Math 9

Name: Key.

Unit 3: Powers and Exponents

Day	Topic	Assignment

Test Day: ______________________

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3.1 – Using Exponents to Describe Numbers

Exponential Form: A shorter way of writing repeated multiplication, using a base and an exponent.

- 5×5 in exponential form is 5^2.
- The above is read as "5 to the power of 2" or "5 squared".

Power: An expression made up of a base and an exponent.

base exponend

$$\boxed{4^2}$$

Power

Base: The number in a power that you multiply. by itself.

Exponent: Tells you the number of times that the base is multiplied by itself.

- In 4^3, 4 is multiplied by itself 3 times: $4^3 = 4 \times 4 \times 4$.

Example 1: Write as a Power in Exponential Form then Evaluate

a) $2 \times 2 \times 2 \times 2$ 4 factors of 2.

$= 2^4$

$= 16$

b) $(-3)(-3)(-3)(-3)$ 4 factors of (-3)

$= (-3)^4$

$= 81$

c) $\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)$ 3 factors of $\left(\frac{1}{2}\right)$

$= \left(\frac{1}{2}\right)^3 = \frac{1}{8}$

d) $n \times n \times n \times n \times n$ 5 factors of n.

$= n^5$

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Be careful with **NEGATIVE bases, notice the difference between:

base = 4
exponent = 2

-4^2

$= -(4^2)$

$= -(4\times4)$

$= -16$

$(-4)^2$ base = (-4)
exponent = 2

$= (-4)\times(-4)$

$= 16.$

Example 2: Evaluate each Power

a) 9^2

$= 9\times9$

$= 81$

b) -3^2

$= -(3^2)$

$= -(3\times3) = -9$

c) $(-2)^4$

$= (-2)\times(-2)\times(-2)\times(-2)$

$= 4\times4 = 16$

d) $(-5)^3$

$= (-5)\times(-5)\times(-5)$

$= (25)\times(-5) = -125$

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

$= (\frac{1}{3})\times(\frac{1}{3})\times(\frac{1}{3})$

$= \frac{1}{27}$

f) -1^{100}

$= -(1^{100})$

$= -1$

g) $2(-3)^2$

$= 2\times(-3)\times(-3)$

$= 2\times9 = 18$

Practice: Textbook pg. 79/# 1-3, 5-7, 9, 12, 16

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3.2 – Exponent Laws

Example 1: Multiplying Powers with the Same Base

Rule: When multiplying powers with the same base, we can **ADD** the exponents.

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

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

$= 2^{3+2}$

$= 2^5$

$2^3 \times 2^2 = (2\times2\times2)\times(2\times2)$

$= 2^5$

Example 2: Dividing Powers with the Same Base

Rule: When dividing powers with the same base, we can **SUBTRACT** the exponents.

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

a) $5^8 \div 5^3$

$= 5^{8-3}$

$= 5^5$

$5^8 \div 5^3 = \dfrac{5\times5\times5\times5\times5\times\cancel{5}\times\cancel{5}\times\cancel{5}}{\cancel{5}\times\cancel{5}\times\cancel{5}}$

$= 5^5$

Example 3: Raising a Power to Another Power

Rule: When a power is raised to another power, we can **MULTIPLY** the exponents.

$$(a^m)^n = a^{mn}$$

a) $(2^3)^2$

$= 2^{3\cdot2}$

$= 2^6$

$(2^3)^2 = (2^3)\times(2^3)$

$= (2\times2\times2)\times(2\times2\times2)$

$= 2^6$

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Give it a Try: Use Exponent Rules to Write as a Single Power. Do not Evaluate

a) $4^3 \times 4^5$

$= 4^{3+5}$

$= 4^8$

b) $\left(\frac{1}{3}\right)^5 \left(\frac{1}{3}\right)^6$

$= \left(\frac{1}{3}\right)^{5+6}$

$= \left(\frac{1}{3}\right)^{11}$

c) $8^5 \div 8^4$

$= 8^{5-4}$

$= 8^1$

d) $\frac{(-4)^3}{(-4)^2}$

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

$= (-4)^1$

e) $(3^2)^4$

$= 3^{2 \cdot 4}$

$= 3^8$

f) $(y)^3 \times (y)^5$

$= y^{3+5}$

$= y^8$

Give it a Try: Use Exponent Rules to Write as a Single Power, then Evaluate

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

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

$= (2)^6$

$= 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 64$

b) $\left(\frac{1}{2}\right)^2 \left(\frac{1}{2}\right)^4$

$= \left(\frac{1}{2}\right)^{2+4}$

$= \left(\frac{1}{2}\right)^6 = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{64}$

c) $12^6 \div 12^5$

$= 12^{6-5}$

$= 12$

d) $\frac{(6)^{10}}{(6)^8}$

$= (6)^{10-8}$

$= (6)^2$

$= 6 \times 6$

$= 36$

e) $((-3)^2)^2$

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

$= (-3)^4$

$= (-3)\times(-3)\times(-3)\times(-3)$

$= 81$

f) $\frac{x^5}{x^3}$

$= x^{5-3}$

$= x^2$

Example 4: Raising a Product to a Power

Rule: When a product is raised to a power, we can distribute the power to each factor in the product.

$$(ab)^m = a^m \times b^m$$

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

$= 3^2 \times 2^2$

$= 9 \times 4$

$= 36$

$(3\times 2)^2 = (3\times 2)\times(3\times 2)$

$= 3^2 \times 2^2$

Example 5: Raising a Quotient to a Power

Rule: When a quotient is raised to a power, we can distribute the power to both the numerator and the denominator of the quotient.

$$\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}$$

a) $\left(\frac{2}{3}\right)^3$

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

$= \frac{8}{27}$

$\left(\frac{2}{3}\right)^3 = \left(\frac{2}{3}\right)\times\left(\frac{2}{3}\right)\times\left(\frac{2}{3}\right)$

$= \frac{2\times 2\times 2}{3\times 3\times 3}$

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

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Example 6: Bases with Exponents of Zero

$* \frac{a^n}{a^n} = a^{n-n} = a^0 = 1$

> **Rule**: All numbers (except zero) raised to the power of zero equal one.
>
> $a^0 = 1$

Give it a Try: Use Exponent Rules to Simplify, then Evaluate

a) $(2 \times 3)^4$

$= 2^4 \times 3^4$

$= 16 \times 81$

$= 1296$

$$\begin{array}{r} 16 \\ \times 81 \\ \hline 16 \\ 1280 \\ \hline 1296 \end{array}$$

b) $(4 \times 5)^2$

$= 4^2 \times 5^2$

$= 16 \times 25$

$= 400$

$$\begin{array}{r} 16 \\ \times 25 \\ \hline 80 \\ 320 \\ \hline 400 \end{array}$$

c) $\left(\frac{1}{3}\right)^2$

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

$= \frac{1}{9}$

d) $\left(\frac{2}{5}\right)^3$

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

$= \frac{8}{125}$

e) $(-8)^0$

$= 1$

f) $(5n)^2$

$= 5^2 n^2$

$= 25n^2$

Practice: Textbook pg. 86/# 1-3, 5-9, 11, 14, 15, 20

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Exponent Laws	
Multiplying Powers	$a^m \times a^n = a^{m+n}$
Dividing Powers	$a^m \div a^n = a^{m-n}$
Power of a Power	$(a^m)^n = a^{mn}$
Power of a Product	$(ab)^m = a^m \times b^m$
Power of a Quotient	$\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}$
Zero Exponent	$a^0 = 1$

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3.3 – Order of Operations with Exponents

Coefficient: A number that multiplies an expression.

- In $-5(4)^2$, the coefficient is -5.

Example 1: Evaluate Powers with Coefficients

a) $3(2)^4$

$= 3 \times 2^4$

$= 3\times 2\times 2\times 2\times 2$

$= 48$

$= 3 \times 16$

$= 48$

b) $-3(-5)^2$

$(-5)^2 = (-5)(-5)$

$= -3(25)$

$= -75$

c) -4^4

$= -[4^4]$

$= -[4\times 4\times 4\times 4]$

$= -256$

d) $6(7)^0$

$(7)^0 = 1$

$= 6(1)$

$= 6$

BEDMAS!

Brackets
Exponents
Multiplication
Division
Addition
Subtraction.

Example 2: Evaluate Expressions with Powers

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

$= 16 - 8 \div 2 + (-9)$

$= 16 - 4 - 9$

$= 16 - 13$

$= 3$

b) $-2(-15-4^2)+4(2+3)^3$

$= -2(-15-16) + 4(5)^3$

$= -2(-31) + 4(125)$

$= 62 + 500$

$= 562$

c) $8(5+2)^2 - 12 \div 2^2$

$= 8(7)^2 - 12 \div 4$

$= 8(49) - 3$

$= 392 - 3 = 389$

d) $-[2+3(2^3+4^2)]$

$= -[2+3(8+16)]$

$= -[2+3(24)]$

$= -[2+72]$

$= -74$

Practice: Textbook pg. 91/#

1, 2, 4ace, 5ace, 6, 15, 16

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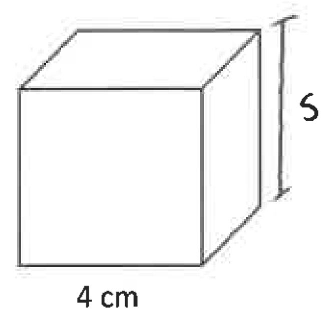
3.4 – Using Exponents to Solve Problems

Example 1: Use Formulas to Solve Problems

Write an expression using exponents to solve each problem.

a) What is the surface area of a cube with an edge length of 4cm?



The surface area of a cube is

$$SA = 6s^2$$

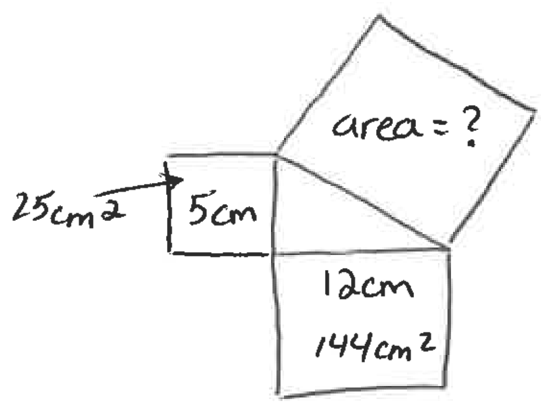
If $s = 4$

$$SA = 6(4)^2$$
$$= 6(16)$$
$$= 96$$

The surface area is $96\ cm^2$

b) Three squares are attached to a right triangle. Find the area of the square attached to the hypotenuse in the diagram.

$$a^2 + b^2 = c^2$$
$$(5)^2 + (12)^2 = c^2$$
$$25 + 144 = c^2$$
$$169 = c^2$$



The area of the square attached to the hypotenuse is $169 cm^2$.

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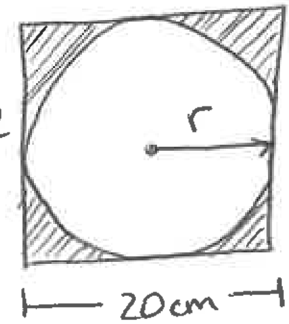
c) A circle is inscribed in a square with a side length of 20cm. What is the area of the shaded region?

Area of shaded region = Area of square − Area of circle



$A_{square} = s^2$
$= 20^2$
$= 400cm^2$

$A_{circle} = \pi r^2$
$= \pi(10)^2$
$= \pi(100)$
$\approx 314\ cm^2$

$r = \frac{d}{2}$
$r = \frac{20cm}{2}$
$r = 10cm$

$A_{shaded\ region} \approx 400 - 314 = \boxed{86cm^2}$

Example 2: Develop a Formula to Solve a Problem

A dish holds 100 bacteria. Under ideal conditions, the bacteria double in number every hour. How many bacteria will be present after each number of hours?

a) 1 hour
b) 5 hours
c) n hours

a) After 1h, the number doubles.
$100 \times 2 = 200$ bacteria.

b) After 5h, the number doubles five times.
$100 \times 2 \times 2 \times 2 \times 2 \times 2$
$= 100(2^5) = 100(32) = 3200$ bacteria.

c) After n hours, the number doubles n times.
Number of bacteria $= 100(2^n)$

Practice: Textbook pg. 98/# 1 – 3, 5, 10