4.1 Investigate Non-Linear Relations

Student Text Pages
164–167

Suggested Timing
70 min

Tools
- ruler
- grid paper
- board at least 1.2 m in length
- 2 textbooks
- 1 can of soup (or other object that rolls)
- metre stick or measuring tape
- stopwatch

Related Resources
- G–1 Grid Paper
- G–3 Coordinate Grids
- BLM 4–3 Section 4.1 Practice Master
- A–4 Presentation Checklist
- A–11 Group Work Assessment Recording Sheet
- A–12 Group Work Assessment General Recording Sheet

TI-Navigator™

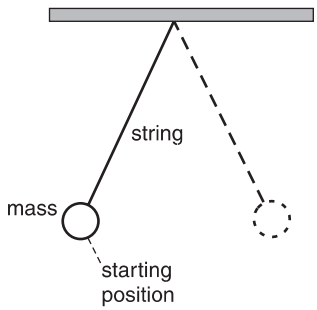
Go to **www.mcgrawhill.ca/books/principles10** and follow the links to the files for this section.

Teaching Suggestions

- You may wish to have half the class do each part of the Investigate, then switch after 20–30 minutes. Use **A–11 Group Work Assessment Recording Sheet** and/or **A–12 Group Work Assessment General Scoring Rubric** when assessing your students.

Investigate

- In **Part A**, make sure all students use the same method of measuring the length of the thumb and the area of the palm. When making the scatter plot, choose a horizontal scale to fit up to 10.0 cm and a vertical scale to fit up to 130 cm^2. This will give a clearer view of a non-linear relationship. When discussing why it is non-linear, students should understand the length versus area relationship, or centimetre versus square centimetres. (20–30 min)
- **Part B** works better if the can contains a dense liquid to reduce wobble. To obtain more accurate measurements, have students roll the can three to five times from the same height and then take the average of the times. As an extension or different version, have each group of students use a different size of can and then compare the curves. A CBR™ (Calculator-Based Ranger) could also be used to plot distance versus time. (20–30 min)
- Alternative experiment: Using a string and a suspended mass, investigate a variety of pendulums released from a set starting position.
  - **a)** Tie a washer to the end of a 60-cm string. Measure the length of the pendulum, which is from the support point to the centre of the mass, or washer. Collect data for one period (time for one full swing back and forth). Then, decrease the string length by 5 cm and repeat.
  - **b)** Make a scatter plot of the length of a pendulum and its period.
  - **c)** Describe the relationship between pendulum length and period.
  - **d)** Investigate the changes in the period as the length of the pendulum increases. What do you notice?



- Other situations that can lead to a good discussion about linear versus non-linear include
  - Modify the board activity: Using a wider board and a tennis ball dipped in water, roll the ball upward and slightly on an angle. It will leave a path in the shape of a parabola.
  - Fill differently shaped containers with water and have students plot depth versus time. This would make for some excellent discussion and a lead-in to linear versus non-linear relations.
- Review the vocabulary in this section (non-linear relation, curve of best fit). (2 min)

Common Errors

- Some students may have difficulties drawing a curve of best fit. They may simply draw a curve that passes through all or most of the points.

R_x Remind students that the curve should follow a path that has about the same number of points above and below it, and need not pass through any points at all.

Accommodations

Visual—Let students work in groups when creating scatter plots using technology.

Perceptual—Encourage students to colour-code the independent variable and the dependent variable when graphing using pencil and paper.

Spatial—Encourage students to colour-code the x- and y-axes on a graph when plotting points, linear relations, and non-linear relations.

Motor—Give students extra time to complete the questions in this section, and let them work with a partner when creating graphs using technology.

Communicate Your Understanding

- As a class, go over the questions in this section. Then assign appropriate homework questions. (5 min)
- Use **BLM 4–3 Section 4.1 Practice Master** for remediation or extra practice.

Investigate Answers (pages 164–165)

Part A

1.–3. Answers will vary.
4. independent variable: thumb length; dependent variable: palm area
5. Graphs will vary.
6. non-linear; the points lie on a curve
7. Answers will vary.
8. A curve of best fit is used because the points lie close to a curve.
9. Answers will vary.

Part B

5. Answers will vary.
6. independent variable: distance; dependent variable: roll time
7. Answers will vary.
8. non-linear; the points lie on a curve
9. Answers will vary.
10. A curve of best fit is used because the points lie close to a curve.
11. Answers will vary.

Communicate Your Understanding Responses (page 166)

C1. a) No, because the points follow a curve.
b), c) Yes, because the points lie close to each curve.

C2. Time is the independent variable because the population changes depending on the time.

Practise

- In **question 4e)**, students may not understand the term "fuel economy" and that less is better. Discuss what happens when a driver steps on the accelerator harder, or a car is less fuel efficient.
- **Question 5** is an interesting relationship. Discuss why the data turn out like this, i.e., all balls have a certain rebound height which is a percent of the height from which they are dropped. In grade 9, the students may have seen the relationship of rebound compared to time, which turns out to be linear; this may confuse students. As an extension, have students test various types of balls.
- **Question 6** refers to the Chapter Problem. Students can answer this question now or save it until the Chapter Problem Wrap-Up.

Literacy Connections

Create a Word Wall for this chapter. Add the new terms that appear in this section to the Word Wall.

Question 4 has students look at fuel economy, and the related Did You Know? provides an opportunity to see a good literacy connection. EnerGuide labels can be found on many items in the home, such as refrigerators, washing machines, and dryers. Have students write a series of paragraphs expressing an opinion on the use of EnerGuides to help sell new items for the home.

Student Success

Research a real-life non-linear relation (e.g., speed versus stopping distance for a car) and write a journal entry or present a brief oral report to the class. Use **A–4 Presentation Checklist** to support this activity.

Mathematical Processes Integration

The table shows questions that provide good opportunities for students to use the mathematical processes.

Process Expectations	Selected Questions
Problem Solving	n/a
Reasoning and Proving	1, 2, 4, 5, 7
Reflecting	n/a
Selecting Tools and Computational Strategies	n/a
Connecting	4–7
Representing	3–7
Communicating	1–7

Ongoing Assessment

- Chapter Problem question 6 can be used as an assessment tool.
- Communicate Your Understanding questions can be used as quizzes to assess students' communication skills.