Lesson Summary:
This lesson begins with a review of graphing linear equations in two variables. Students relate graphing linear inequalities in two variables to graphing linear equations in two variables. Students write inequalities for problem situations, graph the inequalities on coordinate planes and use the graphs to answer questions.

Estimated Duration: Three to four hours

Commentary:
Most situations in everyday life deal with inequalities. Students make decisions about how to spend money on various activities almost daily, such as how to spend money in their budget without going over the amount they have on hand. They have probably used a guess-and-check method to make these decisions. Graphing inequalities using practical everyday situations is another strategy in solving everyday problems.

Pre-Assessment:
Graphing linear equations is the focus of the pre-assessment. Students find three or more ordered pairs for each equation, plot the points on a coordinate grid and draw the line representing each equation.

Instructional Tip:
Decide if students may use their own grid paper or the grids in the attachment and other necessary tools. Assign the pre-assessment a day before the lesson to allow time to assess student work. This also allows enough time for students to complete the assessment.

Instructional Tips:
- Two points determine a line. Using more points helps to determine where calculation errors may occur in determining the points. Instruct students to display their ordered pairs in a table such as a T-table.
- Provide calculators for computational purposes since the focus is on graphing the line of the equations.
**Scoring Guidelines:**
Determine whether students are ready to proceed based on the accuracy of the lines of the equations. Students may understand the concept if the lines for equations 1 and 2 are accurate. Provide intervention for students who have difficulty in plotting points.

**Post-Assessment:**
Students graph the lines of inequalities. They also create inequalities for problem situations and graph the lines of those inequalities.

- Assign the post-assessment, *Graphing Linear Inequalities*, Attachment D. Provide grid paper with at least three coordinate grids to each student using *Coordinates Grids*, Attachment C, and a ruler or straight edge for each student.
- Collect and evaluate the assessment.

**Scoring Guidelines:**
Components to evaluate in this assessment include graphing a given inequality, and writing and graphing an inequality to represent a problem situation. The following rubric may be used to evaluate the post-assessment.

<table>
<thead>
<tr>
<th>Meets Expectations</th>
<th>Adequate Understanding</th>
<th>Needs Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Correctly graphs each inequality with correct shading using five ordered pairs</td>
<td>• Represents the graphs of each inequality but with minor errors as a result of finding the ordered pairs incorrectly or shading inappropriately.</td>
<td>• Makes numerous errors in finding the ordered pairs</td>
</tr>
<tr>
<td>• Correctly represents each problem situation as an inequality and provides the graph of each inequality</td>
<td>• Represents each problem situation as an inequality but with minor errors and provides graphs of inequalities based on the errors</td>
<td>• Attempts to graph at least one of the inequalities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Attempts to write the inequality for one of the situations; may or may not graph the inequality</td>
</tr>
</tbody>
</table>

**Instructional Procedures:**

**Part One**

**Instructional Tip:**
Begin the lesson only if students have complete understanding of finding ordered pairs and are able to plot points to create the line of a linear equation.

1. Review problem 3 of the pre-assessment if the majority of the students did not correctly graph the line of the equation.
2. Write the following problems on the board or overhead projector:
   
   \[ y = x + 2 \]
   
   and
   
   \[ y > x + 2 \]
Linear Inequalities on a Coordinate Plane – Grade Seven

Ask students to give statements regarding the two sentences. Expect students to respond that both contain the same variable, operation sign and the same number. Also, expect students to say one is an equation and the other is an inequality. Ask for the basis of this statement. If students cannot provide the rationale for the difference between an equation and an inequality, ask guiding questions.

3. Allow time for students to discuss how to determine the ordered pairs for the graph of the line of the inequality. Students need to realize that finding the ordered pairs for an inequality is similar to finding the ordered pairs for an equation. The line of the equation represents the boundary line.
   a. Have students find at least five ordered pairs for the equation.
   b. Instruct them to plot the points on a coordinate grid. Tell them to use a dashed line to show that the points on the line are not solutions of \( y > x + 2 \).
   c. Graph the line of the inequality on a transparent grid and display so that students can verify their graph.

Instructional Tip:
Provide grids with the numbers on the \( x \)-axis and \( y \)-axis given to save time during instruction. Also provide grids without the numbers on the \( x \)-axis and \( y \)-axis so that students have practice in numbering the axes.

4. Have the students test one of their points that is not on the line such as \((2, 6)\) to make a true statement.
   a. Have the students look at the line and choose any point that is not on the line to test. For example:
      \[
      \begin{align*}
      \text{If } x &= 2 \text{ and } y = 6, \text{ then } x + 2 &= 2 + 2 = 4, \text{ and because } 6 &> 4, \text{ the point } (2, 6) \text{ satisfies the inequality } y > x + 2. \\
      y &> x + 2 \\
      6 &> 2 + 2 \\
      6 &> 4
      \end{align*}
      \]
   b. Ask students about the importance of choosing the point not on, above or below the line. What determines the location of the “test” point? Note: the “test” point(s) determine the shading to represent the graphing of the inequality.
   c. Plot the test points of several students to verify if the points are above the line.
   d. Ask students what the relationship is between the location of the test points and the inequality symbol. Shading above the line relates to greater than and shading below the line relates to less than, if \( y \) is on the left side of the equation or inequality.

5. Present the inequality \( y \leq x - 3 \).
   a. Have students find at least five ordered pairs to find the boundary line. Have students partner with others to check the ordered pairs for accuracy before plotting the points on a coordinate grid.
   b. Select two students to plot their ordered pairs on transparent grids. Place one grid on top of the other grid.
c. Ask students to compare the lines. They should notice that the points from either line are on both lines. Once lines are drawn, have students test a point that is not on the line to determine the area for the shading.

6. Have students compare the two inequalities they have graphed. Record responses on the board or chart paper. In addition to the inequality symbols being different, students should notice the line under the less than sign. If they have not noted its meaning, ask what ≤ indicates. This means less than or equal to. Points on the line satisfy the inequality. To represent this type of inequality, the boundary line is a solid line instead of a dashed line.

a. Have the students test one of their points from their ordered pairs. For example, the point (1, -2) is on the line. \( \text{If } x = 1, \text{ then } x - 3 = 1 - 3 = -2. \text{ We know that } -2 \text{ is not less than itself, but equal to itself. Therefore, if } y = -2, \text{ then } y = x - 3 \text{ and } (1, 2) \text{ is on the line. This reinforces the boundary line is solid.} \)

\[
\begin{align*}
  y & \leq x - 3 \\
  -2 & \leq 1 - 3 \\
  -2 & \leq -2
\end{align*}
\]

b. Ask the students to test other points that are not on the line.

5. Present as many inequalities as needed in order to ensure students understand the concept.

6. Have the students summarize graphing the line of an inequality and the relationship of graphing the line of an equation in their journals. The summary should also explain the importance of the inequality symbol. Check the journals to ensure students show understanding.

Part Two

7. Write the following statements on the board or on the overhead projector:
   - A number \( n \) is greater than 12. \( (n > 12) \)
   - A number is less than or equal to 4. \( (x \leq 4) \)
   - A number \( y \) is at least four more than three times a number \( x \). \( (y \geq 3x + 4) \)

a. Have students represent each statement algebraically.

b. Select several students to write the answers on the board or overhead projector and have a discussion. Correct any misconceptions. More than one correct answer is possible.

8. Write the following scenario on the board or overhead projector:
   The Drama Club needs at least $3,000 for the end-of-year program. They decided to sell popcorn and potato chips after school. How many $1 bags of popcorn and $0.50 bags of potato chips must they sell in order to reach their goal?

a. Have the students work in pairs to write an inequality for the scenario.

Instructional Tip:
Students may struggle to write the inequality as they have been presented in class. Let them know that the inequality is correct and may be written different ways. Use one of the inequalities from earlier in the lesson, such as \( y \geq 3x + 4 \). Write the inequality as \(-3x + y \geq 4\) and have students write ordered pairs using the same \( x \) values as before.
b. Select students to share the inequality with the class. Have students describe what each variable represents. \((x + \frac{1}{2}y \geq 3000 \text{ or } 2x + y \geq 6000 \text{ or } y \geq 6000 - 2x; \text{ where } x \) represents the number of $1 bags of popcorn and \(y \) represents the number of $0.50 bags of potato chips) Note: students may use 0.50 or 0.5 or \(\frac{1}{2}\).

9. Have students find ordered pairs to graph the inequality. Have students discuss the range of values they might consider for the \(x\) values and share their thoughts with the class. Possible values for \(x\) range from 500 to 3,000. Select students to graph the inequality on the overhead projector and explain the solution for the inequality.

10. Discuss the graphs and solutions.
   a. Ask questions about the shaded portion of the graph such as how to determine where to shade, what type of boundary line represents the inequality, etc.
   b. Test points for the inequality; including negative values for \(x\). Ask what a negative for \(x\) implies (cannot have a negative value to represent the number of bags of potato chips).
   c. Choose points that are outside of the shaded portion. Have students determine why these points are not part of the solution of the inequality.

11. Present similar problem situations. Have students work individually before discussing with other students. Observe the students as they work, asking questions to correct any misconceptions. Select pairs of students to present the inequality and graph to the class.

**Differentiated Instructional Support:**
Instruction is differentiated according to learner needs, to help all learners either meet the intent of the specified indicator(s) or, if the indicator is already met, to advance beyond the specified indicator(s).
- Provide values for \(x\) for students to find the values for \(y\) in the ordered pairs.

**Extension:**
Present equations/inequalities in the form such as \(x + y = 10\) or \(x + y < 10\) and have students solve for \(y\) before graphing the linear equation/inequality.

**Materials and Resources:**
The inclusion of a specific resource in any lesson formulated by the Ohio Department of Education should not be interpreted as an endorsement of that particular resource, or any of its contents, by the Ohio Department of Education. The Ohio Department of Education does not endorse any particular resource. The Web addresses listed are for a given site’s main page, therefore, it may be necessary to search within that site to find the specific information required for a given lesson. Please note that information published on the Internet changes over time, therefore the links provided may no longer contain the specific information related to a given lesson. Teachers are advised to preview all sites before using them with students.
Linear Inequalities on a Coordinate Plane – Grade Seven

For the teacher: Overhead projector, transparent coordinate grids, rulers or straight edges, overhead graphing calculator (optional)

For the students: Coordinate grid paper, transparent coordinate grids, rulers or straight edges, graphing calculators (optional)

Vocabulary:
• at least (≥)
• at most (≤)
• equations
• greater than or equal to (≥)
• inequalities
• less than or equal to (≤)

Technology Connections:
• Allow students to use graphing calculator to self-check the lines of the graph of the equations/inequalities.
• Use the graphing calculator to determine if an ordered pair is on the line of the graph of the equation/inequality.

Research Connections:

General Tips:
• Make a transparency of the graphs of the lines of the equations/inequalities to check the accuracy of students’ lines. Place the transparency on the student paper. Lines should match.
• Assigning the value for x makes it easier to check the ordered pairs and the lines of the graphs of the equations.

Attachments:
Attachment A, Graphing Linear Equations
Attachment B, Graphing Linear Equations Answer Key
Attachment C, Coordinate Grid Paper
Attachment D, Graphing Linear Inequalities
Attachment E, Graphing Linear Inequalities Answer Key
Directions: Find at least three ordered pairs satisfying each equation. Plot the ordered pairs and graph the lines of the equations on separate coordinate grids.

1. \( y = x + 4 \)

2. \( y = 3x \)

3. \( y = -2x - 5 \)
Linear Inequalities on a Coordinate Plane – Grade Seven

Attachment B
Graphing Linear Equations Answer Key

Students’ ordered pairs may vary. Examples of ordered pairs are provided.

1. \( y = x + 4 \)

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>-1</td>
<td>3</td>
</tr>
</tbody>
</table>

2. \( y = 3x \)

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

3. \( y = -2x - 5 \)

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-7</td>
</tr>
<tr>
<td>0</td>
<td>-5</td>
</tr>
<tr>
<td>-1</td>
<td>-3</td>
</tr>
</tbody>
</table>
Attachment C
Coordinate Grid Paper
Directions: Find at least five ordered pairs on the line for each inequality. Plot the ordered pairs and graph the line of the inequalities on separate coordinate grids.

1. $y < x - 4$

2. $y \geq 2x + 1$

3. $y \leq -3x - 2$
Directions: Write an inequality for each situation. Find at least five ordered pairs on the line for each inequality. Plot the ordered pairs and graph the line of the inequality on separate coordinate grids.

4. Jason is practicing free throws and 3-point shots in basketball. How many free throws and 3-point shots must Jason make to score at least 50 points? (A free throw is worth one point.)

5. LaShawn and Rhonda are shopping for paperback books and books on CDs. How many $8 paperback books and $30 books on CDs can they buy if they can spend no more than $420?
1. \( y < x - 4 \)

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
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</thead>
<tbody>
<tr>
<td>-3</td>
<td>-7</td>
</tr>
<tr>
<td>-1</td>
<td>-5</td>
</tr>
<tr>
<td>0</td>
<td>-4</td>
</tr>
<tr>
<td>1</td>
<td>-3</td>
</tr>
<tr>
<td>2</td>
<td>-2</td>
</tr>
</tbody>
</table>

2. \( y \geq 2x + 1 \)

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
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</thead>
<tbody>
<tr>
<td>-3</td>
<td>-5</td>
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<td>-1</td>
<td>-1</td>
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<tr>
<td>0</td>
<td>1</td>
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<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
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</table>

3. \( y \leq -3x - 2 \)

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
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<td>-3</td>
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<td>1</td>
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<td>1</td>
<td>-5</td>
</tr>
<tr>
<td>2</td>
<td>-8</td>
</tr>
</tbody>
</table>
4. Jason is practicing free throws and 3-point shots in basketball. How many free throws and 3-point shots must Jason make to score at least 50 points?

If $x$ represents the number of free throws and $y$ represents the number of 3-point shots, then the inequality is $x + 3y \geq 50$.

<table>
<thead>
<tr>
<th>$x$</th>
<th>$y$</th>
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<tbody>
<tr>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>17</td>
<td>11</td>
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<tr>
<td>20</td>
<td>10</td>
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<tr>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>29</td>
<td>7</td>
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</tbody>
</table>

5. LaShawn and Rhonda are shopping for paperback books and books on CDs. How many $8 paperback books and $30 books on CDs can they buy if than can spend no more than $420?

If $x$ represents the number of $8 paperback book and $y$ represents the number of $30 books on CDs, then the inequality is $8x + 30y \leq 420$.

<table>
<thead>
<tr>
<th>$x$</th>
<th>$y$</th>
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<tbody>
<tr>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>30</td>
<td>6</td>
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<td>45</td>
<td>2</td>
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