

**Unit Name:** Unit 1 – Extending the Number System

**Lesson Plan Number & Title:** Lesson 1 - Integer Exponents

**Grade Level:** High School Math II

**Lesson Overview:**

Students will be able to explain orally or in written format a working definition of equivalent values using exponents with precision and fluency. Although not directly referenced in this standard, lesson goals are to establish readiness for the unit on the topics of exponential laws, radical simplification, equivalency and numeracy.

**Focus/Driving Question:**

Can you think of multiple representations for the same number?

**West Virginia College- and Career-Readiness Standards:**

M.2HS.1

Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents. (e.g., We define  $5^{1/3}$  to be the cube root of 5 because we want  $(5^{1/3})^3 = 5^{(1/3)3}$  to hold, so  $(5^{1/3})^3$  must equal 5.)

**Manage the Lesson:**

**Step 1** - Launch the lesson and establish student background knowledge to guide your instruction by asking students to work in pairs to create a factor tree. On a note card, investigate the following factor pairs for each team (36 and 48) (144 and 12) (9 and 192) (4 and 432) (16 and 108) (24 and 72) (27 and 64). You may need to remind students to factor completely, meaning until only prime numbers remain. Once every team has completed their factorization, have a team leader from each group write their response on the board for comparison to everyone else's. Look for similarities between the answers. Point out that no matter which numbers were used to begin their factorization the final answer is always the same. Do any numbers repeat in the final answer? How do the students think a more concise method for representing their answer could be written? Present their solutions in terms of exponential use showing that all different factorizations yielded  $26 \times 33$ .

**Step 2** - Develop vocabularies and create a word wall with your students and develop the following definitions-relate the vocabulary to their foldable (Step 3) on the exponential rules. Ask them to create examples of the vocabulary on the word wall.

**Step 3** - Build upon student knowledge of the exponential rules- As an introduction or a review of integer exponents creating a classroom list of exponential rules which can be found at Exponent Properties – [http://rock.uwc.edu/sites/rock.uwc.edu/files/imce-uploads/academics/resources/learning-support/files/exponent\\_properties.pdf](http://rock.uwc.edu/sites/rock.uwc.edu/files/imce-uploads/academics/resources/learning-support/files/exponent_properties.pdf) or Properties of Exponents – [http://hotmath.com/hotmath\\_help/topics/properties-of-exponents.html](http://hotmath.com/hotmath_help/topics/properties-of-exponents.html) or [Graphic Organizer](#). As a whole group activity, develop a foldable using notebook paper and tab each exponential law. Students can write a definition and place a personalized example under each flap for a student reminder of each law. You may need to add to the class list as a group or work with students individually to personalize their examples, depending on student ability levels. If you are not familiar with the foldable design concept, here are two websites to investigate use of this teaching strategy: More Algebra 1 Interactive Notebook Pages – <http://mathequalslove.blogspot.com/2012/08/more-algebra-1-interactive-notebook.html> (This website contains many examples of math foldables including exponential laws.) and ALEX Lesson Plan: Exponents and Division – [http://alex.state.al.us/lesson\\_view.php?id=26250](http://alex.state.al.us/lesson_view.php?id=26250) (This lesson contains “how to create a foldable on exponents” PowerPoint. It is an excellent resource for students who are visual learners and need the support in creating the foldable.)

**Step 4** - Students will demonstrate their knowledge through the incorporation of student practice utilizing a variety of materials. The combination of materials listed can be adapted to your students learning styles and abilities. For example, breaking the assignment into shorter tasks can guide your instruction and provide informal assessment on student mastery. All of the materials listed below may not be needed for student mastery of the lesson objective. When planning lesson implementation, select the materials most appropriate for your student's needs.

*Instructional Videos* - Numerous examples of instructional videos are located on the internet. A few are identified below for relating the exponential rules to real-world relevance. How to Apply Properties of Exponents in Real Life – [http://on.aol.com/video/how-to-apply-exponents-to-real-life-275613555?icid=video\\_related\\_1](http://on.aol.com/video/how-to-apply-exponents-to-real-life-275613555?icid=video_related_1) (Part one of two on demonstrating the applications of exponents in the real world.) Learn about Powers and Exponents Applications – [http://on.aol.com/video/learn-about-powers-and-exponents-applications-286301201?icid=video\\_related\\_2](http://on.aol.com/video/learn-about-powers-and-exponents-applications-286301201?icid=video_related_2)

*Instructional Activities:*

Properties of Exponents WS –

<http://cdn.kutasoftware.com/Worksheets/Alg1/Properties%20of%20Exponents.pdf> (Practice handout containing numerical, variables and a combination of both bases)

More Properties of Exponents WS –

<http://cdn.kutasoftware.com/Worksheets/Alg1/More%20Properties%20of%20Exponents.pdf> (Practice handout containing numerical, variables and a combination of both bases)

Exponential Growth and Decay Worksheet –

<http://cf.linnbenton.edu/mathsci/math/mcdowep/upload/extra%20practice%20expt%20equations.pdf> (Practice handout on exponential growth and decay application problems)

Math Worksheets: Exponents – <http://www.dadsworksheets.com/v1/Worksheets/Exponents.html> (Website provides the creation of 4 levels of difficulty in handout format on these topics separately simple exponents and powers of ten, addition with exponents, mixed addition and subtraction of exponents, multiplication with exponents, powers of ten and scientific notation. These materials would be excellent for differentiating classroom instruction.)

Exponent Worksheets – <http://www.mathworksheets4kids.com/exponents.html> Website generates handouts on exponential rules as individual concepts and mixed practice. It includes handouts utilizing exponents with only numerical bases or variable bases. These materials would be excellent for differentiating classroom instruction.

[Cutout Exponents](#) – puzzle for students to match up the simplified form of an exponent

[Cutout Exponents Key](#) – solution for teacher use

Review or assess student knowledge of exponential rules by creating a Jeopardy Game at

<https://www.superteachertools.us/jeopardyx/>

[Graphic Organizer](#) – Graphic organizer to use in developing the exponential laws

<http://www.sascurriculumpathways.com/portal/> (Activity # 89 students answer the question, “When an expression has many exponents, what are the rules for simplifying it?”)

Computer Practice- website to provide individual practice of exponential rules on negative exponents, multiplication, division, mixed practice of multiplication and division, power rule, simplifying expressions, and the properties of exponents as applicable to geometry. Students receive immediate feedback and can adjust their responses accordingly.

IXL – Negative Exponents (Algebra Practice) – <http://www.ixl.com/math/algebra-1/negative-exponents>

IXL – Multiplication with Exponents (Algebra Practice) – <http://www.ixl.com/math/algebra-1/multiplication-with-exponents>

IXL – Division with Exponents (Algebra Practice) – <http://www.ixl.com/math/algebra-1/division-with-exponents>

IXL – Multiplication and Division with Exponents (Algebra Practice) – <http://www.ixl.com/math/algebra-1/multiplication-and-division-with-exponents>

IXL – Power Rule (Algebra Practice) – <http://www.ixl.com/math/algebra-1/power-rule>

IXL – Simplify Expressions involving Exponents (Algebra Practice) – <http://www.ixl.com/math/algebra-1/simplify-expressions-involving-exponents>

IXL – Properties of Exponents (Algebra Practice) – <http://www.ixl.com/math/geometry/properties-of-exponents>

## Games

Exponent Game – <http://www.math-play.com/exponent-game.html> (Interactive game which leaves the 6 rules of exponents on the computer screen for students to refer to during game play)

[The Power of Powers](#) – Instructional strategy handout with the game "Find Someone Who Can?" defined and provides other ideas for bell ringers on exponents (note: not all of the squares in the sample are applicable to this lesson and need to be adjusted to the rule the instructor is assessing)

Games About Multiplication Properties of Exponents – [http://www.ehow.com/info\\_8618681\\_games-multiplication-properties-exponents.html](http://www.ehow.com/info_8618681_games-multiplication-properties-exponents.html) (Suggested ideas for games about the multiplication properties of exponents)

[Exponent Review Game](#) – board and rules to play

**Step 5** – Assess student mastery: In a written explanation, ask the students to solve the following problem  $(-3x^4y^2)^2/(2x^2y^3)^2$  - which rules they would use first and why. Provide a second example where students write their reasoning on solving  $4x^2/x-8$ . Remind them to think of each rule and explain the steps they are using to solve each problem. (Exponent Rules Lessons – Amy Clark's Electronic Portfolio – <https://sites.google.com/site/acclarkportfolio/exponentlessons>)

**Step 6** – Reflect with your students regarding the laws of exponents. Are there any exponents that they are unclear on? Consider your teaching practices and how the lesson organization worked with your students. As a "pair and share" activity, have each student write a sentence or two reacting to the following statements individually and then turn to a partner to share their responses. Complete the activity by inviting everyone to share to the group their thoughts regarding exponents.

I am able to apply the rules of exponents to numerical problems without confusion.

I am able to apply the rules of exponents to variables without confusion.

I feel that I do/do not understand the rules of exponents.

## Academic Vocabulary Development:

Establish a word wall with your students and develop the following definitions-relate the vocabulary to their foldable on the exponential rules.

Ask them to create examples of the vocabulary on the word wall.

*base* (of a power) - one of the equal factors. In  $b^2$ ,  $b$  is the base.

*equal expressions* - expressions that name the same number

*equivalent expressions* - expressions that represent the same number for all of the values of the variable that they contain

*evaluate* - stating the expression in simplified form

*exponent* - in a power, the number of times the base occurs as a factor

*exponential form*- the expression  $b^3$  is the exponential form of the third power of  $b$ .

*perfect square* - an expression raised to the 2<sup>nd</sup> power

## Launch/Introduction:

Develop patterning with your students by considering the factors of 1728. In step 2 of Manage the Lesson, students work together in pairs to investigate factors of 1728. As a class, they compare their multiple factors to develop the pattern of writing the factors as bases and exponents.

**Investigate/Explore:**

Create a Foldable with Properties using Fact Sheet found at Exponent Properties – [http://rock.uwc.edu/sites/rock.uwc.edu/files/imce-uploads/academics/resources/learning-support/files/exponent\\_properties.pdf](http://rock.uwc.edu/sites/rock.uwc.edu/files/imce-uploads/academics/resources/learning-support/files/exponent_properties.pdf) or Properties of Exponents – [http://hotmath.com/hotmath\\_help/topics/properties-of-exponents.html](http://hotmath.com/hotmath_help/topics/properties-of-exponents.html)

The purpose of the lesson is to scaffold necessary skills for the unit by the review of integer exponential laws. The launch activity encourages instructional discovery of the patterns of factors and the development of vocabulary guided by the instructor through the creation of a word wall. Students prepare a foldable of using the exponential rules and develop their knowledge in the creation of corresponding examples for each rule. The instructor can choose to do this portion (create an example) as individual, small group or whole group instruction depending on student abilities or necessary modifications. The process of instructional practice by students can be flexible instruction by the assignment of handouts, games, or online computer practice according to instructional resources and differentiation determined by the instructor. Assessment of the lesson is a continual part of the instructional process, whether informal or formal and should guide the instructor in the directing of instruction. A short assessment in step 5 of Manage the Lesson is provided for students to use justification in their applications of the rules of exponents and encourages students to think through the process. Both students and instructors are encouraged to reflect upon the lesson and knowledge gained in a pair and share/whole group discussion in terms of knowledge gained regarding the use of exponents.

**Summarize/Debrief:**

Students can use a 3-2-1 chart to process their learning and identify misconceptions.

**Materials:**

Graphing Calculator, Word Wall Materials (construction paper, markers), foldable (white copy paper or notebook paper, markers or colored pencils, scissors), optional-computers

[Cutout Exponents](#) - print copies for student use

[Cutout Exponents Key](#) – print copy for teacher use

<https://www.superteachertools.us/jeopardyx/> - review or assess student knowledge

[Graphic Organizer](#) - print copies for student use

[Exponent Review Game](#) – board and rules to play

Suggested websites for instructional information and student use:

[http://rock.uwc.edu/sites/rock.uwc.edu/files/imce-uploads/academics/resources/learning-support/files/exponent\\_properties.pdf](http://rock.uwc.edu/sites/rock.uwc.edu/files/imce-uploads/academics/resources/learning-support/files/exponent_properties.pdf)

[http://hotmath.com/hotmath\\_help/topics/properties-of-exponents.html](http://hotmath.com/hotmath_help/topics/properties-of-exponents.html)

<http://mathequalslove.blogspot.com/2012/08/more-algebra-1-interactive-notebook.html>

[http://alex.state.al.us/lesson\\_view.php?id=26250](http://alex.state.al.us/lesson_view.php?id=26250)[http://on.aol.com/video/how-to-apply-exponents-to-real-life-275613555?icid=video\\_related\\_1](http://on.aol.com/video/how-to-apply-exponents-to-real-life-275613555?icid=video_related_1)

[http://on.aol.com/video/learn-about-powers-and-exponents-applications-286301201?icid=video\\_related\\_2](http://on.aol.com/video/learn-about-powers-and-exponents-applications-286301201?icid=video_related_2)

<http://cdn.kutasoftware.com/Worksheets/Alg1/Properties%20of%20Exponents.pdf>

<http://cf.linnbenton.edu/mathsci/math/mcdowep/upload/extra%20practice%20expt%20equations.pdf>

<http://www.dadsworksheets.com/v1/Worksheets/Exponents.html>

<http://www.mathworksheets4kids.com/exponents.html>

<http://cdn.kutasoftware.com/Worksheets/Alg1/More%20Properties%20of%20Exponents.pdf>

<http://www.ixl.com/math/algebra-1/negative-exponents>

<http://www.ixl.com/math/algebra-1/multiplication-with-exponents>

<http://www.ixl.com/math/algebra-1/division-with-exponents>

<http://www.ixl.com/math/algebra-1/multiplication-and-division-with-exponents>

<http://www.ixl.com/math/algebra-1/power-rule>

<http://www.ixl.com/math/algebra-1/simplify-expressions-involving-exponents>

<http://www.ixl.com/math/geometry/properties-of-exponents>

<http://www.math-play.com/exponent-game.html>

<http://www.sascurriculumpathways.com/portal/>

**Career Connection:**

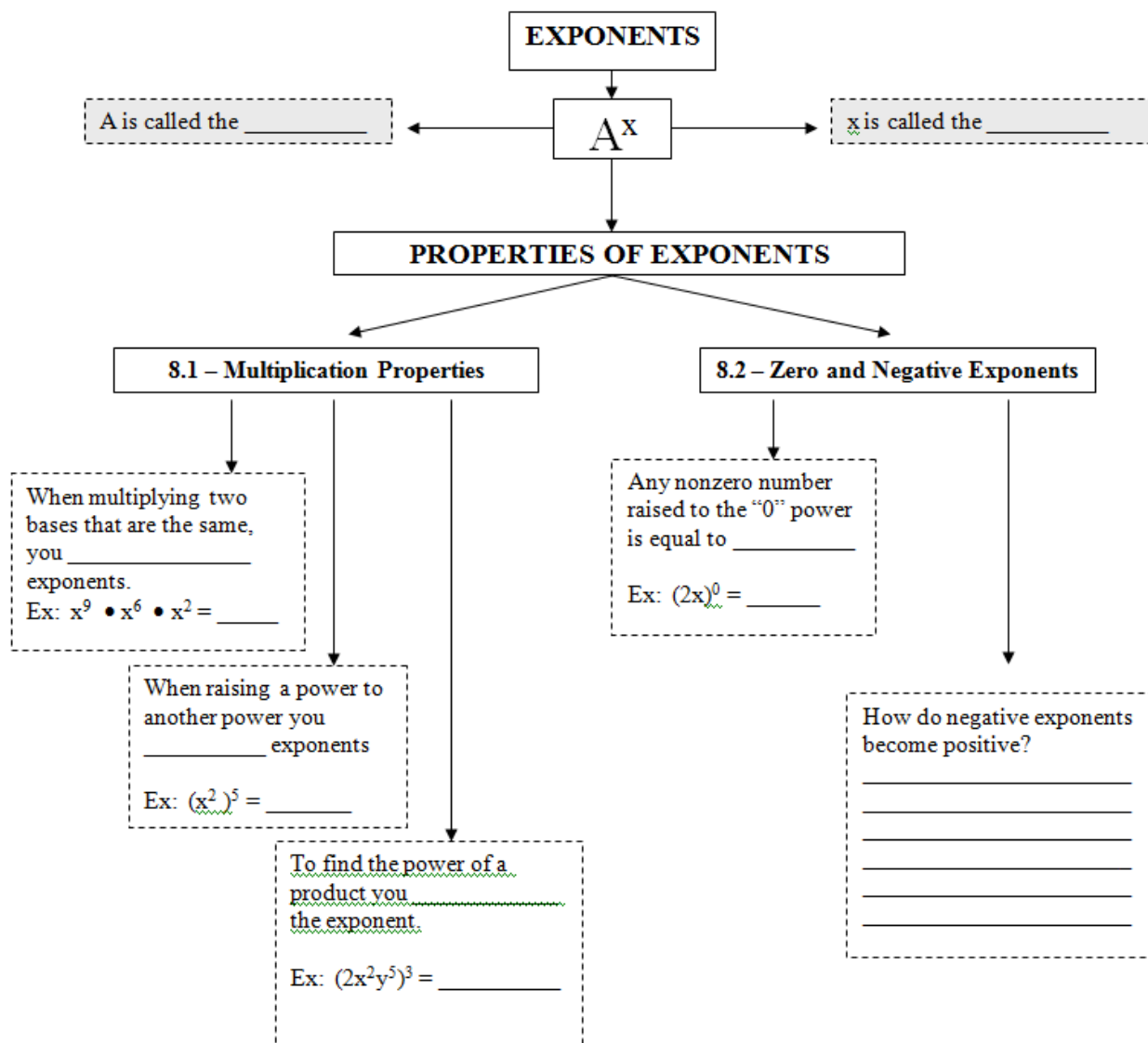
Skills developed in this unit can be related to banking formulas (Business and Marketing Cluster), formulas used in exponential growth and decay of bacteria or chemistry formulas such as Boyle's Law or astronomy in terms of distance/scientific notation(Engineering and Technical Cluster, Health Cluster, Science and Natural Resources Cluster).

**Lesson Reflection:**

In Step 6 of Manage the Lesson, students and the instructor react to statements given in a pair/share partner activity before a whole group discussion on their learning.

**Graphic Organizer**  
**Properties of Exponents**

Fill in the blocks that have dotted lines around them.



**JOURNAL #2**

Using the above information, write a 4 paragraph essay on the back of this sheet. The introduction should tell the definition of an exponent and what they look like. The second paragraph should describe the multiplication properties. The third paragraph should describe the zero and negative properties. The conclusion should tell which property, or properties, you do not understand and why. You may write on your own notebook paper and staple to this sheet if you need more space.

# Simplifying Expressions

Cut-outs – Cut out each puzzle piece and reassemble so that the expressions and their simplified forms match up.

$(12xy^2)(-2x^2y)$ $36x^3y^3$ $108x^6y^2$ $(8x^3)(3xy)^2$	$(-5x^3y^5)(8y)$ $-40x^3y^6$	$(xy^2)(3xy)^2$ $18x^3y^2$ $4(xy)^3(3xy)$ $12x^5y^3$ $(-3xy^2)(-4x^2y)$ $12x^3y^5$	$(3xy^2)(2xy)^3$ $54x^5y^7$ $(9xy^3)(-7x^2y)$ $-63x^3y^5$ $(5x^2y^2)(-xy)^3$ $-5x^3y^5$
$(4x)^2(-2y)^2$ $16x^2y^2$ $3(x^2y)^4(2xy)$ $36x^9y^5$ $(3xy)^2(2x^2)$ $12x^3y^3$	$(-5x^3y^5)(8y)$ $-40x^3y^6$ $(3x^2y)(4x^3)$ $12x^5y^2$	$(5x^2)(2xy)^3$ $20x^5y^3$ $(9x^2y^2)(3xy^3)$ $-27x^5y^5$ $(5x^4)(-3y)$ $-15x^4y$	$(-9xy^2)(-2x^2y)$ $18x^3y^3$ $(2y)^2(3x^2)^3$ $36x^6y^5$ $(3xy)^3(xy)^2$ $27x^4y^5$
$(4xy)^3(xy)^2$ $27x^5y^5$ $(3xy)^2(4x^3y^3)$ $36x^6y^5$	$(2x^4)(3xy)^2$ $12x^6xy^2$ $6(xy)^4(5xy)$ $30x^5y^5$	$(9x^2y^2)(3xy^3)$ $-27x^5y^5$ $(5x^4)(-3y)$ $-15x^4y$	$(2y)^2(3x^2)^3$ $36x^6y^5$ $(-7xy)(xy)^2$ $-7x^2y^3$

# Simplifying Expressions - ANSWERS

Key

Cut-outs - Cut out each puzzle piece and reassemble so that the expressions and their simplified forms match up.

<p>10</p> $(3x^2y)(4x^3)$ <p>12x<sup>5</sup>y</p>	<p>27x<sup>3</sup>y<sup>5</sup></p> $(9x^2y^2)(3xy^3)$	<p>15</p> $(5x^4)(-3y)$ <p>-15x<sup>4</sup>y</p>	<p>24x<sup>4</sup>y<sup>5</sup></p> $(3xy^2)(2xy)^3$	<p>4</p> $(3xy)^3(xy)^2$ <p>27x<sup>5</sup>y<sup>5</sup></p>	<p>8</p> $(9xy^3)(-7x^2y)$ <p>-63x<sup>3</sup>y<sup>4</sup></p>
<p>7</p> $(5x^2)(2xy)^3$ <p>40x<sup>5</sup>y<sup>3</sup></p>	<p>9x<sup>3</sup>y<sup>6</sup></p> $(xy^2)(3xy)^2$	<p>3</p> $4(xy)^3(3xy)$ <p>12x<sup>4</sup>y<sup>4</sup></p>	<p>64x<sup>5</sup>y<sup>5</sup></p> $(4xy)^3(xy)^2$	<p>13</p> $(3xy)^2(4x^3y^3)$ <p>36x<sup>5</sup>y<sup>5</sup></p>	<p>5</p> $(4x)^2(-2y)^2$ <p>3(x<sup>2</sup>y)<sup>4</sup>(2xy)</p> <p>6x<sup>9</sup>y<sup>5</sup></p>
<p>12</p> $(5x^2y^2)(-xy)^3$ <p>-5x<sup>5</sup>y<sup>5</sup></p>	<p>18x<sup>9</sup>y<sup>2</sup></p> $(2x^4)(3xy)^2$	<p>14</p> $6(xy)^4(5xy)$ <p>30x<sup>5</sup>y<sup>5</sup></p>	<p>-24x<sup>3</sup>y<sup>3</sup></p> $(2xy^2)(-2x^2y)$	<p>1</p> $(8x^3)(3xy)^2$ <p>72x<sup>5</sup>y<sup>2</sup></p>	<p>16</p> $(2y)^2(3x^2)^3$ <p>-7xy)(xy)<sup>2</sup></p> <p>-7x<sup>3</sup>y<sup>3</sup></p>
<p>2</p> $(3xy)^2(2x^2)$ <p>18x<sup>4</sup>y<sup>2</sup></p>	<p>12x<sup>3</sup>y<sup>3</sup></p> $(-3xy^2)(-4x^2y)$	<p>9</p>	<p>11</p>	<p>6</p> $(-5x^3y^5)(8y)$ <p>-40x<sup>3</sup>y<sup>6</sup></p>	



## The Power of Powers

**Find Someone Who Can** – Students use sheet provided to find someone who can answer each question dealing with Polynomials and the Laws of Exponents. Students answering questions must write the correct answer in the square and sign/initial the square. Good movement, bell ringer, or exit activity.

**Laws of Exponents Foldable** – Construct a foldable to help students learn and apply the laws of exponents. <https://www.teacherspayteachers.com/Product/Laws-of-Exponents-Foldable-337553>

**Tarsia Puzzles** – Construct a rhombus puzzle by multiplying and dividing monomials and/or play a game of dominoes using the addition, subtraction, and multiplication of polynomials. Tarsia puzzles can be created by downloading a free Tarsia Emulator program from <http://www.mmlsoft.com/index.php/products/tarsia>.

**Algebra Fun Sheets** – Resource for finding ready-made riddles, puzzles, practice pages on a variety of algebra and pre-algebra topics. Annual membership fee gives the rights to use materials in your classroom. The homepage where samples are available or where you can subscribe is found at <http://www.algebrafunsheets.com/home.php>.

**Polynomials and the Law of Exponents Jeopardy** - <https://www.superteachertools.us/jeopardy/>  
Click on “Find a Game,” then search “exponents jeopardy” and select a game.

**FIND SOMEONE WHO CAN...**

Your mission is to find a different person among your classmates to simplify each expression in the table below. Assume that no denominator is equal to zero. Your teammates must write the correct answer in the square and then sign the square. You may not have a person sign/answer more than one square.

$4x^4 \cdot x^6$  _____	$(6n^2p^4)(-3n^3p^3)$  _____	$(r^6u^3)^4$  _____
$\frac{r^5v^3}{r^3v}$  _____	$\frac{32e^2f^{-6}}{4e^{-2}f^2}$  _____	$(4u^2 - u - 3) + (3u^2 - u + 4)$  _____
$(-x^2 + 3x) - (5x + 2x^2)$  _____	$2m^2(2m^2 + 3m - 5)$  _____	$(4c + 1)(2c + 1)$  _____

# EXPONENT REVIEW

**Set Up:** Work in groups of 2-3

**Items need:** Die and pencil

**Rules:**

1. Roll the die to determine who plays first.
2. First player rolls the die and chooses any expression from the appropriate column. (For example, if you roll a 2, use Column 2)
3. Simplify your expression and mark an X in the box. The exponent tells you how many points you receive. (For example, you would get 7 points for the following:  $x^7$ ,  $2c^7$ , or  $\frac{2}{x^7}$ )
4. Each expression can be used only once. If you roll a number in a column with no available expressions, you lose your turn.
5. Watch your opponents: If you catch a mistake in their simplifying, they lose 10 points.
6. When time is called, the player with the highest score wins!!!

1	2	3	4	5	6
$(n^4)^2$	$n^4 \cdot n^{-8}$	$(x^{-2} \cdot x^4)^3$	$p^{-1} \cdot p^{-7}$	$z^{-6} \cdot z^4$	$y^8 \cdot (y^6)^{-2}$
$(d^{-4})^3$	$(a^{-2})^5$	$(c^{-3})^3$	$(f^{-2} \cdot f^3)^5$	$n^{-4} \cdot (n^4)^2$	$e^{-4} \cdot e^{-3}$
$j^2 \cdot j^3$	$(h^4 \cdot h^5)^2$	$u^2 \cdot u^{-7}$	$g^{-6} \cdot (g^{-3})^{-2}$	$(y^{-1} \cdot y^{-2})^3$	$(w^{-6} \cdot w^7)^{-2}$
$\frac{k^3 \cdot k^2}{k^7}$	$\left(\frac{z^2}{z^3}\right)^4$	$\left(\frac{w^{-2}}{w}\right)^2$	$\frac{s^{-3} s^7}{s^4}$	$\left(\frac{m^{-2}}{m^{-4}}\right)^4$	$\frac{p}{p^4}$