Parts & Assembly Manual

C.U.L.E. Robotics

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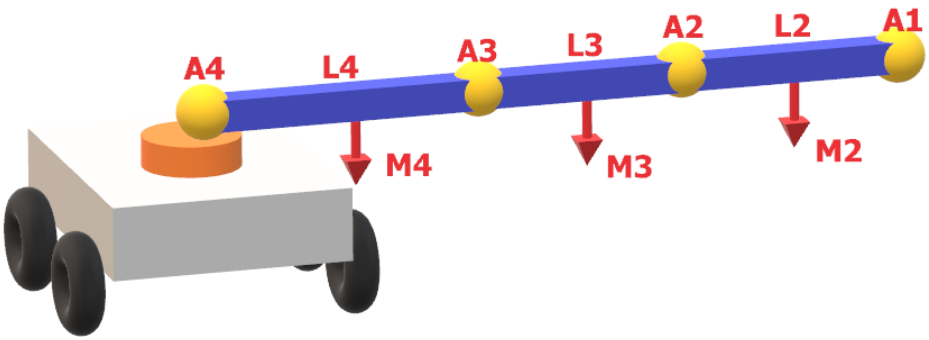
Overview

Torque Calculations

IGUS Joints

The IGUS joint for each degree of freedom was chosen based on the holding torque required in each joint.



Joint Torque FBD

In the figure above the A represents the degree of freedom, M is the mass of that arm section and L is the length of that section. The equations used are shown in the code. L1 and M1 are not shown because there is no arm that A1 is moving since the end-effector will be placed there.

The code below was used in MATLAB to find the torque at different joints. The code uses SI units.

Code

```
%% INPUTS
% L inputs are the lengths from the point to the next. L1 which is the
% the end effector will be placed will be 0 whereas the the section between
% the end effector and the next joint towards the chassis is L2. M#
% represents the weight of that arm section so for arm 1 M1=0 and then for
% M2 would be distance between end-effector and next joint. Finally A#
% represents the motor weight that will be placed at that joint. In this
```

```
% case the end effecor will have the weight of the end effector tool(1 kg) and 2
% NEMA 23 motors each weighing 1 kg(assuming worst case scenario in placing the joints) plus the 5b(2.3kg) load giving a total
% of 5.3 kg for A1
%Constants
g=9.81;%m/s^2

%Area of cross section %Calculated using drawing
Area=19.19;%cm^2

%Material Density g/cm^3
p=2.7;

%Material weight per length kg/cm
wg=(p.*Area)./1000;
%Degrees of freedom
N=4;

%Allocation of Variables
T=num2cell(zeros(N+1,2));
T{1,1}='Length(cm)';
T{1,2}='Torque';
T{1,3}='kg*cm';

%First Arm
L1=15;%cm
M1=L1.*wg;%kg
A1=2.5;%kg

%Second Arm
L2=15;%cm
M2=L2.*wg;%kg
A2=1.16;%kg

%Third Arm
L3=30.5;%cm
M3=L3.*wg;%kg Arm Weight
A3=1.9;%kg Actuator weight
```

```
%Fourth Arm
L4=40;%cm
M4=L4.*wg;%kg
A4=3.25;%kg

%Fifth Arm
L5=0;%cm
M5=0;%kg
A5=0;%kg

%% Calculations Start
%Degree furthest from center of chassis
WA1=A1.*g;%N
F1=M1.*g;%N
T1=((L1.*WA1)+0.5.*L1.*F1)./g;%
T{2,1}=L1;
T{2,2}='T1';
T(2,3)=num2cell(T1);

if N>=2
WA2=A2.*g;%N
F2=M2.*g;%N
T2=(((L1+L2).*WA1)+((0.5.*L1)+L2).*F1+(L2.*WA2)+(0.5.*L2.*F2))./g;%T2 in kg cm
T{3,1}=L2;
T{3,2}='T2';
T(3,3)=num2cell(T2);
end

if N>=3
WA3=A3.*g;%N
F3=M3.*g;%N
T3=(((L1+L2+L3).*WA1)+((L2+L3).*WA2)+(L3.*WA3)+((L3+L2+(0.5.*L1)).*F1)+((L3+(0.5.*L2)).*F2)+((0.5.*L3).*F3))./g;%kg cm
T{4,1}=L3;
T{4,2}='T3';
T(4,3)=num2cell(T3);
end

if N>=4
```

```
WA4=A4.*g;%N

F4=M4.*g;%N

T4=(((L1+L2+L3+L4).*WA1)+((L2+L3+L4).*WA2)+((L3+L4).*WA2)+(L4.*WA4)+(F1.*((L1.*0.5)+L2+L3+L4))+(F2.*((L2.*0.5)+L3+L4))+(F3.*((L3.*0.5)+L4))+(F4.*(L4.*0.5))./g;

T{5,1}=L4;

T{5,2}='T4';

T(5,3)=num2cell(T4);

end


if N>=5

WA5=A5.*g;%N

F5=M5.*g;%N

T5=((WA1.*(L1+L2+L3+L4+L5))+(WA2.*(L2+L3+L4+L5))+(WA3.*(L3+L4+L5))+(WA4.*(L4+L5))+(WA5.*L5)+(F1.*((L1.*0.5)+L2+L3+L4+L5))+(F2.*((L2.*0.5)+L3+L4+L5))+(F3.*((L3.*0.5)+L4+L5))+(F4.*((L4.*0.5)+L5))+(F5.*0.5.*L5))./g;

T{6,1}=L5;

T{6,2}='T5';

T(6,3)=num2cell(T5);

end
```

The torque results are shown below. Here each torque gives the respective torque for its given degree of freedom. For example, T2 is the holding torque needed for actuator A2.

Joint Torques

'Length(cm)'	'Torque'	kg-cm'	N-m'
15	'T1'	43.33	4.25
15	'T2'	115.72	11.35
30.5	'T3'	356.80	35.00
40	'T4'	823.87	80.82

Parts List

Quantity	Description	Price	Total	Reference	Assembly used in
1	RLD-20-S-38-ST	$350	$350	URL	4
1	RLD-30-S-50-ST Joint Symmetric	$350	$350	URL	1,3
1	RLD-30-S-50-ST Joint Asymmetric	$350	$350	URL	1
1	RL-D-50-102-48-01000 Joint	$350	$350	URL	2
3?4?	NEMA 23 23HS22-2804D-E1000	$50.15	$150.45	URL	1,3,4
1	NEMA 23 23HS30-2804D-E1000	$57.12	$57.12	URL	2
1	Coupling 8x8	$6.77	$6.77	URL	4
1	Coupling 8x15	$9.29	$9.29	URL	2
2	Coupling 8x10	$6.67	$13.34	URL	1,3
4	Motor Mount	$2.93	$11.72	URL	1,2,3,4
1	Vacuum Cup SGPN 40 HT 1-60 G1/8-AG	?	?	URL	5
1	SA-NIP N035 G1/8-AG DN500	?	?	URL	5
1	HSH-Flow Mini 6W 12 VDC 12L/Min 120 kPa Air Vacuum	$19.99	$19.99	URL	5
1	Vacuum Tubing Hose ¼” ID	$16.13	$16.13	URL	5
2	Vacuum Tubing Hose 3/8” ID	$1.49	$2.98	URL	5
1	Brass Reducing Hose Joiner HRC-10-06	$4.11	$4.11	URL	5
1	¼” to 5/8” Micro-Great Miniature Hose Clamps	$10.13	$10.13	URL	5
3?	uxcell FL08 8mm Bore Flange Ball Bearing	$8.03	$24.09	URL	4
1	8 mm Shaft	$15.18	$15.18	URL	4
1?	304 Stainless Steel Woven Mesh Sheet	$11.34	$11.34	URL	1,2,3,4

1	M3 Bolts (16 needed)(100 pk)	$4.70	$4.70	URL	1,2,3,4
1	M3 Lock Washer (16 needed)(100 pk)	$2.83	$2.83	URL	1,2,3,4
1	M3 Nuts (16 needed)(100 pk)	$5.55	$5.55	URL	1,2,3,4
1	M5 Bolt (12 needed)(50 pk)	$6.14	$6.14	URL	1,3,4
3	M5 Wedge Lock Washer (12 needed)(5 pk)	$8.96	$26.88	URL	1,3,4
1	M5 External Lock Washer (100 pk)	$3.63	$3.63	URL	1,3,4
1	M5 Nut (100pk)	$5.55	$5.55	URL	1,3,4
1	M6 Bolt (8 needed)(25 pk)	$5.33	$5.33	URL	2
1	M6 External Lock Washer (8 needed)(100 pk)	$3.68	$3.68	URL	2
1	M6 Nut (50pk)	$8.73	$8.73	URL	2
1	M4 Bolt (8 needed) (100 pk)	$8.08	$8.08	URL	4
3	M4 Wedge Lock Washer (8 needed)(5 pk)	$8.96	$26.88	URL	4
1	M4 External Lock Washer (8 needed)(100 pk)	$2.87	$2.87	URL	4
1	M4 Nut (100 pk)	$6.45	$6.45	URL	4
	Total		$1869.94		

Glossary

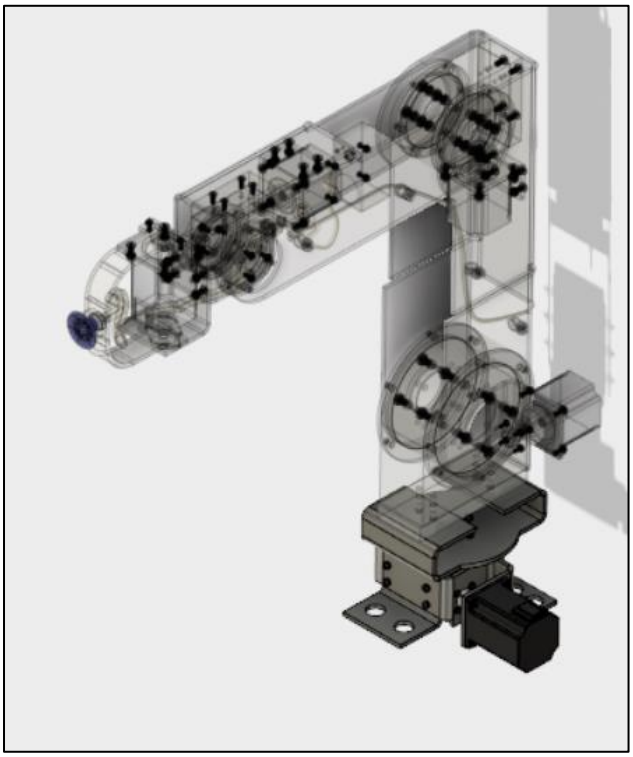
TBM-To be Manufactured

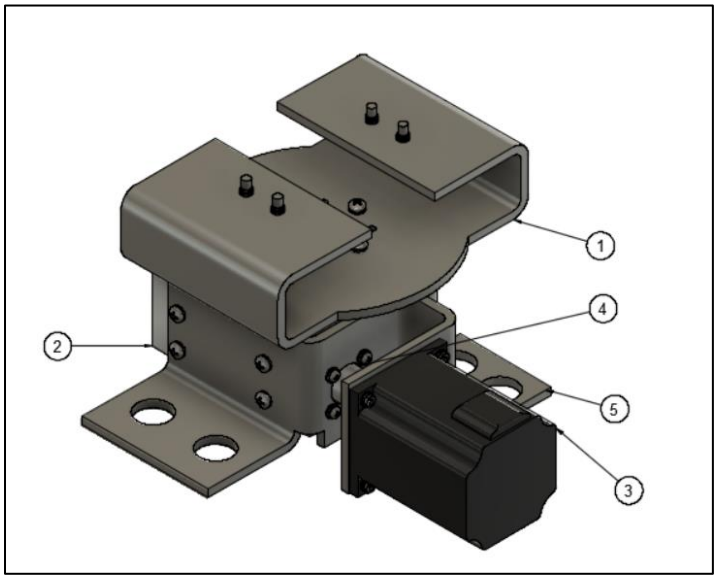
URL-reference link to website

NEMA- National Electrical Manufacturers Association

Holding Torque- Torque required by joint so it doesn’t fail

Assembly 1: Rotary Base





Part ID	Quantity	Part Name	Manufacturer/Seller	Description
1	1	Rotary Connector	-	Connector from rotary base to Arm
2	1	RLD-30 Assembly	IGUS	RLD-30-S-50-ST Joint

3	1	NEMA 23 Closed Loop Stepper Motor	Stepper Online	23HS22-2804D-E1000 1.26Nm
4	1	8x10 mm Coupling	Uxcell	Coupling Connector Between Motor and Joint
5	1	Chassis and Motor Mount	Stepper Online	Secure Motor in place

Summary

The purpose of this subassembly is to rotate the arm around about the chassis to allow it to operate on different areas around the chassis.

Performance Requirements

Arm Mass	15 kg
Arm Weight	148 N
Lever Arm(s)	4 mm x 21.25 mm
Torque	3.145 Nm

Part Details

IGUS Joint: RLD-30-S-50-ST Joint

Breakaway Torque	0.1 Nm
Breaking Torque	60 Nm
Gear Ratio	1:50
Max Output Torque	20 Nm
Max Axial Load	700 N
Weight	0.79 kg
Transmission Efficiency	0.35

Motor: 23HS22-2804D-E1000

Weight	750 grams

Torque with IGUS	1.26 Nm
Torque without IGUS	22.05 Nm
Factor of Safety	17.5

Bolting Hardware

Motor Mount

Part	Description	Quantity
A	M3 Bolts	4
B	M3 Lock Washers	4
C	M3 Nuts	4

Igus Joint

Part	Description	Quantity
D	M4 Bolt	4
E	M4 Wedge Lock Washer	4
F	M3 Bolt	4
G	M3 Nut	4

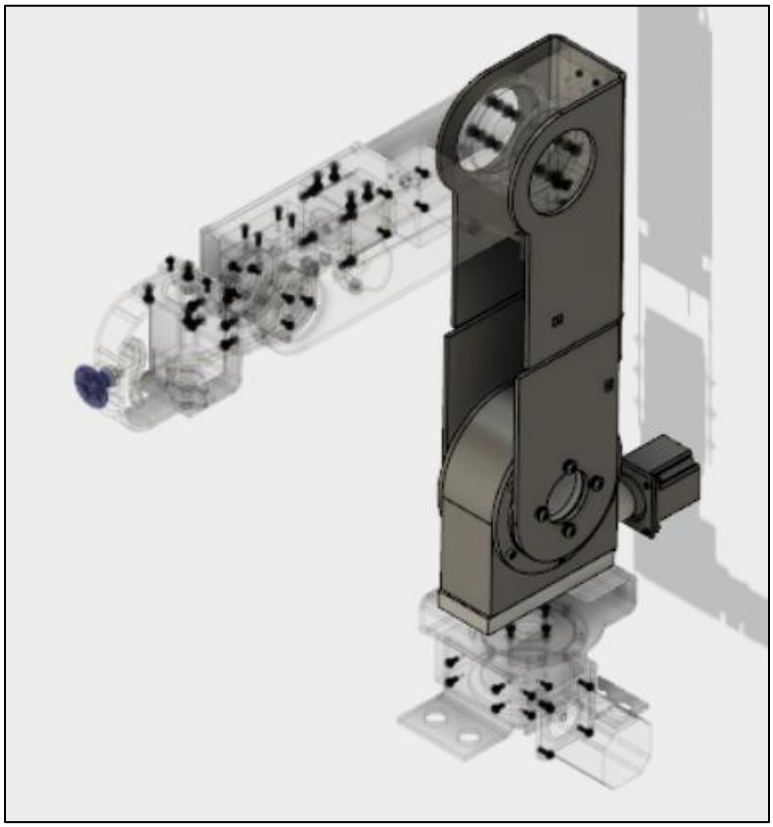
Rotating Bottom Bracket

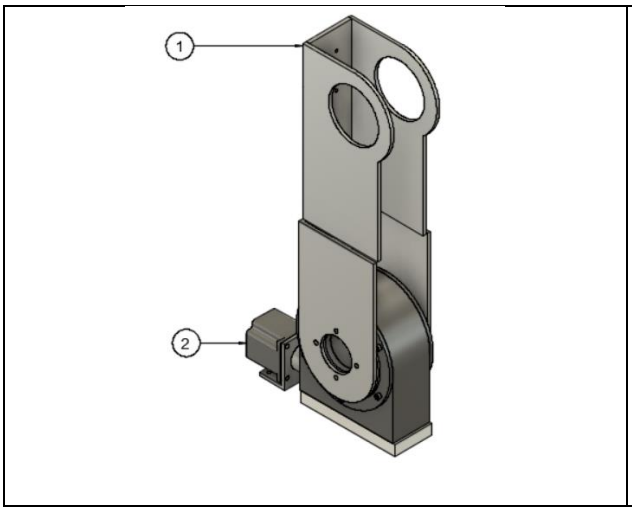
Part	Description	Quantity
H	M4 Bolt	4
I	M4 Wedge Lock Washer	4

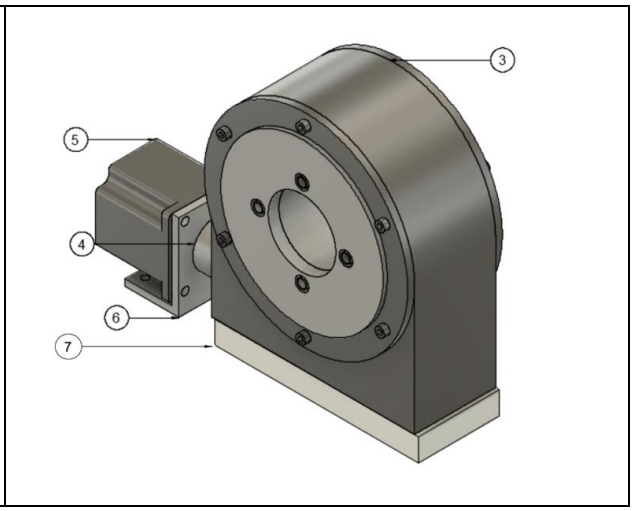
Assembly Instructions

1. Attach IGUS joint (2) to (5), make sure to align the corresponding bolt holes. Use bolts (D) and washers (E) to for bottom flat part of the IGUS. Use bolts (F) and nuts (G) for side segment of the IGUS.
2. Attach coupling (4) to IGUS (1) shaft.
3. Attach stepper motor (3) to (5), making sure the shaft of the motor attaches to the coupling (4) and aligns with the bolt wholes. Use bolts (A), washer (B) and nuts (C) to tighten.
4. Mount (1) to IGUS joint (2) aligning bolts wholes from both components. Use bolts (H) and washers (I)

Assembly 2: Arm Mechanism 1st Degree







Part ID	Part Name	Manufacturer/Seller	Description
1	Arm Section 1	-	34 cm Arm
2	Igus-Motor Assembly	-	-
3	IGUS Joint	IGUS	RLD-30-S-50-ST
4	Coupling	uxcell	8x15 mm
5	NEMA 23	StepperOnline	23HS30-2804D-E1000
6	Motor Mount	StepperOnline	NEMA 23 Motor Mount
7	IGUS Mount	-	IGUS mount

Summary

This Subassembly purpose is to actuate the entire arm and will handle the highest torque. The assembly consists of an Igus Joint actuated by a NEMA 23 motor. This is the largest IGUS joint used in the arm mechanism.

Performance Requirements

Holding Torque	81 Nm

Part Details

IGUS Joint: RL-D-50-102-48-01000 Joint

This joint was chosen since it had a better efficiency compared to the other 50 model that allows us to use a smaller motor that consumes less power.

Breaking Torque	180 Nm
Factor of Safety	2.2
Max Output Torque	50 Nm
Efficiency	0.35
Gear Ratio	1:48
Weight	2.05 kg

Motor: 23HS30-2804D-E1000

Three motors were considered to actuate a double stack NEMA 23, a triple stack NEMA 23 and a single stack NEMA 34. The parameters of interest were the output torque it provides to the IGUS, power consumption, and weight. The table below shows the specifications of each.

MOTOR	Torque Provided (Nm)	Power Requirement (W)	Weight (kg)
NEMA 23 D-Stack	32	9	1.2
NEMA 23 T-Stack	47	16	1.8
NEMA 34	76	12.1	3.2

Another parameter under consideration was the maximum output torque the joint could handle which was 50 N m at 30% duty cycle. The NEMA 34 exceeds this number and weighs the most so it was no longer considered for selection. The one closest to fit the performance for the IGUS was the NEMA 23 T-Stack however this motor requires more power to operate so this would greatly reduce battery life. Thus, the NEMA 23 Double Stack was chosen since it weighed the least and provided an appropriate torque. However, this motor will have to operate at lower RPM to operate adequately so the joint will be slower compared to the others.

Bolting Hardware

Motor Mount

Part	Description	Quantity
A	M3 Bolt	4
B	M3 Lock Washer	4
C	M3 Nuts	4

Igus Joint to Arm

Part	Description	Quantity
D	M6 Bolt	4
E	M6 External Lock Washer	4

Igus Joint

Part	Description	Quantity
F	M6 Bolt	4
G	M6 Lock Washer	4

Assembly Instructions

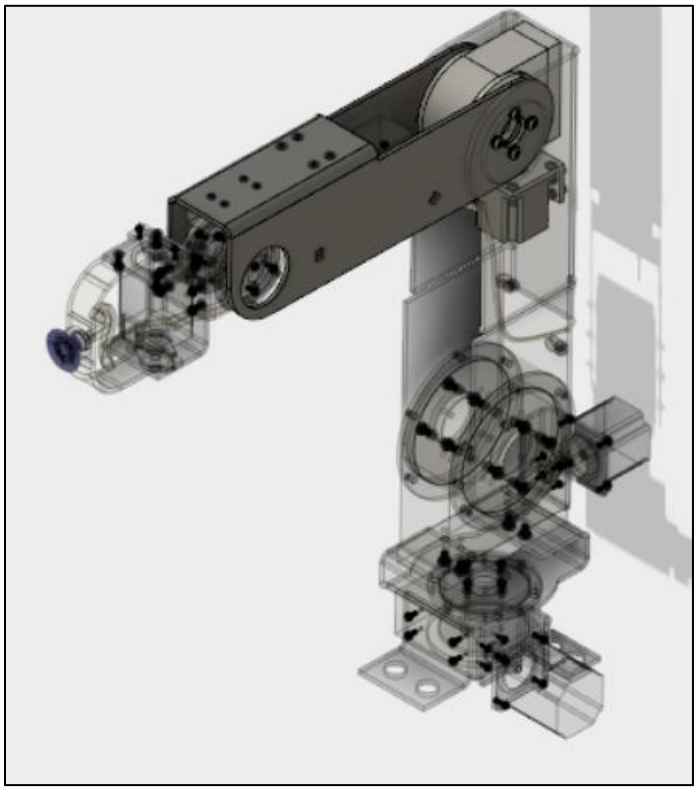
Motor and IGUS mount

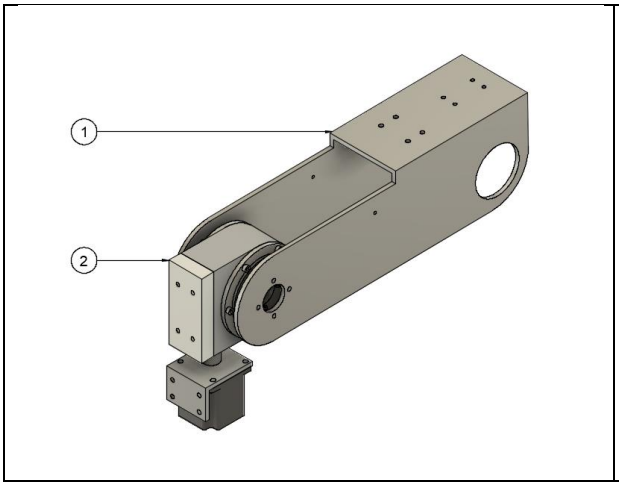
1. Attach motor (5) to mount (6) using bolts (A) and washers (B) and nuts (C).
2. Attach mount (7) to IGUS joint (3) using bolts (F) and washers (G).
3. Join assemblies from previous steps using coupling connection (4).

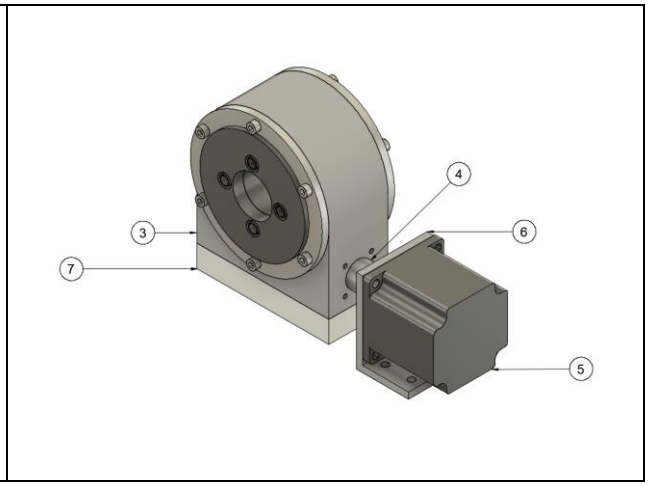
   Igus Joint to Arm

4. Join arm section (1) to assembly (2) using bolts (D) and washers (E).

Assembly 3: Arm Mechanism 2nd Degree







Part ID	Quantity	Part Name	Manufacturer/Seller	Description
1	1	Arm Section 2	-	30.5 cm Arm
2	1	Igus-Motor Assembly	-	-
3	1	IGUS Joint	IGUS	RLD-30-S-50-ST
4	1	Coupling	uxcell	8x10 mm
5	1	NEMA 23	StepperOnline	23HS30-2804D-E1000
6	1	Motor Mount	StepperOnline	NEMA 23 Motor Mount
7	1	IGUS Mount	-	IGUS mount

Summary

This joint is the second degree of freedom arm that also moves about the same axis as the first degree of freedom of the arm. This degree of freedom consists of an Igus 30 Joint, a NEMA 23 and the arm section along with all necessary bolting hardware.

Performance Requirements

Holding Torque	35 Nm

Part Details

IGUS Joint: RLD-30-S-50-ST

This joint was chosen since it is one of the joint USDA-ARS already has in stock and can be used at this joint.

Breaking Torque	80 Nm
Factor of Safety	2.3
Max Output Torque	20 Nm
Efficiency	0.35
Gear Ratio	50:1
Weight	0.79 kg

Motor: 23HS22-2804D-E1000

Torque without IGUS	1.26 Nm
Torque with IGUS	22.05 Nm
Power Consumption	7 W
Weight	0.75 kg

Bolting Hardware

Motor Mount

Part	Description	Quantity
A	M3 Bolts	4
B	M3 Lock Washers	4
C	M3 Nuts	4

Igus Joint

Part	Description	Quantity
D	M4 Bolts	4

Igus Joint-Arm

Part	Description	Quantity
E	M5 Bolt	4
F	M5 Wedge Lock Washer	4

Assembly Instructions

Motor and IGUS mount

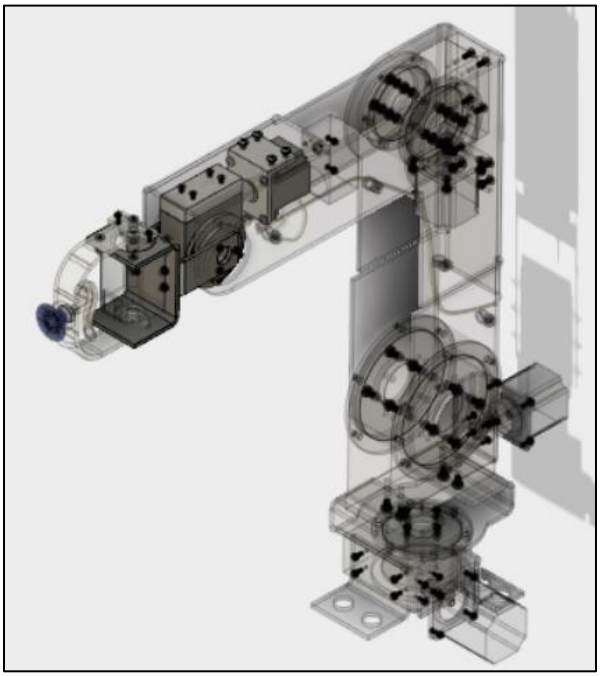
1. Attach motor (5) to mount (6) using bolts (A) and washers (B) and nuts (C).

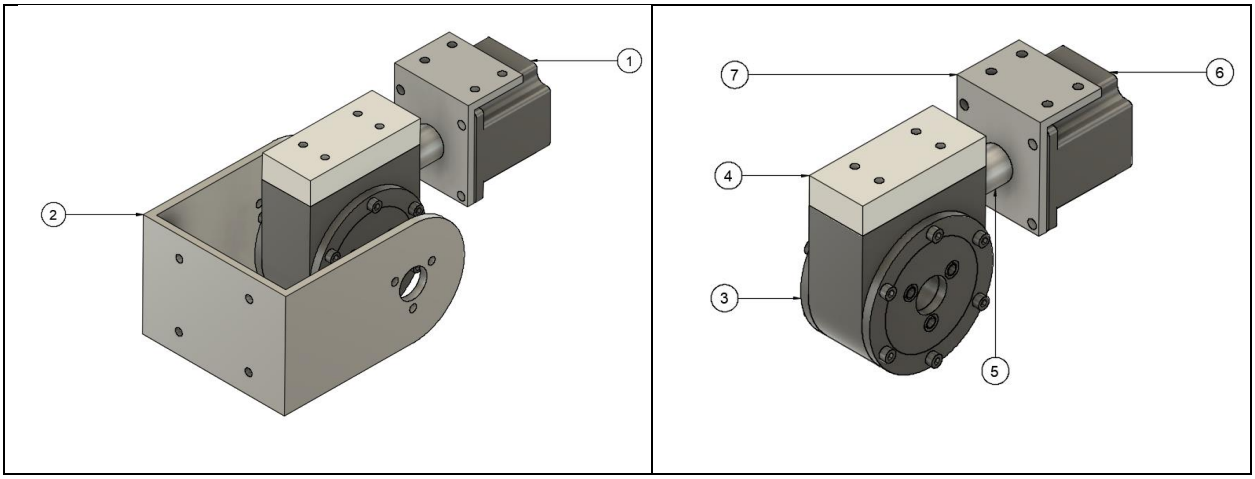
2. Attach mount (7) to IGUS joint (3) using bolts (D)

3. Join assemblies from previous steps using coupling connection (4).

Igus Joint to Arm

Assembly 4: Arm Mechanism 3rd Degree





Part ID	Quantity	Part Name	Manufacturer/Seller	Description
1	1	Igus-Motor Assembly	-	-
2	1	Arm Connection	-	-
3	1	IGUS Joint	IGUS	RLD-20-S-38-ST
4	1	IGUS Mount	-	IGUS Mount
5	1	Coupling	uxcell	8x8 mm
6	1	NEMA 23	StepperOnline	23HS30-2804D-E1000
7	1	Motor Mount	StepperOnline	NEMA 23 Motor Mount

Summary

This is the assembly for the third section of the arm. This section also moves about the same axis as the previous two arm sections.

Performance Requirements

Holding Torque	11.35 Nm

Part Details

IGUS Joint: RLD-20-S-38-ST

This joint was chosen since it was already available with the USDA-ARS and it was shown it could be used for this Joint.

Breaking Torque	30 Nm
Factor of Safety	2.64
Max Output Torque	10 Nm
Efficiency	0.4
Gear Ratio	1:38
Weight	0.41 kg

Motor: 23HS22-2804D-E1000

Torque w/out Igus	1.26 Nm
Torque Provided w/ IGUS	19.15 Nm
Power Consumption	7 W
Weight	0.75 kg

Bolting Hardware

Motor Mount

Part	Description	Quantity
A	M3 Bolt	4
B	M3 Lock Washer	4
C	M3 Nut	4

Igus Joint

Part	Description	Quantity
D	M4 Bolt	4
E	M4 Lock Washer	4

Igus Joint-Arm

Part	Description	Quantity
F	M5 Bolt	3
G	M5 Wedge Lock Washer	3

Assembly Instructions

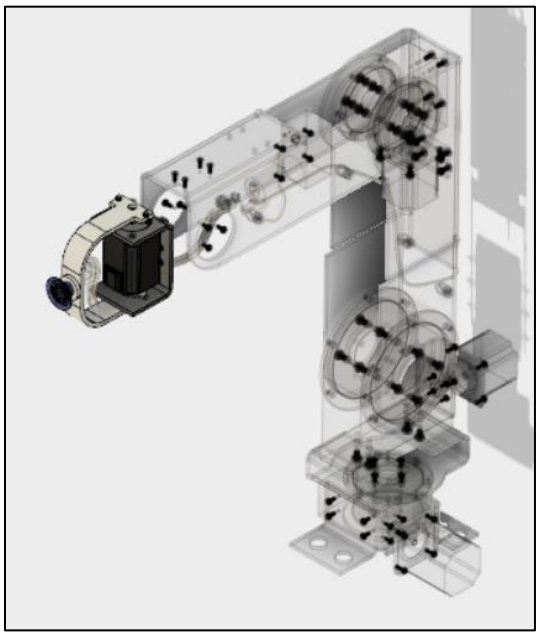
Motor and IGUS mount

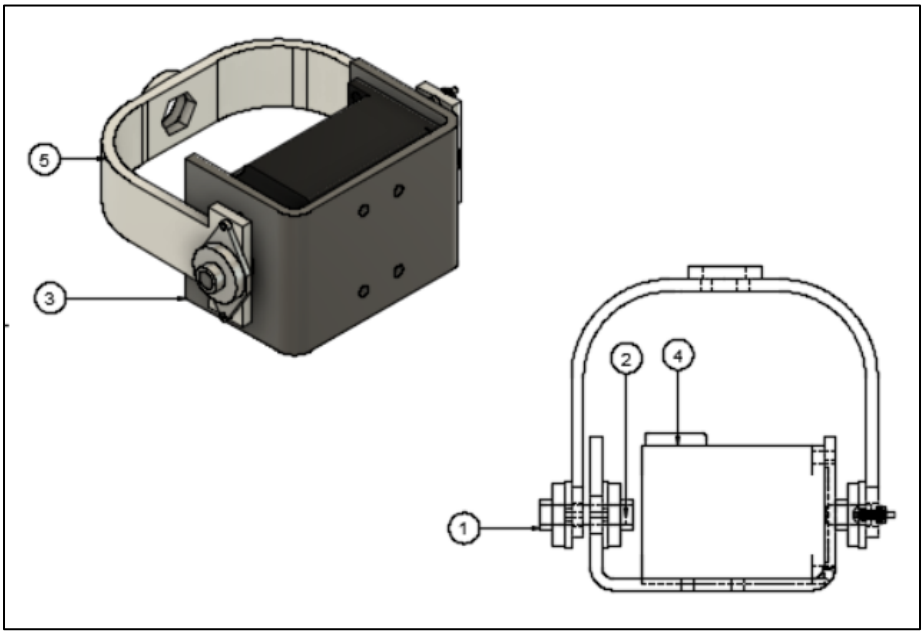
1. Attach motor (6) to mount (7) using bolts (A) and washers (B) and nuts (C).
2. Attach mount (4) to IGUS joint (3) using bolts (D) and washers (E).
3. Join assemblies from previous steps using coupling connection (5).

Igus Joint to Arm

4. Join arm section (1) to assembly (2) using bolts (F) and washers (G).

Assembly 5: Arm Mechanism 4th Degree





Part ID	Quantity	Part Name	Manufacturer/Seller	Description
1	1	Motor Ball-Bearings	Uxcell	8mm Bore Self-aligning Flange
2	1	Motor Shaft	-	-
3	1	Motor Mount	-	-
4	1	NEMA 23	STEPPERONLINE	23HS30-2804D-E1000
5	1	Vacuum Cup Holder	-	8x8 mm

Summary

This is the assembly that the end effector will be mounted on. This section will allow the arm to have a degree of freedom that moves horizontally. This joint is the only one that does not use an Igus Joint since utilizing an Igus joint would be counter-productive due to its weight and that it would limit movement of the previous section.

Performance Requirements

Holding Torque	4.25 Nm

Part Details

Motor: 23HS22-2804D-E1000

Torque	1.26 Nm
Power Consumption	7 W
Weight	0.75 kg

Bolting Hardware

Motor mount

Part	Description	Quantity
A	M3 Bolt	4
B	M3 Wedge Lock Washer	4
C	M3 Nut	4

Assembly Instructions

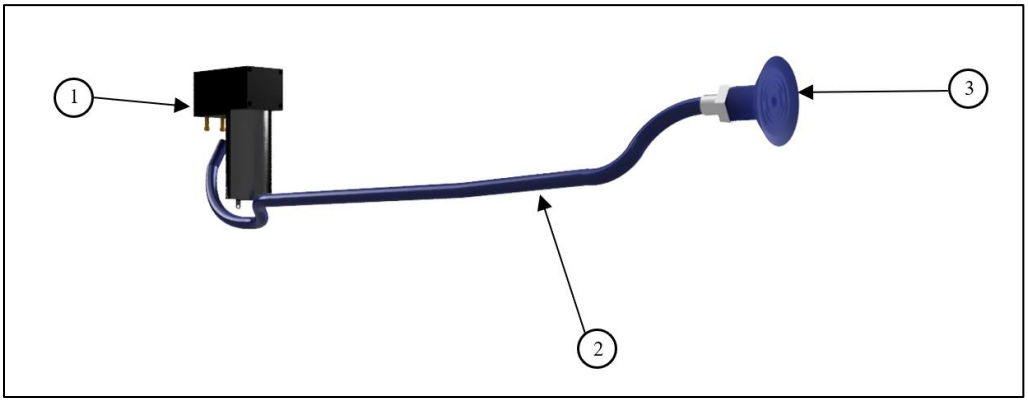
Motor and IGUS mount

1. Attach bearing (1) to mount (3) by aligning perforated wholes.

2. Attach motor (4) to to mount. Make sure to align shaft of the motor throught whole are of mount. Use bolts (A), washer (B) and nut (C) to secure parts.

3. Join assembly from previous steps to end-effector mount (5). And insert shaft (2) to secure assemblies.

End Effector: Vacuum Assembly



Part ID	Quantity	Part Name	Manufacturer/Seller	Description
1	1	AIYIMA Mini Air Pump	AliExpress	DC12V 50Kpa
2a	1	Vacuum Tubing Hose	HPS	60 psi Maximum Pressure, 1/4" ID
2b	1	Vacuum Tubing Hose	Gates	3/8’’ ID
2c	1	Hose Adapter	AFS	1/4" to 3/8’’ Connection
3	1	Vacuum Cup	SCHMALZ	SGPN 40 HT1-60 G1/8-AG

Assembly Instructions

1. Connect hose (2a) with hose (2b) using adaptor (2c).
2. Connect end of hose (2a) to motor (1)
3. Connect end of hose (2b) to vacuum cup (3)

Manufacturing Manual

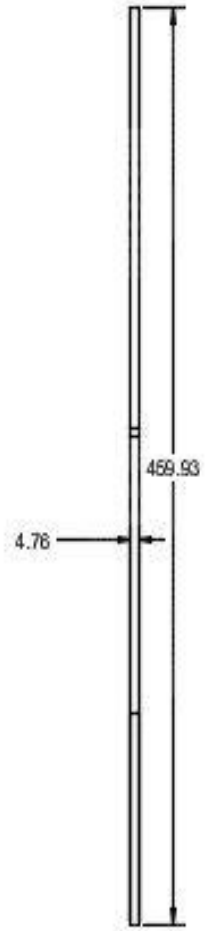
Fabrication

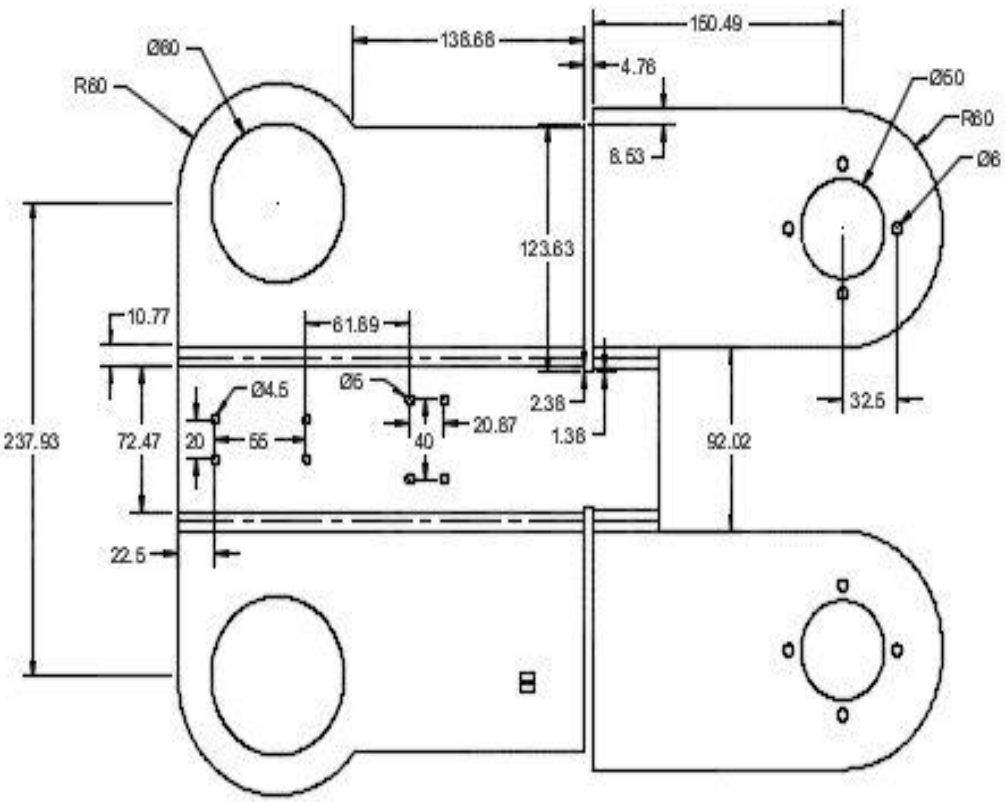
Aluminum components will need fabrication. Arm sections 1 through 3 and final bracket are the components to be manufactured. Sheet metal cutting and bending as well as whole perforations are the machining operations needed to accomplish the arm designs. The appendix contains section sheets, each corresponding to the four arm sections. The sheets contain dimension on size parameters, whole diameters, and whole locations. Each schematic also contains the bend allowances for the appropriate bends to be made on the sheet metal.

3-D Printing

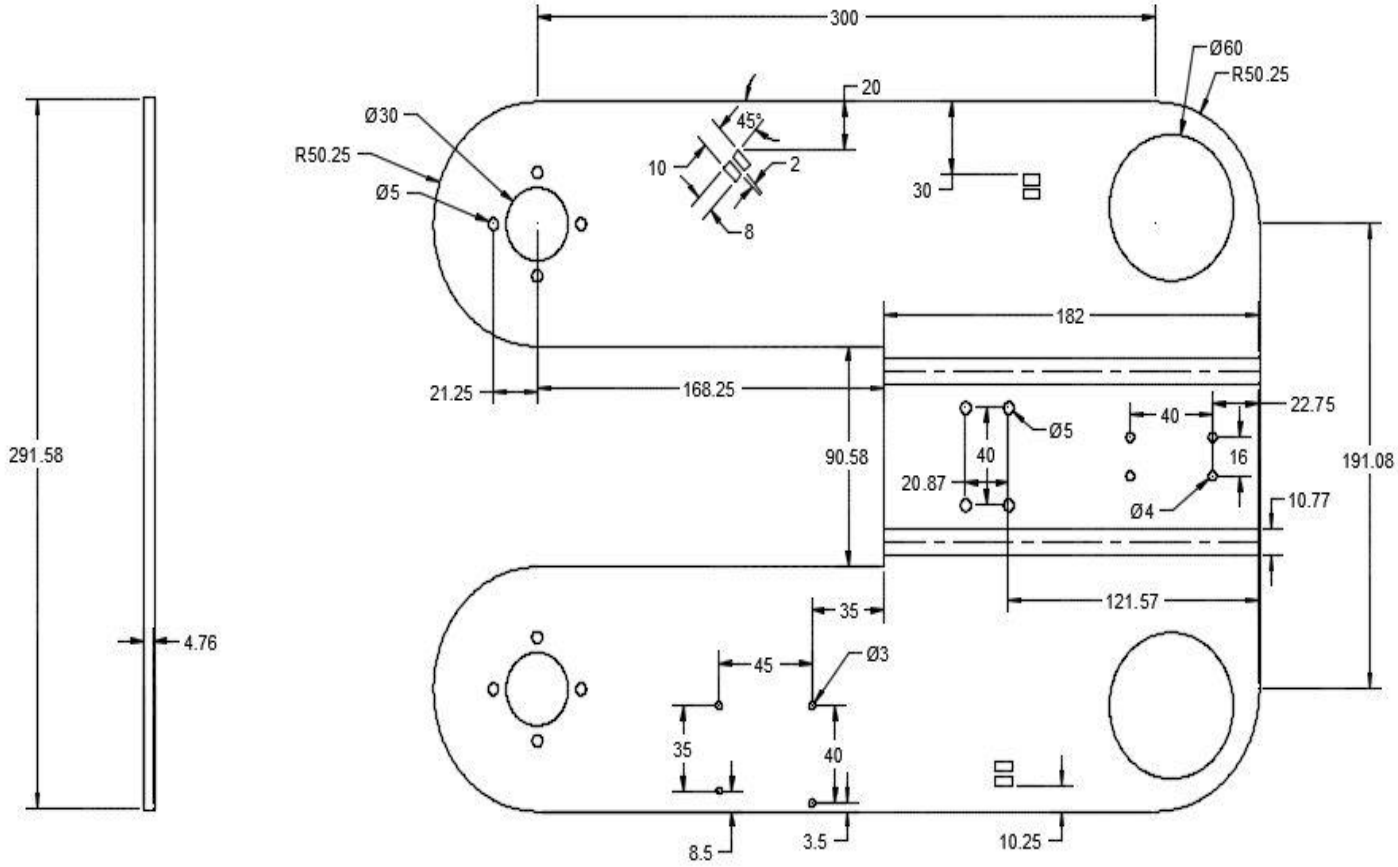
Components such as IGUS mounts and end-effector holders will be 3-D printed. The previous components will be fabricated with PLA plastic. The part sheets containing the dimensions on size parameter, whole diameters and whole locations are seen under the appendix for 3-D printed parts. The proper design CAD files will be submitted to the USDA-ARS.

APPENDIX: FABRICATED PARTS





ALL DIMENSIONS IN MM UNLESS OTHERWISE SPECIFIED		PROJECT: CULE ROBOTICS			
TOLERANCES UNLESS OTHERWISE SPECIFIED		TITLE: Section 1			
	APPROVED	SIZE: B	CODE	DWG NO: CUL-000	REV
REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE SPECIFIED	CHECKED				
	DRAWN	SCALE: 1:4	WEIGHT	SHEET: 1/1	



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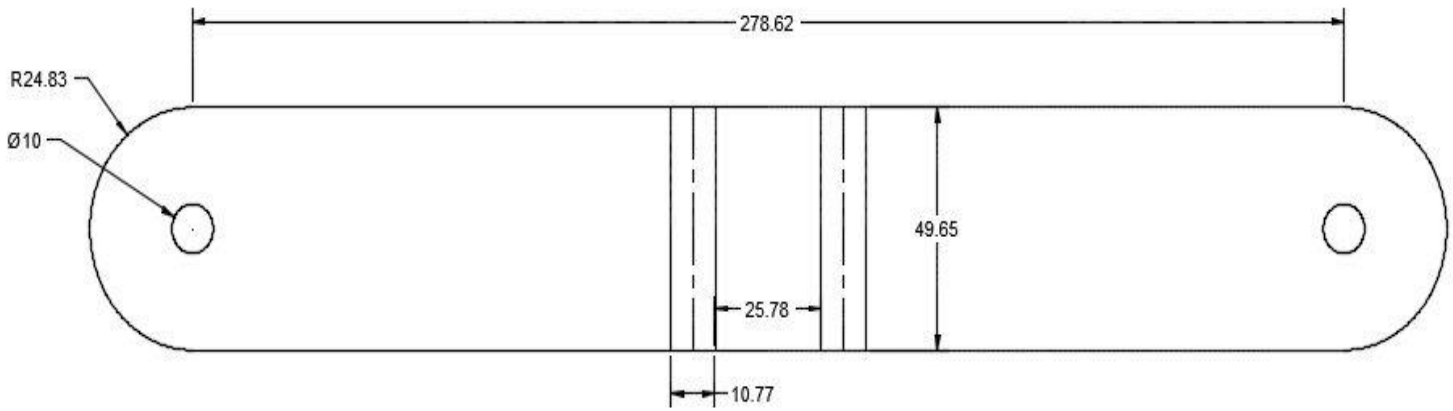
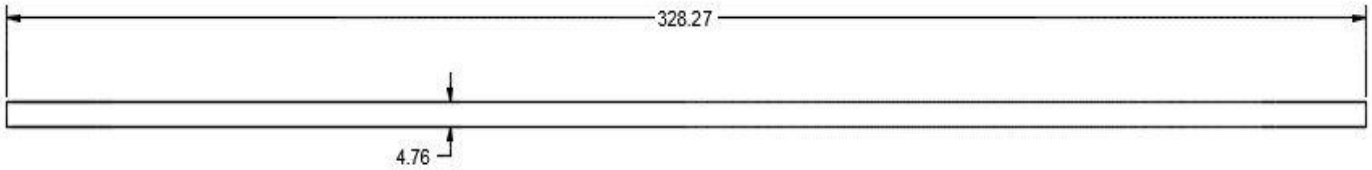
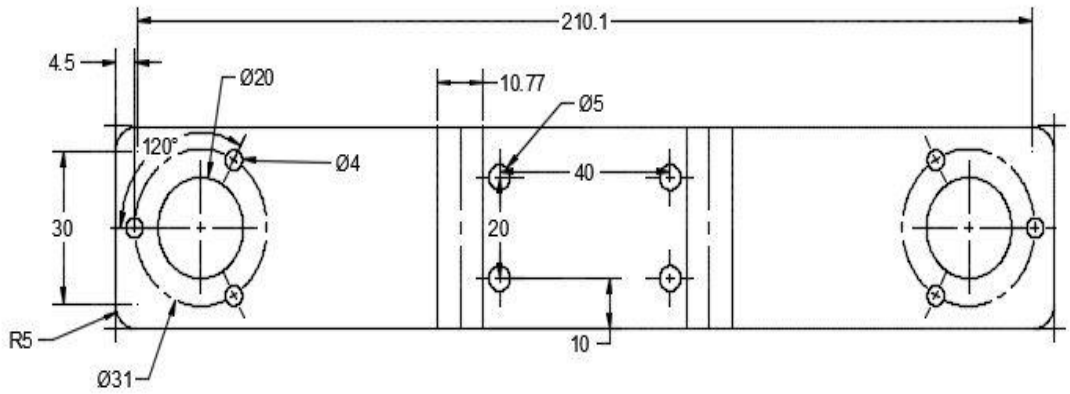
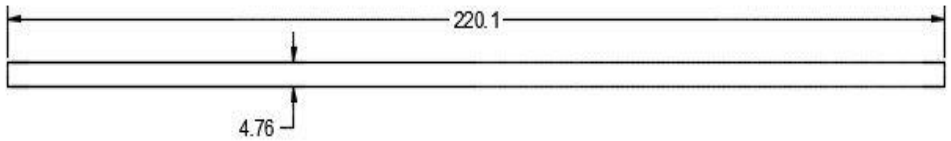
TOLERANCES UNLESS OTHERWISE SPECIFIED		TITLE: Section 2			
	APPROVED	SIZE: B	CODE	DWG NO: CUL-000	REV
REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE SPECIFIED	CHECKED				
	DRAWN	SCALE 1:4	WEIGHT	SHEET 1/1	



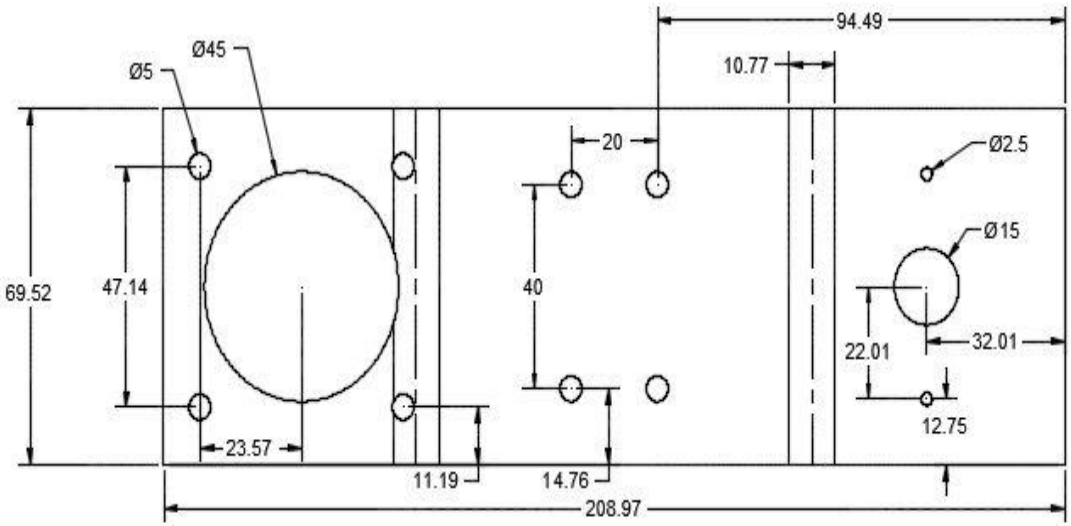


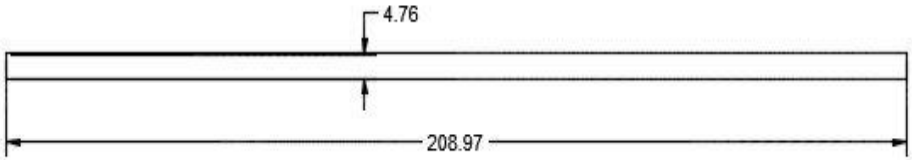
ALL DIMENSIONS IN MM UNLESS OTHERWISE SPECIFIED		PROJECT: CULE ROBOTICS			
TOLERANCES UNLESS OTHERWISE SPECIFIED		TITLE: Section 3			
	APPROVED	SIZE: B	CODE	DWG NO: CUL-000	REV
REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE SPECIFIED	CHECKED				
	DRAWN	SCALE: 1:4	WEIGHT	SHEET: 1/1	



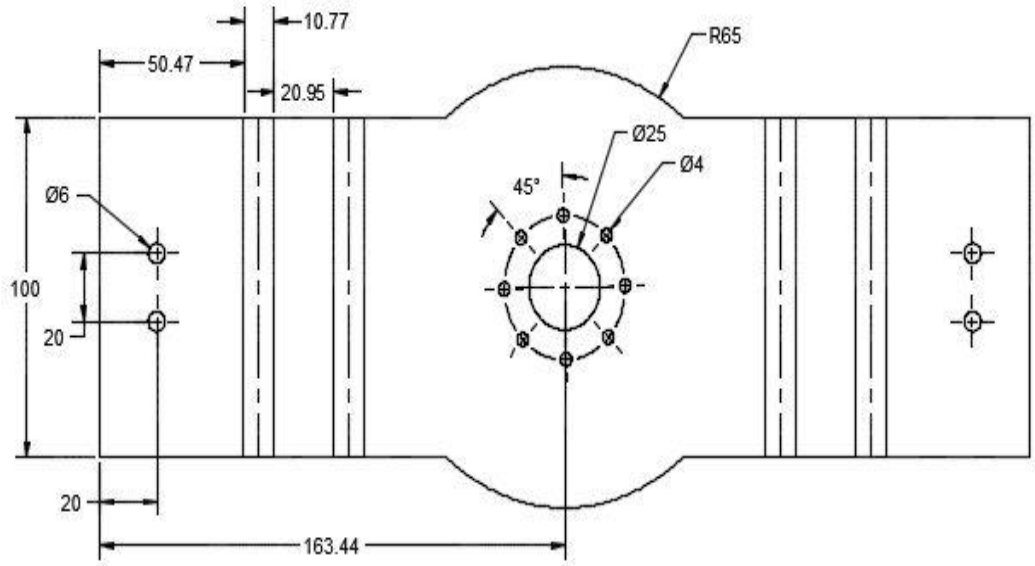


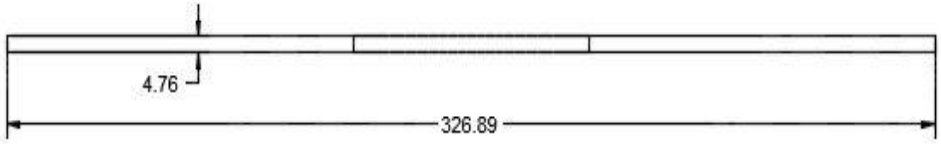
ALL DIMENSIONS IN MM UNLESS OTHERWISE SPECIFIED		PROJECT: CULE ROBOTICS			
TOLERANCES UNLESS OTHERWISE SPECIFIED		TITLE: Section 3 Connector			
	APPROVED	SIZE: B	CODE	DWG NO: CUL-000	REV
REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE SPECIFIED	CHECKED				
	DRAWN	SCALE 1:4	WEIGHT	SHEET 1/1	





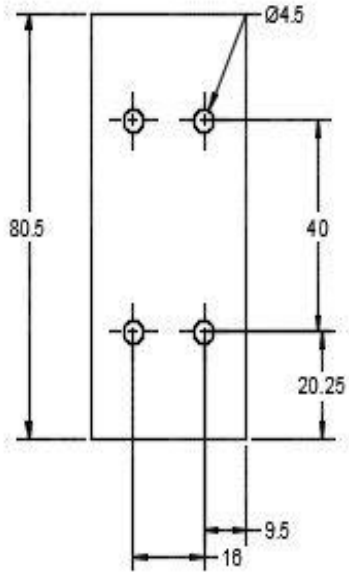
ALL DIMENSIONS IN MM UNLESS OTHERWISE SPECIFIED		PROJECT: CULE ROBOTICS			
TOLERANCES UNLESS OTHERWISE SPECIFIED		TITLE: Final Bracket SM			
	APPROVED	SIZE: B	CODE	DWG NO: CUL-000	REV
REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE SPECIFIED	CHECKED				
	DRAWN	SCALE 1:4	WEIGHT	SHEET 1/1	

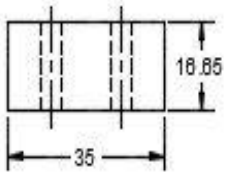


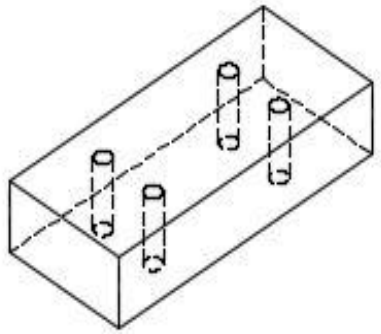


ALL DIMENSIONS IN MM UNLESS OTHERWISE SPECIFIED		PROJECT: CULE ROBOTICS			
TOLERANCES UNLESS OTHERWISE SPECIFIED		TITLE: Rotating Bottom Bracket			
	APPROVED	SIZE: B	CODE	DWG NO: CUL-000	REV
REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE SPECIFIED	CHECKED				
	DRAWN	SCALE 1:4	WEIGHT	SHEET 1/1	

APPENDIX:
3-D PRINTED PARTS







1	1	RLD 20 TO NEMA 23 MOUNT V3		ABS PLASTIC
ITEM	QTY	PART NUMBER	DESCRIPTION	MATERIAL

PARTS LIST

ALL DIMENSIONS IN MM UNLESS OTHERWISE SPECIFIED

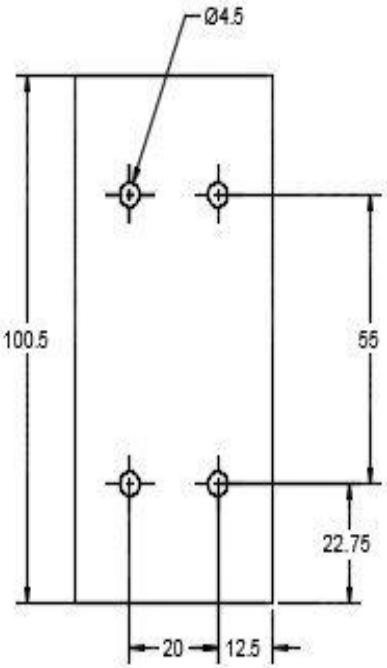
TOLERANCES UNLESS OTHERWISE SPECIFIED X ± .3mm
X.X ± .33
X.XX ± .33mm
ØX.X ± .6mm

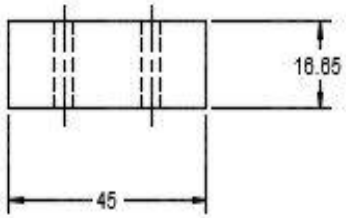
SAND WITH 80 GRIT SAND PAPER AFTER PRINTING NEXT WET SAND WITH 240 GRIT TO SMOOTH SURFACES

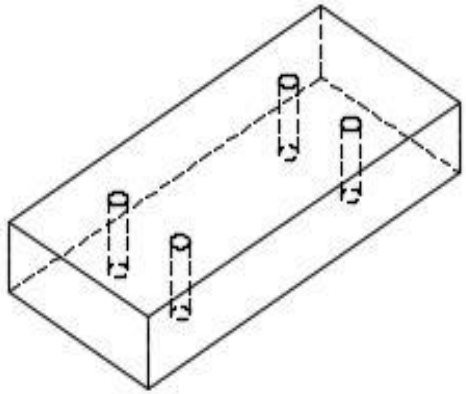
PROJECT
CULE ROBOTICS

TITLE
RLD 20 to Nema 23 Mount v3

APPROVED	SIZE	CODE	DWG NO	REV
CHECKED	B		CUL-000	
DRAWN	SCALE 1:4	WEIGHT	SHEET 1/1	







ITEM	QTY	PART NUMBER	DESCRIPTION	MATERIAL
1	1	RLD 30 TO NEMA 23 MOUNT		ABS PLASTIC

PARTS LIST

ALL DIMENSIONS IN MM UNLESS OTHERWISE SPECIFIED

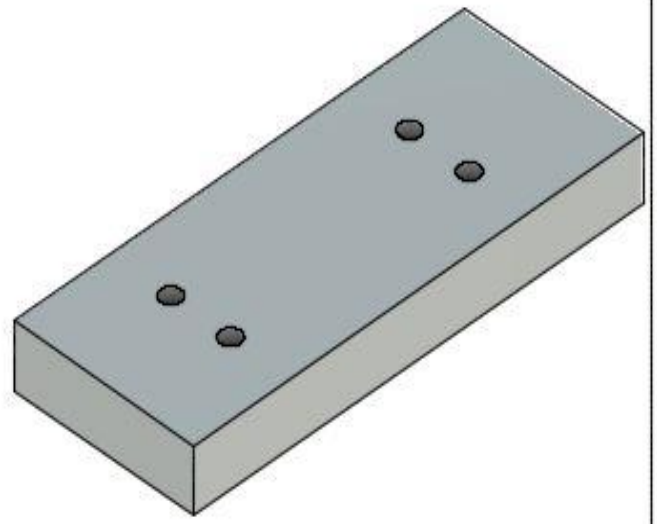
TOLERANCES UNLESS OTHERWISE SPECIFIED
X.XX ± 0.33mm
X.X ± 0.33mm
X ± 0.8mm
Ø ± .6mm

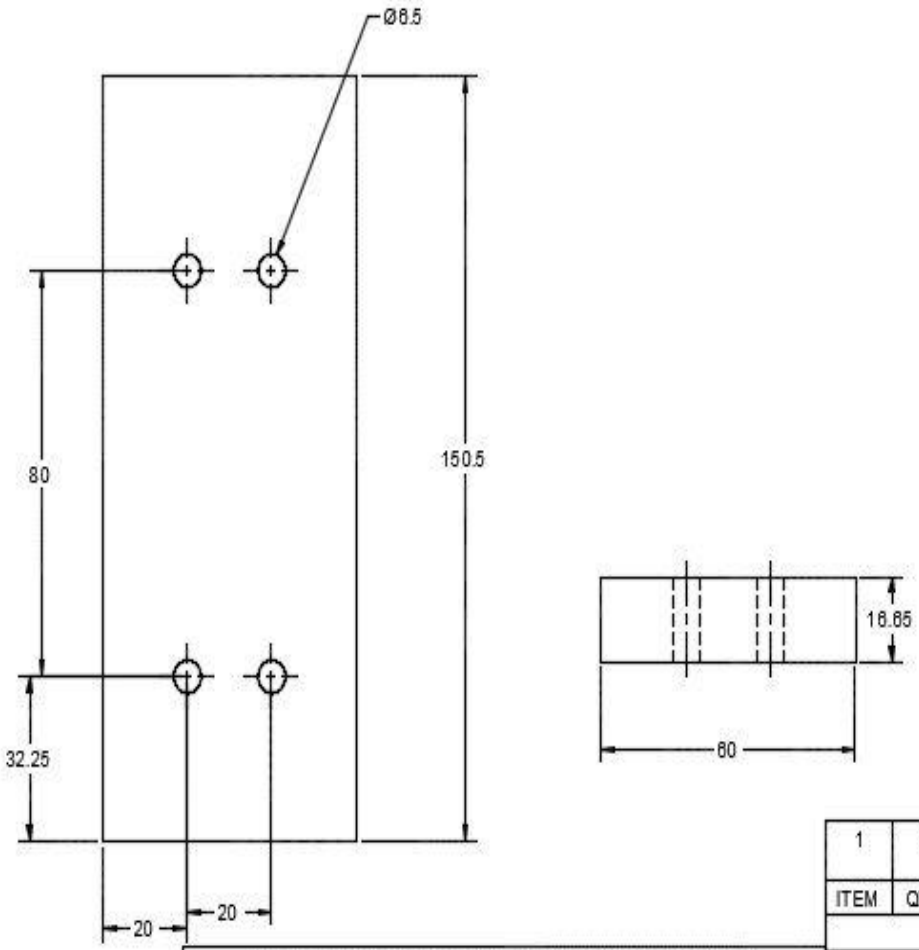
SAND WITH 80 GRIT SAND PAPER AFTER PRINTING THEN WET SAND WITH 240 GRIT TO SMOOTH SURFACES

PROJECT
CULE ROBOTICS

TITLE
RLD 30 to Nema 23 Mount

APPROVED	SIZE	CODE	DWG NO	REV
CHECKED IVAN BADER	B		CUL-000	
DRAWN MARCUS GRAY	SCALE 1:1	WEIGHT	SHEET 1/1	





ITEM	QTY	PART NUMBER	DESCRIPTION	MATERIAL
1	1	RLD 50 TO NEMA 23 MOUNT		ABS PLASTIC

PARTS LIST

ALL DIMENSIONS IN MM UNLESS OTHERWISE SPECIFIED

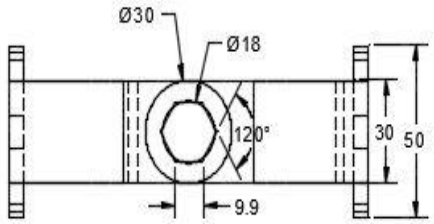
TOLERANCES UNLESS OTHERWISE SPECIFIED
X.XX ± 0.33mm
X.X ± 0.33mm
X ± 0.8mm
ØX.X ± 0.8mm

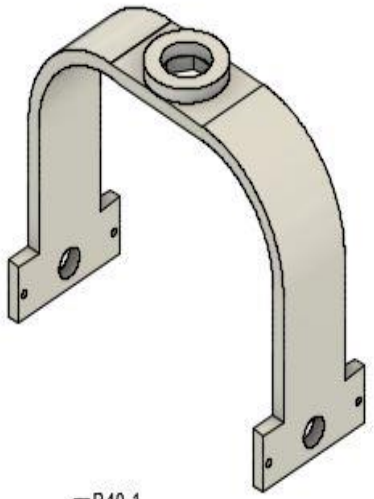
SAND WITH 80 GRIT SAND PAPER AFTER PRINTING THEN WET SAND WITH 240 GRIT TO SMOOTH SURFACES

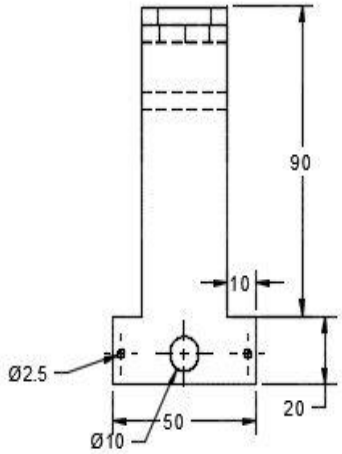
PROJECT
CULE ROBOTICS

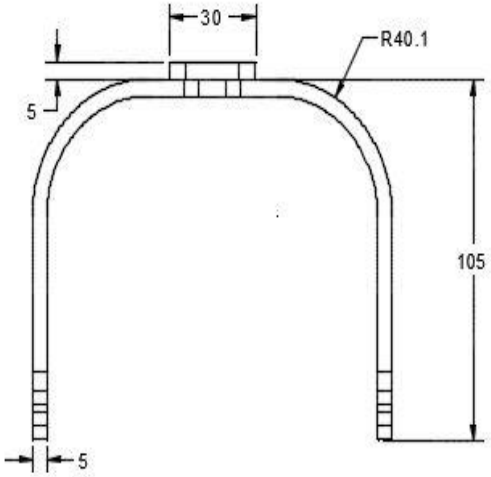
TITLE
RLD 50 to Nema 23 Mount

APPROVED	SIZE	CODE	DWG NO	REV
CHECKED IVAN BADER	B		CUL-000	
DRAWN MARCUS GRAY	SCALE 1:1	WEIGHT	SHEET 1/1	









ALL DIMENSIONS IN MM UNLESS OTHERWISE SPECIFIED		PROJECT: CULE ROBOTICS			
TOLERANCES UNLESS OTHERWISE SPECIFIED		TITLE: End Effector Mount			
	APPROVED	SIZE: B	CODE	DWG NO: CUL-000	REV
REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE SPECIFIED	CHECKED				
	DRAWN	SCALE 1:4	WEIGHT	SHEET 1/1	