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| Date:  | Duration of Lesson:  2 class periods, but could be stretched longer |
| Title of Unit: Operations with Exponents | Title of Lesson: Exploring Exponents |
| Lesson Objectives: Students will analyze patterns to make generalizations about exponent rules.  Students will also communicate their analysis orally with their group and written through their summary. |
| Groupings (e.g., whole class, small groups, co-teaching): Whole class introduction and closure, small group investigation for the majority of the class. |
| Skills & Standards:  8. EE.A.1 - Know and apply the properties of integer exponents to generate equivalent numerical expressions.   |
| **Progression of Learning & Teaching**  |
| Opener:  | * Explain to the students that they will be looking at patterns and laying the foundation for learning in future math classes. If you want, you could answer the “when will we ever use this question” by explaining that the thinking skills of analysis and looking at patterns are the most important skills from this lesson.  You could also start with “What do you notice?  What do you wonder?” to get students to start really looking at the problems.
* Reemphasize that a large goal is analyzing patterns, but students will also be looking for ways to write problems with exponents more simply. How can I reference the learning targets throughout the lesson to remind students of the goal(s)?
* The goal of the lesson is conceptual understanding.  Teachers should give students a minute of quiet think time to think about how they would write out the first multiplication problem before working it together.  Do the same for the first division problem.  (Students generally have an easier time with the multiplication than the division, so the teacher should decide how much guiding to do with each problem before having students work on their own.)
* The teacher can use any warm-up they have.  Then give students about two minutes to complete the Review section of the worksheet.
 | **Points to Remember**  |
| Activities & Tasks:  |  **Instructional Lesson: *(include as much detail as needed for others to understand the lesson)***  * Student: (students start thinking about the problem on their own)
* I Do: Use the first few minutes for students to fill in the Review section of Part 1.  Stop as a class to make sure students have the vocabulary before letting them work in their groups.
* You do: (students share with a partner or a table)
* Students will use the bulk of class to work with a partner/small group to analyze patterns with exponents and work to generalize the patterns.
* Students usually see the patterns easily.  One place to watch out for is different bases.  Teachers will need to monitor and make sure that students are not combining different bases.
* We Do: Facilitate a class discussion
* Teachers can also be ready to provide simpler examples if needed.  You could ask students if 52 • 3 is the same as 152.
* Keep encouraging students to write out the expanded form, even if they don’t get to generalize.
* If not all students are ready to generalize, I would not go over the summary statements at the bottom of Part 1.  They can take more time if needed.

 You Do**:** Recommend not assign homework after Part 1 unless students didn’t finish.  There is independent practice after Part 2.   **Activities/Tasks:**  This lesson is designed to take more than 1 day.    Day 1/Part 1  The first page of Part 1 is a worksheet every student receives.  The second page could be used in different ways.  (a) A few of the problems could be added to the table to give every student the same examples.  (b) The problems could be cut up and put in an envelope.  Then groups could randomly draw different problems to add to their table.  Groups could share out at the end, compare with another group, teach a friend, etc. to go over the different problems.  The teacher could also put differentiate for groups based on the complexity of the problems.   Discuss the learning goal for the day, emphasizing the Mathematical Practices (detailed above) are as important (if not more so) as the math skills in this lesson.   The teacher should model at least one example for the multiplication and division before letting students work on their own.  If the teacher thinks the class is ready, they could type in the examples and have students discover the whole process.   After going over the Review section with the whole class, students work in pairs/small groups to think through the rest of the worksheet.   As groups are working, monitor for support needed, and to see how students are thinking about the math.  Decide if you will bring the whole class to the rule generalization today or not.   As most groups finish/the end of the period, bring the class back together.  Discuss the summary questions, taking the discussion as far as you would like today.   Day 2/Part 2   Part 2 can be done on the next day, or if you want your students to be more fluent with multiplying/dividing, it could be done on any subsequent day.   Part 2 is similar to Part 1.  You can launch today’s lesson by reminding them that we are looking for patterns and the Mathematical Practices they will use.     You may want to make sure students understand how to write out the Power to a Power expanded forms before letting groups work on their own.     Students will need more support with the tables for 0 and Negative Exponents.  Even with the examples, they often make the negative exponents into negative numbers.   As you’re monitoring, if enough students are having trouble with the table, stop there and have a class discussion.     As students finish the front, they should fill out the summary statements again.    The back of the Part 2 sheet is starting fluency practice.  The last page of the lesson has 9 problems you can cut apart and have students draw to fill in the More Examples table.  Then they can complete the Practice.   As the teacher, monitor groups and stop the class for a discussion where you see it needed.  The last Practice section could be completed for homework and/or used as a formative assessment.  | Resources: * [Three Act Math Task - Introducing Exponential Notation and Exponential Relations](https://tapintoteenminds.com/3act-math/penny-a-day/) ([Three Act Math Task How To](https://www.sfusdmath.org/3-act-tasks.html))
* [IM Tasks](https://tasks.illustrativemathematics.org/content-standards/8/EE/A/1) for 8. EE.A.1
* [Harvard Compare and Contrast](https://scholar.harvard.edu/contrastingcases/book/chapter-9-exponents)
* [Teaching Exponents using Concrete Models Video](https://www.youtube.com/watch?v=mtibM7r7XaU)

Vocabulary:  * Exponent - a symbol written above and to the right of a mathematical expression to indicate the operation of raising to a power
* Base - the total count of digits used to express numbers in a number system.
* Power - the product of multiplying a number by itself.

  Scaffolding/Differentiation: * Monitor the small groups as they are working.  Some groups will need more support than others.
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| Level of Cognitive Complexity:  | ☐ Creating ☐ Evaluating  ☐ Analyzing  | ☐ Applying ☐ Understanding ☐ Remembering  |
| Key questions:  | What do you notice?  Does everyone agree?  Could you write this more simply or in a shorter way?  Questions to get students to attend to different bases:  Is 22 • 3 the same as 62?  |
| Closure:  | The Summary questions are good closure discussion starters.  You could also give an exit slip asking one thing students understand well and one thing they are still confused on, or with a few problems to try.     |
| Next Steps:  | The next step is fluency practice.  You can also introduce problems with different bases and the same exponents for students to investigate.     There is also a great [Applying Properties of Exponents](https://www.map.mathshell.org/lessons.php?unit=8110&collection=8) lesson from Mathshell.  | **Formative Assessment Criteria for Success:**The lesson is divided into two parts, so formative assessment can be done after each part.  After Part 1, you can assess by seeing which students/groups were able to generalize the pattern into a rule.  After Part 2, you can assess through the summary and through the more practice problems.    |

**Exploring Exponents Part 1**

**Learning Goal:** I will use patterns to simplify expressions written with exponents through discussing problems with my partner and analyzing solutions with the class.

Review

1. Fill in the blanks with the following terms: *exponent, base, coefficient*

  ex) 7w5    7: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ w: \_\_\_\_\_\_\_\_\_\_\_\_\_\_ 5:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. What does $3^{4}$ mean?
2. What happens when there is the same number or numbers on the numerator and denominator of a fraction?

Ex)  $\frac{9 ∙ 9 ∙ 9 }{9 ∙ 9}$

**Write out each expression.  Simplify the like bases and rewrite each base with only one exponent.  Make sure you do at least 4 multiplication and 4 division problems.**

|  |  |
| --- | --- |
| Problem  | Expanded Form                                                              Simplified  |
| **Multiplication** $$4^{3} • 4 ^{2}$$$$7 • 3^{3}• 7 ^{5}$$    |   |
| **Division** $$\frac{5^{5}}{5^{2}}$$ $$\frac{8^{4}∙10^{2}}{8^{2}}$$      |  |

**Summary:**

Today I learned that when I multiply with exponents,

And I also learned that when I divide with exponents,

These problems can either be cut up for students to “draw,” added to the investigation before printing, or used in any other way.

23 • 24

74 • 72

42 • 93 • 92

83 • 62 • 64 • 82

25 • 43 • 34 • 42

$$\frac{7^{4}}{7^{3}}$$

 $$\frac{4^{5}}{4^{3}}$$

$$\frac{5^{3}⋅5^{2}}{5}$$

 $$\frac{2^{5}⋅6^{3}}{2^{2}⋅6^{2}}$$

$$\frac{3^{2}⋅9^{4}}{3^{5}⋅9}$$

**Exploring Exponents Part 2**

**Power to a Power**

|  |  |
| --- | --- |
| Problem  | Expanded Form                                                                         Simplified  |
| (23)4  |   |
| (45)2  |   |
| (32)3  |   |

**Power and Negative Exponents**

Look at the tables below.  What pattern is building in each?  Complete the tables by filling in the missing values.  Write your answers in fraction form when necessary.

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| --- | --- | --- |
| **Problem**  | **Expanded Form**  | **Simplified**  |
| 103  |   |   |
| 102  | 10 • 10  | 100  |
| 101  |   |   |
| 100  |   |   |
| 10-1  |   |   |
| 10-2  |   |   |
| 10-3  | $$\frac{1}{10∙10∙10}$$  | $$\frac{1}{1000}$$  |
| **Problem**  | **Expanded Form**  | **Simplified**  |
| 24  | 2 • 2 • 2 • 2  | 16  |
| 23  |   |   |
| 22  | 2 • 2  | 4  |
| 21  |   |   |
| 20  |   |   |
| 2-1  |   |   |
| 2-2  | $$\frac{1}{2∙2}$$  | $$\frac{1}{4}$$  |

**Summary:**

Today I learned that when a power is raised to a power, I can

And I also learned that anything to the 0 power is

And finally, I learned that I can make a negative exponent positive by

**More Examples:** Fill in the table with the examples from your group.  Make sure you have an example of all 5 types of problems (multiply, divide, power to a power, zero, and negative).

|  |  |
| --- | --- |
| Problem  | Expanded Form                                                                         Simplified  |
|   |   |
|   |   |
|   |   |
|   |   |
|   |   |
|   |   |
|   |   |

**Practice: Write with a single, positive exponent.**

1.  204•207 2.  (72)5 3.  40

4.  $\frac{12^{3}}{12^{2}}$ 5. 93•94 6.  (323)2

7.  6–2  8.  $\frac{5^{8}}{5^{4}}$ 9.  43•74 •42

10.  53•80 •5–1  11.  $\frac{5^{6}⋅5}{5^{2}}$ 12.  (143)0

1.  6–5  2.  (43)2 3.  93 •20

4.  $\frac{11^{4}⋅11}{11^{3}⋅7^{0}}$ 5.  82•54 •83  6.  $\frac{13^{6}⋅12}{13^{2}⋅12^{4}}$

7.  104 •8–6  8.  (47 •23)5 9.  153 •155