TI-*nspire*™

Grade level: 9-12
Subjects: mathematics, physics
Time required: 40 to 60 minutes

Exploring Parametric Equations With the "Human Cannonball"

by – Lisa Blank, Math & Science Teacher, Lyme Central School, Chaumont, NY

Activity overview

Students will explore the use of parametric equations to model the motion of the "Human Cannonball" after being fired from a cannon. Key graph features will be explored, including maximum height, length of time in the air, and maximum distance traveled through the use of parametric equations and a quadratic regression equation. The quadratic equation will be determined by grabbing points from the graph of the parametric equations.

Concepts

Parametric Equations
Quadratic Regression
Interpreting Graphs of Parametric Equations
Interpreting Graphs of Quadratic Equations
Projectile Motion
Trajectories

Teacher preparation

Load the humancannons.tns file onto all student calculators. Copy the related handout for students to assist in guiding students through the activity and to provide students with directing questions.
The humancannont.tns file is for the instructor to be able to view the results the students should obtain as they work through this activity.

Classroom management tips

The instructor should direct students to open the humancannons.tns file. Once students have opened the file, the teacher should monitor students, assisting them as they work through the steps provided in this activity. Students will likely need assistance if the instructor wants the students to modify axes and/or label the graphs. Remind students that ctrl-G will remove the function window from the bottom of the graph screen to provide larger viewing windows for the graphs.

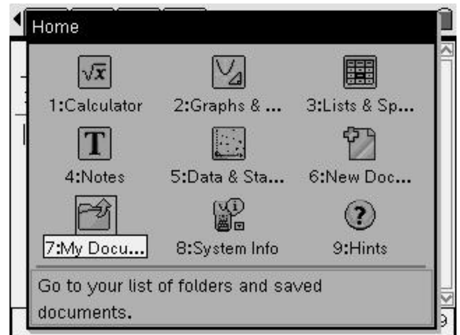
A worksheet is provided with this activity for completion by students.

TI-Nspire Applications

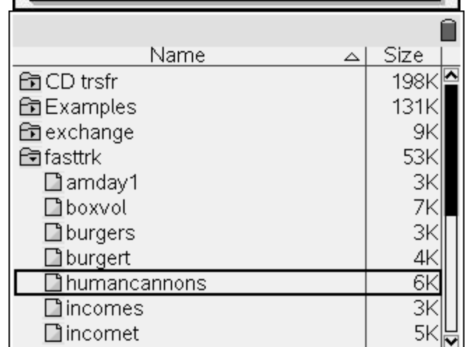
Parametric Graphs
Transferring Data Points from a Graph to a Spreadsheet
Quadratic Regression
Quadratic Graphs
Spreadsheets

Step-by-step directions

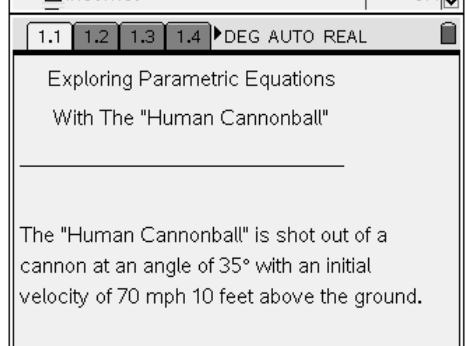
1. At the home screen, select My Documents.



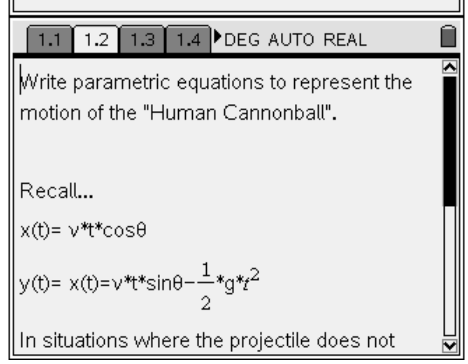
2. Browse to the folder titled *humancannons*.



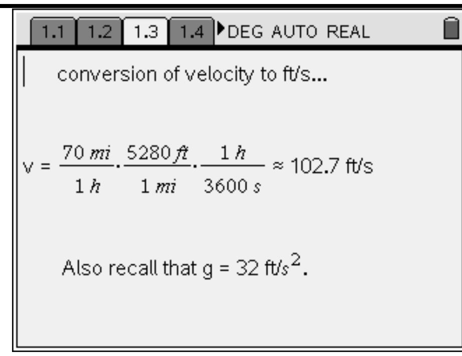
3. The first page of the document should appear as shown. Read this page to become familiar with this activity.



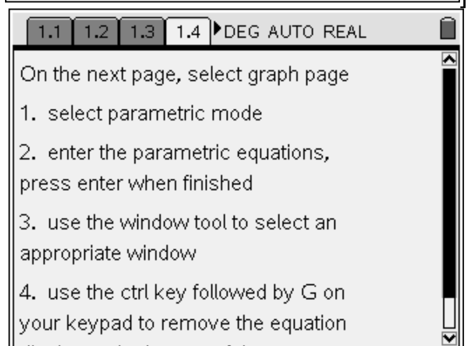
4. Move to the next page of the document by using ctrl ▸. On this page, you will find helpful reminders regarding parametric equations.



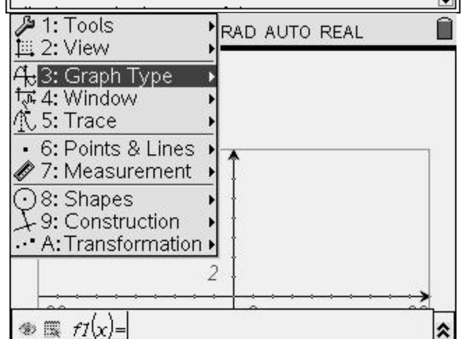
5. Move to the next page of the document by using [ctrl][▸]. On this page, you are to show your work, using dimensional analysis (factor-label), for the conversion of the velocity to ft/s.



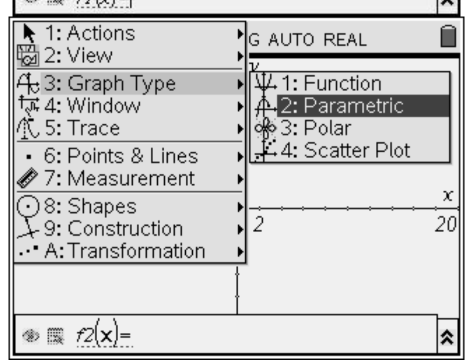
6. Move to the next page of the document by using [ctrl][▸]. This page provides instructions for what is to be done on the following pages.



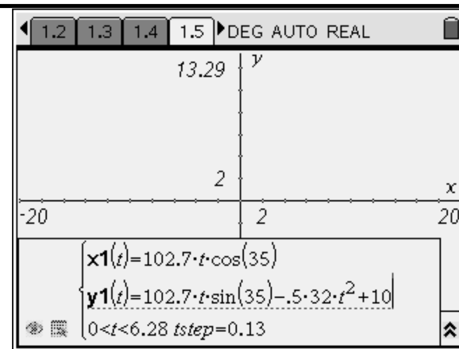
7. Move to the next page and press [menu]. Select Graphs & Geometry, then press [menu] again and select Graph Type from the pull-down menu.



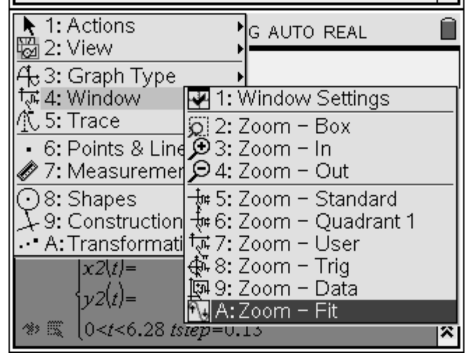
8. Next, select Parametric.

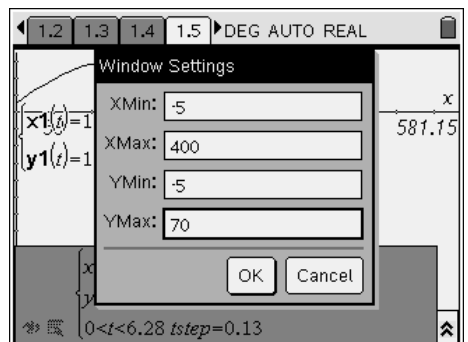


9. The parametric graph window will appear. Move to the parametric equation box at the bottom of the screen and enter the parametric equations developed using the converted velocity and the trajectory angle provided in the problem. You can move from one entry field to another by pressing (tab).

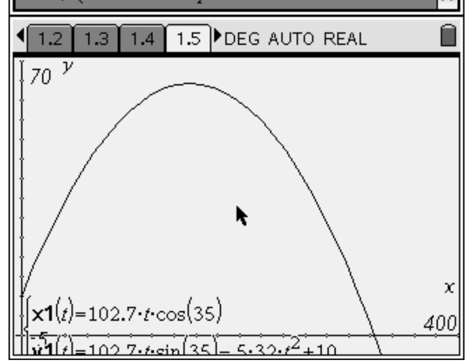


10. Press enter following the entry of your equations and a graph will appear. To adjust the viewing window, press (menu) and select Window, followed by Zoom-Fit. If a user-friendly window does not result, settings for the window may be adjusted using choice 1: Window Settings. Window settings may also be adjusted directly on the screen by clicking and dragging axes, or editing the maximum values shown on the x- and y-axes.

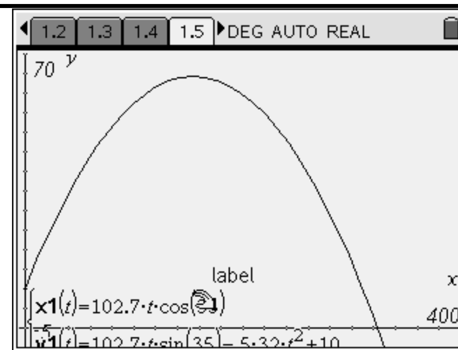




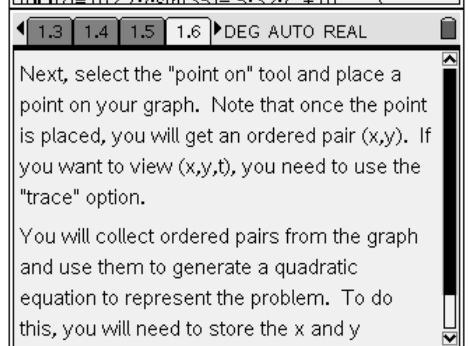
11. To view more of this graph, since a portion of it is covered, fhide the entry box at the bottom of the screen by pressing (ctrl) G, which acts as a toggle to hide or reveal entry boxes for graphs.



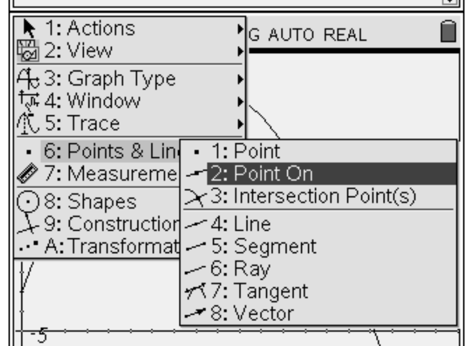
12. To make the equations visible, they can be moved by clicking and dragging to a better location. To do this, move your cursor to the equations. They should flash and a hand will appear. Press ctrl to grab onto the equations and move them. Pressing the center of the Nav Pad will release the grip on the equations so they may be dropped in the desired location.



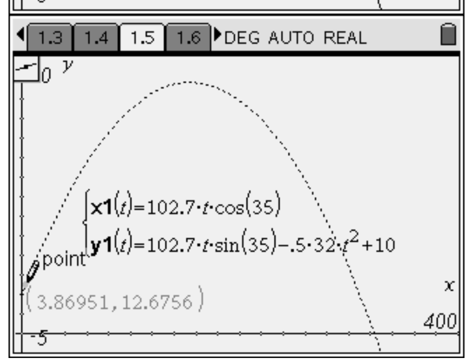
13. Move to the next page using ctrl. Read the given instructions. Then press using ctrl to move back to the previous graph page.



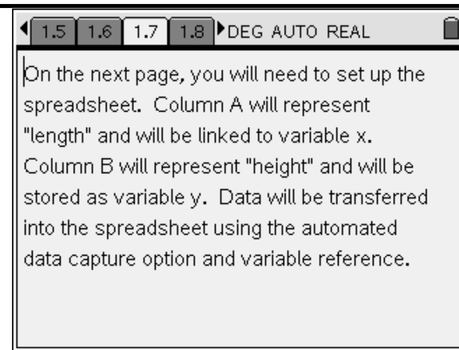
14. Press menu, followed by 6: Points & Lines, followed by 2: Point On.



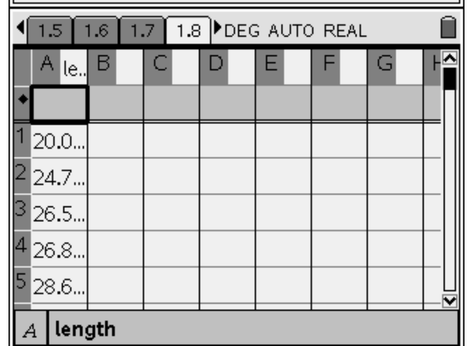
15. Move the cursor to the curve and a pencil tool along with the word *point* will appear. Pressing enter will drop a point label. Moving the pencil along the curve will show the point labels in grey as you trace along the curve without dropping the points.



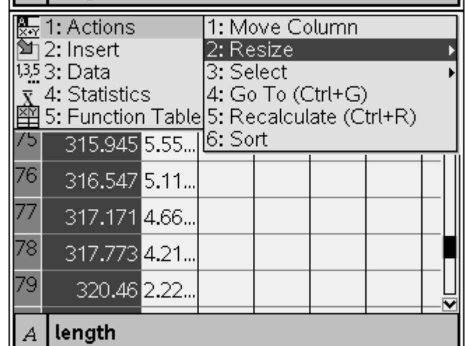
16. Move to page 7 of the document using ctrl ▶. Read the given instructions



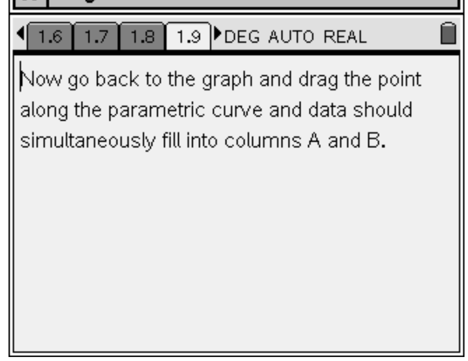
17. Move to page 8 using ctrl ▶. Press menu. Select Lists & Spreadsheets. In the region to the right of A, type *length* and press enter. The data column will fill in with values from the tracing of the parametric graph. Similarly, label column B as *height*.



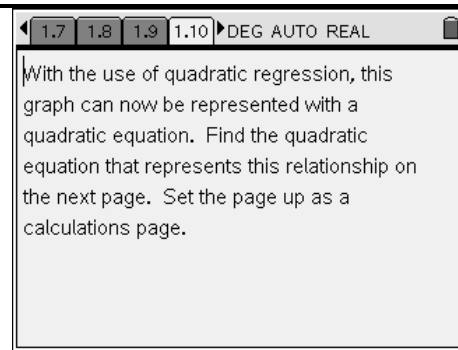
18. To resize columns for better viewing, press menu, followed by 1: Actions, followed by 2: Resize, then 1: Resize Column Width. The selected column will then be grey. Use the left and right arrows of the keypad to resize the column width as desired. Press enter to keep the desired width.



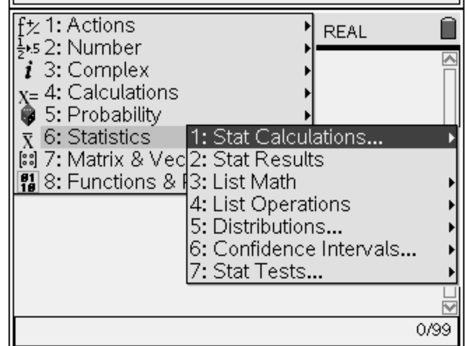
19. Move to the next page of the document by using ctrl ▶. Go back to page 5 and drag the point on pencil tool along the parametric curve to automatically fill additional ordered pairs into the spreadsheet.



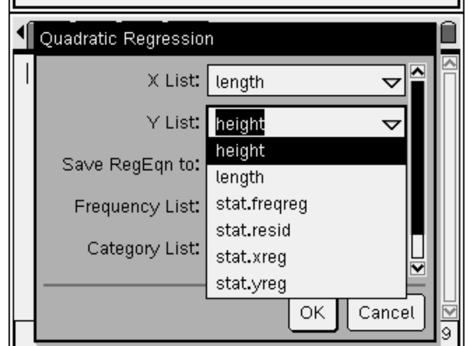
20. Move to the page 10 of the document by using [ctrl] [▶].



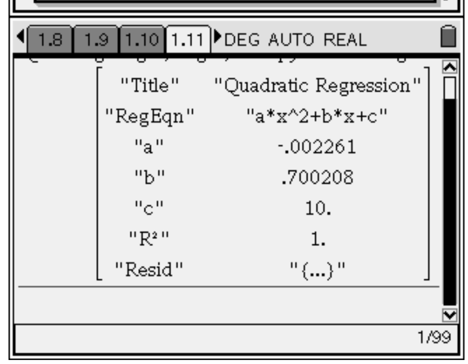
21. Move to the next page of the document by using [ctrl] [▶]. Press [menu]. Select 1: Add Calculator, then press [menu], followed by 6: Statistics, followed by 1: Stat Calculations, then choice 1: Quadratic Regression.



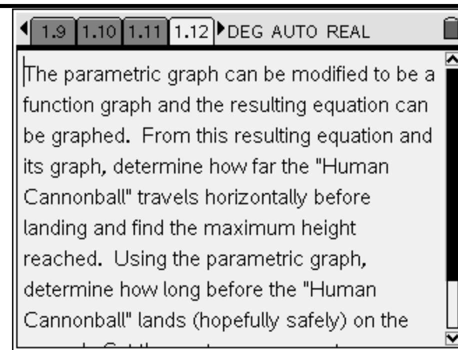
22. You must also choose the appropriate spreadsheet columns for x and y. Use [tab] to move between entry fields.



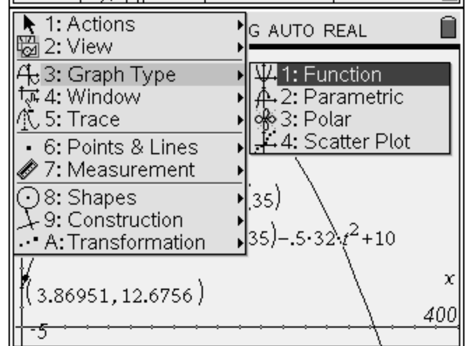
23. Select "OK" at the bottom of the screen after choosing the appropriate x and y lists. The linear regression equation results will appear. These results are automatically saved for function graphing.



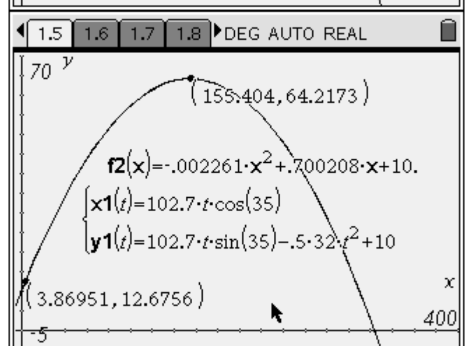
24. Move to the next page of the document by using ctrl ▸. Read this page for additional problem details.



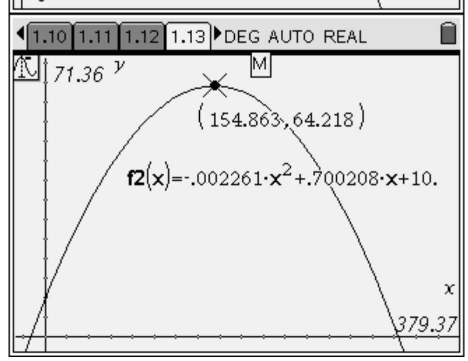
25. Move back to page 5 and press menu. Select 3: Graph Type, followed by 1: Function.



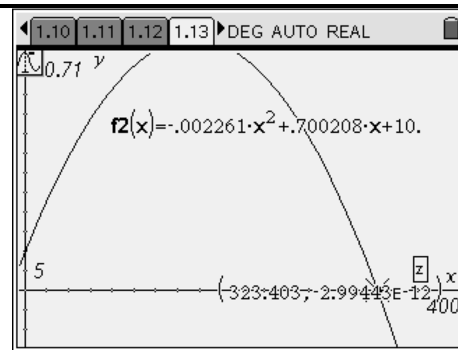
26. In the function window that appears at the bottom, use the up arrow to locate the quadratic equation just obtained. Pressing enter will result in the graph being plotted on top of the existing parametric graph. Note that the quadratic function is also displayed on the graph screen. Pressing ctrl G will remove the function box from the bottom of the screen.



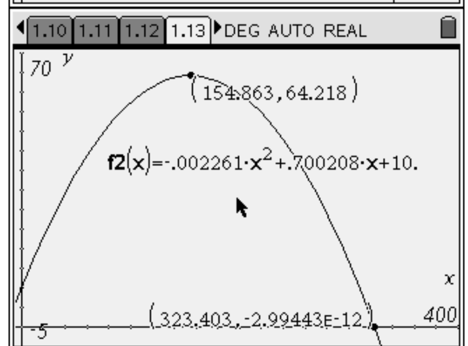
27. The graph on page 5 may be traced, or a new quadratic graph can be set up on page 13, so that quadratic equation alone can be studied. This can be easier for tracing to find key graph points such as max, min, and zeros. The maximum value is identified by the letter M and zeros are similarly identified by the letter z. Be careful to trace slowly so that these letters don't flash too quickly to be seen.



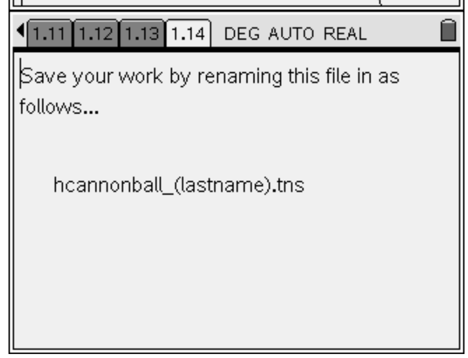
28. Once a key value has been found, pressing enter will drop that point on the graph. If the point label is not fully visible on the screen, it may be grabbed and dragged using the grab hand, ctrl.



29. The quadratic graph provides the maximum height and distance for the path of the "Human Cannonball". The benefit of the parametric equation is that as you trace along the curve, you will be able to obtain time values.



30. The final page of the handheld document provides instructions to the student in saving the document created for review by the instructor.



Assessment and evaluation *(NOTE: this section can be separate or included in the step-by-step directions.)*

- *Evaluate the completed student .tns files*
- *Collect the related student handouts and assess them for understanding.*
- *Follow up with problems from the Parametric Equations Problem Sampler, providing somewhat decreased instruction to check for understanding of the process and concepts involved.*

Activity extensions

- *Study additional parametric equation problems, such as those on the Parametric Equations Problem Sampler.*
- *Have students create their own parametric equations problems that relate to their personal interests. There are many great topics of interest to many students to be related to this activity!*
- *This activity provides an excellent opportunity for math and science teachers to work cooperatively in the study of parametric equations and projectile motion.*

by: Lisa Blank
Grade level: secondary
Subjects: mathematics, physics
Time required: 40 – 60 minutes

Materials: TI-Nspire

Student TI-Nspire Document

humancannons.tns

humancannont

Name	Size
burgers	3K
burgert	4K
humancannons	6K
humancannont	10K
incomes	3K
incomet	5K
incometchr	5K
inscangles	3K
inscanglet	4K
savings	3K
savingstchr	4K

1.1 DEG AUTO REAL

Exploring Parametric Equations With The "Human Cannonball"

The "Human Cannonball" is shot out of a cannon at an angle of 35° with an initial velocity of 70 mph 10 feet above the ground.

1.2 DEG AUTO REAL

Write parametric equations to represent the motion of the "Human Cannonball".

Recall...

x(t)= v*t*cosθ

y(t)= $x(t)=v*t*\sin\theta-\frac{1}{2}*g*t^2$

In situations where the projectile does not

1.3 DEG AUTO REAL

Show work here for conversion of velocity to ft/s. Show units in your work.

1.4 DEG AUTO REAL

On the next page, select graph page

1. select parametric mode
2. enter the parametric equations, press enter when finished
3. use the window tool to select an appropriate window
4. use the ctrl key followed by G on your keypad to remove the equation

1.5 DEG AUTO REAL

Press Menu

1.6 DEG AUTO REAL

Next, select the "point on" tool and place a point on your graph. Note that once the point is placed, you will get an ordered pair (x,y). If you want to view (x,y,t), you need to use the "trace" option.

You will collect ordered pairs from the graph and use them to generate a quadratic equation to represent the problem. To do this, you will need to store the x and y

1.7 DEG AUTO REAL

On the next page, you will need to set up the spreadsheet. Column A will represent "length" and will be linked to variable x. Column B will represent "height" and will be stored as variable y. Data will be transferred into the spreadsheet using the automated data capture option and variable reference.

1.8 DEG AUTO REAL

Press Menu

1.9 DEG AUTO REAL

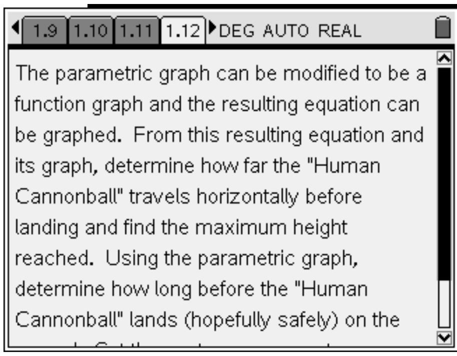
Now go back to the graph and drag the point along the parametric curve and data should simultaneously fill into columns A and B.

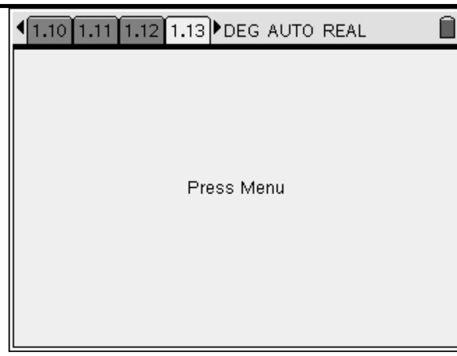
1.10 DEG AUTO REAL

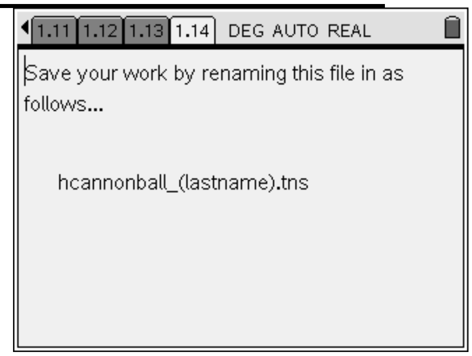
With the use of quadratic regression, this graph can now be represented with a quadratic equation. Find the quadratic equation that represents this relationship on the next page. Set the page up as a calculations page.

1.11 DEG AUTO REAL

Press Menu


1.9 1.10 1.11 1.12 DEG AUTO REAL
The parametric graph can be modified to be a function graph and the resulting equation can be graphed. From this resulting equation and its graph, determine how far the "Human Cannonball" travels horizontally before landing and find the maximum height reached. Using the parametric graph, determine how long before the "Human Cannonball" lands (hopefully safely) on the


1.10 1.11 1.12 1.13 DEG AUTO REAL
Press Menu


1.11 1.12 1.13 1.14 DEG AUTO REAL
Save your work by renaming this file in as follows...
hcannonball_(lastname).tns