Unit 2

Introduction to Algebra

Topic A: Algebraic expressions

- Basic algebraic terms
- Evaluating algebraic expressions

Topic B: Translating words into algebraic expressions

- Key words in word problems
- Translating phrases into algebraic expressions
- Writing algebraic expressions
- Steps for solving word problems

Topic C: Exponents and order of operations

- Introduction to exponents
- Read and write exponential expressions
- Order of operations

Unit 2 Summary

Unit 2 Self-test

Topic A: Algebraic Expressions

Basic Algebraic Terms

Algebra: a branch of mathematics containing numbers, letters and arithmetic operators (+, –, ×, ÷, etc.) with the letters used to represent unknown quantities (variables).

Example: $3 + 2 = 5$ in algebra may look like $x + 2 = 5$ x represents 3.

Constant: a ***number*** stands for a fixed value that does not change.

Example: ***2*** in $x + \boldsymbol{2}$ is a constant.

Variable: a ***letter*** that can be assigned different values (it represents an unknown quantity).

Example: $\boldsymbol{x} + 2$ when $x = 0$, $\boldsymbol{x} + 2 = 0 + 2 = \mathbf{2}$

when $x = 3$, $\boldsymbol{x} + 2 = 3 + 2 = \mathbf{5}$

Coefficient: the ***number*** that in front of a letter (variable).

Example:

$\mathbf{9}\,x$	coefficient:	9
$-\frac{\mathbf{2}}{\mathbf{7}}x$	coefficient:	$-\frac{2}{7}$
x	coefficient:	1

$x = 1 \cdot x$

Algebraic expression: a mathematical phrase that contains numbers, letters, grouping symbols (parentheses) and arithmetic operations (+, –, ×, ÷, etc.)

Example: $5x + 2$, $\frac{2y}{3} + 4$, $(3x - 4y^2) + 6$

Term: a term can be a number, letter, or the product (multiplication) of a number and letter. (Terms are separated by addition or subtraction signs.)

Example: **a)** $3x - 4 + \frac{2}{5} + y$ has four terms: $3x$, -4, $\frac{2}{5}$, and y.

b) $7xyz + 12 - \frac{4}{19}z^2$ has three terms: $7xyz$, 12, and $-\frac{4}{19}z^2$.

Like terms: the terms that have the same variables and exponents.

Example: $2x - 3y^2 - \frac{6}{7} + 5x + 9 + 4y^2$

Like terms:		
$2x$ and $5x$		The same variable: x
$-3y^2$ and $4y^2$		The same variable raised to the same power: y^2
$-\frac{6}{7}$ and 9		All constants are like terms.

Evaluating Algebraic Expressions

Evaluating an algebraic expression: substitute a specific value for a variable and perform the mathematical operations (+, −, ×, ÷, etc.).

Note:

- In algebra, a multiplication sign "×" is usually omitted to avoid confusing it with the letter x.
- If there is no symbol or sign between a number and letter, it means multiplication, such as $3x = 3 \cdot x$.

Steps to evaluate an algebraic expression:

- Replace the variable(s) with number(s).
- Calculate.

Example: Evaluate the following algebraic expressions.

1) $3x - 4$, given $x = 5$.

$3x - 4 = 3 \cdot 5 - 4$ Substitute x for 5.

$= 15 - 4$ Calculate.

$= 11$

2) $\frac{x}{y} + 8$ given $x = -9$ and $y = 3$. Substitute x for -9 and y for 3.

$\frac{x}{y} + 8 = \frac{-9}{3} + 8$

$= 5$

3) $3a - 4 + 2$, given $a = 5$.

$3a - 4 + 2 = 3 \cdot 5 - 4 + 2$ Substitute a for 5.

$= 15 - 4 + 2$ Calculate.

$= 13$

4) $\frac{6x}{y-3} + 7x - 2$, given $x = 1$ and $y = 9$.

$\frac{6x}{y-3} + 7x - 2 = \frac{6 \cdot \mathbf{1}}{\mathbf{9}-3} + 7 \cdot \mathbf{1} - 2$ Substitute x for 1 and y for 9.

$= \frac{6}{6} + 7 - 2$ Calculate.

$= 6$

Topic B: Translating Words into Algebraic Expressions

Key Words in Word Problems

Identifying keywords:

- When trying to figure out the correct operation (+, −, ×, ÷, etc.) in the word problem it is important to pay attention to keywords (clues to what the problem is asking).
- Identifying keywords and pulling out relevant information that appear in the word problem are effective ways for solving mathematical word problems.

Key or clue words in word problems

Addition (+)	Subtraction (−)	Multiplication (×)	Division (÷)	Equals to (=)
add	subtract	times	divided by	equals
sum (of)	difference	product	quotient	is
plus	take away	multiplied by	over	was
total (of)	minus	double	split up	are
altogether	less (than)	twice	fit into	were
increased by	decreased by	triple	per	amounts to
gain (of)	loss (of)	of	each	totals
combined	(amount) left	how much (total)	goes into	results in
in all	savings	how many	as much as	the same as
greater than	withdraw		out of	gives
complete	reduced by		ratio /rate	yields
together	fewer (than)		percent	
more (than)	how much more		share	
additional	how long		average	

Examples:

1) Edward drove from Prince George to Williams Lake (235 km), then to Cache Creek (203 km) and finally to Vancouver (390 km). How many kilometers in ***total*** did Edward drive? 235km + 203 km + 390 km = 828 km The key word: total (+)

2) Emma had $150 in her purse on Friday. She bought a pizza for $15, and a pair of shoes for $35. How much money does she have ***left***?

$150 – 15 – 35 = $100 The key word: left (–)

3) Lucy received $950 per month of rent from Mark for the months September to November. ***How much*** rent in ***total*** did she receive?

$950 · 3 = $2850 The key word: how much total (×)

4) Julia is going to buy a $7500 used car from her uncle. She promises to pay $500 ***per*** month, in how many months she can pay it off?

$7500 ÷ $500 = 15 month The key word: per (÷)

Translating Phrases into Algebraic Expressions

Method to translate words into algebraic expression:

- Look for basic key words for translating word problems from English into algebraic expressions.
- Translate English words into mathematical symbols (the language of mathematics).

Translate words into algebraic expression:

Algebraic expression	Word phrases
$7 + y$	the **sum** of 7 and y
	7 **more than** y
	y **increased by** 7
	7 **plus** y

Algebraic expression	Word phrases
$t - 8$	8 **less than** t
	t **decreased** (or reduced) by 8
	subtract 8 from t
	the **difference** between t and 8

Algebraic expression	Word phrases
$2x$ **or** $2 \cdot x$	the **product** of 2 and x
	2 **multiplied** by x
	double (or twice) of x

Algebraic expression	Word phrases
$z \div 3$ **or** $\frac{z}{3}$	The **quotient** of z and 3
	z **divided** by 3
	One third of z

Algebraic expression	Word phrases
y^3	The **third power** of y
	y **cubed**
	y raised to the **third power**

Algebraic expression	Word phrases
$4y - 9$	9 **less than** 4 **times** y
$2(t - 5)$	**Twice** the **difference** of t and 5
$6 + \frac{2x}{3}$	6 **more than** the **quotient** of $2x$ by 3

Note:

- The order of the subtraction and division is important when translate words into algebraic expression.
- Place the numbers in the correct order for subtraction and division.

Example:

1) The difference between t and 7 means $t - 7$ not $7 - t$. — t appears first.

2) 8 less than t means $t - 8$ not $8 - t$. — 8 less than t not t lees than 8.

3) The quotient of z and 3 means $\frac{z}{3}$ not $\frac{3}{z}$. — z appears first.

Writing Algebraic Expressions

Example: Write a mathematical equation for each of the following:

1) Five ***greater than*** four ***divided*** by a number ***is*** seventeen. **Equation**

$5 \quad + \quad 4 \quad \div \quad x \quad = \quad 17$ $\qquad 5 + \frac{4}{x} = 17$

(Let x = a number)

2) A ***number is*** 7 ***times*** the number y ***added*** to 23.

$x \quad = \quad 7 \quad \cdot \quad y \quad + \quad 23$ $\qquad x = 7y + 23$

(Let x = a number)

Example: Write an algebraic expression for each of the following: **Expression**

1) The difference of y and 3.45. $\qquad y - 3.45$

2) The difference of $\frac{4}{23}$ and w. $\qquad \frac{4}{23} - w$

3) z less than the number 67. $\qquad 67 - z$

4) 27 minus the product of 18 and ***a number***. $\qquad 27 - 18x$

(Let x = a number)

5) The sum of ***a number*** and 7 divided by 2. $\qquad \frac{x+7}{2}$

6) Steve has \$200 in his saving account. If he makes a deposit of x dollars, how much in total will he have in his account? $\qquad 200 + x$

7) Ann weighs 150 pounds. If she loses y pounds, how much will she weigh? $\qquad 150 - y$

8) A piece of wire 30 centimeters long was cut in two pieces and one piece is z centimeters long. How long is the other piece? $\qquad 30 - z$

9) Alice made 3 dozen cupcakes. If it costs her y dollars, what was her cost per dozen cupcakes? What was her cost per cupake? $\qquad \frac{y}{3}$, $\frac{y}{36}$

(1 dozen = 12 , $3 \cdot 12 = 36$)

Steps for Solving Word Problems

Steps for solving word problems:

Steps for solving word problems
- **Organize** the **facts** given from the problem (create a **table** or **diagram** if it will make the problem clearer). - Identify and label the unknown quantity (**let *x* = unknown**). - Convert words into mathematical symbols, and **determine the operation** – write an **equation** (looking for 'key' or 'clue' words). - **Estimate** and **solve** the equation and find the solution(s). - **Check** and state the **answer**. (Check the solution to the equation and check it back into the problem – is it logical?)

Example to illustrate the steps involved

Example: William bought 5 pairs of socks for \$4.35 each. The cashier charged him an additional \$2.15 in sales tax. He left the store with a measly \$5.15. How much money did William start with?

- Organize the facts (make a table):

5 socks	\$4.35 each
Sales tax	\$2.15
Money left	\$5.15

- Determine the unknown: How much did William start with? (***x* = ?)**
- Convert words into math symbols, and determine the operation (find ***key words***):
  - The ***total*** cost without the sales tax: $\$4.35 \times 5$
  - With an ***additional*** \$2.15 sales tax: $(\$4.35 \times 5) + \$2.15$
  - William started with: $x = [(\$4.35 \times 5) + \$2.15] + \mathbf{\$5.15}$
- Estimate and solve the unknown:
  - Estimate: $x = [(\$4 \times 5) + \$2] + \$5$
    $= \$27$
  - Actual solution: $x = [(\$4.35 \times 5) + \$2.15] + \$5.15$
    $= \$29.05$

- Check: If William started with \$29.05, and subtract 5 socks for \$4.35 each and sales tax in \$2.15 to see if it equals \$5.15.

$$\$29.05 - [(\$4.35 \times 5) + \$2.15] \overset{?}{=} \$5.15$$

$$\$29.05 - \$23.9 \overset{\surd}{=} \$5.15 \qquad \text{Correct!}$$

- State the answer: William started with \$29.05.

More examples:

Example: James had 96 toys. He sold 13 on first day, 32 on second day, 21 on third day, 14 on fourth day and 7 on the last day. What percentage of the toys were not sold?

- Organize the facts:

James had	96 toys
The total number of toys sold	13 + 32 + 21 + 14 + 7
The toys not sold	96 – the total number of toys sold

- Determine the unknown: Let x = percentage of the toys were not sold
- The total number of toys sold: $13 + 32 + 21 + 14 + 7 = 87$
- The toys not sold: $96 - 87 = 9$
- Percentage of the toys were not sold: $x = \frac{\text{Toys not sold}}{\text{Total number of toys}} = \frac{9}{96} \approx 0.094 = 9.4\%$
- State the answer: 9.4% percentage of the toys were not sold.

Example: The 60-liter gas tank in Robert's car is 1/2 full. Kelowna is about 390 km from Vancouver and his car averages 7 liters per 100 km. Can Robert make his trip to Vancouver?

- Let x = liters of fuel are required to get to Vancouver.
- The 60-liter gas tank in Robert's car is 1/2 full:

$60\text{ L} \times \frac{1}{2} = 30\text{ L}$ Robert has 30 liters gas in his car.

- Robert's car averages 7 liters per 100 km, and Vancouver is about 390 km from Kelowna.

$\frac{7\text{L}}{100\text{ km}} = \frac{x}{390\text{ km}}$ Proportion: $\frac{a}{b} = \frac{c}{d}$

$(x)(100\text{km}) = (7\text{ L})(390\text{ km})$ Cross multiply and solve for x.

$x = \frac{(7\text{ L})(390\text{km})}{100\text{ km}} = 27.3\text{ L}$ Robert needs 27.3 liters gas to get to Vancouver.

- State the answer: 30L > 27.3L Yes, Robert can make his trip.

Topic C: Exponents and Order of Operations

Introduction to Exponents

Power: the ***product*** of a number repeatedly multiplied by itself.

Example: $3^2 = 3 \cdot 3 = 9$, the "3^{2}" is the ***product*** of 3 repeatedly multiplied by itself.

Exponent: the ***number of times*** a number is multiplied by itself.

Example: In $3^{\mathbf{2}}$, the "2" means 3 is multiplied by itself ***two times***.

Base, exponent and power:

a^n { a is the base. / n is the exponent. / a^n is the power

Exponential notation (exponential expression): a^n or $\text{Base}^{\text{Exponent}}$

Exponential notation	Example
Power, Exponent, Base: $a^n = a \cdot a \cdot a \cdot a \ldots a$ Read "a to the nth" or "the nth power of a."	$2^4 = 2 \cdot 2 \cdot 2 \cdot 2 = 16$ Read "2 to the 4th."

2 is repeatedly multiplied by itself 4 times.

Exponents make it easier to write very long numbers (for multiplications).

Any non-zero number to the zero power equals 1 ($a^0 = 1$). 0^0 is undefined.

Example: $2^0 = 1$, $13000^0 = 1$

Any number raised to the power of 1 equals the number itself ($a^1 = a$).

Example: $4^1 = 4$, $1000^1 = 1000$

Anything raised to the first power is itself. (4 is multiplied by itself one time)

1 raised to any power is still 1 ($1^n = 1$). **Example**: $1^3 = 1$, $1^{10000} = 1$

$1^3 = 1 \cdot 1 \cdot 1 = 1$

Exponents: basic properties:

Name	Property	Example
Zero exponent a^0	$a^0 = 1$ (0^0 is undefined)	$(\frac{3}{4})^0 = 1$, $(2xy)^0 = 1$
One exponent a^1	$a^1 = a$	$4.5^1 = 4.5$, $(3x)^1 = 3x$
	$1^n = 1$	$1^7 = 1$, $1^{389} = 1$

Read and Write Exponential Expressions

How to read exponent expressions:

Base $^{\text{Exponent}}$	Repeated multiplication	Product	Read	
3^2	$3 \cdot 3$	9	3^2	3 squared
10^3	$10 \cdot 10 \cdot 10$	1000	10^3	10 cubed
$(0.2)^2$	$0.2 \cdot 0.2$	0.04	$(0.2)^2$	0.2 squared
1^{10}	$1 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1$	1	1^{10}	1 to the tenth
$(\frac{2}{3})^3$	$\frac{2}{3} \cdot \frac{2}{3} \cdot \frac{2}{3}$	$\frac{8}{27}$	$(\frac{2}{3})^3$	two thirds cubed
10000^0		1	10000^0	10000 to the zero
y^5	$y \cdot y \cdot y \cdot y \cdot y$	y^5	y^5	y to the fifth

Example: Write the following exponential expressions in expanded form.

	Exponential expressions	**Expanded form**	
1)	6^4	$6 \cdot 6 \cdot 6 \cdot 6$	$a^n = a \cdot a \cdot a \ldots$
2)	$(-x)^3$	$(-x)\,(-x)\,(-x)$	
3)	$(3x^2y)^2$	$(3x^2y)\,(3x^2y)$	
4)	$\left(\frac{3}{4}u\right)^4$	$\left(\frac{3}{4}u\right)\left(\frac{3}{4}u\right)\left(\frac{3}{4}u\right)\left(\frac{3}{4}u\right)$	

Example: Write each of the following in the exponential form.

	Expanded form	**Exponential notation**
1)	$(0.2)\,(0.2)\,(0.2)$	$(0.2)^3$
2)	$(5a)\,(5a)\,(5a)\,(5a)$	$(5a)^4$
3)	$\left(\frac{5}{7}t\right)\left(\frac{5}{7}t\right)$	$(\frac{5}{7}t)^2$

Example: Evaluate $(4^2)\,(3^3)\,(6^0)\,(9^1)$.

$4^2 \cdot 3^3 \cdot 6^0 \cdot 9^1 = (4 \cdot 4)\,(3 \cdot 3 \cdot 3)\,(1)\,(9)$ $\qquad a^0 = 1\ ,\quad a^1 = a$

$= 16 \cdot 27 \cdot 1 \cdot 9 = 3888$

Example: Write each of the following as a base with an exponent.

1) Six to the power of eight. 6^8

2) x to the seventh power. x^7

3) Eight cubed. 8^3

Example: Evaluate $\frac{6x^2}{y+3} + 7x - 2$, given $x = 2$ and $y = 9$.

$\frac{6x^2}{y+3} + 7x - 2 = \frac{6 \cdot 2^2}{9+3} + 7 \cdot 2 - 2$ Substitute x for 2 and y for 9.

$= \frac{24}{12} + 14 - 2 = 14$ Calculate.

Order of Operations

Basic operations: addition, subtraction, multiplication, division, exponent, etc.

The order of operations are the rules of which calculation comes first in an expression (when doing expressions with more than one operation).

Order of operations:

Order of operations	
1. the brackets or parentheses (innermost first)	( ) , [ ] , { }
2. exponent (power)	a^n
3. multiplication and division (from left-to-right)	× and ÷
4. addition and subtraction (from left-to-right)	+ and −

Example: $4 \cdot 3^2 + 5 + (2 + 1) - 2 = 4 \cdot 3^2 + 5 + 3 - 2$ ( ), a^n

$= 4 \cdot 9 + 5 + 3 - 2$ ×

$= 36 + 5 + 3 - 2$ +

$= 41 + 3 - 2$ +

$= 44 - 2$ –

$= 42$

Memory aid - BEDMAS

B	E	DM	AS
Brackets	**E**xponents	**D**ivide or **M**ultiply	**A**dd or **S**ubtract

Grouping symbols: if parentheses are inside one another, calculate the inside set first.

- Parentheses ( ) are used in the inner most grouping.
- Square brackets [ ] are used in the second higher level grouping.

Example: $4 \cdot 3 + [5 + (2 + 1)] - 3^2 = 4 \cdot 3 + [5 + 3] - 3^2$ ( ), [ ]

$= 4 \cdot 3 + 8 - 3^2$ a^n

$= 4 \cdot 3 + 8 - 9$ ×

$= 12 + 8 - 9$ +

$= 20 - 9$ –

$= 11$

Unit 2: Summary

Introduction to Algebra

Basic algebraic terms

Algebraic term	Description	Example
Algebraic expression	A mathematical phrase that contains numbers, letters, grouping symbols (parentheses) and arithmetic operations.	$5x + 2$, $3a + (4b - 6)$, $\frac{2}{3} + 4$
Constant	A number.	$x + \mathbf{2}$ constant: 2
Variable	A letter that can be assigned different values.	$3 - \mathbf{x}$ variable: x
Coefficient	The number in front of a variable.	$\mathbf{-6}\,x$ coefficient: -6 x coefficient: 1
Term	A term can be a constant, variable, or the product of a number and variable(s). (Terms are separated by addition or subtraction signs.)	$3x - \frac{2}{5} + 13y^2 + 7xy$ Terms: $3x$, $-\frac{2}{5}$, $13y^2$, $7xy$
Like terms	The terms that have the same variables and exponents.	$2x - y^2 - \frac{2}{5} + 5x - 7 + 13y^2$ Like terms: $2x$ and $5x$ $-y^2$ and $13y^2$, $-\frac{2}{5}$ and -7

Evaluating an algebraic expression: substitute a specific value for a variable and perform the mathematical operations (+, −, ×, ÷, etc.).

To evaluate an expression:

- Replace the variable(s) with number(s).
- Calculate.

Key or clue words in word problems:

Addition (+)	Subtraction (−)	Multiplication (×)	Division (÷)	Equals to (=)
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increased by	decreased by	triple	per	amounts to
gain (of)	loss (of)	of	each	totals
combined	balance	how much (total)	goes into	results in
entire	(amount) left	how many	as much as	the same as
in all	savings		out of	gives
greater than	withdraw		ratio (of)	yields
complete	reduced by		percent	
together	fewer (than)		share	
more (than)	how much more		distribute	
and	how many extra		average	
additional	how long			

Steps for solving word problems:

Steps for solving word problems
- ***Organize*** the ***facts*** given from the problem (create a ***table*** or ***diagram*** if it will make the problem clearer). - Identify and label the unknown quantity (***let x = unknown***). - Convert words into mathematical symbols, and ***determine the operation*** – write an ***equation*** (looking for 'key' or 'clue' words). - ***Estimate*** and **solve** the equation and find the solution(s). - ***Check*** and state the ***answer***. (Check the solution with the equation and check it back into the problem – is it logical?)

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	$1^n = 1$

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3. multiplication or division (from left-to-right)	× and ÷
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Unit 2: Self-Test

Introduction to Algebra

Topic A

1. Identify the constant, coefficient and the variable:

a) $2x - 3$

b) $-4t + 13 + \frac{5}{7}t$

2. Identify the terms for each of the following:

a) $5x + 3 - y$

b) $2r + 16r^2 - \frac{3}{14}r + 1$

3. Identify the like terms in the following expressions:

a) $7 + 2y^2 - \frac{5}{9}x + 5x - 1 + 13y^2$

b) $0.6t + 9uv - 7t + 1.67uv$

4. Evaluate the following algebraic expressions.

a) $7x - 4 + 13x$, given $x = 4$.

b) $\frac{3}{a-7} + 9b + 12$, given $a = 10$ and $b = 5$.

Topic B

5. Write an expression/equation for each of the following:

a) The product of ten and y.

b) The quotient of t and six.

c) The difference between fifteen and a number more than the quotient of three by seven is six.

d) Seven less than six times a number is fifteen.

6. Write an expression for each of the following:

a) Susan has $375 in her checking account. If she makes a deposit of y dollars, how much in total will she have in her account?

b) Mark weighs 175 pounds. If he loses y pounds, how much will he weigh?

c) A piece of wire 45 meters long was cut in two pieces and one piece is w meters long. How long is the other piece?

d) Emily made 4 dozen muffins. If it cost her x dollars, what was her cost per dozen muffins? What was her cost per muffin?

Topic C

7. **a**) In x^3, the base is ( ).

b) In y^4, the exponent is ( ).

8. Write the following exponential expressions in expanded form.

a) 9^3

b) $(-y)^4$

c) $(0.5a^3b)^2$

d) $\left(\frac{2}{7}x\right)^1$

9. Write each of the following in the exponential form.

a) (0.06) (0.06) (0.06) (0.06)

b) $(12y)\ (12y)\ (12y)$

c) $\left(\frac{-2}{9}x\right)\left(\frac{-2}{9}x\right)$

10. Evaluate $(3^2)\ (2^4)\ (23^0)(10^1)$.

11. Write each of the following as a base with an exponent.

a) y to the eighth power.

b) Five cubed.

12. Evaluate the following:

a) $\frac{9a^2}{b+6} + 3a + 4$, if $a = 1$ and $b = 3$.

b) $8xy + 7y^4$, if $x = \frac{1}{4}$ and $y = 1$.

13. Calculate the following:

a) $2 \cdot 4^3 + 7 - (4 + 3) + 5$

b) $5 \cdot 7 + [11 + (4 - 3)] + 4^2$

c) $\frac{104 - 4^2}{6 + 5}$