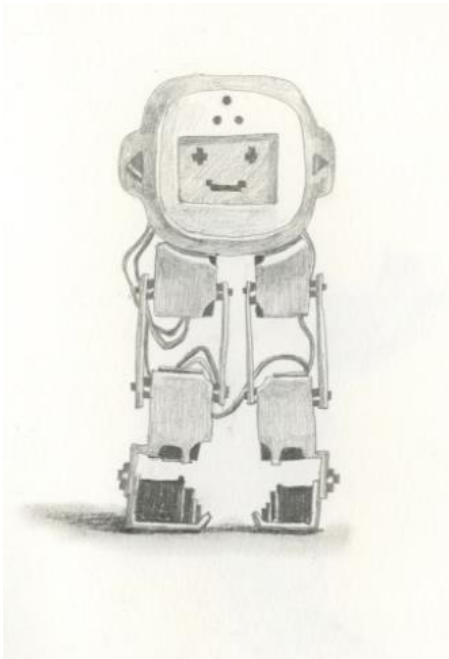


# Robotics Studio MECE 4611

## Fall 2021, Assignment 1



William Xie, Mimi Park

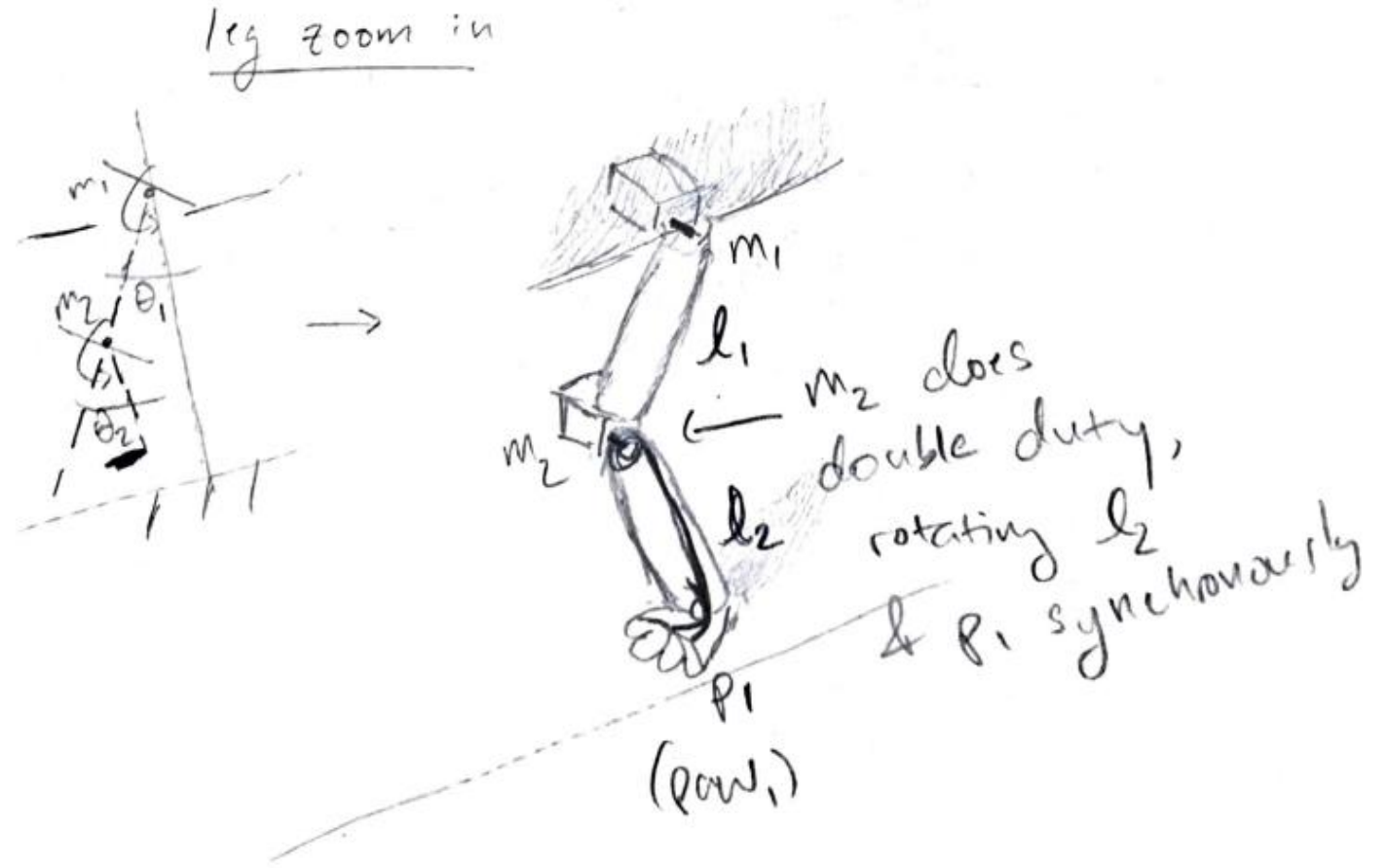
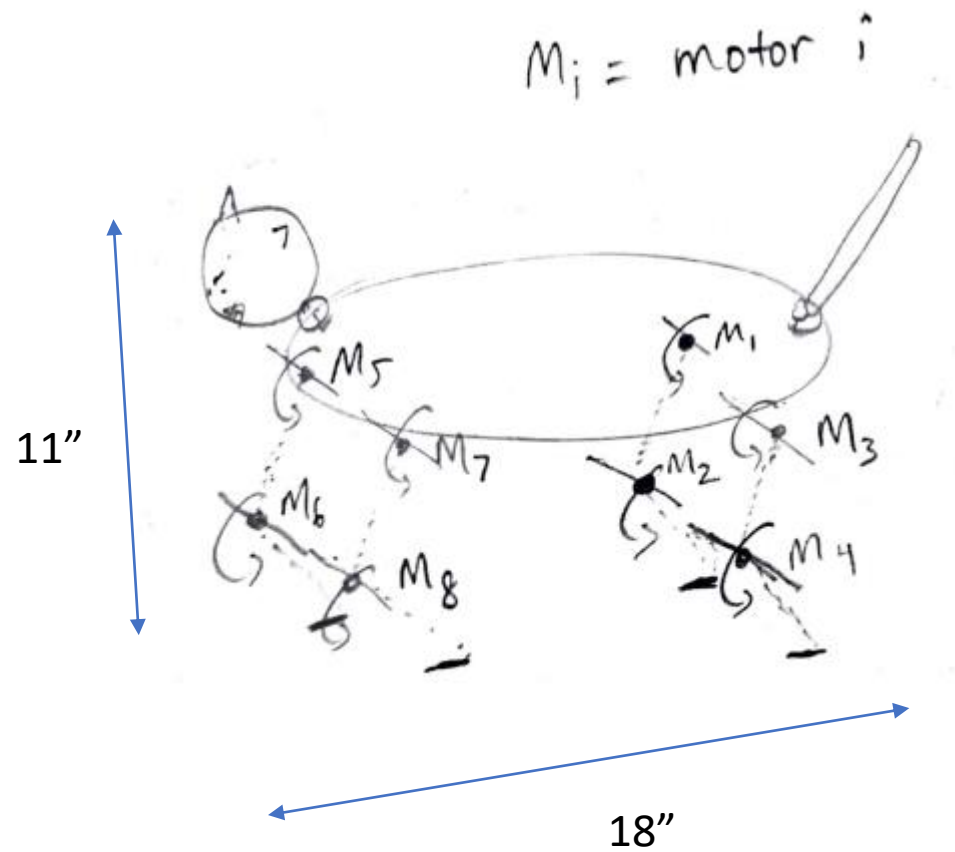
wx2214, mp3942

Submission Date: 9/21/2021 at 11:00 PM

Grace Hours Gained: 1

Grace Hours Remaining: 97

# Concept 1 - Little Kitten

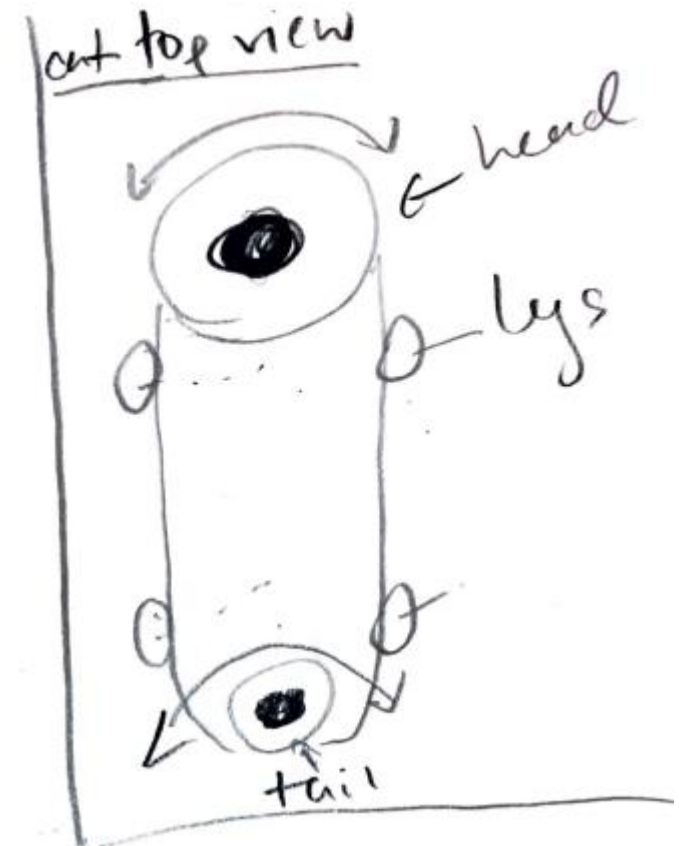
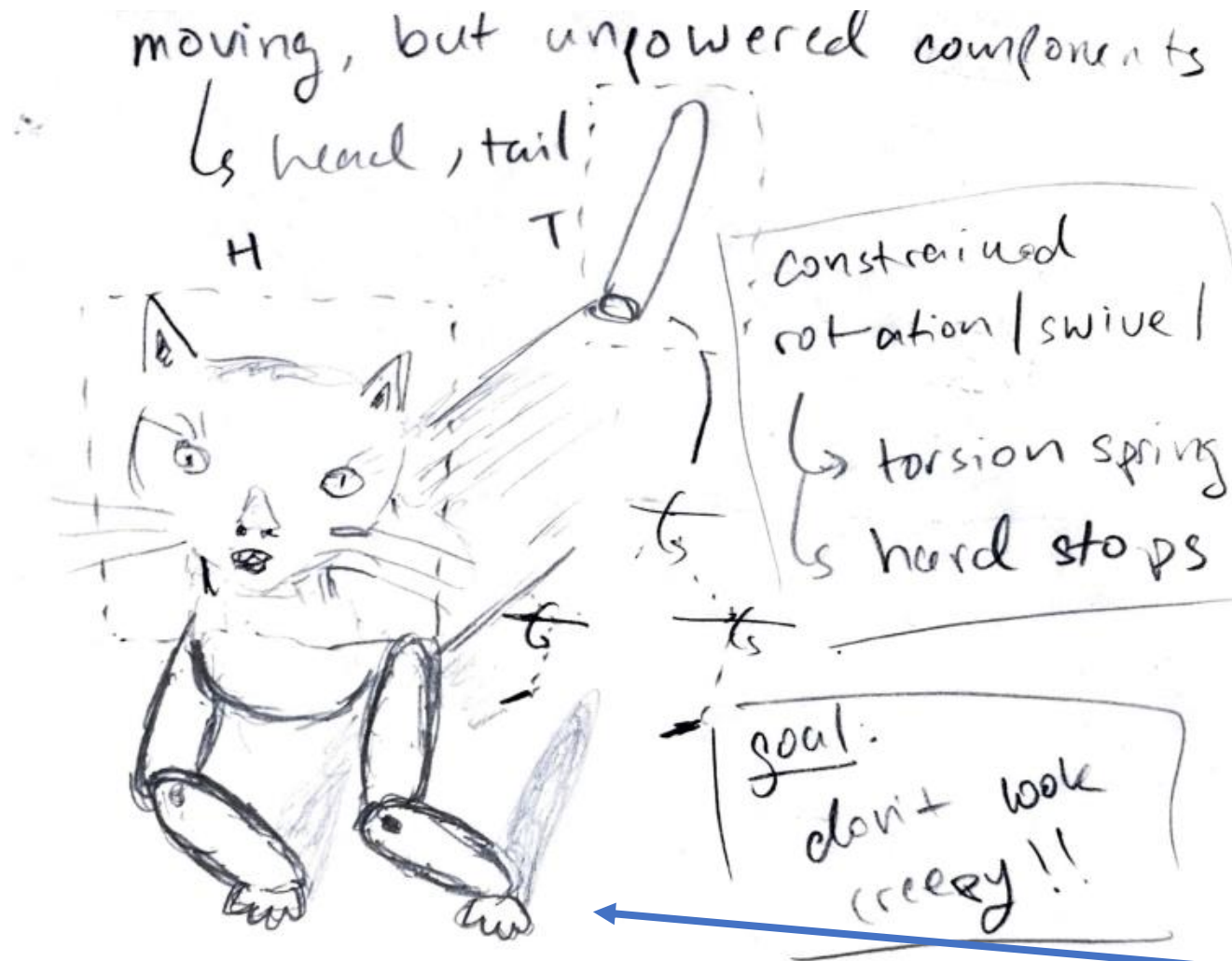


# Concept 1 - Inspiration



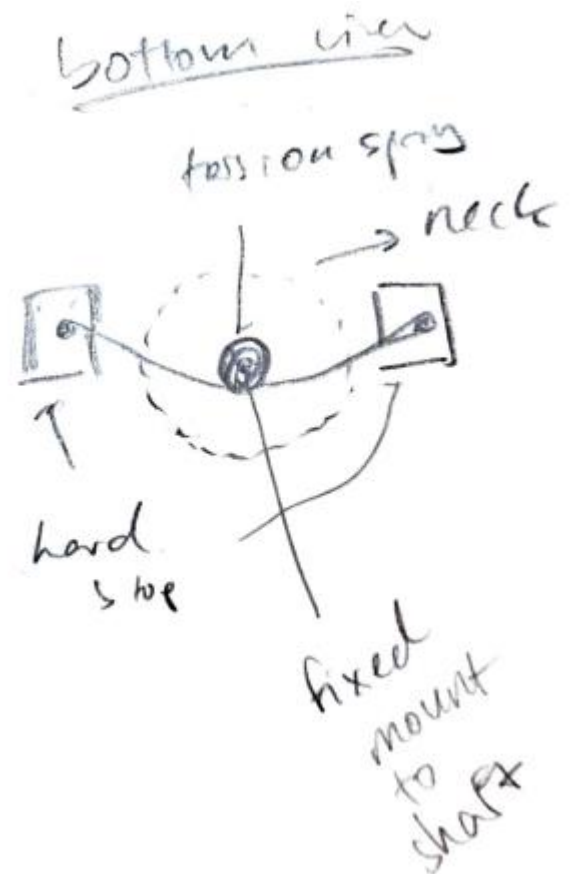
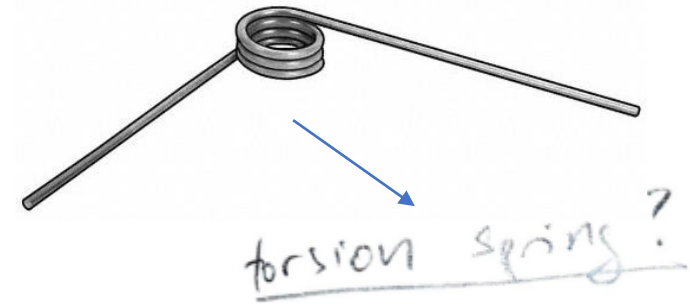
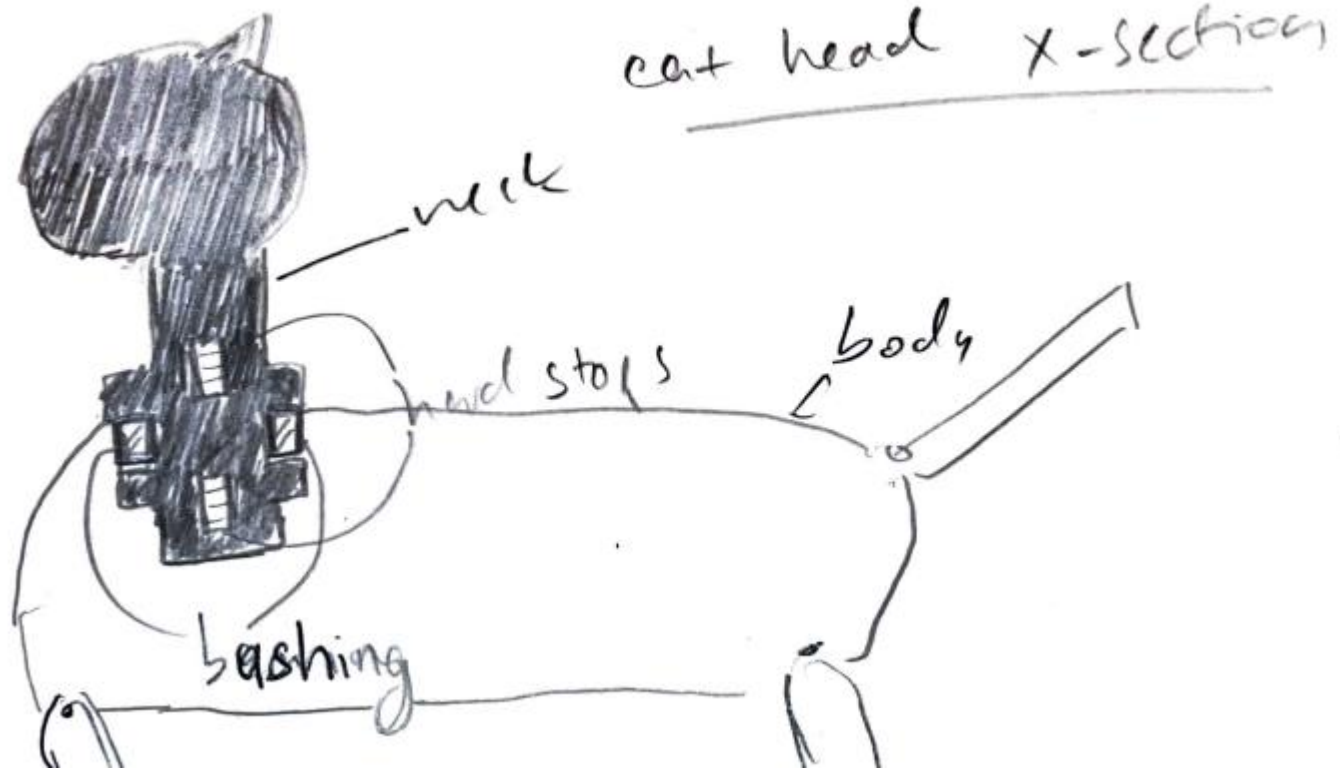
My cats, when they were kittens. I want another kitten and for it to stay a kitten forever.

# Concept 1



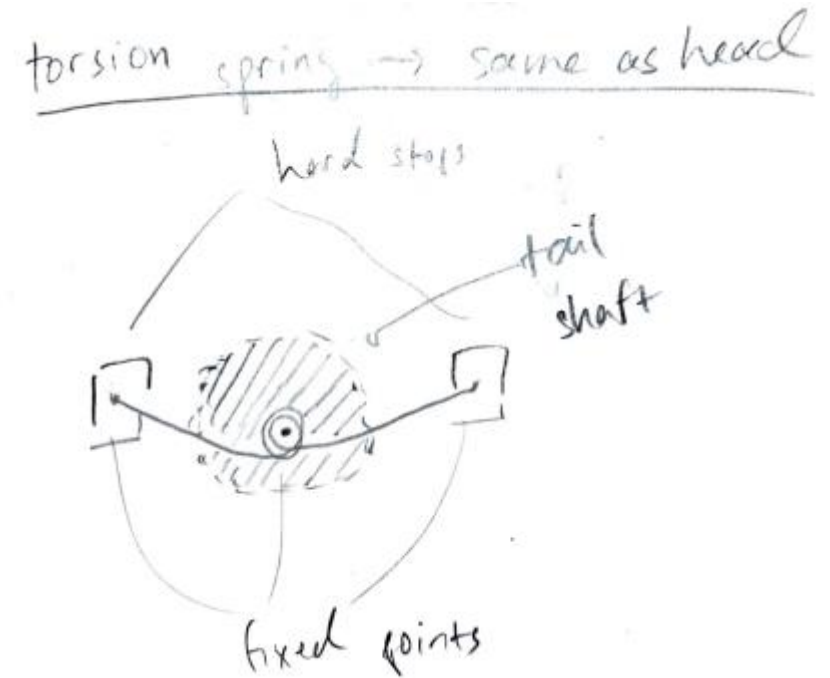
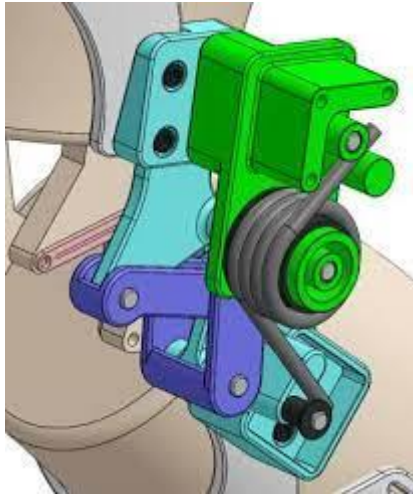
This face looks really creepy, so I already failed to achieve my goals.

# 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.

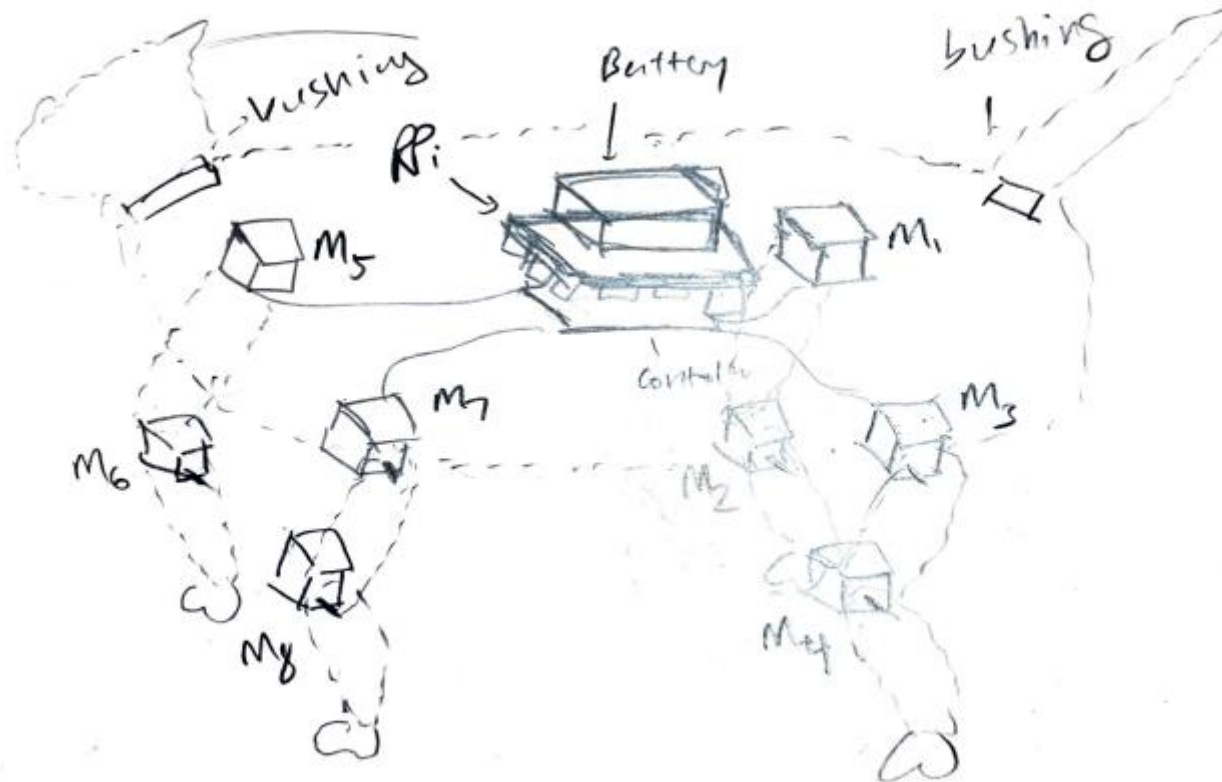
# Concept 1



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

# Concept 1

Component view





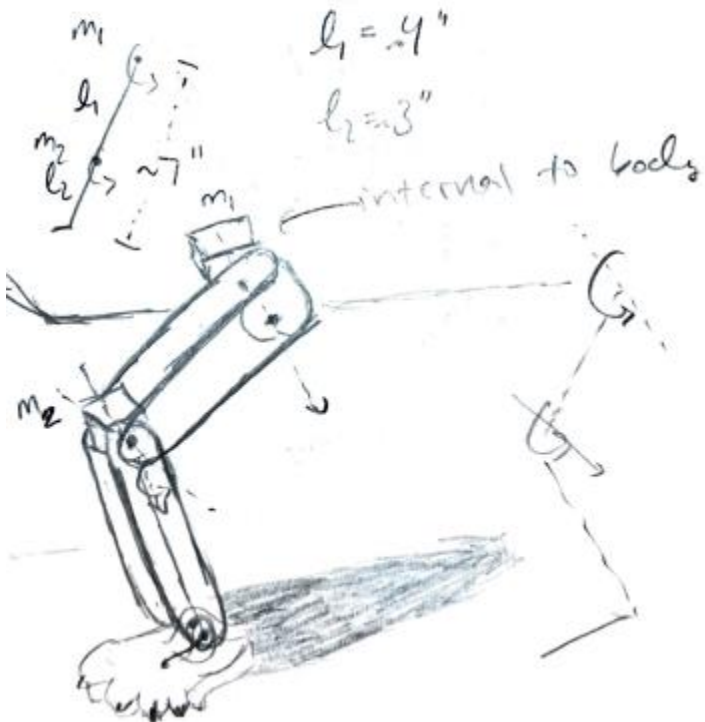
# Concept 1

Actual size:

emulate a small kitten

↳ 4-5 lbs ~ 2 kg

each leg is ~7"



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  $\omega$  (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 ( $F_g + F_r$ )

$$\tau = rF\sin(\theta)$$

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**

$$P = \tau\omega$$

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

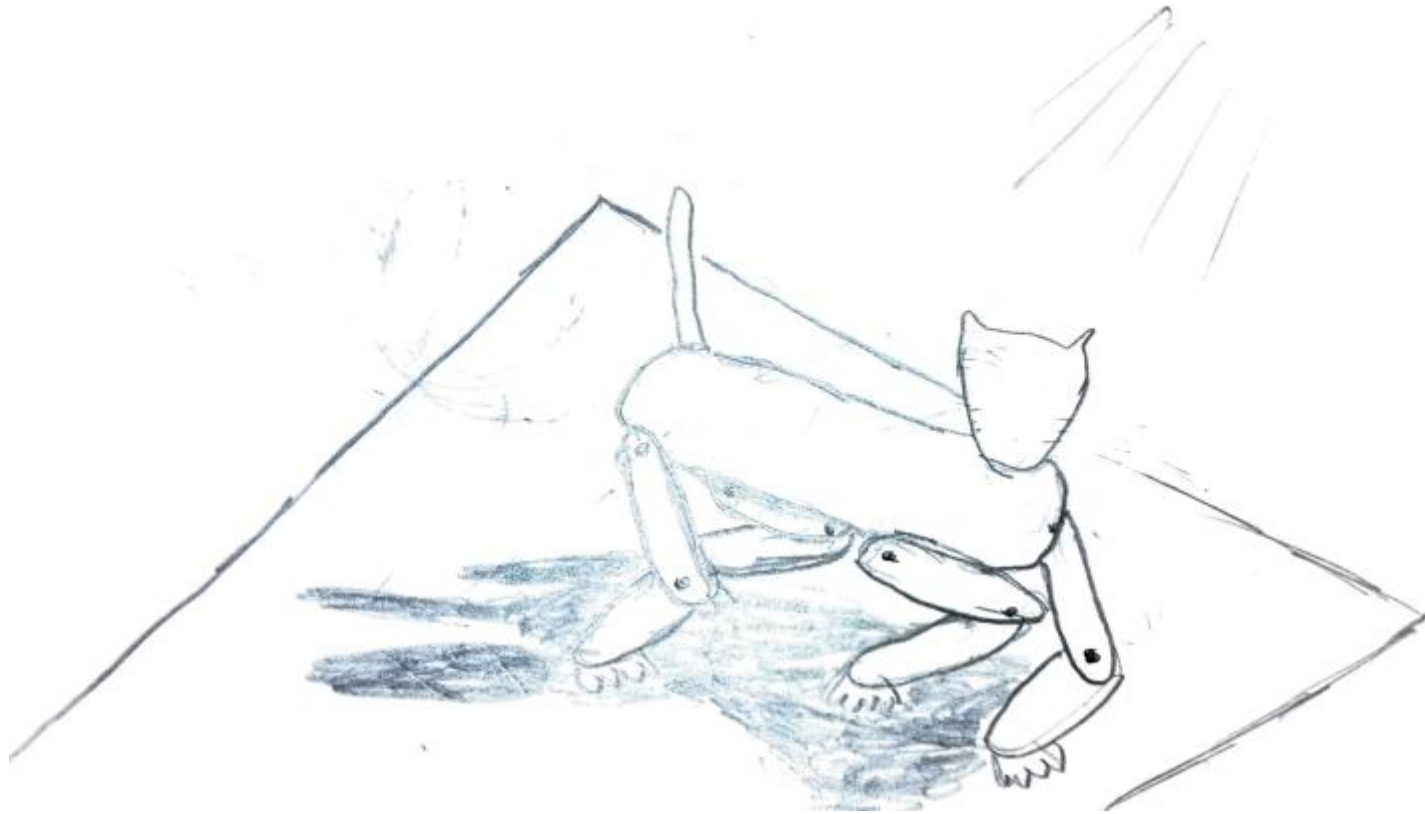
$$\omega = \frac{2\pi RPM}{60}$$

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



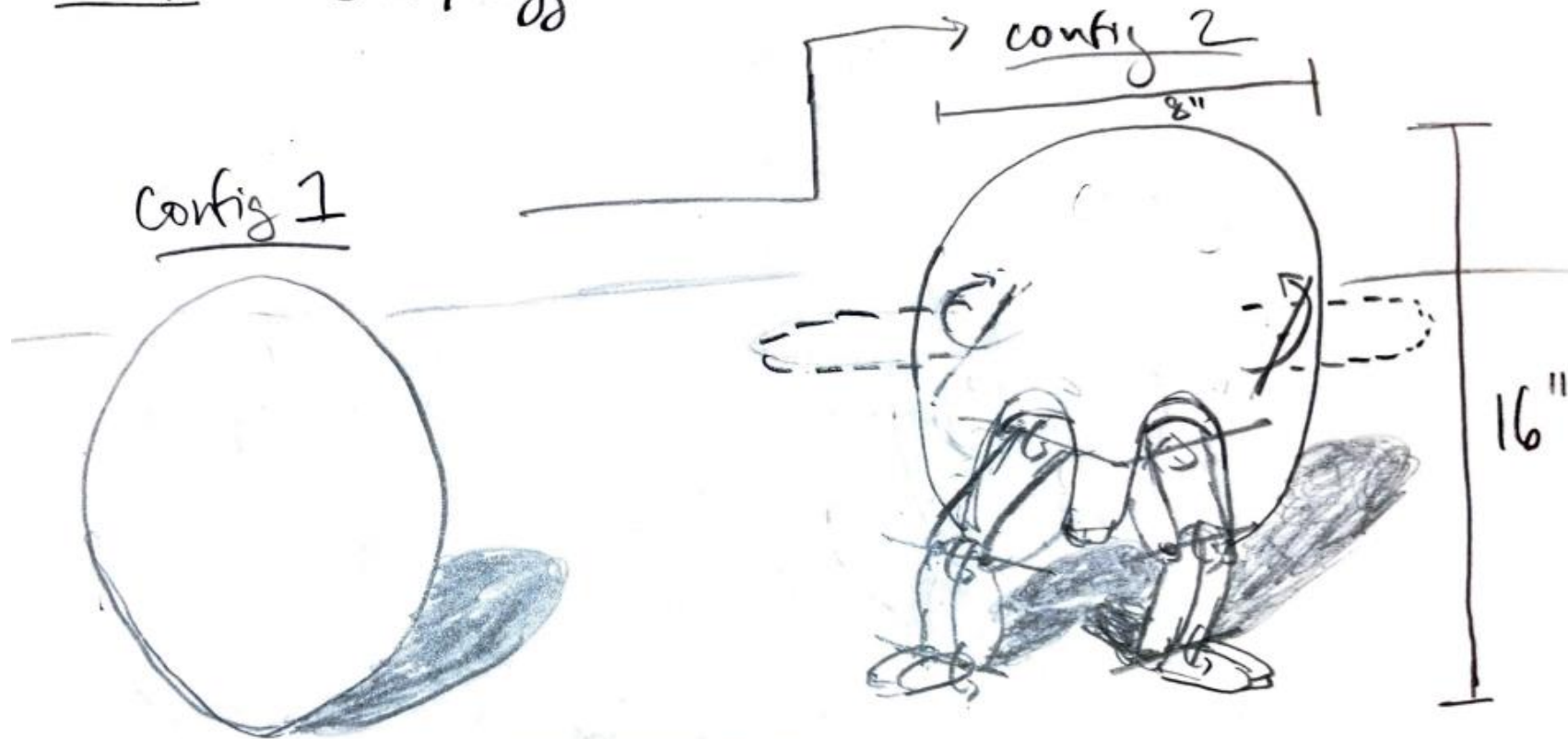
# Concept 1

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



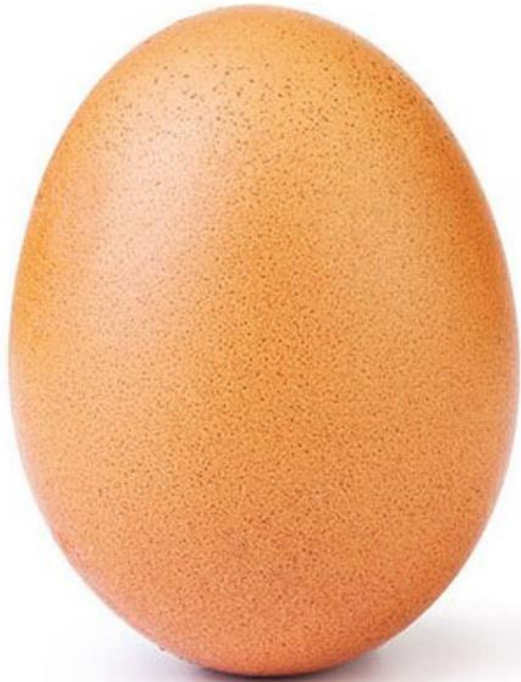
# Concept 2 – Unfolding Ball/Egg

Concept: Ball / Egg Robot



appendages, facial features TBD

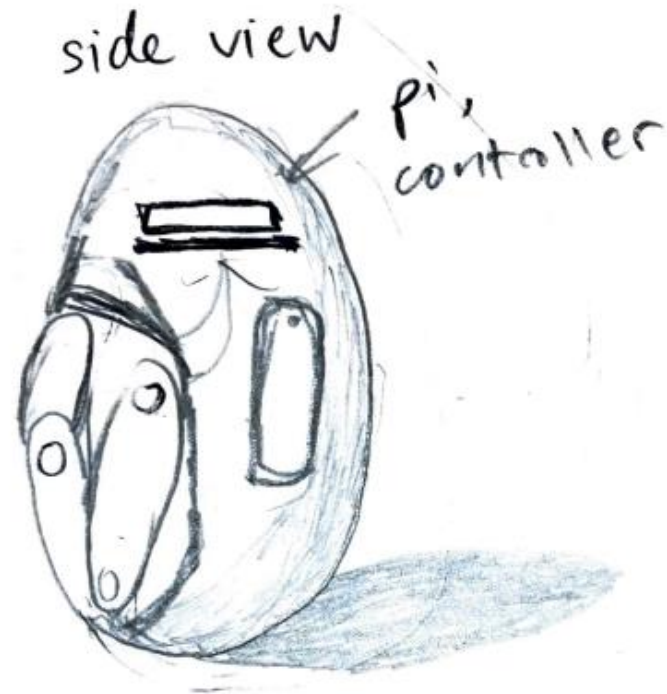
# Concept 2 – Real world inspirations



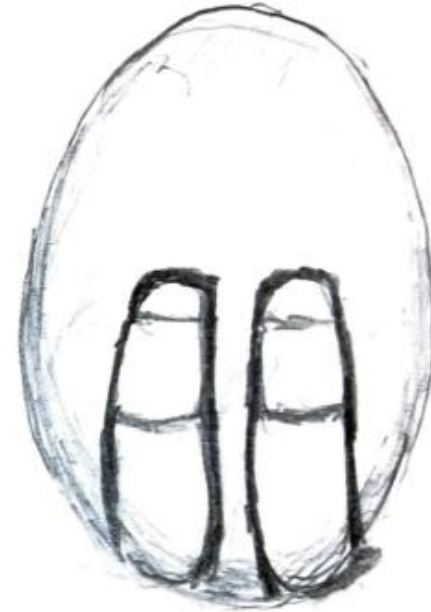
*Diabolical*, video game

# Concept 2

Folding Mechanism



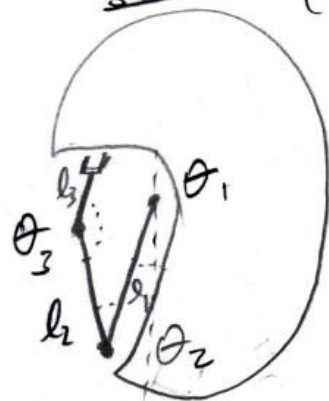
front view



note: probably would not be self-righting /  
require manual orientation

# Concept 2

leg deployment  $s_i = \text{state } i$ , all angle values estimates  
 $s_0$  (side view)  $s_1$   $s_2$



folded config

$$\theta_1 = 10^\circ$$

$$\theta_2 = 20^\circ$$

$$\theta_3 = 110^\circ$$

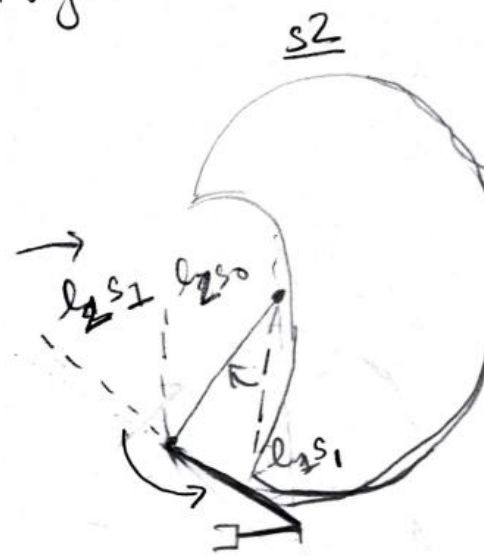


enclosure escape

$$\theta_1 = 10^\circ$$

$$\theta_2 \rightarrow \theta_2 = 75^\circ$$

$$\theta_3 = 110^\circ$$



standing

$$\theta = 40^\circ$$

$$\theta_2 \rightarrow \theta_2 = 270^\circ$$

$$\theta_3 = 25^\circ$$

# Concept 2

arm deployment (much simpler)

top right perspective

folded



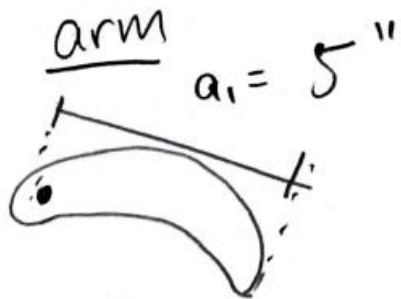
unfolded



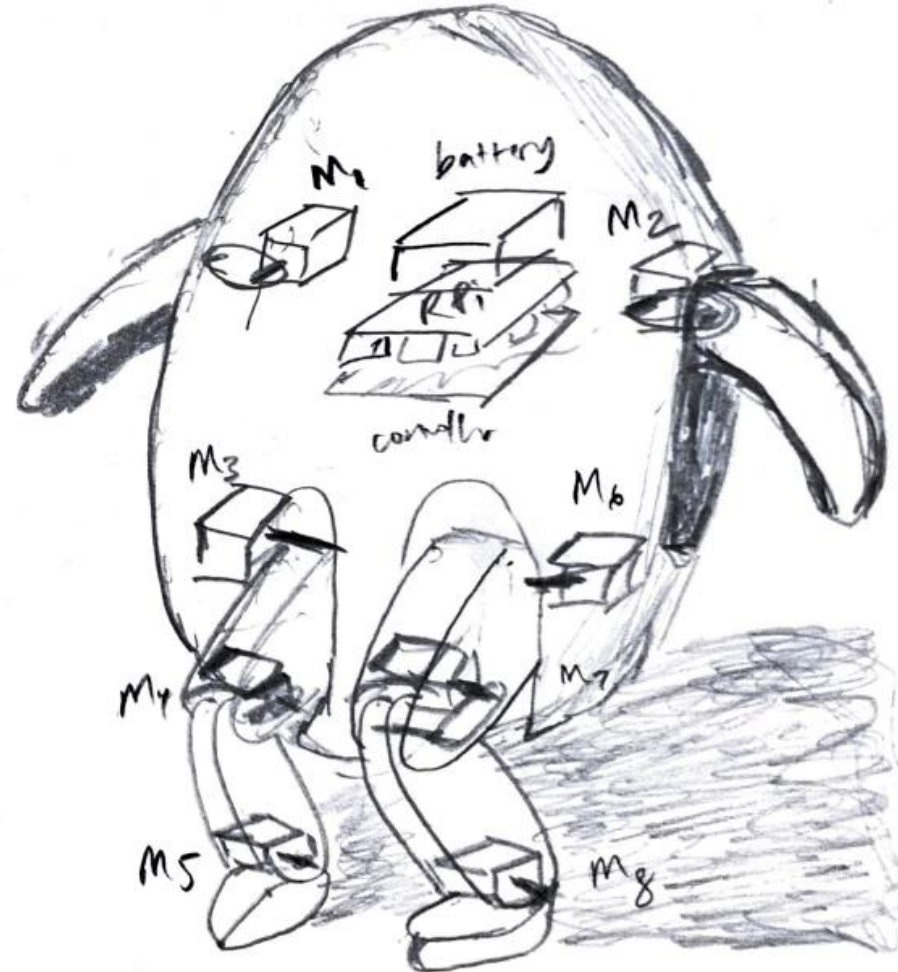


# Concept 2

top view



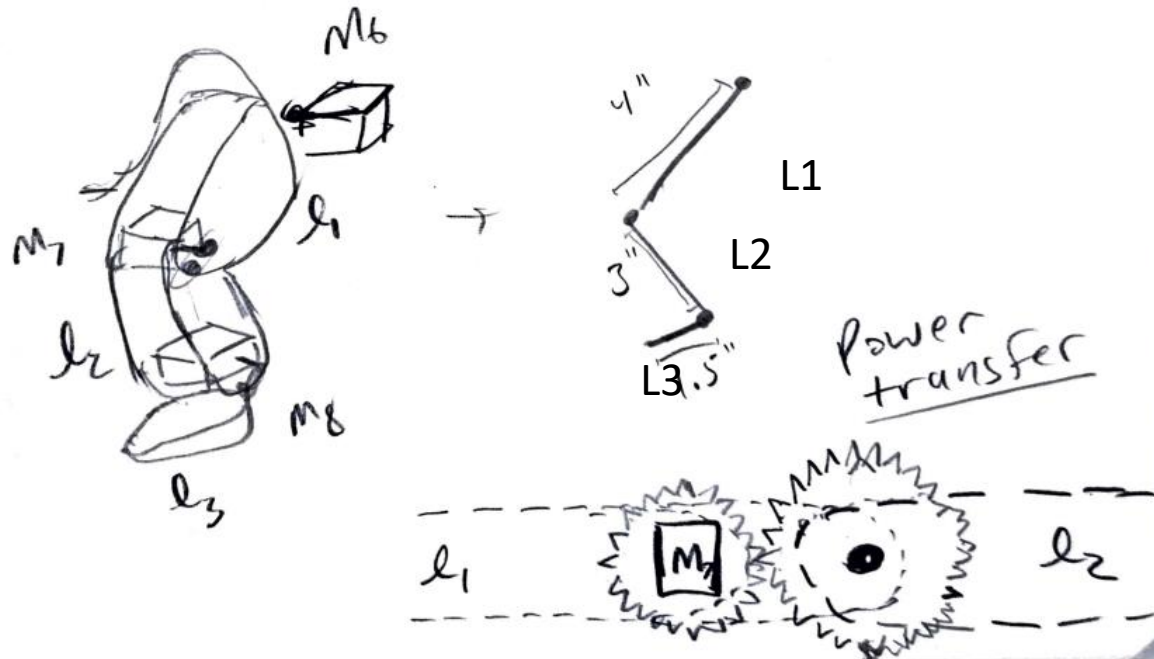
component view





# Concept 2 - Calculations

leg → very similar to cat leg,  
except  $l_3$  ( $p_1$  for the cat)  
is powered, not driven by  $l_2$ 's  
motor



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  $\omega$  (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)

$$\tau = rF\sin(\theta)$$

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**

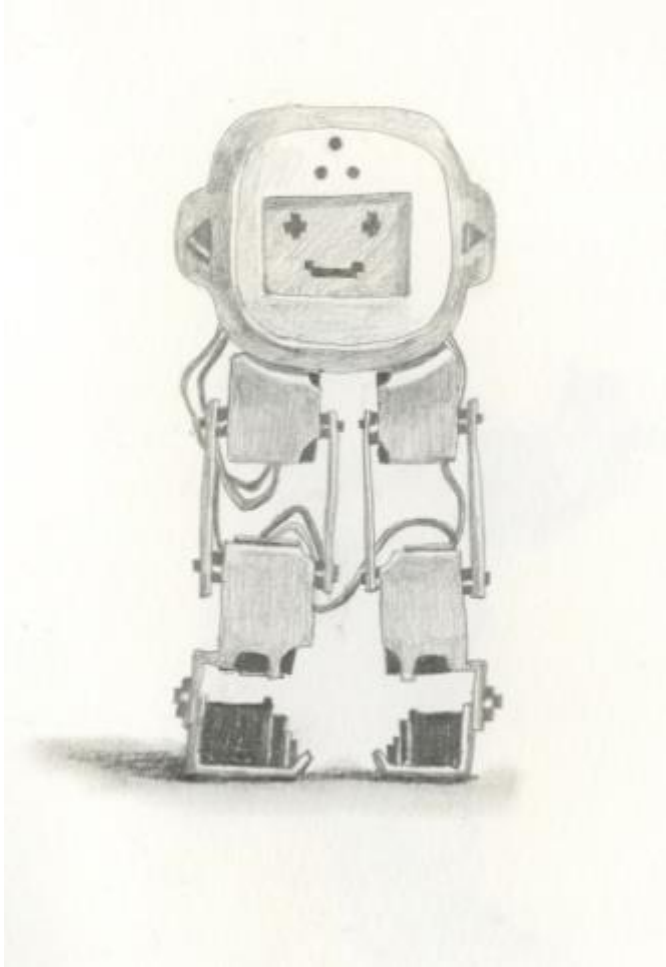
Max power draw from arm motor: **0.12 W**

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.

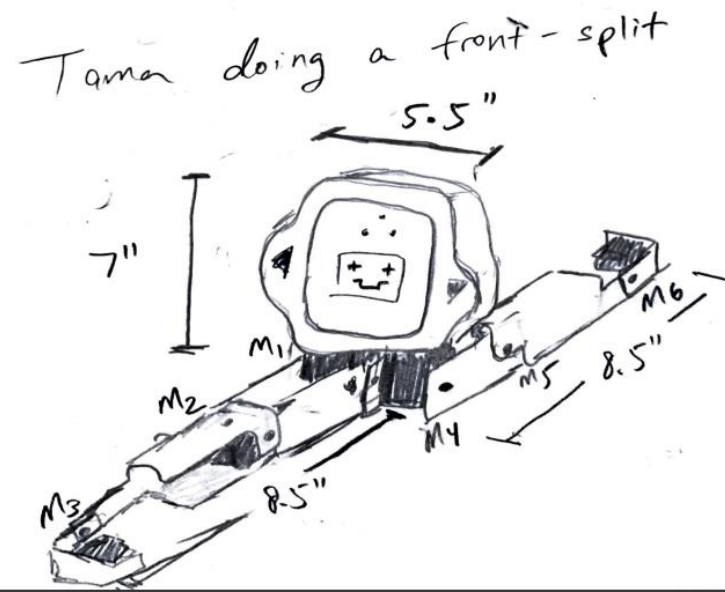
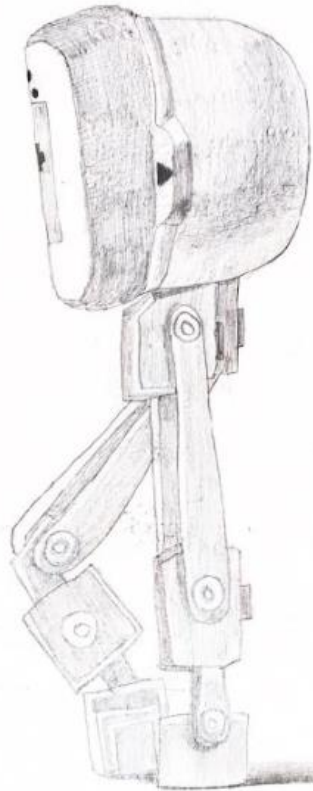
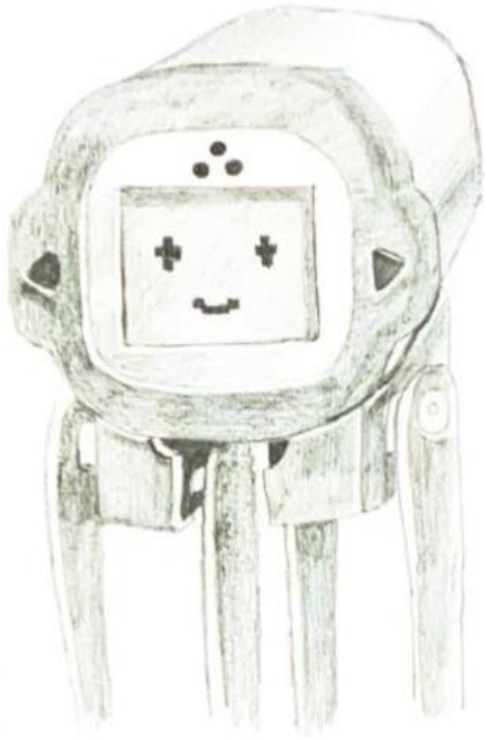
# Concept 3 – Tamagotchi



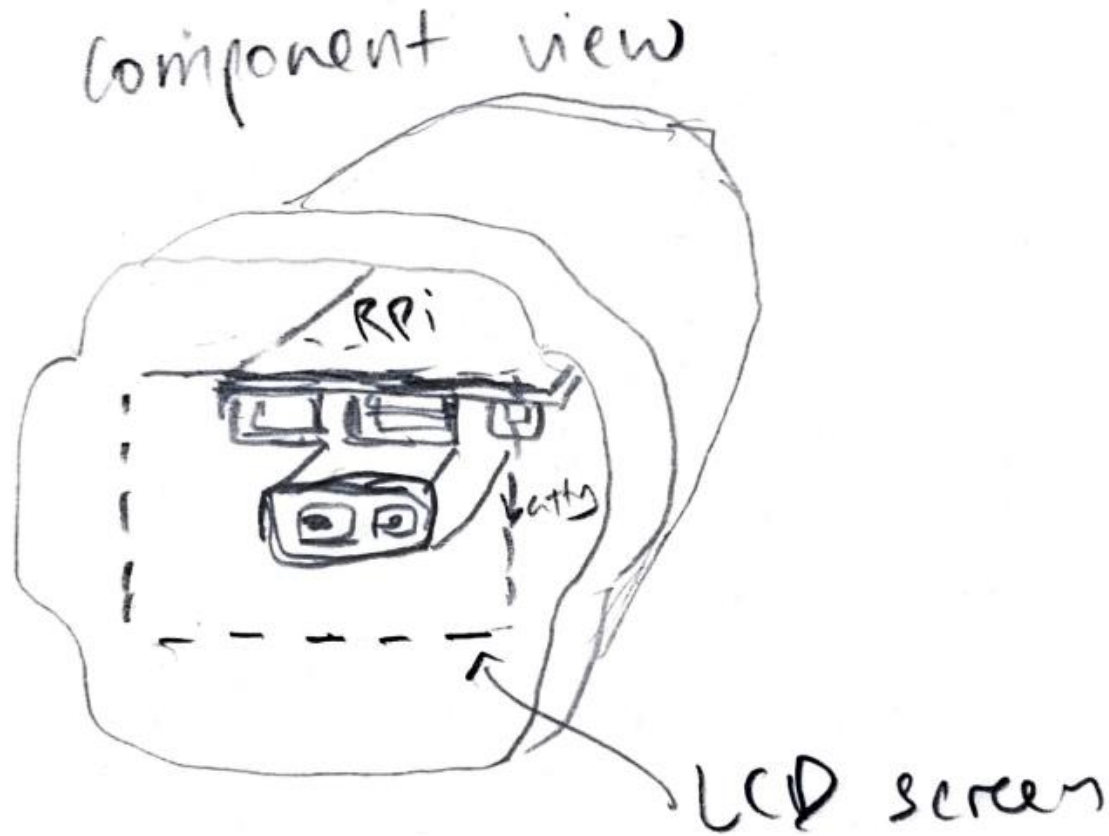
You can tell when Mimi joined the team...



# Concept 3 – Alternate views

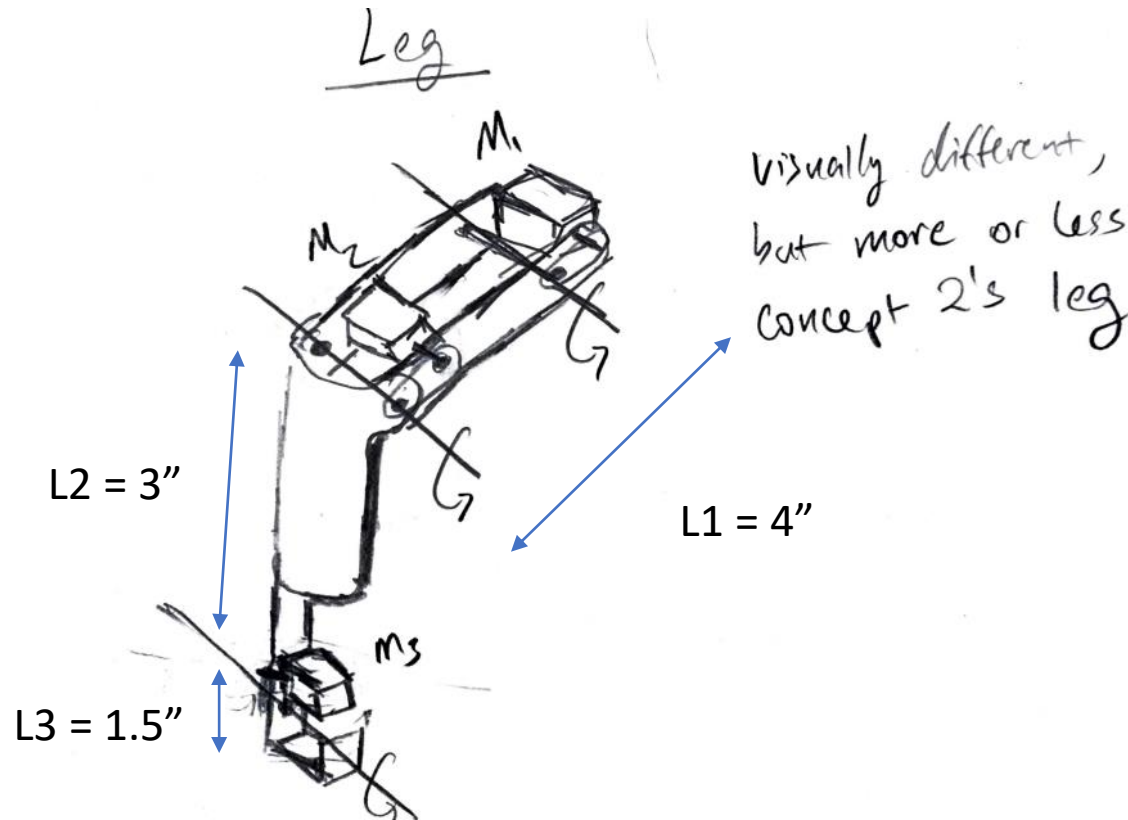


# Concept 3 – Alternate views



# 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')

Max  $\omega$  (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)

$\tau = rF\sin(\theta)$

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 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**

$$P = \tau\omega$$

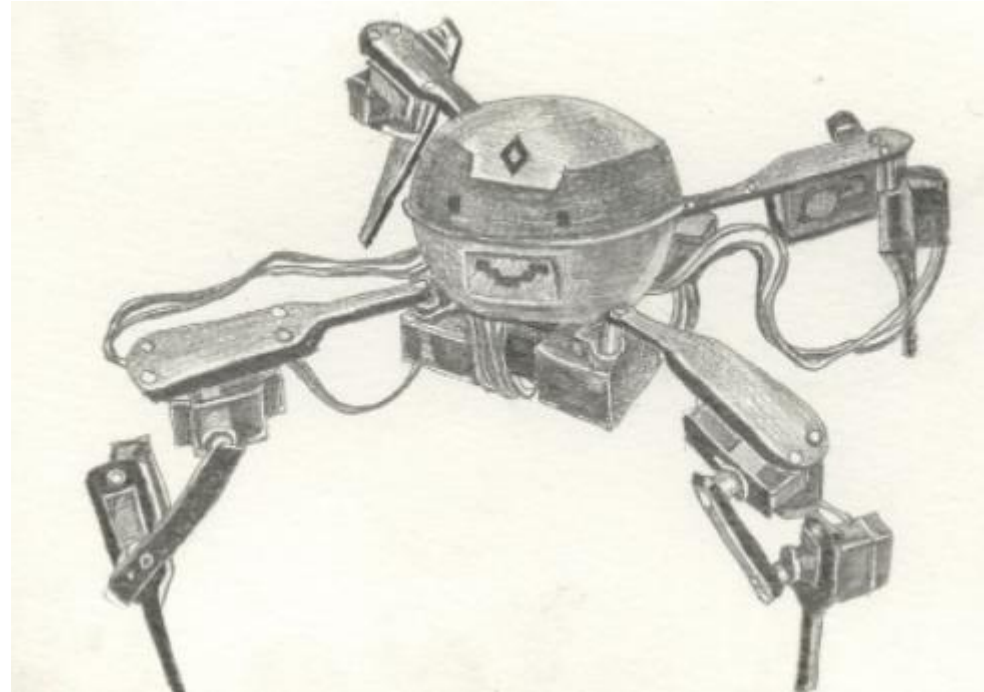
$$\tau = \frac{P}{\omega}$$

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

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



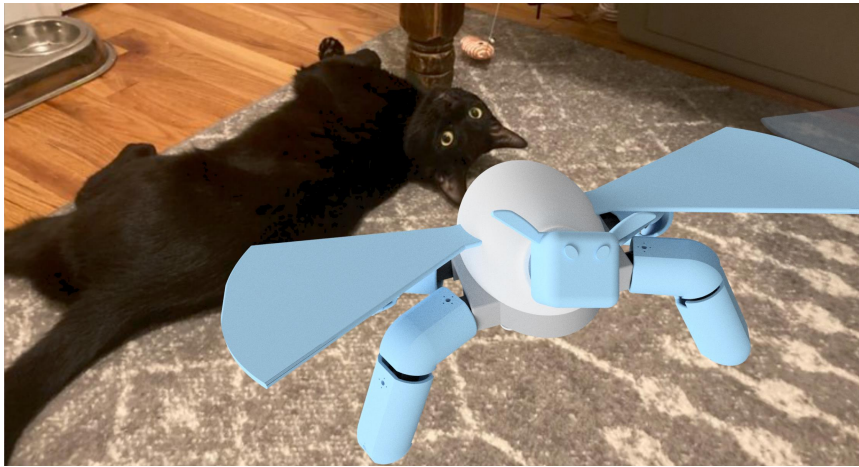
# References

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

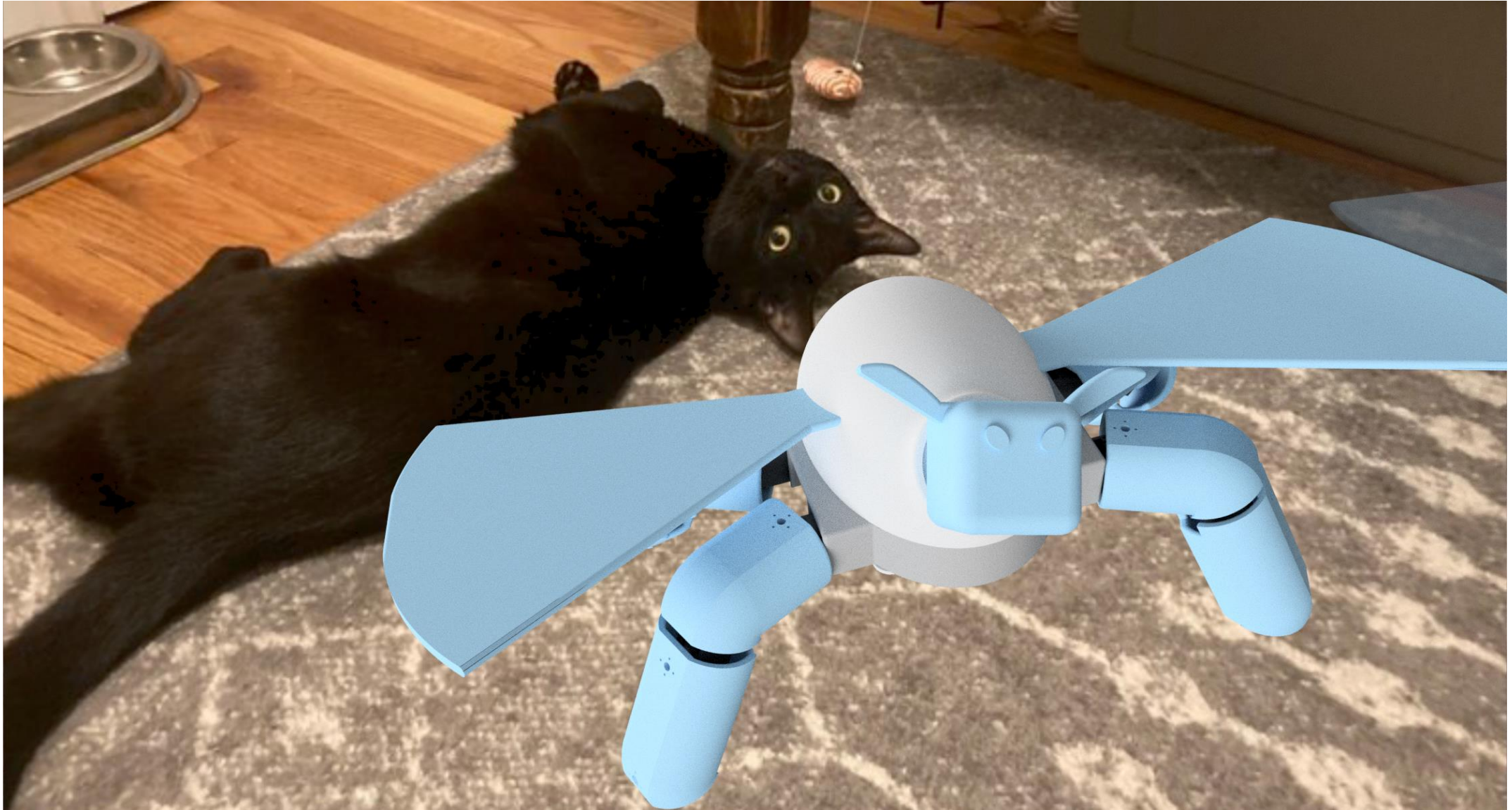
## Fall 2021, Assignment 2



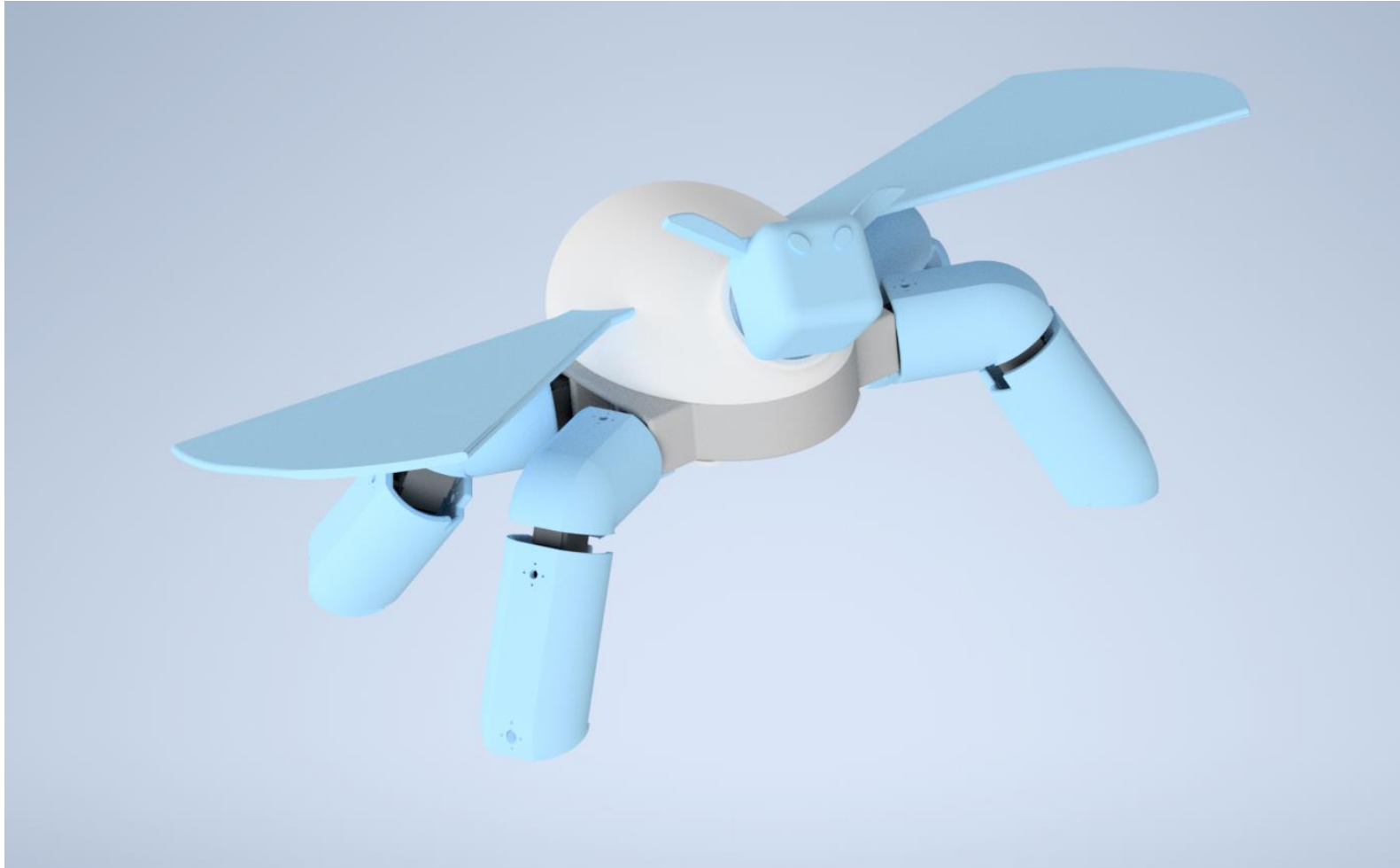
William Xie, Mimi Park  
wx2214, mp3942  
Submission Date: 9/28/2021,  
Robot Name: Poodle Moth  
Grace Hours Used: 3  
Grace Hours Remaining: 94



# Poodle Moth Perspective and Context Render

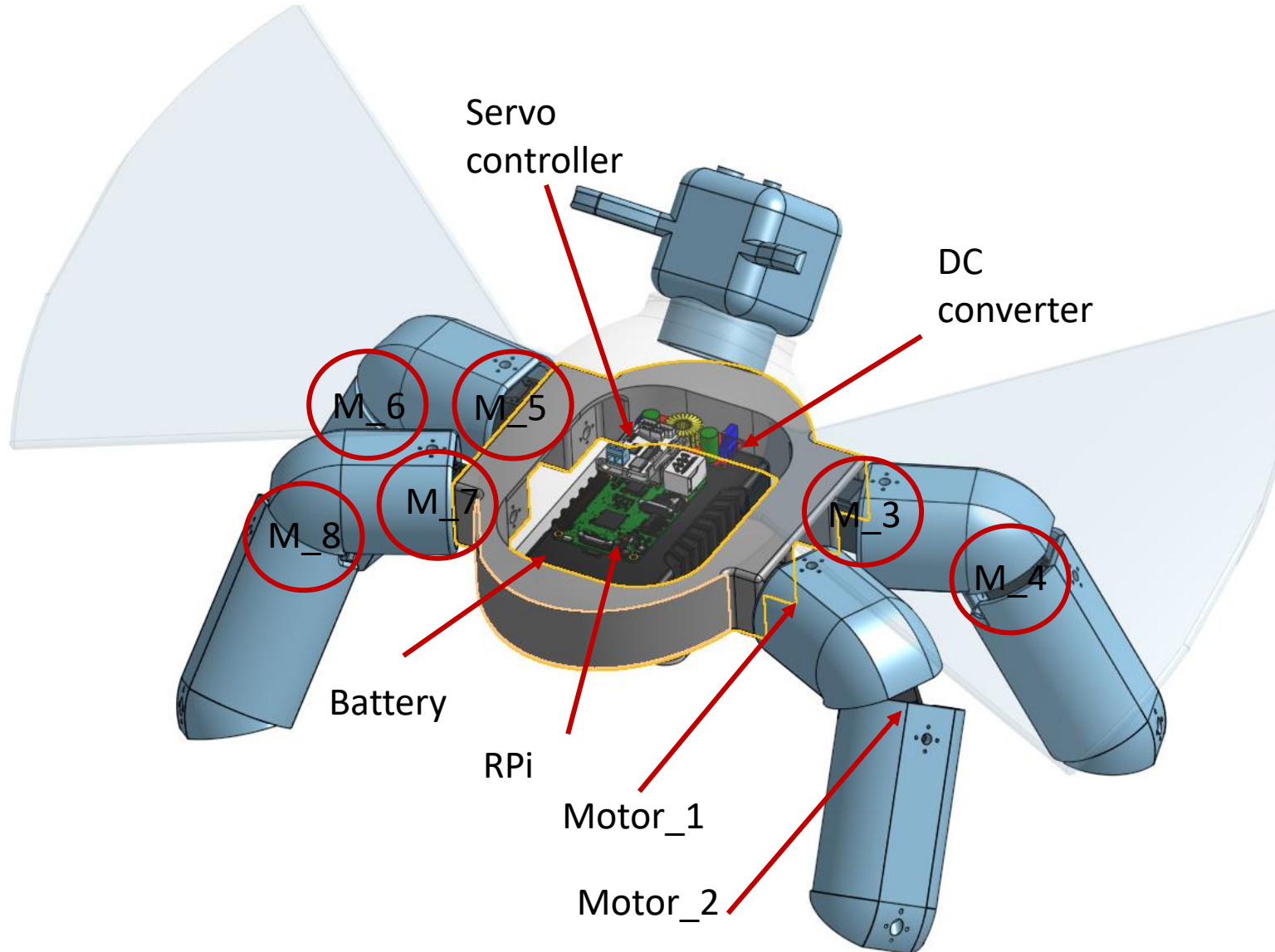


# Poodle Moth Render

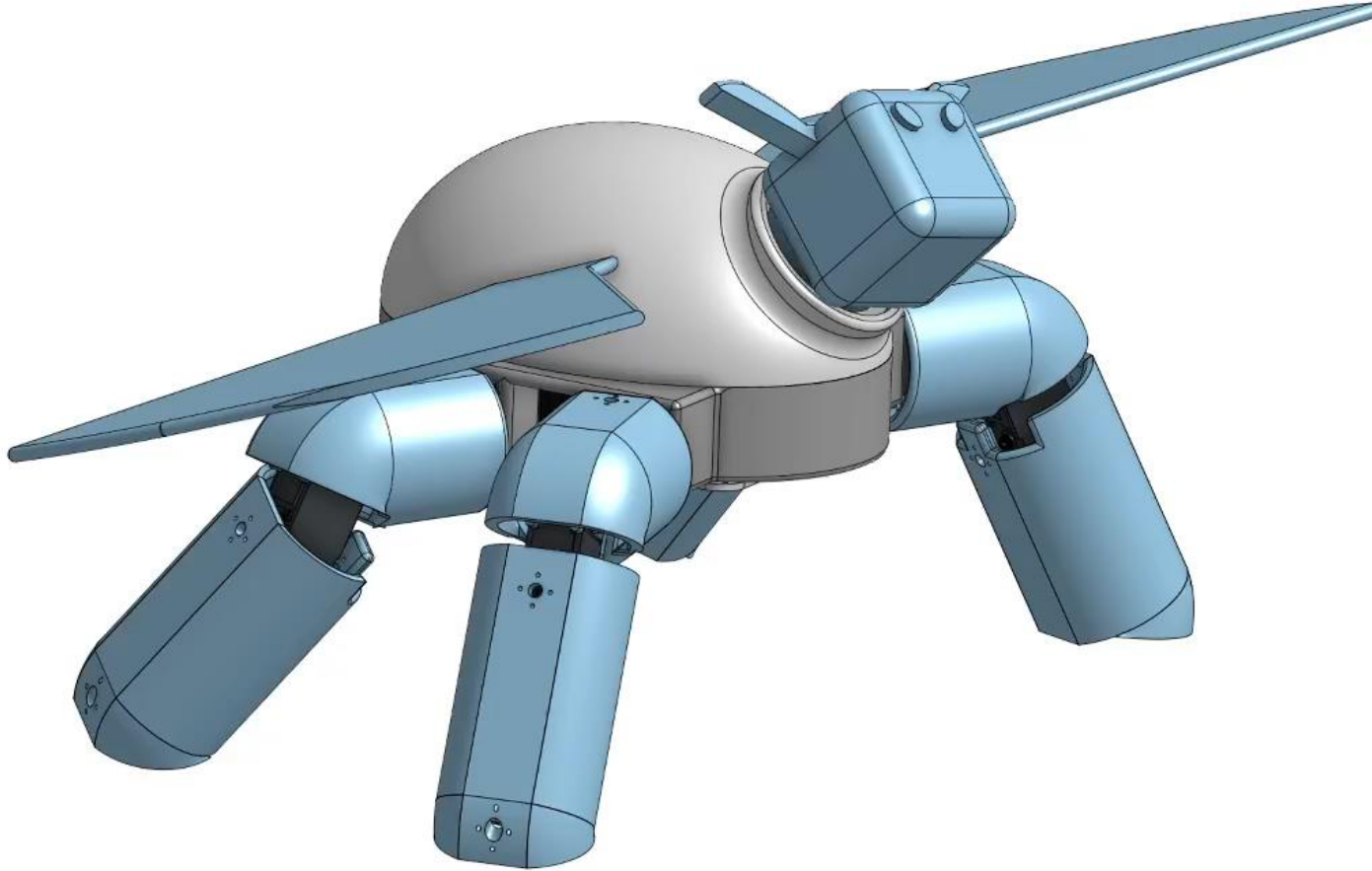




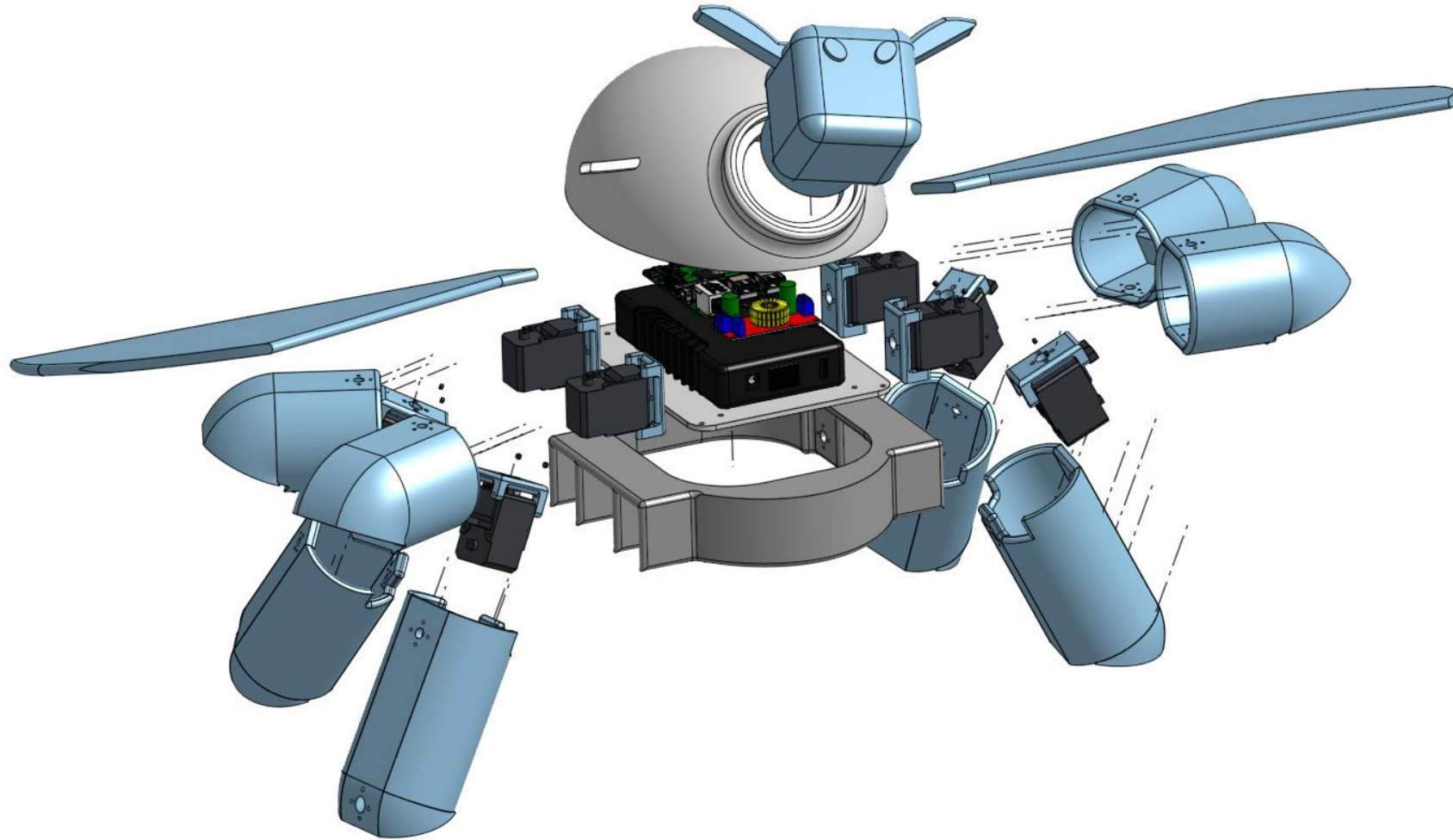
# Poodle Moth Key Components



# 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

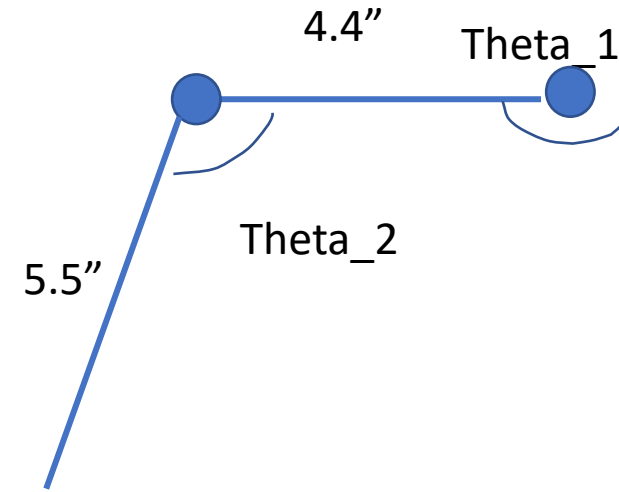
Z

-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"

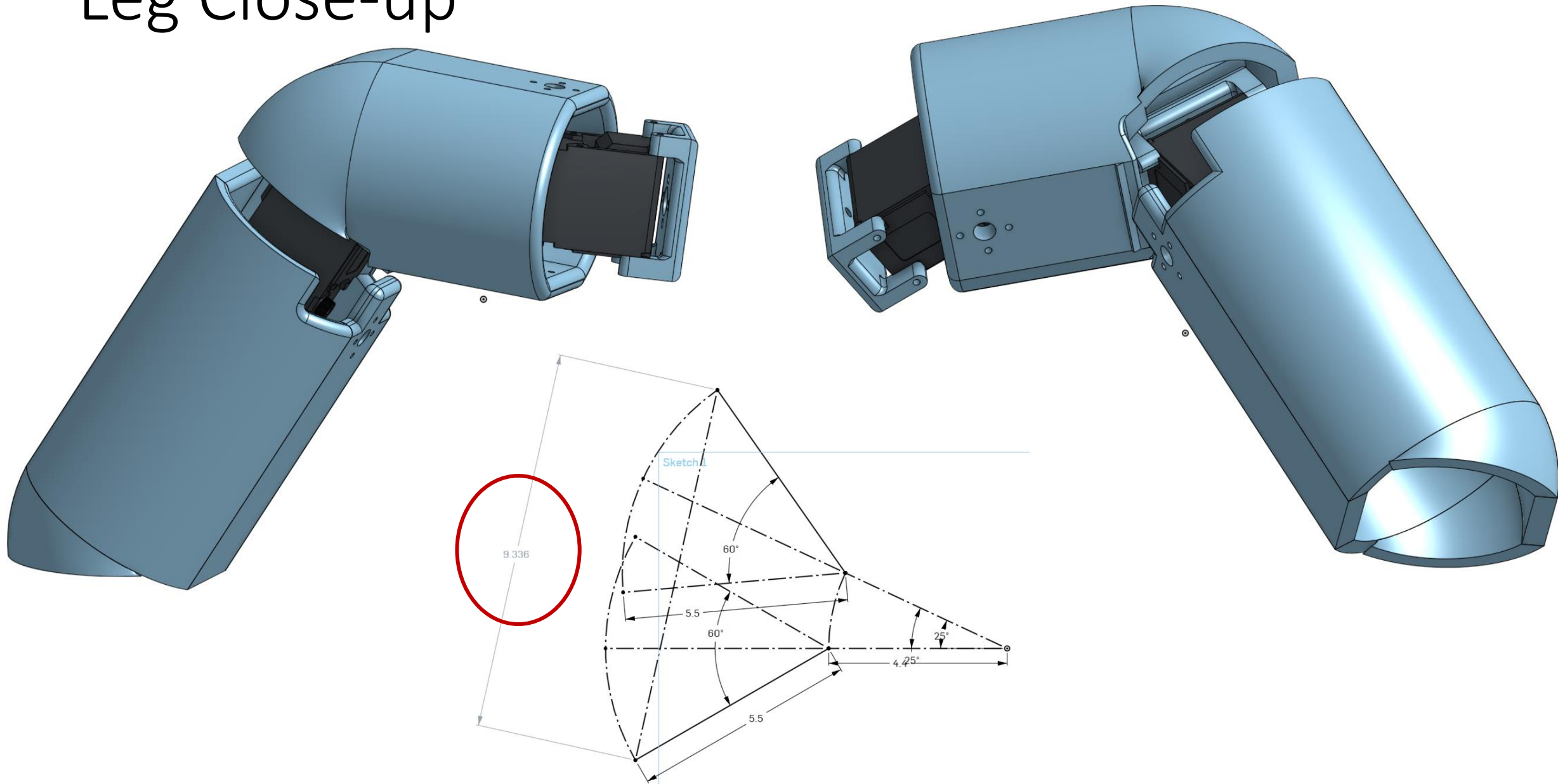
Motor rotation for stride: 60 deg

Strides/minute: 120

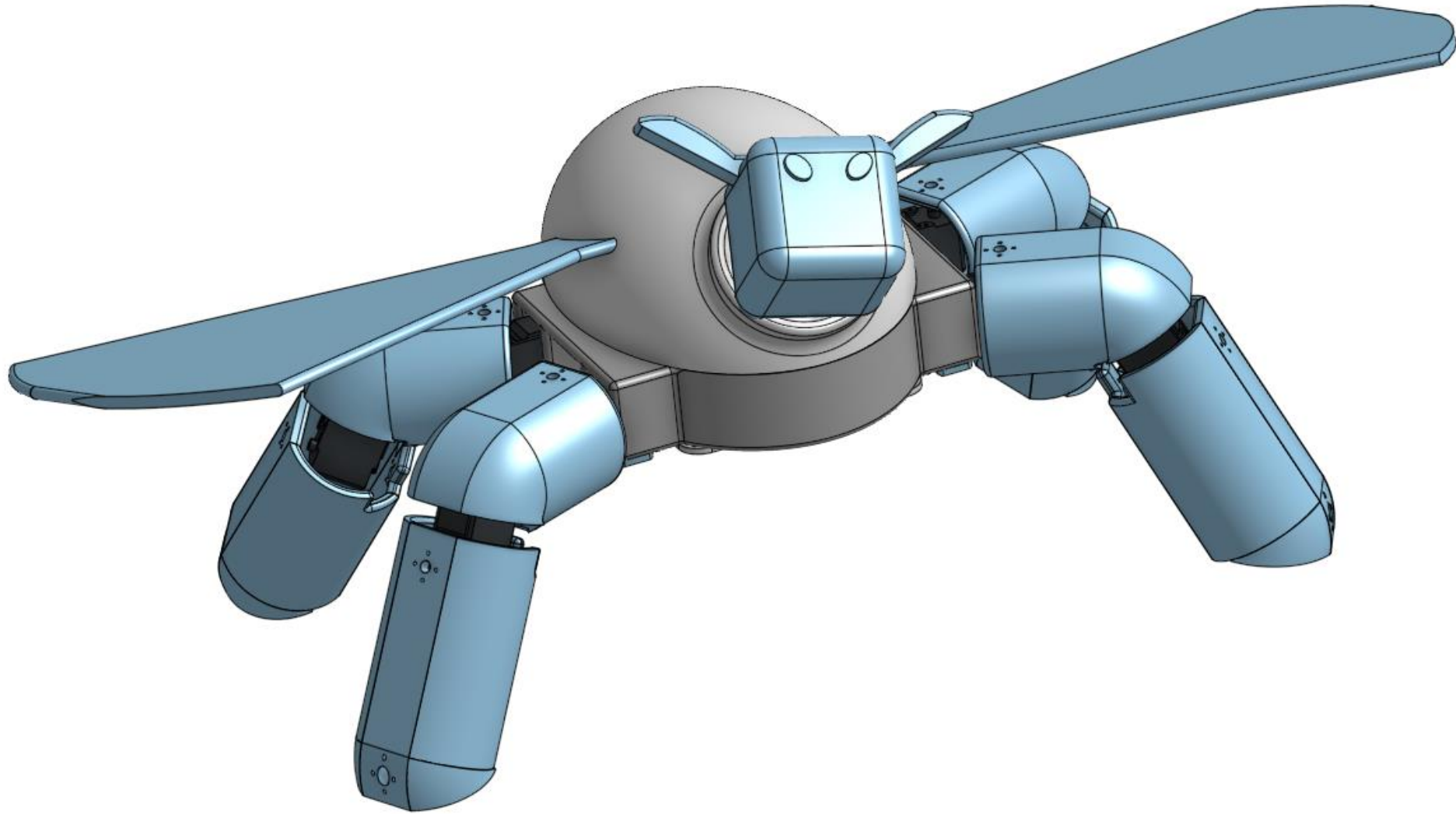
Walking speed: 3" / s



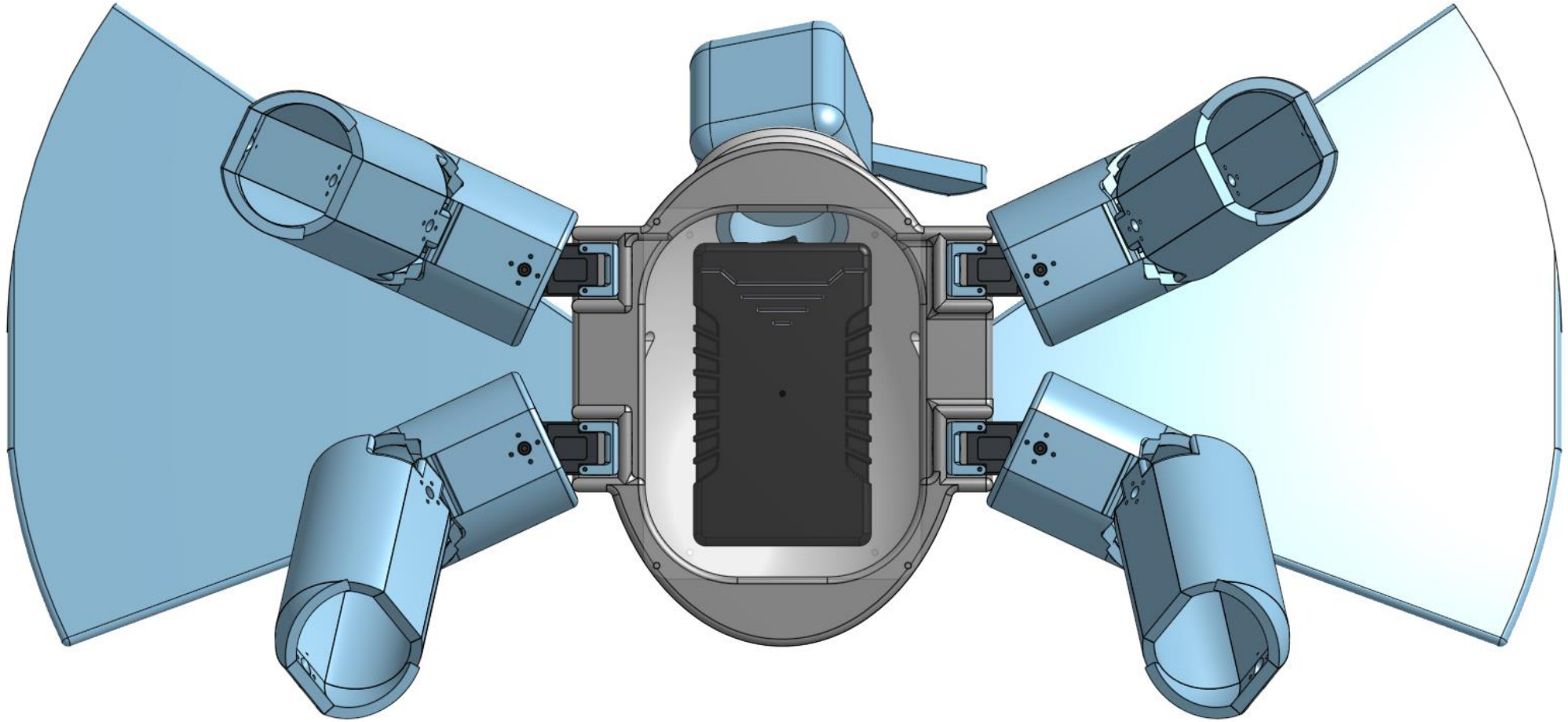
# Leg Close-up



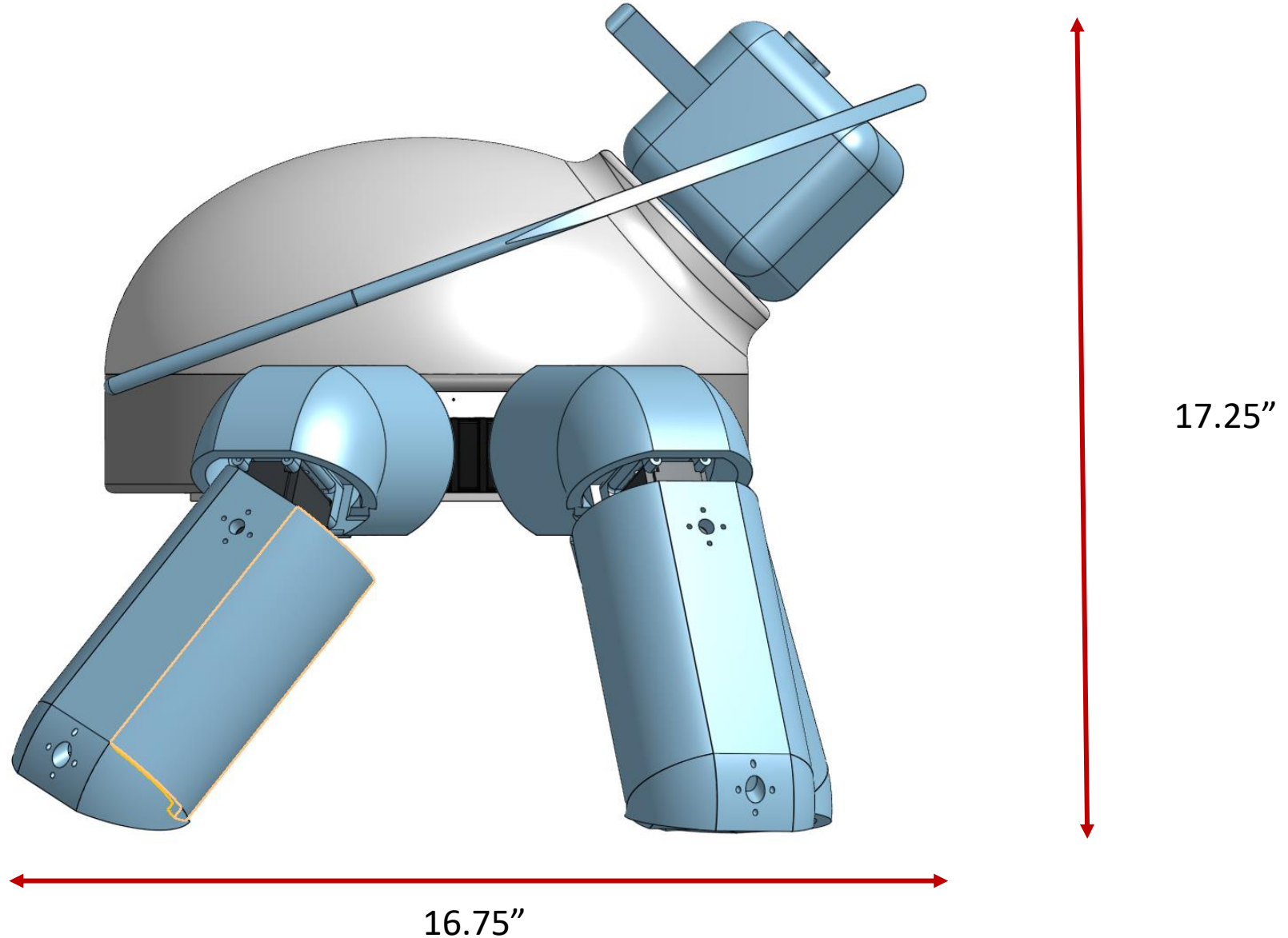
# Poodle Moth Front View



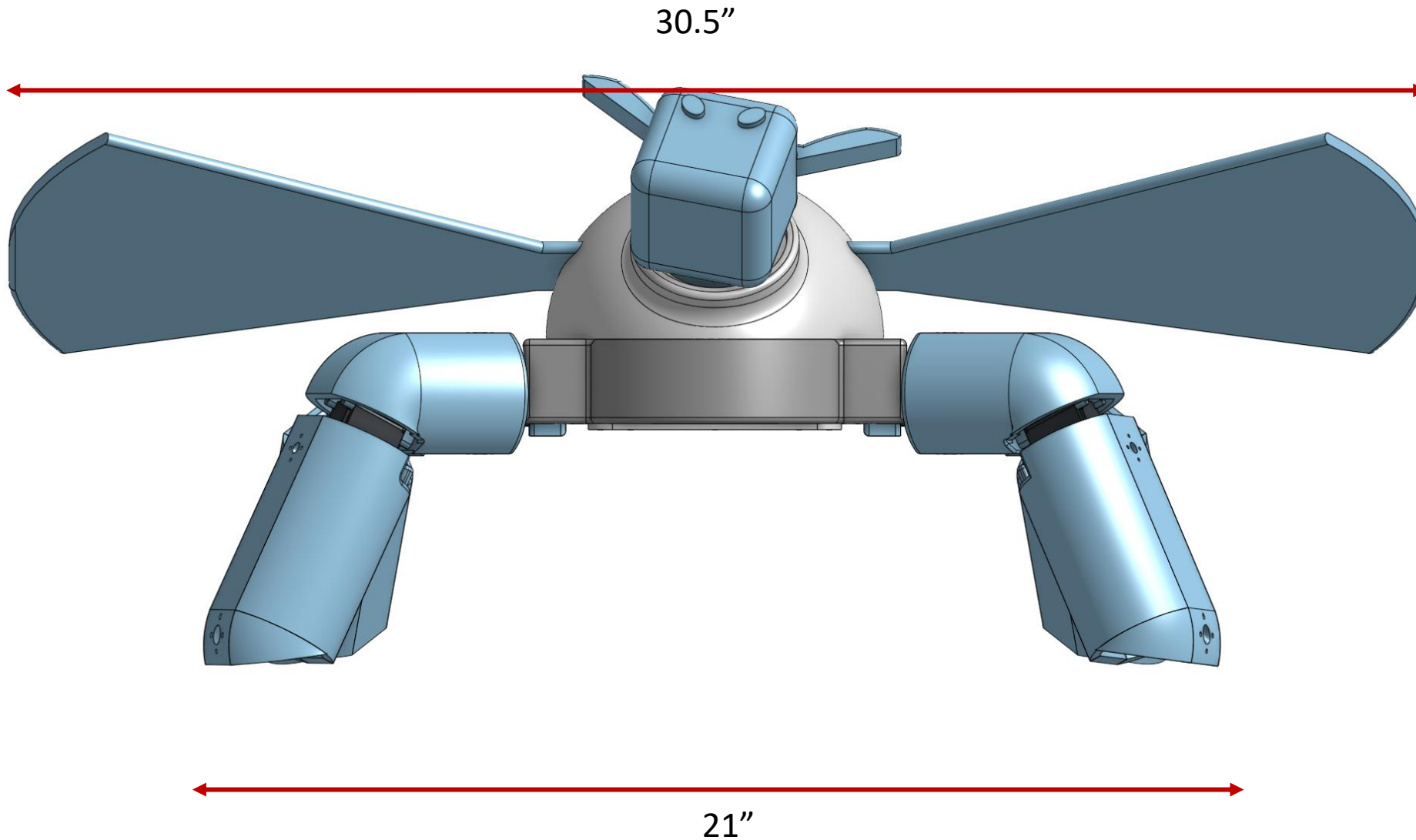
# Poodle Moth Bottom View



# Side View with Dimensions



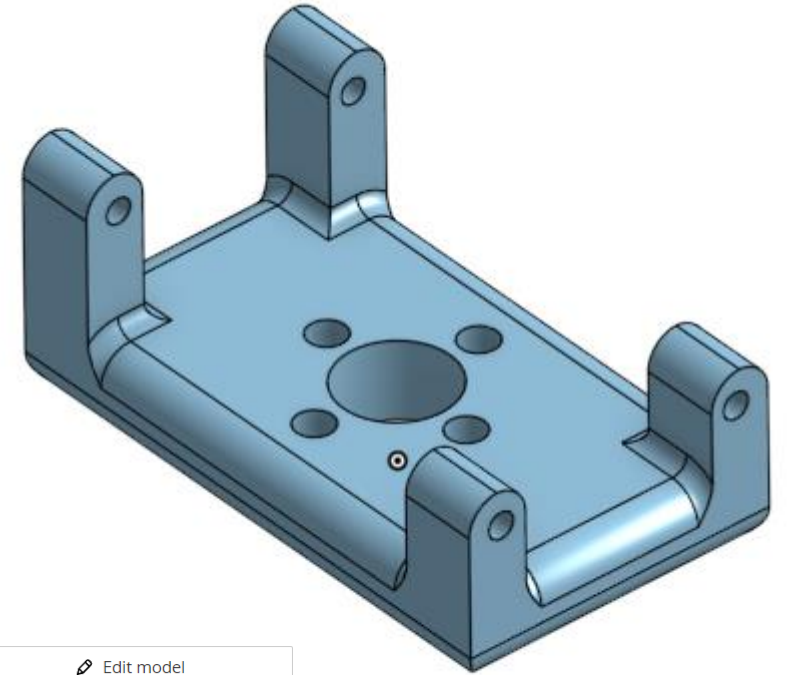
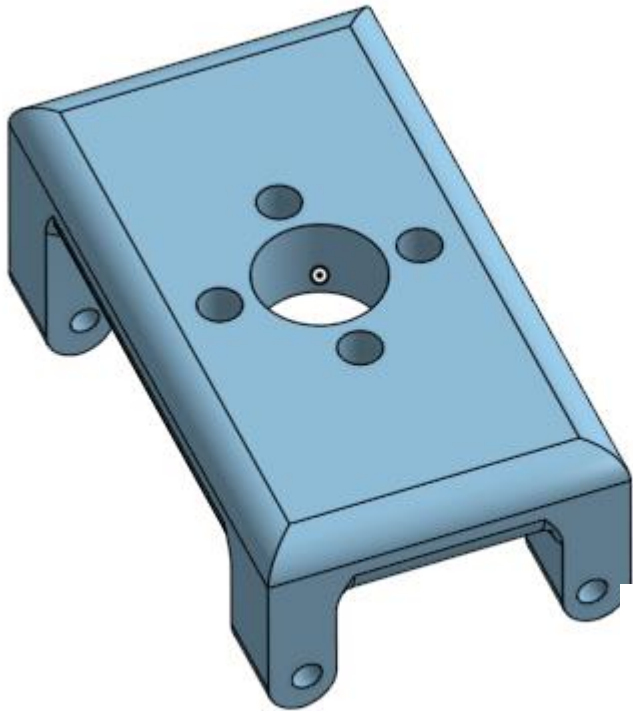
# Side View with Dimensions





# GrabCAD component: LX16A bottom bracket

- [https://grabcad.com/library/lx16a\\_servo\\_bottom\\_bracket-1](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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