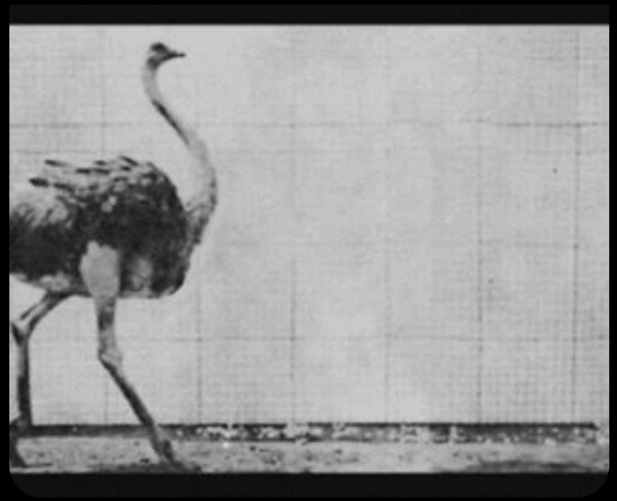


Ostrich Legs

Contributors
Chloe Fox(Hannah Brown), Princess Colon, Deepit Arora, Arya Patel

Overview of Assignment 1

- Project Definition
  - How the gait and stride of the ostrich can change by using two four-bar linkages to represent the knee and ankle.
    - Leg weight
    - Phase Differences
    - Frequency
- Background Research
  - Through the use of multiple sources we determined that the four-bar linkage can affect the overall gait and swing power of an ostrich-like robot.
  - Bipedal robots are not novel but being made from foldable materials is.
- Specifications Table
  - On the right.

Parameter	Unit			Value Range
Total Mass	kg			90-136
Tibiotarsus Length	mm			500-530
Tarsometatarsus Length	mm			450-490
Hip Joint (X, Y, Z)	Degrees	-45 to 45	-45 to 45	-65 to 10
Knee Joint (X, Y, Z)	Degrees	-45 to 45	-45 to 45	-180 to 10
Ankle Joint (X, Y, Z)	Degrees	-45 to 45	-10	-10 to 180
Walking Force	Body Weight Normalization			1.12 ± 0.290
Running Force	Body Weight Normalization			2.14 ± 0.540
Functional Surface Area of Foot	cm^2			144.9 ± 7.6

Fig.1 : Specifications Table

Overview of Assignment 1 cont

- First Prototype

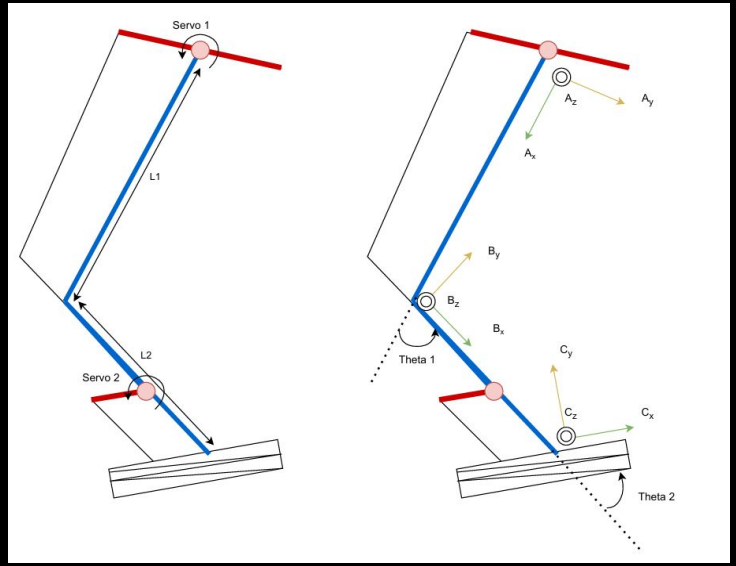


Fig.2 : Vector Drawing of First Prototype

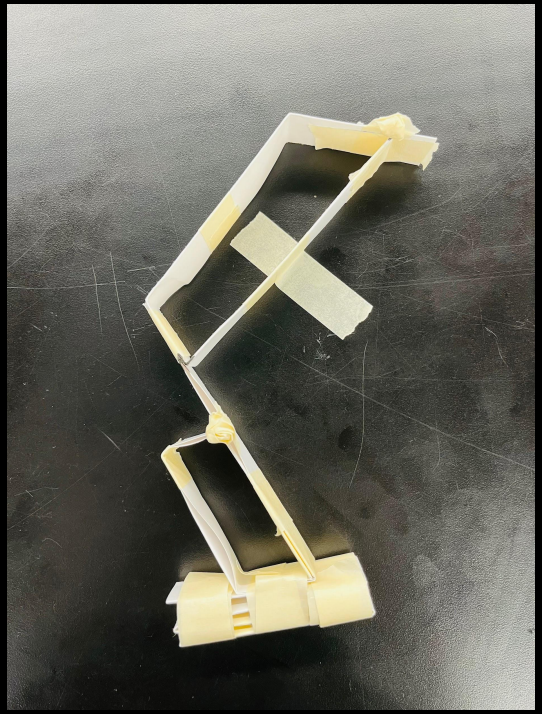


Fig.3 : First Prototype

System model evolution

- The ostrich legs is made up of two four-bar linkage
  - Version 1 and Version 2 are easier to see with this
  - Current version has the first linkage in the same spot, while the second one is now taller than the first
    - One motor will be where the black and red bar meets and the other will be using a string to lift as a knee joint on the four-bar.
    - These two motors will be working at the same time for each leg

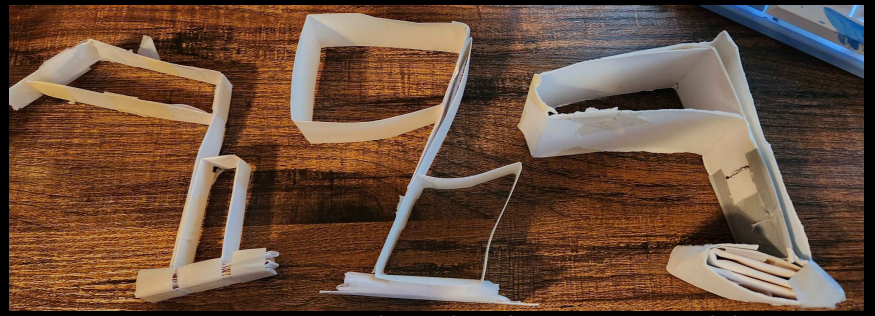


Fig.4 : Past prototypes In the order of version 1, 2, and three

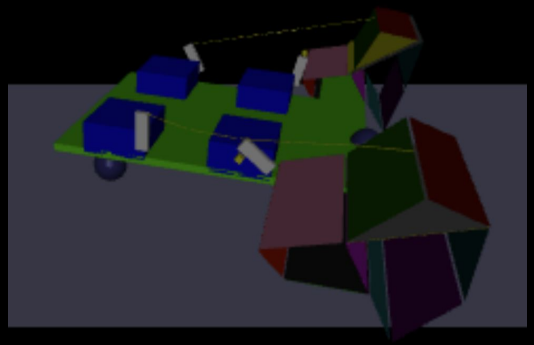


Fig. 5 : Current Model of our ostrich

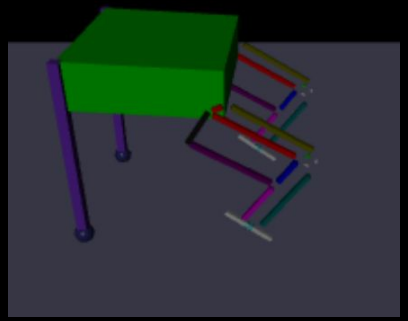


Fig. 6 : Old Model of our ostrich

System model continued

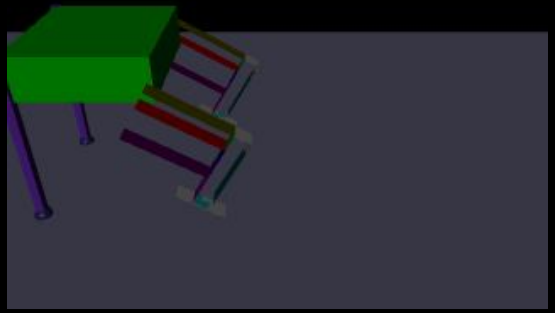


Fig.7 : Old Model of our ostrich moving

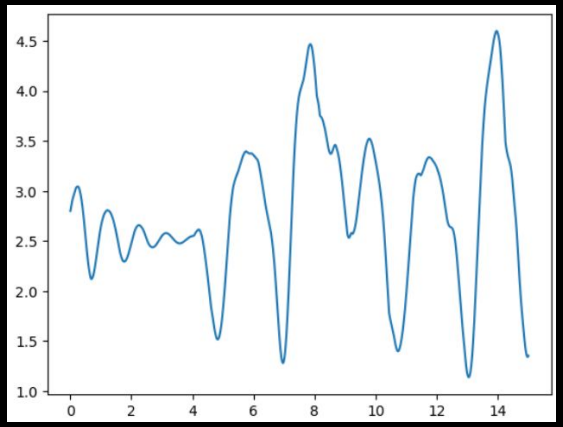


Fig.8 : Logged data of X position

Mujoco Model

- Leg Design:
  - Legs are made using 3 four-bar structures connected with a "knee-like" joint.
  - Four-bar 1 corresponds to Knee
  - Four-bar 2 corresponds to Ankle
  - Four-bar 3 transfers movement of ankle to "hip"
  - Design moves weight of servos closer to center of mass
- Features:
  - XML formatting for link lengths and key properties
  - Displays distance traveled in x-axis as a function of time
- Parameters:
  - Experimental Friction constant applied to feet
  - Approximate dimensions of DXF file
  - Frictionless wheels

Plan and Execute the Manufacturing

- Plan of Action
  - Create the DXF file on LibreCAD
  - Follow the guide given to create the multi-layer manufacturing process
  - Use the laser cutter that we learned about in the innovation hub
  - Fold the laminated ostrich leg and attach the motors and the body
  - Start Testing immediately after connecting the ESP32

- What has actually happened
  - LibreCAD was used to create the DXF file
  - Followed the code to generate the layers
  - Use the vinyl cutter to cut the rigid
  - Next day use the laser and complete the lamination process
  - Build the robot and attach the motors and ESP32
    - Setbacks happened when the small 4-bar would not move properly

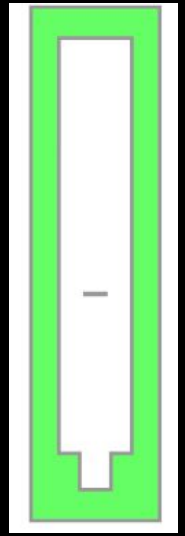


Fig.6 : Final cut in JupyterLab

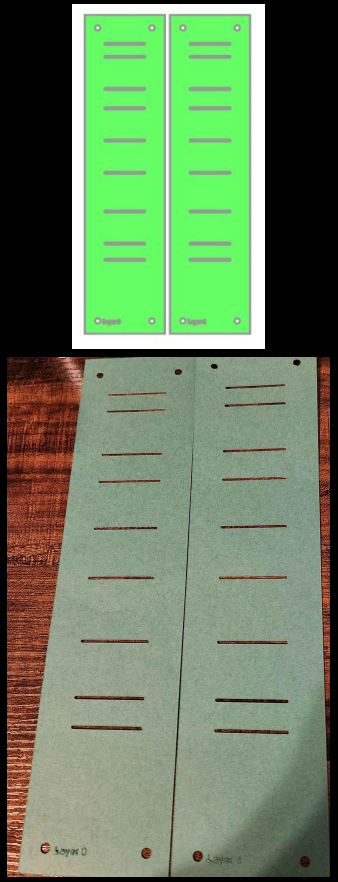


Fig.7 : Layers 0 and 4 in JupyterLab code and in real life

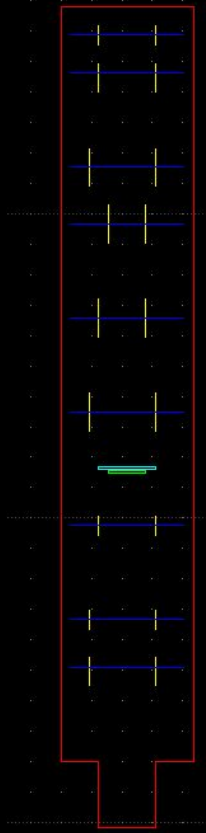


Fig.8 : DXF in LibreCAD

Plan and Execute the Manufacturing continued

- Behold the Ostrich

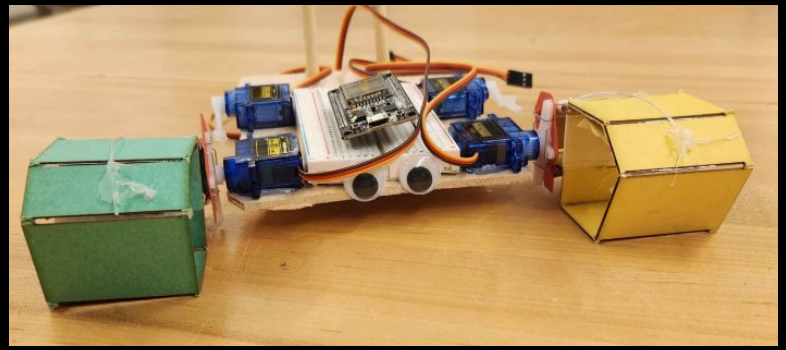


Fig. : First Built Ostrich

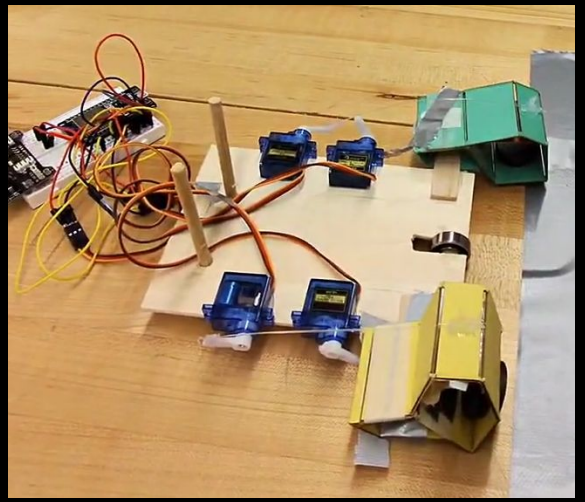


Fig. : Final Ostrich

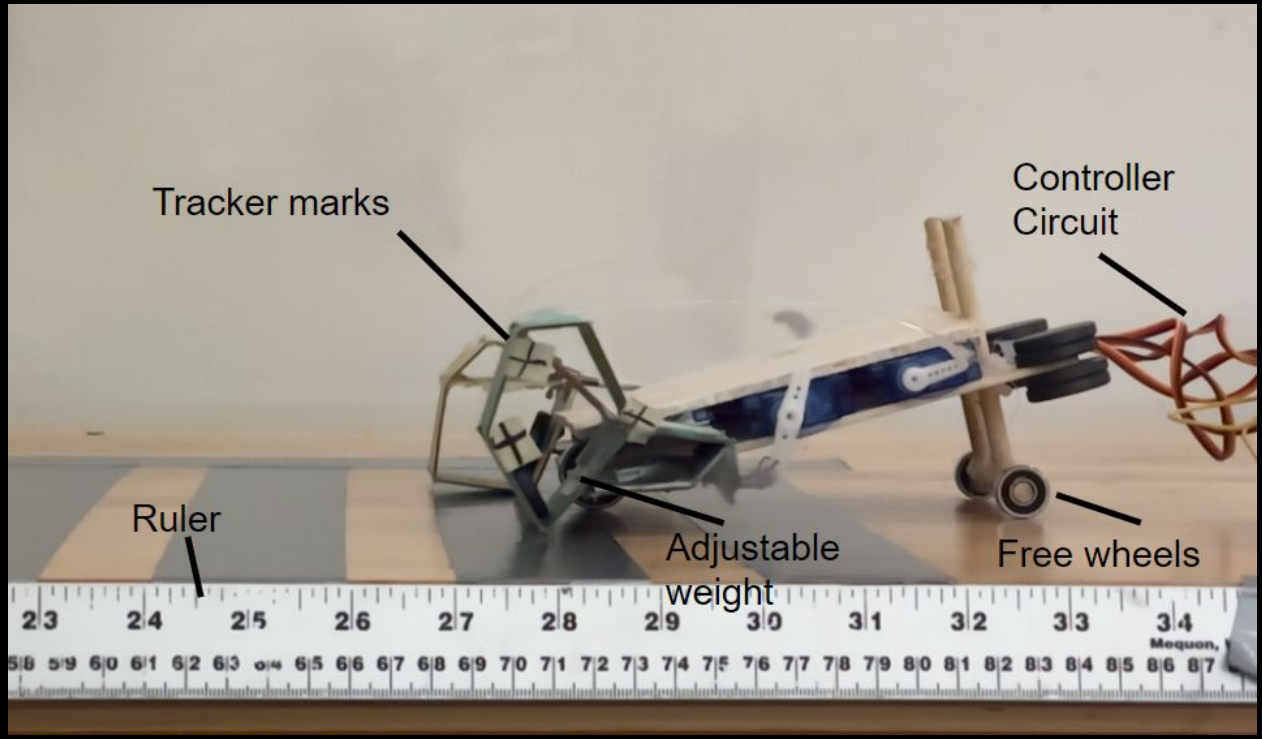
- Before the changes of motor
  - Went through 3 different adjustments

- Final Change in the motor and horn
  - Created the rod used to move the small 4-bar

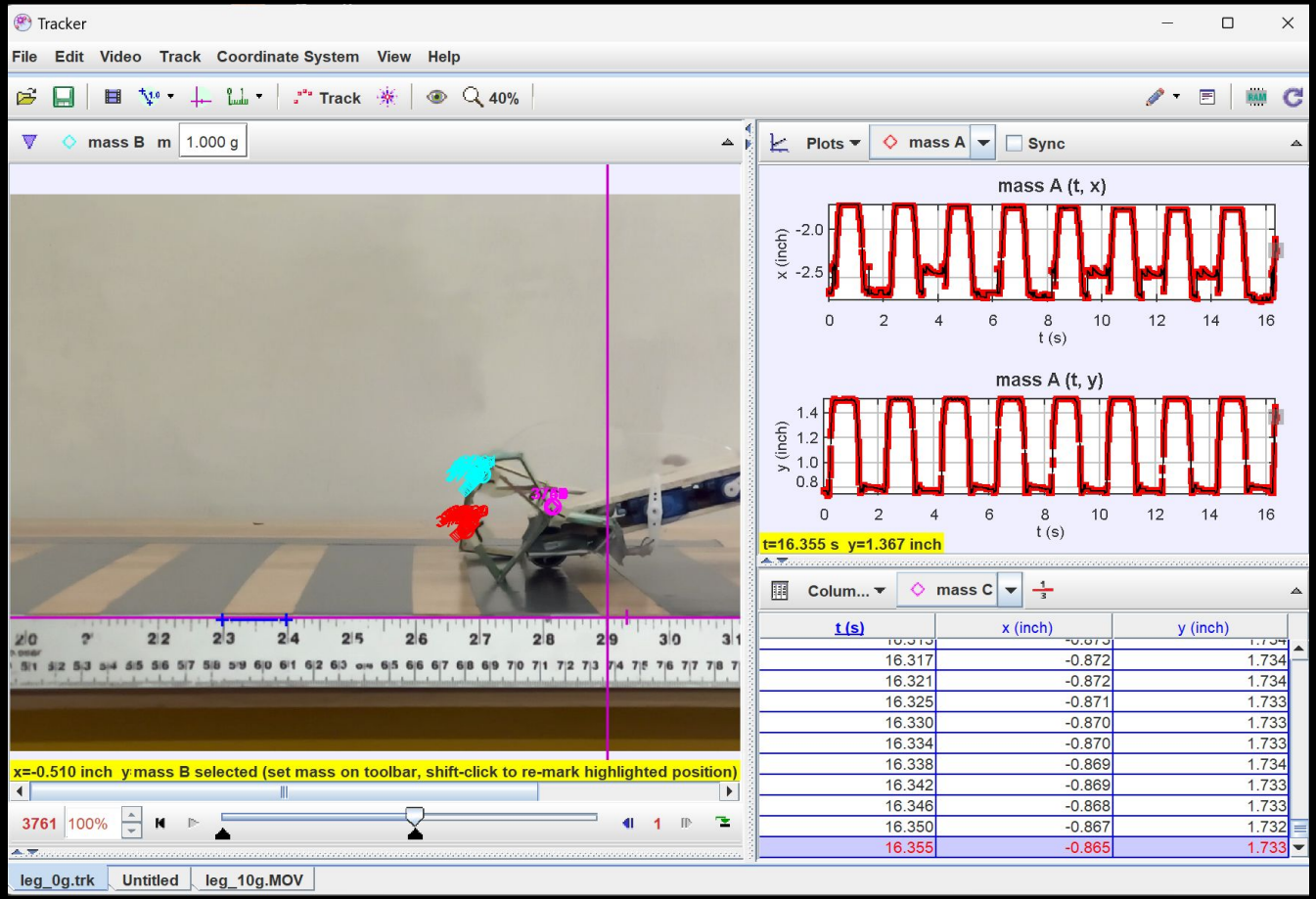
Experimental Validation and Analysis

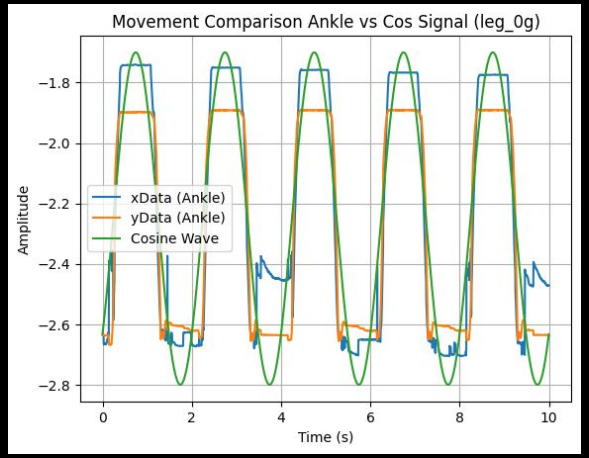
- Plan of Action
  - Goal:
    - Design a gait which will allow the robot to travel the greatest amount of distance in a set period of time.
  - Assumptions:
    - Motion of each joint can be simulated using trig functions
    - Joint movement operates at the same frequency
    - Gait is a phase-shift of each joint relative to each other
  - Methodology:
    - Place robot into controlled environment
    - Implement the use of a photo tracker to measure distance over time
    - Modify phase-shift of each joint, taking into account speed of distance traveled
    - Compare perceived optimized gait with simulated gait

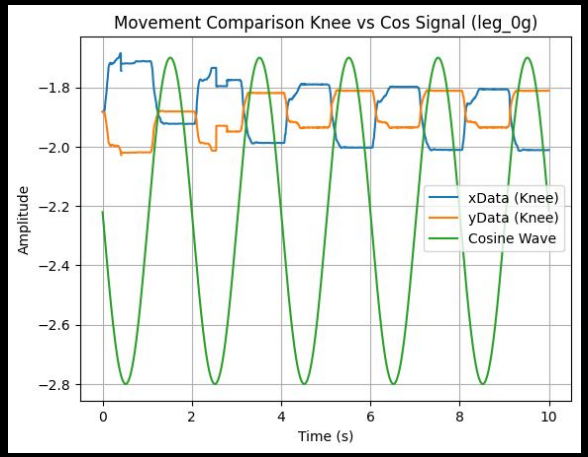
Testing

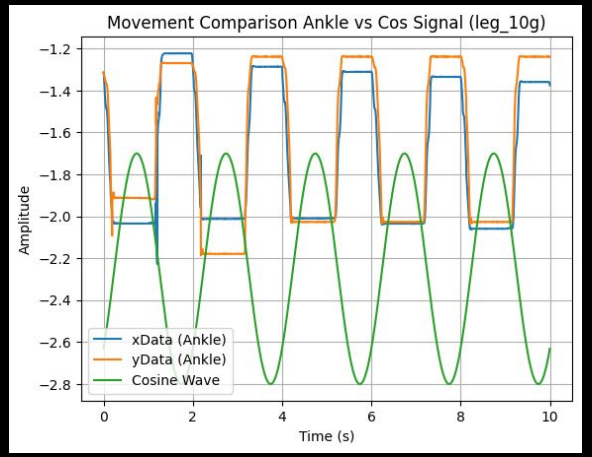

Tracker marks
Controller Circuit
Ruler
Adjustable weight
Free wheels

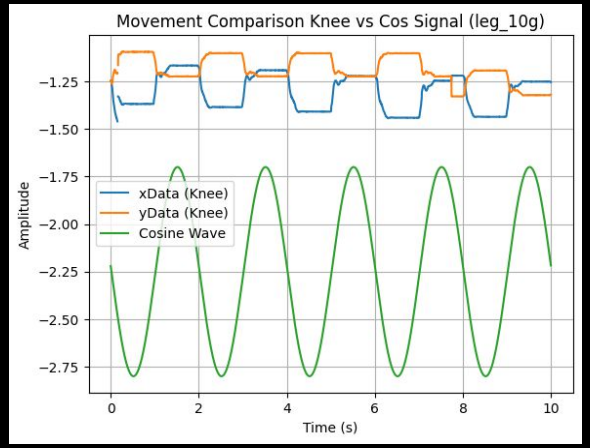
Tracker

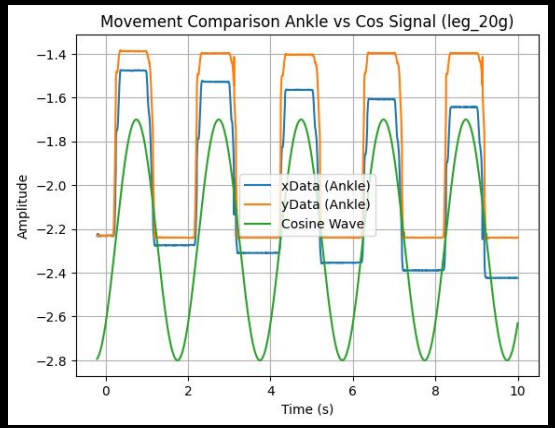

Tracker
File Edit Video Track Coordinate System View Help
Track
40%
mass B m 1.000 g
Plots mass A Sync
mass A (t, x)
x (inch)
-2.0
-2.5
0 2 4 6 8 10 12 14 16
t (s)
mass A (t, y)
y (inch)
1.4
1.2
1.0
0.8
0 2 4 6 8 10 12 14 16
t (s)
t=16.355 s y=1.367 inch
Colum... mass C
t (s) x (inch) y (inch)
16.317 -0.872 1.734
16.321 -0.872 1.734
16.325 -0.871 1.733
16.330 -0.870 1.733
16.334 -0.870 1.733
16.338 -0.869 1.734
16.342 -0.869 1.733
16.346 -0.868 1.733
16.350 -0.867 1.732
16.355 -0.865 1.733
x=-0.510 inch y=mass B selected (set mass on toolbar, shift-click to re-mark highlighted position)
3761 100%
leg_0g.trk Untitled leg_10g.MOV

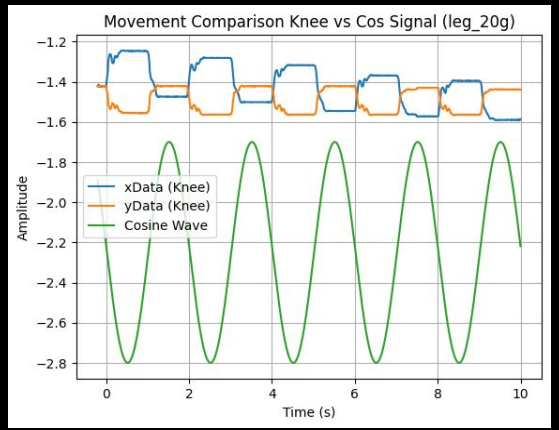

Movement Comparison Ankle vs Cos Signal (leg_0g)
xData (Ankle)
yData (Ankle)
Cosine Wave
Amplitude
Time (s)

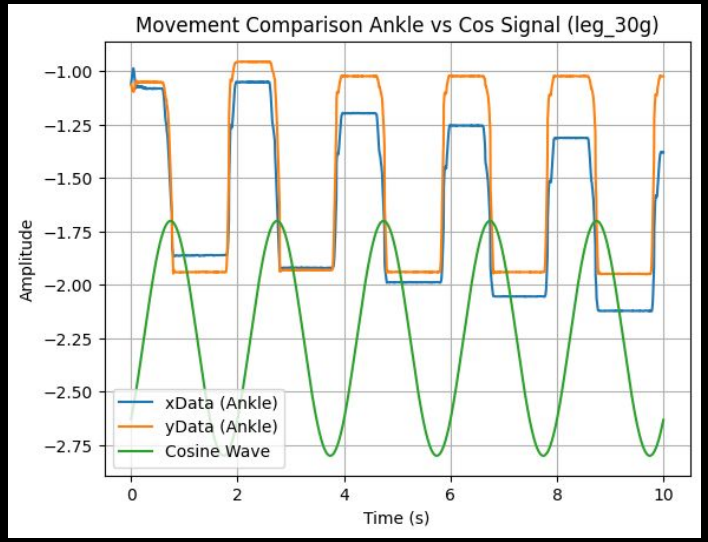

Movement Comparison Knee vs Cos Signal (leg_0g)
xData (Knee)
yData (Knee)
Cosine Wave
Amplitude
Time (s)

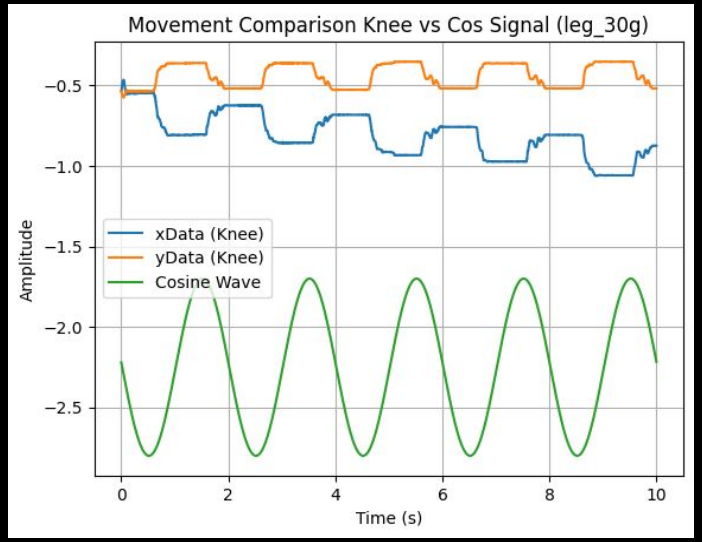

Movement Comparison Ankle vs Cos Signal (leg_10g)
xData (Ankle)
yData (Ankle)
Cosine Wave
Amplitude
Time (s)

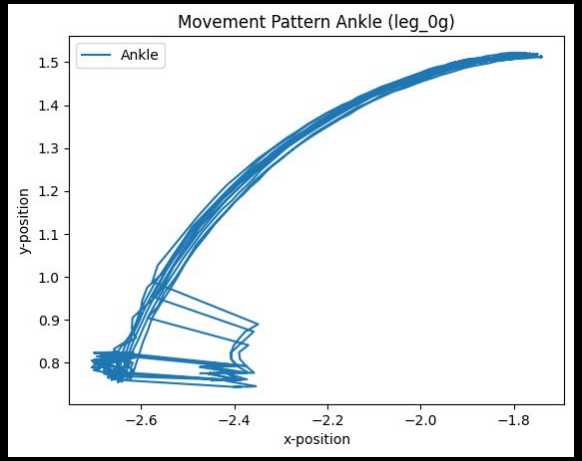

Movement Comparison Knee vs Cos Signal (leg_10g)
xData (Knee)
yData (Knee)
Cosine Wave
Amplitude
Time (s)

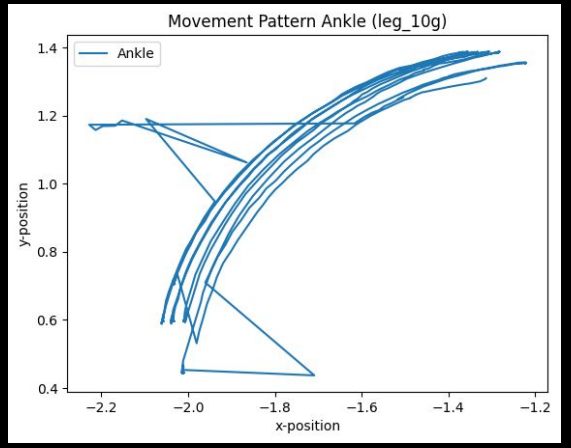

Movement Comparison Ankle vs Cos Signal (leg_20g)
xData (Ankle)
yData (Ankle)
Cosine Wave
Amplitude
Time (s)

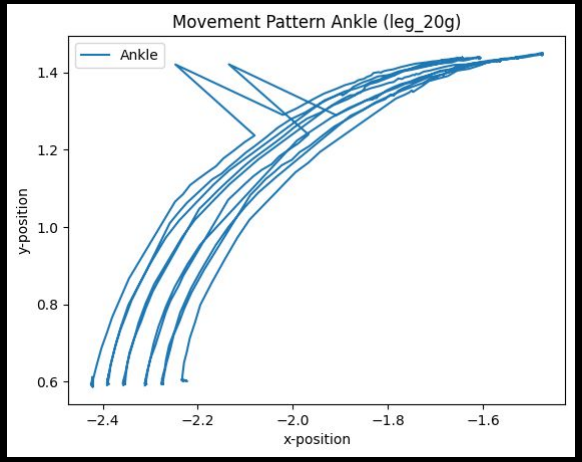

Movement Comparison Knee vs Cos Signal (leg_20g)
xData (Knee)
yData (Knee)
Cosine Wave
Amplitude
Time (s)

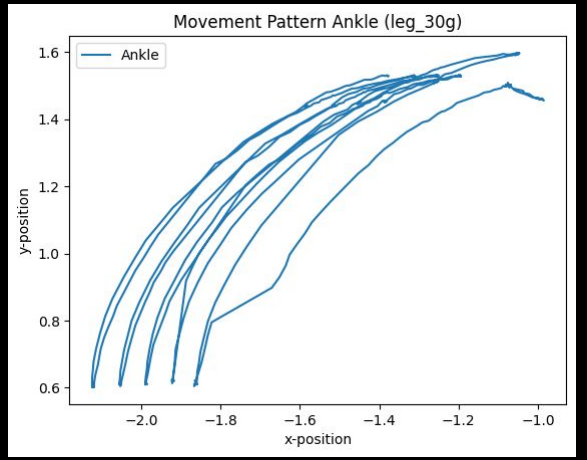

Movement Comparison Ankle vs Cos Signal (leg_30g)
Amplitude
Time (s)
xData (Ankle)
yData (Ankle)
Cosine Wave

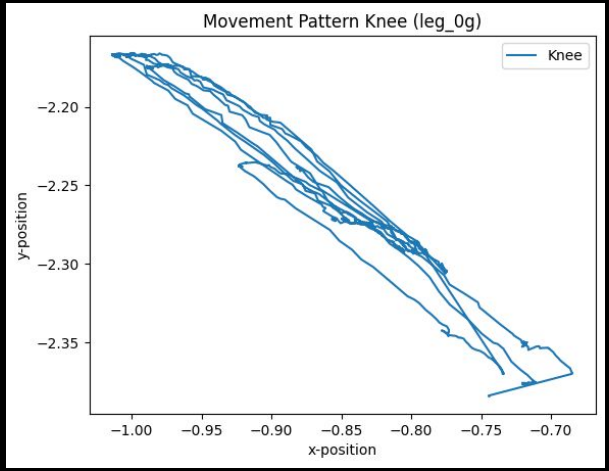

Movement Comparison Knee vs Cos Signal (leg_30g)
Amplitude
Time (s)
xData (Knee)
yData (Knee)
Cosine Wave

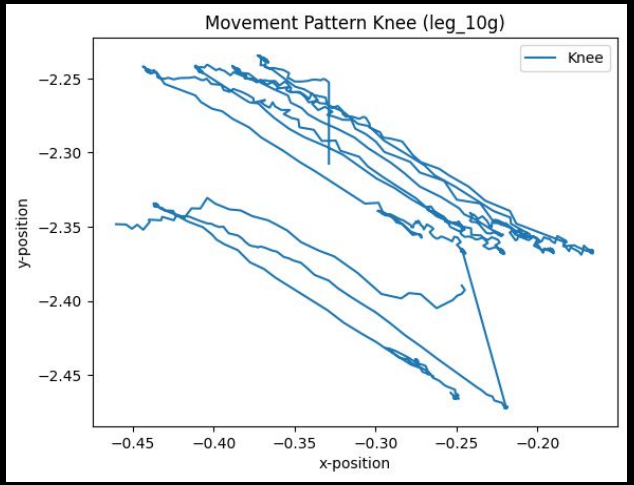

Movement Pattern Ankle (leg_0g)
Ankle
y-position
x-position

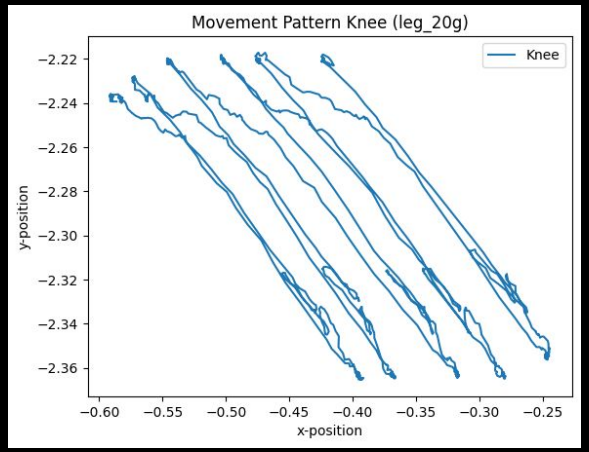

Movement Pattern Ankle (leg_10g)
Ankle
y-position
x-position

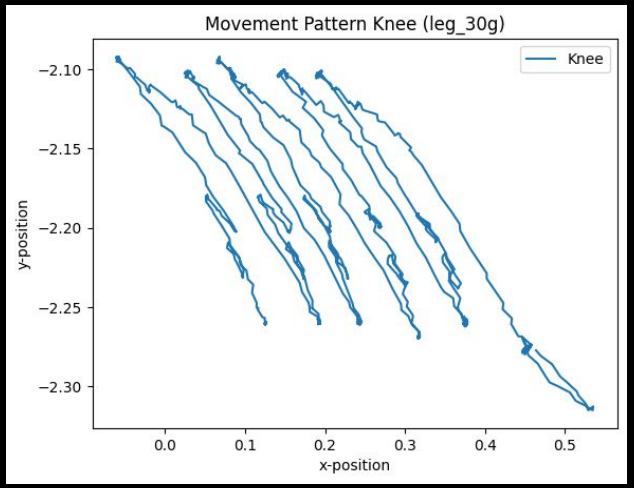

Movement Pattern Ankle (leg_20g)
Ankle
y-position
x-position


Movement Pattern Ankle (leg_30g)
Ankle
y-position
x-position


Movement Pattern Knee (leg_0g)
Knee
y-position
x-position
−2.20
−2.25
−2.30
−2.35
−1.00
−0.95
−0.90
−0.85
−0.80
−0.75
−0.70


Movement Pattern Knee (leg_10g)
Knee
y-position
x-position
−2.25
−2.30
−2.35
−2.40
−2.45
−0.45
−0.40
−0.35
−0.30
−0.25
−0.20


Movement Pattern Knee (leg_20g)
Knee
y-position
x-position
−2.22
−2.24
−2.26
−2.28
−2.30
−2.32
−2.34
−2.36
−0.60
−0.55
−0.50
−0.45
−0.40
−0.35
−0.30
−0.25


Movement Pattern Knee (leg_30g)
Knee
y-position
x-position
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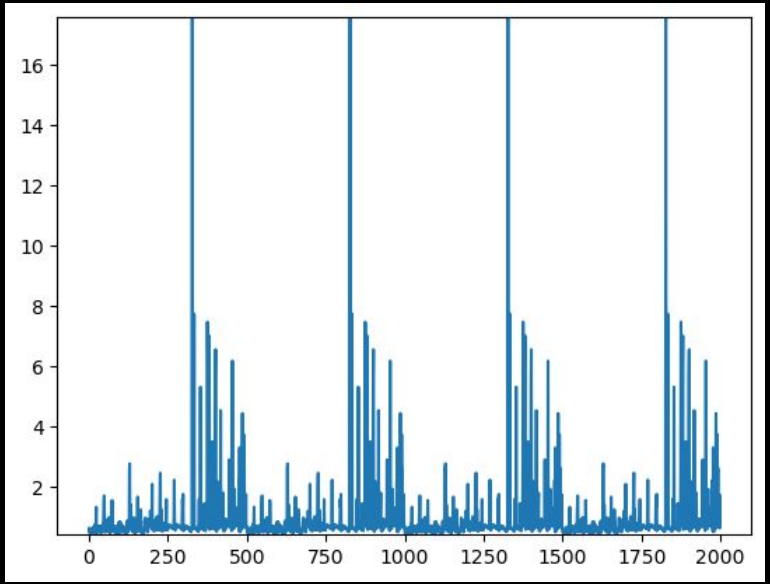
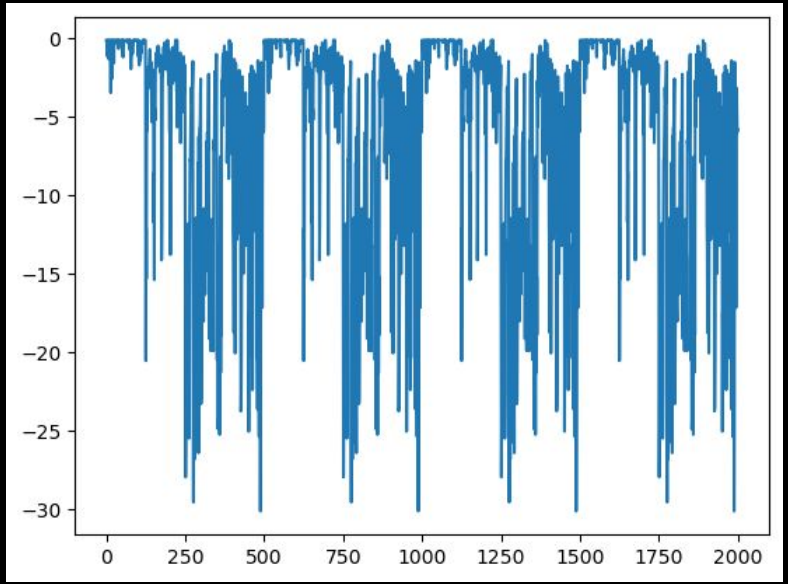
−2.15
−2.20
−2.25
−2.30
0.0
0.1
0.2
0.3
0.4
0.5


16
14
12
10
8
6
4
2
0
250
500
750
1000
1250
1500
1750
2000


0
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−10
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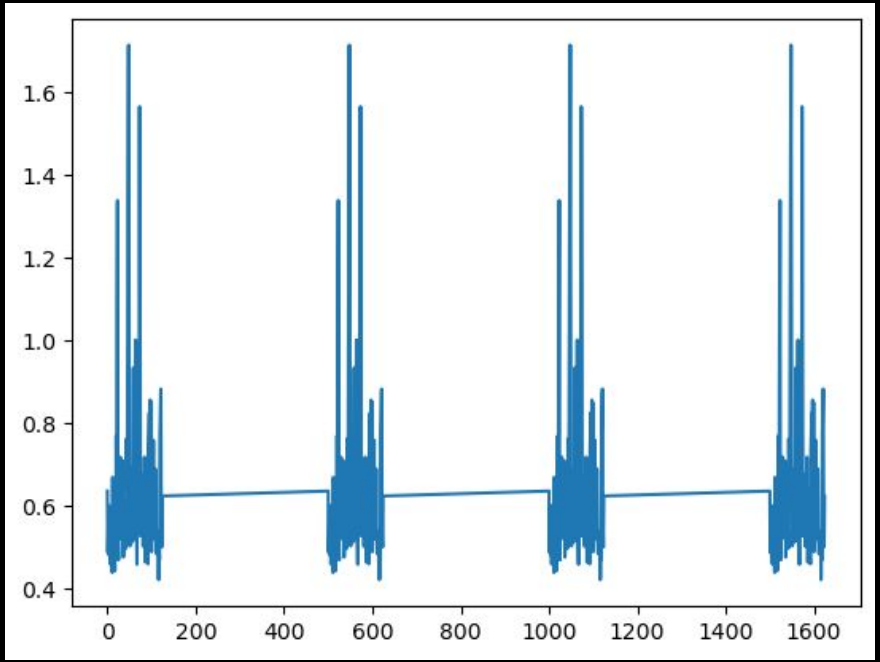
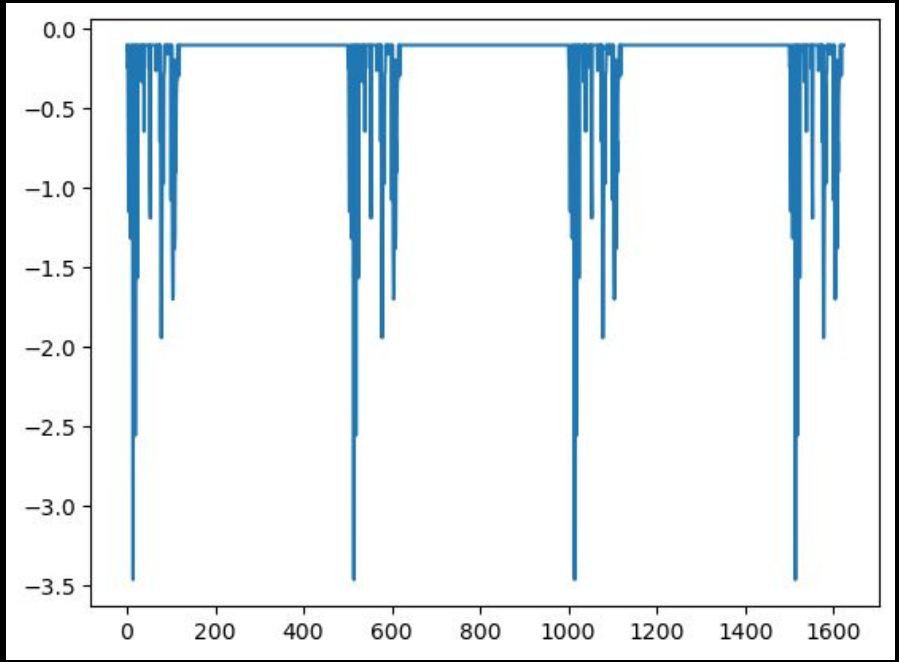
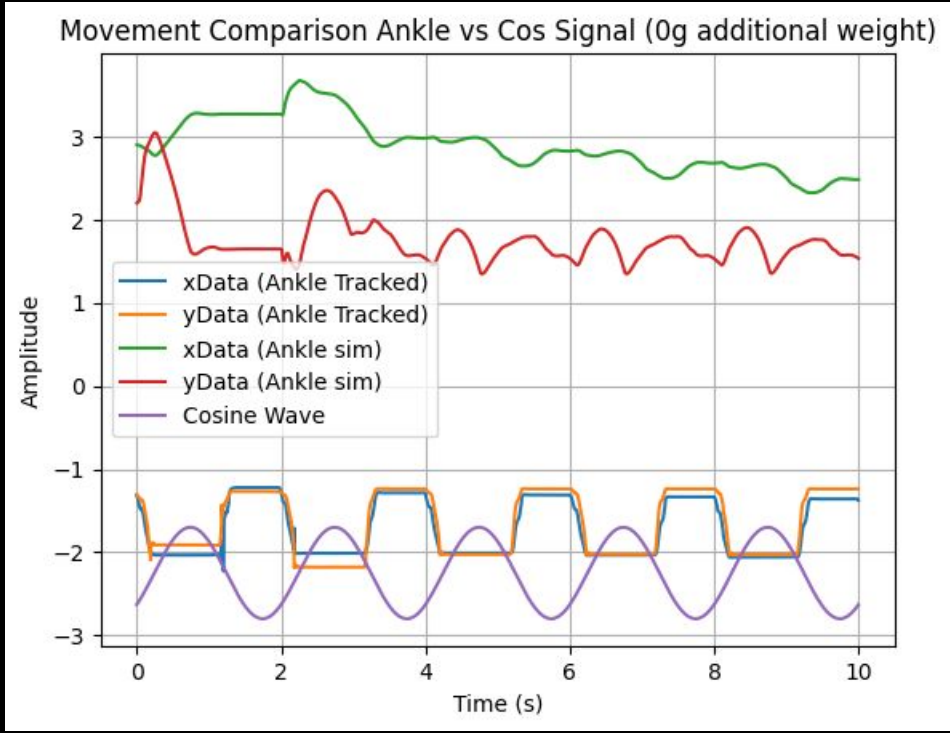
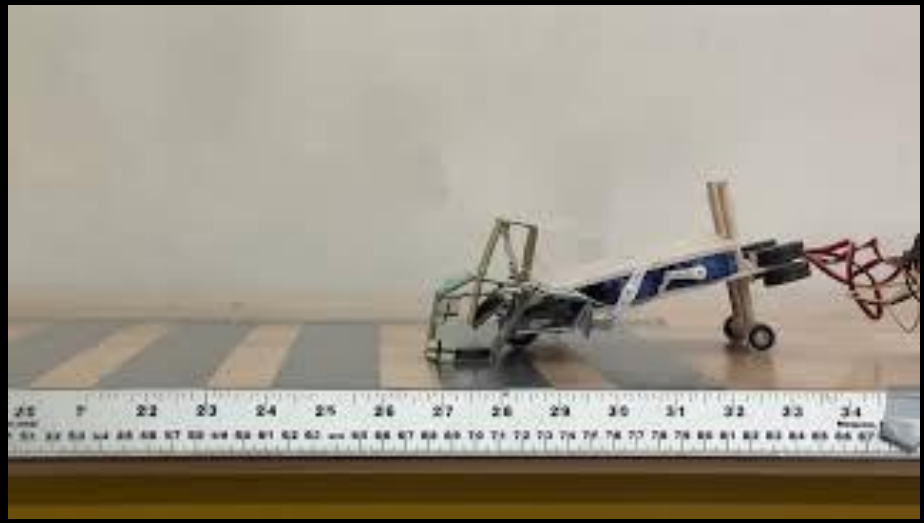
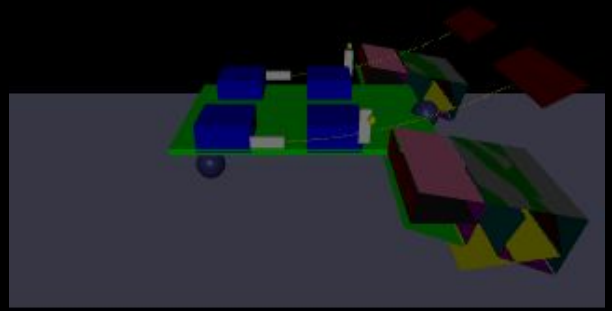
−25
−30
0
250
500
750
1000
1250
1500
1750
2000

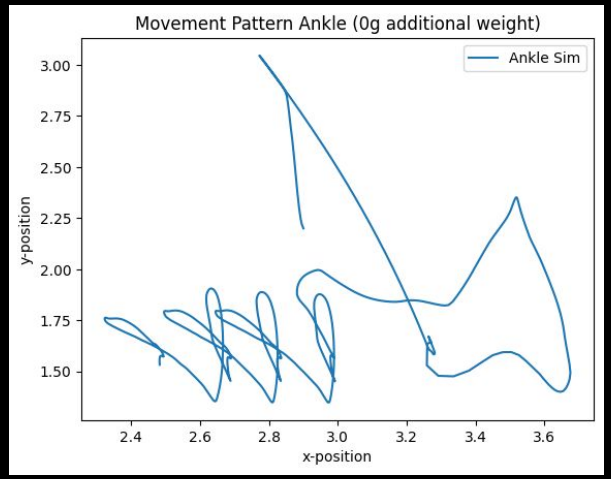

1.6
1.4
1.2
1.0
0.8
0.6
0.4
0
200
400
600
800
1000
1200
1400
1600

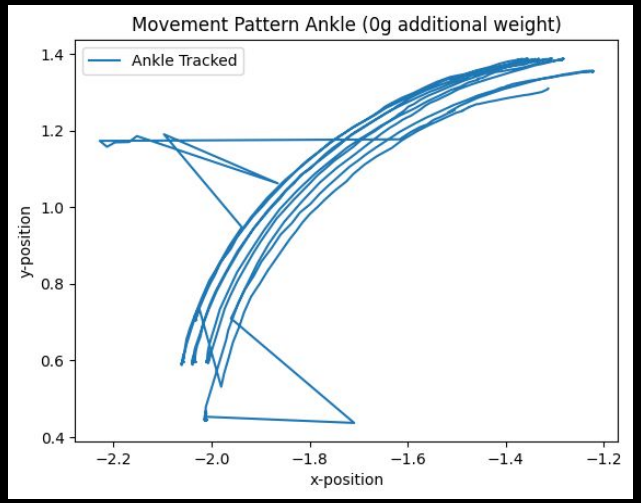

0.0
−0.5
−1.0
−1.5
−2.0
−2.5
−3.0
−3.5
0
200
400
600
800
1000
1200
1400
1600

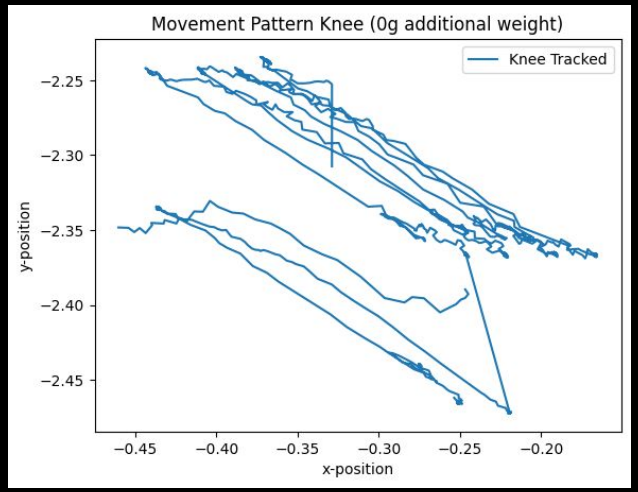

Movement Comparison Ankle vs Cos Signal (0g additional weight)
xData (Ankle Tracked)
yData (Ankle Tracked)
xData (Ankle sim)
yData (Ankle sim)
Cosine Wave
Amplitude
Time (s)
3
2
1
0
−1
−2
−3
0
2
4
6
8
10

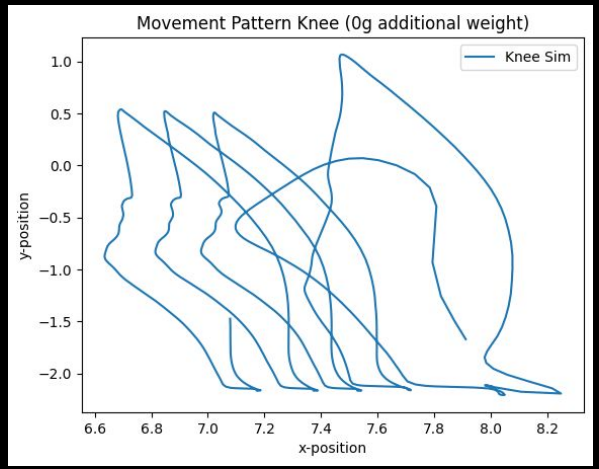





Movement Pattern Ankle (0g additional weight)
Ankle Sim
y-position
x-position
3.00
2.75
2.50
2.25
2.00
1.75
1.50
2.4
2.6
2.8
3.0
3.2
3.4
3.6


Movement Pattern Ankle (0g additional weight)
Ankle Tracked
y-position
x-position
1.4
1.2
1.0
0.8
0.6
0.4
−2.2
−2.0
−1.8
−1.6
−1.4
−1.2


Movement Pattern Knee (0g additional weight)
Knee Tracked
y-position
x-position
−2.25
−2.30
−2.35
−2.40
−2.45
−0.45
−0.40
−0.35
−0.30
−0.25
−0.20


Movement Pattern Knee (0g additional weight)
Knee Sim
y-position
x-position
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
6.6
6.8
7.0
7.2
7.4
7.6
7.8
8.0
8.2

Thank you