Water Rockets: First Derivatives
Teacher Notes and Resources

This document focuses on giving you specific information, resources, and ideas on how to best implement this module into your lesson plan(s).

Introduction:
Imagine building your own water rocket out of a 2-liter plastic bottle and being able to predict just how high it will go. That is exactly what this module shows students how to do.

Audience:
Calculus students

Prerequisite Student Skills:
- Plot and locate (x, y) coordinates in an XY coordinate system.
- Compute a missing side using the trigonometric definition of tangent.
- Enter data into LISTS and use a Graphing calculator's LIST and STAT functions
- Find the first derivative of a function and find its optimum value(s).
- Integrate basic functions.
- Optimization procedure via first derivative.

Time Frame:
Pre-lab takes about 45 to 60 minutes
Lab takes about 45 to 60 minutes
Post-lab takes about 30 to 60 minutes

Required Equipment:
- 1 or more water rocket launcher kits (Aqua Port Launcher, part # W55499, http://www.shop-pitsco.com/pitsco3/finditem.cfm?itemid=244)*
- 1 bicycle air pump with pressure gauge*
- Poster size Post-it grid paper*
- 3 clinometers*
- 10 to 12 two liter plastic bottles
- Graphing calculators (class set)
- Bicycle pump with pressure gauge*
*Provided at AIM/DTEACH workshops

Objectives:
The student will:
1. Record, analyze and process water rocket launch data to find optimum height.
2. Formulate quadratic functions from water rocket data via graphing calculator.
3. Compute and predict a water rocket’s height under a variety of conditions.

Online Resources:
For in-depth and extensive information about rockets and other related web sites go to http://my.execpc.com/~culp/rockets/rockt_eqn.html.
Pre-lab:
The pre-lab reviews the trigonometric definition of tangent to find the height of buildings, utility poles, trees, and water rocket launches. The pre-lab also reviews solution methods for a system of equations. Remind students to set their calculators to DEGREE mode. It is helpful to do a problem or two on the trigonometric definition of tangent and solve a system of equations prior to the pre-lab. The pre-lab is a teacher-led activity.

Lab:
Before the Lab starts, break up the class into three groups and assign each group an activity. The Lab component consists of three activities. First, three water rockets with different volumes (x) at the same air pressure are launched. The rocket’s height (y) is calculated (see pre-lab), three (x, y) points are plotted and then converted into a quadratic equation via graphing calculator technology. Next, the first derivative and optimization is applied to the quadratic expression to find the optimum height reached with a given volume. Finally, all the data is consolidated into a table showing water rocket volume, pressure, and height. Encourage students in each group to check their results before submitting their findings.

Post-lab:
The post-lab consists of one activity: Each student group will use the consolidated data table (from Lab) to calculate the amount of volume and air pressure needed for a water rocket to reach an assigned height. Each group will have only ONE rocket launch to test their calculations. Documents in this component are:
- 3 Lab Groups student handouts
- Lab teacher notes

Assessment:
The Questions Bank gives you flexibility in creating assessment instruments (quiz, test, review, warm up, homework etc.) to fit your classroom objectives and priorities. You have the option to “pick and print” as long or as short an assessment instrument you need. Be creative. The documents in this component are:
- Questions bank
- Questions bank key

To access the Questions Bank go to http://www.engr.utexas.edu/aim/questionbank and follow the directions posted.