EML2322L – Design and Manufacturing Laboratory

Design Report 3 Resubmission

Team Number 11A

Kaio Bui (1)
Talon Coons (2)
Christopher Crouch (3)
Kyle Cunningham (4)

Instructor: Mike Braddock
TA: Connor Bowman

Spring 2021

April 8, 2021

EML2322L – MAE Design and Manufacturing Laboratory

Final Design Checklist

Group Number: 11A **TA Performing Evaluation:** C Bowman

Evaluation Grade: 90% (up to 40% of DR3 1st Submission Grade)

MOBILE PLATFORM DESIGN.

✓ YES □ NO Is there an accurate subassembly model for mobile platform, including frame, attachment brackets, motors and mounts, wheel hubs, wheels, control box, and associated fasteners?

✓ YES □ NO Is the simplified 80/20 part model used to speed up rendering and improve print quality?

✓ YES □ NO Are motor mounts and wheel hubs designed using the provided design guides? (Please don't ask for feedback if you didn't read our provided resources.)

✓ YES □ NO Are material choice, geometry, attachment method, torque transmission method (if applicable), and general design justified for each relevant component?

✓ YES □ NO Does each component model have a concise and meaningful name?

✓ YES □ NO Are appropriate mates employed so each component is fully constrained?

✓ YES □ NO Was the final assembly model used to check clearances and identify interferences? (These types of problems are MUCH more difficult to fix in the prototyping phase of the project.)

✓ YES □ NO Is design feasible and realizable with lab resources? Ask questions before submitting a design you aren't sure can be made within the allotted time frame (or at all).

REMAINING SUBSYSTEMS DESIGN. (Not all items apply to all subsystems.)

□ YES ✓ NO Is there an accurate subassembly model, including all components (custom and OTS), attachment brackets, and fasteners?

✓ YES □ NO Are material choice, geometry, attachment method, torque transmission method (if applicable) and general design justified for each relevant component?

□ YES ✓ NO Is each component adequately constrained against unintended degrees of freedom? (i.e. is each stationary part rigidly attached in a proper manner?)

✓ YES □ NO Does each component model have a concise and meaningful name?

✓ YES □ NO Are appropriate mates employed so each component is fully constrained?

□ YES ✓ NO Are saved configurations created for all moving components? (lifting arms, ball gates, etc.)

✓ YES □ NO Was the final assembly model used to check clearances and identify interferences? (These types of problems are MUCH more difficult to fix in the prototyping phase of the project.)

✓ YES □ NO Is design feasible and realizable with lab resources? Ask questions before submitting a design you aren't sure can be made within the allotted time frame (or at all).

FASTENERS AND THREADS.

✓ YES □ NO Are all fasteners included in the assembly model?

✓ YES □ NO Are included fasteners appropriate in size and accurate in scale? (Download appropriate CAD models from Mcmaster-Carr or other sources, and rename in a meaningful manner)

✓ YES □ NO Are threaded holes designed with AT LEAST FIVE threads of engagement?

□ YES ✓ NO Do fastener head types allow for adequate motion with required assembly tools? (i.e. screwdrivers, allen wrenches, sockets and ratchets, rivet guns, etc.)

✓ YES □ NO When possible are thru bolted holes used instead of threaded holes to reduce mfg. time?

✓ YES □ NO Are selected fasteners routinely stocked in lab? (Smaller fasteners can be ordered by submitting a purchase order form, but doing so creates more work for your team.)

✓ YES □ NO Do motor mounting brackets use all of the provided motor mounting holes? (The Globe motor is the only exception)

SHEETMETAL PARTS.

☑ YES ☐ NO	Is part modeled using SolidWorks sheetmetal tools?
☐ YES ☑ NO	Is thickness appropriate for application? (Too thick is hard to bend; too thin is flimsy.)
☑ YES ☐ NO	Is part designed for manufacturing according to the Sheetmetal Design Guide? (Complex parts need to be split into multiple simpler parts, integrated weld tabs, etc.)
☑ YES ☐ NO	If a part is to be welded, is it specified as steel? (Aluminum is much harder to weld.)

REMAINING DESIGN FOR MANUFACTURING (DFM) TIPS.

☑ YES ☐ NO	Is each part as small as possible without affecting intended function?
☑ YES ☐ NO	Have alternative designs been investigated which may lower manufacturing and assembly times? (e.g. designs which combine or split parts; or designs which use sheetmetal versus billet?)
☑ YES ☐ NO	Have unnecessary features that increase mfg. time been eliminated? (fillets, etc.)
☑ YES ☐ NO	Are similar parts designed to be identical instead of mirror images? (e.g. motor mounts)
☑ YES ☐ NO	Is each part feature designed around nominal (commonly produced) cutter sizes?

GENERAL POINTS.

☑ YES ☐ NO	Does final design meet all design objectives? (i.e. size, storage in box, team number, etc.)
☑ YES ☐ NO	Has each design concept been tested using some type of meaningful prototype? (It's risky to place your hopes in a completely untested design concept.)
☑ YES ☐ NO	Is final design proven capable of entering the arena by importing the ramp model provided in the Project Description into the final assembly?
☑ YES ☐ NO	Is design feasible and realizable with lab resources? Ask questions before submitting a design you aren't sure can be made or made within the allotted time frame.

COMMENTS.

EML2322L – MAE Design and Manufacturing Laboratory

Detailed Design (DR3) Checklist

Group Number: 11A **TA** or **Group Performing Evaluation:** ____________________

Grade: ______ **Original Submission** or **Resubmission** (circle one)

DESIGN CHECKLIST. Are the following items COMPLETE?

- ☑ YES ☐ NO — Accurate assembly model for the mobile platform, including frame, attachment brackets, motors and mounts, wheel hubs, wheels, control box, and associated fasteners?
- ☑ YES ☐ NO — Detail drawing(s) of motor mounts? Is material choice, geometry, attachment method, and general design justified?
- ☑ YES ☐ NO — Detail drawing(s) of wheel hubs? Is material choice, thickness, geometry, torque transmission method, and general design justified?
- ☑ YES ☐ NO — One simplified detail drawing for all unmodified pieces of 80/20 that includes a table with lengths, tols. and part numbers? Additional drawings for modified pieces.
- ☑ YES ☐ NO — Assembly models and detail drawings for all other mechanisms and components?
- ☑ YES ☐ NO — Detail drawings of all OTS components used on the project with clear dimensions of all features used to interface with other components (bolt patterns, shaft details, etc.)?

ASSEMBLY DRAWINGS / BOM. Do the assembly drawings and BOM include the following?

- ☑ YES ☐ NO — Complete BOM of entire design (i.e. one consolidated BOM table for quick reference)?
- ☑ YES ☐ NO — Required assembly drawing template provided on the course webpage?
- ☑ YES ☐ NO — ALL parts of the robot, including OTS components, fasteners, string, tape, etc.?
- ☑ YES ☐ NO — Multiple views clearly showing all components of the design?
- ☑ YES ☐ NO — Is each part's attachment method clearly defined?
- ☑ YES ☐ NO — Required subassemblies of the frame, drivetrain, manipulator(s), hopper, sorter, etc.?
- ☑ YES ☐ NO — Clear exploded views of all subassemblies
- ☑ YES ☐ NO — Unique, sequentially labeled balloons pointing to every piece of the assembly?
- ☑ YES ☐ NO — Assemblies denoted by *EML2322L-A-XXX* in their drawing numbers?
- ☑ YES ☐ NO — Dimensions showing how individual pieces are located with respect to each other? (Individual feature dimensions should remain on detail drawings where they belong.)
- ☑ YES ☐ NO — Proper fasteners for each component? (i.e. 1/4-20 for 80/20, 10-24 for wheel hubs, M6x1.0 & M8x1.25 for Entstort motors, M4x0.7 for Denso motors and 10-32 for Molon motors)
- ☑ YES ☐ NO — Proper fastener descriptions on BOM including thread specification, length and head type? (i.e. *"¼-20 x ½" button head cap screw"* or *"M6x1.0 x 25mm hex head bolt"*)

WRITTEN DESCRIPTION, SCHEDULE, BUDGET & REMAINING CALCULATIONS.

- ☑ YES ☐ NO — Does the written design description clearly explain the final design?
- ☑ YES ☐ NO — Does the group use the required schedule template and is it clearly formatted?
- ☑ YES ☐ NO — Does the schedule contain detailed individual tasks and reasonable deadlines based on the time estimation guidelines provided for part manufacturing?
- ☑ YES ☐ NO — Does the schedule assign individual tasks to individual members?
- ☐ YES ☑ NO — Does the schedule include the welding demo, any holidays, and adequate testing time?
- ☑ YES ☐ NO — Does the group use the required budget template and is it clearly formatted?
- ☑ YES ☐ NO — Does the budget include ALL raw materials needed for prototype manufacturing?
- ☑ YES ☐ NO — Does the group properly compute prices for materials in the budget?
- ☑ YES ☐ NO — Does the total project budget meet the cost limit?
- ☑ YES ☐ NO — Are calculations reported with a reasonable and consistent number of decimal places?

DRAWINGS & DIMENSIONING. Highlights from the Dimensioning Rules document.

1. Never shade isometric or orthographic engineering drawings.
2. Always show hidden lines in orthographic views.
3. Always show tangent lines in isometric views, but never show hidden lines or dimensions.
4. Do not place too many views on one page or scale the views too small (spread across multiple sheets); likewise, do not place too many dimensions on one view if doing so affects drawing presentation.

5. Each dimension should be given clearly so it can be interpreted in only one way.
6. Do not place dimensions on a view unless clarity is promoted and long extension lines are avoided.
7. Dimensions should be placed in the views where the features dimensioned are shown true shape.
8. Dimensioning to hidden lines should always be avoided; use cross sectional views instead.
9. Dimensions should be so given that it will not be necessary for the machinist to calculate, scale, or assume any dimension.

10. Finish marks should be placed on the edge views of all finished surfaces.
11. Drill sizes should be expressed in decimals (i.e. Ø 0.257, Ø 0.266, etc.) with an assigned tolerance.
12. Circles (holes) are always dimensioned by the DIAMETER and arcs (fillets) by the RADIUS.
13. A diameter dimension should always be preceded by the symbol Ø, and a radius dim. by the letter R.
14. When there are several rough, non-critical features obviously the same size (fillets, rounds, ribs, etc.), it is permissible to give only typical (abbreviation TYP) dimensions or to use a note.
15. Decimal dimensions should be used for all machining dimensions. Decimal dimensions less than 1.0 should be preceded with a leading zero (i.e. 0.375).

DETAIL DRAWINGS. Does each drawing have the following information?

☑ YES ☐ NO	Appropriate EML2322L drawing template and title block
☑ YES ☐ NO	Dimensions to properly locate EVERY part feature
☑ YES ☐ NO	Appropriate tolerances for EVERY dimension
☐ YES ☑ NO	Proper surface finish notes for EVERY surface (rarely *"finish all surfaces"*)
☑ YES ☐ NO	Proper hole and thread notes based on the tap chart
☑ YES ☐ NO	Part designer's name
☑ YES ☐ NO	Part drawer's name
☑ YES ☐ NO	Drawing units
☑ YES ☐ NO	Material type
☑ YES ☐ NO	Quantity of parts to be manufactured
☑ YES ☐ NO	Unique part name / number
☑ YES ☐ NO	Deburring instructions
☑ YES ☐ NO	Are the highlighted rules in the Drawings & Dimensioning section followed?
☑ YES ☐ NO	Are drawings full page and of nice print quality? (Print… to pdf, not directly to a printer)
☑ YES ☐ NO	Are dimensions well organized and do they use consistent fonts and line weights?
☑ YES ☐ NO	Do tolerance tables fit individual part requirements? (Modify for each as necessary.)

FASTENERS, THREADS, AND HOLES.

☑ YES ☐ NO	Are threaded holes designed with AT LEAST FIVE threads of engagement?
☑ YES ☐ NO	Are the proper type of threads (coarse or fine) used in the proper type of material?
☑ YES ☐ NO	Are tap drill sizes correct based on the tap chart standards?
☑ YES ☐ NO	Are clearance holes properly sized using close and free fit standards off the tap chart?
☐ YES ☑ NO	Are fasteners selected which are routinely stocked in the lab? (Other fasteners can be ordered by submitting a purchase order form, but doing so creates more work for your team.)
☑ YES ☐ NO	Do fastener head types allow for adequate motion with required assembly tools? (i.e. screwdrivers, allen wrenches, sockets & ratchets, rivet guns, etc.)?
☑ YES ☐ NO	Do motor mounting brackets use all of the provided motor mounting holes? (The Globe motor is the only exception)

SHEETMETAL PARTS.

- ☑ YES ☐ NO Is part modeled using SolidWorks sheetmetal tools?
- ☑ YES ☐ NO Do sheetmetal part drawings include folded AND unfolded part views?
- ☑ YES ☐ NO Is material proper thickness for the application? (Too thick is hard to bend; too thin is flimsy.)
- ☑ YES ☐ NO Is part designed for manufacturing according to the Sheetmetal Design Guide? (Complex parts split into multiple simpler parts, integrated weld tabs, etc.)
- ☑ YES ☐ NO If the part is to be welded, is it specified as steel? (Aluminum is much harder to weld.)

DESIGN FOR MANUFACTURING (DFM).

- ☑ YES ☐ NO Is each part as small as possible without affecting its function?
- ☑ YES ☐ NO Is each feature tolerance as large as possible while still meeting desired design intent? (Mfg. time increases exponentially with feature tolerance.)
- ☑ YES ☐ NO Is each finished surface necessary for part function? Are the coarsest surface finish specifications used wherever possible? (Mfg. time increases exponentially with surface finish.)
- ☑ YES ☐ NO Is the number of dimension datums minimized? (Less edge findings = quicker part production.)
- ☑ YES ☐ NO Are material choices justified? Are lower strength materials that are easier to machine used everywhere possible? (Steel for example requires 3 times as long to machine as aluminum.)
- ☑ YES ☐ NO When possible are thru bolted holes used instead of threaded holes to reduce mfg. time?
- ☑ YES ☐ NO Are nominal (vs. arbitrary) part dimensions used where possible? (i.e. 3.00″ vs. 3.04″)
- ☑ YES ☐ NO Are parts designed for minimum raw-stock removal? (Less material removed = cheaper part.)
- ☑ YES ☐ NO Are similar parts designed to be identical instead of mirror images? (i.e. motor mounts)
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- ☑ YES ☐ NO Is the assembly model accurate and has it been used to check for part interferences while still in the design phase? (The assembly model is not an academic exercise and these types of problems are MUCH more difficult to fix in the prototyping phase of the project.)
- ☑ YES ☐ NO Does the design allow space for assembly tools? (i.e. screwdrivers, sockets, wrenches)
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APPENDICES.

- ☑ YES ☐ NO Is Appendix D (Est. Budget) properly labeled and located using the required template formatting and instructions in the DRT?

GENERAL POINTS.

- ☑ YES ☐ NO Does the final design meet all design objectives? (i.e. size, storage in box, team number, etc.)
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Written Description

<u>Mobile Platform</u>

The mobile platform is the base of the robot which will give it stability while driving and maneuverability when manipulating and dispensing tennis balls along with being the connecting piece for all the other subassemblies. To increase overall stability the center of gravity was put as low as possible. This was done through positioning the heaviest parts as low as possible. The two drive wheel motors were mounted below the frame and the control box was mounted horizontally on top of the mobile platform frame.

In order to attach the other subassemblies, shorter pieces of 80-20 extrusion were mounted on the top of the frame for easy assembly. Each piece of 80-20 on the entire mobile platform is connected using two brackets to minimize any potential failure in the frame.

The mobile platform measures 23.5 inches wide and 17.2 inches long, fitting well withing the starting area of the arena, along with the 24-inch entry near the second ramp. It also has the required power to maneuver over both ramps without slipping.

<u>Ball Manipulator</u>

The function of the ball manipulator is to transport balls from the source tree in the obstacle course to the ball hopper on the robot. The ball manipulator design that was the most cost-efficient, stable, and fast was tested. The design that was tested as the most effectively used a linear actuator to create a retractable base to cup balls and then drop them into the hopper. This was cheap and relatively stable compared to the other designs but was a little slow.

80/20 was used as the arm of the manipulator because it is cheap and sturdy enough to use as a frame for the ball manipulator. The ring that cups over balls at the end of the ball manipulator is made of PVC since there is not any significant force acting on the ring so cheap PVC is cost effective. The piece that holds the linear actuator in place and the retractable base under the PVC are made of 18 GA steel sheets. The steel sheets are sturdier and can hold the linear actuator and tennis ball weight, but the steel sheets themselves are lightweight so there is not much strain on the Globe motor when lifting and lowering the whole ball manipulator mechanism.

<u>Ball Hopper</u>

The general function of the ball hopper is to store the tennis balls while the robot drives from the tree to the bucket. In looking for the most efficient hopper, it was necessary to find a design that will allow for stability, size and flow. If a hopper doesn’t allow for a smooth transition of tennis balls from the manipulator to the release mechanism, then it cannot be trusted for a timed event. The designs created for the hopper were tested in five different categories, with the results being compared to others.

The design selected uses approximately 2.75 square feet of 18-gauge sheet steel, which is durable and strong enough to hold and store tennis balls for a period of time. Since the competition is based off of time and number of balls transferred, it is important that the hopper is big enough to store plenty of balls. This design was able to hold two more balls than the rest of the designs created, so stability and size were great for the mechanism. The beginning width of the hopper is seven inches wide and has a 3.24-inch height. The sheet metal is folded 90 degrees upwards along a straight line providing a box like shape for the balls to be stored in.

The next thing to account for is stability and flow. Stability was measured by moving the hopper around, such as bounces and angles that will be encountered during the course, to see how many balls would fall out. Flow was tested by seeing how often balls would get stuck, preventing it from getting to the bucket. The hopper is angled downward to allow the balls to flow to the release mechanism, so to provide stability, the side panels are angled upwards to prevent tennis balls from falling out during bounces. The hopper begins to narrow after a few inches to provide a more accurate release of the tennis balls, with almost no places for the ball to get stuck. After testing these ideas, this design proved to be most efficient for the final product.

Ball Release

The function of the ball release mechanism is to keep the balls in the hopper until it is activated to release them. This design needs to hold the balls in the hopper while the robot is driving and move to release them when the robot is in position with the bucket. It did this using a globe motor and a sheet metal plate.

The design used a plate of sheet metal that was 10in x 2 in until it was cut. It has two holes for the screws to mount to the globe gearmotor securely. It blocks the exit of the hopper until the motor moves it vertically. The simple sheet metal part allows it to have a low cost and faster manufacturing time. Then it opens the exit and allows the balls to freely flow out of the hopper for a fast release. This design scored highly in the speed category.

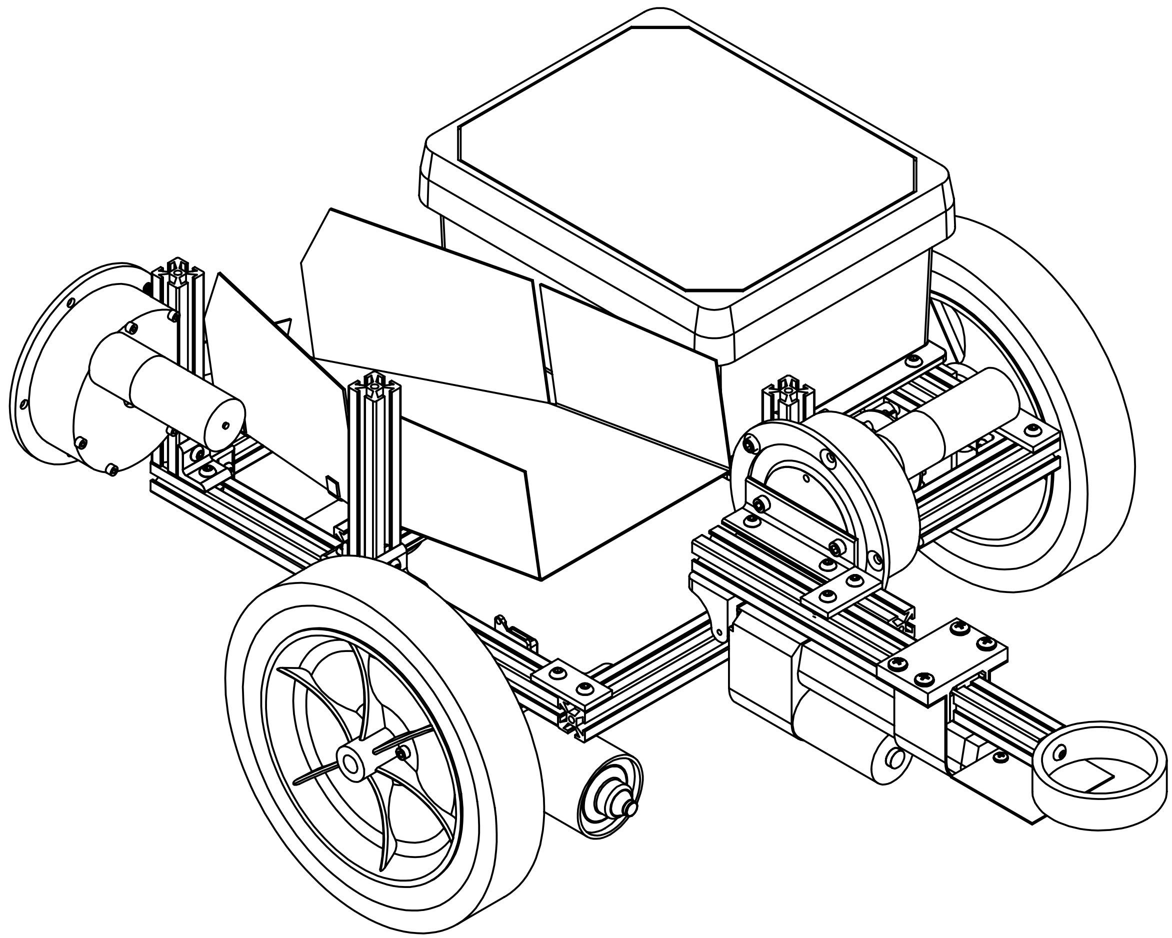
Efficiency was measured by how accurately the balls enter the bucket and this will be done through the way the hopper funnels the balls into the bucket. This release mechanism does not compromise the hopper funnel after it is moved so the balls can fall in a controlled manner into the bucket from a smaller height. Testing showed that this design had the best efficiency. Controllability with this release mechanism is good as the release mechanism should not interfere with the position of the bucket because it is off the ground higher than the bucket and it is a wide design, so the robot does not need to position very precisely. This allows the robot to position more easily next to the bucket for release and save time in testing. Testing found this design to be the best for the controllability.

Project Schedule

Week	Task Description	Responsibility	Est. Time
3/29/2021	Submit third design report	whole team	-
	Submit purchase orders for any materials purchased outside of lab	Kaio Bui	20 min.
	Fabricate motor mount brackets	Christopher Crouch	60 min.
	Fabricate wheel hubs (start)	Talon Coons	60 min.
	Fabricate mobile platform (start)	Kyle Cunningham	60 min.
	Welding Demonstration	whole team	45 min.
	Fabricate Linear Actuator Holder for BM	Kaio Bui	40 min.
	Meet outside lab to work through problems & review who's doing what next week, and prepare any necessary paperwork (POs, ECNs, etc.)	*whole team*	-
4/5/2021	Fabricate Steel Sheet for ball manipulator	Kaio Bui	20 min.
	Fabricate PVC Ring for ball manipulator	Kaio Bui	20 min.
	Fabricate Motor Mount Brackets (finish)	Christopher Crouch	15 min.
	Fabricate wheel hubs (finish)	Talon Coons	40 min
	Fabricate mobile platform (finish)	Christopher Crouch	15 min.
	Assemble motors, hubs & wheels and attach to mobile platform	Kyle Cunningham	45 min.
	Fabricate Plate Cover for ball release	Talon Coons	35 min.
	Work on DR3R	Christopher Crouch	75 min.
	Work on DR3R	Talon Coons	30 min.
	Work on DR3R	Kyle Cunningham	60 min.
	Work on DR3R	Kaio Bui	65 min.
	Meet outside lab to work through problems & review who's doing what next week, and prepare any necessary paperwork (POs, ECNs, etc.)	*whole team*	-
4/12/2021	Fabricate Sheet Metal for ball hopper	Kyle Cunningham	30 min.
	Assemble parts for ball manipulator	Kaio Bui	60 min.
	Assemble parts for ball release	Christopher Crouch	20 min
	Assemble parts for ball hopper	Kaio Bui	25 min
	Attach Subassemlies to Mobile Platform	Christopher Crouch	45 min.
	Attach Subassemlies to Mobile Platform	Talon Coons	45 min.
	Work on DR4	Christopher Crouch	40 min.
	Work on DR4	Talon Coons	60 min.
	Work on DR4	Kyle Cunningham	75 min.
	Work on DR4	Kaio Bui	20 min.
	Meet outside lab to work through problems & review who's doing what next week, and prepare any necessary paperwork (POs, ECNs, etc.)	*whole team*	-
4/19/2021	Work on DR4	Kaio Bui	105 min.
	Work on DR4	Christopher Crouch	105 min.
	Work on DR4	Kyle Cunningham	105 min.
	Work on DR4	Talon Coons	105 min.
	Meet outside lab to work through problems & review who's doing what next week, and prepare any necessary paperwork (POs, ECNs, etc.)	*whole team*	-

Complete Bill of Materials

Item No.	Part Number	Decription	Qty.
1	EML2322L-101	Control Box	1
2	EML2322L-102	Caster Wheel - 3.1 inch load height	1
3	EML2322L-111	10 inch drive wheel	2
4	EML2322L-112	Wheel Hub	2
5	EML2322L-113	Motor Mount	2
6	EML2322L-114	44 RPM Enstort Motor	2
7	EML2322L-A-103	Drive Wheel Assembly	2
8	EML2322L-104	80/20 extrusion	11
9	EML2322L-105	80/20 Angle Bracket Assembly	15
10	EML2322L-106	80/20 Straight Bracket Assembly	5
11	EML2322L-107	80/20 Straight Degree Bracket	5
12	EML2322L-108	80/20 90 Degree Bracket	15
13	EML2322L-A-200	Ball Manipulator	1
14	EML2322L-201	Manipulator Steel Sheet	1
15	EML2322L-202	PVC Ring	1
16	EML2322L-203	Linear Actuator Holder	1
17	EML2322L-204	Globe Motor	2
18	EML2322L-205	Linear Actuator	1
19	EML2322L-206	Linear Acutator Mount	1
20	EML2322L-A-300	Ball Hopper	1
21	EML2322L-301	Steel Sheet Welding Tab	1
22	EML2322L-302	Ball Hopper Base	1
23	EML2322L-303	Ball Hopper Side	2
24	EML2322L-A-400	Ball Release Mechanism	1
25	EML2322L-401	Ball Release Plate Cover	1
26	EML2322L-403	M6 Washer	6
27	EML2322L-115	1/4 - 20 x 1/2 inch BHCS	54
28	EML2322L-116	1/4 - 20 T-nut	54
29	EML2322L-117	M5 x 0.8mm, 20 mm	6
30	EML2322L-118	M6 x 1.0mm, 18mm	8
31	EML2322L-119	1/4-20 3/16 inch screw	2
32	EML2322L-120	1/4 inch washer	3
33	EML2322L-207	Linear Actuator Schoulder Screw	1
34	EML2322L-208	Steel Sheet Screw	1
35	EML2322L-209	PVC Ring Screw	1
36	EML2322L-210	80/20 Linear Slide	1
37	EML2322L-211	Linear Actuator Holder Screw	4
38	EML2322L-A-100	Mobile Platform	1
39	EML2322L- 402	M6 x 1.0mm, 8mm	1



NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TITLE:	Full Assembly		
DRAWN	TALON COONS		
DESIGNED	GROUP 11A		
SIZE	DWG. NO.		REV
A	EML2322L-A-100		B
SCALE: 1:5		SHEET 1 OF 10	

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
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LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

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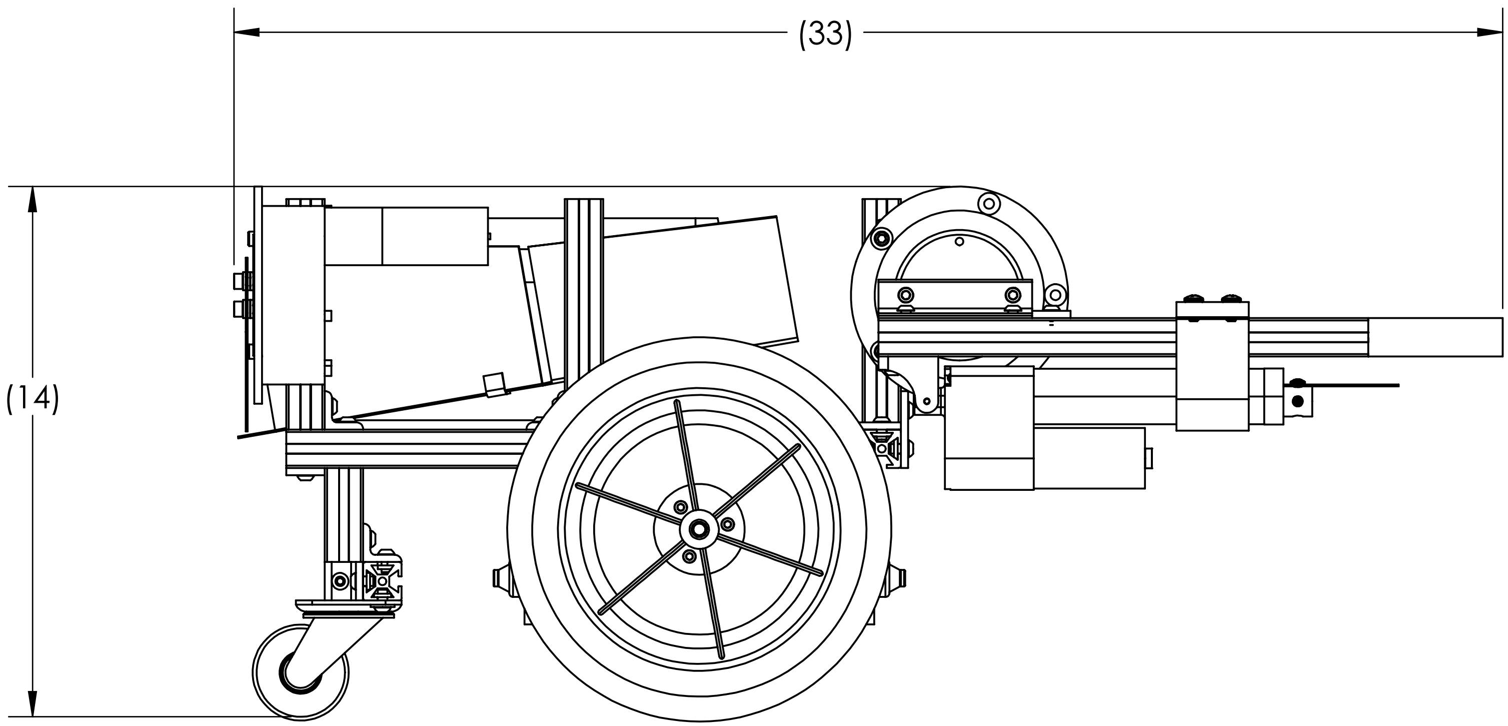

NOTES:
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2. QTY: 1

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
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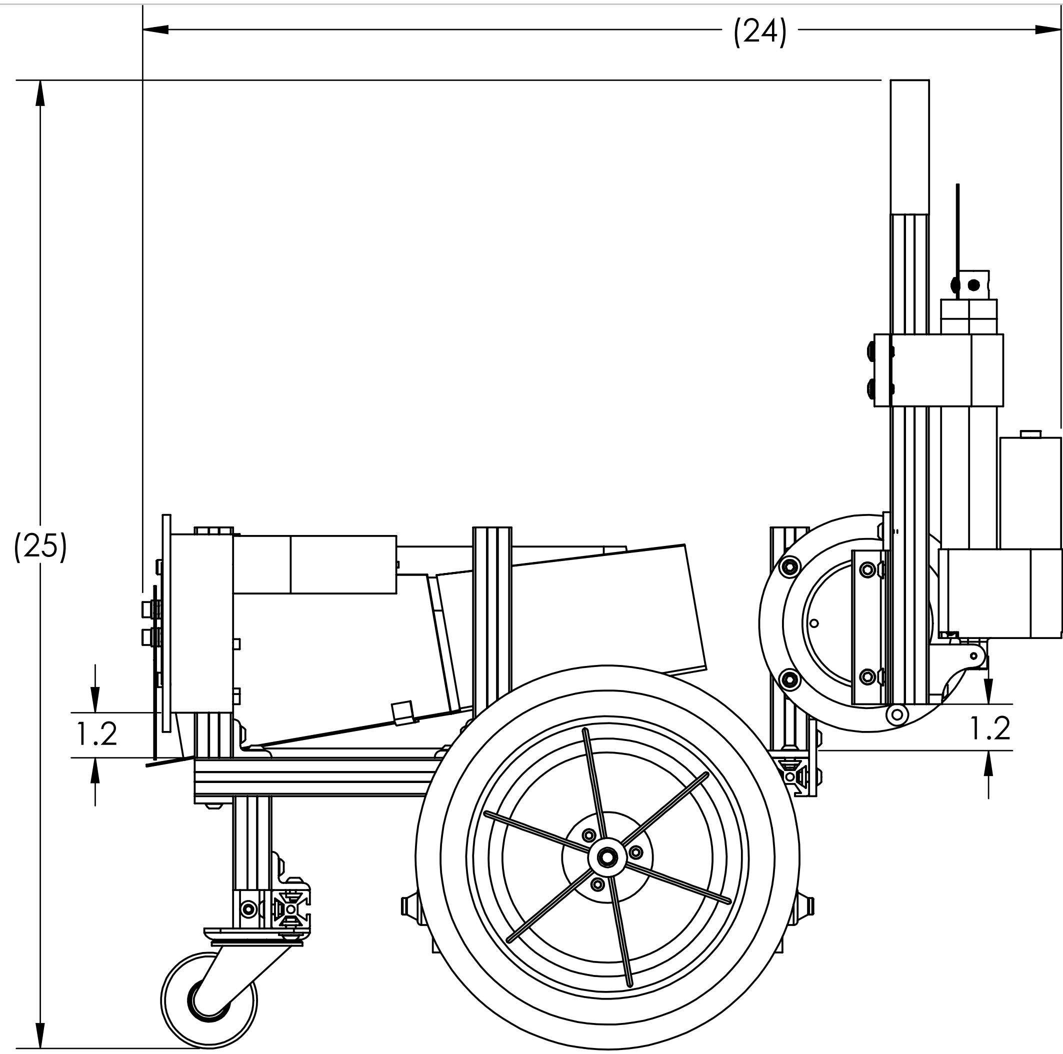
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE: Full Assembly		
DRAWN	TALON COONS	
DESIGNED	GROUP 11A	
SIZE A	DWG. NO. EML2322L-A-100	REV B
SCALE: 1:5		SHEET 2 OF 10

5 4 3 2 1



NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TITLE: Full Assembly

DRAWN TALON COONS

DESIGNED GROUP 11A

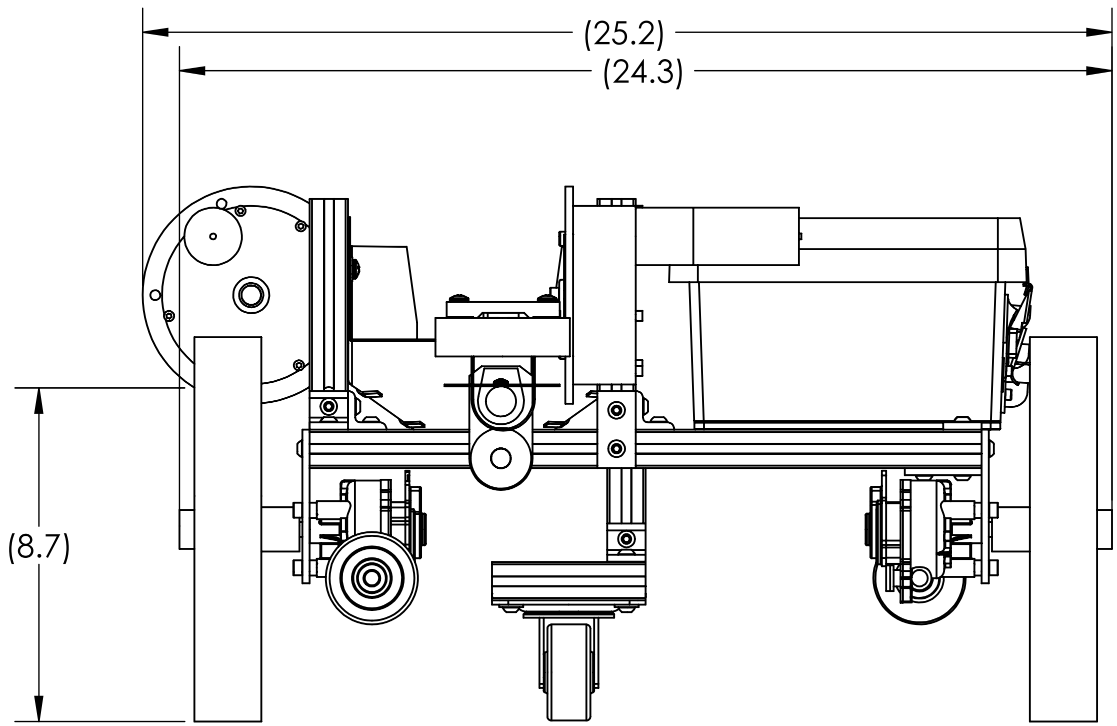
TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

SIZE	DWG. NO.	REV
A	EML2322L-A-100	B

SCALE: 1:5

SHEET 3 OF 10

5 4 3 2 1



NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
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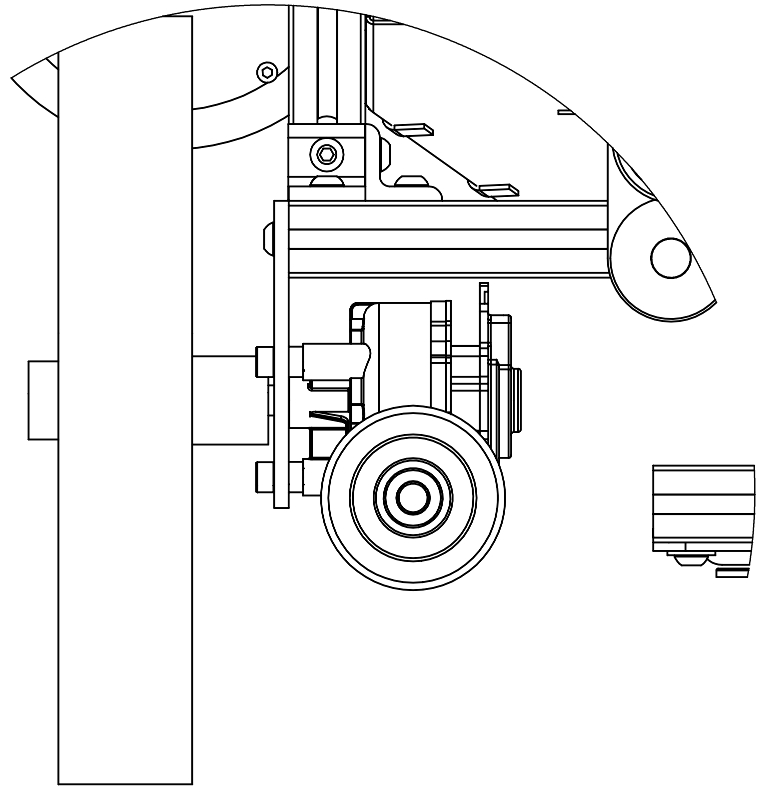
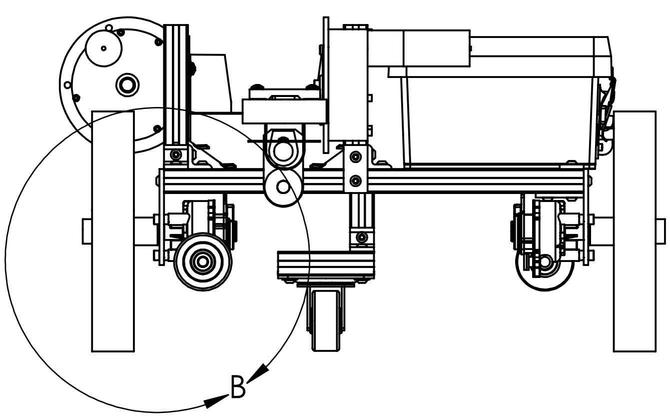
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE:	Full Assembly	
DRAWN	TALON COONS	
DESIGNED	GROUP 11A	
SIZE A	DWG. NO. EML2322L-A-100	REV B
SCALE: 1:5		SHEET 4 OF 10

5 4 3 2 1





DETAIL B
SCALE 2 : 5

NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TITLE: Full Assembly

DRAWN: TALON COONS

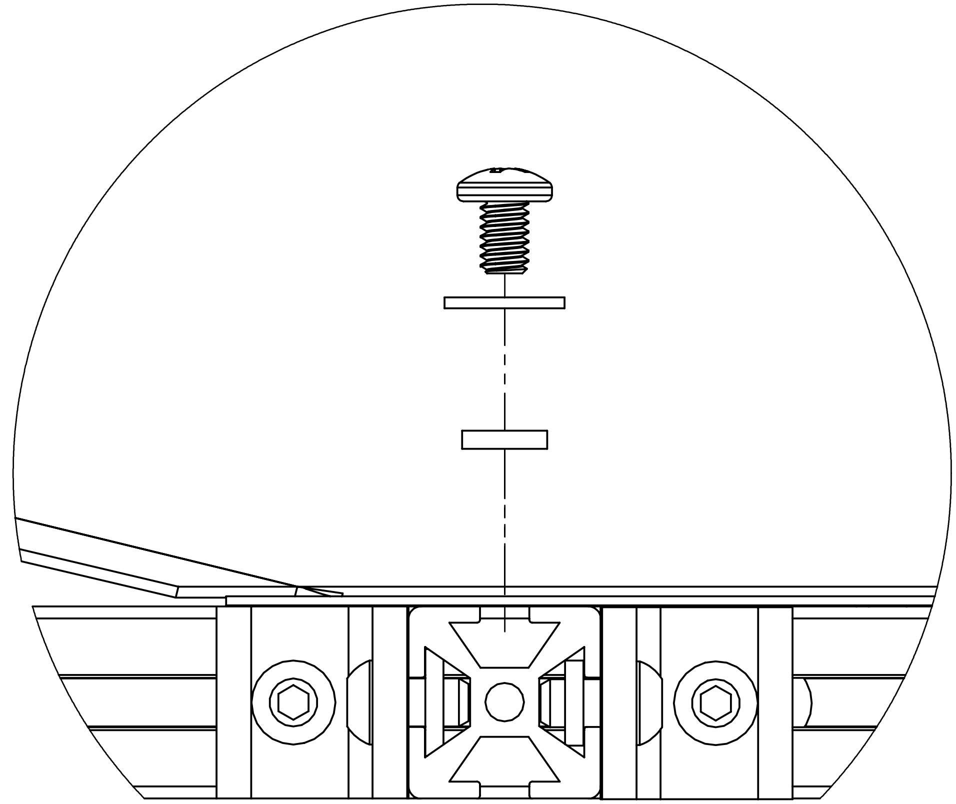
DESIGNED: GROUP 11A

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

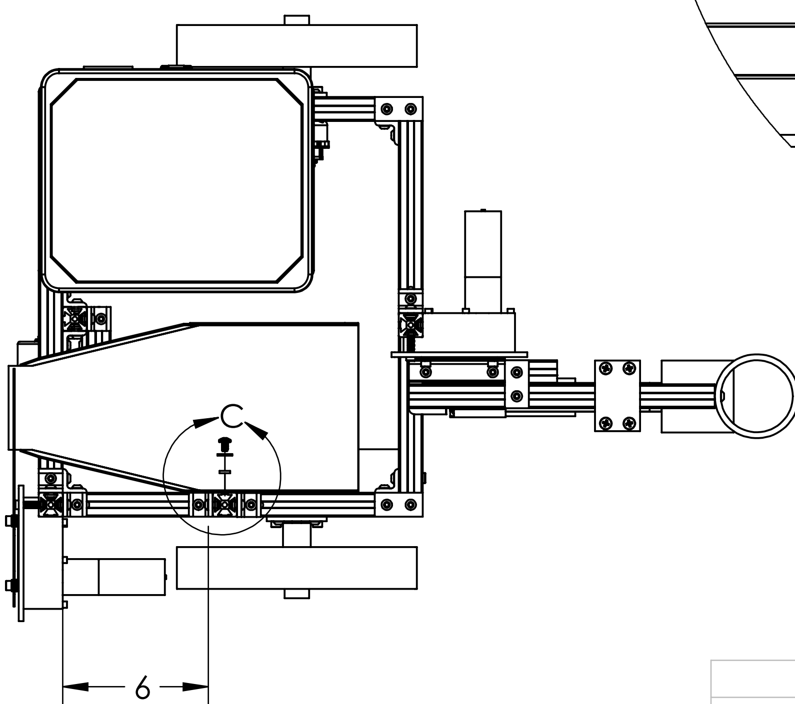
SIZE	DWG. NO.	REV
A	EML2322L-A-100	B

SCALE: 1:5 SHEET 5 OF 10

5 4 3 2 1



DETAIL C
SCALE 1 : 1



NOTES:
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2. QTY: 1

TOLERANCE UNLESS NOTED			
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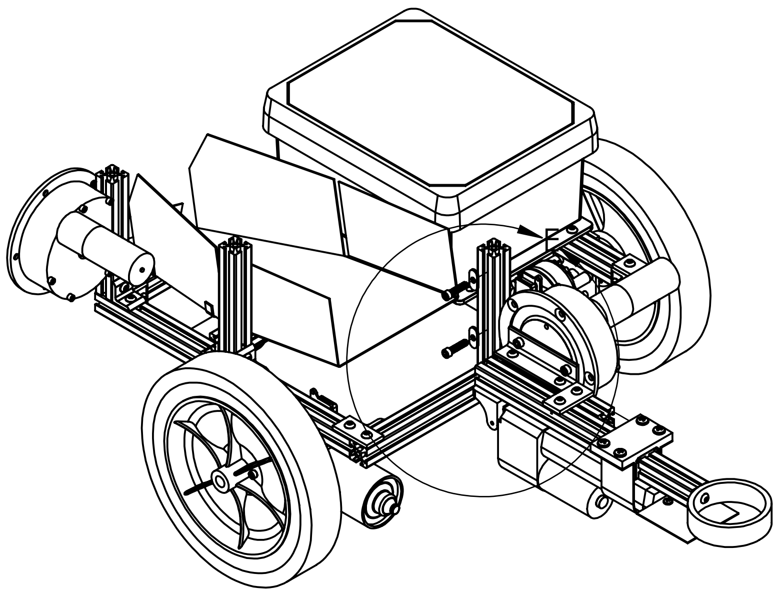
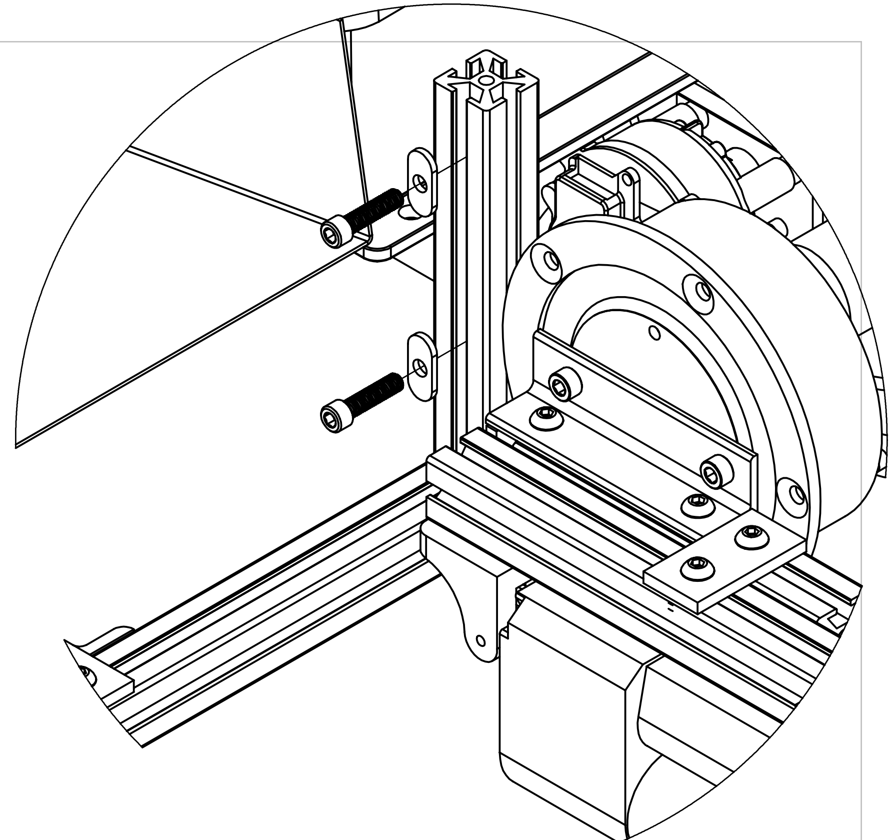
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE:	Full Assembly
DRAWN	TALON COONS
DESIGNED	GROUP 11A
SIZE	A
DWG. NO.	EML2322L-A-100
REV	B
SCALE:	1:8
SHEET 6 OF 10	

5 4 3 2 1





DETAIL E
SCALE 2 : 5

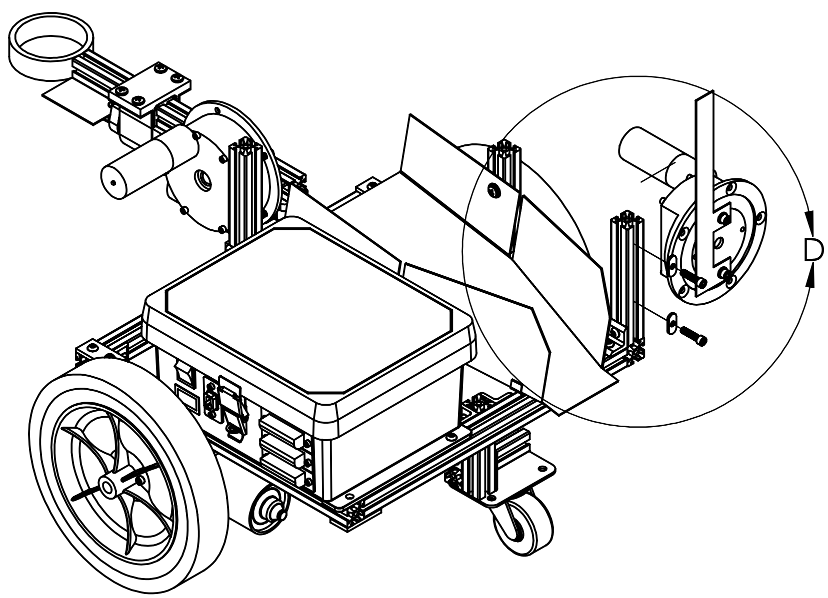
NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

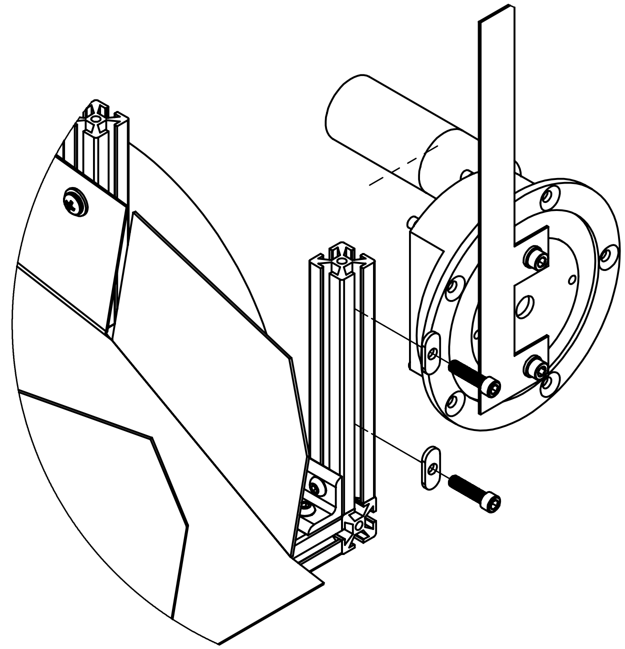
TITLE:	Full Assembly
DRAWN	TALON COONS
DESIGNED	GROUP 11A

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

SIZE	DWG. NO.	REV
A	EML2322L-A-100	B
SCALE: 1:8	SHEET 7 OF 10	

5 4 3 2 1



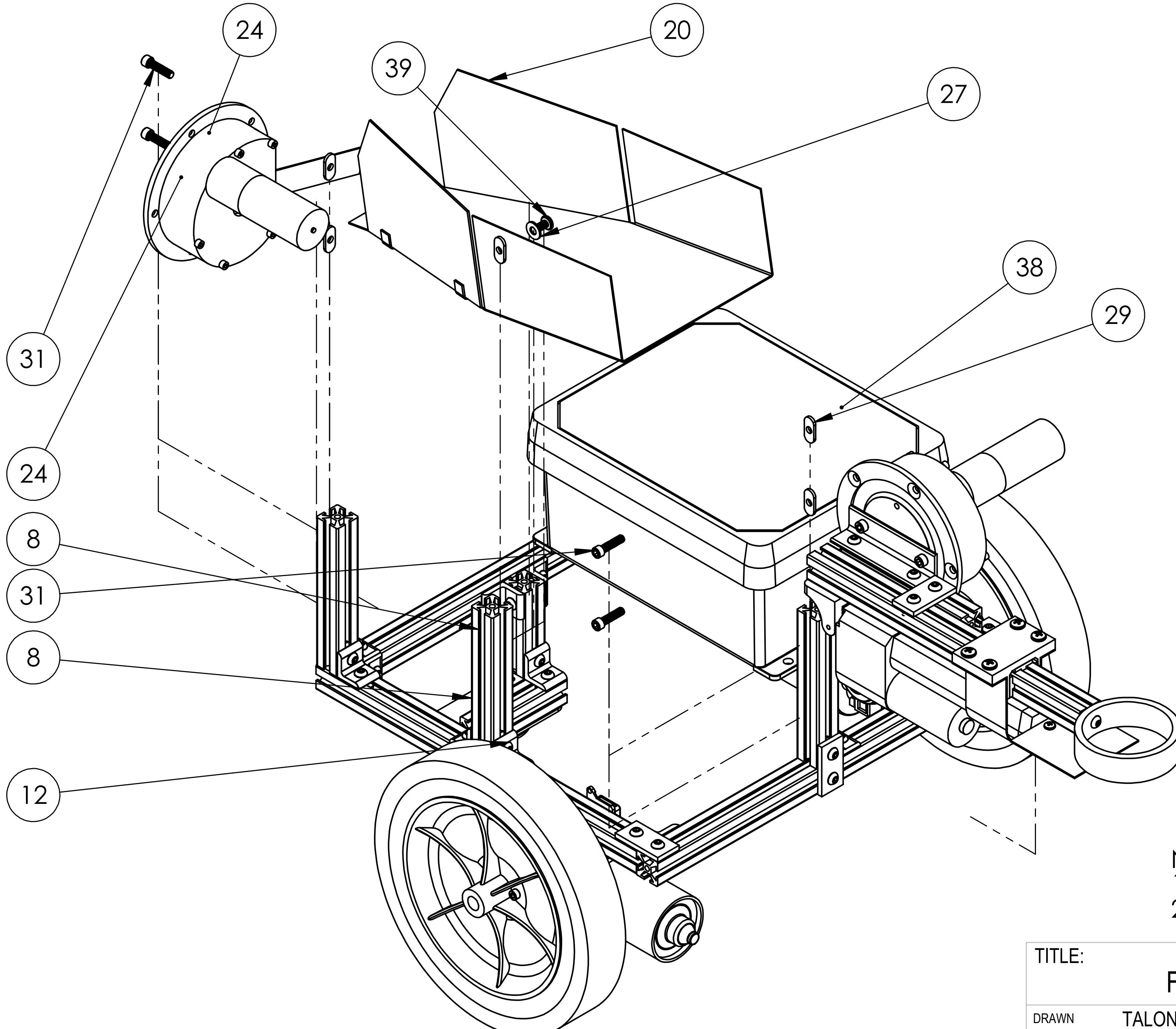


DETAIL D
SCALE 1 : 4

NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

				TITLE: Full Assembly			
				DRAWN	TALON COONS		
TOLERANCE UNLESS NOTED				DESIGNED	GROUP 11A		
DIMENSION TYPE	PLACES IN DIMENSION			SIZE	DWG. NO.		REV
	0.0	0.00	0.000	A	EML2322L-A-100		B
LOCATIONAL	±0.050	±0.020	±0.005				
ANGULAR	±5	±2	±0.5	SCALE: 1:5		SHEET 8 OF 10	

5 4 3 2 1



NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TITLE:	Full Assembly			
DRAWN	TALON COONS			
DESIGNED	GROUP 11A			
SIZE A	DWG. NO. EML2322L-A-100		REV B	
SCALE: 1:5			SHEET 9 OF 10	

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
8	EML2322L-104	80-20 Extrusion - 12.0 inch	1
12	EML2322L-A-OTS2	80-20 90 Degree Bracket Assy	2
13	EML2322L-A-200	BALL MANIPULATOR ASSEMBLY	1
20	EML2322L-A-300	BALL HOPPER ASSEMBLY	1
24	EML2322L-A-400	RELEASE MECHANISM	1
27	EML2322L-403	M6 WASHER	1
29	EML2322L-116	1/4-20 T-Nut	5
31	EML2322L-118	M6X1 18MM SCREW	4
38	EML2322L-A-100	MOBILE PLATFORM ASSEMBLY	1
39	EML2322L-402	M6 x 1mm, 8mm screw	1

NOTES:
1. BILL OF MATERIALS

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE: Full Assembly

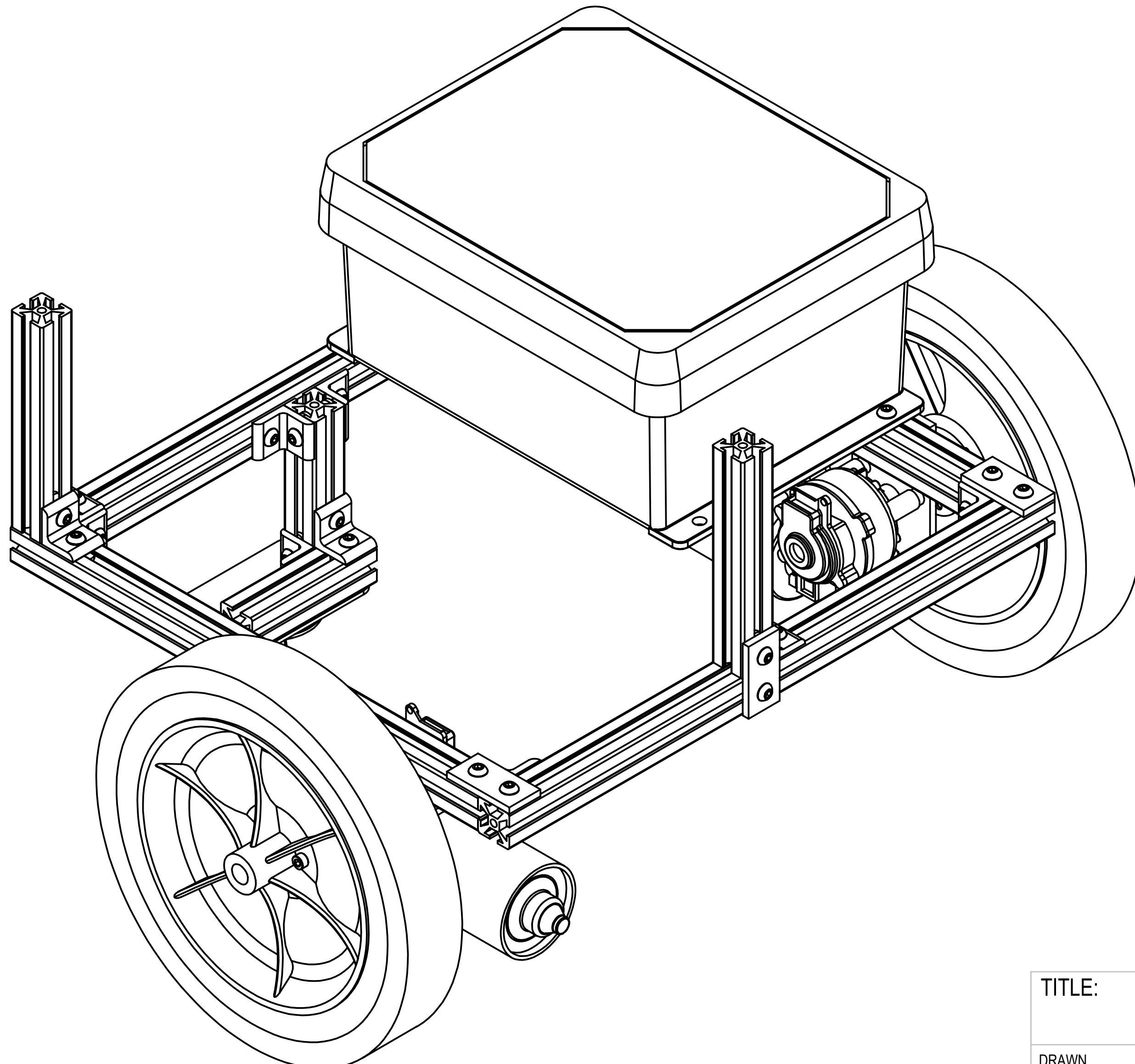
DRAWN: TALON COONS

DESIGNED: GROUP 11A

SIZE: A | DWG. NO.: EML2322L-A-100 | REV: B

SCALE: 1:5 | SHEET 10 OF 10

5 4 3 2 1

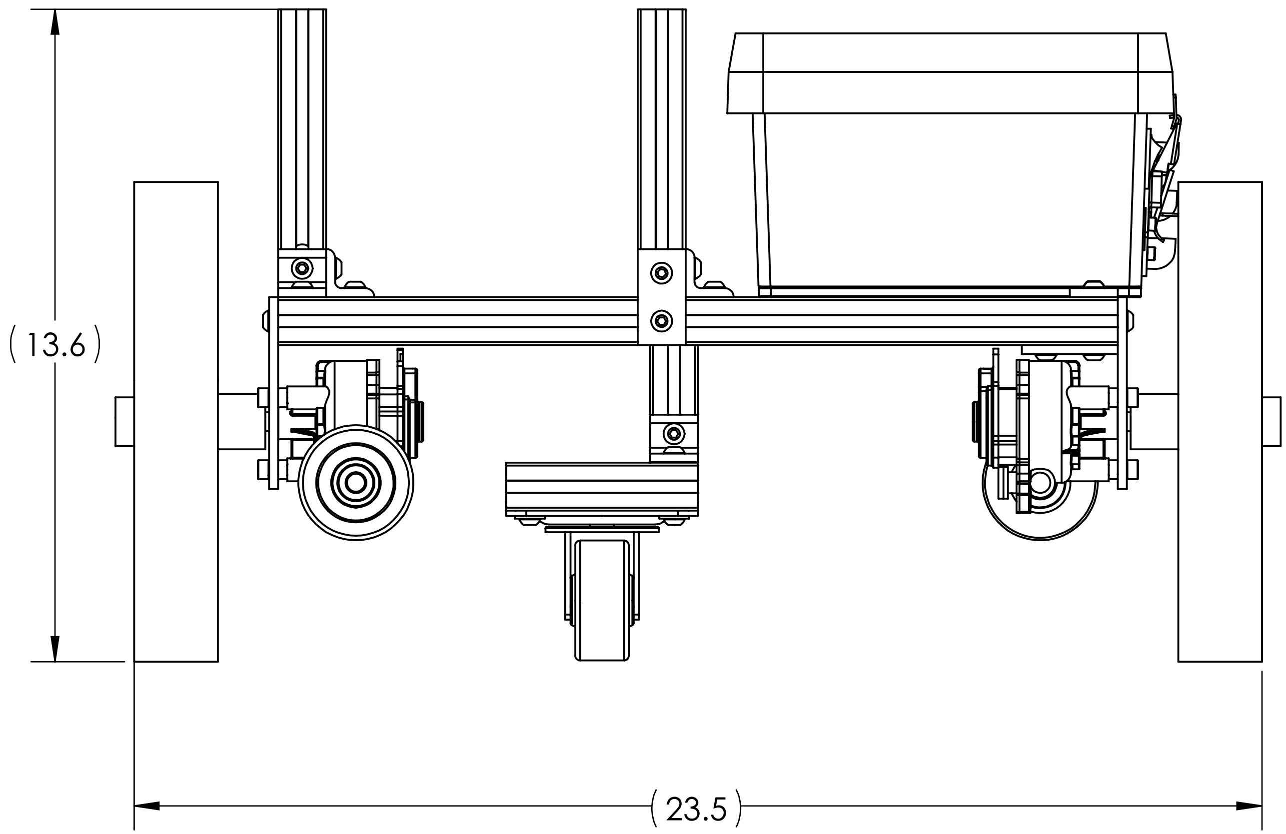


NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE:	Mobile Platform
DRAWN	CHRISTOPHER CROUCH
DESIGNED	CHRISTOPHER CROUCH
SIZE	A
DWG. NO.	EML2322L-11A-100
REV	B
SCALE:	1:16
	SHEET 1 OF 6

5 4 3 2 1



NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TITLE: Mobile Platform			
DRAWN	CHRISTOPHER CROUCH		
DESIGNED	CHRISTOPHER CROUCH		
SIZE A	DWG. NO. EML2322L-11A-100		REV B
SCALE: 1:16		SHEET 2 OF 6	

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
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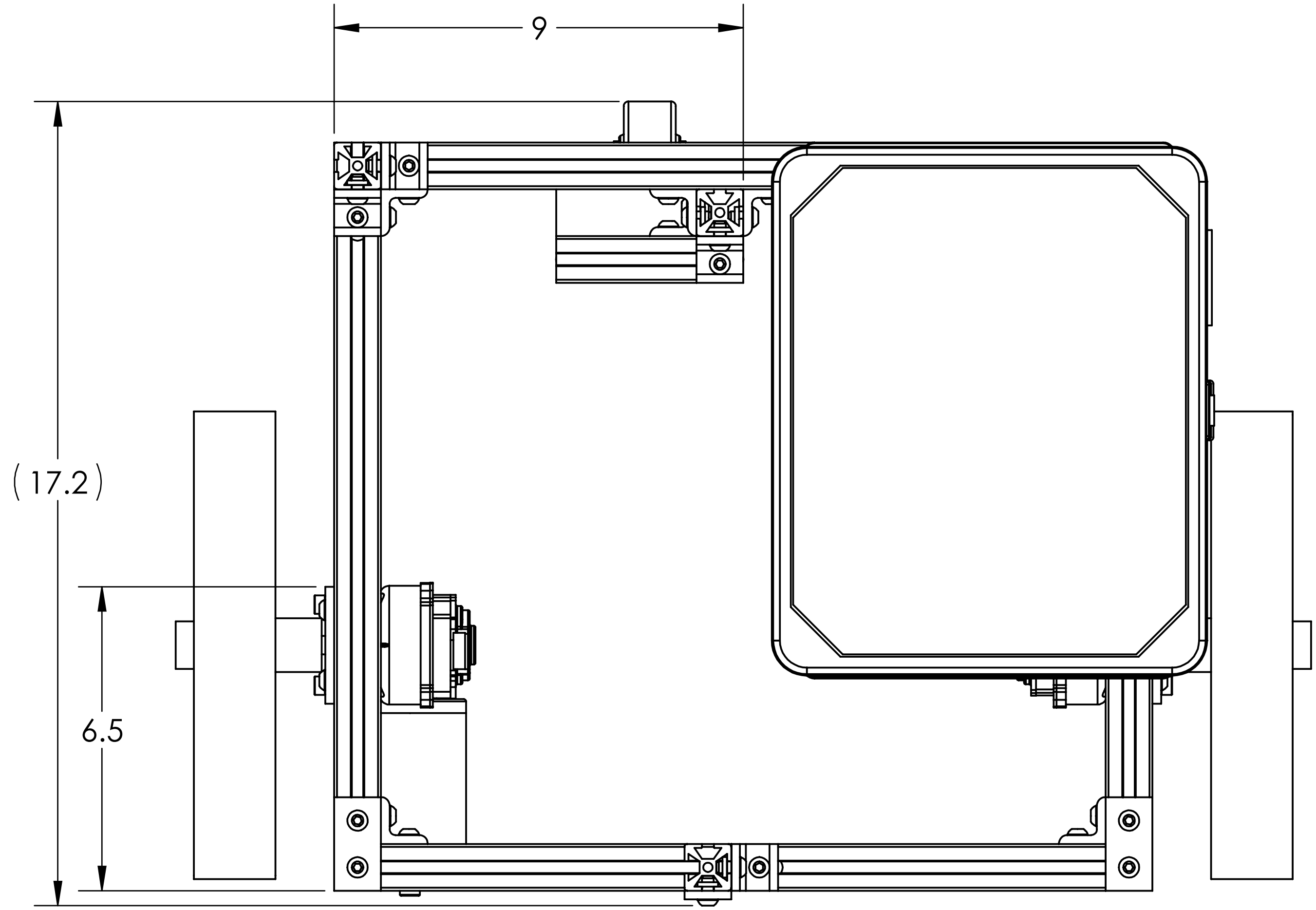
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

5 4 3 2 1



NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
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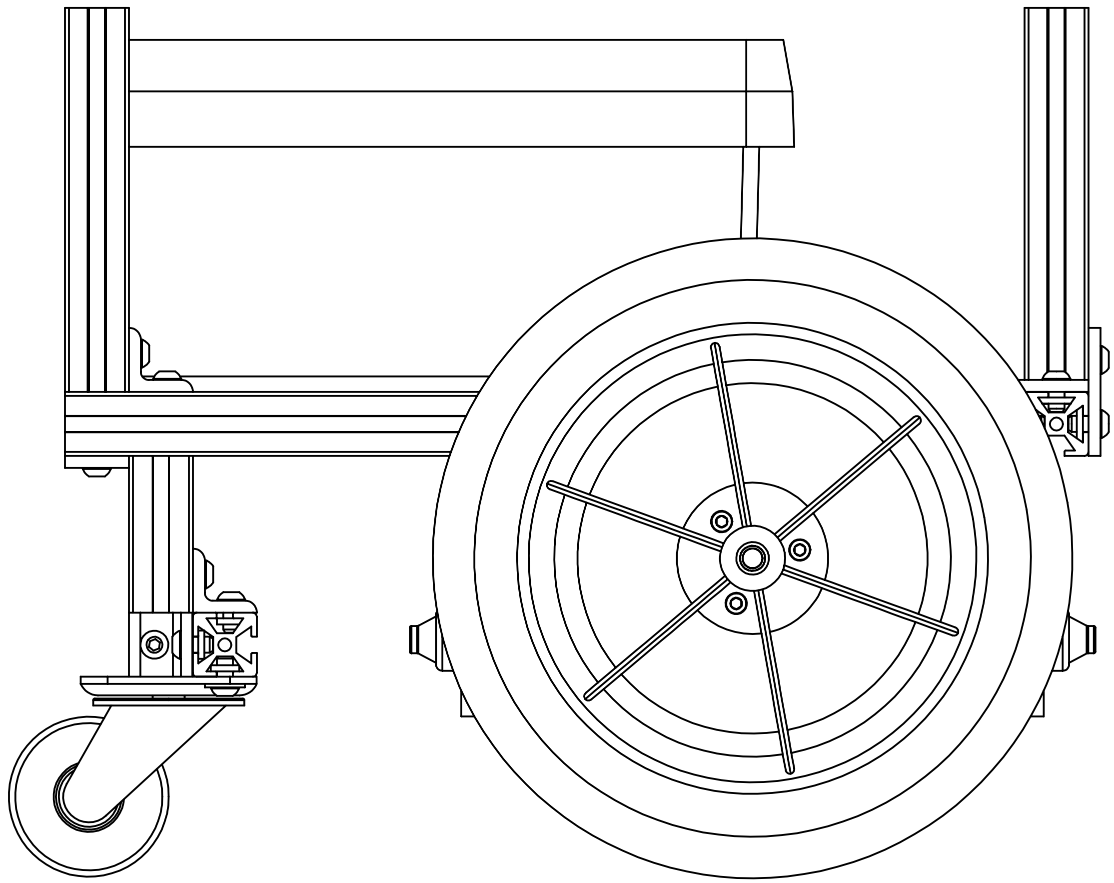
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE: Mobile Platform

DRAWN	CHRISTOPHER CROUCH
DESIGNED	CHRISTOPHER CROUCH
SIZE	A
DWG. NO.	EML2322L-11A-100
REV	B
SCALE:	1:16
SHEET 3 OF 6	

5 4 3 2 1

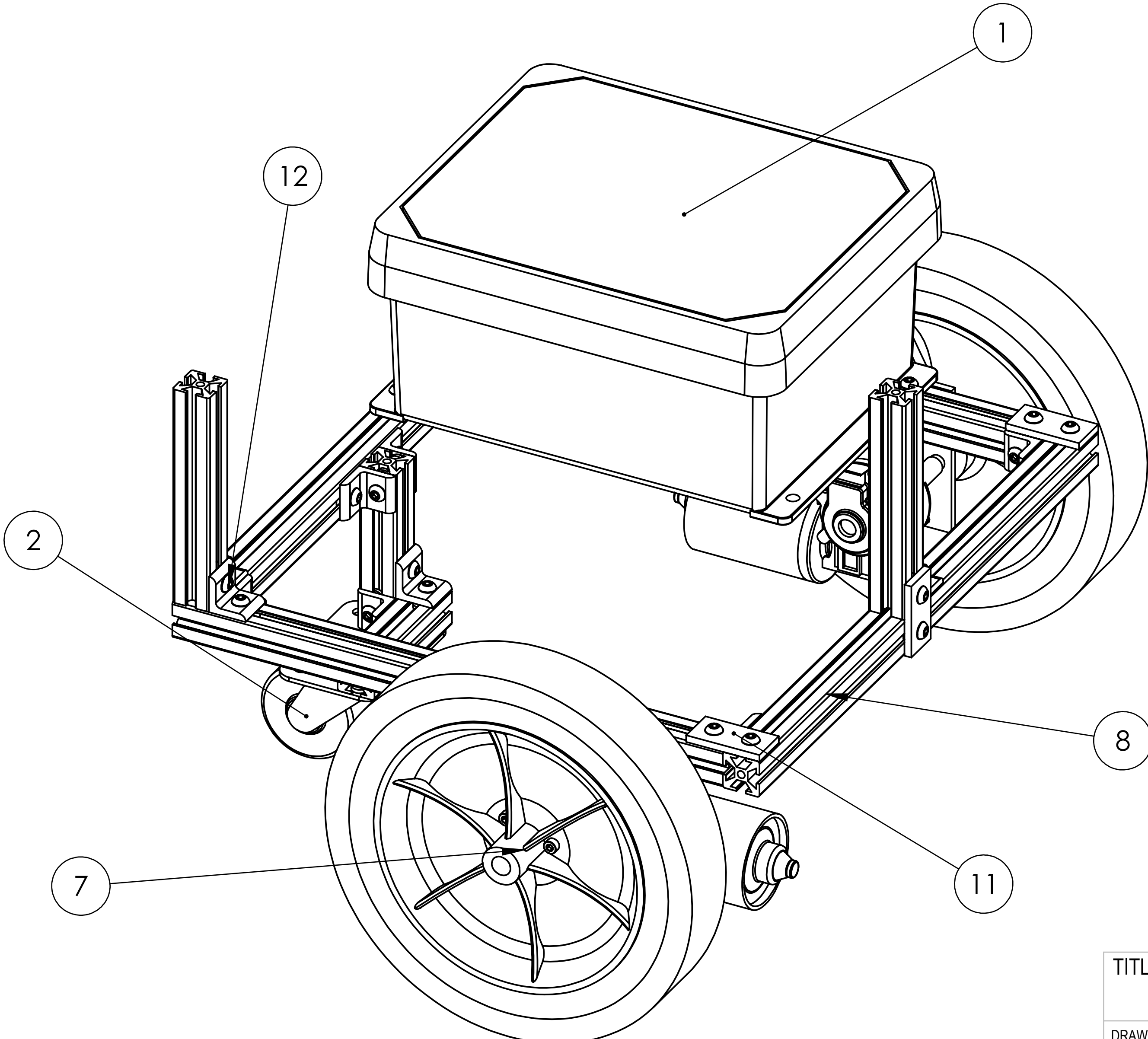


NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TITLE: Mobile Platform			
DRAWN	CHRISTOPHER CROUCH		
DESIGNED	CHRISTOPHER CROUCH		
SIZE A	DWG. NO. EML2322L-11A-100		REV B
SCALE: 1:16			SHEET 4 OF 6

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

5 4 3 2 1



NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE:	Mobile Platform
DRAWN	CHRISTOPHER CROUCH
DESIGNED	CHRISTOPHER CROUCH
SIZE	A
DWG. NO.	EML2322L-11A-100
REV	B
SCALE:	1:16
SHEET 5 OF 6	

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	EML2322L-101	Control Box	1
2	EML2322L-102	Caster Wheel	1
7	EML2322L-103	Drive Wheel Assembly	2
8	EML2322L-104	80-20 Extrusion	1
11	EML2322L-105	80-20 Straight Degree Bracket Assy	4
12	EML2322L-106	80-20 90 Degree Bracket Assy	10

NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE: Mobile Platform

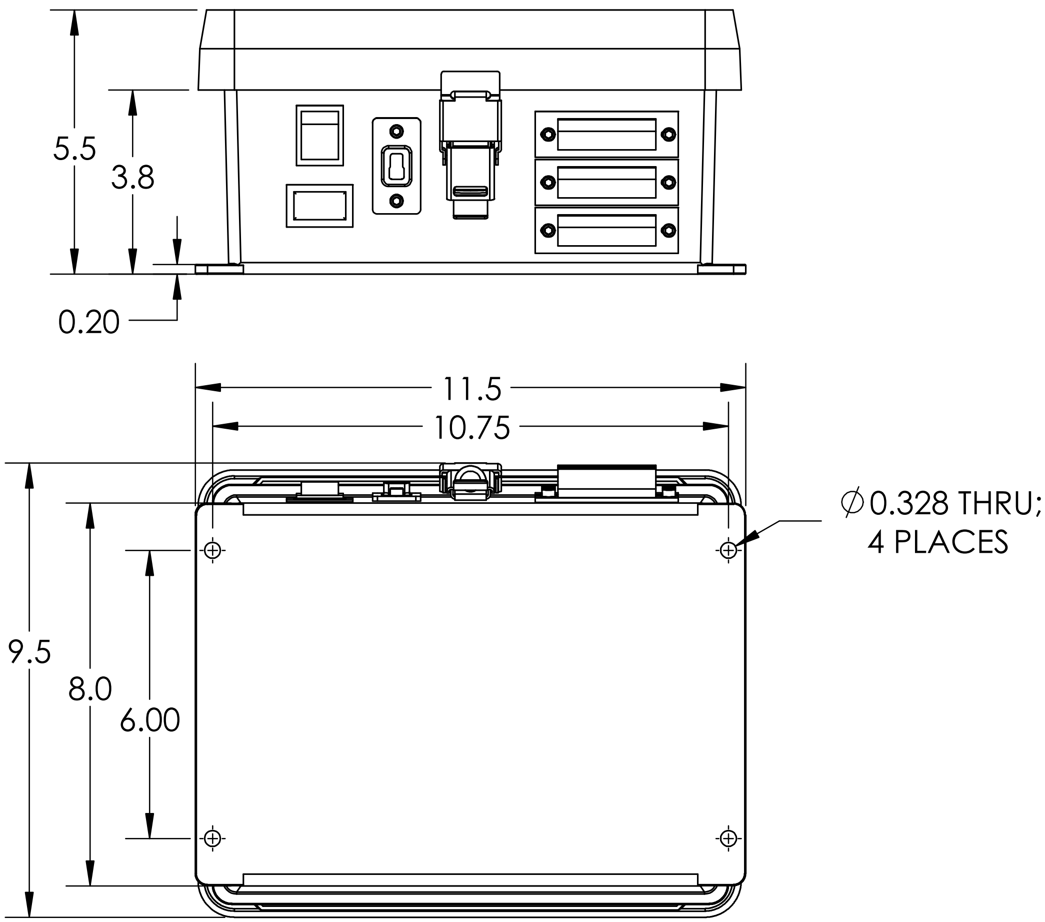
DRAWN CHRISTOPHER CROUCH

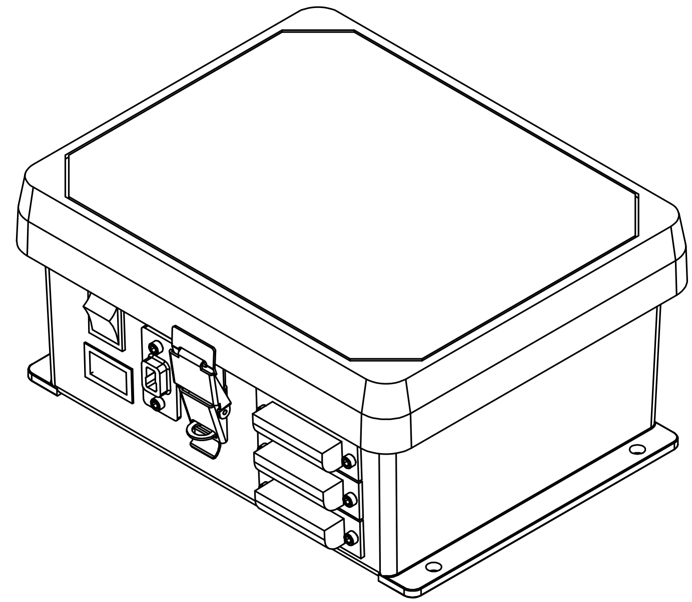
DESIGNED CHRISTOPHER CROUCH

SIZE A | DWG. NO. EML2322L-11A-100 | REV B

SCALE: 1:16 | SHEET 6 OF 6

5 4 3 2 1



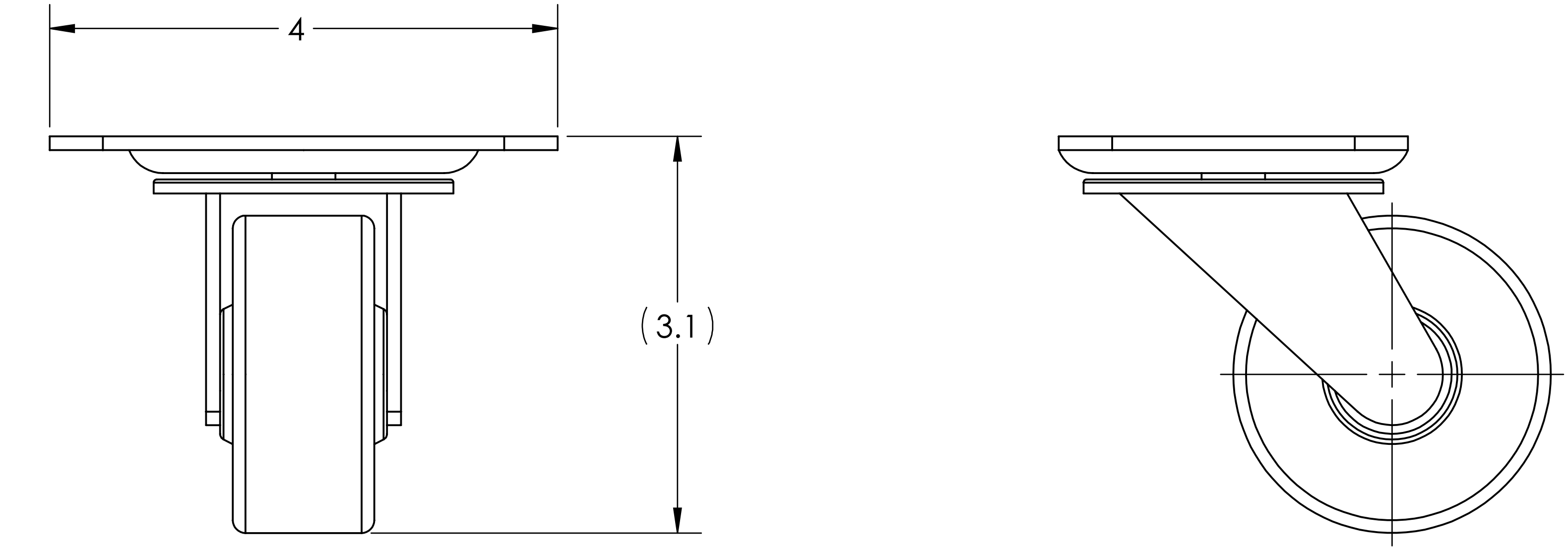


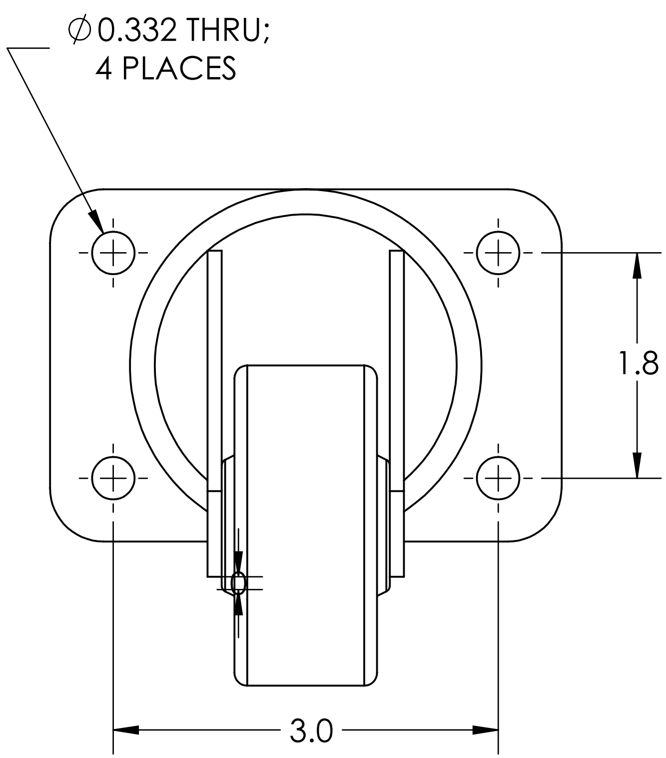
NOTES:
1. DIMS IN INCHES
2. QTY SPECIFIED IN BOM
3. DIM AND MAT'L SPECIFIED BY MANUFACTURER

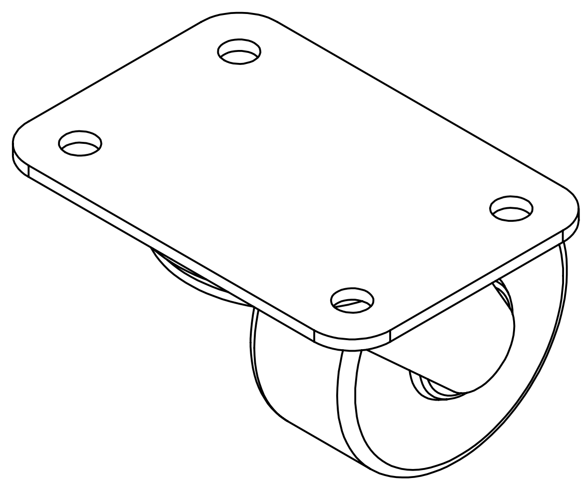
TOLERANCE UNLESS NOTED			
MEASURING INSTRUMENT	PLACES IN DIMENSION		
	0.0	0.00	0.000
CALIPERS			±0.005
PRECISION RULER		±0.015	
TAPE MEASURE	±0.030		
PROTRACTOR	±10	±5	±2

TITLE: Control Box		
DRAWN	KRISTIN BROOKER	
DESIGNED	VYNCKIER ENCLOSURES	
SIZE A	DWG. NO. EML2322L-OTS1	REV B
SCALE: 1:4		SHEET 1 OF 1

4 3 2 1







NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TITLE: Caster Wheel

DRAWN: CHRISTOPHER CROUCH

DESIGNED: CHRISTOPHER CROUCH

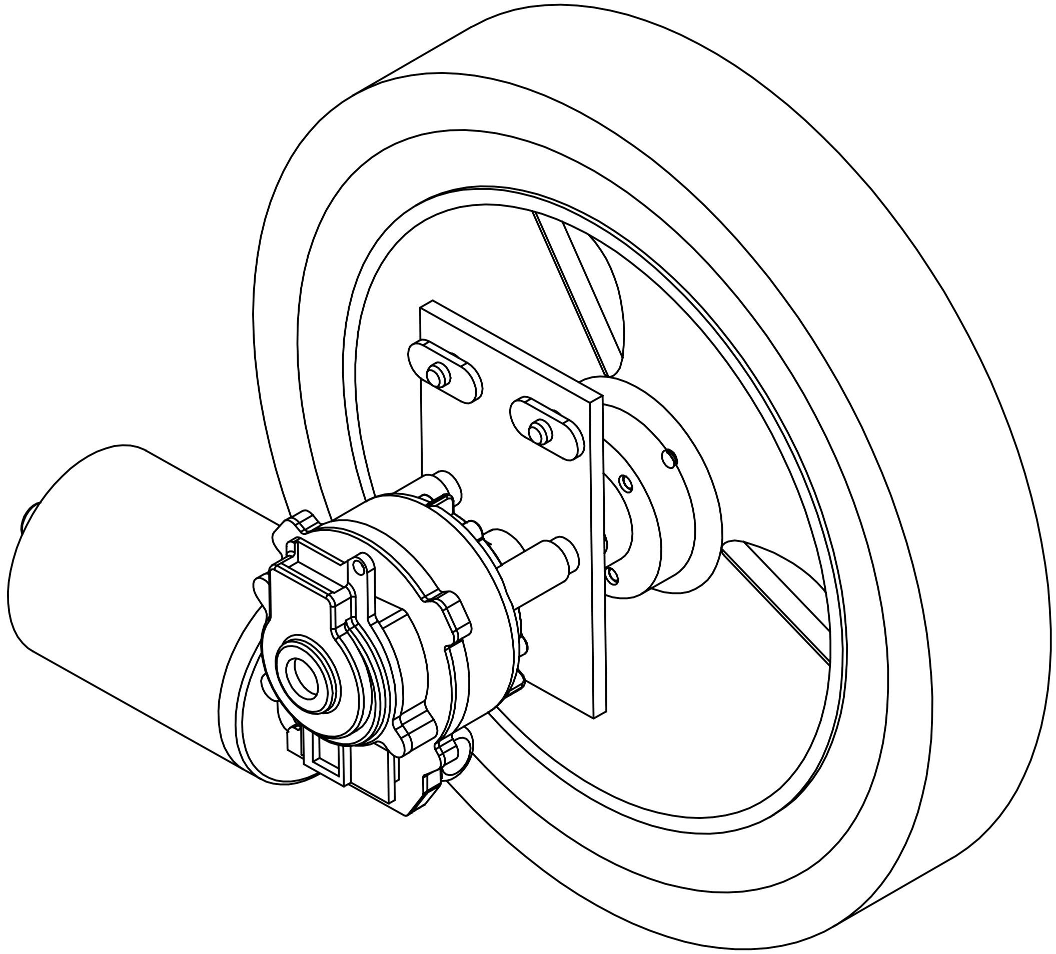
TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

SIZE	DWG. NO.	REV
A	EML2322L-11A-102	B

SCALE: 1:1.5

SHEET 1 OF 1

5 4 3 2 1



NOTES:
1. ALL DIMS IN INCHES
2. QTY: 2

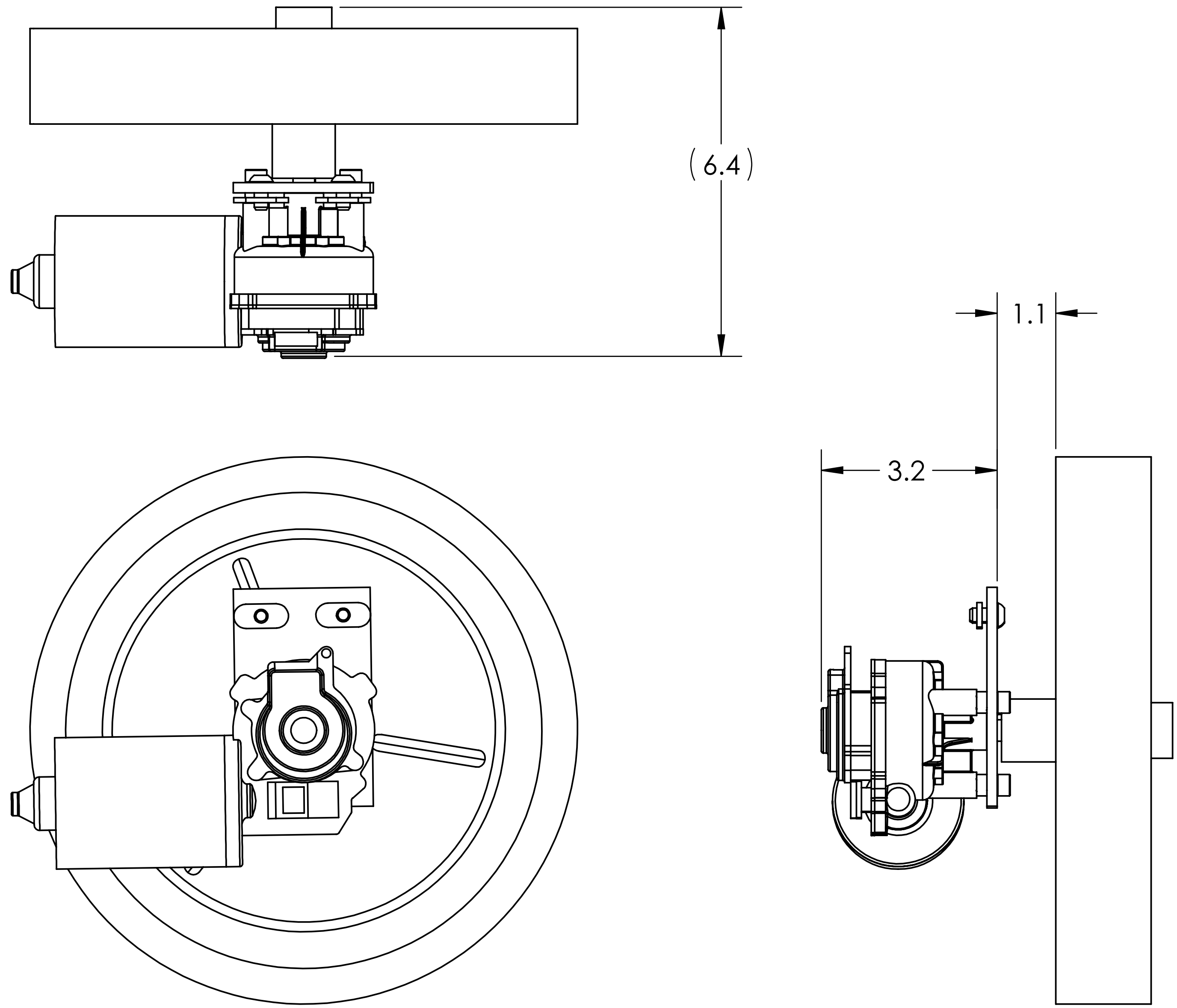
TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE: Drive Wheel

DRAWN	CHRISTOPHER CROUCH
DESIGNED	CHRISTOPHER CROUCH

SIZE	DWG. NO.	REV
A	EML2322L-11A-110	B
SCALE: 1:2	SHEET 1 OF 3	

5 4 3 2 1

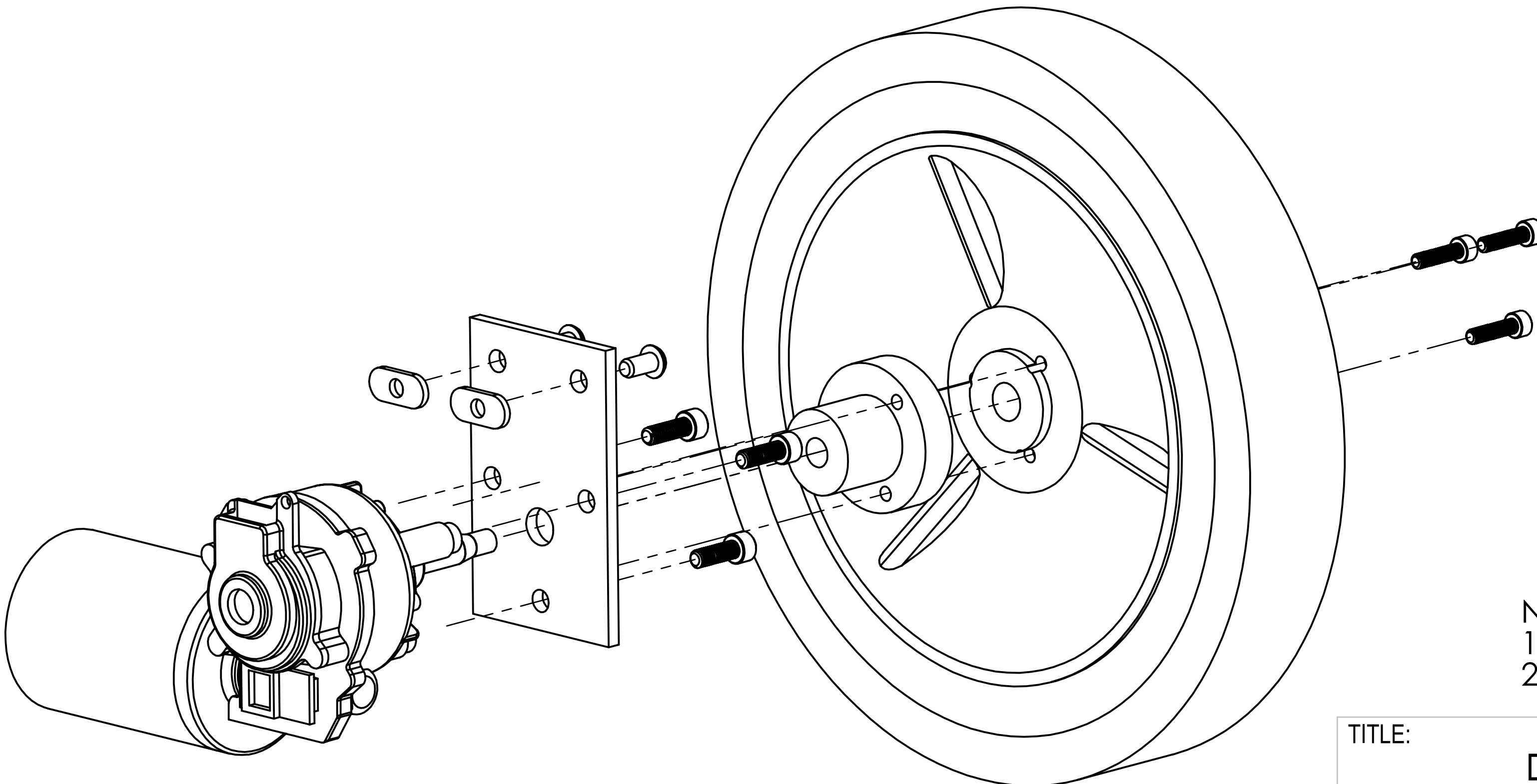


NOTES:
1. ALL DIMS IN INCHES
2. QTY: 2

				TITLE: Drive Wheel			
				DRAWN	CHRISTOPHER CROUCH		
TOLERANCE UNLESS NOTED				DESIGNED	CHRISTOPHER CROUCH		
DIMENSION TYPE	PLACES IN DIMENSION			SIZE	DWG. NO.		REV
	0.0	0.00	0.000	A	EML2322L-11A-110		B
LOCATIONAL	±0.050	±0.020	±0.005				
ANGULAR	±5	±2	±0.5	SCALE: 1:2		SHEET 2 OF 3	

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
3	EML2322L-111	10 Inch Wheel	1
4	EML2322L-112	Wheel Hub	1
5	EML2322L-113	Motor Mount	1
6	EML2322L-114	44 RPM Right Entstort Angle Gear Motor	1
28	EML2322L-115	1/4-20 X 1/2 inch BCHS	2
29	EML2322L-116	1/4-2 T-nut	2
30	EML2322L-117	M5 X 0.8mm, 20mm	3
31	EML2322L-118	M6 X 1.0mm, 15mm	3



NOTES:
1. ALL DIMS IN INCHES
2. QTY: 2

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE: Drive Wheel

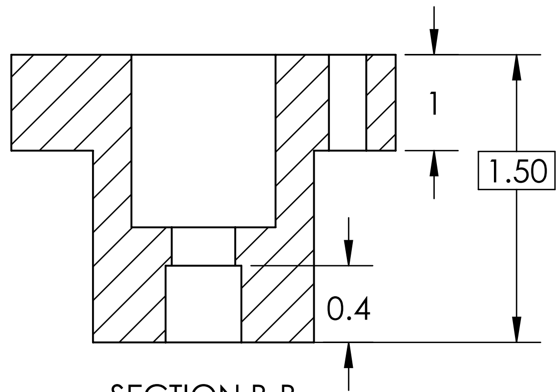
DRAWN: CHRISTOPHER CROUCH

DESIGNED: CHRISTOPHER CROUCH

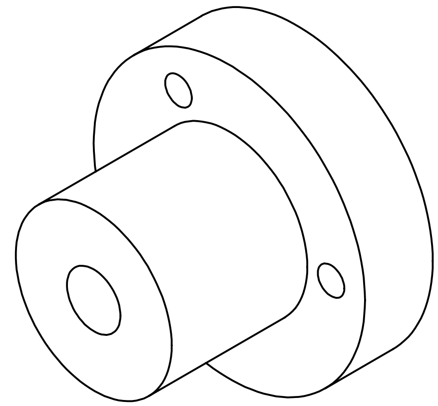
SIZE: A | DWG. NO.: EML2322L-11A-110 | REV: B

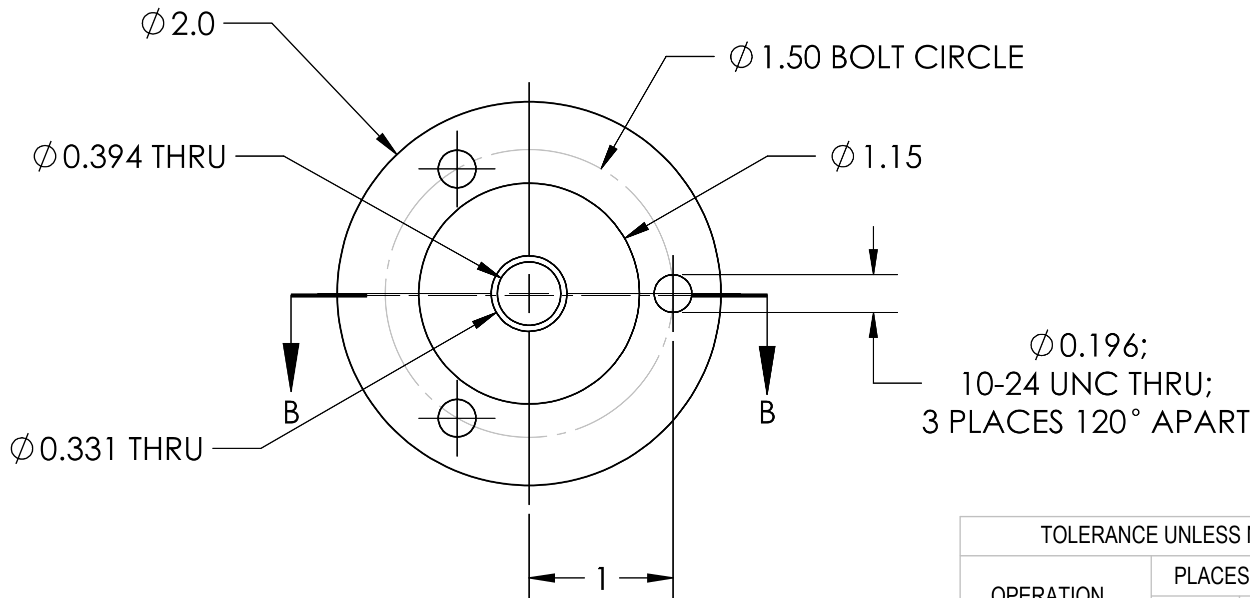
SCALE: 1:2 | SHEET 3 OF 3

5 4 3 2 1



SECTION B-B



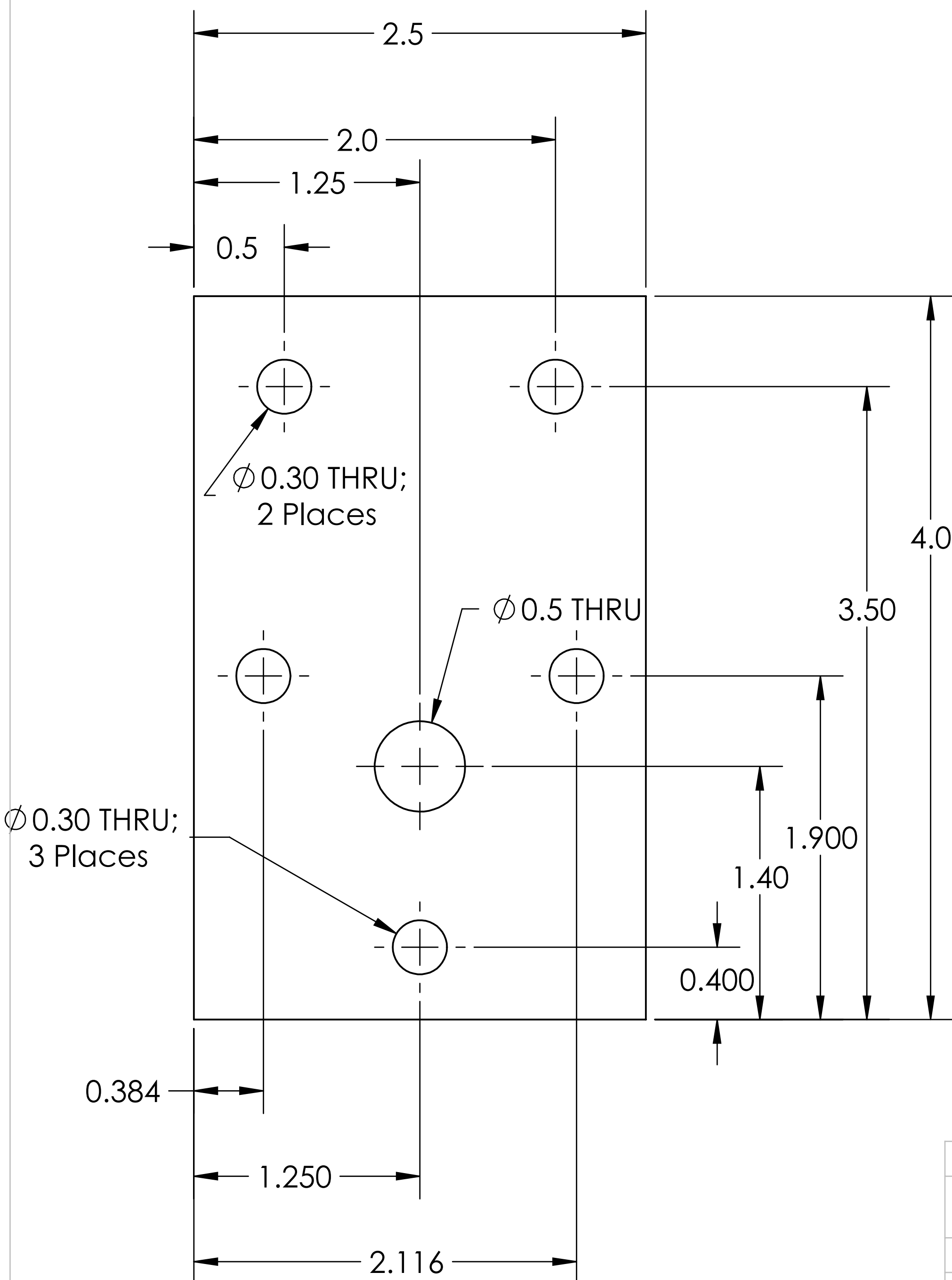


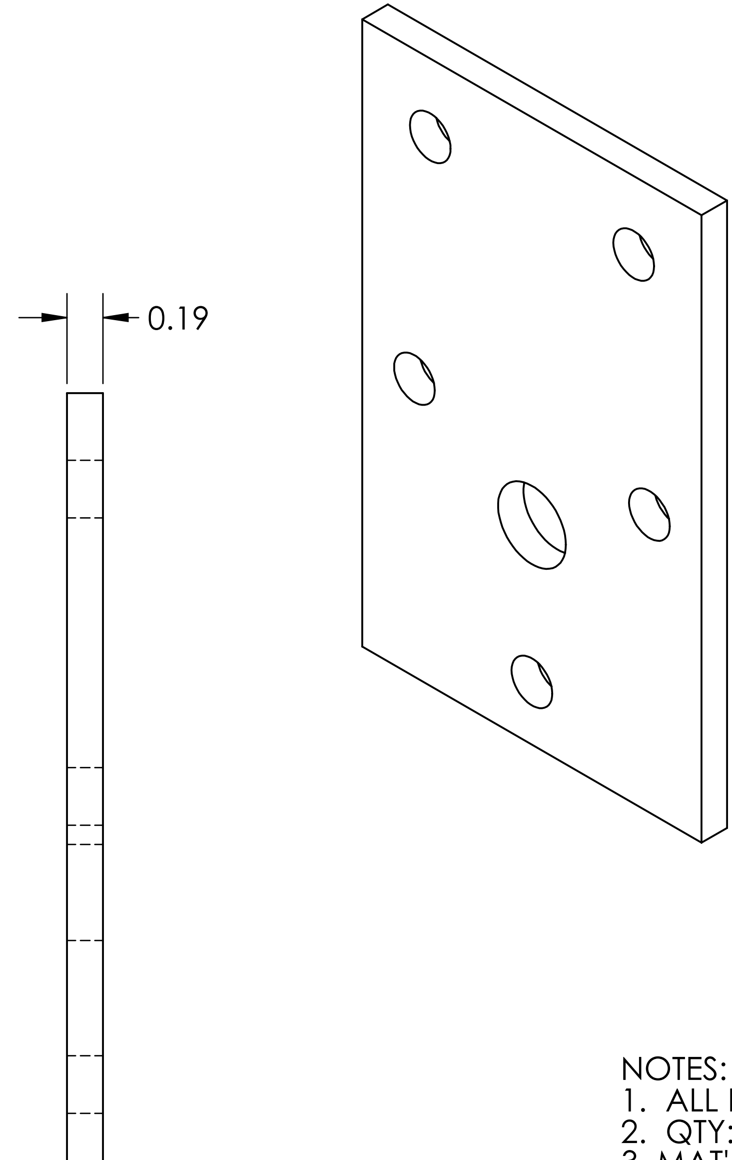
NOTES:
1. QTY:2
2. ALL DIMS IN INCHES
3. MAT'L ALUMINUM
4. BREAK ALL EDGES

TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING	±0.050	±0.020	±0.005
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060	
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	±0.5

TITLE:	Wheel Hub	
DRAWN	KAIO BUI	
DESIGNED	TALON COONS	
SIZE A	DWG. NO. EML2322L-112	REV B
SCALE: 1:1		SHEET 1 OF 1

5 4 3 2 1



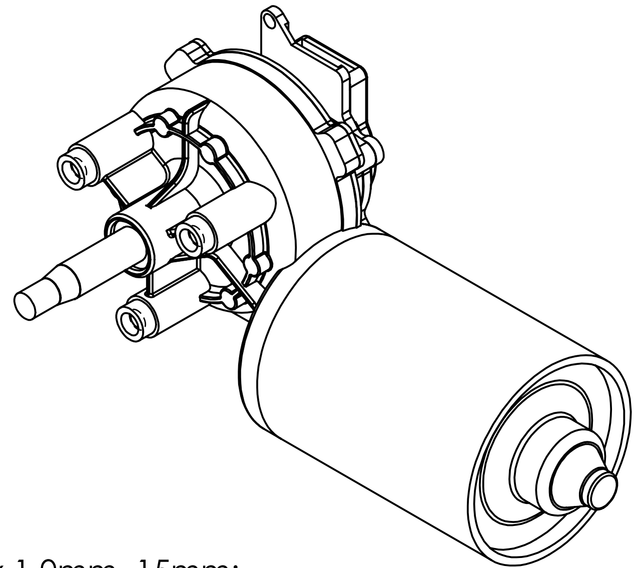


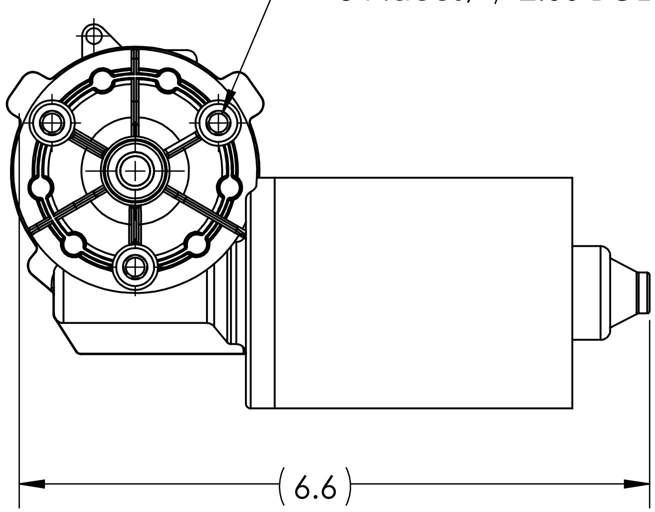
NOTES:
1. ALL DIMS IN INCHES
2. QTY: 2
3. MAT'L: Aluminum

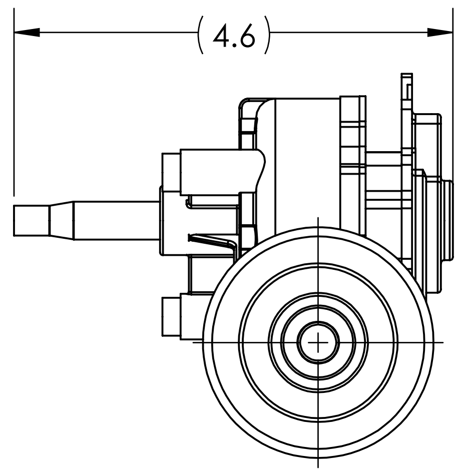
TITLE:	Motor Mount		
DRAWN	CHRISTOPHER CROUCH		
DESIGNED	CHRISTOPHER CROUCH		
SIZE	DWG. NO.		REV
A	EML2322L-11A-113		B
SCALE: 1:1		SHEET 1 OF 1	

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

5 4 3 2 1





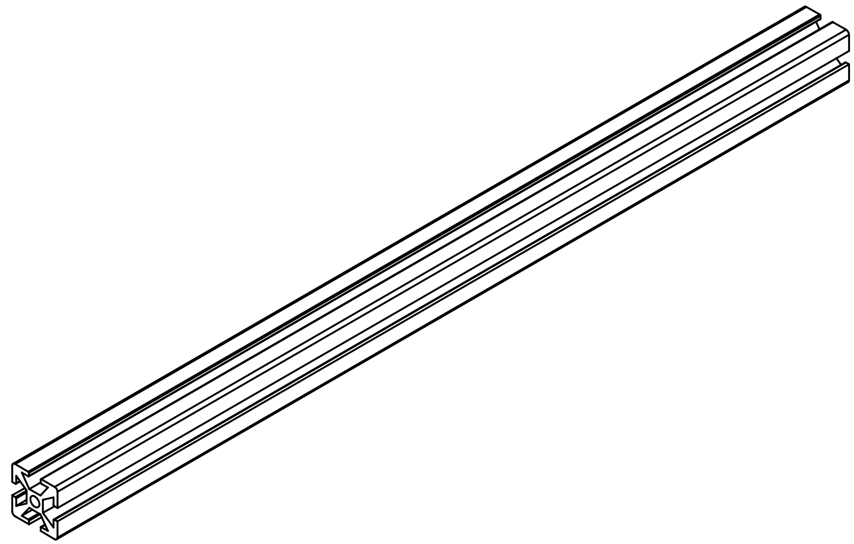


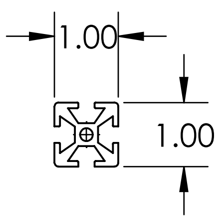
NOTES:
1. ALL DIMS IN INCHES
2. QTY: 2

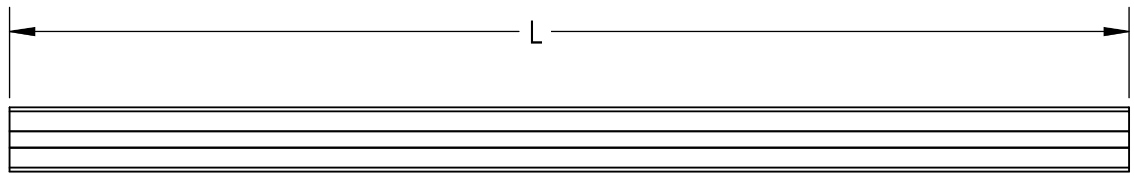
TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING	±0.050	±0.020	±0.005
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060	
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	±0.5

TITLE:	44 RPM Entstort Motor	
DRAWN	CHRISTOPHER CROUCH	
DESIGNED	DML LAB	
SIZE A	DWG. NO. EML2322L-11A-114	REV B
SCALE: 1:2		SHEET 1 OF 1

5 4 3 2 1







NOTES:
1. ALL DIMS IN INCHES

Length (L)	Quantity
3.5	3
4	1
4.45	1
5.6	1
12.75	2
15	1
15.5	1
17.5	1

TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING	±0.050	±0.020	±0.005
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060	
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	±0.5

TITLE: 80-20

DRAWN: CHRISTOPHER CROUCH

DESIGNED: DML LAB

SIZE: A

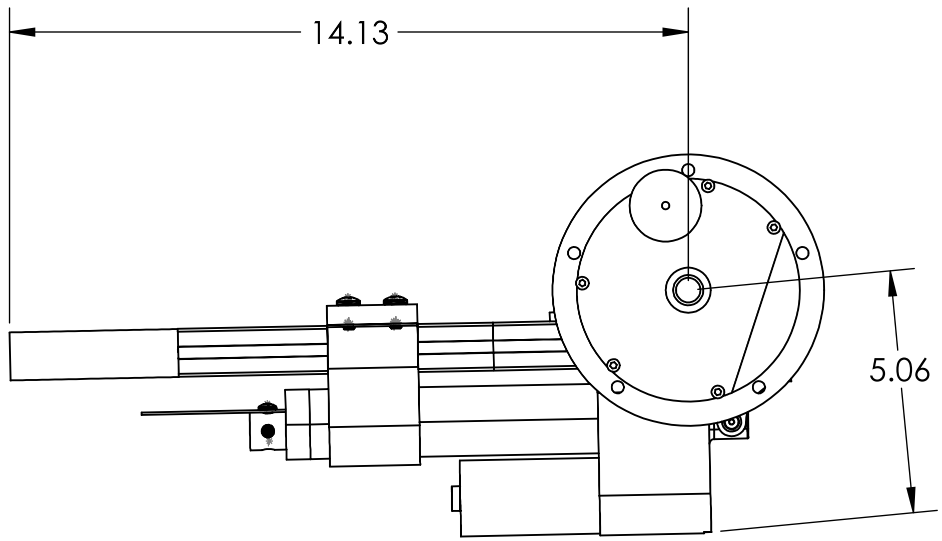
DWG. NO.: EML2322L-11A-104

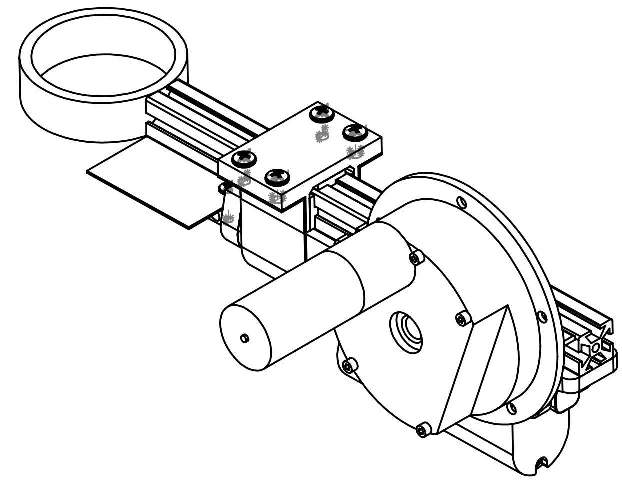
REV: B

SCALE: 1:3

SHEET 1 OF 1

5 4 3 2 1



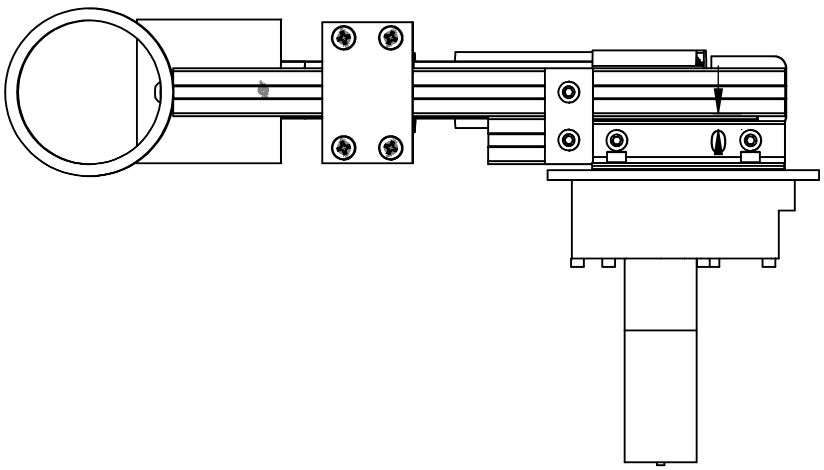


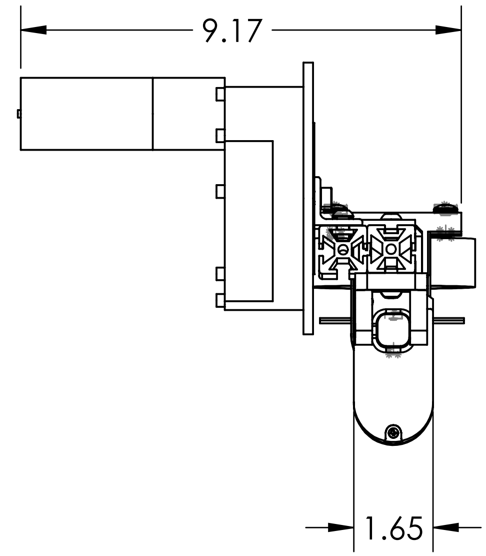
NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE: Ball Manipulator Assembly		
DRAWN	KAIO BUI	
DESIGNED	KAIO BUI	
SIZE A	DWG. NO. EML2322L-A-200	REV B
SCALE: 1:8		SHEET 1 OF 4

5 4 3 2 1





NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TITLE: Ball Manipulator Assembly

DRAWN KAIO BUI

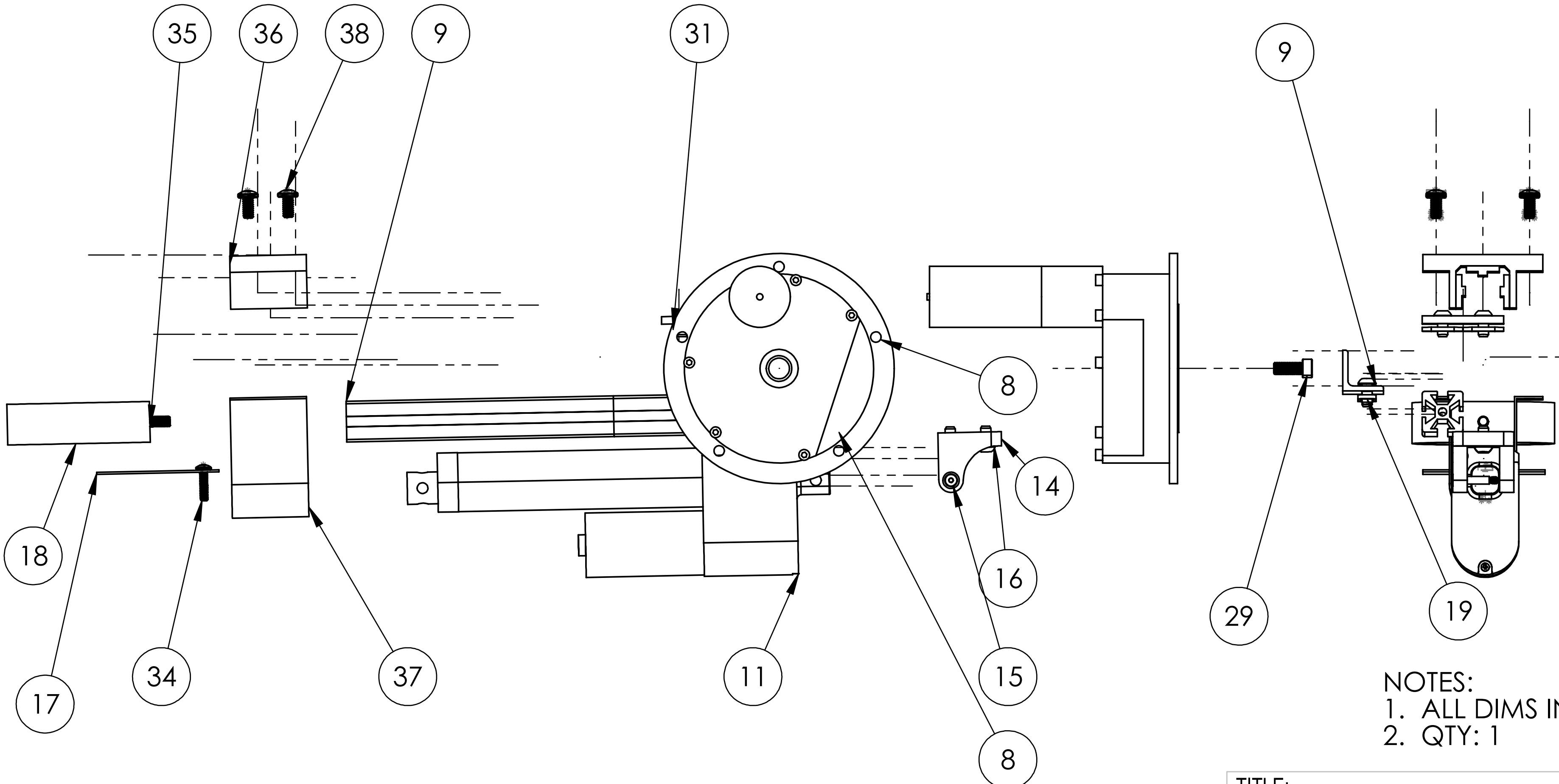
DESIGNED KAIO BUI

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

SIZE	DWG. NO.	REV
A	EML2322L-A-200	B

SCALE: 1:8 SHEET 2 OF 4

5 4 3 2 1



NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE: Ball Manipulator Assembly		
				DRAWN	KAIO BUI	
				DESIGNED	KAIO BUI	
DIMENSION TYPE	PLACES IN DIMENSION			SIZE	DWG. NO.	REV
	0.0	0.00	0.000	A	EML2322L-A-200	B
LOCATIONAL	±0.050	±0.020	±0.005			
ANGULAR	±5	±2	±0.5	SCALE: 1:8	SHEET 3 OF 4	

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
8	EML2322L-104	80-20 Extrusion - 5.6	1
8	EML2322L-104	80-20 Extrusion - 12.75 inch	1
9	EML2322L-105	Angled Bracket	1
11	EML2322L-107	80-20 Straight Degree Bracket Assy	1
14	EML2322L-201	BM Steel Sheet	1
15	EML2322L-202	BM PVC Ring	1
16	EML2322L-203	Linear Actuator Holder	1
17	EML2322L-204	4.5 RPM Globe Gear Motor	1
18	EML2322L-205	30 IPM Spal Linear Actuator (4in)	1
19	EML2322L-206	Linear Actuator Mount (10-24)	1
28	EML2322L-115	1/4-20 X 1/2 inch BHCS	4
29	EML2322L-116	80/20 T-Nut	2
31	EML2322L-118	M6 X 1.0mm Screw	2
34	EML2322L-207	Linear Actuator Shoulder Screw	1
35	EML2322L-208	Steel Sheet Screw	1
36	EML2322L-209	PVC Ring Screw	1
37	EML2322L-210	80-20 Linear Slide	1
38	EML2322L-211	Linear Actuator Holder Screw	4

NOTES:
1. ALL DIMS IN INCHES
2. QTY:1

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE: Ball Manipulator Assembly

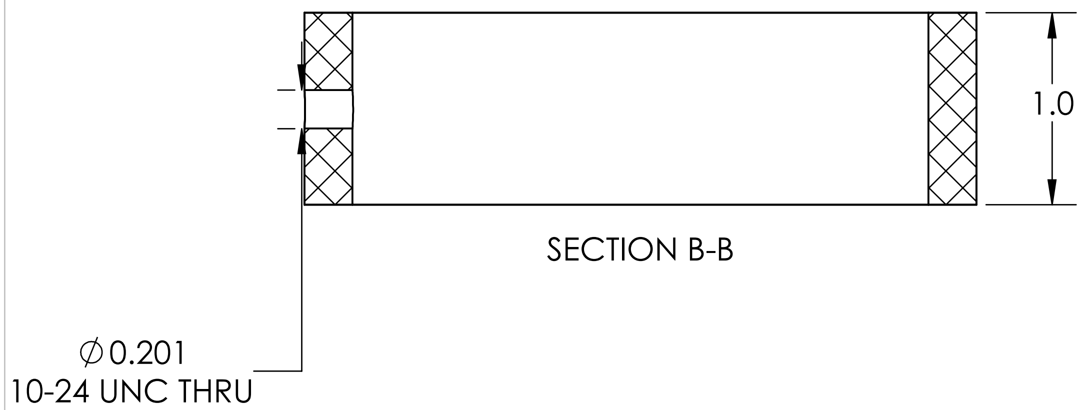
DRAWN KAIO BUI

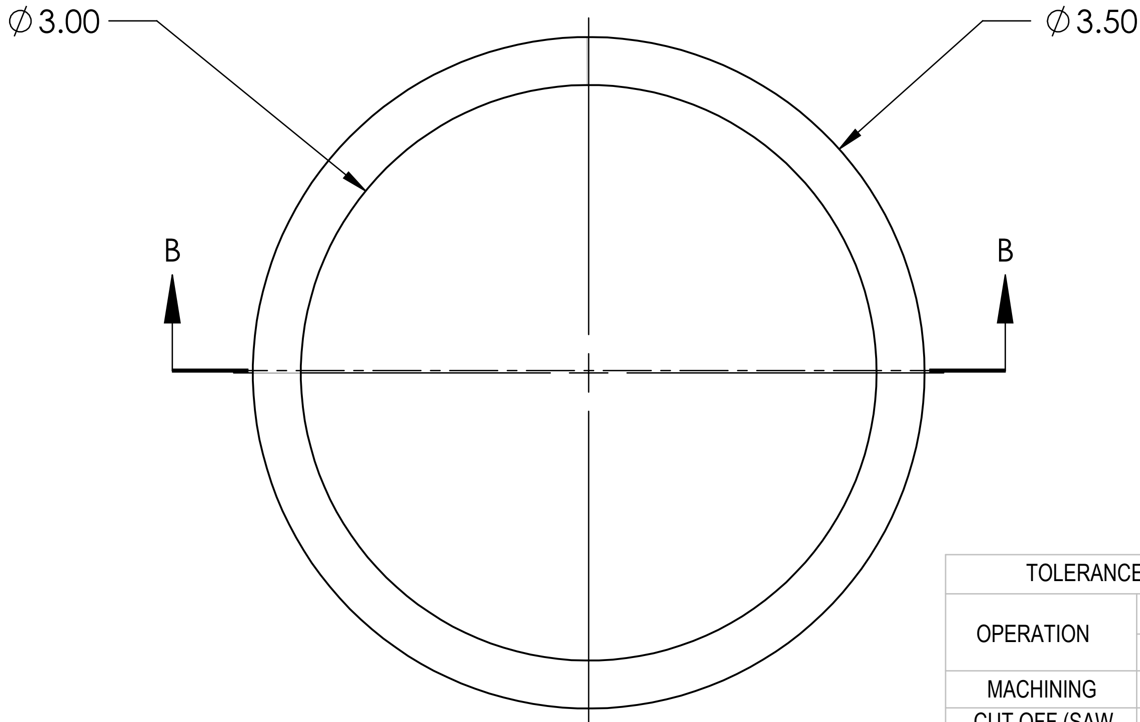
DESIGNED KAIO BUI

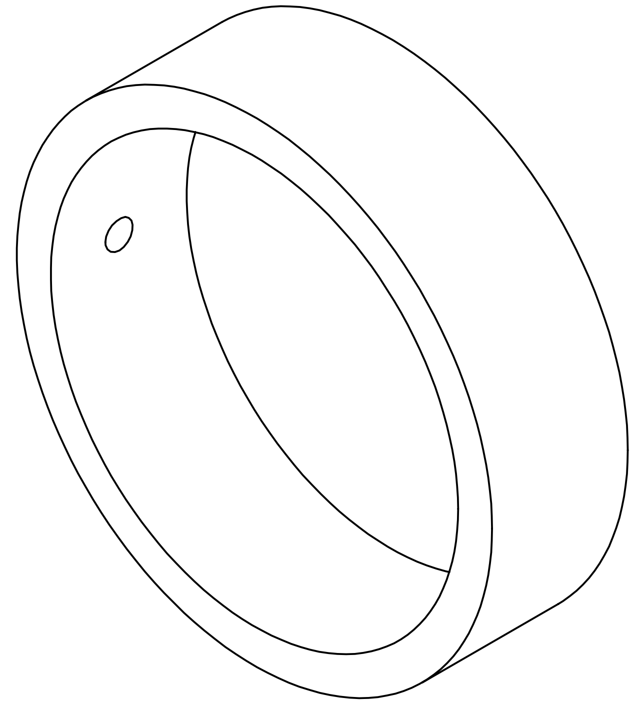
SIZE A | DWG. NO. EML2322L-A-200 | REV B

SCALE: 1:8 | SHEET 4 OF 4

5 4 3 2 1





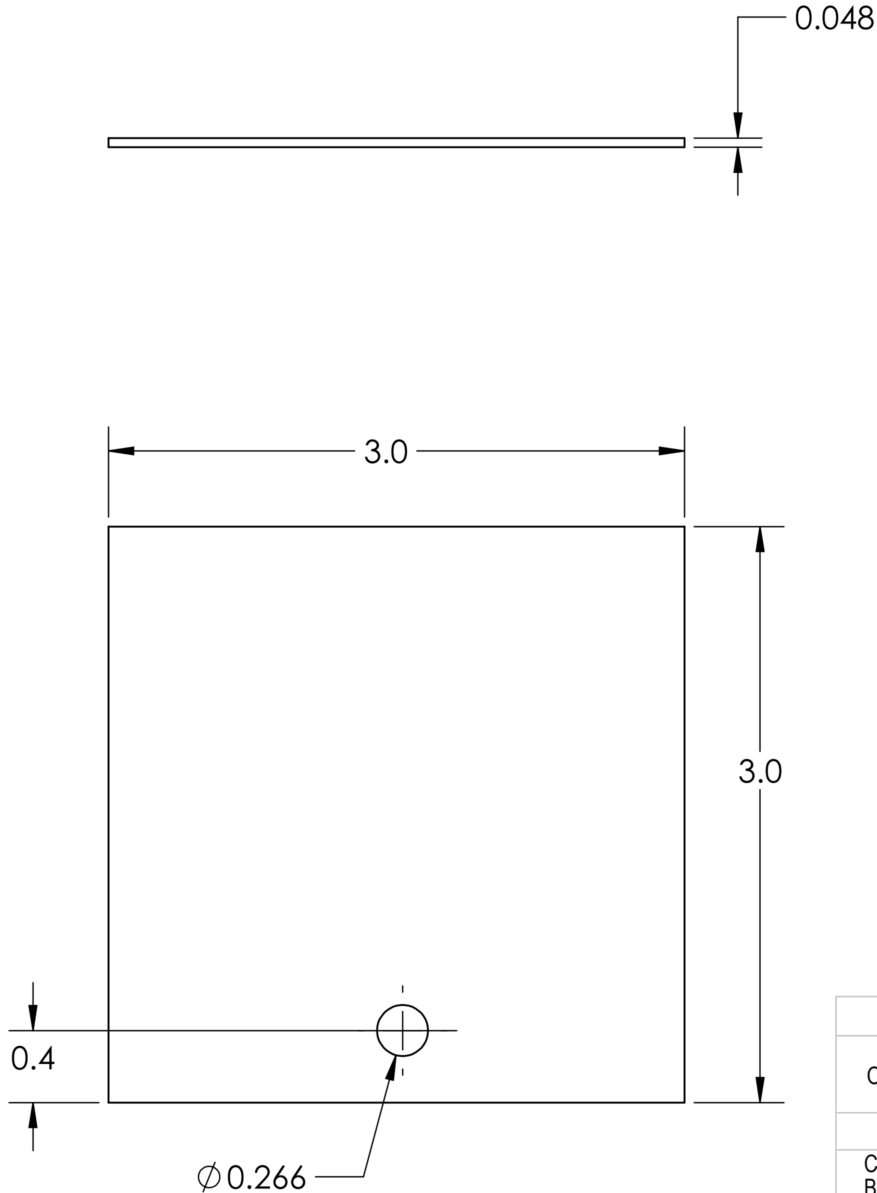


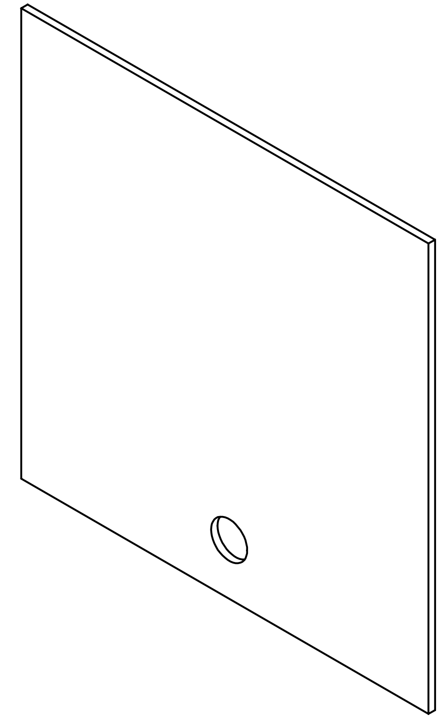
NOTES:
1. QTY: 1
2. ALL DIMS IN INCHES
3. MATL: PVC
4. BREAK ALL SURFACES

TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING	±0.050	±0.020	±0.005
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060	
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	±0.5

TITLE: Ball Manipulator PVC ring		
DRAWN	KAIO BUI	
DESIGNED	KAIO BUI	
SIZE A	DWG. NO. EML2322L-202	REV A
SCALE: 1:1		SHEET 1 OF 1

5 4 3 2 1



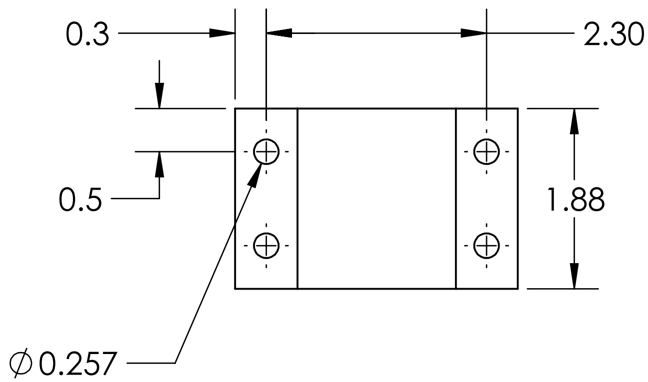


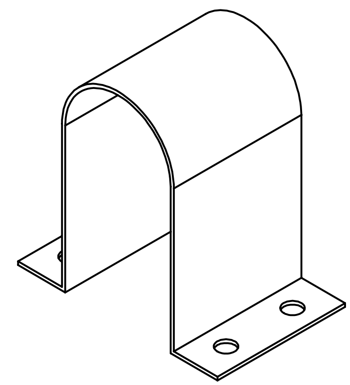
NOTES:
1. QTY: 1
2. ALL DIMS IN INCHES
3. MATL: 16 GA STAINLESS STEEL
4. BREAK ALL EDGES

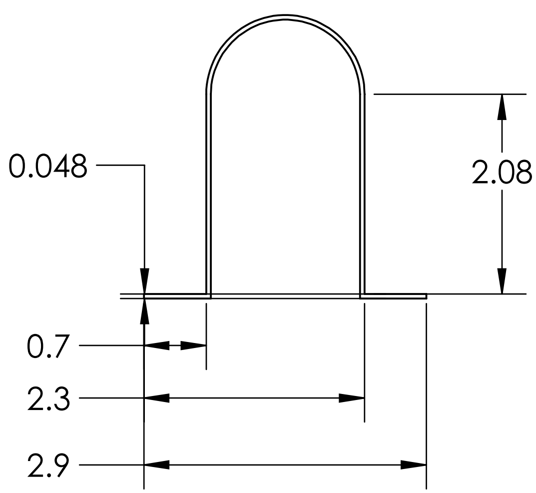
TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING	±0.050	±0.020	±0.005
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060	
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	±0.5

TITLE:	Ball Manipulator Steel Sheet	
DRAWN	KAIO BUI	
DESIGNED	KAIO BUI	
SIZE A	DWG. NO. EML2322L-201	REV B
SCALE: 1:1		SHEET 1 OF 1

5 4 3 2 1





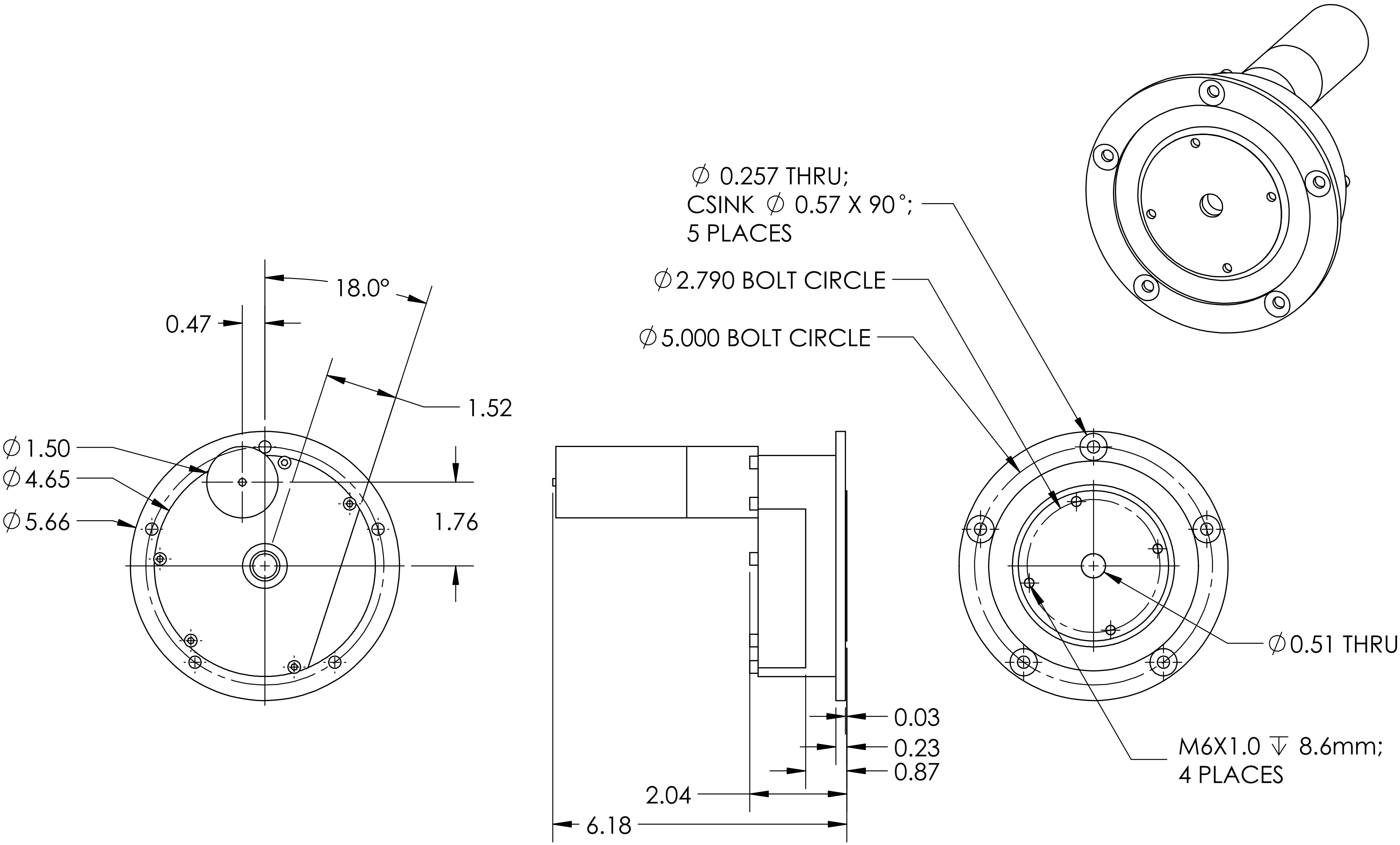


NOTES:
1. QTY: 1
2. ALL DIMS IN INCHES
3. MATL: STAINLESS STEEL
4. BREAK ALL EDGES

TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING	±0.050	±0.020	±0.005
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060	
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	±0.5

TITLE:	Linear Actuator Holder	
DRAWN	KAIO BUI	
DESIGNED	KAIO BUI	
SIZE A	DWG. NO. EML2322L-203	REV B
SCALE: 1:2		SHEET 1 OF 1

5 4 3 2 1

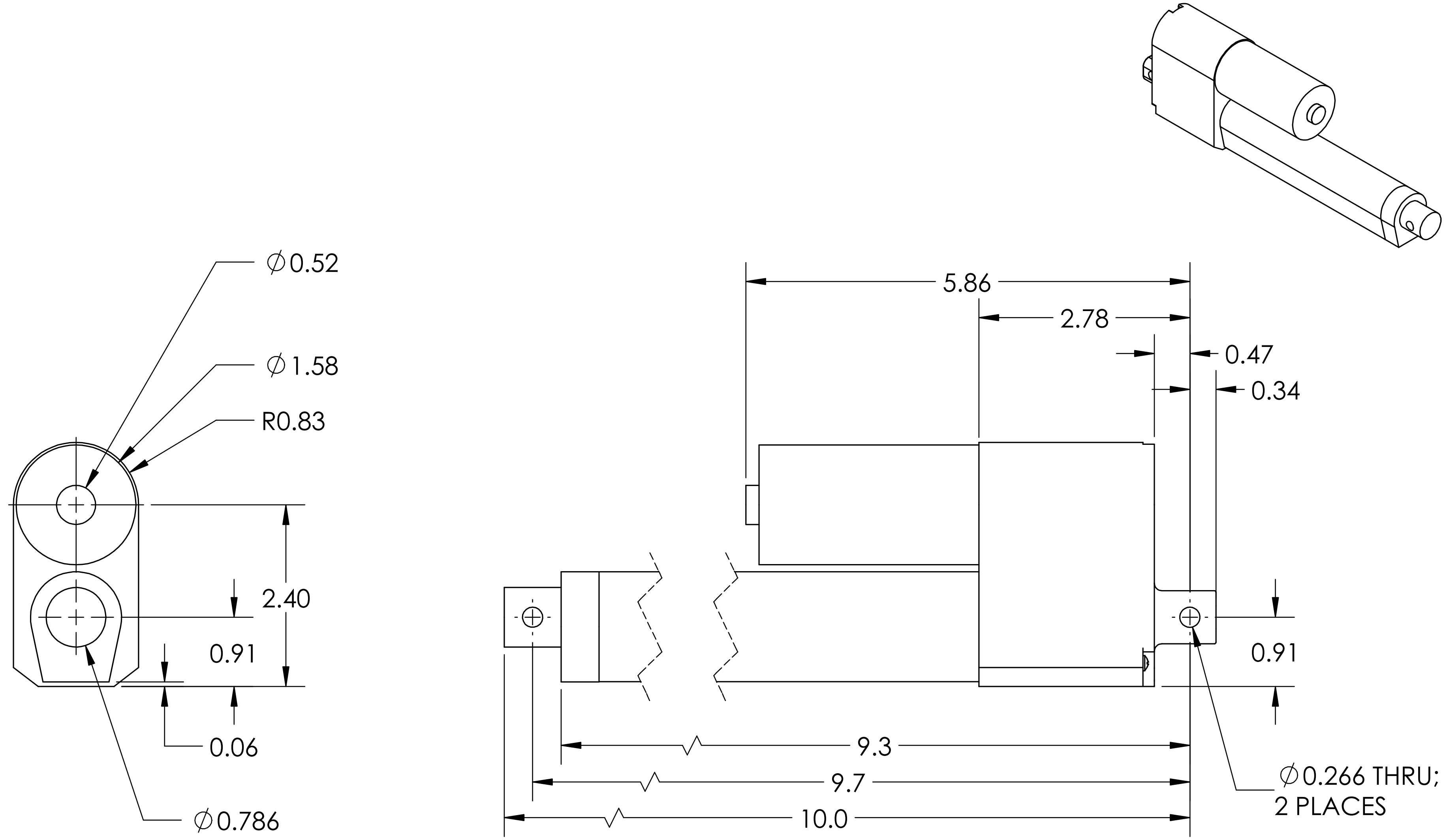


NOTES:
1. DIMS IN INCHES
2. QTY SPECIFIED IN BOM
3. DIMS AND MAT'L SPECIFIED
BY MANUFACTURER

TOLERANCE UNLESS NOTED			
MEASURING INSTRUMENT	PLACES IN DIMENSION		
	0.0	0.00	0.000
CALIPERS			±0.005
PRECISION RULER		±0.015	
TAPE MEASURE	±0.030		
PROTRACTOR	±10	±5	±2

TITLE: 4.5 RPM Globe Gear Motor		
DRAWN J. DERSCH		
DESIGNED GLOBE		
SIZE A	DWG. NO. EML2322L-OTS30	REV A
SCALE: 1:3		SHEET 1 OF 1

3 2 1



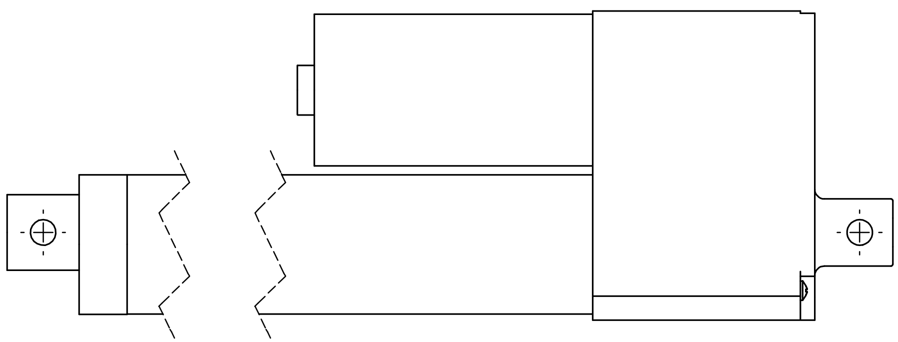
ACTUATOR EXTENDS 4"

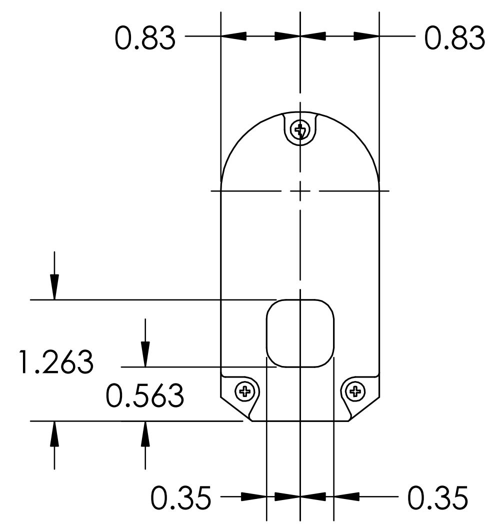
NOTES:
1. DIMS IN INCHES
2. QTY SPECIFIED IN BOM
3. DIMS AND MAT'L SPECIFIED
BY MANUFACTURER

TOLERANCE UNLESS NOTED			
MEASURING INSTRUMENT	PLACES IN DIMENSION		
	0.0	0.00	0.000
CALIPERS			±0.005
PRECISION RULER		±0.015	
TAPE MEASURE	±0.030		
PROTRACTOR	±10	±5	±2

TITLE:	30 IPM Spal Linear Actuator
DRAWN	J. DERSCH
DESIGNED	SPAL
SIZE	A
DWG. NO.	EML2322L-OTS35a
REV	A
SCALE: 1:2	SHEET 1 OF 2

4 3 2 1





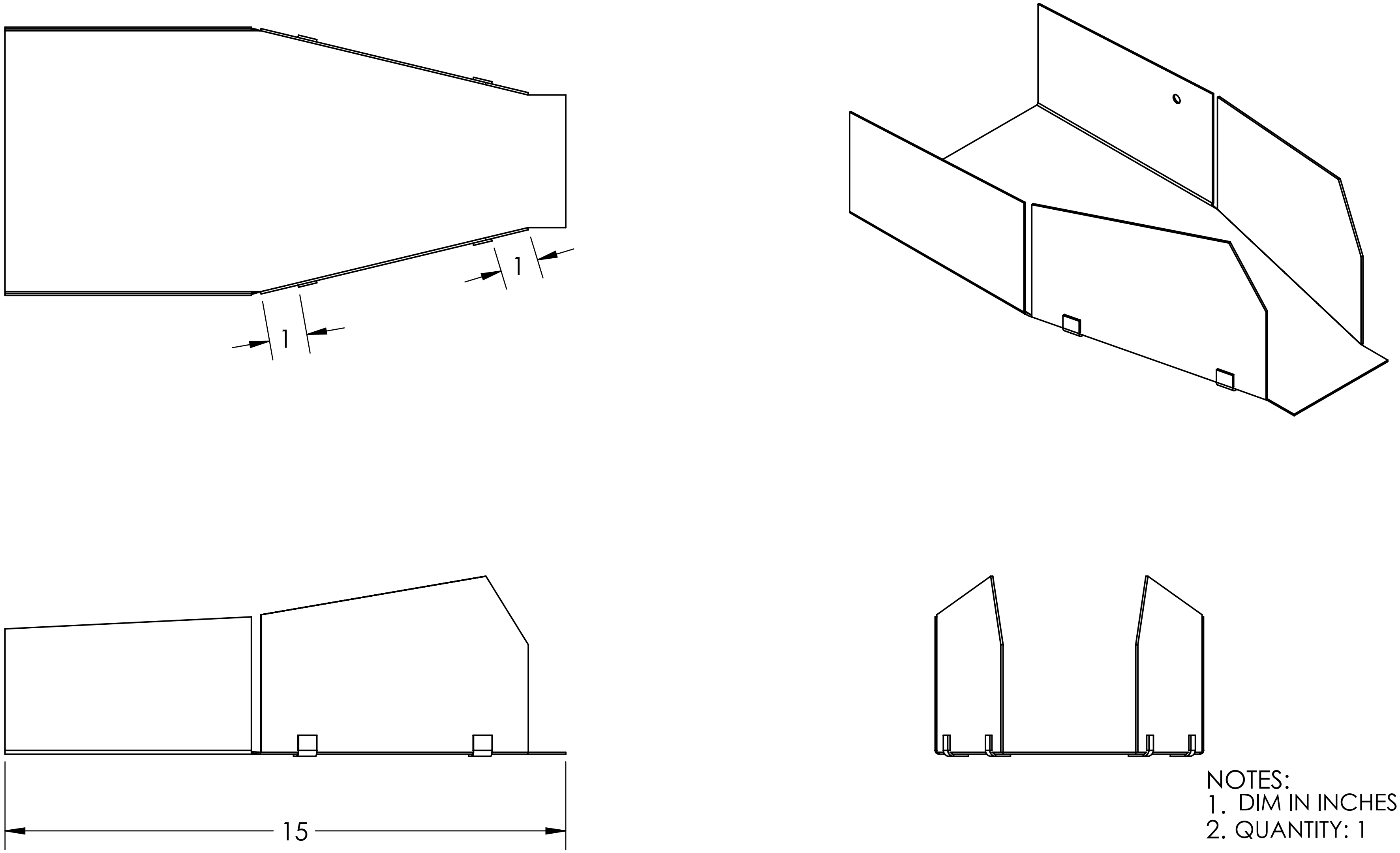
ACTUATOR EXTENDS 4"

NOTES:
1. DIMS IN INCHES
2. QTY SPECIFIED IN BOM
3. DIMS AND MAT'L SPECIFIED BY MANUFACTURER

TOLERANCE UNLESS NOTED			
MEASURING INSTRUMENT	PLACES IN DIMENSION		
	0.0	0.00	0.000
CALIPERS			±0.005
PRECISION RULER		±0.015	
TAPE MEASURE	±0.030		
PROTRACTOR	±10	±5	±2

TITLE: 30 IPM Spal Linear Actuator		
DRAWN J. DERSCH		
DESIGNED SPAL		
SIZE A	DWG. NO. EML2322L-OTS35a	REV A
SCALE: 1:2		SHEET 2 OF 2

4 3 2 1



NOTES:
1. DIM IN INCHES
2. QUANTITY: 1

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE: BALL HOPPER ASSEMBLY

DRAWN Kyle Cunningham

DESIGNED Kyle Cunningham

SIZE A

DWG. NO. EML2322L-A-300

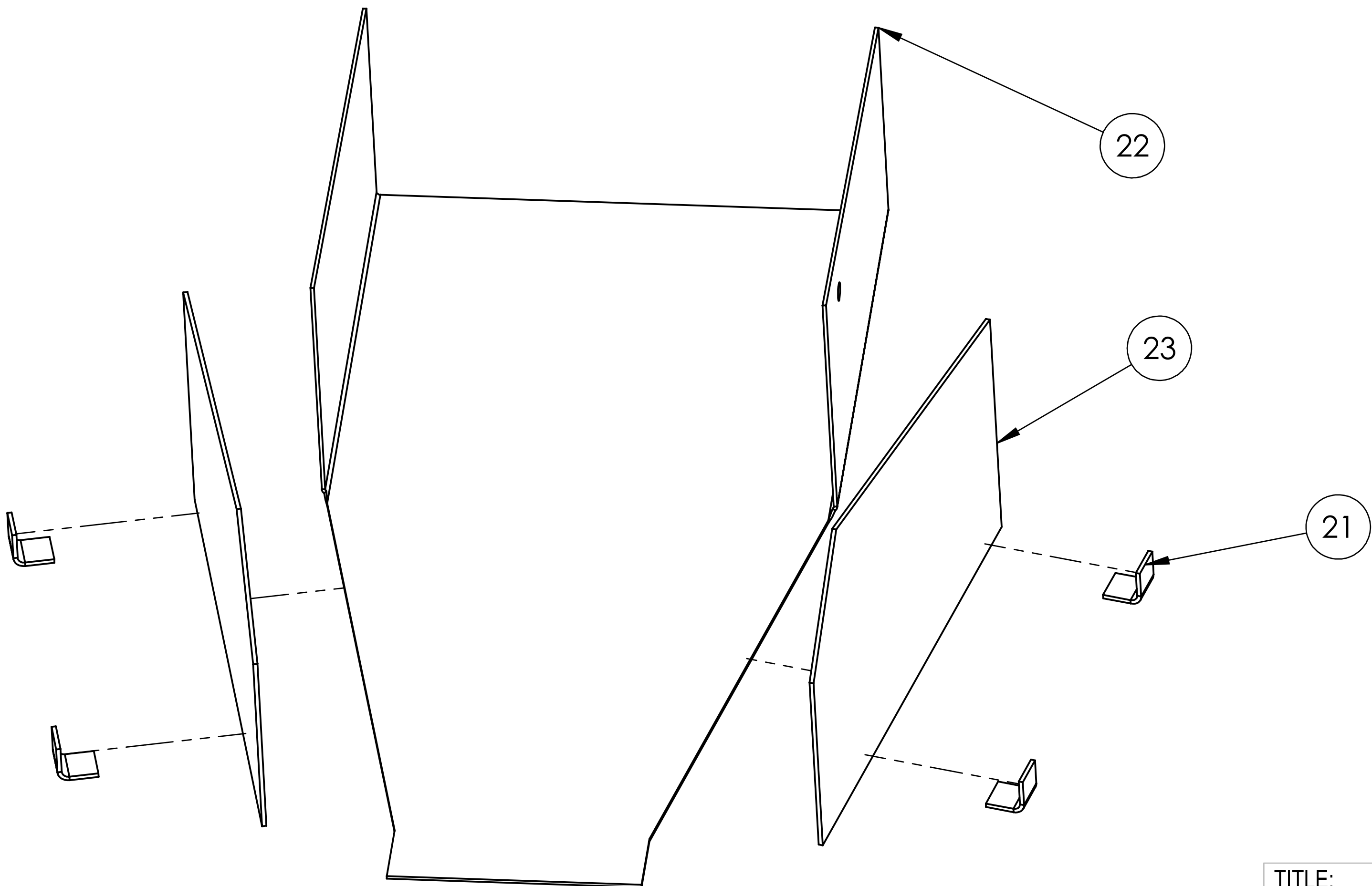
REV B

SCALE: 1:4

SHEET 1 OF 2

5 4 3 2 1

ITEM NO.	PART NUMBER	PART NAME	QTY.
21	EML2322L - 301	STEEL SHEET WELDING TAB	4
22	EML2322L - 302	BALL HOPPER BASE	1
23	EML2322L - 303	BALL HOPPER SIDE	2

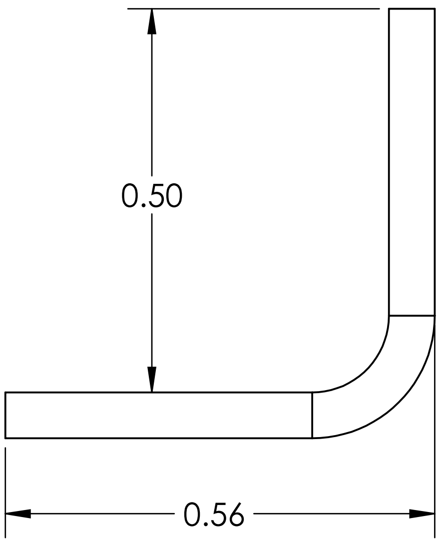


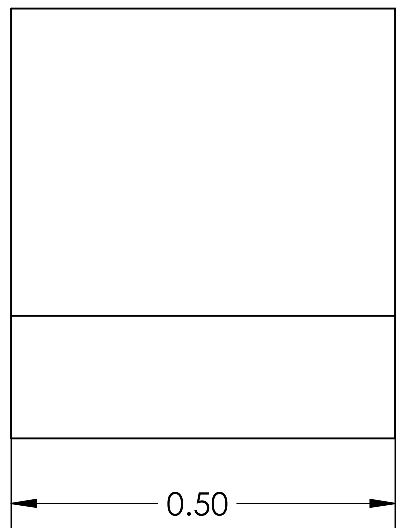
NOTES:
1. DIM IN INCHES
2. QUANTITY: 1

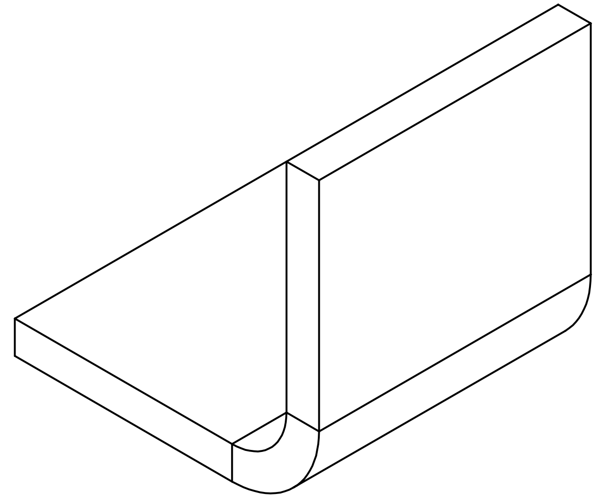
TITLE: BALL HOPPER ASSEMBLY				
DRAWN	Kyle Cunningham			
DESIGNED	Kyle Cunningham			
SIZE A	DWG. NO. EML2322L-A-300			REV B
SCALE: 1:2.5				SHEET 2 OF 2

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

5 4 3 2 1







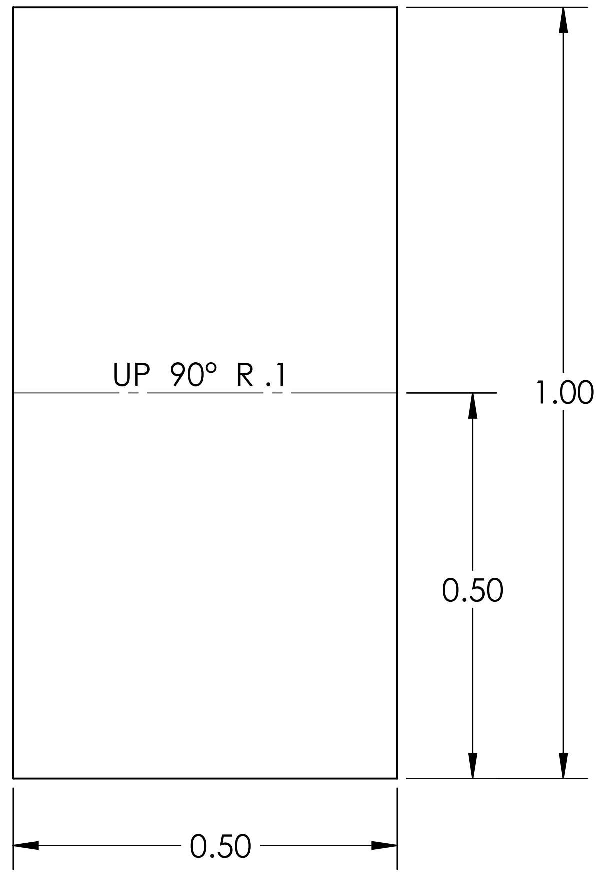
NOTES:
1. DIMS IN INCHES
2. QUANTITY: 4
3. FINISH NOTED SURFACES
4. MATERIAL: 16 GA SHEET STEEL
5. BREAK ALL EDGES

FOLDED VIEW

TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING			
SHEETMETAL (SHEAR, BEND)	±0.1	±0.060	±0.030
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	

TITLE: SHEET METAL WIELDING TAB		
DRAWN	Kyle Cunningham	
DESIGNED	Kyle Cunningham	
SIZE A	DWG. NO. EML2322L-301	REV B
SCALE: 4:1		SHEET 1 OF 2

5 4 3 2 1



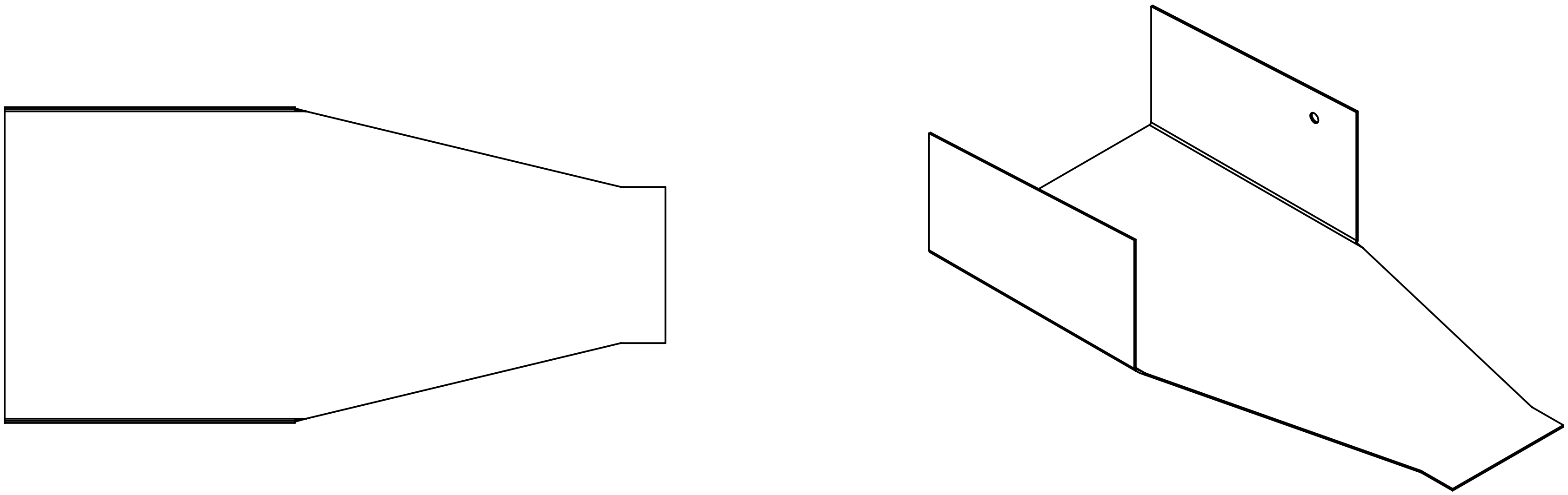
NOTES:
1. DIMS IN INCHES
2. QUANTITY: 4
3. FINISH NOTED SURFACES
4. MATERIAL: 16 GA SHEET STEEL
5. BREAK ALL EDGES

UNFOLDED VIEW

TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING			
SHEETMETAL (SHEAR, BEND)	±0.1	±0.060	±0.030
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	

TITLE: SHEET METAL WELDING TAB		
DRAWN	Kyle Cunningham	
DESIGNED	Kyle Cunningham	
SIZE A	DWG. NO. EML2322L-301	REV B
SCALE: 4:1		SHEET 2 OF 2

5 4 3 2 1



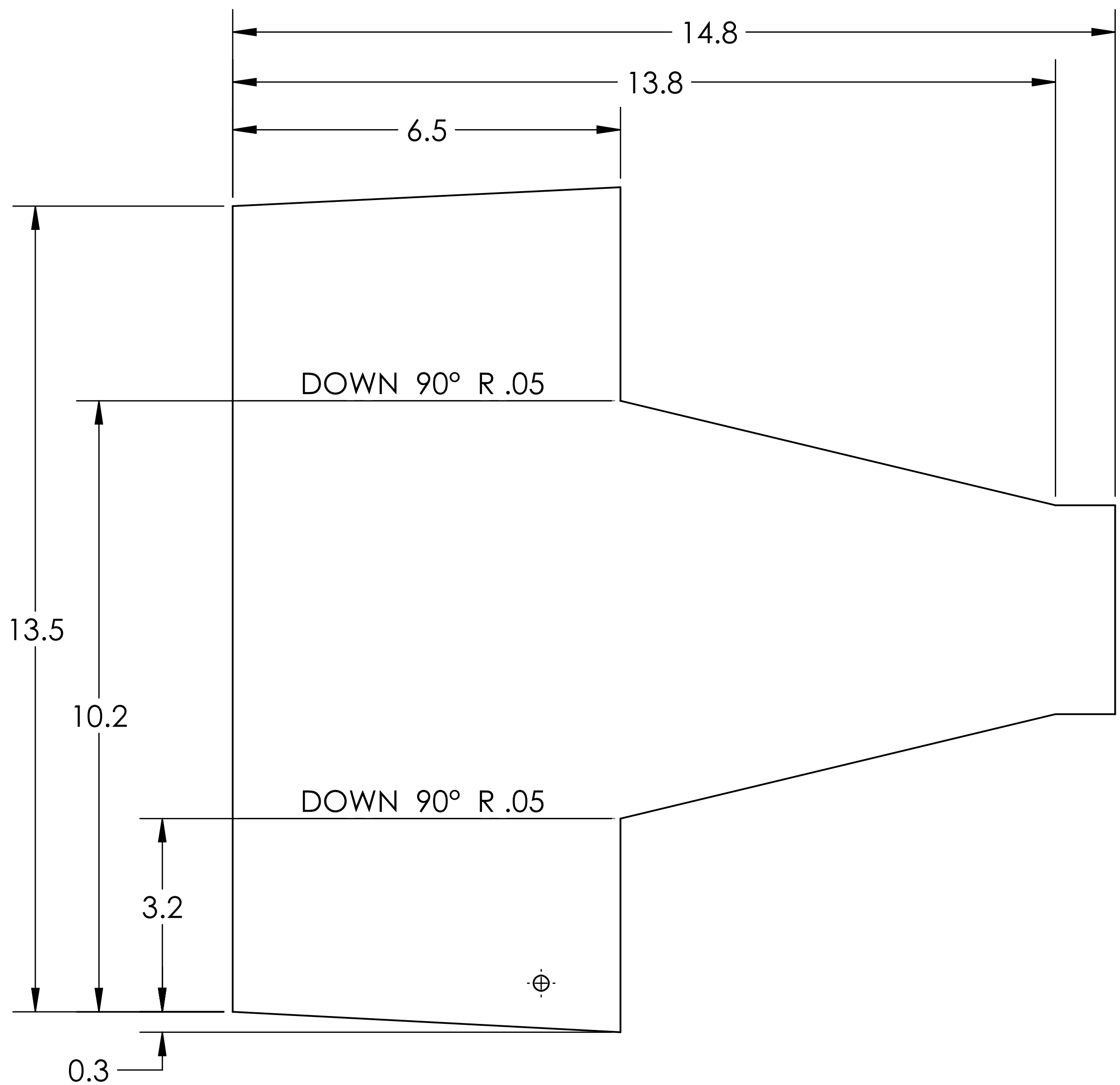
NOTES:
1. DIMS IN INCHES
2. QUANTITY: 1
3. FINISH NOTED SURFACES
4. MATERIAL: 18 GA SHEET STEEL
5. BREAK ALL EDGES

FOLDED VIEW

TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING			
SHEETMETAL (SHEAR, BEND)	±0.1	±0.060	±0.030
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	

TITLE:	BALL HOPPER BASE
DRAWN	Kyle Cunningham
DESIGNED	Kyle Cunningham
SIZE	A
DWG. NO.	EML2322L-302
REV	B
SCALE:	1:4
SHEET 1 OF 3	

5 4 3 2 1



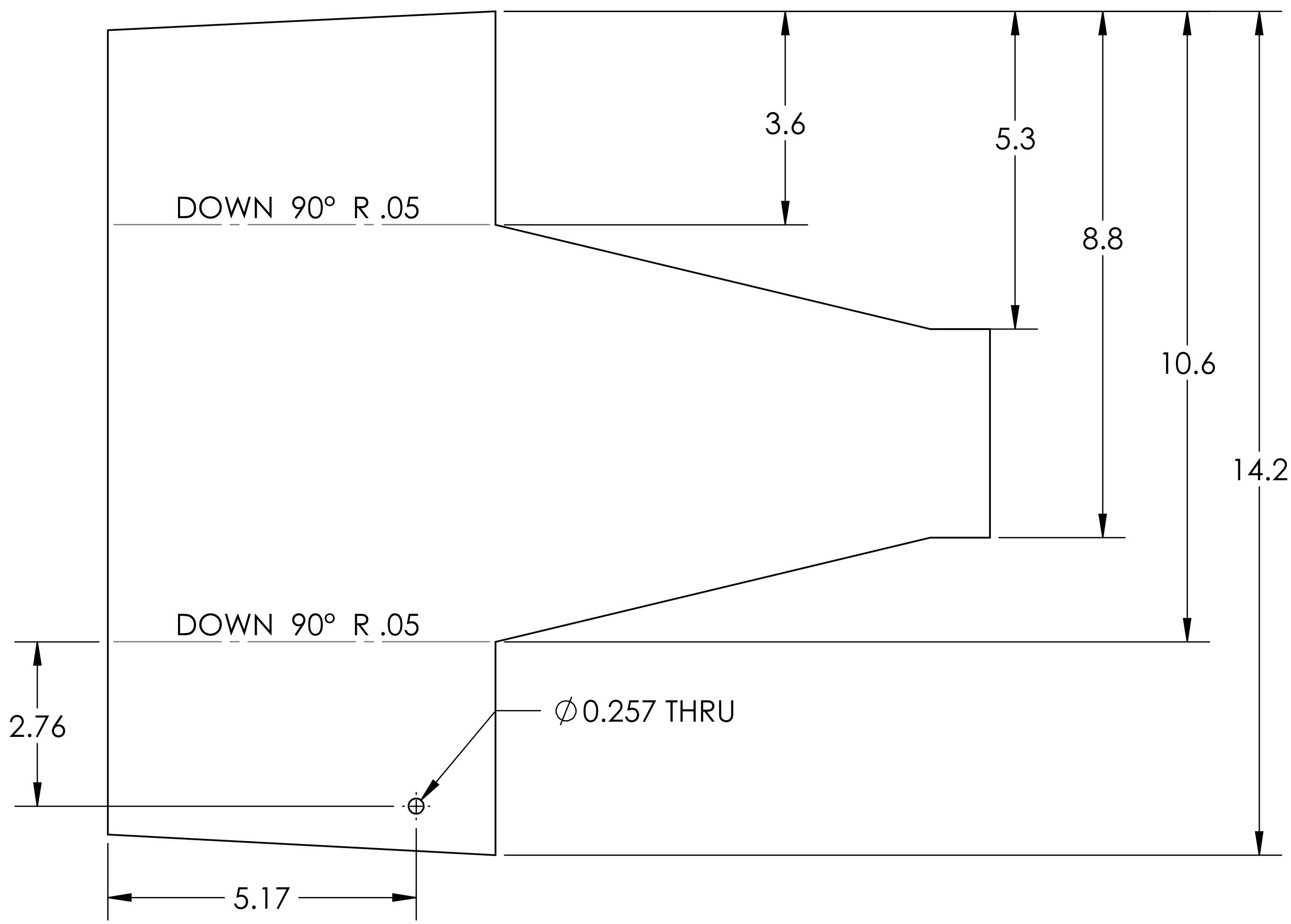
NOTES:
1. DIMS IN INCHES
2. QUANTITY: 1
3. FINISH NOTED SURFACES
4. MATERIAL: 18 GA SHEET STEEL
5. BREAK ALL EDGES

UNFOLDED VIEW

TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING			
SHEETMETAL (SHEAR, BEND)	±0.1	±0.060	±0.030
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	

TITLE:	BALL HOPPER BASE
DRAWN	Kyle Cunningham
DESIGNED	Kyle Cunningham
SIZE	A
DWG. NO.	EML2322L-302
REV	B
SCALE:	1:3
SHEET 2 OF 3	

5 4 3 2 1



NOTES:
1. DIMS IN INCHES
2. QUANTITY: 1
3. FINISH NOTED SURFACES
4. MATERIAL: 18 GA SHEET STEEL
5. BREAK ALL EDGES

UNFOLDED VIEW

TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING			
SHEETMETAL (SHEAR, BEND)	±0.1	±0.060	±0.030
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	

TITLE: BALL HOPPER BASE

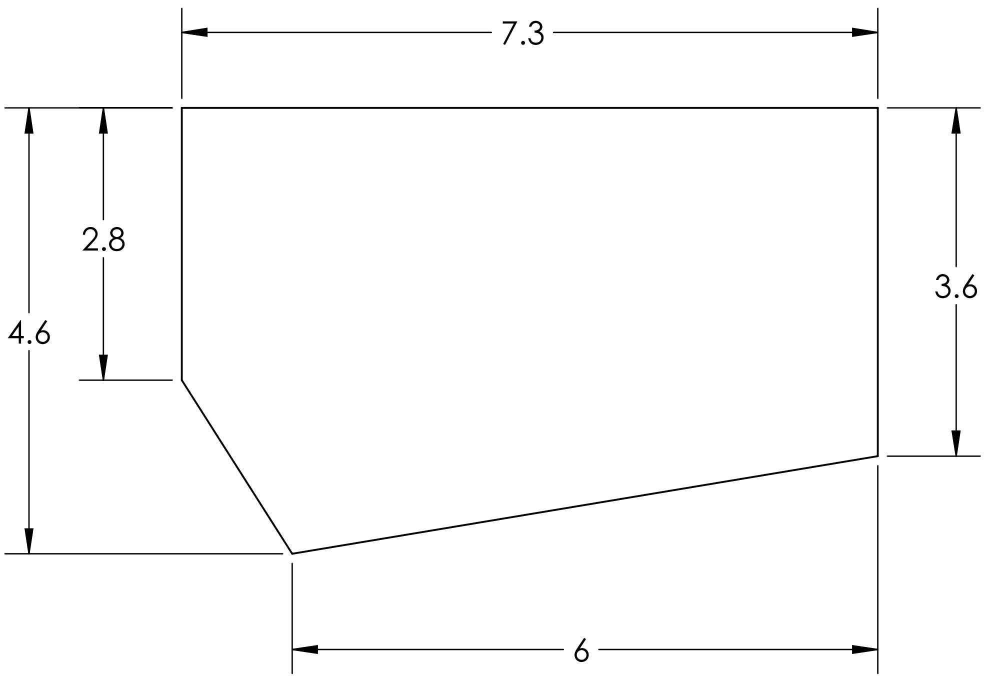
DRAWN Kyle Cunningham

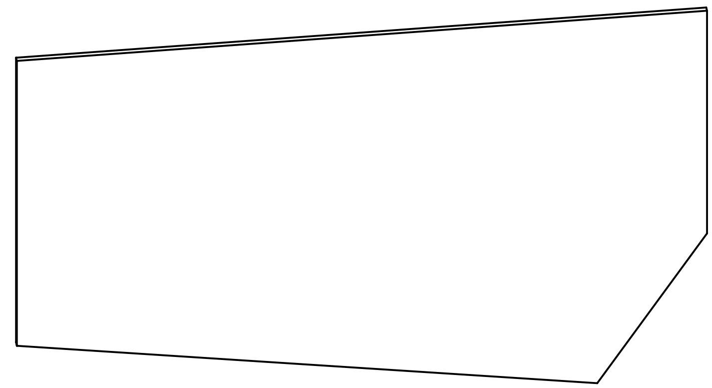
DESIGNED Kyle Cunningham

SIZE A | DWG. NO. EML2322L-302 | REV B

SCALE: 1:3 | SHEET 3 OF 3

5 4 3 2 1

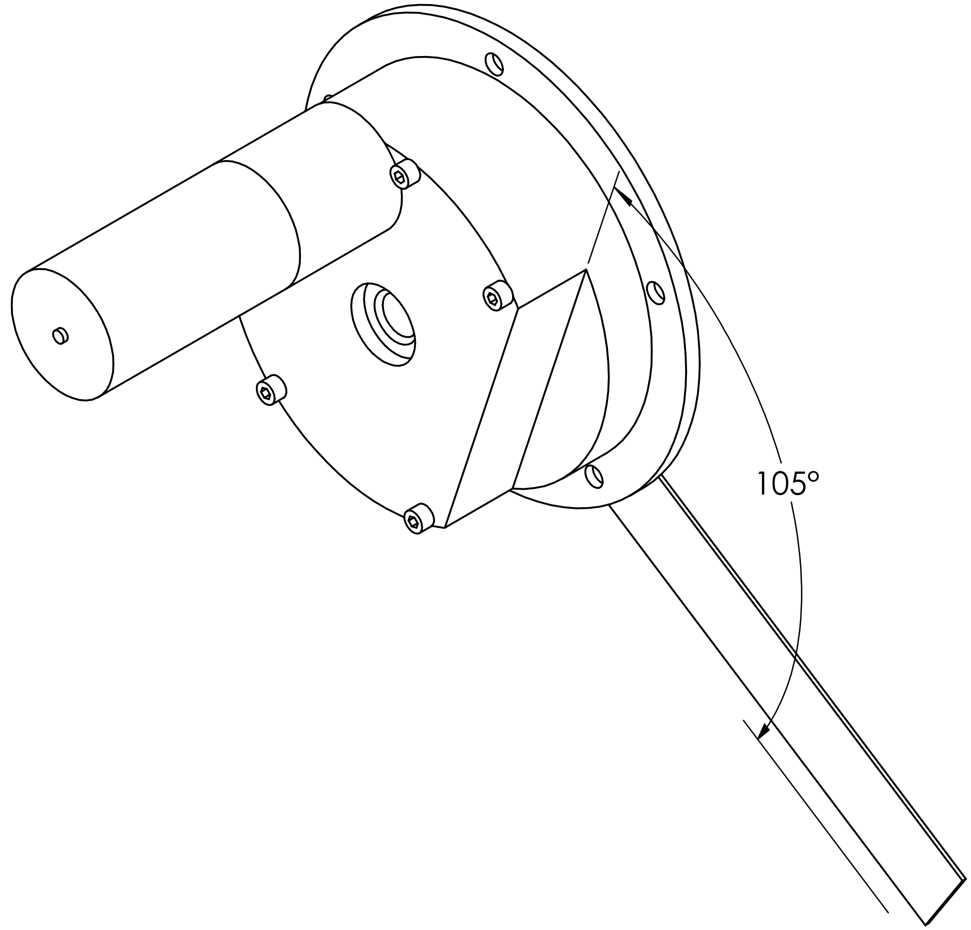




NOTES:
1. DIMS IN INCHES
2. QUANTITY: 1
3. FINISH NOTED SURFACES
4. MATERIAL: 18 GA SHEET STEEL
5. BREAK ALL EDGES

TOLERANCE UNLESS NOTED				TITLE: BALL HOPPER SIDE		
OPERATION	PLACES IN DIMENSION					
	0.0	0.00	0.000	DRAWN	Kyle Cunningham	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	Kyle Cunningham	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE A	DWG. NO. EML2322L-303	REV B
WELDING	±0.1	±0.060				
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:2		SHEET 1 OF 1

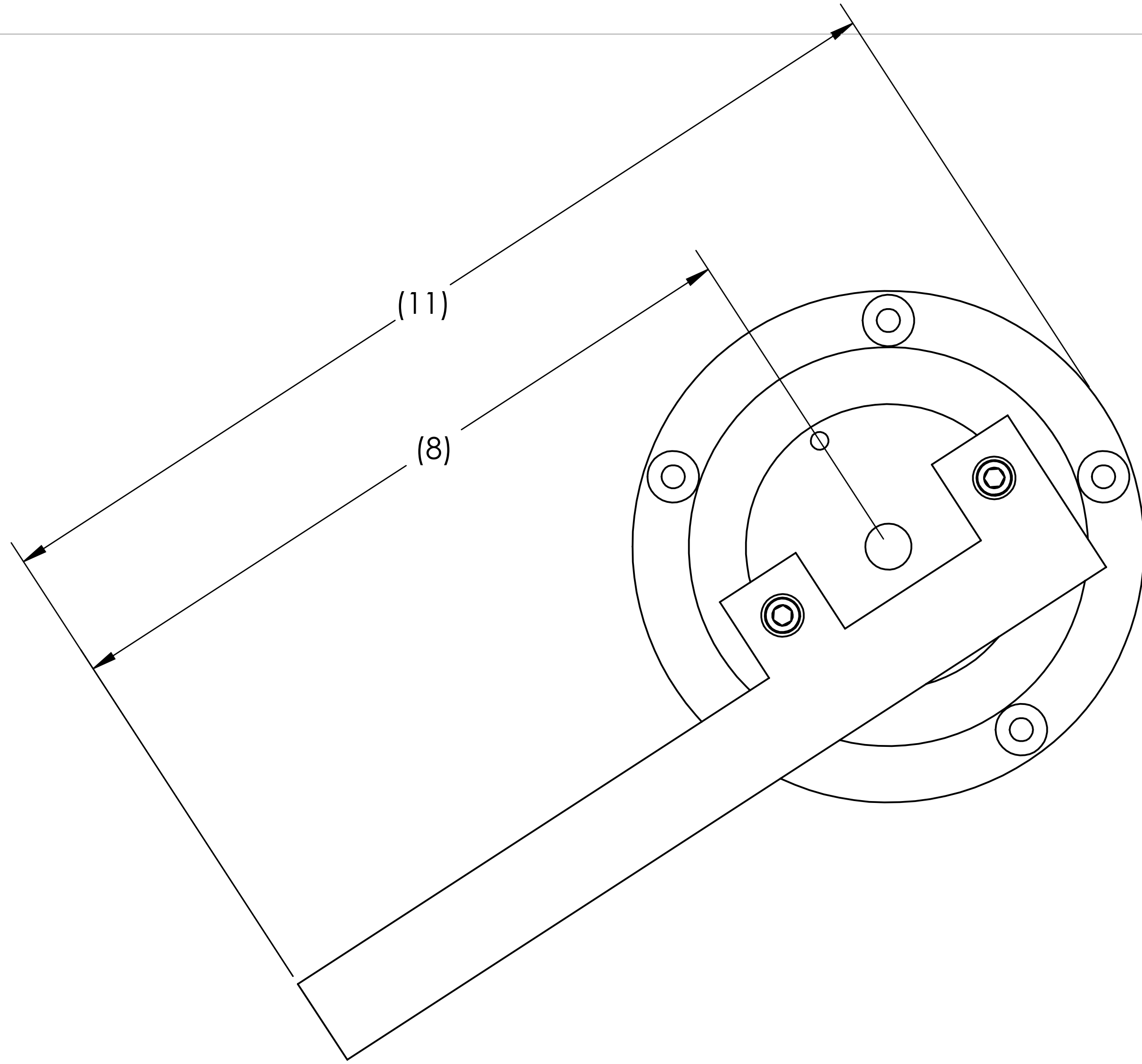
5 4 3 2 1



NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

				TITLE: ReleaseMechanism		
				DRAWN	TALON COONS	
TOLERANCE UNLESS NOTED				DESIGNED	KAIO BUI	
DIMENSION TYPE	PLACES IN DIMENSION			SIZE	DWG. NO.	REV
	0.0	0.00	0.000	A	EML2322L-A-400	B
LOCATIONAL	±0.050	±0.020	±0.005			
ANGULAR	±5	±2	±0.5	SCALE: 1:2		SHEET 1 OF 4

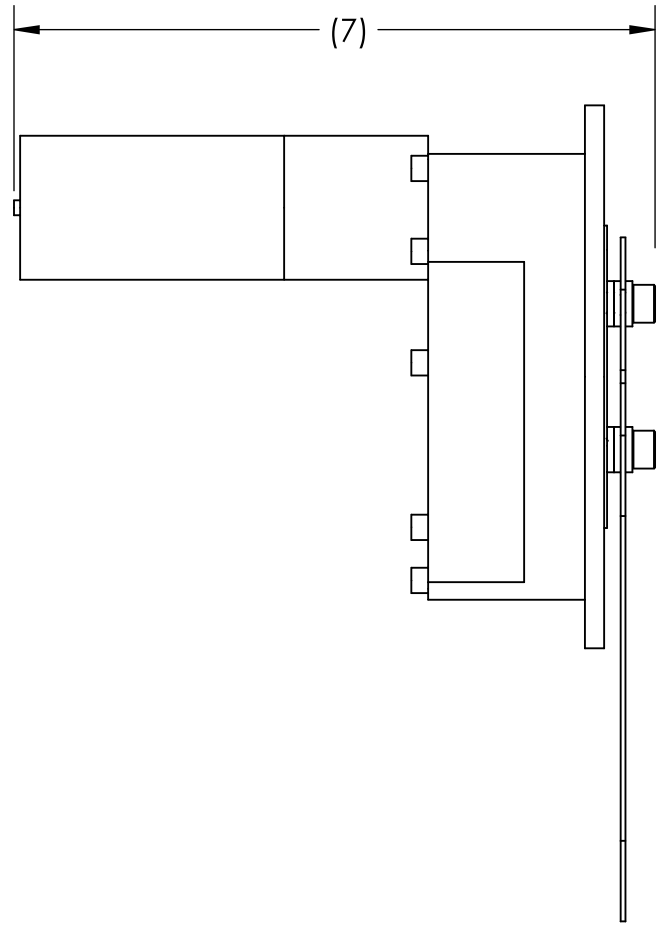
5 4 3 2 1



NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE: ReleaseMechanism			
				DRAWN	TALON COONS		
				DESIGNED	KAIO BUI		
DIMENSION TYPE	PLACES IN DIMENSION			SIZE	DWG. NO.		REV
	0.0	0.00	0.000	A	EML2322L-A-400		B
LOCATIONAL	±0.050	±0.020	±0.005				
ANGULAR	±5	±2	±0.5	SCALE: 1:2		SHEET 2 OF 4	

5 4 3 2 1

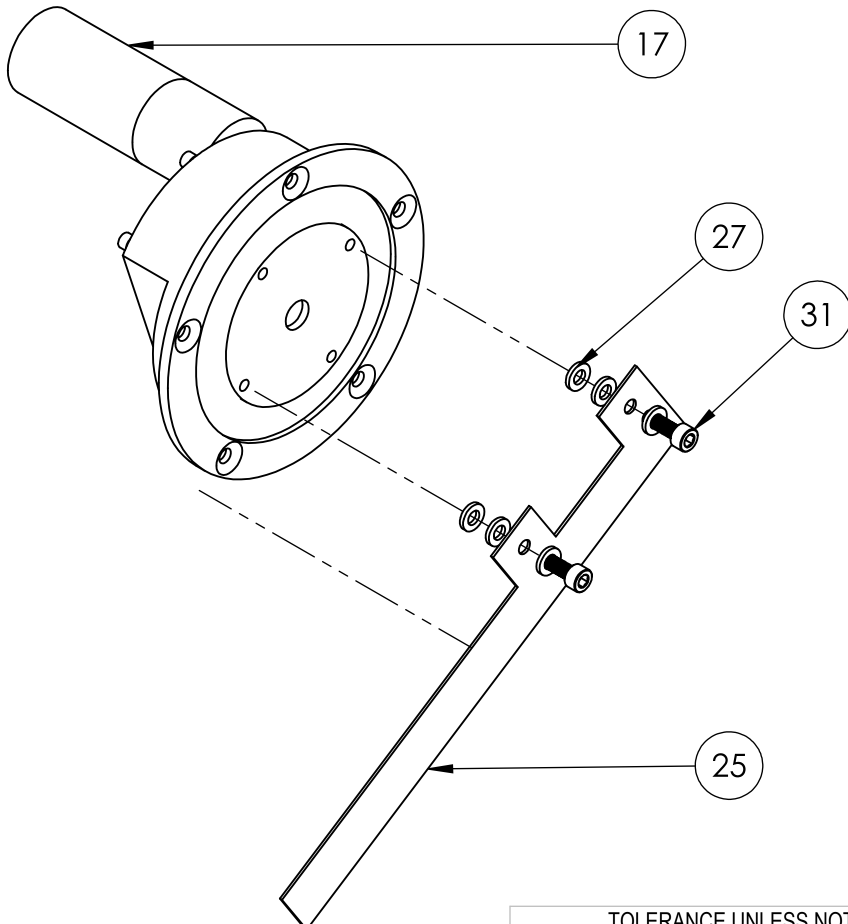


NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE: ReleaseMechanism	
				DRAWN	TALON COONS
				DESIGNED	KAIO BUI
DIMENSION TYPE	PLACES IN DIMENSION			SIZE	DWG. NO. EML2322L-A-400 / REV B
	0.0	0.00	0.000	A	
LOCATIONAL	±0.050	±0.020	±0.005		
ANGULAR	±5	±2	±0.5	SCALE: 1:2	SHEET 3 OF 4

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
17	EML2322L-A-204	4.5 RPM Globe Gear Motor	1
25	EML2322L-401	Plate Cover	1
27	EML2322L-403	M6 WASHER	6
31	EML2322L-118	M6-1 18MM SCREW	2

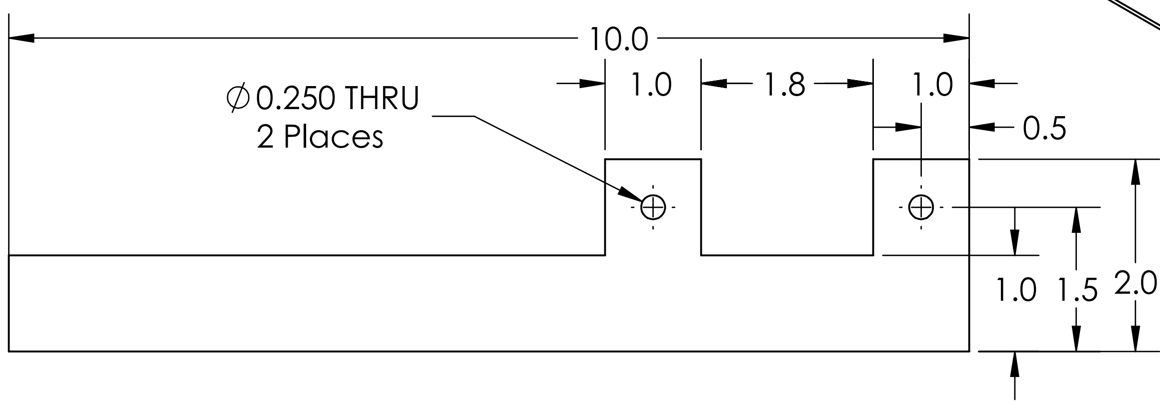


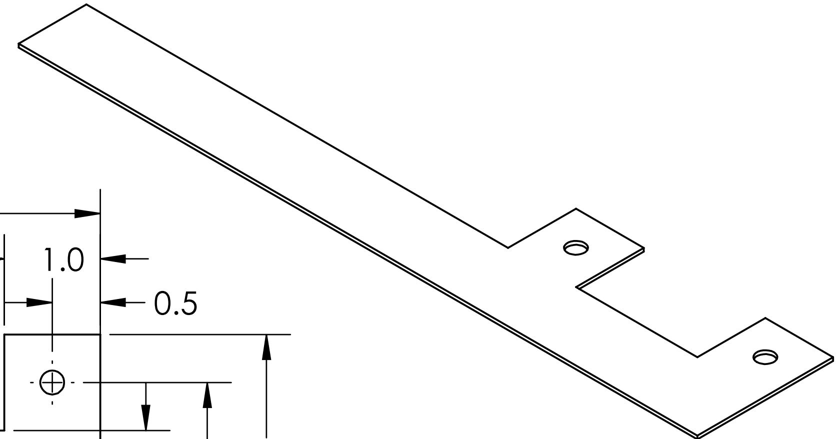
NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED				
DIMENSION TYPE	PLACES IN DIMENSION			
	0.0	0.00	0.000	
LOCATIONAL	±0.050	±0.020	±0.005	
ANGULAR	±5	±2	±0.5	

TITLE: ReleaseMechanism		
DRAWN	TALON COONS	
DESIGNED	KAIO BUI	
SIZE A	DWG. NO. EML2322L-A-400	REV B
SCALE: 1:2		SHEET 4 OF 4

5 4 3 2 1





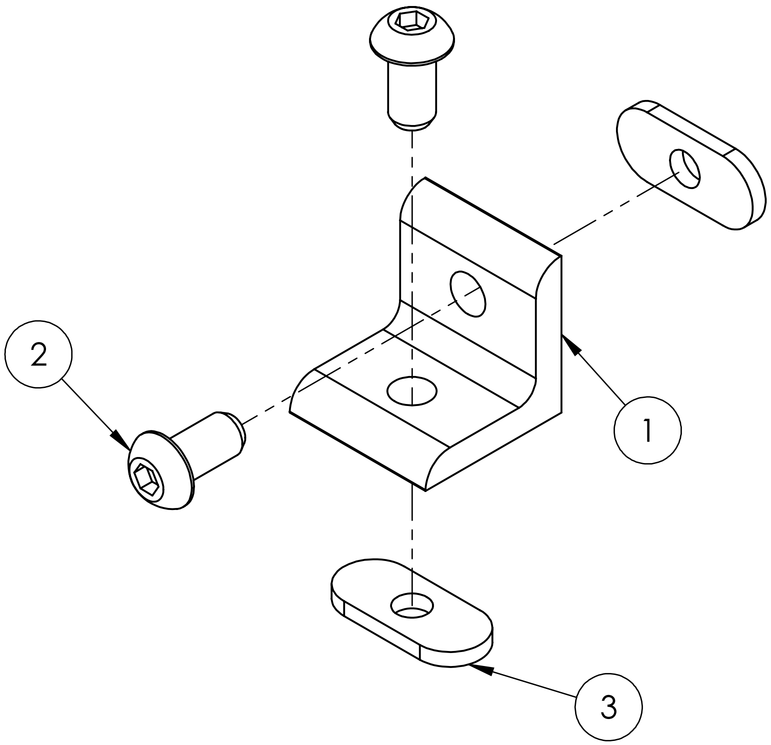
NOTES:
1. ALL DIM IN INCHES
2. QTY: 1
3. MTL: 18 GA SHEET STEEL
4. BREAK EDGES

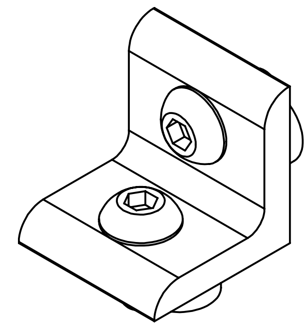
TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING			
SHEETMETAL (SHEAR, BEND)	±0.1	±0.060	±0.030
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	

TITLE: Plate Cover		
DRAWN	TALON COONS	
DESIGNED	TALON COONS	
SIZE A	DWG. NO. EML2322L-401	REV B
SCALE: 1:2		SHEET 1 OF 1

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	EML2322L-OTS12	80/20 90 Degree Angle Bracket	1
2	EML2322L-OTS7	1/4-20 X 1/2 inch BHCS	2
3	EML2322L-OTS6	1/4-20 T-Nut	2

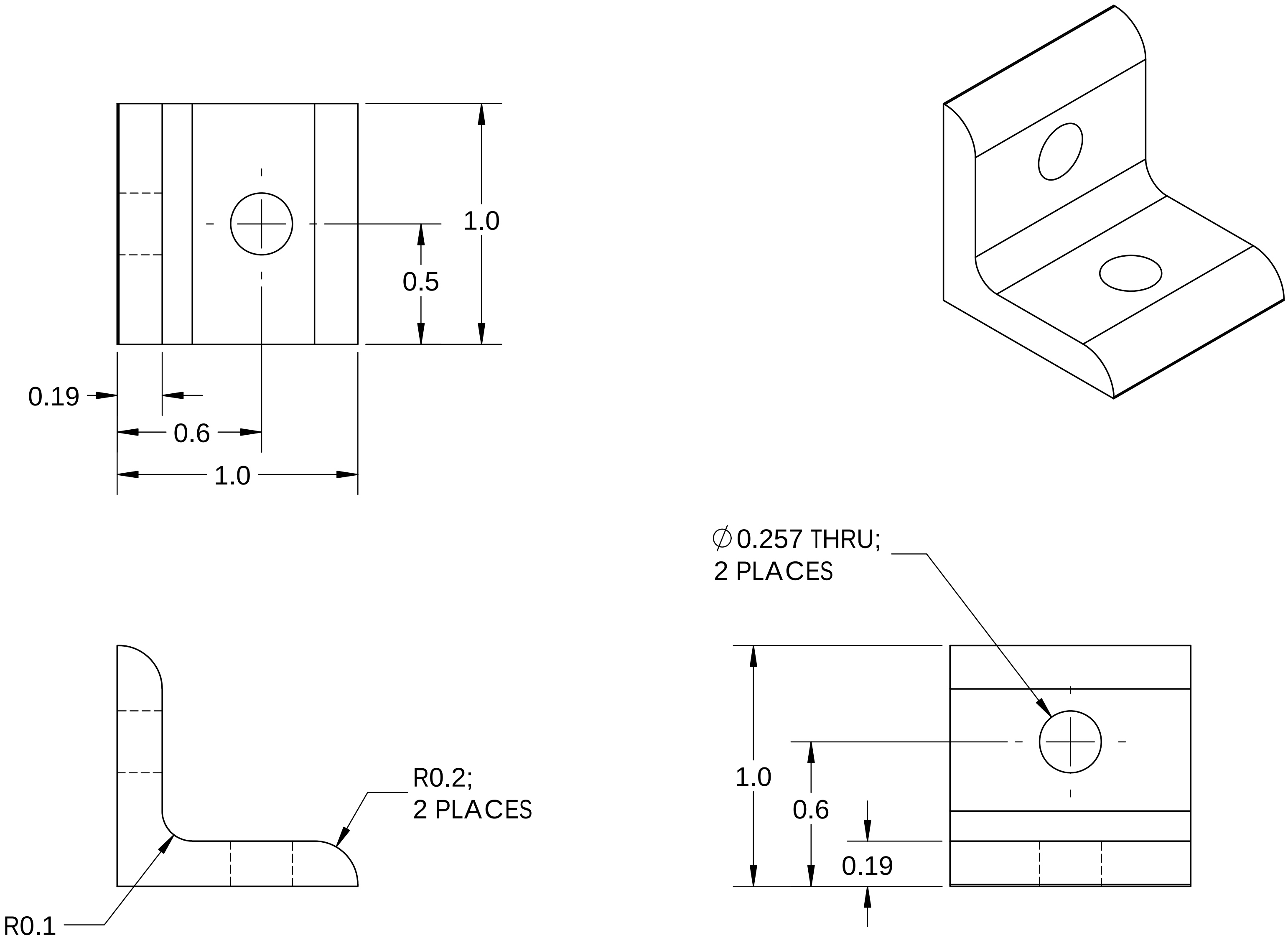




NOTES:
1. DIMS IN INCHES
2. QTY IN BOM

TOLERANCE UNLESS NOTED				TITLE: 80-20 90 Degree Bracket Assy	
				DRAWN	I. WIDJAJA
				DESIGNED	I. WIDJAJA
DIMENSION TYPE	PLACES IN DIMENSION			SIZE A	DWG. NO. EML2322L-A-OTS2 — REV A
	0.0	0.00	0.000		
LOCATIONAL	±0.050	±0.020	±0.005		
ANGULAR	±5	±2	±0.5	SCALE: 1:1	SHEET 1 OF 1

5 4 3 2 1

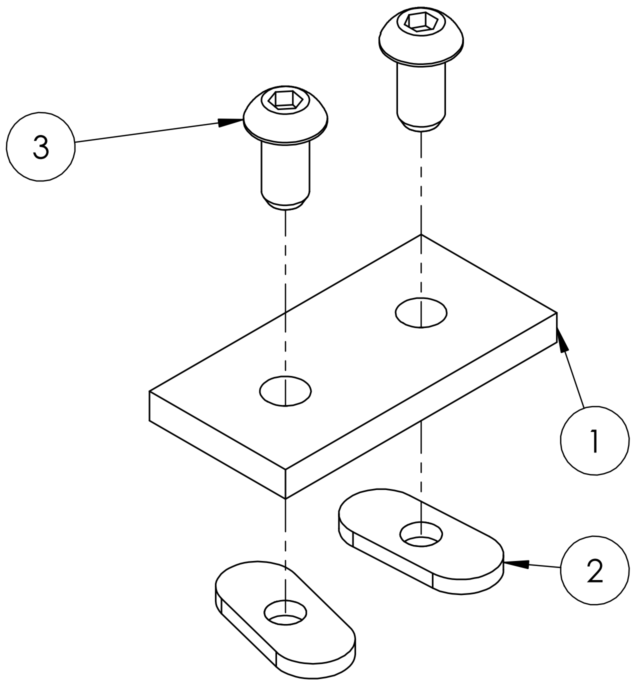


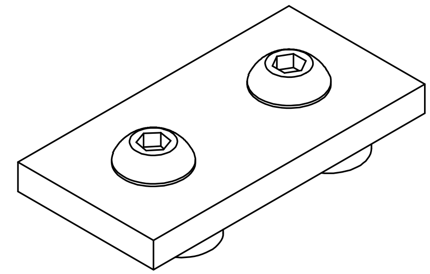
NOTES:
1. DIMS IN INCHES
2. QTY SPECIFIED IN BOM
3. DIMS SPECIFIED BY MANUFACTURER
4. MAT'L: ALUMINUM

TOLERANCE UNLESS NOTED			
MEASURING INSTRUMENT	PLACES IN DIMENSION		
	0.0	0.00	0.000
CALIPERS			±0.005
PRECISION RULER		±0.015	
TAPE MEASURE	±0.030		
PROTRACTOR	±10	±5	±2

TITLE:	80/20 90 Degree Angle Bracket
DRAWN	J. DERSCH
DESIGNED	80/20 INC.
SIZE	A
DWG. NO.	EML2322L-OTS12
REV	A
SCALE: 1.5:1	SHEET 1 OF 1

5 4 3 2 1





ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	EML2322L-OTS13	80/20 Straight Bracket	1
2	EML2322L-OTS6	1/4-20 T-Nut	2
3	EML2322L-OTS7	1/4-20 X 1/2 inch BHCS	2

NOTES:
1. DIMS IN INCHES
2. QTY IN BOM

TITLE:
80-20 Straight Degree Bracket Assy

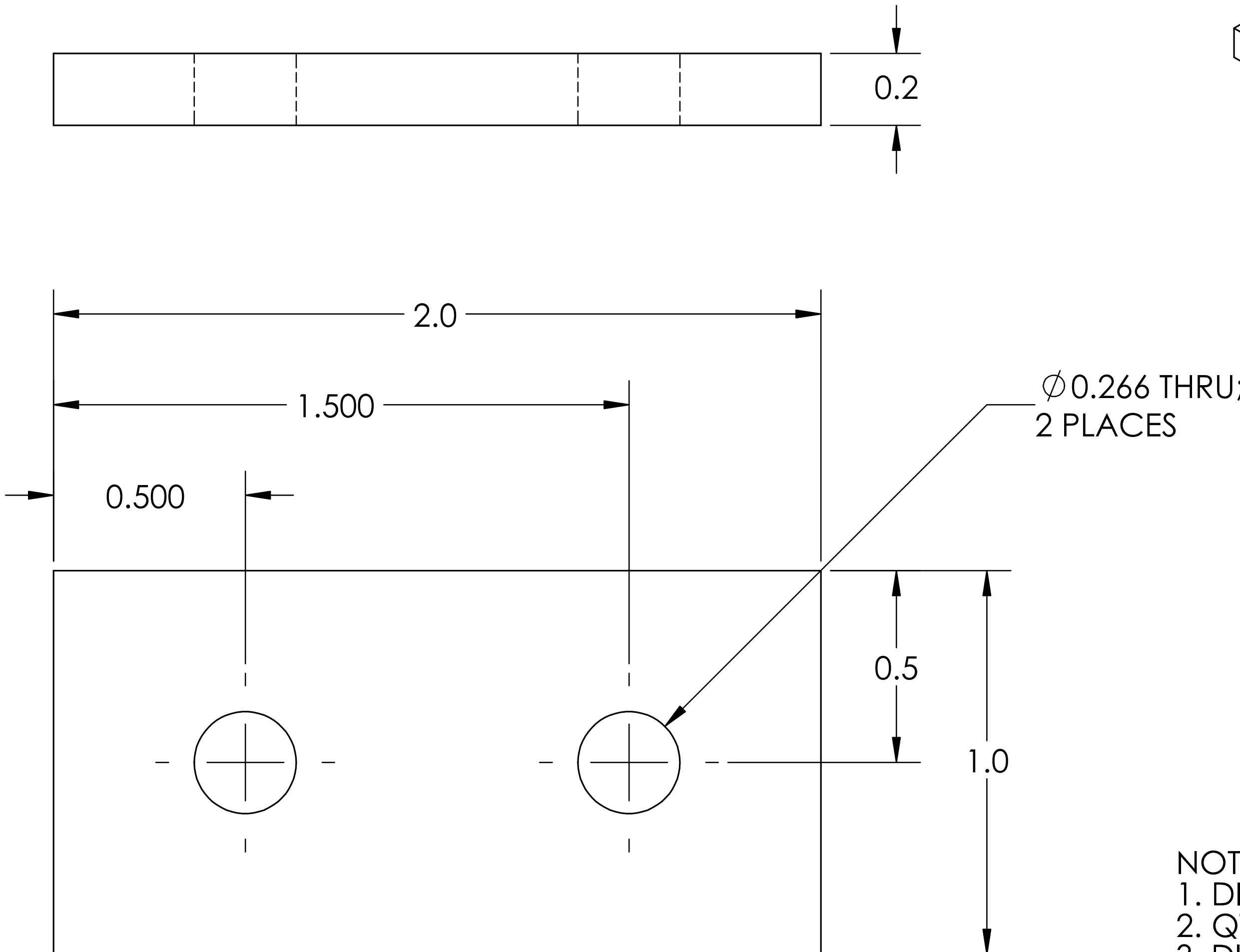
DRAWN I. WIDJAJA

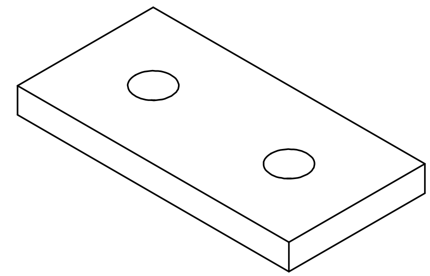
DESIGNED I. WIDJAJA

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

SIZE	DWG. NO.	REV
A	EML2322L-A-OTS1	A
SCALE: 1:1		SHEET 1 OF 1

3 2 1





NOTES:
1. DIMS IN INCHES
2. QTY SPECIFIED IN BOM
3. DIMS SPECIFIED BY MANUFACTURER
4. MAT'L: ALUMINUM

TOLERANCE UNLESS NOTED			
MEASURING INSTRUMENT	PLACES IN DIMENSION		
	0.0	0.00	0.000
CALIPERS			±0.005
PRECISION RULER		±0.015	
TAPE MEASURE	±0.030		
PROTRACTOR	±10	±5	±2

TITLE:	80-20 Straight Bracket	
DRAWN	J. DERSCH	
DESIGNED	80/20 INC.	
SIZE A	DWG. NO. EML2322L-OTS13	REV A
SCALE: 2:1		SHEET 1 OF 1

4 3 2 1

Appendix D: Estimated Project Budget

Project Budget

Item Description	Vendor	Qty	Unit	Unit Price	Subtotal
Mobile Platform					
80/20 1" x 1" aluminum extrusion (*)	LAB	0.65	ft	$3.00	$1.95
3/16" x 3.5" AL rectangular bar stock	LAB	0.67	ft	$2.00	$1.33
Ø 2" AL Round Bar Stock (Wheel Hubs)	LAB	0.33	ft	$20.00	$6.60
Entstort 44 RPM right angle gear motor	LAB	2	each	N/C	N/C
Ø 10" x 2" wide plastic wheel	LAB	2	each	N/C	N/C
Ø 3" swivel caster wheel	LAB	1	each	N/C	N/C
80/20 1" x 1" aluminum extrusion	LAB	6	ft	N/C	N/C
M5 x 0.8mm, 20 mm (wheels)	LAB	3	each	$0.13	$0.39
M6 x 1.0mm, 18mm (wheels)	LAB	3	each	$0.15	$0.45
80/20 aluminum right angle brackets	LAB	15	each	N/C	N/C
80/20 T-nuts	LAB	54	each	N/C	N/C
1/4-20 x 1/2" button head fastener (80/20)	LAB	54	each	N/C	N/C
80/20 straigh degree bracket	LAB	5	each	N/C	N/C
Ball Manipulator					
80/20 1" x 1" aluminum extrusion (*)	LAB	1.5	ft	$3.00	$4.50
3" Schedule 40 PVC pipe	LAB	0.25	ft	$3.00	$0.75
0.048" (18 GA) Steel Sheet	LAB	1	sq ft	$3.20	$3.20
4.5 RPM Globe Geat Motor	LAB	1	each	N/C	N/C
Ball Hopper					
18 GA steel sheetmetal (main hopper)	LAB	2.72	sq ft	$3.20	$8.70
Screw for Mounting Hopper	LAB	1	each	N/C	N/C
Ball Release					
18 GA Steel Sheet	LAB	0.15	sq ft	$3.20	$0.48
4.5 RPM Globe Geat Motor	LAB	1	each	N/C	N/C
M6 x 1.0mm	LAB	2	each	N/C	N/C
M6 washer	LAB	6	each	N/C	N/C

TOTAL $28.36

NOTES:

(*) denotes this is in addition to the 6' provided in the project description

(**) denotes this was provided by the team and not paid for from the project budget