# 3.1 Vectors

**Study Guide and Exercise Book Pages**
44 to 46

**Tools**
- grid paper
- ruler
- protractor
- items to create a spinner, such as a piece of wire, a paper clip, or a piece of string
- graphing calculator
- computer with dynamic geometry software

**Related Resources**
- G–1 Grid Paper
- T–2 *The Geometer's Sketchpad®* 4
- BLM 3–1 Chapter 3 Prerequisite Skills
- BLM 3–2 Chapter 3 Self-Assessment Checklist
- T3–1 How to Do Section 3.1 #10 Using *The Geometer's Sketchpad®*
- T3–2 How to Do Section 3.1 #10 Using TI-83 Plus/TI-84 Plus and TI-Nspire™ CAS
- A–1 Problem Solving
- A–2 Reasoning and Proving
- A–3 Reflecting
- A–4 Selecting Tools and Computational Strategies
- A–5 Connecting
- A–6 Representing
- A–7 Communicating

## Teaching Suggestions

- Before students begin the chapter, you may wish to have them complete **BLM 3–1 Chapter 3 Prerequisite Skills** to activate their prior skills.
- Give students **BLM 3–2 Chapter 3 Self-Assessment Checklist** to keep track of their skills and knowledge. Have students return to it throughout the chapter.
- For further teacher support for this chapter, go to the Instructor Centre on the Online Learning Centre at **www.mcgrawhill.ca/books/mct12**.

### Key Concepts

- Have students create a reference sheet that they can refer to throughout this chapter. They can begin by adding any terminology that is new to them.
- The terms *vector*, *scalar*, and *magnitude* will have to be defined for students. Have students describe the meaning in their own words. If you have students in your class for whom English is not their first language, you might suggest that they first define the term in English and then in their first language.
- Visit some of the notation that will be used in this chapter, including the meaning of the absolute value sign and vector notation, such as $\overrightarrow{AB}$, which will be a new concept for students.
- This is an introductory section. Students need to fully understand the concept of a vector quantity. Stress the difference between a scalar and vector quantity: a scalar quantity has only magnitude, whereas a vector quantity has magnitude and direction.

### Example

- You may want to discuss with students the concepts of force as a vector quantity and a newton, N, as a unit of force. A newton is the force required to accelerate a mass of one kilogram at a rate of one metre per second per second, or $N = 1\text{ kg} \times 1\text{ m/s}^2$.
- You may also want to take this opportunity to discuss the difference between *mass*, a scalar quantity, and *weight*, a vector quantity. Weight is the measurement of the force of gravity, 9.8 N/kg downward on Earth, exerted on a mass. These concepts arise in the practice questions.
- Review the directions of a compass with students.
- Help students understand that when working with true bearings in whole degrees, the bearing is written as a three-digit number, corresponding to the degrees of a circle. North is 0°, and the bearings increase, moving clockwise around the circle: east is 090°, south is 180°, and west is 270°. It is important that students do not confuse this concept with that of the unit circle, where 0° is located along the positive $x$-axis and angles increase moving counterclockwise.
- Students may be confused by the term *quadrant bearing*. They must understand that this use of the word *quadrant* relates to the directions of a compass and not to quadrants on a Cartesian grid (i.e., not to quadrants I, II, III, IV).
- Tell students that quadrant bearings always begin with N or S, and end with E or W.

**Key Terms**

- scalar
- vector
- displacement
- velocity
- magnitude
- direction
- directed line segment
- tail of a vector
- head of a vector
- equivalent vectors
- opposite vectors
- true bearing
- quadrant bearing
- force

Definitions of Key Terms can be found on the Online Learning Centre at **www.mcgrawhill.ca/books/mct12**.

- If students have difficulty understanding the difference between true bearings and quadrant bearings, they could research these terms on the Internet to see how and where they are used. (By worldwide agreement, true bearings are always used in aeronautics. Quadrant bearings are often found in geography and mathematics textbooks.)
- It might be helpful for students to create a directional diagram, illustrating true bearings. Students can create a circle with degrees marked on it. Students can then draw directional arms on the circle, labelling the arms North or 0°, East or 090°, South or 180°, and West or 270°. They can then attach, to the centre of the figure, a spinner or piece of string that can be rotated to illustrate bearings. Suggest that they return their spinners to 0°, or North, between each angle measurement and then rotate the spinner clockwise to the desired bearing. Students could also create a similar diagram to demonstrate quadrant bearings. For a blackline master of a circle with degree marks, go to the Online Learning Centre at **www.mcgrawhill.ca/books/mct12**.
- Help students understand that equal, or equivalent, vectors are vectors that look the same but have been translated or shifted to another position on the plane.
- Help students recognize that the order of letters in a vector is important: $\overrightarrow{AB}$ is the opposite of $\overrightarrow{BA}$. They should also recognize that $\overrightarrow{AB} = -\overrightarrow{BA}$.

## Questions

- Before beginning the questions, ensure students have a firm grasp of the difference between a scalar quantity and a vector quantity. Students could brainstorm, as a class or in pairs, a list of scalar and vector quantities. It might be a good idea to post lists of scalars and vectors in the classroom. As part of their understanding, students must clearly understand the terms *magnitude* and *direction*.
- Consider having students work in pairs to discuss their answers to the practice questions. Many answers involve communicating and making connections.
- For **question 1**, consider having students determine a possible magnitude for all scalar quantities, and a magnitude and direction for all vector quantities.
- When answering **question 2**, students should recognize that the directions change, but the magnitudes do not.
- In **question 8**, ask students to identify the magnitude and/or direction for each.
- In **question 8c**), some students may need to be reminded that a decibel (dB) is a unit of the loudness of sound.
- Have students use their communication skills to describe to each other how to complete **question 9**.
- Encourage students to use a ruler when drawing vectors and to draw diagrams for questions that require them to determine displacement vectors, such as **question 10**.
- Remind students that the Pythagorean relationship will help with **question 10a**), and primary trigonometric ratios will help with **question 10b**).
- Students may have difficulty with **question 11** and may want to know why there is no diagram. Help them to communicate the meanings of the symbols.
- Students have to think in three dimensions for **question 13**. They may have trouble determining equivalent vectors and opposite vectors. Provide them with extra examples to help them better understand these concepts.

**Common Errors**

- Some students have difficulty understanding that force and velocity have direction.

$R_x$ Students can move objects along the floor to act out the concept of a vector. Pushing an object with the same speed but in two different directions can help demonstrate that two vectors are not equal.

**Differentiated Instruction**

- Use **think-pair-share** with **question 7**. Encourage pairs to clearly justify their solution.
- Construct a **word wall** of terms relevant to this chapter. Start with words listed under the Key Terms section. Include figures, pictures, and/or illustrations. Add to this list whenever students encounter an unfamiliar term.

## Technology Suggestions

- *The Geometer's Sketchpad*® is a useful tool for differentiated instruction, especially for the visual learner. It allows you to develop high-quality visual representations in real time. Students can take turns developing these elements under your guidance. If a computer lab is available, solutions to many questions can be illustrated and checked by students individually.
- For **questions 5** and **6**, have students connect numerical bearings with geometric representations. *The Geometer's Sketchpad*® offers a quick and convenient way to illustrate each of the answers to these questions.
- *The Geometer's Sketchpad*® provides a custom tool that is very useful for drawing vector representations. From the **Custom Tools** menu, select **Appearance Tools**, and then **Arrowhead** (**Closed**). Draw an arrow and measure its length. For even more utility, turn on the grid, and draw vectors from the origin. Add an angle measurement to illustrate direction. This tool is helpful for any question that involves drawing vectors, such as **question 7**.
- When measuring lengths of vectors, select **Coordinate Distance** from the **Measure** menu, rather than **Distance** or **Length**. If you use **Coordinate Distance**, the values will change accordingly if you change the scale.
- When selecting three points for an angle measurement, keep in mind that *The Geometer's Sketchpad*® measures angles in a clockwise sense. Further, it will correctly measure acute and obtuse angles, but not reflex angles. To obtain a bearing greater than 180°, subtraction is necessary.
- For **question 9**, use the **Arrowhead** (**Closed**) tool in *The Geometer's Sketchpad*® to illustrate opposite vectors. Draw the vector in one colour and the opposite vector in another colour. On the grid, draw vectors from the origin for an illustration of the meaning of *opposite*. Use length and angle measurements to highlight the relation between a vector and its opposite.
- After students work out **question 10** using pencil and paper, you can use *The Geometer's Sketchpad*® to illustrate and check the solution. See **T3–1 How to Do Section 3.1 #10 Using *The Geometer's Sketchpad*®** for instructions.
- Scientific calculators and graphing calculators, such as the TI-83 Plus/TI-84 Plus or TI-Nspire™ CAS, can be programmed to calculate sides and angles using the Pythagorean theorem, sine law, or cosine law. The programs can be stored for recall whenever required. This prevents the need for repeated calculations to find lengths and angles, such as in **question 10**. See **T3–2 How to Do Section 3.1 #10 Using TI-83 Plus/TI-84 Plus and TI-Nspire™ CAS** for programming instructions.
- For **question 14**, on the grid in *The Geometer's Sketchpad*®, plot one vector using the **Arrowhead** (**Closed**) tool. Select, copy, and paste the vector to represent the remaining vectors. Measure the coordinates of the unknown point.

## Mathematical Process Expectations

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

| Process Expectation | Selected Questions |
|---|---|
| Problem Solving | 13, 14 |
| Reasoning and Proving | 2, 11 |
| Reflecting | 9 |
| Selecting Tools and Computational Strategies | 10 |
| Connecting | 8, 10 |
| Representing | 7 |
| Communicating | 1, 4, 8, 10 |

### Ongoing Assessment

- Use **Assessment Masters A–1** to **A–7** to remind students about the Mathematical Processes Expectations and how you may be assessing them throughout this chapter.
- Have students write a journal entry to describe, in their own words, the main terms from this section, including scalar, vector, magnitude, direction, true bearing, and quadrant bearing.