Name(s)

Grant Gallagher

Project Number

J1708

Project Title

Investigating the Electrostatic Effects of Striking a Tennis Ball with a Tennis Racquet

Abstract

Objectives

The objective of this study is to determine whether charge forms on a tennis racquet and a tennis ball as a result of the racquet hitting the ball.

Methods

1. Construct electrodes to collect charge from the strings of a racquet. 2. Build a circuit that outputs a voltage based on the amount of charge collected by the electrode that is deposited on a capacitor. (The circuit design was obtained from the internet.) 3. Hit a number of tennis balls. 4. Apply an electrode to the strings, collect charge on the capacitor, and measure the resultant voltage. 5. Calculate the charge from the equation Q = CV, where Q is charge, C is the capacitance of the capacitor, and V is the voltage. 6. Create charge distribution maps by moving a small electrode to different positions on the strings. 7. Using a ball-shaped electrode, measure the charge on the ball.

Results

Negative charge as high as about 175 nC was observed on the strings of the racquet. Charge distribution images that map the charge with respect to the location on the strings were produced. The charge distribution images show a distinct peak in charge, which generally appeared on a vertical axis through the center of the racquet, but above the center of the racquet head. The peak may correspond to the location where the ball impacts the strings based on estimates from video obtained while hitting. Positive charge as high as about 40 nC was detected on the ball.

Conclusions

Negative charge can be formed on the strings of a racquet while positive charge may be produced on the ball as a result of the racquet hitting the ball. Interestingly, no observations of charging can be found on the internet, nor does such charging appear to be commonly known among players. The existence of charge, however, is not surprising. The strings comprised polyester, and the surface of the ball comprised nylon. Polyester and nylon are materials that produce a triboelectric effect. Polyester is known to generate negative charge while nylon is positive charge producing. Charge distributions maps show that the charge on the strings is localized. This is not surprising as polyester is a dielectric, and thus, charge does not flow freely. Mapping the charge distribution on the racquet can be useful in determining where the ball contacts the strings. Such information may help direct the player to change their swing to contact the ball more toward the center of the racquet head to enable the player to more efficiently produce ball velocity while decreasing strain on their body, thus potentially reducing injuries to the player's arm, back, or shoulder.

Summary Statement

Charge has been measured on the strings of a racquet, and charge distribution maps show that this charge is concentrated at a location that may correspond to where the ball contacted the racquet.

Help Received

My father provided me direction as to different techniques for plotting in Mathematica, as well as assistance in assembling the circuit, namely, soldering the op amp chips to the bread board adapters.