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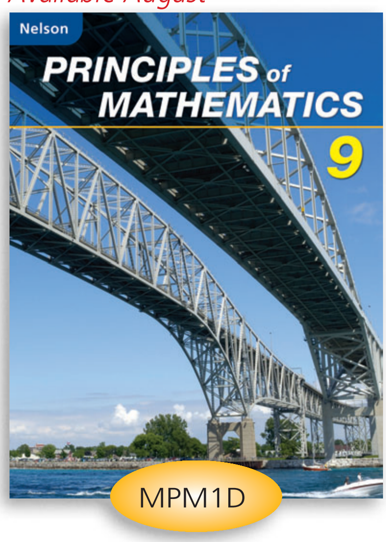

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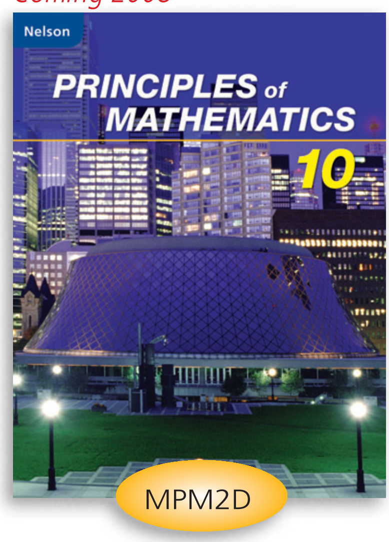

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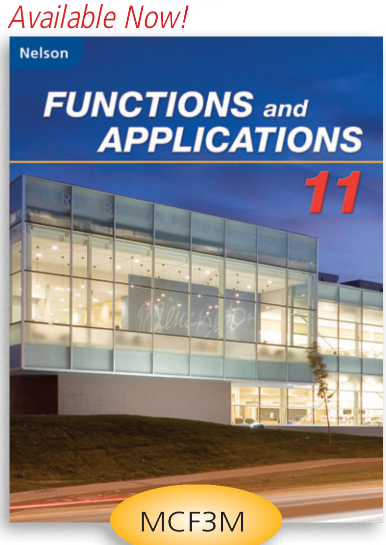

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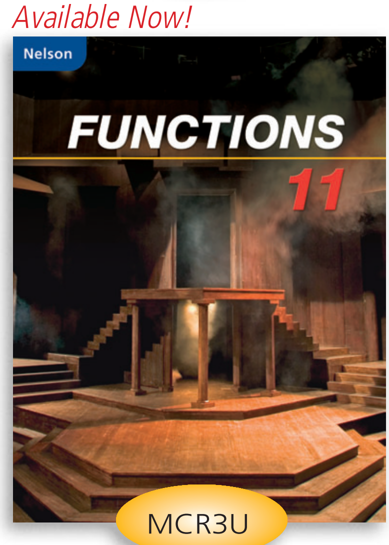

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Calculus and Vectors (MCV4U) • Advanced Functions (MHF4U)

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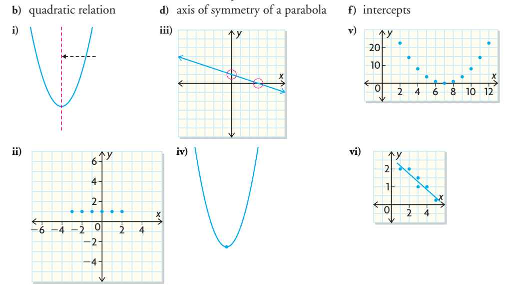
1 Getting Started

WORDS You Need to Know

1. Match the term with the picture or example that best illustrates its definition.

a) linear relation
b) quadratic relation
c) vertex of a parabola
d) axis of symmetry of a parabola
e) line of best fit
f) intercepts

i) ii) iii) iv) v) vi)



SKILLS AND CONCEPTS You Need

Evaluating Algebraic Expressions

Study | Aid
For help, see Essential Skills Appendix, A-5.

An expression may be evaluated for different values of the variables. Substitute the given numerical value of the letter in brackets and evaluate.

EXAMPLE

$3x^2 - 2x + 1$, when $x = -3$
Substitute $x = -3$ (in brackets) into the above algebraic expression
$= 3(-3)^2 - 2(-3) + 1$
$= 3(9) + 6 + 1$
$= 27 + 7$
$= 34$

2. Evaluate each algebraic expression if $a = 0$, $b = 1$, $c = -1$, and $d = 2$.
   a) $b + 3c$
   b) $3b + 2c - d$
   c) $2a^2 + b^2 - d^2$
   d) $(a + 3b)(2c - d)$

Creating a Table of Values and Sketching Graphs of Quadratic Relations

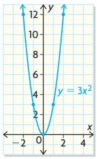
Study | Aid
For help, see Essential Skills Appendix, A-8.

When creating a table of values, select various x values and substitute them into the quadratic relation and solve for y. Plot the ordered pairs to determine the graph.

EXAMPLE

Create a table of values and sketch the graph of $y = 3x^2$.
Select x-values ranging from -2 to $+2$ and solve for each value of y.

x	$y = 3x^2$	Ordered Pair
-2	$y = 3(-2)^2 = 12$	$(-2, 12)$
-1	$y = 3(-1)^2 = 3$	$(-1, 3)$
0	$y = 3(0)^2 = 0$	$(0, 0)$
1	$y = 3(1)^2 = 3$	$(1, 3)$
2	$y = 3(2)^2 = 12$	$(2, 12)$



3. Create a table of values and sketch the graph of each.
   a) $y = 2x^2$
   b) $y = -4x^2 - 3$
   c) $y = 0.5x^2 + 5$
   d) $y = -5x^2 + 5$

PRACTICE

Study | Aid
- For help, see Essential Skills Appendix.

Question	Appendix
4, 5, 6	A-11
7	A-6
10	A-7
11	A-13

4. Solve each equation for y. Then evaluate y for the given value of x.
   a) $y - 5 = -3x; x = 2$
   b) $3x + y = 3; x = 2$
5. a) Does the point $(2, -1)$ lie on the line $y = -3x + 5$?
   b) Does the point $(-4, 10)$ lie on the parabola $y = -2x^2 - 5x + 22$?
6. a) Is $(2, -1)$ a solution of $2x - y = 5$? Explain.
   b) Is $(-1, 29)$ a solution of $y = -2x^2 - 5x + 22$? Explain.
7. For each linear relation, determine the x-intercept, the y-intercept, and the slope.
   a) $2x + 3y = 12$
   b) $-x + 4y = 8$

Functions and Applications 11

1.1 The Characteristics of a Function

YOU WILL NEED
- graph paper
- graphing calculator (optional)

GOAL
Identify the difference between a relation and a function.

Chapter Goals and Lesson Goals help students focus their learning.

INVESTIGATE the Math

Nathan examines two temperature **relations** for the month of March. In relation A, the **dependent variable** y takes on the same or opposite value of the **independent variable** x. In relation B, the dependent variable y takes on the same value of the independent variable x. Each relation is represented by a table of values and a mapping diagram.

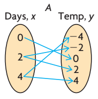
mapping diagram
a drawing with arrows to show the relationship between each value of x and the corresponding values of y

Key math terms defined when they are first encountered.

Tech | Support
For help using the graphing calculator to create a scatter plot, see Technical Appendix, B-10.

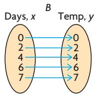
Relation A

Number of Days in the Month, x	0	2	2	4	4
Minimum Daily Temperature (°C), y	0	2	−2	−4	4



Relation B

Number of Days in the Month, x	0	2	4	6	7
Maximum Daily Temperature (°C), y	0	2	4	6	7



Clear, student-friendly design promotes readability.

Functions and Applications 11

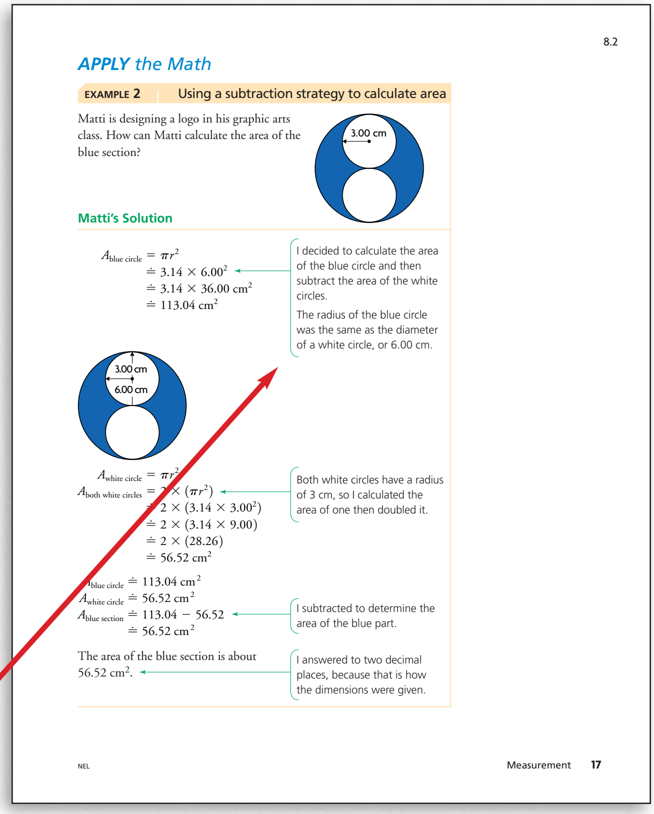
diverse needs of students in the classroom.

Skills review at the beginning of every chapter reviews essential words, skills, concepts.

Review of Essential Skills and Knowledge Appendix provides added support for students needing additional review.

Multiple solved examples with student explanations model types of questions students will encounter.

Frequently Asked Questions in Mid-Chapter Review and Chapter Review provide accessible review for all students.


8.2

APPLY the Math

EXAMPLE 2 Using a subtraction strategy to calculate area

Matti is designing a logo in his graphic arts class. How can Matti calculate the area of the blue section?

3.00 cm

Matti's Solution

$A_{\text{blue circle}} = \pi r^2$
$\doteq 3.14 \times 6.00^2$
$\doteq 3.14 \times 36.00 \text{ cm}^2$
$\doteq 113.04 \text{ cm}^2$

I decided to calculate the area of the blue circle and then subtract the area of the white circles.

The radius of the blue circle was the same as the diameter of a white circle, or 6.00 cm.

3.00 cm
6.00 cm

$A_{\text{white circle}} = \pi r^2$
$A_{\text{both white circles}} = 2 \times (\pi r^2)$
$\doteq 2 \times (3.14 \times 3.00^2)$
$\doteq 2 \times (3.14 \times 9.00)$
$\doteq 2 \times (28.26)$
$\doteq 56.52 \text{ cm}^2$

Both white circles have a radius of 3 cm, so I calculated the area of one then doubled it.

$A_{\text{blue circle}} \doteq 113.04 \text{ cm}^2$
$A_{\text{white circle}} \doteq 56.52 \text{ cm}^2$
$A_{\text{blue section}} \doteq 113.04 - 56.52$
$\doteq 56.52 \text{ cm}^2$

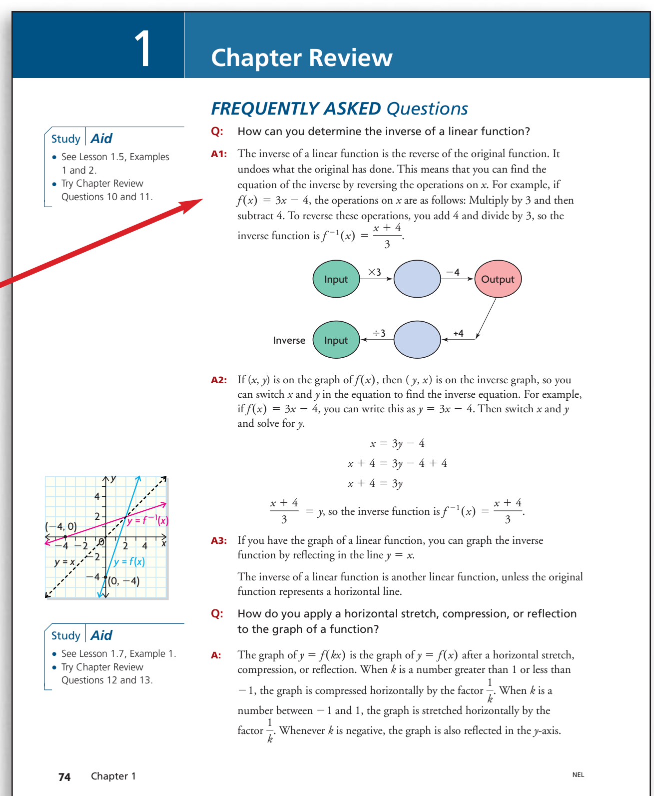
I subtracted to determine the area of the blue part.

The area of the blue section is about 56.52 cm².

I answered to two decimal places, because that is how the dimensions were given.

NEL Measurement 17

Principles of Mathematics 9


1 Chapter Review

FREQUENTLY ASKED Questions

Study Aid
- See Lesson 1.5, Examples 1 and 2.
- Try Chapter Review Questions 10 and 11.

Q: How can you determine the inverse of a linear function?

A1: The inverse of a linear function is the reverse of the original function. It undoes what the original has done. This means that you can find the equation of the inverse by reversing the operations on x. For example, if $f(x) = 3x - 4$, the operations on x are as follows: Multiply by 3 and then subtract 4. To reverse these operations, you add 4 and divide by 3, so the inverse function is $f^{-1}(x) = \frac{x+4}{3}$.

Input ×3 −4 Output
Inverse Input ÷3 +4

A2: If (x, y) is on the graph of $f(x)$, then (y, x) is on the inverse graph, so you can switch x and y in the equation to find the inverse equation. For example, if $f(x) = 3x - 4$, you can write this as $y = 3x - 4$. Then switch x and y and solve for y.

$$x = 3y - 4$$
$$x + 4 = 3y - 4 + 4$$
$$x + 4 = 3y$$
$$\frac{x+4}{3} = y, \text{ so the inverse function is } f^{-1}(x) = \frac{x+4}{3}.$$

A3: If you have the graph of a linear function, you can graph the inverse function by reflecting in the line $y = x$.

The inverse of a linear function is another linear function, unless the original function represents a horizontal line.

(−4, 0) $y = x$ $y = f^{-1}(x)$ $y = f(x)$ (0, −4)

Study Aid
- See Lesson 1.7, Example 1.
- Try Chapter Review Questions 12 and 13.

Q: How do you apply a horizontal stretch, compression, or reflection to the graph of a function?

A: The graph of $y = f(kx)$ is the graph of $y = f(x)$ after a horizontal stretch, compression, or reflection. When k is a number greater than 1 or less than −1, the graph is compressed horizontally by the factor $\frac{1}{k}$. When k is a number between −1 and 1, the graph is stretched horizontally by the factor $\frac{1}{k}$. Whenever k is negative, the graph is also reflected in the y-axis.

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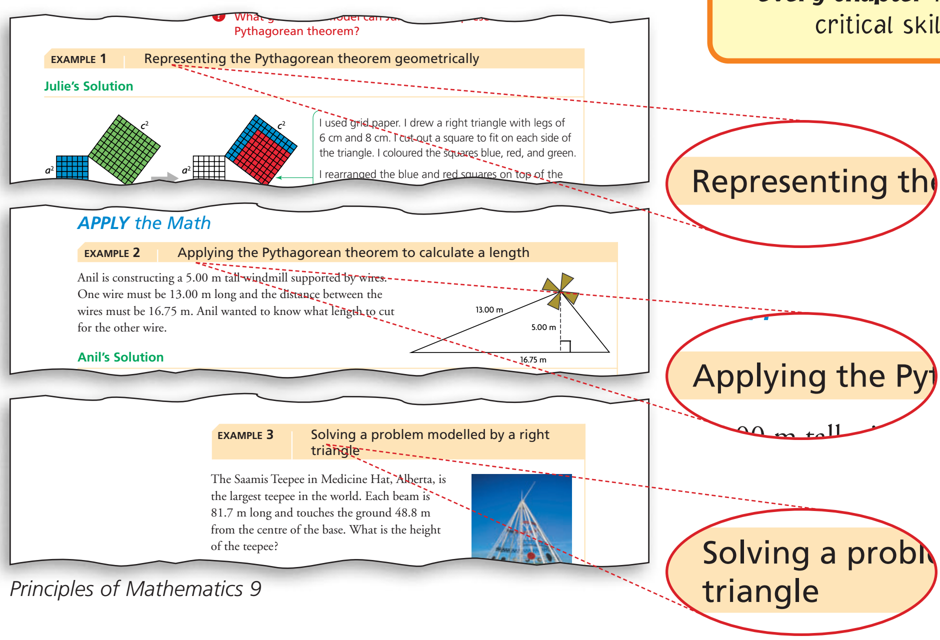
Functions 11

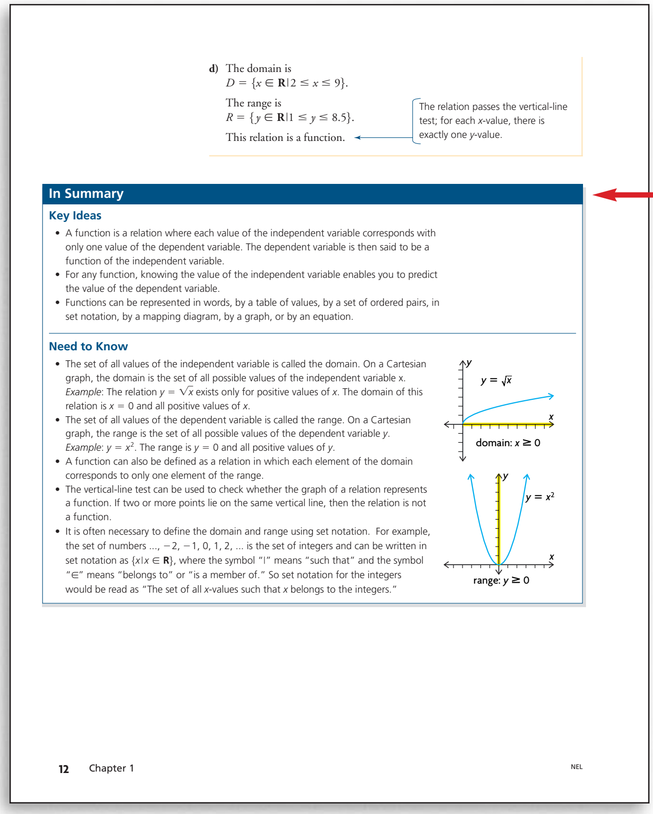
Extensive support for skill development in success in Grade 12 and beyond.

Mathematical processes integrated throughout every chapter help students develop these critical skills throughout the year.



Principles of Mathematics 9

Wide variety of practice questions gradually increasing in difficulty offers multiple entry points for students at different ability levels and builds students' confidence.



d) The domain is
$D = \{x \in \mathbf{R} | 2 \leq x \leq 9\}$.

The range is
$R = \{y \in \mathbf{R} | 1 \leq y \leq 8.5\}$.

This relation is a function.

The relation passes the vertical-line test; for each x-value, there is exactly one y-value.

In Summary

Key Ideas

- A function is a relation where each value of the independent variable corresponds with only one value of the dependent variable. The dependent variable is then said to be a function of the independent variable.
- For any function, knowing the value of the independent variable enables you to predict the value of the dependent variable.
- Functions can be represented in words, by a table of values, by a set of ordered pairs, in set notation, by a mapping diagram, by a graph, or by an equation.

Need to Know

- The set of all values of the independent variable is called the domain. On a Cartesian graph, the domain is the set of all possible values of the independent variable x. *Example*: The relation $y = \sqrt{x}$ exists only for positive values of x. The domain of this relation is $x = 0$ and all positive values of x.
- The set of all values of the dependent variable is called the range. On a Cartesian graph, the range is the set of all possible values of the dependent variable y. *Example*: $y = x^2$. The range is $y = 0$ and all positive values of y.
- A function can also be defined as a relation in which each element of the domain corresponds to only one element of the range.
- The vertical-line test can be used to check whether the graph of a relation represents a function. If two or more points lie on the same vertical line, then the relation is not a function.
- It is often necessary to define the domain and range using set notation. For example, the set of numbers ..., −2, −1, 0, 1, 2, ... is the set of integers and can be written in set notation as $\{x | x \in \mathbf{R}\}$, where the symbol "|" means "such that" and the symbol "∈" means "belongs to" or "is a member of." So set notation for the integers would be read as "The set of all x-values such that x belongs to the integers."

12 Chapter 1 NEL

Summary of key ideas and concepts provides at-a-glance summaries of every lesson.

Functions and Applications 11

every chapter prepares students for

PRACTISING

4. Evaluate $f(-1)$, $f(3)$, and $f(1.5)$ for
   a) $f(x) = (x - 2)^2 - 1$ b) $f(x) = 2 + 3x - 4x^2$
5. For $f(x) = \frac{1}{2x}$, determine
   a) $f(-3)$ b) $f(0)$ c) $f(1) - f(3)$ d) $f\left(\frac{1}{4}\right) + f\left(\frac{3}{4}\right)$
6. The graph of $y = f(x)$ is shown at the right.
   a) State the domain and range of f.
   b) Evaluate.
      i) $f(3)$ iii) $f(5 - 3)$
      ii) $f(5)$ iv) $f(5) - f(3)$
7. For $h(x) = 2x - 5$, determine
   a) $h(a)$ c) $h(3c - 1)$
   b) $h(b + 1)$ d) $h(2 - 5x)$
8. Consider the function $g(t) = 3t + 5$.
   a) Create a table of values and graph the function.
   b) Determine each value.
      i) $g(0)$ iv) $g(2) - g(1)$
      ii) $g(3)$ v) $g(1001) - g(1000)$
      iii) $g(1) - g(0)$ vi) $g(a + 1) - g(a)$
9. Consider the function $f(s) = s^2 - 6s + 9$.
   a) Create a table of values for the function.
   b) Determine each value.
      i) $f(0)$ iv) $f(3)$
      ii) $f(1)$ v) $[f(2) - f(1)] - [f(1) - f(0)]$
      iii) $f(2)$ vi) $[f(3) - f(2)] - [f(2) - f(1)]$
   c) In part (b), what do you notice about the answers to parts (v) and (vi)? Explain why this happens.
10. K The graph at the right shows $f(x) = 2(x - 3)^2 - 1$.
   a) Evaluate $f(-2)$.
   b) What does $f(-2)$ represent on the graph of f?
   c) State the domain and range of the relation.
   d) How do you know that f is a function from its graph?
11. For $g(x) = 4 - 5x$, determine the input for x when the output of $g(x)$ is
   a) -6 b) 2 c) 0 d) $\frac{3}{5}$

Functions 11

12. A company rents cars for \$50 per day plus \$0.15/km.
   a) Express the daily rental cost as a function of the number of kilometres travelled.
   b) Determine the rental cost if you drive 472 km in one day.
   c) Determine how far you can drive in a day for \$80.
13. A As a mental arithmetic exercise, a teacher asked her students to think of a number, triple it, and subtract the resulting number from 24. Finally, they were asked to multiply the resulting difference by the number they first thought of.
   a) Use function notation to express the final answer in terms of the original number.
   b) Determine the result of choosing numbers 3, -5, and 10.
   c) Determine the maximum result possible.

14. T The second span of the Bluewater Bridge in Sarnia, Ontario, is supported by two parabolic arches. Each arch is set in concrete foundations that are on opposite sides of the St. Clair River. The arches are 281 m apart. The top of each arch rises 71 m above the river. Write a function to model the arch.
15. a) Graph the function $f(x) = 3(x - 1)^2 - 4$.
   b) What does $f(-1)$ represent on the graph? Indicate on the graph how you would find $f(-1)$.
   c) Use the equation to determine
      i) $f(2) - f(1)$ ii) $2f(3) - 7$ iii) $f(1 - x)$
16. Let $f(x) = x^2 + 2x - 15$. Determine the values of x for which
   a) $f(x) = 0$ b) $f(x) = -12$ c) $f(x) = -16$
17. Let $f(x) = 3x + 1$ and $g(x) = 2 - x$. Determine values for a such that
   a) $f(a) = g(a)$ b) $f(a^2) = g(2a)$
18. C Explain, with examples, what function notation is and how it relates to the graph of a function. Include a discussion of the advantages of using function notation.

Extending

19. The highest and lowest marks awarded on an examination were 285 and 75. All the marks must be reduced so that the highest and lowest marks become 200 and 60.
   a) Determine a linear function that will convert 285 to 200 and 75 to 60.
   b) Use the function to determine the new marks that correspond to original marks of 95, 175, 215, and 255.
20. A function $f(x)$ has these properties:
   - The domain of f is the set of natural numbers.
   - $f(1) = 1$
   - $f(x + 1) = f(x) + 3x(x + 1) + 1$
   a) Determine $f(2)$, $f(3)$, $f(4)$, $f(5)$, and $f(6)$.
   b) Describe the function.

Sample achievement category questions identified in every lesson.

8 Chapter Task

Storage Capacity of a Silo

Tony is building a new silo to store corn as animal feed. It will be a cylinder topped with a half-sphere, and must store 21 000 t of corn. The entire silo can be filled with corn. Tony wants to minimize the surface area of the silo to reduce materials and paint costs. He has the following information:

- 1 m^3 of corn has a mass of 700 kg.
- Building costs are \$8/m^2, taxes included.
- Paint comes in 3.8 L cans. Each can covers 40 m^2 and costs \$35, taxes included.
- Corn costs \$140 per tonne (\$140/t), taxes included. Recall that 1 t = 1000 kg.

What is the total cost to build, paint, and fill a silo with the least surface area?

A. Sketch the silo. Label any measurements you will need.
B. Calculate the volume of the silo using the mass of feed it must hold.
C. Create a table listing possible dimensions for the silo.
D. Graph the surface area versus base radius.
E. Determine the minimum surface area.
F. Calculate the silo's building cost (before painting).
G. Calculate the silo's paint cost.
H. Calculate the cost to fill the silo with corn.
I. Determine the total cost.
J. Prepare a written report that shows your calculations and explains your thinking.

Task Checklist
- ✔ Did you label all your table values and calculate entries correctly?
- ✔ Did you draw your sketch and label your graph accurately?
- ✔ Did you support your choice of surface area?
- ✔ Did you explain your thinking clearly?

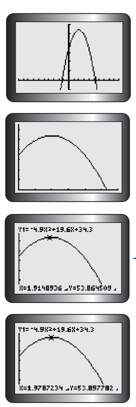
Principles of Mathematics 9

EQAO-style questions and chapter tasks in Grade 9 help students practice throughout the year in preparation for the provincial test.

Appropriate use of technology throughout the resources supports student needs.

Nelson Secondary Mathematics resources support the use of:

- TI-83 Plus
- TI-84 Plus
- TI-89 (CAS)
- The Geometer's Sketchpad®
- Spreadsheets
- Fathom (Grades 11–12)



	5.1	5.2	5.3	
$h(t)$	6.81	3.72	0.539	−2.744

...rocket hit the ground between 5.3 s and 5.4 s after it was shot into the air.

Tina's Solution: Using a Graph of the Height Function

Tech Support
For help graphing and tracing along functions, see Technical Appendix, B-2.

I used the equivalent equation $y = -4.9x^2 + 19.6x + 34.3$ and entered this for Y1 in the equation editior to plot the graph on a graphing calculator.

I adjusted the calculator window to show the part of the graph where the rocket is in the air. The height of the rocket is negative after about 5.3 s, so the domain is from 0 to 5.3 s.

By tracing along the graph, I can see that the maximum height, 53.89 m, occurs sometime between 1.91 s and 1.97 s.

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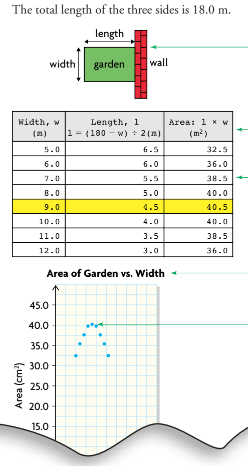
Functions and Applications 11

Technical Skills Appendix provides user tips for all technology used in the book!



EXAMPLE 2 Using graphing technology to determine maximum area

Sunia's horticulture club is exhibiting at the city garden show. Each garden must be bordered by 18.0 m of wood against a brick display wall. What dimensions will maximize the area of the garden?

Sunia's Solution

The total length of the three sides is 18.0 m.

I sketched how the garden might look.

Tech Support
For information on selecting columns from a table of values to form a scatter plot, see Appendix B-X.

Width, w (m)	Length, l l = (180 − w) ÷ 2(m)	Area: l × w (m^2)
5.0	6.5	32.5
6.0	6.0	36.0
7.0	5.5	38.5
8.0	5.0	40.0
9.0	4.5	40.5
10.0	4.0	40.0
11.0	3.5	38.5
12.0	3.0	36.0

I entered possible dimensions for the garden in a table of values on a spreadsheet.

I chose the width, then calculated the length and area for that width.

I graphed area vs. width using the spreadsheet program.

I noticed the area was greatest when the width was double the length: 9.0 m and 4.5 m.

This makes sense. If the border was on all four sides, a square with ... 4.5 m by

Principles of Mathematics 9

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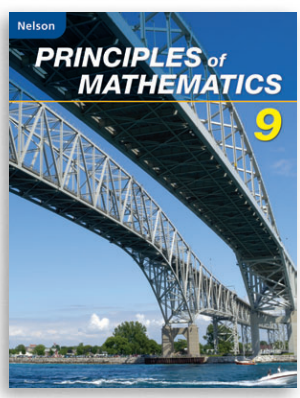

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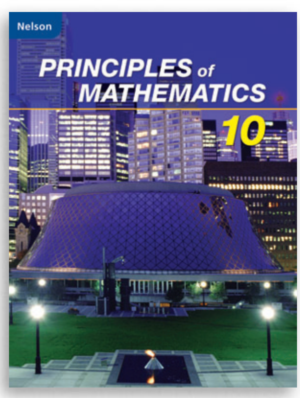

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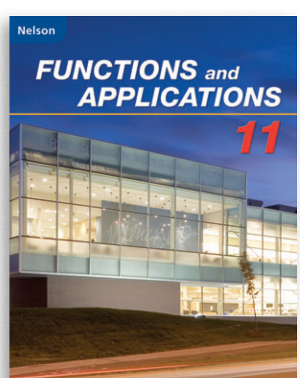

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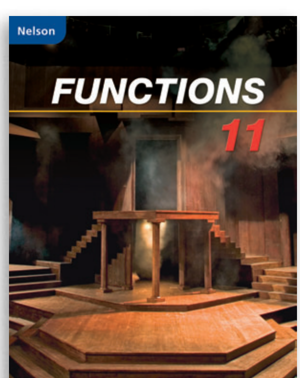

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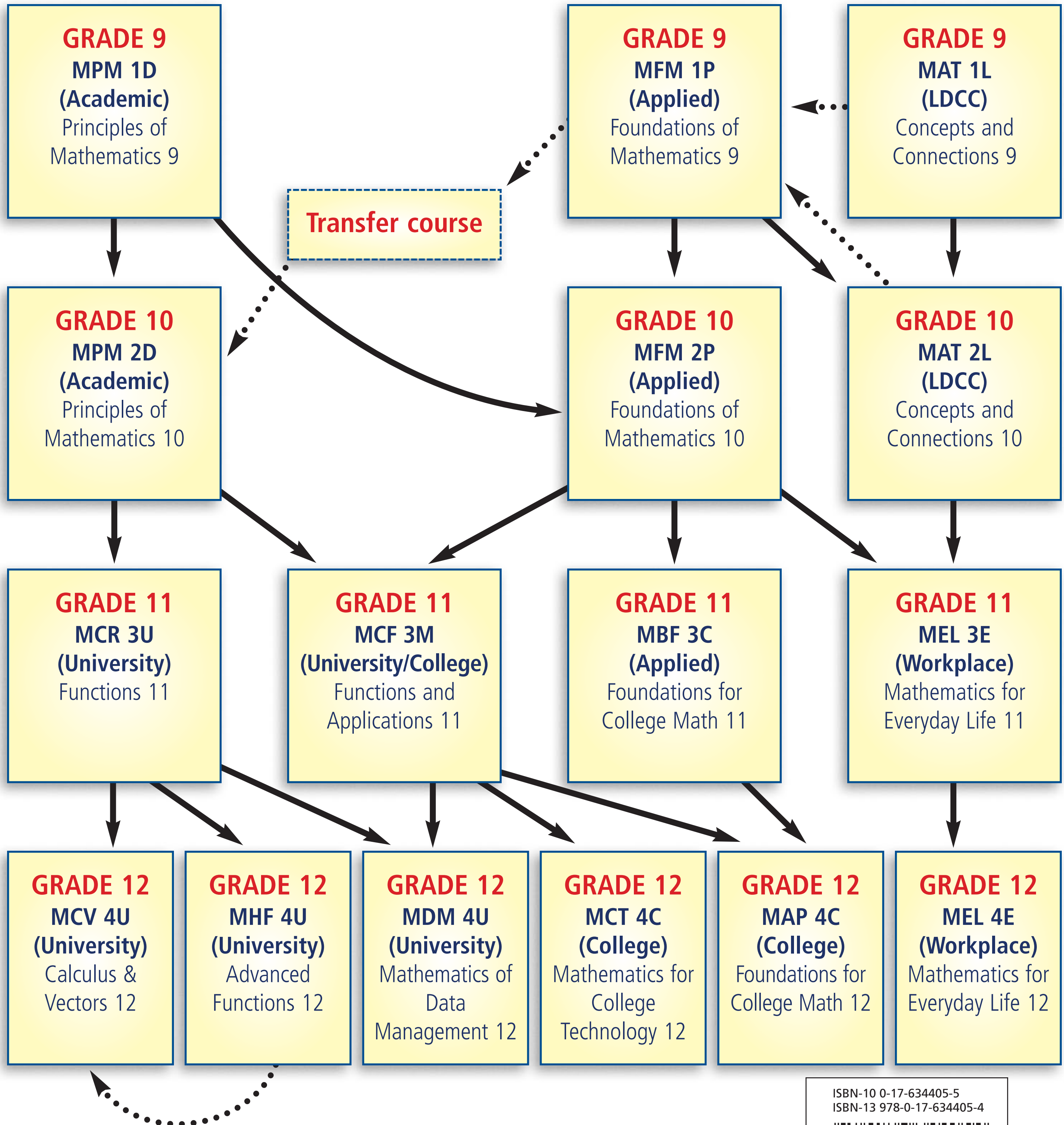

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