## TEXAS

## ALGEBRA



# STUDENT TEXT and HOMEWORK HELPER 

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## PEARSON

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## TEXAS ESSENTIAL KNOWLEDGE AND SKILLS (TEKS) FOCUS

(5)(A) Solve linear equations in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides.
(5)(B) Solve linear inequalities in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides.
(12)(E) Solve mathematic and scientific formulas, and other literal equations, for a specified variable.

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## TEXAS ESSENTIAL KNOWLEDGE AND SKILLS (TEKS) FOCUS

(2)(C) Write linear equations in two variables given a table of values, a graph, and a verbal description.
(3)(C) Graph linear functions on the coordinate plane and identify key features, including $x$-intercept, $y$-intercept, zeros, and slope, in mathematical and real-world problems.
(5)(A) Solve linear equations in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides.
(12)(A) Decide whether relations represented verbally, tabularly, graphically, and symbolically define a function.
(12)(B) Evaluate functions, expressed in function notation, given one or more elements in their domains.

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## TEXAS ESSENTIAL KNOWLEDGE AND SKILLS (TEKS) FOCUS

(2)(B) Write linear equations in two variables in various forms, including $y=m x+b, A x+B y=C$, and $y-y_{1}=m\left(x-x_{1}\right)$, given one point and the slope and given two points.
(2)(C) Write linear equations in two variables given a table of values, a graph, and a verbal description.
(2)(D) Write and solve equations involving direct variation.
(2)(E) Write the equation of a line that contains a given point and is parallel to a given line.
(2)(F) Write the equation of a line that contains a given point and is perpendicular to a given line.
(2)(G) Write an equation of a line that is parallel or perpendicular to the $x$ - or $y$-axis and determine whether the slope of the line is zero or undefined.
(3)(A) Determine the slope of a line given a table of values, a graph, two points on the line, and an equation written in various forms, including $y=m x+b, A x+B y=C$, and $y-y_{1}=m\left(x-x_{1}\right)$.
(3)(B) Calculate the rate of change of a linear function represented tabularly, graphically, or algebraically in context of mathematical and real-world problems.
(3)(C) Graph linear functions on the coordinate plane and identify key features, including $x$-intercept, $y$-intercept, zeros, and slope, in mathematical and real-world problems.
(3)(E) Determine the effects on the graph of the parent function $f(x)=x$ when $f(x)$ is replaced by $a f(x), f(x)+d, f(x-c), f(b x)$ for specific values of $a, b, c$, and $d$.
(4)(C) Write, with and without technology, linear functions that provide a reasonable fit to data to estimate solutions and make predictions for real-world problems.
(12)(B) Evaluate functions, expressed in function notation, given one or more elements in their domains.
(12)(E) Solve mathematic and scientific formulas, and other literal equations, for a specified variable.

## TOPIC 4 Systems of Equations and Inequalities


#### Abstract

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## TEXAS ESSENTIAL KNOWLEDGE AND SKILLS (TEKS) FOCUS

(2)(H) Write linear inequalities in two variables given a table of values, a graph, and a verbal description.
(2)(I) Write systems of two linear equations given a table of values, a graph, and a verbal description.
(3)(D) Graph the solution set of linear inequalities in two variables on the coordinate plane.
(3)(F) Graph systems of two linear equations in two variables on the coordinate plane and determine the solutions if they exist.
(3)(G) Estimate graphically the solutions to systems of two linear equations with two variables in real-world problems.
(3)(H) Graph the solution set of systems of two linear inequalities in two variables on the coordinate plane.
(5)(C) Solve systems of two linear equations with two variables for mathematical and real-world problems.

## $t$

## TOPIC OVERVIEW

1-1 Solving Multi-Step Equations
1-2 Solving Equations With Variables on Both Sides
1-3 Literal Equations
1-4 Solving Proportions
1-5 Proportions and Similar Figures
1-6 Solving Multi-Step Inequalities
1-7 Compound Inequalities

## VOCABULARY

English/Spanish Vocabulary Audio Online:
English
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cross products, p. 22
formula, p. 17
identity, p. 11
literal equation, p. 17
proportion, p. 22
rate, p. 22
ratio, p. 22
scale, p. 27
scale drawing, p. 27
scale model, $p .27$
similar figures, p. 27

## Spanish

desigualdad compuesta
productos cruzados
fórmula
identidad
ecuación literal proporción
tasa
razón
escala
dibujo a escala
modelo de escala
figuras semejantes

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These interactive math tools give you opportunities to explore in greater depth key concepts to help build understanding.

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Not sure how to do some of the practice exercises? Check out the Virtual Nerd videos for stepped-out, multi-level instructional support.

## TEKS FOCUS

TEKS (5)(A) Solve linear equations in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides.

TEKS (1)(A) Apply mathematics to problems arising in everyday life, society, and the workplace.

## Additional TEKS (1)(F)

## VOCABULARY

- Apply - use knowledge or information for a specific purpose, such as solving a problem


## ESSENTIAL UNDERSTANDING

To solve multi-step equations, you form a series of simpler equivalent equations.
To do this, use the properties of equality, inverse operations, and properties of real numbers. You use the properties until you isolate the variable.

## Problem 1

## Think

How is this equation different from equations you've seen before?
The variable occurs in two terms. You can simplify the equation by grouping like terms and combining them.

## Combining Like Terms

What is the solution of $5=5 m-23+2 m$ ?

$$
\begin{aligned}
5 & =5 m-23+2 m & & \\
5 & =5 m+2 m-23 & & \text { Commutative Property of Addition } \\
5 & =7 m-23 & & \text { Combine like terms. } \\
5+23 & =7 m-23+23 & & \text { Add } 23 \text { to each side. } \\
28 & =7 m & & \text { Simplify. } \\
\frac{28}{7} & =\frac{7 m}{7} & & \text { Divide each side by } 7 . \\
4 & =m & & \text { Simplify. }
\end{aligned}
$$

Check $5=5 m-23+2 m$

$$
5 \stackrel{?}{=} 5(4)-23+2(4)
$$

$$
5=5 \quad \downarrow
$$

Substitute 4 for $m$.
Simplify. The solution checks.

## Solving a Multi-Step Equation

Concert Merchandise Martha takes her niece and nephew to a concert. She buys T-shirts and bumper stickers for them. Martha's niece wants 1 shirt and 4 bumper stickers, and her nephew wants 2 shirts but no bumper stickers. If Martha's total is $\$ 67$, what is the cost of one shirt?


## Think

How can a model help you write the equation?
The model shows that the cost of the niece's items plus the cost of the nephew's items is $\$ 67$.


One shirt costs $\$ 21$.

## Solving an Equation Using the Distributive Property

How can you make the equation easier to solve?
Remove the grouping symbols by using the Distributive Property.

What is the solution of $-8(2 x-1)=36$ ?

$$
\begin{aligned}
-8(2 x-1) & =36 & & \\
-16 x+8 & =36 & & \text { Distributive Property } \\
-16 x+8-8 & =36-8 & & \text { Subtract } 8 \text { from each side. } \\
-16 x & =28 & & \text { Simplify. } \\
\frac{-16 x}{-16} & =\frac{28}{-16} & & \text { Divide each side by }-16 . \\
x & =-\frac{7}{4} & & \text { Simplify. }
\end{aligned}
$$

## Plan

How do you get started?
You can either combine like terms by writing the fractions with a common denominator, or you can clear the fractions from the equation.

## Solving an Equation That Contains Fractions

What is the solution of $\frac{3 x}{4}-\frac{x}{3}=10$ ?
Method 1 Write the like terms using a common denominator and solve.

$$
\begin{aligned}
\frac{3}{4} x-\frac{1}{3} x & =10 & & \text { Rewrite the fractions. } \\
\frac{9}{12} x-\frac{4}{12} x & =10 & & \text { Write the fractions using a common denominator, } 12 . \\
\frac{5}{12} x & =10 & & \text { Combine like terms. } \\
\frac{12}{5}\left(\frac{5}{12} x\right) & =\frac{12}{5}(10) & & \text { Multiply each side by } \frac{12}{5}, \text { the reciprocal of } \frac{5}{12} . \\
x & =24 & & \text { Simplify. }
\end{aligned}
$$

Method 2 Clear the fractions from the equation.

$$
\begin{aligned}
12\left(\frac{3 x}{4}-\frac{x}{3}\right) & =12(10) & & \text { Multiply each side by a common denominator, } 12 . \\
12\left(\frac{3 x}{4}\right)-12\left(\frac{x}{3}\right) & =12(10) & & \text { Distributive Property } \\
9 x-4 x & =120 & & \text { Multiply. } \\
5 x & =120 & & \text { Combine like terms. } \\
x & =24 & & \text { Divide each side by } 5 \text { and simplify. }
\end{aligned}
$$

## Problem 5

## Solving an Equation That Contains Decimals

What is the solution of $5.8-0.32 x=-1.48$ ?

The equation contains tenths (5.8) and hundredths ( 0.32 and -1.48 ). The greatest number of digits to the right of any decimal point is 2 . So, multiply each side of the equation by $10^{2}$, or 100 , using the Distributive Property to clear the decimals.

When you multiply a decimal by $10^{n}$, where $n$ is a positive integer, you can move the decimal point $n$ places to the right. For example, $100(5.8)=580$.

$$
\begin{aligned}
& 5.8-0.32 x=-1.48 \\
& 100(5.8-0.32 x)=100(-1.48) \quad \text { Multiply each side by } 10^{2} \text {, or } 100 \text {. } \\
& 580-32 x=-148 \quad \text { Distributive Property } \\
& 580-32 x-580=-148-580 \quad \text { Subtract } 580 \text { from each side. } \\
& -32 x=-728 \quad \text { Simplify. } \\
& \frac{-32 x}{-32}=\frac{-728}{-32} \quad \text { Divide each side by }-32 . \\
& x=22.75 \quad \text { Simplify. } \\
& \text { Check } \\
& 5.8-0.32 x=-1.48 \\
& 5.8-0.32(22.75) \stackrel{?}{=}-1.48 \\
& -1.48=-1.48 \quad \text { Use a calculator to simplify. The solution checks. }
\end{aligned}
$$



For additional support when completing your homework, go to PearsonTEXAS.com.

Solve each equation. Check your answer.

1. $6 p-2-3 p=16$
2. $x+2+x=22$
3. $b-9+6 b=30$
4. $9 t-6-6 t=6$
5. $17=p-3-3 p$
6. $-23=-2 a-10+a$

## Apply Mathematics (1)(A) Write an equation to model each situation.

Then solve the equation.
7. You have a part-time job. You work for 3 h on Friday and 6 h on Saturday. You also receive an allowance of $\$ 20$ per week. You earn $\$ 92$ per week. How much do you earn per hour at your part-time job?
8. A family buys airline tickets online. Each ticket costs $\$ 167$. The family buys travel insurance with each ticket that costs $\$ 19$ per ticket. The Web site charges a fee of $\$ 16$ for the entire purchase. The family is charged a total of $\$ 1132$. How many tickets did the family buy?
Solve each equation. Check your answer.
9. $2(8+4 c)=32$
10. $7(a-1)=45$
11. $15=-2(2 t-1)$
12. $26=6(5-4 w)$
13. $n+5(n-1)=7$
14. $-4(r+6)=-63$

Solve each equation. Choose the method you prefer to use. Check your answer.
15. $\frac{2}{3}+\frac{3 m}{5}=\frac{31}{15}$
16. $\frac{n}{2}-\frac{2 n}{16}=\frac{3}{8}$
17. $\frac{b}{3}+\frac{1}{8}=19$
18. $\frac{1}{4}+\frac{4 x}{5}=\frac{11}{20}$
19. $\frac{11 z}{16}+\frac{7 z}{8}=\frac{5}{16}$
20. $\frac{x}{3}-\frac{7 x}{12}=\frac{2}{3}$
21. Apply Mathematics (1)(A) Jillian and Tyson are shopping for knitting supplies. Jillian wants 3 balls of yarn and 1 set of knitting needles. Tyson wants 1 ball of yarn and 2 sets of knitting needles. Each ball of yarn costs $\$ 6.25$. If their total cost is $\$ 34.60$, what is the cost of 1 set of knitting needles?
22. Create Representations to Communicate Mathematical Ideas (1)(E) Angie and Kenny play online video games. Angie buys 1 software package and 3 months of game play. Kenny buys 1 software package and 2 months of game play. Each software package costs $\$ 20$. If their total cost is $\$ 115$, what is the cost of one month of game play?
23. Describe and correct the error in solving the equation at the right.
24. Explain Mathematical Ideas (1)(G) Suppose you want to solve $-4 m+5+6 m=-3$. What would you do as your first step? Explain.
25. Explain Mathematical Ideas (1)(G) Describe two ways in which you can solve $-\frac{1}{2}(5 x-9)=17$.
26. Apply Mathematics (1)(A) Three friends go bowling. The cost per person per game is $\$ 5.30$. The cost to rent shoes is $\$ 2.50$ per person. Their total cost is $\$ 55.20$. How many games did they play?

Solve each equation. Check your answer.
27. $1.025 v+2.458=7.583$
28. $1.12+1.25 g=8.62$
29. $25.24=5 g+3.89$
30. $0.25 n+0.1 n=9.8$

## Solve each equation.

31. $0.25(d-12)=4$
32. $8 n-(2 n-3)=12$
33. $\frac{2}{3}+n+6=\frac{3}{4}$
34. $0.5 d-3 d+5=0$
35. $-(w+5)=-14$
36. $\frac{a}{20}+\frac{4}{15}=\frac{9}{15}$
37. Apply Mathematics (1)(A) A college student is moving into a campus dormitory. The student rents a moving truck for $\$ 19.95$ plus $\$ .99$ per mile. Before returning the truck, the student fills the tank with gasoline, which costs $\$ 65.32$. The total cost is $\$ 144.67$. How many miles did the student drive the truck?

Find the value of $x$. (Hint: The sum of the angle measures of a quadrilateral is $360^{\circ}$.)
38.

39. $(4 x-4)^{\circ}$

40.

41. Apply Mathematics (1)(A) You are ordering a meal and have $\$ 15$ to spend. The restaurant charges $6 \%$ sales tax. You plan to leave a $15 \%$ tip. The equation $c=x+0.06 x+0.15 x$ gives the total cost $c$ of your meal, where $x$ is the cost before tax and tip. What is the maximum amount you can spend before tax and tip?
42. Apply Mathematics (1)(A) You have $\$ 83$ in your bank account. Each week you plan to deposit $\$ 8$ from your allowance and $\$ 15$ from your paycheck. The equation $b=83+(15+8) w$ gives the amount $b$ in your bank account after $w$ weeks. How many weeks from now will you have $\$ 175$ in your bank account?
43. Find three consecutive integers with a sum of 45 . Show your work.
44. Use a Problem-Solving Model (1)(B) A cook buys two identical bags of rice and uses some of the rice in each bag so that one bag is half full and the other is one-third full. The cook combines them into one bag, which then contains $3 \frac{1}{3}$ cups of rice. How much rice was in a full bag?
45. Apply Mathematics (1)(A) Tim can paint a house in 6 days. Tara can paint the same house in 3 days.
a. What fraction of the house can Tim paint in one day? What fraction of the house can Tara paint in one day?
b. What fraction of the house can Tim paint in $d$ days? What fraction of the house can Tara paint in $d$ days?
c. What fraction of the house can Tim and Tara together paint in one day? What fraction of the house can Tim and Tara together paint in $d$ days?
d. Write and solve an equation to find the number of days it will take Tim and Tara to paint the whole house working together.

## TEXAS End-of-Course PRACTICE

46. When a number is increased by 3 and that number is doubled, the result is -8 . What was the original number?
A. -14
B. -7
C. -5.5
D. -1
47. What is the value of the expression $-3 r+6+r$ when $r=-2$ ?
F. -2
G. 0
H. 10
J. 12
48. Roy's car gets an average gas mileage of $29 \mathrm{mi} / \mathrm{gal}$. Roy starts his trip with the amount of gas shown. About how many gallons of gas are left at the end of his trip?
A. 6 gal
B. 7 gal
C. 8 gal
D. 9 gal

## USE WITH LESSON 1-2

```
TEKS (5)(A), (1)(E)
```

Algebra tiles can help you understand how to solve equations with variables on both sides.

## Activity

Model and solve $3 b-4=b+2$.

$$
b=3
$$



Notice that two green tiles equal six yellow tiles. You can divide the tiles on each side of the equation into two identical groups, as shown.
So, one green tile equals three yellow tiles. The solution of $3 b-4=b+2$ is $b=3$. You can substitute 3 for $b$ to check.

## Exercises

Write the equation modeled by the algebra tiles.
1.

2.


Use algebra tiles to model and solve each equation.
3. $3 x-5=x+3$
4. $6 x-4=3 x+2$
5. $5 x-3=3 x+1$
6. $4 x+4=1+x$

## TEKS FOCUS

TEKS (5)(A) Solve linear equations in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides

TEKS (1)(F) Analyze mathematical relationships to connect and communicate mathematical ideas.

Additional TEKS (1)(A), (1)(C)

## VOCABULARY

- Identity - An identity is an equation that is true for every possible value of the variable. For example, $x+1=x+1$ is an identity.
- Analyze - examine closely objects, ideas, or relationships to learn more about their nature


## ESSENTIAL UNDERSTANDING

To solve equations with variables on both sides, you can use the properties of equality and inverse operations to write a series of simpler equivalent equations.

## Concept Summary Solving Equations

Step 1 Use the Distributive Property to remove any grouping symbols. Use properties of equality to clear decimals and fractions.

Step 2 Combine like terms on each side of the equation.
Step 3 Use the properties of equality to get the variable terms on one side of the equation and the constants on the other.

Step 4 Use the properties of equality to solve for the variable.
Step 5 Check your solution in the original equation.

## *) Problem 1

## Solving an Equation With Variables on Both Sides

## Plan

How do you get started?
There are variable terms on both sides of the equation. Decide which variable term to add or subtract to get the variable on one side only

What is the solution of $5 x+2=2 x+14$ ?

$$
\begin{aligned}
5 x+2 & =2 x+14 & & \\
5 x+2-2 x & =2 x+14-2 x & & \text { Subtract } 2 x \text { from each side. } \\
3 x+2 & =14 & & \text { Simplify. } \\
3 x+2-2 & =14-2 & & \text { Subtract } 2 \text { from each side. } \\
3 x & =12 & & \text { Simplify. } \\
\frac{3 x}{3} & =\frac{12}{3} & & \text { Divide each side by } 3 . \\
x & =4 & & \text { Simplify. }
\end{aligned}
$$

## Problem 1

 continuedCheck $\quad 5 x+2=2 x+14$

$$
\begin{aligned}
5(4)+2 & \stackrel{?}{=} 2(4)+14 & & \text { Substitute } 4 \text { for } x . \\
22 & =22 \boldsymbol{V} & & \text { Simplify. The solution checks. }
\end{aligned}
$$

## Problem 2

Think
Why would you use a calculator to solve this equation? Mental math is difficult to use to simplify the operations with these numbers.

## Think

How can a model help you write the equation?
The model shows that the current design time is equal to the new design time plus the 8 h needed to learn the new software.

| $1.5 p$ |  |
| :---: | :---: |
| $1.25 p$ | 8 |

## Solving an Equation Using Technology

What is the solution of $3.1 x+9.2=2.06-1.15 x$ ?

$$
\begin{aligned}
3.1 x+9.2 & =2.06-1.15 x & & \\
3.1 x+9.2+1.15 x & =2.06-1.15 x+1.15 x & & \text { Add } 1.15 x \text { to each side. } \\
4.25 x+9.2 & =2.06 & & \text { Use a calculator to simplify. } \\
4.25 x+9.2-9.2 & =2.06-9.2 & & \text { Subtract } 9.2 \text { from each side. } \\
4.25 x & =-7.14 & & \text { Use a calculator to simplify. } \\
\frac{4.25 x}{4.25} & =\frac{-7.14}{4.25} & & \text { Divide each side by } 4.25 . \\
x & =-1.68 & & \text { Use a calculator to simplify. } \\
3.1 x+9.2 & =2.06-1.15 x & & \\
3.1(-1.68)+9.2 & \stackrel{?}{=} 2.06-1.15(-1.68) & & \text { Substitute }-1.68 \text { for } x . \\
3.992 & =3.992 \checkmark & & \text { Use a calculator to simplify. }
\end{aligned}
$$

Check

## Problem 3

## Using an Equation With Variables on Both Sides

Graphic Design It takes a graphic designer 1.5 h to make one page of a Web site.
Using new software, the designer could complete each page in 1.25 h , but it takes 8 h to learn the software. How many Web pages would the designer have to make in order to save time using the new software?

Know

- Current design time: 1.5 h per page
- Time with new software: 1.25 h per page
- Time to learn software: 8 h


## Need

The number of pages the designer needs to make for the new software to save time.

Relate \begin{tabular}{c}
current <br>
design time

$=\underset{\text { new software }}{\text { design time with }}+$

time to learn <br>
software
\end{tabular}

Define Let $p=$ the number of pages the designer needs to make.
Write
$1.5 p \quad 1.25 p \quad+\quad 8$

Plan
Write and solve an equation that models the situation.

Problem 3 continued

$$
\begin{aligned}
1.5 p & =1.25 p+8 & & \\
1.5 p-1.25 p & =1.25 p+8-1.25 p & & \text { Subtract } 1.25 p \text { from each side. } \\
0.25 p & =8 & & \text { Simplify. } \\
\frac{0.25 p}{0.25} & =\frac{8}{0.25} & & \text { Divide each side by } 0.25 . \\
p & =32 & & \text { Simplify. }
\end{aligned}
$$

It will take the designer the same amount of time to make 32 Web pages using either software. The designer must make 33 pages or more in order to save time using the new software.

## Problem 4

## Solving an Equation With Grouping Symbols

## Plan

## How do you get

 started?There are parentheses on both sides of the equation. So, remove the parentheses using the Distributive Property.

What is the solution of $2(5 x-1)=3(x+11)$ ?

$$
\begin{aligned}
2(5 x-1) & =3(x+11) \\
10 x-2 & =3 x+33 \\
10 x-2-3 x & =3 x+33-3 x \\
7 x-2 & =33 \\
7 x-2+2 & =33+2 \\
7 x & =35 \\
\frac{7 x}{7} & =\frac{35}{7} \\
x & =5
\end{aligned}
$$

## Think

How can you tell how many solutions an equation has? If you eliminate the variable in the process of solving, the equation is either an identity with infinitely many solutions or an equation with no solution.

## Identities and Equations With No Solution

## What is the solution of each equation?

(A) $10 x+12=2(5 x+6)$
$10 x+12=2(5 x+6)$
$10 x+12=10 x+12$
Distributive Property
There are infinitely many solutions to the equation. The original equation is an identity.
B $9 m-4=-3 m+5+12 m$

$$
\begin{aligned}
9 m-4 & =-3 m+5+12 m & & \\
9 m-4 & =9 m+5 & & \text { Combine like terms. } \\
9 m-4-9 m & =9 m+5-9 m & & \text { Subtract } 9 m \text { from each side. } \\
-4 & =5 \mathbf{x} & & \text { Simplify. }
\end{aligned}
$$

Because $-4 \neq 5$, the original equation has no solution.

For additional support when completing your homework, go to PearsonTEXAS.com.

## Solve each equation. Check your answer.

1. $5 x-1=x+15$
2. $4 p+2=3 p-7$
3. $6 m-2=2 m+6$
4. $3+5 q=9+4 q$
5. $8-2 y=3 y-2$
6. $3 n-5=7 n+11$
7. Use a Probelm-Solving Model (1)(B) Samir and Vinita both have cellphones. Samir pays $\$ 75.89$ per month plus $\$ 0.12$ per text message to use his cellphone. Vinita pays $\$ 27.41$ per month plus $\$ 0.36$ per text message to use her cellphone. One month, they paid the same amount for cellphone service. How many text messages did each send?

## Apply Mathematics (1)(A) Write and solve an equation for each situation.

## Check your solution.

8. An architect is designing a rectangular greenhouse. Along one wall is a 7 - ft storage area and 5 sections for different kinds of plants. On the opposite wall is a 4 -ft storage area and 6 sections for plants. All of the sections for plants are of equal length. What is the length of each wall?

9. A hairdresser is deciding where to open her own studio. If the hairdresser chooses Location A, she will pay $\$ 1200$ per month in rent and will charge $\$ 45$ per haircut. If she chooses Location B, she will pay $\$ 1800$ per month in rent and will charge $\$ 60$ per haircut. How many haircuts would she have to give in one month to make the same profit at either location?

## Solve each equation. Check your answer.

10. $14.4 y-17.998=5.6 y+23.89$
11. $-5.99+24.105 x=-587.72 x-54.936$
12. $3(q-5)=2(q+5)$
13. $8-(3+b)=b-9$
14. $2 r-(5-r)=13+2 r$
15. $5 g+4(-5+3 g)=1-g$

Determine whether each equation is an identity or whether it has no solution.
16. $2(a-4)=4 a-(2 a+4)$
17. $5 y+2=\frac{1}{2}(10 y+4)$
18. $-6 a+3=-3(2 a-1)$
19. $4-d=-(d-4)$
20. Use a Problem-Solving Model (1)(B) Each morning, a deli worker has to make several pies and peel a bucket of potatoes. On Monday, it took the worker 2 h to make the pies and an average of 1.5 min to peel each potato. On Tuesday, the worker finished the work in the same amount of time, but it took 2.5 h to make the pies and an average of 1 min to peel each potato. About how many potatoes are in a bucket?
21. Apply Mathematics (1)(A) Suppose a family drives at an average rate of $60 \mathrm{mi} / \mathrm{h}$ on the way to visit relatives and then at an average rate of $40 \mathrm{mi} / \mathrm{h}$ on the way back. The return trip takes 1 h longer than the trip there.
a. Let $d$ be the distance in miles the family traveled to visit their relatives. How many hours did it take to drive there?
b. In terms of $d$, how many hours did it take to make the return trip?
c. Write and solve an equation to determine the distance the family drove to see their relatives. What was the average rate for the entire trip?
22. Analyze Mathematical Relationships (1)(F) Describe and correct the error in finding the solution of the equation $2 x=6 x$.
23. Justify Mathematical Arguments (1)(G) A skier is trying to decide whether or not to buy a season ski pass. A daily pass costs $\$ 67$. A season ski pass costs $\$ 350$. The skier
 would have to rent skis with either pass for $\$ 25$ per day. How many days would the skier have to go skiing in order to make the season pass less expensive than daily passes?
Solve each equation. If the equation is an identity, write identity. If it has no solution, write no solution.
24. $3.2-4 d=2.3 d+3$
25. $3 d+4=2+3 d-\frac{1}{2}$
26. $2.25(4 x-4)=-2+10 x+12$
27. $3 a+1=-3.6(a-1)$
28. $\frac{1}{2} h+\frac{1}{3}(h-6)=\frac{5}{6} h+2$
29. $0.5 b+4=2(b+2)$
30. $-2(-c-12)=-2 c-12$
31. $3(m+1.5)=1.5(2 m+3)$
32. Apply Mathematics (1)(A) One health club charges a $\$ 50$ sign-up fee and $\$ 65$ per month. Another club charges a $\$ 90$ sign-up fee and $\$ 45$ per month. For what number of months is the cost of the clubs equal?
33. The perimeters of the triangles shown are equal. Find the side lengths of each triangle.

34. Apply Mathematics (1)(A) A small juice company spends $\$ 1200$ per day on business expenses plus $\$ 1.10$ per bottle of juice they make. They charge $\$ 2.50$ for each bottle of juice they produce. How many bottles of juice must the company sell in one day in order to equal its daily costs?
35. Select Tools to Solve Problems (1)(C) You set up a spreadsheet to solve $7(x+1)=3(x-1)$.
a. Does your spreadsheet show the solution of the equation?
b. Between which two values of $x$ is the solution of the equation? How do you know?
c. For what spreadsheet values of $x$ is $7(x+1)$ less than $3(x-1)$ ?
36. Analyze Mathematical Relationships (1)(F)

|  | A | B | C |
| :---: | :---: | :---: | :---: |
| 1 | $x$ | $7(x+1)$ | $3(x-1)$ |
| 2 | -5 | -28 | -18 |
| 3 | -3 | -14 | -12 |
| 4 | -1 | 0 | -6 |
| 5 | 1 | 14 | 0 |
| 6 | 3 | 28 | 6 |

Determine whether each statement is always, sometimes, or never true.
a. An equation of the form $a x+1=a x$ has no solution.
b. An equation in one variable has at least one solution.
c. An equation of the form $\frac{x}{a}=\frac{x}{b}$ has infinitely many solutions.

Use Representations to Communicate Mathematical Ideas (1)(E) Write an equation with a variable on both sides such that you get each solution.
37. $x=5$
38. $x=0$
39. $x$ can be any number.
40. No values of $x$ are solutions.
41. $x$ is a negative number.
42. $x$ is a fraction.
43. Suppose you have three consecutive integers. The greatest of the three integers is twice as great as the sum of the first two. What are the integers?

## TEXAS End-of-Course PRACTICE

44. What is the solution of $-2(3 x-4)=-2 x+2$ ?
A. $-\frac{2}{3}$
B. $\frac{3}{2}$
C. 2
D. 24
45. Two times a number plus three equals one half of the number plus 12 . What is the number?
F. 3.6
G. 6
H. 8
J. 10
46. Josie's goal is to run 30 mi each week. This week she has already run the distances shown in the table. She wants to have one day of rest and to spread out the remaining miles evenly over the rest of the week. Which equation can she use to
 find how many miles $m$ per day she must run?
A. $4+4.5+3.5+3 m=30$
B. $4+4.5+3.5+4 m=30$
C. $30-(4+4.5+3.5)=m$
D. $4+4.5+3.5+m=30$

## TEKS FOCUS

TEKS (12)(E) Solve mathematic and scientific formulas, and other literal equations, for a specified variable.

TEKS (1)(A) Apply mathematics to problems arising in everyday life, society, and the workplace.

Additional TEKS (1)(E)

## VOCABULARY

- Literal equation - A literal equation is an equation that involves two or more variables.
- Formula - A formula is an equation that states a relationship among quantities. Formulas are special types of literal equations.
- Apply - use knowledge or information for a specific purpose, such as solving a problem


## ESSENTIAL UNDERSTANDING

When you work with literal equations, you can use the methods you have learned in this topic to isolate any particular variable.

| E note Summa | Formulas |  |
| :---: | :---: | :---: |
| Formula Name | Formula | Definitions of Variables |
| Perimeter of a rectangle Circumference of a circle | $p=2 \ell+2 w$ | $P=$ perimeter, $\ell=$ length, $w=$ width |
|  | $C=2 \pi r$ | $C=$ circumference, $r=$ radius |
|  | $C=\pi d$ | $C=$ circumference, $d=$ diameter |
| Area of a rectangle | $A=\ell w$ | $A=$ area, $\ell=$ length, $w=$ width |
| Area of a triangle | $A=\frac{1}{2} b h$ | $A=$ area, $b=$ base, $h=$ height |
| Area of a circle | $A=\pi r^{2}$ | $A=$ area, $r=$ radius |
| Distance traveled | $d=r t$ | $d=$ distance, $r=$ rate, $t=$ time |
| Temperature | $C=\frac{5}{9}(F-32)$ | $C=$ degrees Celsius, $F=$ degrees Fahrenheit |

## Think

Why should you rewrite the equation? If you rewrite the equation, you have to isolate $y$ only once. Then substitute for $x$. If you substitute for $x$ first, you must isolate $y$ twice (once for each $x$-value).

## Rewriting a Literal Equation

The equation $10 x+5 y=80$, where $x$ is the number of pizzas and $y$ is the number of sandwiches, models the problem in the Solve It. How many sandwiches can you buy if you buy 3 pizzas? 6 pizzas?

Step 1 Solve the equation $10 x+5 y=80$ for $y$.

$$
\begin{aligned}
10 x+5 y & =80 & & \\
10 x+5 y-10 x & =80-10 x & & \text { Subtract } 10 x \text { from each side. } \\
5 y & =80-10 x & & \text { Simplify. } \\
\frac{5 y}{5} & =\frac{80-10 x}{5} & & \text { Divide each side by } 5 . \\
y & =16-2 x & & \text { Simplify. }
\end{aligned}
$$

Step 2 Use the rewritten equation to find $y$ when $x=3$ and when $x=6$.

$$
\begin{array}{lll}
y=16-2 x & & y=16-2 x \\
y=16-2(3) & \text { Substitute for } x . & y=16-2(6) \\
y=10 & \text { Simplify. } & y=4
\end{array}
$$

If you buy 3 pizzas, you can buy 10 sandwiches. If you buy 6 pizzas, you can buy 4 sandwiches.

## Problem 2

## Think

How can you solve a literal equation for a variable?
When a literal equation contains only variables, treat the variables you are not solving for as constants.

## Rewriting a Literal Equation With Only Variables

What equation do you get when you solve $a x-b x=c$ for $x$ ?

$$
\begin{aligned}
a x-b x & =c & & \\
x(a-b) & =c & & \text { Distributive Property } \\
\frac{x(a-b)}{a-b} & =\frac{c}{a-b} & & \text { Divide each side by } a-b, \text { where } a-b \neq 0 . \\
x & =\frac{c}{a-b} & & \text { Simplify. }
\end{aligned}
$$

## Rewriting a Geometric Formula

## Plan

Choose an appropriate formula and solve it for the variable you need to find. Substitute what you know into the rewritten formula. Use a calculator to simplify. Use 3.14 for $\pi$.

What is the radius of a circle with circumference 64 ft ? Round to the nearest tenth. Use 3.14 for $\pi$.

| $C$ | $=2 \pi r$ |  | Write the appropriate formula. |
| ---: | :--- | ---: | :--- |
| $\frac{C}{2 \pi}$ | $=\frac{2 \pi r}{2 \pi}$ |  | Divide each side by $2 \pi$. |
| $\frac{C}{2 \pi}$ | $=r$ |  | Simplify. |
| $\frac{64}{2 \pi}$ | $=r$ |  | Substitute 64 for $C$. |
| 10.2 | $\approx r$ |  | Simplify. Use 3.14 for $\pi$. |

The radius of the circle is about 10.2 ft .

## Problem 4

## Rewriting a Formula STEM

Biology The monarch butterfly is the only butterfly that migrates annually north and south. The distance that a particular group of monarch butterflies travels is shown. It takes a typical butterfly about 120 days to travel one way. What is the average rate at which a butterfly travels in miles per day? Round to the nearest mile per day.

$$
\begin{aligned}
d & =r t & & \text { Write the appropriate formula. } \\
\frac{d}{t} & =\frac{r t}{t} & & \text { Divide each side by } t . \\
\frac{d}{t} & =r & & \text { Simplify. } \\
\frac{1700}{120} & =r & & \text { Substitute } 1700 \text { for } d \text { and } 120 \text { for } t . \\
14 & \approx r & & \text { Simplify. }
\end{aligned}
$$




For additional support when completing your homework, go to PearsonTEXAS.com.

Solve each equation for $y$. Then find the value of $\boldsymbol{y}$ for each value of $\boldsymbol{x}$.

1. $y+2 x=5 ; x=-1,0,3$
2. $2 y+4 x=8 ; x=-2,1,3$
3. $3 x-5 y=9 ; x=-1,0,1$
4. $4 x=3 y-7 ; x=4,5,6$
5. Apply Mathematics (1)(A) A public park is in the shape of a triangle. The side of the park that forms the base of the triangle is 200 yd long, and the area of the park is $7500 \mathrm{yd}^{2}$. What is the length $\ell$ of the side of the park that forms the height of the triangle?


Solve each problem. Round to the nearest tenth, if necessary. Use 3.14 for $\boldsymbol{\pi}$.
6. What is the radius of a circle with circumference 22 m ?
7. What is the length of a rectangle with width 10 in . and area $45 \mathrm{in} .^{2}$ ?
8. A triangle has height 4 ft and area $32 \mathrm{ft}^{2}$. What is the length of its base?
9. A rectangle has perimeter 84 cm and length 35 cm . What is its width?
10. Explain Mathematical Ideas (1)(G) Describe and correct the error made in solving the literal equation at the right for $n$.
11. The formula for the volume of a cylinder is $V=\pi r^{2} h$, where $r$ is the cylinder's radius and $h$ is its height. Solve the equation for $h$. What is the height of a cylinder with volume $502.4 \mathrm{~cm}^{3}$ and radius 4 cm ?
 Use 3.14 for $\pi$.

## Apply Mathematics (1)(A) Solve each problem. Round to the nearest tenth, if necessary.

12. You can use the formula $a=\frac{h}{n}$ to find the batting average $a$ of a batter who has $h$ hits in $n$ times at bat. Solve the formula for $h$. If a batter has a batting average of . 290 and has been at bat 300 times, how many hits does the batter have?
13. Bricklayers use the formula $n=7 \ell h$ to estimate the number $n$ of bricks needed to build a wall of length $\ell$ and height $h$, where $\ell$ and $h$ are in feet. Solve the formula for $h$. Estimate the height of a wall 28 ft long that requires 1568 bricks.

## Solve each equation for the given variable.

14. $2 m-n x=x+4$ for $x$
15. $\frac{x}{a}-1=\frac{y}{b}$ for $x$
16. $a x+2 x y=14$ for $y$
17. $V=\frac{1}{3} \pi r^{2} h$ for $h$
18. $A=\left(\frac{f+g}{2}\right) h$ for $g$
19. $2(x+a)=4 b$ for $a$
20. Apply Mathematics (1)(A) Polar stratospheric clouds are colorful clouds that form when temperatures fall below $-78^{\circ} \mathrm{C}$. What is this temperature in degrees Fahrenheit?
21. Use a Problem-Solving Model (1)(B) The interior angles of a polygon are the angles formed inside a polygon by two adjacent sides. The sum $S$ of the measures of the interior angles of a polygon with $n$ sides can be found using the formula $S=180(n-2)$. The sum of a polygon's interior angle measures is $1260^{\circ}$. How many sides does the polygon have?


Polar stratospheric clouds
22. Apply Mathematics (1)(A) The energy $E$ of a moving object is called its kinetic energy. It is calculated using the formula $E=\frac{1}{2} m v^{2}$, where $m$ is the object's mass in kilograms and $v$ is its speed in meters per second. The units of kinetic energy are $\frac{\text { kilograms } \cdot \text { meters }^{2}}{\text { second }{ }^{2}}$, abbreviated as $\mathrm{kg} \cdot \mathrm{m}^{2} / \mathrm{s}^{2}$.
a. Solve the given formula for $m$.
b. What is the mass of an object moving at $10 \mathrm{~m} / \mathrm{s}$ with a kinetic energy of $2500 \mathrm{~kg} \cdot \mathrm{~m}^{2} / \mathrm{s}^{2}$ ?

## Solve each equation for $x$.

23. $m x+n x=p$
24. $a x-x=c$
25. $\frac{r x+s x}{t}=1$
26. $y=\frac{x-v}{b}$
27. $S=C+x C$
28. $\frac{x}{a}=\frac{y}{b}$
29. $A=B x t+C$
30. $4(x-b)=x$
31. $\frac{x+2}{y-1}=2$
32. Apply Mathematics (1)(A) The density of an object is calculated using the formula $D=\frac{m}{V}$, where $m$ is the object's mass and $V$ is its volume. Gold has a density of $19.3 \mathrm{~g} / \mathrm{cm}^{3}$. What is the volume of an amount of gold that has a mass of 96.5 g ?
33. Use Multiple Representations to Communicate Mathematical Ideas (1)(D) Write an equation in three variables. Solve the equation for each variable. Show your work.
34. A rectangular prism with height $h$ and with square bases with side length $s$ is shown.
a. If $s$ is 10 cm and the surface area $A$ of the prism is $760 \mathrm{~cm}^{2}$, what is the height of the prism?

b. Create Representations to Communicate Mathematical Ideas (1)(E) Suppose $h$ is equal to $s$. Write a formula for $A$ in terms of $s$ only.
35. Suppose a segment on a number line has endpoints with coordinates $a$ and $b$. The coordinate of the segment's midpoint $m$ is given by the formula $m=\frac{a+b}{2}$. The midpoint of a segment is at 3.5 . One endpoint is at 8.9 . Find the other endpoint.

## TEXAS End-of-Course PRACTICE

36. What is the value of the expression $-\frac{3}{4} m+15$ when $m=12$ ?
37. What is the solution of $9 p+6-3 p=45$ ?
38. The formula $F=\frac{n}{4}+37$ relates the number of chirps $n$ a cricket makes in 1 min to the outside temperature $F$ in degrees Fahrenheit. How many chirps can you expect a cricket to make in 1 min when the outside temperature is $60^{\circ} \mathrm{F}$ ?

| $\star$ | $1-4$ | Solving Proportions |
| :---: | :---: | :---: |

## TEKS FOCUS

TEKS (5)(A) Solve linear equations in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides.

TEKS (1)(F) Analyze mathematical relationships to connect and communicate mathematical ideas.

Additional TEKS (1)(A)

## VOCABULARY

- Cross products - In the proportion $\frac{a}{b}=\frac{c}{d}$, the products $a d$ and $b c$ are called cross products.
- Proportion - A proportion is an equation that states that two ratios are equal. For example, $\frac{a}{b}=\frac{c}{d}$, where $b \neq 0$ and $d \neq 0$ is a proportion.
- Rate - A rate is a ratio of a to $b$ where $a$ and $b$ represent quantities measured in different units.
- Ratio - A ratio is the comparison of two quantities by division.
- Analyze - examine closely objects, ideas, or relationships to learn more about their nature


## ESSENTIAL UNDERSTANDING

If two ratios are equal and a quantity in one of the ratios is unknown, you can write and solve a proportion to find the unknown quantity.

## Property Cross Products Property of a Proportion

Words The cross products of a proportion are equal.
Algebra If $\frac{a}{b}=\frac{c}{d}$, where $b \neq 0$ and $d \neq 0$, then $a d=b c$.
Example $\frac{3}{4}=\frac{9}{12}$, so $3(12)=4(9)$, or $36=36$.

You can use the Multiplication Property of Equality to prove the Cross
Products Property.

$$
\begin{aligned}
\frac{a}{b} & =\frac{c}{d} & & \text { Assume this equation is true. } \\
b d \cdot \frac{a}{b} & =b d \cdot \frac{c}{d} & & \text { Multiplication Property of Equality } \\
b d \cdot \frac{a}{b} & =b d \cdot \frac{c}{d} & & \text { Divide the common factors. } \\
d a & =b c & & \text { Simplify. } \\
a d & =b c & & \text { Commutative Property of Multiplication }
\end{aligned}
$$

For this proportion, $a$ and $d$ are called the extremes of the proportion and $b$ and $c$ are called the means. Notice that in the Cross Products Property the product of the means equals the product of the extremes.

How is this problem related to problems you've solved before? It is similar to solving a one-step equation using multiplication. You can simply multiply by 12 to isolate $m$.

## Solving a Proportion Using the Multiplication Property

What is the solution of the proportion $\frac{7}{8}=\frac{m}{12}$ ?

$$
\begin{aligned}
\frac{7}{8} & =\frac{m}{12} & & \\
12 \cdot \frac{7}{8} & =12 \cdot \frac{m}{12} & & \text { Multiply each side by } 12 . \\
\frac{84}{8} & =m & & \text { Simplify. } \\
10.5 & =m & & \text { Divide. }
\end{aligned}
$$

## Problem 2

Which property should you use? The Cross Products Property can be easier to use when the variable is in the denominator.

## Solving a Proportion Using the Cross Products Property

What is the solution of the proportion $\frac{4}{3}=\frac{8}{x}$ ?

$$
\begin{aligned}
\frac{4}{3} & =\frac{8}{x} & & \\
4 x & =3(8) & & \text { Cross Products Property } \\
4 x & =24 & & \text { Multiply. } \\
x & =6 & & \text { Divide each side by } 4 \text { and simplify. }
\end{aligned}
$$

## Problem 3

How is this proportion different from others you've seen? This proportion looks more complex, but the Cross Products Property is true for any proportion. Treat each numerator as a single variable when you cross-multiply.

## Solving a Multi-Step Proportion

What is the solution of the proportion $\frac{b-8}{5}=\frac{b+3}{4}$ ?

$$
\begin{aligned}
\frac{b-8}{5} & =\frac{b+3}{4} & & \\
4(b-8) & =5(b+3) & & \text { Cross Products Property } \\
4 b-32 & =5 b+15 & & \text { Distributive Property } \\
4 b-32-4 b & =5 b+15-4 b & & \text { Subtract } 4 b \text { from each side. } \\
-32 & =b+15 & & \text { Simplify. } \\
-47 & =b & & \text { Subtract } 15 \text { from each side and simplify. }
\end{aligned}
$$

## Using a Proportion to Solve a Problem

Music A portable media player has 2 gigabytes of storage and can hold about 500 songs. A similar but larger media player has $\mathbf{8 0}$ gigabytes of storage. About how many songs can the larger media player hold?


## Think

Is there only one way to write a proportion? No. You can write other proportions to solve the problem. For example, $\frac{2 \text { gigabytes }}{80 \text { gigabytes }}=\frac{500 \text { songs }}{s \text { songs }}$ also works.

$$
\begin{aligned}
\frac{2 \text { gigabytes }}{500 \text { songs }} & =\frac{80 \text { gigabytes }}{s \text { songs }} & & \text { Write a proportion. } \\
2 s & =500(80) & & \text { Cross Products Property } \\
2 s & =40,000 & & \text { Multiply. } \\
s & =20,000 & & \text { Divide each side by } 2 \text { and simplify. }
\end{aligned}
$$

The larger media player can hold 20,000 songs.

Solve each proportion using the Multiplication Property of Equality.

1. $\frac{q}{8}=\frac{4}{5}$
2. $\frac{-3}{4}=\frac{x}{26}$
3. $\frac{3}{4}=\frac{x}{5}$
4. $\frac{m}{7}=\frac{3}{5}$
5. $\frac{3}{16}=\frac{x}{12}$
6. $\frac{9}{2}=\frac{k}{25}$
7. $\frac{x}{120}=\frac{1}{24}$
8. $\frac{2}{15}=\frac{h}{125}$
9. Use a Problem-Solving Model (1)(B) A gardener is transplanting flowers into a flower bed. She has been working for an hour and has transplanted 14 flowers. She has 35 more flowers to transplant. If she works at the same rate, how many more hours will it take her?
10. Apply Mathematics (1)(A) A florist uses 2 dozen roses to make 5 centerpieces. How many dozens of roses will he need to make 20 centerpieces?
11. Analyze Mathematical Relationships (1)(F) If 5 lb of pasta salad serves 14 people, how much pasta salad should you take to a picnic with 49 people?
12. Apply Mathematics (1)(A) Approximately 3 people out of every 30 are left-handed. About how many left-handed people would you expect in a group of 140 people?
13. Maya runs 100 m in 13.4 s . Amy can run 100 m in 14.1 s . If Amy were to finish a $100-\mathrm{m}$ race at the same time as Maya, how much of a head start, in meters, would Amy need?

## Solve each proportion using the Cross Products Property.

14. $\frac{-9}{b}=\frac{5}{6}$
15. $\frac{8}{p}=\frac{3}{10}$
16. $\frac{-3}{4}=\frac{m}{22}$
17. $\frac{2}{-5}=\frac{6}{t}$

Solve each proportion using any method.
18. $\frac{b+4}{5}=\frac{7}{4}$
19. $\frac{2 c}{11}=\frac{c-3}{4}$
20. $\frac{q+2}{5}=\frac{2 q-11}{7}$
21. $\frac{c+1}{c-2}=\frac{4}{7}$
22. Analyze Mathematical Relationships (1)(F) The electric bill for Ferguson's Furniture is shown at the right. The cost of electricity per kilowatt-hour and the total charges for one month are given. To the nearest tenth, how many kilowatt-hours of electricity did Ferguson's Furniture use in that month?
23. Apply Mathematics (1)(A) A particular computer takes 3 min to download a 45-min TV show. How long will it take
 the computer to download a 2 -hour movie?

## Solve each proportion. Tell whether you used the Multiplication Property of

 Equality or the Cross Products Property for your first step. Explain your choice.24. $\frac{p}{4}=\frac{7}{8}$
25. $\frac{m}{4.5}=\frac{2}{5}$
26. $\frac{1.5}{y}=\frac{2.5}{7}$
27. $\frac{b+13}{2}=\frac{-5 b}{3}$
28. $\frac{3 b}{b-4}=\frac{3}{7}$
29. $\frac{x+2}{2 x-6}=\frac{3}{8}$
30. Explain Mathematical Ideas (1)(G) Describe and correct the error in solving the proportion at the right.
31. Apply Mathematics (1)(A) A bakery sells packages of 10 bagels for $\$ 3.69$. If the bakery starts selling the bagels in packages of 12, how much would you expect a package of 12 to cost?
A. $\$ 3.08$
B. $\$ 4.32$
C. $\$ 4.43$
D. $\$ 4.69$
32. Display Mathematical Ideas (1)(G) Write a proportion that contains a variable. Name the extremes, the means, and the cross products. Solve the proportion. Tell whether you used the Multiplication Property of Equality or the Cross Products Property to solve the proportion. Explain your choice.
33. Apply Mathematics (1)(A) Many trees have concentric rings that can be counted to determine the tree's age. Each ring represents one year's growth. A maple tree with a diameter of 12 in . has 32 rings. If the tree continues to grow at about the same rate, how many rings will the tree have when its diameter is 20 in.?
34. Apply Mathematics (1)(A) Allie wants to meet Grace at a fountain in a park 4 mi away from Allie's house. Allie will bike to the park at an average rate of $10 \mathrm{mi} / \mathrm{h}$. Grace lives 1.2 mi away from the park and walks at an average rate of $3 \mathrm{mi} / \mathrm{h}$. How many minutes ahead of Allie should Grace start out so that they meet at the fountain at the same time?


Solve each proportion.
35. $\frac{4 y-3}{y^{2}+1}=\frac{4}{y}$
36. $\frac{w^{2}+3}{2 w+2}=\frac{w}{2}$
37. $\frac{5 x}{x^{3}+5}=\frac{5}{x^{2}-7}$
38. Use a Problem-Solving Model (1)(B) A group of high school students is making a parade float by stuffing pieces of tissue paper into a wire frame. They use 150 pieces of tissue paper to fill an area 3 ft long and 2 ft wide. The total area they want to fill is 8 ft long and 7 ft wide. How many pieces of tissue paper they will need?
39. Apply Mathematics (1)(A) It takes an insect 15 s to crawl 1 ft . How many hours would it take the insect to crawl 1 mi if the insect crawls at the same rate?

## TEXAS End-of-Course PRACTICE

40. A high school soccer team is making trail mix to sell at a fundraiser. The recipe calls for 3 lb of raisins and 2 lb of peanuts. If the team purchases 54 lb of peanuts, how many pounds of raisins will they need?
A. 27
B. 36
C. 81
D. 162
41. One day during flu season, $\frac{1}{3}$ of the students in a class were out sick, and only 24 students were left. How many students are in the class?
F. 16
G. 30
H. 36
J. 72
42. An art gallery owner is framing a rectangular painting, as shown. The owner wants the width of the framed painting to be $38 \frac{1}{2} \mathrm{in}$. How wide should each of the vertical sections of the frame be?
A. $4 \frac{1}{8} \mathrm{in}$.
B. $4 \frac{1}{4} \mathrm{in}$.
C. $4 \frac{1}{2} \mathrm{in}$.
D. $8 \frac{1}{2} \mathrm{in}$.


# + 

## TEKS FOCUS

TEKS (5)(A) Solve linear equations in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides.

TEKS (1)(A) Apply mathematics to problems arising in everyday life, society, and the workplace

## Additional TEKS (1)(D)

## VOCABULARY

- Scale - A scale is the ratio of any length in a scale drawing to the corresponding actual length. The lengths may be in different units.
- Scale drawing - A scale drawing is a drawing that is similar to an actual object or place.
- Scale model - A scale model is a three-dimensional model that is similar to a three-dimensional object.
- Similar figures - Similar figures have the same shape but not necessarily the same size.
- Apply - use knowledge or information for a specific purpose, such as solving a problem


## ESSENTIAL UNDERSTANDING

You can use proportions to find missing side lengths in similar figures. Such figures can help you measure real-world distances indirectly.

## Key Concept Similar Figures

The symbol $\sim$ means "is similar to." In the diagram, $\triangle A B C \sim \triangle F G H$.


In similar figures, the measures of corresponding angles are equal, and corresponding side lengths are in proportion. The order of the letters when you name similar figures is important because it tells which parts of the figures are corresponding parts. So, because $\triangle A B C \sim \triangle F G H$, the following is true.

$$
\begin{gathered}
\angle A \cong \angle F \quad \angle B \cong \angle G \quad \angle C \cong \angle H \quad \text { and } \quad \frac{A B}{F G}=\frac{A C}{F H}=\frac{B C}{G H} \\
\begin{array}{l}
\text { The symbol } \cong \text { means "is congruent to." } \\
\text { Congruent angles have the same measure. }
\end{array} \text { The ratios are equal. }
\end{gathered}
$$

## Finding the Length of a Side

Multiple Choice In the diagram, $\triangle A B C \sim \triangle D E F$. What is $D E$ ?
(A) 7.5
(C) 21.3
(B) 9.5
(D) 24

## Know

- The length of $\overline{A B}$, which corresponds to $\overline{D E}$
- The lengths of two other corresponding sides, $\overline{B C}$ and $\overline{E F}$
- The triangles are similar.

The length of $\overline{D E}$


$$
\begin{aligned}
\frac{B C}{E F} & =\frac{A B}{D E} & & \text { Write a proportion. } \\
\frac{16}{12} & =\frac{10}{D E} & & \text { Substitute lengths. } \\
16(D E) & =12(10) & & \text { Cross Products Property } \\
16 D E & =120 & & \text { Multiply. } \\
D E & =7.5 & & \text { Divide each side by } 16 \text { and simplify. }
\end{aligned}
$$

$D E$ is 7.5. The correct answer is A .

## Problem 2

## Applying Similarity

Indirect Measurement The sun's rays strike the

## Think

Is there only one way to write a proportion? No. You can write different proportions to find the height. For example, the following proportion also works. $\frac{\text { building's shadow }}{\text { girl's shadow }}=$ $\frac{\text { building's height }}{\text { girl's height }}$ building and the girl at the same angle, forming the two similar triangles shown. How tall is the building?
$\frac{\text { girl's shadow }}{\text { building's shadow }}=\frac{\text { girl's height }}{\text { building's height }}$ Write a proportion.

$$
\begin{aligned}
\frac{3}{15}=\frac{5}{x} & \text { Substitute. } \\
3 x=15(5) & \text { Cross Products } \\
& \text { Property } \\
3 x=75 & \text { Multiply. } \\
x=25 & \text { Divide each side by } 3 .
\end{aligned}
$$

The building is 25 ft tall.


## Interpreting Scale Drawings

Maps What is the actual distance from Jacksonville to Orlando? Use the ruler to measure the distance from Jacksonville to Orlando on the map below.


What does the scale of the map tell you? The scale tells you that each inch on the map represents 110 mi of actual distance.

Relate map scale $=\frac{\text { map distance }}{\text { actual distance }}$
Define Let $x=$ the total distance from Jacksonville to Orlando.
Write $\quad \frac{1}{110}=\frac{1.25}{x}$

$$
\begin{aligned}
1(x) & =110(1.25) & & \text { Cross Products Property } \\
x & =137.5 & & \text { Multiply } .
\end{aligned}
$$

The actual distance from Jacksonville to Orlando is 137.5 mi .

## Problem 4

## Using Scale Models STEM

Science A giant model heart is shown below. The heart is the ideal size for a person who is 170.3 ft tall. About what size would you expect the heart of a man who is $\mathbf{6 ~ f t ~ t a l l ~ t o ~ b e ? ~}$

continued on next page

Is this problem like ones you have seen? Yes. Scale model problems are like scale drawing problems, so you can write a proportion like you did to find the height of the building in Problem 2.

$$
\begin{aligned}
\frac{\text { height of giant heart }}{\text { height of man's heart }} & =\frac{\text { height of giant person }}{\text { height of man }} & & \text { Write a proportion. } \\
\frac{13.9}{x} & =\frac{170.3}{6} & & \text { Substitute. } \\
13.9(6) & =170.3 x & & \text { Cross Products Property } \\
0.49 & \approx x & & \text { Divide each side by } 170.3 \text { and simplify. }
\end{aligned}
$$

The size of the man's heart would be about 0.49 ft , or 5.9 in .


For additional support when completing your homework, go to PearsonTEXAS.com.

## The figures in each pair are similar. Find the unknown length.

1. 


3.

5. Apply Mathematics (1)(A) In the diagram of the park, $\triangle A D F \sim \triangle B C F$. The crosswalk at point $A$ is about 20 yd long. A bridge across the pond will be built, from point $B$ to point $C$. What will the length of the bridge be?
2.

4.


The figures in each pair are similar. Identify the corresponding sides and angles.
6. $\triangle A B C \sim \triangle D E F$

7. FGHI ~KLMN


The scale of a map is $1 \mathrm{~cm}: 15 \mathrm{~km}$. Find the actual distance corresponding to each map distance.
8. 2.5 cm
9. 0.2 cm
10. 15 cm
11. 4.6 cm
12. Analyze Mathematical Relationships (1)(F) A professional model-maker is building a giant scale model of a housefly to be used in a science fiction film. An actual fly is about 0.2 in . long with a wingspan of about 0.5 in . The model fly for the movie will be 27 ft long. What will its wingspan be?
13. Apply Mathematics (1)(A) Abbottsville and Broken Branch are 175 mi apart. On a map, the distance between the two towns is 2.5 in . What is the scale of the map?
Use Representations to Communicate Mathematical Ideas (1)(E) An architect is using the blueprint at the right to remodel a laundry room. The side length of each grid square represents 12 in .
14. Find the actual length and width of the sink.
15. Find the total length and width of the actual room.
16. Will it be possible to wheel a laundry cart that is $3 \frac{1}{2} \mathrm{ft}$
 wide through the room from doorway to doorway? Explain.
17. Apply Mathematics (1)(A) A particular model-rocket kit uses the scale $1: 144$. The actual rocket is 168 ft tall. How tall will the model rocket be when completed?
18. Analyze Mathematical Relationships (1)(F) The two figures at the right are similar. A student uses the proportion $\frac{B C}{C J}=\frac{G H}{F N}$ to find $F N$.
a. What mistake did the student make?
b. What proportion should the student have used instead?

19. Use a Problem-Solving Model (1)(B) An interior designer sketches a design for a rectangular rug. The dimensions of the sketch are 4 in . by 7.5 in . The dimensions of the actual rug will be ten times the dimensions of the drawing, so the scale of the drawing is $1: 10$. How many times the area of the sketch is the area of the actual rug?
20. Apply Mathematics (1)(A) A model of a tractor-trailer is shaped like a rectangular prism and has a width of 2 in ., a length of 9 in ., and a height of 4 in . The scale of the model is $1: 34$. How many times the volume of the model is the volume of the actual tractor-trailer?
21. Justify Mathematical Arguments (1)(G) Are all squares similar? Explain your answer.
22. Explain Mathematical Ideas (1)(G) A boat maker wanted to build a canoe 6 ft long and $2 \frac{1}{2} \mathrm{ft}$ wide but decided that those dimensions were too small. The boat maker wants to add 2 ft to both the length and the width but also wants to keep the canoe the same shape. Explain why this will not work.
23. Apply Mathematics (1)(A) A carpenter is building a tabletop from a sketch. The sketch shows a parallelogram with side lengths 2 in . and 3 in. It specifies that the sides of the finished tabletop should be 4 ft and 6 ft . Can the carpenter be certain that the finished tabletop will be a similar parallelogram? Explain.
24. Apply Mathematics (1)(A) You have a painting that is 30 in . wide and 22.5 in . tall. You would like to reproduce it on a sheet of paper that measures $8 \frac{1}{2} \mathrm{in}$. by 11 in ., leaving at least a 1 -in. margin on all four sides.
a. What scale should you use if you keep the sheet of paper in the normal upright orientation? Assume that the reproduction will be as large as possible.
b. What scale should you use if you turn the paper on its side?
25. Apply Mathematics (1)(A) The height of the Eiffel Tower is 324 m . Which scale was used to make the model of the Eiffel Tower shown at the right?
A. $1 \mathrm{~mm}: 0.9 \mathrm{~m}$
B. $1 \mathrm{~mm}: 6 \mathrm{~m}$
C. $1 \mathrm{~mm}: 30 \mathrm{~m}$
D. $1 \mathrm{~mm}: 324 \mathrm{~m}$


## TEXAS End-of-Course PRACTICE

26. The scale of a map is 1 in : : 80 mi . If the actual distance between two cities is 350 mi , how far apart will they be on the map?
A. $4 \frac{1}{4} \mathrm{in}$.
B. $4 \frac{3}{16}$ in.
C. $4 \frac{3}{8} \mathrm{in}$.
D. $4 \frac{1}{2} \mathrm{in}$.
27. The cost $c$ of purchasing $r$ roses from Sandra's Delivery Service is given by the equation $c=3 r+15$. If Luke has $\$ 50$ to spend on roses, how many roses can he buy?
F. 11
G. $11 \frac{2}{3}$
H. 12
J. 13
28. Which property of addition is illustrated by $a+(b+c)=(a+b)+c$ ?
A. Commutative
B. Associative
C. Inverse
D. Identity
29. Tamara and Will set up two booths to sell papayas at the farmers' market. Tamara sold hers for $\$ 5$ each and Will sold his for $\$ 7$ each. By noon, Tamara had sold 3 more papayas than Will and together they had earned a total of $\$ 147$. How many papayas did they sell altogether?
F. 8
G. 11
H. 14
J. 25

## USE WITH LESSON 1-6

```
TEKS (5)(B), (1)(C)
```

Sometimes you need to perform two or more steps to solve an inequality. Models can help you understand how to solve multi-step inequalities.

## Activity

Model and solve $2 x-3<1$.
$2 x-3<1$

## Exercises

Write an inequality for each model. Use tiles to solve each inequality.
1.

2.



Use tiles to model and solve each inequality.
3. $2 n-5 \geq 3$
4. $-9>4 x-1$
5. $3 w+4<-5$
6. $z+6 \leq 2 z+2$
7. $3 m+7 \geq m-5$
8. $5 b+6>3 b-2$

# $+$ 1-6 Solving Multi-Step Inequalities 

## TEKS FOCUS

TEKS (5)(B) Solve linear inequalities in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides.

## VOCABULARY

- Apply - use knowledge or information for a specific purpose, such as solving a problem

TEKS (1)(A) Apply mathematics to problems arising in everyday life, society, and the workplace.

## Additional TEKS (1)(D)

## ESSENTIAL UNDERSTANDING

You solve a multi-step inequality in the same way you solve a one-step inequality.
You use the properties of inequality to transform the original inequality into a series of simpler, equivalent inequalities.

## Plan

How can you check the solutions?
Check the endpoint, 3. Then choose a value greater than 3 and check the inequality symbol.

## Problem 1

## Using More Than One Step

What are the solutions of $9+4 t>21$ ? Check the solutions.

$$
\begin{array}{rlrl}
9+4 t & >21 & \\
9+4 t-9 & >21-9 & & \text { Subtract } 9 \text { from each side. } \\
4 t & >12 & & \text { Simplify. } \\
\frac{4 t}{4} & >\frac{12}{4} & & \text { Divide each side by } 4 . \\
t & >3 & & \text { Simplify. } \\
\text { Check } 9+4(3) \stackrel{?}{=} 21 & & \begin{array}{l}
\text { Check the endpoint of } t>3 \text { by substituting } 3 \text { for } t \text { in the } \\
\text { related equation. }
\end{array} \\
21 & =21 \checkmark & \begin{array}{l}
\text { Simplify. }
\end{array} \\
9+4(4) \stackrel{?}{>} 21 & & \begin{array}{l}
\text { Check the inequality symbol of } t>3 \text { by substituting } 4 \text { for } t \text { in } \\
\text { the original inequality. }
\end{array} \\
25 & >21 \boldsymbol{} \quad & \begin{array}{l}
\text { Simplify. }
\end{array}
\end{array}
$$

## Writing and Solving a Multi-Step Inequality

Geometry In a community garden, you want to fence in a rectangular garden that is adjacent to your friend's garden. You have at most 42.8 ft of fence. What are the possible lengths of your garden? Check the reasonableness of your answer.


Relate Since the fence will surround the garden, you can use the perimeter formula $P=2 \ell+2 w$.
Twice the

length plus \begin{tabular}{c}
twice the <br>
width

 is at most 

the amount <br>
of fence.
\end{tabular}

Define Let $\ell=$ the length of the garden.

Write | $2 \ell$ | $+2(12.3)$ | $\leq$ |  |
| ---: | :--- | ---: | :--- |
| $2 \ell+2(12.3)$ | $\leq 42.8$ |  |  |
| $2 \ell+24.6$ | $\leq 42.8$ |  | Simplify. |
| $2 \ell+24.6-24.6$ | $\leq 42.8-24.6$ |  | Subtract 24.6 from each side. |
| $2 \ell$ | $\leq 18.2$ |  | Simplify. |
| $\frac{2 \ell}{2} \leq \frac{18.2}{2}$ |  | Divide each side by 2. |  |
| $\ell$ | $\leq 9.1$ |  | Simplify. |

The length of the garden must be 9.1 ft or less.
Check $\quad 2(9.1)+2(12.3) \stackrel{?}{=} 42.8$

$$
18.2+24.6 \stackrel{?}{=} 42.8
$$

$$
42.8=42.8 \downarrow
$$

$$
\begin{aligned}
2(8)+2(12.3) & \stackrel{?}{\leftrightarrows} 42.8 \\
16+24.6 & \stackrel{?}{\leq} 42.8 \\
40.6 & \leq 42.8
\end{aligned}
$$

The answer checks. It is a reasonable answer.

## Problem 3

## Think

You can use reasoning and guess-and-check to solve the problem. If either 9 or 10 is a solution, at least one other answer choice would also be a solution. So, eliminate 9 and 10 as possible answers. Guess that either 8 or 11 is correct and check your guess.

## Using the Distributive Property

Multiple Choice Which is a solution of $3(t+1)-4 t \geq-5$ ?

\[

\]

8 is a solution of the inequality $t \leq 8$. The correct answer is A.

## Problem 4

Think
Why subtract $3 n$ instead of $6 \boldsymbol{n}$ from each side of the inequality?
You can subtract either $3 n$ or $6 n$ from each side. However, subtracting $3 n$ gives you a variable term with a positive coefficient.

## Solving an Inequality With Variables on Both Sides

$$
\text { What are the solutions of } 6 n-1>3 n+8 ?
$$

$$
\begin{aligned}
6 n-1 & >3 n+8 & & \\
6 n-1-3 n & >3 n+8-3 n & & \text { To gather variables on the left, subtract } 3 n \text { from each side. } \\
3 n-1 & >8 & & \text { Simplify. } \\
3 n-1+1 & >8+1 & & \text { To gather the constants on the right, add } 1 \text { to each side. } \\
3 n & >9 & & \text { Simplify. } \\
\frac{3 n}{3} & >\frac{9}{3} & & \text { Divide each side by } 3 . \\
n & >3 & & \text { Simplify. }
\end{aligned}
$$

## Think

Is there another way to solve this inequality?
Yes. Instead of using the Distributive Property, you can first divide each side by 2 .

## Inequalities With Special Solutions

A What are the solutions of $10-8 a \geq 2(5-4 a)$ ?

$$
\begin{aligned}
10-8 a & \geq 2(5-4 a) & & \\
10-8 a & \geq 10-8 a & & \text { Distributive Property } \\
10-8 a+8 a & \geq 10-8 a+8 a & & \text { Add 8a to each side. } \\
10 & \geq 10 & & \text { Simplify. }
\end{aligned}
$$

Since the inequality $10 \geq 10$ is always true, the solutions of $10-8 a \geq 2(5-4 a)$ are all real numbers.

## Problem 5 continued

Without solving, how can you tell that this inequality has no solution?
The variable terms on each side of the inequality are equal, but -5 is not greater than 7 .

B What are the solutions of $6 m-5>7 m+7-m$ ?

$$
\begin{aligned}
6 m-5 & >7 m+7-m & & \\
6 m-5 & >6 m+7 & & \text { Simplify. } \\
6 m-5-6 m & >6 m+7-6 m & & \text { Subtract } 6 m \text { from each side. } \\
-5 & >7 \times & & \text { Simplify. }
\end{aligned}
$$

Since the inequality $-5>7$ is never true, the inequality $6 m-5>7 m+7-m$ has no solution.

## PRACTICE and APPLICATION EXERCISES



For additional support when completing your homework, go to PearsonTEXAS.com.

Solve each inequality. Check your solutions.

1. $5 f+7 \leq 22$
2. $6 n-3>-18$
3. $-5 y-2<8$
4. $6-3 p \geq-9$
5. $9 \leq-12+6 r$
6. $6 \leq 12+4 j$

## Apply Mathematics (1)(A) Write and solve an inequality.

7. On a trip from Buffalo, New York, to St. Augustine, Florida, a family wants to travel at least 250 mi in the first 5 h of driving. What should their average speed be in order to meet this goal?
8. An isosceles triangle has at least two congruent sides. The perimeter of a certain isosceles triangle is at most 12 in . The length of each of the two congruent sides is 5 in . What are the possible lengths of the remaining side?

## Solve each inequality.

9. $3(k-5)+9 k \geq-3$
10. $-(7 c-18)-2 c>0$
11. $-3(j+3)+9 j<-15$
12. $6-3 p \leq 4-p$
13. $3 m-4 \leq 6 m+11$
14. $4 t+17>7+5 t$
15. Use a Problem-Solving Model (1)(B) Your cellphone plan costs $\$ 39.99$ per month plus $\$ .15$ for each text message you send or receive. You have at most $\$ 45$ to spend on your cellphone bill. What is the maximum number of text messages that you can send or receive next month?
16. Explain Mathematical Ideas (1)(G) Suppose a friend is having difficulty solving $3.75(q-5)>4(q+3)$. Explain how to solve the inequality, showing all the necessary steps and identifying the properties you would use.
17. Apply Mathematics (1)(A) The average normal body temperature for humans is $98.6^{\circ} \mathrm{F}$. An abnormal increase in body temperature is classified as hyperthermia, or fever. Which inequality represents the body temperature in degrees Celsius of a person with hyperthermia? (Hint: To convert between degrees Celsius $C$ and degrees Fahrenheit $F$, use the formula $F=\frac{9}{5} C+32$.)
A. $\frac{9}{5} C+32 \geq 98.6$
B. $\frac{9}{5} C+32 \leq 98.6$
C. $\frac{9}{5} C+32<98.6$
D. $\frac{9}{5} C+32>98.6$
18. Apply Mathematics (1)(A) The student council wants to rent a ballroom for the junior prom. The ballroom's rental rate is $\$ 1500$ for 3 h and $\$ 125$ for each additional half hour. Suppose the student council raises $\$ 2125$. What is the maximum number of hours for which they can rent the ballroom?
19. Display Mathematical Ideas (1)(G) Write two different inequalities that you can solve by subtracting 3 from each side and then dividing each side by -5 . Solve each inequality.
20. a. Solve $6 v+5 \leq 9 v-7$ by gathering the variable terms on the left side and the constant terms on the right side of the inequality.
b. Solve $6 v+5 \leq 9 v-7$ by gathering the constant terms on the left side and the variable terms on the right side of the inequality.
c. Which method do you prefer? Explain.
21. Select Techniques to Solve Problems (1)(C) Determine whether each inequality is always true or never true.
a. $5 s+7 \geq 7+5 s$
b. $4 t+6>4 t-3$
c. $5(m+2)<5 m-4$

Solve each inequality, if possible. If the inequality has no solution, write no solution. If the solutions are all real numbers, write all real numbers.
22. $-3(w-3) \geq 9-3 w$
24. $-2(6+s) \geq-15-2 s$
26. $2(n-8)<16+2 n$
28. $\frac{4}{3} s-3<s+\frac{2}{3}-\frac{1}{3} s$
30. $-2(0.5-4 t) \geq-3(4-3.5 t)$
32. $4(3 n-1) \geq 2(n+3)$
23. $-5 r+6 \leq-5(r+2)$
25. $9+2 x<7+2(x-3)$
27. $6 w-4 \leq 2(3 w+6)$
29. $4-2 n \leq 5-n+1$
31. $4(a-2)-6 a \leq-9$
33. $17-(4 k-2) \geq 2(k+3)$
34. Apply Mathematics (1)(A) A sales associate in a shoe store earns $\$ 325$ per week, plus a commission equal to $4 \%$ of her sales. This week her goal is to earn at least $\$ 475$. At least how many dollars' worth of shoes must she sell to reach her goal?
Explain Mathematical Ideas (1)(G) Describe and correct the error in each solution.
35.

36.

37. Apply Mathematics (1)(A) The base of a triangle is 12 in . Its height is $(x+6)$ in. Its area is no more than $72 \mathrm{in} .^{2}$. What are the possible integer values of $x$ ?
38. Apply Mathematics (1)(A) You can earn money by tutoring for $\$ 8$ per hour and by walking dogs for $\$ 7.50$ per hour. You have 15 h available to work. What is the greatest number of hours you can spend walking dogs and still make at least \$115?
39. Analyze Mathematical Relationships (1)(F) A student uses the table at the right to help solve $7 y+2<6(4-y)$.
a. Based on the table, would you expect the solution of $7 y+2<6(4-y)$ to be of the form $y<c$ or $y>c$, where $c$ is a real number? Explain.
b. Based on the table, estimate the value of $c$.

c. Solve the inequality. Compare the actual solution to your estimated solution.
40. Apply Mathematics (1)(A) The elevator of a building can safely carry no more than 4000 lb . A worker moves supplies in $50-\mathrm{lb}$ boxes from the loading dock to the fourth floor of the building. The worker weighs 210 lb . The cart he uses weighs 95 lb .
a. What is the greatest number of boxes he can move in one trip?
b. The worker needs to deliver 275 boxes. How many trips must he make?

## TEXAS End-of-Course PRACTICE

41. The Science Club hopes to collect at least 200 kg of aluminum cans for recycling during a 21 -week semester. The graph shows the first week's results. Let $x$ represent the minimum average mass of cans required per week for the remainder of the semester. What is $x$ ?
42. What is the solution of $2 x+8=4 x+2$ ?
43. What is the solution of $-5 n-16=-7 n$ ?
44. Great Gifts pays its supplier $\$ 65$ for each box of 12 bells. The owner wants to determine the
 minimum amount $x$ he can charge his customers per bell in order to make at least a $50 \%$ profit per box. What is $x$ ? Round to the nearest hundredth if necessary.

| $\star \star$ | $1-7$ | Compound Inequalities |
| :--- | :--- | :--- |

## TEKS FOCUS

TEKS (5)(B) Solve linear inequalities in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides.

TEKS (1)(A) Apply mathematics to problems arising in everyday life, society, and the workplace.

## Additional TEKS (1)(D)

## VOCABULARY

- Compound inequality - A compound inequality consists of two distinct inequalities joined by the word and or the word or.
- Apply - use knowledge or information for a specific purpose, such as solving a problem


## ESSENTIAL UNDERSTANDING

You find the solutions of a compound inequality either by identifying where the solution sets of the distinct inequalities overlap or by combining the solution sets to form a larger solution set.

## Key Concept Graphing Compound Inequalities

The graph of a compound inequality with the word and contains the overlap of the graphs of the two inequalities that form the compound inequality.


The graph of a compound inequality with the word or contains each graph of the two inequalities that form the compound inequality.


You can rewrite a compound inequality involving and as a single inequality. For instance, in the inequality above, you can write $x \geq 3$ and $x \leq 7$ as $3 \leq x \leq 7$. You read this as " $x$ is greater than or equal to 3 and less than or equal to 7 ." Another way to read it is " $x$ is between 3 and 7 , inclusive." In this example, inclusive means the solutions of the inequality include both 3 and 7 .

## Writing a Compound Inequality

What compound inequality represents the phrase? Graph the solutions.

A all real numbers that are greater than -2 and less than 6

$$
\begin{aligned}
& \begin{array}{ll}
n>-2 \text { and } n<6 \\
-2<n \text { and } n<6
\end{array} \\
& -2<n<6 \\
& \hdashline-2
\end{aligned}
$$

B all real numbers that are less than 0 or greater than or equal to 5

$$
t<0 \text { or } t \geq 5
$$



## Problem 2

## Solving a Compound Inequality Involving And

What are the solutions of $-3 \leq m-4<-1$ ? Graph the solutions.

$$
-3 \leq m-4<-1
$$

$$
\begin{aligned}
-3 & \leq m-4 & \text { and } & & m-4 & <-1 \\
-3+4 & \leq m-4+4 & \text { and } & & m-4+4 & <-1+4 \\
1 & \leq m & & \text { and } & & m
\end{aligned}
$$

$$
1 \leq m<3
$$



Write the compound inequality as two inequalities joined by the word and.

Add 4 to each side of each inequality.
Simplify.
Write the solutions as a single inequality.

## Problem 3

## Plan

How is this inequality different from others you've solved? It contains the word or. Unlike an and inequality, it's formed by two inequalities with solutions that do not overlap.

## Solving a Compound Inequality Involving Or

What are the solutions of $3 t+2<-7$ or $-4 t+5<1$ ? Graph the solutions.

| $3 t+2<-7$ | or | $-4 t+5<1$ |
| :---: | :---: | :---: | :---: |
| $3 t+2-2<-7-2$ | or | $-4 t+5-5<1-5$ |
| $3 t<-9$ | or | $-4 t<-4$ |
| $\frac{3 t}{3}<\frac{-9}{3}$ | or | $\frac{-4 t}{-4}>\frac{-4}{-4}$ |
| $t<-3$ | or | $t>1$ |$\quad$| Reverse the inequality |
| :--- |
| symbol when you |
| divide by a negative |
| number. |

The solutions are given by $t<-3$ or $t>1$.


## Writing and Solving a Compound Inequality

Test Average To earn a B in your algebra course, you must achieve an unrounded test average between 84 and 86 , inclusive. What possible scores can you earn on the fourth and final test to earn a $B$ in the course?

| File Edit | Tool View | Chart |  | Class Help |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Math Test Scores |  |  | Math Homework |  |  |
| Class | Student | $\begin{gathered} \text { Test } \\ 1 \end{gathered}$ | $\begin{gathered} \text { Test } \\ 2 \end{gathered}$ | $\begin{gathered} \text { Test } \\ 3 \end{gathered}$ | $\begin{gathered} \text { Test } \\ 4 \end{gathered}$ | Test <br> Average |
| 001 | 17 | 86 | 85 | 80 |  |  |

## Think

What is another way to solve this problem? You can work backward to solve this problem. You can start with the inequality $84 \leq x \leq 86$ where $x$ represents the average of your test scores. Then rewrite the inequality in terms of the sum of your 4 test scores.

| 84 | $\leq \frac{86+85+80+x}{4}$ | $\leq 86$ |  |
| ---: | :--- | ---: | :--- |
| $4(84)$ | $\leq 4\left(\frac{251+x}{4}\right)$ | $\leq 4(86)$ |  |
| 336 | $\leq 251+x$ | $\leq 344$ |  |
| Multitiply a compound part by 4. |  |  |  |
| $336-251$ | $\leq 251+x-251$ | $\leq 344-251$ |  |
| Simplify. |  |  |  |
| 85 | $\leq x$ | $\leq 93$ |  |
| Subtract 251 from each part. |  |  |  |
| Simplify. |  |  |  |

Your score on the fourth test must be between 85 and 93, inclusive.


For additional support when completing your homework, go to PearsonTEXAS.com.

Write a compound inequality that represents each phrase. Graph the solutions.

1. all real numbers that are between -5 and 7
2. The circumference of a women's basketball must be between 28.5 in . and 29 in., inclusive.

## Solve each compound inequality. Graph your solutions.

3. $-4<k+3<8$
4. $5 \leq y+2 \leq 11$
5. $15 \leq \frac{20+11+k}{3} \leq 19$
6. $\frac{1}{4}<\frac{2 x-7}{2}<5$
7. Apply Mathematics (1)(A) The acidity of the water in a swimming pool is considered normal if the average of three pH readings is between 7.2 and 7.8 , inclusive. The first two readings for a swimming pool are 7.4 and 7.9. What possible values for the third reading $p$ will make the average pH normal?
8. Apply Mathematics (1)(A) The force exerted on a spring is proportional to the distance the spring is stretched from its relaxed position. Suppose you stretch a spring a distance of $d$ inches by applying a force of $F$ pounds. For your spring,
 $\frac{d}{F}=0.8$. You apply forces between 25 lb and 40 lb , inclusive. What inequality describes the distances the spring is stretched?
9. Describe the solutions of $4 x-9<7$ or $3 x-10>2$.

Solve each compound inequality. Graph your solutions.
10. $6 b-1<-7$ or $2 b+1>5$
11. $5+m>4$ or $7 m<-35$
12. $5 y+7 \leq-3$ or $3 y-2 \geq 13$
13. $5 z-3>7$ or $4 z-6<-10$
14. Analyze Mathematical Relationships (1)(F) The Triangle Inequality Theorem states that the sum of the lengths of any two sides of a triangle is greater than the length of the third side. The lengths of two sides of a triangle are given. What are the possible lengths $x$ of the third side of the triangle?


9 in.

Use the theorem from Exercise 14 to answer Exercises 15-18. The lengths of two sides of a triangle are given. Find the possible lengths of the third side.
15. 3.75 in., 7 in.
16. $15 \mathrm{ft}, 21 \mathrm{ft}$
17. $14 \mathrm{~mm}, 35 \mathrm{~mm}$
18. $6 \mathrm{~m}, 17 \mathrm{~m}$
19. Apply Mathematics (1)(A) An average 15-year-old male should consume no more than 2200 Calories per day. A moderately active 15-year-old male should consume between 2400 and 2800 Calories per day. An active 15-year-old male should consume between 2800 and 3200 Calories per day. Model these ranges on a number line.

Write a compound inequality that each graph could represent.
20.

21.

22.


## Solve each compound inequality. Justify each step.

23. $4 r-3>11$ or $4 r-3 \leq-11$
24. $2 \leq 0.75 v \leq 4.5$
25. $\frac{4 y+2}{5}-5>3$ or $\frac{4-3 y}{6}>4$
26. $-\frac{4}{3} \leq \frac{1}{7} w-\frac{3}{4}<1$
27. Apply Mathematics (1)(A) Recommended heart rates during exercise vary with age and physical condition. For a healthy person doing moderate to intense exercise, such as hiking, the inequality $0.5(220-a) \leq R \leq 0.9(220-a)$ gives a target range for the heart rate $R$ (in beats per minute), based on age $a$ (in years).
a. What is the target range for heart rates for a person 15 years old?
b. How old is a person whose target range is between 99 and 178.2 beats per minute?
28. Apply Mathematics (1)(A) Matter is in a liquid state when its temperature is between its melting point and its boiling point. The melting point of the element mercury is $-38.87^{\circ} \mathrm{C}$, and its boiling point is $356.58^{\circ} \mathrm{C}$. What is the range of temperatures in degrees Fahrenheit for which mercury is not in a liquid state? (Hint: $C=\frac{5}{9}(F-32)$.) Express the range as a compound inequality.

## TEXAS End-of-Course PRACTICE

29. A taxi traveled 5 mi to John's home and then drove him to the airport 10 mi away. Which inequality represents the possible distances $d$ of the taxi from the airport when it started traveling toward John's home?
A. $5 \leq d \leq 10$
B. $5 \leq d \leq 15$
C. $0 \leq d \leq 5$
D. $0 \leq d \leq 10$
30. A student must earn at least 24 credits in high school in order to graduate. Which inequality or graph does NOT describe this situation?
F. $c \leq 24$
H. $24 \leq c$
G. $c \geq 24$

31. The County Water Department charges a monthly administration fee of $\$ 10.40$ plus $\$ .0059$ for each gallon of water used, up to, but not including, 7500 gal. What are the minimum and maximum numbers of gallons of water used by customers whose monthly charge is at least $\$ 35$ but no more than $\$ 50$ ? Express amounts to the nearest gallon.

## TOPIC VOCABULARY

- compound inequality, p. 40
- cross products, p. 22
- formula, p. 17
- identity, p. 11
- literal equation, p. 17
- proportion, p. 22
- rate, p. 22
- ratio, p. 22
- scale, p. 27
- scale drawing, p. 27
- scale model, p. 27
- similar figures, p. 27


## Check Your Understanding

Choose the correct term to complete each sentence.

1. An equation that is true for every value of the variable is $a(n)$ ?.
2. A ratio of two equivalent measures given in different units is $\mathrm{a}(\mathrm{n})$ ?.
3. On a map, information such as " $1 \mathrm{in} .: 5 \mathrm{mi}$ " is the ? of the map.
4. In the proportion $\frac{a}{b}=\frac{c}{d}$, ad and $b c$ are the ?.
5. Inequalities joined by and or or are ?.

## 1-1 Solving Multi-Step Equations

## Quick Review

To solve some equations, you may need to combine like terms or use the Distributive Property to clear fractions or decimals.

## Example

What is the solution of $12=2 x+\frac{4}{3}-\frac{2 x}{3}$ ?

$$
\begin{aligned}
3 \cdot 12 & =3\left(2 x+\frac{4}{3}-\frac{2 x}{3}\right) & & \text { Multiply by } 3 . \\
36 & =6 x+4-2 x & & \text { Simplify. } \\
36 & =4 x+4 & & \text { Combine like terms. } \\
36-4 & =4 x+4-4 & & \text { Subtract } 4 . \\
32 & =4 x & & \text { Combine like terms. } \\
\frac{32}{4} & =\frac{4 x}{4} & & \text { Divide each side by } 4 . \\
8 & =x & & \text { Simplify. }
\end{aligned}
$$

## Exercises

Solve each equation. Check your answer.
6. $7(s-5)=42$
7. $3 a+2-5 a=-14$
8. $-4 b-5+2 b=10$
9. $3.4 t+0.08=11$
10. $10=\frac{c}{3}-4+\frac{c}{6}$
11. $\frac{2 x}{7}+\frac{4}{5}=5$

## Write an equation to model each situation. Then solve

 the equation.12. Apply Mathematics (1)(A) You work for 4 h on Saturday and 8 h on Sunday. You also receive a $\$ 50$ bonus. You earn $\$ 164$. How much did you earn per hour?
13. Apply Mathematics (1)(A) Online concert tickets cost $\$ 37$ each, plus a service charge of $\$ 8.50$ per ticket. The Web site also charges a transaction fee of $\$ 14.99$ for the purchase. You paid $\$ 242.49$. How many tickets did you buy?

## 1-2 Solving Equations With Variables on Both Sides

## Quick Review

When an equation has variables on both sides, you can use properties of equality to isolate the variable on one side. An equation has no solution if no value of the variable makes it true. An equation is an identity if every value of the variable makes it true.

## Example

What is the solution of $3 x-7=5 x+19$ ?

$$
\begin{aligned}
3 x-7-3 x & =5 x+19-3 x & & \text { Subtract } 3 x . \\
-7 & =2 x+19 & & \text { Simplify. } \\
-7-19 & =2 x+19-19 & & \text { Subtract } 19 . \\
-26 & =2 x & & \text { Simplify. } \\
-\frac{26}{2} & =\frac{2 x}{2} & & \text { Divide each side by } 2 . \\
-13 & =x & & \text { Simplify. }
\end{aligned}
$$

## Exercises

Solve each equation. If the equation is an identity, write identity. If it has no solution, write no solution.
14. $\frac{2}{3} x+4=\frac{3}{5} x-2$
15. $6-0.25 f=f-3$
16. $3(h-4)=-\frac{1}{2}(24-6 h)$
17. $5 n=20(4+0.25 n)$
18. Apply Mathematics (1)(A) Two buildings have the same total height. One building has 8 floors with height $h$. The other building has a ground floor of 16 ft and 6 other floors with height $h$. Write and solve an equation to find the height $h$ of these floors.
19. Apply Mathematics (1)(A) A train makes a trip at $65 \mathrm{mi} / \mathrm{h}$. A plane traveling $130 \mathrm{mi} / \mathrm{h}$ makes the same trip in 3 fewer hours. Write and solve an equation to find the distance of the trip.

## 1-3 Literal Equations

## Quick Review

A literal equation is an equation that involves two or more variables. A formula is an equation that states a relationship among quantities. You can use properties of equality to solve a literal equation for one variable in terms of the others.

## Example

What is the width of a rectangle with area $91 \mathrm{ft}^{2}$ and length 7 ft ?

$$
\begin{aligned}
A & =\ell w & \text { Write the appropriate formula. } \\
\frac{A}{\ell} & =w & \text { Divide each side by } \ell . \\
\frac{91}{7} & =w & \text { Substitute } 91 \text { for } A \text { and } 7 \text { for } \ell . \\
13 & =w & \text { Simplify. }
\end{aligned}
$$

The width of the rectangle is 13 ft .

## Exercises

Solve each equation for $x$.
20. $a x+b x=-c$
21. $\frac{x+r}{t}+1=0$
22. $m-3 x=2 x+p$
23. $\frac{x}{p}+\frac{x}{q}=s$

Solve each problem. Round to the nearest tenth, if necessary. Use 3.14 for $\boldsymbol{\pi}$.
24. What is the width of a rectangle with length 5.5 cm and area $220 \mathrm{~cm}^{2}$ ?
25. What is the radius of a circle with circumference 94.2 mm ?
26. A triangle has height 15 in . and area $120 \mathrm{in} .^{2}$. What is the length of its base?

## 1-4 and 1-5 Solving Proportions and Proportions and Similar Figures

## Quick Review

The cross products of a proportion are equal. If $\frac{a}{b}=\frac{c}{d}$, where $b \neq 0$ and $d \neq 0$, then $a d=b c$.
If two figures are similar, then corresponding angles are congruent and corresponding side lengths are in proportion. You can use proportions to find missing side lengths in similar figures and for indirect measurement.

## Example

A tree casts a shadow 10 m long. At the same time, a signpost next to the tree casts a shadow 4 m long. The signpost is 2.5 m tall. How tall is the tree?

$$
\begin{aligned}
\frac{x}{10} & =\frac{2.5}{4} & & \text { Write a proportion. } \\
4 x & =10(2.5) & & \text { Cross Products Property } \\
4 x & =25 & & \text { Simplify. } \\
x & =6.25 & & \text { Divide each side by } 4 .
\end{aligned}
$$

The tree is 6.25 m tall.

## Exercises

Solve each proportion.
27. $\frac{3}{7}=\frac{9}{x}$
28. $\frac{-8}{10}=\frac{y}{5}$
29. $\frac{6}{15}=\frac{a}{4}$
30. $\frac{3}{-7}=\frac{-9}{t}$
31. $\frac{b+3}{7}=\frac{b-3}{6}$
32. $\frac{5}{2 c-3}=\frac{3}{7 c+4}$
33. Apply Mathematics (1)(A) An airplane has a wingspan of 25 ft and a length of 20 ft . You are designing a model of the airplane with a wingspan of 15 in . What will the length of your model be?
34. Apply Mathematics (1)(A) You project a drawing 7 in. wide and $4 \frac{1}{2}$ in. tall onto a wall. The projected image is 27 in. tall. How wide is the projected image?

## 1-6 Solving Multi-Step Inequalities

## Quick Review

When you solve inequalities, sometimes you need to use more than one step. You need to gather the variable terms on one side of the inequality and the constant terms on the other side.

## Example

What are the solutions of $3 x+5>-1$ ?

$$
\begin{aligned}
3 x+5 & >-1 & & \\
3 x & >-6 & & \text { Subtract } 5 \text { from each side. } \\
x & >-2 & & \text { Divide each side by } 3 .
\end{aligned}
$$

## Exercises

Solve each inequality.
35. $4 k-1 \geq-3$
36. $6(c-1)<-18$
37. $3 t>5 t+12$
38. $-\frac{6}{7} y-6 \geq 42$
39. $4+\frac{x}{2}>2 x$
40. $3 x+5 \leq 2 x-8$
41. $13.5 a+7.4 \leq 85.7$
42. $42 w>2(w+7)$
43. Apply Mathematics (1)(A) A salesperson earns \$200 per week plus a commission equal to $4 \%$ of her sales. This week her goal is to earn no less than $\$ 450$. Write and solve an inequality to find the amount of sales she must have to reach her goal.

## 1-7 Compound Inequalities

## Quick Review

Two inequalities that are joined by the word and or the word or are called compound inequalities. A solution of a compound inequality involving and makes both inequalities true. A solution of an inequality involving or makes either inequality true.

## Example

What are the solutions of $-3 \leq z-1<3$ ?

$$
\begin{aligned}
& -3 \leq z-1<3 \\
& -2 \leq z<4
\end{aligned} \quad \text { Add } 1 \text { to each part of the inequality. }
$$

## Exercises

Solve each compound inequality.
44. $-2 \leq d+\frac{1}{2}<4 \frac{1}{2}$
45. $0<-8 b \leq 12$
46. $2 t \leq-4$ or $7 t \geq 49$
47. $5 m<-10$ or $3 m>9$
48. $-1 \leq a-3 \leq 2$
49. $9.1>1.4 p \geq-6.3$
50. Apply Mathematics (1)(A) A town's high temperature for a given month is $88^{\circ} \mathrm{F}$ and the low temperature is $65^{\circ} \mathrm{F}$. Write a compound inequality to represent the range of temperatures for the given month.

## Topic 1 TEKS Cumulative Practice

## Multiple Choice

## Read each question. Then write the letter of the correct answer on your paper.

1. Belle surveyed her classmates in music class. The ratio of students who prefer playing string instruments to those who prefer wind instruments is $2: 5$. There are 28 students in Belle's class. How many students prefer playing string instruments?
A. 5
B. 8
C. 20
D. 25
2. What is the solution of $-30 c-6=-9 c-3$ ?
F. -7
G. $-\frac{1}{7}$
H. $\frac{3}{13}$
J. $4 \frac{1}{3}$
3. Jim uses 3 cups of peaches to yield 4 jars of peach jam. He also makes strawberry-peach jam. He uses equal amounts of strawberries and peaches. How many cups of strawberries does Jim need to yield 10 jars of strawberry-peach jam?
A. $3 \frac{3}{4} \mathrm{c}$
B. $4 \frac{1}{2} \mathrm{c}$
C. $7 \frac{1}{2} \mathrm{c}$
D. 9 c
4. Use the diagram below, which shows similar triangles formed by the shadows of a person and a tree.


What is the approximate height of the tree?
F. 4 ft
G. 9 ft
H. 12 ft
J. 105 ft
5. A stepped-out solution is shown below.

$$
3(3 x-1)-3(5 x-3)=4
$$

Step 1

$$
9 x-3-15 x+9=4
$$

Step 2

$$
-6 x+6=4
$$

Step 3

$$
-6 x+6-6=4-6
$$

Step 4
Step 5
Step 6

$$
\begin{aligned}
-6 x & =-2 \\
\frac{-6 x}{-6} & =\frac{-2}{-6} \\
x & =\frac{1}{3}
\end{aligned}
$$

Which property justifies Step 1?
A. Division Property of Equality
B. Subtraction Property of Equality
C. Commutative Property
D. Distributive Property
6. The perimeter $P$ of a rectangle with length $\ell$ and width $w$ can be represented by the equation $P=2 \ell+2 w$. Which expression represents the width in relation to the $P$ and $\ell$ ?
F. $P-2 \ell$
G. $P-\ell$
H. $\frac{1}{2} P-2 \ell$
J. $\frac{P-2 \ell}{2}$
7. What are the solutions of $2 u+5.2 \leq 9.4+u$ ?
A. $u \geq 4.2$
B. $u \leq 48.9$
C. $u \leq 14.6$
D. $u \leq 4.2$
8. What is the solution of $w-4=18+3 w$ ?
F. -11
G. -3.5
H. 3.5
J. 11
9. What is the solution of $\frac{18}{x}=\frac{5}{7}$ ?
A. 12.9
B. 20
C. 25.2
D. 35
10. What are the solutions of $-\frac{1}{9} a+1<8$ ?
F. $a>7$
G. $a<7$
H. $a>-63$
J. $a<-63$
11. What are the solutions of $4<6 b-2 \leq 28$ ?
A. $\frac{1}{3}<b \leq \frac{13}{3}$
B. $6<b \leq 30$
C. $\frac{2}{3}<b \leq \frac{14}{3}$
D. $1<b \leq 5$
12. A model car kit is built to a scale of $1: 32$. The length of the actual car is 416 cm . What is the length of the model car?
F. 384 cm
G. 133 cm
H. 13 cm
J. 7 cm
13. Sabrina's car has traveled $28,000 \mathrm{mi}$. If she drives 36 mi each day, which equation can be used to find the total number of miles $m$ Sabrina's car will have traveled after she drives it for $d$ days?
A. $d=36 m+28,000$
B. $m=36 d+28,000$
C. $m+36 d=28,000$
D. $d=28,000 m+36$
14. A fox runs at a rate of $26 \mathrm{mi} / \mathrm{h}$ and a cat runs at a rate of $44 \mathrm{ft} / \mathrm{s}$. What is the difference in their speeds?
(Hint: $1 \mathrm{mi}=5280 \mathrm{ft}$ )
F. $26 \mathrm{ft} / \mathrm{s}$
G. $5.9 \mathrm{ft} / \mathrm{s}$
H. $18 \mathrm{mi} / \mathrm{h}$
J. $30 \mathrm{mi} / \mathrm{h}$

## Gridded Response

15. The perimeter of a rectangle is given by the equation $2 w+33=54$. What is $w$, the width of the rectangle?
16. Pablo can wash 6 cars in 40 min . At this rate, how many cars can Pablo wash in 4 h ?
17. Travis sells black-and-white photos of cities across the country. Each photo's width is half its height. Find the area in square inches of a photo that is 4 in . tall.
18. Isabella is covering a square tabletop with square mosaic tiles. The tabletop is 2 ft long and 2 ft wide. Each tile is $\frac{1}{4} \mathrm{in}$. long and $\frac{1}{4} \mathrm{in}$. wide. What is the minimum number of tiles needed to cover the tabletop?
19. What is the solution of $\frac{7}{5}=\frac{9}{x}$ ? Round your answer to the nearest thousandth if necessary.
20. What is the value of $d$ when $11(d+1)=4(d+8)$ ?
21. The triangles below are similar. What is the value of $x$ ?

22. An insect flies 20 ft in 1 s . How fast does the insect fly in miles per hour? Round to the nearest hundredth if necessary.
23. A hockey puck travels at a constant speed of $20 \mathrm{~m} / \mathrm{s}$. What is the speed in $\mathrm{mi} / \mathrm{h}$ ? Round to the nearest hundredth. ( $1 \mathrm{~m} \approx 3.28 \mathrm{ft}$ )
24. The cost for a taxi is $\$ 2.50$ plus $\$ 2.00$ per mile. If the total for a taxi ride was $\$ 32.50$, how many miles did the customer travel?
25. You are making a scale model of a sports field. The actual field is a rectangle with a length of 315 ft and a width of 300 ft . Your scale model is 15 in . wide. What is its length in inches?
26. Pristine Printing will print business cards for $\$ .10$ each plus a setup charge of $\$ 15$. The Printing Place offers business cards for $\$ .15$ each with a setup charge of $\$ 10$. What number of business cards costs the same from either printer?
27. A new pizza shop is going to print new menus. Each menu costs $\$ .50$ to produce. The owners have a total budget of $\$ 2500$ for the new menus. How many menus can the pizza shop print?
28. Concert tickets cost $\$ 25$ each. A college student ordered some tickets online. There was a service charge of $\$ 3$ per ticket. The total came to $\$ 252$. How many tickets did the student order?

## Constructed Response

29. You have a wireless phone plan that costs $\$ 25$ per month. You must also pay $\$ .10$ per minute for each minute over 500 min . Your phone bill was more than $\$ 30$ last month. Write an inequality to represent the number of minutes $m$ you spent on the phone last month. Suppose you use 525 min next month. How much will your bill be?
30. An electric company charges a monthly fee of $\$ 30.60$ plus $\$ .0176$ for each kilowatt-hour ( kWh ) of energy used. Write an equation to represent the cost of the family's electric bill each month. Suppose the family used 1327 kWh of energy. How much was their bill?
31. The volume $V$ of a cone with radius $r$ and height $h$ is represented by the formula $V=\frac{1}{3} \pi r^{2} h$. What equation do you get when you solve the formula for $h$ ? Show all your work.
32. The cost for using a phone card is 35 cents per call plus 25 cents per minute. Write an expression for the cost of a call that is $n$ minutes long. A certain call costs $\$ 3.60$. How many minutes long was the call? Show your work.
33. You count the number of melons you use based on the number of bowls of fruit salad made, as shown in the table at the right. What is an equation that describes the relationship between the number of bowls of fruit salad $f$ and the number of melons used $m$ ?

| Fruit <br> salad, $\boldsymbol{f}$ | Melons, <br> $\boldsymbol{m}$ |
| :---: | :---: |
| 2 | 1 |
| 4 | 2 |
| 6 | 3 |
| 8 | 4 |
| 10 | 5 |

34. For safety, the weight of each rider of a certain roller coaster must fall in the range given by the inequality $10 \leq \frac{w}{2}-30 \leq 70$ where $w$ is in pounds. Solve for $w$ to find the safe weight range.
35. What graph represents the solutions to the inequality $3(f+2)>2 f+4$ ?
36. You can mow $400 \mathrm{ft}^{2}$ of grass if you work for 5 min , $800 \mathrm{ft}^{2}$ if you work for $10 \mathrm{~min}, 1200 \mathrm{ft}^{2}$ of grass if you work for 15 min , and so on. How many square feet can you mow in 45 min ?
37. A company has $\$ 1500$ in its budget for paper this year. The regular price of paper is $\$ 32$ per box, with a $10 \%$ discount for bulk orders. If the company spends at least $\$ 1400$ on paper, the shipping is free. Write a compound inequality to represent the number of boxes the company can buy with the discount and receive free shipping. What are the possible numbers of boxes the company can buy with the discount and free shipping?
38. There is a $12-\mathrm{ft}$ fence on one side of a rectangular garden. The gardener has 44 ft of fencing to enclose the other three sides. What is the length of the garden's longer dimension?
39. Jonah is planting a rectangular garden. The perimeter of the garden is 120 yd , and the width is 20 yd . What is the length of the garden?
40. A carpenter is filling in an open entranceway with a door and two side panels of the same width. The entranceway is 3 m wide. The door will be 1.2 m wide. How wide should the carpenter make the panels on either side of the door so that the two panels and the door will fill the entranceway exactly?
41. The formula for the area of a triangle is $A=\frac{1}{2} b h$. Solve the formula for $h$. A triangle has a base of 7 cm and an area of $28 \mathrm{~cm}^{2}$. What is its height?
42. Membership for the Alpine rock-climbing gym costs $\$ 25$ per month plus a $\$ 125$ sign-up fee. Membership for Rocco's rock-climbing gym costs $\$ 30$ per month plus a $\$ 50$ sign-up fee. If you only wanted a one-year membership, which gym would you join?
43. A band went to a recording studio and recorded 4 songs in 3 h . How long would it take the band to record 9 songs if they record at the same rate?
44. The scale of a map is $1 \mathrm{~cm}: 75 \mathrm{~km}$. What is the actual distance between two towns that are 3 cm apart on the map?
45. You paid $\$ 600$ for a new guitar. Your guitar cost $\$ 40$ more than twice the cost of your friend's guitar. How much did your friend's guitar cost?

## $\star$ Topic $2 \mid$ An Introduction to Functions

## TOPIC OVERVIEW

2-1 Using Graphs to Relate Two Quantities

2-2 Patterns and Linear Functions
2-3 Patterns and Nonlinear Functions
2-4 Graphing a Function Rule
2-5 Writing a Function Rule
2-6 Formalizing Relations and Functions
2-7 Using Function Notation

## VOCABULARY

English/Spanish Vocabulary Audio Online:
English
continuous graph, p. 70
dependent variable, $p .59$
discrete graph, p. 70
domain, p. 83
function, p. 59
independent variable, p. 59
input, p. 59
linear function, $p .59$
nonlinear function, p. 64
output, p. 59
Spanish
gráfica continua
variable dependiente
gráfica discreta
dominio
función
variable independiente
entrada
función lineal
función no lineal
salida
rango
relación

## Access Your Homework...

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You can do all of your homework online with built-in examples and "Show Me How" support! When you log in to your account, you'll see the homework your teacher has assigned you.

## HOMEWORK TUTOR APP

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## STUDENT TEXT AND HOMEWORK HELPER

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## If You Need Help...

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You'll find definitions of math terms in both English and Spanish. All of the terms have audio support.

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You'll have access to a robust assortment of interactive explorations, including interactive concept explorations, dynamic activitites, and topiclevel exploration activities.

## LEARNING ANIMATIONS

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## STUDENT COMPANION

Refer to your notes and solutions in your Student Companion. Remember that your Student Companion is also available as an ACTIVebook accessible on any digital device.

## INTERACTIVE MATH TOOLS

These interactive math tools give you opportunities to explore in greater depth key concepts to help build understanding.

## VIRTUAL NERD

Not sure how to do some of the practice exercises? Check out the Virtual Nerd videos for stepped-out, multi-level instructional support.

# th <br> 2-1 <br> Using Graphs to Relate Two Quantities 

## TEKS FOCUS

Foundational to TEKS (12)(A) Decide whether relations represented verbally, tabularly, graphically, and symbolically define a function.

TEKS (1)(F) Analyze mathematical relationships to connect and communicate mathematical ideas.

Additional TEKS (1)(A)

## VOCABULARY

- Analyze - closely examine objects, ideas, or relationships to learn more about their nature


## ESSENTIAL UNDERSTANDING

You can use graphs to visually represent the relationship between two variable quantities as they both change.

## Problem 1

## Analyzing a Graph

The graph shows the volume of air in a balloon as you blow it up, until it pops. What are the variables? Describe how the variables are related at various points on the graph.


The variables are volume and time. The volume increases each time you blow, and it stays constant each time you pause to breathe. When the balloon pops in the middle of the fourth blow, the volume decreases to 0 .

## Matching a Table and a Graph

Multiple Choice A band allowed fans to download its new video from its Web site. The table shows the total number of downloads after $1,2,3$, and 4 days. Which graph could represent the data shown in the table?


Video Downloads

| Day | Total <br> Downloads |
| :---: | :---: |
| 1 | 346 |
| 2 | 1011 |
| 3 | 3455 |
| 4 | 10,426 |



The relationship represented by a table

Need Plan
A graph that could represent the relationship

Compare the pattern of changes in the table to each graph.

In the table, the total number of downloads increases each day, and each increase is noticeably greater than the previous increase. So the graph should rise from left to right, and each rise should be steeper than the previous rise. The correct answer is B.

## Problem 3

## Sketching a Graph $\operatorname{IIEM}$

Rocketry A model rocket rises quickly and then slows to a stop as its fuel burns out. It begins to fall quickly until the parachute opens, after which it falls slowly back to Earth.

## Think

How can you get started?
Identify the two variables that are being related, such as height and time. Then look for key words that describe the relationship, such as rises quickly or falls slowly.

What sketch of a graph could represent the height of the rocket during its flight? Label each section.


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## What are the variables in each graph? Describe how the variables are related at

 various points on the graph.1. 


2.

3.


Match each graph with its related table. Explain your answers.
4.

5.

6.

A.

| Time | Temperature ( ${ }^{\circ}$ F) |
| :---: | :---: |
| 1 p.м. | $91^{\circ}$ |
| 3 р.м. | $89^{\circ}$ |
| 5 р.м. | $81^{\circ}$ |
| 7 р.м. | $64^{\circ}$ |

B.

C.

| Time | Temperature ( ${ }^{\circ}$ F) |
| :---: | :---: |
| 1 Р.м. | $24^{\circ}$ |
| 3 р.м. | $26^{\circ}$ |
| 5 Р.м. | $27^{\circ}$ |
| 7 Р.м. | $21^{\circ}$ |

Sketch a graph to represent each situation. Label each section.
7. hours of daylight each day over the course of one year
8. your distance from the ground as you ride a Ferris wheel
9. your pulse rate as you watch a scary movie
10. Create Representations to Communicate Mathematical Ideas (1)(E) The shishiodoshi, a popular Japanese garden ornament, was originally designed to frighten away deer. Using water, it makes a sharp rap each time a bamboo tube rises. Sketch a graph that could represent the volume of water in the bamboo tube as it operates.

11. Use Representations to Communicate Mathematical Ideas (1)(E) Describe a real-world relationship between the area of a rectangle and its width, as the width varies and the length stays the same. Sketch a graph to show this relationship.
12. Apply Mathematics (1)(A) The graph below shows the distance three runners travel during a race. Describe what occurs at times A, B, C, and D. In what order do the runners finish? Explain.

Three-Person Race

13. Apply Mathematics (1)(A) Sketch a graph of each situation. Are the graphs the same? Explain.
a. your speed as you travel on a ski lift from the bottom of a ski slope to the top
b. your speed as you ski from the top of a ski slope to the bottom
14. Explain Mathematical Ideas (1)(G) T-shirts cost $\$ 12.99$ each for the first 5 shirts purchased. Each additional T-shirt costs $\$ 4.99$ each. Describe and correct the error in the graph at the right that represents the relationship between total cost and number of shirts purchased.

15. Analyze Mathematical Relationships (1)(F) The diagram at the left below shows a portion of a bike trail.
a. Explain whether the graph below is a reasonable representation of how the speed might change for the blue bike rider.


Blue Bike's Speed

b. Sketch two graphs that could represent a bike's speed over time. Sketch one graph for the blue bike rider, and the other for the red bike rider.
16. Use Representations to Communicate Mathematical Ideas (1)(E) The graph below shows the vertical distance traveled as Person A walks up a set of stairs and Person B walks up an escalator next to the stairs. Copy the graph. Then draw a line that could represent the vertical distance traveled as Person C rides the escalator standing still. Explain your reasoning.

## Escalator and Stairs



## TEXAS End-of-Course PRACTICE

17. The graph at the right shows your distance from home as you walk to the bus stop, wait for the bus, and then ride the bus to school. Which point represents a time that you are waiting for the bus?
A. A
C. C
B. B
D. D

18. What is the solution of $-2 x<4$ ?
F. $x<2$
G. $x>2$
H. $x<-2$
J. $x>-2$
19. You earn $\$ 8.50$ per hour. Then you receive a raise to $\$ 9.35$ per hour. Find the percent increase. Then find your pay per hour if you receive the same percent increase two more times. Show your work.

## TEKS FOCUS

TEKS (2)(C) Write linear equations in two variables given a table of values, a graph, and a verbal description.

TEKS (1)(F) Analyze mathematical relationships to connect and communicate mathematical ideas.

Additional TEKS (1)(A), (1)(D)

## VOCABULARY

- Dependent variable - The dependent variable is a variable that provides the output values of a function.
- Independent variable - The independent variable is a variable that provides the input values of a function.
- Input - The input is a value of the independent variable.
- Output - The output is a value of the dependent variable.
- Function - A function is a relationship that pairs each input value with exactly one output value.
- Linear function - A linear function is a function whose graph is a nonvertical line. You can represent a linear function with a linear equation.
- Analyze - closely examine objects, ideas, or relationships to learn more about their nature


## ESSENTIAL UNDERSTANDING

The value of one variable may be uniquely determined by the value of another variable. Such relationships may be represented using tables, words, equations, sets of ordered pairs, and graphs.

## Key Concept Functions

A function is a relationship that pairs each input value with exactly one output value.

One way to represent a function is with a graph. A linear function is a function whose graph is a nonvertical line or part of a nonvertical line.


## Representing a Geometric Relationship

In the diagram below, what is the relationship between the number of rectangles and the perimeter of the figure they form? Represent this relationship using a table, words, an equation, and a graph.

## Think

Which variable is the dependent variable? The perimeter depends on the number of rectangles, so perimeter is the dependent variable.


Step 1 Make a table. Use $x$ as the independent variable and $y$ as the dependent variable.
Let $x=$ the number of rectangles.
Let $y=$ the perimeter of the figure.
Write each pair of input and output values, $x$ and $y$, as an ordered pair $(x, y)$.

| Number of <br> Rectangles, $x$ | Perimeter, <br> $y$ | Ordered <br> Pair $(x, y)$ |
| :---: | :---: | :---: |
| 1 | $2(1)+2(6)=14$ | $(1,14)$ |
| 2 | $2(2)+2(6)=16$ | $(2,16)$ |
| 3 | $2(3)+2(6)=18$ | $(3,18)$ |
| 4 | $2(4)+2(6)=20$ | $(4,20)$ |

Step 2 Look for a pattern in the table. Describe the pattern in words so you can write an equation to represent the relationship.
Words Multiply the number of rectangles in each figure by 2 to get the total length of the top and bottom sides of the combined figure. Then add 2(6), or 12 , for the total length of the left and right sides of the combined figure to get the entire perimeter.
Equation $\quad y=2 x+12$
Step 3 Use the table to make a graph.
With a graph, you can see a pattern formed by the relationship between the number of rectangles and the perimeter of the combined figure.


## Representing a Linear Function

Photography The table shows the relationship between the number of photos $x$ you take and the amount of memory $y$ in megabytes (MB) left on your camera's memory chip. Is the relationship a linear function? Describe the relationship using words, an equation, and a graph.

Camera Memory

| Number of Photos, | Memory (MB), |
| :---: | :---: |
| $x$ | $y$ |
| 0 | 512 |
| 1 | 509 |
| 2 | 506 |
| 3 | 503 |

## Know

The amount of memory left given the number of pictures taken, as shown in the table

## Need

Other representations that describe the relationship

Plan
Look for a pattern that you can describe in words to write an equation. Make a graph to show the pattern.

How can you tell if a relationship in a table is a function? If each input is paired with exactly one output, then the relationship is a function.

The amount $y$ of memory left is uniquely determined by the number $x$ of photos you take. You can see this in the table above, where each input value of $x$ corresponds to exactly one output value of $y$. So, $y$ is a function of $x$. To describe the relationship, look at how $y$ changes for each change in $x$ in the table below.


Since the number of MB decreases by the same amount, 3 MB, each time the number of photos increases by 1 , this shows that the relationship is linear.

Words The amount of memory left on the chip is 512 minus the quantity 3 times the number of photos taken.
Equation $y=512-3 x$
Graph You can use the table to make a graph. The points lie on a line, so the relationship between the number of photos taken and the amount of memory remaining is a linear function.



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For each table, determine whether the relationship is a linear function. Then represent the relationship using words, an equation, and a graph.
2.


4. Apply Mathematics (1)(A) The graph at the right shows the distance a runner has traveled as a function of the amount of time (in minutes) she has been running. Draw a graph that shows the time she has been running as a function of the distance she has traveled.
5. Apply Mathematics (1)(A) You can make 5 gal of liquid fertilizer by mixing 8 tsp of powdered fertilizer with water. Represent the relationship between the teaspoons of powder used and the gallons of fertilizer made using a table, an equation, and a graph.
 Is the amount of fertilizer made a function of the amount of powder used? Explain.
6. Analyze Mathematical Relationships (1)(F) Graph the set of ordered pairs $(-2,-3),(0,-1),(1,0),(3,2)$, and $(4,4)$. Determine whether the relationship is a linear function. Explain how you know.
7. Use Multiple Representations to Communicate Mathematical Ideas (1)(D)

Gears are common parts in many types of machinery. In the diagram below, Gear A turns in response to the cranking of Gear B. Describe the relationship between the number of turns of Gear B and the number of turns of Gear A. Use words, an equation, and a graph.

8. Apply Mathematics (1)(A) An automaker makes a car that can travel 40 mi on its charged battery before it begins to use gas. Then the car travels 50 mi per gallon of gas used. Represent the relationship between the amount of gas used and the distance traveled using a table, an equation, and a graph. Is total distance traveled a function of the amount of gas used? What are the independent and dependent variables? Explain.
9. Explain Mathematical Ideas (1)(G) Suppose you know the perimeter of $n$ octagons arranged as shown. Explain what you would do to find the perimeter if 1 more octagon was added.
10. Find the relationship between the number of pentagons and the perimeter of the figure they form. Represent this relationship using a table, words, an equation, and a graph.
For each table, determine whether the relationship is a linear function. Then represent the relationship using words, an equation, and a graph.
11.

| $x$ | $y$ |
| :---: | :---: |
| 0 | 5 |
| 1 | 8 |
| 2 | 11 |
| 3 | 14 |

12. 

| $x$ | $y$ |
| :---: | ---: |
| 0 | -3 |
| 1 | 2 |
| 2 | 7 |
| 3 | 12 |



 1 octagon 2 octagons
3 octagons

1

 1 pentagon 2 pentagons
3 pentagons
13.

| $x$ | $y$ |
| :---: | :---: |
| 0 | 43 |
| 1 | 32 |
| 2 | 21 |
| 3 | 10 |

## TEXAS End-of-Course PRACTICE

14. A 3-ft fire hydrant is next to a road sign. The shadow of the fire hydrant is 4.5 ft long. The shadow of the road sign is 12 ft long. The shadows form similar triangles. What is the height in feet of the sign?
A. 1.6875
B. 8
C. 12
D. 16.5
15. What is the solution of $5 d+6-3 d=12$ ?
F. 2.25
G. 3
H. 9
J. 18
16. The table below shows the relationship between the number of sprays $x$ a bottle of throat spray delivers and the amount of spray $y$ (in milligrams) left in the bottle. Describe the relationship using words, an equation, and a graph.

| Throat Spray |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Number of Sprays, $\boldsymbol{x}$ | 0 | 1 | 2 | 3 | 4 |  |
| Spray Left (mg), $\boldsymbol{y}$ | 62,250 | 62,200 | 62,150 | 62,100 | 62,050 |  |

# + 

## TEKS FOCUS

Foundational to TEKS (12)(D) Write a formula for the $n$th term of arithmetic and geometric sequences, given the value of several of their terms.

TEKS (1)(E) Create and use representations to organize, record, and communicate mathematical ideas.

Additional TEKS (1)(A)

## VOCABULARY

- Nonlinear function - a function whose graph is not a line or part of a line
- Representation - a way to display or describe information. You can use a representation to present mathematical ideas and data.


## ESSENTIAL UNDERSTANDING

Just like linear functions, nonlinear functions can be represented using words, tables, equations, sets of ordered pairs, and graphs.

## Concept Summary Linear and Nonlinear Functions

## Linear Function

A linear function is a function whose graph is a nonvertical line or part of a nonvertical line.


## Nonlinear Function

A nonlinear function is a function whose graph is not a line or part of a line.


## Classifying Functions as Linear or Nonlinear

Pizza The area $A$, in square inches, of a pizza is a function of its radius $r$, in inches. The cost $C$, in dollars, of the sauce for a pizza is a function of the weight $w$, in ounces, of sauce used. Graph these functions shown by the tables below. Is each function linear or nonlinear?

| Pizza Area |  |
| :---: | :---: |
| Radius (in.), $r$ | Area (in. ${ }^{2}$ ), A |
| 2 | 12.57 |
| 4 | 50.27 |
| 6 | 113.10 |
| 8 | 201.06 |
| 10 | 314.16 |


| Sauce Cost |  |
| :---: | :---: |
| Weight (oz), w | Cost, C |
| 2 | $\$ .80$ |
| 4 | $\$ 1.60$ |
| 6 | $\$ 2.40$ |
| 8 | $\$ 3.20$ |
| 10 | $\$ 4.00$ |

## Know

The relationships shown in the tables are functions.

Graph $A$ as a function of $r$.

## Pizza Area



The graph is a curve, not a line, so the function is nonlinear.

## Need

To classify the functions as
linear or nonlinear
plan
Use the tables to make graphs.

Graph $C$ as a function of $w$.


The graph is part of a line, so the function is linear.

## Representing Patterns and Nonlinear Functions

The table shows the total number of blocks in each figure below as a function of the number of blocks on one edge.


| Number of <br> Blocks on Edge, $x$ | Total Number <br> of Blocks, $y$ | Ordered <br> Pair $(x, y)$ |
| :---: | :---: | :---: |
| 1 | 1 | $(1,1)$ |
| 2 | 8 | $(2,8)$ |
| 3 | 27 | $(3,27)$ |
| 4 |  |  |
| 5 |  |  |

What is a pattern you can use to complete the table? Represent the relationship using words, an equation, and a graph.
Draw the next two figures to complete the table.

## Think

How can you use a pattern to complete the table? You can draw figures with 4 and 5 blocks on an edge. Then analyze the figures to determine the total number of blocks they contain.


Words The total number of blocks $y$ is the cube of the number of blocks on one edge $x$.

Equation $y=x^{3}$
You can use the table to make a graph. The points do not lie on a line. So the relationship between the number of blocks on one edge and the total number of blocks is a nonlinear function.


## Writing a Rule to Describe a Nonlinear Function

The ordered pairs $(1,2),(2,4),(3,8),(4,16)$, and $(5,32)$ represent a function. What is a rule that represents this function?

Make a table to organize the $x$ - and $y$-values. For each row, identify rules that produce the given $y$-value when you substitute the $x$-value. Look for a pattern in the $y$-values.

| $X$ | y | What rule produces 2 , given an $x$-value of 1 ? The |
| :---: | :---: | :---: |
| 1 | 2 | $y=2 x, y=x+1$, and $y=2^{x}$ work for (1,2). |
| 2 | 4 | $y=x+1$ does not work for (2,4). $y=2 x$ works |
| 3 | 8 | for $(2,4)$, but not for $(3,8) . y=2^{x}$ works for all three pairs. |
| 4 | 16 |  |
| 5 | 32 | $=2 \cdot 2 \cdot 2$ and $16=2 \cdot 2 \cdot 2 \cdot 2$. The pattern of $y$-values matches $2^{1}, 2^{2}, 2^{3}, 2^{4}, 2^{5}$, or $y=2^{x}$. |

The function can be represented by the rule $y=2^{x}$.

## PRACTICE and APPLICATION EXERCISES



For additional support when completing your homework, go to PearsonTEXAS.com.

The cost $C$, in dollars, for pencils is a function of the number $\boldsymbol{n}$ of pencils purchased. The length $L$ of a pencil, in inches, is a function of the time $t$, in seconds, it has been sharpened. Graph the function shown by each table below. Tell whether the function is linear or nonlinear.
1.

2.


Graph the function shown by each table. Tell whether the function is linear or nonlinear.
3.

| $x$ | $y$ |
| :---: | :---: |
| 0 | 5 |
| 1 | 5 |
| 2 | 5 |
| 3 | 5 |

4. 

| $x$ | $y$ |
| :---: | :---: |
| 0 | -4 |
| 1 | -3 |
| 2 | 0 |
| 3 | 5 |

5. 


6.

7. For the diagram below, the table gives the total number of small triangles $y$ in figure number $x$. What pattern can you use to complete the table? Represent the relationship using words, an equation, and a graph.


| Figure <br> Number, $x$ | Total Small <br> Triangles, $y$ | Ordered <br> Pair $(x, y)$ |
| :---: | :---: | :---: |
| 1 | 3 | $(1,3)$ |
| 2 | 12 | $(2,12)$ |
| 3 | 27 | $(3,27)$ |
| 4 |  |  |
| 5 | $\square$ |  |

Figure 3
Each set of ordered pairs represents a function. Write a rule that represents the function.
8. $(0,0),(1,4),(2,16),(3,36),(4,64)$
9. $\left(1, \frac{2}{3}\right),\left(2, \frac{4}{9}\right),\left(3, \frac{8}{27}\right),\left(4, \frac{16}{81}\right),\left(5, \frac{32}{243}\right)$
10. $(1,2),(2,16),(3,54),(4,128),(5,250)$
11. $(0,0),(1,0.5),(2,2),(3,4.5),(4,8)$
12. Explain Mathematical Ideas (1)(G) The rule $V=\frac{4}{3} \pi r^{3}$ gives the volume $V$ of a sphere as a function of its radius $r$. Identify the independent and dependent variables in this relationship. Explain your reasoning.
13. Create Representations to Communicate Mathematical Ideas (1)(E) Write a rule for a nonlinear function such that $y$ is negative when $x=1$, positive when $x=2$, negative when $x=3$, positive when $x=4$, and so on.
14. Apply Mathematics (1)(A) Concrete forming tubes are used as molds for cylindrical concrete supports. The volume $V$ of a tube is the product of its length $\ell$ and the area $A$ of its circular base. You can make $\frac{2}{3} \mathrm{ft}^{3}$ of concrete per bag of cement. Write a rule to find the number of bags of cement needed to fill a tube 4 ft long as a function of its radius $r$. How many bags are needed to fill a tube with a 4 -in. radius? A 5-in. radius? A 6-in. radius?

15. Apply Mathematics (1)(A) A designer wants to make a circular fountain inside a square of grass, as shown below. What is a rule for the area $A$ of the grass as a function of $r$ ?

16. Explain Mathematical Ideas (1)(G) What is a rule for the function represented by $\left(0, \frac{2}{19}\right),\left(1,1 \frac{2}{19}\right),\left(2,4 \frac{2}{19}\right),\left(3,9 \frac{2}{19}\right),\left(4,16 \frac{2}{19}\right)$, and $\left(5,25 \frac{2}{19}\right)$ ? Explain your reasoning.
17. Explain Mathematical Ideas (1)(G) A certain function fits the following description: As the value of $x$ increases by 1 each time, the value of $y$ continually decreases by a smaller amount each time, and never reaches a value as low as 1 . Is this function linear or nonlinear? Explain your reasoning.

## TEXAS End-of-Course PRACTICE

18. The ordered pairs $(-2,1),(-1,-2),(0,-3),(1,-2)$, and $(2,1)$ represent a function. Which rule could represent the function?
A. $y=-3 x-5$
B. $y=x^{2}-3$
C. $y=x+3$
D. $y=x^{2}+5$
19. You are making a model of the library. The floor plans for the library and the plans for your model are shown. What is the value of $x$ ?

F. 1.4 in.
G. 2.8 in .
H. 23.2 in.
J. 437.5 in .
20. A $15-$ oz can of tomatoes costs $\$ .89$, and a 29 -oz can costs $\$ 1.69$. Which can has the lower cost per ounce? Justify your answer.

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<td style="text-align: center; border-right-style: solid !important; border-right-width: 1px !important; border-bottom: none !important; border-top: none !important; width: auto; vertical-align: middle; ">$2-4$</td>
<td style="text-align: center; border-bottom: none !important; border-top: none !important; width: auto; vertical-align: middle; ">Graphing a Function Rule</td>
</tr>
</tbody>
</table>
<table-markdown style="display: none">| $\star$ | $2-4$ | Graphing a Function Rule |
| :---: | :---: | :---: |</table-markdown></div> 

## TEKS FOCUS

TEKS (3)(C) Graph linear functions on the coordinate plane and identify key features, including $x$-intercept, $y$-intercept, zeros, and slope, in mathematical and real-world problems.

TEKS (1)(D) Communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.

Additional TEKS (1)(A)

## VOCABULARY

- Continuous graph - a graph that is unbroken
- Discrete graph - a graph that is composed of distinct, isolated points
- Representation - a way to display or describe information. You can use a representation to present mathematical ideas and data.


## ESSENTIAL UNDERSTANDING

The set of all solutions of an equation forms the equation's graph. A real-world graph should only show points that make sense in the given situation.

## Key Concept Continuous and Discrete Graphs

## Continuous Graph

A continuous graph is a graph that is unbroken.


## Discrete Graph

A discrete graph is composed of distinct, isolated points.


## Problem 1

## Think

What input values make sense here? It is possible to use any input $x$ in the equation and get an output $y$. Choose integer values of $x$ to produce integer values of $y$, which are easier to graph.

## Graphing a Function Rule

What is the graph of the function rule $y=-2 x+1$ ?

Step 1 Make a table of values.

| $x$ | $y=-2 x+1$ | $(x, y)$ |
| ---: | :---: | :---: |
| -1 | $y=-2(-1)+1=3$ | $(-1,3)$ |
| 0 | $y=-2(0)+1=1$ | $(0,1)$ |
| 1 | $y=-2(1)+1=-1$ | $(1,-1)$ |
| 2 | $y=-2(2)+1=-3$ | $(2,-3)$ |

Step 2 Graph the ordered pairs.


Connect the points with a line to represent all solutions.

## Plan

How do you choose values for a realworld independent variable?
Look for information about what the values can be. The independent variable $c$ in this problem is limited by the capacity of the truck, $200 \mathrm{ft}^{3}$.

## Graphing a Real-World Function Rule

Trucking The function rule $W=146 c+30,000$ represents the total weight $W$, in pounds, of a concrete mixer truck that carries $c$ cubic feet of concrete. If the capacity of the truck is about $200 \mathrm{ft}^{3}$, what is a reasonable graph of the function rule?

## Step 1

Make a table to find ordered pairs $(c, W)$.

The truck can hold 0 to $200 \mathrm{ft}^{3}$ of concrete. So only c-values from 0 to 200 are reasonable.

| $c$ | $W=146 c+30,000$ | $(c, W)$ |
| :---: | :---: | :---: |
| 0 | $W=146(0)+30,000=30,000$ | $(0,30,000)$ |
| 50 | $W=146(50)+30,000=37,300$ | $(50,37,300)$ |
| 100 | $W=146(100)+30,000=44,600$ | $(100,44,600)$ |
| 150 | $W=146(150)+30,000=51,900$ | $(150,51,900)$ |
| 200 | $W=146(200)+30,000=59,200$ | $(200,59,200)$ |

## Step 2

Graph the ordered pairs from the table.
$W$ reaches almost $60,000 \mathrm{lb}$. So $W$-values from 0 to 60,000 in grid increments of 10,000 make sense.


All c-values from 0 to 200 make sense, so connect the points. Stop at $200 \mathrm{ft}^{3}$, the capacity of the truck.

The $c$-values go from 0 to 200 . 200 is evenly divisible by 25 , so use grid increments of 25 .

## Identifying Continuous and Discrete Graphs

Farmers' Market A local cheese maker is making cheddar cheese to sell at a farmers' market. The amount of milk used to make the cheese and the price at which he sells the cheese are shown. Write a function for each situation. Graph each function. Is the graph continuous or discrete?

## Think

## How can you

 decide if a graph is continuous or discrete?Decide what values are reasonable for the independent variable. For example, if 3 and 4 make sense, do 3.3 and 3.7 make sense as well?

## Graphing Nonlinear Function Rules

What is the graph of each function rule?
A $y=|x|-4$

Step 1
Make a table of values.

| $x$ | $y=\|x\|-4$ | $(x, y)$ |
| ---: | :--- | :---: |
| -4 | $y=\|-4\|-4=0$ | $(-4,0)$ |
| -2 | $y=\|-2\|-4=-2$ | $(-2,-2)$ |
| 0 | $y=\|0\|-4=-4$ | $(0,-4)$ |
| 2 | $y=\|2\|-4=-2$ | $(2,-2)$ |
| 4 | $y=\|4\|-4=0$ | $(4,0)$ |

B $y=x^{2}+1$
Step 1
Make a table of values.

| $x$ | $y=x^{2}+1$ | $(x, y)$ |
| ---: | :--- | :---: |
| -2 | $y=(-2)^{2}+1=5$ | $(-2,5)$ |
| -1 | $y=(-1)^{2}+1=2$ | $(-1,2)$ |
| 0 | $y=0^{2}+1=1$ | $(0,1)$ |
| 1 | $y=1^{2}+1=2$ | $(1,2)$ |
| 2 | $y=2^{2}+1=5$ | $(2,5)$ |

Step 2
Graph the ordered pairs. Connect the points.


## Step 2

Graph the ordered pairs. Connect the points.


## PRACTICE and APPLICATION EXERCISES



For additional support when completing your homework, go to PearsonTEXAS.com.

## Graph each function rule.

1. $y=2 x-1$
2. $y=\frac{3}{4} x+2$
3. $y=-\frac{1}{2} x+\frac{1}{2}$

Graph each function rule. Explain your choice of intervals on the axes of the graph. Tell whether the graph is continuous or discrete.
4. The height $h$, in inches, of the juice in a $20-\mathrm{oz}$ bottle depends on the amount of juice $j$, in ounces, that you drink. This situation is represented by the function rule $h=6-0.3 j$.
5. The total weight $w$, in pounds, of a tractor-trailer capable of carrying 8 cars depends on the number of cars $c$ on the trailer. This situation is represented by the function rule $w=37,000+4200 c$.
6. The cost $C$, in dollars, for delivered pizza depends on the number $p$ of pizzas ordered. This situation is represented by the function rule $C=5+9 p$.

## Graph each function rule.

7. $y=|-2 x|-1$
8. $y=-x^{3}$
9. $y=|x-3|-1$
10. Explain Mathematical Ideas (1)(G) The graph below shows the distance $d$ you run, in miles, as a function of time $t$, in minutes, during a $5-\mathrm{mi}$ run. Your friend says that the graph is not continuous because it stops at $d=5$, so the graph is discrete. Do you agree? Explain.

11. Is the point $\left(2,2 \frac{1}{2}\right)$ on the graph of $y=x+2$ ? How do you know?
12. Create Representations to Communicate Mathematical Ideas (1)(E)

The area $A$ of an isosceles right triangle depends on the length $\ell$ of each leg of the triangle. This is represented by the rule $A=\frac{1}{2} \ell^{2}$. Graph the function rule. Is the graph continuous or discrete? How do you know?
13. Apply Mathematics (1)(A) The amount a basketball coach spends at a sporting goods store depends on the number of basketballs the coach buys. The situation is represented by the function rule $a=15 b$.
a. Make a table of values and graph the function rule. Is the graph continuous or discrete? Explain.
b. Suppose the coach spent $\$ 120$ before tax. How many basketballs did she buy?
14. Which function rule is graphed at the right?
A. $y=-\frac{1}{2} x+1$
B. $y=\frac{1}{2} x-1$
C. $y=\left|\frac{1}{2} x\right|-1$
D. $y=\frac{1}{2} x+1$

15. Create Representations to Communicate Mathematical Ideas (1)(E) The height $h$, in inches, of the vinegar in the jars of pickle chips shown at the right depends on the number of chips $p$ you eat. About how many chips must you eat to lower the level of the vinegar in the jar on the left to the level of the jar on the right? Use a graph to find the answer.

16. Apply Mathematics (1)(A) The height $h$, in feet, of an acorn that falls from a branch 100 ft above the ground depends on the time $t$, in seconds, since it has fallen. This is represented by the rule $h=100-16 t^{2}$. About how much time does it take for the acorn to hit the ground? Use a graph and give an answer between two consecutive whole-number values of $t$.
17. Analyze Mathematical Relationships (1)(F) Graph the function rules $y=|x|+1, y=|x|+4, y=|x|-3$ in the same coordinate plane. In the function rule $y=|x|+k$, how does changing the value of $k$ affect the graph?
18. Use Multiple Representations to Communicate Mathematical Ideas (1)(D) Make a table of values and a graph for the function rules $y=2 x$ and $y=2 x^{2}$. How does the value of $y$ change when you double the value of $x$ for each function rule?

## TEXAS End-of-Course PRACTICE

19. A plumber's bill $b$ is based on $\$ 125$ for materials and $\$ 50$ per hour for $t$ hours of labor. This situation can be represented by the function rule $b=50 t+125$. Suppose the plumber works for $3 \frac{1}{4} \mathrm{~h}$. How much is the bill?
20. No more than $\frac{1}{10}$ of the people attending an auto race will be given a free hat. If maximum attendance is 3510 people, what is the greatest number of free hats that can be given away?
21. What is the solution of $\frac{12}{b}=\frac{36}{51}$ ?
22. What is the solution of $2(x-5)=2-x$ ?

## USE WITH LESSON 2-4

```
TEKS (3)(C), (5)(A), (1)(F)
```

You have learned to graph function rules by making a table of values. You can also use a graphing calculator to graph function rules.

## Example 1

Graph $y=\frac{1}{2} x-4$ using a graphing calculator.
Step 1 Press the $\mathbf{y}=$ key. To the right of $\mathbf{Y}_{\mathbf{1}}=$, enter $\frac{1}{2} x-4$ by pressing $1 \div 2 \pi 4$.


Step 2 The screen on the graphing calculator is a "window" that lets you look at only part of the graph. Press the window key to set the borders of the graph. A good window for this function rule is the standard viewing window, $-10 \leq x \leq 10$ and $-10 \leq y \leq 10$.

You can have the axes show 1 unit between tick marks by setting Xscl and Yscl to 1 , as shown.


Step 3 Press the graph key. The graph of the function rule is shown.


In Chapter 1 you learned how to solve equations in one variable. You can also solve equations by using a graphing calculator to graph each side of the equation as a function rule. The $x$-coordinate of the point where the graphs intersect is the solution of the equation.

## Example 2

Solve $7=-\frac{3}{4} k+3$ using a graphing calculator.
Step 1 Press $y=$. Clear any equations. Then enter each side of the given equation. For $\mathbf{Y}_{1}=$, enter 7. For $\mathbf{Y}_{2}=$, enter $-\frac{3}{4} x+3$ by pressing $\int(-) 3<4 \sqrt{\square} \times$. Notice that you must replace the variable $k$ with $x$.

Step 2 Graph the function rules. Use a standard graphing window by pressing 200 m . This gives a window defined by $-10 \leq x \leq 10$
 and $-10 \leq y \leq 10$.

Step 3 Use the CALC feature. Select INTERSECT and press enter 3 times to find the point where the graphs intersect.

The calculator's value for the $x$-coordinate of the point of intersection is -5.333333 . The actual $x$-coordinate is $-5 \frac{1}{3}$.
The solution of the equation $7=-\frac{3}{4} k+3$ is $-5 \frac{1}{3}$.


## Exercises

## Graph each function rule using a graphing calculator.

1. $y=6 x+3$
2. $y=-3 x+8$
3. $y=0.2 x-7$
4. $y=-1.8 x-6$
5. $y=-\frac{1}{3} x+5$
6. $y=\frac{8}{3} x-5$
7. Select Techniques to Solve Problems (1)(C) Graph $y=-0.4 x+8$. Using the window screen, experiment with values for Xmin, Xmax, Ymin, and Ymax until you can see the graph crossing both axes. What values did you use for Xmin, Xmax, Ymin, and Ymax?
8. Analyze Mathematical Relationships (1)(F) How can you graph the equation $2 x+3 y=6$ on a graphing calculator?

Use a graphing calculator to solve each equation.
9. $8 a-12=6$
10. $-4=-3 t+2$
11. $-5=-0.5 x-2$
12. $4+\frac{3}{2} n=-7$
13. $\frac{5}{4} d-\frac{1}{2}=6$
14. $-3 y-1=3.5$

| $\star$ | 2-5 Writing a Function Rule |
| :---: | :---: |

## TEKS FOCUS

TEKS (2)(C) Write linear equations in two variables given a table of values, a graph, and a verbal description.
TEKS (1)(A) Apply mathematics to problems arising in everyday life, society, and the workplace.

Additional TEKS (1)(D), (1)(E)

## VOCABULARY

- Apply - use knowledge or information for a specific purpose, such as solving a problem


## ESSENTIAL UNDERSTANDING

Many real-world functional relationships can be represented by equations. You can use an equation to find the solution of a given real-world problem.

How can a model help you visualize a real-world situation? Use a model like the one below to represent the relationship that is described.


## Writing a Linear Function Rule

Insects You can estimate the temperature by counting the number of chirps of the snowy tree cricket. The outdoor temperature is about $40^{\circ} \mathrm{F}$ more than one fourth the number of chirps the cricket makes in one minute. What is a linear function rule that represents this situation?

Relate Temperature is $40^{\circ} \mathrm{F}$ more than $\frac{1}{4}$ of the number of chirps in 1 min .
Define Let $T=$ the temperature. Let $n=$ the number of chirps in 1 min .
Write $T=40+\frac{1}{4} \cdot n$
A linear function rule that represents this situation is $T=40+\frac{1}{4} n$.

## Problem 2

## Writing and Evaluating a Linear Function Rule

Concert Revenue A concert seating plan is shown below. Reserved seating is sold out. Total revenue from ticket sales will depend on the number of general-seating tickets sold. Write a linear function rule to represent this situation. What is the maximum possible total revenue?


## Plan

How can a model help you write an equation? A model like the one below can help you write an expression for the general-seating revenue.

Add the reserved-seating revenue to get the total revenue.

Relate Total revenue is


Define Let $R=$ the total revenue.
Let $n=$ the number of general-seating tickets sold.
Write $R=10 \quad$ • $\quad=\quad+\quad(25 \cdot 10 \cdot 12)$

$$
R=10 n+3000
$$

The linear function rule $R=10 n+3000$ represents this situation. There are $30 \cdot 16=480$ general-seating tickets. Substitute 480 for $n$ to find the maximum possible revenue.

$$
R=10(480)+3000=7800
$$

The maximum possible revenue from ticket sales is $\$ 7800$.

## Think

How can drawing a diagram help you to write a rule? A diagram visually represents information in the problem. It can give you a clearer understanding of how variables are related.

Step 2 Revise the model to show that the length is 5 ft more than the width.

## Writing a Nonlinear Function Rule

Geometry Write a function rule for the area of a rectangle whose length is 5 ft more than its width. What is the area of the rectangle when its width is 9 ft ?

Step 1 Represent the general relationship first. The area $A$ of a rectangle is the product of its length $\ell$ and its width $w$.


The length is 5 ft more than the width. You can substitute $w+5$ for $\ell$.

Step 3 Use the diagram in Step 2 to write the function rule. The function rule $A=(w+5) w$, or $A=w^{2}+5 w$, represents the rectangle's area.
Substitute 9 for $w$ to find the area when the width is 9 ft .

$$
\begin{aligned}
A & =9^{2}+5(9) \\
& =81+45 \\
& =126
\end{aligned}
$$

When the width of the rectangle is 9 ft , its area is $126 \mathrm{ft}^{2}$.

For additional support when completing your homework, go to PearsonTEXAS.com.

## Write a linear function rule that represents each sentence.

1. $y$ is 5 less than the product of 4 and $x$.
2. $C$ is 8 more than half of $n$.
3. 7 less than three fifths of $b$ is $a$.
4. 2.5 more than the quotient of $h$ and 3 is $w$.
5. Write a function rule for the volume of the cylinder shown at the right with a height 3 in. more than 4 times the radius of the cylinder's base. What is the volume of the cylinder when it has a radius of 2 in.?
6. Write a function rule for the area of a triangle with a base 3 cm greater than 5 times its height. What is the area of the triangle when its height is 6 cm ?
7. Write a function rule for the area of a rectangle with a length 2 ft less than three times its width. What is the area of the rectangle when its width is 2 ft ?
8. Apply Mathematics (1)(A) Write a function rule that models a real-world situation. Evaluate your function for an input value and explain what the output

$V=\pi r^{2} h$ represents.

## Write a linear function rule that represents each situation.

9. A worker's earnings $e$ are a function of the number of hours $n$ worked at a rate of $\$ 8.75$ per hour.
10. The price $p$ of a pizza is $\$ 6.95$ plus $\$ .95$ for each topping $t$ on the pizza.
11. The load $L$, in pounds, of a wheelbarrow is the sum of its own 42-lb The wheelbarrow weight and the weight of the bricks that it carries, as shown at the right. holds $n 4$-lb bricks.
12. The almond extract $a$ remaining in an 8 -oz bottle decreases by $\frac{1}{6} \mathrm{oz}$ for each batch $b$ of waffle cookies made.
13. A helicopter hovers 40 ft above the ground. Then the helicopter climbs at a
 rate of $21 \mathrm{ft} / \mathrm{s}$. Write a rule that represents the helicopter's height $h$ above the ground as a function of time $t$. What is the helicopter's height after 45 s ?
14. A team of divers assembles at an elevation of -10 ft relative to the surface of the water. Then the team dives at a rate of $-50 \mathrm{ft} / \mathrm{min}$. Write a rule that represents the team's depth $d$ as a function of time $t$. What is the team's depth after 3 min ?
15. A new book is being planned. It will have 24 pages of introduction. Then it will have $c$ 12-page chapters and 48 more pages at the end. Write a rule that represents the total number of pages $p$ in the book as a function of the number of chapters. Suppose the book has 25 chapters. How many pages will it have?
16. Apply Mathematics (1)(A) The golden ratio has been studied and used by mathematicians and artists for more than 2000 years. A golden rectangle, constructed using the golden ratio, has a length about 1.6 times its width. Write a rule for the area of a golden rectangle as a function of its width.
17. From an elevation of 3.5 m below the surface of the water, a northern bottlenose whale dives at a rate of $1.8 \mathrm{~m} / \mathrm{s}$. Write a rule that gives the whale's depth $d$ as a function of time in minutes. What is the whale's depth after 4 min ?
18. Apply Mathematics (1)(A) The height $h$, in inches, of the juice in the pitcher shown at the right is a function of the amount of juice $j$, in ounces, that has been poured out of the pitcher. Write a linear function rule that represents this situation. What is the height of the juice after 47 oz have been poured out?
19. Use Multiple Representations to Communicate Mathematical Ideas (1)(D) You go to dinner and decide to leave a $15 \%$ tip for the server. You had $\$ 55$ when you entered the restaurant.
a. Make a table showing how much money you would have left after buying a meal that costs $\$ 15, \$ 21, \$ 24$, or $\$ 30$.
b. Write a linear function rule for the amount of money $m$ you would have left if the meal costs $c$ dollars before the tip.
c. Graph the function rule.

volume $=64 \mathrm{oz}$
20. Apply Mathematics (1)(A) A car rental agency charges $\$ 29$ per day to rent a car and $\$ 13.95$ per day for a global positioning system (GPS). Customers are charged for their full tank of gas at $\$ 3.80$ per gallon.
a. A car has a 12-gal tank and a GPS. Write a rule for the total bill $b$ as a function of the number of days $d$ the car is rented.
b. What is the bill for a 9-day rental?
21. Apply Mathematics (1)(A) You consult your new projector's instruction manual before mounting it on the wall. The manual says to multiply the desired image width by 1.8 to find the correct distance of the projector lens from the wall.
a. Write a rule to describe the distance of the lens from the wall as a function of desired image width.

b. The diagram shows the room in which the projector will be installed. Will you be able to project an image 7 ft wide? Explain.
c. What is the maximum image width you can project in the room?

Create Representations to Communicate Mathematical Ideas (1)(E) Make a table and a graph of each set of ordered pairs $(x, y)$. Then write a function rule to represent the relationship between $x$ and $y$.
22. $(-4,7),(-3,6),(-2,5),(-1,4),(0,3),(1,2),(2,1),(3,0),(4,-1)$
23. $(-4,15),(-3,8),(-2,3),(-1,0),(0,-1),(1,0),(2,3),(3,8),(4,15)$

## TEXAS End-of-Course PRACTICE

24. You buy $x$ pounds of cherries for $\$ 2.99 / \mathrm{lb}$. What is a function rule for the amount of change $C$ you receive from a $\$ 50$ bill?
A. $C=2.99 x-50$
B. $C=50-2.99 x$
C. $C=50 x-2.99$
D. $C=2.99-50 x$
25. What is the solution of $-5<h+2<11$ ?
F. $-3<h<11$
G. $-7<h<9$
H. $-7>h>9$
J. $h<-7$ or $h>9$
26. Which equation do you get when you solve $-a x+b y^{2}=c$ for $b$ ?
A. $b=\frac{c-a x}{y^{2}}$
B. $b=y^{2}(c+a x)$
C. $b=\frac{c+a x}{y^{2}}$
D. $b=\frac{c}{y^{2}}+a x$

# + <br> 2-6 Formalizing Relations and Functions 

## TEKS FOCUS

TEKS (12)(A) Decide whether relations represented verbally, tabularly, graphically, and symbolically define a function.

TEKS (1)(D) Communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.

## Additional TEKS (1)(G)

## VOCABULARY

- Domain - the possible values for the input of a relation or function; the $x$-values
- Range - the possible values for the output of a relation or function; the $y$-values
- Relation - any set of ordered pairs
- Vertical line test - This is a method used to determine if a relation is a function or not. If a vertical line passes through a graph more than once, the graph is not the graph of a function.
- Implication - a conclusion that follows from previously stated ideas or reasoning without being explicitly stated
- Representation - a way to display or describe information. You can use a representation to present mathematical ideas and data.


## ESSENTIAL UNDERSTANDING

A function is a special type of relation in which each value in the domain is paired with exactly one value in the range.

## Identifying Functions Using Mapping Diagrams

## Think

When is a relation not a function? A function maps each domain value to exactly one range value. So a relation that maps a domain value to more than one range value cannot be a function.

Identify the domain and range of each relation. Represent the relation with a mapping diagram. Is the relation a function?

A $\{(-2,0.5),(0,2.5),(4,6.5),(5,2.5)\}$
The domain is $\{-2,0,4,5\}$.
The range is $\{0.5,2.5,6.5\}$.

| Domain Range | Each domain | Domain | Range | The domain value |
| :---: | :---: | :---: | :---: | :---: |
| $-2 \longrightarrow 0.5$ | value is mapped |  | 3 | 6 is mapped to |
| $\rightarrow 2.5$ | to only one range |  |  | two range values. |
| $6.5$ | value. The relation is a function |  |  | The relation is not a function. |

## Problem 2

## Identifying Functions Using Tables

## Think

How can you decide whether the relation shown is a function? In a function, each $x$-value corresponds to exactly one $y$-value.

Decide whether the relation shown in the table defines a function.


In the table, each $x$-value is associated with exactly one $y$-value. This table defines a function.


In this table, there are two different $y$-values associated with $x=4$. This table does not define a function.

## Identifying Functions Using the Vertical Line Test

Is the relation a function? Use the vertical line test.
A $\{(-4,2),(-3,1),(0,-2),(-4,-1),(1,2)\}$
B $y=-x^{2}+3$

## Think

Use a pencil as a vertical line. Place the pencil parallel to the $y$-axis and slide it across the graph. See if the pencil intersects more than one point at any time.


The relation is not a function.

There is no vertical line that passes through more than one point of the graph.


The relation is a function.

## Problem 4

## Plan

How can you determine whether the relation is a function? Identify the input and output variables. For each value of the input variable, there must be exactly one corresponding value of the output variable.

## Identifying Functions Using Verbal Descriptions

Read the description of each relation and decide whether the relation is a function.
A The volume of a sphere is the product of $\frac{4}{3} \pi$ and the cube of the radius.
This relation is a function. For each possible radius measure, there is exactly one associated volume.

Each day, the local weather station records the high temperature for the day, $T$, and the amount of rainfall in inches, $r$.

No, this relation is not a function. Over time, there will be days that have the same high temperature recorded but different amounts of rain.

## Problem 4 continued

C Your friend has a part-time job assembling bicycles for a local store. Each day, he earns $\mathbf{\$ 2 0}$ plus $\$ 15$ for each bike assembled.

Yes, this relation is a function. For a given number of bicycles assembled, there is exactly one corresponding amount earned.


For additional support when completing your homework, go to PearsonTEXAS.com.

Use Multiple Representations to Communicate Mathematical Ideas (1)(D) Identify the domain and range of each relation. Use a mapping diagram to determine whether the relation is a function.

1. $\{(0.04,0.2),(0.2,1),(1,5),(5,25)\}$
2. $\{(4,2),(1,1),(0,0),(1,-1),(4,-2)\}$

Use the vertical line test to determine whether the relation is a function.
3.

4.

5.

6.


Determine whether each relation is a function. Assume that each different variable has a different value.
7. $\{(a, b),(b, a),(c, c),(e, d)\}$
8. $\{(b, b),(c, d),(d, c),(c, a)\}$
9. $\{(c, e),(c, d),(c, b)\}$
10. $\{(a, b),(b, c),(c, d),(d, e)\}$

Determine whether each table represents a function.
11.

| Height (in.) | Weight (lb) |
| :---: | :---: |
| 62 | 108 |
| 68 | 159 |
| 64 | 131 |
| 65 | 128 |
| 60 | 110 |
| 68 | 162 |
| 64 | 115 |
| 67 | 135 |
| 63 | 118 |
| 66 | 140 |

12. 

| $x$ | $y$ |
| ---: | ---: |
| -2 | 4 |
| -1 | 4 |
| 0 | 4 |
| 1 | 4 |
| 2 | 4 |

13. The table to the right shows the number of passes attempted and the number of passes completed for the top 10 quarterbacks during a certain week. Does this table define a function?
14. Create Representations to Communicate Mathematical Ideas (1)(E) Make a table that represents a relation that is not a function. Explain why the relation is not a function.
15. What value of $x$ makes the relation $\{(1,5),(x, 8),(-7,9)\}$ a function?
16. Explain Mathematical Ideas (1)(G) Can the graph of a function be a horizontal line? A vertical line? Explain.
17. To form the inverse of a relation written as a set of ordered pairs, you switch the coordinates of each ordered pair. For example, the inverse of the relation $\{(1,8),(3,5),(7,9)\}$ is $\{(8,1),(5,3),(9,7)\}$. Give an example of a relation that is a function, but whose inverse is not a function.

| Passes <br> Attempted | Passes <br> Completed |
| :---: | :---: |
| 41 | 26 |
| 42 | 25 |
| 37 | 32 |
| 46 | 29 |
| 29 | 16 |
| 50 | 32 |
| 54 | 30 |
| 37 | 23 |
| 28 | 19 |
| 35 | 22 |

18. Analyze Mathematical Relationships (1F) Complete the table using the values 1,2 , and 3 so that the table represents a function.


Determine whether the relation represented by each table is a function. If the relation is a function, state the domain and range.
19.

20.

| $x$ | -4 | -1 | 0 | 3 |
| :---: | :---: | :---: | :---: | :---: |
| $y$ | -4 | -4 | -4 | -4 |

21. Justify Mathematical Arguments (1)(G) Casey throws a baseball up into the air while José uses a video camera to record the height of the ball at different points in time. Is height, $h$, a function of time in seconds, $t$ ? Justify your answer.
22. Does the following relation define a function? Explain your reasoning.

Take the absolute value of the sum of a real number and 12 .
23. A pediatrician is tracking the growth of her patients. For each patient, she records the age (input) and height (output) of the patient. Using the information from all of the patients the pediatrician has seen, will this relation be a function? Explain your reasoning.
24. Ms. Rodriguez records the following information for each student in her class. Identify an input variable and an output variable that define a function.

- Student number
- Grade
- Reading Benchmark Test Score
- Mathematics Benchmark Test Score
- Number of siblings
- Number of pets
- Number of years at the school


## TEXAS End-of-Course PRACTICE

25. Identify the domain and range of the following relation.

$$
\{(3,7),(3,8),(3,-2),(3,4),(3,1)\}
$$

26. Use a mapping diagram to determine whether the relation is a function.

$$
\{(6,-7),(5,-8),(1,4),(7,-7)\}
$$

27. Is the relation a function? Graph and use the vertical line test.
$\{(-4,4),(0,-4),(4,4)\}$
28. What is the domain of the relation $\{(-2,-1),(0,0),(2,1),(4,2)\}$ ?
A. $\{-2,0,2,4\}$
B. $\{-1,0,1,2\}$
C. $\{-2,-1,1,2\}$
D. $\{0,2,4\}$

# * $2-7$ Using Function Notation 

## TEKS FOCUS

TEKS (2)(A) Determine the domain and range of a linear function in mathematical problems; determine reasonable domain and range values for real-world situations, both continuous and discrete; and represent domain and range using inequalities.

TEKS (1)(D) Communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.

Additional TEKS (1)(A), (12)(B)

## VOCABULARY

- Function notation - To write a rule in function notation, you use the symbol $f(x)$ in place of $y$.
- Implication - a conclusion that follows from previously stated ideas or reasoning without being explicitly stated
- Representation - a way to display or describe information. You can use a representation to present mathematical ideas and data.


## ESSENTIAL UNDERSTANDING

Using function notation is another way to write a rule. You can also use function notation to generate tables of values to graph simple functions.

## note <br> Concept Summary Function Notation

You have seen functions represented as equations involving $x$ and $y$, such as $y=-3 x+1$.
Below is the same equation written using function notation.

$$
f(x)=-3 x+1
$$

Notice that $f(x)$ replaces $y$. It is read " $f$ of $x$." The letter $f$ is the name of the function, not a variable. Function notation is used to emphasize that the function value $f(x)$ depends on the independent variable $x$. Other letters besides $f$ can also be used, such as $g$ and $h$.

## Problem 1

## Think

How is this function like ones you've seen before?
The function $w(x)=250 x$ can be written as $y=250 x$. Remember that $w(x)$ does not mean $w$ times $x$.

## Evaluating a Function

Reading The function $w(x)=250 x$ represents the number of words $w(x)$ you can read in $x$ minutes. How many words can you read in 8 min ?

$$
\begin{array}{ll}
w(x)=250 x & \\
w(8)=250(8) & \text { Substitute } 8 \text { for } x . \\
w(8)=2000 & \text { Simplify. }
\end{array}
$$

You can read 2000 words in 8 min.

## Finding the Domain and Range of a Function

A The domain of $f(x)=-1.5 x+4$ is $\{1,2,3,4\}$. What is the range?

## Think

What is another way to think of the domain and range? The domain is the set of input values for the function. The range is the set of output values.

Step 1 Make a table. List the domain values as the $x$-values.

Step 2 Evaluate $f(x)$ for each domain value. The values of $f(x)$ form the range.

The range is $\{-2,-0.5,1,2.5\}$.
B The range of $f(x)=3 x$ is $\{0,3,6,9\}$. What is the domain?
Step 1 Make a table. List the range values as the $f(x)$ values.


Step 2 Solve $f(x)=3 x$ for $x$. Substitute the range value for $f(x)$ to find the domain value $x$.

The domain is $\{0,1,2,3\}$.

## Problem 3

## Identifying a Reasonable Domain and Range

Painting You have 3 qt of paint to paint the trim in your house. A quart of paint covers $100 \mathrm{ft}^{2}$. The function $A(q)=100 q$ represents the area $A(q)$, in square feet, that $q$ quarts of paint cover. What domain and range are reasonable for the function? What is the graph of the function?

| Know | Need | Plan |
| :--- | :--- | :--- |
| - One quart of paint covers | Reasonable domain and | Find the least and greatest amounts of |
| 100 $\mathrm{ft}^{2}$. | paint you can use and areas of trim you <br> - You have 3 qt of paint. | range values in order to <br> graph the function |

The least amount of paint you can use is none. So the least domain value is 0 .
You have only 3 qt of paint, so the most paint you can use is 3 qt . The greatest domain value is 3 . The domain is $0 \leq q \leq 3$.

To find the range, evaluate the function using the least and greatest domain values.

$$
A(0)=100(0)=0 \quad A(3)=100(3)=300
$$

The range is $0 \leq A(q) \leq 300$.
To graph the function, make a table of values. Choose values of $q$ that are in the domain. The graph is a line segment that extends from $(0,0)$ to $(3,300)$.



1. Apply Mathematics (1)(A) Light travels about $186,000 \mathrm{mi} / \mathrm{s}$. The function $d(t)=186,000 t$ gives the distance $d(t)$, in miles, that light travels in $t$ seconds. How far does light travel in 30 s ?

For additional support when completing your homework, go to PearsonTEXAS.com.
2. Apply Mathematics (1)(A) You are buying orange juice for $\$ 4.50$ per container and have a gift card worth $\$ 7$. The function $f(x)=4.50 x-7$ represents your total cost $f(x)$ if you buy $x$ containers of orange juice and use the gift card. How much do you pay to buy 4 containers of orange juice?
Find the domain of each function for the given range.
3. $f(x)=2 x-7 ;\{-11,-9,-7,-5,-3\}$
4. $g(x)=-4 x+1 ;\{-39,-7,1,5,21\}$

Use the functions $f(x)=2 x$ and $g(x)=x^{2}+1$ to find the value of each expression.
5. $f(3)+g(4)$
6. $g(3)+f(4)$
7. $f(5)-2 \cdot g(1)$
8. $f(g(3))$

Find a reasonable domain and range for each function. Represent the domain and range using inequalities. Then graph the function.
9. Apply Mathematics (1)(A) A car can travel 32 mi for each gallon of gasoline. The function $d(x)=32 x$ represents the distance $d(x)$, in miles, that the car can travel with $x$ gallons of gasoline. The car's fuel tank holds 17 gal.
10. Apply Mathematics (1)(A) There are 98 International Units (IUs) of vitamin D in 1 cup of milk. The function $V(c)=98 c$ represents the amount $V(c)$ of vitamin D , in IUs, you get from $c$ cups of milk. You have a 16-cup jug of milk.

Find the range of each function for the given domain.
11. $h(x)=3 x+3 ;\{-1.2,0,0.2,1.2,4\}$
12. $f(x)=8 x-3 ;\left\{-\frac{1}{2}, \frac{1}{8}, \frac{1}{4}, \frac{3}{4}\right\}$
13. Explain Mathematical Ideas (1)(G) If $f(x)=6 x-4$ and $f(a)=26$, what is the value of $a$ ? Explain.
14. Create Representations to Communicate Mathematical Ideas (1)(E) In a factory, a certain machine needs 10 min to warm up. It takes 15 min for the machine to run a cycle. The machine can run a partial or full cycle. The machine can operate for as long as 6 h per day including warm-up time. Draw a graph showing the total time the machine operates during 1 day as a function of the number of cycles it runs. What domain and range are reasonable? Is this a continuous or discrete situation?
15. Apply Mathematics (1)(A) A theater group is having a carwash fundraiser. The group can only spend $\$ 34$ on soap, which is enough to wash 40 cars. Each car is charged $\$ 5$.
a. If $c$ is the total number of cars washed and $p$ is the profit, which is the independent variable and which is the dependent variable?
b. Is the relationship between $c$ and $p$ a function? Explain.
c. Write an equation that shows this relationship.
d. Is this a continuous or discrete situation? Explain.
e. Find a reasonable domain and range for the situation. Represent the domain and range using inequalities.

## TEXAS End-of-Course PRACTICE

16. What is the value of the function $f(x)=7 x$ when $x=0.75$ ?
17. What is the greatest number of $\$ .46$ stamps you can buy for $\$ 5$ ?
18. What is the greatest possible width of the rectangle, to the nearest inch?


## Topic 2 Review

## TOPIC VOCABULARY

- continuous graph, p. 70
- dependent variable, p. 59
- discrete graph, p. 70
- domain, p. 83
- function, p. 59
- function notation, p. 88
- independent variable, p. 59
- input, p. 59


## Check Your Understanding

Choose the vocabulary term that correctly completes the sentence.

1. In a function, if the value of $a$ changes in response to the value of $b$, then $b$ is the ?.
2. The graph of $\mathrm{a}(\mathrm{n})$ ? function is a nonvertical line or part of a nonvertical line.
3. The ? of a function consists of the set of all output values.

## 2-1 Using Graphs to Relate Two Quantities

## Quick Review

You can use graphs to represent the relationship between two variables.

## Example

A dog owner plays fetch with her dog. Sketch a graph to represent the distance between them and the time.

Playing Fetch


## Exercises

4. Apply Mathematics (1)(A) A car's speed increases as it merges onto a highway. The car travels at $65 \mathrm{mi} / \mathrm{h}$ on the highway until it slows to exit. The car then stops at two traffic lights before reaching its destination. Draw a sketch of a graph that shows the car's speed over time. Label each section.
5. A professional surfer paddles out past breaking waves, rides a wave, paddles back out past the breaking waves, rides another wave, and paddles back to the beach. Draw a sketch of a graph that shows the surfer's possible distance from the beach over time.

## 2-2 Patterns and Linear Functions

## Quick Review

A function is a relationship that pairs each input value with exactly one output value. A linear function is a function whose graph is a line or part of a line.

## Example

Represent the relationship shown in the table using words, an equation, and a graph.

| Number of Omelets Made, $x$ | 0 | 1 | 2 | 3 |
| :--- | :---: | :---: | :---: | :---: |
| Number of Eggs Left, $y$ | 12 | 10 | 8 | 6 |

Look for a pattern in the table.
Each time $x$ increases by $1, y$ decreases by 2 . The number $y$ of eggs left is 12 minus the quantity 2 times the number $x$ of omelets made: $y=12-2 x$.


## Exercises

For each table, identify the independent and dependent variables. Represent the relationship using words, an equation, and a graph.
6. Paint in Can

| Number of <br> Chairs <br> Painted, $p$ | Paint <br> Left (oz), $L$ |
| :---: | :---: |
| 0 | 128 |
| 1 | 98 |
| 2 | 68 |
| 3 | 38 |

7. Game Cost

| Number of <br> Snacks <br> Purchased, $s$ | Total <br> Cost, $C$ |
| :---: | :---: |
| 0 | $\$ 18$ |
| 1 | $\$ 21$ |
| 2 | $\$ 24$ |
| 3 | $\$ 27$ |

8. 

Elevation

| Number of Flights of <br> Stairs Climbed, $n$ | 0 | 1 | 2 | 3 |
| :--- | :---: | :---: | :---: | :---: |
| Elevation (ft above sea level), $E$ | 311 | 326 | 341 | 356 |

## 2-3 Patterns and Nonlinear Functions

## Quick Review

A nonlinear function is a function whose graph is not a line or part of a line.

## Example

The area $A$ of a square field is a function of the side length $s$ of the field. Is the function linear or nonlinear?

| Side Length (ft), s | 10 | 15 | 20 | 25 |
| :--- | :---: | :---: | :---: | :---: |
| Area $\left(\mathrm{ft}^{2}\right), ~ A$ | 100 | 225 | 400 | 625 |



Graph the ordered pairs and connect the points. The graph is not a line, so the function is nonlinear.

## Exercises

Graph the function shown by each table. Tell whether the function is linear or nonlinear.
9.

10.

11.

12.


## 2-4 Graphing a Function Rule

## Quick Review

A continuous graph is a graph that is unbroken. A discrete graph is composed of distinct, isolated points. In a realworld graph, show only points that make sense.

## Example

The total height $h$ of a stack of cans is a function of the number $n$ of layers of $4.5-\mathrm{in}$. cans used. This situation is represented by $h=4.5 n$. Graph the function.



The graph is discrete because only whole numbers of layers make sense.

## Exercises

Graph the function rule. Explain why the graph is continuous or discrete.
13. Apply Mathematics (1)(A) Your cost $c$ to buy $w$ pounds of walnuts at $\$ 6 / \mathrm{lb}$ is represented by $c=6 w$.
14. Apply Mathematics (1)(A) A truck originally held 24 chairs. You remove 2 chairs at a time. The number of chairs $n$ remaining after you make $t$ trips is represented by $n=24-2 t$.
15. Apply Mathematics (1)(A) A burst pipe fills a basement with 37 in . of water. A pump empties the water at a rate of $1.5 \mathrm{in} . / \mathrm{h}$. The water level $\ell$, in inches, after $t$ hours is represented by $\ell=37-1.5 t$.
16. Graph $y=-|x|+2$.

## 2-5 Writing a Function Rule

## Quick Review

To write a function rule describing a real-world situation, it is often helpful to start with a verbal model of the situation.

## Example

At a bicycle motocross (BMX) track, you pay $\$ 40$ for a racing license plus $\$ 15$ per race. What is a function rule that represents your total cost?
total cost $=$ license fee + fee per race $\cdot$ number of races $C=40+15 \quad$ $\quad r$
A function rule is $C=40+15 r$.

## Exercises

Write a function rule to represent each situation.
17. Apply Mathematics (1)(A) The volume $V$ remaining in a $243-\mathrm{ft}^{3}$ pile of gravel decreases by $0.2 \mathrm{ft}^{3}$ with each shovelful $s$ of gravel spread in a walkway.
18. Apply Mathematics (1)(A) Your total cost $C$ for hiring a garden designer is $\$ 200$ for an initial consultation plus $\$ 45$ for each hour $h$ the designer spends drawing plans.

## $2-6$ and 2-7 Formalizing Relations and Functions and Using Function Notation

## Quick Review

A relation pairs numbers in the domain with numbers in the range. A relation may or may not be a function. A relation is a function only if each number in the domain is paired with exactly one number in the range.

## Example

Is the relation $\{(0,1),(3,3),(4,4),(0,0)\}$ a function?
The $x$-values of the ordered pairs form the domain, and the $y$-values form the range. The domain value 0 is paired with two range values, 1 and 0 . So the relation is not a function.

## Exercises

Tell whether each relation is a function.
19. $\{(-1,7),(9,4),(3,-2),(5,3),(9,1)\}$
20. $\{(2,5),(3,5),(4,-4),(5,-4),(6,8)\}$

Evaluate each function for $\boldsymbol{x}=2$ and $\boldsymbol{x}=7$.
21. $f(x)=2 x-8$
22. $h(x)=-4 x+61$
23. The domain of $t(x)=-3.8 x-4.2$ is $\{-3,-1.4,0,8\}$. What is the range?
24. The range of $g(x)=4 x-4$ is $\{-12,-4,4,12\}$. What is the domain?

## Topic 2 teks Cumulative Practice

## Multiple Choice

## Read each question. Then write the letter of the correct answer on your paper.

1. Angie uses the equation $E=0.03 s+25,000$ to find her yearly earnings $E$ based on her total sales $s$. What is the independent variable?
A. $E$
B. 0.03
C. $s$
D. 25,000
2. The sum of two consecutive odd integers is 24 . Which equation can be used to find the first integer $n$ ?
F. $n+1=24$
G. $n+2=24$
H. $2 n+1=24$
J. $2 n+2=24$
3. Mr. Washington is buying a gallon of milk for $\$ 3.99$ and some number of boxes $x$ of cereal for $\$ 4.39$ each. If Mr. Washington has $\$ 20$, which inequality can be used to find how many boxes of cereal he can buy?
A. $3.99+4.39 x \leq 20$
B. $4.39+3.99 x \leq 20$
C. $3.99+4.39 x \geq 20$
D. $4.39+3.99 x \geq 20$
4. Which graph could represent the circumference of a balloon as the air is being let out?
F.

H.

G.

J.

5. The table below shows the relationship between how long an ice cube is in the sun and its weight.

| Time (min) | 0 | 1 | 2 | 3 | 4 |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Weight (g) | 9 | 8 | 5 | 2 | 0 |

Which graph best represents the data in the table?
A.

C.

B.

D.

6. A point is missing from the graph of the relation below. The relation is not a function. Which point is missing?

F. $(0,0)$
G. $(1,1)$
H. $(-1,2)$
J. $(2,-2)$
7. During a clinical study, a medical company found that 3 out of 70 people experienced a side effect when using a certain medicine. The company predicts 63,000 people will use the medicine next year. How many people are expected to experience a side effect?
A. 300
B. 900
C. 2700
D. 21,000
8. Which equation can be used to generate the table of values at the right?
F. $y=x+9$
G. $y=2 x+4$
H. $y=x+3$
J. $y=3 x-2$

| $x$ | $y$ |
| :---: | :---: |
| -3 | -11 |
| 0 | -2 |
| 3 | 7 |
| 6 | 16 |

9. In the diagram below, $\triangle A B C$ and $\triangle D E F$ are similar.


Which expression represents $A B$ ?
A. $\frac{q u}{s}$
B. $\frac{r u}{s}$
C. $\frac{q r}{u}$
D. $\frac{r s}{t}$
10. The function $C=2 \pi r$ gives the circumference $C$ of a circle with radius $r$. What is an appropriate domain for the function?
F. all integers
H. positive real numbers
G. positive integers
J. all real numbers

## Gridded Response

## Record your answers in a grid.

11. Sasha is framing a 5 -in.-by-7-in. picture with a frame that is 3 in . wide, as shown below. What is the frame's area in square inches?

12. The rectangles shown below are similar.


The area of rectangle $A$ is $180 \mathrm{ft}^{2}$. The area of rectangle $B$ is $45 \mathrm{ft}^{2}$. What is rectangle $B$ 's perimeter in feet?

## Constructed Response

13. Solve the equation below. Show all your work.

$$
3 x-16=20
$$

14. What values of $x$ make both inequalities true?

$$
\begin{aligned}
& 3 x<4 x+6 \\
& 2 x+1<15
\end{aligned}
$$

15. Lindsey is using a map to find the distance between her house and Juanita's house. On the map, the distance is 2.5 in . If the map scale is $\frac{1}{8} \mathrm{in}$ : 1.5 mi , how far from Juanita does Lindsey live?
16. Pedro ran 2 more than $\frac{3}{4}$ the number of miles that Cierra ran. Write an equation that represents the relationship between the number of miles $p$ that Pedro ran and the number of miles $c$ that Cierra ran.
17. The relationship between degrees Fahrenheit $F$ and degrees Celsius $C$ can be given by $C=\frac{5}{9}(F-32)$. Solve the equation for $F$.
18. Draw a number line that displays the solution of the compound inequality $-5<-2 x+7<15$.
19. A particular washing machine uses an average of 41 gallons of water for every load of laundry.
a. Identify the independent and dependent variables in this situation.
b. Write a function rule to represent the situation.
c. Suppose you used 533 gallons of water for laundry in one month. How many loads of laundry did you wash?

## TOPIC OVERVIEW

3-1 Rate of Change and Slope
3-2 Direct Variation
3-3 Slope-Intercept Form
3-4 Point-Slope Form
3-5 Standard Form
3-6 Parallel and Perpendicular Lines
3-7 Transformations of Linear Functions
3-8 Scatter Plots and Trend Lines

## VOCABULARY

English/Spanish Vocabulary Audio Online:

English
causation, p. 144
direct variation, p. 108
linear equation, p. 115
parent function, p. 115
point-slope form, p. 120
rate of change, p. 100
slope, p. 100
slope-intercept form, p. 115
standard form, p. 125
trend line, p. 145
x-intercept, p. 125
$y$-intercept, p. 115

Spanish causalidad variación directa ecuación lineal función elemental forma punto-pendiente tasa de cambio pendiente forma pendiente-intercepto forma norma línea de tendencia intercepto en $x$ intercepto en $y$
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## $\star$ 3-1 Rate of Change and Slope

## TEKS FOCUS

TEKS (3)(B) Calculate the rate of change of a linear function represented tabularly, graphically, or algebraically in context of mathematical and real-world problems.

TEKS (1)(D) Communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.

Additional TEKS (1)(G), (2)(G), (3)(A)

## VOCABULARY

- Rate of change - shows the relationship between two changing quantities as the ratio of the change in the dependent variable to the change in the independent variable
- Slope - the ratio of the vertical change to the horizontal change between two points on a line
- Implication - a conclusion that follows from previously stated ideas or reasoning without being explicitly stated
- Representation - a way to display or describe information. You can use a representation to present mathematical ideas and data.


## ESSENTIAL UNDERSTANDING

You can use ratios to show a relationship between changing quantities, such as vertical and horizontal change.

## Key Concept Rate of Change and Slope

## Rate of Change

Rate of change shows the relationship between two changing quantities in a function.
When one quantity depends on the other, the following is true.

$$
\text { rate of change }=\frac{\text { change in the dependent variable }}{\text { change in the independent variable }}
$$

## Slope

When data are linear, the rate of change is constant. The slope of a line is the ratio of the vertical change to the horizontal change of any two points on the line.

$$
\text { slope }=\frac{\text { vertical change }}{\text { horizontal change }}=\frac{\text { rise }}{\text { run }}
$$



## Ke note Key Concept The Slope Formula

slope $=\frac{\text { rise }}{\text { run }}=\frac{y_{2}-y_{1}}{x_{2}-x_{1}}$, where $x_{2}-x_{1} \neq 0$
The $x$-coordinate you use first in the denominator must belong to the same ordered pair as the $y$-coordinate you use first in the numerator.


## Concept Summary Slopes of Lines

A line with positive slope slants upward from left to right.


A line with a slope of 0 is horizontal.


A line with negative slope slants downward from left to right.


A line with an undefined slope is vertical.


## Problem 1

## Finding Rate of Change and Slope Using a Table

The table shows the distance a band marches over time.
A Is the rate of change in distance with respect to time constant? What does the rate of change represent?

$$
\text { rate of change }=\frac{\text { change in distance }}{\text { change in time }}
$$

Calculate the rate of change from one row of the table to the next.

Distance Marched

| Time <br> $(\mathrm{min})$ | Distance <br> $(\mathrm{ft})$ |
| :---: | :---: |
| 1 | 260 |
| 2 | 520 |
| 3 | 780 |
| 4 | 1040 |

How can you use the data in the table to find the rate of change? Each data point corresponds to an ordered pair from the table: $(1,260)$ and $(2,520)$.

$$
\frac{520-260}{2-1}=\frac{260}{1} \quad \frac{780-520}{3-2}=\frac{260}{1} \quad \frac{1040-780}{4-3}=\frac{260}{1}
$$

The rate of change is constant and equals $\frac{260 \mathrm{ft}}{1 \mathrm{~min}}$. It represents the distance the band marches per minute.
B Determine whether the data represent a linear relationship. If so, find the slope of the line containing the points given in the table.
The relationship between time and the distance the band marched is a linear relationship shown in the graph on the right.

$$
\text { slope }=\frac{\text { vertical change }}{\text { horizontal change }}=\frac{\text { rise }}{\text { run }}=\frac{260}{1}=260
$$

Distance Marched


## Problem 2

## Finding the Rate of Change of a Linear Function

Calculate the rate of change of each linear function. What does the rate of change tell you about the relationship between $x$ and $y$ ?

## Plan

Which entries in the table should you choose?
Any two pairs of entries will show the same rate of change. Choose numbers that are easy to work with.
(A)


$$
\begin{gathered}
(2,4) \text { and }(1,7) \\
4-7=-3 \\
2-1=1 \\
\frac{-3}{1}=-3
\end{gathered}
$$

Choose two points.
Subtract $y$-values.
Subtract $x$-values.
Divide change in $y$ by change in $x$.
The rate of change is -3 . This means that when the $x$-value increases by 1 , the $y$-value decreases by 3 .

B


$$
\begin{aligned}
(-4,2) \text { and }(1,3) & \text { Identify two points on } t \\
3-2=1 & \text { Subtract } y \text {-coordinates. } \\
1-(-4)=5 & \text { Subtract } x \text {-coordinates. }
\end{aligned}
$$

Divide the change in $y$ by the change in $x$ to get the rate of change, $\frac{1}{5}$. This means that when the $x$-value increases by 5 , the $y$-value increases by 1 .

## Problem 3

## Think

How does the slope of a line show rate of change?
The slope equals the rate of change. A line that increases from left to right shows a positive rate of change. A line that decreases shows a negative rate of change.

## Finding Slope Using a Graph

## What is the slope of each line?



$$
\begin{aligned}
\text { slope } & =\frac{\text { rise }}{\text { run }} \\
& =\frac{2}{3}
\end{aligned}
$$

The slope of the line is $\frac{2}{3}$.

B


$$
\begin{aligned}
\text { slope } & =\frac{\text { rise }}{\text { run }} \\
& =\frac{-4}{5}=-\frac{4}{5}
\end{aligned}
$$

The slope of the line is $-\frac{4}{5}$.

## Finding Slope Using Points

What is the slope of the line through $(-1,0)$ and $(3,-2)$ ?


## Problem 5

## Finding Rate of Change in Real-World Situations

Find the rate of change represented in each situation.

A The graph shows the length of time, in minutes, required to print a document $x$ pages long. What is the rate of change in the data?

$$
\text { rate of change }=\frac{\text { change in pages }}{\text { change in time }}
$$

Calculate the rate of change from one data point to the next.

$$
\frac{9-6}{\frac{3}{4}-\frac{1}{2}}=\frac{12}{1}
$$

The rate of change is constant and equals 12 pages per minute.


B The mass of a textbook, in grams, is modeled by the function $M(x)=3.5 x+56$, where $x$ is the number of pages in the book.

Since the mass is modeled by a linear function, the rate of change can be determined from any two ordered pairs generated by the model.

According to the model, a book with 100 pages, has a mass of $3.5(100)+56=406$
grams. A book with 300 pages has a mass of $3.5(300)+56=1106$ grams.

$$
\text { rate of change }=\frac{\text { change in mass }}{\text { change in pages }}=\frac{1106-406}{300-100}=\frac{7}{2}
$$

The rate of change equals $\frac{7}{2}$, or 3.5 grams per page.

## Finding Slopes of Horizontal and Vertical Lines

What is the slope of each line?

## Think

Can you generalize these results? Yes. All points on a horizontal line have the same $y$-value, so the slope is always zero. Finding the slope of a vertical line always leads to division by zero. The slope is always undefined.


Let $\left(x_{1}, y_{1}\right)=(-3,2)$ and $\left(x_{2}, y_{2}\right)=(2,2)$.
slope $=\frac{y_{2}-y_{1}}{x_{2}-x_{1}}=\frac{2-2}{2-(-3)}=\frac{0}{5}=0$
The slope of the horizontal line is 0 .

B


Let $\left(x_{1}, y_{1}\right)=(-2,-2)$ and $\left(x_{2}, y_{2}\right)=(-2,1)$.
slope $=\frac{y_{2}-y_{1}}{x_{2}-x_{1}}=\frac{1-(-2)}{-2-(-2)}=\frac{3}{0}$
Division by zero is undefined. The slope of the vertical line is undefined.


For additional support when completing your homework, go to PearsonTEXAS.com.

Determine whether each rate of change is constant. If it is, find the rate of change and explain what it represents.
1.

| Turtle Waiking |  |
| :---: | :---: |
| Time $(\mathrm{min})$ | Distance $(\mathrm{m})$ |
| 1 | 6 |
| 2 | 12 |
| 3 | 15 |
| 4 | 21 |

2. Hot Dogs and Buns

| Hot Dogs | Buns |
| :---: | :---: |
| 1 | 1 |
| 2 | 2 |
| 3 | 3 |
| 4 | 4 |

Find the slope of each line.
4.

5.

3.

| Time (min) | Elevation $(\mathrm{ft})$ |
| :---: | :---: |
| 0 | 30,000 |
| 2 | 29,000 |
| 5 | 27,500 |
| 12 | 24,000 |

6. 



Without graphing, tell whether the slope of a line that models each linear relationship is positive, negative, zero, or undefined. Then find the slope.
7. The length of a bus route is 4 mi long on the sixth day and 4 mi long on the seventeenth day.
8. A babysitter earns $\$ 9$ for 1 h and $\$ 36$ for 4 h .
9. A student earns a 98 on a test for answering one question incorrectly and earns a 90 for answering five questions incorrectly.
10. The total cost, including shipping, for ordering five uniforms is $\$ 66$. The total cost, including shipping, for ordering nine uniforms is $\$ 114$.

State the independent variable and the dependent variable in each linear relationship. Then find the rate of change for each situation.
11. Snow is 0.02 m deep after 1 h and 0.06 m deep after 3 h .
12. The cost of tickets is $\$ 36$ for three people and $\$ 84$ for seven people.
13. A car is 200 km from its destination after 1 h and 80 km from its destination after 3 h .

Use the slope formula to find the slope of the line that passes through each pair of points. Then plot the points and sketch the line that passes through them. Does the slope you found using the formula match the direction of the line you sketched?
14. $(-2,1),(7,1)$
15. $(4.25,0),(3.5,3)$
16. $\left(-\frac{1}{2}, \frac{4}{7}\right),\left(8, \frac{4}{7}\right)$
17. $(-5,0.124),(-5,-0.584)$
18. $(-42.25,5.2),(3.25,3)$
19. $\left(-2, \frac{2}{11}\right),\left(-2, \frac{7}{13}\right)$
20. Analyze Mathematical Relationships (1)(F) Find the rate of change for the function $y=-5 x+6$. Describe what the rate of change tells you about the relationship between $x$ and $y$.
Find the slope of the line that passes through each pair of points.
21. $(0,0),(3,3)$
24. $(0,-1),(2,3)$

Find the slope of each line.
27.

22. $(1,3),(5,5)$
25. $(-6,1),(4,8)$
28.

23. $(4,4),(5,3)$
26. $(2,-3),(5,-4)$
29.

30. Use Representations to Communicate Mathematical Ideas (1)(E) The graph shows the average growth rates for three different animals. Which animal's growth shows the fastest rate of change? The slowest rate of change?
31. Select Techniques to Solve Problems (1)(C) Find two points that lie on a line with slope -9 .
32. Apply Mathematics (1)(A) John's business made $\$ 4500$ in January and $\$ 8600$ in March. What is the rate of change

Rate of Growth
 in his profit for this time period?

Each pair of points lies on a line with the given slope. Find $x$ or $y$.
33. $(2,4),(x, 8)$; slope $=-2$
35. $(2,4),(x, 8)$; slope $=-\frac{1}{2}$
37. $(-4, y),(2,4 y) ;$ slope $=6$
34. $(4,3),(5, y)$; slope $=3$
36. $(3, y),(1,9)$; slope $=-\frac{5}{2}$
38. $(3,5),(x, 2)$; undefined slope
39. Justify Mathematical Arguments (1)(G) Is it true that a line with slope 1 always passes through the origin? Explain your reasoning.

Analyze Mathematical Relationships (1)(F) Find the rate of change of each linear function. Describe what the rate of change tells you about the relationship between $x$ and $y$.
40.

41.

42.


Determine whether the data represent a linear relationship. If so, find the slope of the line containing the points given in the table and explain what it represents.
43.

| Time <br> $(\mathbf{m i n})$ | Distance <br> $(\mathrm{m})$ |
| :---: | :---: |
| 1 | 20 |
| 2 | 40 |
| 3 | 65 |
| 4 | 80 |

44. 

| Number <br> of Tickets | Price <br> $(\$)$ |
| :---: | :---: |
| 1 | 15 |
| 2 | 30 |
| 3 | 45 |
| 4 | 60 |

45. 

| Triangles | Sides |
| :---: | :---: |
| 3 | 9 |
| 4 | 12 |
| 5 | 15 |
| 6 | 18 |

Justify Mathematical Arguments (1)(G) Do the points in each set lie on the same line? Explain your answer.
46. $A(1,3), B(4,2), C(-2,4)$
47. $G(3,5), H(-1,3), I(7,7)$
48. $D(-2,3), E(0,-1), F(2,1)$
49. $P(4,2), Q(-3,2), R(2,5)$
50. $G(1,-2), H(-1,-5), I(5,4)$
51. $S(-3,4), T(0,2), X(-3,0)$

Find the slope of the line that passes through each pair of points.
52. $(a,-b),(-a,-b)$
53. $(-m, n),(3 m,-n)$
54. $(2 a, b),(c, 2 d)$
55. Create Representations to Communicate Mathematical Ideas (1)(E) The table shows the number of participants in the town soccer program over a five-year period. Represent this situation algebraically. At what rate is participation in the program changing?

Soccer Program

| Year | Participants |
| :---: | :---: |
| 1 | 67 |
| 2 | 71 |
| 3 | 75 |
| 4 | 79 |
| 5 | 83 |

## TEXAS End-of-Course PRACTICE

56. A line has slope $\frac{4}{3}$. Through which two points could this line pass?
A. $(24,19),(8,10)$
B. $(10,8),(16,0)$
C. $(28,10),(22,2)$
D. $(4,20),(0,17)$
57. Let the domain of the function $f(x)=\frac{1}{5} x-12$ be $\{-5,0,10\}$. What is the range?
F. $\{-5,0,10\}$
G. $\{0,12,13\}$
H. $\{-13,-12,-11\}$
J. $\{-13,-12,-10\}$
58. The perimeter of the rectangle below is less than 30 in . and greater than 20 in . What is a graph that shows all the possible perimeters of the triangle?


# $t$ <br> 3-2 Direct Variation 

## TEKS FOCUS

TEKS (2)(D) Write and solve equations involving direct variation.

TEKS (1)(D) Communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.

Additional TEKS (1)(G), (2)(C), (3)(C), (12)(E)

## VOCABULARY

- Constant of variation for a direct variation - the nonzero constant $k$ in the function $y=k x$
- Direct variation - Direct variation is a linear function defined by an equation of the form $y=k x$, where $k \neq 0$.
- Implication - a conclusion that follows from previously stated ideas or reasoning without being explicitly stated
- Representation - a way to display or describe information. You can use a representation to present mathematical ideas and data.


## ESSENTIAL UNDERSTANDING

If the ratio of two variables is constant, then the variables have a special relationship, known as a direct variation.

## Concept Summary Graphs of Direct Variations

The graph of a direct variation equation $y=k x$ is a line with the following properties.

- The line passes through $(0,0)$.
- The slope of the line is $k$.

$k>0$

$k<0$


## Problem 1

## Identifying a Direct Variation

## Think

Do these equations look like ones you've seen before? Yes. They contain two variables, so they're literal equations. To determine whether they're direct variation equations, solve for $y$.

Does the equation represent a direct variation? If so, find the constant of variation.

$$
\text { A } \begin{aligned}
7 y & =2 x \\
y & =\frac{2}{7} x
\end{aligned} \quad \leftarrow \text { Solve each equation for } y . \rightarrow \quad \begin{aligned}
3 y+4 x & =\mathbf{8} \\
3 y & =8-4 x \\
y & =\frac{8}{3}-\frac{4}{3} x
\end{aligned}
$$

The equation has the form $y=k x$, so the equation is a direct variation. Its constant of variation is $\frac{2}{7}$.

You cannot write the equation in the form $y=k x$. It is not a direct variation.

## Think

Make sure you don't stop at $7=k$. To write the direct variation equation you have to substitute 7 for $k$ in $y=k x$.

## Writing a Direct Variation Equation

Suppose $y$ varies directly with $x$, and $y=35$ when $x=5$. What direct variation equation relates $x$ and $y$ ? What is the value of $y$ when $x=9$ ?

$$
\begin{aligned}
y & =k x & & \text { Start with the function form of a direct variation. } \\
35 & =k(5) & & \text { Substitute } 5 \text { for } x \text { and } 35 \text { for } y . \\
7 & =k & & \text { Divide each side by } 5 \text { to solve for } k . \\
y & =7 x & & \text { Write an equation. Substitute } 7 \text { for } k \text { in } y=k x .
\end{aligned}
$$

The equation $y=7 x$ relates $x$ and $y$. When $x=9, y=7(9)$, or 63 .

## Problem 3

## Graphing a Direct Variation STEM

Space Exploration Weight on Mars $y$ varies directly with weight on Earth $x$. The weights of the science instruments onboard the Phoenix Mars Lander on Earth and Mars are shown.

What is an equation that relates weight, in pounds, on Earth $x$ and weight on Mars $y$ ?

## Think

Have you graphed equations like $y=0.38 x$ before? Yes. In Topic 2, you graphed linear functions by making a table of values and plotting the points.

$$
\begin{aligned}
y & =k x & & \text { Start with the function form of a direct variation. } \\
50 & =k(130) & & \text { Substitute } 130 \text { for } x \text { and } 50 \text { for } y . \\
0.38 & \approx k & & \text { Divide each side by } 130 \text { to solve for } k . \\
y & =0.38 x & & \text { Write an equation. Substitute } 0.38 \text { for } k \text { in } y=k x .
\end{aligned}
$$

The equation $y=0.38 x$ gives the approximate weight $y$ on Mars, in pounds, of an object that weighs $x$ pounds on Earth.

B What is the graph of the equation in part (A)? Make a table of values. Then draw the graph.

| $x$ | $y$ |
| ---: | :---: |
| 0 | $0.38(0)=0$ |
| 50 | $0.38(50)=19$ |
| 100 | $0.38(100)=38$ |
| 150 | $0.38(150)=57$ |

## Problem 4

## Writing a Direct Variation From a Table

For the data in the table, does $y$ vary directly with $x$ ? If it does, write an equation for the direct variation.

## Plan

How can you check your answer? Graph the ordered pairs in the coordinate plane. If you can connect them with a line that passes through ( 0,0 ), then $y$ varies directly with $x$.

A


Find $\frac{y}{x}$ for each ordered pair.
$\frac{6}{4}=1.5 \quad \frac{12}{8}=1.5 \quad \frac{15}{10}=1.5$
The ratio $\frac{y}{x}=1.5$ for each data pair. So $y$ varies directly with $x$. The direct variation equation is $y=1.5 x$.

B


Find $\frac{y}{\bar{x}}$ for each ordered pair.
$\frac{3.2}{-2}=-1.6 \quad \frac{2.4}{1}=2.4 \quad \frac{1.6}{4}=0.4$
The ratio $\frac{y}{x}$ is not the same for all data pairs. So $y$ does not vary directly with $x$.

For additional support when completing your homework, go to PearsonTEXAS.com.

Use Multiple Representations to Communicate Mathematical Ideas (1)(D) For the data in each table, tell whether $y$ varies directly with $x$. If it does, write an equation for the direct variation. Check your answer by plotting the points from the table and sketching the line.


Suppose $y$ varies directly with $x$. Write a direct variation equation that relates $x$ and $y$. Then graph the equation.
4. $y=\frac{1}{2}$ when $x=3$
5. $y=-5$ when $x=\frac{1}{4}$
6. $y=\frac{6}{5}$ when $x=\frac{5}{-6}$
7. $y=7.2$ when $x=1.2$
8. Apply Mathematics (1)(A) The amount of blood in a person's body varies directly with body weight. A person who weighs 160 lb has about 4.6 qt of blood. About how many quarts of blood are in the body of a $175-\mathrm{lb}$ person?
9. Apply Mathematics (1)(A) Ohm's Law $V=I \times R$ relates the voltage, current, and resistance of a circuit. $V$ is the voltage measured in volts. $I$ is the current measured in amperes. $R$ is the resistance measured in ohms.
a. Find the voltage of a circuit with a current of 24 amperes and a resistance of 2 ohms.
b. Find the resistance of a circuit with a current of 24 amperes and a voltage of 18 volts.

Determine whether each equation represents a direct variation. If it does, find the constant of variation.
10. $2 y=5 x+1$
11. $8 x+9 y=10$
12. $-12 x=6 y$
13. $y+8=-x$
14. $-4+7 x+4=3 y$
15. $0.7 x-1.4 y=0$

Suppose $y$ varies directly with $x$. Write a direct variation equation that relates $x$ and $y$. Then find the value of $y$ when $x=12$.
16. $y=-10$ when $x=2$
17. $y=7 \frac{1}{2}$ when $x=3$
18. $y=5$ when $x=2$
19. $y=125$ when $x=-5$
20. $y=10.4$ when $x=4$
21. $y=9 \frac{1}{3}$ when $x=-\frac{1}{2}$

Explain Mathematical Ideas (1)(G) Tell whether the two quantities vary directly. Explain your reasoning.
22. the number of ounces of cereal and the number of Calories the cereal contains
23. the time it takes to travel a certain distance and the rate at which you travel
24. the perimeter of a square and the side length of the square
25. the amount of money you have left and the number of items you purchased
26. Graph the following direct variation equations in the same coordinate plane: $y=x, y=2 x, y=3 x$, and $y=4 x$. Use these graphs to help predict how the graph of $y=\frac{1}{2} x$ would appear.
27. Analyze Mathematical Relationships (1)(F) Use the table at the right. A student says that $y$ varies directly with $x$ because as $x$ increases by $1, y$ also increases by 1 . Explain the student's error.
28. Explain Mathematical Ideas (1)(G) Suppose $y$ varies directly with $x$. Explain how the value of $y$ changes in each situation.
a. The value of $x$ is doubled.
b. The value of $x$ is halved.

Graph each direct variation equation.
29. $y=2 x$
30. $y=\frac{1}{3} x$
31. $y=-x$
32. $y=-\frac{1}{2} x$
33. Apply Mathematics (1)(A) The distance $d$ you bike varies directly with the amount of time $t$ you bike. Suppose you bike 13.2 mi in 1.25 h . What is an equation that relates $d$ and $t$ ? What is the graph of the equation?
34. Analyze Mathematical Relationships (1)(F) The perimeter $p$ of a regular hexagon varies directly with the length $\ell$ of one side of the hexagon. What is an equation that relates $p$ and $\ell$ ? What is the graph of the equation?
35. Apply Mathematics (1)(A) The force you need to apply to a lever varies directly with the weight you want to lift. Suppose you can lift a $50-\mathrm{lb}$ weight by applying 20 lb of force to a certain lever. Write an equation relating force and weight. What is the force you need to lift a friend who weighs 130 lb ?
The ordered pairs in each exercise are for the same direct variation. Find each missing value.
36. $(3,4)$ and $(9, y)$
37. $(1, y)$ and $\left(\frac{3}{2},-9\right)$
38. $(-5,3)$ and $(x,-4.8)$
39. Use a Problem-Solving Model (1)(B) A car gets 32 mi per gallon. The number of gallons $g$ of gasoline used varies directly with the number of miles $m$ traveled. Suppose the price of gasoline is $\$ 3.85$ per gallon. How much will it cost to buy gasoline for a 240-mi trip?

## TEXAS End-of-Course PRACTICE

40. The price $p$ you pay varies directly with the number of pencils you buy. Suppose you buy 3 pencils for $\$ .51$. How much is each pencil, in dollars?
41. A scooter can travel 72 mi per gallon of gasoline and holds 2.3 gal. The function $d(x)=72 x$ represents the distance $d(x)$, in miles, that the scooter can travel with $x$ gallons of gasoline. How many miles can the scooter go with a full tank of gas?
42. The table at the right shows the number of hours a clerk works per week and the amount of money she earns before taxes. If she worked 34 h per week, how much money would she earn, in dollars?
43. What is the greatest value in the range of $y=x^{2}-3$ for the domain $\{-3,0,1\}$ ?
Weekly Wages

| Time <br> (h) | Wages <br> $(\mathrm{S})$ |
| :---: | :---: |
| 12 | 99.00 |
| 17 | 140.25 |
| 21 | 173.25 |
| 32 | 264.00 |

## USE WITH LESSON 3-3

```
TEKS (3)(C), (3)(E), (1)(E)
```

You can use a graphing calculator to explore the graph of an equation in the form $y=m x+b$. For this activity, choose a standard screen by pressing $200 m$.

1. Graph these equations on the same screen. Then complete each statement.

$$
y=x+3 \quad y=2 x+3 \quad y=\frac{1}{2} x+3
$$

a. The graph of ? is steepest.
b. The graph of ? is the least steep.
2. Match each equation with the best choice for its graph.
A. $y=\frac{1}{4} x-2$
B. $y=4 x-2$
C. $y=x-2$
I.

II.

III.

3. Graph these equations on the same screen.

$$
\begin{aligned}
& y=2 x+3 \\
& y=-2 x+3
\end{aligned}
$$

How does the sign of $m$ affect the graph of the equation?
4. Analyze Mathematical Relationships (1)(F) How does changing the value of $m$ affect the graph of an equation in the form $y=m x+b$ ?
5. Graph these equations on the same screen.

$$
\begin{aligned}
& y=2 x+3 \\
& y=2 x-3 \\
& y=2 x+2
\end{aligned}
$$

Where does the graph of each equation cross the $y$-axis? (Hint: Use the ZOOM feature to better see the points of intersection.)
6. Match each equation with the best choice for its graph.
A. $y=\frac{1}{3} x-3$
B. $y=\frac{1}{3} x+1$
C. $y=\frac{1}{3} x$
I.

7. Analyze Mathematical Relationships (1)(F) How does changing the value of $b$ affect the graph of an equation in the form $y=m x+b$ ?

## TAKS FOCUS

TEKS (2)(B) Write linear equations in two variables in various forms, including $y=m x+b, A x+B y=C$, and $y-y_{1}=$ $m\left(x-x_{1}\right)$, given one point and the slope and given two points.

TEKS (1)(F) Analyze mathematical relationships to connect and communicate mathematical ideas.

Additional TEKS (1)(A), (2)(C), (3)(A), (3)(B), (3)(C)

## VOCABULARY

- Linear equation - an equation whose graph forms a straight line
- Linear parent function the simplest form of a linear function
- Parent function - A family of functions is a group of functions with common characteristics. A parent function is the simplest function with these characteristics.
- Slope-intercept form - The slope-intercept form of a linear equation is $y=m x+b$, where $m$ is the slope of the line and $b$ is the $y$-intercept.
- $y$-Intercept - the $y$-coordinate of a point where a graph crosses the $y$-axis
- Analyze - closely examine objects, ideas, or relationships to learn more about their nature


## ESSENTIAL UNDERSTANDING

You can use the slope and $y$-intercept of a line to write and graph an equation of the line.

## Key Concept Slope-Intercept Form of a Linear Equation

The slope-intercept form of a linear equation of a nonvertical line is $y=m x+b$.

## Identifying Slope and $\boldsymbol{y}$-Intercept

## Think

Why isn't the $y$-intercept 2? In slope-intercept form, the $y$-intercept $b$ is added to the term $m x$. Instead of subtracting 2 , you add the opposite, -2 .

What are the slope and $y$-intercept of the graph of the linear function $y=5 x-2$ ? What is the rate of change of the function?

$$
\begin{aligned}
& y=m x+b \quad \text { Use slope-intercept form. } \\
& y=5 x+(-2) \quad \text { Think of } y=5 x-2 \text { as } y=5 x+(-2) \text {. } y \text {-intercept } \\
& y=0 \text {. }
\end{aligned}
$$

The slope of the graph is 5 ; the $y$-intercept is -2 . The rate of change of the related function is equal to the slope of the line, or 5 .

## Writing an Equation in Slope-Intercept Form

When can you use slope-intercept form? You can write an equation of a nonvertical line in slope-intercept form if you know its slope and $y$-intercept.

What is an equation of the line with slope $-\frac{4}{5}$ and $y$-intercept 7 ?

$$
\begin{array}{ll}
y=m x+b & \text { Use slope-intercept form } \\
y=-\frac{4}{5} x+7 & \text { Substitute }-\frac{4}{5} \text { for } m \text { and } 7 \text { for } b .
\end{array}
$$

An equation for the line is $y=-\frac{4}{5} x+7$.

## Problem 3

## Writing an Equation From a Graph

Think
What does the graph tell you about the slope? Since the line slants up from left to right, the slope of the line should be positive. The line is also fairly steep, so the slope of the line should be greater than 1 .

Multiple Choice Which equation represents the line shown?
(A) $y=-2 x+1$
(C) $y=\frac{1}{2} x-2$
(B) $y=2 x+1$
(D) $y=2 x-2$

Find the slope. Two points on the line are $(0,-2)$ and $(2,2)$.

$$
\text { slope }=\frac{2-(-2)}{2-0}=\frac{4}{2}=2
$$

The $y$-intercept is -2 . Write an equation in slope-intercept form.


$$
\begin{aligned}
& y=m x+b \\
& y=2 x+(-2) \quad \text { Substitute } 2 \text { for } m \text { and }-2 \text { for } b .
\end{aligned}
$$

An equation for the line is $y=2 x-2$. The correct answer is D .

## Problem 4

## Writing an Equation From Two Points

What equation in slope-intercept form represents the line that passes through the points $(2,1)$ and $(5,-8)$ ?


Step 1 Use the two points to find the slope.

$$
\text { slope }=\frac{-8-1}{5-2}=\frac{-9}{3}=-3
$$

Can you use either point to find the $y$-intercept? Yes. You can substitute the slope and the coordinates of any point on the line into the form $y=m x+b$ and solve for $b$.

Step 2 Use the slope and the coordinates of one of the points to find $b$.

$$
\begin{array}{ll}
y=m x+b & \\
\begin{array}{ll}
\text { Use slope-intercept form. } \\
1=-3(2)+b & \\
7=b & \text { Substitute }-3 \text { for } m, 2 \text { for } x \text {, and } 1 \text { for } y . \\
7 & \text { Solve for } b .
\end{array} .
\end{array}
$$

Step 3 Substitute the slope and $y$-intercept into the slope-intercept form.

$$
\begin{array}{ll}
y=m x+b & \text { Use slope-intercept form. } \\
y=-3 x+7 & \text { Substitute }-3 \text { for } m \text { and } 7 \text { for } b .
\end{array}
$$

An equation of the line is $y=-3 x+7$.

## What information can

 you use?The slope tells you the ratio of vertical change to horizontal change. Plot the $y$-intercept. Then use the slope to plot another point on the line.

## Graphing a Linear Equation

What is the graph of $y=2 x-1$ ?

Step 1 The $y$-intercept is -1 . So plot a point at $(0,-1)$.


Step 2 The slope is 2 , or $\frac{2}{1}$. Move up 2 units and right 1 unit. Plot another point.

Step 3 Draw a line through the two points.

## Problem 6

## Modeling a Function SIEM

Physics Water pressure can be measured in atmospheres (atm). Use the information in the diagram to write an equation that models the pressure $y$ at a depth of $x$ meters. What graph models the pressure?

How do you identify the $y$-intercept? The $y$-intercept is the $y$-value when $x=0$. So the $y$-intercept is the pressure at a depth of 0 m . This is the starting value, 1 atm .

Step 1 Identify the slope and the $y$-intercept.
The slope is the rate of change, $0.1 \mathrm{~atm} / \mathrm{m}$.
The $y$-intercept is the starting value, 1 atm .
Step 2 Substitute the slope and $y$-intercept into the slope-intercept form.

$$
\begin{array}{ll}
y=m x+b & \text { Use slope-intercept form. } \\
y=0.1 x+1 & \text { Substitute } 0.1 \text { for } m \text { and } 1 \text { for } b .
\end{array}
$$

Step 3 Graph the equation.
The $y$-intercept is 1 . Plot the point $(0,1)$.
The slope is 0.1 , which equals $\frac{1}{10}$. Plot a second point 1 unit above and 10 units to the right of the $y$-intercept. Then draw a line through the two points.

Pressure Under Water



For additional support when completing your homework, go to PearsonTEXAS.com.

Find the slope and $y$-intercept of the graph of each linear function.
What is the rate of change of the function?

1. $y=3 x+1$
2. $y=-0.2 x+3$
3. $y=\frac{1}{4} x-\frac{1}{3}$

Write an equation in slope-intercept form of the line with the given slope $m$ and $y$-intercept $b$.
4. $m=1, b=-1$
5. $m=-0.5, b=1.5$
6. $m=-2, b=\frac{8}{5}$
7. Display Mathematical Ideas (1)(G) A student drew the graph at the right for the equation $y=-2 x+1$. What error did the student make? Draw the correct graph.
8. Apply Mathematics (1)(A) A computer repair service charges $\$ 50$ for diagnosis and $\$ 35$ per hour for repairs. Let $x$ be the number of hours it takes to repair a computer. Let $y$ be the total cost of the repair. Graph the equation that relates $x$ and $y$. Explain why you should draw the line only in Quadrant I.
9. Use Multiple Representations to Communicate Mathematical
 Ideas (1)(D) Suppose you have a $\$ 5$-off coupon at a fabric store. You buy fabric that costs $\$ 7.50$ per yard. Write an equation that models the total amount of money $y$ you pay if you buy $x$ yards of fabric. What is the graph of the equation?
10. Using the tables at the right, predict whether the two graphs will intersect. Plot the points and sketch the lines. Do the two lines appear to intersect? Explain.
11. Apply Mathematics (1)(A) The temperature at sunrise is $65^{\circ} \mathrm{F}$. Each hour during the day, the temperature rises $5^{\circ} \mathrm{F}$. Write an equation that models the temperature $y$, in degrees Fahrenheit, after $x$ hours during the day. What is the graph of the equation?
12. Use a Problem-Solving Model (1)(B) Polar bears are listed as a threatened species. In 2005, there were about 25,000 polar bears in the world. If the number of polar bears declines by 1000 each year, in what year will polar bears become extinct?

Find the slope and $y$-intercept of the graph of each equation.
13. $-2 y=6(5-3 x)$
14. $y-d=c x$
15. $y=(2-a) x+a$
16. $2 y+4 n=-6 x$
17. Apply Mathematics (1)(A) A sailboat begins a voyage with 145 lb of food. The crew plans to eat a total of 15 lb of food per day. The crew plans to have 25 lb of food remaining when they end their voyage. How many days does the crew expect their voyage to last?

Use the slope and $y$-intercept to graph each equation.
18. $y=7-3 x$
19. $4 x+3 y=2 x-1$
20. $-2(3 x+4)+y=0$

Write an equation in slope-intercept form of each line.
21.

22.

23.


Write an equation in slope-intercept form of the line that passes through the given points.
24. $(0,3)$ and $(2,5)$
25. ( $-2,4$ ) and ( $3,-1$ )
26. $(-3,3)$ and $(1,2)$

Graph each equation.
27. $y=x+5$
28. $y=3 x+4$
29. $y=-2 x+3$
30. Explain Mathematical Ideas (1)(G) Describe two ways you can determine whether an equation is linear.
31. Apply Mathematics (1)(A) Suppose you are doing a 5000-piece puzzle. You have already placed 175 pieces. Every minute you place 10 more pieces. After 50 more minutes, how many pieces will you have placed?
Find the value of $a$ such that the graph of the equation has the given slope $m$.
32. $y=2 a x+4, m=-1$
33. $y=-\frac{1}{2} a x-5, m=\frac{5}{2}$
34. $y=\frac{3}{4} a x+3, m=\frac{9}{16}$

## TEXAS End-of-Course PRACTICE

35. What is the slope of the line that passes through the points $(-5,3)$ and $(1,7)$ ?
A. $-\frac{5}{3}$
B. $-\frac{2}{3}$
C. $\frac{2}{3}$
D. $\frac{3}{2}$
36. Which equation represents the graph at the right?
F. $y=-\frac{3}{2} x+4$
G. $y=-4 x+\frac{3}{2}$
H. $y=-\frac{2}{3} x+4$
J. $y=4 x-\frac{2}{3}$
37. If $a, b$, and $c$ are real numbers, $a \neq 0$, and $b>c$, is the statement $a b>a c$ always, sometimes, or never true? Explain.


## TEKS FOCUS

TEKS (2)(B) Write linear equations in two variables in various forms, including $y=m x+b, A x+B y=C$, and $y-y_{1}=m\left(x-x_{1}\right)$, given one point and the slope and given two points.

TEKS (1)(F) Analyze mathematical relationships to connect and communicate mathematical ideas.

Additional TEKS (1)(A), (2)(C), (3)(A), (3)(B), (3)(C), (12)(E)

## VOCABULARY

- Point-slope form - The point-slope form of an equation of a nonvertical line with slope $m$ and through point $\left(x_{1}, y_{1}\right)$ is $y-y_{1}=m\left(x-x_{1}\right)$
- Analyze - closely examine objects, ideas, or relationships to learn more about their nature


## ESSENTIAL UNDERSTANDING

You can use the slope of a line and any point on the line to write and graph an equation of the line. Any two equations for the same line are equivalent.

## Definition

The point-slope form of an equation of a nonvertical line with slope $m$ and through point $\left(x_{1}, y_{1}\right)$ is $y-y_{1}=m\left(x-x_{1}\right)$.

## Symbols

$$
y-y_{1}=m\left(x-x_{1}\right)
$$

$\uparrow \quad \uparrow \quad \uparrow$
$y$-coordinate slope $x$-coordinate

Graph


When you use $y-y_{1}=m\left(x-x_{1}\right)$, $\left(x_{1}, y_{1}\right)$ represents a specific point and $(x, y)$ represents any point.

Problem 1

## Writing an Equation in Point-Slope Form

Since you know a point and the slope, use point-slope form.

A line passes through $(-3,6)$ and has slope -5 . What is an equation of the line?

$$
\begin{aligned}
& y-y_{1}=m\left(x-x_{1}\right) \quad \text { Use point-slope form. } \\
& \begin{array}{ll}
y_{1}=6 \\
y-6=-5[x-(-3)] \quad & \text { Substitute }(-3,6) \text { for }\left(x_{1}, y_{1}\right) \text { and }-5 \text { for } m . \\
y-6=-5(x+3) \quad & \text { Simplify inside grouping symbols. }
\end{array}
\end{aligned}
$$

## Plan

How does the equation help you make a graph? Use the point from the equation. Use the slope of the line from the equation to find another point. Graph using the two points.

## Graphing Using Point-Slope Form

What is the graph of the equation $y-1=\frac{2}{3}(x-2)$ ?
The equation is in point-slope form, $y-y_{1}=m\left(x-x_{1}\right)$. A point $\left(x_{1}, y_{1}\right)$ on the line is $(2,1)$, and the slope of the line is $m=\frac{2}{3}$.

Step 1 Graph a point at $(2,1)$.

Step 2 Use the slope of the line, $\frac{2}{3}$. Go up 2 units and right 3 units. Draw a point.

Step 3 Draw a line through the two points.

## Problem 3

## How does the graph help you write an equation?

 You can use two points on the line to find the slope. Then use point-slope form.
## Using Two Points to Write an Equation

What is an equation of the line at the right?

## Think

You need the slope $m$, so start with the slope formula.

Use the given points to find the slope.

Use point-slope form.

$$
y-y_{1}=m\left(x-x_{1}\right)
$$

Use either given
point for $\left(x_{1}, y_{1}\right)$. For

$$
y-4=\frac{7}{3}(x-1)
$$

use $(1,4)$.


## Plan

How does the table help you write an equation? The table gives four points. You can use any two of the points to find the slope. Then use point-slope form.

## Using a Table to Write an Equation

Recreation The table shows the altitude of a hot-air balloon during its linear descent. What equation in slope-intercept form gives the balloon's altitude at any time? What do the slope and $y$-intercept represent?

$$
\begin{array}{rlrl}
m & =\frac{590-640}{30-10}=-2.5 & \begin{array}{l}
\text { Use two points, such as }(10,640) \\
\text { and }(30,590), \text { to find the slope. }
\end{array} \\
y-y_{1} & =m\left(x-x_{1}\right) & & \text { Use point-slope form. } \\
y-640 & =-2.5(x-10) & & \begin{array}{l}
\text { Use the data point }(10,640) \text { and } \\
\text { the slope }-2.5 .
\end{array} \\
y & =-2.5 x+665 & & \text { Rewrite in slope-intercept form. }
\end{array}
$$

Hot-Air Balloon Descent

| Time, $x$ <br> $(\mathrm{~s})$ | Altitude, $y$ <br> $(\mathrm{~m})$ |
| :---: | :---: |
| 10 | 640 |
| 30 | 590 |
| 70 | 490 |
| 90 | 440 |

The slope -2.5 represents the rate of descent of the balloon in meters per second. The $y$-intercept 665 represents the initial altitude of the balloon in meters.


For additional support when completing your homework, go to PearsonTEXAS.com.

1. What is the slope of the line with equation $y+3=2(x-1)$ ?

## Graph each equation.

2. $y-1=-3(x+2)$
3. $y+5=-(x+2)$
4. $y-2=\frac{4}{9}(x-3)$

## Write an equation in point-slope form for each line.

5. 


6.

7.

8. Apply Mathematics (1)(A) The relationship of degrees Fahrenheit ( ${ }^{\circ} \mathrm{F}$ ) and degrees Celsius $\left({ }^{\circ} \mathrm{C}\right)$ is linear. When the temperature is $50^{\circ} \mathrm{F}$, it is $10^{\circ} \mathrm{C}$. When the temperature is $77^{\circ} \mathrm{F}$, it is $25^{\circ} \mathrm{C}$. Write an equation in point-slope form giving the Celsius temperature $C$ in terms of the Fahrenheit temperature $F$. What is the Celsius temperature when it is $59^{\circ} \mathrm{F}$ ?

Write an equation in point-slope form of the line that passes through the given point and with the given slope $m$.
9. $(3,-4) ; m=6$
10. $(4,2) ; m=-\frac{5}{3}$
11. $(-2,-7) ; m=\frac{4}{5}$
12. $(4,0) ; m=-1$
13. Analyze Mathematical Relationships (1)(F) Figure $A B C D$ is a rectangle. Write equations in point-slope form of the lines containing the sides of $A B C D$. Use your results to make a conjecture about the slopes of parallel lines.
14. Apply Mathematics (1)(A) The relationship between altitude and the boiling point of water is linear. At an altitude of 8000 ft , water boils at $197.6^{\circ} \mathrm{F}$. At an altitude of 4500 ft , water boils at $203.9^{\circ} \mathrm{F}$. Write an equation in point-slope form for the boiling point $b$ of water, in degrees Fahrenheit, in terms of the altitude $a$, in feet.
 What is the boiling point of water at 2500 ft ?
15. Using a graphing calculator, graph $f(x)=3 x+2$.
a. If $f(x)=3 x+2$ and $g(x)=4 f(x)$, write the equation for $g(x)$. Graph $g(x)$ and compare it to the graph of $f(x)$.
b. If $f(x)=3 x+2$ and $h(x)=f(4 x)$, write the equation for $h(x)$. Graph $h(x)$ and compare it to the graph of $f(x)$.
c. Compare how multiplying a function by a nonzero number and multiplying the $x$-value of a function by a nonzero number change the graphs of the functions.
16. Using a graphing calculator, graph $f(x)=2 x-5$.
a. If $f(x)=2 x-5$ and $j(x)=f(x)+3$, write the equation for $j(x)$. Graph $j(x)$ and compare it to the graph of $f(x)$.
b. If $f(x)=2 x-5$ and $k(x)=f(x+3)$, write the equation for $k(x)$. Graph $k(x)$ and compare it to the graph of $f(x)$.
c. Compare how adding a nonzero number to a function and adding a number to the $x$-value of a function change the graphs of the functions.

Write an equation in point-slope form of the line that passes through the given points. Then write the equation in slope-intercept form.
17. $(1,4),(-1,1)$
18. $(2,4),(-3,-6)$
19. $(-6,6),(3,3)$

Model the data in each table with a linear equation in slope-intercept form. Then tell what the slope and $y$-intercept represent.
20.

| Time <br> Painting, $x$ (days) | Volume of <br> Paint, $y$ (gal) |
| :---: | :---: |
| 2 | 56 |
| 3 | 44 |
| 5 | 20 |

21. 

| Time <br> Worked, $x(\mathrm{~h})$ | Wages <br> Earned, $y(\$)$ |
| :---: | :---: |
| 1 | 8.50 |
| 3 | 25.50 |
| 6 | 51.00 |

Graph the line that passes through the given point and has the given slope $m$.
22. $(-3,-2) ; m=2$
23. $(6,-1) ; m=-\frac{5}{3}$
24. $(-3,1) ; m=\frac{1}{3}$
25. Apply Mathematics (1)(A) A forester plants a tree and measures its circumference yearly over the next four years. The table shows the forester's measurements.

a. Predict the circumference of the tree after 10 yr .
b. The circumference of the tree after 10 yr was actually 43 in . After four more years, the circumference was 49 in . Based on this new information, does the relationship between time and circumference continue to be linear? Explain.

## TEXAS End-of-Course PRACTICE

26. A company's revenue has been increasing by $\$ 20,000$ each year. In 2011 , the revenue was $\$ 730,000$. Which is an equation that gives the company's revenue $y$ (in thousands of dollars) $x$ years after 2000?
A. $y-730=20(x-11)$
B. $x-11=20(y-730)$
C. $y=20 x+730$
D. $x=20 y+11$
27. Which equation is equivalent to $y+12=-3(x-2)$ ?
F. $y=-15(x-2)$
G. $y=-3 x-14$
H. $y=-3 x-6$
J. $y=9 x+6$
28. The table shows the number of text messages sent from a cellular phone and the monthly cost of the phone plan.

| Phone Plan Cost |  |  |  |
| :--- | :---: | :---: | :---: |
| Text Messages Sent | 20 | 50 | 80 |
| Monthly Cost (\$) | 41.99 | 44.99 | 47.99 |

a. Graph the data.
b. Write an equation in slope-intercept form that represents the relationship between the number of messages sent $n$ and the monthly cost $c$ ?

\section*{| $\star$ | $3-5$ | Standard Form |
| :---: | :---: | :---: | :---: |}

## TEKS FOCUS

TEKS (2)(B) Write linear equations in two variables in various forms, including $y=m x+b, A x+B y=C$, and $y-y_{1}=m\left(x-x_{1}\right)$, given one point and the slope and given two points.

TEKS (1)(F) Analyze mathematical relationships to connect and communicate mathematical ideas.

Additional TEKS (1)(G), (2)(A), (2)(C), (2)(G), (3)(A), (3)(C)

## VOCABULARY

- Standard form of a linear equation - The standard form of a linear equation is $A x+B y=C$, where $A, B$, and $C$ are real numbers and $A$ and $B$ are not both zero.
- $x$-Intercept - the $x$-coordinate of a point where a graph crosses the $x$-axis; The point itself is also sometimes referred to as an $x$-intercept of the graph.
- Zero of a function - A zero of a function $y=f(x)$ is a value of $x$ for which $y=0$. The realnumber zeros of a function are the $x$-intercepts of the function's graph.


## - Analyze - closely examine

 objects, ideas, or relationships to learn more about their nature
## ESSENTIAL UNDERSTANDING

One form of a linear equation, called standard form, allows you to find intercepts quickly. You can use the intercepts to draw the graph.

## Key Concept Standard Form of a Linear Equation

The standard form of a linear equation is $A x+B y=C$, where $A, B$, and $C$ are real numbers, and $A$ and $B$ are not both zero.

## Concept Summary Linear Equations

You can describe any line using one or more of these forms of a linear equation. Any two equations for the same line are equivalent.

## Graph



## Forms

Slope-Intercept Form
$y=m x+b$
$y=-\frac{2}{3} x+6$

Point-Slope Form
$y-y_{1}=m\left(x-x_{1}\right)$
$y-4=-\frac{2}{3}(x-3)$

Standard Form
$A x+B y=C$
$2 x+3 y=18$

## Finding $\boldsymbol{x}$ - and $\boldsymbol{y}$-Intercepts and Slope

Why do you substitute 0 for $y$ to find the $x$-intercept? The $x$-intercept is the $x$-coordinate of a point on the $x$-axis. Any point on the $x$-axis has a $y$-coordinate of 0 .

What are the $x$ - and $y$-intercepts and the slope of the graph of $3 x+4 y=24$ ?
Step 1 To find the $x$-intercept, substitute 0 for $y$. Solve for $x$.

$$
\begin{aligned}
3 x+4 y & =24 \\
3 x+4(0) & =24 \\
3 x & =24 \\
x & =8
\end{aligned}
$$

Step 2 To find the $y$-intercept, substitute 0 for $x$. Solve for $y$.

$$
\begin{aligned}
3 x+4 y & =24 \\
3(0)+4 y & =24 \\
4 y & =24 \\
y & =6
\end{aligned}
$$

The $y$-intercept is 6 .

Step 3 To find the slope $m$, rewrite the equation in slope-intercept form.

$$
\begin{aligned}
3 x+4 y & =24 & & \\
3 x-3 x+4 y & =-3 x+24 & & \text { Subtract } 3 x \text { from each side. } \\
4 y & =-3 x+24 & & \text { Simplify. } \\
\frac{4 y}{4} & =\frac{-3 x+24}{4} & & \text { Divide each side by } 4 . \\
y & =-\frac{3}{4} x+6 & & \text { Simplify. } \\
m & =-\frac{3}{4} & &
\end{aligned}
$$

The slope is $-\frac{3}{4}$.

## Problem 2

## Graphing a Line Using Intercepts

What is the graph of $x-2 y=-2$ ?


Step 1 Find the intercepts.

## Think

What points do the intercepts represent? The $x$-intercept, or zero, is -2 , so the graph crosses the $x$-axis at $(-2,0)$. The $y$-intercept is 1 , so the graph crosses the $y$-axis at $(0,1)$.

$$
\begin{aligned}
x-2 y & =-2 \\
x-2(0) & =-2 \\
x & =-2 \quad \leftarrow \text {-intercept } \\
x-2 y & =-2 \\
0-2 y & =-2 \\
-2 y & =-2
\end{aligned}
$$

Find and plot the $x$ - and $y$-intercepts. Draw a line through the points.

Step 2 Plot $(-2,0)$ and $(0,1)$. Draw a line through the points.


## Problem 3

## Think

How are the equations of the vertical line in Part A and the horizontal line in Part B consistent with what you know about the slopes of these lines? If you try to write the equation of the horizontal line in slope-intercept form, you see that its slope is 0 . The equation of the vertical line cannot be written in slopeintercept form. The slope is undefined.

## Writing Equations for Horizontal and Vertical Lines

What is the equation of each line? Identify the values of $A, B$, and $C$ in the standard form of the equation.

A


Notice that a vertical line is parallel to the $y$-axis and perpendicular to the $x$-axis, and that the $x$-coordinate of every point on a vertical line is the same.

For this line, $x$ is 3 for all values of $y$, so the equation of the line is $x=3$.

You can write the equation $x=3$ in standard form as $1 x+0 y=3$, with $A=1, B=0$, and $C=3$.

B


Notice that a horizontal line is parallel to the $x$-axis and perpendicular to the $y$-axis, and that the $y$-coordinate of every point on a horizontal line is the same.

For this line, $y$ is 3 for all values of $x$, so the equation of the line is $y=3$.

You can write the equation $y=3$ in standard form as $0 x+1 y=3$, with $A=0, B=1$, and $C=3$.

## Problem 4

## Writing Linear Equations in Standard Form

A What is an equation, in standard form, of the line through $(-5,7)$ with slope $\frac{2}{3}$ ?

$$
\begin{aligned}
y-y_{1} & =m\left(x-x_{1}\right) & & \text { Point-slope form } \\
y-7 & =\frac{2}{3}(x-(-5)) & & \text { Substitute }(-5,7) \text { for }\left(x_{1}, y_{1}\right) \text { and } \frac{2}{3} \text { for } m . \\
y-7 & =\frac{2}{3}(x)-\frac{2}{3}(-5) & & \text { Distributive Property } \\
y-7 & =\frac{2}{3} x+\frac{10}{3} & & \text { Simplify. } \\
y & =\frac{2}{3} x+\frac{31}{3} & & \text { Add } 7 \text { to each side. } \\
-\frac{2}{3} x+y & \frac{31}{3} & & \text { Subtract } \frac{2}{3} x \text { from each side. } \\
2 x-3 y & =-31 & & \text { Multiply both sides by }-3 .
\end{aligned}
$$

The graph of $2 x-3 y=-31$ has a slope of $\frac{2}{3}$ and passes through the point $(-5,7)$.

## Problem 4 continued

Think
Does it matter which ordered pair is used to find the equation? No, either ordered pair can be used because every point on the line represents a set of $x$ - and $y$-values which satisfy the equation.

## Think

Is there another way to find solutions? You can guess and check by substituting values for one variable and solving for the other. Then check if your solution makes sense in the context of the problem. Graphing is the quickest way to see all the solutions.

B Write an equation, in standard form, of the line passing through $(9,-1)$ and $(11,3)$. First, find the slope of the line. Then, substitute into the point-slope form.

$$
\begin{aligned}
\text { slope }=\frac{y_{2}-y_{1}}{x_{2}-x_{1}} & =\frac{3-(-1)}{11-9}=2 & & \\
y-y_{1} & =m\left(x-x_{1}\right) & & \text { Point-slope form } \\
y-(-1) & =2(x-9) & & \text { Substitute }(9,-1) \text { for }\left(x_{1}, y_{1}\right) \text { and } 2 \text { for } m . \\
y+1 & =2 x-18 & & \text { Distributive Property } \\
y & =2 x-19 & & \text { Subtract } 1 \text { from each side. } \\
-2 x+y & =-19 & & \text { Subtract } 2 x \text { from each side. } \\
2 x-y & =19 & & \text { Multiply each side by }-1 .
\end{aligned}
$$

The graph of $2 x-y=19$ passes through the points $(9,-1)$ and $(11,3)$.

## Problem 5

## Using Standard Form as a Model

Online Shopping An online store sells songs for \$1 each and movies for \$12 each.
You have $\$ 60$ to spend.
A Write and graph a linear equation that describes the items you can purchase if you spend the full $\$ 60$. What are three combinations of numbers of songs and movies you can purchase?

| Relate | Cost of a song | times | number of songs | plus | cost of a movie | times | number of movies | equals | \$60. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Define | Let $x$ | $=$ the number of songs purchased. |  |  |  |  |  |  |  |
|  | Let $y$ | $=$ the number of movies purchased. |  |  |  |  |  |  |  |
| Write | 1 | - | $x$ | + | 12 | - | $y$ | $=$ | 60 |

An equation for this situation is $x+12 y=60$.
Find the intercepts.

$$
\begin{array}{rlrl}
x+12 y & =60 & x+12 y & =60 \\
x+12(0) & =60 & 0+12 y & =60 \\
x & =60 & y & =5
\end{array}
$$

Use the intercepts to draw the graph. Only points in the first quadrant make sense.

The intercepts give you two combinations of songs and movies. Use the graph to identify a third combination. Each of the red points is a possible solution.

continued on next page

## Problem 5 continued

B What are reasonable domain and range values of the linear function in Part $A$, in terms of this real-world situation? What is the zero of the function and what does it mean in terms of the situation?

You cannot buy a fraction of a song or movie. The graph is a line, but only points with integer coordinates are solutions. So reasonable domain values are $0,12,24,36,48$, and 60 and reasonable range values are $0,1,2,3,4$, and 5 .

The zero of the function is the $x$-value for which $y$ is 0 , which corresponds to the $x$-intercept of the graph. So, the zero of the function is 60 . In this situation, the zero of 60 means that you can buy 60 songs if you buy 0 movies.

## Problem 6

## Identifying Features of a Linear Function

Choose a tool, such as paper and pencil or technology, to graph the linear function represented by the table. Identify the $x$-intercept, $y$-intercept, and slope of the graph, and the zero of the function. Then write the equation of the line in standard form.

The coordinates are integers and relatively close together, so graph the linear function using paper and pencil to plot the points and draw the line.Without knowing the equation of the line you cannot use technology to graph the function.


From the graph, the $x$-intercept is 6 and the $y$-intercept is 3 . The slope is $-\frac{1}{2}$. The function has one zero at $x=6$.

Use the slope and the $y$-intercept to write the equation

## Think

## How can you use

 technology to check your results? After writing the equation of the line, use the slope-intercept form to graph the line on a graphing calculator. of the line.$$
\begin{array}{rlrl}
y & =m x+b & & \text { Slope-Intercept form } \\
y & =-\frac{1}{2} x+3 \\
x+2 y & =6 & & \text { Substitute }-\frac{1}{2} \text { for } m \text { and } 3 \text { for } b . \\
& & \text { Rewrite in standard form. }
\end{array}
$$

## PRACTICE and APPLICATION EXERCISES



For additional support when completing your homework, go to PearsonTEXAS.com.

Find the slope and $x$ - and $y$-intercepts of the graph of each equation.

1. $x+y=9$
2. $7 x-y=21$
3. $-5 x+3 y=-7.5$
4. $A x+B y=C$
5. Explain Mathematical Ideas (1)(G) The three forms of linear equations you have studied are slope-intercept form, point-slope form, and standard form. Explain when each form is most useful.
6. Apply Mathematics (1)(A) In a video game, you earn 5 points for each jewel you find. You earn 2 points for each star you find. Graph a linear function that represents the numbers of jewels and stars you must find to earn 250 points. What are reasonable domain and range values for the function in terms of this real-world situation? Identify the zero of the function and explain what it means in terms of the situation. What are three combinations of jewels and stars that will earn you 250 points?
Graph each equation using $x$ - and $y$-intercepts.
7. $x+y=4$
8. $-4 x+y=-12$
9. $6 x-2 y=18$
10. Apply Mathematics (1)(A) You are preparing a fruit salad. You want the total carbohydrates from pineapple and watermelon to equal 24 g . Pineapple has 3 g of carbohydrates per ounce and watermelon has 2 g of carbohydrates per ounce. Graph a linear function that shows all possible combinations of ounces of pineapple and ounces of watermelon. What are reasonable domain and range values for the function in terms of this real-world situation? Identify the zero of the function and explain what it means in terms of the situation.

Graph the linear function represented by the table. Identify the $x$-intercept, $y$-intercept, and slope of the graph, and the zero of the function.
11.

12.

13.

14. Analyze Mathematical Relationships (1)(F) Graph $3 x+y=6,3 x-y=6$, and $-3 x+y=6$. How are the graphs similar? How are they different?
15. Justify Mathematical Arguments (1)(G) A student says $y=4 x+1$ can be written in standard form as $4 x-y=1$. Describe and correct the student's error.
16. Explain Mathematical Ideas (1)(G) The coefficients of $x$ and $y$ in the standard form of a linear equation cannot both be zero. Explain why.
Write an equation in standard form of the line passing through the given points.
17. $(8,3),(-4,-4)$
18. $(-2,-1),(-3,-6)$
19. Use Multiple Representations to Communicate Mathematical Ideas (1)(D) The graph below represents one function, and the table represents a different function. How are the functions similar? How are they different?



Find the $x$ - and $y$-intercepts of the line that passes through the given points.
20. $(-6,4),(3,-5)$
21. $(-5,-5),(4,-2)$
22. $(-7,6),(-4,11)$

What is the equation of each line? Identify the values of $A, B$, and $C$ in the standard form of the equation.
23.

24.

25.

26. Write an equation of a line in standard form that has the same slope as $4 x-y=5$ and the same $y$-intercept as the graph of $3 y-13 x=6$.
27. a. Select Tools to Solve Problems (1)(C) Choose a tool, such as paper and pencil or technology, to graph $2 x+3 y=6,2 x+3 y=12$, and $2 x+3 y=18$ in the same coordinate plane. Which tool did you use and why?
b. How are the lines you graphed in part (a) related? As $C$ increases, what happens to the graph of $2 x+3 y=C$ ?
28. Apply Mathematics (1)(A) Your school is having a talent show to raise money for new band supplies. You think that 200 students and 150 adults will attend. It will cost $\$ 200$ to put on the talent show. What is an equation that describes the ticket prices you can set for students and adults to raise $\$ 1000$ ? Graph your equation. What are three possible prices you could set for student and adult tickets?
29. Apply Mathematics (1)(A) The scoreboard for a football game is shown at the right. All of the points the home team scored came from field goals worth 3 points and touchdowns with successful extra-point attempts worth 7 points. Write and graph a linear equation that represents this situation. List every possible combination of field
 goals and touchdowns the team could have scored.

## TEXAS End-of-Course PRACTICE

30. What is $y=-\frac{3}{4} x+2$ written in standard form using integers?
A. $\frac{3}{4} x+y=2$
B. $3 x+4 y=2$
C. $3 x+4 y=8$
D. $-3 x-4 y=8$
31. Which equation models a line with the same $y$-intercept but half the slope of the line $y=6-8 x$ ?
F. $y=-4 x+3$
G. $y=6-4 x$
H. $y=3-8 x$
J. $y=-16 x+6$
32. The drama club plans to attend a professional production. Between 10 and 15 students will go. Each ticket costs $\$ 25$ plus a $\$ 2$ surcharge. There is a one-time handling fee of $\$ 3$ for the entire order. What is a linear function that models this situation? What domain and range are reasonable for the function?

# * 3-6 Parallel and Perpendicular Lines 

## TEKS FOCUS

TEKS (2)(E) Write the equation of a line that contains a given point and is parallel to a given line.

TEKS (2)(F) Write the equation of a line that contains a given point and is perpendicular to a given line.

TEKS (1)(G) Display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication.

Additional TEKS (1)(A), (2)(B), (2)(C), (3)(A)

## VOCABULARY

- Opposite reciprocals - two numbers whose product is -1
- Parallel lines - lines in the same plane that never intersect
- Argument - a set of statements put forth to show the truth or falsehood of a mathematical claim
- Perpendicular lines - lines that intersect to form right angles


## ESSENTIAL UNDERSTANDING

You can determine the relationship between two lines by comparing their slopes and $y$-intercepts.

## Key Concept Slopes of Parallel Lines

## Words

Nonvertical lines are parallel if they have the same slope and different $y$-intercepts. Vertical lines are parallel if they have different $x$-intercepts.

## Example

The graphs of $y=\frac{1}{2} x+1$ and $y=\frac{1}{2} x-2$ are lines that have the same slope, $\frac{1}{2}$, and different $y$-intercepts. The lines are parallel.

Graph


## Key Concept Slopes of Perpendicular Lines

## Words

Two nonvertical lines are perpendicular if the product of their slopes is -1 . A vertical line and a horizontal line are also perpendicular.

## Example

The graph of $y=\frac{1}{2} x-1$ has a slope of $\frac{1}{2}$. The graph of $y=-2 x+1$ has a slope of -2 .

Graph


## Problem 1

## Writing an Equation of a Parallel Line

A line passes through $(12,5)$ and is parallel to the graph of $y=\frac{2}{3} x-1$. What equation represents the line in slope-intercept form?
Step 1 Identify the slope of the given line. The slope of the graph of $y=\frac{2}{3} x-1$ is $\frac{2}{3}$. The parallel line has the same slope.

Step 2 Write an equation in slope-intercept form of the line through $(12,5)$ with slope $\frac{2}{3}$.

$$
\begin{aligned}
y-y_{1} & =m\left(x-x_{1}\right) & & \text { Start with point-slope form. } \\
y-5 & =\frac{2}{3}(x-12) & & \text { Substitute }(12,5) \text { for }\left(x_{1}, y_{1}\right) \text { and } \frac{2}{3} \text { for } m . \\
y-5 & =\frac{2}{3} x-\frac{2}{3}(12) & & \text { Distributive Property } \\
y-5 & =\frac{2}{3} x-8 & & \text { Simplify. } \\
y & =\frac{2}{3} x-3 & & \text { Add } 5 \text { to each side. }
\end{aligned}
$$

The graph of $y=\frac{2}{3} x-3$ passes through $(12,5)$ and is parallel to the graph of $y=\frac{2}{3} x-1$.

Problem 2

## Classifying Lines

Why write each equation in slopeintercept form? You can easily identify the slope of a line written in slope-intercept form. Just look at the coefficient of $x$.

Are the graphs of $4 y=-5 x+12$ and $y=\frac{4}{5} x-8$ parallel, perpendicular, or neither? Explain.
Step 1 Find the slope of each line by writing its equation in slope-intercept form, if necessary. Only the first equation needs to be rewritten.

$$
\begin{aligned}
4 y & =-5 x+12 & & \text { Write the first equation. } \\
\frac{4 y}{4} & =\frac{-5 x+12}{4} & & \text { Divide each side by } 4 . \\
y & =-\frac{5}{4} x+3 & & \text { Simplify. }
\end{aligned}
$$

The slope of the graph of $y=-\frac{5}{4} x+3$ is $-\frac{5}{4}$.
The slope of the graph of $y=\frac{4}{5} x-8$ is $\frac{4}{5}$.
Step 2 The slopes are not the same, so the lines cannot be parallel. Multiply the slopes to see if they are opposite reciprocals.

$$
-\frac{5}{4} \cdot \frac{4}{5}=-1
$$

The slopes are opposite reciprocals, so the lines are perpendicular.

## Writing an Equation of a Perpendicular Line

Multiple Choice Which equation represents the line that passes through $(2,4)$ and is perpendicular to the graph of $y=\frac{1}{3} x-1$ ?

## Think

How do you know you have found the opposite reciprocal? Multiply the two numbers together as a check. If the product is -1 , the numbers are opposite reciprocals: $\frac{1}{3}(-3)=-1$.
$\begin{array}{llll}\text { (A) } y=\frac{1}{3} x+10 & \text { (B) } y=3 x+10 & \text { (C) } y=-3 x-2 & \text { (D) } y=-3 x+10\end{array}$
Step 1 Identify the slope of the graph of the given equation. The slope is $\frac{1}{3}$.
Step 2 Find the opposite reciprocal of the slope from Step 1. The opposite reciprocal of $\frac{1}{3}$ is -3 . So, the perpendicular line has a slope of -3 .
Step 3 Use point-slope form to write an equation of the perpendicular line.

$$
\begin{aligned}
y-y_{1} & =m\left(x-x_{1}\right) & & \text { Write point-slope form. } \\
y-4 & =-3(x-2) & & \text { Substitute }(2,4) \text { for }\left(x_{1}, y_{1}\right) \text { and }-3 \text { for } m . \\
y-4 & =-3 x+6 & & \text { Distributive Property } \\
y & =-3 x+10 & & \text { Add 4 to each side. }
\end{aligned}
$$

The equation is $y=-3 x+10$. The correct answer is D .

## Problem 4

## Solving a Real-World Problem STEM

Architecture An architect uses software to design the ceiling of a room. The architect needs to enter an equation that represents a new beam. The new beam will be perpendicular to the existing beam, which is represented by the red line. The new beam will pass through the corner represented by the blue point. What is an equation that represents the new beam?
Step 1 Use the slope formula to find the slope of the red line that represents the existing beam.

$$
\begin{array}{rlrl}
m & =\frac{4-6}{6-3} & & \text { Points }(3,6) \text { and }(6,4) \text { are } \\
& & \text { on the red line. } \\
& =-\frac{2}{3} & & \text { Simplify. }
\end{array}
$$

The slope of the line that represents the existing beam is $-\frac{2}{3}$.
Step 2 Find the opposite reciprocal of the slope from Step 1 . The opposite reciprocal of $-\frac{2}{3}$ is $\frac{3}{2}$.
Step 3 Use point-slope form to write an equation. The slope of the line that represents the new beam is $\frac{3}{2}$. It will pass through $(12,10)$. An equation that represents the new beam is $y-10=\frac{3}{2}(x-12)$ or, in slope-intercept form, $y=\frac{3}{2} x-8$.

For additional support when completing your homework, go to PearsonTEXAS.com.

Write an equation in slope-intercept form of the line that passes through the given point and is parallel to the graph of the given equation.

1. $(1,3) ; y=3 x+2$
2. $(2,-2) ; y=-x-2$
3. $(1,-3) ; y+2=4(x-1)$
4. $(2,-1) ; y=-\frac{3}{2} x+6$
5. $(0,0) ; y=\frac{2}{3} x+1$
6. $(4,2) ; x=-3$

## Determine whether the graphs of the given equations are parallel,

 perpendicular, or neither. Explain.7. $y=x+11$
$y=-x+2$
8. $y=\frac{3}{4} x-1$
$y=\frac{3}{4} x+29$
9. $y=-2 x+3$
$2 x+y=7$
10. $y-4=3(x+2)$
$2 x+6 y=10$
11. $y=-7$
$x=2$
12. $y=4 x-2$
$-x+4 y=0$
13. Apply Mathematics (1)(A) A path for a new city park will connect the park entrance to Main Street. The path should be perpendicular to Main Street. What is an equation that represents the path?
14. Apply Mathematics (1)(A) A bike path is being planned for the park in Exercise 13. The bike path will be parallel to Main Street and will pass through the park entrance. What is an equation of the line that represents the bike path?
15. Identify each pair of parallel lines. Then identify each pair of perpendicular lines.
line $a: y=3 x+3$
line $b: x=-1$
line $c: y-5=\frac{1}{2}(x-2)$
line $d: y=3$
line $e: y+4=-2(x+6)$
line $f: 9 x-3 y=5$

Determine whether each statement is always, sometimes, or never true. Explain.
16. A horizontal line is parallel to the $x$-axis.
17. Two lines with positive slopes are parallel.
18. Two lines with the same slope and different $y$-intercepts are perpendicular.
19. Explain Mathematical Ideas (1)(G) Will the graph of the line represented by the table intersect the graph of $y=4 x+5$ ? Explain.
Write an equation in slope-intercept form of the line that passes through the given point and is perpendicular to the graph of the
 given equation.
20. $(0,0) ; y=-3 x+2$
21. $(-2,3) ; y=\frac{1}{2} x-1$
22. $(1,-2) ; y=5 x+4$
23. $(-3,2) ; x-2 y=7$
24. $(5,0) ; y+1=2(x-3)$
25. $(1,-6) ; x-2 y=4$
26. Apply Mathematics (1)(A) A designer is creating a new logo, as shown at the right. The designer wants to add a line to the logo that will be perpendicular to the red line and pass through the blue point. What equation represents the new line?
27. Analyze Mathematical Relationships (1)(F) For what value of $k$ are the graphs of $12 y=-3 x+8$ and $6 y=k x-5$ parallel? For what value of $k$ are they perpendicular?
28. Apply Mathematics (1)(A) Two farmers use combines to harvest corn
 from their fields. One farmer has 600 acres of corn, and the other has 1000 acres of corn. Each farmer's combine can harvest 100 acres per day. Write two equations for the number of acres $y$ of corn not harvested after $x$ days. Are the graphs of the equations parallel, perpendicular, or neither? How do you know?
29. Analyze Mathematical Relationships (1)(F) In a rectangle, opposite sides are parallel and adjacent sides are perpendicular. Figure $A B C D$ has vertices $A(-3,3), B(-1,-2), C(4,0)$, and $D(2,5)$. Show that $A B C D$ is a rectangle.
30. Explain Mathematical Ideas (1)(G) A right triangle has two sides that are perpendicular to each other. Triangle $P Q R$ has vertices $P(4,3), Q(2,-1)$, and $R(0,1)$. Determine whether $P Q R$ is a right triangle. Explain your reasoning.

## Write the equation of a line that fits the given description.

31. parallel to $y$-axis;
$x$-intercept: -2
32. perpendicular to $x$-axis; $x$-intercept: -4
33. parallel to $x$-axis;
$y$-intercept: 3
34. perpendicular to $y$-axis;
$y$-intercept: 3

## TEXAS End-of-Course PRACTICE

35. Which equation represents the graph of a line parallel to the line at the right?
A. $y=\frac{1}{2} x+5$
B. $y=2 x-6$
C. $y=-2 x+4$
D. $y=-\frac{1}{2} x-2$
36. What is the solution of $(5 x-1)+(-2 x+7)=9$ ?

F. $\frac{3}{7}$
G. 1
H. 3
J. 5
37. Sal's Supermarket sells cases of twenty-four 12-oz bottles of water for $\$ 15.50$. Shopper's World sells 12 -packs of 12 -oz bottles of water for $\$ 8.15$. Which store has the better price per bottle? Explain.

| $\downarrow \star$ | $3-7$ | Transformations of Linear Functions |
| :--- | :--- | :--- |

## TEKS FOCUS

TEKS (3)(E) Determine the effects on the graph of the parent function $f(x)=x$ when $f(x)$ is replaced by af(x), $f(x)+d, f(x-c)$, $f(b x)$ for specific values of $a, b, c$, and $d$.

TEKS (1)(D) Communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.

Additional TEKS (1)(A), (3)(C), (12)(B)

## VOCABULARY

- Reflection - A reflection is a transformation that flips a graph across a line, such as the $x$ - or $y$-axis.
- Transformation - A
transformation of a function is a simple change to the equation of the function that results in a change in the graph of the function, such as a translation or reflection.
- Translation - A translation is a transformation that shifts a
graph vertically, horizontally, or both, without changing its shape or orientation.
- Implication - a conclusion that follows from previously stated ideas or reasoning without being explicitly stated
- Representation - a way to display or describe information. You can use a representation to present mathematical ideas and data.


## ESSENTIAL UNDERSTANDING

The graph of any linear function is a transformation of the graph of the parent function $f(x)=x$.

## Key Concept Translation

A translation shifts the graph of a function vertically, horizontally, or both, without changing its shape or orientation. A translation of a linear function changes the $y$-intercept of the graph. The slope does not change.


If $d>0$, then $y=f(x)+d$ translates the graph of $y=f(x)$ up.
If $d<0$, then $y=f(x)+d$ translates the graph of $y=f(x)$ down.

If $c>0$, then $y=f(x-c)$ translates the graph of $y=f(x)$ to the right.
If $c<0$, then $y=f(x-c)$ translates the graph of $y=f(x)$ to the left.

A reflection flips the graph of a function across a line, such as the $x$ - or $y$-axis. Each point on the graph of the reflected function is the same distance from the line of reflection as its corresponding point on the graph of the original function.



## Key Concept Slope Change

For a linear function $y=f(x)$, multiplying either $f(x)$ or $x$ by a constant affects the slope of the graph.


Multiplying the outputs by a changes the slope. The $y$-intercept may also be affected.

Multiplying the inputs by $b$ changes the slope.

When $a>1$, the graph becomes steeper. If $f(x)$ has a $y$-intercept other than 0 , then the $y$-intercept is further from the origin.

When $0<a<1$, the graph becomes less steep. If $f(x)$ has a $y$-intercept other than 0 , then the $y$-intercept is closer to the origin.

When $b>1$, the graph becomes steeper. The $y$-intercept does not change.

When $0<b<1$, the graph becomes less steep. The $y$-intercept does not change.

## Vertical and Horizontal Translation, $\mathbf{f}(\mathbf{x})+\boldsymbol{d}$ and $\boldsymbol{f}(\boldsymbol{x}-\boldsymbol{c})$

A Determine the effects on the graph of the parent function
$f(x)=x$ when $g(x)=f(x)+4$. Graph both functions on the same coordinate grid.
Find the equation for $g(x)$ :

$$
\begin{aligned}
& g(x)=f(x)+4 \\
& g(x)=x+4 \quad \text { Replace } f(x) \text { with } x .
\end{aligned}
$$

Graph the functions $f(x)$ and $g(x)$.
The graph of $g(x)=x+4$ has the same slope as the graph of $f(x)=x$, and a different $y$-intercept of 4 . It represents a translation of the parent function 4 units up.


B Determine the effects on the graph of the parent function $f(x)=x$ when $g(x)=f(x-2)$. Graph both functions on the same coordinate grid.
Find the equation for $g(x)$ :

$$
\begin{aligned}
& g(x)=f(x-2) \\
& g(x)=x-2 \quad \text { Replace } x \text { with } x-2 .
\end{aligned}
$$

Graph the functions $f(x)$ and $g(x)$.
The graph of $g(x)=x-2$ has the same slope as the graph of $f(x)=x$, and a different $y$-intercept of -2 . It represents a translation of the parent function 2 units to the right.


## Problem 2

## Reflection Across the $\boldsymbol{x}$ - and $\boldsymbol{y}$-axes, $-\boldsymbol{f}(\boldsymbol{x})$ and $\boldsymbol{f}(-\boldsymbol{x})$

A Determine the effects on the graph of the parent function
$f(x)=x$ when $g(x)=-f(x)$. Would the effect be similar for $f(x)=x+1$ ?
The graph of $g(x)=-f(x)$ is a reflection of the graph of $f(x)$ across the $x$-axis. The slope changes signs, and the $y$-intercept is the same.


## Problem 2 continued

For $f(x)=x+1, g(x)=-x-1$. The graph of $g(x)$ is a reflection of the graph of $f(x)$ across the $x$-axis. The slope changes signs, and the $y$-intercept changes to -1 .


## Think

How do I recognize a reflection across an axis?
The graph of $f(x)$ is a mirror image of itself over the axis.

Determine the effects on the graph of the parent function $f(x)=x$ when $g(x)=f(-x)$. Would the effect be similar for $f(x)=x+1$ ?
The graph of $g(x)=f(-x)$ is a reflection of $f(x)$ across the $y$-axis. The slope changes signs, and the $y$-intercept is the same.

For $f(x)=x+1, g(x)=-x+1$. The graph of $g(x)$ is a reflection of the graph of $f(x)$ across the $y$-axis. The slope changes signs, and the $y$-intercept is the same.



## Problem 3

## Multiplication by a Constant, $f(b x)$ and $a f(x)$

A Determine the effects on the graph of the parent function $f(x)=x$ when $g(x)=f(3 x)$. Would the effect be similar for $f(x)=2 x+5$ ?
The equation for $g(x)$ is $g(x)=3 x$. The slope of the graph of $g(x)$ is 3 times the slope of the graph of $f(x)$. The graph of $g(x)$ is steeper than the graph of $f(x)$. The $y$-intercept does not change.

continued on next page

## Problem 3 continued

Find $g(x)$ for $f(x)=2 x+5$ :

$$
\begin{aligned}
g(x) & =f(3 x) \\
& =2(3 x)+5 \\
& =6 x+5
\end{aligned}
$$

The slope of the graph of $g(x)$ is 3 times the slope of the graph of $f(x)$. The graph of $g(x)$ is steeper than the graph of $f(x)$. The $y$-intercept does not change.


What effects can I describe?
Consider changes to the slope and intercepts of the linear functions.
$B$ Determine the effects on the graph of the parent function $f(x)=x$ when $g(x)=2 f(x)$. Would the effect be similar for $f(x)=2 x+5$ ?
The equation for $g(x)$ is $g(x)=2 x$. The slope of the graph of $g(x)$ is 2 times the slope of the graph of $f(x)$. The graph of $g(x)$ is steeper than the graph of $f(x)$. The $y$-intercept does not change.


Find $g(x)$ for $f(x)=2 x+5$ :

$$
\begin{aligned}
g(x) & =2 f(x) \\
& =2(2 x+5) \\
& =4 x+10
\end{aligned}
$$

The slope of the graph of $g(x)$ is 2 times the slope of the graph of $f(x)$. The graph of $g(x)$ is steeper than the graph of $f(x)$. The $y$-intercept changes from 5 to 10 .


Problem 4
TEKS Process Standard (1)(A)

## Applying Transformations

A gym charges $\$ 20$ per month for membership. The function $f(x)=20 x$ represents the membership cost for $x$ months.
A The owner increases the monthly membership fee by $25 \%$. Write the function $g(x)$, which gives the new cost per month, as a transformation of $f(x)$. Graph $f(x)$ and $g(x)$. Compare the graphs of $f(x)$ and $g(x)$. Identify the $x$-intercept, the $y$-intercept, and the slope of each line, and the zero of each function. Explain their meaning in this context.

## Think

Why do the graphs of $g(x)$ and $f(x)$ only include values in Quadrant I? In the context of the problem, only positive values of $x$ make sense. You cannot have a negative number months of membership.

$$
\begin{aligned}
f(x) & =20 x & & \text { Write } f(x) . \\
g(x) & =20(1.25 x) & & f(b x) ; b=1.25 \\
& =25 x & & \text { Simplify. }
\end{aligned}
$$

The graph of $g(x)$ is steeper than the graph of $f(x)$. The slope has changed, but the $x$ - and $y$-intercepts are the same.
The $x$ - and $y$-intercepts of each graph are 0 . The zero of each function is also 0 . This means that the cost for 0 months of
 membership is $\$ 0$. The slope of $f(x)$ is 20 and the slope of $g(x)$ is 25 . Each slope represents the cost of membership per month for that pricing plan.
Compare the values $f(8)$ and $g(8)$. Explain their meaning in this context.
The graph shows that $f(8)=160$, and $g(8)=200$. Check these values by substituting 8 for $x$ into the corresponding equation. The cost of 8 months of membership will increase from $\$ 160$ to $\$ 200$.


For additional support when completing your homework, go to PearsonTEXAS.com.

Determine the effects on the graph of the parent function $f(x)=x$ for each $g(x)$ function. Graph both functions on the same coordinate grid.

1. $g(x)=f(x)+3$
2. $g(x)=f(x+7)$
3. $g(x)=f(x)-3 \frac{1}{2}$
4. $g(x)=f(x-5)$
5. Analyze Mathematical Relationships (1)(F) For the parent function $f(x)=x$, explain when a vertical translation of $d$ units is equivalent to a horizontal translation of $c$ units. Include the direction of each translation in your explanation.
Find an equation for $g(x)$ when $g(x)=-f(x)$. Graph both
functions on the same coordinate grid.
6. $f(x)=x+2$
7. $f(x)=3 x$
8. $f(x)=\frac{2}{3} x+5$
9. $f(x)=3-x$

Find an equation for $g(x)$ when $g(x)=f(-x)$. Graph both functions on the same coordinate grid.
10. $f(x)=-2 x$
11. $f(x)=\frac{x}{2}-1$
12. $f(x)=1+x$
13. $f(x)=-x-2$

Determine the effects on the graph of the parent function $f(x)=x$ for each $g(x)$. Graph both functions on the same coordinate grid.
14. $g(x)=f(2 x)$
15. $g(x)=4 f(x)$
16. $g(x)=f\left(\frac{1}{3} x\right)$
17. $g(x)=1.8 f(x)$
18. Explain Mathematical Ideas (1)(G) For the transformations in this lesson, how would each affect the graph of a linear function of the form $y=3$ ? Use graphs to help explain your reasoning.
19. The graph shows the linear function $f(x)=2 x+3$ and the linear function $g(x)$.
a. Find the value of $b$ such that $g(x)=f(b x)$.
b. Is it possible to find a value of $a$ such that $g(x)=a f(x)$ ? If so, give the value. If not, explain.
20. Apply Mathematics (1)(A) You plan to buy $x$ pizzas for $\$ 12$ each. The function $f(x)=12 x$ represents the total cost of the pizzas.

a. Your friend plans to buy 4 more pizzas than you. The function $g(x)$ represents the total cost of your friend's pizzas. Write $g(x)$ as a transformation of the function $f(x)$, then simplify it.
b. Suppose your friend buys her pizzas at a different pizza shop. The pizzas cost $25 \%$ more than the pizzas you will buy. She still buys 4 more pizzas than you do. The function $h(x)$ represents the total cost of your friend's pizzas. Write $h(x)$ as a transformation of the function $f(x)$, then simplify it.
c. Graph the functions $f(x)$ and $h(x)$ on the same graph. Identify the $x$-intercept, the $y$-intercept, and the slope of each line, and the zero of each function.
d. Find the value of $f(4)+h(4)$. Explain what it means in this context.

## TEXAS End-of-Course PRACTICE

21. The function $g(x)$ is a transformation of the function $f(x)$. Which of the following correctly describes $f(x)$ and $g(x)$ ?
A. $f(x)=x-2 ; g(x)=f(-x)$
B. $f(x)=x-2 ; g(x)=-f(x)$
C. $f(x)=-x+2 ; g(x)=f(-x)$
D. $f(x)=x+2 ; g(x)=-f(x)$
22. What is the effect on the graph of the parent function $f(x)=x$ when $g(x)=9 f(x)$ ?
F. The graph shifts to the left 9 units.

G. The graph shifts up 9 units.
H. The graph becomes steeper, and the intercepts stay the same.
$J$. The graph becomes steeper, and the $y$-intercept changes.
23. A linear function $f(x)$ has $y$-intercept -2 . What is the $y$-intercept of $g(x)=f(x-5)$ ?
A. -2
C. -5
B. -3
D. Cannot be determined from the given information.

## TEKS FOCUS

TEKS (4)(C) Write, with and without technology, linear functions that provide a reasonable fit to data to estimate solutions and make predictions for real-world problems.

TEKS (1)(D) Communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.

Additional TEKS (1)(A), (1)(F), (2)(B), (2)(C),
(3)(A), (3)(B), (4)(A),
(4)(B)

## VOCABULARY

- Causation - when a change in one quantity causes a change in another
- Correlation coefficient - a number $r$ from -1 to 1 that tells you how closely the equation models the data set
- Extrapolation - Extrapolation is predicting a value outside of the range of known values.
- Interpolation - Interpolation is estimating a value between two known values.
- Line of best fit - a trend line that shows the relationship between two sets of data most accurately
- Negative correlation - when $y$ tends to decrease as $x$ increases in a relationship between two sets of data
- No correlation - when two sets of data are not related
- Positive correlation - when $y$ tends to increase as $x$ increases in a relationship between two sets of data
- Scatter plot - a graph that relates two different sets of data by displaying them as ordered pairs
- Trend line - a line on a scatter plot, drawn near the points, that shows a correlation
- Implication - a conclusion that follows from previously stated ideas or reasoning without being explicitly stated
- Representation - a way to display or describe information. You can use a representation to present mathematical ideas and data.


## ESSENTIAL UNDERSTANDING

You can determine whether two sets of numerical data are related by graphing them as ordered pairs. If the two sets of
data are related, you may be able to use a line to estimate or predict values.

## Key Concept Scatter Plots

A scatter plot is a graph that relates two different sets of data by displaying them as ordered pairs. Most scatter plots are in the first quadrant of the coordinate plane because the data are usually positive numbers. You can use scatter plots to find trends in data. The scatter plots below show the three types of relationships that two sets of data may have.


When $y$ tends to increase as $x$ increases, the two sets of data have a positive correlation.


When $y$ tends to decrease as $x$ increases, the two sets of data have a negative correlation.


When $x$ and $y$ are not related, the two sets of data have no correlation.

## Key Concept Trend Lines

When two sets of data have a positive or negative correlation, you can use a trend line to show the correlation more clearly. A trend line is a line on a scatter plot, drawn near the points, that shows a correlation.

You can use a trend line to estimate a value between two known data values or to predict a value outside the range of known data values. Interpolation is estimating a value between two known

 values. Extrapolation is predicting a value outside of the range of known values.

## Key Concept Line of Best Fit and Correlation Coefficient

The trend line that shows the relationship between two sets of data most accurately is called the line of best fit. A graphing calculator computes the equation of the line of best fit using a method called linear regression.

The graphing calculator also gives you the correlation coefficient $r$, a number from -1 to 1 , that tells you how closely the equation models the data.


The nearer $r$ is to 1 or -1 , the more closely the data cluster around the line of best fit.
If $r$ is near 1 , the data lie close to a line of best fit with positive slope. If $r$ is near -1 , the data lie close to a line of best fit with negative slope.

## Making a Scatter Plot and Describing Its Correlation

Temperature The table shows the altitude of an airplane and the temperature outside the plane.

| Plane Altitude and Outside Temperature |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Altitude (m) | 0 | 500 | 1000 | 1500 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | 5000 |
| Temperature ( ${ }^{\circ} \mathrm{F}$ ) | 59.0 | 59.2 | 61.3 | 55.5 | 41.6 | 29.8 | 29.9 | 18.1 | 26.2 | 12.4 | 0.6 |

## Think

The highest altitude is 5000 m . So a reasonable scale on the altitude axis is 0 to 5500 with every 1000 m labeled. You can use similar reasoning to label the temperature axis.

## Make a scatter plot of the data.

Treat the data as ordered pairs. For altitude of 1500 m and temperature of $55.5^{\circ} \mathrm{F}$, plot $(1500,55.5)$.
B What type of relationship does the scatter plot show? The temperature outside the plane tends to decrease as the altitude of the plane increases. So the data have a negative correlation.

Plane Altitude and Outside Temperature


## Plan

How do you draw an accurate trend line? An accurate trend line should fit the data closely. There should be about the same number of points above the line as below it.

## Think

How can you check the reasonableness of your answer? Since $x=7$ is visible on the graph, find its corresponding $y$-value. When $x=7, y \approx 32.7$. So the estimate is reasonable.

## Writing an Equation of a Trend Line STEM

Biology Make a scatter plot of the data at the right. What is the approximate weight of a 7 -month-old panda? Based on the data for the panda's weight for the first 12 months, predict the weight of a 15-month-old panda.

Step 1 Make a scatter plot and draw a trend line. Estimate the coordinates of two points on the line.


Two points on the trend line are $(4,17.1)$ and (8, 37.9).

Step 2 Write an equation of the trend line.

$$
\begin{aligned}
m=\frac{y_{2}-y_{1}}{x_{2}-x_{1}} & =\frac{37.9-17.1}{8-4}=\frac{20.8}{4}=5.2 \\
y-y_{1} & =m\left(x-x_{1}\right) \\
y-17.1 & =5.2(x-4) \\
y-17.1 & =5.2 x-20.8 \\
y & =5.2 x-3.7
\end{aligned}
$$



Find the slope of the trend line.
Use point-slope form.
Substitute 5.2 for $m$ and $(4,17.1)$ for $\left(x_{1}, y_{1}\right)$.
Distributive Property
Add 17.1 to each side.

Step 3 Estimate the weight of a 7-month-old panda.

$$
\begin{array}{ll}
y=5.2(7)-3.7 & \text { Substitute } 7 \text { for } x . \\
y=32.7 & \text { Simplify. }
\end{array}
$$

The weight of a 7 -month-old panda is about 32.7 lb .
Step 4 Predict the weight of a 15-month-old panda.

$$
\begin{aligned}
y & =5.2(15)-3.7 \\
& =74.3
\end{aligned}
$$

| Age <br> (months) | Weight <br> $(\mathrm{lb})$ |
| :---: | :---: |
| 1 | 2.5 |
| 2 | 7.6 |
| 3 | 12.5 |
| 4 | 17.1 |
| 6 | 24.3 |
| 8 | 37.9 |
| 10 | 49.2 |
| 12 | 54.9 |

Substitute 15 for $x$.
Simplify.

You can predict that a 15-month-old panda will weigh about 74.3 pounds.

## Finding the Line of Best Fit

College Tuition Use a graphing calculator to find the equation of the line of best fit for the data at the right. What is the correlation coefficient to three decimal places? Describe the strength of the correlation coefficient. Use the line of best fit to estimate the cost of attending in the 2012-2013 academic year.

Step 1 Press . From the EDIT menu, choose Edit. Enter the years into $\mathrm{L}_{1}$. Let $x=2000$ represent academic year 2000-2001, $x=2001$ represent 2001-2002, and so on. Enter the costs into $\mathrm{L}_{2}$.

Step 2 Press stat . Choose $\operatorname{LinReg}(\mathbf{a x}+\mathrm{b})$ from the CALC menu. Press enter to find the equation of the line of best fit and the correlation coefficient. The calculator uses the form $y=a x+b$ for the equation.

Average Tuition and Fees at Public 4-Year Colleges

| Academic <br> Year | Cost <br> (\$) |
| :---: | :---: |
| $2000-2001$ | 3508 |
| $2001-2002$ | 3766 |
| $2002-2003$ | 4098 |
| $2003-2004$ | 4645 |
| $2004-2005$ | 5126 |
| $2005-2006$ | 5492 |
| $2006-2007$ | 5836 |

Source: The College Board

## Think

What does the value of the correlation coefficient mean? The correlation coefficient of 0.996 is close to 1 . So there is a strong positive correlation between the academic year and the cost of attending college.


Round to the nearest hundredth. The equation of the line of best fit is $y=409.43 x-815,446.71$. The correlation coefficient is about 0.996 , which is a strong correlation.

Step 3 Estimate the cost of attending in the 2012-2013 academic year.

$$
\begin{array}{ll}
y=409.43 x-815,446.71 & \text { Use the equation of the line of best fit. } \\
y=409.43(2012)-815,446.71 & \text { Substitute } 2012 \text { for } x . \\
y \approx 8326 & \text { Simplify. Round to the nearest whole number. }
\end{array}
$$

The cost of attending a four-year public college in the 2012-2013 academic year is estimated to be about $\$ 8326$.

## Compare and Contrast Association and Causation

In the following situations, is there likely to be a correlation? If so, does the correlation reflect a causal relationship or an association? Explain.

Causal relationships always have a correlation. However, two data sets that have a correlation may not have a causal relationship.

## A the number of loaves of bread baked and the amount of flour used

There is a positive correlation and also a causal relationship. As the number of loaves of bread baked increases, the amount of flour used increases.
$B$ the number of mailboxes and the number of firefighters in a city
There is likely to be a positive correlation because both the number of mailboxes and the number of firefighters tend to increase as the population of a city increases. However, installing more mailboxes will not cause the number of firefighters to increase, so there is no causal relationship. There is only an association between the number of mailboxes and the number of firefighters in a city.


For additional support when completing your homework, go to PearsonTEXAS.com.

For each table, make a scatter plot of the data. Describe the type of correlation the scatter plot shows.
1.

2.


Apply Mathematics (1)(A) Use the table below for Exercises 3 and 4.

| Attendance and Revenue at U.S. Theme Parks |  |  |  |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Year | 1990 | 1992 | 1994 | 1996 | 1998 | 2000 | 2002 | 2004 | 2006 |
| Attendance (millions) | 253 | 267 | 267 | 290 | 300 | 317 | 324 | 328 | 335 |
| Revenue <br> (billions of dollars) | 5.7 | 6.5 | 7.0 | 7.9 | 8.7 | 9.6 | 9.9 | 10.8 | 11.5 |

Source: International Association of Amusement Parks and Attractions
3. Make a scatter plot of the data pairs (year, attendance). Draw a trend line and write its equation. Estimate the attendance at U.S. theme parks in 2005.
4. Make a scatter plot of the data pairs (year, revenue). Draw a trend line and write its equation. Predict the revenue at U.S. theme parks in 2012.
5. Apply Mathematics (1)(A) Use a graphing calculator to find the equation of the line of best fit for the data in the table. Find the value of the correlation coefficient $r$ to three decimal places. Describe the strength of the linear association. Then predict the number of movie tickets sold in the U.S. in 2014.


In each situation, tell whether a correlation is likely. If it is, tell whether the correlation reflects a causal relationship or an association. Explain your reasoning.
6. the amount of time you study for a test and the score you receive
7. a person's height and the number of letters in the person's name
8. the shoe size and the salary of a teacher
9. the price of hamburger at a grocery store and the amount of hamburger sold
10. Analyze Mathematical Relationships (1)(F) Describe three real-world situations: one with a positive correlation, one with a negative correlation, and one with no correlation.
11. Explain Mathematical Ideas (1)(G) Give two data sets that are correlated but do not have a causal relationship.
12. Apply Mathematics (1)(A) During one month at a local deli, the amount of ham sold decreased as the amount of turkey sold increased. Is this an example of positive correlation, negative correlation, or no correlation?
13. Use Multiple Representations to Communicate Mathematical Ideas (1)(D) Students measured the diameters and circumferences of the tops of a variety of cylinders. Below are the data that they collected. Estimate the diameter of a cylinder with circumference 22 cm .

| Cylinder Tops |  |  |  |  |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Diameter (cm) | 3 | 3 | 5 | 6 | 8 | 8 | 9.5 | 10 | 10 | 12 |
| Circumference (cm) | 9.3 | 9.5 | 16 | 18.8 | 25 | 25.6 | 29.5 | 31.5 | 30.9 | 39.5 |

14. Apply Mathematics (1)(A) Use the data below.

| Estimated Population of the United States (thousands) |  |  |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |  |
| Male | 138,482 | 140,079 | 141,592 | 142,937 | 144,467 | 145,973 | 147,512 |  |
| Female | 143,734 | 145,147 | 146,533 | 147,858 | 149,170 | 150,533 | 151,886 |  |

Source: U.S. Census Bureau
a. Use the data to estimate the U.S. female population if the U.S. male population increases to $150,000,000$.
b. Explain Mathematical Ideas (1)(G) Consider a scatter plot of the data pairs (year, male population). Would it be reasonable to use this scatter plot to estimate the U.S. male population in 2035? Explain your reasoning.
15. a. Use a graphing calculator to find the equation of the line of best fit for the data below. Let $x=8$ represent 1998, $x=9$ represent 1999, and so on.

b. What is the slope of the line of best fit? What does the slope mean in terms of the number of computer and video game units sold?
c. What is the $y$-intercept of the line of best fit? What does the $y$-intercept mean in terms of the number of computer and video game units sold?
16. a. Make a scatter plot of the data below. Then find the equation of the line of best fit. Draw the line of best fit on your scatter plot.

| Car Stopping Distances |  |  |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Speed (mi/h) | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
| Stopping Distance (ft) | 27 | 44 | 63 | 85 | 109 | 136 | 164 | 196 |

b. Use your equation to predict the stopping distance at $90 \mathrm{mi} / \mathrm{h}$.
c. Apply Mathematics (1)(A) The actual stopping distance at $90 \mathrm{mi} / \mathrm{h}$ is close to 584 ft . Why do you think this distance is not close to your prediction?
d. Suppose you plot $(90,584)$ on your scatter plot. What effect would it have on the slope and $y$-intercept of the line of best fit you found in part (a)?
17. Suppose you survey each school in your state. What relationship would you expect between the number of students and the number of teachers in each school?
A. positive correlation
B. negative correlation
C. no correlation
D. none of the above
18. A horizontal line passes through $(5,-2)$. Which other point is also on the line?
F. $(5,2)$
G. $(-5,-2)$
H. $(-5,2)$
J. $(5,0)$
19. When 18 gal of water are pumped into an empty tank, the tank is filled to three fourths of its capacity. How many gallons of water does the tank hold?
A. 12
B. 13.5
C. 18.5
D. 24
20. The table shows the balance of a student's bank account at various times. Estimate how much money is in the student's bank account in Week 6.
Justify your answer.


## Topic 3 Review

## TOPIC VOCABULARY

- causation, p. 144
- constant of variation for a direct variation, p. 108
- correlation coefficient, p. 145
- direct variation, p. 108
- extrapolation, p. 145
- interpolation, p. 145
- linear equation, p. 115
- linear parent function, p. 115
- line of best fit, p. 145
- negative correlation, p. 144
- no correlation, p. 144
- opposite reciprocals, p. 132
- parallel lines, p. 132
- parent function, p. 115
- perpendicular lines, p. 132
- point-slope form, p. 120
- positive correlation, p. 144
- rate of change, p. 100
- reflection, p. 138
- scatter plot, p. 144
- slope, p. 100
- slope-intercept form, p. 115
- standard form of a linear equation, p. 125


## Check Your Understanding

Choose the vocabulary term that correctly completes the sentence.

1. Estimating a value between two known values in a data set is called ?.
2. The slope of a line models the ? of a function.
3. The form of a linear equation that shows the slope and one point is the ?.
4. Two lines are perpendicular when their slopes are ?.
5. The line that most accurately models data in a scatter plot is the ?.

## 3-1 Rate of Change and Slope

## Quick Review

Rate of change shows the relationship between two changing quantities. The slope of a line is the ratio of the vertical change (the rise) to the horizontal change (the run).
slope $=\frac{\text { rise }}{\text { run }}=\frac{y_{2}-y_{1}}{x_{2}-x_{1}}$
The slope of a horizontal line is 0 , and the slope of a vertical line is undefined.

## Example

What is the slope of the line that passes through the points $(1,12)$ and $(6,22)$ ?
slope $=\frac{y_{2}-y_{1}}{x_{2}-x_{1}}=\frac{22-12}{6-1}=\frac{10}{5}=2$

## Exercises

Find the slope of the line that passes through each pair of points.
6. $(2,2),(3,1)$
7. $(4,2),(0,2)$
8. $(-1,2),(0,5)$
9. $(-3,-2),(-3,2)$

Find the slope of each line.
10.

11.


## 3-2 Direct Variation

## Quick Review

A function represents a direct variation if it has the form $y=k x$, where $k \neq 0$. The coefficient $k$ is the constant of variation.

## Example

Suppose $y$ varies directly with $x$, and $y=15$ when $x=5$.
Write a direct variation equation that relates $x$ and $y$. What is the value of $y$ when $x=9$ ?

$$
\begin{aligned}
y & =k x & & \text { Start with the general form of a direct variation. } \\
15 & =k(5) & & \text { Substitute } 5 \text { for } x \text { and } 15 \text { for } y . \\
3 & =k & & \text { Divide each side by } 5 \text { to solve for } k . \\
y & =3 x & & \text { Write an equation. Substitute } 3 \text { for } k \text { in } y=k x .
\end{aligned}
$$

The equation $y=3 x$ relates $x$ and $y$. When $x=9, y=3(9)$, or 27 .

## Exercises

Suppose $y$ varies directly with $x$. Write a direct variation equation that relates $x$ and $y$. Then find the value of $y$ when $x=7$.
12. $y=8$ when $x=-4$
13. $y=15$ when $x=6$
14. $y=3$ when $x=9$
15. $y=-4$ when $x=4$

For each table, tell whether $y$ varies directly with $x$. If it does, write an equation for the direct variation.
16.

17.


## 3-3, 3-4, and 3-5 Forms of Linear Equations

## Quick Review

The graph of a linear equation is a line. You can write a linear equation in different forms.
The slope-intercept form of a linear equation is $y=m x+b$, where $m$ is the slope and $b$ is the $\boldsymbol{y}$-intercept.
The point-slope form of a linear equation is
$y-y_{1}=m\left(x-x_{1}\right)$, where $m$ is the slope and $\left(x_{1}, y_{1}\right)$ is a point on the line.
The standard form of a linear equation is $A x+B y=C$, where $A, B$, and $C$ are real numbers, and $A$ and $B$ are not both zero.

## Example

What is an equation of the line that has slope -4 and passes through the point $(-1,7)$ ?

$$
\begin{aligned}
y-y_{1} & =m\left(x-x_{1}\right) & & \text { Use point-slope form. } \\
y-7 & =-4(x-(-1)) & & \text { Substitute }(-1,7) \text { for }\left(x_{1}, y_{1}\right) \text { and } \\
y-7 & =-4(x+1) & & -4 \text { for } m .
\end{aligned}
$$

An equation of the line is $y-7=-4(x+1)$.

## Exercises

Write an equation in slope-intercept form of the line that passes through the given points.
18. $(-3,4),(1,4)$
19. $(3,-2),(6,1)$

Write an equation of each line.
20.

21.


Graph each equation.
22. $y=4 x-3$
24. $y+3=2(x-1)$
23. $y=2$
25. $x+4 y=10$

## 3-6 Parallel and Perpendicular Lines

## Quick Review

Parallel lines are lines in the same plane that never intersect. Two lines are perpendicular if they intersect to form right angles.

## Example

Are the graphs of $y=\frac{4}{3} x+5$ and $y=-\frac{3}{4} x+2$ parallel, perpendicular, or neither? Explain.
The slope of the graph of $y=\frac{4}{3} x+5$ is $\frac{4}{3}$.
The slope of the graph of $y=-\frac{3}{4} x+2$ is $-\frac{3}{4}$.

$$
\frac{4}{3}\left(-\frac{3}{4}\right)=-1
$$

The slopes are opposite reciprocals, so the graphs are perpendicular.

## Exercises

Write an equation of the line that passes through the given point and is parallel to the graph of the given equation.
26. $(2,-1) ; y=5 x-2$
27. $(0,-5) ; y=9 x$

Determine whether the graphs of the two equations are parallel, perpendicular, or neither. Explain.
28. $y=6 x+2$
29. $2 x-5 y=0$
$18 x-3 y=15$
$y+3=\frac{5}{2} x$

Write an equation of the line that passes through the given point and is perpendicular to the graph of the given equation.
30. $(3,5) ; y=-3 x+7$
31. $(4,10) ; y=8 x-1$

## 3-7 Transformations of Linear Functions

## Quick Review

If $y=f(x)$ is a linear function, $y=f(x)+d$ is a vertical translation of $y=f(x)$ by $|d|$ units up, if $d>0$, or $|d|$ units down, if $d<0$. The function $y=f(x+c)$ is a horizontal translation of $y=f(x)$ by $|c|$ units to the left, if $c>0$, or $|c|$ units to the right, if $c<0$.
A reflection across the $x$-axis is given by $y=f(x)$. A reflection across the $y$-axis is given by $y=f(-x)$.

## Example

Determine the effects on the graph of the function $f(x)=x+3$ when $g(x)=f(-x)$.

$$
\begin{aligned}
g(x) & =f(-x) & & \text { Original function } \\
& =-x+3 & & \text { Substitute }-x \text { for } x \text { in } f(x) .
\end{aligned}
$$

The slope changed signs, but the $y$-intercept stayed the same.
The graph shows that $f(-x)$ is a reflection of $f(x)$ over the $y$-axis.


## Exercises

Determine the effects on the graph of $f(x)$ when $g(x)=-f(x)$. Graph both functions on the same coordinate grid.
32. $f(x)=x-2.5$
33. $f(x)=8 x$

Determine the effects on the graph of $f(x)$ when $g(x)=f(-x)$. Graph both functions on the same coordinate grid.
34. $f(x)=-x+4$
35. $f(x)=\frac{2 x}{3}$

Determine the effects on the graph of the parent function $f(x)=x$ for each $g(x)$ function. Graph both functions on the same coordinate grid.
36. $g(x)=f(4 x)$
37. $g(x)=f(-2+x)$
38. $g(x)=\frac{1}{3} f(x)$
39. $g(x)=f(-0.5 x)$
40. $g(x)=f(x)+3$
41. $g(x)=-3 f(x)$
42. $g(x)=f(x+1)$
43. $g(x)=f(x)-2$

## 3-8 Scatter Plots and Trend Lines

## Quick Review

A scatter plot displays two sets of data as ordered pairs. A trend line for a scatter plot shows the correlation between the two sets of data. The most accurate trend line is the line of best fit. To estimate or predict values on a scatter plot, you can use interpolation or extrapolation.

## Example

Estimate the length of the kudzu vine in Week 3.
When $w=3, \ell \approx 10$. So in Week 3 , the length of the kudzu vine was about 10 ft .

Predict the length of the kudzu vine in Week 11.

$$
\begin{array}{ll}
\ell=3.5 w & \begin{array}{l}
\text { Use the equation of } \\
\text { the trend line. }
\end{array} \\
\ell=3.5(11) & \text { Substitute } 11 \text { for } w . \\
\ell=38.5 & \text { Simplify. }
\end{array}
$$



The length of the vine in Week 11 will be about 38.5 ft .

## Exercises

Describe the type of correlation each scatter plot shows.
44.

45.


47. a. Make a scatter plot of the data below.

| Heights and Arm Spans |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Height (m) | 1.5 | 1.8 | 1.7 | 2.0 | 1.7 | 2.1 |
| Arm Span (m) | 1.4 | 1.7 | 1.7 | 1.9 | 1.6 | 2.0 |

b. Write an equation of a reasonable trend line or use a graphing calculator to find the equation of the line of best fit.
c. Estimate the arm span of someone who is 1.6 m tall.
d. Predict the arm span of someone who is 2.2 m tall.

## Topic 3 TEKS Cumulative Practice

## Multiple Choice

## Read each question. Then write the letter of the correct answer on your paper.

1. Which is an equation of a line with slope 3 ?
A. $y=3 x-4$
B. $y=-3 x+3$
C. $y=4 x-3$
D. $y=-3 x-5$
2. Ben has a cellphone plan where he pays $\$ 12$ per month plus $\$ .10$ per minute of talk time. The equation $y=0.10 x+12$ can be used to find his monthly phone bill $y$ given the number of minutes $x$ he spends talking. Which set or inequality represents a reasonable range of the function?
F. $\{0,12\}$
G. $0 \leq y \leq 12$
H. $12 \leq y$
J. $0 \leq y$
3. What is the slope of the line at the right?
A. -2
B. $\frac{2}{3}$
C. $\frac{3}{2}$
D. 3

4. Tim uses the function $g=0.14 d$ to find how much money $g$ he needs for gasoline based on the number of miles $d$ he travels. Which statement is true?
F. The number of miles Tim travels depends on how much money he needs for gasoline.
G. The number of miles Tim travels depends on the price of a gallon of gasoline.
H. The amount of money Tim needs for gasoline depends on the number of miles he travels.
J. The amount of money Tim needs for gasoline is constant.
5. The perimeter $P$ of a rectangle can be found using the formula $P=2(\ell+w)$, where $\ell$ represents the length and $w$ represents the width. Which equation represents the width in terms of $P$ and $\ell$ ?
A. $w=2(P-\ell)$
B. $w=\frac{P-\ell}{2}$
C. $w=2 P-\ell$
D. $w=\frac{P}{2}-\ell$
6. Use the graph at the right. If the $y$-intercept increases by 2 and the slope remains the same, what will the $x$-intercept be?
F. -3
G. -2
H. 1
J. 4

7. The U.S. Mint charges $\$ 25$ for a limited edition coin, plus a $\$ 6$ shipping charge. The cost $c$ of purchasing $n$ coins can be found using the function $c=25 n+6$. There is a limit of 5 coins per purchase. What is a reasonable domain of the function?
A. $\{5\}$
B. $\{1,2,3,4,5\}$
C. $\{25,50,75,100,125\}$
D. $\{31,56,81,106,131\}$
8. The scatter plot shows the amount of money earned and saved each year by people ages 20-29. Which best describes the slope of the line of best fit?
F. positive
H. zero

G. negative
J. undefined
9. Which graph shows a line with slope $\frac{1}{3}$ and $y$-intercept -1 ?
A.

C.

B.

D.

10. A line passes through the point $(2,1)$ and has a slope of $-\frac{3}{5}$. What is an equation of the line?
F. $y-1=-\frac{3}{5}(x-2)$
G. $y-1=-\frac{5}{3}(x-2)$
H. $y-2=-\frac{3}{5}(x-1)$
J. $y-2=-\frac{5}{3}(x-1)$

## Gridded Response

11. The points $(-2,11)$ and $(6,3)$ lie on the same line. What is the $x$-intercept of the line?
12. What is the solution of the equation $4 x+7=9 x+2$ ?
13. An online bookseller charges $\$ 3$ per order plus $\$ 1$ per book for shipping. John places an order for four books that have the same price. The total cost of his order is $\$ 30$. What is the price, in dollars, of each book?
14. $\triangle A B C \sim \triangle D E F$. What is $D E$ ?

15. What is the slope of a line perpendicular to the line $2 x+4 y=12$ ?
16. What is the $y$-intercept of the line $-3 x-2 y=18$ ?
17. What is the solution of the equation $\frac{h}{3}=18$ ?
18. What is the slope of a line that is parallel to the line $y=4 x-10$ ?
19. What is the slope of a line that is perpendicular to the line shown at the right?


## Constructed Response

20. Line $p$ passes through the point $(5,-2)$ and has a slope of 0 . Line $q$ passes through the point $(-13,-9)$ and is parallel to line $p$. What is an equation of line $q$ ? Show your work.
21. You can find the area of a triangle using the formula $A=\frac{1}{2} b h$, where $b$ is the length of the base, and $h$ is the height. Write the equation for $b$ in terms of $A$ and $h$. Show all your work.
22. A student reads 40 pages of a book in 50 minutes. At this rate, how many pages can the student read in 80 minutes?
23. Write an equation in point-slope form of the line that passes through the point $(-2,7)$ and has a slope of -1 .
24. Tell whether the graph is a function. Explain your answer.

25. Solve the inequality $8 \leq x+2<13$.
26. The perimeter of a square is 16 in . A trapezoid has the same area and height as the square. The area of a trapezoid is $\frac{1}{2} h\left(b_{1}+b_{2}\right)$, where $h$ is the height and $b_{1}$ and $b_{2}$ are the lengths of the bases. If one base of the trapezoid is 3 in . long, what is the length of the other base? Show your work.
27. Solve the equation below. Show all your work and give the property that justifies each step.

$$
6(2 x-5)=4 x+2
$$

## $\star$ Topic 4 Systems of Equations and Inequalities

## TOPIC OVERVIEW

4-1 Solving Systems by Graphing
4-2 Solving Systems Using Substitution
4-3 Solving Systems Using Elimination
4-4 Applications of Linear Systems
4-5 Linear Inequalities
4-6 Systems of Linear Inequalities

## VOCABULARY

English/Spanish Vocabulary Audio Online:

English
consistent system, p. 160
dependent system, p. 160
elimination method, p. 175
inconsistent system, p. 160
independent system, p. 160
linear inequality, p. 187
solution of an
inequality, p. 187
solution of a system of linear equations, p. 160 solution of a system of linear inequalities, p. 194
substitution method, p. 169

Spanish
sistema consistente sistema dependiente eliminación sistema incompatible sistema independiente desigualdad lineal solución de una desigualdad
solución de un sistema de ecuaciones lineales solución de un sistema de desigualdades lineales método de sustitución

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\section*{| $\star \times$ | $4-1$ Solving Systems by Graphing |
| :--- | :--- |}

## TEKS FOCUS

TEKS (3)(F) Graph systems of two linear equations in two variables on the coordinate plane and determine the solutions if they exist.

TEKS (1)(D) Communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.

Additional TEKS (1)(A), (2)(I), (5)(C)

## VOCABULARY

- Consistent system - a system of equations that has at least one solution
- Dependent system - a system of equations that does not have a unique solution
- Inconsistent system - a system of equations that has no solution
- Independent system - a system of equations that has a unique solution
- Solution of a system of linear equations - any ordered pair in a system that makes all of the equations of that system true
- System of linear equations two or more linear equations using the same variables
- Implication - a conclusion that follows from previously stated ideas or reasoning without being explicitly stated
- Representation - a way to display or describe information. You can use a representation to present mathematical ideas and data.


## ESSENTIAL UNDERSTANDING

You can use systems of linear equations to model problems. Systems of equations can be solved in more than one way. One method is to graph each equation and find the intersection point, if one exists.

One solution


The lines intersect at one point. The lines have different slopes. The equations are consistent and independent.

Infinitely many solutions


The lines are the same. The lines have the same slope and $y$-intercept. The equations are consistent and dependent.

No solution


The lines are parallel. The lines have the same slope and different $y$-intercepts. The equations are inconsistent.

## Problem 1

## Solving a System of Equations by Graphing

## Think

How does graphing each equation help you find the solution?
A line represents the solutions of one linear equation. The intersection point is a solution of both equations.

What is the solution of the system? Use a graph. $y=x+2$

$$
y=3 x-2
$$

Graph both equations in the same coordinate plane.

$$
\begin{array}{ll}
y=x+2 & \text { The slope is } 1 \text {. The } y \text {-intercept is } 2 . \\
y=3 x-2 & \text { The slope is } 3 \text {. The } y \text {-intercept is }-2 .
\end{array}
$$

Find the point of intersection. The lines appear to intersect at $(2,4)$. Check to see if $(2,4)$ makes both equations true.

$$
\begin{array}{lll}
y=x+2 \\
4 \stackrel{?}{=} 2+2 \\
4=4 \boldsymbol{\checkmark} & \text { Substitute }(2,4) & y=3 x-2 \\
& \text { for }(x, y) . & 4 \stackrel{?}{=} 3(2)-2 \\
4=4 \boldsymbol{\iota}
\end{array}
$$



The solution of the system is $(2,4)$.

## Problem 2

## Writing a System of Equations STEM

Biology Scientists studied the weights of two alligators over a period of 12 months. Use the tables below to determine the initial weight and the rate of growth for Alligator 1 and Alligator 2. After how many months did the alligators weigh the same amount?

How can you get started?
You can use the tables to gather the necessary information. The tables show the weight of each alligator after 1 month, 2 months, and so on.


## Problem 2

 continuedRelate
Alligator

weight is \begin{tabular}{c}
initial <br>
weight

 plus 

growth <br>
rate
\end{tabular} times time.

Define Let $w=$ alligator weight in pounds.

$$
\text { Let } t=\text { time in months. }
$$

Write

$$
\begin{array}{ll}
\text { Alligator } 1: & w \\
\text { Alligator } 2: & w
\end{array}=6+1.5 \cdot t
$$

Graph both equations in the same coordinate plane.

$$
\begin{array}{ll}
w=4+1.5 t & \text { The slope is } 1.5 \text {. The } w \text {-intercept is } 4 . \\
w=6+t & \text { The slope is } 1 . \text { The } w \text {-intercept is } 6 .
\end{array}
$$

The lines intersect at $(4,10)$.
After 4 months, both alligators weighed 10 lb .


## Problem 3

If two equations have the same slope and $y$-intercept, their graphs will be the same line. If two equations have the same slope but different $y$-intercepts, their graphs will be parallel lines.

## Systems With Infinitely Many Solutions or No Solution

## What is the solution of each system? Use a graph.

(A) $2 y-x=2$
$y=\frac{1}{2} x+1$
Graph the equations $2 y-x=2$ and $y=\frac{1}{2} x+1$ in the same coordinate plane.
The equations represent the same line. Any point on the line is a solution of the system, so there are infinitely many
 solutions. The system is consistent and dependent.

B $y=2 x+2$
$y=2 x-1$
Graph the equations $y=2 x+2$ and $y=2 x-1$ in the same coordinate plane.

The lines are parallel, so there is no solution. The system is inconsistent.


## Problem 4

## Solving Systems Using Tables and Graphs With Technology

Use a graphing calculator to solve the equations.
A One mountain climber is 7 feet below a ledge climbing up the mountain at a rate of 3 feet per minute. A second mountain climber is 7 feet above the same ledge and descending at a rate of 0.5 foot per minute. When are the two mountain climbers at the same height relative to the ledge?

The system $\left\{\begin{array}{l}y=3 x-7 \\ y=-0.5 x+7\end{array}\right.$ represents this situation, where $x$ is the number of minutes and $y$ is the height in feet.

What are the advantages and disadvantages of solving systems of equations using a table?
A table will give you an exact answer if your answer involves integers. However, for other solutions, it may take some time to close in on an approximate solution.

Step 1
Enter the equations in the


Step 2
Use the tiblset function. Set TblStart to 0 and $\Delta$ Tbl to 1 .


## Step 3

Press (table to show the table on the screen.


The answer is $(4,5)$ since when $x$ is $4, y$ is 5 for both equations. The solution of the system is $(4,5)$. After 4 minutes, the mountain climbers will both be at 5 feet above the ledge.

B The equations $y=-5 x+6$ and $y=-x-2$ represent the depth $y$ (in feet) of two anchors after $x$ seconds, where $x>0$. After how many seconds are the anchors at the same depth? Estimate the solution using a graph.

Step 1 Enter the equations in the $y=$ screen.
Step 2 Graph the equations. Use a standard graphing window.
Step 3 Use the feature. Choose INTERSECT to find the point where the lines intersect.


You can check that the solution $(2,-4)$ satisfies each equation. After 2 seconds, each anchor is 4 feet below the water.

For additional support when completing your homework, go to PearsonTEXAS.com.

Solve each system by graphing. Check your solution.

1. $y=-\frac{1}{2} x+2$
$y=\frac{1}{2} x+6$
2. $2 x-y=-5$
$-2 x-y=-1$
3. $x=-3$
$y=5$
4. Apply Mathematics (1)(A) The number of right-handed students in a mathematics class is nine times the number of left-handed students. The total number of students in the class is 30 . How many right-handed students are in the class? How many left-handed students are in the class?
5. Use Multiple Representations to Communicate Mathematical Ideas (1)(D) Use the tables below to determine the initial height and rate of growth of the two trees. Then use this information to write a system of linear equations. After how many years will the trees be the same height?

Tree 1


Tree 2

6. Apply Mathematics (1)(A) At a local fitness center, members pay a $\$ 20$ membership fee and $\$ 3$ for each aerobics class. Nonmembers pay $\$ 5$ for each aerobics class. For what number of aerobics classes will the cost for members and nonmembers be the same?
7. Apply Mathematics (1)(A) You are looking for an after-school job. One job pays $\$ 9$ per hour. Another pays $\$ 12$ per hour, but you must buy a uniform that costs $\$ 39$. After how many hours of work would your net earnings from either job be the same?
8. Analyze Mathematical Relationships (1)(F) A student graphs the system $y=-x+3$ and $y=-2 x-1$ as shown at the right. The student concludes there is no solution. Describe and correct the student's error.
9. Explain Mathematical Ideas (1)(G) Suppose you graph a system of linear equations and the intersection point appears to be $(3,7)$. Can you be sure that the ordered pair $(3,7)$ is the solution? What must you do to be sure?

10. Apply Mathematics (1)(A) A cellphone provider offers a plan that costs $\$ 40$ per month plus $\$ .20$ per text message sent or received. A comparable plan costs $\$ 60$ per month but offers unlimited text messaging.
a. How many text messages would you have to send or receive in order for the plans to cost the same each month?
b. If you send or receive an average of 50 text messages each month, which plan would you choose? Why?

Solve each system by graphing. Tell whether the system has one solution, infinitely many solutions, or no solution.
11. $2 x+2 y=4$
$12-3 x=3 y$
12. $2 y=x-2$
$3 y=\frac{3}{2} x-3$
13. $3 x-y=2$
$4 y=-x+5$

Without graphing, decide whether each system has one solution, infinitely many solutions, or no solution. Justify your answer.
14. $y=x-4$
$y=x-3$
15. $x-y=-\frac{1}{2}$
$2 x-2 y=-1$
16. $y=5 x-1$
$10 x=2 y+2$
17. $3 x+2 y=1$
$4 y=6 x+2$
18. Apply Mathematics (1)(A) The graph at the right shows the balances in two bank accounts over time. Use the graph to write a system of equations giving the amount in each account over time. Let $t=$ the time in weeks and let $b=$ the balance in dollars. If the accounts continue to grow as shown, when will they have the same balance?
19. One equation in a system is $y=\frac{1}{2} x-2$. Write three separate equations to show the following: a system that has one solution, a system that has no solution, and a system that has infinitely
 many solutions.

$$
\begin{aligned}
& y=g x+3 \\
& y=h x+7
\end{aligned}
$$

a. If $g \geq h$, will the system always, sometimes, or never have exactly one solution? Explain your reasoning.
b. If $g \leq h$, will the system always, sometimes, or never have infinitely many solutions? Explain your reasoning.
21. Apply Mathematics (1)(A) Two hikers are walking along a marked trail. The first hiker starts at a point 6 mi from the beginning of the trail and walks at a speed of $4 \mathrm{mi} / \mathrm{h}$. At the same time, the second hiker starts 1 mi from the beginning and walks at a speed of $3 \mathrm{mi} / \mathrm{h}$.
a. What is a system of equations that models the situation?
b. Graph the two equations and find the intersection point.
c. Is the intersection point meaningful in this situation? Explain.

Estimate the solution to each system using your graphing calculator. Round your answer to the nearest integer.
22. $y=-2 x+6$
$y=x-4$
23. $y=-2 x+2.5$
$y=-\frac{1}{2} x-1.5$
24. Apply Mathematics (1)(A) The county fair provides 2 prices for midway rides. Fairgoers can pay $\$ 15.00$ for an armband and $\$ .75$ per ride or they can pay $\$ 1.50$ per ride. Write a system of equations to represent the situation and solve the system graphically. Use the graph to estimate the solution. Then interpret the solution.
25. A new company is purchasing a copier for their office. The table shows the costs associated with each copier. Write a system of equations for this situation. Then use a graphing calculator to estimate the number of copies that gives the same total cost.

| Copier Costs |  |  |
| :---: | :---: | :---: |
| Copier | Initial Cost | Cost Per Copy |
| A | $\$ 750$ | $\$ .03$ |
| B | $\$ 500$ | $\$ .05$ |

## TEXAS End-of-Course PRACTICE

26. Which ordered pair is the solution of the system? $\quad 2 x+3 y=-17$

$$
3 x+2 y=-8
$$

A. $(2,-7)$
B. $(-4,2)$
C. $(-2,-1)$
D. $\left(-\frac{4}{3},-2\right)$
27. Which expression is equivalent to $5(m-12)+8$ ?
F. $5 m-68$
G. $5 m-20$
H. $5 m-4$
J. $5 m-52$
28. The costs for parking in two different parking garages are given in the table below.

| Garage Parking Fees |  |  |
| :---: | :---: | :---: |
| Garage Flat Fee Hourly Fee <br> A $\$ 5$ $\$ 2.50$ <br> B $\$ 20$ $\$ 0$ |  |  |

a. What is a system of equations that models the situation?
b. How many hours of parking would cost the same in either garage?
c. If you needed to park a car for 3 h , which garage would you choose? Why?

## USE WITH LESSON 4-2

## TEKS (5)(C), (1)(E)

Just as algebra tiles can help you solve linear equations in one variable, they can also help you solve systems of linear equations in two variables.

## Activity

Model and solve the system.

$$
\begin{aligned}
& -x+2 y=4 \\
& y=x+1
\end{aligned} \quad \begin{aligned}
& \text { Since } y=x+1 \text {, use tiles } \\
& \text { for } x+1 \text { to model } y .
\end{aligned}
$$

Equation

$$
\begin{array}{r}
-x+2 y=4 \\
-x+2(x+1)=4 \\
-x+2 x+2=4
\end{array}
$$

$$
\begin{aligned}
(-x+x)+x+2 & =4 \\
x+2 & =4
\end{aligned}
$$

$$
x+2-2=4-2
$$

The solution of the system is $(2,3)$.


$$
x=2
$$

Algebra Tiles


$$
\begin{aligned}
& y=x+1 \\
& y=2+1 \\
& y=3
\end{aligned}
$$

$\square$

$y \mid\lrcorner\lrcorner \perp$

Subtract 2 from each side. Remove zero pairs.
Remove the zero pair $x$ and $-x$.
Substitute $x+1$ for $y$ in the first equation.

Model the second equation.

## Steps



## Solve for $x$. <br> S



Substitute 2 for $x$ and simplify.

## Exercises

Exercises 1-6 model the system of equations at the right. $\left\{\begin{array}{l}2 y-x=6 \\ y=x+2\end{array}\right.$
Explain each step.
1.

2.

3.

4.

5.

6.
$y \left\lvert\, \begin{aligned} & \lrcorner \\ & \lrcorner\end{aligned}\right.$
Model and solve each system.
7. $y=x+1$
$2 x+y=10$
8. $x+4 y=1$
$x+4=y$
9. $\begin{aligned} y & =2 x-1 \\ y & =x+2\end{aligned}$
10. $x+3 y=7$
$x+1=y$

# d 

## TEKS FOCUS

TEKS (5)(C) Solve systems of two linear equations with two variables for mathematical and real-world problems.

TEKS (1)(F) Analyze mathematical relationships to connect and communicate mathematical ideas.

Additional TEKS (1)(A), (1)(G), (2)(I), (3)(G)

## VOCABULARY

- Substitution method - a method of solving a system of equations by replacing one variable with an equivalent expression containing the other variable
- Analyze - closely examine objects, ideas, or relationships to learn more about their nature


## ESSENTIAL UNDERSTANDING

Systems of equations can be solved in more than one way. When a system has at least one equation that can be solved quickly for a variable, the system can be solved efficiently using substitution.

## Plan

How can you get started?
If one equation is already solved for one variable, use it for the substitution If both equations are solved for a variable, you can use either one.

## Using Substitution

What is the solution of the system? Use substitution.

$$
\begin{aligned}
& y=3 x \\
& x+y=-32
\end{aligned}
$$

Step 1 Because $y=3 x$, you can substitute $3 x$ for $y$ in $x+y=-32$.

$$
\begin{aligned}
x+y & =-32 & & \text { Write the second equation. } \\
x+3 x & =-32 & & \text { Substitute } 3 x \text { for } y . \\
4 x & =-32 & & \text { Simplify. } \\
x & =-8 & & \text { Divide each side by } 4 .
\end{aligned}
$$

Step 2 Substitute -8 for $x$ in either equation and solve for $y$.

$$
\begin{array}{ll}
y=3 x & \text { Write either equation. } \\
y=3(-8)=-24 & \text { Substitute }-8 \text { for } x \text { and solve. }
\end{array}
$$

The solution is $(-8,-24)$. Check by substituting $(-8,-24)$ into each equation.

$$
\text { Check } \begin{array}{rlrl}
y & =3 x & x+y & =-32 \\
-24 & \stackrel{?}{3} 3(-8) & -8+(-24) & \stackrel{?}{=}-32 \\
-24 & =-24 \boldsymbol{V} & -32 & =-32
\end{array}
$$

## Solving for a Variable and Using Substitution

What is the solution of the system? Use substitution.

$$
\begin{aligned}
3 y+4 x & =14 \\
-2 x+y & =-3
\end{aligned}
$$

Know
Neither equation is solved for one of the variables.

Need
The solution of the system

Plan
Solve one of the equations for one of the variables. Then use the substitution method to find the solution of the system.

Step 1 Solve one of the equations for one of the variables.

$$
\begin{aligned}
-2 x+y & =-3 & & \text { Write the second equation. } \\
-2 x+y+2 x & =-3+2 x & & \text { Add } 2 x \text { to each side. } \\
y & =2 x-3 & & \text { Simplify. }
\end{aligned}
$$

Step 2 Substitute $2 x-3$ for $y$ in the other equation and solve for $x$.

$$
\begin{aligned}
3 y+4 x & =14 & & \text { Write the first equation. } \\
3(2 x-3)+4 x & =14 & & \text { Substitute } 2 x-3 \text { for } y . \text { Use parentheses. } \\
6 x-9+4 x & =14 & & \text { Distributive Property } \\
10 x & =23 & & \text { Add } 9 \text { to each side. Simplify. } \\
x & =2.3 & & \text { Divide each side by } 10 .
\end{aligned}
$$

Step 3 Substitute 2.3 for $x$ in either equation and solve for $y$.

$$
\begin{array}{rll}
-2 x+y & =-3 & \text { Write either equation. } \\
-2(2.3)+y & =-3 & \text { Substitute } 2.3 \text { for } x . \\
-4.6+y & =-3 & \text { Simplify. } \\
y & =1.6 & \text { Add } 4.6 \text { to each side. }
\end{array}
$$

The solution is (2.3, 1.6).

## Problem 3

## Using Systems of Equations

Snack Bar A snack bar sells two sizes of snack packs. A large snack pack is $\$ 5$, and a small snack pack is $\$ 3$. In one day, the snack bar sold 60 snack packs for a total of $\mathbf{\$ 2 2 0}$. How many small snack packs did the snack bar sell?
Step 1 Write the system of equations. Let $x=$ the number of large $\$ 5$ snack packs, and let $y=$ the number of small $\$ 3$ snack packs.

$$
\begin{aligned}
x+y & =60 & & \text { Represent the total number of snack packs. } \\
5 x+3 y & =220 & & \text { Represent the amount earned from } 60 \text { snack packs. }
\end{aligned}
$$

## Problem 3 continued

## Think

## What does the solution represent in the real world? <br> Check what the assigned variables represent. Here, $(20,40)$ represents 20 large snack packs and 40 small snack packs.

Step $2 x+y=60$

$$
y=60-x
$$

Step $35 x+3(60-x)=220$

$$
5 x+180-3 x=220
$$

$$
2 x=40
$$

$$
x=20
$$

Step $420+y=60$

$$
y=40
$$

Use the first equation to solve for $y$. Subtract $x$ from each side.

Substitute $60-x$ for $y$ in the second equation.
Distributive Property
Subtract 180 from each side and simplify.
Divide each side by 2.
Substitute 20 for $x$ in the first equation.
Subtract 20 from each side.

The system's solution is $(20,40)$. The snack bar sold 40 small snack packs.

## Problem 4

## Using Substitution to Verify an Estimate

The graph shows the distance $y$ (in miles) that Car 1 and Car 2 are from a rest stop on the highway after $x$ minutes. Use the graph to estimate the solution of the system. What does the solution mean in this situation? Use substitution to verify your solution.

A Estimate the solution of the system that is represented by the graphs.

The $x$-value of the intersection point appears to be about 10 . The $y$-value appears to be about 8 . So, an estimate for the solution of the system is $(10,8)$. This represents Car 1 and Car 2 being the same distance from the rest stop, 8 miles, after 10 minutes.


B Write the system and solve it algebraically. Check your estimate.
The graph of Car 1 passes through $(0,20)$ and $(16,0)$. The graph of Car 2 passes through $(4,12)$ and $(20,0)$. Write equations using point-slope form.

Car 1: $y-20=-\frac{5}{4}(x-0)$ or $y=-\frac{5}{4} x+20 \quad$ Write an equation.
Car 2: $y-0=-\frac{3}{4}(x-20)$ or $y=-\frac{3}{4} x+15 \quad$ Write an equation.

$$
\begin{aligned}
-\frac{5}{4} x+20 & =-\frac{3}{4} x+15 & & \text { Substitute. } \\
-5 x+80 & =-3 x+60 & & \text { Multiply by } 4 . \\
-2 x & =-20 & & \text { Combine like terms. } \\
x & =10 & & \text { Divide. }
\end{aligned}
$$

Substituting $x=10$ into either equation gives $y=7.5$. The solution is $(10,7.5)$.
The estimate was not equal to the exact solution, but it was a good estimate.

## Think

How many solutions can a system of linear equations have? A system can have exactly one solution infinitely many solutions, or no solution.

## Systems With Infinitely Many Solutions or No Solution

How many solutions does each system have?
A $x=-2 y+4$
$3.5 x+7 y=14$
Substitute $-2 y+4$ for $x$ in
$3.5 x+7 y=14$.

$$
\begin{aligned}
3.5 x+7 y & =14 \\
3.5(-2 y+4)+7 y & =14 \\
-7 y+14+7 y & =14 \\
14 & =14
\end{aligned}
$$

$$
\begin{array}{rl}
\text { B } y & y x-11 \\
y & -3 x=-13
\end{array}
$$

Substitute $3 x-11$ for $y$ in $y-3 x=-13$.

$$
\begin{aligned}
y-3 x & =-13 \\
(3 x-11)-3 x & =-13 \\
-11 & =-13 \quad x
\end{aligned}
$$

The system has no solution.

The system has infinitely many solutions.

For additional support when completing your homework, go to PearsonTEXAS.com.

1. Apply Mathematics (1)(A) A farmer grows corn, tomatoes, and sunflowers on a 320-acre farm. This year, the farmer wants to plant twice as many acres of tomatoes as acres of sunflowers. The farmer also wants to plant 40 more acres of corn than of tomatoes. How many acres of each crop should the farmer plant?
2. Apply Mathematics (1)(A) Michelle and Pam are running a $200-\mathrm{m}$ race. Michelle runs at an average of $7.5 \mathrm{~m} / \mathrm{s}$. Pam averages $7.8 \mathrm{~m} / \mathrm{s}$, but she starts 1 s after Michelle.
a. How long will it take Pam to catch up to Michelle?
b. Will Pam overtake Michelle before the finish line? Explain.

Solve each system using substitution. Check your answer.
3. $x+y=8$
4. $2 x+2 y=38$
$y=3 x$
$y=x+3$
5. $x+3=y$
$3 x+4 y=7$
6. $y=8-x$
$7=2-y$
7. $y=-2 x+6$
$3 y-x+3=0$
8. $3 x+2 y=23$
$\frac{1}{2} x-4=y$
9. Apply Mathematics (1)(A) Adult tickets to a play cost $\$ 22$. Tickets for children cost $\$ 15$. Tickets for a group of 11 people cost a total of $\$ 228$. Write and solve a system of equations to find how many children and how many adults were in the group.
10. Apply Mathematics (1)(A) A school is planning a field trip for 142 people. The trip will use six drivers and two types of vehicles: buses and vans. A bus can seat 51 passengers. A van can seat 10 passengers. Write and solve a system of equations to find how many buses and how many vans will be needed.
11. A rectangle has a perimeter of 34 cm . Its length is 5 more than twice its width. Write and solve a system of equations to find the dimensions of the rectangle.
12. Explain Mathematical Ideas (1)(G) What would your first step be in solving the system below? Explain.

$$
\begin{aligned}
& 1.2 x+y=2 \\
& 1.4 y=2.8 x+1
\end{aligned}
$$

13. Apply Mathematics (1)(A) You have $\$ 3.70$ in dimes and quarters. You have 5 more quarters than dimes. How many of each type of coin do you have?
14. Explain Mathematical Ideas (1)(G) Let $a$ be any real number. $y=a x$ Will the system at the right always, sometimes, or never have a $\quad y=a x+4$ solution? Explain.
15. The measure of one acute angle in a right triangle is four times the measure of the other acute angle. Write and solve a system of equations to find the measures of the acute angles.
16. Explain Mathematical Ideas (1)(G) Explain how you can use $y+x=x$ substitution to show that the system at the right has no solution. $\frac{3 x}{2 y}=4$
17. A bookstore charges a standard rate for paperback or hardback books. The cost of a paperback book is 8 dollars less than the cost of a hardback book. Recently, one day of sales totaled $\$ 699.30$. That day the bookstore sold 53 paperback books and 41 hardback books. How much does each type of book cost? Write a system representing this situation. Use the graph to estimate the solution of the system. What does the solution mean in this situation? Use substitution to verify your solution.
18. The school store wants to order shirts with the school logo. One company charges $\$ 10.65$ per shirt plus a setup fee of $\$ 18$. Another company charges $\$ 9.40$ per shirt plus a $\$ 26$ fee. For what number of shirts would the cost be the same? Write a system representing this situation. Use the graph to estimate the solution of the system. What does the solution mean in this situation? Use substitution to verify your solution.

The coordinate grid shows the graphs of two linear equations. Use the graph for Exercises 19 and 20.
19. Use the graph to estimate the solution of the system.
20. Is it possible to write the system of linear equations represented by the graphs? Explain your answer.

21. Use a Problem-Solving Model (1)(B) At a certain high school, 350 students are taking an algebra course. The ratio of boys to girls taking algebra is $33: 37$. How many more girls are taking algebra than boys?

## Tell whether the system has one solution, infinitely many solutions,

 or no solution.22. $5=\frac{1}{2} x+3 y$
$10-x=6 y$
23. $17=11 y+12 x$
$12 x+11 y=14$
24. $1.5 x+2 y=11$
$3 x+6 y=22$
25. Analyze Mathematical Relationships (1)(F) a. Using a graph, how can you tell when a system of linear equations has no solution?
b. Using substitution, how can you tell when a system of linear equations has no solution?
c. How can you tell by looking at a table of values if two lines will intersect in one point, no points, or an infinite number of points?
26. Apply Mathematics (1)(A) A pyrotechnician plans for two fireworks to explode together at the same height in the air. They travel at speeds shown at the right. Firework B is launched 0.25 s before Firework A. How many seconds after Firework B launches will both fireworks explode?


## TEXAS End-of-Course PRACTICE

27. What is the value of the $x$-coordinate of the solution of the given system?

$$
\begin{aligned}
& 2 x+3 y=144 \\
& y-x=24
\end{aligned}
$$

28. You are making blueberry muffins and need to buy a muffin tin and baking cups. Each package of baking cups has 50 baking cups and costs $\$ 1.25$. The muffin tin costs $\$ 15$. If you have $\$ 22$ to spend, at most how many baking cups can you buy?
29. What is the $x$-intercept of $2 y-3 x=24$ ?
30. An online store charges $4 \%$ of the cost of an order to cover shipping costs. How much would you pay in dollars for shipping on an order that costs $\$ 146$ ?
31. What is the solution of the equation $2 x-3=8$ ?

## $\star$ 4-3 Solving Systems Using Elimination

## TEKS FOCUS

TEKS (5)(C) Solve systems of two linear equations with two variables for mathematical and real-world problems.

TEKS (1)(G) Display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication

Additional TEKS (1)(A), (2)(I)

## VOCABULARY

- Elimination method - Use the Addition and Subtraction Properties of Equality to add or subtract equations in order to eliminate a variable in the system.
- Justify - explain with logical reasoning. You can justify a mathematical argument.
- Argument - a set of statements put forth to show the truth or falsehood of a mathematical claim


## ESSENTIAL UNDERSTANDING

There is more than one way to solve a system of equations. Some systems are written in a way that makes eliminating a variable a good method to use.

## Key Concept Elimination Method

By the Addition and Subtraction Properties of Equality, if $a=b$ and $c=d$, then $a+c=b+d$ and $a-c=b-d$. For example, $5+1=6$ and $3+4=7$, so $(5+1)+(3+4)=6+7$. In the elimination method, you use these properties to add or subtract equations in order to eliminate a variable in a system.
A variable can be eliminated when the sum or difference of its coefficients is zero. Sometimes you need to multiply both sides of one or both equations by a nonzero number in order to get equations that can be added or subtracted to eliminate a variable. Once a variable is eliminated, you can solve for the other variable.
Substitute in either original equation to find the value of the eliminated variable.

## Key Concept Using the Elimination Method

The flowchart below can help you decide which steps to take when solving a system of equations using elimination.

```
Can I eliminate a variable yes Do so.
by adding or subtracting
the given equations?
yes Doso.
```

Can I multiply one of the equations by a number, and then add or subtract the equations?

Do so.

Multiply both equations by different numbers. Then add or subtract the equations.

## Problem 1

## Solving a System by Adding Equations

## Plan

Which variable should you eliminate? You can eliminate either variable. Since the coefficients of $y$ are opposites, you can add the equations to eliminate $y$ in one step.

## What is the solution of the system? Use elimination.

$$
\begin{aligned}
& 2 x+5 y=17 \\
& 6 x-5 y=-9
\end{aligned}
$$

Step 1 Eliminate one variable. Since the sum of the coefficients of $y$ is 0 , add the equations to eliminate $y$.

$$
\begin{array}{rlrl}
2 x+5 y & =17 & \\
6 x-5 y & =-9 \\
\hline 8 x+0 & =8 & & \\
x & =1
\end{array} \quad \begin{array}{ll}
\text { Add the two equations. } \\
\text { Solve for } x .
\end{array}
$$

Step 2 Substitute 1 for $x$ to solve for the eliminated variable.

$$
\begin{aligned}
2 x+5 y & =17 & & \text { You can use the first equation. } \\
2(1)+5 y & =17 & & \text { Substitute } 1 \text { for } x . \\
2+5 y & =17 & & \text { Simplify. } \\
y & =3 & & \text { Solve for } y .
\end{aligned}
$$

Since $x=1$ and $y=3$, the solution is $(1,3)$.

## Problem 2

## Solving a System by Subtracting Equations

Multiple Choice The theater club sells a total of 101 tickets to its first play. A student ticket costs $\$ 1$. An adult ticket costs $\$ 2.50$. Total ticket sales are $\$ 164$. How many student tickets were sold?
(A) 25
(B) 42
(C) 59

Define Let $a=$ the number of adult tickets sold.
Let $s=$ the number of student tickets sold.
Relate total number of tickets total ticket sales
Write $\quad a+s=101$

$$
2.5 a+s=164
$$

Step 1 Eliminate one variable. Since the difference of the coefficients of $s$ is 0 , eliminate $s$.

$$
\begin{array}{rlrl}
a+s & =101 & & \\
-2.5 a+s & =164 \\
-1.5 a+0 & =-63 \\
a & =42 & & \\
\text { Subtract the equations. } \\
\text { Solve for } a .
\end{array}
$$

## Problem 2 continued

Step 2 Solve for the eliminated variable. Use either equation.

$$
\begin{aligned}
a+s & =101 & & \text { You can use the first equation. } \\
42+s & =101 & & \text { Substitute } 42 \text { for } a . \\
s & =59 & & \text { Solve for } s .
\end{aligned}
$$

There were 59 student tickets sold. The correct answer is C.
Check 42 is close to 40 and 59 is close to 60 . The total number of tickets is about $40+60=100$, which is close to 101 . The total sales are about $\$ 2.50(40)+\$ 60=\$ 160$, which is close to $\$ 164$. The solution is reasonable.

## Problem 3

## Solving a System by Multiplying One Equation

What is the solution of the system? Use elimination.


Step 1 To eliminate one variable, you can multiply $7 x-5 y=17$ by 3 and then add.

$$
\begin{array}{rlrl}
-2 x+15 y & =-32 \\
7 x-5 y & =17 & \text { Multiply by 3. } \quad & \begin{aligned}
-2 x+15 y & =-32 \\
21 x-15 y & =51 \\
\hline 19 x+0 & =19 \\
x & =1
\end{aligned}
\end{array} \begin{aligned}
& \text { Add the equ } \\
& \text { Solve for } x .
\end{aligned}
$$

Step 2 Solve for the eliminated variable. Use either of the original equations.

$$
\begin{aligned}
7 x-5 y & =17 & & \text { You can use the second equation. } \\
7(1)-5 y & =17 & & \text { Substitute } 1 \text { for } x . \\
y & =-2 & & \text { Solve for } y .
\end{aligned}
$$

The solution is $(1,-2)$.

## Solving a System by Multiplying Both Equations

What is the solution of the system? Use elimination. $\quad 3 x+2 y=1$

$$
4 x+3 y=-2
$$

How can you get started?
Find the LCM of the coefficients of the variable that you want to eliminate. Multiply to make the coefficients equal to the LCM.

Step 1 Multiply each equation so you can eliminate one variable.

$$
\begin{array}{lll}
3 x+2 y=1 & \text { Multiply by } 3 . & 9 x+6 y=3 \\
4 x+3 y=-2 & \text { Multiply by } 2 . & \frac{8 x+6 y=-4}{x+0=7}
\end{array}
$$

Subtract the equations.
Step 2 Solve for the eliminated variable. Use either of the original equations.

$$
\begin{aligned}
3 x+2 y & =1 & & \text { You can use the first equation. } \\
3(7)+2 y & =1 & & \text { Substitute } 7 \text { for } x . \\
2 y & =-20 & & \text { Subtract } 21 \text { from each side. Simplify. } \\
y & =-10 & & \text { Solve for } y .
\end{aligned}
$$

The solution is $(7,-10)$.

## Problem 5

Think
Could you have solved this problem another way? Yes. For example, you could have multiplied the second equation by 2 and subtracted.

## Finding the Number of Solutions

How many solutions does the system have?

$$
\begin{aligned}
& 2 x+6 y=18 \\
& x+3 y=9
\end{aligned}
$$

Multiply the second equation by -2 .

$$
\begin{array}{rlrlrl}
2 x+6 y & =18 \\
x+3 y & =9 & \text { Multiply by }-2 . & & \begin{aligned}
2 x+6 y & =18 \\
-2 x-6 y & =-18 \\
0 & =0
\end{aligned}
\end{array}
$$

Add the equations.
Because $0=0$ is an identity, there are infinitely many solutions.


For additional support when completing your homework, go to PearsonTEXAS.com.

Solve each system using elimination.

1. $4 x-7 y=3$
$x-7 y=-15$
2. $5 x-y=0$
$3 x+y=24$
3. $6 x+5 y=39$
$3 x+5 y=27$
4. Apply Mathematics (1)(A) A carpenter is designing a drop-leaf table with two drop leaves of equal size. The lengths of the table when one leaf is folded up and when both leaves are folded up are shown. How


Tell whether the system has one solution, infinitely many solutions, or no solution.
5. $5 x-3 y=10$
$10 x+6 y=20$
6. $2 x-5 y=17$
$6 x-15 y=51$
7. $9 x+8 y=15$
$9 x+8 y=30$
8. Apply Mathematics (1)(A) A photo studio offers portraits in $8 \times 10$ and wallet-sized formats. One customer bought two $8 \times 10$ portraits and four wallet-sized portraits and paid $\$ 52$. Another customer bought three $8 \times 10$ portraits and two wallet-sized portraits and paid $\$ 50$. What is the cost of an $8 \times 10$ portrait? What is the cost of a wallet-sized portrait?

## Solve each system using elimination.

9. $3 x+2 y=17$
$2 x+5 y=26$
10. $6 x-3 y=15$
$7 x+4 y=10$
11. $5 x-9 y=-43$
$3 x+8 y=68$
12. Explain Mathematical Ideas (1)(G) A student solved a system of equations by elimination. Describe and correct the error made in the part of the solution shown.

13. Apply Mathematics (1)(A) A toy store worker packed two boxes of identical dolls and plush toys for shipping in boxes that weigh 1 oz when empty. One box held 3 dolls and 4 plush toys. The worker marked the weight as 12 oz . The other box held 2 dolls and 3 plush toys. The worker marked the weight as 10 oz . Explain why the worker must have made a mistake.
14. Apply Mathematics (1)(A) Half a pepperoni pizza plus three fourths of a ham-and-pineapple pizza contains 765 Calories. One fourth of a pepperoni pizza plus a whole ham-and-pineapple pizza contains 745 Calories. Write a system of equations to model the situation. How many Calories are in a whole pepperoni pizza? How many Calories are in a whole ham-and-pineapple pizza?
15. Explain Mathematical Ideas (1)(G) Use the dartboard below. Can you score exactly 100 points with seven darts that all land on the board? Explain.

16. Justify Mathematical Arguments (1)(G) What do the substitution method and the elimination method have in common? Explain. Give an example of a system that you would prefer to solve using one method instead of the other. Justify your choice.

Solve each system using any method. Explain why you chose the method you used.
17. $y=\frac{2}{3} x+1$
$2 x+3 y=27$
18. $x+y=1.5$
$2 x+y=1$
19. $\frac{1}{3} x+\frac{1}{2} y=0$
$\frac{1}{2} x+\frac{1}{5} y=\frac{11}{5}$
20. Apply Mathematics (1)(A) A hotel offers two activity packages. One costs $\$ 192$ and includes 3 h of horseback riding and 2 h of parasailing. The second costs $\$ 213$ and includes 2 h of horseback riding and 3 h of parasailing. What is the cost for 1 h of each activity?
21. Each of the squares in the figures shown at the right has the same area, and each of the triangles has the same area. The total area of Figure A is $141 \mathrm{~cm}^{2}$. The total area of Figure B is $192 \mathrm{~cm}^{2}$. What is the area of each square and each triangle?


Solve each system using elimination.
22. $\frac{2}{x}-\frac{3}{y}=-5$
$\frac{4}{x}+\frac{6}{y}=14$
23. $2 x=5(2-y)$
$y=3(-x+5)$
24. $2 x-3 y+z=0$
$2 x+y+z=12$
$y-z=4$
25. Explain Mathematical Ideas (1)(G) Write a system of equations that can be solved efficiently by elimination. Explain what you would do to eliminate one of the variables. Then solve the system.

## TEXAS End-of-Course PRACTICE

26. What is the value of the $y$-coordinate of the solution of the given system?
$4 x+3 y=33$
$3 x+2 y=23$
27. What is the $y$-intercept of $2 x+5 y=15$ ?
28. You buy a toothbrush for $\$ 2.83$ and a tube of toothpaste for $\$ 2.37$. There is a $5 \%$ sales tax. Including the tax, what is the total cost in dollars of your purchases?
29. Three fire trucks and 4 ambulances can fit into a parking lane 152 ft long. Two fire trucks and 5 ambulances can fit into a lane 136 ft long. How many feet long must a parking lane be for 1 fire truck and 5 ambulances? Assume there is 1 ft of space between each vehicle.

30. You are competing in a mountain bike race. Your average speed is $10 \mathrm{mi} / \mathrm{h}$. If the racecourse is 65 mi long, how many minutes will it take you to finish the race?

# 故 

## TEKS FOCUS

TEKS (2)(I) Write systems of two linear equations given a table of values, a graph, and a verbal description.

TEKS (1)(A) Apply mathematics to problems arising in everyday life, society, and the workplace.

Additional TEKS (1)(E), (1)(G), (5)(C)

## VOCABULARY

- Apply - use knowledge or information for a specific purpose, such as solving a problem


## ESSENTIAL UNDERSTANDING

You can solve systems of linear equations using a graph, the substitution method, or the elimination method. The best method to use depends on the forms of the given equations and how precise the solution should be.

## Concept Summary Choosing a Method for Solving Linear Systems

## Method

Graphing
Substitution

## When to Use

When you want a visual display of the equations, or when you want to estimate a solution
When one equation is already solved for one of the variables, or when it is easy to solve for one of the variables

Elimination
When the coefficients of one variable are the same or opposites, or when it is not convenient to use graphing or substitution

## Key Concept Using Systems of Equations to Model Problems

Systems of equations are useful for modeling problems involving mixtures, rates, and break-even points.

The break-even point for a business is the point at which income equals expenses. The graph shows the break-even point for one business.

Notice that the values of $y$ on the red line represent dollars spent on expenses. The values of $y$ on the blue line represent dollars received as income. So $y$ is used to represent both expenses and income.


## Finding a Break-Even Point

Business A fashion designer makes and sells hats. Use the graph to estimate how many hats the designer must sell to break even. Then write and solve a system of equations to determine if your estimate is correct.


Step 1 Estimate the coordinates of the break-even point.
Let $x=$ the number of hats sold and let $y=$ the number of dollars of expense or income. The lines appear to intersect at $(100,1250)$. So, the designer would need to sell 100 hats to break even.

Step 2 Write the system of equations.
The income line passes through $(0,0)$ and $(10,125)$.
slope: $\frac{125-0}{10-0}=\frac{125}{10}=12.5 \quad y$-intercept: 0
The income line is $y=12.5 x$.
The expense line passes through $(0,700)$ and $(50,975)$.
slope: $\frac{975-700}{50-0}=\frac{275}{50}=5.5 \quad y$-intercept: 700
The expense line is $y=5.5 x+700$.
Step 3 Choose a method. Use substitution since both equations are solved for $y$.

$$
\begin{aligned}
y & =5.5 x+700 & & \text { Start with one equation. } \\
12.5 x & =5.5 x+700 & & \text { Substitute } 12.5 x \text { for } y . \\
7 x & =700 & & \text { Subtract } 5.5 x \text { from each side. } \\
x & =100 & & \text { Divide each side by } 7 .
\end{aligned}
$$

Since $x$ is the number of hats, the designer must sell 100 hats to break even.
This indicates that the estimate found when using the graph makes sense.

## Identifying Constraints and Viable Solutions

Zoo The local zoo is filling two water tanks for the elephant exhibit. When will the two tanks have the same amount of water? Explain.

## What are the

 constraints of the system? If $x$ represents time, then $x \geq 0$. If $y$ represents the number of gallons, then $y \geq 0$.Step 1 Write a system of equations. Let $x=$ the number of hours the tanks are filling and let $y=$ the number of gallons in the tank.

$$
\text { Tank 1: } y=10 x+50 \quad \text { Tank 2: } y=3 x+29
$$

Step 2 The system is easy to solve using substitution. Substitute $10 x+50$ for $y$ in the second equation and solve for $x$.

$$
\begin{aligned}
y & =3 x+29 & & \text { Write the second equation. } \\
10 x+50 & =3 x+29 & & \text { Substitute } 10 x+50 \text { for } y . \\
7 x+50 & =29 & & \text { Subtract } 3 x \text { from each side. Then simplify. } \\
7 x & =-21 & & \text { Subtract } 50 \text { from each side. Then simplify. } \\
x & =-3 & & \text { Divide each side by } 7 .
\end{aligned}
$$

Step 3 Substitute -3 for $x$ in either equation and solve for $y$.

$$
\begin{array}{ll}
y=10(-3)+50 & \text { Substitute }-3 \text { for } x \text { in the first equation. } \\
y=20 & \text { Simplify. }
\end{array}
$$

The solution to the system is $(-3,20)$. This is not a viable solution because it is not possible to have time be -3 hours. So, the tanks never have the same amount of water.

## Solving a Wind or Current Problem

Travel A traveler flies from Charlotte, North Carolina, to Los Angeles, California. At the same time, another traveler flies from Los Angeles to Charlotte. The airspeed of each plane is the same. The groundspeeds are shown below. What is the airspeed? What is the wind speed?

## Think

How are the speeds related?
The airspeed is a plane's speed with no wind. Add wind speed and airspeed to get the groundspeed with a tailwind. Subtract wind speed from airspeed to find the groundspeed with a headwind.


Use the groundspeed with the tailwind and with the headwind to write the system.
Let $a=$ the airspeed of the planes. Let $w=$ the wind speed.


Choose a method to solve the system. Use elimination.

$$
\begin{array}{rlrl}
a+w & =550 & \\
a-w & =495 \\
\hline 2 a+0 & =1045 & & \\
a & =522.5 \quad & \text { Add the eq } \\
\text { Solve for } a .
\end{array}
$$

Substitute 522.5 for $a$ in either equation and solve for $w$.

$$
\begin{aligned}
522.5+w & =550 & & \text { Substitute } 522.5 \text { for } a \text { in the first equation. } \\
w & =27.5 & & \text { Solve for } w .
\end{aligned}
$$

The airspeed is $522.5 \mathrm{mi} / \mathrm{h}$. The wind speed is $27.5 \mathrm{mi} / \mathrm{h}$.

STEM 1. Apply Mathematics (1)(A) A group of scientists studied the effect of a chemical on various strains of bacteria. Strain A started with 6000 cells and decreased at a constant rate of 2000 cells per hour after the chemical was applied. Strain B started with 2000 cells and decreased at a constant rate of 1000 cells per hour after the chemical was applied. When will the strains have the same number of cells? Explain.

For additional support when completing your homework, go to PearsonTEXAS.com.
2. Apply Mathematics (1)(A) You split $\$ 1500$ between two savings accounts. Account A pays $5 \%$ annual interest and Account B pays $4 \%$ annual interest. After one year, you have earned a total of $\$ 69.50$ in interest. How much money did you invest in each account? Explain.
3. Apply Mathematics (1)(A) A traveler is walking on a moving walkway in an airport. The traveler must walk back on the walkway to get a bag he forgot. The traveler's speed is $2 \mathrm{ft} / \mathrm{s}$ against the walkway and $6 \mathrm{ft} / \mathrm{s}$ with the walkway. What is the traveler's speed off the walkway? What is the speed of the moving walkway?
4. Explain Mathematical Ideas (1)(G) You have a jar of pennies and quarters. You want to choose 15 coins that are worth exactly $\$ 4.35$.
a. Write and solve a system of equations that models the situation.
b. Is your solution reasonable in terms of the original problem? Explain.
5. A carpenter makes and sells rocking chairs. Use the graph to estimate how many chairs the carpenter must sell to break even. Then write and solve a system of equations to determine if your estimate is correct.


Solve each system. Explain why you chose the method you used.
6. $4 x+5 y=3$
$3 x-2 y=8$
7. $2 x+7 y=-20$
$y=3 x+7$
8. $5 x+2 y=17$
$x-2 y=8$
9. Find $A$ and $B$ so that the system below has the solution $(2,3)$.

$$
\begin{aligned}
& A x-2 B y=6 \\
& 3 A x-B y=-12
\end{aligned}
$$

10. Apply Mathematics (1)(A) A tugboat can pull a boat 24 mi downstream in 2 h .

Going upstream, the tugboat can pull the same boat 16 mi in 2 h . What is the speed of the tugboat in still water? What is the speed of the current?

Without solving, decide which method you would use to solve each system: graphing, substitution, or elimination. Explain.
11. $y=3 x-1$
$y=4 x$
12. $3 m-4 n=1$
$3 m-2 n=-1$
13. $4 s-3 t=8$
$t=-2 s-1$
14. Use Representations to Communicate Mathematical Ideas (1)(E) A kayaker paddles upstream from camp to photograph a waterfall and returns. The kayaker's speeds while traveling upstream and downstream are shown below. Use the information in the diagram to write a system of equations. What is the kayaker's speed in still water? What is the speed of the current?

15. Apply Mathematics (1)(A) A perfume maker has stocks of two perfumes on hand. Perfume A sells for $\$ 15$ per ounce. Perfume B sells for $\$ 35$ per ounce. How much of each should be combined to make a 3-oz bottle of perfume that can be sold for $\$ 63$ ?
16. In a chemistry lab, you have two vinegars. One is $5 \%$ acetic acid, and one is $6.5 \%$ acetic acid. You want to make 200 mL of a vinegar with $6 \%$ acetic acid. How many milliliters of each vinegar do you need to mix together?
17. Apply Mathematics (1)(A) A boat is traveling in a river with a current that has a speed of $1.5 \mathrm{~km} / \mathrm{h}$. In one hour, the boat can travel twice the distance downstream that it can travel upstream. What is the boat's speed in still water?
18. Explain Mathematical Ideas (1)(G) A student claims that the best way to solve the system at the right is by substitution. Do you agree? Explain.

$$
y-3 x=4
$$

19. Apply Mathematics (1)(A) A contestant on a quiz show gets 150 points for

$$
y-6 x=12
$$ every correct answer and loses 250 points for each incorrect answer. After answering 20 questions, the contestant has 200 points. How many questions has the contestant answered correctly? Incorrectly?

## TEXAS End-of-Course PRACTICE

20. Last year, one fourth of the students in your class played an instrument. This year, 6 students joined the class. Four of the new students play an instrument. Now, one third of the students play an instrument. How many students are in your class now?
A. 18
B. 24
C. 30
D. 48
21. Which answer choice shows $2 x-y=z$ correctly solved for $y$ ?
F. $y=2 x+z$
G. $y=2 x-z$
H. $y=-2 x+z$
J. $y=-2 x-z$
22. What is an equation of a line passing through the points $(3,1)$ and $(4,3)$ written in slope-intercept form?

## TEKS FOCUS

TEKS (3)(D) Graph the solution set of linear inequalities in two variables on the coordinate plane.

TEKS (1)(G) Display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication.

Additional TEKS (1)(D), (2)(H)

## VOCABULARY

- Linear inequality - an inequality in two variables whose graph is a region of the coordinate plane that is bounded by a line; each point in the region is a solution of the inequality.
- Solution of an inequality - any ordered pair that makes the inequality true
- Argument - a set of statements put forth to show the truth or falsehood of a mathematical claim
- Justify - explain with logical reasoning. You can justify a mathematical argument.


## ESSENTIAL UNDERSTANDING

A linear inequality in two variables has an infinite number of solutions. These solutions can be represented in the coordinate plane as the set of all points on one side of a boundary line.

## Enote Key Concept Graph of a Linear Inequality in Two Variables

The graph of a linear inequality in two variables consists of all points in the coordinate plane that represent solutions. The graph is a region called a half-plane that is bounded by a line. All points on one side of the boundary line are solutions, while all points on the other side are not solutions.


Each point on a dashed line is not a solution. A dashed line is used for inequalities with $>$ or $<$.


Each point on a solid line is a solution. A solid line is used for inequalities with $\geq$ or $\leq$.

## Problem 1

Have you tested solutions before? Yes. You have tested solutions of equations. Now you will test ordered pairs to see whether they satisfy an inequality.

## Identifying Solutions of a Linear Inequality

Is the ordered pair a solution of $y>x-3$ ?

A $(1,2)$
$y>x-3 \quad \leftarrow$ Write the inequality. $\rightarrow$
$2 \stackrel{?}{>} 1-3 \quad \leftarrow$ Substitute. $\rightarrow$
$2>-2 \boldsymbol{\iota} \quad \leftarrow$ Simplify. $\rightarrow$
$(1,2)$ is a solution.

B $(-3,-7)$

$$
\begin{array}{rl}
y & >x-3 \\
-7 & ?-3-3 \\
-7 & >-6 \boldsymbol{x}
\end{array}
$$

$(-3,-7)$ is not a solution.

## Think

Why does $y=x-2$ represent the boundary line? For any value of $x$, the corresponding value of $y$ is the boundary between values of $y$ that are greater than $x-2$ and values of $y$ that are less than $x-2$.

## Graphing an Inequality in Two Variables

## What is the graph of $y>x-2$ ?

First, graph the boundary line $y=x-2$. Since the inequality symbol is $>$, the points on the boundary line are not solutions. Use a dashed line to indicate that the points are not included in the solution.

To determine which side of the boundary line to shade, test a point that is not on the line. For example, test the point $(0,0)$.


$$
\begin{array}{ll}
y>x-2 & \\
0 \stackrel{?}{>} 0-2 & \text { Substitute }(0,0) \text { for }(x, y) \\
0>-2 \boldsymbol{\sim} & (0,0) \text { is a solution. }
\end{array}
$$

Because the point $(0,0)$ is a solution of the inequality, so are all the points on the same side of the boundary line as $(0,0)$. Shade the area above the boundary line.

## Think

Have you graphed inequalities like these before? Yes. In Lesson 1-7, you graphed inequalities in one variable on a number line. Here you graph them in the coordinate plane.

## Graphing a Linear Inequality in One Variable

## What is the graph of each inequality in the coordinate plane?

A $x>-1$
Graph $x=-1$ using a dashed line. Use $(0,0)$ as a test point.

$$
\begin{aligned}
& x>-1 \\
& 0>-1 \boldsymbol{V}
\end{aligned}
$$



The inequality indicates $x$-values that are greater than -1 , so you shade to the right of the boundary line.

Shade on the side of the line that contains $(0,0)$.
B $y \geq 2$
Graph $y=2$ using a solid line.
Use $(0,0)$ as a test point.

$$
\begin{aligned}
& y \geq 2 \\
& 0 \geq 2 \quad x
\end{aligned}
$$



The inequality indicates $y$-values that are greater than or equal to 2 , so you shade above the boundary line.

Shade on the side of the line that does not contain $(0,0)$.

## Problem 4

## Rewriting to Graph an Inequality

Interior Design An interior decorator is going to remodel a kitchen. The wall above the stove and the counter is going to be redone as shown. The owners can spend $\$ 420$ or less. Write a linear inequality and graph the solutions. What are three possible prices for the wallpaper and tiles?


Let $x=$ the cost per square foot of the wallpaper.
Let $y=$ the cost per square foot of the tiles.
Write an inequality and solve it for $y$.

$$
\begin{aligned}
24 x+12 y & \leq 420 & & \text { Total cost is } \$ 420 \text { or less. } \\
12 y & \leq-24 x+420 & & \text { Subtract } 24 x \text { from each side. } \\
y & \leq-2 x+35 & & \text { Divide each side by } 12 .
\end{aligned}
$$

Graph $y \leq-2 x+35$. The inequality symbol is $\leq$, so the boundary line is solid and you shade below it.


The graph makes sense only in the first quadrant. Three possible prices per square foot for wallpaper and tiles are $\$ 5$ and $\$ 25, \$ 5$ and $\$ 15$, and $\$ 10$ and $\$ 10$.

Think
Can you eliminate choices?
Yes. The boundary line is solid and the region below it is shaded, so you know the inequality symbol must be $\leq$. You can eliminate choices C and D .

## Writing an Inequality From a Graph and a Table

A Multiple Choice Which inequality represents the graph at the right?
(A) $y \leq 2 x+1$
(C) $y \geq 2 x+1$
(B) $y \leq x+1$
(D) $y<2 x+1$

The slope of the line is 2 and the $y$-intercept is 1 , so the equation of the boundary line is $y=2 x+1$. The boundary line is solid, so the inequality symbol is either $\leq$ or $\geq$. The symbol must be $\leq$, because
 the region below the boundary line is shaded. The inequality is $y \leq 2 x+1$.
The correct answer is A.
B Write a linear inequality in two variables so that each pair of values in the table at the right satisfies the inequality.
Your answers may vary. You should test the values in the table to see if they make a linear inequality true.
Start with $y \leq 2 x$. Not all of the values in the table make this inequality true.

$$
2 \leq 2(1) \quad 3 \not \approx 2(1) \quad 4 \not \approx 2(1) \quad 4 \leq 2(2) \quad 5 \not \equiv 2(2)
$$

Now try $y \geq 2 x$. All of the values in the table make this inequality true.

$2 \geq 2$ (1) $\quad 3 \geq 2$ (1) $\quad 4 \geq 2$ (1) $\quad 4 \geq 2$ (2) $\quad 5 \geq 2$ (2)
A linear inequality that you could write using this table of values is $y \geq 2 x$.
Other inequalities that you could write using this table of values are $y>x, y \leq 4 x$, and $y<2 x+3$.

## Problem 6

## Graphing Linear Inequalities

Graph the inequality $y \leq 3 x-7$ using your graphing calculator.

Step 1 Move the cursor to the left of $\mathbf{Y}_{\mathbf{1}}$. Press enter repeatedly until the less-than icon appears.

Think
How can you check your work?
One way is to test a point in the shaded region of the graph and see if it makes the inequality a true statement.


Step 3 Before graphing, choose an appropriate viewing window. Press graph to graph the inequality.
The graph is displayed.



For additional support when completing your homework, go to PearsonTEXAS.com.

## Determine whether the ordered pair is a solution of the linear inequality.

1. $y \leq-2 x+1 ;(2,2)$
2. $x<2$; $(-1,0)$
3. $y \geq 3 x-2 ;(0,0)$
4. Apply Mathematics (1)(A) You budget $\$ 200$ for wooden planks for outdoor furniture. Cedar costs $\$ 2.50$ per foot and pine costs $\$ 1.75$ per foot. Let $x=$ the number of feet of cedar and let $y=$ the number of feet of pine. What is an inequality that shows how much of each type of wood can be bought? Graph the inequality. What are three possible amounts of each type of wood that can be bought within your budget?
5. Apply Mathematics (1)(A) A fish market charges $\$ 9$ per pound for cod and $\$ 12$ per pound for flounder. Let $x=$ the number of pounds of cod. Let $y=$ the number of pounds of flounder. What is an inequality that shows how much of each type of fish the store must sell today to reach a daily quota of at least $\$ 120$ ? Graph the inequality. What are three possible amounts of each fish that would satisfy the quota?
6. Explain Mathematical Ideas (1)(G) A student graphed $y \geq 2 x+3$ as shown below. Describe and correct the student's error.

7. Explain Mathematical Ideas (1)(G) A truck that can carry no more than 6400 lb is being used to transport refrigerators and upright pianos. Each refrigerator weighs 250 lb and each piano weighs 475 lb . Write and graph an inequality to show how many refrigerators and how many pianos the truck could carry. Will 12 refrigerators and 8 pianos overload the truck? Explain.
8. Apply Mathematics (1)(A) A student with two summer jobs earns $\$ 10$ per hour at a cafe and $\$ 8$ per hour at a market. The student would like to earn at least $\$ 800$ per month. Write and graph an inequality to represent the situation.
9. When graphing an inequality, can you always use $(0,0)$ as a test point to determine where to shade? If not, how would you choose a test point?
10. Apply Mathematics (1)(A) A music store sells used CDs for $\$ 5$ each and buys used CDs for $\$ 1.50$ each. You go to the store with $\$ 20$ and some CDs to sell. You want to have at least $\$ 10$ left when you leave the store. Write and graph an inequality to show how many CDs you could buy and sell.

## Graph each linear inequality.

11. $y<5 x-5$
12. $y \leq \frac{1}{2} x-3$
13. $y>-3 x$
14. $y \geq-x$

Graph each inequality in the coordinate plane.
15. $x \leq 4$
16. $y \geq-1$
17. $x+3 y<15$
18. $4 x-y>2$

Write a linear inequality that represents each graph.
19.

20.


Use a graphing calculator to graph each linear inequality.
21. $y \leq 2 x-8$
22. $y \geq 3$
23. $y \leq \frac{1}{2} x+\frac{3}{4}$
24. Use Multiple Representations to Communicate Mathematical Ideas (1)(D) A gardener wants to plant tomato and pepper plants. Tomato plants cost $\$ 5.50$ each and pepper plants cost $\$ 4.25$ each. The gardener has $\$ 40$ to spend on plants.
a. Write an inequality to represent this situation. Let $x$ represent the number of tomato plants and $y$ represent the number of pepper plants.
b. Graph the inequality.
c. Use the graph to determine if the gardener can buy 6 tomato plants and 3 pepper plants with the money he has. Explain.
25. Apply Mathematics (1)(A) At your grocery store, milk normally costs $\$ 3.60$ per gallon. Ground beef costs $\$ 3$ per pound. Today there are specials: Milk is discounted $\$ .50$ per gallon, and ground beef is $20 \%$ off. You want to spend no more than $\$ 20$. Write and graph a linear inequality to show how many gallons of milk and how many pounds of ground beef you can buy today.
26. Explain Mathematical Ideas (1)(G) You are graphing a linear inequality of the form $y>m x+b$. The point $(1,2)$ is not a solution, but $(3,2)$ is. Is the slope of the boundary line positive, negative, zero, or undefined? Explain.
27. Write a linear inequality in two variables given each table of values shown below.
a.

| $x$ | $y$ |
| :---: | :---: |
| 0 | -3 |
| 1 | -4 |
| 2 | -5 |
| 3 | -6 |
| 4 | -7 |

b.


## TEXAS End-of-Course PRACTICE

28. What is the inequality of the graph shown?
A. $y+x \geq-3$
B. $y-x \geq 3$
C. $x-y>-3$
D. $y>-x+3$
29. You secure pictures to your scrapbook using 3 stickers. You started with 24 stickers. There are now 2 pictures in your scrapbook. You write the
 equation $3(x+2)=24$ to find the number $x$ of additional pictures you can put in your scrapbook. How many more pictures can you add?
F. 4
G. 6
H. 8
J. 12
30. At Market A, 1-lb packages of rice are sold for the price shown. At Market B, rice is sold in bulk for the price shown. For each market, write a function describing the cost of buying rice in terms of the weight. How are the domains of the two functions different?


# to <br> <br> 4-6 Systems of Linear Inequalities 

 <br> <br> 4-6 Systems of Linear Inequalities}

## TEKS FOCUS

TEKS (3)(H) Graph the solution set of systems of two linear inequalities in two variables on the coordinate plane.

TEKS (1)(D) Communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.

Additional TEKS (1)(F), (2)(H), (3)(D)

## VOCABULARY

- System of linear inequalities - two or more linear inequalities using the same variables
- Solution of a system of linear inequalities - any ordered pair that makes all of the inequalities in the system true
- Implication - a conclusion that follows from previously stated ideas or reasoning without being explicitly stated
- Representation - a way to display or describe information. You can use a representation to present mathematical ideas and data.


## ESSENTIAL UNDERSTANDING

You can graph the solutions of a system of linear inequalities in the coordinate plane. The graph of the system is the region where the graphs of the individual inequalities overlap.

## Graphing a System of Inequalities

Think
Have you seen a problem like this before?
Yes. The solution of a system of equations is shown by the intersection of two lines. The solutions of a system of inequalities are shown by the intersection of two shaded areas.

What is the graph of the system? $\quad \begin{aligned} & y<2 x-3 \\ & 2 x+y>2\end{aligned}$
Graph $y<2 x-3$ and $2 x+y>2$.

The blue region represents solutions of $2 x+y>2$.

The yellow region represents solutions of $y<2 x-3$.
 represents solutions of both inequalities

The system's solutions lie in the green region where the graphs overlap.
Check $(3,0)$ is in the green region. See if $(3,0)$ satisfies both inequalities.

$$
\begin{array}{lcr}
y \stackrel{?}{<} 2 x-3 & \leftarrow \text { Write both inequalities. } \rightarrow & 2 x+y \stackrel{?}{>} 2 \\
0 \stackrel{?}{\gtrless} 2(3)-3 & \leftarrow \text { Substitute }(3,0) \text { for }(x, y) . \rightarrow & 2(3)+0 \stackrel{?}{>} 2 \\
0<3 \boldsymbol{\checkmark} & \leftarrow \text { Simplify. The solution checks. } \rightarrow & 6>2 \boldsymbol{レ}
\end{array}
$$

## Think

Have you seen a problem like this one before?
Yes. You wrote an inequality from a graph in Lesson 4-5. Now you'll write two inequalities.

## Writing a System of Inequalities From a Graph

## What system of inequalities is represented by the graph below?



To write a system that is represented by the graph, write an inequality that represents the yellow region and an inequality that represents the blue region.

The red boundary line is $y=-\frac{1}{2} x+5$. The region does not include the line, only points below. The inequality is $y<-\frac{1}{2} x+5$.


The blue boundary line is $y=x-1$. The region includes the boundary line and points above. The inequality is $y \geq x-1$.

The graph shows the intersection of the system $y<-\frac{1}{2} x+5$ and $y \geq x-1$.

## Problem 3

## Using a System of Inequalities

Time Management You are planning what to do after school. You can spend at most 6 h daily playing basketball and doing homework. You want to spend less than 2 h playing basketball. You must spend at least $1 \frac{1}{2} \mathrm{~h}$ on homework. What is a graph showing how you can spend your time?

| Know | Need | Plan |
| :--- | :--- | :--- |
| - At most 6 h playing basketball | To find different ways | Write and graph an inequality |
| and doing homework | you can spend your | for each restriction. Find |
| - Less than 2 h playing basketball | time | the region where all three |
| - At least $1 \frac{1}{2} \mathrm{~h}$ doing homework |  | restrictions are met. |

Let $x=$ the number of hours playing basketball.
Let $y=$ the number of hours doing homework.

## Problem 3 continued

Write a system of inequalities.

$$
\begin{array}{ll}
x+y \leq 6 & \text { At most } 6 \mathrm{~h} \text { of basketball and homework } \\
x<2 & \text { Less than } 2 \mathrm{~h} \text { of basketball } \\
y \geq 1 \frac{1}{2} & \text { At least } 1 \frac{1}{2} \mathrm{~h} \text { of homework }
\end{array}
$$

Graph the system. Because time cannot be negative, the graph makes sense only in the first quadrant. The solutions of the system are all of the points in the shaded region, including the points on the solid boundary lines.


## Problem 4

## Graphing Linear Inequalities

## Plan

Does it matter which inequality is graphed first?
No. This is a system of linear inequalities. You can graph either inequality first. The answer will be the same.

Graph this system using your graphing calculator.

$$
\begin{aligned}
& y \leq-2 x-3 \\
& y \geq x+4
\end{aligned}
$$

Step 1 Move the cursor to the left of $\mathbf{Y}_{1}$. Press enter repeatedly to select the appropriate inequality mode. Enter the first inequality for $\mathbf{Y}_{\mathbf{1}}$.

Step 2 Then move the cursor to the left of $\mathbf{Y}_{2}$. Press enter repeatedly to select the appropriate inequality mode. the second inequality for $\mathbf{Y}_{\mathbf{2}}$.

Step 3 Press graph to graph the system of inequalities.
The graph is displayed.


For additional support when completing your homework, go to PearsonTEXAS.com.

Determine whether the ordered pair is a solution of the given system.

1. $(2,12)$;
$y>2 x+4$
2. $(8,2)$;
$y<3 x+7$
$3 x-2 y \leq 17$
$0.3 x+4 y>9$
3. $(-3,17)$;
$y>-5 x+2$
$y \geq-5 x+7$

Write a system of inequalities for each graph.
4.

5.

6. Apply Mathematics (1)(A) Suppose you have a job mowing lawns that pays $\$ 12$ per hour. You also have a job at a clothing store that pays $\$ 10$ per hour. You need to earn at least $\$ 350$ per week, but you can work no more than 35 h per week. You must work a minimum of 10 h per week at the clothing store. What is a graph showing how many hours per week you can work at each job?
7. Apply Mathematics (1)(A) Two friends agree to split the driving on a road trip from Philadelphia, Pennsylvania, to Denver, Colorado. One friend drives at an average speed of $60 \mathrm{mi} / \mathrm{h}$. The other friend drives at an average speed of $55 \mathrm{mi} / \mathrm{h}$. They want to drive at least 500 mi per day. They plan to spend no more than 10 h driving each day. The friend who drives slower wants to drive fewer hours. What is a graph showing how they can split the driving each day?

## Solve each system of inequalities by graphing.

8. $y<2 x+4$
$-3 x-2 y \geq 6$
9. $y>\frac{1}{4} x$
$y \leq-x+4$
10. $y<2 x+4$
$2 x-y \leq 4$
11. $y<2 x-3$
$y>5$
12. $y>2 x+4$
$2 x-y \leq 4$
13. $y \leq-\frac{1}{3} x+7$ $y \geq-x+1$
14. Display Mathematical Ideas (1)(G) You are fencing in a rectangular area for a garden. You have only 150 ft of fence. You want the length of the garden to be at least 40 ft . You want the width of the garden to be at least 5 ft . What is a graph showing the possible dimensions your garden could have?
15. a. Graph the system $y>3 x+3$ and $y \leq 3 x-5$.
b. Will the boundary lines $y=3 x+3$ and $y=3 x-5$ ever intersect? How do you know?
c. Do the shaded regions in the graph from part (a) overlap?
d. Does the system of inequalities have any solutions? Explain.
16. Analyze Mathematical Relationships (1)(F) A student graphs the system as shown below. Describe and correct the student's error.

17. Apply Mathematics (1)(A) You received a $\$ 100$ gift certificate to a clothing store. The store sells T-shirts for $\$ 15$ and dress shirts for $\$ 22$. You want to spend no more than the amount of the gift certificate. You want to leave at most $\$ 10$ of the gift certificate unspent. You need at least one dress shirt. What are all of the possible combinations of T-shirts and dress shirts you could buy?
18. a. Graph the system of linear inequalities.
b. Describe the shape of the solution region.
c. Find the vertices of the solution region.
d. Find the area of the solution region.
19. Solve $|y| \geq x$. (Hint: Write two inequalities and then graph them.)
20. Apply Mathematics (1)(A) A teacher wants to post a row of student artwork on a wall that is 20 ft long. Some pieces are 8.5 in . wide. Other pieces are 11 in . wide. She is going to leave 3 in . of space to the left of each art piece. She wants to post at least 16 pieces of art. Write and graph a system of inequalities that describes how many pieces of each size she can post.

## Use a graphing calculator to graph each system of linear inequalities.

21. $y \leq-3 x+2$
22. $y \leq 2$
$y \geq 2 x-7$
23. $y \leq-x$
$y \geq \frac{1}{2} x+3$
24. $y \geq 5 x$
$y \geq-x-2$

## TEXAS End-of-Course PRACTICE

25. The point $(-3,11)$ is a solution of which of the following systems?
A. $y \geq x-2$
B. $y>x+8$
C. $y>-x+8$
D. $y \leq-3 x+1$
$2 x+y \leq 5$
$3 x+y>2$
$2 x+3 y \geq 7$
$x-y \geq-15$
26. A plane has 18 passengers. Some have 1 bag and others have 2 bags. There are a total of 27 bags. Let $b=$ the number of passengers with 1 bag and $t=$ the number of passengers with 2 bags. Which system describes this situation?
F. $b+t=27$
$b+2 t=18$
G. $t=18-b$
$b+2 t=27$
H. $b+t=18$
$b=27+2 t$
J. $b=18-t$
$b+2 t=18$
27. You fill your glass with ice and then add room-temperature water. Which graph best represents the change in temperature of the glass?
A.

C.

B.

D.


## Topic 4 Review

## TOPIC VOCABULARY

- consistent system, p. 160
- dependent system, p. 160
- elimination method, p. 175
- inconsistent system, p. 160
- independent system, p. 160
- linear inequality, p. 187
- solution of an inequality, p. 187
- solution of a system of linear equations, p. 160
- solution of a system of linear inequalities, p. 194


## Check Your Understanding

Choose the vocabulary term that correctly completes the sentence.

1. A system of equations that has no solution is said to be $\mathrm{a}(\mathrm{n})$ ?.
2. You can solve a system of equations by adding or subtracting the equations in such a way that one variable drops out. This is called the ? method.
3. Two or more linear equations together form $\mathrm{a}(\mathrm{n})$ ?.

## 4-1 Solving Systems by Graphing

## Quick Review

One way to solve a system of linear equations is by graphing each equation and finding the intersection point of the graph, if one exists.

## Example

What is the solution of the system?

$$
\begin{aligned}
& y=-2 x+2 \\
& y=0.5 x-3
\end{aligned}
$$

$$
\begin{array}{ll}
y=-2 x+2 & \text { Slope is }-2 ; y \text {-intercept is } 2 . \\
y=0.5 x-3 & \text { Slope is } 0.5 ; y \text {-intercept is }-3 .
\end{array}
$$

The lines appear to intersect at $(2,-2)$. Check if $(2,-2)$ makes both equations true.

$$
\begin{aligned}
& -2=-2(2)+2 \\
& -2=0.5(2)-3
\end{aligned}
$$

So, the solution is $(2,-2)$.


- substitution method, p. 169
- system of linear equations, p. 160
- system of linear inequalities, p. 194


## 4-2 Solving Systems Using Substitution

## Quick Review

You can solve a system of equations by solving one equation for one variable and then substituting the expression for that variable into the other equation.

## Example

What is the solution of the system?

$$
\begin{aligned}
& y=-\frac{1}{3} x \\
& 3 x+3 y=-18
\end{aligned}
$$

$$
\begin{aligned}
3 x+3 y & =-18 & & \text { Write the second equation. } \\
3 x+3\left(-\frac{1}{3} x\right) & =-18 & & \text { Substitute }-\frac{1}{3} x \text { for } y . \\
2 x & =-18 & & \text { Simplify. } \\
x & =-9 & & \text { Solve for } x . \\
y & =-\frac{1}{3}(-9) & & \text { Substitute }-9 \text { for } x \text { in the } \\
y & =3 & & \text { first equation. }
\end{aligned}
$$

The solution is $(-9,3)$.

## Exercises

Solve each system using substitution. Tell whether the system has one solution, infinitely many solutions, or no solution.
12. $y=2 x-1$
$2 x+2 y=22$
14. $2 x+y=-12$
$-4 x-2 y=30$
16. $y=x-7$
$3 x-3 y=21$
13. $-x+y=-13$
$3 x-y=19$
15. $\frac{1}{3} y=\frac{7}{3} x+\frac{5}{3}$
$x-3 y=5$
18. The owner of a hair salon charges $\$ 20$ more per haircut than the assistant. Yesterday the assistant gave 12 haircuts. The owner gave 6 haircuts. The total earnings from haircuts were $\$ 750$. How much does the owner charge for a haircut? Solve by writing and solving a system of equations.

## 4-3 and 4-4 Solving Systems Using Elimination; Applications of Systems

## Quick Review

You can add or subtract equations in a system to eliminate a variable. Before you add or subtract, you may have to multiply one or both equations by a constant to make eliminating a variable possible.

## Example

What is the solution of the system?

$$
3 x+2 y=41
$$

$$
5 x-3 y=24
$$

$$
\text { Multiply by } 2 .
$$

$$
\begin{aligned}
3 x+2 y & =41 \\
5 x-3 y & =24 \\
9 x+6 y & =123 \\
10 x-6 y & =48 \\
\hline 19 x+0 & =171 \\
x & =9
\end{aligned}
$$

Add.

$$
\begin{aligned}
3 x+2 y & =41 & & \text { Write the first equation. } \\
3(9)+2 y & =41 & & \text { Substitute } 9 \text { for } x . \\
y & =7 & & \text { Solve for } y .
\end{aligned}
$$

The solution is $(9,7)$.

## Exercises

Solve each system using elimination. Tell whether the system has one solution, infinitely many solutions, or no solution.
19. $x+2 y=23$
$5 x+10 y=55$
21. $5 x+4 y=-83$
$3 x-3 y=-12$
23. $4 x+y=21$
$-2 x+6 y=9$
20. $7 x+y=6$
$5 x+3 y=34$
22. $9 x+\frac{1}{2} y=51$
$7 x+\frac{1}{3} y=39$
25. It takes a florist 3 h 15 min to make 3 small centerpieces and 3 large centerpieces. It takes 6 h 20 min to make 4 small centerpieces and 7 large centerpieces. How long does it take to make each small centerpiece and each large centerpiece? Write and solve a system of equations to find your answer.

## 4-5 and 4-6 Linear Inequalities and Systems of Linear Inequalities

## Quick Review

A linear inequality describes a region of the coordinate plane with a boundary line. Two or more inequalities form a system of linear inequalities. The system's solutions lie where the graphs of the inequalities overlap.

## Example

What is the graph of the system? $y>2 x-4$

$$
y \leq-x+2
$$



Graph the boundary lines $y=2 x-4$ and $y=-x+2$. For $y>2 x-4$, use a dashed boundary line and shade above it. For $y \leq-x+2$, use a solid boundary line and shade below. The green region of overlap contains the system's solutions.

## Exercises

Solve each system of inequalities by graphing.
26. $y \geq x+4$
$y<2 x-1$
27. $4 y<-3 x$
$y<-\frac{3}{4} x$
28. $2 x-y>0$
$3 x+2 y \leq-14$
29. $x+0.5 y \geq 5.5$
$0.5 x+y<6.5$
30. $y<10 x$
$y>x-5$
31. You have 60 megabytes (MB) of space left on your portable media player. You can choose to download song files that use 3.5 MB or video files that use 8 MB . You want to download at least 12 files. What is a graph showing the numbers of song and video files you can download?

## Topic 4 TEKS Cumulative Practice

## Multiple Choice

## Read each question. Then write the letter of the correct answer on your paper.

1. A group of students are going on a field trip. If the group takes 3 vans and 1 car, 22 students can be transported. If the group takes 2 vans and 4 cars, 28 students can be transported. How many students can fit in each van?
A. 2
B. 4
C. 6
D. 10
2. Greg's school paid $\$ 1012.50$ for 135 homecoming T-shirts. How much would it cost the school to purchase 235 T-shirts?
F. $\$ 750.00$
H. \$2025.00
G. $\$ 1762.50$
J. $\$ 2775.00$
3. What is the solution of $12(x+1)=36$ ?
A. 12
B. 8
C. 2
D. -2
4. Which equation describes a line with slope 12 and $y$-intercept 4 ?
F. $y=12 x+4$
G. $y=12(x+4)$
H. $y=4 x+12$
J. $y=x+3$
5. What is the solution of the system of equations shown below?
A. $(1,-1)$
B. $(-1,1)$
C. $(-1,-1)$
D. $(1,1)$

6. The width of Ben's rectangular family room is 3 ft less than the length. The perimeter is 70 ft . Which equation can be used to find the length $\ell$ of the room?
F. $70=\ell-3$
G. $70=2 \ell-3$
H. $70=2(\ell-3)$
J. $2 \ell+2(\ell-3)$
7. Marisa's Flower Shop charges $\$ 3$ per rose plus $\$ 16$ for a delivery. Chris wants to have a bouquet of roses delivered to his mother. Which value is in the range of the function that gives the bouquet's cost in terms of the number of roses?
A. $\$ 16$
B. $\$ 27$
C. $\$ 34$
D. $\$ 48$
8. Which number is a solution of $8>3 x-1$ ?
F. 0
G. 3
H. 4
J. 6
9. The formula for the area $A$ of a trapezoid is $A=\frac{1}{2}\left(b_{1}+b_{2}\right) h$, where $b_{1}$ and $b_{2}$ represent the lengths of the bases and $h$ represents the height. Which equation can be used to find the height of a trapezoid?
A. $h=2 A-b_{1}-b_{2}$
B. $h=\frac{2 A}{b_{1}+b_{2}}$
C. $h=\frac{A\left(b_{1}+b_{2}\right)}{2}$
D. $h=\frac{A-2}{b_{1}+b_{2}}$
10. Martin used 400 ft of fencing to enclose a rectangular area in his backyard. Isabella wants to enclose a similar area that is twice as long and twice as wide as the one in Martin's backyard. How much fencing does Isabella need?
F. 800 ft
G. 1200 ft
H. 1600 ft
J. 2000 ft
11. At the Conic Company, a new employee's earnings $E$, in dollars, can be calculated using the function $E=0.05 s+30,000$, where $s$ represents the employee's total sales, in dollars. All of the new employees earned between $\$ 50,000$ and $\$ 60,000$ last year. Which value is in the domain of the function?
A. $\$ 34,000$
B. $\$ 300,000$
C. $\$ 430,000$
D. $\$ 3,400,000$

## Gridded Response

## Record your answer in a grid.

12. Rhonda has 25 coins in her pocket. All of the coins are either dimes or nickels. If Rhonda has a total of \$2.30, how many dimes does she have?
13. What is the value of $x$ in the proportion?
$\frac{2}{5}=\frac{x}{21-x}$
14. An artist is adding a frame to a rectangular painting that is 12 in . wide and 19 in . long. The frame is 3 in . wide on each side. To the nearest square inch, what is the area of the painting including the frame?
15. What is the solution of $4(-3 x+6)-1=-13$ ?
16. In a regular polygon, all sides have the same length. Suppose a regular hexagon has a perimeter of 25.2 in . What is the length of each side in inches?
17. The sum of four consecutive integers is 250 . What is the greatest of these integers?
18. What is the slope of a line that is perpendicular to the line with equation $y=-5 x+8$ ?
19. On a map, Julia's home is 8.5 in . from the library. If the map scale is 1 in . : 0.25 mi , how many miles from the library does Julia live?
20. Sam is ordering pizza. Tony's Pizza charges $\$ 7$ for a large cheese pizza plus $\$ .75$ for each additional topping. Maria's Pizza charges $\$ 8$ for a large cheese pizza plus $\$ .50$ for each additional topping. For what number of toppings will the cost of a large pizza be the same at either restaurant?
21. The graph shows Jillian's distance from her house as she walks home from school. How many blocks per minute does Jillian walk?


## Constructed Response

22. The graph below is the solution of a linear system. How many solutions does the system have?

23. Write a system of inequalities for the graph below.

24. The volume $V$ of a cube is given by the formula $V=s^{3}$, where $s$ represents the length of an edge of the cube. Suppose the edge length is 24 in . What is the volume of the cube in cubic feet? Show your work.
25. You plan to mail surveys to different households. A box of 50 envelopes costs $\$ 3.50$, and a postage stamp costs $\$ .46$. How much will it cost you to mail 400 surveys?

## Additional Practice

## Topic 1

## Lessons 1-1 and 1-2

Solve each equation. Check your answer using a calculator if necessary.

1. $8 j-5+j=67$
2. $\frac{7}{12} x=\frac{3}{14}+\frac{1}{2} x$
3. $-n+8.4 n+1.2=23.4$

Solve each equation using the Distributive Property.
4. $6(t+5)=-36$
5. $\frac{1}{2}(s+5)=7.5$
6. $-3.5(5.1-z)=18.9$

Define a variable and write an equation for each situation. Then solve.
7. Your test scores for the semester are 87,84 , and 85 out of 100. Can you raise your test average to 90 with your next test?
8. You spend $\frac{1}{2}$ of your allowance each week on school lunches. Each lunch costs $\$ 1.25$. How much is your weekly allowance?

If the equation is an identity, write identity. If it has no solution, write no solution. Otherwise, solve the equation.
9. $4 h+5=9 h$
10. $2(3 x-6)=3(2 x-4)$
11. $-b+4 b=8 b-b$
12. $6 p+1=3(2 p+1)$
13. $3(g-1)+7=3 g+4$
14. $17-20 q=(-13-5 q) 4$

Write an equation to model the situation. Then solve.
15. A shopper's discount club charges a monthly fee of $\$ 15$ and sells gasoline for $\$ 3.55$ per gallon. The gas station across the street sells gasoline for $\$ 3.85$ per gallon and charges no fee. How many gallons of gasoline would you have to buy in one month to spend the same amount at either store?

## Lesson 1-3

## Solve each equation for $\boldsymbol{y}$. Then find the value of $\boldsymbol{y}$ for each value of $\boldsymbol{x}$.

16. $y+3 x=8 ; x=-2,0,2$
17. $4 x-2 y=15 ; x=2,4,6$

## Solve each equation for $\boldsymbol{x}$.

18. $p x+q x=r$
19. $c=b-b x$
20. $\frac{x-3}{y}=x$

Solve each problem. Round to the nearest tenth, if necessary. Use $\mathbf{3 . 1 4}$ for $\boldsymbol{\pi}$.
21. What is the radius of a circle with a circumference of 15 cm ?
22. What is the height of a triangle that has a base of 8 in . and an area of $28 \mathrm{in} .^{2}$ ?
23. How long does it take to travel 150 miles at a rate of $60 \mathrm{mi} / \mathrm{h}$ ?

## Lesson 1-4

## Solve each proportion.

24. $\frac{3}{4}=\frac{-6}{m}$
25. $\frac{t}{7}=\frac{3}{21}$
26. $\frac{9}{j}=\frac{3}{16}$
27. $\frac{2}{5}=\frac{w}{6.5}$
28. $\frac{9}{4.3}=\frac{6.3}{x}$
29. $\frac{2.3}{z}=\frac{1.8}{4.5}$
30. $\frac{p+1}{p-4}=\frac{1}{6}$
31. $\frac{q+2}{8}=\frac{5 q}{16}$

## Lesson 1-4 continued

32. Rajiv is cooking rice. He knows that for 1 cup of rice, he needs 1.5 cups of water. How much water will he need for 5 cups of rice?

## Lesson 1-5

## The figures in each pair are similar. Find the missing length.


34.

35. The scale on a map is 1 in : 15 mi . The distance between two cities is 25 mi . Find the distance in inches between the cities on the map.
36. A $40: 1$ scale model of an airplane is being used to conduct wind-tunnel tests. If the model is 4.5 feet long, how long is the actual airplane?

## Lesson 1-6

Solve each inequality. Graph and check your solution.
37. $-8 w<24$
38. $\frac{3 c}{5}-5 \geq 1$
39. $-8 \ell+3.7 \leq 31.7$
40. $8 r-\frac{1}{6}>\frac{r}{6}-8$
41. $1.4+2.1 x<0.7 x$
42. $-3(2 t-1)+5 t>7$

## Write and solve an inequality for each situation.

43. Janet has a balance of $\$ 125$ on a credit card. On her next statement, she wants to reduce her balance to no more than $\$ 60$. How much does she need to pay off?
44. You are reading a book with 19 chapters. How many chapters should you read each week if you want to finish the book in 5 weeks or less?
45. Kim raises chickens, and sells the eggs to a local market. She sells the eggs by the dozen and makes a profit of $\$ 0.20$ per egg. If she wants to build a new chicken coop that costs $\$ 35$, how many dozen eggs will she need to sell?

## Lesson 1-7

Write a compound inequality that represents each phrase. Graph your solution.
46. all real numbers that are less than or equal to -3 or greater than -1
47. a parking space that is at least 8 ft and no more than 11 ft

Solve each compound inequality. Graph your solution.
48. $8<w+3<10$
49. $-6<t-1<6$
50. $6 m-15 \leq 9$ or $10 m>84$
51. $9 j-5 j \geq 20$

## Topic 2

## Lesson 2-1

Match each graph with its related table. Explain your answers.
1.

2.

3.

A.

| Time (s) | Height (m) |
| :---: | :---: |
| 1 | 5 |
| 2 | 10 |
| 3 | 15 |
| 4 | 20 |

B.

| Time $(\mathrm{s})$ | Height $(\mathrm{m})$ |
| :---: | :---: |
| 1 | 2 |
| 2 | 3 |
| 3 | 5 |
| 4 | 9 |

C.

| Time (s) | Height (m) |
| :---: | :---: |
| 1 | 4 |
| 2 | 3 |
| 3 | 5 |
| 4 | 7 |

## Sketch a graph to describe each situation. Label each section of the graph.

4. the number of apples on a tree over one year
5. the amount of milk in your bowl as you eat cereal
6. the energy you use in a 24 -h period
7. your distance from home plate after your home run

## Lesson 2-2

8. For the diagram below, find the relationship between the number of shapes and the perimeter of the figure they form. Represent this relationship using a table, words, an equation, and a graph.


1 trapezoid


For each table, determine whether the relationship is a function. Then represent the relationship using words, an equation, and a graph.
9.

| Hours <br> Raining | Total Rainfall <br> (in.) |
| :---: | :---: |
| 0 | 0 |
| 1 | 1.3 |
| 2 | 2.6 |
| 3 | 3.9 |

10. 

| Paint in Can |  |
| :---: | :---: |
| Area Painted <br> $\left(\mathrm{ft}^{2}\right)$ | Gallons of <br> Paint |
| 0 | 4.5 |
| 100 | 4.2 |
| 200 | 3.9 |
| 300 | 3.6 |

11. 

| Gallons of Milk | Total Bill |
| :---: | :---: |
| 0 | $\$ 35.27$ |
| 1 | $\$ 38.56$ |
| 2 | $\$ 41.85$ |
| 3 | $\$ 45.14$ |

## Lesson 2-3

Graph the function shown by each table. Tell whether the function is linear or nonlinear.
12.

| $x$ | $y$ |
| :---: | :---: |
| 0 | -2 |
| 1 | 1 |
| 2 | 4 |
| 3 | 7 |

13. 


14.

| $x$ | $y$ |
| :---: | ---: |
| 0 | 0 |
| 1 | -1 |
| 2 | 3 |
| 3 | 5 |

Each set of ordered pairs represents a function. Write a rule that represents the function.
15. $\left(1, \frac{1}{2}\right),\left(2, \frac{1}{4}\right),\left(3, \frac{1}{8}\right),\left(4, \frac{1}{16}\right),\left(5, \frac{1}{32}\right)$
16. $(0,0),(1,-3),(2,-12),(3,-27),(4,-48)$

## Lesson 2-4

Graph each function.
17. $y=2 x+1$
18. $y=4-x$
19. $y=|x|-2$
20. $y=x^{2}-3$

## Lesson 2-5

Write a function rule that represents each sentence. Then find the value of $\boldsymbol{y}$ for the given value of $\boldsymbol{x}$.
21. $y$ is 4 more than the product of 7 and $x ; x=3$
22. $y$ is 11 less than $\frac{1}{3}$ of $x$; $x=72$
23. 6.5 more than the quotient of $x$ and 4 is $y ; x=7$

## Lesson 2-6

## Determine whether each relation is a function.

24. $\{(1,2),(2,3),(3,4),(4,5),(5,6)\}$
25. 


25. $\{(5,2),(1,3),(4,7),(5,6),(0,4)\}$
27.


## Lesson 2-7

Find the range of each function when the domain is $\{-4,-1,0,3\}$.
28. $y=6 x-5$
29. $y=|x|-2$
30. $y=-x^{2}-x$

Find a reasonable domain and range for the function. Then graph the function.
31. A fruit punch recipe calls for 5 ounces of pineapple juice in every quart of punch. The function $p(q)=5 q$ represents the amount of pineapple juice $p(q)$, in ounces, needed to make $q$ quarts of fruit punch. You have a large punch bowl that can hold 8 quarts.

## Topic 3

## Lesson 3-1

Find the slope of each line.
1.

2.

3.


Find the rate of change for each situation.
4. The cost of four movie tickets is $\$ 30$ and the cost of seven tickets is $\$ 52.50$.
5. Five seconds after jumping out of the plane, a skydiver is $10,000 \mathrm{ft}$ above the ground. After 30 seconds, the skydiver is 3750 ft above the ground.
6. Find the slope of the line that includes the points $(1,4)$ and $(-3,-2)$.

## Lesson 3-2

Tell whether each equation is a direct variation. If it is, find the constant of variation.
7. $y=2 x-2$
8. $4 y=x$
9. $\frac{y}{x}=3$
10. $x y=5$

Graph the direct variation that includes the given point. Write the equation of the line.
11. $(5,4)$
12. $(7,7)$
13. $(-3,-10)$
14. $(4,-8)$

Write a direct variation to model each situation. Then answer the question.
15. After 30 minutes, a car moving at a constant speed has traveled 25 miles.

Moving at the same speed, how far will it travel in 140 minutes?
16. What is the perimeter of a square with side length 13.4 inches?

## Lesson 3-3

Find the slope and $\boldsymbol{y}$-intercept.
17. $y=6 x+8$
18. $3 x+4 y=-24$
19. $2 y=8$
20. $y=-\frac{3}{4} x-8$

A line passes through the given points. Write an equation for the line in slope-intercept form.
21. $(-2,4)$ and $(3,9)$
22. $(1,6)$ and $(9,-4)$
23. $(0,-7)$ and ( $-1,0$ )
24. $(7,0)$ and $(3,-4)$

Graph each equation.
25. $y=2 x-3$
26. $y=\frac{2}{3} x-4$
27. $2 y=3 x-1$
28. $4 y+1=5$
29. An airplane with no fuel weighs 2575 lbs. Each gallon of gasoline added to the fuel tanks weighs 6 lbs . Write an equation in slope-intercept form for this situation.

## Lessons 3-4 and 3-5

## Write an equation in point-slope form for the line through the given point with the given slope.

30. $(4,6) ; m=-5$
31. $(3,-1) ; m=1$
32. $(8,5) ; m=\frac{1}{2}$

Find the $\boldsymbol{x}$ - and $\boldsymbol{y}$-intercepts for each equation.
33. $y=-7 x$
34. $y=\frac{1}{2} x+3$
35. $-2 y=5 x-12$

Graph each equation.
36. $y-5=-2(x+1)$
37. $x+3=0$
38. $y+1=-\frac{1}{2}(x+2)$

## Lesson 3-6

## Write an equation in standard form that satisfies the given conditions.

39. parallel to $y=4 x+1$, through $(-3,5)$
40. perpendicular to $y=-x-3$, through $(0,0)$
41. perpendicular to $3 x+4 y=12$, through $(7,1)$
42. through $(4,44)$ and parallel to the $y$-axis

## Lesson 3-7

Determine the effects on the graph of the parent function $f(x)$ for each $\boldsymbol{g}(\boldsymbol{x})$ function. Graph both functions on the same coordinate grid.
43. $f(x)=2 x, g(x)=f(x)-2$
44. $f(x)=-x+1, g(x)=f(x-1)$
45. $f(x)=x+3, g(x)=-f(x)$

Graph both functions on the same coordinate grid.
46. $f(x)=-x, g(x)=f(-x)$
47. $f(x)=\frac{1}{2} x, g(x)=4[f(x)]$
48. $f(x)=x-1, g(x)=-2[f(3 x)]$

## Lesson 3-8

49. a. Graph the (ages, grades) data of some students in a school.
$(10,6),(16,10),(15,10),(18,12),(17,11)$
$(17,12),(19,12),(16,11),(11,7),(15,9),(13,8)$
b. Draw a trend line.
c. Find the equation of the line of best fit.
50. Use a calculator to find a line of best fit for the data in the chart. Find the value of the correlation coefficient $r$. Let $x=0$ correspond to 1960 .

| Total U.S. Vehicle Production (millions) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| 1960 | 1970 | 1980 | 1990 | 2000 |
| 7.9 | 8.8 | 8.0 | 9.8 | 12.8 |

## Topic 4

## Lesson 4-1

## Solve each system by graphing.

1. $x-y=7$
$3 x+2 y=6$
2. $y=2 x+3$
$y=-\frac{3}{2} x-4$
3. $y=-2 x+6$
$3 x+4 y=24$

## Write and solve a system of equations by graphing.

4. One calling card has a $\$ .50$ connection fee and charges $\$ .02$ per minute. Another card has a $\$ .25$ connection fee and charges $\$ .03$ per minute. At how many minutes would a call cost the same amount using either card?
5. Suppose that you have $\$ 75$ in your savings account and you save an additional $\$ 5$ per week. Your friend has $\$ 30$ in his savings account and saves an additional $\$ 10$ per week. In how many weeks will you both have the same amount of money in your accounts?

## Lesson 4-2

## Solve each system by using substitution.

6. $x-y=13$
$y-x=-13$
7. $3 x-y=4$
$x+5 y=-4$
8. $x+y=4$
$y=7 x+4$

## Write and solve a system of equations by substitution.

9. A farmer grows corn and soybeans on her 300 -acre farm. She wants to plant 110 more acres of soybeans than corn. How many acres of each crop does she need to plant?
10. The perimeter of a rectangle is 34 cm . The length is 1 cm longer than the width. What are the dimensions of the rectangle?

## Lesson 4-3

## Solve each system by elimination.

11. $x+y=19$
$x-y=-7$
12. $-3 x+4 y=29$
$3 x+2 y=-17$
13. $6 x+y=13$
$y-x=-8$
14. $4 x-9 y=61$
$10 x+3 y=25$
15. $3 x+y=3$
$-3 x+2 y=-30$
16. $4 x-y=105$
$x+7 y=-10$

## Write and solve a system of equations using elimination.

17. Two groups of people order food at a restaurant. One group orders 4 hamburgers and 7 chicken sandwiches for $\$ 34.50$. The other group orders 8 hamburgers and 3 chicken sandwiches for $\$ 30.50$. Find the cost of each item.
18. The sum of two numbers is 25 . Their difference is 9 . What are the two numbers?

## Lesson 4-4

## Write a system of equations to model each problem and solve.

19. Suppose you have 12 coins that total 32 cents. Some of the coins are nickels and the rest are pennies. How many of each coin do you have?
20. Claire bought three bars of soap and five sponges for $\$ 2.31$. Steve bought five bars of soap and three sponges for $\$ 3.05$. Find the cost of each item.
21. A chemist wants to make a $10 \%$ solution of fertilizer. How much of a $5 \%$ solution and how much of a $30 \%$ solution should the chemist mix to get 30 L of a $10 \%$ solution?

## Write and solve a system of equations for each situation by any method.

22. The ratio of boys to girls at a college is $4: 5$. How many boys and girls are there if the total number of students is 3321 ?
23. A boat travels 18 miles downstream in 1.5 hours. It then takes the boat 3 hours to travel upstream the same distance. Find the speed of the boat in still water and the speed of the current.

## Lesson 4-5

## Determine whether the ordered pair is a solution of the linear inequality.

24. $y>x-7$; $(2,5)$
25. $x \leq 3 ;(-2,6)$
26. $y \geq 4 x+3 ;(3,9)$

## Graph each linear inequality.

27. $y<x$
28. $2 x+3 y \leq 6$
29. $y>-6 x+5$

## Write and graph a linear inequality for each situation.

30. Suppose you can spend up to $\$ 10$ on bananas and apples. Apples cost $\$ 3$ per pound and bananas cost $\$ 1$ per pound. List three possible combinations of apples and bananas you can buy.
31. Trenton is going to make a rectangular garden in his yard. He wants the perimeter to be no larger than 40 ft . What are three possible sets of dimensions that the garden can have?

## Lesson 4-6

## Solve each system by graphing.

32. $\begin{aligned} y & \leq 5 x+1 \\ y & >x-3\end{aligned}$

$$
\text { 33. } \begin{aligned}
y & >4 x+3 \\
y & \geq-2 x-1
\end{aligned}
$$

34. $y \leq 5$
$y \geq-x+1$
35. Hideo plans to spend no more than $\$ 60$ at an entertainment store on DVDs and CDs. DVDs cost $\$ 17$ each and CDs cost $\$ 14$ each. He wants to buy at least two items. Write and graph a system of linear inequalities that describes the situation. What are three possible combinations of CDs and DVDs that he can buy?
