2–1

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Study Guide

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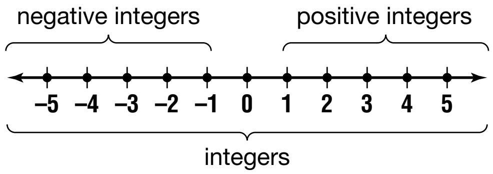
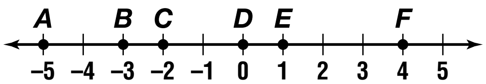
Pages 52–57

Graphing Integers on a Number Line

The numbers displayed on the number line below belong to the set of **integers**. The arrows at both ends of the number line indicate that the numbers continue indefinitely in both directions. Notice that the integers are equally spaced.

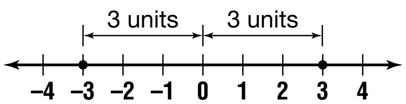


Use dots to graph numbers on a number line. You can label the dots with capital letters.



The coordinate of B is -3 and the coordinate of D is 0.

Because 3 is to the right of -3 on the number line, $3 > -3$. And because -5 is to the left of 1, $-5 < 1$. Because 3 and -3 are the same distance from 0, they have the same **absolute value**, 3. Use two vertical lines to represent absolute value.



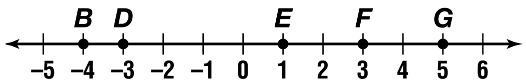
$|3| = 3$ *The absolute value of 3 is 3.*

$|-3| = 3$ *The absolute value of −3 is 3.*

Example: Evaluate $|-12| + |10|$.

$$|-12| + |10| = 12 + 10 \qquad |-12| = 12 \text{ and } |10| = 10$$
$$= 22$$

Name the coordinate of each point.

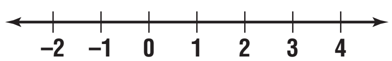


1. B **2.** D **3.** G

Graph each set of numbers on a number line.

4. $\{-3, 2, 4\}$

5. $\{-1, 0, 3\}$



Write < or > in each blank to make a true sentence.

6. -7 ______ 5 **7.** -3 ______ -8 **8.** $|-1|$ ______ 0

Evaluate each expression.

9. $|9|$ **10.** $|-15|$ **11.** $|-20| - |10|$

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2–1 Practice

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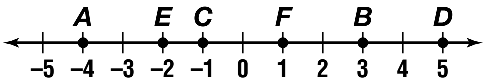
Graphing Integers on a Number Line

Name the coordinate of each point.

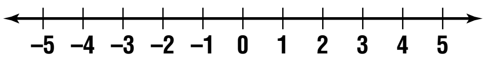


1. A **2.** B **3.** C

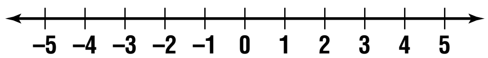
4. D **5.** E **6.** F

Graph each set of numbers on a number line.

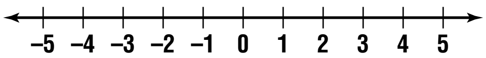
7. $\{-5, 0, 2\}$



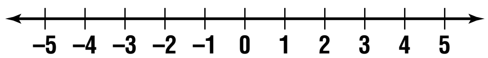
8. $\{4, -1, -2\}$



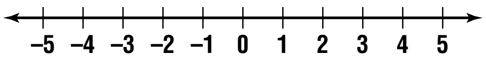
9. $\{3, -4, -3\}$



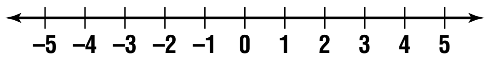
10. $\{-2, 5, 1\}$



11. $\{2, -5, 0\}$



12. $\{-4, 3, -2, 4\}$



Write $<$ or $>$ in each blank to make a true sentence.

13. 7 ______ 9 **14.** 0 ______ −1 **15.** −2 ______ 2

16. 6 ______ −3 **17.** −4 ______ −5 **18.** −7 ______ −3

19. −8 ______ 0 **20.** −11 ______ 2 **21.** −5 ______ −6

Evaluate each expression.

22. $|-4|$

23. $|6|$

24. $|-3| + |1|$

25. $|9| - |-8|$

26. $|-7| - |-2|$

27. $|-8| + |11|$

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Enrichment

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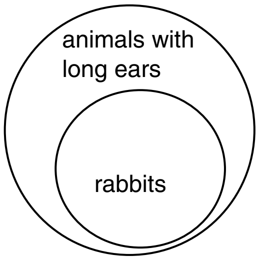
Pages 52–57

Venn Diagrams

A type of drawing called a **Venn diagram** can be useful in explaining conditional statements. A Venn diagram uses circles to represent sets of objects.

Consider the statement "All rabbits have long ears." To make a Venn diagram for this statement, a large circle is drawn to represent all animals with long ears. Then a smaller circle is drawn inside the first to represent all rabbits. The Venn diagram shows that every rabbit is included in the group of long-eared animals.



The set of rabbits is called a **subset** of the set of long-eared animals.

The Venn diagram can also explain how to write the statement, "All rabbits have long ears," in if-then form. Every rabbit is in the group of long-eared animals, so if an animal is a rabbit, then it has long ears.

For each statement, draw a Venn diagram. The write the sentence in if-then form.

1. Every dog has long hair.

2. All rational numbers are real.

3. People who live in Iowa like corn.

4. Staff members are allowed in the faculty lounge.

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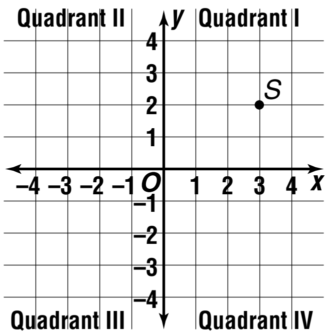
The Coordinate Plane

The two intersecting lines and the grid at the right form a **coordinate system**. The horizontal number line is called the ***x*-axis,** and the vertical number line is called the ***y*-axis**. The *x*- and *y*-axes divide the coordinate plane into **four quadrants**. Point *S* in Quadrant I is the graph of the **ordered pair** (3, 2). The ***x*-coordinate** of point *S* is 3, and the ***y*-coordinate** of point *S* is 2.



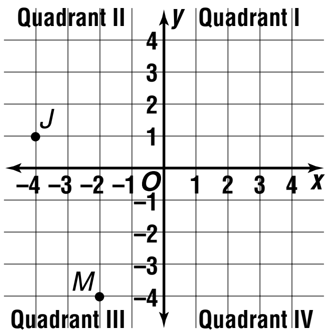
The point at which the axes meet has coordinates (0, 0) and is called the **origin**.

Example 1: What is the ordered pair for point *J*? In what quadrant is point *J* located?

You move 4 units to the left of the origin and then 1 unit up to get to *J*. So the ordered pair for *J* is (−4, 1). Point *J* is located in Quadrant II.

Example 2: Graph *M*(−2, − 4) on the coordinate plane.

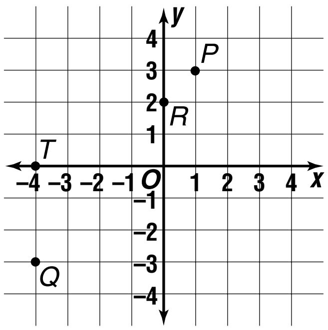
Start at the origin. Move left on the *x*-axis to −2 and then down 4 units. Draw a dot here and label it *M*.



Write the ordered pair that names each point.

1. *P* **2.** *Q*

3. *R* **4.** *T*

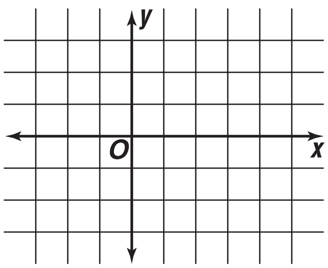


Graph each point on the coordinate plane. Name the quadrant, if any, in which each point is located.

5. *A*(5, −1) **6.** *B*(−3, 0)

7. *C*(−3, 1) **8.** *D*(0, 1)

9. *E*(3, 3) **10.** *F*(−1, −2)



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Practice

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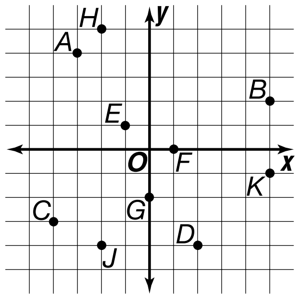
Pages 58–63

The Coordinate Plane

Write the ordered pair that names each point.



1. A **2.** B

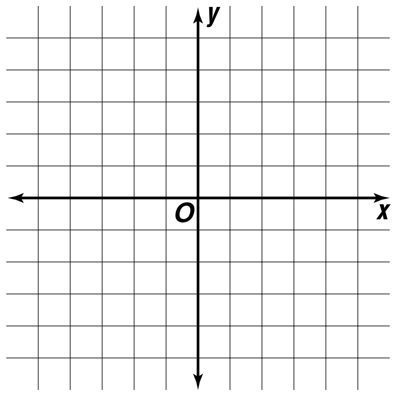
3. C **4.** D

5. E **6.** F

7. G **8.** H

9. J **10.** K

Graph each point on the coordinate plane.



11. $K(0, -3)$ **12.** $L(-2, 3)$

13. $M(4, 4)$ **14.** $N(-3, 0)$

15. $P(-4, -1)$ **16.** $Q(1, -2)$

17. $R(-5, 5)$ **18.** $S(3, 2)$

19. $T(2, 1)$ **20.** $W(-1, -4)$

Name the quadrant in which each point is located.

21. $(1, 9)$ **22.** $(-2, -7)$

23. $(0, -1)$ **24.** $(-4, 6)$

25. $(5, -3)$ **26.** $(-3, 0)$

27. $(-1, -1)$ **28.** $(6, -5)$

29. $(-8, 4)$ **30.** $(-9, -2)$

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Enrichment

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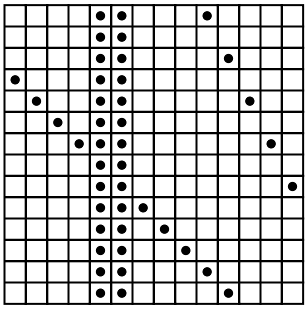
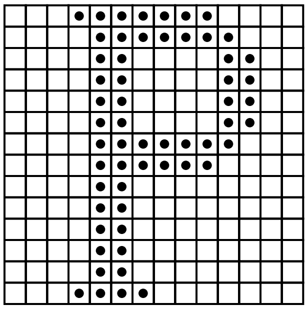
Points and Lines on a Matrix



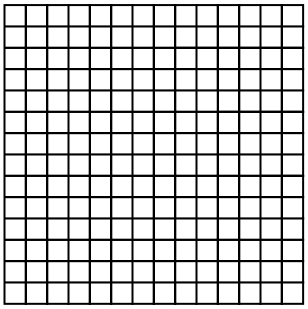
A **matrix** is a rectangular array of rows and columns. Points and lines on a matrix are not defined in the same way as in Euclidean geometry. A **point** on a matrix is a dot, which can be small or large. A **line** on a matrix is a path of dots that "line up." Between two points on a line there may or may not be other points. Three examples of lines are shown at the upper right. The broad line can be thought of as a single line or as two narrow lines side by side.



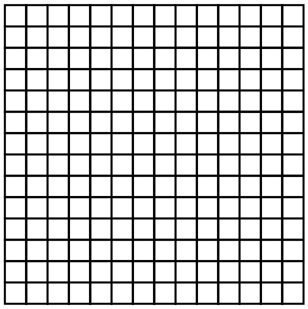
A dot-matrix printer for a computer uses dots to form characters. The dots are often called **pixels**. The matrix at the right shows how a dot-matrix printer might print the letter P.

Draw points on each matrix to create the given figures.

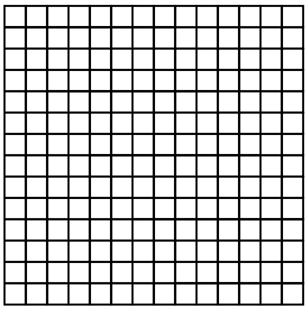
1. Draw two intersecting lines that have four points in common.



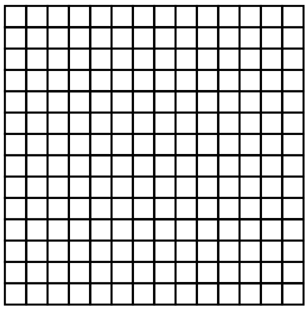
2. Draw two lines that cross but have no common points.



3. Make the number 0 (zero) so that it extends to the top and bottom sides of the matrix.



4. Make the capital letter O so that it extends to each side of the matrix.

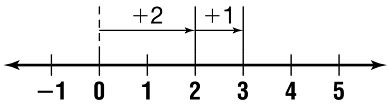


5. Using separate grid paper, make dot designs for several other letters. Which were the easiest and which were the most difficult?

Study Guide

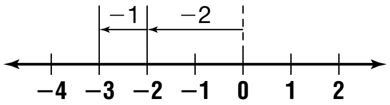
Adding Integers

You can use a number line to add integers. Start at 0. Then move to the right for positive integers and move to the left for negative integers.



2 + 1 = 3

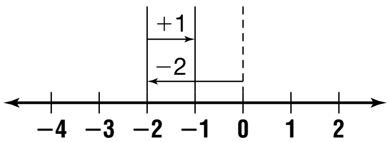
Both integers are positive.
First move 2 units right from 0.
Then move 1 more unit right.



−2 + (−1) = −3

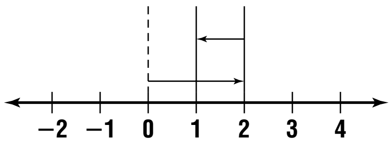
Both integers are negative.
First move 2 units left from 0.
Then move 1 more unit left.

When you add one positive integer and one negative integer on the number line, you change directions, which results in one move being subtracted from the other move.



−2 + 1 = −1

Move 2 units left, then 1 unit right.



2 + (−1) = 1

Move 2 units right, then 1 unit left.

Use the following rules to add two integers and to simplify expressions.

Rule	Examples
To add integers with the same sign, add their absolute values. Give the result the same sign as the integers.	$7 + 4 = 11$ $-8 + (-2) = -10$ $-5x + (-3x) = -8x$
To add integers with different signs, subtract their absolute values. Give the result the same sign as the integer with the greater absolute value.	$9 + (-6) = 3$ $1 + (-5) = -4$ $-2x + 9x = 7x$ $3y + (-4y) = -y$

Find each sum.

1. $5 + 8$ **2.** $-8 + (-9)$ **3.** $12 + (-8)$ **4.** $-16 + 5$

5. $5 + (-8) + (-5)$ **6.** $-8 + (-8) + 20$ **7.** $12 + 5 + (-1)$

Simplify each expression.

8. $3x + (-6x)$ **9.** $-5y + (-7y)$ **10.** $2m + (-4m) + (-2m)$

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Practice

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Adding Integers

Find each sum.

1. $8 + 4$ **2.** $-3 + 5$ **3.** $9 + (-2)$

4. $-5 + 11$ **5.** $-7 + (-4)$ **6.** $12 + (-4)$

7. $-9 + 10$ **8.** $-4 + 4$ **9.** $2 + (-8)$

10. $17 + (-4)$ **11.** $-13 + 3$ **12.** $6 + (-7)$

13. $-8 + (-9)$ **14.** $-2 + 11$ **15.** $-9 + (-2)$

16. $-1 + 3$ **17.** $6 + (-5)$ **18.** $-11 + 7$

19. $-8 + (-8)$ **20.** $-6 + 3$ **21.** $2 + (-2)$

22. $7 + (-5) + 2$ **23.** $-4 + 8 + (-3)$ **24.** $-5 + (-5) + 5$

Simplify each expression.

25. $5a + (-3a)$ **26.** $-7y + 2y$ **27.** $-9m + (-4m)$

28. $-2z + (-4z)$ **29.** $8x + (-4x)$ **30.** $-10p + 5p$

31. $5b + (-2b)$ **32.** $-4s + 7s$ **33.** $2n + (-4n)$

34. $5a + (-6a) + 4a$ **35.** $-6x + 3x + (-5x)$ **36.** $7z + 2z + (-3z)$

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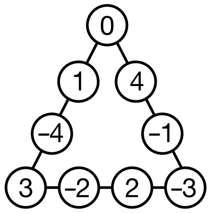
Enrichment

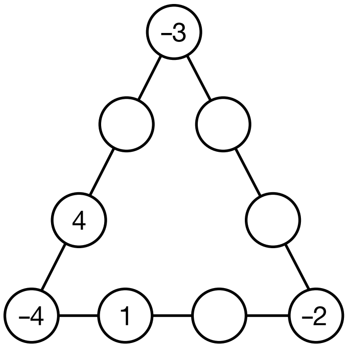
Integer Magic

A **magic triangle** is a triangular arrangement of numbers in which the sum of the numbers along each side is the same number. For example, in the magic triangle shown at the right, the sum of the numbers along each side is 0.

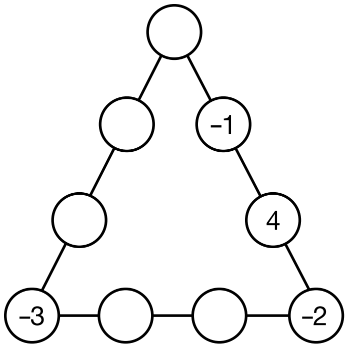


In each triangle, each of the integers from −4 to 4 appears exactly once. Complete the triangle so that the sum of the integers along each side is −3.

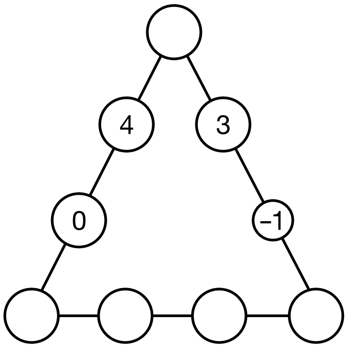
1.



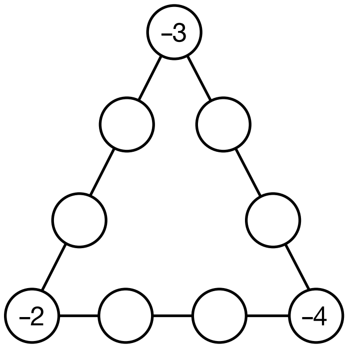
2.



3.

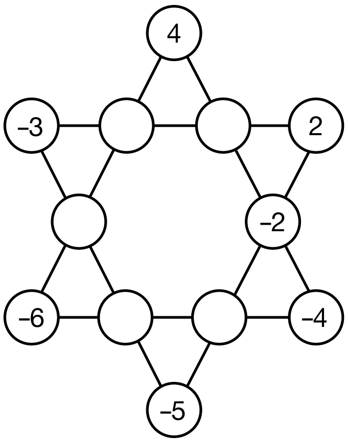


4.

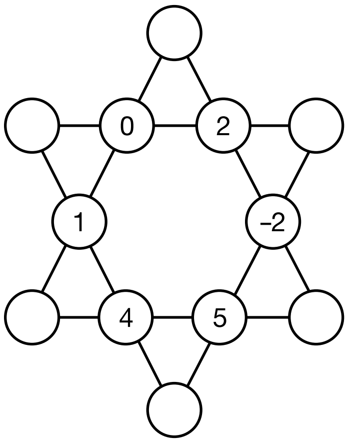


In these magic stars, the sum of the integers along each line of the star is −2. Complete each magic star using the integers from −6 to 5 exactly once.

5.



6.



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Study Guide

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Subtracting Integers

If the sum of two integers is 0, the numbers are **opposites** or **additive inverses**.

Example 1: **a.** -3 is the opposite of 3 because $-3 + 3 = 0$

b. 17 is the opposite of -17 because $17 + (-17) = 0$

Use this rule to subtract integers.

To subtract an integer, add its opposite or additive inverse.

Example 2: Find each difference.

a. $5 - 2$

$5 - 2 = 5 + (-2)$ *Subtracting 2 is the same as adding its*
$= 3$ *opposite, −2.*

b. $-7 - (-1)$

$-7 - (-1) = -7 + 1$ *Subtracting −1 is the same as adding its*
$= -6$ *opposite, 1.*

Example 3: Evaluate $c + d - e$ if $c = -1$, $d = 7$, and $e = -3$.

$c + d - e = -1 + 7 - (-3)$ *Replace c with −1, d with 7, and e with −3.*
$= -1 + 7 + 3$ *Write 7 − (−3) as 7 + 3.*
$= 6 + 3$ *−1 + 7 = 6*
$= 9$ *6 + 3 = 9*

Find each difference.

1. $5 - 8$ **2.** $-8 - (-9)$ **3.** $-2 - 8$ **4.** $-4 - (-5)$

5. $16 - 8$ **6.** $10 - (-10)$ **7.** $0 - 10$ **8.** $0 - (-18)$

Simplify each expression.

9. $3x - 9x$ **10.** $-4y - (-6y)$ **11.** $2m - 8m - (-2m)$

Evaluate each expression if x = −1, y = 2, and z = −4.

12. $x - y$ **13.** $y - z - 5$ **14.** $z - y - (-2)$

15. $9 - x$ **16.** $x - z - z$ **17.** $0 - y$

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Practice

Subtracting Integers

Find each difference.

1. $9 - 3$

2. $-1 - 2$

3. $4 - (-5)$

4. $6 - (-1)$

5. $-7 - (-4)$

6. $8 - 10$

7. $-2 - 5$

8. $-6 - (-7)$

9. $2 - 8$

10. $-10 - (-2)$

11. $-4 - 6$

12. $5 - 3$

13. $-8 - (-4)$

14. $7 - 9$

15. $-9 - (-11)$

16. $-3 - 4$

17. $6 - (-5)$

18. $6 - 5$

Evaluate each expression if a = −1, b = 5, c = −2, and d = −4.

19. $b - c$

20. $a - b$

21. $c - d$

22. $a + c - d$

23. $a - b + c$

24. $a - c + d$

25. $b - c + d$

26. $b - c - d$

27. $a - b - c$

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Enrichment

Closure

A **binary operation** matches two numbers in a set to just one number. Addition is a binary operation on the set of whole numbers. It matches two numbers such as 4 and 5 to a single number, their sum.

If the result of a binary operation is always a member of the original set, the set is said to be **closed** under the operation. For example, the set of whole numbers is not closed under subtraction because $3 - 6$ is not a whole number.

***Is each operation binary? Write* yes *or* no.**

1. the operation $\hookleftarrow$, where $a \hookleftarrow b$ means to choose the lesser number from a and b

2. the operation ©, where a © b means to cube the sum of a and b

3. the operation *sq*, where $sq(a)$ means to square the number a

4. the operation *exp*, where $exp(a, b)$ means to find the value of a^b

5. the operation $\Uparrow$, where $a \Uparrow b$ means to match a and b to any number greater than either number

6. the operation $\Rightarrow$, where $a \Rightarrow b$ means to round the product of a and b up to the nearest 10

Is each set closed under addition? Write* yes *or* no. *If your answer is no, give an example.

7. even numbers

8. odd numbers

9. multiples of 3

10. multiples of 5

11. prime numbers

12. nonprime numbers

Is the set of whole numbers closed under each operation? Write* yes *or* no. *If your answer is no, give an example.

13. multiplication: $a \times b$

14. division: $a \div b$

15. exponentation: a^b

16. squaring the sum: $(a + b)^2$

Study Guide

Multiplying Integers

Use these rules to multiply integers and to simplify expressions.

The product of two positive integers is positive. The product of two negative integers is positive. The product of a positive integer and a negative integer is negative.

Example 1: Find each product.

a. $7(12)$

$7(12) = 84$ — *Both factors are positive, so the product is positive.*

b. $-5(-9)$

$-5(-9) = 45$ — *Both factors are negative, so the product is positive.*

c. $-4(8)$

$-4(8) = -32$ — *The factors have different signs, so the product is negative.*

Example 2: Evaluate $-3ab$ if $a = 3$ and $b = -5$.

$-3ab = -3(3)(-5)$ — *Replace a with 3 and b with −5.*

$= -9(-5)$ — *−3 · 3 = −9*

$= 45$ — *Both factors are negative.*

Example 3: Simplify $-12(4x)$.

$-12(4x) = (-12 \cdot 4)(x)$ — *Associative Property*

$= -48x$ — *−12 · 4 = −48*

Find each product.

1. $3(8)$ **2.** $(-7)(-9)$ **3.** $12(-1)$ **4.** $-6(5)$

5. $4(-1)(-5)$ **6.** $(-8)(-8)(-2)$ **7.** $2(-5)(10)$

Evaluate each expression if a = 3, b = −2, and c = −3.

8. $5c$ **9.** $2ab$ **10.** abc **11.** $3b - c$

Simplify each expression.

12. $3(-6x)$ **13.** $-5(-7y)$ **14.** $(2p)(-4q)$

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Practice

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Multiplying Integers

Find each product.

1. $3(-7)$ **2.** $-2(8)$ **3.** $4(5)$

4. $-7(-7)$ **5.** $-9(3)$ **6.** $8(-6)$

7. $6(2)$ **8.** $-5(-7)$ **9.** $2(-8)$

10. $-10(-2)$ **11.** $9(-8)$ **12.** $12(0)$

13. $-4(-4)(2)$ **14.** $7(-9)(-1)$ **15.** $-3(5)(2)$

16. $3(-4)(-2)(2)$ **17.** $6(-1)(2)(1)$ **18.** $-5(-3)(-2)(-1)$

Evaluate each expression if a = –3 and b = –5.

19. $-6b$ **20.** $8a$ **21.** $4ab$

22. $-3ab$ **23.** $-9a$ **24.** $-2ab$

Simplify each expression.

25. $5(-5y)$ **26.** $-7(-3b)$ **27.** $-3(6n)$

28. $(6a)(-2b)$ **29.** $(-4m)(-9n)$ **30.** $(-8x)(7y)$

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Enrichment

The Binary Number System

Our standard number system in base ten has ten digits, 0 through 9. In base ten, the values of the places are powers of 10.

A system of numeration that is used in computer technology is the **binary number system**. In a **binary number**, the place value of each digit is two times the place value of the digit to its right. There are only two digits in the binary system: 0 and 1.

The binary number 10111 is written 10111_{two}. You can use a place-value chart like the one at the right to find the standard number that is equivalent to this number.

$8 \times 2 = 16$	$4 \times 2 = 8$	$2 \times 2 = 4$	$1 \times 2 = 2$	1
1	0	1	1	1

$$\begin{aligned} 10111_{two} &= 1 \times 16 + 0 \times 8 + 1 \times 4 + 1 \times 2 + 1 \times 1 \\ &= 16 + 0 + 4 + 2 + 1 \\ &= 23 \end{aligned}$$

Write each binary number as a standard number.

1. 11_{two}

2. 111_{two}

3. 100_{two}

4. 1001_{two}

5. 11001_{two}

6. 100101_{two}

Write each standard number as a binary number.

7. 8

8. 10

9. 15

10. 17

11. 28

12. 34

Write each answer as a binary number.

13. $1_{two} + 10_{two}$

14. $101_{two} - 10_{two}$

15. $10_{two} \times 11_{two}$

16. $10000_{two} \div 10_{two}$

17. What standard number is equivalent to 12021_{three}?

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Dividing Integers

Example 1: Use the multiplication problems at the right to find each quotient.

$3 \cdot 5 = 15$
$-3(-5) = 15$
$-3 \cdot 5 = -15$
$3(-5) = -15$

a. $15 \div 5$
Since $3 \cdot 5 = 15$, $15 \div 5 = 3$.

b. $15 \div (-5)$
Since $-3 \cdot (-5) = 15$, $15 \div (-5) = -3$.

c. $-15 \div 5$
Since $-3 \cdot 5 = -15$, $-15 \div 5 = -3$.

d. $-15 \div (-5)$
Since $3 \cdot (-5) = -15$, $-15 \div (-5) = 3$.

Use these rules to divide integers.

> The quotient of two positive integers is positive.
> The quotient of two negative integers is positive.
> The quotient of a positive integer and a negative integer is negative.

Example 2: Evaluate $\frac{-3r}{s}$ if $r = 8$ and $s = -2$.

$\frac{-3r}{s} = \frac{-3 \cdot 8}{-2}$ *Replace r with 8 and s with −2.*

$= \frac{-24}{-2}$ *$-3 \cdot 8 = -24$*

$= 12$ *$-24 \div (-2) = 12$*

Find each quotient.

1. $36 \div 9$ **2.** $-63 \div (-7)$ **3.** $25(-1)$ **4.** $-60 \div 5$

5. $\frac{20}{-5}$ **6.** $\frac{-18}{-3}$ **7.** $\frac{-1}{-1}$ **8.** $\frac{-56}{8}$

Evaluate each expression if k = −1, m = 3, and n = −2.

9. $-21 \div m$ **10.** $\frac{2n}{k}$ **11.** $m \div k$ **12.** $\frac{m + 5}{n}$

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Practice

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Dividing Integers

Find each quotient.

1. $28 \div 7$

2. $-33 \div 3$

3. $42 \div (-6)$

4. $-81 \div (-9)$

5. $12 \div 4$

6. $72 \div (-9)$

7. $15 \div 15$

8. $-30 \div 5$

9. $-40 \div (-8)$

10. $56 \div (-7)$

11. $-21 \div (-3)$

12. $-64 \div 8$

13. $-8 \div 8$

14. $-22 \div (-2)$

15. $32 \div (-8)$

16. $-54 \div (-9)$

17. $60 \div (-6)$

18. $63 \div 9$

19. $-45 \div (-9)$

20. $-60 \div 5$

21. $24 \div (-3)$

22. $\frac{-12}{6}$

23. $\frac{40}{-10}$

24. $\frac{-45}{-9}$

Evaluate each expression if a = 4, b = −9, and c = −6.

25. $-48 \div a$

26. $b \div 3$

27. $9c \div b$

28. $\frac{ab}{c}$

29. $\frac{bc}{-6}$

30. $\frac{3c}{b}$

31. $\frac{12a}{c}$

32. $\frac{-4b}{a}$

33. $\frac{ac}{6}$

Enrichment

Day of the Week Formula

The following formula can be used to determine the specific day of the week on which a date occurred.

$$s = d + 2m + [(3m + 3) \div 5] + y + \left[\frac{y}{4}\right] - \left[\frac{y}{100}\right] + \left[\frac{y}{100}\right] + 2$$

s = sum
d = day of the month, using numbers from 1–31
m = month, beginning with March is 3, April is 4, and so on, up to December is 12, January is 13, and February is 14
y = year except for dates in January or February when the previous year is used

For example, for February 13, 1985, $d = 13$, $m = 14$, and $y = 1984$; and for July 4, 1776, $d = 4$, $m = 7$, and $y = 1776$

The brackets, [ ], mean you are to do the division inside them, discard the remainder, and use only the whole number part of the quotient. The next step is to divide s by 7 and note the remainder. The remainder 0 is Saturday, 1 is Sunday, 2 is Monday, and so on, up to 6 is Friday.

Example: What day of the week was October 3, 1854?

For October 3, 1854, $d = 3$, $m = 10$, and $y = 1854$.

$$\begin{aligned} s &= 3 + [\underbrace{2(10)}_{20}] + [\underbrace{(3 \times 10 + 3) \div 5}_{6}] + 1854 + \left[\frac{1854}{4}\right] - \left[\frac{1854}{100}\right] + \left[\frac{1854}{400}\right] + 2 \\ &= 3 + 20 + 6 + 1854 + 463 - 18 + 4 + 2 \\ &= 2334 \end{aligned}$$

$$\begin{aligned} s \div 7 &= 2334 \div 7 \\ &= 333 \text{ R3} \end{aligned}$$

Since the remainder is 3, the day of the week was Tuesday.

Solve.

1. See if the formula works for today's date.

2. On what day of the week were you born?

3. What will be the day of the week on April 13, 2006?

4. On what day of the week was July 4, 1776?

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School-to-Workplace

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Submersibles (Diving Technician)

As a diver descends into the murky ocean depths, pressure increases. Thus, there is a point beyond which human beings in diving gear cannot descend. Diving technicians help overcome the problem of extreme pressure.

Some diving technicians work in scientific projects or salvage operations. They help develop, build, and outfit *submersibles*, small submarines that are controlled by technicians aboard ship. These technicians then guide a submersible by viewing the ocean depths on video screens.

The table at the right lists some ocean and sea depths in feet.

Region	Depth
Bering Sea	4893
Sea of Japan	5468
Hudson Bay	305
Black Sea	3906
Gulf of California	2375

If a submersible is guided to a depth of 2000 feet in the Gulf of California, then guided 275 feet farther down, and finally guided 525 feet upwards, at what depth is the submersible?

Find the sum $-2000 - 275 + 525$.

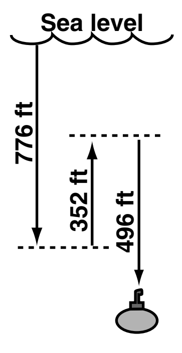
$$-2000 - 275 + 525 = (-2000 - 275) + 525$$
$$= -2275 + 525$$
$$= -1750$$

The submersible is now 1750 feet below sea level.

Solve.

1. Divers use the *fathom* as well as the foot as a unit of measurement. One fathom is equivalent to six feet. Suppose that researchers lower a submersible into the Black Sea. During the research operation, the submersible explores the ocean at a depth of 450 fathoms. It is then raised 182 fathoms for further exploration. At what depth is the submersible now?

2. The diagram at the right shows the progress of one submersible. At what depth is the submersible in the third stage of its exploration?



3. If a submersible descends to a depth of 180 feet in Hudson Bay, can it descend another 80 feet? Explain.