCALE 1.500
3.30
1.80
6.89
SCALE 1.500
Bumble Bees
Group 3
Field coil with hole
Copper/magnet wire
C
D4
Nov-14-23
168.4g
KA
1.5
KA
KP
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠ 1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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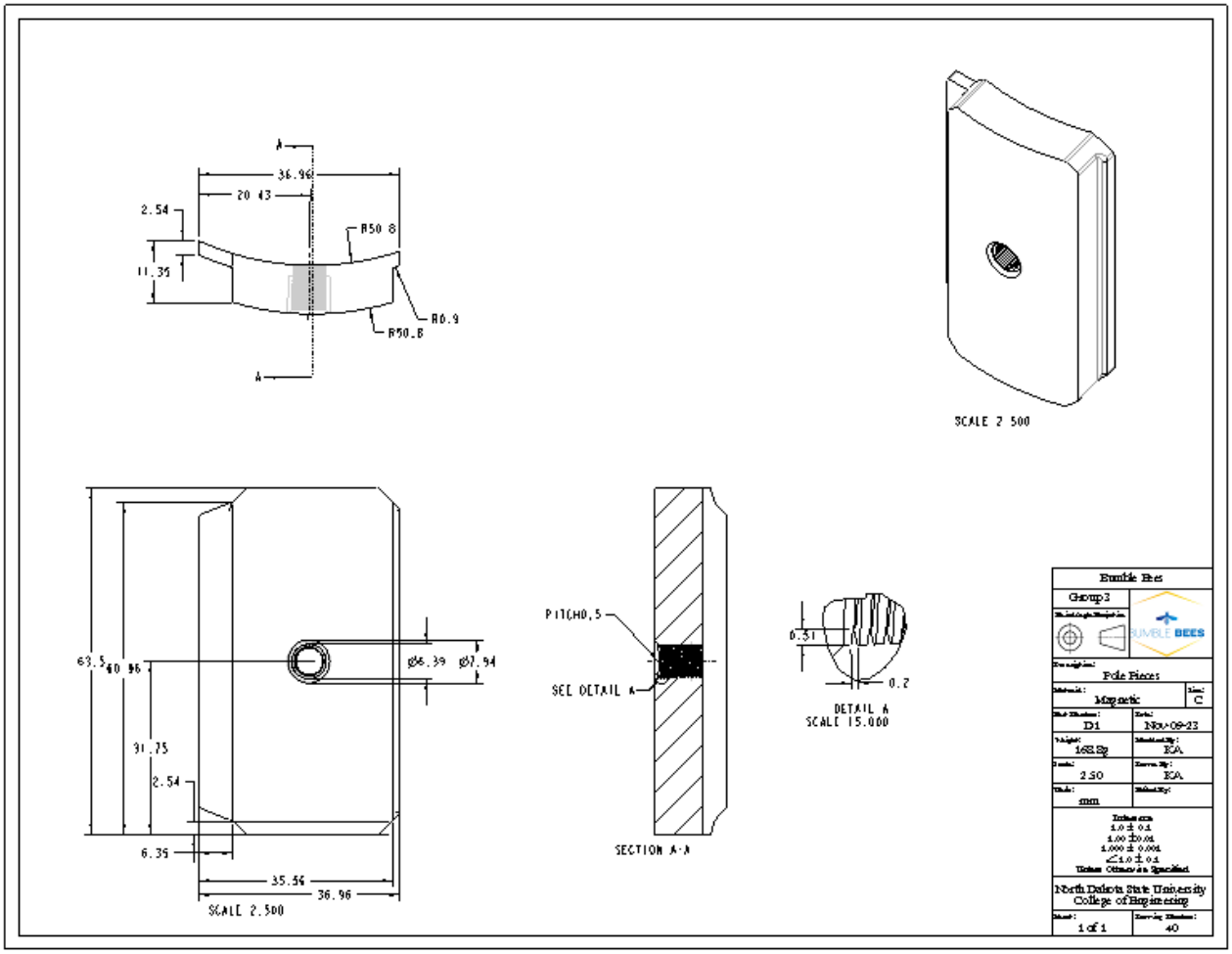
A
36.96
20.43
2.54
11.35
R50.8
R0.9
R50.8
A
SCALE 2.500
63.5
60.96
31.75
2.54
6.35
35.56
36.96
ø6.39
ø7.94
SCALE 2.500
PITCH0.5
SEE DETAIL A
SECTION A-A
0.31
0.2
DETAIL A
SCALE 15.000
Bumble Bee
Group 3
BUMBLE BEES
Pole Pieces
Magnetic
C
D1
DWG-09-23
168.8g
EA
2.50
EA
mm
Tolerances
1.0 ± 0.1
1.00 ± 0.01
1.000 ± 0.001
≤ 1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
College of Engineering
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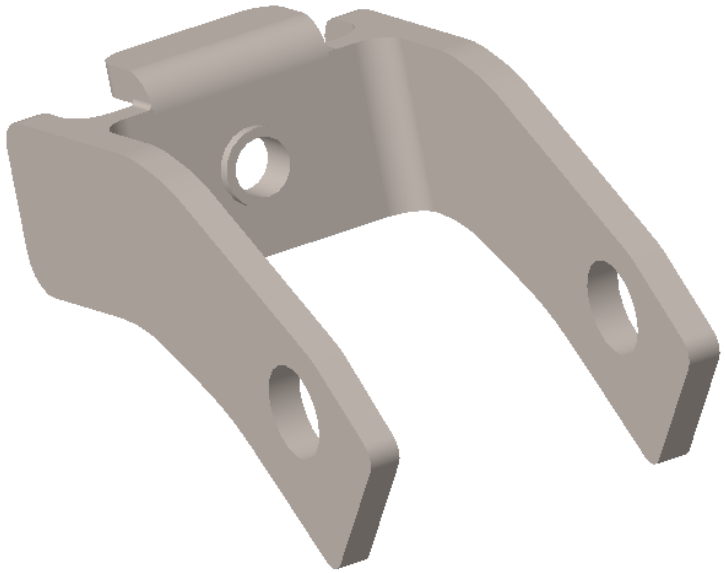
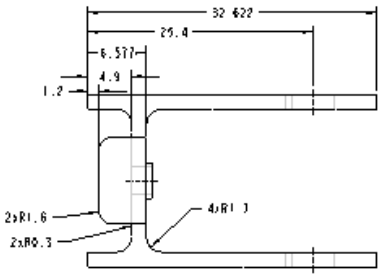
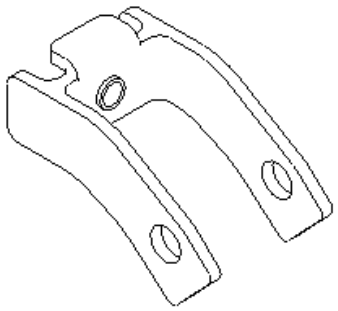
MODIFICATION & DESIGN CHANGE

[I] BRUSH HOLDER

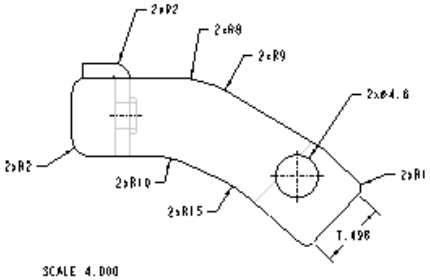
I picked the brush holder to be the part that I modified. I chose this part because I thought a few simple modifications would improve the stability of the part. The first modification that I added was two extra plates on the front of the brush holder. The point of this is to keep the brush in a more stable position and to keep it from moving. The second modification I made was taking both sides of the brush holder and extending them and making them squared off instead of rounded. I did this because there is a spring that sits in between the two sides. With the ends of the holder being rounded, some of the springs will stick out. Now that they are squared off, the spring will fit more comfortably inside of the brush holder. It also will help protect the spring.



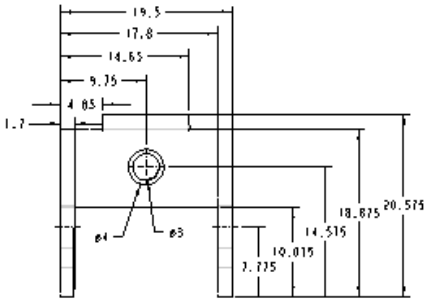




SCALE 4.000



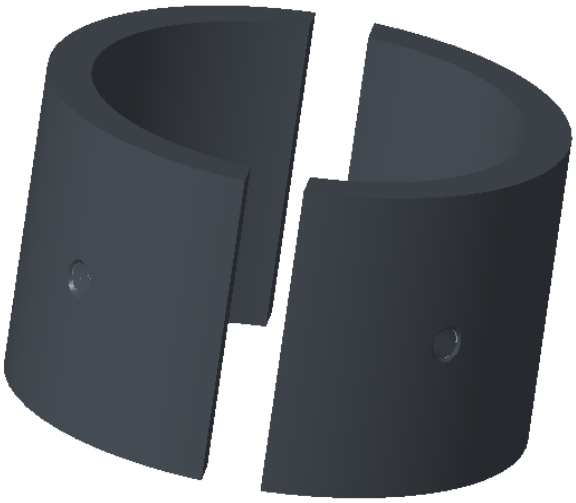
SCALE 4.000

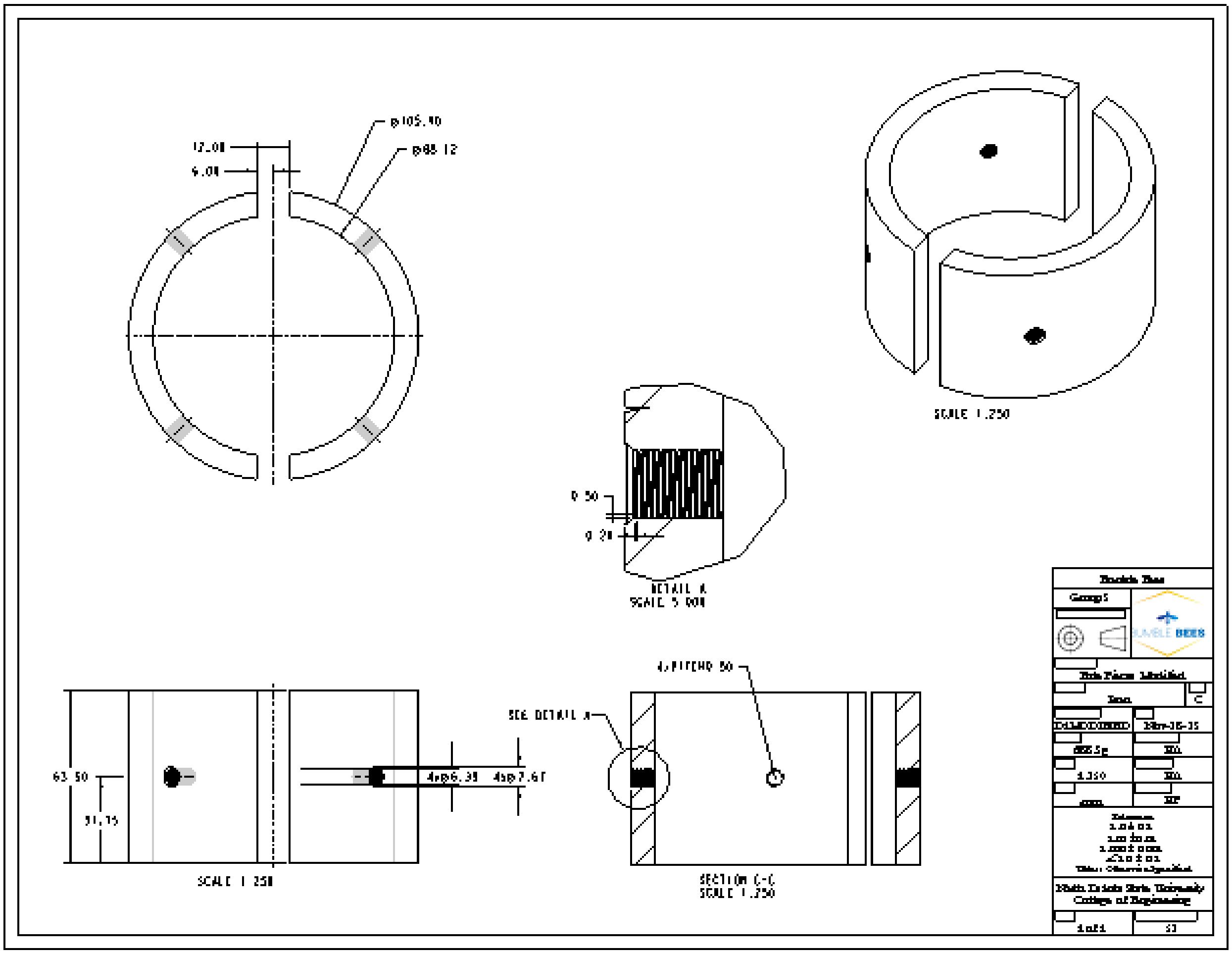


Bumble Bees	
Group 3	
Description: Bench Holder - Modified	
Material: Copper	Rev.: C
Part Number: C2 Modified	Date: NOV-15-23
Weight: 7.90	Manufacturing: SM
Scale: 4.00	Inspection: SM
Unit: mm	Finishing: EA
Tolerances: 1.0 ± 0.1 1.00 ± 0.01 1.000 ± 0.001 ∠1.0 ± 0.1 Unless Otherwise Specified	
North Dakota State University College of Engineering	
Sheet: 1 of 1	Drawing Number: 02

[II] MAGNETIC FIELDS

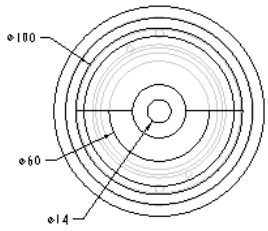
I decided to modify the pole pieces and field coils. I did some research and found that it is more efficient to have a magnet around the entire inside of the drive housing. I decided on this modification because it is a simpler structure, gives higher power, and is more cost-effective. Having a magnet around the whole inside causes the armature to spin faster, increasing the torque. This also reduces the amount of parts inside the starter motor. The start motor would be lighter in weight and easier to move around. I believe that having solid magnets on the inside would create a better and more efficient start for our motor.

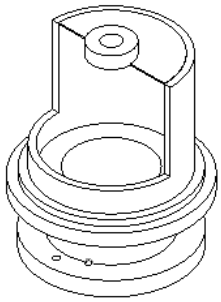


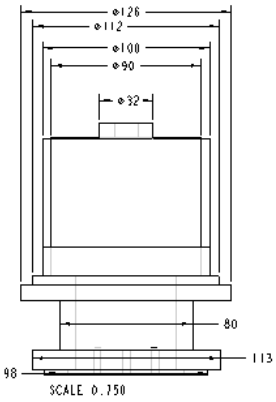

SCALE 1.250
DETAIL A
SCALE 5.000
SEE DETAIL A
SECTION C-C
SCALE 1.250
North Dakota State University
College of Engineering

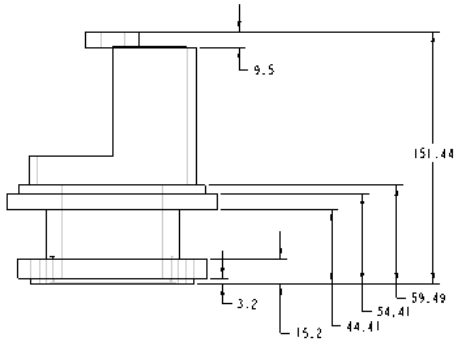
[III] DRIVE HOUSING

I altered the design of the drive housing, and after thorough research, I have determined that a simplified, cylindrical shape would offer significant manufacturing advantages. This modification reduces the intricacy of the component, making it more straightforward to produce. The cylindrical form facilitates seamless installation and diminishes the number of required screws to maintain structural integrity. By opting for this streamlined shape, the manufacturing process becomes more efficient, while the ease of assembly enhances the overall functionality of the part, making me believe this would be beneficial for our project.









Bumble Bees	
Group 3	
Third Angle Projection	BUMBLE BEES
Description: Drive Housing	
Material: Steel	Size: C
Part Number: E1M0D	Date: Nov-16-23
Weight:	Checked By: KP
Scale: 0.75	Drawn By: KP
Units: mm	Tested By:

Tolerance
1.0 ± 0.1
1.00 ± 0.01
1.000 ± 0.001
∠ 1.0 ± 0.1
Unless Otherwise Specified

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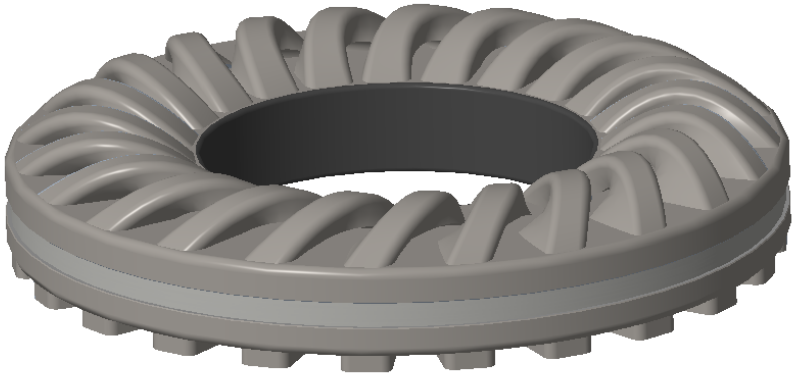
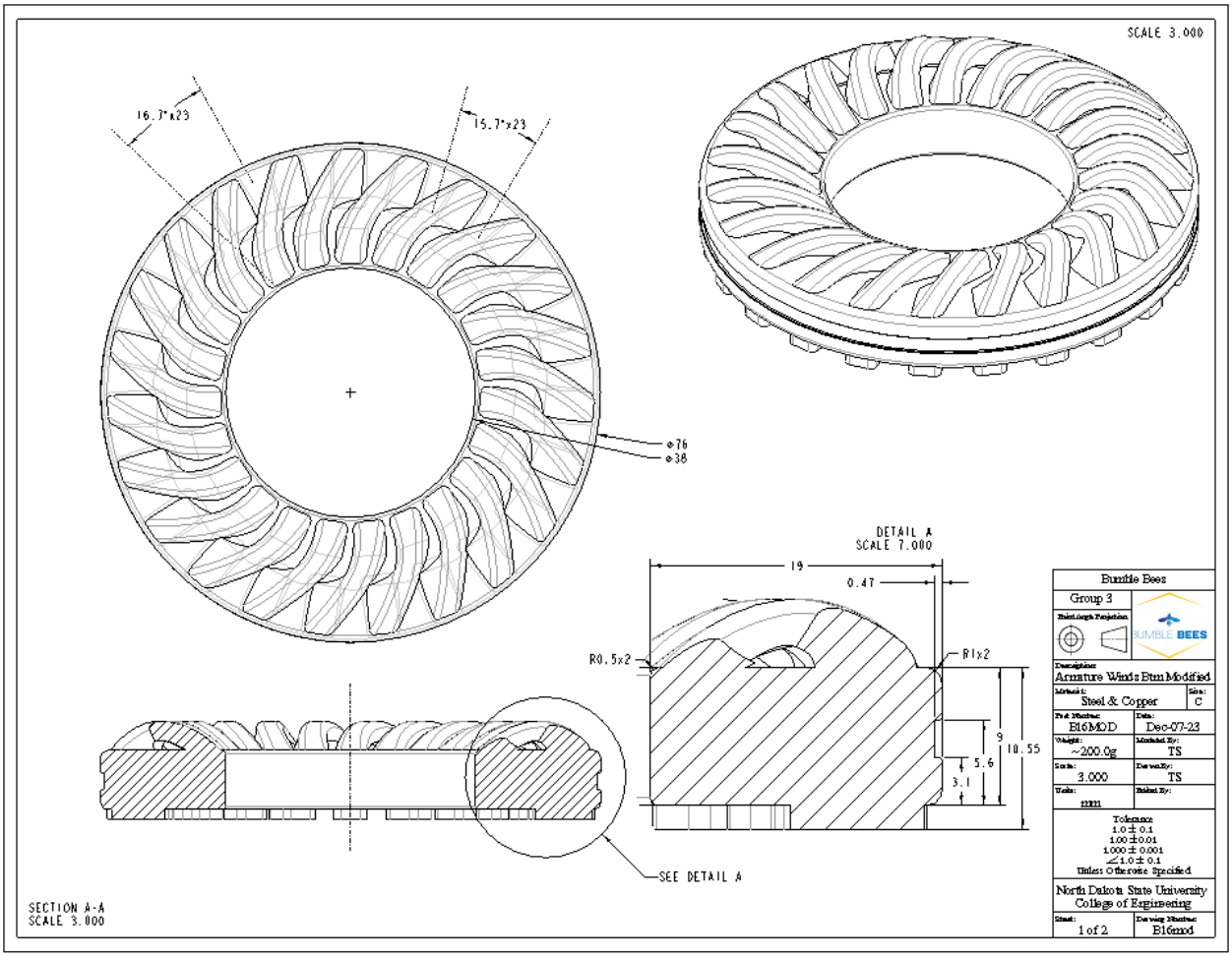
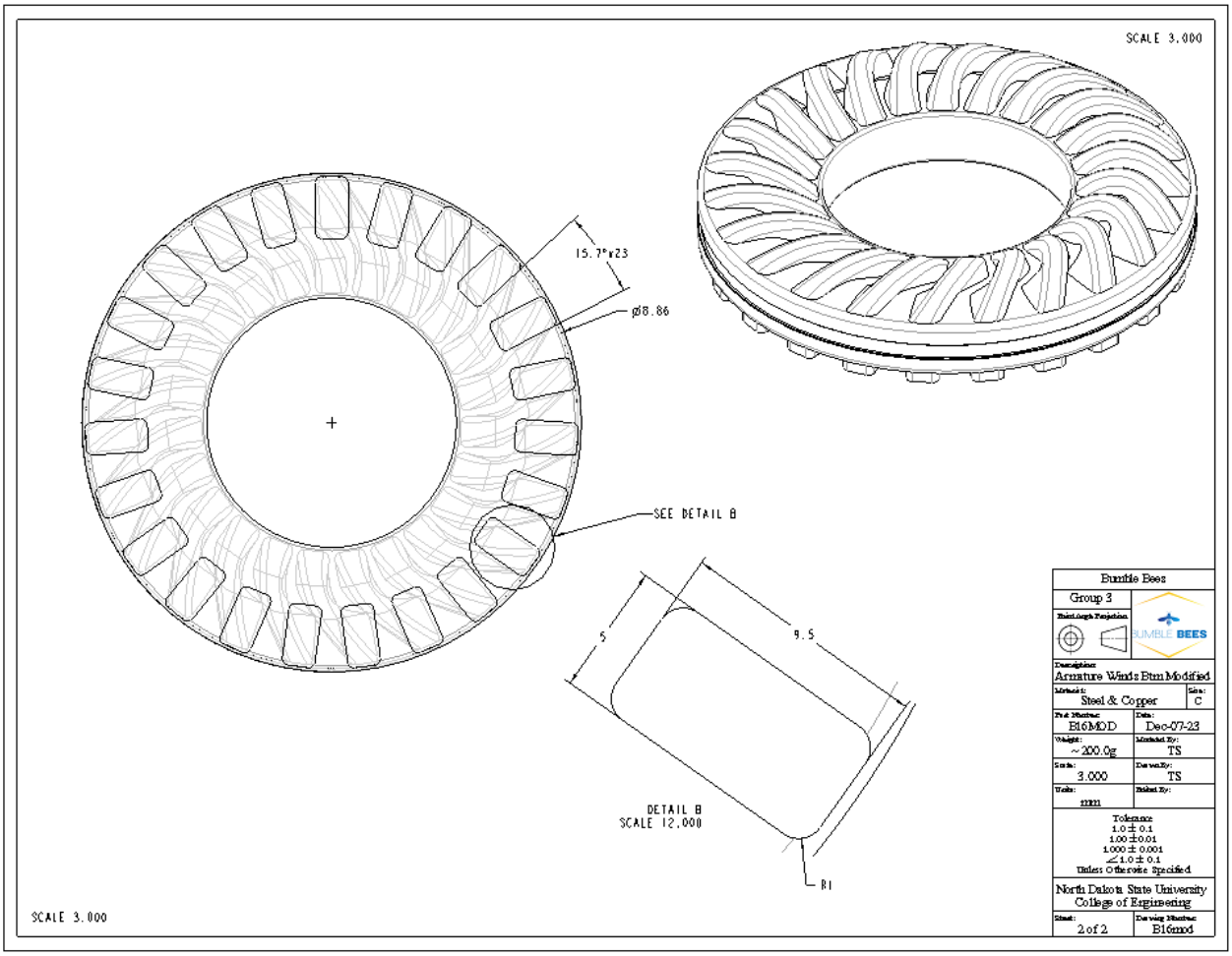
Sheet: 1 of 1	Drawing Number:

[IV] BOTTOM ARMATURE COILS

I altered the winds of the armature coils. In its present configuration, it is difficult to maintain if ever needing maintenance and may be subject to unwanted forces when manufacturing. Upon inspection, it became apparent that the winds were made straight then bent at a later point to create the winds. This modification would add a large solid bar between the winds to reduce the stress at the points of shear during the manufacturing of the winds and would reduce the need for insulation at the top of the commutator. This also simplifies the part by reducing the extra “twist” the winds need during manufacturing while reducing the chances of the material to break.

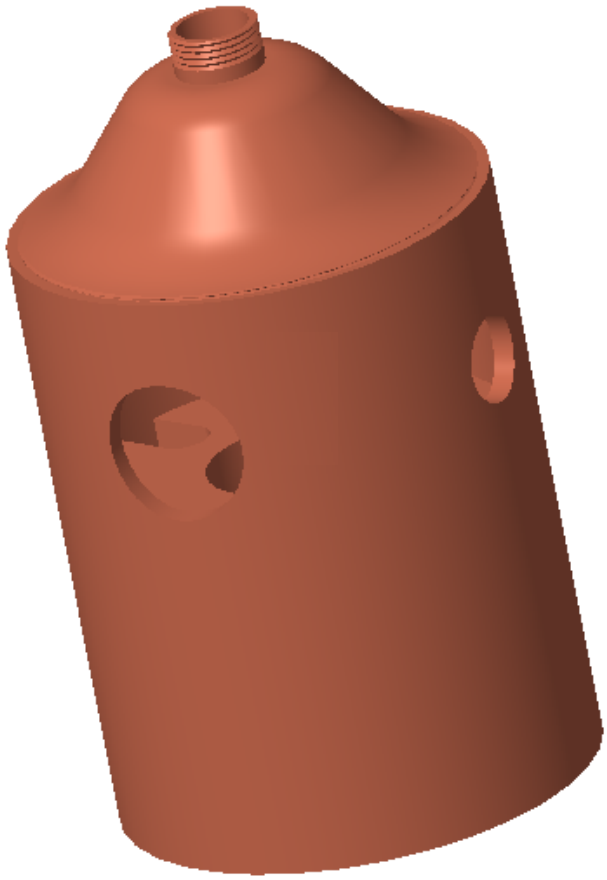


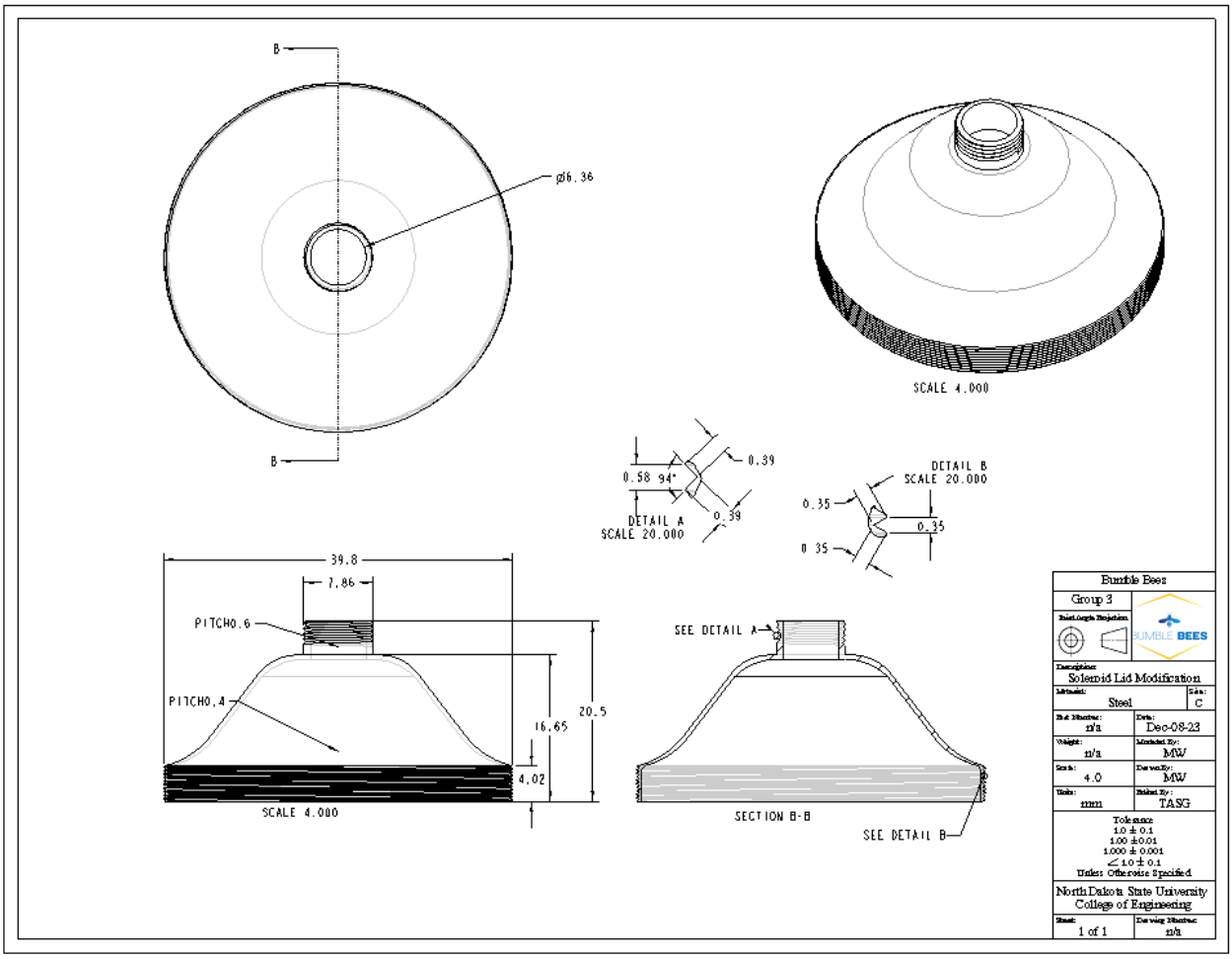

SCALE 3.000
16.7°x23
15.7°x23
ø76
ø38
DETAIL A
SCALE 7.000
19
0.47
R0.5x2
R1x2
9
10.55
5.6
3.1
SEE DETAIL A
SECTION A-A
SCALE 3.000
Bumble Bees
Group 3
Description:
Armature Winds Rtm Modified
Material:
Steel & Copper
Size:
C
Part Number:
B16MOD
Date:
Dec-07-23
Weight:
~200.0g
Modified By:
TS
Scale:
3.000
Drawn By:
TS
Units:
mm
Tolerance
1.0 ± 0.1
1.00 ± 0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
College of Engineering
Sheet:
1 of 2
Drawing Number:
B16mod

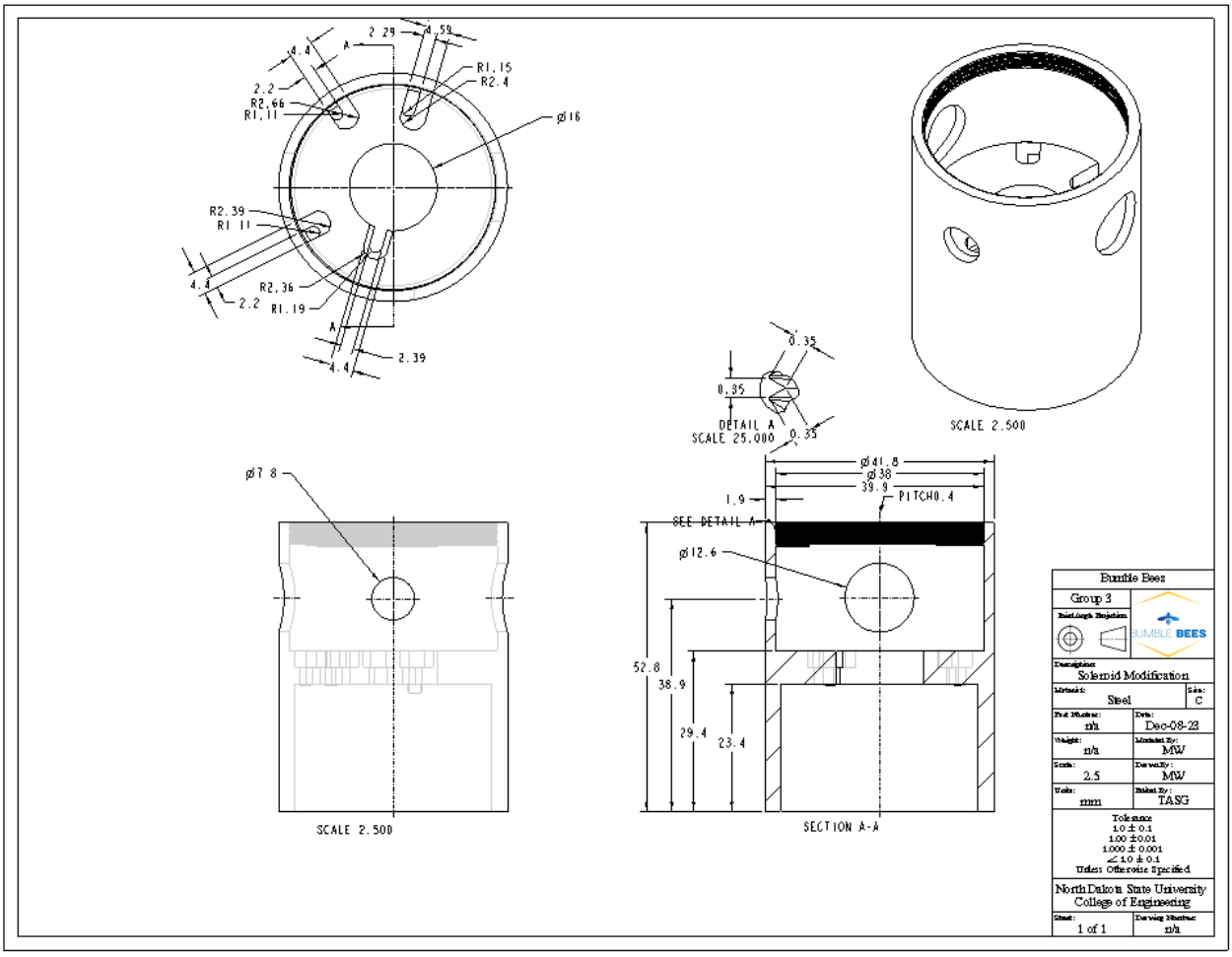

SCALE 3.000
15.7°x23
ø8.86
SEE DETAIL B
5
9.5
R1
DETAIL B
SCALE 12.000
SCALE 3.000
Bumble Bees
Group 3
Third Angle Projection
Description:
Armature Winds Btm Modified
Material:
Steel & Copper
Size:
C
Part Number:
B16MOD
Date:
Dec-07-23
Weight:
~200.0g
Checked By:
TS
Scale:
3.000
Drawn By:
TS
Units:
mm
Tolerance
1.0 ± 0.1
1.00 ± 0.01
1.000 ± 0.001
∠ 1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
College of Engineering
Sheet:
2 of 2
Drawing Number:
B16mod

[V] SOLENOID

One of the first main issues our group ran into was the disassembly of the solenoid. The cap was press-fit into the main body of the solenoid with excess steel being bent over the top edge to hold it in place. In order to get access to the inside of the part, we had to cut it open. This modification is making the disassembly and access to the inside of the solenoid much easier. I have decided to extend the bottom of the cap 4 millimeters straight down in order to put threads on that wall, and on the wall of the solenoid body. With access to the inside of the solenoid now being held together by threads, maintenance and disassembly will be much easier.

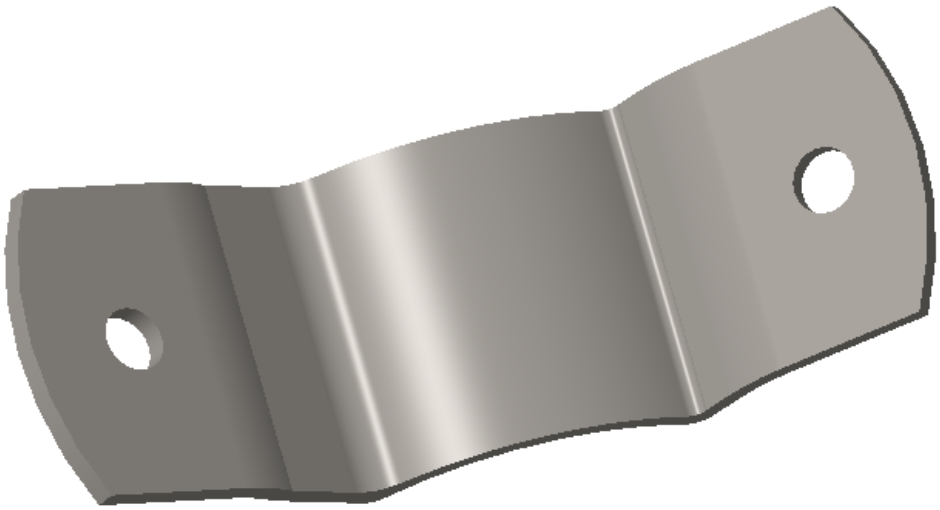


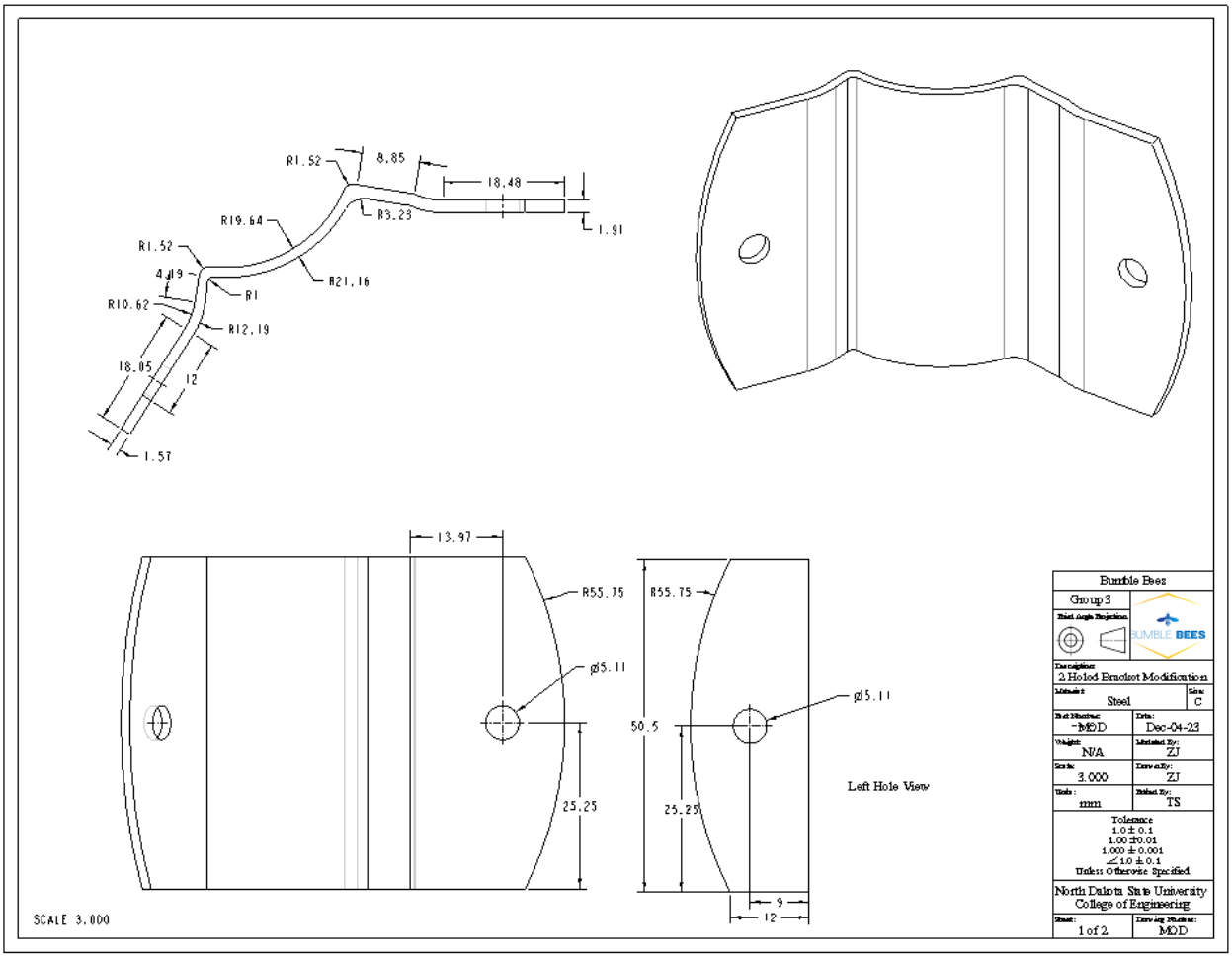

B
ø6.36
B
SCALE 4.000
0.39
0.58 94°
DETAIL A
SCALE 20.000
0.39
DETAIL B
SCALE 20.000
0.35
0.35
0.35
39.8
7.86
PITCH0.6
PITCH0.4
16.65
20.5
4.02
SCALE 4.000
SEE DETAIL A
SECTION B-B
SEE DETAIL B
Bumble Bees
Group 3
Description:
Solenoid Lid Modification
Material:
Steel
Size:
C
Dwg Number:
n/a
Date:
Dec-08-23
Weight:
n/a
Modeled By:
MW
Scale:
4.0
Drawn By:
MW
Units:
mm
Tested By:
TASG
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠ 1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
College of Engineering
Sheet:
1 of 1
Drawing Number:
n/a


2.29
4.59
4.4
A
R1.15
R2.4
2.2
R2.66
R1.11
ø16
R2.39
R1.11
4.4
2.2
R2.36
R1.19
A
2.39
4.4
SCALE 2.500
0.35
0.35
DETAIL A
SCALE 25.000
0.35
ø7.8
SCALE 2.500
ø41.8
ø38
39.8
1.9
PITCH0.4
SEE DETAIL A
ø12.6
52.8
38.9
29.4
23.4
SECTION A-A
Bumble Bees
Group 3
BUMBLE BEES
Description:
Solenoid Modification
Material:
Steel
Size:
C
Part Number:
n/a
Date:
Dec-08-23
Weight:
n/a
Modified By:
MW
Scale:
2.5
Drawn By:
MW
Units:
mm
Tested By:
TASG
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠ 1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
College of Engineering
Sheet:
1 of 1
Drawing Number:
n/a

[VI] TWO HOLED BRACKET

The part that was modified was part A9, the 2 holed bracket. This part was chosen to be modified because of the difficulties it caused to disassemble the solenoid. The current design of the 2 holed bracket blocks access to another bolt that is required to remove the solenoid from the rest of the starter. In order to remove these bolts our group had to use excessive force and a vice grip. This method seemed unnecessary and tedious to remove a bolt. Modifying the 2 holed bracket will make the entire solenoid easier to remove from the rest of the starter. The new design of the 2 holed bracket will include making the bracket larger and changing the placement of the bracket down. This will fix the issue of blocking access to other bolts, therefore making it easier to disassemble the solenoid.




R1.52
8.85
18.48
R19.64
R3.23
1.91
R1.52
4.19
R1
R21.16
R10.62
R12.19
18.05
12
1.57
13.97
R55.75
ø5.11
25.25
R55.75
ø5.11
50.5
25.25
9
12
Left Hole View
SCALE 3.000
Bumble Bees
Group 3
2 Holed Bracket Modification
Steel
C
MOD
Dec-04-23
N/A
ZJ
3.000
ZJ
mm
TS
Tolerance
1.0 ± 0.1
1.00 ±0.01
1.000 ± 0.001
∠1.0 ± 0.1
Unless Otherwise Specified
North Dakota State University
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1 of 2
MOD