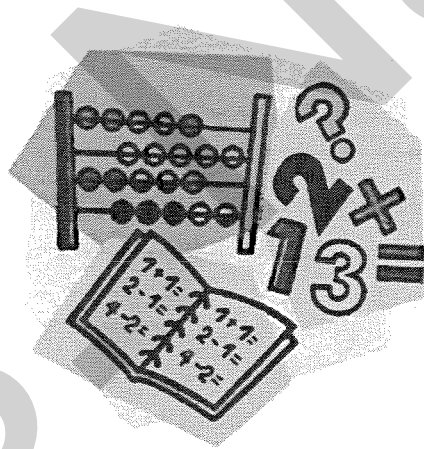


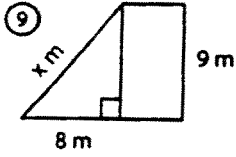
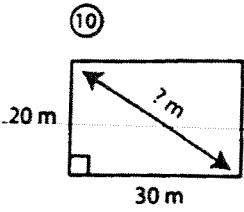
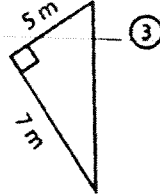
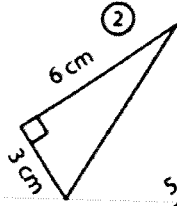
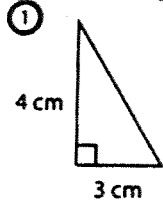
**PYTHAGOREAN THEOREM,  
REAL NUMBERS,  
EXPONENTS,  
POWERS OF TEN,  
SCIENTIFIC NOTATION,  
POLYNOMIAL  
BOOKLET**



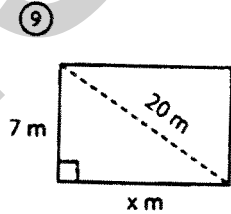
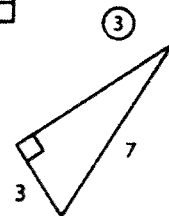
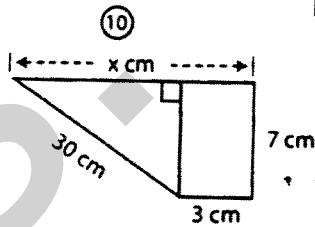
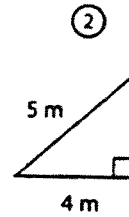
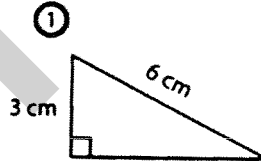
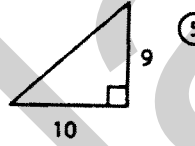
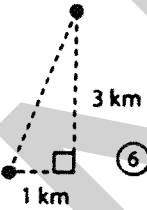
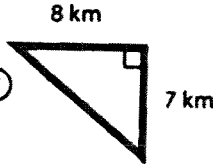
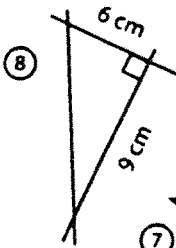
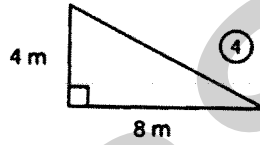
**SECONDARY 3  
CULTURAL  
MS. NASSIF**

# PYTHAGOREAN THEOREM

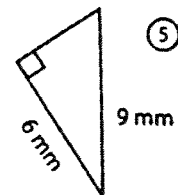
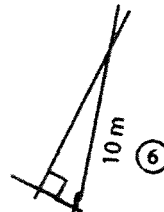
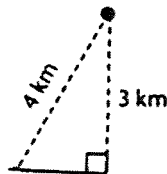
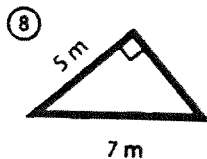
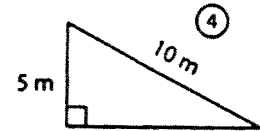
Find the missing side in each case below.



## Set 1



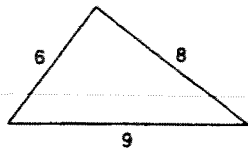
## Set 2



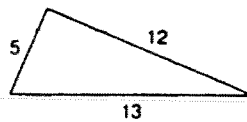
# PYTHAGOREAN THEOREM

Do the following lengths form a right triangle?

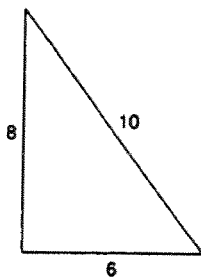
1)



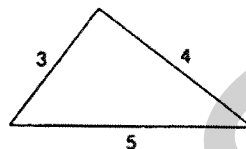
2)



3)



4)



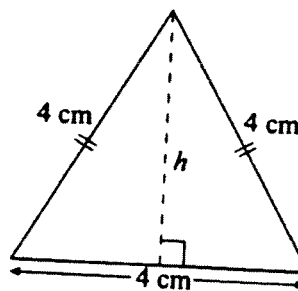
5)  $a = 6.4$ ,  $b = 12$ ,  $c = 12.2$

6)  $a = 2.1$ ,  $b = 7.2$ ,  $c = 7.5$

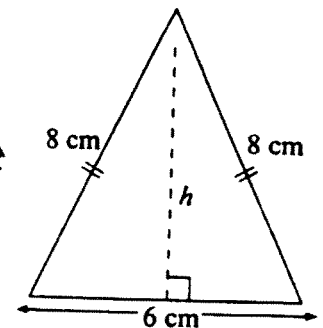
7) Use Pythagoras' Theorem to determine which of the sets of numbers below are Pythagorean triples:

- a) 15, 20, 25
- b) 10, 24, 26
- c) 11, 22, 30
- d) 6, 8, 9

8) Calculate the height of this equilateral triangle.



9) Calculate the height of the isosceles triangle.



10) The width of a rectangle is 5 cm and the length of its diagonal is 13 cm.

a) How long is the other side of the rectangle?

b) What is the area of the rectangle?

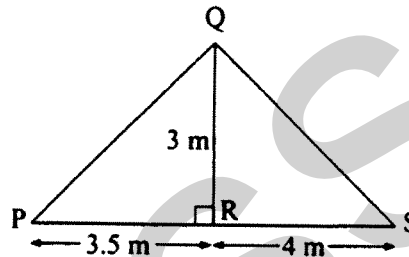
# PYTHAGOREAN THEOREM

3. A rectangle has sides of lengths 5 cm and 10 cm.  
How long is the diagonal of the rectangle?

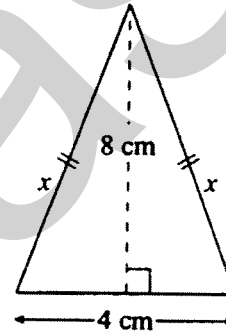
4. Calculate the length of the diagonal of a square with sides of length 6 cm.

5. The diagram shows a wooden frame that is to be part of the roof of a house:

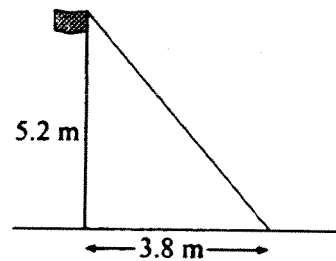
- (a) Use Pythagoras' Theorem in triangle PQR to find the length PQ.  
(b) Calculate the length QS.  
(c) Calculate the total length of wood needed to make the frame.



6. An isosceles triangle has a base of length 4 cm and perpendicular height 8 cm. Giving your answers correct to 1 decimal place, calculate:  
(a) the length,  $x$  cm, of one of the equal sides,  
(b) the perimeter of the triangle.

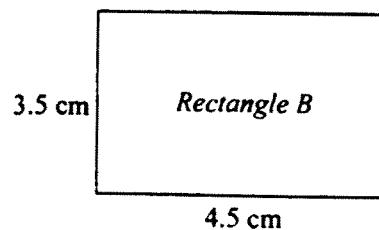
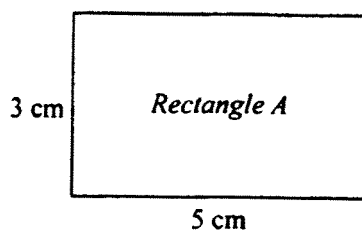


7. One end of a rope is tied to the top of a vertical flagpole of height 5.2 m. When the rope is pulled tight, the other end is on the ground 3.8 m from the base of the flagpole.  
Calculate the length of the rope, giving your answer correct to 1 decimal place.



8. A rectangular lawn is 12.5 m long and 8 m wide. Matthew walks diagonally across the lawn from one corner to the other. He returns to the first corner by walking round the edge of the lawn. How much further does he walk on his return journey?

9. Which of the rectangles below has the longer diagonal?



# REAL NUMBERS

Directions: Name ALL the set(s) of numbers to which each number belongs.

*Real, Rational, Irrational, Integer, Whole, Natural*

1.  $-\frac{5}{6}$  \_\_\_\_\_

2. 35.99 \_\_\_\_\_

3. 0 \_\_\_\_\_

4.  $4\frac{1}{8}$  \_\_\_\_\_

5.  $\sqrt{5}$  \_\_\_\_\_

6. -80 \_\_\_\_\_

7.  $\frac{12}{3}$  \_\_\_\_\_

8.  $\sqrt{100}$  \_\_\_\_\_

9.  $-\sqrt{4}$  \_\_\_\_\_

10. 3.24 \_\_\_\_\_

11.  $3\pi$  \_\_\_\_\_

**Check the box(es) if the number belongs in that group.**

	<b>Number</b>	<b><u>N</u>atural Numbers</b>	<b><u>W</u>hole Numbers</b>	<b><u>I</u>ntegers</b>	<b><u>R</u>ational Numbers</b>	<b><u>I</u>rrational Numbers</b>	<b><u>R</u>eal Numbers</b>
16.	$\sqrt{13}$						
17.	-5						
18.	$\frac{2}{3}$						
19.	-0.083						
20.	27						
21.	$2.\overline{647}$						
22.	$3.0\overline{505}$						
23.	-198						
24.	$-\frac{1}{2}$						
25.	10						

# REAL NUMBERS

**1. Write each number using periodic notation and indicate the period of the decimal.**

	Periodic Notation	Period
<b>Example:</b> 3.11525252....	3.11 $\overline{52}$	52
<b>a)</b> 12.444 444 444 ...		
<b>b)</b> 4.567 676 767...		
<b>c)</b> 768.143 214 321...		
<b>d)</b> 4.543 777 777...		
<b>e)</b> 154.902 902 902 ...		
<b>f)</b> 0.383 838 383...		

**2. Write each number using periodic notation.**

**a)**  $\frac{4}{5}$

**d)**  $\frac{-7}{55}$

**b)**  $\frac{8}{9}$

**e)**  $\frac{7}{6}$

**c)**  $\frac{132}{111}$

**f)**  $\frac{8}{11}$

**3. Write each number as a reduced fraction. (Period = 0)**

**a)** 0.9

**e)** 1.7215

**b)** 0.25

**f)** 138.9

**c)** 4.75

**g)** 1.5

**d)** 2.5

**h)** 9.36

**4. Write each numbers as a reduced fraction (Period ≠ 0)**

**a)**  $1.\overline{02}$

**e)**  $0.\overline{1}$

**b)**  $0.\overline{52}$

**f)**  $0.\overline{18}$

**c)**  $0.\overline{24}$

**g)**  $0.\overline{27}$

**d)**  $0.\overline{125}$

**h)**  $0.\overline{25}$

Name \_\_\_\_\_

Date \_\_\_\_\_

## Exponents and Multiplication

Simplify. Use Rule 1



1)  $4^2 \cdot 4^2$

2)  $4 \cdot 4^2$

3)  $3^2 \cdot 3^2$

4)  $2 \cdot 2^2 \cdot 2^2$

5)  $2n^4 \cdot 5n^4$

6)  $6r \cdot 5r^2$

7)  $2n^4 \cdot 6n^4$

8)  $6k^2 \cdot k$

9)  $5b^2 \cdot 8b$

10)  $4x^2 \cdot 3x$

11)  $6x \cdot 2x^2$

12)  $6x \cdot 6x^3$

13)  $7v^3 \cdot 10u^3v^5 \cdot 8uv^3$

14)  $9xy^2 \cdot 9x^5y^2$

15)  $6m^3n^3 \cdot 8m^2n^3$

16)  $6x^2 \cdot 6x^3y^4$

17)  $7u^2v^5 \cdot 9uv^3$

18)  $uv \cdot 4uv^5$

19)  $10xy^3 \cdot 8x^5y^3$

20)  $3u^4v^5 \cdot 7u^2v^3$





NAME: \_\_\_\_\_



**13.3 MULTIPLICATION WITH EXPONENTS**

When multiplying numbers with exponents and the bases are the same, we add the exponents and keep the base the same as shown in the examples below.

**EXAMPLE #1:**

$$5^3 \times 5^2 = 5 \times 5 \times 5 \times 5 \times 5 = 5^5 \text{ or}$$

$$5^3 \times 5^2 = 5^{(3+2)} = 5^5$$

**EXAMPLE #2:**

$$7^2 \cdot 4^3 \cdot 7^8 \cdot 4^6 = 7^{(2+8)} \cdot 4^{(3+6)}$$

$$= 7^{10} \cdot 4^9$$

(We add the exponents of the bases that are the same.)

**EXAMPLE #3:**

$$(3^4)(5^2)(8^3) = (3^4)(5^2)(8^3)$$

(None of the bases were the same so we could not add the exponents.)

**EXAMPLE #4:**

$$3^{-2} \times 3^{-4} = 3^{(-2)+(-4)} = 3^{-6}$$

A. Write each first in factored form and then in exponential form.

1.  $8^4 \times 8^2$

2.  $7^3 \times 7^5$

3.  $15^2 \times 15^3$

4.  $9^3 \times 9^3$

5.  $18^5 \times 18^0$

6.  $(\frac{3}{4})^2 \times (\frac{3}{4})^3$

7.  $(-9)^2 \times (-9)^4$

8.  $(-3)^1 \times (-3)^4$

9.  $(+3)^1 \times (-3)^3$

10.  $(7)^{-5} \times (7)^{-1}$

11.  $(8^0) \times (8)^0$

12.  $3^{-3} \times 3^{-5}$

13.  $5^2 \cdot 5^5 \cdot 5^3$

14.  $8^1 \cdot 8^1 \cdot 8^2$

15.  $6^3 \cdot 6^4 \cdot 6^0$

16.  $2^1 \cdot 2^2 \cdot 2^3$

17.  $8^6 \cdot 6^8$

18.  $6^{-6} \cdot 6^{+6}$

B. Calculate each of the following and leave your answers in exponential form.

1.  $2^3 \times 2^4$

2.  $5^2 \times 5^7$

3.  $5^4 \times 5^4$

4.  $8^3 \times 8^7$

5.  $9^3 \times 9^9$

6.  $8^4 \times 8^6$

7.  $8^3 \times 8^5$

8.  $(-3)^5 \times (-3)^6$

9.  $(-5)^7 \times (-5)^8$

~~10.  $(\frac{3}{4})^2 \cdot (\frac{3}{4})^8$~~

11.  $19^{-3} \times 19^{-6}$

12.  $20^5 \times 20^{-5}$

13.  $2^4 \times 2^3 \times 2^5$

14.  $5^3 \times 5^3 \times 5^7$

15.  $8^2 \times 8^3 \times 8^7$

16.  $3^4 \times 5^7$

17.  $15^0 \cdot 15^6 \cdot 15^4$

18.  $(-5)^7 \cdot (-5)^6 \cdot (-5)^3$

19.  $7^{-2} \cdot 7^{-3} \cdot 7^{-4}$

~~20.  $(\frac{3}{4})^5 \cdot (\frac{3}{4})^6 \cdot (\frac{3}{4})^7$~~

21.  $8^5 \cdot 7^5 \cdot 6^5$

22.  $3^2 \times 3^4 \times 3^{-8}$

23.  $5^{-7} \cdot 5^{-9} \cdot 5^{-8}$

24.  $(8^3)(8^5)(8^{-9})$

C. Calculate each of the following and leave your answer in exponential form.

1.  $2^{10} \times 2^4$

2.  $6^3 \times 6^3$

3.  $7^5 \times 7^{-2}$

4.  $(-2)^4 \times (-2)^6$

5.  $5^{-3} \times 5^5$

6.  $(-2)^4 \times (-2)^{-7}$

7.  $(\frac{3}{4})^5 \times (\frac{3}{4})^2$

8.  $(-8)^5 \cdot (-8)^{-8}$

9.  $3^8 \times 3^{-2}$

10.  $7^5 \times 7^{-5}$

11.  $5^2 \cdot 5^{-3} \cdot 5^{-4}$

12.  $x^2 x^7 x^8$

13.  $7^6 7^4 7^3$

14.  $y^7 y^3 y^5 y^4$

15.  $2^{-1} \times 2^{-2}$

16.  $3^4 \cdot 3^{-3} \cdot 3^2 \cdot 3^5$

17.  $8^3 7^3 8^3 7^5$

18.  $y^{2x} y^{6x}$

19.  $(3^4)^3$

20.  $x^3 y^3 x^4 y^1$

21.  $49^x \cdot 49^x$

22.  $3^2 4^2 3^5 4^7$

23.  $5^3 4^3 5^5 4^7$

24.  $y^{100} y^{-53} y^{-86}$

25.  $42^5 42^{-7} 42^2$

26.  $(2x)^{12} (2x)^{14}$

27.  $(3^4)^2 \cdot (3^4)^{-3}$

D. Calculate each of the following and leave your answer in exponential form.

1.  $a^5 a^4$

2.  $2^4 \cdot 2^5 \cdot 2^7$

3.  $x^6 x^5 x^3$

4.  $a^2 b^2 a^5 b^7$

5.  $5^5 4^3 5^7 4^3$

6.  $(x^5)(x^{-4})(x^3)$

7.  $a^4 b^9$

8.  $x^3 y^7 x^{-3} y^5 y$

9.  $x^5 y^7 x^3$

10.  $3^5 3^5 4^5 5^6$

11.  $3^5 a^7 3^4 a^8$

12.  $5^2 a^2 5^2 a^2$

13.  $x^3 y^3 x^5 y^{-7}$

14.  $y^{100} y^{-50} y^{-25}$

15.  $x^6 x^7 x^8$

16.  $5^0 \cdot 5^0 \cdot 5$

17.  $(a)(b^2)(a^3)(b^5)(b)$

18.  $7^2 7^3 7^5$

19.  $5^{-1} \cdot 5^{-2} \cdot 5^{-3}$

20.  $(4^2)(4^3)(4^5)(4)$

21.  $a^2 b^2 a^3 b^3$

22.  $4^4 5^5 6^6$

23.  $3^3 3^3 3^3 3$

24.  $x^4 y^5 z^7 x^6 y^5 z^3$

## 13.4 DIVISION WITH EXPONENTS

When dividing numbers with exponents and the bases are the same, we can either subtract the exponents or write the reciprocal of the divisor and then multiply as shown in the examples.

**EXAMPLE #1:**  $8^5 \div 8^2 = \frac{8 \times 8 \times 8 \times 8 \times 8}{8 \times 8} = 8^3$ , or  $8^{(5-2)} = 8^3$

**EXAMPLE #2:**  $\frac{5^6}{5^{-4}} = 5^{(6)-(-4)} = 5^{6+4} = 5^{10}$

**EXAMPLE #3:**  $\frac{8^3 \times 4^4 \times 8^5}{4^{-3} \times 8^3 \times 4^6} = 8^3 \times 4^4 \times 8^5 \times 4^3 \times 8^{-3} \times 4^{-6}$   
 $= 8^{3+5-3} \cdot 4^{4+3-6}$   
 $= 8^5 \cdot 4^1$

A. Divide each of the following and leave your answer in exponential form.

1.  $3^3 \div 3^2$

2.  $5^5 \div 5^2$

3.  $4^3 \div 4^3$

4.  $(-5)^3 \div (-5)^2$

5.  $(\frac{1}{2})^5 \div (\frac{1}{2})^4$

6.  $x^6 \div x^4$

7.  $(0.5)^6 \div (0.5)^3$

8.  $7^2 \div 7^3$

9.  $8^5 \div 8^7$

10.  $10^4 \div 10^2$

11.  $c^5 \div c^{-4}$

12.  $x^3 \div x^{-4}$

13.  $5^{13} \div 5^5$

14.  $7^{15} \div 7^{12}$

15.  $8^{-3} \div 8^6$

16.  $15^{-12} \div 15^{-10}$

17.  $(-2)^5 \div (-2)^3$

18.  $x^8 \div x^6$

19.  $9^{-12} \div 9^{-12}$

20.  $(-6)^5 \div (-6)^5$

21.  $7^{-10} \div 7^{-3}$

22.  $8^{15} \div 8^{12}$

23.  $(6.2)^{15} \div (6.2)^{-8}$

24.  $19^{10} \div 19^7$

25.  $12^0 \div 12^{-3}$

26.  $15^3 \div 15^{-7}$

27.  $82^{-9} \div 82^{-10}$

28.  $x^7 \div x^{-8}$

29.  $m^{-6} \div m^{-12}$

30.  $7^{15} \div 7^{-13}$

31.  $x^{-13} \div x^{-12}$

32.  $x^0 \div x^{-1}$

33.  $34^6 \div 34^2$

34.  $13^{-23} \div 13^4$

35.  $25^3 \div 25^{-3}$

36.  $8^{-5} \div 8^{-6}$

Name \_\_\_\_\_

## Exponents and Division

Date \_\_\_\_\_

Simplify. Your answer should contain only positive exponents. Use Rule 2

1)  $\frac{5^4}{5}$

2)  $\frac{3}{3^3}$

3)  $\frac{2^2}{2^3}$

4)  $\frac{2^4}{2^2}$

5)  $\frac{3r^3}{2r}$

6)  $\frac{7k^2}{4k^3}$

7)  $\frac{10p^4}{6p}$

8)  $\frac{3b}{10b^3}$

9)  $\frac{8m^3}{10m^3}$

10)  $\frac{7n^3}{2n^5}$

11)  $\frac{2n^2}{n}$

12)  $\frac{8x^3}{10x^5}$

13)  $\frac{12x^3}{9y^8}$

14)  $\frac{14x^4y^7}{6x^5y^4}$

15)  $\frac{11u^4}{17u^7v^9}$

16)  $\frac{4y^4}{14yx^8}$

17)  $\frac{12yx^4}{10yx^8}$

18)  $\frac{18x^8y^8}{10x^3}$

19)  $\frac{5n^8}{20n^8}$

20)  $\frac{16yx^4}{9x^8y^2}$

B. Simplify each of the following.

1.  $\frac{8^5 \times 8^6}{8^3 \times 8^4}$

2.  $\frac{7^{10} \times 7^5}{7^{-3}}$

3.  $\frac{5^{-3} \times 6^{-3} \times 9^{-4}}{5^{-6} \times 6^{-5} \times 9^{-3}}$

4.  $\frac{12^1 \times 12^2 \times 12^{-3}}{12^{-5}}$

5.  $\frac{8^{-3} \times 7^{-6}}{8^{-3} \times 7^{-6}}$

6.  $\frac{7^{-12} \times 7^6 \times 7^9}{7^6 \times 7^8}$

7.  $\frac{5^{-3} \times 8^6 \times 5^{-4} \times 8^7}{5^{-8} \times 8^5 \times 5^{-3}}$

8.  $\frac{7^8 \times 8^5 \times 9^3 \times 8^5}{7^5 \times 9^4 \times 8^3}$

9.  $\frac{6^3 \times 6^5 \div 6^8}{6^7 \times 6^3 \times 6^2}$

10.  $\frac{x^0 y^8 z^0}{x^0 y^{-8} z^0}$

11.  $\frac{15^{-10} \times 5^{-4}}{5^{-8} \times 15^{-10}}$

12.  $\frac{x^3 y^3 z^5}{x^{-2} y^5 z^{-8}}$

13.  $\frac{x^{15} \cdot y^{-20} \cdot z^{-20}}{x^6 \cdot y^{-30} \cdot z^{-8}}$

14.  $\frac{4^{-3} \cdot x^{-5} \cdot y^{-6}}{4^8 \cdot x^{-6} \cdot y^7}$

15.  $\frac{5^{10} \cdot x^7 \cdot y^8}{5^2 \cdot x^6 y^2}$

16.  $\frac{12^{16} 15^{-21} 17^{-4} 12^5 15^3 17^5}{12^{-4} 15^{-3} 17^4 15^6}$

17.  $\frac{12^2 \cdot 13^{-5} \cdot 12^{-5} \cdot 13^{-7} \cdot 12^3}{12^5 \cdot 13^3 \cdot 13^6 \cdot 12^5}$

18.  $\frac{y^8 x^1 (x^{24} + x^{14}) x^1 y^9}{(y^7 + y^5) x^1 x^{16}}$

19.  $\frac{x^{16} \div x^{12}}{x^{14} + x^9}$

20.  $\frac{5^2 \cdot 6^3 \cdot 5^{-4} \cdot 6^{-3}}{5^5 \cdot 6^{-4} \cdot 5^8 \cdot 6^{-7}}$

Name \_\_\_\_\_

Date \_\_\_\_\_

# Powers of Products ~~and Quotients~~

Simplify. Your answer should contain only positive exponents.

Use Rule 3 and 4

1)  $(3a^2)^3$

2)  $(2n^4)^4$

3)  $(3x^4)^4$

4)  $(6b^2)^2$

5)  $(7y^4)^2$

6)  $(3ab^4)^4$

7)  $(2x^4y^4)^3$

8)  $(5mn^3)^3$

9)  $(x^2y^2)^2$

10)  $(6yx^4)^2$

11)  $(u^4v^3)^2$

12)  $(2x^4y^4)^4$

13)  $(3x^2 \cdot 2x^2)^2$

14)  $(2p^3 \cdot 2p)^2$

15)  $(4n^3 \cdot n^2)^2$

16)  $(3x \cdot 2x)^2$

17)  $(4x^4 \cdot x^4)^3$

18)  $(4n^4 \cdot n)^2$

## 13.5 POWER OF A POWER PROPERTY

To solve an equation with more than one exponent associated with only one base, such as  $(5^4)^3$ , we can use the exponent on the outside of the brackets to tell us how many times to write the expression inside the brackets.  $\therefore (5^4)^3 = 5^4 \times 5^4 \times 5^4 = 5^{12}$

But if we use the power of a power property, we can exponentially solve this question by multiplying as shown in the examples below.

**EXAMPLES:** Use the power of a power property to solve each and leave your answer in exponential form.

$$1. (12^4)^5 = 12^{4 \times 5} = 12^{20}$$

$$2. [(8^{-3})^7]^2 = 8^{-3 \cdot 7 \cdot 2} = 8^{-42}$$

$$3. (5^2 \cdot 6^3)^4 = 5^{2 \cdot 4} \cdot 6^{3 \cdot 4} \\ = 5^8 \cdot 6^{12}$$

$$4. (3^4 a^2 b^3)^5 = 3^{4 \cdot 5} a^{2 \cdot 5} b^{3 \cdot 5} \\ = 3^{20} a^{10} b^{15}$$

A. Use the power of a power property and write each out in simplest exponential notation.

1.  $(2^4)^3$

2.  $(3^2)^6$

3.  $(5^3)^4$

4.  $(6^2)^4$

5.  $(3^2)^{-5}$

6.  $(8^{-2})^6$

7.  $(3^{-8})^3$

8.  $(2^{-5})^{-2}$

9.  $(2^{-3})^{-4}$

10.  $(7^{-4})^{-3}$

11.  $(6^{-4})^5$

12.  $(5^0)^{-3}$

13.  $(4^{-7})^4$

14.  $(7^8)^0$

15.  $(15^3)^{-7}$

16.  $(3^0)^0$

17.  $(y^3)^2$

18.  $(m^2)^4$

19.  $(x^5)^7$

20.  $(z^4)^5$

21.  $(y^3)^2$

22.  $(z^{-3})^4$

23.  $(z^{-5})^6$

24.  $(y^{-6})^{-2}$

25.  $(a^{-7})^{-2}$

26.  $(x^0)^7$

27.  $(z^{-8})^0$

28.  $(y^0)^0$

29.  $(m^{-8})^{-7}$

30.  $(y^5)^3$

31.  $(7^2)^2$

32.  $(3^2)^2$

33.  $(5^3)^4$

34.  $(6^2)^3$

35.  $(m^{-3})^3$

36.  $(5^{-4})^2$

37.  $(6^{-4})^3$

38.  $(8^3)^5$

39.  $(3^{16})^{23}$

40.  $(45^8)^{-34}$

41.  $(67^{20})^{-20}$

42.  $(67^{67})^{67}$

43.  $(12^{13})^{13}$

44.  $(5^{65})^0$

45.  $[(x^7)^5]^2$

Name \_\_\_\_\_

## Exponent Properties - WORKSHEET 2.2 - #1

Date \_\_\_\_\_

Simplify.

1)  $2^3 \cdot 2^2 \cdot 2^3$

3)  $2^3 \cdot 3^4$

5)  $3x^3 \cdot 2x^2$

7)  $2n^3 \cdot n^2 \cdot -3n^3$

9)  $-3x^2y^3 \cdot -2x^3y^3$

11)  $3ba^3c^4 \cdot a^4b^2c^4$

13)  $3^{-2}$

15)  $2nm^{-2}$

17)  $4y^{-2}z^4$

2)  $(-3)^3 \cdot (-3)^2$

4)  $9 \cdot 9^8 \cdot 9^{10}$

6)  $2v^2 \cdot 2v^3 \cdot 3v^2$

8)  $nm^3 \cdot m^3n^3$

10)  $3x^3y^3 \cdot 2x^2y^2 \cdot -2yx^3$

12)  $3xzy^3 \cdot 3x^3y^4z^2 \cdot 3yx^3z^4$

14)  $\frac{1}{2^{-4}}$

16)  $4u^{-3}v^{-4}$

18)  $h^3j^{-1}k^{-3}$

19)  $\frac{5^6}{5^2}$

20)  $\frac{5^4}{5^6}$

21)  $\frac{p^5}{p^2}$

22)  $\frac{3a^4}{a^6}$

23)  $-\frac{2x^4y^3}{x^2y^2}$

24)  $\frac{4x^2y^6}{3x^4y^3}$

25)  $\frac{yx^4z^2}{xy^4z^3}$

26)  $-\frac{2x^2y^2}{x^2y^4z^4}$

27)  $(2^3)^4$

28)  $((-4)^2)^4$

29)  $(n^4)^3$

30)  $(2x^3)^4$

31)  $(m^4n^2)^4$

32)  $(-4vu^2)^3$

33)  $(4x^2y^2z^4)^2$

34)  $(x^4y^2z^4)^4$



## 10.11 EXPONENTS REVIEW

A. Simplify each of the following and leave your answers in exponential form.

- $(7x^4)^5$
- $(abc)^2$
- $(4^4 y^5)^6$
- $(9x^2)(7x^3)$
- $x^2 y^3 x^4 y^5 x^6$
- $(7x^4y) + (21x^3y^3)$
- $(14x^8y^6) + (7x^6y^3)$
- $9(a^4b^6)^0$
- $(12x^2) \cdot (-3) + (4x^2)$
- $(-10mn^2) + (-10mn)$
- $(8abc)(c^2)(4a^2b^3c)$
- $(3x^4y^5) + (xy^3)$
- $-(5x^6)(-5x^6)$
- $(80a^2b^3) + (-16ab)$
- $(5x^6) + (2x^2)$
- ~~$(7x^2)^2 + (\frac{1}{2}x^2)$~~
- $(3x)^2(3x)(3x)^0(3x^0)$
- $(5x^2y^2z^3)^2 + (15x^3y^4z^5)$

B. Use the rules for exponents to simplify each and leave your answers in exponential form.

- $[(-8)^5]^4$
- $x^2y^3x^5$
- $x^{10} + x^5$
- $(x^2)^3 + (x^4)^1$
- $(5^{-2})^7 (5^3)^4$
- $(4x^2)^3 + (4x^{-2})$
- $x^{-7} \div z^{-5}$
- $(5x^3)(6x^2)$
- $(-6y^8)(7y^{-8})$
- $(0.9)^4 (0.9)^5 (0.9)^6 (0.9)$
- $(5^2)^4 (5^5)$
- $(7^8)^0 (7^8)^1$
- $(5x^2)^3 (5x^3)^2$
- $(3x^5)(4y^3)(2x^{-3})(5y^5)$
- $(y^2)^3 (y^3)^5 (y^5)^{-3}$
- $(9 \cdot 8)^4$
- $[r^{-4} x^{-3} z^{-2}]^{-4}$
- $4^{-2} m^3 n^{-5}$
- $(2 \cdot 3 \cdot 7)^4$
- $(x^{-3} y^{-5}) + (x^{-4} y^5)^2$

F. Extra Practice. Simplify each of the following and leave your answers in exponential form.

- |  |  |   |
|--|--|---|
| 1. $3^1 \times 3^4 \times 3^5$   | 2. $x^6 y^7 x^8$   | 3. $(x^4)^3$  |
| 4. $(7x^3) \cdot (5x^4)$   | 5. $[(x^7)^2]^3$   | 6. $y^{-8} + y^{-9}$                                      |
| 7. $(x^0)^4$   | 8. $\left[\frac{x}{2}\right]^{-2}$                       | 9. $(x^5)^7 + (x^4)^3$                                    |
| 10. $\left[\frac{x^2}{3}\right]^4$   | 11. $(3x^2y^5)^2$  | 12. $\left[\frac{2}{3}\right]^{-4}$                       |
| 13. $(x^2y^4)^2 \cdot (xy)^2$  | 14. $(3x)^2 \cdot (3x)^7$                                | 15. $(x^{-2}y^{-7})^3$                                    |
| 16. $(2.1)^2 \cdot (1.2)^3$  | 17. $(rs^{-3})^4$  | 18. $(-3a^5b^7)^6$  |
| 19. $\frac{x^5 x^{-3} x^7}{x^6 x^{-3}}$  | 20. $\frac{9^7 a^7 b^4 c^{10} d^7}{9^6 a^3 b^9 c^8 d^9}$ | 21. $(y^3)^2 + (y)$                                       |
| 22. $\frac{y^{-25} z^{-35}}{y^{-25} z^{-25}}$  | 23. $(x^{-3})^7 \cdot (x^{-3})^{-8}$                     | 24. $\frac{a^4 b^3 a^{-7} b^{14}}{a^7 b^{10}}$            |
| 25. $(x^{-4})(x^{-3})(y^2)(y^7)$   | 26. $(-5y^9) \cdot (4y^{-5})$                            | 27. $\left[\frac{3}{4}\right]^{-2}$                       |
| 28. $[(x^0)^{10}]^{21}$  | 29. $\frac{125 x^7 y^8 z^{12}}{25 x^9 y^5 z^5}$          | 30. $(2x^3)^2 \cdot (3x^4)^5$                             |
| 31. $\left[\frac{x}{y}\right]^2 \left[\frac{y}{z}\right]^3 \left[\frac{z}{x}\right]^4$ | 32. $(5^2)^3$  | 33. $\frac{(x^4)^5 \cdot (x^7)^6}{(x^7)^3 \cdot (x^3)^2}$ |

G. Write a standard numeral for each of the following.

- |                                  |                                      |
|----------------------------------|--------------------------------------|
| 1. $8.2 \times 10\ 000\ 000$     | 2. $7.77 \times \frac{1}{100}$       |
| 3. $16 \times \frac{1}{10\ 000}$ | 4. $-2.677 \times \frac{1}{10\ 000}$ |
| 5. $8 \times 10^{-2}$            | 6. $7.39 \times 10^{-6}$             |
| 7. $-6.842 \times 10^6$          | 8. $2.0 \times 10^3$                 |
| 9. $-2.893 \times \frac{1}{100}$ | 10. $-4.253\ 115 \times 10^3$        |
| 11. $10^{-4}$                    | 12. $6.4 \times 10^3$                |
| 13. $18.66 \times 10^{-3}$       | 14. $-3.6 \times 10^1$               |

# "THE LAWS OF EXPONENTS"

► SIMPLIFY: HIGHLIGHT YOUR FINAL ANSWER!

I) SIMPLIFY EACH POWER:

a)  $(x^6 y^8 z)^3$

b)  $(a^5 b^3 c d^6)^4$

c)  $(3n^6 p^8 r)^3$

d)  $(9xy^3 z^9)^2$

e)  $\left(\frac{a^5 b^3}{c^7}\right)^3$

f)  $\left(\frac{m^4 n^6}{m}\right)^3$

II) MULTIPLY EACH POWER:

a)  $6^{-2} \cdot 6^{-3} \cdot 6^6$

b)  $4m \cdot m^3 \cdot m \cdot m^7$

c)  $2^3 \cdot 2^6 \cdot 2 \cdot 2^{-4}$

d)  $-3x^5 \cdot x \cdot 2y^3 \cdot y$

e)  $p^9 \cdot 2p \cdot 3q \cdot q^4$

f)  $-c^4 \cdot 2e^4 \cdot a^4 \cdot b^3$

g)  $a^6 \cdot b \cdot c^4 \cdot 2a^3 \cdot b^6$

h)  $3^5 \cdot 3 \cdot 3^{-2}$

III) DIVIDE EACH POWER:

a)  $\frac{20x^6 y^8 z}{4x^3 y^7 z}$

b)  $\frac{-8m^{10} n p^5}{-2m^6 n}$

c)  $\frac{7a^7 b^6 c^8}{7a^4 b^2 c^3}$

d)  $\frac{16m^6 n^{10}}{8mn^5}$

e)  $\frac{(2^{10})(3^4)}{(2^6)(3^2)}$

f)  $\frac{32de^9 f^8}{9e^7 f^3}$

g)  $\frac{5^{30}}{5^{26}}$

h)  $\frac{m^9 n}{m^3 n}$

i)  $\frac{(20^4)(3^5)}{(20^3)(3)}$

# EXPONENTS REVIEW

B. Use the power of a power property to solve each of the following.

- |                                      |                                      |   |
|--------------------------------------|--------------------------------------|---|
| 1. $(3^2)^3$                         | 2. $(6^5)^3$                         | 3. $(7^6)^4$                                |
| 4. $(x^3)^2$                         | 5. $(-3)^2$                          | 6. $(3^{-2})^2$                             |
| 7. $(4^{-2})^{-3}$                   | 8. $(3x^2)^2$                        | 9. $(ab)^5$                                 |
| 10. $(3 \cdot 4)^7$                  | 11. $(a^2 b^3)^2$                    | 12. $(x^2 y^3)^5$                           |
| 13. $(a^4 b^{-5})^6$                 | 14. $(a^2/b^3)^4$                    | 15. $(5x^2)^4$                              |
| 16. $\left\{\frac{x}{3}\right\}^5$   | 17. $(4a^2b)^{-5}$                   | 18. $\left\{\frac{3}{x}\right\}^{-3}$       |
| 19. $(-3y^3)^7$                      | 20. $\left\{\frac{5x}{3y}\right\}^5$ | 21. $[(5^2)^3]^0$                           |
| 22. $(y^4)^{-3}$                     | 23. $(x^2 y^8)^{-6}$                 | 24. $(x^2 y^2 z^2)^3$                       |
| 25. $(y^{-3} z^{-1})^5$              | 26. $(8^2 y^3 z^5)^2$                | 27. $(r^7 s^5 t^4)^3$                       |
| 28. $\left\{\frac{x^2}{4}\right\}^2$ | 29. $(a^2 b^2)^3$                    | 30. $(3x^3)^7$                              |
| 31. $(5y^2 z^3)^7$                   | 32. $(xy)^2$                         | 33. $(3^5)^7$                               |
| 34. $[(ab)^2]^3$                     | 35. $(3 a^2 b^{-3})^4$               | 36. $[(1^2)^3]^5$                           |
| 37. $(m^2 n^2)^3$                    | 38. $[(x^2)^4]^3$                    | 39. $[(a^2 b^3)^{-4}]^{-3}$                 |
| 40. $[(7^2)^3]^4$                    | 41. $[(a^2 b)^4]^3$                  | 42. $\left\{\frac{3a^2 b^3}{c^4}\right\}^7$ |

C. Use all the rules for exponents you have already taken and write each answer in simplest exponential form.

- |                                 |  |                                  |
|---------------------------------|--|----------------------------------|
| 1. $5^3 \times 5^2 \times 5^5$  | 2. $(5^3)^2$   | 3. $(4^{-4})^2$                  |
| 4. $5^{-2} \cdot 5^{-5}$        | 5. $(x^2)^3 (x^5)^3$                                   | 6. $z^{-8} + z^{-6}$             |
| 7. $(0.9)^6 (0.9)^7 (0.9)$      | 8. $(x^5 y^{-3}) + (x^{-3} y^7)$                       | 9. $(2 \cdot 3 \cdot x)^6$       |
| 10. $(9^2)^4 (9^2)^5$           | 11. $(xyz)^3 (xy^2)^2$                                 | 12. $(2xy)^5$                    |
| 13. $(x^4 y^5) + (x y^{-4})$    | 14. $x^{-2} + x^{-3}$                                  | 15. $(y^2)^3 (y^3)^5 (y^5)^{-3}$ |
| 16. $(y^7) \cdot (y^8) + (y^3)$ | 17. $(a^4)^2 (a^5)^3$                                  | 18. $a^4 \cdot a^2 + a^3$        |
| 19. $[(x^6)^{10}]^{21}$         | 20. $x^6 y^7 x^8 y^9$                                  | 21. $(a^2 b)^7$                  |
| 22. $\{[(5^2)^3]^4\}^5$         | 23. $\left\{\frac{a^2 b^3 c^6}{a^3 b^6 c^8}\right\}^7$ | 24. $(5 a^3 b^{-3} c^5)^6$       |

NAME: \_\_\_\_\_



Math Sec 3

## POSITIVE EXPONENTS

Put each into positive exponents.

1)  $5^{-2} =$

2)  $6^2 \cdot 6^{-3} =$

3)  $3m^{-2} =$

4)  $4^{-1}mn^2 =$

5)  $14^{-2}m^{-1}n^3 =$

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

7)  $\frac{m}{5^{-2}} =$

8)  $\frac{3m}{6^{-1}} =$

9)  $5m^2 \cdot 6m^{-5} =$

10)  $\frac{6^{-3}}{2^{-1}} =$

11)  $x^2y^3x^{-1}y^{-6} =$

12)  $2m^2 \cdot 3m^{-10} =$

13)  $\frac{5^{-2}}{3^{-3}} =$

14)  $\frac{6^{-1}}{8^{-3}} =$

$$15) 3^{-2} \cdot 4^{-1} \cdot 5^2 =$$

$$16) 3^{-1} \cdot 3^2 \cdot 3^{-4} =$$

$$17) 4^{-2} m^{-2} n^{-3} =$$

$$18) 4^{-2} m n^2 =$$

$$19) 3 m n^{-1} =$$

$$20) 4 m^{-2} n^2 \cdot 3 m n^2 =$$

$$21) 2 m^2 n^2 \cdot (-2) m^{-1} n^{-3} =$$

$$22) \frac{4^{-2}}{3^{-3}} =$$

$$23) \frac{4}{m^{-2}} =$$

$$24) \frac{3}{m n^{-2}} =$$

$$25) \frac{4}{m^{-2} n^3} =$$

$$26) 3 m^{-1} \cdot 4 m^{-2} =$$

$$27) 2^{-1} m \cdot 2^2 m^4 =$$

$$28) 2 m \cdot 2 m^{-1} =$$

$$29) 4 m^{-1} \cdot 4 m^{-1} =$$

$$30) \frac{1}{2} x^3 \cdot \frac{2}{3} x^2$$

$$31) 4^{-2} \cdot 4^3 \cdot 4^{-4} =$$

$$32) 4^{-2} \cdot 3^{-1} \cdot 4^2 \cdot 3^{-1} =$$

## POWERS OF TEN

**MULTIPLICATION AND DIVISION USING POWERS OF TEN:** Solve for the questions below.

1) Rewrite the values of ten as powers, then multiply:

**example:**  $100 \times 3.76 \rightarrow 10^2 \times 3.76 = 376$

a)  $0.001 \times 789.43 =$

f)  $0.000001 \times 2 =$

b)  $\frac{1}{10} \times 66.87 =$

g)  $\frac{1}{100} \times 2.4 =$

c)  $10,000 \times 2.5 =$

h)  $\frac{1}{1000} \times 60.196 =$

d)  $0.01 \times 400 =$

i)  $100 \times 0.0026 =$

e)  $1000 \times 6.5 =$

j)  $1000 \times 3.72 =$

2) Rewrite the following questions in power form, then solve:

**Example:**  $10 \times 100 = 1000$   
 $10^1 \times 10^2 = 10^3$

a)  $1000 \times 100 =$

f)  $0.1 \times 1000 =$

b)  $1\,000,000 \div 100,000 =$

g)  $0.001 \div 1 =$

c)  $100 \times 100 =$

h)  $0.1 \div 0.01 =$

d)  $100,000 \div 100 =$

i)  $1\,000,000 \div 0.01 =$

e)  $0.01 \times 1000 =$

3) Solve for each (Without your calculator):

$$10^{-3} \times 3400 =$$

$$10^{-3} \times 3.4 =$$

$$10^{-3} \times 340 =$$

$$10^{-3} \times 0.34 =$$

$$10^{-3} \times 34 =$$

4) Multiply: (Express your answer in power form and standard form:

**Example:**  $10^2 \times 10^{-1} = 10$  or  $10^1$

$$a) 10^3 \times 10^2 =$$

$$d) 10^{-3} \times 10^{-1} =$$

$$b) 10^6 \times 10^2 =$$

$$e) 10^{-5} \times 10^{-3} =$$

$$c) 10^{-2} \times 10^3 =$$

$$f) 10^4 \times 10^{-2} =$$

5) Divide: (Express your answer as a power of ten, and a standard number)

$$a) 10^3 \div 10^5 =$$

$$d) 10^{-3} \div 10^{-1} =$$

$$b) 10^{-4} \div 10^3 =$$

$$e) 10^4 \div 10^{-2} =$$

$$c) 10^{-4} \div 10^{-3} =$$

$$f) 10^{-5} \div 10^{-5} =$$

6) Solve for the following without your calculators:

$$2.7 \times 10^2 =$$

$$8 \times 10^4 =$$

$$7.5 \times 10^{-3} =$$

$$5 \times 10^6 =$$

$$3.72 \times 10^4 =$$

$$7 \times 10^{-2} =$$

$$8.9 \times 10^{-2} =$$

$$1.26 \times 10^{-2} =$$

$$6.5 \times 10^3 =$$

$$2 \times 10^{-6} =$$

$$5.76 \times 10^5 =$$



Name: \_\_\_\_\_  
Group: \_\_\_\_\_

**EXERCISE:**  
"SCIENTIFIC NOTATION"  
and Review of "Powers of Ten"

**PART A:**  
Place the following in Scientific Notation:

1. 3200000
2. 600
3. 1989000000
4. 1000
5. 910000000000
6. 890
7. 306000
8. 4000000
9. 234000
10. 1654000000
11. 0.00076
12. 0.0000054
13. 0.098
14. 0.0077
15. 0.000032
16. 0.00000000014
17. 0.00082
18. 0.0023
19. 0.066
20. 0.4897

**PART B:**  
Rewrite each value as a power of ten, then solve: (Keep your answer in power form)

1. 1000 x 100 000
2. 1 000 + 10, 000
3. 100 x 0.00001
4. 100, 000 + 1000
5. 0.0001 x 100
6. 0.1 x 10

7. 0.001 + 10
8. 0.1 + 0.01
9. 1 000 + 0.01
10. 0.01 X 1000

**PART C:**

Use the laws of exponents to solve the following: (Keep your answer in power form)

1.  $10^3 \times 10^6$
2.  $10^6 \times 10^7$
3.  $10^{-2} \times 10^2$
4.  $10^{-3} \times 10^{-9}$
5.  $10^{-5} \times 10^{-7}$
6.  $10^4 \times 10^{-4}$
7.  $10^3 + 10^{-1}$
8.  $10^{-4} + 10^{-9}$
9.  $10^{-4} + 10^{-5}$
10.  $10^{-3} + 10^{-12}$
11.  $10^4 + 10^{-13}$
12.  $10^{-5} + 10^{-22}$

**PART D:**

Solve. In order to find the standard form for each notation expression:

1.  $3.2 \times 10^9$
2.  $7.4 \times 10^6$
3.  $6.988 \times 10^{-3}$
4.  $5.03 \times 10^{-2}$
5.  $6.08 \times 10^1$
6.  $4.397 \times 10^{12}$
7.  $3.27 \times 10^5$
8.  $9.4 \times 10^6$
9.  $8.587 \times 10^8$
10.  $3.982 \times 10^7$
11.  $1.423 \times 10^{-3}$
12.  $6.2 \times 10^{-3}$

**PART E:**

**Rewrite all the values as powers of ten, then solve: (Keep your answer in power form)**

1.  $100\ 000 \times 100 =$

6.  $0.01 \times 100\ 000 =$

13.  $8.7 \times 10^{-4}$

2.  $1\ 000,000 + 100,000 =$

7.  $0.000001 + 100 =$

14.  $2.5 \times 10^3$

3.  $100 \times 100 =$

8.  $1000 + 0.001 =$

15.  $3.29 \times 10^2$

4.  $100 + 1000 =$

9.  $1\ 000,000 + 0.0001 =$

16.  $5 \times 10^{-8}$

5.  $0.001 \times 100 =$

20.  $4.3 \times 10^{-7}$

17.  $4.274 \times 10^8$

18.  $3.39 \times 10^9$

19.  $9.966 \times 10^{-3}$

**8.** Write the following numbers as a power of 10.

a)  $100\ 000 =$  \_\_\_\_\_ b)  $0.01 =$  \_\_\_\_\_ c)  $1\ 000\ 000 =$  \_\_\_\_\_

d)  $0.1 =$  \_\_\_\_\_ e)  $100\ 000\ 000 =$  \_\_\_\_\_ f)  $0.000\ 01 =$  \_\_\_\_\_

**9.** Write the following numbers as a power of 10.

a)  $100^2 =$  \_\_\_\_\_ b)  $100 \times 10^3 =$  \_\_\_\_\_ c)  $(0.01)^2 =$  \_\_\_\_\_

d)  $(0.01)^{-3} =$  \_\_\_\_\_ e)  $1000 \times 10^{-5} =$  \_\_\_\_\_ f)  $(0.01) \times (0.0001) =$  \_\_\_\_\_

g)  $(0.1)^{-2} \times 10^2 =$  \_\_\_\_\_ h)  $(0.01)^{-3} \times (0.001)^2 =$  \_\_\_\_\_ i)  $(0.01)^2 \times (0.1)^{-1} =$  \_\_\_\_\_

## EXERCISES

**A** 1. Express in scientific notation.

a.  $27\ 000\ 000$

b.  $8\ 560\ 000$

c.  $425\ 000\ 000\ 000$

d.  $0.000\ 05$

e.  $0.000\ 000\ 365$

f.  $0.000\ 007$

g.  $2\ 650\ 500$

h.  $0.001\ 05$

i.  $13\ 840\ 000\ 000\ 000$

j.  $43.2$

k.  $708.21$

l.  $0.000\ 800\ 000\ 001$

**1.** Calculate the following products

a)  $2.645 \times 10^2$  \_\_\_\_\_

b)  $0.315 \times 10^4$  \_\_\_\_\_

c)  $25.18 \times 10^{-1}$  \_\_\_\_\_

d)  $3.189 \times 10^{-2}$  \_\_\_\_\_

e)  $2.56 \times 10^0$  \_\_\_\_\_

f)  $25 \times 10^{-3}$  \_\_\_\_\_

g)  $31.4 \times 1000$  \_\_\_\_\_

h)  $25.6 \times 0,1$  \_\_\_\_\_

i)  $28.35 \times 0,001$  \_\_\_\_\_

j)  $4.5 \times 10\ 000$  \_\_\_\_\_

**2.** Complete the following with the appropriate exponent.

a)  $0.025 = 2.5 \times 10^{\square}$

b)  $2860 = 2.86 \times 10^{\square}$

c)  $123.45 = 12.345 \times 10^{\square}$

d)  $123.45 = 12\ 345 \times 10^{\square}$

2. Express in decimal notation.

- a.  $1.3 \times 10^6$     b.  $2.75 \times 10^9$     c.  $8.4 \times 10^5$     d.  $7.2 \times 10^7$   
e.  $1.1 \times 10^{-5}$     f.  $3.4 \times 10^{-7}$     g.  $5.25 \times 10^{-3}$     h.  $8.9 \times 10^{-6}$   
i.  $9.04 \times 10^{-4}$     j.  $6.6 \times 10^8$     k.  $3.47 \times 10^{10}$     l.  $2.601 \times 10^{-8}$

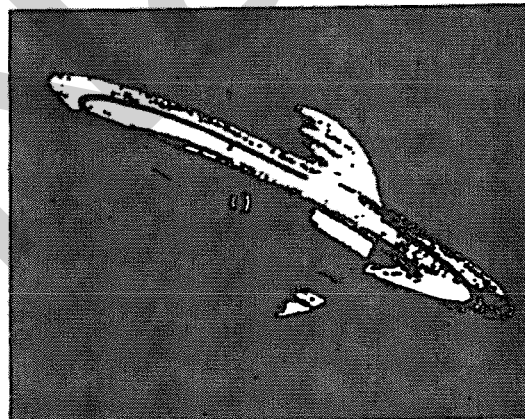
**B** 3. In astronomy, distances are very large. To measure distances to the stars and galaxies beyond our solar system, the light year is used. One light year, the distance that light travels in 1 year, is 9 460 528 405 000 km. The speed of light is 299 792 458 m/s. Express both in scientific notation.

4. Express the distance in decimal notation.

- a. The most massive known star is  $1.79 \times 10^6$  light years away.  
b. Our solar system is  $2.8 \times 10^5$  light years from the centre of our galaxy, the Milky Way.  
c. The Virgo cluster of galaxies is  $5 \times 10^7$  light years away.  
d. The Lynx-Ursa Major and Pisces-Perseus Superclusters are  $7 \times 10^8$  light years long.

5. Express each measurement in scientific notation.

- a. The average distance from Earth to the sun is 149 600 000 km.  
b. Our solar system revolves around the centre of the Milky Way every 225 000 000 years.  
c. The largest sun spot has an area of 18 000 000 000 km<sup>2</sup>.  
d. The internal temperature of the sun is about 14 000 000°C.  
e. Pluto, the most distant planet, is 5 898 000 000 km from the sun.  
f. Saturn, the ringed planet, has a diameter of 119 300 km.



7. Express the measurement of each virus in decimal notation.

- a. A polio virus has a diameter of  $12 \times 10^{-6}$  mm.  
b. A yellow fever virus has a diameter of  $22 \times 10^{-7}$  cm.  
c. An influenza virus has a diameter of  $11.5 \times 10^{-5}$  mm.

~~3. Calculate the following using the laws of exponents.~~

~~a)  $2^3 \cdot 2^{-5} \cdot 2 =$  \_\_\_\_\_~~

~~b)  $(2^3 \times 3^{-1})^{-2} =$  \_\_\_\_\_~~

~~c)  $\left(\frac{3}{5}\right)^{-2} =$  \_\_\_\_\_~~

~~d)  $\left(-\frac{2}{3}\right)^{-3} \times \left(\frac{4}{9}\right)^2 =$  \_\_\_\_\_~~

4. Write the following numbers in scientific notation.

- a) 3 485 000 \_\_\_\_\_ b) 0.000 256 \_\_\_\_\_  
c) 345.62 \_\_\_\_\_ d) 0.005 620 \_\_\_\_\_  
e) 356 000 000 \_\_\_\_\_ f) 0.000 005 \_\_\_\_\_  
g) 12 000 000 000 \_\_\_\_\_ h) 0.000 000 002 \_\_\_\_\_

5. Determine the following real numbers.

- a)  $1.56 \times 10^5$  \_\_\_\_\_ b)  $2.5 \times 10^{-4}$  \_\_\_\_\_  
c)  $3.14 \times 10^{-6}$  \_\_\_\_\_ d)  $1.28 \times 10^6$  \_\_\_\_\_  
e)  $7.0562 \times 10^5$  \_\_\_\_\_ f)  $4.18 \times 10^0$  \_\_\_\_\_

7. Write the following quantities in scientific notation.

- a) 1 light year (distance traveled in one year at the speed of light) is equal to 9 461 000 000 000 km.  
\_\_\_\_\_
- b) 1 astronomical unit is approximately equal to 149 600 000 km. \_\_\_\_\_
- c) 1 angstrom is equal to 0.1 nanometres. \_\_\_\_\_
- d) 1 micron is equal to a thousandth of a millimetre. \_\_\_\_\_
- e) 1 nautical mile is equal to 1852 m. \_\_\_\_\_

8. a) Write, in decimal notation, the surface area of the North American great lakes.

- Lake Superior:  $8.27 \times 10^4 \text{ km}^2$  \_\_\_\_\_  
Lake Michigan:  $5.83 \times 10^4 \text{ km}^2$  \_\_\_\_\_  
Lake Huron:  $6.16 \times 10^4 \text{ km}^2$  \_\_\_\_\_  
Lake Erie:  $2.5 \times 10^4 \text{ km}^2$  \_\_\_\_\_  
Lake Ontario:  $1.95 \times 10^4 \text{ km}^2$  \_\_\_\_\_

b) Express the total surface area of the great lakes in scientific notation. \_\_\_\_\_

9. a) Of all the planets in our solar system, Mercury is the closest to the sun, located 57 900 000 km from the sun. Earth, on the other hand is 149 600 000 km away.

Express these two distances using scientific notation.

Mercury: \_\_\_\_\_ Earth: \_\_\_\_\_

b) Of all the planets in our solar system, Jupiter is the biggest, with its diameter equal to 142 800 km. Earth's diameter is equal to 12 756 km. Express these two measures in scientific notation.

Jupiter: \_\_\_\_\_ Earth: \_\_\_\_\_

4. Express each result in the form  $a^n$ .

- a)  $5^{-2} \times 5 \times 5^3 =$  \_\_\_\_\_ b)  $2^{-2} \times \frac{1}{2^4} \times 2^3 =$  \_\_\_\_\_  
c)  $(-3)^2 \times (-3)^3 \times (-3)^{-1} =$  \_\_\_\_\_ d)  $\left(\frac{2^{-2} \times 2^4}{2^3}\right)^{-2} =$  \_\_\_\_\_

## 13.7 SCIENTIFIC NOTATION

Mathematicians have developed a compact method to write very large and also very small numbers that contain many zeros. This method is known as **scientific notation**. The examples below show how we would write a number in scientific notation given its standard form.

Standard Form	Scientific Notation	To convert any number into scientific notation, we must first locate the decimal and then move the decimal behind the <u>first non-zero digit</u> . We then count the number of places we have moved the decimal and this becomes the exponent. If we moved the decimal to the left, the exponent will be positive, if we moved the decimal to the right, the exponent will be negative. Numbers greater than one have positive or zero exponents, and numbers less than one, have negative exponents.
1. 95 000 000 000	$9.5 \times 10^{10}$	
2. 865 000 000	$8.65 \times 10^8$	
3. 0.000 000 035	$3.5 \times 10^{-8}$	
4. -156 200 000 000 000	$-1.562 \times 10^{14}$	
5. 0.000 808	$8.08 \times 10^{-4}$	

A. Multiply the following by the powers of ten indicated by moving the decimal the required number of spaces.

- $5.4778 \times 10^6$
- $0.087844706 \times 10^8$
- $389.8116798 \times 10^{13}$
- $842121094.22 \times 10^{-7}$
- $486 \times 10^{-9}$
- $56.7 \times 10^0$
- $8.34 \times 10^4$
- $7.6 \times 10^{-5}$
- $8.3652 \times 10^3$
- $76.35 \times 10^8$

B. Write each of the following in standard form.

- $3.45 \times 10^6$
- $-6.786 \times 10^5$
- $5.7429 \times 10^9$
- $8.54 \times 10^{-7}$
- $7.951 \times 10^{-3}$

28

C. Write the following as powers of ten. (The first one is done for you.)

1.  $1000 = 10^3$

2. 100

3. 10 000

4. 1 000 000

5. 1 000 000 000

6. 10

7. 10 000 000 000

8. 100 000

9. 100 000 000

10. 100 000 000 000 000

11.  $\frac{1}{100}$

12.  $\frac{1}{1000}$

13.  $\frac{1}{100\,000}$

14.  $\frac{1}{1\,000\,000\,000}$

15.  $\frac{1}{10}$

16.  $\frac{1}{1\,000\,000\,000\,000\,000\,000}$

17.  $\frac{1}{10\,000}$

18.  $\frac{1}{100\,000\,000}$

19.  $\frac{1}{1}$

20.  $\frac{100}{1000}$

D. Write each of the following in scientific notation.

1. 866 000

2. 58 700

3. 4 700 000

4. 0.000 687 3

5. 0.000 84

6. 156 800 000

7. 0.000 35

8. -6 536 000 000

9. 500 000 000

10. 55 000 000

11. -0.000 000 000 792

12. 0.000 000 000 600 05

13. -4 790 000 000

14. 500

15. 6 306 000

16. 54 000 000 000

17. 763 000 000

18. -300 700 000 000

19. 0.000 000 67

20. 5 632.87

# HOMWORK

## Working with Powers and Exponents

Name: \_\_\_\_\_



### Repeated Multiplication

Remember multiplication is a way to write repeated addition. To say  $3+3+3+3$  we write  $3 \times 4$ .

Sometimes multiplication is done over and over and over. To write  $3 \times 3 \times 3 \times 3$  we write  $3^4$ .

$4^2$  (read "four squared") means  $4 \times 4$  so  $4^2 = 16$      $5^3$  (read "five cubed") is  $5 \times 5 \times 5 = 125$

➤ Practice: Write the indicated operation using exponents. Then perform the operation.

- |   |  |   |
|---|--|---|
| a) $4 \times 4 \times 4 =$                      | $10 \times 10 \times 10 \times 10 \times 10 =$ | $2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 =$ |
| b) $5 \times 5 =$                               | $3 \times 3 \times 3 \times 3 =$               | $9 \times 9 \times 9 =$                                     |
| c) $0.3 \times 0.3 \times 0.3 =$                | $5.1 \times 5.1 =$                             | $(-1.2)(-1.2)(-1.2) =$                                      |
| d) $0.2 \times 0.2 \times 0.2 \times 0.2 =$     | $0.01 \times 0.01 \times 0.01 \times 0.01 =$   | $1.5 \times 1.5 =$  |
| e) $(-3) \times (-3) \times (-3) \times (-3) =$ | $-(100) \times (100) \times (100) =$           | $(-1) \times (-1) \times (-1) \times (-1) \times (-1) =$    |
| f) $aaaaa =$ (answer: $a^5$ )                   | $xxxxxxxxxxxx =$                               | $2f2f2f2f =$  |

➤ Practice: Perform the indicated operation.

- |                |             |             |
|----------------|-------------|-------------|
| g) $2^5 =$     | $7^2 =$     | $8^2 =$     |
| h) $12^2 =$    | $15^2 =$    | $25^2 =$    |
| i) $(-4)^2 =$  | $(-10)^2 =$ | $(-13)^2 =$ |
| j) $(-4)^3 =$  | $(-12)^2 =$ | $(-5)^3 =$  |
| k) $(-10)^3 =$ | $(0.5)^4 =$ | $(0.2)^5 =$ |

## Exponent Rules

### Multiplying

Remember:  $3^4 = 3(3)(3)(3)$  so  $3^4(3^3) = 3(3)(3)(3)(3)(3)(3) = 3^7$

$x^5 x^3 = xxxxxxxx = x^8$  and  $2^3 s^2 3^2 s^5 = 8ss9sssss = 72sssssss = 72s^7$

**Rule:**  $a^m a^n = a^{m+n}$

so  $f^{52} f^{123} = f^{175}$  and  $2w^{1/8} 3w^{3/4} = 6w^{7/8}$

(don't worry what fractional exponents mean...yet.)

When multiplying like bases, add the exponents.  $3y^3 z 4y^5 z^5 = 12y^{3+5} z^{1+5} = 12y^8 z^6$

➤ Practice: Simplify.

- |                |             |             |             |
|----------------|-------------|-------------|-------------|
| a) $a^1 a^1 =$ | $c^2 c^7 =$ | $e^2 e^2 =$ | $g^9 g^7 =$ |
| b) $b^6 b^3 =$ | $d^5 d^1 =$ | $f^4 f^8 =$ | $h^5 h^5 =$ |

## Negative exponents

Notice what happens with the example  $\frac{h^3}{h^6} = \frac{\cancel{h}\cancel{h}\cancel{h}}{\cancel{h}\cancel{h}\cancel{h}\cancel{h}\cancel{h}\cancel{h}} = \frac{1}{hhh} = \frac{1}{h^3} = h^{-3} = h^{-3}$

This leads to another rule.

**Rule:**  $a^{-n} = \frac{1}{a^n}$  and  $\frac{1}{a^{-n}} = a^n$

$$s^{-3} = \frac{1}{s^3} \quad \text{and} \quad \frac{1}{d^{-5}} = d^5$$

Practice: Write each answer two ways, as a fraction with positive exponents and without using fractions but using negative exponents.

f) $\frac{w^4}{w^7} = w^{-3}$ or $\frac{1}{w^3}$	$\frac{x}{x^5} =$	$\frac{w^{32}}{w^{34}} =$	$\frac{w^4}{w^2} =$
g) $\frac{a^7}{a^{12}} =$	$\frac{q^{41}}{q^{52}} =$	$\frac{s^4}{s^5} =$	$\frac{z^{14}}{z^{15}} =$

## Dividing Monomials

$$\frac{36r^2r^5s^{12}}{45r^7s^7} = \frac{9 \cdot 4 \cdot 2rr^5s^{12}}{9 \cdot 5r^7s^7} = \frac{8r^6s^{12}}{5r^7s^7} = \frac{8}{5}r^{6-7}s^{12-7} = \frac{8s^5}{5r} = \frac{8}{5}r^{-1}s^5$$

h) $\frac{3e^3}{4e^6}$	$\frac{7f^7}{4f^6}$	$\frac{9p^3}{3p^5}$	$\frac{36y^{13}}{6y^{16}}$
i) $\frac{30j^{30}}{25j^{60}}$	$\frac{j^3}{5j^{10}}$	$\frac{12t^8}{15t^{15}}$	$\frac{56r^{98}}{48r^{123}}$
j) $\frac{28x^5y^5}{21x^3y^7}$	$\frac{81m^3n^5}{144m^3n^7}$	$\frac{35s^2t^5}{21s^3t^{17}}$	$\frac{32x^{51}y^{15}}{12x^{30}y^{71}}$
k) $\frac{32t^{16}}{56t^{25}}$	$\frac{2t}{6t}$	$\frac{42e^{65}}{48e^{79}}$	$\frac{12t^{90}}{48t^{205}}$
l) $\frac{10k^{12}l^{51}}{45k^{36}l^{27}}$	$\frac{k^{31}l}{5k^{36}l^7}$	$\frac{3m^{14}3m^{13}}{45m^{61}}$	$\frac{24f^{12}e^{41}}{4e^{26}f^{27}}$

## Zero Exponent

$\frac{x^3}{x^3} = x^{3-3} = x^0$  or the powers cancel for an answer of 1.

**Rule:**  $a^0 = 1$

Anything to the zero power is 1.

Practice: Simplify

m) $3^0 =$	$x^0 =$	$(4y)^0 =$	$(3st^5)^0 =$	$(5-8+9-7-12)^0 =$
n) $4x^0 =$	$8e^0 =$	$2s5x^0 =$	$2(3st^5)^0$	$\frac{1}{2}(3st^5)^0$



→ c) $a^{10}a^{10} =$	$c^{23}c^{33} =$	$e^{71}e^{53} =$	$g^{29}g^{47} =$
d) $b^{600}b^{30} =$	$d^{-5}d^1 =$	$f^N f^N =$	$h^{6/3}h^{3/2} =$
e) $4a^14a^1 =$	$8c^25c^7 =$	$2e^22e^2 =$	$Ng^9Ng^7 =$
f) $4b^77b^4 =$	$3d^39d^2 =$	$3^4 f^3 4^3 f^8 =$	$3^{(3+1)}h^7 3^4 h^3 =$
g) $2^5 y^3 3^2 a =$	$4^2 c^3 5^2 c^7 =$	$3d^3 5d^5 =$	$4^4 g^4 4^4 g^4 =$
h) $3^6 b^6 b^3 =$	$5^2 d^3 4d^1 =$	$4^3 f^4 6^3 f^8 =$	$5^2 h^3 5^3 h^5 =$
i) $3a^1 x^2 a^2 x^1 3 =$	$4x^3 c^3 x^9 10c^7 =$	$(9+1)xe^4 x^{10} e^4 =$	$1.5x^{1.1} g^9 7.5x^{2.1} g^6 =$
j) $x^3 2b^3 2x^3 b^3 =$	$x^{3.4} d^5 x^3 d^2 5 =$	$7x^6 f^4 x^9 f^9 =$	$4x^6 h^7 x^9 h^2 =$

### Dividing

Remember how to cancel. Make a 1 out of common factors.

$$\frac{14(6)}{4(15)} = \frac{7(2)}{2(5)} = \frac{7}{5}$$

$$\frac{r^5}{r^3} = \frac{\cancel{rrrr}r}{\cancel{rrr}} = \frac{\cancel{rrr}r}{\cancel{rr}} = \frac{r}{1} = r^2$$

$$\frac{h^3}{h^6} = \frac{\cancel{hhh}}{\cancel{hhhhh}} = \frac{1}{hhh} = \frac{1}{h^3}$$

$$\frac{a^3 b^2}{a^2 b^4} = \frac{\cancel{aa}abb}{\cancel{aa}bbbb} = \frac{\cancel{ab}bb}{\cancel{ab}bb} = \frac{a}{bb} = \frac{a}{b^2}$$

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

$$\frac{k^{543}}{k^{215}} = k^{543-215} = k^{328}$$

$$\frac{12s^{25}}{20s^{16}} = \frac{3}{5}s^9$$

When dividing like bases, subtract the exponents.

$$\frac{r^5}{r^3} = \frac{\cancel{rrrr}r}{\cancel{rrr}} = \frac{\cancel{rrr}r}{\cancel{rr}} = \frac{r}{1} = r^2 \text{ is the same as } r^{5-3}$$

→ Practice: Simplify.

a) $\frac{w^4}{w^2} =$	$\frac{e^5}{e^3} =$	$\frac{r^8}{r^2} =$	$\frac{y^7}{y^5} =$	$\frac{p^{12}}{p^8} =$
b) $\frac{q^3}{q^4} =$	$\frac{r^8}{r^3} =$	$\frac{w^4}{w^4} =$	$\frac{x^{21}}{x^{21}} =$	$\frac{b^{14}}{b^{13}} =$
c) $\frac{q^{24}}{q^{10}} =$	$\frac{x^{54}}{x^{110}} =$	$\frac{m^{45}}{m^{73}} =$	$\frac{w^{64}}{w^{92}} =$	$\frac{f^{31}}{f} =$
d) $\frac{4e^7}{12e^2} =$	$\frac{14f^{14}}{21f^{12}} =$	$\frac{45x^{64}}{9x^{54}} =$	$\frac{144k^{12}}{60k^5} =$	$\frac{72h^{46}}{56h^{45}} =$
e) $\frac{2x^3 5x^5}{15x^4} =$	$\frac{15y^{13} 21y^{52}}{3^2 x^{45}} =$	$\frac{4a^{25} 5a^8}{20a^{30}} =$	$\frac{12a^5 56a^{81}}{64a^{50}} =$	$\frac{3x^3 2x^2}{5x^5} =$

### Power of a Power

$(x^3)^5 = x^3 x^3 x^3 x^3 x^3 = x^{15} = x^{3 \cdot 5}$  using a previous rule.

**Rule:**  $(a^m)^n = a^{mn}$

An easier way would be to multiply the 3 and 5 to get the new exponent of 15.

Practice: Simplify.

- o)  $(s^2)^3 =$        $(x^{12})^3 =$        $(w^4)^5 =$        $(x^3)^5 =$   
 p)  $(x^{21})^3 =$        $(y^{25})^4 =$        $(m^8)^5 =$        $(u^{52})^6 =$   
 q)  $(2x^2)^3 =$        $(5r^3)^4 =$        $(3t^2)^5 =$        $(3x^{12})^2 =$   
 r)  $(4a^2b^3c)^3 = 64a^6b^{15}c^3$        $(3d^3e^3f)^4 =$        $(2u^2v^3u)^5 =$        $(4a^{21}2b^{31})^2 =$   
 s)  $\left(\left(\frac{2}{5}\right)^2\right)^2 =$        $((2.5)^2)^3 =$        $(0.2x^3 \cdot 0.5x^3)^2 =$        $(0.5r^3 \cdot 1.2r^4)^3 =$   
 t)  $\left(\frac{3xy^3}{6x^5y^2}\right)^2 =$        $\left(\frac{x^5y^3}{x^5y^2}\right)^3 =$        $\left(\frac{56k^3 \cdot 10k^3}{16k^8 \cdot 7^2 \cdot 14k^{10}}\right)^2 =$        $\left(\frac{12a^3 \cdot 4a^3b^3}{6a^8b^5}\right)^2 =$

### When the rules don't work

Notice:  $5x^3 + 3x^2$  are not like terms and cannot be combined.

Contrast this with  $5x^3 \cdot 3x^4 = 15x^7$ . The multiplication can be done.

$4m^3 + 5m^3 = 9m^3$  Don't add the exponents.       $4m^3 \cdot 5m^3 = 20m^6$  Do add the exponents.

- a)  $3d^5 + 2d^5 =$        $3d^5 \cdot 2d^5 =$        $2x^3 + 2x^3 =$        $2x^3 \cdot 2x^3 =$   
 b)  $7e^3 \cdot 2e^3 =$        $7e^3 + 2e^3 =$        $3u^3 + 2u^3 =$        $3u^3 \cdot 2u^3 =$   
 c)  $4s - 7s + 8s^2 =$        $4s(-7s)(8s^2) =$        $7r^4 + 7r^3 =$        $7r^4(7r^3) =$   
 d)  $3x^2 - (-4x^2) - 8x^2 =$        $3x^2(-4x^2)(-8x^2) =$        $w - 6w - (-7w^2) =$        $w(-6w)(-7w^2) =$

Mixed practice: Simplify

- e)  $4q^3p^{18} \cdot 5q^{-4}p^{-9} =$        $4q^3p^{18} - 5q^{-4}p^{-9} + 4q^3p^{18} =$        $2(3t^3)^4(5t^2)^3$   
 f)  $-\frac{3}{5}a - \frac{1}{4}a + \frac{1}{12}a$        $(3nm^2)^2 + 5nm^2 \cdot 2nm^2 =$        $4e^2 - 7e^3 + 3e =$   
 g)  $\left(\frac{36x^8y^3}{48x^7y^{12}}\right)^4 =$        $\frac{3a^2}{5}\left(3\frac{1}{3}a\right) =$        $\frac{(2w^3)^2 - 7w \cdot 3w^3}{34w^3} =$   
 h)  $3x^2 \cdot 4x^2 - 7x^2 =$        $(4e^2)(-7e^3)(3e) =$        $(-3s^5)^2 \cdot 5s^4 =$   
 i)  $\frac{3}{8}t^2 - \frac{1}{6}t^3 - \frac{1}{3}t^3 =$        $(\frac{3}{8}t^2)(-\frac{1}{6}t^3)(-\frac{1}{3}t^3) =$        $(\frac{3}{10}x^3)^3 - x^9 =$

**Repeated Multiplication**

- a)  $4^3 = 64$   $10^6 = 1\,000\,000$   $2^8 = 256$  b)  $5^2 = 25$   $3^5 = 243$   $9^3 = 729$   
 c)  $0.3^3 = 0.027$   $5.1^2 = 26.01$   $(-1.2)^3 = -1.728$  d)  $0.2^4 = 0.0016$   $0.01^4 = 0.00000001$   $1.5^2 = 2.25$   
 e)  $(-3)^4 = 81$   $(-100)^3 = -1\,000\,000$   $(-1)^5 = -1$  f)  $a^2 \cdot x^{11}$   $(2f)^4 = 16f^4$   
 g) 32 49 64 h) 144 225 625 i) 16 100 169  
 j) -64 144 -125 k) -1000 0.0625 0.00032

**Multiplying**

- a)  $a^2 \cdot c^5 \cdot e^4 \cdot g^{16}$  b)  $b^9 \cdot d^6 \cdot f^{12} \cdot h^{10}$  c)  $a^{20} \cdot c^{28} \cdot e^{106} \cdot g^{76}$   
 d)  $b^{600} \cdot d^4 \cdot f^{20} \cdot h^{7/2}$  e)  $16a^2 \cdot 40c^9 \cdot 4e^4 \cdot N^2g^{16}$  f)  $28b^{11} \cdot 27d^7 \cdot 3^4 \cdot 4^3 \cdot f^{11} \cdot 3^8 \cdot h^{12}$   
 g)  $2^5 \cdot 3^2 \cdot y^3 \cdot a$   $4^2 \cdot 5^2 \cdot c^{10}$   $15d^8$   $4^8 \cdot g^8$  h)  $3^6 \cdot b^9$   $100d^6$   $24^3 \cdot f^{12}$   $5^2 \cdot h^{12}$   
 i)  $9a^3 \cdot x^3$   $40x^{12} \cdot c^{12}$   $10x^{11} \cdot e^8$   $11.25x^{12} \cdot g^{15}$  j)  $4x^8 \cdot b^8$   $5x^6 \cdot d^7$   $7x^{15} \cdot f^{13}$   $36x^7 \cdot h^9$

**Dividing**

- a)  $w^2 \cdot e^2 \cdot r^6 \cdot y^2 \cdot p^4$  b)  $q \cdot t^5 \cdot 1 \cdot 1 \cdot b$  c)  $q^{14} \cdot x^{56} \cdot m^{28} \cdot w^4 \cdot f^{20}$   
 d)  $\frac{e^5}{3}$   $\frac{2f^2}{3}$   $5x^{10}$   $\frac{12k^7}{5}$   $\frac{9h}{7}$  e)  $\frac{2x^4}{3}$   $\frac{35y^{65}}{x^{45}}$   $a^2$   $\frac{21a^{26}}{2}$   $\frac{6}{5}$   
 f)  $w^{-3} = \frac{1}{w^3}$   $x^{-4} = \frac{1}{x^4}$   $w^{-2} = \frac{1}{w^2}$   $w^2$  g)  $a^{-5} = \frac{1}{a^5}$   $q^{-11} = \frac{1}{q^{11}}$   $s^{-1} = \frac{1}{s}$   $z^{-1} = \frac{1}{z}$   
 h)  $\frac{3}{4e^3}$   $\frac{7f}{4}$   $\frac{3}{p^2}$   $\frac{6}{y^3}$  i)  $\frac{6}{5j^{20}}$   $\frac{1}{5j^7}$   $\frac{4}{5t^7}$   $\frac{7}{6r^{25}}$  j)  $\frac{4x^2}{3y^2}$   $\frac{9}{16n^2}$   $\frac{5}{3st^{12}}$   $\frac{8x^{21}}{3y^{36}}$   
 k)  $\frac{4}{7t^9}$   $\frac{1}{3}$   $\frac{7}{8e^{13}}$   $\frac{1}{4r^{115}}$  l)  $\frac{2j^{24}}{9k^{24}}$   $\frac{1}{5k^3j^6}$   $\frac{1}{5m^{24}}$   $\frac{6e^{15}}{f^{15}}$   
 m) 1 1 1 1 1 n) 4 8 10s 2  $\frac{1}{2}$

**Power of a Power**

- o)  $s^6 \cdot x^{36} \cdot w^{20} \cdot x^{15}$  p)  $x^{63} \cdot y^{100} \cdot m \cdot u^{112}$  q)  $8x^6 \cdot 625r^{20} \cdot 243t^{10} \cdot 9x^{24}$   
 r)  $64a^6 \cdot b^{15} \cdot c^3$   $81d^{20} \cdot e^{20} \cdot f^4$   $32u^{15} \cdot v^{25}$   $64a^{42} \cdot b^{102}$  s)  $\frac{16}{625}$   $2.5^6$   $0.01x^{16}$   $0.6r^{21}$   
 t)  $\frac{y^2}{4x^4}$   $y^3$   $\frac{25l^2}{4k^{28}}$   $\frac{64}{b^4}$

**When the rules don't work**

- a)  $5d^3$   $6d^{10}$   $2x^3 + 2x^2$   $4x^8$  b)  $14e^{10}$   $9e^5$   $3u^3 + 2u^2$   $6u^8$   
 c)  $-3s + 8s^2$   $-224s^4$   $7r^4 + 7r^3$   $49r^7$  d)  $-x^2$   $96x^6$   $-5w + 7w^2$   $42w^4$   
 e)  $20q^{-3} \cdot p^9$   $8q^3 \cdot p^{18} - \frac{5}{q^8 \cdot p^9}$   $20250t^{18}$  f)  $-a$   $19n^2 \cdot m^4$   $4e^2 - 7e^3 + 3e$   
 g)  $\frac{81x^4}{256y^{36}}$   $2a^3$   $\frac{-w^3}{2}$  h)  $12x^4 - 7x^2$   $-84e^6$   $-135s^{19}$  i)  $\frac{3}{8}r^2 - \frac{25}{24}r^3$   $\frac{3}{32}r^4$   $\frac{-991}{1000}x^9$

# Name: \_\_\_\_\_ Polynomials Booklet

Classify as a monomial, binomial, or trinomial.

1. $-20x^2 + 15x + 17$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input checked="" type="checkbox"/> TRI	2. $43s^4$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI
3. $-13x^2 + 10x + 15$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI	4. $15x^2 + 13x - 16$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI
5. $12x^5 + 4x$ <input checked="" type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI	6. $62$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI
7. $6x + 4$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI	8. $64d$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI
9. $-15x - 11$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI	10. $16x^2 - 9x$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI
11. $43g$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI	12. $-13x^2 - 16x - 8$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI
13. $17x^2 + 12x$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input checked="" type="checkbox"/> TRI	14. $35e$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI
15. $5x^2 + 12$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI	16. $-16x^2 - 9x - 19$ <input type="checkbox"/> Monomial <input type="checkbox"/> Binomial <input type="checkbox"/> TRI

1. $(14x + 5) + (10x + 5)$	2. $(10x + 12) + (6x + 20)$
3. $(19x^2 + 12x + 12) + (7x^2 + 10x + 13)$	4. $(17x^2 + 20x + 11) + (15x^2 + 11x + 17)$
5. $(-15x^2 - 5x + 9) + (-6x^2 - 19x - 16) + (-15x^2 - 14x - 13) + (9x^2 - 14x + 20)$	6. $(-13x^2 - 13x - 10) + (19x^2 - 19x - 5)$
7. $(4x^2 - 6x + 7) + (-19x^2 - 15x - 18)$	8. $(-13x^2 - 5x - 14) + (-14x^2 - 20x + 8)$
9. $(20x^7 - 10x^6 - 9x^5 - 14x^4 + 18x) + (-6x^6 - 12x^5 - 9x^4 - 9x)$	10. $(-20x^2 + 13x - 4) + (11x^2 - 13x - 10)$
11. $(-14x^2 - 15x - 17) + (14x^2 + 9x - 17)$	12. $(-10x^6 + 18x^3 + 13) + (7x^6 - 7x^2 + 17)$
13. $(11x^2 + 5x + 6) + (18x^2 + 17x + 17)$	14. $(4x^2 - 19x + 15) + (-18x^2 + 15x + 16)$
15. $(-7x^2 + 14x + 17) + (19x^2 - 6x - 20) + (-14x^2 - 18x + 20) + (20x^2 + 19x + 17)$	16. $(-14x^7 + 19x^6 - 17) + (5x^5 - 10x^4 + 18)$
17. $(9x^6 - 4) + (10x^5 - 15x^4 + 14)$	18. $(-17x^6 - 6x^3 - 20x) + (-10x^4 + 9x^3 - 18)$
19. $(20x^2 + 15x + 13) + (-19x^2 + 17x + 5)$	20. $(5x^6 + 9x^3 - 6x) + (-9x^7 - 20x^2 - 6x)$

## Adding and Subtracting Polynomials

Simplify each expression.

1)  $(5p^2 - 3) + (2p^2 - 3p^3)$

2)  $(a^3 - 2a^2) - (3a^2 - 4a^3)$

3)  $(4 + 2n^3) + (5n^3 + 2)$

4)  $(4n - 3n^3) - (3n^3 + 4n)$

5)  $(3a^2 + 1) - (4 + 2a^2)$

6)  $(4r^3 + 3r^4) - (r^4 - 5r^3)$

7)  $(5a + 4) - (5a + 3)$

8)  $(3x^4 - 3x) - (3x - 3x^4)$

9)  $(-4k^4 + 14 + 3k^2) + (-3k^4 - 14k^2 - 8)$

10)  $(3 - 6n^5 - 8n^4) - (-6n^4 - 3n - 8n^5)$

11)  $(12a^5 - 6a - 10a^3) - (10a - 2a^5 - 14a^4)$

12)  $(8n - 3n^4 + 10n^2) - (3n^2 + 11n^4 - 7)$

13)  $(-x^4 + 13x^5 + 6x^3) + (6x^3 + 5x^5 + 7x^4)$

14)  $(9r^3 + 5r^2 + 11r) + (-2r^3 + 9r - 8r^2)$

15)  $(13n^2 + 11n - 2n^4) + (-13n^2 - 3n - 6n^4)$

16)  $(-7x^5 + 14 - 2x) + (10x^4 + 7x + 5x^5)$

17)  $(7 - 13x^3 - 11x) - (2x^3 + 8 - 4x^5)$

18)  $(13a^2 - 6a^5 - 2a) - (-10a^2 - 11a^5 + 9a)$

## Adding and Subtracting Polynomials

Simplify each expression.

1)  $(8a - 4a^2) - (7a^3 - a)$

2)  $(6a - 3a^2) + (2a^2 - 3a)$

3)  $(x^2 - x) + (8x - 2x^2)$

4)  $(2a^2 + 4a^3) - (3a^3 + 8)$

5)  $(5x^2 + 4) - (5 + 5x^3)$

6)  $(8n^2 - 2n^3) + (6n^3 - 8n^2)$

7)  $(8b^3 + 8) - (6 - 7b^3)$

8)  $(4x^3 - 6) + (5x^3 + 3)$

9)  $(10p^4 + 11) - (11p^4 + 13 + 16p^2)$

10)  $(20v^2 - 9v^3) - (7v^3 - 10v^4 - 14v^2)$

11)  $(10x^4 - 16) + (12 - 6x^3 + 11x^4)$

12)  $(14 + 12a^3) + (17a^4 + 15 - 5a^3)$

13)  $(17v^2 - 8) + (17v^2 + 10 + v^3)$

14)  $(20n + 11n^4) - (15n + 16n^2 - 17n^4)$

15)  $(10k^4 + 17k^3) - (14k^3 - 2k + 9k^4)$

16)  $(9r + 6r^4) + (12r - 2r^4 - 17)$

17)  $(11n + 7n^5 + 5) - (7n - 11n^5 + 6n^3) - (4 + 4n^5)$

18)  $(9a^4 + 1 - 11a^2) - (a + 8a^2 + 2) - (6a^2 - 9)$

19)  $(6k^5 - 6k^3 - 6k) + (4k + 11k^4 - 11) + (k^2 - 12)$

20)  $(12x^4 + 3x^5 + 3x^2) - (6x - 5x^2 + 4) + (5x^5 + 7x)$

21)  $(10v^2 - 1 - v^3) + (10v^5 - 5v^3 + 5) - (4v^3 - 11v^5)$

22)  $(7x^2 - 4x^4 - 12) + (4x^5 - 7x^4 - 5x^2) + (4x^2 - 3x^4)$

23)  $(10 + 9v^5 - 8v^2) + (4v^4 + 3v^5 + 10) - (6 - 7v^4)$

24)  $(8r - 7r^5 + 6r^3) + (10r^5 + r + 4r^3) + (2r + 12r^5)$

Eliminate the brackets by distributing, then grouping "like" terms:

1)  $-3(5e + 4)$

2)  $-2(3a + 4b)$

3)  $5(-m + 6)$

4)  $4(9 - 3a)$

5)  $2(-10m^2 + 4m - 6)$

6)  $8(5 - 2w) - (w - 9)$

7)  $-2(-7m + m) - 1(5m + 6)$

8)  $7(-2m + 7) - 5(m + 2)$

9)  $-2(-6y + xy) + y - 4xy$

10)  $2(-8w + 7) + 6(5w - 4)$

11)  $-3(5a + b) + 2(-a + 4b)$

12)  $-8(h - 2m) + 5(-3h + m)$

13)  $6(3x - y) + 2(5 - 8x)$

14)  $4(8 + 2f) - 3(7 + 5f) + 6f$

15)  $-5(a + 3) + 2 - 3(a - 1)$

16)  $12x - 5(2x + 3) - 2$

**Multiply.**

1. $(12x)(12x + 11)$	2. $(9x)(4x + 2)$
3. $x(9x^2 + 4x + 3)$	4. $(2x + 7)(8x)$
5. $(4x)(-8x - 9)$	6. $5x(-6x - 3)$
7. $(11x)(-5x^3 + 8x^2 + 9x + 8)$	8. $-9x(-3x^2 + 9x + 11)$
9. $(-4x)(8x - 5)$	10. $-3x(-4x^2 - 10x + 12)$
11. $(-2x)(11x^3 - 10x^2 + 4x + 6)$	12. $x(-9x^2 + 7x + 4)$
13. $(6x)(11x + 7)$	14. $-11x(2x - 3)$
15. $(-7x + 2)(9x)$	16. $(-7x)(5x + 10)$
17. $-10x(-9x - 5)$	18. $(-3x)(7x + 8)$
19. $(-5x + 4)(6x^2)$	20. $(11x^2)(7x - 4)$

**Use FOIL.**

1. $(11x + 11)(11x + 10)$	2. $(9x + 9)(3x + 3)$
3. $(8x + 11)(5x + 11)$	4. $(9x + 7)(6x + 4)$
5. $(11x + 5)(-11x + 12)$	6. $(8x + 11)(-3x + 6)$
7. $(6x + 3)(-5x + 2)$	8. $(7x + 7)(5x - 4)$
9. $(-10x + 11)(7x + 5)$	10. $(-9x + 5)(-10x - 6)$
11. $(8x - 13)(20x + 11)$	12. $(16x - 19)(8x - 8)$
13. $(18x - 20)(-12x - 6)$	14. $(10x - 11)(-14x + 9)$
15. $(-20x - 12)(-19x - 15)$	16. $(-14x + 11)(-9x + 19)$
17. $(-7x - 11)(19x - 14)$	18. $(6x + 7)(20x - 9)$
19. $(12x - 13)(-12x + 12)$	20. $(16x + 13)(-8x + 15)$

Name \_\_\_\_\_

## Multiplying a Polynomial and a Monomial

Date \_\_\_\_\_ Period \_\_\_\_\_

Find each product.

1)  $8x(6x + 6)$

2)  $7n(6n + 3)$

3)  $3r(7r - 8)$

4)  $8(8k - 8)$

5)  $10a(a - 10b)$

6)  $2(9x - 2y)$

7)  $7x(6x + 4y)$

8)  $4a(8a - 8b)$

9)  $3n(n^2 - 6n + 5)$

10)  $2k^3(2k^2 + 5k - 4)$

11)  $8r^2(4r^2 - 5r + 7)$

12)  $3(3v^2 + 8v - 5)$

13)  $7(6x^2 + 9xy + 10y^2)$

14)  $2u(6u^2 - 9uv + v^2)$

15)  $9(x^2 + xy - 8y^2)$

16)  $9v^2(u^2 + uv - 5v^2)$



Name \_\_\_\_\_

Date \_\_\_\_\_ Period \_\_\_\_\_

## Multiplying Binomials

Find each product.

1)  $(3n + 2)(n + 3)$

2)  $(n - 1)(2n - 2)$

3)  $(2x + 3)(2x - 3)$

4)  $(r + 1)(r - 3)$

5)  $(2n + 3)(2n + 1)$

6)  $(3p - 3)(p - 1)$

7)  $(3p + 3)(3p + 2)$

8)  $(k - 2)(k - 3)$

9)  $(v - 1)(3v - 3)$

10)  $(2x - 3)(3x + 3)$

11)  $(4n + 4)(5n - 8)$

12)  $(5x - 2)(5x - 8)$

13)  $(6x + 2)(2x + 8)$

14)  $(3x + 3)(x + 4)$

15)  $(5v + 4)(3v - 6)$

16)  $(x - 4)(x - 7)$

17)  $(5x + 6)(8x - 4)$

18)  $(8b - 1)(5b - 5)$

Divide.

1. $(6x^3 + 30x^2 + 24x) \div 12$	2. $(15x^3 + 20x^2 + 5x) \div 5$
3. $(14x^4 + 10x^2 + 6x) \div 6x$	4. $(72x^4 + 81x^2 + 9x) \div 9x$
5. $(60x^{12} + 60x^{11} + 30x^8) \div 30x$	6. $(60x^{12} + 24x^{10} + 24x^3) \div 12x^2$
7. $(33x^7 + 99x^3 + 11x^2) \div 33x$	8. $(18x^{12} + 21x^9 + 24x^7) \div 6x^2$
9. $(28x^{12} - 42x^7 - 28x^6) \div 21x^2$	10. $(-24x^9 + 42x^7 + 42x^6) \div 18x$
11. $(-40x^{12} + 30x^{10} - 10x^4 + 30x^3 + 80x) \div 20x^2$	12. $(77x^{11} + 33x^{10} + 99x^6 + 88x^5 + 44x) \div 11x^3$
13. $(-40x^{12} - 20x^{11} - 25x^9 - 30x^2) \div 15x^3$	14. $(32x^{11} + 12x^7 + 20x^4 - 28x^2) \div 8x^2$
15. $(18x^{10} - 9x^8 + 72x^7 + 9x^5 + 36x^2) \div 36x^2$	16. $(6x^{11} + 24x^9 - 27x^8 + 3x^6 - 3x^5) \div 24x$
17. $(112x^{12} - 72x^{10} + 40x^9 - 144x^8) \div (-136x^5)$	18. $(14x^{12} - 18x^{11} - 12x^{10} - 18x^5) \div 28x^7$
19. $(36x^{12} + 96x^{11} - 54x^8 + 96x) \div 102x^5$	20. $(192x^{12} + 72x^{11} + 84x^8 - 36x^3 - 216x^2) \div (-120x^8)$

Complete.

1. $(-8x^4 + 8x^2) \div (-4x)$	2. $(-20x^4 + 80x^3 - 40x^2 - 240x + 300) \div (20)$
3. $(-3x^4 + 3x^3 - 30x^2 + 30x) \div (-3x)$	4. $(-8x^4 + 1152x^2) \div (-2x)$
5. $(-3x^4 + 36x^3 - 24x^2 + 288x) \div (-3x)$	6. $(-12x^3 - 84x^2) \div (4x)$
7. $(2x^4 + 24x^3 + 4x^2 + 48x) \div (2x)$	8. $(-8x^4 + 128x^2) \div (-4x)$
9. $(-26x^4 - 78x^3 + 195x^2 + 780x + 650) \div (13)$	10. $(-3x^4 - 21x^3 + 18x^2 + 126x) \div (-3x)$
11. $(6x^4 - 6x^2) \div (-2x)$	12. $(-22x^4 + 2178x^2 + 2200) \div (-22)$
13. $(3x^4 - 36x^3 - 18x^2 + 216x) \div (3x)$	14. $(-22x^4 - 10x^3 + 6x^2) \div (-x)$
15. $(2x^4 - 4x^3 - 10x^2 + 20x) \div (2x)$	16. $(-700x^3 + 1200x^2 + 900x) \div (25)$
17. $(x^5 - 122x^3 + 121x) \div (x)$	18. $(2x^4 + 22x^3 + 288x^2 + 3168x) \div (2x)$
19. $(6x^5 + 27x^4 - 30x^3 - 306x^2 - 360x) \div (-3x)$	20. $(-12x^4 - 72x^2) \div (4x)$
21. $(2x^4 - 10x^3 - 128x^2 + 640x) \div (2x)$	22. $(28x^3 + 252x^2 - 196x) \div (-14)$
23. $(-3x^5 - 264x^3 + 3600x) \div (-3x)$	24. $(-5x^5 - 12x^4 + 21x^3 + 72x^2 + 54x) \div (x)$
25. $(4x^4 + 40x^3 - 40x^2 - 400x) \div (4x)$	26. $(-24x^5 + 36x^4 - 64x^3 + 144x^2 + 128x) \div (-4x)$
27. $(-5x^5 + 2x^4 + 79x^3 - 32x^2 + 16x) \div (-x)$	28. $(-12x^4 + 96x^2) \div (-4x)$
29. $(-2x^5 - 196x^3 + 400x) \div (-2x)$	30. $(12x^5 - 48x^4 - 1496x^3 + 5808x^2 + 5324x) \div (4x)$