

Human Body Motion Analysis in Soccer Kicking

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Introduction



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Background & Motivation

Background

- People have different forms/techniques of kicking soccer balls
- Investigating which **kinematic components** are most important in effectively kicking a soccer ball
 - Kinematic components:
 - Acceleration of Leg
 - Velocity of Leg
 - Evaluation of Kick Effectiveness:
 - Max Velocity of Ball
- Preservation of KE in kicking soccer ball?



Main Concepts

Kinetic Energy: $K = mv^2$

Momentum: $p = mv$

Conservation of Momentum: $m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

Kinematic Displacement: $x(t) = x_0 + v_0t + (1/2)at^2$

Question for Motivation

Hypothesis

- 1) Is increasing Leg Acceleration OR Leg Velocity more important in ultimately increasing Soccer Ball Velocity?
 - Max Leg Acceleration is more important in increasing ball velocity

Data Collection

Experimental Setup

The Arduino sensor was taped to the kicker's knee.

Due to the constant bluetooth module problems all year, the Arduino sensor was connected to the computer to collect and transfer data, rather than wirelessly.

The kicker stood right in front of the ball before kicking it.

This is so the kicker does not step into kicking the ball, since this could cause more uncertainty in the kicking motion.

Experimental Setup Pictures

Initial



Swing Back



Swing Forward



Experimental Setup cont.



Data Taking Protocols

9 Trials:

- 3 at “Soft” kick
- 3 at “Medium” kick
- 3 at “Hard” kick

Each trial, the following data metrics were recorded:

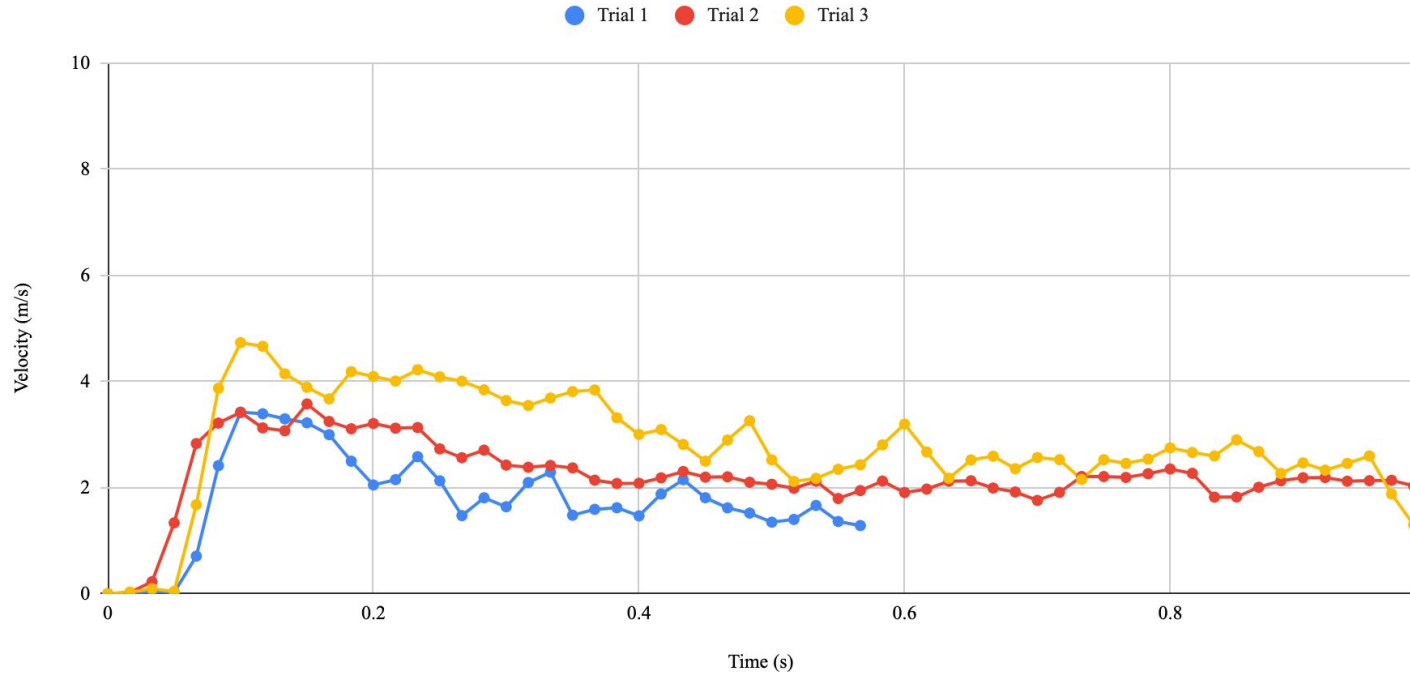
- Leg Acceleration (m/s^2) - **Arduino**
- Leg Velocity (m/s) - **Tracker software**
- Ball Velocity (m/s) - **Tracker software**

Raw Data Observation

Data Analysis: Trials 1-3

Velocity vs Time of Ball

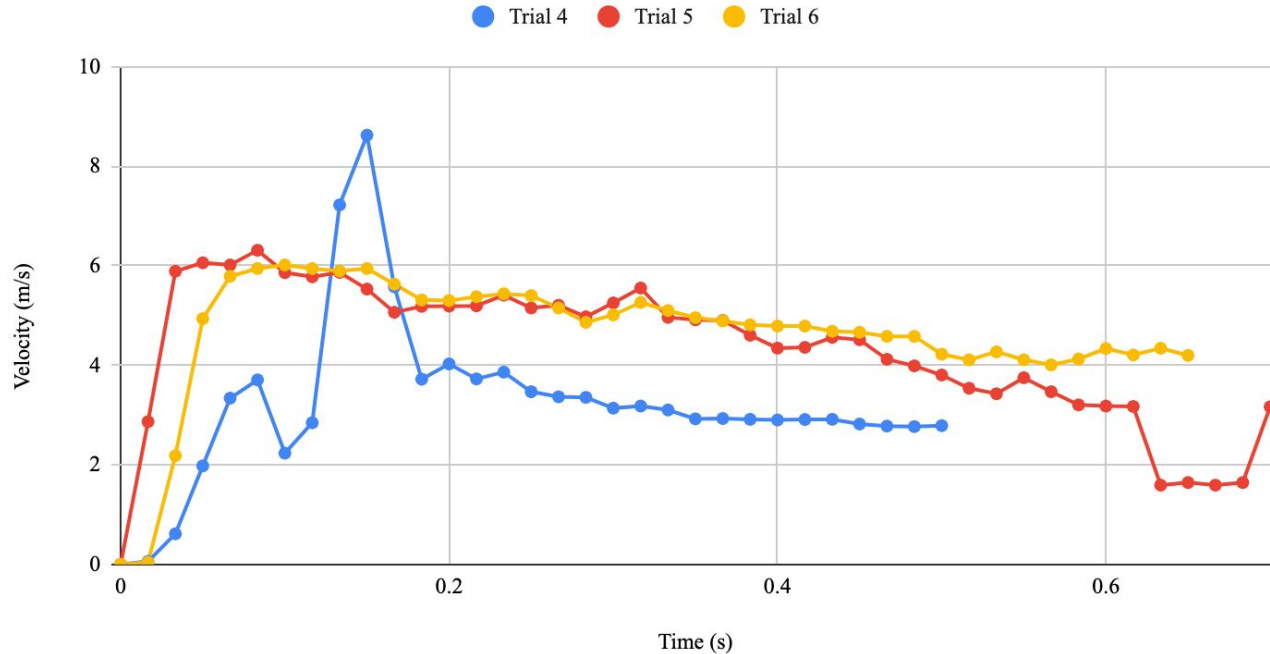
Low Speed Kick



Data Analysis: Trials 4-6

Velocity vs Time of Ball

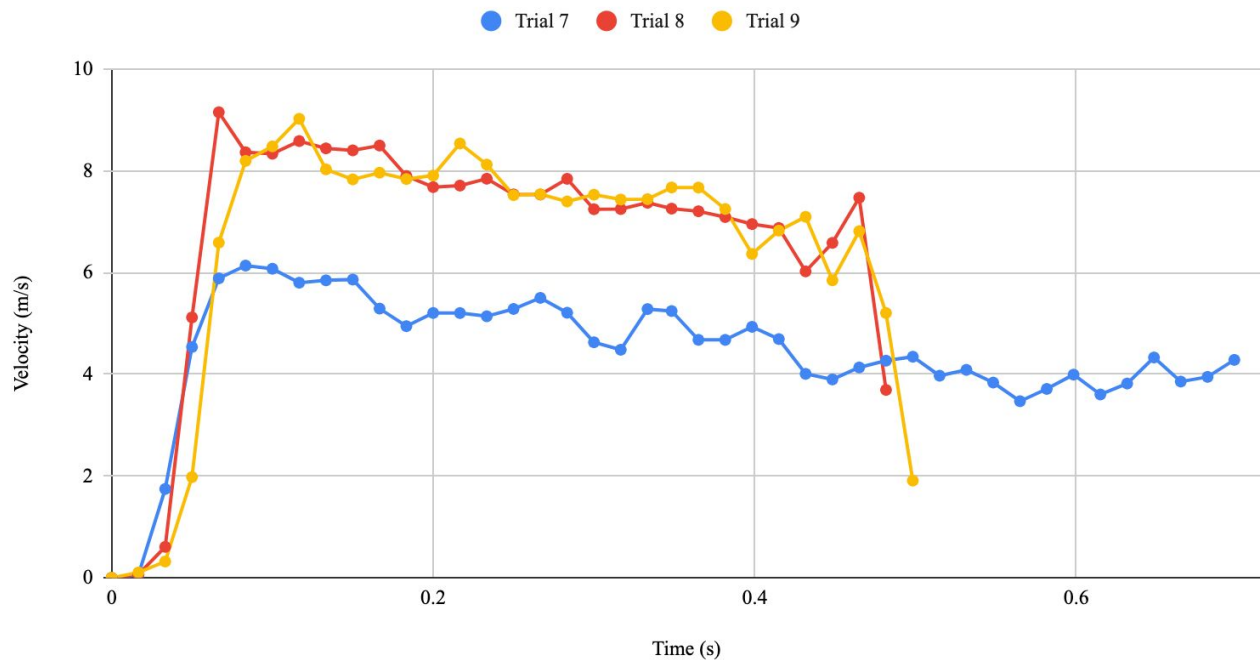
Medium Speed Kick



Data Analysis: Trials 7-9

Velocity vs Time of Ball

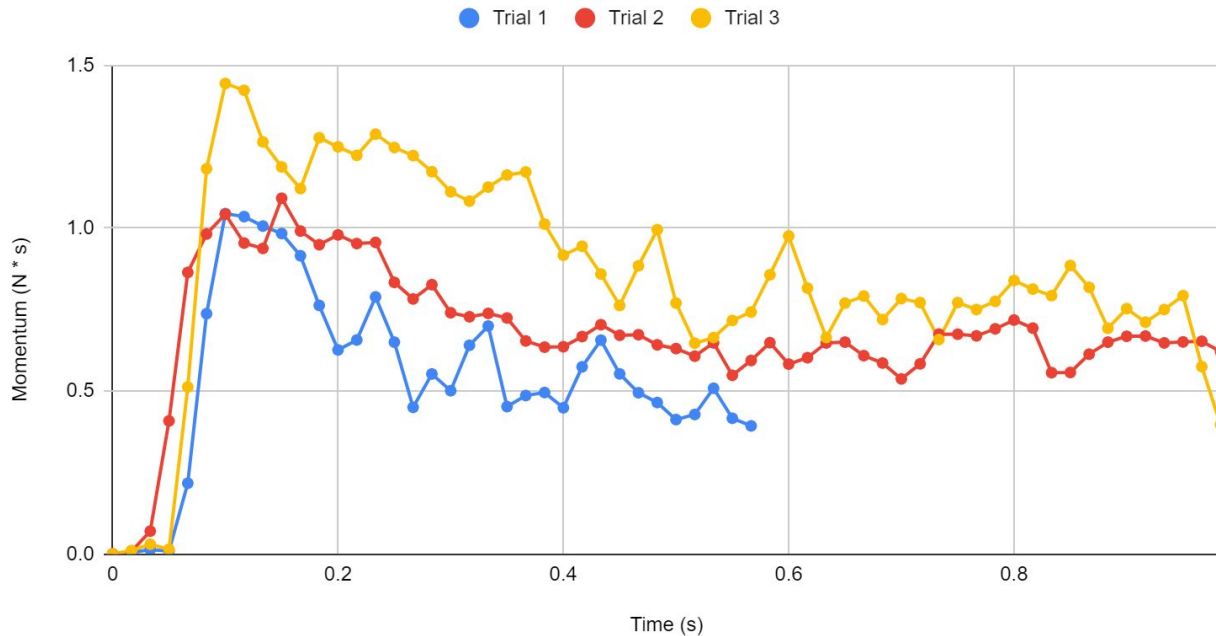
High Speed Kick



Data Analysis: Momentum Graph (Trials 1-3)

Momentum vs Time for Ball

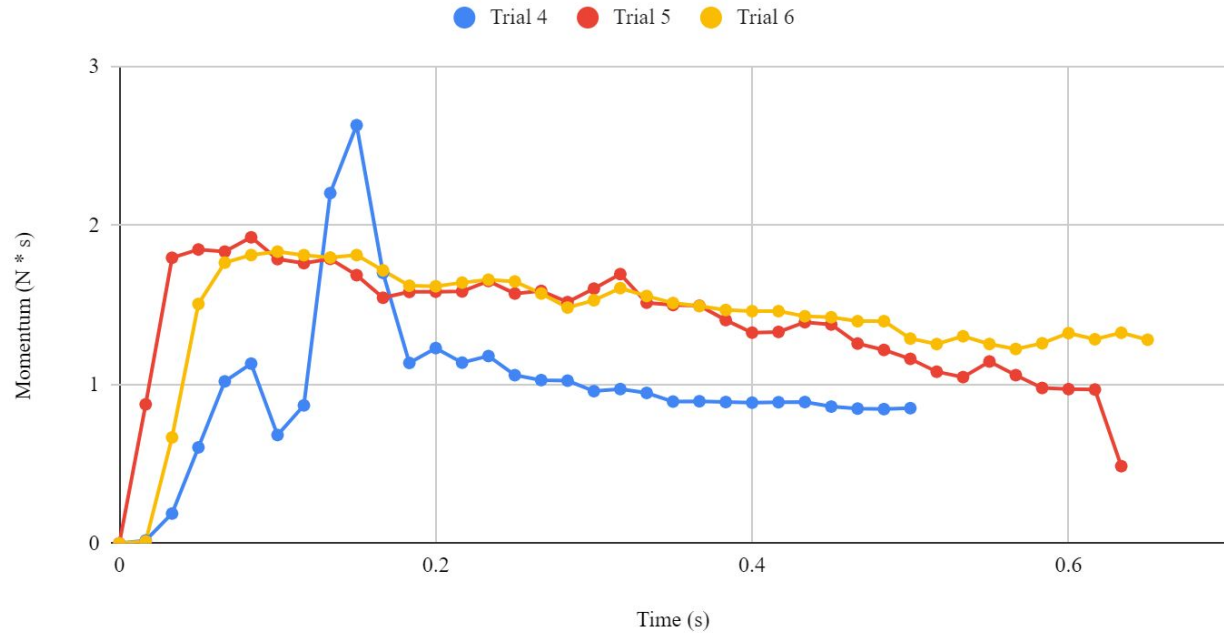
Low Speed Kick



Data Analysis: Momentum (Trials 4-6)

Momentum vs Time of Ball

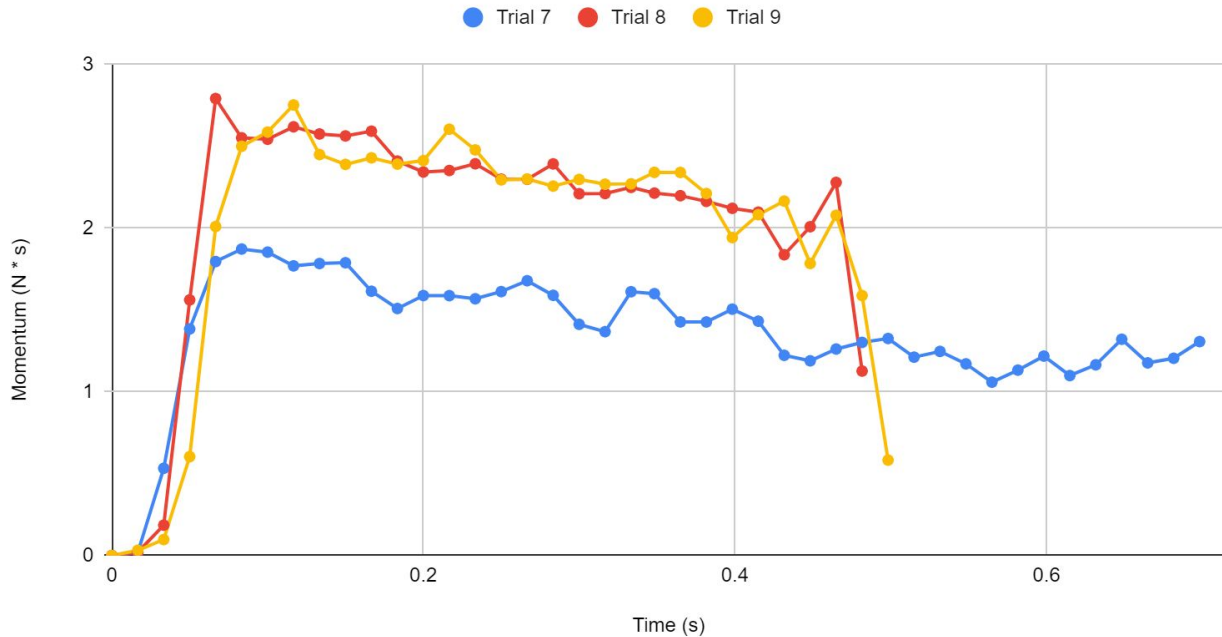
Medium Speed Kick



Data Analysis: Momentum (Trials 7-9)

Momentum vs Time for Ball

High Speed Kick



Evaluation of Significance

With this precise kicking form and contact with the ball, we can know the ball will move based from how much power is put into the kick.

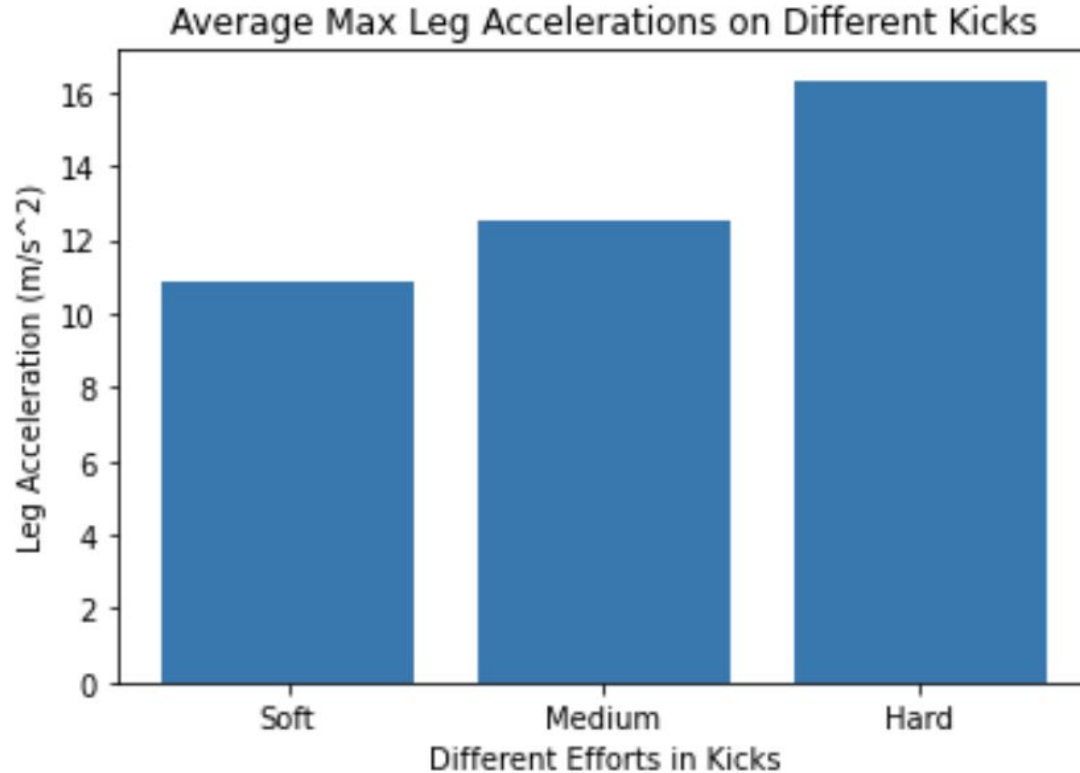
This similar experiment can be done for different ways for kicking a soccer ball: inside of the foot, top of the foot, outside of the foot, etc.

One could add analysis for more information on how the ball moves/acts after a kick.

Question

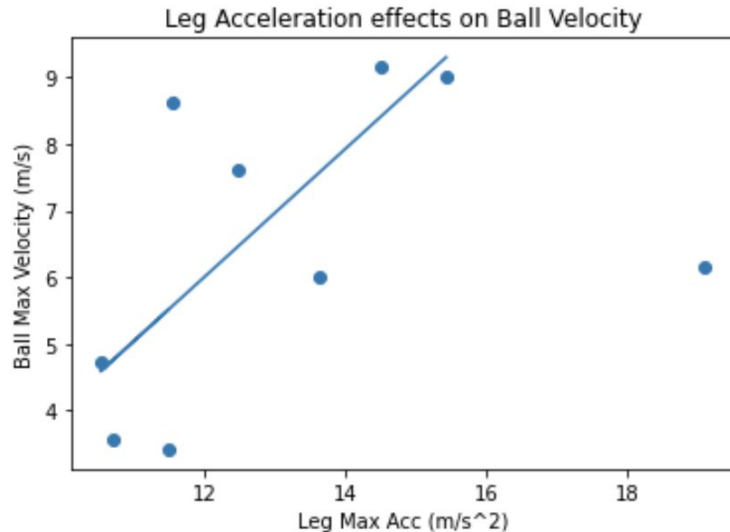
Is increasing Leg Acceleration or Leg Velocity more important in ultimately increasing Soccer Ball Velocity (efficiency)?

Data Analysis: Avg Max Kick Accelerations



Effects of **Leg Acceleration** on Ball Velocity

- For each trail (datapoint), we recorded the **max** leg acceleration reached, as well as the the max ball velocity achieved



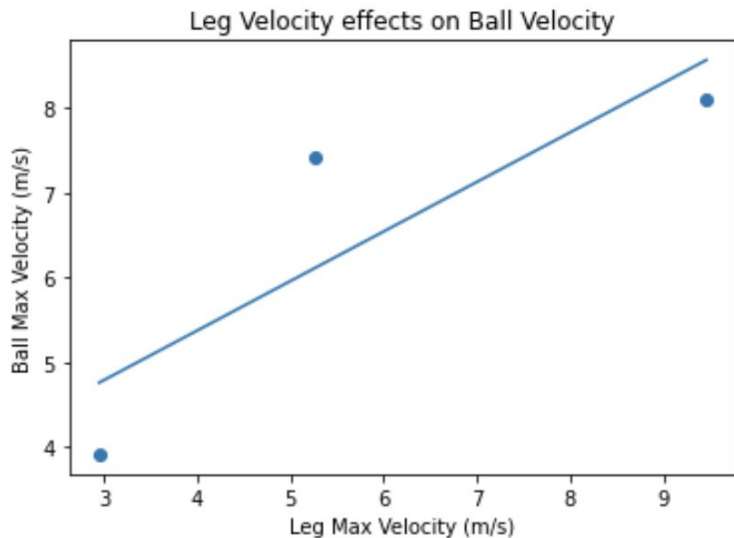
Slope: 0.9614764502827126

Slope Interpretation:

There is a **0.9614 m/s** increase in ball velocity for every 1 m/s² increase in max Leg Acceleration

Effects of **Leg Velocity** on Ball Velocity

- For each datapoint, we recorded the average **max** leg velocity reached in each kick effort category, as well as the the average max ball velocity achieved



Slope: 0.5856628751365589

Slope Interpretation:

There is a **0.5857 m/s** increase in ball velocity for every 1 m/s increase in max Leg Velocity

Therefore, **Leg Acceleration (0.9614 m/s per unit increase)** is more important in increasing ball velocity

Final Thoughts

Conclusions

As displayed through Python analysis, Leg Acceleration is more influential in increasing the velocity of the ball (efficiency).

Sources of Error / Struggles

- Surface we kicked ball on was concrete
 - Made ball bounce inconsistently, may have affected true velocity of ball
- Different points of contact on the ball
- Restricted range of motion with Arduino connected to leg
- Project-long connectivity issues with Arduino to computer for data transmission
 - Bluetooth and wired

Future Prospects

- Study conservation of momentum and KE from foot to ball
- To discover a more efficient way to analyze the contents in this experiment.
- To study other sports/exercise movements, like shooting a basketball or lifting weights
- To analyze deeper concepts of kicking a soccer ball, like different ways of shooting and passing (curving/lifting the ball).
- Can analyze more efficient biomechanical techniques for kicking a ball, like kicking with a straighter leg, or with a knee snapping motion.

Acknowledgements

We would like to thank our TA Ananyo for all he has done this year!

He explained concepts very well and taught how to use the Arduinos and analyze its data very effectively!

References

<https://www.youtube.com/watch?v=Dn0Zz7rtkZw>