MISSISSIPPI DEPARTMENT OF EDUCATION

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MISSISSIPPI

EXEMPLAR Units & Lessons

MATHEMATICS

Grade 6

Grant funded by:

W.K. KELLOGG FOUNDATION

Lesson 5: Small Groups/Stations – Exponents and Order of Operations

Focus Standard(s): 6.EE.1, 6EE.2

Standards for Mathematical Practice: SMP.1, SMP.3, SMP.6, SMP.7

Estimated Time: 120 min

Resources and Materials:

- Chart paper
- Index cards
- Copy paper
- Colored pencils
- Glue
- Handout 5.1: Order of Operations 4x4 Square
- Handout 5.2: Birthday Math Problem
- Handout 5.3: Krypto as Order
- Handout 5.4: Order of Operations Hot Potato
- Handout 5.5: Find the Teacher's Mistakes!
- Handout 5.6: Exponents Galore
- Handout 5.7: Krypto Math Rules

Learning Target(s):

- Students will evaluate numerical expressions involving whole-number exponents.
- Students will evaluate numerical expressions using the order of operations.
- Students will identify and correct calculation errors when evaluating numerical expressions.

Guiding Question(s):

- What pattern is evident in numbers with exponents?
- Why is it important to use a specific order when evaluating numerical expressions?

Vocabulary	
Academic Vocabulary: • Base • Cubed • Exponent • Numeric expression • Squared	**Instructional Strategies for Academic Vocabulary:** ☐ Model how to use the words in discussion. ☐ Read and discuss the meaning of word in a mathematical context ☐ Students write/discuss using the words

Symbol	Type of Text and Interpretation of Symbol
	Instructional support and/or extension suggestions for students who are EL, have disabilities, or perform well below the grade level and/or for students who perform well above grade level.
✓	Assessment (Pre-assessment, Formative, Self, or Summative)

Instructional Plan

Understanding Lesson Purpose and Student Outcomes: Students will evaluate exponential expressions, work in centers to complete stations to practice exponents and order of operations, and work independently to complete an exponent task.

Anticipatory Set/Introduction to the Lesson:
Display the following on the board:

A. $7 + 7 \times 2 + 2^2$ B. $5^2 - 12 - 12 + 4 = 25$
C. $2^3 \times 2 + 9 \div 3 - 2$ D. $5 \times 5^2 \div 5$

Instruct students to find which expressions have equivalent values and justify their answers (SMP.6). For those that do have equivalent values (A & D), ask students to see if they can do two or more operations simultaneously and still have a value of 25. Call on students to demonstrate their work on the board. Discuss students' work and clarify any misconceptions.

Activity 1: **Exponent/Order of Operations Stations**
Assign students to small groups and arrange centers and number of centers to fit your classroom.

- ✓ **Station 1 - Handout 5.1: Order of Operations 4 x 4 Square**. Students work independently to complete a 4x4 square. On scratch paper, students solve the numerical expressions on their cards (SMP.1). Students match the numerical expression sides with the corresponding value side of another square. Glue the completed 4x4 square to a piece of copy paper.

For students who are EL, have disabilities, or perform well below the grade-level:
- Students will use order of operations cards to help solve the numerical expressions.

Extensions for students with high interest or working above grade level:
- Students will create additional squares using blank squares that will connect with the outside edges.

Note: The template is the key as well. Before the lesson, cut out enough templets for each student.

- ✓ **Station 2 - Handout 5.2: Birthday Math Problem.** Students create a math problem where the solution is their birthday (month and day only). The students in the group will use the rubric to solve for each group member's birthday (SMP.3).

- ✓ **Station 3 - Handout 5.3: Krypto As Order.** Students write numerical expressions using the Order of Operations. Students will be given numbers to use for their numerical expressions and a target value. Students may use all four operations, exponents, parentheses, and brackets (SMP.6).

- ✓ **Station 4 - Handout 5.4: Order of Operations Hot Potato.** Distribute different colored pencils or pens to students. Students pass around a list of numerical expressions to find the value of the expression. Each student checks the work of a previous player and completes one step in the expression (SMP.3). Play continues until all the numerical expressions have been solved. Tell students to write their name with their colored pencil on the back of the Hot Potato page.

- ✓ **Station 5 – Handout 5.5: Find the Teacher's Mistakes!** Following the order of operations, students analyze the teacher's work for evaluating numerical expressions and identify steps that are incorrect. Students correctly evaluate the same expressions and show their calculations.

- ✓ **Station 6 – Handout 5.6: Exponents Galore** Students complete a worksheet using their knowledge of bases and exponents to solve problems (SMP.7).

Reflection and Closing:

- ✓ Facilitate a whole group discussion with prompting questions.
  Prompting questions:
  - Why is it important to show every step when evaluating numerical expressions?
  - Will you always get the same answer if you combine operations?

Exit Ticket

Tell students to complete the exit ticket and reflect on the week's activities.

3: List three things you learned this week.
2: List two questions you still have regarding this topic.
1: List one thing you would like to learn next week.

Homework
No homework.

Handout 5.1: Order of Operations 4x4 Square

ARI Curriculum Companion – Using Order of Operations and Exploring Properties

	$24 \div 5 + 3$			$44 \div 6^2 + 1$			$(36 + 4) \div 12$			$5^2 \div 2 + 4$	
43		$16 - 2 \cdot 6 + 1$	5		$5 \cdot 2 + 4 \div 2$	12		$(2^2 + 6) + 5$	2		$(5 \cdot 2) + 3$
	15			8			11			2	
	$(6 - 2)^2 - 1$			$7 + 15 \div 3 - 4$			$21 - 5 \cdot 2$			$24 \div (6 \cdot 2)$	
52		$25 \div (4 + 1)$	5		$(2 \cdot 3)^2 - 25$	11		$(24 \div 6) + (2 \cdot 5)$	14		$(4 \cdot 7) - 6$
	8			16			8			37	
	$30 \div (1 + 4) + 2$			$4 \cdot 3 + 8 \div 2$			$24 \div 6 \cdot 2$			$(8 + 4) \cdot (1 + 2) + 1$	
28		$(5^2 + 3) \div 2$	14		$(6 - 2) \cdot 1 + 6$	10		$4 + 6^2 \div 2$	22		$2 \cdot 9^2 + 13$
	3			36			9			14	
	$6 - (2^2 - 1)$			$(30 \div 1) + (4 + 2)$			$8 + 4 \div (1 + 2 + 1)$			$36 \div 6 + 2 \cdot 4$	
31		$14 + 1 - 6 + 3$	13		$7 - (2 \cdot 6) + 2$	1		$6 + 5 \cdot 4 - 2$	24		$17 + 6 + 3$
	64			69			72			12	

Handout 5.2: Birthday Math Problem

Name: _____ Date: _____

Create a math problem where the solution is your birthday (month and day only). For instance, Carlos was born on January 31th (1/31). He could create the following math problem:

$$10^2 + 7(2+2) + 3$$
$$10^2 + 7(4) + 3$$
$$100 + 7(4) + 3$$
$$100 + 28 + 3$$
$$128 + 3$$
$$131$$

It must have each of the following:

• Parentheses	20 points
• Exponent	20 points
• Three different operations	20 points
• The answer MUST be your birthday.	15 points
• It must be neat!	10 points
• You must show your work.	10 points
• It must have your name.	5 points
• TOTAL:	100 points

Your Work Here:

Handout 5.3: Krypto as Order

Name: _____ Date: _____

There is a certain order in which operations must be performed when evaluating expressions. Solve the following Krypto challenges. Use the cards listed for each problem and write a numerical expression with the value of the target number. Explain your solution to a partner, and then record your solution below the challenge. Be sure to use the order of operations when writing your expressions. Use parentheses or other grouping symbols to make sure that your expression is correct!

1. Cards: 1, 2, 4, 5, 6
   Target Number: 7

   _____= 7

2. Cards: 1, 3, 7, 12, 20
   Target Number: 12

   _____= 12

3. Cards: 2, 3, 6, 9, 17
   Target Number: 17

   _____= 17

4. Cards: 2, 4, 9, 11, 22
   Target Number: 11

   _____= 11

5. Cards: 2, 6, 7, 17, 21
   Target Number: 14

   _____= 14

6. Cards: 2, 4, 5, 8, 16
   Target Number: 10

   _____= 10

7. Cards: 3, 3, 4, 12, 21
   Target Number: 7

   _____= 7

8. Cards: 2, 11, 15, 17, 24
   Target Number: 8

   _____= 8

9. Cards: 4, 7, 11, 15, 19
   Target Number: 17

   _____= 17

10. Cards: 3, 11, 18, 23, 25
    Target Number: 19

    _____= 19

Handout 5.4: Order of Operations Hot Potato

Directions: Begin with numerical expression #1. First player calculates the first step then passes the page to the next player. The next player can either correct the previous work or continue with the next step. Each player checks the work of the previous players. When one expression has been solved, start on the next one.

#1) $13 + (7 \div 7) \cdot 6$	#6) $96 \div 6 + [97 - (12 \cdot 4)]$
#2) $19 + (27 \cdot 2) \div 3$	#7) $[(3^2 - 2 + 1)5] \cdot \frac{1}{2}$
#3) $85 - 6(3^2 - 2) + 1.8$	#8) $2.08 \cdot \frac{1}{4} \div 2 + 6$
#4) $12^2 \div 4 + 2 \cdot 5$	#9) $2(8^2 \div 4 \cdot \frac{1}{2})$
#5) $7 \cdot (9 + 3) + (8.8 \div 4)$	#10) $16 + [6\ (30 \div 5)]2$

Handout 5.4: Order of Operations Hot Potato - Key

1) $13 + (7 \div 7) \cdot 6$ $13 + 1 \cdot 6$ $13 + 6$ 19	#6) $96 \div 6 + [97 - (12 \cdot 4)]$ $96 \div 6 + [97 - 48]$ $96 \div 6 + 49$ $16 + 49$ 65
#2) $19 + (27 \cdot 2) \div 3$ $19 + 54 \div 3$ $19 + 18$ 37	#7) $[(3^2 - 2 + 1)5] \cdot \frac{1}{2}$ $[(9 - 2 + 1)5] \cdot \frac{1}{2}$ $[(7 + 1)5] \cdot \frac{1}{2}$ $[(8)5] \cdot \frac{1}{2}$ $40 \cdot \frac{1}{2}$ 20
#3) $85 - 6(3^2 - 2) + 1.8$ $85 - 6(9 - 2) + 1.8$ $85 - 6(7) + 1.8$ $85 - 42 + 1.8$ $43 + 1.8$ 44.8	#8) $2.08 \cdot \frac{1}{4} \div 2 + 6$ $0.52 \div 2 + 6$ $0.26 + 6$ 6.26
#4) $12^2 \div 4 + 2 \cdot 5$ $144 \div 4 + 2 \cdot 5$ $36 + 2 \cdot 5$ $36 + 10$ 46	#9) $2(8^2 \div 4 \cdot \frac{1}{2})$ $2(64 \div 4 \cdot \frac{1}{2})$ $2(16 \cdot \frac{1}{2})$ $2(8)$ 16
#5) $7 \cdot (9 + 3) + (8.8 \div 4)$ $7 \cdot (12) + (8.8 \div 4)$ $7 \cdot (12) + (2.2)$ $84 + 2.2$ 86.2	#10) $16 + [6\ (30 \div 5)]2$ $16 + [6\ (6)]2$ $16 + [36]2$ $16 + 72$ 88

Handout 5.5: Find the Teacher's Mistakes!

Name: _____ Date: _____

Directions: Find and circle all the mistakes for the expressions in the cells in the left column. In the right column, correctly evaluate the numerical expressions.

#1)	$133 \div (8 - 7) + 12$ $133 \div 1 + 12$ $133 \div 13$ $10\frac{3}{13}$	#1)
#2)	$(12- 2) \cdot 4^2 - 6$ $10 \cdot 4^2 – 6$ $10 \cdot 16 – 6$ $10 \cdot 10$ 100	#2)
#3)	$(4 + 36 \div 4) + 4^2 \div 2$ $(40 \div 4) + 4^2 \div 2$ $10 + 4^2 \div 2$ $10 + 16 \div 2$ $26 \div 2$ 13	#3)
#4)	$2 + (5 \cdot 4) - 7 + 2$ $2 + 20 - 7 + 2$ $22 – 7 + 2$ $22 – 9$ 13	#4)
#5)	$10 \cdot 2 + (5^3 \cdot 2) + 60 \div 10$ $10 \cdot 2 + (125 \cdot 2) + 60 \div 10$ $10 \cdot 2 + 250 + 60 \div 10$ $10 \cdot 2 + 310 \div 10$ $10 \cdot 312 \div 10$ $3120 \div 10$ 312	#5)

Handout 5.5: Find the Teacher's Mistakes! – Key (Mistakes are highlighted)

#1)	$133 \div (8 - 7) + 12$ $133 \div 1 + 12$ $133 \div 13$ $10\frac{3}{13}$	#1)	$133 \div (8 - 7) + 12$ $133 \div 1 + 12$ $133 + 12$ 145
#2)	$(12- 2) \cdot 4^2 - 6$ $10 \cdot 4^2 - 6$ $10 \cdot 16 - 6$ $10 \cdot 10$ 100	#2)	$(12- 2) \cdot 4^2 - 6$ $10 \cdot 4^2 - 6$ $10 \cdot 16 - 6$ $160 - 6$ 154
#3)	$(4 + 36 \div 4) + 4^2 \div 2$ $(40 \div 4) + 4^2 \div 2$ $10 + 4^2 \div 2$ $10 + 16 \div 2$ $26 \div 2$ 13	#3)	$(4 + 36 \div 4) + 4^2 \div 2$ $(4 + 6) + 4^2 \div 2$ $10 + 4^2 \div 2$ $10 + 16 \div 2$ $10 + 8$ 18
#4)	$2 + (5 \cdot 4) - 7 + 2$ $2 + 20 - 7 + 2$ $22 - 7 + 2$ $22 - 9$ 13	#4)	$2 + (5 \cdot 4) - 7 + 2$ $2 + 20 - 7 + 2$ $22 - 7 + 2$ $15 + 2$ 17
#5)	$10 \cdot 2 + (5^3 \cdot 2) + 60 \div 10$ $10 \cdot 2 + (125 \cdot 2) + 60 \div 10$ $10 \cdot 2 + 250 + 60 \div 10$ $10 \cdot 2 + 310 \div 10$ $10 \cdot 312 \div 10$ $3120 \div 10$ 312	#5)	$10 \cdot 2 + (5^3 \cdot 2) + 60 \div 10$ $10 \cdot 2 + (125 \cdot 2) + 60 \div 10$ $10 \cdot 2 + 250 + 60 \div 10$ $20 + 250 + 60 \div 10$ $20 + 250 + 6$ $270 + 6$ 276

Handout 5.6: Exponents Galore

Name: _____ Date: _____

Identify the base and exponent in each expression, write in expanded form, and find the value.

1. 15^2

Base = _____

Exponent = _____

Expanded form = _____

Standard form = _____

2. 7^5

Base = _____

Exponent = _____

Expanded form = _____

Standard form= _____

Solve the problems.

Jonna is making tiles for a mosaic. She notices a pattern of the area of the mosaic as she increases the side length.

3. These data can be shown in a table. Complete the table.

Length of Side	1	2	3	4	5	6
Area of Square	1	4	9			

4. Write an expression using an exponent to show the area of the mosaic if the length of the side is 8.

_____

5. What would the area of the mosaic be if the side length is 10 tiles??

_____

6. There is a mathematical meaning to the word *googol.* To represent a googol as a number, you write the digit 10 followed by 100 zeros. How can you represent a googol using an exponent?

_____

7. Tammy says that if *a* is a positive integer, a^3 is always greater than a^2. William says that is not true. Who is correct? Explain your answer.

_____

_____

8. What is the value of 10^1? _____

Handout 5.6: Exponents Galore - Key
Identify the base and the exponent in each expression.

1. 15^2

Base = ___15_____

Exponent = __2___

Expanded form = __15 x 15___

Value = ___125____

2. 7^5

Base = __7__

Exponent = __5____

Expanded form = _7 x 7 x 7 x 7 x 7_

Value = __16,807____

Solve the problems.

Jonna is making tiles for a mosaic. She notices a pattern of the area of the tiles as she increases the side length.

3. These data can be shown in a table. Complete the table.

Number of hours	1	2	3	4	5	6
Number of bacteria	1	4	**9**	**16**	**25**	**36**

4. Write an expression using an exponent to show the area of the mosaic if the length of the side is 8.

_____8^2_____

5. What would the area of the mosaic be if the side length is 10 tiles??

_____100 sq tiles_____

6. There is a mathematical meaning to the word *googol.* To represent a googol as a number, you write the digit 10 followed by 100 zeros. How can you represent a googol using an exponent?

Answer __**10^{100}**__

7. Tammy says that if *a* is a positive integer, a^3 is always greater than a^2. William says that is not true. Who is correct?

Answer __**William, because 1^3 and 1^2 are both equal to 1. One times anything is equal to 1 – the Identity Property of Multiplication .**

8. What is the value of 10^1?

Answer__**10**__

Handout 5.7: Krypto Math Rules

The game of Krypto is played with a deck of 52 cards: three each of the numbers 1 to 10, two each of the numbers 11 to 17, and one each of the numbers 18 to 25.

Sets of Krypto cards — including Primary Krypto (only numbers from 1 to 10) and the Fraction Supplement — can be purchased from MPH Games, Inc., P.O. Box 1125, Fairfield, CT 06432. They can also be ordered from Amazon and other online retailers.

Playing the Game

In the center of the table, deal five playing cards, number side up. Then turn over a sixth card which is the Target Card. Each player will add, subtract, multiply, or divide using each of the numbers on the five playing cards. Fractions, decimals, negative numbers, roots, and exponents are not permitted. Each card must be used once and only once to obtain a final solution equal to the number on the Target Card.

Example 1

Playing Cards: 2, 1, 2, 2, 3 Target Card: *20*

$2 + 1 = 3$
$3 \times 3 = 9$
$9 \times 2 = 18$
$18 + 2 = 20$

Notice that the numbers on all five playing cards were used once and only once to equal the target number.

Example 2

Playing Cards: 1, 3, 7, 1, 8 Target Card: *1*

$3 - 1 = 2$
$2 + 7 = 9$
$9 \div 1 = 9$
$9 - 8 = 1$

Example 3

Playing Cards: 24, 22, 23, 20, 21 Target Card: *1*

22 + 24 = 46
46 ÷ 23 = 2
2 + 20 = 22
22 – 21 = *1*

Krypto Strategies

There are many strategies that are helpful when playing Krypto. Several are given below, but you should try to find others.

Zero Strategy

When the number on the target card is equal to a number on a playing card, obtain a zero as one of the steps in the solution. Then, you can use the zero property of multiplication or the identity property of addition.

Examples of Zero Strategy

Playing Cards: 8, 10, 4, 8, 21 Target Card: *21*

8 – 8 = 0
0 × 10 = 0
0 × 4 = 0
0 + 21 = *1*

Even if the target number is not the same as one of the playing cards, zero can still be useful:

Playing Cards: 5, 2, 7, 21, 3 Target: *6*

7 × **3** =
21 – 21 =
0 + **2** =
2 × **3** =

One Strategy

Obtaining a one can also be helpful. Then, you can use the identity property of multiplication.
Example of One Strategy

Playing Cards: 6, 9, 5, 18, 3 Target Card: *14*

18 ÷ 3 = 6
6 ÷ 6 = 1
1 × 9 = 9
9 + 5 = *14*

Addition and Subtraction Strategy

Generally, it's easier to add and subtract than it is to multiply and divide. Therefore, looking for a solution that involves only addition and subtraction may allow to you find an answer more quickly.

Sometimes, it's not possible to find a solution that uses only addition and subtraction. Use this simple test:

1. Find the sum of all five values from the playing cards.
2. Compare the sum to the target number.
3. If one of them is odd and the other is even, then there is no solution that involves only addition and subtraction. But, if both are odd or both are even, there is a very good chance that a solution using only addition and subtraction exists.

Example of Addition and Subtraction Strategy

Playing Cards: 23, 5, 7, 9, 4 Target Number: *13*

- Sum of playing cards: 23 + 5 + 7 + 9 + 4 = 48 (even)
- Target number = 13 (odd)

The sum is even, and the target number is odd. Therefore, no solution exists that uses only addition and subtraction. Don't waste your time looking for one.

Playing Cards: 23, 5, 7, 9, 4 Target Number: *16*

- Sum of playing cards: 23 + 5 + 7 + 9 + 4 = 48 (even)
- Target number = 16 (even)

Both the sum and the target number are even, so it's likely that a solution involving only addition and subtraction exists. In fact, here is one such solution:

$$23 + 5 = 28$$
$$28 + 4 = 32$$
$$32 - 9 = 23$$
$$23 - 7 = \textit{16}$$

Modification for Beginners

Use only the cards numbered 1 to 10. The game of Primary Krypto actually contains cards with those values only. As skill levels increase, add the numbers 11 to 25.

Unsolvable Hands

It is possible to be dealt a hand without a solution.

For example, a hand with playing cards 1, 2, 3, 1, 2 and a target card of 23 cannot be solved. (You can get close, with $(1 + 2 + 1) \times 2 \times 3 = 24$, but it's not possible to get 23.)

However, an unsolvable hand is *very* rare. There are over 3,000,000 possible sets of five playing cards, and approximately 1,000 do not have a solution. Consequently, the chance of being dealt a hand without a solution is about 1 in 3,000. Because there are so few unsolvable hands, if you don't find a solution quickly, keep trying!

For training or questions regarding this unit,
please contact:

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