

Algebra I

Lesson 7-3

Standard:

N.RN.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.

Learning Goal:

- I can raise a power to a power.
- I can raise a product to a power.

Handwritten mathematical derivation showing the relationship between different forms of the expression $(x^5)^2$:

$$(x^5)^2$$
$$(x^5)(x^5)$$
$$x^{5+5} = x^{10}$$
$$(x^5)^2 = x^{5 \cdot 2} = x^{10}$$

The diagram includes blue circles around $(x^5)^2$ and x^{10} , and a blue arrow pointing from the top circle to the bottom circle.

Raising a Power to a Power

To raise a power to a power, multiply the exponents.

$$(a^m)^n = a^{mn} \quad \text{where } a \neq 0 \text{ and } m \text{ and } n \text{ are rational numbers}$$

$$\begin{array}{l} (5^4)^2 \\ 5^{4 \cdot 2} = 5^8 \end{array}$$

$$\begin{array}{l} (m^3)^5 \\ m^{3 \cdot 5} = m^{15} \end{array}$$

$$\begin{array}{l} (a^{\frac{3}{2}})^3 \\ a^{\frac{9}{2}} \end{array}$$

$$\begin{array}{l} (x^{\frac{1}{5}})^3 \\ x^{\frac{3}{10}} \end{array}$$

Simplifying a Power Raised to a Power

What is the simplified form of each?

$$\begin{array}{l} (n^4)^7 \\ n^{28} \end{array}$$

$$\begin{array}{l} (x^{\frac{2}{3}})^{\frac{1}{2}} \\ x^{\frac{2}{3} \cdot \frac{1}{2}} = x^{\frac{1}{3}} \end{array}$$

Got It?

What is the simplified form of each?

$$(p^5)^4$$

p²⁰

$$(p^4)^5$$

p²⁰

$$(p^{\frac{1}{2}})^{\frac{1}{4}}$$

p^{1/8}

$$(p^{\frac{1}{4}})^{\frac{1}{2}}$$

p^{1/8}

$$(a^m)^n = (a^n)^m$$

Simplifying an Expression with Powers

What is the simplified form of the expression?

$$y^3(y^{\frac{5}{2}})^{-2}$$

$$y^3 y^{-5}$$

$$y^{-2} = \left(\frac{1}{y^2}\right)$$

Got It?

What is the simplified form of each expression?

$$x^2(x^6)^{-4}$$

$$\frac{1}{x^{22}}$$

$$w^{-2}(w^{\frac{5}{3}})^3$$

$$w^3$$

$$w^{-2} w^{\frac{5}{3} \cdot 3}$$

$$w^{-2} w^5$$

$$w^{-2+5} = w^3$$

$$(v^{-5})^{-\frac{1}{2}}(v^{\frac{3}{2}})$$

$$v^{-5(\frac{1}{2})} v^{\frac{3}{2}}$$

$$v^{\frac{5}{2}} v^{\frac{3}{2}}$$

$$v^{\frac{5}{2} + \frac{3}{2}} = v^{\frac{8}{2}} = v^4$$

Assignment

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$$\begin{aligned}
 & (4m^{\frac{1}{2}})^3 \\
 & (4m^{\frac{1}{2}}) \cdot (4m^{\frac{1}{2}}) \cdot (4m^{\frac{1}{2}}) \\
 & 4 \cdot 4 \cdot 4 \cdot m^{\frac{1}{2}} \cdot m^{\frac{1}{2}} \cdot m^{\frac{1}{2}} \\
 & 64 m^{\frac{3}{2}}
 \end{aligned}$$

Raising a Product to a Power

To raise a product to a power, raise each factor to the power and multiply

$$(ab)^n = a^n b^n$$

where $a \neq 0$, $b \neq 0$, and n is a rational number

$$\begin{aligned}
 & (3x)^4 \\
 & 3^4 \cdot x^4 \\
 & 81x^4
 \end{aligned}$$

$$\begin{aligned}
 & (4b)^{\frac{3}{2}} \\
 & 4^{\frac{3}{2}} \cdot b^{\frac{3}{2}} \\
 & 4^{\frac{1}{2}} \cdot 4^{\frac{1}{2}} \cdot 4^{\frac{1}{2}} \cdot b^{\frac{3}{2}} \\
 & 2 \cdot 2 \cdot 2 \cdot b^{\frac{3}{2}} \\
 & 8b^{\frac{3}{2}}
 \end{aligned}$$

Simplifying a Product Raised to a Power

Write an expression that represents the area of the square.

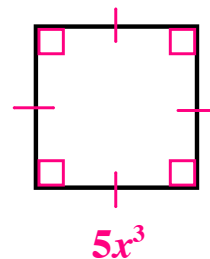
$$A = S^2 \quad \text{S = length of one side}$$

$$S = 5x^3$$

$$A = (5x^3)^2$$

$$A = 5^2 x^6$$

$$A = 25x^6$$



Got It?

What is the simplified form of each expression?

$$(7m^9)^3$$

$$343m^{27}$$

$$(2z)^{-4}$$

$$\frac{1}{16z^4}$$

$$(3g^4)^{-2}$$

$$\frac{1}{9g^8}$$

Simplifying an Expression with Products

What is the simplified form of the expression?

$$\begin{aligned} & (n^{\frac{1}{2}})^{10} (4mn^{-\frac{2}{3}})^3 \\ & n^5 \cdot 4^3 \cdot m^3 \cdot n^{-2} \\ & 64 m^3 \cdot n^5 \cdot n^{-2} \\ & \boxed{64m^3n^3} \end{aligned}$$

Got It?

What is the simplified form of each expression?

$$(x^{-2})^2(3xy^5)^4$$

$$81y^{20}$$

$$(3c^{\frac{5}{2}})^4(c^2)^3$$

$$81c^{16}$$

$$(6ab)^3(5a^{-3})^2$$

$$\frac{5400b^3}{a^3}$$

$$\begin{aligned} & 6^3 a^3 b^3 5^2 a^6 \\ & 6^3 \cdot 5^2 \cdot a^3 \cdot a^6 \cdot b^3 \\ & 216 \cdot 25 \cdot a^3 \cdot b^3 \\ & \frac{5400b^3}{a^3} \end{aligned}$$

Assignment

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Raising a Number in Scientific Notation to a Power

The expression $\frac{1}{2}mv^2$ gives the kinetic energy, in joules, of an object with a mass of m kg traveling at a speed of v meters per second. What is the kinetic energy of an experimental unmanned jet with a mass of 1.3×10^3 kg traveling at a speed of about 3.1×10^3 m/s?

$$\begin{aligned} & \frac{1}{2}mv^2 && \text{about} \\ & \frac{1}{2}(1.3 \times 10^3)(3.1 \times 10^3)^2 && 6.2465 \times 10^9 \text{ joules} \\ & \frac{1}{2}(1.3 \times 10^3)(3.1^2 \times 10^6) \\ & \frac{1}{2} \cdot 1.3 \cdot 9.61 \cdot 10^3 \cdot 10^6 \\ & 6.2465 \times 10^9 \end{aligned}$$

Got It?

What is the kinetic energy of an aircraft with a mass of 2.5×10^5 kg traveling at a speed of about 3×10^2 m/s?

$$\frac{1}{2}(2.5 \times 10^5)(3 \times 10^2)^2$$

$$\left(\frac{1}{2}\right)(2.5)(9)(10^5)(10^4)$$

$$11.25 \times 10^9$$

$$1.125 \times 10^1 \times 10^9$$

about 1.125×10^{10} joules

The expression $\frac{1}{2}mv^2$ gives the kinetic energy, in joules, of an object with a mass of m kg traveling at a speed of v meters per second.

Assignment

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