CALCULATING WITH CATAPULTS:
DISCOVERING PARABOLIC PROPERTIES

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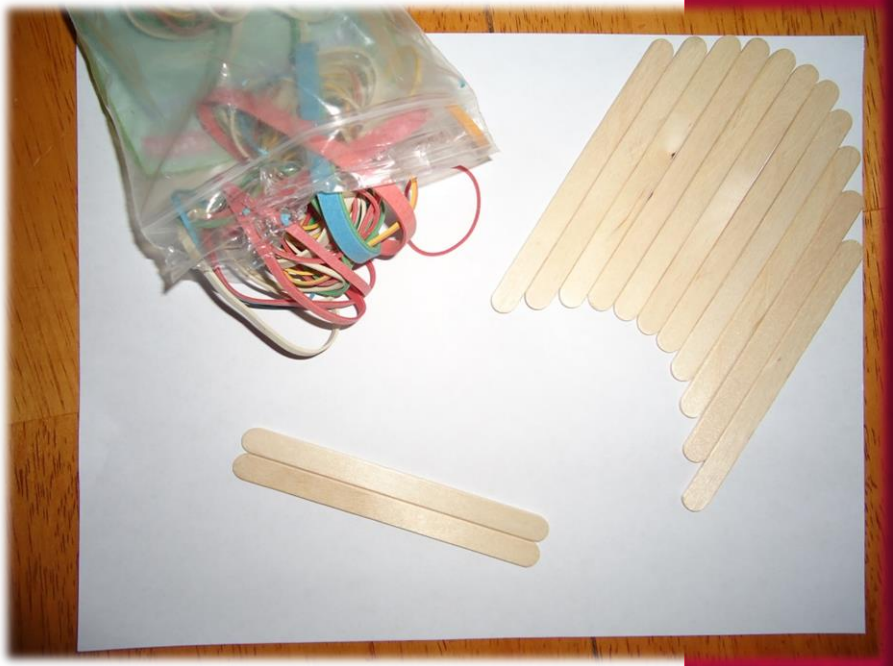
INTENT

- Grade Level: high school
- Objectives:
  - Follow visual/auditory instructions to construct a catapult
  - Measure launch height and distance traveled by projectile
  - Use graphing calculator to model a parabolic path
  - Use catapult and graph to study factors that affect the projectile
  - Study real life applications of projectile motion/parabolas

MATERIALS

- Approximately 13 popsicle sticks
- 3 rubber bands
- Ruler/Tape Measure
- Dime (or other projectile)
- Graphing calculator
- Paper and pencil

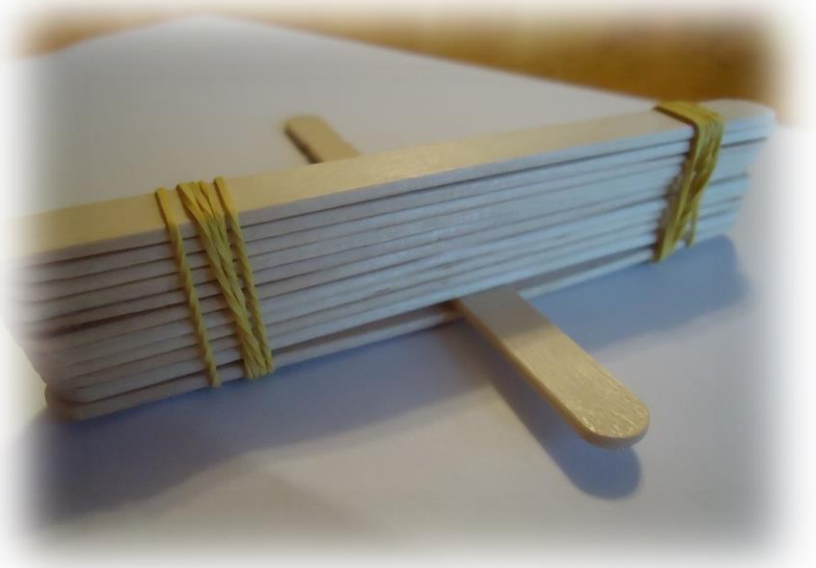


CREATING THE CATAPULT . . .

- Stack eleven popsicle sticks and rubber band each end tightly
- Carve two notches at one end of each of the remaining two popsicle sticks

CREATING THE CATAPULT CONT.

- Insert one notched popsicle stick above the bottom popsicle stick in the stack
- Place the other notched popsicle stick on top of the stack
- Loosely rubber band the notched popsicle sticks to make the arm



ACTIVITY PROCEDURE

Step 1: Create groups of 3-4 students. Distribute worksheet to each student and materials to each group.

Step 2: Instruct each group to construct the catapult and perform practice trials.

Step 3: Read worksheet directions aloud and assign group member roles;

Recorder- measure and record launch heights and projectile distances

The Foundation- holds the stack and launch arm base

The Launcher- lightly holds the projectile on the arm and launches it

ACTIVITY PROCEDURE CONT.

- **Step 4:** Perform launch trials, filling out the chart provided on the worksheet

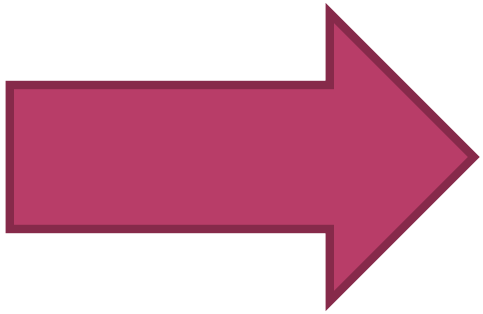
- **Step 5:** Guide students in creating a quadratic regression on the graphing calculator.

- **Step 6:** Ask students to complete analysis questions, (and extension questions), in their groups to prepare for class discussion.

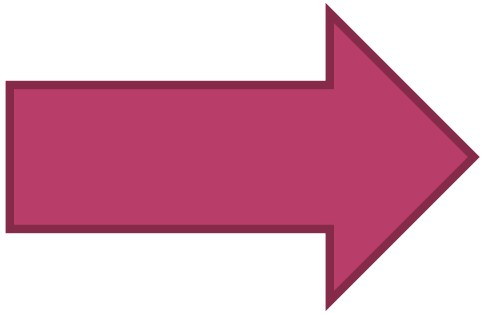
AN EXAMPLE: DATA

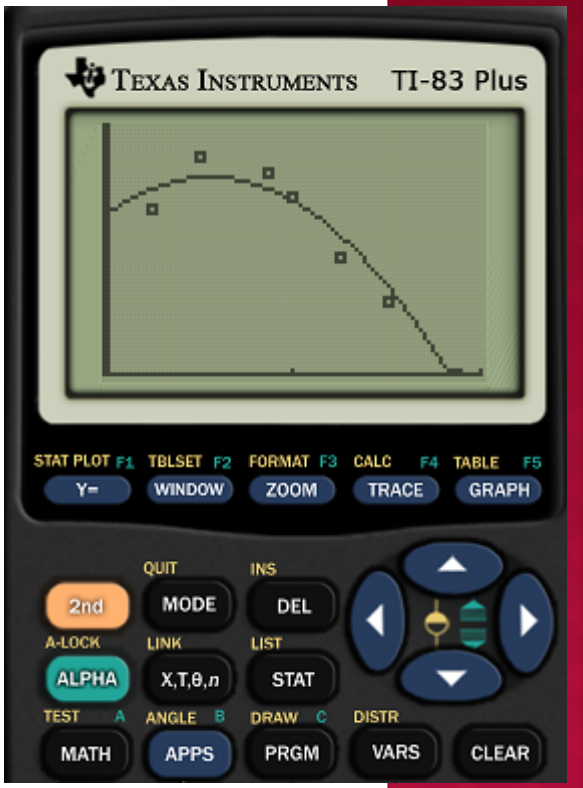
Launch Height (inches)	Trial 1 (inches)	Trial 2 (inches)	Trial 3 (inches)	Trial 4 (inches)	Trial 5 (inches)	Average Distance (inches)
¼	47	44	42	47	52	46.4
½	64	61	59	65	58	61.4
$^{7}/_{8}$	59 $^{3}/_{4}$	59 $^{3}/_{4}$	57 $^{1}/_{4}$	52 $^{7}/_{8}$	54 $^{1}/_{2}$	56.8
1	51 $^{1}/_{16}$	49 $^{11}/_{16}$	51 $^{15}/_{16}$	50	47 $^{1}/_{2}$	49.9
1 ¼	35 $^{1}/_{2}$	31	29 $^{1}/_{2}$	34 $^{5}/_{16}$	34 $^{1}/_{2}$	33.0
1 ½	20 $^{1}/_{2}$	20 $^{1}/_{2}$	22 $^{1}/_{2}$	21 $^{1}/_{2}$	17 $^{9}/_{16}$	20.5
1 $^{7}/_{8}$	0	0	0	0	0	0

AN EXAMPLE: CALCULATOR WORK



AN EXAMPLE: CALCULATOR WORK CONT.





ANALYSIS

Purpose: Discover properties of a parabola and make connections.

Higher-Level Thinking:

- While the projectile does travel in a parabolic arc, the graph is NOT showing the path of the projectile.
- Relating the students' hands-on, experimental work to mathematical vocabulary

Once students answer worksheet questions , the instructor can introduce the vocabulary that accompanies their discoveries:

1.) **Turning Point:** the ordered pair that represents the highest/lowest point on the curve, has a slope of 0, indicates change in curve's slope

2.) **Maximum:** the launch height at which the projectile travels furthest

3.) **Axis of Symmetry:** the vertical line, $x = c$, that passes through the turning point and divides the parabola into mirror image halves.

4.) **Concavity:** the direction in which the parabola opens

EXTENSION: MAKING PREDICTIONS

- List sports/occupations in which an understanding of projectile motion is useful.

- Predict the launch height needed to land the projectile in a basket at a known distance.

SOURCES

- Algebra Fun Sheets. (2012, February 1). *Quadratic Equations and Projectile Motion*. Retrieved from The Math Teacher's Resource Site: Resources for Middle School Math and Algebra: http://algebrafunsheets.com/blog/category/quadratic-equations/