

Outcome 2B Review Worksheet

CO#2B: Students will demonstrate understanding of irrational numbers in exponent form

Beginning	Approaching	Proficient	Mastery
I need help/I am inconsistent	I am consistently able to evaluate and simplify expressions using all exponent laws including a negative or rational exponent (numerical and variable bases) where there is one step	I am consistently able to simplify expressions by applying the exponent laws (numerical and variable bases) involving more than one step, including negative and rational exponents.	I am able to perform error analysis. I am able to determine which value is larger/smaller in a set of numbers. I am able to answer situational questions. I am able to explain my strategies.

Example 1

Given $16 = 2^4$ (Level 2)

- 4 is the exponent
- 2 is the base
- 16 is the standard (decimal) form
- 2^4 is the power
- $2 \times 2 \times 2 \times 2$ is repeated multiplication

1. For each of the following, determine:

- the exponent
- the base
- standard form
- the power
- repeated multiplication

a) $8 = 2^3$

b) $5^2 = 25$

c) $16 = 4^2$

d) $2^5 = 32$

Example 2

When multiplying SAME bases you ADD exponents (Level 2)

a) $x^5 \times x^3$
 $= x^{5+3}$
 $= x^8$

b) $m^4 \times m^3 \times m$
 $= m^{4+3+1}$
 m^8

c) $(-2)^3 \times (-2)^4$
 $= (-2)^{3+4}$
 $= (-2)^7$

2. Simplify the following:

a) $m^3 \times m^2$

b) $a^7 \times a$

c) $p^6 \times p^3 \times p^4$

d) $n^3 \times n^7 \times n$

e) $(-3)^4 \times (-3)^5$

f) $2^7 \times 2 \times 2^3$

g) $(-0.1)^4 (-0.1)^3$

h) $q^5 \times q^3 \times q \times q^6$

l) $k^3 \times k^7 \times k^2$

Example 3When dividing same bases you SUBTRACT exponents (Level 2)

a)	$m^9 \div m^3$	b)	$a^7 \div a$	c)	$\frac{n^5}{n^3}$	d)	$\frac{3^8}{3^5}$
	$= m^{9-3}$		$= a^{7-1}$		n^{5-3}		$= 3^{8-5}$
	$= m^6$		$= a^6$		$= n^2$		$= 3^3$

3. Simplify the following

a)	$m^{12} \div m^5$	b)	$m^6 \div m^3$	c)	$a^3 \div a$	d)	$\frac{m^7}{m^3}$
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e)	$\frac{5^3}{5^2}$	f)	$\frac{r^9}{r^6}$	g)	$\frac{a^{15}}{a^3}$	h)	$\frac{(-0.1)^5}{(-0.1)^3}$	i)	$\frac{7^3}{7}$
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Example 4To raise a power to a power, you MULTIPLY exponents (Level 2)

a)	$(a^5)^3$	b)	$(3^2)^4$
	$= a^{5 \times 3}$		$= 3^{2 \times 4}$
	$= a^{15}$		$= 3^8$

4. Simplify the following

a)	$(m^5)^2$	b)	$(a^3)^3$	c)	$(4^2)^5$	d)	$(3^3)^4$	e)	$(p^7)^2$
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Example 5

Exponent of zero gives a value of one (level 2)

a)	a^0	b)	$(-a)^0$	c)	$-a^0$	d)	$(2a)^0$	e)	$2a^0$
	$=1$		$=1$		$=-1$		$=1$		$=2$

5. Evaluate

a)	$-m^0$	b)	m^0	c)	$(-m)^0$	d)	$3m^0$	e)	$-3m^0$
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f)	$(3m)^0$	g)	$(-3m)^0$
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Example 6 To change a negative exponent to a positive exponent, you determine the reciprocal (Level 2)

a)	a^{-2}	b)	m^{-5}	c)	3^{-4}
	$= \frac{1}{a^2}$		$= \frac{1}{m^5}$		$= \frac{1}{3^4}$

6. Write with a positive exponent

a) m^{-3} b) a^{-7} c) n^{-9} d) p^{-1} e) 2^{-5} f) 3^{-6}

g) $(-4)^{-9}$ h) a^{-10} i) b^{-12} j) k^{-11} k) 7^{-3} l) $(-5)^{-3}$

Example 7 (Level 2)

a) $\frac{1}{5^{-2}}$
 $= 5^2$

b) $\frac{1}{m^{-3}}$
 $= m^3$

c) $\frac{1}{a^{-4}}$
 $= a^4$

7. Write with a positive exponent

a) $\frac{1}{a^{-5}}$ b) $\frac{1}{a^{-6}}$ c) $\frac{1}{m^{-2}}$ d) $\frac{1}{2^{-4}}$ e) $\frac{1}{3^{-5}}$ f) $\frac{1}{4^{-2}}$

Example 8 Simplify and write with positive exponents (Level 3)

a) $a^7 \times a^{-5} \times a^{-4}$
 $= a^{7+(-5)+(-4)}$
 $= a^{-2}$
 $= \frac{1}{a^2}$

b) $m^5 \times m^{-7}$
 $= m^{5+(-7)}$
 $= m^{-2}$
 $= \frac{1}{m^2}$

c) $n^{-3} \times n^{-2}$
 $= n^{-3+(-2)}$
 $= n^{-5}$
 $= \frac{1}{n^5}$

8. Simplify and write with positive exponents

a) $m^3 \times m^{-6}$ b) $a^{-3} \times a$ c) $q^{-5} \times q^3 \times q^{-4}$ d) $m^2 \times m^{-5} \times m^{-1}$

Example 9 Simplify and write with positive exponents (Level 3)

a) $n^2 \div n^5$
 $= n^{2-5}$
 $= n^{-3}$
 $= \frac{1}{n^3}$

b) $n^{-4} \div n^2$
 $= n^{-4-2}$
 $= n^{-6}$
 $= \frac{1}{n^6}$

c) $n^3 \div n^{-4}$
 $= n^{3-(-4)}$
 $= n^7$

d) $n^{-5} \div n^{-2}$
 $= n^{-5-(-2)}$
 $= n^{-3}$
 $= \frac{1}{n^3}$

9. Simplify and write with positive exponents

a) $m^3 \div m^5$ b) $a^7 \div a^9$ c) $a^{-4} \div a^3$ d) $a^{-2} \div a$

e) $m^{-3} \div m^5$ f) $n^5 \div n^{-2}$ g) $n^3 \div n^{-4}$ h) $n^5 \div n^{-9}$

i) $n^{-4} \div n^{-2}$ j) $n^{-3} \div n^{-5}$ k) $n^{-2} \div n^{-3}$ l) $n^{-1} \div n^{-4}$

Example 10 Simplify and write with positive exponents (Level 3)

a) $\frac{m^3 \times m^4}{m^9}$
 $= m^{3+4-9}$
 $= m^{-2}$
 $= \frac{1}{m^2}$

b) $\frac{a^{-2} \times a^4}{a^{-3}}$
 $= a^{-2+4-(-3)}$
 $= a^5$

c) $(m^5 n^2)^3$
 $= m^{5 \times 3} n^{2 \times 3}$
 $= m^{15} n^6$

d) $(a^{-2} b^{-3})^2$
 $= a^{-2 \times 2} b^{-3 \times 2}$
 $= a^{-4} b^{-6}$
 $= \frac{1}{a^4 b^6}$

e) $(m^3 n^2)^{-4}$
 $= m^{3 \times -4} n^{2 \times -4}$
 $= m^{-12} n^{-8}$
 $= \frac{1}{m^{12} n^8}$

f) $(a^3 b^{-2})^4$
 $= a^{3 \times 4} b^{-2 \times 4}$
 $= a^{12} b^{-8}$
 $= \frac{a^{12}}{b^8}$

g) $\frac{a^3}{b^{-2}}$
 $= a^3 b^2$

h) $\frac{a^{-3}}{b^2}$
 $= \frac{1}{a^3 b^2}$

10. Simplify and write with positive exponents.

a) $\frac{n^5 n^2}{n^6}$ b) $\frac{n^3 n^4}{n^{10}}$ c) $\frac{n^{-2} n^{-3}}{n^{-5}}$ d) $\frac{n^{-1} n^3}{n^{-5}}$ e) $\frac{n^{-2} n^{-2}}{n^5}$ f) $(a^2 b^5)^3$

g) $(m^3 n^2)^5$ h) $(a^4 b)^7$ i) $(m^2 n)^5$ j) $(a^{-3} b^{-4})^2$ k) $(m^{-1} n^{-2})^3$ l) $(m^{-4} n^{-3})^2$

m) $(m^{-2}n^{-3})^4$ n) $(a^2b^5)^{-1}$ o) $(a^3b^4)^{-2}$ p) $(m^7n^3)^{-5}$ q) $(a^5b^2)^{-3}$ r) $(s^5t^3)^{-2}$

s) $(m^5n^{-2})^4$ t) $(a^{-3}b^4)^5$ u) $(m^4n^{-2})^3$ v) $(a^{-7}b^4)^2$ w) $(m^{-3}n^2)^{-4}$ x) $(a^{-2}b^1)^{-4}$

y) $\frac{a^5}{b^{-3}}$ z) $\frac{m^7}{n^{-5}}$ aa) $\frac{b^8}{c^{-4}}$ bb) $\frac{d^7}{e^{-2}}$ cc) $\frac{f^3}{g^{-5}}$ dd) $\frac{h^9}{i^{-3}}$

ee) $\frac{a^{-3}}{b^4}$ ff) $\frac{c^{-2}}{d^8}$ gg) $\frac{e^{-4}}{f^5}$ hh) $\frac{g^{-3}}{h^5}$ ii) $\frac{j^{-7}}{k^3}$ jj) $\frac{m^{-5}}{n^4}$

Example 11 Evaluate (level 2)

a) 2^3
 $=2 \times 2 \times 2$
 $=8$ b) -2^3
 $=-2 \times 2 \times 2$
 $=-8$ c) $(-2)^3$
 $=-2 \times -2 \times -2$
 $=-8$ d) -2^4
 $=-2 \times 2 \times 2 \times 2$
 $=-16$ e) $(-2)^4$
 $=-2 \times -2 \times -2 \times -2$
 $=16$

11. Evaluate

a) 4^2 b) -4^2 c) $(-4)^2$ d) 4^3 e) -4^3 f) $(-4)^3$

g) 3^2 h) -3^2 i) $(-3)^2$ j) 3^3 k) -3^3 l) $(-3)^3$

m) 5^2 n) -5^2 o) $(-5)^2$ p) 5^3 q) -5^3 r) $(-5)^3$

Example 12 Evaluate (Level 2)

a) 2^{-3}	b) -2^{-3}	c) $(-2)^{-3}$	d) -2^{-4}	e) $(-2)^{-4}$
$= \frac{1}{2^3}$	$= \frac{1}{-2^3}$	$= \frac{1}{(-2)^3}$	$= \frac{1}{-2^4}$	$= \frac{1}{(-2)^4}$
$= \frac{1}{8}$	$= \frac{1}{-8}$	$= \frac{1}{-8}$	$= \frac{1}{-16}$	$= \frac{1}{16}$
	$= \frac{-1}{8}$	$= \frac{-1}{8}$	$= \frac{-1}{16}$	

12. Evaluate (Do NOT write your answer as a decimal)

a) 4^{-3} b) -4^{-3} c) $(-4)^{-3}$ d) -4^{-4} e) $(-4)^{-4}$ f) 4^{-4}

g) 3^{-3} h) 3^{-3} i) $(-3)^{-3}$ j) -3^{-4} k) $(-3)^{-4}$ l) 3^{-4}

m) 5^{-2} n) -5^{-2} o) $(-5)^{-2}$ p) -5^{-3} q) $(-5)^{-3}$ r) 5^{-3}

Example 13 Write each power as a radical (Level 2). The denominator ends up as the index (inside the "hook") and the numerator becomes the exponent. Keep in mind an exponent of 1 doesn't show the 1, and a square root does not have to put the 2 in the "hook".

a) $7^{\frac{1}{3}}$	b) $25^{\frac{2}{5}}$	c) $125^{\frac{5}{4}}$	d) $64^{\frac{1}{2}}$
$\sqrt[3]{7}$	$\sqrt[5]{25^2}$	$\sqrt[4]{125^5}$	$\sqrt{64}$

13. Write each power as a radical

a) $40^{\frac{5}{3}}$ b) $26^{\frac{1}{2}}$ c) $49^{\frac{2}{3}}$ d) $15^{\frac{1}{5}}$ e) $80^{\frac{4}{5}}$

Example 14 Write each radical as a power (Level 2). The number in the “hook” goes in the denominator, the exponent goes in the numerator.

a) $\sqrt[3]{12} = 12^{\frac{1}{3}}$ b) $\sqrt[5]{65^3} = 65^{\frac{3}{5}}$ c) $\sqrt{20} = 20^{\frac{1}{2}}$ d) $\sqrt[4]{56^3} = 56^{\frac{3}{4}}$

14. Write each radical as a power.

a) $\sqrt[4]{75^3}$ b) $\sqrt[5]{18^2}$ c) $\sqrt[3]{15}$ d) $\sqrt{28}$ e) $\sqrt{14^3}$

Example 15 Evaluate (Level 2). Write in radical form and then evaluate.

a) $81^{\frac{3}{2}} = \sqrt{81^3} = 9^3 = 729$ b) $27^{\frac{2}{3}} = \sqrt[3]{27^2} = 3^2 = 9$ c) $81^{\frac{3}{4}} = \sqrt[4]{81^3} = 3^3 = 27$

15. Evaluate

a) $27^{\frac{2}{3}}$ b) $25^{\frac{1}{5}}$ c) $125^{\frac{2}{5}}$ d) $256^{\frac{3}{4}}$ e) $81^{\frac{5}{4}}$

Example 16 Simplify. Write answers with positive exponents (Level 3)

a) $(3a)^2 = 3^2 a^2 = 9a^2$ b) $(-2m^{-3}n^2)^3 = -2^3 m^{3 \times 3} n^{2 \times 3} = -8m^9 n^6$ c) $(3mn^2)^{-2} = 3^{-2} m^{-2} n^{2 \times -2} = 3^{-2} m^{-2} n^{-4} = \frac{1}{3^2 m^2 n^4} = \frac{1}{9m^2 n^4}$

16. Simplify. Write answers with positive exponents

a) $(5m)^3$ b) $(-4a^3b^5)^5$ c) $(2ab^5)^{-3}$ d) $(3m^3n)^{-2}$

Example 17 Simplify. Write all answers with positive exponents (Level 3)

a) $\left[\frac{4a^{-5}}{9b^{-3}} \right]^{-2}$

$$\frac{4^{-2}a^{-5 \times -2}}{9^{-2}b^{-3 \times -2}}$$

$$\frac{4^{-2}a^{10}}{9^{-2}b^6}$$

$$\frac{9^2 a^{10}}{4^2 b^6}$$

$$\frac{81a^{10}}{16b^6}$$

$$\frac{81a^{10}}{16b^6}$$

17. Simplify. Write all answers with positive exponents

a) $\left[\frac{2a^{-5}}{3b^{-3}} \right]^{-3}$

b) $\left[\frac{4a^{-3}}{9b^{-4}} \right]^2$

c) $\left[\frac{2a^{-5}}{3b^2} \right]^{-4}$

d) $\left[\frac{4a^{-5}b^2}{9a^{-7}b^{-3}} \right]^{-2}$

e) $\left[\frac{2a^{-5}b^{-5}}{5a^7b^{-3}} \right]^3$

f) $\left[\frac{5a^{-5}b^5c^{-3}}{9a^{-6}b^{-3}c^{-7}} \right]^2$

Example 18 Simplify. Write all answers with positive exponents. (Level 3)

$$\begin{aligned}
 \text{a) } & \left(\frac{2^3}{9}\right)^{\frac{1}{2}} \\
 & \frac{2^{3 \times \frac{1}{2}}}{9^{\frac{1}{2}}} \\
 & \frac{2^{\frac{3}{2}}}{9^{\frac{1}{2}}} \\
 & \frac{\sqrt{2^3}}{\sqrt{9}} \\
 & \frac{\sqrt{8}}{3} \\
 & \frac{2\sqrt{2}}{3}
 \end{aligned}$$

$$\begin{aligned}
 \text{b) } & (x^{\frac{5}{4}}y)(x^{\frac{3}{4}}y^{-4}) \\
 & x^{\frac{5}{4}+\frac{3}{4}}y^{1+(-4)} \\
 & x^{\frac{8}{4}}y^{-3} \\
 & \frac{x^2}{y^3}
 \end{aligned}$$

$$\begin{aligned}
 \text{c) } & 81^{\frac{-3}{4}} \\
 & \frac{1}{81^{\frac{3}{4}}} \\
 & \frac{1}{\sqrt[4]{81^3}} \\
 & \frac{1}{3^3} \\
 & \frac{1}{27}
 \end{aligned}$$

18. Simplify. Write all answers with positive exponents.

$$\text{a) } \left(\frac{4^4}{25}\right)^{\frac{-1}{2}}$$

$$\text{b) } (x^{\frac{1}{5}}y)(x^{\frac{2}{5}}y^{-3})$$

$$\text{c) } 16^{\frac{-3}{4}}$$

Level 4

The rubric states: I am able to perform error analysis. I am able to determine which value is larger/smaller in a set of numbers. I am able to answer situational questions. I am able to explain my strategies.

Go through your practice assignments to review these types of questions.