Science Lessons for Grades 6-8

"Introduction to Optimization: Water Balloon Launcher"

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Discipline: Mathematics and/or Physics
Grade: 6 to 8

Purpose/Goal
The students should have some idea of curve fitting, multivariable functions, and model building. Also, they should have an idea of how to optimize some function beyond rudimentary guess-and-check. Lastly, the students should be better at solving unique problems.

Context
This lesson can be incorporated anywhere within a physics curriculum. It can easily be tweaked to introduce or wrap up concepts such as force or potential and kinetic energy. In a mathematics course, the lesson could expose students to multi variable functions, mathematical models, problem solving, and curve fitting.

Preparation
The most critical items are a water balloon launcher and a way to measure distance traveled by the balloon.

Website
None

Motivation
Give the each student a single rubber band and place a garbage can in the middle of the room. Have the students form a circle around the basket and try to fire their single shot into the basket. Since each student only has one chance, suggest the students work together to get an idea of what does/doesn't work.

Description
I start the lesson by telling the students they have one chance to hit me with a water balloon. Each student (or each group of students) will get a water balloon. They mass the balloon and go outside to the launcher. For consistency, the handles of the launcher are fixed and the only variable is how far back the student wants to pull the launcher. For each student, the distance pulled back and the distance traveled by the balloon is recorded. I then give the entire class one last water balloon, with a different mass from any of the previous balloons. I tell them exactly where I am going to stand, but I pick a position where a balloon hasn't landed. Then, the class decides how far back they want to pull their one balloon. I go stand in the agreed upon position, and the students see if they can hit me.

A natural extension is to try to fire the balloon the farthest. Since I don't want to break the launcher, I prescribe a firing position and ask the students to vary the mass of their balloons to see what mass goes furthest. We graph the data, fit a curve, and find what is the optimal mass for the given pull-back distance.

Follow-Up Activities
There are countless follow-up optimization questions that can be asked. I like asking the following example: Say you operate a business that produces Wii's, Playstation's, and Xbox's and the profit earned per console is $10, $20, and $30 respectively. I then give constraints on the amount of time required to produce each box, along with the amount of material required for each console. I ask the students how many of each they should make to make the most money. I am looking for results beyond blind guess and check. Most students will invent sophisticated and unique ways to find the optimal solution.

This lesson provides a great opportunity to introduce multi-entrance, multi-exit problems that really allow students to show what they've learned. I find optimization problems to be a good base, since they provide a

quantifiable function the students can try to optimize. I stress that improved critical thinking and problem solving are the goals, not necessarily the answer.