**Unit 2: Investigation 5 (2 days)**

**Formulas and Literal Equations**

**CCSS: A-CED 4, A-REI 3**

**Overview**

Students apply the principles of solving equations to literal equations in order to change the subject of an equation or formula.

**Assessment Activities**

**Evidence of Success: What students will be able to do?**

Change the subject of a formula in a literal equation and explain why one would want to change the subject of a formula.

**Assessment Tools: How they will show what they know.**

* **Exit Slip 2.5** asks students to change the subject of a formula.
* **Journal Entry 1** has students explain what it means to solve for a particular variable.
* **Journal Entry 2** has students show that they understand the meaning of “literal equation.”

**Launch Notes**

You may pose the following problem to the class: “Tanya is selling shoes at a shoe store. She finds out that shoe size and foot length are related by the formula *S =* 3*F –* 24 where *S* represents the shoe size and *F* represents the length of a foot, in inches. Tanya wants to know how large the feet of her customers are on a certain day.”

First ask students to complete a table, similar to below, using the given formula.

|  |  |
| --- | --- |
| ***S*** | ***F*** |
| 5 |  |
| 6 |  |
| 9 |  |
| 11 |  |

Next ask students to use the formula $F=\frac{S+24}{3} $ to find values for *F* (using the same S values from the table). Ask students what they notice about the two sets of values. Ask them which method is easier to use to find *F* values. Students should see the benefit in having an equation in which the variable of interest is the subject of the equation.

**Closure Notes**

Use the group activity to assess students’ ability to manipulate literal equations. Ask students to summarize what they learned about solving literal equations.

**Teaching Strategies**

1. Use the example from the launch notes to introduce the topic of formulas. The formula *S* = 3*F* –24 gives us the shoe size when the length of the foot (in inches) is given. Inform students that *S* is the *subject* of the formula. We can find values of the subject by substituting in for the other variable or variables. Since we know how to solve equations we can also find values of the other variables in the formula when the subject is known. For example, if we know a value of *S*, we can solve for the corresponding value of F (as we was done to fill in the table).

However, we can also rearrange the formula to make a different variable the subject. We can do that with the formula *S =* 3*F –* 24 by applying the properties of equality we use to solve equations (add 24 on both sides, and then divide both sides by 3). This results in the formula $F=\frac{S+24}{3}$ given above. Mention that this formula would be useful if we had a large number of shoe size values and wanted to find their corresponding foot lengths.

1. Introduce the term *literal equation*, which may be defined as an equation with more than one variable. (The word “literal” refers to “letter’). In the example above, *S =* 3*F –* 24 is as a literal equation. It is *solved for F in terms of S.* “Changing the subject of the formula” and “solving a literal equation” are two ways to describe the process of solving for a different variable.
2. In **Activity 2.5.1 Literal Equations**, students explore a variety of literal equations. Students manipulate formulas for temperature, surface area, sum of angles in a regular polygon, cricket chirps based on temperature, and simple interest. You may want to consult with science teachers about what formulas students are using in their science classes. These would provide additional meaningful examples for changing the subject of a formula because students will be using them in more than one discipline.
3. In **Activity 2.5.2 More Literal Equations**, students solve for variables using formulas which they have previously used. From their previous, studies should recognize the geometrical formulas in the activity. Many of these formulas are used on the Connecticut Academic Performance Test.
4. In **Activity 2.5.3 Literal Equations with Flowcharts**, students use flowcharts to transform literal equations. The flowcharts require students to identify the operations *being done* on the variable they wish to solve for, and then use flowcharts to identify the inverse operations which must be performed to make the variable the subject. This activity utilizes prior knowledge and use of flowcharts developed in Activity 2.2.1.

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

Flowcharts (**Activity 2.5.3**) provide visual cues and are recommended for students who have difficulty identifying the appropriate steps.

1. **Activity 2.5.4 Green Problems** provides students an opportunity to explore equations which relate to environmental and conservational issues.

**Differentiated Instruction (Enrichment)**

The green problems (**Activity 2.5.4**) require students to research energy costs and information about home appliance energy efficiency ratings and insulation energy efficiency ratings.

1. You can also motivate the need to change the subject of a formula by having students write simple programs for the TI-83/84 calculator to evaluate a formula on their calculators. For example, the program below on the left side finds the perimeter of a rectangle given its length and the width. The program below on the right side finds width of a rectangle given the rectangle’s length and perimeter. Students may then solve for W and write a program to find the width.

|  |  |
| --- | --- |
| **PROGRAM PERIM**:Prompt L:Prompt W:2L + 2W 🡪 P:Disp “P =”:Disp P | **PROGRAM WIDTH**:Prompt L:Prompt P:(P – 2L)/2 🡪 W:Disp “W =”:Disp W |

1. Give students equations in two variables, *x* and *y*, and ask them to solve for *y* in terms of *x*. This is a skill that will be used in Unit 4 to transform linear equations from one form to another and in Unit 6 to solve systems of equations by substitution.

For example, given the equation 12*x +* 4*y* = 20, we can solve for *y* when *x* is known, say *x* = 2, or when *x* is unknown. Either way we will implement the similar steps. The left side shows the process when *x* = 2, and the right side shows the process when *x* is unknown.

|  |  |
| --- | --- |
| $$24+4y=20 $$ – 24 – 24$$4y=-4$$$$\frac{4y}{4}=\frac{-4}{4}$$$$y=-1$$ | $$12x+4y=20 $$ – 12*x* – 12*x*$$ 4y=20-12x$$ $$\frac{4y}{4}=\frac{20-12x}{4}$$$$y=5-3x $$ |

You may use a power point designed by Skip Tyler, a teacher at Varina High School in Henrico County, Virginia. It may be found at

<http://teachers.henrico.k12.va.us/math/hcpsalgebra1/module3-5.html>

The power point helps students see that the same steps used to solve an equation in one variable can be used to solve a literal equation.

**Differentiated Instruction (Enrichment)**

Put the following equations on the board and ask students if these are in fact the same formula.  They must justify their answer.

$$s=\frac{n}{n+1} \frac{s}{s-1}=n$$

**Group Activity**

Pick four problems involving literal equations, possibly from **Activity 2.5.1** or **Activity 2.5.2**, and place them in stations around the room. Break students up into groups of four. Within each group, assign each student a number from 1 to 4. Students then go to the station that has their assigned number. There they work for three to five minutes individually to solve the problem. They may then work with others at their station to find the solution. Once they have the solution they should discuss it so that each of them can explain the solution process.

Then have students return to the original group as an “expert” on the problem they just solved. Each student takes 3 minutes to explain the solution to his or her problem with the other students writing the problems and solutions in their math notebooks. This will take about 25 to 30 minutes. Encourage others in the group to ask questions for clarification.

You may then ask students to generalize what they have learned about solving literal equations in a whole class discussion to provide closure to this investigation.

**Journal Entry**

1. Given an equation that has *x* as a variable, what does “solve for *x*” mean?
2. Explain why $r=\frac{6.27}{2π}$ is not a literal equation.

**Resources and Materials**

* **Activity 2.5.1** Literal Equations
* **Activity 2.5.2** More Literal Equations
* **Activity 2.5.3** Literal Equations with Flowcharts
* **Activity 2.5.4** Green Problems
* **Exit Slip 2.5** Cricket Chirps
* Graphing calculators
* Student Journals
* Link to the instructions for writing simple programs for the TI-83 or TI-84 graphing calculators <http://education.ti.com/>.
* Link to power point for solving literal equations <http://teachers.henrico.k12.va.us/math/hcpsalgebra1/module3-5.html>