LESSON 22: Graphing Linear Inequalities

[Objective]

The student will be introduced to the concept of graphing inequalities on a coordinate plane.

[Materials]

Student pages **S186–S195**
Transparencies **T483, T485, T487, T489, T492, T493**
Wall-size four-quadrant grid
Optional: graphing calculators

[Essential Questions]

1. What is a difference between a linear equation and a linear inequality?
2. How are linear inequalities similar to linear equations?

[Grouping]

Cooperative Pairs, Whole Group, Individual

[Levels of Teacher Support]

Modeling (M), Guided Practice (GP), Independent Practice (IP)

[Multiple Representations]

SOLVE, Graph, Algebraic Formula, Verbal Description

[Warm-Up] (5 minutes – IP) S186 (Answers on T482.)

- Have students turn to S186 in their books to begin the Warm-Up. Students will practice solving and graphing inequalities on a number line. Monitor students to see if any of them need help during the Warm-Up. Give students 3 minutes to complete the problems and then spend 2 minutes reviewing the answers as a class. **{Graph, Algebraic Formula}**

[Homework]: (5 minutes)

Take time to go over the homework from the previous night.

[Lesson]: (50–55 minutes – M, GP, IP)

SOLVE Problem (5 minutes – M, GP) T483, S187 (Answers on T484.)

Have students turn to S187 in their books, and place T483 on the overhead. The first problem is a SOLVE problem. You are only going to complete the S step with students at this point. Tell students that during the lesson they will learn how to graph inequalities on a coordinate grid. They will use this knowledge to complete this SOLVE problem at the end of the lesson. **{SOLVE}**

Linear Inequalities (12 minutes – M, GP) T483, S187 (Answers on T484.)

Use the following modeling activities to model for students how to graph an inequality on a coordinate grid and how to determine whether or not a point is a solution to the inequality. **{Graph, Algebraic Formula, Verbal Description}**

MODELING

Linear Inequalities

Step 1: Remind students that to graph a linear **equation**, they need to first solve the equation for y. When the equation for the line is in slope-intercept form ($y = mx + b$), students know where to start the graph because they know the y-intercept, b, and they can use the slope, m, to find other points on the line. Explain that students must do the same thing to graph linear **inequalities.** Students must solve the inequality for y so they can find the y-intercept and the slope.

Direct students' attention to the inequality in Example 1. The inequality is already in slope-intercept form ($y > x + 1$). Have students identify the slope and y-intercept. m (slope) = 1, b (y-intercept) = 1.

Step 2: Have students make a point at the y-intercept (0, 1) and then use the slope of $1 = \frac{1}{1}$ (which means rise 1, run 1) to find other points. Before students connect the points with a line, explain that, with inequalities, the line can be solid or dotted. Explain that, if the inequality is < (less than) or > (greater than), then the line is dotted. If the inequality is ≤ (less than or equal to) or ≥ (greater than or equal to), then the line is solid. For Example 1, have students connect the points with a dotted line.
Optional: Graph on the wall-size four-quadrant grid.

Step 3: Explain to students that it is necessary to check a point in the graph to see if the x- and y-values for the point make a correct statement. If it is a correct statement, then students shade the side of the graph which contains the point. If it is an incorrect statement, then students shade the side of the graph which does not contain the point.

For Example 1, model how to test the point (0, 0) by plugging the x- and y-values into the inequality: $0 > 0 + 1$. These values do not make a correct statement, so students should shade the side of the graph which does not contain (0, 0). Model how to shade the graph to show all of the solutions.

Repeat the steps above to model how to graph the inequalities in Examples 2 and 3. For Example 2, students will first need to write the inequality in slope-intercept form. For Example 3, the line will be horizontal.

Graph Inequalities

(7 minutes – GP, IP) T485, S188 (Answers on T486.)

5 minutes – IP: Have students turn to S188 in their books and graph the inequalities in Problems 1 and 2 in cooperative pairs. Remind students that it is much easier to graph a line when its equation is in slope-intercept form, $y = mx + b$. Once the equation is in slope-intercept form, students should make a point at the y-intercept and then use the slope, $\frac{\text{rise}}{\text{run}}$, to find other points. The vertical line in Problem 1 might confuse some students. Monitor them closely and provide help as needed. Review students' graphs to make sure they are correct. **{Graph, Algebraic Formula, Verbal Description}**

2 minutes – GP: Answer the questions below each graph as a class. Make sure to discuss the differences between each type of inequality.

More Graphing

(7 minutes – GP, IP) T487, S189 (Answers on T488.)

5 minutes – IP: Have students turn to S189 in their books and graph the inequalities and answer the questions either in cooperative pairs or independently. The vertical line in Problem 4 might confuse some students. Monitor them closely to make sure they do not need help. Review students' graphs to make sure they are correct. **{Graph, Algebraic Formula, Verbal Description}**

2 minutes – GP: Use 2 minutes to review the answers.

More Graphing

(9 minutes – IP) T489, S190 (Answers on T490.)

Have students turn to S190 (T489) in their books and complete Examples 1–3 in cooperative pairs. If students are having problems, you could complete the problems as a class. Give students 6 minutes to complete the problems. Use 3 minutes to review the answers. **{Graph, Algebraic Formula, Verbal Description}**

If time permits... **(5 minutes – IP) S191 (Answers on T491.)**

3 minutes – IP: Have students turn to S191 in their books and complete Problems 1–3 independently or in cooperative pairs. Make sure students show their work. **{Graph, Algebraic Formula}**

2 minutes: Review the answers to the problems as a class.

Instructions for the graphing calculator are included on S192 and T492. Please use these if they are appropriate for your students.

SOLVE Problem **(10 minutes – GP) T493, S193 (Answers on T494.)**

Remind students that the SOLVE problem is the same one from the beginning of the lesson. Complete the SOLVE problem with your students. Ask them for possible connections from the SOLVE problem to the lesson. (By graphing the inequality, students can find the solutions.) **{SOLVE, Graph, Algebraic Formula, Verbal Description}**

[Closure]: (5 minutes)

- To wrap up the lesson, go back to the essential questions and discuss them with students.
  - What is a difference between a linear equation and a linear inequality? *(The solution to a linear inequality is an entire section of the coordinate plane. The line can be dotted in a linear inequality.)*
  - How are linear inequalities similar to linear equations? *(We use $y = mx + b$ to find the y-intercept and slope when graphing both linear equations and linear inequalities.)*

[Homework]: Assign S194 and S195 for homework. (Answers on T495, T496.)

[Quiz Answers] T497–T502

1. A 2. A 3. B 4. C 5. D 6. C 7. C 8. D 9. D 10. B

The quiz can be used at any time as extra homework or to see how the students did on understanding how to graph linear inequalities.

Here is the key to **S186**.

Warm–Up

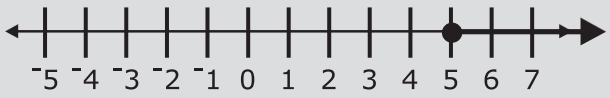
Directions: Solve and graph the inequalities.

1. $2x - 3 \geq 7$

$+3 \quad +3$

$\frac{2x}{2} \geq \frac{10}{2}$

$x \geq 5$



2. $-2x + 1 > -1$

$-1 \quad -1$

$\frac{-2x}{-2} > \frac{-2}{-2}$

$x < 1$

3. $\frac{-x}{2} - 3 \geq -1$

$+3 \quad +3$

$2 \bullet \frac{-x}{2} \geq 2 \bullet 2$

$\frac{-x}{-1} \geq \frac{4}{-1}$

$x \leq -4$

4. $-3x + 6 < 9$

$-6 \quad -6$

$\frac{-3x}{-3} < \frac{3}{-3}$

$x > -1$

TRANSPARENCY MASTER

Directions: Complete the following SOLVE problem with your teacher. You will only complete the S step.

Shane is going to the movies with his friends. His mom gave them $15.00 for snacks. Drinks cost $2.00 each and candy costs $3.00 each. How many of each can Shane buy?

S Underline the question.

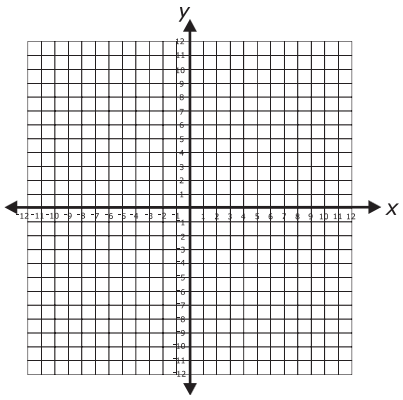
This problem is asking me to find _____.

Directions: Complete the rest of this page with your teacher.

Example 1: $y > x + 1$

Is (0, 0) a solution?

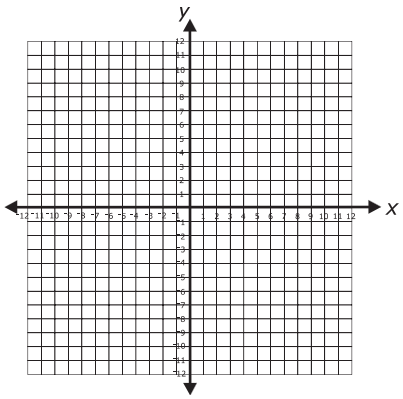
_____



Example 2: $2x - y \geq 4$

Is (1, 2) a solution?

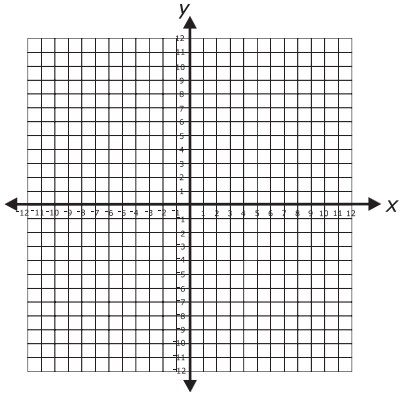
_____



Example 3: $y > 2$

Is (3, 2) a solution?

_____



LESSON 22: Graphing Linear Inequalities

Here is the key to **S187**.

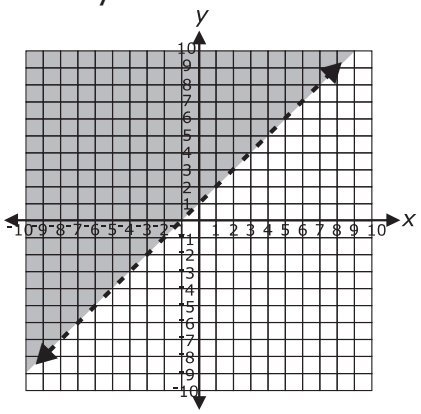
Directions: Complete the following SOLVE problem with your teacher. You will only complete the S step.

Shane is going to the movies with his friends. His mom gave them $15.00 for snacks. Drinks cost $2.00 each and candy costs $3.00 each. How many of each can Shane buy?

S Underline the question.
This problem is asking me to find **the number of drinks and candy he can buy.**

Directions: Complete the rest of this page with your teacher.

Example 1: $y > x + 1$



Is (0, 0) a solution?

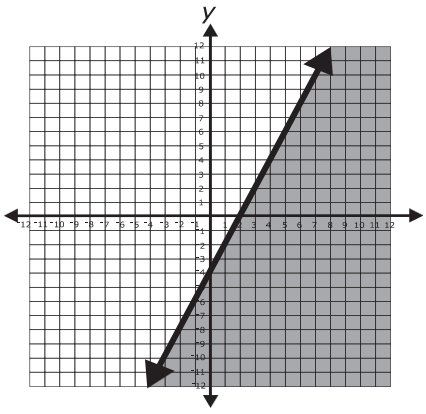
No

Example 2: $2x - y \geq 4$

$$\frac{-2x \qquad -2x}{}$$

$$\frac{-y}{-1} \geq \frac{-2x}{-1} + \frac{4}{-1}$$

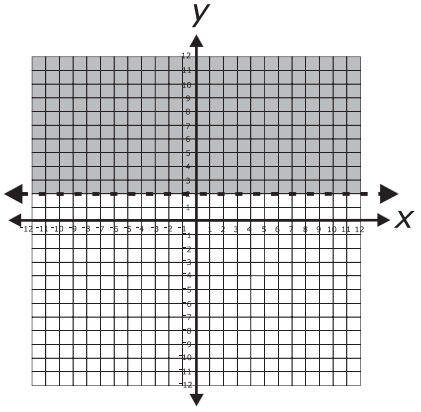
$$y \leq 2x - 4$$



Is (1, 2) a solution?

No

Example 3: $y > 2$



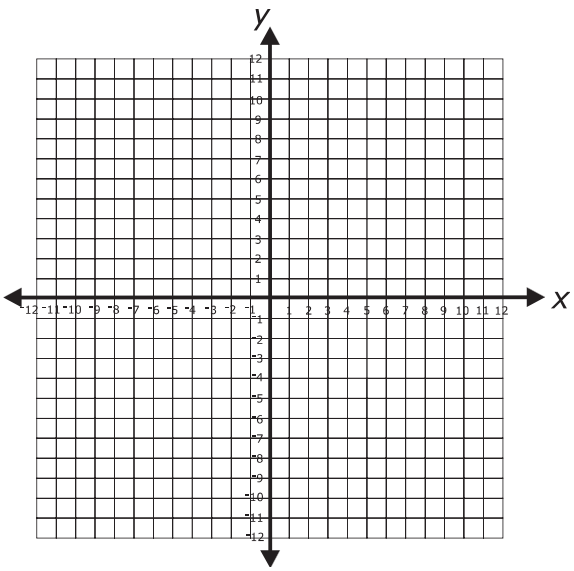
Is (3, 2) a solution?

No, because it is on the dotted line.

TRANSPARENCY MASTER

Directions: Graph each inequality. Answer the questions under each problem.

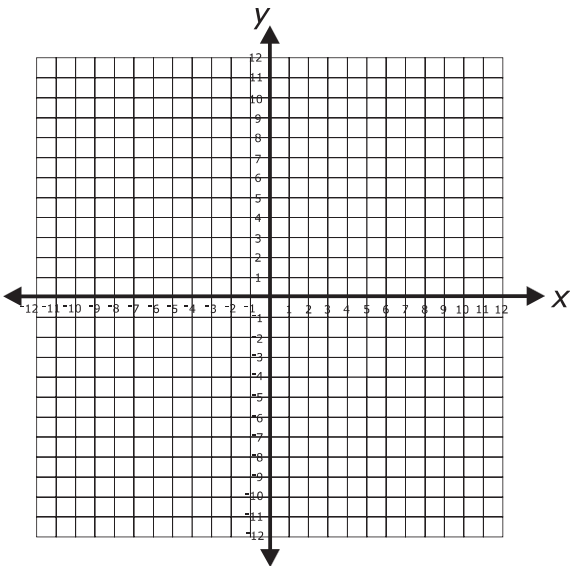
1. $x > 3$



a) What difference(s) would there be if the inequality were $x < 3$?

b) What difference(s) would there be if the inequality were $x \geq 3$?

2. $y \leq 2x$



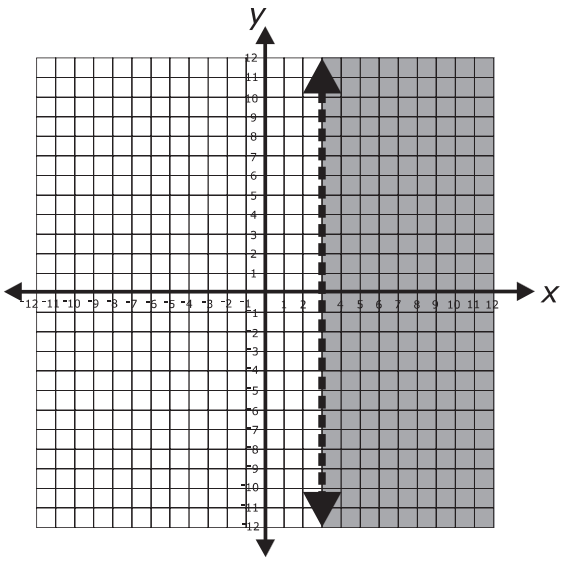
a) What difference(s) would there be if the inequality were $y \geq 2x$?

b) What difference(s) would there be if the inequality were $y < 2x$?

Here is the key to **S188**.

Directions: Graph each inequality. Answer the questions under each problem.

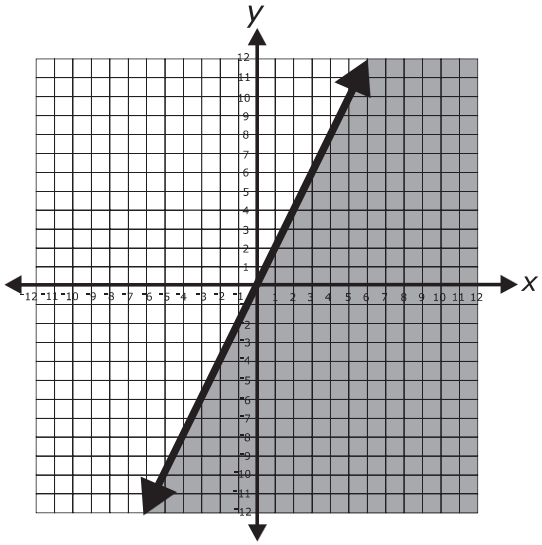
1. $x > 3$



a) What difference(s) would there be if the inequality were $x < 3$?
The graph would be shaded on the opposite side.

b) What difference(s) would there be if the inequality were $x \geq 3$?
The line would be solid, rather than dotted.

2. $y \leq 2x$



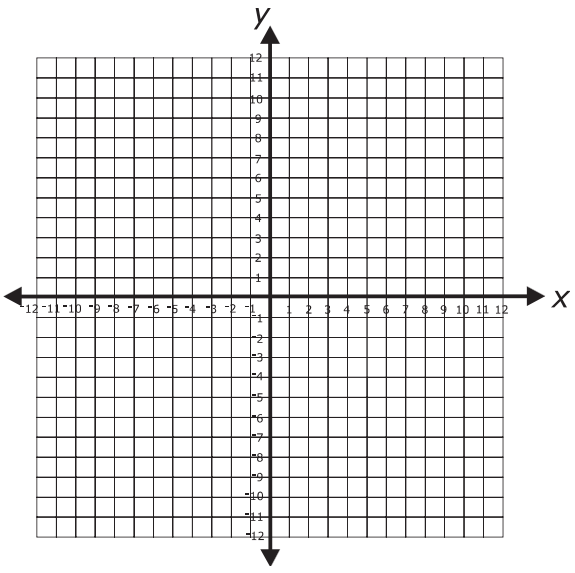
a) What difference(s) would there be if the inequality were $y \geq 2x$?
The graph would be shaded on the opposite side.

b) What difference(s) would there be if the inequality were $y < 2x$?
The line would be dotted, rather than solid.

TRANSPARENCY MASTER

Directions: Graph each inequality. Answer the questions under each problem.

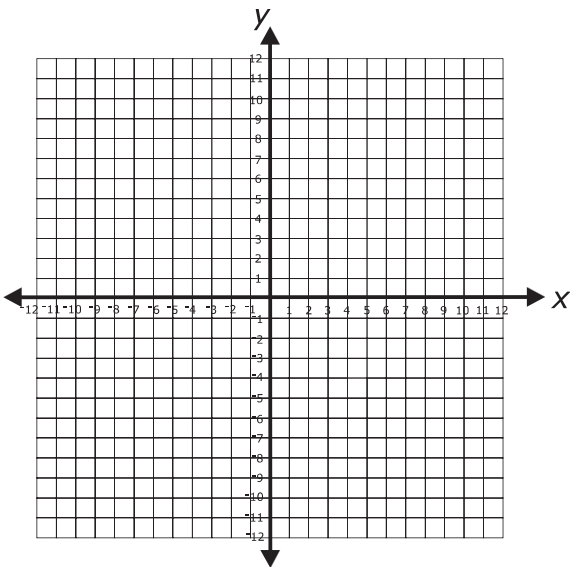
3. $x - y < 2$



a) What difference(s) would there be if the inequality were $x - y > 2$?

b) What difference(s) would there be if the inequality were $x - y \leq 2$?

4. $x > -1$



a) What difference(s) would there be if the inequality were $x < -1$?

b) What difference(s) would there be if the inequality were $x \geq -1$?

Here is the key to **S189**.

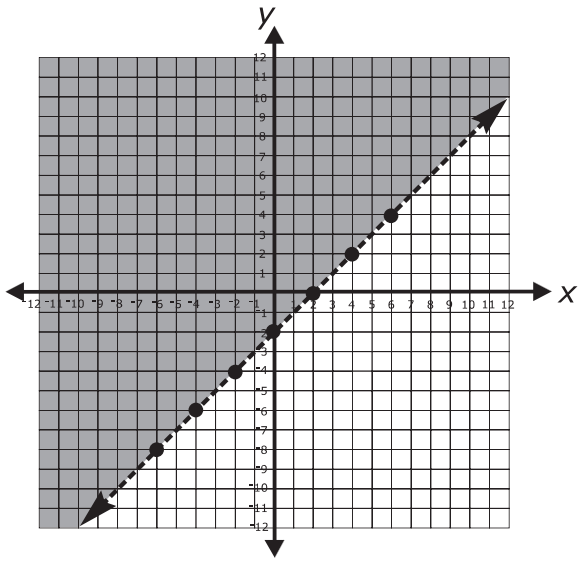
Directions: Graph each inequality. Answer the questions under each problem.

3. $x - y < 2$

$$\begin{array}{r} -x \quad -x \\ \hline \end{array}$$

$$\frac{-y}{-1} < \frac{-x}{-1} + \frac{2}{-1}$$

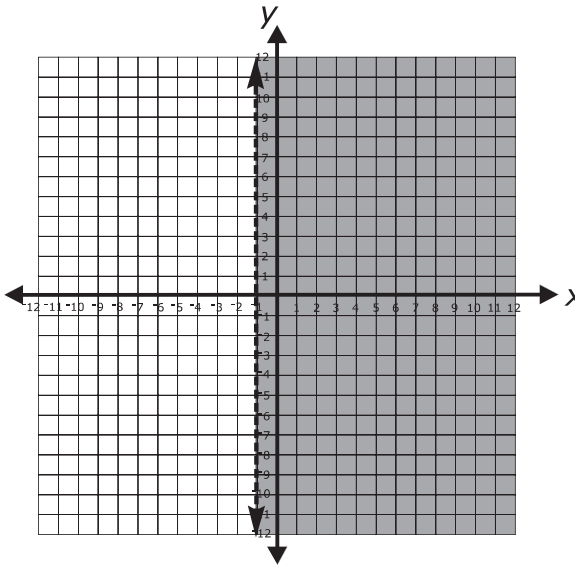
$$y > x - 2$$



a) What difference(s) would there be if the inequality were $x - y > 2$?
The graph would be shaded on the opposite side.

b) What difference(s) would there be if the inequality were $x - y \leq 2$
The line would be solid, rather than dotted.

4. $x > -1$



a) What difference(s) would there be if the inequality were $x < -1$?
The graph would be shaded on the opposite side.

b) What difference(s) would there be if the inequality were $x \geq -1$?
The line would be solid, rather than dotted.

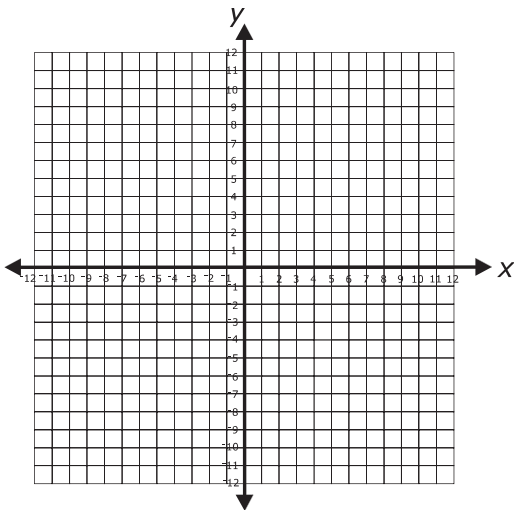
TRANSPARENCY MASTER

Directions: Work with your partner to graph each inequality.

Example 1: $y \geq x - 2$

Is (2, 2) a solution?

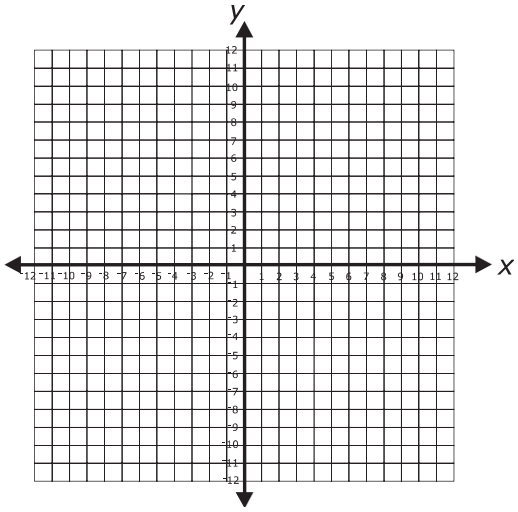
_____



Example 2: $2x + y < 0$

Is (¯1, 2) a solution?

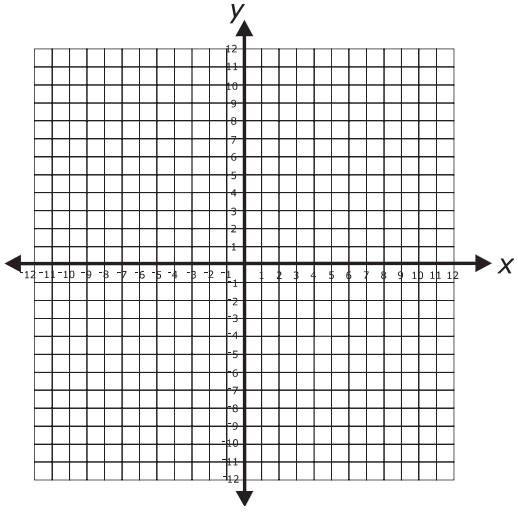
_____



Example 3: $4x - 2y \leq 6$

Is (0, 0) a solution?

_____



LESSON 22: Graphing Linear Inequalities

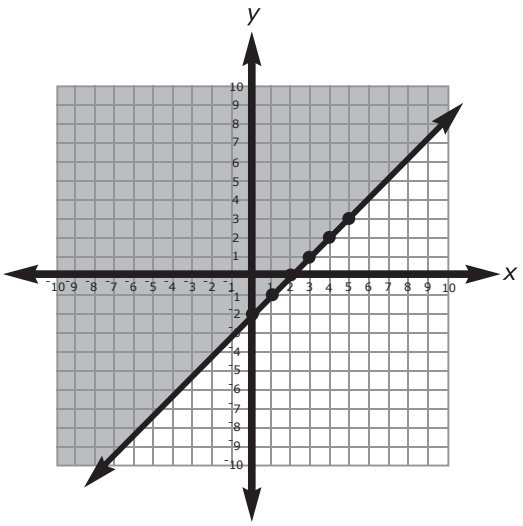
Here is the key to **S190**.

Directions: Work with your partner to graph each inequality.

Example 1: $y \geq x - 2$

Is (2, 2) a solution?

Yes

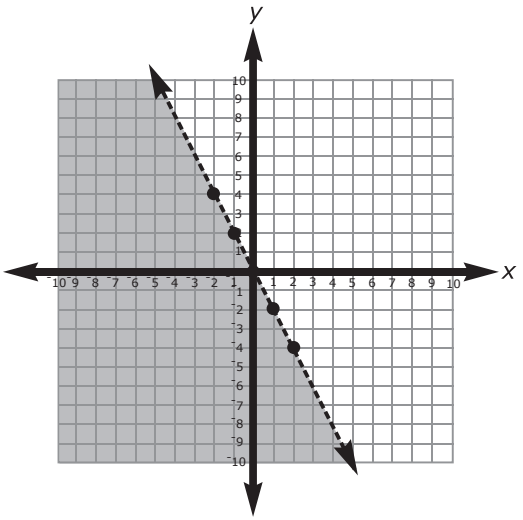


Example 2: $2x + y < 0$

$$\underline{-2x \qquad -2x}$$
$$y < -2x$$

Is (-1, 2) a solution?

No

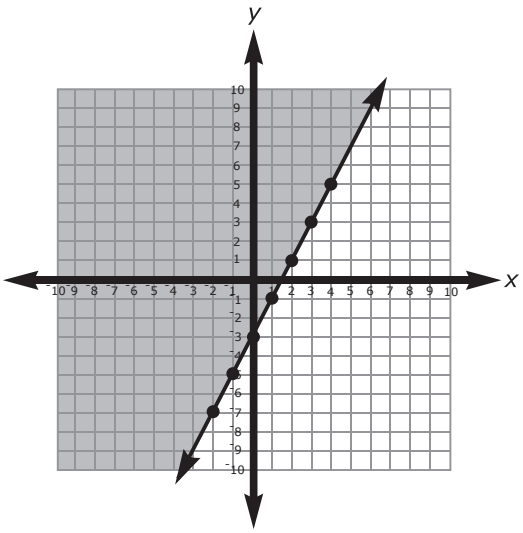


Example 3: $4x - 2y \leq 6$

$$\underline{-4x \qquad -4x}$$
$$\frac{-2y}{-2} \leq \frac{-4x}{-2} + \frac{6}{-2}$$
$$y \geq 2x - 3$$

Is (0, 0) a solution?

Yes



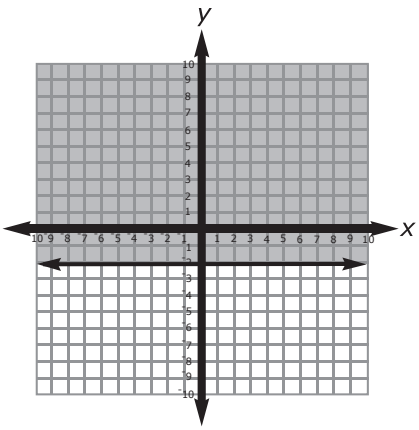
Here is the key to **S191**.

Directions: Match each inequality with the correct graph below.

1. $3x + 5 < y$

2. $2x + y \geq 1$

3. $y \geq -2$



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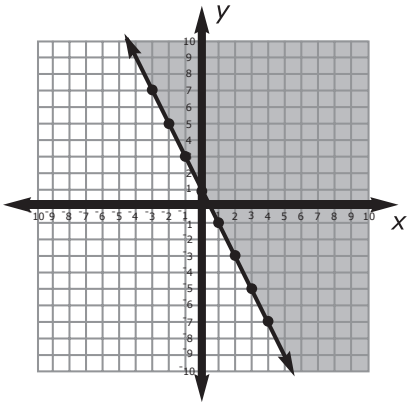

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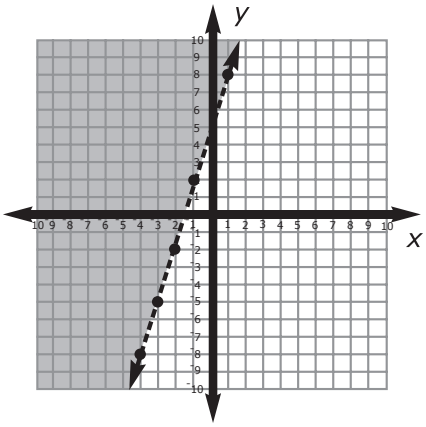

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TRANSPARENCY MASTER

Graphing Calculator Instructions

Inequalities

Steps:

1. Y=

2. ◁ ◁ to the \ before y=

3. Press ENTER until you get to the symbol you want to use.

   a. \ standard line

   b. thick line

   c. greater than

   d. less than

   e. –0 draws the line (can pause drawing by pressing ENTER)

   f. 0 draws the line (invisible)

   g. dotted line

   Your graphing calculator will not show a difference between a solid or dotted line when graphing an inequality.

4. Go back to the right side of y= and enter the rest of the inequality.

5. GRAPH

TRANSPARENCY MASTER

Directions: Complete the following SOLVE problem with your teacher.

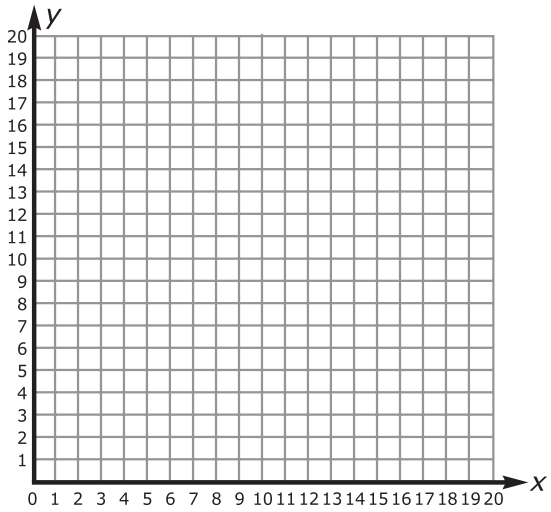
Shane is going to the movies with his friends. His mom gave them $15.00 for snacks. Drinks cost $2.00 each and candy costs $3.00 each. How many of each can Shane buy?

S Underline the question.
This problem is asking me to find _____.

O Identify the facts.
Eliminate the unnecessary facts.
List the necessary facts.

L Choose an operation or operations.
Write in words what your plan of action will be.

V Estimate your answer.
Carry out your plan.



E Does your answer make sense? (Compare your answer to the question.)
Is your answer reasonable? (Compare your answer to the estimate.)
Is your answer accurate? (Check your work.)
Write your answer in a complete sentence.

Here is the key to **S193**.

Directions: Complete the following SOLVE problem with your teacher.

~~Shane is going to the movies with his friends~~. **|**His mom gave them $15.00 for snacks. **|**Drinks cost $2.00 each and candy costs $3.00 each. **|**How many of each can Shane buy?

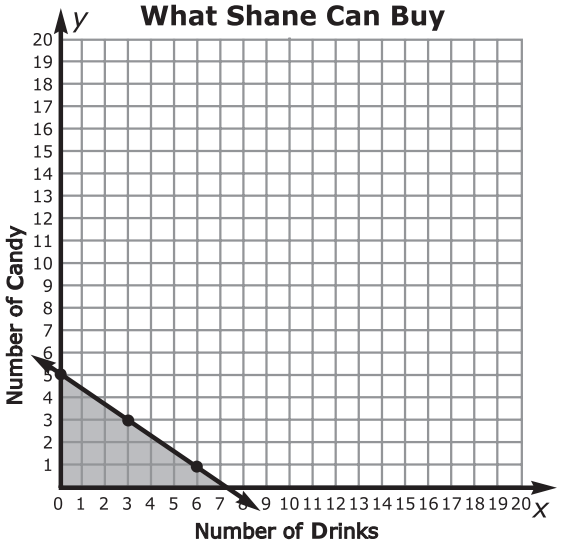
S Underline the question.
This problem is asking me to find **the number of drinks and candy he can buy.**

O Identify the facts.
Eliminate the unnecessary facts.
List the necessary facts. **$15.00 for Snacks, Drinks $ 2.00 each, Candy $3.00 each**
Let x = number of drinks. Let y = number of candy.

L Choose an operation or operations. **Subtraction and division**
Write in words what your plan of action will be. **Write an inequality to represent the situation. Solve the inequality for slope-intercept form. Graph the inequality to find the solutions.**

V Estimate your answer.
Under 8 of either snack
Carry out your plan.

$$2x + 3y \leq 15$$
$$-2x \quad -2x$$
$$\frac{3y}{3} \leq \frac{-2x}{3} + \frac{15}{3}$$
$$y \leq \frac{-2x}{3} + 5$$



E Does your answer make sense? (Compare your answer to the question.) **Yes.**
Is your answer reasonable? (Compare your answer to the estimate.) **Yes.**
Is your answer accurate? (Check your work.) **Yes.**
Write your answer in a complete sentence. **He can buy any number of snacks in the solution of $y \leq \frac{-2x}{3} + 5$.**

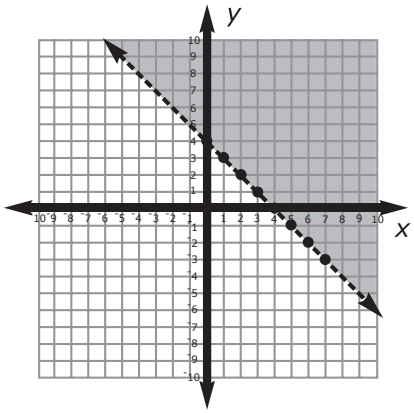
Here is the key to **S194**.

Homework

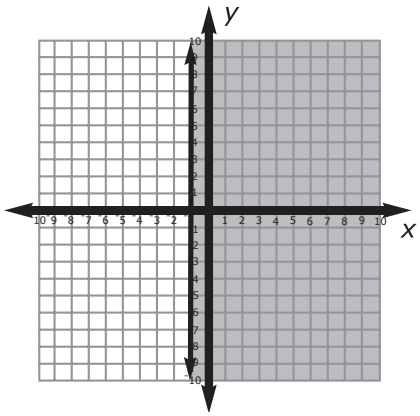
Directions: Graph the following inequalities and name an ordered pair that is a solution.

Ordered pairs will vary.

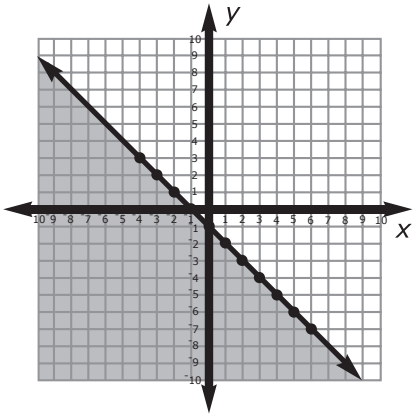
1. $y > -x + 4$



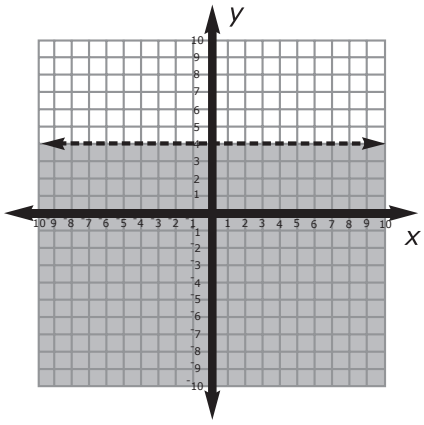
2. $x \geq -1$



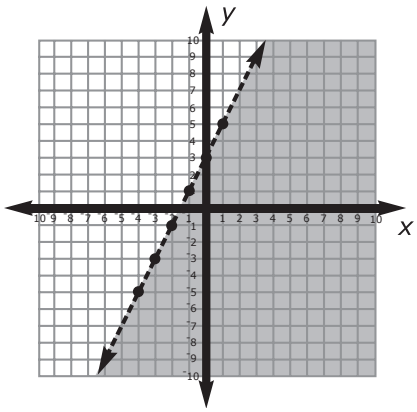
3. $x + y \leq -1$



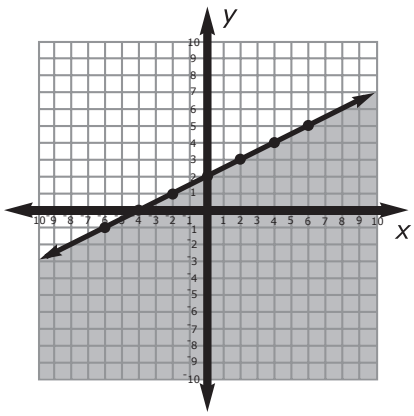
4. $y < 4$



5. $2x - y > -3$



6. $-x + 2y \leq 4$



Here is the key to **S195**.

Homework

7. Which quadrant does not have a solution to the linear inequality $y > 2x + 3$?

Quadrant IV

8. Which quadrant does not have a solution to the linear inequality $y > -x + 5$?

Quadrant III

9. Is (0, 0) a solution to the linear inequality $x + 3y < 1$?

Yes.

10. Is $(-1, -3)$ a solution to the linear inequality $2x - y \geq -5$?

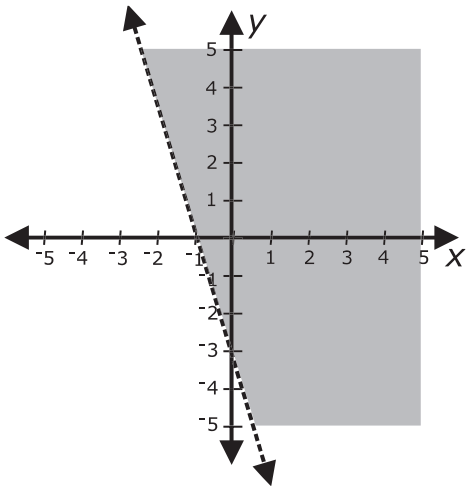
Yes.

Name _____ Date _____

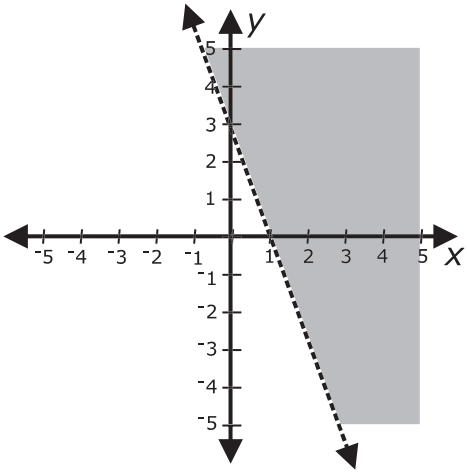
Quiz

1. Which graph below represents the inequality $y > -3x - 3$?

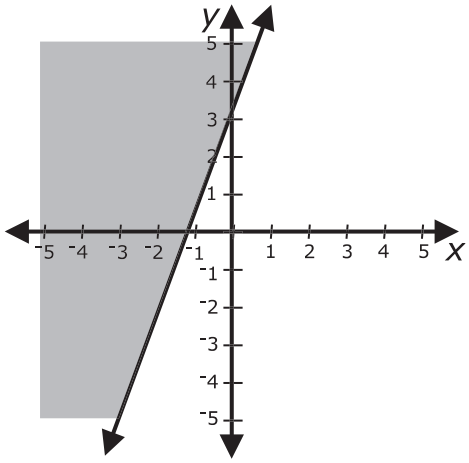
A.



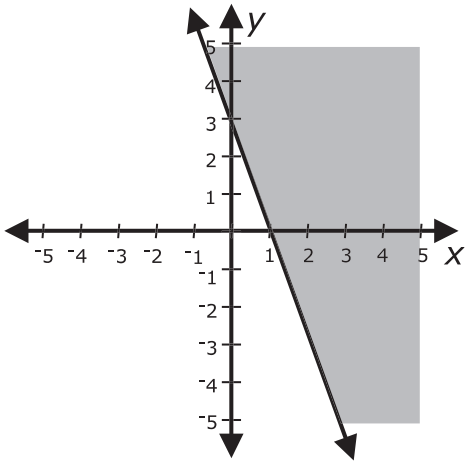
B.



C.

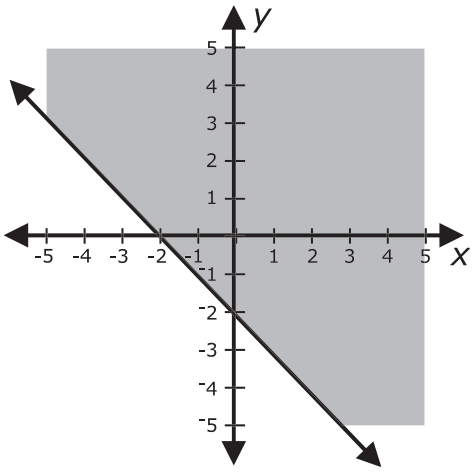


D.

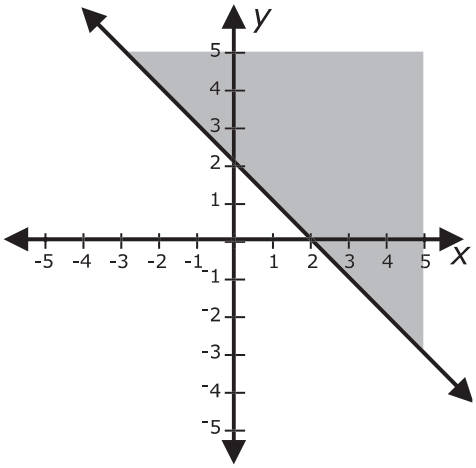


2. Which graph below represents the inequality $y \geq \bar{x} - 2$?

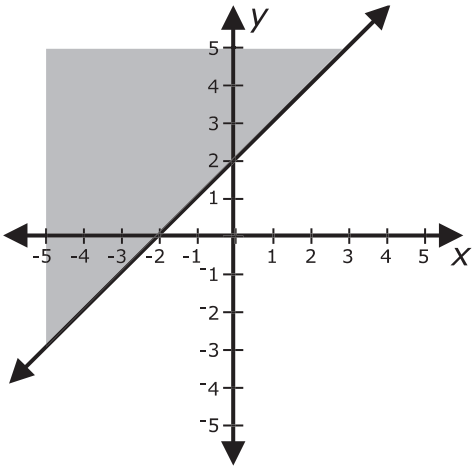
A.



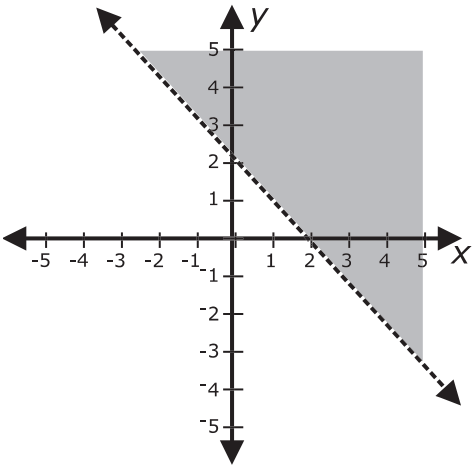
B.



C.

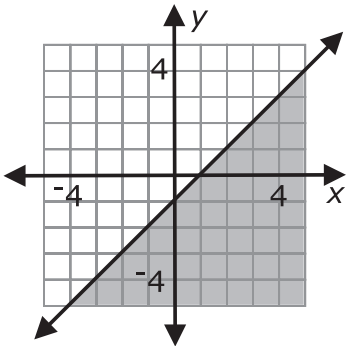


D.



3. Look at the graph at the right.

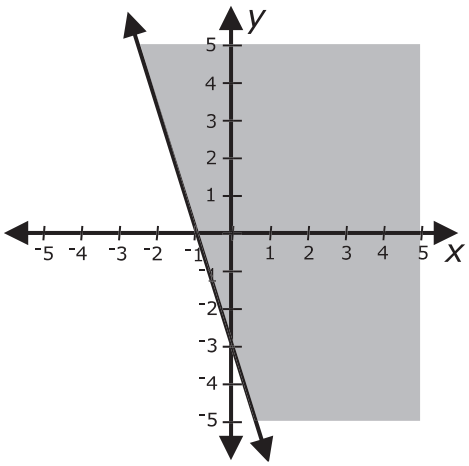
Which of these inequalities best describes this graph?



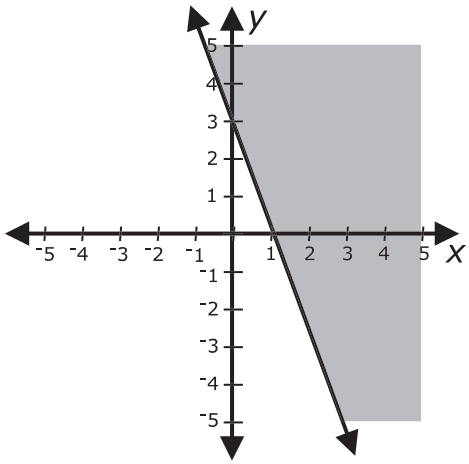
A. $y \geq x - 1$
B. $y \leq x - 1$
C. $y > x - 1$
D. $y < x - 1$

4. Which graph below represents the inequality $y \geq 3x + 3$?

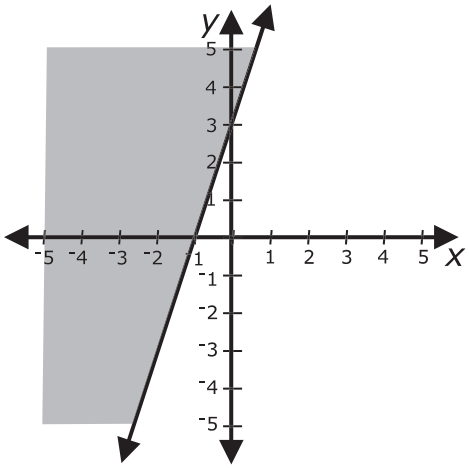
A.



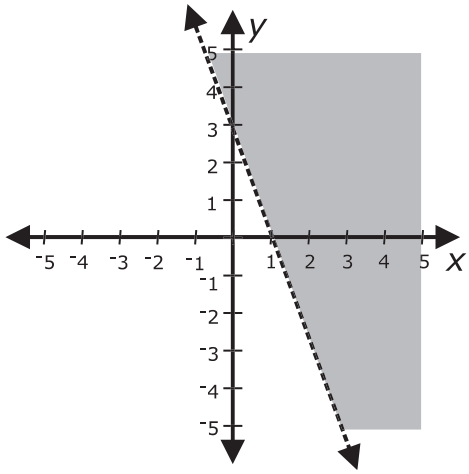
B.



C.

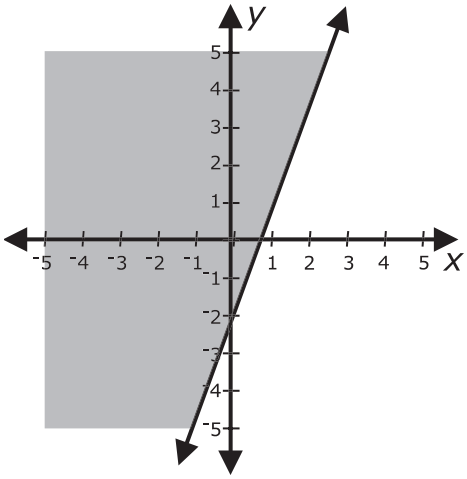


D.

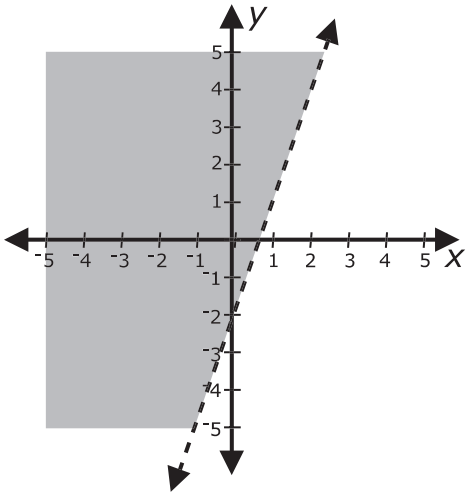


5. Which graph below represents the inequality $y \geq 2x + 2$?

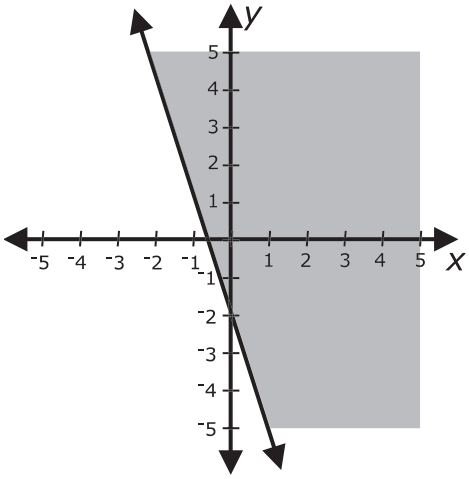
A.



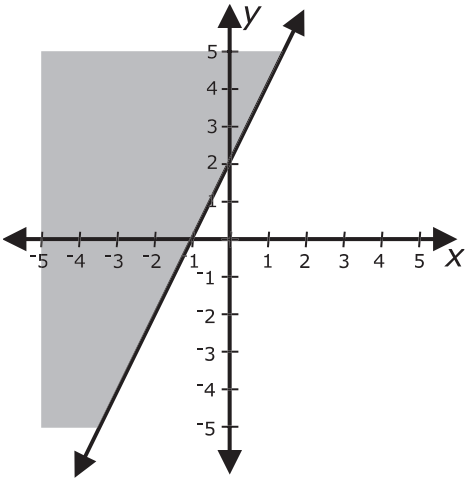
B.



C.



D.

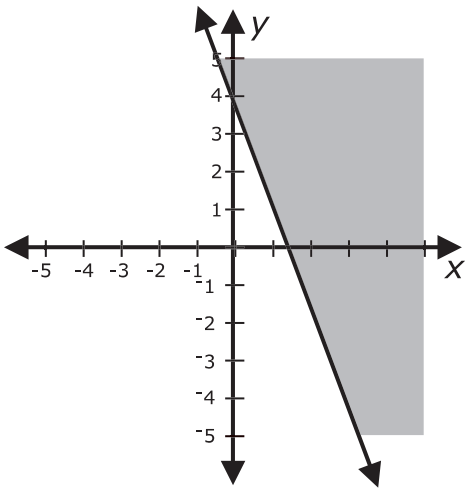


6. Which point is not a solution to the linear inequality $5x + 4y \geq 6$?

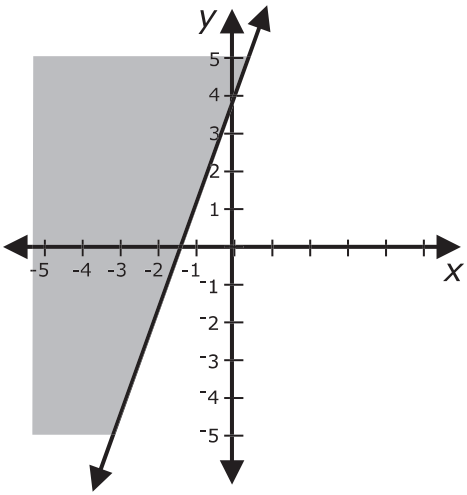
A. $(^{-}2, 4)$
B. (5, 5)
C. (0, 0)
D. (1, 1)

7. Which graph below represents the inequality $y \geq -3x - 4$?

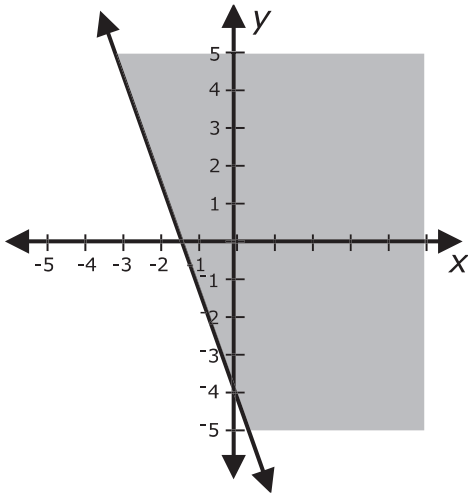
A.



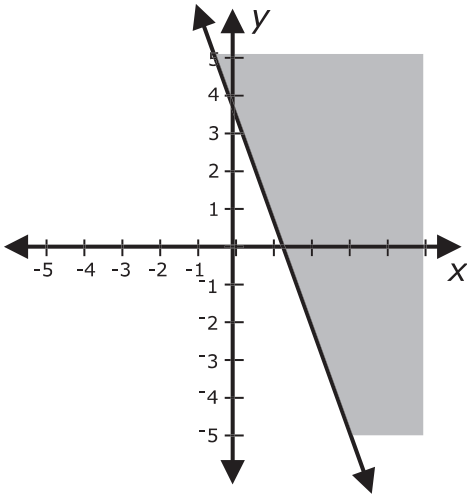
B.



C.



D.



8. Which quadrant does not contain a solution to the inequality $y \geq 2x + 5$?

A. Quadrant I
B. Quadrant II
C. Quadrant III
D. Quadrant IV

9. Which of the following is a solution to the inequality $y < \bar{x} + 4$?

A. $(\bar{2}, 6)$
B. $(1, 5)$
C. $(4, 0)$
D. $(6, \bar{3})$

---

10. Which of the following is **not** a solution to the inequality $y \leq \frac{1}{2}x - 3$?

A. $(1, \bar{4})$
B. $(2, 0)$
C. $(2, \bar{5})$
D. $(12, 2)$