

EML2322L – Design and Manufacturing Laboratory

Design Report 3R

Team 8B

Vincent Furey (1)
Colton Mays (2)
Cyril Moran (3)

Instructor: Sean Niemi
TA: Juliana Mishur

Summer 2021

7/22/2021

Detailed Design Revision

Detailed Design (DR3) Checklist

Group Number: 8B

Grade: 75%

TA or Group Performing Evaluation: Juliana Mishur

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? ^{sheetmetal 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. "1/4-20 x 1/2" 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?

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

FASTENERS, THREADS, AND HOLES.

- | | |
|---|--|
| <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO | Are threaded holes designed with AT LEAST FIVE threads of engagement? |
| <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO | Are the proper type of threads (coarse or fine) used in the proper type of material? |
| <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO | Are tap drill sizes correct based on the tap chart standards? |
| <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO | Are clearance holes properly sized using close and free fit standards off the tap chart ? |
| <input checked="" type="checkbox"/> YES <input type="checkbox"/> 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.) |
| <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO | Do fastener head types allow for adequate motion with required assembly tools? (i.e. screwdrivers, allen wrenches, sockets & ratchets, rivet guns , etc.)? |
| <input checked="" type="checkbox"/> YES <input type="checkbox"/> 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?
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- ☐ YES ☐ NO Is each part feature designed around nominal (commonly produced) cutter sizes?
- ☐ YES ☐ NO Have unnecessary features that increase manufacturing time been eliminated? (fillets, etc.)
- ☐ 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)
- ☐ YES ☐ NO Have alternative designs been investigated which may lower manufacturing and assembly times? (i.e. designs which combine parts, or split parts; or designs which use sheetmetal vs. billet)?

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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- ☐ YES ☒ NO Are computer-generated, glued-in page tabs used to organize the report in the order shown in the [DRT](#)?

Written Description

The final design was created by reviewing the designs from all group members and determining the most effective concept to solve the design challenge. This was done using a decision matrix to review the mobile platform, ball manipulator, and ball hopper subassemblies. After reviewing the decision matrix, it was decided that design 3 possessed the best attributes. The model was created using the drawings from DR1 and some changes to improve the design.

The first subsystem is the mobile platform which is framed with 80/20 aluminum extrusion. This 80/20 is the basis for the rest of the robot. The total length is 27.1 inches, height of 22.1 inches, and a width of 18.5 inches. This will allow the robot to fit in the 30x30 inch starting area. Connected to this frame is the wheel and motor assemblies. The motor is a 44 rpm Entstort Motor with 8-inch wheels attached. This combination was chosen as it provides the high level of maneuvering that is needed for the robot trajectory and positioning. It is connected using a motor mount and wheel hub. The motor mount is made of aluminum to in order to make it easier to manufacture. The motor mount is what connects to the 80/20 frame as well as the motor. The wheel hub is the connection from the motor to the actual wheel. Both the hub and mount will be manufactured using lightweight aluminum. To ensure the least amount of friction strict tolerances will be used on these parts, especially with the fasteners. The robot turns using differential steering allowing for the robot to turn with a very small radius. A caster wheel at the rear of the robot is used to balance it out as well as allow the robot to use the differential steering to turn. The motor mount is mounted on the left side of the robot and to counteract its weight one 15 lb plate from one of our home gyms will be strapped to the right side to balance out the robot.

The ball manipulator is the next subsystem. This is made up of a lever arm as well as the manipulator itself. The lever arm is 80/20 that is positioned 7 inches vertically from the mobile platform and is secured using 80/20 angle brackets. Attached to the lever arm is a 15 rpm SEI Gear Motor and its corresponding mount. The mount attaches to the 5-inch 80/20 on the lever arm as well as the motor. The motor is then connected to another piece of 80/20 which is what rotates up and down. The motor allows this arm to be rotated 90 degrees to first grab the ball at a horizontal position and then deposit it at a vertical one. The arm is one inch taller than the hopper to ensure no balls are missed or are dropped from too high. At the end of this 80/20 is the actual ball grabber that is designed out of 16-gauge sheet metal. This gauge was chosen to provide the stability and strength to grab balls. This grabber uses two arms that are 2 inches apart to secure a ball with bands of sheet metal on the bottom. The robot will use its differential steering to put the robot in a place where the grabber can

secure a ball. This ball grabber design effectively solves the design challenge of picking up tennis balls from the source tree and depositing them in the hopper for storage.

The ball hopper is what the balls are deposited into before they are released into the final bucket. It is attached to the mobile platform using 2 80/20 vertical extrusions that is then fastened to the hopper itself. The hopper is constructed using 16-gauge sheet metal to ensure it is strong enough to support all the balls. The hopper is a walled ramp that allows the balls to roll down to the release gate to wait until it is time to be deposited. The hopper is designed to hold 6 balls to fulfill the design challenge in case there is any error when depositing into the final bucket.

The release gate is connected to the back of the ball hopper by using a piece of 80/20 extruding vertically from the mobile platform. This release gate is controlled via a 15 rpm SEI Gear Motor. It is connected by welding the motor mount to the actual release gate. The clearance between the ball hopper opening and the release gate is 1 inch which secures the tennis balls until the robot is in position over the bucket. When the motor is activated the release gate rotates downwards allowing the tennis balls to flow out into the deposit bucket. This allows for many balls to be deposited at a rapid pace into the deposit bucket.

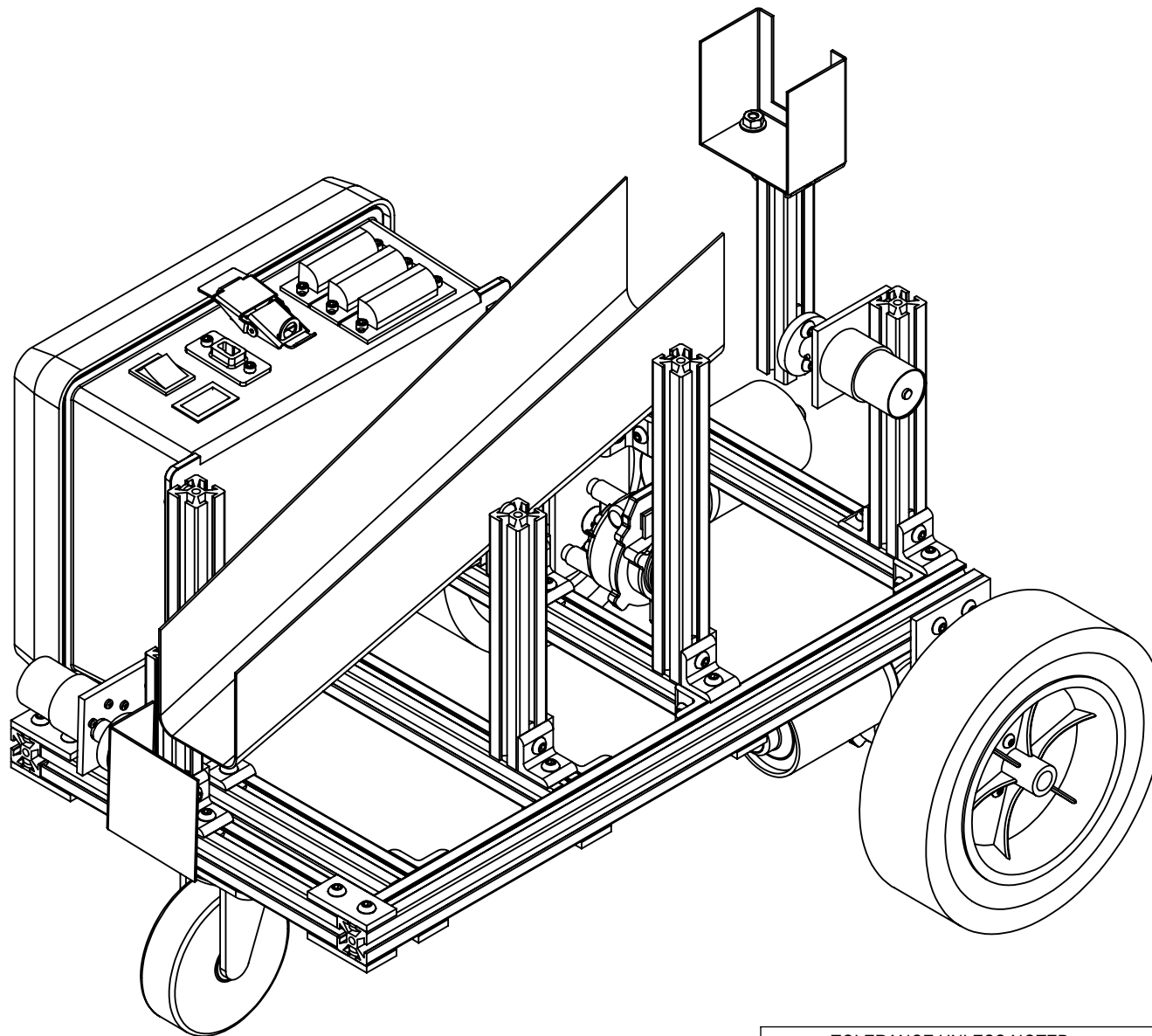
The mobile platform, ball grabber, ball hopper, and release mechanism subsystems come together to create an effective robot to solve the design challenge. The balanced mobile platform creates a base for the other components to sit securely on. The ball grabber combined with the tight turn radius allows the robot to pickup the balls and deposit them using the lever arm. The ball hopper can hold more than enough balls to satisfy the design challenge and the release gate is able to hold the balls until it is ready to be deposited.

Project Schedule for Team 8B

Week	Task Description	Responsibility	Est. Time
7/15/2021	Submit DR3R Before Lab	Whole Team	-
	Submit Purchase Orders	Whole Team	-
	Welding Demonstration	Whole Team	45 min.
	Fabricate the wheel hubs for Enstort Motor (Start)	Cyril Moran	110 min.
	Fabricate motor mounts for Enstort Motor (Start)	Colton Mays	110 min.
	Fabricate motor mount for 15 RPM SEI Motor for Lever Arm	Vincent Furey	75 min
	Fabricate wheel hub for 15 RPM SEI Motor for Release Gate	Vincent Furey	35min.
	Lab clean up	Whole Team	10 min.
	<i>Meet outside lab to work through problems & review who's doing what next week, and prepare any necessary paperwork (POs, ECNs, etc.)</i>	<i>whole team</i>	-
7/22/2021	Fabricate the wheel hubs for Enstort Motor (Finish)	Cyril Moran	155 min.
	Fabricate the wheel hubs for Enstort Motor (Finish)	Vincent Furey	145 min.
	Fabricate motor mounts for Enstort Motor (Finish)	Colton Mays	45 min.
	Fabricate motor mount for Release Gate (Start)	Vincent Furey	10 min.
	Fabricate the Ball Hopper	Colton Mays	70 min.
	Fabricate the Release Gate	Colton Mays	40 min.
	Lab Clean up	Whole Team	10 min.
	<i>Meet outside lab to work through problems & review who's doing what next week, and prepare any necessary paperwork (POs, ECNs, etc.)</i>	<i>whole team</i>	-
7/29/2021	Fabricate the Ball Manipulator sheetmetal part	Cyril Moran	60 min.
	Assemble the Ball Manipulator	Cyril Moran	30 min.
	Fabricate wheel hub for 15 RPM SEI Motor for Lever Arm	Colton Mays	55 min.
	Assemble the Mobile Platform by cutting and fastening all of the 80/20 and attaching the control box	Colton Mays	100 min.
	Assemble the Lever Arm by attaching the motor mount, wheel hub, the caster wheel, and 15 RPM SEI Motor to 80/20 and the Mobile Platform	Cyril Moran	65 min.
	Attach the wheel hub, motor mount, wheels, and Enstort Motors to the Mobile Platform	Vincent Furey	30 min.
	Attach the Ball Hopper to the Mobile Platform	Vincent Furey	45 min.
	Fabricate motor mount for Release Gate (Finish)	Vincent Furey	40 min.
	Assemble the Release Gate Mechanism by attaching the motor mount, wheel hub, and 15 RPM SEI Motor to the Release Gate and 80/20 support	Vincent Furey	40 min.
	Lab clean up	Whole Team	10 min.
	<i>Meet outside lab to work through problems & review who's doing what next week, and prepare any necessary paperwork (POs, ECNs, etc.)</i>	Whole Team	-
8/5/2021	Attach the Release gate Mechanism to the Mobile Platform	Cyril Moran	30 min.
	Attatch Ball Manipulator to Lever Arm	Colton Mays	30 min.
	Check all of the fasteners to ensure safety during testing	Vincent Furey	30 min.
	Testing	Whole Team	125 min.
	Lab clean up	Whole Team	10 min.
	<i>Meet outside lab to work through problems and troubleshoot issues found during tesing.</i>	Whole Team	-
8/12/2021	Competition Day	Whole Team	155 min.
	Lab clean up	Whole Team	10 min.

Complete BOM for Team 8B

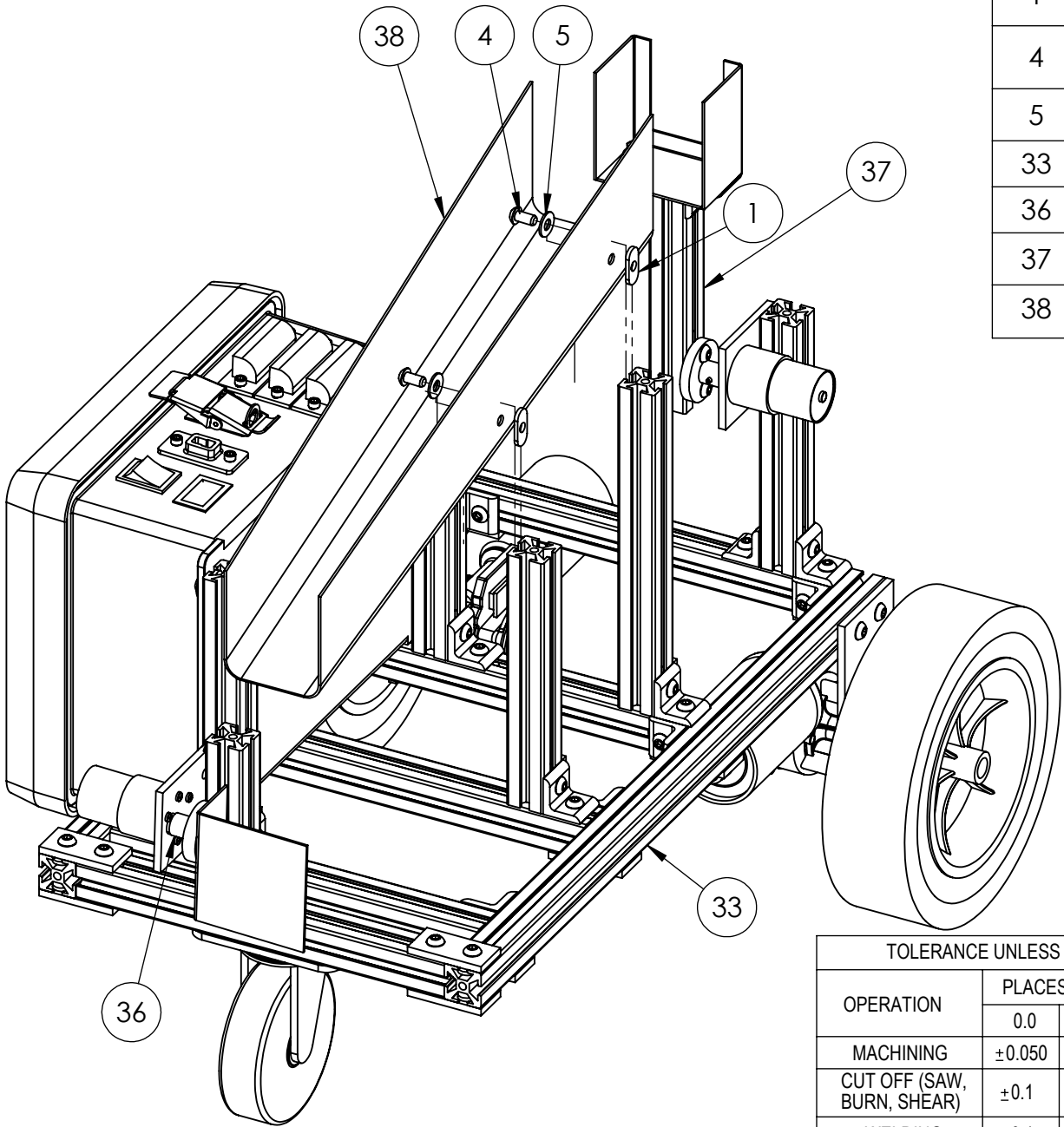
Item No.	Part Number	Decription	Qty.
1	EML2322L-OTS-6	1/4-20 T-Nut	70
2	EML2322L-OTS1	Control Box	1
3	EML2322L-OTS20	5" Caster Wheel	1
4	EML2322L-OTS-7	1/4-20 x 1/2 inch BHCS	86
5	EML2322L-005	1/4" Washer	6
7	EML2322L-007	80-20 Extrusion, 20.9"	2
8	EML2322L-008	80-20 Extrusion, 10.0"	5
9	EML2322L-OTS-13	80/20 Straight Bracket	17
10	EML2322L-OTS-12	80/20 90 Degree Angle Bracket	17
11	EML2322-011	80-20 Extrusion 7.8"	2
12	EML2322-OTS-22	8" Wheel Type 1	2
13	EML2322L-013	Entstort Wheel Hub	2
14	EML2322L-014	10-24 1inch Button Head Screw	6
15	EML2322L-OTS-31	44 RPM Entstort Right Angle Gear Motor	2
16	EML2322L-016	Entstort Motor Mount	2
17	EML2322L-017	M6-20mm Hex Head Screw	6
18	EML2322L-018	M8 x 1.25 Hex Nut	2
19	EML2322L-019	M3 X 10mm Screw	8
20	EML2322L-OTS-29	15 RPM SEI Gear Motor	2
21	EML2322L-021	80-20 Extrusion 7.0"	2
22	EML2322L-022	80-20 Extrusion 6.5"	1
23	EML2322L-023	15 RPM SEI Gear Motor Mount	2
24	EML2322L-024	15 RPM SEI Gear Wheel Hub Lever Arm	1
25	EML2322L-025	Ball Grabber	1
26	EML2322L-026	1/4-20 Hex Nut	2
27	EML2322L-027	1/4-20 X 3/8" BHCS	4
28	EML2322L-028	80-20 Extrusion 9"	1
29	EML2322L-029	Ball Hopper Part	1
30	EML23221L-030	4-40 1/4" Set Screw	2
31	EML2322L-031	15 RPM SEI Gear Motor Hub Release Gate	1
32	EML2322L-032	Release Gate Part	1
33	EML2322L-A-001	Mobile Platform	1
34	EML2322L-A-002	Drive Assembly	2
35	EML2322-A-003	Frame Assembly	1
36	EML2322L-A-004	Release Gate	1
37	EML2322L-A-005	Lever Arm	1
38	EML2322L-A-006	Ball Hopper	1
39	EML2322L-A-007	Final Assembly	1



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

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Final Assembly		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-007	A
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4	SHEET 1 OF 7	

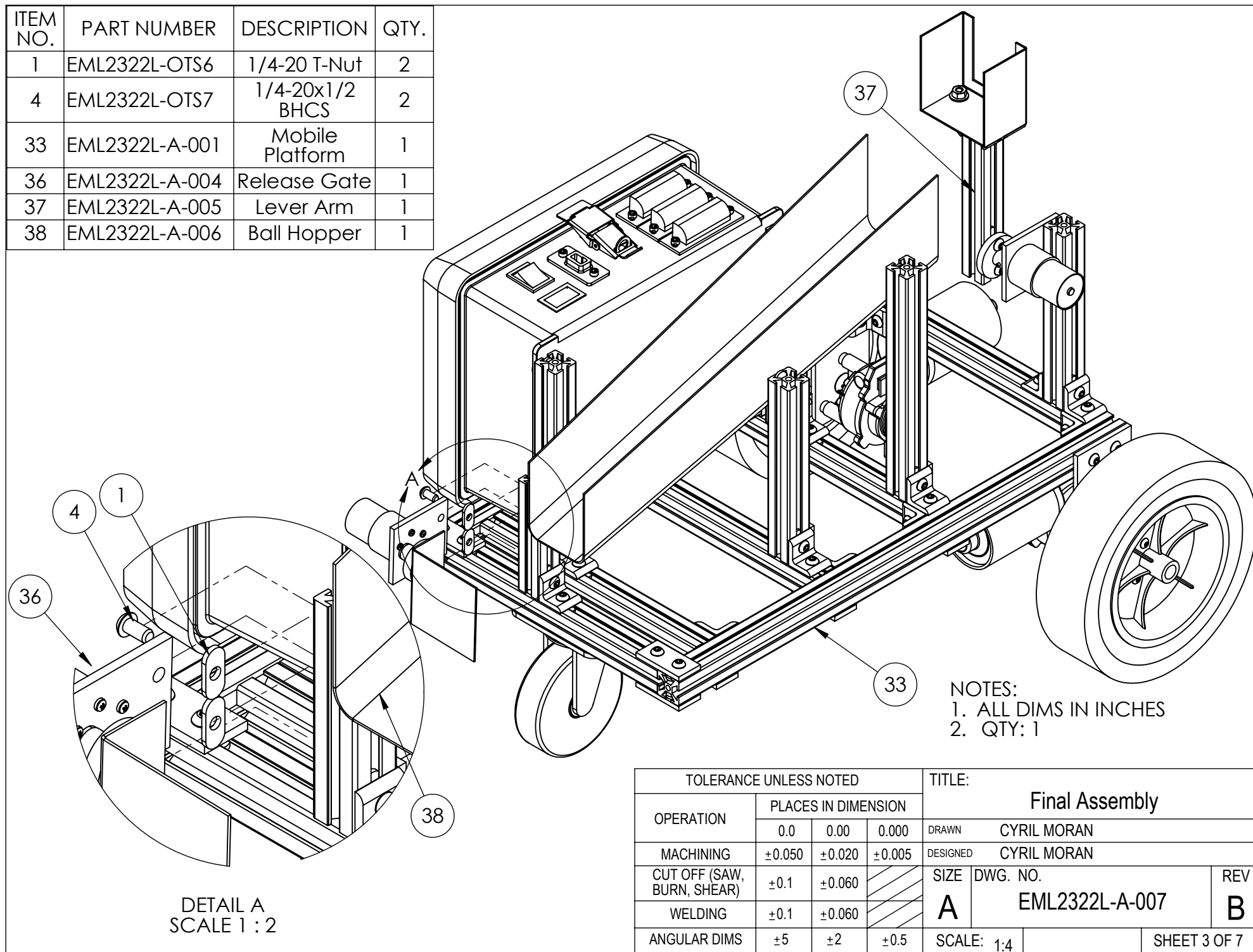
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	EML2322L-OTS6	1/4-20 T-Nut	2
4	EML2322L-OTS7	1/4-20 X1/2 BHCS	2
5	EML2322L-005	1/4" Washer	2
33	EML2322L-A-001	Mobile Platform	1
36	EML2322L-A-004	Release Gate	1
37	EML2322L-A-005	Lever Arm	1
38	EML2322L-A-006	Ball Hopper	1



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

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Final Assembly		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-007	B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4	SHEET 2 OF 7	

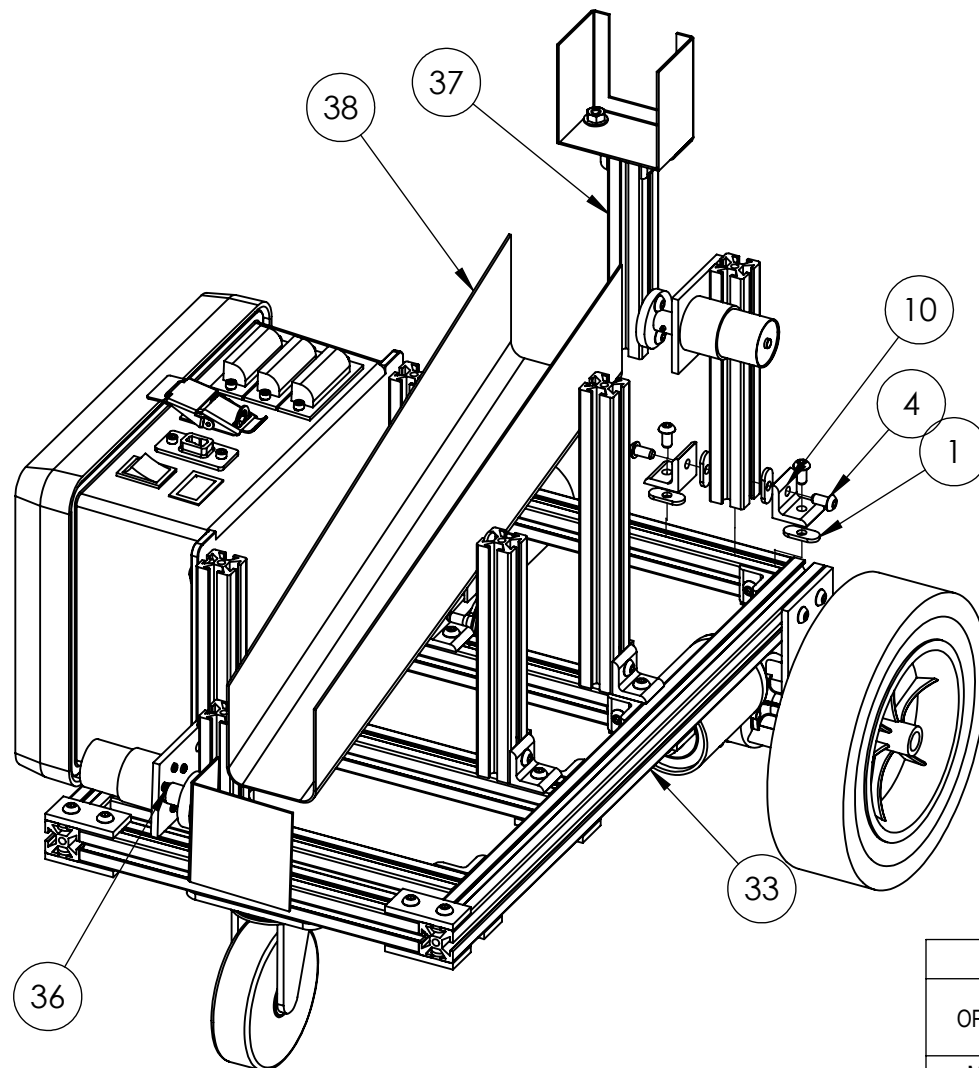
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1	EML2322L-OTS6	1/4-20 T-Nut	2
4	EML2322L-OTS7	1/4-20x1/2 BHCS	2
33	EML2322L-A-001	Mobile Platform	1
36	EML2322L-A-004	Release Gate	1
37	EML2322L-A-005	Lever Arm	1
38	EML2322L-A-006	Ball Hopper	1



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

DETAIL A
SCALE 1 : 2

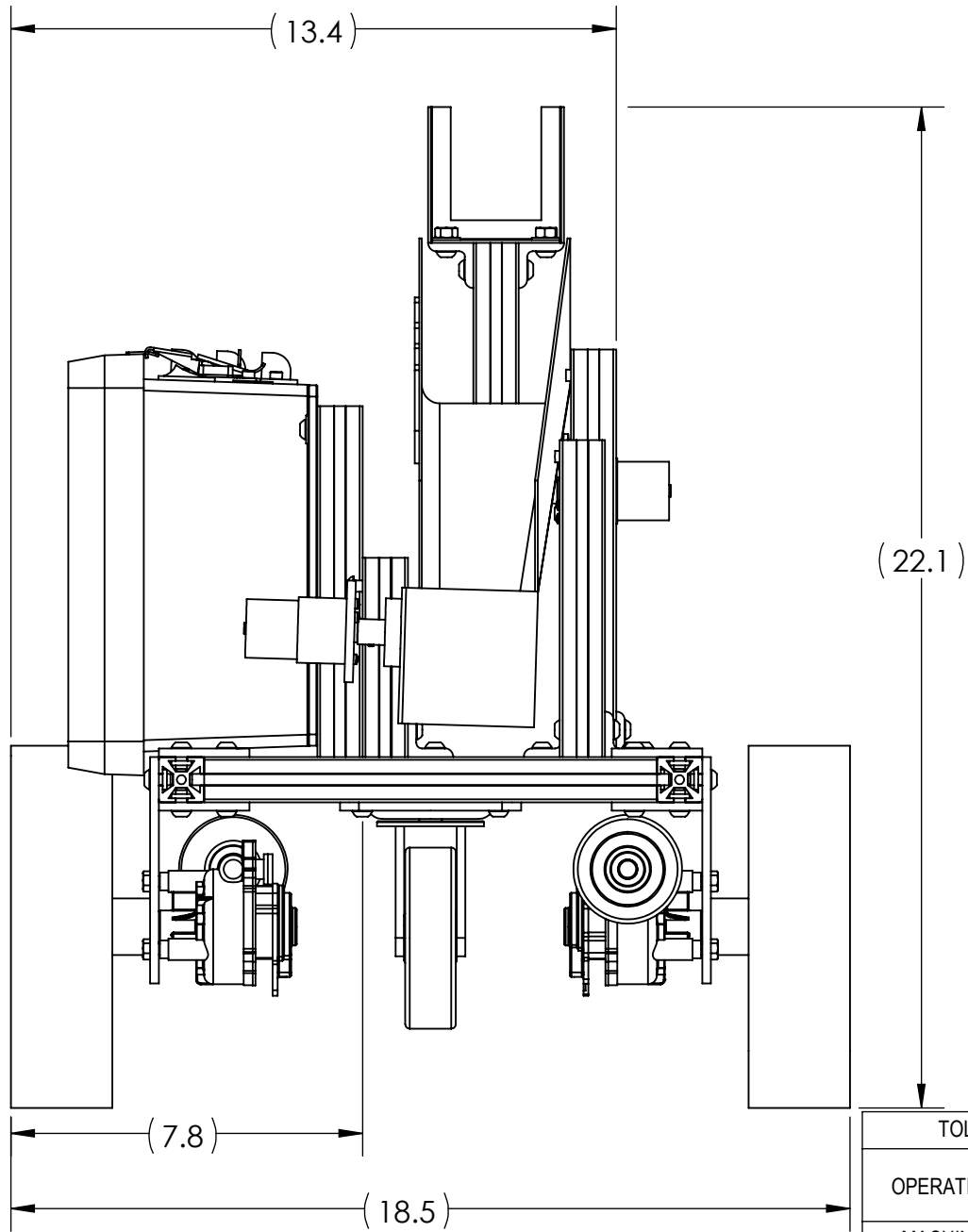
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OPERATION	PLACES IN DIMENSION			Final Assembly		
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MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-007	B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4	SHEET 3 OF 7	



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	EML2322L-OTS6	1/4-20 T-Nut	4
4	EML2322L-OTS7	1/4-20 X1/2 BHCS	4
10	EML2322L-OTS12	80/20 90 Degree Angle Bracket	2
33	EML2322L-A-001	Mobile Platform	1
36	EML2322L-A-004	Release Gate	1
37	EML2322L-A-005	Lever Arm	1
38	EML2322L-A-006	Ball Hopper	1

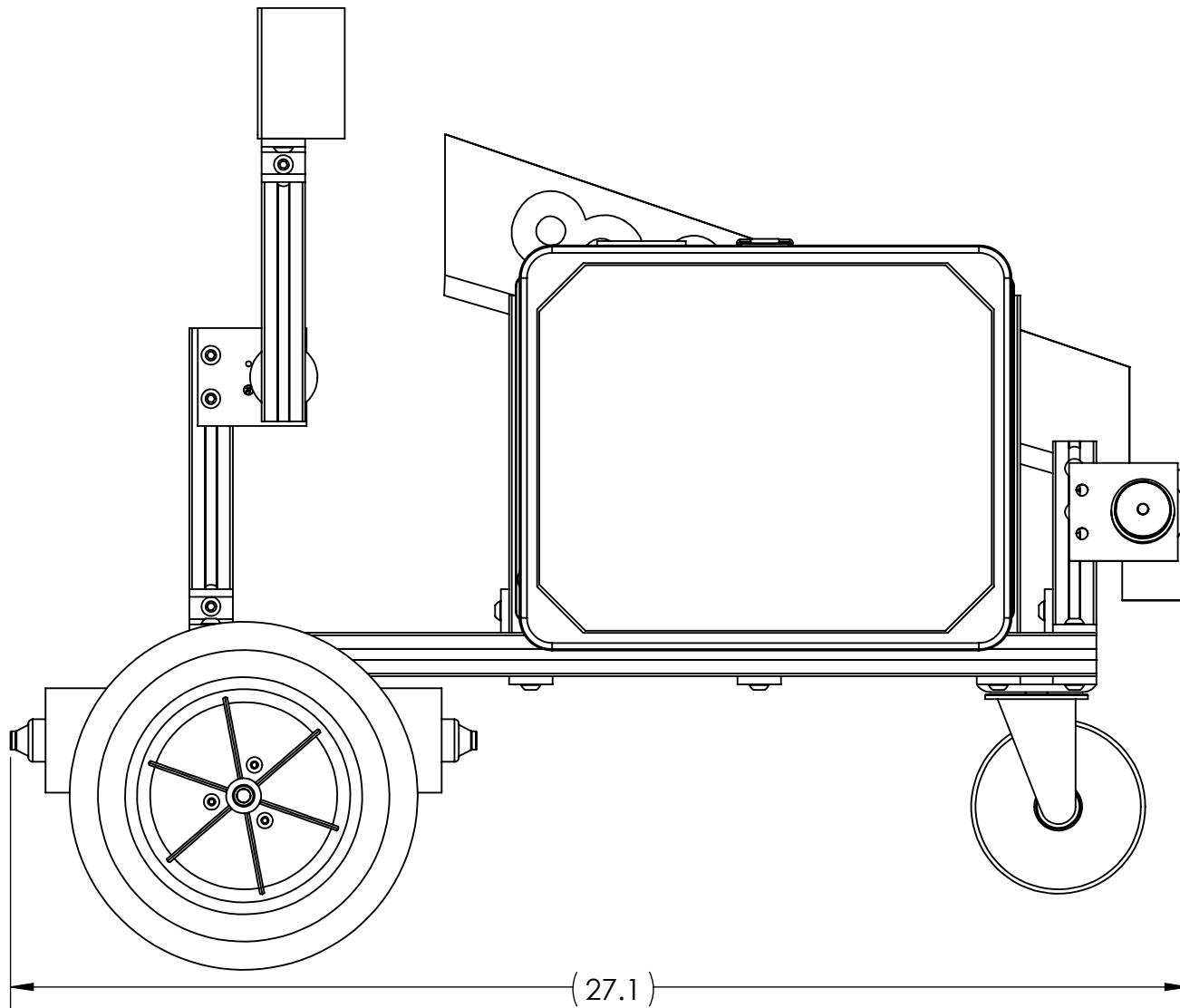
NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Final Assembly		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-007	B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4	SHEET 4 OF 7	



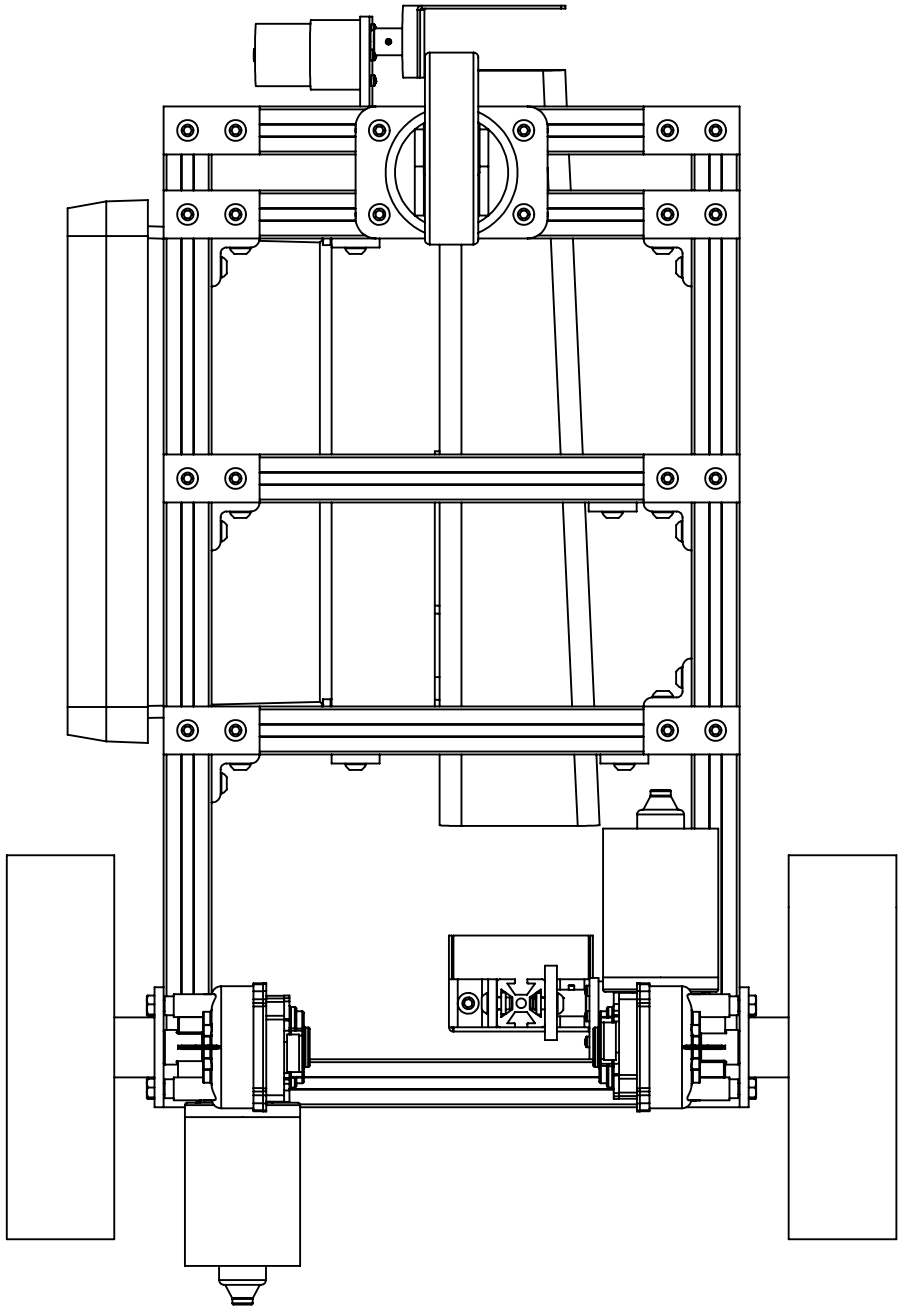
NOTES:
 1. ALL DIMS IN INCHES
 2. QTY:1

TOLERANCE UNLESS NOTED				TITLE: Final Assembly		
OPERATION	PLACES IN DIMENSION			DRAWN CYRIL MORAN		
	0.0	0.00	0.000	DESIGNED CYRIL MORAN		
MACHINING	±0.050	±0.020	±0.005	SIZE A		
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		DWG. NO. EML2322L-A-007		REV B
WELDING	±0.1	±0.060		SCALE: 1:4		
ANGULAR DIMS	±5	±2	±0.5			SHEET 5 OF 7



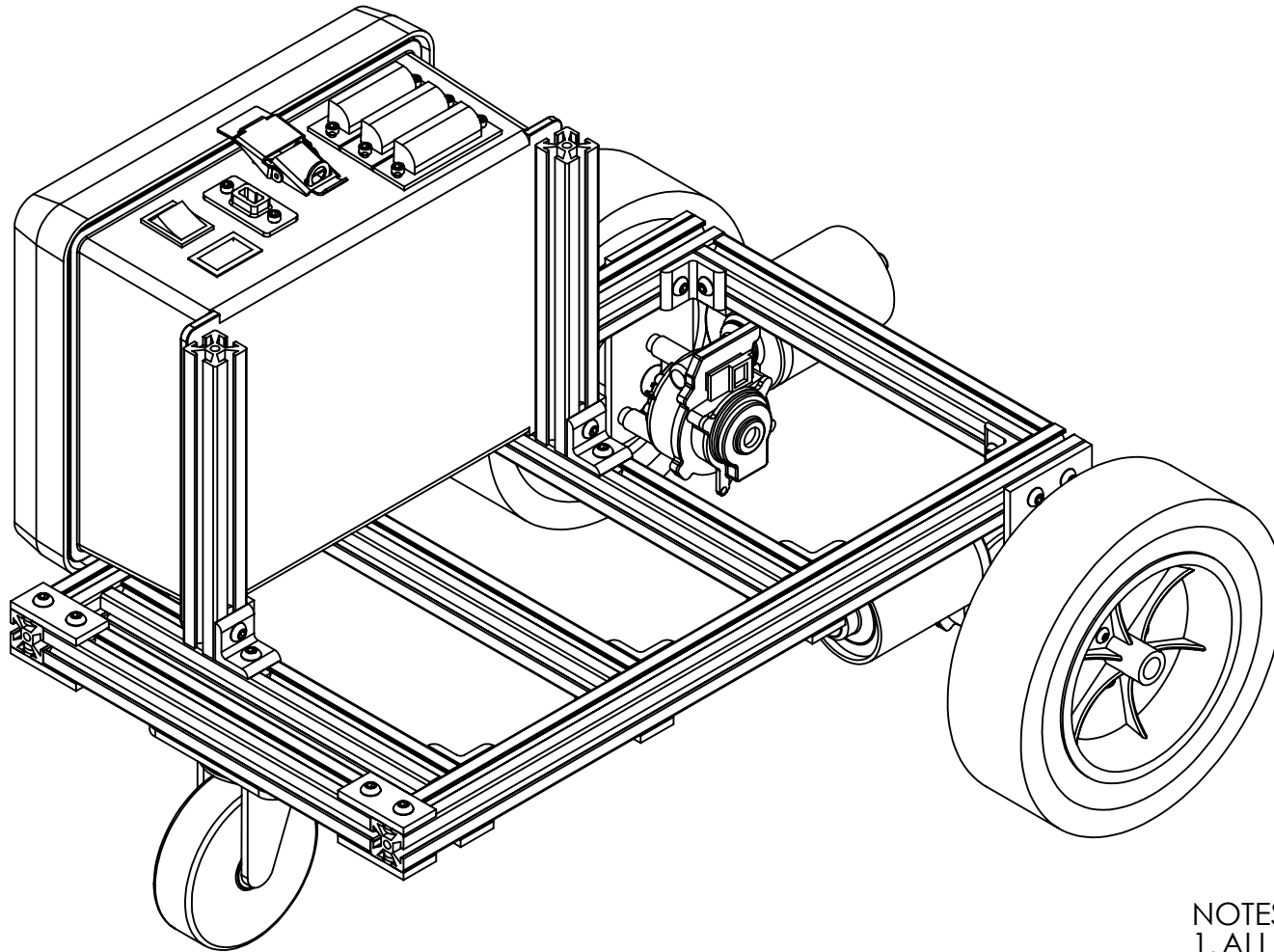
NOTES:
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 2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Final Assembly		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-007	A
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4		SHEET 6 OF 7



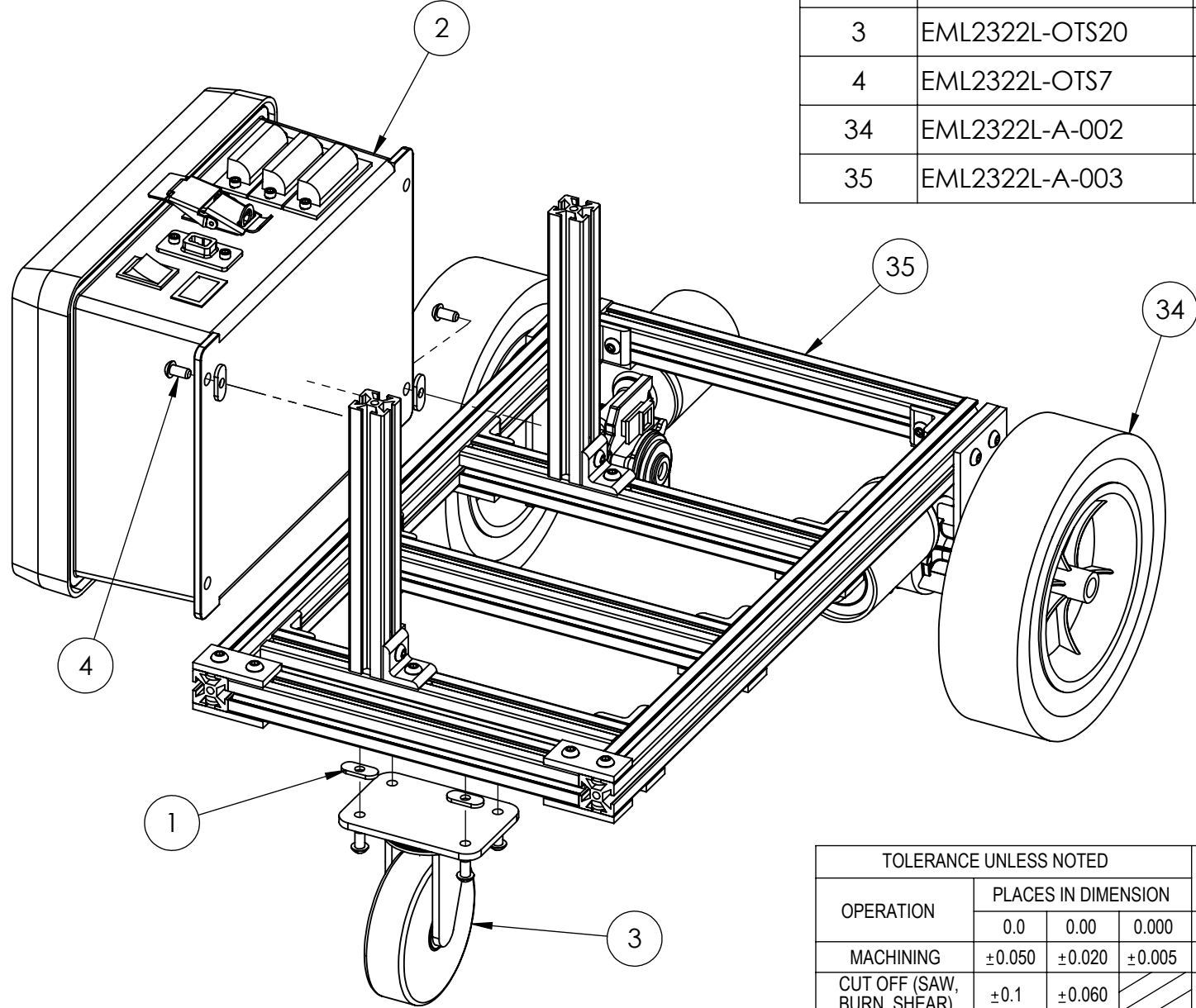
NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Final Assembly		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-007	A
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4		SHEET 7 OF 7



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

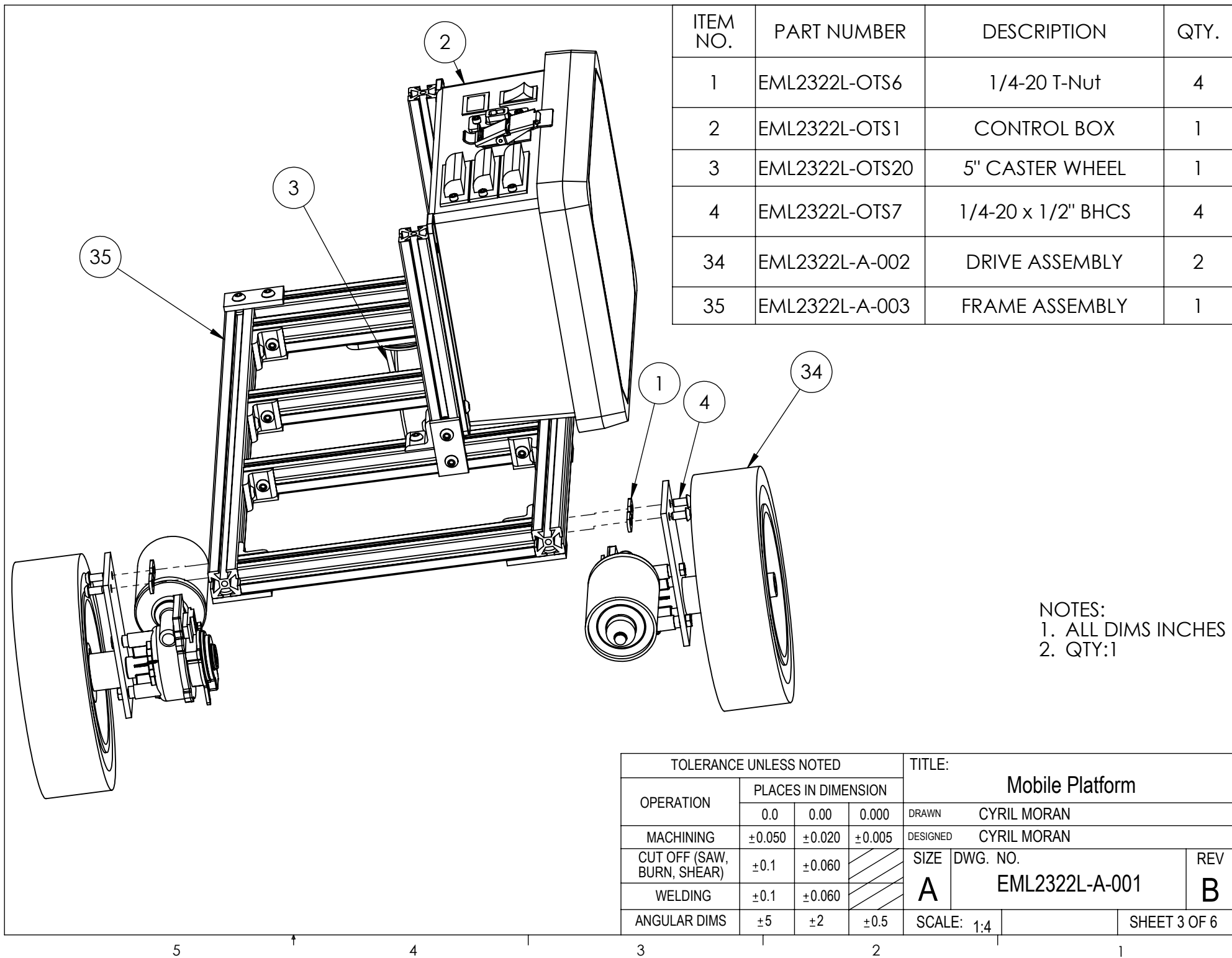
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OPERATION	PLACES IN DIMENSION			Mobile Platform		
	0.0	0.00	0.000	DRAWN	Cyril Moran	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	Cyril Moran	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-001	A
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4	SHEET 1 OF 6	



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	EML2322L-OTS6	1/4-20 T-Nut	6
2	EML2322L-OTS1	CONTROL BOX	1
3	EML2322L-OTS20	5" CASTER WHEEL	1
4	EML2322L-OTS7	1/4-20 X 1/2 BHCS	6
34	EML2322L-A-002	DRIVE ASSEMBLY	2
35	EML2322L-A-003	FRAME ASSEMBLY	1

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

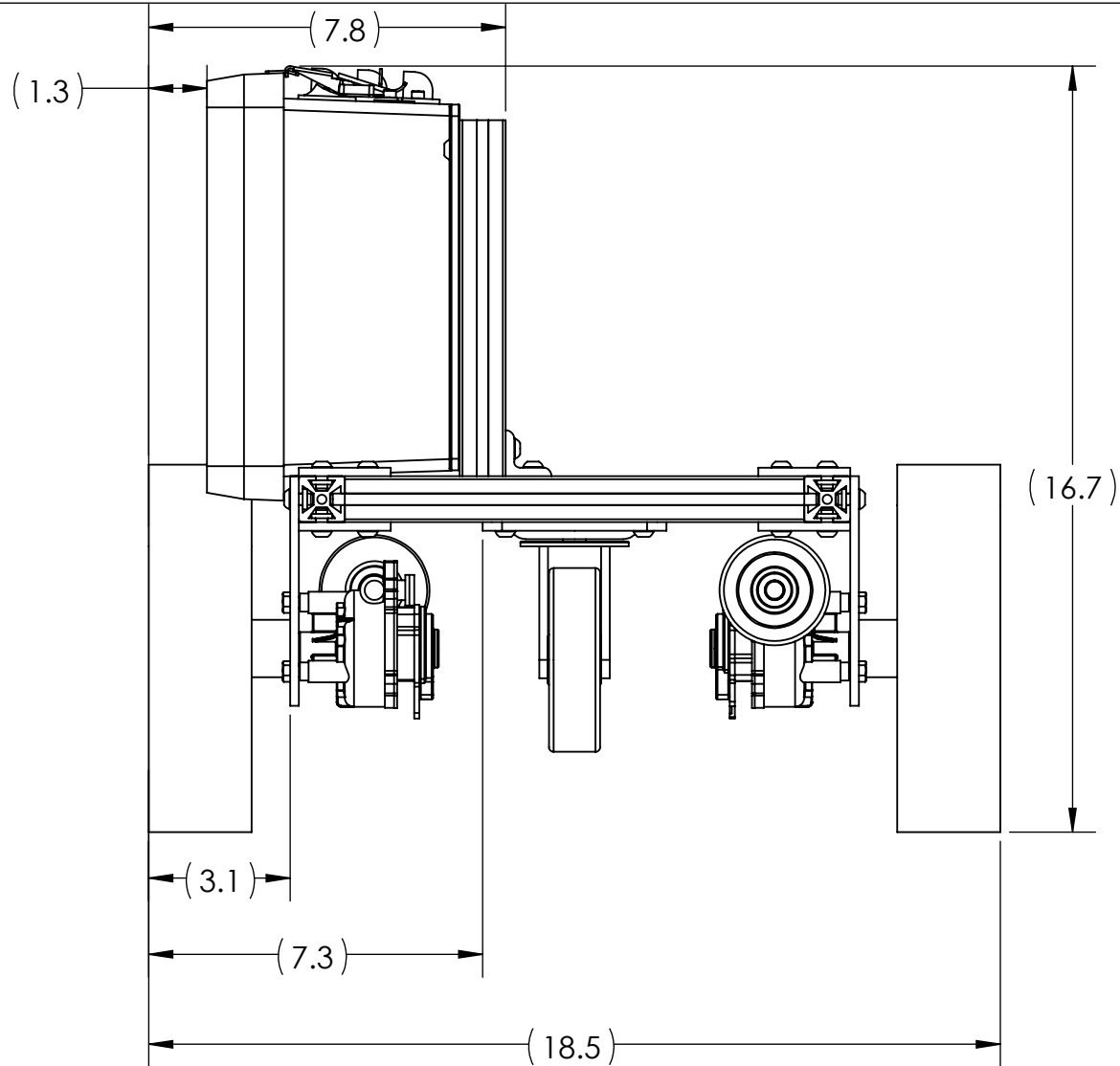
TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Mobile Platform		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-001	B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4	SHEET 2 OF 6	



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	EML2322L-OTS6	1/4-20 T-Nut	4
2	EML2322L-OTS1	CONTROL BOX	1
3	EML2322L-OTS20	5" CASTER WHEEL	1
4	EML2322L-OTS7	1/4-20 x 1/2" BHCS	4
34	EML2322L-A-002	DRIVE ASSEMBLY	2
35	EML2322L-A-003	FRAME ASSEMBLY	1

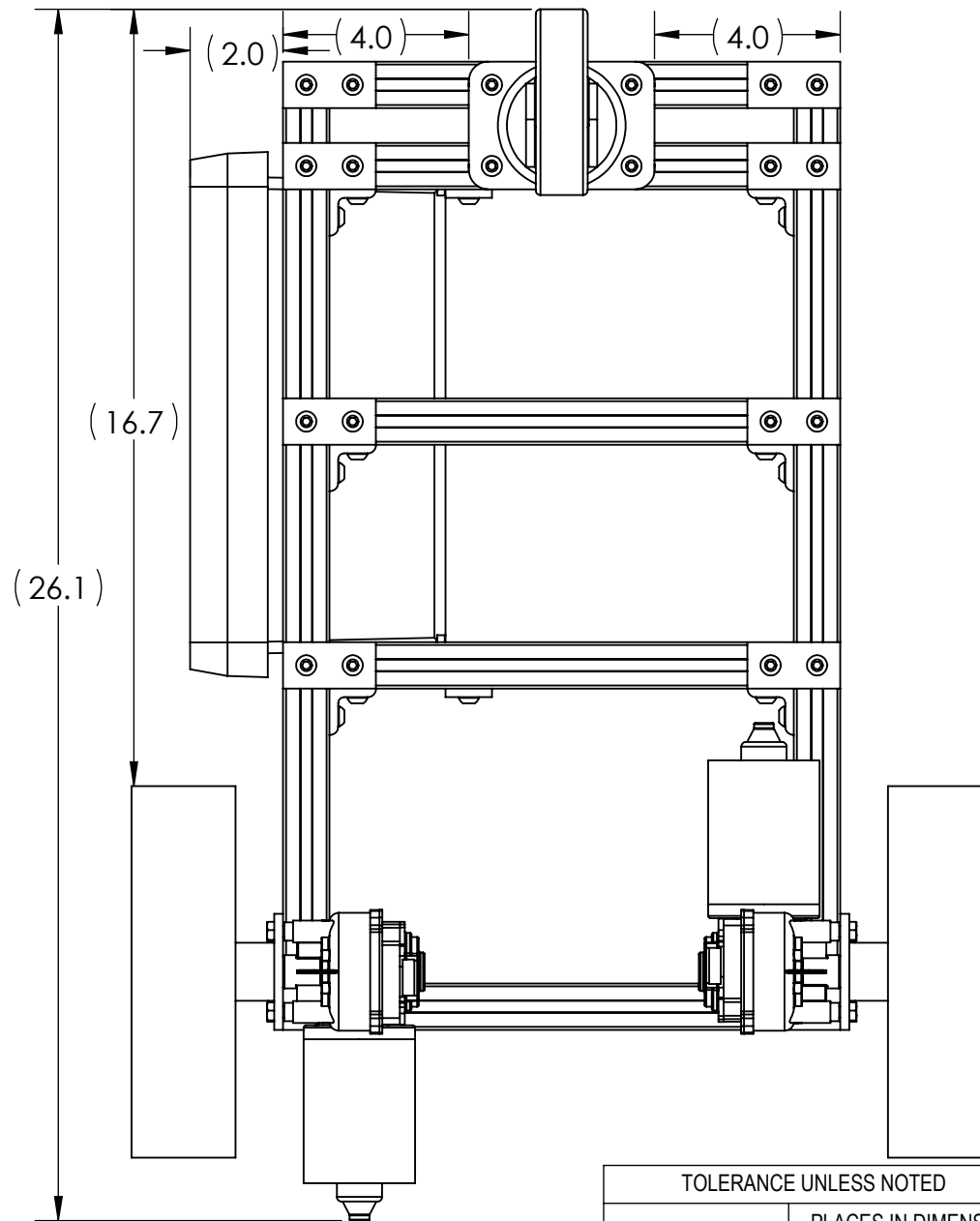
NOTES:
1. ALL DIMS INCHES
2. QTY:1

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Mobile Platform		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-001	B
ANGULAR DIMS	±5	±2	±0.5	SCALE:	1:4	SHEET 3 OF 6



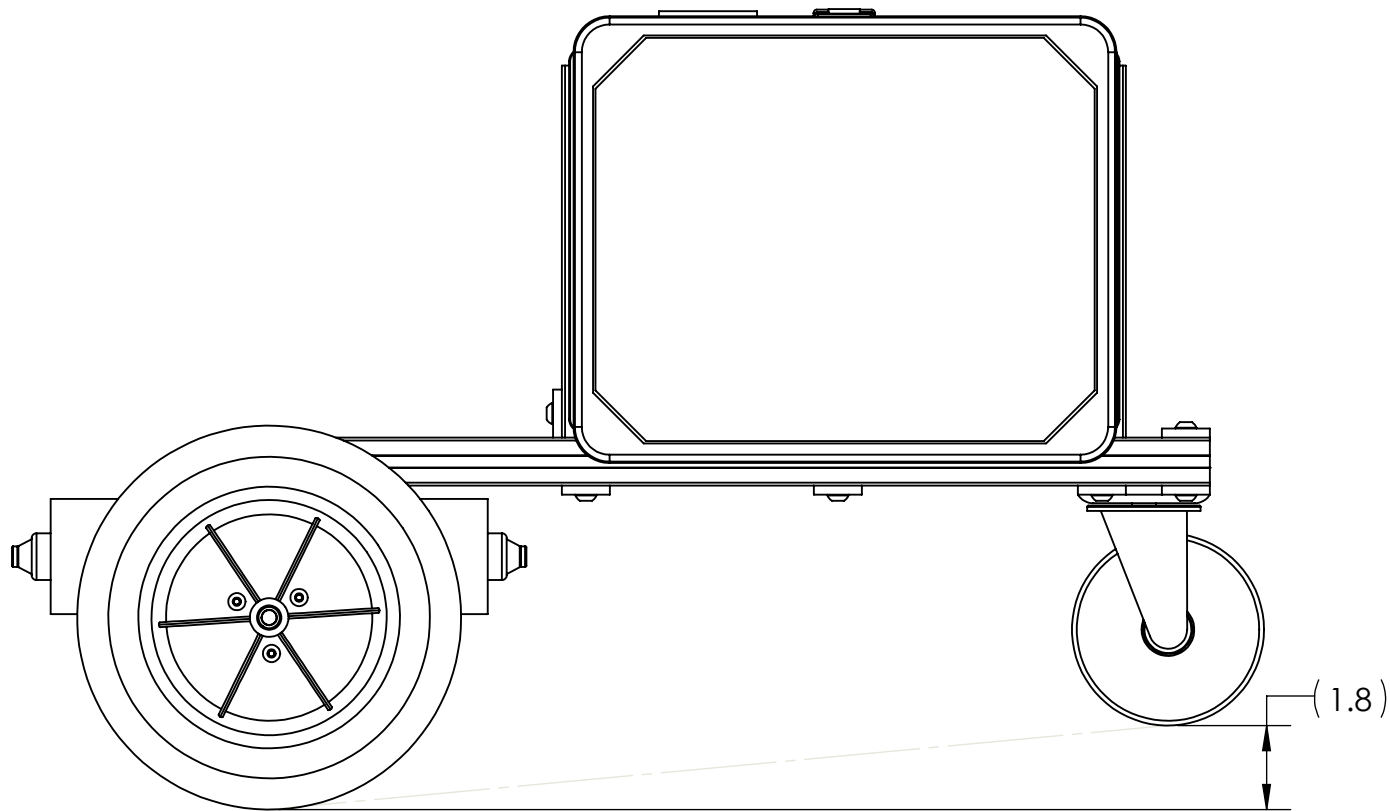
NOTES:
 1. ALL DIMS IN INCHES
 2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Mobile Platform		
	0.0	0.00	0.000	DRAWN CYRIL MORAN		
MACHINING	±0.050	±0.020	±0.005	DESIGNED CYRIL MORAN		
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-001	B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4		SHEET 4 OF 6



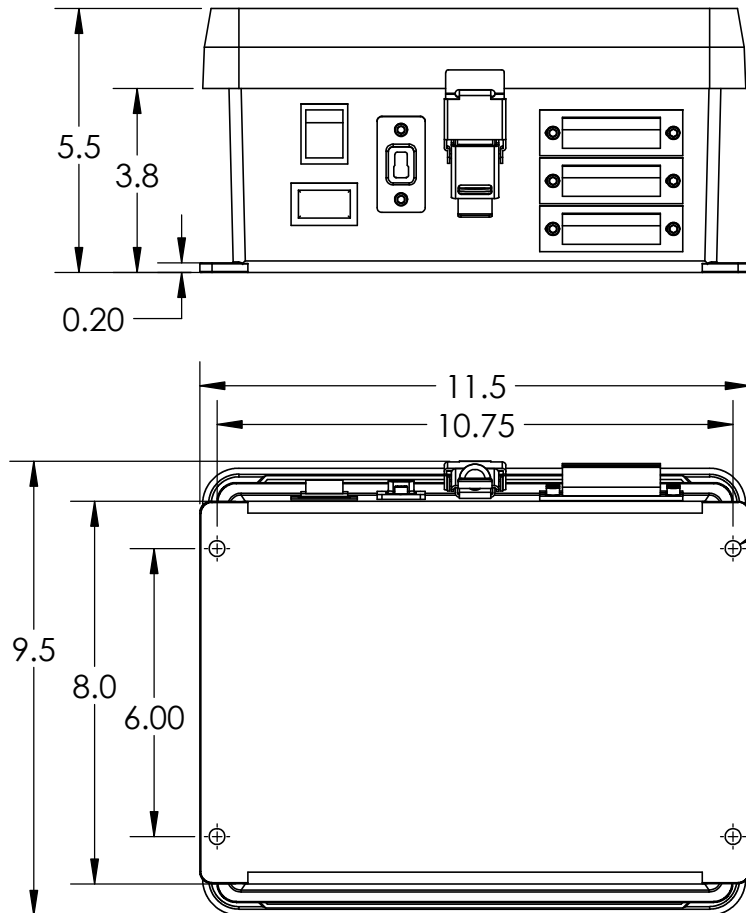
NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Mobile Platform		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-001	B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4	SHEET 5 OF 6	

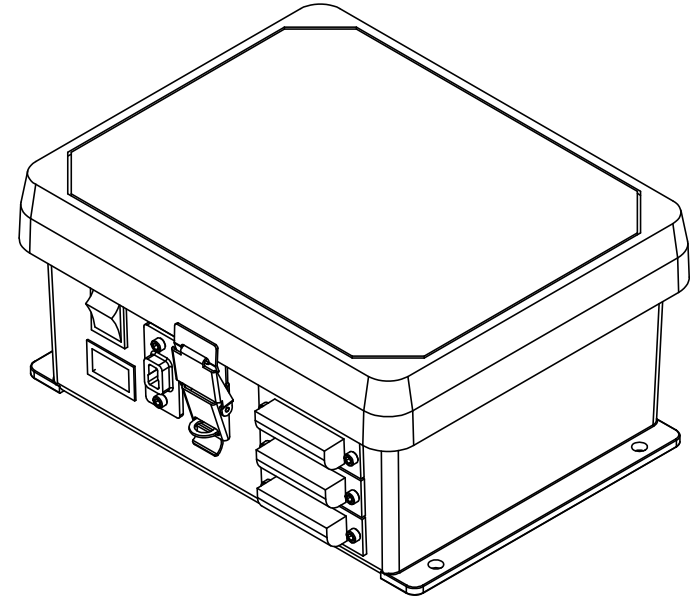


NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Mobile Platform		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-001	B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4		SHEET 6 OF 6

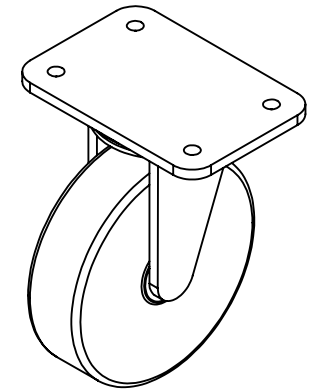
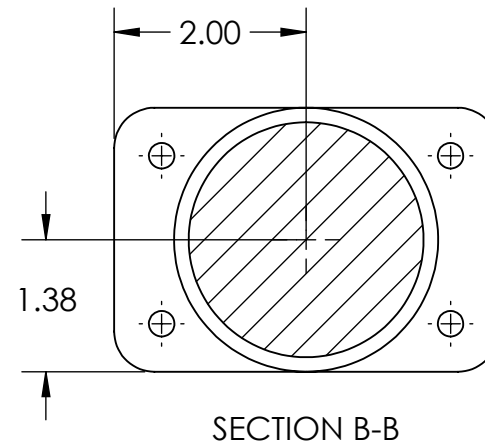
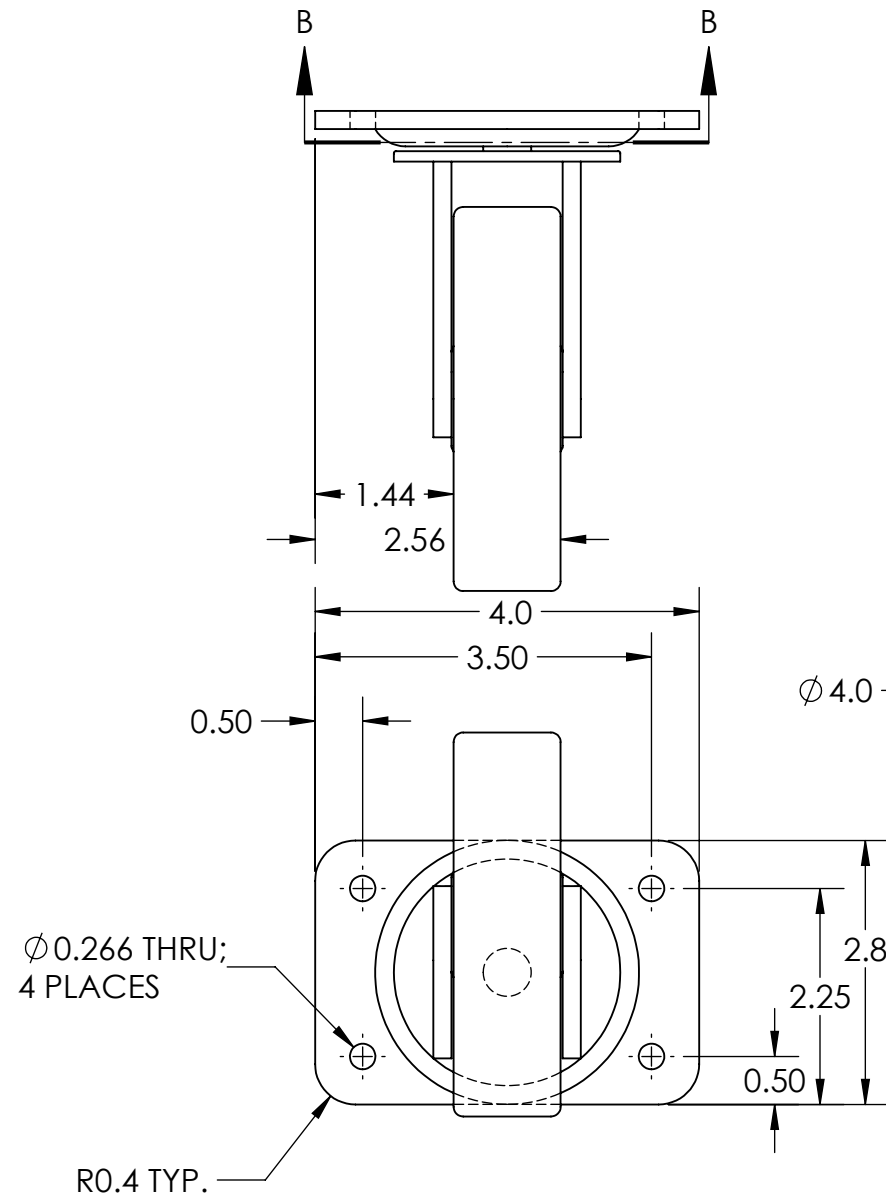


Ø 0.328 THRU;
4 PLACES



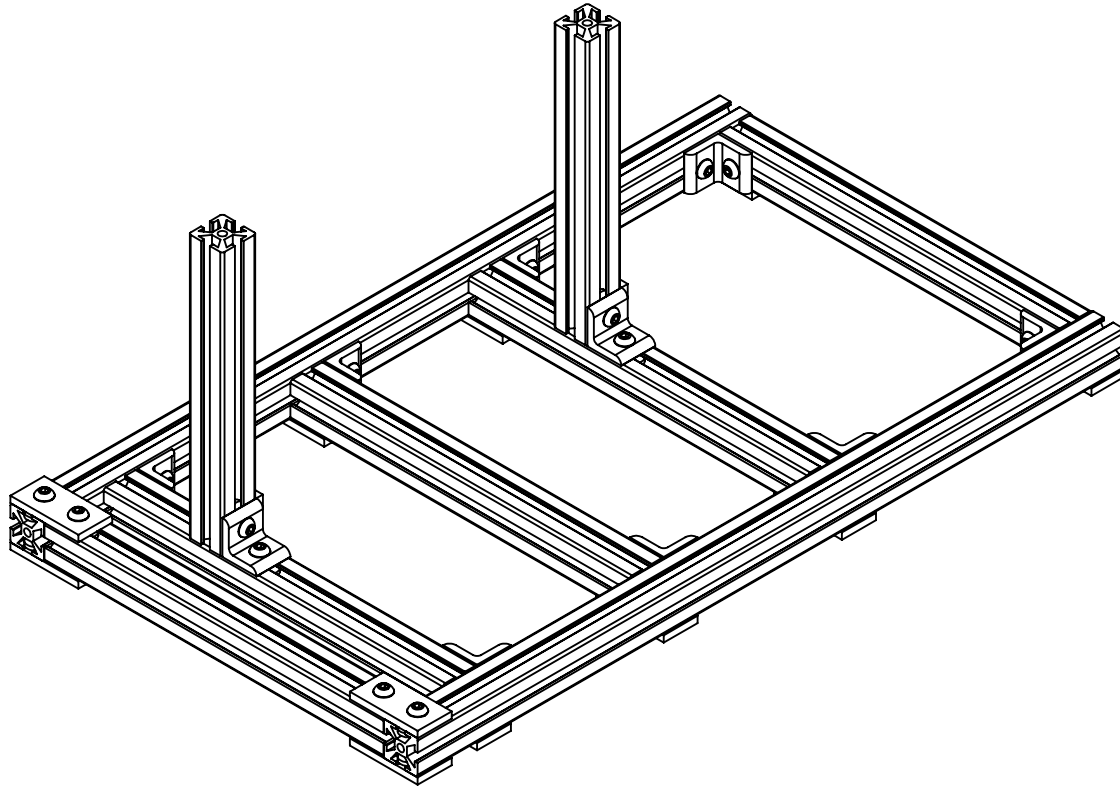
- NOTES:
 1. DIMS IN INCHES
 2. QTY SPECIFIED IN BOM
 3. DIM AND MAT'L SPECIFIED BY MANUFACTURER

TOLERANCE UNLESS NOTED				TITLE:		
MEASURING INSTRUMENT	PLACES IN DIMENSION			Control Box		
	0.0	0.00	0.000	DRAWN	KRISTIN BROOKER	
CALIPERS	/	/	±0.005	DESIGNED	VYNCKIER ENCLOSURES	
PRECISION RULER	/	±0.015	/	SIZE	DWG. NO.	REV
TAPE MEASURE	±0.030	/	/	A	EML2322L-OTS1	B
PROTRACTOR	±10	±5	±2	SCALE: 1:4		SHEET 1 OF 1



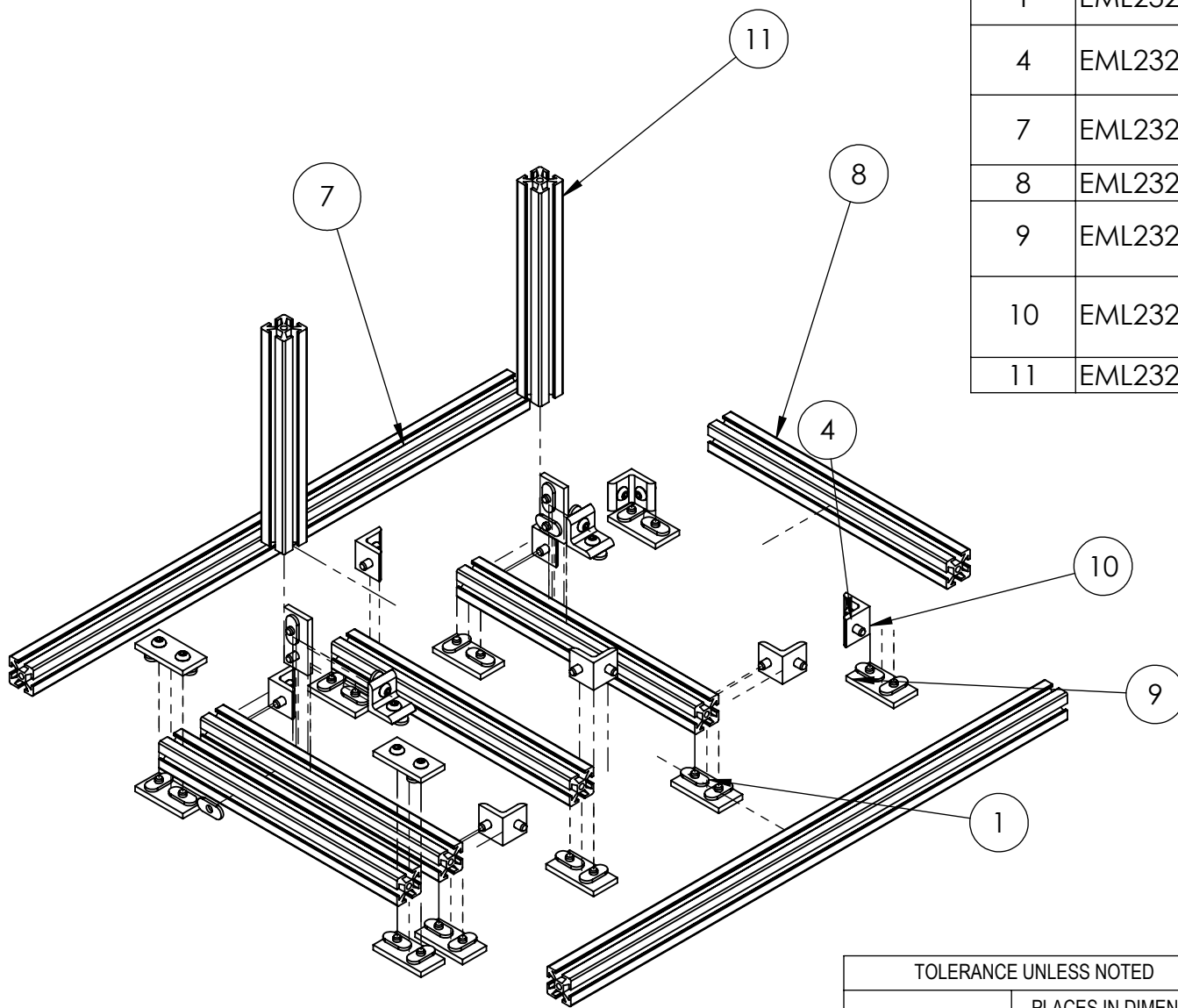
- NOTES:
1. DIMS IN INCHES
 2. QUANTITY: 1
 3. DIMS AND MAT'L SPECIFIED BY MANUFACTURER

TOLERANCE UNLESS NOTED				TITLE: Caster Wheel		
MEASURING INSTRUMENT	PLACES IN DIMENSION			DRAWN: DRAWER'S NAME		
	0.0	0.00	0.000	DESIGNED: ARNOLD		
CALIPERS			± 0.005	SIZE: A		
PRECISION RULER		± 0.015		DWG. NO. EML2322L-OTS20		
TAPE MEASURE	± 0.030			REV: B		
PROTRACTOR	± 10	± 5	± 2	SCALE: 1:2		
				SHEET 1 OF 1		



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

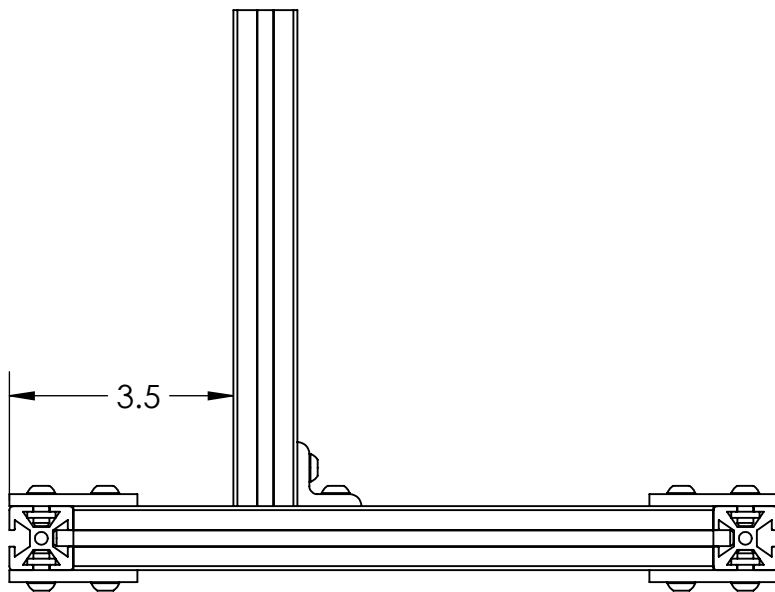
TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Frame Assembly		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-003	B
ANGULAR DIMS	±5	±2		SCALE: 1:4		SHEET 1 OF 5



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	EML2322L-OTS6	1/4-20 T-Nut	48
4	EML2322L-OTS7	1/4-20 X 1/2 inch BHCS	48
7	EML2322L-007	80-20 Extrusion, 20.9"	2
8	EML2322L-008	80-20 Extrusion, 10.0"	5
9	EML2322L-OTS13	80/20 Straight Bracket	14
10	EML2322L-OTS12	80/20 90 Degree Angle Bracket	10
11	EML2322L-011	80-20 Extrusion 7.8"	2

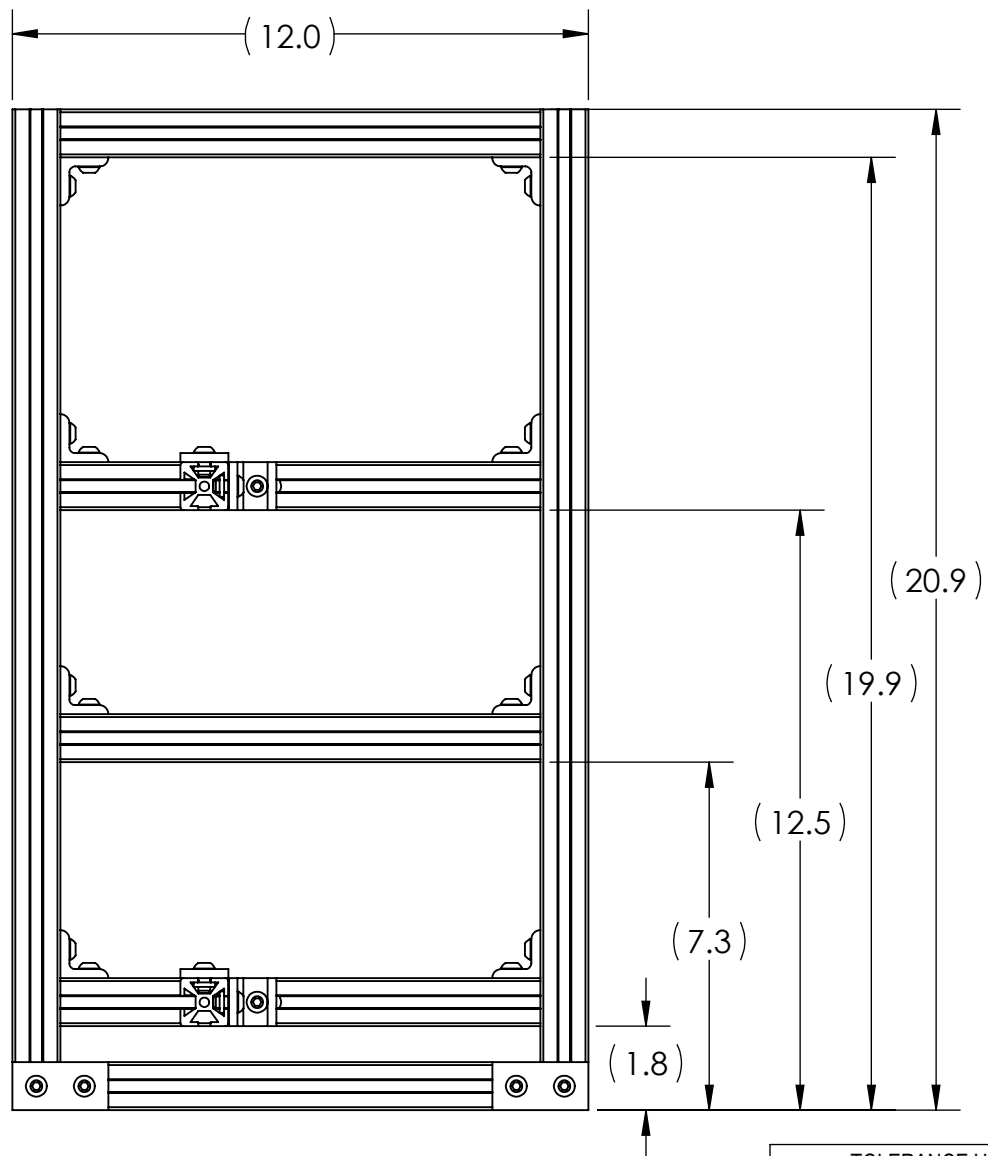
NOTES:
 1. ALL DIMS IN INCHES
 2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Frame Assembly		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-003	B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:5	SHEET 2 OF 5	



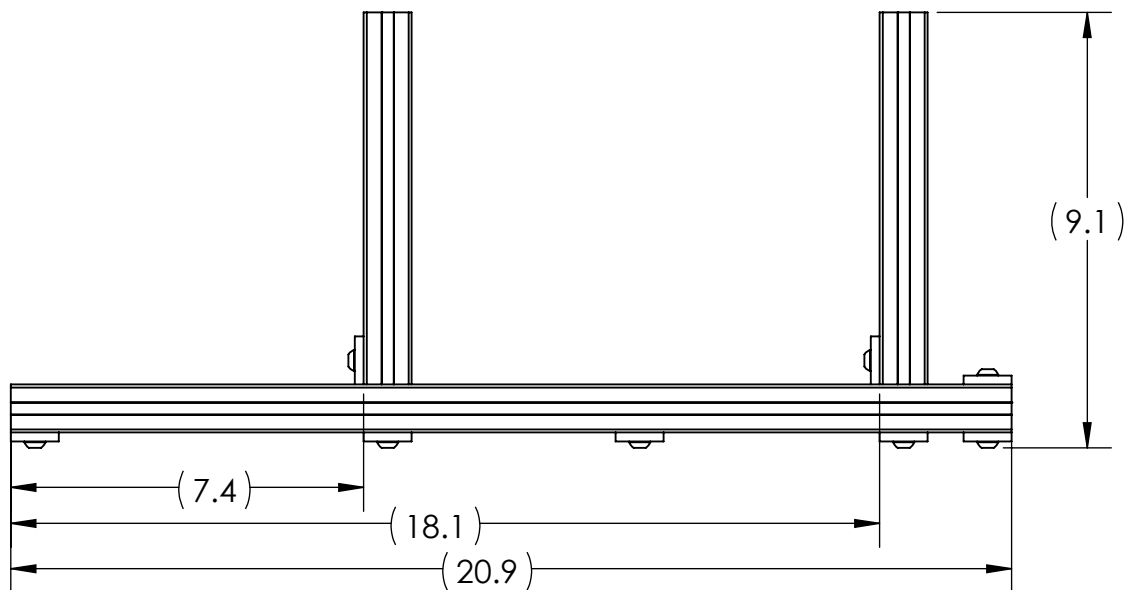
NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Frame Assembly		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-003	B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:3		SHEET 3 OF 5





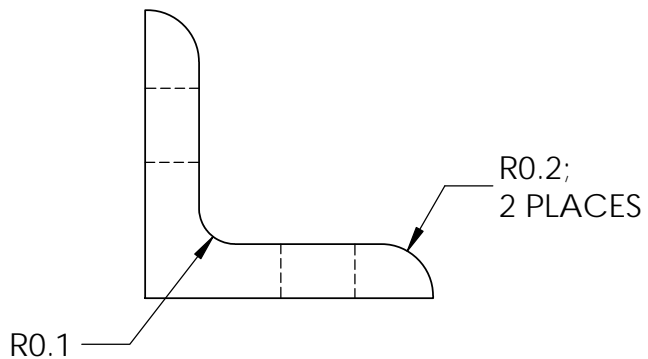
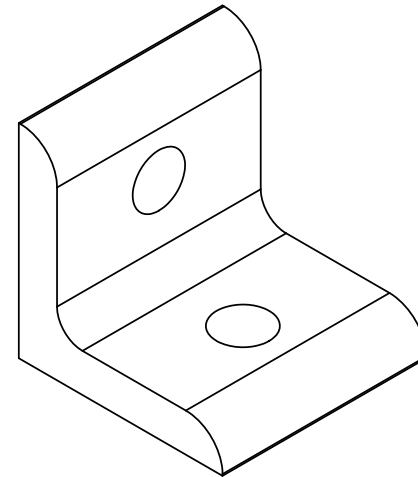
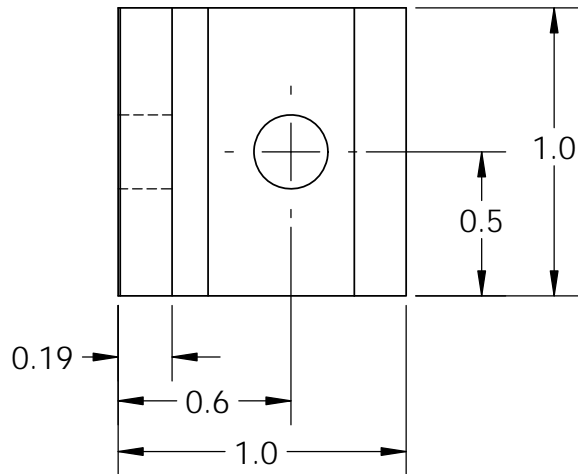
NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Frame Assembly		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-A-003	B
ANGULAR DIMS	±5	±2	±0.5	SCALE:	1:4	SHEET 4 OF 5

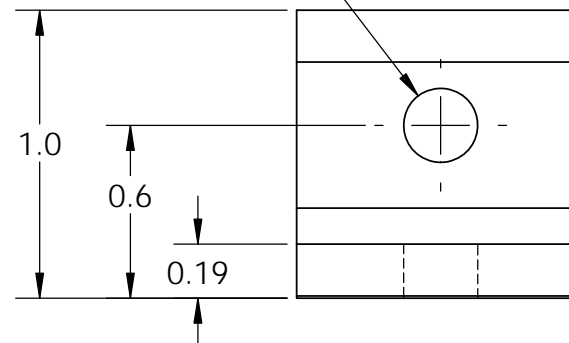


NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TOLERANCE UNLESS NOTED				TITLE:			
OPERATION	PLACES IN DIMENSION			Frame Assembly			
	0.0	0.00	0.000	DRAWN	CYRIL MORAN		
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN		
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.		REV
WELDING	±0.1	±0.060		A	EML2322L-A-003		B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4		SHEET 5 OF 5	



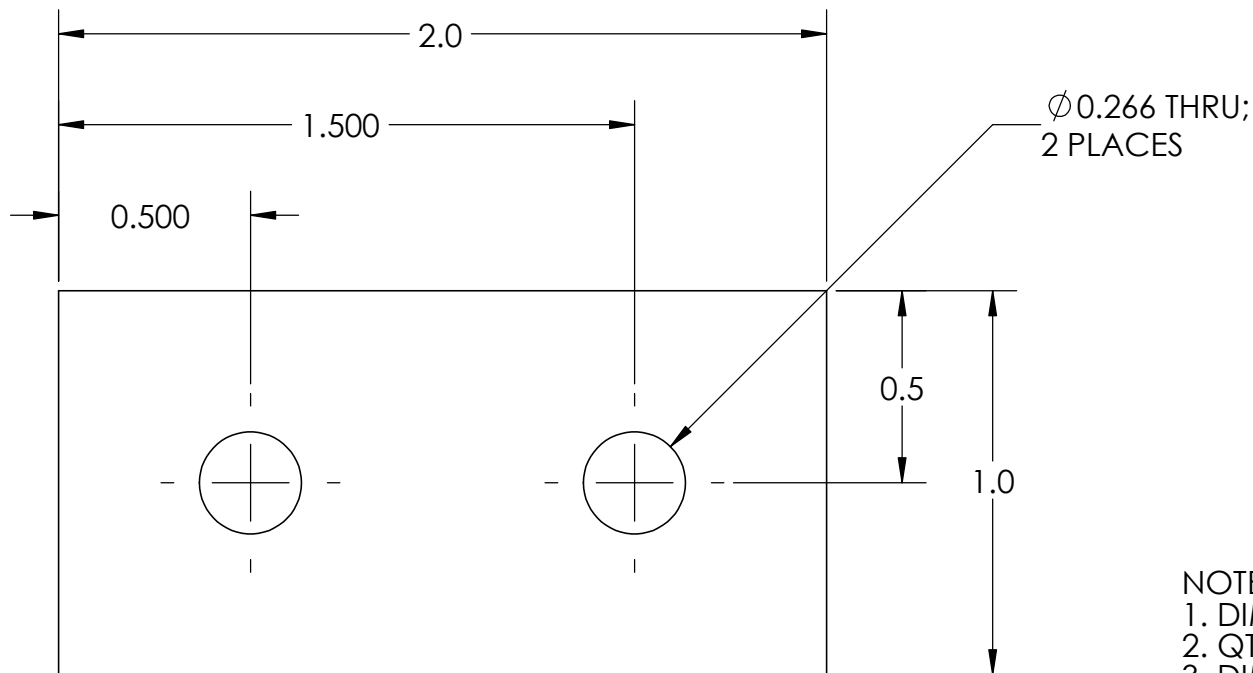
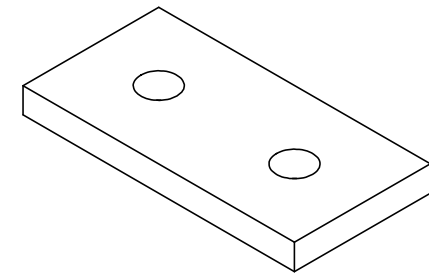
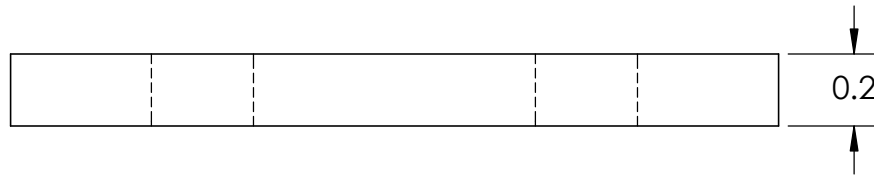
Ø0.257 THRU;
2 PLACES



NOTES:

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

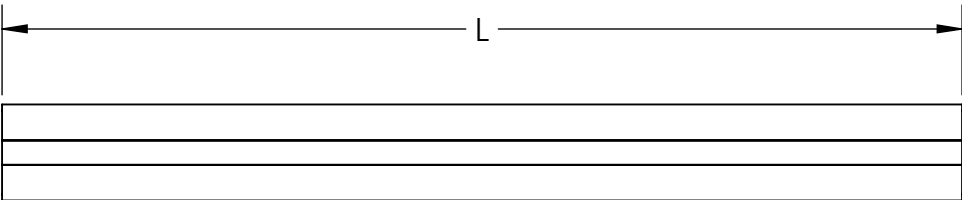
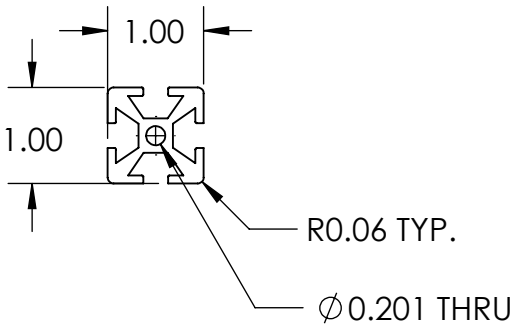
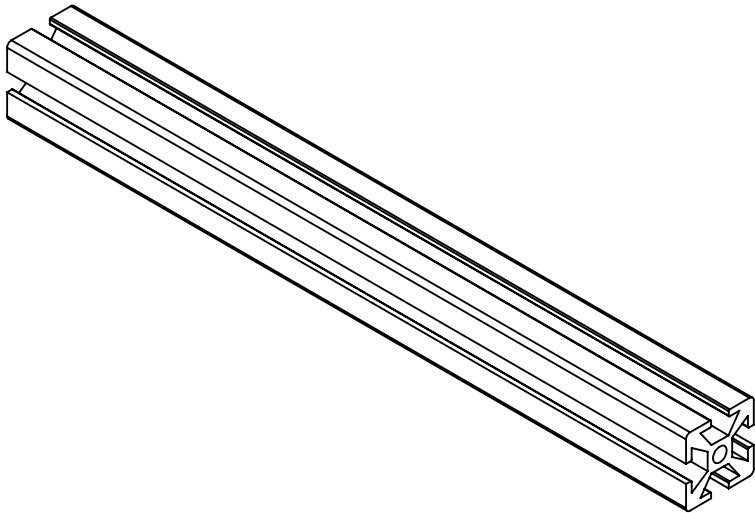
TOLERANCE UNLESS NOTED				TITLE:		
MEASURING INSTRUMENT	PLACES IN DIMENSION			80/20 90 Degree Angle Bracket		
	0.0	0.00	0.000	DRAWN	J. DERSCH	
CALIPERS			±0.005	DESIGNED	80/20 INC.	
PRECISION RULER		±0.015		SIZE	DWG. NO.	REV
TAPE MEASURE	±0.030			A	EML2322L-OTS12	A
PROTRACTOR	±10	±5	±2	SCALE: 1.5:1		SHEET 1 OF 1



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

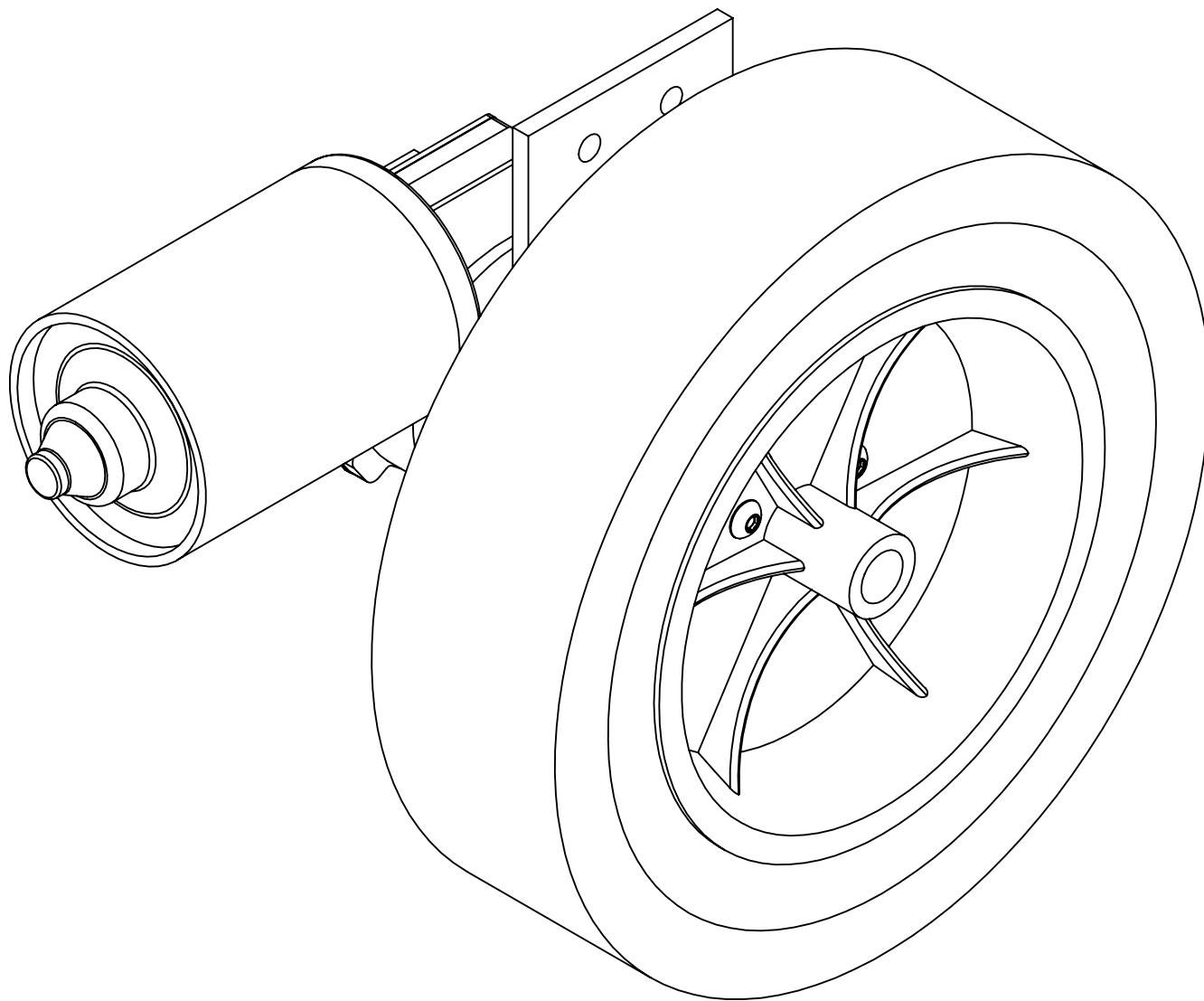
TOLERANCE UNLESS NOTED				TITLE:		
MEASURING INSTRUMENT	PLACES IN DIMENSION			80-20 Straight Bracket		
	0.0	0.00	0.000	DRAWN	J. DERSCH	
CALIPERS	/	/	±0.005	DESIGNED	80/20 INC.	
PRECISION RULER	/	±0.015	/	SIZE	DWG. NO.	REV
TAPE MEASURE	±0.030	/	/	A	EML2322L-OTS13	A
PROTRACTOR	±10	±5	±2	SCALE: 2:1		SHEET 1 OF 1

Part Number	Length (in.)	Quantity
EML2322L-007	20.9	2
EML2322L-008	10.0	5
EML2322L-011	7.8	2
EML2322L-021	7.0	2
EML2322L-022	6.5	1
EML2322L-028	9.0	1



- NOTES:
1. DIMS IN INCHES
 2. MAT'L: 80/20 AL EXTRUSION
 3. BREAK CUT ENDS
 4. FINISH NO SURFACES
 5. QTY SPECIFIED IN TABLE
 6. USE CUT OFF TOLERANCES

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			80/20 Extrusion (simplified)		
	0.0	0.00	0.000	DRAWN	DRAWER'S NAME	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	I. WIDJAJA	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-000	B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:2		SHEET 1 OF 1

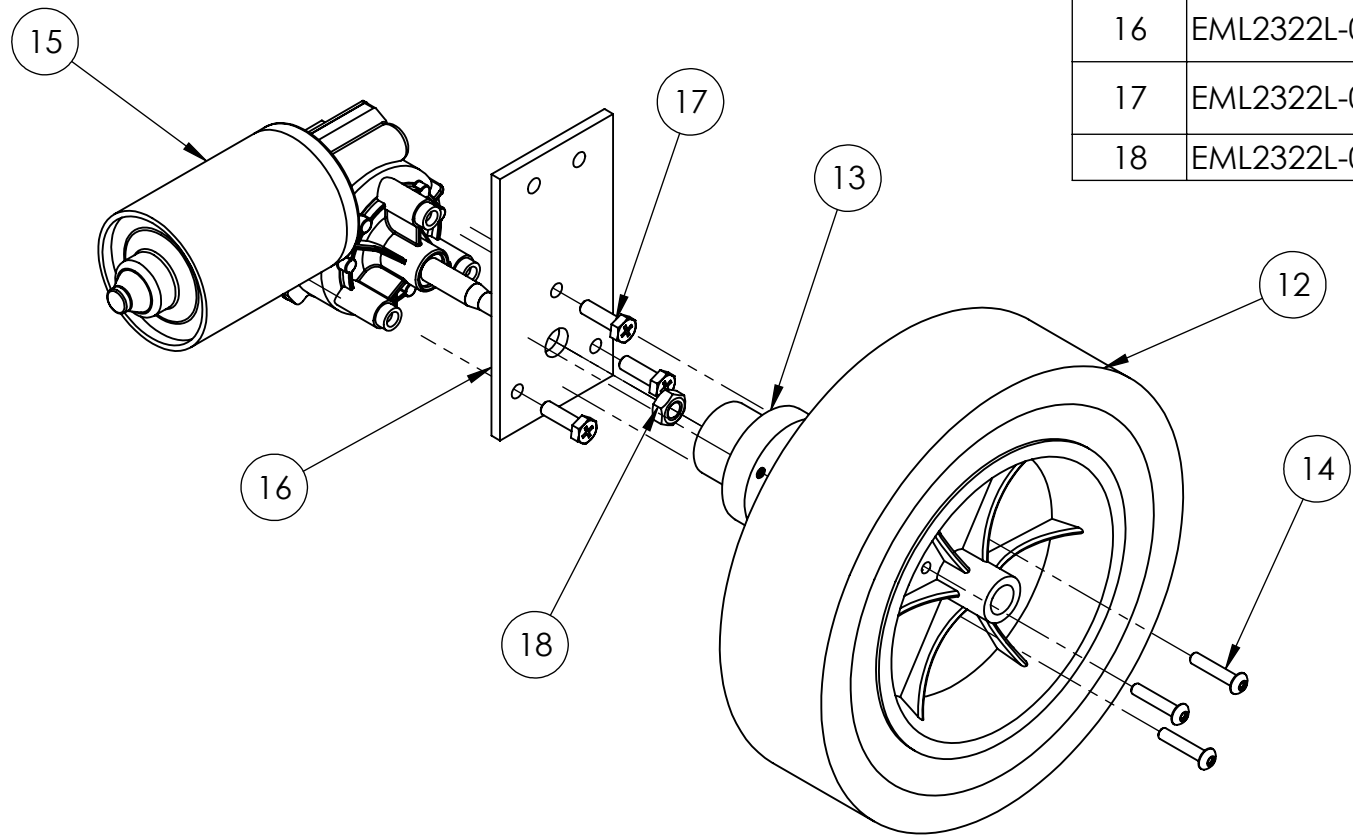


NOTES:
 1. ALL DIMS IN INCHES
 2. QTY: 2

TITLE:			
Drive Assembly			
DRAWN		COLTON MAYS	
DESIGNED		CYRIL MORAN	
SIZE	DWG. NO.		REV
A	EML2322L-A-002		A
SCALE: 2:3		SHEET 1 OF 3	

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

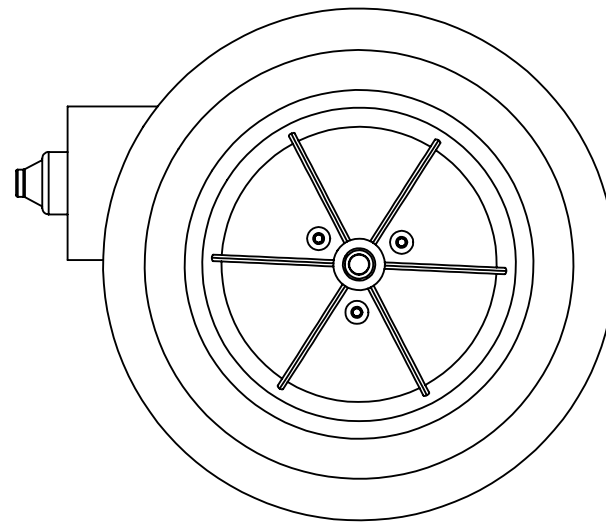
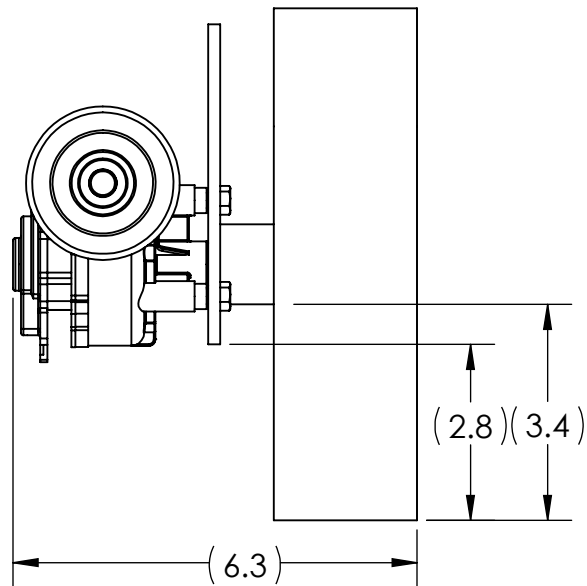
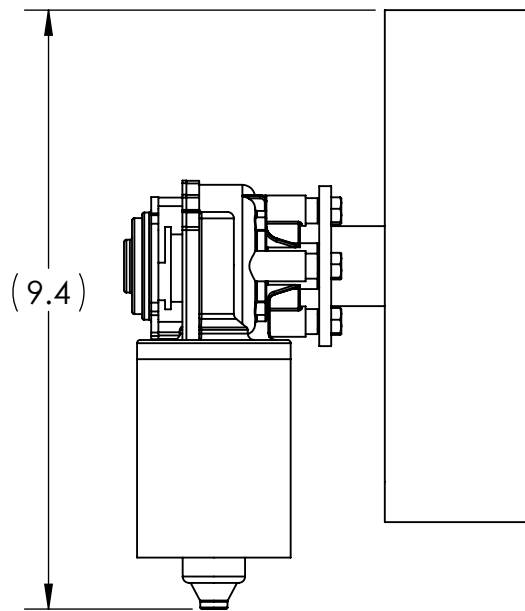
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
12	EML2322L-OTS22	8" Wheel Type 1	1
13	EML2322L-013	Entstort Wheel Hub	1
14	EML2322L-014	10-24 1" Button Head Screw	3
15	EML2322L-OTS31	44 RPM Entstort Right Angle Gear Motor	1
16	EML2322L-016	Entstort Motor Mount	1
17	EML2322L-017	M6-20mm Hex Head Screw	3
18	EML2322L-018	M8 x 1.25 Hex Nut	1



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

TITLE:			
Drive Assembly			
DRAWN COLTON MAYS			
DESIGNED CYRIL MORAN			
SIZE	DWG. NO.		REV
A	EML2322L-A-002		B
SCALE: 1:3		SHEET 2 OF 3	

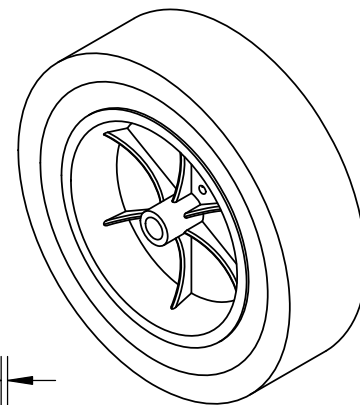
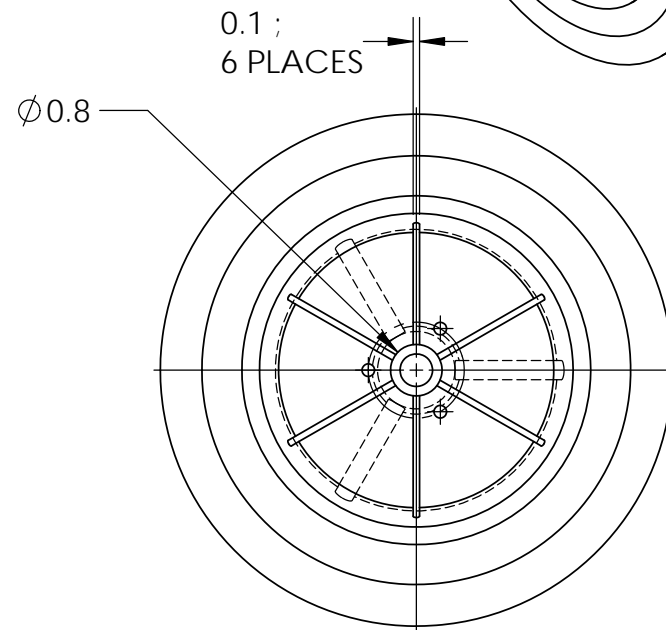
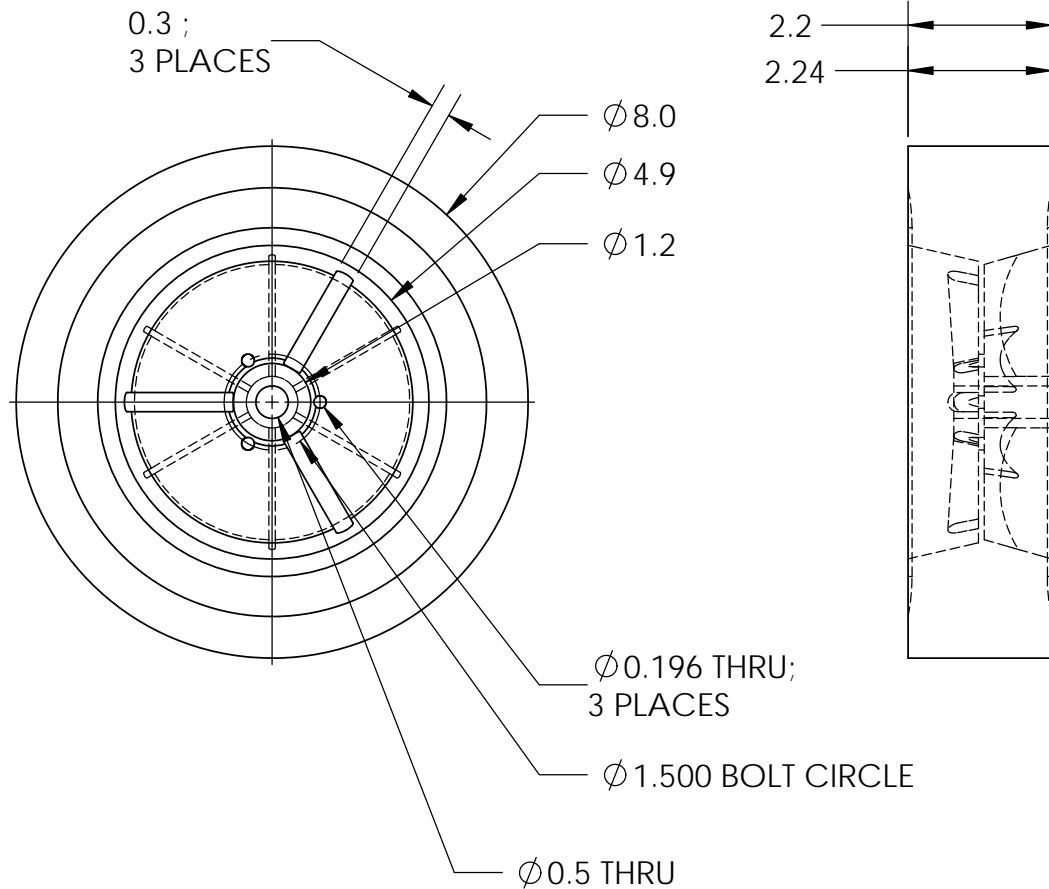
TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5



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

TITLE:				Drive Assembly			
DRAWN		COLTON MAYS					
DESIGNED		CYRIL MORAN					
SIZE		DWG. NO.				REV	
A		EML2322L-A-002				A	
SCALE: 1:3					SHEET 3 OF 3		

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

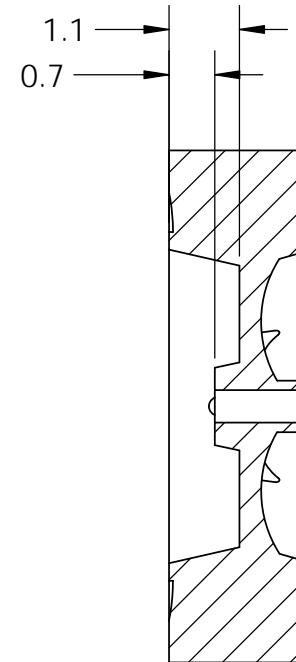
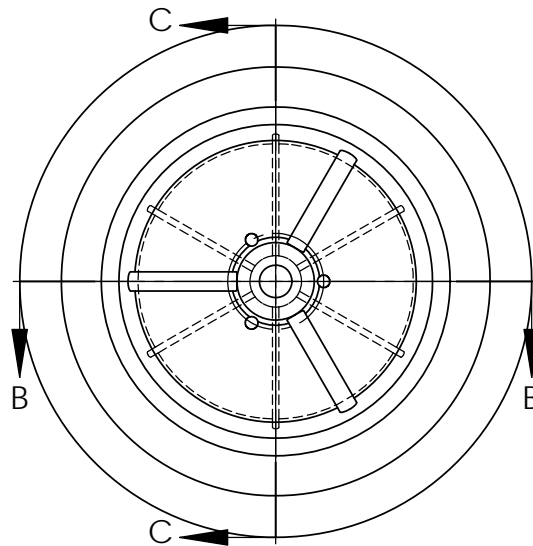
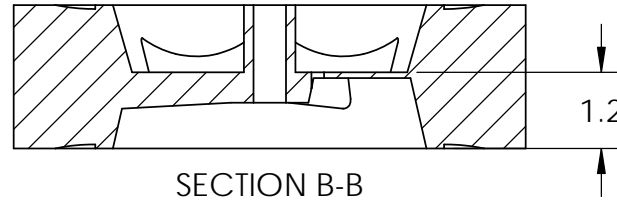


NOTES:

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

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Academic Use Only

TOLERANCE UNLESS NOTED				TITLE:		
MEASURING INSTRUMENT	PLACES IN DIMENSION			8 Inch Wheel Type 1		
	0.0	0.00	0.000	DRAWN	J. DERSCH	
CALIPERS			±0.005	DESIGNED	ARNOLD	
PRECISION RULER		±0.015		SIZE	DWG. NO.	REV
TAPE MEASURE	±0.030			A	EML2322L-OTS22	A
PROTRACTOR	±10	±5	±2	SCALE: 1:3		SHEET 1 OF 2



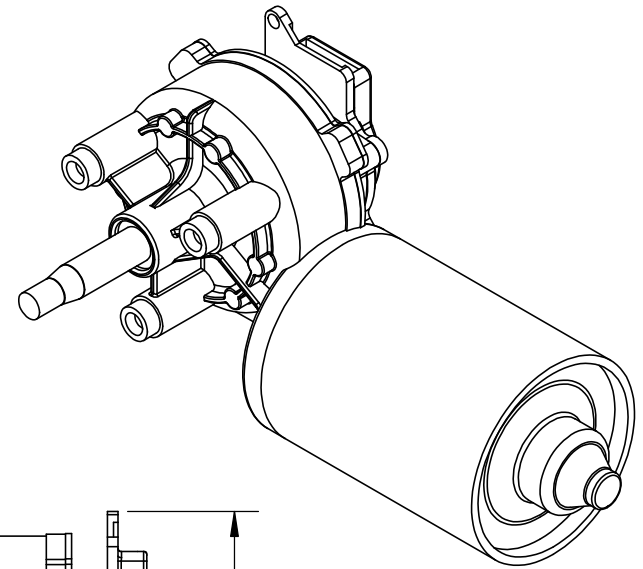
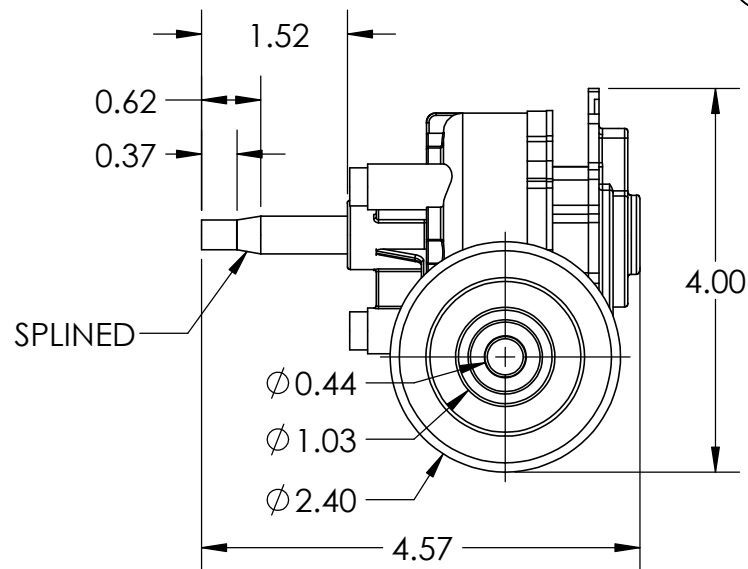
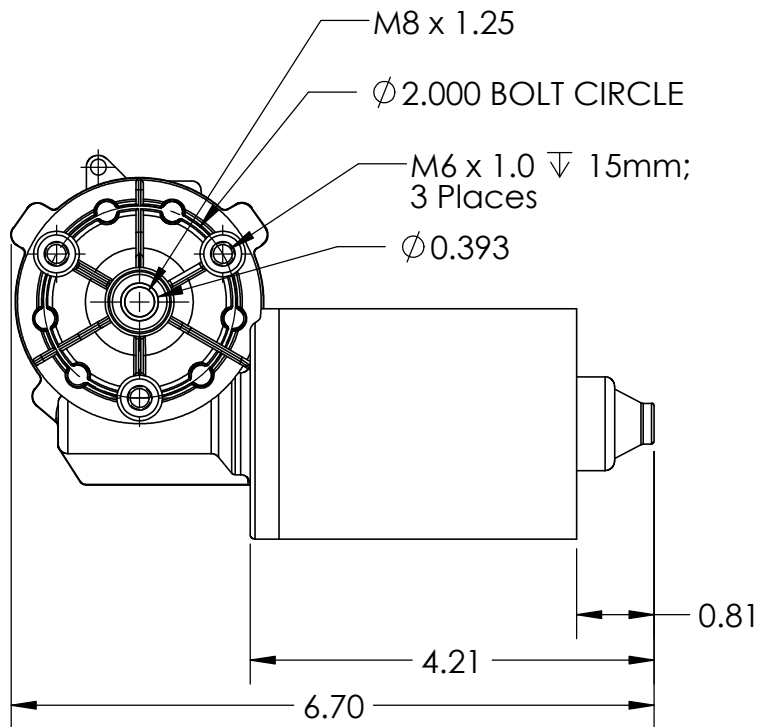
SECTION C-C

NOTES:

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

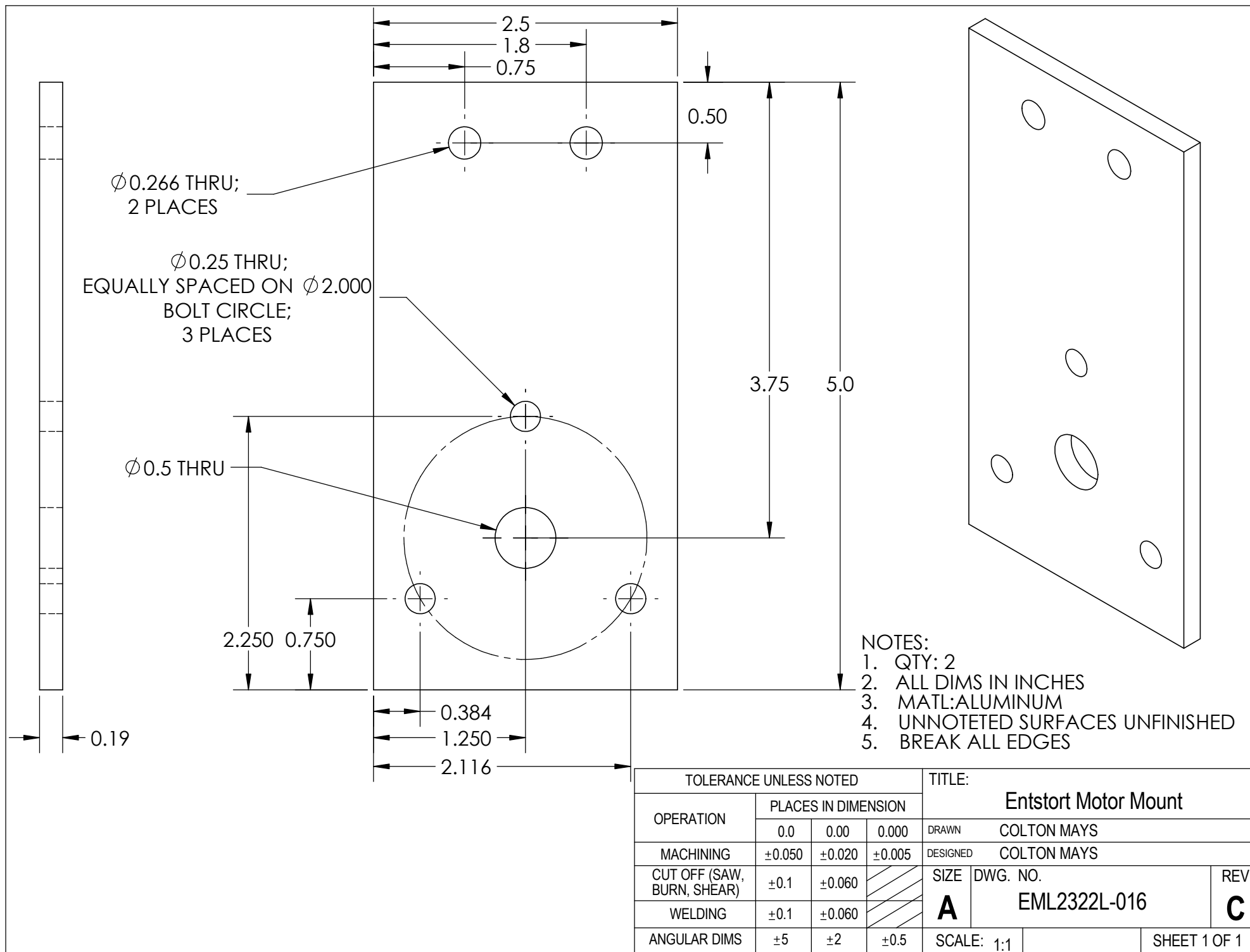
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Academic Use Only

TOLERANCE UNLESS NOTED				TITLE: 8 Inch Wheel Type 1			
MEASURING INSTRUMENT	PLACES IN DIMENSION						
	0.0	0.00	0.000	DRAWN	J. DERSCH		
CALIPERS			±0.005	DESIGNED	ARNOLD		
PRECISION RULER		±0.015		SIZE	DWG. NO.		REV
TAPE MEASURE	±0.030			A	EML2322L-OTS22		A
PROTRACTOR	±10	±5	±2	SCALE: 1:3		SHEET 2 OF 2	

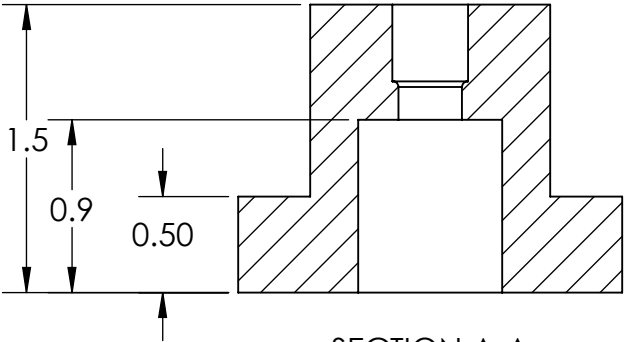
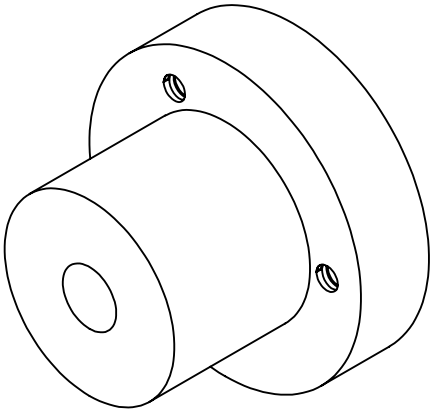
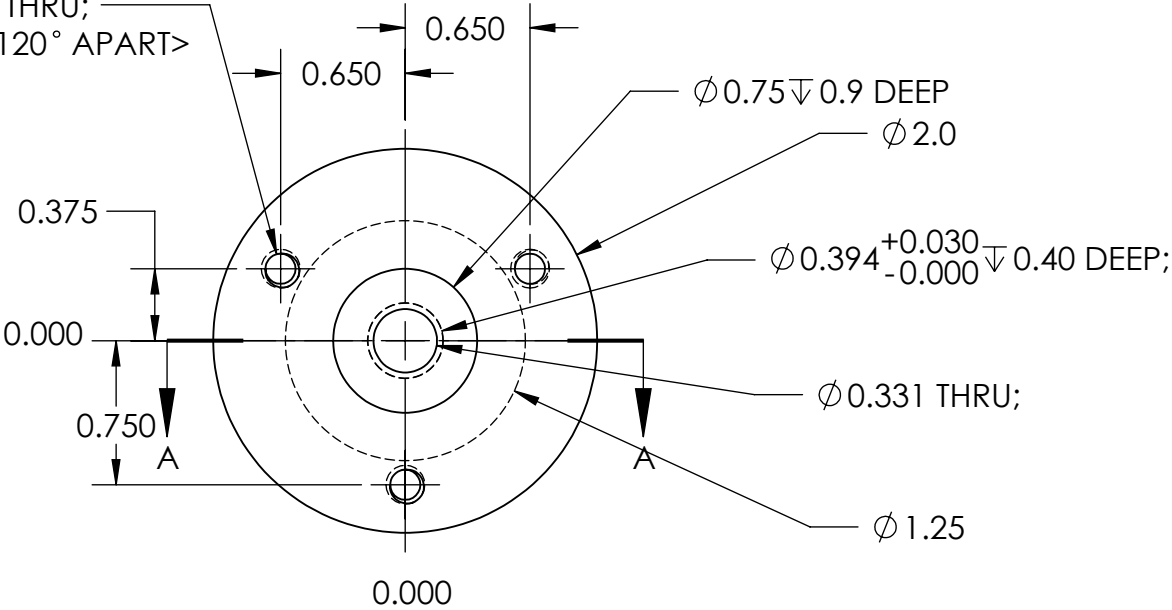


- NOTES:
1. DIMS IN INCHES
 2. QTY SPECIFIED IN BOM
 3. DIMS AND MAT'L SPECIFIED BY MANUFACTURER

TOLERANCE UNLESS NOTED				TITLE:		
MEASURING INSTRUMENT	PLACES IN DIMENSION			44 RPM Entstort Right Angle Gear Motor		
	0.0	0.00	0.000	DRAWN	J. DERSCH	
CALIPERS			±0.005	DESIGNED	ENTSTORT	
PRECISION RULER		±0.015		SIZE	DWG. NO.	REV
TAPE MEASURE	±0.030			A	EML2322L-OTS31	A
PROTRACTOR	±10	±5	±2	SCALE: 1:2		SHEET 1 OF 1

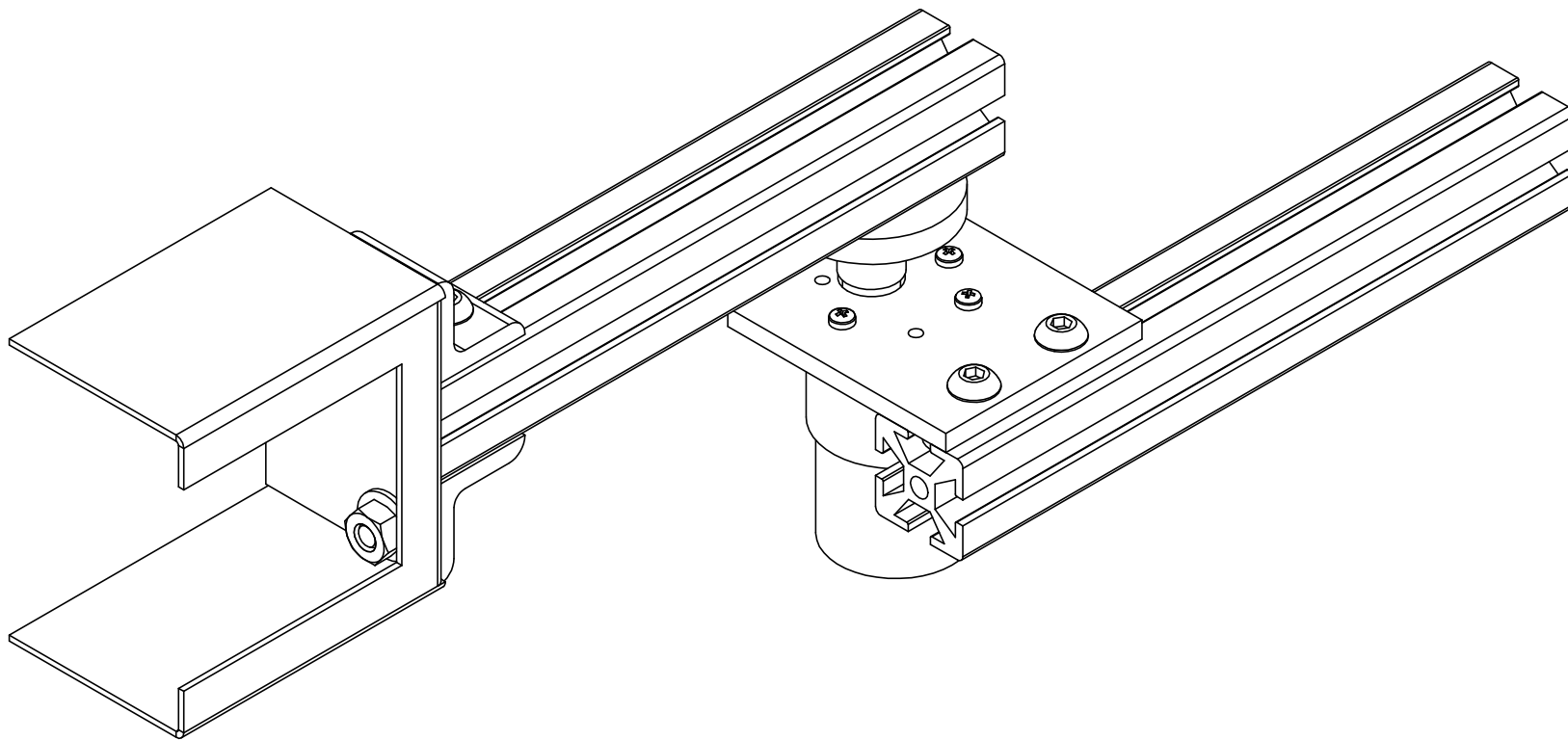


$\varnothing 0.157$ THRU;
 10-24 UNC THRU;
 3 PLACES <120° APART>



- NOTES:
1. DIMS IN INCHES
 2. QUANTITY: 1
 3. MAT'L ALUMINUM
 4. BREAK ALL EDGES
 5. FINISH NOTES SURFACES

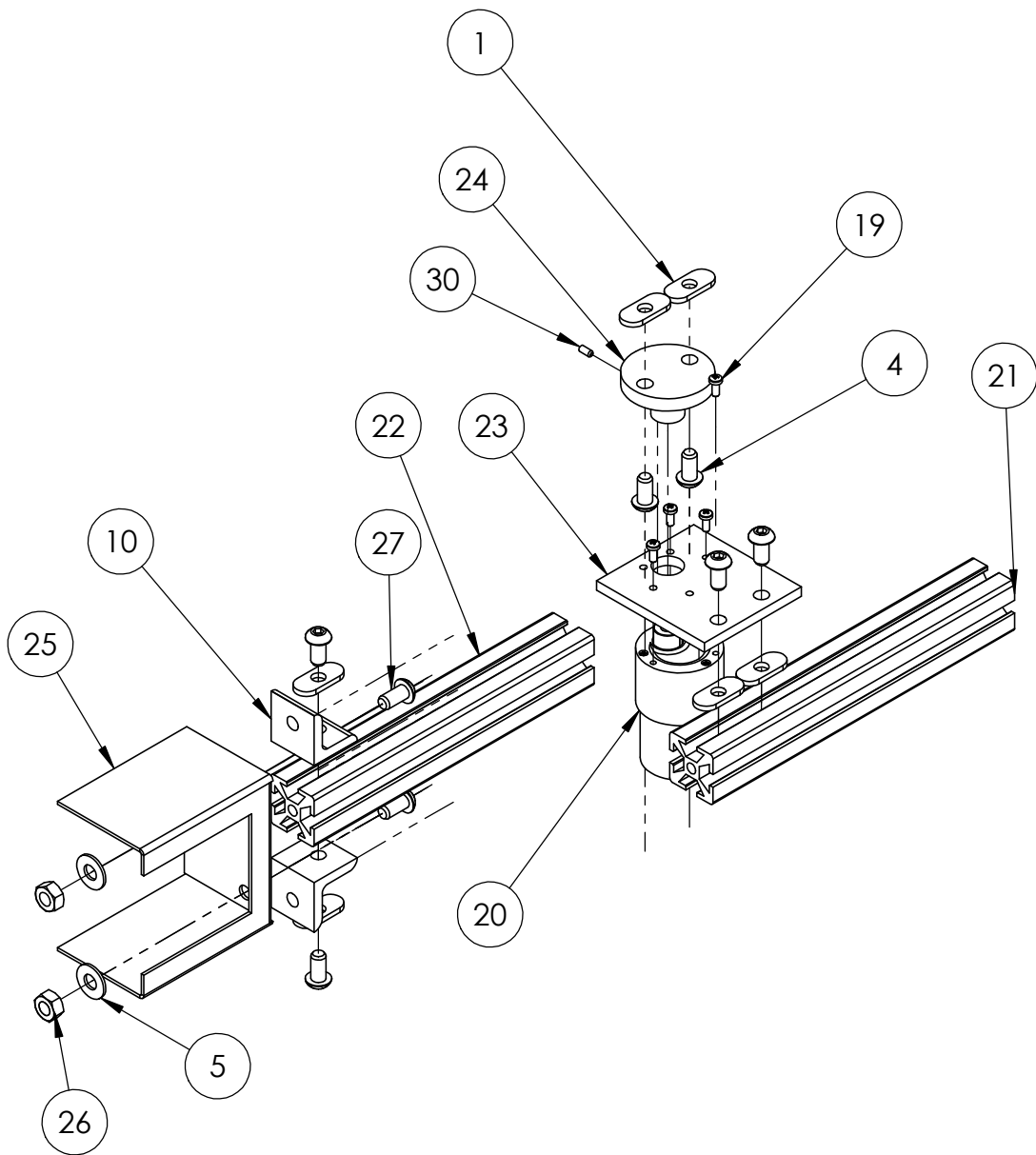
TOLERANCE UNLESS NOTED				TITLE:			
OPERATION	PLACES IN DIMENSION			Entstort Wheel Hub			
	0.0	0.00	0.000	DRAWN	CYRIL MORAN		
MACHINING	±0.050	±0.020	±0.005	DESIGNED	CYRIL MORAN		
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060	<div></div>	SIZE	DWG. NO.		REV
WELDING	±0.1	±0.060	<div></div>	A	EML2322L-013		C
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:1			SHEET 1 OF 1



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

TITLE:			
Lever Arm			
DRAWN COLTON MAYS			
DESIGNED COLTON MAYS			
SIZE	DWG. NO.		REV
A	EML2322L-A-005		A
SCALE: 2:3		SHEET 1 OF 3	

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

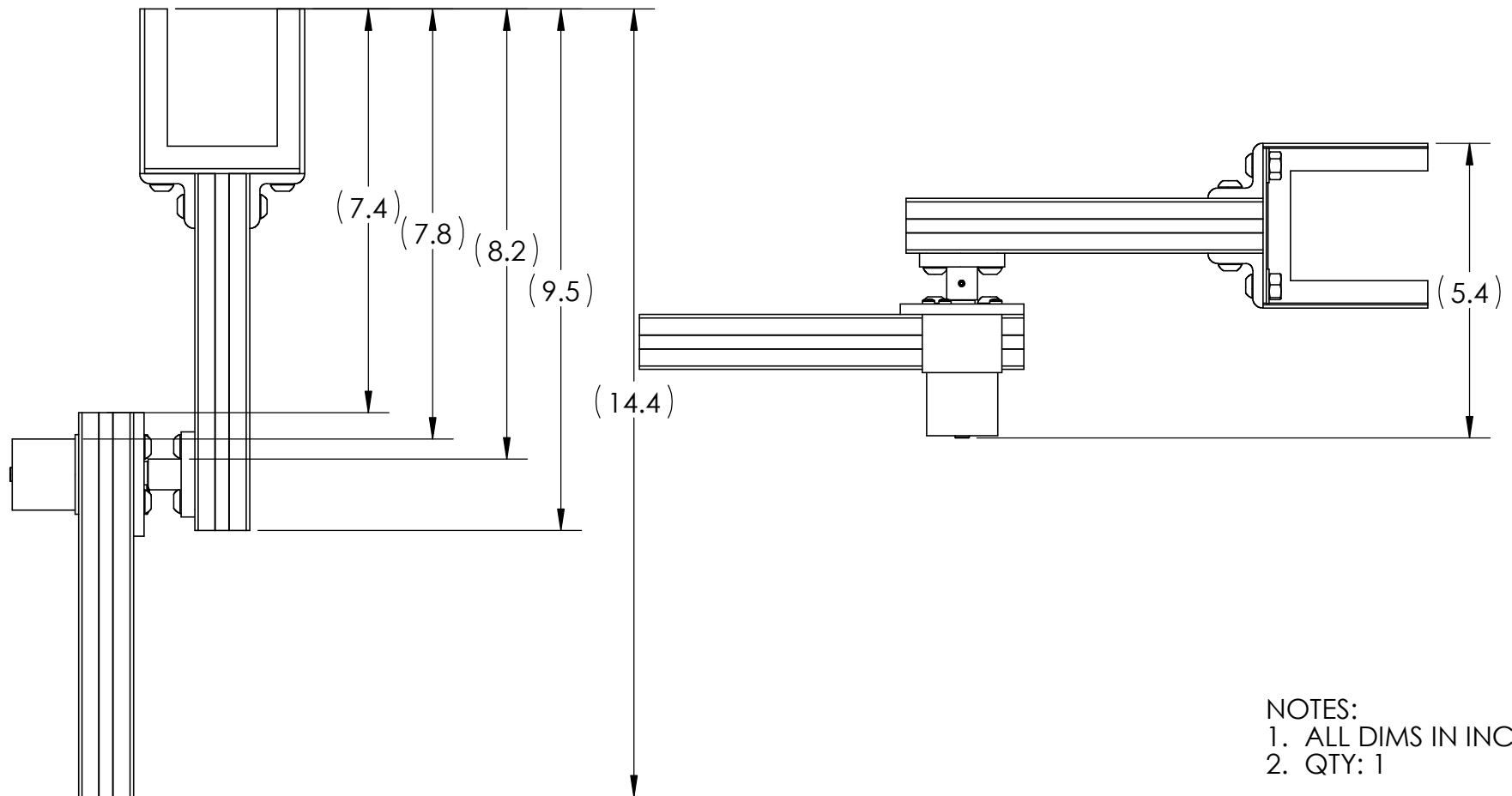


ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	EML2322L-OTS6	1/4-20 T-Nut	6
4	EML2322L-OTS7	1/4-20 x1/2" BHCS	6
5	EML2322L-005	1/4" Washer	2
10	EML2322L-OTS12	80/20 90 Degree Angle Bracket	2
19	EML2322L-019	M3 X 10mm Screw	4
20	EML2322L-OTS29	15 RPM SEI Gear Motor	1
21	EML2322L-021	80-20 Extrusion. 7.0"	1
22	EML2322L-022	80-20 Extrusion, 6.5"	1
23	EML2322L-023	15RPM SEI Gear Motor Mount	1
24	EML2322L-024	15 RPM SEI Gear Wheel Hub Lever Arm	1
25	EML2322L-025	Ball Grabber	1
26	EML2322L-026	1/4-20 Hex Nut	2
27	EML2322L-027	1/4-20 X 3/8" BHCS	2
30	EML2322L-030	4-40 1/4" Set Screw	1

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

TITLE: Lever Arm			
DRAWN COLTON MAYS			
DESIGNED COLTON MAYS			
SIZE A	DWG. NO. EML2322L-A-005		REV B
SCALE: 1:3		SHEET 2 OF 3	

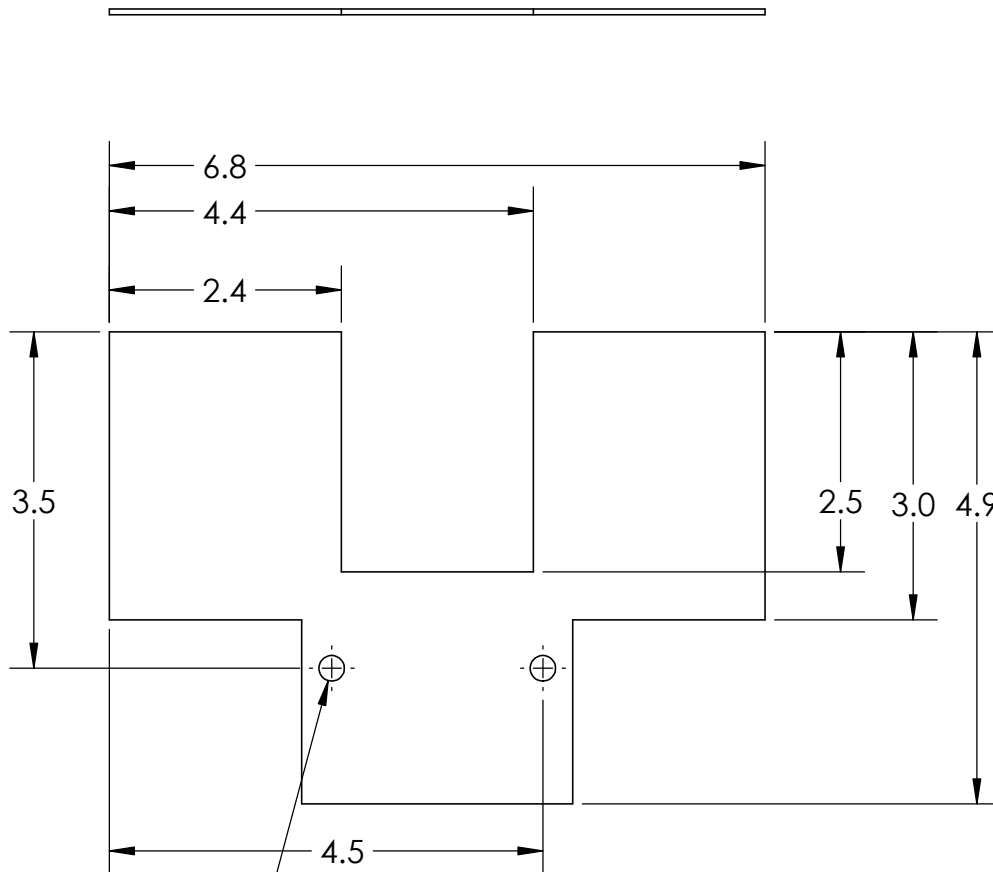
TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5



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

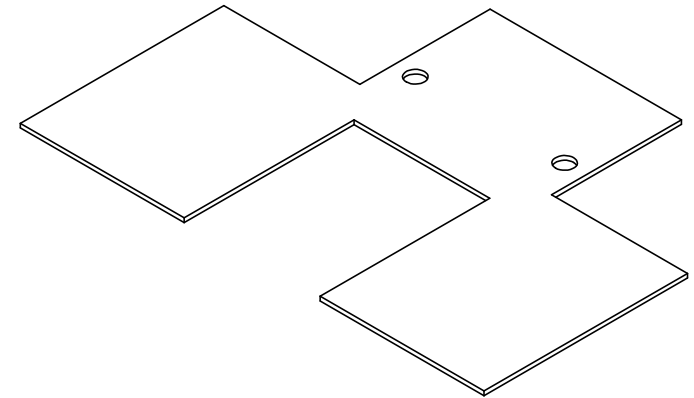
TITLE:			
Lever Arm			
DRAWN		COLTON MAYS	
DESIGNED		COLTON MAYS	
SIZE	DWG. NO.		REV
A	EML2322L-A-005		B
SCALE: 1:3		SHEET 3 OF 3	

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



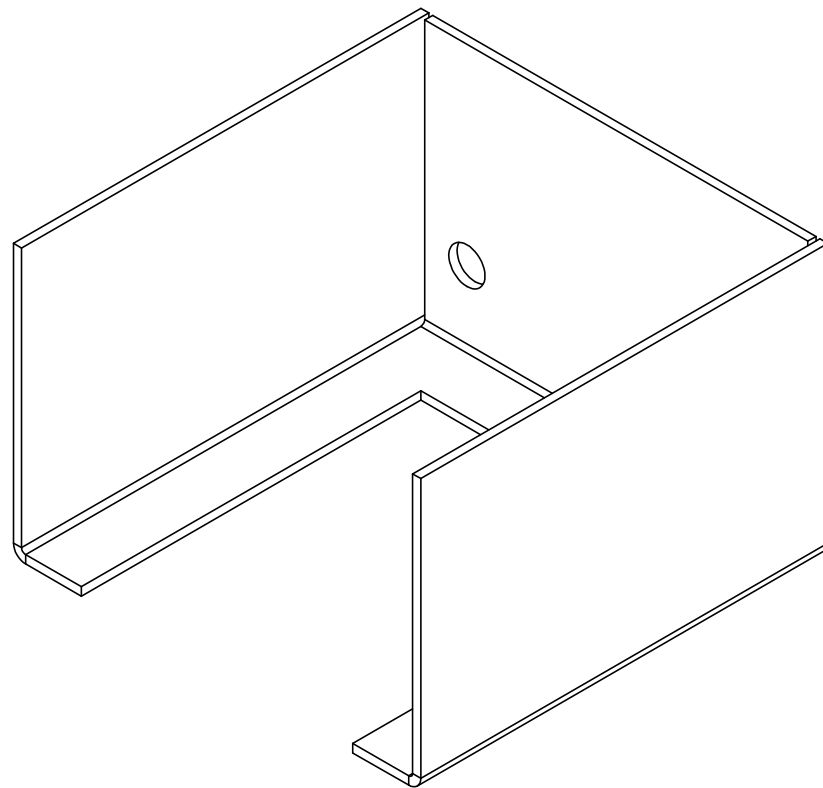
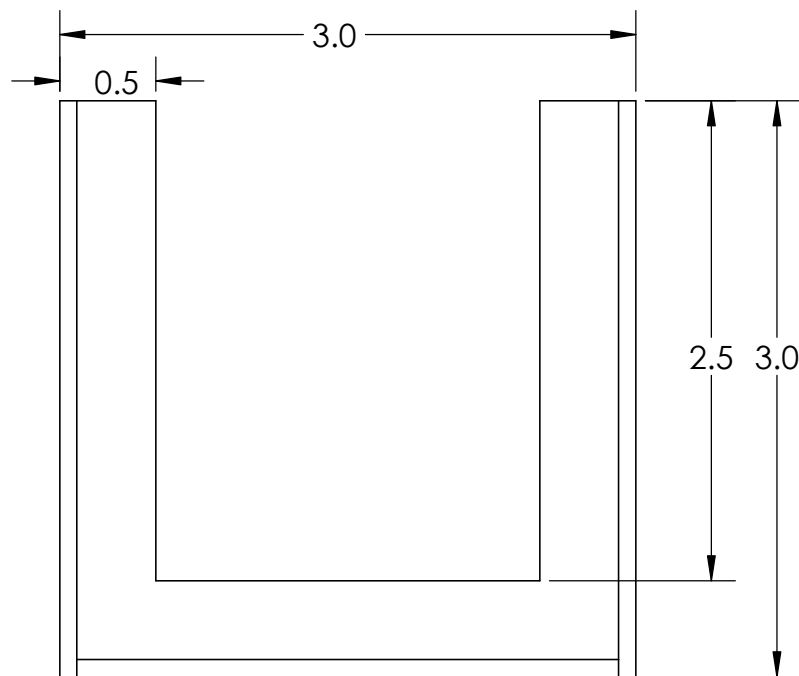
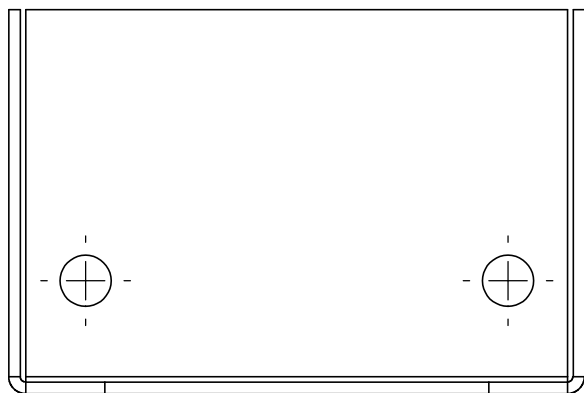
Ø 0.27 THRU; 2 PLACES

UNFOLDED VIEW
(IF APPLICABLE)



- NOTES:
 1. DIMS IN INCHES
 2. QTY: 1
 3. FINISH NOTED SURFACES
 4. MAT'L: 16 GAUGE STEEL SHEET METAL
 5. BREAK ALL EDGES

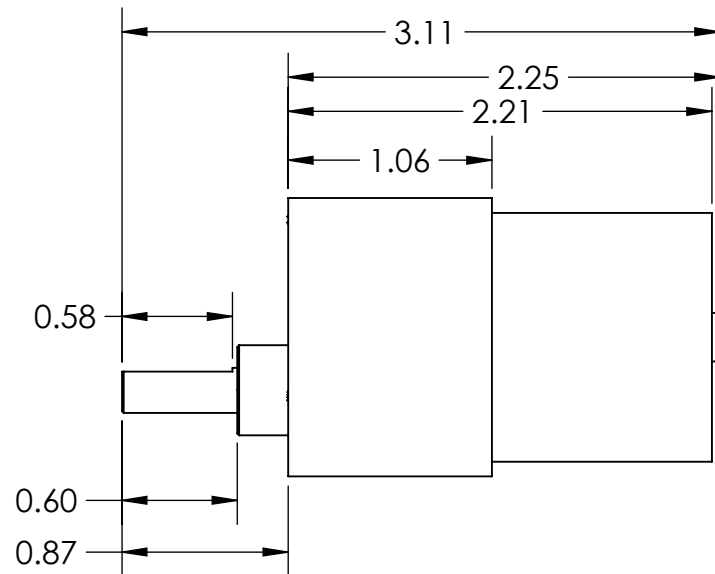
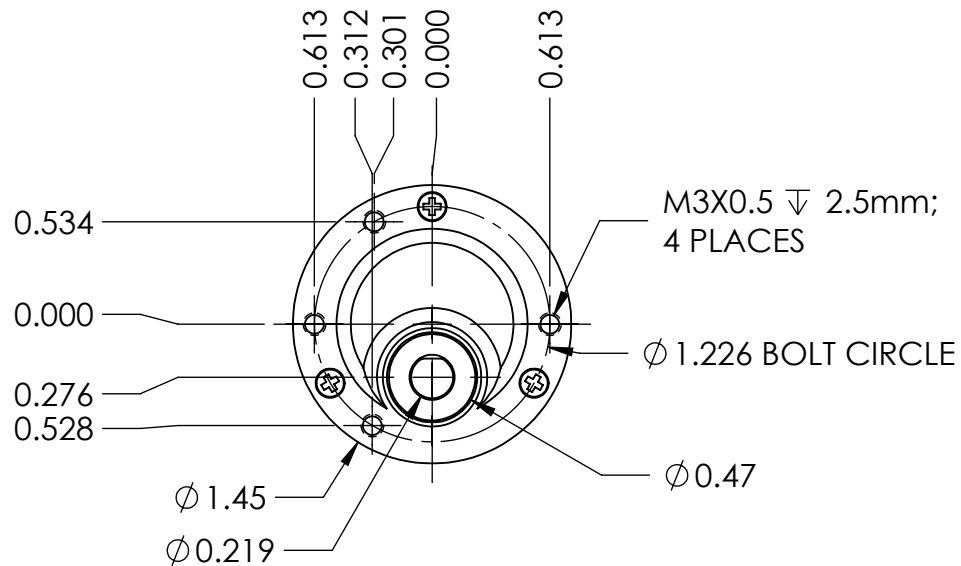
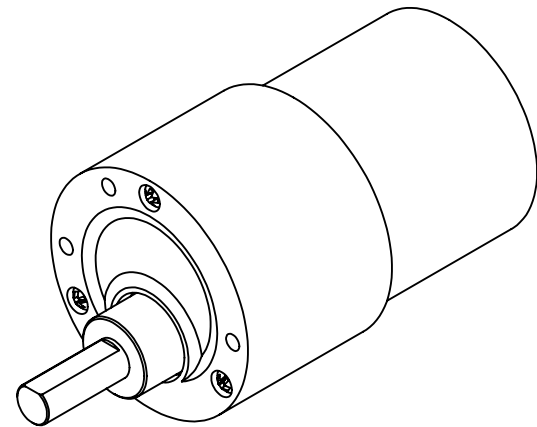
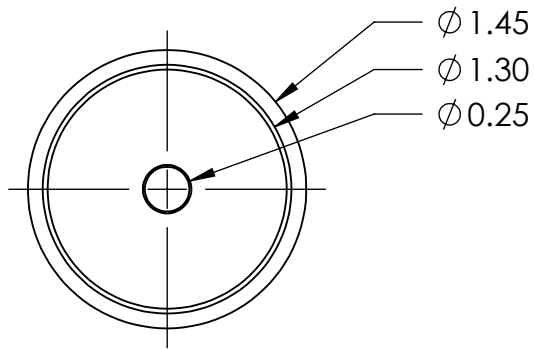
TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Ball Grabber Part		
	0.0	0.00	0.000	DRAWN	COLTON MAYS	
MACHINING				DESIGNED	COLTON MAYS	
SHEETMETAL (SHEAR, BEND)	±0.1	±0.060	±0.030	SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-025	B
ANGULAR DIMS	±5	±2		SCALE	1:2	SHEET 1 OF 2
			3			1
			2			



- NOTES:
1. ALL DIMS IN INCHES
 2. QTY: 1
 3. FINISH NOTED SURFACES
 4. MAT'L 16 GAUGE SHEET METAL
 5. BREAK ALL EDGES

FOLDED VIEW
(IF APPLICABLE)

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Ball Grabber Part		
	0.0	0.00	0.000	DRAWN	CYRIL MORAN	
MACHINING				DESIGNED	CYRIL MORAN	
SHEETMETAL (SHEAR, BEND)	±0.1	±0.060	±0.030	SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-025	B
ANGULAR DIMS	±5	±2		SCALE:	1:1	SHEET 2 OF 2
3	2			1		



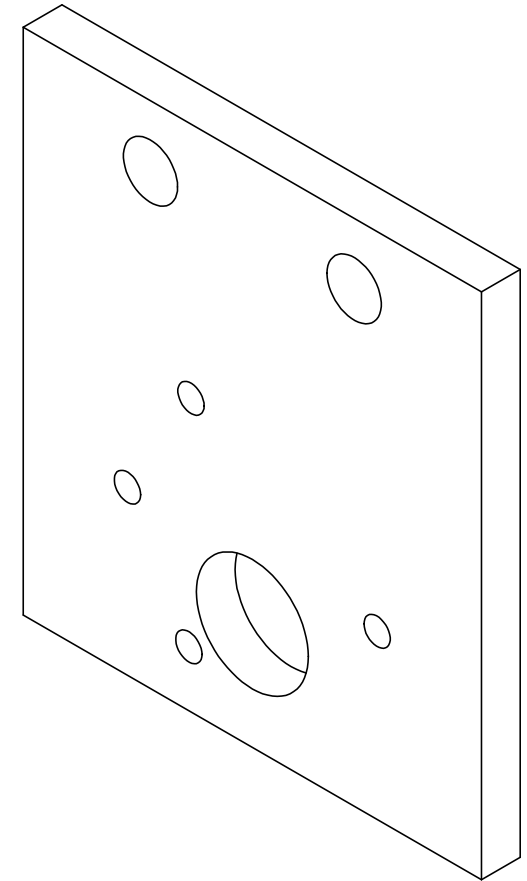
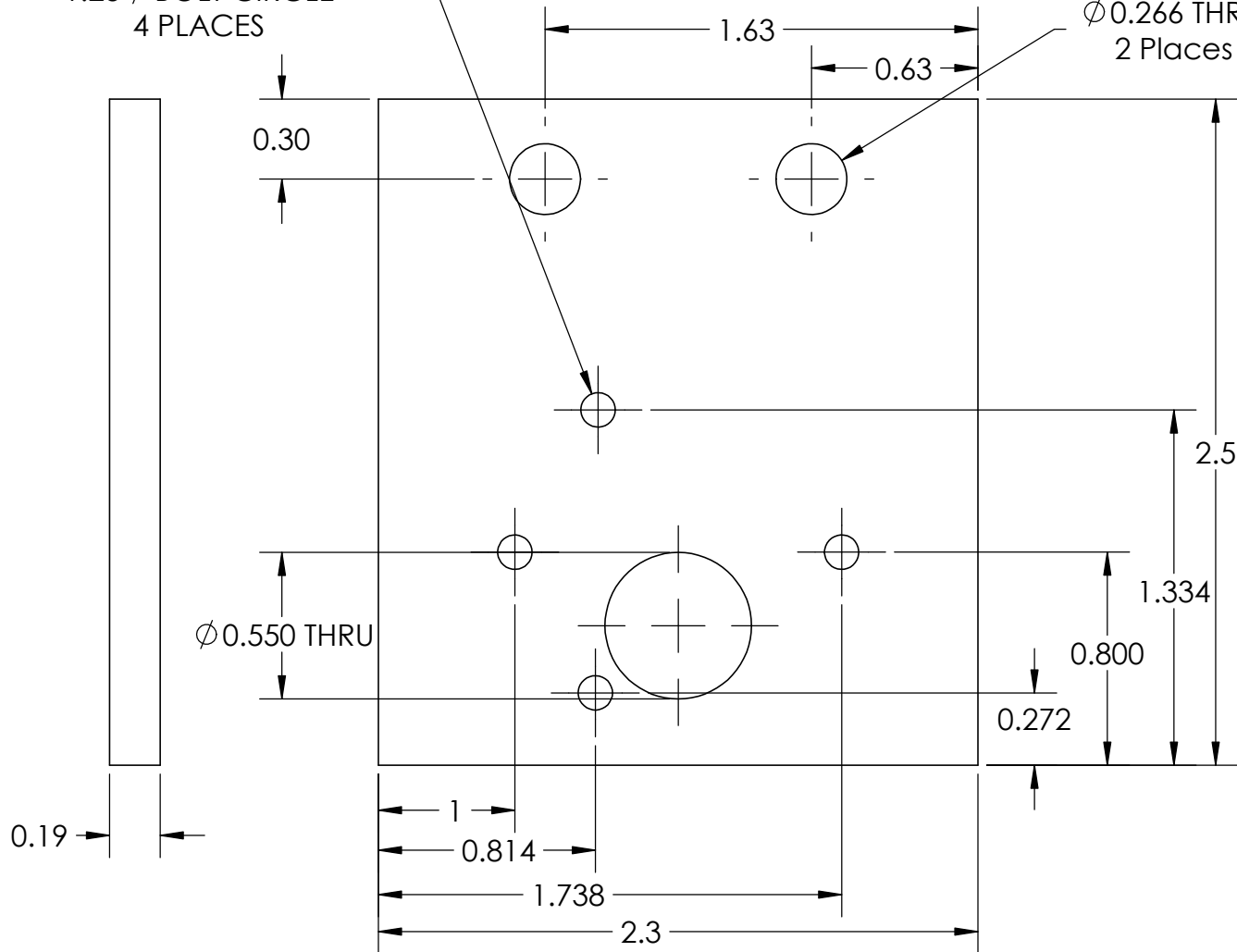
NOTES:

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

TOLERANCE UNLESS NOTED				TITLE:		
MEASURING INSTRUMENT	PLACES IN DIMENSION			15 RPM SEI Gear Motor		
	0.0	0.00	0.000	DRAWN	A. LEWIS	
CALIPERS			±0.005	DESIGNED	SEI	
PRECISION RULER		±0.015		SIZE	DWG. NO.	REV
TAPE MEASURE	±0.030			A	EML2322L-OTS29	A
PROTRACTOR	±10	±5	±2	SCALE: 1:1		SHEET 1 OF 1

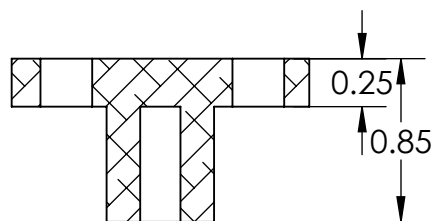
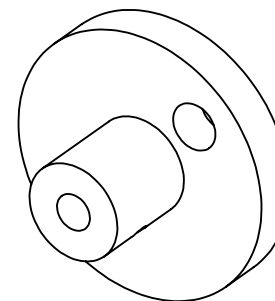
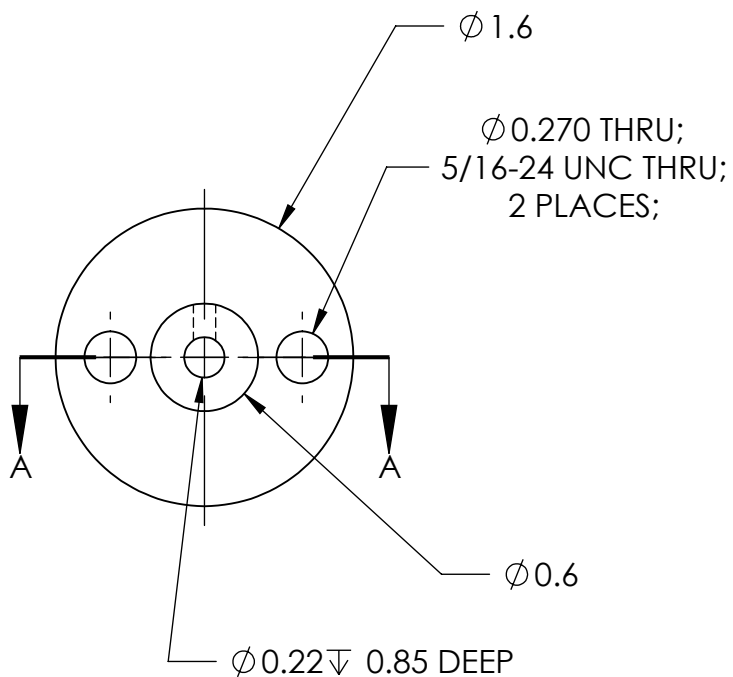
Ø0.129 THRU; SPACED ON
1.23 Ø BOLT CIRCLE
4 PLACES

Ø0.266 THRU:
2 Places



- NOTES:
1. ALL DIMS IN INCHES
 2. QTY 2
 3. MAT'L ALUMINUM
 4. FINISH NOTED SURFACES
 5. BREAK ALL EDGES

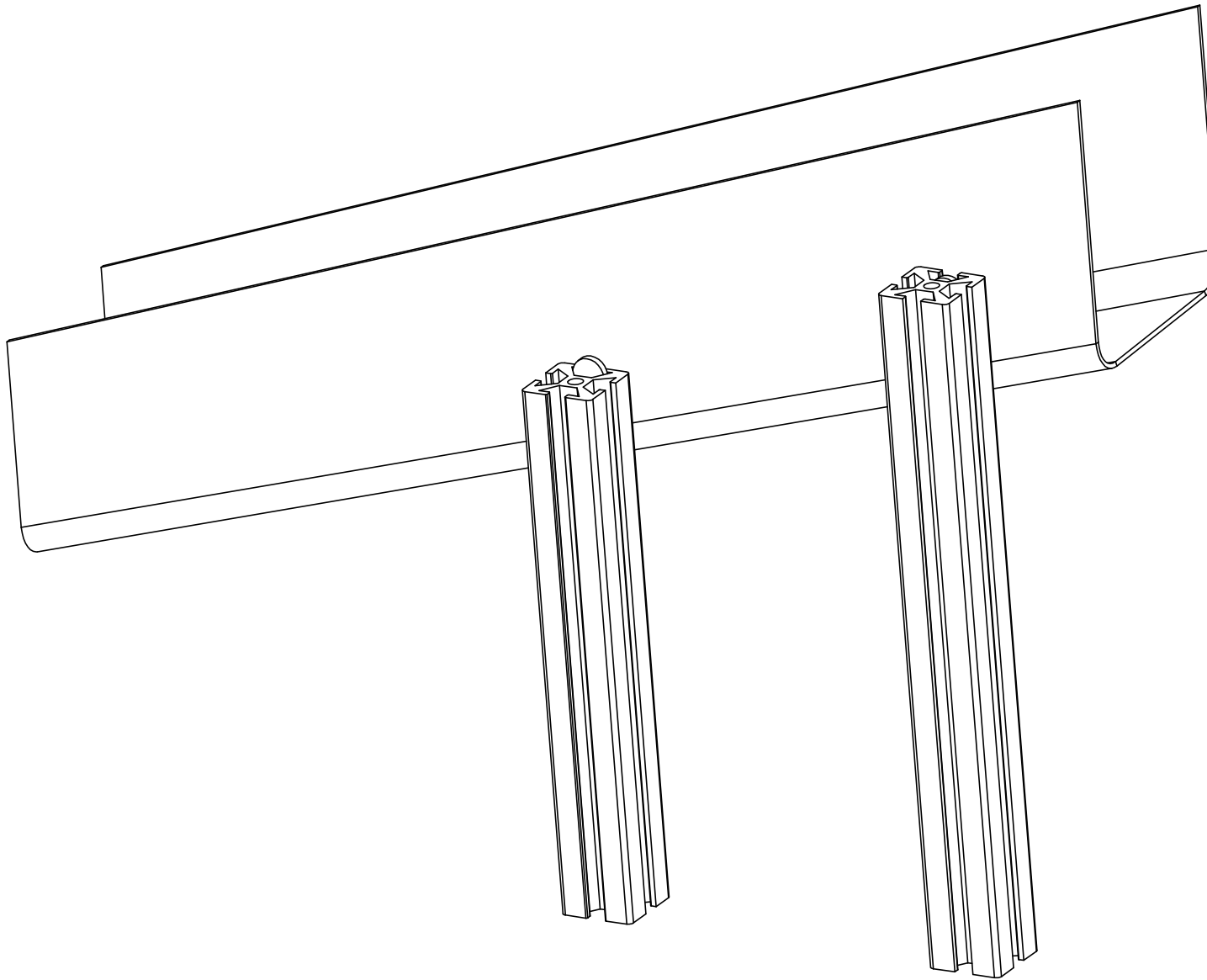
TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			15 RPM SEI Gear Motor Mount		
	0.0	0.00	0.000	DRAWN	COLTON MAYS	
MACHINING	±0.050	±0.020	±0.005	DESIGNED	COLTON MAYS	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-023	B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1.5:1	SHEET 1 OF 1	



SECTION A-A

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

TOLERANCE UNLESS NOTED				TITLE: 15 RPM SEI Gear Motor Hub Lever Arm				
OPERATION	PLACES IN DIMENSION							
	0.0	0.00	0.000	DRAWN CYRIL MORAN				
MACHINING	±0.050	±0.020	±0.005	DESIGNED CYRIL MORAN				
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060	<div></div>	SIZE	DWG. NO.			REV
WELDING	±0.1	±0.060	<div></div>	A	EML2322L-024			B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:1		SHEET 1 OF 1		

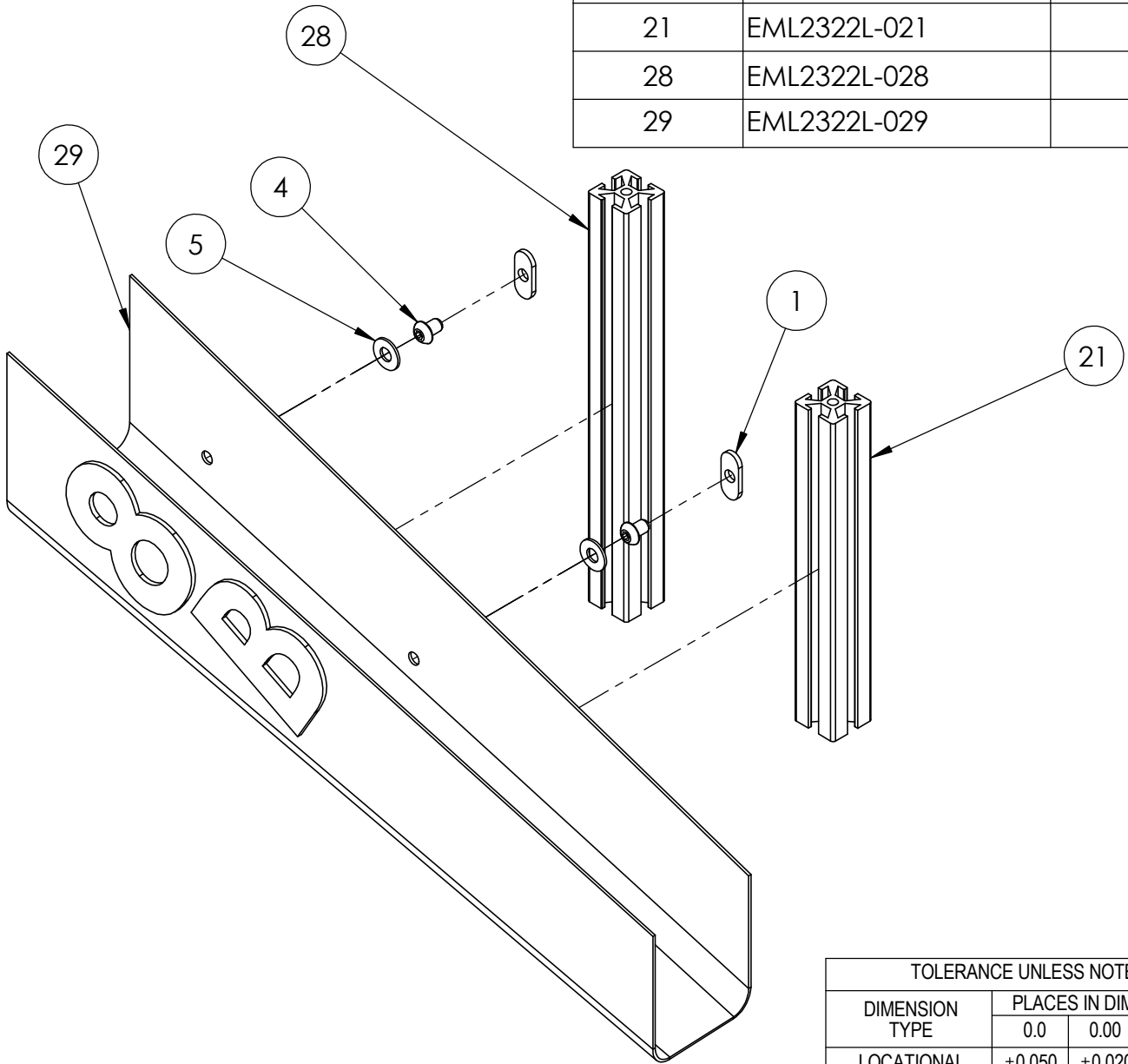


NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TITLE:				Ball Hopper		
DRAWN				COLTON MAYS		
DESIGNED				WYNN FUREY		
SIZE		DWG. NO.				REV
A		EML2322L-A-006				A
SCALE: 1:2					SHEET 1 OF 3	

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

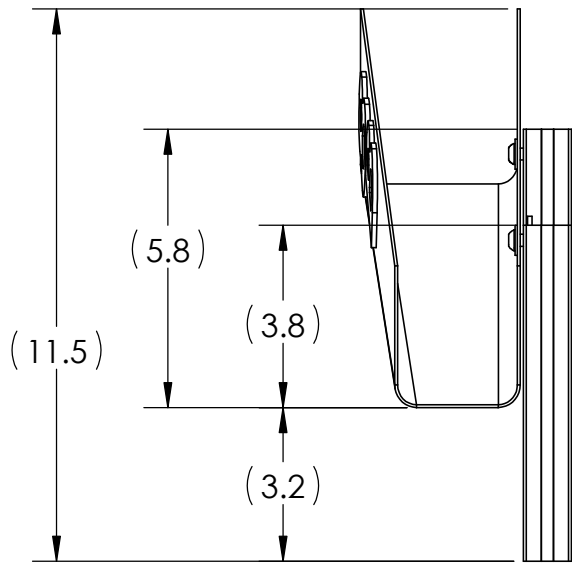
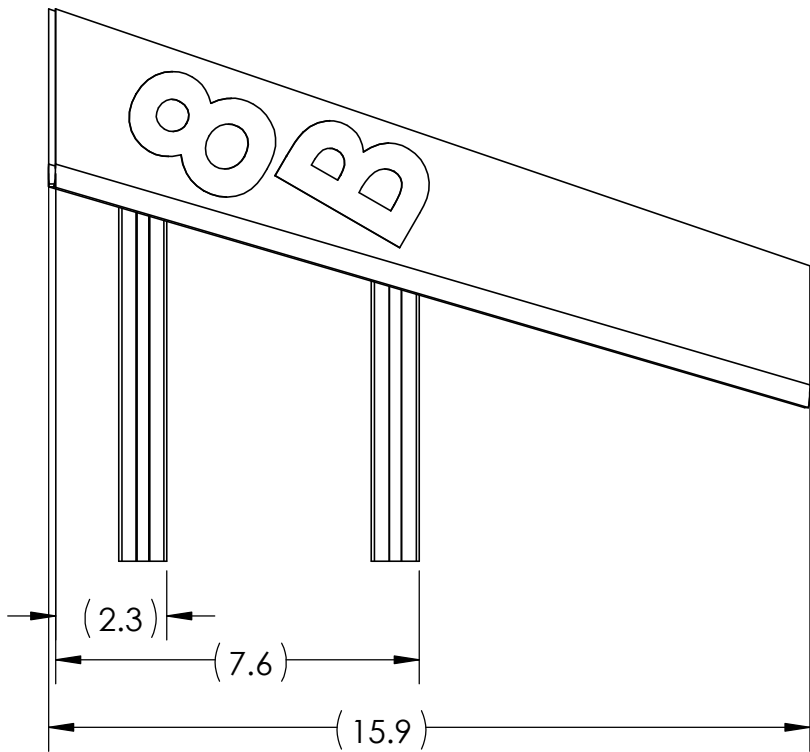
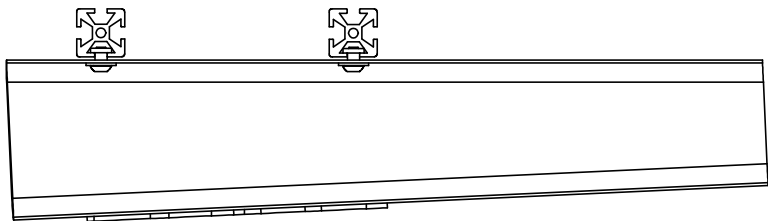
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	EML2322L-OTS6	1/4-20 T-Nut	2
4	EML2322L-OTS7	1/4-20 X 1/2 inch BHCS	2
5	EML2322L-005	1/4" Washer	2
21	EML2322L-021	80-20 Extrusion, 7.0"	1
28	EML2322L-028	80-20 Extrusion, 9.0"	1
29	EML2322L-029	Ball Hopper Part	1



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

TITLE: Ball Hopper			
DRAWN COLTON MAYS			
DESIGNED WYNN FUREY			
SIZE A	DWG. NO. EML2322L-A-006		REV A
SCALE: 1:3		SHEET 2 OF 3	

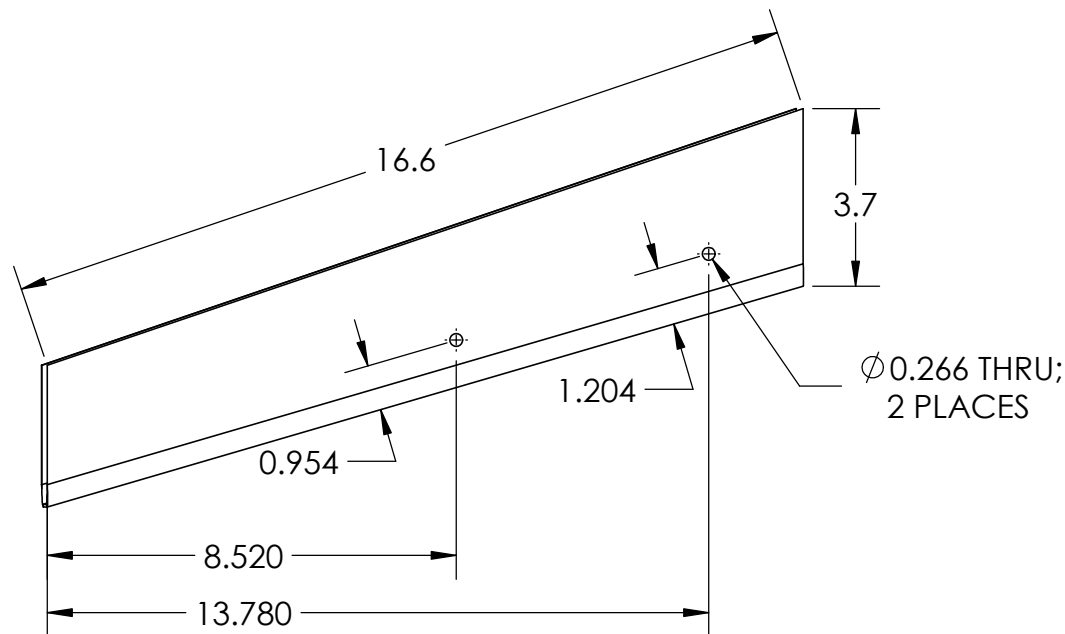
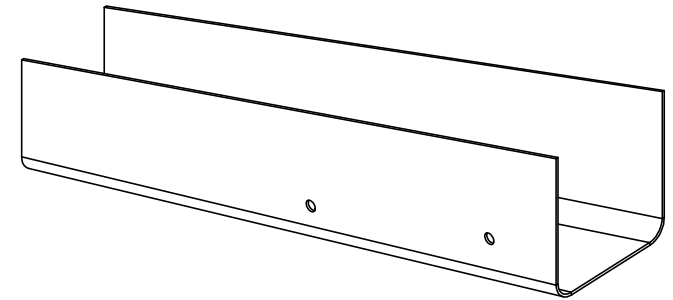
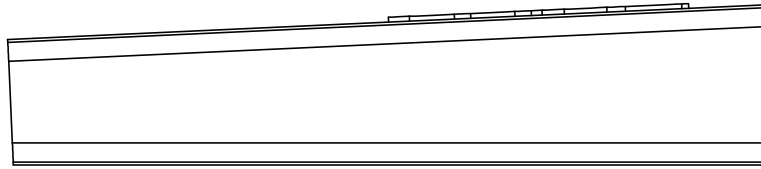
TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5



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

TITLE:			
Ball Hopper			
DRAWN COLTON MAYS			
DESIGNED WYNN FUREY			
SIZE	DWG. NO.		REV
A	EML2322L-A-006		A
SCALE: 1:4		SHEET 3 OF 3	

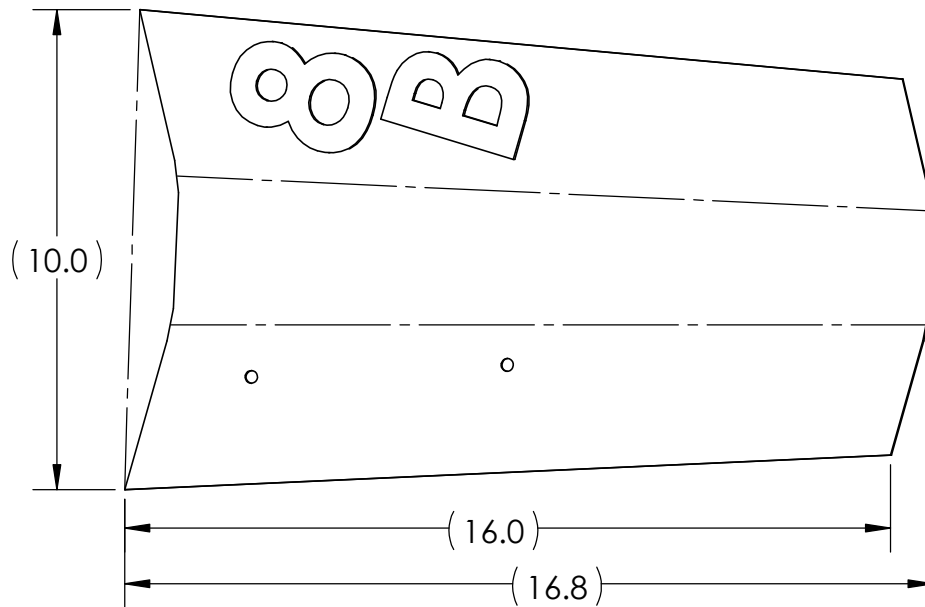
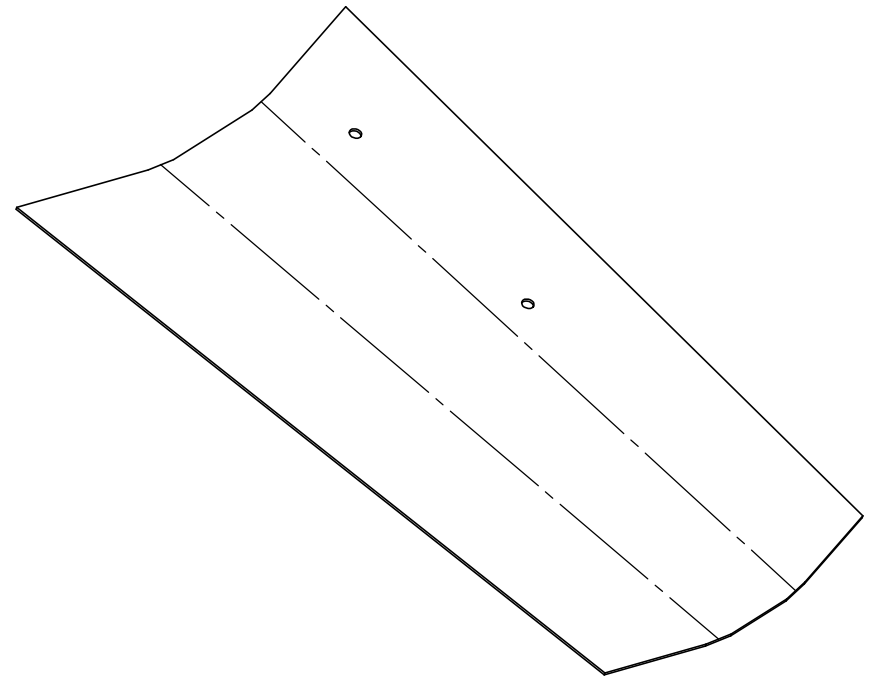
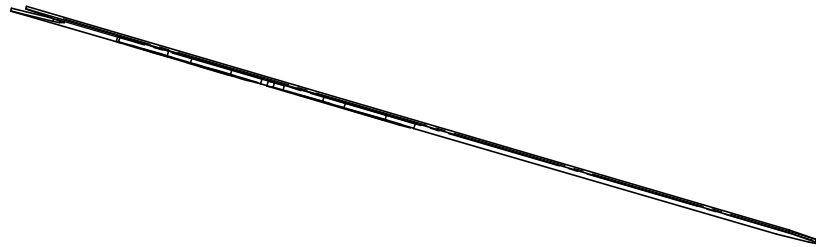
TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5



FOLDED VIEW
(IF APPLICABLE)

- NOTES:
1. DIMS IN INCHES
 2. QTY: 1
 3. MAT'L 18 GAUGE SHEET METAL
 4. BREAK ALL EDGES
 5. FINISH NOTED SURFACES

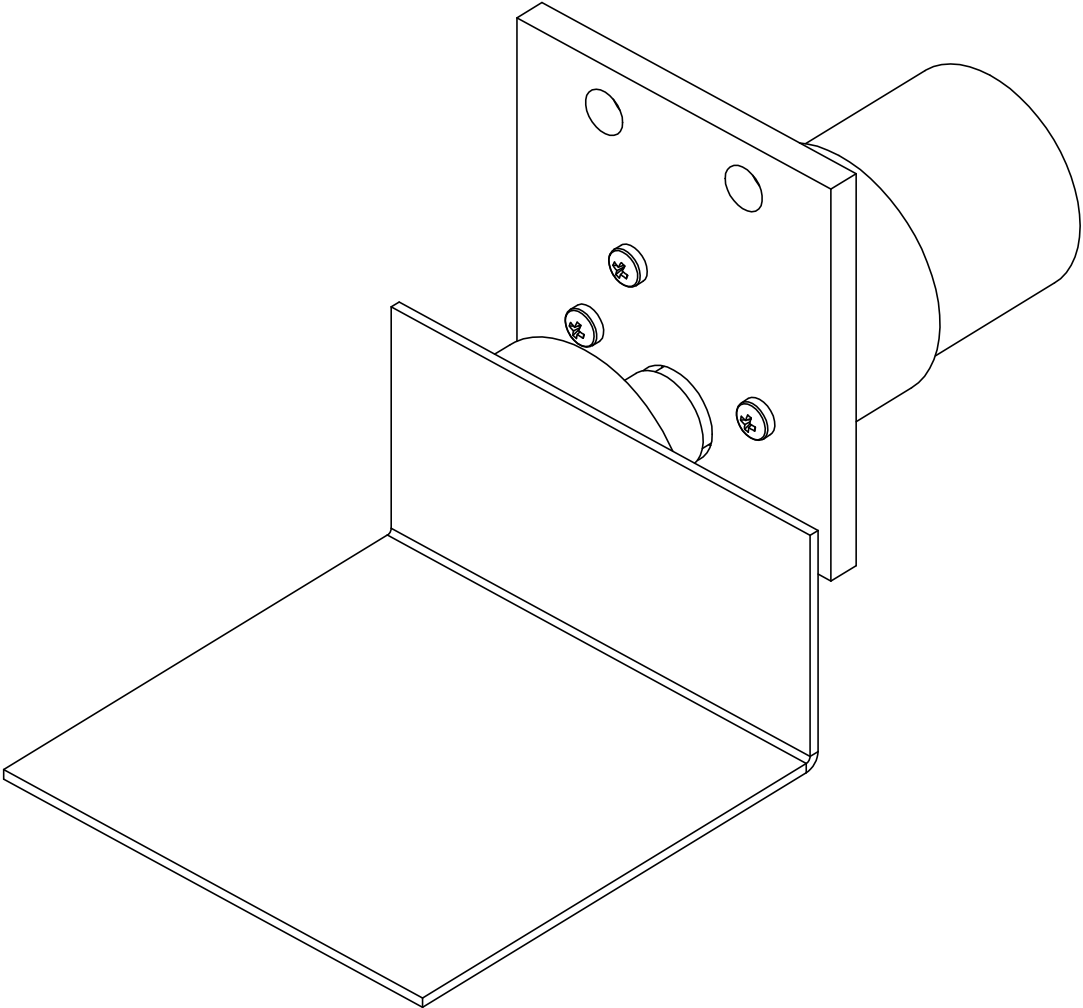
TOLERANCE UNLESS NOTED				TITLE: Ball Hopper Part		
OPERATION	PLACES IN DIMENSION					
	0.0	0.00	0.000	DRAWN	COLTON MAYS	
MACHINING				DESIGNED	WYNN FUREY	
SHEETMETAL (SHEAR, BEND)	±0.1	±0.060	±0.030	SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-029	B
ANGULAR DIMS	±5	±2				
				SCALE: 1:4		SHEET 1 OF 2



UNFOLDED VIEW
(IF APPLICABLE)

- NOTES:
 1. DIMS IN INCHES
 2. QTY: 1
 3. MTL: 16 GA SHEET METAL
 4. FINISH NOTED SURFACES
 5. BREAK ALL EDGES

TOLERANCE UNLESS NOTED				TITLE: Ball Hopper Part		
OPERATION	PLACES IN DIMENSION			DRAWN COLTON MAYS		
	0.0	0.00	0.000	DESIGNED WYNN FUREY		
MACHINING				SIZE DWG. NO. REV		
SHEETMETAL (SHEAR, BEND)	±0.1	±0.060	±0.030	A EML2322L-029		B
WELDING	±0.1	±0.060		SCALE: 1:4		
ANGULAR DIMS	±5	±2		SHEET 2 OF 2		

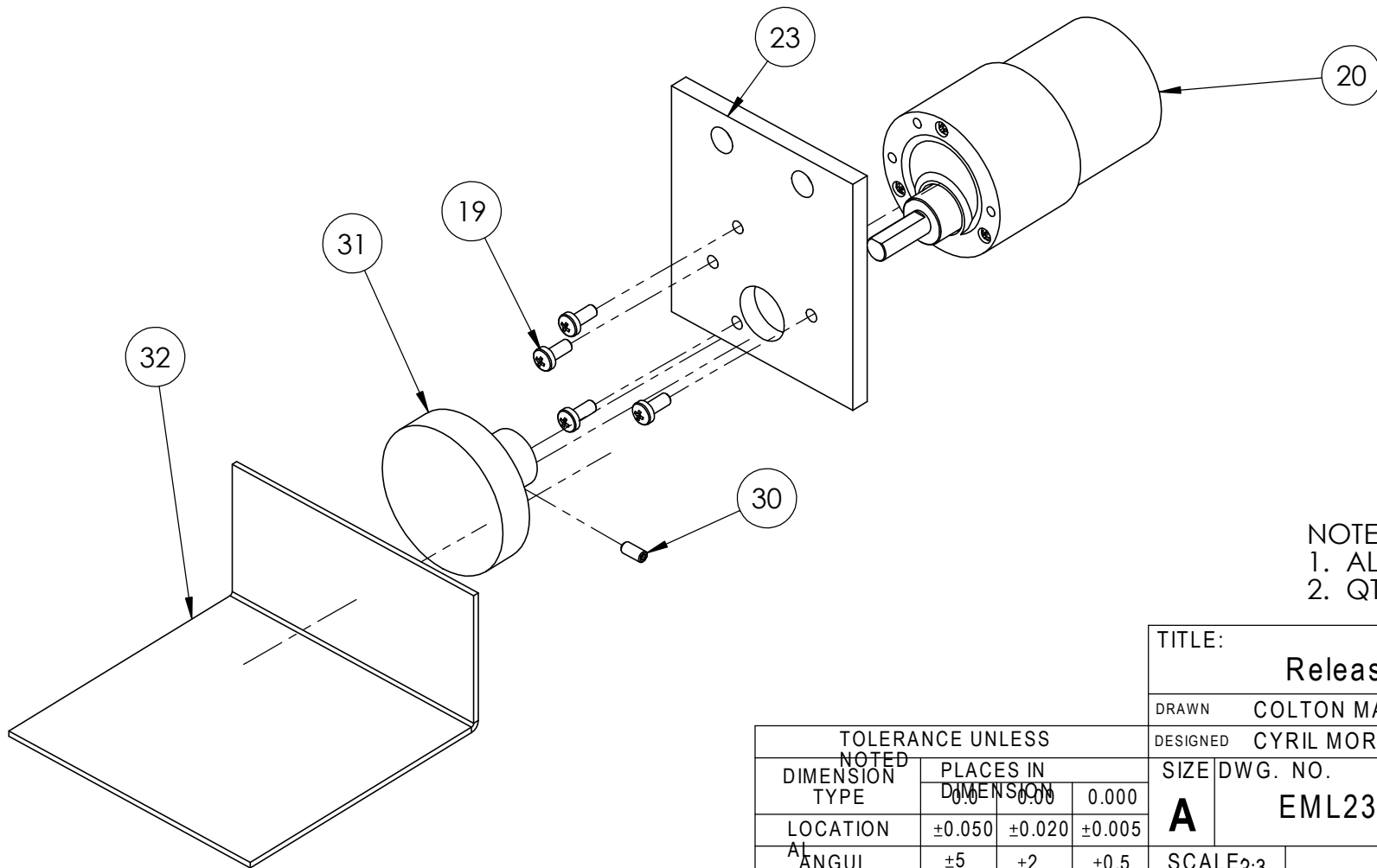


NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1

TITLE: Release Gate			
DRAWN COLTON MAYS			
DESIGNED COLTON MAYS			
SIZE A	DWG. NO. EML2322L-A-004		REV B
SCALE 1:1			SHEET 1 OF 3

TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.00	0.00	0.00
LOCATION	±0.050	±0.020	±0.005
ANGUL	±5	±2	±0.5

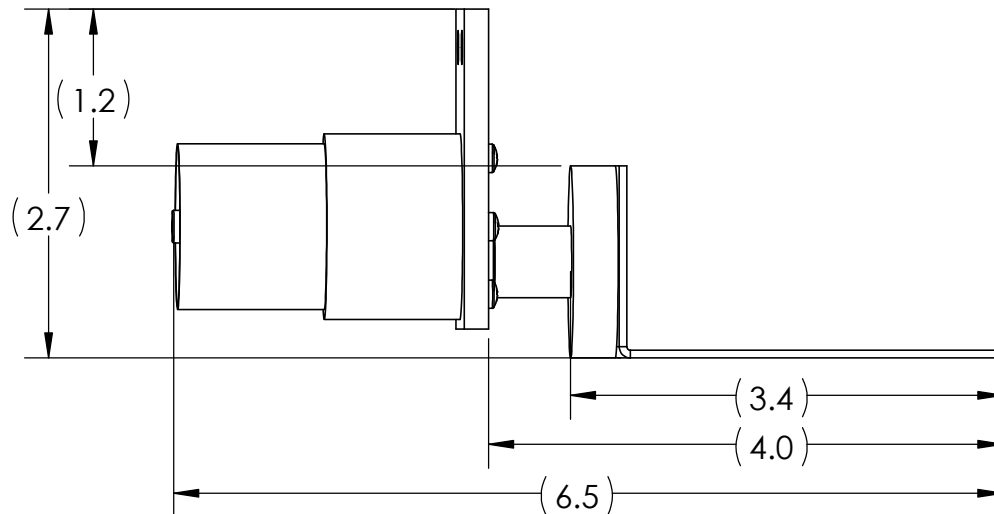
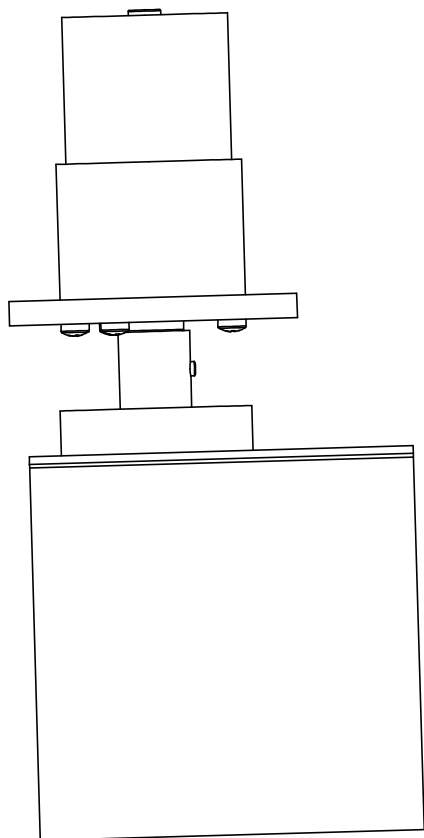
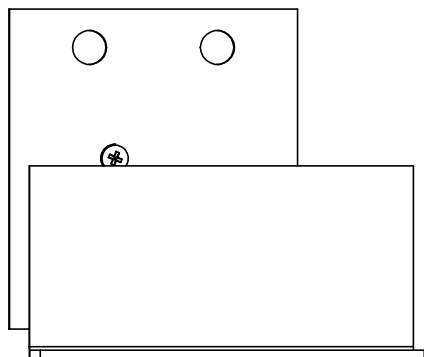
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
19	EML2322L-019	M3 X 10mm Screw	4
20	EML2322L-OTS29	15 RPM SEI Gear Motor	1
23	EML2322-023	15 RPM SEI Gear Motor Mount	1
30	EML2322-030	Alloy Steel Cup-Point Set Screw	1
31	EML2322L-031	15 RPMSEI Gear Motor Hub Release Gate	1
32	EML2322L-032	Release Gate Part	1



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

TITLE:			
Release Gate			
DRAWN COLTON MAYS			
DESIGNED CYRIL MORAN			
SIZE	DWG. NO.		REV
A	EML2322L-A-004		B
SCALE	2:3	SHEET 2 OF 3	

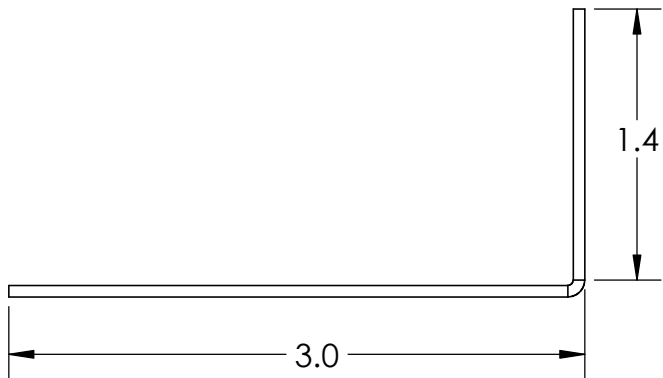
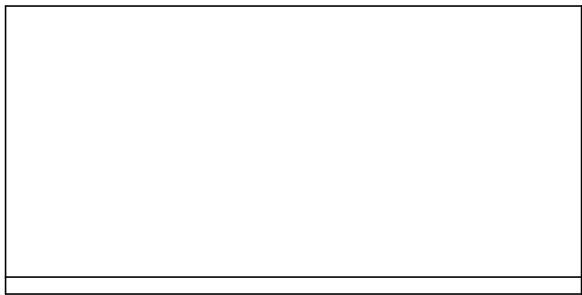
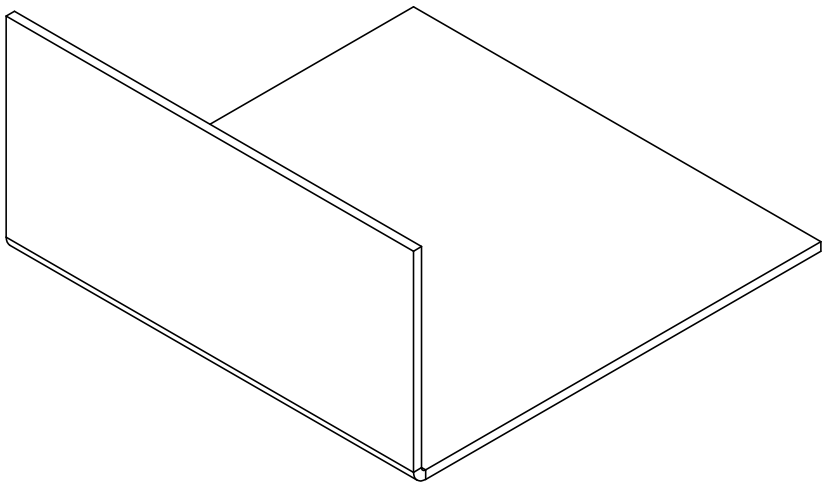
TOLERANCE UNLESS NOTED			
DIMENSION TYPE	PLACES IN DIMENSION		
	0.00	0.00	0.00
LOCATION	±0.050	±0.020	±0.005
ANGUL	±5	±2	±0.5



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

TITLE:			
Release Gate			
DRAWN		COLTON MAYS	
DESIGNED		COLTON MAYS	
SIZE	DWG. NO.		REV
A	EML2322L-A-004		B
SCALE: 2:3		SHEET 3 OF 3	

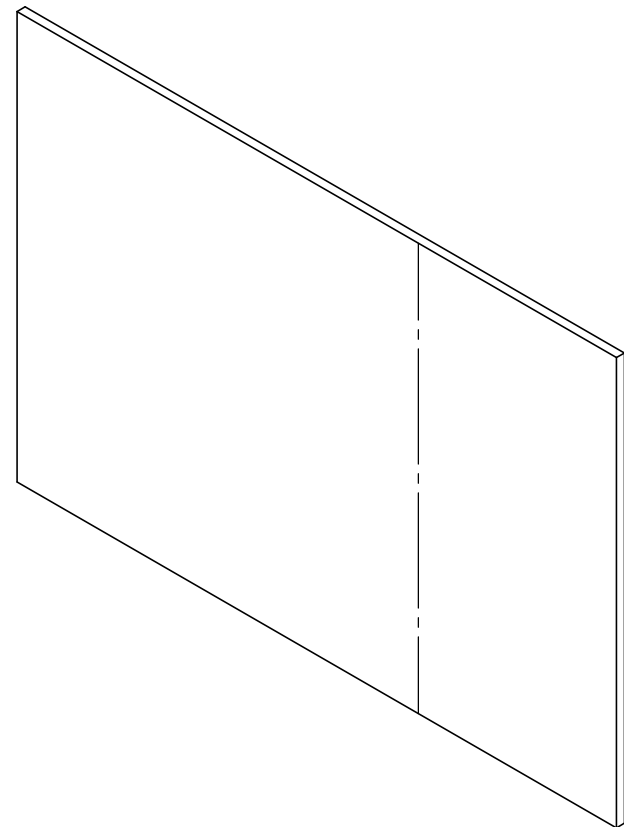
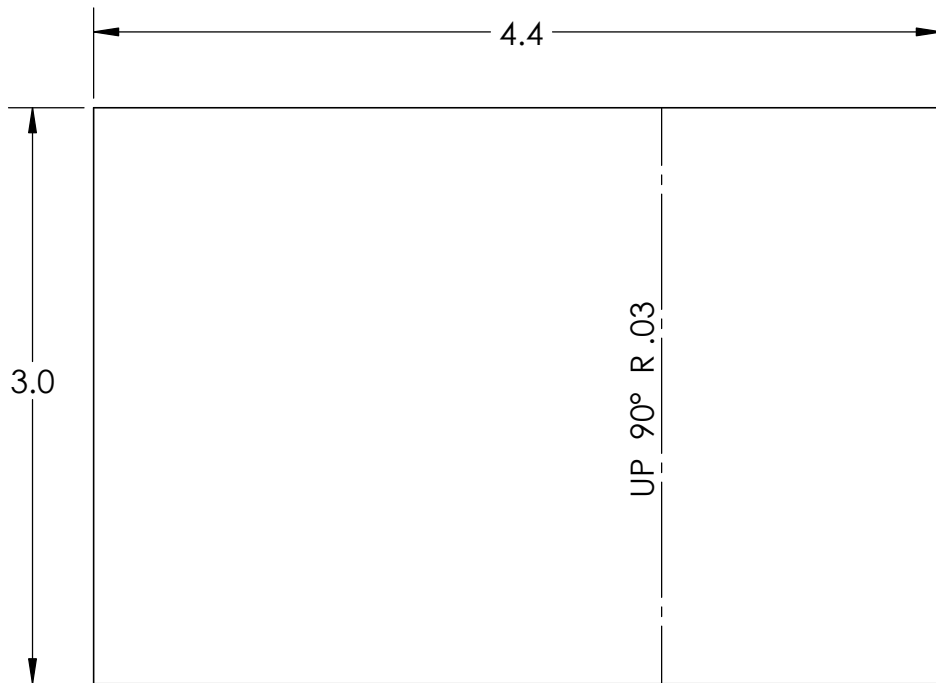
DIMENSION TYPE	PLACES IN DIMENSION		
	0.0	0.00	0.000
LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5



FOLDED VIEW
(IF APPLICABLE)

- NOTES:
1. ALL DIMS IN INCHES
2. QTY: 1
3. FINISH NOTED SURFACES
4. MAT'L 16 GAUGE SHEET METAL
5. BREAK ALL EDGES

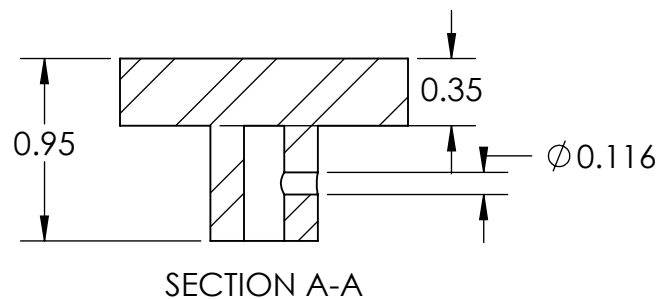
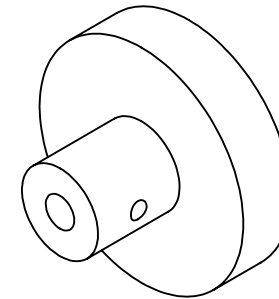
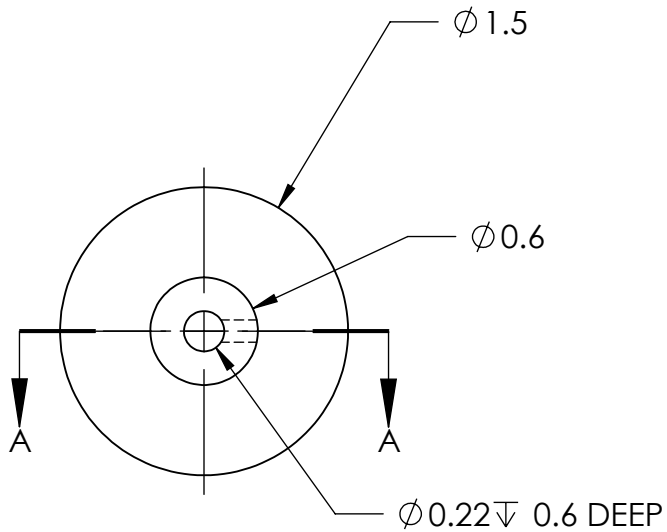
TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Release Gate Part		
	0.0	0.00	0.000	DRAWN	COLTON MAYS	
MACHINING				DESIGNED	COLTON MAYS	
SHEETMETAL (SHEAR, BEND)	±0.1	±0.060	±0.030	SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-032	A
ANGULAR DIMS	±5	±2		SCALE: 1:1		SHEET 1 OF 2



UNFOLDED VIEW
(IF APPLICABLE)

- NOTES:
1. ALL DIMS IN INCHES
 2. QTY: 1
 3. FINISH NOTED SURFACES
 4. MAT'L 16 GAUGE SHEET METAL
 5. BREAK ALL EDGES

TOLERANCE UNLESS NOTED				TITLE: Release Gate Part		
OPERATION	PLACES IN DIMENSION					
	0.0	0.00	0.000	DRAWN	COLTON MAYS	
MACHINING				DESIGNED	COLTON MAYS	
SHEETMETAL (SHEAR, BEND)	±0.1	±0.060	±0.030	SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-032	
ANGULAR DIMS	±5	±2				
				SCALE: 1:1		SHEET 2 OF 2



- NOTES:
1. QTY: 1
 2. ALL DIMS IN INCHES
 3. MAT'L STEEL
 4. FINISHED NOTES SURFACES
 5. BREAK ALL EDGES

TOLERANCE UNLESS NOTED				TITLE: SEI Motor Hub Release Gate			
OPERATION	PLACES IN DIMENSION						
	0.0	0.00	0.000	DRAWN CYRIL MORAN			
MACHINING	±0.050	±0.020	±0.005	DESIGNED CYRIL MORAN			
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.		REV
WELDING	±0.1	±0.060		A	EML2322L-031		B
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:1		SHEET 1 OF 1	

Appendix D: Estimated Project Budget

Project Budget for Team 8B

Item Description	Vendor	Qty	Unit	Unit Price	Subtotal
Ø 2.0" AL round bar stock (wheel hubs)	LAB	0.33	ft	\$20.00	\$6.60
3/16" x 2.50" AL rect. bar stock (motor mounts)	LAB	1.25	ft	\$3.75	\$4.69
16 gauge steel sheetmetal (release mechanism, hopper, ball manipulator)	LAB	2	ft ²	\$4.00	\$8.00
80/20 1" x 1" aluminum extrusion (*)	LAB	5.8	ft	\$3.00	\$17.40
Ø 1.5" steel round bar stock (release gate wheel hub)	LAB	1	in.	\$10.00	\$10.00
Entstort 44 RPM right angle gear motor	LAB	2	each	N/C	N/C
Ø 8" Type 1 Wheel	LAB	2	each	N/C	N/C
Ø 5" Swivel Caster Wheel	LAB	1	each	N/C	N/C
15 RPM SEI Gear Motor	LAB	2	each	N/C	N/C
1/4 - 20 Hex Nut	LAB	2	each	N/C	N/C
80/20 1" x 1" aluminum extrusion	LAB	6	ft	N/C	N/C
80/20 aluminum right angle brackets	LAB	17	each	N/C	N/C
1/4-20 T-Nut	LAB	70	each	N/C	N/C
1/4-20 x 1/2" button head fastener (80/20)	LAB	86	each	N/C	N/C
10-24 x 1" button head screw (wheel hubs)	LAB	6	each	N/C	N/C
M8 x 1.25 nut (wheel hubs)	LAB	2	each	N/C	N/C
80/20 aluminum straight bracket	LAB	17	each	N/C	N/C
M3 x 0.5 10 mm screw	LAB	8	each	N/C	N/C
1/4 in. washer	LAB	6	each	N/C	N/C
M6 x 1.0 20 mm hex head screw	LAB	6	each	N/C	N/C
1/4-20 X 3/8" BHCS	LAB	4	each	N/C	N/C
4-40 1/4" set screw	LAB	2	each	N/C	N/C

TOTAL \$46.69

NOTES:

(*) denotes this is in addition to the 12' provided in the project description

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