ENGINEER 1C03 - Engineering Design & Graphics
Engineering 1 Cornerstone Design Project
Instructor: Dr. McDonald
Technical Report
Team 33
Lab Section: L10

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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 this 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 [Thomas Armena, 400078381] ____________________
Signature

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 this 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 [Maaz Azam, 400069421] ____________________
Signature

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 this 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 [Youssef Asham, 400062761] ____________________
Signature

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 this 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 [Nadeem Talaat, 400088168] ____________________
Signature

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Introduction

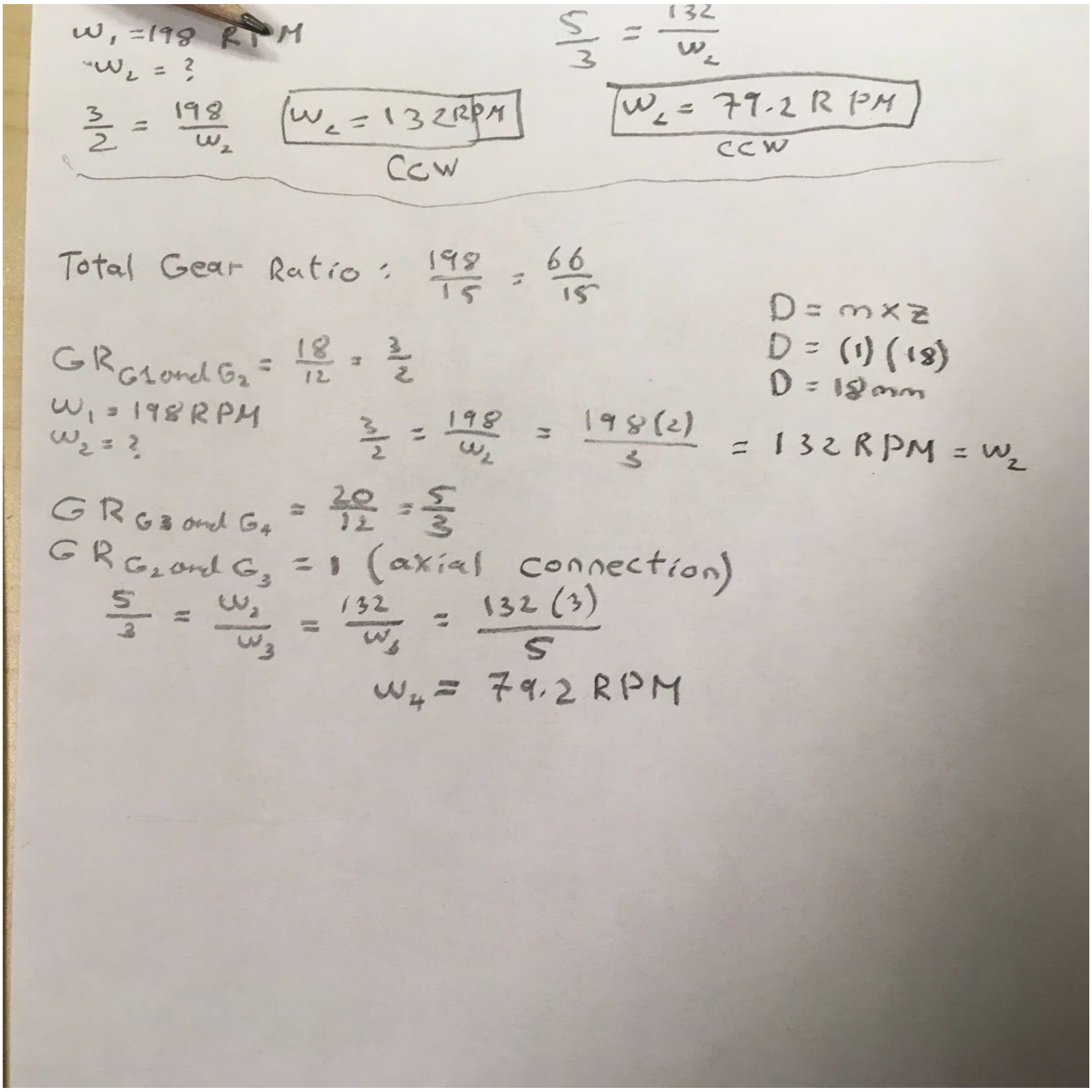
Prosthetics is a new and expanding field of study in the world of technology. Many companies, a leading example in the industry being Openbionics, have done years of research and modelling in the creation of a prosthetic hand. Through the use of 3D scanning and printing technology, a prosthetic hand prototype could be modelled to represent anthropomorphic (human-like) actions, such as general finger movements or the grasping of an object at a high degree of mobility and dexterity. The prosthetic hand replicates the most prominent joints found in a human hand in order to successfully re-enact the movements of the hand as well.

The McMaster Engineering team was hired by the biomedical company, 'BME Devices' and presented with the assignment of creating a low-cost gripping apparatus, resembling a prosthetic hand. This design consists of a gearing mechanism controlled by a single motor that is capable of finger-like movements, such as the opening and closing of the index finger and thumb. The design was created by a series of spur gears (gear train) held together by a mounting bracket, with a unique given input speed of 198 RPM and a final output speed of 15 RPM. The combination of meshing and axial gears together allowed for the manipulation for the direction and speed of the output gears that control the fingers. The fingers must be able to rotate about a fixed axis and the tips of the fingers must be able to contact each other within a specified volume of space.

Our Mechanism

For our design, we intend to use only spur gears, to avoid potential complexities and to make the design easier to build. We will use both meshing and axial gears in a gear train in order to manipulate the direction and speed of the output gears that control the fingers. In our project, the input speed of the motor is 198 RPM and the targeted output speed of the motor is 15 RPM. Due to the fact that the width of the prosthetic hand is 70mm we had to adjust the gears such that they fit vertically in the frame. Our proposed design initially starts with the 12mm gear that is attached to the motor due to the fact that the motor was 15mm in diameter and thus a small gear was needed to be placed. Following it is an 18mm gear meshed to it and then axially connected to another 12mm gear. This reduces the speed to 132 RPM and later the diameter of the gears increase, keeping in mind that the 20mm and the 24mm gears will be underneath the arc of the frame. This will cause the speed to decrease by a factor of 2 twice, between the 24mm and the 12mm gears as shown in the sketch and the gear parameters table. After that duplicated process, the speed is further decreased by a factor of 4/3 and at the end, two idle gears were added to change the direction and to rotate the thumb and the index finger. In order for the thumb and the index finger to touch eather other, we had to ensure that gear 12 rotates counterclockwise as it is connected to the index finger and gear 11 to rotate clockwise as it is connected to the thumb.

Calculations


$\omega_1 = 198$ RPM
$\omega_2 = ?$
$\frac{3}{2} = \frac{198}{\omega_2}$
$\omega_2 = 132$ RPM
CCW

$\frac{5}{3} = \frac{132}{\omega_2}$
$\omega_2 = 79.2$ RPM
CCW

Total Gear Ratio: $\frac{198}{15} = \frac{66}{15}$

$D = m \times z$
$D = (1)(18)$
$D = 18$ mm

$GR_{G1 \text{ and } G_2} = \frac{18}{12} = \frac{3}{2}$
$\omega_1 = 198$ RPM
$\omega_2 = ?$
$\frac{3}{2} = \frac{198}{\omega_2} = \frac{198(2)}{3} = 132 \text{ RPM} = \omega_2$

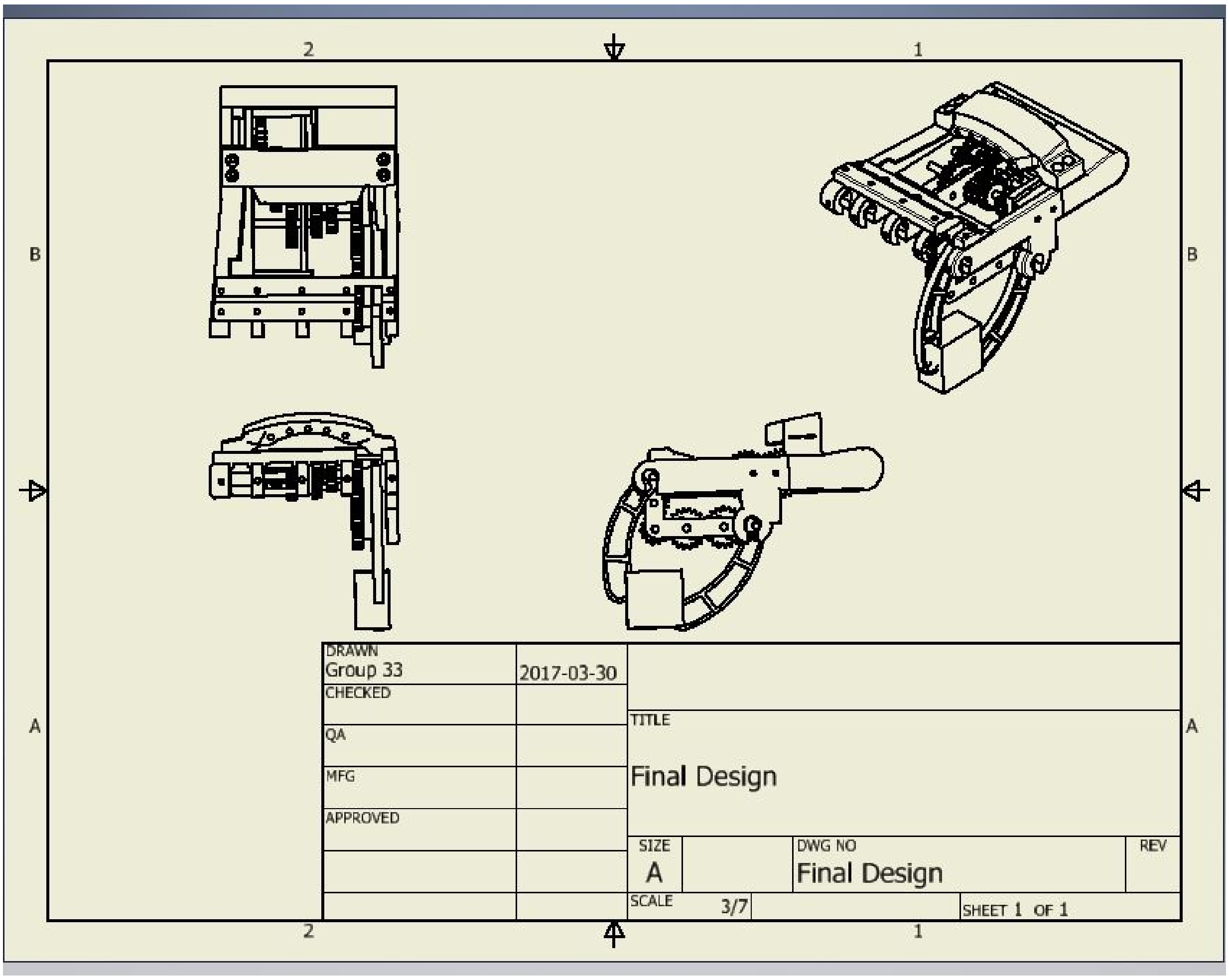
$GR_{G3 \text{ and } G_4} = \frac{20}{12} = \frac{5}{3}$
$GR_{G_2 \text{ and } G_3} = 1$ (axial connection)
$\frac{5}{3} = \frac{\omega_2}{\omega_3} = \frac{132}{\omega_4} = \frac{132(3)}{5}$
$\omega_4 = 79.2$ RPM

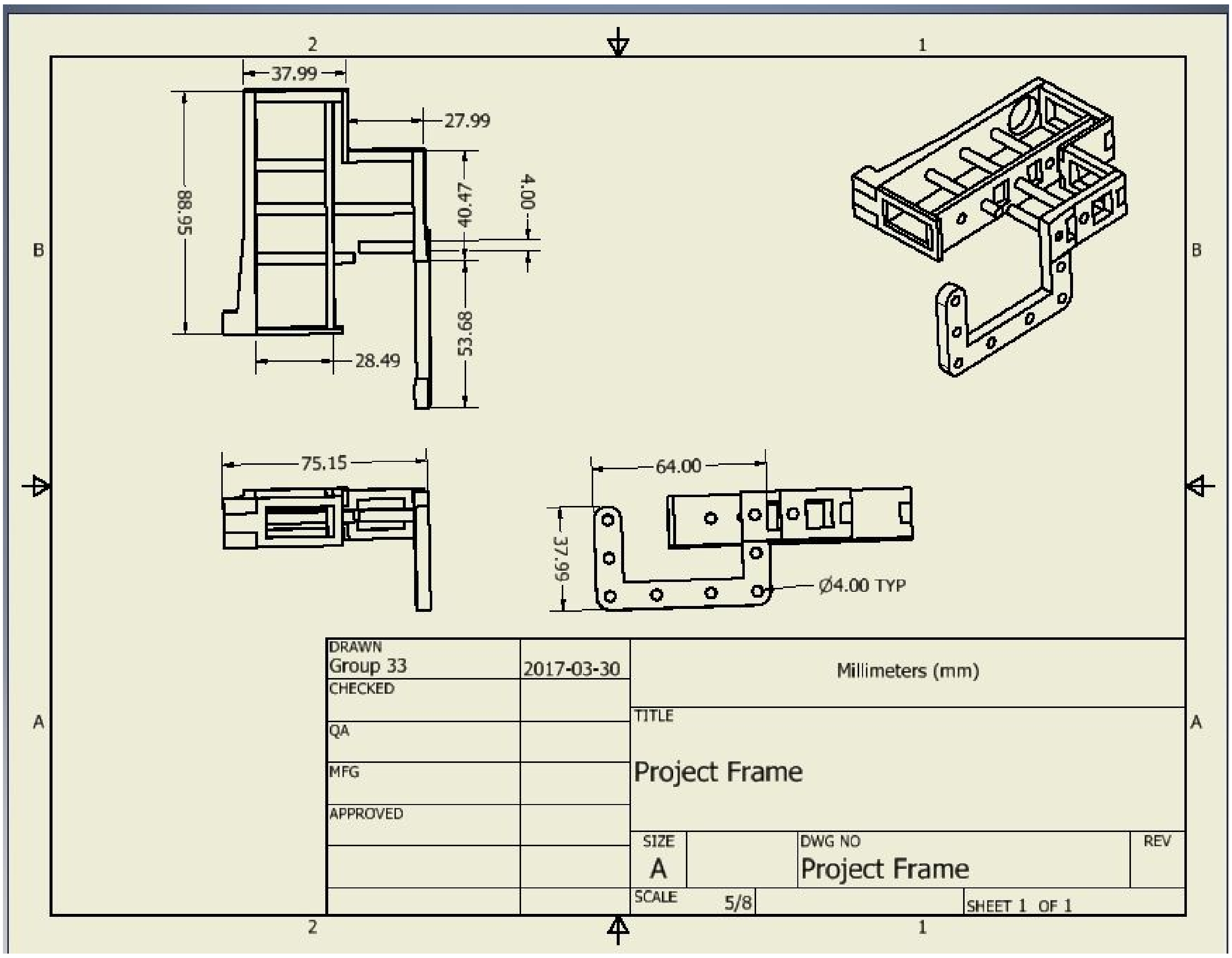
Mechanism Design Parameters

	Pitch Diameter (mm)	Module (mm/tooth)	Number of teeth	Speed (RPM)	Direction of motion (CW/CCW)	Facewidth (mm)	Gear ratio with previous gear
Gear 1	12	1	12	198	CCW	5	
Gear 2	18	1	18	132	CW	5	3/2
Gear 3	12	1	12	132	CW	5	N/A
Gear 4	20	1	20	79.2	CCW	5	5/3
Gear 5	12	1	12	79.2	CCW	5	N/A
Gear 6	24	1	24	39.6	CW	5	2
Gear 7	12	1	12	39.6	CW	5	N/A
Gear 8	24	1	24	19.8	CCW	5	2
Gear 9	12	1	12	19.8	CCW	5	N/A
Gear 10	16	1	16	14.85	CW	5	4/3
Gear 11	14	1	14	14.85	CW	5	N/A
Gear 12	14	1	14	14.85	CCW	5	1/1

Gear 13	14	1	14	14.85	CW	5	1/1
Gear 14	20	1	20	10.40	CCW	5	10/7
Gear 15	20	1	20	10.40	CW	5	1/1
Gear 16	14	1	14	14.85	CCW	5	7/10
Gear 17	14	1	14	14.85	CW	5	1/1
Gear 18	14	1	14	14.85	CCW	5	1/1

Gearing Mechanism Design:

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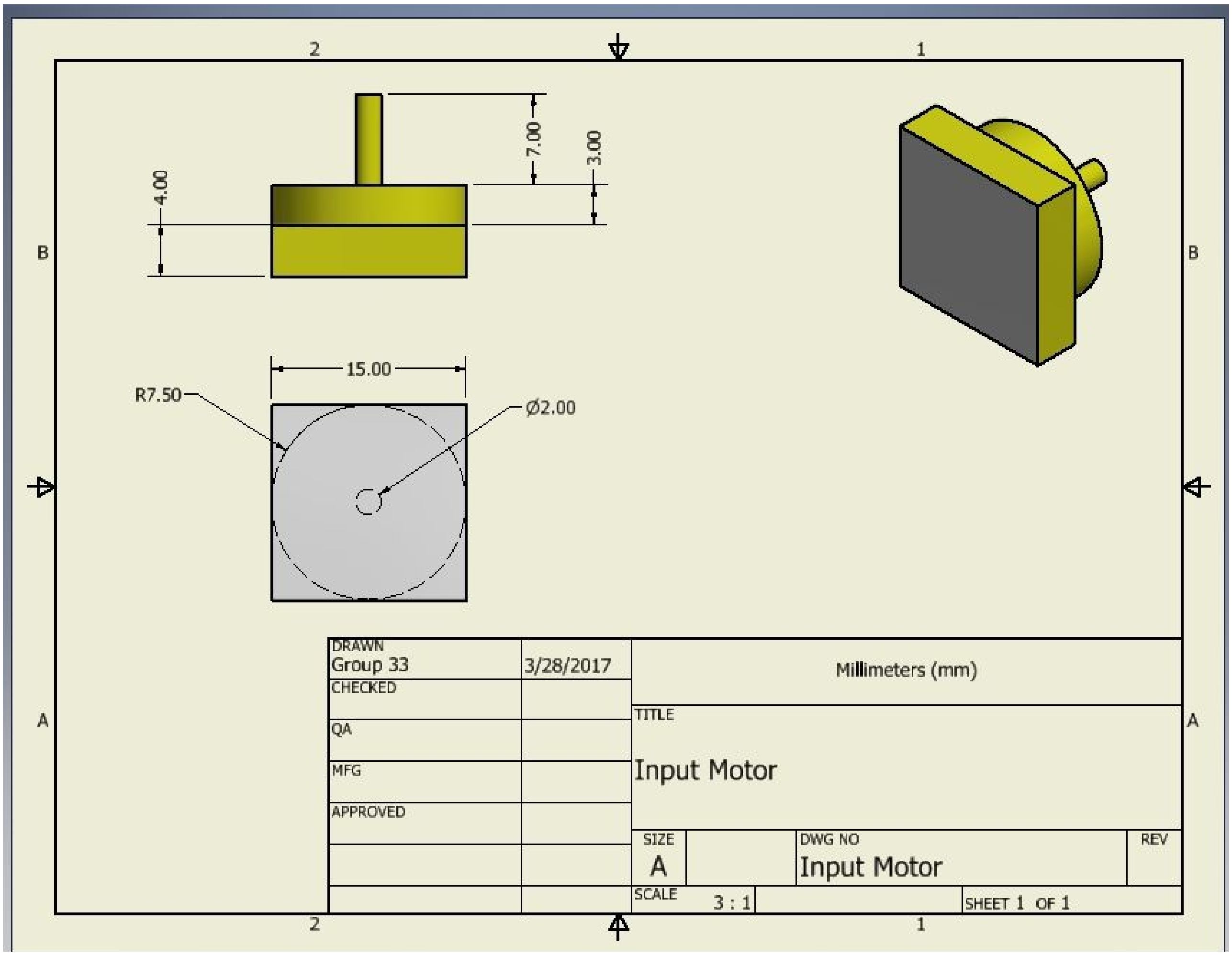

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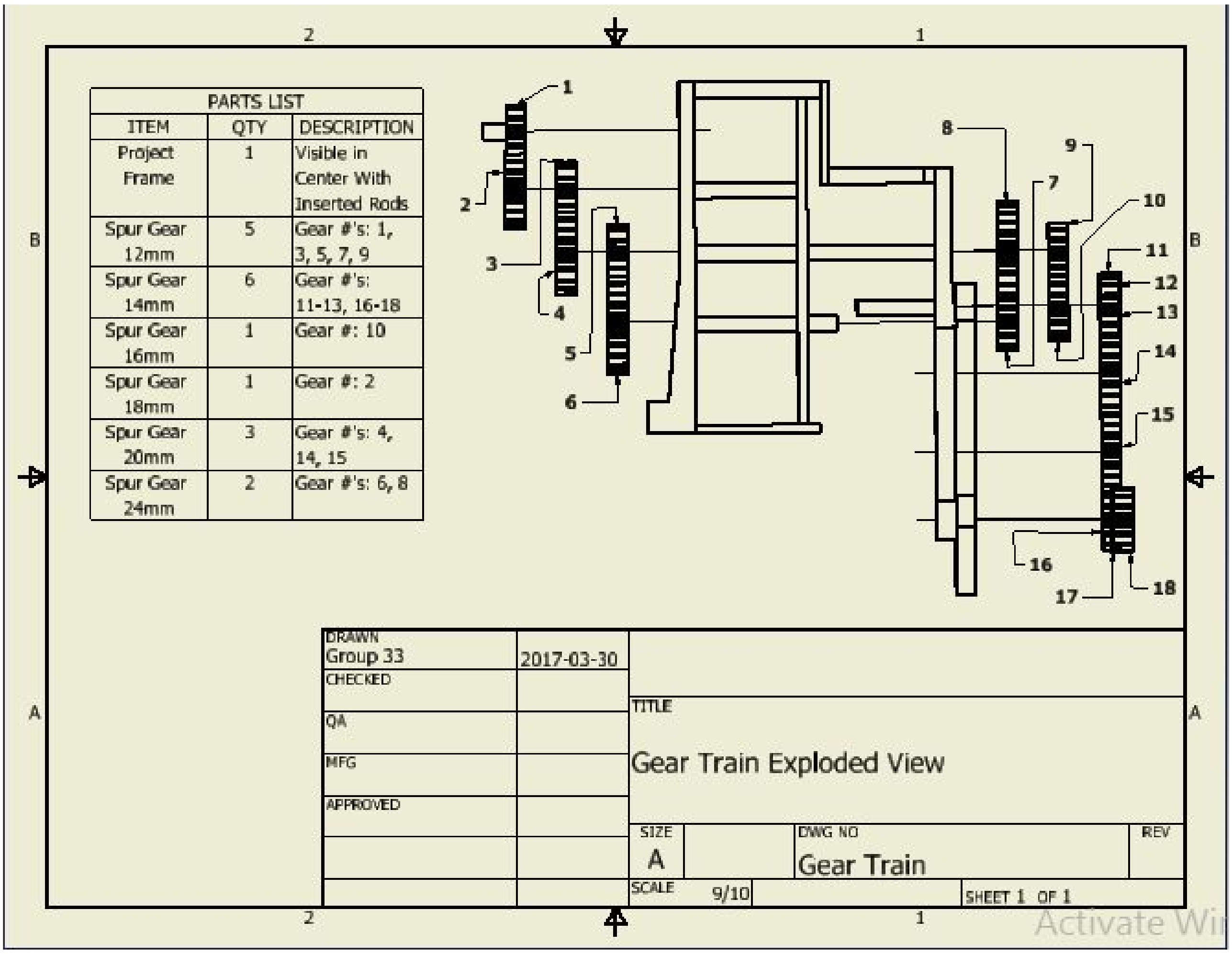
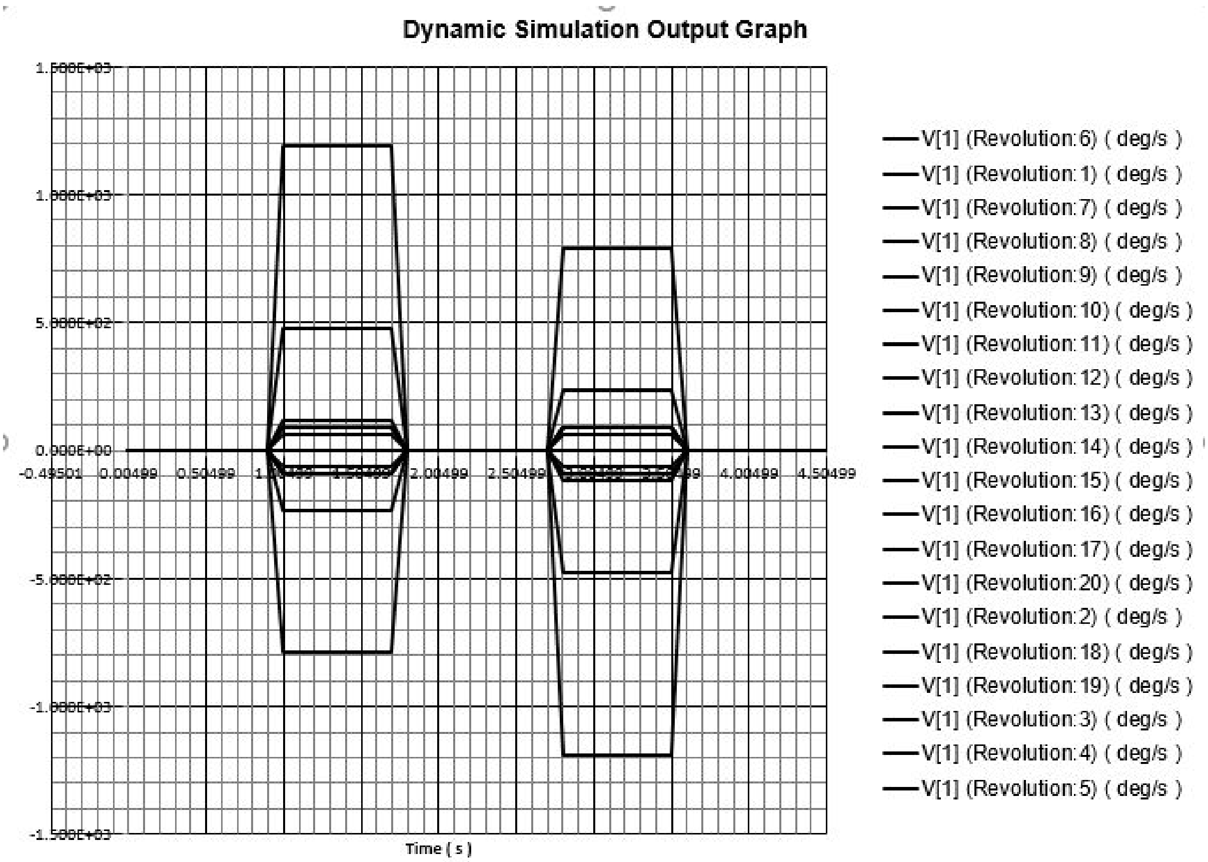
Exploded View:



<u>Stimulation Output Graph:</u>



Prototype explanation:

The project was a really good experience for the group. One of the challenges that we faced was using metal rods as the group did not account for the durability and the strength of the metal and there was a short time of amount left. Therefore, wooden chopsticks were rather used as rods for the gear design. Another challenge that the group encountered was meshing the gears as they were inaccurate and were not able to mesh together properly. By printing the gears and the mounting bracket outside of the university the accuracy level was increased however the printing error could not be eliminated. Our design uses only spur gears compared to other designs that have worms, worm gears, and bevel gears. The target of the group was to make a design that is as simple as possible and uses minimal gears to achieve the goal of the project. These two targets were achieved and that is what makes the design unique.

List of Contributions

Maaz	• Working Drawings • Preliminary Design • Gears Printing • Pre-existing Mechanism Research • Final Report • Prototype Development • Model and Assemble of Gear Train (on Inventor)
Nadeem	• Finger Design • Preliminary Design • Milestone 1 Gantt chart • Solid Model Design • Mounting Bracket design • Prototype Development
Youssef	• Initial and final calculations • Gears printing • Final Report • Preliminary Design • Milestone 1 Proposed Design • Prototype Development
Thomas	• Gears printing • Solid Model Design (on Inventor) • Model and Assemble of Gear Train (on Inventor) • Milestone 2 Brief Picture of the Gears • Prototype Development • Dynamic Simulation • Measuring and Graphing Data

Team Meetings & Attendance:

Tuesday March 21st (5:30pm - 8:30pm):

Revised all gear drawings on Inventor and discussed about the preliminary design and revised design of the gear train, in addition to and all the spur gears (from Milestone 1). There was also some debate on whether we should include the worm in our design, although the group had come to a consensus to use only spur gears as this would make the design simpler and more easy to follow and understand.

Thursday March 23rd (4:30pm - 7:30pm):

Our group went for the second 3D printing session, where majority of our spur gears were printed and briefly observed for functionality. Our group had split up tasks briefly, being:

Maaz - working drawings of gears and other parts, and briefly edited technical report

Thomas & Nadeem - gear train and inventor assembly

Youssef - final report and design sketches

Our group had decided to set deadlines for our work for next meeting, where together as a group we would revise every group member's individual work and edit anything if necessary.

Monday March 27th (4:30pm - 6:30pm):

Our group had met up and revised all the assigned work each of the group members have done, made slight changes to each others parts. As a group, we had started to write up our final report, and managed to complete the majority of the report.

Wednesday March 29th (5:30pm - 9:00pm):

Our group meeting consisted of finalizing any final parts needed to be printed and/or bought from a hardware store, in addition to reviewing the prosthetic design for the final interview. This involved finalizing and making any necessary changes to all Inventor files needed for our final 3D printing session.

Thursday March 30th (11:00am - 2:30pm):

Our group had met up at the EPIC lab for our final printing session, and constructed the prototype. Afterwards, we had slightly tested our prototype to see if there was any interference between spur gears or any other problems that had arisen. There was a brief problem with the movement of the gears on the rod, which was resolved by changing the rod that we had used. Apart from this, we had proof-read, edited, and printed a hard copy of the abbreviated report required for the interview.

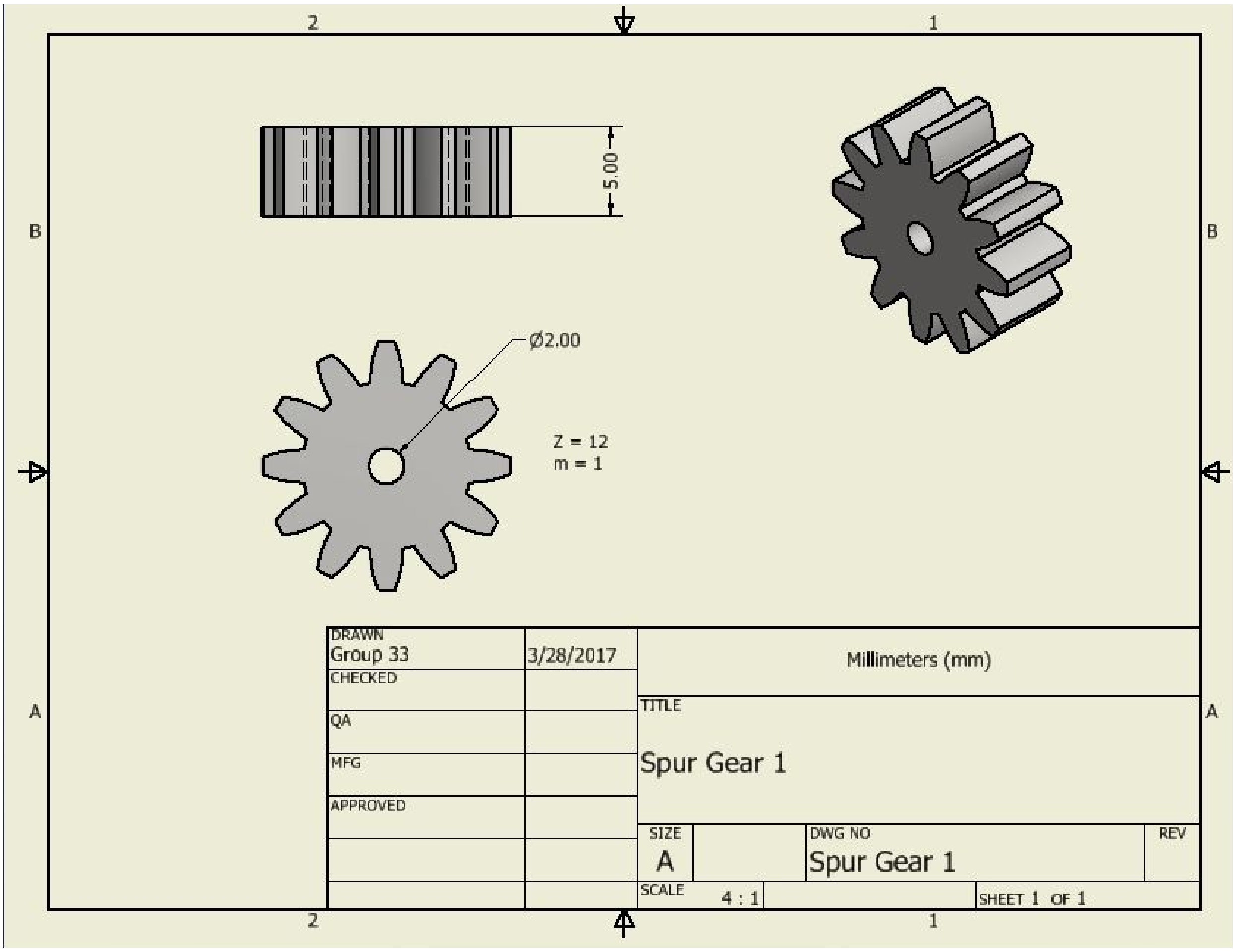
All group members were present for all meetings.

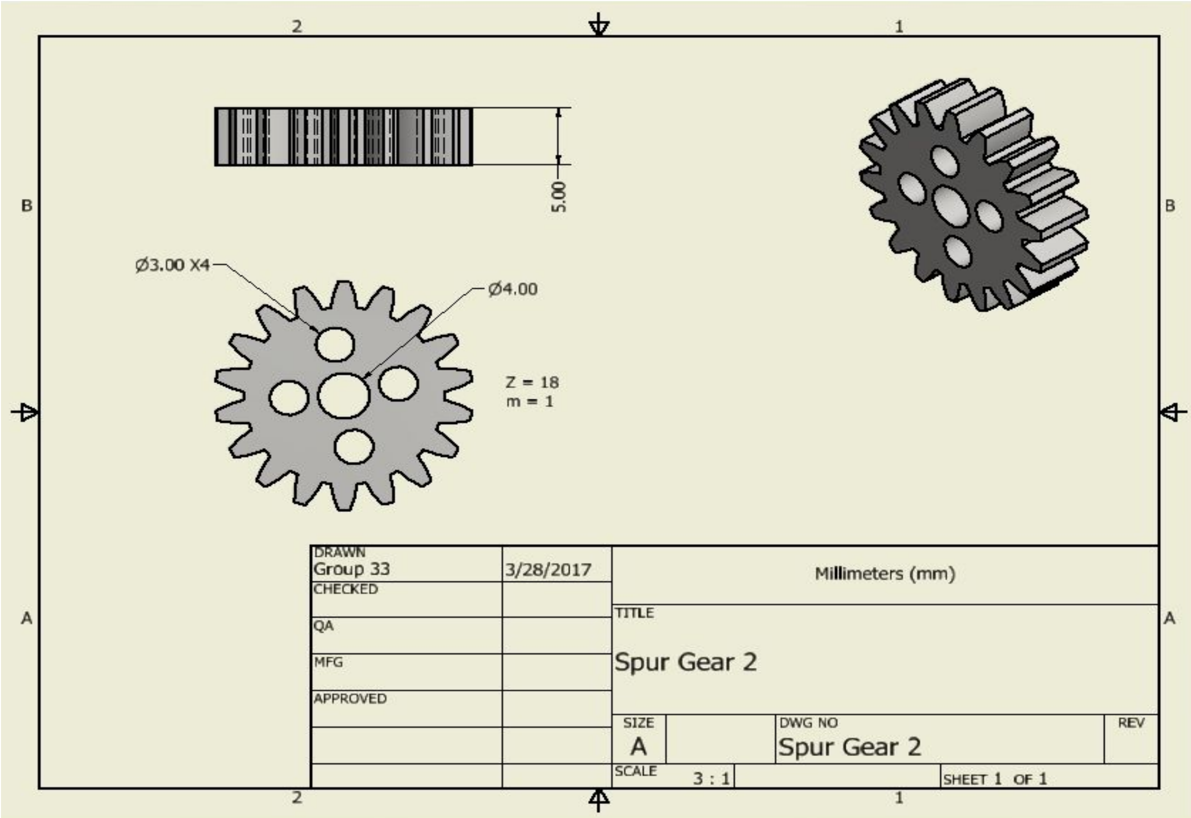
Gantt Chart:

	February	March				
	27	2	9	16	23	31
Milestone 1:						
Select Design	All	--------	--------	--------	--------	--------
Pre-existing Mechanism Research	Maaz	--------	--------	--------	--------	--------
Pre-existing Mechanism sketches	Thomas	--------	--------	--------	--------	--------
Calculations	Youssef	--------	--------	--------	--------	--------
Milestone 2:						
Solid Model Design (Inventor)	--------	--------	Nadeem and Thomas	--------	--------	--------
Printing Gears	--------	--------	Thomas	--------	--------	--------
Milestone 3:						
Finger design and calculation	--------	--------	Nadeem	--------	--------	--------
Hand design and calculation	--------	--------	Nadeem and Thomas	--------	--------	--------
Model and assembly of gears	--------	--------	--------	--------	Thomas	--------
Measuring data, graph	--------	--------	--------	--------	Thomas and Maaz	--------
Creating drawings	--------	--------	--------	--------	Maaz	--------
Gears printing	--------	--------	--------	--------	Thomas and Maaz	--------
Final report:						
Calculations	--------	--------	--------	--------	--------	Youssef
How mechanism works	--------	--------	--------	--------	--------	Youssef

Compiling drawings	--------	--------	--------	--------	--------	Maaz
Introduction/compilation of entire report	--------	--------	--------	--------	--------	Maaz and Youssef

Working Drawings:





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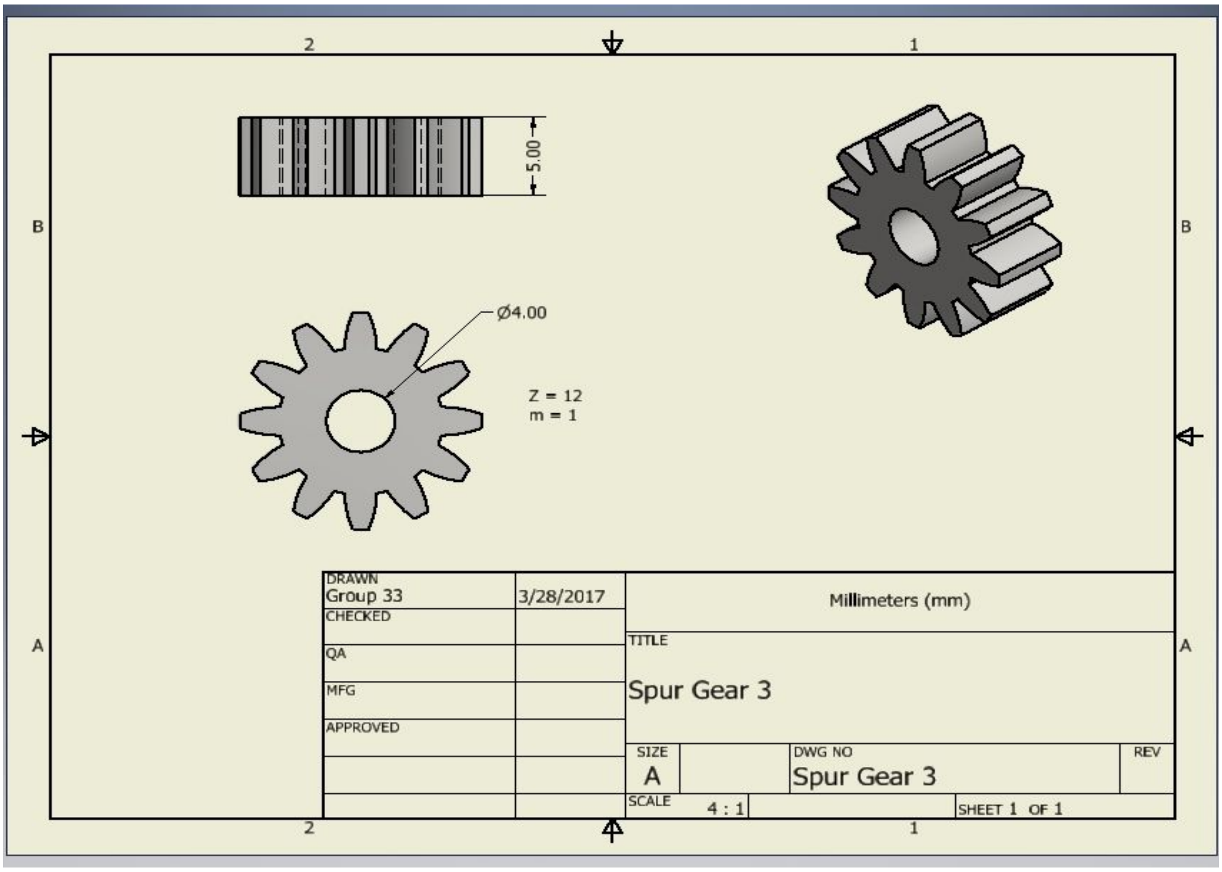

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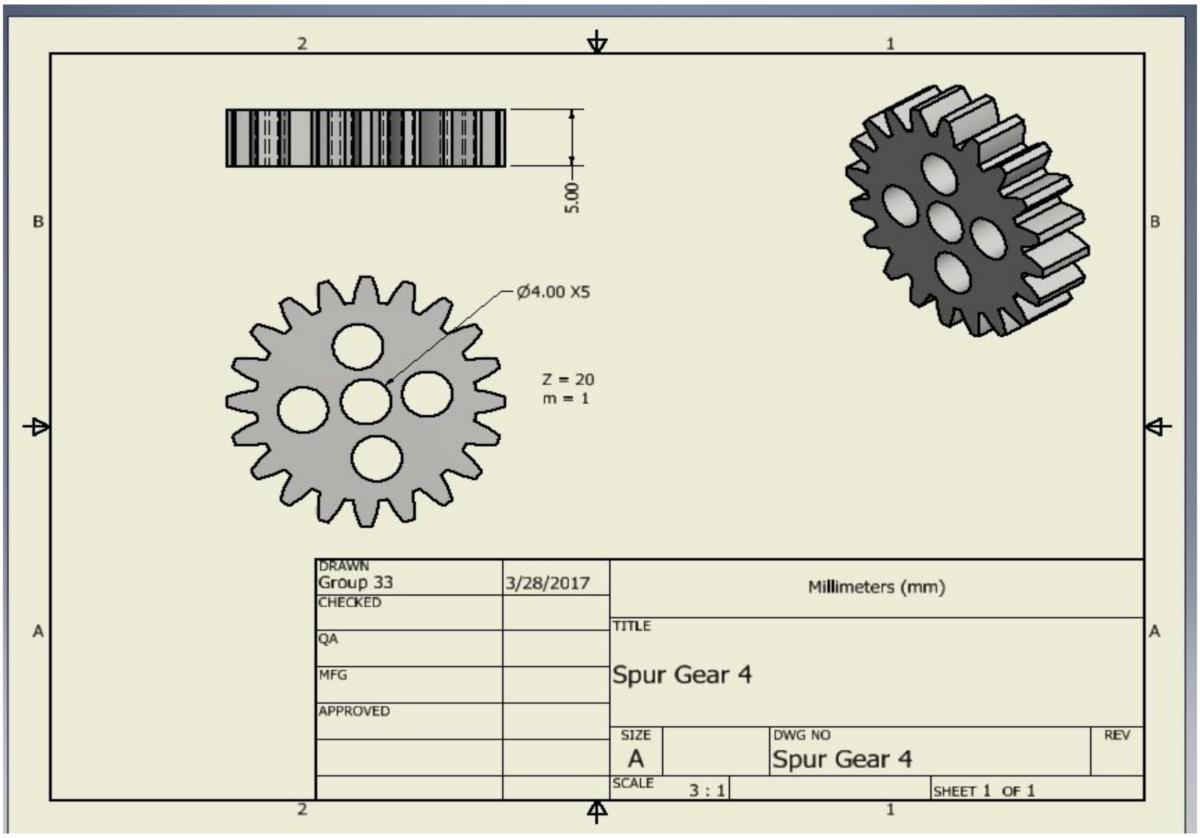
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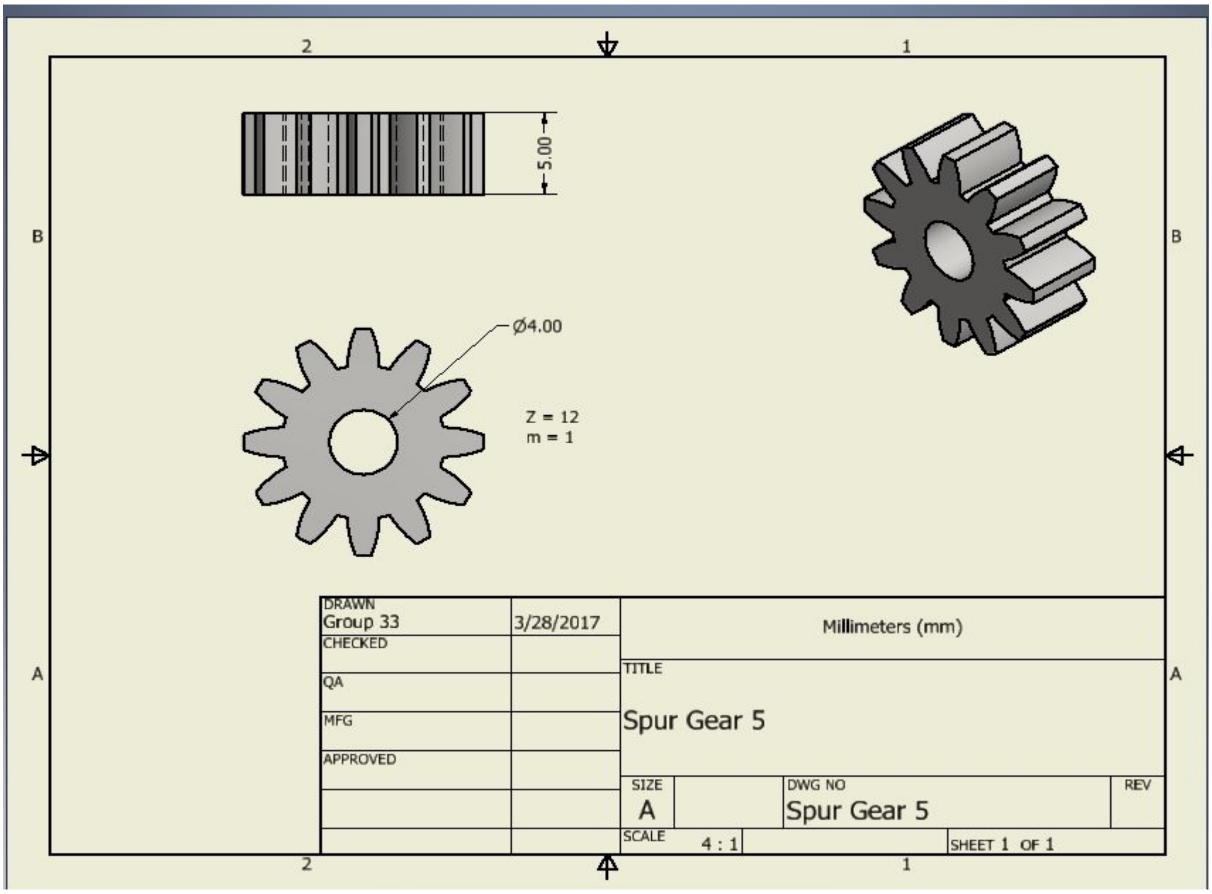
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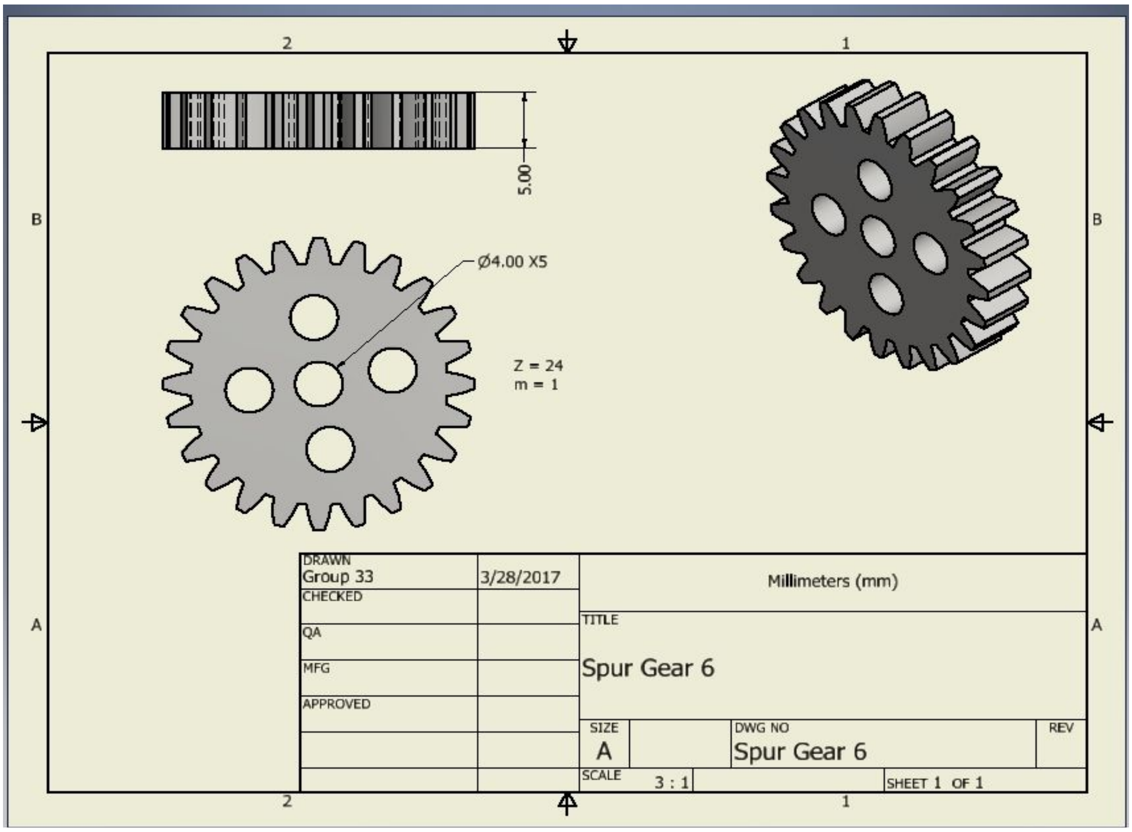
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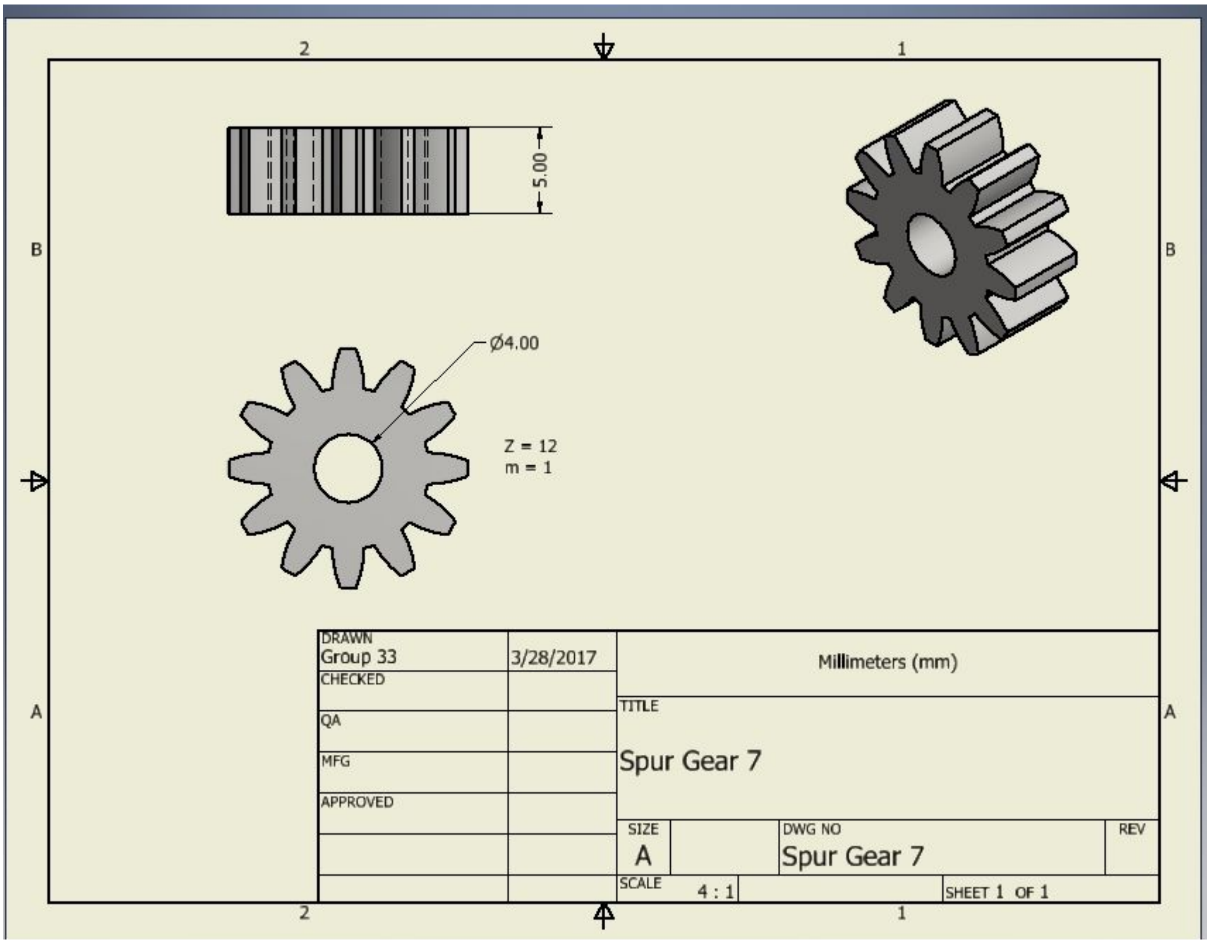
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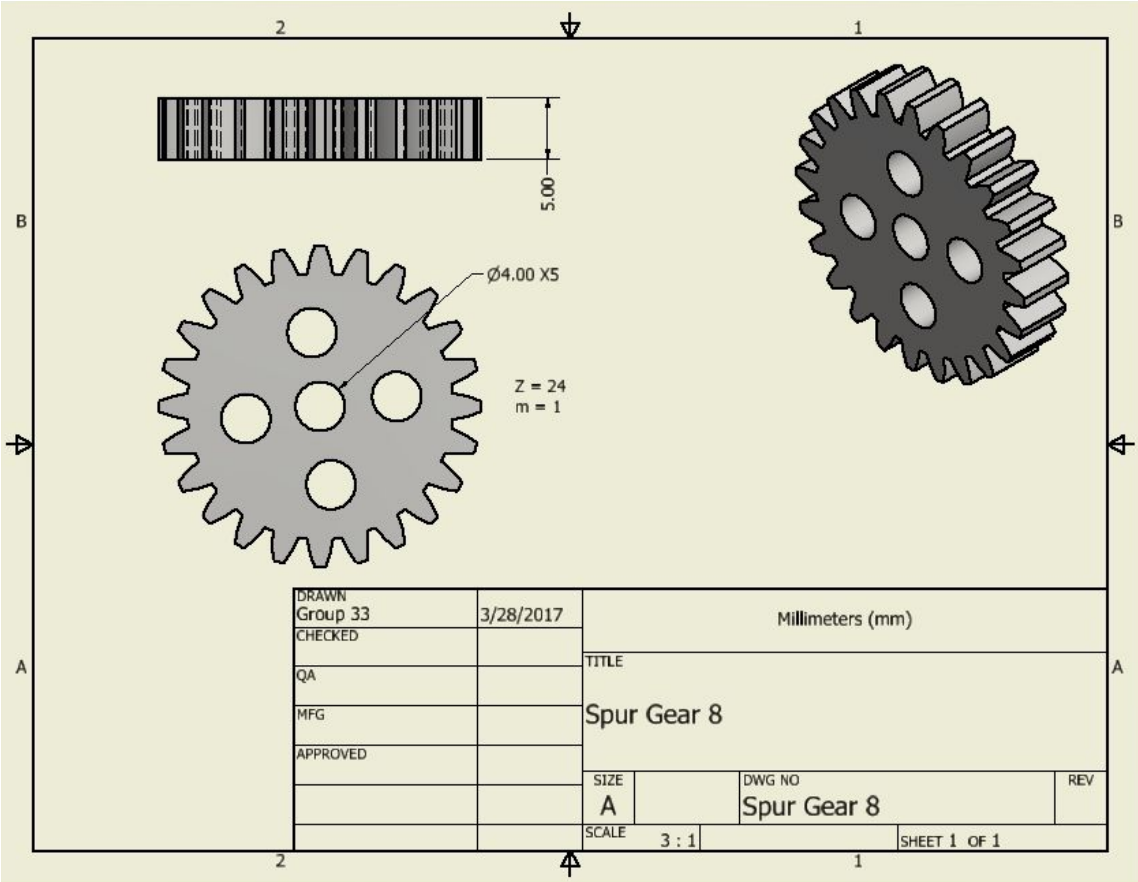
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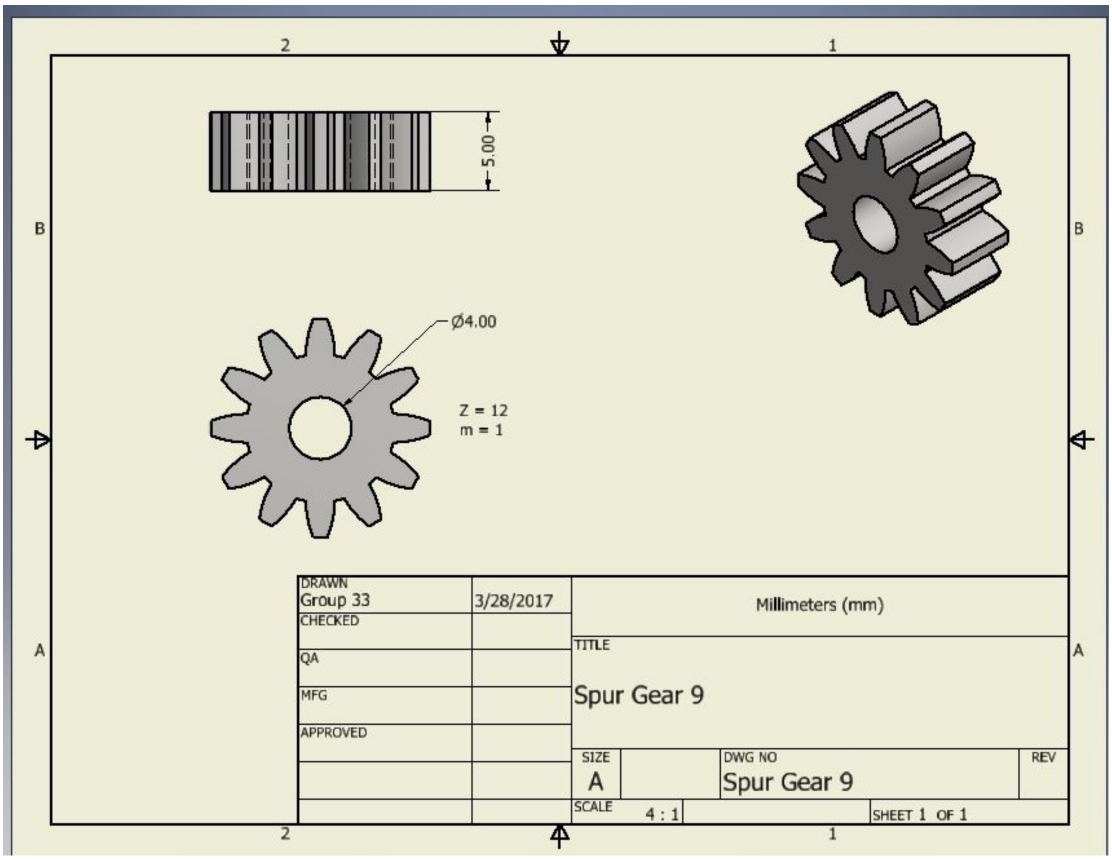
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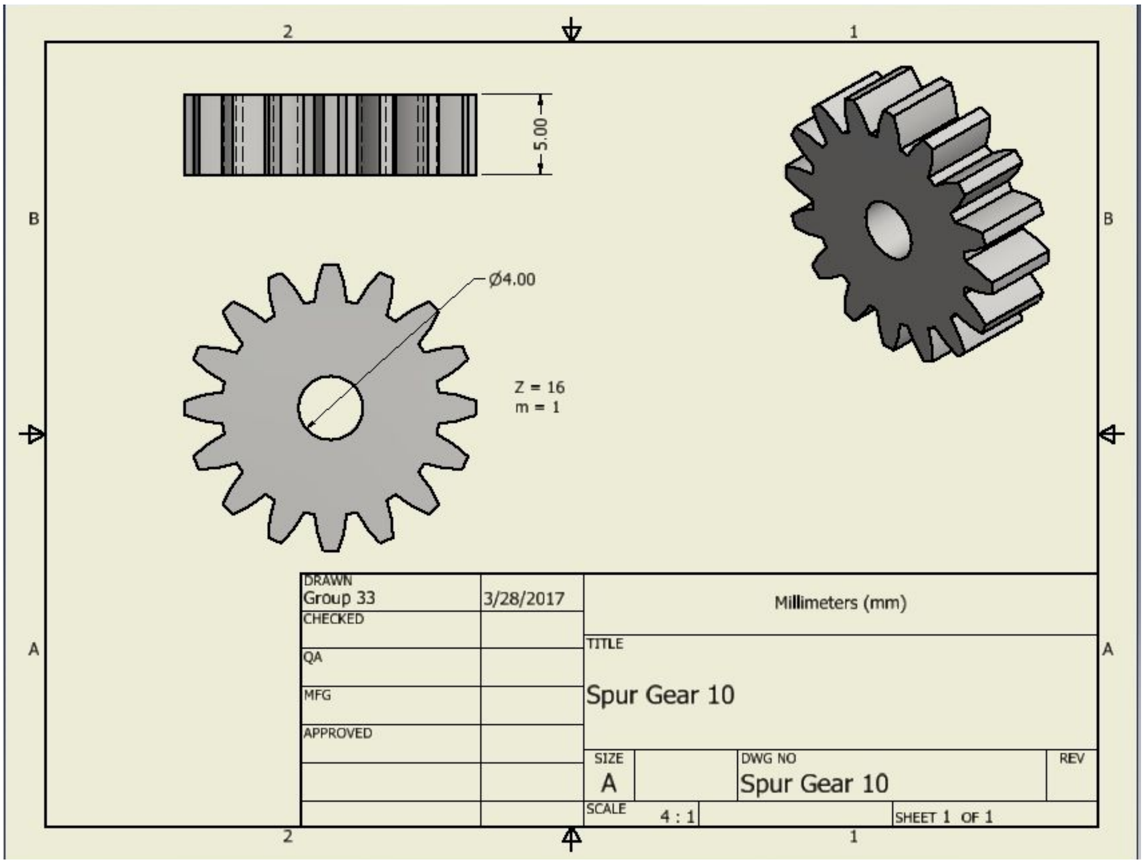

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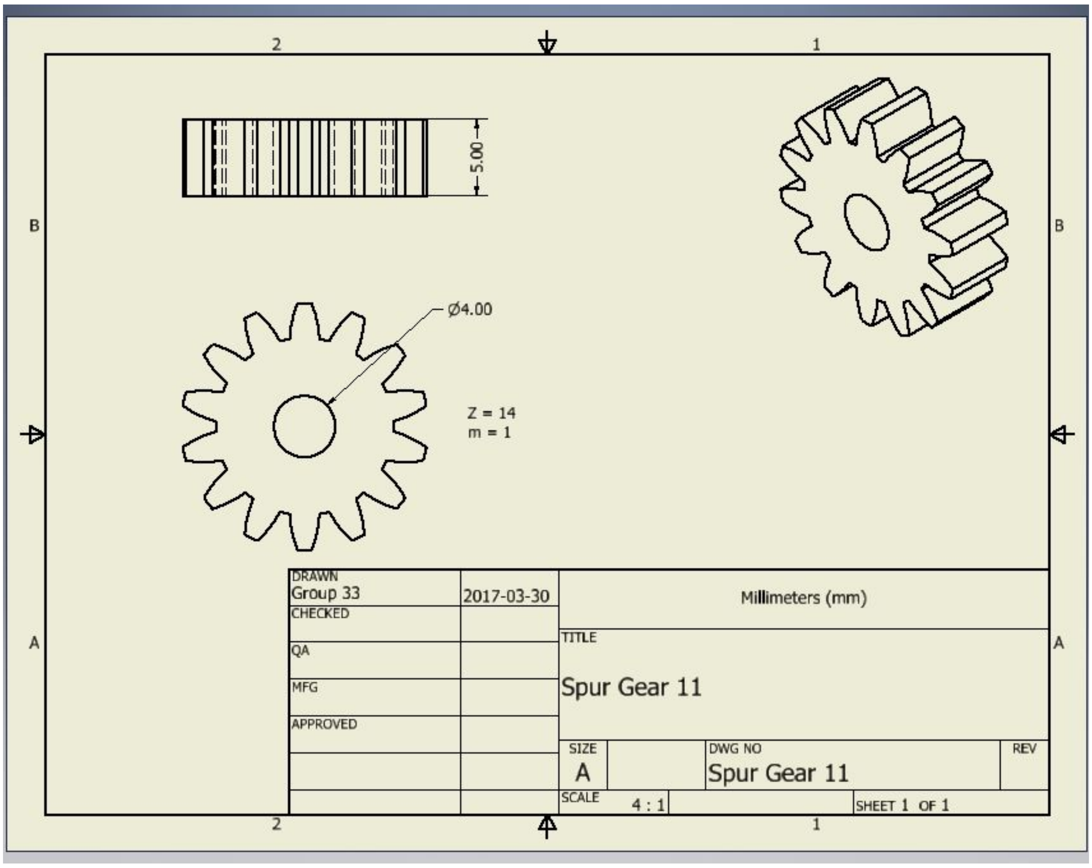

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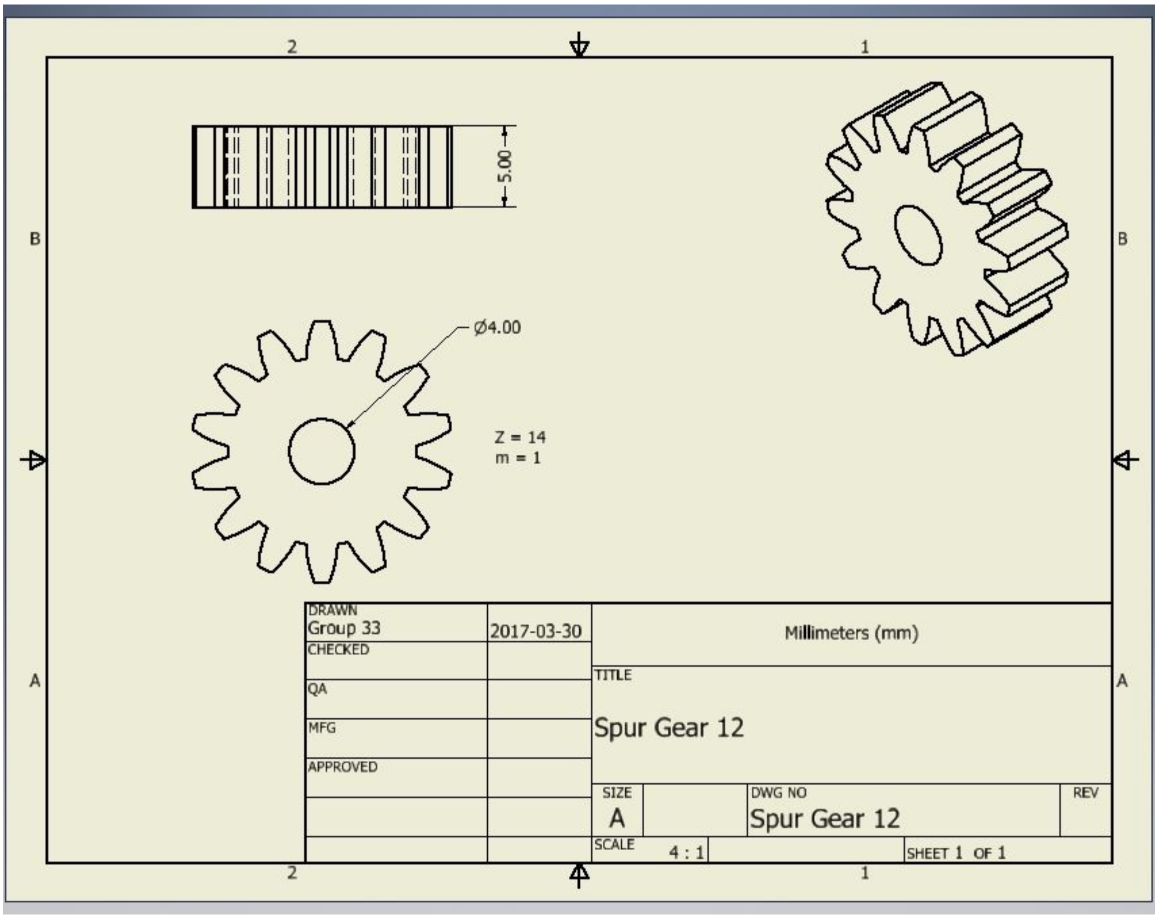
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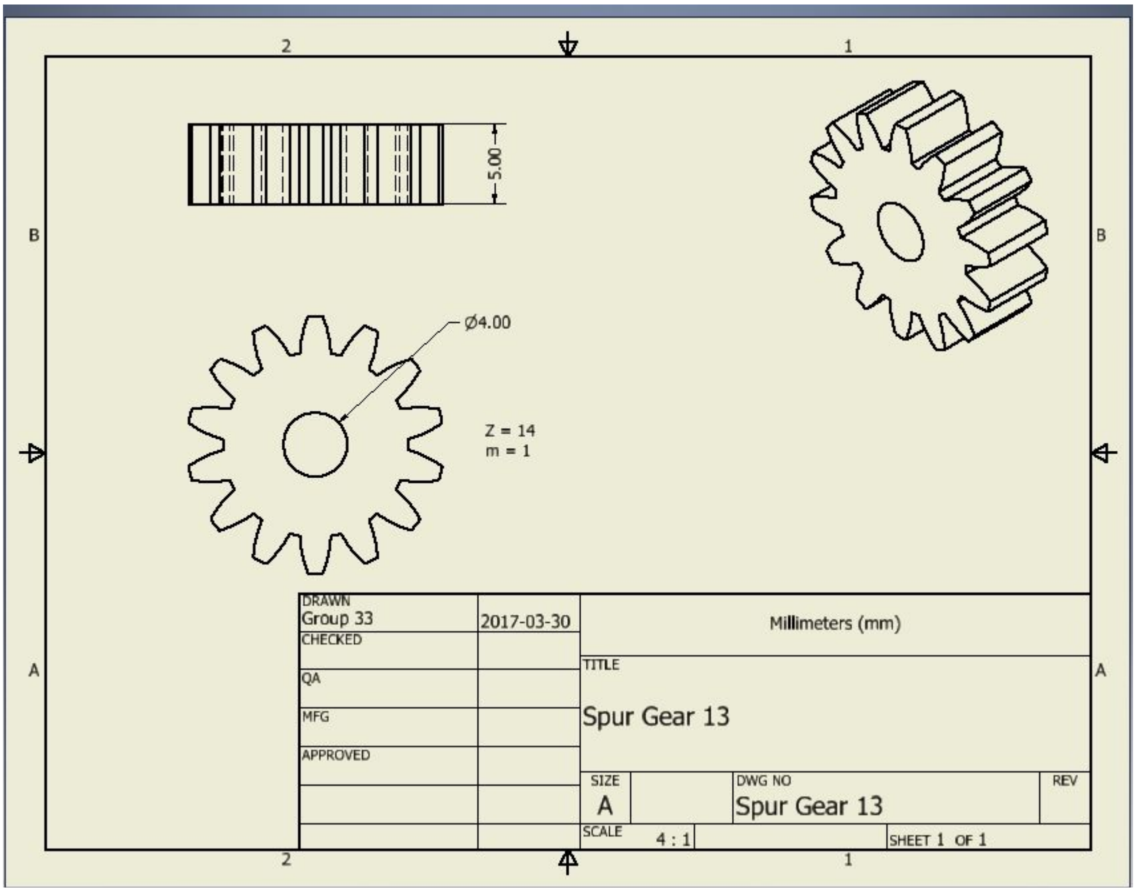
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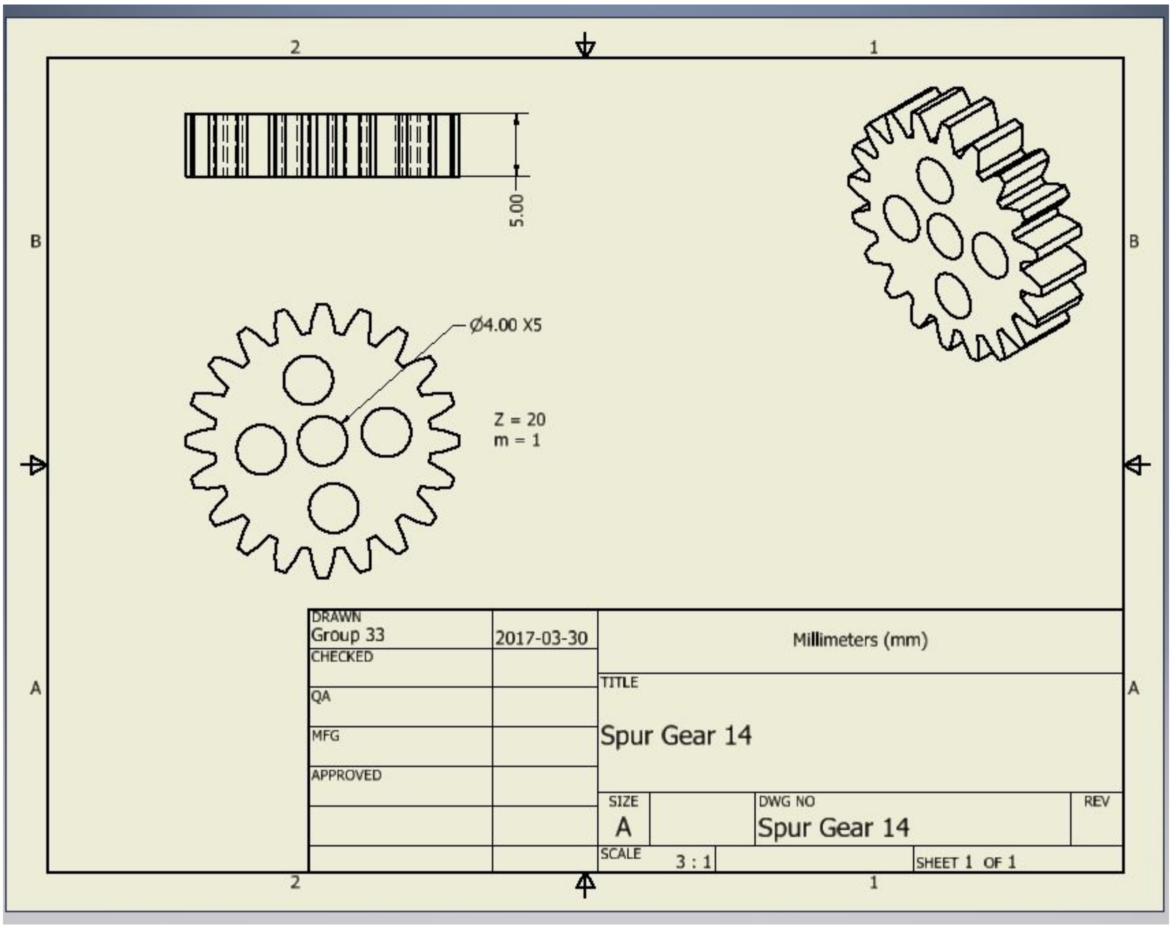
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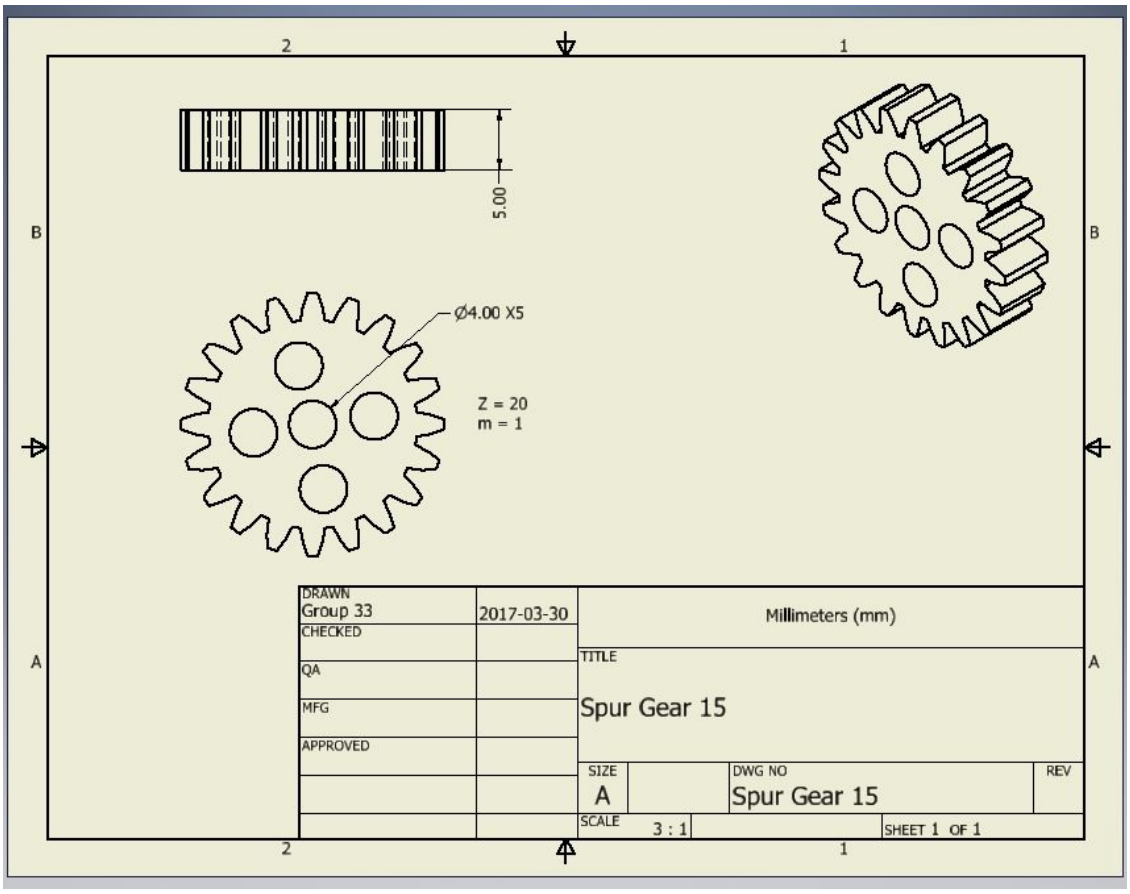
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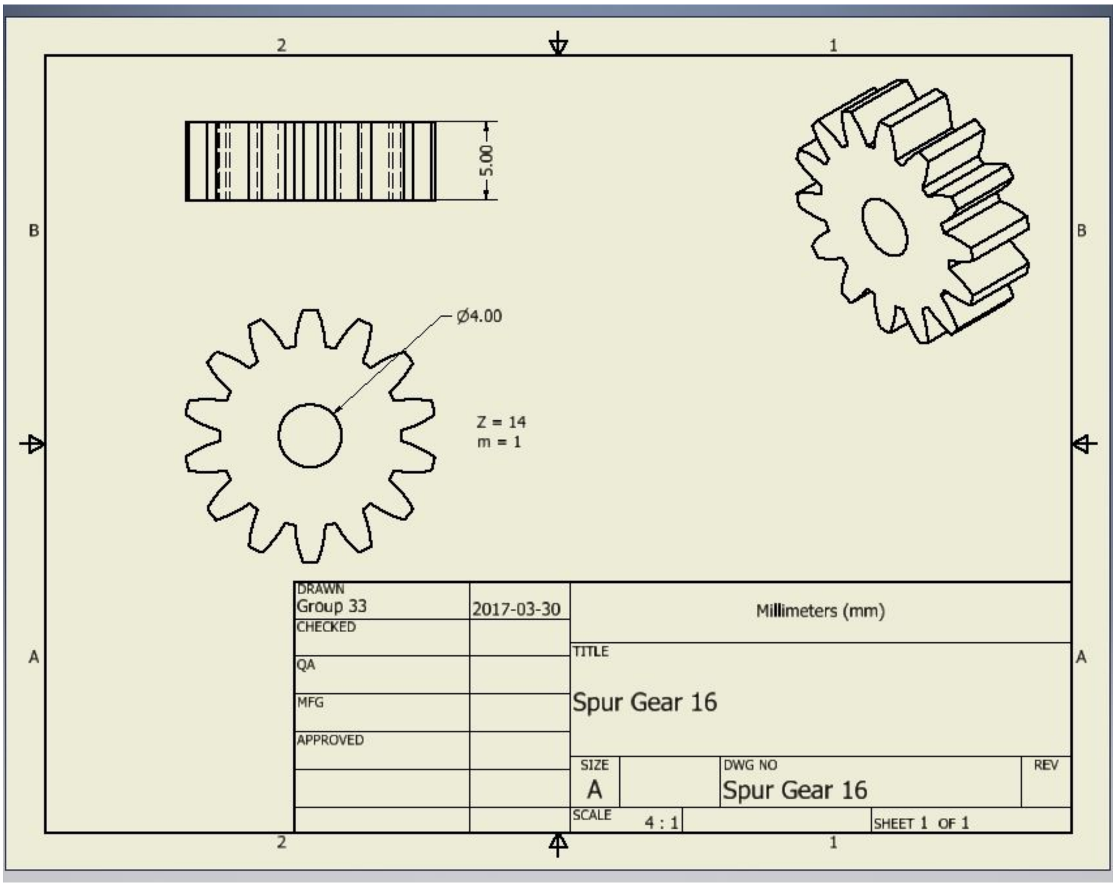
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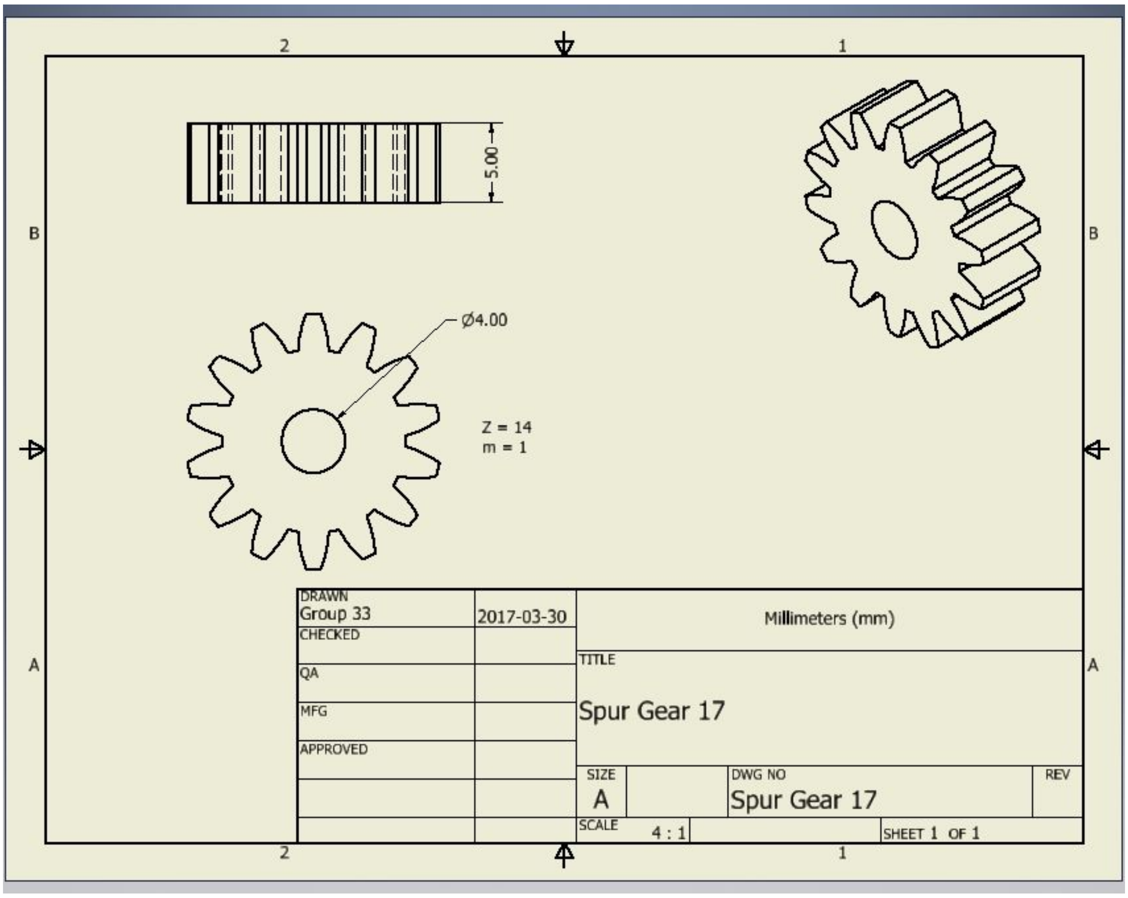
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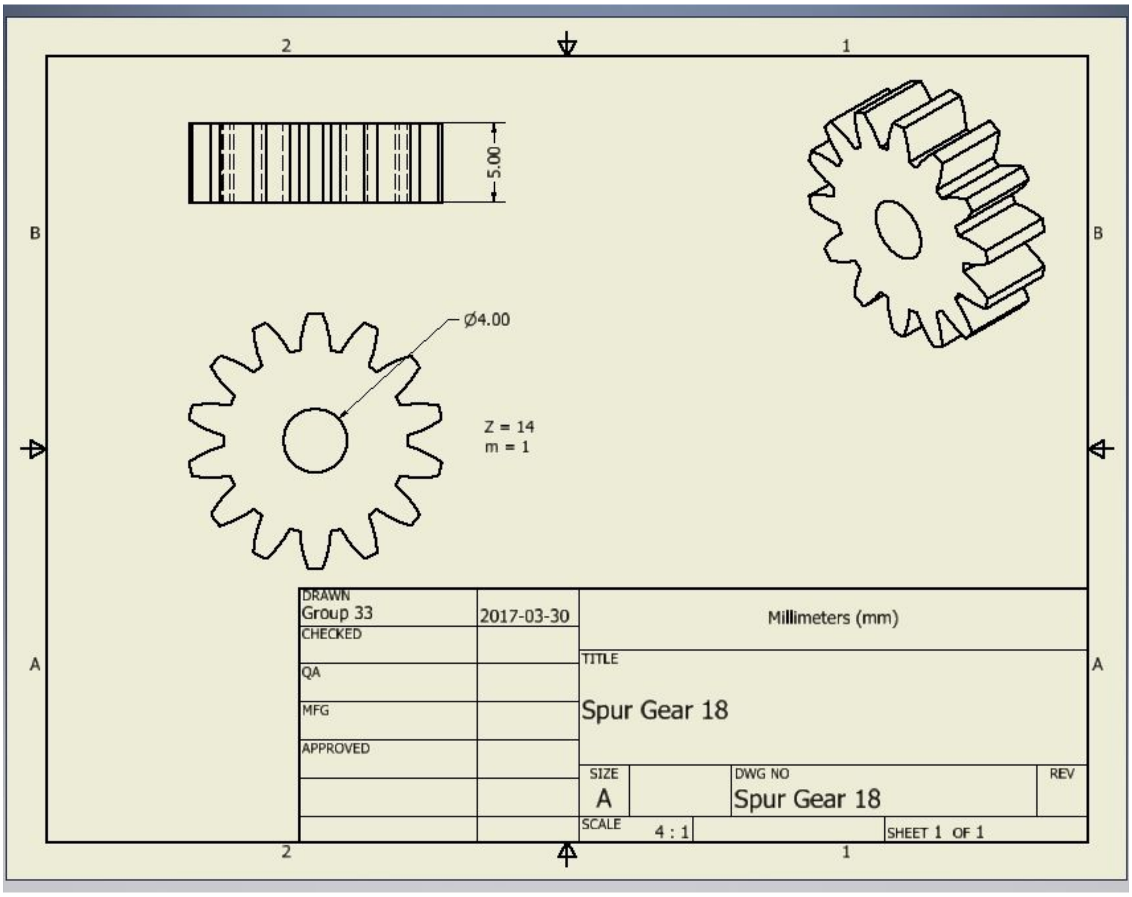

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