CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)
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Project Number
J0119

Project Title
Put a Spin on It: Measuring the Magnus Force Generated by a Spinning Tennis Ball

Abstract

Objectives/Goals
The objective was to measure the Magnus force generated by a spinning tennis ball in a moving air flow at various spin rates and in both directions.

Methods/Materials
A conventional fan-powered wind tunnel was assembled from melamine coated hardboard, glue, duct tape, egg-crate light panels, and a household fan. The wind tunnel simulated a tennis ball flying through the air.

A tennis ball mounted on a shaft driven by two slightly geared down motors provided the source of the Magnus force. A variable voltage supply set the speed of the motors. A slotted opto coupler connected to a frequency meter measured the spin rate. The motor mechanism built from various LEGO elements permitted the shaft to pivot about an axle mounted on top of the test chamber. The Magnus force pushed the spinning shaft sideways, moving the ball upwards against the force of gravity until the Magnus force and force of gravity were equal. This angle was recorded for each spin rate.

To calibrate the mechanism, the shaft was rotated to the horizontal position and a postal scale was placed under the tennis ball. The weight measurement represented the net downward force of gravity on the ball at 90 degrees. To obtain the force at other angles, this value was multiplied by the sine of those angles. This gave the Magnus force.

Three trials each consisting of 19 angle measurements taken at 83 RPM intervals ranging from 0 to 1500 RPM in both clockwise and counter-clockwise spin directions were made.

Results
For spin rates ranging from 0 to 1500 RPM in 83 RPM increments, the Magnus force increased continually from 100 dynes to 7,700 dynes. At 0 RPM, the ball fluctuated wildly. Balls spinning clockwise (as viewed from the top) tilted to the right (as viewed from the exhausting fan). Balls spinning counter-clockwise way tilted to the left.

Conclusions/Discussion
The principle observation confirms the hypothesis that the greater the spin rate, the greater the Magnus force. In addition, a zero spin rate produced great instability, which probably accounts for the erratic behavior of knuckle ball pitches in baseball. Finally, when the ball was spun in one direction, the ball always swung to the same side. When the ball spin was reversed, the ball swung in the opposite direction but to the same degree for the same spin rate.

Summary Statement
This project measured the Magnus force of a spinning tennis ball in a moving air flow at various spin rates and in both directions.

Help Received
Father helped design and construct wind tunnel, explain unit conversions, and record measurements. Mother helped create backboard and record measurements. Brother helped assemble wind tunnel and record measurements.