**Unit 2: Investigation 6 (4 Days)**

**Linear Inequalities**

***CCSS: A-CED 1, A-REI 3***

**Overview**

Students write linear inequalities that model real world scenarios and solve multi-step linear inequalities.

**Assessment Activities**

**Evidence of Success: What Will Students Be Able to Do?**

Write and solve linear inequalities in context, justify why the inequality symbol is reversed when multiplying or dividing by a negative number, and solve multi-step linear inequalities.

**Assessment Strategies: How Will They Show What They Know?**

* **Exit Slip 2.6.1** asks students solve multi-step linear inequalities.
* **Exit Slip 2.6.2** asks students to write a linear inequality to model a situation and then solve the inequality and interpret the solution.
* **Journal Entry** asks students to explain when and why they reverse an inequality symbol when solving an inequality.

**Launch Notes**

Introduce students to several real-life examples of linear inequalities by showing them situations which involve maximum and minimum values. **Activity 2.6.1 Representing Inequalities** contains several examples and can be used for this purpose. The first example in this activity is, “To serve as president of the United States you must be at least 35 years old.” Students will recognize that this is an example of an inequality and that it can be represented by a set of numbers on a number line. At this time you may lead a discussion about the nature of continuous variables (when *x* ≥ 35, *x* isn’t only satisfied by integers, but all real numbers greater than or equal to 35).

**Closure Notes**

Students should recognize the difference between an equation and an inequality. You may lead a class discussion on their similarities and difference between linear equations and linear inequalities.

**Teaching Strategies**

1. **Activity 2.6.1 Representing Inequalities** uses real world examples to show students how to represent inequalities on a number line. As students complete the activity, make sure that they understand the nature of continuous variables. A common misconception among students is that a solution set only contains integers. For example, if a student is asked to graph *x* > 16, many will start at 17. You may ask students questions like “Is 16.1 greater than 16? Where is it located on the number line? How can we represent this number?” Students should recognize that this is a situation which warrants an open circle as shown below.



Here is another example. “To get on this ride, a child must be less than 4 feet tall to play here.” The set of numbers described in this statement is all numbers between 0 and 4. If students are only considering integers between 0 and 4, ask them, “what about a child who is 3 feet 11 inches tall? How can we represent that 3 feet 11 inches is included?”



This example may be used to show how open circles represent endpoints that are not in the desired set. Make sure students understand why both 0 and 4 must be excluded from the solution set and draw the number line representation.

You may also mention that in some real world situations all real numbers may not be appropriate. Suppose you have $100 to buy books, each book costs $13.85, and you want to find out how many books you can buy? Solutions of this problem only include positive integers and zero. Negative numbers will not make any sense. Linear inequalities in one variable provide us an opportunity to talk about the different sets of numbers and why we select one set over another in a given contextual situation.

1. In **Activity 2.6.2 Equations and Inequalities**, students examine the distinction between the solution of an equation and the solution of an inequality, determine whether numbers are included in a solution set, and learn about how solutions are represented on a number line. Students also construct written descriptions of solution sets and identify terminology and phrases associated with inequality symbols.
2. Once students are familiar with how to represent an inequality on a number line, they are ready to solve multi-step inequalities. The rules for solving equations will be used, with one important exception: when multiplying or dividing both sides of an inequality by a negative number, we reverse the direction of the inequality symbol. Students may refer to this as “flipping” the inequality symbol. This concept is developed in **Activity 2.6.3 When Do We Flip It?** In this activity, students discover that adding a positive or negative number to an inequality does not *affect* the inequality symbol, but multiplying or dividing by a negative number does lead to a reversed inequality symbol. The activity culminates with students applying this property to solve multi-step linear inequalities and graph solutions.
3. The concept of reversing the inequality symbol can be developed by taking an inequality such as 2 < 4, graphing 2 and 4 on a number line, noting that 2 lies to the left of 4, then multiplying 2 and 4 by –1, hence generating their *opposites*, and then having students graph the two opposites on a number line. Students will see that the order is not retained. This process can be repeated with additional inequalities like

–10 < 9, and – 4 < 7. Help students understand that when we multiply or divide by a negative quantity we are now trying to relate the opposites of the original numbers (or multiples of the numbers). The opposites are related in reverse as a consequence of the definition of an opposite.

1. The TI-84 program LINEQUA allows students to represent inequalities by tables and graphs on their graphing calculators. The program is supported by teacher notes and a student activity sheet. In order for students to use the program LINEQUA, it must be downloaded into their graphing calculators. (Program and website can be found at <http://education.ti.com/xchange/US/Math/AlgebraI/8773/LinearInequalities_Teacher.doc>
2. **Activity 2.6.4 Working with Inequalities** provides students additional practice solving one- and two-step inequalities. Students express inequalities in words and on a number line, and identify numbers in a solution set and check whether the numbers they chose satisfies the inequality. Students also identify inequalities given solution sets graphed on number lines.

**Differentiated Instruction (For Learners Needing More Help)**

Some students have difficulty recognizing that an inequality like 8 > *x* is equivalent to the inequality *x* < 8. Questions 15 and 16 in **Activity 2.6.2** specifically address this issue. If confusion on this score persists, you may teach students to always get the variable on the left side. This will help in graphing the solution set once the inequality is solved. A mnemonic that helps is to use the direction of the inequality symbol to show which side of the end point to shade. For *x* > 8 we shade to the right of 8 (the direction the symbol is pointing). For *x* < 8 we shade to the left. If you teach this strategy, emphasize that the variable must be on the left for this to work. **Activity 2.6.4** provides opportunities for students to rewrite expressions.

1. **Activity 2.6.5 Practice Solving Inequalities** has a variety of multi-step linear inequalities. Students get practice applying the distributive property and combining like terms.
2. **Activity 2.6.6** **Putting It All Together** designates problems for students to work on individually, problems for students to work on as a class, and problems for the instructor to work on to model the solution process. The activity starts with two-step inequalities, and then moves to contextual problems, and then multi-step inequalities. The inequalities include an identity and contradiction.

**Group Activity**

In **Activity 2.6.7 Passing Linear Inequalities** students collaboratively solve problems by “passing the problem” within a group. Divide students into groups of size three and assign each student in the group a different problem set. They should each do the first step in solving the inequality and then pass the problem to another student in their group. That student will do the second step and then pass the problem to the third student. The third student will graph the solution on the number line. The problem is then passed back to the original student to check the work. This process is then repeated for two additional problems. The last problem is a word problem. In this problem, the first student should write the inequality, the second student should solve the inequality, and the final student should graph it *and* write the solution in a sentence.

**Journal Prompt**

Explain when you have to “flip” the inequality symbol and why you have to “flip” it.

1. In **Activity 2.6.8 Inequalities in the Real World**, students solve inequalities arising from real world situations. Each problem requires that they first write an inequality to model a situation. The final problem in the activity focuses on the cost of a cellular phone family plan based on the number of phone lines. As an extension to this problem, students could compare cellular plans and set up inequalities to determine when a family plan for several people is cheaper than individual phone plans for each family member.

You may introduce the value of modeling with inequalities by presenting the following school fundraising scenario. “You have been selected to pick out a T-shirt that everyone should wear at the annual pep rally. The student council has set aside $6,000 to purchase the shirts. Go online (to a website like [www.prepsportswear.com](http://www.prepsportswear.com)) and look up the cost of a shirt that you like. If the online shipping cost is $14, how many of the shirts that you selected can the student council buy?”

At this point, you might want to remind students that schools are tax-exempt. Students may suggest setting up an equation at this point. You can have a discussion with the students about how you don’t have to spend all $6,000 dollars but you definitely can’t spend more than that. If the T-shirts are $21.96 each, then the inequality would be $21.96*x* + 14.00  $6000, where *x* is the number of T-shirts. Ask students to explain how they would solve for *x* and ask them show their steps and check their answer. In this case, *x* is about 272.6. Facilitate a class discussion about this answer and why the solution shows that they can buy up to 272 T-shirts. Have them discuss why rounding down in this case is necessary versus rounding up to the closer value of 273 shirts. For more practice, students could solve similar problems related to purchasing school uniforms, school equipment, or other school objects of interest.

1. You may introduce problems modeled by inequalities with variables on both sides. For example, in **Activity 2.3.7 Comparing Cab Fares**, students determined the distance for which two companies charged the same amount. You can modify these problems to find when one company is less expensive or more expensive than another company.

**Differentiated Instruction (Enrichment)**

Have each student construct a contextual problem that can be solved with a linear inequality. Ask them to solve it and write the answer on a separate piece of paper. Collect all of the problems (without answers) and shuffle them. Then, have students select a problem from the deck and attempt to solve it. Answers can be distributed at the end of the activity, and the problems can be discussed.

**Resources and Materials**

* **Activity 2.6.1** Representing Inequalities
* **Activity 2.6.2** Equations and Inequalities
* **Activity 2.6.3** When Do We Flip It?
* **Activity 2.6.4** Working with Inequalities
* **Activity 2.6.5** Practice Solving Inequalities
* **Activity 2.6.6** Putting It All Together
* **Activity 2.6.7** Passing Linear Inequalities
* **Activity 2.6.8** Inequalities in the Real World
* **Exit Slip 2.6.1** Solving Inequalities
* **Exit Slip 2.6.2** How Many Pizzas?
* Student Journals
* Graphing Calculators
* LINEQUA information on TI website <http://education.ti.com/educationportal/sites/US/homePage/index.html>
* Website that sells customized clothing [www.prepsportswear.com](http://www.prepsportswear.com)