STATION 1

PRODUCT RULE: $a^m \cdot a^n = a^{m+n}$

Use the Product Rule to simplify the below expressions:

1. $x^5 \cdot x$ x^6
2. $x^5 \cdot x^2 \cdot x^4$ x^{11}
3. $3a^2b^3 \cdot -2ab^4$ $-6a^3b^7$

QUOTIENT RULE: $\frac{a^m}{a^n} = a^{m-n}$ or where are there more? How many more?

Use the **Quotient Rule** to simplify the below expressions:

4. $\frac{a^4}{a}$ a^3
5. $\frac{6x^7}{4x^5}$ $\frac{3x^2}{2}$
6. $\frac{6x^6y^3}{12x^5yz^4}$ $= \frac{xy^2}{2z^4}$

Power to Power Rule: $(a^m)^n = a^{m \cdot n}$

$(am)^n = a^m a^n = (2x^3)^2 = 2^2(x^3)^2$

AND:

$$\left(\frac{4y^2}{3x}\right)^3 = \frac{4^3(y^2)^3}{3^3x^3} = \frac{64y^6}{27x^3}$$

Use the **Power to a Power Rule** to simplify the below expressions:

7. $(x^3)^6$ x^{18}
8. $(x^4y^6)^8$ $x^{32}y^{48}$
9. $(-3xy^2)^4$ $(-3)^4x^4y^8 = 81x^4y^8$

Use the **Fraction to a Power Rule** to simplify the below expressions: $\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}$
Remember to ***SIMPLIFY INSIDE THE ( )s first if possible!***

10. $\left(\frac{4}{x}\right)^2$ $= \frac{16}{x^2}$
11. $\left(\frac{3yx^2}{5x}\right)^2$ = simplify 1st $= \left(\frac{3xy}{5x}\right)^2 = \frac{9y^2x^2}{25x^2} = \frac{9x^2y^2}{25}$
12. $\left(\frac{2b^6c}{4b^4c}\right)^2$ simplify 1st $\left(\frac{b^2}{2}\right)^2 = \frac{b^4}{4}$

STATION #2

NEGATIVE EXPONENT RULES: $a^{neg} = \frac{1}{a^{pos}}$ & $\frac{1}{a^{neg}} = a^{pos}$

Use the **Negative Exponent Rule** to simplify the below expressions; all exponents in the final answer must be positive!

Examples: $3^{-3} = \frac{1}{3^3} = \frac{1}{27}$ $\left(\frac{1}{3}\right)^{-2} = \left(\frac{3}{1}\right)^2 = 9$

$\left(\frac{6x^2}{3x^3}\right)^{-3} =$ ↑ simplify 1st $= \left(\frac{2}{x}\right)^{-3}$ → apply neg exp → $\left(\frac{x}{2}\right)^3 = \frac{x^3}{8}$

$5x^{-3} = \frac{5}{x^3}$

$5x^2y^0 = 5x^2$ } zero

$(5x^2y)^0 = 1$

1. 3^{-1}

$\frac{1}{3}$

2. $\left(\frac{6}{x}\right)^{-2}$

$\left(\frac{x}{6}\right)^2 = \frac{x^2}{36}$

3. $\left(\frac{x^4y}{x^2y^4}\right) = \frac{x^2}{y^3}$

4. $\frac{5^{-3}}{5^{-8}}$

$5^{-3--8} = 5^5$

or $\frac{5^8}{5^3} = 5^5$

5. $\frac{12x^{-3}}{4x^2}$

$= \frac{3}{x^5}$

6. $(3x^2y^{-1})^{-3}$

$= 3^{-3}(x^2)^{-3}(y^{-1})^{-3}$

$= \frac{1}{27}x^{-6}y^3$

$= \frac{1y^3}{27x^6}$

7. $\frac{3x^{-2}}{9x}$

$\frac{x^{-2}}{3x} = \frac{1}{3x^3}$

8. $\left(\frac{33x^{-1}y^2}{11x^2y^{-3}}\right)^{-2}$

↑ simplify 1st

$\left(\frac{3y^5}{x^3}\right)^{-2} = \left(\frac{x^3}{3y^5}\right)^2 = \frac{x^6}{9y^{10}}$

STATION #3 – RATIONAL EXPONENTS

RULE: $a^{m/n} = \left(\sqrt[n]{a}\right)^m = \sqrt[n]{a^m}$

Roots grow underground!

$(64x^2)^{\frac{1}{2}} = \sqrt{64x^2} = 8x$ $\quad (-27x^6)^{\frac{2}{3}} = \left(\sqrt[3]{-27x^6}\right)^2 = (-3x^2)^2 = 9x^4$

Rewrite the following expressions as a base with a rational exponent. Simplify if possible (no calculator!)

1. $\sqrt{x} = x^{\frac{1}{2}}$ 2. $\sqrt[3]{64} = 64^{\frac{1}{3}} = 4$ 3. $\sqrt[4]{a^3} = a^{\frac{3}{4}}$

Rewrite the following expressions as radicals. Simplify if possible.

4. $32^{\frac{1}{5}}$ $\quad \sqrt[5]{32} = 2$

5. $b^{\frac{1}{4}}$ $\quad \sqrt[4]{b}$

6. $z^{\frac{2}{3}}$ $\quad \sqrt[3]{z^2}$

7. $64^{\frac{2}{3}}$ $\quad \left(\sqrt[3]{64}\right)^2 = 4^2 = 16$

8. $(-8)^{\frac{2}{3}}$ $\quad \left(\sqrt[3]{-8}\right)^2 = (-2)^2 = 4$

9. $16^{-\frac{1}{4}}$ $\quad \sqrt[4]{16} = 2$

ZERO AS AN EXPONENT:

RULE: $a^0 = 1$

10. $3a^0$ $\quad = 3(1) = 3$

11. $(3x)^0 = 1$

12. $4x^2y^0 = 4x^2$

key

STATION 4 - CAN YOU CREATE LIKE BASES?

Rule: If $a^m = a^n$, then m = n

Solve:

$3^{2x} = 3^{x+4}$

$2x = x + 4$

$x = 4$

$25^{x+1} = 5^{3x-5}$

$5^{2(x+1)} = 5^{3x-5}$

$2x + 2 = 3x - 5$

$-1x = -7$

$x = 7$

$9^{x+3} = 27^{2x-6}$

$3^{2(x+3)} = 3^{3(2x-6)}$

$2x + 6 = 6x - 18$

$-4x = -24$

$x = 6$

$4^{x-1} = 1$

$4^{x-1} = 4^0$

$x - 1 = 0$

$x = 1$

SOLVE by creating like bases!

1. $-27 = (-3)^{2x+1}$

$(-3)^3 = (-3)^{2x+1}$

$3 = 2x + 1$

$2 = 2x$

$x = 1$ check ✓

2. $\frac{1}{2} = 2^{3x-1}$

$2^{-1} = 2^{3x-1}$

$-1 = 3x - 1$

$0 = 3x$

$x = 0$

check ✓

3. $5^{2x-1} = 125^{x-3}$

$5^{2x-1} = 5^{3(x-3)}$

$2x - 1 = 3x - 9$

$8 = x$

check ✓

Key

STATION 5 - ALL MIXED UP

Simplify the below expressions. Use all applicable exponent properties.
All exponents must be positive in the final answer!

1. $\dfrac{4x^2}{(2x^2)^3}$

$= \dfrac{4x^2}{8x^6} = \dfrac{1}{2x^4}$

2. $-6a^3(ab^2)^2$

$-6a^3a^2b^4$

$= -6a^5b^4$

3. $(16x^4y^8z^3)^{\frac{1}{4}}$

$= 2xy^2z^{\frac{3}{4}}$

4. $3a(-4a^2b^3)^0$

$= 3a$

5. $(-4a^2bc^3)\cdot(2ab^2c^{-2})$

$= -8a^3b^3c$

6. $\left(\dfrac{4x^{-2}y}{16xy^3}\right)^{-2}$ 1st

$\left(\dfrac{1}{4x^3y^2}\right)^{-2} = (4x^3y^2)^2$

$= 16x^6y^4$

Hint – one big parenthesis – simplify inside first!

7. $\dfrac{(-2w^{-2}y^2)^4}{(w^4y^{-1})^3} = \dfrac{16w^{-8}y^8}{w^{12}y^{-3}}$

You can't simplify this one first!

$= \dfrac{16y^{11}}{w^{20}}$

8. $\dfrac{8x^3y^{-3}}{(2xy)^{-2}}$ ← do 1st

$= \dfrac{8x^3y^{-3}}{2^{-2}x^{-2}y^{-2}}$

$= 8x^3y^{-3}\cdot 2^2x^2y^2$

$= \dfrac{32x^5}{y}$

9. $\dfrac{x^{10}y^5(2xy^3)^3}{-2x^2z^{15}}$

$= \dfrac{x^{10}y^5(8x^3y^9)}{-2x^2z^{15}}$

$= \dfrac{8x^{13}y^{14}}{-2x^2z^{15}}$

$= -4x^{11}y^{14}/z^{15}$

 Key

STATION 6 – You need to know all numbers squared (between 1 and 13) and cubed between 1 and 5, and all powers of 10.

Express as a base raised to an exponent

$2 = 2^1$

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

$121 = 11^2$

$144 = 12^2$

$8 = 2^3$

$1/8 = 2^{-3}$

$16 = \frac{4^2}{} = \frac{2^4}{}$

$25 = 5^2$

$1/25 = 5^{-2}$

$125 = 5^3$

$1/125 = 5^{-3}$

$32 = 2^5$

$1/32 = 2^{-5}$

$1000 = 10^3$

$1/100 = 10^{-2}$

$64 = \frac{4^3}{} = \frac{2^6}{}$

$27 = 3^3$

$1/27 = 3^{-3}$

$1 = a^0$

3^0

$(\frac{1}{3})^0$

$(\text{any nonzero})^0$