

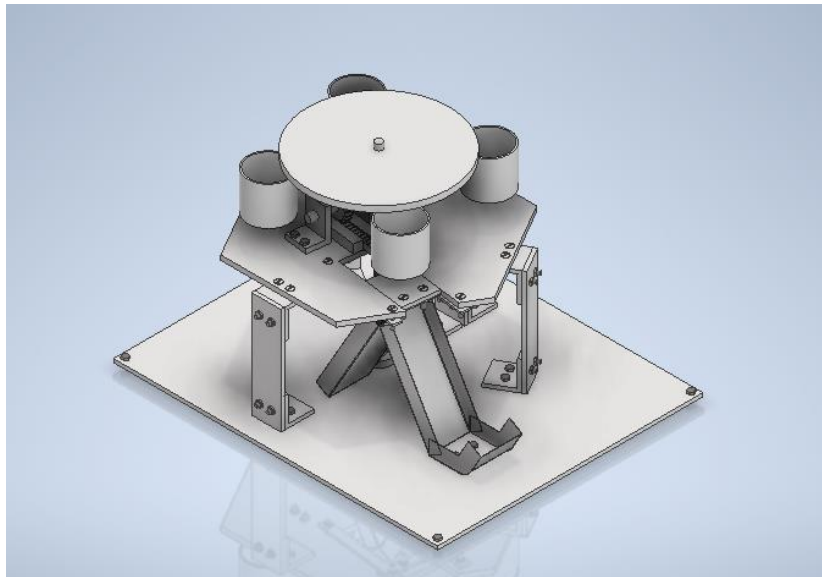


TA202A: MANUFACTURING PROCESSES II

GROUP NO.: 43

LAB DAY: THURSDAY

VENDING MACHINE



COURSE INSTRUCTOR: Dr. Mohit Law

LAB INCHARGE: Mr. Srinivasulu-ji

TUTOR: Dr. Mohit Law

GUIDE: Mr. Rahul

Group Members

- | | |
|---------------------------------|-------------------------------------|
| 1. Alka (210100) | 7. Prabhat Kumar Purbay (210731) |
| 2. Arun Dwivedi (210196) | 8. Prakhar Chhalotre (210737) |
| 3. Ashish Kumar Gupta (210213) | 9. Roy Shivam Ram Shreshtt (210877) |
| 4. Chavan Omkar Deepak (210280) | 10. Sujeet Kumar (211067) |
| 5. Dharmendra Yadav (210335) | 11. Yaman Manish Oza (211186) |
| 6. Garima Mittal (210380) | 12. Neeraj Swami (190543) |

OVERVIEW

We have designed a small-scale prototype of a bottle vending machine for the hot summers of Kanpur. The number of parts manufactured by us was around 30. The estimated price for the product, including the labor cost, is 24,306.75 Indian rupees. There are many things that we feel can be improved, such as the bottle-carrying capacity and the accuracy of the motors. The tolerance of the bottle-dropping mechanism should be increased to let the bottles fall easily. There can be some system that keeps the bottles cool.

ACKNOWLEDGEMENT

We sincerely express our gratitude to our tutor **DR. Mohit law** our laboratory in-charge, **Mr. G Shreenivasulu**, and our laboratory guide, **Mr. Rahul** for their valuable support and advice in this project. This wouldn't have been possible without their technical and moral support.

We would like to express our gratitude toward all lab staff for their constant supervision and encouragement which helped us in the completion of the project.

Special thanks to our TAs, and for taking out time for us.

Overall, we thank our instructor in charge, **DR. Mohit Law** for providing us with this opportunity to learn, explore and make something valuable using different manufacturing processes.

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DESIGN CALCULATIONS

• CALCULATIONS FOR BEVEL GEARS

	Pinion	Gear
Shaft Angle, Σ	$\Sigma = 90^\circ$	$\Sigma = 90^\circ$
Module, m	$m = 1.5 \text{ mm}$	$m = 1.5 \text{ mm}$
Pressure angle, α	$\alpha = 20^\circ$	$\alpha = 20^\circ$
Number of teeth, z	$z_1 = 20$	$z_2 = 40$
Pitch diameter, d	$d_1 = m \cdot z_1 = (1.5)(20) = 30 \text{ mm}$	$d_2 = m \cdot z_2 = (1.5)(40) = 60 \text{ mm}$
Pitch cone angle, δ_1, δ_2	$\delta_1 = \tan^{-1} \left(\frac{\sin \Sigma}{\frac{z_1}{z_2} + \cos \Sigma} \right)$ $= \tan^{-1}(2)$ $= 63.4350^\circ$	$\delta_2 = \Sigma - \delta_1 = 90^\circ - 63.435^\circ$ $= 26.5650^\circ$
Cone distance, R_e	$R_e = \frac{d_2}{2 \sin \delta_2} = \frac{60}{2(0.4472)}$ $= 67.0841 \text{ mm}$	$R_e = \frac{d_2}{2 \sin \delta_2}$ $= \frac{60}{2(0.4472)}$ $= 67.0841 \text{ mm}$
Face width, b	$b = 6.7 \text{ mm} \leq \frac{R_e}{3}$	$b = 6.7 \text{ mm} \leq \frac{R_e}{3}$
Addendum, h_a	$h_a = m = 1.5 \text{ mm}$	$h_a = m = 1.5 \text{ mm}$
Dedendum, h_f	$h_f = 1.25m = 1.875 \text{ mm}$	$h_f = 1.25 = 1.875 \text{ mm}$
Dedendum angle, θ_f	$\theta_f = \tan^{-1} \left(\frac{h_f}{R_e} \right)$ $= \tan^{-1}(0.0279)$ $= 1.5981^\circ$	θ_f $= \tan^{-1} \left(\frac{h_f}{R_e} \right)$ $= \tan^{-1}(0.0279)$ $= 1.5981^\circ$

Addendum angle, θ_f	$\theta_a = \tan^{-1} \left(\frac{h_a}{R_e} \right)$ $= \tan^{-1}(0.0224)$ $= 1.2832^\circ$	$\theta_a = \tan^{-1} \left(\frac{h_a}{R_e} \right)$ $= \tan^{-1}(0.0224)$ $= 1.2832^\circ$
Outer cone angle, $\delta_{a_1}, \delta_{a_2}$	$\delta_{a_1} = \delta_1 + \theta_a$ $= 63.4350^\circ$ $+ 1.2832^\circ$ $= 64.7182^\circ$	$\delta_{a_2} = \delta_2 + \theta_a$ $= 26.5650^\circ$ $+ 1.2832^\circ$ $= 27.8482^\circ$
Root cone angle, $\delta_{f_1}, \delta_{f_2}$	$\delta_{f_1} = \delta_1 - \theta_f$ $= 63.4350^\circ$ $- 1.5981^\circ$ $= 61.8369^\circ$	$\delta_{f_2} = \delta_2 - \theta_f$ $= 26.5650^\circ$ $- 1.5981^\circ$ $= 24.9669^\circ$
Outside diameter, d_{a_1}, d_{a_2}	$d_{a_1} = d_1 + 2h_a \cos \delta_1$ $= 30$ $+ 2(1.5)(0.4472)$ $= 31.3416 \text{ mm}$	$d_{a_2} = d_2 + 2h_a \cos \delta_2$ $= 60$ $+ 2(1.875)(0.8944)$ $= 63.3540 \text{ mm}$
Pitch apex to crown, X_1, X_2	$X_1 = R_e \cos \delta_1 - h_a \sin \delta_1$ $= 67.0841(0.4472)$ $- 1.5(0.8944) = 28.6391 \text{ mm}$	$X_2 = R_e \cos \delta_2 - h_a \sin \delta_2$ $= 67.0841(0.8944)$ $- 1.5(0.4472)$ $= 59.3292 \text{ mm}$
Axial face width, X_{b_1}, X_{b_2}	$X_{b_1} = \frac{b \cos \delta_{a_1}}{\cos \theta_a} = \frac{6.7(0.4271)}{0.9997}$ $= 2.8624 \text{ mm}$	$X_{b_2} = \frac{b \cos \delta_{a_2}}{\cos \theta_a}$ $= \frac{6.7(0.8842)}{0.9997}$ $= 5.9259 \text{ mm}$
Inner outside diameter, d_{i_1}, d_{i_2}	$d_{i_1} = d_{a_1} - \frac{2b \sin \delta_{a_1}}{\cos \theta_a}$ $= 31.3416$ $- \frac{2(6.7)(0.9042)}{0.9997}$ $= 19.2217 \text{ mm}$	$d_{i_2} = d_{a_2} - \frac{2b \sin \delta_{a_2}}{\cos \theta_a}$ $= 63.3540$ $- \frac{2(6.7)(0.4671)}{0.9997}$ $= 57.0930 \text{ mm}$
Depth of cut	$2.157 \cdot m = 2.157(1.5)$ $= 3.2355 \text{ mm}$	$2.157 \cdot m = 2.157(1.5)$ $= 3.2355 \text{ mm}$

- CALCULATIONS FOR RACK AND PINION**

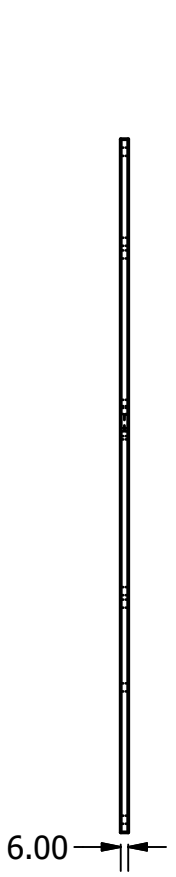
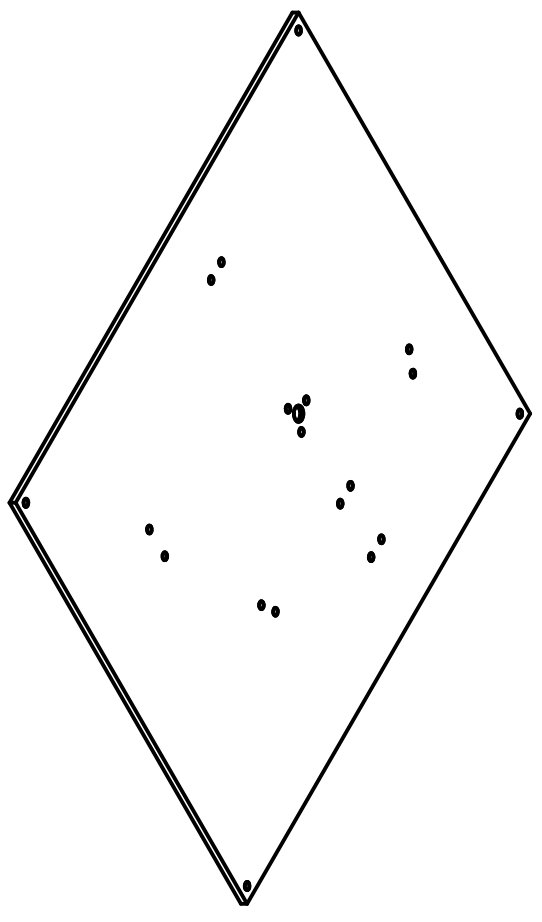
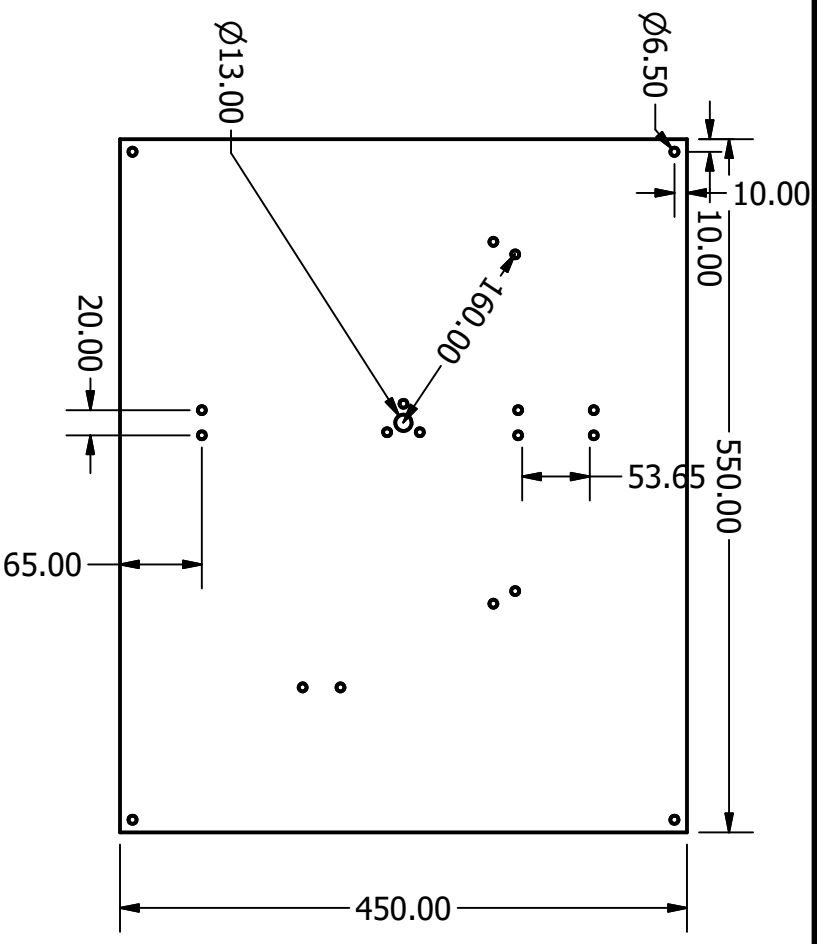
<i>Spur Gear-Number of teeth, N_1</i>	$N_1 = 20$
<i>Rack -Number of teeth, N_2</i>	$N_2 = 18$
<i>Module, M</i>	$M = 2 \text{ mm}$
<i>Pressure angle, α</i>	$\alpha = 20^\circ$
<i>Pitch of rack, p</i>	$p = \pi M = 6.2832 \text{ mm}$
<i>Tooth depth, h</i>	$h = 2.25M = 4.5 \text{ mm}$
<i>Addendum, h_a</i>	$h_a = M = 2 \text{ mm}$
<i>Dedendum, h_f</i>	$h_f = 1.25M = 2.5 \text{ mm}$
<i>Dedendum fillet radius, R</i>	$R = 0.38M = 0.76 \text{ mm}$
<i>Outer diameter, OD</i>	$OD = M(N_1 + 2) = 44 \text{ mm}$
<i>Pitch diameter, d</i>	$d = MN_1 = 40 \text{ mm}$
<i>Length of rack, L</i>	$L = 127.101 \text{ mm}$
<i>Depth of cut</i>	$2.157M = 4.314 \text{ mm}$
<i>Indexing</i>	$\frac{40}{N_1} = \frac{40}{20} = 2$

- TORQUE CALCULATIONS**

Moment of Inertia of (main shaft) + (circular assembly) + (bottles)	0.105 kg.m ²
Angular velocity of (main shaft) + (circular assembly) + (bottles)	15 rpm
Final Angular momentum of (main shaft) + (circular assembly) + (bottles)	0.165 kg.m ² /s
Moment of Inertia of (shaft attached to the motor)	0.0242 kg.m ²
Angular velocity of (shaft attached to the motor)	30 rpm
Final Angular momentum of (shaft attached to the motor)	0.076 kg.m ² /s
Time of Acceleration	2s
Factor of Safety	3
Torque required	0.315N.m<1N.m

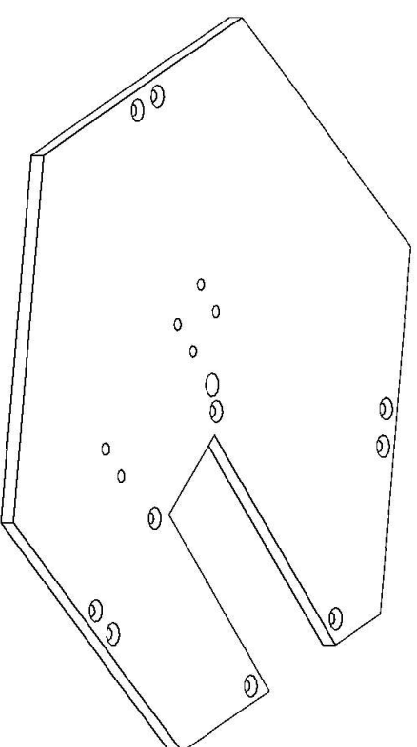
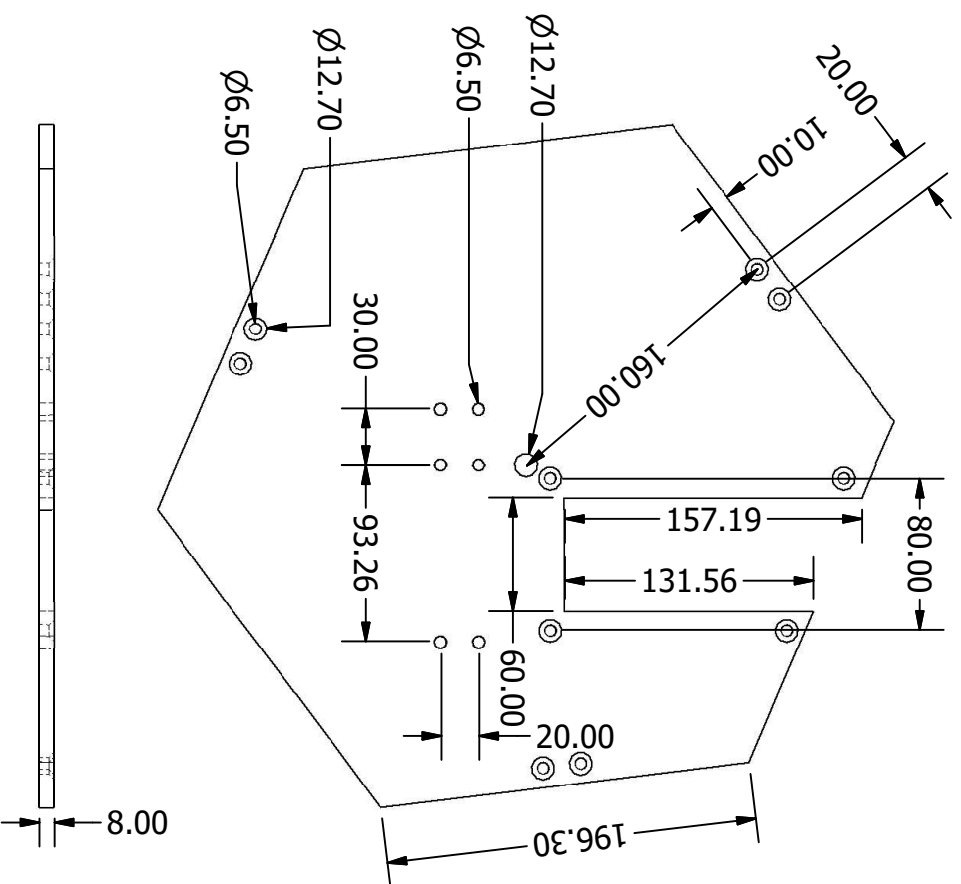
PARTS LIST:

Part Name	Quantity	Material	Manufactured/Bought	Machining processes
<i>Baseplate</i>	1	Mild Steel	Manufactured	Cutting, Drilling,
<i>Hexagonal disk</i>	1	Mild Steel	Manufactured	Cutting, Drilling, Milling
<i>L-support (L)</i>	3	Mild Steel	Manufactured	Cutting, Drilling
<i>L-support (for pinion)</i>	2	Mild Steel	Manufactured	Cutting, Drilling
<i>Main Shaft</i>	1	Mild Steel	Manufactured	Cutting
<i>Collar</i>	1	Mild Steel	Manufactured	Cutting, Drilling
<i>L-support (for Bevel Gear (20))</i>	2	Mild Steel	Manufactured	Cutting, Drilling
<i>L-support (S)</i>	8	Mild Steel	Manufactured	Cutting, Drilling
<i>Shaft (for Bevel Gear (20))</i>	1	Mild Steel	Manufactured	Cutting, Drilling
<i>Rack</i>	1	Mild Steel	Manufactured	Cutting, Drilling, Turning, Milling
<i>Pinion</i>	1	Mild Steel	Manufactured	Cutting, Drilling, Turning, Milling
<i>Shaft (for pinion)</i>	1	Mild Steel	Manufactured	Cutting, Drilling
<i>Bevel Gear (20)</i>	1	Mild Steel	Manufactured	Cutting, Drilling, Turning, Milling
<i>Bevel Gear (40)</i>	1	Mild Steel	Manufactured	Cutting, Drilling, Turning, Milling
<i>Slot-Slider</i>	1	Mild Steel	Manufactured	Cutting, Drilling
<i>Circular-Assembly</i>	1	Mild Steel	Manufactured	Cutting, Drilling
<i>Guider</i>	2	Mild Steel	Manufactured	Cutting, Drilling
<i>Bottle-Collector</i>	1	GI Sheet	Manufactured	Cutting
<i>Railing-1</i>	1	Mild Steel	Manufactured	Cutting, Drilling
<i>Railing-2</i>	1	Mild Steel	Manufactured	Cutting, Drilling
<i>Railing-3</i>	1	Mild Steel	Manufactured	Cutting, Drilling
<i>Motor- support</i>	1	Mild Steel	Manufactured	Cutting, Drilling
<i>Motor holder</i>	1	Polylactic acid (PLA)	Manufactured	3D Printing

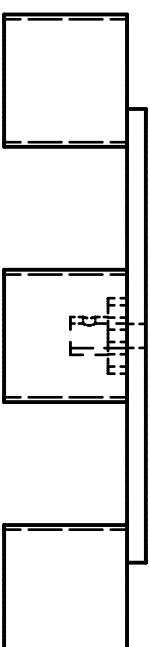
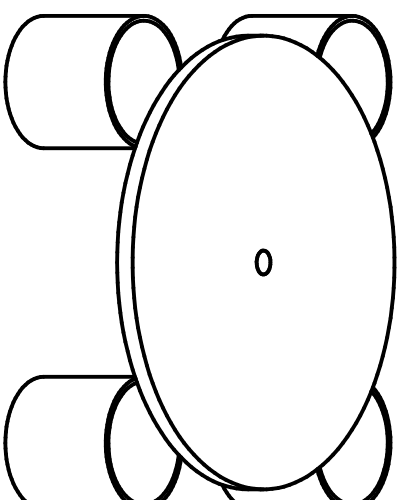
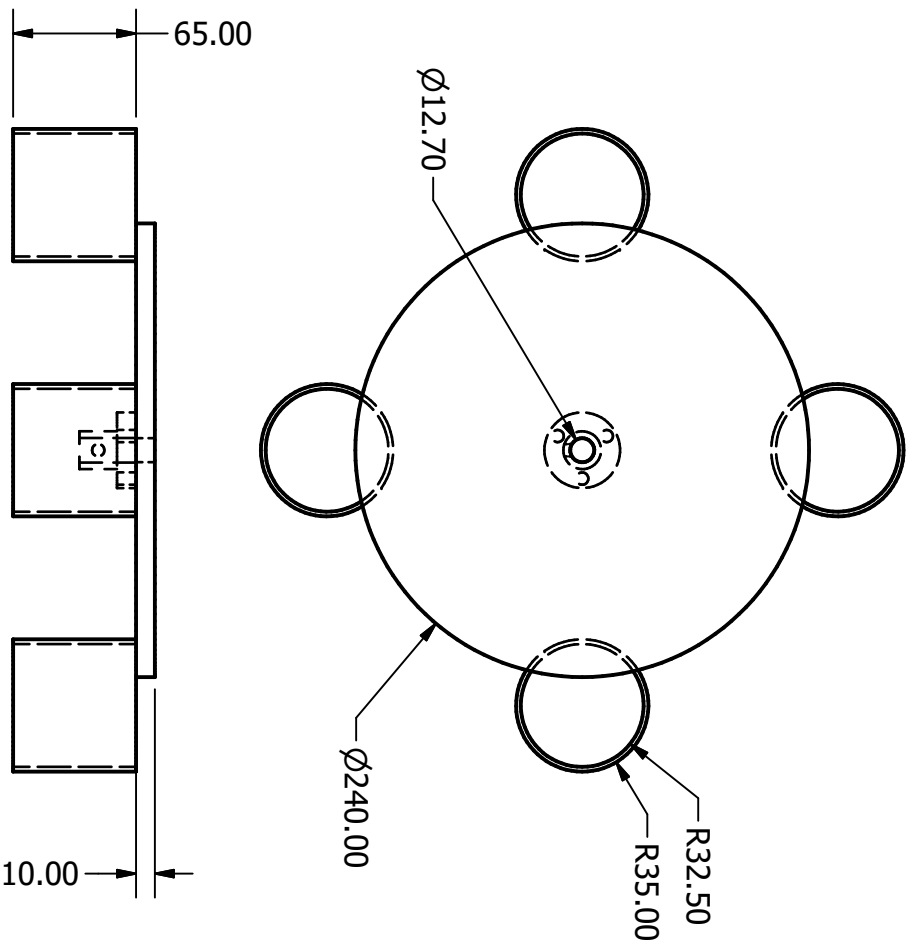


ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Baseplate
MADE BY:	Omkar, Ashish, Arun
MATERIAL USED:	Mild Steel
SCALE:	1:6
GUIDE:	Mr. Rahul

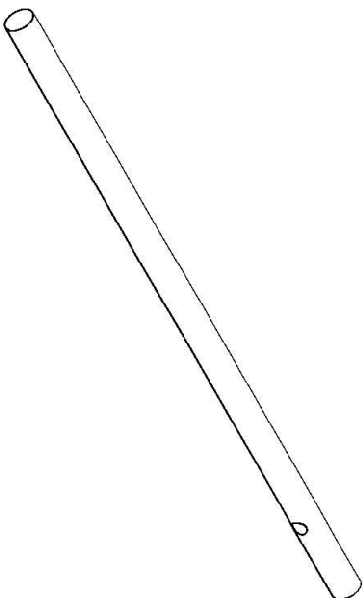
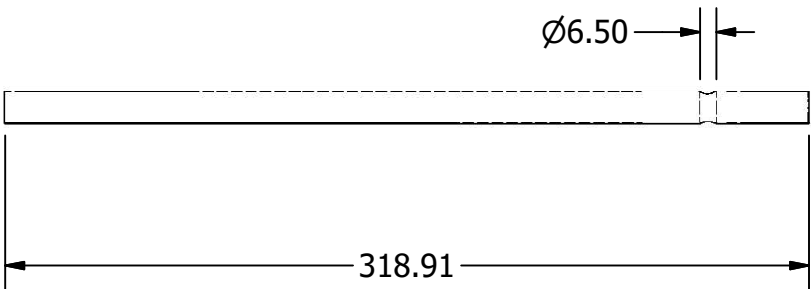


ALL DIMENSIONS ARE IN MM	
TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Hexagonal plate
MADE BY:	Prabhat, Shivam, Arun, Prakhar
MATERIAL USED:	Mild Steel
SCALE:	1:4
GUIDE:	Mr. Rahul



ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Circular- Assembly
MADE BY:	Ashish, Arun, Alka
MATERIAL USED:	Mild Steel
SCALE:	1:4
GUIDE:	Mr. Rahul



$\phi 12.70$

318.91

$\phi 6.50$

ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE

GROUP: 43, THURSDAY

PART NAME:

Main Shaft

MADE BY:

Shivam

MATERIAL USED:

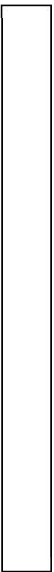
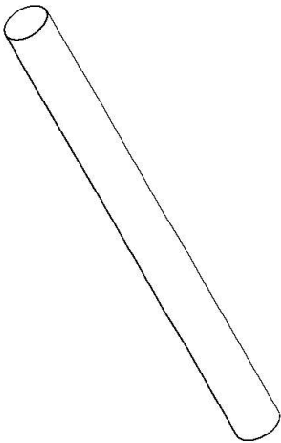
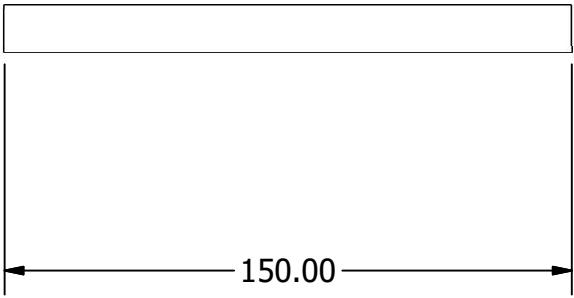
Mild Steel

SCALE:

1:3

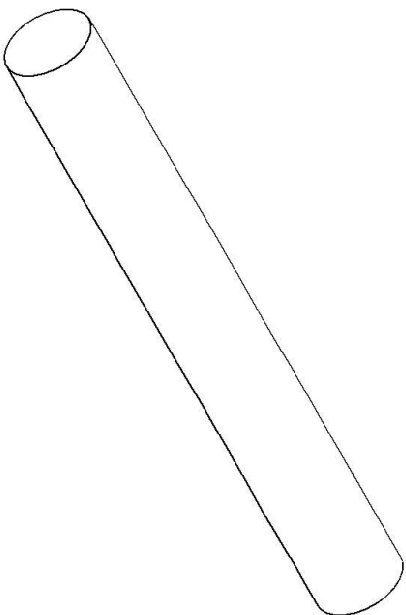
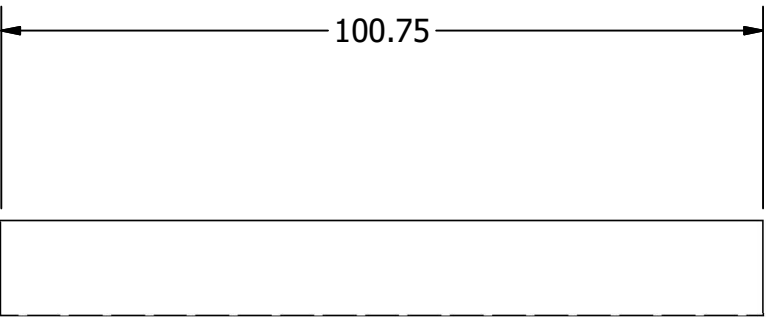
GUIDE:

Mr. Rahul



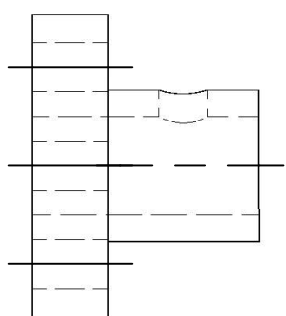
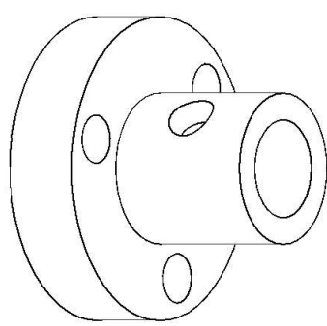
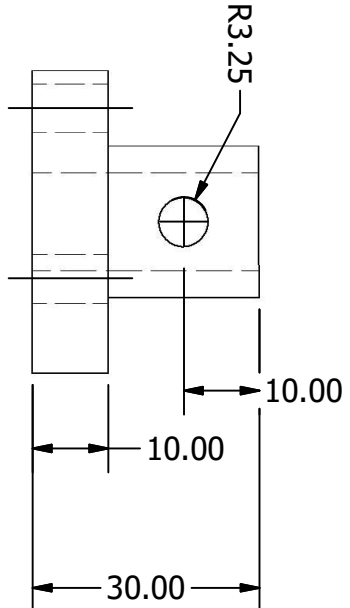
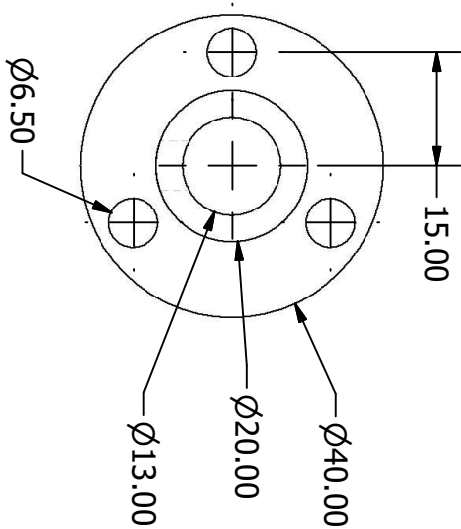
ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Shaft (for Bevel gear (20))
MADE BY:	Shivam
MATERIAL USED:	Mild Steel
SCALE:	1:2
GUIDE:	Mr. Rahul



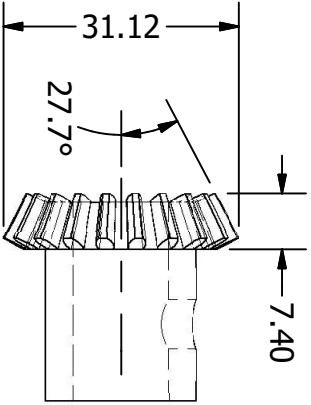
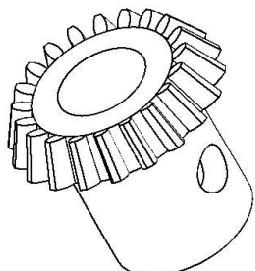
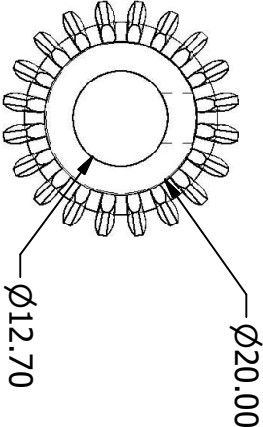
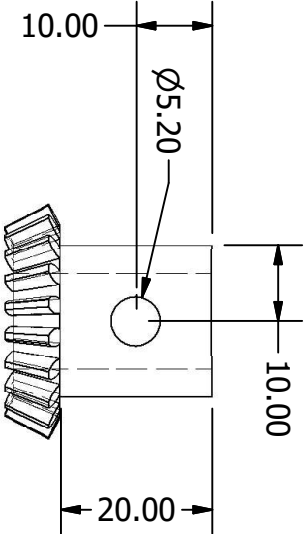
ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Shaft (for pinion)
MADE BY:	Neeraj, Sujeet
MATERIAL USED:	Mild Steel
SCALE:	1:1
GUIDE:	Mr. Rahul



ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Collar
MADE BY:	Dharmendra
MATERIAL USED:	Mild Steel
SCALE:	1:1
GUIDE:	Mr. Rahul

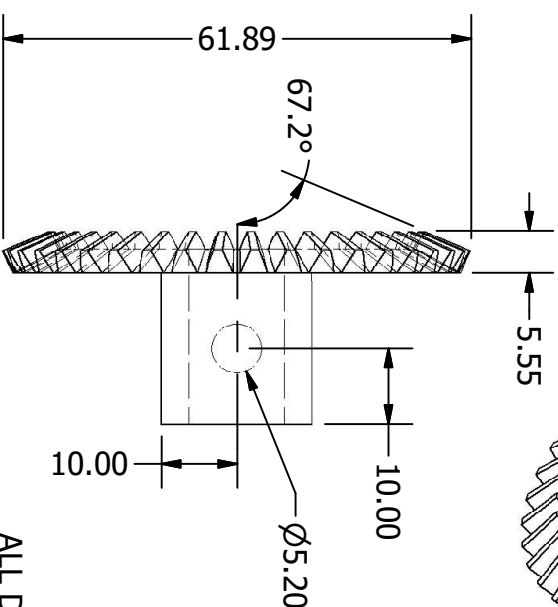
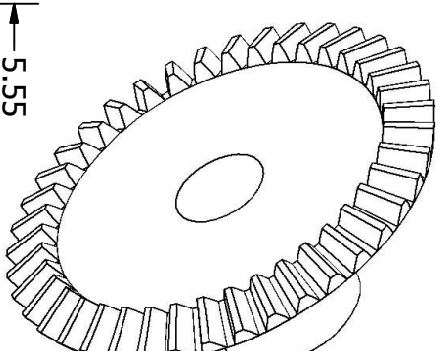
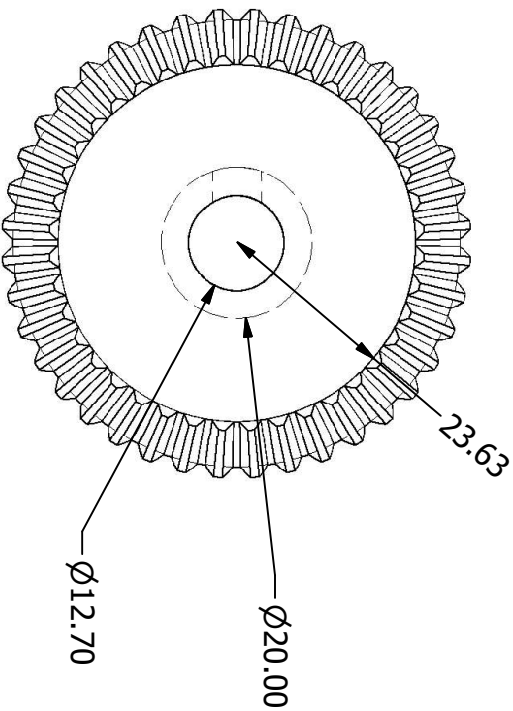
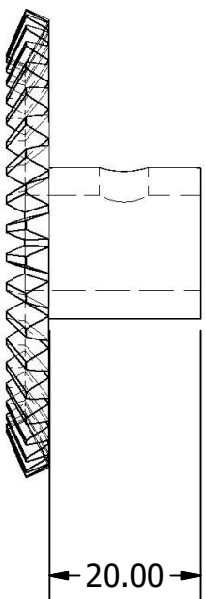


FACE ANGLE
NO. OF TEETH (N)
MODULE (M)
INDEXING = 40/N

= 27.7°
= 20
= 1.5
= 2 ROTATION

ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Bevel Gear (20)
MADE BY:	Alka, Yaman, Dharmendra
MATERIAL USED:	Mild Steel
SCALE:	1:1
GUIDE:	Mr. Rahul



ALL DIMENSIONS ARE IN MM

FACE ANGLE = 67.2°
 NO. OF TEETH (N) = 40
 MODULE (M) = 1.5
 INDEXING = 40/N = 1 ROTATION

TA202A - VENDING MACHINE

GROUP: 43, THURSDAY

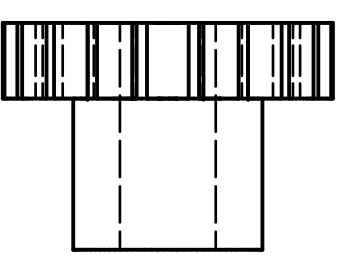
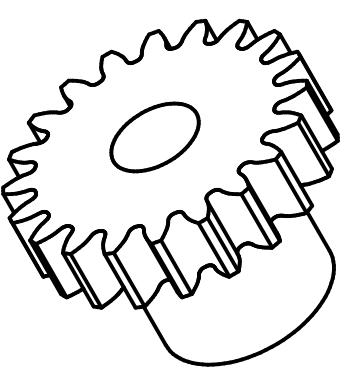
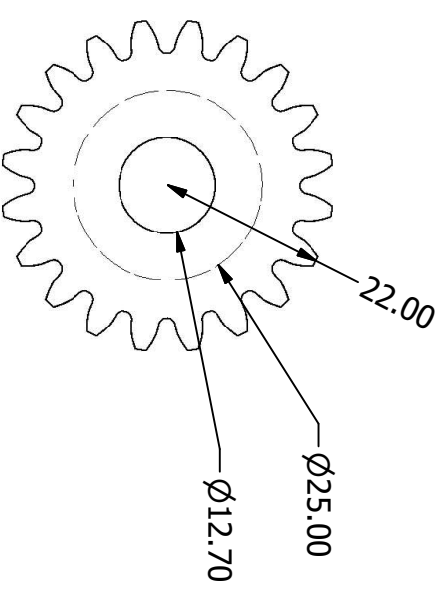
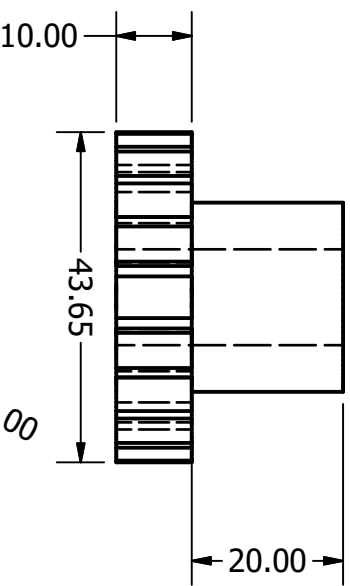
PART NAME: Bevel Gear (40)

MADE BY: Alka, Garima, Yaman, Dharmendra

MATERIAL USED: Mild Steel

SCALE: 1:1

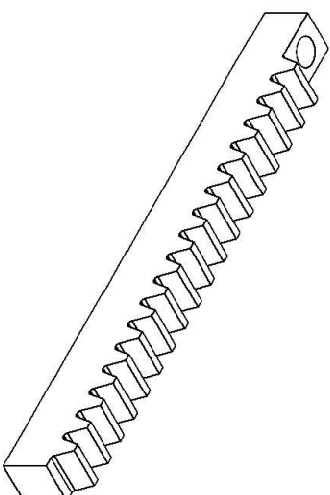
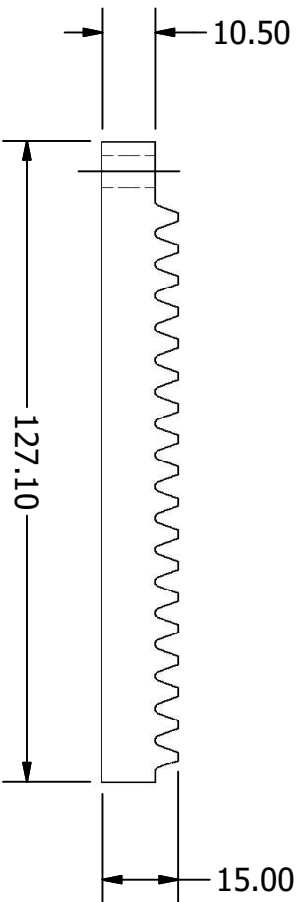
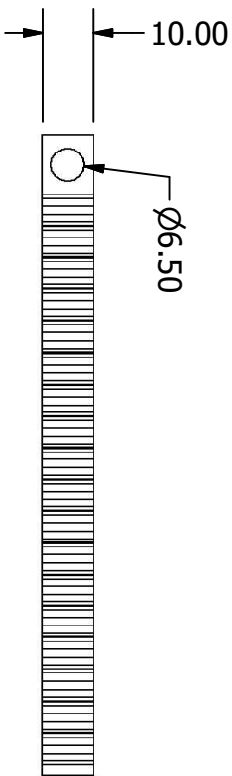
GUIDE: Mr. Rahul



ALL DIMENSIONS ARE IN MM

NO. OF TEETH (N) = 20
 MODULE (M) = 2
 OUTER DIAMETER (OD) = 44 MM
 INNER DIAMETER (IN) = 12.7 MM
 DEPTH OF CUT = 2.157 X M = 4.314 MM
 INDEXING = 40/N = 2 ROTATION

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Pinion
MADE BY:	Garima, Neeraj, Dharmendra
MATERIAL USED:	Mild Steel
SCALE:	1:1
GUIDE:	Mr. Rahul

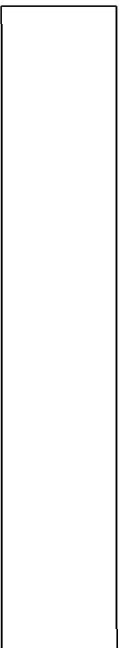
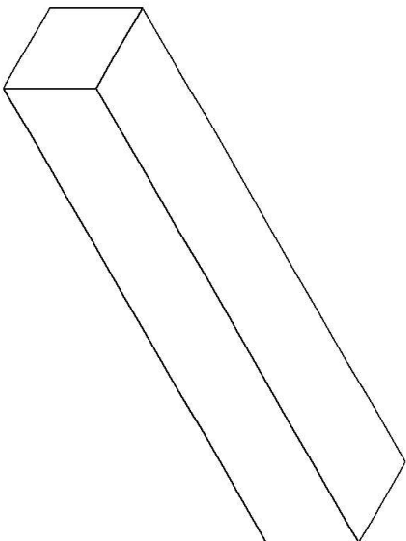
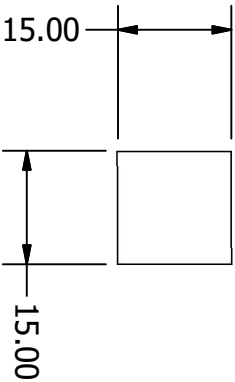
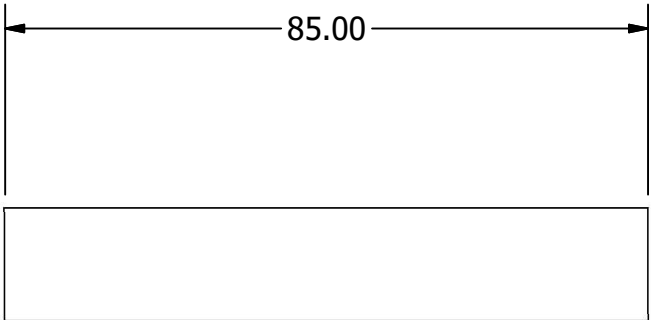


MODULE (M)
TOOTH DEPTH = 2.25 X M
PITCH OF RACK = π X M

= 2
= 4.50 MM
= 6.28 MM

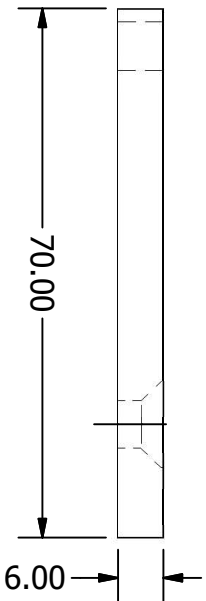
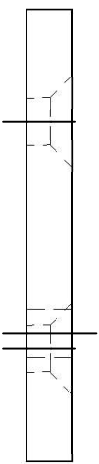
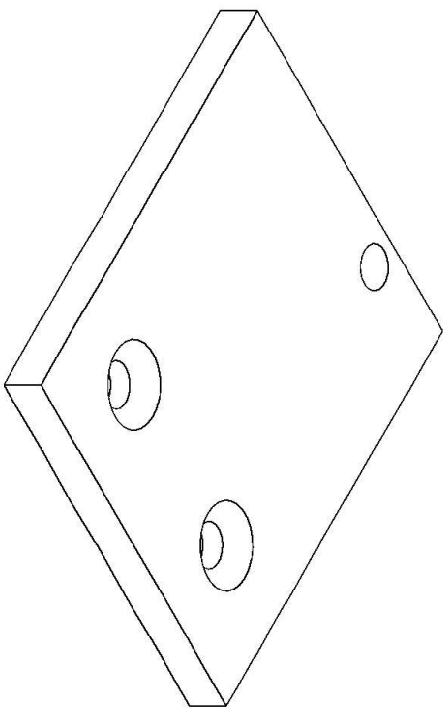
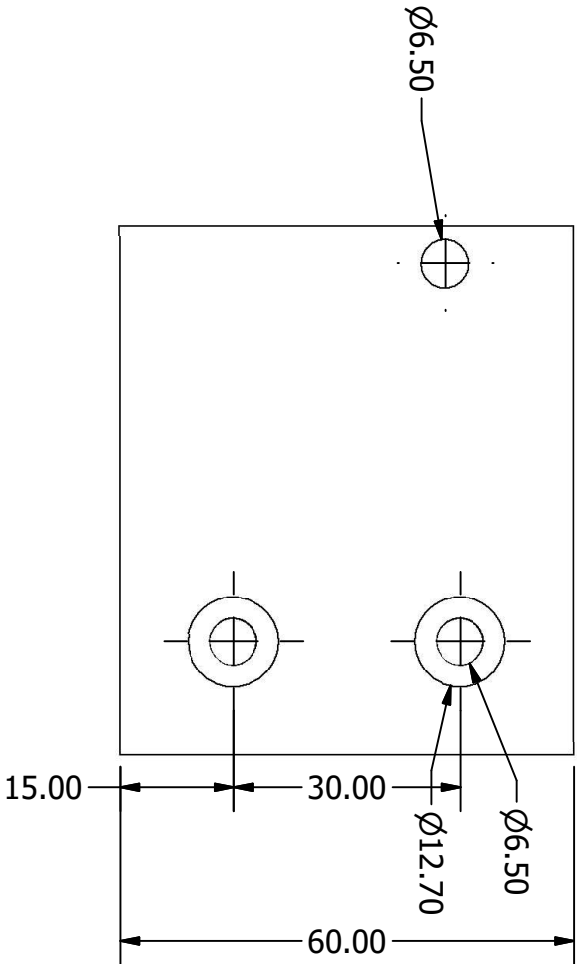
ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Rack
MADE BY:	Garima, Neeraj
MATERIAL USED:	Mild Steel
SCALE:	1:1.5
GUIDE:	Mr. Rahul



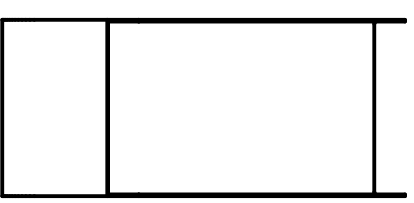
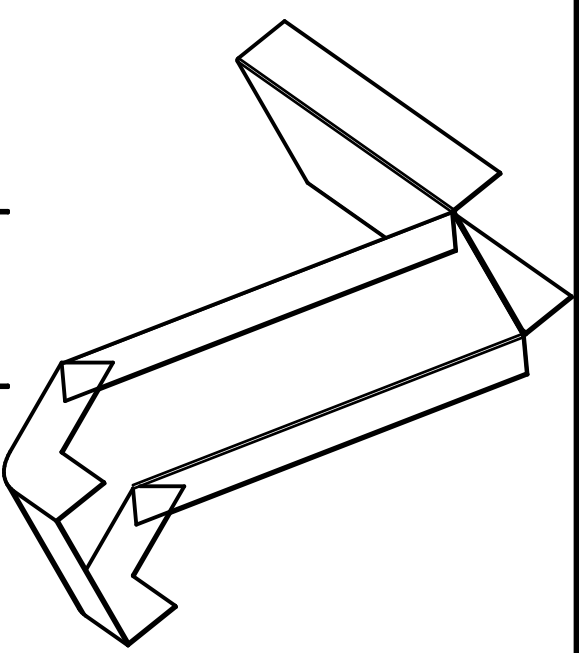
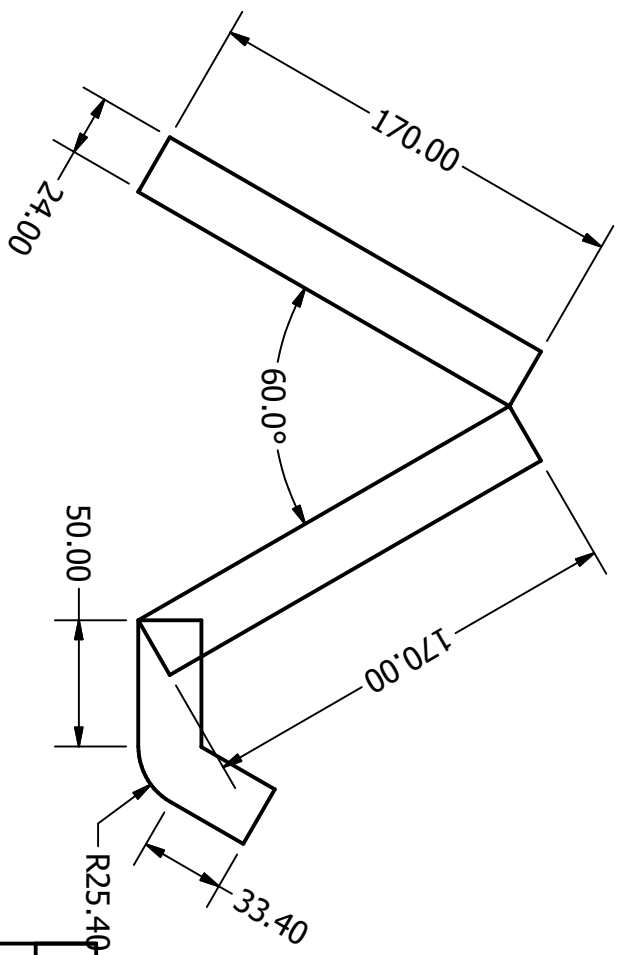
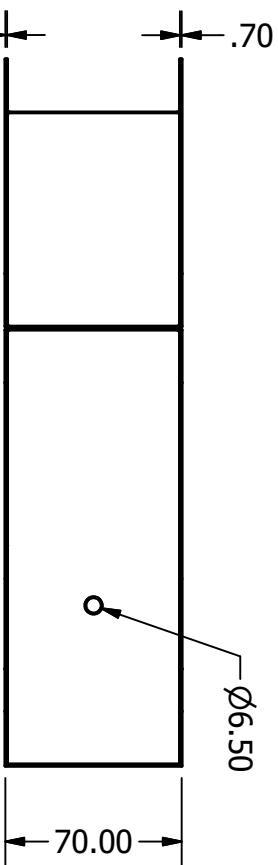
ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Guider
MADE BY:	Prakhar, Shivam
MATERIAL USED:	Mild Steel
SCALE:	1:1
GUIDE:	Mr. Rahul



ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Slot-slider
MADE BY:	Prakhar, Sujeet
MATERIAL USED:	Mild Steel
SCALE:	1:1
GUIDE:	Mr. Rahul



ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE

GROUP: 43, THURSDAY

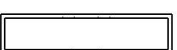
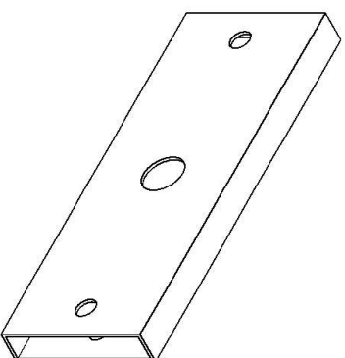
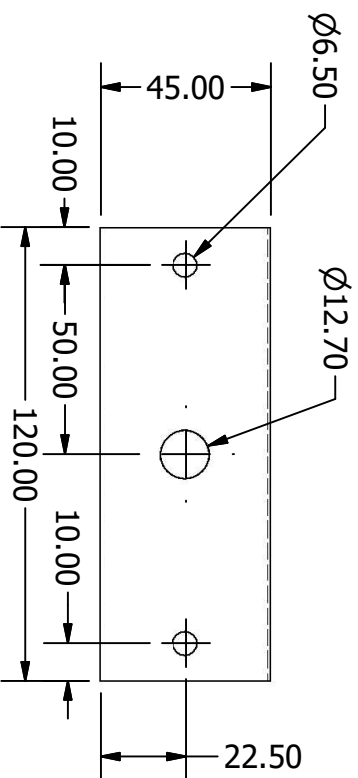
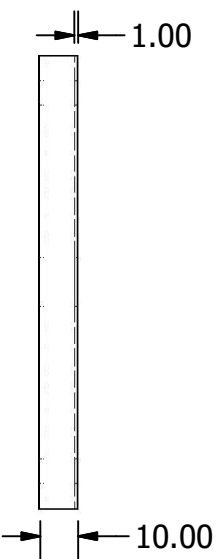
PART NAME: Bottle-Collector

MADE BY: Alka, Sujeet

MATERIAL USED: GI Sheet

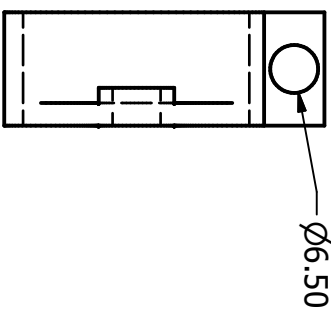
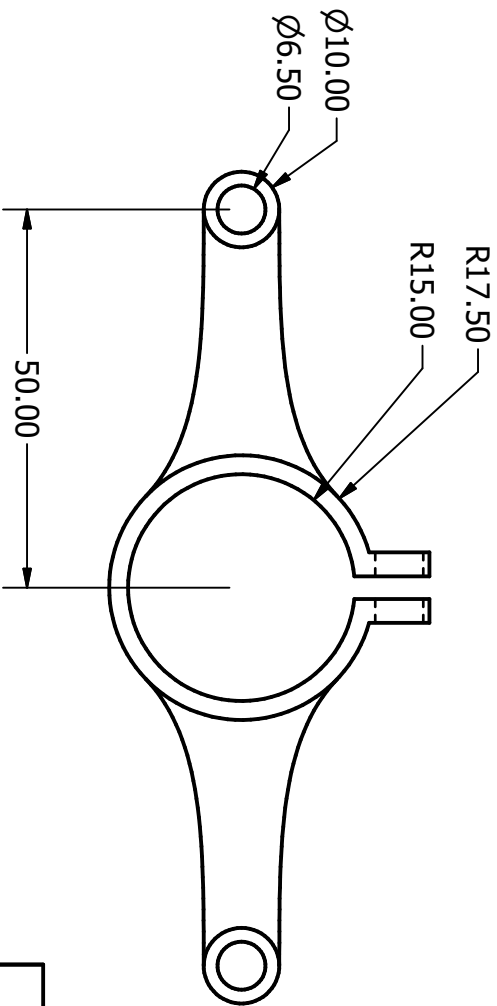
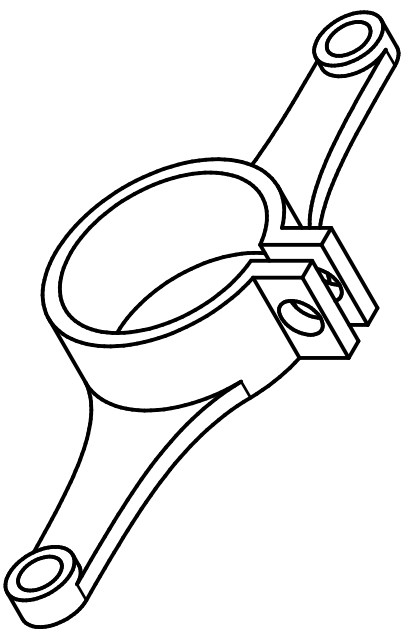
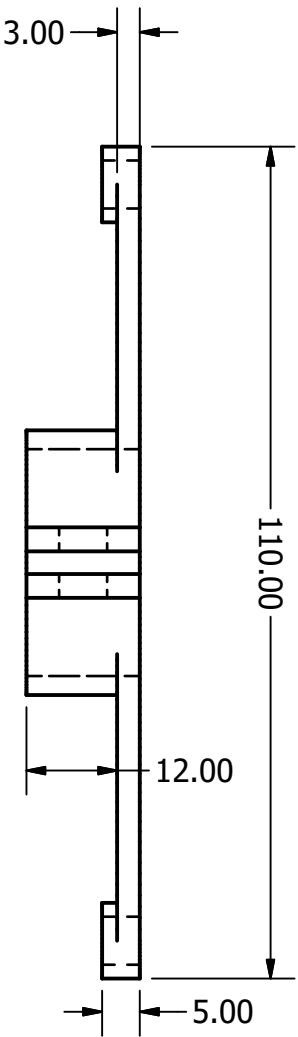
SCALE: 1:3

GUIDE: Mr. Rahul



ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Motor-support
MADE BY:	Shivam
MATERIAL USED:	Mild Steel
SCALE:	1:2
GUIDE:	Mr. Rahul



ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE

GROUP: 43, THURSDAY

PART NAME:

Motor-holder

MADE BY:

Prakhar, Neeraj

MATERIAL USED:

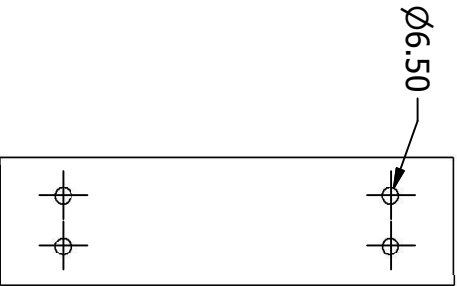
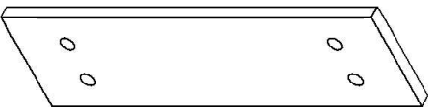
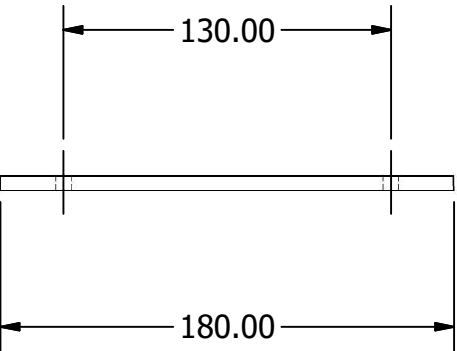
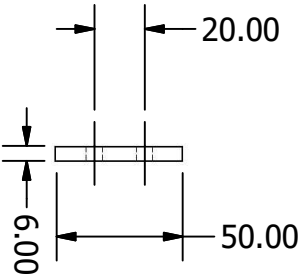
Polyactic acid (PLA)

SCALE:

1:1

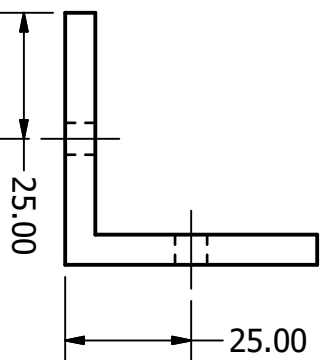
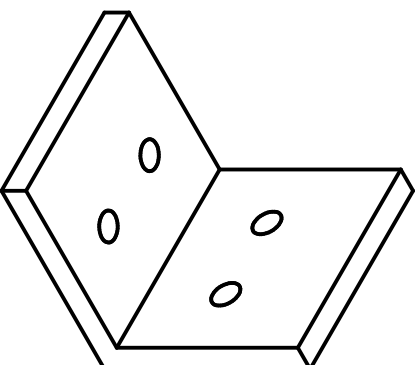
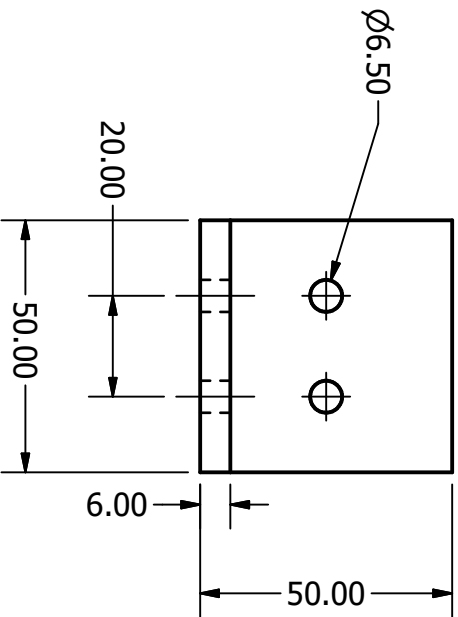
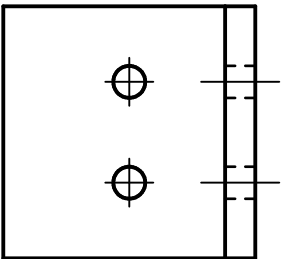
GUIDE:

Mr. Rahul



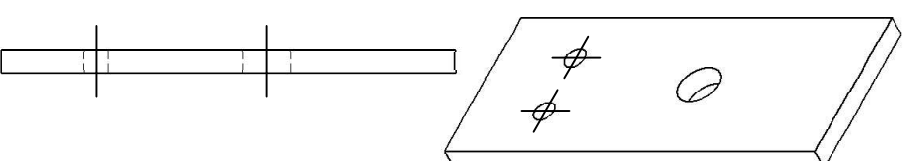
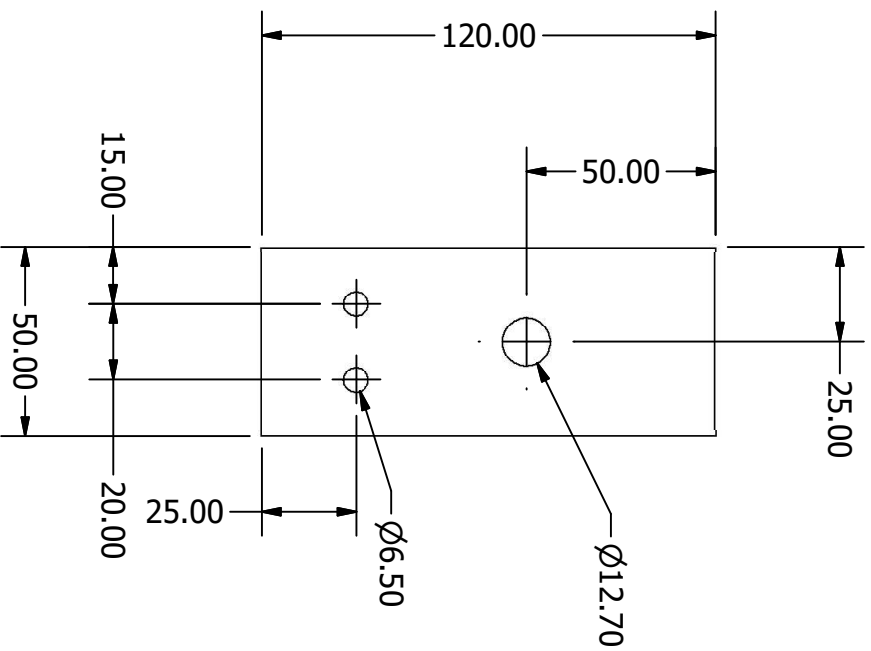
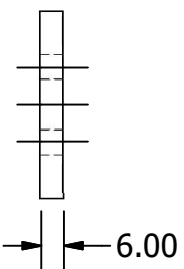
ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	L-support (L)
MADE BY:	Omkar, Ashish, Arun
MATERIAL USED:	Mild Steel
SCALE:	1:3
GUIDE:	Mr. Rahul



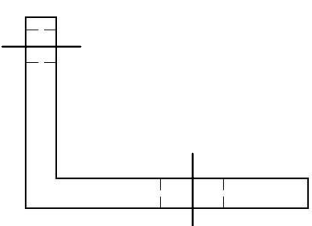
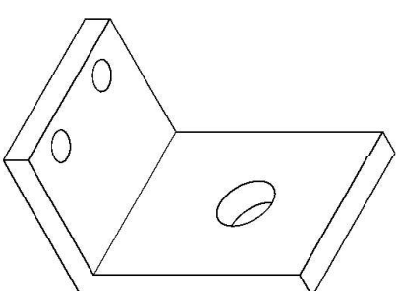
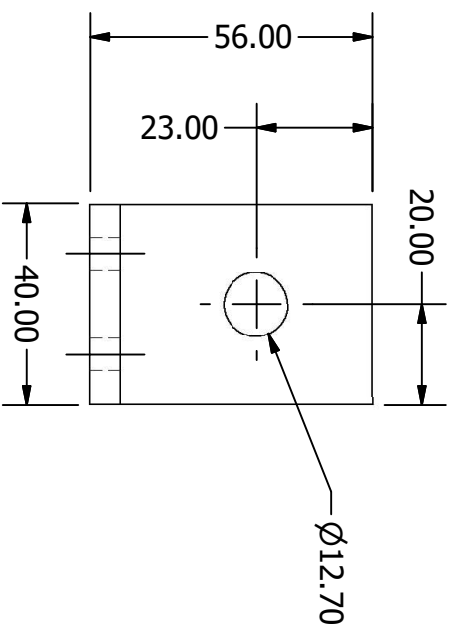
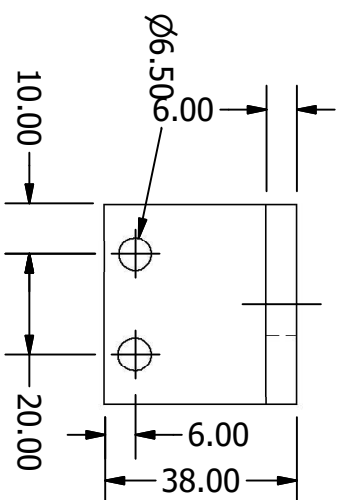
ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	L-support (S)
MADE BY:	Omkar, Prakhar
MATERIAL USED:	Mild Steel
SCALE:	1:1.5
GUIDE:	Mr. Rahul



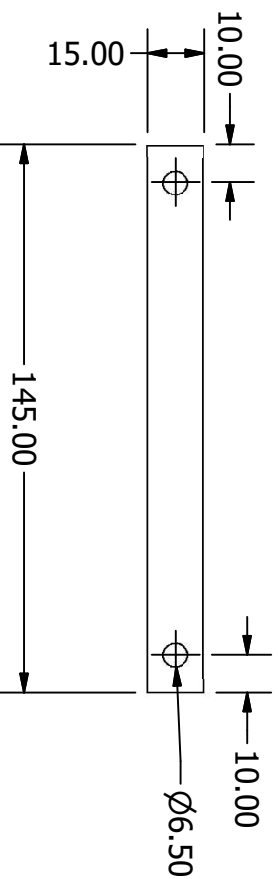
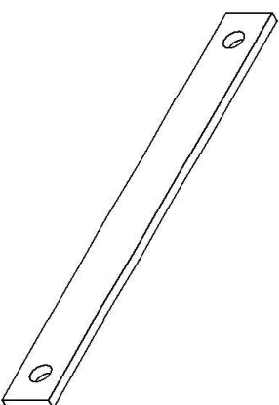
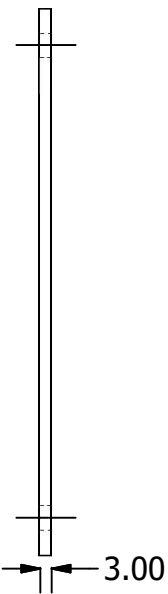
ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	L-support (for Bevel gear (20))
MADE BY:	Prabhat, Ashish
MATERIAL USED:	Mild Steel
SCALE:	1:2
GUIDE:	Mr. Rahul



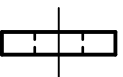
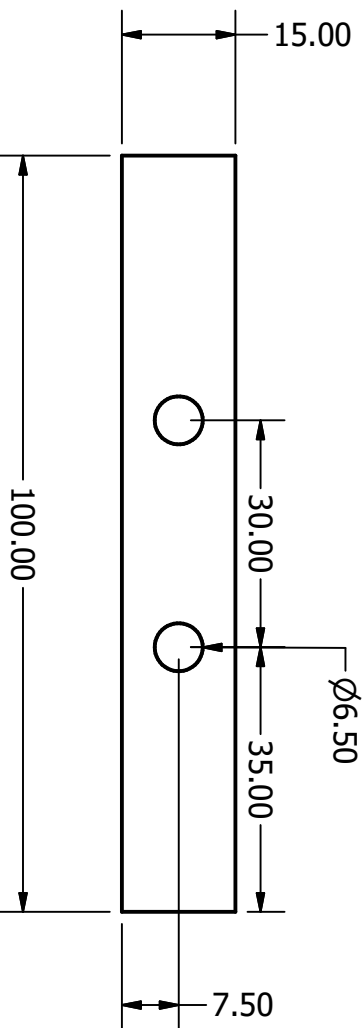
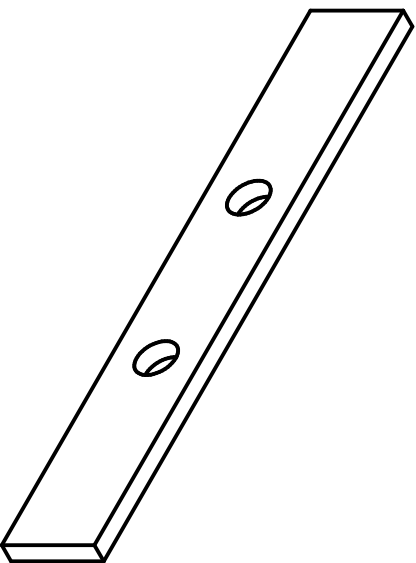
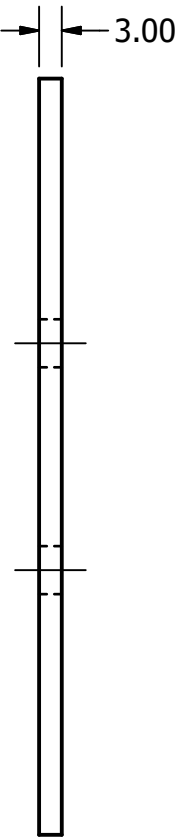
ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	L-support (for pinion)
MADE BY:	Prabhat, Sujeet
MATERIAL USED:	Mild Steel
SCALE:	1:1.5
GUIDE:	Mr. Rahul



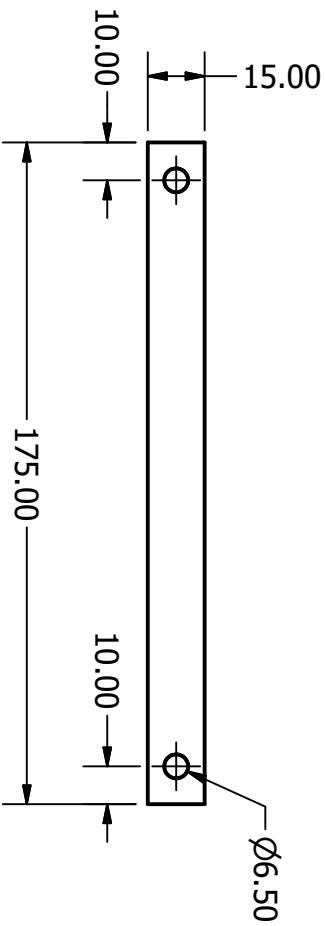
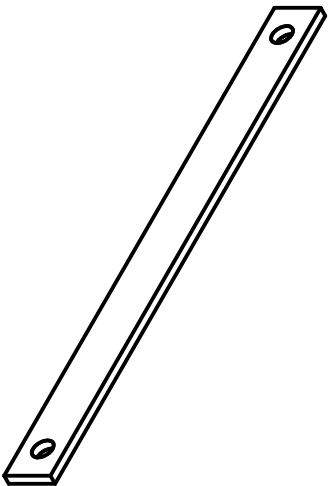
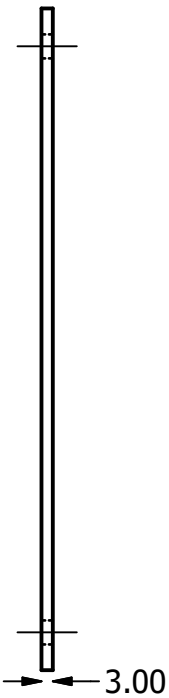
ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Railing-1
MADE BY:	Prabhat
MATERIAL USED:	Mild Steel
SCALE:	1:2
GUIDE:	Mr. Rahul



ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Railing-2
MADE BY:	Prabhat
MATERIAL USED:	Mild Steel
SCALE:	1:1
GUIDE:	Mr. Rahul



ALL DIMENSIONS ARE IN MM

TA202A - VENDING MACHINE	
GROUP: 43, THURSDAY	
PART NAME:	Railing-3
MADE BY:	Prabhat
MATERIAL USED:	Mild Steel
SCALE:	1:2
GUIDE:	Mr. Rahul

COST ANALYSIS

Material Cost

Material	Quantity	Rate	Total price
Mild Steel	25.032 kg	100 Rs/Kg	2503 Rs
Galvanized Iron	300 gm	75 Rs/Kg	22.5 Rs
Motors	1 Electric kit	1000 Rs/Kit	1000 Rs

Machining Cost

Process	Rate (Rs/hour)	Time (hours)	Total Price (Rs)
Milling	250	5	1250
Turning (Lathe)	150	5	750
3D Printing	100	2	200
Drilling	75	5	375

Labor Cost

Labor	Rate (Rs/8 hour)	Number of People	Time (hours)	Total Cost (Rs/hour)
Unskilled	650	7	18*7	10237.5
Skilled	850	5	15*5	7968.75

Total Labor Cost = 18,228.75 Rs

Total Project Cost = 24,306.75 Rs