Toronto Metropolitan University
Department of Mechanical, Industrial, and Mechatronics Engineering
Faculty of Engineering & Architectural Science

Department of Mechanical, Industrial, and Mechatronics Engineering

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Course Number	MEC 322
Course Title	Manufacturing Fundamentals
Semester/Year	Winter/2025
Instructor	Dr. Krishnan Venkatakrishnan
Section Number	10

Group Report

Report Title	Group Report
Group	1
Lab Performed	N/A
Submission Date	April 4, 2025
Due Date	Apr 4, 2025

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Grace Jeremy	6751	G.J
Alishba Aamir	35964	A.A.
Valentina Salazar Correa	3953	VSC
Mehrad Kandifard	2435	M.K
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Daniel Wu	3171	D.W

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1. Abstract

This project involves creating a mechanism that will grab styrofoam, metal, and plastic balls of 3/4" diameter and place them in their corresponding boxes. The materials given include a 24’’ string, two rubber bands, 12 nuts, 12 bolts, and a 10 x 8 in acrylic sheet. There are several constraints such as no simple levers, hands can not pass the red line, the base must fit in dowel pins and a four-bar linkage must be used. The goal is to create a mechanism that is the most efficient in picking up the most balls and placing them in the boxes in the 1-minute time frame.

This project allows the group to engineer a mechanism, including calculations, design, prototypes, and simulations. Throughout the process, several drawings were made and a morphological chart was used to choose the final design. The design was created in SOLIDWORKS, the parts were cut out and the system was assembled and used in a trial run. Following the trial run the final modifications were made for the most efficient design. Using a four-bar linkage arm, hair clip-like claw, and gears in the base allowed for the most efficient system to be created.

3. Introduction

This project effectively demonstrates and models a rudimentary feature in engineering systems, equipment sorting, and delivery implementation. This assignment allows for the combination of theoretical fundamentals with real-world applications, allowing one to fully grasp key engineering concepts.

The mechanism created should be able to pick up a Ø ¾ inch of styrofoam, plastic, or metal ball from a large plastic tray and deposit it into a 2 cm hole in its respective container, all placed at varying lengths on the board. The acrylic design must be fitted onto two wooden dowels of Ø 0.250 ± 0.001". The rest of the materials allowed include 2 rubber bands, a string, and a paperclip. Working with strict material constraints, the design's goal was to ensure simplicity and functional efficiency. Allowing that the mechanism would perform reliably while making most of the limited components available.

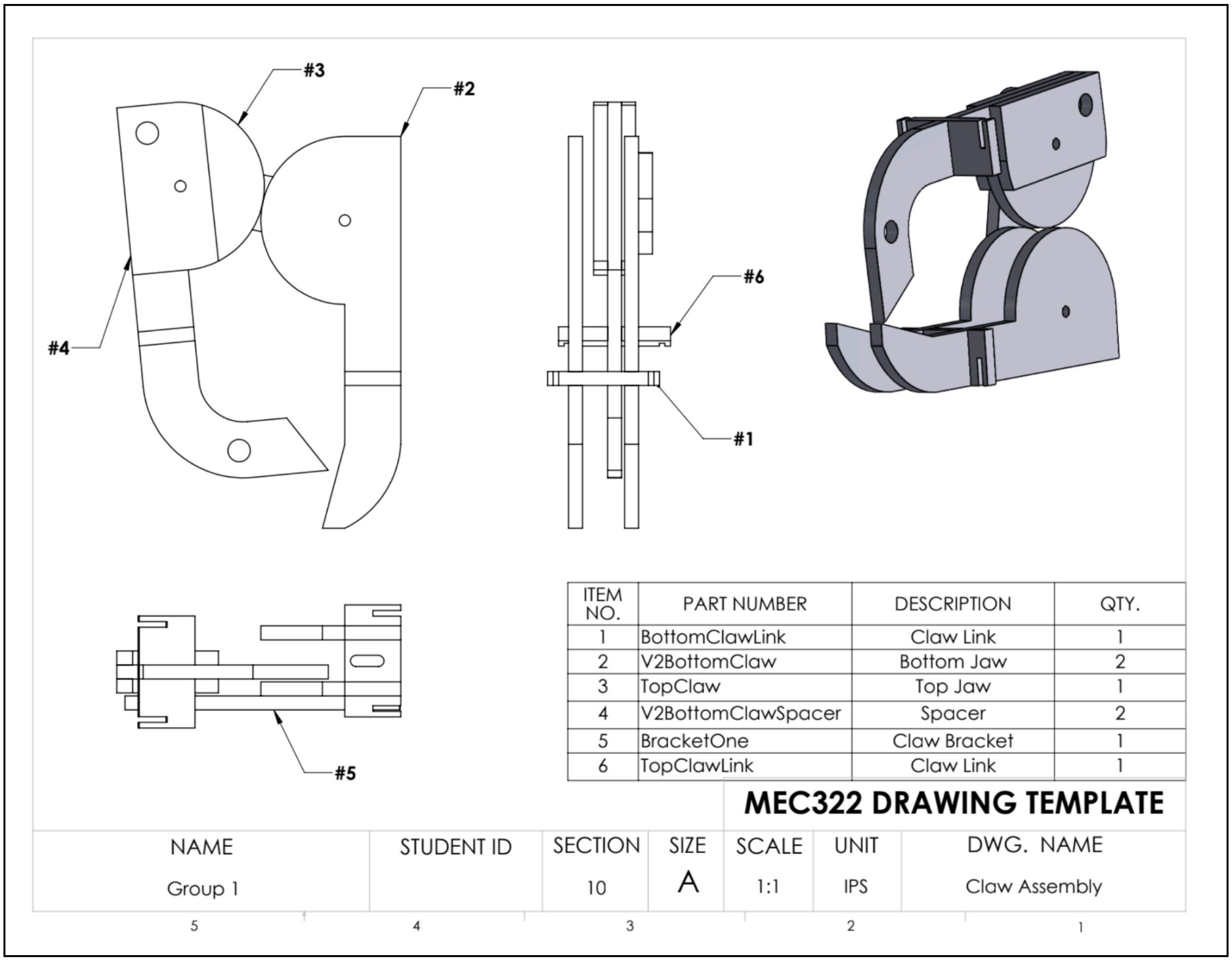
To successfully pick up, maneuver, and deposit any of the desired balls, several fundamental principles of physics and engineering must be put to use. Namely, density, weight, tension, and a four-bar linkage mechanism. Density and weight are critical properties to keep in mind when sorting through the balls and picking them up. Metal balls have a higher density than plastic and styrofoam. This indirectly affects the amount of force needed to pick up the ball since $density(\rho) = m/V$. Hence, the higher the density, the higher the mass, which directly affects the amount of force needed as $F = ma.$ [3] To implement a working claw mechanism, a rubber band was used to ensure the claw was closed. When the operator pulled on the string, the tension force opened the claw. Hooke's Law of the rubber band and the moment of the part directly affects the amount of tension force needed to open the claw. [4] To execute the back-and-forth motion of the claw, a four-bar linkage system was incorporated into the design, which in essence is four rigid rods connected by pin joints. Using the input angle alpha (α), the entire system is propelled forward, resulting in output angle beta (β). [2]. This allows for full range of movement in the z-plane.

Another major factor to consider when designing the mechanical system is the relationship between length of the arm and the system's tipping point. The furthest box the balls can go into is around 14" away from the dowels. It is important to consider how the system will act once the arm is fully extended while holding the ball. If the weight of the claw and arm are too heavy then the moment about the dowels will not be zero, causing the entire mechanism to tip forward. However, if the arm was made shorter to conserve materials and reduce weight then it will not be sufficient to reach the furthest box. Since the only major material used in the mechanism is acrylic, a simple design in both the arm and the claw are necessary to avoid tipping.

3. CAD Designs

Note that the tolerance on all parts is 0.01in and on all holes is 0.02;

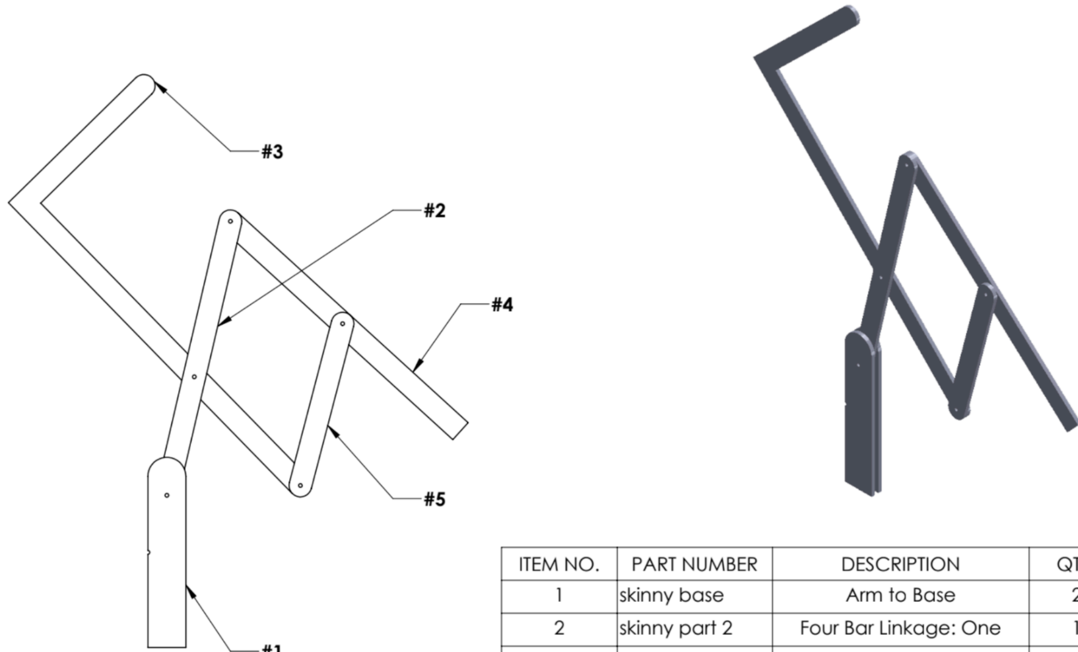
<u>ASSEMBLY 1: CLAW</u>



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	BottomClawLink	Claw Link	1
2	V2BottomClaw	Bottom Jaw	2
3	TopClaw	Top Jaw	1
4	V2BottomClawSpacer	Spacer	2
5	BracketOne	Claw Bracket	1
6	TopClawLink	Claw Link	1

Figure 1.0: Claw Assemblage

ASSEMBLY 2: BASE



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	skinny base	Arm to Base	2
2	skinny part 2	Four Bar Linkage: One	1
3	skinny part 3	Handle	1
4	skinny part 4	Four Bar Linkage: Two	1
5	Skinny Part5 (2)	Four Bar Linkage: Three	1

MEC322 DRAWING TEMPLATE

NAME	STUDENT ID	SECTION	SIZE	SCALE	UNIT	DWG. NAME
Group 1		10	A	1:3	IPS	Arm Assembly

5 4 3 2 1

Figure 2.0: Arm Assemblage

<u>ASSEMBLY 3: ARM</u>

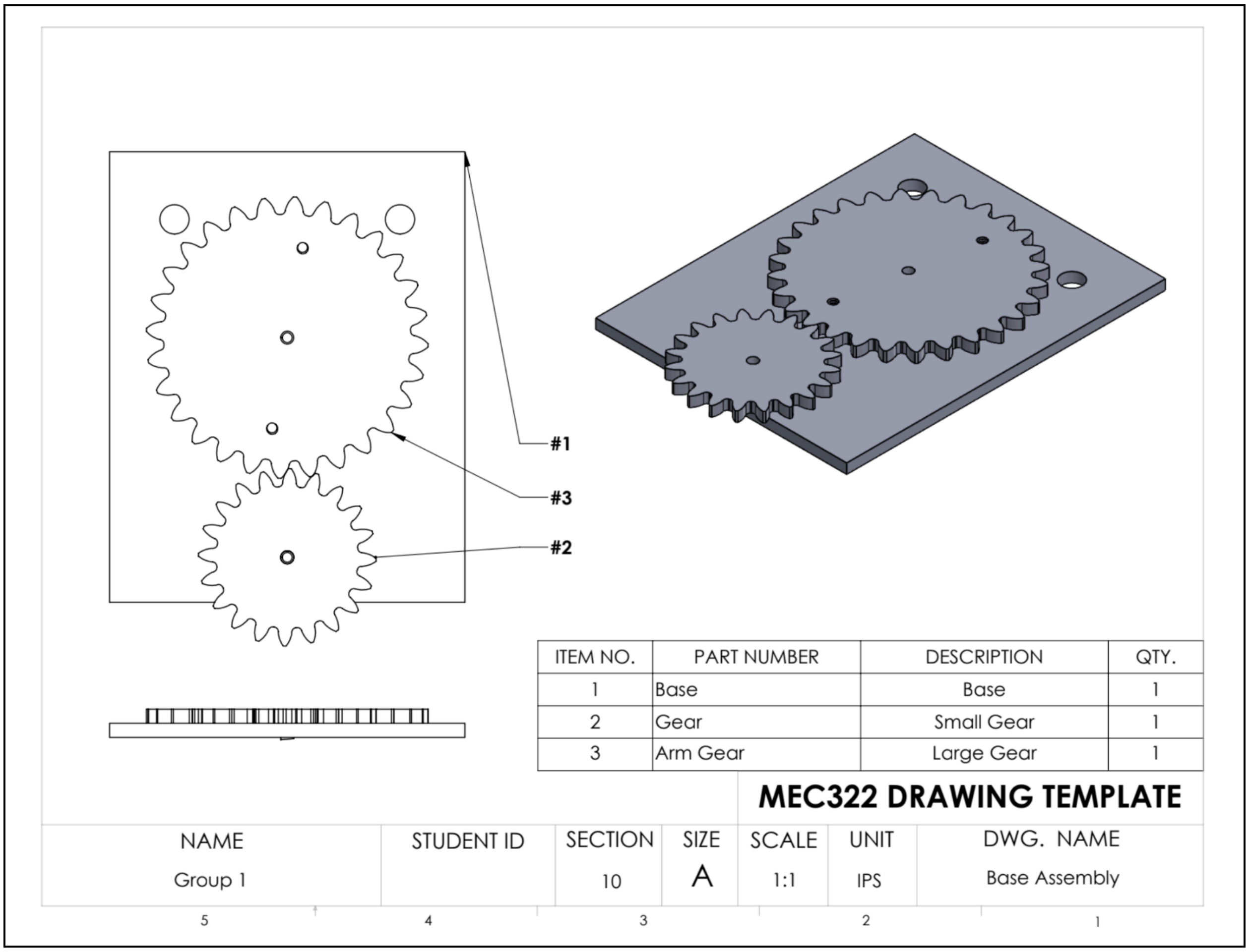


Figure 3.0: Base Assemblage

COMPLETE BILL OF MATERIALS

ITEM No.	PART No.	DESCRIPTION	QTY:
ASSEMBLY 1: CLAW			
1	BottomClawLink	Claw Link	1
2	V2BottomClaw	Bottom Jaw	2
3	TopClaw	Top Jaw	1
4	V2BottomClawSpacer	Spacer	2
5	BracketOne	Claw Bracket	1
6	TopClawLink	Claw Link	1
ASSEMBLY 2: BASE			
1	Base	Base	1
2	Gear	Small gear	1
3	Arm gear	Large gear	1
ASSEMBLY 3: ARM			
1	skinny base	Arm to Base	2
2	skinny part 2	Four Bar Linkage: One	1
3	skinny part 3	Handle	1
4	skinny part 4	Four Bar Linkage: Two	1
5	skinny part 5	Four Bar Linkage: Three	1
ADDITIONAL PARTS USED FOR FULL ASSEMBLY			
1	String	Operate claw	1
2	Rubber band	Hold claw together	1
3	Nut and Bolt	Misc.	11 each
4	Paperclip	Holds handle	1

4. References

[1] K. Venkatakrishnan, "MEC322 Project Outline 2025," TEAM PROJECT

[2] M. West, “Four-Bar Linkages,” *dynref.engr.illinois.edu*, 2015. https://dynref.engr.illinois.edu/aml.html

[3] R. C. Hibbeler and Kai Beng Yap, *Dynamics*. Singapore Pearson, 2013.

[4]F. P. Beer, *Vector mechanics for engineers statics and dynamics*. Boston Mcgraw-Hill Higher Education, 2010.

5. Appendices

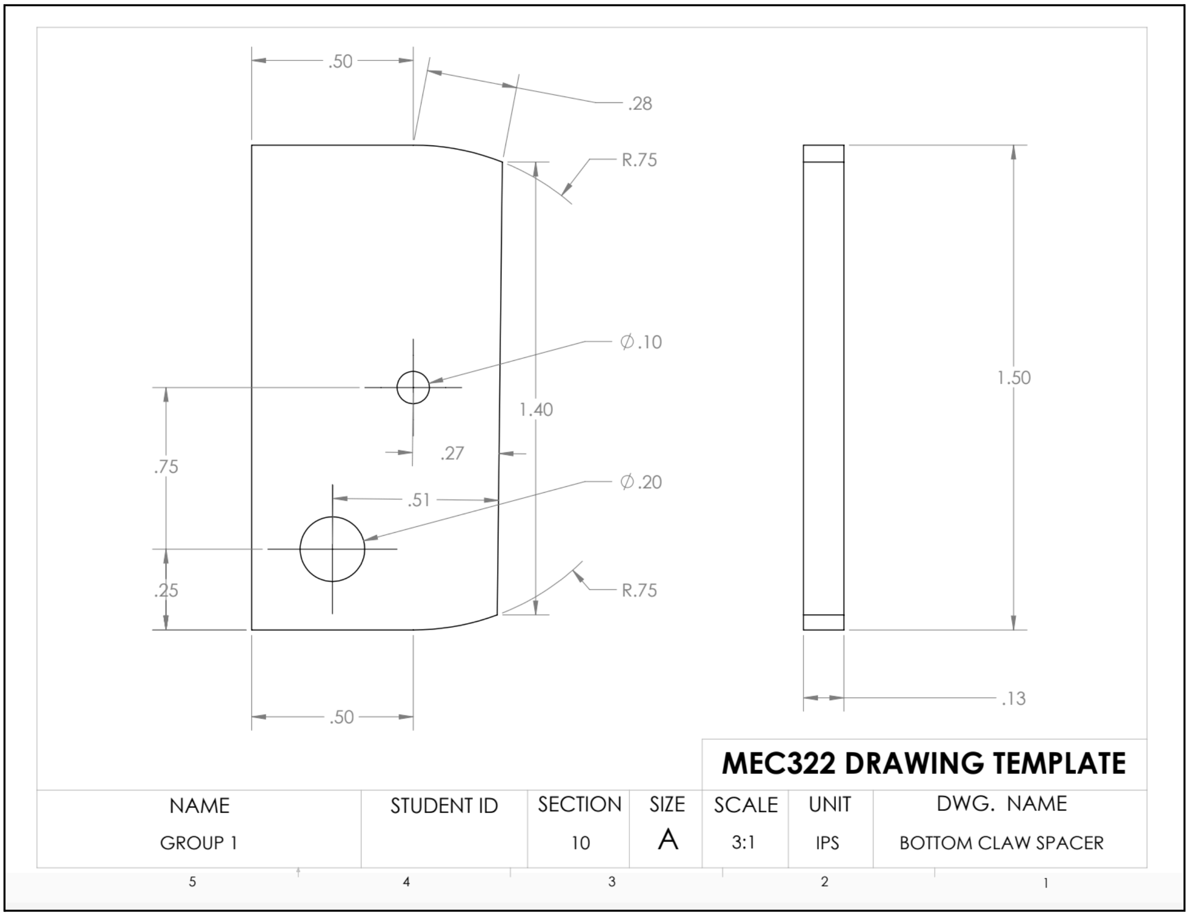


Figure 4. Bottom Claw Spacer

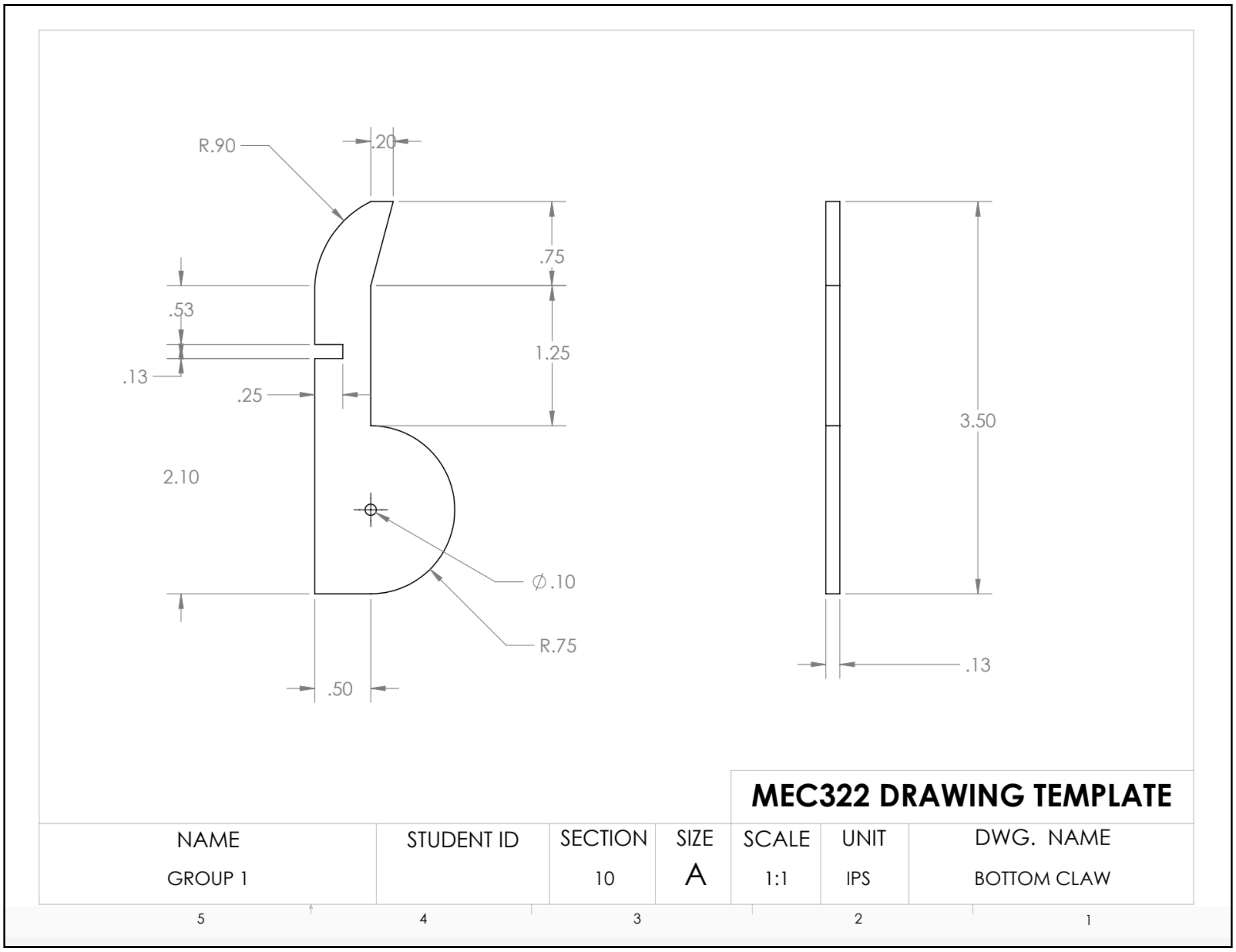


Figure 5. BottomClaw

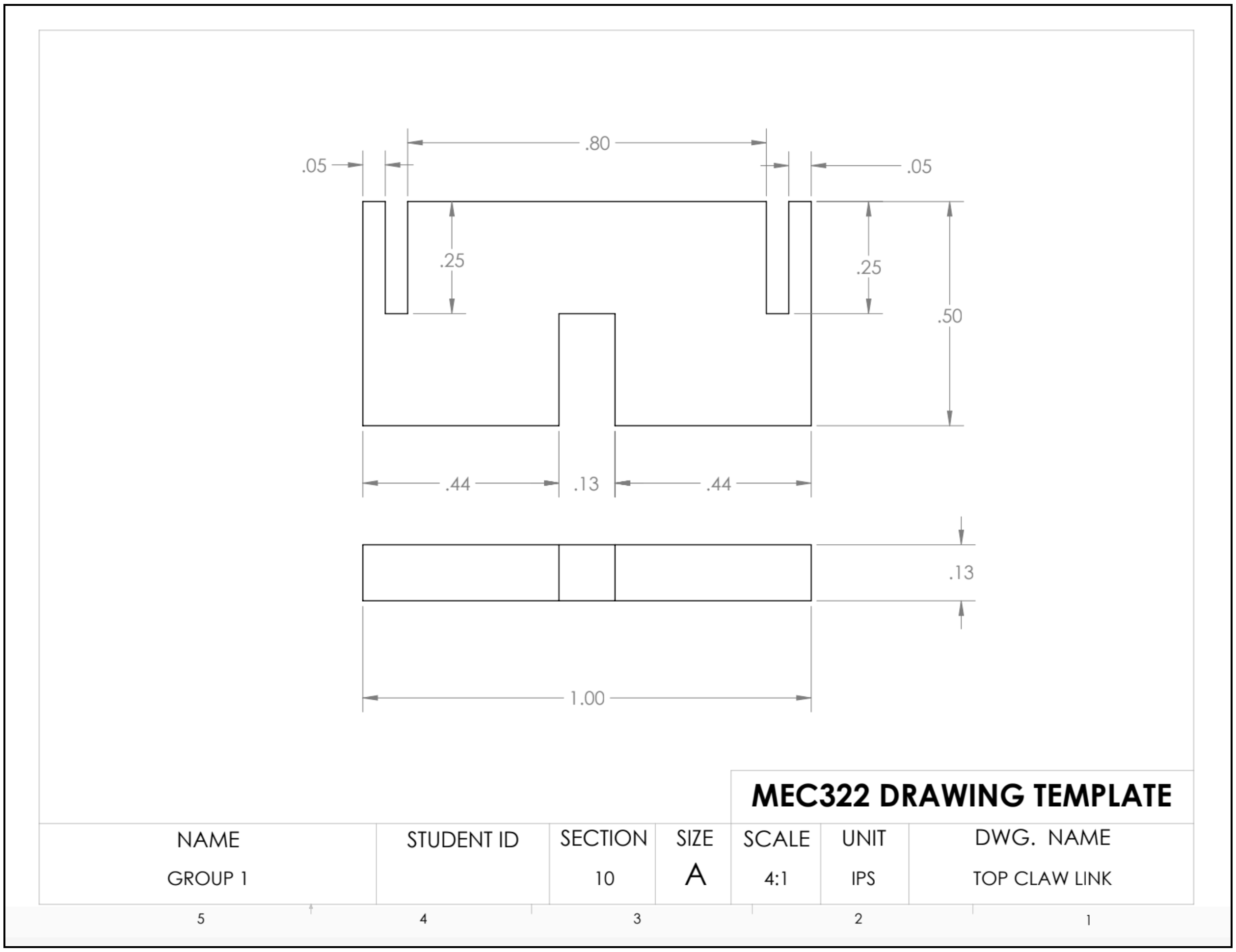


Figure 6. Top Claw Link

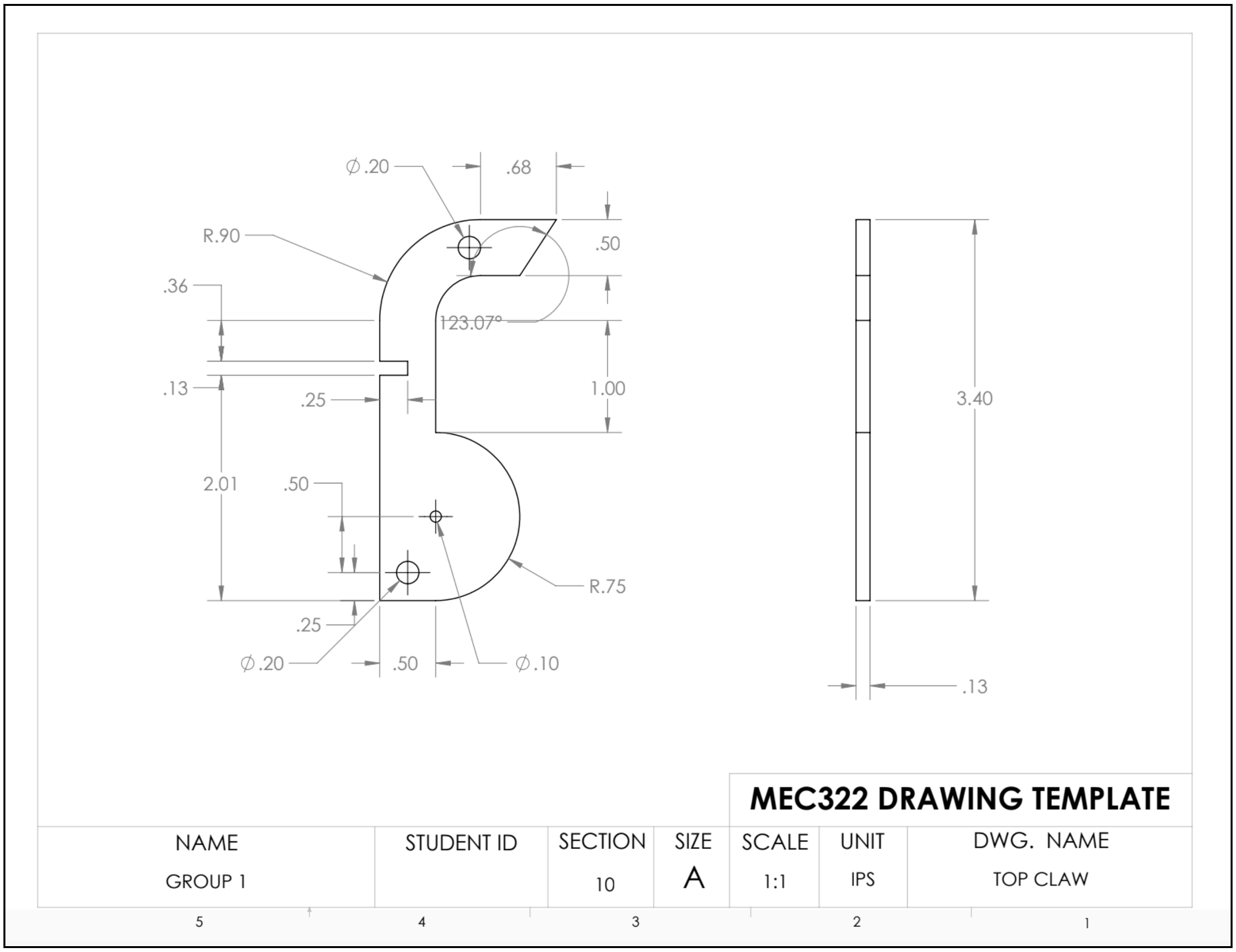


Figure 7. Top Claw

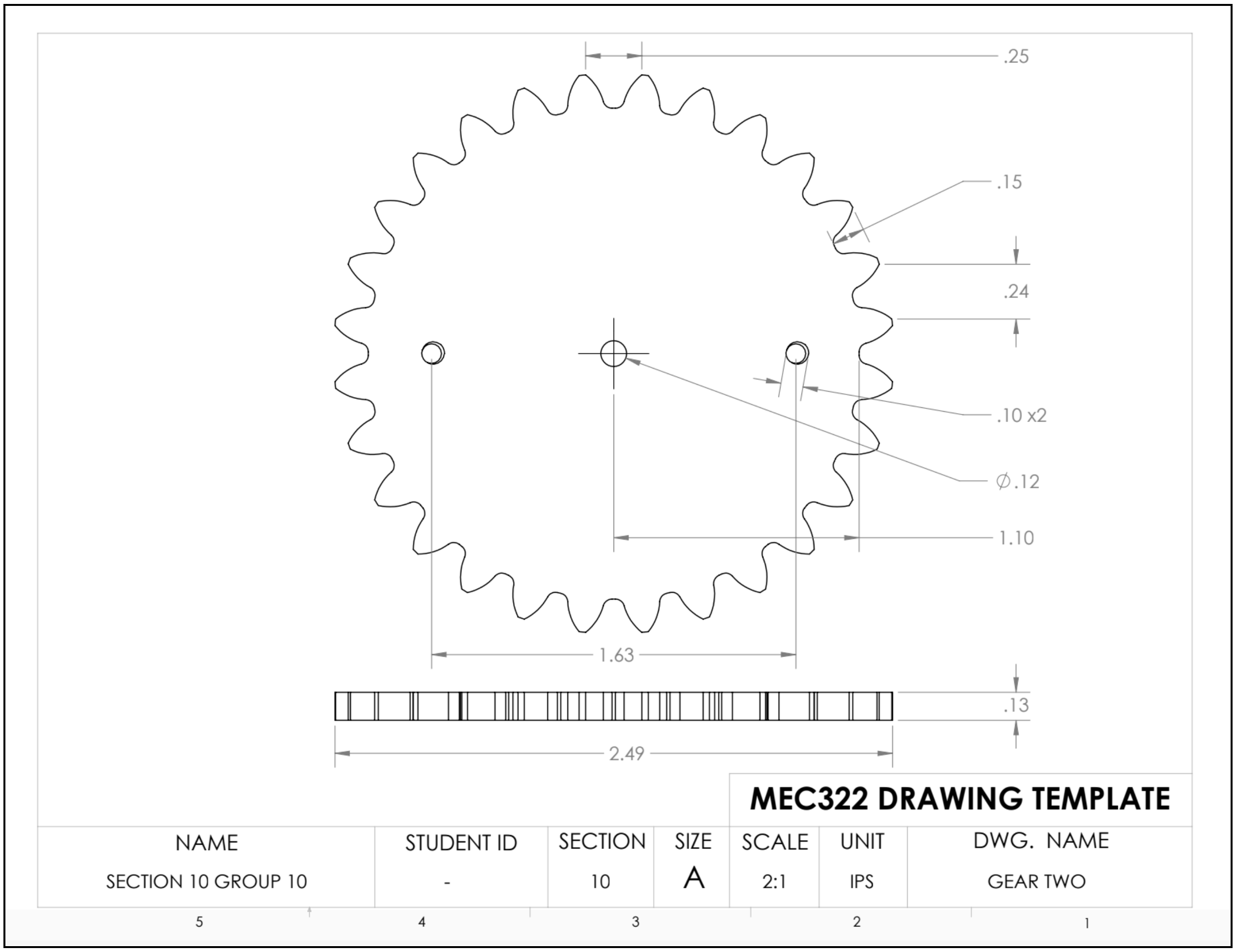


Figure 8. Gear big

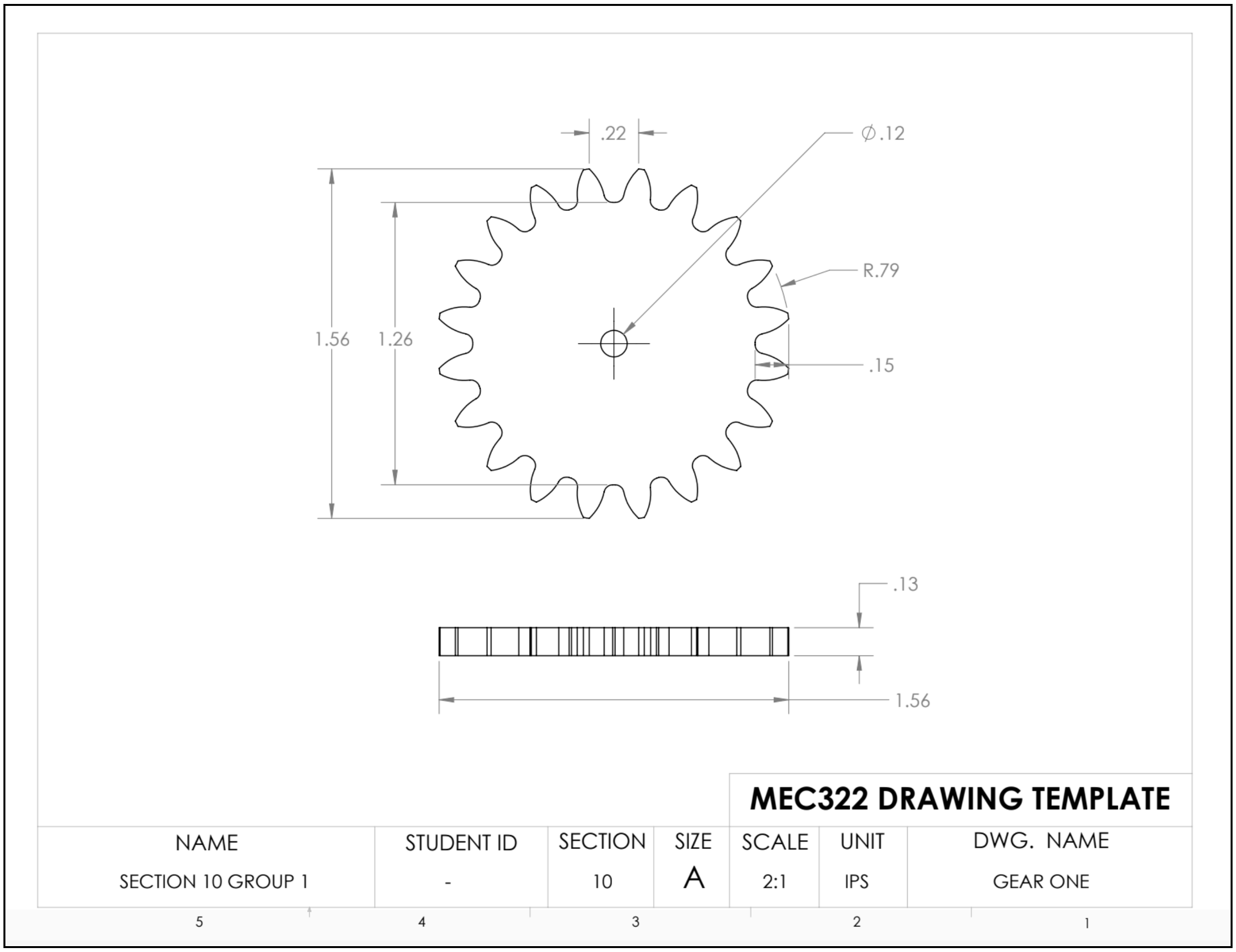


Figure 9. Gear small

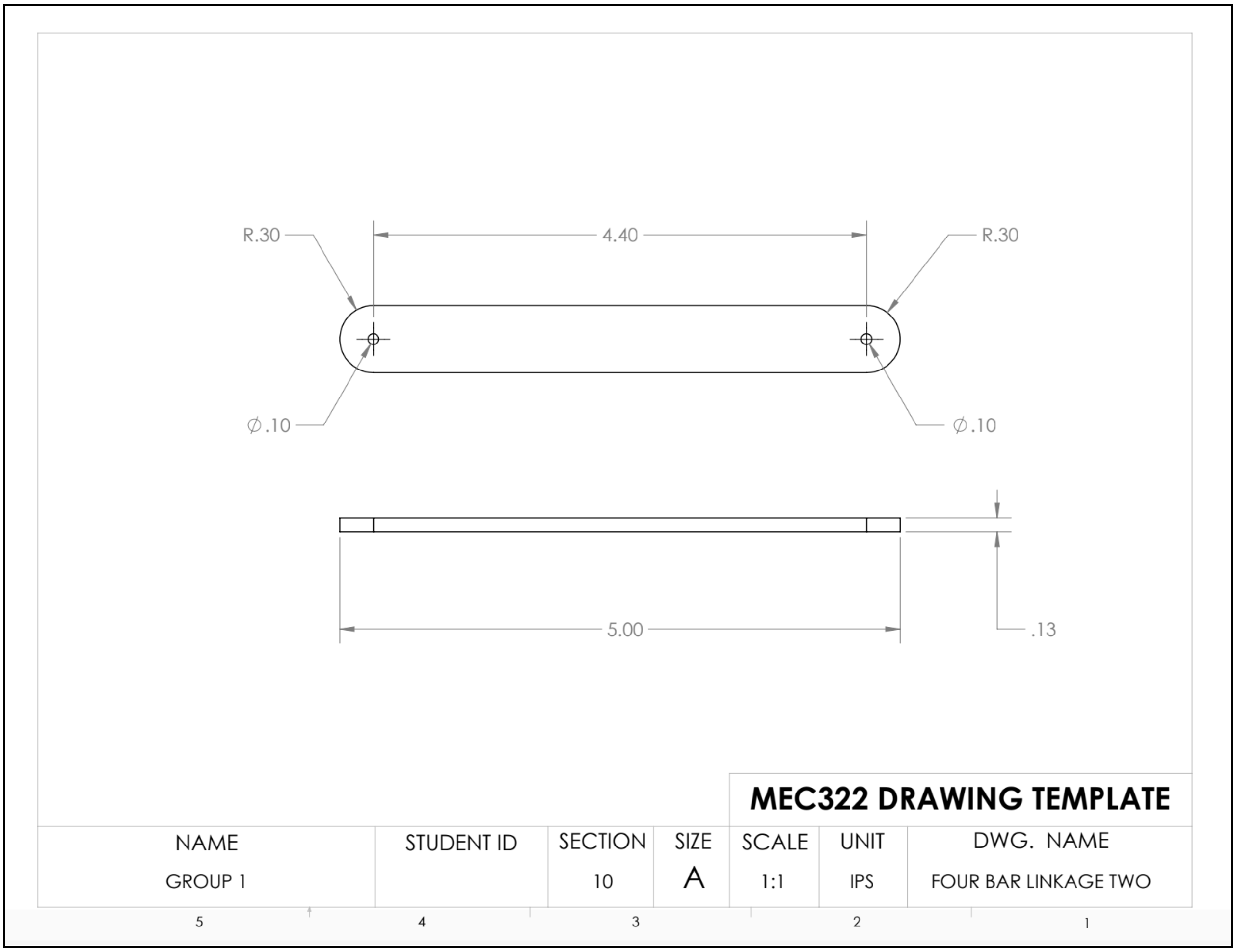


Figure 10. Four Bar Linkage Two

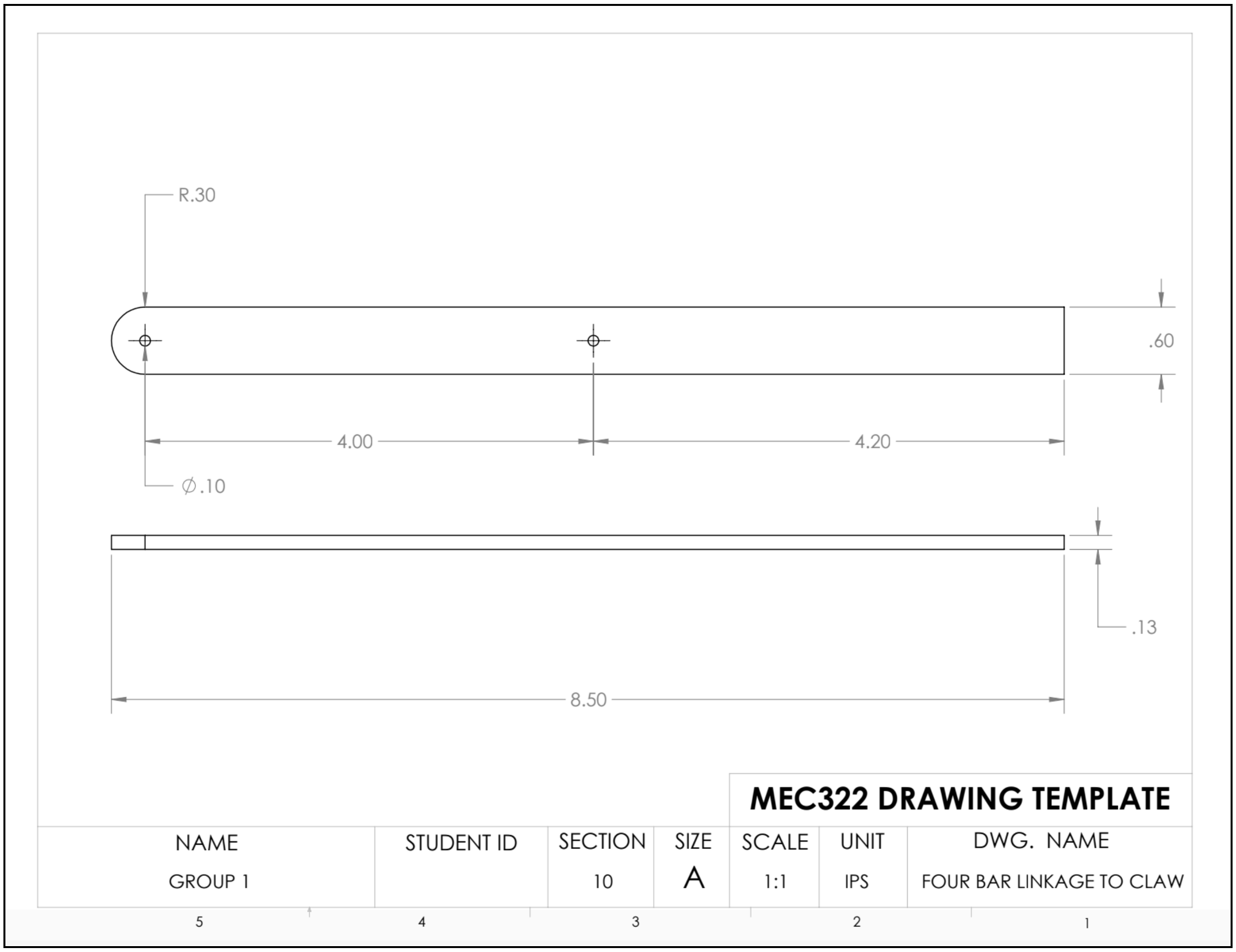


Figure 11. Four Bar Linkage To Clam

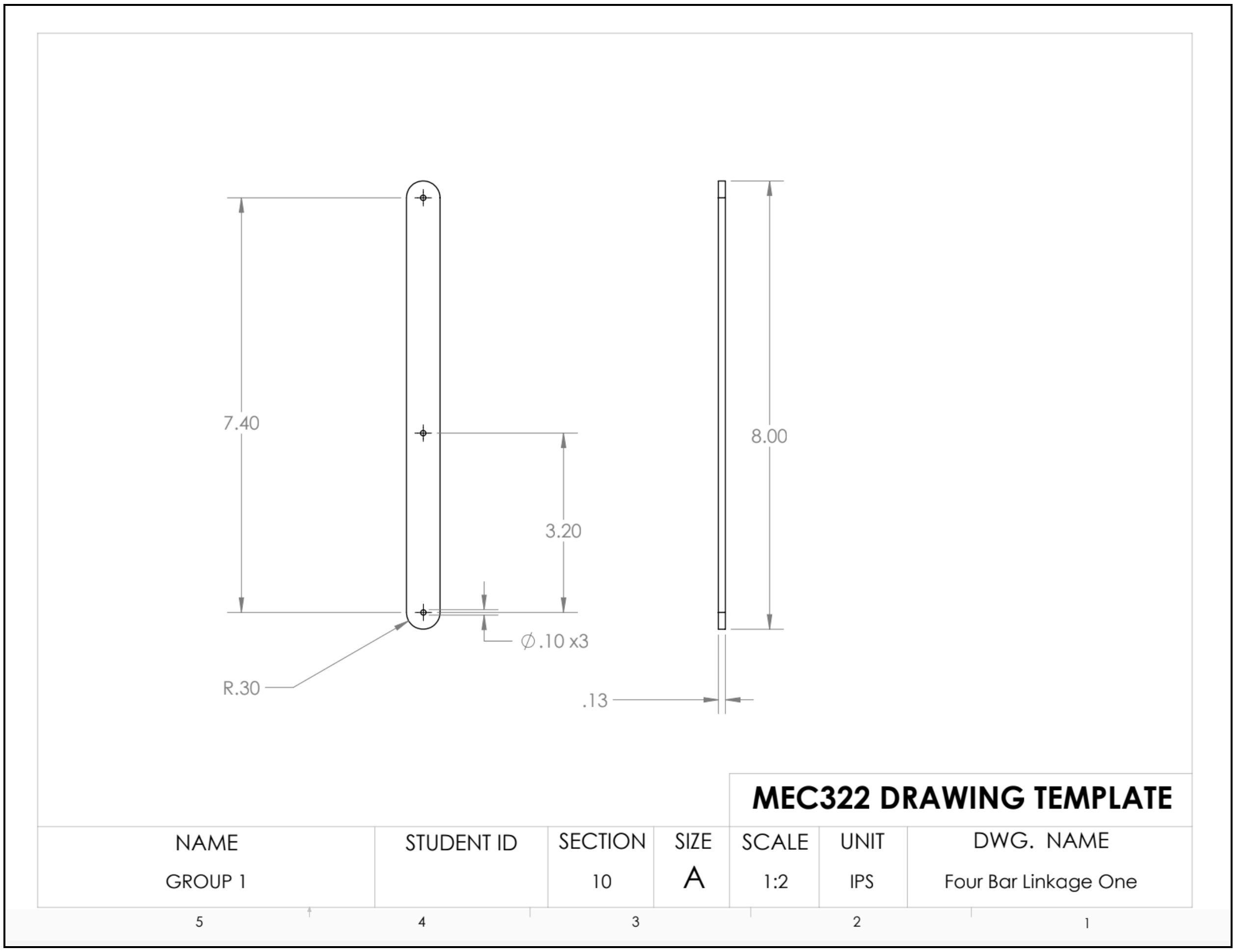


Figure 12. Four Bar Linkage One

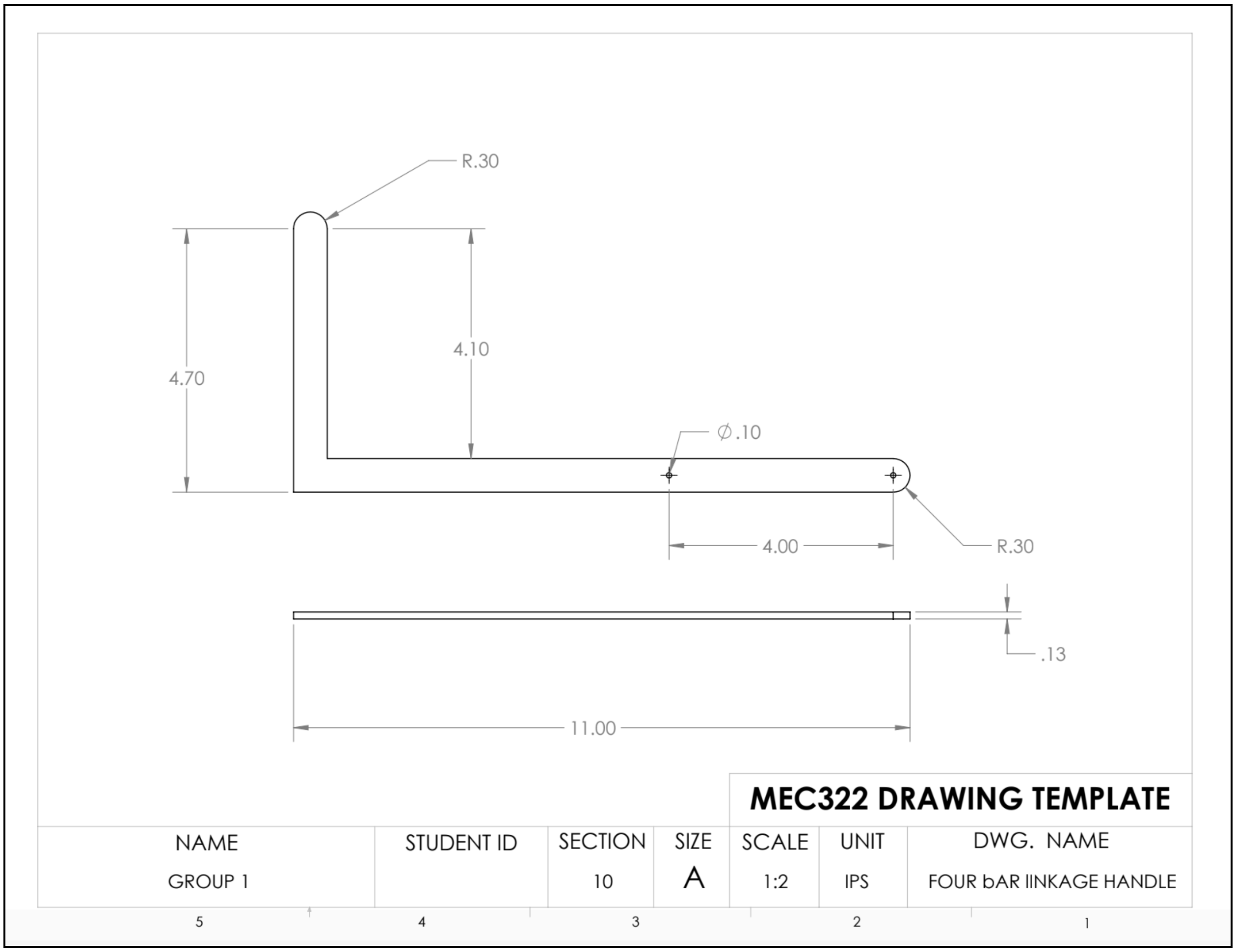


Figure 13. Four Bar Linkage Handle

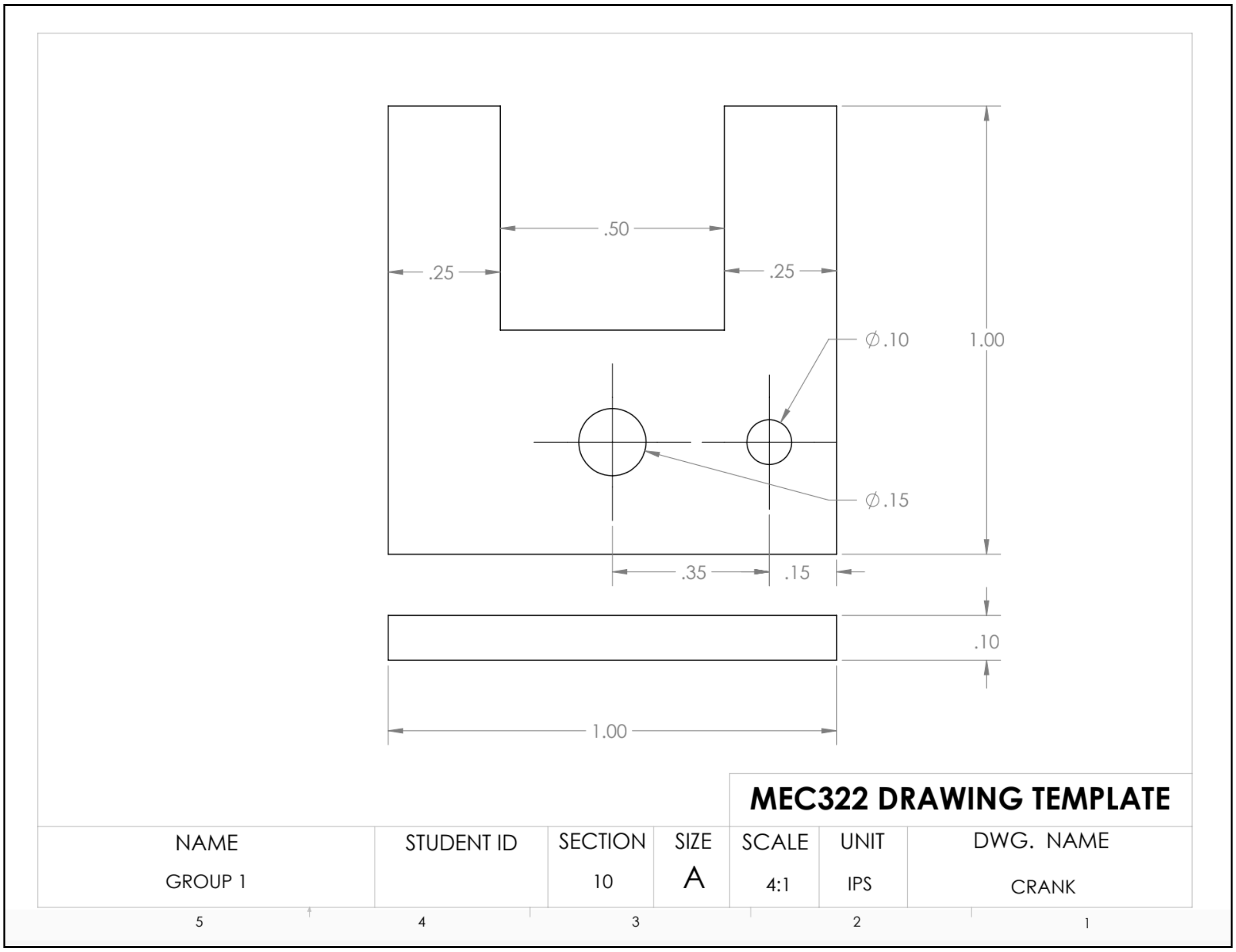


Figure 14. Crank

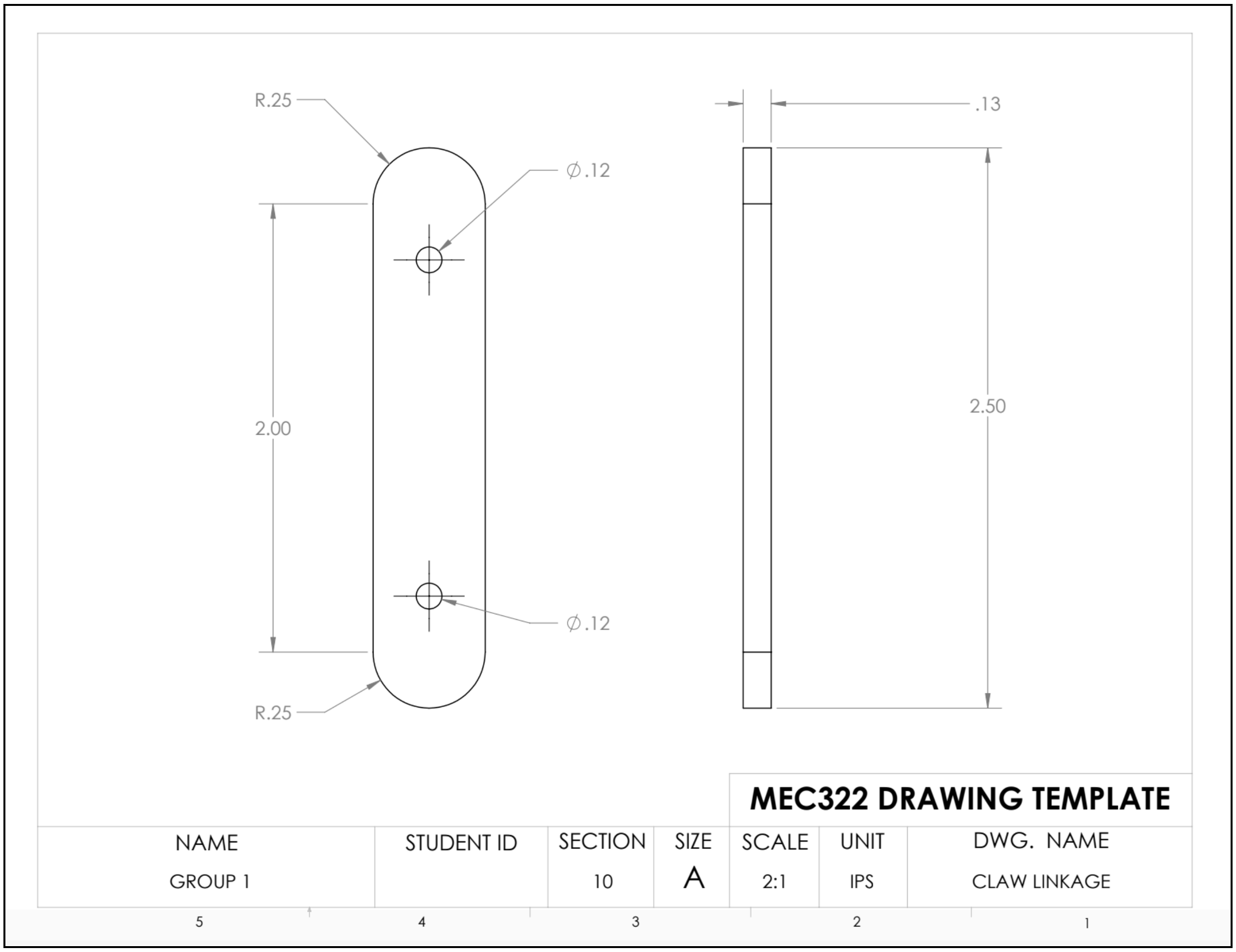


Figure 15. Claw Linkage

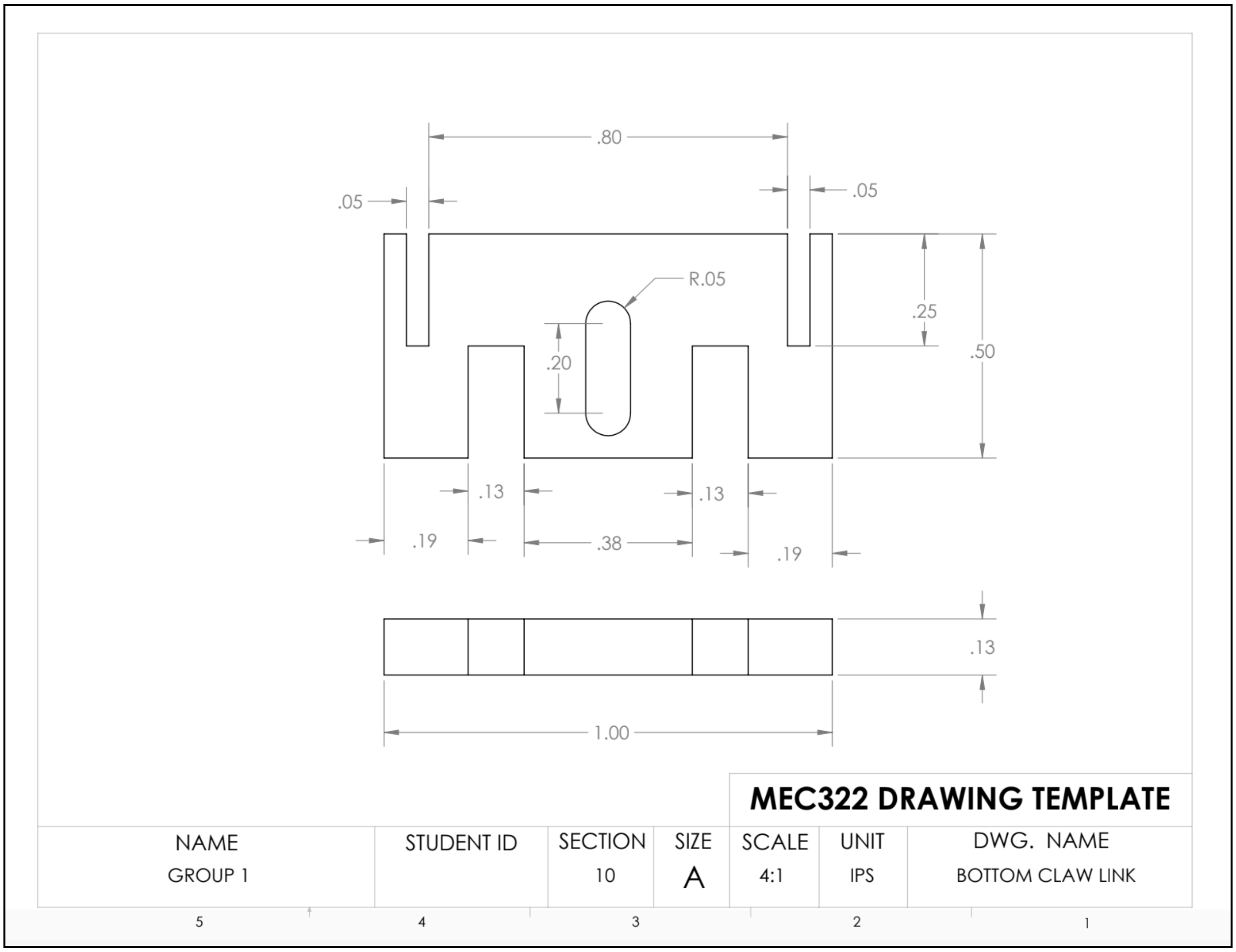


Figure 16. Bottom Claw Link

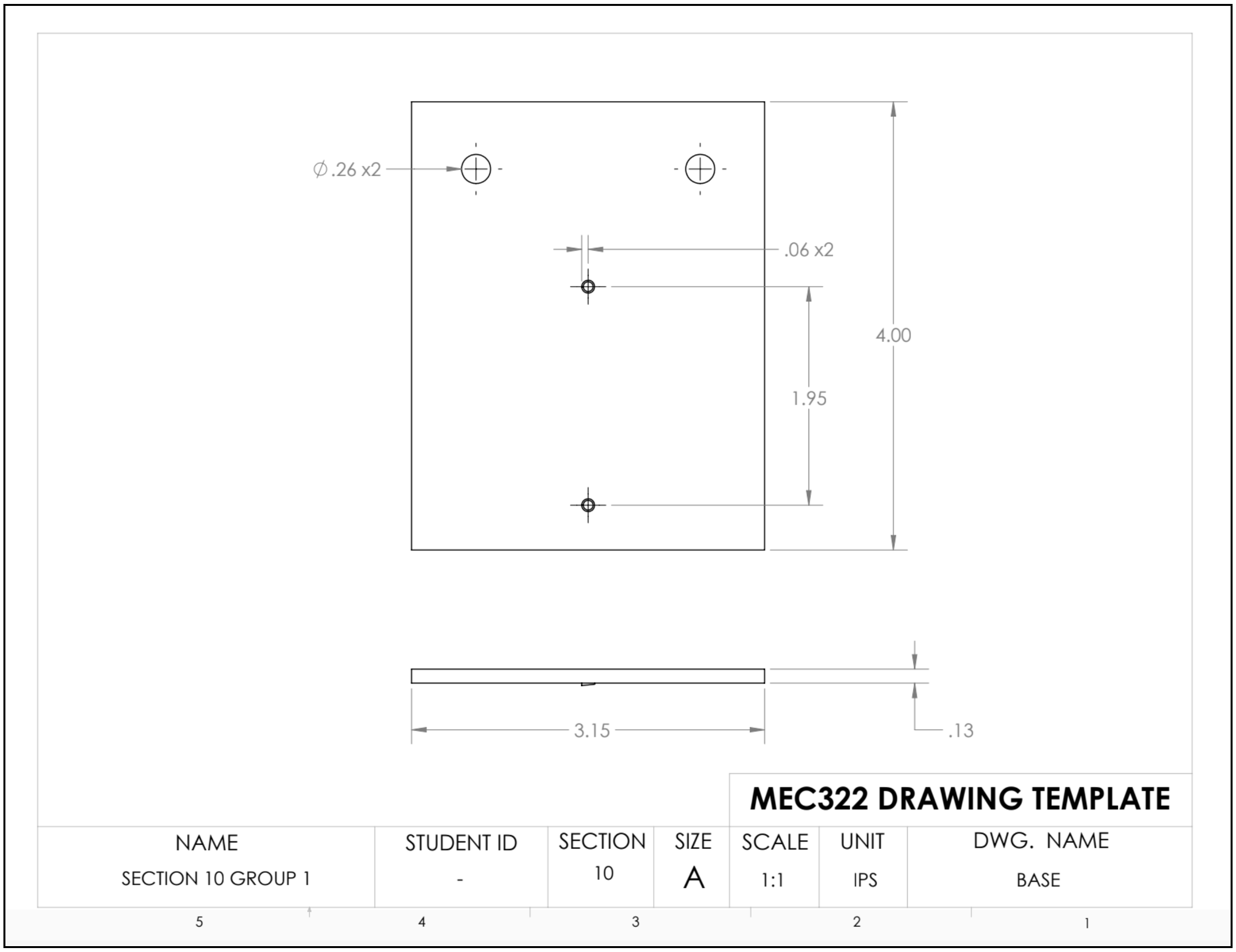


Figure 17. Base

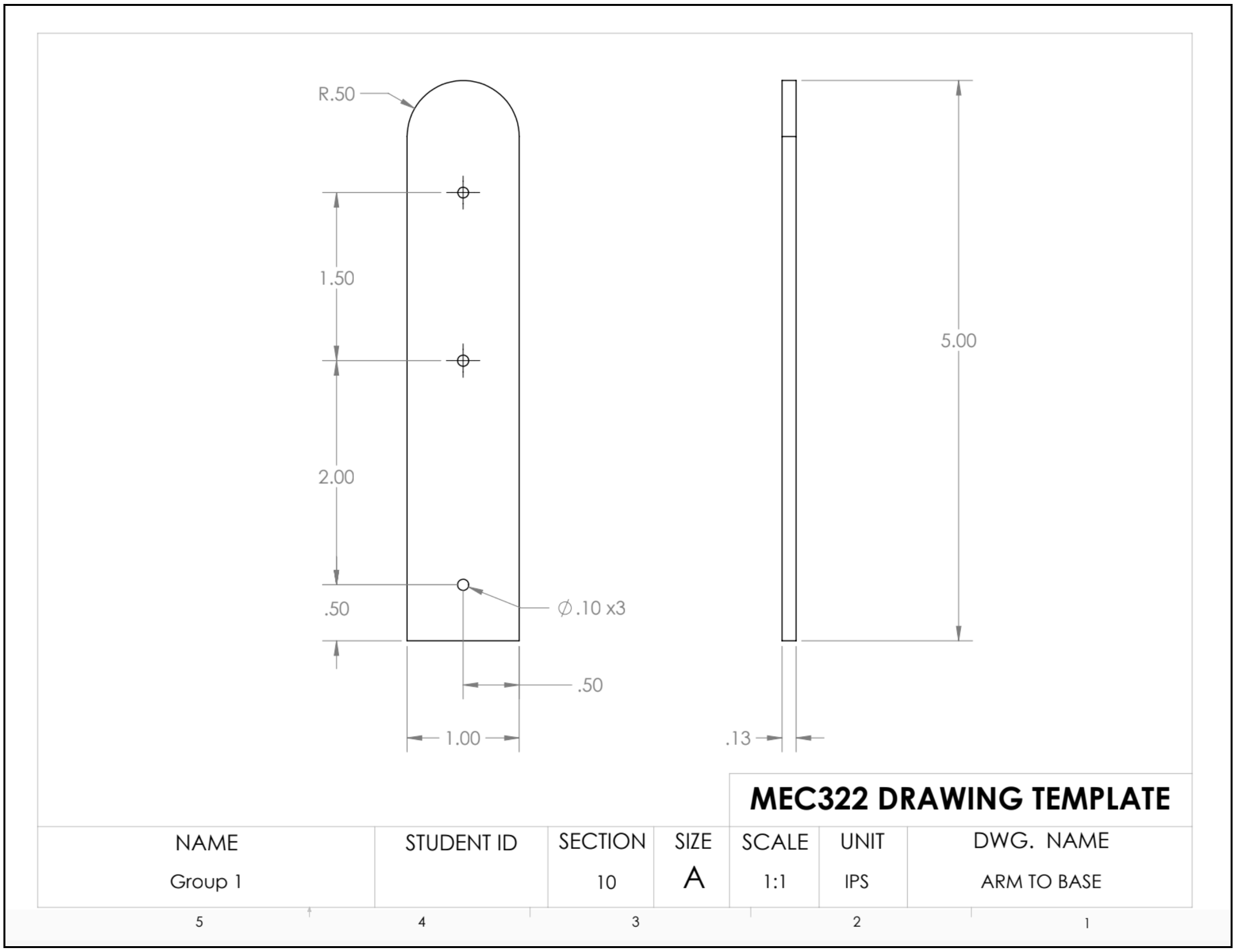


Figure 18. Arm to base

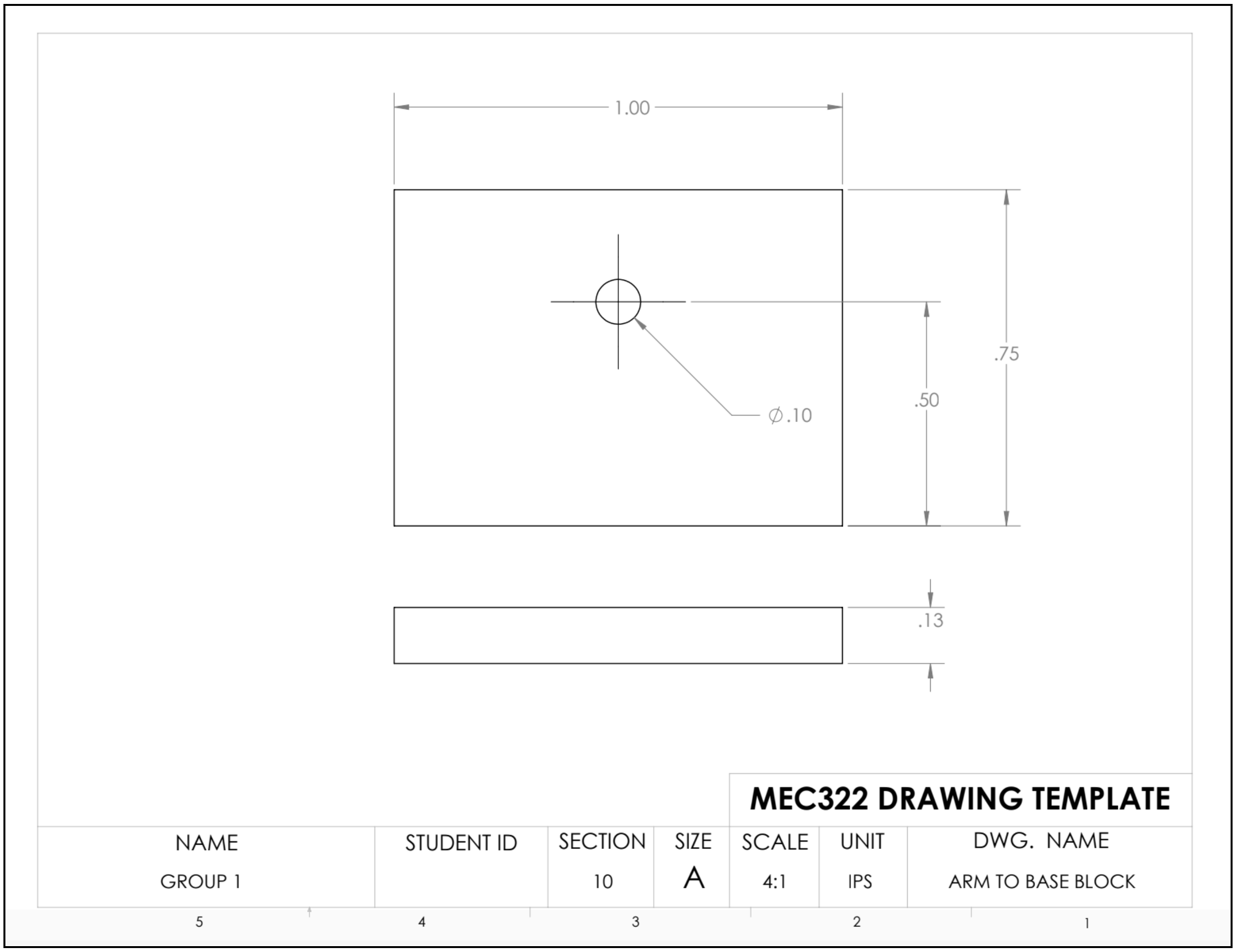


Figure 19. Arm to base Block

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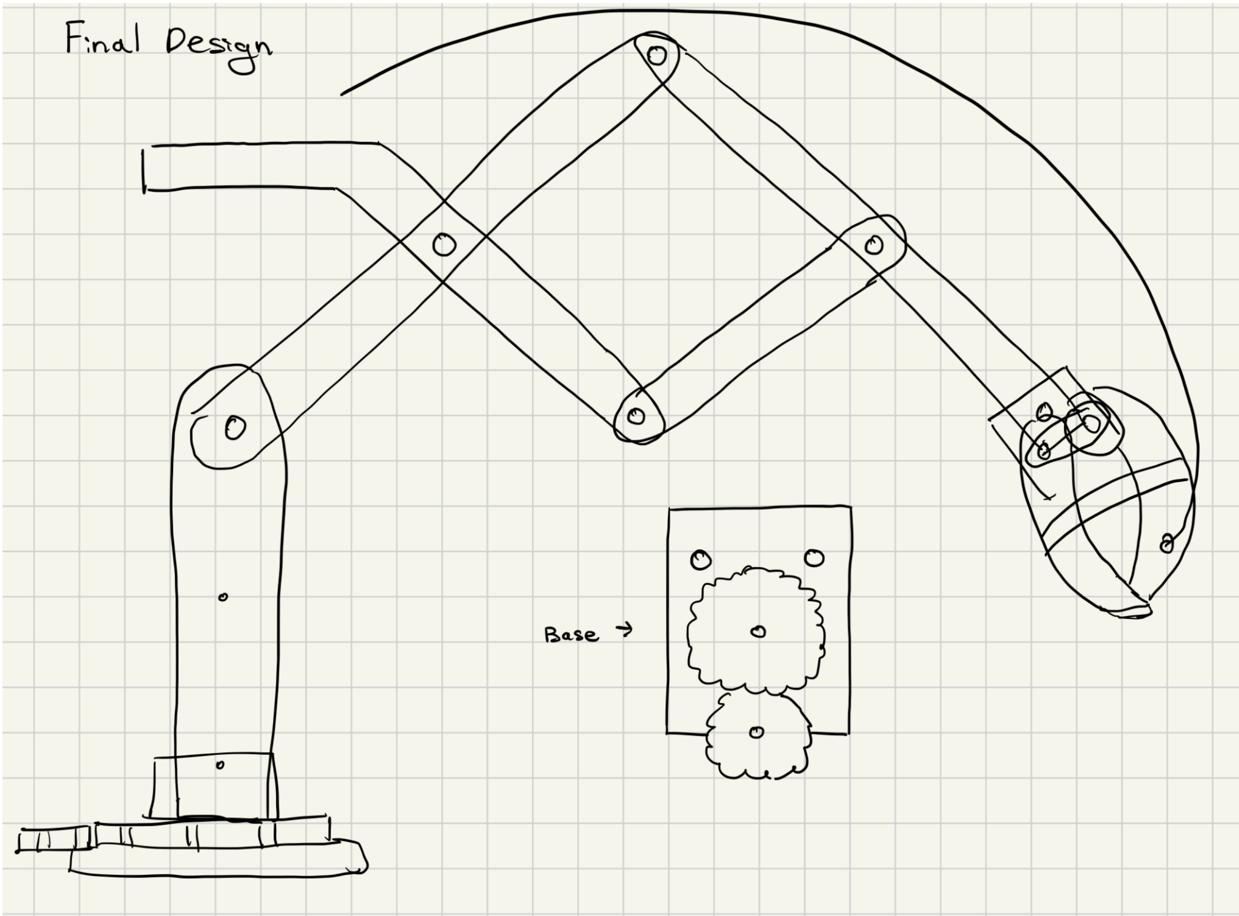

My great ugly bs