Air Resistance
Teacher Notes

Introduction

In this activity students use the CBR2 to record motion data of a falling paper cone weighted with a piece of plasticene. It is possible to use TI-Nspire to show that the cone achieves a terminal speed. When that occurs the combined weight of the cone and plasticene must equal the air resistance.

By repeating the experiment for various weights it is possible to show that air resistance varies as the square of terminal speed.

Resources

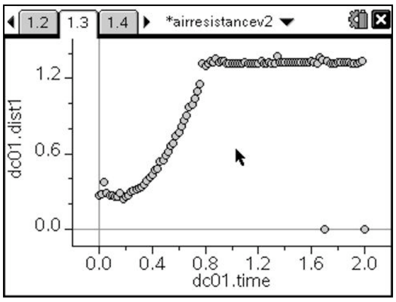
There is a TI-Nspire document entitled airresistance.tns that contains the sort of data and analysis that might be expected.

The activity

Step 1

1. Set up the CBR 2 so that it is about 2m above the floor and pointing downward. Plug the CBR 2 into the TI-Nspire handheld and select Data & Statistics. Tab to *OK* and press *enter.*

2. Weigh a paper cone and hold it about 30cm beneath the CBR 2. Press *enter* on the data-logging console, then drop the cone (you will hear rapid clicking from the CBR 2 when it has started collecting data). If the data look good save them (automatically named dc01.dist1 and dc01.time1) and get ready to collect another data-set.

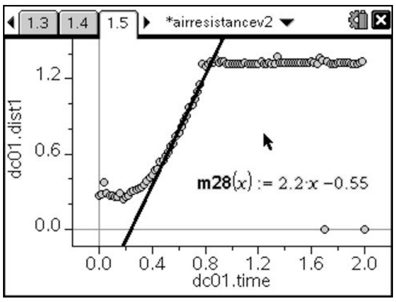


3. Load the cone with a piece of plasticene, weigh it and repeat. Continue until you have five or six data-sets, each with a different weight of plasticene.

Step 2

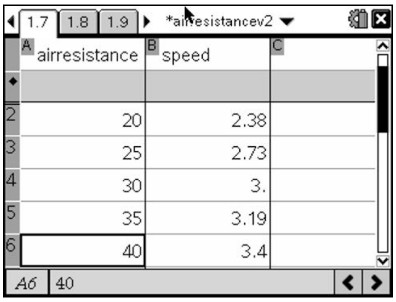
1. Select one of the data sets by moving the cursor to each axis in turn, pressing *enter*, and selecting the appropriate variable.

2. Add a movable line and move it so that it fits the final few points of the data set, where the cone has reached terminal speed. To do this, press *menu*, select *Analyse/Add Moveable Line* and press *enter*. Moving the cursor over the movable line will reveal a *rotate* symbol at each end and a *translate* symbol in the middle. N.B. Pressing *ctrl* whilst the *rotate* symbol is showing allows you to rotate the line. Pressing *ctrl* whilst the *translate* symbol is showing allows you to move the line. You will be able to read off the terminal speed from the displayed equation of the movable line.



3. Repeat this for all the data-sets.

Step 3

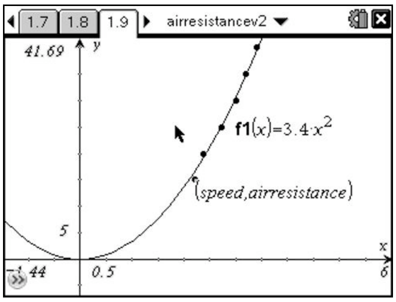


1. Open a Lists & Spreadsheet page.

2. Type *airresistance* at the top of column A and *speed* at the top of column B. The air resistance for each data-set is simply the weight (in grams) of the cone plus plasticene, because at terminal speed (velocity) the forces are balanced and so the weight equals the air resistance.

3. Enter the data in the two columns that you have collected previously.

Step 4

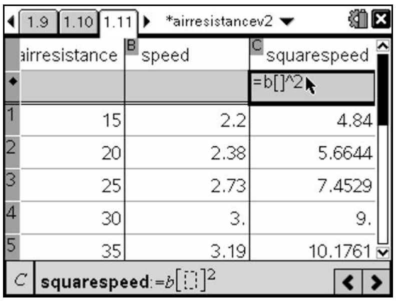


1. Open a Graphs page and select *Graph Type/Scatter Plot*.

2. Select *speed* for the x-axis and *airresistance* for the y-axis. Choose suitable window settings.

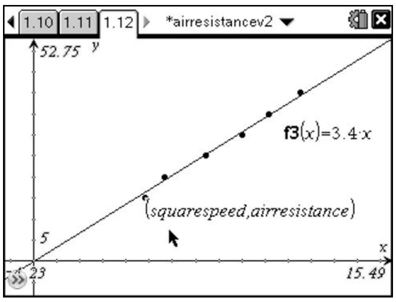
3. Study the points and decide what function might fit. Select *Graph Type/Function Plot* and enter an appropriate function. You will probably find that a parabola will fit quite well. Although a straight line looks possible, it will not go anywhere near the origin as it should.

Step 5



1. If the parabola through the origin is a good fit it means that air resistance is varying as the speed squared, so go back to the Lists & Spreadsheet page add *squarespeed* to column C. The data can be entered in the column using the formula shown on the right.

2. Open another Graphs page (or use the one already open), select *Graph Type/Scatter Plot* and plot *airresistance* against *squarespeed*.



3. Select *Graph Type/Function Plot* and draw the graph of y=x.
   Grab the end of the line and rotate it until you have a good straight line fit through the data and the origin.

4. At this point you are justified in saying that air resistance is proportional to the square of the speed.