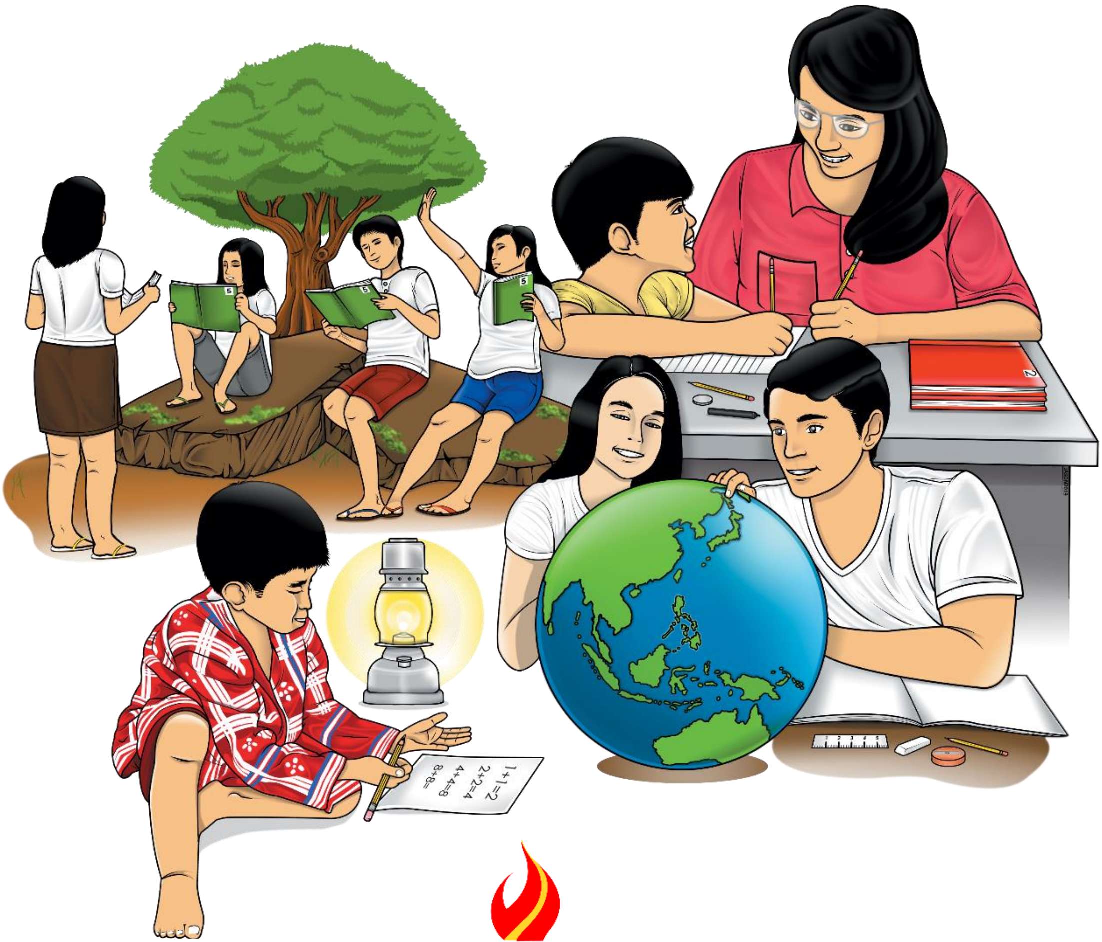
7

Mathematics

Quarter 2 – Module 5:
Operations Involving Polynomials



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Quarter 2 – Module 5: Operations Involving Polynomials
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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.

What I Need to Know

This module was designed and written with you in mind. It is here to help you master the Operations Involving Polynomials. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course. But the order in which you read them can be changed to correspond with the textbook you are now using.

This module is comprised of only one lesson:

- Lesson – Operations Involving Polynomials

After going through this module, you are expected to:

1. add and subtract polynomials;
2. solve problems involving addition and subtraction of polynomials;
3. derive the laws of exponents;
4. apply the laws of exponents in simplifying expressions;
5. multiply polynomials such as:
   a. monomial by monomial;
   b. monomial by polynomial with more than one term;
   c. binomial by binomial;
   d. polynomial with more than one term to polynomial with three or more terms;
6. divide polynomials such as:
   a. polynomial by a monomial;
   b. polynomial by a polynomial with more than one term; and
7. solve problems involving multiplication and division of polynomials.

What I Know

Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. Which of the following below are like terms?
   A. $2x, 3x, 4x, 5x$
   B. $-4a, -3a, -2a, ab$
   C. $3x, x^2, x^3, x^4$
   D. $xy, 3xy, 5y, 4z$
2. Which of the following would result to a sum of $5ab$?
   A. $2a + 3b$
   B. $4a + b$
   C. $2ab + 3ab$
   D. $3a + 2b$
3. What is the simplified term of $3x + x - 2x + 5x$?
   A. $6x$
   B. $7x$
   C. $8x$
   D. $9x$
4. What must be subtracted from $8a + 3$ to make a difference of $5a + 1$?
   A. $3a + 2$
   B. $3a - 2$
   C. $3a + 4$
   D. $3a - 4$
5. Mark saved $15x + 8$ from his allowance. How much did he have after buying a gift worth $10x + 3$ for his mother's birthday?
   A. $5x - 5$
   B. $5x + 5$
   C. $5x - 11$
   D. $5x + 11$
6. Which of the following illustrates the law $a^n = a \cdot a \cdot a \cdot a \ldots \cdot a\ (n\ times)$?
   A. $x^5 = x \cdot x \cdot x \cdot x \cdot x$
   B. $2^3 = 3 \cdot 3$
   C. $3^4 = 3 \cdot 4$
   D. $x^5 = x \cdot 5$
7. Which of the following statements illustrates the law: $a^n \cdot a^m = a^{n+m}$?
   A. $2^3 \cdot 3^4 = 6^7$
   B. $3^3 \cdot 2^5 = 6^{15}$
   C. $2^3 \cdot 2^4 = 2^{12}$
   D. $3^2 \cdot 3^4 = 3^6$
8. hich of the following is true?
   A. $5^2 + 5^3 = 5^5$
   B. $\frac{2^2}{2^3} = \frac{1}{2}$
   C. $(3^2)^9 = 9^{18}$
   D. $(4^3)^2 = 4^5$

9. Divide $(4x^2 - 24x + 35) \div (2x - 5)$.
    - A. 2x – 7
    - B. 2x + 12
    - C. 2x – 12
    - D. 2x + 7

10. The length of the rectangle is 2x – 3 and its width is equal to x – 1. Find the area of the rectangle.
    - A. x – 2
    - B. 3x – 4
    - C. $2x^2 - x - 3$
    - D. $2x^2 - 5x + 3$

11. Which of the following is the result when $(3a^2b^3)$ is multiplied to $(4a^3b^2)$?
    - A. $7a^5b^5$
    - B. $7a^6b^6$
    - C. $12a^6b^6$
    - D. $12a^5b^5$

12. Which of the following describes the product of $(b + 5)(b + 5)$?
    - A. a monomial
    - B. a binomial
    - C. a trinomial
    - D. a multinomial

13. Which of the following is the result when $(x + 7)$ is multiplied to $(x + 4)$?
    - A. $x^2 + 11x + 28$
    - B. $x^2 + 28x + 11$
    - C. $x^2 + 7x + 28$
    - D. $x^2 + 8x + 28$

14. Divide $12x^3y^4 + 9x^2y^3 - 3x^5y^2$ by $3x^2y$.
    - A. $6x^2y^4$
    - B. $6xy^3 + y^2 - x^3y$
    - C. $3x^4 + 2y^4$
    - D. $4xy^3 + 3y^2 - x^3y$

15. The product of $4x^2y^5$ and a certain monomial is $28x^7y^9z^2$. What is the missing factor?
    - A. $7x^5y^4$
    - B. $7x^9y^{14}z^2$
    - C. $7x^5y^2z^2$
    - D. $7x^5y^4z^2$

Very Good! You did a good job. You're now ready for the next set of activities.

Lesson 1 Operations Involving Polynomials

A great day to start with another module! Do you know that there are a lot of real-life experiences that you can apply using operations of polynomials? Engineers use it in designing roads, bridges, building and other structures. It is also applied in predicting traffic patterns to design appropriate traffic control measures, and even in determining the best combination of grocery items and its quantity that will suit one's budget.

Simplifying expressions by making use of the laws of exponents is also an exciting thing to do!

What's In

In order to add, subtract, multiply and divide polynomials, you need to review the operations on integers.

Rules for Adding Integers

1. If the integers have the same sign, copy the sign then add the numbers.
   Examples: 5 + 2 = 7 -3 + (-5) = -8
   6 + 5 = 11 -8 + (-4) = -12
2. If the integers have different signs, subtract the numbers then copy the sign of the larger number.
   Examples: -7 + 4 = -3 8 + (-8) = 0
   6 + (-5) = 1 -2 + 2 = 0

Rules for Subtracting Integers

1. Change the sign of the subtrahend then proceed to addition.
2. Follow the rules in adding integers.
   Examples: 5 – 2 = 3 -5 – (-2) = -5 + 2 = -3
   6 – 8 = 6 + (-8) = -2 6 – (-2) = 6 + 2 = 8

Rules for Multiplying Integers

1. When multiplying two integers with the same sign, the product is positive.
   Examples: (7)(8) = 56 (-8)(-5) = 40
   (6)(2) = 12 (-6)(-2) = 12
2. When you multiply two integers with different signs, the product is negative.
   Examples: (7)(-2) = -14 (-2)(3) = -6
3. Any number multiplied by 0 gives a product of 0.
   Examples: (0)(5) = 0 (-2)(0) = 0

For a product with no zero factors:

4. If the number of negative factors is odd, the product is negative.
   Examples: (-2)(3)(1) = -6 (4)(-3)(-2)(-1) = -24

5. If the number of negative factors is even, the product is positive.
   Examples: (-2)(-3)(1) = 6 (-1)(-2)(3)(2)(-3)(-2) = 72

Rules for Dividing Integers

1. When two integers with the same sign are divided, the quotient is always positive.
   Examples: 42 ÷ 7 = 6 -45 ÷ (-9) = 5
2. When two integers with different signs are divided, the quotient is always negative.
   Examples: 63 ÷ (-9) = -7 -56 ÷ 7 = -8
3. The rules for dividing zero by a non-zero number and for division by zero still hold.
   $\frac{(0)}{(non-zero\ number)} = 0$ $\frac{(any\ number)}{(0)} = undefined$
   Examples: $\frac{0}{-2}$ = 0 $\frac{5}{0}$ = undefined

For a quotient with no zero divisor and dividend:

4. If the number of negative integers to be divided is odd, the product is negative.
   Examples: -4 ÷ 2 ÷ 1 = -2 -10 ÷ (-2) ÷ 1 ÷ (-1) = -5
5. If the number of negative integers to be divided is even, the product is negative.
   Examples: -2 ÷ 1 ÷ (-1) ÷ 1 = 2 -4 ÷ 4 ÷ (-1) ÷ (-1) ÷ (-1) = 1

Can you still remember these rules? Well, let's see! Let's apply these rules in doing the next activity. Enjoy!

Activity 1: Who Am I?

Reveal who is being referred to in the statements above by performing the indicated operation in Column A and matching it to the answers in Column B.

"I am the father of Archimedes. Do you know my name?"
Find it out by decoding the hidden message below.

No.	Column A		Column B
1.	$8 + (-5)$	S	-2
2.	$(-12) + (-8)$	H	-20
3.	$(-2) + 1$	I	-1
4.	$(4)(-7)$	P	3
5.	$(-5) \div (5)$	A	6
6.	$(-2)(-3)$	E	-13
7.	$(-6) \div (3)$	D	-28
		V	28

______ ______ ______ ______ ______ ______ ______
1 2 3 4 5 6 7

Great! The activity revealed who is the father of Archimedes. If you were able to name him correctly, then you really have remembered the operations on integers which is very useful in this module.

Activity 2: Agree or Disagree!

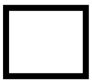
In this activity, you will guess whether the following statements is correct or not. Write A if you agree with the statements; otherwise, write D. Write your answer on a separate sheet of paper.

Statement	Response
1. Any number raised to zero is equal to one (1).	
2. An expression with exponents CANNOT be simplified even if we follow the laws of exponents.	
3. 2^3 is equal to $\frac{1}{8}$.	
4. Laws of exponents may be used to simplify expressions with exponents.	
5. $\frac{1}{3^2} = 9$	
6. $3^0 4^2 = 16$	
7. $\frac{1}{(32x^3y^5)^2}$ may be written as $(32x^3y^5)^2$ where $x \neq 0$ and $y \neq 0$.	
8. $3^2 \cdot 4^0 + 1^2 \cdot 5^0 = 11$	

Nice one! You are now ready to discover more about operations of polynomials.

What's New

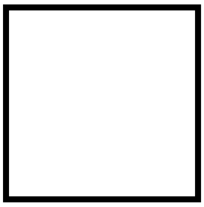
Familiarize yourself with the tiles below:

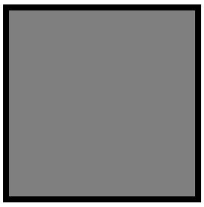

Stands for (+1)


Stands for (-1)


Stands for (+x)


Stands for (-x)


Stands for (x^2)

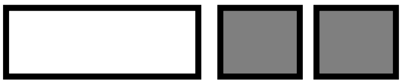

Stands for ($-x^2$)

Can you represent the following quantities using the above tiles?

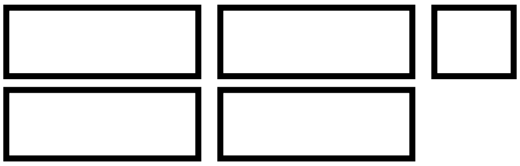
a. $x - 2$ b. $4x + 1$

The tiles can make operations on polynomials easy to understand and follow. Look and observe the following examples.

a. To represent $x - 2$, we get one ($+x$) and two (-1) tiles.



b. To represent $4x + 1$, we get four ($+x$) and one (+1) tiles.



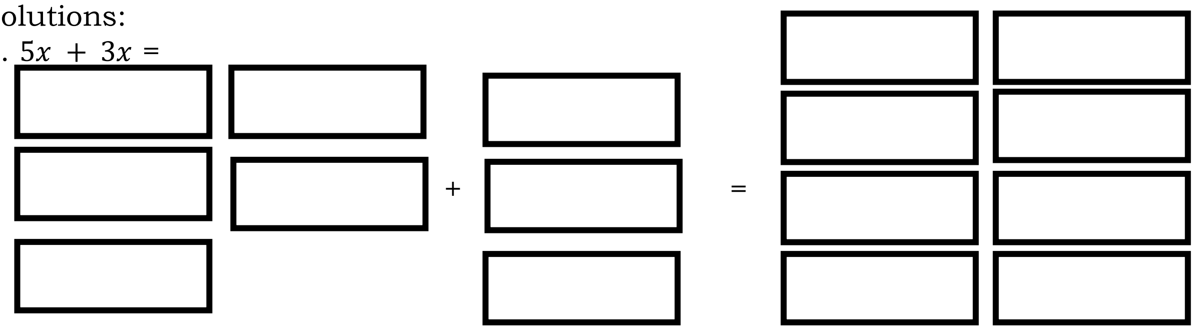
Try this!

Use the tiles to perform the operations on the following polynomials.

1. $5x + 3x$
2. $(3x - 4) - 6x$
3. $(2x^2 - 5x + 2) + (3x^2 + 2x)$
4. $(3x)(x)$
5. $(3 - x)(x + 2)$
6. $(x^2 + 7x + 6) \div (x + 1)$

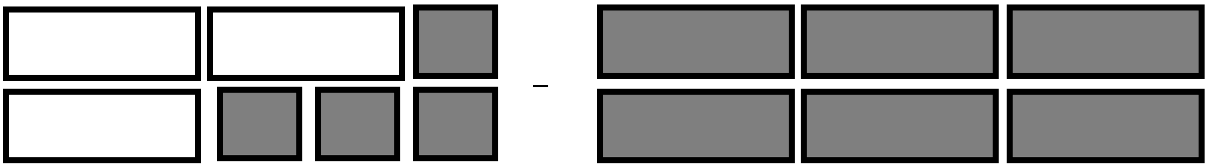
Solutions:

1. $5x + 3x =$

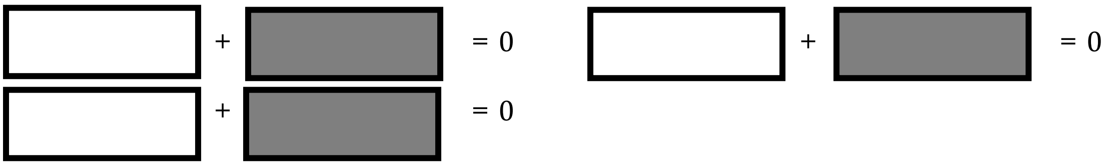


Since there are eight $(+x)$ altogether, therefore, $\mathbf{5x + 3x = 8x}$.

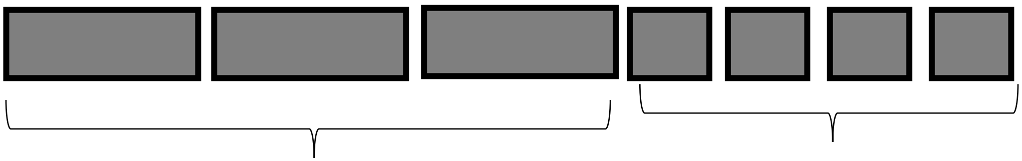
2. $(3x - 4) - 6x$



Recall that combining $(+x)$ and $(-x)$ will result to zero.



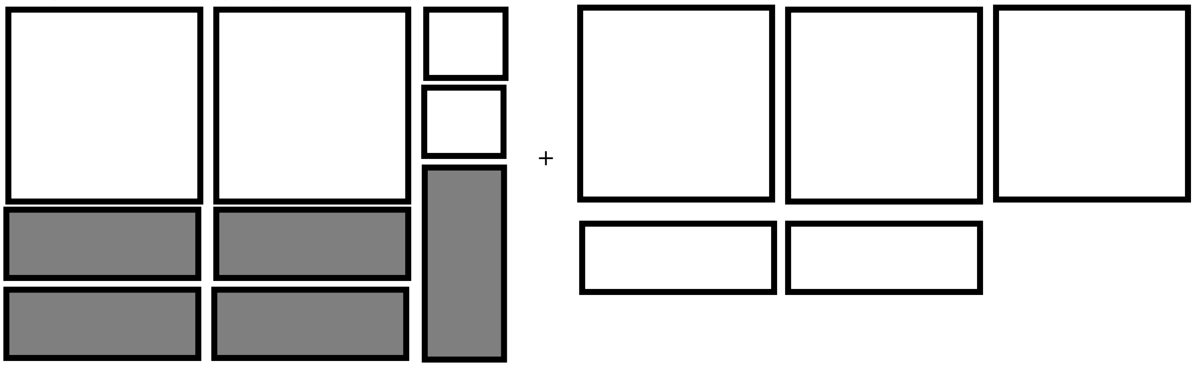
Note: There are 3 pairs of $(+x)$ and $(-x)$ on the illustration above. After combining the $(+x)$ and $(-x)$, notice that there are no other tiles to be paired. The tiles that are left are:



$\underbrace{\text{There are three(3) } (-x)}_{-3x}\text{ tiles}$ and $\underbrace{\text{four(4) } (-1) \text{ tiles}}_{-4}$

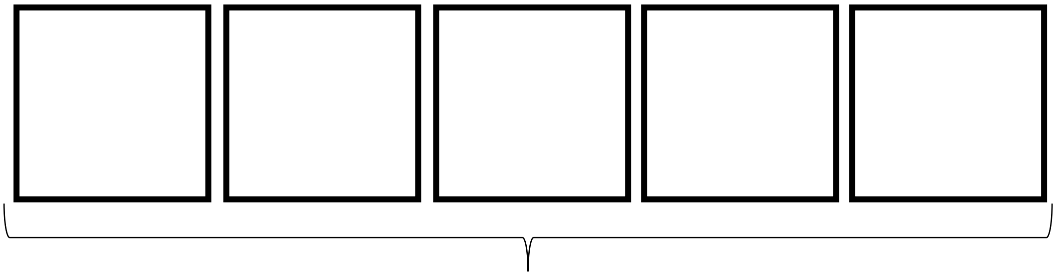
Therefore, $(3x - 4) - 6x = \mathbf{-3x - 4}$

3. $(2x^2 - 5x + 2) + (3x^2 + 2x)$

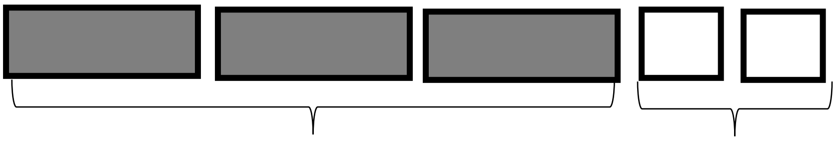


Note: Combining $(+x)$ and $(-x)$ will result to zero.

From the illustration above, it can be noticed that there are only two pairs of $(+x)$ and $(-x)$. There are no other tiles that can be paired that will be equal to zero. The tiles that are left are:



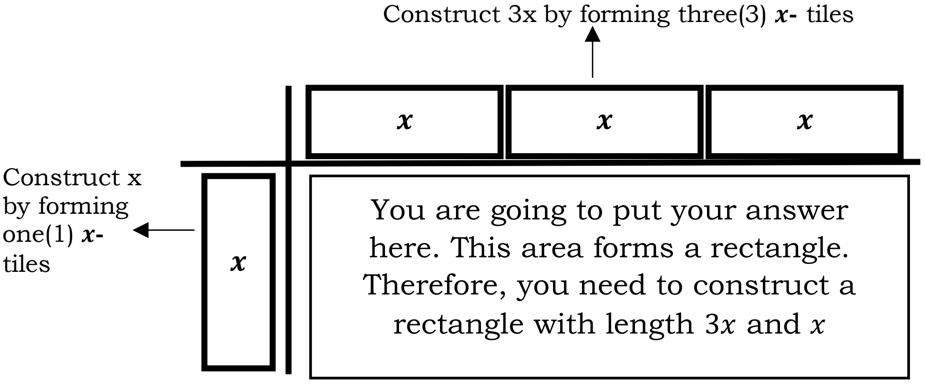
five(5) $(+x^2)$ tiles = $5x^2$



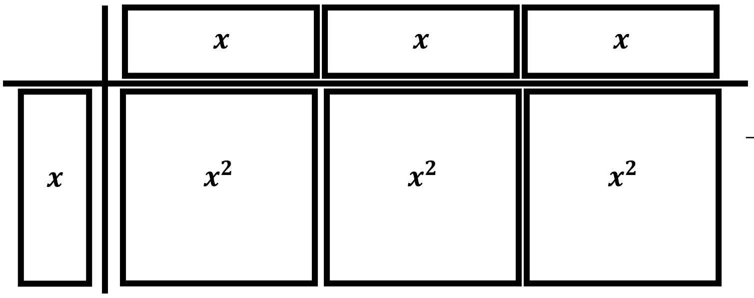
three(3) $(-x)$ tiles = $-3x$ and two(2) $(+1)$ tiles = $+2$

Therefore, $(2x^2 - 5x + 2) + (3x^2 + 2x) = \mathbf{5x^2 - 3x + 2}$

4. $(3x)(x)$



You are going to put your answer here. This area forms a rectangle. Therefore, you need to construct a rectangle with length $3x$ and x

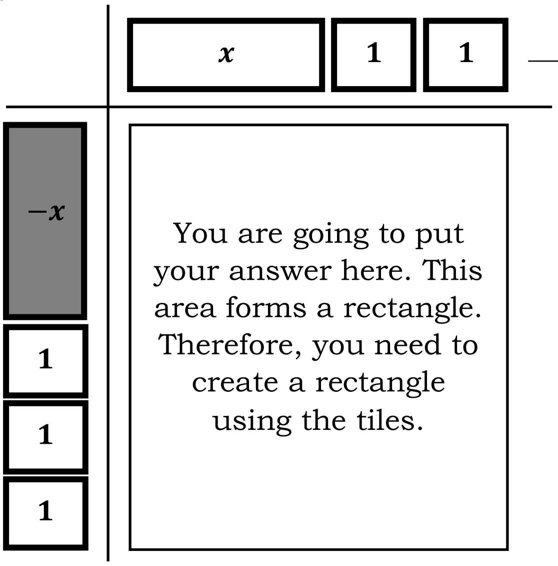


(Take note: multiplying white tile to a white tile will also result to a white tile.)

Notice that you need to put three(3) x^2 tile that will fit together and will form a rectangle.

Therefore, $(3x)(x) = \mathbf{3x^2}$

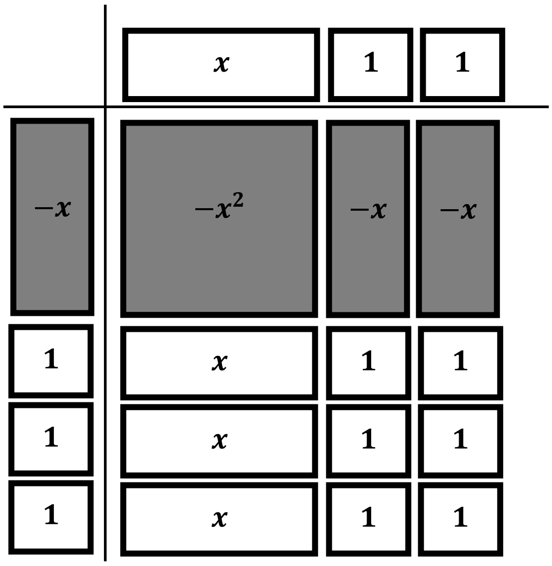
5. $(3 - x)(x + 2)$



You are going to put your answer here. This area forms a rectangle. Therefore, you need to create a rectangle using the tiles.

Construct $(x + 2)$ by forming one(1) $\boldsymbol{x}$ **tile** and two(2) **1-tiles**

Construct $(3 - x)$ by forming one(1) $\boldsymbol{-x}$**-tile** and three(3) **1-tiles**

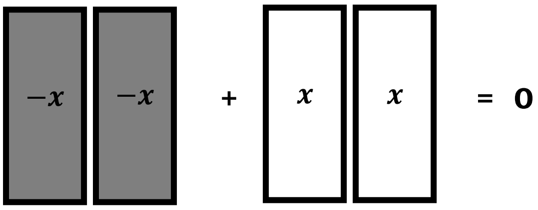


Multiplying white tiles to black tiles will result to black tiles.

Multiplying white tiles to white tiles will result to white tiles.

Notice that you need to put one(1) $\boldsymbol{-x^2}$-tile, two(2) $\boldsymbol{-x}$-tiles, three(3) $\boldsymbol{x}$-tiles, and six(6) 1-tiles that will fit together and will form a rectangle.

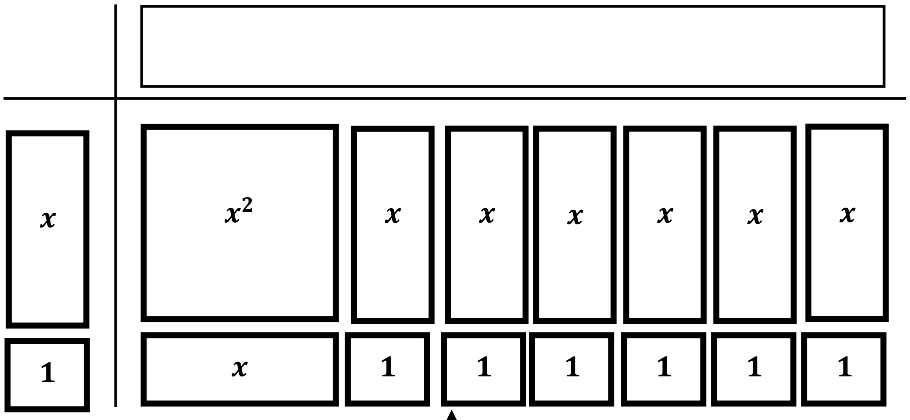
Take note that combining $(+x)$ tiles and $(-x)$ will result to zero.



Therefore, $(3 - x)(x + 2) = \boldsymbol{-x^2 + x + 6}$.

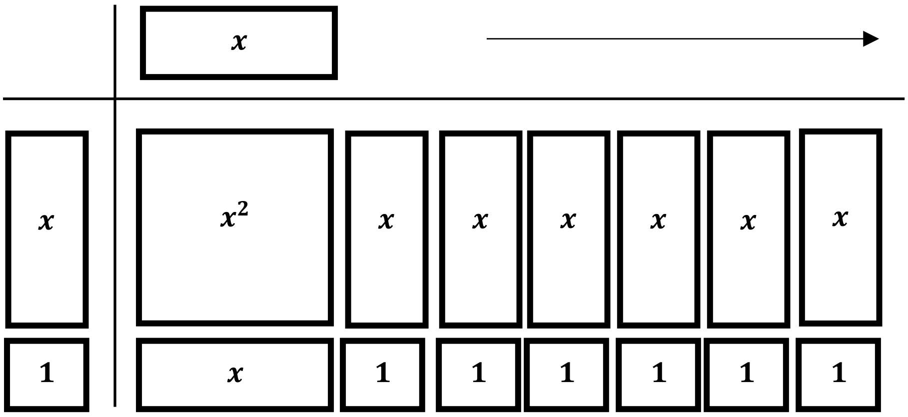
6. $(x^2 + 7\text{x} + 6) \div (\text{x} + 1)$

You are going to put your answer here. Use the tiles that will perfectly fit the rectangle



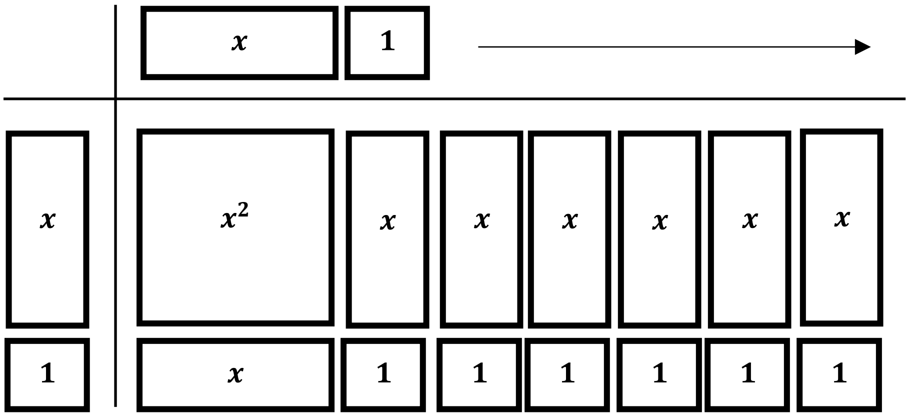
You are going to form the divisor $(x + 1)$ here by putting one(1) **x-tile** and one(1) **1-tile**

The dividend $(x^2 + 7x + 6)$ is placed in this rectangular area formed by putting one(1) **x^2-tile**, seven(7) **x-tiles** and six(6) **1-tiles**

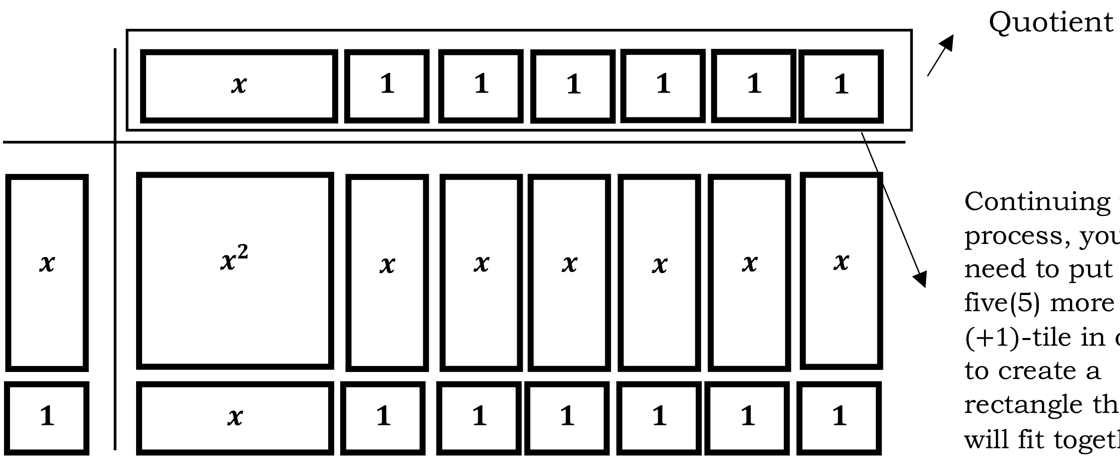


(Take note: Dividing white tile by a white tile will also result to a white tile.)

Notice that the tile that will fit on the length of the dividend $(+x^2)$- tile and length of the divisor x-tile is the x-tile. So it is placed on this area of the quotient. Take note that you should be able to create a rectangle.

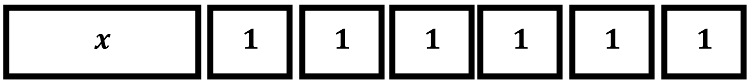


You need to put some more tiles in order to create a rectangle whose length is the same as the length of the whole dividend. Now, it is clear that you are going to put (+1)-tile.



Continuing the process, you need to put five(5) more (+1)-tile in order to create a rectangle that will fit together.

After performing the process, it can be noticed that rectangle on the quotient portion is composed of these tiles:



Therefore, $(x^2 + 7\text{x} + 6) \div (\text{x} + 1) = \boldsymbol{x + 6}$

What is It

ADDITION AND SUBTRACTION OF POLYNOMIALS

It is important that we know what are like or similar terms before we proceed with the addition and subtraction of polynomials. Terms with the same literal coefficients are called like terms or similar terms.

2ab, 6ab and -ab are similar terms because they have the same literal coefficients which is *ab.*

2a, 3ab and -5b are not similar terms because their literal coefficients are not the same (the literal coefficients are *a, ab,* and *b,* respectively)

Try this! Write inside the box the terms that are similar. The first one is done for you.

Given	Similar terms
$3xy, -6x, xy, \frac{1}{2}xy$	$3xy$, xy and $\frac{1}{2}xy$
1. $-ab, 0.5ab, 8by, \frac{3ab}{10}$	
2. $4(x+y)$, $-7xy$, $(x+y)$, $13(x+y)$	
3. $a^2b^3, -a^2b^3, -a^3b^2$	

From the exercise, the similar terms in Item No.1 are $-ab, 0.5ab$ and $\frac{3ab}{10}$ because they have the same literal coefficient which is ab. Meanwhile in Item No. 2, $4(x+y)$, $(x+y)$, and $13(x+y)$ are similar terms because they have the same literal coefficient which is $(x+y)$. Furthermore, in Item No. 3 only a^2b^3 and $-a^2b^3$ are similar terms because they have common literal coefficient which is a^2b^3. The term $-a^3b^2$ is not similar to a^2b^3 and $-a^2b^3$ for the reason that their exponents are not the same.

Thus, for them to be called similar terms, they should have the same literal coefficients including its exponents.

Rules for Adding Polynomials

To add polynomials, simply combine like terms or similar terms. To combine similar terms, get the sum of the numerical coefficients and copy the same literal coefficients. For convenience, write similar terms in the same column.

Example 1:

Find the sum.

a. $5a + (2a + 6)$ b. $(2x + 4) + (4x - 1)$

Solution:

a. $5a + (2a + 6) = (5a + 2a) + 6$ Group like terms.

$= (5 + 2)a + 6$ Add the numerical coefficients of the like terms, then simplify.

$= \mathbf{7a + 6}$

b. $(2x + 4) + (4x - 1) = (2x + 4x) + (4 - 1)$ Group like terms.

$= (2 + 4)x + (4 - 1)$ Add the numerical coefficients of the like terms, then simplify.

$= \mathbf{6x + 3}$

Example 2:

Simplify each.

a. $(5a + 8b - 2c) + (8a + 7b - 8c)$

b. $(4x + 10y - 6z) + (7x - 4y + 7z) + (3x + 9z)$

Solution:

a. By removing the parentheses and grouping and combining like terms, we get:

$(5a + 8b - 2c) + (8a + 7b - 8c)$

$= (5a + 8a) + (8b + 7b) + (-2c - 8c)$ Group like terms.

$= (5 + 8)a + (8 + 7)b + (-2 - 8)c$ Combine the numerical coefficients of each term, then simplify.

$= 13a + 15b - 10c$

By aligning the terms vertically, we get:

$$\begin{array}{rrrr} & 5a & +\ 8b & -\ 2c \\ + & 8a & +\ 7b & -\ 8c \\ \hline & 13a & +\ 15b & -\ 10c \end{array}$$

In this procedure, align all the terms with the same literal coefficients and then combine them.

Using any of the two procedures will result to $13a + 15b - 10c$.

Therefore, $(5a + 8b - 2c) + (8a + 7b - 8c) = \mathbf{13a + 15b - 10c}$.

b. By removing the parentheses and grouping and combining like terms, we get:

$(4x + 10y - 6z) + (7x - 4y + 7z) + (3x + 9z)$

$= (4x + 7x + 3x) + (10y - 4y) + (-6z + 7z + 9z)$ Group like terms.

$= (4 + 7 + 3)x + (10 - 4)y + (-6 + 7 + 9)z$ Combine the numerical coefficients of each term, then simplify.

$= 14x + 6y + 10z$

By aligning the terms vertically, we get:

$$\begin{array}{rrrr} & 4x & +\ 10y & -\ 6z \\ & 7x & -\ \ 4y & +\ 7z \\ + & 3x & & +\ 9z \\ \hline & 14x & +\ 6y & +\ 10z \end{array}$$

In this procedure, align all the terms with the same literal coefficients and then combine them.

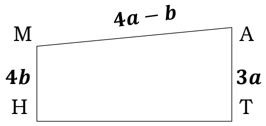
Notice that the middle part is left blank because the expression has no term which is similar to the term aligned above it.

Using any of the two procedures will result to $14x + 6y + 10z$.

Therefore, $(4x + 10y - 6z) + (7x - 4y + 7z) + (3x + 9z) = \mathbf{14x + 6y + 10z.}$

Example 3:

The lengths of the sides of quadrilateral MATH are shown in the diagram. Find the perimeter of the quadrilateral MATH.



Solution:

To find the perimeter, add the lengths of the sides.

$P = (4a - b) + (3a) + (5a + 2b) + (4b)$

$= (4a + 3a + 5a) + (-b + 2b + 4b)$

$= (4 + 3 + 5)a + (-1 + 2 + 4)b$

$= 12a + 5b$

Therefore, the perimeter is $12a + 5b$.

Example 4:

Vincent Vann saved (2x + 3y)pesos from his allowance on Monday and (6x – y)pesos on Tuesday. What is his total savings for two days?

Solution:

To find his savings for two days, add how much he has saved on Monday and Tuesday.

Total Savings $= (2x + 3y) + (6x - y)$

$= 2x + 6x + 3y + (-y)$

$= 8x + 2y$

Therefore, he has saved a total of (8x + 2y)pesos in two days.

Rule for Subtracting Polynomials

To subtract a polynomial from another polynomial, change the sign of the subtrahend and proceed to addition. Keep in mind that in adding polynomials, you can only add those that are similar or like terms.

$a - b = a + (-b)$

minuend subtrahend

Subtract.

a. $(5x + 4) - (7x + 3)$
b. $(9x + 3) - (-4x + 5)$
c. $(6x^2 - 4x + 8) - (3x^2 - x - 5)$
d. $(8x^3 - 2x^2 + 2x - 2) - (3x^2 + 4x + 7)$

Solution:

a.	$(5x + 4) - (7x + 3)$	Given
	$= (5x + 4) + (-7x - 3)$	Definition of Subtraction
	$= (5x - 7x) + (4 - 3)$	Group like terms
	$= \mathbf{-2x + 1}$	Simplify

b.	$(9x + 3) - (-4x + 5)$	Given
	$= (9x + 3) + (4x - 5)$	Definition of Subtraction
	$= (9x + 4x) + (3 - 5)$	Group like terms
	$= \mathbf{13x - 2}$	Simplify

c. Applying horizontal subtraction, we get

$\underset{\text{minuend}}{(6x^2 - 4x + 8)} - \underset{\text{subtrahend}}{(3x^2 - x - 5)}$	Given
$= 6x^2 - 4x + 8 - 3x^2 + x + 5$	Remove the grouping symbols and change the sign of the subtrahend
$= \mathbf{3x^2 - 3x + 13}$	Simplify

Applying vertical subtraction, we get

(align like terms) (change the sign of the subtrahend and proceed to addition)

$$\begin{array}{r} 6x^2 - 4x + 8 \\ \underline{-\ \ (3x^2 - x - 5)} \end{array} \quad \longrightarrow \quad \begin{array}{r} 6x^2 - 4x + 8 \\ \underline{+\ \ -3x^2 + x + 5} \\ \mathbf{3x^2 - 3x + 13} \end{array}$$

d.	$(8x^3 - 2x^2 + 2x - 2) - (3x^2 + 4x + 7)$	Given
	$= (8x^3 - 2x^2 + 2x - 2) + (-3x^2 - 4x - 7)$	Definition of Subtraction
	$= 8x^3 + (-2x^2 - 3x^2) + (2x - 4x) + (-2 - 7)$	Group like terms
	$= \mathbf{8x^3 - 5x^2 - 2x - 9}$	Simplify

Example 2.

Subtract $6x^2 - 5x - 2$ from $4x^2 - 2x$.

Solution:

"Subtract $6x^2 - 5x - 2$ from $4x^2 - 2x$" means $(6x^2 - 5x - 2) - (4x^2 - 2x)$.
Thus,

$(4x^2 - 2x) - (6x^2 - 5x - 2)$
$= (4x^2 - 2x) + (-6x^2 + 5x + 2)$
$= (4x^2 - 6x^2) + (-2x + 5x) + (2)$
$= -2x^2 + 3x + 2$

To do it vertically, we have

(align like terms) (change the sign of the subtrahend and proceed to addition)

$$\begin{array}{r} 4x^2 - 2x \\ \underline{-\ \ (6x^2 - 5x - 2)} \end{array} \longrightarrow \begin{array}{r} 4x^2 - 2x \\ \underline{+\ \ -6x^2 + 5x + 2} \\ \mathbf{-2x^2 + 3x + 2} \end{array}$$

Example 3:

There are $14a^2 + 2a + 16$ children in a classroom. If the number of boys is $5a^2 - 9a + 7$, how many girls are in the classroom?

Solution:

In order to determine the number of girls in the classroom, we should subtract the number of boys from the total number of children in the classroom. Hence,

Number of girls = total number of children – number of boys

$= (14a^2 + 2a + 16) - (5a^2 - 9a + 7)$

$= 14a^2 + 2a + 16 - 5a^2 + 9a - 7$

$= 14a^2 - 5a^2 + 2a + 9a + 16 - 7$

$= 9a^2 + 11a + 9$

Therefore, there are $9a^2 + 11a + 9$ number of girls in the classroom. Addition and subtraction of polynomials is just easy, right? Try this exercise to check your understanding before proceeding to the next topic.

Exercise:

Simplify each of the given expressions.

1. $(3x - 7) + (-4x - 2)$
2. $(9x^2 - 2x) - (8x^2 + 4x)$
3. $(-3x^2 - 2x + 5) + (5x^2 + 2x - 8)$
4. $(8x^3 - 2x^2 + 2x - 2) - (3x^2 + 4x + 7)$
5. $(3x^2 - 7xy + 2y^2) + (5x^2 + 6xy - 4y^2)$

Now, let us derive the laws of exponents. These will be used in simplifying expressions and in multiplying and dividing polynomials.

LAWS OF EXPONENTS

Activity 3.1: Answer Me. Faster!

Give the product of each of the following as fast as you can. Write it on the space provided. Do not forget to record the time you spent in answering.

1. 3 *x* 3 = ________

2. 4 *x* 4 *x* 4 = ________

3. 5 *x* 5 *x* 5 = ________

4. 2 *x* 2 *x* 2 = ________

5. 2 *x* 2 *x* 2 *x* 2 = ________

6. 2 *x* 2 *x* 2 *x* 2 *x* 2 = ________

Time Spent in Answering	____sec/mins

This leads us to the definition of exponents.

LAW OF EXPONENTS

A. $\boldsymbol{a^n} = \overbrace{\boldsymbol{a \cdot a \cdot a \cdot a \ldots \cdot a}}^{\text{(n times)}}$ where $a \neq 0$ and n is an integer

In a^n, a is called the base and n is called the exponent.

The exponent will tell how many times we are going to multiply the base by itself.

Examples:

1. Which of the following is/are correct?

   Answers:

   a. $4^2 = 4\,x\,4 = 16$ CORRECT

   b. $2^4 = 2\,x\,2\,x\,2\,x\,2 = 8$ INCORRECT

   c. $2^5 = 2\,x\,5 = 10$ INCORRECT

2. Give the value of each of the following as fast as you can.

   Answers

   a. 2^3 = _____ 8

   b. 2^5 = _____ 32

   c. 3^4 = _____ 81

Note: Do not multiply the exponent by its base.

INCORRECT: $4^2 = 4 \cdot 2$ **CORRECT:** $4^2 = 4 \cdot 4$

Activity 3.2: Let's Investigate!

Evaluate the following by applying the law that we have discussed. Investigate the result. Make a simple guess on it after completing the table. The first two were done for you.

Given	Factored Form Using the Previous Law	Long Process	Result
1. $(2^3)^2$	$2^3 \cdot 2^3$	$2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$	64
2. $(x^4)^3$	$x^4 \cdot x^4 \cdot x^4$	$x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x$	x^{12}
3. $(3^2)^2$	$3^2 \cdot 3^2$		
4. $(2^2)^3$		$2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$	

The activity leads us to the next law on exponents:

LAW OF EXPONENTS

(Power of Powers)

B. $\boldsymbol{(a^n)^m = a^{nm}}$

When a power is raised to another power or when an exponential expression is raised to another exponent, multiply the exponents.

Examples:

1. $(x^{100})^3 = x^{(100)(3)}$ Using the Power of Powers Law, multiply the exponents.
   $= x^{300}$ Simplify.

2. $(y^{12})^5 = y^{(12)(5)}$ Using the Power of Powers Law, multiply the exponents.
   $= y^{60}$ Simplify.

Activity 3.3: Can You Notice Something?

Evaluate the following by completing the table. Notice that the bases are the same. The first example is done for you.

Given	Long Form	Exponential Form	Result
1. $(2^3)(2^2)$	$(2 \cdot 2 \cdot 2) \cdot (2 \cdot 2)$	2^5	32
2. $(x^5)(x^4)$		x^9	
3. $(3^2)(3^3)$	$(3 \cdot 3) \cdot (3 \cdot 3 \cdot 3)$		
4. $(2^4)(2^5)$			512

Did you notice something?

What can you conclude about $\boldsymbol{a^n \cdot a^m}$? What will you do with $\boldsymbol{a}$, $\boldsymbol{n}$ and $\boldsymbol{m}$?

LAW OF EXPONENTS
(Product of a Power)
C. $\boldsymbol{a^n \cdot a^m = a^{n+m}}$

In multiplying exponential expressions whose bases are the same, just copy the common base and then add its exponents.

Examples:

1. $(x^{32})(x^{25})$ $= x^{32+35}$ Since they have common base which is "x", copy the common base and add the exponents
$= x^{57}$ Simplify the result

2. $(y^{59})(y^{51})$ $= y^{59+51}$ Copy the common base "y" and add the exponents.
$= y^{110}$ Simplify the result.

Activity 3.4: Evaluate us!

Evaluate each of the following. Notice that the bases are the same. The first example is done for you.

Given	Solution	Result	Equivalent Exponential Form
1. $\frac{2^7}{2^3}$	$= \frac{\cancel{2} \cdot \cancel{2} \cdot \cancel{2} \cdot 2 \cdot 2 \cdot 2 \cdot 2}{\cancel{2} \cdot \cancel{2} \cdot \cancel{2}}$	16	2^4
2. $\frac{3^5}{3^3}$		9	
3. $\frac{4^3}{4^2}$	$= \frac{\cancel{4} \cdot \cancel{4} \cdot 4}{\cancel{4} \cdot \cancel{4}}$		4^1

Did you notice something?

What can you conclude about $\frac{a^n}{a^m}$? What will you do with $\boldsymbol{a}$, $\boldsymbol{n}$ and $\boldsymbol{m}$?

LAW OF EXPONENTS
(Quotient of a Power)

D. $\frac{a^n}{a^m} = a^{n-m}$

Note: This is only applicable if the exponent on the numerator *(denoted by n)* is greater than the exponent on the denominator *(denoted by m).*

In dividing exponential expressions with the same bases, copy the common base and subtract its exponents.

Examples:

1. $\frac{x^{20}}{x^{13}} = x^{20-13}$ Copy the common base "x" and subtract the exponents.
   $= x^7$ Simplify the result.
2. $\frac{y^{105}}{y^{87}} = y^{105-87}$ Copy the common base "y" and subtract the exponents.
   $= y^{18}$ Simplify the result.

***Note**: The law of exponent that we have just discussed applies only to expressions in which the exponent on the numerator is greater than the exponent on the denominator. There is another law that will be followed if the exponent on the numerator is lesser than the exponent on the denominator. However, this law will be discussed when you will be in Grade 9.*

Notice what happens on the expressions inside the table.

No	Given (Start Here)	Applying a law of exponent	Result	Answer	Reason
1.	$\frac{5}{5}$	5^{1-1}	5^0	1	Any number divided by itself is equal to 1.
2.	$\frac{100}{100}$	100^{1-1}	100^0	1	
3.	$\frac{x}{x}$	x^{1-1}	x^0	1	
4.	$\frac{a^5}{a^5}$	a^{5-5}	a^0	1	

LAW OF EXPONENTS
(Law For Zero Exponent)

E. $a^0 = 1 \text{ where } a \neq 0$

Always take note that any nonzero number raised to a zero exponent is always equal to 1.

Examples:
1. $(7,654,321)^0 = 1$
2. $3^0 + x^0 + (3y)^0 = 1 + 1 + 1$

Let us summarize the laws of exponents discussed in this lesson.

LAWS ON EXPONENTS

For any real number $a \neq 0$ and positive integers m and n:

1. $(a^n)^m = a^{nm}$ ***Power of Powers***
2. $a^n \cdot a^m = a^{n+m}$ ***Product of a Power***
3. $\frac{a^n}{a^m} = a^{n-m}$, **where** $n > m$ ***Quotient of a Power***
4. $a^0 = 1$ *where* $a \neq 0$ ***Law for Zero Exponent***

There are still other Laws of Exponents which you will learn in Grade 9. For now, you have to learn first the basic laws discussed above so that you will be able to understand other laws to be discussed in higher grade level.

MULTIPLYING POLYNOMIALS

Unlike the processes of addition and subtraction, multiplication of polynomials considers not only the numerical coefficients but also the literal coefficients.

Rules in Multiplying Polynomials

A. Monomial by Monomial

To multiply a monomial with another monomial, simply multiply the numerical coefficients then multiply the literal coefficients by applying the basic laws of exponents.

Examples:

1. $(x^3)(x^5) = x^{3+5}$ Applying the law of exponent, copy the common base ***"x"*** and add the exponents ***"3"*** and ***"5"***

$= \boldsymbol{x^8}$ Simplify the result.

2. $(3x^2)(-5x^{10}) = (3)(-5)(x^{2+10})$ Multiply the numerical coefficients ***"3"*** and ***"-5"*** and copy the common base ***"x"*** then add the exponents ***"2"*** and ***"10"***

$= \boldsymbol{-15x^{12}}$ Simplify the result.

3. $(-8x^2y^3)(-9xy^8)$

$= (-8)(-9)(x^{2+1})(y^{3+8})$ Multiply the numerical coefficients ***"-8"*** and ***"-9"*** and copy the common base ***"x"*** then add the exponents ***"2"*** and ***"1"*** and the common base ***"y"*** and add the exponents ***"3"*** and ***"8"***

$= \boldsymbol{72x^3y^{11}}$ Simplify the result.

B. Monomial by a Polynomial

To multiply a monomial with a polynomial, simply apply the distributive property and follow the rule in multiplying monomial by a polynomial. Multiplication of monomial by a polynomial could also be done vertically. In the examples below, the solutions are presented into two ways:

Examples:

1. $(3x)(x^2 - 5x + 7)$

Solutions:

Using the distributive property,

$$\begin{aligned}&(3x)(x^2 - 5x + 7)\\ &= (\mathbf{3x})(x^2) + (\mathbf{3x})(-5x) + (\mathbf{3x})(7)\\ &= (3x^{1+2}) + (-15x^{1+1}) + (21x)\\ &= \mathbf{3x^3 - 15x^2 + 21x}\end{aligned}$$

Using the Vertical Solving,

$$\begin{array}{lr} & x^2 \;-\; 5x \;+\; 7\\ \underline{\text{x}} & \underline{3x}\\ \multicolumn{2}{c}{\mathbf{3x^3 - 15x^2 + 21x}}\end{array}$$

2. $(-5x^2y^3)(2x^2y - 3x + 4y^5)$

Solutions:

Using the distributive property,

$$\begin{aligned}&(-5x^2y^3)(2x^2y - 3x + 4y^5)\\ &= (\mathbf{-5x^2y^3})(2x^2y) + (\mathbf{-5x^2y^3})(-3x) + (\mathbf{-5x^2y^3})(4y^5)\\ &= (-5)(2)(x^{2+2})(y^{3+1}) + (-5)(-3)(x^{2+1})(y^3) + (-5)(4)(x^2)(y^{3+5})\\ &= \mathbf{-10x^4y^4 + 15x^3y^3 - 20x^2y^8}\end{aligned}$$

Solving vertically,

$$\begin{array}{lr} & 2x^2y \quad - \quad 3x \quad + \quad 4y^5\\ \underline{\text{x}} & \underline{-5x^2y^3}\\ \multicolumn{2}{c}{\mathbf{-10x^4y^4 + 15x^3y^3 - 20x^2y^8}}\end{array}$$

C. Binomial by a Binomial

To multiply a binomial with another binomial, you can use F-O-I-L Method or Smile Method. F-O-I-L stands for F-First, O-Outer, I-Inner, and L-Last. This acronym represents the order in which you should multiply the binomials' terms to get the product. You can draw arcs from the first to first terms and outer to outer terms over the top of the expression and draw arcs from the inner to inner terms and last to last terms on the bottom. When you do, you create a smiley face!

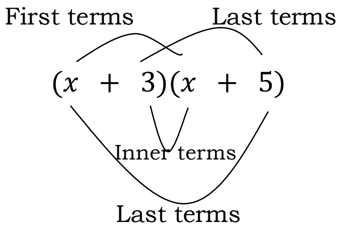
Another way is the vertical way of multiplying which is the conventional one.

Examples:

1. $(x + 3)(x + 5)$

Solutions:

Using F-O-I-L Method,



F-irst terms	→$(x)(x)$	= x^2
O-outer terms	→$(x)(5)$	= $5x$
I-nner terms	→$(3)(x)$	= $3x$
L-ast terms	→$(3)(5)$	= 15

Since $5x$ and $3x$ are similar terms, we can combine them. →5x + 3x = 8x.
The final answer is $\boldsymbol{x^2 + 8x + 15}$.

Using the vertical way,

$$\begin{array}{rrrrrr} & & x & + & & 3 \\ \text{x} & & x & + & & 5 \\ \hline & & x^2 & + & 3x & \\ + & & & & 5x & + \ 15 \\ \hline & & \mathbf{x^2} & + & \mathbf{8x} & + \ \mathbf{15} \end{array}$$

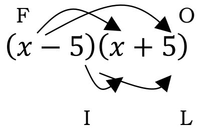
→ Multiply x to $(x + 3)$

→ Multiply 5 to $(x + 3)$. Align similar terms.

Notice that any of the two solutions will give you the same answer which is $\boldsymbol{x^2 + 8x + 15}$.

2. $(x - 5)(x + 5)$

Solution:



$$= \overset{F}{x^2} + \overset{O}{5x} - \overset{I}{5x} - \overset{L}{25}$$

$$= \boldsymbol{x^2 - 25}$$

Since "5x" and "-5x" are similar terms, they will be combined and will result to 0.

Therefore, $(x - 5)(x + 5) = \boldsymbol{x^2 - 25}$

3. $(x + 6)^2$

Solution:

$(x + 6)^2 = (x + 6)(x + 6) \quad = x^2 + 6x + 6x + 36$ Combine like terms: "6x" and "6x"

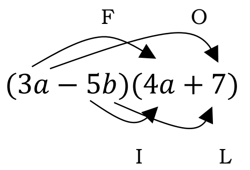
$= \boldsymbol{x^2 + 12x + 36}$

Therefore, $(x + 6)^2 = \boldsymbol{x^2 + 12x + 36}$

4. $(3a - 5b)(4a + 7)$

Solutions:

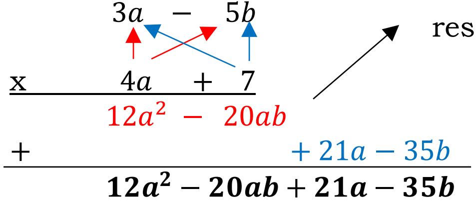
Using the FOIL Method,



$= \overset{F}{(3a)(4a)} + \overset{O}{(3a)(7)} + \overset{I}{(-5b)(4a)} + \overset{L}{(-5b)(7)}$

$= \mathbf{12a^2 + 21a - 20ab - 35b}$

Using the vertical way,



$$\begin{array}{lr} & 3a - 5b \\ \times & 4a + 7 \\ \hline & 12a^2 - 20ab \\ + & +21a - 35b \\ \hline & \mathbf{12a^2 - 20ab + 21a - 35b} \end{array}$$

Multiply $4a$ to $(3a - 5b)$ and 7 to $(3a - 5b)$, respectively

→ Notice that no terms are aligned because there are no terms which are similar.

D. Polynomial with more than one term to Polynomial with three or more terms

To multiply a polynomial with more than one term to a polynomial with three or more terms, simply apply the Distributive Property of Multiplication over Addition. Multiply the first term of the first polynomial to each term of the other polynomial. Repeat the procedure up to the last term and simplify the results by combining similar terms.

Another way of multiplying this is using the vertical way which is the conventional one.

Examples:

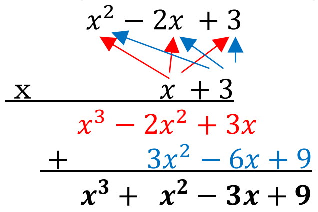
1. $(x + 3)(x^2 - 2x + 3)$

Solutions:

Using the Distributive Property,

$(x + 3)(x^2 - 2x + 3)$
$= \boldsymbol{x}(x^2 - 2x + 3) + \mathbf{3}(x^2 - 2x + 3)$
$= (x^3 - 2x^2 + 3x) + (3x^2 - 6x + 9)$
$= \boldsymbol{x^3 + x^2 - 3x + 9}$

Using the vertical way,



$$\begin{array}{lr} & x^2 - 2x + 3 \\ \times & x + 3 \\ \hline & x^3 - 2x^2 + 3x \\ + & 3x^2 - 6x + 9 \\ \hline & \boldsymbol{x^3 + x^2 - 3x + 9} \end{array}$$

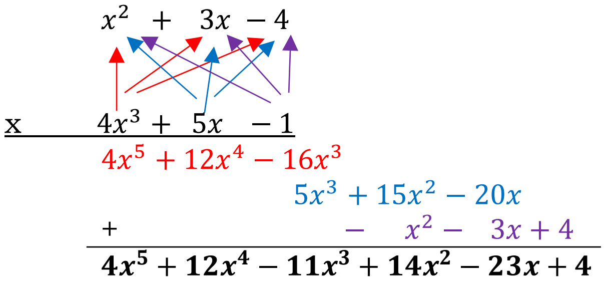
2. $(x^2 + 3x - 4)(4x^3 + 5x - 1)$

Solutions:

Using the distributive property,

$(x^2 + 3x - 4)(4x^3 + 5x - 1)$
$= \boldsymbol{x^2}(4x^3 + 5x - 1) + \boldsymbol{3x}(4x^3 + 5x - 1) - \mathbf{4}(4x^3 + 5x - 1)$
$= 4x^5 + 5x^3 - x^2 + 12x^4 + 15x^2 - 3x - 16x^3 - 20x + 4$
$= 4x^5 + 12x^4 + 5x^3 - 16x^3 - x^2 + 15x^2 - 3x - 20x + 4$
$= \boldsymbol{4x^5 + 12x^4 - 11x^3 + 14x^2 - 23x + 4}$

Using the vertical way,



$$\begin{array}{lr} & x^2 + 3x - 4 \\ \times & 4x^3 + 5x - 1 \\ \hline & 4x^5 + 12x^4 - 16x^3 \qquad\qquad\qquad \\ & 5x^3 + 15x^2 - 20x \qquad \\ + & - x^2 - 3x + 4 \\ \hline & \mathbf{4x^5 + 12x^4 - 11x^3 + 14x^2 - 23x + 4} \end{array}$$

3. $(2x - 3)(3x + 2)(x^2 - 2x - 1)$
   Solution:
   Multiply $(2x - 3)$ and $(3x + 2)$ first. By FOIL Method,

$$(2x - 3)(3x + 2) = 6x^2 + 4x - 9x - 6 = \mathbf{6x^2 - 5x - 6}$$

The result will then be multiplied to $(x^2 - 2x - 1)$.

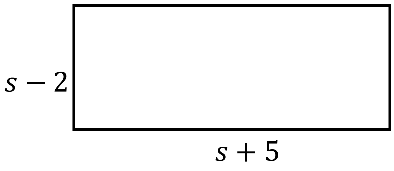
$$\begin{aligned}(6x^2 - 5x - 6)(x^2 - 2x - 1) &= \mathbf{6x^2}(x^2 - 2x - 1) - \mathbf{5x}(x^2 - 2x - 1) - \mathbf{6}(x^2 - 2x - 1) \\ &= 6x^4 - 12x^3 - 6x^2 - 5x^3 + 10x^2 + 5x - 6x^2 + 12x + 6 \\ &= 6x^4 - 12x^3 - 5x^3 - 6x^2 + 10x^2 - 6x^2 + 5x + 12x + 6 \\ &= \mathbf{6x^4 - 17x^3 - 2x^2 + 17x + 6}\end{aligned}$$

Alright! Let us apply the skills we have learned from multiplying polynomials into solving real-life problems. Let's study this!

Tina has a square garden with a side of length s feet. If she increased the length by 5 feet and then decreased the width by 2 feet, what trinomial represents the area of the new rectangular garden?

Solution:

The length of the new garden is $s + 5$ and the width is $s - 2$.



Multiply the length and width of the new garden by following the procedure in multiplying binomials.

$$\begin{aligned}(s + 5)(s - 2) &= \mathbf{s}(s - 2) + \mathbf{5}(s - 2) \\ &= s^2 - 2s + 5s - 10 \\ &= s^2 + 3s - 10\end{aligned}$$

Therefore, the trinomial that represents the area of the new rectangular garden is $\mathbf{s^2 + 3s - 10.}$

DIVIDING POLYNOMIALS

Like in multiplication, the division of polynomials applies the laws of exponents.

Rules in Dividing Polynomials

A. Polynomial by Monomial

To divide a polynomial by a monomial, simply divide each term of the polynomial by the given divisor.

Examples:

1. Divide $12x^4 - 16x^3 + 8x^2$ by $4x^2$.

Solution:

$$\frac{12x^4 - 16x^3 + 8x^2}{4x^2} \qquad \begin{aligned} &= \frac{12x^4}{4x^2} - \frac{16x^3}{4x^2} + \frac{8x^2}{4x^2} \\ &= 3x^{4-2} - 4x^{3-2} + 2x^{2-2} \\ &= 3x^2 - 4x + 2x^0 \\ &= 3x^2 - 4x + 2(1) \\ &= \mathbf{3x^2 - 4x + 2} \end{aligned}$$

B. Polynomial by a Polynomial with more than one term

To divide a polynomial by a polynomial with more than one term by long division, simply follow the procedure in dividing numbers by long division:

1. Check the dividend and the divisor to see if they are in standard form.
2. Set-up the long division by writing the division symbol where the divisor is outside the division symbol and the dividend inside it.
3. You may now start the division process.
4. You can stop the cycle when:
   a. The quotient (answer) has reached the constant term.
   b. The exponent of the divisor is greater than the exponent of the dividend.

Examples:

1. Divide $x^2 - 3x - 10$ by $x + 2$

Solution:

$x^2 - 3x - 10$ and $x + 2$ are already in standard form.

$\mathbf{x} - 5$	
$\mathbf{x} + 2\overline{)\,\mathbf{x^2} - 3x - 10}$	→ Divide $\mathbf{x^2}$ by $\mathbf{x}$ and write the result on top.
$\underline{x^2 + 2x}$	→ Multiply the result $\mathbf{x}$ to $\mathbf{x+2}$. Subtract the product $\mathbf{x^2+2x}$ (subtrahend) from $\mathbf{x^2-3x}$ (minuend).
$-5x - 10$	→ Remember to change the sign of the subtrahend then proceed to addition. Bring down the remaining term $\mathbf{-10}$. Then, divide $\mathbf{-5x}$ by $\mathbf{x}$.
$\underline{-5x - 10}$	→ Multiply the result $\mathbf{-5}$ to $\mathbf{x+2}$.
0	→ Subtract the product $\mathbf{-5x-10}$ from $-5x - \mathbf{10}$. Thus, the remainder is **0**.

Therefore, the quotient is $\boldsymbol{x-5.}$

2. Divide $x^3-6x^2+11x+6$ by $x-3$

Solution:

Since the terms in the dividend and divisor are in standard form, then,

$\overline{x^2-\ 3x+2}$	
$x-3\,)\,x^3-6x^2+11x-6$	→ Divide $\boldsymbol{x^3}$ by $\boldsymbol{x}$ and write the result on top.
$\underline{x^3-3x^2}$	→ Multiply the result $\boldsymbol{x^2}$ to $\boldsymbol{x}$ - 3. Subtract the product $\boldsymbol{x^3-3x^2}$ (subtrahend) from $\boldsymbol{x^3-6x^2}$ (minuend).
$-3x^2+11x$	→ Remember to change the sign of the subtrahend then proceed to addition. Bring down $\boldsymbol{11x}$. Then, divide $\boldsymbol{-3x^2}$ by $\boldsymbol{x}$.
$\underline{-3x^2+\ 9x}$	→ Multiply the result $\boldsymbol{-3x}$ to $\boldsymbol{x}$ **- 3**.
$2x-6$	→ Subtract the product $\boldsymbol{-3x^2+9x}$ from $\boldsymbol{-3x^2+11x}$ and bring down $\boldsymbol{-6}$. Then, divide $\boldsymbol{2x}$ by $\boldsymbol{x}$.
$\underline{2x-6}$	→ Multiply the result **2** to $\boldsymbol{x-3}$.
0	→ Subtract the product $\boldsymbol{2x-6}$ from $\boldsymbol{2x-6.}$ Thus, the remainder is **0.**

Therefore, the quotient is $\boldsymbol{x^2-3x+2.}$

Doing great! Now, let us solve related problems on dividing polynomials.

1. There are $28x^2+36x-16$ oranges in a basket. Mother divides them equally among 4 children. How many oranges does each child get?

   Solution:

   In order to determine how many oranges will each child get, we need to divide the total number of oranges in a basket by 4 since it will divided equally among 4 children. In doing so, we have

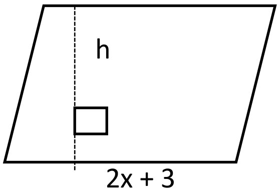
$$\frac{28x^2+36x-16}{4}=\frac{28x^2}{4}+\frac{36x}{4}-\frac{16}{4}$$
$$=\frac{28}{4}x^2+\frac{36}{4}x-\frac{16}{4}$$
$$=7x^2+9x-4$$

   Therefore, each child will get $7x^2+9x-4$ of oranges equally.

2. The area of a parallelogram is $8x^2+10x-3$. If its base is $2x+3$, what is its height?

   Solution:

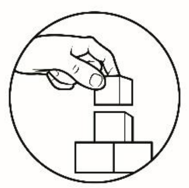
$A=bh$	Area formula of a parallelogram
$h=\frac{A}{b}$	Divide both sides by *b*.
$=\frac{8x^2+10x-3}{2x+3}$	Substitute the values.



Use long division to solve for h.

$$\begin{array}{rl} 4x - 1 & \\ 2x + 3\ \overline{)\ 8x^2 + 10x - 3} & \rightarrow \text{Divide } 8x^2 \text{ by } 2x \\ \underline{8x^2 + 12x} & \rightarrow \text{Multiply the result } 4x \text{ to the divisor } 2x + 3 \\ -2x - 3 & \rightarrow \text{Subtract } 8x^2 + 12x \text{ from } 8x^2 + 10x\text{. Remember to change the sign of the subtrahend and proceed to addition. Then divide } -2x \text{ by } 2x \\ \underline{-2x - 3} & \rightarrow \text{Multiply the result } -1 \text{ to } 2x + 3. \\ 0 & \text{Subtract } -2x - 3 \text{ from } -2x - 3. \text{ The remainder is 0.} \end{array}$$

Therefore, the height of the parallelogram is $\mathbf{4x - 1}$.



What's More

Let us try to answer more challenging set of problem and activities about performing operations involving polynomials.

A. Find the term that makes each statement true. An example is done for you.

Example:

Given : $-8a + \_\_\_\_ = 4a$

Solution : We need to determine what should be written on the blank in order to make the statement correct. So, we have

$-8a + \_\_\_\_ = 4a$

$-8a + \_\_\_\_ + 8a = 4a + 8a$ Add 8a to both sides of the equation to eliminate -8a at the right side of the equation.

$\_\_\_\_ = 12a$ Combining like terms.

This means that we need to write $12a$ on the blank in order to make the statement correct.

Answer : $-8a + \underline{\mathbf{12a}} = 4a$

1. $(-6a) + \_\_\_ = 2a$
2. $5m + (-9m) + \_\_\_ = 2m$
3. $4ab - \_\_\_ = 2ab$
4. $3x + \_\_ + (-5x) = 2x$
5. $(-6xy^2) - 10xy^2 = \_\_\_\_$
6. $3y^2 + \_\_\_ + (-2y^2) = 5y^2$
7. $(-2xy) + (-8xy) + \_\_\_ = 3xy$
8. $(-3c) - (5c) = \_\_\_\_\_\_$
9. $10x^2 - \_\_\_ = 5x^2$
10. $8b + (-4b) + \_\_\_ = 5b$

B. sssTell whether the given statement is True or False. Write True if the statement is correct. Otherwise, write False. Write your answer on a separate sheet.

1. $3^2 \cdot 3^4 = 9^6$
2. $4^2 \cdot 4^4 = 4^8$
3. $(x^2)^3 = x^8$
4. $(2^3 \cdot 3^2)^2 = 6^{12}$
5. $(m^2)^2 = (m^6)^3$
6. $-7^2 = -49$
7. $(t^3)^2 = t^9$
8. $(2^2 \cdot 4)^3 = 2^{12}$
9. $(4 + 5) = 3^4$
10. $(3 + 4)^2 = 3^2 + 4^2$

C. Perform the indicated operations. Choose your answer inside the box.

$-24y^6$	$2x+1$	$x-3$
$12x^5y^5$	$x^2-6x+27$	$2x^2-x-6$
$x-4$	x^2+5x+6	$36x^3-61x^2-72x-15$
$8x^2y+4xy^2$	$x^2+6x-27$	$6x^5-21x^4-24x^3$

1. $(3x^2y^3)(4x^3y^2)$
2. $(3y^2)(-2y)(4y^3)$
3. $(3x^3)(2x^2-7x-8)$
4. $(x+3)(x+2)$
5. $(x-3)(x+9)$
6. $(4x^2-9x-3)(9x+5)$
7. $(2x^2-3x-2)\div(x-2)$
8. $(8x^3-4x^2-24x)\div 4x$
9. $(x^2-8x+16)\div(x-4)$
10. $(x^2-9)\div(x+3)$

Good job! Get ready for another learning battle ahead!

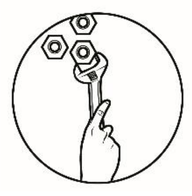
What I Have Learned

Write the correct word or phrase make the statement true. Choose your answer inside the box.

1	numerical coefficient	general	standard form
add	Distributive Property	literal coefficient	subtract
Associative Property	divisor	positive	subtrahend

1. To add like polynomials, add their ___________________ and copy the ___________________.
2. To subtract a polynomial from another polynomial, change the sign of the ___________________ and proceed to addition.
3. To multiply powers having the same base, keep the base and ___________________ the exponents.
4. To divide powers having the same base, keep the base and ___________________ the exponents.
5. Any number, excluding zero, raised to zero is always equal to ___________________.
6. To multiply a monomial by a polynomial with more than one terms, we will make use of ___________________.
7. In dividing polynomials by a monomial, divide each term in the dividend by the ___________________.
8. In dividing polynomial with more than one term by another polynomial with more than one term, the first thing that we are going to do is to see to it that both dividend and the divisor are in ___________________.

Nice work! Now you're up for the next challenge of this lesson.



What I Can Do

Here is another activity that will let you apply what you have learned about performing operations on polynomials by simplifying it to real-life situations.

Solve the following problems.

1. The three sides of a triangle measures $(3x^2 + x - 2)$, $(-5x^2 + 4)$ and $(15x^2 - 4x - 9)$ respectively. What is the perimeter of the triangle?
2. There are $(12a^2 + 4a + 15)$ children in a classroom. If the number of boys is $4a^2 - 9a + 8$, how many girls are in the classroom?
3. John Ike made a layout of the garden where he planned to put his Aglonema and Sanseveria Plants for business. In order to protect his plants from direct sunlight, he needs to cover the garden with nets on top of it. To determine the dimensions of the net he needs to buy to cover the top of a garden, he must be able to compute the area of the garden first. The length of the garden is x^5 and its width is x^3. What expression represents the area of the garden? (*Hint: The area of a rectangle is A = lw)*
4. Yvanna has a square garden with a side of length s feet. If she increases the length by 5 feet and then decreased the width by 2 feet, what trinomial represents the area of the new rectangular garden?

Assessment

For you to determine how much you've learned, please answer the questions by choosing the letter of the best answer.

1. What should be added to $5a + 2$ to get a sum of $10a^2 + 4$?
   A. $5a + 2$
   B. $5a^2 + 2$
   C. $10a^2 + 5a + 2$
   D. $10a^2 - 5a + 2$
2. What is the sum of $3a^2 - 5a + 2$ and $a^2 - 2a + 4$?
   A. $3a^2 + 7a + 6$
   B. $3a^2 - 7a + 6$
   C. $4a^2 + 7a + 6$
   D. $4a^2 - 7a + 6$
3. What must be added to $5b - 3$ to obtain 0?
   A. $-5b - 3$
   B. $-5b + 3$
   C. $5b - 3$
   D. $5b + 3$
4. If the length of the rectangle in terms of x is $8x^2 + 4x + 7$ and its width is $7x + 8$, what is the perimeter of the rectangle?
   A. $16x^2 + 22x + 30$
   B. $16x^4 + 22x^2 + 30$

C. $16x^2 + 30x + 15$
D. $16x^4 + 22x^2 + 15$

5. What must be subtracted from $9x^2 - 2x$ to make a difference of $5x^2 + 3$?
   A. $4x^2 - 2x - 3$
   B. $4x^2 + 2x + 3$
   C. $4x^2 - x - 3$
   D. $4x^2 + x - 3$
6. Which of the following illustrates the law $(a^n)^m = a^{nm}$?
   A. $(2^3)^8 = 2^{24}$
   B. $(3^2)^4 = 3^{2+4}$
   C. $(x^4)^2 = x^{4-2}$
   D. $(2^2)^4 = 4^{(2)(4)}$
7. Which of the following expressions when simplified is equal to 1 ?
   A. $(4a^5)^0$
   B. $(5a^0)^2$
   C. $\frac{3^2}{3^0}$
   D. 0^3
8. Which of the following statements follows the law: $\frac{a^n}{a^m} = a^{n-m}$?
   A. $\frac{2^6}{3^4} = 6^2$
   B. $\frac{2^3}{2^4} = 2$
   C. $\frac{3^4}{3^2} = 9$
   D. $\frac{3^2}{3^4} = 9$

9. Which of the following is the result when $(3a^2b^3)$ is multiplied to $(4a^3b^2)$?
   A. $12a^6b^6$
   B. $12a^5b^5$
   C. $7a^5b^5$
   D. $7a^6b^6$
10. Which of the following laws of exponents will be useful in simplifying the expression: $(\frac{b^5}{b^3})^3$?

    I. $(a^n)^m = a^{nm}$ III. $\frac{a^n}{a^m} = a^{n-m}$
    II. $a^n \cdot a^m = a^{n+m}$ IV. $a^{-n} = \frac{1}{a^n}$

    A. I and II
    B. II and IV
    C. III and IV
    D. I and III
11. What is the simplified form of $(4^0)(5^2)(6^1)(100^0)$?
    A. 1
    B. 10
    C. 25
    D. 150
12. What is the result when $(x - 5)$ is multiplied to $(x + 5)$?
    A. a multinomial
    B. a trinomial
    C. a binomial
    D. a monomial

13. Which of the following is the quotient when $(x^2 + 8x + 15)$ is divided by $(x + 5)$?
    A. $x + 3$
    B. $x + 5$
    C. $x + 5 + \frac{3}{x+5}$
    D. $x + 3 + \frac{5}{x+3}$

14. The product of $4x^2y^5$ and a certain monomial is $28x^7y^9z^2$. What is the missing factor?
    A. $7x^9y^{14}z^2$
    B. $7x^5y^2z^2$
    C. $7x^5y^4z^2$
    D. $7x^5y^4$

15. The length and width of the top of the rectangular study table is represented by the expression $(x + 5)$ meter and $(x + 3)$ meter, respectively. What is the area of the top of the table?
    A. $x^2 + 15\ square\ meter$
    B. $9x + 15\ square\ meter$
    C. $x^2 + 8x + 15\ square\ meter$
    D. $x^2 + 15x + 8\ square\ meter$

Good Job! You did well on this module! Keep going!

Additional Activities

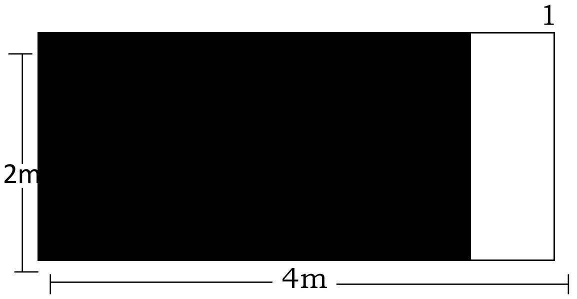
This section includes supplementary activities related to operations involving polynomials.

Do the following activities.

1. Use tiles to illustrate the sum of the following expressions.

   a. $5x + 2x$
   c. $(x - 1) + (x + 2)$
   b. $3x^2 + 4x - x$
   d. $(x^2 - 2x + 3) + (x^2 + 2x - 5)$

2. Write an expression for the area of the shaded region below. Choose the answer inside the box opposite to the figure.

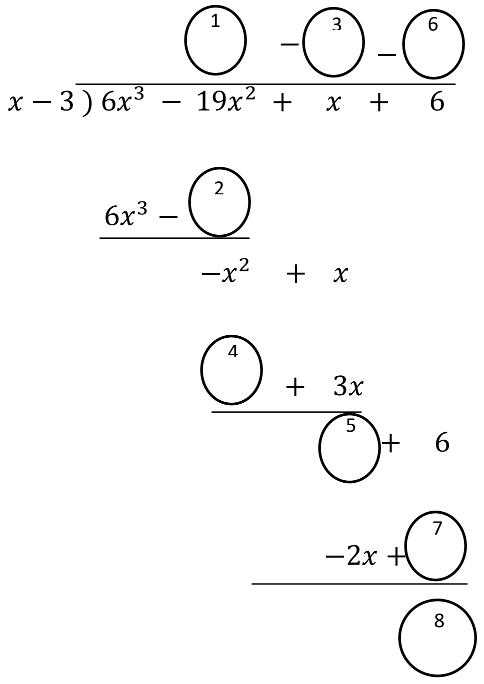


   A. $8m^2 + 2m$
   B. $8m^2 - 2m$
   C. $8m^2 + 4m$
   D. $8m^2 - 4m$

   Answer: ________________________

3. Supply the missing term in B that will make the division procedure in A correct.

A



B

A. $-2x$
B. 6
C. $6x^2$
D. 0
E. $-x$
F. -2
G. $18x^2$
H. $-x^2$

Answer Key

What I Know

1. A
2. C
3. B
4. A
5. B
6. A
7. D
8. B
9. A
10. D
11. D
12. C
13. A
14. D
15. D

What's In

Activity 1:
PHIDIAS

Activity 2:
1. A
2. D
3. D
4. A
5. D
6. A
7. D
8. D

What Is It

Activity 3.1
1. 9
2. 64
3. 125
4. 8
5. 16
6. 32

Activity 3.2
3.$3 \cdot 3 \cdot 3 \cdot 3, 81$
4.$2^2 \cdot 2^2 \cdot 2^2, 64$

Activity 3.3
2. $x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x,$ x^9
3. $3^5, 243$
4. $2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot$ 2, 2^9

Activity 3.4
2. $\frac{243}{27}, 3^2$
3. 4

What's More

A.1. $8a$
2. $6m$
3. $2ab$
4. $4x$
5. $-16xy^2$
6. $4y^2$
7. $13xy$
8. $-8c$
9. $5x^2$
10. b

B.1. False
2. False
3. False
4. False
5. False
6. True
7. False
8. True
9. False
10. False

C.1. $12x^5y^5$
2. $-24y^6$
3. $6x^5 - 21x^4 - 24x^3$
4. $x^2 + 5x + 6$
5. $\mathbf{x^2 + 6x - 27}$
6. $\mathbf{36x^3 - 61x^2 - 72x - 15}$
7. $\mathbf{2x + 1}$
8. $\mathbf{2x^2 - x - 6}$
9. $\mathbf{x + 2 + \frac{4}{x-4}}$
10. $\mathbf{x - 3}$

What I Have Learned

1. numerical coefficient, literal coefficient
2. subtrahend
3. add
4. subtract
5. 1
6. Distributive Property
7. divisor
8. standard form

What I Can Do

1. $13x^2 - 3x - 7$
2. $8a^2 + 13a + 7$
3. x^8
4. $s^2 + 3s - 10$

Assessment

1. D
2. D
3. B
4. A
5. A
6. A
7. A
8. C
9. B
10. D
11. D
12. C
13. A
14. C
15. C

Additional Activities

1. a. $7x$
   b. $3x^2 + 3x$
   c. $2x + 1$
   d. $2x^2 - 2$
2. B

3. 1. C
   2. G
   3. E
   4. H
   5. A
   6. F
   7. B
   8. D

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