The Effect of Spin on The Flight Path of a Baseball

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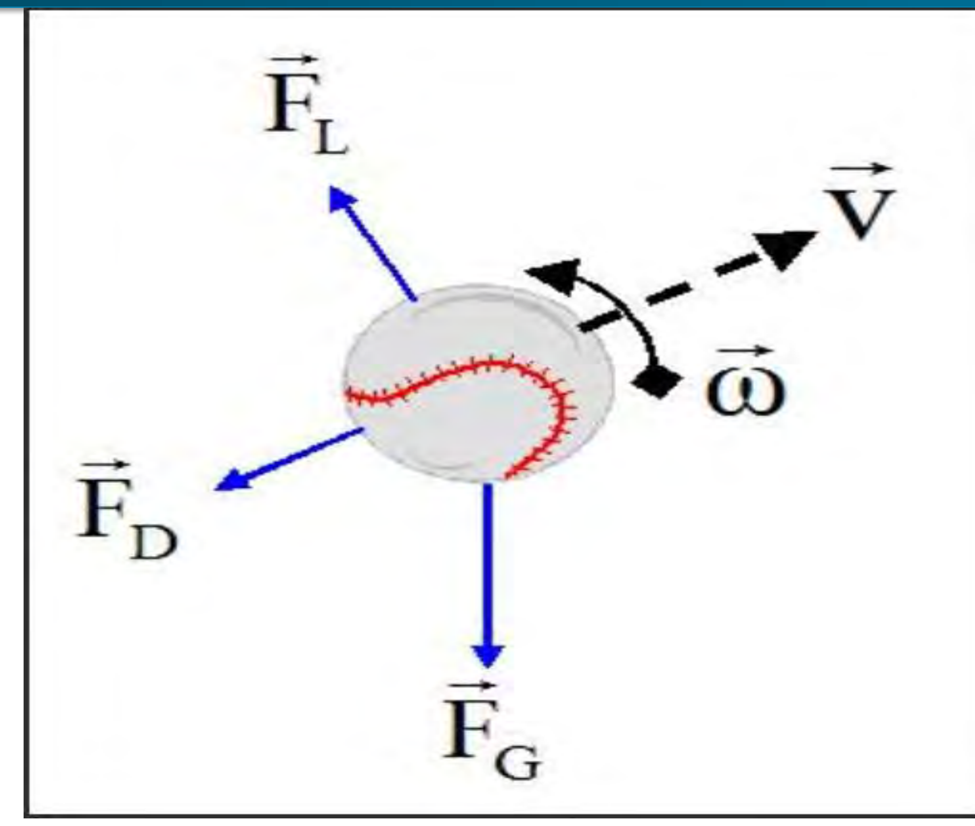
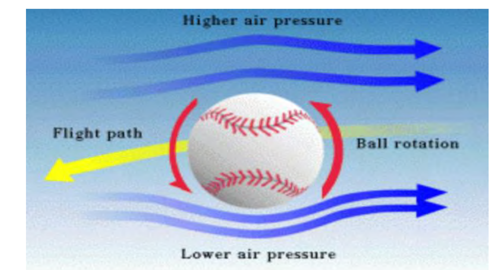
Introduction

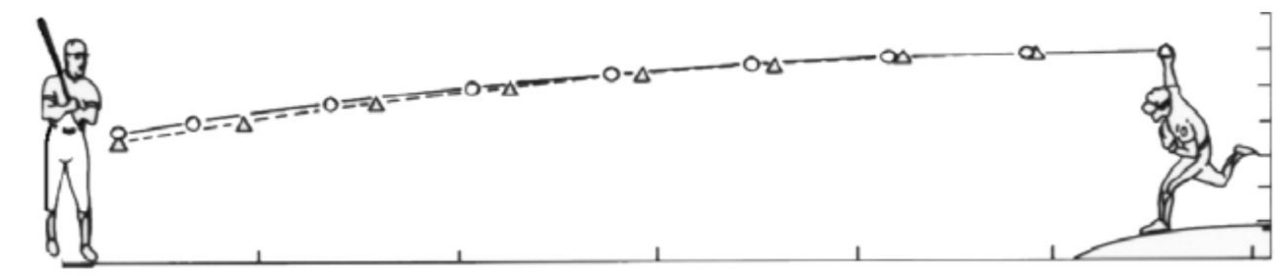
It is common knowledge between players, fans and scientists that a spinning object curves. In physics, the explanation for this is due to the Magnus force, which was first observed by Isaac Newton with tennis balls. This force is responsible for most of the uncertainty between pitchers and batters today, but also corresponds to the baseball's distance off the bat. Hitters, as well as golfers, understand that undercutting the ball will increase the flight path by a significant amount. The purpose of this study is to explain the common coaching term 'hit under the ball'.



Abstract

This study is performed to show the effect of spin on the flight path of a baseball. Forces, such as the Magnus and drag, change the trajectory of any spinning object dramatically. Trajectories are also dependent on atmospheric pressure. Using MATLAB and Excel, a simulation will be used to show the different flight paths based on angular velocities, altitude, and release angles.





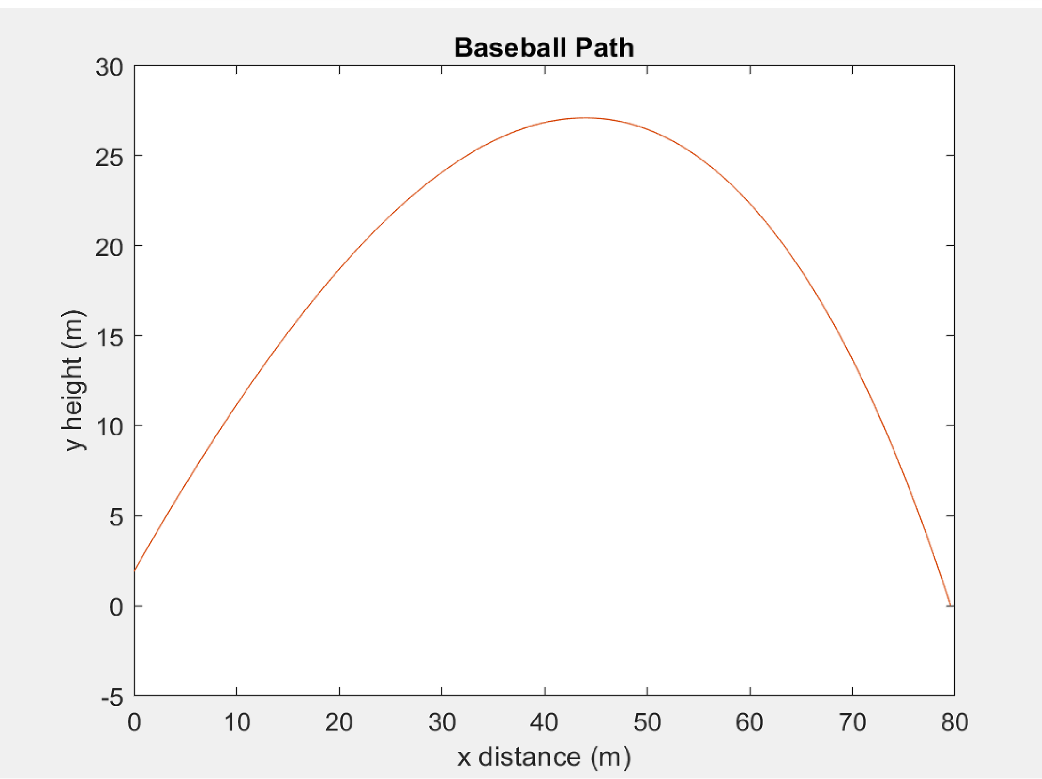


*Figure 1:Ball thrown at 45-degree angle at a velocity of 38 m/s (85 mph). This figure refers to a baseball **with** air resistance. Final landing - 79.59m in the x-direction.*

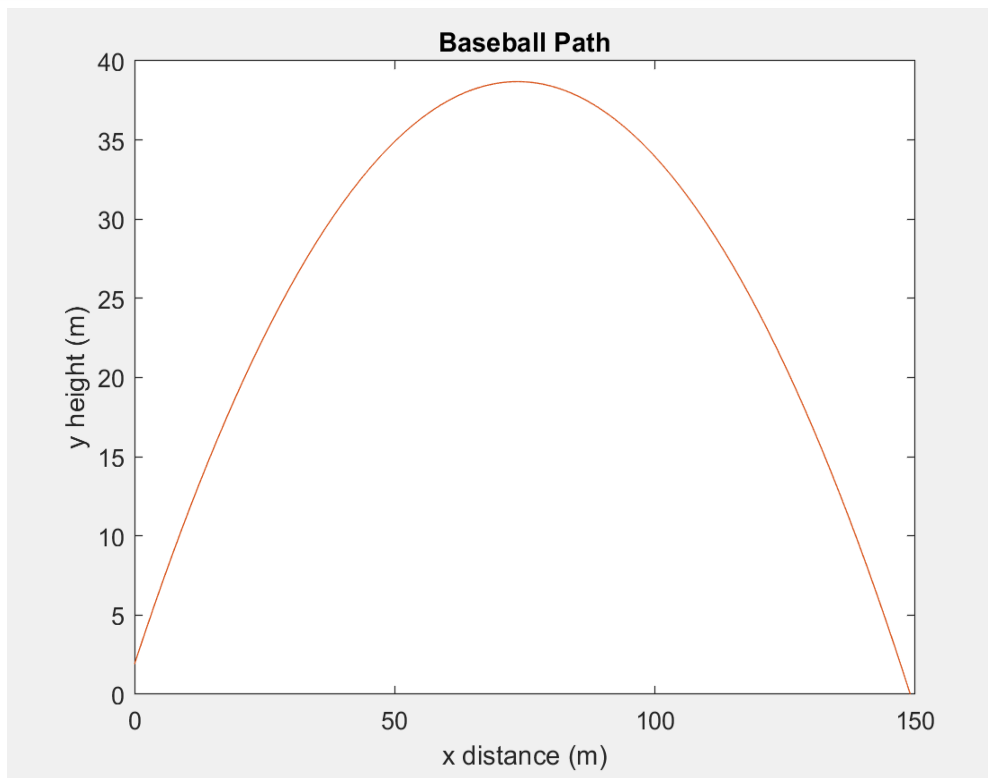


*Figure 2: Ball thrown at 45-degree angle at a velocity of 38 m/s (85 mph). This figure refers to a baseball **without** air resistance. Final landing - 149.04m in the x-direction.*

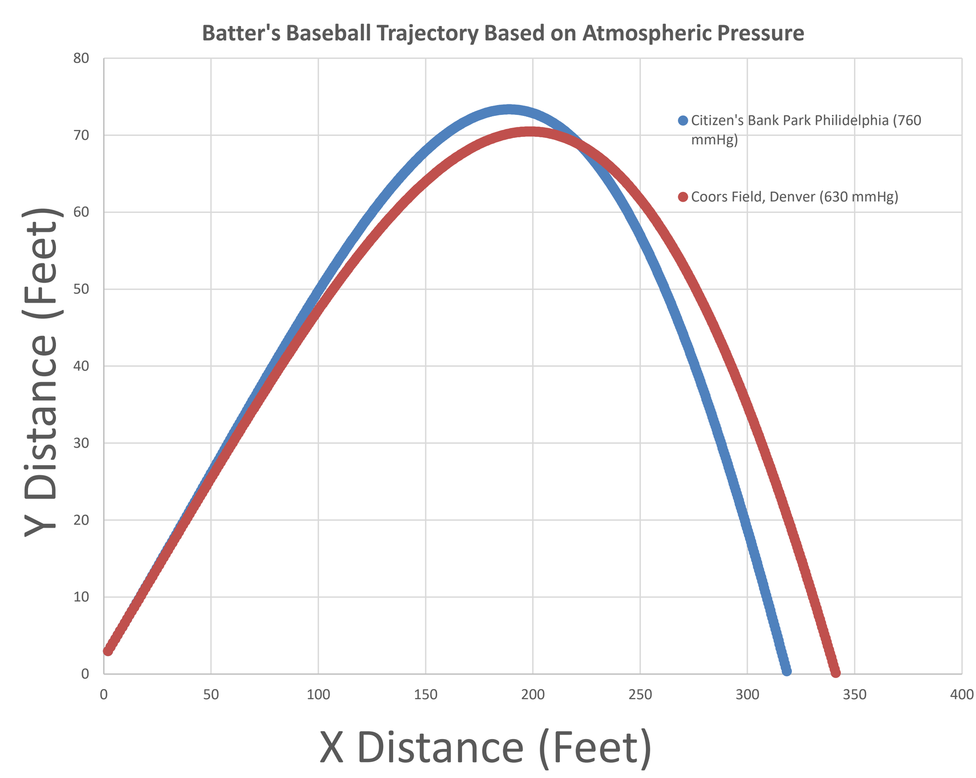


Figure 3: Citizen's Bank field (760 mmHg) versus Coors Field (630 mmHg). Coors field yielded 23 more feet in the x-direction.

Magnus Force

$$F_m = \pi \rho r^3 v \omega$$

- The Magnus effect works by creating low pressure and on one side of the ball and high on the other.
- The rotation speeds up the air on one side, while slowing it down on the other, creating 'lift'.
- The magnus force depends on air density and velocity
- At high velocities, the rotational energy turns into kinetic

Results and Discussion

The simulated data proved that atmospheric pressure, air resistance, and the Magnus force all have a dramatic effect on the trajectory of a baseball. For atmospheric pressures, a ball hit at Coors Field in Denver going 85 mph with a 25-degree angle (z-direction) will travel 341 feet (x-direction), with a hang time of about 5.06 seconds. A ball hit at Citizen's Bank Park (760 mmHg) in Philadelphia will travel around 318 feet, with a hang time of about 5.18 seconds. Thus proving it is 'easier' to hit a home run at Coors. Secondly, a ball with backspin (6160 rpm), with the Magnus force in the positive vertical, will travel approximately 318 feet at sea level. A ball with topspin (-6160 rpm), with the magnus in the negative vertical, will travel 158 feet. A difference in 157 feet proves a common coach phrase 'hit the bottom of the baseball'. Lastly, the Magnus force affects the pitcher's ability to manipulate the flight path, thus deceiving the batter with a 'riser', or 'curveball'.

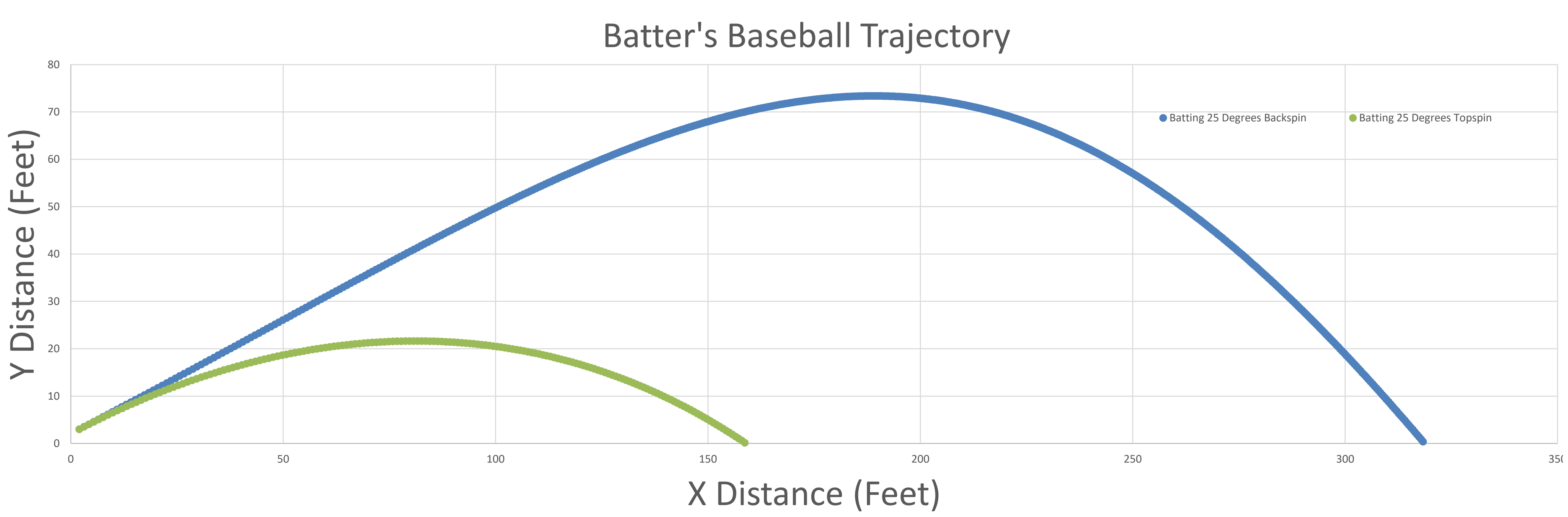


Figure 4: Magnus force simulation of a BATTED baseball (25 degrees) spinning at 6160 revolutions per minute, with both top (158 feet) and backspin (318 feet). The baseball with backspin yielded 157 more feet in the x-direction. These calculations were taken at 760 mmHg (sea level).

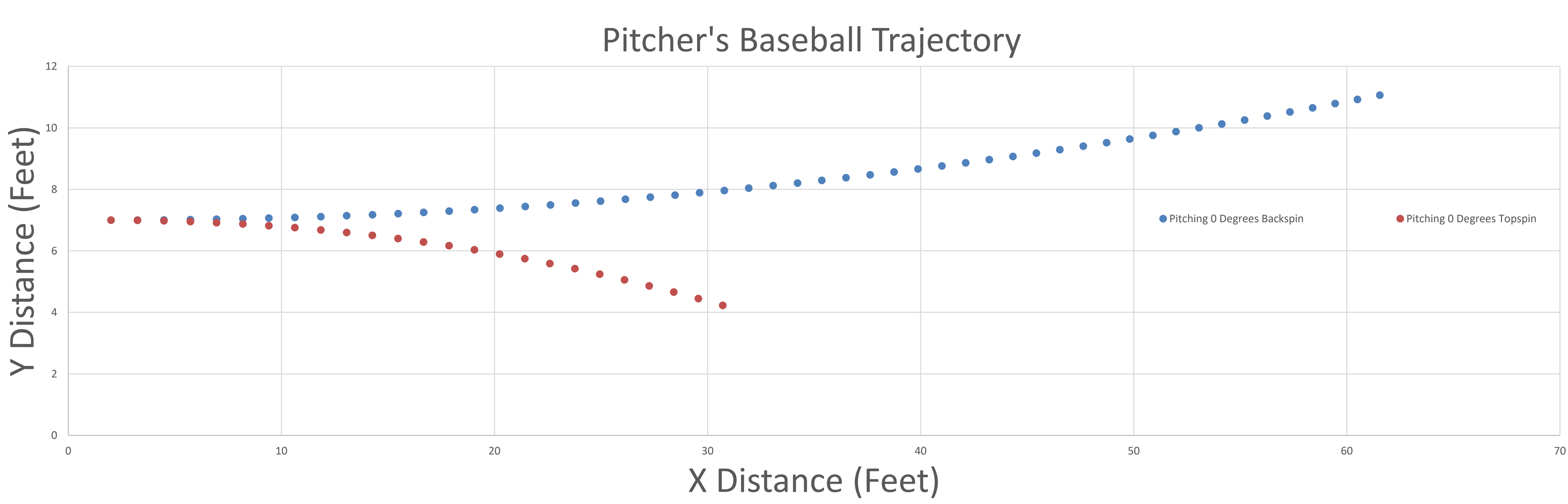
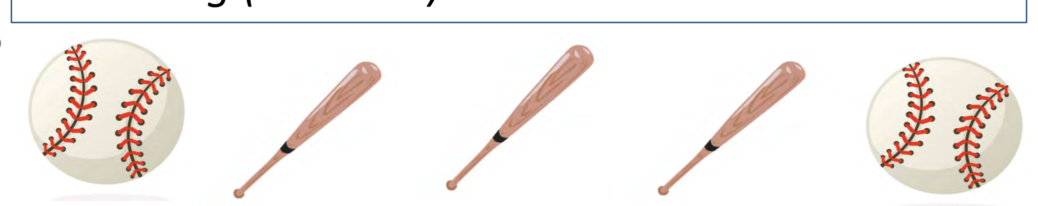


Figure 5: Magnus force simulation of a PITCHED baseball spinning at 6160 revolutions per minute, with both top and backspin. The baseball with backspin rose vertically, corresponding to a pitch named 'riser'. Secondly, the ball with topspin landed before the plate, which is considered a 'curveball'. These calculations were taken at 760mmHg (sea level).



Future Work

With use of high-speed cameras, data can be drawn by triangulating the coordinates of the baseball. With real coordinates, a true model of the flight path can be determined.

Criteria to calculate:

- RPMs of an 85 mph out of a pitching machine
- Hitting versus pitching a baseball (differences)
- Determining the difference in trajectory between little league, high school and professional baseballs.

Acknowledgements

I would like to thank the following for their continued support and advice:

- Faculty of the Physics Department in general, and Dr. Szapiro and Dr. Peterson in particular
- Junior and Senior Physics Majors
- Friends/ Family