Tennis Racket Head Speed Sensor: An Experiment in Device Functionality
Elizabeth Collier, Electrical Engineering
Project Advisor: Dr. Mitchell

Abstract
This project is designed as an experiment to find the velocity of a tennis ball using the linear acceleration data provided by an accelerometer. A frictionless, controlled environment was created to prove the accelerometer can accurately measure ball velocity. Further experimentation would be needed to have enough data for a fully functioning tennis racket sensor.

Procedure
• Two pendulum apparatus: frictionless, trajectory controlled experiment
• Mimics linear motion similar to a tennis racket swing
• Tennis ball and accelerometer attached to the microcontroller mounted from the ceiling using a string
• Tennis ball is released at an angle, makes contact with microcontroller pendulum
• Optical sensors measure the “actual” velocity, accelerometer measures the experimental velocity
• Data is collected to determine whether the accelerometer can accurately measure linear acceleration data

Components
STM32F446 Nucleo Microcontroller
Adafruit LSM9DS0 Accelerometer/ Gyroscope

Experiment Apparatus

Figure 1
Pendulum 1 holds the microcontroller and accelerometer. Pendulum 2 holds the tennis ball at a known distance, d.

Figure 2
Tennis ball is pulled back at a known angle from pendulum 1.

Figure 3
Pendulum 2 is released and makes contact with pendulum 1, causing it to shift backwards: a frictionless system.

Conclusion
It is essential that an extensive experimentation process is followed in order to ensure that a tennis racket sensor has the highest accuracy possible. Comparing the measured data collected from the apparatus to the theoretical calculations will provide reliable evidence that the chosen method of measurement is indeed appropriate and accurate.

Theoretical Calculations

\[ \omega = \frac{\Delta \theta}{\Delta t} \]

Angular Velocity Equation

\[ v = r \omega \]

Linear Velocity Equation

\[ v(t) = \int_{0}^{t} a(t) \, dt \]

Measured acceleration data will be read from the accelerometer and then integrated to find the measured velocity.