

Texas Instruments Activity #3

Title: It's Outta Here

Author: Charles P. Kost II

Estimated Time: 2 40-50 Minute Periods

NCTM Standards:

Communication Standard – Organize and consolidate their mathematical thinking through communication.

Connections Standard – Recognize and apply mathematics in contexts outside of mathematics.

Algebra Standard – Understand patterns, relations, and functions. Approximate and interpret rates of change from graphical and numerical data. Understand and compare the properties of classes of functions.

Topics in Calculus:

Differential Equations, Graphing Differential Equations

Overview:

This activity will use the TI-89 and the CBR to determine how far the baseball will travel and whether or not it would be a homerun at a Major League baseball game. This activity uses differential equations to determine the distance traveled.

Teacher Directions:

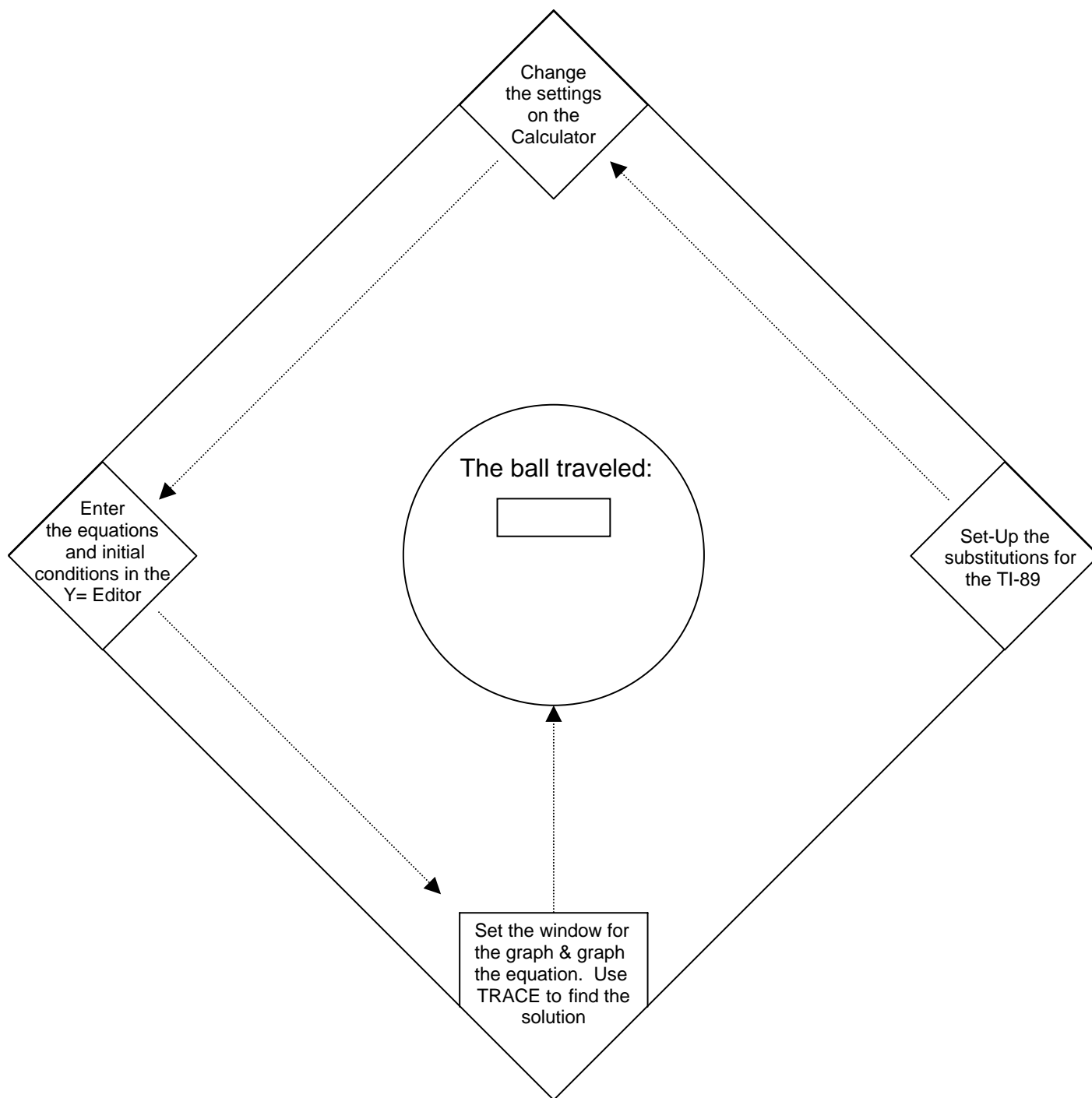
Split the students into groups of four. While one student hits the ball, other students will measure the angle of the ball leaving the bat and the velocity at which the ball leaves the bat. Using this information and a TI-89 graphing calculator, the students will be able to find the path of the ball and determine whether the ball would be a home run.

Let each student take three swings and have the other members of the group measure each one of the hits. If the CBR has a difficult time picking up the baseball, then switch to a softball. If you do not have a field to available, use a gymnasium and have the students aim the ball toward a wall.

The students will need to know that the vertical acceleration from gravity is -32 ft/s^2 . Also, to find the initial horizontal velocity and initial vertical velocity use the following functions, respectively, $\text{initial velocity} \cdot \cos(\text{angle})$ and $\text{initial velocity} \cdot \sin(\text{angle})$, where *angle* refers to the angle at which the ball was hit.

There is an optional transparency included to help emphasize the steps.

Supplies: TI-89 Graphing Calculator, CBR, Baseball, Baseball Bat, Yard Stick, Protractor, Baseball Tee, Batting Helmets.



Name: _____ Date: _____

IT'S OUTTA HERE!

During the 2001 baseball season, the Pittsburgh Pirates adopted a new home, called PNC Park. The ballpark is unique because it is only one of a few fields that offer a “splash homerun.” This means that you can hit a ball into the nearby Allegheny River. The objective of this activity is to take measurements when you hit a baseball and determine whether or not you can hit a homerun at PNC Park.

Record your data in the spaces provided. Circle which direction the ball traveled.

The Height of the Tee: _____ feet.

First Swing

Velocity of the Ball: _____ feet/ sec. Angle the Ball was hit at: _____ °
Left Left/Center Center Right/Center Right

Second Swing

Velocity of the Ball: _____ feet/ sec. Angle the Ball was hit at: _____ °
Left Left/Center Center Right/Center Right

Third Swing

Velocity of the Ball: _____ feet/ sec. Angle the Ball was hit at: _____ °
Left Left/Center Center Right/Center Right

To find the initial velocity using the CBR, connect the CBR to the TI-89, press $\boxed{2nd}\boxed{[VAR-LINK]}$, and select the *ranger.prgm* from the menu. Press \boxed{ENTER} . Then, press $\boxed{)}\boxed{ENTER}$ to run the program. Press \boxed{ENTER} and select **1: Setup/Sample** from the menu, by pressing \boxed{ENTER} . Make the changes that appear to the right on the screen that appears. Press \boxed{ENTER} when you are finished. When everyone is in place, press \boxed{ENTER} . There will be a ten second delay before the CBR records the data. (The red light will blink until the green light appears. When the green light appears, the CBR is collecting data.)



To measure the angle that the ball was hit stand perpendicular to the person hitting the ball. Line up the mark in the center of the protractor with the ball on the tee. Determine the angle, when the ball passes the edge of the protractor. Be sure to **stand at least ten feet away from the tee.**



In order to graph the path of the ball, we are going to say that there is an air resistance constant of -0.05 . Then, we will use the velocity of the ball and the angle that the ball traveled to find the distance the ball traveled. Follow each of the bases on the next page to graph the path of the ball.

First Base: Set-Up the Substitutions for the TI-89

Horizontal distance (x) = $y1$
Initial Horizontal distance = $yi1 =$ _____
Horizontal velocity = $y1'$ which is $y2$
Initial horizontal velocity = $yi2 =$ _____
Horizontal acceleration = $y1''$ which is $y2' =$ _____
Vertical distance (y) = $y3$
Initial vertical distance = (Height of Tee) = $yi3 =$ _____
Vertical velocity = $y3' = y4$
Initial vertical velocity = $yi4 =$ _____
Vertical acceleration = $y4' =$ _____

Second Base: Change the settings on the calculator

- A. In the **MODE** dialog box
Set **Graph=DIFF EQUATIONS**
Set **Angle=DEGREE**, then press ENTER.

- B. Press **[Y=]** then **[F1] ⌂, 9:Format**
Set **Solution Method=RK**
Set **Fields=FLDOFF**, then press ENTER.

- C. Press **2nd [F7] (Axes)**
Set **Axes=CUSTOM**
Set **x Axis=y1**
Set **y Axis=y3**

Third Base: Enter the equations and initial conditions on the Y= Editor

$y1 =$ _____ $y4 =$ _____
 $yi1 =$ _____ $yi4 =$ _____
 $y2 =$ _____ $y5 =$ _____
 $yi2 =$ _____ $yi5 =$ _____
 $y3 =$ _____ $y6 =$ _____
 $yi3 =$ _____ $yi6 =$ _____

Home Plate: Set the window and graph the equation.

$T0 =$ _____ $xmin =$ _____ $ymax =$ _____ $tmax =$ _____
 $xmax =$ _____ $yscl =$ _____ $tstep =$ _____ $xsc1 =$ _____

ncurves=_____ tplot=_____ ymin=_____ diftol=_____

Press the trace button (F3) in the graph window) and scroll (⬅️ ➡️) to the end of the graph to find the total distance. Write the total distance that the ball traveled in the space below.

First Swing _____ feet

Second Swing _____ feet

Third Swing _____ feet

Now, below is a map of the field at PNC Park. Notice that the homerun wall is uneven, so depending where you hit the ball, 325 feet may be a home run or 399 feet may be a homerun. Notice that the numbers in black is the horizontal distance to the wall, whereas the numbers in red represent the vertical height of the wall.

Determine where you would have hit the ball by using the direction you circled on page one. Draw a line from home plate to the homerun wall where the ball would have landed. Write the horizontal distance and the vertical height of the wall for each of your swings. (These can be found on the map to the right.)

First Swing

Horizontal Distance: _____ ft.

Vertical Distance: _____ ft.

Second Swing

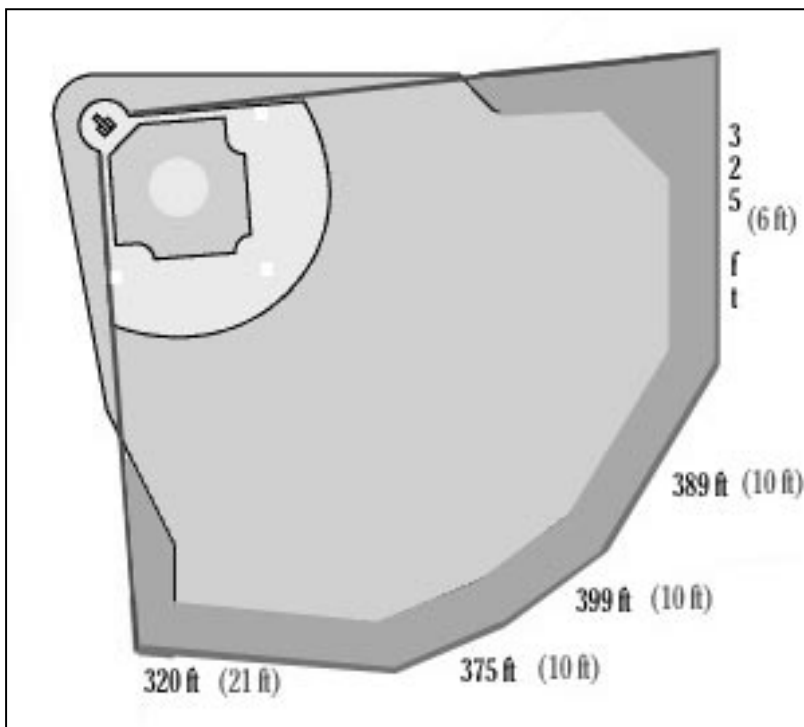
Horizontal Distance: _____ ft.

Vertical Distance: _____ ft.

Third Swing

Horizontal Distance: _____ ft.

Vertical Distance: _____ ft.



Now, press F5 to open the table. Scroll (⬇️ ⬆️) to find the horizontal distance. If the vertical distance (height), on the calculator is greater than that of the homerun wall, then you scored a homerun.



Was your first swing a homerun? Yes No

Was your second swing a homerun? Yes No

Was your third swing a homerun? Yes No