UNIT 2

Powers and Exponent Laws

What You'll Learn

- Use powers to show repeated multiplication.
- Evaluate powers with exponent 0.
- Write numbers using powers of 10.
- Use the order of operations with exponents.
- Use the exponent laws to simplify and evaluate expressions.

Why It's Important

Powers are used by

- lab technicians, when they interpret a patient's test results
- reporters, when they write large numbers in a news story

Key Words

integer	exponent
opposite	squared
positive	cubed
negative	standard form
factor	product
power	quotient
base	

2.1 Skill Builder

Multiplying Integers

When multiplying 2 integers, look at the sign of each integer:

- When the integers have the same sign, their product is positive.
- When the integers have different signs, their product is negative.

×	(−)	(+)
(−)	(+)	(−)
(+)	(−)	(+)

$6 \times (-3)$ These 2 integers have different signs, so their product is negative.

$6 \times (-3) = -18$

$(-10) \times (-2)$ These 2 integers have the same sign, so their product is positive.

$(-10) \times (-2) = 20$

When an integer is positive, we do not have to write the + sign in front.

Check

1. Will the product be positive or negative?

a) 7×4 _____ **b)** $3 \times (-6)$ _____

c) $(-9) \times 10$ _____ **d)** $(-5) \times (-9)$ _____

2. Multiply.

a) $7 \times 4 =$ _____ **b)** $3 \times (-6) =$ _____

c) $(-9) \times 10 =$ _____ **d)** $(-5) \times (-9) =$ _____

e) $(-3) \times (-5) =$ _____ **f)** $2 \times (-5) =$ _____

g) $(-8) \times 2 =$ _____ **h)** $(-4) \times 3 =$ _____

Multiplying More than 2 Integers

We can multiply more than 2 integers.
Multiply pairs of integers, from left to right.

$(-1) \times (-2) \times (-3)$
$= 2 \times (-3)$
$= -6$

The product of 3 negative factors is negative.

$(-1) \times (-2) \times (-3) \times (-4)$
$= 2 \times (-3) \times (-4)$
$= (-6) \times (-4)$
$= 24$

The product of 4 negative factors is positive.

Multiplying Integers
When the number of negative factors is *even*, the product is positive.
When the number of negative factors is *odd*, the product is negative.

We can show products of integers in different ways:
$(-2) \times (-2) \times 3 \times (-2)$ is the same as $(-2)(-2)(3)(-2)$.

So, $(-2) \times (-2) \times 3 \times (-2) = (-2)(-2)(3)(-2)$
$= -24$

Check

1. Multiply.

a) $(-3) \times (-2) \times (-1) \times 1$ _____

b) $(-2)(-1)(-2)(-2)(2)$ _____

c) $(-2)(-2)(-1)(-2)(-2)$ _____

d) $3 \times 3 \times 2$ _____

Is the answer positive or negative? How can you tell?

2.1 What Is a Power?

FOCUS **Show repeated multiplication as a power.**

We can use powers to show repeated multiplication.

$$2 \times 2 \times 2 \times 2 \times 2 = 2^5$$

Repeated multiplication
5 **factors** of 2

Power

*2 is the **base**.*
*5 is the **exponent**.*
*2^5 is a **power**.*

We read 2^5 as "2 to the 5th."
Here are some other powers of 2.

Repeated Multiplication	Power	Read as...
$\underbrace{2}_{\text{1 factor of 2}}$	2^1	2 to the 1st
$\underbrace{2 \times 2}_{\text{2 factors of 2}}$	2^2	2 to the 2nd, or 2 squared
$\underbrace{2 \times 2 \times 2}_{\text{3 factors of 2}}$	2^3	2 to the 3rd, or 2 cubed
$\underbrace{2 \times 2 \times 2 \times 2}_{\text{4 factors of 2}}$	2^4	2 to the 4th

In each case, the exponent in the power is equal to the number of factors in the repeated multiplication.

Example 1 Writing Powers

Write as a power.

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

b) 3

Solution

a) The base is 4.

$$\underbrace{4 \times 4 \times 4 \times 4 \times 4 \times 4}_{\text{6 factors of 4}} = 4^6$$

So, $4 \times 4 \times 4 \times 4 \times 4 \times 4 = 4^6$

b) The base is 3.

$$\underbrace{3}_{\text{1 factor of 3}}$$

So, $3 = 3^1$

Check

1. Write as a power.

a) $2 \times 2 \times 2 \times 2 \times 2 \times 2 = 2$___

b) $5 \times 5 \times 5 \times 5 = 5$___

c) $(-10)(-10)(-10) =$ _____

d) $4 \times 4 =$ _____

e) $(-7)(-7)(-7)(-7)(-7)(-7)(-7)(-7) =$ _____

2. Complete the table.

	Repeated Multiplication	Power	Read as...
a)	$8 \times 8 \times 8 \times 8$	_____	8 to the 4th
b)	7×7	_____	_____
c)	$3 \times 3 \times 3 \times 3 \times 3 \times 3$	_____	3 to the 6th
d)	$2 \times 2 \times 2$	_____	_____

Power	Repeated Multiplication	Standard Form
2^5	$2 \times 2 \times 2 \times 2 \times 2$	32

Example 2 Evaluating Powers

Write as repeated multiplication and in standard form.

a) 2^4 **b)** 5^3

Solution

a) $2^4 = 2 \times 2 \times 2 \times 2$ As repeated multiplication
$= 16$ Standard form

b) $5^3 = 5 \times 5 \times 5$ As repeated multiplication
$= 125$ Standard form

Check

1. Complete the table.

Power	Repeated Multiplication	Standard Form
2^3	$2 \times 2 \times 2$	_____
6^2	_____	36
3^4	_____	_____
10^4	_____	_____
8 squared	_____	_____
7 cubed	_____	_____

To evaluate a power that contains negative integers, identify the base of the power. Then, apply the rules for multiplying integers.

Example 3 Evaluating Expressions Involving Negative Signs

Identify the base, then evaluate each power.

a) $(-5)^4$ **b)** -5^4

Solution

a) $(-5)^4$

The brackets tell us that the base of this power is (-5).

$$(-5)^4 = (-5) \times (-5) \times (-5) \times (-5)$$
$$= 625$$

There is an even number of negative integers, so the product is positive.

b) -5^4

There are no brackets. So, the base of this power is 5. The negative sign applies to the whole expression.

$$-5^4 = -(5 \times 5 \times 5 \times 5)$$
$$= -625$$

Check

1. Identify the base of each power, then evaluate.

a) $(-1)^3$

The base is _____.

$(-1)^3 =$ _____

$=$ _____

b) -10^3

The base is _____.

$-10^3 =$ _____

$=$ _____

c) $(-7)^2$

The base is _____.

$(-7)^2 =$ _____

$=$ _____

d) $-(-5)^4$

The first negative sign applies to the whole expression.

The base is _____.

$-(-5)^4 =$ _____

$=$ _____

Practice

1. Write as a power.

a) $\underbrace{8 \times 8 \times 8 \times 8 \times 8 \times 8 \times 8}_{\text{7 factors of 8}}$

The base is 8. There are _____ equal factors, so the exponent is _____.

$8 \times 8 \times 8 \times 8 \times 8 \times 8 \times 8 = 8^{\_\_}$

b) $\underbrace{10 \times 10 \times 10 \times 10 \times 10}_{\text{5 factors of 10}}$

The base is _____. There are _____ equal factors, so the exponent is _____.

So, $10 \times 10 \times 10 \times 10 \times 10 =$ _____

c) $\underbrace{(-2)(-2)(-2)}_{\text{3 factors of \_\_\_\_}}$

The base is _____. There are _____ equal factors, so the exponent is _____.

So, $(-2)(-2)(-2) =$ _____

d) $(-13)(-13)(-13)(-13)(-13)(-13)$

_____ factors of _____

The base is _____. There are _____ equal factors, so the exponent is _____.

So, $(-13)(-13)(-13)(-13)(-13)(-13) =$ _____

2. Write each expression as a power.

a) $9 \times 9 \times 9 \times 9 =$ _____^{4}

b) $(5)(5)(5)(5)(5)(5) = 5^{\_\_}$

c) $11 \times 11 =$ _____

d) $(-12)(-12)(-12)(-12)(-12) =$ _____

3. Write each power as repeated multiplication.

a) $3^2 =$ _____ **b)** $3^4 =$ _____

c) $2^7 =$ _____

d) $10^8 =$ _____

Identify the base first.

4. State whether the answer will be positive or negative.

a) $(-3)^2$ _____ **b)** 6^3 _____

c) $(-10)^3$ _____ **d)** -4^3 _____

5. Write each power as repeated multiplication and in standard form.

Predict. Will the answer be positive or negative?

a) $(-3)^2 =$ _____
$=$ _____

b) $6^3 =$ _____
$=$ _____

c) $(-10)^3 =$ _____
$=$ _____

d) $-4^3 =$ _____
$=$ _____

6. Write each product as a power and in standard form.

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

b) $(-8)(-8) =$ _____
$=$ _____

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

d) $-(-1)(-1)(-1)(-1)(-1)(-1)(-1) =$ _____
$=$ _____

7. Identify any errors and correct them.

a) $4^3 = 12$ _____
_____

b) $(-2)^9$ is negative. _____
_____

c) $(-9)^2$ is negative. _____
_____

d) $3^2 = 2^3$ _____
_____

e) $(-10)^2 = 100$ _____
_____