



Science Objectives

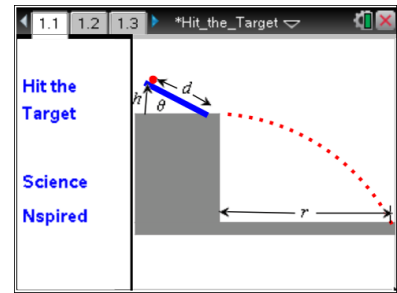
- Students will explore the range of a marble that rolls down a ramp and off a table.
- Students will investigate the relationship between the range of the marble, the angle of the ramp, and the release distance up the ramp. They will also develop a mathematical model relating these variables.
- Students will use their model to hit a target placed on the floor.

Vocabulary

- mathematical model
- range

About the Lesson

- This lesson is an exploration by students of the range of a marble that rolls down a ramp and off a table. The goal is for students to develop a mathematical model that will allow them to hit a target placed on the floor on the first try.
- As a result, students will:
 - Make systematic measurements and record the data in an organized fashion.
 - Use graphs to analyze the data and develop a mathematical model relating: 1. the range of the projectile to the release distance up the ramp and 2. the angle of the ramp.
 - Use their model to determine the appropriate angle and release distance needed to make the marble hit a target on the floor.



Tech Tips:




- This activity includes screen captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at <http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials>



TI-Nspire™ Navigator™

- Send out the *Hit_the_Target.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.

Activity Materials

- Compatible TI Technologies:  TI-Nspire™ CX Handhelds,  TI-Nspire™ Apps for iPad®,  TI-Nspire™ Software

Lesson Files:

Student Activity

- Hit_the_Target_Student.doc
 - Hit_the_Target_Student.pdf
- TI-Nspire document*
- Hit_the_Target.tns




Additional Materials for the Lab

- marble
- ruler with a center groove or an alternate flat surface to use as a ramp
- carbon paper or an alternate method for marking the landing spot of the marble
- plumb line (a weight hanging from a string)
- meterstick or measuring tape
- paper, pencil, and tape

Procedure for Students

1. Prop up the ramp so that the lower end of the ramp is near the edge of the table.
2. Measure the length of the ramp, L , and the height, h , of the upper end from the table surface.
3. Calculate and record the angle of the ramp using $q = \sin^{-1}\left(\frac{h}{L}\right)$. Make sure your TI-Nspire™ is in degree mode. To check, from the Home screen on the handheld, choose **Settings > Document Settings**. Make sure the Angle setting is Degree and not Radian.



Tech Tip: To check the angle setting, have students select . The **Document Settings** menu will appear. Students should make sure that the Angle setting is Degree and not Radian.

4. Place the marble on the ramp. Allow it to roll down the ramp to get a general idea where it will hit the floor. Tape a piece of paper to the floor at this location. If you have carbon paper, lay it with the carbon side down on top of the paper taped to the floor. If you have another method for marking the landing spot of the marble, prepare it.
5. Return the marble to the ramp. Measure and record the distance along the ramp from the bottom of the ramp to the place where the marble is released. This is the “release distance.” Release the marble so that it rolls down the ramp, rolls off the table, and hits the floor. Verify that the marble left a mark on the paper taped to the floor.
6. Use the plumb line to mark the point on the floor directly below the place where the marble leaves the table. Carefully measure and record the distance from this point to the location where the marble hits the floor. This is the range of the projectile.



- Systematically vary the release distance and the angle of the ramp. Remember to change one variable at a time. Carefully record the angle of the ramp, the release distance, and the range of the projectile for each trial. Test several release distances for each angle. Complete enough trials that you have a wide variety of ranges for the projectile.

Teacher Tip: Encourage students to explore a wide variety of release distances and angle to use a large variation in range. Students will need to carefully record and organize the data to facilitate useful analysis.

Analysis

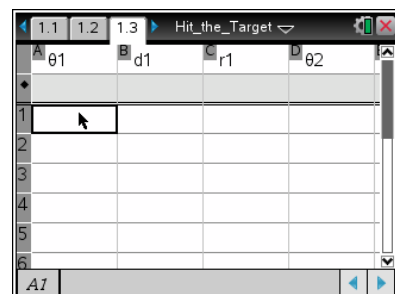
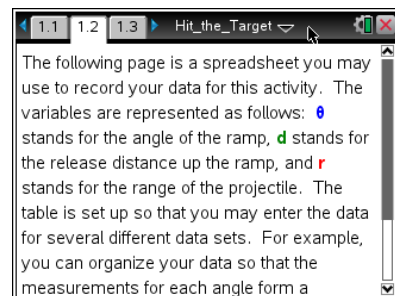
The TNS file has a basic structure to get students started on the analysis of the data, but encourage students to pursue their own ideas. They may modify the file or create their own. The ultimate goal is for students to develop their own models to effectively determine what combination of release distance and ramp angle will produce a given range.

The TNS file is structured so that the data associated with each angle of the ramp is a separate data set. This will produce a family of curves relating the range of the projectile to the release distance up the ramp. Each curve represents a different angle of the ramp. Some students may want to analyze the data from a different perspective. Encourage them to explore what seems most useful.

When a lab group indicates that they have developed a model, give them a target to hit within the range of their data.

Move to pages 1.2 and 1.3.

- The students will record the data in the Lists & Spreadsheet on page 1.2. The variables are represented as follows: θ stands for the angle of the ramp, d stands for the release distance up the ramp, and r stands for the range of the projectile. The spreadsheet is set up so that students may enter several different data sets. For example, students can organize their data so that the measurements for each angle form a separate data set. In this case, all of the angles in a particular column will be the same. This will allow students to make separate range vs. release-distance graphs for each angle. You may add columns as needed.

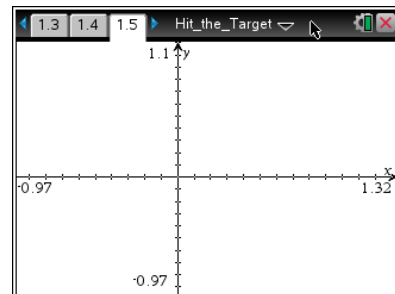
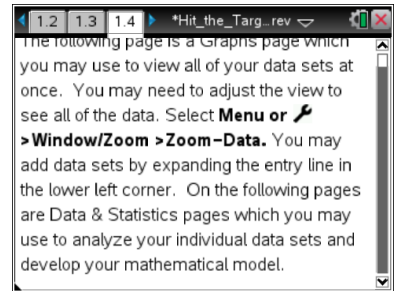


Tech Tip: To add or modify the data in a spreadsheet cell, double-tap the cell. The keyboard will appear. Enter the numerical value and then select enter.



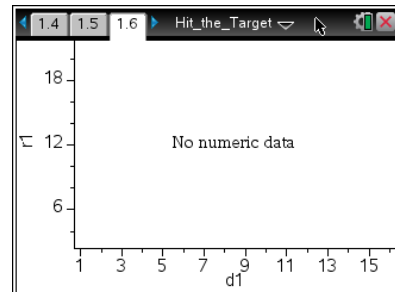
Move to pages 1.4 and 1.5.


- This Graphs page allows students to view all of their data sets at once. Students should add data sets if needed by expanding the entry line near the lower left corner of the screen. The page is set up to plot the range of the projectile on the y -axis and the release distance up the ramp on the x -axis. Students may wish to add a label beside each data set to identify the corresponding ramp angle.



Move to pages 1.6–1.8.

- These pages are Data & Statistics pages, which students may use to analyze their data sets individually. The students will find some analysis tools to help them by selecting **Menu > Analyze**. They will develop a mathematical model that allows them to relate the range of the projectile to the release distance up the ramp and the angle of the ramp. Students will record their models here:



Tech Tip: To access the analysis tools, students will need to select **> Analyze**. Note that in some cases, a student may need to back-out to the main Tools Menu  to see the desired menu option.

- The students will inform you when they have developed their models. You will give each student a target to hit on the floor. They will measure the range to the target, and record it here:

Ramp angle, θ : _____

Students will then use the model from their analysis to determine: 1. the angle of the ramp and 2. the release distance up the ramp needed to make the projectile hit the target. They will record their values here:

Ramp angle, θ : _____



Release distance, d : _____

If the students have collected sufficient data and analyzed it appropriately, they should be able to hit the target on the first try.

5. The students will write a report explaining their data analysis and the results of their tests. If the students did not hit the target, they should report the amount of error, discuss likely sources of error, and suggest ways to improve.



TI-Nspire Navigator Opportunities

Make a student a Live Presenter to demonstrate how they are analyzing their data.

Wrap Up

Students should compose a lab report, which includes their data, analysis, and a discussion of the results of their test. Students may choose to use the TI-Nspire™ Student Edition software to convert their .tns files to PublishView Documents.

Assessment

- Student lab reports will be used for assessment of this activity.