

# 10

## Patterns and Expressions

Time as we know it is all about patterns. Years, months, days, and hours are all patterns. The length of a year is based on the pattern of Earth's journey around the sun. Our months are based on the patterns of the moon. Even your school timetable may be based on a pattern. Can you find a pattern in how many times you have math class and art class in one week?

### What You Will Learn

- to write a repeating decimal as a fraction
- to solve problems using patterns
- to write an expression to represent a pattern
- to evaluate an expression, given the value of the variable
- to create a table of values and a graph from a linear relation
- to solve problems using the graph of a linear relation

### Key Words

pattern  
variable  
expression  
value  
constant  
numerical coefficient  
table of values  
linear relation  
graph  
relationship

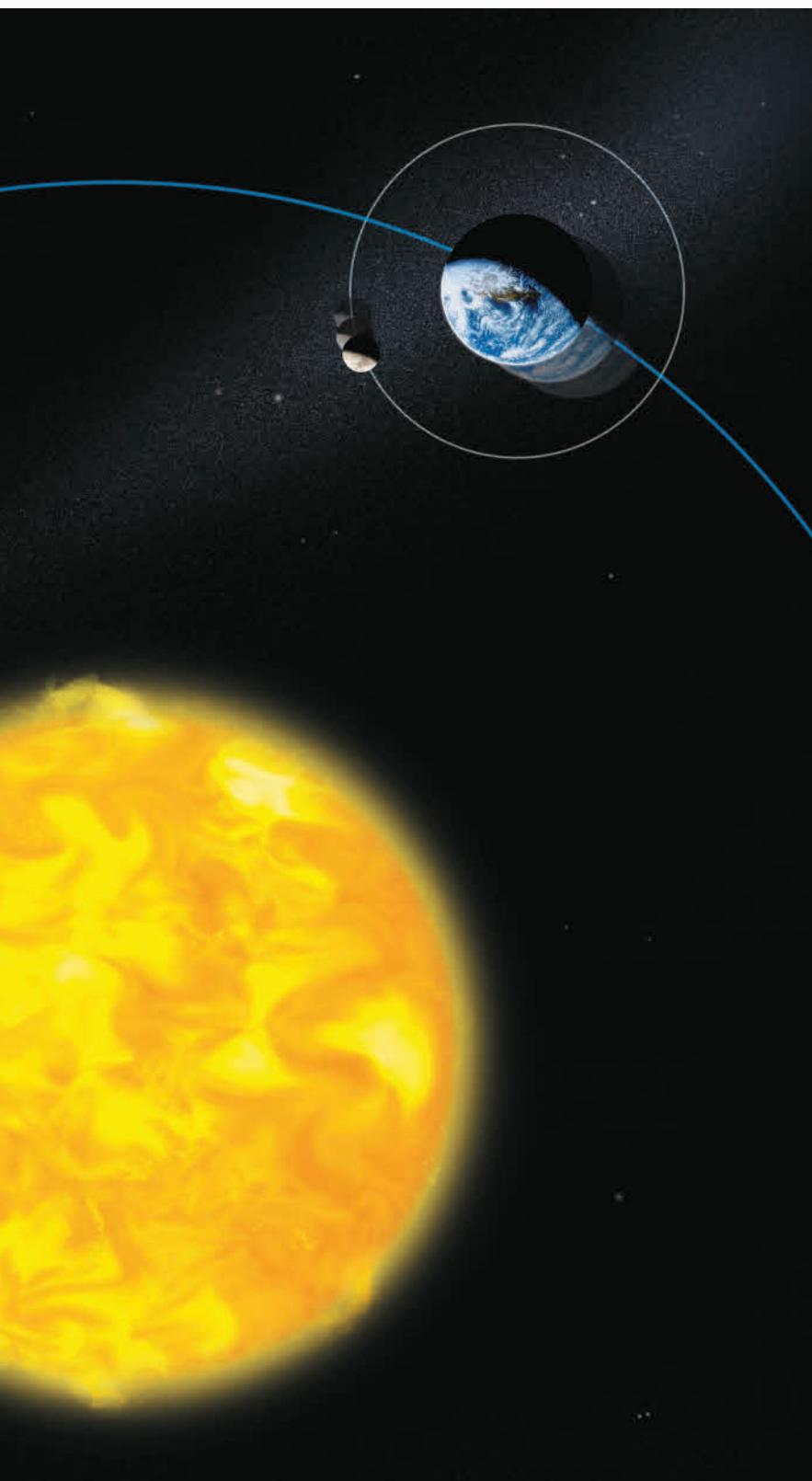
### MATH LINK

The numbers on a calendar form patterns. If you know the date for one Friday in February, what are the dates for other Fridays in February? If your birthday falls on a Monday this year, what day will it fall on next year? In this chapter, you will discover some of the hidden patterns that calendars hold. You will use them to uncover a mystery pattern at the end of the chapter.

### February



| S   | M   | T   | W   | T   | F   | S   |
|-----|-----|-----|-----|-----|-----|-----|
| Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|     |     |     |     | 1   | 2   | 3   |
| 4   | 5   | 6   | 7   | 8   | 9   | 10  |
| 11  | 12  | 13  | 14  | 15  | 16  | 17  |
| 18  | 19  | 20  | 21  | 22  | 23  | 24  |
| 25  | 26  | 27  | 28  |     |     |     |
|     |     |     |     |     |     |     |

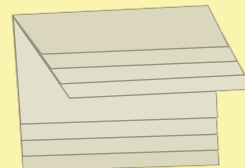


**Make the following Foldable to organize what you learn in Chapter 10.**

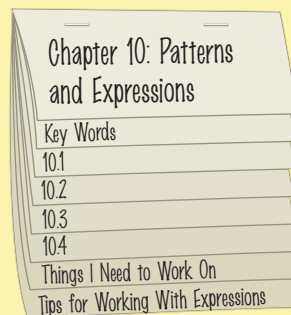
**Step 1** Collect four sheets of paper and place them 2 cm apart. Keep the edges straight.



**Step 2** Fold the top edge of the paper. Stop 2 cm from the bottom edge. This makes all tabs the same size. Staple together along the fold.



**Step 3** Label the tabs.



**Literacy  Link**

As you work through Chapter 10, take notes under the appropriate tab. Include information about the key words, examples, and key ideas. Once you have completed the Chapter Review, make a list of “Tips for Working With Expressions.”

# 10.1

## Describe Patterns

### Focus on...

After this lesson, you will be able to...

- describe patterns using words, tables, or diagrams
- use patterns with repeating decimal numbers

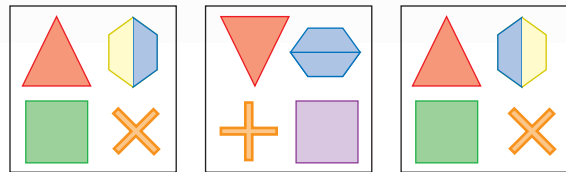


### pattern

- an arrangement of shapes, colours, numbers, letters, words, and so on, for which you can predict what comes next

**P**atterns can be made of shapes, colours, numbers, letters, words, and more. Some patterns are quite easy to describe. Look at the delta braiding in the photograph. How would you describe one of these patterns?

Other patterns are more difficult. Look at these shapes. Can you describe the pattern?



### Explore the Math

#### Materials

- scissors

#### How can you describe a pattern?

1. Cut a 1 cm × 20 cm strip of paper.



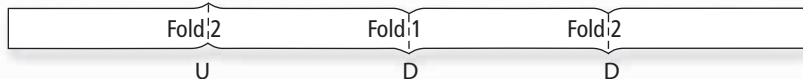
2. Fold it in half. In this activity, always fold from left to right. Open your strip. Label this fold “Fold 1.”



3. Fold the strip back as it was in step 2. Fold it in half again. Open your strip. Label each of the new folds “Fold 2.”



4. The folds marked D in the diagram point down. Those marked U point up. Was Fold 1 up or down?



5. Fold your strip back as it was in step 3. Predict what the pattern of ups and downs will be after another fold in half.
6. Fold your strip in half again. Open your strip. Was your prediction correct?
7. Label each of the four new folds from step 6 “Fold 3.”
8. Copy the table. Finish filling it in to help you find a pattern.

| Fold Number | Ups and Downs |
|-------------|---------------|
| 1           | D             |
| 2           | U, D          |
| 3           |               |

9. Predict what the ups and downs will be after another fold in half.
10. Fold your strip back as it was in step 6. Fold it in half again. Was your prediction correct?

### Reflect on Your Findings

11. a) Did you find this pattern difficult to predict? Why or why not?  
 b) What problem-solving strategies did you use? Which worked best?

### Example 1: Describe a Pattern of Shapes

- a) Describe the pattern shown.

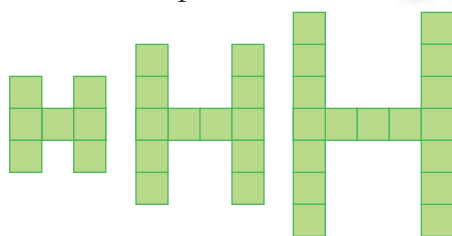


Figure 1

Figure 2

Figure 3

You can describe this pattern by saying how the number of squares relates to the previous figure.

- b) How many squares will be in Figure 6?

#### Solution

##### Strategies

##### Make a Table

Refer to page xvii.

a)

| Figure | Number of Squares |
|--------|-------------------|
| 1      | 7                 |
| 2      | 12                |
| 3      | 17                |
| 4      | 22                |
| 5      | 27                |

In the pattern, each figure has 5 more squares than the previous figure. One square is added to the width, and one square is added to each of the 4 ends of the H.

- b) Figure 6 will have 32 squares because  $27 + 5 = 32$ .

#### Show You Know

- a) Describe the pattern.

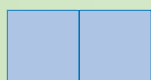


Figure 1

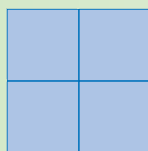


Figure 2

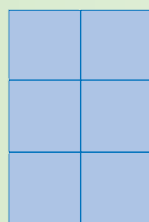


Figure 3

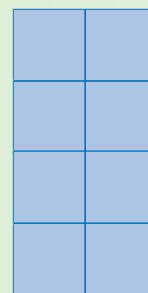


Figure 4

- b) How many squares will be in Figure 5? Explain your reasoning.

## Example 2: Describe a Number Pattern

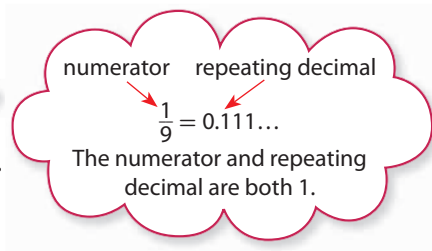
Denise and Anwar were changing fractions into decimal numbers. They noticed a pattern when changing ninths into decimal numbers.

$$\frac{1}{9} = 0.111\dots \quad \frac{2}{9} = 0.222\dots \quad \frac{3}{9} = 0.333\dots$$

- Describe the pattern.
- Write  $\frac{5}{9}$  as a decimal number, using bar notation. Check your answer.
- Write  $0.\overline{7}$  as a fraction.

### Solution

- When you change ninths to decimal numbers, the numerator of the fraction becomes the digit used as a repeating decimal.



- Continue the pattern.

$$\frac{4}{9} = 0.444\dots$$

$$\frac{5}{9} = 0.555\dots$$

In bar notation,  $\frac{5}{9} = 0.\overline{5}$ .

Check:

*Pencil and Paper*

$$\begin{array}{r} 0.555 \\ 9 \overline{) 5.000} \\ \underline{45} \phantom{00} \\ 50 \phantom{0} \\ \underline{45} \phantom{0} \\ 50 \\ \underline{45} \\ 5 \end{array}$$

*Calculator*

$$\boxed{C} \boxed{5} \boxed{\div} \boxed{9} \boxed{=} 0.555555556$$

- Continue the pattern to determine  $0.\overline{7}$  as a fraction.

$$0.\overline{5} = \frac{5}{9} \quad 0.\overline{6} = \frac{6}{9} \quad 0.\overline{7} = \frac{7}{9}$$

### Show You Know

Tim changed the following fractions into decimal numbers.

$$\frac{1}{90} = 0.0111\dots \quad \frac{2}{90} = 0.0222\dots \quad \frac{3}{90} = 0.0333\dots$$

Write  $\frac{7}{90}$  as a decimal number, using bar notation. Check your answer.

### Literacy Link

A repeating decimal number has one or more digits that repeat continuously.

It can be written using bar notation.

$$0.333\dots = 0.\overline{3}$$

$$0.181818\dots = 0.\overline{18}$$

### Tech Link

Some calculators round up the decimal number  $0.555\dots$  to  $0.555555556$ .

## Key Ideas

- Patterns come in many forms, including numbers and shapes.
- You can use a pattern to predict what comes next.
- To describe a pattern, say how to get the next item.
- You can write repeating decimal numbers as fractions.

### Communicate the Ideas

1. a) Create a pattern. Use either shapes or numbers.
  - b) Write a description of your pattern.
  - c) Exchange patterns with a classmate. Write a description of your classmate's pattern.
  - d) Compare your description to your classmate's.
2. Look at the pattern in the chart.
  - a) Draw a set of figures that show this pattern.
  - b) Compare your figures to a partner's. Discuss how they are different and how they are the same.

|               |   |   |   |   |
|---------------|---|---|---|---|
| <b>Figure</b> | 1 | 2 | 3 | 4 |
| <b>Number</b> | 3 | 5 | 7 | 9 |

3. Chad makes up the following number pattern.

1.8, 1.5, 1.2, 0.9, ...

He tells everyone that his pattern is difficult. Kelly disagrees and says that the next two numbers are 0.6 and 0.3. Do you agree with Kelly? Why or why not?

4. Describe in words what a repeating decimal is.

### Practise

For help with #5 and #6, refer to Example 1 on page 352.

5. a) Describe the pattern of squares.



Figure 1



Figure 2



Figure 3

- b) Draw Figure 4.

6. a) Describe the pattern of dots.

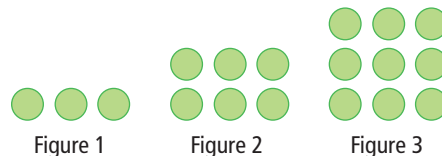


Figure 1

Figure 2

Figure 3

- b) How many dots would be in Figure 5?

For help with #7 and #8, refer to Example 2 on page 353.

7. a) Write each repeating decimal using bar notation.

$$\frac{1}{6} = 0.1\overline{666}\dots$$

$$\frac{7}{6} = 1.1\overline{666}\dots$$

$$\frac{13}{6} = 2.1\overline{666}\dots$$

$$\frac{19}{6} = 3.1\overline{666}\dots$$

- b) Describe the pattern.  
 c) What is the next fraction in the pattern?  
 d) What is the next decimal number in the pattern?
8. Mary and Tyler were changing elevenths into repeating decimals with a calculator. The table shows their results.

| Fraction       | Keying Sequence | Calculator Screen |
|----------------|-----------------|-------------------|
| $\frac{1}{11}$ |                 | 0.090909091       |
| $\frac{2}{11}$ |                 | 0.181818182       |
| $\frac{3}{11}$ |                 | 0.272727273       |

- a) Describe the pattern.  
 b) Without using a calculator, predict the next row in the chart.  
 c) What fraction is equivalent to  $0.\overline{54}$ ? Explain how you got your answer. Use a calculator to check your answer.  
 d) Write  $0.\overline{81}$  as a fraction. Explain how you got your answer.

## Apply

9. For each of the following, fill in the . Then explain the pattern.

a) 1200, 800, , 0

b) 1.3, 2.4, 3.5, , 5.7

c) , , ,

d) , , , ,

10. a) The numbers in each row of the table form a pattern. Copy and complete the table.

|          |  |      |      |      |
|----------|--|------|------|------|
| <b>A</b> |  |      | 3    | 4    |
| <b>B</b> |  | 20   |      | 40   |
| <b>C</b> |  | 200  | 300  |      |
| <b>D</b> |  | 2000 | 3000 | 4000 |

- b) Describe each pattern in rows A, B, C, and D, from left to right.
11. a) Describe any patterns you see in the red and green squares. Include patterns in the squares and in the colours.



Figure 1

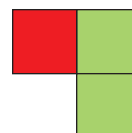


Figure 2

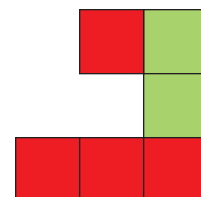


Figure 3

- b) What is a possible Figure 4 in the pattern? Draw it.  
 c) Show that there is more than one possible Figure 4.



12. The table shows fractions and their decimal equivalents.

| Fraction      | Decimal Number   |
|---------------|------------------|
| $\frac{1}{9}$ | $0.\overline{1}$ |
| $\frac{2}{9}$ | $0.\overline{2}$ |
| $\frac{3}{9}$ | $0.\overline{3}$ |
| $\frac{4}{9}$ | $0.\overline{4}$ |

- a) Describe any patterns you see in the table.
- b) What are the decimal equivalents of  $\frac{8}{9}$  and  $\frac{9}{9}$ ? Check your answer with a calculator.
- c) What did you notice?
- d) Predict what happens to the pattern after  $\frac{9}{9}$ .
- e) Continue the table in your notebook. Include all the ninths from  $\frac{5}{9}$  to  $\frac{18}{9}$ . Fill in the decimal equivalent for each fraction.
- f) Without using your calculator, predict the decimal equivalent of  $\frac{19}{9}$ . Check your answer.

13. The old Chinese calendar used three 10-day weeks.

|    |    |    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|----|----|
| 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |

- a) Choose any nine numbers that form a  $3 \times 3$  square.

- b) Add the numbers along each diagonal of the  $3 \times 3$  square. What do you notice about these two sums?
- c) Repeat b) with two other  $3 \times 3$  squares.
- d) Describe the pattern in words.
- e) What do you think will happen with  $2 \times 2$  squares? Check to see if you are correct.

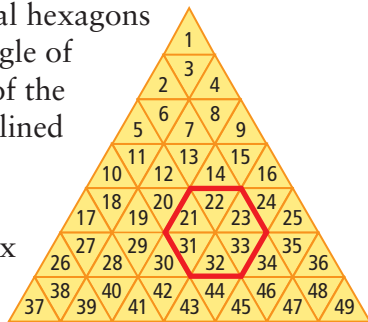
14. a) Choose any four numbers that form a  $2 \times 2$  square on the calendar.

| January |     |     |     |     |     |     |
|---------|-----|-----|-----|-----|-----|-----|
| S       | M   | T   | W   | T   | F   | S   |
| Sun     | Mon | Tue | Wed | Thu | Fri | Sat |
|         | 1   | 2   | 3   | 4   | 5   | 6   |
| 7       | 8   | 9   | 10  | 11  | 12  | 13  |
| 14      | 15  | 16  | 17  | 18  | 19  | 20  |
| 21      | 22  | 23  | 24  | 25  | 26  | 27  |
| 28      | 29  | 30  | 31  |     |     |     |
|         |     |     |     |     |     |     |

- b) Multiply the two numbers along each diagonal of the  $2 \times 2$  square.
- c) Repeat b) with another square of four numbers.
- d) Describe the pattern in words.
15. a) What is a repeating decimal pattern in the following fractions?  
 $\frac{1}{3}, \frac{2}{3}, \frac{3}{3}, \frac{4}{3}, \dots$
- b) Use this pattern to write a set of pattern problems for a classmate to answer.

**Extend**

16. There are several hexagons within the triangle of numbers. One of the hexagons is outlined in red.



- a) What is the sum of the six numbers in the red hexagon?
- b) Describe a method for determining the sum without adding the six numbers. Hint: If there are tens digits in the six numbers, add them. Add the ones digits in the six numbers.

c) Choose a different hexagon. Use your method to determine the sum of the numbers in this hexagon.

17. The numbers in the pattern shown increase by the same amount.

2, ■, ■, ■, 14

What are the three missing numbers?

18. The numbers in a pattern decrease by the same amount. The first number is 200 and the sixth number is 140. What are the other four numbers?

**MATH LINK**

A calendar year has 365 days, unless it is a leap year. Every four years, the month of February has 29 days. That means that a leap year has 366 days.

- a) What day of the week is your birthday this year?
- b) If next year is not a leap year, what day will your birthday be next year?
- c) If next year is a leap year, what day will your birthday be?
- d) Describe in words a pattern for the day of the week that your birthday will be each year.
- e) Record the number of days in a regular year in your notebook. You will use this number to uncover the mystery pattern at the end of the chapter.

*February*

| S   | M   | T   | W   | T   | F   | S   |
|-----|-----|-----|-----|-----|-----|-----|
| Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|     |     |     |     |     | 1   | 2   |
| 3   | 4   | 5   | 6   | 7   | 8   | 9   |
| 10  | 11  | 12  | 13  | 14  | 15  | 16  |
| 17  | 18  | 19  | 20  | 21  | 22  | 23  |
| 24  | 25  | 26  | 27  | 28  | 29  |     |
|     |     |     |     |     |     |     |

**WWW** Web Link

Research the history of calendars. Go to [www.mathlinks7.ca](http://www.mathlinks7.ca) and follow the links.

**Did You Know?**

It takes 365.2422 days for Earth to make one revolution around the sun. Our calendar has only 365 days. Leap years were added every fourth year so that the calendar will always follow the seasons.



# 10.2

## Variables and Expressions

### Focus on...

After this lesson, you will be able to...

- write an expression to represent a pattern
- identify and provide examples of variables in expressions
- change from a word statement to an expression

The average height of a miniature horse is about 81 cm tall. The fences for these animals do not have to be very high.

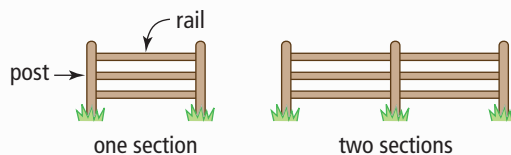
If a farmer wants to build a fence, how many rails and posts will be needed? The answer depends on how many sections the fence will have.



### Explore the Math

#### How can you predict and describe a pattern?

1. Use toothpicks to build the first five sections of the fence pattern shown.



2. In a table, record the number of posts and the number of rails for each size of fence.
3. **a)** How many posts and rails are in five sections?  
**b)** Predict the number of posts and the number of rails in ten sections.
4. Check your predictions in #3b) by building the fences with toothpicks. How close were your predictions to the toothpick fences?

#### Reflect on Your Findings

5. **a)** Describe in words the number of posts in relation to the number of sections of fence.  
**b)** Use the **variable**  $s$  to represent the number of sections of fence. Write an **expression** for the number of posts in relation to  $s$ .  
**c)** Describe in words the number of rails in relation to the number of sections of fence.  
**d)** Use the variable  $s$  to represent the number of sections of fence. Write an expression for the number of rails in relation to  $s$ .

### Materials

- toothpicks

#### variable

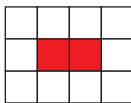
- a letter that represents an unknown number
- for example,  $x$ ,  $A$ ,  $n$

#### expression

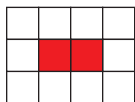
- any single number or variable, or a combination of operations ( $+$ ,  $-$ ,  $\times$ ,  $\div$ ) involving numbers and variables
- for example,  $5$ ,  $r$ ,  $8t$ ,  $x + 9$ ,  $2y - 7$

### Example 1: Describe a Pattern Using a Variable

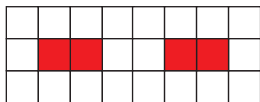
A kitchen floor is being covered with red and white tiles. The basic design is shown.



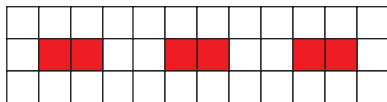
Several of these basic designs fitted together make a pattern.



Design 1



Design 2



Design 3

- Make a table showing the number of red and white tiles in the first five designs. Describe the pattern.
- Choose a variable and tell what it represents. Then use the variable to write an expression for the number of white tiles.
- How many white tiles will there be if there are 16 red tiles?

### Solution

a)

|                    |    |    |    |    |    |
|--------------------|----|----|----|----|----|
| <b>Red Tiles</b>   | 2  | 4  | 6  | 8  | 10 |
| <b>White Tiles</b> | 10 | 20 | 30 | 40 | 50 |

The number of white tiles is 5 times the number of red tiles.

- Let  $r$  represent the number of red tiles.  $5 \times r$ , or  $5r$  expresses the number of white tiles.
- The number of white tiles is 5 times the number of red tiles. If there are 16 red tiles, there will be  $5 \times 16 = 80$  white tiles.

**Strategies**

**Make a Table**  
Refer to page xvii.

**Literacy Link**

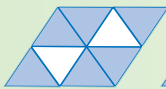
In algebra,  $5 \times r$  is written as  $5r$ .  
It is read as "five  $r$ ."

### Show You Know

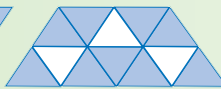
- Make a table showing the number of white and blue triangles in the first 5 designs.



Design 1



Design 2



Design 3

- Describe the pattern for the number of blue triangles in relation to the number of white triangles.
- Choose a variable and tell what it represents. Then use the variable to write an expression for the number of blue triangles.
- How many blue triangles will there be if there are 9 white triangles?

### value

- a known or calculated amount

### constant

- a number that does not change
- increases or decreases the value of an expression

### numerical coefficient

- a number that multiplies the variable

### Literacy Link

#### Choosing Variables

You can choose any letter as a variable. It can be helpful to choose a meaningful variable. For example,  $C$  for cost,  $d$  for distance, and  $t$  for time.

## Example 2: Describe Patterns Using Expressions

- a) Three employees work at the food bank. Every day, some volunteers arrive to help out. What is an expression for the number of people working at the food bank? What is the **value** of the **constant**?
- b) Simon creates this pattern of toothpick triangles. What is an expression for the perimeter of any triangle in this pattern in relation to the base? What is the value of the **numerical coefficient**?
- c) Theresa is sharing some grapes equally among her 4 friends. What is an expression for the number of grapes each friend gets?



### Solution

- a) Let the number of volunteers be represented by  $v$ .  
The number of people is 3 more than  $v$ , or  $v + 3$ .  
The constant is 3.

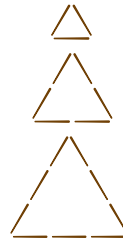
- b) If the base is 1, the perimeter is 3.

If the base is 2, the perimeter is 6.

If the base is 3, the perimeter is 9.

Let the base of the triangle be represented by  $b$ .  
The perimeter of any triangle in this pattern is  $3b$ .  
The numerical coefficient is 3.

- c) Let the original number of grapes be represented by  $g$ .  
The number of grapes each friend gets is  $g \div 4$ , or  $\frac{g}{4}$ .

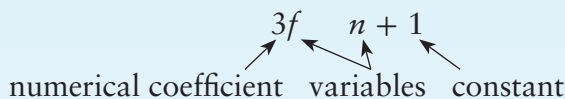


### Show You Know

- a) A group of students are talking between classes. Two friends leave the group. What is an expression for the number in the group after the friends leave?
- b) You walk into a store to buy 4 boxes of cereal. What is an expression for the cost of 4 boxes of cereal?

## Key Ideas

- An expression gives you a simple, quick way to describe a pattern.



- Any letter can be used as a variable to represent a number or amount.
- To write a pattern as an expression,
  - choose a variable and tell what it represents
  - describe the pattern using the variable, numbers, and operations

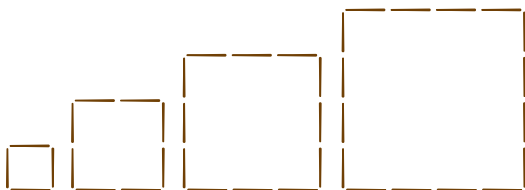
## Communicate the Ideas

1. Write a brief description of a pattern that could be represented by the expression  $c + 3$ .
2. Explain what an expression is to a classmate. Use examples in your explanation.
3. What is a good reason to use expressions instead of words to describe a pattern? Give an example.

## Practise

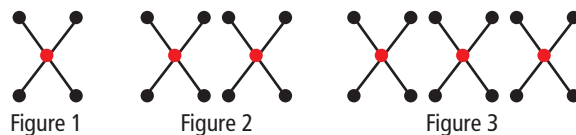
For help with #4 and #5, refer to Example 1 on page 359.

4. Ed uses toothpicks to make a pattern of squares.



- a) Make a table that shows the base and the perimeter of the first 6 squares.
- b) Describe in words the perimeter of the squares as the bases increase.
- c) What is an expression for the perimeter of any square in terms of the base?
- d) What would be the perimeter of a square with a base of 10?

5. The following figures are made of lines, red dots, and black dots.



- a) Describe as many patterns as you can.
- b) What is the number of red dots in Figure 100 of this pattern?
- c) Make a table that shows the figure number and number of black dots for the first 7 figures.
- d) What is an expression for the number of black dots in any figure?
- e) What is the number of black dots in Figure 51 of the pattern?

For help with #6 and #7, refer to Example 2 on page 360.

6. Identify the variable and then write an expression for each of the following.
  - a) A number of students try out for parts in the school play. Seven students do not get parts. How many students get parts in the play?
  - b) Alice's family is entering the spring fishing contest to see who can catch the largest Arctic char. Five of her family do not catch a char. How many family members do catch a char?
  - c) Amani is giving two books to each of his family members as gifts for Kwanzaa. How many books is he giving?

#### Did You Know?

Kwanzaa is a holiday when people in North America and around the world celebrate their African culture. It is held from December 26 to January 1. The celebration includes lighting candles and giving gifts.

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7. For each of the following, identify the variable. Then write an expression.
  - a) triple the width of a rectangle
  - b) 8 years younger than Vijay
  - c) the area increased by  $15 \text{ cm}^2$
  - d) pencils shared equally among 4 students
  - e) double the length decreased by 2 cm

### Apply

8. You go shopping for chocolate milk and canned peaches.

|                       |        |
|-----------------------|--------|
| 1 L of chocolate milk | \$1.35 |
| 1 can of peaches      | \$1.79 |

- a) What is an expression for the cost of  $p$  cans of peaches?
  - b) What is an expression for the cost of  $c$  litres of chocolate milk?
  - c) What is an expression for the cost of  $p$  cans of peaches and 1 L of chocolate milk?
- There is a constant in this expression. What is it?
9. a) Describe a pattern that could be represented by the expression  $4m$ .
    - b) What does your variable represent?
  10. a) Draw a pattern that could be represented by  $b + 3$ .
    - b) What does the variable represent?
  11. What is the expression for the number of boys
    - a) if there are  $x$  girls in a class of 30 students?
    - b) if there are 11 girls in a class of  $n$  students?
    - c) if there are  $x$  girls in a class of  $p$  students?
  12. For each of the following statements, write an expression. Where possible, identify the variable, constant, and numerical coefficient in each one.
    - a) Kate's wage is increased by \$3 an hour.
    - b) The number of people at a party doubles.
    - c) They sold half of the concert tickets that they expected to sell.

- 13.** Salma gets \$7 per hour to baby-sit. She gets a bonus if she has to baby-sit past 10 p.m. The expression  $7h + 3$  represents what Salma was paid last night. She baby-sat from 5:30 p.m. to 10:30 p.m.

- What is the variable in the expression? Explain what it represents.
- What does 3 represent?
- How much did she earn last night?

- 14.** A grocer orders  $w$  white loaves and  $b$  brown loaves of bread every day for  $d$  days.



Describe in words what each of the following expressions represents.

- $w + b$
  - $wd$
- 15.** Large bags of dog food hold 25 kg each. Small bags hold 10 kg each.



What is the expression for the total mass in kilograms if

- the number of large bags of dog food is  $x$ ?
- the number of small bags of dog food is  $y$ ?
- there are  $x$  large bags plus  $y$  small bags of dog food?

- 16.** Where possible, identify the variable, numerical coefficient, and constant in each expression.

- $7a - 8$
- $100 - 3h$
- $8q$
- $\frac{n}{3} - 5$

- 17.** Study the red H on the hundreds chart.

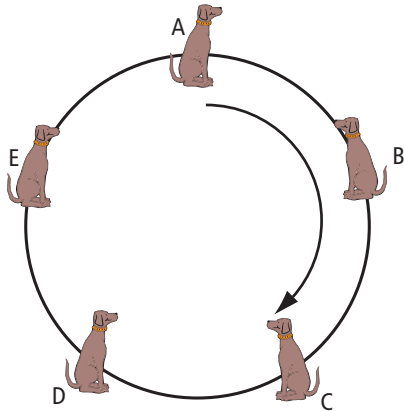
|    |    |    |    |    |    |    |    |    |     |
|----|----|----|----|----|----|----|----|----|-----|
| 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10  |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20  |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30  |
| 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40  |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50  |
| 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60  |
| 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70  |
| 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80  |
| 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90  |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |

- What patterns do you notice in the numbers in the red H?
- What is the sum of the numbers in the red H?
- Describe a method for determining the sum without adding all the numbers. Hint: Look at the middle number, 24. Then count how many numbers are in the H.
- Make another H in the chart that is the same size and shape as the first one. Use your method to determine the sum of the numbers in your H. Check your answer.
- Find an expression for the sum of the numbers in an H in the hundreds chart. Make your variable represent the middle number in the H.



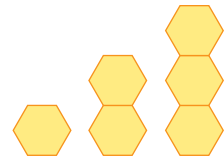
## Extend

18. Chris is training his dogs to sit in a circle. He gives each dog a treat if it stays in position. He starts with dog A and walks clockwise around the circle. The variable  $t$  represents the number of times that Chris walks around the circle.



- All the dogs stay in position. What is an expression for the number of treats Chris gives the dogs in total?
- Chris has given out  $5t - 3$  treats. Which dog did he just walk past?

19. Sanjay finds out that bees use hexagons to build their beehives. He wants to know the perimeter of each of these hexagon towers.



The table shows two patterns for determining the perimeter.

| Height | Perimeter | Pattern A       | Pattern B   |
|--------|-----------|-----------------|-------------|
| 1      | 6         | $2 + 4$         | 6           |
| 2      | 10        | $2 + 4 + 4$     | $6 + 4$     |
| 3      | 14        | $2 + 4 + 4 + 4$ | $6 + 4 + 4$ |

- Choose either Pattern A or Pattern B. Use that pattern to find the perimeter of a tower with a height of 150 hexagons.
- For the pattern you chose, write an expression for the perimeter in relation to the height.
- Write an expression for the other pattern.



## MATH LINK

- Copy any  $3 \times 3$  square from the calendar into your notebook. Your square should contain 9 numbers. What is the sum of all the numbers in your  $3 \times 3$  square?
- Repeat using a different  $3 \times 3$  square.
- Describe in words an easy way to find the sum using the middle number in a  $3 \times 3$  square.
- Use  $m$  to represent the middle number. Write an expression in relation to  $m$  for the sum of all the dates in a  $3 \times 3$  grid.
- What is the numerical coefficient in your expression? Record this number. You will use it to uncover the mystery pattern at the end of the chapter.

| S   | M   | T   | W   | T   | F   | S   |
|-----|-----|-----|-----|-----|-----|-----|
| Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|     |     |     |     |     |     | 1   |
| 2   | 3   | 4   | 5   | 6   | 7   | 8   |
| 9   | 10  | 11  | 12  | 13  | 14  | 15  |
| 16  | 17  | 18  | 19  | 20  | 21  | 22  |
| 23  | 24  | 25  | 26  | 27  | 28  | 29  |
| 30  | 31  |     |     |     |     |     |

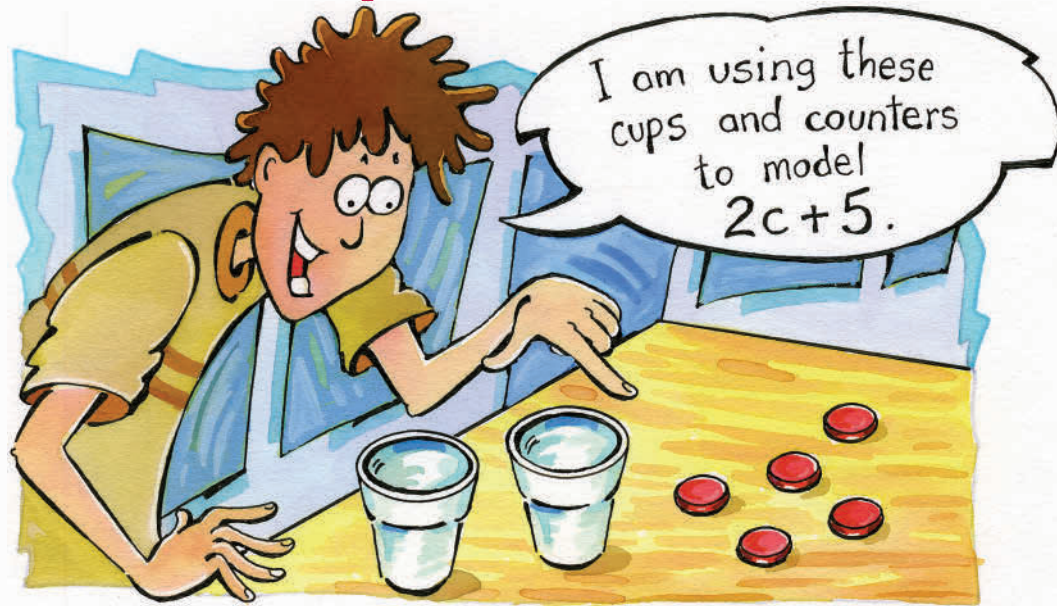
# 10.3

## Evaluate Expressions

### Focus on...

After this lesson, you will be able to...

- model an expression
- evaluate an expression
- make a table of values for an expression



Sam is modelling an expression. What do the cups represent? What do the counters represent?

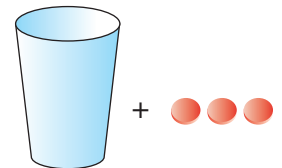
### Explore the Math

#### Materials

- cups or plastic containers
- counters

#### How can you model an expression?

1. Let the variable  $c$  represent the unknown number of counters in the cup shown in the diagram. What is an expression for the total number of counters shown?



2. Put 6 counters in the cup. What is the value for  $c$ ?
3. How many counters do you have in total?
4. If you substitute  $c = 6$ , what is the value of your expression in step 1?

#### Reflect on Your Findings

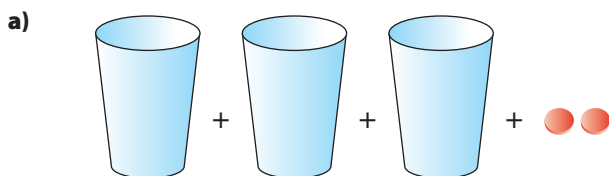
- a) Describe what the cup represents.
- b) Describe what the 3 counters represent.

Evaluate means to determine the result or answer of an expression.

### Example 1: Evaluate Expressions

- Use cups and counters to model the expression  $3x + 2$ .
- Evaluate  $3x + 2$  when
  - $x = 3$
  - $x = 4$

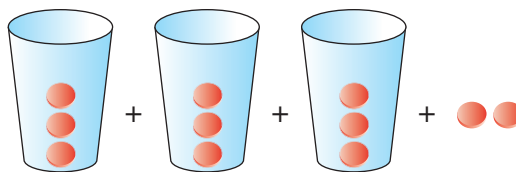
#### Solution



b) *Method 1: Use Cups and Counters*

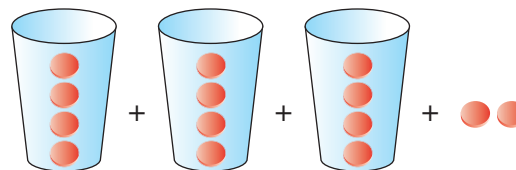
When  $x = 3$

$$3 + 3 + 3 + 2 = 11$$



When  $x = 4$

$$4 + 4 + 4 + 2 = 14$$



*Method 2: Substitute Into the Expression  $3x + 2$*

When  $x = 3$

$$\begin{aligned} 3x + 2 &= 3(3) + 2 \\ &= 9 + 2 \\ &= 11 \end{aligned}$$

When  $x = 4$

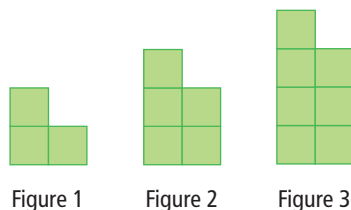
$$\begin{aligned} 3x + 2 &= 3(4) + 2 \\ &= 12 + 2 \\ &= 14 \end{aligned}$$

### Show You Know

- Use cups and counters to model the expression  $2y + 4$ .
- Determine the value of the expression  $2y + 4$  when
  - $y = 1$
  - $y = 3$

## Example 2: Make a Table of Values

Look at the pattern of squares. It can be described using the expression  $2n + 1$ , where  $n$  is the figure number.



- What does  $2n + 1$  represent?
- Make a **table of values** for  $n$  and  $2n + 1$ . Use whole numbers from 1 to 6 for  $n$ .
- How many squares are in Figure 30 of the pattern?

### table of values

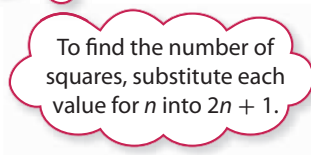
- a table showing two sets of related numbers

### Solution

- $2n + 1$  represents the number of squares in the figure.

b)

| Figure Number ( $n$ ) | Number of Squares ( $2n + 1$ ) |
|-----------------------|--------------------------------|
| 1                     | 3                              |
| 2                     | 5                              |
| 3                     | 7                              |
| 4                     | 9                              |
| 5                     | 11                             |
| 6                     | 13                             |



### Strategies

#### Make a Table

Refer to page xvii.

- Substitute  $n = 30$  into  $2n + 1$ .  

$$2n + 1 = 2(30) + 1$$

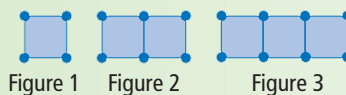
$$= 60 + 1$$

$$= 61$$

There are 61 squares in Figure 30.

## Show You Know

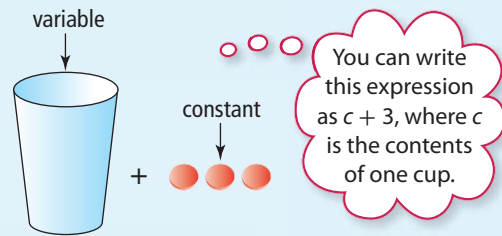
The number of line segments that form the squares can be described using the expression  $3s + 1$ , where  $s$  is the number of squares.



- Make a table of values for  $s$  and  $3s + 1$ . Use whole numbers from 1 to 6 for  $s$ .
- How many line segments are in Figure 12 of this pattern?

## Key Ideas

- You can model expressions using cups and counters.
- Evaluate an expression by substituting a number for the variable in the expression.
- You can make a table of values for an expression.



## Communicate the Ideas

1. Use cups and counters to model the expression  $3x + 4$ .
  - a) What do the cups represent?
  - b) What do the counters represent?
2. a) Show two methods for evaluating the expression  $2a + 3$  when  $a = 1$ .
  - b) Which method do you prefer? Why?
3. Michelle and Liam were asked to model “3 more than a number.” Who is correct? Why?

*Michelle's Model*



*Liam's Model*



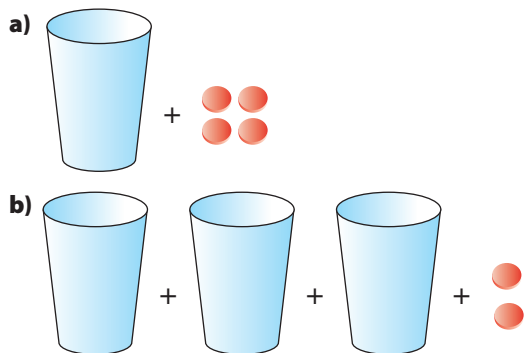
4. a) Give an example of an expression that has a total value of 7 when 1 is substituted for the variable.
  - b) How can you show that your expression is correct?

## Practise

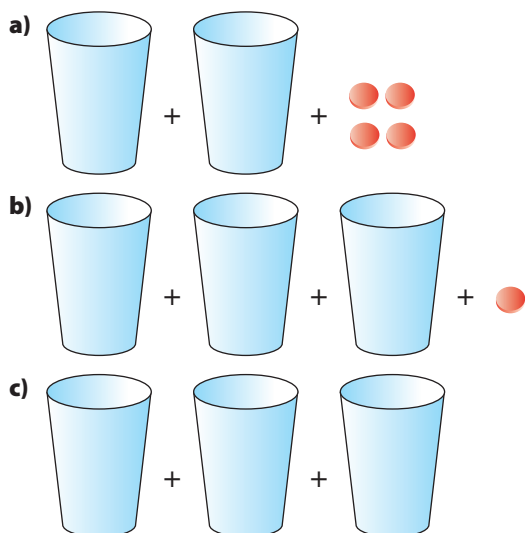
For help with #5 to #10, refer to Example 1 on page 366.

5. Model each expression using cups and counters.
  - a)  $4y$
  - b)  $2c + 1$
  - c)  $3x + 5$
6. Use cups and counters to model each expression.
  - a)  $5x$
  - b)  $t + 3$
  - c)  $2y + 2$

7. What is an expression for each model?



8. What expression does each diagram model?



9. Evaluate each expression.

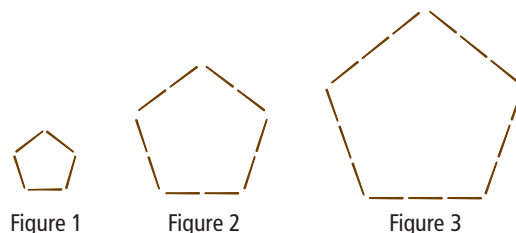
- a)  $t + 5$  when  $t = 3$
- b)  $d - 4$  when  $d = 7$
- c)  $4r - 3$  when  $r = 5$

10. Substitute to determine the value of each expression.

- a)  $3 + 2y$  when  $y = 4$
- b)  $\frac{m}{10}$  when  $m = 30$
- c)  $3x + 11$  when  $x = 2$

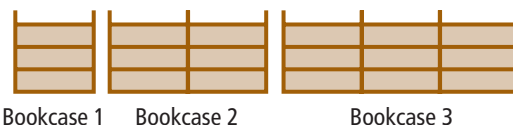
For help with #11 to #14, refer to Example 2 on page 367.

11. The expression  $5t$  represents the number of toothpicks in the perimeter of a pentagon.



- a) Make a table of values for the first six figures in the pattern.
- b) What would be the number of toothpicks in Figure 12?

12. The diagram shows a pattern of shelves. Note that each horizontal segment in a bookcase counts as a shelf.



- a) Copy the table of values into your notebook. Complete the table for the first five bookcases in the pattern.

| Bookcase | Number of Shelves |
|----------|-------------------|
| 1        | 4                 |
| 2        | 8                 |

- b) What is an expression for the number of shelves in a bookcase?
- c) What does your variable represent?

13. Make a table of values for the expression  $3x + 4$ . Use whole number values of 0 to 4 for  $x$ .

14. An expression for the number of toothpicks in the pattern shown is  $5n + 1$  where  $n$  is the figure number.



Figure 1



Figure 2



Figure 3

- Make a table of values showing the number of toothpicks in the first seven figures.
- How many toothpicks would be in Figure 9?
- How many toothpicks would be in Figure 100?

### Apply

15. An expression for the area of a triangle is  $b \times h \div 2$ , where  $b$  is the base and  $h$  is the height of the triangle.

- What is the area of a triangle if  $b = 7$  cm and  $h = 4$  cm?
- What is the area of a triangle where the base and the height are each double the values in part a)?

16. Lucy pours 100 mL of juice into a large empty Thermos™. Then, she adds another 100 mL of juice.

- Record the new total volume.
- Lucy continues to add 100 mL of juice. Make a table of values showing each total volume of juice for the first seven times she pours.
- What is an expression for the total volume of juice in the Thermos™?
- What does your variable represent?
- How much juice is in the Thermos™ after Lucy pours 15 times?

17. If  $p = 4$ ,  $q = 5$ , and  $r = 2$ , what is the value of each expression?

- $3p + 5$
- $2q - 3$
- $4q + r$
- $pq$

18. The number of black squares can be written as  $2(r - 1)$ , where  $r$  is the number of red squares in the figure.



Figure 1



Figure 2

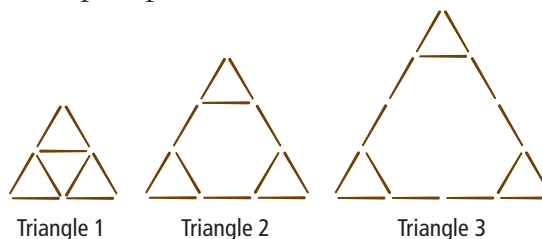


Figure 3

- Make a table of values showing the number of red squares and black squares in this pattern for the first six figures.
- What is another expression for the number of black squares in any figure?

### Extend

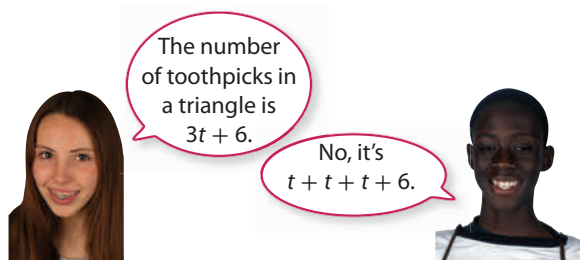
19. Karin and James are working on a toothpick pattern.



Triangle 1

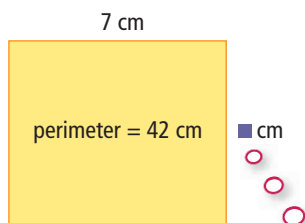
Triangle 2

Triangle 3



- Make a table of values showing the number of toothpicks in the first five triangles for both Karin's expression and James's expression.
- Who is correct? Why?

20. a) The perimeter of a rectangle is 42 cm. One side of the rectangle is 7 cm long. What is the length of the other side?



- b) The perimeter of a rectangle is  $p$  cm. One side is  $q$  cm long. What is an expression for the length of the other side?

21. The table of values gives the number of black squares and the number of white squares in a pattern.

|       | Figure 1 | Figure 2 | Figure 3 | Figure 4 |
|-------|----------|----------|----------|----------|
| Black | 4        | 8        | 12       | 16       |
| White | 5        | 10       | 15       | 20       |

- a) What are the numbers of black and white squares for Figures 5 and 6 in the pattern?
- b) What is an expression for the number of black squares in any figure in the pattern?
- c) Draw a pattern with black and white squares that matches the table of values.
- d) Explain how you came up with your pattern.

## MATH LINK

- a) Add the date of the first Thursday in March to the date of the second Thursday in March. Repeat for the first and second Fridays, Saturdays, and Sundays.
- b) Look at the sums. Write an expression for the pattern.
- c) Substitute to determine the next three numbers in the pattern.
- d) Predict whether the same expression would work for a different month. Check your prediction.
- e) What is the numerical coefficient in your expression from b)? Record this number in your notebook. Later, you will use it to discover the mystery pattern at the end of the chapter.

## March



| S   | M   | T   | W   | T   | F   | S   |
|-----|-----|-----|-----|-----|-----|-----|
| Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|     |     |     |     | 1   | 2   | 3   |
| 4   | 5   | 6   | 7   | 8   | 9   | 10  |
| 11  | 12  | 13  | 14  | 15  | 16  | 17  |
| 18  | 19  | 20  | 21  | 22  | 23  | 24  |
| 25  | 26  | 27  | 28  | 29  | 30  | 31  |
|     |     |     |     |     |     |     |



# 10.4

## Graph Linear Relations

### Focus on...

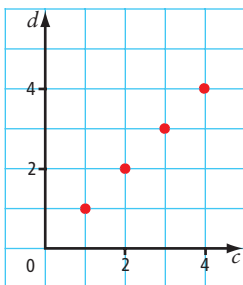
After this lesson, you will be able to...

- graph a linear relation
- describe the relationship shown on a graph



### linear relation

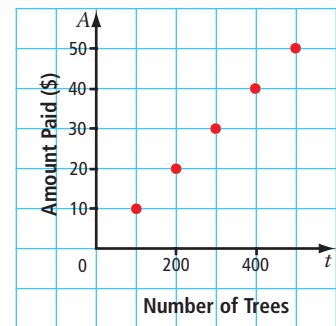
- a pattern made by two sets of numbers that results in points along a straight line on a coordinate grid



Brenda has a summer job working for a tree planting company in British Columbia. She gets \$10 for every 100 trees she plants. That means if she plants

- 200 trees she gets \$20
- 300 trees she gets \$30
- 400 trees she gets \$40

This pattern can be shown on a coordinate grid. The pattern is a **linear relation**.



### Explore the Math

#### How can you determine a pattern on a coordinate grid?

The game of Detective is played on a coordinate grid. Players try to guess the location of a footprint.

- The footprint may be placed horizontally or vertically on the intersecting lines of the grid.
- The footprint is made up of 3 side-by-side points.
- To find the footprint, you must locate all 3 points.

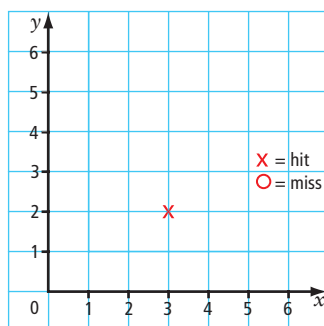
### Materials

- grid paper

1. Draw a coordinate grid. Label the  $x$ -axis and  $y$ -axis from 0 to 6.

2. You make a guess of  $(3, 2)$ . You hit the footprint! Mark  $(3, 2)$  with  $\times$ . What two lines could the footprint be along?

3. Your next guess is  $(3, 3)$ . It's a miss. Mark  $(3, 3)$  with  $\circ$ . Could the footprint be along the vertical line through  $(3, 2)$ ? Why?



4. Next, you try  $(2, 2)$ . It's a hit! Mark  $(2, 2)$  with  $\times$ . What are the possible coordinates for the last point of the footprint?

### Reflect on Your Findings

5. a) Imagine you hit a footprint on your first try. How many possible locations are there for the rest of the points on the footprint?
- b) Why is it necessary to play Detective on a coordinate grid instead of on a plain piece of paper?
- c) Describe strategies for locating a footprint.



## Example 1: Plot Points and Describe Patterns

Dr. Seuss often described patterns in unique ways. He once wrote about a pup in a cup and three fish in a tree.

- a) Copy and complete the table.

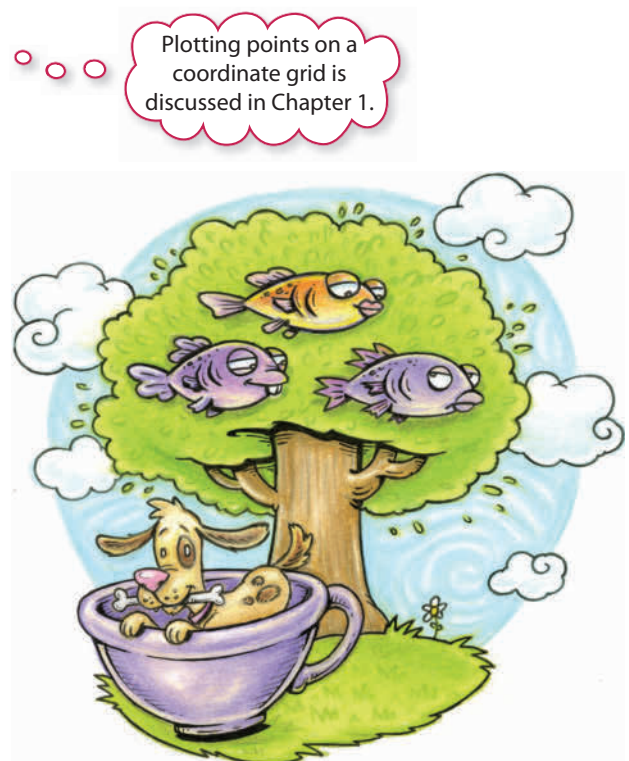
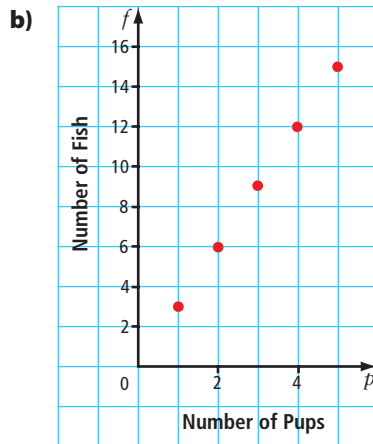
| Number of Pups, $p$ | Number of Fish, $f$ | Ordered Pair $(p, f)$ |
|---------------------|---------------------|-----------------------|
| 1                   | 3                   | (1, 3)                |
| 2                   | 6                   |                       |
| 3                   |                     |                       |
| 4                   |                     |                       |
| 5                   |                     |                       |

- b) Make a **graph** using the ordered pairs in your table.  
 c) Describe the pattern of points on your graph.

### Solution

a)

| Number of Pups, $p$ | Number of Fish, $f$ | Ordered Pair $(p, f)$ |
|---------------------|---------------------|-----------------------|
| 1                   | 3                   | (1, 3)                |
| 2                   | 6                   | (2, 6)                |
| 3                   | 9                   | (3, 9)                |
| 4                   | 12                  | (4, 12)               |
| 5                   | 15                  | (5, 15)               |



### graph

- a visual way to show how two sets of numbers relate to each other

### Strategies

#### Make a Table

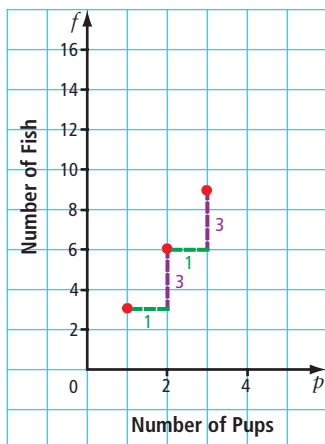
Refer to page xvii.

c) **Method 1: Describe Using Words**

The pattern of points forms a straight line, starting at (1, 3).  
The  $f$ -coordinate is 3 times the  $p$ -coordinate.

**Method 2: Describe Using Horizontal and Vertical Distances**

The points increase by 1 unit to the right, then 3 units up, starting at (1, 3).



**Method 3: Describe Using a Relationship**

The number of pups is  $p$ . The number of fish is  $f$ .

The coordinates of the points are  $(p, f)$ .

The relationship between  $p$  and  $f$  is linear and can be expressed as  $(p, 3p)$  or  $f = 3p$ .

**relationship**

- a pattern formed by two sets of numbers

**Show You Know**

Imagine that for every pup in a cup, there are four fish at the store.

a) In your notebook, copy and complete the table.

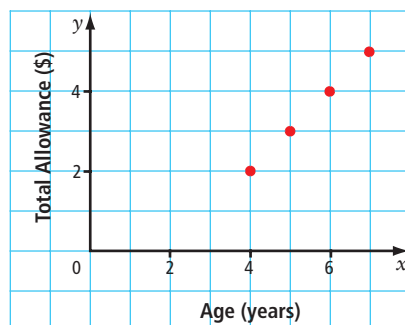
| Number of Pups, $p$ | Number of Fish, $f$ | Ordered Pair $(p, f)$ |
|---------------------|---------------------|-----------------------|
| 1                   | 4                   |                       |
| 2                   | 8                   |                       |
| 3                   | 12                  |                       |
| 4                   |                     |                       |
| 5                   |                     |                       |

b) Graph the ordered pairs.

c) Describe the pattern of points on your graph. Use words, horizontal and vertical distances, and a relationship.

## Example 2: Describe a Graph to Solve a Problem

Armand is four years old. His allowance starts at \$2 per week. Each year he will get a \$1 per week increase. The graph shows what his total allowance will be after the increase each year.



- Continue the pattern. Make a table of values for the first 6 values of  $x$ .
- Describe the pattern of points on the graph.
- What will Armand's allowance be when he is 15?

### Solution

#### Strategies

##### Make a Table

Refer to page xvii.

a)

|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
| <b>Age (<math>x</math>)</b>             | 4 | 5 | 6 | 7 | 8 | 9 |
| <b>Total Allowance (<math>y</math>)</b> | 2 | 3 | 4 | 5 | 6 | 7 |

- b) *Describe Using Words*

The pattern of points forms a straight line, starting at (4, 2). The  $y$ -coordinate is 2 fewer than the  $x$ -coordinate.

*Describe Using Horizontal and Vertical Distances*

The points increase by 1 unit to the right and 1 unit up, starting at (4, 2).

*Describe Using a Relationship*

The number of years is  $x$ . The total allowance is  $y$ .

The coordinates of the points are  $(x, y)$ .

The relationship is linear and can be expressed as  $(x, x - 2)$  or  $y = x - 2$ .

- c) Substitute  $x = 15$  into the linear relation.

$$y = x - 2$$

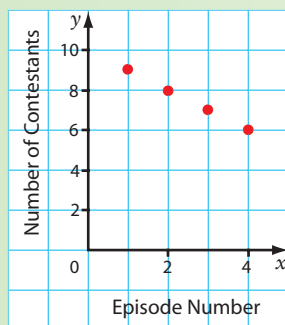
$$y = 15 - 2$$

$$y = 13$$

When he is 15, Armand's allowance will be \$13 per week.

## Show You Know

During each episode, a contestant is eliminated from the Canadian Star singing competition. The competition starts with 10 contestants. The graph shows the number of contestants left after each episode.



- Continue the pattern to make a table of values for the first 6 values of  $x$ .
- Describe the pattern of points on the graph.
- How many contestants will be left after episode 9?

## Key Ideas

- Patterns can be shown by listing ordered pairs in a table of values or by plotting the ordered pairs on a graph.

|          |   |   |   |   |   |
|----------|---|---|---|---|---|
| <b>x</b> | 0 | 1 | 2 | 3 | 4 |
| <b>y</b> | 0 | 1 | 2 | 3 | 4 |

- Patterns can be described in several ways:

### Words

The pattern forms a straight line, starting at  $(0, 0)$ . Each  $y$ -coordinate is the same as its  $x$ -coordinate.

### Horizontal and Vertical Distances

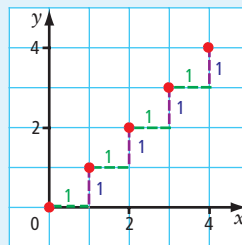
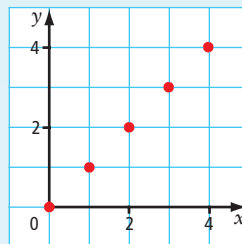
The points increase by 1 unit to the right, then 1 unit up, starting at  $(0, 0)$ .

### Relationship

The coordinates of the points are  $(x, y)$ .

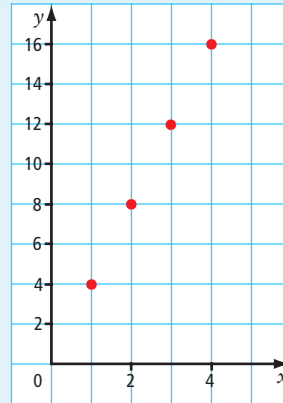
The relationship is linear and can be expressed as  $(x, x)$  or  $y = x$ .

- You can use patterns in graphs to solve problems.



## Communicate the Ideas

1. **a)** Make a table of values for the ordered pairs shown on the graph.
- b)** Think of a real-life example of this pattern.
- c)** Explain your example to a partner.



2. Diane and George are trying to determine a relationship that would result in the table of values shown. Who is correct? How do you know?

|          |   |   |   |   |
|----------|---|---|---|---|
| <b>x</b> | 1 | 2 | 3 | 4 |
| <b>y</b> | 0 | 2 | 4 | 6 |



The relationship is  $(x, 2x - 2)$ , which is the linear relation  $y = 2x - 2$ .

No, it is  $(x, 2x - 1)$ , which is  $y = 2x - 1$ .



## Practise

For help with #3 and #4, refer to Example 1 on pages 374–375.

3. Kim makes a pattern with red and white tiles.

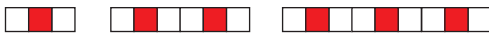


Figure 1

Figure 2

Figure 3

- a)** Make a table of values showing the number of red tiles compared to the number of white tiles. Complete your table for the first five figures in the pattern.
- b)** Draw a graph using the ordered pairs in your table of values.
- c)** Describe the pattern on your graph. Use words, distances on a graph, and a relationship.

4. The diagram shows a pattern of yellow and green triangles.



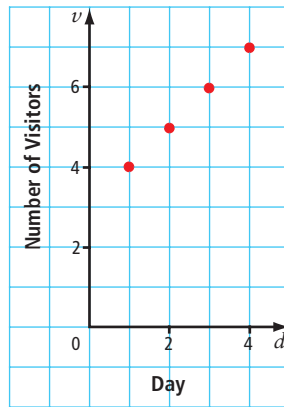
The table of values shows the number of yellow triangles,  $x$ , in relation to the number of green triangles,  $y$ .

|          |   |   |   |   |
|----------|---|---|---|---|
| <b>x</b> | 1 | 2 | 3 | 4 |
| <b>y</b> | 2 | 3 | 4 | 5 |

- a)** Draw a graph using the ordered pairs in the table of values.
- b)** Describe the pattern on your graph, using words, distances on a graph, and a relationship.

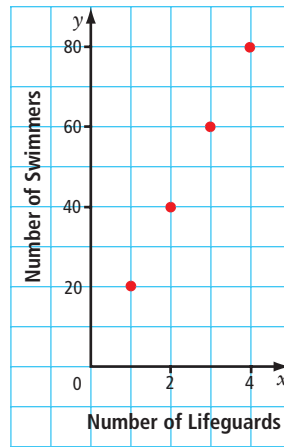
For help with #5 and #6, refer to Example 2 on page 376.

5. The graph shows how many people visited a new web site each day.
- a) Imagine the pattern continues. Make a table of values for the first 7 values of  $d$  starting at  $d = 1$ .

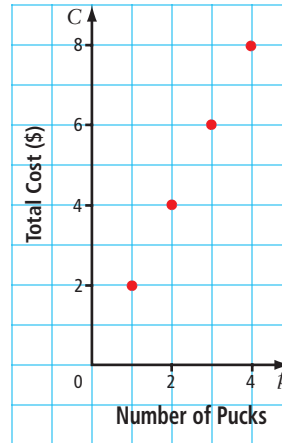


- b) Describe the pattern.
- c) If the pattern continues, how many people will visit the web site on day 12?

6. The graph shows the number of swimmers allowed in a pool in relation to the number of lifeguards on duty.
- a) Make a table of values for the first 6 values of  $x$  starting at  $x = 1$ .
- b) Describe the pattern.
- c) If there are 12 lifeguards on duty, how many swimmers are allowed in the pool?

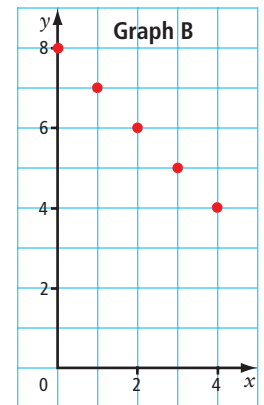
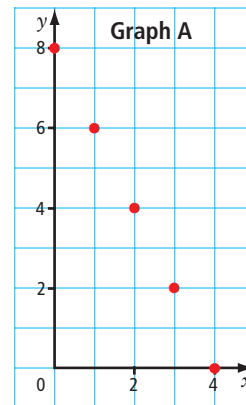


8. The graph shows the total cost in relation to the number of hockey pucks you buy.



- a) Describe the relationship between the total cost and the number of pucks you buy.
- b) How much do 9 pucks cost?
- c) You decide to buy a hockey stick for \$30 and some pucks. What is the relationship now?

9. Faheen says that Graph A shows  $y = 8 - 2x$ , and Graph B shows  $y = 8 - x$ . Is she correct? Explain how you know.



### Apply

7. For each table of values, describe the relationship between  $y$  and  $x$ . Use an expression and a linear relation.

a)

| $x$ | $y$ |
|-----|-----|
| 0   | 0   |
| 1   | 7   |
| 2   | 14  |
| 3   | 21  |

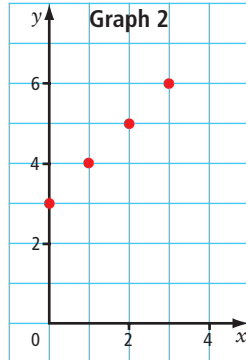
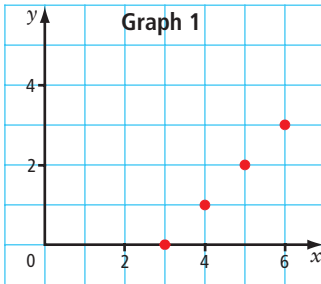
b)

| $x$ | $y$ |
|-----|-----|
| 3   | 1   |
| 4   | 2   |
| 5   | 3   |
| 6   | 4   |

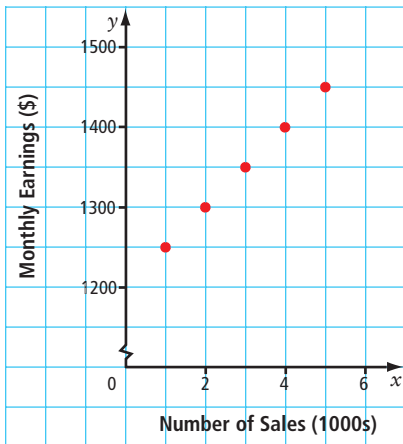


10. a) The relationship  $(n, 2n + 3)$ , can be written as the linear relation  $f = 2n + 3$ . Make a table of values for  $n = 0, 1, 2, 3, 4, 5, 6$ .
- b) Draw a graph using the ordered pairs from your table of values.
- c) What is the value of  $f$  if  $n = 12$ ?

11. Which linear relation goes with each graph?



- a)  $y = x + 3$
- b)  $y = x - 3$
12. The following graph shows the monthly earnings for a salesperson selling widgets in quantities of 1000.



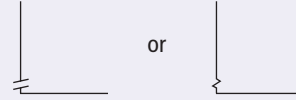
- a) Make a table of values for the five points shown on the graph.
- b) Explain how you could use the graph to find the monthly earnings if the salesperson sold 8000 widgets.

- c) If the pattern continues, how many widgets would need to be sold in a month to make \$1700?

### Literacy Link

A break in the  $y$ -axis of a graph means the length of the axis has been shortened.

The break is shown as

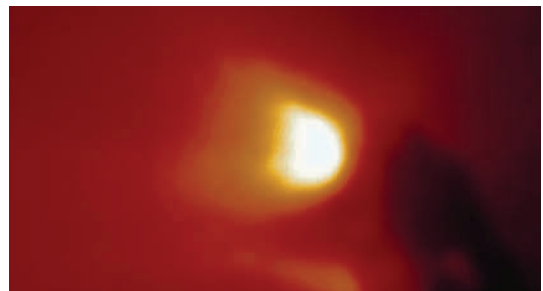


13. Halley's comet appears on average every 76 years.

- a) Copy and complete the table of values to show when it has appeared since it appeared in 1606.

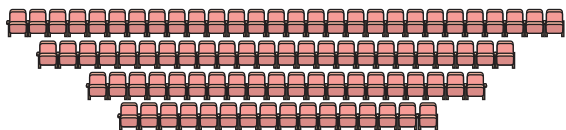
| Sightings After 1606 | Year |
|----------------------|------|
| 1                    |      |
| 2                    |      |
| 3                    |      |
| 4                    |      |
| 5                    |      |

- b) How many times has Halley's comet appeared since 1606?
- c) In what year is Halley's comet expected to appear next?
- d) What is an expression that describes the year Halley's comet will appear for the  $n$ th time? What does  $n$  represent?
- e) In what year will Halley's comet appear for the fifteenth time after 1606? Show how you found this answer.



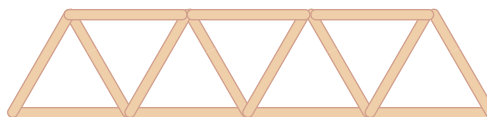
## Extend

14. A school's theatre has 16 seats in the first row, 20 seats in the second row, 24 seats in the third row, and so on.



- Make a table of values to show the number of seats in the first 6 rows.
- Draw a graph showing the data from your table of values.
- What is the relationship between the number of seats in a row and the row number?
- How many seats are in the fifteenth row? Explain two ways to find this answer.

15. James makes a pattern of triangles from stir sticks.



- How many triangles are shown in the diagram?
- Make a table of values showing the total number of sticks each time one triangle is added. Include from 1 to 8 triangles in your table.
- Graph the table of values.
- What is the relationship between the number of sticks and the number of triangles?
- How many sticks are needed to make 2007 triangles?

## MATH LINK

- What is the date of the first Friday in November? the second Friday in November? the third?
- Make a table of values of the results.
- Write an expression for the dates of Fridays in November.
- Determine the dates for all Fridays in November. Record the results in your table of values.
- Graph your table of values.
- Repeat c), d) and e) using another day of the week in November.
- Compare the patterns in your two graphs. Explain the similarities and differences.
- What is the numerical coefficient in your expression for the dates of Fridays in November? Record this number because you will use it to discover the mystery pattern at the end of the chapter.

## November

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| S   | M   | T   | W   | T   | F   | S   |
|-----|-----|-----|-----|-----|-----|-----|
| Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|     |     |     |     |     | 1   | 2   |
| 3   | 4   | 5   | 6   | 7   | 8   | 9   |
| 10  | 11  | 12  | 13  | 14  | 15  | 16  |
| 17  | 18  | 19  | 20  | 21  | 22  | 23  |
| 24  | 25  | 26  | 27  | 28  | 29  | 30  |
|     |     |     |     |     |     |     |

## Key Words

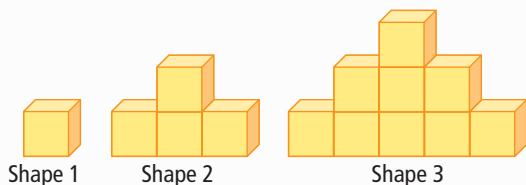
For #1 to #5, write in your notebook the word from the list that goes in each blank.

variable    expression    linear relation  
numerical coefficient    constant

- In  $3x - 5$ ,  $x$  is a(n)  .
- $3b$  is an example of a(n)  .
- In  $n - 4$ , the number 4 is called a(n)  .
- In  $10f + 1$ , the number 10 is called a(n)  .
- $C = d + 2$  is an example of a(n)  .

## 10.1 Describe Patterns, pages 350–357

6. Nikola built a pattern of cubes.



- Describe how you think Nikola should build the fourth shape in the pattern.
- How many cubes would Nikola need to build the fifth shape in the pattern?

7. Use the number patterns below to answer the questions that follow.

$$\frac{1}{9} = 0.\overline{1} \quad \frac{2}{9} = 0.\overline{2} \quad \frac{3}{9} = 0.\overline{3}$$

- What is the decimal equivalent of  $\frac{5}{9}$ ?  $\frac{7}{9}$ ?
- What is the fraction equivalent of  $0.\overline{4}$ ?
- What is  $0.888\dots$  written in fraction form?

8. Look at the following pattern.

$$\frac{1}{18} = 0.0555\dots$$

$$\frac{3}{18} = 0.1666\dots$$

$$\frac{5}{18} = 0.2777\dots$$

- What do you think  $\frac{7}{18}$  will be as a repeating decimal? How do you get that answer without using a calculator?
- What is  $\frac{1}{18}$  written as a repeating decimal using bar notation?



- How many triangles make up Figure 4?
- Is the last triangle in Figure 4 pointing up or down?
- In Figure 35, would the last triangle be pointing up or down? Explain.

## 10.2 Variables and Expressions, pages 358–364

10. Answer each question with an expression. Then explain what each variable represents.
- Some birds are sitting in a tree. Five fly away. How many are left?
  - Each can of soup costs the same amount. You buy 8 cans. What did you pay?
  - Peter has a piece of rope. Teng gives him another 3 m of rope. What is the total length of rope that Peter now has?
  - Joseph feeds a total of 8 fish to his sled dogs. How many fish does each dog get?

11. An electric train has a total length in metres of  $t$ . The train is made up of  $c$  cars, each with 8 wheels.



- a) What does the expression  $8c$  represent?  
 b) What does the expression  $\frac{t}{c}$  represent?

### 10.3 Evaluate Expressions, pages 365–371

12. Use cups and counters to help you find the value of  $3x + 2$  when  $x = 4$ .

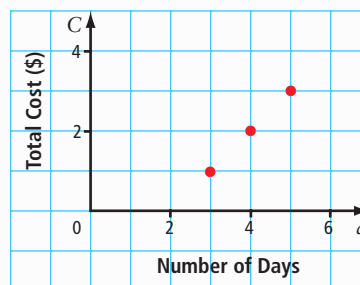
13. Naveed sells samosas for \$2.50 each.



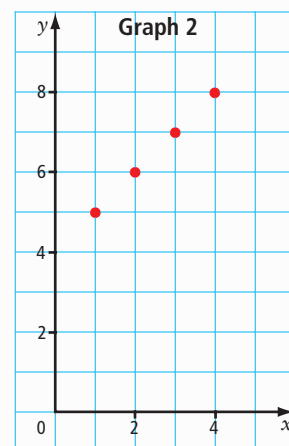
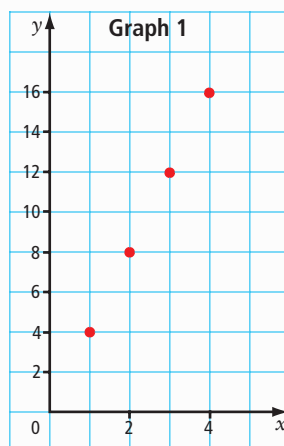
- a) Make a table of values showing the number of samosas sold and their total cost to the customer. Complete your table for 1 to 6 samosas.
- b) What is an expression that describes the cost for any number of samosas? What does your variable represent?
- c) How much would 9 samosas cost?
14. Evaluate each expression. Write the answer using the appropriate units, as needed.
- a)  $d - 7$  when  $d = 20$
- b)  $\pi r^2$  when  $r = 2.4$  cm. Give your answer to the nearest tenth of a square centimetre.
- c)  $2(l + w)$  when  $l = 7$  mm and  $w = 9$  mm

### 10.4 Graph Linear Relations, pages 372–381

15. To play the online computer game Mystic Relics, the first 3 days cost \$1. Each day after that costs \$1.



- a) Make a table of values in which the number of days is a whole number from 3 to 7.
- b) Describe the pattern on the graph in three ways: using words, using horizontal and vertical distances, using a relationship.
- c) If  $d = 2$ , what is the value of  $C$ ? Does this make sense? Why?
- d) If you play for 48 days, how much does it cost? Explain how you got your answer.
16. Which linear relation goes with each graph?
- a)  $y = 4x$
- b)  $y = x + 4$



For #1 to #4, select the best answer.

1. Look at the pattern of repeating decimal numbers.

$$\frac{3}{3} = 1 \quad \frac{4}{3} = 1.\bar{3} \quad \frac{5}{3} = 1.\bar{6} \quad \frac{6}{3} = 2 \quad \frac{7}{3} = 2.\bar{3}$$

What is the decimal equivalent for  $\frac{8}{3}$ ?

- A  $3.\bar{6}$                       B  $2.\bar{3}$   
 C  $3.\bar{3}$                         D  $2.\bar{6}$
2. The table shows the number of chair legs in relation to the number of chairs.

| Number of Chairs (c) | Number of Chair Legs |
|----------------------|----------------------|
| 1                    | 4                    |
| 2                    | 8                    |
| 3                    | 12                   |

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Which expression represents the number of chair legs?

- A  $5c - 1$                       B  $3c$   
 C  $4c$                               D  $c + 4$
3. Which table of values represents the linear relationship  $y = 3x - 2$ ?

A

| x | y |
|---|---|
| 1 | 1 |
| 2 | 4 |
| 3 | 8 |

B

| x | y  |
|---|----|
| 1 | 1  |
| 2 | 5  |
| 3 | 10 |

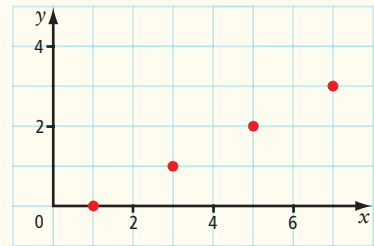
C

| x | y  |
|---|----|
| 2 | 4  |
| 3 | 7  |
| 4 | 10 |

D

| x | y  |
|---|----|
| 3 | 7  |
| 5 | 15 |
| 7 | 23 |

4. Which table of values represents the graph shown?



A

| x | y |
|---|---|
| 1 | 0 |
| 3 | 1 |
| 5 | 2 |
| 7 | 3 |

B

| x | y |
|---|---|
| 0 | 1 |
| 3 | 1 |
| 5 | 2 |
| 7 | 3 |

C

| x | y |
|---|---|
| 1 | 0 |
| 3 | 1 |
| 5 | 3 |
| 7 | 5 |

D

| x | y |
|---|---|
| 1 | 0 |
| 3 | 1 |
| 5 | 2 |
| 6 | 3 |

### Short Answer

5. If  $c$  represents the number of cats in the schoolyard, describe a situation that each of the following expressions could represent.

a)  $c - 3$                       b)  $\frac{c}{2}$

6. The table of values shows the number of triangles in an increasing pattern.

| Figure              | 1 | 2 | 3 | 4 |
|---------------------|---|---|---|---|
| Number of Triangles | 3 | 5 | 7 |   |

- a) How many triangles are in Figure 4?  
 b) Graph the table of values. Use the figure number as  $x$ , and the number of triangles as  $y$ .  
 c) Draw Figures 1 to 4.

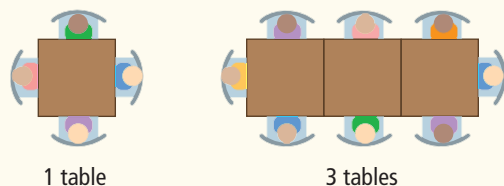
## Extended Response

7. A large pizza costs \$10, plus \$2 for each topping.



- What is an expression for the total cost of a pizza with any number of toppings?
- Make a table of values showing the cost of a pizza with 1 to 4 toppings.
- What is the relationship between the cost of a pizza and the number of toppings?
- Make a graph showing the total cost as the number of toppings increases from 1 to 4.

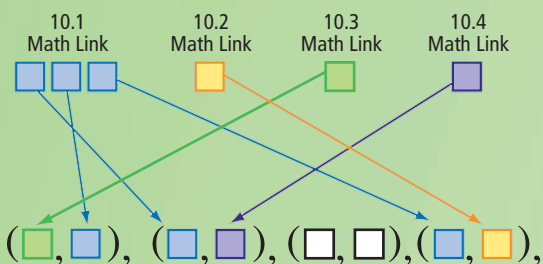
8. The diagram shows the number of guests that can be seated at 1 small table, and at 3 small tables.



- How many guests do you think can be seated at 5 small tables?
- Make a table of values showing the number of guests that can be seated at 1, 3, 5, and 7 small tables.
- Draw a graph using the values in the table.
- What is the relationship between the number of guests and the number of small tables?

## WRAP IT UP!

To get the mystery pattern, first copy the boxes into your notebook. Fill in the numbers from the Math Links in this chapter.





- Determine the missing ordered pair.
- Use the mystery pattern to create a math problem involving a real-life situation.
- Exchange problems with a partner. Solve your partner's problem.

For examples of problems, look at #13 and #15 of the Chapter 10 Review.

# Math Games

## Materials

- cross-number puzzle and clues for #1 
- cross-number puzzle and blank list of clues for #2 

## Puzzling Expressions

In a crossword puzzle, the answer to each clue is a word. In a cross-number puzzle, the answer to each clue is a number.

1. a) Complete a copy of the following cross-number puzzle by evaluating each expression for the given value of the variable.

*Across*

2.  $x + 2$ ;  $x = 9$   
 4.  $6a$ ;  $a = 12$   
 6.  $4z - 1$ ;  $z = 11$   
 8.  $\frac{n}{2}$ ;  $n = 24$   
 11.  $7v$ ;  $v = 8$   
 13.  $15 + 5b$ ;  $b = 5$   
 14.  $4(k + 1)$ ;  $k = 6$

*Down*

1.  $3y - 3$ ;  $y = 10$   
 3.  $2c + 6$ ;  $c = 4$   
 5.  $3m - 3$ ;  $m = 8$   
 7.  $5t + 10$ ;  $t = 4$   
 9.  $8s + 1$ ;  $s = 3$   
 10.  $20 - 2g$ ;  $g = 3$   
 12.  $10u - 8$ ;  $u = 7$

|     |    |     |     |    |
|-----|----|-----|-----|----|
| 1.  |    | 2.  | 3.  |    |
| 4.  | 5. |     | 6.  | 7. |
|     | 8. | 9.  |     |    |
| 10. |    | 11. | 12. |    |
| 13. |    |     | 14. |    |

- b) Compare your completed puzzle with a classmate's to check that the solutions agree.
2. a) As a class or in a group, brainstorm how you would write clues for a cross-number puzzle.

- b) On a copy of the following puzzle, work individually to write the clues. Each clue must include
- an expression with one variable
  - a given whole-number value of the variable

*Across*

1.   
 4.   
 6.   
 8. 

*Down*

2.   
 3.   
 5.   
 7. 

|    |    |    |    |
|----|----|----|----|
|    | 1. | 2. |    |
| 3. |    | 4. | 5. |
| 6. | 7. |    |    |
|    | 8. |    |    |

- c) Check that your clues give your intended solution to the puzzle.  
 d) Have a classmate use your clues to solve the puzzle. Check your classmate's solution.

# Challenge in Real Life

## Your Life Line


Your heart beat can tell you about your health. On average, a physically fit person has a lower heart rate than someone who is less fit.

Trainers work with athletes to get them into the best possible physical condition. They set heart rate goals for the athletes to reach during their training sessions.

You be the trainer!

Work in a group to measure heart beats during three simulated training sessions.



- a) Take the pulse of each group member
  - when they are seated quietly
  - after 1 min of brisk walking on the spot
  - after 1 min of running on the spotCount the number of beats every 10 s for 60 s. Record your own results in a table. 
- b) Use your results to create a graph showing the relationship between the number of beats and the time. Plot the results for each activity in a different colour on the graph. Include a legend.
- c) For each activity, use words to describe the relationship between the number of beats and the time.
- d) Is there a difference in the relationship when the type of activity changes? If so, describe the change.