



## Math Objectives

- Students will explore the basics of graphing a linear inequality, e.g., the differences among the graphs of  $y > ax + b$ ,  $y \geq ax + b$ ,  $y < ax + b$ , and  $y \leq ax + b$ .
- Students will graph the solutions to a linear inequality in two variables as a half-plane and select a test point to verify the solution set.
- Students will identify patterns in the graphs of linear inequalities and use graphing tools strategically.

## Vocabulary

- linear inequality
- half plane
- solution set

## About the Lesson

- This lesson involves the basics of graphing linear inequalities.
- As a result, students will:
  - Move a point that is part of the solution set to an inequality in the coordinate plane and observe how the algebraic representation changes based on the location of the point.
  - Select an inequality symbol to see when the boundary line is included in the graph of the inequality and move a point to see if it is part of the solution.
  - Understand the basic concepts of graphing inequalities.
  - Graph systems of inequalities.

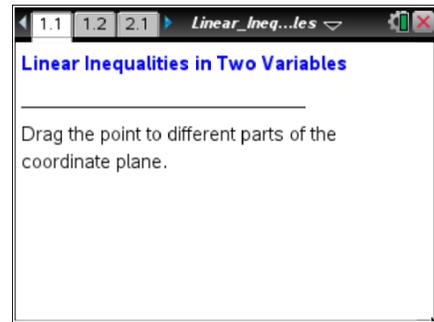


## TI-Nspire™ Navigator™ System

- Send out the *Linear\_Inequalities\_in\_Two\_Variables.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers

## Activity Materials

- Compatible TI Technologies:  TI-Nspire™ CX Handhelds,  TI-Nspire™ Apps for iPad®,  TI-Nspire™ Software



### Tech Tips:

- This activity includes screen captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at <http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials>

### Lesson Files:

#### Student Activity

- Linear\_Inequalities\_in\_Two\_Variables\_Student.pdf
  - Linear\_Inequalities\_in\_Two\_Variables\_Student.doc
- TI-Nspire document*
- Linear\_Inequalities\_in\_Two\_Variables.tns

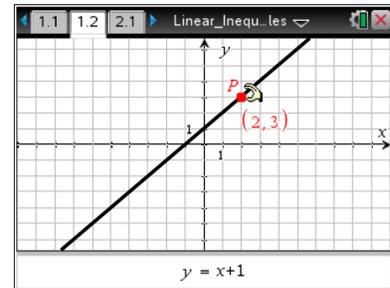


### Discussion Points and Possible Answers

#### Move to page 1.2.

1. Move point  $P$ . Describe the changes that occur as you move the point. What stays the same?

**Sample Answer:** The coordinates of the point change, the equality sign changes back and forth to an inequality sign, and the shading changes as the point moves from one side of the boundary line to the other. The slope of the boundary line remains the same. The  $y$  remains on the left, and  $x + 1$  remains on the right.



**Tech Tip:** If students experience difficulty dragging the point, check to make sure that they have moved the arrow until it becomes a hand () getting ready to grab the point. Select **ctrl** () to grab the point and close the hand (). Select **esc** to release the point or deselect other objects.



**Tech Tip:** If students experience difficulty grabbing and dragging a point, have them tap and hold the desired point for a few seconds and then drag the point to the desired location.

**Teacher Tip:** Be sure students start on the point  $(2, 3)$ . Because they are familiar with graphing lines, students will be able to start on familiar ground (a line) and make the transition from graphing equalities to graphing inequalities. Give students enough time to explore. Encourage them to provide more than one answer to the question.

2. Why do you think the line  $y = x + 1$  is called a *boundary line*?

**Answer:** The line  $y = x + 1$  is called a boundary line because it is the boundary or “edge” of the solution of the inequality.

**Teacher Tip:** This might be a good opportunity to go over some of the vocabulary that students will need for this topic. Other questions that you might ask: Can the  $x$ -value ever be greater than the  $y$ -value? What is the maximum value that  $x$  can have when  $y = 3$ ?



3. Complete the table below by moving the point to three locations: above the boundary line, on the boundary line, and below the boundary line.

**Answer:** Completed table is below.

	Above the Boundary line	On the Boundary line	Below the Boundary line
Coordinates $(x, y)$ of the Point	<b>Example: <math>(1, 4)</math></b>	<b>Example: <math>(-3, -2)</math></b>	<b>Example: <math>(1, -5)</math></b>
Equation or Inequality on Screen	$y > x + 1$	$y = x + 1$	$y < x + 1$
Verify by substituting the coordinates into the equation or inequality.	$4 > 1 + 1$ $4 > 2$ (check)	$-2 = -3 + 1$ $-2 = -2$ (check)	$-5 < 1 + 1$ $-5 < 2$ (check)

**Teacher Tip:** Have students share their answers with the class. You may want to project the calculator screen on the board, and have students come up to plot their points. Students should start to discover that there are an infinite number of points that satisfy the equation/inequalities, and that the shaded region contains all solutions to the inequality.



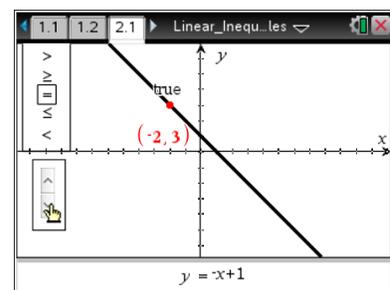
**TI-Nspire Navigator Opportunity: *Live Presenter***

See Note 1 at the end of this lesson.

Move to page 2.1.

4. The words *true* or *false* appear depending on where the point is located. What does *true* or *false* refer to in this context?

**Answer:** *True* or *false* refers to whether or not the  $x$ - and  $y$ -values at that location satisfy the equation or inequality.



**Teacher Tip:** Make sure that students start with the equality sign and select the point  $(-2, 3)$ , which lies on the line. By starting with the point  $(-2, 3)$ , which is on the line, students start with a true statement. From here, they can better understand why moving the point off the line produces a false statement. This part of the activity introduces students to the concept of utilizing a test point to determine the solution of a linear inequality.

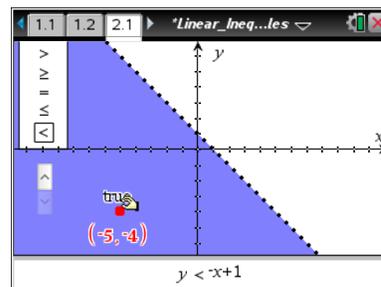


**Tech Tip:** When the cursor is not hovering over an object, students can use **tab** to select the up and down arrows on page 2.1. Then, they can use the arrows to select an inequality.



**Tech Tip:** To select an inequality symbol, students will need to tap the up and down arrows once to select the slider and then again to change the symbol selection. To move the point again, they will need to tap outside of the slider and then grab and drag the point.

5. a. Select  $<$  for the inequality symbol by using the up or down arrows on the screen so that the inequality reads  $y < -x + 1$ . Now move the point to a location where this inequality is true. Show work to verify that the coordinates of the point you choose make the inequality a true statement. We say that such a point *satisfies the inequality*.



**Sample Answer:** Many answers are possible as long as the chosen point's coordinates satisfy the inequality. Students will show their work by substituting values of a coordinate into the inequality.

- b. Explain why every point directly below this point must also satisfy the same inequality.

**Sample Answer:** Each point directly below this point will have exactly the same  $x$ -coordinate, so the right-hand side of the inequality won't change value. The  $y$ -coordinate will be LESS than the original  $y$ -coordinate; so the left-hand side of the inequality will be SMALLER; and the inequality will still hold.

- c. Explain why every point directly to the left of this point must also satisfy the same inequality.

**Sample Answer:** Each point directly to the left of this point will have exactly the same  $y$ -coordinate, so the left-hand side of the inequality won't change value. The  $x$ -coordinate will be LESS than the original  $x$ -coordinate; so  $-x$  will be larger and the right-hand side of the inequality will be even LARGER; and the inequality will still hold.



**TI-Nspire Navigator Opportunity: *Live Presenter***

**See Note 2 at the end of this lesson.**



6. a. Select  $>$  for the inequality symbol by using the up or down arrows on the screen so that the inequality reads  $y > -x + 1$ . Now move the point to a location where this inequality is true. Verify that the coordinates of the point you chose satisfy the inequality.

**Sample Answer:** Many answers are possible as long as the chosen point's coordinates satisfy the inequality.

- b. Explain why every point directly above this point must also satisfy the same inequality.

**Sample Answer:** Each point directly above this point will have exactly the same  $x$ -coordinate, so the right-hand side of the inequality won't change value. The  $y$ -coordinate will be GREATER than the original  $y$ -coordinate, so the left-hand side of the inequality will be LARGER than the original. The inequality will still hold.

- c. Explain why every point directly to the right of this point must also satisfy the same inequality.

**Sample Answer:** Each point directly to the right of this point will have exactly the same  $y$ -coordinate, so the left-hand side of the inequality won't change value. The  $x$ -coordinate will be GREATER than the original  $x$ -coordinate, so  $-x$  will be SMALLER and the right-hand side of the inequality will be SMALLER than the original. The inequality will still hold.

**Teacher Tip:** This is another opportunity for students to share their reasoning. Not only is the student's test point a solution to the inequality, but so are all of the other solutions that lie in the same half-plane.

7. The *solution set* for an inequality in two variables ( $x, y$ ) is the set of all points in the plane that satisfy that inequality.
- a. Use the up or down arrows on the screen to change the inequality symbol to  $\leq$  and then to  $\geq$ . Which points satisfy these new inequalities that did not satisfy the inequalities in Questions 5 or 6?

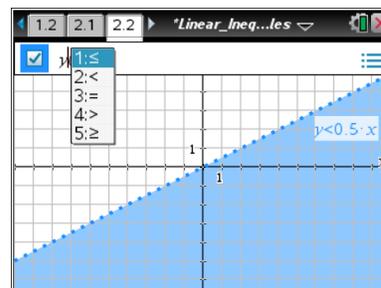
**Answer:** The points on the line itself now satisfy these inequalities.

- b. Explain in your own words how to graph the solution set to an inequality.

**Sample Answer:** First, find the line represented by replacing the inequality symbol with an equality symbol. Then find which side of the line satisfies the inequality by testing with a point. Shade that side. Use a dotted line for strict inequalities and a solid line for inclusive inequalities.



Students can explore inequalities on a TI-Nspire Graph application, by deleting the equal sign in the entry line and selecting the desired inequality, as shown in the screen shot on the right.

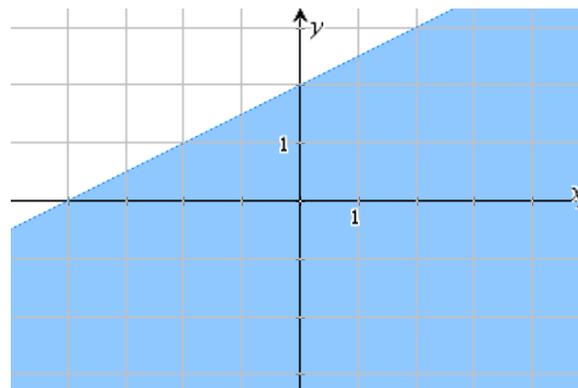
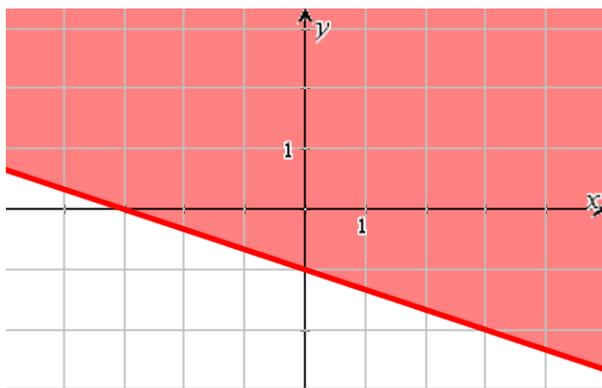


8. Write the linear inequality that is represented by these graphs. Check your solution on a TI-Nspire Graph page. Press  after f1(x) = to remove the equal sign and choose an inequality.

**Answer:**

a.  $y \geq -\frac{1}{3}x - 1$

b.  $y < \frac{1}{2}x + 2$



## Wrap Up

Upon completion of the discussion, the teacher should ensure that students understand:

- The purpose of the boundary line
  - When to include it in the graph of the inequality
  - When it is solid and when it is dotted
- The shading of the appropriate half-plane
  - How to determine which side of the boundary line to shade
  - When to shade below the boundary line

To check for understanding, teachers can verbally ask students to respond either *True* or *False* to the following statements. You may want to write the inequalities on the board. Have students discuss why they chose what they did or why the answer was false and how to make it true.

1. In the graph of  $y < 2x + 3$ , the boundary line will be a solid line. (Answer: False)
2. In the graph of  $y \geq 3x - 2$ , the boundary line will be a dotted or dashed line. (Answer: False)
3. In the graph of  $y > x + 1$ , the point (0, 1) is in the graph of the solution. (Answer: False. The point (0, 1) is on the boundary line, which is a dotted or dashed line.)



TI-Nspire Navigator Opportunity: *Quick Poll*

See Note 3 at the end of this lesson.



## TI-Nspire Navigator

### Note 1

**Question 3, *Live Presenter*:** Select a student to be the *Live Presenter* and illustrate the answers to Question 3. Have the presenter show that there is more than one correct answer for each cell in the first and third rows of the table.

### Note 2

**Question 5, *Live Presenter*:** Select a student to be the *Live Presenter* to illustrate how to select the up or down arrow symbols to move through the equality and inequality signs. Recall the Tech Tip that students with the TI-Nspire handheld can use `tab` when they are not hovering over an object.

### Note 3

**Question 7, *Quick Poll*:** Create a Quick Poll. Choose the *True/False* response template. Ask the students the questions in the Wrap Up section.