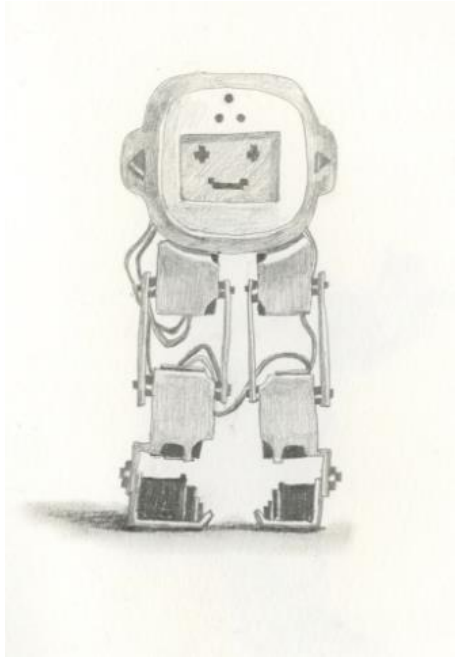
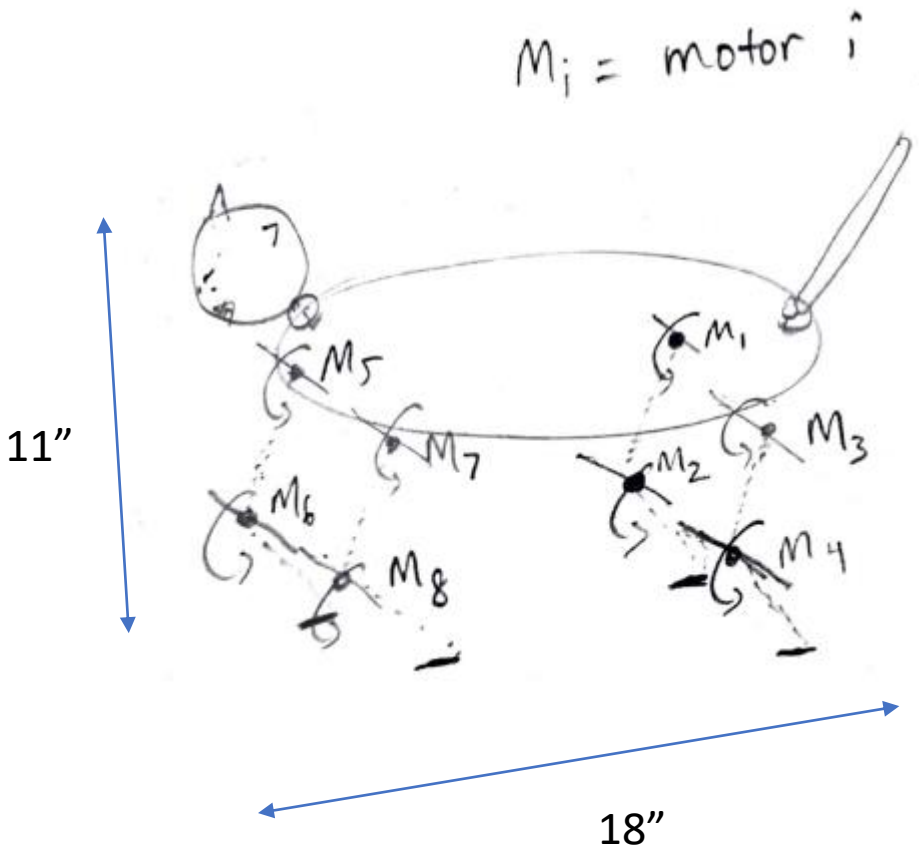
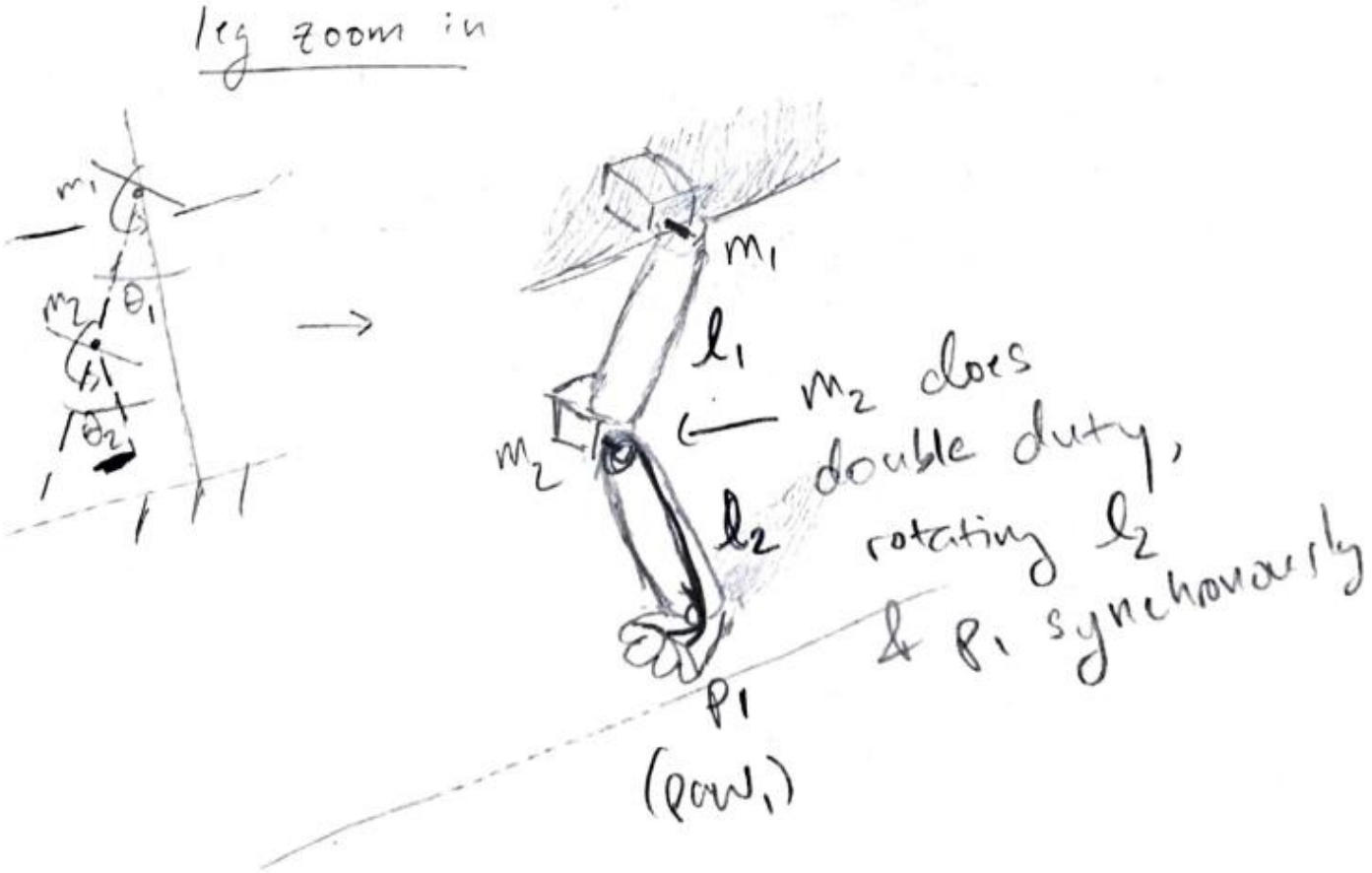
Robotics Studio MECE 4611
Fall 2021, Assignment 1



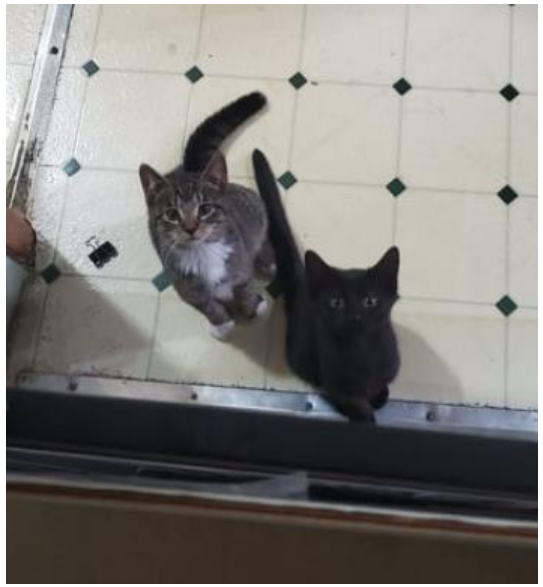
William Xie, Mimi Park
wx2214, mp3942
Submission Date: 9/21/2021 at 11:00 PM
Grace Hours Gained: 1
Grace Hours Remaining: 97

Concept 1 - Little Kitten





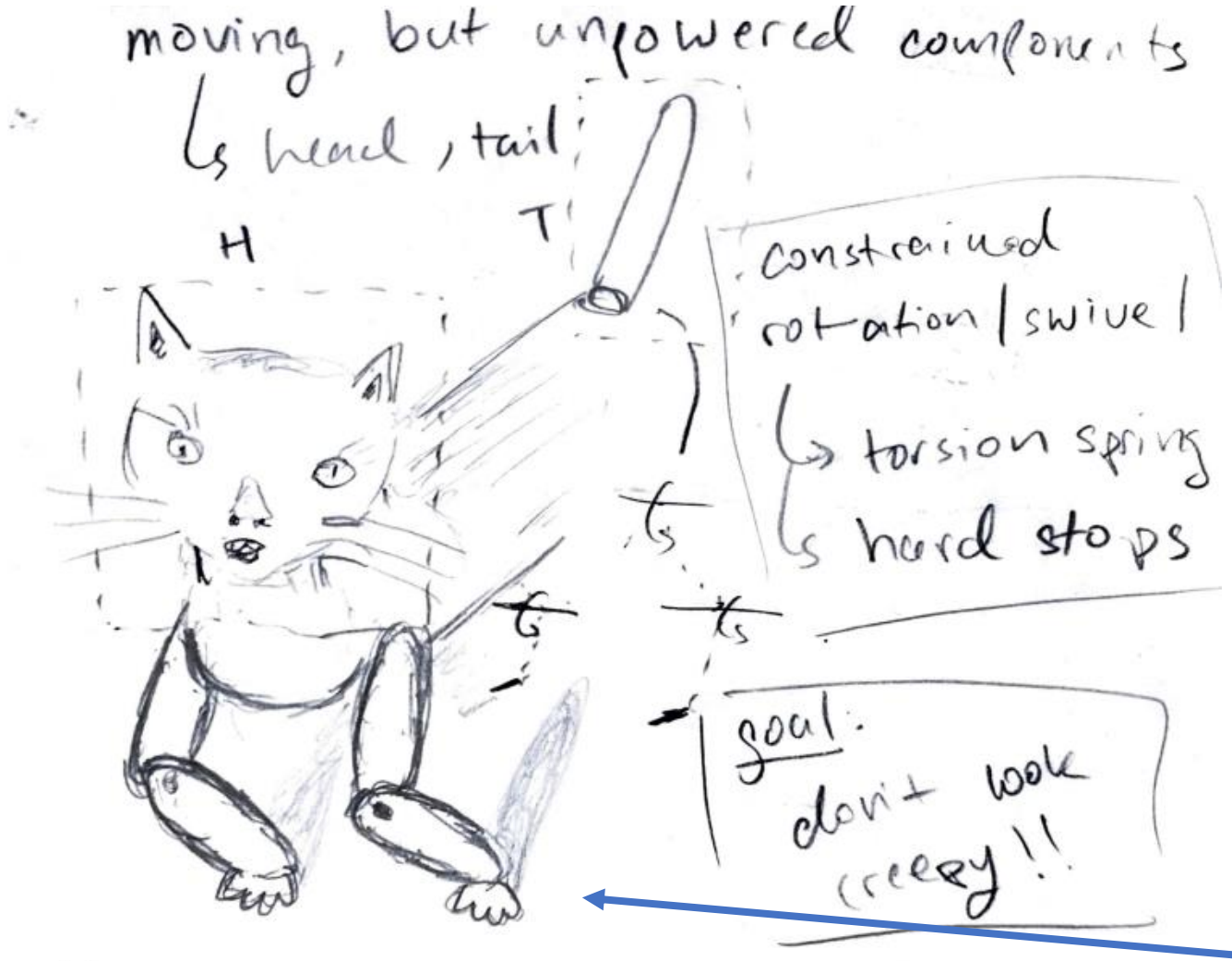
Concept 1 - Inspiration

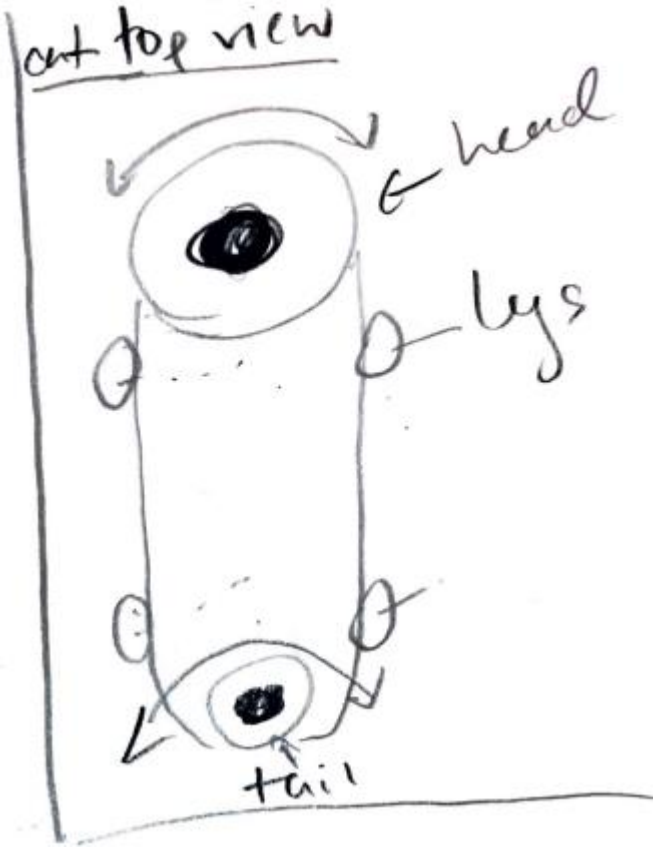


My cats, when they were kittens. I want another kitten and for it to stay a kitten forever.

They would probably hate this robot.

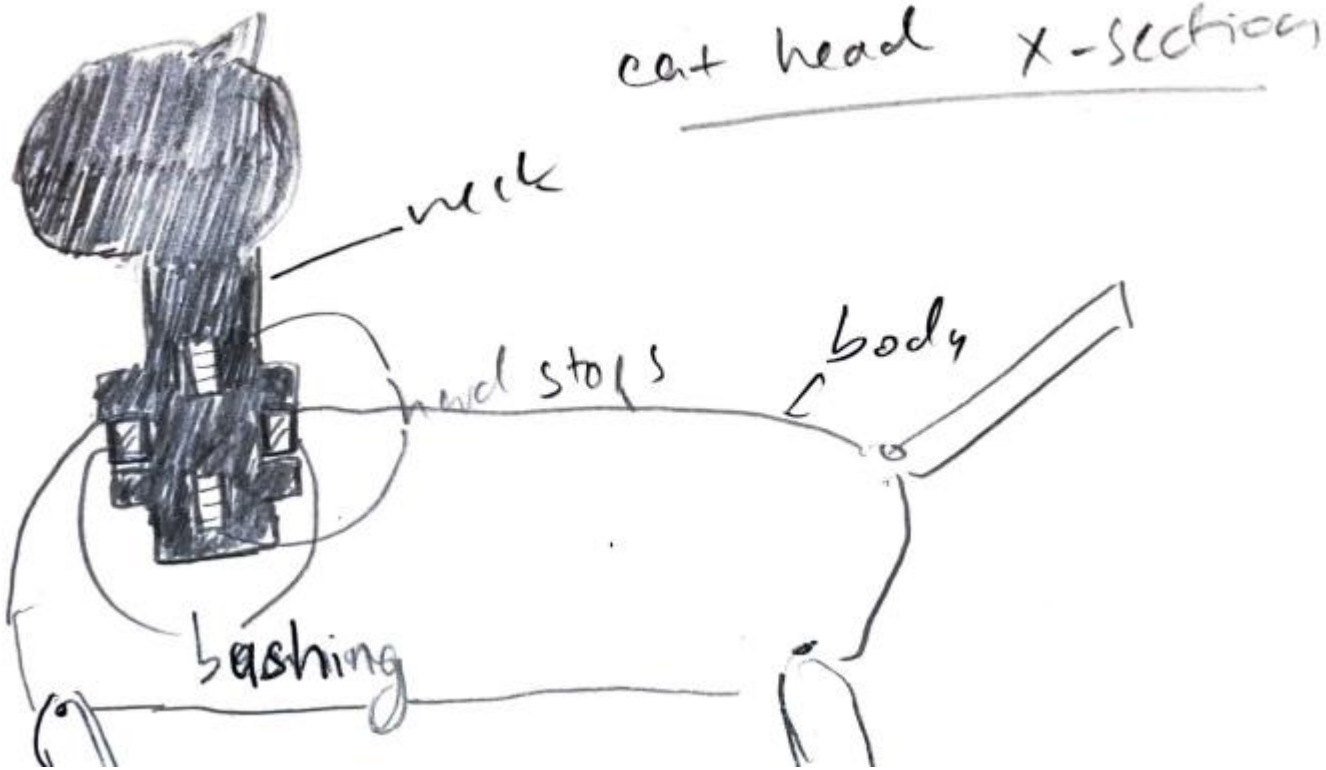
Concept 1

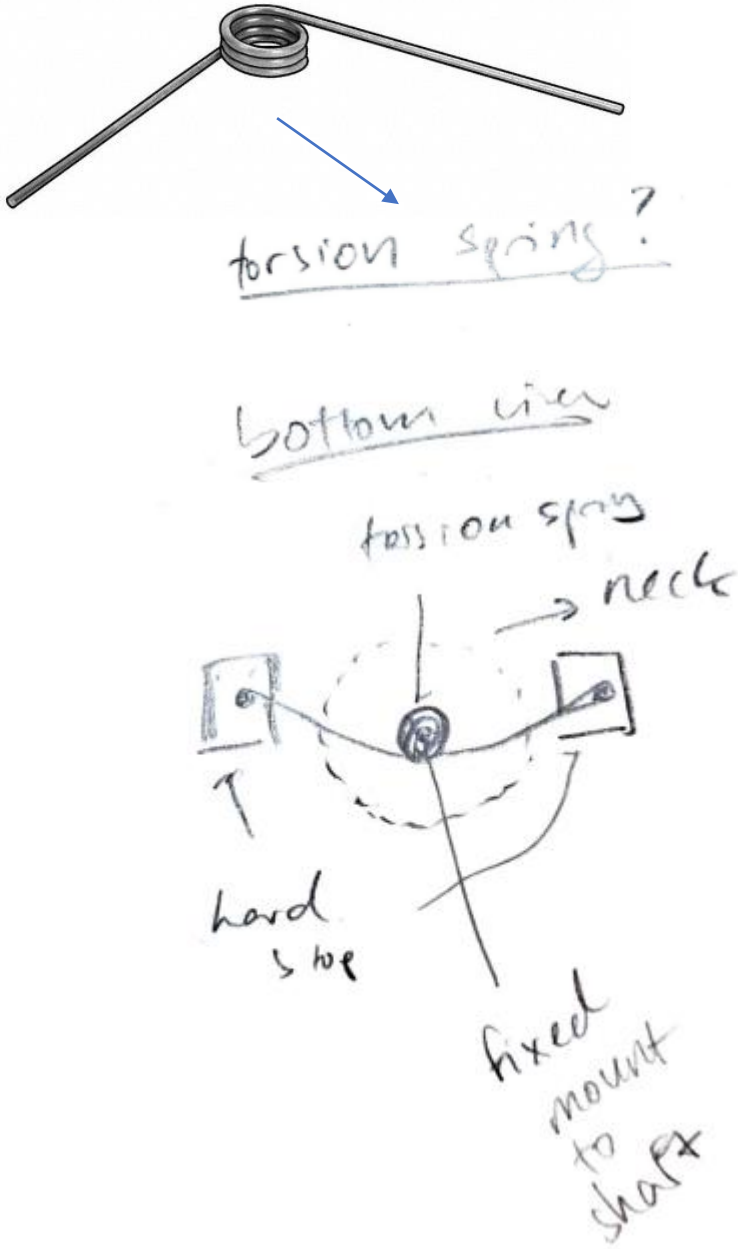




This face looks really creepy, so I already failed to achieve my goals.

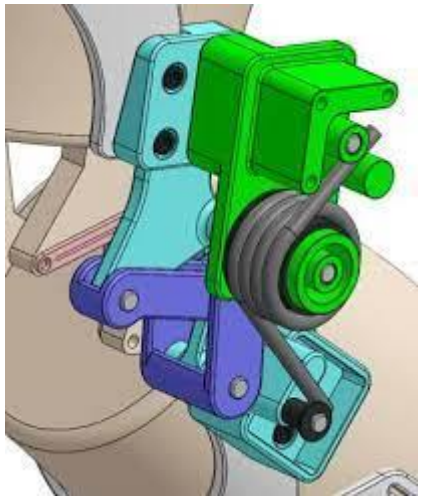
Concept 1 – Passive Joints

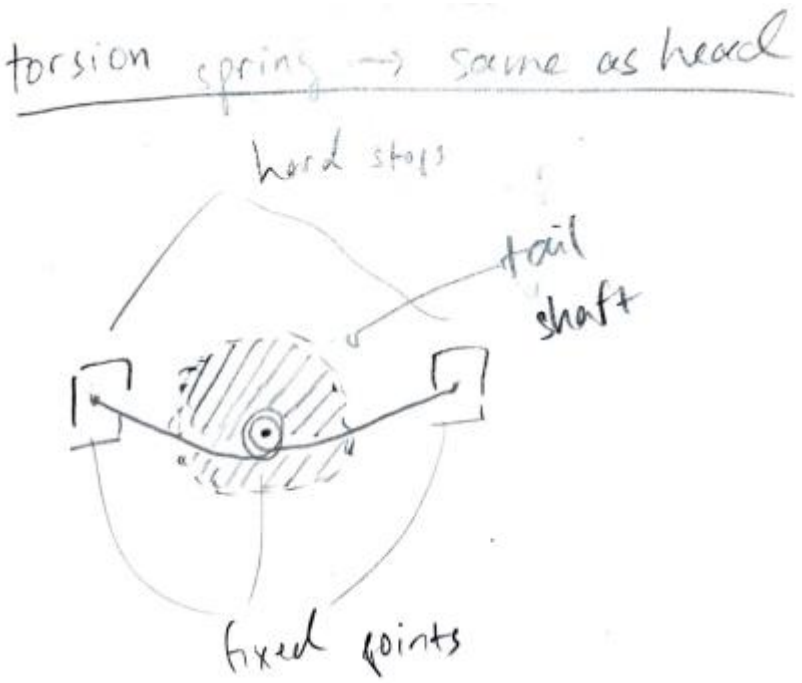




All 8 motors are allotted toward the legs, but I still want the head and tail to swivel a little bit. The plan is to constrain their rotation with hard stops and dampen the rotation with a torsion spring.

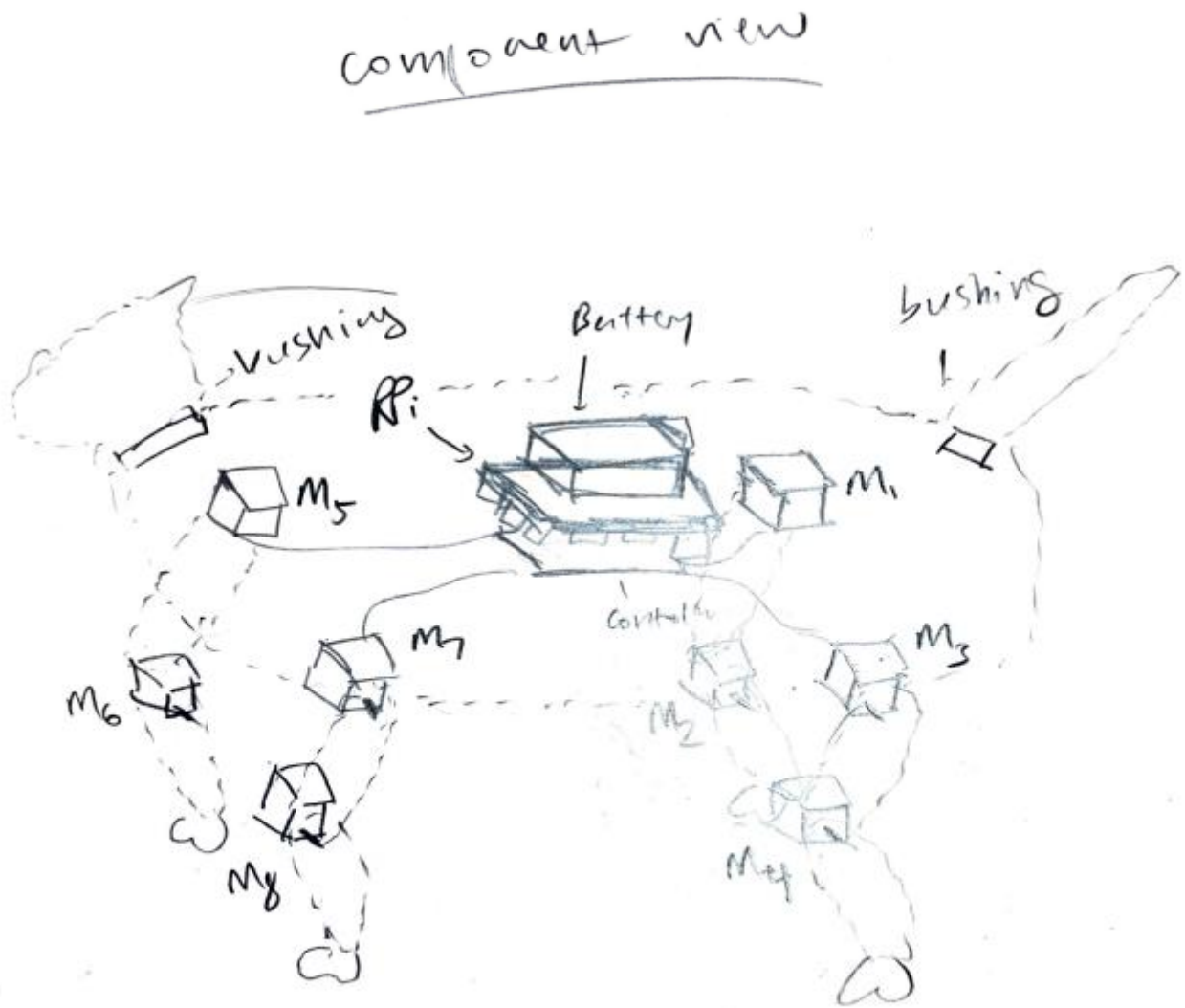
Concept 1



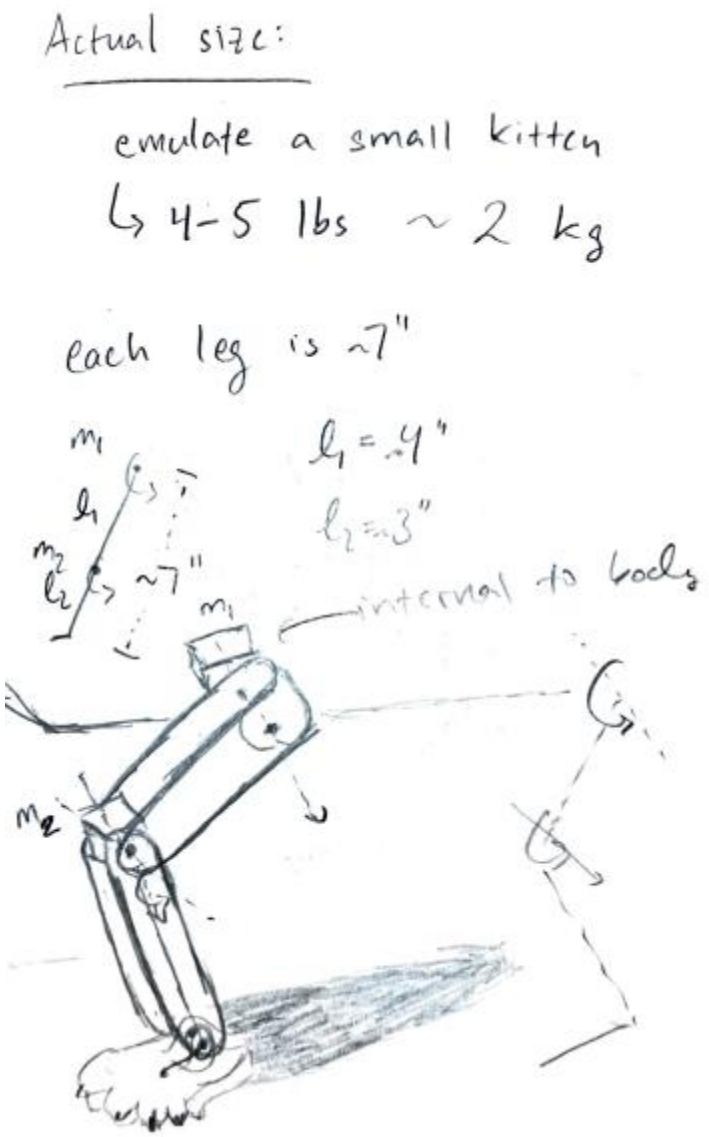


"Passive knee exoskeleton using torsion spring for cycling assistance", Chaichaowarat et al. (2017)

Concept 1


component view
bushing
Battery
bushing
Pi
M5
M1
M7
M6
M3
M2
M8
M4

Concept 1



Estimated weight = **~5 lbs**
Paw thickness = ~0.5”
Entire leg weight = ~8 oz. (0.5 lb)
L2 + paw weight = ~4 oz. (0.25 lb)

Leg length = ~7.5” (0.625’)
L2 + paw length = ~3.5” (0.29’)

Max ω (L1 or L2) = ~20 rpm (2.9 rad/s)
F_r = mv^2/r = 0.082 lbf (whole leg), 0.019 lbf (L2 + paw)
F_g = ma (assumed holding force—just combatting gravity—of fully extended leg parallel to the ground)

Defining dynamic torque as torque in motion (F_g + F_r)

$$P = \tau\omega$$

$$\tau = \frac{P}{\omega}$$

$$\omega = \frac{2\pi RPM}{60}$$

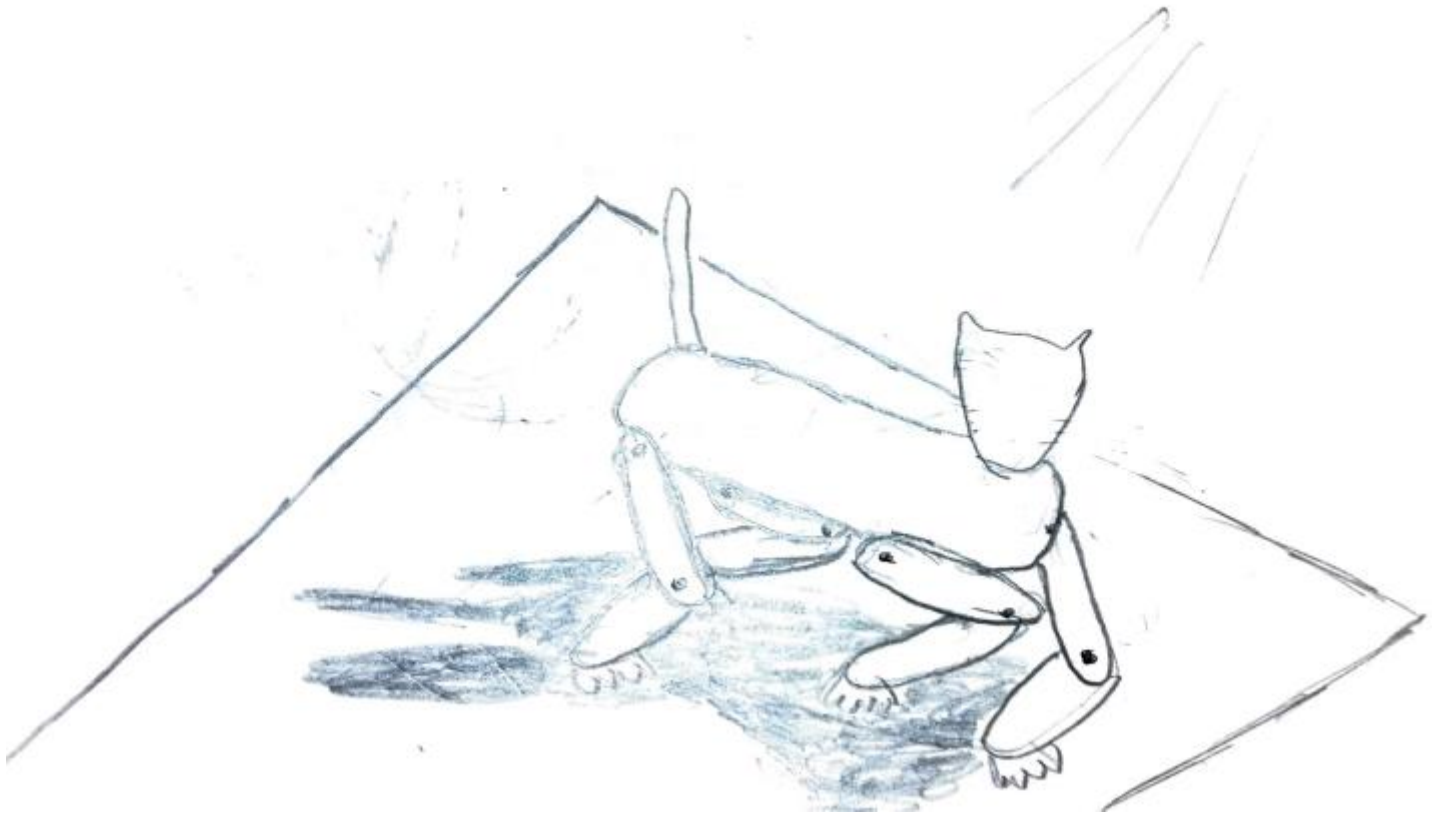
τ = rFsin(ϑ)
Max holding torque on motor 1: **0.3125 ft-lb**
Max dynamic torque on motor 1: **0.3750 ft-lb**
Max holding torque on motor 2: **0.0725 ft-lb**
Max dynamic torque on motor 2: **0.0957 ft-lb**

Max power from m1: **1.06 W**
Max power from m2: **0.28 W**
Per leg power draw: **1.34 W**
Whole robot (4 legs): **5.32 W**

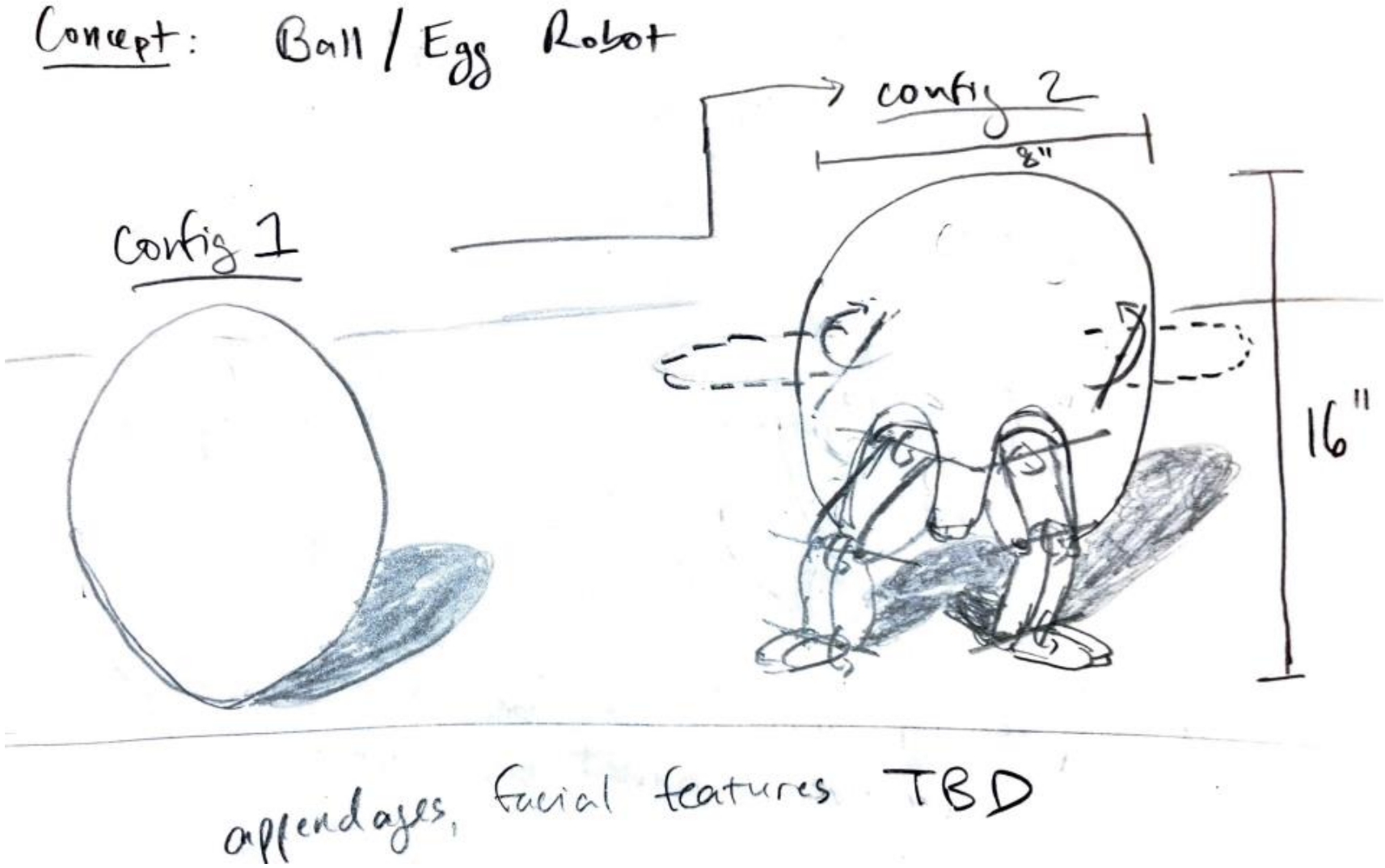
Each motor is within its 6 W envelope, and the robot is within the 30 W battery envelope.

Concept 1

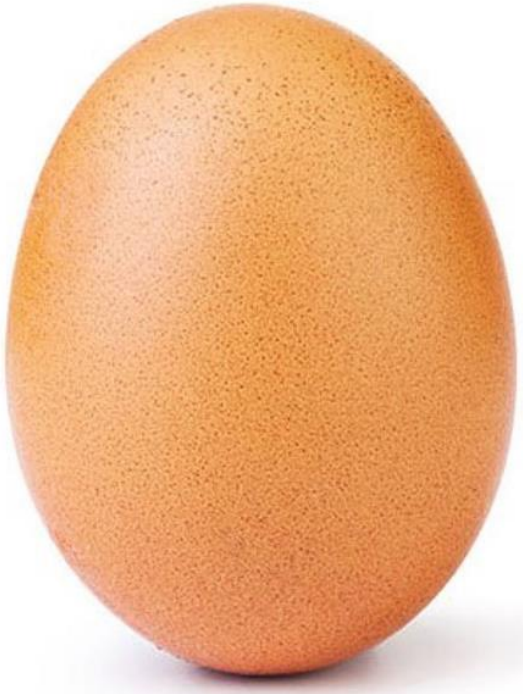
With a small-kitten-scale, robot should be able to balance on 2 paws at a time



Concept 2 – Unfolding Ball/Egg

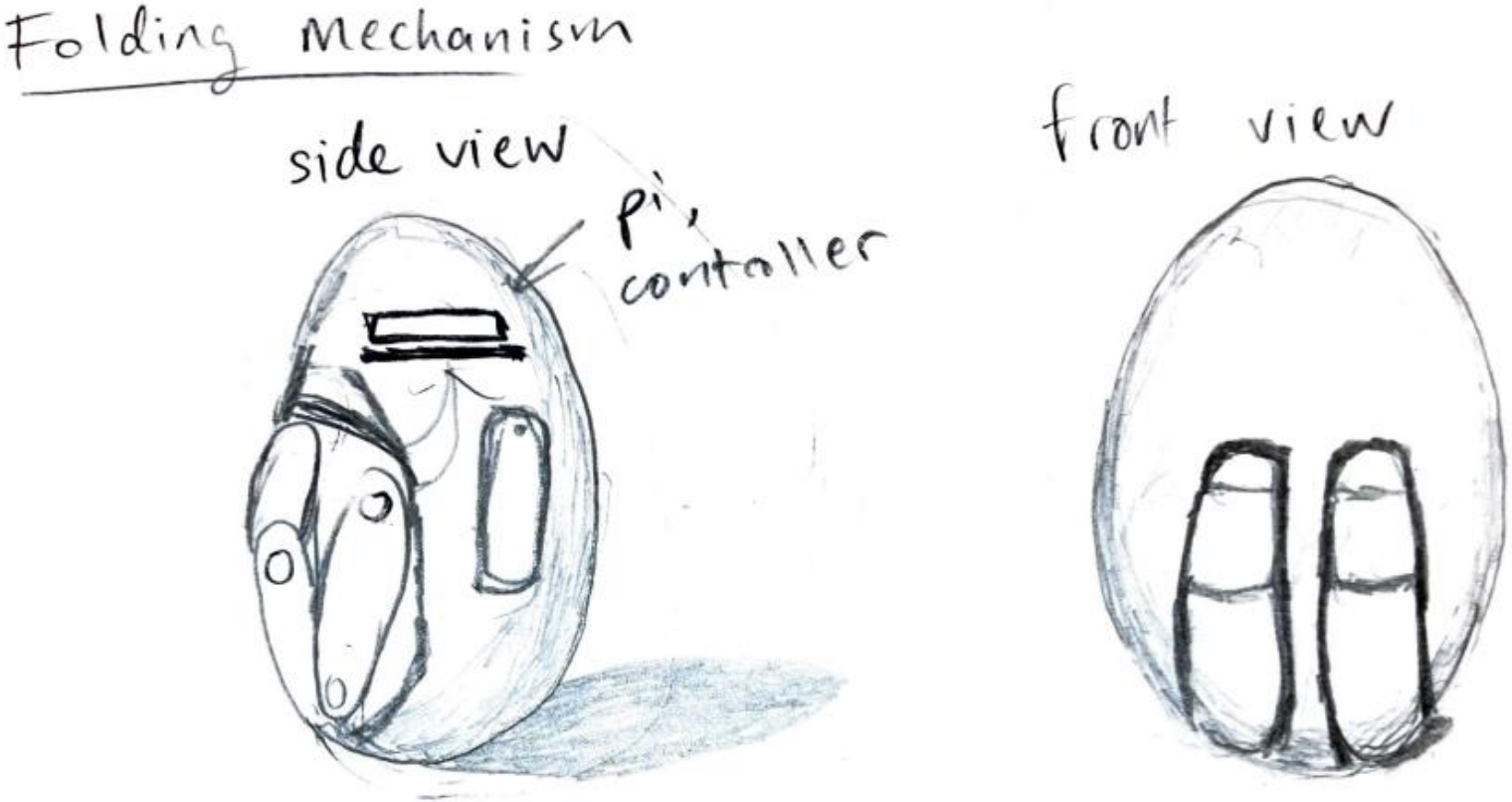


Concept 2 – Real world inspirations

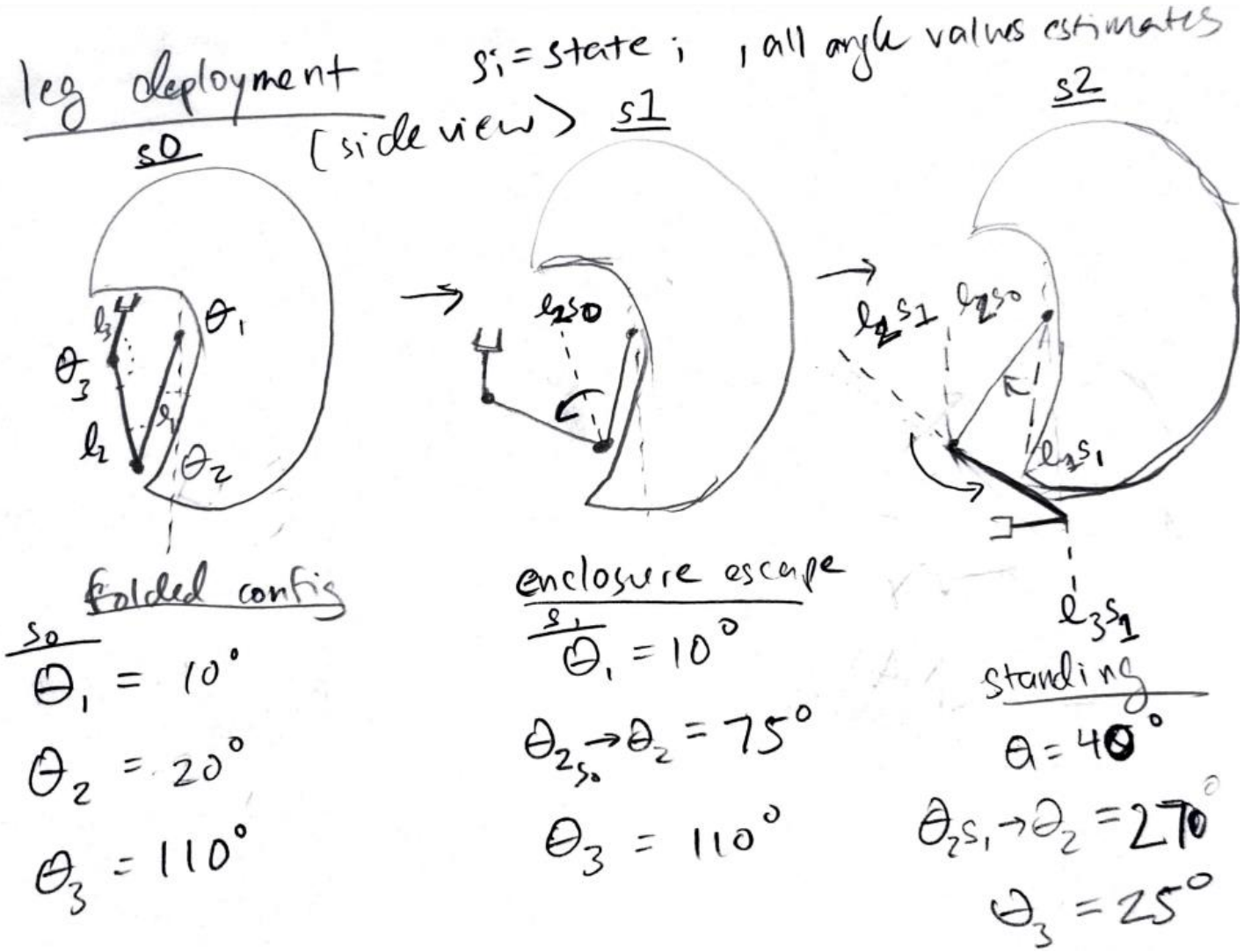


Diabotical, video game

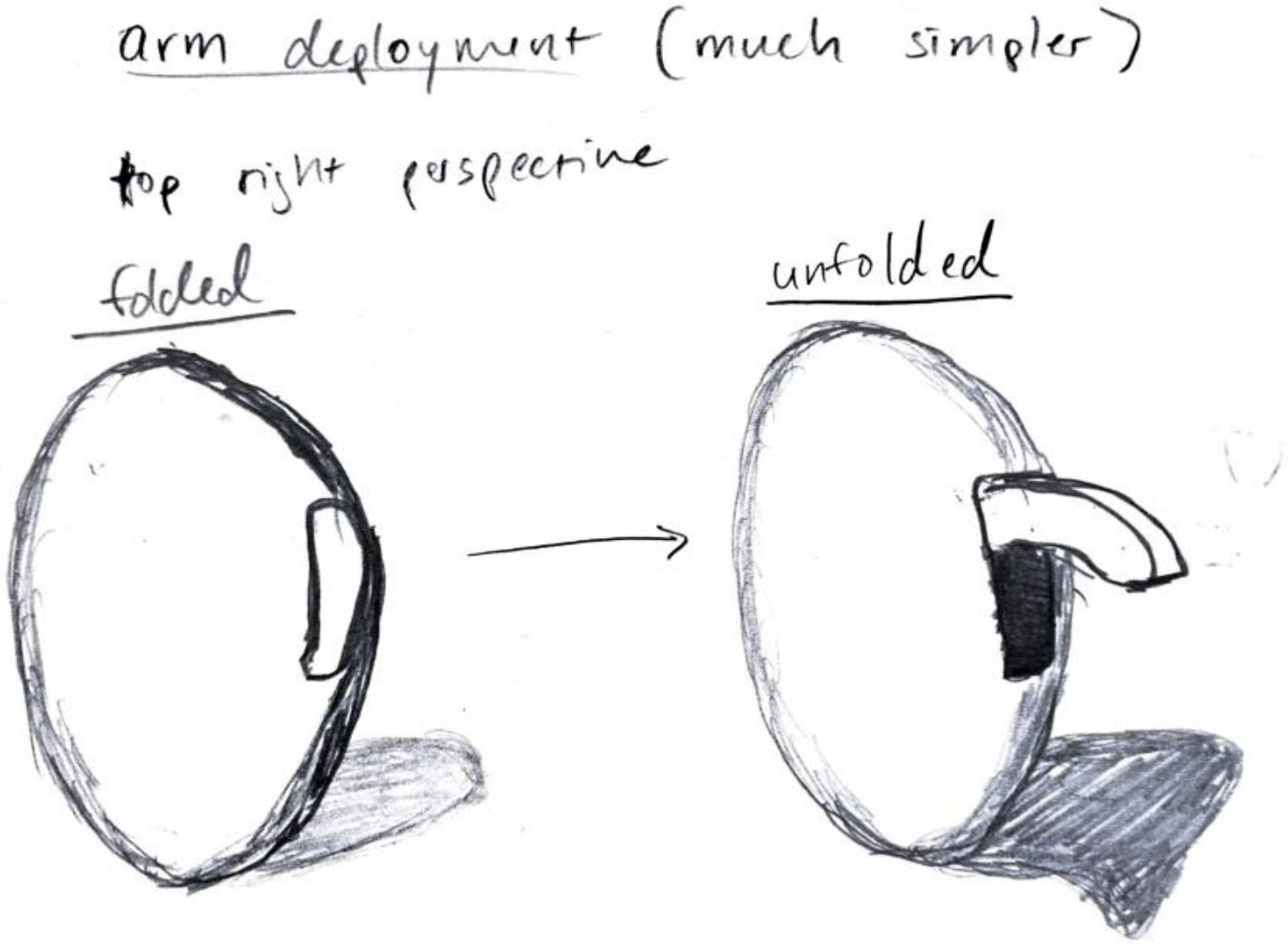
Concept 2


Folding Mechanism
side view
Pi, controller
front view
note: probably would not be self-righting / require manual orientation

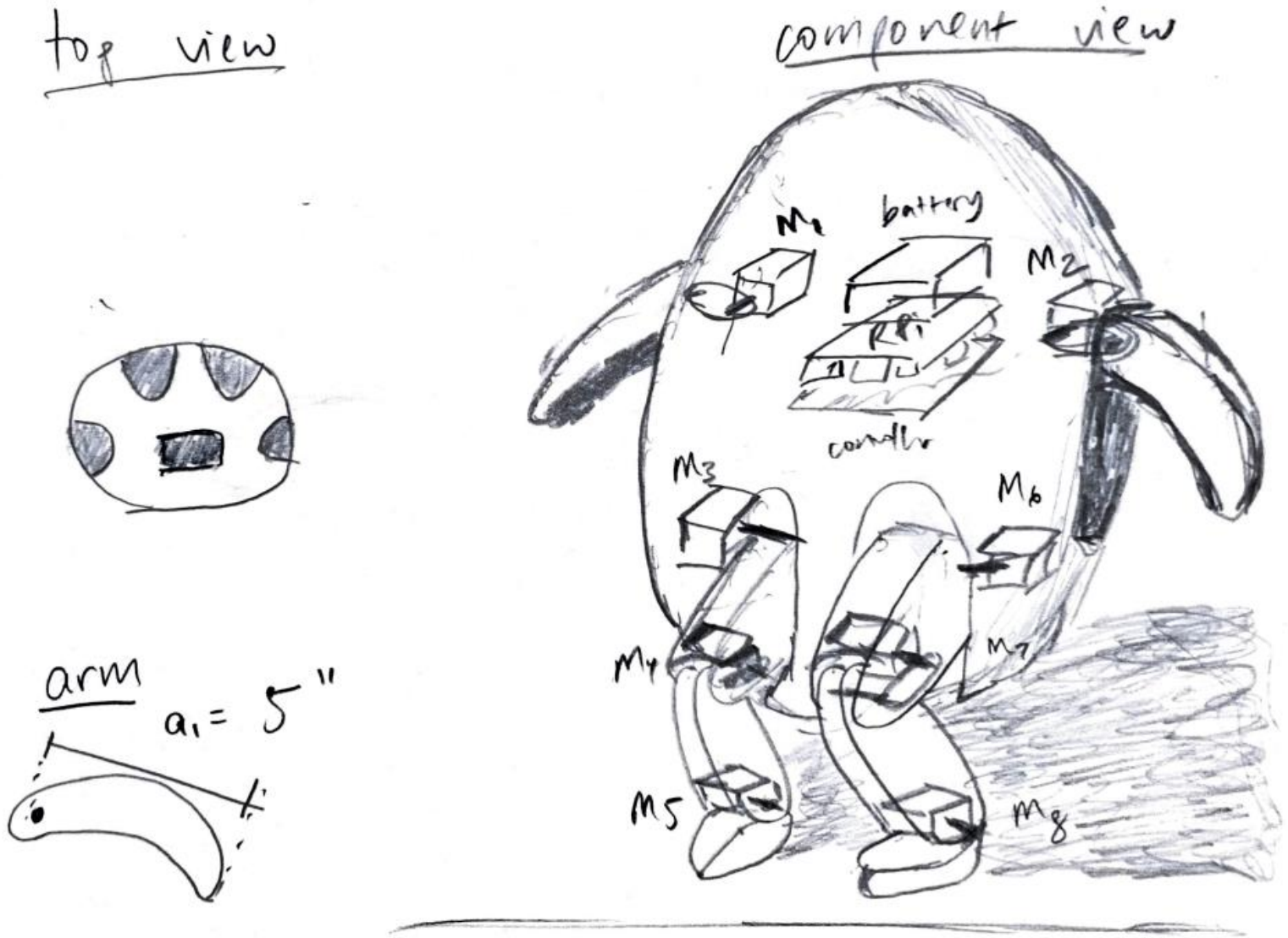
Concept 2


leg deployment
s_i = state i
, all angle values estimates
(side view)
s0
s1
s2
θ_1
θ_2
θ_3
l_1
l_2
l_3
l_{2s0}
l_{2s1}
l_{3s1}
folded config
enclosure escape
standing
$\theta_1 = 10°$
$\theta_2 = 20°$
$\theta_3 = 110°$
$\theta_{2s0} \rightarrow \theta_2 = 75°$
$\theta_3 = 110°$
$\theta = 40°$
$\theta_{2s1} \rightarrow \theta_2 = 270°$
$\theta_3 = 25°$

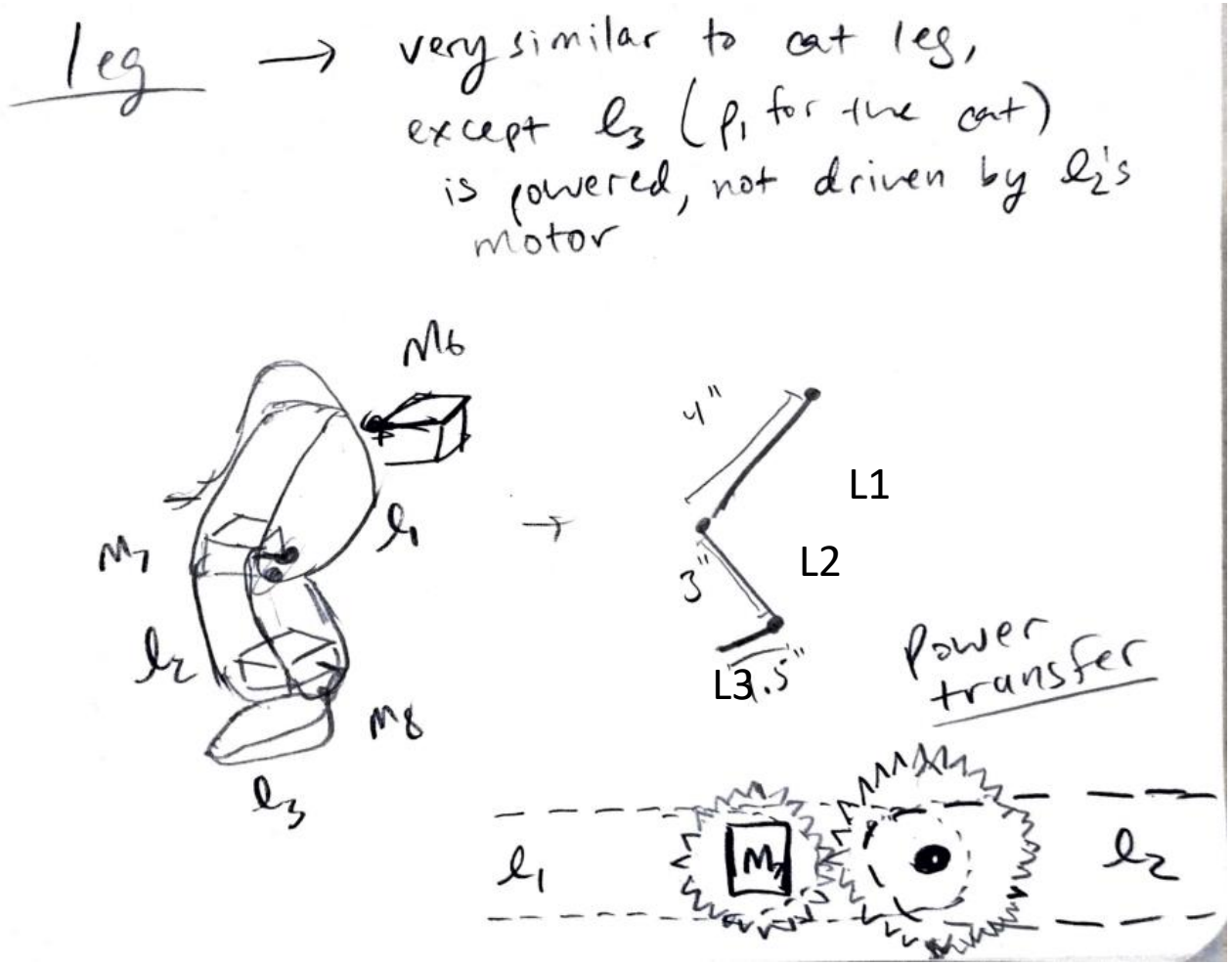
Concept 2


arm deployment (much simpler)
top right perspective
folded
unfolded

Concept 2



Concept 2 - Calculations



Robot weight = **~5 lbs**
Entire leg weight = ~10 oz. (0.5 lb)
L2 + L3 weight = ~6 oz. (0.25 lb)
L3 weight = ~2 oz.
Arm weight = ~3 oz.

Leg length = ~8.5" (0.708')
L2 + L3 length = ~4.5" (0.375')

Max ω (L1/L2/L3) = ~20 rpm (2.9 rad/s)
F_r = mv^2/r = 0.115, 0.037, 0.004 lbf (whole leg, L2+L3, L3)
F_g = ma (assumed holding force—just combatting gravity—of fully extended leg parallel to the ground)

$\tau = rF\sin(\vartheta)$
Max holding torque on motor 1: **0.443 ft-lb**
Max dynamic torque on motor 1: **0.521 ft-lb**
Max holding torque on motor 2: **0.141 ft-lb**
Max dynamic torque on motor 2: **0.154 ft-lb**
Max holding torque on motor 3: **0.016 ft-lb**
Max dynamic torque on motor 3**: 0.016 ft-lb**
Max holding torque on arm motor: **0.079 ft-lb**
Max dynamic torque on arm motor: **0.088 ft-lb**

$$P = \tau\omega$$

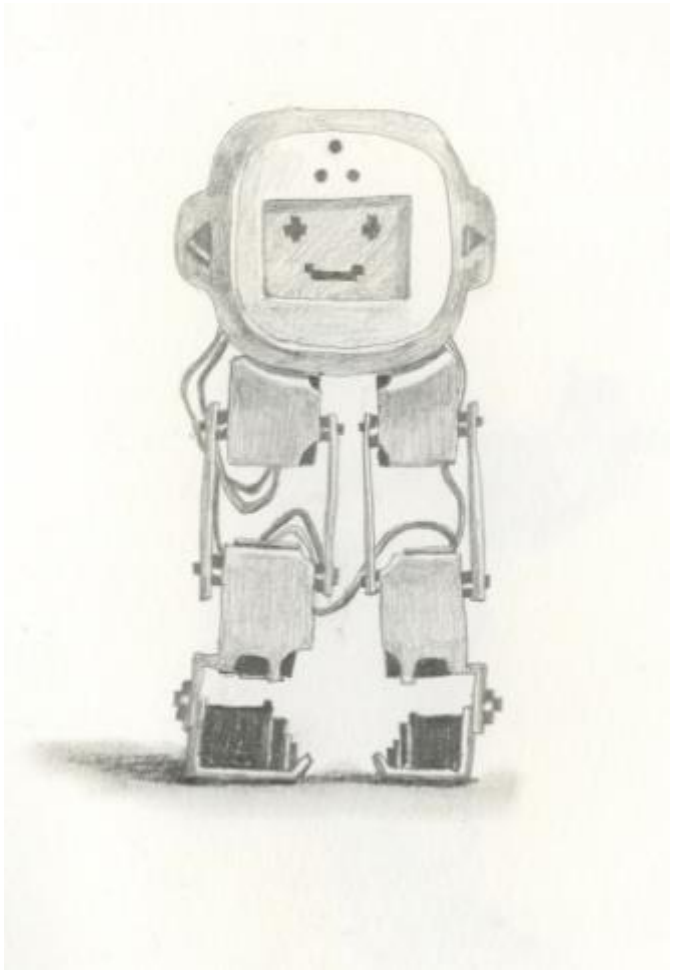
$$\tau = \frac{P}{\omega}$$

$$\omega = \frac{2\pi RPM}{60}$$

Max power draw from m1: **1.48 W**
Max power draw from m2: **0.44 W**
Max power draw from m3: **0.05 W**
Max power draw from arm motor: **0.12 W**
One side total: **2.09 W**
Both sides: **4.18 W**

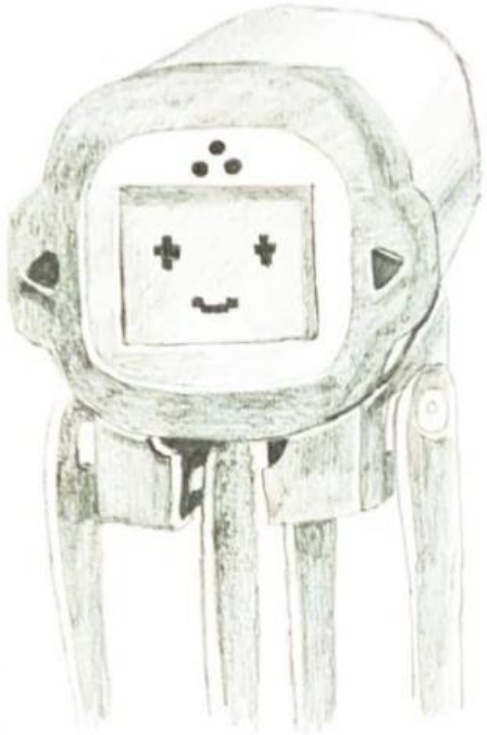
All motors are well within the individual 6W power envelope, and the robot is well within the 30 W battery power envelope.

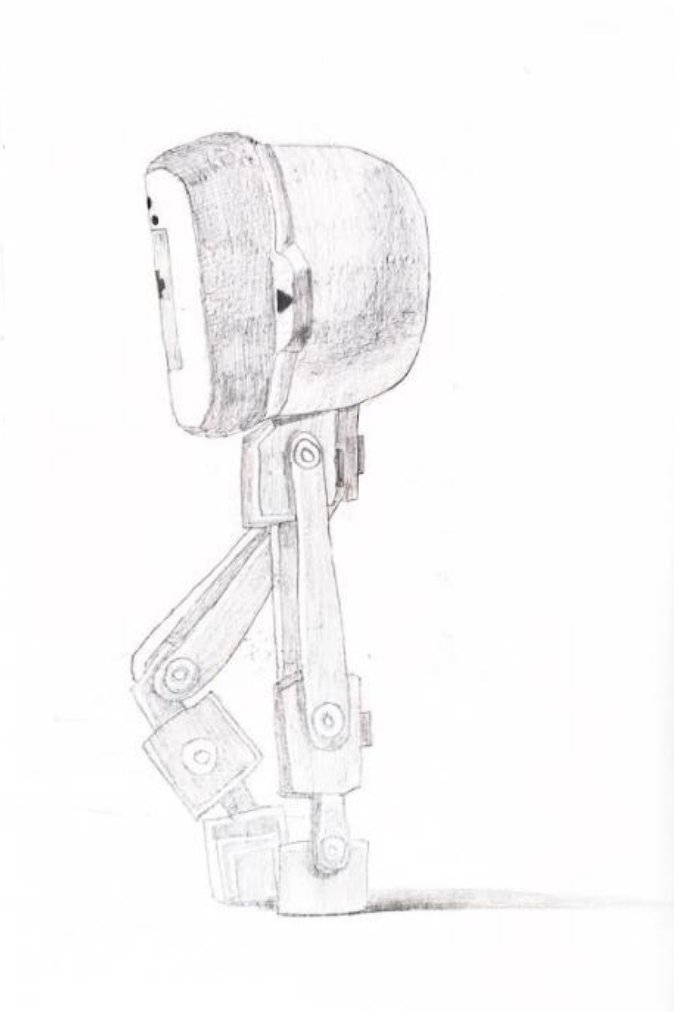
Concept 3 – Tamagotchi

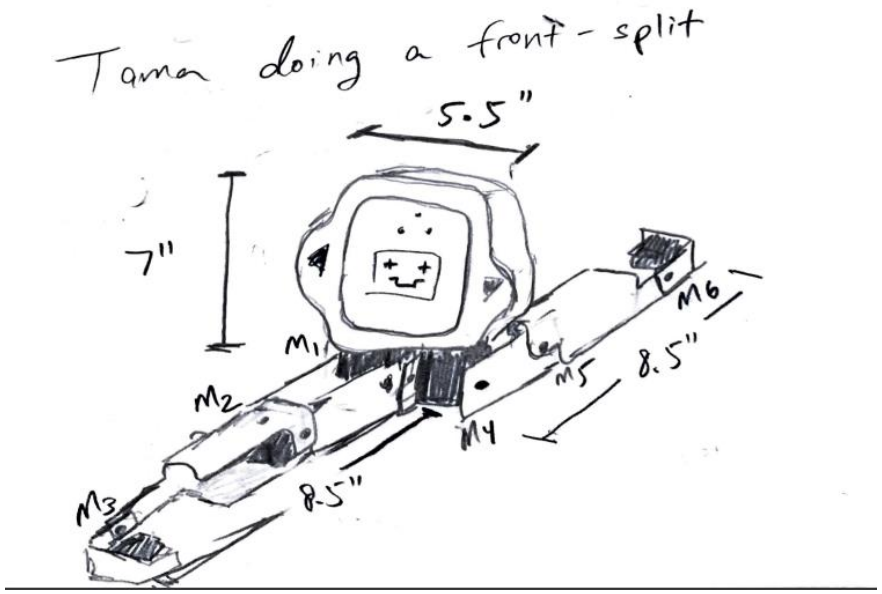


You can tell when Mimi joined the team…

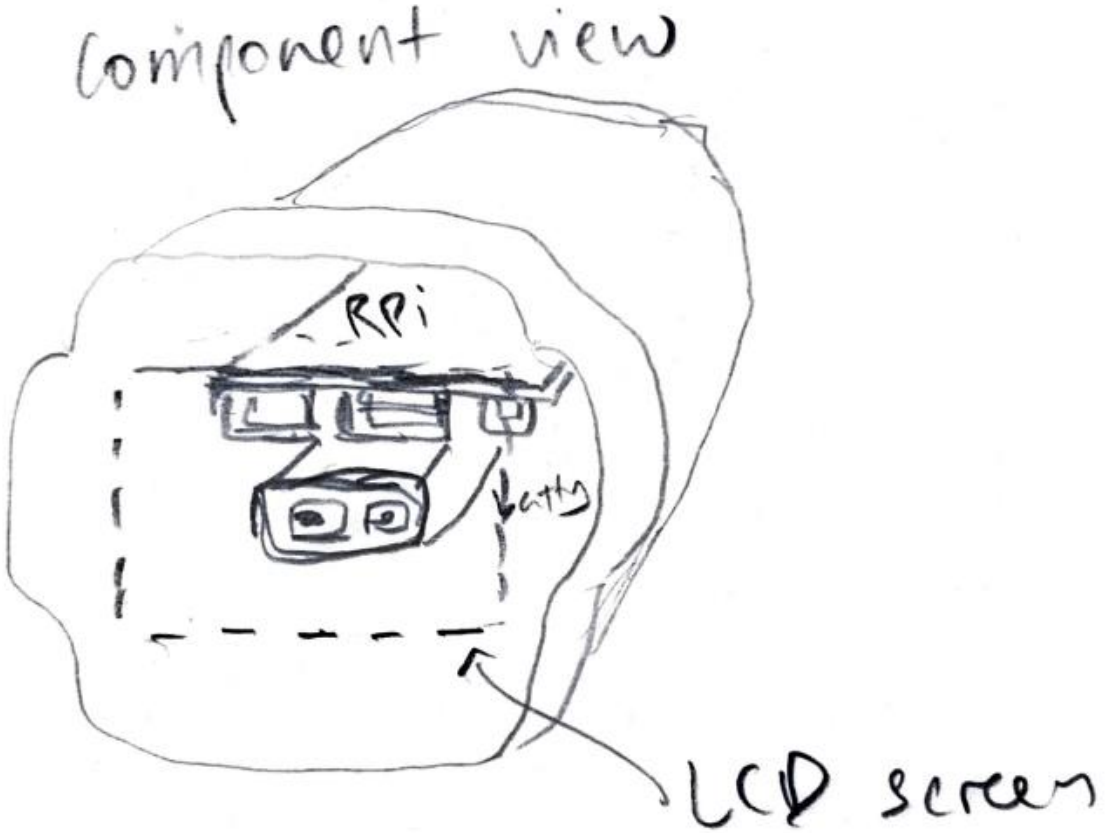
Concept 3 – Alternate views





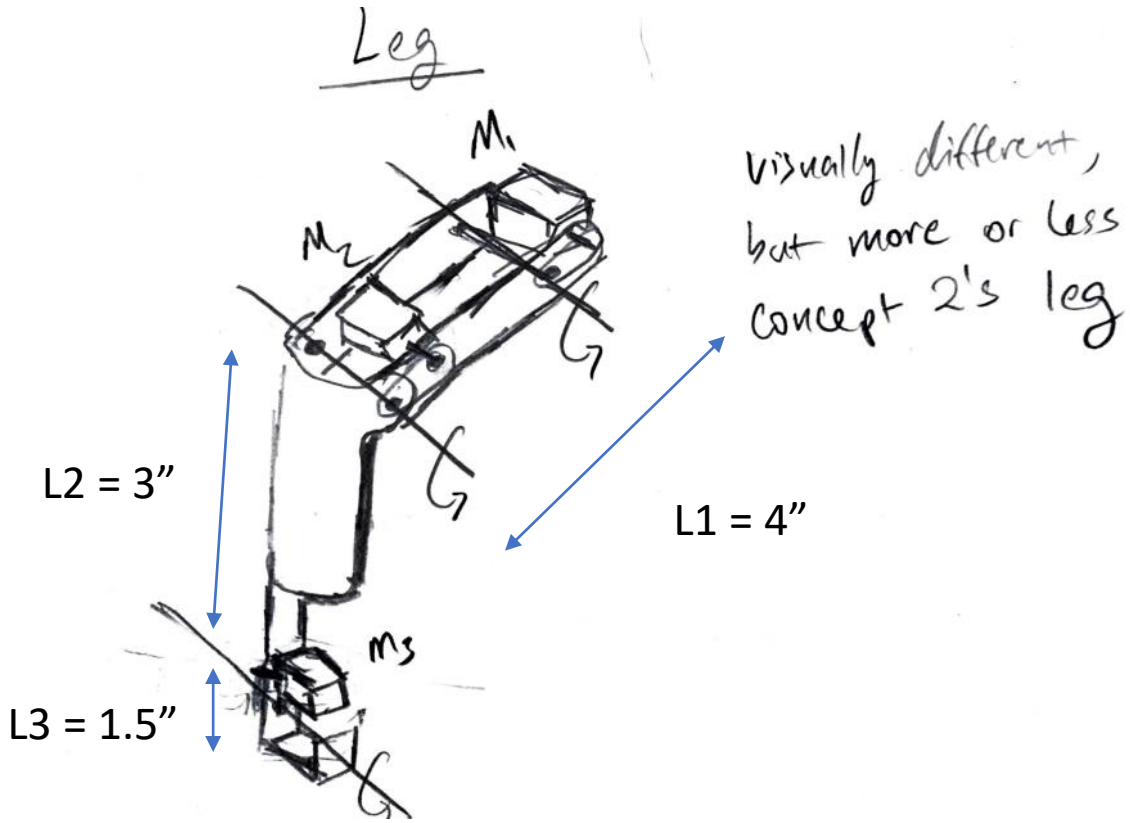


Concept 3 – Alternate views



Concept 3

Copying over from concept 2 because the legs are mechanically similar—these rough calculations apply approximately well to both concepts.



Robot weight = **~4 lbs**
Entire leg weight = ~10 oz. (0.5 lb)
L2 + L3 weight = ~6 oz. (0.25 lb)
L3 weight = ~2 oz.

Leg length = ~8.5” (0.708’)
L2 + L3 length = ~4.5” (0.375’)

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Max dynamic torque on motor 2: **0.154 ft-lb**
Max holding torque on motor 3: **0.016 ft-lb**
Max dynamic torque on motor 3**: 0.016 ft-lb**

$$P = \tau\omega$$

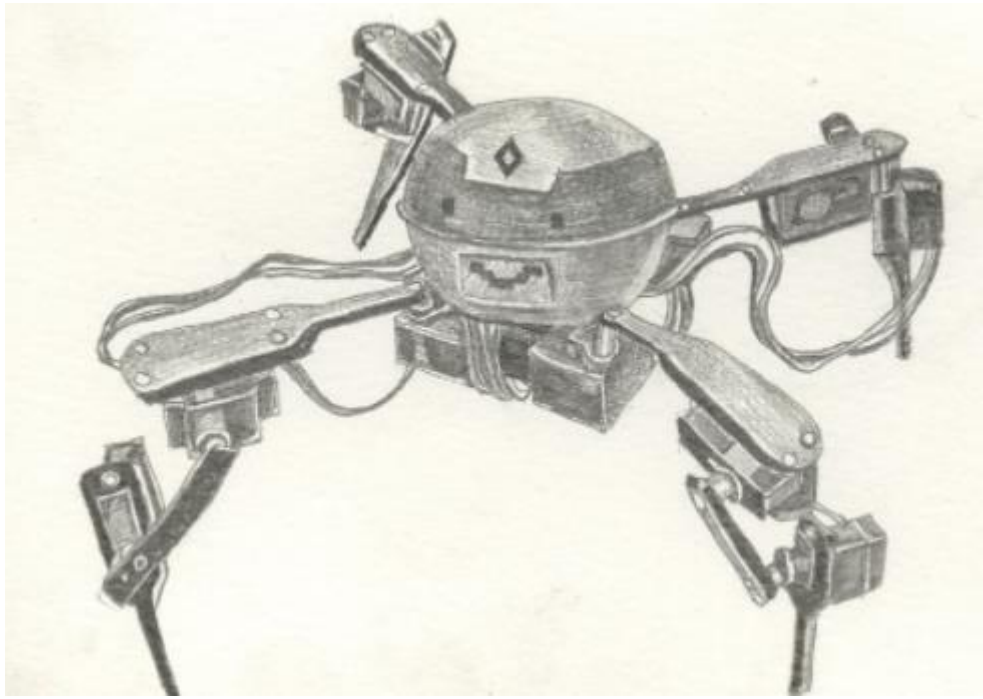
$$\tau = \frac{P}{\omega}$$

$$\omega = \frac{2\pi RPM}{60}$$

Max power draw from m1: **1.48 W**
Max power draw from m2: **0.44 W**
Max power draw from m3: **0.05 W**
One side total: **1.97 W**
Both sides: **3.94 W**

All motors are well within the individual 6W power envelope, and the robot is well within the 30 W battery power envelope.

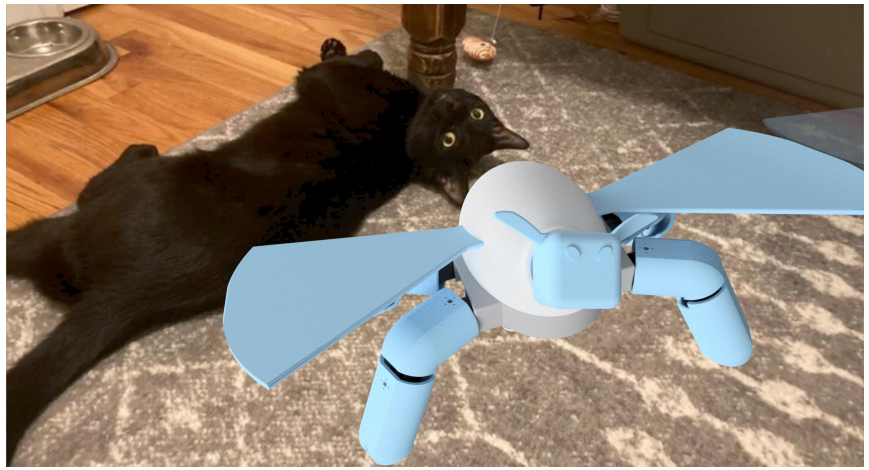
Concept 3 - Alternates



References

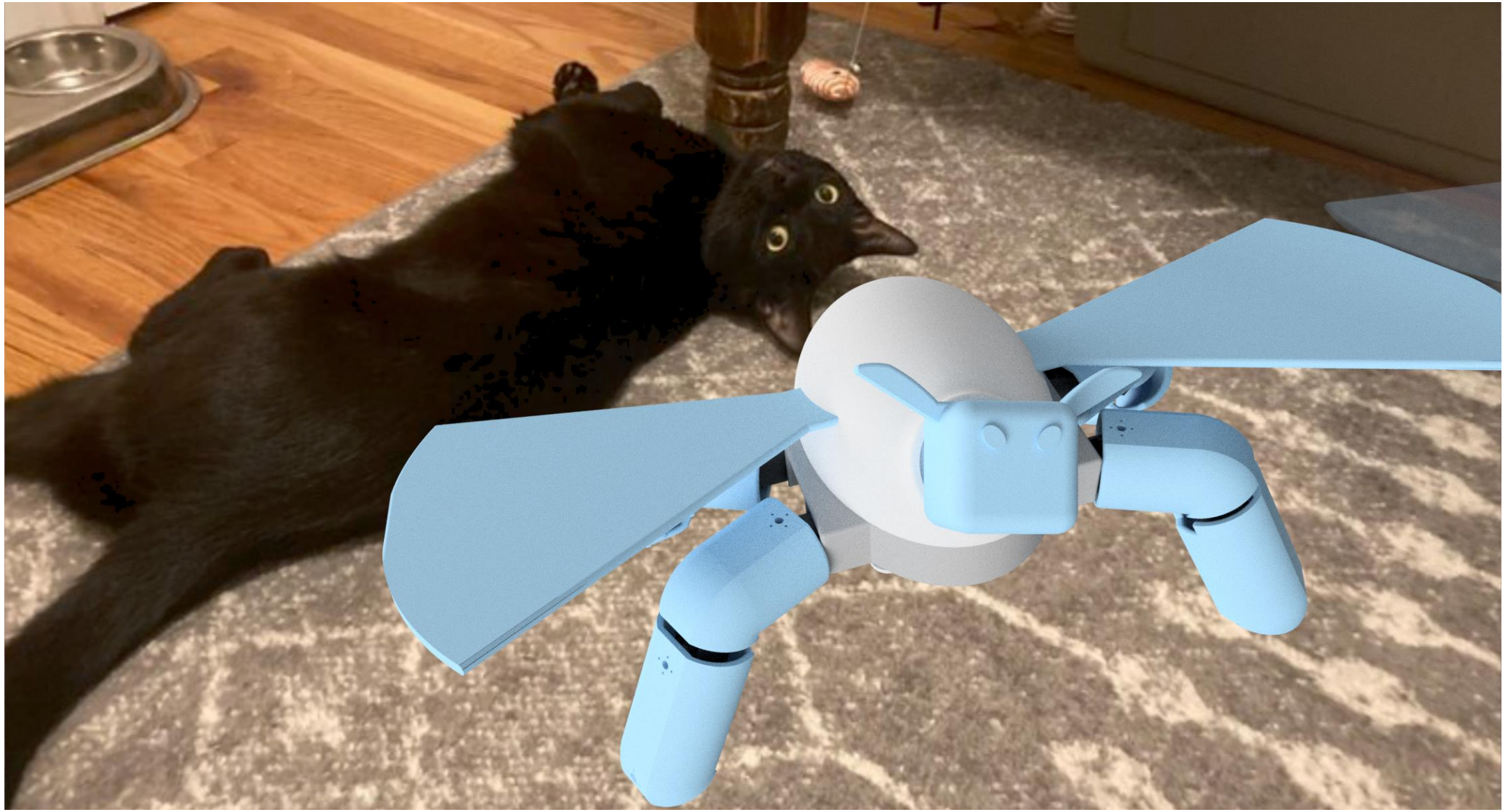
R. Chaichaowarat, D. F. P. Granados, J. Kinugawa and K. Kosuge, "Passive knee exoskeleton using torsion spring for cycling assistance," *2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2017, pp. 3069-3074, doi: 10.1109/IROS.2017.8206146.

Robotics Studio MECE 4611
Fall 2021, Assignment 2

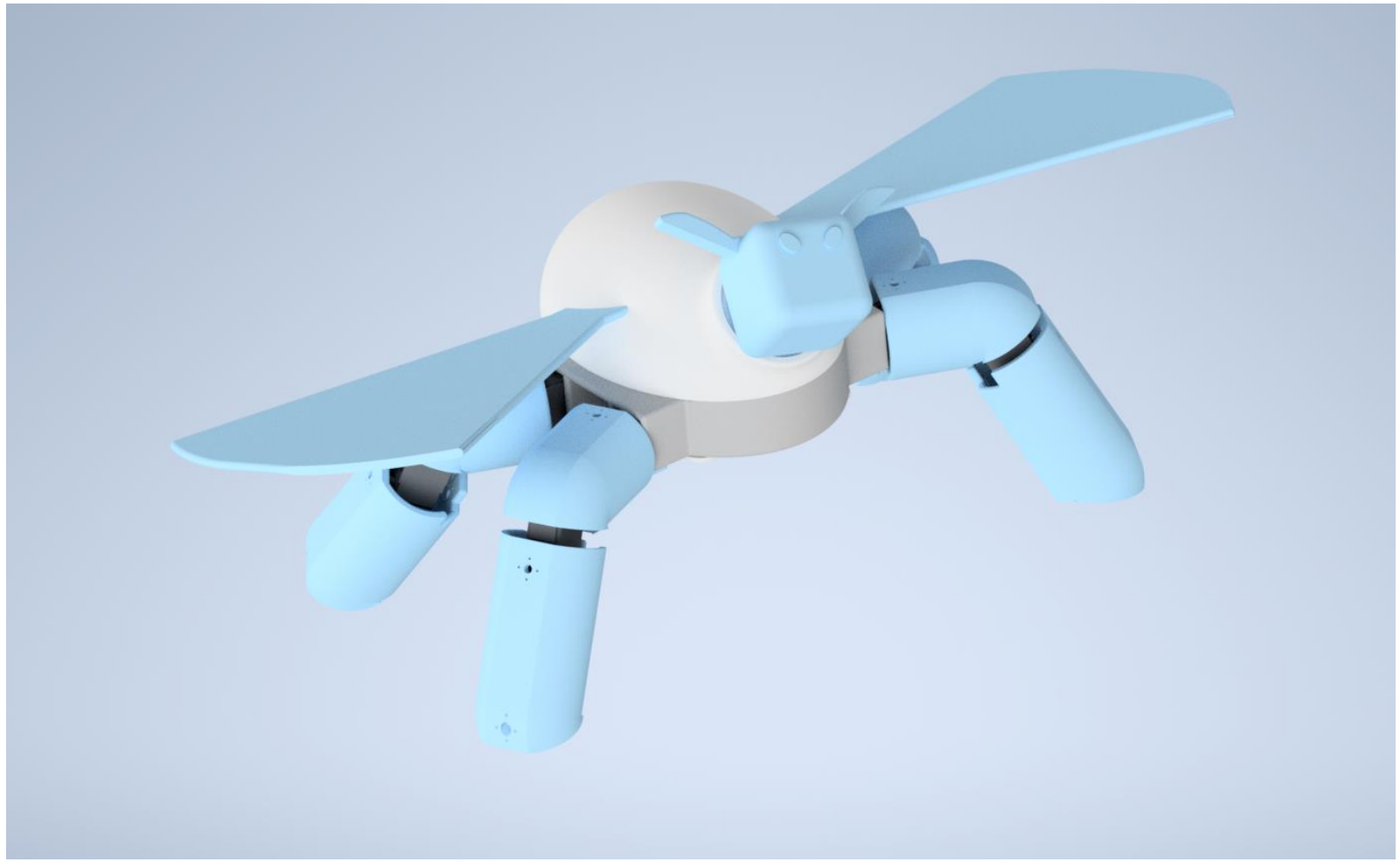


William Xie, Mimi Park
wx2214, mp3942
Submission Date: 9/28/2021,
Robot Name: Poodle Moth
Grace Hours Used: 3
Grace Hours Remaining: 94

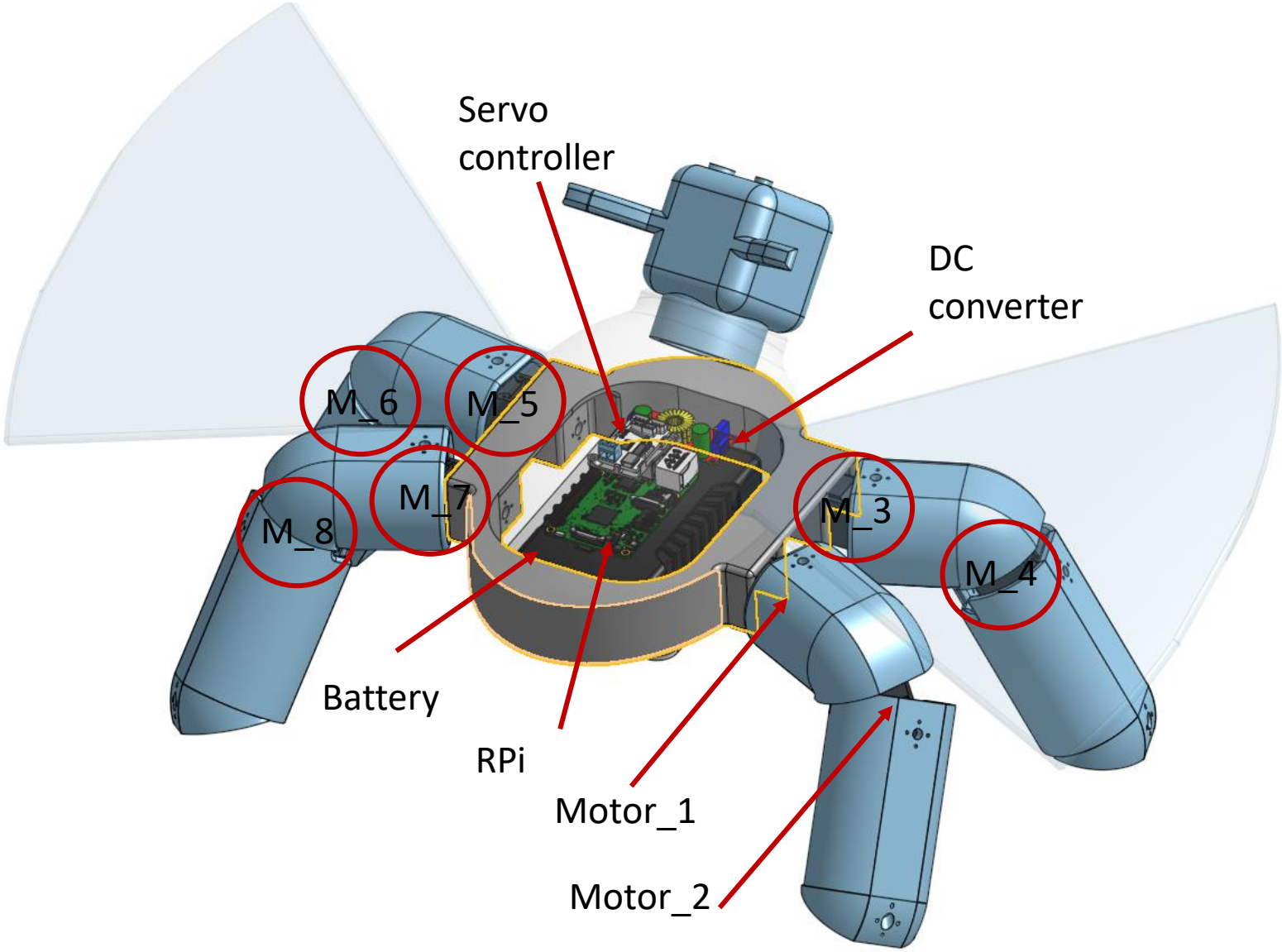
Poodle Moth Perspective and Context Render



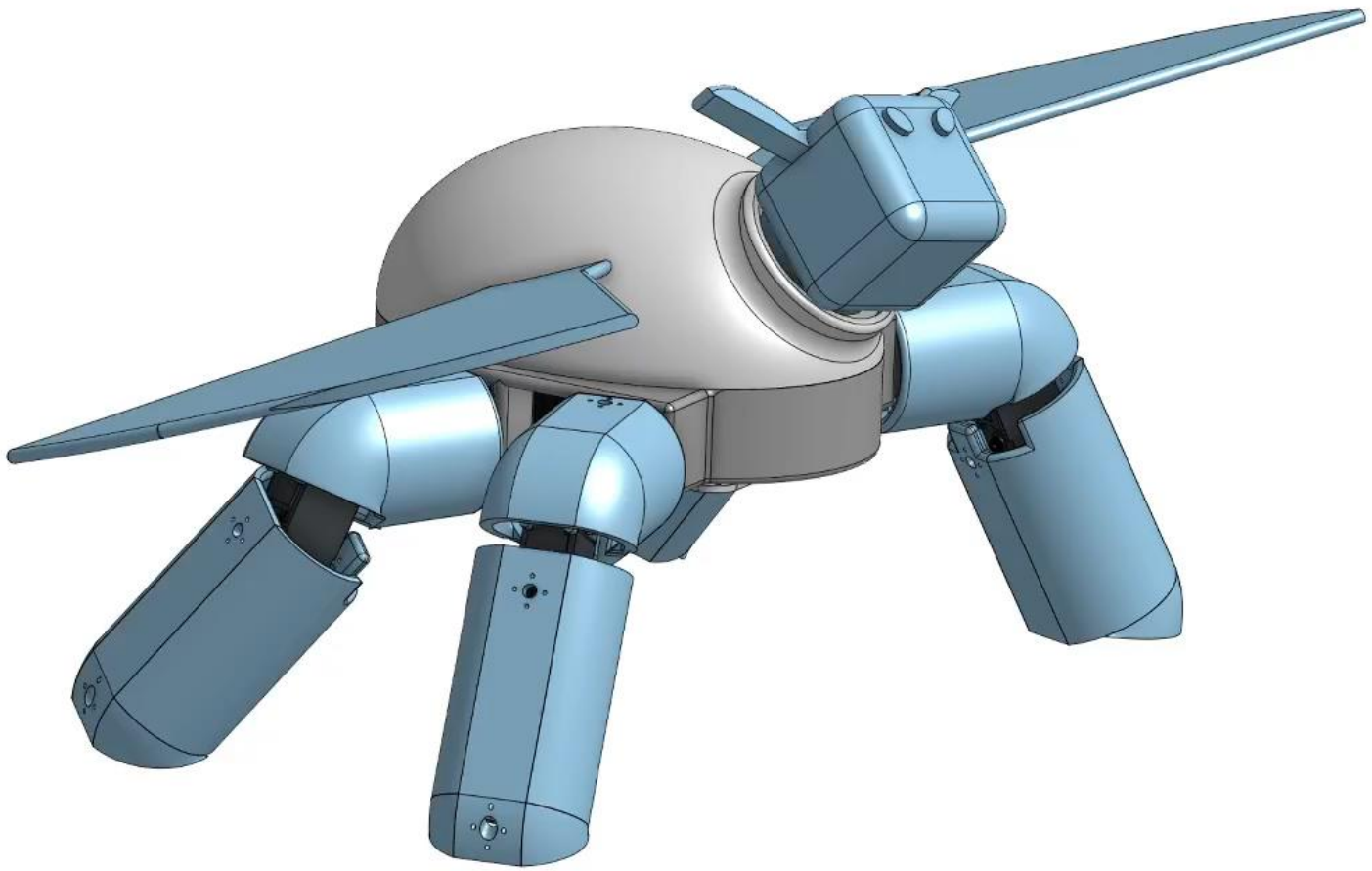
Poodle Moth Render



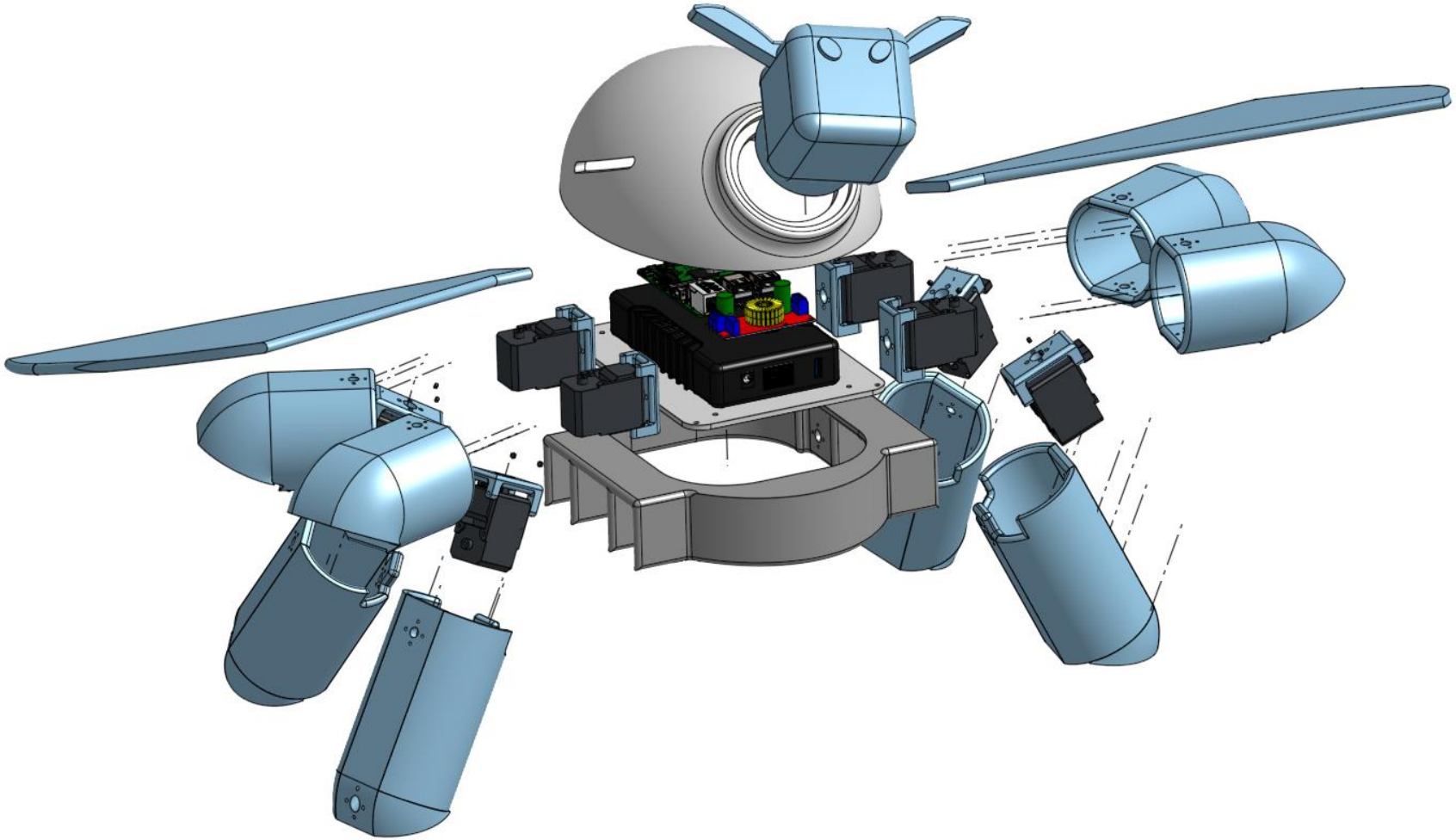
Poodle Moth Key Components



Poodle Moth Model Joint Animation



Poodle Moth Exploded View



Poodle Moth Key Specs

Mass properties

Instances to measure: base_with_legs

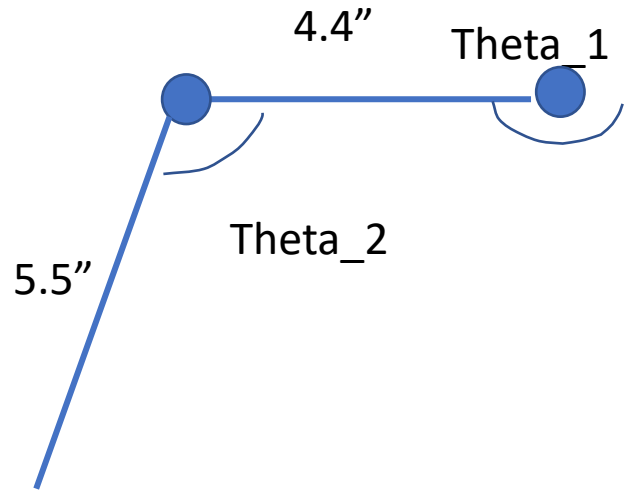
Mate connector for reference frame

Show calculation variance

Mass	Override	7.429 lb
Volume		328.122 in³
Surface area		1968.161 in²
Center of mass	Override	
X ↘		-1.102 in
Y ↗		6.415 in
Z ↑		-3.576 in

Mass moments of inertia (in² lb) Override

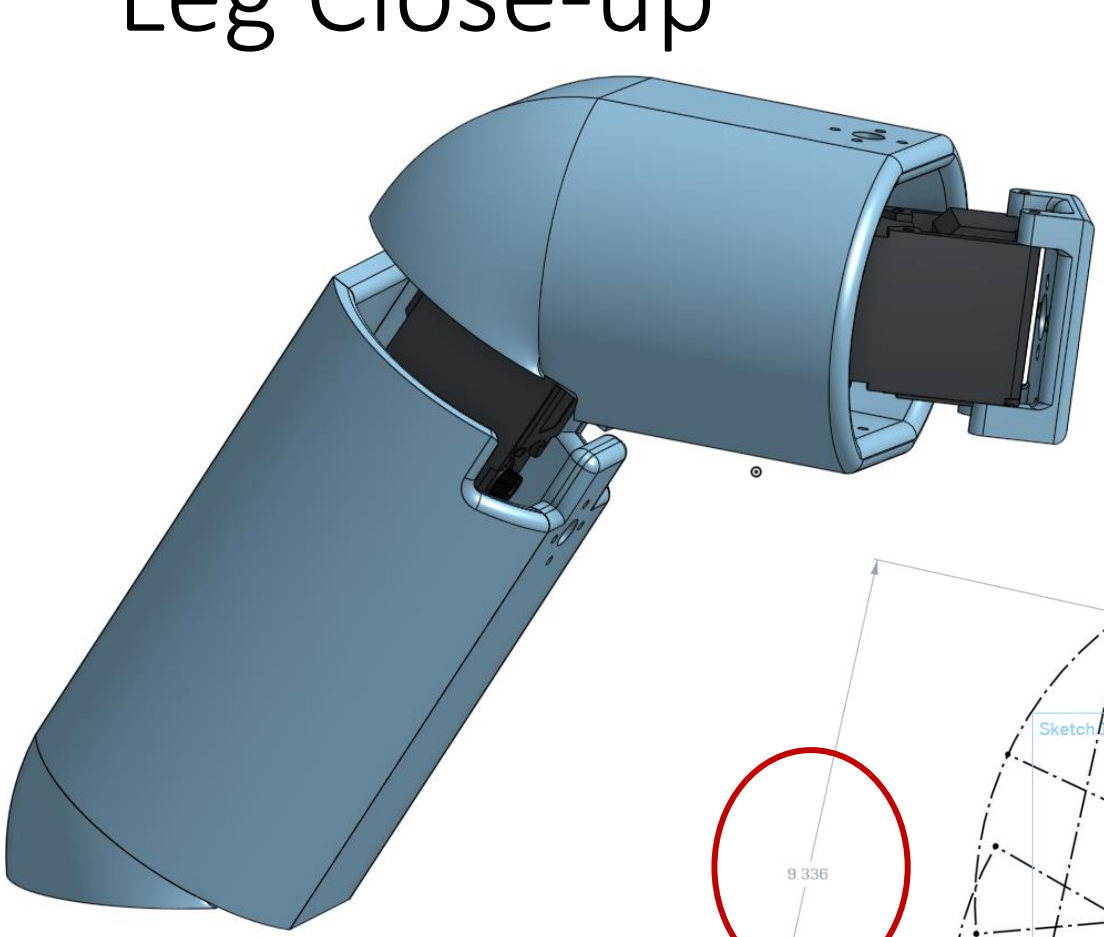
Lxx	441.437	Lxy	3.539	Lxz	9.663
Lyx	3.539	Lyy	108.356	Lyz	-0.11
Lzx	9.663	Lzy	-0.11	Lzz	458.363

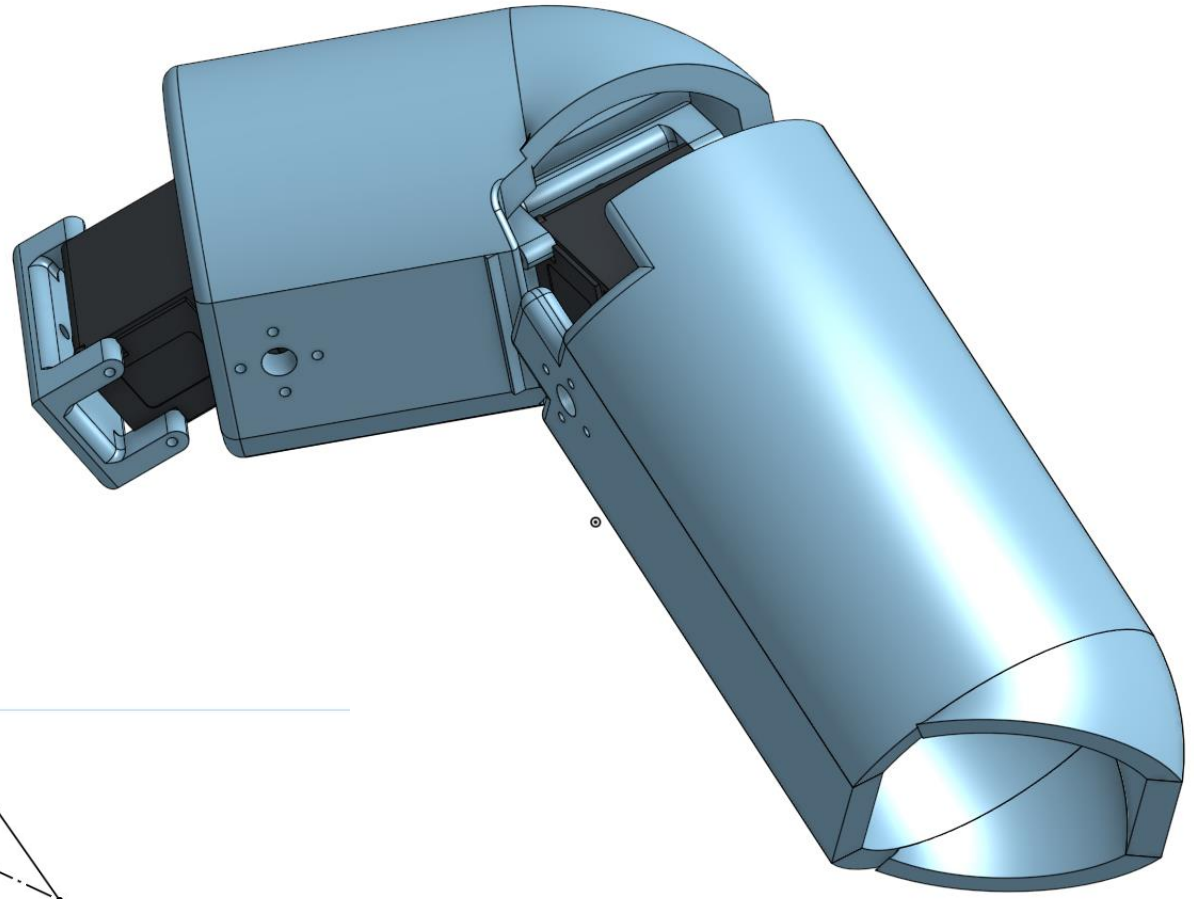


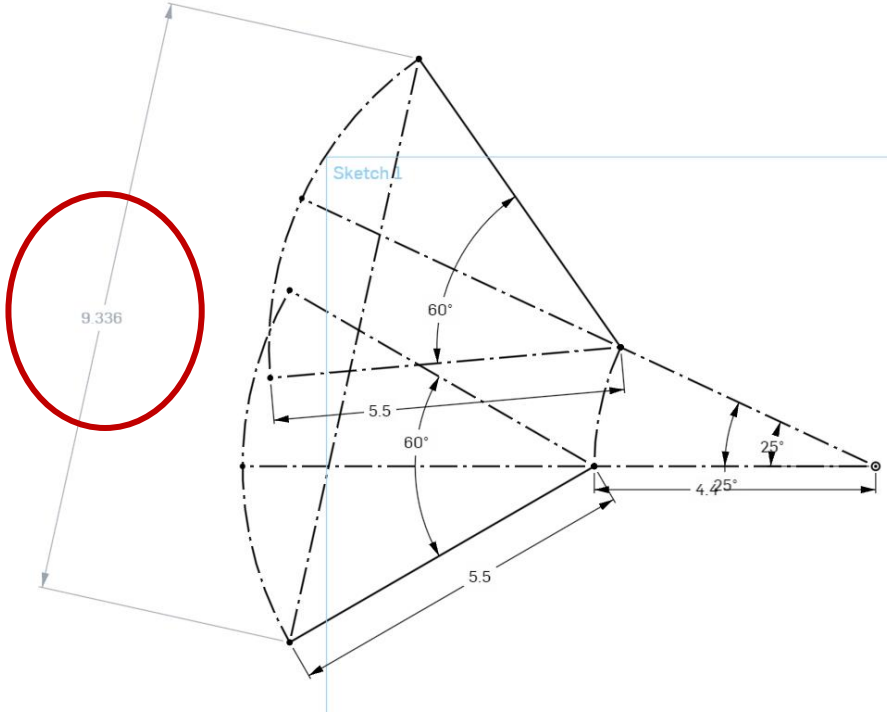
Theta_1: 155 deg < theta < 205 deg
Theta_2: 150 deg < theta < 210 deg

Max angular vel: 20 rpm
Max stride length: 9.4” (see next slide)
Expected stride length: ~3”
Motor rotation for stride: 60 deg
Strides/minute: 120
Walking speed: 3” / s

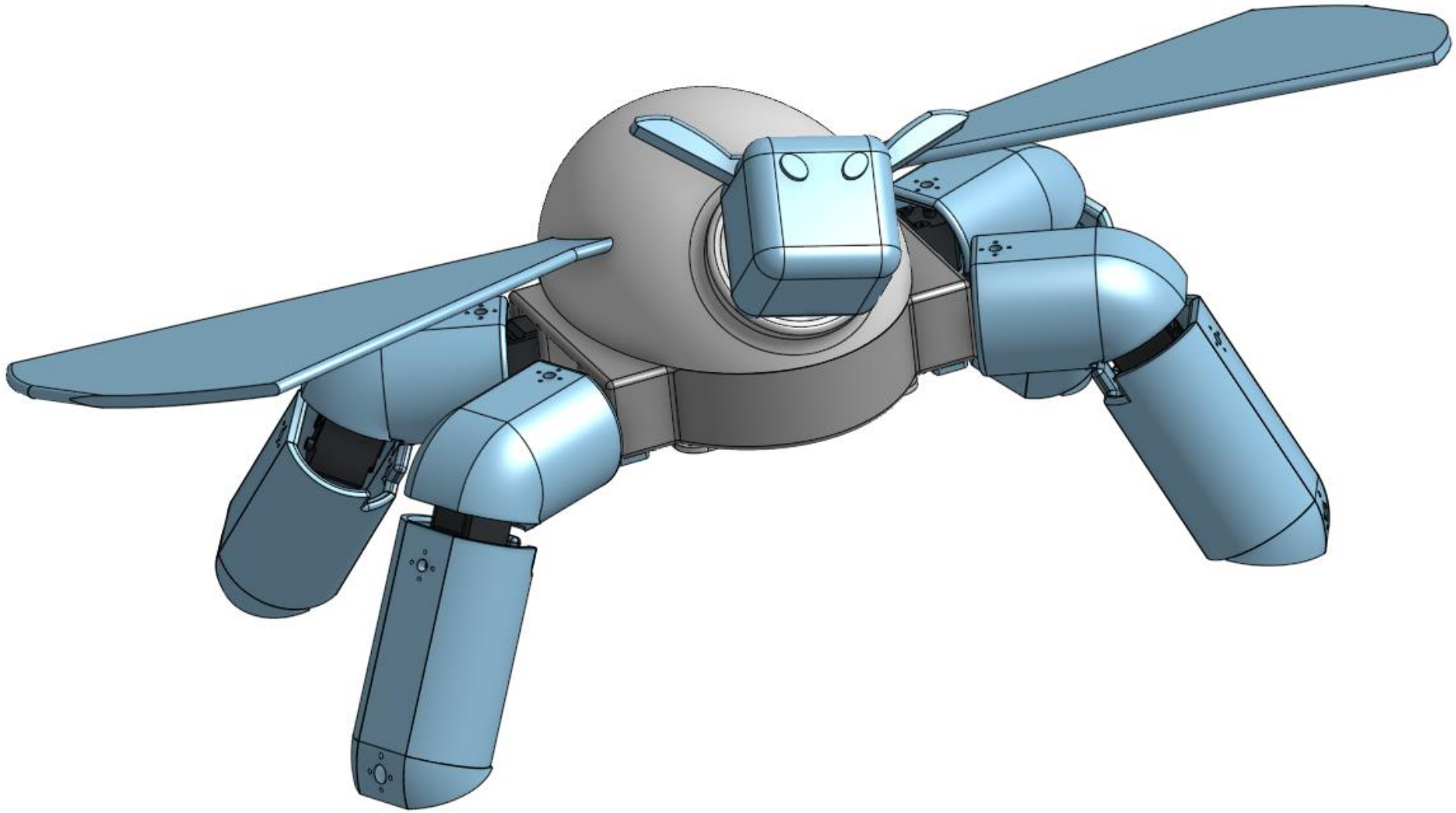
Leg Close-up



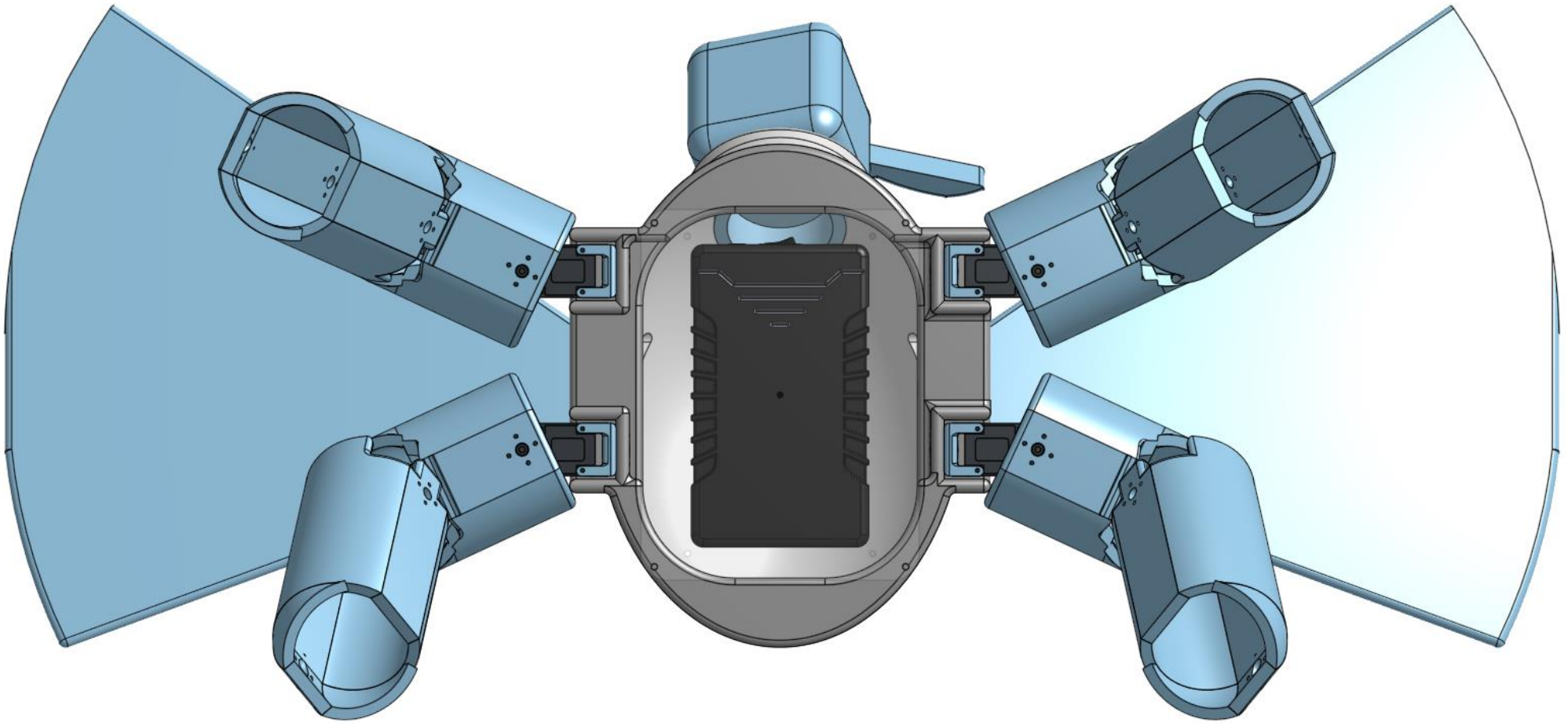




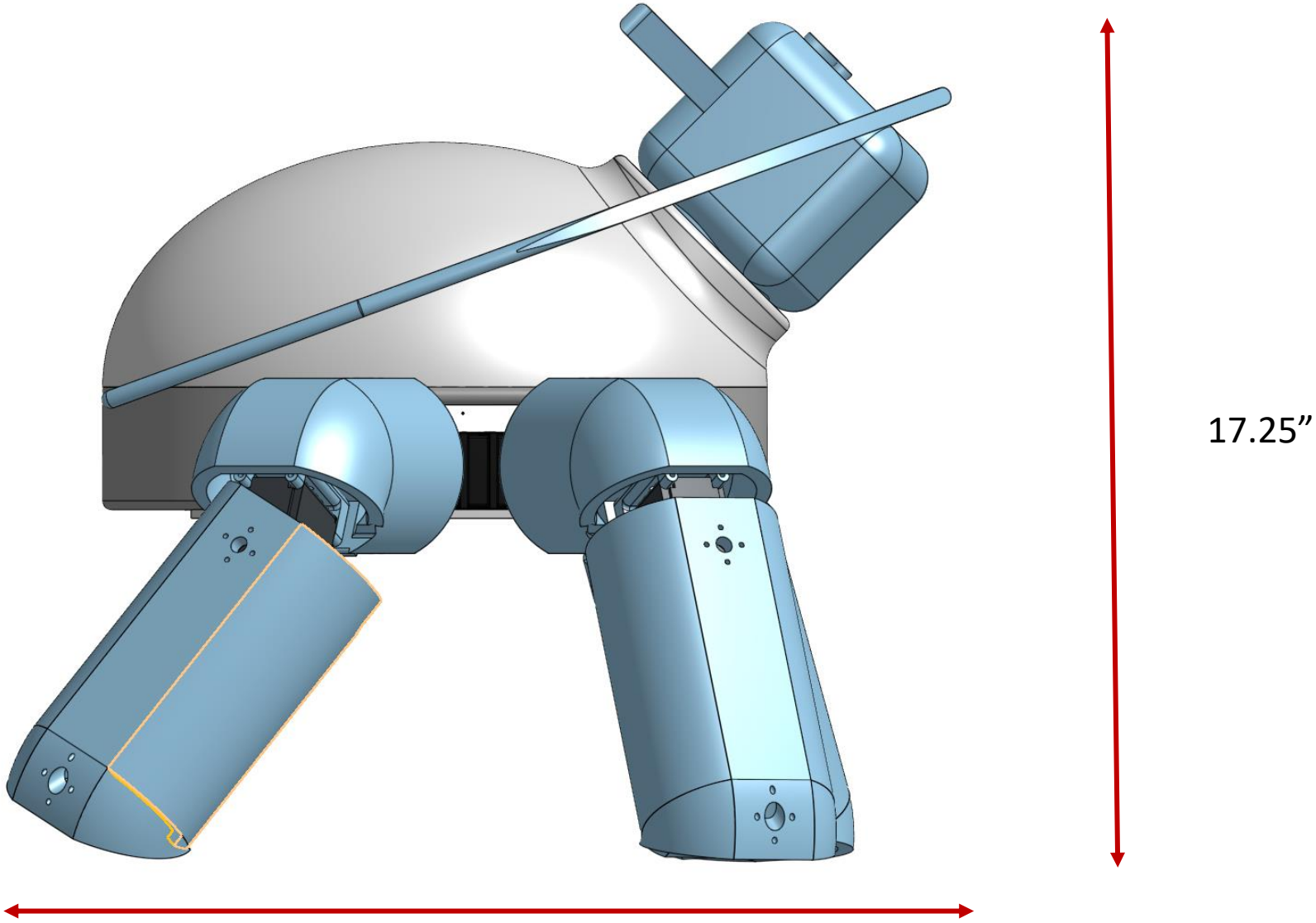
Poodle Moth Front View



Poodle Moth Bottom View

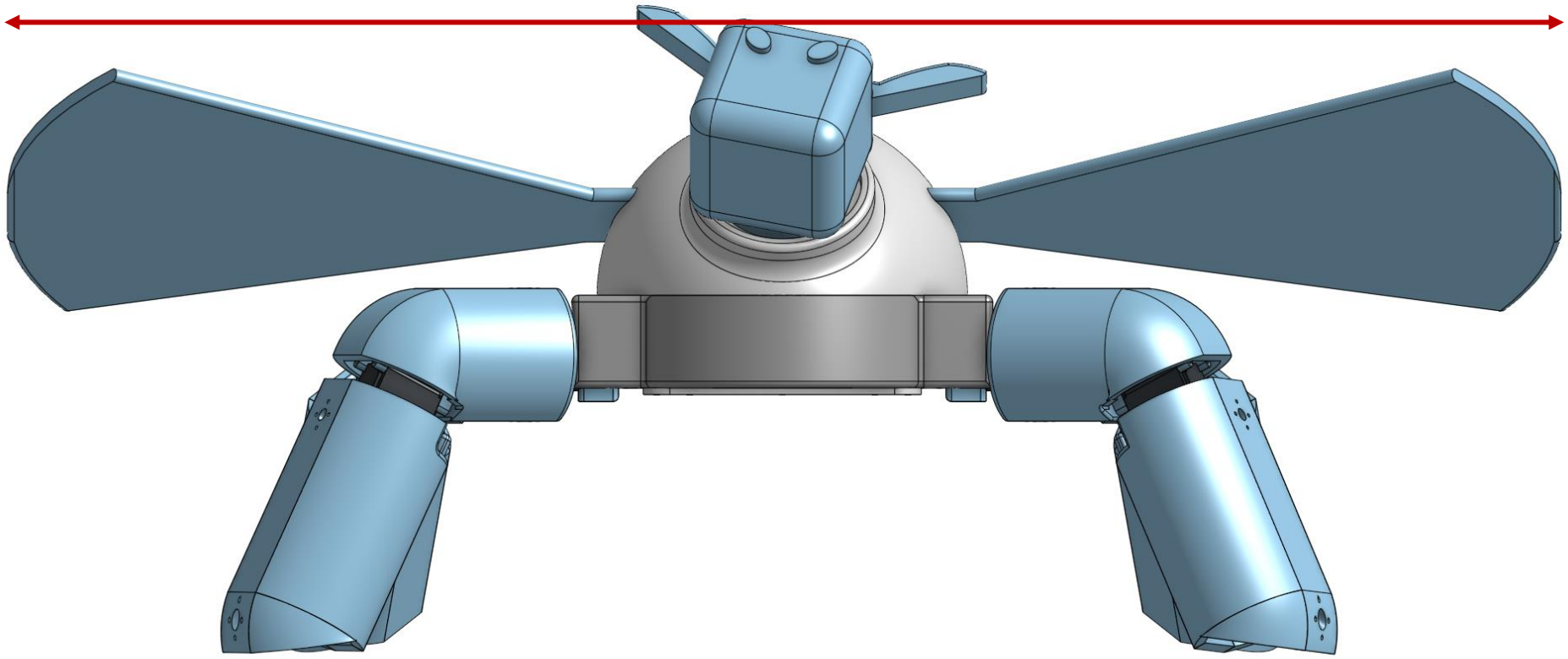


Side View with Dimensions



Side View with Dimensions

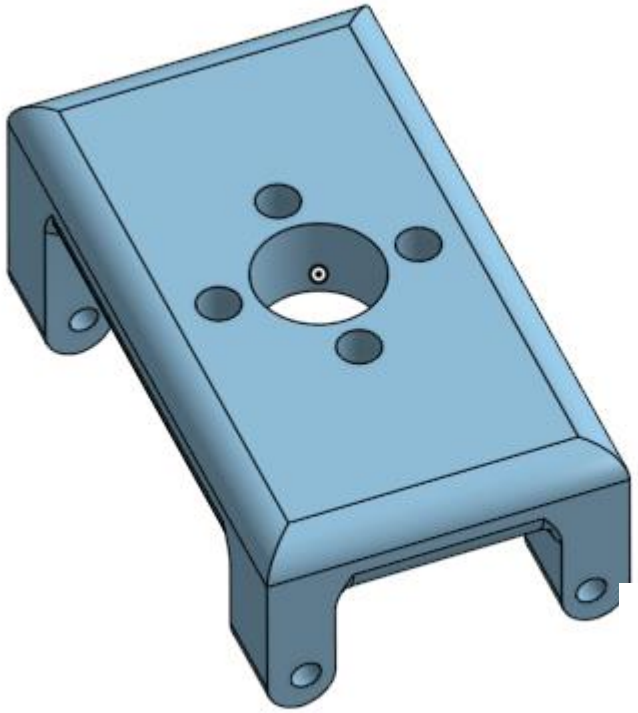
30.5”

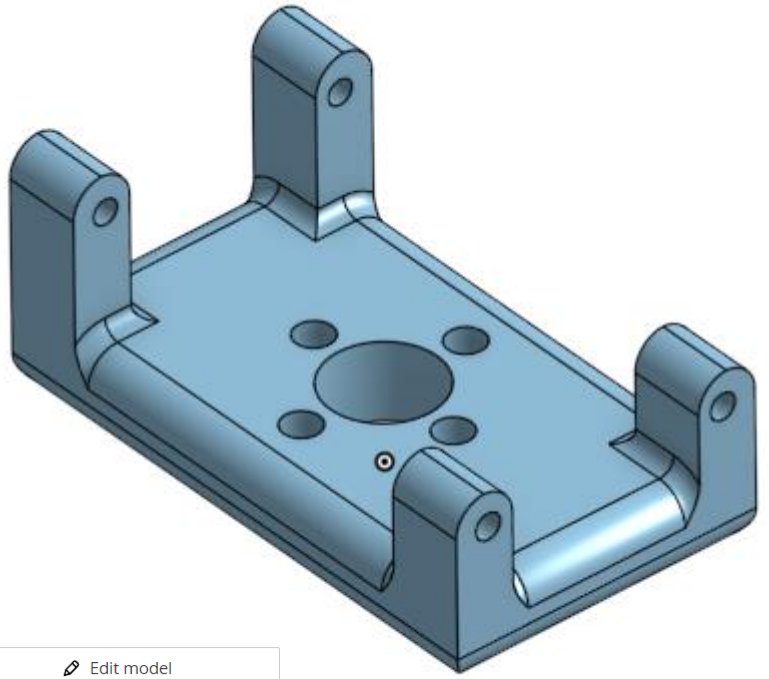


21”

GrabCAD component: LX16A bottom bracket

- https://grabcad.com/library/lx16a_servo_bottom_bracket-1





lx16a_servo_bottom_bracket

william xie
September 29th, 2021

3d printable version of the lewansoul lx16a servo bottom bracket.

Files (1)

lx16a_servo_bottom_bracket /		
lx16a_servo_bottom_bracket.step	step	September 29th, 2021

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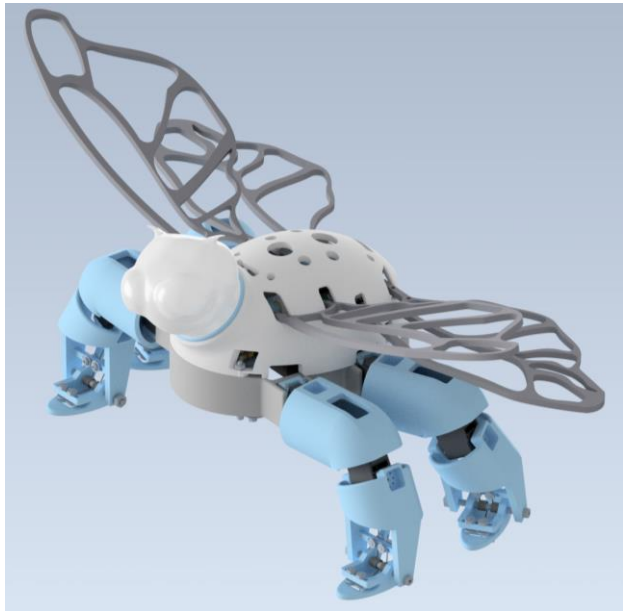
Details

Uploaded: September 29th, 2021

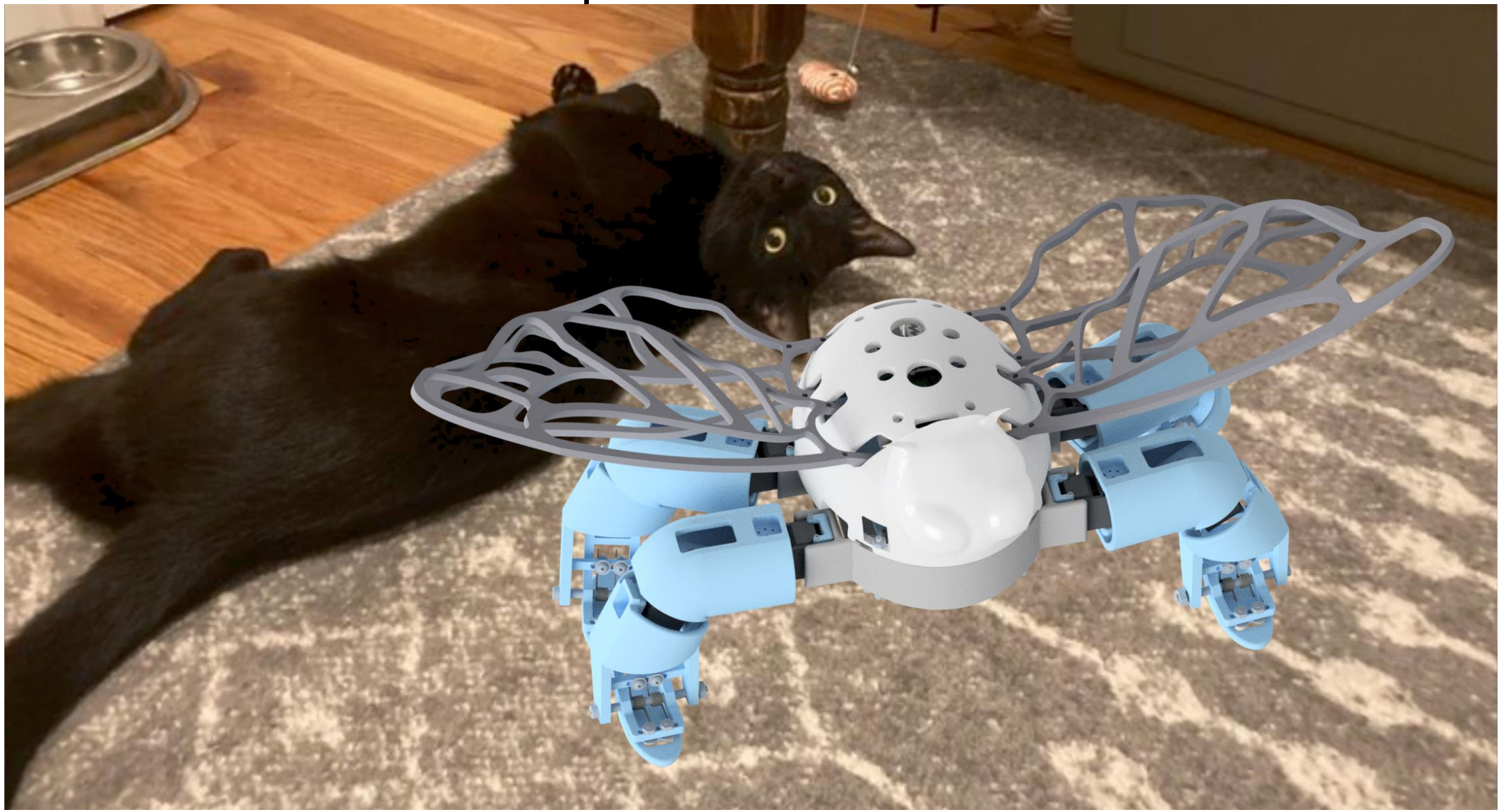
Robotics Studio MECE 4611
Fall 2021, Assignment 3

William Xie, Mimi Park
wx2214, mp3942
Submission Date: 10/13/2021,
Robot Name: Poodle Moth
Grace Hours Used: 1
Grace Hours Remaining: 93

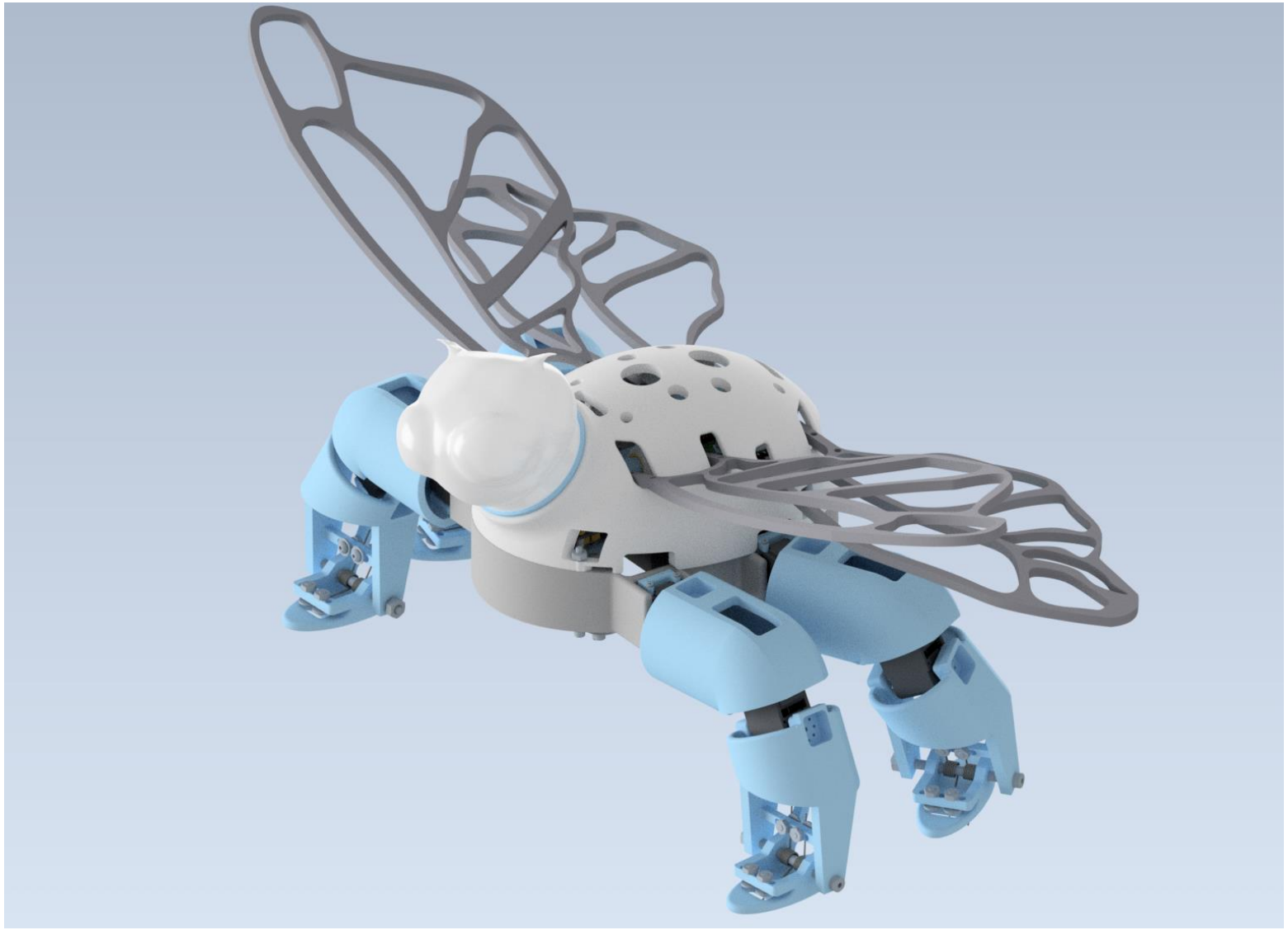


Brush Drawing – Post Manufacturing Detailing

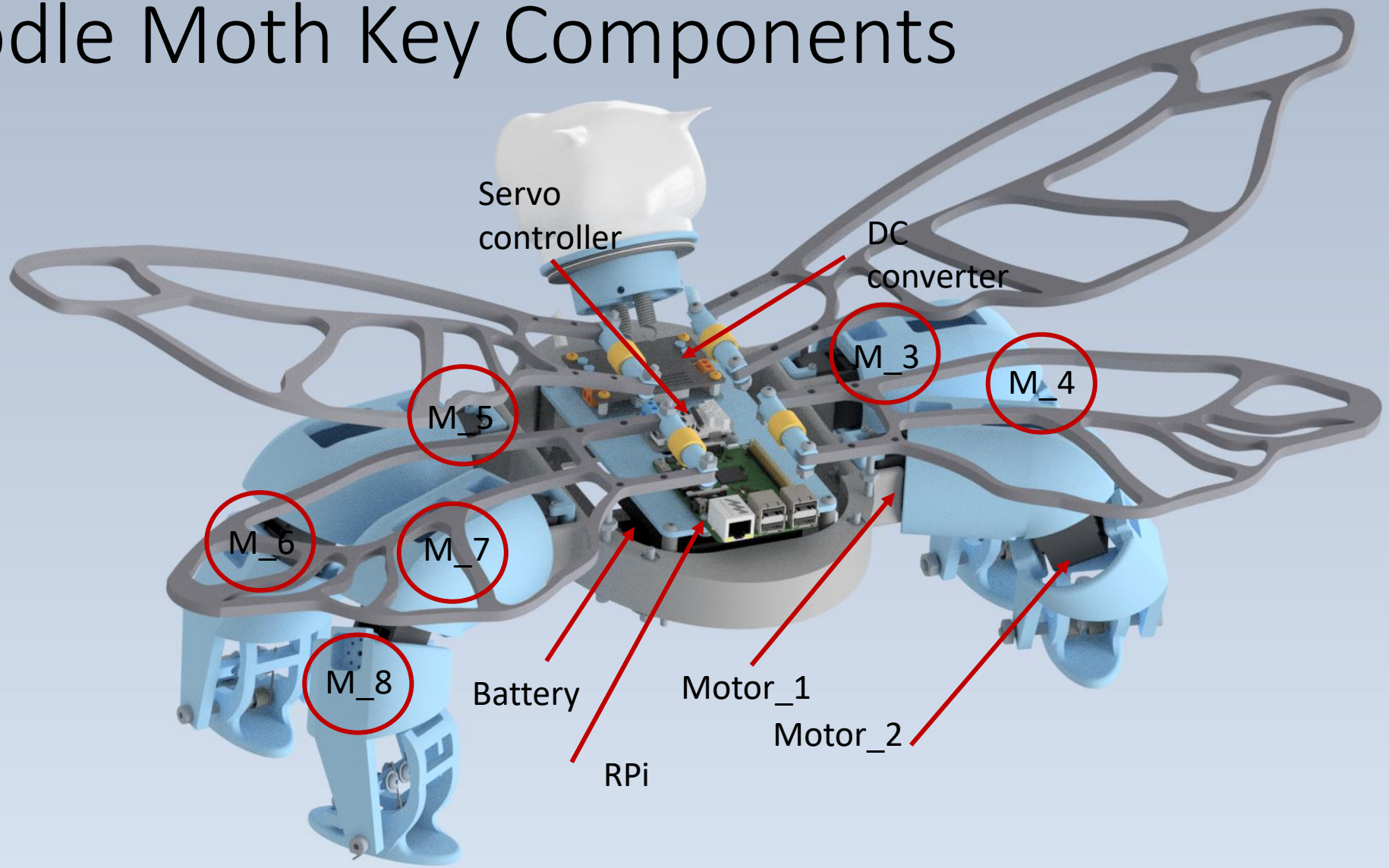
Poodle Moth Perspective and Context Render



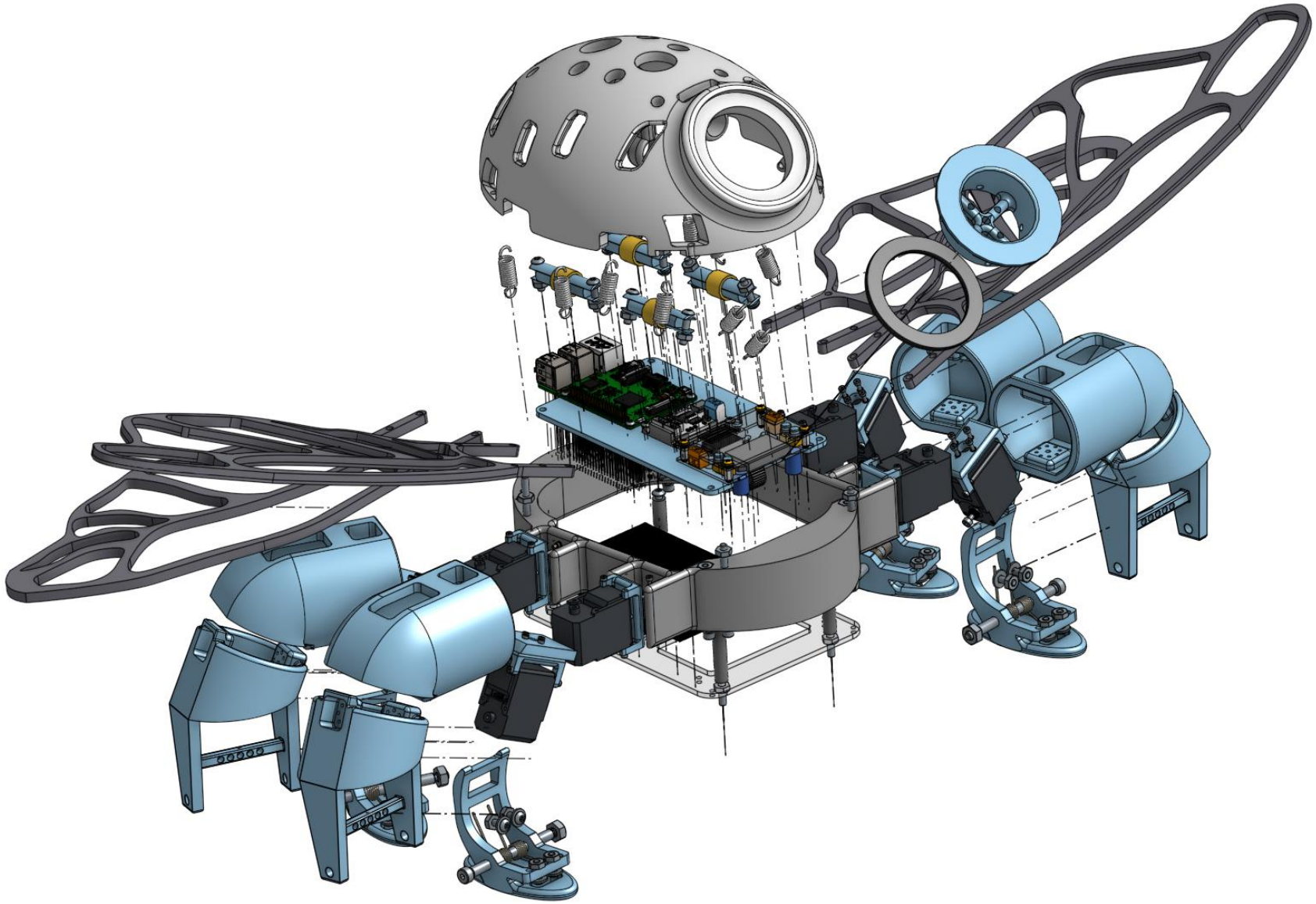
Poodle Moth Render



Poodle Moth Key Components



Poodle Moth Exploded View



Poodle Moth Key Specs

Unchanged from HW2

Mass properties

Instances to measure: base_with_legs

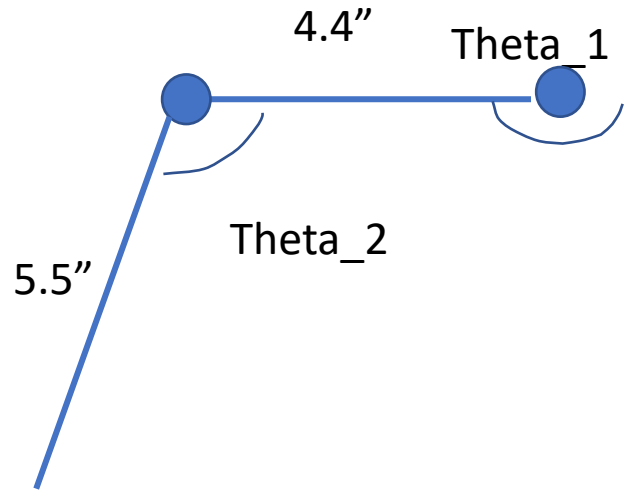
Mate connector for reference frame

Show calculation variance

Mass	Override	7.429 lb
Volume		328.122 in³
Surface area		1968.161 in²
Center of mass	Override	
X ↘		-1.102 in
Y ↗		6.415 in
Z ↑		-3.576 in

Mass moments of inertia (in² lb) Override

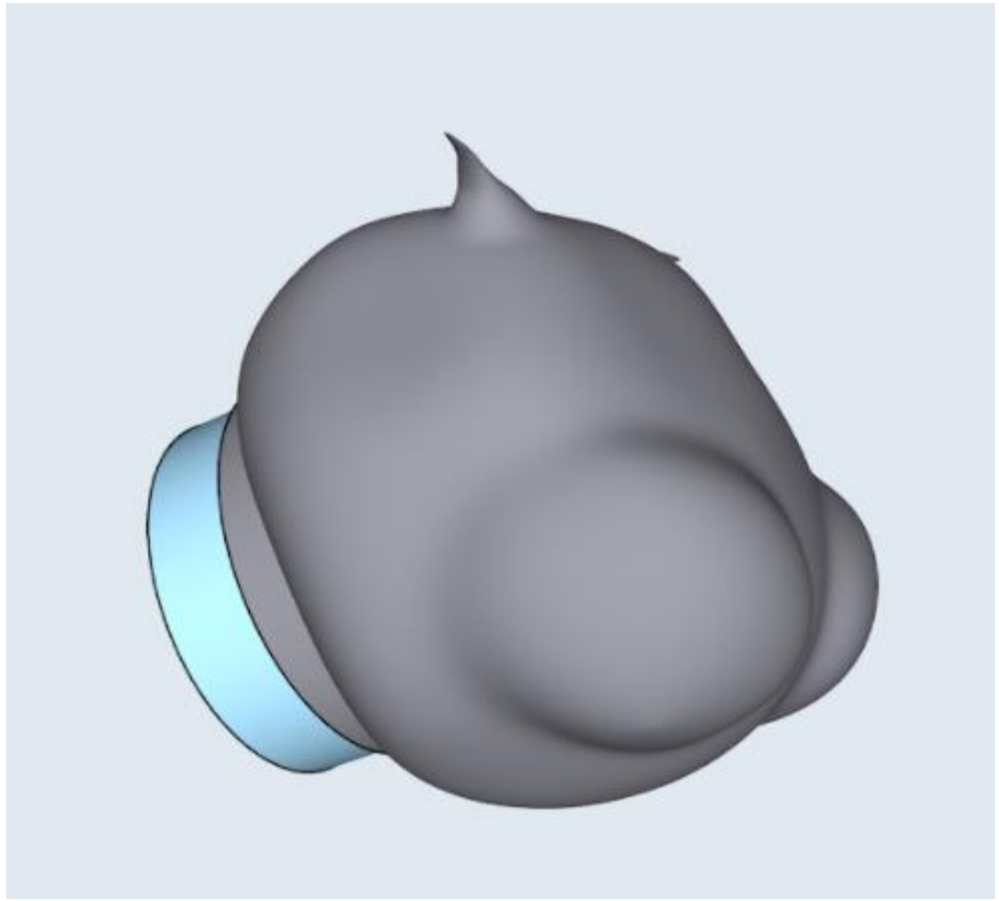
Lxx	441.437	Lxy	3.539	Lxz	9.663
Lyx	3.539	Lyy	108.356	Lyz	-0.11
Lzx	9.663	Lzy	-0.11	Lzz	458.363

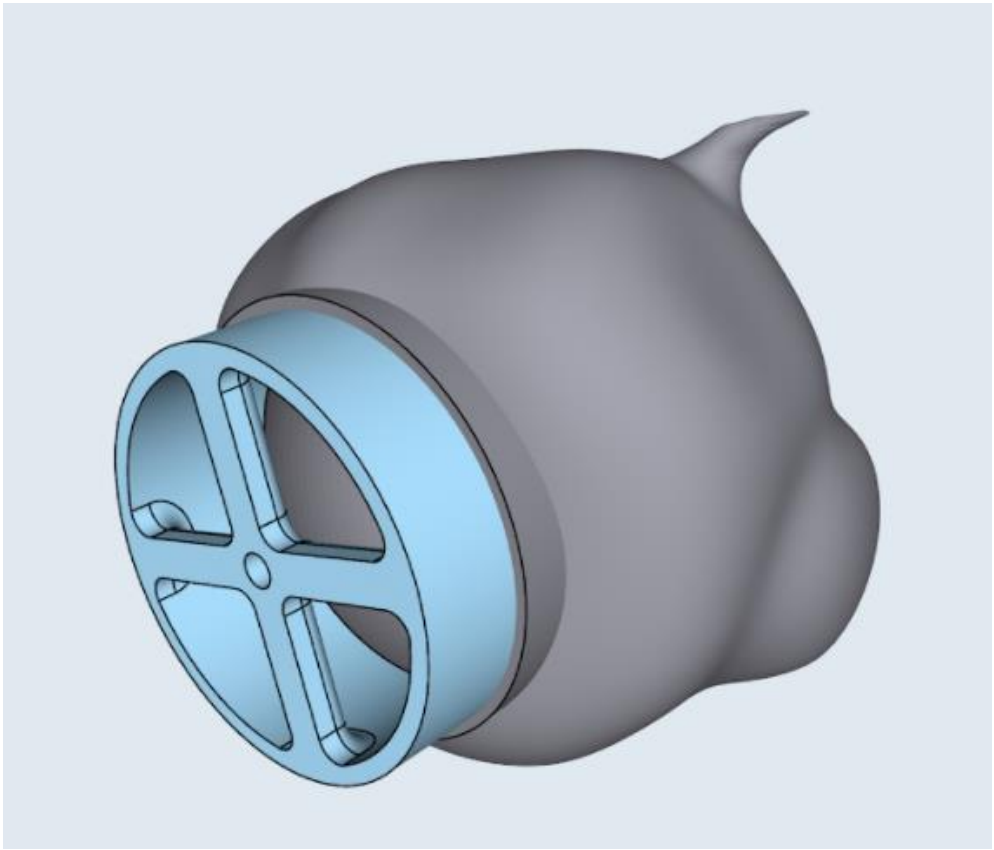


Theta_1: 155 deg < theta < 205 deg
Theta_2: 150 deg < theta < 210 deg

Max angular vel: 20 rpm
Max stride length: 9.4” (see next slide)
Expected stride length: ~3”
Motor rotation for stride: 60 deg
Strides/minute: 120
Walking speed: 3” / s

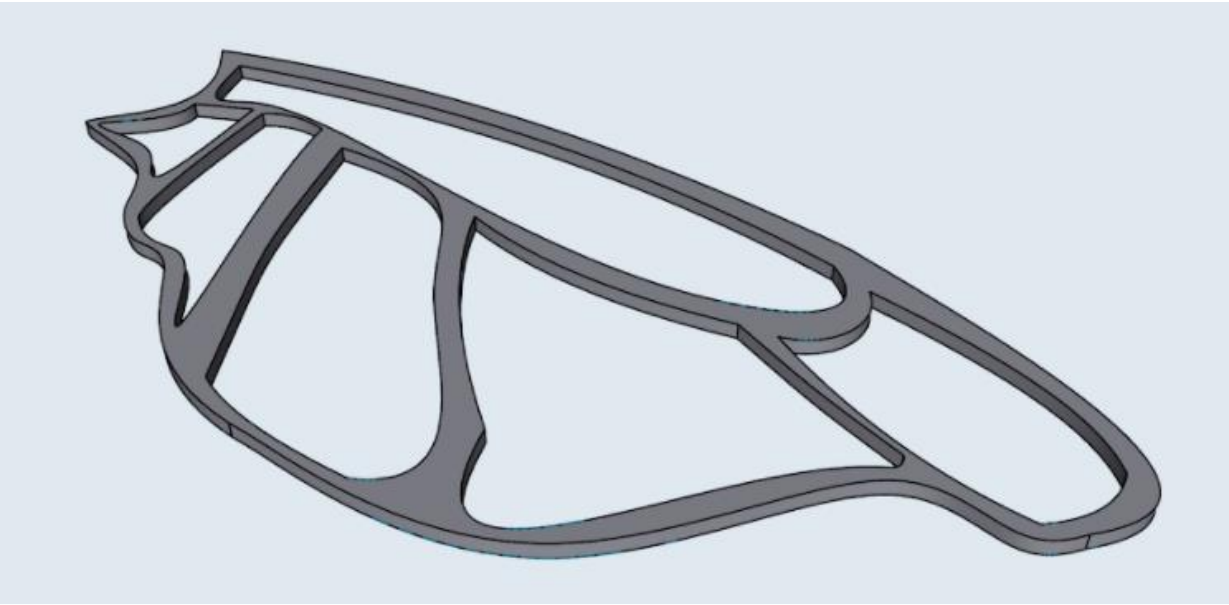
Head Close-up



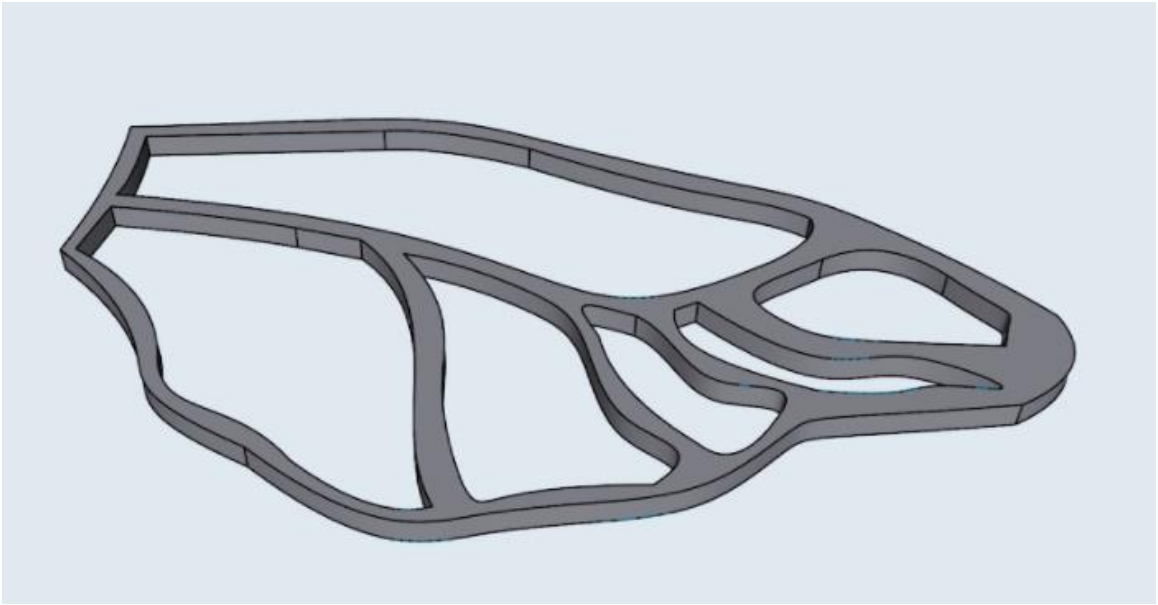


Wing Close-up

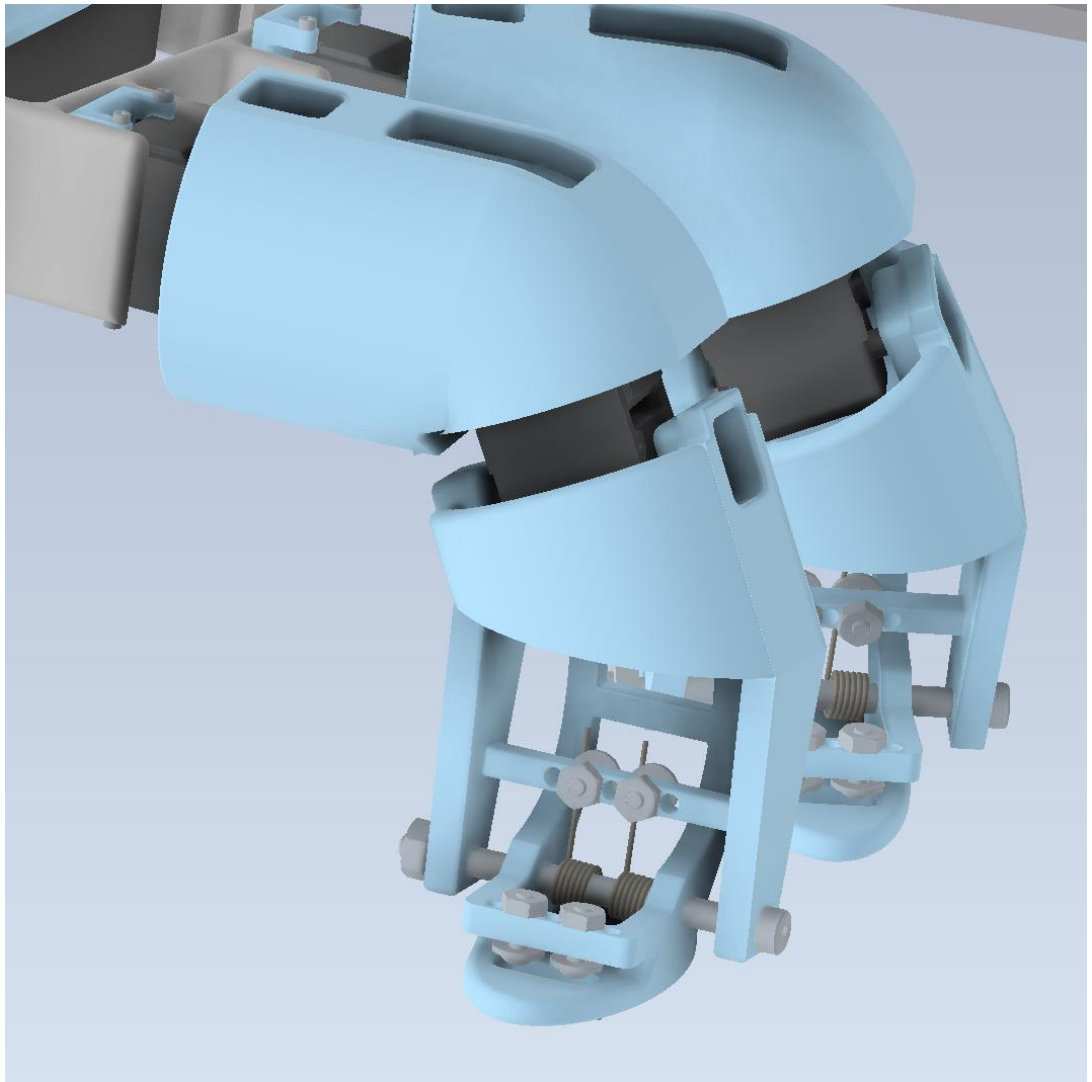
Top



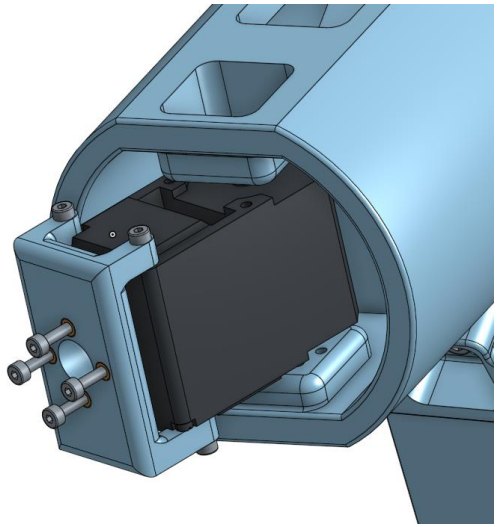
Bottom



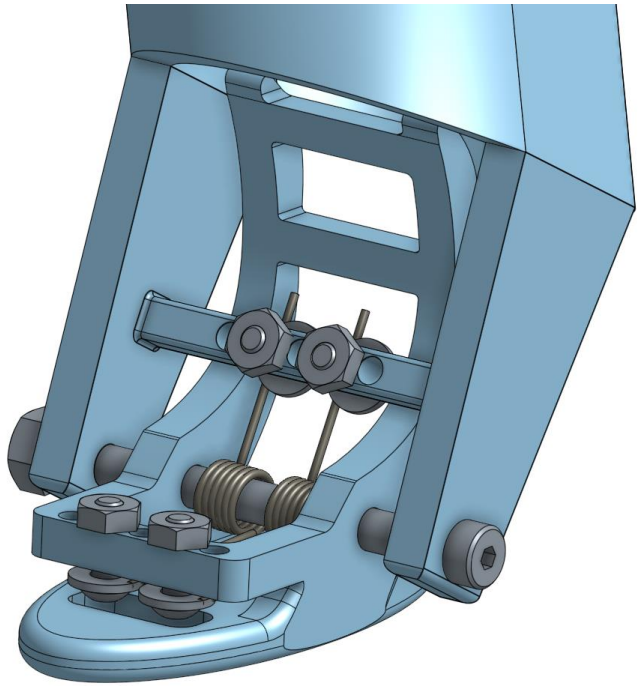
Leg Close-up



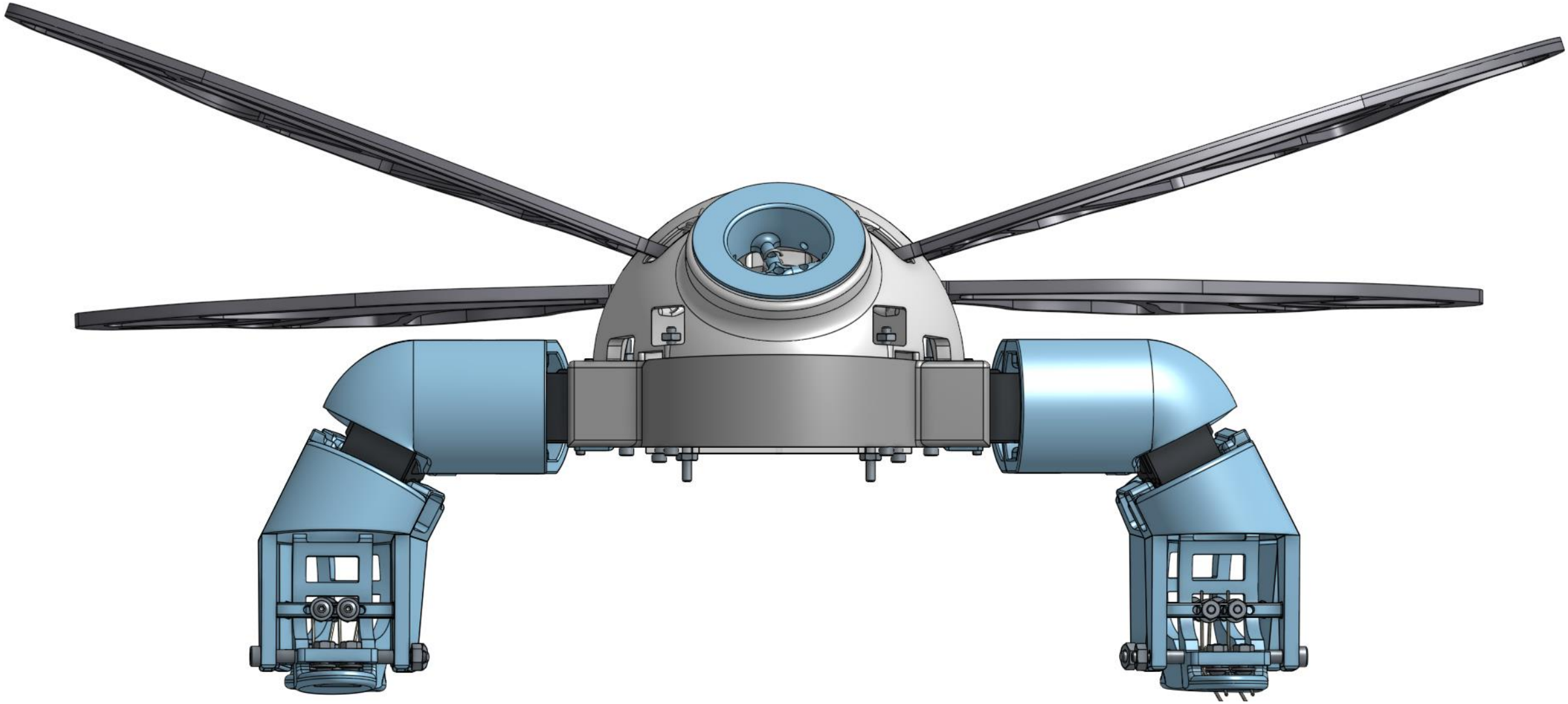
Motor Mounting



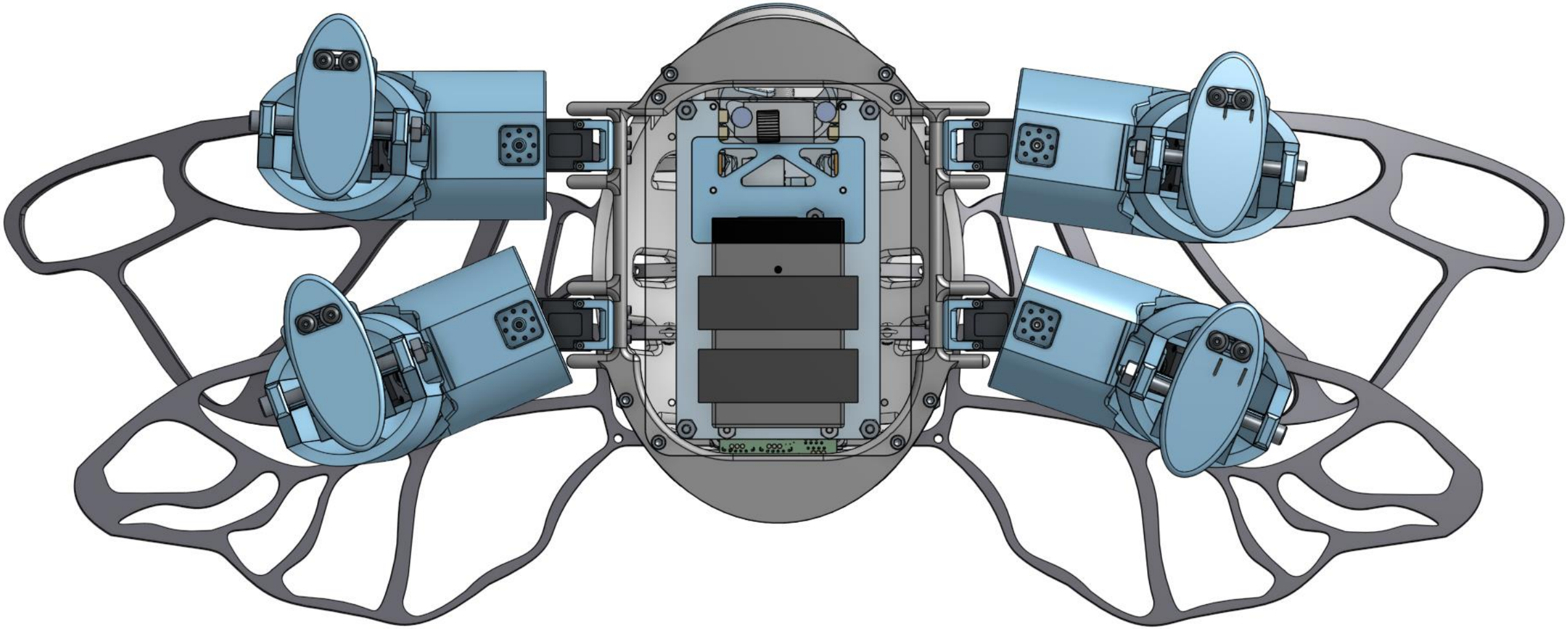
Foot Close-up
TBD: Add shaft spacers



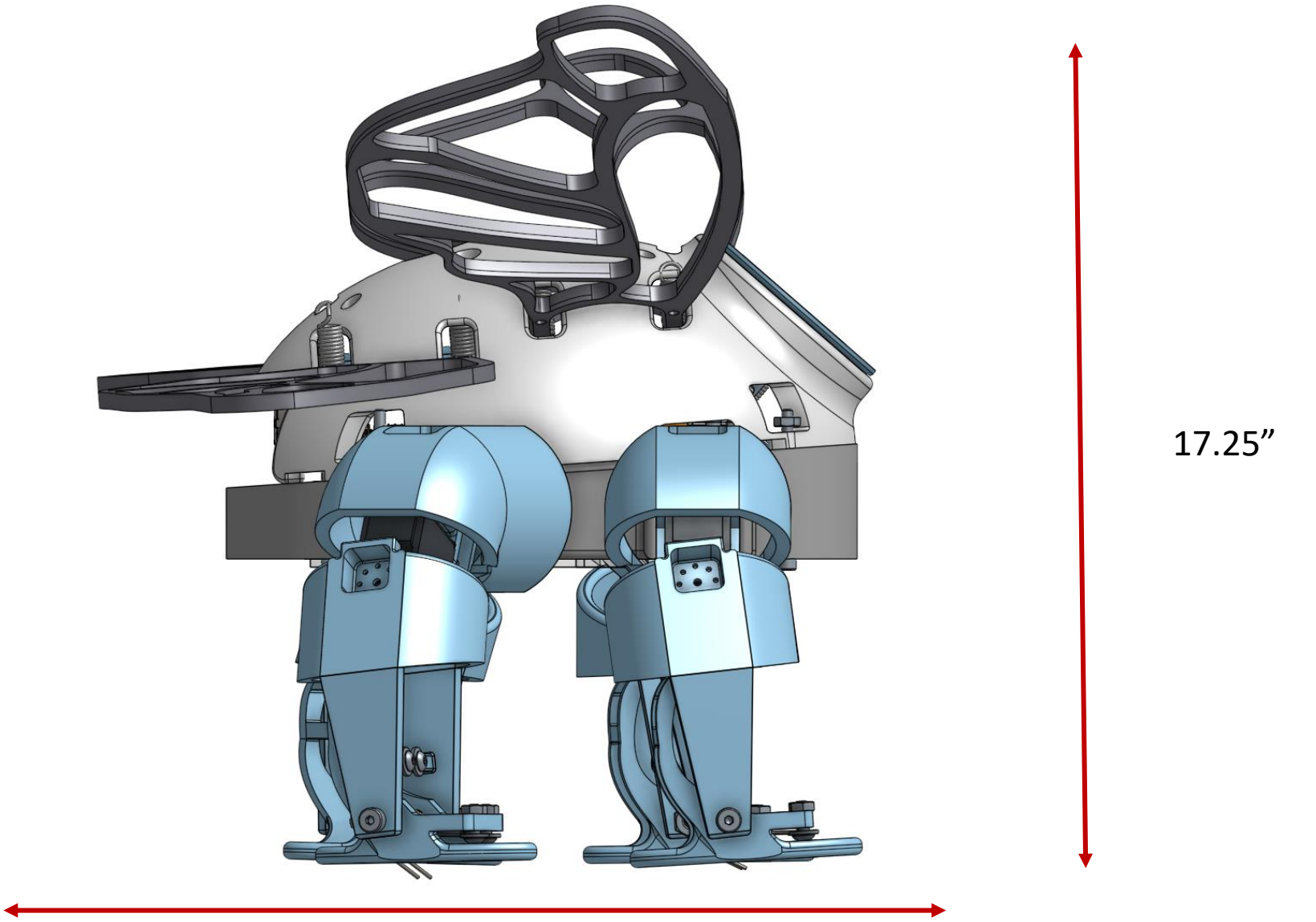
Poodle Moth Front View



Poodle Moth Bottom View

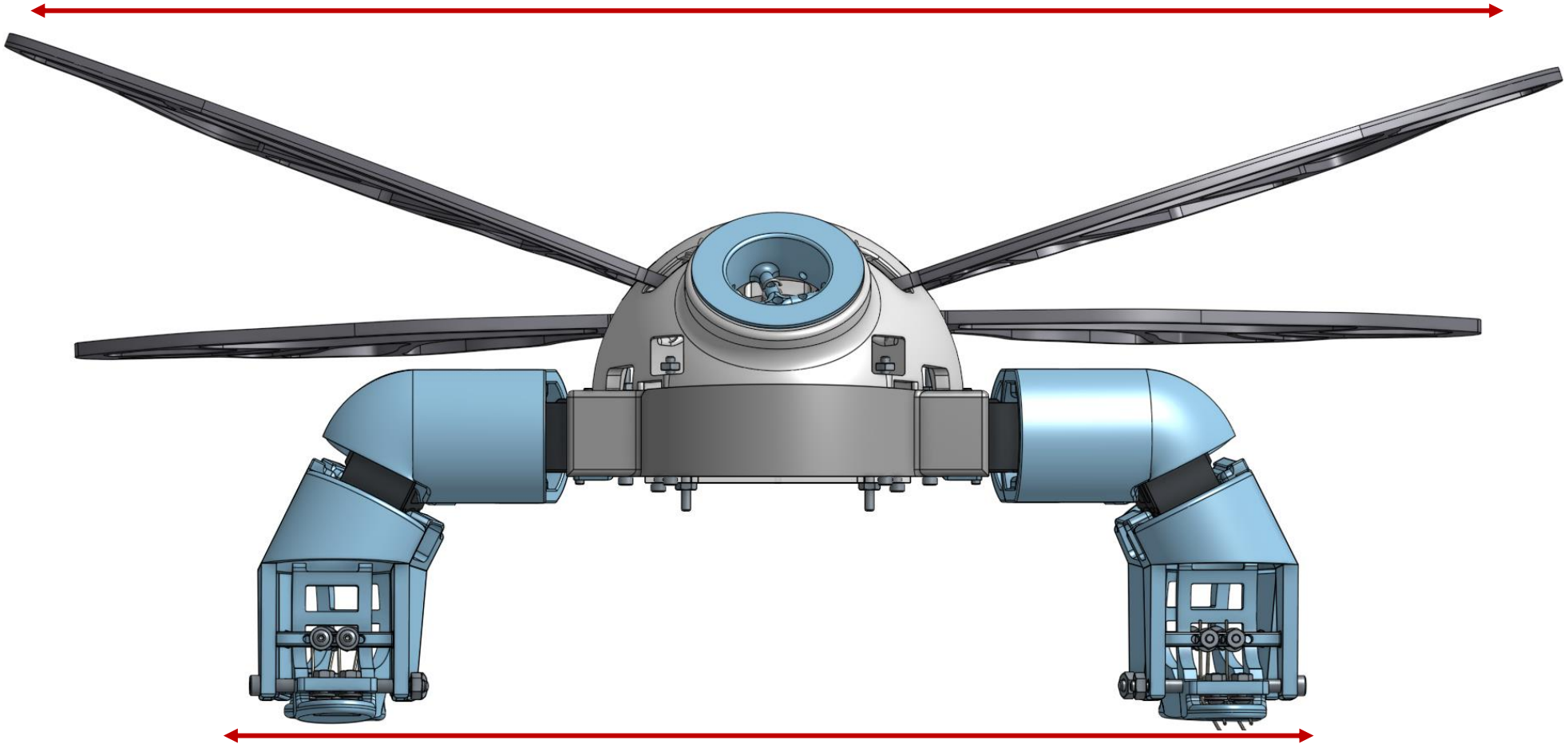


Side View with Dimensions



Side View with Dimensions

30.5”



21”

Discussion Board

https://edstem.org/us/courses/13723/discussion/717397