# Ohio ABLE Lesson Plan – Exponents

## Program Information

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<th>[Title of Lesson]</th>
<th>TEACHER NAME</th>
<th>PROGRAM NAME</th>
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<td>Exponents</td>
<td>Jolene Seuffert</td>
<td>Parma City School District</td>
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<th>[Unit Title]</th>
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## ABE/ASE Standards – Mathematics

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**Benchmarks identified in RED are priority benchmarks. To view a complete list of priority benchmarks and related Ohio ABLE lesson plans, please see the Curriculum Alignments located on the Teacher Resource Center (TRC).**

## Mathematical Practices (MP)

<table>
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<th>Make sense of problems and persevere in solving them. (MP.1)</th>
<th>Use appropriate tools strategically. (MP.5)</th>
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<td>□ Reason abstractly and quantitatively. (MP.2)</td>
<td>□ Attend to precision. (MP.6)</td>
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<td>□ Construct viable arguments and critique the reasoning of others. (MP.3)</td>
<td>□ Look for and make use of structure. (MP.7)</td>
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<td>□ Look for and express regularity in repeated reasoning. (MP.8)</td>
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| • Students will be able to recognize that some expressions can be rewritten utilizing exponents to condense and assist in evaluation.  
• Students will be able to simplify independent exponential functions and expressions with exponents.  
• Students will be able to demonstrate (85%) accuracy in simplifying exponential functions and expressions on lesson quiz. | Formative:  
• Verbal check-in with students as they are working on warm-up – i.e. circulating the groups as students are working out the problem. Gauge if students are discussing during warm-up or if extra directives are needed.  
  o Offer individual, group or class assistance if needed. For example, remind students of PEMDAS.  
  o Review concepts as a class for accuracy and areas of difficulty, if need-be.  
• Provide more practice problems in form of worksheets if group/individual needs more time. Select and print any worksheet deemed appropriate from www.math-drills.com. |

<table>
<thead>
<tr>
<th>LEARNER PRIOR KNOWLEDGE:</th>
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| • Terms: exponents, order of operations.  
• Math concepts: PEMDAS; math operations (addition, subtraction, multiplication, division). | Summative:  
• Collect quizzes and grade/check for accuracy.  
• If utilized, collect homework next class and grade.  
Next Steps:  
• Incorporate exponents into multistep algebraic equations or begin scientific notation.  
• Introduce scientific notation (under resources) – optional. |
### INSTRUCTIONAL ACTIVITIES

1. **Warm-up activity:** Pair students in groups of 3 or 4. Pose this problem on the board: \(3 \times 2 	imes 2 	imes 2 	imes 2 \times 2 - 4 \div 2\)

2. Have students solve the problem individually then share their solutions with the other members of their group. Groups should discuss and compare their answers and approaches for solving the problem.

3. Student groups should select one answer from the members that they feel is correct (or most likely to be correct). When all groups make a selection, have a student from each group write their selected answer on the board.

4. Teacher identifies correct answers or shares with class correct answer to problem. (The answer is 33 when utilizing order of operations). Provide students the opportunity to voice their misconceptions or issues in the solving process.

5. Using your own knowledge, introduce the term exponent to the students. (Optional definitions: a quantity that is raised by a power; or, a symbol that is written above to the right of a number to indicate how many times the number should be multiplied by itself).

6. Utilize a class volunteer, or do yourself – write an example of an exponent. Then have the class verbally indicate how to write it out. (Example: \(4^3\) is 4x4x4).

7. Refocus class’ attention to original warm-up problem. Inquire to the class if there is any part of the problem that can be re-written utilizing the exponent function. Write out \(3 \times 2^5 \div 4 \div 2\) on the board. Have students individually try to solve the problem. Discuss the difference solving the original problem versus the rewritten problem.

8. **Video Lesson** – play [MuchoMath Exponents video](https://www.youtube.com/watch?v=i_1Lvd8MVw). Teacher can play video to class via projector or students can watch the video individually on the computer using headphones. Alternatively, students can be paired to watch video together if space allows due to sound.

9. Teacher choice: distribute [Optional In-Class Practice Worksheet - Exponents](attached) to students and allow them to complete it either individually or, in the interest of differentiating for the varied levels in the class.

### RESOURCES

- White/chalkboard/chart paper (choose one)
- Student paper for in-class exercises
- Classroom projector with speakers that can hook up to a laptop/computer with internet for MuchoMath video lesson. Or, computer lab with sufficient internet accessible computers and headphones for students to watch MuchoMath video lesson independently or in pairs
- MuchoMath Exponents Video Lesson, accessible here: [https://www.youtube.com/watch?v=i_1Lvd8MVw](https://www.youtube.com/watch?v=i_1Lvd8MVw)
- Student copies of [Optional In-Class Practice Worksheet](attached)
- Student copies of [Exponent Quiz](attached)
  - Quiz 1 Exponents - Beginner
  - Quiz 2 Exponents - Advanced
- [Answer Key Quiz 1 Exponents - Beginner](attached)
- [Answer Key Quiz 2 Exponents - Advanced](attached)
- Student copies of [Teacher-Generated Supplemental Practice](attached) worksheets. Retrieved from: [http://www.k5learning.com/free-math-worksheets/sixth-grade-6/exponents](http://www.k5learning.com/free-math-worksheets/sixth-grade-6/exponents) (Teacher can utilize link to create a class appropriate worksheet. Site allows for teacher to...
classroom, in structured pairs which allow advanced students to work with struggling students.

10. Practice quiz: pass out *Exponents Quiz* (attached) based upon student comfort with concepts (either *Beginner* or *Advanced*). Allow students to complete quiz individually to gauge acquisition of knowledge.

11. Optional: pass out *Teacher-Generated Supplemental Practice* homework worksheets, which can be tailored to the class’s unique needs on the website [http://www.k5learning.com/free-math-worksheets/sixth-grade-6/exponents](http://www.k5learning.com/free-math-worksheets/sixth-grade-6/exponents) as extra take-home practice or homework.

12. Collect homework and grade/check for accuracy and understanding of new concepts.


**DIFFERENTIATION (options)**

- Distribute *Vocabulary Sheet - Exponents* with terms and definitions to students who appear to be struggling.
- Video lesson: teacher can play video on large screen for entire class; students can watch video individually on a computer.
- Pairing: students can be paired to watch the lesson together; (teacher preference to pair same level or low with high-level).
- Higher level option: advanced quiz, homework options via website in resources.
- Circulate room to provide additional assistance throughout activities/exercises.

Student copies of *Vocabulary Sheet – Exponents* (attached)


Student copies of *Scientific Notation Practice Worksheet* (attached)
In-Class Practice Worksheet

Exponents

The rule of exponents

1. \(2^2 \times 2^3 = 2 \times 2 \times 2 \times 2 \times 2 = \)

2. \(2^5 \div 2^3 = \frac{2 \times 2 \times 2 \times 2 \times 2}{2 \times 2 \times 2} = 2 \times 2 = \)

3. \((2^2)^3 = 2^2 \times 2^2 \times 2^2 = \)

The number being raised to a power (2 in this case) is called the base.
Note: You can only apply these rules to numbers involving the same base.
So, for example, you cannot apply the rules of exponents to \(3^2 + 2^3\)

Try these:

Ex1
\[2^4 \times 2^7 = \]

Ex2
\[3^8 \div 3^4 = \]

Ex3
\[(5^3)^6 = \]

Ex4

Ex5

Ex6

Negative Exponents

\[2^{-1} = \]

\[3^{-2} = \]

\[2^{-4} = \]

\[4^{-3} = \]

Now consider \(2^3 \times 2^{-3} = \)

But \(2^3 \times 2^{-3} = 8 \times \frac{1}{8} = \)

So,

And generally,
QUIZ 1: EXPONENTS

Name: _________________________________________________________________

Powers and Exponents

Express the following as an exponent:
$9\cdot 9 \cdot 9 \cdot 9 \cdot 9$

○ a) $9^5$
○ b) $9^3$
○ c) $5^9$
○ d) $5^5$

1. 

Powers and Exponents

Express the following as an exponent:
$-12 \cdot 12 \cdot a \cdot a \cdot a$

○ a) $-12^2 \cdot a^3$
○ b) $(-12)^3 \cdot a^3$
○ c) $-(12a)^5$
○ d) $-12^3 \cdot a^5$

2. 
### QUIZ 1 EXPONENTS

**Powers and Exponents**

Express the following as a product of terms:

\((-z)^3 \cdot 19^3\)

- a) \(- z\cdot z\cdot z \cdot 19 \cdot 19 \cdot 19\)
- b) \(- z\cdot z\cdot z \cdot 19 \cdot 19 \cdot 19\)
- c) \(- 3 \cdot 19 \cdot 19 \cdot 19\)
- d) \(- z\cdot z\cdot 19 \cdot 19\)

3. 

---

**Powers and Exponents**

Express the following as a product of terms:

\(8^2 \cdot x^2 \cdot 11^4\)

- a) \(8 \cdot 8 \cdot x \cdot x \cdot 11 \cdot 11 \cdot 11 \cdot 11\)
- b) \(8 \cdot x \cdot 11 \cdot 11 \cdot 11 \cdot 11\)
- c) \(8 \cdot 8 \cdot x \cdot x \cdot 11 \cdot 11 \cdot 11 \cdot 11\)
- d) \(8 \cdot 8 \cdot x \cdot x \cdot 11 \cdot 11 \cdot 11 \cdot 11\)

4. 

---
5. 

Powers and Exponents

Simplify the following:

$$6^3 \cdot 6^6$$

- a) $6^{24}$
- b) $6^{10}$
- c) $6^3$
- d) $10^6$

6. 

Powers and Exponents

Simplify the following:

$$z^2 \cdot z^3 \cdot y^2$$

- a) $z^5 \cdot y^2$
- b) $z^6 \cdot y^2$
- c) $5z \cdot 2y$
- d) $(zy)^7$
Powers and Exponents

Simplify the following:
\[
\frac{31^5}{31^4}
\]

- a) \(31^1\)
- b) \(31^0\)
- c) \(31^0\)
- d) \(31\)
ANSWER KEY – QUIZ 1 BEGINNER

1. B
2. A
3. A
4. D
5. B
6. D
7. B
MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

Simplify the expression. Use positive exponents. Assume variables represent nonzero real numbers.

1) $6^4 \cdot 6^5$
   A) $6^{20}$ \hspace{1cm} B) $6^9$ \hspace{1cm} C) $36^9$ \hspace{1cm} D) $36^{20}$
   1)

2) $(-5p^4)(-8p^3)$
   A) $40p^7$ \hspace{1cm} B) $40p^{12}$ \hspace{1cm} C) $-40p^{12}$ \hspace{1cm} D) $-40p^7$
   2)

Use the power rules for exponents to simplify. Write the answer in exponential form.

3) $(r^3)^5$
   A) $9r^5$ \hspace{1cm} B) $9r^5t$ \hspace{1cm} C) $95r^5t^5$ \hspace{1cm} D) $9r^5t^5$
   3)

4) $(3)^3$
   A) $3^6$ \hspace{1cm} B) $-39$ \hspace{1cm} C) $3^9$ \hspace{1cm} D) $-36$
   4)

Evaluate.

5) $(-11)^0 + (-3)^0$
   A) $-2$ \hspace{1cm} B) $-14$ \hspace{1cm} C) $0$ \hspace{1cm} D) $2$
   5)

Evaluate the expression.

6) $(-5)^{-4}$
   A) $-\frac{1}{625}$ \hspace{1cm} B) $625$ \hspace{1cm} C) $\frac{1}{625}$ \hspace{1cm} D) $-625$
   6)

Perform the division.

7) $\frac{(6m^2 + 13m - 15)}{(m + 3)}$
   A) $m - 5$ \hspace{1cm} B) $6m + 5$ \hspace{1cm} C) $6m - 5$ \hspace{1cm} D) $6m - 5 + \frac{4}{m - 5}$
   7)

Perform the indicated operation.

8) $(7 + 6x^3 + 8x^5 - 4x^4) + (-5x^4 + 2x^3 - 2 + 7x^5)$
   A) $2x^5 + 2x^4 + 6x^3 + 3$
   B) $15x^5 - 9x^4 + 8x^3 + 5$
   C) $14x^{24} + 5$
   D) $15x^{10} - 9x^8 + 8x^6 + 5$
   8)

9) $(4x^7 + 7x^9 + 6 - 2x^8) - (-5 - 5x^8 + 9x^9 + 8x^7)$
   A) $16x^9 - 7x^8 + 12x^7 + 1$
   B) $-2x^9 + 3x^8 - 4x^7 + 11$
   C) $16x^9 - 7x^8 + 12x^7 + 11$
   D) $-2x^9 - 7x^8 + 12x^7 + 1$
   9)
ANSWER KEY – QUIZ 2 ADVANCED

1. B
2. A
3. A
4. D
5. B
6. D
7. B
**Variables** – a factor or quantity that can vary, or change; represented in math by a letter such as x or y

**Numbers** – an arithmetical value expressed by a symbol or word, represents a quantity

**Operators** – addition, subtraction, multiplication, and division symbols

**Exponents** – a quantity representing the power a given number or expression is to be raised

**Parenthesis** – ( ), a pair of rounded brackets used to mark off a mathematical number or expression

**Expression** – numbers and symbols with operators (+, -, x, /) grouped together to show the value of something

**Algebraic Expression** – a mathematical phrase that contains numbers, variables and operators

**PEMDAS** – Acronym for “Please Excuse My Dear Aunt Sally” to help learners remember the order to work through/solve operations. The order of operations should be parenthesis first ( ); exponents second; multiplication and division third from left to right; and addition and subtraction last from left to right
Scientists need to express small measurements, such as the mass of the proton at the center of a hydrogen atom (0.000 000 000 000 000 000 000 000 001 673 kg), and large measurements, such as the temperature at the center of the Sun (15 000 000 K). To do this conveniently, they express the numerical values of small and large measurements in scientific notation, which has two parts.

A number in which only one digit is placed to the left of the decimal

\[ N \times 10^n \]

An exponent of 10 by which the number is multiplied

Thus, the temperature of the Sun, 15 million kelvins, is written as \(1.5 \times 10^7\) K in scientific notation.

**Positive Exponents** Express 1234.56 in scientific notation.

\[
\begin{align*}
1234.56 & \\
1234.56 \times 10^0 & = 123.456 \times 10^1 \\
123.456 \times 10^1 & = 12.3456 \times 10^2 \\
12.3456 \times 10^2 & = 1.23456 \times 10^3 \\
1.234 56 \times 10^3 &
\end{align*}
\]

Each time the decimal place is moved one place to the left, the exponent is increased by one.

**Negative Exponents** Express 0.006 57 in scientific notation.

\[
\begin{align*}
0.006 57 & \\
0.006 57 \times 10^0 & = 0.0657 \times 10^{-1} \\
0.0657 \times 10^{-1} & = 0.657 \times 10^{-2} \\
0.657 \times 10^{-2} & = 6.57 \times 10^{-3} \\
6.57 \times 10^{-3} &
\end{align*}
\]

Each time the decimal place is moved one place to the right, the exponent is decreased by one.
1. Express each of the following numbers in scientific notation.
   a. 230
   b. 5601
   c. 14 100 000
   d. 56 million
   e. 2/10
   f. 0.450 13
   g. 0.089
   h. 0.000 26
   i. 0.000 000 698
   j. 12 thousandth

2. Express each of the following measurements in scientific notation.
   a. speed of light in a vacuum, 299 792 458 m/s
   b. number of seconds in a day, 86 400 s
   c. mean radius of Earth, 6378 km
   d. density of oxygen gas at 0°C and pressure of 101 kPa, 0.001 42 g/mL
   e. radius of an argon atom, 0.000 000 098 m
Scientists very often deal with very small and very large numbers, which can lead to a lot of confusion when counting zeros! We have learned to express these numbers as powers of 10.

Scientific notation takes the form of $M \times 10^n$ where $1 \leq M < 10$ and "n" represents the number of decimal places to be moved. Positive n indicates the standard form is a large number. Negative n indicates a number between zero and one.

**Example 1:** Convert 1,500,000 to scientific notation.

We move the decimal point so that there is only one digit to its left, a total of 6 places.

$$1,500,000 = 1.5 \times 10^6$$

**Example 2:** Convert 0.000025 to scientific notation.

For this, we move the decimal point 5 places to the right.

$$0.000025 = 2.5 \times 10^{-5}$$

(Note that when a number starts out less than one, the exponent is always negative.)

Convert the following to scientific notation.

1. $0.005 = \underline{\hspace{2cm}}$
2. $5.050 = \underline{\hspace{2cm}}$
3. $0.0008 = \underline{\hspace{2cm}}$
4. $1.000 = \underline{\hspace{2cm}}$
5. $1,000,000 = \underline{\hspace{2cm}}$
6. $0.25 = \underline{\hspace{2cm}}$
7. $0.025 = \underline{\hspace{2cm}}$
8. $0.0025 = \underline{\hspace{2cm}}$
9. $500 = \underline{\hspace{2cm}}$
10. $5,000 = \underline{\hspace{2cm}}$

Convert the following to standard notation.

1. $1.5 \times 10^3 = \underline{\hspace{2cm}}$
2. $1.5 \times 10^{-3} = \underline{\hspace{2cm}}$
3. $3.75 \times 10^2 = \underline{\hspace{2cm}}$
4. $3.75 \times 10^2 = \underline{\hspace{2cm}}$
5. $2.2 \times 10^5 = \underline{\hspace{2cm}}$
6. $3.35 \times 10^{-1} = \underline{\hspace{2cm}}$
7. $1.2 \times 10^4 = \underline{\hspace{2cm}}$
8. $1 \times 10^4 = \underline{\hspace{2cm}}$
9. $1 \times 10^{-1} = \underline{\hspace{2cm}}$
10. $4 \times 10^0 = \underline{\hspace{2cm}}$
Operations with Scientific Notation

Addition and Subtraction
Before numbers in scientific notation can be added or subtracted, the exponents must be equal.

Not equal

Not equal

Equal

Equal

The decimal is moved to the left to increase the exponent.

(3.4 \times 10^2) + (4.57 \times 10^3) = (0.34 \times 10^3) + (4.57 \times 10^3)

= (0.34 + 4.57) \times 10^3

= 4.91 \times 10^3

Multiplication
When numbers in scientific notation are multiplied, only the number is multiplied. The exponents are added.

(2.00 \times 10^3)(4.00 \times 10^4) = (2.00)(4.00) \times 10^{3+4}

= 8.00 \times 10^7

Division
When numbers in scientific notation are divided, only the number is divided. The exponents are subtracted.

\[
\frac{9.60 \times 10^7}{1.60 \times 10^4} = \frac{9.60}{1.60} \times 10^{7-4}
\]

= 6.00 \times 10^3
1. Perform the following operations and express the answers in scientific notation.
   a. \((1.2 \times 10^5) + (5.35 \times 10^6)\)

   b. \((6.91 \times 10^{-2}) + (2.4 \times 10^{-3})\)

   c. \((9.70 \times 10^6) + (8.3 \times 10^5)\)

   d. \((3.67 \times 10^2) - (1.6 \times 10^1)\)

   e. \((8.41 \times 10^{-3}) - (7.9 \times 10^{-6})\)

   f. \((1.33 \times 10^5) - (4.9 \times 10^4)\)

2. Perform the following operations and express the answers in scientific notation.
   a. \((4.3 \times 10^8) \times (2.0 \times 10^6)\)

   b. \((6.0 \times 10^3) \times (1.5 \times 10^{-2})\)

   c. \((1.5 \times 10^{-2}) \times (8.0 \times 10^{-1})\)

   d. \([\frac{7.8 \times 10^3}{1.2 \times 10^4}]\)

   e. \([\frac{8.1 \times 10^{-2}}{9.0 \times 10^2}]\)

   f. \([\frac{6.48 \times 10^5}{(2.4 \times 10^4)(1.8 \times 10^{-2})}]\)
1. Express each of the following numbers in scientific notation.

- a. \(230 = 2.3 \times 10^2\)
- b. \(5001 = 5.001 \times 10^3\)
- c. \(14,100,000 = 1.41 \times 10^7\)
- d. \(60\) million \(= 6.0 \times 10^7\)
- e. \(310 = 2 \times 10^{-1}\)
- f. \(0.049\) 13 \(= 4.9 \times 10^{-1}\)
- g. \(0.009 = 9 \times 10^{-3}\)
- h. \(0.00036 = 3.6 \times 10^{-4}\)
- i. \(0.00000004 = 4 \times 10^{-8}\)
- j. \(12,000\) 12 thousandth \(= 0.0012 = 1.2 \times 10^{-3}\)

2. Express each of the following measurements in scientific notation.

- a. speed of light \(= 299,792,458 \text{ m/s} = 2.997 \times 10^8 \text{ m/s}\)
- b. number of seconds in a year \(= 365,250 \times 86,400 = 3.15 \times 10^7 \text{ s}\)
- c. mass of Earth \(= 5.97 \times 10^{24} \text{ kg}\)
- d. density of concrete at \(0^\circ\) \(= 1523 \text{ kg/m}^3 = 1.523 \times 10^3 \text{ kg/m}^3\)
- e. volume of an oxygen atom \(= 0.00000000008\) cm \(= 8.0 \times 10^{-10} \text{ cm}\)
SCIENTIFIC NOTATION

Scientists very often deal with very small and very large numbers, which can lead to a lot of confusion when counting zeros. We have learned to express these numbers in powers of 10. Scientific notation takes the form of \( m \times 10^n \) where \( m \) is a number between 1 and 10 and \( n \) represents the number of decimal places to be moved. Positive \( n \) indicates the standard form is larger than zero whereas negative \( n \) would indicate a number smaller than zero.

Example 1: Convert 1,000,000 to scientific notation.
We move the decimal point so that there is only one digit to the left, a total of 6 places.
\[ 1,000,000 = 1.0 \times 10^6 \]

Example 2: Convert 0.000025 to scientific notation.
For this, we move the decimal point 5 places to the right.
\[ 0.000025 = 2.5 \times 10^{-5} \] (Note that when a number starts out less than one, the exponent is always negative.)

Convert the following to scientific notation:
1. \( 0.005 = 5 \times 10^{-3} \)
2. \( 0.06 = 6 \times 10^{-2} \)
3. \( 0.0006 = 6 \times 10^{-4} \)
4. \( 1.2 = 1 \times 10^0 \)
5. \( 1,000,000 = 1 \times 10^6 \)
6. \( 2.5 \times 10^{-1} \)
7. \( 2.5 \times 10^{-2} \)
8. \( 2.5 \times 10^{-3} \)
9. \( 2.5 \times 10^{-4} \)
10. \( 2.5 \times 10^{-5} \)

Convert the following to standard notation:
1. \( 1.5 = 0.0015 \)
2. \( 1.5 = 0.0015 \)
3. \( 1.5 = 0.0015 \)
4. \( 1.5 = 0.0015 \)
5. \( 1.5 = 0.0015 \)
6. \( 3.0 = 0.335 \)
7. \( 1.2 = 0.0012 \)
8. \( 1 = 0.000001 \)
9. \( 1 = 0.000001 \)
10. \( 1 = 0.000001 \)