

# Engineering 1CO3 - Engineering Design & Graphics

## Engineering 1 Cornerstone Design Project

### Final Report

Team: 146

Lab Section: 10

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As a future member of the engineering profession, the student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting the work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University and the Code of Conduct of the Professional Engineers of Ontario  
Submitted by [Pavneet Gill, 400129924]



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Submitted by [Karanbir Singh, 400139204]



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Submitted by [Samandeep Virdi, 400131893]

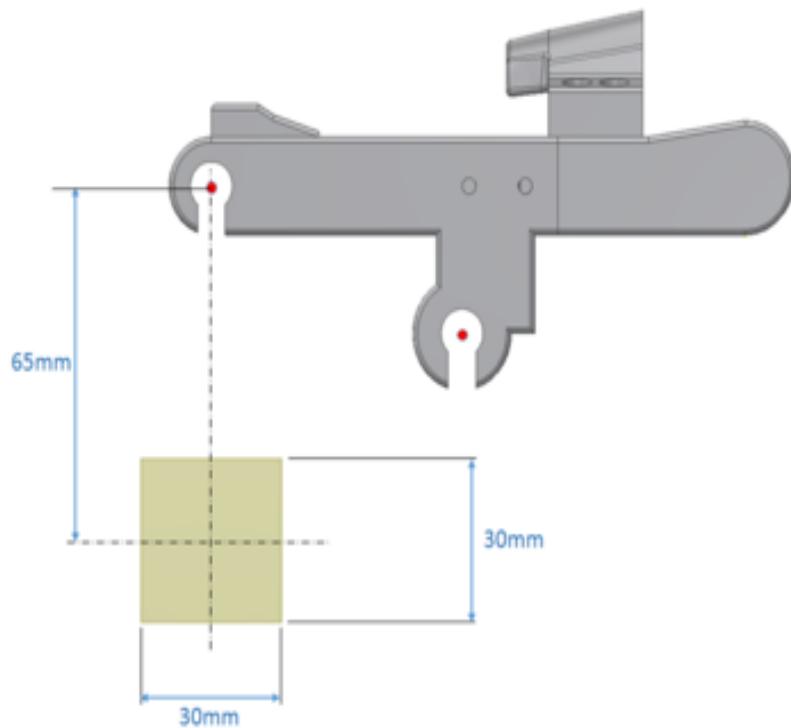


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## 1.0 INTRODUCTION

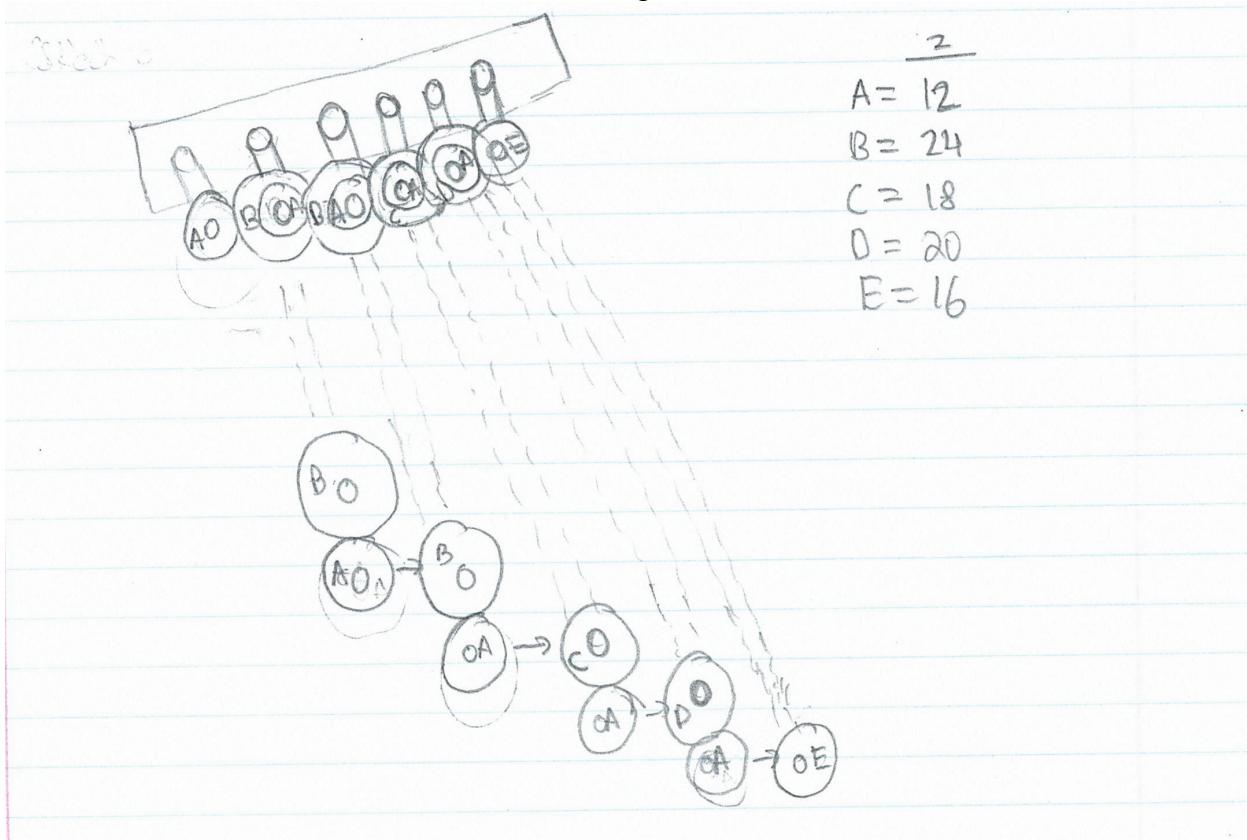
The McMaster Engineering Design team was presented with a assignment to build a low-cost prosthetic apparatus with a gear based mechanism rather than the string based mechanism it originally came with. The constraints present in the challenge were that the gear-train based mechanism has to be powered by a motor and obtain a specified output speed of 0.1 RPS with a given input speed of 80.3 RPM. To make this assignment unique, each group had a different which was determined based on their group number. The input speed of 80.3 RPM was calculated by multiplying the assigned group number of 146 by 0.55. Then there were specific gear ratios made to bring the speed down to the specified 0.1 RPS. The only fingers that will be moving is the index finger and thumb. The tips of the fingers have to touch in a 30-mm x 30-mm functional workspace which is located 65 mm below the index finger. Another constraint present in the assignment was that the dimensions of the original prosthetic was not supposed to be changed, therefore a gear box had to be specially designed to fit inside the original prosthetic. The Engineering design team revised the challenge and took a look at the objectives that had to be accomplished while abiding by the constraints. The gear-train consists of only spur gears because spur gears that were printed out in the EPIC lab mesh better than the worm gears. The gear-train starts off with the motor spinning at 80.3 RPS, which will result in two spur gears moving at 0.1 RPS that will have the index finger and thumb axially connected to them. The validity of the design was examined by creating the simple gear mechanism in Autodesk Inventor 2017 and then using the dynamic simulation mode to make sure all the gears meshed correctly.



**FIGURE 1.0 Location of the functional workspace relative to the forefinger axis of rotation**

## 2.0 Description of How the Gear Train Works

Originally the gear train had bevel gears and worm gears. Due to its complexity in design it was removed. The gear train only relies on spur gears. This was because through test prints we realized that the bevel and worm gears take a longer time to print. Resulting in a selection of the gear train being out of spur gears. Below is a description of the operating gear train, the design and the calculation to show why those ratios of gears were selected. The system begins where the motor is located. Each gear is classified by the number of teeth it has. This system begins with a gear with 12 teeth ( $z=12$ ) gears and follows given gear train design below. Each gear has a module of 1. Which is seen in the sketches below. The rotation of the fingers occurs at 16 teeth gear ( $z=16$ ). After being meshed by the 12 teeth gears. By following this gear train design, we were able to convert the given speed of 80.3 rpm to 6 rpm.

**FIGURE 2.0** Final Sketch of Gear Train Design

**FIGURE 3.0** Calculations For Output Speed

Group #146: Input Speed = 80.3 rpm  
 Required output speed = 6 rpm  
 Module = 1.0 mm/tooth (all gears)

Ratios  $(12:24) \times 2$   $(12:18)(12:20)$   $(12:16)$

Output Speed

$$= (80.3) \cdot \left(\frac{12}{24}\right) \cdot \left(\frac{12}{18}\right) \cdot \left(\frac{12}{20}\right) \cdot \left(\frac{12}{16}\right)$$

$= 6.0225 \text{ RPM}$

$$\text{Accuracy Percentage} \rightarrow \frac{6.0225 - 6}{6} = \boxed{\% 0.375}$$

**FIGURE 4.0** Calculations For Gear Train

Set of Calculations for gear train design					
Gear	Module	# OF teeth	Diameter	Face width	
A	1mm/tooth	12	12mm	5mm	
B	1mm/tooth	24	24mm	5mm	
C	1mm/tooth	18	18mm	5mm	
D	1mm/tooth	20	20mm	5mm	
E	1mm/tooth	16	16mm	5mm	

Diagram showing the gear train setup with dimensions:

- Total width: 10.66cm
- Total height: 9.12cm
- Center-to-center distances: A-B = 5.8cm, B-C = 5mm, C-D = 5mm, D-E = 5mm
- Total center-to-center length: 6.5cm

Calculus for gear A:

$$\begin{aligned} A &= A + B + B + C \\ &= 12\text{mm} + 24\text{mm} \\ &\quad + 20\text{mm} + 16\text{mm} \\ &= 6.52\text{cm} < 9.12\text{cm} \end{aligned}$$

Calculus for gear B:

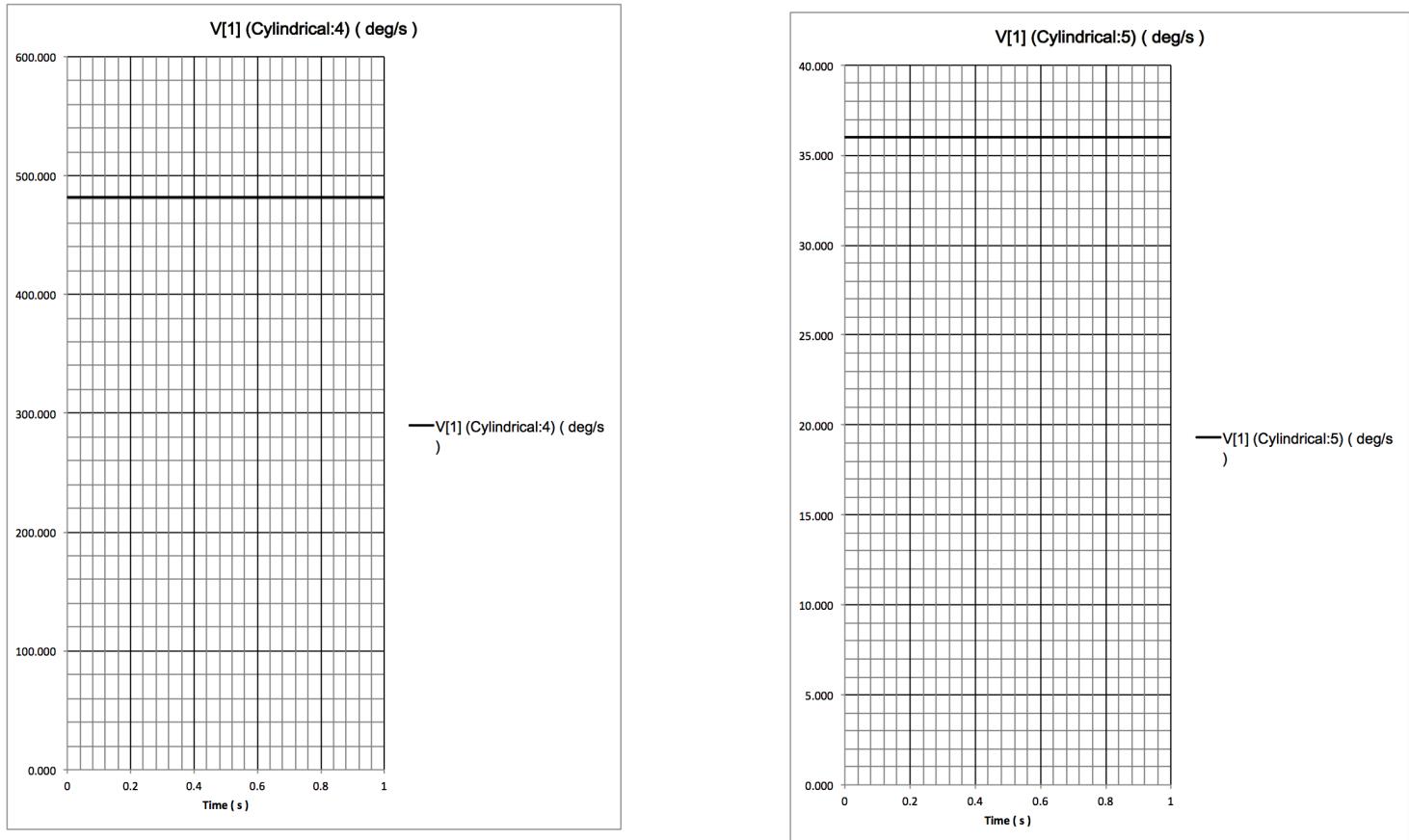
$$\begin{aligned} B &= 5.72\text{cm} \\ -D \rightarrow A &= 20\text{mm} + 12\text{mm} \\ &= 57.2\text{mm} \end{aligned}$$

Calculus for gear E:

$$\begin{aligned} E &= 2.52\text{cm} \leq 6.5\text{cm} \\ = 3.52\text{cm} &+ (A+E) + (1 \cdot A) \\ &= 9.92\text{cm} < 10.66\text{cm} \end{aligned}$$

Note: \*final correction down to last gear

### 3.0 Dynamic Simulation Graphs



Export to FEA	Time ( s )	V[1] (Cylindrical:4) ( deg/s )	V[1] (Cylindrical:5) ( deg/s )
	0.00000	481.80000	35.99894
	0.05000	481.80000	35.99894
	0.10000	481.80000	35.99894
	0.15000	481.80000	35.99894
	0.20000	481.80000	35.99894
	0.25000	481.80000	35.99894
	0.30000	481.80000	35.99894
	0.35000	481.80000	35.99894
	0.40000	481.80000	35.99894
	0.45000	481.80000	35.99894
	0.50000	481.80000	35.99894
	0.55000	481.80000	35.99894
	0.60000	481.80000	35.99894
	0.65000	481.80000	35.99894
	0.70000	481.80000	35.99894
	0.75000	481.80000	35.99894
	0.80000	481.80000	35.99894
	0.85000	481.80000	35.99894
	0.90000	481.80000	35.99894
	0.95000	481.80000	35.99894
	1.00000	481.80000	35.99894

## 4.0 Summary of Contributions

<b>Team Member</b>	<b>Summary of Contributions</b>
Samandeep Singh Virdi	<ul style="list-style-type: none"> <li>• Milestone 1</li> <li>• Milestone 2</li> <li>• 3D Printing of Components</li> <li>• Autodesk Inventer</li> <li>• Gearbox design</li> <li>• Spur-Gears</li> </ul>
Pavneet Singh Gill	<ul style="list-style-type: none"> <li>• Milestone 0</li> <li>• Milestone 1</li> <li>• Initial Sketch of Gear Train</li> <li>• 3D Printing of Components</li> <li>• Gear Ratio Calculations</li> <li>• Autodesk Inventer</li> <li>• Gearbox design</li> <li>• Spur-Gears</li> </ul>
Karanbir Singh	<ul style="list-style-type: none"> <li>• Milestone 1</li> <li>• Milestone 2</li> <li>• 3D Printing of Components</li> <li>• Engineering Drawings For Technical Report</li> <li>• Output Graphs</li> <li>• Autodesk Inventer</li> <li>• Spur-Gears</li> <li>• Gearbox Design</li> <li>• Design of Index Finger and Thumb</li> </ul>

## 5.0 Summary of Meetings

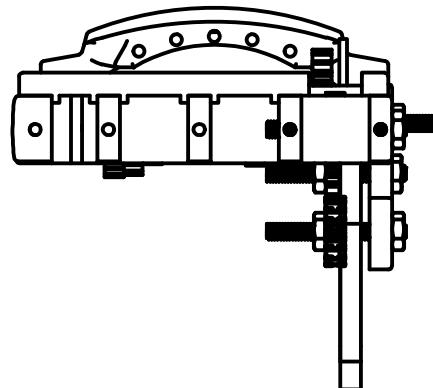
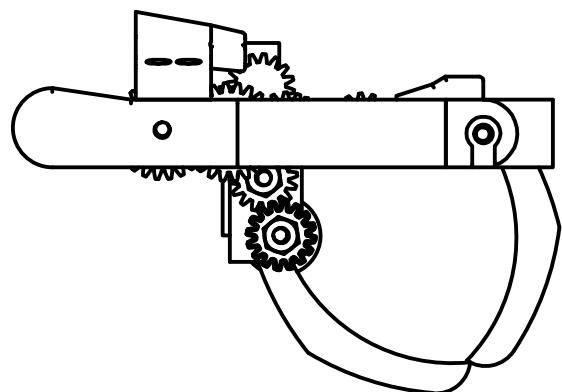
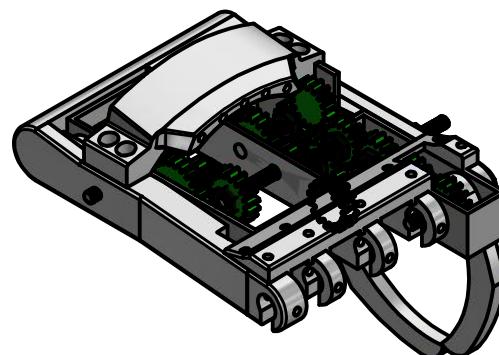
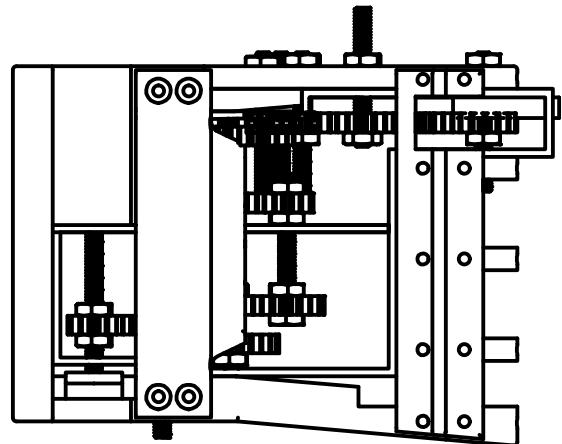
<b>Meeting Date</b>	<b>Summary of Meetings</b>
October 27	<ul style="list-style-type: none"> <li>• Timeline and Agreement</li> <li>• Preliminary design</li> <li>• Gear modules and face widths were determined</li> </ul>
November 9 - Date Postponed to November 10	<ul style="list-style-type: none"> <li>• 3D printed Gears testing</li> <li>• Resulted in removal of existing worm and bevel gears in design</li> <li>• Found holes were too small for rods to fit through</li> <li>• New gear ratios were designed for testing</li> </ul>
November 17	<ul style="list-style-type: none"> <li>• New 3d printed gears were tested</li> <li>• Bracket design was made for gears to be installed in with holes</li> <li>• Introduction for report was completed</li> </ul>
November 24- Date preposed to November 23	<ul style="list-style-type: none"> <li>-Bracket was tested</li> <li>-Checked to see if the rods fit within the hole sizes of the bracket</li> <li>Checked gear to see if any gears were missing</li> <li>- printed fingers were checked to see if they meet</li> </ul>
December 1	<ul style="list-style-type: none"> <li>• Started to put the working pieces together resulting in an overall design</li> <li>• Came up with a plan to distribute work and finish the final report</li> </ul>

## 6.0 Engineering Drawing Index

Figure #	Description
1	Hand Assembly
2	Gear House Assembly
3	Inner Gear Housing
4	Exploded View of Gear Housing
5	Finger
5	Gear 1, $z = 12$ Teeth
6	Gear 2, $z = 24$ Teeth
7	Gear 3, $z = 18$ Teeth
8	Gear 4, $z = 20$ Teeth
9	Gear 5, $z = 16$ Teeth

2

1



DRAWN Group 146	2017-12-04			
CHECKED				
QA		TITLE		
MFG		Full Assembly in Hand Frame		
APPROVED				
		SIZE <b>A</b>	DWG NO <b>1</b>	REV
		SCALE 1:2		SHEET 1 OF 1

2

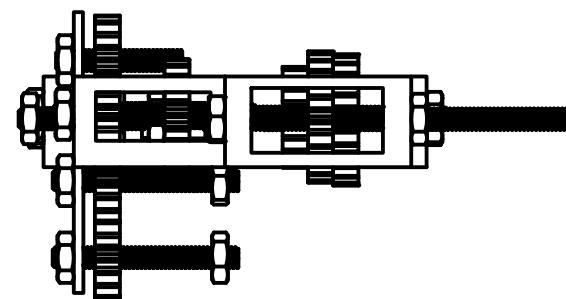
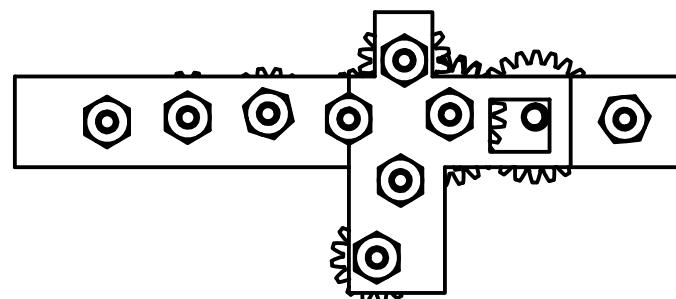
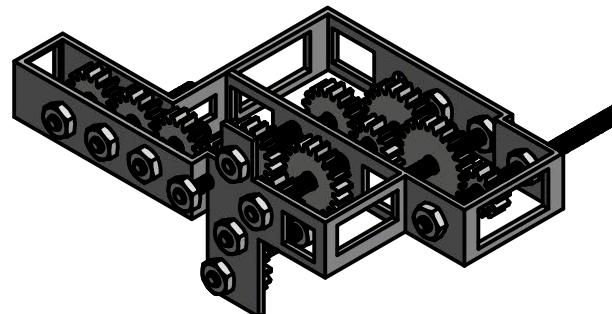
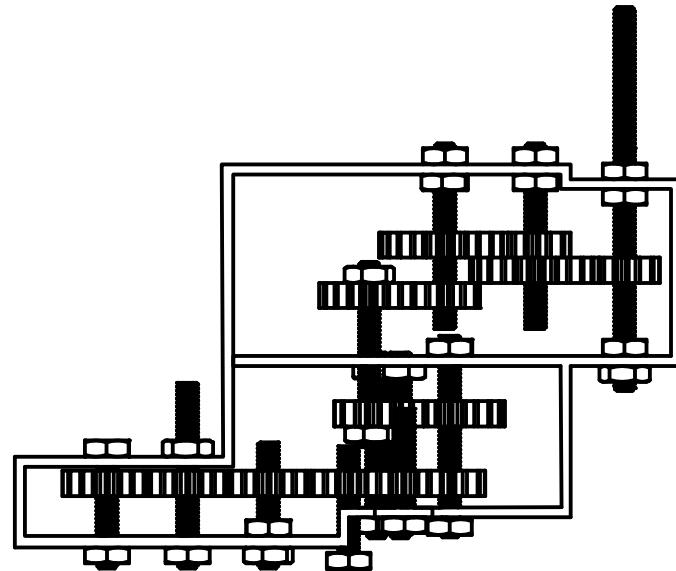
1

A

2

1

B



A

DRAWN  
Group 146

2017-12-05

CHECKED

QA

MFG

APPROVED

TITLE

## Gear Housing Assembly

SIZE

A

DWG NO

2

REV

SCALE

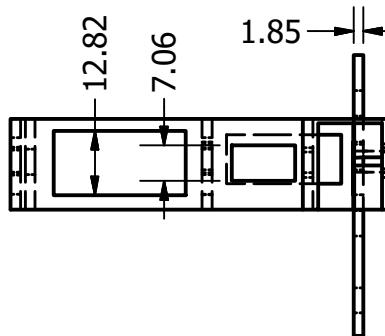
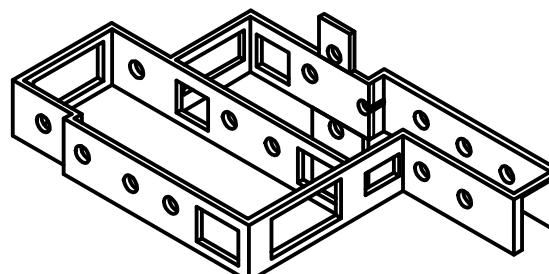
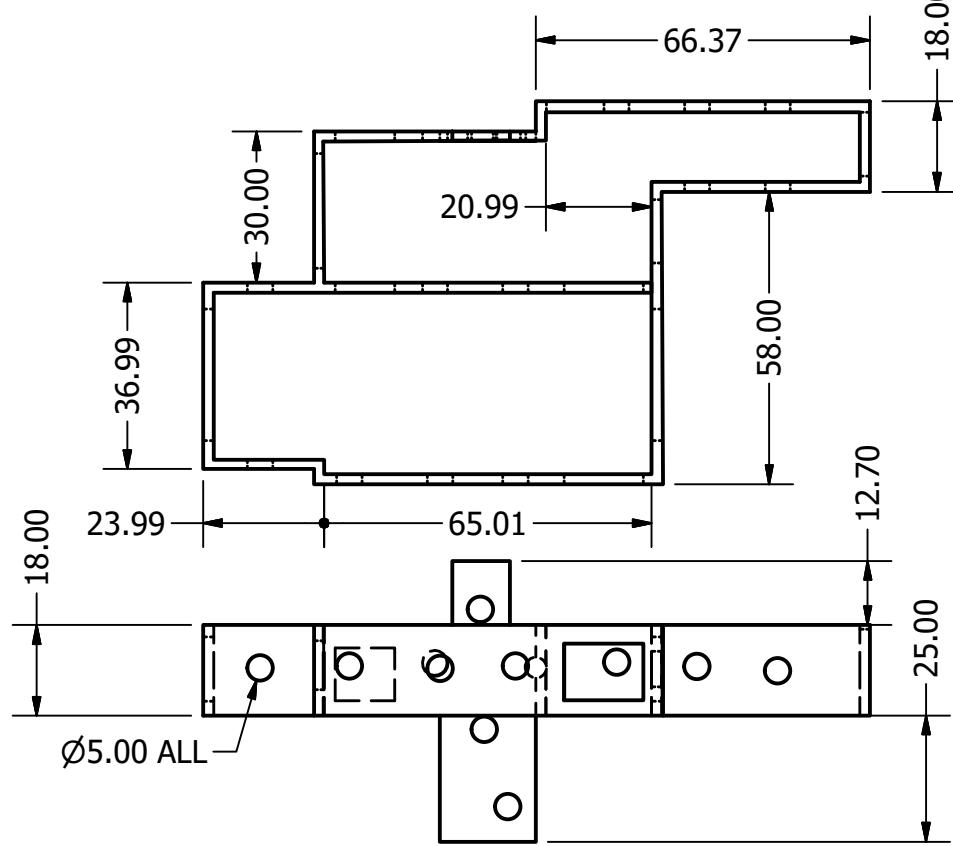
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SHEET 1 OF 1

2

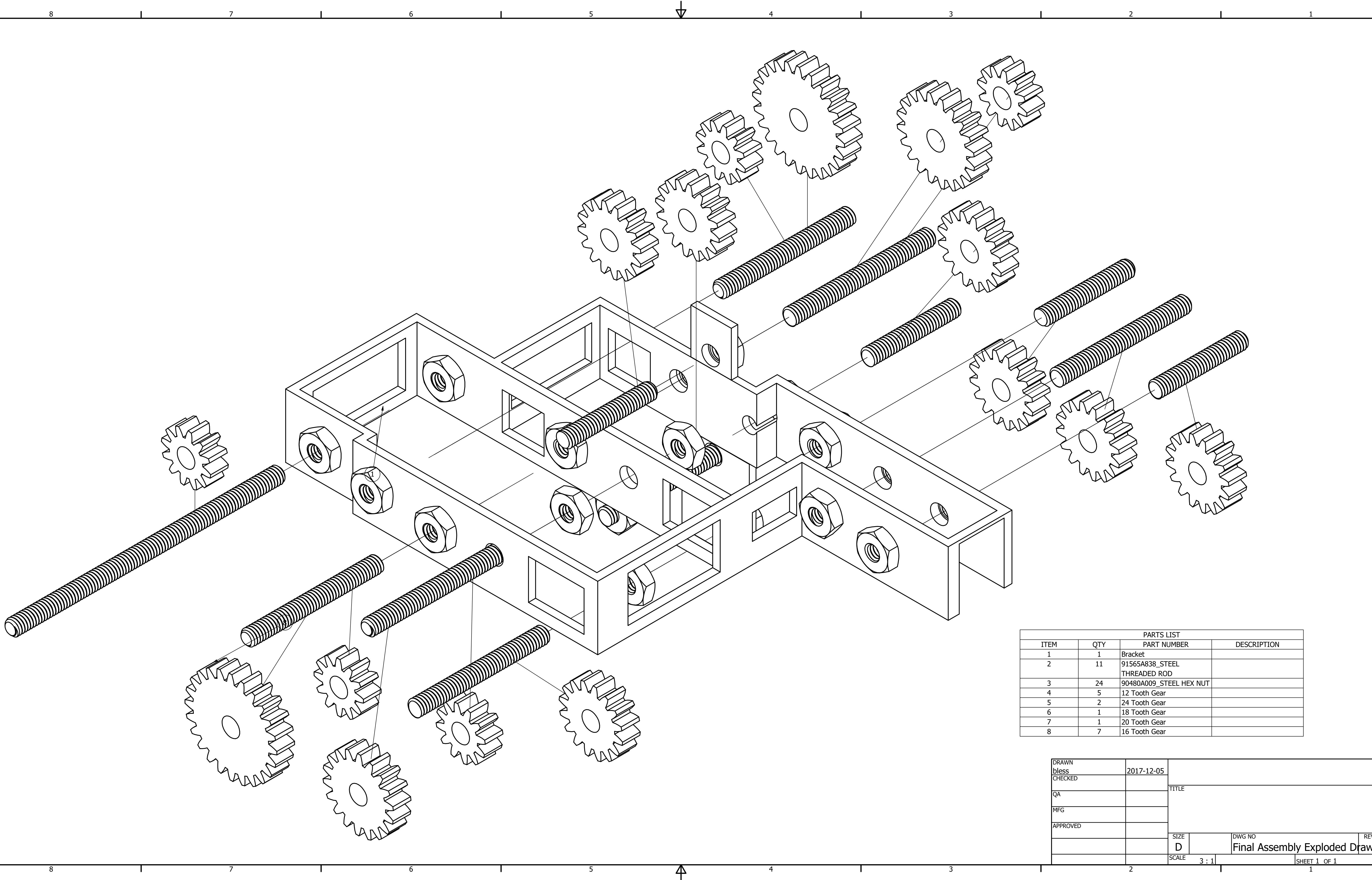
1

A



DRAWN Group 146	2017-12-04	TITLE		
CHECKED				
QA				
MFG				
APPROVED				
		SIZE A	DWG NO 4	REV
		SCALE 2:3		SHEET 1 OF 1

Inner Gear Housing



2

1



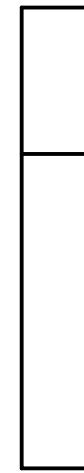
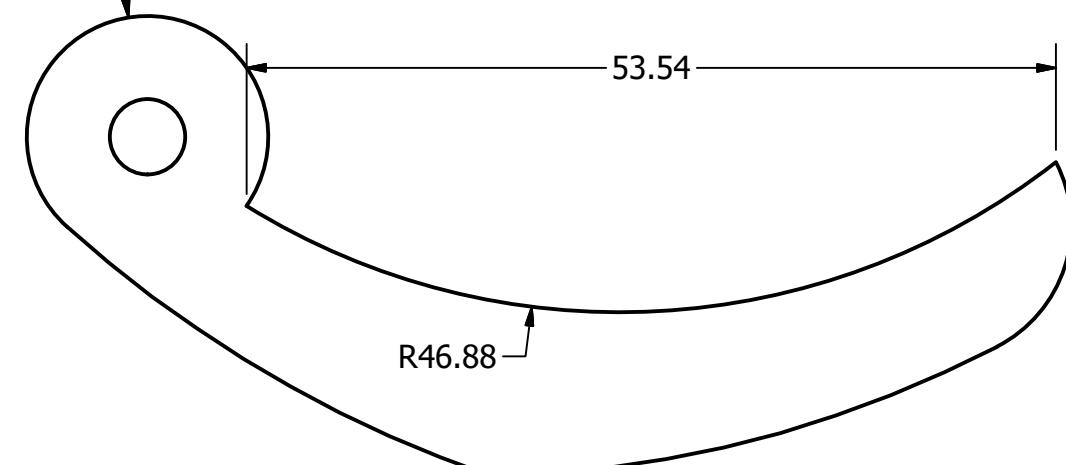
5.50

B

R8.00

53.54

R46.88



A

B



A

DRAWN  
Group 146

2017-12-04

CHECKED

QA

MFG

APPROVED

TITLE

Index Finger and Thumb

SIZE

A

DWG NO

3

REV

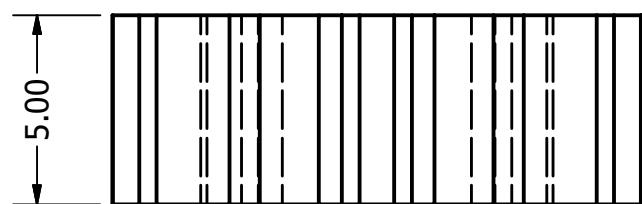
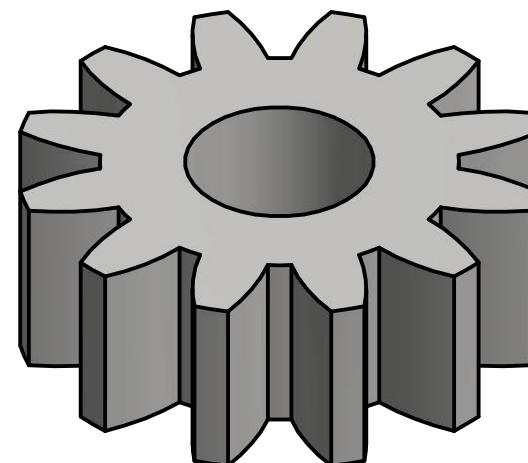
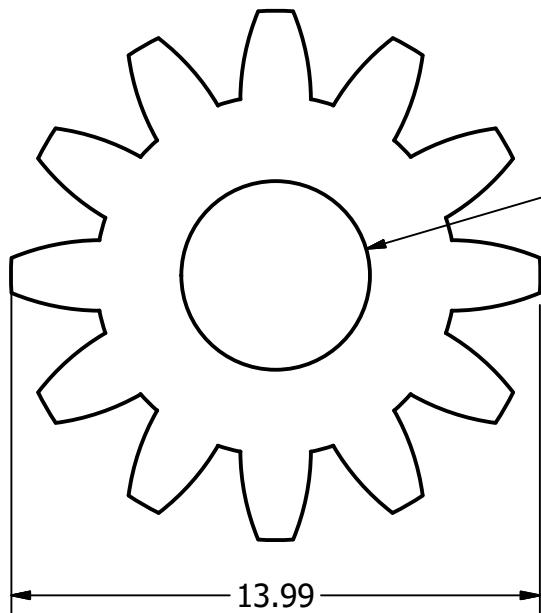
SCALE

2

SHEET 1 OF 1

2

1

DRAWN  
Group 146

2017-12-05

CHECKED

QA

MFG

APPROVED

TITLE

12 Tooth Gear

SIZE

A

DWG NO

5

REV

SCALE

5 : 1

SHEET 1 OF 1

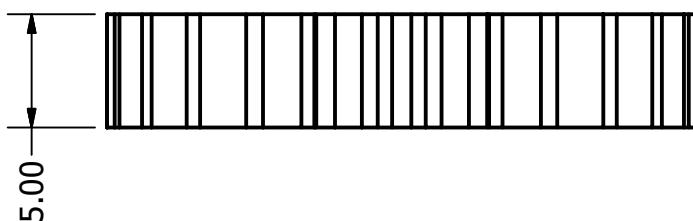
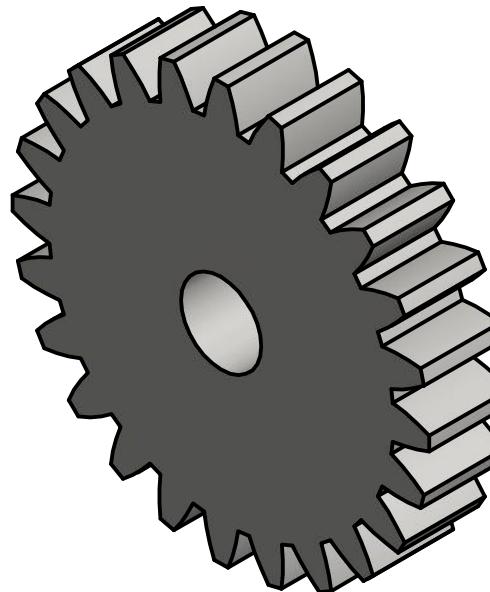
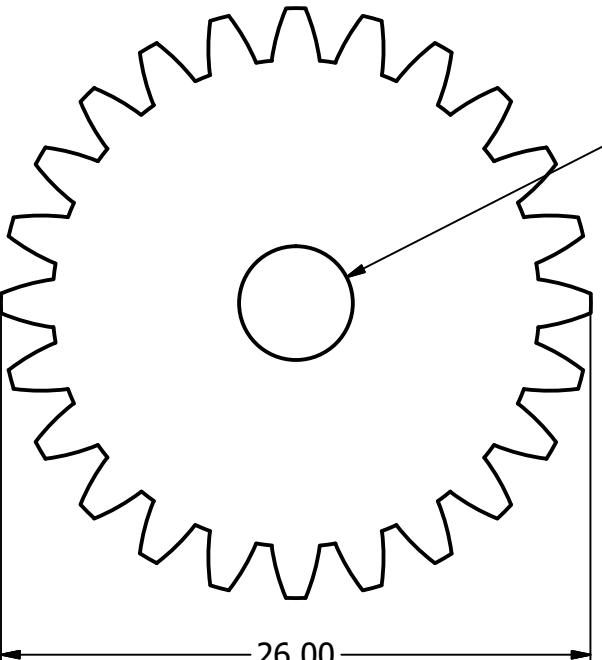
2

1

2

1

B



5.00

DRAWN  
Group 146

2017-12-05

CHECKED

QA

MFG

APPROVED

TITLE

24 Tooth Gear

SIZE

A

DWG NO

6

REV

SCALE

3 : 1

SHEET 1 OF 1

2

1

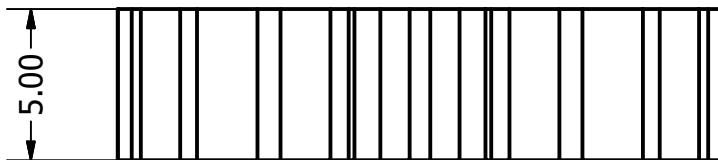
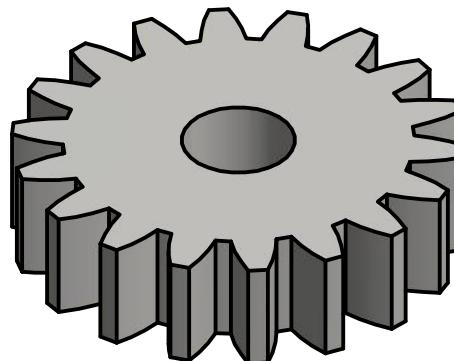
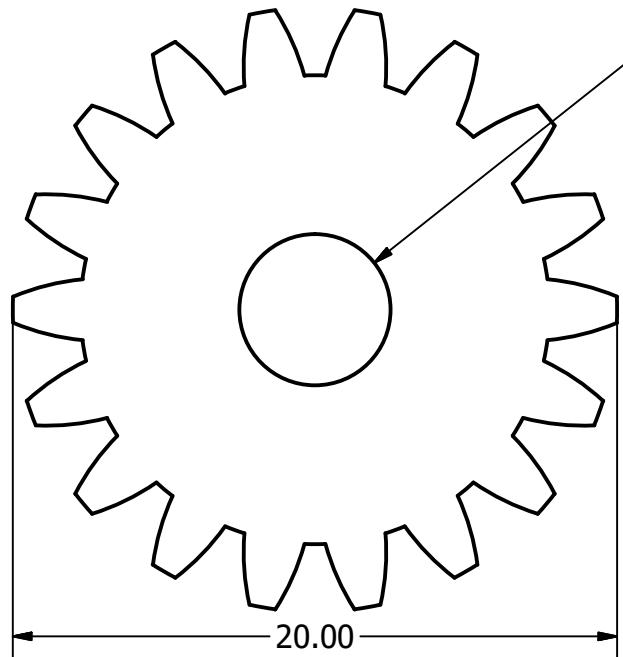
4

2

1

B

B



A

A

DRAWN  
Group 146

2017-12-05

CHECKED

QA

MFG

APPROVED

TITLE

18 Tooth Gear

SIZE

A

DWG NO

7

REV

SCALE

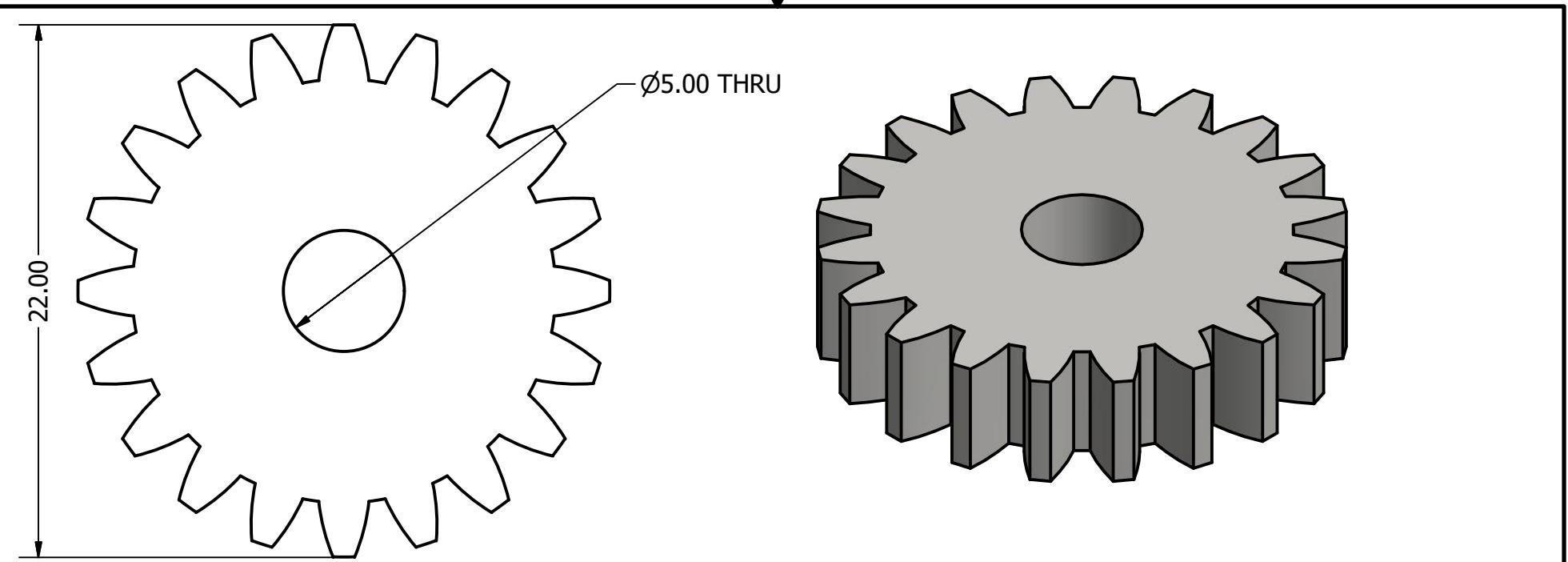
4 : 1

SHEET 1 OF 1

2

1

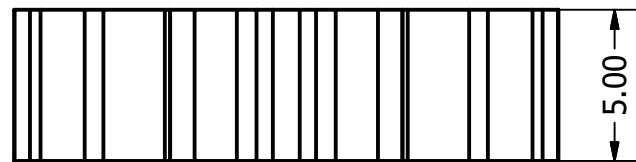
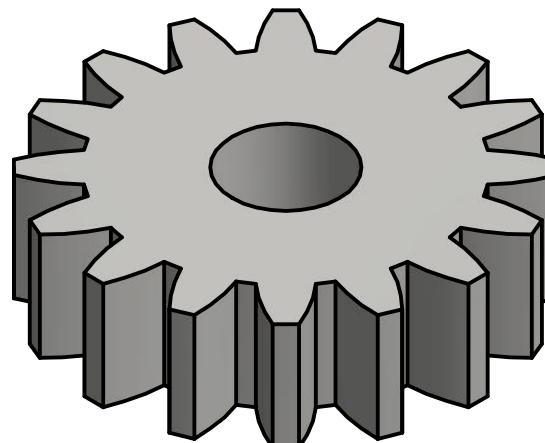
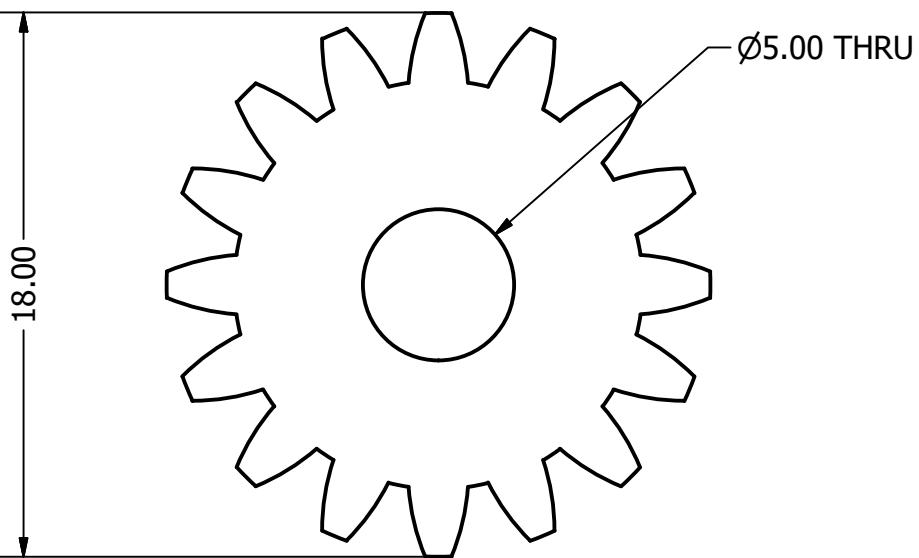
A



DRAWN Group 146	2017-12-05	TITLE		
CHECKED		20 Tooth Gear		
QA				
MFG				
APPROVED		SIZE A	DWG NO 8	REV
		SCALE 4:1		SHEET 1 OF 1

2

1



DRAWN  
Group 146      2017-12-05

CHECKED

QA

MFG

APPROVED

TITLE

16 Tooth Gear

SIZE

A

DWG NO

9

REV

SCALE

4:1

SHEET 1 OF 1

2

1