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5.1. Advanced Algebra Properties of Exponents (Monomials)

DATE: _____

Target 6A. Simplify expressions using properties of exponents

Monomials - a number, a variable, or a product of a number and one or more variables

Examples: $4x$, $20x^2yw^3$, -3 , a^2b^3 , $3yz$ are all monomials.

Note: Monomials cannot contain variables in denominators, variables with negative exponents, or variables under radicals.

Constant - a monomial that is a number without a variable.

Examples: 6 , 201 , $1,000,001$, -3^2 , π , e , ...

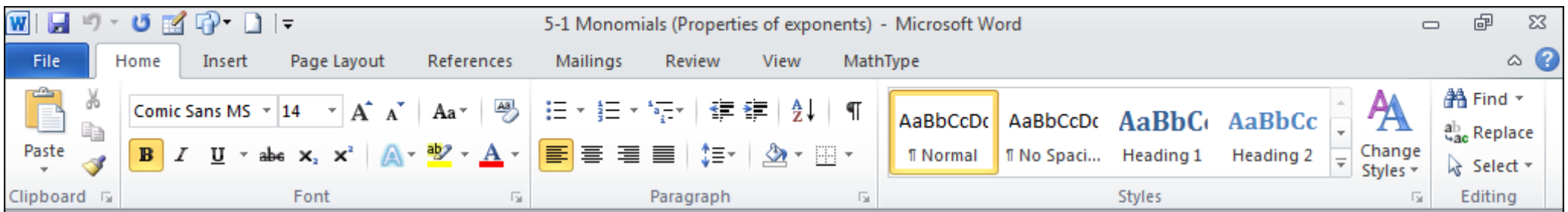
Coefficient - the numerical factor of a monomial.

Base - In an expression of the form x^n , the base is x .

Exponent/Power - In an expression of the form x^n , the exponent/power is n .

The **degree** of a monomial is the sum of the exponents of its variables. The degree of a constant is always 0.

Examples: $3m^6 \rightarrow \text{degree} = 6$, $5t^1g^1h^{12} \rightarrow \text{degree} = 14$



Writing Monomials Using Exponents

Rewrite the following expressions using exponents.

1. $x \cdot x \cdot x \cdot x \cdot y \cdot y$

$x^4 y^2$

2. $5 \cdot a \cdot a \cdot b \cdot b \cdot b \cdot b \cdot c \cdot c \cdot c$

$5a^2 b^4 c^3$

Writing Expressions WITHOUT Exponents

Write out each expression without exponents (as multiplication).

3. $8a^3 b^2$

$8 \cdot a \cdot a \cdot a \cdot b \cdot b$

4. $(xy)^4$

$(x y)(x y)(x y)(x y)$

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

PRODUCT OF POWERS

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PRODUCT OF POWERS

5. Simplify the following expression: (First write out in expanded form, and then rewrite using exponents)
 $(5a^2)(a^5)$

$$5(a \cdot a)(a \cdot a \cdot a \cdot a \cdot a) = 5a^7 \quad \text{So add exponents}$$

PRODUCT OF POWERS RULE

For any real number a , and integers m and n ,

$$a^m \cdot a^n = a^{m+n}$$

6. $a^9 \cdot a^4$
 a^{13}

7. $w^2 \cdot w^{10}$
 w^{12}

8. $r \cdot r^5$
 r^6

9. $(k^5)(k^3)$
 k^8

10. $x^2 \cdot y^2$
 x^2y^2

Multiplying Monomials

If the monomials have coefficients, multiply those, but still add the powers.

11. $(4a^9)(2a^4)$
 $8a^{13}$

12. $(7w^2)(10w^{10})$
 $70w^{12}$

13. $(2r)(-3r^5)$
 $-6r^6$

14. $(3k^5)(7k^3)$
 $21k^8$

15. $(12x^2)(2y^2)$
 $24x^2y^2$

If the monomials have a mixture of different variables, only add powers of like variables.

16. $(4a^9b^3)(2a^4b)$
 $8a^{13}b^4$

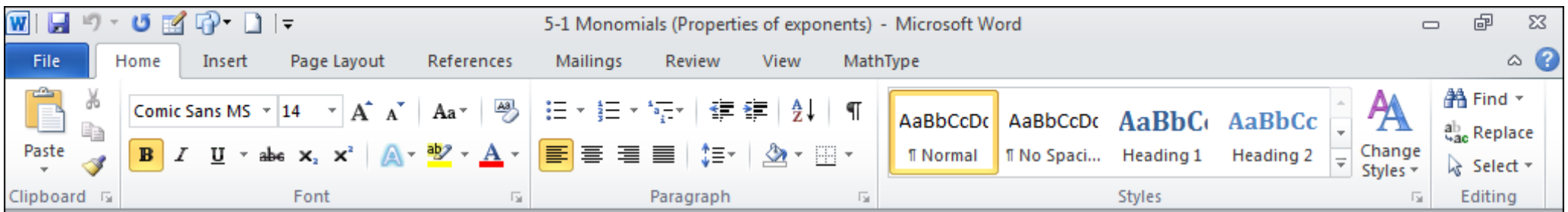
17. $(2rt^3)(-3r^5)$
 $-6r^6t^3$

18. $(3k^5mn^4)(7k^3m^3n^3)$
 $21k^8m^4n^7$

19. $(12x^2y^3)(2xy^2)$
 $24x^3y^5$

You try it!

You try it!



QUOTIENT OF POWRS RULE

For any real number $a \neq 0$, and integers m and n ,

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

Dividing Monomials

20. $\frac{-f^3 g^2 h^2}{f^1 g^1 h^1} = -f^2 g h$

3-1 for f
2-1 for g
2-1 for h

METHOD 2:

$$\frac{-\cancel{f} \cdot \cancel{f} \cdot \cancel{f} \cdot \cancel{g} \cdot \cancel{g} \cdot h \cdot h}{\cancel{f} \cdot \cancel{g} \cdot \cancel{h}} = -f^2 g h$$

21. $\frac{24x^3 y^5}{-6xy^4} = -4x^2 y$

$\frac{24}{-6} = -4$
3-1 for x
5-4 for y

NEGATIVE EXPONENT RULE

For any real number $a \neq 0$ and any integer n , $a^{-n} = \frac{1}{a^n}$ and $\frac{1}{a^{-n}} = a^n$ "flip" negative exponents ONLY

22. $\frac{1}{x^{-9} y^{-3}} = \frac{1}{x^9 y^3} = \frac{1}{x^{10} w^6 u^2 y^3}$

23. $\frac{x^{-6}}{x^{-8}} = \frac{x^8}{x^6} = x^2$
 $8-6=2$

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PROPERTIES OF POWERS

Suppose a and b are real numbers and m and n are integers. Then the following properties hold:

Power of Zero: $a^0 = 1$

(any number raised to the power of zero is always one)

Ex: $2^0 = 1$

Power of a Power: $(a^m)^n = a^{mn}$

Ex: $(3^5)^4 = 3^{5 \cdot 4}$

Power of a Product: $(ab)^m = a^m b^m$

Ex: $(2 \cdot 7)^3 = 2^3 \cdot 7^3$

Power of a Quotient: $\left(\frac{a}{b}\right)^n = \left(\frac{a^n}{b^n}\right)$, $b \neq 0$ and
 $\left(\frac{a}{b}\right)^{-n} = \left(\frac{b}{a}\right)^n = \left(\frac{b^n}{a^n}\right)$

Ex: $\left(\frac{2}{3}\right)^5 = \frac{2^5}{3^5}$
 $\left(\frac{2}{3}\right)^{-5} = \frac{2^{-5}}{3^{-5}} = \frac{3^5}{2^5}$

Simplify each expression.

24. $x^0 \cdot y^2 = 1 \cdot y^2 = y^2$

25. $(ab)^0 = a^0 \cdot b^0 = 1 \cdot 1 = 1$

26. $(b^9)^{10} = b^{9 \cdot 10} = b^{90}$

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27. $(c^3)^3$

You try it!

28. $(2b^9)^3 = 2^3 b^{27} = 8b^{27}$

$2^3 = 2 \cdot 2 \cdot 2$

29. $(7w^{12})^2$

You try it!

30. $(5w^3xy^2)^4 = 5^4 w^{12} x^4 y^8$

31. $(7w^{12}y^4z)^2$

You try it!

32. $\frac{5^0 t^4 w u^2}{t^2 w^3 u^2} = \frac{1 \cdot t^4 \cdot w^1 \cdot u^2}{t^2 \cdot w^3 \cdot u^2} = t^2 w^{-2} u^0 = t^2 w^{-2} \cdot 1 = \frac{t^2}{w^2}$

$4-2$ $1-3$ $2-2$

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$$33. \frac{-27x^4y^5}{-9x^2y^6} = 3x^2y^{-1} = \frac{3x^2}{y} = \frac{3x^2}{y}$$

$\frac{-27}{-9} = 3$ $4-2$ $5-6$

You try it!

$$34. \frac{30x^{-10}y^2z^{16}}{5x^{-5}y^6z^{-4}}$$

$$35. \frac{(x^2y^6)(x^5y)}{(x^8y)^3} = \frac{x^7y^7}{x^{24}y^3} = x^{-17}y^4 = \frac{y^4}{x^{17}}$$

$7-24$ $7-3$

multiply

$$36. \frac{(-7a^5b^4c^0)^{-4}}{(5a^7b^3c^3)^{-4}} = \frac{(-7)^{-4} a^{-20} b^{-16} c^0}{(5)^{-4} a^{-28} b^{-12} c^{-12}} = \frac{5^4 a^{16} b^{12} c^{12}}{(-7)^4 a^{20} b^{16}} = \frac{5^4 a^{-4} b^{-4} c^{12}}{(-7)^4} = \frac{5^4 c^{12}}{(-7)^4 a^4 b^4}$$

$16-20$ $12-16$

$c^0 = 1$

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$$36. \left(\frac{-7a^5b^4c^0}{5a^4b^3c^3} \right)^{-4}$$

$$37. \frac{(4^3x^5y^4)^{-2}}{(4^5x^{-1}y^5)^{-4}}$$

You try it!