Science Objectives

- Students will define terminal velocity.
- Students will analyze the relationship between mass and terminal velocity

Vocabulary

- gravity
- gravitational acceleration
- velocity
- terminal velocity
- wind resistance

About the Lesson

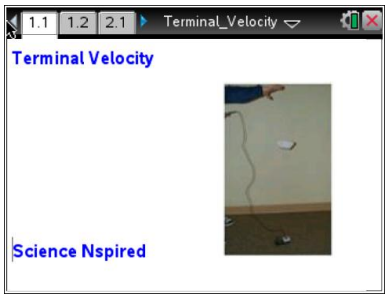
- This lesson involves students dropping coffee filters over a motion detector to determine terminal velocity.
- As a result of changing the number of filters, students will:
  - Understand that the terminal velocity is related to mass.

TI-Nspire™ Navigator™ System

- Quick Polls can be used after Trial 1 to see how each group's data compares to one another.
- A Quick Poll can be given to see if they see a difference between one, two, etc, filters.

Activity Materials

- *Terminal_Velocity.tns*
- TI-Nspire™ handheld
- CBR 2™ with USB Cable
- Basket-style coffee filters



TI-Nspire™ Technology Skills:

- Download a TI-Nspire™ document
- Open a document
- Move between pages
- Grab and drag a point

Tech Tip:

Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

- Terminal_Velocity_MG_Student.pdf
- Terminal_Velocity_MG_Student.doc

TI-Nspire document

- Terminal_Veloicty.tns

Discussion Points and Possible Answers

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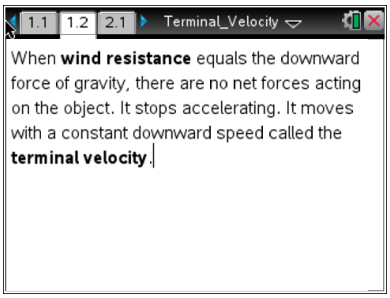
Allow students to read the background information on page 1.2 of the .tns file and on their student worksheet.



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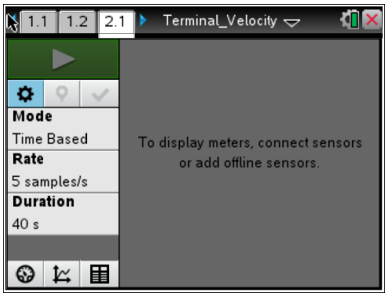
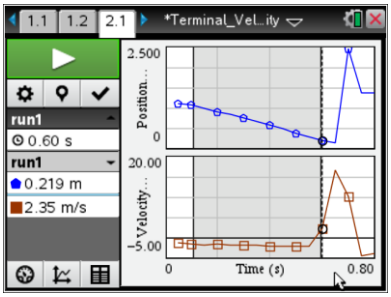
1. Students are to connect a CBR 2™ to the TI-Nspire™ handheld. The DataQuest application will automatically configure the data collection.



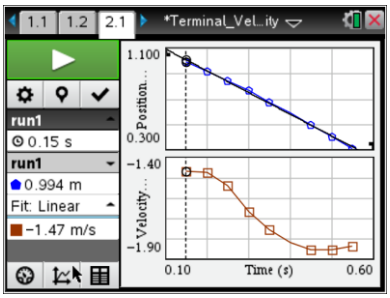
2. Students should place the CBR 2 on the floor facing upward.
3. Students should hold a coffee filter directly above the probe at their shoulder height.
4. Click the Start button ▶ in the DataQuest app to begin collecting data.
5. When they hear the CBR 2 begin clicking, they should drop the coffee filter.
6. When the coffee filter lands on the CBR 2, students need to click the Stop button ■ in the DataQuest app.

Analysis:

7. On the main screen, students should select graph view and then select the region that represents the coffee filter falling by moving the cursor to the start point of the drop and clicking to set the left bound.
8. Then they need to move the cursor to the right to expand the selection region, and click to select the right bound.
9. Have students select **MENU > Data > Strike Data > Outside Selected Region**.



10. Students can analyze the Linear segment by selecting **MENU > Analyze > Curve Fit > Linear** and finding the velocity of the single coffee filter.



Note: Because the graph is distance and time, the slope of the line is the velocity of the coffee filter.

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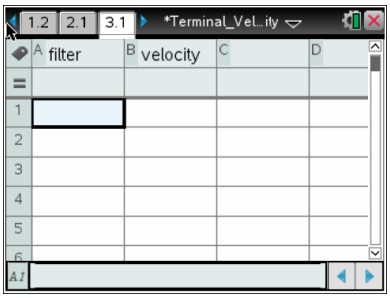


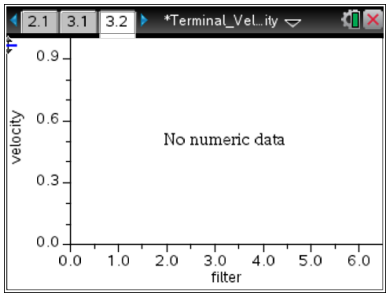
11. Students will see a *Lists & Spreadsheet* page with the columns **filter** and **velocity**. Have them enter the number of filters in the Filter Column and the corresponding velocity in Velocity Column.
12. They should repeat the data collection process by dropping 2, 3, 4, 5, and 6 filters stacked together.

TI-Nspire Navigator Opportunity

TI-Nspire Navigator can be used to gather the complete class's data. Then you can calculate an average of the velocity for 1, 2, 3, 4, and 5 filters to determine if the average can give them a better model of the velocity vs. filter.

Move to page 3.2

13. Students will see a *Data & Statistics* page with the plot of velocity vs. filters. They can place a linear regression on the velocity vs. filters data by selecting **Menu > Analyze > Regression > Show Linear (mx + b)**.



Move to page 4.1.

Have students answer questions 1-3 on either the handheld, on their activity sheet, or both.

Q1. What relationship is there between the mass of the objects dropped (number of coffee filters) and the velocity?

Answer: The greater the mass the greater the velocity. It is a direct variation.

Q2. What would the velocity of the filters be if there were 8 filters? (Hint: Find the value of the linear regression when $x = 8$.)

Answer: Answers will vary depending on the size of filters used.

Q3. What is the ratio of velocities between 2 filters and 4 filters?

$$\frac{\text{velocity of 4 filters}}{\text{velocity of 2 filters}} = \frac{\square}{\square} = \_\_\_\_\_$$

Answer: The velocity should roughly double.

Wrap Up

Questions for students:

- What does the selected region of the graph represent?

  Answer: The velocity of each sample.

- What does the linear regression on Page 1.4 represent?

  Answer: The velocity to mass ratio or model.

- How can we use this predict other events?

  Answer: Answers will vary.

Assessment

A Quick Poll can be run to determine the students understanding of the relationship between distance and time, and mass and velocity.