

A photograph of a baseball in mid-air, slightly out of focus, with a blurred pitcher in the background on a baseball field. The sky is blue with some clouds.

Instrumented Baseball

David Adams | Mathew Brown | Riley Ferrer | Yanni Giannareas | Charles Whitaker

Meet Team 516



David Adams

*Design
Engineer*



Mathew Brown

*Mechatronics
Engineer*



Riley Ferrer

*Manufacturing
Engineer*



Yanni Giannareas

*Systems
Engineer*



Charles Whitaker

Test Engineer

Riley Ferrer

Sponsor and Advisor



Dr. William Oates, P.E.

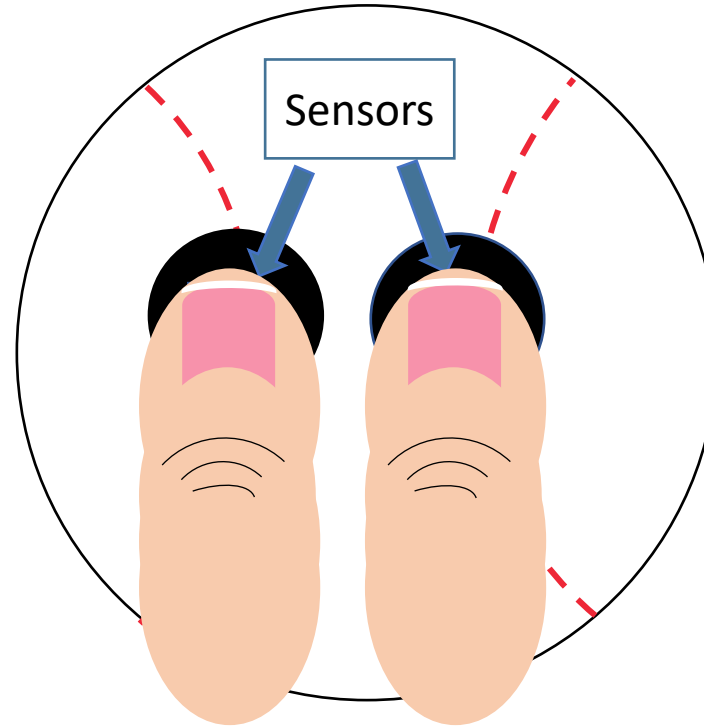
*FAMU-FSU
College of Engineering*

Riley Ferrer

Project Objective



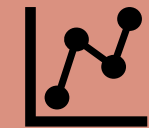
Develop technology to monitor dynamic fingertip forces on a baseball



Develop accurate method of measurement



Maintain the original characteristics of a ball



Facilitate access to the gathered data

Riley Ferrer

Background

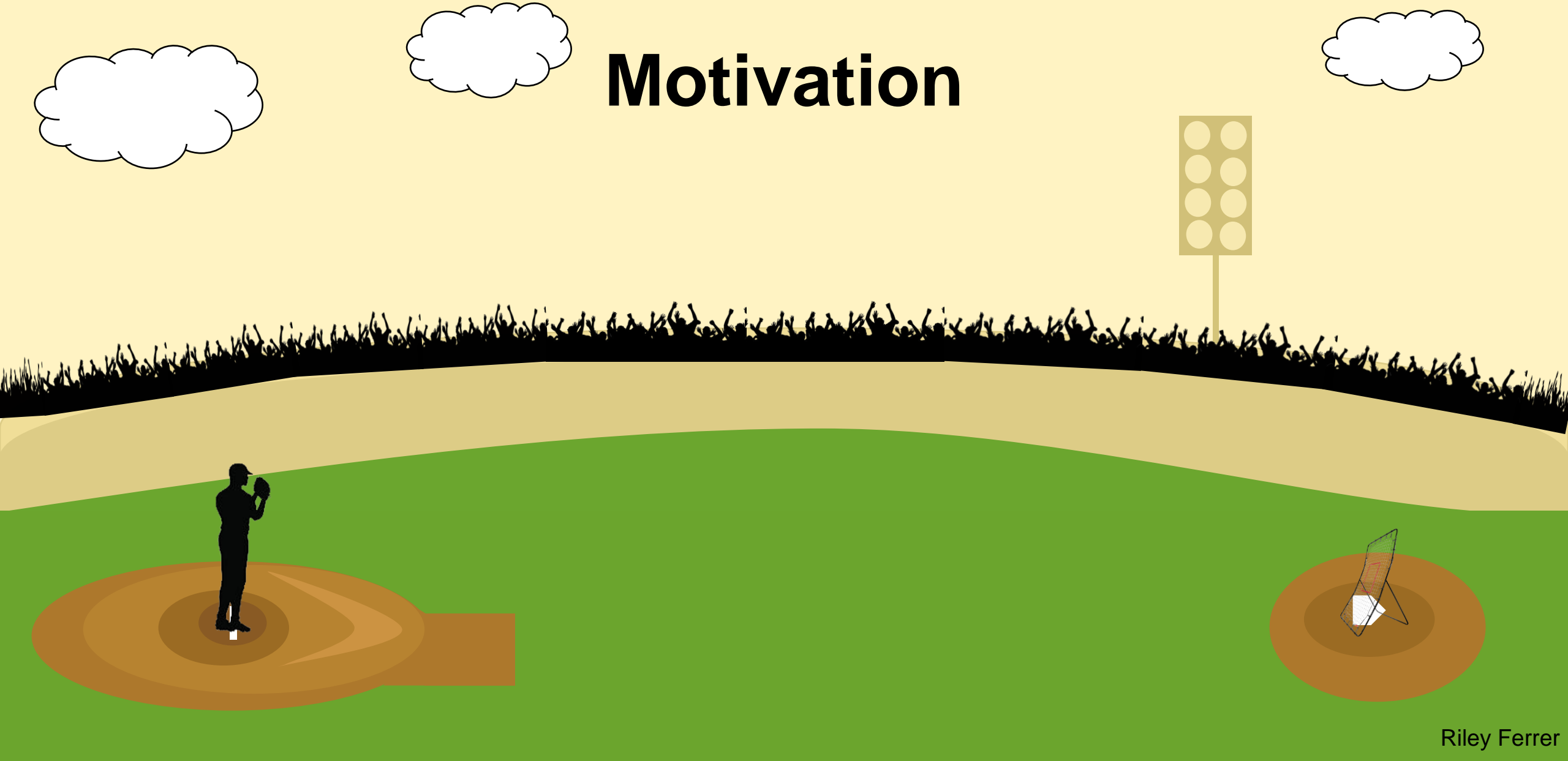


Your goal shouldn't be to buy players. Your goal should be to buy wins. In order to buy wins, you need to buy runs.
- *Michael Lewis, Moneyball*



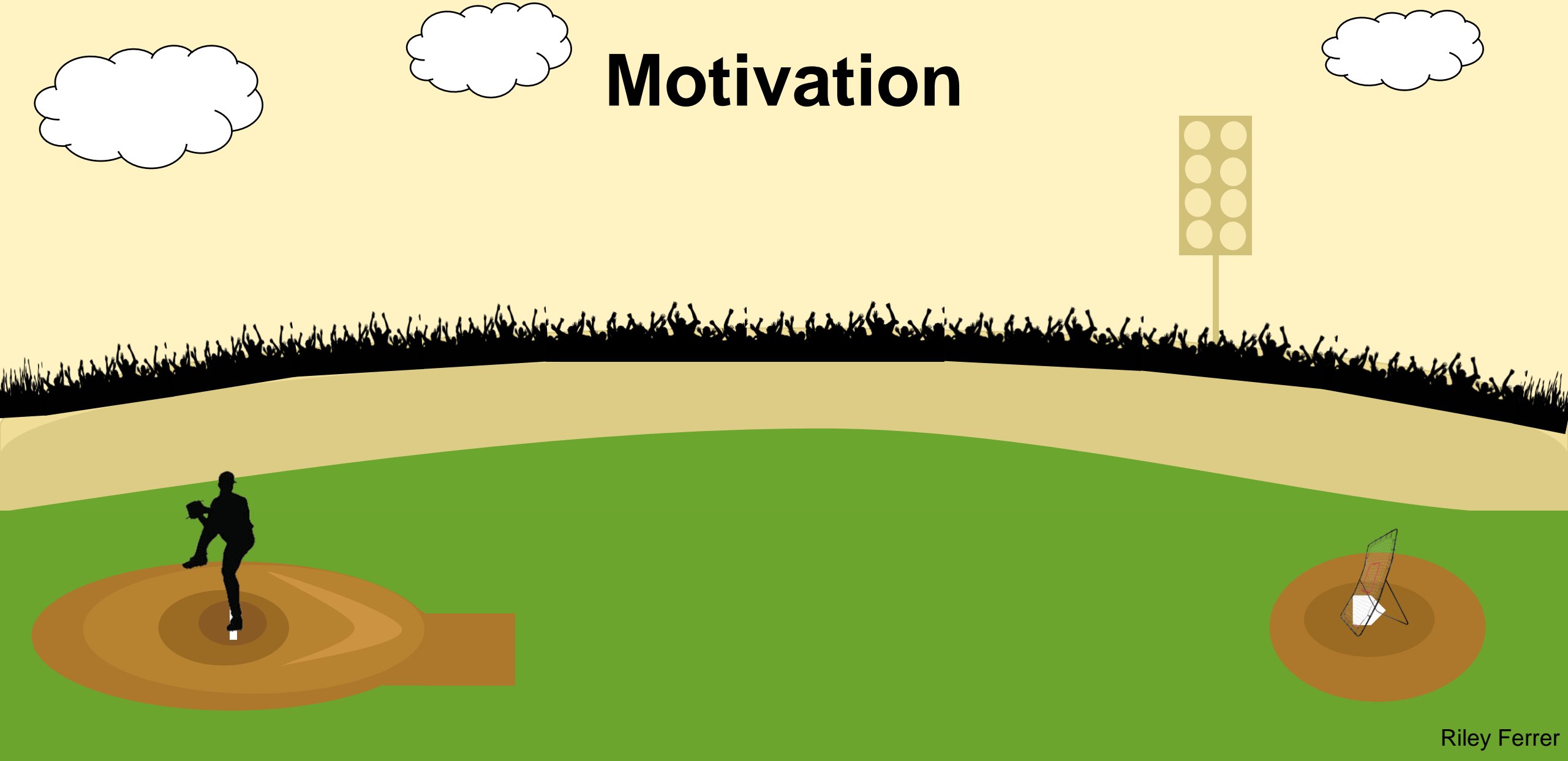
Riley Ferrer

Motivation



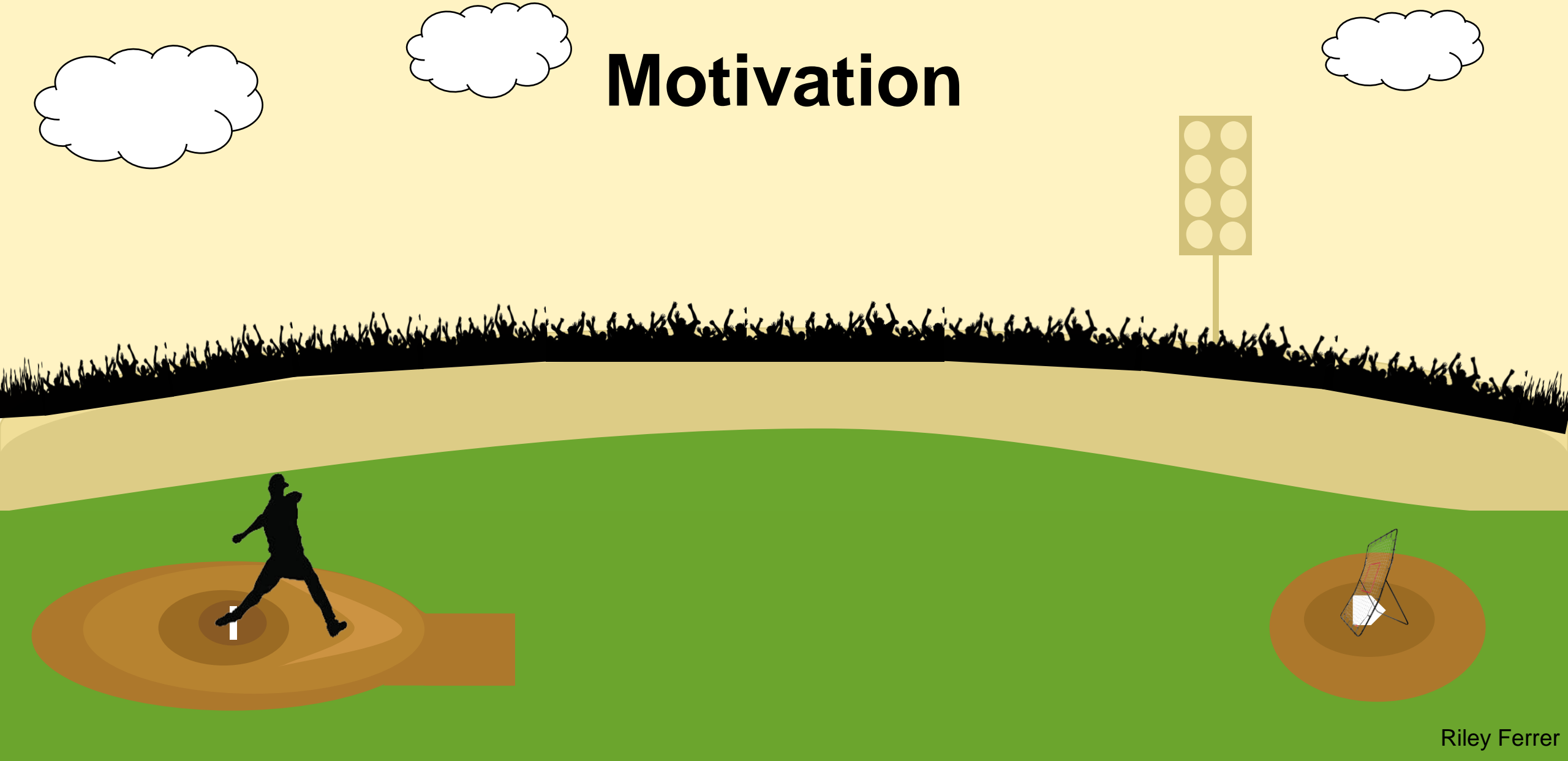
Riley Ferrer

Motivation

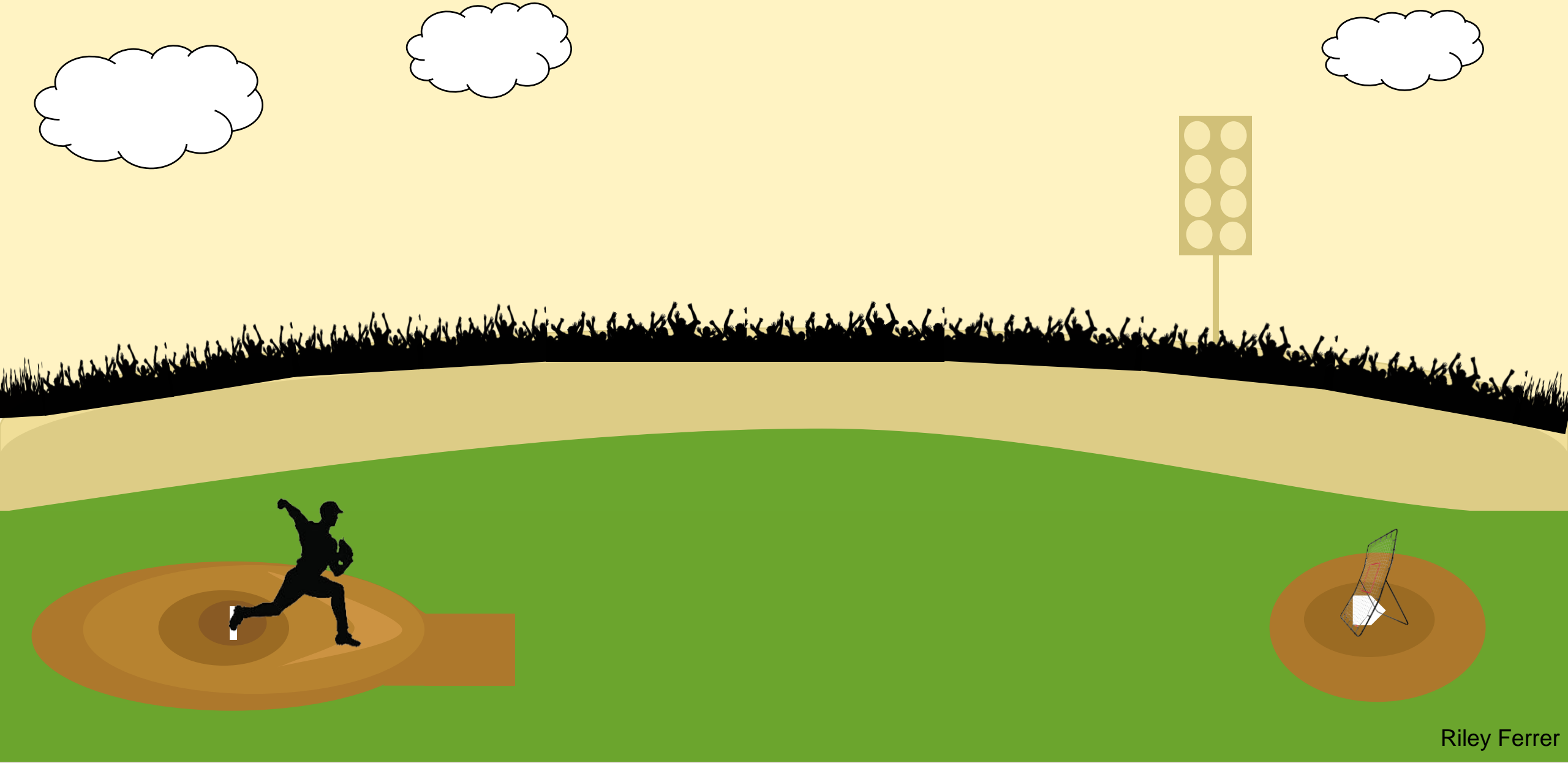


Riley Ferrer

Motivation



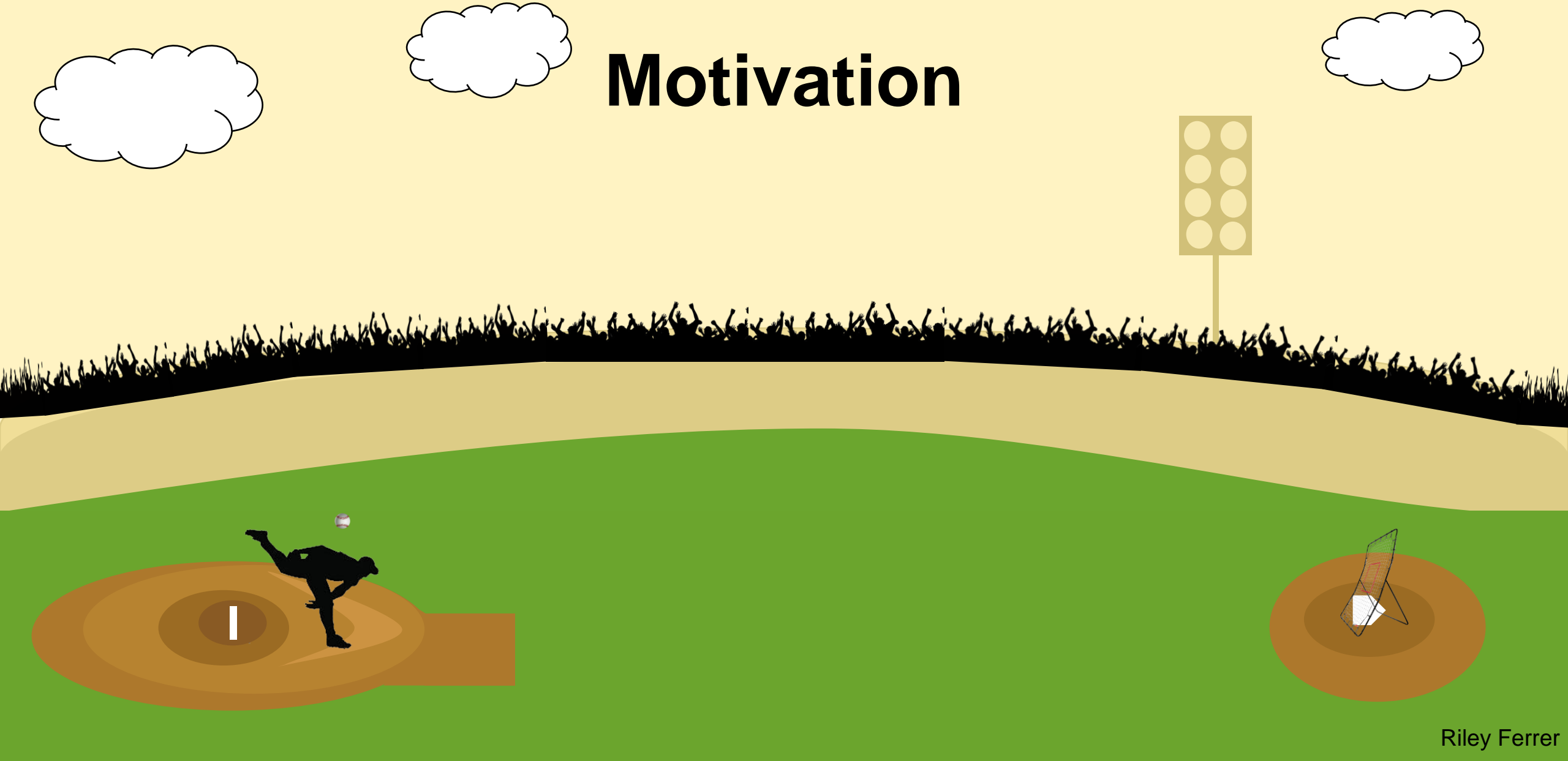
Riley Ferrer



Riley Ferrer

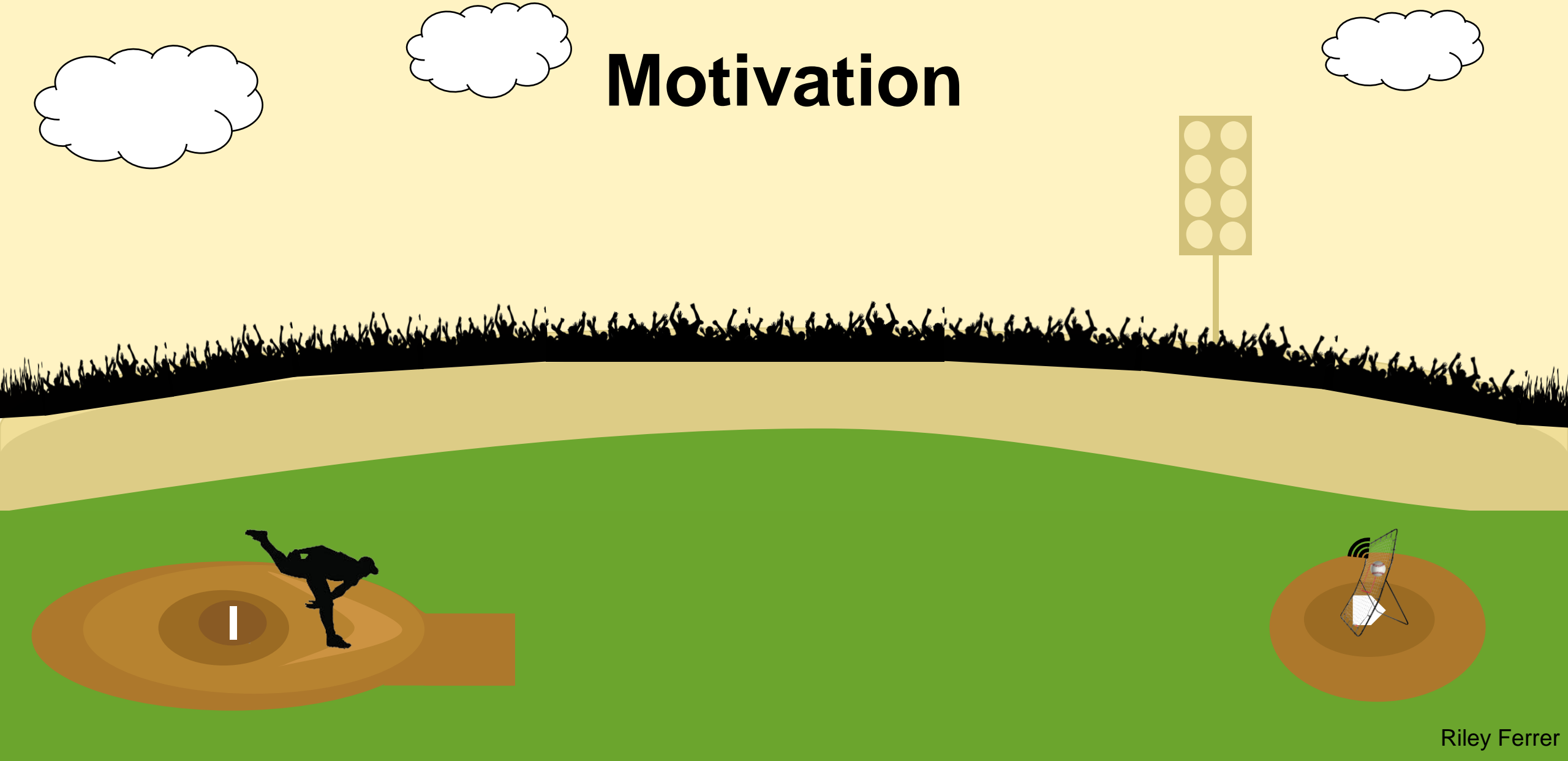


Motivation



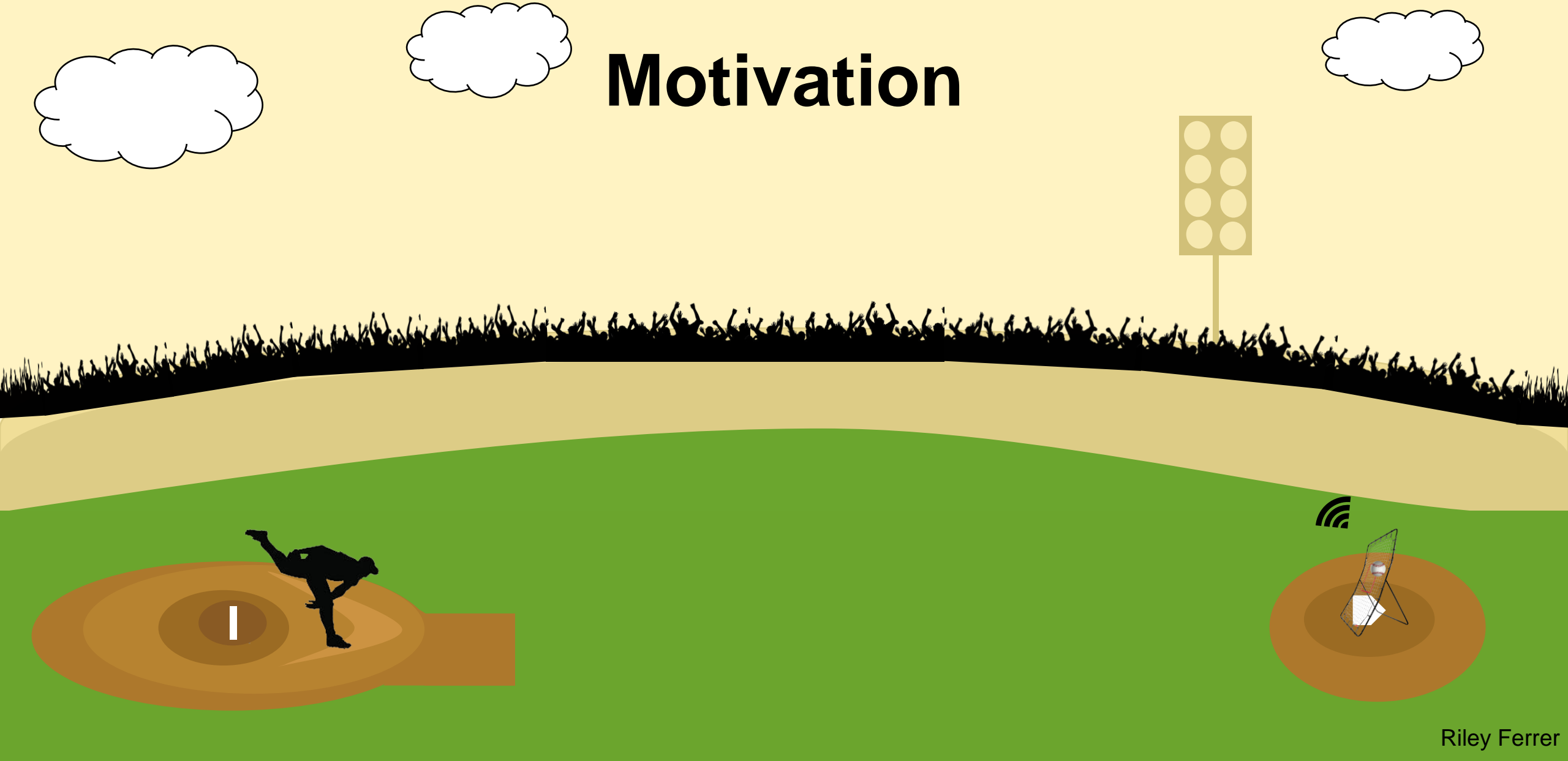
Riley Ferrer

Motivation



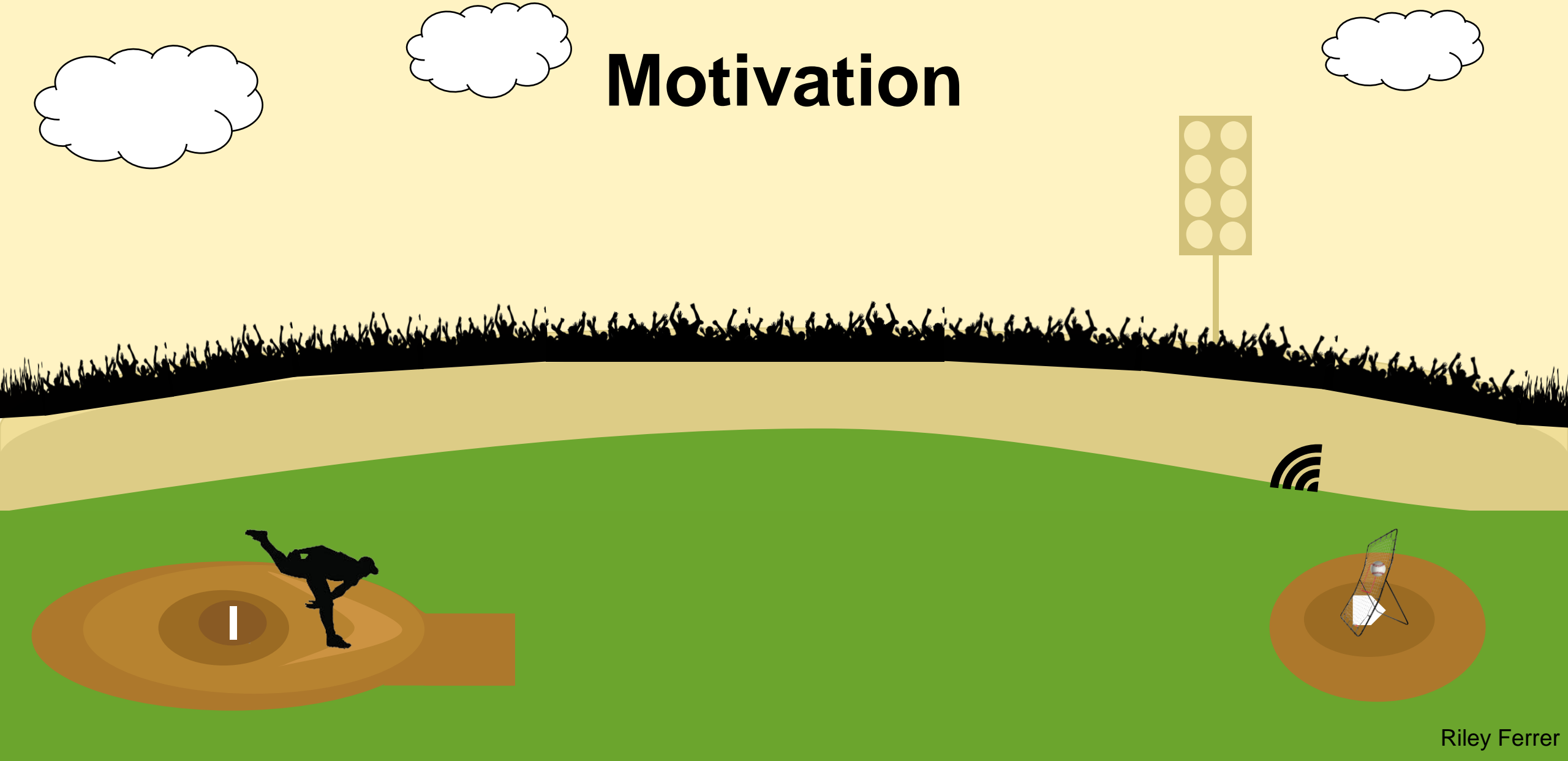
Riley Ferrer

Motivation



Riley Ferrer

Motivation



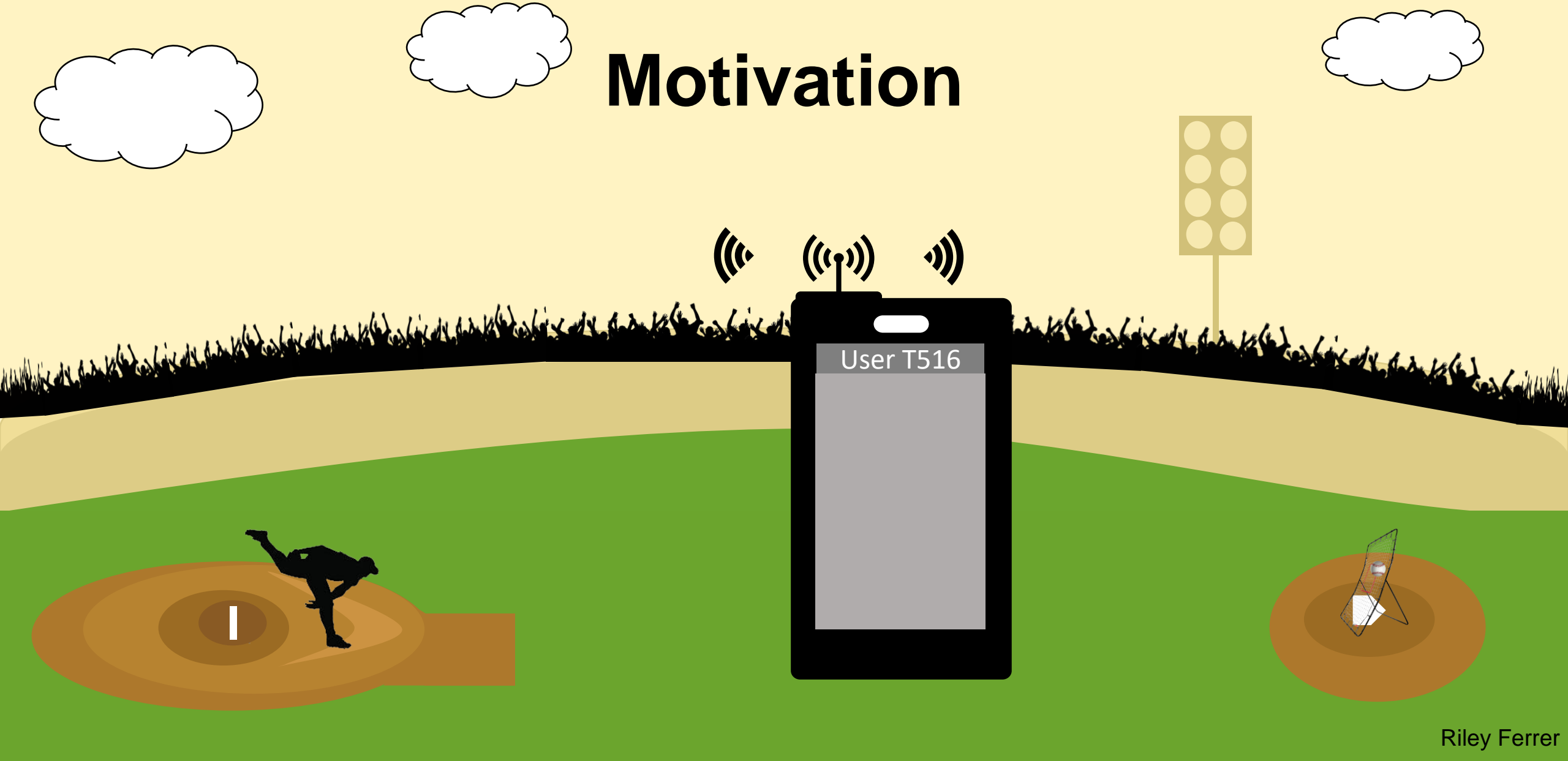
Riley Ferrer

Motivation



Riley Ferrer

Motivation



Riley Ferrer

Motivation



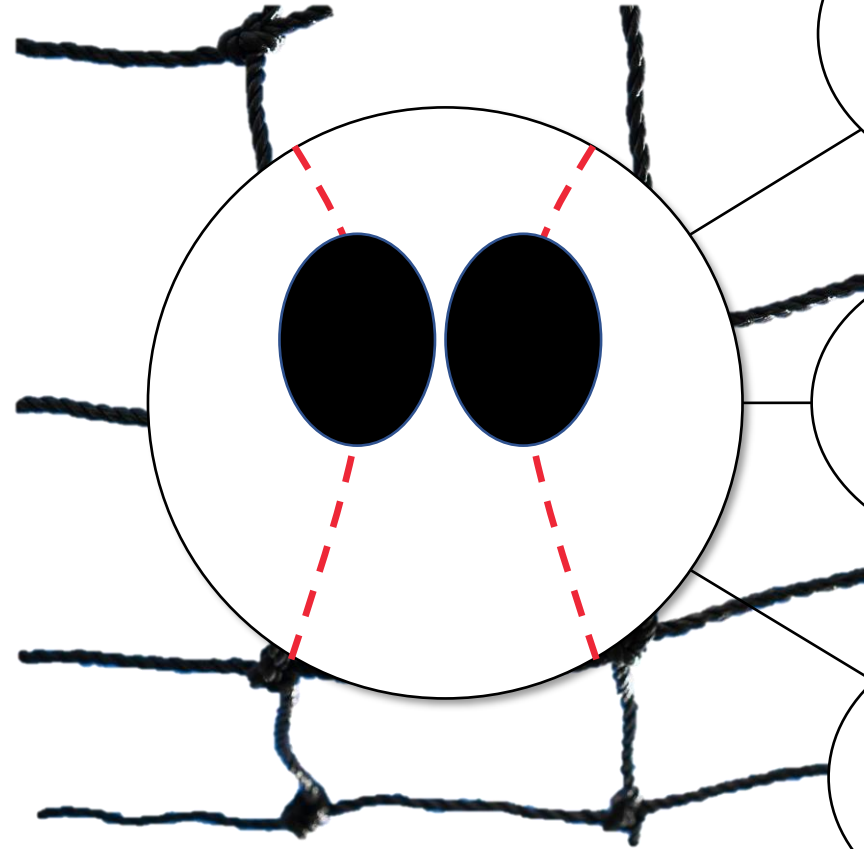
Riley Ferrer

Motivation



Riley Ferrer

Assumptions



Ball is safely caught after the throw by a net.

Ball is thrown in a specific position.

Device can be used to read the data.

Riley Ferrer

Customer Needs

The device can be charged repeatedly.

The device doesn't interfere with the pitcher.

Device is tailored to detect forces on the index and middle fingers.

The device captures pressure and shear forces.

Device is tailored to a 4-seam style.

Riley Ferrer

Functional Decomposition



Contains
supplied
voltage



Transforms
signals from
analog to
digital

Plot time-
dependent
data



Senses
applied load

Isolates
region for
fingertip
application



Match
moment of
inertia close
to standard

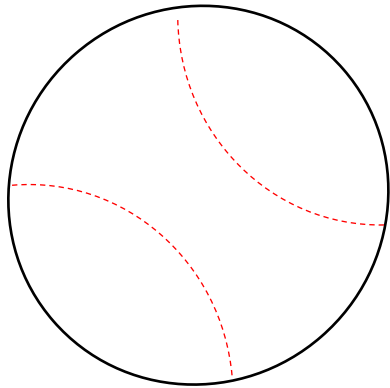
Lock
components
in place

Supports
weight of
components

Riley Ferrer

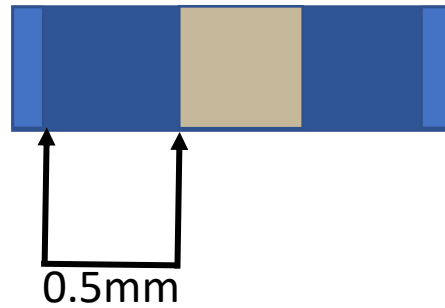
Targets And Metrics

Standard Moment of Inertia

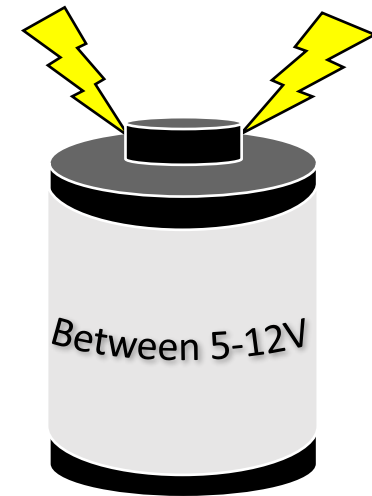


$81.56 \pm 5\% \text{ kg}\cdot\text{mm}^2$

Component Movement



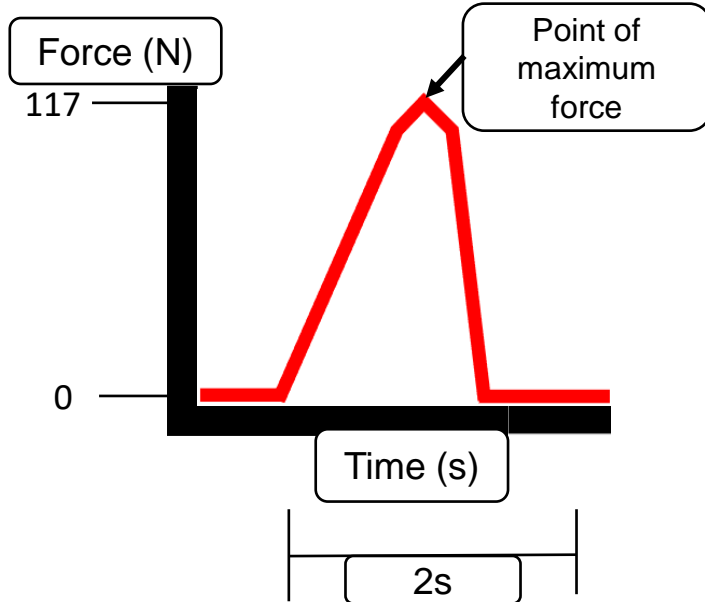
Supplied Voltage



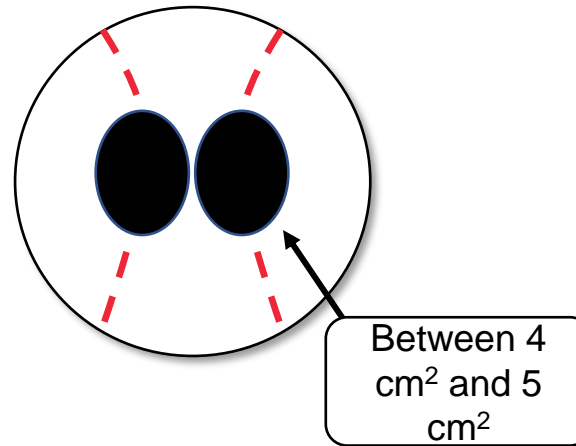
Yanni Giannareas

Targets And Metrics

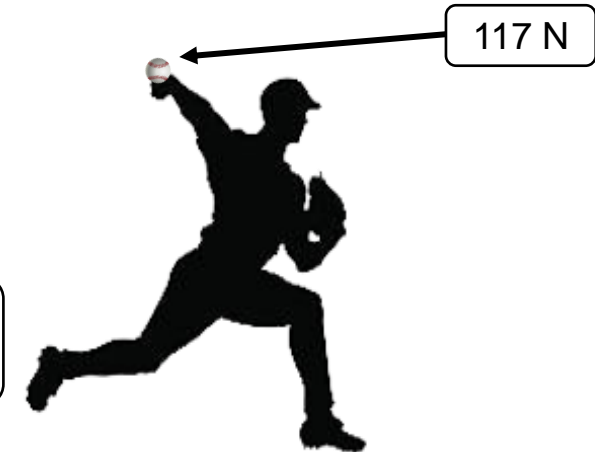
Plot time-dependent data



Region for index and middle finger application



Senses applied load



Yanni Giannareas

Piezo
Sensors

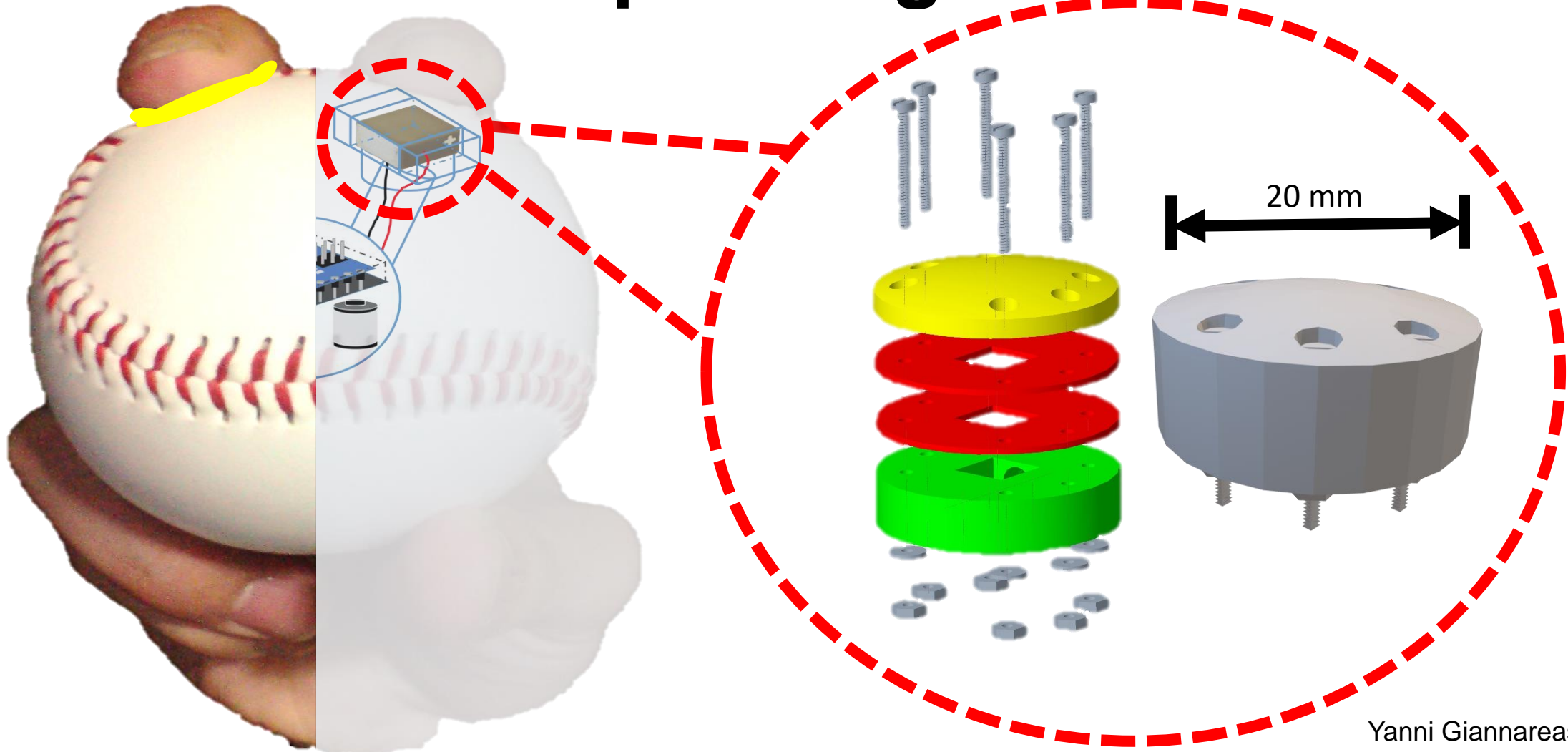
Concept Design

3D Printed
Housing

Arduino
Blue
Nano

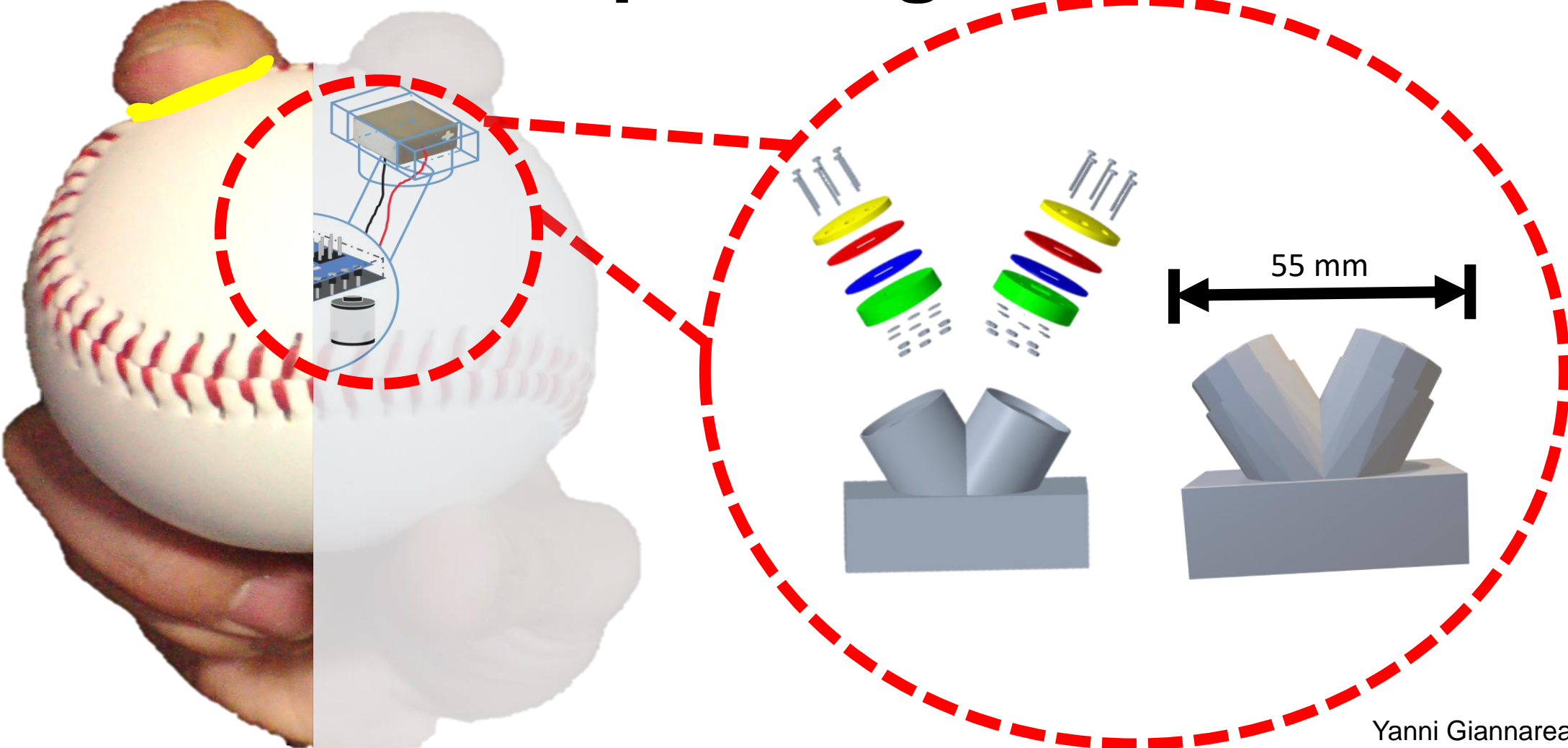
Lithium-
ion Battery

Indications



Yanni Giannareas

Concept Design



Piezo Sensors

3D Printed Housing

Arduino Blue Nano

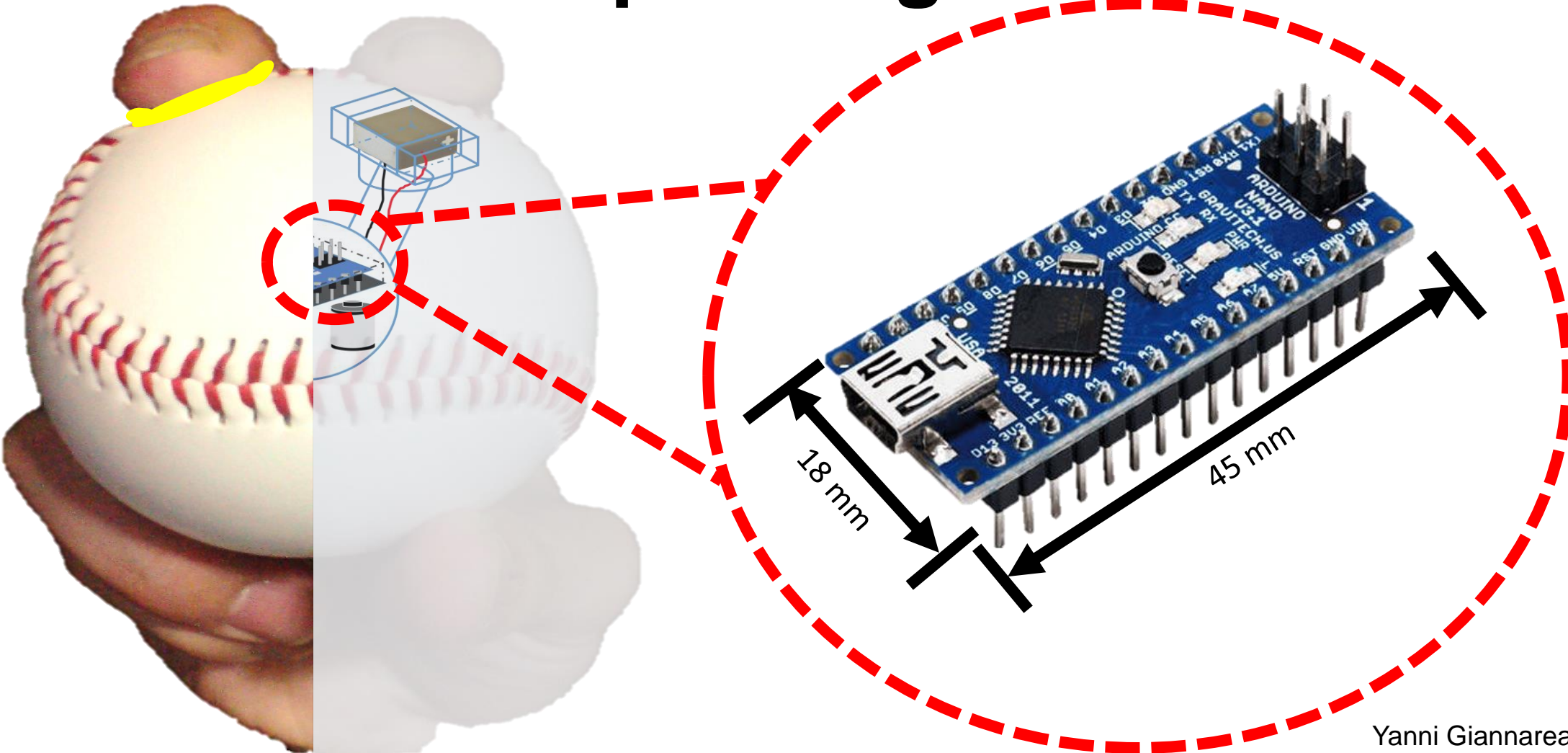
Lithium-ion Battery

Indications

Yanni Giannareas

Concept Design

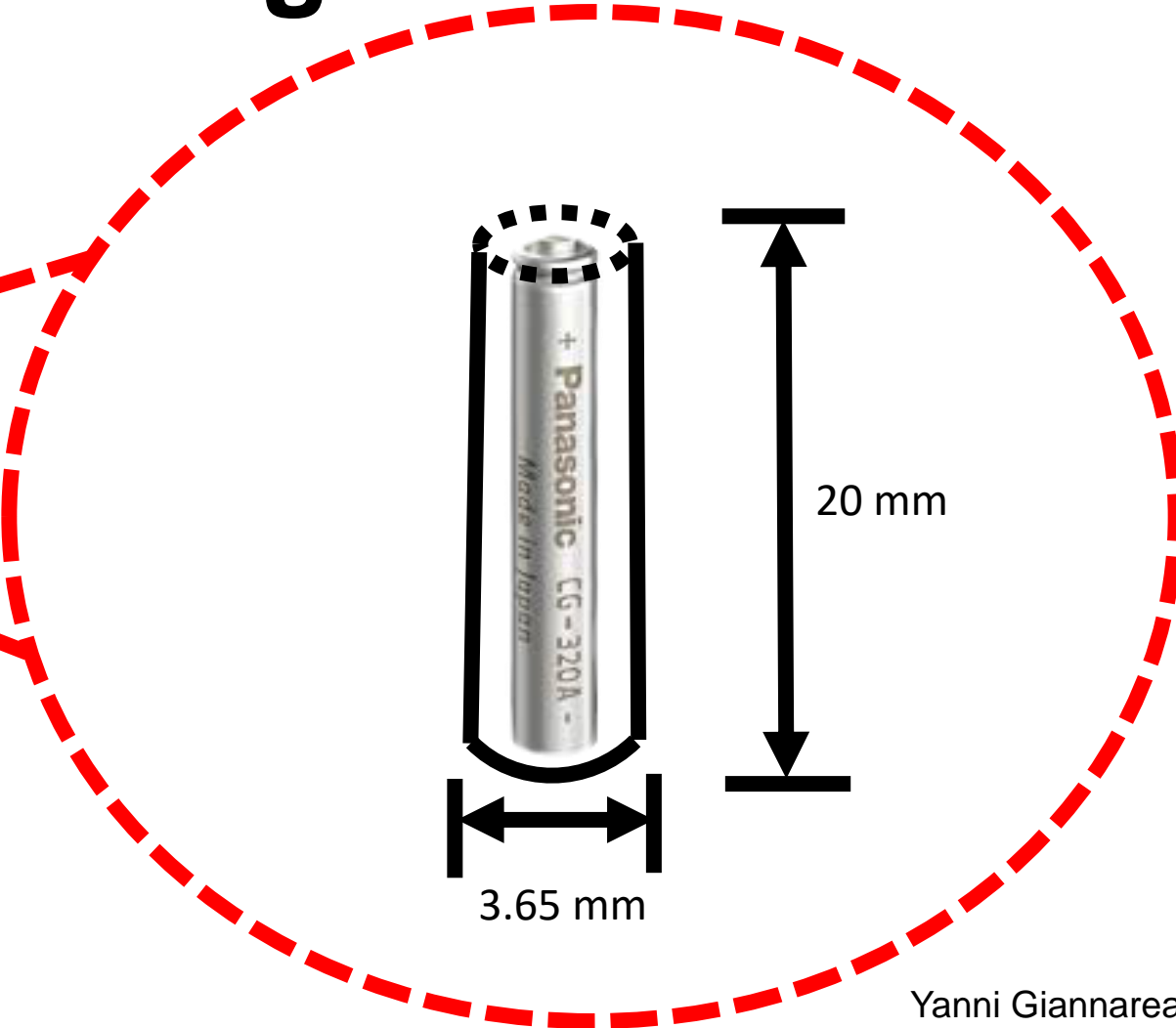
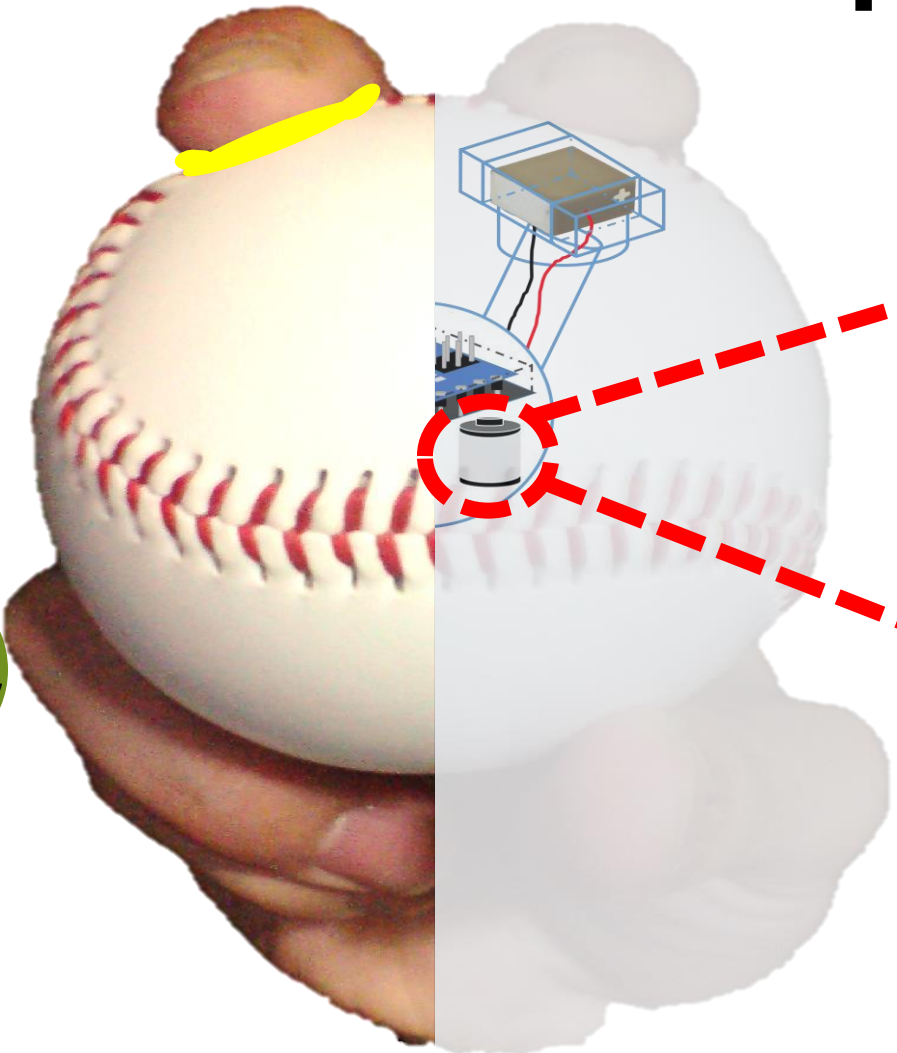
- Piezo Sensors
- 3D Printed Housing
- Arduino Blue Nano
- Lithium-ion Battery
- Indications



Yanni Giannareas

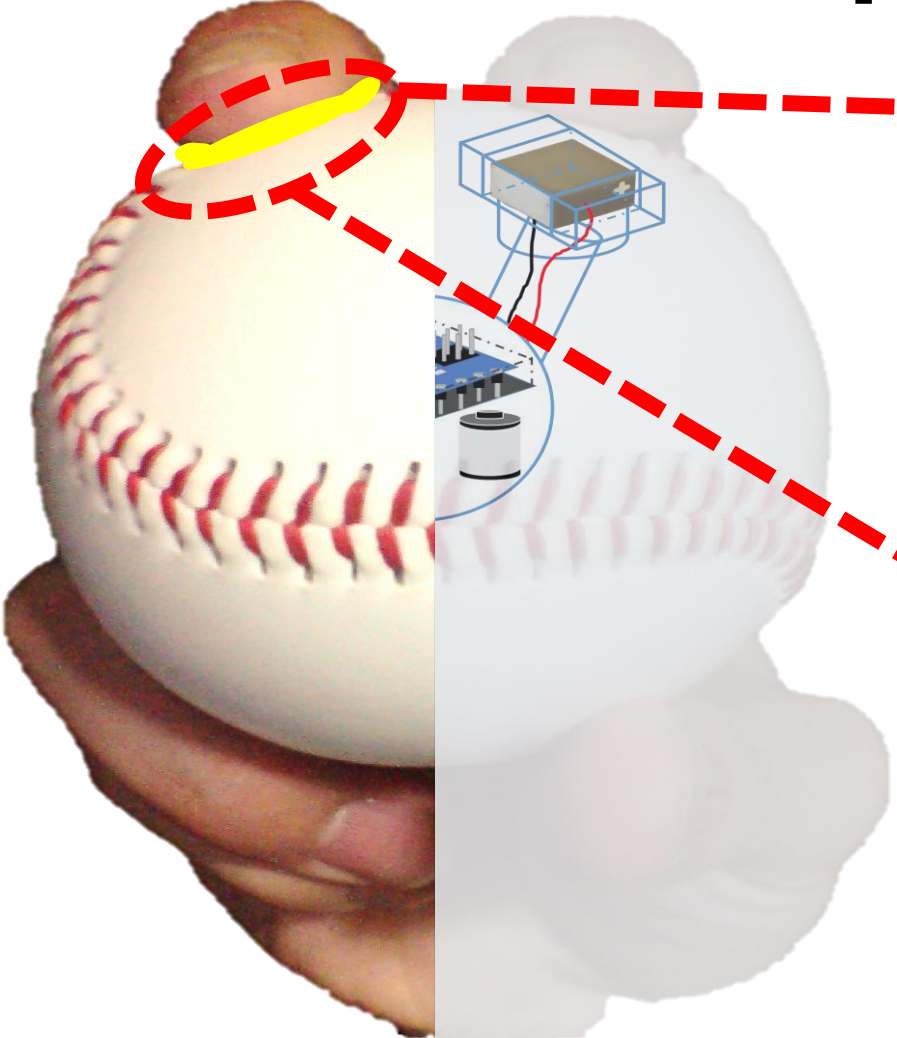
Concept Design

- Piezo Sensors
- 3D Printed Housing
- Arduino Blue Nano
- Lithium-ion Battery
- Indications



Yanni Giannareas

Concept Design



Piezo Sensors

3D Printed Housing

Arduino Blue Nano

Lithium-ion Battery

Indications

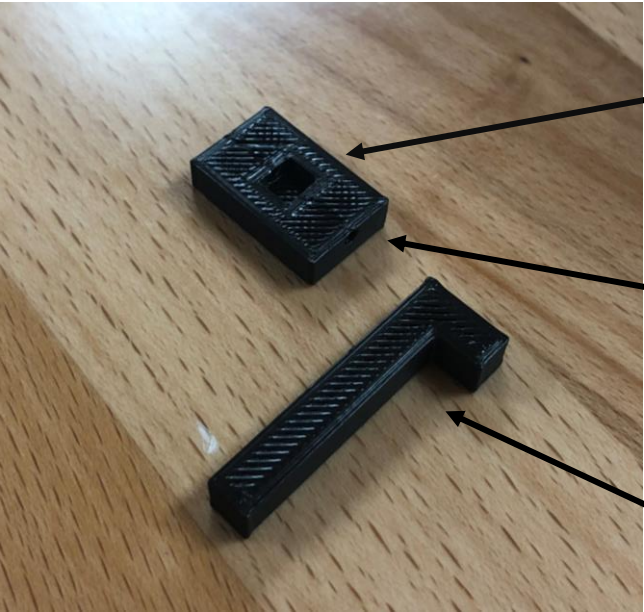
Middle Finger
X

Index Finger
X

Yanni Giannareas

Initial Prototyping

3D-Printed Housing

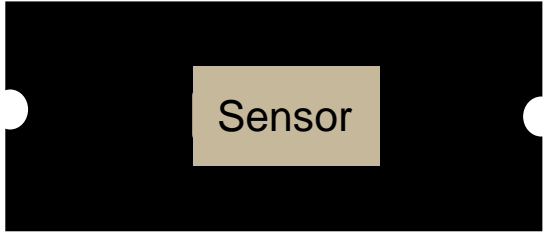


Gap for sensor

Opening for cable connection

Bracket for force application

Top view



15 mm

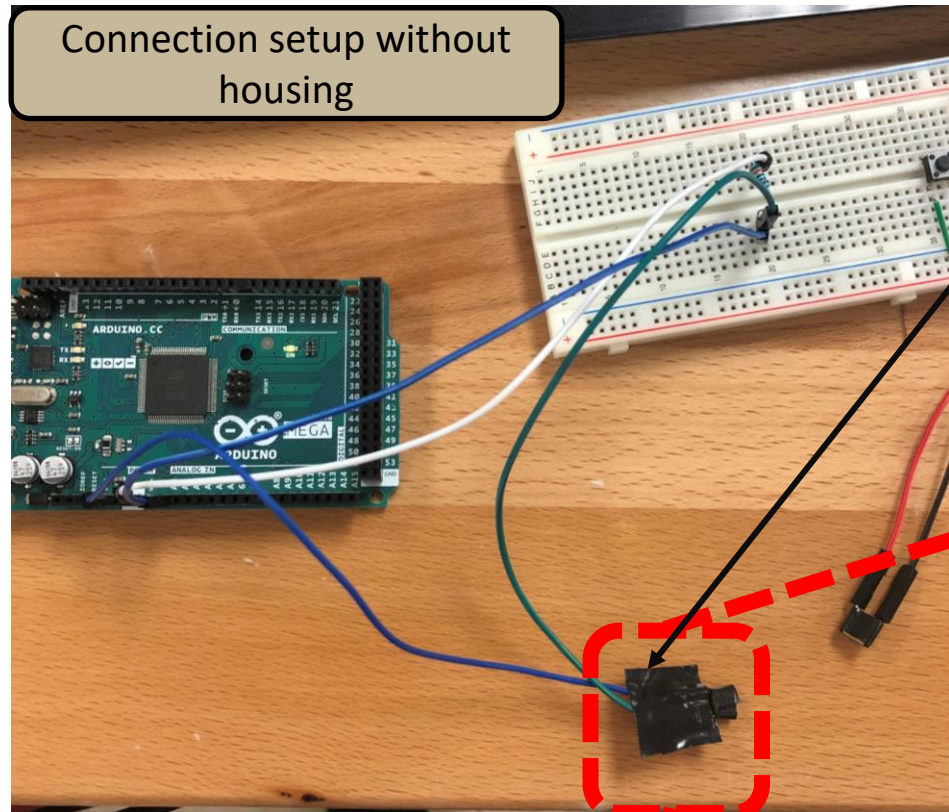
Side view

Force applied



Yanni Giannareas

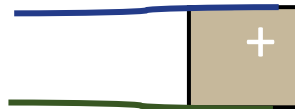
Sensor Testing



Insulating tape

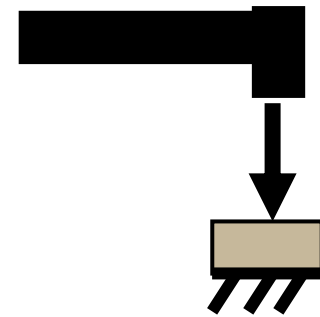


Connected to A0

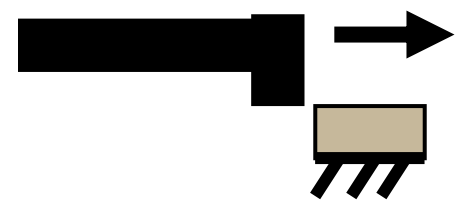


Connected to GND

Testing pressure force



Testing shear force



Yanni Giannareas

Sensor Testing

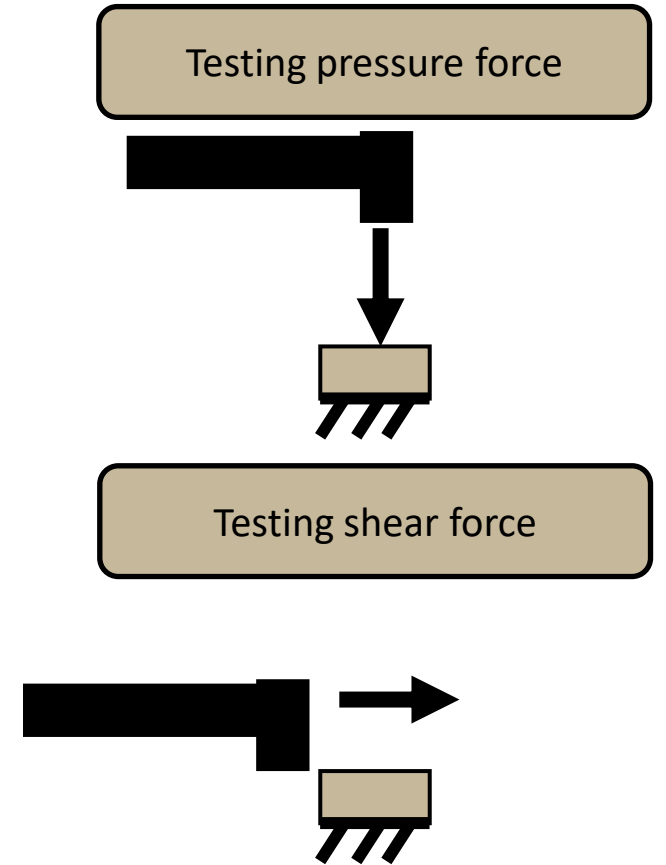
The screenshot shows a terminal window titled 'COM3' with a list of analog readings. An arrow points from the first few lines of text to a callout box. Below the text is a scatter plot with 'Analog reading' on the y-axis and 'Pressure/Shear applied' on the x-axis. The plot shows a positive correlation between the two variables.

```
COM3
Analog reading = 105
Analog reading = 103
Analog reading = 102
Analog reading = 102
Analog reading = 100
Analog reading = 102
Analog reading = 101
Analog reading = 101
Analog reading = 100
Analog reading = 100
Analog reading = 100
Analog reading = 102
Analog reading = 103
Analog reading = 102
Analog reading = 101
Analog r
```

Higher readings for higher pressure

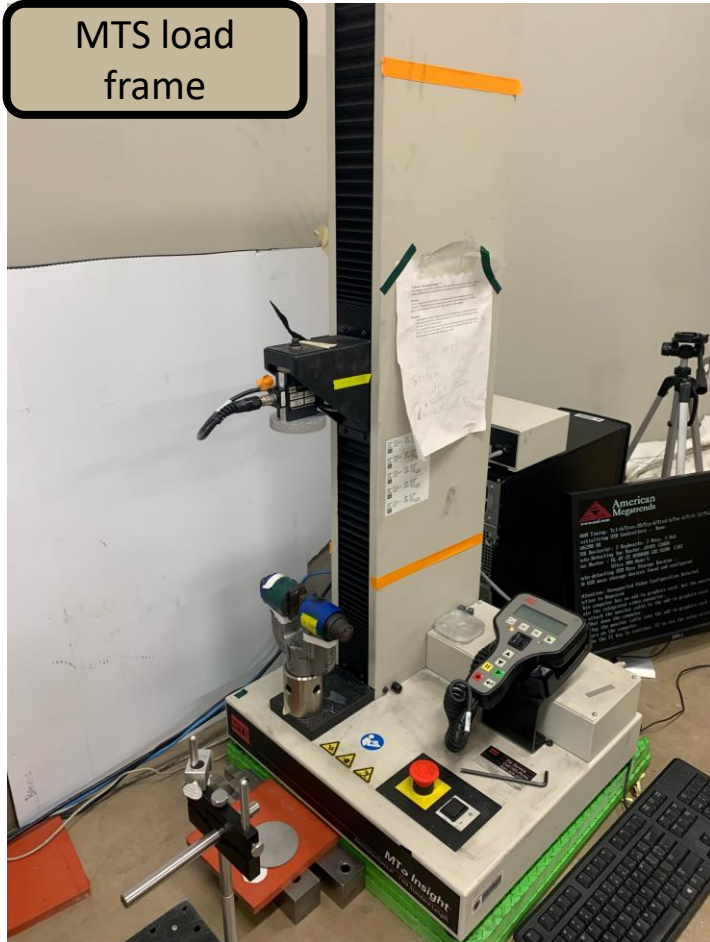
Analog reading

Pressure/Shear applied



Yanni Giannareas

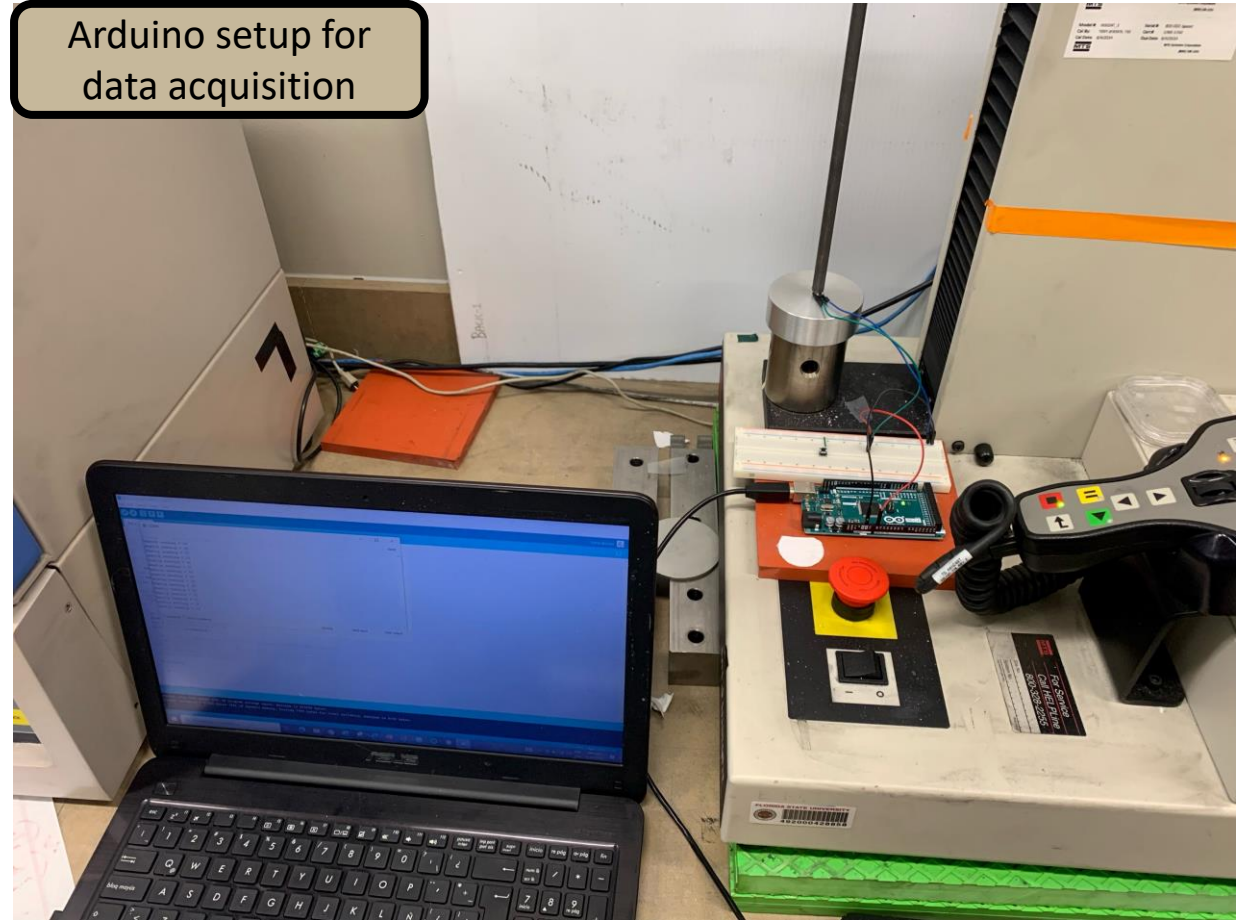
Sensor Testing



Digital force gauge



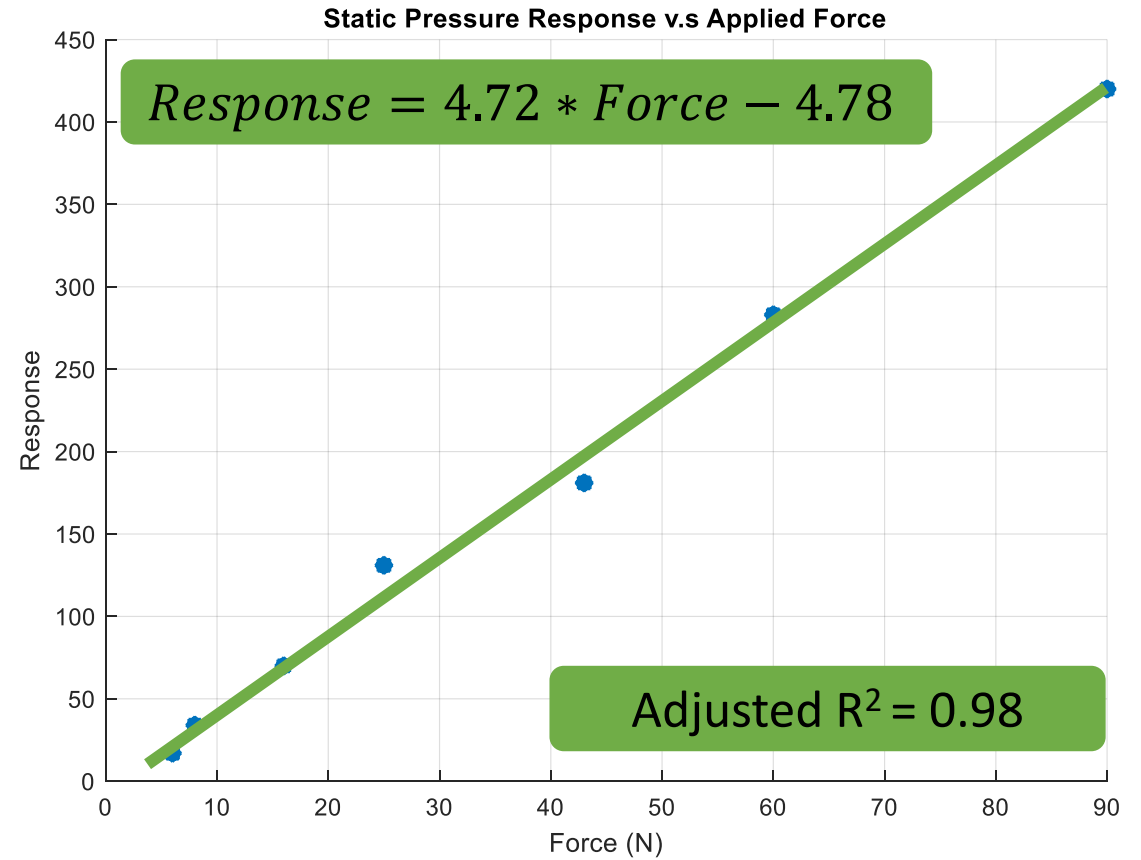
Arduino setup for data acquisition



Mathew Brown

Sensor Testing

Force (N)	Response
6	17
8	34
16	70
25	131
43	181
60	283
90	420



Mathew Brown

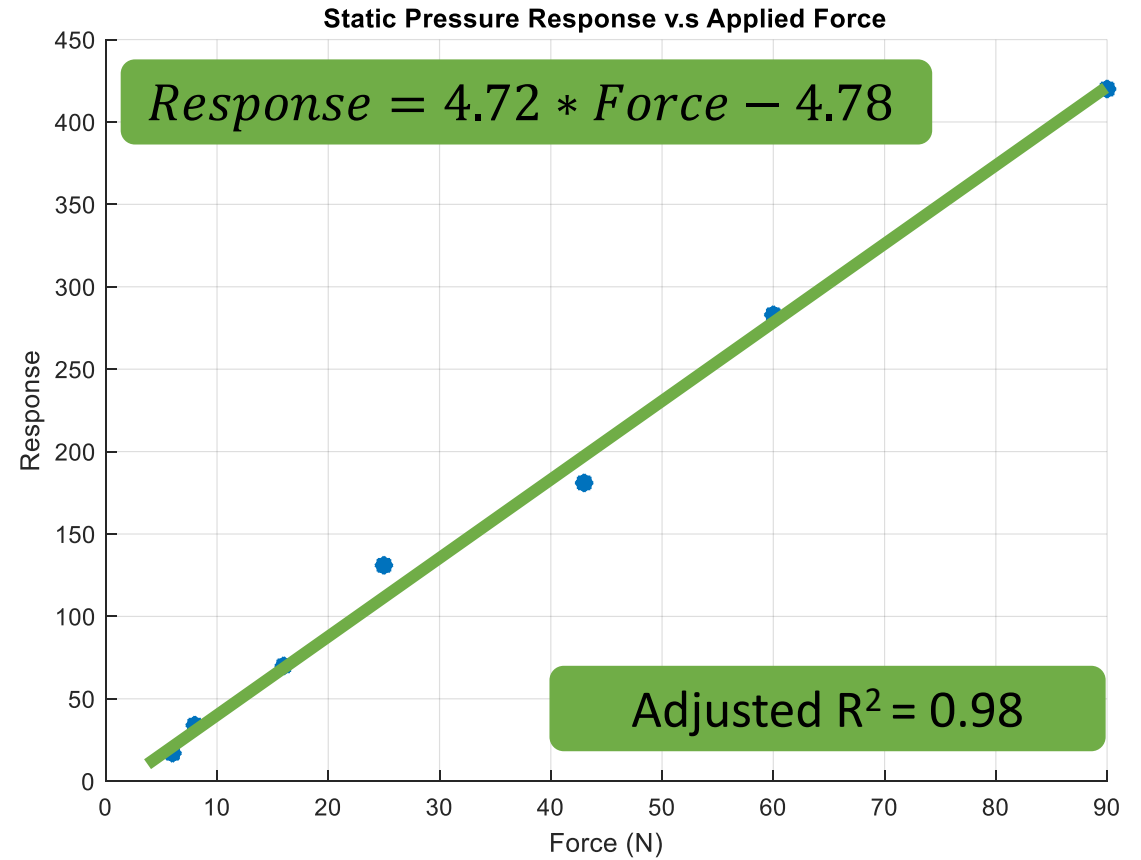
Sensor Testing

Before

Analog reading = 21
Analog reading = 22
Analog reading = 22
Analog reading = 28

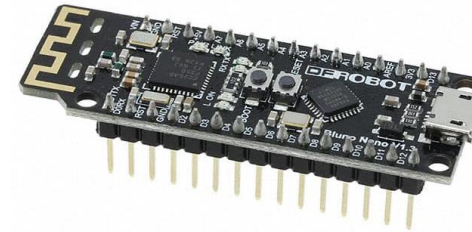
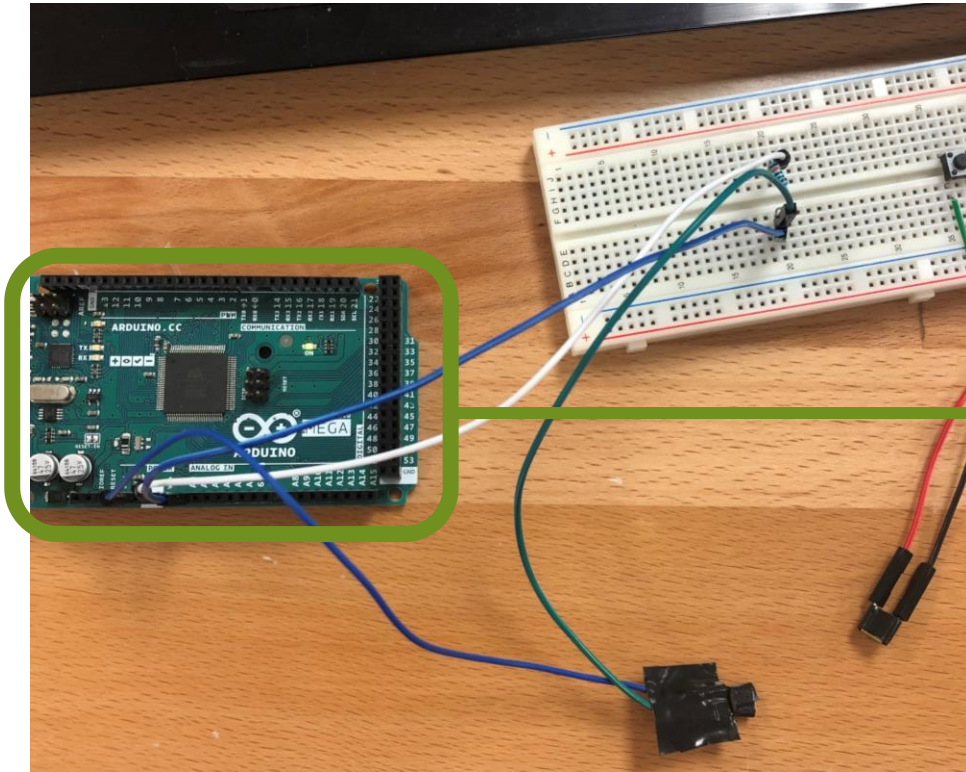
After

Force = 5.46 N
Force = 5.67 N
Force = 5.67 N
Force = 6.94 N



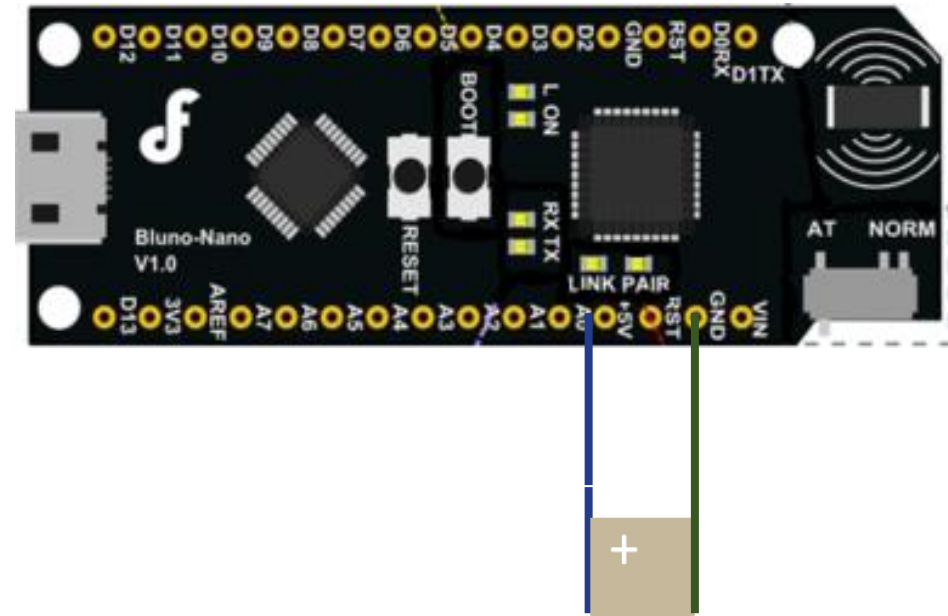
Mathew Brown

Bluetooth Incorporation



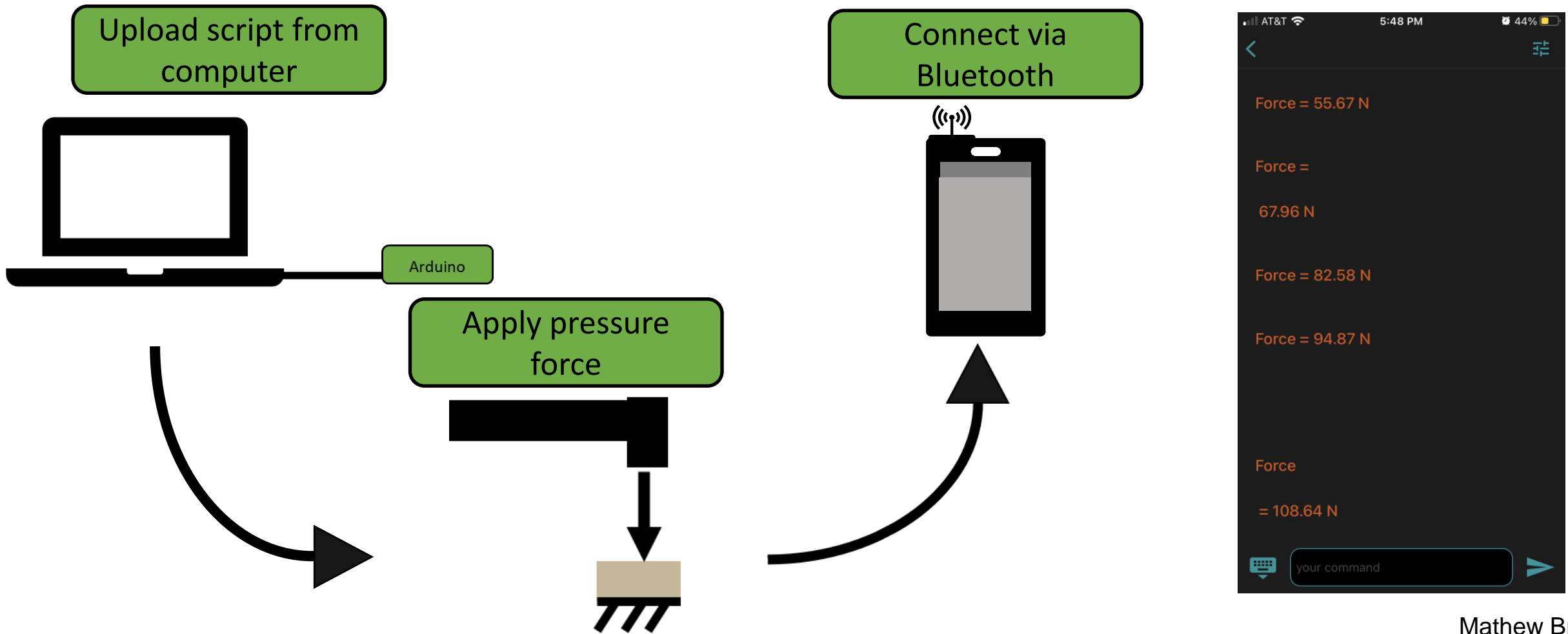
Bluetooth module incorporated

Sufficient pins for our purpose



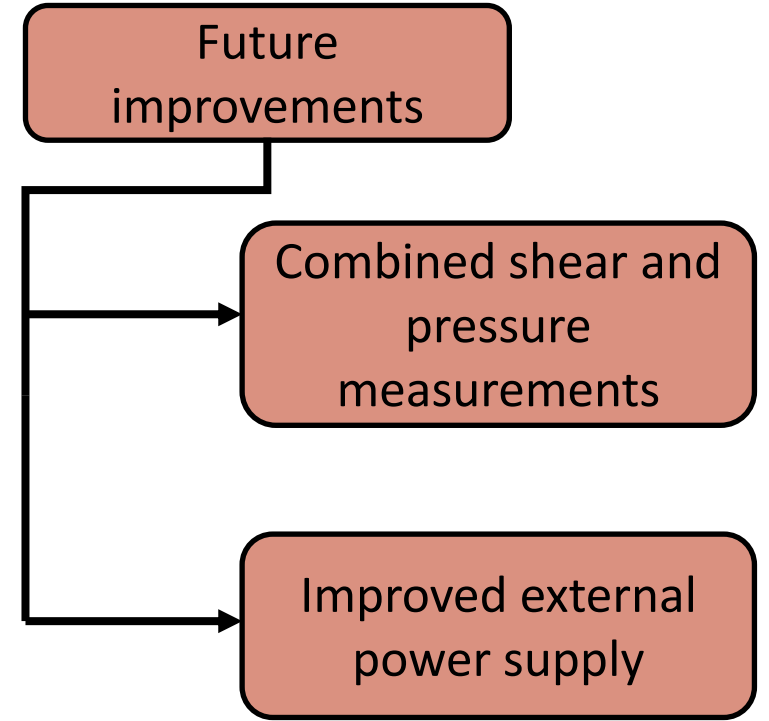
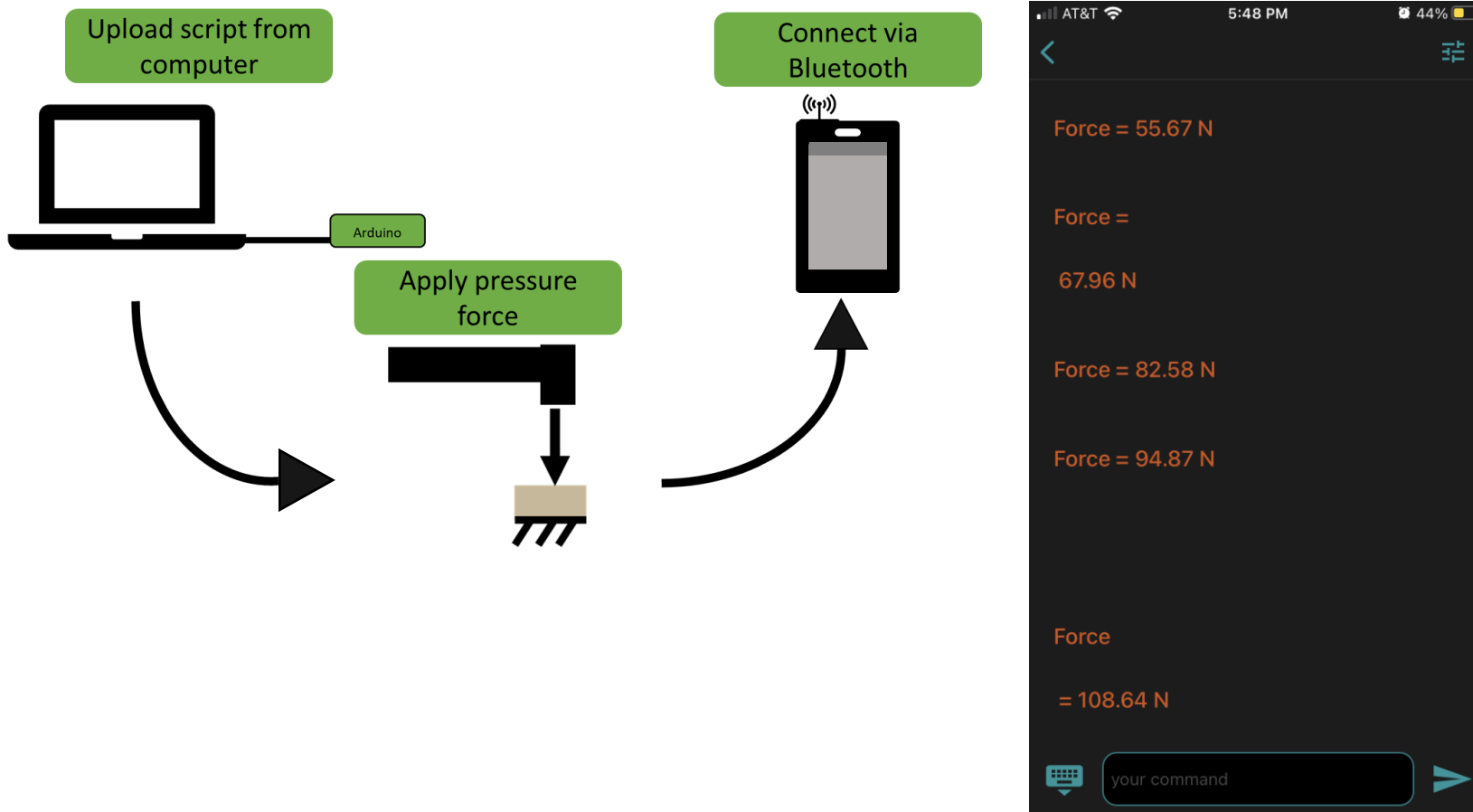
Mathew Brown

Bluetooth Incorporation



Mathew Brown

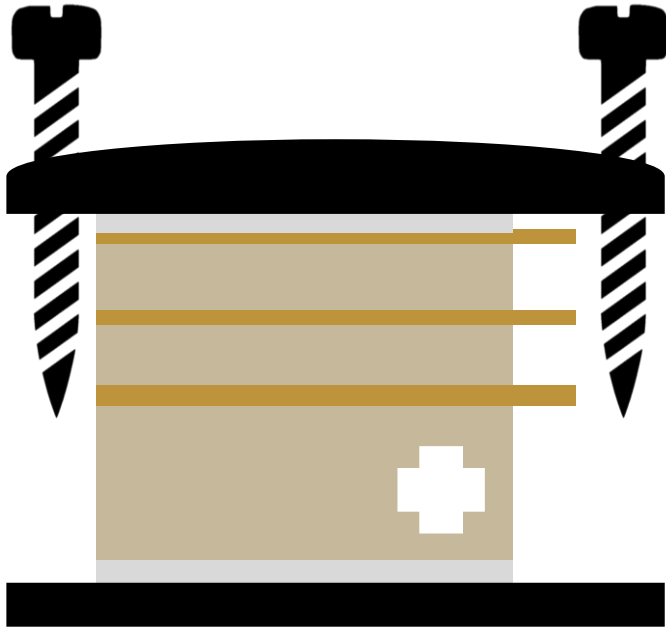
Bluetooth Incorporation



Mathew Brown

Sensor Preloading

Piezoelectric stack
(before preload)



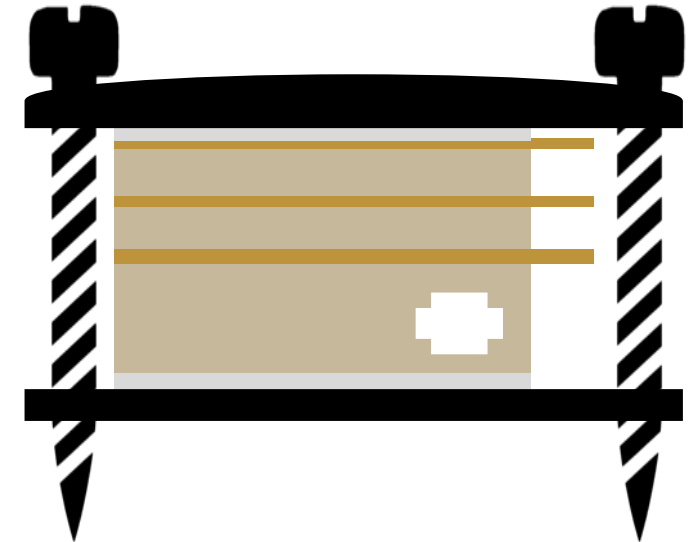
Preload specs

F.O.S = 2.5

$$F_{load} = -180 \text{ N}$$

$$\sigma_{load} = -7.2 \text{ MPa}$$

Piezoelectric stack
(Under preload)

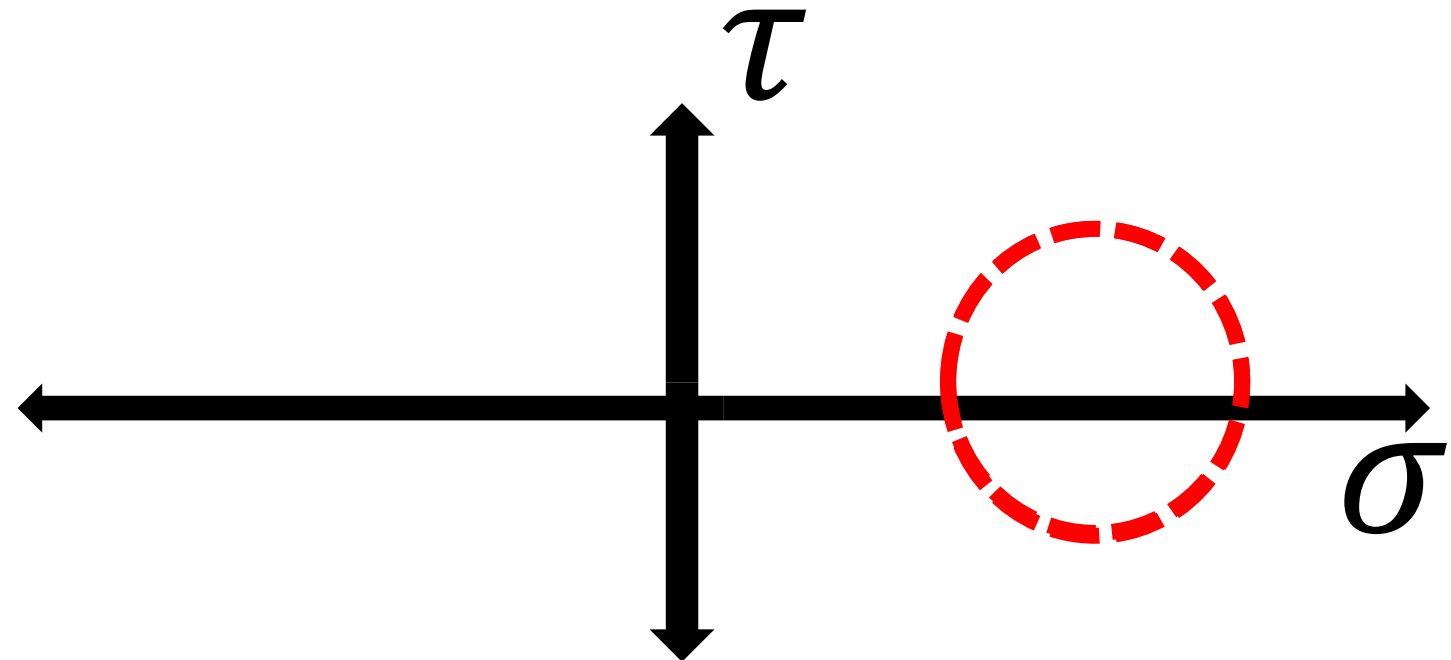


Mathew Brown

Sensor Preloading

Force (N)	120 N Normal Load Values			
-120	30	45	60	DEG
Sigma_x	4.743	-4.084	1.463	MPa
Tau_xy	-1.234	-4.203	7.619	MPa
Sigma_avg	2.371	-2.042	0.732	MPa
R - Radius	2.673	4.672	7.654	MPa
Sigma_1	5.044	2.630	8.386	MPa
Sigma_2	-0.302	-6.715	-6.923	MPa

Force (N)	300 N - Preload Values			
-300	30	45	60	DEG
Sigma_x	11.856	-10.211	3.658	MPa
Tau_xy	-3.085	-10.506	19.048	MPa
Sigma_avg	5.928	-5.105	1.829	MPa
R - Radius	6.683	11.681	19.136	MPa
Sigma_1	12.611	6.576	20.965	MPa
Sigma_2	-0.755	-16.787	-17.307	MPa



Mathew Brown

Sensor Preloading

Initial stack prototype



Subjected to compression



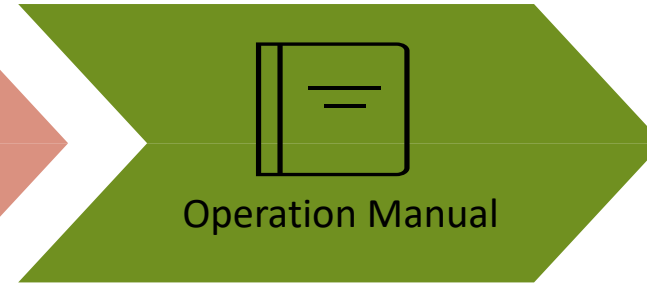
Smaller preload stack



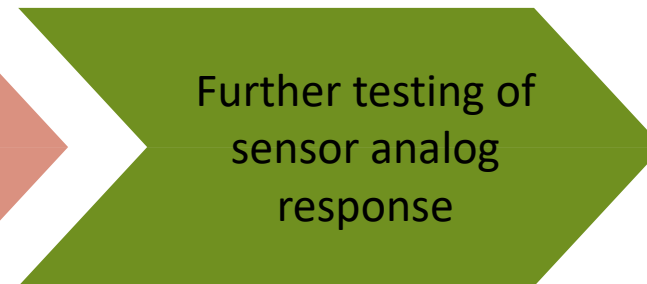
Mathew Brown

Future Work

Deliverables



Prototyping



Mathew Brown



Instrumented Baseball

David Adams | Mathew Brown | Riley Ferrer | Yanni Giannareas | Charles Whitaker