Name: _____ Date: _____

3.1 Warm Up

1. Evaluate.

a) $2 \times 2 \times 2 =$ _____

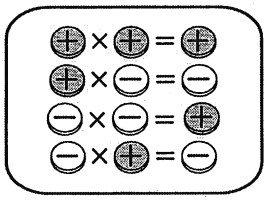
b) $5 \times 5 =$ _____

c) $1 \times 1 \times 1 \times 1 \times 1 =$ _____

d) $3 \times 3 \times 3 =$ _____

2. Evaluate.

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



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

c) $(-8) \times (-8) =$ _____

d) $(-7) \times (+7) =$ _____

e) $(-3) \times (-3) \times (-3)$

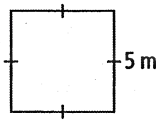
$=$ _____ $\times (-3)$

$=$ _____

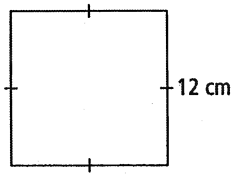
f) $(-2) \times (-2) \times (-2) \times (-2)$

3. Find the area of each square. $s^2 = s \times s$

a)



b)



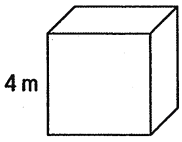
$A = s^2$ ← Formula →

← Substitute →

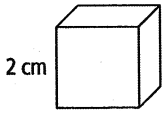
← Solve →

4. Find the volume of each cube. $s^3 = s \times s \times s$

a)



b)



$V = s^3$ ← Formula →

← Substitute →

← Solve →

Name: _____ Date: _____

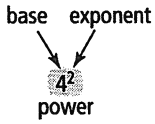
3.1 Using Exponents to Describe Numbers

Link the Ideas

Working Example 1: Write and Evaluate Powers

power
- an expression made up of a base and an exponent

base
- the number you multiply by itself in a power



FOLDABLES™ Study Tool

exponent
- the number of times you multiply the base in a power

exponential form
- a shorter way of writing repeated multiplication, using a base and an exponent
- example: $5 \times 5 \times 5 = 5^3$ (3 factors of 5)

Literacy Link

You can read 2^5 as
- two to the fifth power
- two to the exponent five

a) Write $2 \times 2 \times 2 \times 2 \times 2$ in **exponential form**.

Solution

There are _____ factors of 2 in the expression $2 \times 2 \times 2 \times 2 \times 2$.
$2 \times 2 \times 2 \times 2 \times 2 = 2^5$

The **base** of the **power** is 2. The **exponent** of the **power** is _____.

b) Evaluate the power 2^5.

Solution

Find the product: $2 \times 2 \times 2 \times 2 \times 2 =$ _____

So, $2^5 =$ _____

Show You Know

Write each repeated multiplication in exponential form. Then, evaluate.

a) $4 \times 4 \times 4 = \square^{3}$

$=$ _____

b) $10 \times 10 \times 10 \times 10$

Name: _____ Date: _____

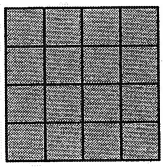
Working Example 2: Powers With Positive Bases

Evaluate each power.

a) 4^2 — Read as "four squared."

Solution

Use a model of a square to show any power with an exponent of 2.



Each side of the square = 4 units

Area of the large square = _____ small squares

In 4^2, the base is _____ and the exponent is _____.

$4^2 = 4 \times 4$

$=$ _____

b) 2^3 — Read as "two cubed."

Solution

Use a model of a cube to show any power with an exponent of 3.

Each edge of the large cube = 2 units

Volume of the large cube = _____ small cubes

In 2^3, the base is _____ and the exponent is _____.

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

$=$ _____

c) 3^6 — Read as "three to the sixth power."

Solution

In 3^6, the base is _____ and the exponent is _____.

$3^6 = 3 \times 3 \times 3 \times 3 \times 3 \times 3$

$=$ _____

C 3 y 6 = 729

You could think of 3^6 as

$(3 \times 3) \times (3 \times 3) \times (3 \times 3)$

$= 9 \times 9 \times 9$

$= 9^3$

or

$(3 \times 3 \times 3) \times (3 \times 3 \times 3)$

$= 27 \times 27$

$= 27^2$

Name: _____ Date: _____

Show You Know

Complete the chart. An example is done for you.

Power	Repeated Multiplication	Evaluate
2^4	$2 \times 2 \times 2 \times 2$	16
a) 6^2		
b) 3^4		
c) 5^3		

Working Example 3: Powers With Negative Bases

Evaluate each power.

a) $(-2)^4$

Solution

In $(-2)^4$, the base is -2 and the exponent is _____.

Write $(-2)^4$ as repeated multiplication.

In $(-2)^4$, the exponent applies to the negative sign because it is *inside* the brackets.

$(-2)^4 = (-2) \times (-2) \times$ _____ $\times$ _____

$= 4 \times$ _____

$=$ _____

b) -2^4

Solution

In -2^4, the base is 2 and the exponent is _____.

In -2^4, the exponent *does not* apply to the negative sign because it is *not* inside the brackets.

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

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

$= -$_____

Name: _____ Date: _____

c) $(-4)^3$

Solution

In $(-4)^3$, the base is -4 and the exponent is _____.

$(-4)^3 = (-4) \times (-4) \times (-4)$

$= 16 \times (-4)$

$= -$_____

⊕ × ⊖ = ⊖

d) $-(-5)^6$

Solution

In $-(-5)^6$, the base is -5 and the exponent is _____.

$-(-5)^6 = -[(-5) \times (-5) \times (-5) \times (-5) \times (\_\_\_\_\_) \times (\_\_\_\_\_)]$

In $-(-5)^6$, the exponent *does not* apply to the first negative sign because it is *outside* the brackets.

$= -(\_\_\_\_\_)$

$= -$_____

C − (5 +/−) y^x 6 = −15625

Show You Know

a) Give 1 reason why $(-5)^2$ and -5^2 are different.

_____

b) Give 1 reason why $(-5)^2$ and -5^2 are similar.

_____

c) Evaluate.

i) $(-3)^2$

ii) $(-3)^5$

iii) -3^2

iv) -3^5

Name: _____ Date: _____

Check Your Understanding

Communicate the Ideas

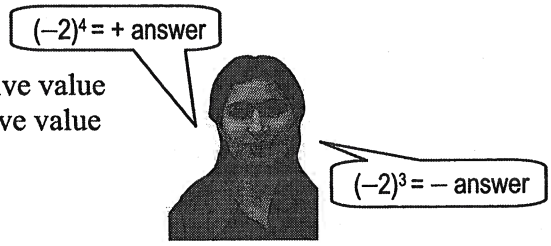
a) Give 1 reason why it is easier to write an expression as a power rather than as repeated multiplication.

_____

b) Give an example to show your thinking in part a).

2. Pani thinks

- A power with a negative base and an even exponent = a positive value
- A power with a negative base and an odd exponent = a negative value



a) Is Pani correct? Circle YES or NO.

b) Evaluate each power to check your answer.

Practise

3. Write each expression as a power.

a) $7 \times 7 =$ _____

b) $10 \times 10 \times 10 \times 10 \times 10 \times 10 =$ _____

4. Identify the base and the exponent.

a) $1 \times 1 \times 1 \times 1$

Base: _____

Exponent: _____

b) 13

Base: _____

Exponent: _____

5. What is the value of each power?

a) $3^5 =$ _____ × _____ × _____ × _____ × _____

$=$ _____

b) 1^9

Name: _____ Date: _____

6. Complete the chart.

Repeated Multiplication	Exponential Form	Value
(a) $6 \times 6 \times 6$	6^3	
(b) $3 \times 3 \times 3 \times 3$		
c) _____ × _____		49
(d)	11^2	
e) _____ × _____ × _____		8

7. Evaluate each power.

a) $(-9)^2 = (-9) \times$ _____

$=$ _____

b) $-5^3 = -(5 \times$ _____ $\times$ _____$)$

$= -($_____$)$

$=$ _____

c) $(-1)^5$

d) $-(-3)^3$

8. Does $(-2)^4 = -2^4$? Circle YES or NO.
Evaluate each power to check your answer.

$(-2)^4$

$=$

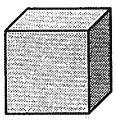
-2^4

$=$

Name: _____ Date: _____

Apply

9. The volume of a cube with an edge length of 3 cm is 27 cm^3.
Write the volume in repeated multiplication form and exponential form.



Repeated multiplication: _____

Exponential form: _____

10. In a children's story, Double Dan the Dragonfly is growing fast.
His body length doubles every month.
At the beginning of the story, his length is 1 cm.

a) Complete the table to show how Dan's body length increases every month for 10 months.

End of Month	Body Length	Power
June	$1 \times 2 = 2$	2^1
July	$2 \times 2 =$ _____	2^2
August	$4 \times 2 =$ _____	2^3
September	$8 \times 2 =$ _____	2^4
October		
November		
December		
January		
February		
March		

b) What is his body length after 5 months? _____

Write your answer as a power: _____

c) After how many months is his body length more than 50 cm? _____

Name: _____ Date: _____

11. Arrange the powers in ascending order (least to greatest).

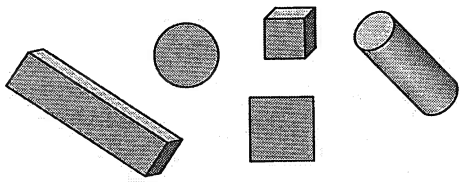
Evaluate each power.

1^{13} 3^4 4^3 2^5 7^2

_____

Math Link

Some formulas use exponents.



a) Rewrite each formula using repeated multiplication.

$SA = 6s^2$

$= 6 \times$ _____ $\times$ _____

$V = \pi \times r^2 \times h$

= _____ $\times$ _____ $\times$ _____ $\times$ _____

$A = s^2$, $A = \pi r^2$
$C = \pi d$ or $C = 2\pi r$
SA = area of top and bottom + area of 2 ends + area of 2 sides
$SA = 6s^2$, $SA = 2\pi r^2 + 2\pi rh$
$V = lwh$, $V = \pi r^2 h$, $V = s^3$

b) Fill in the blanks.

Use $SA = 6s^2$ to find the surface area of a _____.

Use $V = \pi \times r^2 \times h$ to find the _____ of a _____.

c) You will use formulas for the mobile you will build at the end of the chapter. Complete the chart for 2 shapes.

Shape	Formula With Exponents	Formula Using Repeated Multiplication

Name: _____ Date: _____

3.2 Warm Up

1. Write in exponential form.

a) $6 \times 6 \times 6 \times 6 =$ _____

b) $3 \times 3 \times 3 \times 3 \times 3 \times 3 \times 3 =$ _____

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

d) $(-9) \times (-9) =$ _____

2. Evaluate.

a) 3^4

b) $(-2)^3$

c) $(-1)^7$

d) -2^2

e) $-(-4)^2$

f) -5^2

3. Complete the table.

Repeated Multiplication	Exponential Form	Value
a) $5 \times 5 \times 5 \times 5$		625
b) $(-3) \times (-3) \times (-3)$	$(-3)^3$	
c)		25
d)	$(-7)^2$	
e) $(-10) \times (-10) \times (-10) \times (-10)$		

4. Arrange the powers in ascending order.

Evaluate each power.

$(-3)^3$ $(-4)^2$ 1^{10} -2^4

Name: _____ Date: _____

3.2 Exponent Laws

Link the Ideas

Working Example 1: Multiply Powers With the Same Base

Write each product of powers as a single power. Then, evaluate the power.

The *product* is the answer when you multiply.

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

Solution

Method 1: Use Repeated Multiplication

$2^3 \times 2^2$

$= (2 \times 2 \times$ _____$) \times (2 \times$ _____$)$ Rewrite using repeated multiplication.

$= 2^5$ Write as a single power.

$=$ _____ Evaluate.

Method 2: Apply the Exponent Laws

Literacy Link

Multiplying Powers With the Same Base
- Add the exponents.
- $5^2 \times 5^3 = 5^{2+3}$
  $= 5^5$

Since the bases are the same, add the exponents.

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

$= 2^{\square}$

$= 32$

Repeated multiplication and applying the exponent law give the same answer.

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

Solution

Since the bases are the same, _____ the exponents.

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

$= (-3)^{\square}$

$=$ _____

C (3 +/−) x^y 7 = −2187

Name: _____ Date: _____

Show You Know

Evaluate each expression in two different ways.

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

Repeated Multiplication:

$4^3 \times 4^5$

$= (\_\_\_\_ \times \_\_\_\_ \times \_\_\_\_) \times (\_\_\_\_ \times \_\_\_\_ \times \_\_\_\_ \times \_\_\_\_ \times \_\_\_\_)$

$= 4^{\square}$

$= \_\_\_\_$

Exponent Laws:

$4^3 \times 4^5$

$= 4^{\square + \square}$

$= 4^{\square}$

$= \_\_\_\_$

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

Did You Know?

Some common viruses require at least 2^{87} viral particles in the human body before symptoms occur.

Name: _____ Date: _____

Working Example 2: Divide Powers With the Same Base

Write each quotient as a single power.
Then, evaluate the power.

The *quotient* is the answer when you divide.

a) $2^6 \div 2^2$

Solution

Method 1: Use Repeated Multiplication

Rewrite each power using repeated multiplication.

$2^6 \div 2^2 = (2 \times 2 \times 2 \times 2 \times$ _____ $\times$ _____$) \div (2 \times$ _____$)$

$= \dfrac{2 \times 2 \times 2 \times 2 \times 2 \times 2}{2 \times 2}$

Divide the common factors in the numerator and denominator.

$= \dfrac{2 \times 2 \times 2 \times 2 \times \cancel{2}^{1} \times \cancel{2}^{1}}{\cancel{2}_{1} \times \cancel{2}_{1}}$

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

There are 4 factors of 2 left. This is the same as if you subtracted the exponents: (6 – 2 = 4).

$= 2^{\square}$

$=$ _____

Method 2: Apply the Exponent Laws

Since the bases are _____, subtract the exponents.
(*the same* or *different*)

$2^6 \div 2^2 = 2^{6-2}$

$= 2^{\square}$

$=$ _____

Literacy Link

Dividing Powers With the Same Base
- Subtract the exponents.
- $2^6 \div 2^3 = 2^{6-3}$
  $= 2^3$

b) $(-5)^9 \div (-5)^6$

Solution

Since the bases are _____, subtract the exponents.
(*the same* or *different*)

$(-5)^9 \div (-5)^6 = (-5)^{9-6}$

$= (-5)^{\square}$

$=$ _____

Name: _____ Date: _____

Show You Know

Evaluate each expression in two different ways.

a) $2^5 \div 2^3$

Repeated Multiplication:

$2^5 \div 2^3$

$= (\_\_\_\_ \times \_\_\_\_ \times \_\_\_\_ \times \_\_\_\_ \times \_\_\_\_) \div (\_\_\_\_ \times \_\_\_\_ \times \_\_\_\_)$

$= \dfrac{2 \times 2 \times 2 \times 2 \times 2}{2 \times 2 \times \square}$ Divide the common factors.

$= 2^{\square}$ Evaluate.

$= \_\_\_\_$

Exponent Laws:

$2^5 \div 2^3$

$= 2^{\square - \square}$

$= 2^{\square}$

$= \_\_\_\_$

b) $(-3)^7 \div (-3)^4$

Name: _____ Date: _____

Working Example 3: Raise Powers, Products, and Quotients to an Exponent

a) Write $(2^3)^2$ as a single power. Then, evaluate.

Solution

Method 1: Use Repeated Multiplication

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

$= (2 \times \_\_\_\_\_ \times \_\_\_\_\_) \times (2 \times \_\_\_\_\_ \times \_\_\_\_\_)$

$= 2^{\square}$ How many factors of 2 are there?

$= 64$

Method 2: Apply the Exponent Laws

When a power is raised to an exponent, multiply the exponents.

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

$= 2^{\square}$

$= \_\_\_\_\_$

Literacy Link

Raising a Power to an Exponent
- Multiply the exponents.
- $(3^2)^4 = 3^{2 \times 4}$
  $= 3^8$

b) Write $[2 \times (-3)]^4$ as the product of two powers. Then, evaluate.

power × power

Solution

Method 1: Use Repeated Multiplication

$[2 \times (-3)]^4 = [2 \times (-3)] \times [2 \times (-3)] \times [2 \times (-3)] \times [2 \times (-3)]$

$= 2 \times (-3) \times 2 \times (-3) \times 2 \times (-3) \times 2 \times (-3)$ Rewrite without the square brackets.

$= 2 \times 2 \times 2 \times 2 \times (-3) \times (-3) \times (-3) \times (-3)$ Group similar factors.

$= 2^4 \times \_\_\_\_\_$ Find the product of 2 powers.

$= 16 \times \_\_\_\_\_$ Evaluate.

$= \_\_\_\_\_$

Method 2: Apply the Exponent Laws

Write each factor in the product with the same exponent.

$[2 \times (-3)]^4 = 2^4 \times (-3)^4$

$= \_\_\_\_\_ \times \_\_\_\_\_$

$= \_\_\_\_\_$ C 2 y^x 4 × ( ) +/− 3) y^x 4 = 1296

Literacy Link

Raising a Product to an Exponent
- Write each factor in the product with the same exponent.
- $(3 \times 5)^4 = (3^1 \times 5^1)^4$
  $= 3^4 5^4$

Name: _____ Date: _____

c) Write $\left(\frac{3}{4}\right)^3$ as the quotient of two powers. Then, evaluate.

power / power =

Solution

Method 1: Use Repeated Multiplication

$$\left(\frac{3}{4}\right)^3 = \frac{3}{4} \times \frac{3}{4} \times \frac{3}{4}$$

$$= \frac{3 \times 3 \times 3}{4 \times 4 \times 4}$$

$$= \frac{3\square}{4\square}$$

$$= \frac{\square}{\square}$$

Multiply 3 × 3 × 3 or use your calculator: C 3 y^x 3 =

Method 2: Apply the Exponent Laws

Write each number in the quotient with the same exponent.

$$\left(\frac{3}{4}\right)^3 = \frac{3\square}{4^3}$$

$$= \frac{\square}{64}$$

Literacy Link

Raising a Quotient to an Exponent

- Write each number in the quotient with the same exponent.
- $\left(\frac{2}{3}\right)^4 = \frac{2^4}{3^4}$

Name: _____ Date: _____

Show You Know

a) Write $(3^2)^3$ as a single power in two different ways. Then, evaluate.

Repeated Multiplication:

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

$= (3 \times 3) \times$ (_____) $\times$ (_____)

$= 3\square$

$=$ _____

Exponent Laws:

$(3^2)^3$ Multiply the exponents.

Evaluate.

b) Write $(5 \times 4)^2$ as the product of two powers. Then evaluate.

Repeated Multiplication:

$(5 \times 4)^2 = (5 \times 4) \times$ _____

$=$ _____ $\times$ _____

$=$ _____

Exponent Laws:

$(5 \times 4)^2 = 5\square \times 4\square$

$=$ _____ $\times$ _____

$=$ _____

c) Write $\left(\frac{2}{5}\right)^5$ as the quotient of two powers. Then, evaluate.

Repeated Multiplication:

$\left(\frac{2}{5}\right)^5 = \frac{\square}{5} \times \frac{\square}{5} \times \frac{\square}{5} \times \frac{\square}{5} \times \frac{\square}{5}$

$= \frac{2 \times \square \times \square \times \square \times \square}{5 \times \square \times \square \times \square \times \square}$

$= \frac{2\square}{5\square}$

$= \frac{\square}{\square}$

Exponent Laws:

$\left(\frac{2}{5}\right)^5 = \frac{\square^5}{\square^5}$

$= \frac{\square}{\square}$

Name: _____ Date: _____

Working Example 4: Evaluate Quantities With an Exponent of Zero

a) Evaluate 3^0.

Solution

Complete the table to find a pattern in the powers of 3.

Power	Value
3^4	81
3^3	27
3^2	
3^1	
3^0	

Find the pattern in the values.

$81 \div 3 =$ _____

$27 \div 3 =$ _____

$9 \div 3 =$ _____

$3 \div 3 =$ _____

So, $3^0 = 1$.

You can find each value by dividing the value above it by 3.

Literacy Link

Raising a Quantity to an Exponent of Zero

- When the exponent of a power is 0, the value is 1. The base *cannot* equal 0.
- $5^0 = 1$

Check:

Use division to show that $3^0 = 1$.
Choose any power of 3, such as 3^4.
Divide it by itself.

$\frac{3^4}{3^4} = 3^{4-4}$ *or* $\frac{3^4}{3^4} = \frac{\cancel{3^4}^{1}}{\cancel{3^4}_{1}}$

$\frac{3^4}{3^4} = \frac{81}{81} = 1$

$= 3^{\square}$ $= $ _____

So, $3^0 =$ _____.

Use a calculator to check. C 3 y^x 0 = 1

b) Prove that $(-2)^0 = 1$.

Solution

Use division to show that $(-2)^0 = 1$.
Choose any power of (-2).
Divide it by itself.

$\frac{(-2)^3}{(-2)^3} = \frac{-8}{-8}$

$=$ _____

So, $(-2)^0 =$ _____.

Name: _____ Date: _____

Show You Know

Evaluate each expression.
Remember, the negative sign *must* be in the brackets to apply the power.

a) $(-5)^0 =$ _____

b) $-5^0 =$ _____

c) $-(5)^0 =$ _____

d) $5^0 =$ _____

Exponent Laws

Multiplying Powers With the Same Base
- Add the exponents.
- $5^2 \times 5^3 = 5^{2+3}$
  $= 5^5$

Dividing Powers With the Same Base
- Subtract the exponents.
- $2^6 \div 2^3 = 2^{6-3}$
  $= 2^3$

Raising a Power to an Exponent
- Multiply the exponents.
- $(3^2)^4 = 3^{2 \times 4}$
  $= 3^8$

Raising a Product to an Exponent
- Write each factor in the product with the same exponent.
- $(3 \times 5)^4 = 3^4 5^4$

Raising a Quotient to an Exponent
- Write each number in the quotient with the same exponent.
- $\left(\frac{2}{3}\right)^4 = \frac{2^4}{3^4}$

Raising a Quantity to an Exponent of Zero
- When the exponent of a power is 0, the value is 1. The base *cannot* equal 0.
- $5^0 = 1$

Name: _____ Date: _____

Check Your Understanding

Communicate the Ideas

1. Give 1 reason why $(4^2)^5 = 4^{10}$.

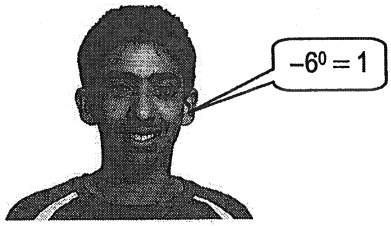
_____

2. Explain why $\left(\frac{3}{4}\right)^4 = \frac{81}{256}$.

_____

_____

3. Is Ranbir correct? Circle YES or NO.
Give 1 reason for your answer.



_____

_____

Practise

4. Write as a single power. Then, evaluate each power.

Choose the method you like to use.

(a) $4^3 \times 4^2 = 4^{3+2}$ *or* $4^3 \times 4^2 = (4 \times 4 \times$ _____$) \times (4 \times$ _____$)$

$= 4^{\square}$ ← Single power → $= 4^{\square}$

$=$ _____ ← Evaluate → $=$ _____

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

c) $8^1 \times 8^2$

(d) $(-3)^3 \times (-3)^1$

e) $(-2)^3 \times (-2)^4$

5. Write as a product of two powers. Then, write as a single power.

(a) $(4 \times 4 \times 4) \times (4 \times 4)$

$= 4^{\square} \times 4^2$

$= 4^{\square+\square}$

$= 4^{\square}$

b) $(2 \times 2 \times 2 \times 2 \times 2) \times (2 \times 2)$

Name: _____ Date: _____

6. Write as a single power. Then, evaluate each power.

Choose the method you like to use.

a) $5^5 \div 5^3$ *or* $5^5 \div 5^3$

$= (5 \times 5 \times 5 \times 5 \times 5) \div (5 \times 5 \times 5)$ $= 5^{5-3}$

$= \dfrac{5 \times 5 \times \overset{1}{\cancel{5}} \times \overset{1}{\cancel{5}} \times \overset{1}{\cancel{5}}}{\underset{1}{\cancel{5}} \times \underset{1}{\cancel{5}} \times \underset{1}{\cancel{5}}}$ $= 5^{\square}$

$= 5^{\square}$ $=$ _____

$=$ _____

b) $(-4)^6 \div (-4)^4$ **c)** $7^4 \div 7^1$

7. Write as a quotient of two powers. Then, write as a single power.

The *quotient* is the answer when you divide.

a) $(6 \times 6 \times 6 \times 6) \div (6 \times 6 \times 6)$ **b)** $(5 \times 5 \times 5 \times 5 \times 5 \times 5 \times 5) \div (5)$

$= 6^4 \div 6^{\square}$

$= 6^{4-\square}$

$= 6^{\square}$

8. Write as a single power. Then, evaluate.

Choose the method you like to use.

a) $(3^2)^3$ *or* $(3^2)^3$

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

$= (3 \times 3) \times (3 \times 3) \times$ (_____) $= 3^{\square}$

$= 3^{\square}$ $=$ _____

$=$ _____

b) $(5^2)^2$ **c)** $-(4^2)^2$

Name: _____ Date: _____

9. Write as a product of two powers. Then, evaluate.

Choose the method you like to use.

a) $[5 \times (-4)]^2$ *or* $[5 \times (-4)]^2$

$= [5 \times (-4)] \times [5 \times (-4)]$

$= 5 \times 5 \times (-4) \times (-4)$

$= 5^{\square} \times (-4)^{\square}$

$= \_\_\_\_ \times \_\_\_\_$

$= \_\_\_\_$

$= 5^2 \times (-4)^{\square}$

$= \_\_\_\_ \times \_\_\_\_$

$= \_\_\_\_ \times \_\_\_\_$

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

c) $[2 \times (-1)]^4$

10. Write as the division of two powers. Then, evaluate.

Choose the method you like to use.

$\left(\frac{5}{6}\right)^3$ *or* $\left(\frac{5}{6}\right)^3$

$= \frac{5}{6} \times \frac{5}{6} \times \frac{5}{6}$

$= \frac{5^{\square}}{6^{\square}}$

$= \frac{\square}{\square}$

$= \frac{5^3}{6^{\square}}$

$= \frac{\square}{\square}$

Apply

11. Jenny wants to write the expression as a product of two powers, and then solve it.

a) Circle Jenny's mistake.

b) Explain Jenny's mistake.

$(7 \times 7 \times 7 \times 7 \times 7) \times (7 \times 7 \times 7)$

$= 7^5 \times 7^3$

$= 7^{5 \times 3}$

$= 7^{15}$

_____

_____

12. Write $(3^2)^4 \times 3^3$ as a single power.

Name: _____ Date: _____

3.3 Warm Up

1. Complete the chart.

Power	Repeated Multiplication	Value
a)	$3 \times 3 \times 3$	
b) $(-10)^5$		
c) -4^2		
d) $-(-9^2)$		

2. Write as a single power. Then, evaluate.

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

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

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

d) $(-9)^5 \div (-9)^3$

Order of operations:
- Brackets
- Exponents
- ÷ and × in order from left to right
- + and − in order from left to right

3. Use the order of operations to solve each expression.

a) $5 - 6 \div 2 + 12$

$= 5 - \_\_\_\_\_ + 12$ Divide.

$= \_\_\_\_\_ + 12$ Subtract.

$= \_\_\_\_\_$

b) $-18 + (15 - 12) - 10 \times 2$

$= -18 + \_\_\_\_\_ - 10 \times 2$ Brackets.

$= -18 + \_\_\_\_\_ - \_\_\_\_\_$ Multiply.

$= -\_\_\_\_\_ - \_\_\_\_\_$ Add.

$= \_\_\_\_\_$

c) $15 - (6 + 2) + 12 \div 6$

d) $-9 + 2(15 - 12) - 10$

$2(15 - 12)$ is the same as $2 \times (15 - 12)$.

Name: _____ Date: _____

3.3 Order of Operations

Link the Ideas

Working Example 1: Determine the Product of a Power

Literacy Link

Order of Operations
- brackets
- exponents (powers)
- ÷ and × in order from left to right
- + and − in order from left to right

Evaluate.

a) $3(2)^4$

Solution

Method 1: Use Repeated Multiplication

$3(2)^4 = 3 \times (2)^4$ Write using a coefficient and a power.

$= 3 \times 2 \times 2 \times$ _____ $\times$ _____ Use repeated multiplication for the power.

$=$ _____ Evaluate.

Literacy Link

A *coefficient* is a number that multiplies an expression. Example: In $-5(4)^2$, the *coefficient* is -5.

Method 2: Use Order of Operations

$3(2)^4 = 3 \times (2)^4$ Evaluate the exponent.

$= 3 \times 16$ Multiply.

$=$ _____

Method 3: Use a Calculator

C 3 × 2 y^x 4 = 48.

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

Solution

$-3(-5)^2 = -3 \times (-5)^2$ Write using a coefficient and a power.

$= -3 \times$ _____ Evaluate the exponent. $(-5) \times (-5)$

$= -$_____ Multiply.

c) -4^4

Solution

Only the 4 has an exponent, not the negative sign: $-(4^4)$. So, use -1 as a coefficient.

$-4^4 = -1 \times 4^4$ Write using a coefficient and a power.

$= -1 \times$ _____ Evaluate the exponent. C +/− 1 × 4 y^x 4 =

$=$ _____ Multiply.

Name: _____ Date: _____

Show You Know

Write using a coefficient and a power. Use a calculator to check your answers.

a) 4×3^2

b) $6(-5)^3$

← Evaluate exponents →

← Multiply →

c) -7^2

$= -1 \times 7^2$ ← Write using a coefficient and a power →

$= -1 \times$ _____ ← Evaluate exponents →

$=$ _____ ← Multiply →

d) -2^3

Working Example 2: Evaluate Expressions With Powers

Evaluate.

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

Solution

Method 1: Use Order of Operations

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

$=$ _____ $- 8 \div 2 + (-$_____$)$ Exponents first.

$=$ _____ $-$ _____ $+ (-$_____$)$ Divide.

$=$ _____ $+ (-9)$ Subtract.

$=$ _____ Add.

Add and subtract in order from left to right.

Method 2: Use a Calculator

C 4 y^x 2 − 8 ÷ 2 + (3 +/−) y^x 2 = 3.

You may need to use a different key sequence on your calculator.

Name: _____ Date: _____

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

Solution

Method 1: Use Order of Operations

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

$= -2(-15 - \_\_\_\_\_) + 4(2 + 3)^3$ Do the exponents in the brackets first.

$= -2(-31) + 4(\_\_\_\_\_)^3$ Brackets.

$= -2(-31) + 4(\_\_\_\_\_)$ Exponents.

$= \_\_\_\_\_ + 500$ Multiply.

$= \_\_\_\_\_$ Add.

Method 2: Use a Calculator

C 2 +/− × (15 +/− − 4 x^2 2) + 4 × (2 + 3) y^x 3 = 562.

Show You Know

Evaluate.

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

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

Brackets.

Exponents.

Multiply and divide.

Subtract.

Check Your Understanding

Communicate the Ideas

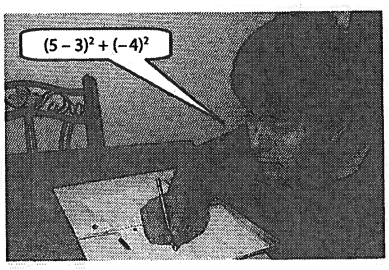
1. Han needs help with his homework.
Explain how to evaluate $(5 - 3)^2 + (-4)^2$.

Step 1: _____

_____

Step 2: _____

_____



Step 3: _____

_____

Name: _____ Date: _____

2. Maria evaluated 8×5^3.

8×5^3
$= 40^3$
$= 64\,000$

a) What mistake did Maria make?

_____

b) Show how to correct it.

Practise

3. Write using a coefficient and a power.
Then, find the value of each expression.

a) $4 \times 2 \times 2 \times 2 \times 2$

$= 4(2^{\square})$ ← Coefficient and a power →

$=$ ← Evaluate →

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

c) $7(10)(10)(10)(10)(10)$

d) $-1 \times 9 \times 9$

4. Evaluate.

a) $4(2^5)$
$= 4 \times 2^5$ ← Evaluate the exponent →
$= 4 \times$ _____
$=$ _____

b) $7(-3)^2$

c) $-2(5^3)$

d) $3(-2^2)$

Name: _____ Date: _____

5. Write the calculator key sequence you would use to find each answer. Then, write the answer.

a) 4×2^5

b) $-5(4)^3$

_____ _____ _____ _____

6. Evaluate using order of operations. Check your answer with a calculator.

You cannot use the power laws.

a) $3^2 + 3^2$

Exponents.

Add.

b) $(2 + 7)^2 - 11$

$= \_\_\_\_\_^2 - 11$ Brackets.

$= \_\_\_\_\_ - 11$ Exponent.

$= \_\_\_\_\_$ Subtract.

c) $7^2 - 3(-4)^2$

$= \_\_\_\_\_ - 3(\_\_\_\_\_)$ ← Exponents →

← Multiply →

← Evaluate →

d) $9 + (-2)^3 - 2(-6)^2$

$= 9 + (\_\_\_\_\_) - 2(\_\_\_\_\_)$

e) $(-2)^4 \div 4^2$

f) $24 - 2^2 + (7^2 - 5^2)$

Name: _____ Date: _____

Apply

7. Evaluate. Circle the larger expression.

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

b) $(2+4)^2$ 2^2+4^2

8. **a)** Circle the step where Justin made his first error. **b)** Find the correct answer.

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

$= 3^2 - 4 \times 3^2$ *Step 1*

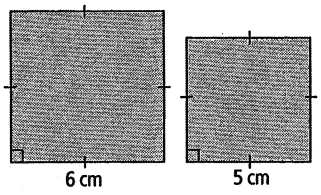
$= 9 - 4 \times 9$ *Step 2*

$= 5 \times 9$ *Step 3*

$= 45$ *Step 4*

9. **a)** Write an expression with powers to find the difference between the area of the large square and the area of the small square.

Area of large square – area of small square = Expression with powers



Area = (side)^2

b) Evaluate your expression to find the difference.

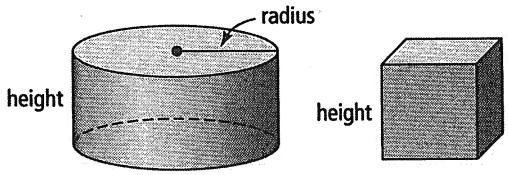
Expression:

Sentence: _____

Name: _____ Date: _____

Math Link

You want to build a mobile with a cylinder and a cube.



a) The height of both shapes and the radius of the cylinder are the *same* measurement.
Choose a whole number measurement between 1 cm and 10 cm.

height of cylinder = _____ cm height of cube = _____ cm

radius of cylinder = _____ cm

Calculate the surface area of each shape.

b) Find the area of material needed to make each shape.

Cylinder *Cube*

$SA = 2\pi r^2 + 2\pi rh$ $SA = 6s^2$

← Substitute →

c) Which shape needs more material? Circle CYLINDER or CUBE.
How much more? Round your answer to the nearest tenth.

Sentence: _____

d) Write an expression in exponential form to find the total area of material needed to make both shapes.

_____

e) Find the total area of material needed to make both shapes.
Round your answer to the nearest tenth.

Total SA = _____ ← Formula

← Substitute

← Evaluate

Sentence: _____