Robotics Studio MECE 4611

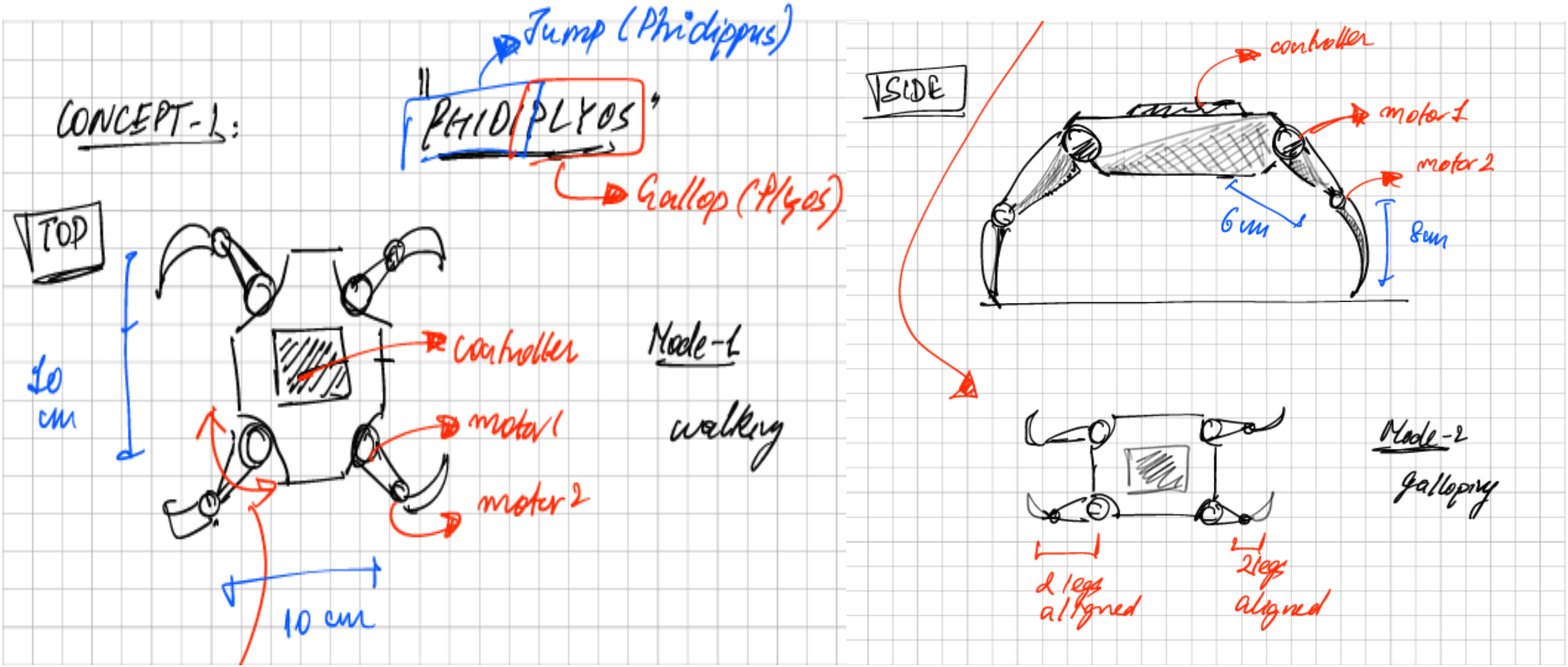
Semester -1, Assignment – 1

Name 1: Anushtup Nandy UNI 1: an3314

Name 2: Barath Kumar Jayachandran Kanchanamalini UNI 2: bj2519

Submitted Date: 8/7/2024

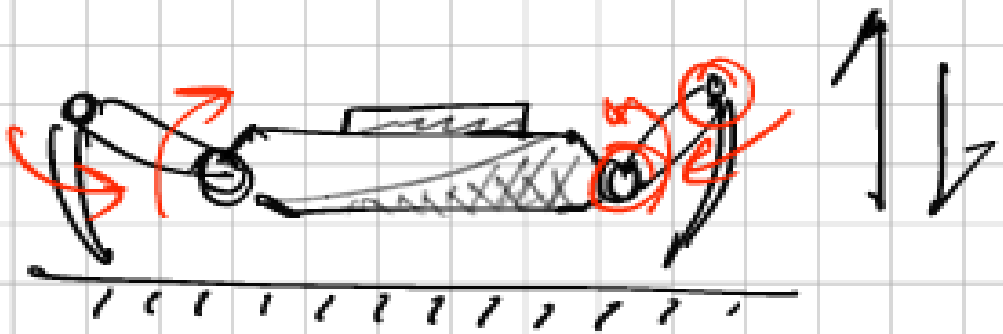
Concept 1


CONCEPT-1:
PHIDIPLYOS
Jump (Phidippus)
Gallop (Plyos)
TOP
10 cm
controller
motor 1
motor 2
10 cm
Mode-1
walking
SIDE
controller
motor 1
motor 2
6 cm
8cm
Mode-2
galloping
2 legs aligned
2 legs aligned

Concept 1

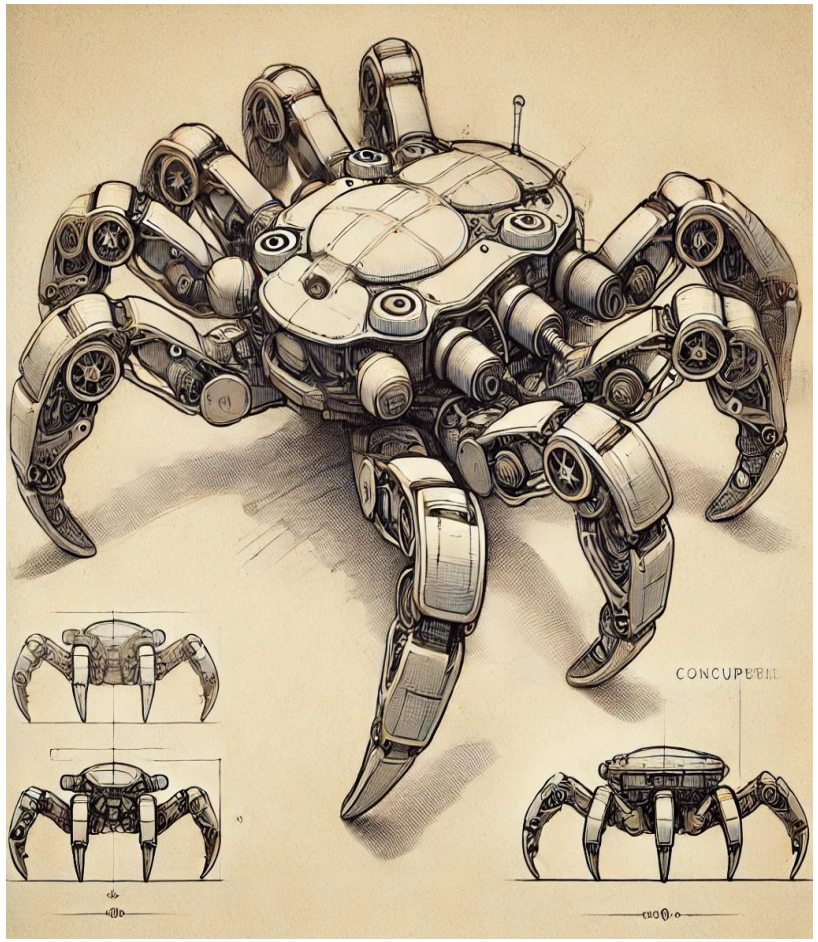
Mode-3

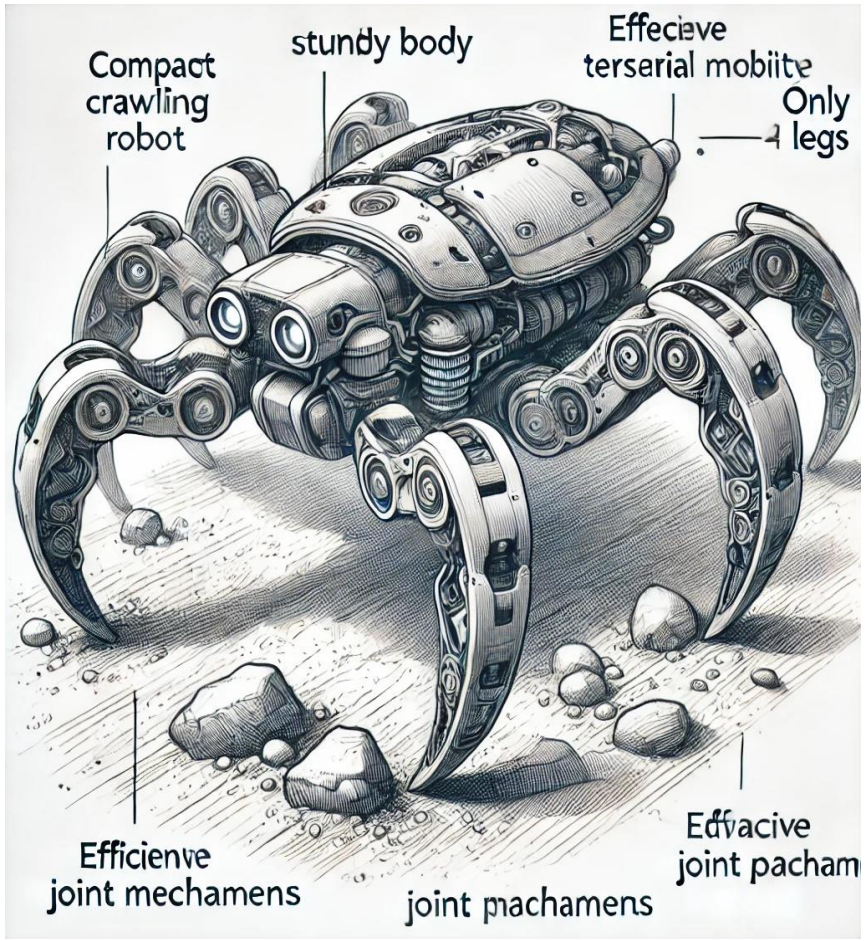
Jumping

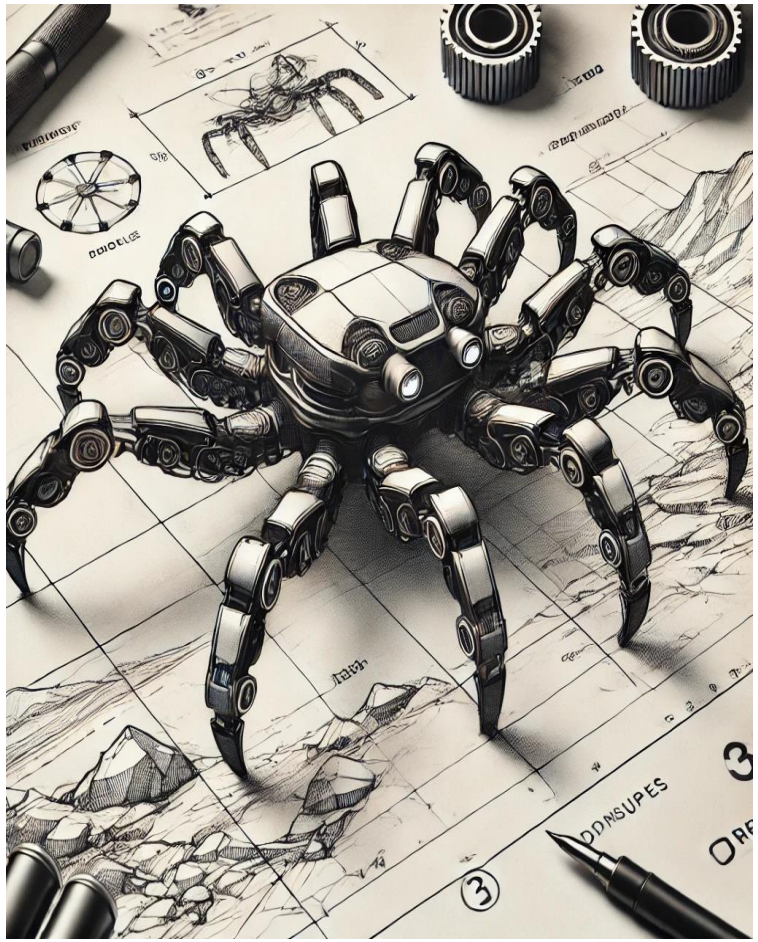


Body will be pushed down and a spring like action will be executed

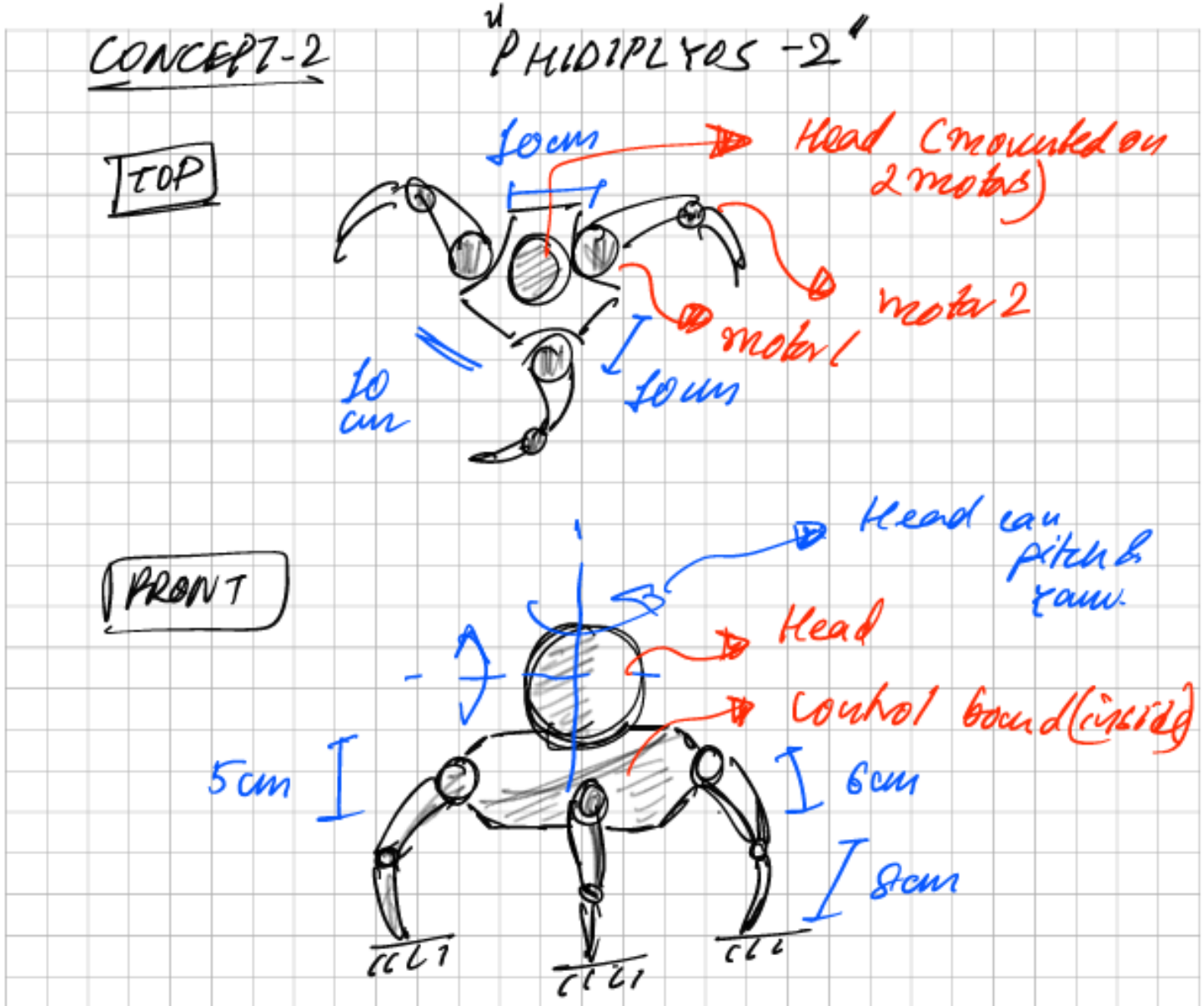
Generative AI Assistance



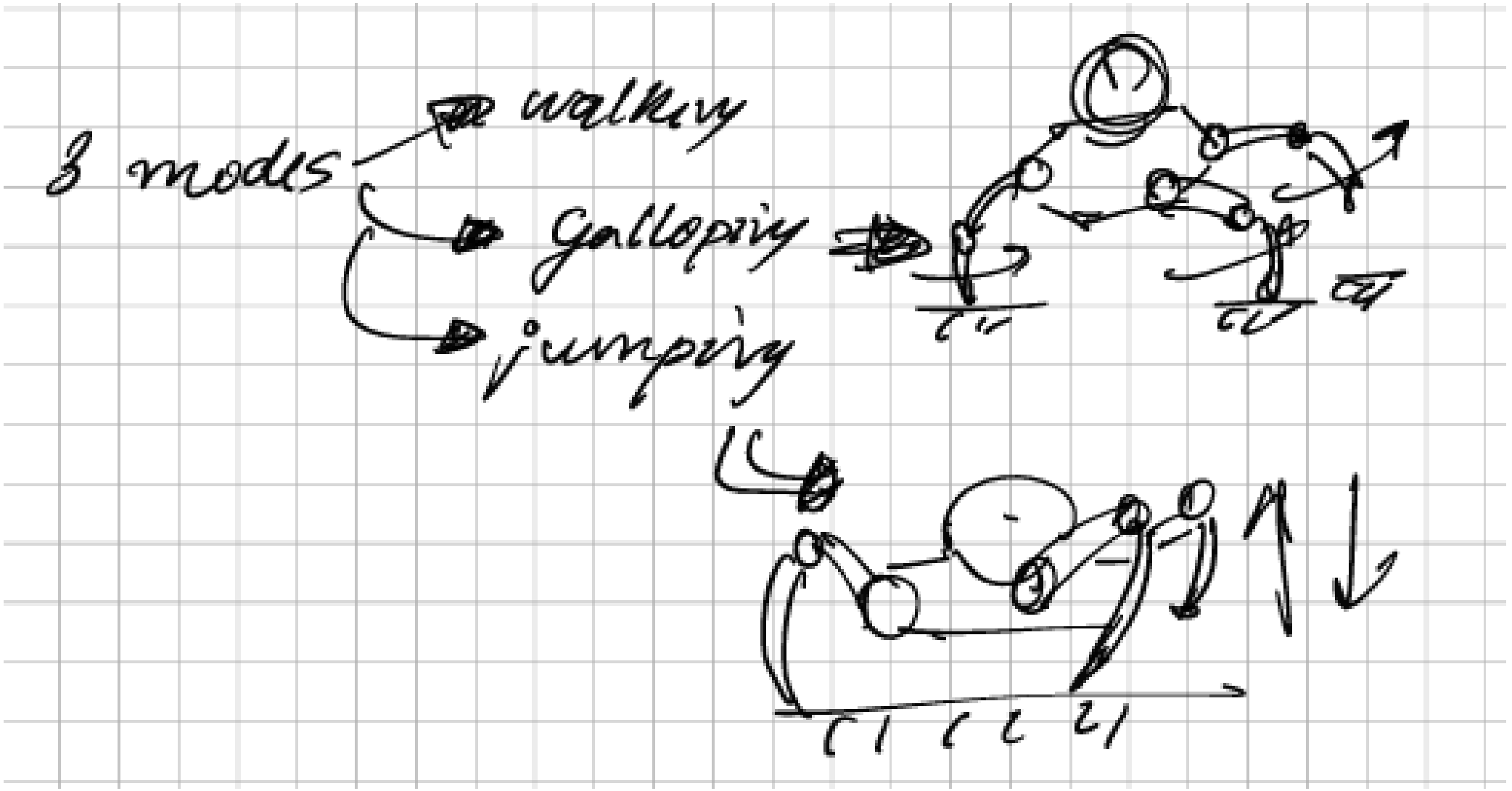




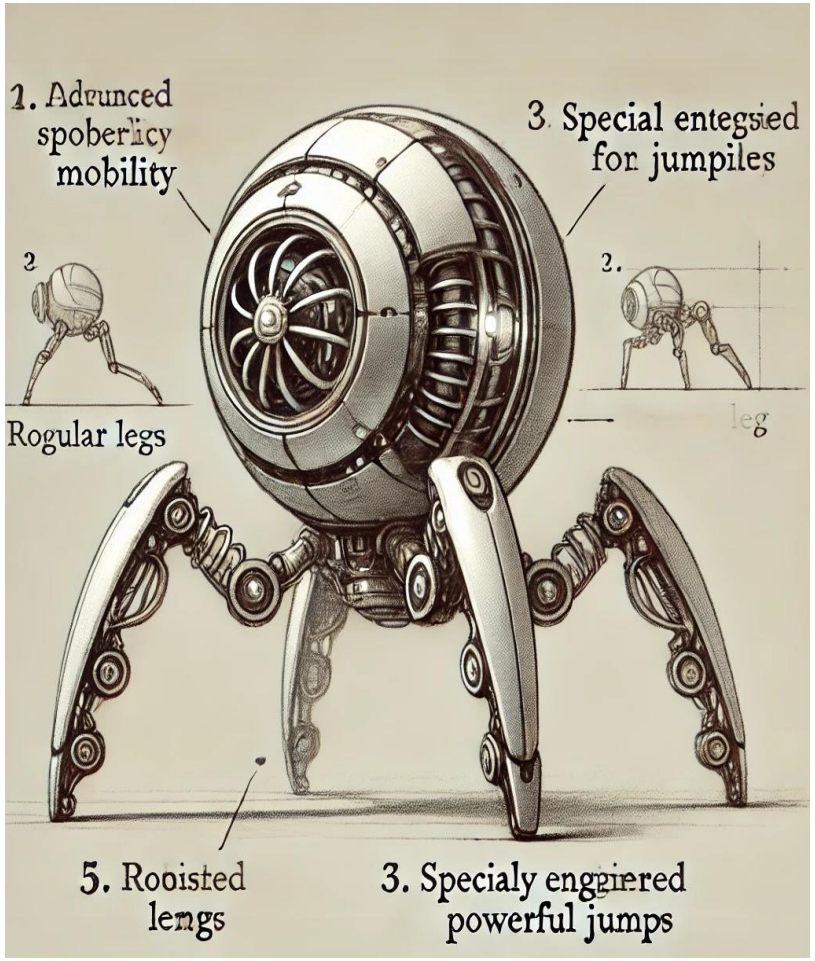
Concept 2

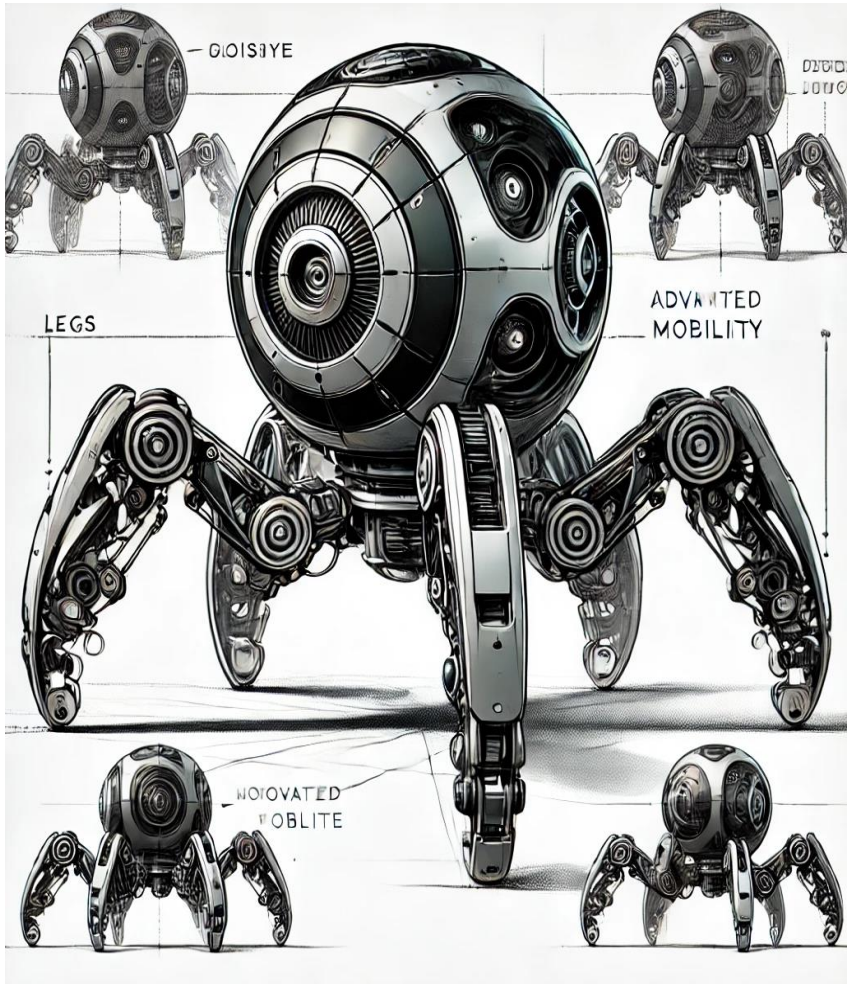

CONCEPT-2
"PHILIPLYOS -2"
TOP
10cm
Head (mounted on 2 motors)
motor 2
motor 1
10 cm
10cm
FRONT
Head can pitch & yaw
Head
control board (inside)
5cm
6cm
8cm

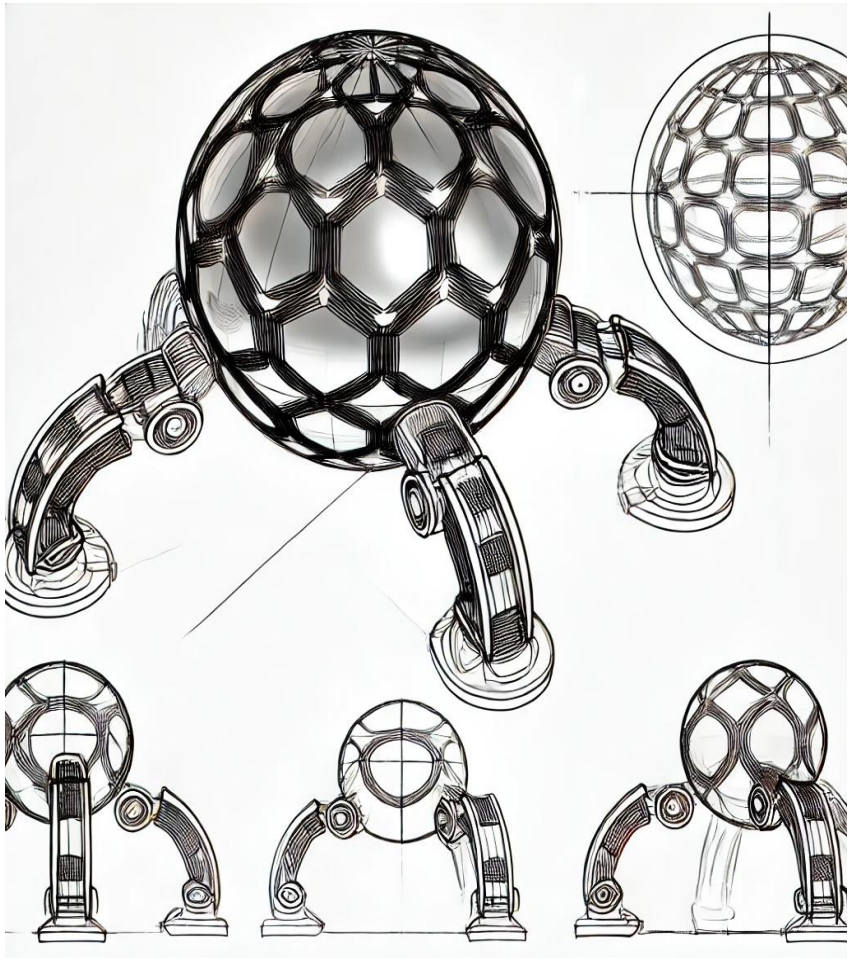
Concept 2



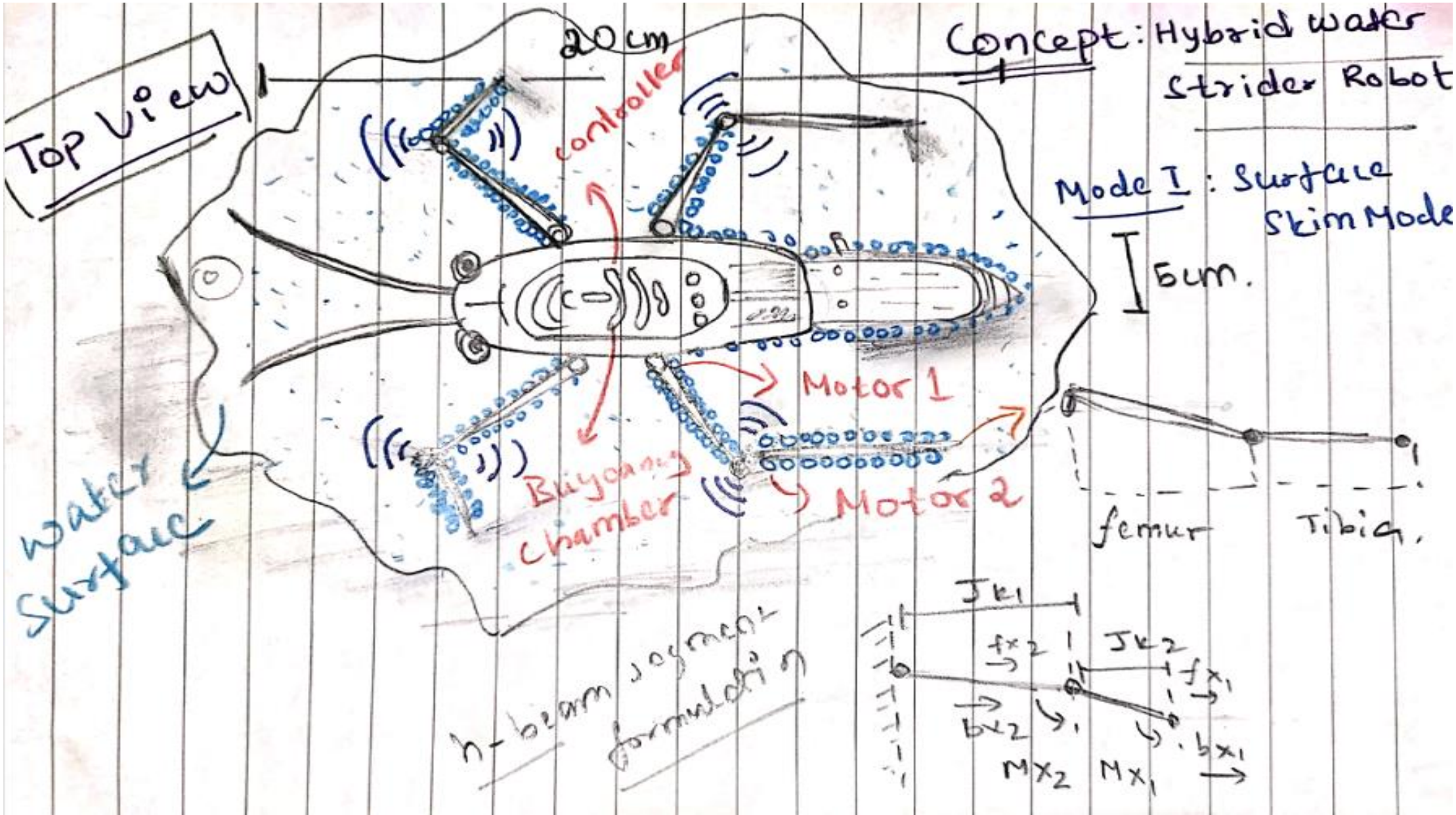
Generative AI Assistance



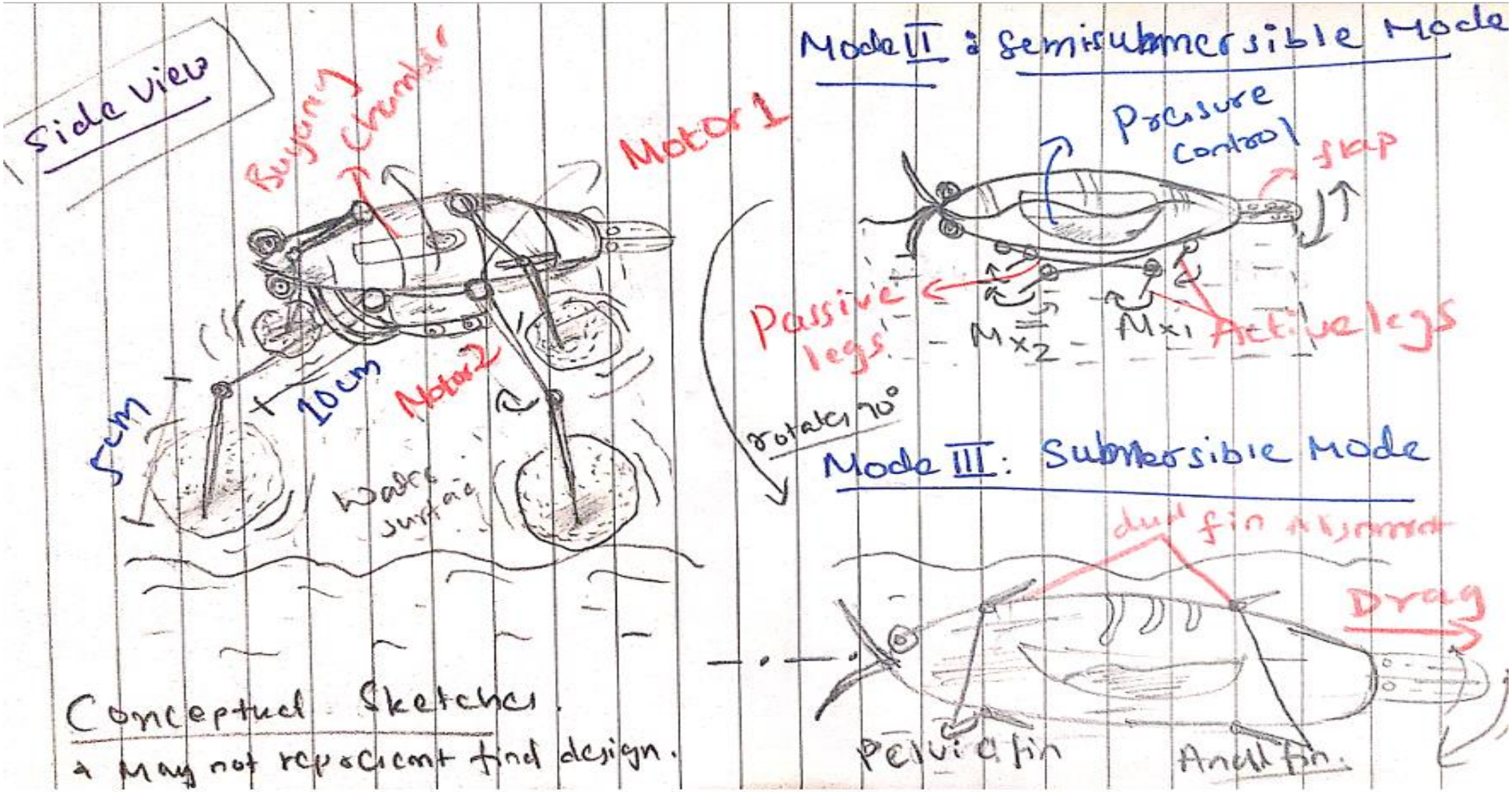




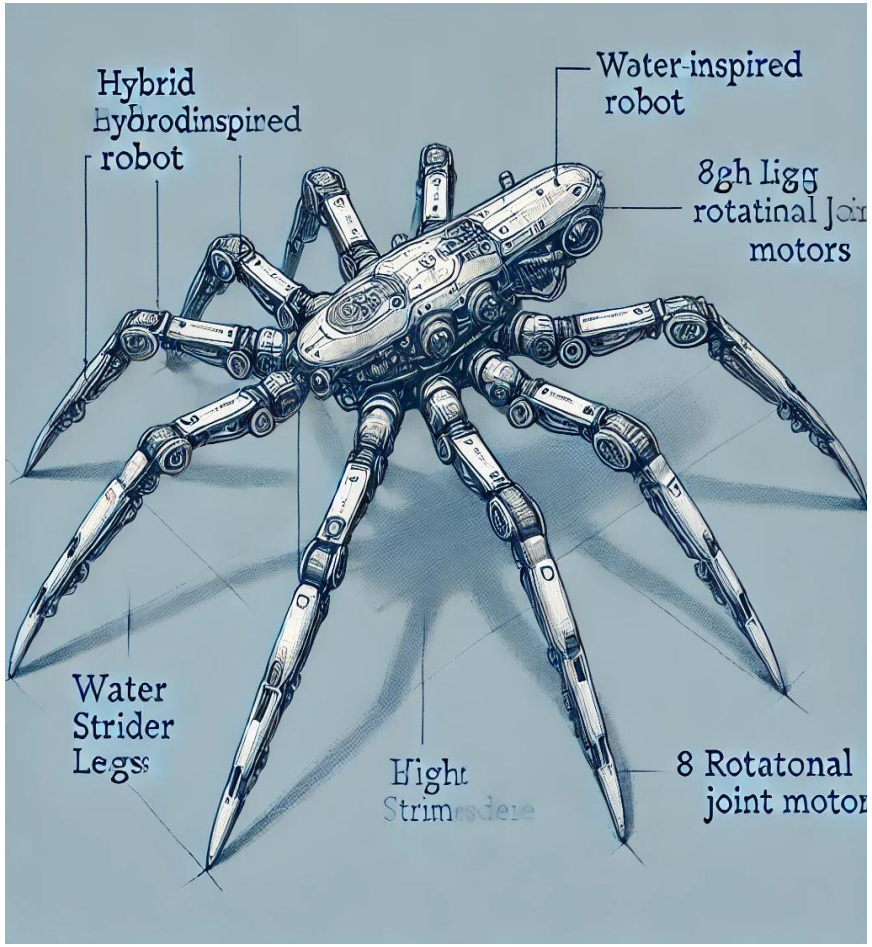
Concept 3

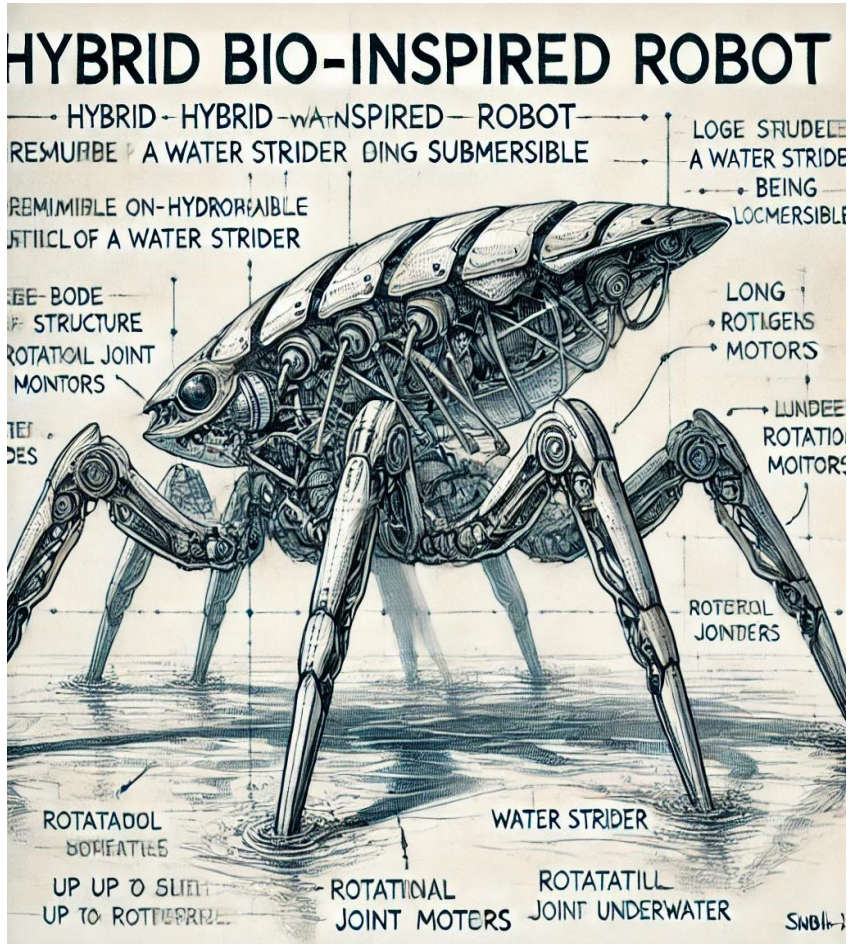

Concept: Hybrid water Strider Robot
Top View
20 cm
controller
Mode I : Surface Skim Mode
5 cm.
Motor 1
Motor 2
Buoyancy chamber
water surface
femur
Tibia
h-beam segment formulation
Jk1
Jk2
fx2
fx1
bx2
bx1
Mx2
Mx1

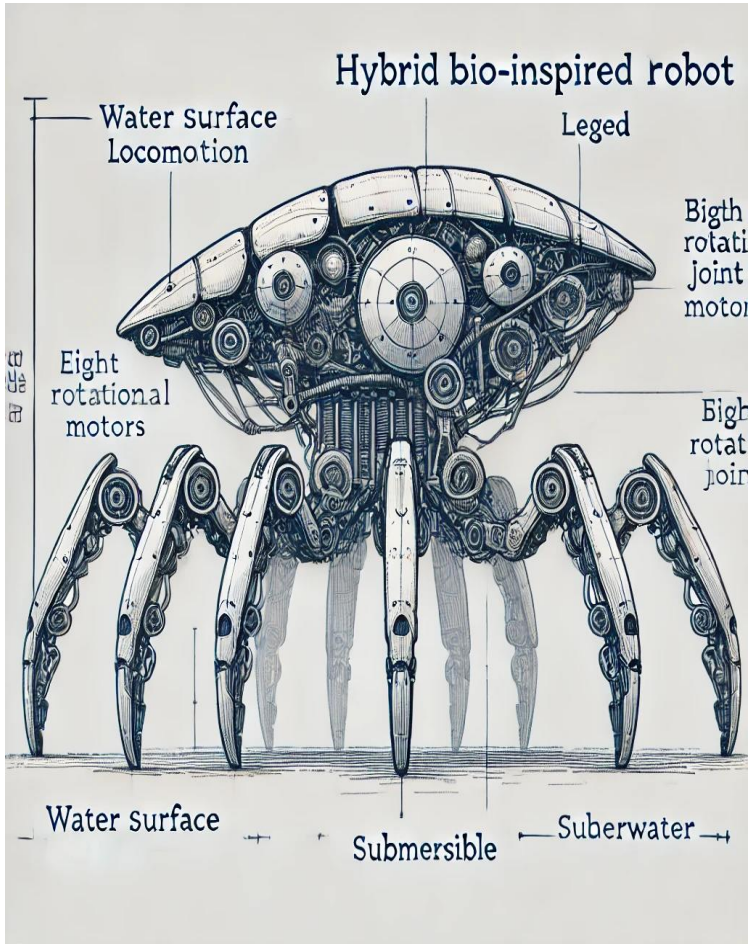
Concept 3


Side View
Buoyancy Chamber
Motor 1
Motor 2
10cm
5cm
Water surface
Mode II : Semisubmersible Mode
Pressure control
Jump
Passive legs
Mx2
Mx1
Active legs
rotate 90°
Mode III: Submersible Mode
dual fin thruster
Drag
Pelvic fin
Anal fin.
Conceptual Sketches.
* May not represent final design.

Generative AI Assistance







Robotics Studio MECE 4611

Semester -1, Assignment – 2

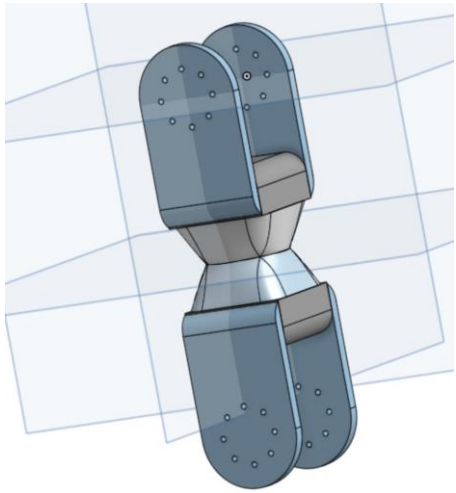
Name 1: Anushtup Nandy UNI 1: an3314

Name 2: Barath Kumar Jayachandran Kanchanamalini UNI 2: bj2519

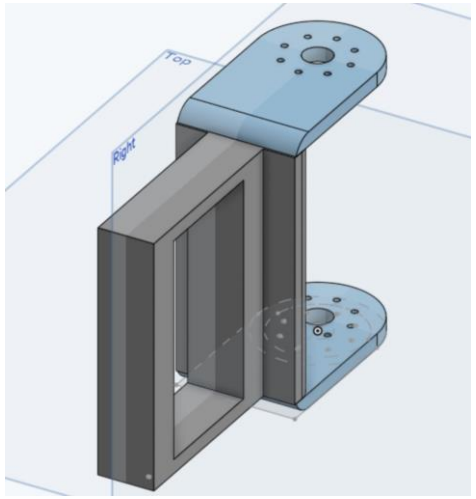
Submitted Date: 9/17/2024

3D Renderings of individual parts

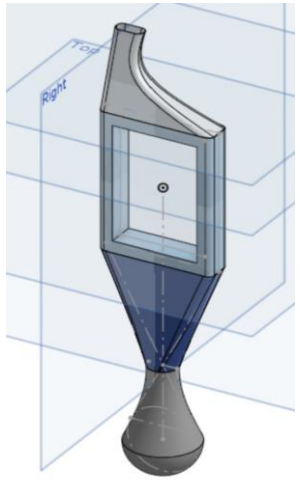
Middle leg



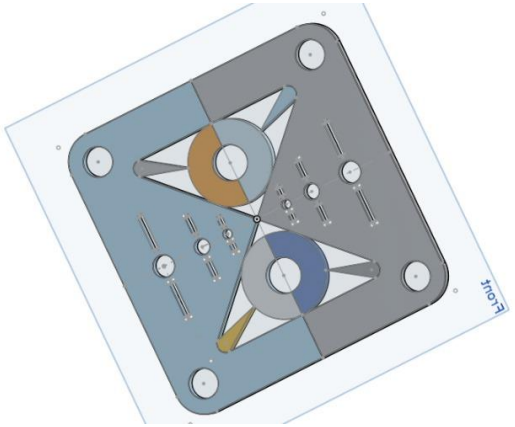
Upper Leg



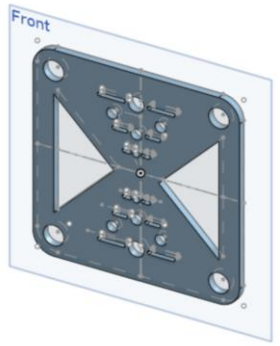
Lower leg



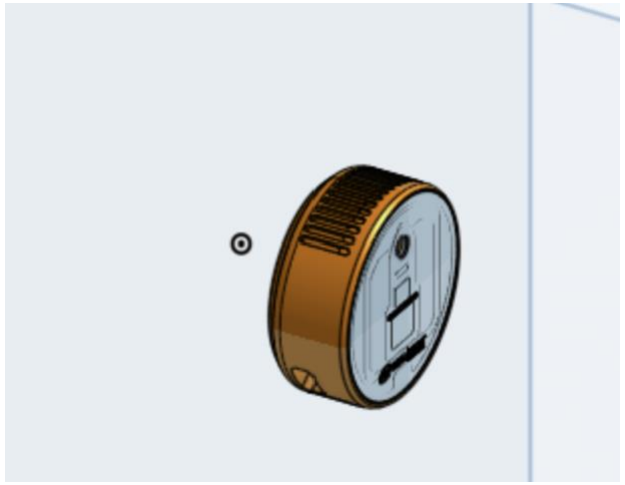
Bottom plate



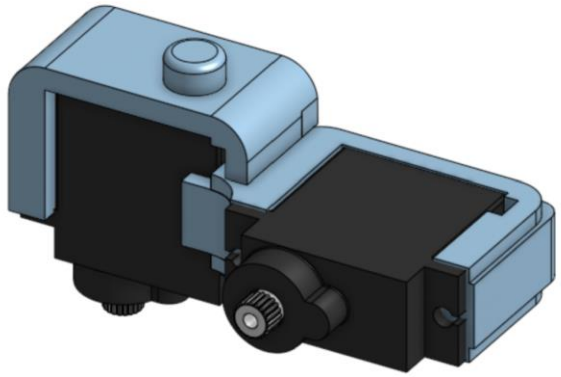
Top plate



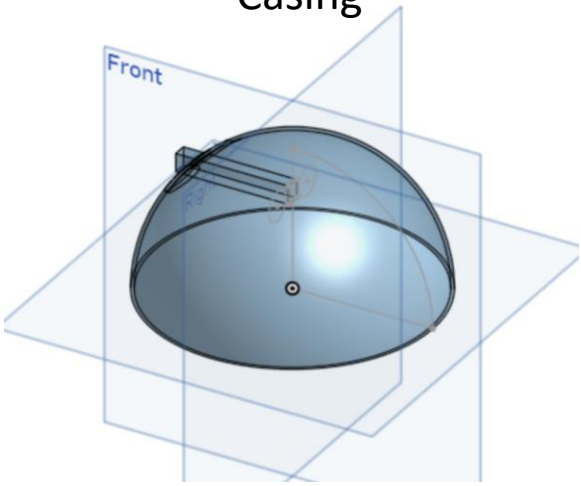
Lidar



Servos and Brackets

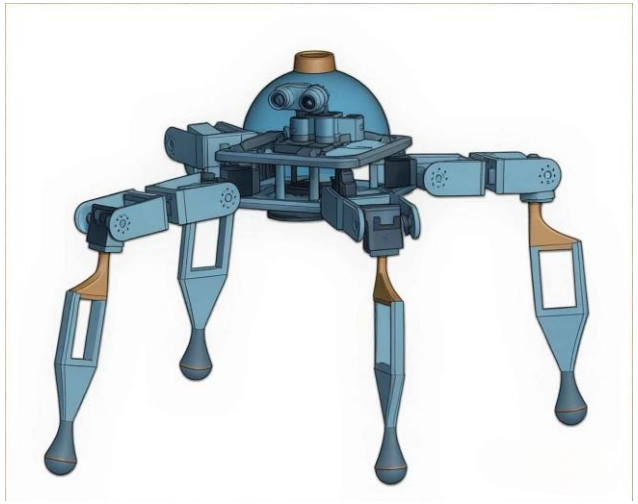


Casing

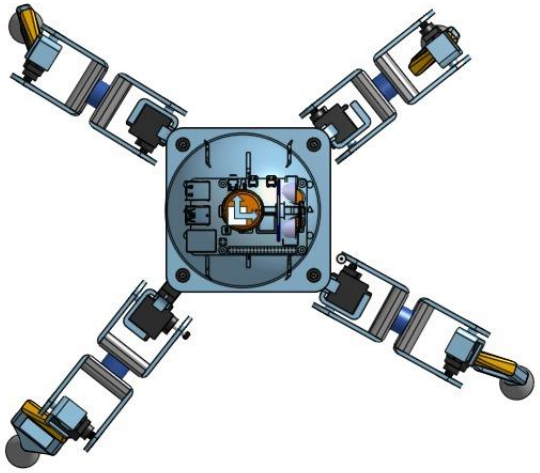


3D Renderings Different Poses

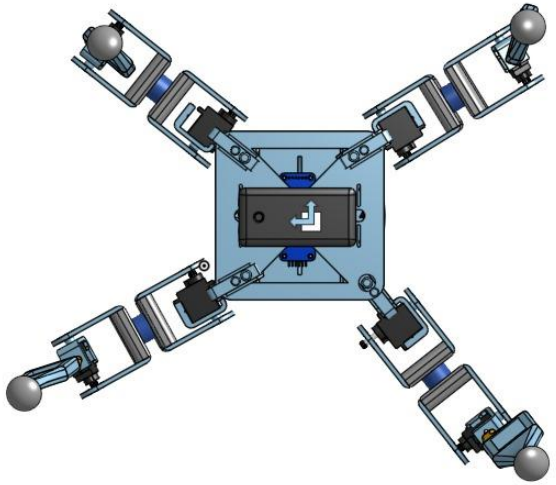
Pose 1



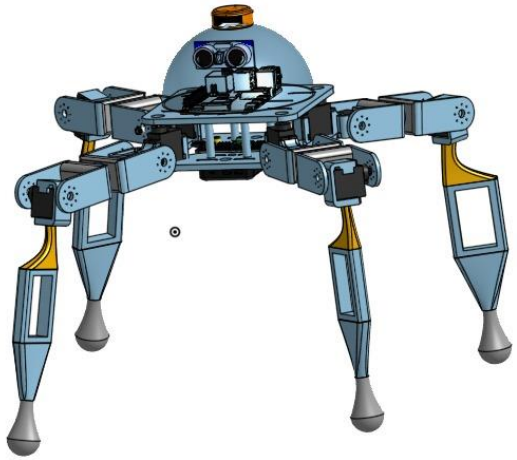
Pose 2



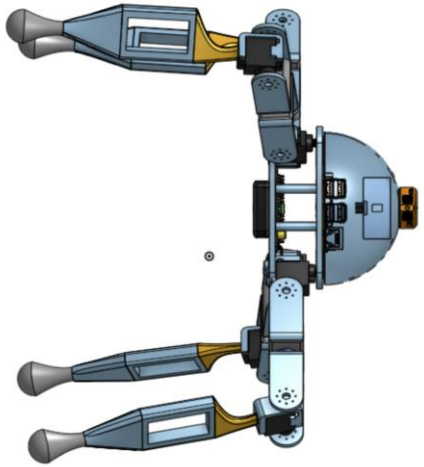
Pose 3



Pose 4



Pose 5



Photorealistic and Context Renderings

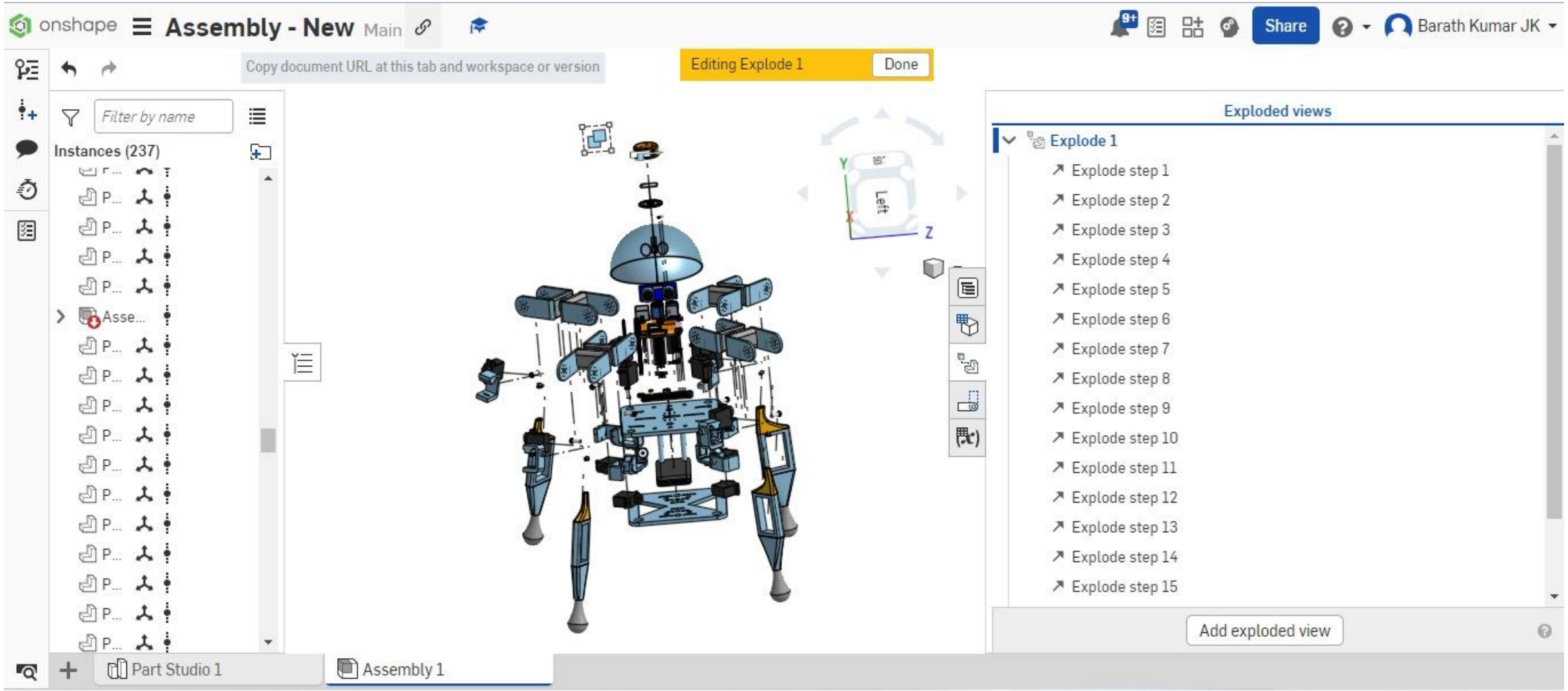
Render 1

Render 2

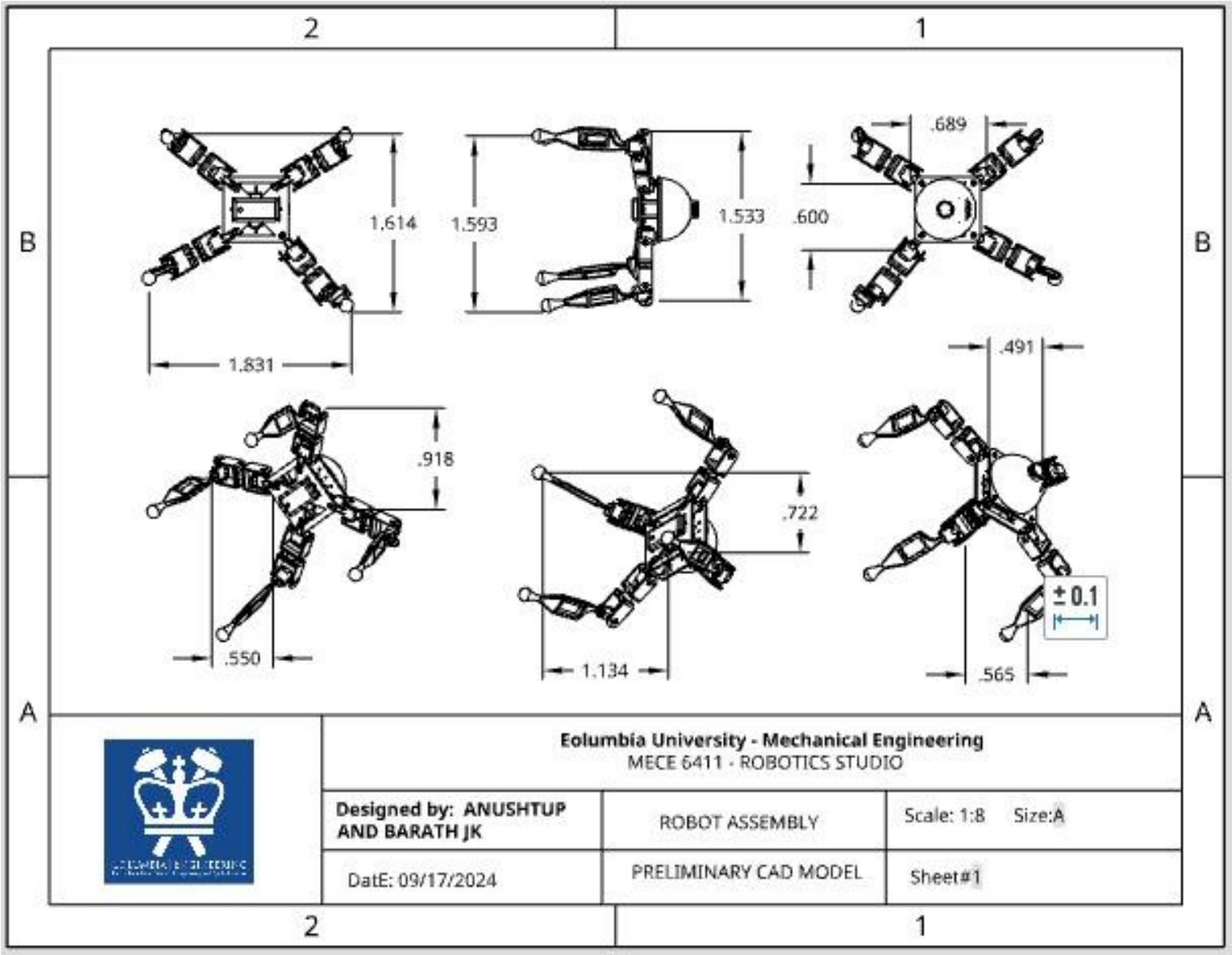
Render 3

Render 4

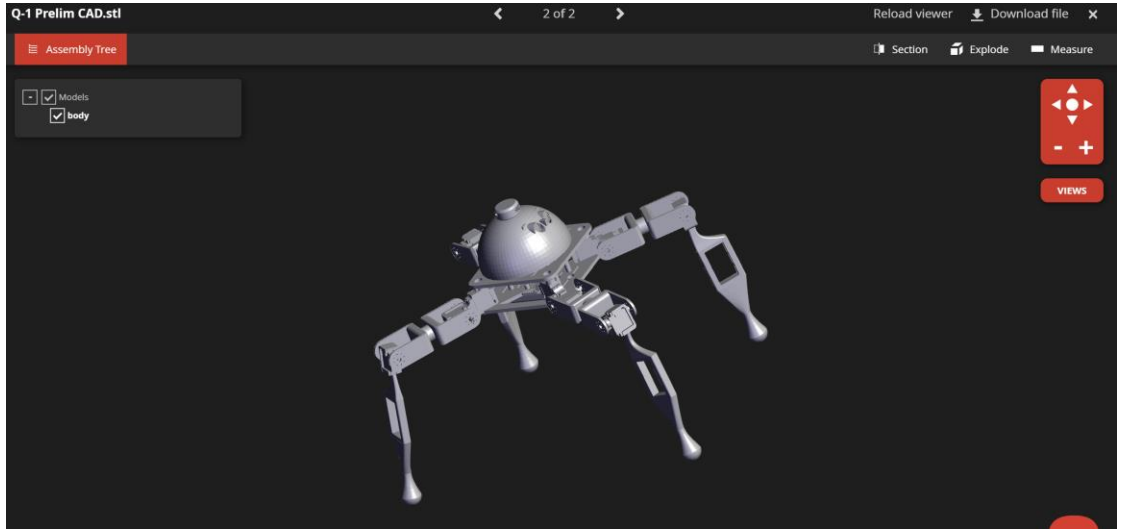
Exploded view and parts

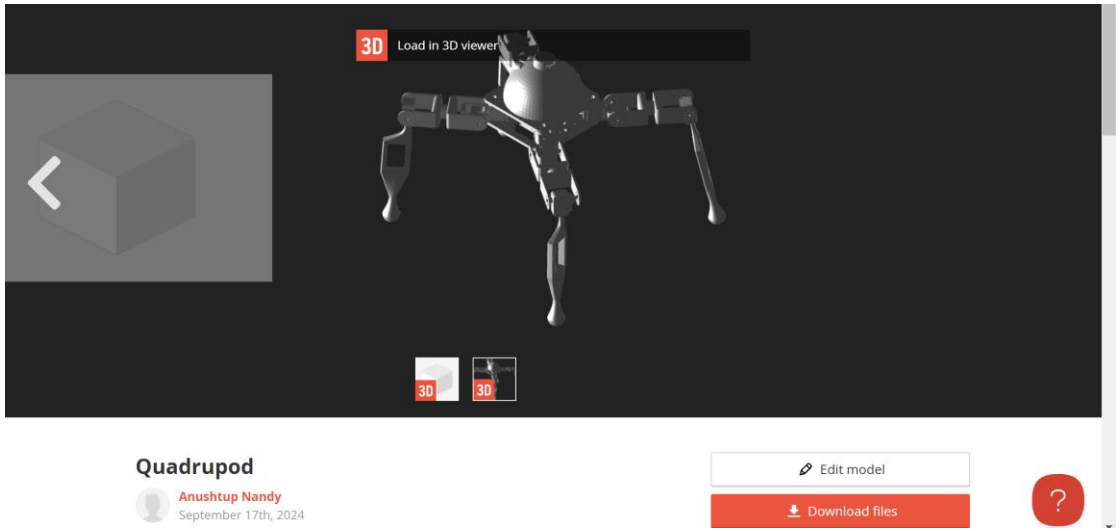


Detail and Side view with parts



GrabCad Upload





Robotics Studio MECE 4611

Semester -1, Assignment – 3

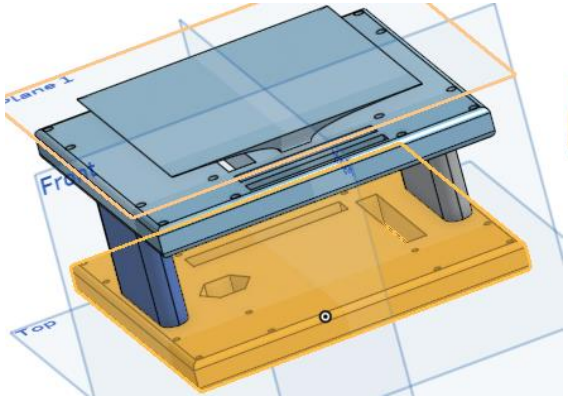
Name 1: Anushtup Nandy UNI 1: an3314

Name 2: Barath Kumar Jayachandran Kanchanamalini UNI 2: bj2519

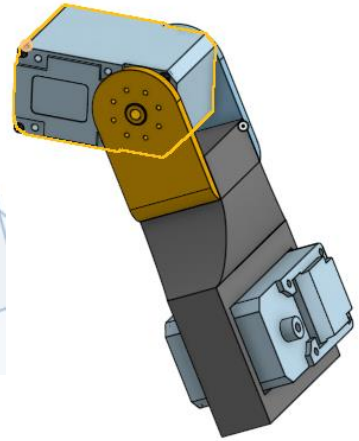
Submitted Date: 10/1/2024

3D Renderings of individual parts

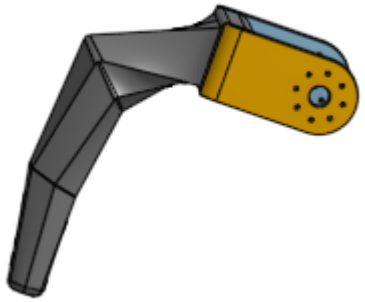
Body Plates



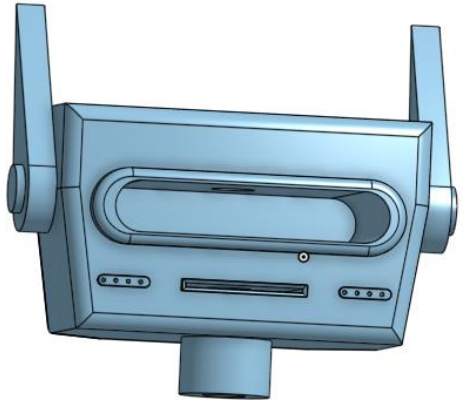
Upper Leg



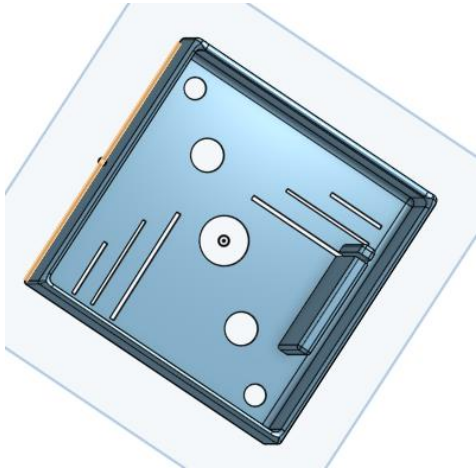
Lower leg



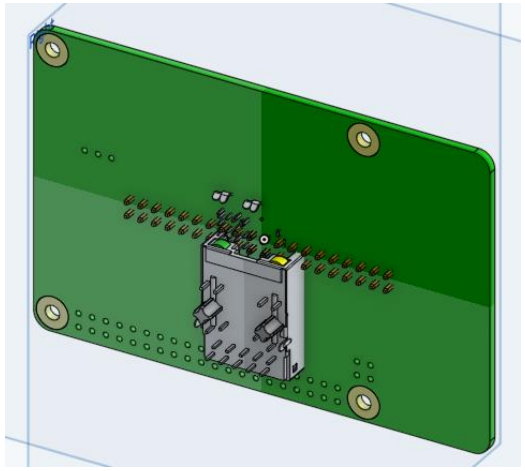
Head



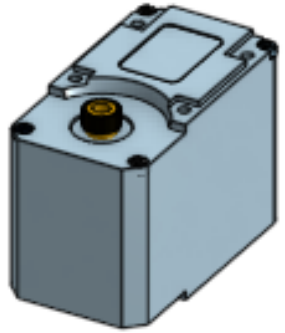
Controller enclosure



Raspberry Pi 4 Board



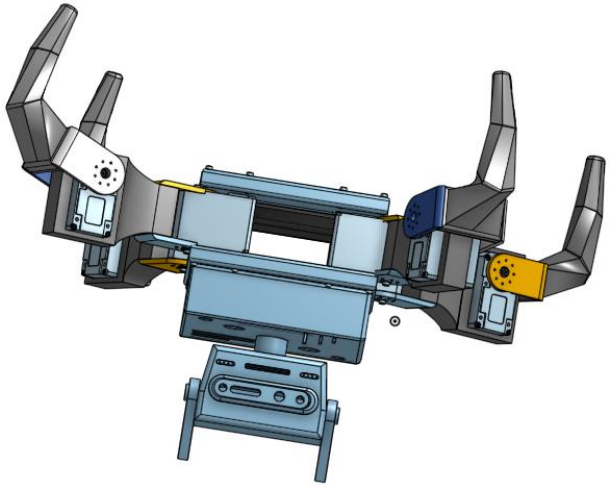
Servos



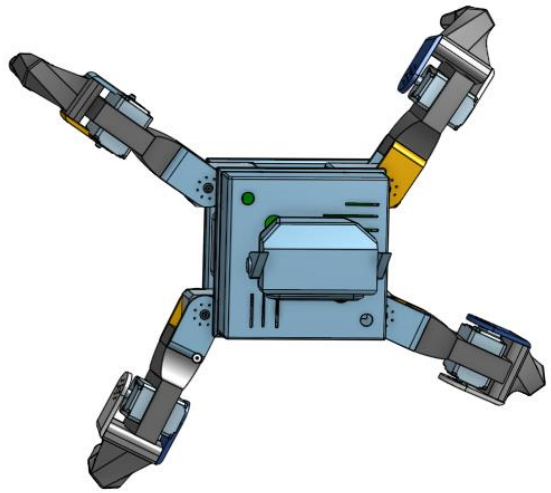
Battery

3D Renderings Different Poses

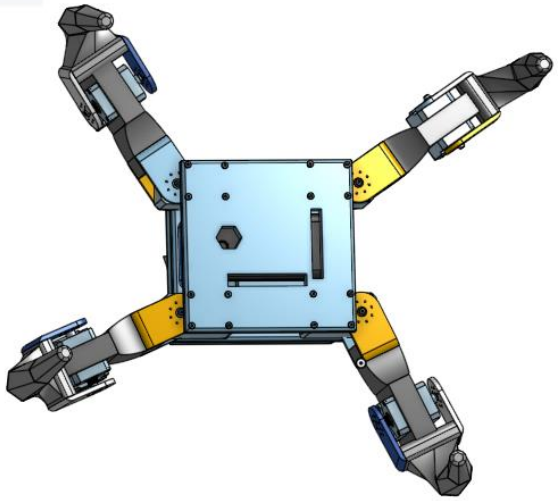
Pose 1



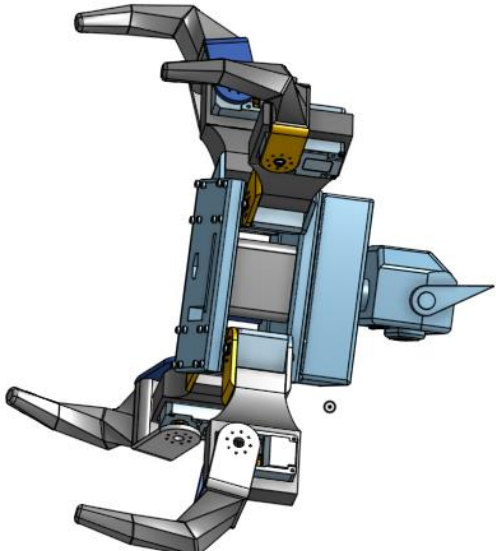
Pose 2



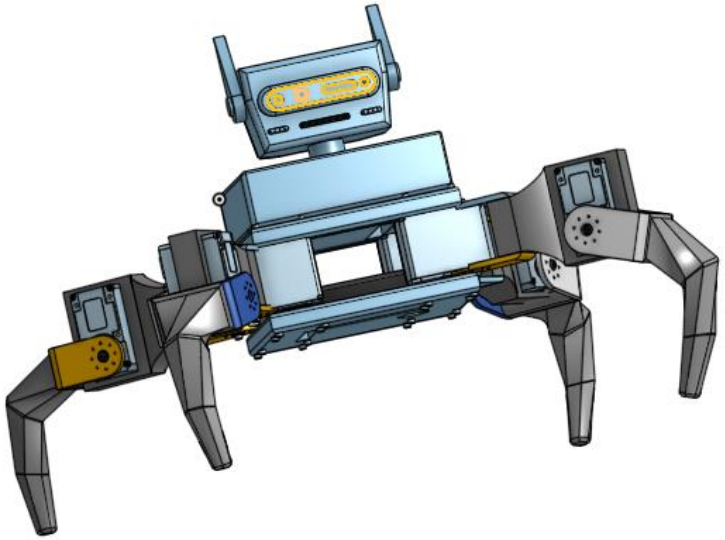
Pose 3



Pose 4



Pose 5



Photorealistic and Context Renderings

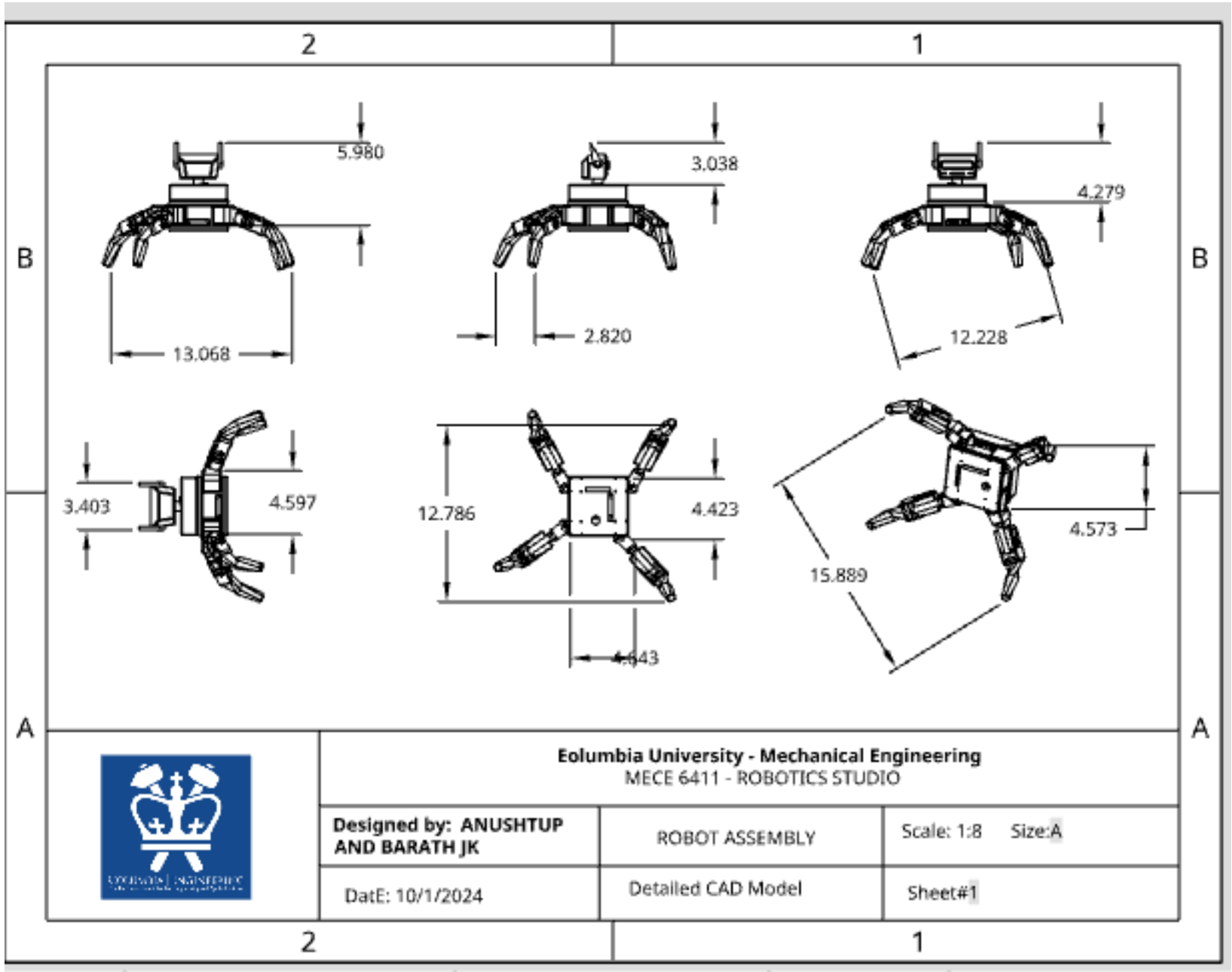
Render 1

Render 2

Render 3

Render 4

Detail and Side view with parts



Weight and Speed Rough Calculation

Weight Calculations

Weight of 3D printed part = Volume x Density
= 601.61856 cm^3 x 1.25 g/cc (for PLA)
= 752.02 g

Weight of servo (Lx16a) = 54g

There are 12 servos in total = 54 x 12 = 648 g

Weight of RPI + Battery + transformer = 45 g + 125g + 50 g = 220g

Total weight = 1.6kgs

Speed Calculations

Stride length is approximately = leg length = 25cm

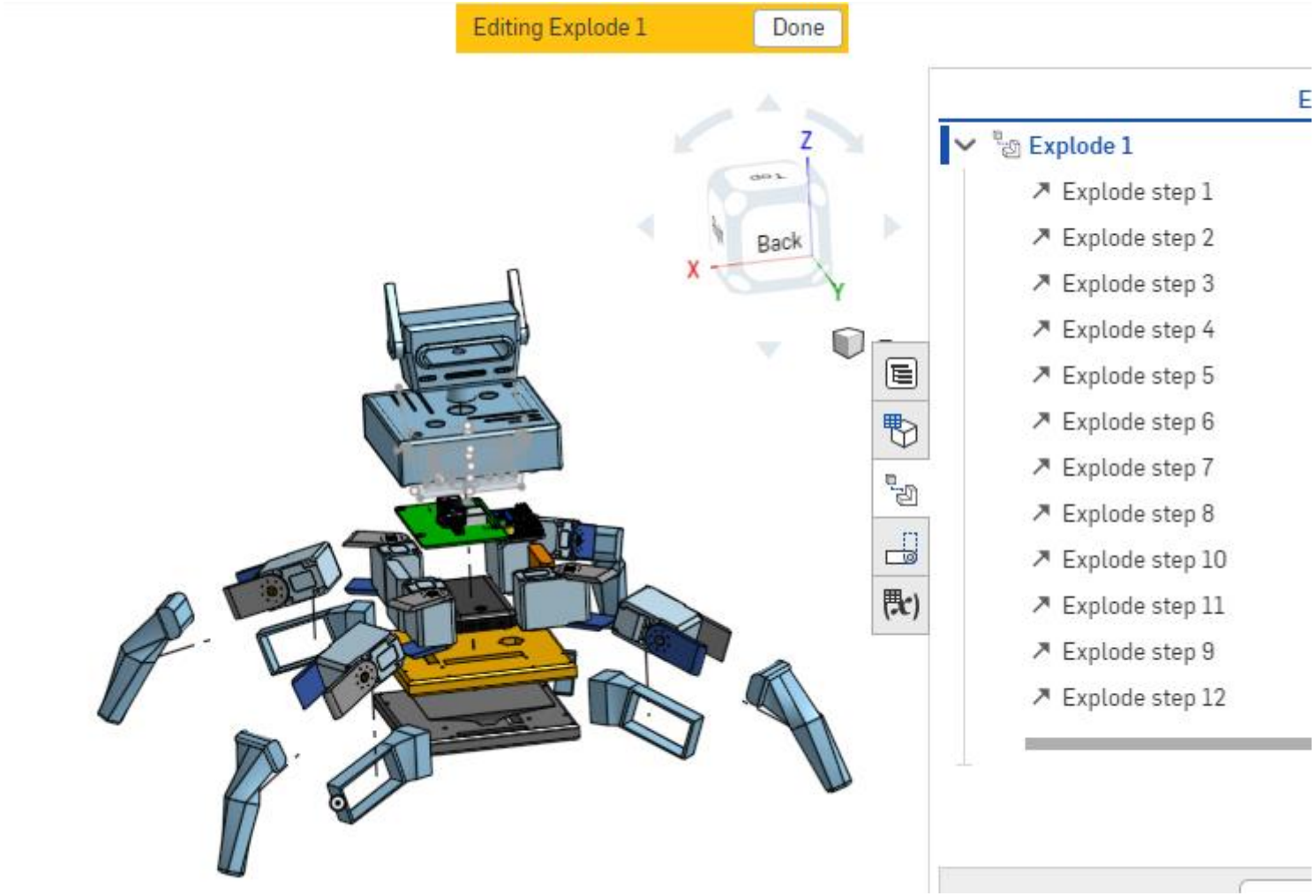
Servo speed = 0.19 s to move 60 degrees

Upper bound on servo time for full rotation = 0.19 x (360/60) = 1.14s

Since quadrupeds move legs sequentially, therefore time taken for all 4 to move = 1.14 x 4 = 4.56

Speed = (stride length/time for 1 cycle) = 5.48cm/s

Exploded view and parts



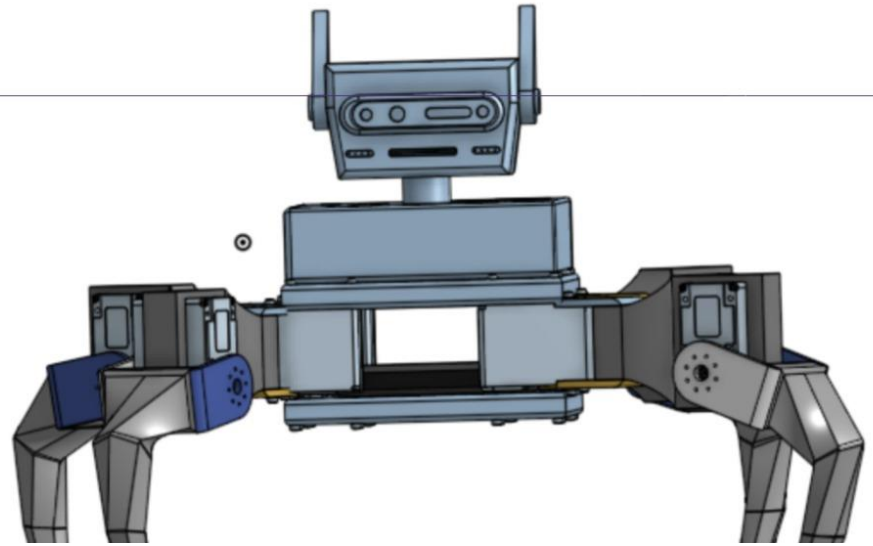
Posted in ED

A Anushtup Nandy
22 hours ago in General

STAR WATCHING 69 VIEWS

Hi everyone!

Barath and I have made a detailed CAD for our quadrupod. We might need to improve upon the leg design since they might not print properly. But do let us know your thoughts on it!



Bill of Materials

Bill of Materials

Item No.	Description	Quantity	Unit
1	SanDisk Ultra microSD Card	1	Piece
2	Raspberry Pi 4 Model B Board	1	Piece
3	M2 x 8mm Screws	100	Pieces
4	TalentCell 12V Lithium Battery Pack	1	Piece
5	M2 x 12mm Screws	100	Pieces
6	Genuine Dodge	100	Pieces
7	LX-16A Servos	8	Pieces
8	Connector Wires	14	Pieces
9	USB A to USB C Connector	1	Piece
10	HDMI Cable with Ethernet	1	Piece

Robotics Studio MECE 4611

Semester -1, Assignment – 4

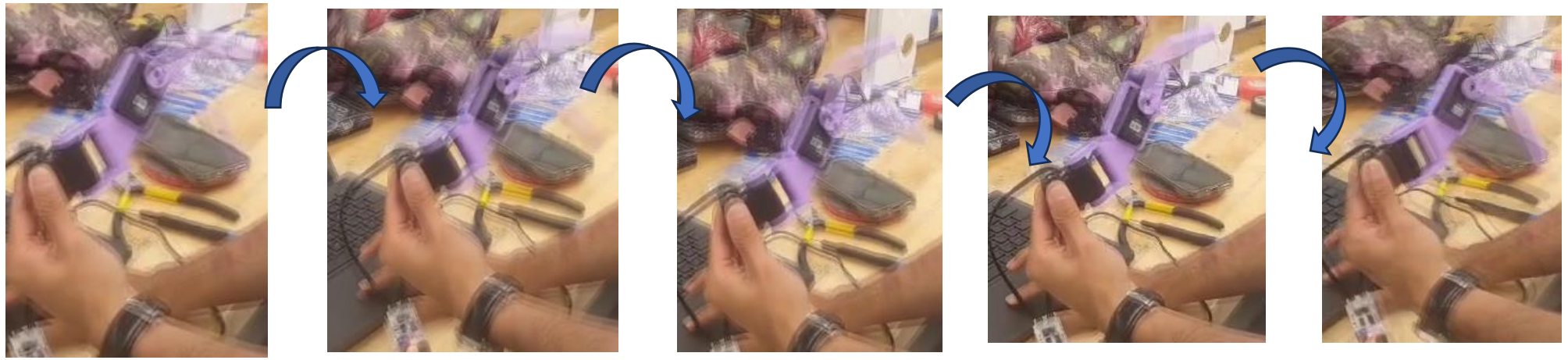
Name 1: Anushtup Nandy UNI 1: an3314

Name 2: Barath Kumar Jayachandran Kanchanamalini UNI 2: bj2519

Submitted Date: 10/23/2024

Leg Motion Sequence

Primary Leg Motion Sequence



Secondary Leg Motion Sequence

Extreme Leg Positions Tested

Testing in extreme conditions leads to breakage of the secondary leg

Posted in ED

Working Leg - Video - Team 23 #230

B Barath Kumar Jayachandran Kanchanamali
Yesterday in **General**

STAR WATCHING 49 VIEWS

Here's the first video of the working leg of our robot along with my group mate Anushtup :)

https://drive.google.com/file/d/1gq4AUh0fUYqoeN23f38nz-9olQAwpBSv/view?usp=drivesdk

Comment Edit Delete •••

Sort by Newest

Add comment

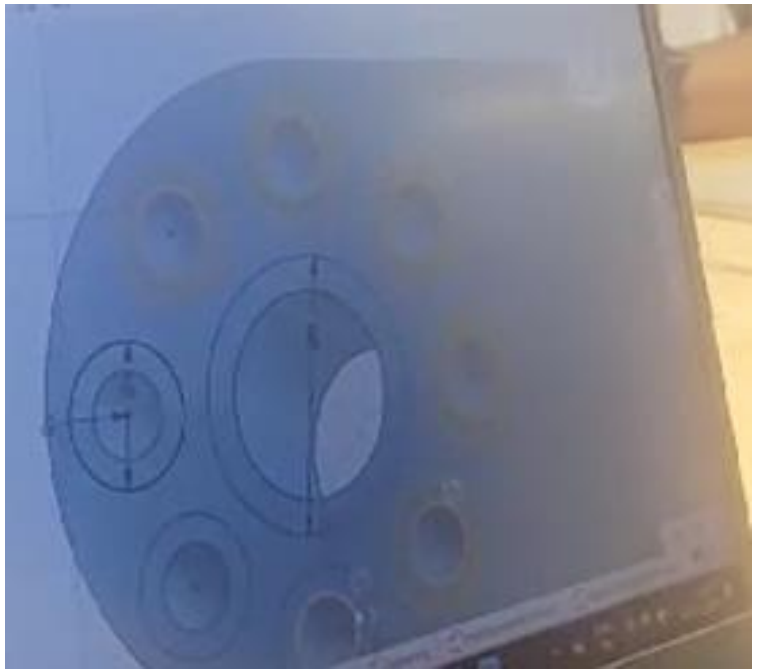
W Wei-Po Hsu 4h
Great design! It moves really smoomtly.
Reply •••

L Lantian Zhang 5h
Cool design! The structure is compact and lightweight.
Reply •••

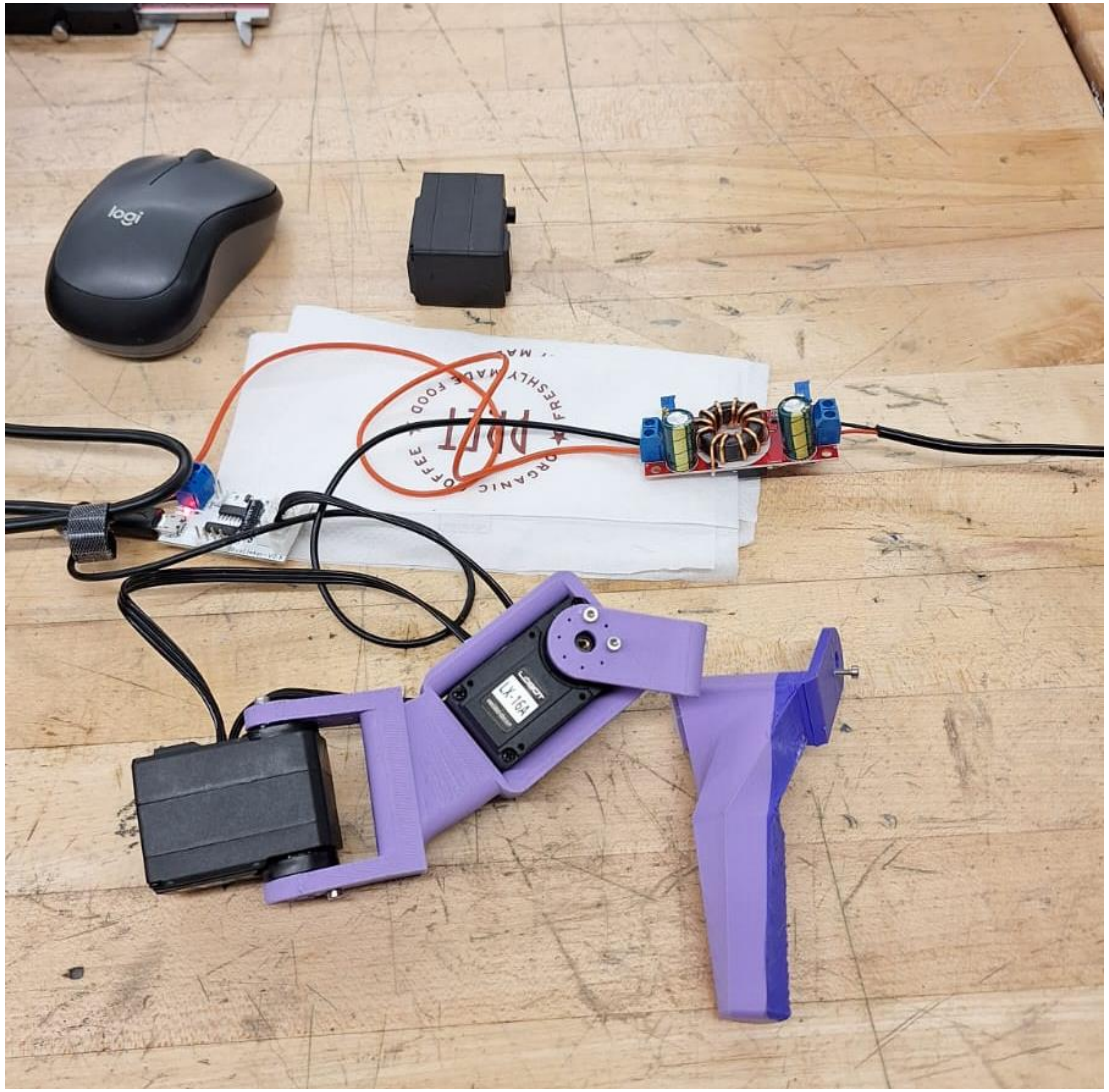
N Naian Tao 1d
Beautiful colors, exquisite and delicate design.
Reply •••

Form and Fit Issues identified

1. Servo motors Shaft was 4 x mm in depth. However, in Grabcad, the models were 3.45mm in depth.
2. The screw holes are smaller when 3d printed so we need to increase the size
3. Leg to servo attachments are too thin, we need to thicken them and apply a counter bore



Cable Routing



3D Print Quality, Structures Removed

Different Leg Motion Patterns Explored

- Leg Motion Pattern 1 – Wave input: https://drive.google.com/file/d/1PtXXYkzPGVUS3kGl_mnBlp_n8KnGTDBN/view?usp=sharing
- Leg Motion Pattern 2 – Step Input: https://drive.google.com/file/d/1s_f4PNsxI39-rv73H4byUAVqcACvznBX/view?usp=sharing

Leg Modularity Demonstrated

- Leg Modularity - https://drive.google.com/file/d/1LuuHfoLCtRo3Mm6455mpanWpXymVcpAf/view?usp=sharing

Leg Modularity Demonstrated

- Leg Modularity - https://drive.google.com/file/d/1LuuHfoLCtRo3Mm6455mpanWpXymVcpAf/view?usp=sharing

Exception handling in our code

```
try:
    servo = LX16A(id)
    servo.servo_mode()
    servo.set_angle_limits(0, 240)
    return servo
except ServoTimeoutError:
    print(f"Servo {id} is not responding on the bus. Check connections and ID.")
    return None
except Exception as e:
    print(f"Error initializing servo {id}: {str(e)}")
    return None
```

- **Line of code:** try-except block inside the setup_servo function.
- **What it does:** It catches:ServoTimeoutError: Raised when the servo does not respond, likely due to connection issues.
- **A general Exception:** Catches any other error that might occur during servo initialization, printing an error message for debugging purposes.

Exception handling in our code

```
try:
    for pos1, pos2, delay in positions:
        servo1.move(pos1)
        servo2.move(pos2)
        time.sleep(delay)
except ServoTimeoutError:
    print("Communication error - check servo connections")
except Exception as e:
    print(f"Error during movement: {str(e)}")
```

- **Line of code:** try-except block inside the step_gait function.
- **What it does:** It catches:ServoTimeoutError: Raised when communication with the servos fails, possibly due to wiring or bus issues.
- **A general Exception:** Catches any other error during the movement sequence and prints the error message.

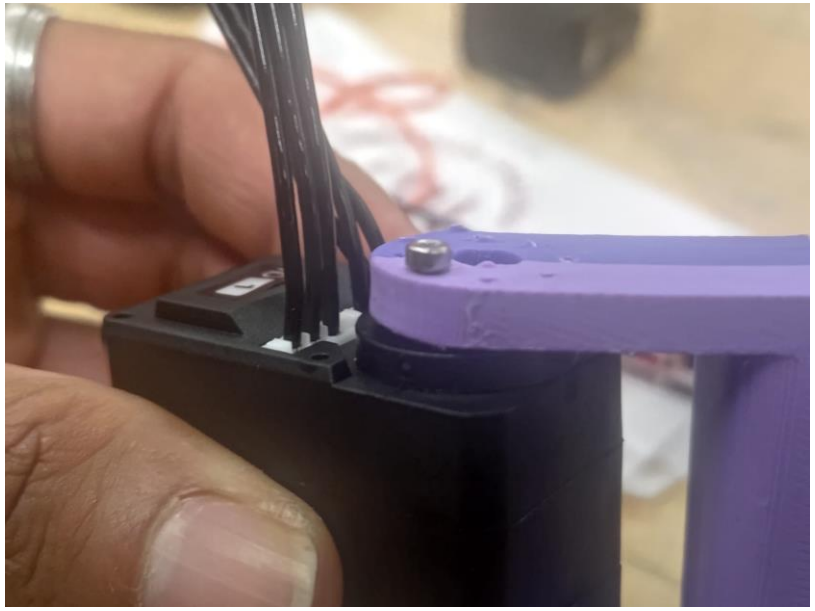
Exception handling in our code

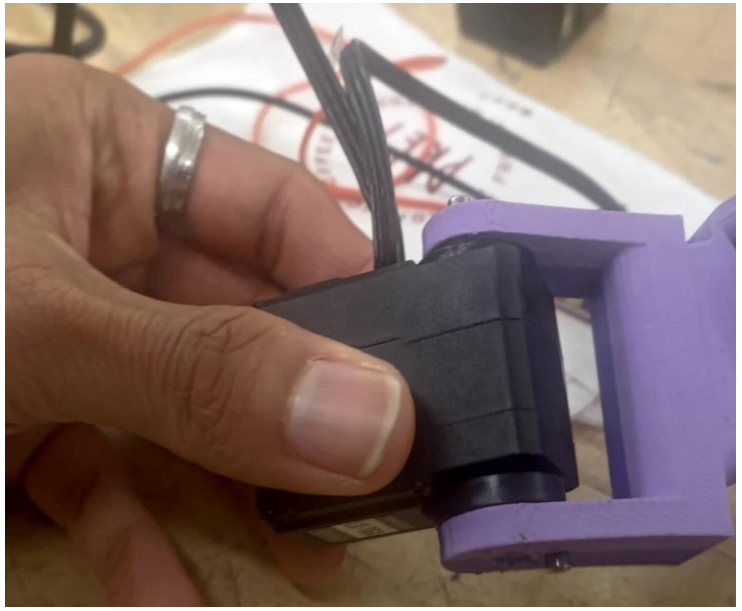
```
try:
    # Code initializing servos and running the loop
except KeyboardInterrupt:
    print("\nProgram stopped by user")
except Exception as e:
    print(f"Unexpected error: {str(e)}")
```

- **Line of code:** try-except block around the main logic of the program.
- **What it does:** It catches: KeyboardInterrupt: This is triggered when the user stops the program using Ctrl + C.
- **A general Exception:** Catches any unexpected errors during the main execution loop and prints an error message.

Code Link: https://drive.google.com/file/d/1pYj8SR0r_vepHv8367MHg3u1Kf6l4Rtp/view?usp=sharing

Bolts and Nuts Added





Marks Deserved

No.	Rubrics Completed	Slide(s)	Marks
1.	Title slide complete	27	5
2.	Overall aesthetics, layout and formatting of the slides	27-40	5
3.	Sequence of photos showing leg in motion	28	10
4.	Posting video of moving leg on the discussion board	30	10
5.	Extreme leg positions tested and measured	29	10
6.	form/fit issues identified, listed and addressed	31	10
7.	3D-print quality, support structure removed	33	10
8.	Different leg motion patterns explored	34	10
9.	Leg Modularity demonstrated	36	10
10.	Cables routed properly and securely	32	10
11.	Exception handling in code catches motor disconnect	37-39	10
12.	Points all components properly bolted and connected	40	10

Total Marks Deserved = 110

Robotics Studio MECE 4611

Semester -1, Assignment – 5

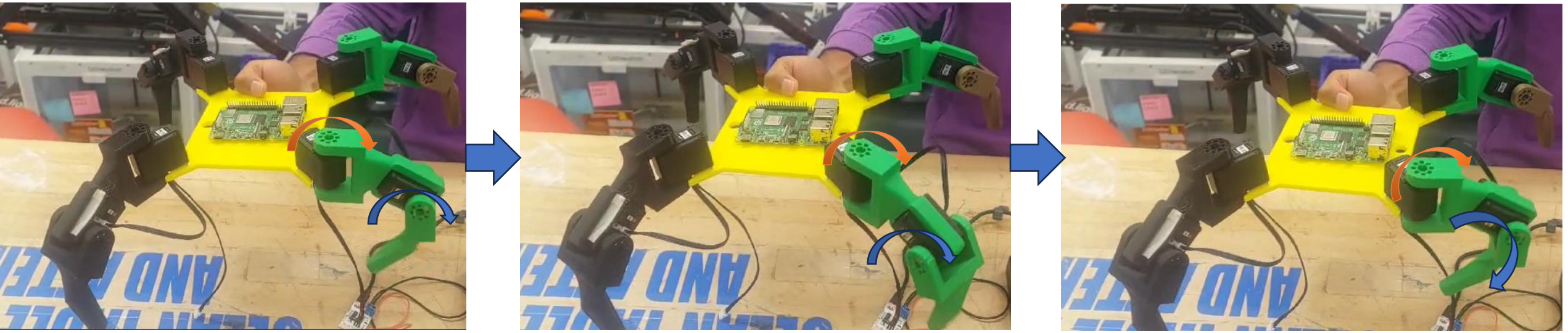
Name 1: Anushtup Nandy UNI 1: an3314

Name 2: Barath Kumar Jayachandran Kanchanamalini UNI 2: bj2519

Submitted Date: 11/8/2024

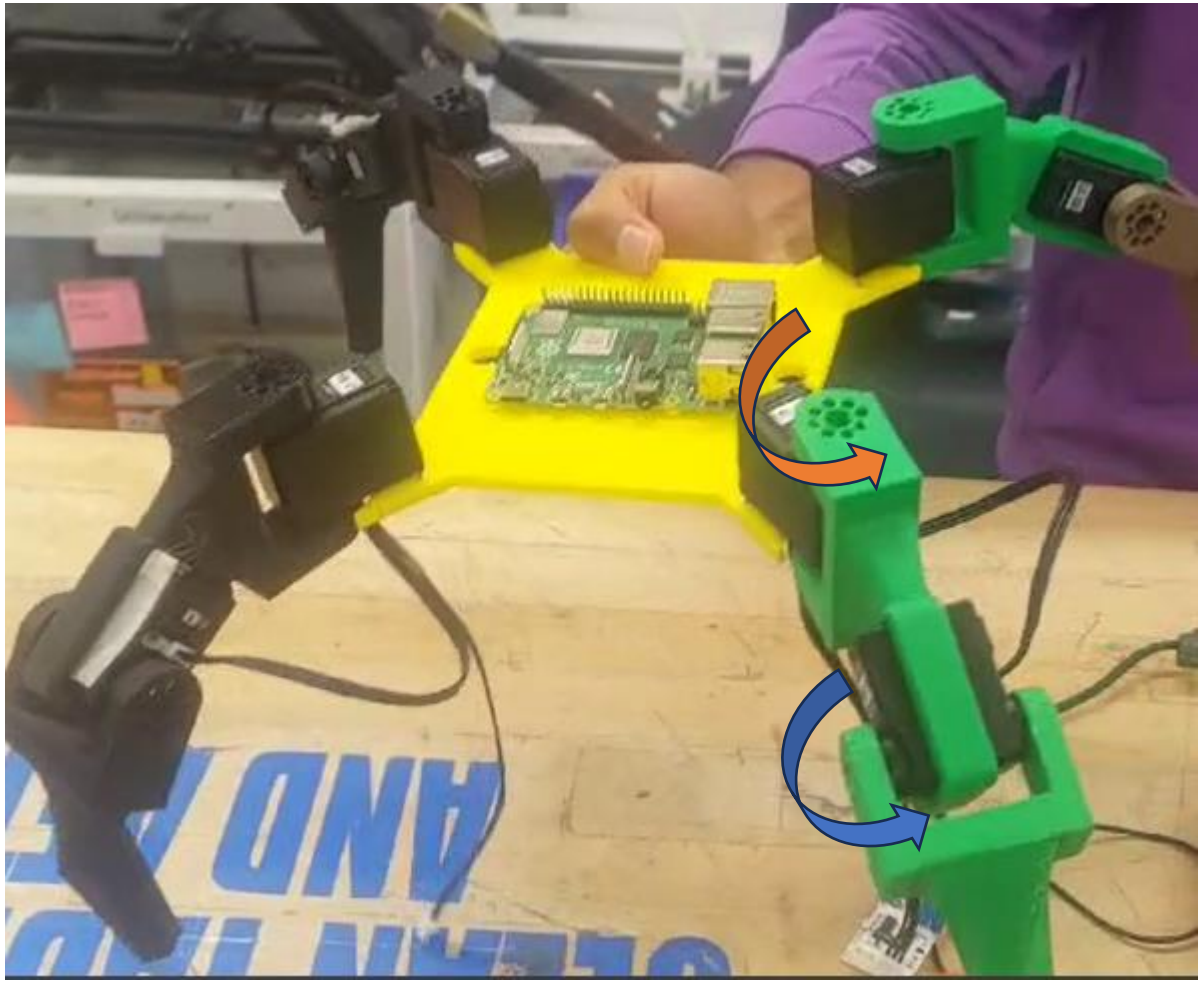
Glamour Photo of the Printed Robot

Robot Legs Moving

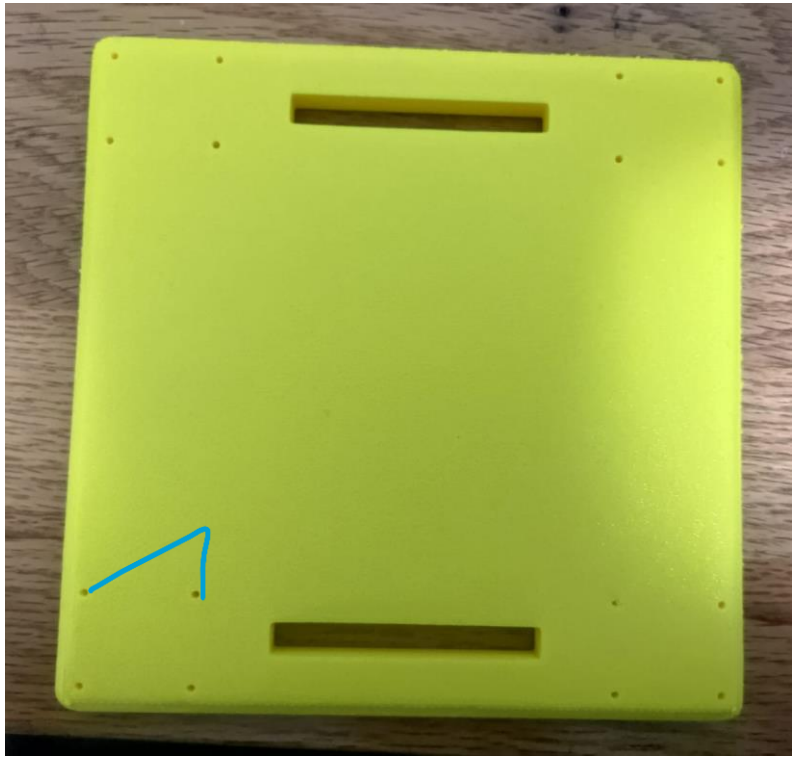


Link: https://drive.google.com/file/d/1g9hXkHHtZ1kKU6eSsrUatJHR-t1kZ3xl/view?usp=sharing

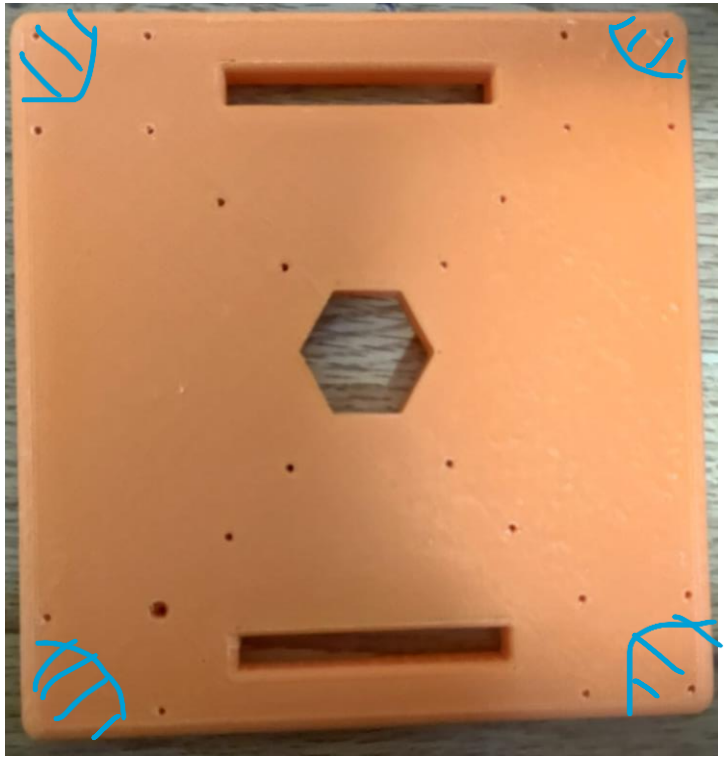
Extreme Leg Interference



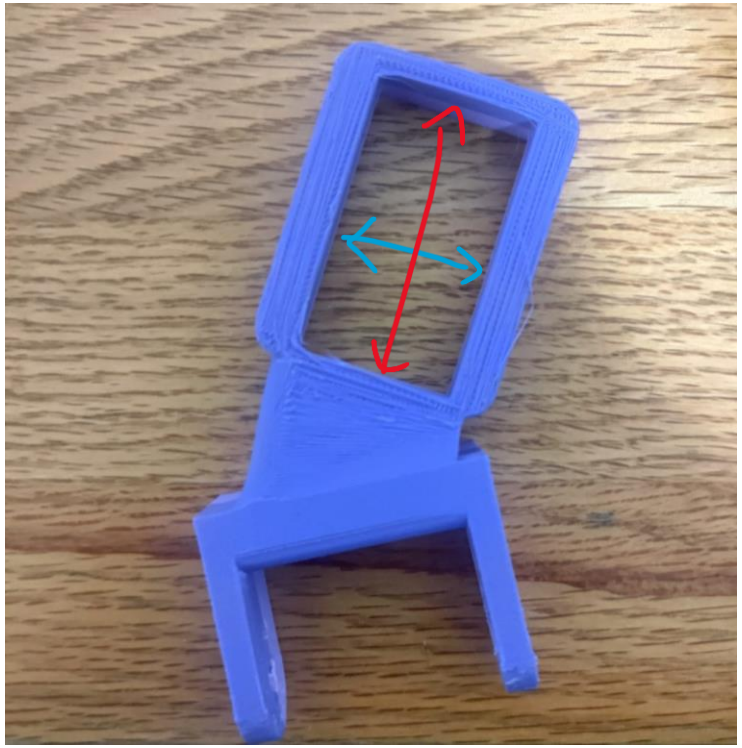
Form and Fit Issues



Motor insertion holes were not aligned

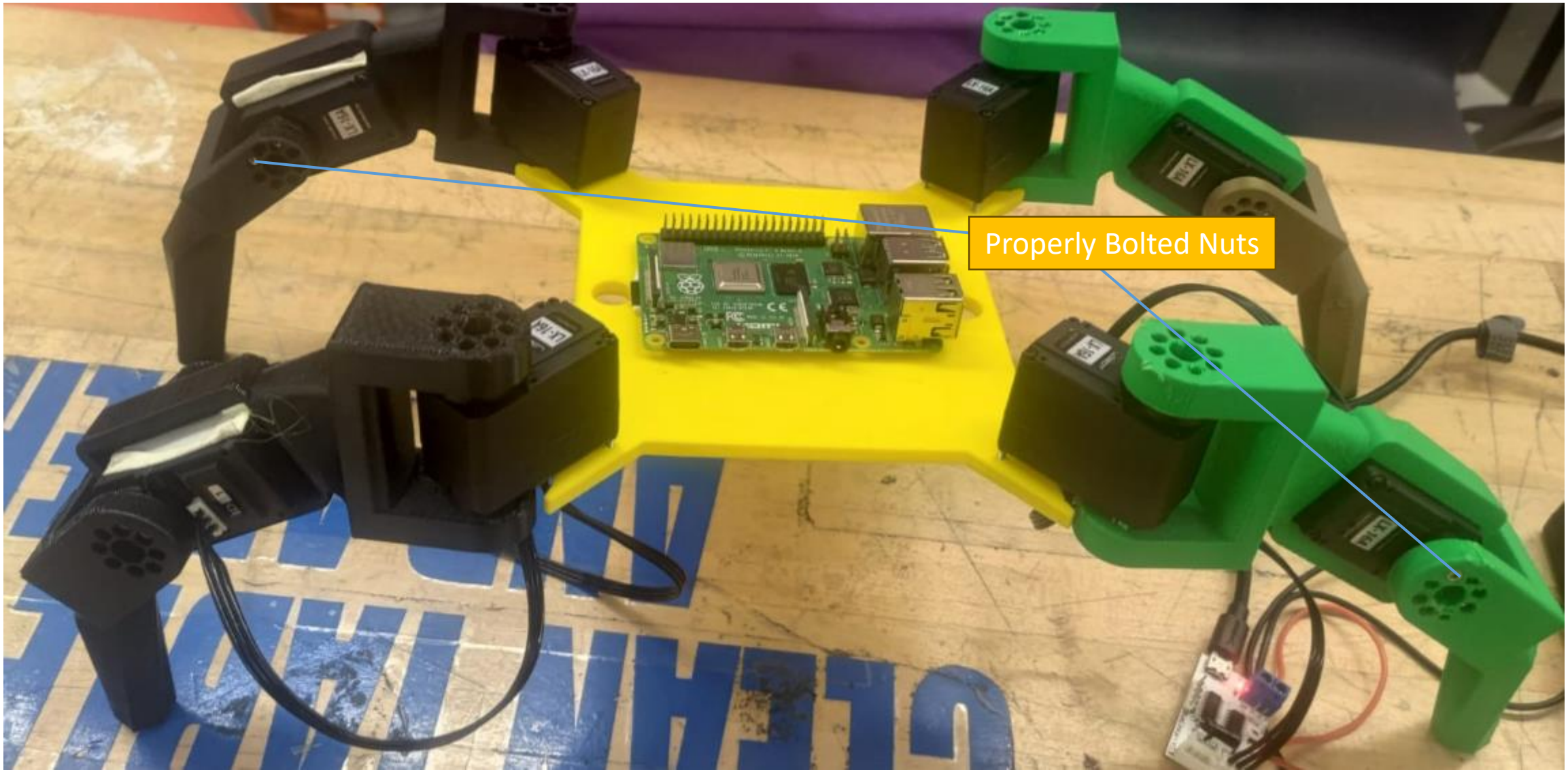


Corners were not arc-cut to accommodate motor movement

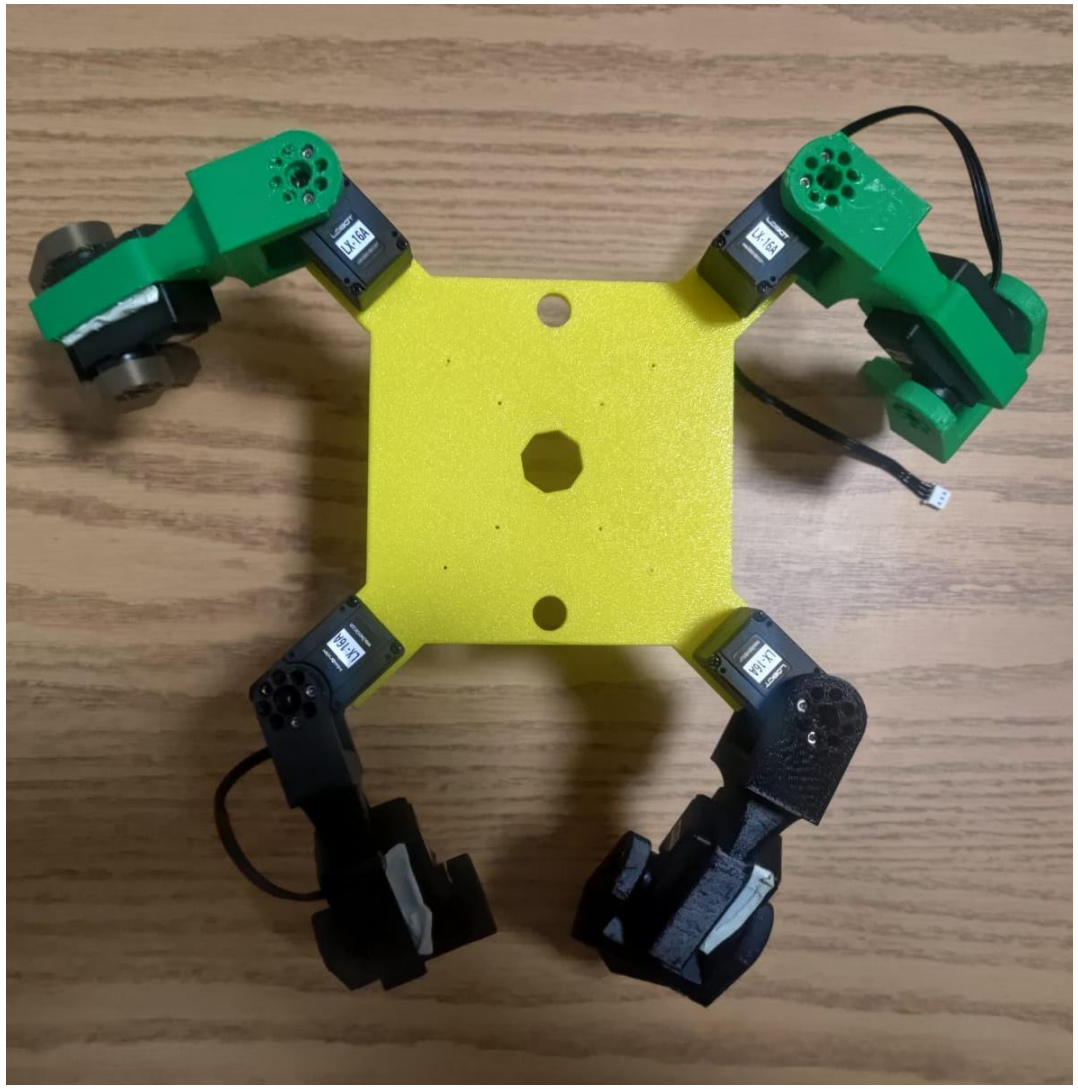


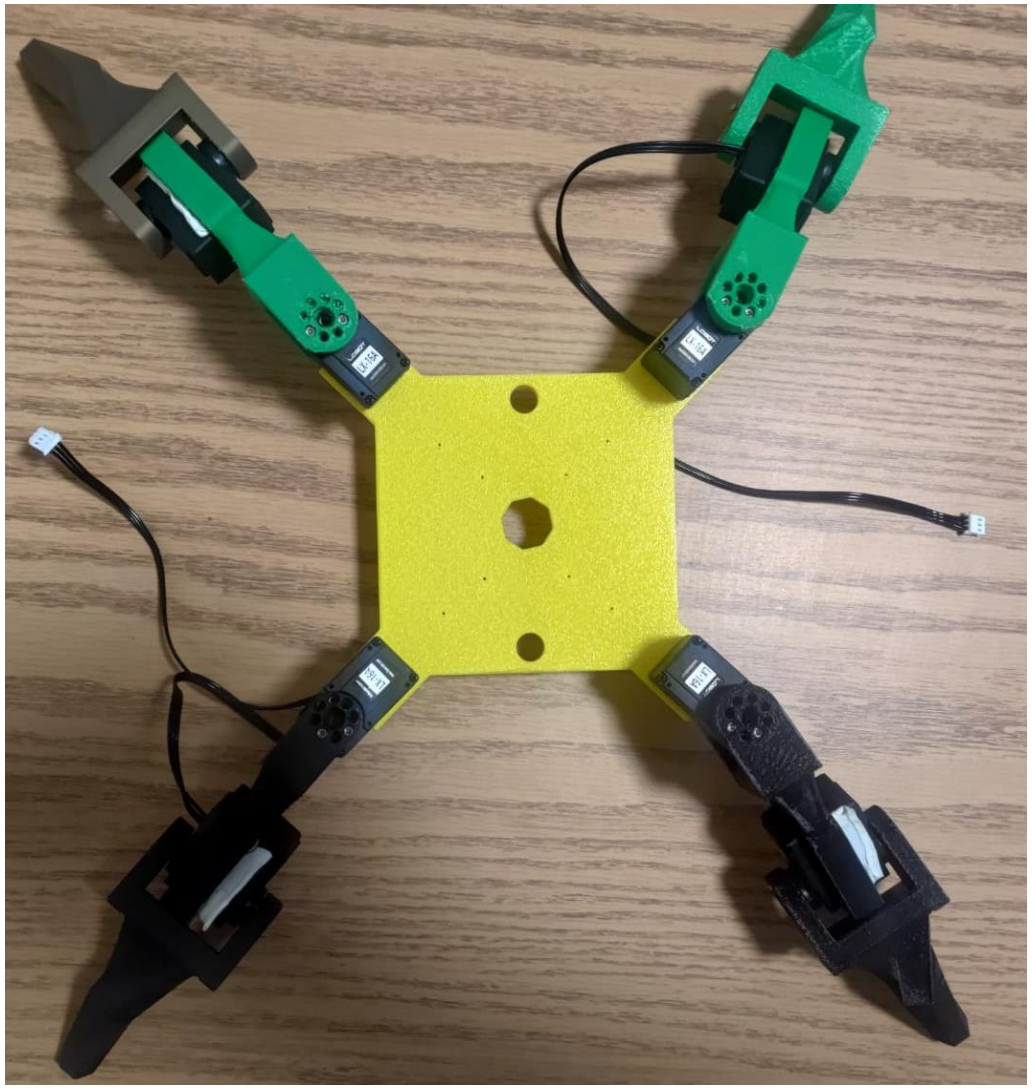
Movement of the Motor gets constrained
and motor did not properly seat in slot

Properly Bolted Nuts

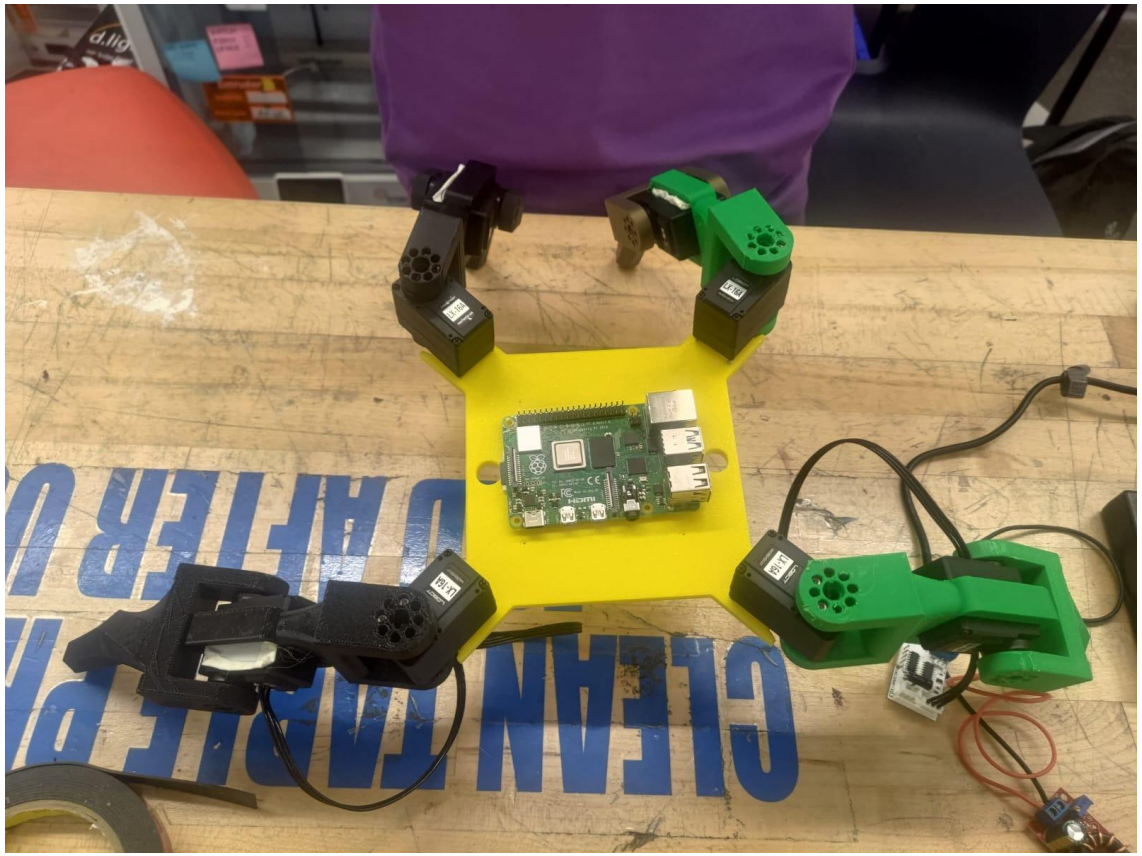


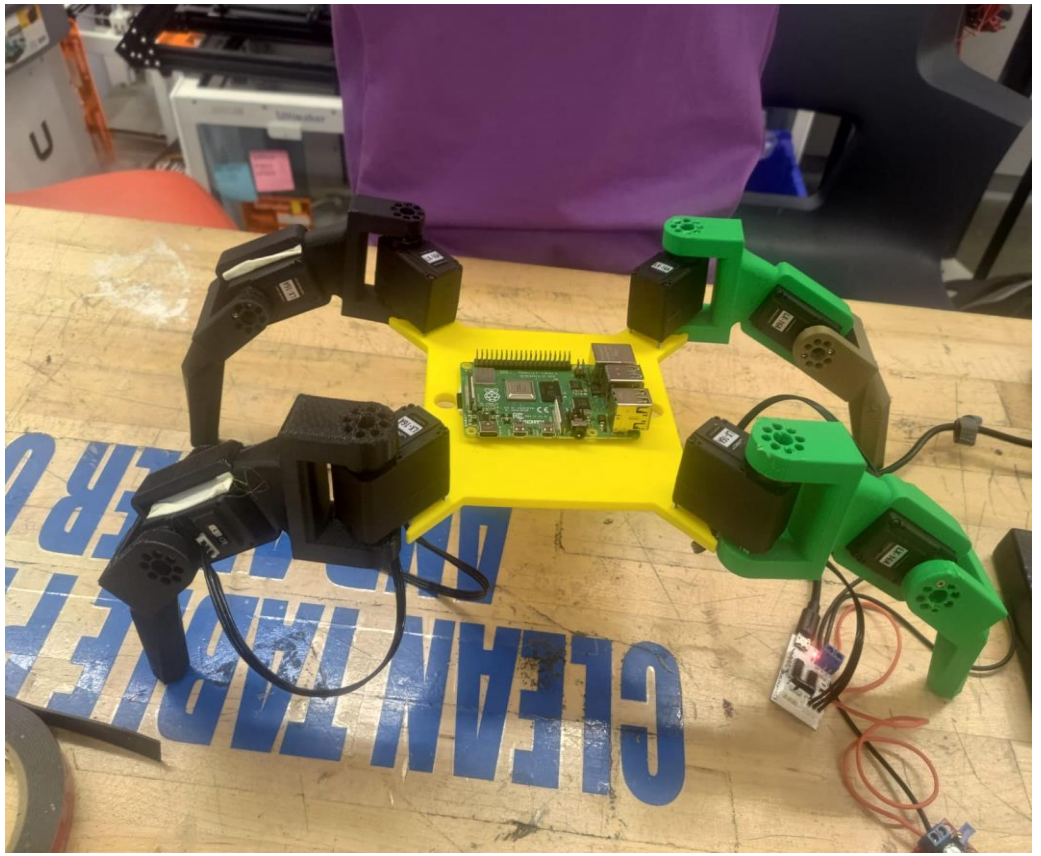
Stability Verified in Different Configurations





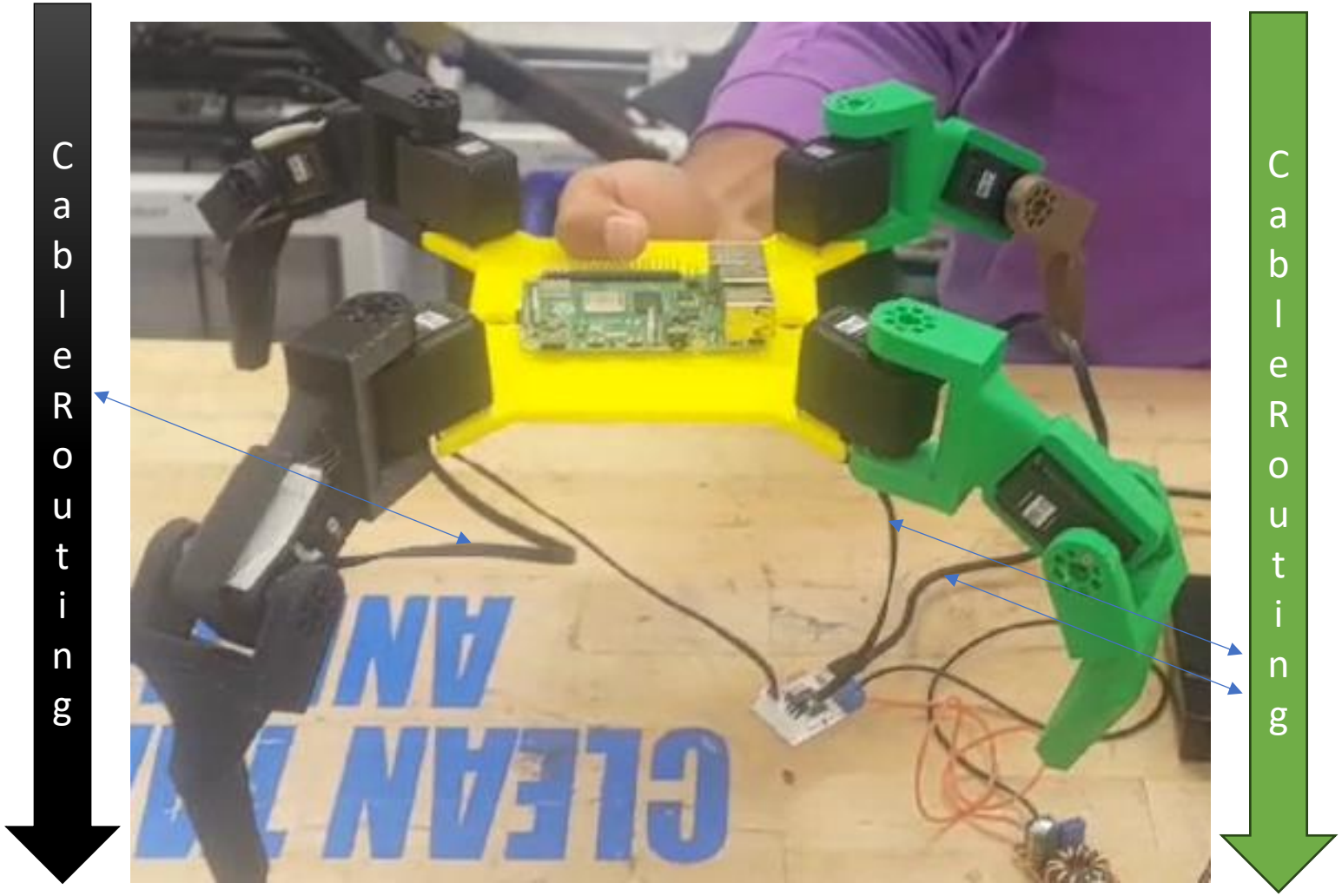
Stability Verified in Different Configurations





3D Print Quality Support Structures Removed

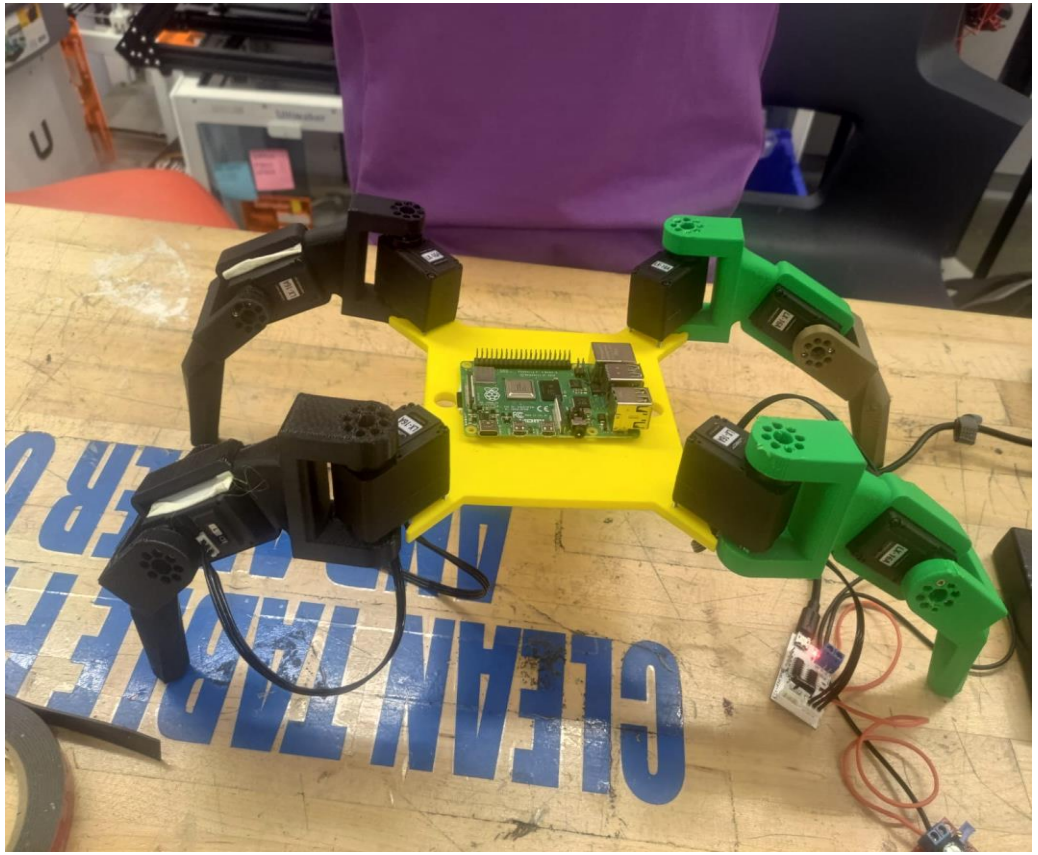
Properly Routed Cables

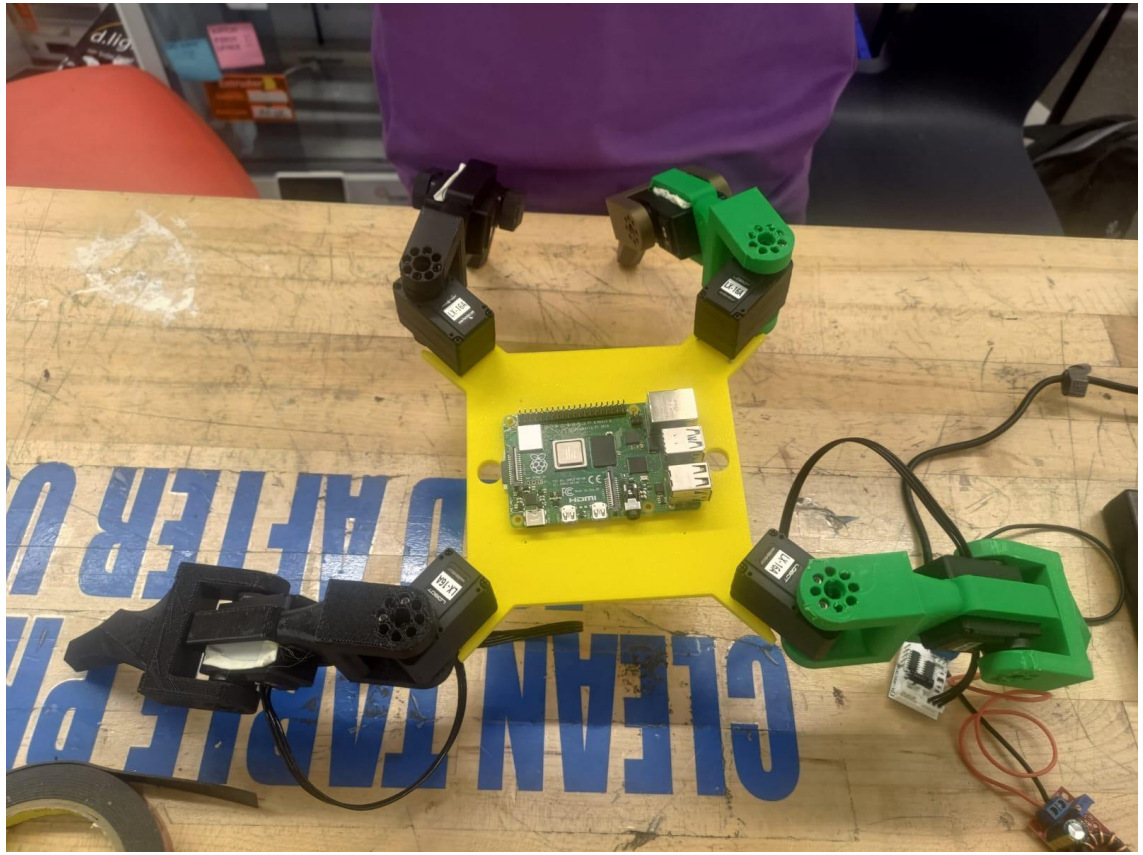


Robot Modularity Demonstrated

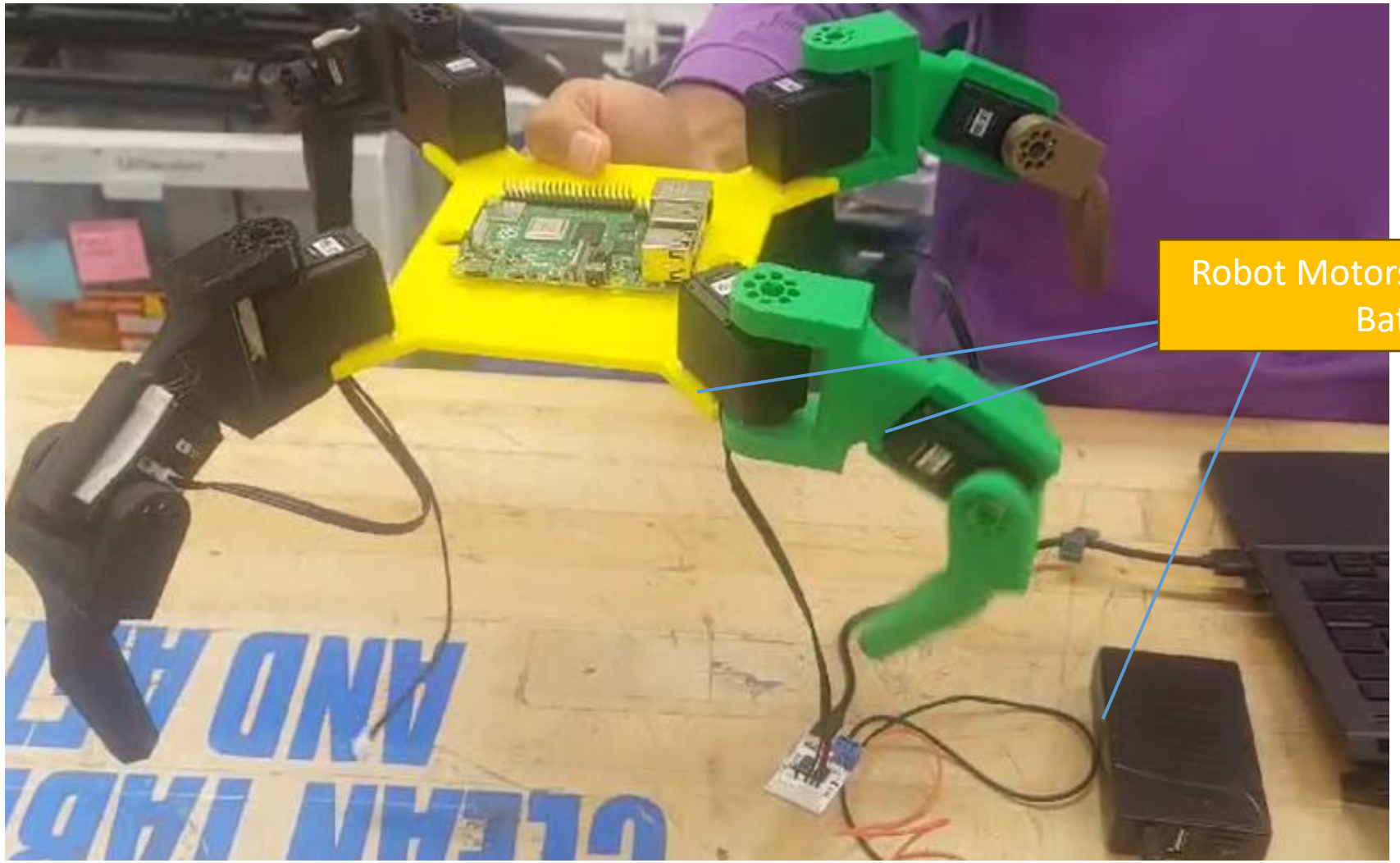
- Different leg variants can be used on the lower legs.
- Additionally different join mechanisms can be implemented along the middle leg using a joint enclosure

Multiple Robot Configurations





Robot Motors Controlled by Battery



Robot Home Routine

Marks Deserved

No.	Rubrics Completed	Slide(s)	Marks
1.	Title slide complete	42	5
2.	Overall aesthetics, layout and formatting of the slides	42-56	5
3.	Points glamour photo of printed robot	43	10
4.	Points robot legs moving (frames shown + link to video)	44	10
5.	Extreme leg positions tested and measured	45	10
6.	form/fit issues identified, listed and addressed	46	10
7.	3D-print quality, support structure removed	50	10
8.	Points stability verified in various configurations	53	10
9.	Robot Modularity demonstrated	52	10
10.	Cables routed properly and securely	32	10
11.	motors powered using battery	54	10
12	all components properly bolted and connected	47	10
13.	Multiple configurations tested	40	10

Total Marks Deserved = 120

Grace Days Used

Grace days accumulated = 5 (default) + 1 (submitted early assignment-1)

Grace days used = 3 (W + Th + F)

Grace days left = 3

Total Marks Deserved = 120

Robotics Studio MECE 4611

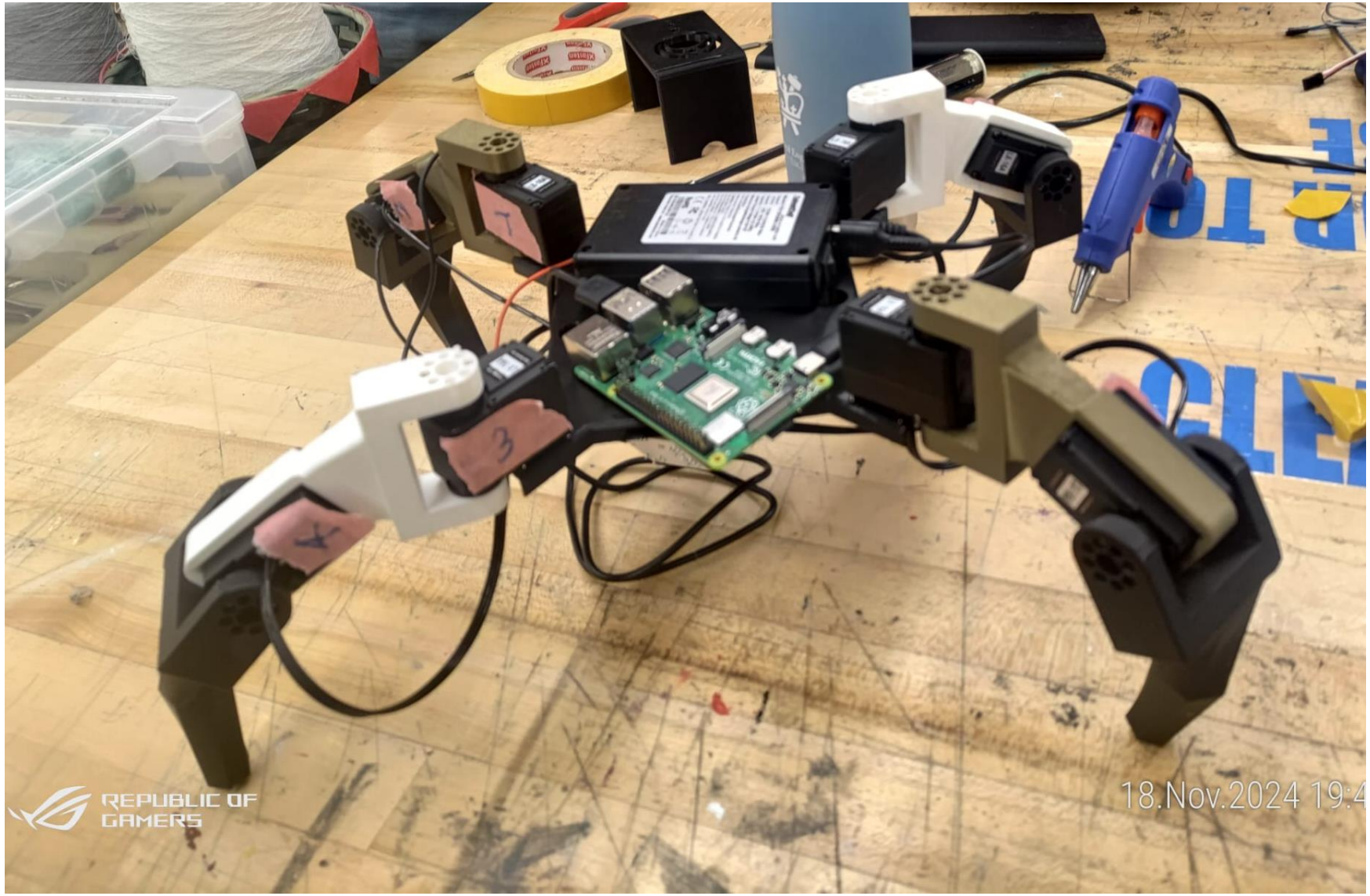
Semester -1, Assignment – 6

Name 1: Anushtup Nandy UNI 1: an3314

Name 2: Barath Kumar Jayachandran Kanchanamalini UNI 2: bj2519

Submitted Date: 11/19/2024

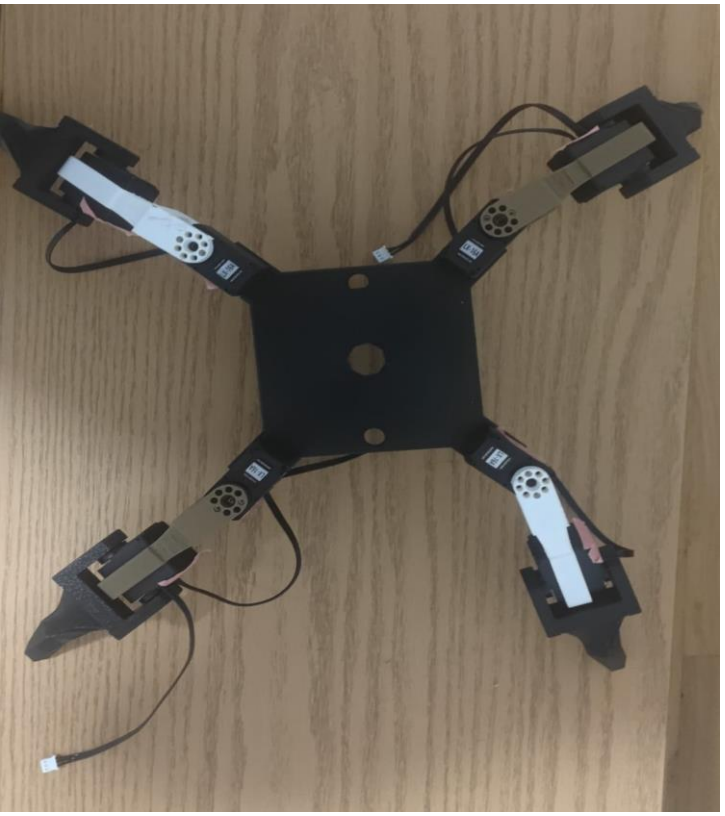
Glamour Photo of Working Robot

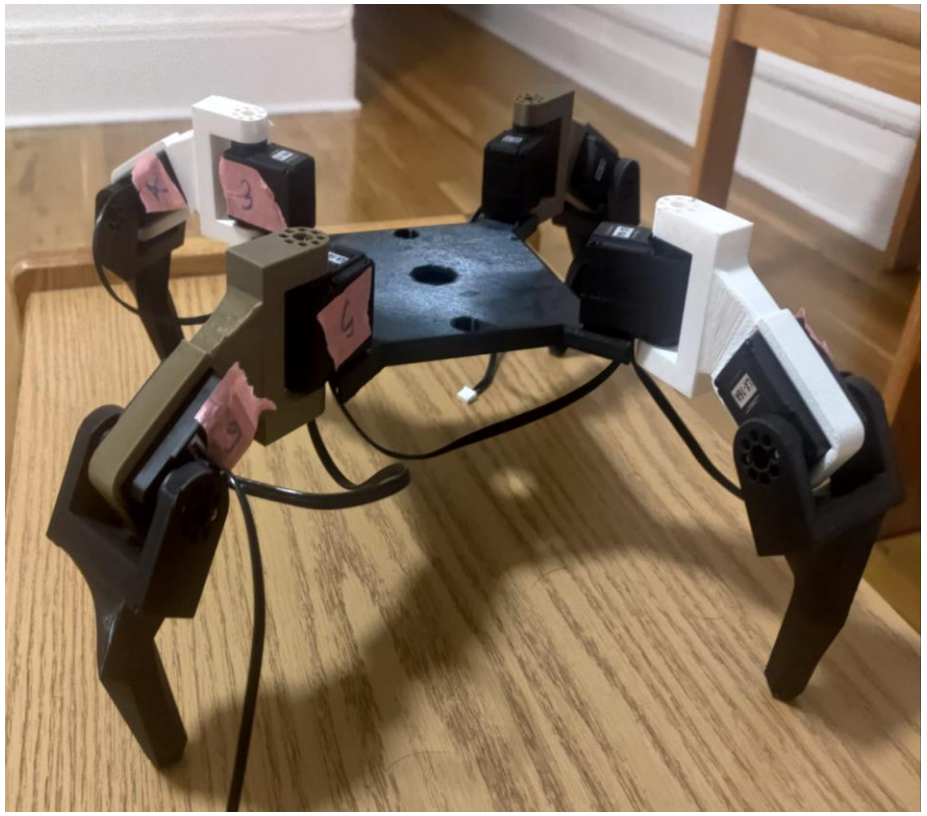


Robot Moving (Frames Shown + Link to Video)

https://drive.google.com/file/d/1Tr3bNbF62JJRQjVHkQrie8IEe1RA3XGW/view?usp=sharing

Robot Stability in Locomotion Configurations

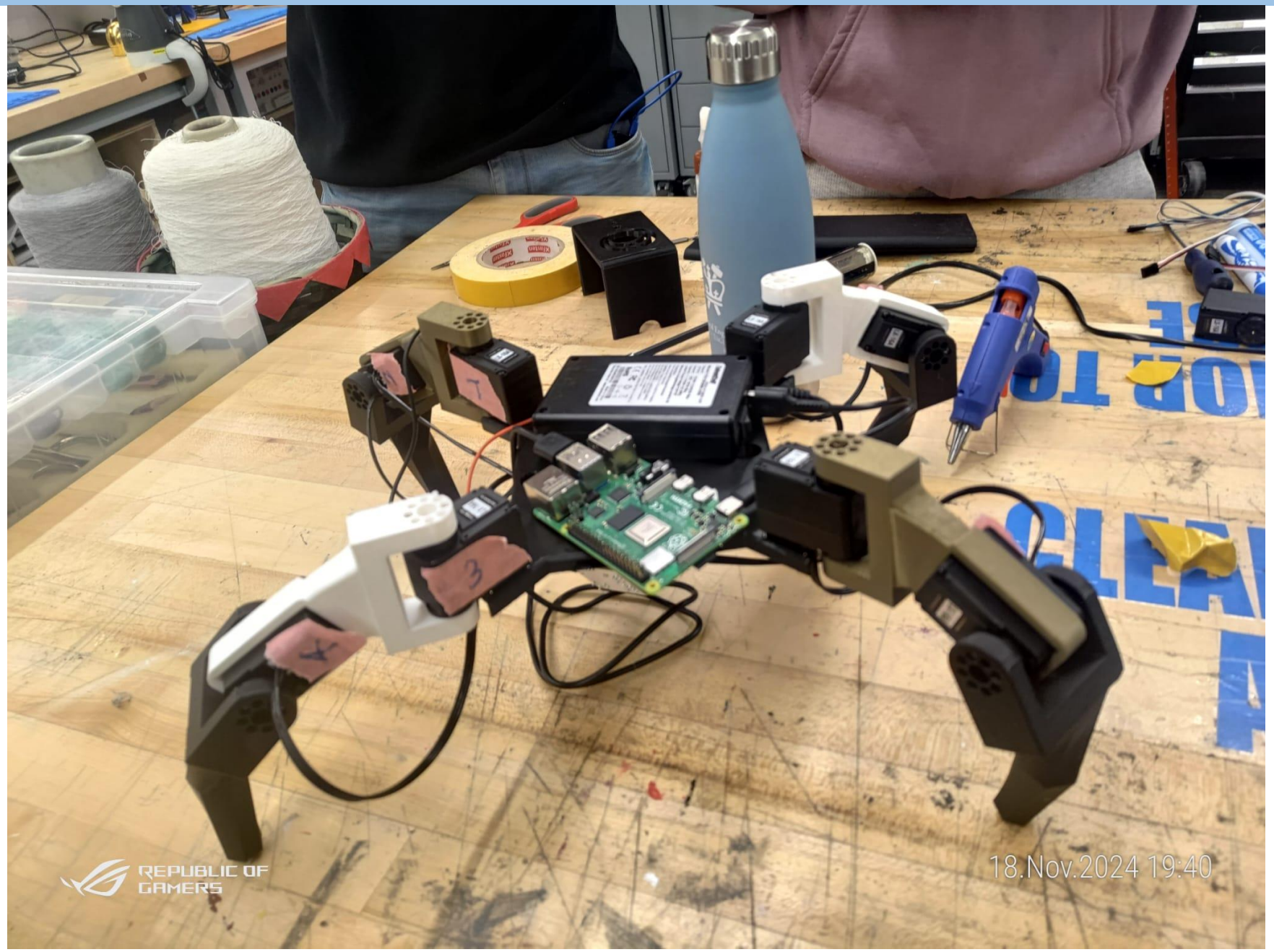




Properly Bolted Parts

Robot Sanded

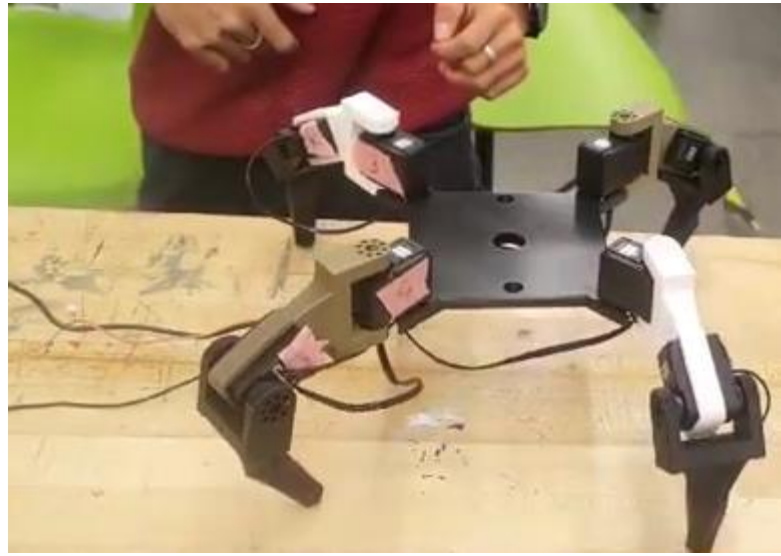
Motors Powered using Battery



Support Structures Removed

Routed Wires

Multiple Walking Patterns Tested

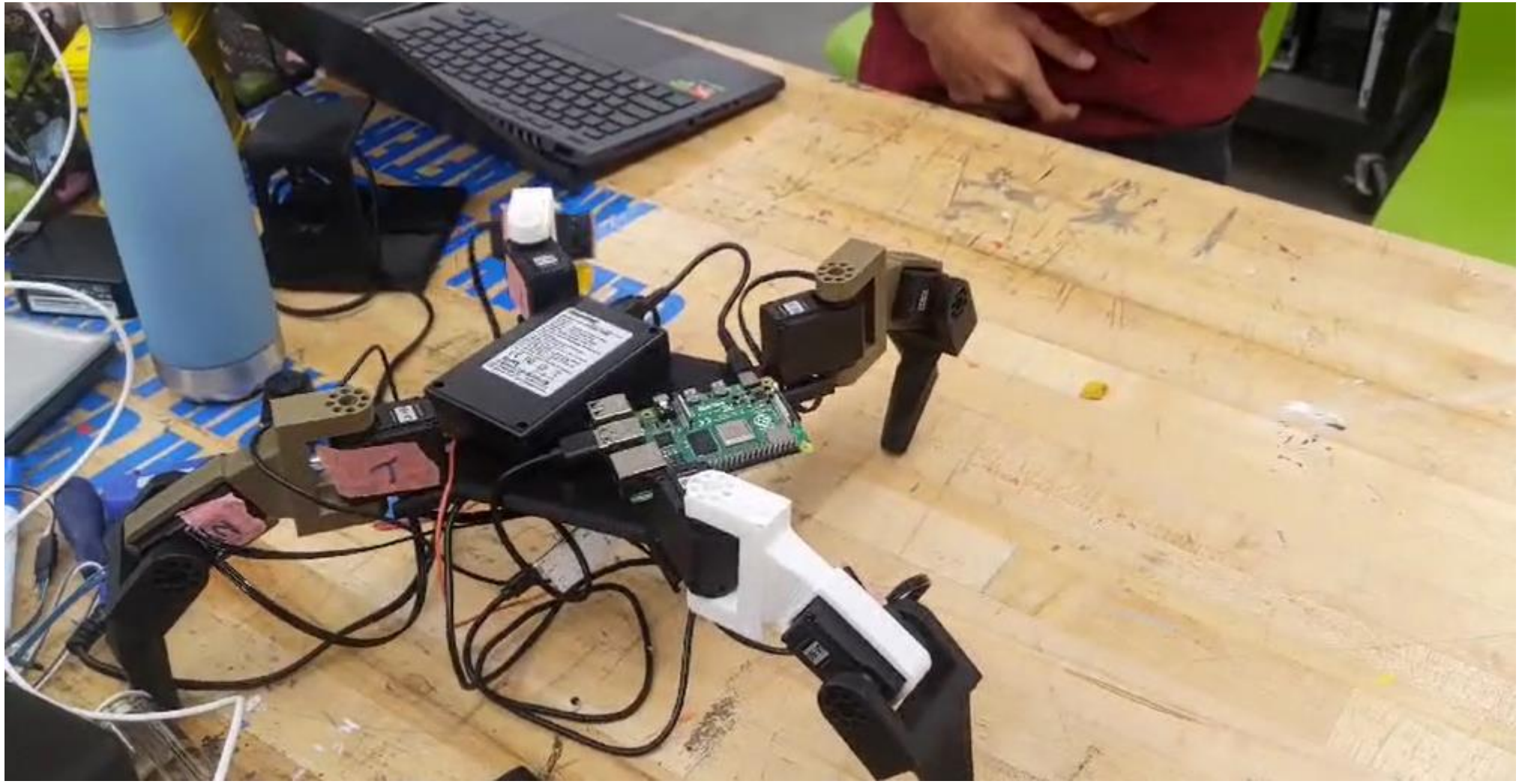


Walking Pattern 1: https://drive.google.com/file/d/1gBmziYLmlfSjgeYTW7B4th147d_vbCtg/view?usp=drive_link

Walking Pattern 2: https://drive.google.com/file/d/1Uhn4DsvqR3MoBlwI-B2DA3NWg2VxkIro/view?usp=sharing

Walking Pattern 3: https://drive.google.com/file/d/14q-G4rvT6DV1JdRnMLHf5Kv5OAvI398Q/view?usp=drive_link

Motors Controlled directly from RPI



Motors controlled directly from RPI:

https://drive.google.com/file/d/1oCm_SSSXODX81yflE3k1oKK7dRpVNHA/view?usp=sharing

Robot’s Shutdown Routine Implemented

https://drive.google.com/file/d/14z6Td0D6YlkkNAF-ShDPgdPCGvRENO_f/view?usp=sharing

Marks Deserved

No.	Rubrics Completed	Slide(s)	Marks
1.	Title slide complete	42	5
2.	Overall aesthetics, layout and formatting of the slides	42-56	5
3.	Glamour Photo of Working Robot	59	10
4.	Robot moving(frames shown + link to video)	60	10
5.	Robot stability in Locomotion	61	10
6.	Properly Bolted Parts	62	10
7.	Robot Sanded	63	10
8.	Motors Powered using battery	64	10
9.	Support Structures Removed	65	10
10.	Cables routed properly	66	10
11.	Multiple walking patterns tested	67	10
12	Motors controlled directly from RPI	68	10
13.	Robot's Shutdown Routine Implemented	69	10

Total Marks Deserved = 120

Robotics Studio MECE 4611

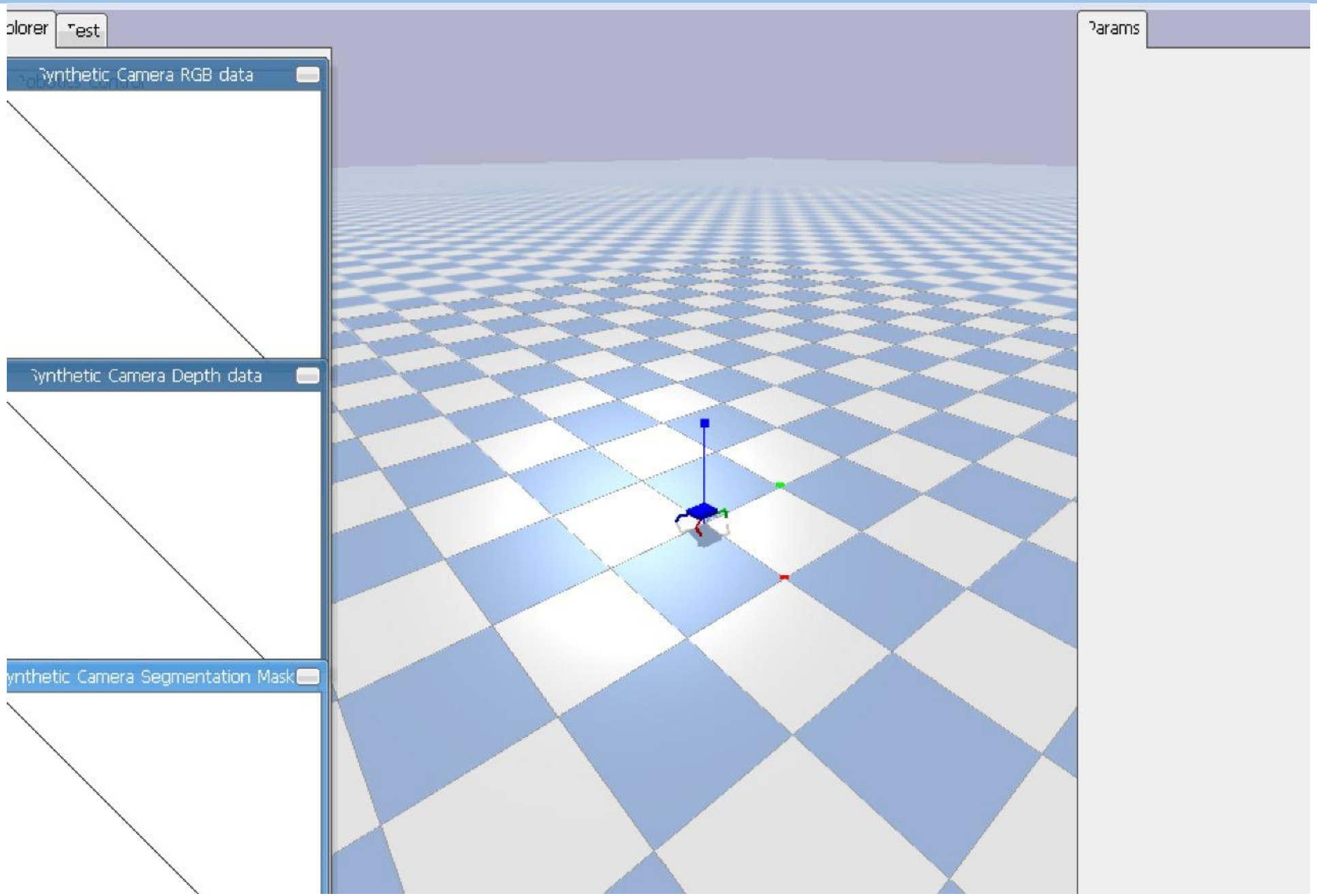
Semester -1, Assignment – 7

Name 1: Anushtup Nandy UNI 1: an3314

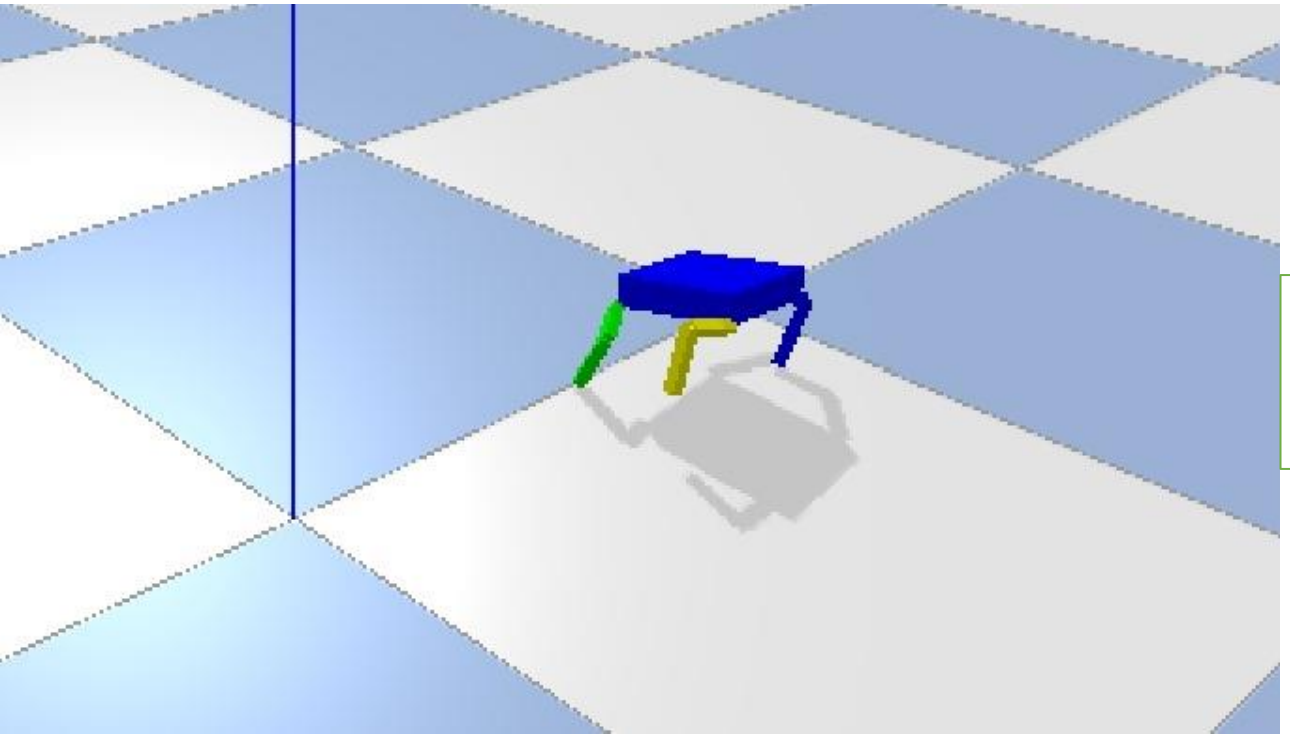
Name 2: Barath Kumar Jayachandran Kanchanamalini UNI 2: bj2519

Submitted Date: 11/19/2024

PyBullet Environment



PyBullet Walking



Video Link:
https://drive.google.com/file/d/1edjDm0TugXv0W1Tz5_5PdSFwgj5qDNf_/view?usp=sharing

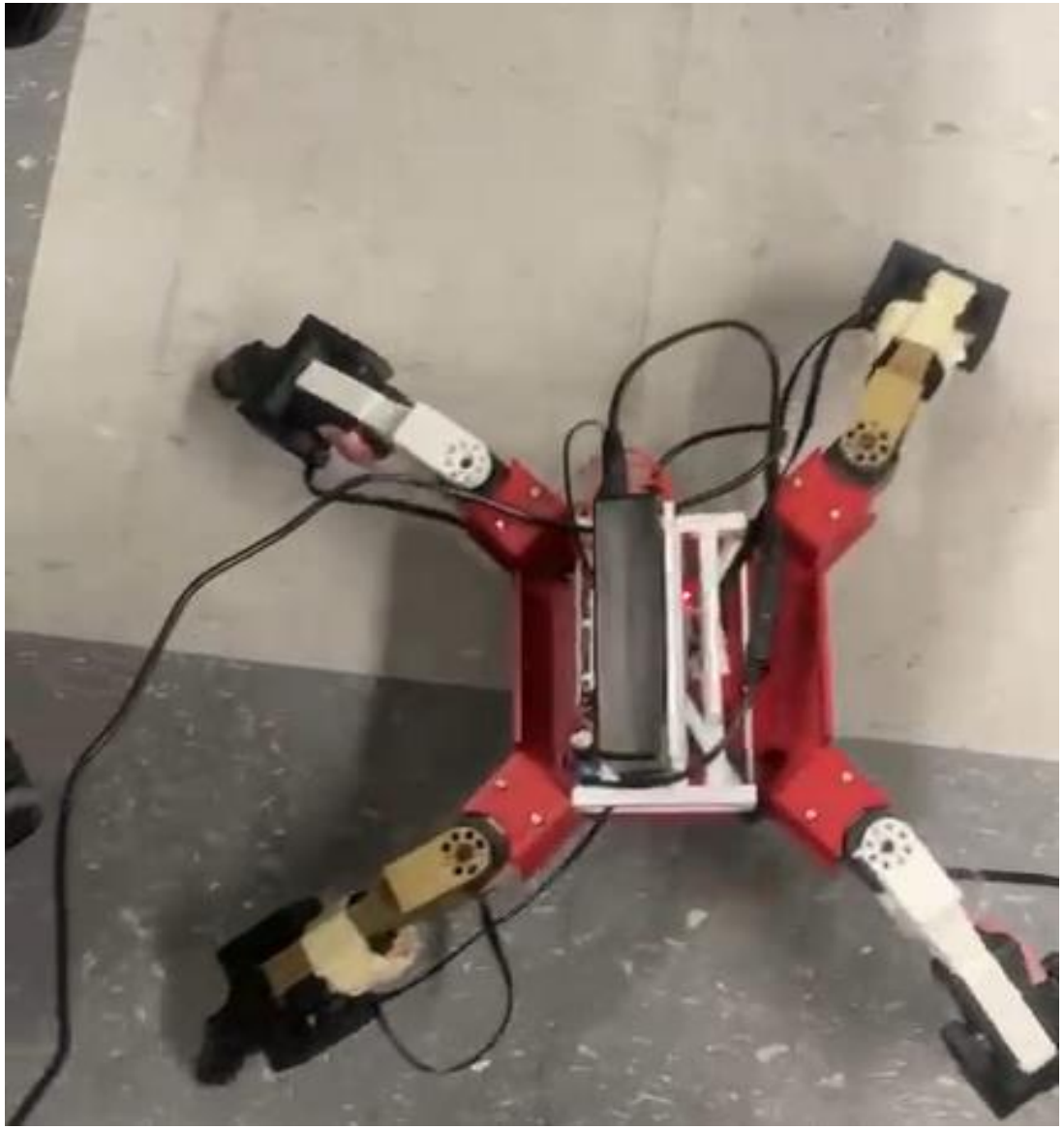
Unoptimized Gait

Video Link:
https://drive.google.com/file/d/1v2VPQ5uWLXg2DQwpQNcyvtfe5oFe3usO/view?usp=drive_link

Testing the Robot

Video Link:
https://drive.google.com/file/d/1v2VPQ5uWLXg2DQwpQNcyvtfe5oFe3usO/view?usp=drive_link

Dancing Gait



Video Link:
https://drive.google.com/file/d/1KlzgkHufRiDW-YsNKH9FYGmgxrSxW6nY/view?usp=sharing

Gait Specifications

1. **Diagonal Leg Coordination**
   - Front left pairs with rear right leg
   - Front right pairs with rear left leg
   - Ensures constant stability with two legs always on the ground

2. **Three-Phase Movement Cycle**
   - Lift: Knee servos raise the leg
   - Forward Motion: Hip servos swing leg forward
   - Lowering: Leg returns to ground contact
   - Each phase must be completed before the next one begins

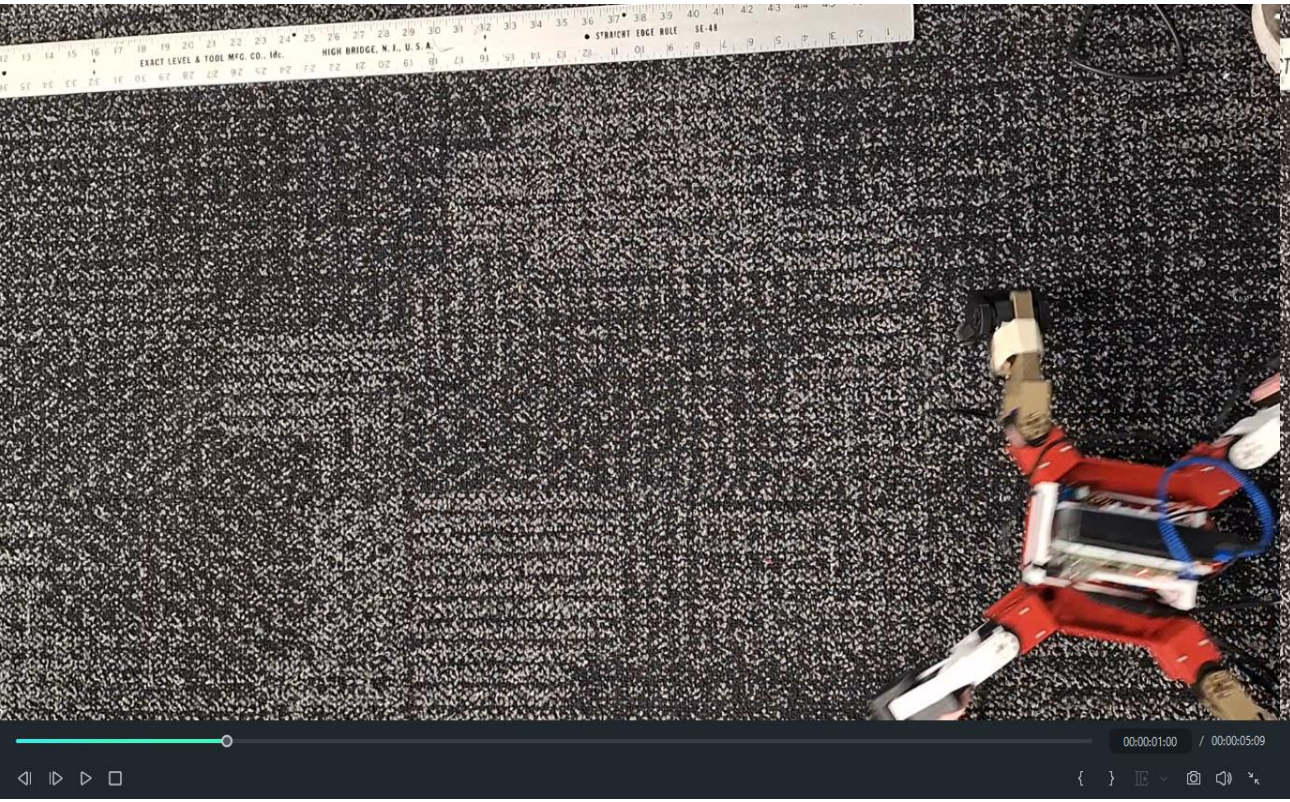
3. **Movement Sequence**
   - First diagonal pair (front left + rear right) moves
   The second diagonal pair (front right + rear left) follows
   - Alternating pattern creates continuous forward motion
   - Requires precise timing between pairs

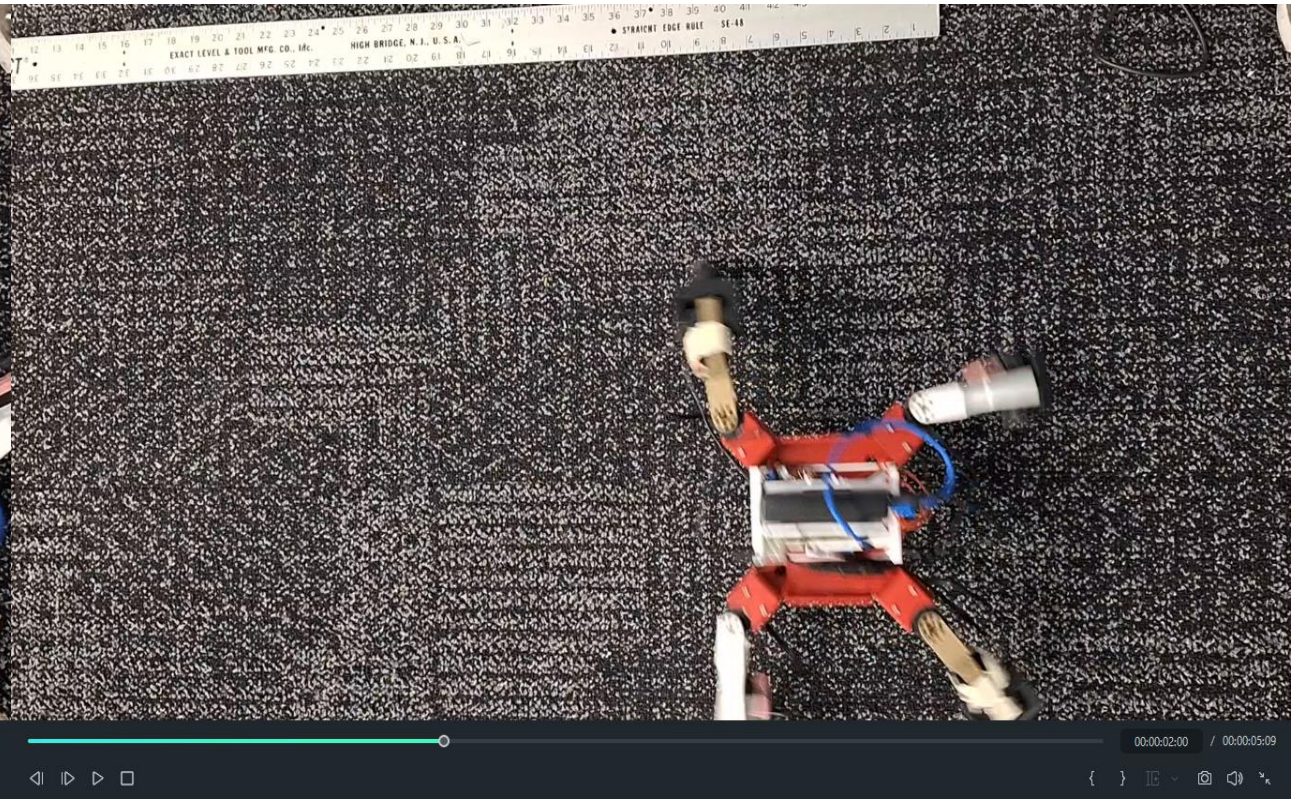
4. Stability Mechanism
   - Center of gravity stays within support polygon
   - Weight distributes evenly across supporting legs
   - Diagonal leg pairs provide optimal balance
   - Maintains stability during continuous motion

5. Movement Sequence
   - First diagonal pair (front left + rear right) moves
   - Second diagonal pair (front right + rear left) follows
   - Alternating pattern creates continuous forward motion
   - Requires precise timing between pairs

6. Performance Characteristics
   - Best suited for flat terrain movement
   - Good balance of speed and stability
   - Energy efficient for standard walking
   - Adaptable to different speeds and loads

First and Last Frame – Enter, Robot - Quail!





At t0=1 seconds the robot is at 1 inch

At t1=2 seconds the robot is at 11 inches

The Robot achieves 25.4 cm in 1 seconds

Video Link:
https://drive.google.com/file/d/1t58b_Tkjobyt2QUnO3x3wWcmM2OAgdww/view?usp=sharing

Curtains Down! Thank you..!