SAXON®
ALGEBRA 1

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LESSON 1

Classifying Real Numbers

Warm Up

Start off each lesson by practicing prerequisite skills and math vocabulary that will make you more successful with today's new concept.

1. **Vocabulary** A ________ (*Venn diagram, line plot*) shows the relationship between sets. (SB 30)

Write each fraction as a decimal.

2. $\frac{2}{9}$ (SB 5)

3. $4\frac{3}{8}$ (SB 5)

Write each decimal as a fraction in simplest form.

4. 0.6 (SB 6)

5. 5.75 (SB 6)

New Concepts

A **set** is a collection of objects. Each object in the set is called an element. A set is written by enclosing the elements within braces. There are three types of sets. A set with no elements is called the null or **empty set.** A set with a finite number of elements is a **finite set.** An **infinite set** has an infinite number of elements.

{12, 24, 36}	{1, 3, 5,...}	{ } or ∅
finite set	infinite set	null or empty set

The subsets of real numbers are infinite sets.

Reading Math

The three dots inside the braces are called an ellipsis. An ellipsis shows that the numbers in the set continue on without end.

Subsets of Real Numbers	
Natural Numbers	The numbers used to count objects or things. {1, 2, 3, 4,...}
Whole Numbers	The set of natural numbers and zero. {0, 1, 2, 3, 4,...}
Integers	The set of whole numbers and the opposites of the natural numbers. {..., −4, −3, −2, −1, 0, 1, 2, 3, 4,...}
Rational Numbers	Numbers that can be written in the form $\frac{a}{b}$, where a and b are integers and $b \neq 0$. In decimal form, rational numbers either terminate or repeat. Examples: $\frac{1}{2}$, $0.\overline{3}$, $-\frac{2}{3}$, 0.125
Irrational Numbers	Numbers that cannot be written as the quotient of two integers. In decimal form, irrational numbers neither terminate nor repeat. Examples: $\sqrt[3]{5}$, $\sqrt{2}$, $-\sqrt{2}$, $3\sqrt{3}$, π, 3π
Real Numbers	The set including all rational and irrational numbers.

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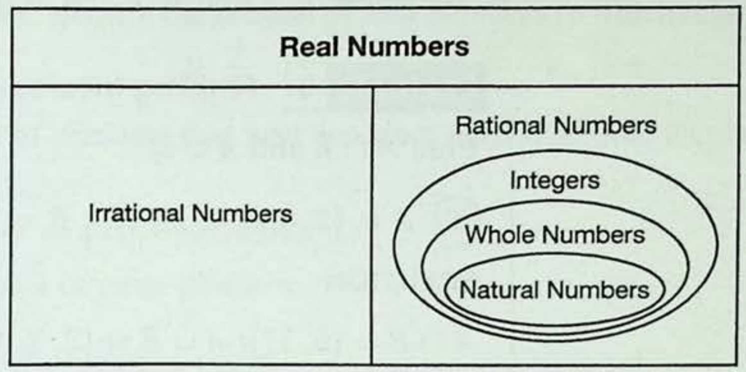
The Venn diagram below shows how the sets of numbers are related.



Math Language

The set of natural numbers is a **subset** of the set of real numbers because every natural number is a real number.

Example 1 Identifying Sets

For each number, identify the subsets of real numbers to which it belongs.

a. $\frac{1}{2}$

SOLUTION

{rational numbers, real numbers}

b. 5

SOLUTION

{natural numbers, whole numbers, integers, rational numbers, real numbers}

c. $3\sqrt{2}$

SOLUTION

{irrational numbers, real numbers}

Each day brings you a **New Concept** where a new topic is introduced and explained through thorough **Examples** — using a variety of methods and real-world applications.

You will be reviewing and building on this concept throughout the year to gain a solid understanding and ensure mastery on the test.

Example 2 Identifying Sets for Real-World Situations

Identify the set of numbers that best describes each situation. Explain your choice.

a. the value of the bills in a person's wallet

SOLUTION The set of whole numbers best describes the situation. The wallet may contain no bills or any number of bills.

b. the balance of a checking account

SOLUTION The set of rational numbers best describes the situation. The balance could be positive or negative and may contain decimal amounts.

c. the circumference of a circular table when the diameter is a rational number

SOLUTION The set of irrational numbers describes the situation. Since circumference is equal to the diameter multiplied by pi, it will be an irrational number.

The **intersection of sets** A and B, $A \cap B$, is the set of elements that are in A and B. The **union** of A and B, $A \cup B$, is the set of all elements that are in A or B.

Example 3 Finding Intersections and Unions of Sets

Find $A \cap B$ and $A \cup B$.

a. $A = \{2, 4, 6, 8, 10, 12\}; B = \{3, 6, 9, 12\}$

SOLUTION

$A \cap B = \{6, 12\}; A \cup B = \{2, 3, 4, 6, 8, 9, 10, 12\}$

b. $A = \{11, 13, 15, 17\}; B = \{12, 14, 16, 18\}$

SOLUTION

$A \cap B = \{\ \}$ or $\varnothing$; $A \cup B = \{11, 12, 13, 14, 15, 16, 17, 18\}$

In some lessons, **Explorations** allow you to go into more depth with the mathematics by investigating math concepts with manipulatives, through patterns, and in a variety of other ways.

A set of numbers has **closure,** or is closed, under a given operation if the outcome of the operation on any two members of the set is also a member of the set. For example, the sum of any two natural numbers is also a natural number. Therefore, the set of natural numbers is closed under addition.

One example is all that is needed to prove that a statement is false. An example that proves a statement false is called a **counterexample.**

Example 4 Identifying a Closed Set Under a Given Operation

Determine whether each statement is true or false. Give a counterexample for false statements.

a. The set of whole numbers is closed under addition.

SOLUTION

Verify the statement by adding two whole numbers.

$2 + 3 = 5$

$9 + 11 = 20$

$100 + 1000 = 1100$

The sum is always a whole number.

The statement is true.

b. The set of whole number is closed under subtraction.

SOLUTION

Verify the statement by subtracting two whole numbers.

$6 - 4 = 2$

$100 - 90 = 10$

$4 - 6 = -2$

$4 - 6$ is a counterexample. The difference is not a whole number.

The statement is false.

Lesson Practice

The **Lesson Practice** lets you check to see if you understand today's new concept.

The italic numbers refer to the Example in this lesson in which the major concept of that particular problem is introduced. You can refer to the lesson examples if you need additional help.

For each number, identify the subsets of real numbers to which it belongs.
(Ex 1)

a. -73 **b.** $\frac{5}{9}$ **c.** 18π

Identify the set of numbers that best describes each situation. Explain your choice.
(Ex 2)

d. the number of people on a bus

e. the area of a circular platform

f. the value of coins in a purse

Find $C \cap D$ and $C \cup D$.
(Ex 3)

g. $C = \{4, 8, 12, 16, 20\}$; $D = \{5, 10, 15, 20\}$

h. $C = \{6, 12, 18, 24\}$; $D = \{7, 14, 21, 28\}$

Verify **Determine whether each statement is true or false. Provide a counterexample for false statements.**
(Ex 4)

i. The set of whole numbers is closed under multiplication.

j. The set of natural numbers is closed under division.

Practice Distributed and Integrated

The *italic numbers* refer to the lesson(s) in which the major concept of that particular problem is introduced. You can refer to the examples or practice in that lesson, if you need additional help.

1. *(SB 2)* Multiply 26.1×6.15.

2. *(SB 3)* Add $\frac{4}{7} + \frac{1}{8} + \frac{1}{2}$.

3. *(SB 2)* Divide $954 \div 0.9$.

4. *(SB 3)* Add $\frac{3}{5} + \frac{1}{8} + \frac{1}{8}$.

5. *(SB 5)* Write $\frac{3}{8}$ as a decimal.

6. *(SB 6)* Write $0.6\overline{66}$ as a fraction.

7. *(SB 3)* Add $2\frac{1}{2} + 3\frac{1}{5}$.

8. *(SB 7)* Name a fraction equivalent to $\frac{2}{5}$.

9. *(SB 12)* **Error Analysis** Two students determine the prime factorization of 72. Which student is correct? Explain the error.

Student A	Student B
72	72
$= 9 \cdot 8$	$= 9 \cdot 8$
$= 9 \cdot 4 \cdot 2$	$= 9 \cdot 4 \cdot 2$
$= 9 \cdot 2 \cdot 2 \cdot 2$	$= 3 \cdot 3 \cdot 2 \cdot 2 \cdot 2$

10. *(SB 12)* Find the prime factorization of 144.

11. *(SB 5)* Write 0.15 as a percent. If necessary, round to the nearest tenth.

12. *(SB 5)* Write 7.2 as a percent. If necessary, round to the nearest tenth.

*13. Use braces and digits to designate the set of natural numbers.
(1)

*14. The set {0, 1, 2, 3,...} represents what set of numbers?
(1)

*15. Represent the following numbers as being members of set K: 2, 4, 2, 0, 6, 0, 10, 8.
(1)

*16. **Multiple Choice** Which of the following numbers is an irrational number?
(1)

A 15 **B** $\sqrt{15}$ **C** 15.15151515... **D** $-\frac{15}{3}$

*17. **Measurement** The surface area of a cube is defined as $6s^2$, where s is the length of the side of the cube. If s is an integer, then would the surface area of a cube be a rational or irrational number?
(1)

18. **Verify** True or False: A right triangle can have an obtuse angle. Explain your answer.
(SB 1)

19. **Anatomy** A baby's head is approximately one fourth of its total body length. If the baby's body measures 19 inches, what does the baby's head measure?
(SB 3)

20. True or False: An acute triangle has 3 acute angles. Explain your answer.
(SB 13)

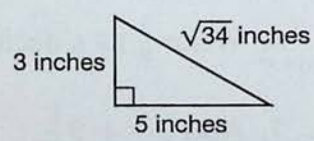
21. True or False: A trapezoid has two pairs of parallel sides. Explain your answer.
(SB 14)

*22. **Track Practice** Tyrone ran 7 laps on the quarter-mile track during practice. Which subset of real numbers would include the distance Tyrone ran at practice?
(1)

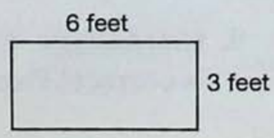
23. True or False: A parallelogram has two pairs of parallel sides. Explain your answer.
(SB 14)

24. **Write** Use the divisibility test to determine if 1248 is divisible by 2. Explain your answer.
(SB 4)

*25. **Geometry** The diagram shows a right triangle. The length of the hypotenuse is a member of which subset(s) of real numbers?
(1)



*26. **Multi-Step** The diagram shows a rectangle.
(1)



a. Find the area of the rectangle.

b. The number of square feet is a member of which subset(s) of real numbers?

27. **Lunar Rover** The surface-speed record set by the lunar rover on the moon is 10.56 miles per hour. At that speed, how far would the rover travel in 3.5 hours?
(SB 2)

28. **Write** Use the divisibility test to determine if 207 is divisible by 3. Explain your answer.
(SB 4)

29. **Swimming** Vidiana and Jaime went swimming before school. Vidiana swam $\frac{3}{5}$ mile and Jaime swam $\frac{4}{7}$ mile. Write a comparison to show who swam farther. Use <, >, or =.
(SB 1)

*30. **Banking** Shayla is balancing her checkbook. Which subset of real numbers best describes her balance?
(1)

In the **Practice,** you will review today's new concept as well as math you learned in earlier lessons. By practicing problems from many lessons every day, you will begin to see how math concepts relate and connect to each other and to the real world.

Also, because you practice the same topic in a variety of ways over several lessons, you will have "time to learn" the concept and will have multiple opportunities to show that you understand.

The mixed set of Practice is just like the mixed format of your state test. You'll be practicing for the "big" test every day!

The starred problems usually cover challenging or recently presented content. Because of that, it is suggested that these exercises be worked first, in case you might want help.

LESSON 2

Understanding Variables and Expressions

Warm Up

1. **Vocabulary** When two numbers are multiplied, the result is called the ________. ***(quotient, product)***
(SB 2)

Add.

2. $\frac{2}{5} + \frac{1}{3}$
(SB 3)

3. $654.1 + 78.39$
(SB 2)

Multiply.

4. $4.5(0.23)$
(SB 2)

5. $\frac{3}{8}\left(\frac{2}{9}\right)$
(SB 3)

New Concepts

A symbol, usually a letter, used to represent an unknown number is called a **variable.** In the algebraic expression $4 + x$, x is a variable. The number 4 in this expression does not change value. A quantity whose value does not change is called a **constant.**

Example 1 Identifying Variables and Constants

Identify the constants and the variables in each expression.

a. $6 - 3x$

SOLUTION

The numbers 6 and 3 are constants because they never change. The letter x is a variable because it represents an unknown number.

b. $71wz + 28y$

SOLUTION

The numbers 71 and 28 are constants because they never change. The letters w, y, and z are variables because they represent unknown numbers.

Math Reasoning

Connect What other term can be used to describe the coefficient in the expression 5*mn*?

The expression $4xy$ can also be written as $4 \cdot x \cdot y$. When two or more quantities are multiplied, each is a **factor** of the product. The numeric factor of a product including a variable is called the numeric coefficient, or simply the **coefficient.**

coefficient

↓

4xy

↑↑↑

factors

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Example 2 Identifying Factors and Coefficients in Expressions

Identify the factors and coefficients in each expression.

a. $7vw$

SOLUTION

The factors are 7, v, and w. The coefficient is 7.

b. $-5rst$

SOLUTION

The factors are -5, r, s, and t. The coefficient is -5.

c. $\frac{y}{3}$

SOLUTION

The factors are $\frac{1}{3}$ and y. The coefficient is $\frac{1}{3}$.

Hint

$\frac{y}{3} = \frac{1}{3}y$

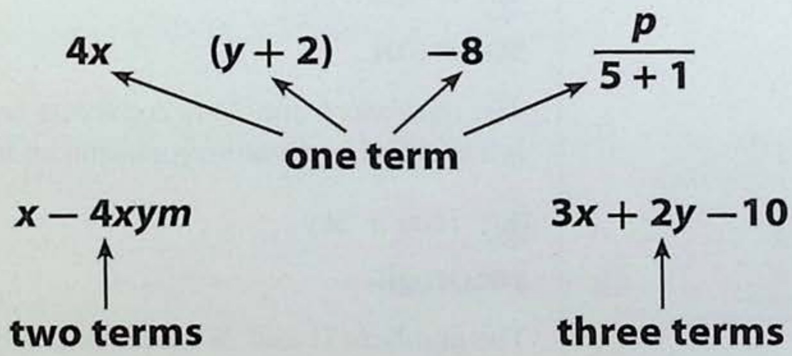
$cd = 1cd$

d. cd

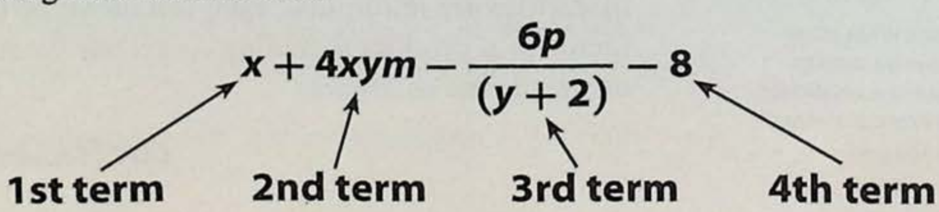
SOLUTION

The factors are c and d. The expression cd has an implied coefficient of 1.

Parts of an expression separated by + or − signs are called **terms of an expression.** A term that is in parentheses such as $(y + 2)$ can include a plus or minus sign.



You can refer to a particular term of an expression by its placement within the expression. The terms of an expression are numbered from left to right, beginning with the first term.



Example 3 Identifying Terms

Identify the terms in each expression.

a. $6xy + 57w - \frac{24x}{5y}$

SOLUTION

The first term is $6xy$.

The second term is $57w$.

The third term is $\frac{24x}{5y}$.

b. $m + 3mn - \frac{5t}{(d + 8)} - 9$

SOLUTION

The first term is m.

The second term is $3mn$.

The third term is $\frac{5t}{(d+8)}$.

The fourth term is 9.

Example 4 Application: Telecommunications

The local telephone company uses the expression below to determine the monthly charges for individual customers.

$$0.1m + 4.95$$

a. How many terms are in the expression?

SOLUTION There are two terms.

b. Identify the constant(s).

SOLUTION The constants are 0.1 and 4.95.

c. Identify the variable(s).

SOLUTION The variable is m.

Lesson Practice

Identify the constants and variables in each expression.
(Ex 1)

a. $65qrs + 12x$

b. $4gh - 71yz$

Identify the factors and coefficients in each expression.
(Ex 2)

c. $17def$

d. $\frac{uv}{4}$

e. $-3st$

f. abc

Identify the terms in each expression.
(Ex 3)

g. $8v - 17yz + \frac{63b}{4gh}$

h. $\frac{(4 + 2x)}{38q} + 18s - 47jkl$

Bill's Bikes uses the expression below to calculate rental fees.
(Ex 4)

$$6.50 + 3.25h - 0.75b$$

i. How many terms are in the expression?

j. Identify the constants.

k. Identify the variables.

Practice Distributed and Integrated

Find the GCF of each pair of numbers.

1. 24, 32 *(SB 9)*

2. 28, 42 *(SB 9)*

Find the LCM of each group of numbers.

3. 9, 12 *(SB 10)*

4. 3, 5, 6 *(SB 10)*

Multiply or divide.

5. $\frac{3}{4} \cdot \frac{8}{15}$ *(SB 3)*

6. $\frac{7}{15} \div \frac{21}{25}$ *(SB 3)*

Identify the coefficients and variables in each expression.

***7.** $rst - 12v$ *(2)*

***8.** $2xy + 7w - 8$ *(2)*

***9.** $47s + \frac{2}{5}t$ *(2)*

Identify the following statements as true or false. Explain your choice.

***10.** **Verify** All whole numbers are natural numbers. *(1)*

11. **Verify** All integers are real numbers. *(1)*

12. **Verify** A number can be a member of the set of rational numbers and the set of irrational numbers. *(1)*

13. **Multi-Step** Use the following set of data. *(SB 29)*

3, 6, 4, 3, 6, 5, 6, 7, 4, 3, 2, 4, 6

a. What is the frequency of each number?

b. Display the set of data in a line plot.

14. All natural numbers are members of which other subsets of real numbers? *(1)*

15. **Measurement** Add $7\frac{3}{8}$ meters + $6\frac{1}{3}$ meters. Does the sum belong to the set of rational numbers, integers, or whole numbers? *(1, SB 3)*

16. Find the prime factorization of 153. *(SB 12)*

17. **Verify** True or False: An obtuse triangle can have more than one obtuse angle. Explain your choice. *(SB 13)*

18. **Geometry** A line can be classified as a __________ angle. *(SB 13)*

19. **Write** Use the divisibility test to determine if 2345 is divisible by 4. Explain your answer. *(SB 4)*

20. Write 0.003 as a percent. If necessary, round to the nearest tenth. *(SB 5)*

21. *(1)* Use braces and digits to designate the set of whole numbers.

22. *(1)* The set $\{1, 2, 3, \ldots\}$ represents what set of numbers?

***23.** *(2)* **Multiple Choice** What is the second term in the expression $\sqrt{8} + \frac{gh}{5} + (3x + y) + 15gh$?

A $(3x + y)$ **B** $15gh$ **C** $\sqrt{8}$ **D** $\frac{gh}{5}$

***24.** *(2)* **Astronomy** To calculate the amount of time it takes for a planet to travel around the sun, you use the following expression: $\frac{2\pi r}{v}$. Which values are constants, which are variables, and which are coefficients?

***25.** *(2)* **Entertainment** Admission price for a matinee movie is \$5.75 for children and \$6.25 for adults. Brad uses the expression $\$5.75c + \$6.25a$ to calculate the cost for his family. What are the variables in the expression?

***26.** *(2)* **Error Analysis** The surface area of a rectangular prism is $2lw + 2lh + 2wh$. Two students determined the variables in the formula. Which student is correct? What was the error of the other student?

Student A
variables: $2lw$, $2lh$

Student B
variables: l, w, h

***27.** *(2)* **Cost Analysis** A large medical organization wants to put two cylindrical aquariums in the pharmacy area. It will cost the pharmacy 53 cents per cubic inch of aquarium. This is the formula for figuring out the cost: $P = (\pi r^2 h)(\$0.53)$.

a. Find the coefficients of the expression.

b. Find the variables of the expression.

28. *(SB 14)* **Multiple Choice** Which shape is not a parallelogram?

A square **B** rectangle **C** trapezoid **D** rhombus

***29.** *(2)* **Cycling** A bicycle shop uses the expression $\$5 + \$2.25h$ to determine the charges for bike rentals. How many terms are in the expression?

30. *(1)* **Attendance** The attendance clerk keeps records of students' attendance. Which subset of real numbers would include the number of students in attendance each school day?

LESSON 3

Simplifying Expressions Using the Product Property of Exponents

Warm Up

1. (2) **Vocabulary** In the term $4x$, x is the ________. (*variable, coefficient*)

Simplify.

2. (SB 2) (1.2)(0.7)

3. (SB 2) (0.5)(11)(0.9)

4. (SB 3) $\left(\frac{2}{3}\right)\left(\frac{6}{7}\right)$

5. (SB 3) $\left(\frac{1}{2}\right)\left(\frac{4}{5}\right)\left(\frac{15}{16}\right)$

New Concepts

An exponent can be used to show repeated multiplication.

$$\text{base} \rightarrow 5^{3} \leftarrow \text{exponent}$$

The **base of a power** is the number used as a factor. If the **exponent** is a natural number, it indicates how many times the base is used as a factor.

Words	Power	Multiplication	Value
five to the first power	5^1	5	5
five to the second power or five squared	5^2	$5 \cdot 5$	25
five to the third power or five cubed	5^3	$5 \cdot 5 \cdot 5$	125
five to the fourth power	5^4	$5 \cdot 5 \cdot 5 \cdot 5$	625

Caution

Be careful not to multiply the base and the exponent when simplifying powers.

Example 1 Simplifying Expressions with Exponents

Simplify each expression.

a. 7^3

SOLUTION

The exponent 3 indicates that the base is a factor three times.

7^3

$= 7 \cdot 7 \cdot 7$

$= 343$

b. $(0.3)^4$

SOLUTION

The exponent 4 indicates that the base is a factor four times.

$(0.3)^4$

$= (0.3)(0.3)(0.3)(0.3)$

$= 0.0081$

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Math Reasoning

Generalize Examine the powers of 10. What pattern do you see?

c. $\left(\frac{1}{2}\right)^5$

SOLUTION

The exponent 5 indicates that the base is a factor five times.

$$\left(\frac{1}{2}\right)^5$$
$$= \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2}$$
$$= \frac{1}{32}$$

d. 10^3

SOLUTION

The exponent 3 indicates that the base is a factor three times.

$$10^3$$
$$= 10 \cdot 10 \cdot 10$$
$$= 1000$$

The product of powers whose bases are the same can be found by writing each power as repeated multiplication.

$$5^4 \cdot 5^5 = (5 \cdot 5 \cdot 5 \cdot 5) \cdot (5 \cdot 5 \cdot 5 \cdot 5 \cdot 5) = 5^9$$

The sum of the exponents in the factors is equal to the exponent in the product.

Product Property of Exponents
If m and n are real numbers and $x \neq 0$, then $x^m \cdot x^n = x^{m+n}$.

Example 2 Applying the Product Property of Exponents

Simplify each expression.

a. $x^5 \cdot x^7 \cdot x^2$

SOLUTION

Since each of the factors has the same base, the exponents can be added to find the power of the product.

$x^{5+7+2} = x^{14}$

b. $m^3 \cdot m^2 \cdot m^4 \cdot n^6 \cdot n^7$

SOLUTION

The first three factors have m as the base. The exponents can be added to find the product of those three factors. The last two factors have n as the base. The exponents can be added to find the product of the last two factors.

$m^{3+2+4} \cdot n^{6+7} = m^9n^{13}$

Math Reasoning

Estimate Use the order of magnitude to estimate 1,127,000 times 108.

The **order of magnitude** is defined as the nearest power of ten to a given quantity. The order of magnitude can be used to estimate when performing calculations mentally.

Example 3 Application: Speed of a Supercomputer

In 2006, the fastest supercomputer's performance topped out at about one PFLOPS. One PFLOPS is equal to 10^3 TFLOPS. Each TFLOPS is equal to 10^{12} FLOPS. What was the computer's speed in FLOPS?

SOLUTION

Understand

1 PFLOPS = 10^3 TFLOPS

1 TFLOPS = 10^{12} FLOPS

Find the number of FLOPS in one PFLOPS.

Plan

Write an expression to find the number of FLOPS in one PFLOPS.

Solve

To find the speed in FLOPS, find the product of the number of TFLOPS, 10^3, and the number of FLOPS in a TFLOPS, 10^{12}.

$10^3 \cdot 10^{12}$

$= 10^{3+12}$

$= 10^{15}$

The computer performed at a speed of 10^{15} FLOPS.

Check

$$10^3 \cdot 10^{12} \stackrel{?}{=} 10^{15}$$

$$(10 \cdot 10 \cdot 10)(10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10) \stackrel{?}{=} 10^{15}$$

$$10^{15} = 10^{15} \checkmark$$

Lesson Practice

Simplify each expression.

a. 6^4 (Ex 1)

b. $(1.4)^2$ (Ex 1)

c. $\left(\frac{2}{5}\right)^3$ (Ex 1)

d. 10^6 (Ex 1)

e. $w^3 \cdot w^5 \cdot w^4$ (Ex 2)

f. $y^6 \cdot y^5 \cdot z^3 \cdot z^{11} \cdot z^2$ (Ex 2)

g. (Ex 3) If a supercomputer has a top speed of one EFLOPS which is equal to 10^9 GFLOPS, and if one GFLOPS is 10^9 FLOPS, what is the computer's speed in FLOPS?

Practice Distributed and Integrated

Find the GCF for each pair of numbers.

1. 15, 35 (SB 9)

2. 32, 48 (SB 9)

Find the LCM for each group of numbers.

3. 8, 12
(SB 10)

4. 2, 4, 7
(SB 10)

Multiply or divide.

5. $\frac{9}{16} \cdot \frac{12}{15}$
(SB 3)

6. $\frac{6}{15} \div \frac{24}{30}$
(SB 3)

Identify the coefficients and variables in each expression.

7. $6mn + 4b$
(2)

8. $5j - 9cd + 2$
(2)

9. $23t + \frac{4}{7}w$
(2)

Identify the following statements as true or false. Explain your choice.

***10.** **Verify** All real numbers are integers.
(1)

11. **Verify** All natural numbers are whole numbers.
(2)

12. **Verify** All irrational numbers are real numbers.
(2)

Complete the comparisons. Use <, >, or =.

13. 42.53 ○ 42.35
(SB 1)

14. $\frac{5}{9}$ ○ $\frac{7}{12}$
(SB 1)

15. Add $1\frac{1}{8} + 7\frac{2}{5}$.
(SB 3)

16. **Measurement** Use braces and digits to designate the set of integers. Which measurement can be described by the set of integers: temperature or volume?
(1)

17. Find the prime factorization of 98.
(SB 12)

***18.** **Error Analysis** Two students are trying to simplify the expression $x^2 \cdot x^5$. Which student is correct? Explain the error.
(3)

Student A	Student B
$x^2 \cdot x^5$ $x^{2 \cdot 5} = x^{10}$	$x^2 \cdot x^5$ $x^{2+5} = x^7$

19. **Verify** True or False: A rhombus is always a square. Explain your choice.
(SB 14)

20. **Write** Use the divisibility test to determine if 306 is divisible by 6. Explain your answer.
(SB 4)

***21.** The expression 3^6 indicates the number of times 3 is used as a factor.
(3)

a. Which number in the expression is the base?

b. Which number is the exponent?

c. What is the simplified value of this expression?

*22. **Multiple Choice** MFLOPS, TFLOPS, and PFLOPS are used to measure the speed
(3)
of a computer. One PFLOP is equal to 10^3 TFLOPS. Each TFLOP is equal to 10^6 MFLOPS. How many MFLOPS are in a PFLOP?

A 10^{18} **B** 10^9 **C** 10^6 **D** 10^3

*23. **Cooking** A cooking magazine advertises 4^4 recipes in every issue. How many
(3)
recipes are in 4^2 issues?

*24. **Multi-Step** A business is worth 10^6 dollars this year. The business expects to be 10^3
(3)
more valuable in five years.

a. Simplify 10^3 to determine how many times more valuable the business will be.

b. What will the business be worth in five years? Express your answer in exponential form, then simplify your answer.

*25. **Population** The population of Bridgetown triples every decade. If the population
(3)
in the year 2000 was 25,000, how many people will be living in Bridgetown in 2030?

26. **Multiple Choice** Which triangle is a right triangle?
(SB 13)

A a triangle with angle measures of 45°, 45°, and 90°

B a triangle with angle measures of 40°, 110°, and 30°

C a triangle with angle measures of 55°, 45°, and 80°

D a triangle with angle measures of 60°, 60°, and 60°

*27. **Bacteria** The population of a certain bacteria doubles in size every 3 hours. If
(3)
a population begins with one bacterium, how many will there be after one day? Simplify the expression $1 \cdot (2)^8$ to determine the population after one day.

28. **Geometry** You can calculate the area of a trapezoid using the following equation:
(2)
$A = h \times \frac{b_1 + b_2}{2}$. Identify the constant(s) in the equation.

*29. **Aquarium** A fish tank is in the shape of a cube. Each side measures 3 feet. What is
(SB 26)
the volume of the fish tank?

*30. **Remodeling** Vanessa is remodeling her bathroom. She uses the expression $2l + 2w$
(2)
to determine the amount of wallpaper border she needs.

a. How many terms are in the expression?

b. What are the variables?

LESSON 4

Using Order of Operations

Warm Up

1. (3) **Vocabulary** A(n) ________ can be used to show repeated multiplication.

Simplify.

2. (SB 2) $28.75 + 13.5$

3. (SB 2) $89.6 - 7.4$

4. (SB 3) $\frac{2}{3} \cdot \frac{9}{16}$

5. (SB 3) $4\frac{1}{5} \div 3\frac{1}{2}$

New Concepts

To **simplify** an expression means to perform all indicated operations. Simplifying an expression could produce multiple answers without rules concerning the order in which operations are performed. Consider the example below.

Method 1: $\frac{2 \cdot (3)^2}{6} = \frac{2 \cdot 9}{6} = \frac{18}{6} = 3$

Method 2: $\frac{2 \cdot (3)^2}{6} = \frac{(2 \cdot 3)^2}{6} = \frac{6^2}{6} = \frac{36}{6} = 6$

To avoid confusion, mathematicians have agreed to use the order of operations. The **order of operations** is a set of rules for simplifying expressions. Method 1 followed the order of operations.

Order of Operations
1. Work inside grouping symbols.
2. Simplify powers and roots.
3. Multiply and divide from left to right.
4. Add and subtract from left to right.

Example 1 Simplifying Expressions with Parentheses

Simplify. Justify each step.

$(10 \cdot 3) + 7 \cdot (5 + 4)$

SOLUTION

Write the expression. Then use the order of operations to simplify.

$(10 \cdot 3) + 7 \cdot (5 + 4)$

$= 30 + 7 \cdot 9$ Simplify inside the parentheses.

$= 30 + 63$ Multiply.

$= 93$ Add.

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Example 2 Simplifying Expressions with Exponents

Simplify each expression. Justify each step.

a. $4^3 + 9 \div 3 - 2 \cdot (3)^2$

SOLUTION Write the expression. Then use the order of operations to simplify.

$4^3 + 9 \div 3 - 2 \cdot (3)^2$	
$= 64 + 9 \div 3 - 2 \cdot 9$	Simplify exponents.
$= 64 + 3 - 18$	Multiply and divide from left to right.
$= 49$	Add and subtract from left to right.

Hint

Remember to use the order of operations inside parentheses as well.

b. $\frac{(2 \cdot 3 - 2)^2}{2}$

SOLUTION Write the expression. Then use the order of operations to simplify.

$\frac{(2 \cdot 3 - 2)^2}{2}$	
$= \frac{(6 - 2)^2}{2}$	Multiply inside the parentheses.
$= \frac{(4)^2}{2}$	Subtract inside the parentheses.
$= \frac{16}{2}$	Simplify the exponent.
$= 8$	Divide.

Example 3 Comparing Expressions

Compare the expressions. Use $<$, $>$, or $=$.

$$(1.5 + 3) \div 9 + 3^3 \bigcirc \frac{(18 + 8)}{2} - 8 \div 4$$

SOLUTION

Use the order of operations to simplify the two expressions.

$(1.5 + 3) \div 9 + 3^3$	$\frac{(18 + 8)}{2} - 8 \div 4$
$= (4.5) \div 9 + 3^3$	$= \frac{26}{2} - 8 \div 4$
$= 4.5 \div 9 + 27$	$= 13 - 8 \div 4$
$= 0.5 + 27$	$= 13 - 2$
$= 27.5$	$= 11$

Hint

Remember to compare the original expressions in the inequality.

Since $27.5 > 11$, $(1.5 + 3) \div 9 + 3^3 \textcircled{>} \frac{(18 + 8)}{2} - 8 \div 4$.

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