Engineering Design and Graphics 1C03
McMaster Engineering 1 Cornerstone Project

Instructor: Dr. Doyle

Part 1 – Mechanical Design Research Report

Group 115

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Introduction

As a small team of engineers, we were hired by XYZ Mechanisms. This is a company whose sole purpose is to develop novel ways to accomplish a diverse set of mechanical engineering-related tasks. We were given our first assignment of modifying one of the company's product designs due to a lack of availability of the original motor mechanism. Our job as an engineering team was quite straightforward: we had to develop a different way of controlling the read-head mechanism of a computer CD-ROM drive given an alternate motor with orientation and drive characteristics.

Assigned a modeling and validation modality of Simulation and Prototyping (SAP), it was our job as a team to arrive at a solution to the problem at hand and present it to our clients through the use of various hard modelling and simulation programs as well as constructing a slightly larger scale gear train with all of the necessary parameters. The prototype was to be used simply to demonstrate the final gear ratio and the fact that the components (including gears and worms) worked as expected from the information gathered in the simulations completed.

The task given to our engineering team was done to a high degree of effectiveness. All needs were met and accuracy was maintained. Achieving an exact gear ratio of 0.8282 (400/483) is a simple demonstration of the great attention that this small team had to detail.

Description of Mechanisms

One of the main purposes of the computer CD-ROM drive, and the one focused on for this project, was the control the movement of the read-head. This is accomplished through the use of a mechanism to control the read-head. This mechanism quite often contains various spur gears, worms and worm gears that work in tandem to attain, for one, a particular pre-determined gear ratio. This gear ratio is attained by using ratios of pitch diameters or number of teeth of gears. The use of diverse components also allows for the change of axis of rotation and direction of motion, both of which could not be attained through the use of a simple spur gear train.

In simple terms, the mechanism to control the read-head converts the initial rotational speed of a motor of 120.75 RPS into a final rotational speed of 100RPS which translates to a constant linear speed of 0.1875m/s that will be transferred to the read-head. This constant linear velocity is critical in how accurately information from the disc is gathered and converted. The gear train design presented in this report is a good example of this process from input to output. But, between the initial and final steps of this gear train, there are many crucial interstitial stages.

A worm coming out directly from the motor is then meshed with a worm gear to greatly lower the rotational speed and to change the axis of rotation of the following gears by 90°. A worm gear can only be attached axially to a spur gear, giving them both the same rotational speed (any two gears attached coaxially have the same rotational speed). The spur gear then meshes with another spur gear, changing the direction of rotation and increasing the gear ratio. This type of gearing pattern is followed for two more stages. An odd number of meshes means that the final gear will be rotating in the opposite direction to the first gear. From the final spur gear in the train, an output worm is attached coaxially. Combined with a rack, as the worm turns, it will cause a linear movement of the rack (or read-head, in this case) along the length of the worm.

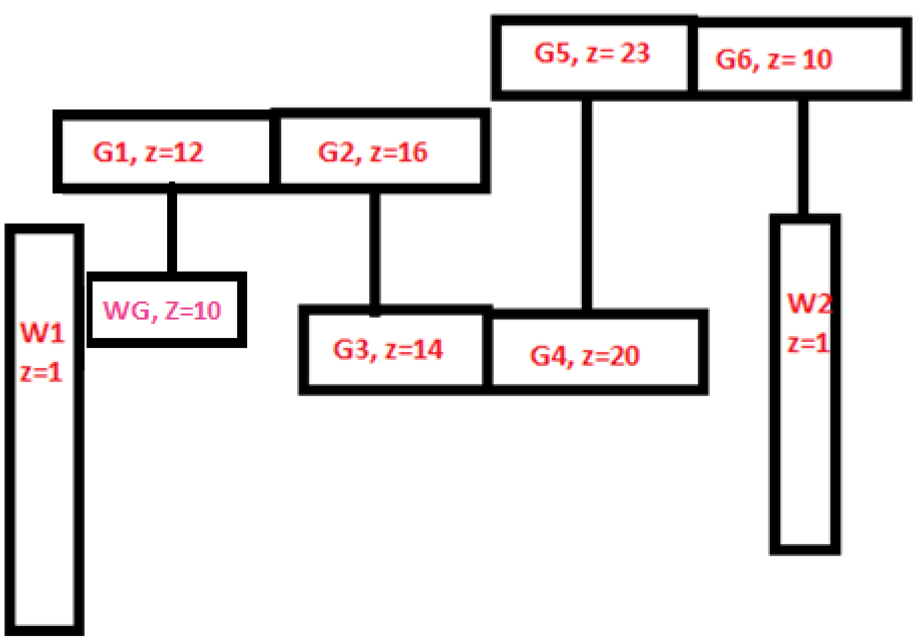
Calculations for Gear Train Design

Motor input speed = 115*63 = 7245 RPM /60s = 120.75 RPS
W_{in} = 120.75 RPS, W_{out}=100 RPS

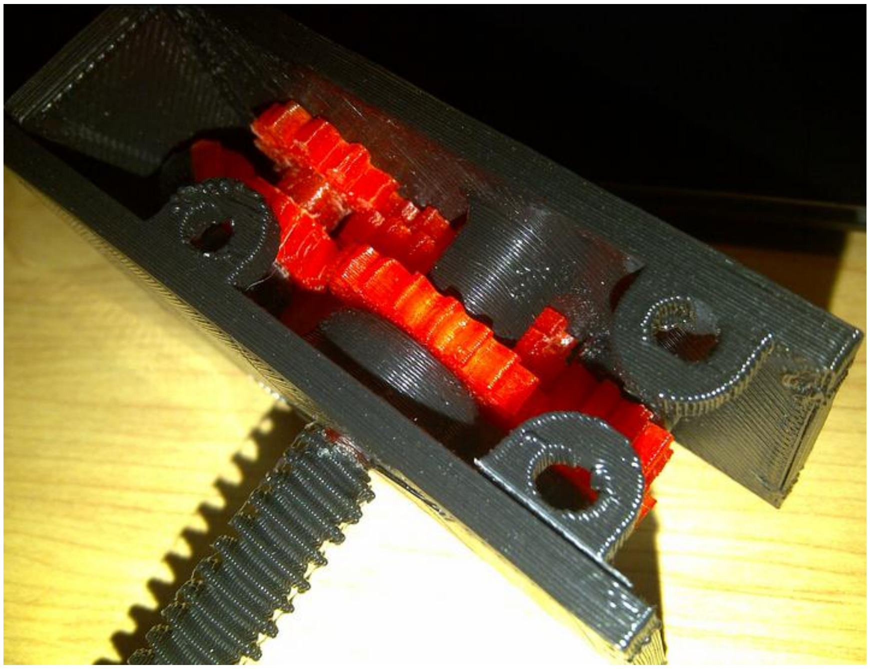
W_{out} =W_{in}/(Gear Ratio)
Gear Ratio = 100/120.75 = 0.8282

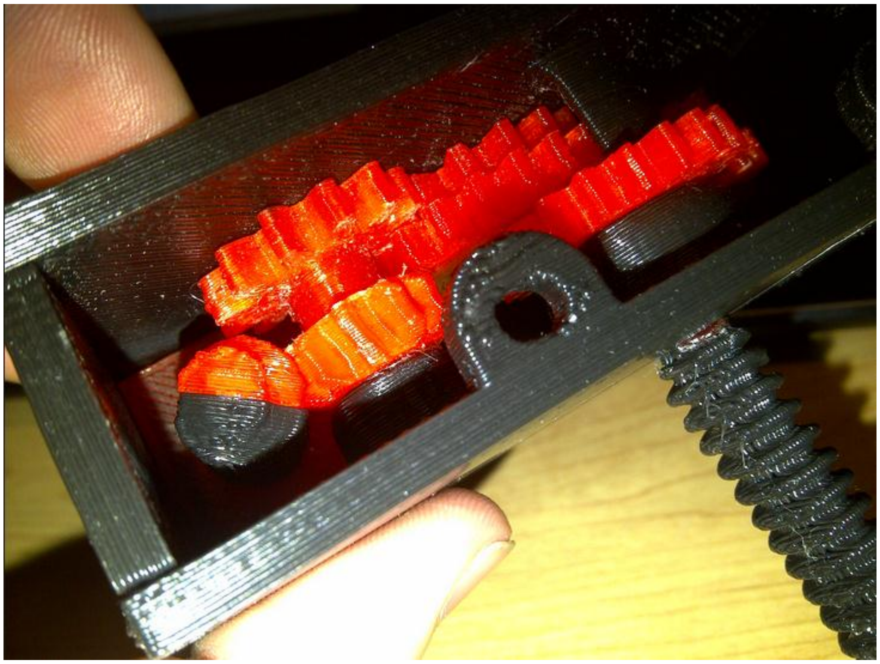
Gear Ratio= D2/D1 * D3/D2 * D4/D3 * D5/D4 * D6/D5
Gear Ratio = (16/12) * 1 * (20/14) * 1 * (10/23)
= 400/483
= 0.8282

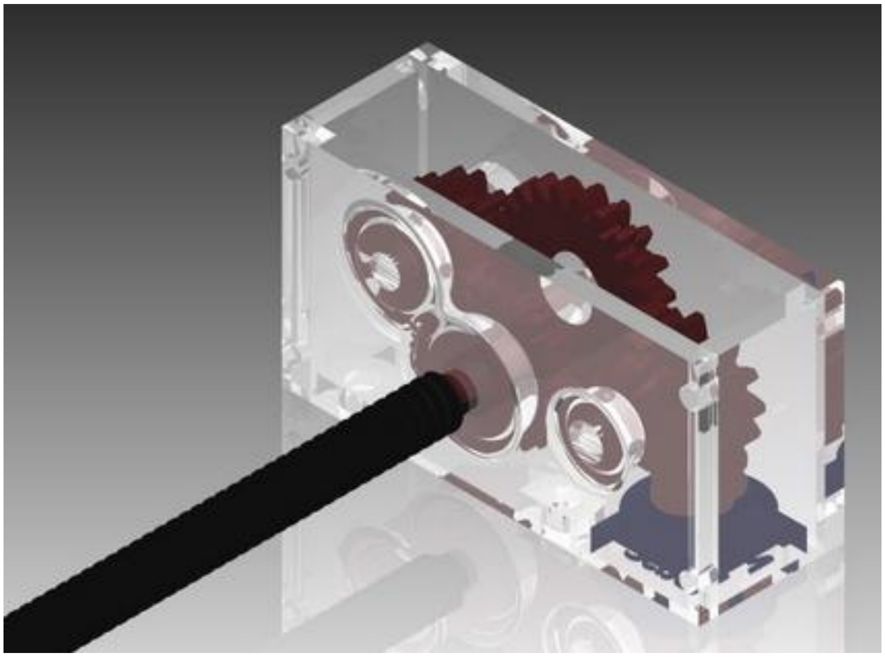
	Pitch Diameter (mm)	Module (mm)	Number of Teeth
Worm 1	N/A	Tan mod =1 ACP = pi= 3.14	1
Worm Gear 1	10	1	10
Gear 1	12	1	12
Gear 2	16	1	16
Gear 3	14	1	14
Gear 4	20	1	20
Gear 5	23	1	23
Gear 6	10	1	10
Worm 2	N/A	Tan mod = 0.0597 ACP = 0.1875	1

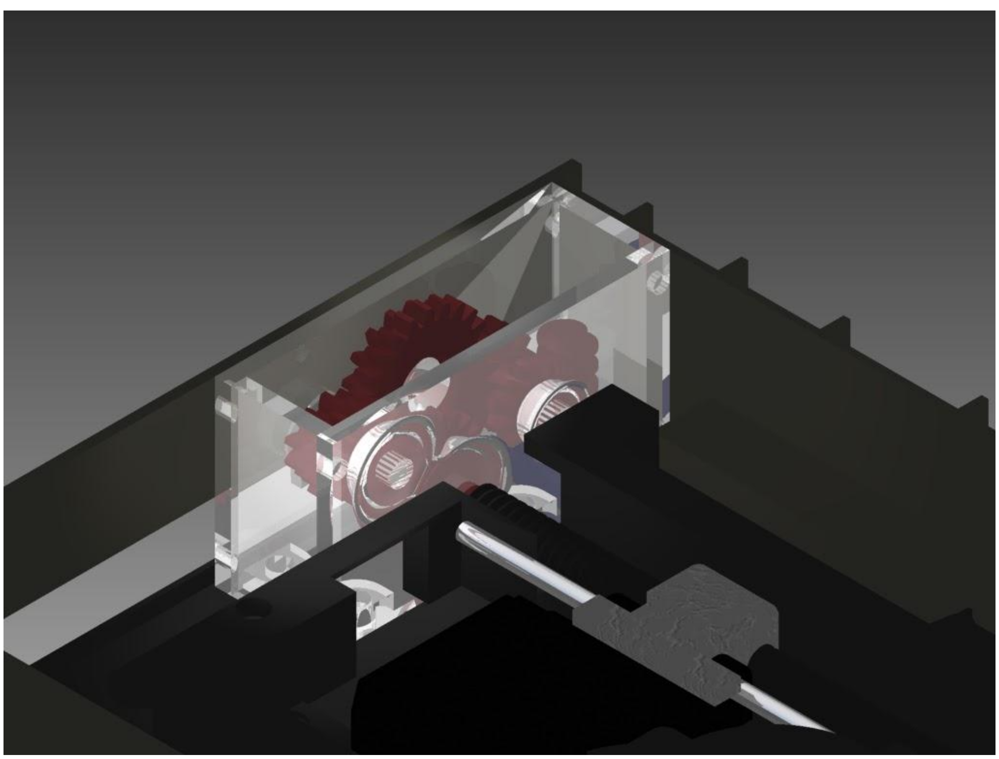


Gear Train Design (Photos and Assembly)



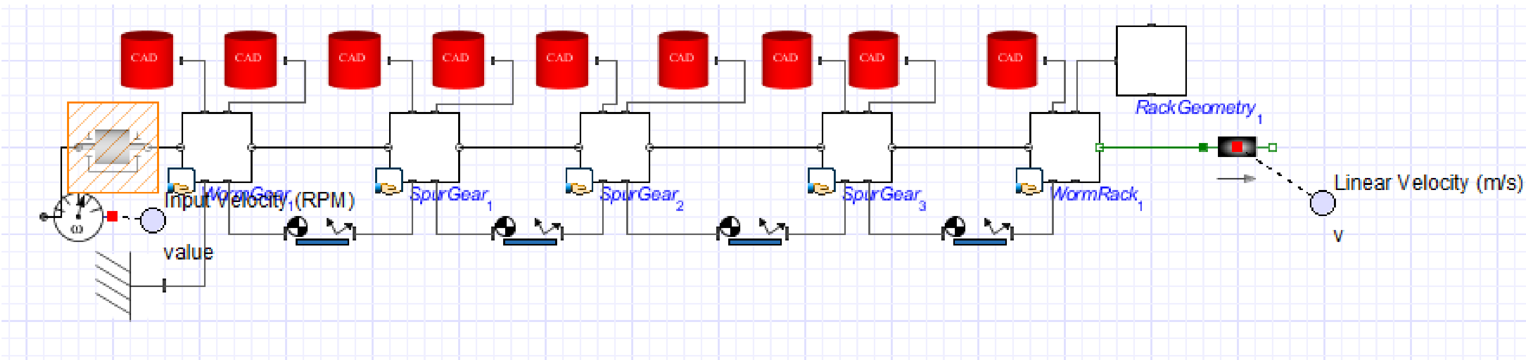




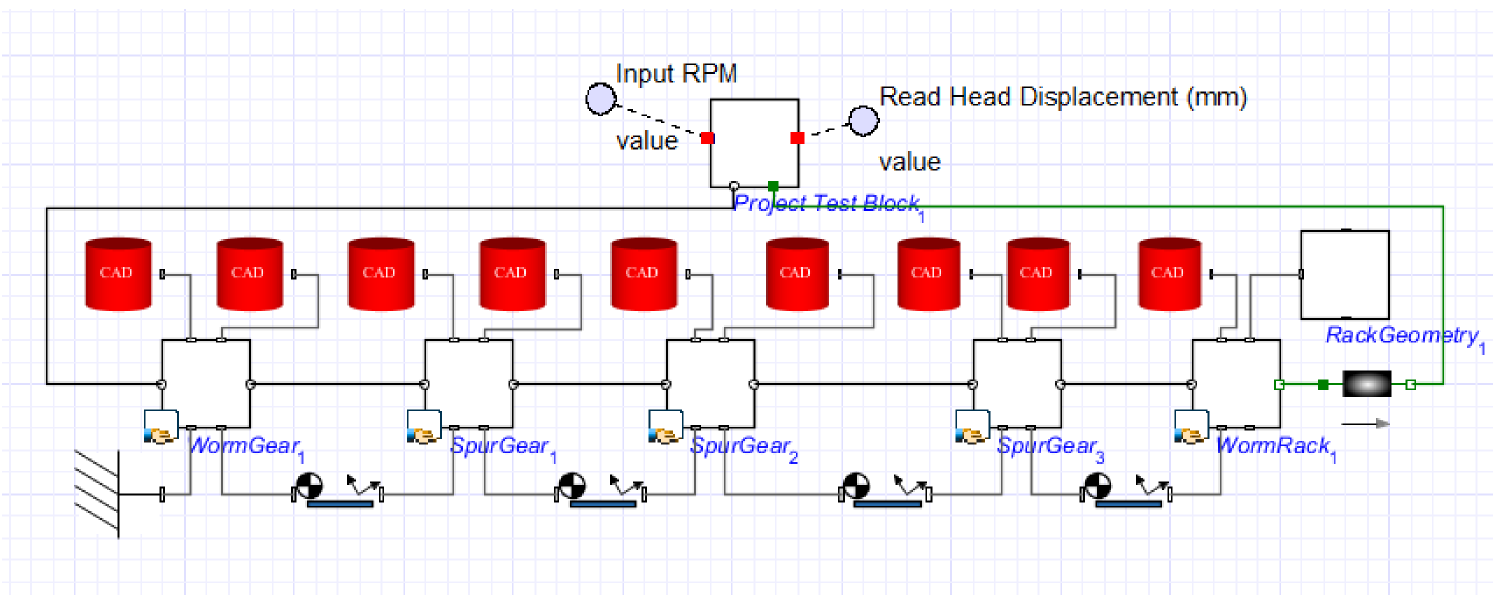


Final MapleSim 2-D Schematic Model

Conventional CD-ROM Simulation

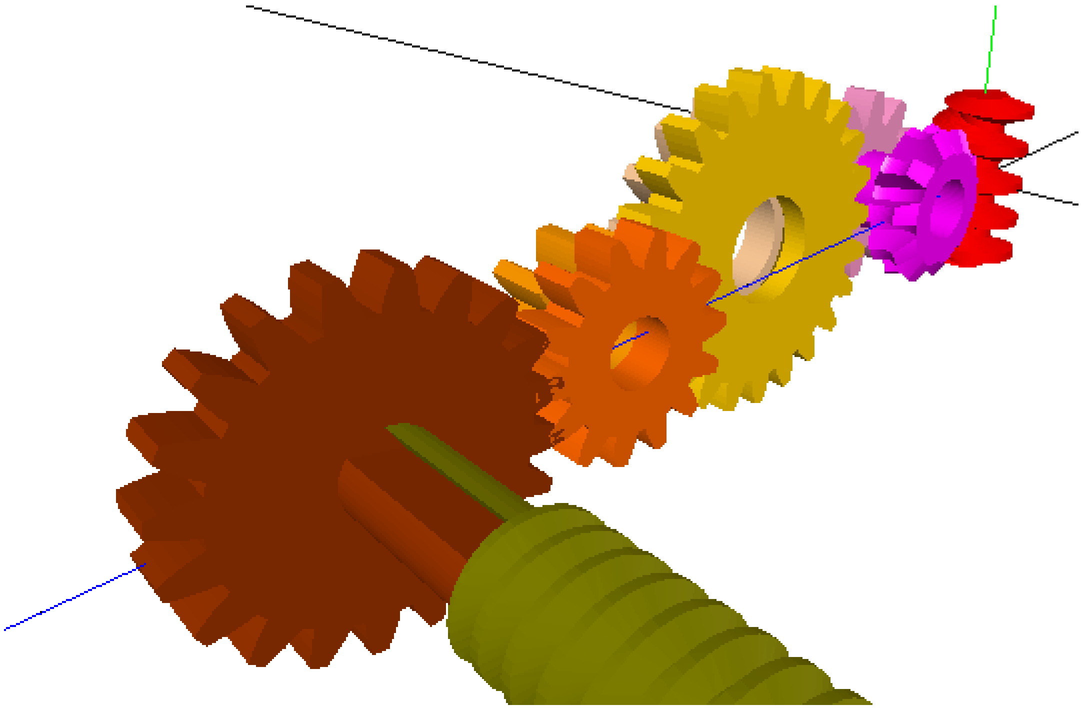


CD-ROM Simulation with test block

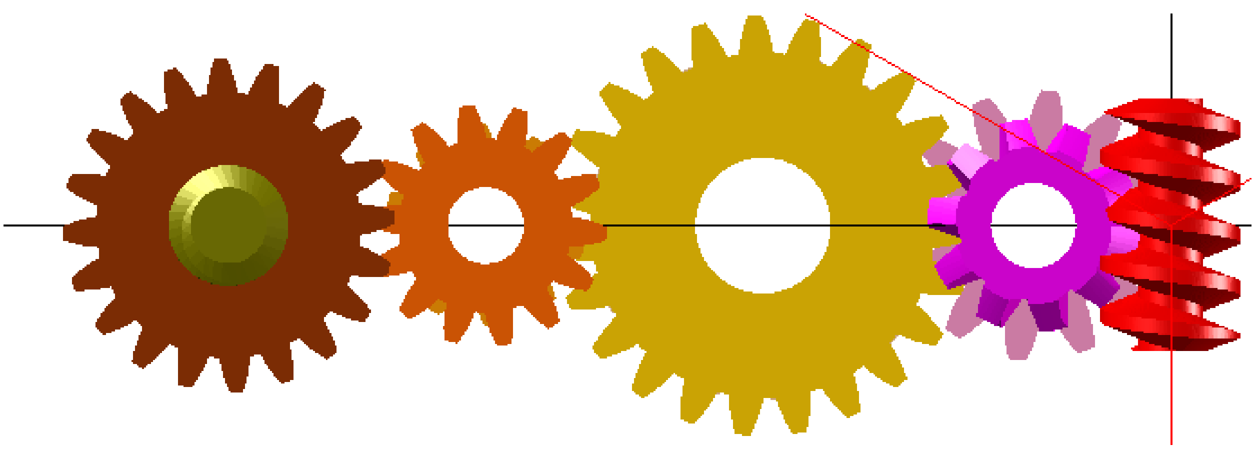


Final MapleSim 3-D Graphical Model

Generic View



View showing which gears are coaxial



Probe Graphs

Input and Output Graphs for Gear Train

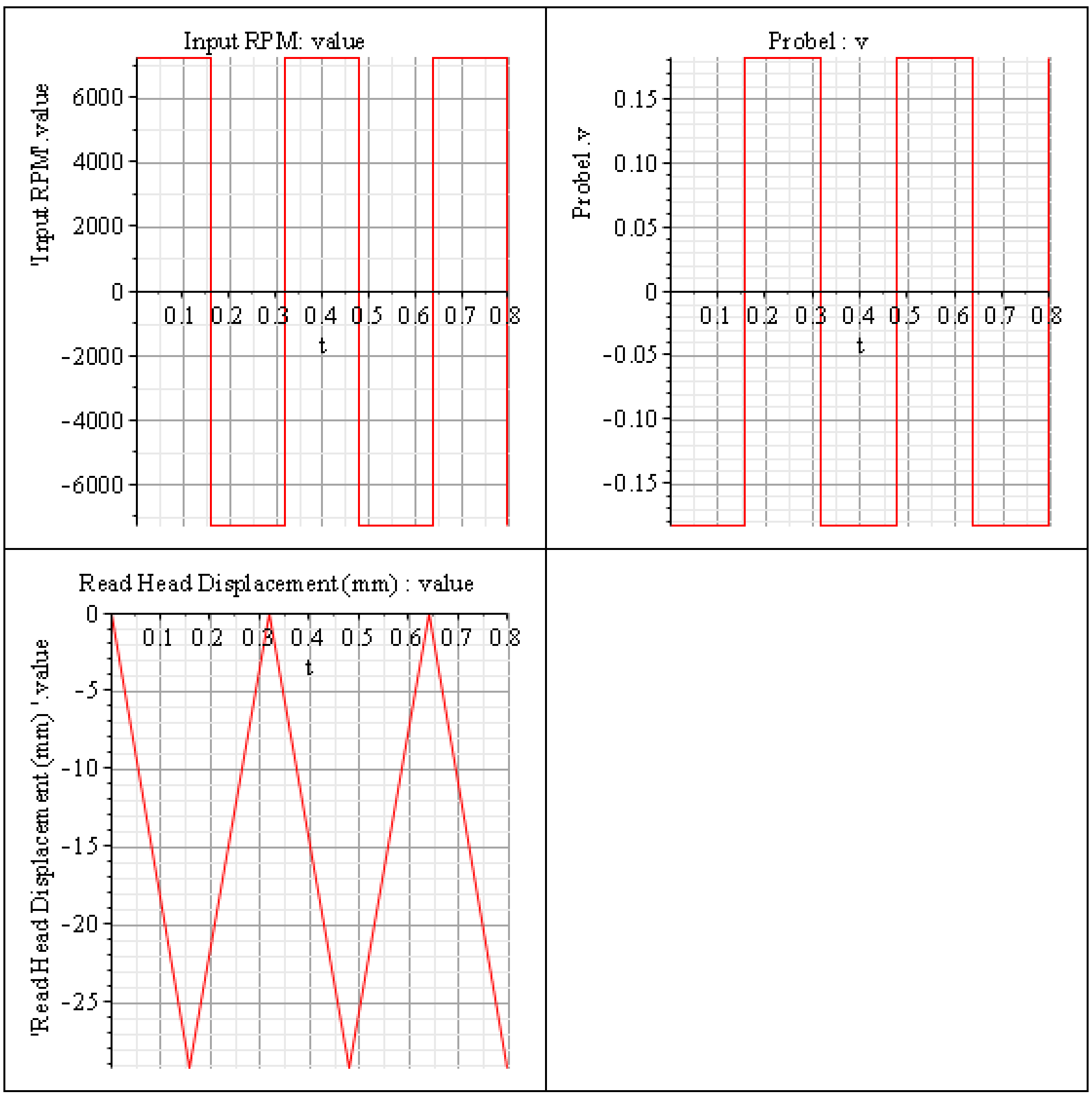


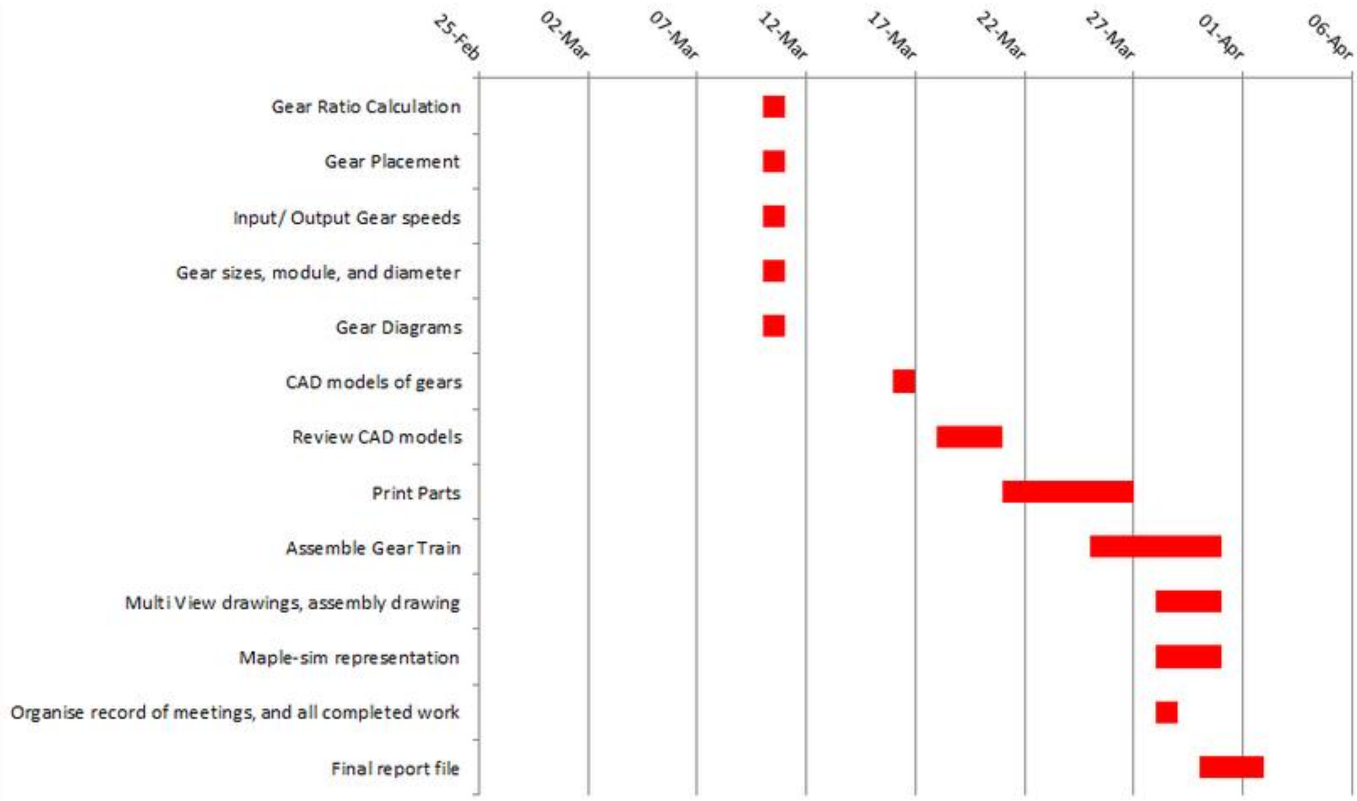
Table of Member Contributions

Task\\Group Member	Eric	Prakhar	Jonathan	Date Completed
Secretary/ keeper of minutes	✓			N/A
Gear Ratio Calculation	✓	✓	✓	March 10
Gear Placement	✓	✓	✓	March 10
Input/ Output Gear speeds	✓	✓	✓	March 10
Gear sizes, module, and diameter	✓	✓	✓	March 10
Gear Diagrams	✓	✓	✓	March 10
CAD models of gears		✓		March 16
Review CAD models	✓	✓	✓	March 20
Print Parts (day 1)	✓	✓	✓	March 21
Print Parts (day 2)	✓	✓		March 25
Assemble Gear Train	✓			March 25
Print Parts (day 3)	✓	✓	✓	March 27
Multi View drawings, assembly drawing		✓		March 28-29
Maple-sim representation		✓		March 28-29
Organise record of meetings, and all completed work	✓			March 28-29
Final report file			✓	March 29-31

Records of Team Meetings

Date	Attendance	Topic	Result
March 10	Jonathan Eric Prakhar	Milestone 1 -Gear Ratio/Input-Output speeds -Gear placement in tray -Table of gear information -Gear diagrams	-Successfully completed all topics on the agenda, within a few hours. Submitted the milestone 1 project.
March 13	Jonathan Eric Prakhar	-What's next?	-Discussed what to do next for the project. 3-D CAD models of the gears must be made.
March 16	Prakhar	-Make CAD models of all gears, and a mounting bracket (gears made from milestone 1 data)	-Accurate CAD models created to be printed.
March 20	Jonathan Eric Prakhar	-Review the CAD models, and improve the mounting bracket (make sure all gears are right, make improvements if necessary)	-All CAD models are correct. Mounting bracket is well designed, and needs no changes. (Good job Prakhar!)
March 21	Jonathan Eric Prakhar	-Printing Day 1 -Print all the parts (mounting bracket, axles, gears) to make the gear train	-Had some minor printer difficulties. Only managed to print the mounting bracket pieces. Printer left printing overnight, parts to be picked up the following day.
March 25	Jonathan Eric Prakhar	-Printing Day 2 -Print all gears, and re-print parts of the frame	-Spent a long time working with a broken printer. Eventually changed to a new printer, and printed all remaining parts.
March 25	Eric	-Assembly of the gear train -Smooth out axles, and make parts fit together. Make the gear train run smoothly	-Successfully made all parts fit together. Gears all turn freely on their axles; mounting bracket holds gears in place.
March 27	Jonathan Eric Prakhar	-Realised we forgot the final (output) worm. -Make a CAD model and print the final worm	-Set the printer up to print, and left for class. Came back a few hours later and the worm printed successfully.
March 28-29	Prakhar	-Create multi view drawings of all gears and mounting bracket pieces. - Create assembly drawings of the gear train and mounting bracket -Make a MapleSim 2-D and 3-D model of the gear train	-Required more time and caused more difficulty than initially expected. -Took a few tries to get files into a format that can be shared with other computers
March 28-29	Eric	-Attach the final output worm, and input worm to the gear train. -Organise and update all meeting records	-The final output worm did not print well, causing it to not be attached smoothly. -The starting worm (out of the motor) does not mesh perfectly with its worm gear, making the gear train not run smoothly
March 30-31	Jonathan	-Take all technical drawings, calculations, meeting records, etc and compile them into 1 tidy PDF document to be submitted	-Took multiple tries to transfer all files properly between computers.

Gantt Chart


25-Feb
02-Mar
07-Mar
12-Mar
17-Mar
22-Mar
27-Mar
01-Apr
06-Apr
Gear Ratio Calculation
Gear Placement
Input/ Output Gear speeds
Gear sizes, module, and diameter
Gear Diagrams
CAD models of gears
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Final report file

Index of Engineering Drawings

Figure 1

Isometric Drawing of Assembly

By: Prakhar Garg

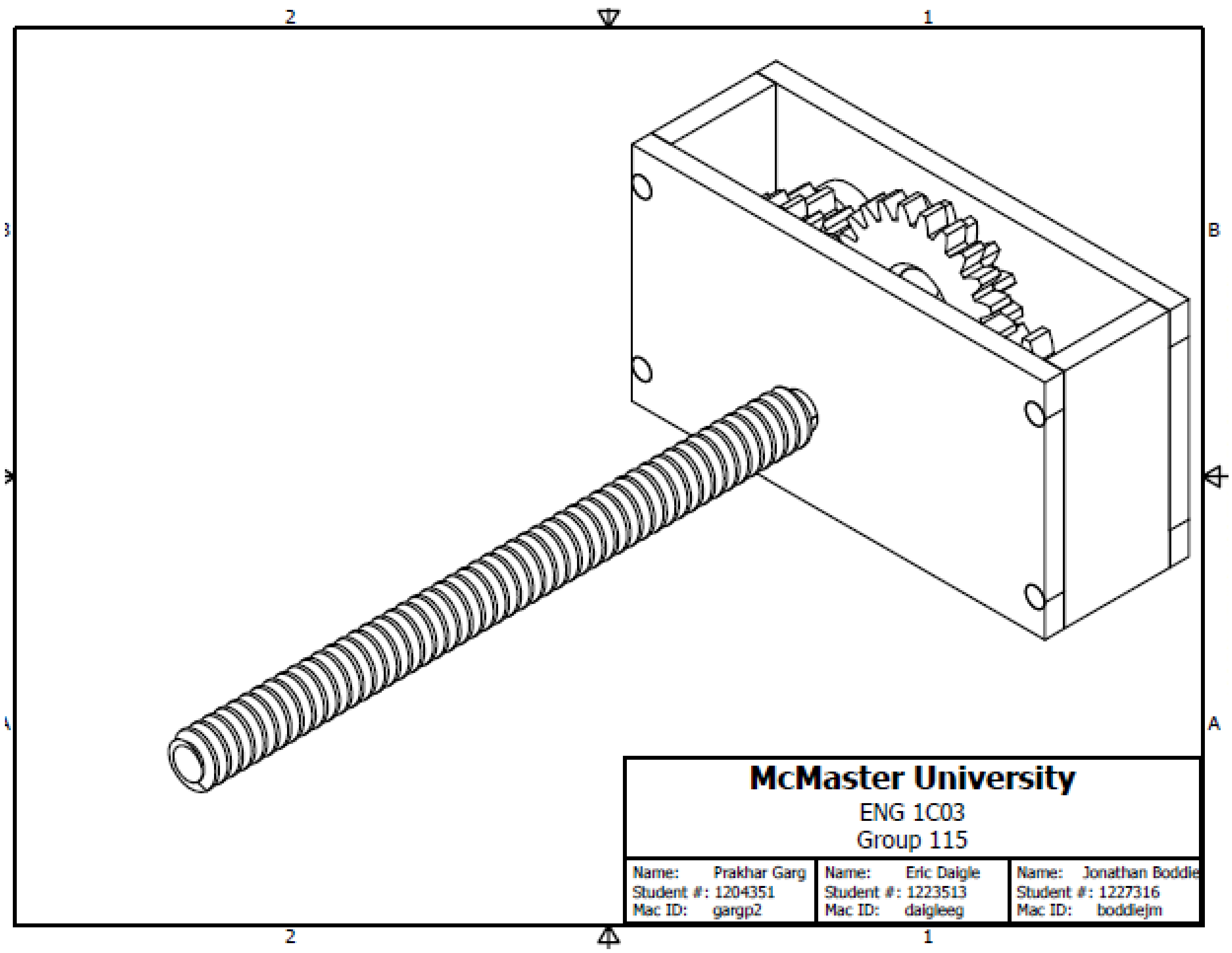


Figure 2

3-Profile Drawing of Assembly with Rear-facing Isometric

By: Prakhar Garg

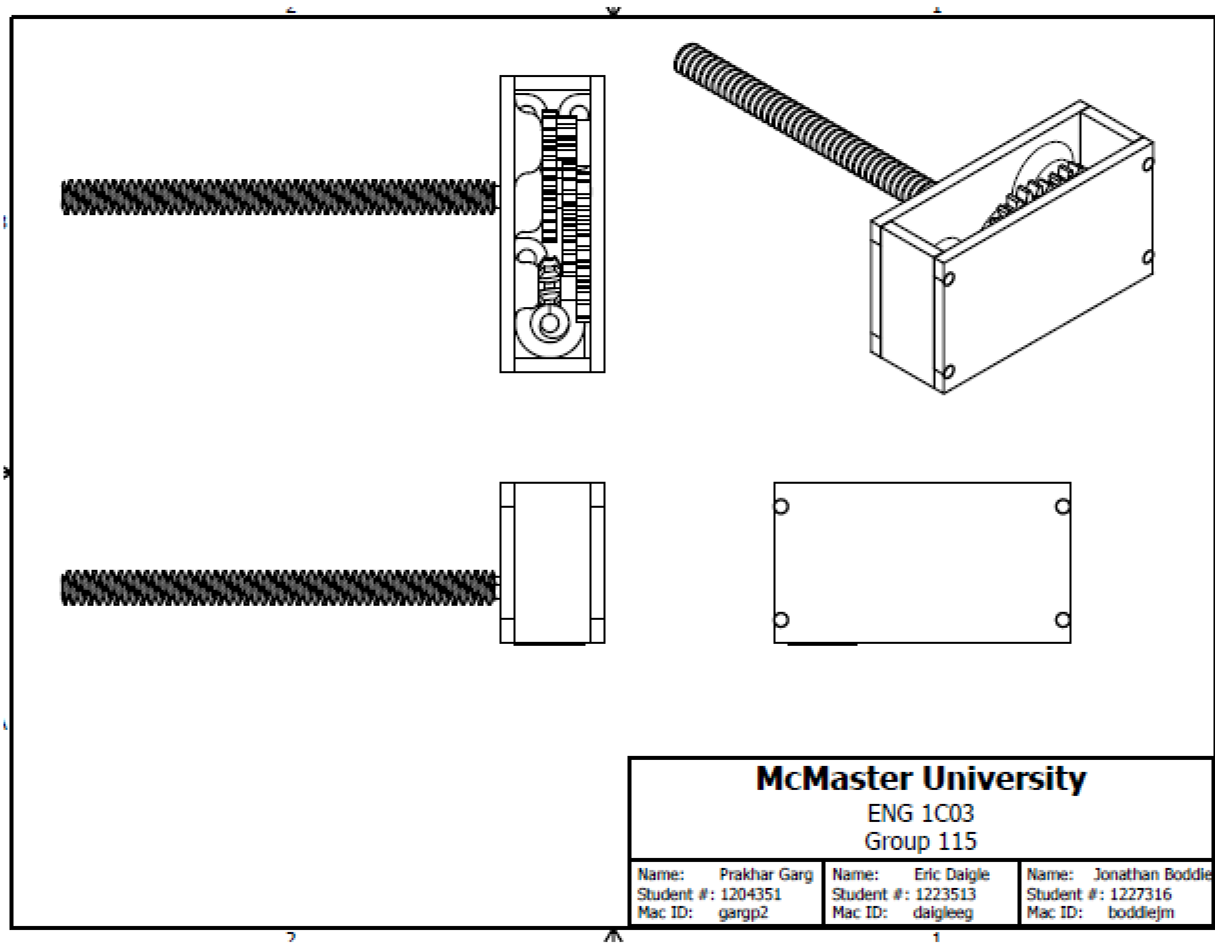
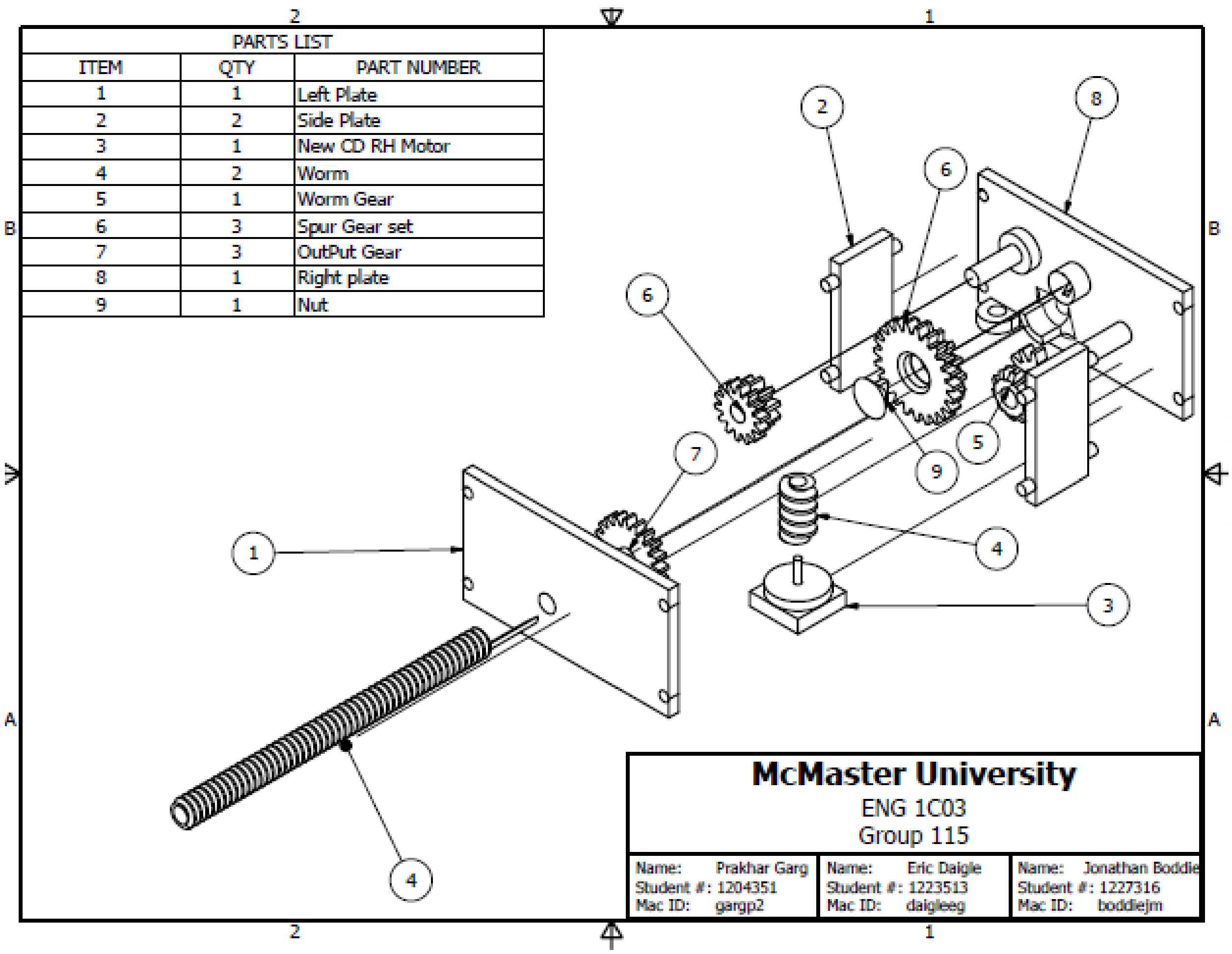


Figure 3

Exploded Assembly Drawing

By: Prakhar Garg



PARTS LIST		
ITEM	QTY	PART NUMBER
1	1	Left Plate
2	2	Side Plate
3	1	New CD RH Motor
4	2	Worm
5	1	Worm Gear
6	3	Spur Gear set
7	3	OutPut Gear
8	1	Right plate
9	1	Nut

Figure 4

Detailed Drawings of Gears and Worms

By: Prakhar Garg

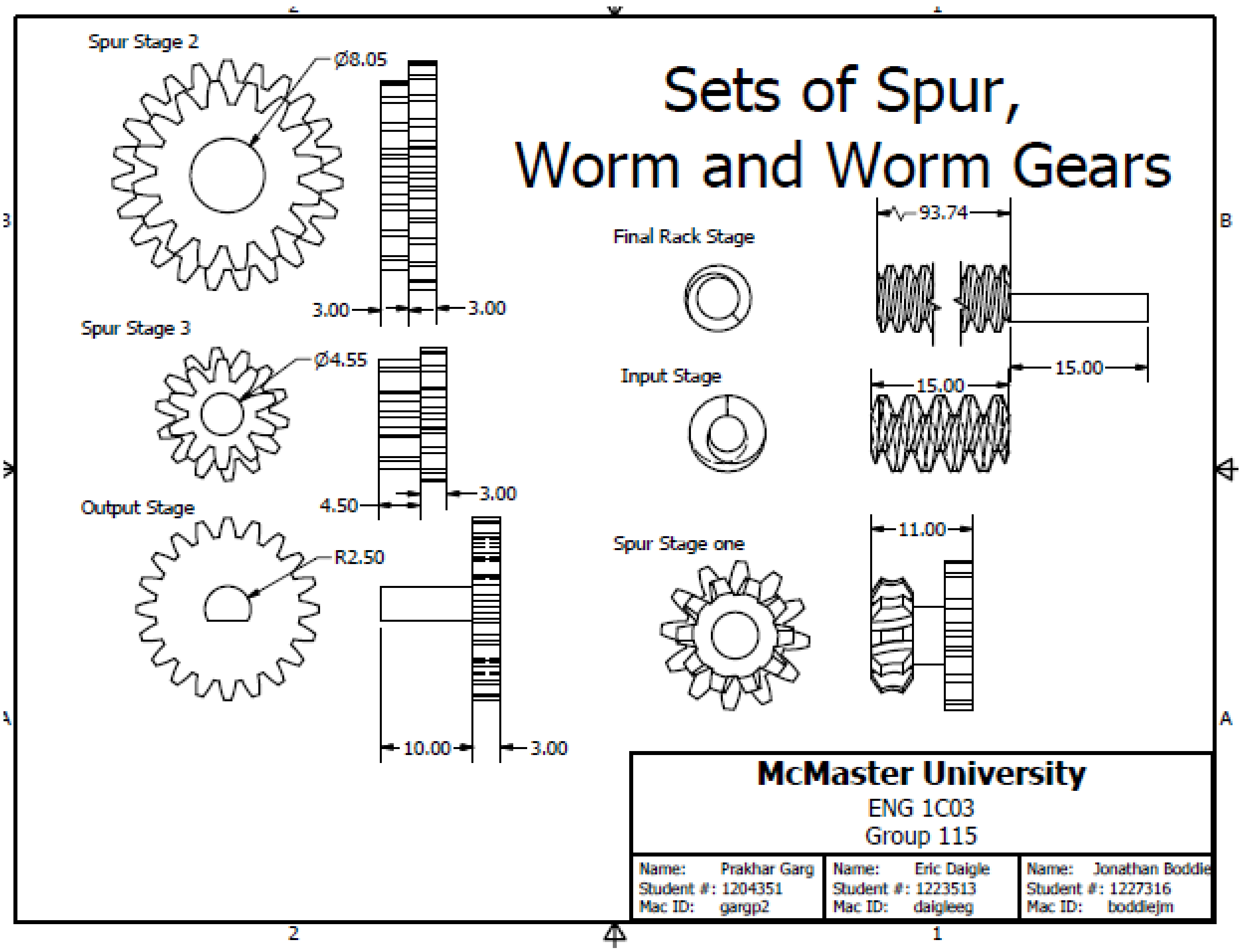


Figure 5

Detailed Drawing of Left Mounting Plate

By: Prakhar Garg

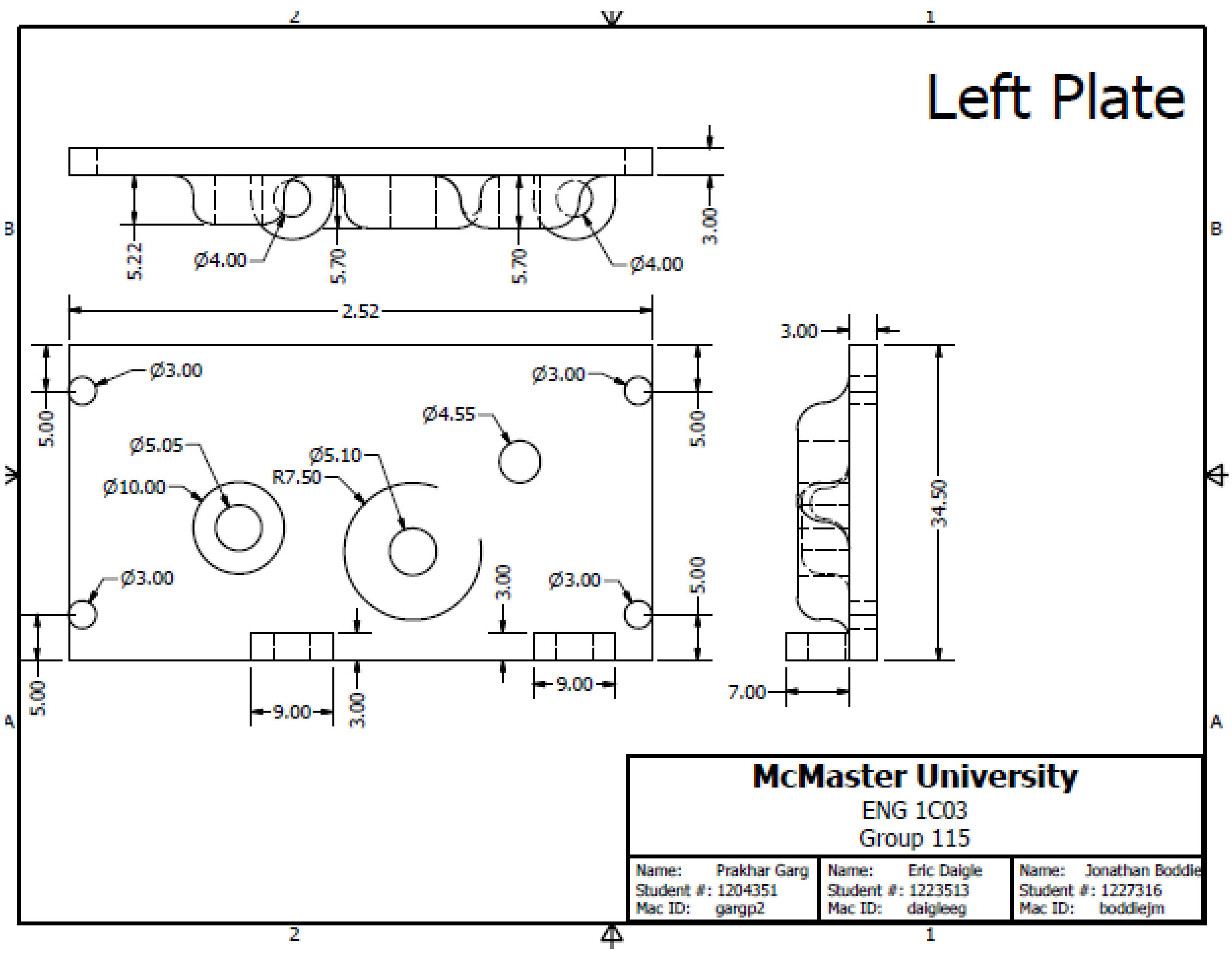


Figure 6

Detailed Drawing of Right Mounting Plate

By: Prakhar Garg

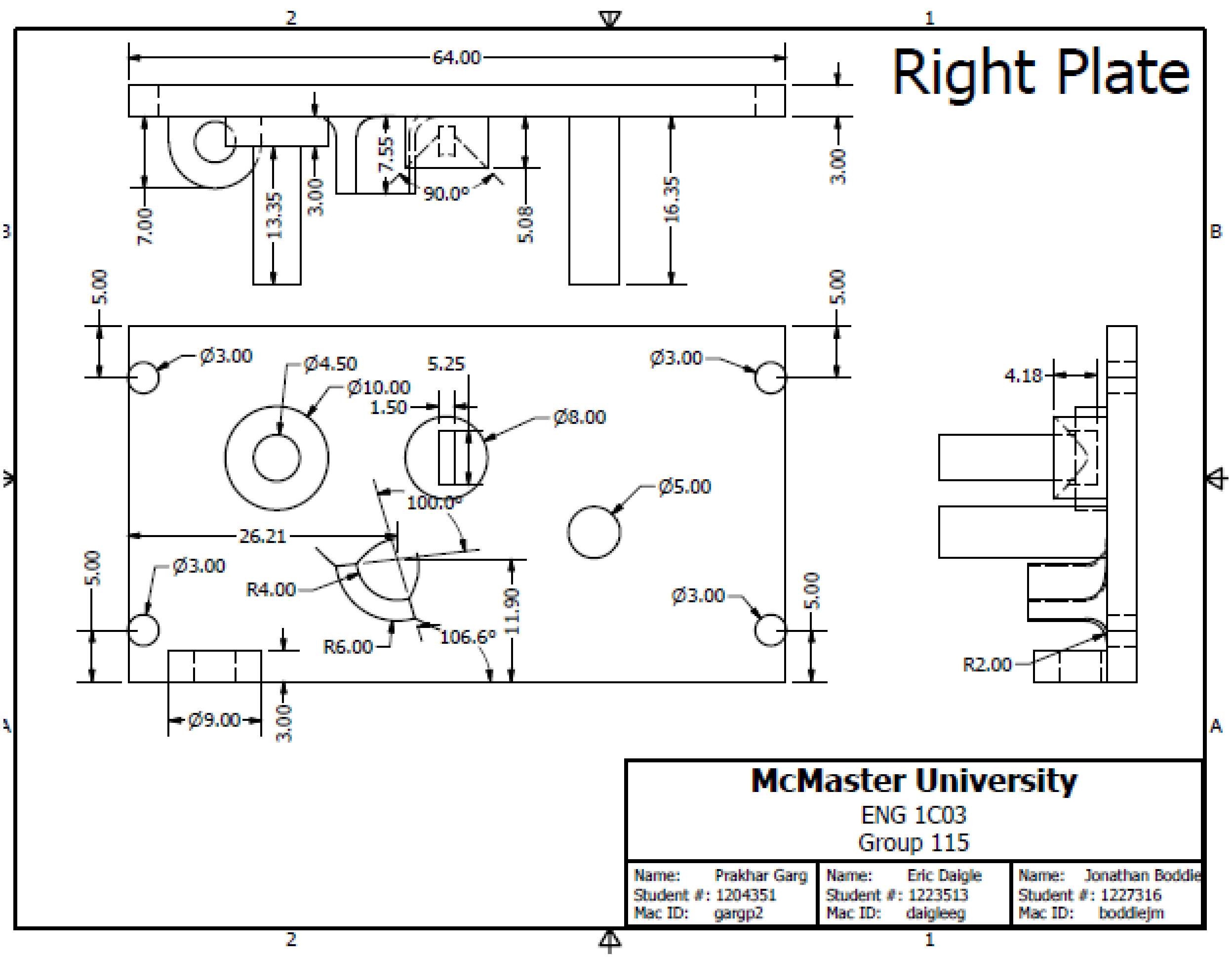


Figure 7

Detailed Drawings of Side Mounting Plate and Nut

By: Prakhar Garg