LessonTitle: Quadratic Function Labs		**Alg 7.9b**
Utah State Core Standard and Indicators Algebra Standard 2.1.3 Process Standards 1-5		
Summary In these labs, students experience the growth described by quadratic equations. In the first lab, students use CBRs to examine the patterns in ball bounces. In "The Arrow, The Ball and the Rock," students solve problems using the standard quadratic equation relating height and time.		
Enduring Understanding Nonlinear functions are found in many real world situations. Growth patterns and rates of change determine the equations and graphs of nonlinear functions.	**Essential Questions** What are quadratic equations? What are some contexts in which we find the growth described in quadratic equations?	
Skill Focus Exponential and quadratic patterns, equations, graphs	**Vocabulary Focus**	
Assessment		
Materials: graphing calculators		
Launch		
Explore		
Summarize		
Apply		

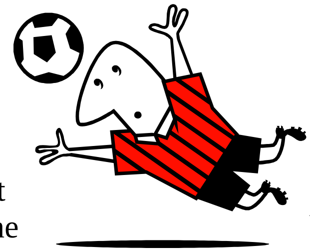
Directions: The following labs are meant to introduce contexts in which we find exponential and quadratic equations. We suggest that you intersperse the following labs with factoring and solving quadratic equations assignments. The connection to real contexts will help give purpose to the factoring and solving problems.

At the conclusion of this module, students will investigate and present their own exponential and quadratic lab projects.

Ball Bounce (see below)
The Arrow, the Ball and the Rock (see below)
Information for potential use:

- Exponential and quadratic functions involve repeated multiplication. That is, instead of having a constant pattern of change (the change is the same at every step–linear), the change at every step increases or decreases. If the repeated multiplication involves a decimal then the change is decay instead of growth.
  - Quadratic functions involve two solutions and an increasing rate of change The graph of a quadratic equation is a parabola curving in opposite directions. The standard form of a quadratic function is $y = ax^2 + bx + c$.
  - Exponential change involves repeated multiplication of the same base.. The standard exponential change equation is $y = ab^x$. The variable (x) is the number of times the change occurs, the exponent. The rate of change (b) is repeated at each stage. The original population or amount is (a). Exponential change approaches a limit.

Bouncing Ball

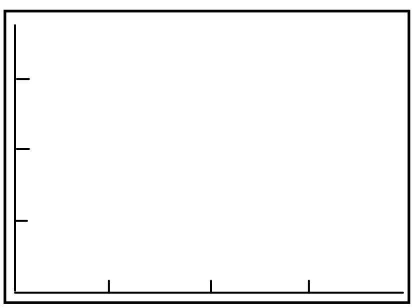


Questions to Think About
If a ball bounces from a given height, what type of a graph does it create? What does the graph represent? How does the graph change as the ball continues to bounce?

Overview
In this activity, you will graph the height of the ball versus time after it is dropped from some height. You will then examine the ball bounce and investigate its vertex and x-intercepts.

Materials
1 CBR unit
1 Graphing Calculator
Ball (a racquet ball works well)

Instructions
1. Run the **RANGER** program on your calculator
2. From the **MAIN MENU** of the **RANGER** program, select **3:APPLICATIONS**.
3. Select **1:METERS**, then select **3:BALL BOUNCE**.
4. Follow the directions on the screen of your calculator. Release the ball. Press the **TRIGGER** key on the CBR as the ball strikes the ground.
5. Your graph should have at least five bounces. If you are not satisfied with the results of your experiment, press **ENTER**, select **5:REPEAT SAMPLE**, and try again.
6. When you are satisfied with your data, sketch a Distance-Time plot. On the grid below. *Label the axes*.



Data Collection

1. The goal here is to "capture" one parabola. Choose the best parabola that your bouncing ball created. Press **ENTER** and go to **4: PLOT TOOLS**. Choose **1: SELECT DOMAIN**. Use the *right arrow* to trace to a point near the lower left side of the parabola that you chose and press **ENTER**. Continue tracing until you reach a point near the lower right side of this parabola and press **ENTER**.

2. Record the graph of this parabola in the window below. *Label the axes.*

3. Press **ENTER** to return to the PLOT MENU. Select **7:QUIT** to exit the **RANGER** program. Press **GRAPH**.

Analyzing the data

1. What is the maximum height reached during the ball bounce?

   What does this represent on the graph? Mark this point on the graph.

2. How long did it take the ball to reach its maximum height on this bounce? *(Hint: If the bounce you chose does not start at time = 0, then you will need to find the difference between the starting time and the time when the ball was at its maximum height.)*

3. How long did it take for the ball to complete the bounce? *(Hint: If the bounce you chose does not start at time = 0, then you will need to find the difference between the starting time and the time when the ball reached the ground.)*

   What does this represent on the graph? Mark this point on the graph.

4. How is this graph different from the graph of a linear function?

5. Using the quadratic regression on your calculator, find the equation that fits your graph.

   y = ________________

6. What do you think *a* (the coefficient in front of x^2) represent in this equation?

Overview

Using the sketch of your original ball bounces, answer the following questions.

1. If a ball bounces from a given height, what type of a graph does it create?

2. What does the graph represent?

3. How does the graph change as the ball continues to bounce?

The Arrow, the Ball, and the Rock

(a typical quadratic function ($y = ax^2 + bx + c$) problem)

1) Suppose an arrow is fired vertically into the air with an initial speed of 112 feet per second. The height (h) of the arrow in feet is a function of the time (t) in seconds. You can model the relationship between the height and the time of the arrow's flight with the following quadratic equation. **$H = -16t^2 + 112t$**

6) Independent (x) stands for ________________ Dependent (y) is __________________

- Make a table of values for height as relation to time. Then graph the points. (below)
- How long is the arrow in the air? ______ At what time does the arrow reach it's maximum height? _____ What is the maximum height of the arrow? ____________

2) Sally's coach has clocked the speed of her fastball (softball) at 64 feet per second.
$H = -16t^2 + 64t + 0$

- Make a table of values for height as relation to time. Then graph the points. (below)
- If she throws the ball upward with a speed of 64 feet per second, what is the ball's maximum height___________ and how long is the ball in the air?

3) Suppose a person stands on a 70 foot cliff and throws a rock with the same upward speed as Sally's fastball. Equation ___________________________

- Make a table of values for height as relation to time. Then graph the points. (below
- What is the maximum height reached by the rock? _____________ How long will the rock fly through the air before it hits the ground? ____________

Time (x)	Height (y)

Time (x)	Height (y)

Time (x)	Height (y)

Graphs