Tennis Testing Project

Mechanical and Aerospace Engineering
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Abstract

This project is sponsored by Mr. Jerry Allen. The purpose of this project is to determine changes in the RPM of a tennis ball based on the application of a tacky substance to tennis racket strings. Data is produced for the coefficient of friction and the RPM of a tennis ball and tennis racket.

Customer Needs and Requirements

- Data for Coefficient of Friction
- Data for RPM in various situations
  - Static and dynamic
- A large variety of credible data
  - Multiple string types
  - Multiple linear speeds
  - Multiple racket angles


Figure 1. Black String


Figure 2. Gold String


Figure 3. Red String

Three different strings with different cross-sectional shapes and spin potentials were used

Coefficient of Friction

Coefficient of friction represents how difficult it is to move two objects in contact past each other.

String Test


Figure 4. Coefficient of Friction String Test

Racket Test


Figure 5. Coefficient of Friction Racket Test

String COF Data

	Black String	Gold String	Red String
Non-Tacky	0.136 ± 0.018	0.159 ± 0.010	0.124 ± 0.008
Tacky	0.483 ± 0.046	0.571 ± 0.034	0.422 ± 0.024
Percent Change	255%	259%	241%

Racket COF Data

	Black Racket	Gold Racket	Red Racket
Non-Tacky	0.181 ± 0.013	0.213 ± 0.036	0.195 ± 0.015
Tacky	0.739 ± 0.021	0.476 ± 0.023	0.476 ± 0.026
Percent Change	142%	124%	144%

The application of a tacky substance to the strings and rackets increased the coefficient of friction.

Stationary Racket Testing

Stationary racket testing was conducted with the use of the Trine tennis launcher and a static apparatus to prevent the racket from moving.

Trine Tennis Launcher


Figure 6. Trine Tennis Launcher

Static Apparatus


Figure 7. Static Apparatus CAD Isometric View

Test Set Up


Figure 8. Stationary Racket Test Set Up

Pneumatic Testing

A pneumatic launcher was designed and built to be able to test at higher ball speeds.

Pneumatic Launcher

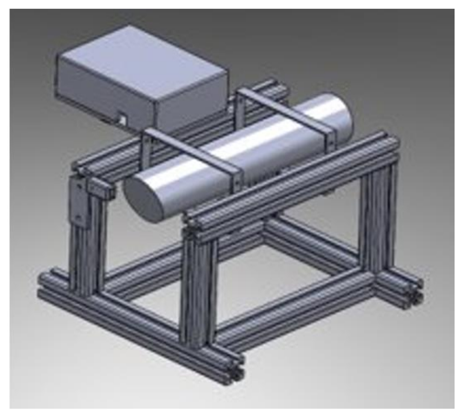


Figure 9. Pneumatic Launcher CAD Isometric View

Sensors


Figure 11. Infrared Sensor

Two Infrared Sensors were used to actuate the pneumatic launcher.

Modified Apparatus

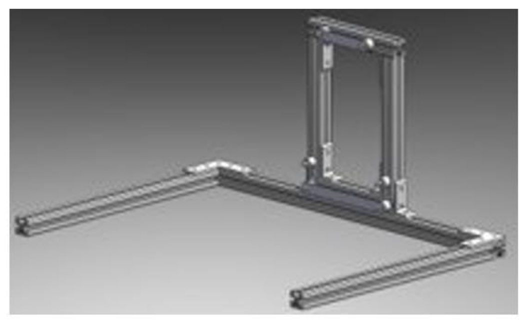


Figure 10. Modified Apparatus CAD Isometric View

Test Set Up

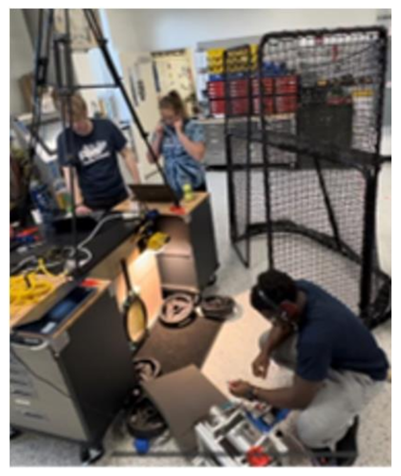


Figure 12. Pneumatic Test Set Up

Moving Racket Testing

With the use of the biomechanics lab, an apparatus was built to guide a tennis racket for a consistent tennis swing.

Live Swing Apparatus

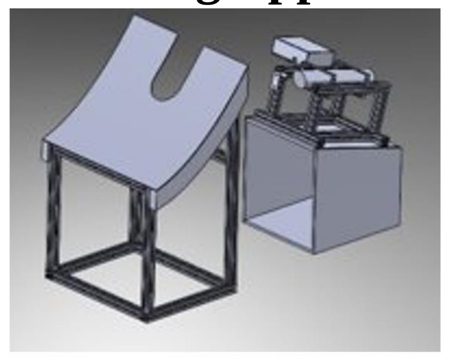


Figure 13. Live Swing Apparatus CAD Isometric View

Sensors

Two Infrared Sensors were used to trigger the pneumatic launcher once it sensed the racket on the apparatus.

Test Set Up

Figure 14. Moving Racket Test Set Up

Data Processing

Used a high-speed camera to capture and a coding software to identify the tennis ball and calculate rotation

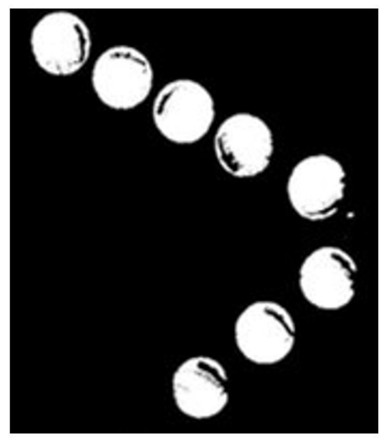


Figure 15. Tennis Ball Path from High-Speed Camera

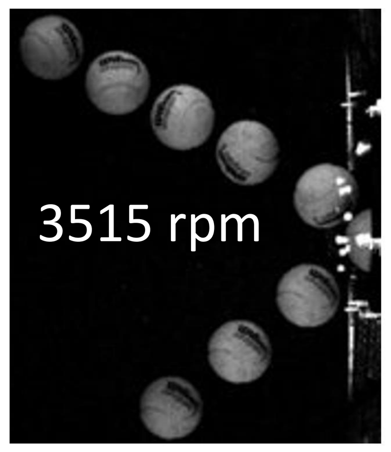


Figure 16. Tennis Ball Path Processed from High-Speed Camera

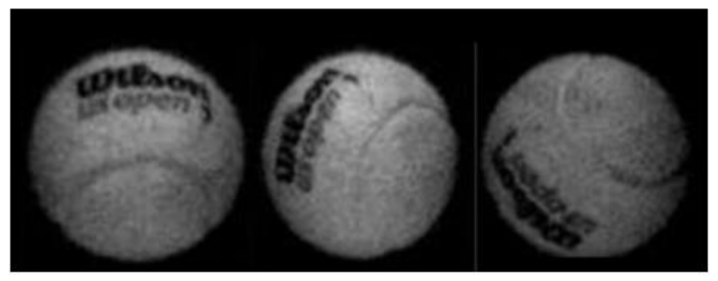
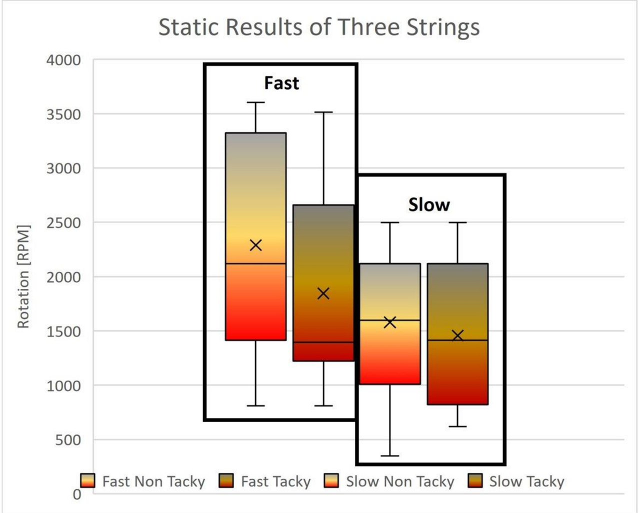


Figure 17. Tennis Ball Rotating Frames

Testing and Results

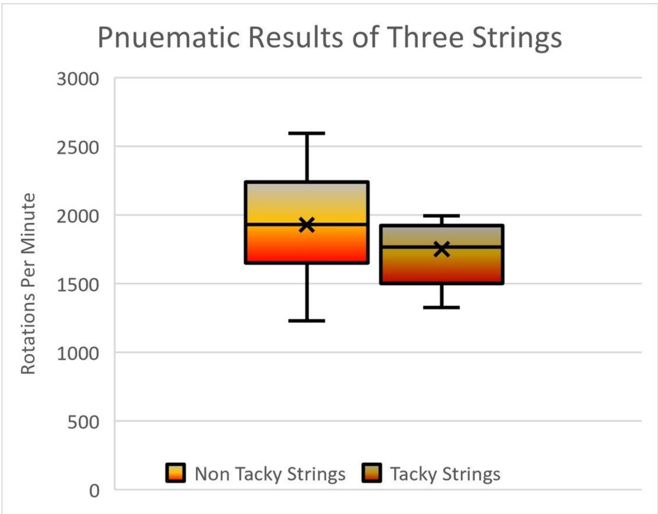
Stationary Racket Testing

- Different Strings
  - Black, Gold, Red
- Different Angles
  - 45°, 60°, and 75°
- Different Speeds
  - Fast (75mph) and Slow (45mph)
- Decrease in spin
  - Fast – Average decrease of 450 rpm
  - Slow – Average decrease of 120 rpm



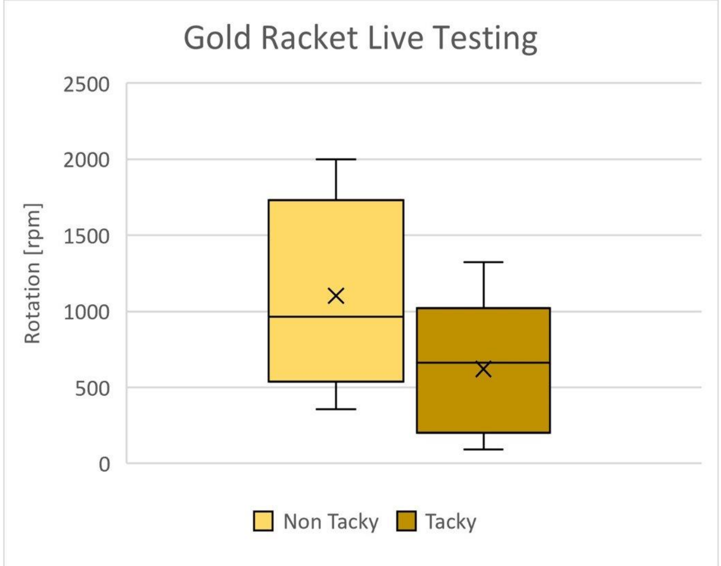
Pneumatic Testing

- Different Strings
  - Black, Gold, Red
- Most Common Angle
  - 55°
- Speed from Pnuematic Launcher
  - 85-95 mph
- Decrease in spin
  - Average decrease of 200 rpm



Moving Racket Testing

- Gold String
- Most Common Angle
  - 55° upwards into launcher
- Speed from Pnuematic Launcher
  - 35-45 mph
- Decrease in spin after racket contact
  - Average decrease of 480 rpm



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