Background Information

1. ***Electric DC motors***

What type of power supply is used for this project? What are the pros and cons of brush-type versus brushless-type DC motors? If cost is an important factor for the project, which type of motor would be the better choice?

The type of power supply used for this project is direct current (DC.)

Brush-type DC motors are inexpensive and capable of controlling speed and torque easily. However, these motors create a significant amount of friction due to the brushes, have electrical resistance in the brush-to-commutator interface, and may dangerously spark as a result of the mechanical swinging of the armature current.

On the other hand, brushless-type DC motors offer more torque per weight with improved efficiency, make more power yet less noise, and are more durable, reliable, and safer because they do not spark. These motor are generally more expensive because they require electronic speed controllers for use.

If cost is an important factor for the project, then a brush-type DC motor is the better choice due to its inexpensiveness.

2. ***Robot controllers***

Summarize the difference between relay and proportional control. For what type of function on the project might each type of control be used? How many control channels of each type (relay and proportional) do the laboratory controllers provide?

Relay control sends a fixed voltage to a device. Therefore, relay control has two pre-set settings, “on” and “off.” By reversing polarity, we may flip the direction of motion of the motor but the motor’s speed remains fixed. This means that the user has control over the direction but not the speed. Relay control is often useful for lifting arms because the speed at which we lift objects with the robot shouldn’t require a variable speed.

Proportional control sends a variable voltage that is dependent on the user’s input. In our case, moving the joystick different distances will result in different motor speeds. Similar to relay control, the direction of motion may be flipped by reversing the polarity. Thus we may control both speed and direction. Proportional control is useful for powering the robot’s wheels to allow for optimal maneuverability in the course.

The laboratory controller provides four relay and two proportional control ports.

3. ***Mobile robotic platforms***

Summarize three commonly used mobile platform types for robotic applications and explain the pros and cons of each. Which type of mobile platform did you select for your conceptual design and why did you select it over the other options?

The three-wheel platform is a system in which there are two rear mounted drive wheels and a single front mounted caster wheel that is free to rotate. This design guarantees that all wheels will remain on a ground at all times. This is ideal for good traction with the floor while not requiring a suspension system. This system will likely make mounting objects on the robot more difficult due to its more complex geometry.

The four-wheel platform is a system in which there are two rear mounted drive wheels and two front mounted caster wheels that are free to rotate. Without a suspension system, this design will result in one wheel losing traction if the robot is not perfectly built or if the ground on which it maneuvers is not perfectly flat. This means that there is a high risk of losing control of the robot. This design is simple in its geometry, potentially perfectly square, thus mounting objects to the frame should be relatively easy.

Continuous tracks are another system which allows a device to crawl over large threads. Motion may be powered by drive wheels or sprockets. This design offers the best traction on nearly all surfaces and an even weight distribution over a larger surface area. However, it is more difficult to build.

The platform that I selected for my design is a three-wheel platform because it is simple to build and allows for good traction with the ground.

4. ***Steering mechanisms***

Summarize three common methods of steering for robotic applications and explain the pros and cons of each. Which steering method did you select for your design and why did you choose it over the other options? Would front or rear steering more desirable for your design and why?

Differential steering involves two independently driven wheels on opposite sides of the frame that share the same axis of rotation. The magnitude of the turn is determined by the ratio of the velocities of each drive wheel. This design is very simple as it doesn't require any additional mechanisms to turn and robot maneuverability is superior.

Rack and pinion steering involves linearly moving a steering shaft to pivot wheels and allow the robot to turn. The design gets further intricate with the use of a steering wheel which requires a gear system to convert rotational motion of a steering wheel to linear motion of the steering shaft. This method is complicated to build but offers excellent feedback and longevity.

Go kart steering is a similar method to rack and pinion steering but it uses a simple crank-rocker to convert rotational motion to linear motion. The benefits of this method are similar to rack and pinion steering but usually it isn't as durable or responsive.

I chose differential steering for my design because it is extremely simple to build while still yielding excellent maneuverability in the course. Also I chose to use front wheel steering because the driver will have excellent control in manipulating the objects in front of the robot.

5. ***Wheels and tires***

What are the differences between regular wheels and caster wheels? When would each type of wheel be used? What are the pros and cons of pneumatic versus semi-rigid versus solid tires/wheels? Which type(s) of wheel(s) do you believe would be most beneficial for the project and why?

Regular wheels are cylindrical disks that rotate about one axis and are mounted on an axle or hub. Caster wheels have their own mounting axle and are able to rotate and pivot around a secondary axis. Regular wheels would commonly be used as drive wheels where power is to be supplied. Caster wheels are usually used as non-drive wheels that simply allow the robot to rotate.

Pneumatic wheels require replacement of just the tire if damaged occurred to it and air pressure may be adjusted to manipulate traction and load capacity. Semi-rigid solid wheels have a similar load rating yet are less expensive.

For my design, I believe that regular wheels will be used as the front drive wheels and cast wheel will be used for maneuverability in the back. Also semi rigid wheels will be used because of their simplicity and inexpensiveness.

6. ***Friction coefficients***

Why are friction coefficients important for this project? What are typical static friction coefficient ranges for common wheel materials (plastic and rubber) in contact with concrete surfaces?

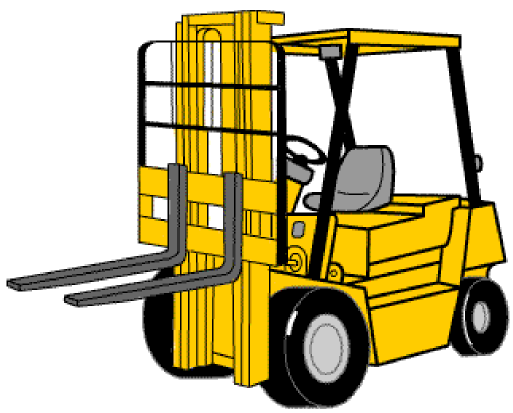
Friction is a vital component because it allows objects to move relative to each other. For example, there must be sufficient friction between the wheels and the ground for the robot to move. If friction was not present, then the wheels would simple slip and rotate in place causing no movement to occur. Typical friction coefficients for plastic and rubber on concrete range from 0.30 to 0.85.

7. ***Bucket and ball lifting mechanisms / manipulators***

Summarize and graphically illustrate (by hand or by including downloaded images which clearly help explain the concepts) common types of manipulator mechanisms and explain the pros and cons of each. What type of manipulator does your conceptual design use to grab the buckets/balls for this project? (Do not feel limited to the two types of manipulators noted above.)

Movable grippers use movable linkage to clamp down on objects and grasp them. They offer good maneuverability because objects don't have to be perfectly aligned with the robot. However, they may have difficulty grasping irregularly shaped objects.

Stationary grippers do not grasp objects but have the objects rest on a surface for lifting. They require a perfect alignment with the object and a surface to press the object against. They are however good at moving irregularly shaped objects.



My design uses a stationary gripper to lift the buckets.

8. <u>Ball hoppers</u>

Summarize and graphically illustrate (by hand or by including downloaded images which clearly help explain the concepts) common options for ball hoppers and explain the pros and cons of each.

A bucket has a lid and removable handle (this may make it easy to grasp and lift.) These are inexpensive and can carry a lot of balls but are not rigid and are easily bendable.

9. ***Ball dispensing mechanisms / strategies***
Summarize and graphically illustrate (by hand or by including downloaded images which clearly help explain the concepts) three methods for dispensing balls.

Chute doors can allow a ball to dispense by simple rotating a handle that is directly attached to a door via gears to open and close.

10. Gears / gearing
What are gears? What is the purpose of gearing? List five types of gearing, a common application for each, and explain why a particular type of gearing is useful in each application (perform additional research to answer this last part). Will gears be beneficial on this project?

Gears are objects that mesh together at variable speeds and forces. The purpose of gearing is to change the speed at which something moves and the torque applied to the movement.

Spur gears are circular objects with straight teeth that are mounted on parallel axes. Spur gears can be used in succession to make dramatic changes in gearing. They are noisy at high speeds and undergo a lot of wear and tear. They are common in electric screwdrivers, washing machine, and dryers.

Helical gears have teeth that are cut at an angle to the face of the gear to create less stress when they mesh. They operate relatively smoothly and quietly yet produce heavy thrust loads. Helical gears are commonly used in automotive transmissions for these reasons.

Bevel gears are mounted perpendicular to each other to change the direction of motion. Some contain straight teeth which yields a lot of wear. Some have curved teeth that allow for a smoother mesh. These are common in car differentials because they may conserve space which can make more space for vehicle interior.

Worm gears, comprised of a worm and gear, are used to make large gear reductions. The worm can easily turn the gear but the gear cannot easily turn the worm due to their respective angles and positions. For this reason, conveyor systems implement them because the system has a braking mechanism.

Rack and pinion gears convert rotational motion into linear motion. The system is simple to move things along a line which is why they are used in some scales to display weight.

Gears may be useful in this project to allow us to manipulate the speed and torque at which we move the containers. For example, if our motors are not capable of moving a container full of balls quickly enough we may manipulate the speed at which it may move through a gear ratio.

11. Materials / material selection
List the pros and cons of steel, aluminum, plastic, wood and 80-20, as well as three common applications of each. What materials will be best suited for which parts of the project?

Steel is extremely stiff, strong, ductile, and may be easy weldable. Steel is also quite dense, which may make it heavy relative to other materials. Since it is an alloy, making steel requires great expertise. Steel is used in car doors, buildings, and bridges.

Aluminum is soft, durable, ductile, malleable, and has low density (lightweight.) Aluminum is relatively expensive. Aluminum is commonly used in aircraft, automobiles and bicycle frames.

Wood is low weight, readily available, and inexpensive. Wood is fibrous material that must be treated and maintained. Wood is used for framing walls and in the construction of boats, furniture and flooring.

80-20 is highly functional, simple, durable, reusable, and requires little tools. It is, however, expensive, not bendable, and not easily weldable. It is commonly used in angle brackets, robots, shelving, and tabling.

80-20 will be best suited for the robot frame.

12. __Material properties__

Define the following material properties and explain why each might be important for this project: cost, density, ductility, machinability, stiffness, strength and weldability.

Cost is the capital that must be invested to build our robot. Cost must be kept reasonably low for any project to be done efficiently. For example, the strength and hardness of a material is usually inversely proportional to the cost of the material. So manufacturing elements so that they are just strong enough to fulfil their job helps keep cost low.

Density is defined as an objects mass per unit volume. Density is important because we want our robot to occupy a small amount of space and be lightweight. This is because a smaller robot is easier to maneuver through obstacles and a lighter robot moves more efficiently. Thus, selecting building materials of low density would be highly beneficial.

Ductility is an objects ability to bend upon being acted on by a tensile force. No parts of our robot should be very ductile because we require a rigid frame to accomplish on tasks.

Machinability refers to how easily a material may be machined. For parts that we would like to custom build we should choose a material to be highly machinable allowing us to change it to meet our design criteria.

Stiff ness is the rigidity of an object. It is important that our robot be constructed of stiff material so that it may not bend upon being acted on by a force.

Strength is the ability of material to undergo force and not be compromised. It is important that we construct our robot out of strong materials to ensure its structure remains sound.

Weldability is the ability of a material to have its parts welded to one another. Any parts of our robot that need to be custom built should be made of weldable materials to ensure customizability for the job.

13. __Balls__

What information about balls is useful for the project and why? Be specific (i.e. quantify size(s), weight(s), material(s), coefficient(s) of restitution, etcetera, with actual numbers).

Official tennis balls are 2.575 - 2.700 inches in diameter and 1.975 - 2.095 ounces in weight. Tennis ball are inflated with air and are covered in a uniform felt-covered rubber compound at the surface. Dropping a tennis ball from a height of 100 inches onto concrete at 68 degrees Fahrenheit should yield a vertical bounce of 53 - 58 inches.

Official golf balls are at least 1.680 inches in diameter and no more than 1.620 ounces in weight. Materials used to make them include synthetic materials like surlyn or urethane blends. “The dimples on the surface of the golf ball cause the boundary layer on the ball to transition from laminar to turbulent, which remains attached to the surface of the ball much longer, creating a lower pressure wake and thus less pressure drag.”

Design Description

Mobile Platform

Power is delivered to two 10" drive wheels through the use of two 44 RPM Entstort Motors (one for each wheel). This wheel-motor combination outputs a maximum tractive torque of 84 lb*in and a maximum velocity of 1.4 ft/sec. As a result, the device is capable of traveling over ramps and traversing the course at ample speed. To facilitate the transmission of power, a cylindrical wheel hub made of aluminum is used. The hub features three threaded holes that allow each hub to be securely fastened to its respective wheel via three machine screws. On the opposite end of the hub is a counter-bore. The motor's rotational shaft is inserted into this area and tightened onto the hub using a hex nut. Through the use of splines and the nut, power is able to be transmitted from motor shaft to wheel. The wheels are attached to the frame via screws into a motor mount and the motor mount into the 80/20 frame.

Bucket Manipulator

The bucket manipulator is powered by a Globe motor. This motor offers significant torque so that the arm and filled bucket can be lifted. The globe motor is attached to the 80/20 frame directly through the use of screws. The actual arm is attached to the Globe motor by using angle brackets that allow the parallel position of the arm to be in line with the bucket's upper lip. The arm is made entirely out of 80/20 and 90 degree angle brackets. The angle brackets on the arm help to ensure the bucket cannot fall into the hopper as the arm moves more than 90 degrees above parallel to deposit balls. For bonus ball retrieval, on the right side of the arm, there is 80/20 with 1" x 2" angle brackets that allow for the arm to be used in scooping up the balls. The gap between the brackets is big enough to fit the PVC yet not big enough for the bonus ball to fit through. This makes scooping and putting the bonus ball into the hopper simple.

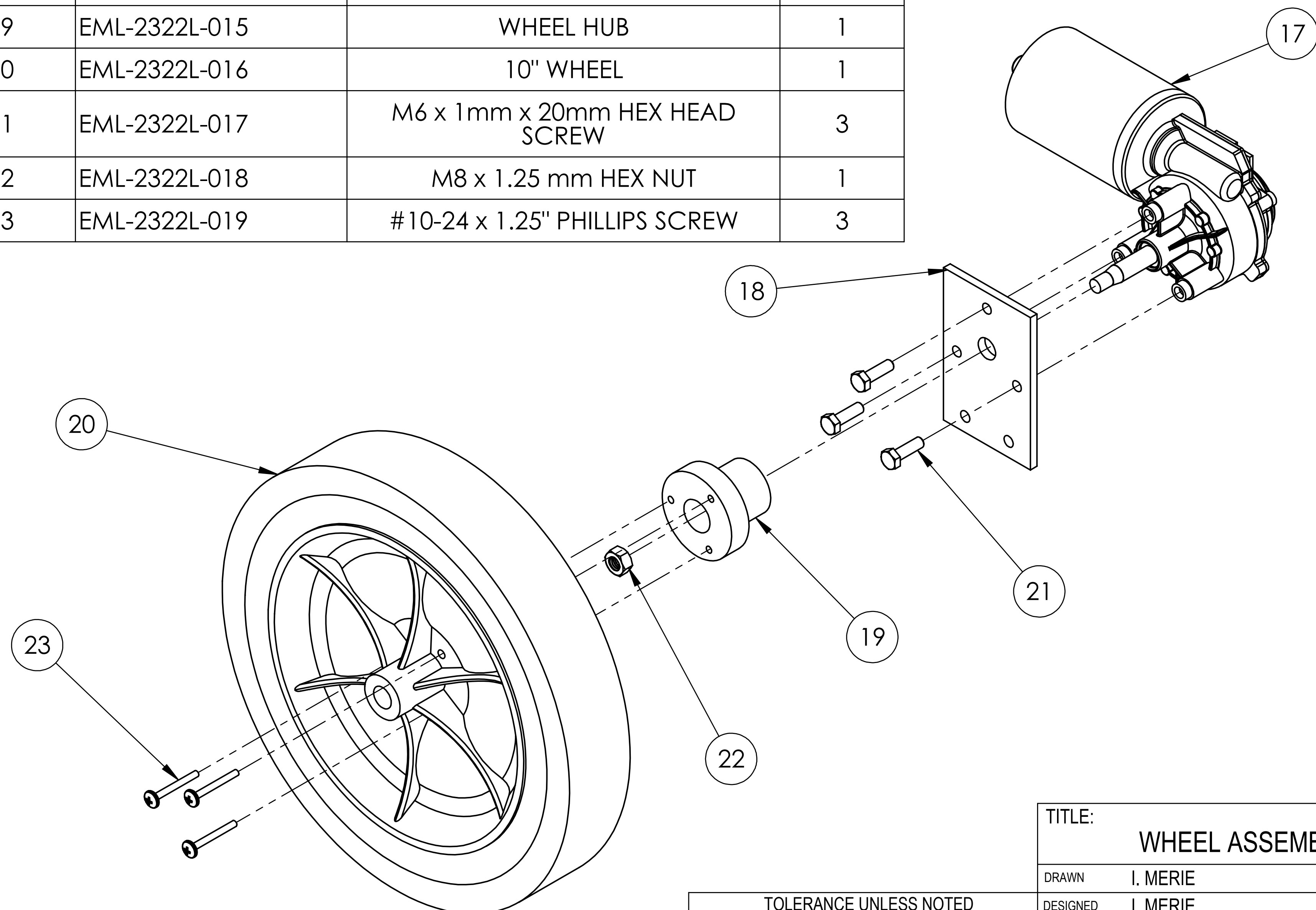
Ball Hopper and Sorter

The ball hopper is made up of four pieces of 20 GA sheet metal that funnel assorted balls into a large slit. The sheet metal is put together through the use of spot welding. The hopper is attached to the frame through the use of angle brackets from the sheet metal to four 80/20 extrusions. The balls fall through the slit onto a partially cut piece of 3" PVC that is attached to a cut 2" piece of PVC using adhesive. These two pieces of PVC run parallel at an angle so that the balls roll down the PVC. As the balls roll, there is a slit under the 3" PVC big enough for the golf balls to fall through but not big enough for the golf balls to fall through. The balls will be sorted as they roll down the PVC as a result of this slit. The PVC is going to be attached to the frame of the robot by using an angled hole into the 2" PVC that will use a screw to go into the 80/20 frame through the bottom of the PVC. On the lowered part of the PVC, screws will attach the PVC to the 80/20 frame at either side of the 3" PVC pipe. Additionally, a 20 GA piece of sheet metal will attach to the back of the PVC pipe at the part that is angled up in order to ensure that balls cannot fall out through the back of the pipe. This piece of sheet metal will be attached directly to the PVC via screws. The balls, already sorted, will wait for the release mechanism to let them out.

Release Mechanism

The release mechanism is powered by a 9 RPM Buehler motor. This motor is attached to the frame by using an aluminum plate that screws into both the motor and the 80/20 frame. The motor transmits rotational motion by using an additional aluminum plate through the use of a set screw. The plate with the set screw is attached to an 18 GA sheet metal piece meant to stop the balls from falling out. By rotating the plate and sheet metal 90 degrees clockwise from the starting location, the golf balls can be released. By rotating the components 90 degrees counter-clockwise, the tennis balls can be released. There is also an “L” shaped piece of sheet metal that will be attached to the frame via angle bracket that will go just over the bucket top so that as the balls release and fall onto the bucket, the bucket cannot tip over.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
17	EML-2322L-013	44 RPM ENTSTORT MOTOR	1
18	EML-2322L-014	ENTSTORT MOTOR MOUNT	1
19	EML-2322L-015	WHEEL HUB	1
20	EML-2322L-016	10'' WHEEL	1
21	EML-2322L-017	M6 x 1mm x 20mm HEX HEAD SCREW	3
22	EML-2322L-018	M8 x 1.25 mm HEX NUT	1
23	EML-2322L-019	#10-24 x 1.25'' PHILLIPS SCREW	3



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ANGULAR	±5	±2	±0.5

TITLE: WHEEL ASSEMBLY

DRAWN I. MERIE

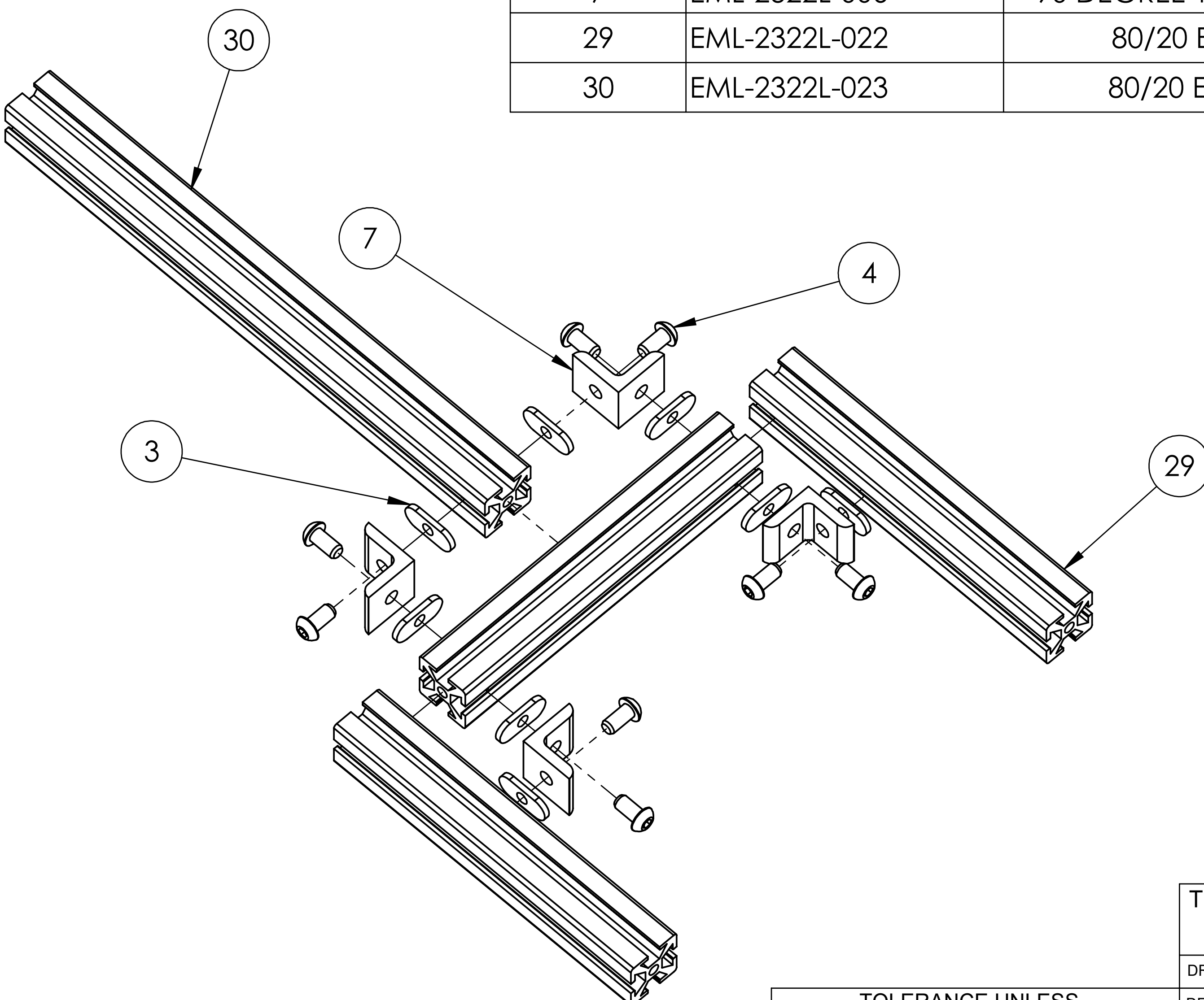
DESIGNED I. MERIE

SIZE A | DWG. NO. EML2322L-A-003 | REV B

SCALE: 1:3 | SHEET 1 OF 1

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
3	EML-2322L-002	1/4-20 T-NUT	8
4	EML-2322L-003	1/4-20X3/16" BUTTON HEAD CAP SCREW	8
7	EML-2322L-006	90 DEGREE 1X1 ANGLE BRACKET	4
29	EML-2322L-022	80/20 EXTRUSION-6.5"	3
30	EML-2322L-023	80/20 EXTRUSION-10.5	1



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ANGULAR	±5	±2	±0.5

TITLE: BUCKET FORK ASSEMBLY

DRAWN J. HARTIGAN

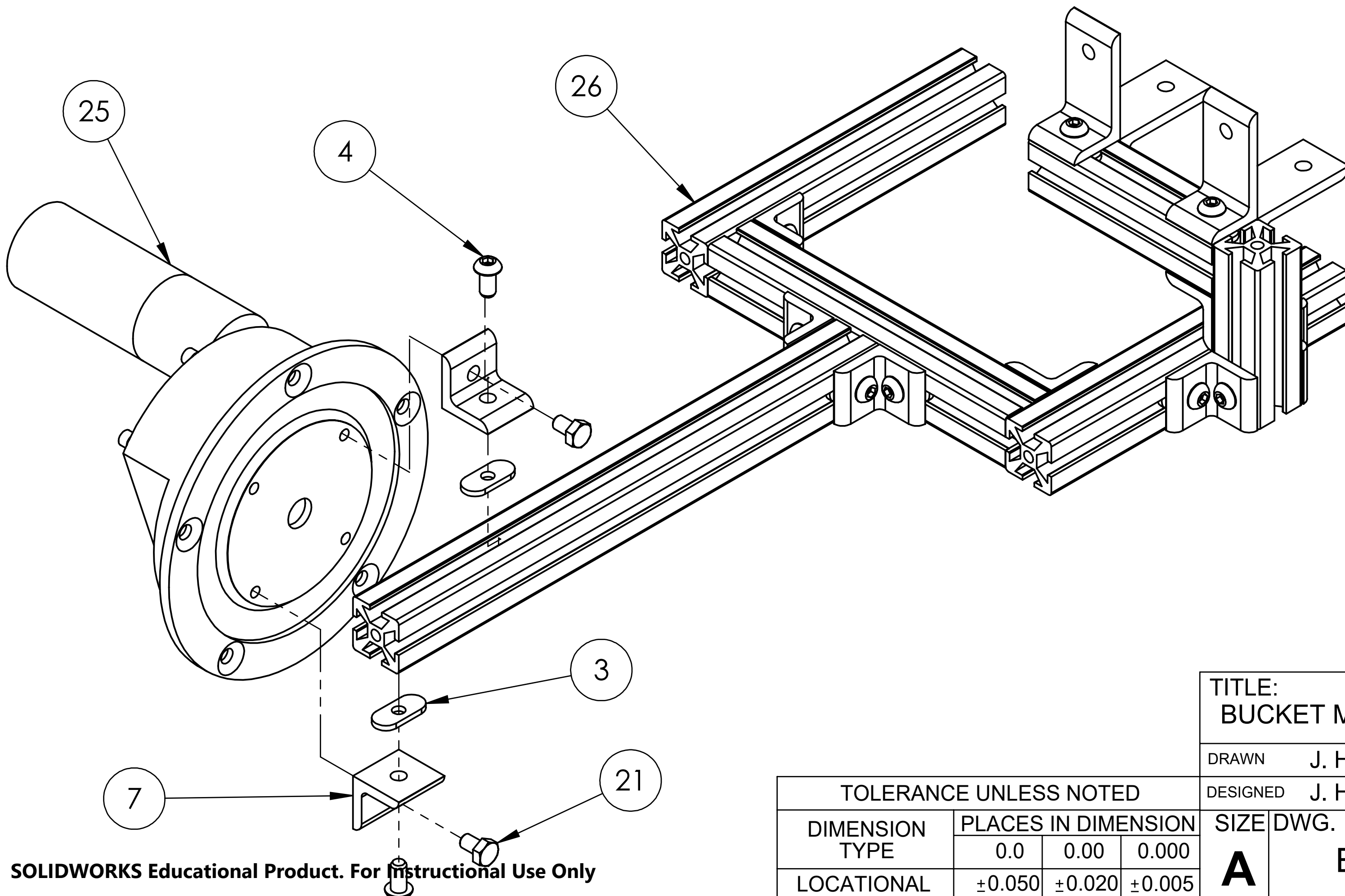
DESIGNED J. HARTIGAN

SIZE	DWG. NO.	REV
A	EML2322L-A-006	A

SCALE: 3:8 SHEET 1 OF 1

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
3	EML-2322L-002	1/4-20 T-NUT	2
4	EML-2322L-003	1/4-20X3/16" BUTTON HEAD CAP SCREW	2
7	EML-2322L-006	90 DEGREE 1X1 ANGLE BRACKET	2
21	EML-2322L-017	M6X10MM HEX HEAD SCREW	2
25	EML-2322L-020	GLOBE MOTOR	1
26	EML-2322L-A005	ARM ASSEMBLY	1



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ANGULAR	±5	±2	±0.5

TITLE: BUCKET MANIPULATOR ASSEMBLY

DRAWN	J. HARTIGAN
DESIGNED	J. HARTIGAN

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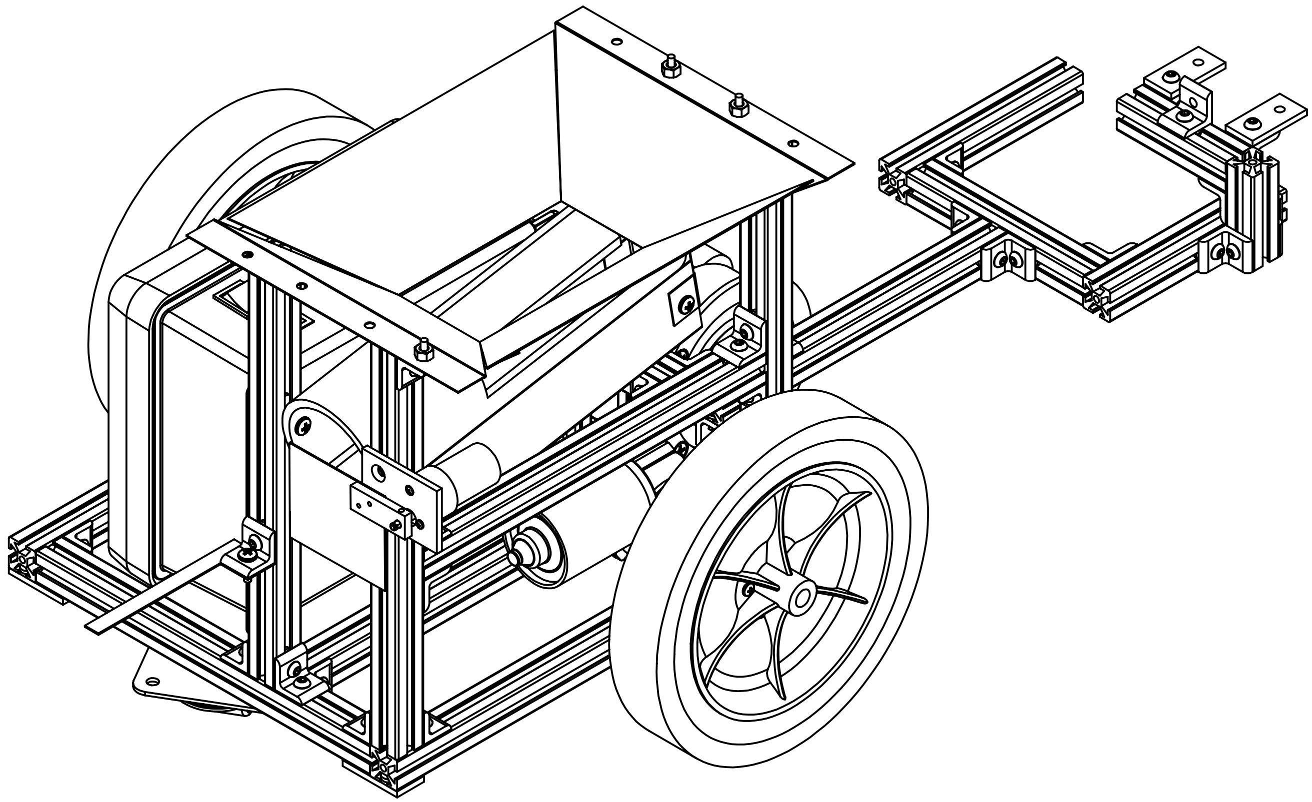

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ANGULAR	±5	±2	±0.5

TITLE: TOTAL ASSEMBLY

DRAWN I. MERIE

DESIGNED TEAM 11D

SIZE	DWG. NO.	REV
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SCALE: 1:5		SHEET 1 OF 1

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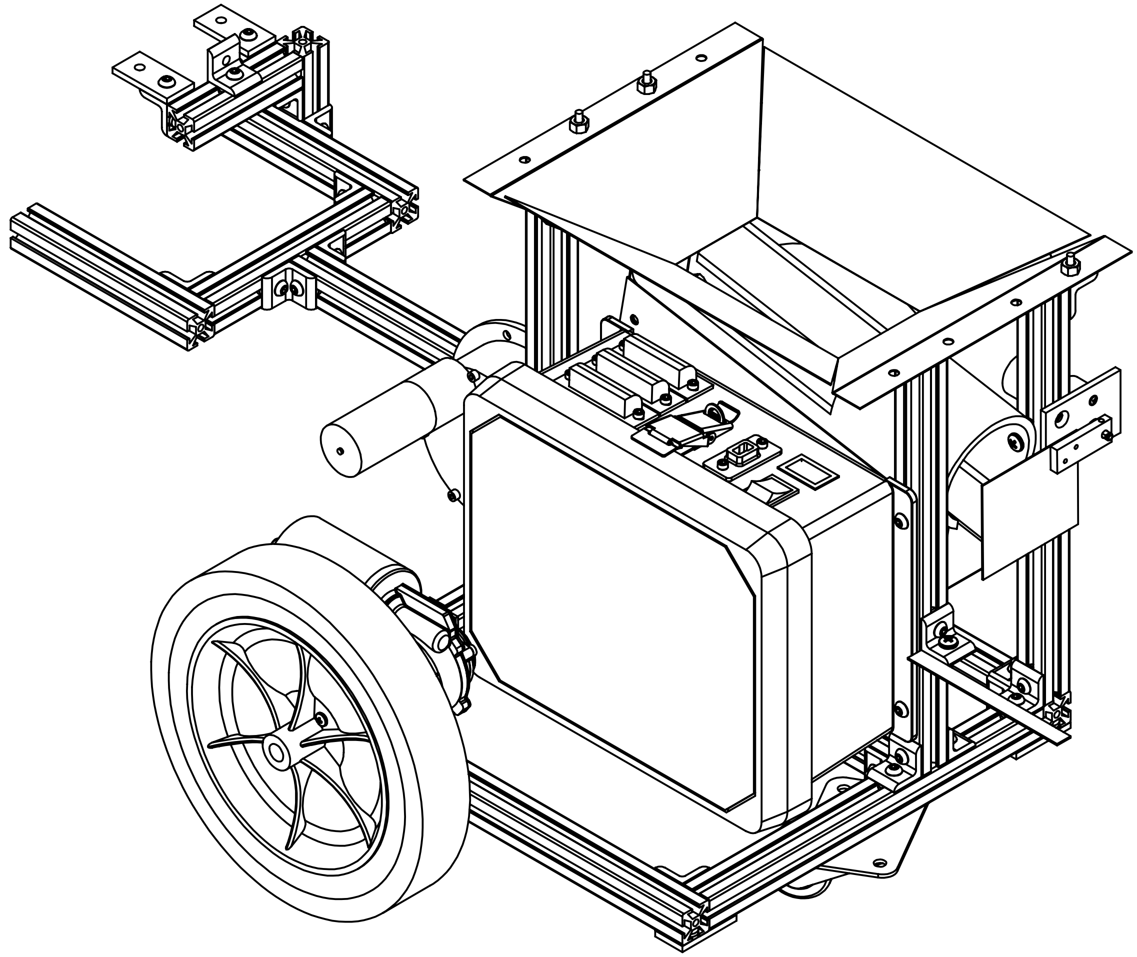

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TITLE:	TOTAL ASSEMBLY
DRAWN	I. MERIE
DESIGNED	TEAM 11D
SIZE	A
DWG. NO.	EML2322L-A-001
REV	B
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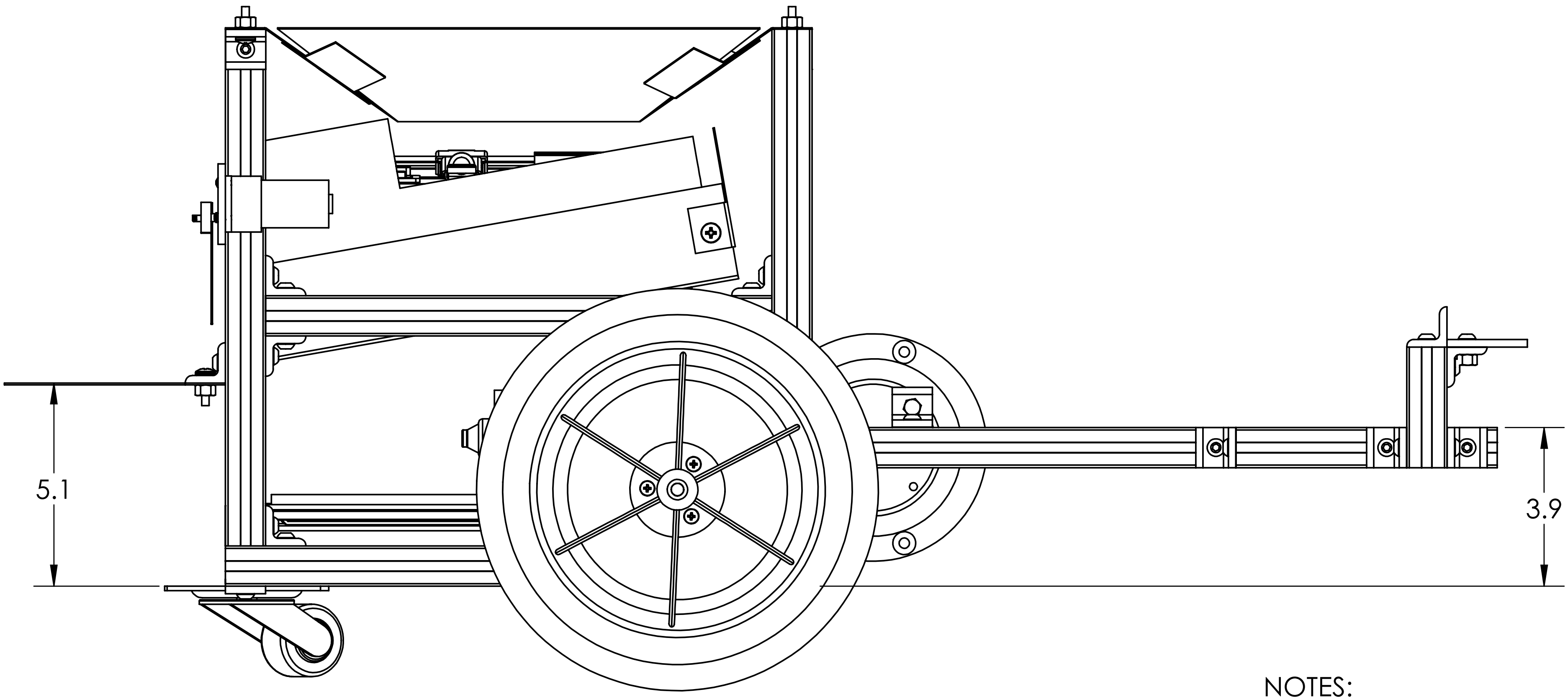

NOTES:
1. ALL DIMS IN INCHES

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LOCATIONAL	±0.050	±0.020	±0.005
ANGULAR	±5	±2	±0.5

TITLE: TOTAL ASSEMBLY

DRAWN: I. MERIE

DESIGNED: TEAM 11D

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SCALE: 1:4		SHEET 1 OF 1

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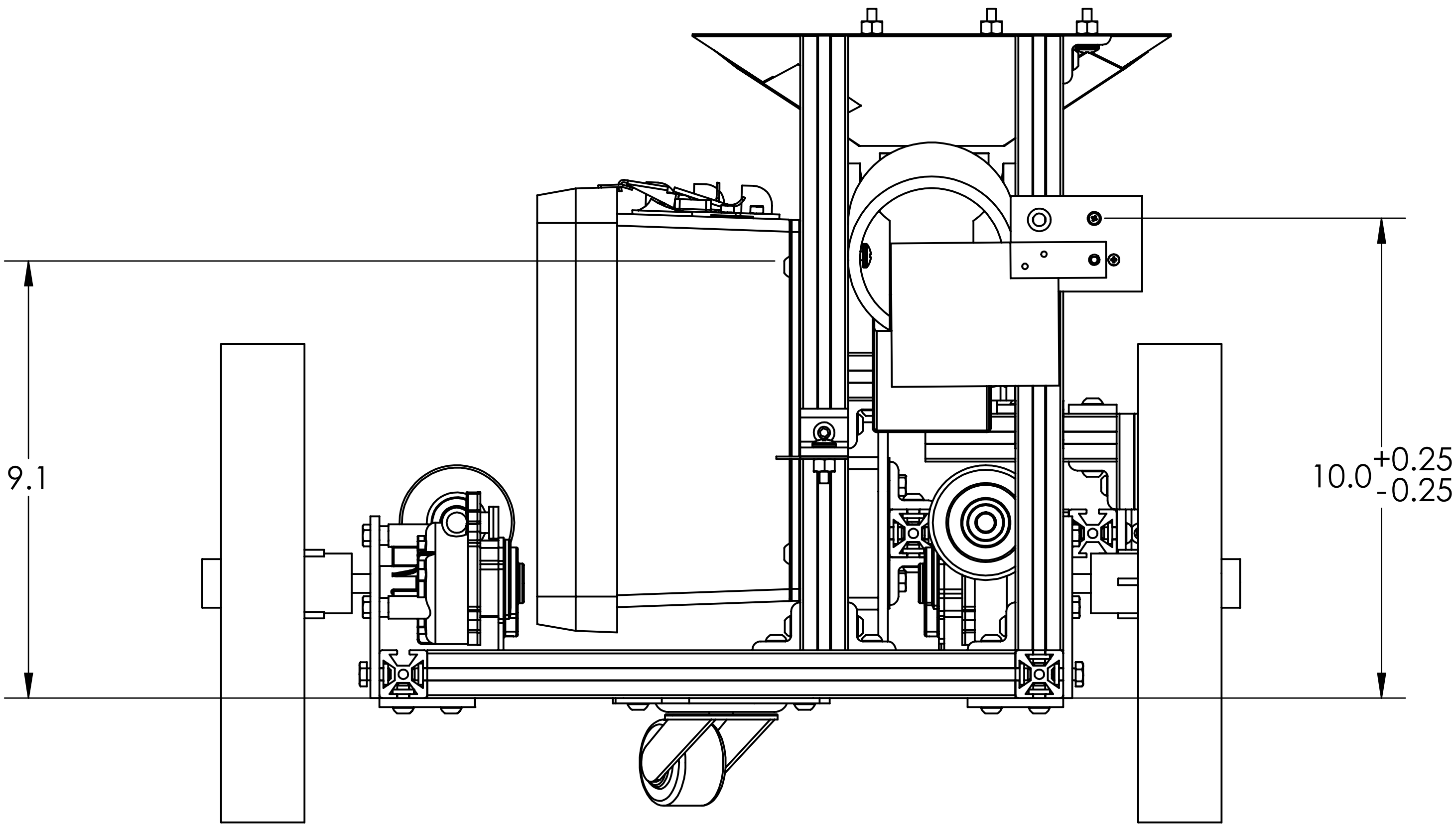

NOTES:
1. ALL DIMS IN INCHES

TITLE:			TOTAL ASSEMBLY
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DESIGNED	TEAM 11D		
SIZE A	DWG. NO. EML2322L-A-001		REV C
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TOLERANCE UNLESS NOTED			
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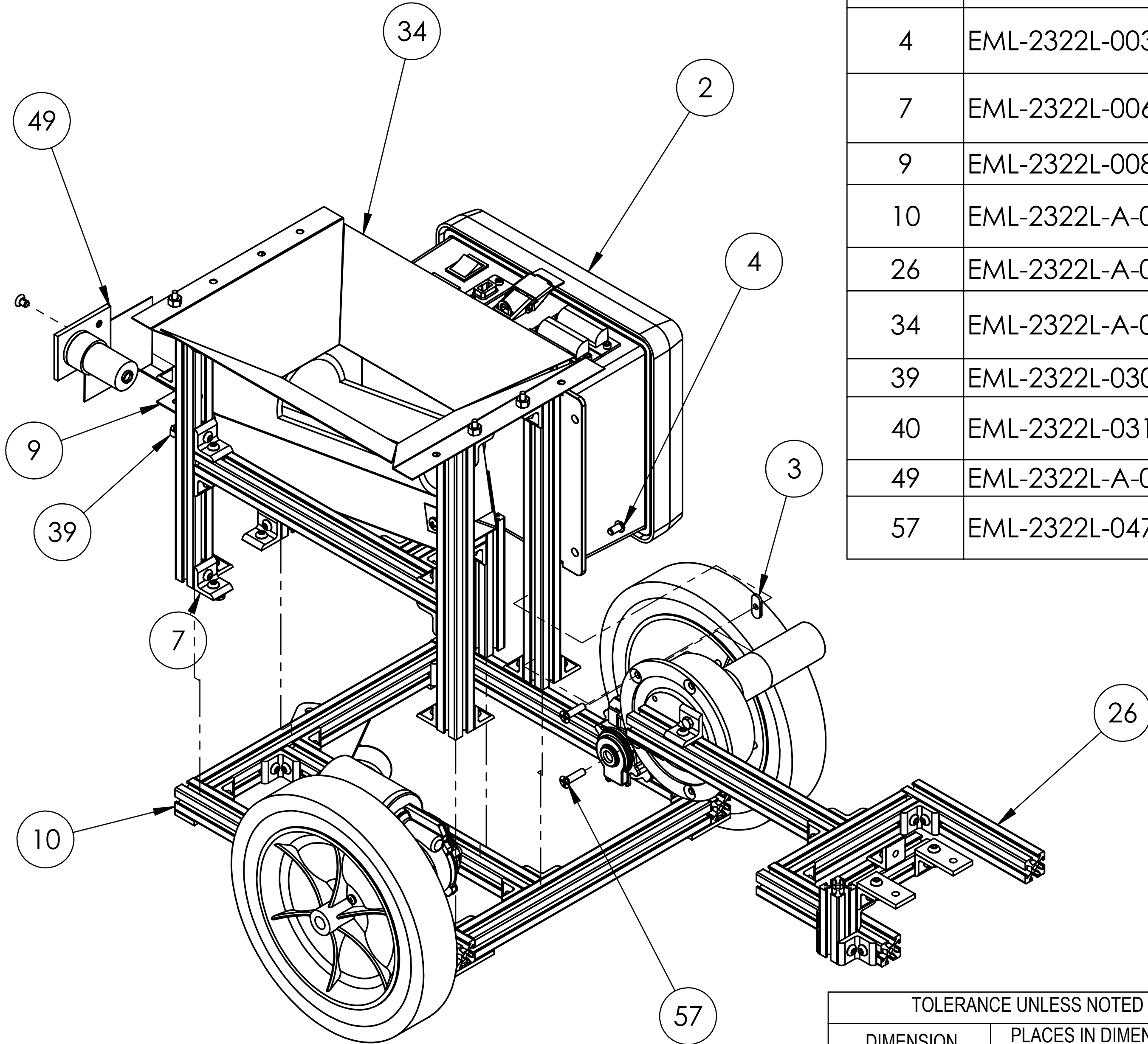

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
2	EML-2322L-001	CONTROL BOX	1
3	EML-2322L-002	1/4-20 T-NUT	92
4	EML-2322L-003	1/4-20 x 3/16" BUTTON HEAD CAP SCREW	86
7	EML-2322L-006	90 DEGREE 1x1 ANGLE BRACKET	40
9	EML-2322L-008	BUCKET LIP	1
10	EML-2322L-A-001	MOBILE PLATFORM ASSEMBLY	1
26	EML-2322L-A-005	ARM ASSEMBLY	1
34	EML-2322L-A-008	HOPPER SORTER ASSEMBLY	1
39	EML-2322L-030	1/4-20 HEX NUT	7
40	EML-2322L-031	1/4-20 3/4" HEX CAP SCREW	5
49	EML-2322L-A-012	RELEASE ASSEMBLY	1
57	EML-2322L-047	1/4-20 x 3/4" FLATHEAD SCREW	2

NOTES:
1. EXPLODED LINES ARE NOT SHOWN FOR ANGLE BRACKETS FOR CLARITY

TOLERANCE UNLESS NOTED			
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TITLE:	TOTAL ASSEMBLY	
DRAWN	I. MERIE	
DESIGNED	TEAM 11D	
SIZE A	DWG. NO. EML2322L-A-001	REV B
SCALE: 1:6		SHEET 1 OF 1

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