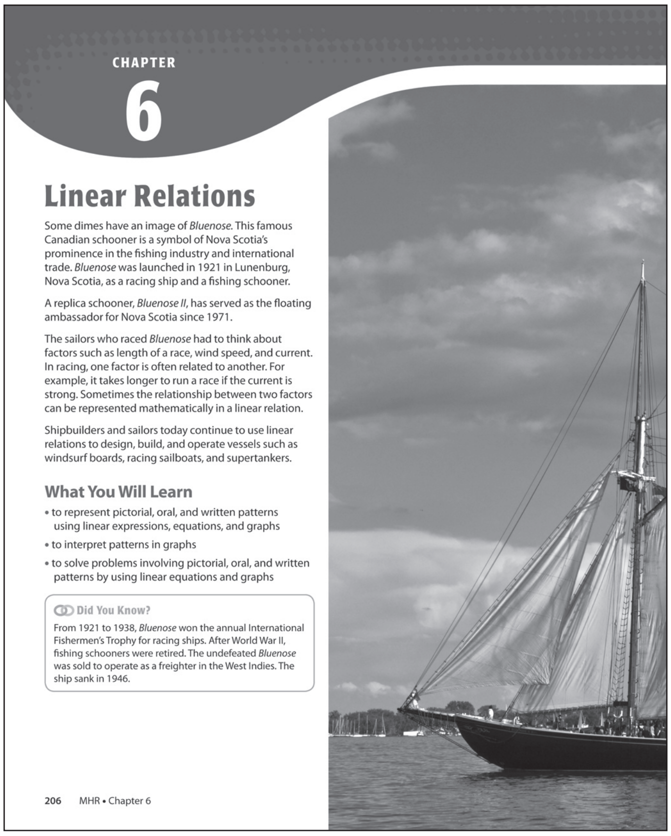

CHAPTER 6

Linear Relations

Some dimes have an image of *Bluenose*. This famous Canadian schooner is a symbol of Nova Scotia's prominence in the fishing industry and international trade. *Bluenose* was launched in 1921 in Lunenburg, Nova Scotia, as a racing ship and a fishing schooner.

A replica schooner, *Bluenose II*, has served as the floating ambassador for Nova Scotia since 1971.

The sailors who raced *Bluenose* had to think about factors such as length of a race, wind speed, and current. In racing, one factor is often related to another. For example, it takes longer to run a race if the current is strong. Sometimes the relationship between two factors can be represented mathematically in a linear relation.

Shipbuilders and sailors today continue to use linear relations to design, build, and operate vessels such as windsurf boards, racing sailboats, and supertankers.

What You Will Learn

- to represent pictorial, oral, and written patterns using linear expressions, equations, and graphs
- to interpret patterns in graphs
- to solve problems involving pictorial, oral, and written patterns by using linear equations and graphs

Did You Know?

From 1921 to 1938, *Bluenose* won the annual International Fishermen's Trophy for racing ships. After World War II, fishing schooners were retired. The undefeated *Bluenose* was sold to operate as a freighter in the West Indies. The ship sank in 1946.

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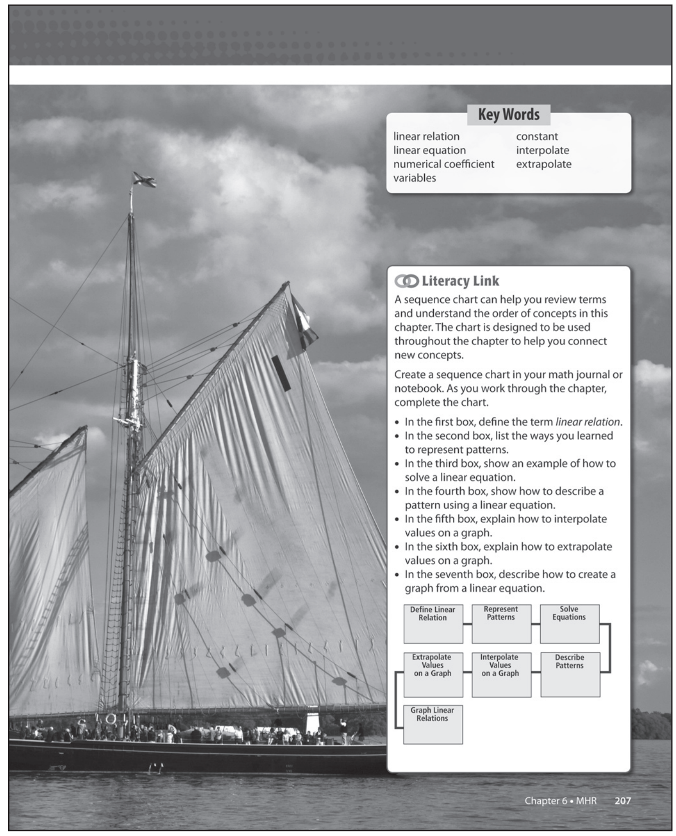

Key Words

linear relation
linear equation
numerical coefficient
variables
constant
interpolate
extrapolate

Literacy Link

A sequence chart can help you review terms and understand the order of concepts in this chapter. The chart is designed to be used throughout the chapter to help you connect new concepts.

Create a sequence chart in your math journal or notebook. As you work through the chapter, complete the chart.

- In the first box, define the term *linear relation*.
- In the second box, list the ways you learned to represent patterns.
- In the third box, show an example of how to solve a linear equation.
- In the fourth box, show how to describe a pattern using a linear equation.
- In the fifth box, explain how to interpolate values on a graph.
- In the sixth box, explain how to extrapolate values on a graph.
- In the seventh box, describe how to create a graph from a linear equation.

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MathLinks 9, pages 206–209

Suggested Timing

40–50 minutes

Materials

- sheet of 11 × 17 paper
- ruler
- sheet of 8.5 × 11 paper
- scissors
- three sheets of 8.5 × 11 grid paper
- stapler

Blackline Masters

Master 8 Centimetre Grid Paper
Master 9 0.5 Centimetre Grid Paper
Master 18 Sequence Chart
BLM 6–1 Chapter 6 Math Link Introduction
BLM 6–2 Chapter 6 Get Ready
BLM 6–4 Chapter 6 Problems of the Week

Key Words

linear relation	constant
linear equation	interpolate
numerical coefficient	extrapolate
variables	

What's the Math?

In this chapter, students solve problems that involve linear relations. This entails representing linear patterns by using a table of values, a linear equation, or a graph. Students begin by exploring pictorial, written, and oral patterns and representing them with linear equations, and then verifying linear equations by substituting values. Next, they examine patterns in graphs and learn how to use interpolation and extrapolation to estimate unknown values on graphs. Finally, students practise graphing linear equations, determine linear equations from graphs, and analyse graphs that involve linear relations.

Planning Notes

As a class, read and discuss the information about *Bluenose*. *Bluenose II* visited Vancouver, British Columbia in 1986 to participate in the international festival, Expo ‘86. Sailors tried to take the boat back to British Columbia in 1998, but had to return to the port in Nova Scotia. You may wish to discuss reasons why sailing ships might have to return to port, such as bad weather, no wind or too much wind, or damage.

Students who have grown up with motorized vehicles may need to use their imagination to realize what travelling was like before engines allowed people to travel in many kinds of weather.

Draw students' attention to the information about length of a race, wind speed, and current. Consider asking students how they might represent the relationship between two factors, such as the time it takes to run a race and wind speed. (Students might say they would use a table or a graph.) Have students recall what they know about coordinate grids, tables of values, and drawing graphs. Emphasize the labelling of axes, what the coordinates represent, and how the coordinate points line up. As a class, consider drawing and labelling a graph of a linear relation involving a racing ship or a racing scenario that students choose. Have students discuss how points on the graph relate to specific events in the scenario.

Literacy Link Sequence charts are graphic organizers that help students review terms, make connections between concepts, and understand the order of concepts.

At the beginning of the chapter, have students create a sequence chart in their notebook or journal. Demonstrate how to use a sequence chart by working with students to complete the entry for the first box by defining the term *linear relation*. Consider using an overhead copy of **Master 18 Sequence Chart**. Have students define the term on their own copy. Remind students to make each box on the sequence chart large enough to allow them to record their notes.

Have students use the sequence chart throughout the chapter to show what they have learned about the concepts in each of the remaining boxes. Encourage them to use visuals as examples. They can complete the boxes either at the end of the section or during the section as they learn the concepts.

- By the end of section 6.1, have students complete the second, third, and fourth boxes for representing patterns, solving equations, and describing patterns respectively. They should list ways to represent patterns using an example, show an example of how to solve a linear equation by substituting values, and describe a pattern using a table of values and a linear equation.
- By the end of section 6.2, have students complete the fifth and sixth boxes for interpolating and extrapolating values on a graph. Have them develop an example and a graph and explain how to interpolate and extrapolate values on the graph.
- By the end of section 6.3, have students complete the seventh box by describing how to graph a linear relation. Encourage students to develop a situation and a linear equation, and then graph the linear equation to help them explain the process.

Meeting Student Needs

- Consider having students complete the questions on **BLM 6–2 Chapter 6 Get Ready** to activate the prerequisite skills for this chapter.
- Some students may not be familiar with the history of *Bluenose*. You might show pictures of *Bluenose* and discuss how it differs from the types of vessels used for fishing in other regions. Why might they be different? (Possible answers include differences in fishing styles, prey, building materials available, and geography or hazards.)
- Some students may benefit from using **Master 18 Sequence Chart**, which provides scaffolding for the Literacy Link activity.

ELL

- Before beginning this chapter, students may benefit from reactivating their knowledge of the term *linear relation*.
- English language learners may not be familiar with terms such as *dime*, *schooner*, *prominence*, *replica*, *ambassador*, *wind speed*, *current*, *windsurf boards*, *supertankers*, and *freighter*. Have students add any new terms to their personal dictionary.

Gifted and Enrichment

- Have students research the development of racing sailboats in terms of the speeds they can reach. Challenge students to create distance-time graphs that show the progress of technology for racing sailboats. Students may find the related Web Link that follows is a helpful starting point.

WWW Web Link

For information about an international sailboat race called the America's Cup, go to www.mathlinks9.ca and follow the links.

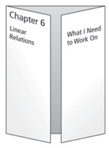
FOLDABLES™
Study Tool

Making the Foldable

Materials
- sheet of 11 × 17 paper
- ruler
- three sheets of 8.5 × 11 grid paper
- stapler
- sheet of 8.5 × 11 paper
- scissors

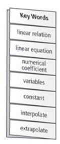
Step 1

Fold the long side of a sheet of 11 × 17 paper in half. Pinch it at the midpoint. Fold the outer edges of the paper to meet at the midpoint. Label it as shown.



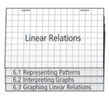
Step 2

Fold the short side of a sheet of 8.5 × 11 paper in half. On half of the sheet, cut a straight line across the width every 3.5 cm, forming eight tabs. Label the tabs as shown.



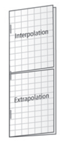
Step 3

Stack two sheets of 8.5 × 11 grid paper so that the bottom edges are 2.5 cm apart. Fold the top edge of the sheets and align the edges so that all tabs are the same size. Staple along the fold. Label as shown.



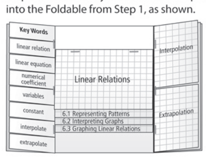
Step 4

Fold the short side of a sheet of 8.5 × 11 grid paper in half. Fold in two the opposite way. Make a cut through one thickness of paper, forming two tabs. Label the tabs as shown.



Step 5

Staple the booklets you made from Steps 2, 3, and 4 into the Foldable from Step 1, as shown.



Using the Foldable

As you work through Chapter 6, define the Key Words, and record notes, examples, and Key Ideas in the appropriate section. Use the grid paper to show examples of interpolation and extrapolation.

Use the back of the Foldable to record your ideas for the Math Link: Wrap It Up!

On the front of the Foldable, keep track of what you need to work on. Check off each item as you deal with it.

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Math Link

Marine Travel

You may never get to see a supertanker, even if you live on the coast, because they are too large to enter most ports. Supertankers can weigh 200 000 to 400 000 tonnes. The top speed of a supertanker when carrying a full load is only about 30 km/h. Once they are moving, they are hard to stop.

A crash stop manoeuvre from "full ahead" to "full reverse" can stop a loaded supertanker in about 15 min within approximately 3 km. The table of values shows the speed of a supertanker during a crash stop.

Time, t (min)	Speed, s (km/h)
0	30
3	24
6	18
9	12
12	6
15	0

1. **a)** What do you think the speed will be at 4 min? 5 min?
   b) Describe the pattern you see in the data. What do you notice about how the values change from one set of coordinate pairs to the next?
2. **a)** On a graph, plot the coordinate pairs in the table.
   b) Which variable did you plot on the horizontal axis? Why did you select that variable?
   c) Which variable did you plot on the vertical axis? Why did you select that variable?
   d) Does the graph match your pattern description? Explain.
3. Write an equation to model the data on the graph.
4. **a)** What value did you choose for the numerical coefficient and the constant?
   b) How did you determine each value?
5. A smaller tanker can stop in less time. The equation $s = -3t + 30$, where speed, s, in km/h, and time, t, in min, models stopping the smaller tanker.
   a) What would be the speed of the tanker at 7 min? How did you determine your answer?
   b) How much time would it take for the tanker to slow down to 8 km/h? Compare your solution with that of a classmate. Explain how you arrived at your answer.

Literacy Link
A metric tonne (t) is a measurement of mass that equals 1000 kg.

In this chapter, you will explore mathematical relationships between variables, such as time and distance for different types of boats. At the end of the chapter, you will research and plan an adventure trip on water, showing mathematical relationships between variables.

WWW Web Link
For more information about supertankers and other oil tankers, go to www.mathlinks9.ca and follow the links.

Math Link • MHR 209

Foldables Study Tool

Have students make the Foldable in the student resource to keep track of the information in the chapter. Have them define Key Words, and record notes, examples, and Key Ideas in the appropriate booklets. They should use the grid paper to show examples of interpolation and extrapolation in the appropriate booklet.

Filling in the What I Need to Work On section as they progress through the chapter will assist students in identifying and solving difficulties with concepts, skills, and processes.

As they work through the chapter, have students record ideas for the Wrap It Up! on the back of the Foldable. Note that there is no room on this Foldable for the Math Links throughout the chapter. You may wish to have students keep track of this work in their math portfolio or slip it into the plastic envelope mentioned below.

Have students store the Foldable in a binder by punching holes along one of the long sides. Alternatively, you may wish to provide students with a plastic envelope that fits into their binder.

You may wish to provide students with **Master 9 0.5 Centimetre Grid Paper**, but **Master 8 Centimetre Grid Paper** will likely work better.

Math Link

As a class, read the opening paragraph of the Math Link introduction. Discuss the photo and ask questions such as the following:
- Have you ever seen a supertanker?
- What do supertankers carry? (liquids such as oil; not tourists)
- Why do supertankers move so slowly?
- Why is stopping considered a linear relation?

Help students relate to a large number such as 400 000 t by relating it to familiar objects such as cars. For example, consider the world's largest parking lot (at the West Edmonton Mall). If the parking lot was jam-packed with cars, it would still take more than 10 of these full parking lots to equal the mass of a supertanker.

Have students work individually or in pairs to complete the Math Link introduction. These questions begin making connections between verbal, pictorial, and algebraic representations of a linear relation. You may wish to provide students with grid paper for drawing graphs.

Although the Math Links for this chapter are related to boating, the individual Math Links do not form part of the Wrap It Up! Instead, each Math Link provides a different context for students to apply the skills, processes, and concepts developed in the respective section. Have students read the Wrap It Up! on page 247 to give them a sense of where the Math Link is heading. The Wrap It Up! problem is a summative assessment.

Meeting Student Needs

- Consider creating the chapter Foldable ahead of time to use as a model.
- Encourage students to use the Foldable and record notes about the Key Words they are already familiar with from previous math courses.
- Students may benefit from using **BLM 6–1 Chapter 6 Math Link Introduction**, which provides scaffolding for this activity.
- Help students reactivate their knowledge of the following terms: *table of values* (a table showing two sets of values); *coordinate pair* (a set of x and y values; for example, (0, 30) is a coordinate pair); *variable* (a letter that represents an unknown number); *numerical coefficient* (a number that multiplies a variable); and *constant* (a number that does not change; increases or decreases the value of an expression no matter what the value of the variable). Encourage students to add notes about these terms to their Foldable.
- Some students may not be familiar with the nautical terms used in the Math Links. Consider inviting a guest speaker who is familiar with boating to share personal knowledge and provide a richer context for the use of linear relations in the Math Links.
- Give the scenario a local context by refocusing the activity on a local boat, either motorized or human powered. Ask students about the boat's top speed and how long (both time and distance) it would take to stop. You may wish to invite an expert to share this information. You might approach a law enforcement agency, a search and rescue team, a recreational club, or a boating school for a possible speaker. As a class, create a table of values using this information and then use the data to answer the questions in the Math Link introduction.
- Alternatively, consider having students use data about the stopping distance for a car, bicycle, or other familiar means of transport to answer the questions in the Math Link introduction.

ELL

- Explain that a *crash stop manoeuvre* involves the action needed to bring a boat to a stop in an emergency.
- Teach the following terms in context: *coast*, *ports*, *full ahead*, and *full reverse*.
- Allow students to explain their process in their first language. This may help them to ask for the missing vocabulary in English.

Common Errors

- Students may confuse the x- and y-variables when creating a graph, a table of values, or an equation.

Rx Remind students that the independent variable (the variable that is changed, controlled, or manipulated) goes on the horizontal or x-axis and the first column (or row) of a table of values. The dependent or responding variable (the variable that changes as a result) goes on the vertical or y-axis and in the second column (or row) of the table of values. An equation expresses the dependent variable in terms of the independent variable.

- Students may incorrectly identify coordinate pairs when graphing.

Rx Remind students that a table of values arranges data in pairs of x- and y-values. A coordinate pair is the x- and y-values that appear on the same row (in a vertical table) or in the same column (in a horizontal table).

- Students may mix up values when substituting in an equation.

Rx Point out that the variables in an equation represent the variables in a relationship. Use an example such as time, t, and speed, s, and have students identify the variable that is changed, t, and the variable that changes as a result, s, to help with understanding.

WWW Web Link

For games to practise graphing coordinate pairs, go to www.mathlinks9.ca and follow the links.

For information on *Bluenose* including its history and tradition, go to www.mathlinks9.ca and follow the links.

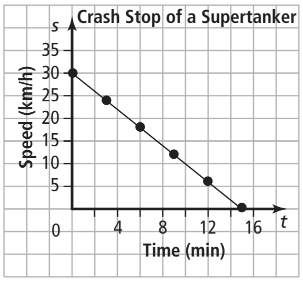
Answers

Math Link

1. a) Example: 22 km/h; 20 km/h

b) Example: The speed of the supertanker decreases by 6 km/h every 3 min, or by 2 km/h each min.

2. a)



b) Time (min) is the variable that is changed.

c) Speed (km/h) is the variable that changes as a result.

d) Example: Yes, the values of t increase in intervals of 3 s. The values of s decrease by 2 km/h each min.

3. $s = -2t + 30$

4. a) −2, 30

b) Example: The numerical coefficient is related to the rate of slowing down. The constant is the initial speed.

5. a) 9 km/h; Example: Substitute $t = 7$ into the equation, and solve for s.

b) $7\frac{1}{3}$ min or 7 min 20 s; Example: Substitute $s = 8$ into the equation and solve for t.