Day 1 Warm-up:

Use the definition of an "exponent" to expand each of the following:

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

① $4 \cdot 4 \cdot 4 \cdot 4 \cdot 4 \cdot 4 \cdot 4 \cdot 4$

② $x \cdot x \cdot x \cdot x \cdot x \cdot y \cdot y$

③ $4x \cdot 4x \cdot 4x \cdot 2y \cdot 2y \cdot 2y \cdot 2y \cdot 2y \cdot 2y$

④ $(x+3)(x+3)(x+3)(x+3)$

⑤ $\frac{3 \cdot 3}{5 \cdot 5 \cdot 5}$

⑥ $5yz \cdot 5yz \cdot 5yz \cdot 5yz \cdot 5yz \cdot 5yz$

⑦ $(3x-1)(3x-1)(3x-1)$

⑧ $\frac{2}{7} \cdot \frac{2}{7} \cdot \frac{2}{7} \cdot \frac{2}{7} \cdot \frac{2}{7}$

Day 2 Warm-up:

Rewrite each expression using exponents:

1. 4 * 4 * 4 * 4 * 4 * 4 * 4
2. (-5x)(-5x)(-5x)
3. (x 1) (x 1) (x 1) (x 1) (x 1) (x 1)
4. (1/7) (1/7) (1/7) (1/7)
5. x * x * x * q * q * q * q
6. 3 * 3 * 3 * 3 * w * w * w * x * x * y

① 4^7

② $(-5x)^3$

③ $1^6 \cdot x^6 = x^6$

④ $(\frac{1}{7})^4$

⑤ x^3q^4

⑥ $3^4w^3x^2y$

Day 3 Warm-up

1. Expand the expression $(d^3)(d^2)$ using the definition of an exponent. $(d \cdot d \cdot d)(d \cdot d)$
2. Rewrite the expanded form in #1 using exponents. d^5
3. Compare the exponent in #2 to the exponents in the #1. What operation - add, subtract, multiply, or divide - can be used on the exponents in the problem #1 to get the exponents in #2? add
4. You have reviewed the **product rule for exponents**. Write the rule in your own words. Write the rule symbolically.
   When multiplying powers with the same base, keep the base and add the exponents. $a^m \cdot a^n = a^{m+n}$
5. Use your rule to simplify the following: $(c^{23})(c^{54}) = c^{77}$
6. Use your rule to simplify the following: $(m^7n^{10})(m^{15}n^{19}) = m^{22}n^{29}$
7. Use your rule to simplify the following: $(3x^5y^7)(5x^7y^8) = 15x^{12}y^{15}$

Day 4 Warm-up ⊛ Note: For now, allow negative exponents.

Simplify the following:

1. $(3x^4y^7z^9)(5x^3y^4z^5) = 15x^7y^{11}z^{14}$
2. $(p^{2x\,3})(p^{3x-4}) = p^6 p^{-12} = p^{-6}$
3. Expand the expression $(c^4)/(c^2)$ using the definition of an exponent. $\frac{c \cdot c \cdot c \cdot c}{c \cdot c}$
4. Rewrite the expanded form in #3 using exponents. c^2
5. Compare the exponent in #4 to the exponents in the #3. What operation - add, subtract, multiply, or divide - can be used on the exponents in the problem #3 to get the exponents in #4? subtract
6. You have reviewed the **quotient rule for exponents**. Write the rule in your own words. Write the rule symbolically.
   When dividing powers with the same base, keep the base and subtract the exponents from top to bottom. $\frac{a^m}{a^n} = a^{m-n}$
7. Use your rule to simplify the following: $(c^{23})/(c^{14}) = c^9$
8. Use your rule to simplify the following: $(m^7n^{10})/(m^{15}n^{19}) = m^{-8}n^{-9}$

Day 5 Warm-up

Simplify the following:

1. d^{35}/d^{20}
2. $s^{12}t^{25}/s^{24}t^{13}$
3. $12g^9h^4/10g^{11}h^2$
4. $3ab^5 \div 4a^6b^7$
5. $(m^{-5x\,1})(m^{3x\,5})$

① d^{15}

② $s^{-12}t^{12}$

③ $\frac{6}{5}g^{-2}h^2$

④ $\frac{3}{4}a^{-5}b^{-2}$

⑤ $m^{-5}m^{15} = m^{10}$

Day 6 Warm-up:

1. Expand the expression $(x^2)^5$ using the definition of an exponent. $x^2 \cdot x^2 \cdot x^2 \cdot x^2 \cdot x^2$
2. Rewrite the expanded form in #1 using exponents. x^{10}
3. Compare the exponent in #2 to the exponents in the #1. What operation - add, subtract, multiply, or divide - can be used on the exponents in the problem #1 to get the exponents in #2? multiply
4. You have reviewed the **Power of a Power Rule** for exponents. Write the rule in your own words. Write the rule symbolically.

   When raising a power to a power, keep the base and multiply the exponents. $(a^m)^n = a^{m \cdot n}$
5. Use your rule to simplify the following: $(y^4)^3 = y^{12}$
6. Use your rule to simplify the following: $(m^2n)^6 = m^{12}n^6$
7. Use your rule to simplify the following: $(3x^2y^5)^4 = 3^4x^8y^{20} = 81x^8y^{20}$

Day 7 Warm-up:

1. Expand the expression $(x^2/y^3)^2$ using the definition of an exponent. $\frac{x^2}{y^3} \cdot \frac{x^2}{y^3}$
2. Rewrite the expanded form in #1 using exponents. $\frac{x^4}{y^6}$
3. Compare the exponent in #2 to the exponents in the #1. What operation - add, subtract, multiply, or divide - can be used on the exponents in the problem #1 to get the exponents in #2? multiply
4. You have reviewed the **Power of a Quotient Rule** for exponents. Write the rule in your own words. Write the rule symbolically.

   When raising a quotient to a power, multiply each exponent in the quotient by the power. $\left(\frac{a^m}{b^n}\right)^p = \frac{a^{mp}}{b^{np}}$
5. Use your rule to simplify the following: $(y^4/z^2)^3 = \frac{y^{12}}{z^6}$
6. Use your rule to simplify the following: $(m^2n^5p/x^2y^3z^4)^4 = \frac{m^8 n^{20} p^4}{x^8 y^{12} z^{16}}$
7. Use your rule to simplify the following: $(3j^2k^4/5g^7h)^2 = \frac{9j^4k^8}{25g^{14}h^2}$

Day 8 Warm-up:

Positive & Negative Exponents Worksheet

Day 9 Warm-up:

Simplify each expression. All exponents must be positive.

1. $(j^2p^5g)^{11}$ $= j^{22}p^{55}g^{11}$
2. $(2mn^4p^8)^7$ $= 128m^7n^{28}p^{56}$
3. $(5u^2w^7)^3$ $= 125u^6w^{21}$
4. $(w^6x^2y^7/w^2x^4y^2)^4$ $= w^{16}x^{-8}y^{20} = \frac{w^{16}y^{20}}{x^8}$
5. $(3k^6m^6/9k^5m^5)^3$ $= \frac{1}{27}k^3m^3 = \frac{k^3m^3}{27}$
6. $(8c^2d^3/4cd^2)^5$ $= 32c^5d^5$

Day 10 Warm-up:

Rewrite each expression without negative or zero exponents.

1. w^{-4} $= \frac{1}{w^4}$
2. $1/h^{-5}$ $= h^5$
3. w^{-3}/d^0 $= \frac{1}{w^3}$
4. k^6p^{-7} $= \frac{k^6}{p^7}$
5. $x^4w^{-8}/d^0g^{-7}h^5$ $= \frac{x^4g^7}{w^8h^5}$
6. $m^{-8}w^{-3}/v^{-5}j^0h^7$ $= \frac{v^5}{m^8w^3h^7}$

Positive & Negative Exponents Investigation

2^4	16	3^4	81	4^4	256
2^3	8	3^3	27	4^3	64
2^2	4	3^2	9	4^2	16
2^1	2	3^1	3	4^1	4
2^0	1	3^0	1	4^0	1
2^{-1}	$1/2$	3^{-1}	$1/3$	4^{-1}	$1/4$
2^{-2}	$1/4$	3^{-2}	$1/9$	4^{-2}	$1/16$
2^{-3}	$1/8$	3^{-3}	$1/27$	4^{-3}	$1/64$

1. Complete the first 4 rows of the table above.
2. Look at columns 1, 3, 5 of the table, and then describe the pattern in the exponents as you look from the top of the table to the bottom of the table.

   The exponents are going down by 1.

3. Based upon your observations above, continue the pattern for columns 1, 3, 5 of the table.
4. Observe the numbers in columns 2, 4, 6 of the table from the top down. Describe the pattern you see.

   each column represents a geometric sequence.

   Column 2: divide by 2 Column 4: divide by 3 Column 6: divide by 4
5. Based on your observations in problem 4, continue the pattern for columns 2, 4, 6 of the table, writing your answers in fraction form when necessary.
6. Look at row 5, which has zero as an exponent. Describe the pattern that you see.

   When a number is raised to the power of zero, the solution is 1.

   $a^0 = 1$
7. Based on your description in problem 6, evaluate 53^0.

   $53^\circ = 1$
8. Look at row 6, which has -1 as an exponent. Describe the pattern you see.

   Each solution is the reciprocal of the base.
9. Based on your description in problem 8, evaluate 23^{-1}.

   $23^{-1} = \frac{1}{23}$
10. Look at row 7, which has -2 as an exponent. Describe the pattern you see.

    Each is the square of the reciprocal of the base.
11. Based on your description in problem 10, evaluate 8^{-2}.

    $8^{-2} = \frac{1}{8^2} = \frac{1}{64}$

12. Look at row 8, which has -3 as an exponent. Describe the pattern you see.

Each is the cube of the reciprocal of the base.

13. Based on your description in problem 12, evaluate 6^{-3}.

$$6^{-3} = \frac{1}{6^3} = \frac{1}{216}$$

14. Now describe in general, what happens when you have an exponent of zero. Write this description symbolically.

A power with an exponent of zero equals 1.

$$a^0 = 1$$

15. Now describe in general, what happens when you have a negative exponent. Write this description symbolically.

Take the reciprocal of the base and raise it to the positive exponent.

$$a^{-m} = \frac{1}{a^m}$$

Warm-Up Day 11

- Distribute the **Exponent Cards** to students.
- Students mix and mingle around the classroom and find a partner to work with.
- Partners quiz each other regarding the problem on their cards.
- Once each partner is clear as to the correct answer, partners trade cards and mix again.
- Students continue to quiz and trade with partners as many times as the teacher sees fit. (I recommend that they do 3 rounds.)
- When the teacher yells, "Freeze! Find your match!" students purposely seek out someone whose problems yields the same answer as their and moves to the perimeter of the room.

Adapted from Cooperative Learning Activities for High School Mathematics, Kagan Publishing, 2001.

Exponent cards are found on the following pages.

Exponent Cards – page 1

Simplify using only positive exponents. $\frac{5x^{-4}}{y^3}$ $\frac{5}{x^4y^3}$	**Simplify using only positive exponents.** $\frac{10x^{-2}y^{-3}}{2x^2}$ $\frac{5}{x^4y^3}$
Simplify using only positive exponents. $\frac{4x^{-3}y}{2x^3y^2}$ $\frac{2}{x^6y}$	**Simplify using only positive exponents.** $\frac{2y^2x^{-7}}{x^{-1}y^3}$ $\frac{2}{x^6y}$
Simplify using only positive exponents. $\frac{2^{-1}x^7y}{x^{-1}y^{-5}}$ $\frac{x^8y^6}{2}$	**Simplify using only positive exponents.** $\frac{2y^6}{4(x^{-4})^2}$ $\frac{x^8y^6}{2}$
Simplify using only positive exponents. $\frac{6x(y^{-3})^2}{x^7}$ $\frac{6}{x^6y^6}$	**Simplify using only positive exponents.** $\frac{30x^{-4}y^{-1}}{5x^2y^5}$ $\frac{6}{x^6y^6}$
Simplify using only positive exponents. $\frac{(4x)^0}{2x^{-5}y^8}$ $\frac{x^5}{2y^8}$	**Simplify using only positive exponents.** $\frac{(5y^{-1}x)(3y^{-5}x^4)}{30y^2}$ $\frac{x^5}{2y^8}$

Adapted from Cooperative Learning Activities for High School Mathematics, Kagan Publishing, 2001.

Exponent Cards – page 2

Simplify using only positive exponents. $\frac{y^{-2}}{(6x^5)^{-1}}$ $\frac{6x^5}{y^2}$	**Simplify using only positive exponents.** $\frac{6x^3y^{-2}}{x^{-2}}$ $\frac{6x^5}{y^2}$
Simplify using only positive exponents. $\frac{12x^3}{(2x^2)^2y^{-2}}$ $\frac{3y^2}{x}$	**Simplify using only positive exponents.** $\frac{3x^{-4}y^3}{x^{-3}y}$ $\frac{3y^2}{x}$
Simplify using only positive exponents. $\frac{(3x^{-1})^3}{9x^{-7}y^{-4}}$ $3x^4y^4$	**Simplify using only positive exponents.** $\frac{3xy}{(xy)^{-3}}$ $3x^4y^4$
Simplify using only positive exponents. $\frac{(2y)^2x^{-3}}{x^0y^{-1}}$ $\frac{4y^3}{x^3}$	**Simplify using only positive exponents.** $\frac{xy^3}{(2x^{-2})^{-2}}$ $\frac{4y^3}{x^3}$
Simplify using only positive exponents. $\frac{x^{-4}}{(4x)(2y^{-1})}$ $\frac{y}{8x^5}$	**Simplify using only positive exponents.** $\frac{(2x)^{-3}y^2}{x^2y}$ $\frac{y}{8x^5}$

Adapted from Cooperative Learning Activities for High School Mathematics, Kagan Publishing, 2001.

Exponent Cards – page 3

Simplify using only positive exponents. $\frac{(4x)^{-2}}{y^3}$ $\frac{1}{16y^3x^2}$	**Simplify using only positive exponents.** $\frac{xy^{-2}}{16x^3y}$ $\frac{1}{16x^2y^3}$
Simplify using only positive exponents. $\frac{(2x^{-3})^2}{yx}$ $\frac{4}{yx^7}$	**Simplify using only positive exponents.** $\frac{4xy^{-1}}{x^8}$ $\frac{4}{yx^7}$
Simplify using only positive exponents. $\frac{2(x^{-2}y)^2}{xy^2}$ $\frac{2}{x^5}$	**Simplify using only positive exponents.** $\frac{8x^{-3}y}{(2x)^2y}$ $\frac{2}{x^5}$
Simplify using only positive exponents. $\frac{3x^{-2}y}{x^3(y^2)^{-1}}$ $\frac{3y^3}{x^5}$	**Simplify using only positive exponents.** $\frac{(9x^{-3})(2xy)}{6y^{-2}x^3}$ $\frac{3y^3}{x^5}$
Simplify using only positive exponents. $\frac{2x^0y^{-4}}{x^{-3}y^3}$ $\frac{2x^3}{y^7}$	**Simplify using only positive exponents.** $\frac{8x^{-4}y^{-2}}{4x^{-7}y^5}$ $\frac{2x^3}{y^7}$

Adapted from Cooperative Learning Activities for High School Mathematics, Kagan Publishing, 2001.