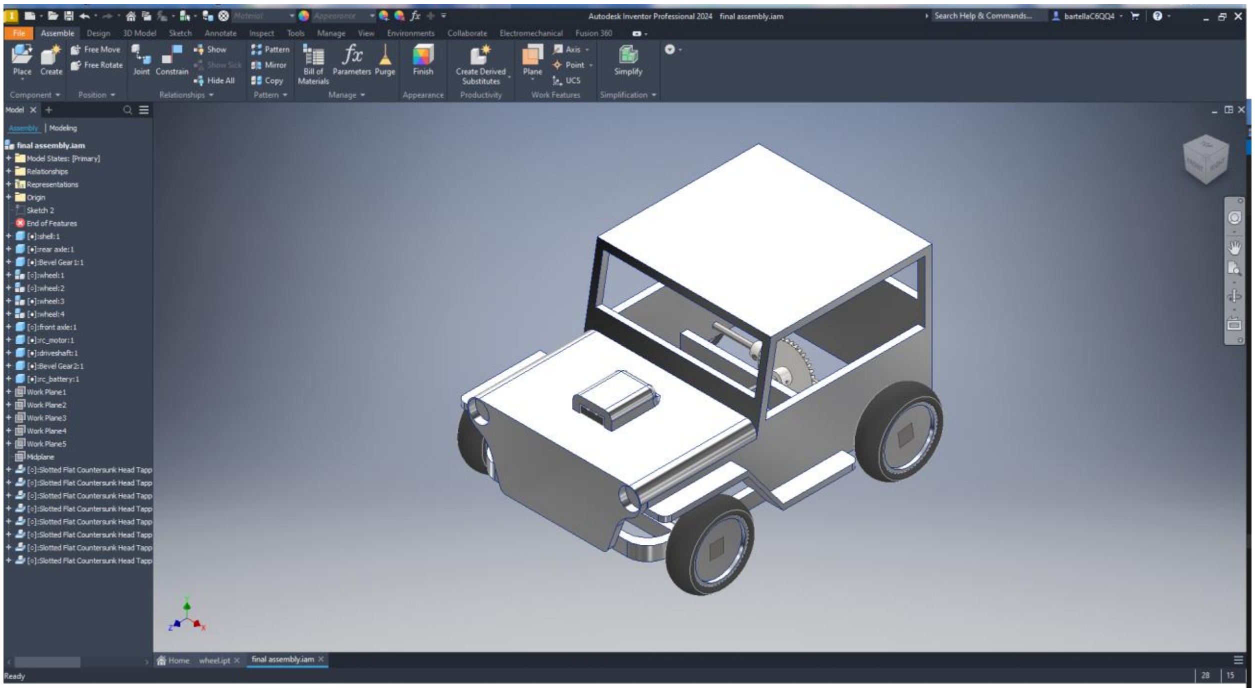
Alex Bartella April 14th, 2024

ME4Z03 final assignment

For my project, I had a motor location of front, a gear ratio of 12:40, and an SUV body shape. For the body shape I wanted to design one like the classic and boxy Willy's Jeep, since it is an iconic and simple design. I tried to go for a traditional front motor rear wheel drive design, as my large gear ratio would make it difficult to allocate space for the gearbox in a front wheel drive & front engine design.



I used solid axels (no suspension) connected directly to the wheels via a square cutout on the wheel. Getting the driveshaft angle right was a challenge, as I didn't want the two axles to interfere, and this made things more complicated in terms of mounting the motor. In retrospect, I could have used a 2-piece driveline to allow for more flexibility of the motor position.

Please note that a README file is included in the submission package, which gives the names of important files in the package.

Simulations

Static Analysis

My first simulation was a **static analysis** on the wheel. I wanted to analyze the effect of the weight of the vehicle on each wheel to identify points of failure and room for improvements. I chose a surface load of 100 N (the weight of the entire RC car, overestimated for good measure) acting downward. Mesh element size was decreased with every iteration of the tests.

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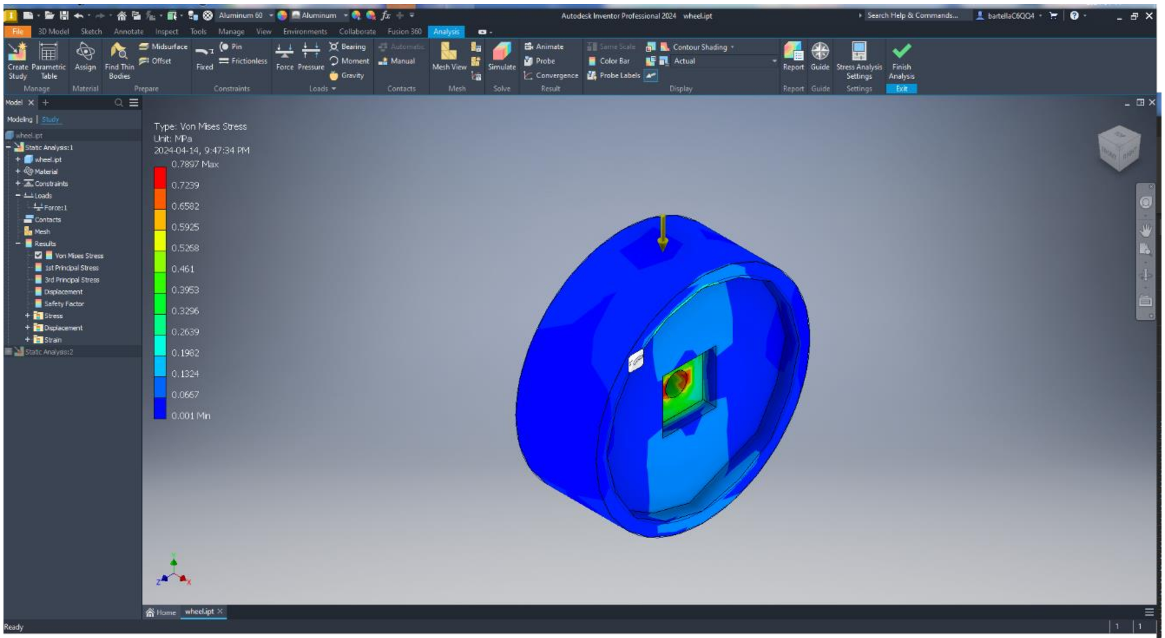
Test 1:



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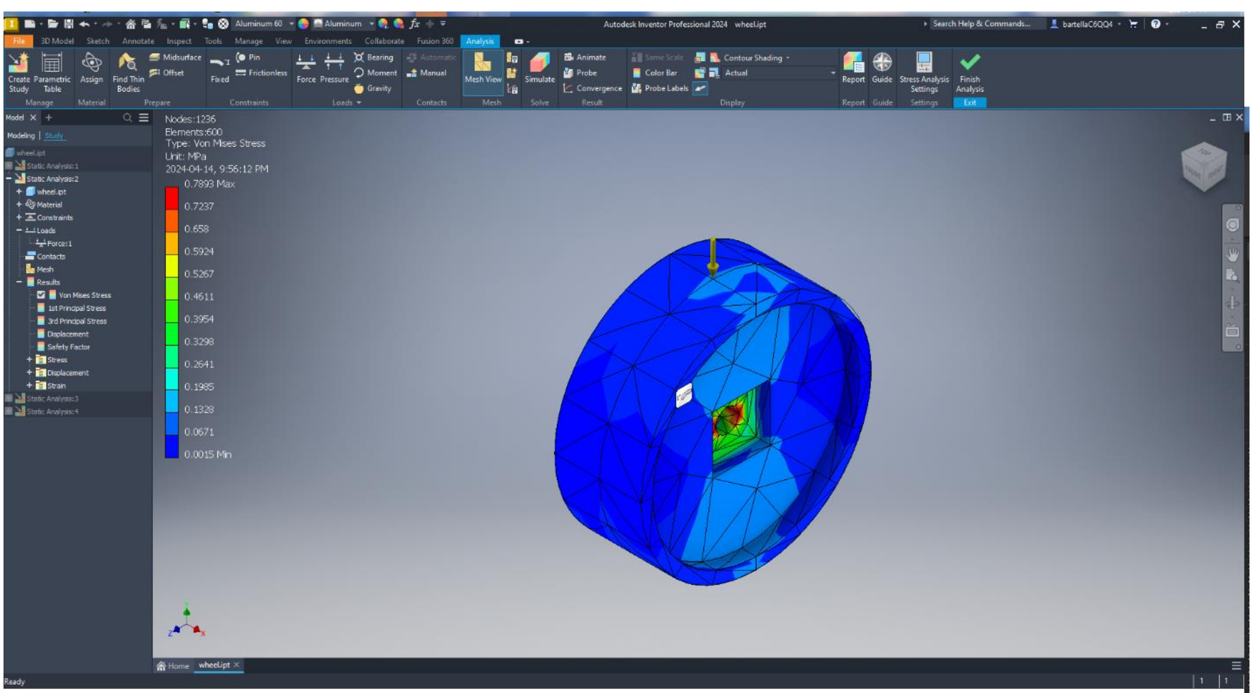

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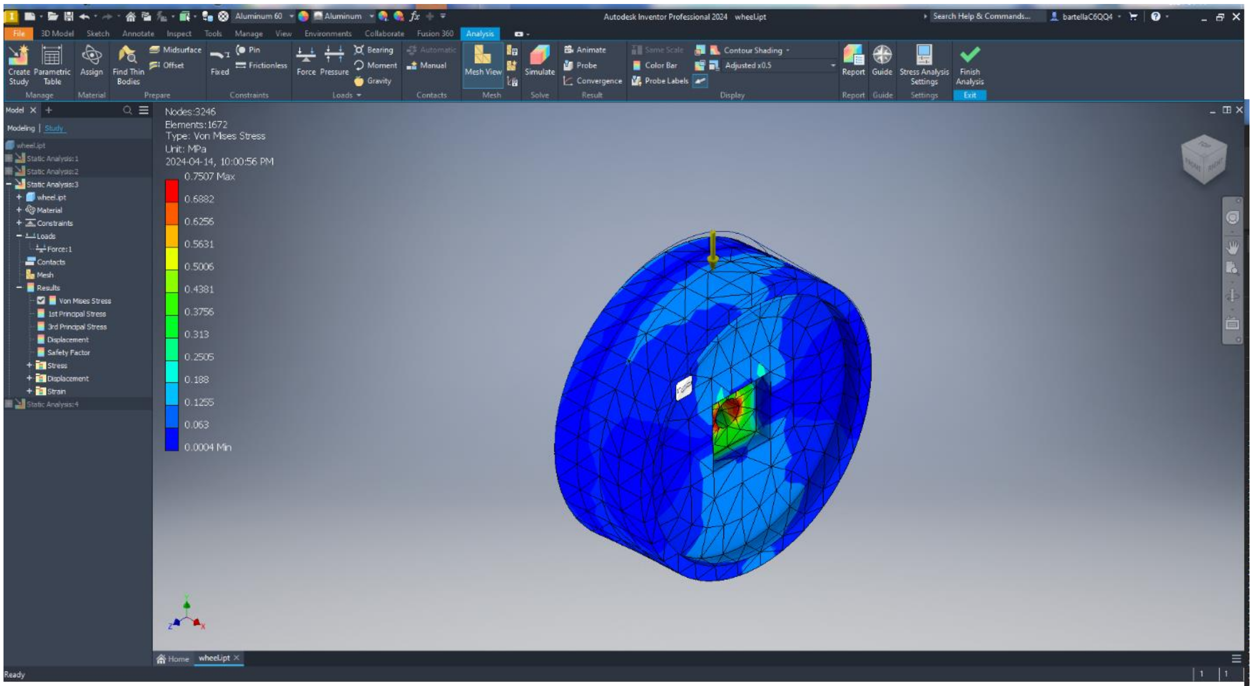
Test 3:



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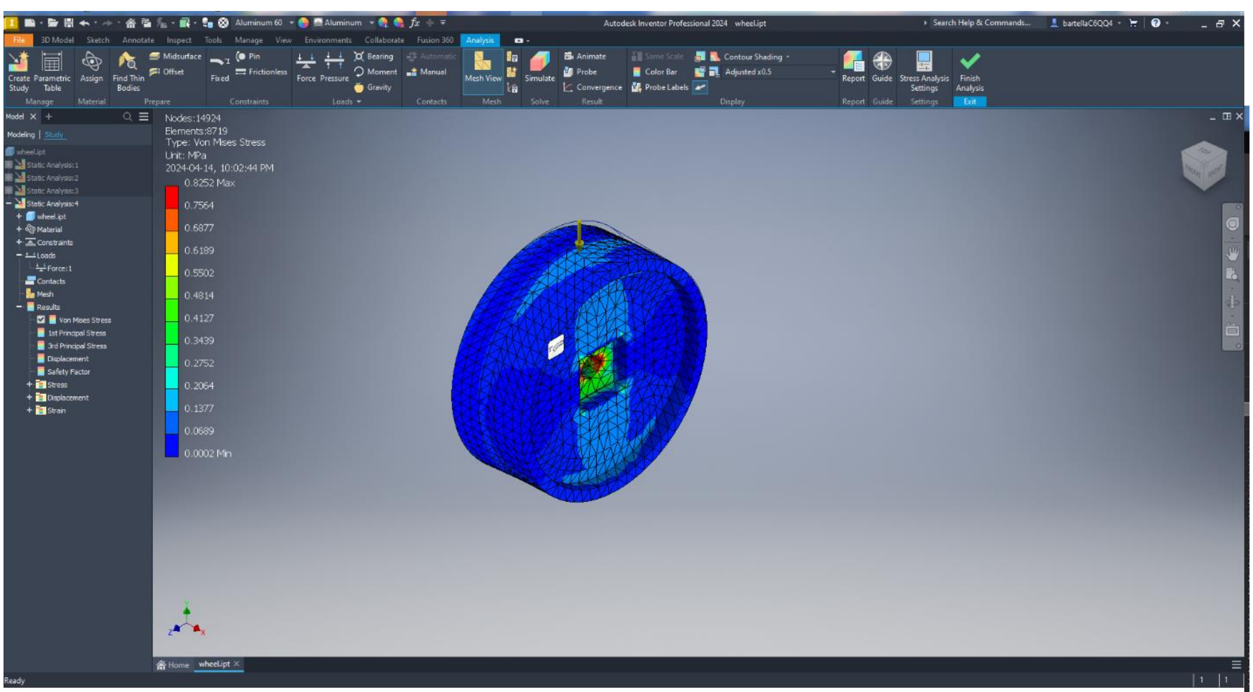

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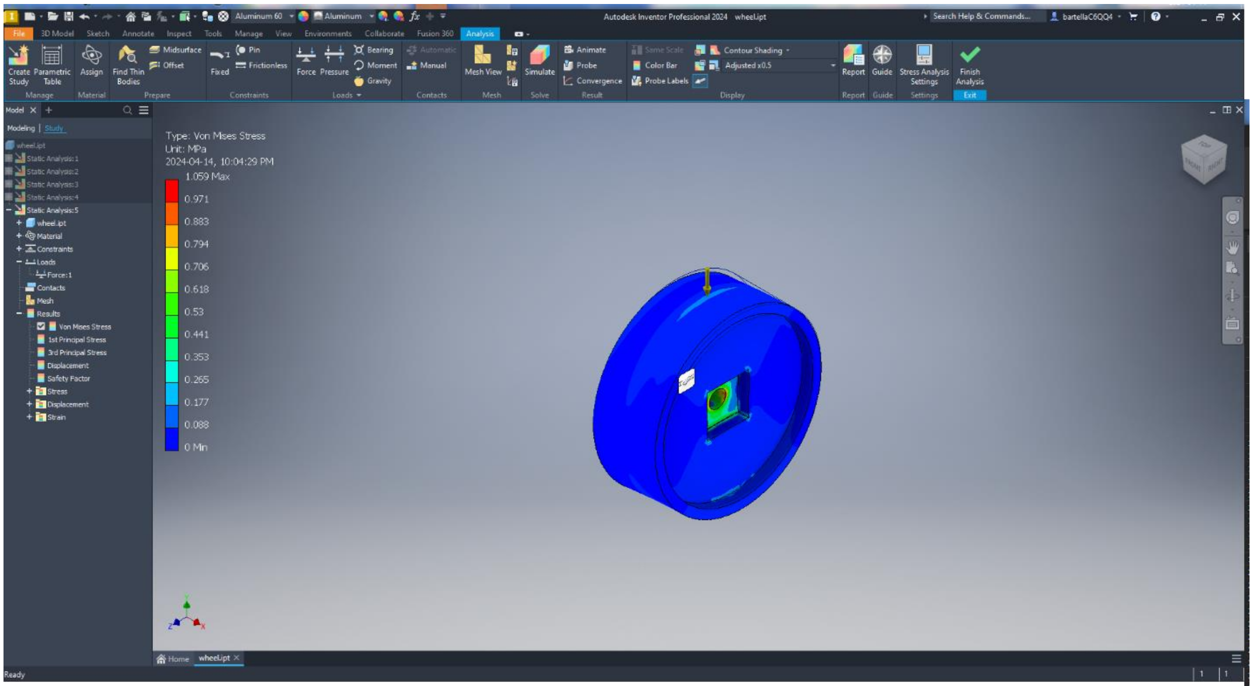
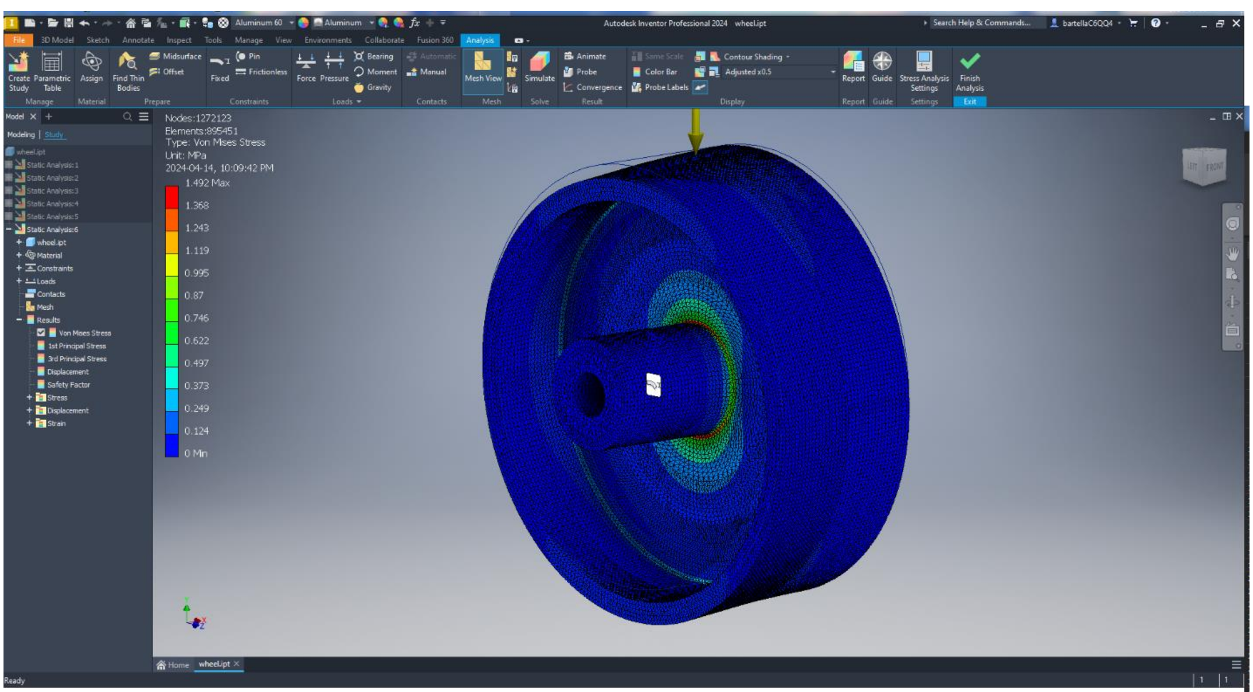
Test 5:

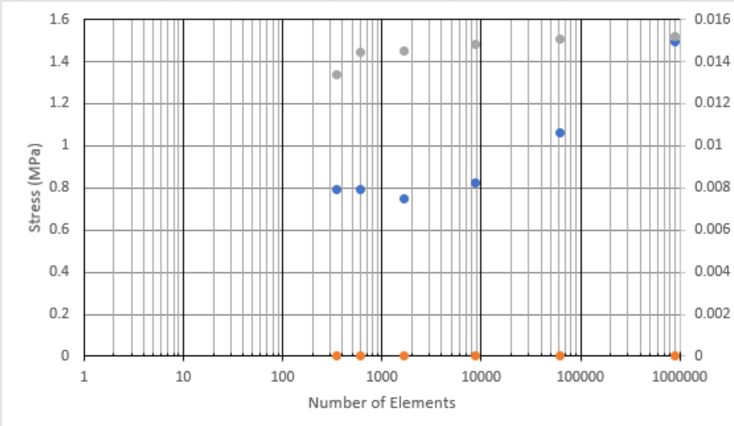


Test 6:



Results:

MATERIAL: ABS PLASTIC										
Test Number	Average Element Size (fraction of bounding box length)	Minimum Element Size (fraction of average size)	Grading Factor	Maximum Turn Angle	Create Curved Mesh Elements	Mesh Size [Elements]	Force kN	Von Mises [Min] MPa	Von Mises [Max] MPa	Deflection [Max] mm
1	0.4	0.2	1.5	60°	Yes	354	0.1	0.001	0.7897	0.01337
2	0.2	0.2	1.5	60°	Yes	600	0.1	0.0015	0.7893	0.01443
3	0.1	0.1	1.5	60°	Yes	1672	0.1	0.004	0.7507	0.01449
4	0.05	0.1	1.5	60°	Yes	8719	0.1	0.0002	0.8252	0.01482
5	0.025	0.1	1.5	60°	Yes	62239	0.1	0	1.059	0.01507
6	0.01	0.1	1.5	60°	Yes	895451	0.1	0	1.492	0.0152



With this I can conclude that there is a significant point of weakness in the wheel: the point where the wheel itself and the component that the axle passes through connect. A fillet would likely alleviate the stress on this area by spreading it more evenly. Additionally, 6 tests were enough to accurately determine the deflection, but a smaller mesh size might be needed for the von mises stress.

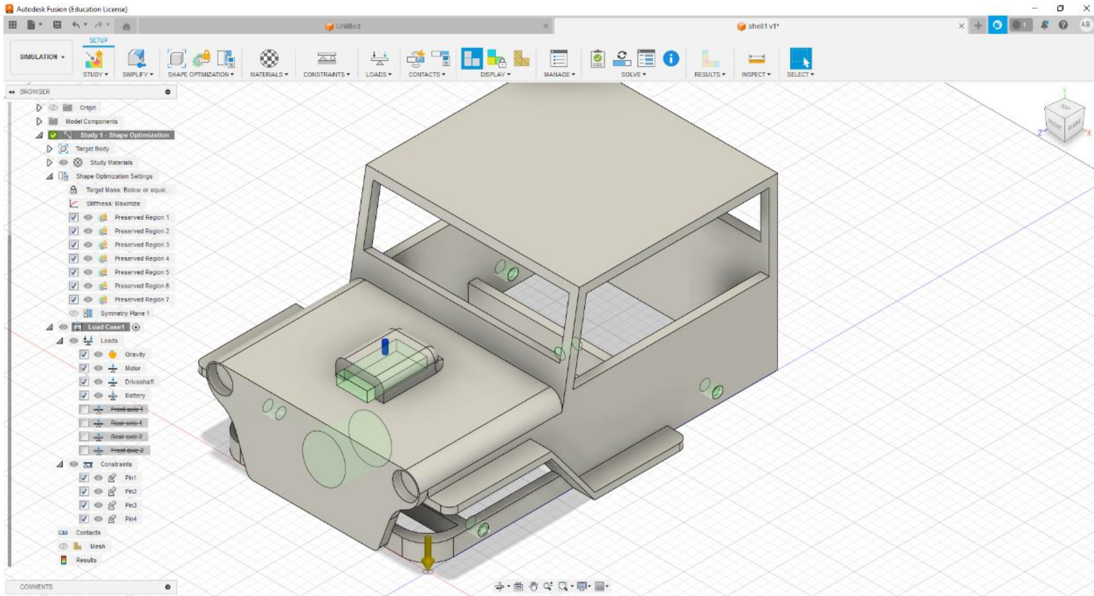
Motion Study

Next, I conducted a **motion study**, where I spun the driveshaft via the "motor" forward and backward 2 complete spins. This ensures the functionality of the drivetrain being as expected, smooth, and without issue. This can be found in the pack and go labeled "motion study bottom view.wmv". I chose to observe the study from the bottom to see the gearbox and drivetrain in action. Please note that I named the driving constraint "driver" to make it more convenient to find it in the tree, if you wish to test the assembly in inventor.

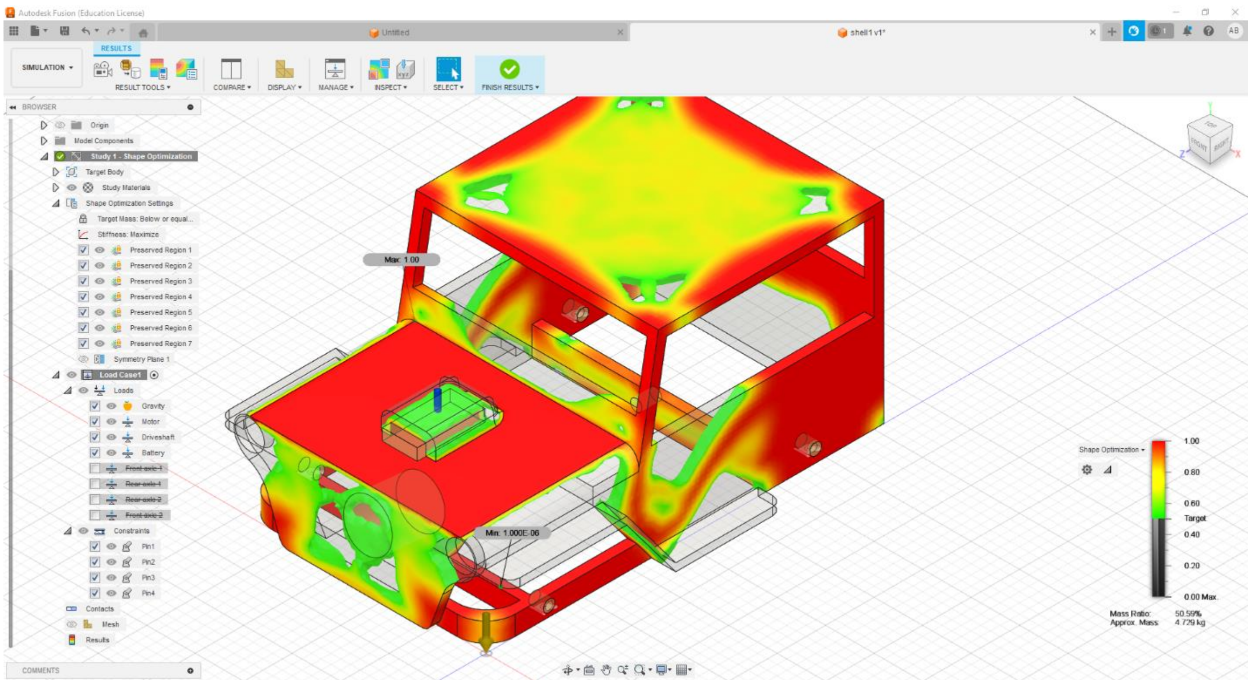
Optimization

I decided to do an optimization simulation on the chassis/shell of the car to determine the minimal amount of material needed to properly support the weight of the chassis itself (gravity) and the motor, driveshaft, axles, and battery resting on the chassis. Finding a minimal chassis is great for weight reduction, which will increase the top speed and acceleration of the RC car.

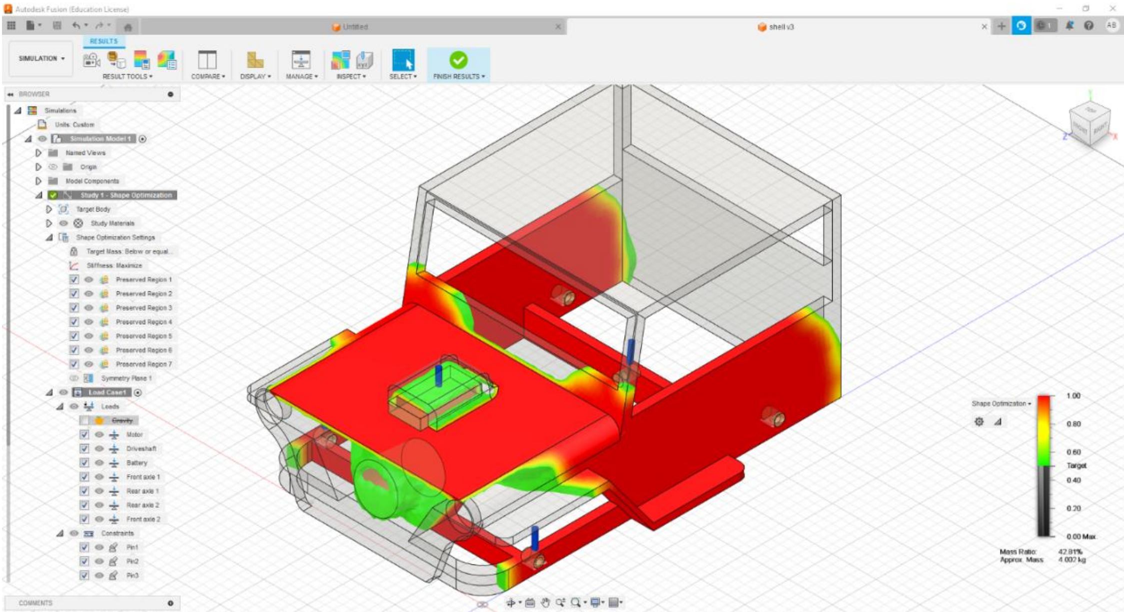
This yielded the following results:



Above shows the regions which were set to preserve shape.



The above is the optimized shape with gravity applied to the shell.

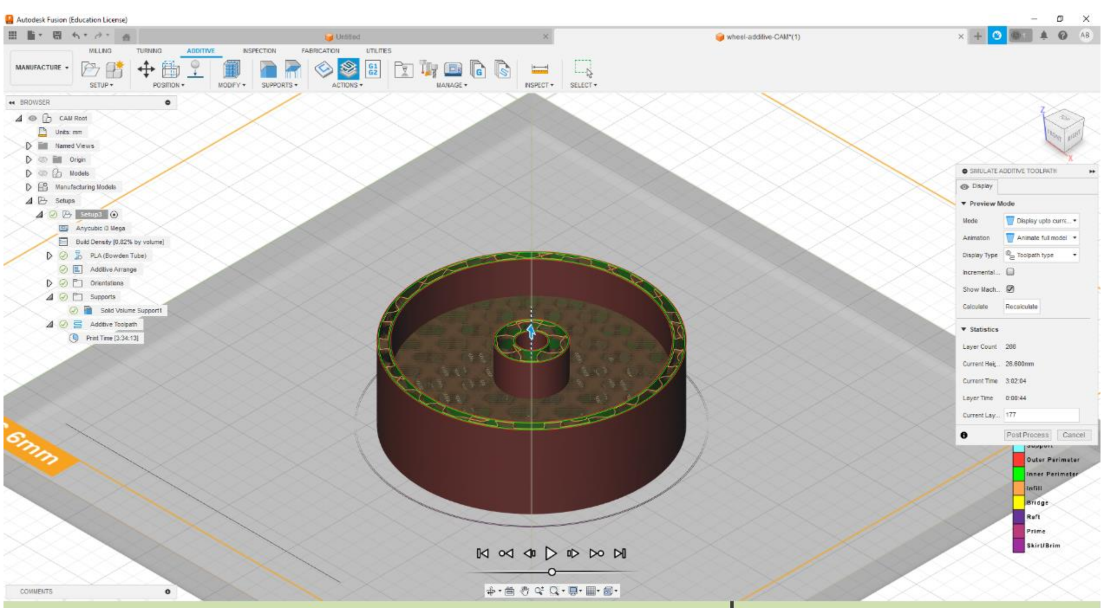


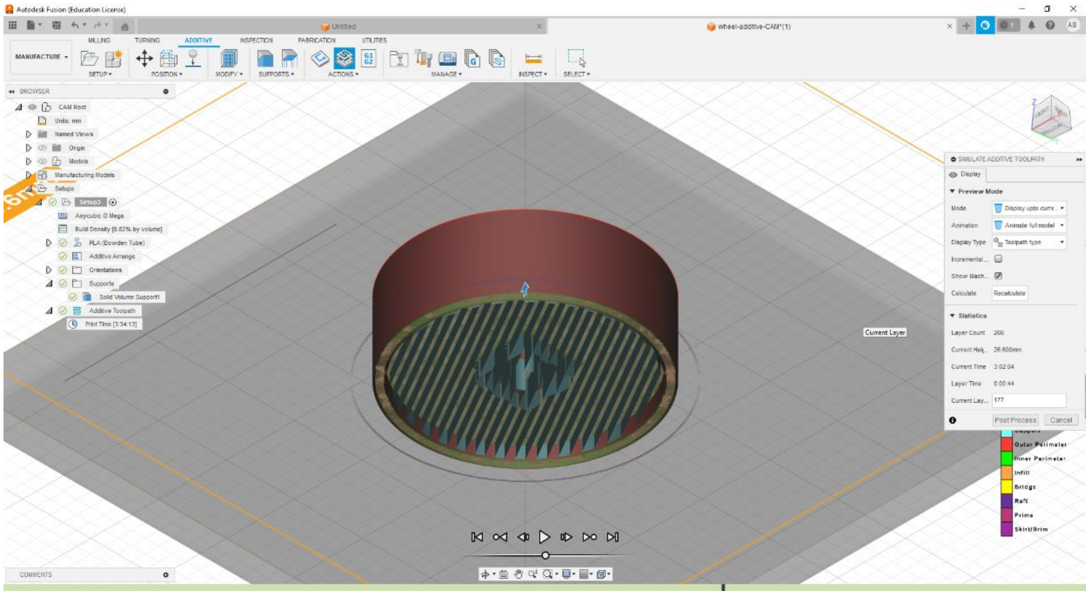
The above is the optimized shape with no gravity applied, but force applied to the axle holes. Interestingly this requires significantly less material.

With this it can be observed that significantly less material is required to retain a stable and robust chassis. This study could allow me to significantly decrease weight and material consumption.

Additive manufacturing

For the manufacturing simulation, I chose to 3D print the wheels. I oriented the wheel face-down with the axle support pointing upwards. I added supports for the inner wheel face as well as the square cutout (which locks in the axle). Printed from PLA with an Anycubic i3 mega, the print time was 3 hours 34 minutes and 13 seconds.

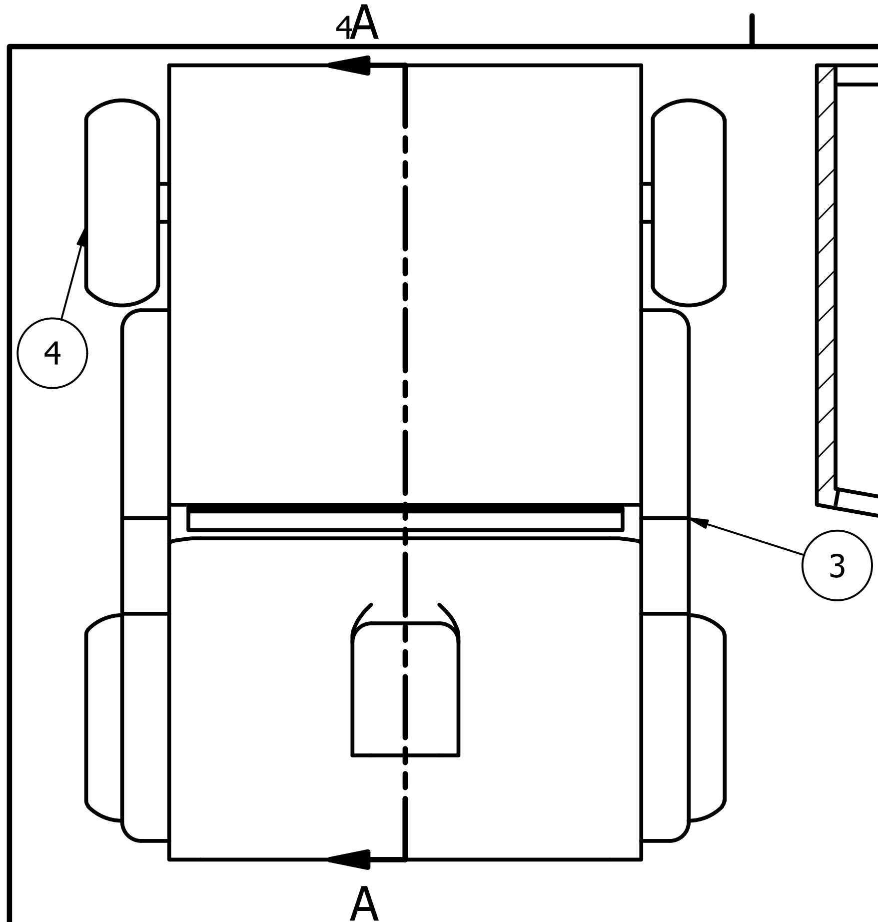


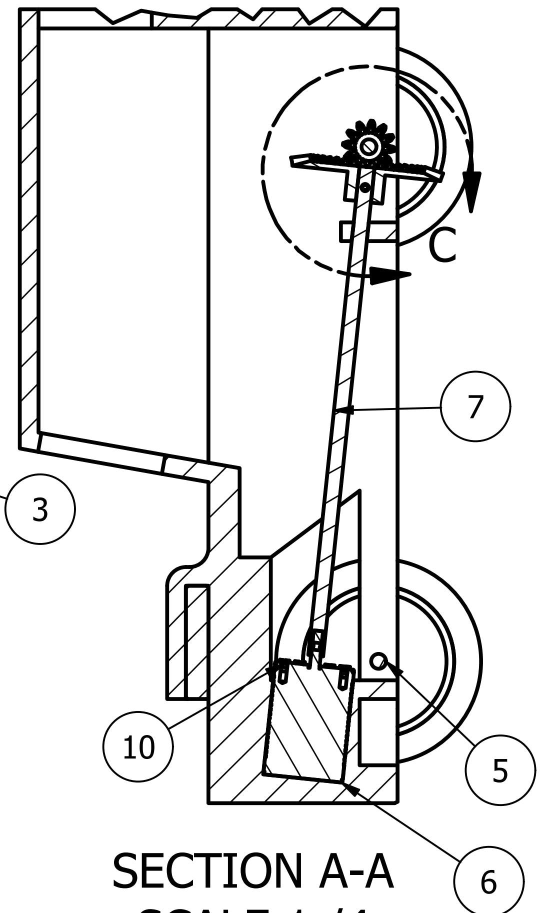


A video of the print process is included under the filename “additive manufacturing.mkv”.

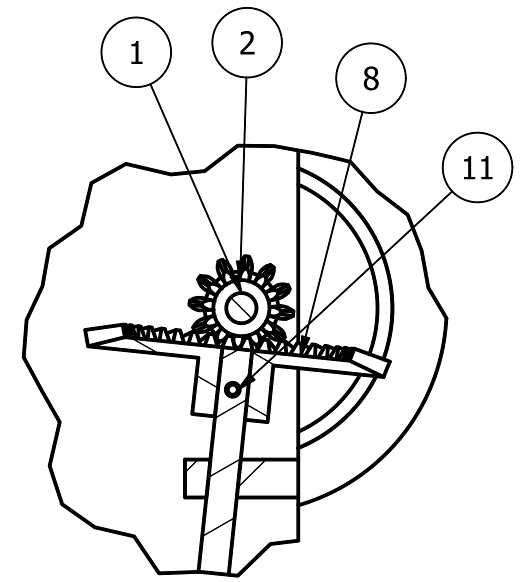
Conclusion

In all, I am satisfied with this project and although a lot of time was put into it, I enjoyed the challenge of designing something from the ground up and working through all we have learned until this point. The very large gear ratio made it difficult to generate appropriately sized gears. The simulations show that the shell and wheels could be optimized to use less material while maintaining structural integrity, so there is much room for improvement down the line. Overall, I tried to keep this build simple, effective, and aesthetically pleasing.



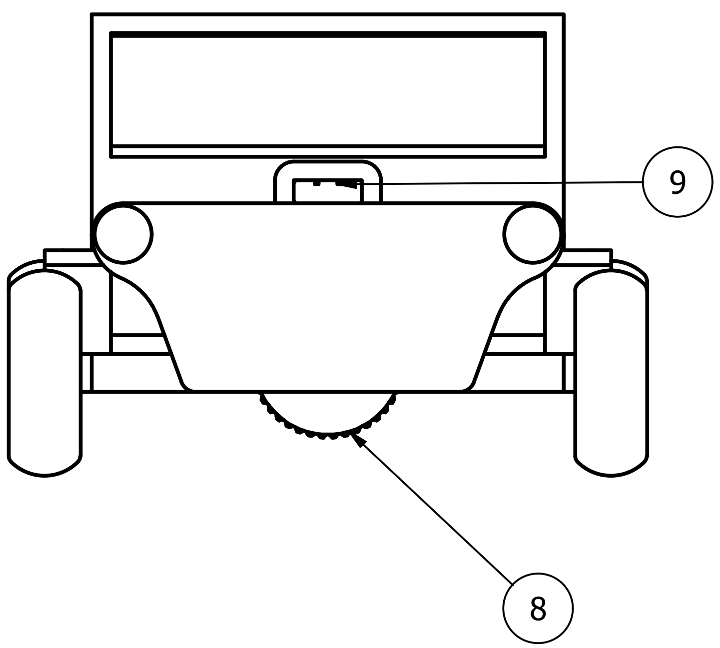


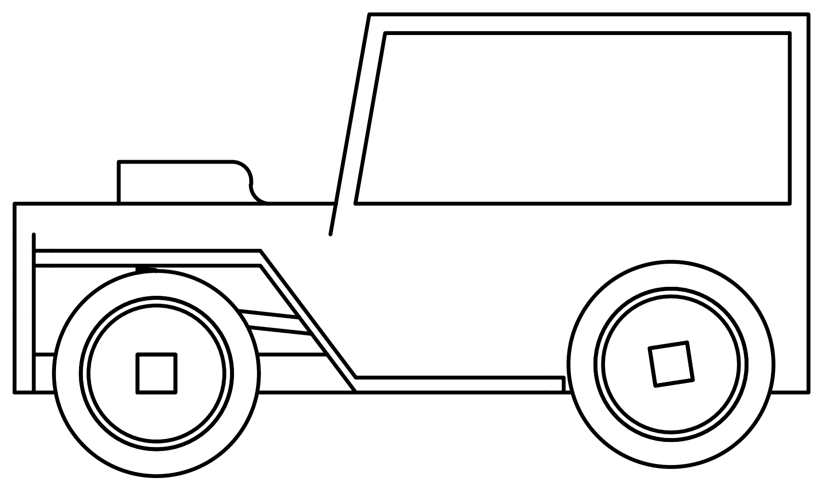
SECTION A-A
SCALE 1 /4

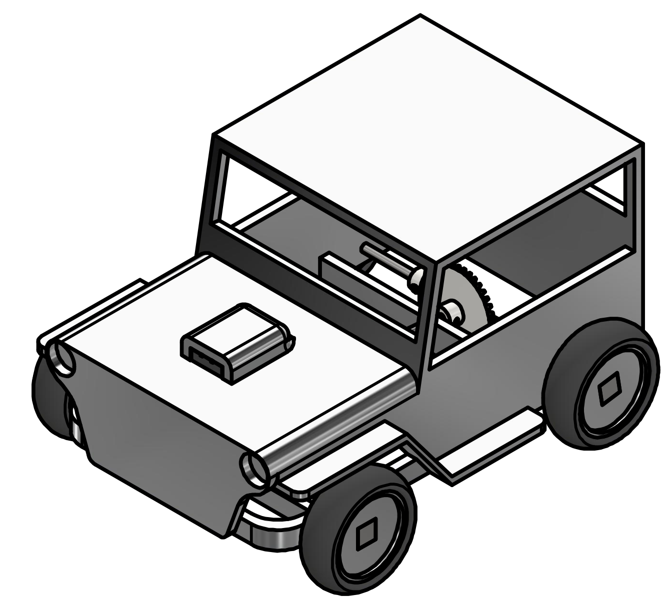


DETAIL C
SCALE 1 / 2

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Rear axle	
2	1	Driven bevel gear	
3	1	Shell	
4	4	Wheel and tire	Wheel and tire subassembly
5	1	Front axle	
6	1	rc_motor	STEP AP214
7	1	Driveshaft	
8	1	Driver bevel gear	
9	1	rc_battery	STEP AP214
10	6	ANSI/ASME B18.6.5M - M3x0.5 x 6, SFCHTSTTM	Slotted Flat Countersunk Head Tapping Screw - Type T - Metric
11	2	ANSI/ASME B18.6.5M - M3.5x0.6 x 20, SFCHTSTTM	Slotted Flat Countersunk Head Tapping Screw - Type T - Metric







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CHECKED		
QA		TITLE ME4Z03 RC Car - Bartella (complete assembly)
MFG		
APPROVED		
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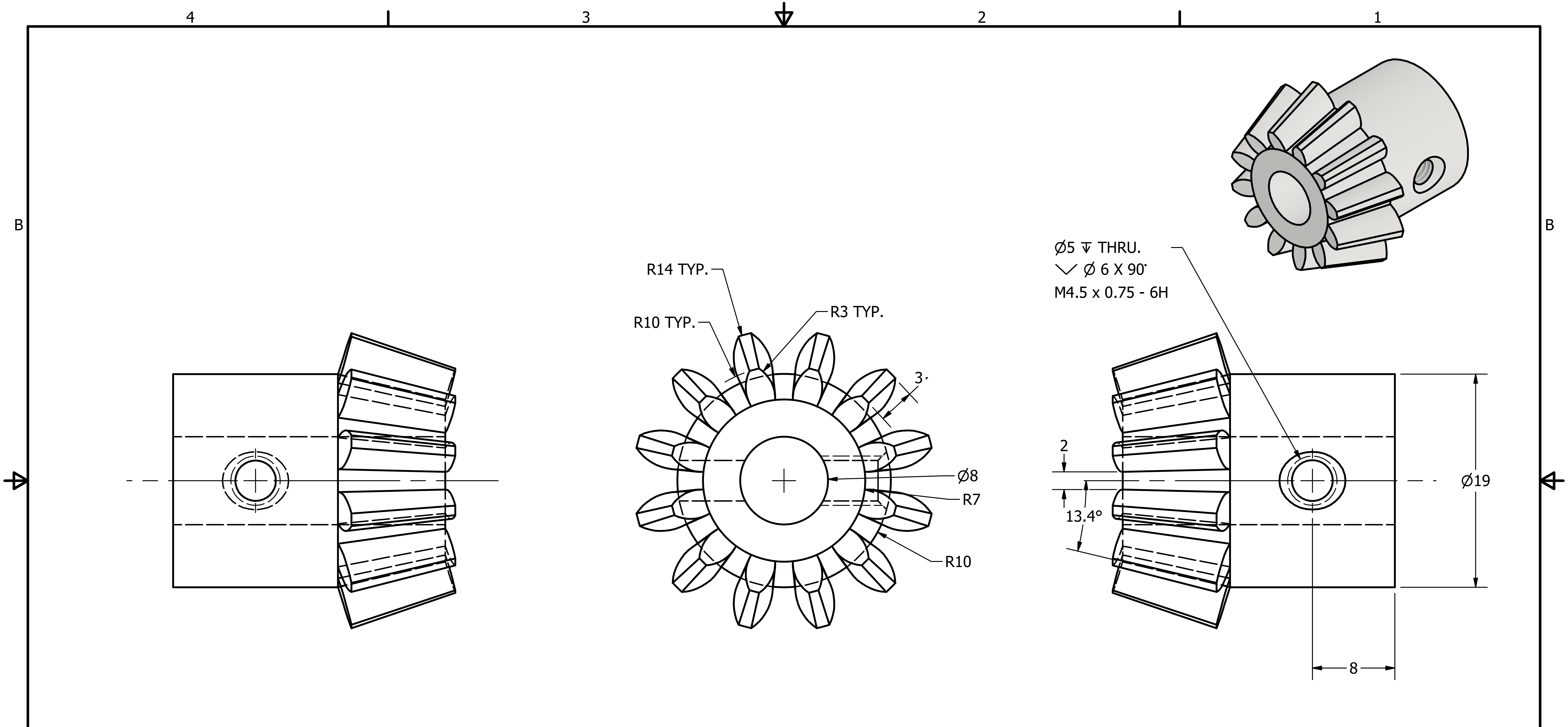
		SCALE 1 /4; SHEET 1 OF 12



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QA		TITLE Driven bevel gear - 18 tooth	
MFG			
APPROVED			
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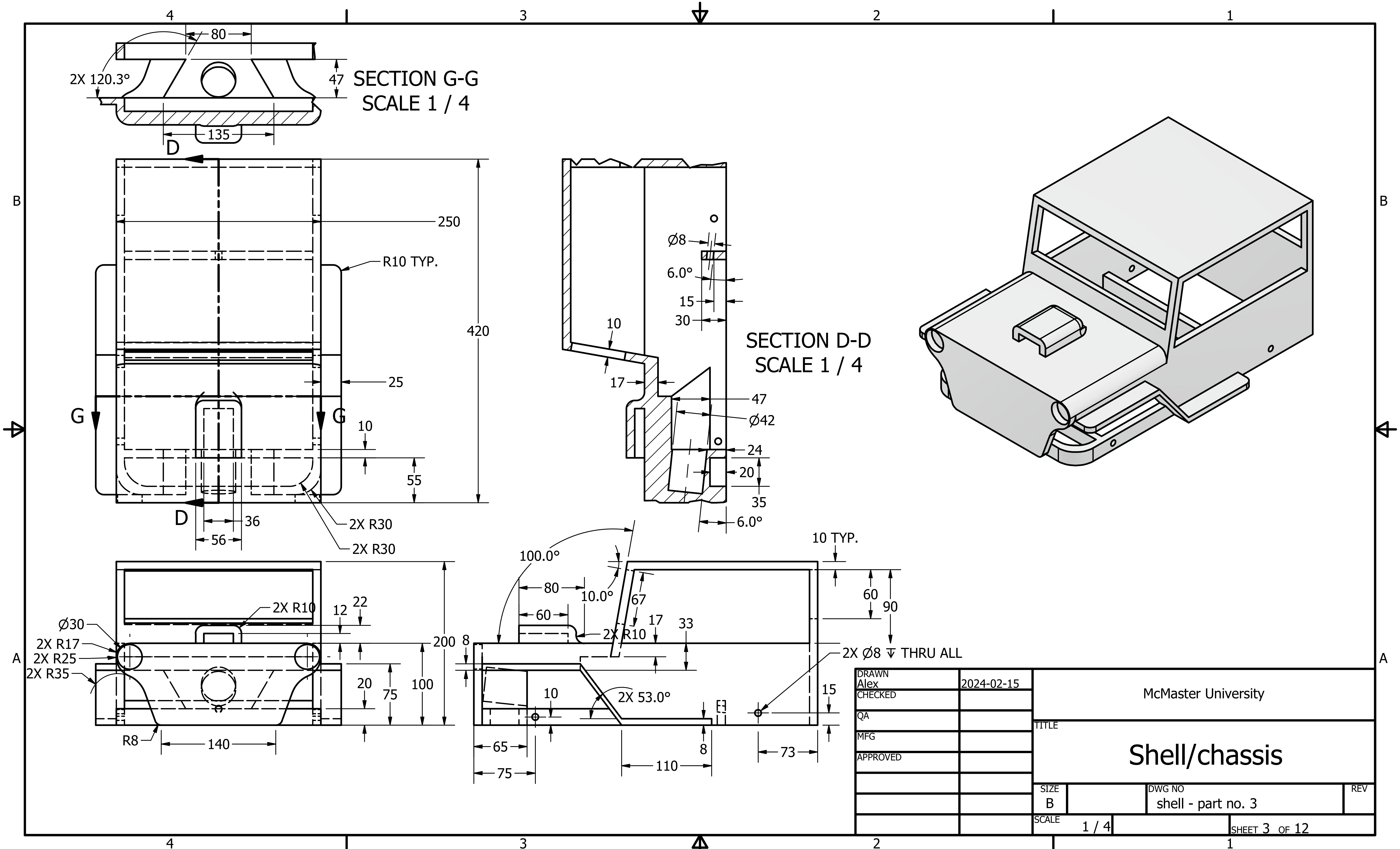
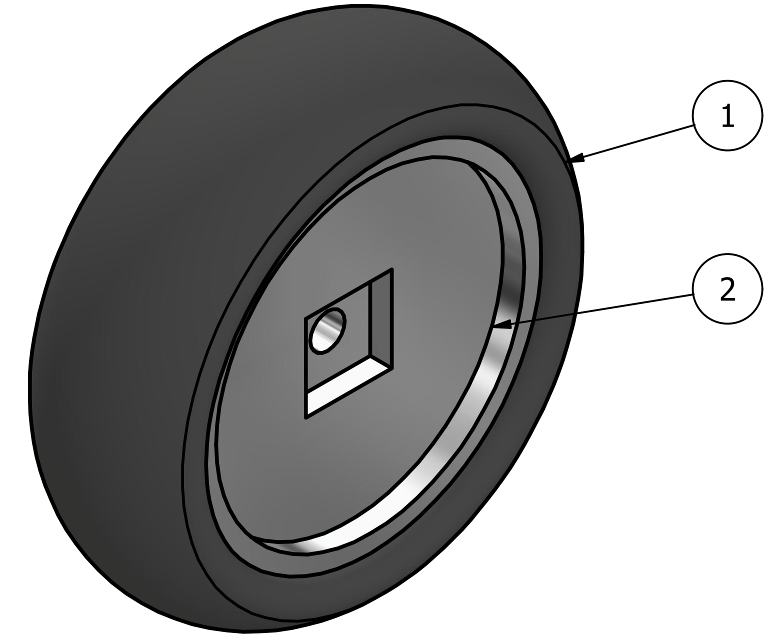
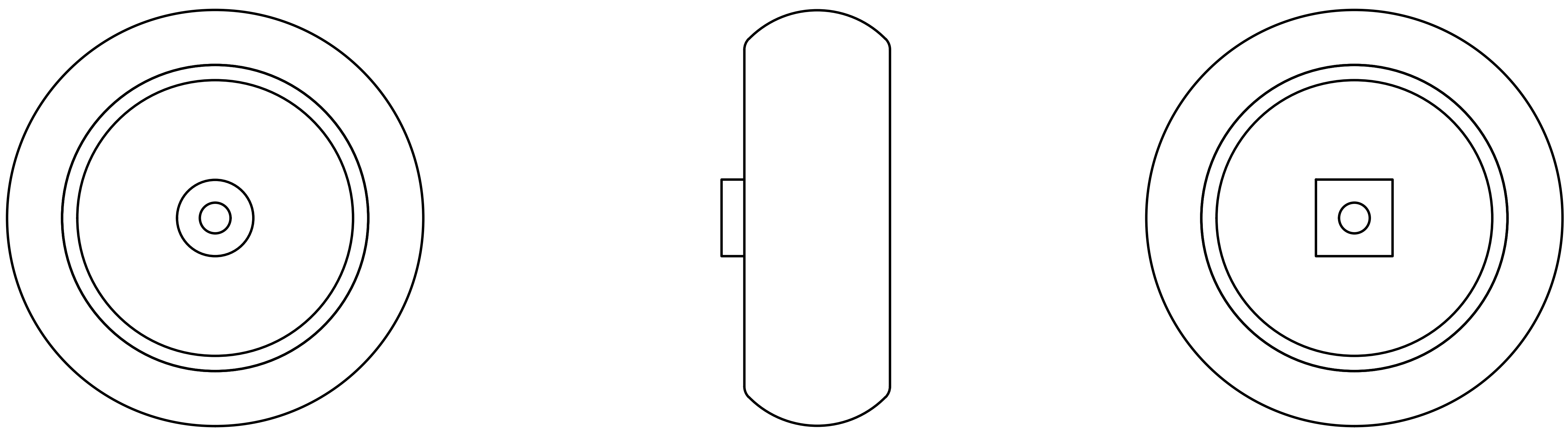
		SCALE 3 : 1	SHEET 2 OF 12



SECTION G-G
SCALE 1 / 4
80
2X 120.3°
47
135
D
250
R10 TYP.
420
25
G
G
10
55
D
36
56
2X R30
2X R30
SECTION D-D
SCALE 1 / 4
Ø8
6.0°
15
30
10
17
47
Ø42
24
20
35
6.0°
100.0°
10 TYP.
80
10.0°
67
60
60
90
17
33
2X R10
2X Ø8 ↧ THRU ALL
8
Ø30
2X R10
12
22
2X R17
2X R25
2X R35
200
20
75
100
R8
140
10
2X 53.0°
15
65
75
110
8
73
DRAWN
Alex
2024-02-15
CHECKED
QA
MFG
APPROVED
McMaster University
TITLE
Shell/chassis
SIZE
B
DWG NO
shell - part no. 3
REV
SCALE
1 / 4
SHEET 3 OF 12

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Tire	
2	1	Wheel	





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MFG			
APPROVED			
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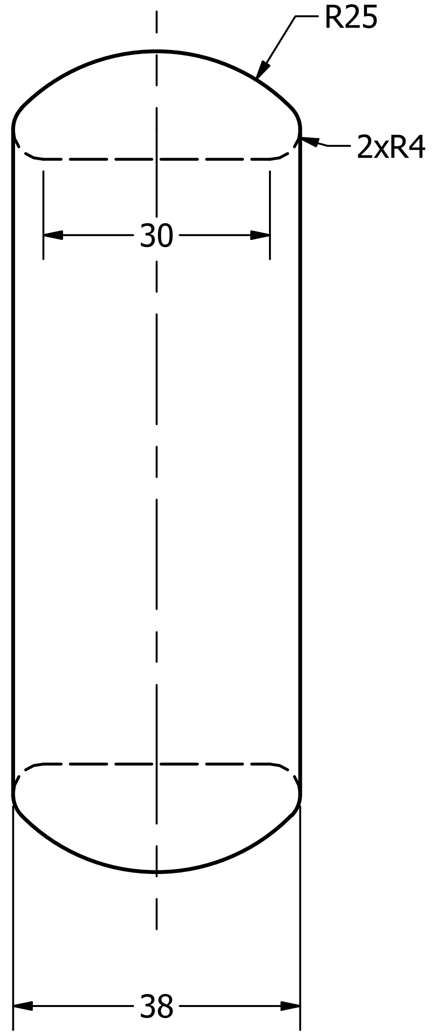
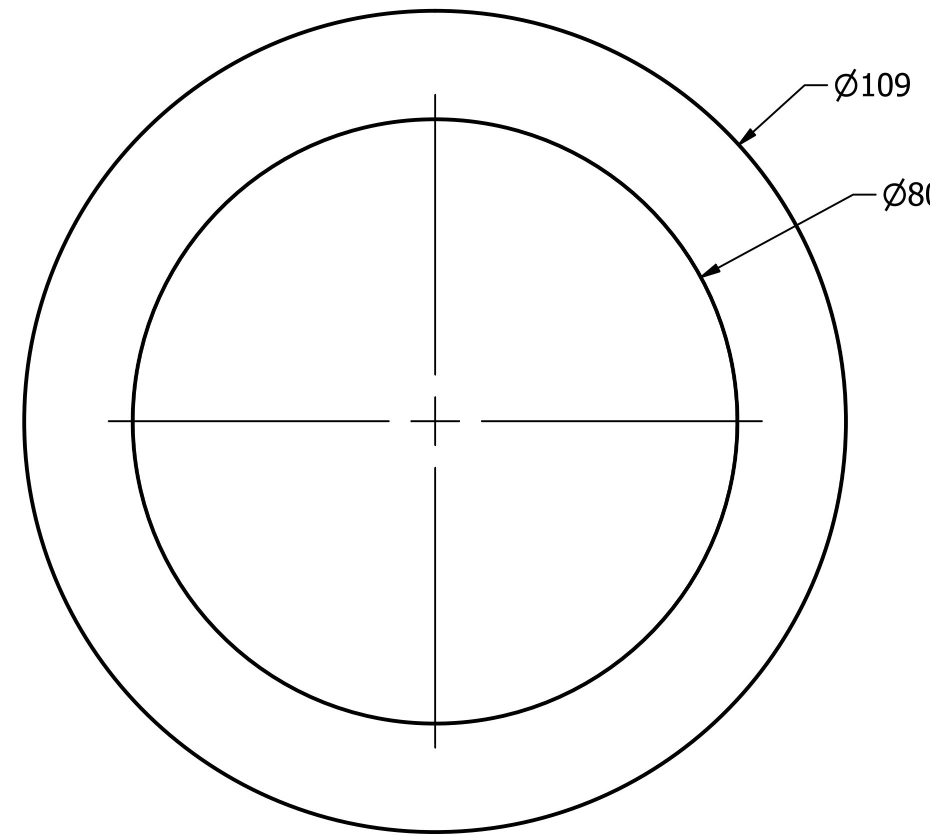
		SCALE 4/5	SHEET 4 OF 12





DRAWN Alex	2024-02-15	McMaster University			
CHECKED					
QA		TITLE			
MFG		Tire			
APPROVED					
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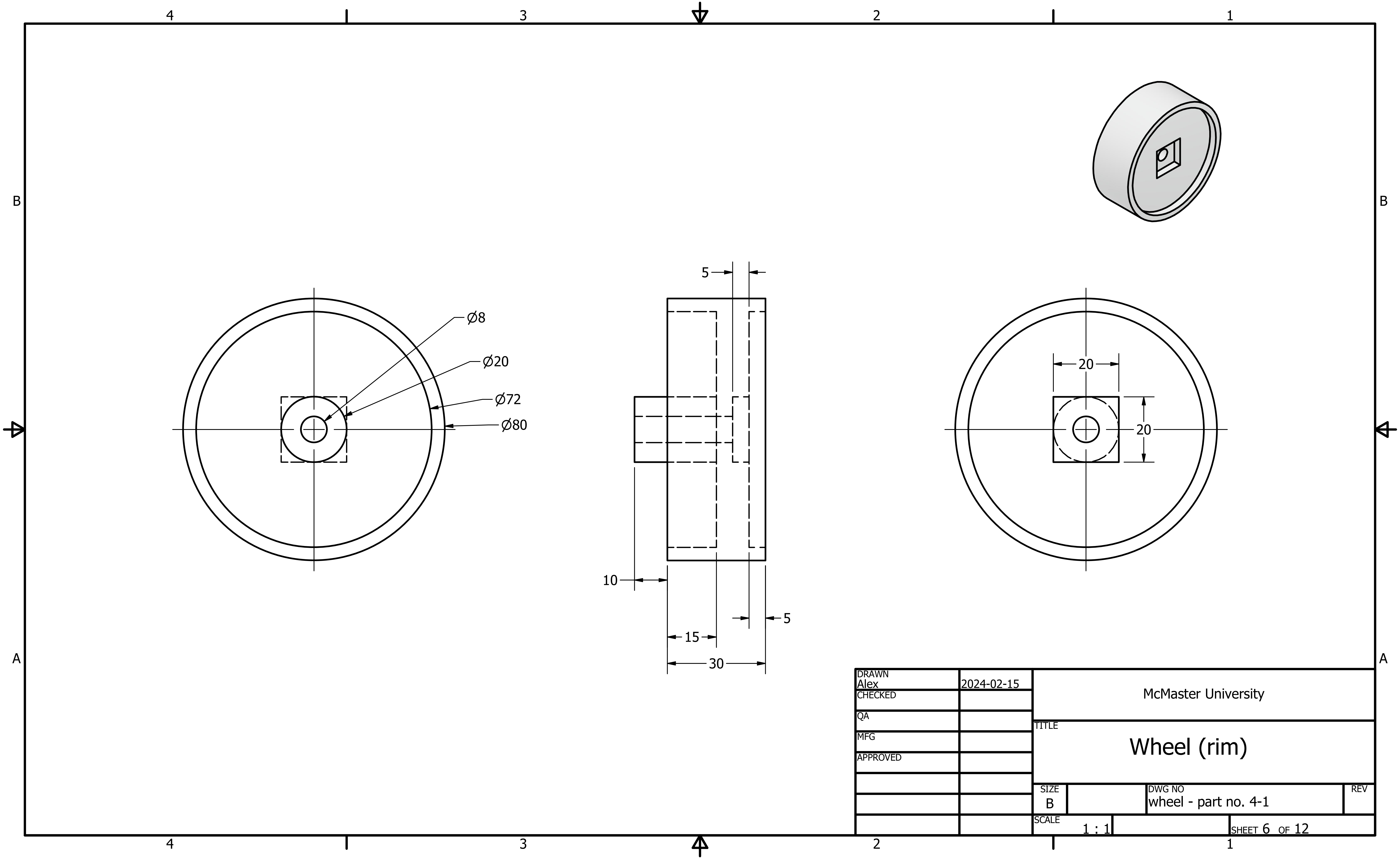
		SCALE 1		SHEET 5 OF 12	



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CHECKED		
QA		TITLE Wheel (rim)
MFG		
APPROVED		
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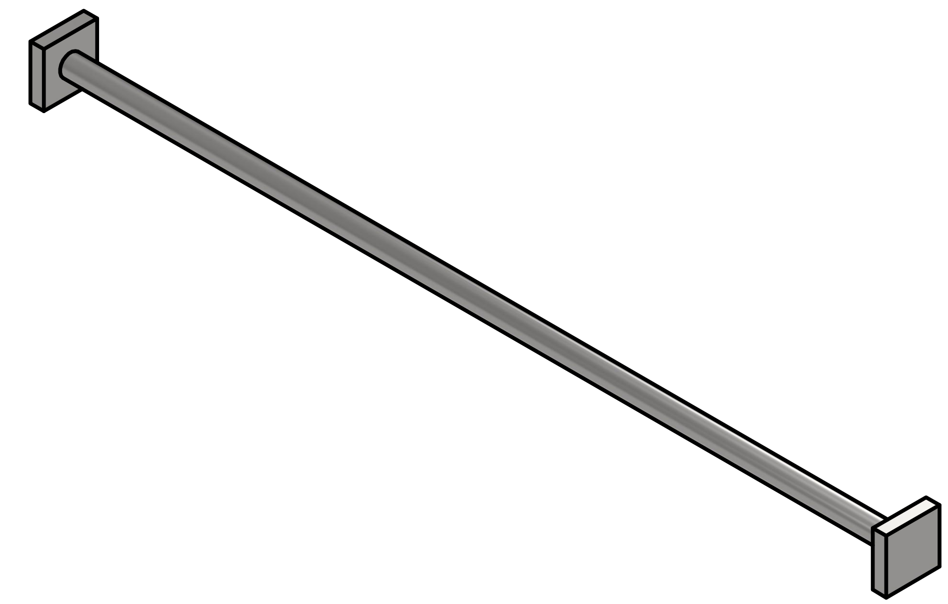
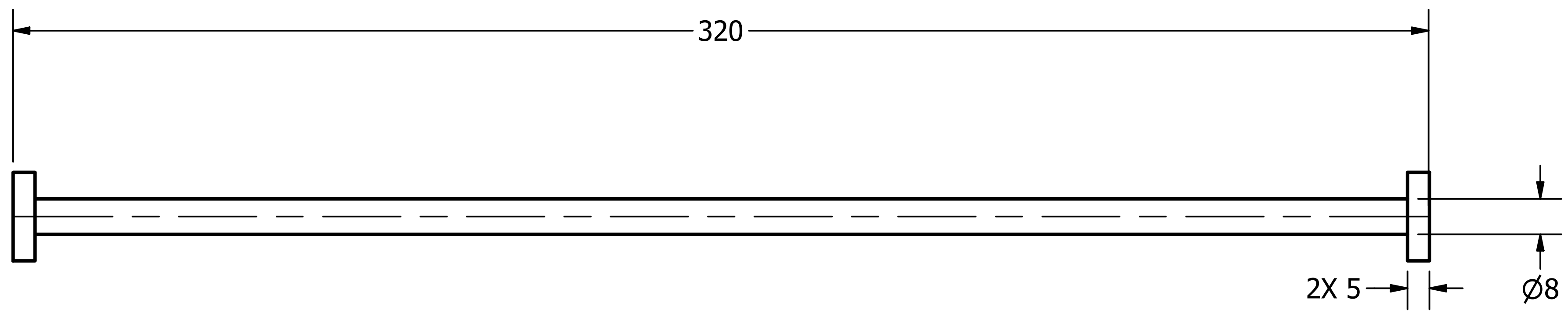
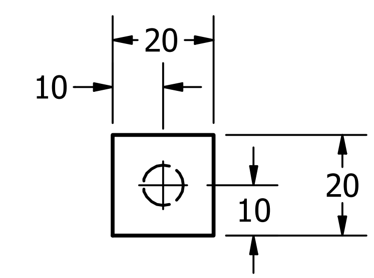
		SCALE 1 : 1 / SHEET 6 OF 12







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CHECKED				
QA		TITLE		
MFG		Front axle		
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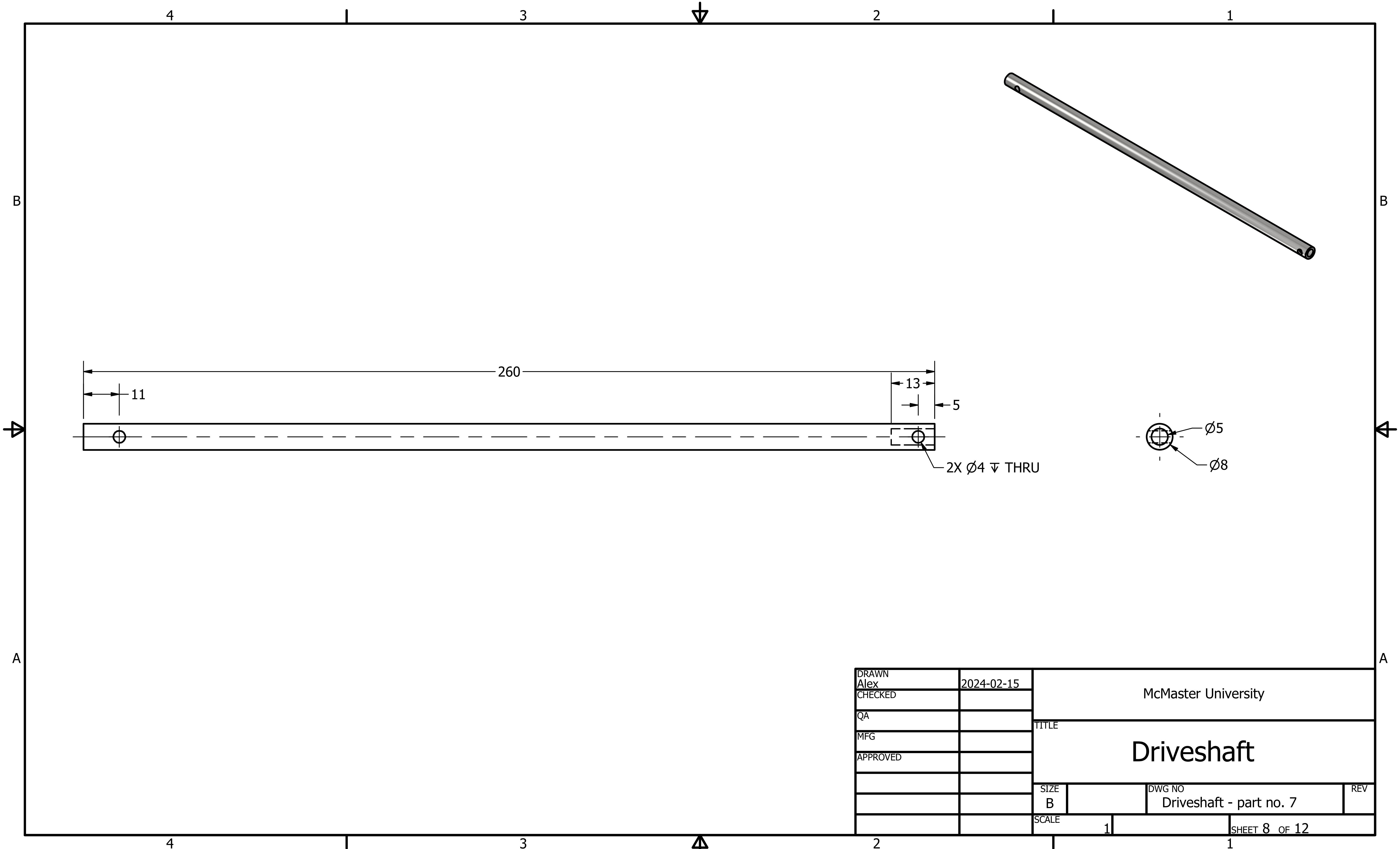

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QA		
MFG		
APPROVED		
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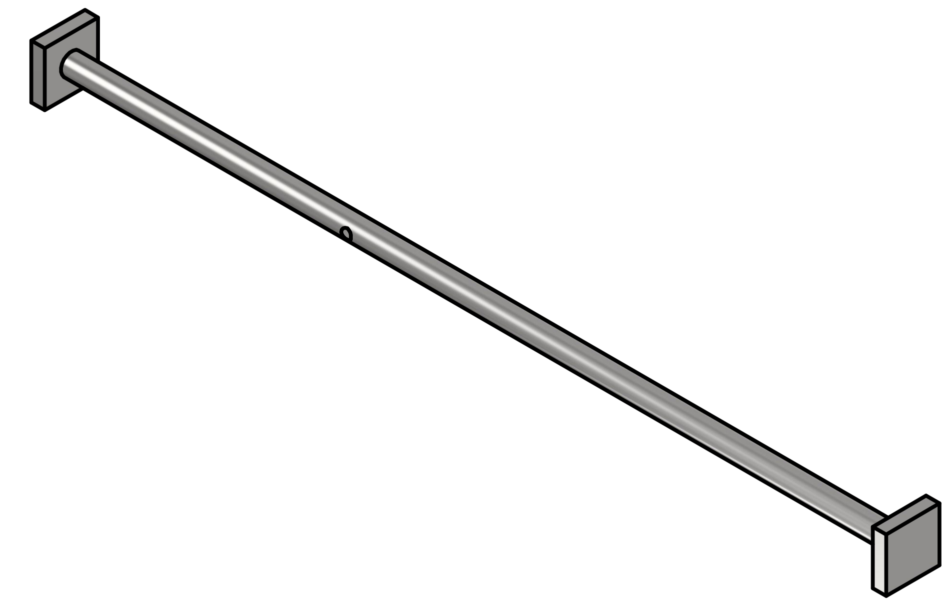
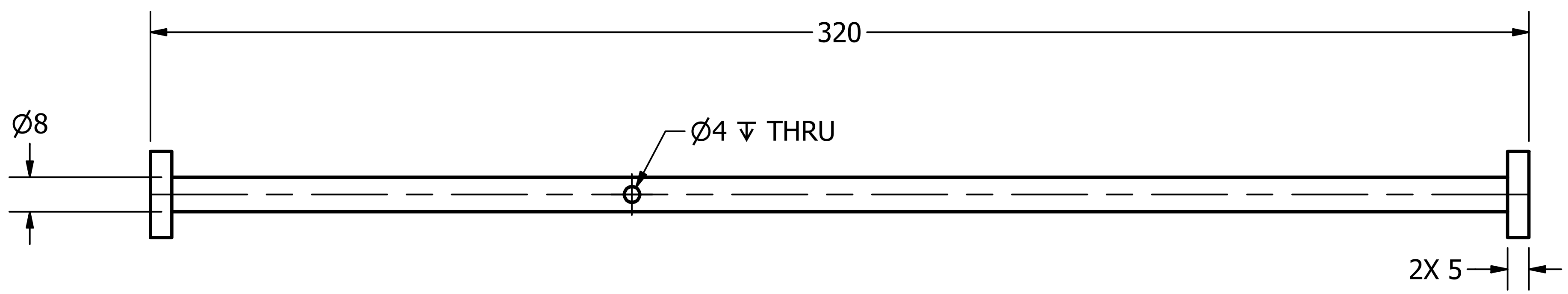
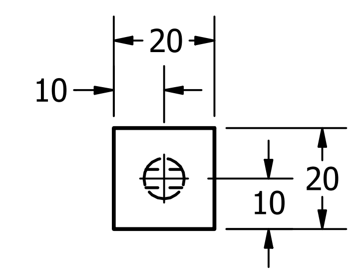
		SCALE 1 / SHEET 8 OF 12







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CHECKED		TITLE Rear axle	
QA			
MFG			
APPROVED			
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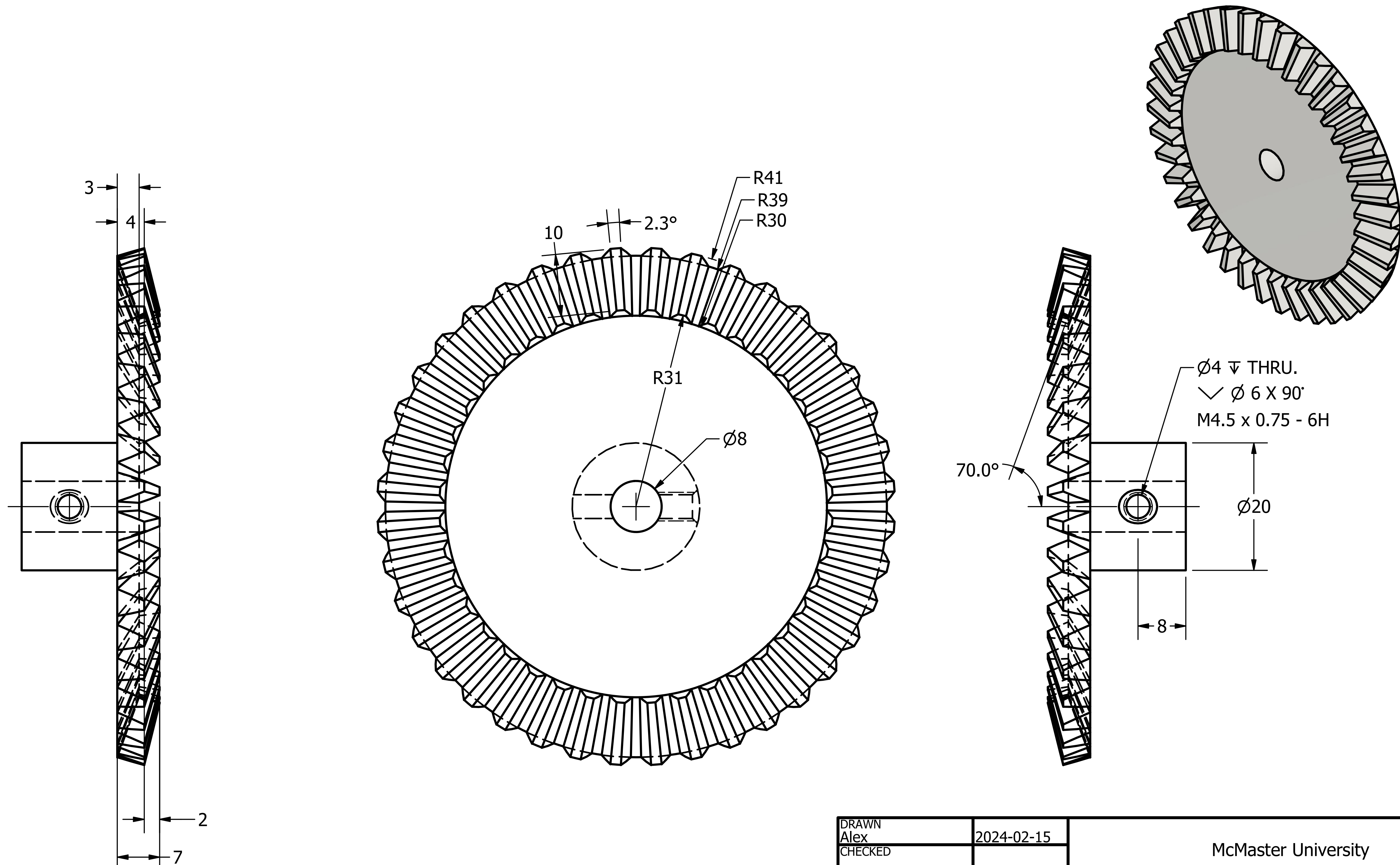
		SCALE 2/3	SHEET 9 OF 12



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CHECKED					
QA		TITLE Driver bevel gear - 60 tooth			
MFG					
APPROVED					
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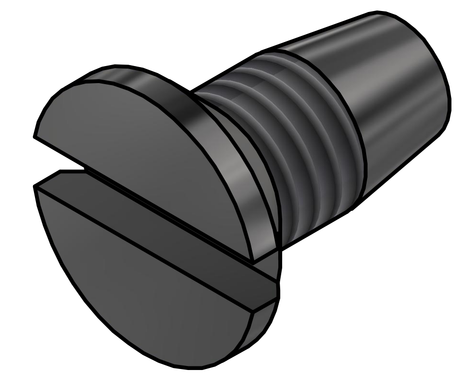
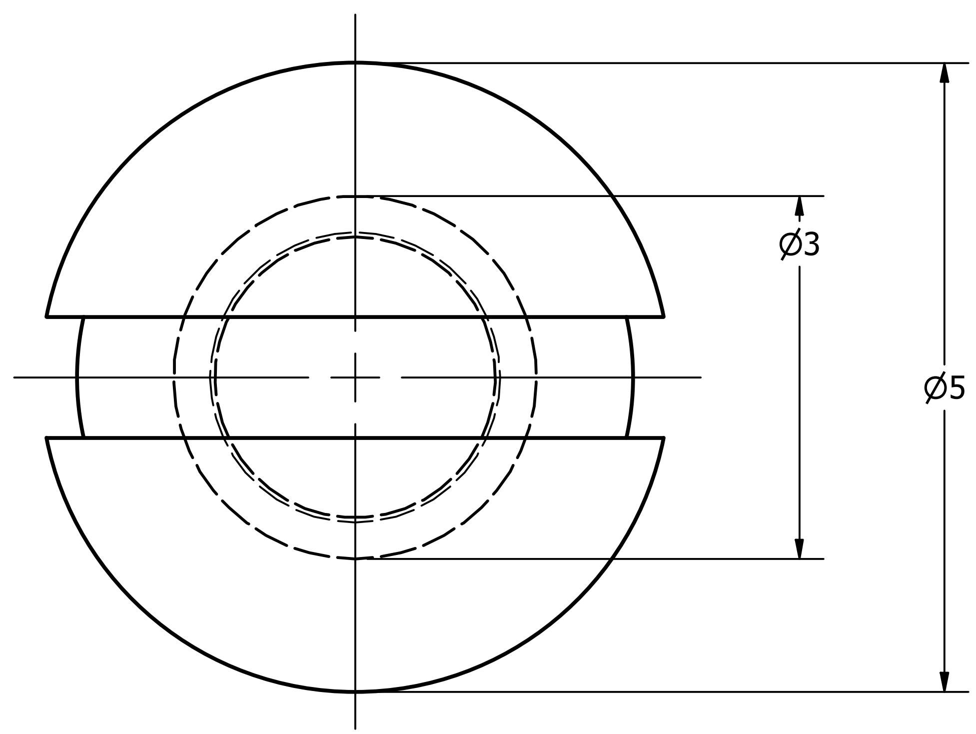
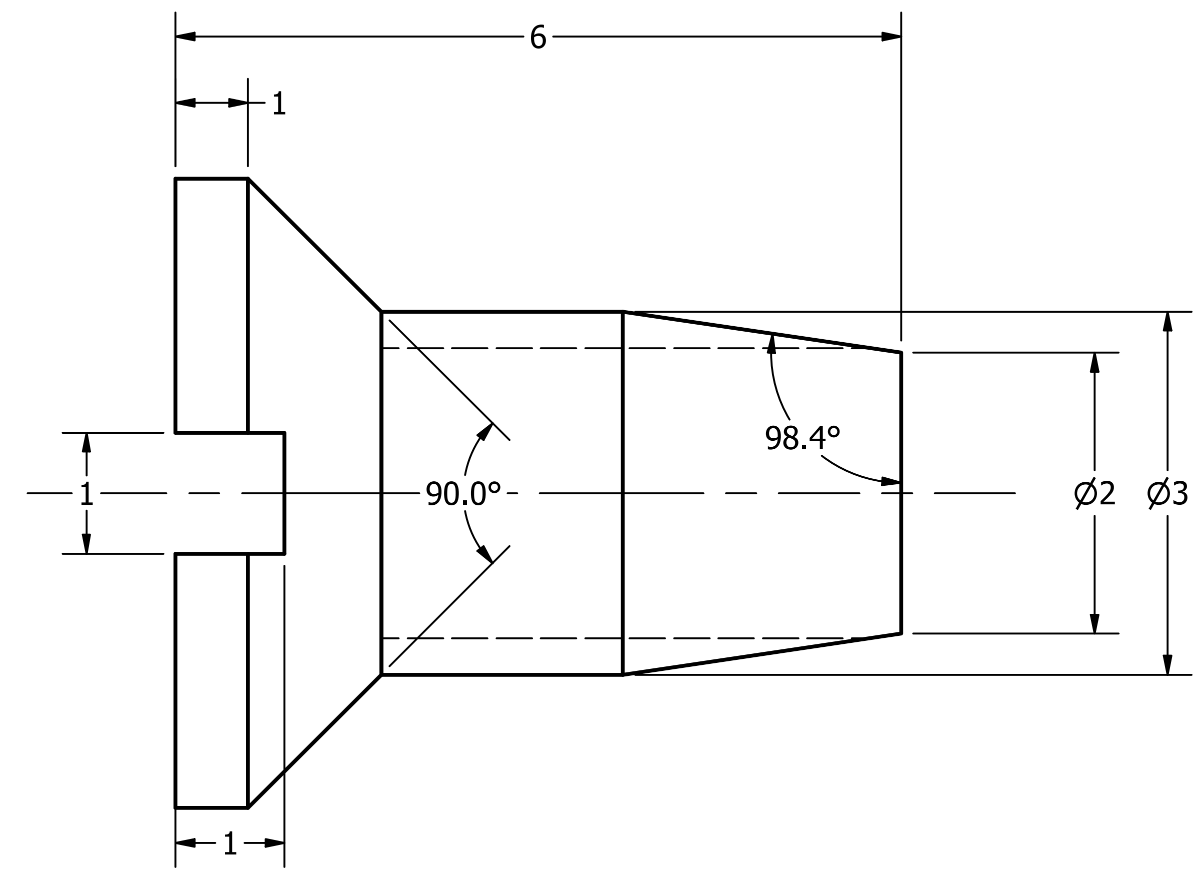
		SCALE 3/2		SHEET 10 OF 12	







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QA		TITLE		
MFG		Motor fasteners (source: ANSI content lib)		
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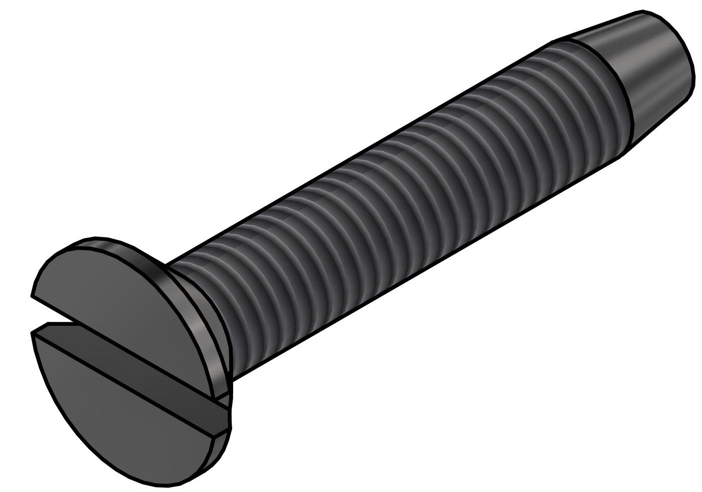
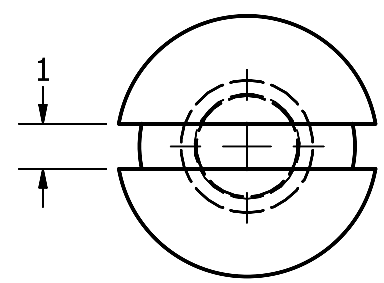
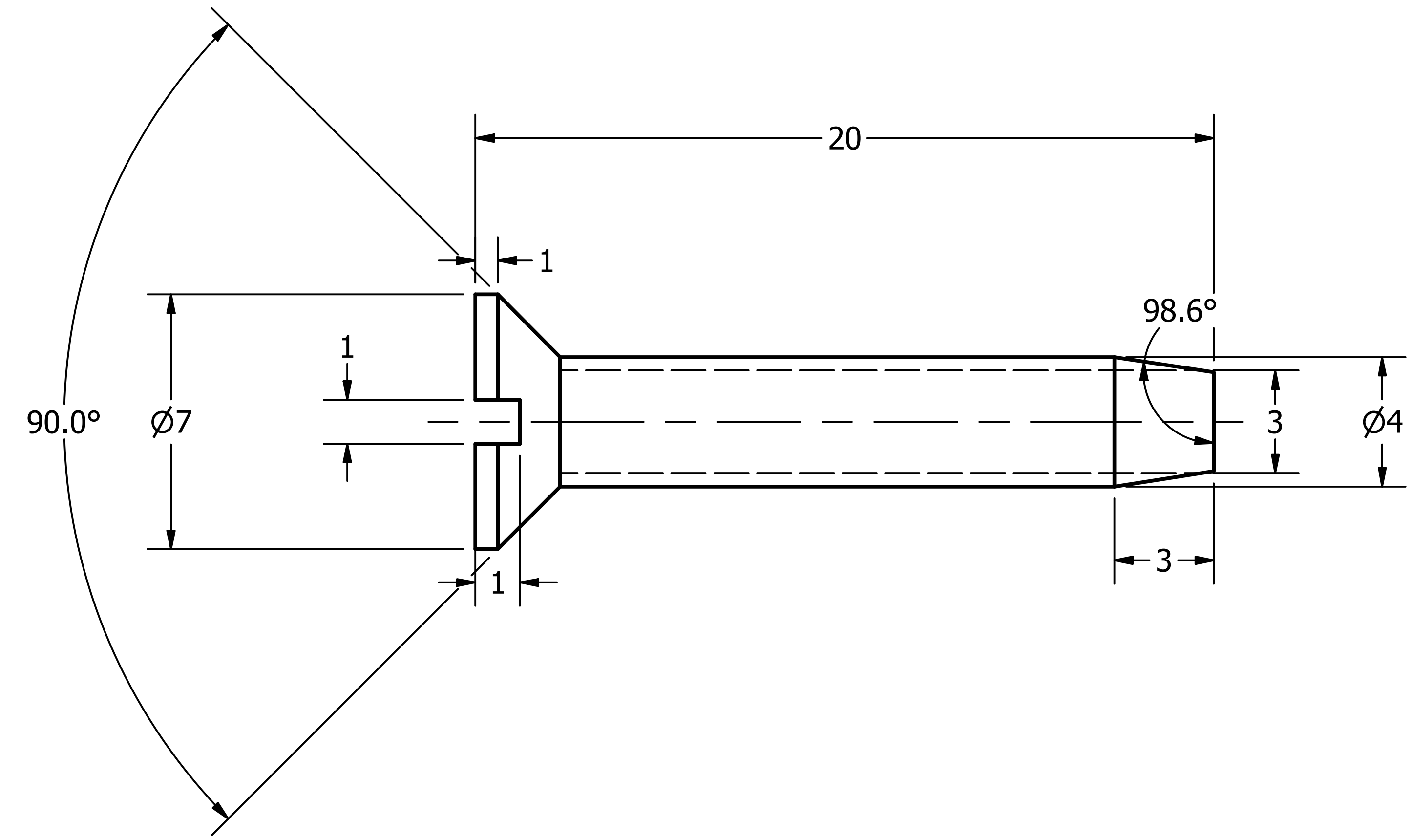
		SCALE 16 : 1		SHEET 11 OF 12







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QA		TITLE Gear fasteners (source: ANSI content lib)	
MFG			
APPROVED			
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		SCALE 5 : 1	SHEET 12 OF 12