Extensions of Linear Concepts

Unit Overview
In this unit, you will extend your study of linear concepts to the study of piecewise-defined functions and systems of linear equations and inequalities. You will learn to solve systems of equations and inequalities in a variety of ways.

Key Terms
As you study this unit, add these and other terms to your math notebook. Include in your notes your prior knowledge of each word, as well as your experiences in using the word in different mathematical examples. If needed, ask for help in pronouncing new words and add information on pronunciation to your math notebook. It is important that you learn new terms and use them correctly in your class discussions and in your problem solutions.

Math Terms
• piecewise-defined function
• linear inequality
• solutions of a linear inequality
• boundary line
• half-plane
• closed half-plane
• open half-plane
• system of linear equations
• substitution method
• elimination method
• parallel
• coincident
• slope-intercept form
• independent
• dependent
• inconsistent
• consistent
• system of linear inequalities
• solution region

ESSENTIAL QUESTIONS
Why would you use multiple representations of linear equations and inequalities?
How are systems of linear equations and systems of linear inequalities useful in analyzing real-world situations?

EMBEDDED ASSESSMENTS
These assessments, following Activities 16 and 18, will give you an opportunity to demonstrate what you have learned about piecewise-defined functions, inequalities, and systems of equations and inequalities.

Embedded Assessment 1:
Graphing Inequalities and Piecewise-Defined Functions  p. 249

Embedded Assessment 2:
Systems of Equations and Inequalities  p. 283
1. Which of the following tables of values represents linear data?

A. 
\[
\begin{array}{|c|c|}
\hline
x & y \\
\hline
2 & 3 \\
4 & 6 \\
6 & 6 \\
8 & 3 \\
\hline
\end{array}
\]

B. 
\[
\begin{array}{|c|c|}
\hline
x & y \\
\hline
1 & 1 \\
2 & 4 \\
3 & 7 \\
4 & 10 \\
\hline
\end{array}
\]

C. 
\[
\begin{array}{|c|c|}
\hline
x & y \\
\hline
2 & 3 \\
3 & 4 \\
4 & 3 \\
6 & 4 \\
\hline
\end{array}
\]

D. 
\[
\begin{array}{|c|c|}
\hline
x & y \\
\hline
1 & 3 \\
2 & 6 \\
3 & 12 \\
4 & 24 \\
\hline
\end{array}
\]

2. Give an algebraic representation of these data.

\[
\begin{array}{|c|c|c|c|c|}
\hline
x & 1 & 4 & 7 & 10 \\
\hline
y & 1 & 7 & 13 & 19 \\
\hline
\end{array}
\]

3. You open a savings account with a deposit of $100. In each month after your initial deposit, you add $25 to your account. Provide a table to display the total amount of money in the account after 1, 2, 3, and 4 months. Give a graphical and an algebraic representation that would allow you to determine the amount of money A in dollars you have deposited after \(m\) months.

4. Graph \(2x + 3y = 4\).

5. Describe the graph of \(y = 3\).

6. Which ordered pair is a solution of \(y > x + 5\)?
   A. \((2, 8)\)  
   B. \((-5, 0)\)  
   C. \((1, 6)\)  
   D. \((0, -5)\)

7. Compare and contrast the graphs of these two compound statements:
   \(-1 < x \leq 3\)
   \(x < -1\) or \(x \geq 3\)

8. Which of the following represents a function with a constant rate of change?

A. 
\[
\begin{array}{|c|c|c|c|c|c|}
\hline
x & -10 & -8 & -6 & -4 & -2 \\
\hline
y & -10 & -8 & -6 & -4 & -2 \\
\hline
\end{array}
\]

B. 
\[
\begin{array}{|c|c|c|c|c|}
\hline
x & 1 & 2 & 3 & 4 \\
\hline
y & 10 & 20 & 30 & 40 \\
\hline
\end{array}
\]

C. \(y = \frac{4}{x}\)

D. 
\[
\begin{array}{|c|c|c|c|}
\hline
x & 1 & 4 & 16 \\
\hline
y & 5 & 10 & 20 \\
\hline
\end{array}
\]
Miriam has accepted a job at a veterinarian’s office. Her first assignment is to feed the dogs that are housed there. The bag of dog food was already torn open, and she found only part of the label that described the amount of dog food to feed each dog.

Barko Dog Food Feeding Chart

<table>
<thead>
<tr>
<th>Weight of Dog (pounds)</th>
<th>Daily Amount of Barko (ounces)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Each dog has an information card that gives the dog’s name and weight. Using this information, Miriam fed each dog the amount of food she thought was appropriate.

1. How many ounces of dog food per day do you think Miriam gave each dog? Complete the table below.

<table>
<thead>
<tr>
<th>Dog</th>
<th>Dog’s Weight (pounds)</th>
<th>Amount of Dog Food (ounces)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muffy</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Trixie</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Rags</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Hercules</td>
<td>68</td>
<td></td>
</tr>
</tbody>
</table>

2. a. Based on the dog’s weight and the partial label at the top of the page, write a verbal rule that Miriam could use to determine the ounces of dog food per day to feed each dog.

b. **Reason abstractly**: Could this verbal rule be represented with function notation? Why or why not?
3. **Model with mathematics.** Let \( w \) be a dog’s weight in pounds and let \( A(w) \) be the amount of food in ounces that the dog should be fed each day. Use the table in Item 1 and function notation to write a function that expresses \( A(w) \) in terms of \( w \).

After several hours, all of the dogs had finished their food except for Hercules. The vet asked, “How much food did you give Hercules?”

After hearing Miriam’s answer, the vet told Miriam that she had overfed Hercules and suggested that Miriam check the complete feeding chart posted on the office wall.

<table>
<thead>
<tr>
<th>Barko Dog Food Feeding Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of Dog (pounds)</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>over 100 pounds</td>
</tr>
</tbody>
</table>

4. Miriam had assumed that each dog should be fed as many ounces of dog food as the dog weighed in pounds. Explain why the data in the new chart indicate that her original assumption was not correct.

Adult dogs that weigh less than 20 pounds are classified as *small* dogs. Dogs that weigh 20 to 100 pounds are classified as *mid-size* dogs. Finally, dogs that weigh more than 100 pounds are classified as *large* dogs. Miriam had not known that the formulas for feeding small, mid-size, and large dogs are all different.
Lesson 14-1
Function Notation and Rate of Change

5. The vet tells Miriam that the data for feeding mid-size dogs are linear. Verify the vet’s statement using the feeding chart.

6. Determine a rate of change that describes the number of additional ounces of food a mid-size dog should be fed for each pound of weight greater than 20. Explain how you found your answer.

7. Using the rate of change you found in Item 6 and the feeding chart, use function notation to write a function that expresses $A(w)$, the ounces of dog food, in terms of $w$, the dog’s weight in pounds, for mid-size dogs.

8. How many ounces was Hercules overfed? Justify your response.

Check Your Understanding
Use the table for Items 9 and 10.

<table>
<thead>
<tr>
<th>Grapes (pounds)</th>
<th>Cost (dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>$1.20</td>
</tr>
<tr>
<td>1.5</td>
<td>$3.60</td>
</tr>
<tr>
<td>2.0</td>
<td>$4.80</td>
</tr>
</tbody>
</table>

9. Determine the rate of change of the data. Express the rate as cost per pound.

10. Do the data in the table represent a linear relationship? Explain.

11. Tom has read the first 40 pages of a book. He plans to read another 12 pages each day. Use function notation to write a function that expresses the number of pages read $p$ after $d$ days.
LESSON 14-1 PRACTICE

12. Todd had five gallons of gasoline in his motorbike. After driving 100 miles, he has three gallons left. What is Todd's rate of change in miles per gallon?

13. This table shows how the balance in John's savings account has changed over the course of a year.

<table>
<thead>
<tr>
<th>Month</th>
<th>Balance (dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$400</td>
</tr>
<tr>
<td>3</td>
<td>$600</td>
</tr>
<tr>
<td>7</td>
<td>$1000</td>
</tr>
<tr>
<td>10</td>
<td>$1300</td>
</tr>
<tr>
<td>12</td>
<td>$1500</td>
</tr>
</tbody>
</table>

How much did John save per month during the year?

14. Linda purchased a house for $144,000. Thinking of possibly refinancing after 11 years, she had her house appraised and found that it is now worth $245,000. Find the rate of change of the value of the house in dollars per year.

15. **Make sense of problems.** The cost in dollars of producing \( x \) vehicles for a company is given by \( C(x) = 1200x + 5500 \). Interpret the rate of change of this linear function.

16. A 500-liter tank full of oil is being drained at the constant rate of 20 liters per minute. Use function notation to write a linear function expressing the number of liters in the tank \( V \) after \( t \) minutes.
Lesson 14-2
Writing Functions and Finding Domain and Range

Learning Targets:
- Write linear equations in two variables given a table of values, a graph, or a verbal description.
- Determine the domain and range of a linear function, determine their reasonableness, and represent them using inequalities.

SUGGESTED LEARNING STRATEGIES: Identify a Subtask, Think-Pair-Share, Create Representations, Construct an Argument, Interactive Word Wall

1. Rewrite the function that you wrote in Item 7 in Lesson 14-1.

2. **a.** Remember that this function is true only for mid-size dogs. Describe the appropriate input values for the function.

   **b.** Use your description of the appropriate input values to express the domain of the function using set notation.
   
   \[
   \text{domain} = \{ w: \ \text{______________} \} 
   \]

   Miriam knows that she also has several large dogs to feed. When she looks at the chart, she reads the instruction “60 ounces plus 1 ounce for each additional 10 pounds of weight.”

3. How much additional dog food should large dogs be fed for each pound of weight greater than 100 pounds?

4. **Critique the reasoning of others.** A 140-pound Great Dane has arrived for a short stay at the kennel. Miriam says that the dog should be fed 64 ounces of food per day. Her friend Chase says that the dog requires 100 ounces of food per day. Who is correct? Justify your response.
5. Write a function that expresses the amount of food, \( A(w) \), in ounces that a large dog should be fed, as a function of \( w \), the weight of the dog in pounds. Determine the domain and range of the function.

Miriam realizes that there are three different algebraic feeding rules to follow because dogs are different sizes. She organizes her feeding rules in a list so that she can quickly refer to them whenever she has to decide how much food to feed a dog.

6. Complete Miriam’s list by writing the appropriate function. Indicate the domain by writing the appropriate inequality symbols.

\[
A(w) = \underline{\hspace{2cm}}, \text{ when } 0 \underline{\hspace{2cm}} w \underline{\hspace{2cm}} 20
\]

\[
A(w) = \underline{\hspace{2cm}}, \text{ when } 20 \underline{\hspace{2cm}} w \underline{\hspace{2cm}} 100
\]

\[
A(w) = \underline{\hspace{2cm}}, \text{ when } w \underline{\hspace{2cm}} 100
\]

7. The vet has a German Shepherd named Max, and Miriam knows that the vet feeds Max 63 ounces of food each day. Miriam also knows that the vet feeds her cocker spaniel Min 32 ounces of food each day. If the two dogs are being correctly fed, what is each dog’s weight? Explain your reasoning.
8. Complete the table using the rules you wrote in Item 6.

<table>
<thead>
<tr>
<th>Weight of Dog (pounds)</th>
<th>Amount of Dog Food (ounces)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td></td>
</tr>
<tr>
<td>107</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

The functions in Item 6 can be written as **piecewise-defined functions**. Every possible weight \( w \) has exactly one feeding amount \( A \) assigned to it, but the rule for determining that feeding amount changes for dogs of different sizes. The different feeding rules, along with their domains, are considered to be the pieces of a single piecewise-defined function.

9. Miriam decides to write a piecewise-defined function to represent the functions she wrote in Item 6.
   a. Explain how you know that each equation in Item 6 represents a function.

   b. Complete the piecewise-defined function for the feeding rules.

   \[
   A(w) = \begin{cases} 
   \text{w, } & \text{when } 20 \leq w \leq 100 \\
   \text{0.1w + 50, when } & \text{ } \\
   \end{cases}
   \]

   c. Explain why the equation from part b is also a function. Use the domain of each rule to help justify your answer.
A wholesale grocery store has the following sale on mixed nuts:

**SALE!**
Mixed nuts
Less than 4 lbs: $2/lb
4–10 lbs: $6 + $0.50/lb

10. Write a function to represent the cost $C(x)$ of buying less than four pounds of mixed nuts. Identify the domain and range.

11. Write a function to represent the cost $C(x)$ of buying 4 to 10 pounds of mixed nuts. Identify the domain and range.

12. Make a table to show the cost of 4, 5, and 8 pounds of mixed nuts.

13. Use your answers to Items 10 and 11 to write a piecewise-defined function to represent the cost $C(x)$ of $x$ pounds of mixed nuts.

**LESSON 14-2 PRACTICE**

14. Speed Cell Wireless offers a plan of $40 for the first 400 minutes, and an additional $0.50 for every minute over 400. Let $t$ represent the total talk time in minutes. Write a piecewise-defined function to represent the cost $C(t)$.

15. If Pam works more than 40 hours per week, her hourly wage for every hour over 40 is 1.5 times her normal hourly wage of $7. Write a piecewise-defined function that gives Pam’s weekly pay $P(h)$ in terms of the number of hours $h$ that she works.

16. A man walks for 45 minutes at a rate of 3 mi/h, then jogs for 75 minutes at a rate of 5 mi/h, then rests for 30 minutes, and finally walks for 90 minutes at a rate of 3 mi/h. Write a piecewise-defined function expressing the distance $D(t)$ he traveled as a function of time $t$.

17. **Model with mathematics.** A state income tax law reads as follows:

<table>
<thead>
<tr>
<th>Annual Income (dollars)</th>
<th>Tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; $2000</td>
<td>$0 tax</td>
</tr>
<tr>
<td>$2000 – $6000</td>
<td>2% of income over $2000</td>
</tr>
<tr>
<td>&gt; $6000</td>
<td>$80 plus 5% of income over $6000</td>
</tr>
</tbody>
</table>

Write a piecewise-defined function to represent the income tax law.
Lesson 14-3
Evaluating Functions and Graphing Piecewise-Defined Linear Functions

Learning Targets:
- Evaluate a function at specific inputs within the function's domain.
- Graph piecewise-defined functions.

SUGGESTED LEARNING STRATEGIES: Identify a Subtask, Think-Pair-Share, Construct an Argument, Create Representations, Discussion Groups

1. Rewrite the piecewise-defined feeding function that you wrote in Item 9 in Lesson 14-2.

2. Miriam must feed a dog that weighs 57 pounds.
   a. Which piece of the feeding function should Miriam use? Explain your answer.
   b. Use your answer to part a to evaluate $A(57)$.

3. Make use of structure. When graphing a piecewise-defined function, it is necessary to graph each piece of the function only for its appropriate interval of the domain. Graph the feeding function on the axes below. When finished, your graph should consist of three line segments.

To graph a piecewise-defined function in your calculator, enter the function into $Y =$, in dot mode, using parentheses to indicate the domain intervals. For example $f(x) = \begin{cases} \frac{-x^2 - 1}{2}, & \text{when } x < 1 \\ x + 2, & \text{when } x \geq 1 \end{cases}$ would be entered as $Y_1 = (-x^2 - 1)(x < 1) + (x + 2)(x \geq 1)$.
Lesson 14-3
Evaluating Functions and Graphing Piecewise-Defined Linear Functions

4. Why is the graph of a piecewise-defined function more useful than three separate graphs?

5. How can you conclude that the graph represents a function?

Check Your Understanding
Use the piecewise-defined function for Items 6 and 7.

\[
f(x) = \begin{cases} 
  x + 1, & \text{when } -3 < x \leq 1 \\
  2x, & \text{when } 1 < x \leq 4 \\
  x - 1, & \text{when } 4 < x < 10
\end{cases}
\]

6. Find \(f(1)\) and \(f(4)\). Explain which piece of the function you used to find each value.
7. Sketch a graph of the function.

LESSON 14-3 PRACTICE
8. Model with mathematics. Graph the piecewise-defined function that you wrote in Item 15 in Lesson 14-2 to describe Pam’s pay.

For Items 9 and 10, graph each piecewise-defined function.

9. \(f(x) = \begin{cases} 
  2x, & \text{when } x > 0 \\
  x, & \text{when } x \leq 0
\end{cases}\)

10. \(f(x) = \begin{cases} 
  \frac{1}{2}x + \frac{3}{2}, & \text{when } x < 1 \\
  -x + 3, & \text{when } x \geq 1
\end{cases}\)

For Items 11 and 12, consider the piecewise-defined function

\[f(x) = \begin{cases} 
  \frac{1}{2}x - 10, & \text{when } x \leq 3 \\
  -x - 1, & \text{when } x > 3
\end{cases}\]

11. Find \(f(-4)\).
12. Find \(f(6)\).
Learning Target:
• Compare the properties of two functions each represented in a different way.

SUGGESTED LEARNING STRATEGIES: Think-Pair-Share, Discussion Groups, Construct an Argument, Create Representations

When Miriam looks at the graph of the feeding function, she notices that for small dogs, each increase of 1 pound in weight causes an increase of 1 ounce of food. She concludes that the rate of change of the feeding rule for small dogs is 1 ounce per pound.

1. Express regularity in repeated reasoning. What is the rate of change of the feeding rule for large dogs?

2. Miriam compares the rates of change of the feeding rules for each type of dog. She concludes that the feeding rule for small dogs has the greatest rate of change.
   a. How does the graph in Item 3 in Lesson 14-3 support Miriam’s conclusion?

   b. What parts of the algebraic feeding rules in Item 6 in Lesson 14-2 support Miriam’s conclusion?

3. Dogs in one size category have a greater rate of change in feeding than other dogs. Explain why you think this might be true.
The graph below shows how many ounces of water a dog should drink daily, based on the dog’s weight.

4. How much water should a 20-pound dog consume each day?

5. How much water should a 100-pound dog consume each day?

6. Compare the water function with the feeding function. Describe the similarities and differences.

7. Write a piecewise-defined function for the graph.
Lesson 14-4
Comparing Functions

Check Your Understanding

8. Write a piecewise-defined function for the graph, including the domain for each part.

Use the piecewise-defined function below for Items 9 and 10.

\[ f(x) = \begin{cases} 
  x - 1, & \text{when } 0 < x \leq 5 \\
  1.5x, & \text{when } 5 < x \leq 11 
\end{cases} \]

9. Compare the function with the function from Item 8. Describe the similarities and differences.

10. Is the value \( x = 5.5 \) in the domain of the function you wrote in Item 8? If so, what is the value of the function when \( x = 5.5 \)? Justify your response.
LESSON 14-4 PRACTICE

11. Write a piecewise-defined function for the graph shown.

12. **Reason abstractly.** Compare the function in Item 11 to the function

   \[ f(x) = \begin{cases} 
   2x + 1, & \text{when } x < 1 \\
   -x + 4, & \text{when } x \geq 1 
   \end{cases} \]

   Describe the similarities and differences.

13. Graph the function \( f(x) = \begin{cases} 
   2x + 8, & \text{when } x < -2 \\
   4, & \text{when } -2 \leq x < 2 \\
   -2x + 8, & \text{when } x \geq 2
   \end{cases} \). State the domain and range.

14. How does the function in Item 13 compare to the function shown in the graph below?
**ACTIVITY 14 PRACTICE**

Write your answers on notebook paper. Show your work.

**Lesson 14-1**

Use the tables for Items 1–5.

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>7</td>
<td>−6</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>8</td>
<td>−7</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>9</td>
<td>−8</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>10</td>
<td>−9</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>11</td>
<td>−10</td>
</tr>
</tbody>
</table>

1. Find the rate of change for each table.
2. At what x-value does the rate of change switch patterns?
3. Find a function that represents the first table of data, and write the domain for the function.
4. Find a function that represents the second table of data, and write the domain for the function.

**Lesson 14-2**

5. Write the piecewise-defined function that represents the data in the tables.
6. A store is having a special sale on designer soaps. For every three bars of soap purchased, one is given for free. The bars of soap cost $2 each, and there is a limit of eight bars of soap per customer (including free ones).
   a. Write a piecewise-defined function C(b) that gives the total cost C for b bars of soap.
   b. Write the domain for this function in terms of the context.
7. A museum has the following prices for admission:
   - Children under 12: free
   - Kids age 12–17: $3
   - Adults age 18–64: $8
   - Senior citizens 65 and over: $4
   Write a piecewise-defined function that gives the cost C(n) for a museum visitor who is n years old. What is the range of the function?

**Lesson 14-3**

8. A piecewise-defined function is shown.
   \[ h(x) = \begin{cases} 
   x + 3, & \text{when } x < 3 \\
   bx, & \text{when } x \geq 3 
   \end{cases} \]
   What value of b is needed so that \( h(3) = 6 \)?
   A. 1  
   B. 2  
   C. 3  
   D. 6
9. Sketch a graph of the function.
   \[ f(x) = \begin{cases} 
   x, & \text{when } x < 2 \\
   -x + 4, & \text{when } x \geq 2 
   \end{cases} \]
10. Ashley participated in a triathlon.
   - She swam for 10 minutes at a rate of 40 meters/min.
   - Then she biked for 40 minutes at a rate of 400 meters/min.
   - Finally, she ran for 25 minutes at a rate of 200 meters/min.
   a. Write a piecewise-defined function expressing the distance \( d(t) \) in meters that Ashley traveled as a function of time \( t \) in minutes.
   b. Graph your function from part a.

**Lesson 14-4**

11. Refer back to Item 10. Wanda competed in the same triathlon as Ashley. A graph of the distance that Wanda covered as a function of time is shown below.

   a. Tell who completed each leg of the triathlon (swimming, biking, and running) faster, Ashley or Wanda. Justify your answers.
   b. Who completed the triathlon first, Ashley or Wanda? Justify your answer.
Use the graph for Items 12–15.

12. What is the domain of the piecewise-defined function?
   A. $0 \leq x \leq 18$  
   B. $0 \leq x < 10$
   C. $4 \leq x \leq 10$  
   D. $x \neq 6$

13. What is the value of the function for $x = 6$?
   A. 5  
   B. 6
   C. 7
   D. 10

14. Which of the following defines the function for the domain $0 \leq x < 6$?
   A. $y = 0.5x$  
   B. $y = 0.5x + 4$
   C. $y = 2$
   D. $y = -x + 2$

15. What is the range of the piecewise-defined function?
   A. $0 \leq y \leq 18$  
   B. $0 \leq y \leq 10$
   C. $4 \leq y \leq 10$  
   D. $y = 7$

16. What are the domain and range of the function?
   A. $0 \leq x \leq 11, 0 \leq y \leq 17$
   B. $0 \leq x \leq 17, 0 \leq y \leq 11$
   C. $0 \leq x \leq 7, 0 \leq y \leq 4$
   D. $0 \leq x \leq 4, 0 \leq y \leq 7$

17. Which statement is true?
   A. After 7 minutes, Tanya’s average speed increased.
   B. After 7 minutes, Tanya’s average speed decreased.
   C. After 4 minutes, Tanya’s average speed increased.
   D. After 4 minutes, Tanya’s average speed decreased.

18. How far does Tanya live from her friend’s house?
   A. 4 miles  
   B. 7 miles
   C. 11 miles
   D. 17 miles

MATHEMATICAL PRACTICES
Attend to Precision

19. Explain why a restricted domain and a restricted range are sometimes appropriate for a piecewise-defined function. Describe instances when the domain and range need not be restricted.
Learning Targets:

- Write a linear equation given a graph or a table.
- Analyze key features of a function given its graph.

SUGGESTED LEARNING STRATEGIES: Summarizing, Visualization, Look for a Pattern, Create Representations, Discussion Groups, RAFT

Travis Smith and his brother, Roy, are co-owners of a trucking company. One of their regular weekly jobs is to transport fruit grown in Pecos, Texas, to a Dallas, Texas, distributing plant. Travis knows that his customers are concerned about the speed with which the brothers can deliver the produce, because fruit will spoil after a certain length of time.

1. Travis wants to address his customers’ concerns with facts and figures. He knows that a typical trip between Pecos and Dallas takes 7.5 hours. He makes the following graph.

a. What information does the graph provide?

b. Locate the point with coordinates of (3, 270) on the graph. Label it point A. Describe the information these coordinates provide.
Lesson 15-1
Writing Equations from Graphs and Tables

2. Complete the table to show Travis’s distance from Dallas at each hour.

<table>
<thead>
<tr>
<th>Hours Since Leaving Pecos, h</th>
<th>Distance from Dallas, d</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

3. Model with mathematics. Use your table and the graph to write an equation that expresses Travis’s distance $d$ from Dallas as a function of the number of hours $h$ since he left Pecos.

4. The graph of an equation in two variables is the set of all solutions of the equation plotted in the coordinate plane.
   a. The graph appears to pass through the point $(6, 90)$. Use your equation to verify this.
Lesson 15-1
Writing Equations from Graphs and Tables

b. Generate four more ordered-pair solutions to your equation by substituting 1, 5, 8, and 10 for $h$. Does each point appear on the graph showing Travis’s distance from Dallas? Explain.

c. Which of the solution points you generated in part b make sense in this context?

d. Explain why only some solution points make sense in this context.

e. Use what you know about the solution points and the graph to state a reasonable domain and range for the function in the given context.

f. Use the graph to identify the zero of the function.

Check Your Understanding

The graph shows the amount of water remaining in a tank after a leak occurs. Use the graph for Items 5–7.

5. Make a table to show the amount of water in the tank at five different times. Use the graph to identify the zero of the function.

6. Make use of structure. Use your table and the graph to write an equation that expresses the amount of water in the tank $a$ as a function of the number of hours $h$ since the leak occurred.

7. State a reasonable domain and range for the function in the given context.
**Lesson 15-1 Practice**

A farm in Plainville, Texas, will ship fruit to the distribution plant in Dallas. The farm is 350 miles from the plant.

8. The table shows part of a trip that Travis and Roy made from the farm to the distribution plant.

<table>
<thead>
<tr>
<th>Time $h$ (hours)</th>
<th>Distance $d$ (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>230</td>
</tr>
<tr>
<td>2.5</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>170</td>
</tr>
<tr>
<td>3.5</td>
<td>140</td>
</tr>
</tbody>
</table>

Determine and interpret the rate of change of the data in the table.

9. A competing shipping company guarantees the fastest delivery times. The graph shows a recent trip from the farm to the distribution plant.

Determine and interpret the rate of change of the data in the graph.

10. Suppose both companies leave the farm at the same time and head to Dallas. Predict who will arrive first.

11. Write equations to represent the trip for each company. Determine how long it takes each company to drive from the farm to the plant in Dallas.

12. **Construct viable arguments.** Suppose you work at the farm. Write a memo to your supervisor about which trucking company to use and why.

---

**MATH TIP**

When writing your answer to Item 12, you can use a RAFT.

- **Role**—farm worker
- **Audience**—your supervisor
- **Format**—a memo
- **Topic**—which trucking company to use and why

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Learning Targets:
- Graph and analyze functions on the same coordinate plane.
- Write inequalities to represent real-world situations.

SUGGESTED LEARNING STRATEGIES: Think-Pair-Share, Create Representations, Sharing and Responding, Discussion Groups

Travis knows that his first graph represents a model for an ideal travel scenario. In reality, he assumes that his average speed will be lower because he will need to stop to refuel. He also decides that he must account for concerns about road construction and traffic.

1. Experience tells Travis that his average speed will decrease to 45 mi/h. Travis's ideal travel scenario is shown on the grid below. On these same axes, draw the graph of his distance from Dallas, based upon his assumption that he will maintain a 45 mi/h average speed throughout his trip.

2. Write an equation for the line you drew in Item 1. Interpret the meaning of the constant and the coefficient of $h$ in terms of the context.
3. Travis can average anywhere from 45 mi/h to 60 mi/h, as shown on the two previous graphs.
   a. On the graph in Item 1, sketch the vertical line \( h = 3 \). Highlight the segment of that line that gives all the possible distances from Dallas three hours after Travis leaves Pecos.
   
   b. How far might Travis be from Dallas after 3 hours of travel? Explain in your own words and then write your answer as an inequality.

   The distances you found in Item 3b are the possible distances after three hours of travel. The line segment can be described as the set of ordered pairs \((h, d)\) where \( h = 3 \) and the value of \( d \) is between the values indicated in the inequality you wrote in Item 3b.

4. Travis can average anywhere from 45 mi/h to 60 mi/h, as shown on the graph in Item 1.
   a. On the graph, sketch the vertical line \( h = 5 \). Highlight the segment of that line that gives all the possible distances from Dallas five hours after Travis leaves Pecos.
   
   b. Reason quantitatively. How far might Travis be from Dallas after 5 hours of travel? Explain in your own words, and then write your answer as an inequality.
   
   c. Describe what the inequality and the line segment tell Travis about his trip.

5. Use the graph in Item 1.
   a. Draw the line segment for \( h = 7.5 \). How far might Travis be from Dallas after 7.5 hours of travel? Write your answer as an inequality.
   
   b. Describe what the inequality and the line segment tell Travis about his trip.
Lesson 15-2
Comparing Functions with Inequalities

6. Use the graph in Item 1.
   a. Draw the line segment for \( h = 9 \). How far might Travis be from Dallas after 9 hours of travel? Write your answer as an inequality.

   b. Describe what the inequality and the line segment tell Travis about his trip.

7. There is a region that could be filled by similar vertical line segments for all values of \( h \) that Travis could be on his trip. Shade this region on the graph in Item 1.

8. Travis likes to stop for a break after driving half the distance to Dallas.
   a. On the graph in Item 1, sketch the horizontal line that represents half the distance to Dallas. What is the equation of this line? Highlight the segment of the line that gives all possible times that he may stop.

   b. How much time might remain in the trip when Travis stops for a break? Explain how you know.

9. After Travis drives for 4 hours and 20 minutes at 45 mi/h, he wonders how much farther he has to drive.
   a. Would you prefer to use the graph or the equation to determine the answer? Explain your choice.

   b. How much farther does Travis have to drive? Justify your response.
LESSON 15-2 PRACTICE

Travis’s sister, Amy, lives in Midland, which is 100 miles from Pecos. After visiting his sister, Travis plans to drive his truck to Dallas. The graph shows his planned trip.

13. At what average speed does Travis expect to travel?

14. Travis hopes he will be able to maintain an average speed of 60 mi/h once he leaves his sister’s house. Copy the graph above and draw the graph of Travis’s distance from Pecos, based on an average speed of 60 mi/h.

15. Make sense of problems. Write an equation for the line you graphed in Item 14. Interpret the meanings of the constant and the coefficient of \( h \) in terms of the context.

16. How far might Travis be from Pecos after 3 hours of travel? Write your answer as an inequality.
Lesson 15-3
Writing Equations from Verbal Descriptions

Learning Targets:
• Write a linear equation given a verbal description.
• Graph and analyze functions on the same coordinate plane.

SUGGESTED LEARNING STRATEGIES: Look for a Pattern, Create Representations, Identify a Subtask

1. Suppose that the speed limit on all parts of Interstate 20 has been changed to 70 mi/h. Travis finds that he can now average between 50 mi/h and 70 mi/h on the trip between Pecos and Dallas.
   a. Write an equation that expresses Travis’s distance \( d \) from Dallas as a function of the hours \( h \) since he left Pecos if his average speed is 50 mi/h.

   b. Write an equation that expresses Travis’s distance \( d \) from Dallas as a function of the hours \( h \) since he left Pecos if his average speed is 70 mi/h.

   c. Reason abstractly. On the grid below, graph the two equations that you found in parts a and b. Describe how changing the coefficient of \( h \) in the equation affects the graph. Explain why this makes sense.

   ![Graph with time in hours on the x-axis and distance in miles on the y-axis, ranging from 0 to 450 miles, and 0 to 12 hours.](image)

   d. Shade the region of the graph above for the ordered pairs \((h, d)\) such that \( h \) represents all the possible times and \( d \) represents all the possible distances from Dallas after \( h \) hours of travel.
e. Describe Travis’s possible distances from Dallas after 4 hours of travel. Travis will be at least 170 miles, but not more than 250 miles, from Dallas.

f. Write an inequality to represent Travis’s possible distances from Dallas after 4 hours.
   \[170 \leq d \leq 250\]

**Check Your Understanding**

Sumi and Jerome start riding their bikes at the same time, traveling in the same direction on the same bike path. Sumi rides at a constant speed of 10 ft/s. Jerome rides at a constant speed of 15 ft/s.

2. Write an equation that expresses the distance \(d\) that Sumi has traveled as a function of the time \(s\) in seconds since she started riding her bike.

3. Write an equation that expresses the distance \(d\) that Jerome has traveled as a function of the time \(s\) in seconds since he started riding his bike.

4. Graph the equations from Items 2 and 3 on the same coordinate plane.

5. Explain how to use your graph to find the distance between Sumi and Jerome after they have ridden their bikes for 5 seconds.

**LESSON 15-3 PRACTICE**

Graph the equations for Items 6 and 7 in the first quadrant of the same graph. The equations represent the height \(y\) in centimeters of Ellie’s and James’s model gliders after \(x\) seconds.

6. Ellie: \(y = -20x + 220\)

7. James: \(y = -15x + 220\)

8. Draw a vertical line segment that connects the graphs at \(x = 5\). Describe what the segment represents in words and with an inequality.

9. Interpret the meanings of the coefficients of \(x\) and the constants in terms of the context.

10. **Construct viable arguments.** Whose glider was in the air longer? Justify your response.

11. Julian’s model glider begins at an initial height of 300 centimeters and descends at a rate of 18 cm per second. Write an equation that expresses the height \(y\) of Julian’s glider after \(x\) seconds.
**ACTIVITY 15 PRACTICE**

Write your answers on notebook paper. Show your work.

**Lesson 15-1**

1. The graph shows the number of gallons of water $y$ remaining in a tub $x$ minutes after the tub began draining.

![Graph](image)

Which describes something that is being drained at nine times the rate of the tub?

A. A pool is drained at a rate of nine gallons per minute.
B. A rain barrel is drained at a rate of six gallons per minute.
C. A cooler is drained at a rate of 12 gallons per minute.
D. A pond is drained at a rate of 18 gallons per minute.

2. The equation $d = 30 - 60h$ gives the distance $d$ in miles that a bus is from the station $h$ hours after leaving an arena. How far is the station from the arena?

A. 0.5 miles  
B. 30 miles  
C. 60 miles  
D. 120 miles

3. Claire walks home from a friend’s house two miles away. She sketches a graph of her walk, showing her distance from home as a function of time in minutes. Is the slope of the graph positive or negative? Explain.

Use the table for Items 4–9.

<table>
<thead>
<tr>
<th>Minutes Since Leaving Store, $m$</th>
<th>Distance in Miles from Home, $d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.5</td>
</tr>
<tr>
<td>15</td>
<td>1.25</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
</tr>
</tbody>
</table>

4. The table represents Holly’s walk home from the store. What is Holly’s rate in miles per minute?

5. How far is the store from Holly’s home? Explain how you know.

6. Write an equation that relates distance $d$ to the number of minutes $m$.

**Lesson 15-2**

7. Tim left school on his bike at the same time Holly left the store. The equation $d = 4 - \frac{m}{5}$ gives Tim’s distance from Holly’s house after $m$ minutes. Sketch a graph of Holly’s and Tim’s trips on the same coordinate plane.

8. Compare the total time for Tim’s trip to the total time for Holly’s trip.

9. Part of Tim’s trip includes the way Holly will walk. Use your graph to estimate when Tim will run into Holly.

10. Kane researched the cost of a taxi ride in a nearby city. He found conflicting information about the per-mile cost of a ride. The graph below shows his findings.

![Graph](image)

a. What can you conclude about the cost per mile of a taxi ride?

b. How much should Kane expect to pay for a five-mile taxi ride? Explain.
The graph shows the planned descent of a hot-air balloon. Use the graph for Items 11–16.

11. Write an equation that expresses the height of the balloon \( h \) as a function of the time \( t \) since the beginning of the descent.

12. State a reasonable domain and range for the function in Item 11 in this context.

13. The pilot thinks it may be possible to increase the rate of descent to a maximum of 400 ft/min. Copy the above graph and then draw a graph of the descent at 400 ft/min on the same coordinate plane.

14. On your graph from Item 13, draw the vertical line \( t = 3 \). Use the line to determine all the possible heights of the balloon after 3 minutes. Write your answer as an inequality.

15. The actual descent of the hot-air balloon is given by the equation \( h = 1600 - 250t \). Compare the graph of the actual descent to the two lines graphed in Item 13.

16. How long does it take the hot-air balloon to make the descent? Explain your reasoning.

17. Wendy leaves Sacramento and heads to San Jose. She averages 50 mi/h on the 120-mile trip. Which equation describes Wendy’s distance \( d \) from San Jose \( h \) hours after she leaves Sacramento?
   A. \( d = 50h - 120 \)  
   B. \( d = 120 - 50h \)  
   C. \( d = 120 + 50h \)  
   D. \( d = 50h \)

18. Fresno is 150 miles from Bakersfield. A driver traveling to Bakersfield leaves Fresno and averages 62 miles per hour. Write an equation for the distance \( d \) from Fresno, given the time \( t \) in hours since the driver left.

19. A driver traveling from Fresno to Bakersfield averaged 57 miles per hour. Write an equation for the distance \( d \) from Fresno, given the time \( t \) in hours since the driver left.

20. Sketch a graph of the equations you created in Items 18 and 19 on the same coordinate axis.

21. If a driver traveling between Fresno and Bakersfield knew he could average between 57 and 62 miles per hour, sketch a graph of the region that represents all possible distances from Fresno that the driver could be at time \( t \).

### MATHEMATICAL PRACTICES

**Make Sense of Problems and Persevere in Solving Them**

22. The amount of water \( w \) in aquarium A, in gallons, is given by \( w = 50 - 3.5m \), where \( m \) is the number of minutes since the aquarium started draining. The amount of water \( w \) in aquarium B, in gallons, \( m \) minutes after the aquarium started draining, is given by the table below. Which aquarium drains more quickly, and how long does it take until it is empty?

<table>
<thead>
<tr>
<th>Minutes, ( m )</th>
<th>Gallons of Water, ( w )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
</tr>
</tbody>
</table>
Inequalities in Two Variables

Shared Storage

Lesson 16-1 Writing and Graphing Inequalities in Two Variables

**Learning Targets:**
- Write linear inequalities in two variables.
- Read and interpret the graph of the solutions of a linear inequality in two variables.

**SUGGESTED LEARNING STRATEGIES:** Marking the Text, Look for a Pattern, Think-Pair-Share, Create Representations, Sharing and Responding

Axl and Aneeza pay for and share memory storage at a remote Internet site. Their plan allows them to upload 250 terabytes (TB) or less of data each month. Let \( x \) represent the number of terabytes Axl uploads in a month, and let \( y \) represent the number of terabytes Aneeza uploads in a month.

1. Look at the data for four months below. Determine if Axl and Aneeza stayed within the limits of their monthly plan.

<table>
<thead>
<tr>
<th>Axl’s Uploads (( x ))</th>
<th>Aneeza’s Uploads (( y ))</th>
<th>Within Plan? (Yes/No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 TB</td>
<td>120 TB</td>
<td></td>
</tr>
<tr>
<td>135 TB</td>
<td>100 TB</td>
<td></td>
</tr>
<tr>
<td>100 TB</td>
<td>150 TB</td>
<td></td>
</tr>
<tr>
<td>162 TB</td>
<td>128 TB</td>
<td></td>
</tr>
</tbody>
</table>

2. Write an inequality that models the plan’s restriction on uploading.

3. **Reason quantitatively.** If Axl uploads 100 terabytes, write an inequality that shows how many terabytes Aneeza can upload.

4. If Aneeza uploads 75 terabytes, write an inequality that shows how many terabytes Axl can upload.
The graph below represents the possible values for the number of terabytes that Axl and Aneeza can upload. An ordered pair \((x, y)\) represents the number of terabytes that Axl and Aneeza upload. For example, the coordinates \((100, 75)\) mean that Axl uploaded 100 TB and Aneeza uploaded 75 TB of data.

5. Graph each ordered pair on the graph above. Determine if it will allow Axl and Aneeza to remain within their plan, and explain your answers.
   a. \((200, 50)\)
   b. \((150, 150)\)
   c. \((225, 25)\)
   d. \((20, 120)\)
   e. \((120, 200)\)

The graph of Axl and Aneeza's storage plan above is an example of a graph of a linear inequality in two variables. All the points in the shaded region are solutions of the linear inequality.
Lesson 16-1
Writing and Graphing Inequalities in Two Variables

Check Your Understanding

Axl and Aneeza decide to change to a 350-terabyte plan. Use this information for Items 6–8.

6. How does the graph in Item 5 change?

7. Graph the inequality that represents Axl and Aneeza’s new plan. Let \( x \) represent the number of terabytes Axl can upload, and let \( y \) represent the number of terabytes Aneeza can upload.

8. Which ordered pairs will work with the new plan? Justify your response.
   a. \((200, 50)\)
   b. \((150, 150)\)
   c. \((240, 180)\)
   d. \((0, 300)\)
   e. \((210, 180)\)
   f. \((360, -10)\)

9. Explain how to decide whether an ordered pair is a solution to a linear inequality.

LESSON 16-1 PRACTICE

You are on a treasure-diving ship that is hunting for gold and silver coins. You reel in a wire basket that contains gold and silver coins, among other things. The basket holds no more than 50 pounds of material. Each gold coin weighs about 0.5 ounce, and each silver coin weighs about 0.25 ounce. You want to know the different numbers of each type of coin that could be in the basket.

10. Write an inequality that models the weight in the basket.


12. Construct viable arguments. Explain why there cannot be 400 gold coins and 2800 silver coins in the basket.

13. Mitch and Mindy are in charge of purchasing art supplies for their local senior-citizen center. The monthly budget for supplies is $325, so the total they can spend in a month cannot exceed $325. This table displays how much each spent from January through April.

<table>
<thead>
<tr>
<th>Month</th>
<th>Amount Mitch Spent ((x))</th>
<th>Amount Mindy Spent ((y))</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>150</td>
<td>155</td>
</tr>
<tr>
<td>February</td>
<td>215</td>
<td>110</td>
</tr>
<tr>
<td>March</td>
<td>60</td>
<td>252</td>
</tr>
<tr>
<td>April</td>
<td>175</td>
<td>150</td>
</tr>
</tbody>
</table>

Write an inequality in two variables that models how much Mitch and Mindy can spend together and stay within the budget.
Learning Targets:
- Graph on a coordinate plane the solutions of a linear inequality in two variables.
- Interpret the graph of the solutions of a linear inequality in two variables.

SUGGESTED LEARNING STRATEGIES: Vocabulary Organizer, Interactive Word Wall, Create Representations, Identify a Subtask, Construct an Argument

The solutions of a linear inequality in two variables can be represented in the coordinate plane.

Example A
Graph the linear inequality \( y \leq 2x + 3 \).

Step 1: Graph the corresponding linear equation \( y = 2x + 3 \). The line you graphed is the boundary line.

Step 2: Test a point in one of the half-planes to see if it is a solution of the inequality. Using (0, 0), \( 0 \leq 2(0) + 3 \) is a true statement. So (0, 0) is a solution.

Step 3: If the point you tested is a solution, shade the half-plane in which it lies. If it is not, shade the other half-plane. (0, 0) is a solution, so shade the half-plane containing the solution point (0, 0).

In Example A, the solution set includes the points on the boundary line. The solution set is a closed half-plane. In an inequality containing < or > the solution set does not include the points on the boundary line, so the boundary line is dashed, and the solution set is an open half-plane.
Lesson 16-2
Graphing Inequalities in Two Variables

Example B

Graph \( x + 2y > 8 \).

Step 1: Solve the inequality for \( y \).

\[
\begin{align*}
    \quad & x - x + 2y > 8 - x \\
    \quad & 2y > -x + 8 \\
    \quad & \frac{2y}{2} > \frac{-x + 8}{2} \\
    \quad & y > -\frac{1}{2}x + 4
\end{align*}
\]

Subtract \( x \) from each side. Divide each side by 2. Simplify.

Step 2: Graph the boundary line, \( y = -\frac{1}{2}x + 4 \). Since the inequality uses the < symbol, the solution set is an open half-plane. Draw a dashed line.

Step 3: Check the test point (0, 0):

\[
0 > -\frac{1}{2}(0) + 4
\]

is false. Shade the half-plane that does not contain the point (0, 0).

Try These A–B

Graph each inequality.

a. \( 3x - 4y \geq -12 \)  
   b. \( y < 3x - 2 \)

1. When graphing a linear inequality, is it possible for a test point located on the boundary line to determine which half-plane should be shaded? Explain.

MATH TIP

When multiplying or dividing each side of an inequality by a negative number, you must reverse the inequality symbol.
2. **Critique the reasoning of others.** Axl tried to graph the inequality $2x + 4y < 8$. He first graphed the linear equation $2x + 4y = 8$. He then chose the test point $(2, 1)$ and used his result to shade above the line. Explain Axl’s mistake and how he should correct it.

3. Axl and Aneeza try a new plan in which they can upload no more than 350 terabytes per month. On the grids below, the $x$-axis represents the number of terabytes that Axl can upload and the $y$-axis represents the number of terabytes that Aneeza can upload.

   a. Suppose Aneeza does not upload anything for a month. Write an inequality that represents the amount of data that Axl can upload during that month. Graph the inequality on the grid.

   b. Suppose Axl does not upload anything for a month. Write an inequality that represents the amount of data that Aneeza can upload during that month. Graph the inequality on the grid.
4. The graph below represents another plan that Axl and Aneeza considered. The $x$-axis represents the number of terabytes of data from photos that can be uploaded each month. The $y$-axis represents the number of terabytes of data from text files.

![Graph showing photos (TB) and text files (TB)]

a. Identify the $x$-intercept and $y$-intercept. What do they represent in this context?

b. Determine the equation for the boundary line of the graph. Justify your response.

c. Model with mathematics. Write a linear inequality to represent this situation. Then describe the plan in your own words.
LESSON 16-2 PRACTICE

Graph each inequality on the coordinate plane.

9. \( x - y \leq 4 \)
10. \( 2x - y > 1 \)
11. \( y \geq 3x + 7 \)
12. \( -x + 6 > y \)
13. Make sense of problems. Write the inequality whose solutions are shown in the graph.
**ACTIVITY 16 PRACTICE**

Write your answers on notebook paper. Show your work.

**Lesson 16-1**

1. Which ordered pairs are solutions of the inequality $5y - 3x \leq 7$?
   - A. $(0, 0)$
   - B. $(3, 5)$
   - C. $(-2, -5)$
   - D. $(1, 2.5)$
   - E. $(5, -3)$

2. Apple juice costs $2 per bottle, and cranberry juice costs $3 per bottle. Tamiko has at most $18 with which to buy drinks for a club picnic. She lets $x$ represent the number of bottles of apple juice and lets $y$ represent the number of bottles of cranberry juice. Then she graphs the inequality $2x + 3y \leq 18$, as shown below.

   - a. Tamiko states that the graph does not help her decide how many bottles of each type of juice to buy, because there are infinitely many solutions. Do you agree or disagree? Why?
   - b. Suppose Tamiko decides to buy two bottles of apple juice. Explain how she can use the graph to determine the possible numbers of bottles of cranberry juice she can buy.

**Lesson 16-2**

4. Write an inequality for the half-plane. Is the half-plane open or closed?

5. Write an inequality for the half-plane. Is the half-plane open or closed?

6. Sketch a graph of the inequality $y \geq -\frac{2}{3}x + 2$.

7. Sketch a graph of the inequality $3y > 7x - 15$. 

3. Describe a real-world situation that can be represented by the inequality shown in the graph.
8. Which inequality represents all of the points in the first and fourth quadrants?
   A. $x < 0$   B. $x > 0$
   C. $y < 0$   D. $y > 0$

9. There are at most 30 students in Mr. Moreno’s history class.
   a. Write an inequality in two variables that represents the possible numbers of boys $b$ and girls $g$ in the class.
   b. Graph the inequality on a coordinate plane.
   c. Explain whether your graph has a solid boundary line or a dashed boundary line.
   d. Choose a point in the shaded region of your graph and explain what the point represents.

10. Which graph represents the solutions of the inequality $2x - y \geq 6$?

11. Tickets for the school play cost $3 for students and $6 for adults. The drama club hopes to bring in at least $450 in sales. The auditorium has 120 seats. Let $a$ represent the number of adult tickets and $s$ represent the number of student tickets.
   a. Write an inequality in two variables that represents the desired ticket sales.
   b. Write an inequality in two variables that represents the possible numbers of tickets that can be sold.
   c. Sketch both inequalities on the same grid. What does the intersection of the two graphs represent?

12. When is the boundary line of the graph of an inequality in two variables part of the solution?

**MATHEMATICAL PRACTICES**

**Look For and Make Use of Structure**

13. Graph the inequality $x < 3$ on a number line and on the coordinate plane. Describe the differences in the graphs.
1. Steve works at a restaurant. He earns $8.50 per hour.
   a. Write an equation that indicates the amount of money $m$ in dollars that Steve can earn as a function of the hours $h$ that he worked.
   b. Steve works at least 10 hours and not more than 30 hours per week. Describe the reasonable domain and range for your function from part a.
   c. The cost of any food that Steve buys while working is deducted from his earnings. Write an inequality that represents the possible amounts of money he can earn after buying food.
   d. Copy the grid below. Graph the inequality you wrote in part c.

   ![Graph](image)

   e. Determine whether the ordered pair (16, 126) is a solution of the inequality you wrote in part c. If so, interpret its meaning. If not, explain why not.

2. Bob has been working at the restaurant longer than Steve. He earns $9 per hour. During some weeks he works more than 40 hours. The hours he works beyond 40 are considered overtime. For overtime pay, Bob earns double time, or $18 per hour.

   a. Write a function $B(h)$ that will give Bob's pay for working 40 hours or less.
   b. Identify a reasonable domain and range for the function in this context.

3. a. Write a function $B(h)$ that will give Bob's pay for working more than 40 hours.
   b. Identify a reasonable domain and range for the function in this context.

4. Write a piecewise-defined function $B(h)$ that gives Bob's pay for any number of hours $h$.

5. Graph your function from Item 4.
<table>
<thead>
<tr>
<th>Scoring Guide</th>
<th>Exemplary</th>
<th>Proficient</th>
<th>Emerging</th>
<th>Incomplete</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mathematics Knowledge and Thinking</strong></td>
<td>• Clear understanding and accurate identification of reasonable domain and range</td>
<td>• Adequate understanding and accurate identification of reasonable domain and range</td>
<td>• Partial understanding and partially accurate identification of reasonable domain and range</td>
<td>• No understanding and inaccurate identification of reasonable domain and range</td>
</tr>
<tr>
<td>(Items 1b, 2b, 3b)</td>
<td></td>
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<tr>
<td><strong>Problem Solving</strong></td>
<td></td>
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<tr>
<td>(Item 1e)</td>
<td>• Appropriate and efficient strategy that results in a correct answer</td>
<td>• Strategy that may include unnecessary steps but results in a correct answer</td>
<td>• Strategy that results in some incorrect answers</td>
<td>• No clear strategy when solving problems</td>
</tr>
<tr>
<td><strong>Mathematical Modeling / Representations</strong></td>
<td>• Effective understanding of how to represent a real-world scenario using equations, inequalities, graphs, and functions</td>
<td>• Little difficulty representing a real-world scenario using equations, inequalities, graphs, and functions</td>
<td>• Partial understanding of how to represent a real-world scenario using equations, inequalities, graphs, and functions</td>
<td>• Little or no understanding of how to represent a real-world scenario using equations, inequalities, graphs, and functions</td>
</tr>
<tr>
<td>(Items 1a, 1c, 1d, 2a, 3a, 4, 5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reasoning and Communication</strong></td>
<td>• Precise use of appropriate math terms and language to explain whether an ordered pair is a solution of an inequality</td>
<td>• Adequate explanation of whether an ordered pair is a solution of an inequality</td>
<td>• Misleading or confusing explanation of whether an ordered pair is a solution of an inequality</td>
<td>• Incomplete or inaccurate explanation of whether an ordered pair is a solution of an inequality</td>
</tr>
<tr>
<td>(Item 1e)</td>
<td>• Ease and accuracy describing the relationship between a mathematical result and a real-world scenario</td>
<td>• Little difficulty describing the relationship between a mathematical result and a real-world scenario</td>
<td>• Partially correct description of the relationship between a mathematical result and a real-world scenario</td>
<td>• Little or no understanding of how a mathematical result might relate to a real-world scenario</td>
</tr>
</tbody>
</table>
Travis Smith and his brother, Roy, are co-owners of a trucking company. The company needs to transport two truckloads of fruit grown in Pecos, Texas, to a distributing plant in Dallas, Texas. If the fruit does not get to Dallas quickly, it will spoil. The farmers offer Travis a bonus if he can get both truckloads to Dallas within 24 hours.

Due to road construction, Travis knows it will take 10 hours to drive from Pecos to Dallas. The return trip to Pecos will take only 7.5 hours. He estimates it will take 1.5 hours to load the fruit onto the truck and 1 hour to unload it.

1. Why is it impossible for Travis to earn the bonus by himself?

2. Travis wants to earn the bonus so he asks his brother, Roy, if he will help. With Roy’s assistance, can the brothers meet the deadline and earn the bonus? Explain why or why not.

Roy is in Dallas ready to leave for Pecos. To meet the deadline and earn the bonus, Travis will leave Pecos first and meet Roy somewhere along the interstate to give him a key to the storage area in Pecos.

3. From Pecos to Dallas, Travis averages 45 mi/h. If Dallas is 450 mi from Pecos, write an equation that expresses Travis’s distance $d$ in miles from Dallas as a function of the hours $h$ since he left Pecos.
4. Graph the equation you wrote in Item 3.

5. Roy leaves Dallas one-half hour before Travis leaves Pecos. In terms of the hours $h$ since Travis left Pecos, write an expression that represents the time since Roy left Dallas.

6. Roy travels 60 mi/h from Dallas to Pecos. Write an equation that expresses Roy’s distance $d$ from Dallas as a function of the hours $h$ since Travis left Pecos.

7. Graph the equation from Item 6 on the grid in Item 4.

8. Identify the intersection point of the two lines. Describe the information these coordinates provide.
Lesson 17-1
The Graphing Method

The two equations you wrote in Items 3 and 6 form a **system of linear equations**.

To determine the solution of a system of linear equations, you must identify all the ordered pairs that make both equations true. One method is to graph each equation and determine the intersection point.

9. Graph each system of linear equations. Give each solution as an ordered pair. Check that the point of intersection is a solution of both equations by substituting the solution values into the equations.

   a. \( y = 2x - 10 \)
      \( y = -3x + 5 \)

   b. **Reason abstractly**. Edgar has nine coins in his pocket. All of the coins are nickels or dimes and are worth a total of $0.55. The system shown below represents this situation. How many of each type of coin does Edgar have in his pocket?
      \( n + d = 9 \)
      \( n + 2d = 11 \)
Lesson 17-1
The Graphing Method

c. \[ y = 3x - 5 \]
   \[ y = -2x + 4 \]

d. \[ 3x + y = 1 \]
   \[ 6x + 2y = 10 \]

e. What made finding the solutions to parts c and d challenging?

10. Lena graphs the system \( x - 2y = 3 \) and \( 2x - y = -3 \) and determines the solution to be \((1, -1)\). She checks her solution algebraically and decides the solution is correct. Explain her error.
Lesson 17-1
The Graphing Method

Check Your Understanding

11. Solve each system.
   a. \( y = -2x + 5 \)
      \( y = \frac{1}{8}x - \frac{7}{2} \)
   b. \( 3x - y = 5 \)
      \( 4x - 2y = 4 \)
   c. \( y = -2x + 3 \)
   d. \( 2x + y = 5 \)
      \( 4x - 1 = y \)

12. Roberto has eight coins that are all dimes or nickels. They are worth $0.50. The system \( n + d = 8 \) and \( n + 2d = 10 \) represents this situation. Graph the system to determine how many of each coin Roberto has.

LESSON 17-1 PRACTICE

13. Solve each system.
   a. \( y = 2x + 2 \)
      \( y = -2x - 6 \)
   b. \( y = \frac{1}{3}x - 2 \)
      \( y = -x + 2 \)
   c. \( 3x + 2y = 6 \)
      \( x - y = -3 \)
   d. \( y = -2 \)
      \( 2y = -x - 1 \)

14. Sandeep ordered peanuts and raisins for his bakery. He ordered a total of eight pounds of these ingredients. Peanuts cost $1 per pound, and raisins cost $2 per pound. He spent a total of $10. The system \( p + r = 8 \) and \( p + 2r = 10 \) represents this situation. Graph the system to determine how many pounds of peanuts and raisins Sandeep ordered.

15. Critique the reasoning of others.
   Kyla was asked to solve the system of equations below. She made the graph shown and stated that the solution of the system is \((-4, -1)\). Is Kyla correct? Justify your response and identify Kyla’s errors, if they exist.
   \( x + y = 3 \)
   \( x - 3y = -1 \)

16. Write the system of equations represented by this graph.
Learning Targets:

- Solve a system of linear equations using a table or the substitution method.
- Interpret the solution of a system of linear equations.

SUGGESTED LEARNING STRATEGIES: Think-Pair-Share, Note Taking, Marking the Text, Guess and Check, Simplify the Problem

On another trip, Travis is traveling from Pecos to Dallas, and Roy is driving from Dallas to Pecos. They agree to meet for lunch along the way. Each driver averages 60 mi/h but Roy leaves 1.5 hours before his brother does. To determine when and where they will meet, you will solve this system of linear equations.

\[
\begin{align*}
  d &= 450 - 60h \\
  d &= 60h + 90
\end{align*}
\]

1. What do the coefficient 60 and the constants 90 and 450 represent in the context of the problem?

2. Which equation represents Roy’s distance from Dallas? How do you know?

In addition to graphing, a system of equations can be solved by first making a table of values. Then look for an ordered pair that is common to both equations.

3. Complete each table.

<table>
<thead>
<tr>
<th>( h )</th>
<th>( d )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<tr>
<td>3</td>
<td></td>
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<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>( h )</th>
<th>( d )</th>
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<tbody>
<tr>
<td>0</td>
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<td>3</td>
<td></td>
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<tr>
<td>4</td>
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</tbody>
</table>

4. What ordered pair do the two equations have in common?
Lesson 17-2
Using Tables and the Substitution Method

5. Use appropriate tools strategically. Graph the equations on a graphing calculator. Identify the solution of the linear system. Describe its meaning in terms of the situation.

6. Is it possible that the intersection point from a graph of a linear system does not show up on a table of values? How could the solution be determined if it is not shown in the table?

Check Your Understanding

7. Solve each system.
   a. \( y = 2x + 6 \)
   \( y = -3x + 16 \)
   b. \( x + y = 8 \)
   \( 3x + 2y = 14 \)
   c. \( y = 100 - 2x \)
   \( y = 20 + 6x \)
   d. \( 2x + y = 6 \)
   \( 2x + 3y = 8 \)

8. What challenges did you encounter when solving these systems of linear equations?

Sometimes it is difficult to solve a system of equations by graphing or by using tables of values, and another solution method is necessary.

On another trip, Roy leaves from Pecos one hour before his brother and averages 55 mi/h. Travis leaves from Dallas during rush hour so he averages only 45 mi/h.

This system of linear equations represents each brother’s distance \( d \) from Dallas, \( h \) hours after Roy leaves Pecos.

\[
\begin{align*}
\text{Roy:} & \quad d = 450 - 55h \\
\text{Travis:} & \quad d = 45(h - 1)
\end{align*}
\]

Solve the system by finding when Travis’s distance from Dallas is the same as Roy’s distance.

Travis’s distance = Roy’s distance
\( 45(h - 1) = 450 - 55h \)

9. Solve the equation for \( h \) and show your work.
10. **Reason quantitatively.** What does the answer to Item 9 represent? Is your answer reasonable?

11. Use a graphing calculator to graph the system above.
   a. What is the intersection point of the graphs? How would you use this point to answer Item 9?

   b. The second coordinate of the intersection point represents the distance that the brothers are from Dallas. How could you confirm this using the equations?

Another method for solving systems of equations is the **substitution method**, in which one equation is solved for one of the variables. Then the expression for that variable is substituted into the other equation.

**Example A**

For a Valentine’s Day dance, tickets for couples cost $12 and tickets for individuals cost $8. Suppose 250 students attended the dance, and $1580 was collected from ticket sales. How many of each type of ticket was sold?

**Step 1:** Let \( x \) = number of couples, and \( y \) = number of individuals.

**Step 2:** Write an equation to represent the number of people attending.

\[
2x + y = 250
\]

The number of attendees is 250.

Write another equation to represent the money collected.

\[
12x + 8y = 1580
\]

The total ticket sales is $1580.

**Step 3:** Use substitution to solve this system.

\[
y = 250 - 2x
\]

Solve the first equation for \( y \).

\[
12x + 8(250 - 2x) = 1580
\]

Substitute for \( y \) in the second equation.

\[
12x + 2000 - 16x = 1580
\]

Solve for \( x \).

\[
-4x = -420
\]

\[
x = 105
\]
Lesson 17-2
Using Tables and the Substitution Method

Step 4: Substitute the value of \( x \) into one of the original equations to find \( y \).

\[
2x + y = 250 \\
2(105) + y = 250 \quad \text{Substitute 105 for } x.
\]

\[
210 + y = 250 \\
y = 40
\]

Solution: For the dance, 105 couples’ tickets and 40 individual tickets were sold.

Try These A
Solve each system using substitution.

a. \( x + 2y = 8 \) and \( 3x - 4y = 4 \)

b. \( 5x - 2y = 0 \) and \( 3x + y = -1 \)

c. Patty and Toby live 345 miles apart. They decide to drive to meet one another. Patty leaves at noon, traveling at an average rate of 45 mi/h, and Toby leaves at 3:00 PM, traveling at an average speed of 60 mi/h. At what time will they meet?

12. Write the system of equations represented by these tables of values. Then use any method to solve the system.

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>( x )</td>
<td>-2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>( y )</td>
<td>-4</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>( x )</td>
<td>-1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>( y )</td>
<td>7</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

Check Your Understanding

Solve the systems by any method. Explain why you chose the method you did.

13. \( x - 5y = 2 \) and \( x + y = 8 \)

14. \( 2y = x \) and \( x - 7y = 10 \)

LESSON 17-2 PRACTICE

16. Delano was asked to solve the system \( y = 2x - 4.5 \) and \( y = -x + 6 \). He made the tables shown below.

\[
\begin{array}{cc|cc}
\hline
x & y & x & y \\
\hline
0 & -4.5 & 0 & 6 \\
1 & -2.5 & 1 & 5 \\
2 & -0.5 & 2 & 4 \\
3 & 1.5 & 3 & 3 \\
4 & 3.5 & 4 & 2 \\
5 & 5.5 & 5 & 1 \\
\hline
\end{array}
\]

a. Are any of the ordered pairs in the tables solutions of the system? Why or why not?

b. What can you conclude about the solution of the system? Explain your reasoning.

c. Would you choose to solve the system graphically or algebraically? Justify your choice.

17. A rock-climbing gym called Rock-and-Roll charges $2.75 to rent shoes, and $3 per hour to climb. A competing gym, Climb the Walls, charges $4.25 to rent shoes, and $2.50 per hour to climb.

a. Write an equation that gives the cost \( y \) of renting shoes and climbing for \( x \) hours at Rock-and-Roll.

b. Write an equation that gives the cost \( y \) of renting shoes and climbing for \( x \) hours at Climb the Walls.

c. Solve the system of the two equations you wrote in parts a and b using any method. Why did you choose the solution method you did?

d. What does your solution to the system represent in the context of the problem?

e. Construct viable arguments. Suppose you plan to rent shoes and go rock climbing for 4 hours. Which gym offers a better deal in this case? Justify your response.

18. Write the system of equations represented by these tables of values. Then use any method to solve the system.

\[
\begin{array}{c|cccc}
\hline
x & -2 & -1 & 1 & 2 \\
\hline
y & -2 & 0 & 4 & 6 \\
\hline
\end{array}
\]

\[
\begin{array}{c|cccc}
\hline
x & -2 & 2 & 4 & 6 \\
\hline
y & 1 & 3 & 4 & 5 \\
\hline
\end{array}
\]
Learning Targets:

- Use the elimination method to solve a system of linear equations.
- Write a system of linear equations to model a situation.

**SUGGESTED LEARNING STRATEGIES:** Note Taking, Discussion Groups, Critique Reasoning, Vocabulary Organizer, Marking the Text

Elimination is another algebraic method that may be used to solve a system of equations. Two equations can be combined to yield a third equation that is also true. The **elimination method** creates like terms that add to zero.

**Example A**

Solve the system using the elimination method:

\[
\begin{align*}
4x - 5y &= 30 \\
3x + 4y &= 7
\end{align*}
\]

**Step 1:** To solve this system of equations by elimination, decide to eliminate the \( y \) variable.

Original system

Multiply the first equation by 4.

Multiply the second equation by 5.

\[
\begin{align*}
4x - 5y &= 30 \\
3x + 4y &= 7
\end{align*}
\]

\[
\begin{align*}
4(4x - 5y) &= 4(30) \\
5(3x + 4y) &= 5(7)
\end{align*}
\]

\[
\begin{align*}
16x - 20y &= 120 \\
15x + 20y &= 35
\end{align*}
\]

\[
31x = 155
\]

Solve for \( x \).

\[x = 5\]

**Step 2:** Find \( y \) by substituting the value of \( x \) into one of the original equations.

\[
\begin{align*}
4x - 5y &= 30 \\
4(5) - 5y &= 30
\end{align*}
\]

Substitute 5 for \( x \).

\[
\begin{align*}
20 - 5y &= 30 \\
-5y &= 10 \\
y &= -2
\end{align*}
\]

**Step 3:** Check \((5, -2)\) in the second equation \(3x + 4y = 7\).

\[
\begin{align*}
3x + 4y &= 7 \\
3(5) + 4(-2) &= 7 \\
15 - 8 &= 7 \\
7 &= 7 \quad \text{check}
\end{align*}
\]

**Solution:** The solution is \((5, -2)\).

**Try These A**

Solve each system using elimination.

\[
\begin{align*}
a. \quad 3x - 2y &= -21 \\
\quad 2x + 5y &= 5
\end{align*}
\]

\[
\begin{align*}
b. \quad 7x + 5y &= 9 \\
\quad 4x - 3y &= 11
\end{align*}
\]
Example B

Noah is given two beakers of saline solution in chemistry class. One contains a 3% saline solution and the other an 8% saline solution. How much of each type of solution will Noah need to mix to create 150 mL of a 5% solution?

Step 1: To solve this problem, write and solve a system of linear equations.

Let \( x \) = number of mL of 3% solution.
Let \( y \) = number of mL of 8% solution.

Step 2: Write one equation based on the amounts of liquid being mixed. Write another equation on the amount of saline in the final solution.

\[ x + y = 150 \quad \text{The amount of the mixture is 150 mL.} \]
\[ 0.03x + 0.08y = 0.05(150) \quad \text{The amount of saline in the mixture is 5%.} \]

Step 3: To solve this system of equations by elimination, decide to eliminate the \( x \) variable.

\[ -3(x + y) = -3(150) \quad \text{Multiply the first equation by } -3. \]
\[ 100(0.03x + 0.08y) = 100(7.5) \quad \text{Multiply the second equation by 100 to remove decimals.} \]

\[ -3x - 3y = -450 \quad \text{Add the two equations to eliminate } x. \]
\[ 3x + 8y = 750 \quad \text{Solve for } y. \]
\[ 5y = 300 \]
\[ y = 60 \]

Step 4: Find the value of the eliminated variable \( x \) by using one of the original equations.

\[ x + y = 150 \]
\[ x + 60 = 150 \quad \text{Substitute 60 for } y. \]
\[ x = 90 \quad \text{Subtract 60 from both sides.} \]

Step 5: Check your answers by substituting into the original second equation.

\[ 0.03x + 0.08y = 0.05(150) \]
\[ 0.03(90) + 0.08(60) \quad ? \quad 0.05(150) \quad \text{Substitute 90 for } x \text{ and 60 for } y. \]
\[ 2.7 + 4.8 \quad ? \quad 7.5 \]
\[ 7.5 = 7.5 \quad \text{check} \]

Solution: Noah needs 90 mL of 3% solution mixed with 60 mL of 8% solution to make 150 mL of the 5% solution.
Lesson 17-3
The Elimination Method

Try These B
Solve each system using elimination.

a. \[7x + 5y = -1\]
   \[4x - y = -16\]

b. **Make sense of problems.** Mary had $25,000 to invest. She invested part of that amount at 3% annual interest and part at 5% annual interest for one year. The amount of interest she earned for both investments was $1100. How much was invested at each rate?

2. Sylvia wants to mix 100 pounds of Breakfast Blend coffee that will sell for $25 per pound. She is using two types of coffee to create the mixture. Kona coffee sells for $51 per pound and Columbian coffee sells for $11 per pound. How many pounds of each type of coffee should Sylvia use?

Check Your Understanding

3. Fay wants to solve the system \[2x - 3y = 5\] and \[3x + 2y = -5\] using elimination. She multiplies the second equation by 1.5 to get \[4.5x + 3y = -7.5\].
   a. Do you think Fay’s approach is correct? Explain why or why not.
   b. Describe how Fay could have multiplied to avoid decimal coefficients.

LESSON 17-3 PRACTICE
For each situation, write and solve a system of equations.

4. **Attend to precision.** A pharmacist has a 10% alcohol solution and a 25% alcohol solution. How many milliliters of each solution will she need to mix together in order to have 200 mL of a 20% alcohol solution?

5. Alyssa invested a total of $1500 in two accounts. One account paid 2% annual interest, and the other account paid 4% annual interest. After one year, Alyssa earned a total of $44 interest. How much did she invest in each account?

6. Kendall is Jamal’s older brother. The sum of their ages is 39. The difference of their ages is 9. How old are Kendall and Jamal?

7. Yolanda wants to solve the system shown below.
   \[3x - 4y = 5\]
   \[2x + 3y = -2\]
   She decides to use the elimination method to eliminate the \(x\) variable. Describe how she can do this.
Learning Targets:
- Explain when a system of linear equations has no solution.
- Explain when a system of linear equations has infinitely many solutions.

SUGGESTED LEARNING STRATEGIES: Create Representations, Marking the Text, Close Reading, Think-Pair-Share

The graph of a system of linear inequalities does not always result in a unique intersection point. **Parallel** lines have graphs that do not intersect. **Coincident** lines have graphs that intersect infinitely many times.

<table>
<thead>
<tr>
<th>A System of Parallel Lines</th>
<th>A System of Coincident Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No Solution</strong></td>
<td><strong>Infinitely Many Solutions</strong></td>
</tr>
<tr>
<td>( y = -2x + 2 )</td>
<td>( y = -2x + 2 )</td>
</tr>
<tr>
<td>( y = -2x - 2 )</td>
<td>( 6x = 6 - 3y )</td>
</tr>
</tbody>
</table>

On a particular trip, Roy leaves from Pecos driving 55 mi/h. After 20 minutes, Travis realizes Roy forgot two cases of peaches. In 4 minutes, Travis loads the cases into his truck and heads out after Roy, traveling 55 mi/h.

This system of equations represents each brother’s distance \( d \) from Dallas \( h \) hours after Roy leaves Pecos.

- **Roy:** \( d = 450 - 55h \)
- **Travis:** \( d = 450 - 55(h - 0.4) \)

1. **Model with mathematics.** Graph the system of equations. Describe the graph.
Lesson 17-4
Systems Without a Unique Solution

2. What information about Travis and Roy does the graph provide?

3. How many solutions exist to the system of equations? How is this shown in the graph?

The system below represents a return trip from Dallas to Pecos, where \( d \) represents the distance from Pecos \( h \) hours after Roy leaves Dallas.

- Travis: \( d = 450 - 60h \)
- Roy: \( d = -10(6h - 45) \)

4. **Model with mathematics.** Graph the system of equations. Describe the graph.

5. What information about Travis and Roy does the graph provide?

6. How many solutions exist to the system of equations? How is this shown in the graph?
Lesson 17-4
Systems Without a Unique Solution

Check Your Understanding

7. Solve each system.
   a. \( y = 50 + 3x \)
   \( y = 100 - 2x \)
   b. \( x + 3y = 9 \)
   \( -3x + 2y = 8 \)

8. Tom leaves for Los Angeles averaging 65 mi/h. Michelle leaves for Los Angeles one hour later than Tom from the same location. She travels the same route averaging 70 mi/h. When will she pass Tom?

9. Juan bought a house for $200,000 and each year its value increases by $10,000. Tia bought a house for $350,000 and its value is decreasing annually by $5000. When will the two homes be worth the same amount of money?

10. Solve each system by graphing. If the lines are parallel, write no solution. If the lines are coincident, write infinitely many solutions.
   a. \( 4x + 2y = 10 \)
   \( y = -2x + 5 \)
   b. \( y - 2x = 4 \)
   \( y = 5 + 2x \)

LESSON 17-4 PRACTICE

Speedy Plumber charges $75 for a house call and $40 per hour for work done during the visit. Drains-R-Us charges $35 for a house call and $60 per hour for work done during the visit. Use this information for Items 11–13.

11. Reason quantitatively. Write and solve a system of equations to determine how many hours of work result in the same total cost for a house call from either company. What is the cost in this case? How many hours must each company work to charge the same amount?

12. Eliza has a coupon for $40 off the fee for a house call from Speedy Plumber. How does this change your answer to Item 11? Is the total cost for the two companies ever the same? If so, after how many hours?

13. Tyrone has a coupon that lowers the hourly rate for Drains-R-Us to $40 per hour. How does this change your answer to Item 11? Is the total cost for the two companies ever the same? If so, after how many hours?
Lesson 17-5
Classifying Systems of Equations

Learning Targets:
- Determine the number of solutions of a system of equations.
- Classify a system of linear equations as independent or dependent and as consistent or inconsistent.

SUGGESTED LEARNING STRATEGIES: Summarizing, Paraphrasing, Sharing and Responding, Interactive Word Wall, Predict and Confirm

When a system of two linear equations in two variables is solved, three possible relationships can occur.
- Two distinct lines that intersect produce one ordered pair as the solution.
- Two distinct parallel lines that do not intersect produce no solutions.
- Two lines that are coincident produce the same solution set—an infinite set of ordered pairs that satisfy both equations.

The three systems in the chart represent each of the possible relationships described above.

<table>
<thead>
<tr>
<th>Relationship of Lines</th>
<th>Sketch</th>
<th>Number of Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>two intersecting lines</td>
<td></td>
<td>one solution</td>
</tr>
<tr>
<td>two parallel lines</td>
<td></td>
<td>no solution</td>
</tr>
<tr>
<td>two coincident lines</td>
<td></td>
<td>infinitely many</td>
</tr>
</tbody>
</table>

1. Use the system \(4x - 2y = 21\) \(y - 2x = 10\) to answer parts a–d below.

a. Make use of structure. Write each equation in the system in slope-intercept form. Compare the slopes and y-intercepts.

b. Make a conjecture about the graph and the solution of this system.

MATH TERMS

The slope-intercept form of a linear equation is \(y = mx + b\); \(m\) is the slope of the line and \((0, b)\) is the y-intercept.
c. Check the conjecture from part b by graphing the system on a graphing calculator. Revise the conjecture if necessary.

d. Solve the system using either the substitution method or the elimination method. Describe the result.

2. Use the system \( \begin{align*}
2x &= -y + 1 \\
6x + 3y &= 3
\end{align*} \) to answer parts a–d below.

a. Write each equation in the system in slope-intercept form. Compare the slopes and y-intercepts.

b. Make a conjecture about the graph and the solution of this system.

c. Check the conjecture from part b by graphing the system on a graphing calculator. Revise the conjecture if necessary.

d. Solve the system using either the substitution method or the elimination method. Describe the result.

3. Write each equation in the system \( \begin{align*}
2x - y &= 6 \\
x &= 6 - y
\end{align*} \) in slope-intercept form.


5. Verify your answer to Item 4 by solving the system using any method. Revise your answer to Item 4 if necessary.

Systems of linear equations are classified by the relationships of their lines.
- Systems that produce two distinct lines when graphed are independent.
- Systems that produce coincident lines are dependent.
- Systems that have no solution are inconsistent. Systems that have at least one solution are consistent.

6. Classify the systems in Items 1, 2, and 3.
Lesson 17-5
Classifying Systems of Equations

7. For each system below, complete the table with the information requested.

<table>
<thead>
<tr>
<th>The Nature of Solutions to a System of Two Linear Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equations in Standard Form:</strong></td>
</tr>
<tr>
<td>(2x + y = 2) (6x + 3y = 6) (2x + y = 2) (x + y = 3) (2x + y = 2) (4x + 2y = -4)</td>
</tr>
<tr>
<td><strong>Graph Each System:</strong></td>
</tr>
<tr>
<td>![Graph 1] ![Graph 2] ![Graph 3]</td>
</tr>
<tr>
<td><strong>Write the Number of Solutions:</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Write the Relationship of the Lines:</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Solve Algebraically:</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Write the Equations in Slope-Intercept Form:</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Compare the Slopes and y-intercepts:</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Classify the System:</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Lesson 17-5
Classifying Systems of Equations

Check Your Understanding

For each system below:

a. Tell how many solutions the system has.
b. Describe the graph.
c. Classify the system.

8. \[2x - 2y = 6 \quad \text{and} \quad y - x = -3\]
9. \[y = 1.5x + 5 \quad \text{and} \quad 3x - 2y = 10\]
10. \[y = \frac{2}{3}x + 1 \quad \text{and} \quad 4x - 6y = -6\]
11. \[3x + 4y = 1 \quad \text{and} \quad 2x - 5y = 16\]

LESSON 17-5 PRACTICE

12. Solve the system \[3x + 4y = 8 \quad \text{and} \quad y = \frac{3}{4}x - 2\] using any method. Classify the system.

13. Approximate the point of intersection for the system of linear equations graphed below. Verify algebraically using substitution or elimination that the selected point is a solution for the system.

\[
\begin{align*}
y &= 2x - 1 \\
y &= -\frac{1}{2}x + 9
\end{align*}
\]

14. Monica claims that the system \[3x + y = 16 \quad \text{and} \quad 2x + 2y = 12\] has the same solutions as the system \[6x + 2y = 32 \quad \text{and} \quad 2x + 2y = 12\]. Explain how you can tell whether Monica is correct without solving the systems.

15. Find the solution of the system \[y = -\frac{2}{3}x + 1 \quad \text{and} \quad 2x + 5y = 3\] by any method. Classify the system.

16. Critique the reasoning of others. Kristen graphed the system \[y = 3x + 5 \quad \text{and} \quad 10y = 30x + 51\] on her graphing calculator. She saw a single line on the screen and concluded that the system was dependent and consistent. Do you agree or disagree? Explain.
ACTIVITY 17 PRACTICE

Write your answers on notebook paper. Show your work.

Lesson 17-1

1. Solve each system of linear equations.
   a. \( y = 3x - 4 \)
      \( y = \frac{2}{3}x + 9 \)
   b. \( x + y = 7 \)
      \( x - 3y = -1 \)

2. Which ordered pair is a solution to the system shown at right?
   \( y = \frac{2}{3}x + 3 \)
   \( y = -3x + 14 \)
   A. \((-3, 1)\)  B. \((5, -1)\)
   C. \((3, 5)\)  D. \((5, 3)\)

3. Which system’s solution is represented by the graphs shown below?

   A. \( y = 2x + 3 \)
      \( y = \frac{1}{5}x - 6 \)
   B. \( y = 2x - 6 \)
      \( y = \frac{1}{5}x + 3 \)
   C. \( y = 5x - 6 \)
      \( y = \frac{1}{2}x + 3 \)
   D. \( y = 5x + 3 \)
      \( y = \frac{1}{2}x - 6 \)

Lesson 17-2

4. A bushel of apples currently costs \$10 and the price is increasing by \$0.50 per week. A bushel of pears currently costs \$15 and the price is decreasing by \$0.25 per week. Which system of linear equations could be used to determine when the two fruits will cost the same amount per bushel?
   A. \( y = 0.5x + 10 \)
      \( y = -0.25x + 15 \)
   B. \( y = 0.25x + 15 \)
      \( y = -0.5x + 10 \)
   C. \( y = 10x + 0.5 \)
      \( y = 15x - 0.25 \)
   D. \( y = 5x + 3 \)
      \( y = \frac{1}{2}x - 6 \)

5. Ray starts walking to school at a rate of 2 mi/h. Ten minutes later, his sister runs after him with his lunch, averaging 6 mi/h.
   a. Write a system of linear equations to represent this situation.
   b. Solve the system to determine how much time it took Ray’s sister to catch up to him.

6. Colleen is in charge of ordering office supplies for her company. Last month she ordered ink cartridges and toner cartridges for the office printers. The cost of a toner cartridge is \$19.50 more than the cost of an ink cartridge. Colleen ordered 11 ink cartridges and 4 toner cartridges, and the total cost was \$460.50. Write and solve a system of equations to find the cost of each cartridge.
7. At Rocking Horse Ranch, admission is $45 and trail rides are $22.50 per hour. At Saddlecreek Ranch, admission is $30 and trail rides are $35 per hour.
   a. Write a system of equations that shows the total cost $c$ for a trail ride that lasts $h$ hours at each ranch.
   b. Solve your system from part a. Interpret the meaning of the solution in the context of the problem.
   c. Janelle has $125, and she wants to go on a three-hour trail ride. Which ranch should Janelle choose? Justify your answer.

Lesson 17-3

8. Lawrence has 10 coins in his pocket. One coin is a quarter, and the others are all nickels or dimes. The coins are worth 90 cents.
   a. Write a system that represents this situation.
   b. Solve the system to determine the number of dimes and nickels in Lawrence’s pocket.

9. Pedro placed an order with an online nursery for 6 apple trees and 5 azaleas and the order came to $147. The next order for 3 apple trees and 4 azaleas came to $96. What was the unit cost for each apple tree and for each azalea?

10. Jeremiah scored 28 points in yesterday’s basketball game. He made a total of 17 baskets. Some of the baskets were field goals (worth two points) and the rest were free throws (worth one point). Write and solve a system of equations to find the number of field goals and the number of free throws that Jeremiah made.

Lesson 17-4

11. Graph each system of linear equations and describe the solutions.
    a. $x + y = 3$ and $2x + 2y = 6$
    b. $2x + 3y = 6$ and $-x + y = -3$
    c. $x - 4y = 1$ and $2x - 9 = 8y$

12. Ming graphs a system of linear equations on his calculator. When he looks at the result, he sees only one line. Assuming he graphed the equations correctly, what could this mean?
    A. The system has infinitely many solutions.
    B. The system has no solution.
    C. The system has exactly one solution.
    D. Every possible ordered pair $(x, y)$ is a solution.

Lesson 17-5

13. Which is the best way to classify the system $y = 1.5x - 2$ and $3y = 4.5x - 7$?
    A. Independent and inconsistent
    B. Independent and consistent
    C. Dependent and inconsistent
    D. Dependent and consistent

14. Solve the system $3x + 4y = 8$ and $y = -\frac{3}{4}x + 2$ and classify the system.

15. The equation $3x - y = -1$ is part of a system of linear equations that is dependent and consistent. Write an equation that could be the other equation in the system.

16. Three friends decide to increase their exercise programs at the same time. Carolyn walks 7 miles per week and decides to increase the number of miles she walks by 1.5 miles per week. Eduardo walks 3 miles per week and decides to increase the number of miles he walks by 3.5 miles per week. Kendra walks 5 miles per week and decides to increase the number of miles she walks by 3.5 miles per week.
   a. Write and solve a system of equations to determine how many weeks it will be until Carolyn and Eduardo are walking the same distance each week.
   b. Write a system of equations you could use to determine how many weeks it will be until Eduardo and Kendra are walking the same distance each week.
   c. Classify the systems you wrote in parts a and b.
   d. Describe what would happen if you tried to solve the system you wrote in part b using the graphing method.

MATHEMATICAL PRACTICES
Look for and Make Use of Structure

17. Explain how you can determine whether a system of two linear equations has a unique solution by examining the equations.
### Learning Targets:
- Determine whether an ordered pair is a solution of a system of linear inequalities.
- Graph the solutions of a system of linear inequalities.

**SUGGESTED LEARNING STRATEGIES:** Create Representations, Look for a Pattern, Discussion Groups, Quickwrite, Graphic Organizer

1. Graph each inequality on the number lines and grids.

<table>
<thead>
<tr>
<th>Inequality</th>
<th>Graph all $x$</th>
<th>Graph all $(x, y)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x &lt; 2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$x \geq -3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$x &lt; 2$ and $x \geq -3$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Compare and contrast the graphs you made in the third row of the table. In your explanation, compare the graphs to those in the first two rows and use the following words: dimension, half-line, half-plane, open, closed, and intersection.
Lesson 18-1
Representing the Solution of a System of Inequalities

3. On the coordinate grid, graph the solutions common to the inequalities $y \leq 4$ and $y > 1$.

Solving a **system of linear inequalities** means finding all solutions that are common to all inequalities in the system.

4. **Reason quantitatively.** For the inequalities below, complete the table showing whether each ordered pair is a solution of the system of inequalities by deciding whether the ordered pair is a solution of both inequalities. Justify your responses.

   $x + y > 2$
   $2x - y \geq -5$

<table>
<thead>
<tr>
<th>Ordered Pair</th>
<th>Is it a Solution?</th>
<th>Why or Why Not?</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(-2, -3)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$(3, 2)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$(3, -1)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$(0, 5)$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. **Make use of structure.** Find two more solutions of the system in Item 4.
Lesson 18-1
Representing the Solution of a System of Inequalities

Since a system of inequalities has infinitely many solutions, you can represent all solutions using a graph. To solve a system of inequalities, graph each inequality on the same coordinate grid by shading a half-plane. The region that is the intersection of the two shaded half-planes, called the solution region, represents all solutions of the system.

Example A
Solve the system of inequalities.
\[ x + y \geq 1 \]
\[ x - 3y > 3 \]
Step 1: First, graph \( x + y \geq 1 \).

Step 2: Next, graph \( x - 3y > 3 \).

Step 3: Identify the solution region.

Solution: The solution region is the double shaded region shown in Step 3.
Lesson 18-1
Representing the Solution of a System of Inequalities

Try These A
Solve each system of inequalities using the coordinate grids in the My Notes section.

a. \[ \begin{align*}
    x + y &> 2 \\
    2x - y &\geq -5
\end{align*} \]

b. \[ \begin{align*}
    y &\geq x - 1 \\
    y &\leq -\frac{1}{2}x + 2
\end{align*} \]

c. \[ \begin{align*}
    2x + 3y &> 6 \\
    x - 2y &< 4
\end{align*} \]

6. The system in Try These Part (a) is the same as the system in Item 4. Plot the points listed in Items 4 and 5 on the graph you made for Try These A part a. Where do the points that are solutions lie? Where do the points that are not solutions lie? Give three additional points that are solutions.

Check Your Understanding

7. The graph below shows the solution of a system of inequalities.

a. Name an ordered pair that is a solution of the system.

b. Name an ordered pair that is not a solution of the system.

c. Is the ordered pair \((0, 3)\) a solution of the system? Explain how you know.

Solve each system of inequalities.

8. \[ \begin{align*}
    y &< 2x - 1 \\
    y &\geq -x
\end{align*} \]

9. \[ \begin{align*}
    3x + y &< 3 \\
    x - y &> 1
\end{align*} \]

10. \[ \begin{align*}
    y &\geq \frac{2}{3}x + 4 \\
    x + 2y &< 6
\end{align*} \]
Lesson 18-1
Representing the Solution of a System of Inequalities

LESSON 18-1 PRACTICE

Solve each system of inequalities.

11. \[ y \geq x - 3 \]
   \[ y \leq \frac{1}{2}x + 1 \]

12. \[ 3x + 3y > 1 \]
   \[ 2y < 11 \]

13. \[ y < \frac{1}{3}x \]
   \[ x + y \geq -2 \]

14. Name three ordered pairs that are solutions of the system of inequalities shown below.
   \[ y < 4x + 4 \]
   \[ x - y > 3 \]

15. Write a system of inequalities whose solution is shown by the overlapping regions in the graph below.

16. Critique the reasoning of others. A student was asked to solve the system \[ y \geq \frac{1}{2}x + 4 \] and \[ x + 4y \leq -20 \]. She made the graph shown below. She noticed that the two shaded regions do not overlap, so she concluded that the system of inequalities has no solution. Do you agree or disagree? Justify your reasoning.
**Learning Targets:**

- Identify solutions to systems of linear inequalities when the solution region is determined by parallel lines.
- Interpret solutions of systems of linear inequalities.

**SUGGESTED LEARNING STRATEGIES:** Create Representations, Look for a Pattern, Discussion Groups, Close Reading, Marking the Text

As you share your ideas, be sure to use mathematical terms and academic vocabulary precisely. Make notes to help you remember the meaning of new words and how they are used to describe mathematical concepts.

1. Determine the solutions to the systems of inequalities by graphing.
   a. \[ y > \frac{1}{2}x + 2 \]
   \[ x - 2y > 8 \]

2. Compare and contrast the systems in Items 1a and 1b.
3. Ray plays on the basketball team. Last week, he scored all of his points from free throws (worth one point each) and field goals (worth two points each). He has forgotten how many points he scored, but he remembers some facts from the game. Review with your group the background information that is given as you solve the items below.

a. **Reason abstractly.** Let $f$ represent the number of free throws and $g$ represent the number of field goals. Write an inequality for each of the facts below.

   Ray scored fewer than 20 points.

   $f + 2g < 20$

   Ray made fewer than six free throws.

   $f < 6$

   At most, Ray made twice as many free throws as he made field goals.

   $f \leq 2g$

b. Graph the solutions to the system represented by your inequalities from part a.

   ![Graph of inequalities](image)

   $f + 2g < 20$
   $f < 6$
   $f \leq 2g$

   $g$ range: 0 to 20
   $f$ range: 0 to 20

   Solution region: Quadrant II

   Solution points: (0, 10), (2, 8), (4, 6), (6, 4), (8, 3), (10, 2), (12, 1), (14, 0)

   The point (10, 0) is not in the solution region.

   Solutions that make sense: (0, 10), (2, 8), (4, 6), (6, 4), (8, 3), (10, 2), (12, 1), (14, 0).

   Solution that does not make sense: (10, 0).

   Reason: The point (10, 0) represents an impossible combination of free throws and field goals for Ray to have scored fewer than 20 points.

   Ray could not have scored fewer than 20 points because he scored 0 free throws and 10 field goals, which is already more than 20 points.

   Reason quantitatively. In the solution region you graphed in part b not every point makes sense in this context. Give two solutions that make sense in the context of the problem and one that does not. Explain your reasoning.
Lesson 18-2
Interpreting the Solution of a System of Inequalities

Check Your Understanding

4. Use guess and check to identify an ordered pair that is a solution to the system of inequalities.

\[ 3x + y \geq 6 \]
\[ x + 3y < 3 \]

5. Solve the system in Item 4 by graphing. Confirm that the ordered pair you wrote in Item 4 is a solution. Explain.

6. Solve the system of linear inequalities.

\[ y > 2x - 3 \]
\[ y < 4x - 3 \]

7. Write a system of inequalities whose solution region is all the points in the third quadrant.

LESSON 18-2 PRACTICE

Catherine bought apples and pears for a school picnic. The total number of pieces of fruit that she bought was less than 100. She bought more apples than pears. Use this information for Items 8–11.

8. Model with mathematics. Write a system of inequalities that describes the situation. Let \( x \) represent the number of apples Catherine bought and let \( y \) represent the number of pears Catherine bought.

9. Graph the solutions of the system you wrote in Item 8.

10. Give two ordered pairs from the solution region that make sense in the context of the problem.

11. Give an ordered pair from the solution region that does not make sense in the context of the problem. Explain why the ordered pair does not make sense.

12. Describe the solution region of the system of the inequalities \(-x + 2y \leq 6\) and \(2y \geq x + 6\).
Solving Systems of Linear Inequalities
Which Region Is It?

ACTIVITY 18 PRACTICE
Write your answers on notebook paper. Show your work.

Lesson 18-1

1. Determine which of the following ordered pairs are solutions to each of the given systems of inequalities.
   \{(5, 3), (-2, 1), (1, 2), (2, -3), (3, 5), (-2, 3), (2, 0)\}
   a. \(y < -x + 3\)
      \(y \geq x - 2\)
   b. \(2x - y \leq 0\)
      \(y > -\frac{1}{2}x + 1\)
   c. \(3x - y > 6\)
      \(y \leq 3\)

2. Graph each of the systems of inequalities in Item 1. Graph the points that you chose as solutions from Item 1 on the same coordinate grid to verify that they are solutions.

3. Identify four ordered pairs that are solutions to the following system of equations. Explain how you chose your points.
   \[\begin{align*}
   4x + 3y &\geq -12 \\
   2x - y &< 4
   \end{align*}\]

4. Solve the following systems of inequalities.
   a. \(2x + 3y \geq 15\)
      \(5x - y \geq 3\)
   b. \(x - 4y \geq 4\)
      \(4y - x > 8\)

5. Tickets for the school play cost $3 for students and $6 for adults. The drama club hopes to bring in at least $450 in sales, and the auditorium has 120 seats. Let \(a\) represent the number of adult tickets, and let \(s\) represent the number of student tickets.
   a. Write a system of inequalities representing this situation.
   b. Show the solutions to the system of inequalities by graphing.
   c. If the show sells out, what is the greatest number of student tickets that could be sold to get the desired amount of sales?

6. Which system of inequalities represents all of the points in the second quadrant?
   A. \(x > 0, y < 0\)  B. \(x > 0, y > 0\)
   C. \(x < 0, y < 0\)  D. \(x < 0, y > 0\)

7. Which graph represents the system of inequalities shown?
   \[\begin{align*}
   2x - y &> 3 \\
   x + y &> 4
   \end{align*}\]
8. Which system of inequalities has the solution region shown in the graph below?

A. \(3y < x \quad x + y > 2\)
B. \(3y < x \quad x + y > -2\)
C. \(3y > x \quad x + y > 2\)
D. \(3y > x \quad x + y > -2\)

9. The graph shows the solution of a system of inequalities. Which statement is true?

A. \((2, -2)\) is a solution.
B. The origin is not a solution.
C. Any ordered pair with a negative \(x\)-coordinate is a solution.
D. \((2, -4)\) is not a solution.

10. Consider the system of inequalities shown below.
\[
\begin{align*}
x + 2y &\leq 6 \\
x + 2y &\geq -2
\end{align*}
\]

a. Graph the solution of the system of inequalities.
b. Describe the solution region.
c. Name three ordered pairs that are solutions of the system.
d. How would the solution be different if the inequality signs were reversed? That is, what is the solution of the system \(x + 2y \geq 6\) and \(x + 2y \leq -2\)? Explain why your answer makes sense.

11. Connor bought used books from a Web site. The paperbacks cost $2 each, and the hardcovers cost $3 each. He spent no more than $90 on the books, and he bought no more than 35 books.

a. Write a system of inequalities to represent the situation. State what the variables represent.
b. Graph the solution of the system of inequalities you wrote in part a.
c. Name two ordered pairs that are solutions. Interpret the meaning of each ordered pair in the context of the problem.
d. Suppose you know that Connor spent exactly $90 and that he bought exactly 35 books. What can you conclude in this case? Why?

12. a. Write a system of linear inequalities that has no solutions.
b. Is it possible for a system of linear inequalities with no solutions to have nonparallel boundary lines? If so, explain why and give an example. If not, explain why not. (Hint: Consider coincident boundary lines.)

**MATHEMATICAL PRACTICES**

**Attend to Precision**

13. Explain why graphing is the preferred method of representing the solutions of a system of linear inequalities.
1. Rajesh and his brother Mohib are each mailing a birthday gift to a friend. Rajesh’s package weighs three more pounds than twice the weight of Mohib’s package. The combined weight of both packages is 15 pounds.
   a. Write a system to represent this situation. Define each variable that you use.
   b. Solve the system using substitution or elimination to determine the weight of each package. Justify the reasonableness of your solution.
   c. Rajesh and Mohib each graph the system that represents this situation. Who is correct? Explain why.

![Graphs of Rajesh's and Mohib's packages]

Rajesh’s Graph
Mohib’s Graph

2. Rajesh and Mohib will mail rectangular packages that meet the weight and height requirements of their delivery service. Their packages are described in the table.

<table>
<thead>
<tr>
<th></th>
<th>Height</th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rajesh’s package</td>
<td>7 in.</td>
<td>18 in.</td>
<td>15 in.</td>
</tr>
<tr>
<td>Mohib’s package</td>
<td>8 in.</td>
<td>19 in.</td>
<td>13 in.</td>
</tr>
</tbody>
</table>

   a. The delivery service also requires that both the length and width of the packages be 20 inches or less and that the length plus the width be no more than 32 inches. Write a system of inequalities to represent this situation.
   b. Graph the system from part a to show all of the possible dimensions of length and width that the packages could have.
   c. Is either package unacceptable? Justify your answer using the table or the graph.
<table>
<thead>
<tr>
<th>Scoring Guide</th>
<th>Exemplary</th>
<th>Proficient</th>
<th>Emerging</th>
<th>Incomplete</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mathematics Knowledge and Thinking</strong> (Items 1b, 2b)</td>
<td>Effective understanding of and accuracy in solving systems of equations and inequalities</td>
<td>Adequate understanding of and accuracy in solving systems of equations and inequalities</td>
<td>Partial understanding of and some difficulty solving systems of equations and inequalities</td>
<td>Incomplete understanding of and significant difficulty solving systems of equations and inequalities</td>
</tr>
<tr>
<td><strong>Problem Solving</strong> (Items 1b, 2c)</td>
<td>Appropriate and efficient strategy that results in a correct answer</td>
<td>Strategy that may include unnecessary steps but results in a correct answer</td>
<td>Strategy that results in some incorrect answers</td>
<td>No clear strategy when solving problems</td>
</tr>
<tr>
<td><strong>Mathematical Modeling / Representations</strong> (Items 1a, 2a)</td>
<td>Fluency in representing real-world scenarios using systems of equations and inequalities</td>
<td>Little difficulty representing a real-world scenario using systems of equations and inequalities</td>
<td>Partial understanding of how to represent real-world scenarios using systems of equations and inequalities</td>
<td>Little or no understanding of how to represent real-world scenarios using systems of equations and inequalities</td>
</tr>
<tr>
<td><strong>Reasoning and Communication</strong> (Items 1c, 2c)</td>
<td>Precise use of appropriate math terms and language to identify and explain an error</td>
<td>Correct identification of an error with an adequate explanation</td>
<td>Misleading or confusing explanation of an error</td>
<td>Inaccurate identification of an error with an incomplete or inaccurate explanation</td>
</tr>
<tr>
<td></td>
<td>Ease and accuracy describing the relationship between a table or a graph and a real-world scenario</td>
<td>Little difficulty describing the relationship between a table or a graph and a real-world scenario</td>
<td>Partially correct description of the relationship between a table or a graph and a real-world scenario</td>
<td>Little or no understanding of how a table or a graph might relate to a real-world scenario</td>
</tr>
</tbody>
</table>