DAY 2: What's Your Attribute?

Materials

Copies:	2.1 What's Your Attribute? page 1, copied separately with student names on each of the whole number coordinates (see directions below) 2.1 What's Your Attribute? pages 2 – 4 copied together 2.2 Writing Linear Equations from Word Problems - Part II Ticket out the Door – Day 2
Supplies:	colored pencils, at least 9 colors per student (groups can share) rulers – one per student
Word Wall Words:	System of Equations

Objective

Students will develop an understanding that a single linear equation has many solutions and that a system of two linear equations has one solution, no solution or infinitely many solutions (at a later date) by working on a graphing activity about classmates attributes. Students will continue to use patterns to help them write linear equations from word problems in preparation for solving systems of equations problems.

Student Talk Strategy

Think-pair-share – activity 2.1, Part A

Academic Language Use

Linear Equation – An equation that makes a straight line when graphed, and is often written in the form $y = \text{m}x + \text{b}$.
Solution to a Linear Equation – A solution to a linear equation $y = mx + b$ is an ordered pair (c, d) with the property that when you substitute c for x and d for y in the equation, the equation is satisfied, or is *true.*
System of Equations – A system of equations involves the relationship between two or more equations and can be used to model a number of real-world situations.
Solution to a System of Linear Equations - A *solution* to a system of linear equations is the point(s) of intersection of the lines or the value of the variables that satisfy the equations. The number of *solutions* can vary from one, to none, to infinitely many solutions.

Activity Notes

40 minutes: What's Your Attribute?

Note: Prior to class, obtain page 1 of activity sheet 2.1. Hand write student names on to each whole number coordinate before making copies for the class. The names should be small enough that they do not overlap on to another whole number coordinate. The names will correspond to certain attributes during the activity. If there are fewer students in the class than names on the coordinate plane, you will need to make up names.

As you are passing out activity sheet 2.1 (graph and packet), colored pencils and rulers, write the following two problems on the board or elmo, and have the students graph the two equations on a piece of scratch paper. Allow two-minutes for them to work quietly, and then move next to a partner to share their graphs.

$y = x - 2$ and $-2x + y = 4$

Randomly select two pairs of students to show their graphs and explain their work. At this time, have 2 pairs join together to form a group of four. Tell the students that they are going to be graphing the lines in the table on page two of activity sheet 2.1 on to the graph with their classmates' names and then they are going to be answering some questions to discover their classmates' attributes on the following pages of 2.1. Each equation/attribute should be shaded a different color, and graphed in that color on page 1 of activity sheet 2.1. Model graphing and labeling the first equation, *Smart* $y = 2x + 2$ with the class, using a colored pencil of your choice; shade it on the table as well. Students may use different colors from you and each other, but each attribute should be a different color. Label the line *Smart*. Ask students questions to check for understanding about what their task is, and how they are to complete the graph. Be sure to emphasize using different colors and a ruler, which will help for accuracy when answering future questions.

Allow the students 20 minutes to continue graphing the remainder of the attributes, while you walk around and monitor for correctness. Set at timer, and at the end of 20 minutes have students complete Part A, number 1a and b using think-pair-share. Come to an agreement as a class for the answers to 1a and b.

Note: It is important to do the first one or two problems with the students, as they are to ONLY write down names that the line actually passes through, and not simply touches. Some names may be longer, and a line may "touch" a name, but not pass through actual coordinate associated with the name.

Set a timer for 5-minutes and allow students to finish Part A with their group. When time is up, or most groups are finished, have students present their solutions. Groups may have different ideas about responses to questions two and three, so it is important for them to come away with the idea that a single linear equation has many different solutions (we are not looking for specific numbers of solutions, but just that there are many).

Let the students know that they will now be working on Part B, which is going to ask them to now look at two attributes at the same time. Have groups complete 1a and then agree upon an answer as a class, having one student showing the class how they came

up with the solution. Set a timer for 10-minutes and have groups complete Part B while you circulate the room, checking for understanding. The discovery in Part B is that when we have two (or three) linear equations, there is only one solution or no solution (at this time). If students are struggling with answering the questions, stop the class and work together; otherwise, have students volunteer to present their findings to their classmates.
The last few minutes of the activity are to complete the Conclusion questions. The final question discusses the possibility of having another type of solution besides one or zero solutions, infinitely many solutions. It is not important that they have a full understanding of infinitely many solutions at this time as it will explored in greater depth in days to come. Let the class know that when they were looking for two or more attributes that they were find the solution to a *system of linear equations*. Introduce the word wall word and post it on your word wall. Let them know that the student name that they found is the *solution to the system of linear equations*. Post this on your word wall as well.

15 minutes: Writing a Linear Equation from a Word Problem
Pass out activity sheet 2.2, and have students move out of groups of four and move next to a partner. Let them know that they are going to continue to explore patterns in word problems to write linear equations.

Ask for a volunteer to read through Problem 1, which is similar to the problems they completed on Day 1. Let the class know that they will have 3 minutes to fill out the table and answer the two questions and write the equation. If they are struggling, they may use activity sheet 1.3 from Day 1. At the end of 3 minutes, randomly select a pair to share their work with the class. Ask the class if anyone has anything different, and have them share their work. It is important that the class agrees on the structure of the problem, and that you clear up any misconceptions before moving on. Allow partners 2 minutes to read through and complete Problem 2. Encourage students who are struggling to make a table and look for patterns. At the end of two minutes, select a pair of students, whom you know did the work correctly, to present and explain their work to the class.

Problems 3 and 4 are situations students often encounter when solving a system of equations. In these two problems, which are related, the total is the constant. Ask for a volunteer to read through the directions and the situation. Allow students 1 minute to continue filling in the table and answer the two follow-up questions and then have students offer their solutions to the table. Explain that we cannot solve this problem, because we do not have enough information. (We cannot accurately determine a **solution** for x nor y). Go through the remainder of the problem as a class and ask questions about how this problem is different than problems 1 and 2, and why.
Let the class know that there is a method to solve problem three, but we need more information about the situation. We cannot simply guess the number of students or adults, and hope we are correct. Ask a volunteer to read through the situation for Problem 4. Ask students what is the same in the problem and what is new. Work through the problem as a class, making sure that when the students show work in the two tables that it looks like the following:

$2 per Student
1 student: $2(1) = $2
2 students: $2(2) = $4
3 students: $2(3) = $6
4 students: $2(4) = $8
x students: $2($x$) = 2x$

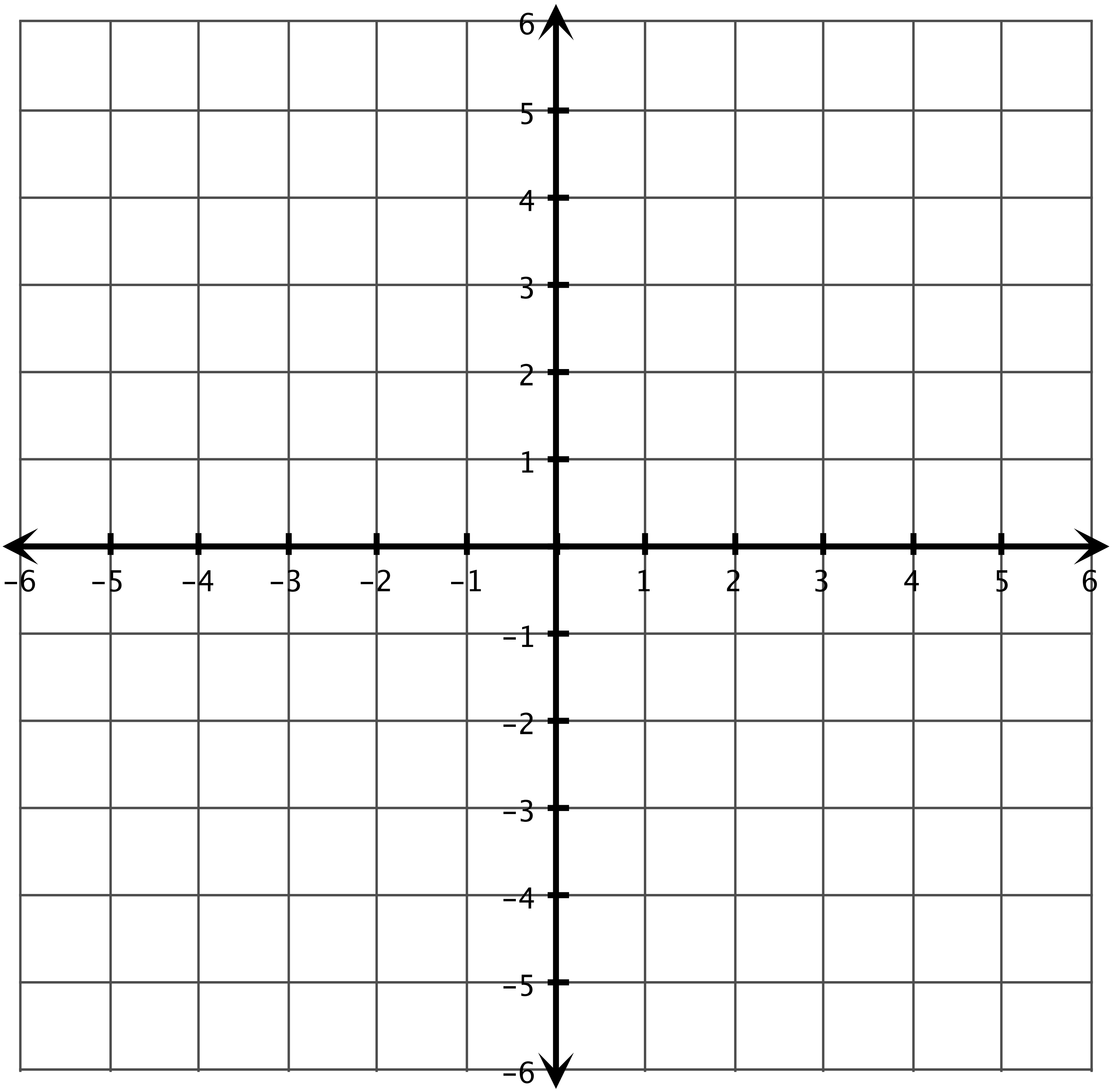
$4 per Adult
1 adult: $4(1) = $4
2 adults: $4(2) = $8
3 adults: $4(3)= $12
4 adults: $4(4) = $16
y adults: $4($y$) = 4y$

This is because we want to show a pattern that the coefficients of $2 and $4 remain the same in each row, but the number of students/adults continues to change, which are our variables. Allow students to work with their partner to fill in the final row of the table, which is the equation with variables. Let them know that we now have enough information to solve the problem, but we will learn how to solve it on another day.

5 minutes: Ticket out the Door
Pass out the Ticket out the Door and collect it as soon as each student finishes (so that you can discuss mistakes with students as they turn it in).

What's Your Attribute?
Graph

Directions: Use the graph below and the table on the "What's Your Attribute?" *Equations* page to answer the questions.



What's Your Attribute?
Equations

Directions: Use this page with the "What's Your Attribute?" graph to help you answer the following questions.

Smart	$y = 2x + 2$
Charming	$y = -x + 4$
Funny	$y = -2x + 6$
Sensitive	$y = -3x - 3$
Athletic	$y = 3$
Cheerful	$x = 3$
Diligent	$y = x$
Happy	$y = \frac{-2}{3}x - 3$
Calm	$y = 2x - 5$

Part A

1) List all of the students who are:

a) Smart: ____________________

b) Charming: ____________________

c) Funny: ____________________

d) Sensitive: ____________________

e) Athletic: ____________________

f) Cheerful: ____________________

g) Diligent: ____________________

h) Happy: ____________________

2) Is there only one *solution* or many *solutions* to each attribute in question #1? Explain.

3) What do you notice that is *different* about each of your answers to question #1?

Part B

1) List all of the students who are:
   a) Smart and Funny: ______________________________

   b) Cheerful and Funny: ______________________________

   c) Sensitive and Happy: ______________________________

   d) Happy and Cheerful: ______________________________

   e) Charming and Calm: ______________________________

   f) Athletic and Charming: ______________________________

   g) Funny and Diligent: ______________________________

   h) Smart and Sensitive: ______________________________

   i) Athletic and Cheerful: ______________________________

   j) Diligent and Smart: ______________________________

2) What do you notice that is the ***same*** about each of your answers to question #1 in Part B? (How many *solutions* are there?)

3) What do you notice that is ***different*** about each answer to question #1 in Part B?

4) The person who is funny and diligent is also _______________. Why do you think there are three adjectives to describe this person?

5) What is different about the number of answers or *solutions* to #1 in Part A, and #1 in Part B?

   Make a conjecture as to why sometimes there are *many solutions*, and why sometimes there is only *one solution*?

6) How many solutions were there for the student who is *calm* and *smart*? Why do you think that happened? (Hint: look at the equations, what is the same about them, and what is the same about their graphs?)

Conclusion

1) From this activity, I think the word *solution* means:

2) A single line has ____________________ *solutions* and two lines can have __________ *solution* or ______________ solution.

3) Two lines have *one solution* when the two lines ____________________.

4) Two lines have *no solution* when the two lines _____________________.

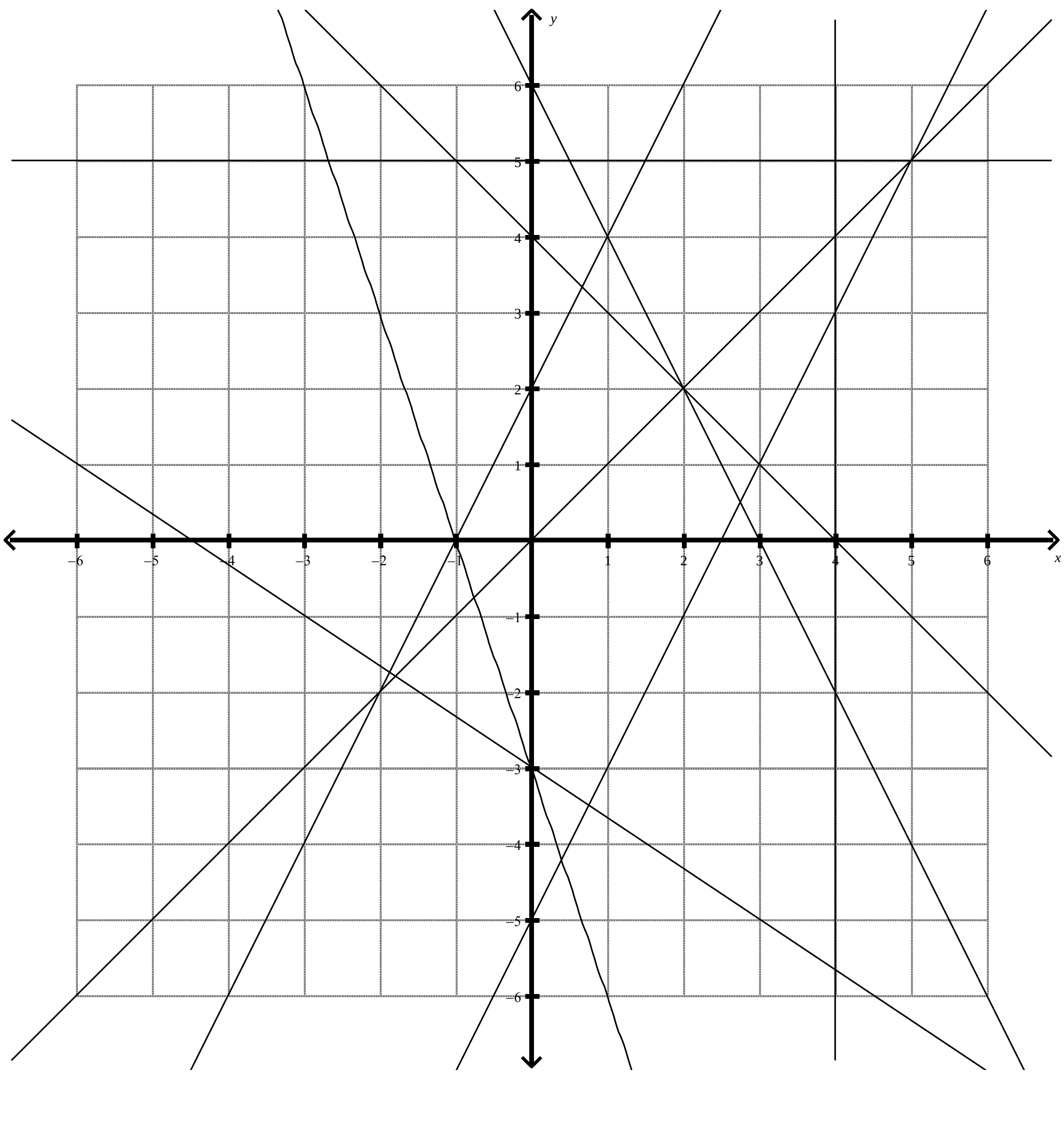
5) Can you think of a situation in which two lines would have *infinitely many solutions*? What would that look like if the two lines were graphed?

WHERE'S MY SEAT??

Mrs. Spykerman is a fun lovable math teacher that is obsessed with math. She uses math for everything including making her seating chart. Mrs. Spykerman has turned her seating chart into a coordinate plane and has drawn lines that represent the different characteristics that she sees in her students. Here are the guidelines she uses to make her seating chart:

1) Seats are represented by ordered pairs that are made up of only integers.
2) Each student in her class sits in a seat that is on one of the lines representing a characteristic.
3) Each student's name appears on the seating chart only once.

The students are supposed to find out where they sit today, but Mrs. Spykerman has a substitute. She left a copy of the graphed lines, the characteristics each line represents, and a list of her students and their characteristics. Help the students to figure out where they sit.



Equation	Characteristic
$y = 2x + 2$	Quiet
$y = -x + 4$	Honest
$y = -2x + 6$	Smart
$y = -3x - 3$	Athletic
$y = 5$	Funny
$x = 4$	Creative
$y = x$	Happy
$y = \frac{-2}{3}x - 3$	Hardworking
$y = 2x - 5$	Talkative

Student Name	Characteristic(s)
Rosa	Athletic & Quiet
Steven	Creative & Happy
Areli	Honest & Creative
Peter	Funny & Creative
Eduardo	Talkative & Creative
Edgar	Happy
Anthony	Athletic
Oscar	Funny & Honest
Austin	Talkative
Julian	Honest, Smart, & Happy
Martha	Smart
Rebecca	Smart & Creative
Ashley	Talkative & Honest
Angel	Funny
Joceline	Quiet
Yulissa	Hardworking
Ivette	Athletic & Hardworking
Martin	Smart & Quiet
Valeria	Creative
Lenny	Quiet & Happy
David	Talkative, Happy, & Funny
Samantha	Happy
Cristian	Honest

Directions: Label each line on the graph with the characteristic it represents and draw a point on each possible seat. Use the characteristics to find the students seat and write their name on the graph. Complete the table below by writing the ordered pair for each student's seat and giving a reason why the student sits there.

Student Name	Seat (Ordered Pair)	Reason Student sits in this seat
Rosa		
Steven		
Areli		
Peter		
Eduardo		
Edgar		
Anthony		
Oscar		
Austin		
Julian		
Martha		
Rebecca		
Ashley		
Angel		
Joceline		
Yulissa		

Student Name	Seat (Ordered Pair)	Reason Student sits in this seat
Ivette		
Martin		
Valeria		
Lenny		
David		
Samantha		
Cristian		

Questions:

1) Why do you think the majority of Mrs. Spykerman's students have more than one characteristic listed?

    a. Does having more than one characteristic make it easier or harder to figure out where they sit? Why?

    b. Would it be possible for any of these students to switch seats? Why or why not?

    c. Use the ordered pair for Rebecca's seat and plug it into the equations for "smart" and "creative". What do you notice?

    d. Do you think this will be true for all of the students' seats and their corresponding characteristics? Why?

2) Which students have more than 1 possible seat?

    a. What makes these students different than the rest of the students in the class?

    b. Which 2 students could switch seats with each other and still follow all of the seating chart guidelines?

3) Mrs. Spykerman gets a new student in her class named Jacob. Jacob is both athletic and honest. Is Jacob's seat on the seating chart?

    a. Would it ever be possible for somebody that is characterized as both athletic and honest to have a seat? Why or why not?

    b. Would it be possible for somebody to have a seat and be characterized as both quiet and talkative? Why or why not?

DAY 4: Asteroid Abstraction

Materials

Copies:	4.1 Asteroid Abstraction Ticket out the Door – Day 4
Supplies:	rulers – one per student Masking Tape or Chalk 1 – 25′ Rope Graph Paper Filled Water Balloons (2 of same color per team) Large Area to Make a 22′ x 22′ Coordinate Plane, marked with chalk or tape prior to class beginning
Word Wall Words:	no new words today

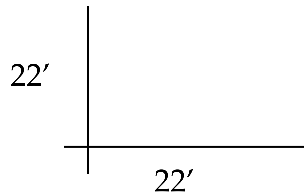
Objective
Students participate in a problem-solving activity for a system of equations and verify their answers graphically and algebraically.

Student Talk Strategy
Numbered heads for 4.1

Academic Language Use
Linear Equation – An equation that makes a straight line when graphed, and is often written in the form $y = mx + b$.
Solution to a Linear Equation – A solution to a linear equation $y = mx + b$ is an ordered pair (c, d) with the property that when you substitute c for x and d for y in the equation, the equation is satisfied, or is *true.*
System of Equations – A system of equations involves the relationship between two or more equations and can be used to model a number of real-world situations.
Solution to a System of Linear Equations - A *solution* to a system of linear equations is the point(s) of intersection of the lines or the value of the variables that satisfy the equations. The number of *solutions* can vary from one, to none, to infinitely many solutions.

Activity Notes
55 minutes: Asteroid Abstraction
Activity Overview: Students will be given a situation in which they will play the role of a NASA Scientist who is sending a data-collecting instrument to collect data from a pair of asteroids that are passing relatively close to the Earth. To do this, they will graph the asteroids' expected trajectory, and a given NASA flight path. They will use the intersection to decide where to release the data-collecting instrument.

After finding their points of intersection, the students will go outside and place water balloons at their derived solutions. The instructor (or a willing student!) will walk the trajectory of each asteroid, popping water balloons along the way!
Note on Location: You will need a large enough area to tape/mark off with chalk a 22′ by 22′ grid. Mark each axis using increments of 1. You will need to do it before class begins.



Task 1 (20 minutes)
There are eight (8) NASA Missions, so the class needs to be divided into eight teams. Pass out activity sheet 4.2 and graph paper to teach student. Ask for a volunteer to read through the problem situation and let students know that this is a situation in which real scientists work, but at a much more sophisticated level, since space is not 2-dimensional. Have another volunteer read through Question 1, and check for understanding by asking questions such as, "Where is the Earth located on the coordinate plane?"; "What is one way we can determine if the asteroids are going to hit the Earth?"; and "What would be a second way to verify that?" Tell students that they are going to verify that the asteroids will not hit earth both graphically and algebraically, by using substitution. Let them know that they will not be given a pre-made coordinate plane, so we will need to make one on the graph paper that is provided.

Note: Representing Earth as the point (0, 0) is a very simple abstract model. If we were going to be more realistic then the Earth would be modeled as a disk centered at the origin, given some radius. However the problem would then become more complicated because we would have to explore methods to determine when a line intersects a circle. (If students have more questions about this, they can Google "determining when a line intersects a circle" at http://mathworld.wolfram.com.

Give groups 30-seconds to discuss how the coordinate plane should be set up so that the numbers will fit easily and make sense. As students are discussing, go around the classroom and number each student in each group (1-3, or 1-4, depending upon number of students per group.) Use numbered-heads (#2) to collect responses from each group.

Guide students into an answer that is similar to the sketched graph above, which is mainly in quadrant 1. Use numbered-heads a second time to have students think about the Hats Off activity from Day 3 and the increments that were used (each increment was a unit of 2 on the y-axis). The question for students is, "What increments should be used to set up our graph?" (You may want to let them know that they will be graphing to +22 on the x-and y-axis.)

After collecting responses from groups, have the class agree that we can use units of 1 or 2, but anything larger would result in a graph that is not as accurate. Have students complete Question 1 in their groups, showing their work both graphically (labeling each line Alpha or Beta) and algebraically (by substituting in (0, 0) to each equation and showing that it is *not* a solution to Alpha nor Beta). Let students know they will have

15-minutes for this question and set a timer. While students are working, walk around and monitor students to be sure that each student is working on their own graph; they are setting up the coordinate plane correctly; and graphing the two equations correctly. (If the equations are not graphed correctly, their answers will be incorrect for Question 2.) At the end of 15-minutes have one group come up and show their graph to verify the asteroids will not hit the earth and then have a second group come up and show their verification algebraically.

Task 2 (15 minutes)
For Question 2, each team is to be assigned ***one*** mission. Each student should graph his or her own set of equations for their teams' given mission. (Check for understanding by asking students how many sets of lines they will be graphing – only two more, their given mission.) Let students know that not all of the solutions will be whole number coordinates, as there have been in the past. Instruct students that after they have completed their graphs and found a solution, they should compare their answers with the rest of their group and verify their answers as well. The groups will need to decide upon a final set of solutions before proceeding outside. (It is okay if they are incorrect, they will learn from their mistakes.) Allow for 15-minutes for students to complete the work for Question 2.

Task 3 (20 minutes)
Instruct students that you will be going outside, and remind them of the appropriate behaviors that are expected as students walk to the location, and once at the location. They will need to bring one paper from their group, with their solutions. Once outside, each team should be given two of the same color water balloons (if possible) to tape down at their derived solutions. (Students can keep track if their water balloons were popped.) The teacher will need to bring outside: the rope; water balloons; tape.
After all groups have placed their balloons, use the rope to "graph" the asteroids trajectory and as a guide for you to follow on your "walk." Once the rope is laid down, the teacher (or volunteer student) will walk the course of the asteroid and pop those balloons that are in the asteroids' trajectory. Have a quick discussion about any balloons that were not popped and why they were not popped.
Once back inside the classroom, have the groups answer Question 3.

Asteroid Abstraction Answer Key:
1) No, the asteroids will not intersect with the earth.
2) See Table.

Shuttle Mission #	Flight Path	Intersection with Alpha	Intersection with Beta
1	2x + y = 8	(1.5, 5)	(4, 0)
2	x + 2y = 20	(3.2, 8.4)	(12, 4)
3	2x + 3y = 36	(3.75, 9.5)	(12, 4)
4	x + 5y = 60	(4.5, 11.1)	(20, 8)
5	2x + 3y = 54	(6, 14)	(17.25, 6.5)
6	4x + 5y = 80	(5, 12)	(13.8, 4.9)
7	2x + 5y = 35	(2.1, 6.2)	(10, 3)
8	7x + 8y = 160	(6.3, 14.6)	(16, 6)

3) Answers Vary.

5 **minutes: Ticket out the Door**
Pass out the Ticket out the Door and collect it as soon as each student finishes (so that you can discuss mistakes with students as they turn it in).

Asteroid Abstraction

NASA has discovered that two asteroids (which they have named Alpha and Beta) will be passing relatively close to the Earth. They want to take advantage of this rarity by collecting new sets of data. It will be your job to send a space mission close enough to the asteroids to fire a data-collecting instrument into them. NASA has determined the paths of the asteroids to be:

Alpha: $2x - y = -2$ & Beta: $2x - 4y = 8$

Question 1: If Earth is centered on a Cartesian plane at the origin (0, 0), will the asteroids ever come into contact with Earth? Verify your response by graphing the data, as well as using substitution. Use a piece of graph paper and a ruler for accuracy.

Answer:

NASA has determined the flight path of your mission so that it will intersect with the asteroids' trajectory. In order to collect various types of data, several missions have been scheduled. It is your job to determine at which point of your mission you should shoot the data instrument into the asteroid. You will have to find this point by graphing, and should verify your answer. NASA will now tell you which mission is your will be responsibility.

Question 2: Fill in the table below with your suspected intersection with each asteroid and then graph your flight path to determine the intersection points. Use the same graph you used for question one. Once you have a coordinate, use substitution to verify your answers. Note: Not all intersections will be whole number coordinates!

Mission #	Flight Path	Intersection with Alpha	Intersection with Beta
1	2x + y = 8		
2	x + 2y = 20		
3	2x + 3y = 36		
4	x + 5y = 60		
5	2x + 3y = 54		
6	4x + 5y = 80		
7	2x + 5y = 35		
8	7x + 8y = 160		

Application: When everyone has calculated their intersections, you will receive two water balloons, which you will take outside and tape to your suspected intersection for Alpha and Beta. Your teacher (or student volunteer) will play the role of "asteroid" and walk along its path.

Question 3: How close was your calculation to the actual answer? Explain in 2-3 sentences.
If your calculation(s) did not match the actual answer(s), go back to your graph and work and try to find your error. Describe where you made your mistake.

DAY 5: Fair Trades

Materials

Copies:	5.1 Fair Trades 5.2 Patterns in Linear Systems 5.3 Solving Linear Systems – Thinking Map Ticket out the Door – Day 5
Supplies:	rulers – 1 per student pattern blocks – 6 green triangles, 3 blue rhombi, 2 red trapezoid and 1 yellow hexagon per pair
Word Wall Words:	no new words today

Objective

Students will trade equivalent pattern blocks to understand the concept of substitution. Students will compare slopes and y-intercepts of graphs that meet at one point, are the same line and are parallel to discover the number of solutions for a system linear equations without graphing.

Student Talk Strategy

Report to a Partner for activity 5.1
Think-Pair-Share for intro to activity 5.2 and 5.3

Academic Language Use

Linear Equation – An equation that makes a straight line when graphed, and is often written in the form $y = \mathrm{m}x + \mathrm{b}$.
Solution to a Linear Equation – A solution to a linear equation $y = mx + b$ is an ordered pair (c, d) with the property that when you substitute c for x and d for y in the equation, the equation is satisfied, or is *true.*
System of Equations – A system of equations involves the relationship between two or more equations and can be used to model a number of real-world situations.
Solution to a System of Linear Equations - A *solution* to a system of linear equations is the point(s) of intersection of the lines or the value of the variables that satisfy the equations. The number of *solutions* can vary from one, to none, to infinitely many solutions.

Activity Notes

25 Minutes – Exploring Substitution Using Pattern Blocks
Pass out activity sheet 5.1. Have the students get into pairs. Direct the students' attention to the opening question, and have them report to a partner about what it means to substitute a player in a soccer game. Elicit other ideas or contexts about what substitution means. Remind the students that today's lesson is working towards

understanding a faster and more efficient way to solve a system of equations, especially for cases when the answer involves decimals, such as the solution for the asteroids. You may even want to ask why some of the intersections were difficult to find during the asteroids activity.

While students are reporting to a partner, pass out the pattern blocks to each pair. Direct the students' eyes to the table with a picture of each block and the corresponding variable assigned to it. Have a volunteer read problem #1 and then give the pairs 3 minutes to solve it. Use random selection to have a student present their solution (you are looking for $y = 2r$. Ask if anyone has a different solution, as it is also correct to write $y = r + r$. Once the class understands, set the timer for 10 minutes and have them complete problems 2-6. Come back together and have students, who you know have correctly written equations, share their work.

Direct the students' attention to part 2. Explain that they will now use their equations for fair trades to solve for values of each letter. Again, give the pairs 3 minutes to complete #1 and have a volunteer share their work. Below is the work you would like to see.

$2y = 24$

$2(3b) = 24$

$6b = 24$

$b = 4$

If the class is struggling, you may need to guide them through by first recording the equation $2y = 24$ and then asking them to recall how many *b* blocks it takes to make a fair trade with 1 yellow block. Then ask them how they can trade or substitute that for the blocks it takes to make a fair trade with 1 yellow block. Then ask them how they can trade or substitute that for the *y* and model this.

Set the time for 8 minutes and have pairs complete the rest of the page. Note: it is okay if they don't get the challenge; it is truly a challenge! At the end of the 8 minutes, choose students who did the work correctly to share their work with the class.

End this section by explaining that the trades they made in the equations is what we call "substitution" in solving systems of equations and they will learn more about this method in future days.

20 Minutes: Looking for Patterns when Solving Systems by Graphing
Pass out activity sheet 5.1 and a ruler to each student. While you are passing out the supplies put the following problem the board for students to complete using scratch paper: Convert $2x – 3y = 6$ in to slope-intercept form. Tell students that they are to be finished with the problem by the time you are done passing out the activity sheet and rulers. Ask for a volunteer to present their solution.

Have students move their desk next to a partner and complete questions 1-3. Set a timer for 3 minutes. After 3 minutes, put up the solutions.

Inform students that they will now solve several systems of linear equations by graphing. Remind them that a *solution* must satisfy both equations. Have students work in partners to complete problems 4 through 9. Students must complete their own work. Set a timer for 15 minutes. While students are working, walk around and check for correctness; answer questions about how to verify *no solution* or *infinitely many solutions*; ask questions about why the system has *one solution, no solution* or *infinitely many solutions*. Some of the problems are already graphed for students and they are only required to find the solution by looking at the graph.
The solutions to the problems are: 4) (4, 1); 5) no solution; 6) (2, 1); 7) infinitely many solutions; 8) infinitely many solutions; 9) no solution.

After 15 minutes, bring the class together and read the directions for completing the table. Number four has been completed for the students. The objective for the table is for students to find commonalities in equations based upon the type of solution they arrived at. Give students 8 minutes to fill in the table and answer the three concluding questions, with their partner. After 8 minutes, have pairs compare their results to questions 1 through 3 with another pair. Or, if you feel the class is struggling with the concept, you can answer the questions together as a class. Answer to each of the problems should be similar to:

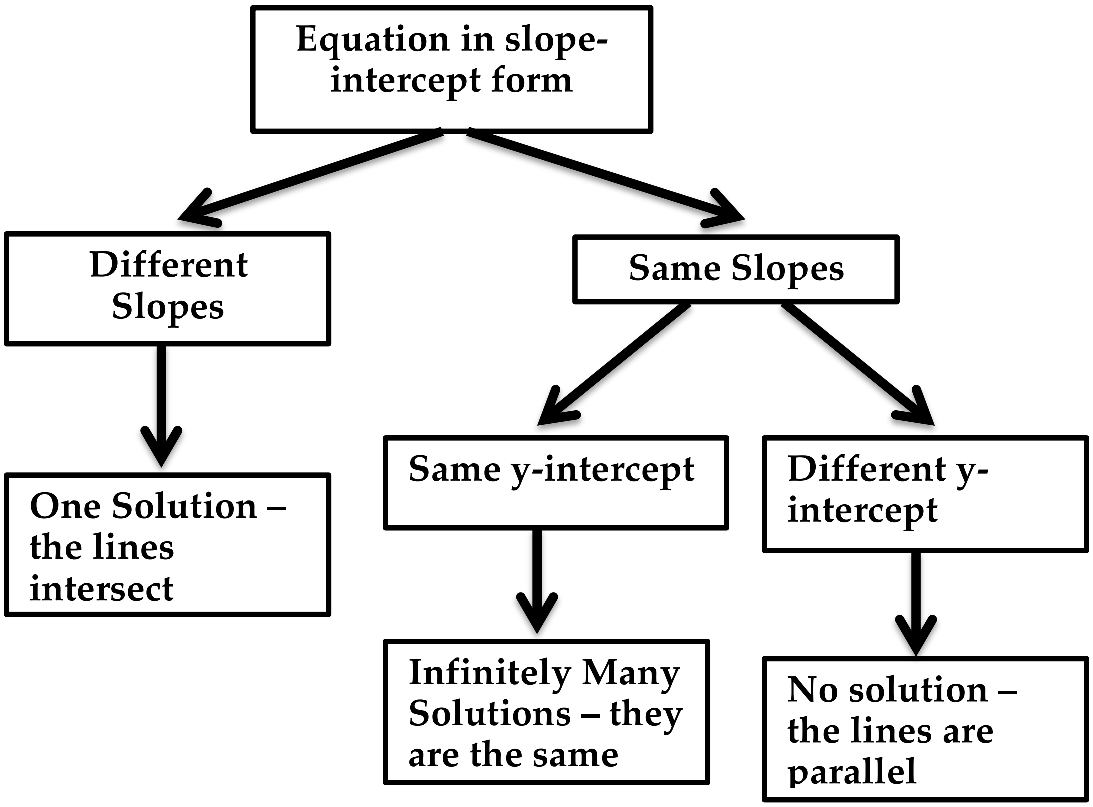
1) Looking at each of the problems that had ***one solution***, what do you notice about the slopes and y-intercepts of their equations? *I noticed that when there is one solution, both the slope and y-intercepts are different in the equations.*

2) Looking at each of the problems that had ***no solution***, what do you notice about the slopes and y-intercepts of their equations? *I noticed that when there is no solution, the slopes are the same, but the y-intercepts are different in the equations.*

3) Looking at each of the problems that had ***infinitely many solutions***, what do you notice about the slopes and y-intercepts of their equations? *I noticed that when there are infinitely many solutions, the slope and y-intercept are the same in* ***both*** *equations.*

10 Minutes: Patterns in Systems of Linear Equations - Thinking Map
Tell students that they will need to keep out page 3 of activity sheet 5.1 to help them complete the next activity. Put students back into pairs and pass out activity sheet 5.2. Have students use think-pair-share the answer to complete the sentence frame. Write this sentence on the board:
"When the slopes are different in the two equations, there will be _____________ solution."
Allow students 15 seconds to "think" and 30 seconds to "share" with their partner. Randomly select a pair of students to read through the sentence frame with their answers. Use thumbs up/down to see if the rest of the class agrees. If students disagree, ask them to explain why they disagree, while having them refer to the table they made in activity 5.1 After the class agrees that there is one solution, have them fill in the box underneath "Different Slopes" on worksheet 5.2. (See the thinking map below for suggested language.)

Repeat the process above two more times, by writing up the following sentence frames, one at a time and then discussing as a class: "When the slopes are different and the y-intercepts are the same for both equations, there will be _________ solutions" and "When the slopes are the same but the y-intercepts are different, there will be ___________ solution."



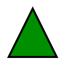
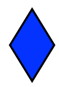
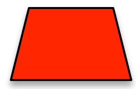
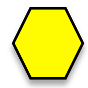
Once more, after the organizer is complete, have students think-pair-share as to why this thinking map is valuable when solving systems of equations. Have students "think" for 30-seconds and "share" for 1 minute. Ask for volunteers to share what they and their partner came up with. The value of the thinking map is that it allows us to determine the type of solution before we even begin solving. If we know something will have *no solution* or *infinitely many solutions* then it is not necessary to solve the system. We would only need to *solve* if there is *one solution*.

5 Minutes: Ticket out the Door

Pass out the Ticket out the Door and collect it as soon as each student finishes (so that you can discuss mistakes with students as they turn it in).

Fair Trades

Opening Question: What does it mean when a coach substitutes a player in a soccer game? How does it work?

Shape				
Represents	g	b	r	y

Part 1: Comparing and Trading

1. How many red (r) trapezoids would you trade to be equal to 1 yellow hexagon (y)?

Write this as an equation in the box to the right using r and y.

2. How many blue (b) rhombi would you trade to be equal to 1 yellow hexagon (y)?

Write this as an equation in the box to the right using b and y.

3. How many green (g) triangles would you trade to be equal to 1 yellow hexagon (y)?

Write this as an equation in the box to the right using g and y.

4. How many green triangles (g) would you trade to be equal to 1 red trapezoid (*r*)?

Write this as an equation in the box to the right using *r* and *g*.

5. How would you trade, equally, a red trapezoid (r) for a combination of blue rhombi (*b*) and green triangles (*g*)?

Write this as an equation in the box to the right using *r*, *b* and *g*.

6. Use your pattern blocks to complete the equation below so that the trade is fair.

$y =$ ______ r + _____ g

Part 2: Calculating Values
Directions: Use the given equation and your knowledge of the equations of the fair trades you wrote in the boxes above to find the value of other blocks.

1. Given $2y = 24$, find the value 1 blue rhombus (*b*), by writing the equation using ONLY the letter *b* and solving it.

2. Given $2y = 24$, find the value 1 green triangle (*g*), by writing the equation using ONLY the letter *g* and solving it.

3. Given $2y = 24$, find the value 1 red trapezoid (*r*), by writing the equation using ONLY the letter *r* and solving it.

4. Given $2r = 30$, find the value 1 green triangle (*g*), by writing the equation using ONLY the letter *g* and solving it.

CHALLENGE
Given $2y = 24$, write the equation using the letters *r* and *g* (see the equation you wrote for # 6 above).

Now re-write the equation using ONLY the letter *g* (keeping all trades fair-see the equation you wrote for #4 above) and solve the equation.

Patterns in Linear Systems

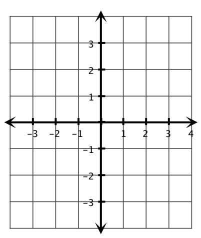
<u>Review</u> – Fill in the blanks to each of the sentence frames.

1) A *solution* to a *system of linear equations* is a set of values that makes each equation ____________ (*true, false*).

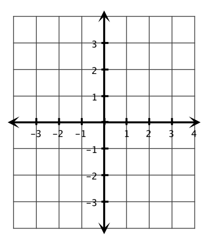
2) For a system of two linear equations whose graphs are intersecting lines, there is/are__________ (*one, none, infinitely many*) solutions.

3) We have learned that there are three different types of *solutions* that can result for a system of two linear equations. Sketch of each of the possible solutions, as described.

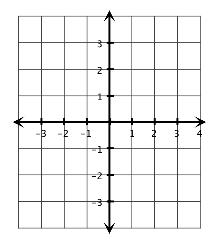
One Solution



No Solution



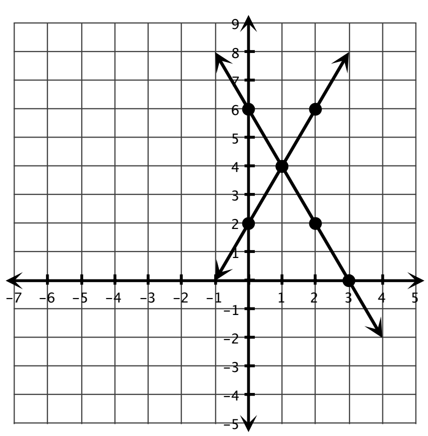
Infinitely Many Solutions



For problems four through nine, graph each system of equations and then verify your solution by using substitution.

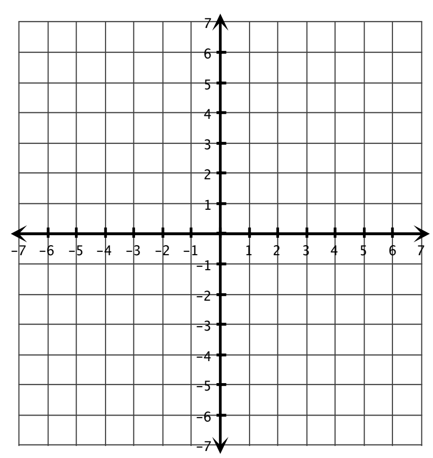
4) $\begin{cases} y = -2x + 6 \\ y = 2x + 2 \end{cases}$

The *solution* is _______________.



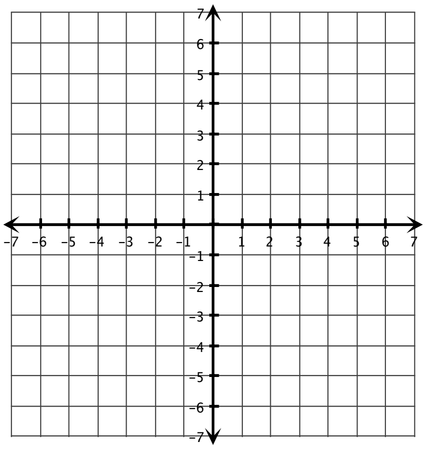
5) $\begin{cases} y = 6x - 5 \\ 12x - 2y = -2 \end{cases}$

The *solution* is____________.



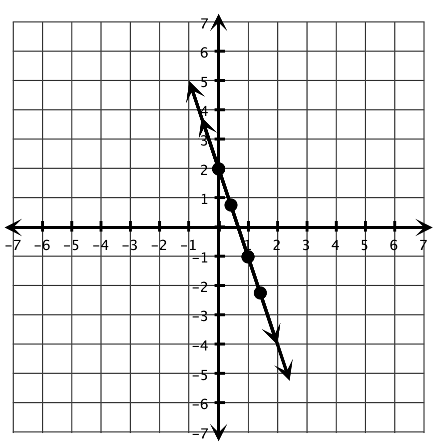
6) $\begin{cases} y = x - 1 \\ y = -\dfrac{1}{2}x + 2 \end{cases}$

The *solution* is ____________.



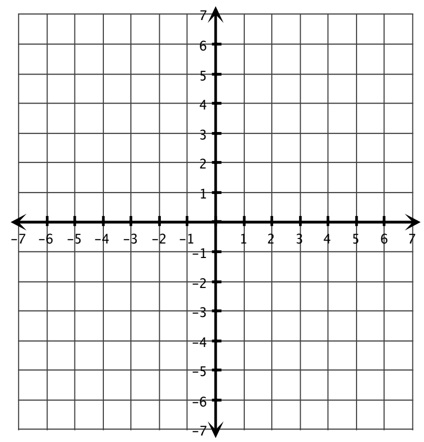
7) $\begin{cases} y = -3x + 2 \\ 3x + y = 2 \end{cases}$

The solution is: ____________.



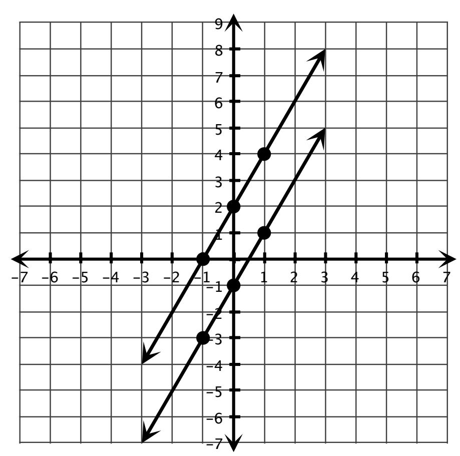
8) $\begin{cases} y = \dfrac{-1}{3}x - 1 \\ -2x - 6y = 6 \end{cases}$

The *solution* is ____________.



9) $\begin{cases} y = 2x - 1 \\ y = 2x + 2 \end{cases}$

The solution is: ____________.



Complete the table below based upon your results from problems 4-9. Use the able to answer the questions below. Number 4 has been filled in for you.

#	**Type of Solution (*one, none, infinitely many*)**	**Equations in slope-intercept form**	**Slope for each equation**	***Y*-intercept for each equation**
4	one solution	$\begin{cases} y = -2x + 6 \\ y = 2x + 2 \end{cases}$	m = -2; m = 2	b = 6; b = 2
5				
6				
7				
8				
9				

1) Looking at each of the problems that had ***one solution***, what do you notice about the slopes and *y*-intercepts of their equations?

The slopes are _________________, but the *y*-intercepts may be the __________ or

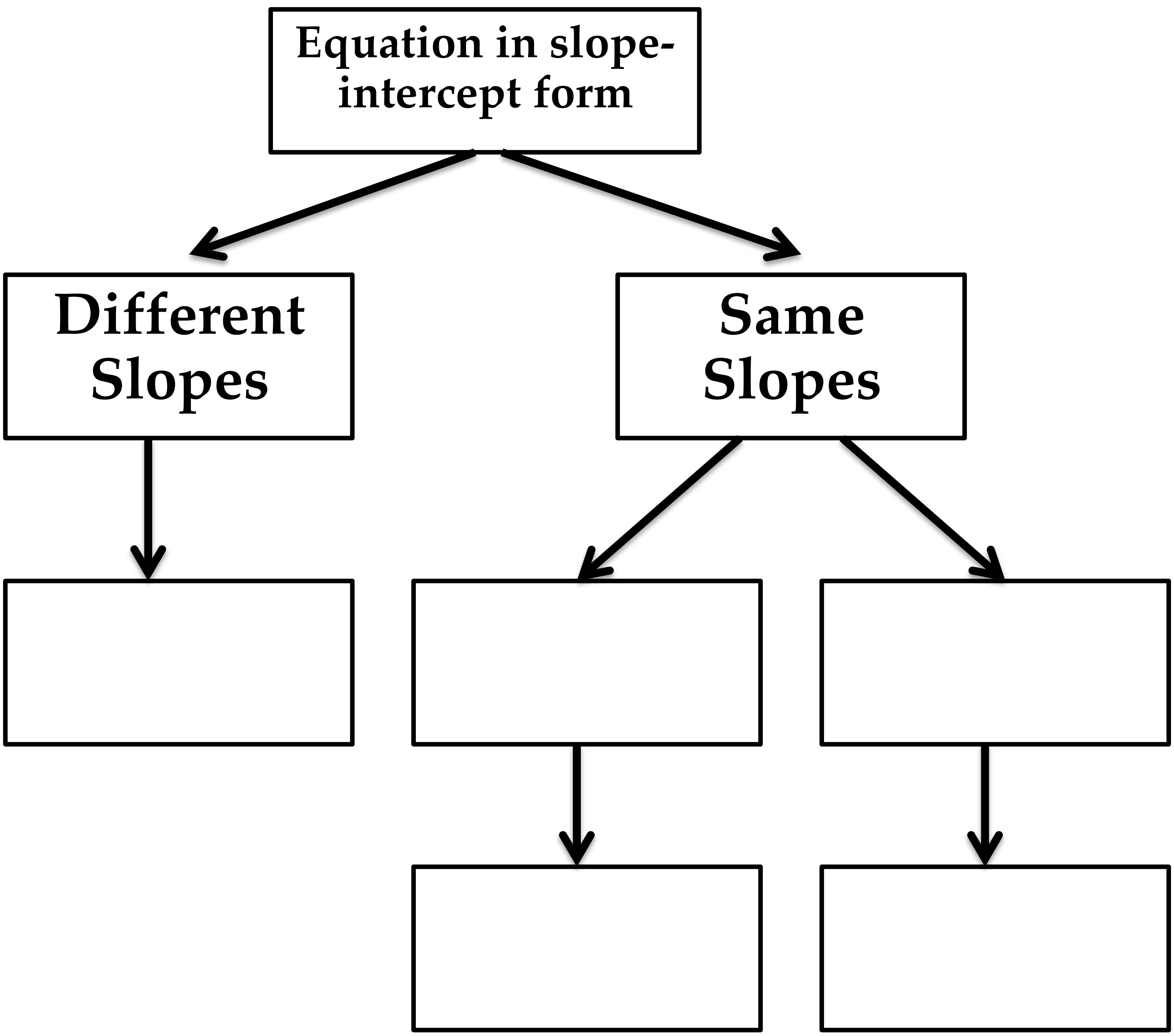
________________.

2) Looking at each of the problems that had ***no solution***, what do you notice about the slopes and *y*-intercepts of their equations?

3) Looking at each of the problems that had ***infinitely many solutions***, what do you notice about the slopes and *y*-intercepts of their equations?

Solving Linear Systems – Thinking Map

Directions: Fill in the graphic organizer to help you determine the number of solutions a system of two linear equations will have. Use page 3 of activity sheet 5.1 to help you fill it in.



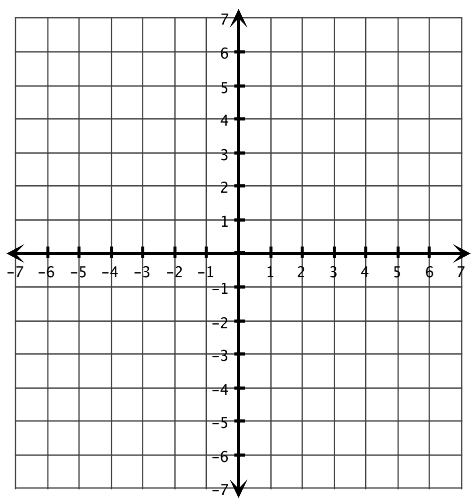
The Substitute

1) Using your thinking map, determine the type of solution that is to be expected for problem #2. Describe how you reached your answer.

There will be _____________solution(s) because _______________________.

Solve by graphing:

2) $\begin{cases} y = x + 4 \\ y = -3x - 2 \end{cases}$



Verify by using substitution.

The *solution* is

_____________.

Why was finding the solution to this system of linear equations more difficult than problems that you have solved previously? ________________

____.

Sometimes solving a system of linear equations by graphing is difficult due to factors such as: the solution to one or more of the variables is a decimal or fraction; the intersection is a large number that is difficult to graph.

Another method for solving a system of linear equations is: _____________.

I think this means that I take one of the equations and ________________

____.

3) Using your thinking map, determine the type of solution that is to be expected for problem #3. Describe how you reached your answer.

There will be ____________solution(s) because _______________________.

$$\begin{cases} y = -5x - 4 & \text{Equation 1} \\ y = x + 2 & \text{Equation 2} \end{cases}$$

Write equation 1:	$y = -5x - 4$	What does y equal in equation 2? _________
Replace the y in equation 1 for the value of y in equation 2.	______ $= -5x - 4$	
Solve for x.		
The value of x *is:*		

We have found the value of x, but still need to find the value of y. Substitute the value of x into both equation 1 and equation 2 and explain what you found out. Equation 1 has been started for you.

Equation 1: $y = -5x - 4$
$y = -5(\quad) - 4$

$y =$ _____

Equation 2: $y = x + 2$

$y =$ _____

I found out that the solution to the system is: (,). It ___________ (*does* or *does not*) matter which equation I substituted the x value in to. The value of y was the ____________ (*same* or *different*). I was _________ (*correct* or *incorrect*) in my prediction that there would be _______________ solution(s).

Why is it important to find the value of x **and** y. In other words, why can we not stop after we have found the value of only one variable?

Recall the definition for a ***solution to a system of linear equations***: A *SOLUTION* to a system of linear equations is the _______________ __________________of the lines or the value of the variables that satisfy the equations.

4) Using your thinking map, determine the type of solution that is to be expected for problem #3. Describe how you reached your answer.

There will be _____________solution(s) because _______________________.

$$\begin{cases} y = 2x + 5 & \text{Equation 1} \\ y = -3x + 10 & \text{Equation 2} \end{cases}$$

Write equation 1:		What does *y* equal in equation 2? __________
Replace the *y* in equation 1 for the value of *y* in equation 2.	_______ = ______	
Solve for *x*.		
The value of *x* *is:*		

Find the value of *y*. (See problem 3 if you are having trouble.)

The solution to the system is: (,).

Verify your answer by using substitution:

Equation 1	Equation 2

I was ___________ (*correct* or *incorrect*) in my prediction that there would be _________________ solution(s).

5) $\begin{cases} y = x + 4 & \text{Equation 1} \\ -2x + y = -1 & \text{Equation 2} \end{cases}$

a)Using your thinking map, determine the type of solution that is to be expected for the problem.

There will be ______________solution(s) because _________________________.

b)

- How are the equations different than the systems you solved for in number 3 & 4? ____.
- Which of the two equations do you think will be easier to substitute into the other? Why? ____.

c) $y = x + 4;\ -2x + y = -1$

c) Verify your solution by substitution.

The solution is ________________; my prediction was __________________.

DAY 1: Police Chase

Materials

Copies: 1.1 Police Chase
1.2 *Show* Me the Money
Ticket out the Door – Day 1

Supplies: Rulers – one per student
Colored Pencils – 3 per student

Word Wall Words: Linear Equation
Solution for a Linear Equation
Systems of Equations
Solution to a System of Linear Equations

Objective

Students will review how to solve a system of linear equations by graphing and substitution through an activity in which they are trying to catch burglary suspects. Students will also review how to write and solve a system of linear equations from a word problem, through observed patterns in a table.

Student Talk Strategy

Think-Pair-Share – Activity 1.1 and 1.2

Academic Language Use

Linear Equation – An equation that makes a straight line when graphed, and is often written in the form $y = \mathrm{m}x + \mathrm{b}$.
Solution to a Linear Equation – A solution to a linear equation $y = mx + b$ is an ordered pair (c, d) with the property that when you substitute c for x and d for y in the equation, the equation is satisfied, or is *true.*
System of Equations – A system of equations involves the relationship between two or more equations and can be used to model a number of real-world situations.
Solution to a System of Linear Equations - A *solution* to a system of linear equations is the point(s) of intersection of the lines or the value of the variables that satisfy the equations. The number of *solutions* can vary from one, to none, to infinitely many solutions.

Activity Notes

5 minutes: Introduction

Introduce yourself and the objectives for this 9-day intervention unit. Explain some guiding principles you would like to have established for this unit. Some examples may include the following: 1) the students will be active learners, using manipulatives, drawing and talking with each other and the class; 2) error is a great way to learn and you will reward students who take risks and have consequences for those who would show any form of disrespect to a classmate; 3) it is important that the students *understand* the math and not just memorize or do it without being able to explain.

35 minutes: Graphing Review
Have students move their desk next to a partner. Write the following sentence frames on the board have students discuss with their partner what they would put in the blanks while you are passing out activity sheet 1.1, 3 colored pencils and one ruler per student.

When an equation is written in the form of y=mx+b, this is in ________________ form, where m represents the ____________ and b represents the __________________. When I graph an equation in this form, I start at the point (,) and then move using slope as _______ over ____.

Randomly select a pair of students to read through the statements while recording responses in the blanks. Ask two other pairs if they agree or disagree with the given responses. If they disagree, probe as to why they disagree.

Have students look at page 1 of activity 1.1, and to orient students to the map, ask students to think-pair-share the following questions:

1) At which intersection (two streets that cross) is the origin (0, 0) closest to on the graph? (E 17th St. and N Grand Ave)

2) At which coordinate is Sierra closest to? (1, 2)

3) What is the equation of the line that could represent East 21st St? ($y = 3$)

Ask a student to read the scenario at the top of page 2 and then ask several students to reiterate what the initial directions are. (To graph and label each of the three equations, using a different colored pencil.)

Set a timer for 5-minutes and have students work with their partner (each on their own graph). Walk around monitoring student graphs. When time is up select a pair of students to present their three graphed equations. Ask the class if anyone has anything different and clear up any misconceptions.

Have students read through question 1 and quietly write the point where the robbery occurred and the suspects fled from. (9, -4) Be sure that all students agree that this is the initial point and show, by pointing at the graph, that the suspects are traveling in a Northwest direction from the scene of the robbery.

Ask a student to read through problem 2a, and then ask the class what they think they should do to answer this question. Elicit answers until you hear something similar to "graph $y = -2$ and find the point(s) of intersection." Have students graph the equation and record any intersections. Randomly select students to share out any points of intersection that an officer may intersect a suspect at, if they were traveling on 14th St. Ask students to *verify their solutions* by using substitution. (You may need to have a brief conversation reviewing what a *solution* to a system is as well as how to verify the solution. Walk students through 2b if necessary.)

Set a timer for 20 minutes and have partners complete questions 3 through 7. Monitor students solutions and check for understanding by asking probing questions, such as:
Eliciting Observations:
• What do you see going on here?
• What did you notice when ___happened?
• When or where does ___ occur?
Eliciting hypotheses without explanation:
• What would you predict about ___?
• What has happened here? (at level of inference)
• What would happen if ___?

Be sure that at the 10-minute mark students know that they should be working on question 5. At the end of the 20 minutes, ask pairs to share their solutions to the problems. Have a brief discussion with students after they answer the conclusion questions, and post up the words “System of Linear Equations” and “Solution to a System of Linear Equations.”

15 minutes: Writing and Solving Linear Equations from Word Problems
This activity is to serve as a review as to how to write a set of linear equations from a word problem, and then solve the system by use of the substitution method.

Pass out activity sheet 1.2 and select a volunteer to read the word problem. Have students circle key words and numbers, such as “adult tickets” and “$10 per ticket.” Using think-pair-share, where students think for ten second and then share for twenty seconds, have students discuss what the question is asking them to find, and then randomly select pairs to share their discussion.

Instruct students that they have 3 minutes to work with their partner through the first table and to answer the two bulleted questions. After 3 minutes, ask one pair, how you know have the table and questions answered correctly to share their answers with the class. Ask if students have anything different. Other sets of partners may offer that they have two other numbers that add to 150. This would be an excellent time to discuss why there are so many variances, and lead students to determine that since we cannot find a constant number that works every time, that the students and adults must be variables, which can be represented by many different numbers. Give students 1 minute to finish the bottom table and to write an equation for the total number of students and adults that attended the play. Put the answer up for students to see and use thumbs up/down to have students agree or disagree that they arrived at the same equation that you did. Clear up any misconceptions.

Have students flip their paper over and instruct the partners that they will have 3 minutes to fill in the two tables, and the table with the equation. Once again, select one pair of students that have the correct work, and have them present their solutions to the class. Ask the class if anyone has anything different. Have students rewrite both equations and then ask a student to read the question “Do you think it would be easier to *solve* this *system of equations* using the substitution method or by graphing?” Tell students that this is a matter of personal choice, and that they are to fill in the sentence frame on their own. Some students would prefer to graph, but this is a good time to discuss why these particular equations may be difficult to graph (the numbers being large).

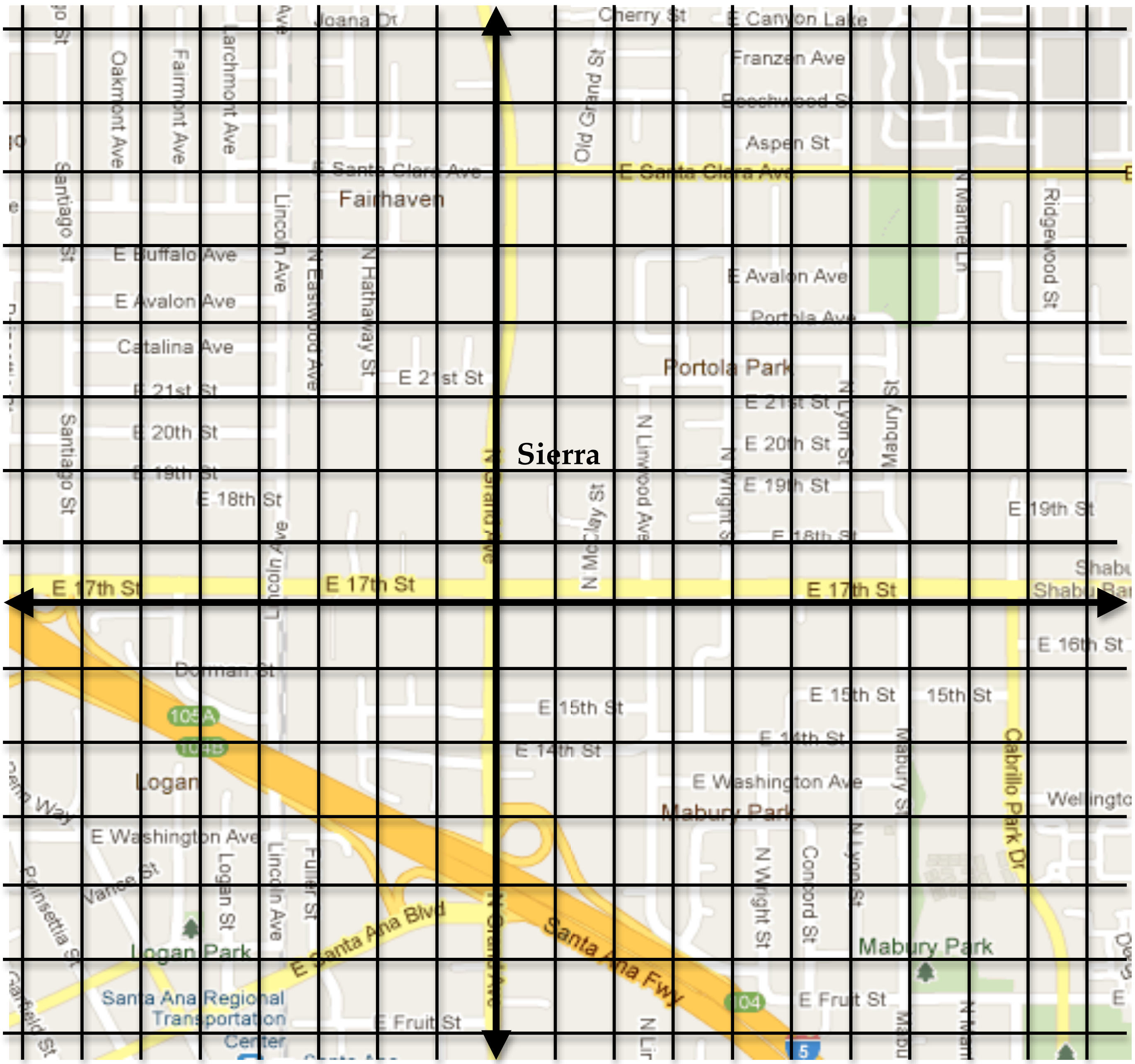
For the last 5 minutes of the activity, have students solve the system of equations by using the substitution method. You may want to lead students in getting started, by asking the question, "Are either of my equations ready to be *substituted* in to the other?" and "If they are not, what do I need to do first before I can use the *substitution* method?" Have students continue solving and remind them that this in one of the few times in Algebra we can check to make sure we have the correct answer, by substituting our values for x and y back in to both equations to make sure that those values make both of the equations true. Review the word wall word *Solution to a System of Linear Equations.*

5 minutes: Ticket out the Door
Pass out the Ticket out the Door and collect it as soon as each student finishes (so that you can discuss mistakes with students as they turn it in).

Police Chase

Task 1

Use the map below to answer the questions on the following page.



Note: The origin is located near the intersection of Grand and 17th.

The SAPD is chasing after several suspects in a burglary case. Each suspect took off in a different direction, to throw the police off their trail. All suspects ran in a Northwest direction. Graph each suspect's path, using a different color for each suspect. Be sure to label them on the graph.

A) $y = \frac{-2}{3}x + 2$ B) $y = -\frac{4}{3}x + 8$ C) $y = \frac{-2}{9}x - 2$

Answer the following questions using your graph.

1) Where did the robbery occur? ____________________

2) a) If an officer was driving East on 14th Street (y = -2), would they intercept any of the suspects? If so, where?

The point(s) of intersection: ___________________________________.

b) Substitute your *solutions* into the equations to verify your answer(s) to 2a.

3) a) Another officer, responding to the call is proceeding South on Grand Avenue (x = 0). Will she intercept any of the suspects? If so, where?

The point(s) of intersection: ___________________________________.

b) Using substitution, verify your answer(s) to 3a.

4) a) A third officer, is proceeding East on 17th Street (y = 0). Will he intercept any of the suspects? If so, where?

The point(s) of intersection: ___________________________________.

B) Using substitution, verify your answer(s) to 4a.

5) The police helicopter is following a flight path of $y = \frac{2}{3}x + 2$. Where would the helicopter be likely to see each of the suspects when directly overhead?

It would see Suspect A near _______________; Suspect B near _______________; and Suspect C near _________________.

6) Using the equation for the helicopter and Suspect A, use the method of substitution to find the exact location of where the helicopter would pick up sight of Suspect A.

Helicopter: Suspect A:

7) Now suppose the helicopter is flying a different path than the given one above. If the helicopter *never* gains sight of Suspect B, that is, the path of the helicopter never intersects the path of Suspect B, then it is _________________________ to the path of Suspect B.
Draw a line on your graph and write the equation of the line that could represent this situation.
The equation of the helicopter could be:_________________. When two lines never intersect, they are said to have ________ *solution*.

Conclusions:
1) What does it mean to *solve* as *system of equations*?

When I *solve* a *system of equations* I am ____
____.

DAY 2: Sewer Gator

Materials

Copies: 2.1 Stinky Feet – Odor Eliminator!
2.2 Sewer Gator
Ticket out the Door – Day 2

Supplies: Rulers – one per student
Colored Pencils – 2 different colors per student

Word Wall Words: Linear Equation
Solution for a Linear Equation
Systems of Equations
Solution to a System of Linear Equations

Objective

Students will learn how to *eliminate* a variable in a system of linear equations by: a) looking at patterns and coming to the conclusion that when integers are opposites of each other they have a value of zero or cancel each other out and; b) working through an activity which combines two linear equations together that have one set of common variable coefficients that are opposites of each other and notice that that variable will cancel, leaving one equation with one variable to be solved.

Student Talk Strategy

Think-Pair-Share for activity 2.1 and activity 2.2

Academic Language Use

Linear Equation – An equation that makes a straight line when graphed, and is often written in the form $y = \mathrm{m}x + \mathrm{b}$.
Solution to a Linear Equation – A solution to a linear equation $y = mx + b$ is an ordered pair (c, d) with the property that when you substitute c for x and d for y in the equation, the equation is satisfied, or is *true.*
System of Equations – A system of equations involves the relationship between two or more equations and can be used to model a number of real-world situations.
Solution to a System of Linear Equations - A *solution* to a system of linear equations is the point(s) of intersection of the lines or the value of the variables that satisfy the equations. The number of *solutions* can vary from one, to none, to infinitely many solutions.

Activity Notes

10 minutes: Stinky Feet

Pass out activity sheet 2.1 and have students move their desks next to a partner. Ask for volunteers to read the first three sentences, one student per sentence. Select one more volunteer to read the final paragraph before number 1 and then complete number one as a class, asking students to think for 10 seconds on their own, and then share with their partner the answer to this question: "If a point is positioned on the number line at negative six, how many units and in which direction do I need to move to get to zero?" Randomly select a pair of students to share what they discussed. Continue asking pairs until you hear something similar to: "I would need to move six units in the positive direction."

Set a timer for 5 minutes and instruct students that they are to work on problems 2 through 5 with their partner. At the end of 5 minutes, randomly select partners to come up and share their answers to problems 2 through 4. Go through problem number 5 with the class as a whole, randomly selecting students to provide their answers to 5a and then 5b. Record answers and then have a quick discussion about 5a and the fact that 7 and -7 are opposites of each other and when they are combined they have a value of 0. Answers may vary for 5b.

Have students individually answer the conclusion question, "What does it mean to "eliminate" something? After 1 minute, have student share with their partner, then randomly select students to share what they wrote. Write down student definitions, and focus on a definition such as "when something cancels out" or "when we get rid of something."

45 minutes: Sewer Gator – Learning the Elimination Method
Pass out activity sheet 2.2, a ruler and two different colored pencils per students. Have students remain next to their partner. Randomly select volunteers to read the introduction up to question number 1 at the bottom of the page. Stop after each bullet and ask clarifying questions, such as "What is a manhole?"; "What does it mean that there is a manhole at every street intersection?"; " What do you think the two paths (tunnels) that the Sewer Gator travels through would look like when graphed?"

Have students read through question 1, and fill in the blanks. They may work with their partner. The two methods are *graphing* and *substitution.* Have students graph the two equations on the coordinate plane provided, using a different color for each equation. Set a timer for 3 minutes and check to see if students are graphing correctly and helping those students who may need assistance in remembering how to graph by using intercepts, or by converting the equations to in to slope-intercept form. Once three minutes have passed, have one student (whom you know has graphed correctly) present their graph to class. Ask by show of thumbs up/down who agrees that the equations have been graph correctly. Have students who did not graph correctly copy the correct graph on to their paper.

Ask students to look at the two equations (you can have them re-write the equations, in standard form, in the margin at the top of the page for easier reference) and ask if they can easily solve one of the equations for either x or y? Allow students 1 minute to work through question 2, filling in the blanks. After one minute have students share with their partners for 30 seconds and then and go through question 2 as a class, having students' choral response answers.

> 2) Can you "solve" the equations as they are written? *No* (Yes/No) I *can not* (can/can not) easily see or solve for the value of x or y by looking at the two equations above because *there are two different variables to solve for*. What if there

was only 1-variable? _Yes,_ (Yes/No) I _can_ (can/can not) easily solve for the value of x in a single-variable equations (for example, $2x + 2 = 6$).

Have students quietly answer question 3, you may want to give a hint that they should be writing something about the relationship of the number one the "Stinky Feet Indicator" and the number of sprays it took to *eliminate* the odor. Once again, after about 1 minute have students share what they wrote with a partner 30 seconds and then randomly select partners to share. The big idea students should take away from this question is that when two numbers are opposites of each other, they cancel out.

Say, "Knowing now that opposites cancel each other out, if we combined the two equations could we easily eliminate one of the variables?" while pointing to the two equations. Do not ask for any one to answer, but have students complete question 4. Ask for a volunteer to read through the sentence frame.

Instruct students to complete 5a, and have one student come up and show their work, explaining what they did as a class. Fill in 5b together, as a class, clarifying academic language as you go through it, paying particular attention to the words *coefficient*, *opposites,* and *elimination method*.

> 5b) What happened when you added the two equations together? _The "y"s cancelled out_. This is because the _coefficients_ of the cancelled variables were _opposites_ of each other. This is known as the _elimination_ method.

Have students continue on through 5c and 5d, stopping to have a student present how they solved the remaining equation for x. With a partner, have students complete 5e and find the name of the street on the map in which they would drive down, and record it in the sentence frame. Select one student to read through their response and then use thumbs up/down to get a class consensus. If any students disagree, have them explain what they think the street it and why, until all students agree it should be *Fairview*.

Continue on to 5f, 5g, and 5h as a class. Have volunteer read through question 6 and have students "think" for 30 seconds as to whether or not they now have enough information and then share for with a partner if they have enough information, and how they can determine which manhole to make the drop under. Once they have conferred, randomly select pairs to share where they think they should drop the food and then fill in the sentence from for number 6.

The next part of the activity is a summary of steps that the students just used to find the answer to the Sewer Gator problem. Guide students through each of the steps, asking for a student volunteer to read the direction box for step. Have students then verify that the solution they arrived at (2, 5) is correct by using substitution.

Instruct the class that they are now going to practice solving some systems of equations using the elimination method with their partner. Set a timer for 4 minutes and have students work through problem 7. During this time, monitor the class by walking around and checking for understanding as well as students using the procedures correctly at each step. After 4 minutes, have partners compare their answers to each step with another set of partners. After 1 minute, ask for a volunteer to come up and present their groups solution.

To begin number 8, write the following questions on the board, and ask students to silently for 10 seconds think about their answer to:

> "If these two equations are added together, will one of the variables be *eliminated? Why or why not?"*

Ask for volunteers to answer the question. The hopeful answer is that neither of the variables will be eliminated because neither of the coefficients of the variables are not opposites of each other. The equation, when added would result in $5x + 2y = 22$.

Pose the following question verbally to students, and ask them to think quietly for 10 seconds:

> "What would happen if the bottom equation was subtracted from the top equation?"

After 10 seconds of silence ask for several volunteers to answer the question. The hopeful answer is that the "*y*"s would cancel each other. Have students add in a subtraction sign at the first step and then subtract the two equations. Ask for a volunteer to come write their resulting equation up at the front. Set a timer for 3 minutes and have partners continue working through number 8 while walking around to check for understanding. Once the 3 minutes are up, select a student (or pair) whom you know have done the work completely and accurately to present to the class how they arrived at their solution.

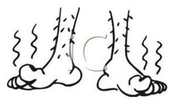
Instruct students that they are now going to have 6 minutes to follow the four steps for using the *elimination method* to solve problems 9 and 10 with their partner. When the 6 minutes have elapsed, select partners to present how they solved each of the systems of equations.

5 minutes: Ticket out the Door
Pass out the Ticket out the Door and collect it as soon as each student finishes (so that you can discuss mistakes with students as they turn it in).

Stinky Feet – Odor Eliminator!

Dr. Smarts' company of odor eliminating products is in the process of making a new product that eliminates stinky feet odor in a few easy sprays.

The scientists working at Dr. Smarts have invented a strip of paper, that when placed in a shoe for 5 minutes will show a "Stinky Feet" indicator on a scale of -10 to 0.

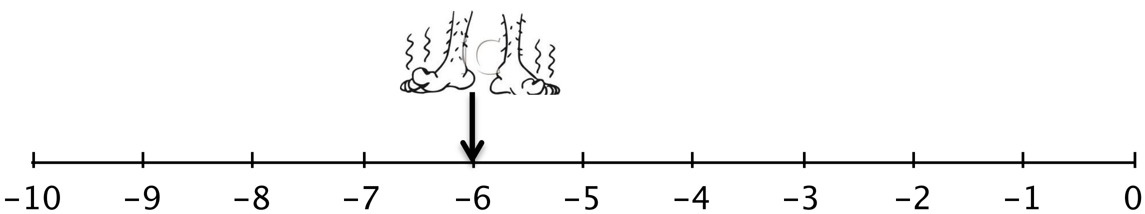


← Stinky Feet Indicator

The scientists also noticed that each spray of Fresh Feet would increase the stink number by one (move the Stinky Feet Indicator in a positive direction by one unit).

You are the scientist assigned to complete a research project to test out this theory. Based upon the shoes below, how many sprays would you spray in each shoe?

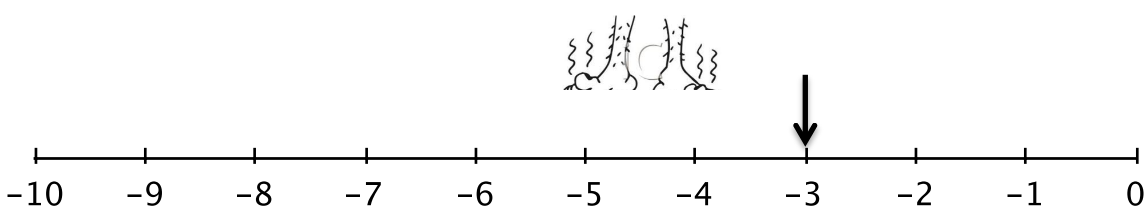
1)



If the Stinky Feet Indicator is at -6, how many sprays would be needed eliminate the odor and bring the "stink" to 0? __________ sprays

math equation: ______ (indicator #) + _______(sprays) = 0

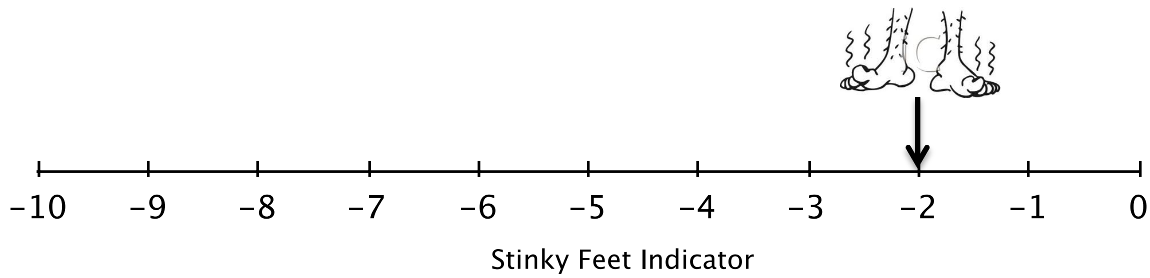
2)



If the Stinky Feet Indicator is at -3, how many sprays would be needed eliminate the odor and bring the "stink" to 0? __________ sprays

math equation: ______ (indicator #) + _______(sprays) = 0

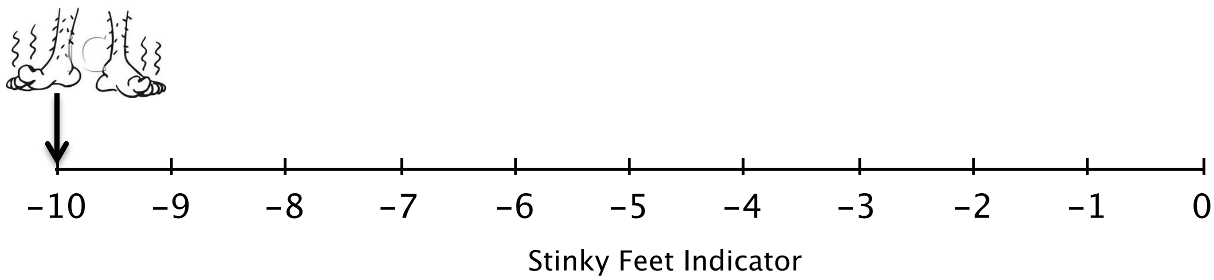
3)



If the Stinky Feet Indicator is at -2, how many sprays would be needed eliminate the odor and bring the "stink" to 0? __________ sprays

math equation: ______ (indicator #) + ________(sprays) = 0

4)



If the Stinky Feet Indicator is at -10, how many sprays would be needed eliminate the odor and bring the "stink" to 0? __________ sprays

math equation: ______ (indicator #) + ________(sprays) = 0

5) a) If the Stinky Feet Indicator indicated a foot smell of -7, how many sprays would be needed to eliminate the odor?

b) What do you notice about the relationship between the "stink number" in each of the problems above in relation to the number of sprays it took to have "zero" smell?
To "eliminate" the odor ____
____.

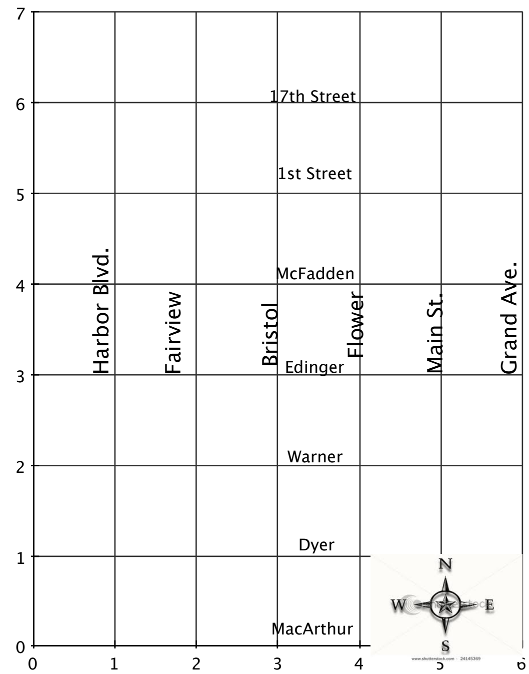
Congratulations, your research project was a success! You have eliminated the odor in each of your test shoes and have received a promotion to Head Researcher at Dr. Smarts' company.

<u>Conclusion</u>

What does it mean to "eliminate" something? To eliminate something means to ____.

Sewer Gator!

Use the graph and information below to capture the Santa Ana Sewer Gator!



You have been commissioned by the city of Santa Ana to capture the notorious Sewer Gator because the city has received numerous complaints about resident's pets disappearing. You've been given the following facts:

- There are manhole covers at every street intersection.
- The Sewer Gator has been known to eat rats, small dogs and cats, as well as McDonald's® Big Macs.

- The Sewer Gator travels through two main underground tunnels, whose paths are represented by:
    - $2x - y = -1$
    - $x + y = 7$

Your job is to: a) determine the tunnel intersection where there is the best chance that the Sewer Gator would eat poisonous food dropped under the manhole cover, given that you are starting at the origin (0, 0); b) go to the location and drop the poisoned food.

Use the following questions to help guide you to the best location.

1) What method(s) have you learned that would allow you to find where to place the poison (to find the *solution* or point intersection)? ______________ ________________________________ Graph the two equations above on the grid above. (You may need to convert them to slope-intercept form first.)

2) Can you "solve" the equations as they are written? ______(Yes/No) I _________ (can/can not) easily see or solve for the value of x or y by looking at the two equations above because ___________________________. What if there was only 1-variable? ______(Yes/No) I _________ (can/can not) easily solve for the value of x in a single-variable equations (for example, $2x + 2 = 6$).

3) What did you learn in the Stinky Feet activity about how to "eliminate" something? I learned ____ ____.

4) Looking at the 2 equations you graphed on the first page, does it seem like one variable could be eliminated easily? ______(Yes/No) I _________ (can/can not) easily eliminate one of the variables because they are opposites of each other.

5) a) Rewrite the original equations from the first page, one directly above the other and then add them together.

\+ ______________________

(new equation)

b) What happened when you added the two equations together? _________ ___________________________. This is because the _____________ of the cancelled variables were _______________ of each other. This is known as the ___________________ method.

c) Can you solve for one of the variables now? Explain.
______(Yes/No) I _______ (can/can not) easily see or solve for the value of ______(x/y) by looking at the equation above because __________________.

d) Write your new equation here and solve for the variable.

e) The value of _____ (x/y) is ______. On the street map on the first page, this is represented by ____________ (street name).

f) Do you have enough information to determine which manhole cover to drop the poisonous food under? Why or why not?

g) If you have one variable, how do you find the value of the other variable? I would ________________ the value of _____(x/y) in to ________ (one/both) of the given equations and then solve. Solve for the missing variable.

h) The value of ______(x/y) is _________. On the street map on the first page, this is represented by ______________(street name).

6) Do you have enough information to determine which manhole cover you should use and does it match the point of intersection when you graphed? Explain and then draw a manhole cover on the map on the first page as to where you would make the drop.

______(Yes/No) I ___________ (do/do not) have enough information. I know this because ____.

Good job! Head on over to McDonald's® and pick up a Big Mac and rid the city of Santa Ana of the pet eating Sewer Gator!

<u>Let's summarize what we learned about the ***Elimination Method*** by looking at what we did to solve the *Sewer* Gator problem*:*</u>

1st:

$$\begin{array}{r} 2x - y = -1 \\ + \quad x + y = 7 \\ \hline 3x = 6 \end{array}$$

1. Can I add or subtract the two equations to eliminate a variable?

If the two equations are added together, the y's cancel.

2nd: $3x = 6$

$x = 2$

2. Solve for the remaining variable.

3rd: $x + y = 7; x = 2$

$2 + y = 7$

$y = 5$

Solution (2, 5)

3. Solve for the eliminated variable by substituting the known variable value into either of the original equations.

4th: $2x - y = -1$ | $x + y = 7$

4. Verify your solution by substituting the values in to ***both*** equations.

Try one on your own, using the *elimination method* summary steps above!

7) What if the Sewer Gator had two babies, and one of them travels through the following tunnels:

- $x - y = 2$
- $x + y = 4$

ALLIGATOR FOUND IN UPTOWN SEWER

Youths Shoveling Snow Into Manhole See the Animal Churning in Icy Water.

SNARE IT AND DRAG IT OUT

Reptile Slain by Rescuers When It Gets Vicious—Whence It Came Is Mystery.

1st:

1. Can I add or subtract the two equations to eliminate a variable?

________________ new equation

2nd:

2. Solve for the remaining variable.

3rd:

3. Solve for the eliminated variable by substituting the known variable value into either of the original equations.

4th:

4. Verify your solution by substituting the values in to ***both*** equations.

The point of intersection (*solution*) is __________ and I should drop the food under the intersection of ____________ and ___________.

8) The second Sewer Gator baby travels through:

- $4x + y = 17$
- $x + y = 5$

1st:

1. Can I add or subtract the two equations to eliminate a variable?

____________________ new equation

2nd:

2. Solve for the remaining variable.

3rd:

3. Solve for the eliminated variable by substituting the known variable value into either of the original equations.

4th:

4. Verify your solution by substituting the values in to ***both*** equations.

The point of intersection (*solution*) is __________ and I should drop the food under the intersection of ____________ and ___________.

Go on to the next page →

Practice solving the following *systems of equations* by following the four steps of ***elimination*** on the prior page:

9) $\begin{cases} 3x + 2y = 5 \\ x - 2y = 1 \end{cases}$

Verify:

The *solution* is _____________.

10) $\begin{cases} -5x + 3y = 5 \\ 5x - 2y = 1 \end{cases}$

Verify:

The *solution* is ______________.

The Eliminator!

Using what your learned in the Sewer Gator activity, solve the following systems of equations by the e*limination* method.

1) $\begin{cases} 2x - y = 7 \\ x + y = 2 \end{cases}$

1st:

1. Can I add or subtract the two equations to eliminate a variable?

____________________ new equation

2nd:

2. Solve for the remaining variable.

3rd:

3. Solve for the eliminated variable by substituting the known variable value into either of the original equations.

4th:

$2x - y = 7$	$x + y = 2$

4. Verify your solution by substituting the values in to ***both*** equations.

The point of intersection (*solution*) is __________.

2) $\begin{cases} 3x + 2y = 5 \\ 3x + y = 1 \end{cases}$

1st:

1. Can I add or subtract the two equations to eliminate a variable?

______________ new equation

2nd:

2. Solve for the remaining variable.

3rd:

3. Solve for the eliminated variable by substituting the known variable value into either of the original equations.

4th:

$3x + 2y = 5$	$3x + y = 1$

4. Verify your solution by substituting the values in to ***both*** equations.

The point of intersection (*solution*) is __________.

Practice solving the following *systems of equations* by following the five steps of ***elimination*** on the prior page:

3) $\begin{cases} 3x+2y=5 \\ x-2y=1 \end{cases}$

The *solution* is ____________.

4) $\begin{cases} -5x+3y=5 \\ 5x-2y=1 \end{cases}$

The *solution* is _____________.

5) $\begin{cases} 3x+2y=5 \\ x+2y=1 \end{cases}$

The *solution* is ____________.

6) $\begin{cases} x+y=-5 \\ x-2y=1 \end{cases}$

The *solution* is _____________.

Conclusion: When using the *elimination* method, if the _____________ of one of the variables are ______________ of each other I ____________ (add/subtract) them to *eliminate* a variable OR if the _____________ of one set of variables are the same I ______________ (add/subtract) to *eliminate* one of the variables.

DAY 6: Putting It All Together

Materials

Copies: 6.1 Putting It All Together
6.2 Thinking Map: Systems of Linear Equations
Ticket out the Door – Day 6

Supplies: Rulers – 1 per group of 3 students

Word Wall Words: Linear Equation
Solution for a Linear Equation
Systems of Equations
Solution to a System of Linear Equations

Objective

Students will explore all three methods of solving a *system of linear equations* by working collaboratively to solve the same problem by substitution, elimination and graphing. When solving the problems, students will learn that for some systems, some methods may be more appropriate than others and identify their favorite method of solving. Students will create a thinking map in which they will list all three methods and write a sample problem that would be easiest to solve using that particular method.

Student Talk Strategy

Numbered Heads for activity 6.1

Academic Language Use

Linear Equation – An equation that makes a straight line when graphed, and is often written in the form $y = mx + b$.
Solution to a Linear Equation – A solution to a linear equation $y = mx + b$ is an ordered pair (c, d) with the property that when you substitute c for x and d for y in the equation, the equation is satisfied, or is *true.*
System of Equations – A system of equations involves the relationship between two or more equations and can be used to model a number of real-world situations.
Solution to a System of Linear Equations - A *solution* to a system of linear equations is the point(s) of intersection of the lines or the value of the variables that satisfy the equations. The number of *solutions* can vary from one, to none, to infinitely many solutions.

Activity Notes

30 minutes: Task 1, Putting It All Together

Put students in to groups of three and write the following on the board:

- Discuss with your group the three methods you have learned to solve a system of linear equations.
- Share with your group members which method is your favorite, and why.

As students are discussing with their group, pass out activity sheet 6.1 and one ruler per group. After passing out the papers, have students number themselves 1, 2 or 3. Use Numbered Heads for randomly selecting a number and a group to share what the three methods are solving a system of linear equations, and what their favorite method is and why. Record the three methods at the front and ask for a volunteer to describe each of the three methods.

Instruct students that they are going to solve problems 1 through 3 on activity sheet 6.1 as a group, but each student is only responsible for one method, their favorite method. (See next paragraph for what to do if all kids pick the same method.) Once the group completes each method they are to **share and discuss their method/solution with each other**. **Each student is also responsible for recording the work for all 3 problems, all 3 methods.** Note: It is important that students discuss how they solved each problem using their given method so that they will have enough information about each problem to complete the table on the bottom of page 2.

When students are picking "their method;" more than one student may prefer the same method, so you will need to assign a method to each student. For example, if everyone wants to graph, write on the board something such as: shortest hair: substitution; medium hair: elimination; longest hair: graph. Clarify directions for students by asking questions such as, "Does each person in the group have to solve all three problems by all three methods?" "Raise your hand if you are going to be the substitution expert in your group." "Raise your hand if you are going to be the elimination expert in your group." "Should you all end up with the same solution for each problem?" "If one of your group members is stuck, should you help them?"

Tell students that their group will have 15 minutes to work through all three problems; set a timer for 15 minutes where all students can see. At 5-minute intervals, announce to students that they should be done with a problem and be moving on to the next one. Walk around to monitor student progress and to pay special attention to those students who are working on substitution and elimination.

- Substitution students may have difficulty solving problems where at least one of the equations is not already written in slope-intercept form. (#2)
- Elimination students may have difficulty solving problems where the equations are not written in standard form. (#1, #3 – can be solved easily, but students may "lose" the equal sign.)
- Graphing students may have difficulty graphing equations in standard form, unless they are proficient at recognizing and using intercepts or converting to slope-intercept form. (#1, #2)

When 15 minutes have elapsed, or most groups are finished, have the class come to agreement on the solutions to all three systems. Instruct students that they will now complete the table on the bottom of page 2 by themselves, as it is their opinion about how they would prefer to solve each system of linear equations. In the first column, students are to rewrite the **original equations** for each problem. In the next two columns, students will be asked to determine if seeing the equations originally written would lead them to the conclusion that one method for solving a system of linear equations may be more appropriate over another. They will then write a sentence describing why one method is easier for them to solve the system.

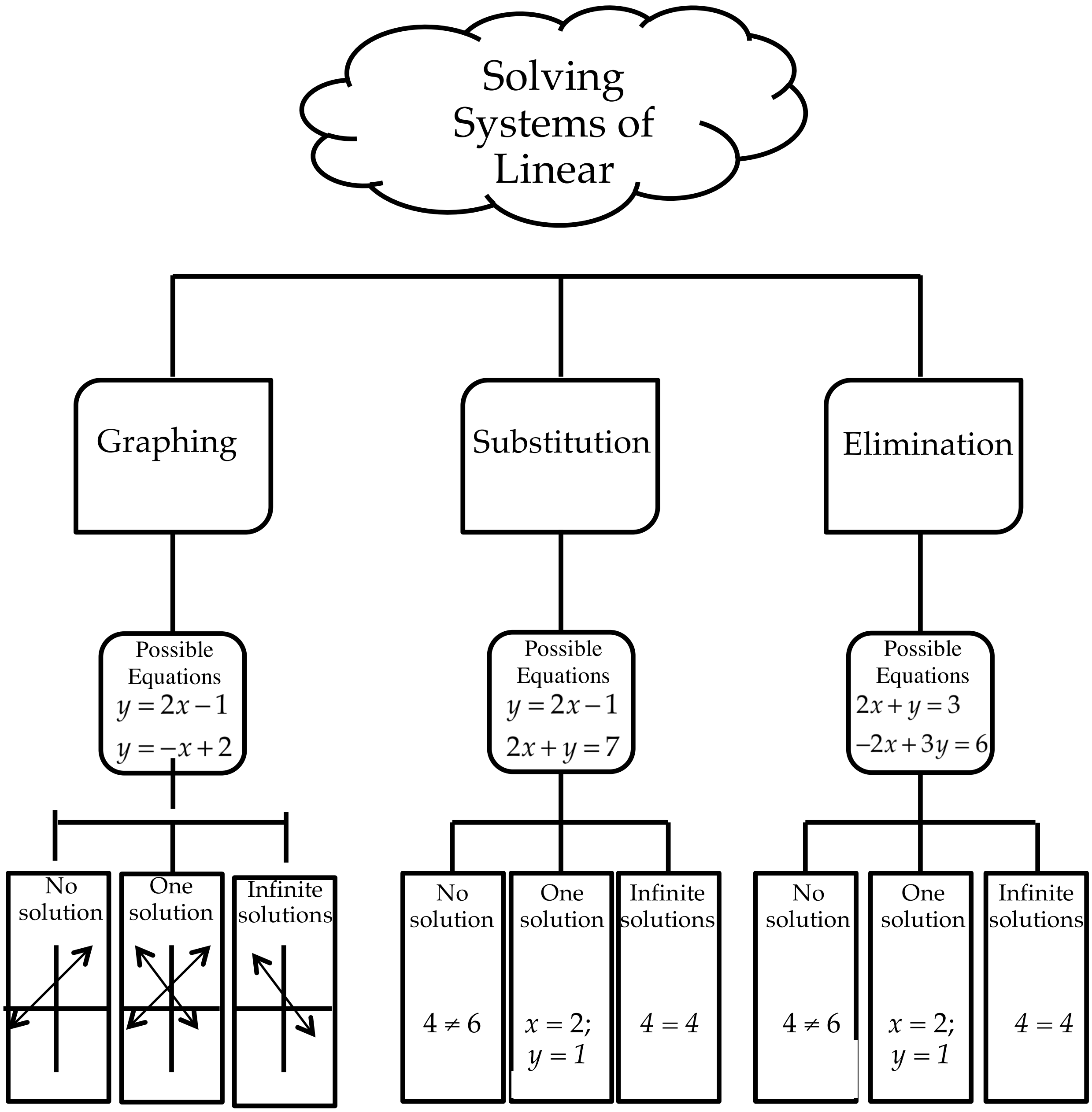
I found it is easier to solve the system using __________ (substitution, elimination, graphing).	The reason I believe that this method is easier is because…

Instruct students that they will have 10 minutes to complete this task, and that you expect the third column to be written in complete sentences. Set a timer for 10 minutes, and have students work silently. Once students are finished, ask students if they would like to share their preferred method to solve each of the problems. It really is a matter of personal opinion, and you could even poll the class for each problem to show students that many of their peers also prefer the same method. However, it is hopeful that students would see that substitution is easiest for problem 1; elimination is easiest for problem 2; and graphing is easiest for problem 3 (although substitution could be just as easy for many students).

15 minutes: Task 2, Putting It All Together
Keep students in the same group of three and instruct students that they are going to remain the "expert" in their method of solving a system of linear equations. The directions are the same as Task 1, in that each student will solve the problem and then share their method with each other. Set a timer for 10 minutes, and have students solve the two problems. Walk around and monitor student progress. The "elimination" student may have difficulty as this is the first time they will work with problems in which there is *no solution* or *infinitely many solutions.* Though the resulting patterns are roughly the same when solving as those for substituting, the graph for each problem will serve as a visual understanding of what it means to have *no solution* (the lines are parallel; inconsistent system), or *infinitely many solutions* (the lines are in fact the same; consistent, dependent system).

Once groups have completed the two problems and discussed each method with their group, have students turn the page and answer the three conclusion questions as a class. At this time you may also want to have students put examples under each sentence that illustrate what a possible solution might look like for *one solution, no solution* & *infinitely many solutions* (i.e., ($x = 3$, $y = 4$, *one solution*); $4 \neq 6$, *no solution*; $3 = 3$, *infinitely many solutions*). This will be helpful when students move on to the thinking map.

10 minutes: Thinking Map
Have students remain in their group, pass out activity sheet 6.2, and tell them to keep out activity sheet 6.1. Read through each bullet as a class. Ask for a volunteer to explain what should be in the top row (substitution, elimination, graphing). Work through one of the columns with students, referencing the sample problems, and then the three types of solutions possible for that column. If you are beginning the graphing column first (suggested, as it has the best visuals), have students draw a graph for each of the 3 possible solution types. Repeat the procedure with the remaining columns. A sample is given below.



5 minutes: Ticket out the Door
Pass out the Ticket out the Door and collect it as soon as each student finishes (so that you can discuss mistakes with students as they turn it in).

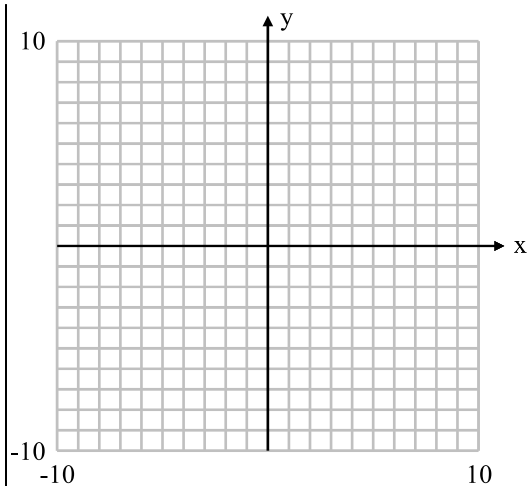
Putting It All Together

TASK 1

Find the solution to each system of equations by substitution, elimination and graphing, and then answer the conclusion questions.

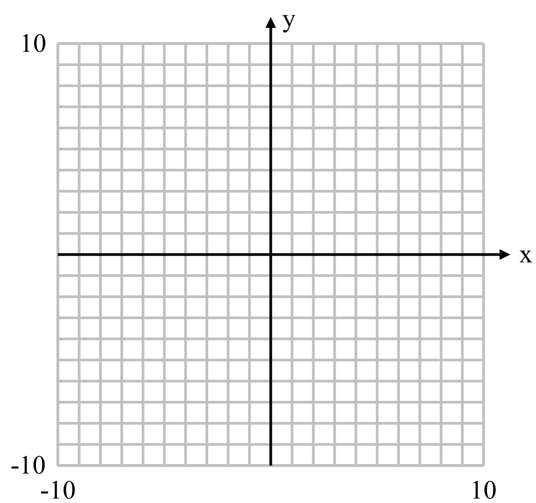
1.) $\begin{cases} 2x - y = 1 \\ y = x + 1 \end{cases}$ Solution: ____________

substitution | elimination



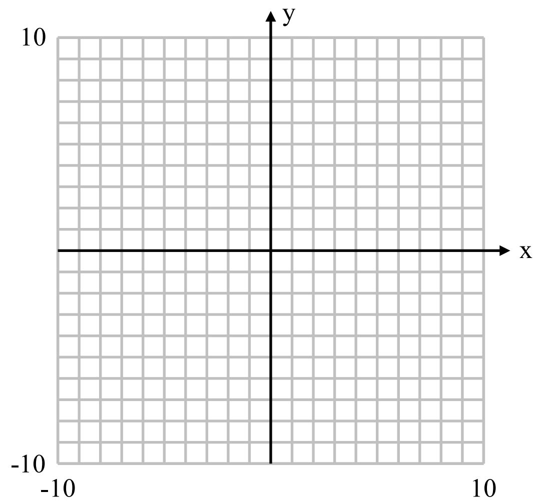
2.) $\begin{cases} -x + 2y = 6 \\ x + 4y = 24 \end{cases}$ Solution: _______________

substitution | elimination



3.) $\begin{cases} y = 4x - 4 \\ y = 2x + 2 \end{cases}$ Solution: ___________________

substitution | elimination



Complete the table to help determine which method is easier to *solve* a *system of linear equations,* and then answer the conclusion questions.

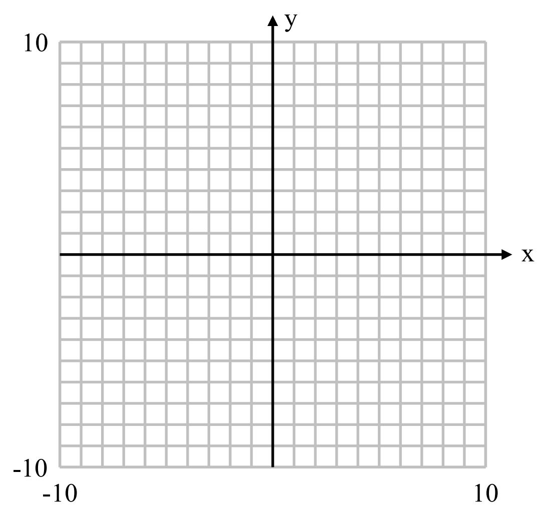
Problem Number	Rewrite the equations from each problem, in their original form and state if they are in *Standard* or *Slope-Intercept Form*.	I found it is easier to solve the system using __________ (substitution, elimination, graphing).	The reason I believe that this method is easier is because…
#1			
#2			
#3			

TASK 2

Find the solution to each system of equations by substitution, elimination and graphing and then answer the conclusion questions on the following page.

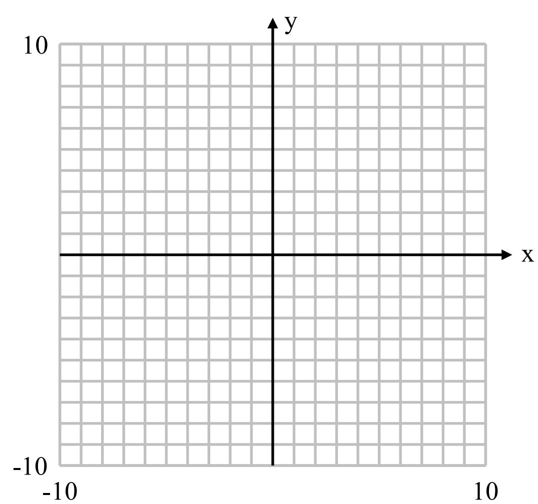
1.) $\begin{cases} 4x+4y=8 \\ x+y=2 \end{cases}$ Solution: _______________

substitution | elimination



2.) $\begin{cases} 3x+3y=6 \\ y=-x+4 \end{cases}$ Solution: _______________

substitution | elimination



Go on

Conclusion

A) In Task 1, all three *systems of linear equations* resulted in ____________ (one, none, infinitely many) *solution(s)*. This is because the equations in each of the problems are the ____________ (same/different) equation(s).

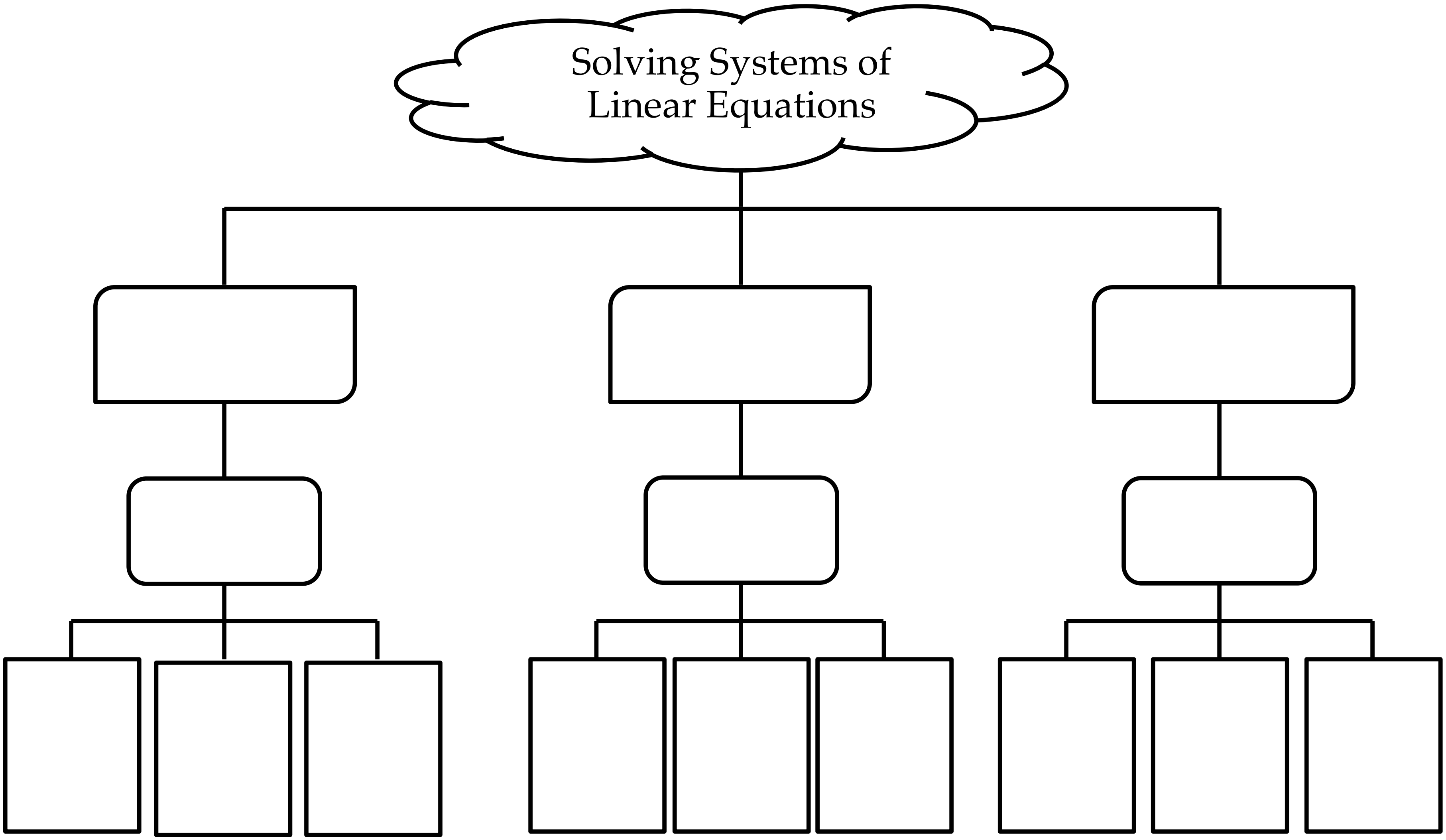
B) In Task 2, #1, the *system of linear equations* resulted in ___________ (one, none, infinitely many) *solution(s).* This is because the equations are the ____________ (same/different) equation(s).

C) In Task 2, #2, the *system of linear equations* resulted in ___________ (one, none, infinitely many) *solution(s).* This is because the equations, when graphed, never ____________, the lines are _____________.

Thinking Map: Systems of Linear Equations

Complete the thinking map on the following page, following the directions below.

- In the first row, write each of the different methods that you have learned to *solve* a *system of linear equations*.
- Below each method, *create a sample problem* (2 equations) that you would solve using that method. DO NOT SOLVE.
- Below the sample problem, write the 3 options for solutions and show what they look like for that method. Use the "Putting It All Together" worksheet for reference.


Solving Systems of
Linear Equations