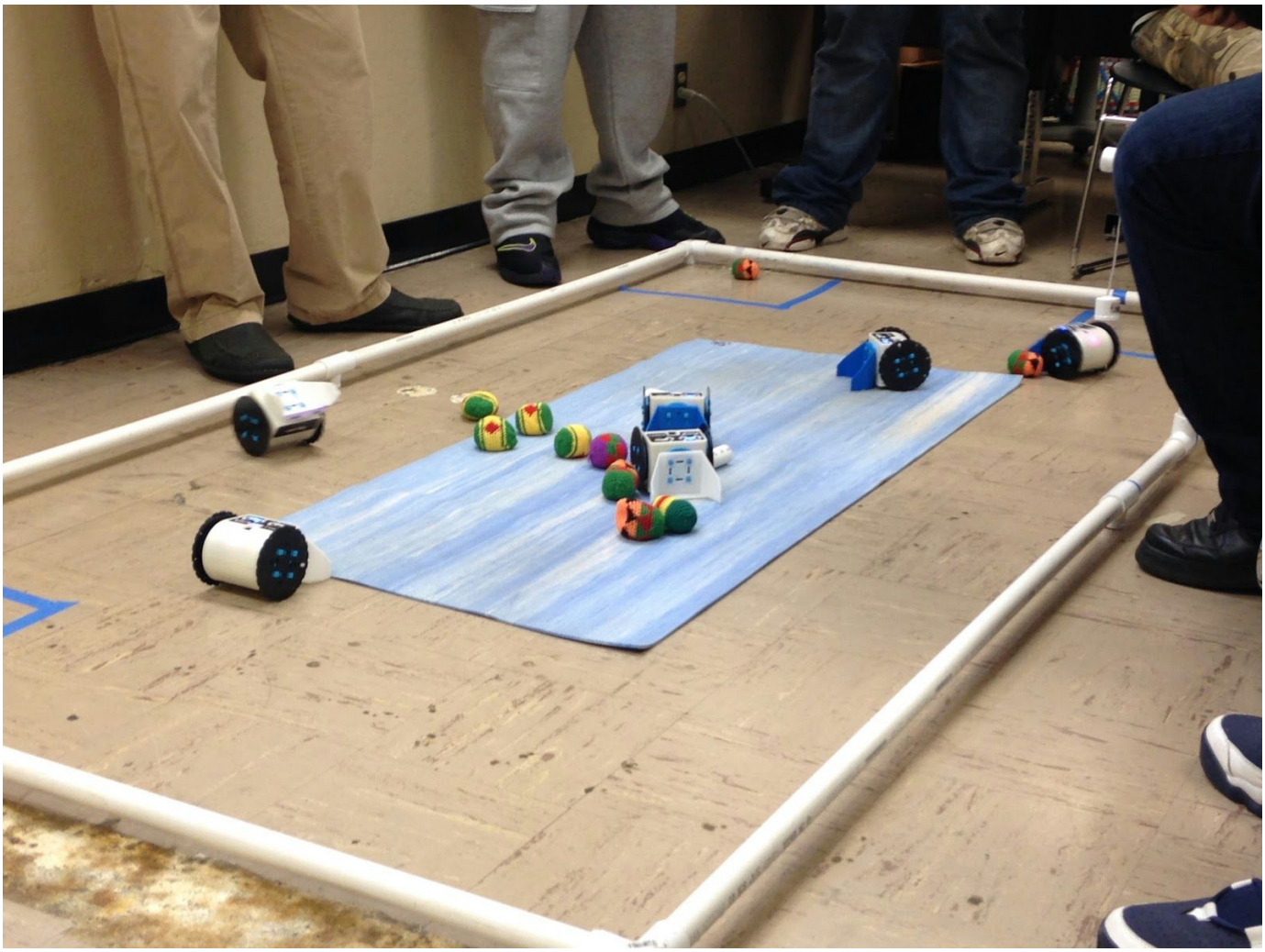
y=mx+robot

Projects for Algebra 1 with Robots



Python Edition v1.1

ALAMEDA COUNTY OFFICE OF EDUCATION
CORE LEARNING
L. Karen Monroe, Superintendent

y=mx+robot

Projects for Algebra 1 with Robots

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ALAMEDA COUNTY OFFICE OF EDUCATION
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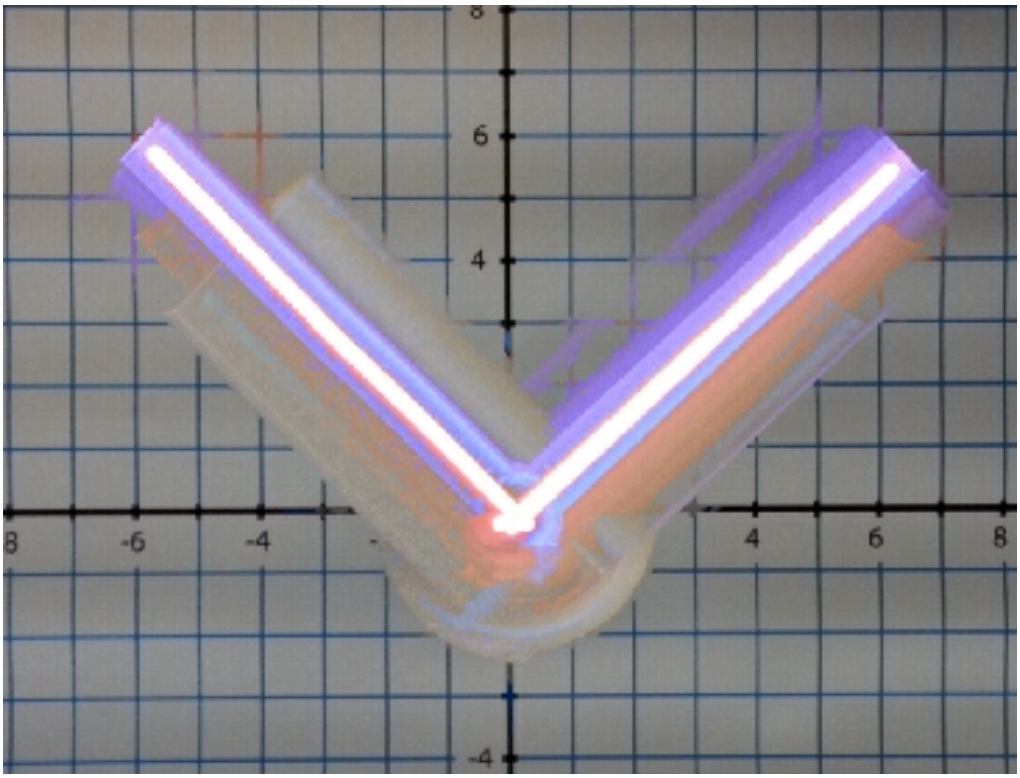
These projects are designed to support the Algebra I with Computing and Robotics (C-STEM) course that is approved by the UC office of the President to meet the 'c' mathematics requirement. Approved course outline.

If you would like to become a contributor and improve the current projects or add you own to the catalogue, please contact James Town (jtown(a)acoe.org). This is an open source project, it can only get better with your help!

Though this course was written for the Barobo Linkbots in Python or Ch, many (if not all) of the projects can be adapted to work with other classroom robots (Finchbots, Lego NXT, etc). We would be happy to help you translate any of the projects and incorporate adjustments you made so that more teachers and students can benefit from this course. Please contact James Town (jtown(a)acoe.org) for assistance.



Project List

Projects*	**Big Ideas**	**C-STEM Unit Overlap**
Height Challenge pgs. 7-17	Linear Equations, Graphing, Evaluating Expressions	Intro - Unit 1 Linear Models - Unit 3
Testing Tolerances pgs. 18-26	Statistics	Prob and Stat - Unit 6
Race to Tie pgs. 27-35	Functions, Linear Equations, Statistics, Systems of Equations	Functions - Unit 2 Linear Models - Unit 3
Race to Tie 2 pgs. 36-74	Systems of Equations, Functions	Functions - Unit 2 Linear Models - Unit 3
Gravity Car pgs. 76-91	Quadratics, Piecewise Functions	Quadratics - Unit 4 Piecewise - Unit 5
Quadratic Calculator pgs. 93-121	Quadratics, Evaluating Expressions	Intro - Unit 1 Quadratics - Unit 4
The Big Race pgs. 123-156	Functions, comparing Quadratic, Linear, and Exponentials	Functions - Unit 2
Light Graphing pgs. 158-171	Absolute Value, Transformations	Piecewise and Absolute Value - Unit 5
Radioactivebots pgs. 173-195	Exponents, sequences	Functions - Unit 2

*Projects are listed in the order in which we would teach them

Big Ideas

Big Ideas*	**Project Overlap**	**C-STEM Unit Alignment**
Linear Equations	Height Challenge, Race to Tie, The Big Race	Linear Models - Unit 3
Functions - Graphing - f(x) - words - table	The Big Race, Race to Tie (1 and 2), Quadratic Calculator, Radioactivebots	Functions - Unit 2
Evaluating expressions with real numbers	Height Challenge, The Big Race, Quadratic Calculator	Intro - Unit 1
Transformations	Quadratic Calculator, Race to Tie (some), The Big Race (some), Light Graphing	Quadratics - Unit 4
Creating equations, describe numbers	Height Challenge, The Big Race, Race to Tie (some), Radioactivebots	Intro - Unit 1
Quadratics	Gravity Car, The Big Race, Quadratic Calculator	Quadratics - Unit 4
Prob and Stats	Testing Tolerances, Race to Tie, Gravity Car, The Big Race	Prob and Stat - Unit 6
Systems	Race to Tie (1 and 2)	Systems of equations - Unit 3
Piecewise Functions	Gravity Car	Piecewise - Unit 5
Absolute Value	Light Graphing	Absolute Value - Unit 5

*Big Ideas are listed in no particular order

C-STEM Units

C-STEM Units*	**Suggested Project(s)**	**Big Ideas**
Intro - Unit 1	Height Challenge	Evaluating expressions with real numbers, creating equations, describe numbers
Functions - Unit 2	The Big Race, Radioactivebots	Functions (sequences, linear, quadratic, exponents) - Graphing - f(x) - words - table
Linear Models - Unit 3	Race to Tie (1 and 2)	Linear equations and systems of equations
Quadratics - Unit 4	Quadratic Calculator	Quadratics, transformations
Piecewise and Absolute Value - Unit 5	Gravity Car Light Graphing	Transformations, absolute value
Prob and Stat - Unit 6	Testing Tolerances	Statistics

*Units are listed in the same order as the C-STEM: Algebra 1 with Robotics and Computing Course

Height Challenge Calendar (90 min block)

Week	Mon	Tues	Wed	Thur	Fri

1	- Intro to week
	- Do Now: Measurement
	- Contracts/norms
	- Height Challenge Entry Doc
	- K/NTK/NS
	- **py**
	  - Take data
	  - height.py
	- **ch**
	  - Take data
	  - height.ch
		- Do Now: Graphing
		- Finish taking data
		- Graph data
		- Workshop: Graphing Data
		- Workshop: Function from Data
		- Answer questions from Take data document
			- Do Now: Slope
			- Finish answering questions from Take data document and test prediction for number 4
			- Planning final answer and presentation
			- Twist*
				- Do Now: Make answer public
				- Present: each pair will present to their counterpart in their group of four.
				- Test answer
				- Debrief/Reflect	

2					
3					

*Twist: Put the linkbots away and tell them there is a twist, each team's robot actually has to go the combined height of your group of four.

Team Height Challenge:

Dear Students,

You are in a lucky position to have access to these Linkbots. The only problem is you don't know how to program them to do what you want!

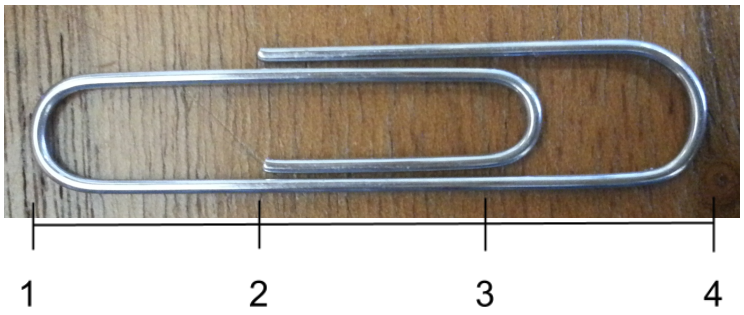
Can you make the robot travel exactly the combined height of your team?

Know:	Need to Know:	Next Steps:

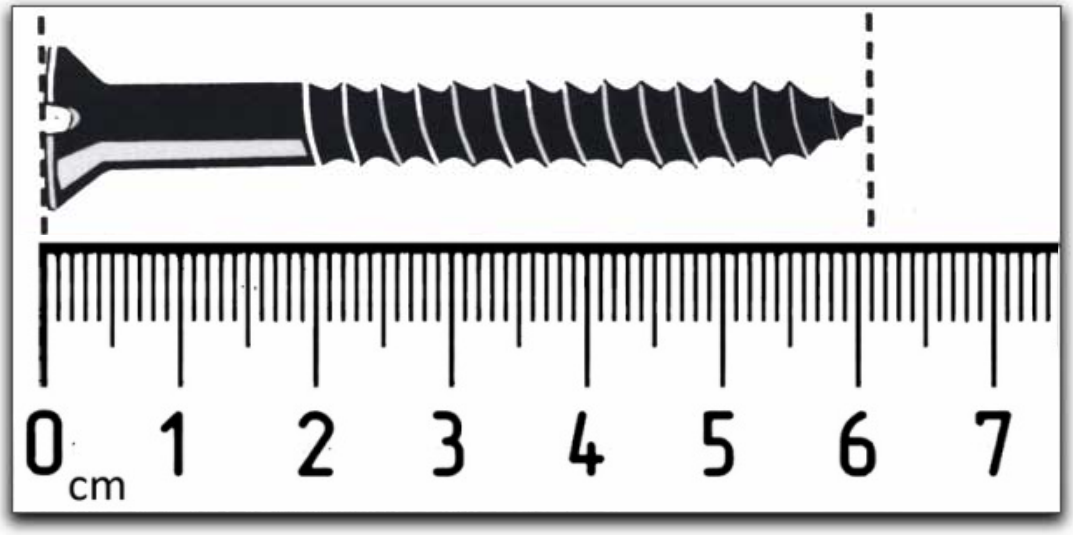
Warm-up: Find the Errors

A student made 2 mistakes below. Find and correct both mistakes.

1. The paperclip is 4 units long.



2. The screw is 6.0 cm long.



Name:_____ Date:_____

Team Height Challenge

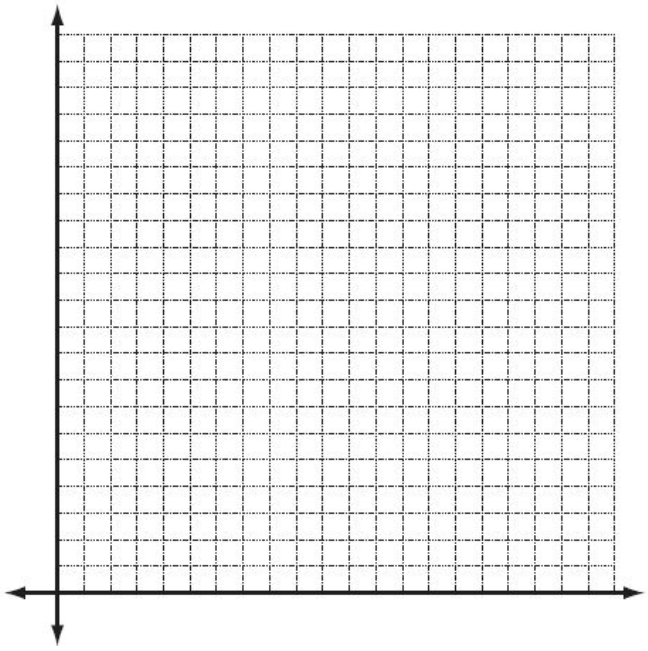
Can you make the robot travel exactly the height of your team?

In this lab we will figure out how to predict how far the robot will go using the command:

robot.move(*some number of degrees, 0, -some number of degrees*)

1. In the table below, record the "*some number of degrees*" in the first column and how far your robot went in the second column. Repeat this six times for six different rotations. **Download the Linkbot code here: http://tinyurl.com/heightChallenge-py**

Rotation (Degrees)	Distance ( )



2. Next graph your points on the axis provided. What type of function is it? How do you know?

3. Find the function for your graph.

4. Use the function you found to predict how far the robot will go in 400 degrees.

5. Test to see if your prediction was correct, if not add this point to your graph and recalculate your function.

6. If your function is linear, what is the slope? What does the slope mean?

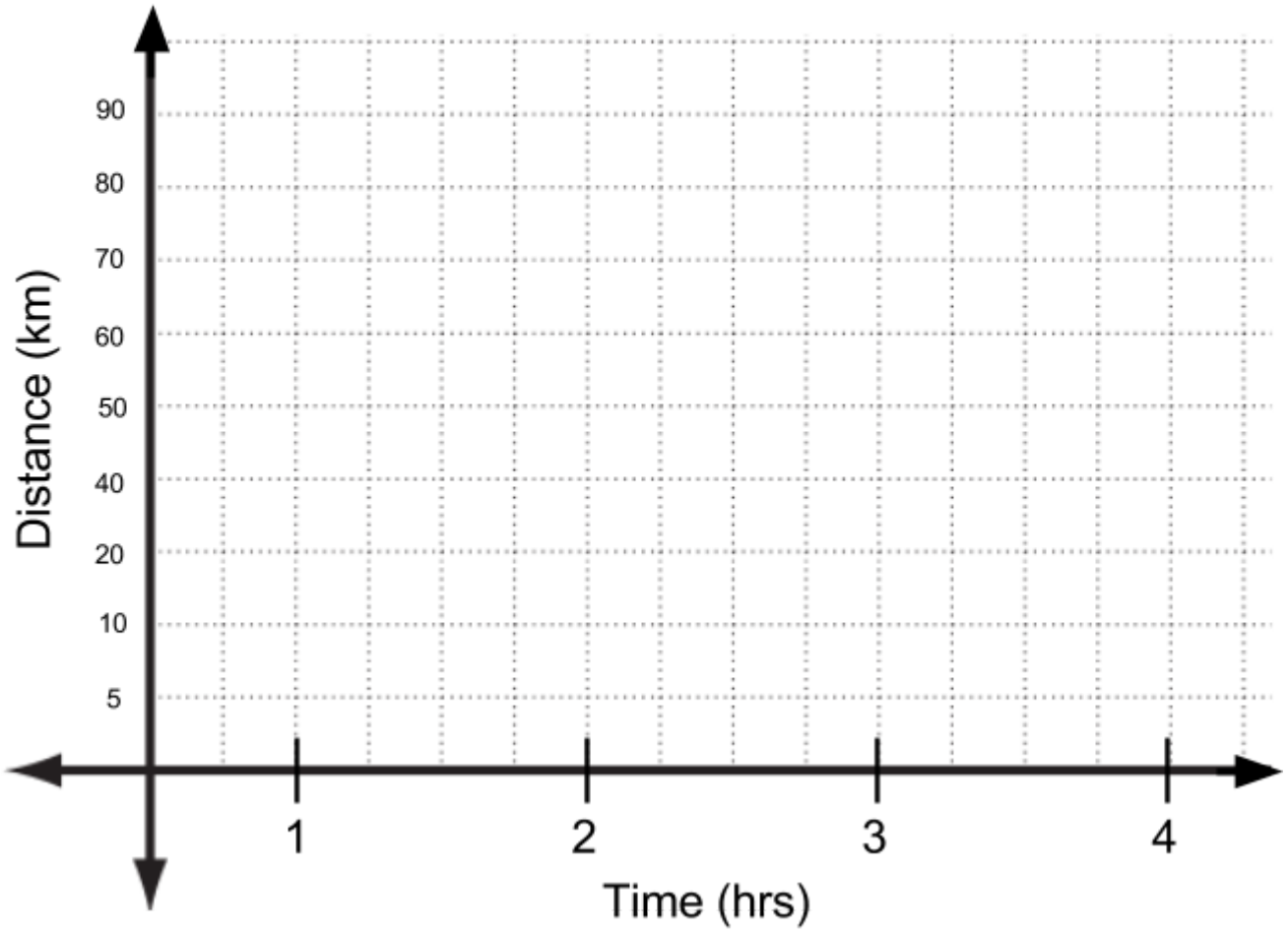
If your function is not linear, why does this make sense in terms of the robot traveling?

7. Calculate the circumference of your wheel (Remember C=pi*d). How does the circumference relate to your slope? Why?

8. If your wheels were replaced with 4” diameter wheels, how would that change your slope?

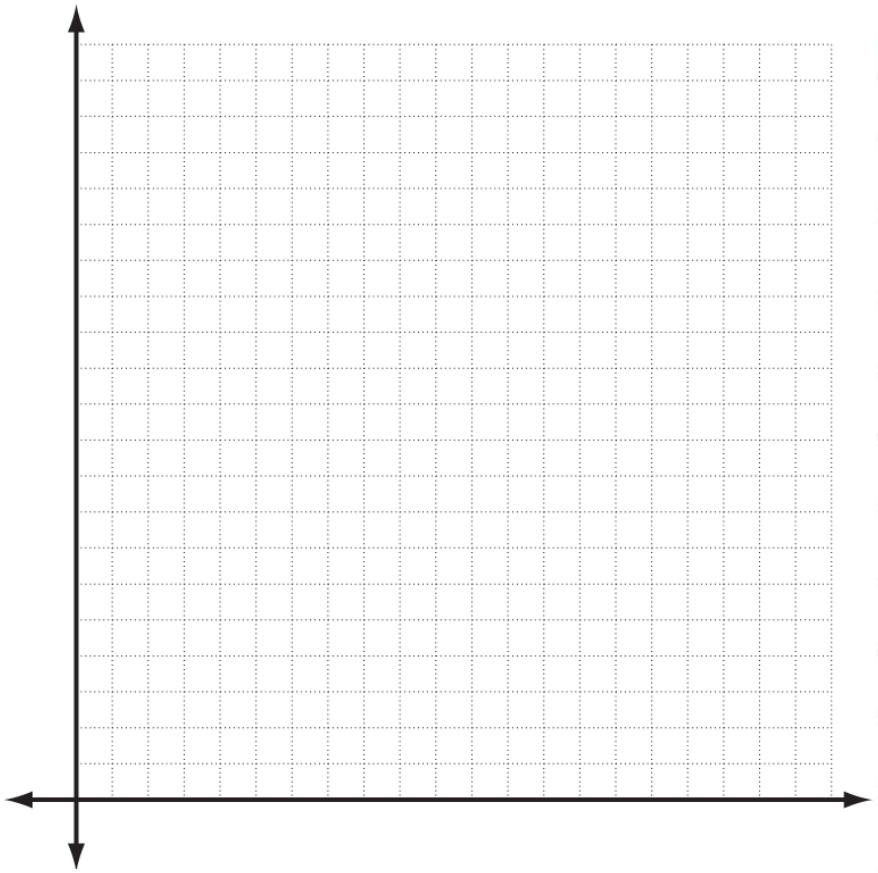
Warm-up: Find the Errors

A student made several mistakes when setting up their graph below. Find and correct each mistake.



Workshop A: Graphing Data

The table shows data for a cyclist's drive from home during a four hour ride.
a. Make a scatter plot of the data.



Time (hours)	Distance (km)
0	0
0.25	6.4
0.5	12.8
1	24
1.5	40
2	57.6
2.25	64
2.75	65.6
3	70.4
3.5	76.8
4	96

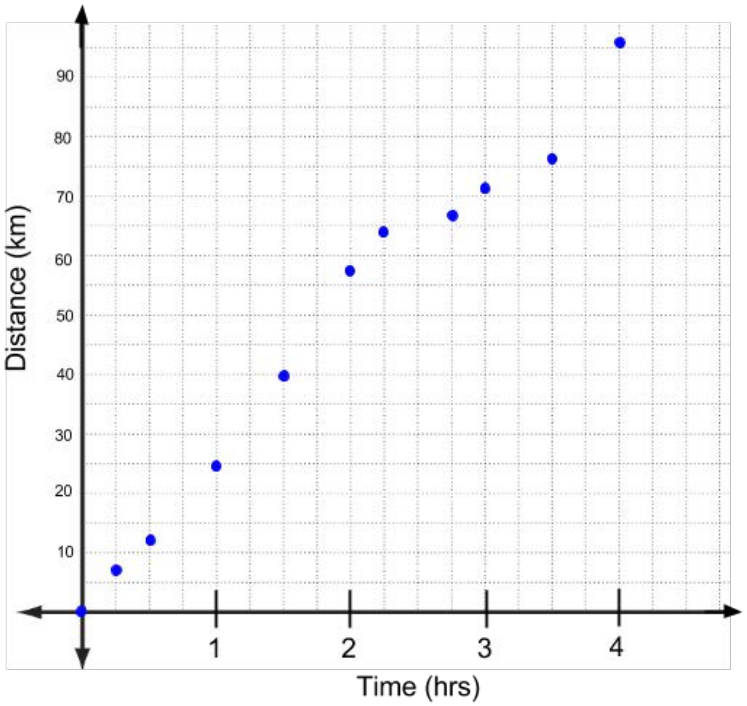
Workshop B: Writing Function from Data

The table shows data for a cyclist's drive from home during a four hour ride.

b. Find the cyclist's average speed.

c. Find an equation that models the data and graph it on the scatter plot.

d. At what times might the cyclist be coasting downhill or riding uphill? Explain.

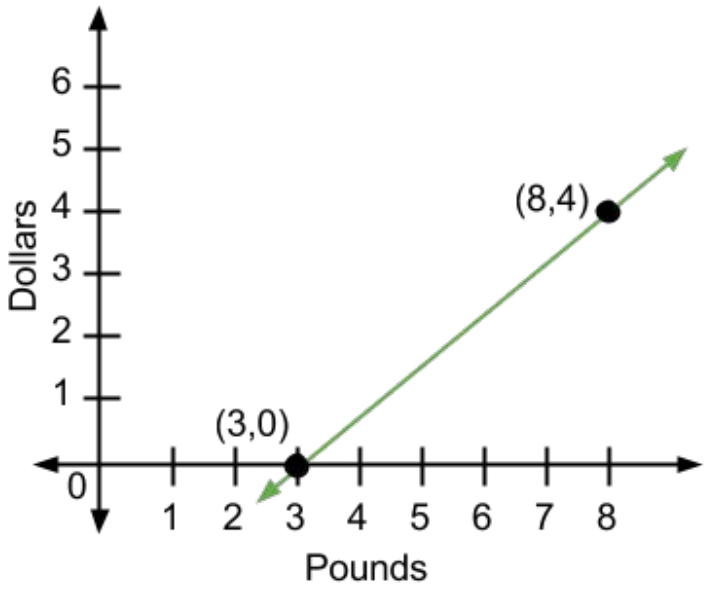


Time (hours)	Distance (km)
0	0
0.25	6.4
0.5	12.8
1	24
1.5	40
2	57.6
2.25	64
2.75	65.6
3	70.4
3.5	76.8
4	96

Warm-up: Find the Errors

A student made 2 mistakes below. Identify and correct each mistake.

1.

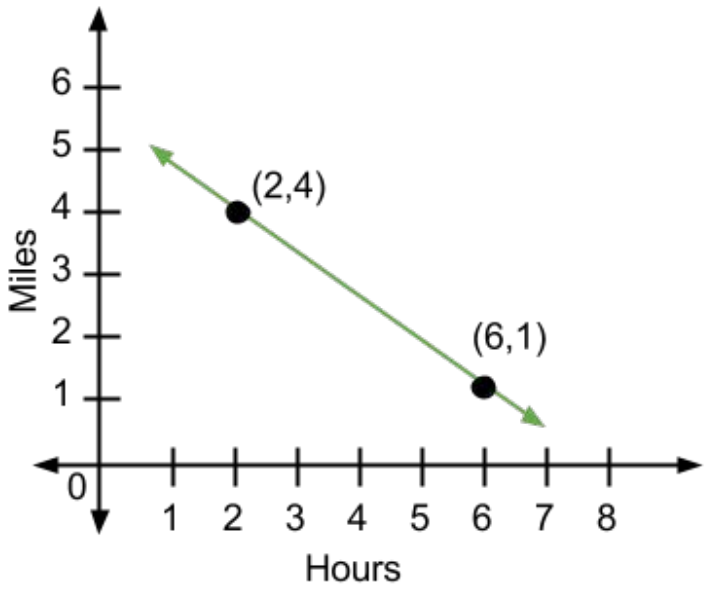


4 - 0 = 4

8 - 3 = 5

slope = $\frac{5 \text{ Dollars}}{4 \text{ Pounds}}$

2.



4 - 1 = 3

6 - 2 = 4

slope = $\frac{3 \text{ Miles}}{4 \text{ Hours}}$

Team Height Challenge: Planning

How far does your Linkbot go every degree?
How tall is your team altogether?
How many degrees does your Linkbot have to go to travel over the entire height of your team?

Space to plan for your presentation:

Team Names	Slope of Line	Total Height	Total Degrees

Testing Tolerances Calendar (90 min block)

Week	Mon	Tues	Wed	Thur	Fri

1	- Entry Doc
	- K/NtK/NS
	- Make a plan
		- Test bots using plan
		- Program bots
		  - py code
		  - ch code
		- Record data
		- Workshops
		  - Dot plots
		  - Box plots
		  - Histograms
			- Do Now: Mean, Median, Mode
			- Analyze data
			- Write Memo
			- The Twist
				- Update Memos
				- Quiz	

2					
3					

Possible student solution

- py code
- ch code

Dear Product Testers,

We here at Barobo know we make awesome Linkbots, however we have received customer feedback that at certain speeds the bots start acting funny. Your task is to create a memo reporting your results. In order to test these in an organized way, you should come up with a plan to find the maximum speed of the Linkbot before it starts going in circles. You should test at least six Linkbots and your memo should include one or more graphs to clearly show your results. Your memos need to be ready to send by _____.

Thanks,
Barobo Support

Know:	Need to Know:	Next Steps:

Name _____ Date_____

Dot Plot Workshop

A biologist collected data to answer the question: "How many eggs do robins lay?"

The following is a frequency table of the collected data:

Number of Eggs	Tally	Frequency
1	| |	
2	𝍸 𝍸 ||	
3	𝍸 𝍸 𝍸 |||	
4	𝍸 ||||	
5	|	

1. Complete the frequency column.

2. Draw a dot plot of the number of eggs a robin lays.

3. What number of eggs describes the center of the data?

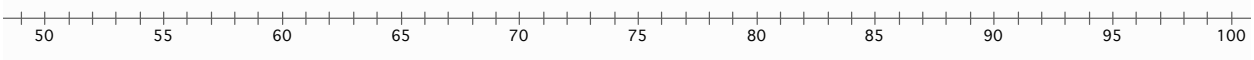
Box Plot and Histogram Workshop Modeling Data 8.1

Set

Topic: Examining data distributions in a box-and-whisker plot

60, 64, 68, 68, 72, 76, 76, 80, 80, 80, 84, 84, 84, 84, 88, 88, 88, 92, 92, 96, 96, 96, 96, 96, 96, 96, 100, 100

6. Make a box-and-whisker plot for the following test scores.



7a. How much of the data is represented by the box?

b. How much is represented by each whisker?

8. What does the graph tell you about student success on the test?

Go

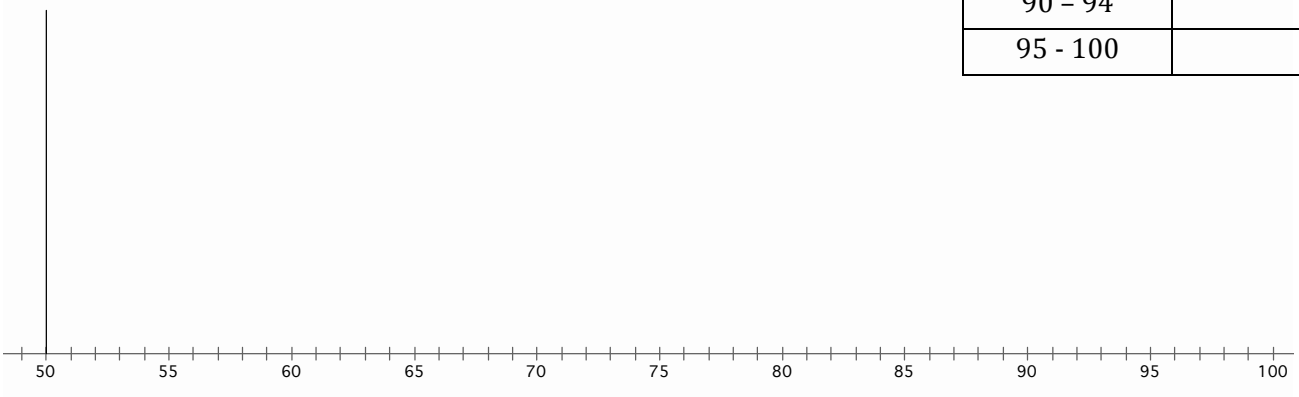
Topic: Drawing histograms.

Use the data from the SET section to answer the following questions

9. Make a frequency table with intervals. Use an interval of 5.

Score	Frequency
60 – 64	
65 – 69	
70 – 74	
75 – 79	
80 – 84	
85 – 89	
90 – 94	
95 - 100	

10. Make a histogram of the data using your intervals of 5.



Need Help? Check out these related videos:

http://www.khanacademy.org/math/statistics/e/mean_median_and_mode

http://www.khanacademy.org/math/algebra/ck12-algebra-1/v/box-and-whisker-plot

http://www.khanacademy.org/math/algebra/ck12-algebra-1/v/histograms

Name: Modeling Data | 8.1

Warm-up:

http://www.flickr.com/photos/garryknight/740038

Ready

Topic: Measures of central tendency

Sam's test scores for the term were 60, 89, 83, 99, 95, and 60.

1. Suppose that Sam's teacher decided to base the term grade on the mean.
   a. What grade would Sam receive?

   b. Do you think this is a fair grade? Explain your reasoning.

2. Suppose that Sam's teacher decided to base the term grade on his median score.
   a. What grade would Sam receive?

   b. Do you think this is a fair grade? Explain your reasoning.

3. Suppose that Sam's teacher decided to base the term grade on the mode score.
   a. What grade would Sam receive?

   b. Do you think this is a fair grade? Explain your reasoning.

4. Aiden's test scores for the same term were 30, 70, 90, 90, 91, and 99. Which measure of central tendency would Aiden want his teacher to base his grade on? Justify your thinking.

5. Most teachers base grades on the mean. Do you think this is a fair way to assign grades? Why or why not?

Twist Ideas: Something about comparing two different data sets:

“So as to not overwhelm Barobo we should compare all of our memos and create one class memo that represents everyone’s data.”

or

“Share your memos with another group, compare your results to their results. How are they similar, how are they different? How does this change your recommended maximum speed?”

Testing Tolerances Memo Rubric

STUDENT: _____

EVALUATOR: _____ DATE: _____

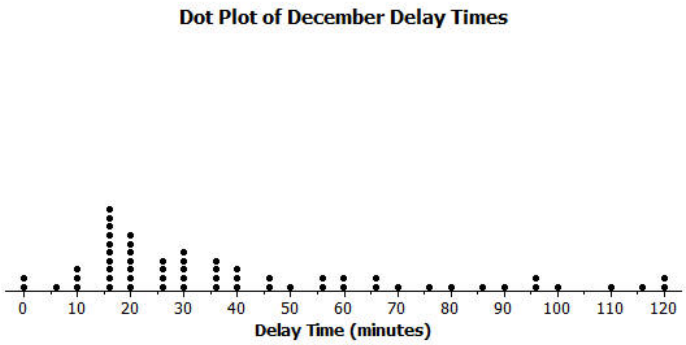
CRITERIA	UNSATISFACTORY (Below Performance Standards)	PROFICIENT (Meets Standards)	ADVANCED (Demonstrates Exceptional Performance)
Memo Clarity and Professionalism (50%)	● Fails to meet any of the Proficient Descriptors. ● Common Pitfall: - Uses informal or conversational words - Includes graph, but doesn't talk about it 0 - - - - - - - - - - - - 8 - - - - - - - - - - - - 16	● Memo has a professional tone and uses academic vocabulary appropriately. ● Memo includes at least one graph to clearly show results. ● Graph is referred to in the analysis. 17 - - - - - - - - - - - - 19 - - - - - - - - - - - - 21	In addition to meeting the PROFICIENT criteria... ● Memo includes two or more graphs to help show results 23 - - - - - - - - - - - -24 - - - - - - - - - - - - 25
Accuracy of Data Analysis (50%)	● Fails to meet any of the Proficient Descriptors. ● Common Pitfalls: - Graph doesn't include all data - Forgets to explain all conclusions using data 0 - - - - - - - - - - - - 8 - - - - - - - - - - - - 16	● Graph is matches recorded data.. ● Analysis of data correctly represents the given graph. 17 - - - - - - - - - - - - 19 - - - - - - - - - - - - 21	In addition to meeting the PROFICIENT criteria ... ● Includes mention of another group's results and how it changed their memo. 23 - - - - - - - - - - - -24 - - - - - - - - - - - - 25

COMMENTS:

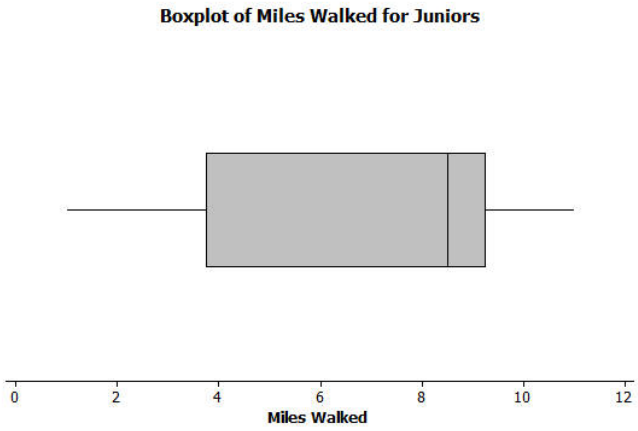
Name _____ Date_____

Assessment: Distributions and Their Shapes

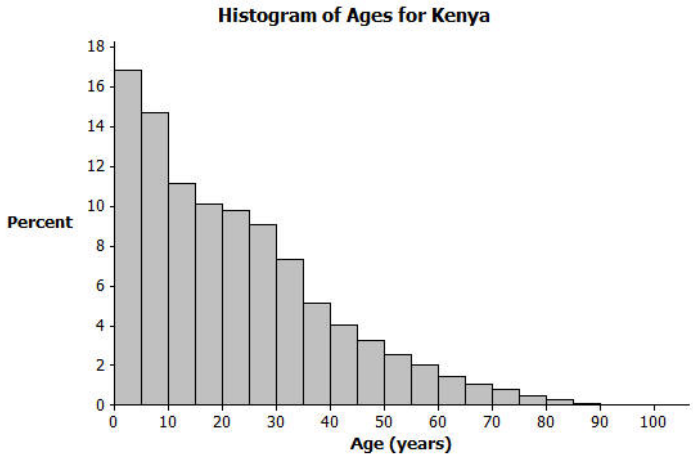
1. Sam said that a typical flight delay for the sixty BigAir flights was approximately one hour. Do you agree? Why or why not?



2. Sam said that 50% of the twenty-two juniors at River City High School who participated in the walkathon walked at least ten miles. Do you agree? Why or why not?



3. Sam said that young people from the ages of 0 to 10 years old make up nearly one-third of the Kenyan population. Do you agree? Why or why not?



Race to Tie Calendar (90 min block)

Week	Mon	Tues	Wed	Thur	Fri
1	1. Entry Doc 2. Collect data from teacher car. 3. Begin Part 1 data analysis	1. Review linear functions – tables, graphs and equations (Function Flyer Applet) 2. Finish Part 1 data analysis.	1. Warm-up Review of project to date Ask students: "What is next?" 2. Linkbot Car: - py code - ch code 3. Linkbot Car data collection and analysis.	1. Finish data collection and analysis. 2. Figure out starting position.	1. Go through rubric. 2. Gather and organize materials for portfolio and prepare for presentation.
2	1. Presentations 2. Race 3. Finish portfolio 4. Reflection (rubric)	1. Assessment			
3					

Race to Tie:

Dear Students,
I just got this cool little car and want to race it in the classroom. The problem is, it really isn't fair that mine is a racecar and yours is just a little robot. To give you a chance of winning I will change the rules of the race. In this race your robot car will have to tie mine. You may start your car from wherever you would like.
Since how fast your Linkbot car is does not matter in the race, I will assign each team a speed. Even with the new race rules, I am still a little nervous about beating you so each team must show that their Linkbot car placement will result in a tie, the presentation must include:

- A name for your Linkbot car.
- A graph showing your car's motion.
- The velocity for your car.
- The placement of your car in the race so that it will tie the pace car.
- The final equation for your car.

After I am satisfied, each team will have two chances to tie my car.

Sincerely,
Your Teacher

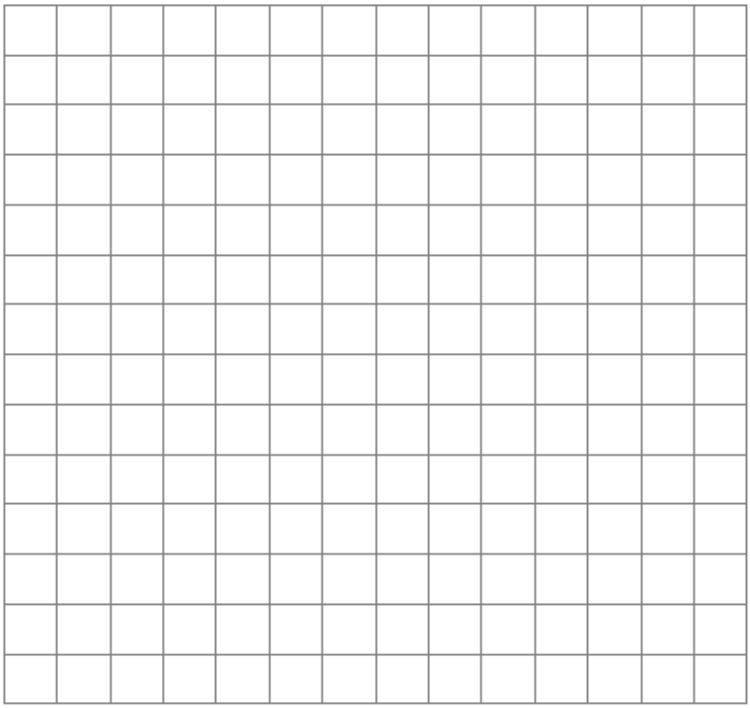
Know	Need to Know	Next Steps

Name:_____ Date:_____

Race to Tie - Teacher's Car

Data:

Graph:



1. What is the equation for the car?

2. How did you find the equation?

3. What does the slope mean?

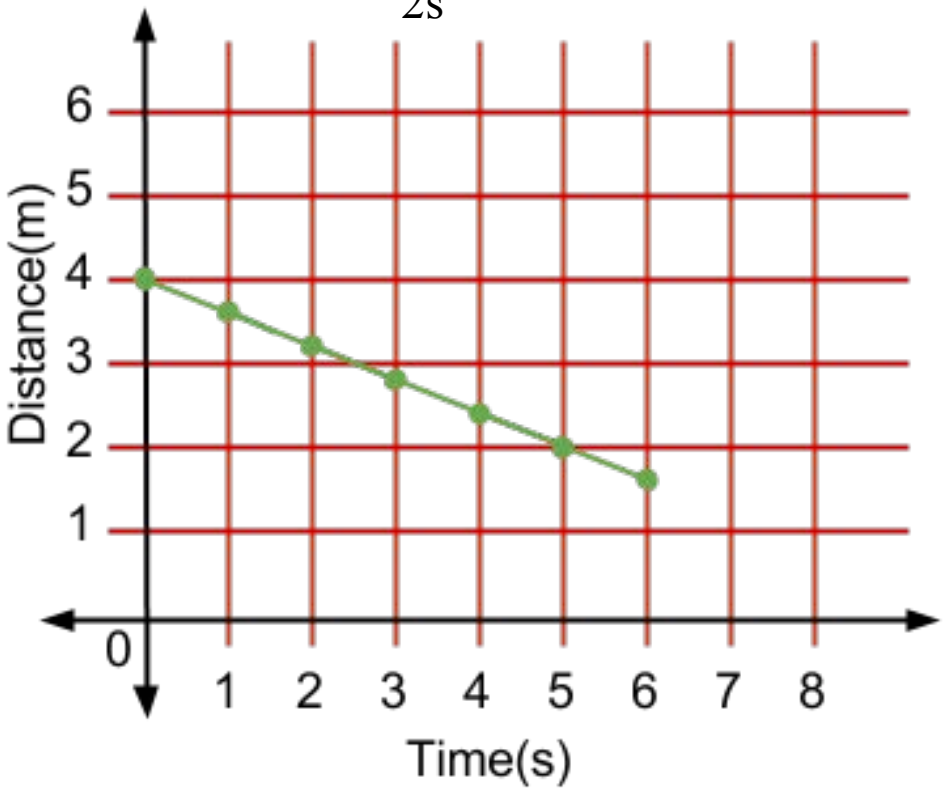
4. How far will the car go in 3.5 seconds?

5. How long will it take for the car to go 5 meters?

Warm-up: Find the Error

A student made 1 mistake below, find and correct the mistake.

1. The rule is: $4\text{m} - \frac{5\text{m}}{2\text{s}} \cdot x = y$



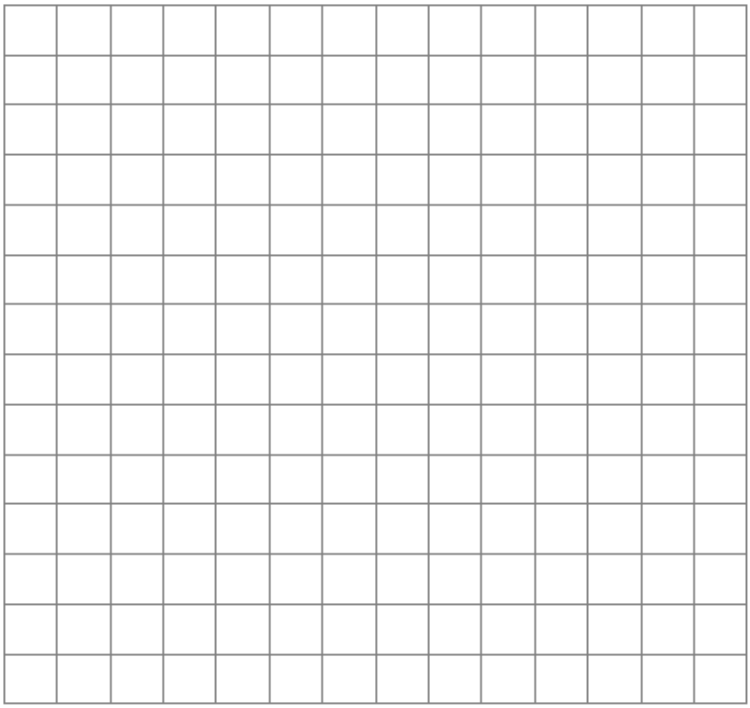
Race to Tie - Linkbot Car

Name:_____ Date:_____

Your assigned speed is _____.
The code for changing your Linkbot car's speed is: robot.setJointSpeeds(*speed*, 0, *speed*)

Data:

Graph:



1. What is the equation for the car?

2. How did you find the equation?

3. What does the slope mean?

4. How far will the car go in 3.5 seconds?

5. How long will it take for the car to go 5 meters?

Race to Tie Rubric

STUDENT: _____

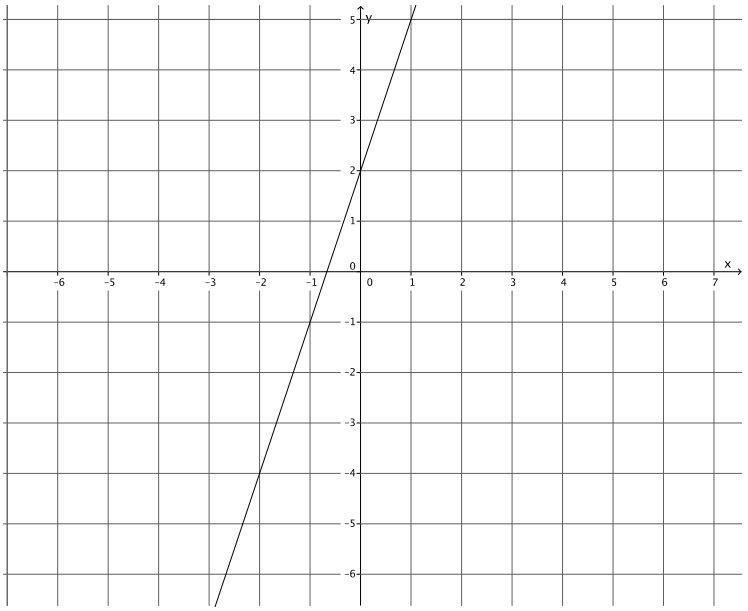
EVALUATOR: _____ DATE: _____

CRITERIA	UNSATISFACTORY (Below Performance Standards)	PROFICIENT (Meets Standards)	ADVANCED (Demonstrates Exceptional Performance)
Portfolio An organized collection of work from the project.	Fails to meet any of the *Proficient* descriptors Potential Pitfalls: • Fails to take into account the different starting position. • Graphs are sloppy, difficult to read, mislabeled, or lack labels. • Not all group members participate in exploration. • Did not include all work. • Majority of calculations incorrect. 0 - - - - - - - - - - - - 8 - - - - - - - - - - - - 16	• Includes all major work for the project (data sheets, graphs, etc) **and you…** • List the car's name • Provide an accurate graph of the race showing each car's motion an where they tie • Calculate the velocity of each car • Calculate the placement of your car so it will tie the pace car • Show the final equation for your car. 17 - - - - - - - - - - - - 19 - - - - - - - - - - - - 21	In addition to meeting the PROFICIENT criteria… • All graphs are easy to read • All calculations are correct 23 - - - - - - - - - - - -24 - - - - - - - - - - - - 25
Presentation Students should explain the big ideas of their project.	Fails to meet any of the *Proficient* descriptors. Potential Pitfalls: • Not all group members participate in presentation. • Group is not engaged in other group's presentations. • Body language and delivery is somewhat unprofessional. 0 - - - - - - - - - - - - 8 - - - - - - - - - - - - 16	• Methodology for each calculation is accurately and clearly explained • Accurately addresses questions posed • Majority of calculations correct – no major procedural errors • Conduct a professional presentation: a. Maintain eye contact with audience b. Maintain appropriate volume and inflection c. Use appropriate gestures d. Exercise good timing; Avoid awkward pauses e. Presentation is relevant; does not exclude any required information 17 - - - - - - - - - - - - 19 - - - - - - - - - - - - 21	In addition to meeting the PROFICIENT criteria… • During presentation explained why the graph is a straight line. • During presentation, can verbally relate how to find slope with what the slope means. • All graphs are easy to read. • All calculations are correct. 23 - - - - - - - - - - - -24 - - - - - - - - - - - - 25
Race Tolerance measured when pace car completes the race.	Fails to meet any of the *Proficient* descriptors Potential Pitfalls: • Starts car too early. • Calculations incorrect. • Did not measure properly. 0 - - - - - - - - - - - - 2 - - - - - - - - - - - - 4	• The car is within 5 to 7 inches of the finish line when the teacher car finishes in first or final heat. 5 - - - - - - - - - - - - 6.5 - - - - - - - - - - - - 8	In addition to meeting the PROFICIENT criteria… • The car is within 0 to 3 inches of the finish line when the teacher car finishes in either heat • The car is within 5 to 7 inches of the finish line when the teacher car finishes in both first and final heats. 9 - - - - - - - - - - -9.5 - - - - - - - - - - - - 10

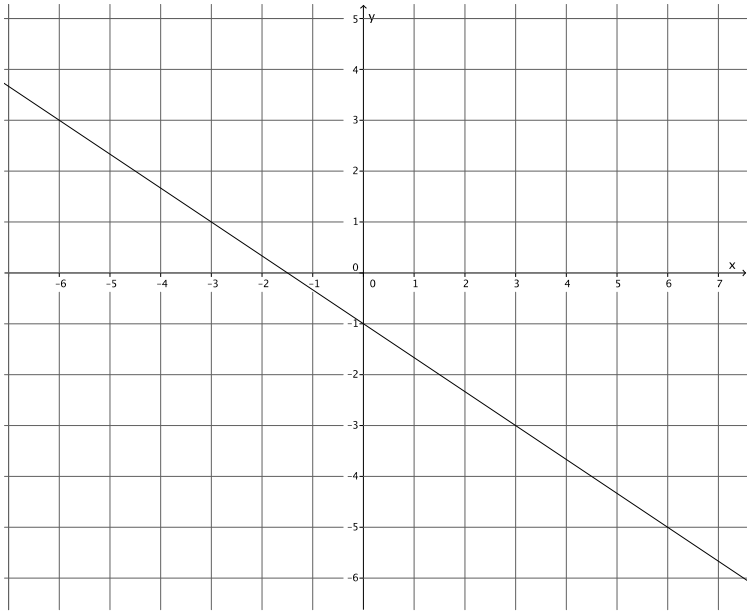
Final Reflection How they did and what they might do better next time.	Fails to meet any of the *Proficient* descriptors Potential Pitfalls: • Student does not accurately describe the difficulties • Sentences are not complete • Reflection does not address problem solving strategies • Ignores possible ways to improve results. 0 - - - - - - - - - - - - 2 - - - - - - - - - - - - 4	• Student describes the math they learned and the difficulties they encountered • Reflection explains some of the problem solving strategies used • Discusses possible ways to improve 5 - - - - - - - - - - - - 6.5 - - - - - - - - - - - - 8	In addition to meeting the PROFICIENT criteria… • Student expresses the reasons behind the difficulties encountered by other groups as well as their own • Thoughtful and well written complete sentences a. Response is supported by examples and personal reflections b. Illustrates a complex and important issue and simplifies it c. No grammatical or spelling errors • Specific examples of how you could improve your results? 9 - - - - - - - - - - -9.5 - - - - - - - - - - - - 10

COMMENTS:

1. Write the equation that represents the line shown.



2. Write the equation that represents the line shown.

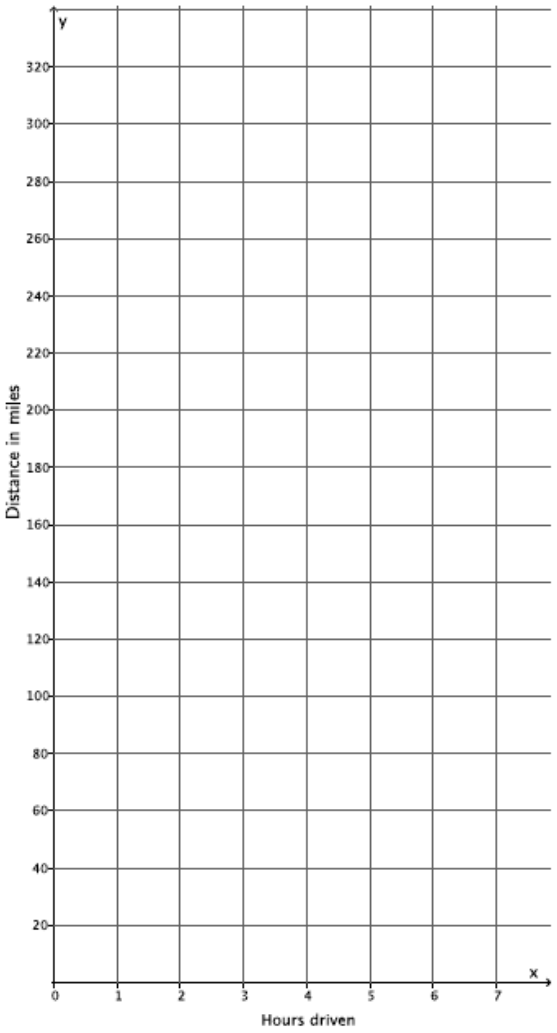


3. A group of friends are on a road trip. So far, they have driven 120 miles. They continue their trip and drive at a constant rate of 50 miles per hour.

   a. Let y represent the total distance traveled in x hours. Write an equation to represent the total number of miles driven in x hours.

   b. Identify the slope and the y-intercept. What do these numbers represent?

   c. Graph the equation on the given coordinate plane.



   d. Could any other line represent this situation? For example, could a line through point $(0, 120)$ with slope 75 represent the total distance the friends drive? Explain.

   e. How long would you estimate they had been driving to reach the first 120 miles? Explain.

   f. How long will it take them to drive 420 miles? Explain.

Race To Tie 2 Calendar (90 min block)

Week	Mon	Tues	Wed	Thur	Fri
1	- Do Now: Linear Systems 1 - Entry Doc - Workshop: Speed Conversion	- Do Now: Circumferences/Revolutions - Workshop: Systems Intro - Part 1: LinkBot Car 1 data	- Workshop: Graphing Systems using Desmos - Part 2: LinkBot Car 2 data	- Do Now: Linear Systems 2 - Workshop: Solving Linear Systems Algebraically	- Do Now: Linear Systems 3 - Linear Systems: Group Quiz 1 - Linkbot equation verification
2	- Do Now: Linear Systems 4 - Linear Systems Review - Part 3: LinkBots Together	- Do Now: Linear Systems 5 - Finish Checklist - Run races/Twists	- Finish races/twists - Presentations - Solving Systems Algebraically Recap/Practice	- Do Now: Linear Systems 6 - Solving Systems Recap (finish)	- Do Now: Linear Systems 7 - Group Quiz 2
3	- Review	- Unit Assessment			

Scaffolded Code for Race to Tie 2
- ch code
- py code

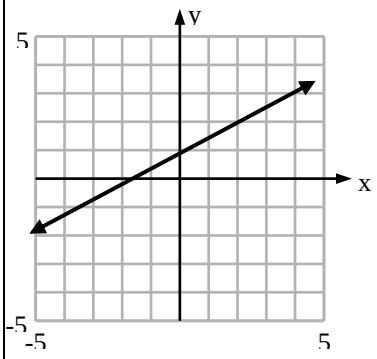
Name: _____
Date: _____ Per: __

Warm-up: Linear Systems 1

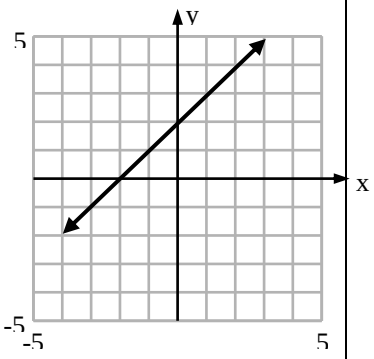
1. Which of the following is the graph of

$$y = \frac{1}{2}x + 2$$

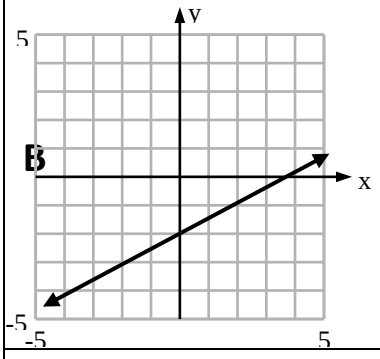
A



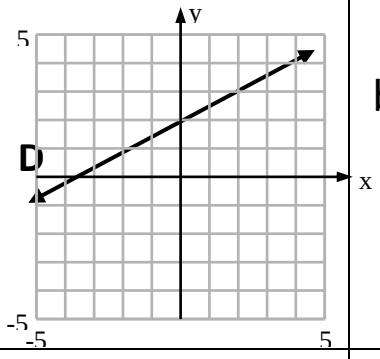
C



B



D



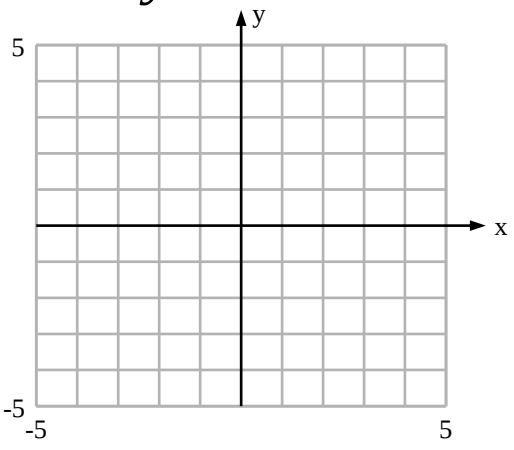
2. Find the slope and the *y*-intercept of each line.

a) $y = -2x + 3$

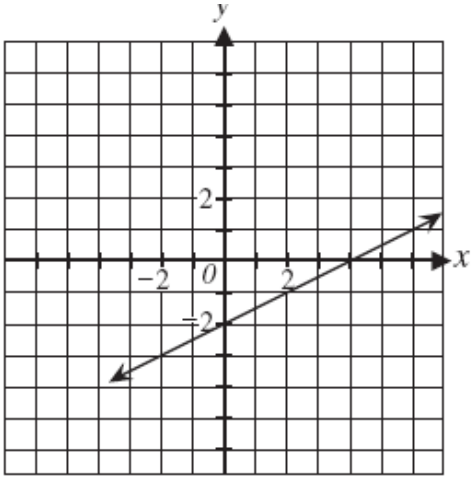
b) $-3x + 2y = 8$

3. Graph the line.

$$-5x + 3y = -15$$



4. What is the slope of the line shown?



Race to Tie 2:

Dear Students,

We just finished Race to Tie and everyone did a great job of getting their bot to tie the pace car. Realizing how easy you made the last lab look, I decided to add some more challenges to the format. In Race to Tie 2, you will have two robots that travel different speeds race to tie each other. Robot 1 must travel three times as fast as Robot 2. Robot 1 must start the race 10 inches up the racetrack while Robot 2 must start the race 40 inches up the racetrack. You may pick whatever speeds you want, just as long as Robot 1 is three times faster than Robot 2. So that everyone in class can understand your excellence, each team must show that their Linkbot car placement will result in a tie. The presentation must include:

- Names for your Linkbot cars.
- A graph showing the motion of both cars.
- The velocity of each car.
- The final equation for each car.
- The length of time needed to complete the race.
- The point at which the Linkbot cars will tie.

Once your explanation is accepted, your team will have two chances to get the Linkbot cars to tie.

Sincerely,
Your Teacher

Know	Need to Know	Next Steps

Workshop: Speed Conversion

Degrees per second vs. Centimeters per second

A. The Linkbot has wheels with a diameter of 9.2 cm. How can we find out how far the wheel will go in one full 360 degree turn?

We will use the formula for the Circumference of a Circle: C= 2***π***(radius)

The distance the wheel rolls in one turn is equal to the distance around the wheel.

So the distance is about 28.9 cm.

B. A Linkbot's speed is controlled by the number of degrees it turns in one second. So a speed of 360 degrees per second means the wheel will turn exactly one time every second.

How many times will the wheel turn if it rotates 720 degrees?

How many seconds will it take?

Note: Linkbots do not work to well at speeds over 200 degrees per second. So we will usually use speeds below that.

C. How many times will the wheel turn in 4 seconds, if its speed is 180 degrees per second?

D. How many times will the wheel turn in 8 seconds, if its speed is 90 degrees per second?

E. If a Linkbot's wheels are turning at a speed of 180 degrees per second for 4 seconds, how can we find out how far it will go? Explain the reasoning for each step below.

In four seconds the wheel will turn 4*180 degrees = 720 degrees. _____

720 degrees/ 360 degrees per turn = 2 turns _____

2 turns(28.9 cm per turn)= 57.8 cm _____

F. If a Linkbot's wheels are turning at a speed of 90 degrees per second for 12 seconds, how far it will go?

G. Suppose we need our Linkbot to travel exactly 40 cm in exactly 6 seconds. What speed will the robot have to travel in degrees per second to achieve this?

6sec(s)=40cm
s=40cm/6sec
s=6.67 cm per second

However this speed is in cm per second and we require our speed in degrees per second. Hint: Consider how far the car will move if the wheel only turns one degree?

How can we convert this speed into degrees per second?

(S degrees per second/360 degrees per turn) gives the number of turns the wheel makes in 1 second. There are 28.9 cm per turn.

so…

(S degrees per second/360 degrees per turn)(28.9 cm per turn) gives the number of centimeters per second which in this case is 6.67 cm/sec.

thus we can write the equation:

(S deg per sec/360 deg per turn)(28.9 cm per turn) = 6.67 cm per sec

and solve:

S deg per sec=(6.67 cm per sec)(360 deg per turn)/(28.9 deg per turn)

and simplify:

S=83.08 degrees per second

H. Suppose we need our Linkbot to travel 80 cm in 10 seconds. What speed will the robot have to travel in degrees per second to achieve this?

Robots & Math

Name: _____

Date: _____ Per: __

Warm-up: Circumferences/Revolutions

Show ALL work and box final answers.

1.) If a LinkBot's wheels are turning at a speed of 180 degrees per second for 10 seconds, how far will it travel (in inches)?

2.) If a LinkBot's wheels are turning at a speed of 280 degrees per second for 9 seconds, how far will it travel (in inches)?

3.) Suppose we need our Linkbot to travel exactly 60 inches in exactly 5 seconds. What speed will the robot have to travel in degrees per second to achieve this?

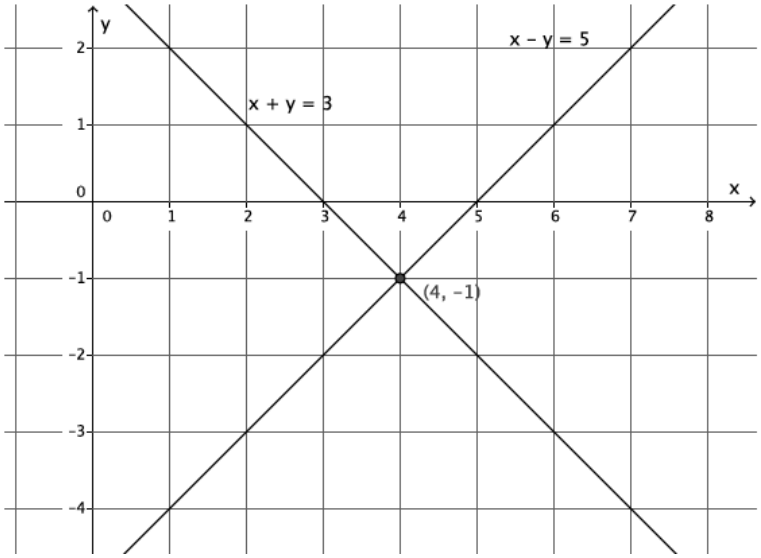
4.) Suppose we need our Linkbot to travel exactly 75 inches in exactly 17 seconds. What speed will the robot have to travel in degrees per second to achieve this?

Workshop: Systems Intro

Lesson Summary

When the graphs of a system of linear equations are sketched, and if they are not parallel lines, then the point of intersection of the lines of the graph represents the solution to the system. Two distinct lines intersect at most at one point, if they intersect. The coordinates of that point (x, y) represent values that make both equations of the system true.

Example: The system $\begin{cases} x + y = 3 \\ x - y = 5 \end{cases}$ graphs as shown below.



The lines intersect at $(4, -1)$. That means the equations in the system are true when $x = 4$ and $y = -1$.

$$\begin{aligned} x + y &= 3 \\ 4 + (-1) &= 3 \\ 3 &= 3 \end{aligned}$$

$$\begin{aligned} x - y &= 5 \\ 4 - (-1) &= 5 \\ 5 &= 5 \end{aligned}$$

Problem Set

1. Sketch the graphs of the linear system on a coordinate plane: $\begin{cases} y = \frac{1}{3}x + 1 \\ y = -3x + 11 \end{cases}$

   a. Name the ordered pair where the graphs of the two linear equations intersect.

   b. Verify that the ordered pair named in part (a) is a solution to $y = \frac{1}{3}x + 1$.

   c. Verify that the ordered pair named in part (a) is a solution to $y = -3x + 11$.

2. Sketch the graphs of the linear system on a coordinate plane: $\begin{cases} y = \frac{1}{2}x + 4 \\ x + 4y = 4 \end{cases}$

   a. Name the ordered pair where the graphs of the two linear equations intersect.

   b. Verify that the ordered pair named in part (a) is a solution to $y = \frac{1}{2}x + 4$.

   c. Verify that the ordered pair named in part (a) is a solution to $x + 4y = 4$.

3. Sketch the graphs of the linear system on a coordinate plane: $\begin{cases} y = 2 \\ x + 2y = 10 \end{cases}$

   a. Name the ordered pair where the graphs of the two linear equations intersect.

   b. Verify that the ordered pair named in part (a) is a solution to $y = 2$.

   c. Verify that the ordered pair named in part (a) is a solution to $x + 2y = 10$.

4. Sketch the graphs of the linear system on a coordinate plane: $\begin{cases} -2x + 3y = 18 \\ 2x + 3y = 6 \end{cases}$

   a. Name the ordered pair where the graphs of the two linear equations intersect.

   b. Verify that the ordered pair named in part (a) is a solution to $-2x + 3y = 18$.

   c. Verify that the ordered pair named in part (a) is a solution to $2x + 3y = 6$.

5. Sketch the graphs of the linear system on a coordinate plane: $\begin{cases} x + 2y = 2 \\ y = \frac{2}{3}x - 6 \end{cases}$

   a. Name the ordered pair where the graphs of the two linear equations intersect.

   b. Verify that the ordered pair named in part (a) is a solution to $x + 2y = 2$.

   c. Verify that the ordered pair named in part (a) is a solution to $y = \frac{2}{3}x - 6$.

6. Without sketching the graph, name the ordered pair where the graphs of the two linear equations intersect.

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

Race to Tie 2 - Linkbot Car 1

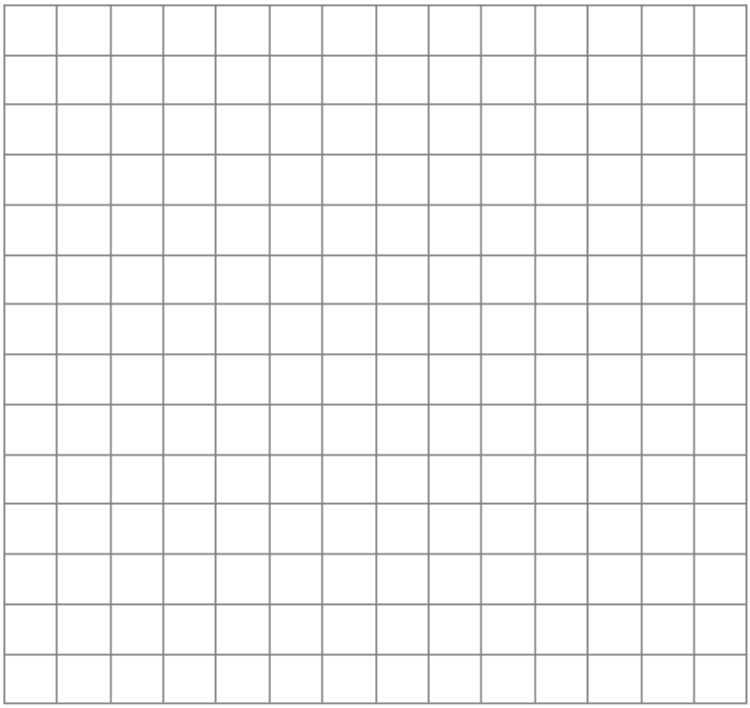
Name:_____ Date:_____

Your speed is _____.

The code for changing your Linkbot car's speed is: robot.setJointSpeeds(*speed*, 0, *speed*)

Data:

Graph:



1. What is the equation for the car?

2. How did you find the equation?

3. What does the slope mean?

4. How far will the car go in 5 seconds?

5. How long will it take for the car to go 3 meters?

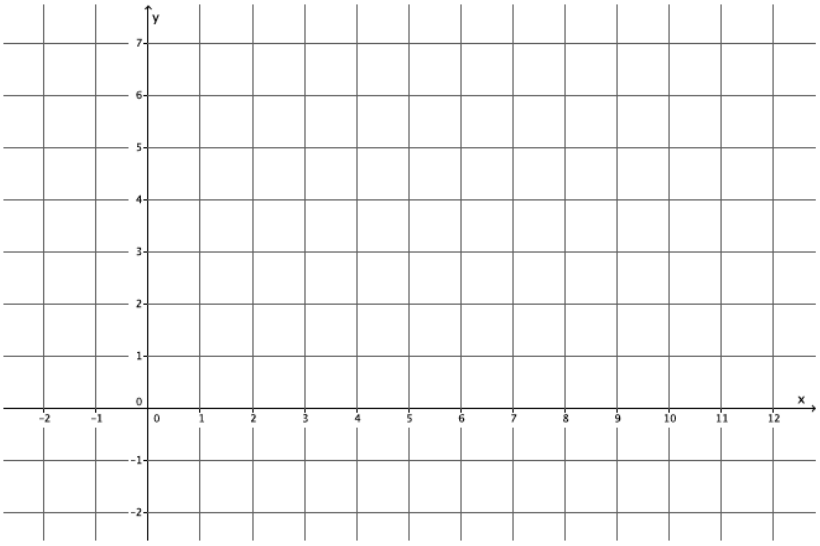
Workshop: Graphing Systems

Lesson 25: Geometric Interpretation of the Solutions of a Linear System

Classwork

Exploratory Challenge/Exercises 1–5

1. Sketch the graphs of the linear system on a coordinate plane: $\begin{cases} 2y + x = 12 \\ y = \frac{5}{6}x - 2 \end{cases}$



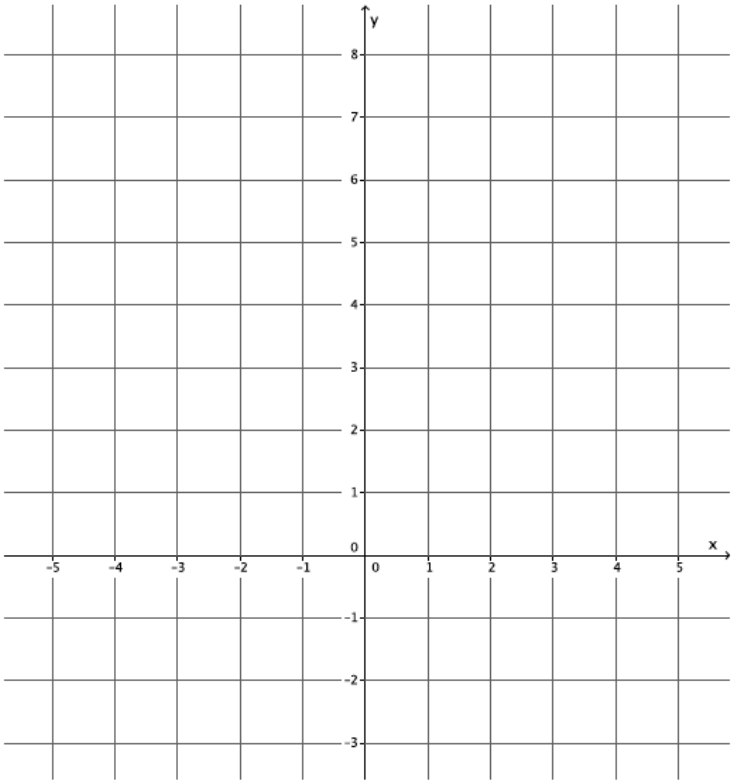
a. Name the ordered pair where the graphs of the two linear equations intersect.

b. Verify that the ordered pair named in part (a) is a solution to $2y + x = 12$.

c. Verify that the ordered pair named in part (a) is a solution to $y = \frac{5}{6}x - 2$.

d. Could the point $(4, 4)$ be a solution to the system of linear equations? That is, would $(4, 4)$ make both equations true? Why or why not?

2. Sketch the graphs of the linear system on a coordinate plane: $\begin{cases} x + y = -2 \\ y = 4x + 3 \end{cases}$



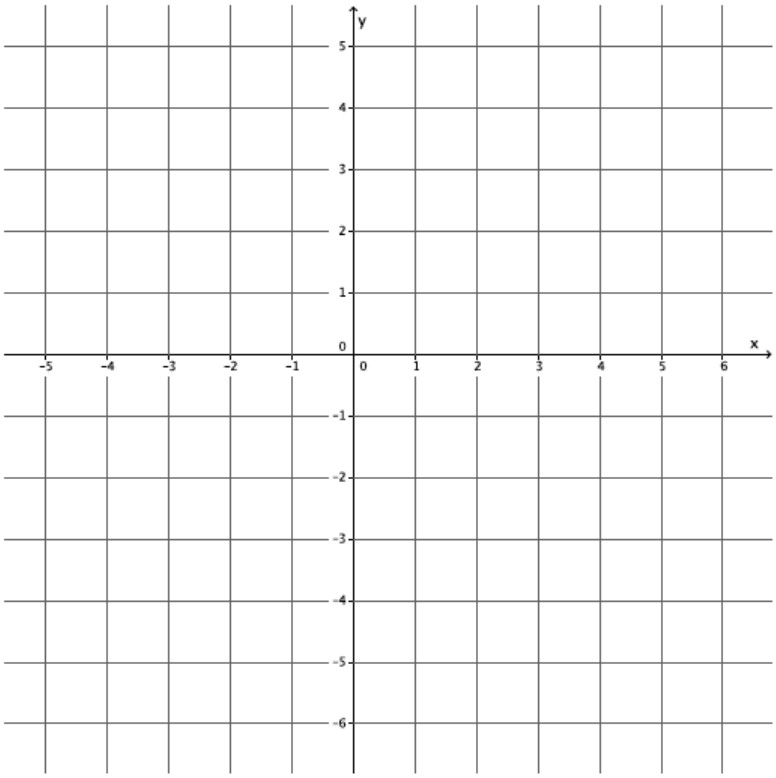
a. Name the ordered pair where the graphs of the two linear equations intersect.

b. Verify that the ordered pair named in part (a) is a solution to $x + y = -2$.

c. Verify that the ordered pair named in part (a) is a solution to $y = 4x + 3$.

d. Could the point $(-4, 2)$ be a solution to the system of linear equations? That is, would $(-4, 2)$ make both equations true? Why or why not?

3. Sketch the graphs of the linear system on a coordinate plane: $\begin{cases} 3x + y = -3 \\ -2x + y = 2 \end{cases}$



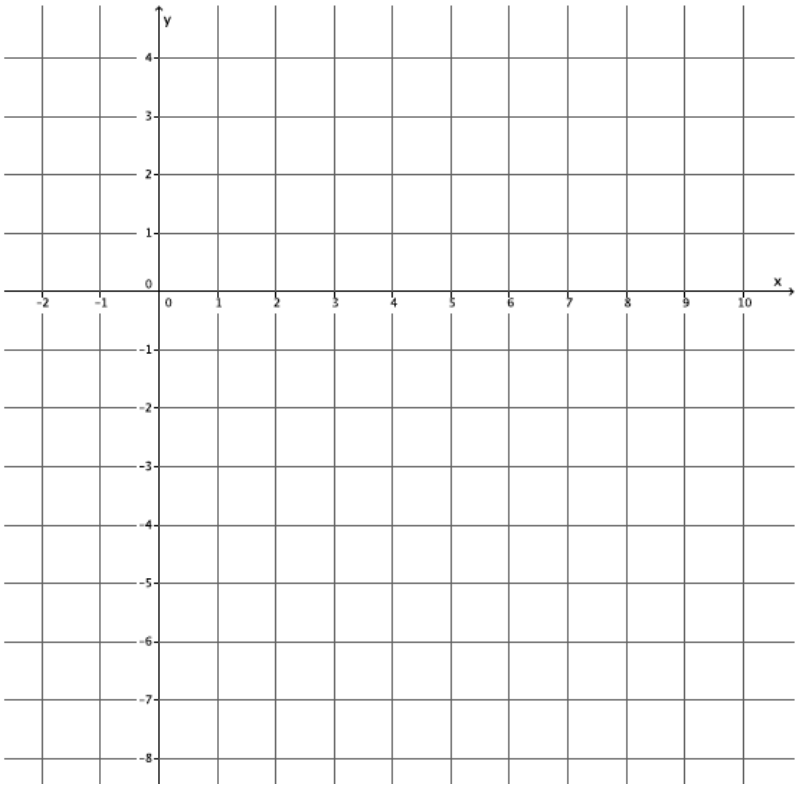
a. Name the ordered pair where the graphs of the two linear equations intersect.

b. Verify that the ordered pair named in part (a) is a solution to $3x + y = -3$.

c. Verify that the ordered pair named in part (a) is a solution to $-2x + y = 2$.

d. Could the point $(1, 4)$ be a solution to the system of linear equations? That is, would $(1, 4)$ make both equations true? Why or why not?

4. Sketch the graphs of the linear system on a coordinate plane: $\begin{cases} 2x - 3y = 18 \\ 2x + y = 2 \end{cases}$



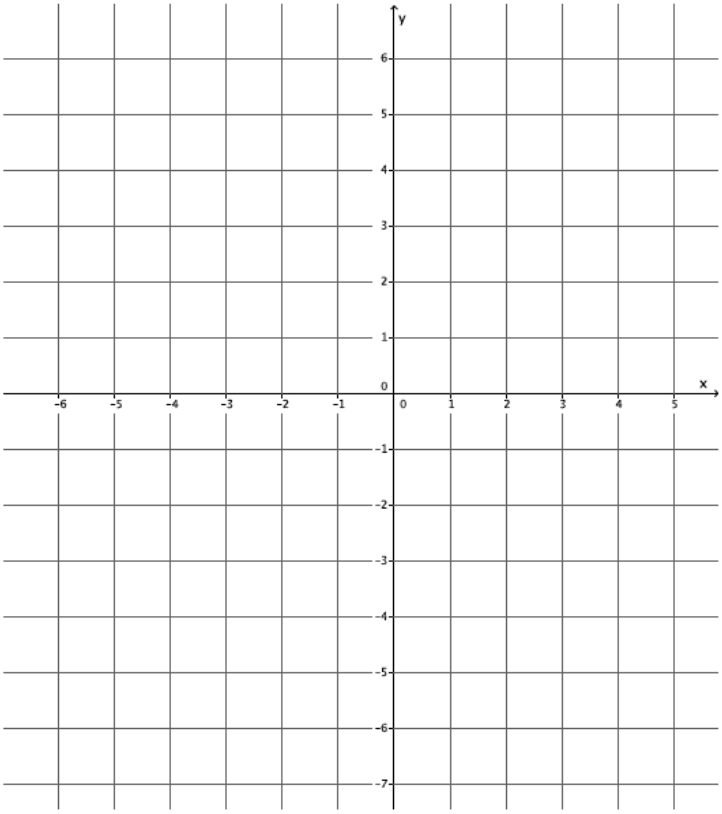
a. Name the ordered pair where the graphs of the two linear equations intersect.

b. Verify that the ordered pair named in part (a) is a solution to $2x - 3y = 18$.

c. Verify that the ordered pair named in part (a) is a solution to $2x + y = 2$.

d. Could the point $(3, -1)$ be a solution to the system of linear equations? That is, would $(3, -1)$ make both equations true? Why or why not?

5. Sketch the graphs of the linear system on a coordinate plane: $\begin{cases} y - x = 3 \\ y = -4x - 2 \end{cases}$



a. Name the ordered pair where the graphs of the two linear equations intersect.

b. Verify that the ordered pair named in part (a) is a solution to $y - x = 3$.

c. Verify that the ordered pair named in part (a) is a solution to $y = -4x - 2$.

d. Could the point $(-2, 6)$ be a solution to the system of linear equations? That is, would $(-2, 6)$ make both equations true? Why or why not?

Exercise 6

6. Write two different systems of equations with $(1, -2)$ as the solution.

Race to Tie 2 - Linkbot Car 2

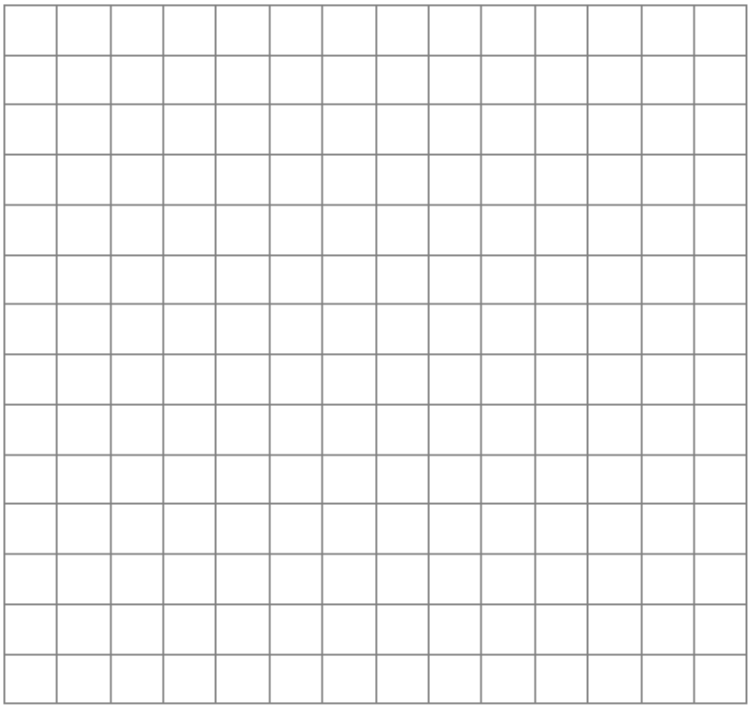
Name:_____ Date:_____

The speed you chose is _____.

The code for changing your Linkbot car's speed is: robot.setJointSpeeds(*speed*, 0, *speed*)

Data:

Graph:



1. What is the equation for the car?

2. How did you find the equation?

3. What does the slope mean?

4. How far will the car go in 4 seconds?

5. How long will it take for the car to go 6 meters?

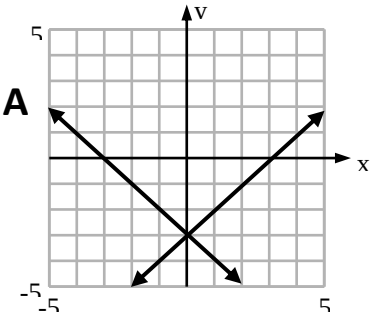
Name: _____
Date: _____ Per: __

Warm-up: Linear Systems 2

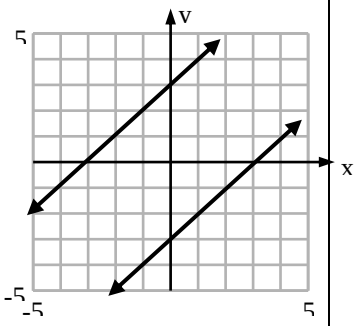
1) Which graph represents the system of equations shown below?

$$y = -x + 3$$
$$y = x + 3$$

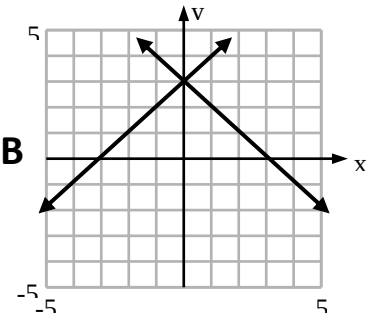
A

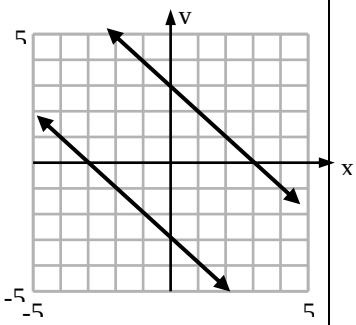


C



B



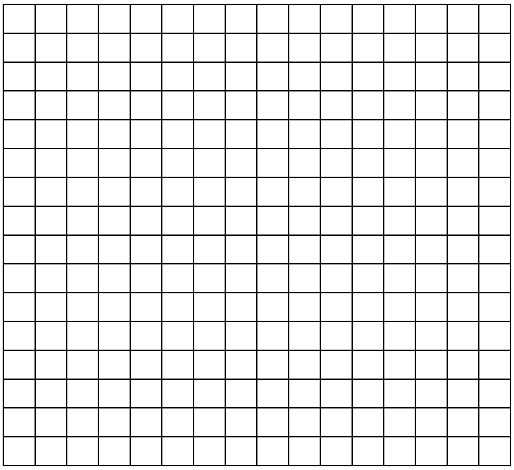


D

What is the solution of the system?

2) Solve the system by graphing.

$$y = x - 2$$
$$y = x + 1$$



3) Match each statement in the first column with the correct description from the second column.

1. parallel lines	A. infinite solutions
2. intersecting lines	B. no solution
3. same line	C. one solution

4) Determine if the ordered pair (-2, 5) is a solution for the equation.

$$y = -2x + 1$$

Workshop: Solving Linear Equations

Lesson 28: Another Computational Method of Solving a Linear System

Classwork

Example 1

Use what you noticed about adding equivalent expressions to solve the following system by elimination.

$$\begin{cases} 6x - 5y = 21 \\ 2x + 5y = -5 \end{cases}$$

Example 2

Solve the following system by elimination.

$$\begin{cases} -2x + 7y = 5 \\ 4x - 2y = 14 \end{cases}$$

Example 3

Solve the following system by elimination.

$$\begin{cases} 7x - 5y = -2 \\ 3x - 3y = 7 \end{cases}$$

Exercises

Each of the following systems has a solution. Determine the solution to the system by eliminating one of the variables. Verify the solution using the graph of the system.

1. $\begin{cases} 6x - 7y = -10 \\ 3x + 7y = -8 \end{cases}$

2. $\begin{cases} x - 4y = 7 \\ 5x + 9y = 6 \end{cases}$

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

Name: _____
Date: _____ Per: __

Warm-up: Linear Systems 3

1)

$$y = 3x - 5$$
$$y = 2x$$

What is the solution of the system of equations shown above?

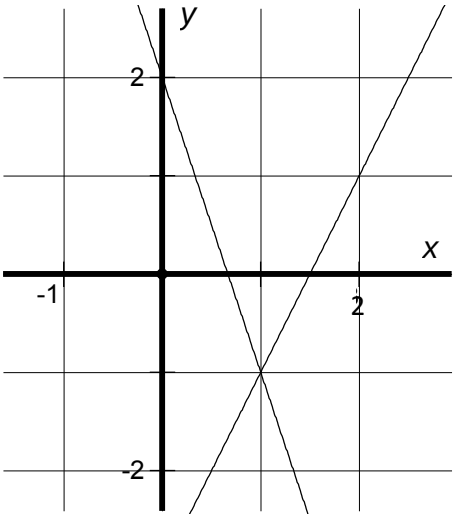
A. $(1, -2)$

B. $(1, \ 2)$

C. $(\ 5, \ 10)$

D. $(-5, -10)$

2) What is the solution for the system graphed below?



Write an equation for each line.

3) Solve by using substitution.

$$y = \frac{3}{2}x - 3$$
$$y = x - 3$$

4) Solve.

$$6x - 2(x + 7) = 5x - 3$$

Robots & Math

Name: _____
Date: _____ Per: __

Group Quiz 1

Show ALL work and box final answers.

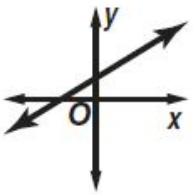
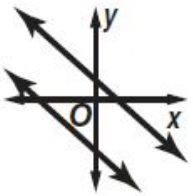
1a.) If a LinkBot's wheels are turning at a speed of 200 degrees per second for 10 seconds, how far will it travel (in inches)?

1b.) If a LinkBot's wheels are turning at a speed of 450 degrees per second for 8 seconds, how far will it travel (in inches)?

2a.) Suppose we need our Linkbot to travel exactly 70 inches in exactly 14 seconds. What speed will the robot have to travel in degrees per second to achieve this?

2b.) Suppose we need our Linkbot to travel exactly 55 inches in exactly 15 seconds. What speed will the robot have to travel in degrees per second to achieve this?

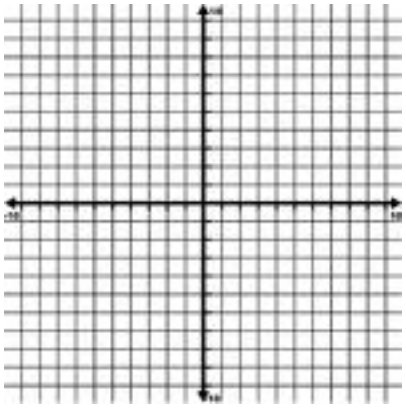
3.) How many solutions are shown in each graph below?

intersecting lines	same line	parallel lines
		

a.) _____ b.) _____ c.) _____

4.) Solve the following system of linear equations by graphing. ***State the number of solutions. If a solution does exists, indicate what it is.***

$y = 2x + 1$
$y = x - 4$



number of solutions: _____

solution (if any): _____

5.) Solve using substitution.

$y = 4x - 8$
$y = 2x + 2$

Linkbot Equation Verification

By this point we know that there is a relationship between degrees the wheels rotate and the distance the bot travels. We completed a linkbot motion worksheet and discovered that the relationship is 0.03 inches traveled for every one degree the wheel rotates.

Remember that this information helps us to calculate how far our bot will travel according to a specified number of degrees. We can use this math concept along with the speed of our robot to create linear equations for our bots.

Example:

A Linkbot named “Wild Bill” travels at a speed of 300 degrees per second. What is the function that models “Wild Bill’s” speed?

Explanation:

We know that speed is a ratio that compares a distance with time. A speed ratio we hear often is miles per hour. Miles are a measure of distance and hours are a measure of time. 25 miles per hour would mean that the object would travel a total distance of 25 miles if it traveled at a constant rate of speed for 1 hour.

Since we know that “Wild Bill’s” speed is constant, we should model his speed with a linear function. We are familiar with linear functions that are in slope-intercept form and look like $y = mx + b$ with m representing slope and b representing the y-intercept.

Answer:

We will start our answer with the basic form of a linear equation in slope-intercept form: $y = mx + b$ or $d = rt + b$ (distance equals rate times time plus a head start)

We are assuming that our distance units will be in inches and our time units will be in seconds. Therefore, x = time in seconds and y = distance in inches. The slope will need to be calculated and show the relationship or rate between inches and seconds. Our y-intercept will be 0 in this example because we are starting at zero distance traveled in zero seconds. So,
$y = mx$ or $d = rt$

Using the relationship of inches per degree, we take “Wild Bill’s” speed of 300 degrees per second and multiply by 0.03 to get 9 inches. Because “Wild Bill’s” speed was 300 degrees per second and we just converted to inches, we can say the speed is actually 9 inches per second. This makes our equation:
$y = 9x$ or $d = 9t$

1) Use the speed in degrees that you picked to calculate the slope of LinkBot 1 and write a linear equation that models its speed.

2) Does this equation match the equation you wrote from the data in part 1? If not, explain why you think there are differences.

3) Moving forward, are you going to use the equation you generated from the data or the equation you calculated? Why?

4) Use the speed in degrees that you picked to calculate the slope of LinkBot 2 and write a linear equation that models its speed.

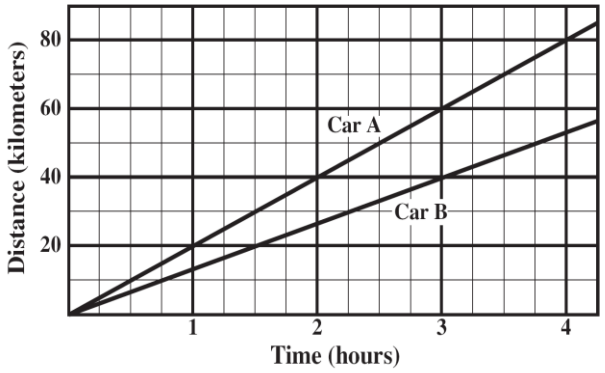
5) Does this equation match the equation you wrote from the data in part 2? If not, explain why you think there are differences.

6) Moving forward, are you going to use the equation you generated from the data or the equation you calculated? Why?

Name: _____
Date: _____ Per: __

Warm-up: Linear Systems 4

1)



After three hours of travel, Car A is about how many kilometers ahead of Car B?

A. 2

B. 20

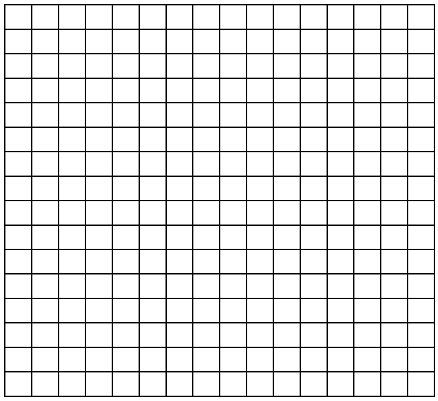
C. 40

D. 60

2) Solve the system by graphing.

$$y = 2x$$

$$y = x + 2$$



Solution:_____

3) Solve for y.

$$x - 3y = 3$$

4) Solve.

$$3(x+2) < 5x - 14$$

Robots & Math

Name: _____
Date: _____ Per: __

Linear Systems Review

Determine if the given ordered pair is a solution to the system.

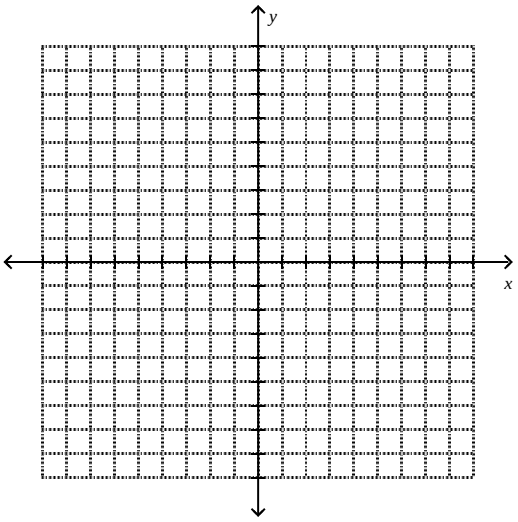
1) $\begin{cases} 3x - y = -5 \\ 2x + 3y = 4 \end{cases}$, $(-2,-1)$

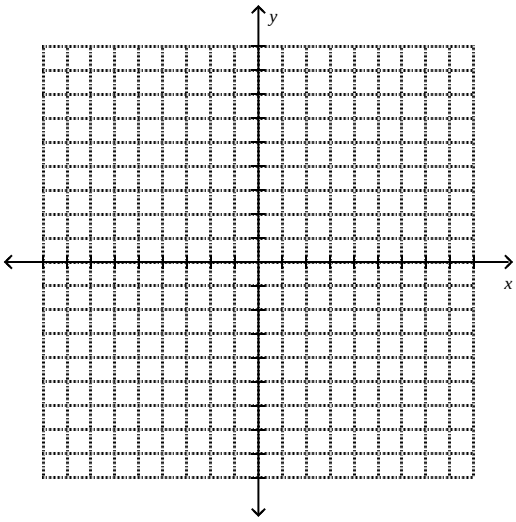
2) $\begin{cases} x - y = 2 \\ 2x + y = 4 \end{cases}$, $(2,0)$

Solve the following systems by graphing.

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

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





Solve using substitution.

5) $\begin{cases} y = x - 3 \\ y = -4x + 32 \end{cases}$

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

7) $\begin{cases} y = -2x - 4 \\ y = -2x + 8 \end{cases}$

Race to Tie 2

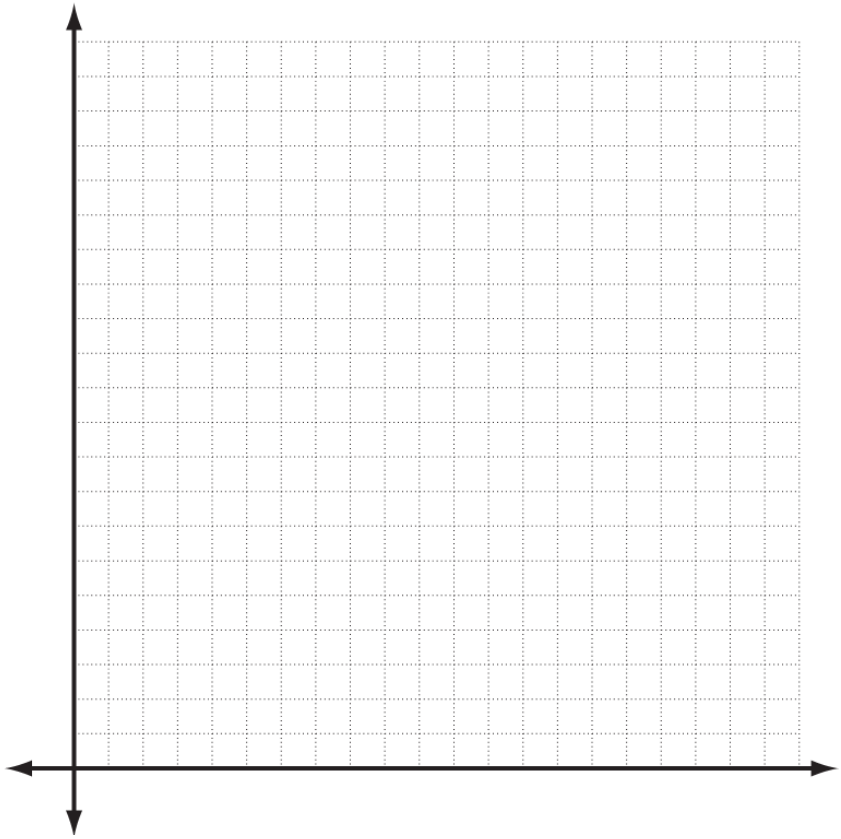
Part 3 – Linkbot Cars Together

1. The speed you picked for the LinkBot cars were: _____ & _____

The code for changing your Linkbot car's speed is:

robot.setJointSpeeds(*speed*, 0, *speed*)

2. Using a starting place of 10 inches for LinkBot car 1 and 40 inches for LinkBot car 2 along with the equations you determined in parts 1 and 2, graph lines for both bots.



3. Do the lines intersect? At what point do the lines intersect? What do the coordinates of these points represent? (Use complete sentences)

4. Write the final equations for each bot, making sure to include their starting points.

<u>LinkBot 1</u> <u>LinkBot 2</u>

5. Use the final equations to solve for the "tie point" Algebraically. Show all work and label each part.

Robots & Math

Name: _____
Date: _____ Per: __

Warm-up: Linear Systems 5

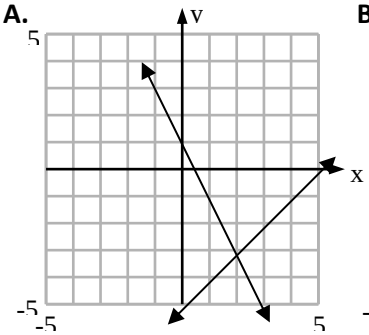
Multiple Choice

Identify the choice that best completes the statement or answers the question.

1. Solve the system by graphing.

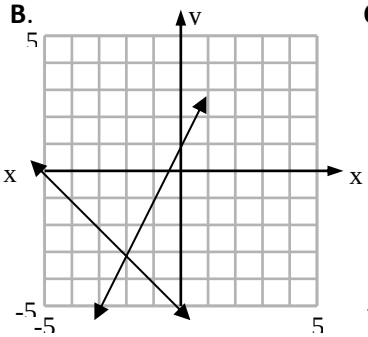
$$-x + y = -5$$
$$2x + y = 1$$

A.



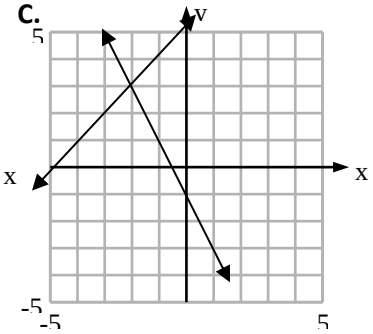
Solution: $(2, -3)$

B.



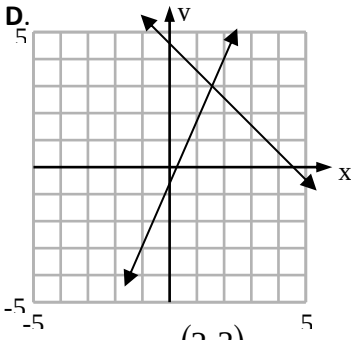
Solution: $(-2, -3)$

C.



Solution: $(-2, 3)$

D.



Solution: $(2, 3)$

2. Solve the system using substitution.

$$y = -5x + 12$$
$$3x + 2y = 3$$

A. (1, 7) **B.** (2, 2) **C.** (3, -3) **D.** (1, 0)

3. Dave solved the following system using substitution. What is the first line in his solution that contains an error?

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

Dave's solution:

$4x - (4x + 2) = 2$	*Line* 1
$4x - 4x - 2 = 2$	*Line* 2
$x - 2 = 2$	*Line* 3
$x = 4$	*Line* 4
$y = 4(4) + 2$	*Line* 5
$y = 18$	*Line* 6
Solution : $(-4, 18)$	

A. Line 1 **B.** Line 2 **C.** Line 3 **D.** Line 4

Race to Tie 2: Twists

Groups that finish early have the following twists available:

1) Keeping bot 1 at a 10 inches up the track, move bot 2 forward 10 inches to a start at 50 inches up the track. Will the bots take less or more time to tie? Make a prediction. Redesign your equations and calculate where the bots will tie. Once your calculations are complete, test your hypothesis. What happened?

2) Start both bots at 10 inches and 40 inches as they are in the original lab. Now the speed of bot 1 must be 4 times the speed of bot 2. Make a prediction about what you think will happen. Pick two speeds that satisfy the parameters and write the two linear equations that model the speeds and starting places of the bots (remember that the slope must be the speed in inches, not degrees). Calculate where the bots will tie and test the hypothesis. What happened?

3) Your bots need to tie at a point where the y-coordinate (distance in inches) is double your x-coordinate (time in seconds). The x-coordinate must be greater than 4 (the race must be longer than 4 seconds). Pick speeds and determine the linear equations for both bots such that they satisfy the parameters. Test your hypothesis for accuracy.

Solving Systems Recap/Practice

Lesson Summary

Systems of linear equations can be solved by eliminating one of the variables from the system. One way to eliminate a variable is by setting both equations equal to the same variable, then writing the expressions equal to one another.

Example: Solve the system $\begin{cases} y = 3x - 4 \\ y = 2x + 1 \end{cases}$

Since both equations of the system are equal to y, then we can write and solve the equation:

$$3x - 4 = 2x + 1$$

Another way to eliminate a variable is by multiplying each term of an equation by the same constant to make an equivalent equation. Then use the equivalent equation to eliminate one of the variables and solve the system.

Example: Solve the system $\begin{cases} 2x + y = 8 \\ x + y = 10 \end{cases}$

Multiply the second equation by -2 to eliminate the x:

$$-2(x + y = 10)$$
$$-2x - 2y = -20$$

Now we have the system $\begin{cases} 2x + y = 8 \\ -2x - 2y = -20 \end{cases}$

When the equations are added together, the x is eliminated:

$$2x + y - 2x - 2y = 8 + (-20)$$
$$y - 2y = 8 + (-20)$$

Once a solution has been found, verify the solution graphically or by substitution.

Problem Set

Determine the solution, if it exists, for each system of linear equations. Verify your solution on the coordinate plane.

1. $\begin{cases} \frac{1}{2}x + 5 = y \\ 2x + y = 1 \end{cases}$

2. $\begin{cases} 9x + 2y = 9 \\ -3x + y = 2 \end{cases}$

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

4. $\begin{cases} 8x + 5y = 19 \\ -8x + y = -1 \end{cases}$

5. $\begin{cases} x + 3 = y \\ 3x + 4y = 7 \end{cases}$

6. $\begin{cases} y = 3x + 2 \\ 4y = 12 + 12x \end{cases}$

7. $\begin{cases} 4x - 3y = 16 \\ -2x + 4y = -2 \end{cases}$

8. $\begin{cases} 2x + 2y = 4 \\ 12 - 3x = 3y \end{cases}$

9. $\begin{cases} y = -2x + 6 \\ 3y = x - 3 \end{cases}$

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

11. $\begin{cases} 3x - 5y = 17 \\ 6x + 5y = 10 \end{cases}$

12. $\begin{cases} y = \frac{4}{3}x - 9 \\ y = x + 3 \end{cases}$

13. $\begin{cases} 4x - 7y = 11 \\ x + 2y = 10 \end{cases}$

14. $\begin{cases} 21x + 14y = 7 \\ 12x + 8y = 16 \end{cases}$

Name: _____
Date: _____ Per: __

Warm-up: Linear Systems 6

1) The perimeter of a rectangle is 32 inches. The length is 3 times the width.

If x = the width of the rectangle and y = the length, which linear system models the situation?

A. $\begin{cases} x + y = 32 \\ x = 3y \end{cases}$

C. $\begin{cases} 2x + 2y = 32 \\ x = 3y \end{cases}$

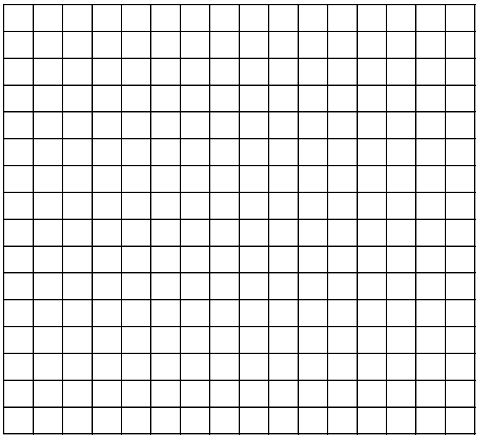
B. $\begin{cases} x + y = 32 \\ y = 3x \end{cases}$

D. $\begin{cases} 2x + 2y = 32 \\ y = 3x \end{cases}$

2) Solve by graphing.

$y = -3$

$2x + y = 1$



Solution:_____

3) Solve using substitution.

$y = -7$

$y = 3$

4) Solve using substitution.

$-x + 2y = -1$

$x = y + 4$

Name: _____
Date: _____ Per: __

Warm-up: **Linear Systems 7**

1)

$$7x + 3y = -8$$
$$-4x - y = 6$$

What is the solution of the system of equations shown above?

A. $(2, 2)$

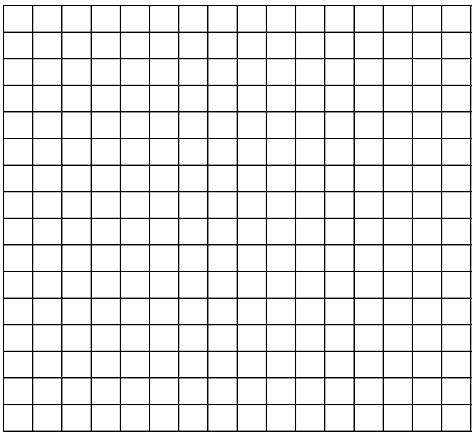
B. $(2, -2)$

C. $(-2, 2)$

D. $(-2, -2)$

2) Solve by graphing.

$$x + 3y = -3$$
$$x - y = 5$$



Solution:_____

3) Solve using substitution.

$$x + 3y = -3$$
$$x - y = 5$$

4) Solve using elimination.

$$x + 3y = -3$$
$$x - y = 5$$

Robots & Math

Name: _____

Date: _____ Per: __

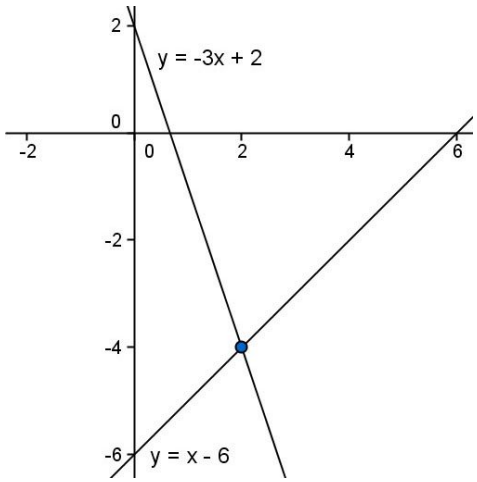
Group Quiz 2

Show ALL work and box final answers.

1) A tire with a 3.5 inch diameter rotates 650 degrees. How far has the tire traveled?

2) You have a linkbot wheel with a 12 inch circumference that must travel 19 inches. How many degrees do the wheels need to be programmed to spin?

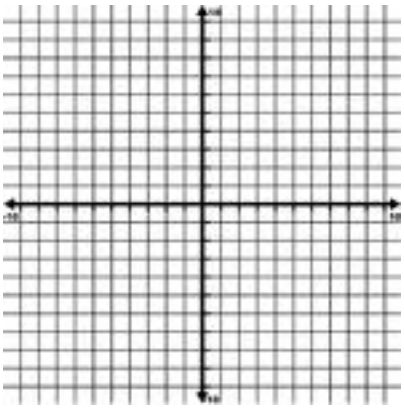
3) The following graph shows a linear system. Does the system have one solution, no solutions, or infinitely many solutions? If it has a solution, name it.



4) Solve the following system by graphing.

$y = -4x + 8$

$y = 3x + 1$



Solution: _____

5) Solve the following systems using substitution.

a) $y = 7x - 3$
$y = -x + 13$

b) $y = -6x - 3$
$-8x + 8y = 88$

6) Solve the following systems using elimination.

a) $4x + 8y = 20$
$-4x + 2y = -30$

b) $7x + 2y = 24$
$8x + 2y = 30$

c) $-4x + 9y = 9$
$x - 3y = -6$

Robots & Math
Teacher Name

Name: _____
Date: _____ Per: __

Unit Assessment

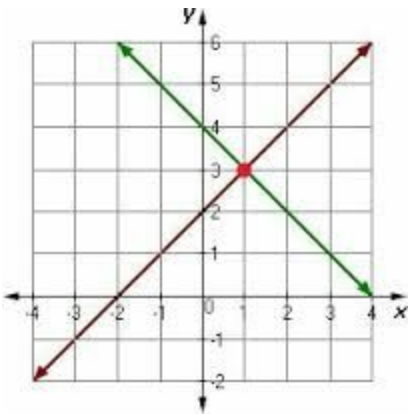
Show ALL work and box final answers. Round decimals to the nearest tenth.

1) A tire with a 3.2 inch diameter rotates 1,250 degrees. How far has the tire traveled?

2) You have a linkbot wheel with a 15 inch circumference that must travel 23 inches. How many degrees do the wheels need to be programmed to spin?

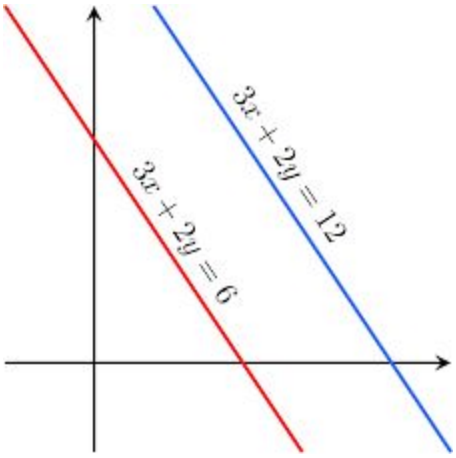
3) The following graph shows a linear system. Does the system have one solution, no solutions, or infinitely many solutions? If it has a solution, name it.

a.)



solution: _____

b.)

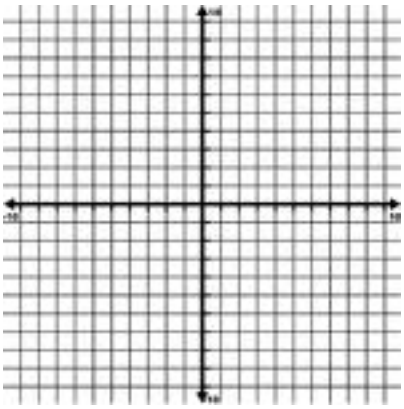


solution: _____

4) Solve the following system by graphing.

$y = -5x + 7$

$y = -4x + 5$



Solution: _____

5) Solve the following systems using substitution.

a) $y = 8x + 3$
$y = -x + 12$

b) $y = -5x + 1$
$7x - 7y = 77$

6) Solve the following systems using elimination.

a) $3x + 5y = 23$
$-3x + 2y = -37$

b) $-2x - 3y = 14$
$3x - 3y = 39$

c) $-8x + 28y = 40$
$4x + 8y = 24$

Starting Position

Hare bot and Tortoise bot both start before the starting line.

Objective

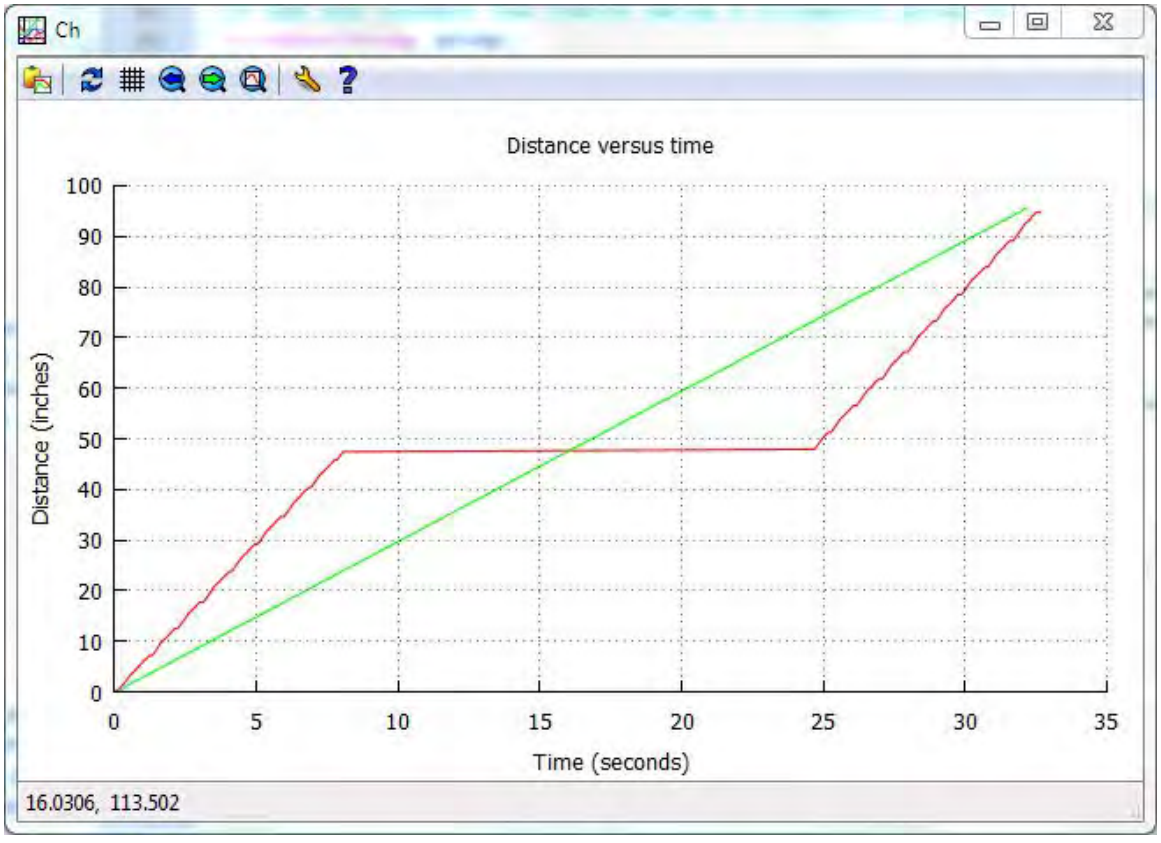
Graph both bots for Distance over Time. Label graph appropriately to be scored.

Hare Bot travels half-way to the finish line, pauses for a period of time, and crosses the finish line at the same time as the Tortoise Bot.

Tortoise Bot starts at the same time as Hare Bot, travels at half the speed of Hare Bot, does not stop, and crosses the finish line at the same time as Hare Bot.

Scoring

#	Description	Points
1	Tortoise and Hare Bot start at the same time.	5
2	**Tortoise and Hare Bot end at the same time at the finish line.**	15
3	Tortoise Bot graph has shape as illustrated below.	20
4	Hare Bot graph has shape as illustrated below.	40



Gravity Car Calendar (90 min block)

Week	Mon	Tues	Wed	Thur	Fri

1	- Entry Doc
	- K/NtK/NS
	- Lab - Gravity Car
	  - 8s video
	  - Gravity Car Data Sheet
		- Do Now: Average Rate of Change/Piecewise
		- Finish Gravity Car Data Sheet
		- Start Planning Document Python
		- Start Planning Document Ch
			- Do Now: What's My Function?
			- Finish Planning Document
			- Program cars
			  - py code
			  - ch code
				- Do Now: Graphing Data
				- The Twist:
				  - 10s video
				  - student data sheet
					- Do Now: Fit a parabola to data?
					- Loops Workshop: Loops Ch, Loops Python
					- Program cars
					- Take data
					- Prepare for Code Review
					- Rubric for Code Review

2	- Code Review - Group Quiz	- Individual Test			
3					

Gravity Car Graph Challenge:

Dear Students,

Now that we've had fun with my racecar, I wanted to try something that doesn't need batteries. This gravity car accelerates down the ramp through the power of gravity. Does your Linkbot car do the same thing? Can you make the Linkbot's motion mirror the motion of my gravity car? Your challenge is to have the graph of your Linkbot look exactly the same as the graph of my gravity car at one second intervals.

Your proof of this will not just be a graph, but well documented code. Well documented means every line or item that isn't self explanatory should have a comment that helps the reader understand what you did. Often the reader is you at a later date trying to reuse the code, the comments will help future you save time. And isn't that what life is, but trying to make sure future you is set up for awesomeness?

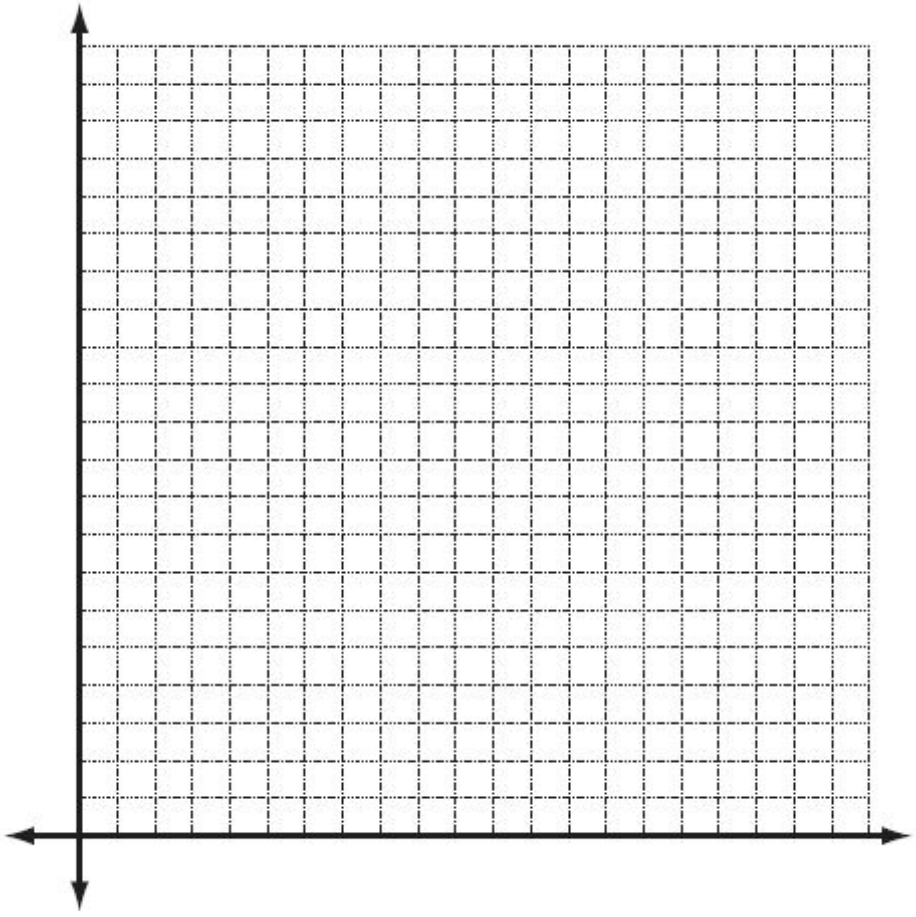
Sincerely,
Your Teacher

Gravity Car Data

IV: _____ DV:_____

Data:

Graph:



1. a. Does the car move at a constant speed down the ramp? Give evidence from the table to back up your answer.

1. b. Describe the motion of the car.

2. How does your graph show the car's motion?

3. What is the average speed between 0 and 1 second?

Add your answer to the table below and fill in the rest of the table.

Seconds	Average Speed
0-1	
1-2	
2-3	
3-4	
4-5	
5-6	
6-7	
7-8	

4. How do your answers in the table in #3 support what you said in #1 and #2?

Warm-up: Average Rate of Change/Piecewise

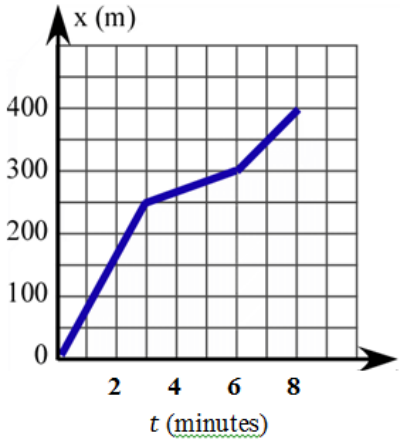
6. The graph below shows Glenn's distance from home as he rode his bicycle to school, which is just down his street. His next-door neighbor Pablo, who lives 100 m closer to the school, leaves his house at the same time as Glenn. He walks at a constant velocity, and they both arrive at school at the same time.

   a. Graph a linear function that represents Pablo's distance from Glenn's home as a function of time.

   b. Estimate when the two boys pass each other.

   c. Write piecewise-linear functions to represent each boy's distance and use them to verify your answer to part (b).

   d. What is the averagae rate of change for the two boys?



Linkbot Planning:

You will learn several new commands today to help you make the Linkbot's motion match the gravity car's motion. Everything after the hashtag (or pound symbol) is a comment that the computer will ignore, but the reader may find helpful. The following program makes the robot go at speed1 for one second, then speed2 for one second.

```
import linkbot   # loads 'linkbot' module
import time

robotID = input('Enter Linkbot ID: ')  # prompts user for a Linkbot ID and
                                       # stores the result in a variable called
                                       # "robotID"
robot = linkbot.Linkbot(robotID)   # Gets a handle to the robot with the serial
                                   # ID stored in "robotID"

robot.setJointSpeeds(speed1, 0, speed1) #changes the robot's speed
                                            #in degrees/second
robot.moveContinuous(1, 0, -1) #1 means go, 0 means stop
time.sleep(1) #1 second
robot.setJointSpeeds(speed2, 0, speed2)
time.sleep(1)
robot.moveContinuous(0,0,0)
```

How might this be useful for matching the motion of the gravity car?

Use the file gravityCar.py to get your started. Remember to comment each line with things like, *what the line does* and *why you are doing that*.

Once you think your Linkbot is right, run your program, take data, then graph the data on the next page.

Does your graph match the gravity car graph? What needs to be fixed?

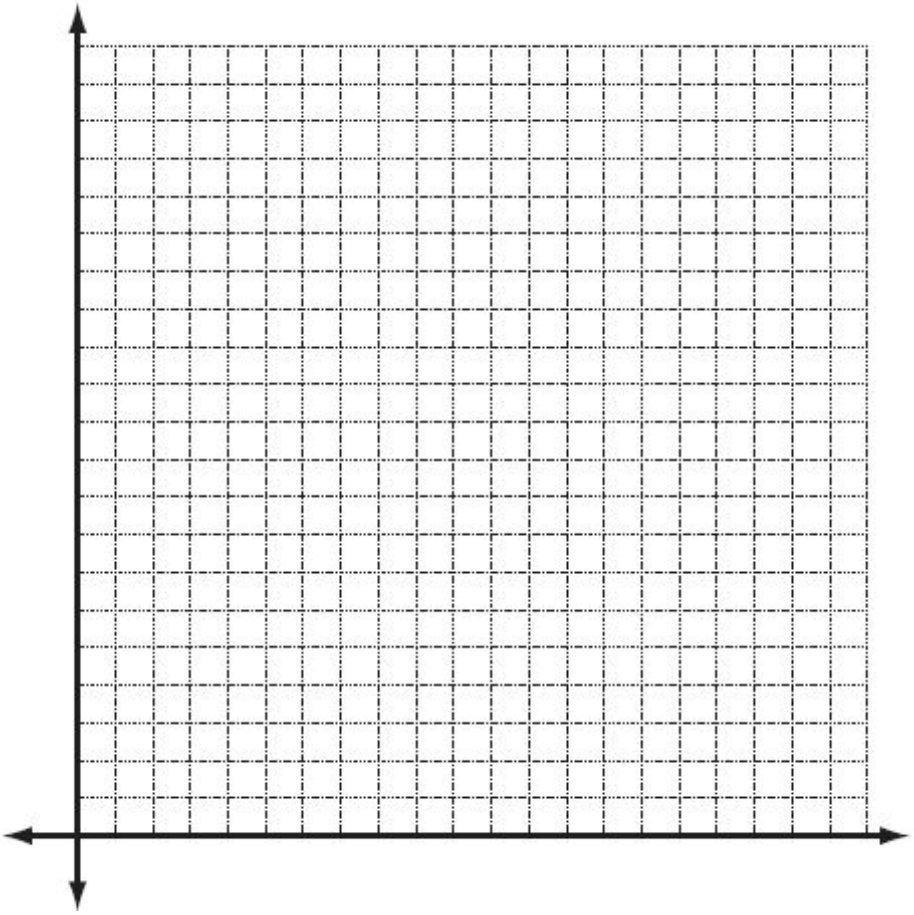
Are your graphs linear like the previous challenges or is it something else?

Linkbot Data

IV: _____ DV:_____

Data:

Graph:

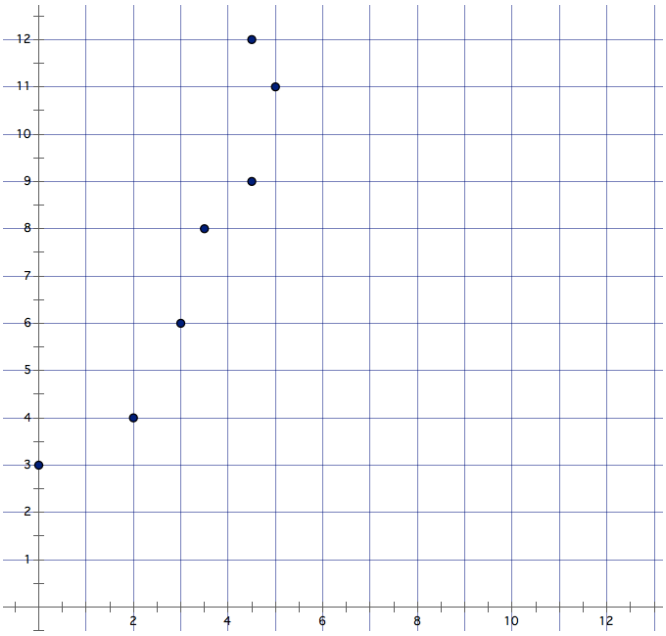


Set

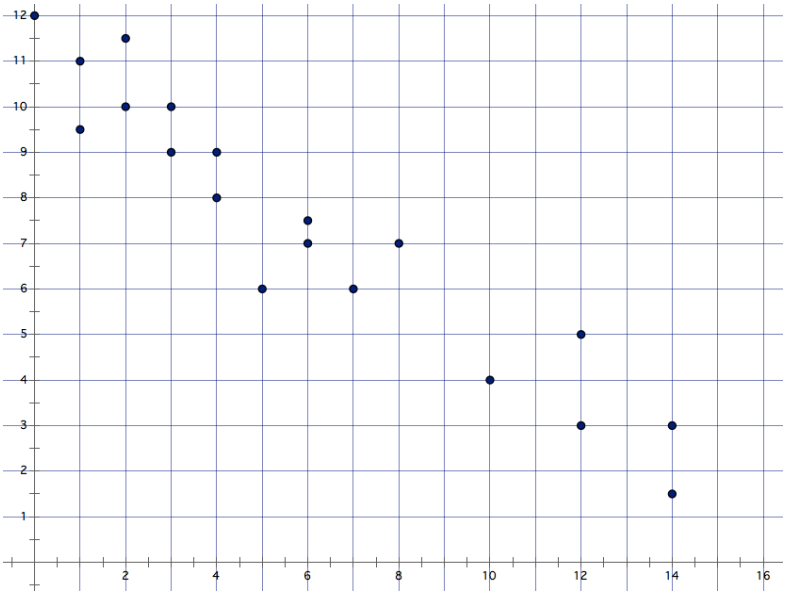
Topic: Creating and analyzing scatter plots.

Determine whether a linear or a quadratic model would be best for the given scatter plots. Then sketch a model on the graph that could be used to make predictions.

6.

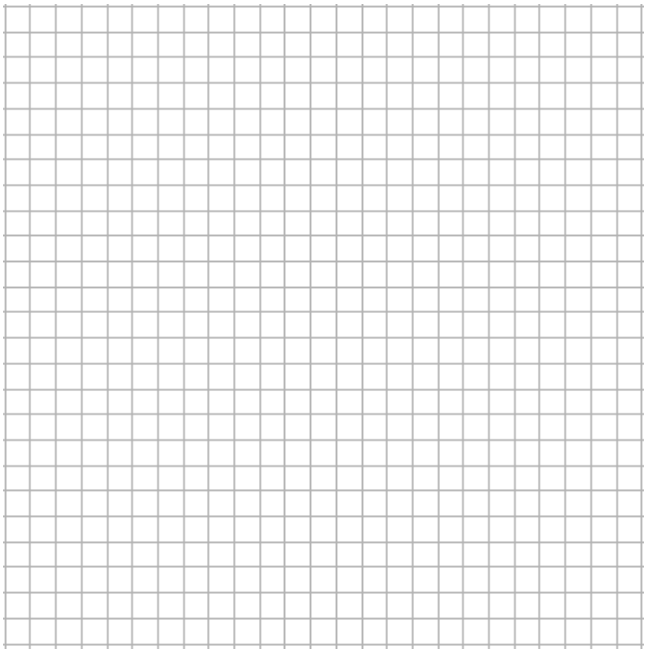


7.



8. Use the data to make a scatter plot. Then answer the questions.

Weeks since school started	Money in savings
1	200
3	175
4	162
7	120
10	87
13	57
20	5



9. Is the correlation of the graph positive or negative? Why?

10. What would you estimate the correlation coefficient to be? Why?
(If you have a calculator or software that can calculate it precisely then do so.)

11. Create a regression line and find the regression equation. What is the regression equation?

12. What does the slope of the regression equation mean in terms of the variables?

13. Most school years are 36 weeks. If the rate of spending is kept the same how much more money needs to be saved during the summer in order for there to be money to last all 36 weeks.

Warm-up: Fit a Parabola to Data

2. The table shows the average sale price, p, of a house in New York City, for various years, t, since 1960.

Years since 1960, t	0	1	2	3	4	5	6
Average sale price (in thousands of dollars), p	45	36	29	24	21	20	21

a. What type of function most appropriately represents this set of data? Explain your reasoning.

b. In what year is the price at the lowest? Explain how you know.

c. Write a function to represent the data. Show your work.

d. Can this function ever be equal to zero? Explain why or why not.

e. Mr. Samuels bought his house in New York City in 1970. If the trend continued, how much was he likely to have paid? Explain and provide mathematical evidence to support your answer.

Workshop: Loops

For loops:

for i in range(0,10,1):

In python, for a simple loop, the **for** keyword is followed by a the words, “in range” followed by a set of parentheses containing three parts separated by commas.

for variable in range (*init*, *max*, *increment*):

The intent of this **for** loop is to enable stepping a variable through a series of numbers, like counting from 0 to 9. The part before the first comma (*init*) is the number at which the variable will start counting. The part between the two commas (*max*) is the number the variable will count to but not include. And the part following the final comma (*increment*) is what the variable will be counting by. If init and increment are not given, they are assumed to be 0 and 1 respectively.

In practice, **for** loops are used most often for counting out n iterations. The standard idiom for this is the following.

```
for i in range (n):
    body
```

Here we have a counter variable i whose value starts at 0. With each iteration, we test whether i has reached n or not; and if it hasn't, then we execute the **for** statement's body and then i goes to the following integer. The result is that the body is executed for each value of i from 0 up to n – 1. Note: Python uses whitespace to differentiate between the body and something outside of the **for** loop that happens afterwards. That is, every statement you want to be repeated must be indented below the **for** statement.

But you can use a **for** loop for other purposes, too. In the following example, we display the multiples of 2 up to (but not including) 12. Notice how the *increment* portion of the **for** statement has changed to 2.

```
for p in range(0,12,2):
    print(p)
```

While loops:

```
while (test):
    body
```

The **while** statement works by checking the test condition, if it is true then the body will be executed. After the body is executed it will check the test condition again and repeat until the test condition is no longer true.

```
i=10
while (i >= 0):
  print(i)
  i-=1
```

Again, Python uses whitespace to differentiate between the body and something outside of the **while** loop that happens afterwards. That is, every statement you want to be repeated must be indented below the **while** statement.

CODE REVIEW RUBRIC

STUDENT: _____

EVALUATOR: _____ DATE: _____

CRITERIA	UNSATISFACTORY (Below Performance Standards)	PROFICIENT (Meets Standards)	ADVANCED (Demonstrates Exceptional Performance)
Description Documented Code (40%)	● Fails to meet any of the Proficient Descriptors. ● Common Pitfall: - Assuming a line is self explanatory that actually isn't (when in doubt, add a comment) 0 - - - - - - - - - - - - 7 - - - - - - - - - - - - 13	● Each line is either self explanatory or comment helps understand it ● Code runs without errors and makes the Linkbot move in a quadratic fashion. 14 - - - - - - - - - - - - 16 - - - - - - - - - - - - 18	In addition to meeting the PROFICIENT criteria... ● Code is parameterized 19 - 20
Description Justification of Motion (60%)	● Fails to meet any of the Proficient Descriptors ● Common Pitfalls: - Graph doesn't start at 0 - Graph scales are inconsistent, too big, or too small 0 - - - - - - - - - - - -11 - - - - - - - - - - - - 22	● Student can justify how their car is moving quadratically by referencing the graph, equation, and table. ● Student can explain how the motion of the Linkbot is an approximation of a quadratic, and is actually a piecewise linear graph. ● Student references the average rate of change between two measured points during their explanation. 23 - - - - - - - - - - - - 25 - - - - - - - - - - - - 27	In addition to meeting the PROFICIENT criteria ... ● Student can explain the equation of each piece of the piecewise graph 28 - - - - - - - - - - - -29 - - - - - - - - - - - - 30

COMMENTS:

Group Quiz

Coefficients of 3 and 5

If we list first few values greater than zero for quadratics with coefficients of three and five below 50 we get 3, 5, 12, 20, 27, and 45. The sum of these values is 112. Find the sum of all values of quadratics with coefficients of 3 or 5 below 1000.

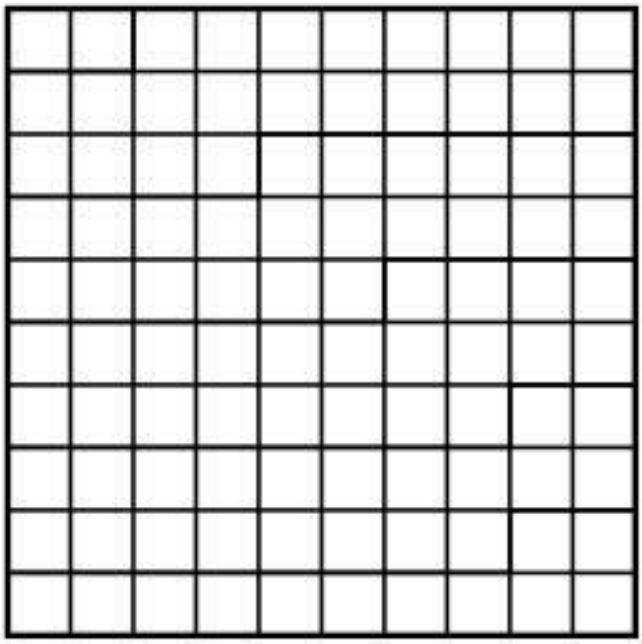
Robots & Math **Name**_____

Gravity Car Assessment

1) You have been selected through a contest to win one million dollars. You must shoot a basketball from the top of a building so that it goes over a billboard and lands in a hoop on the ground. The following table compares the height of the basketball from the ground to the amount of time it is in the air.

IV:	0	1	2	3
DV:	80	128	144	128

a) Graph the data. Be sure to label your axes and pick a good scale.



b) Write the recursive rule for the function.

c) Use the recursive rule to find f(4) (show all calculations).

d) Write the explicit rule of the function.

e) Use the explicit rule to determine how many seconds it takes the ball to get to the rim (show all calculations).

Mini-Project B: Project Euler Problem 45 - Triangular, Pentagonal, and Hexagonal

Triangular, pentagonal, and hexagonal numbers are generated by the following formulae:

Name	**Function**	**First five values**
Triangle	$T(n)=n(n+1)/2$	1, 3, 6, 10, 15, ...
Pentagonal	$P(n)=n(3n−1)/2$	1, 5, 12, 22, 35, ...
Hexagonal	$H(n)=n(2n−1)$	1, 6, 15, 28, 45, ...

We can see that $T(5)=H(3)=15$ so 15 is both triangular and hexagonal.

We can also see that $T(1) = P(1) = H(1) = 1$ so 1 is triangular, pentagonal, and hexagonal.

Find the next triangular number that is also pentagonal, and hexagonal.

Support: Students will need to learn/know: if statements, functions, and while loops.

Standard addressed: F-IF2 - Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.

Quadratic Calculator Calendar (90 min block)

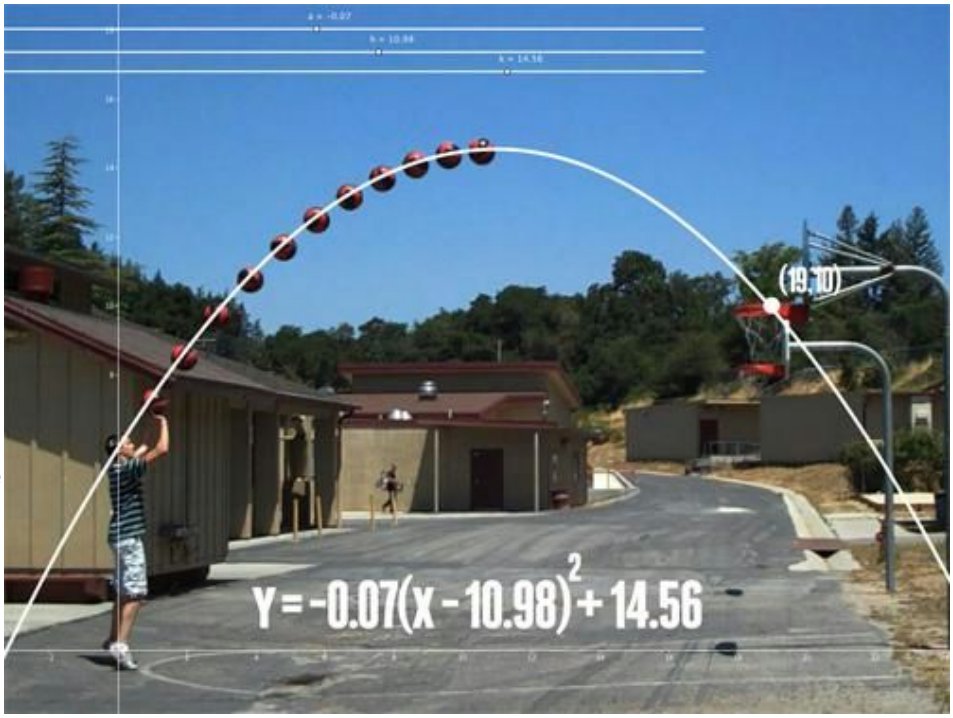
Week	Mon	Tues	Wed	Thur	Fri
1	- Group intro activity - Group contracts - Entry Doc - **K/NTK**/NS	- Do Now: Graphing - K/NTK/**NS** **- ch** - Graphing with code - graphing.ch - **py** - Graphing with code - graphing.py - Graphing Exploration - Debrief	- Do Now: Find the zeros - Introduce quadratic formula - Quadratic Formula Worksheet	- Add quadratic formula solver to program - Check your answers from yesterday's worksheet	- Do Now: How many solutions? - Add discriminant solver to program
2	- Do Now: Axis of Symmetry - Completing the Square Exploration (part 1)	- Do Now: Vertex (pg 2) - Finish Completing the Square Exploration (part 2)	- Use the patterns you noticed about the vertex and the axis of symmetry to add these to your program	- Group Problem Solving Quiz (may use program) - 3 Act PBL Graphic Organizer	- Try out another group's program - Critical friends feedback about functionality and comments
3	Review	Test			

Possible student solution
- py code (w/ functions)
- ch code (w/o functions)

Quadratic Calculator:

Dear Students,

Quadratics are all around us, from the path of a basketball, to the area of a garden, to the net centripetal force of a satellite orbiting the earth. Unfortunately, many students have trouble with them. Wouldn't it be nice if there were a Quadratic Calculator where you could just enter the coefficients of the quadratic and get the graph of the quadratic between -10 and 10, zeros, value of the discriminant (and what it means), the vertex, and the equation of the axis of symmetry? You can use the power of coding to make this dream a reality!



Sincerely,
Your Teacher

Know	Need to Know	Next Steps

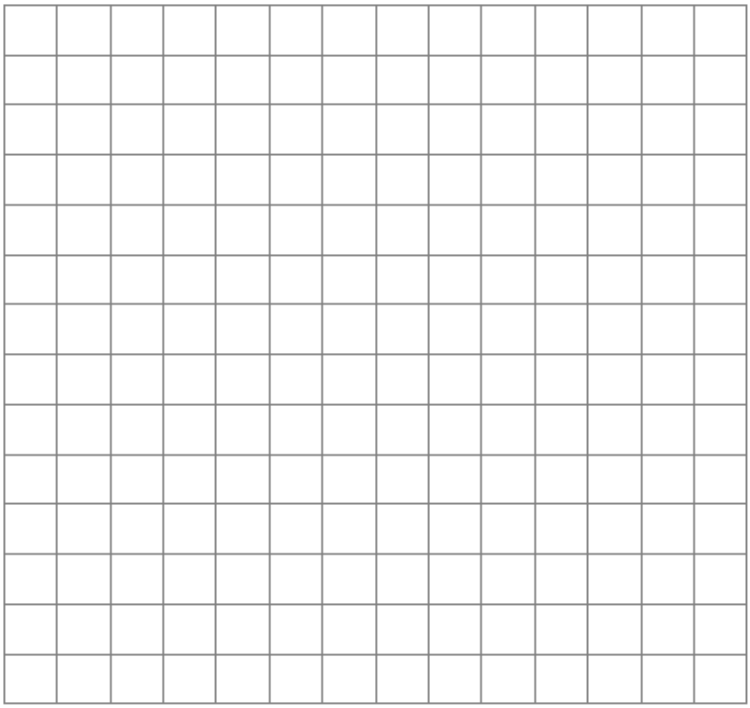
Photo credit: Dan Meyer from http://blog.mrmeyer.com/2010/wcydwt-will-it-hit-the-hoop/

Name:_____ Date:_____

Warm-up: Graph the equation: $y=2x^2+3x-4$

Table:

Graph:



1. What do you notice about the graph?

2. How did you graph it? (First I did..., then I did..., etc)

Remember how you did the graph of the parabola for the warm-up?

Graphing with code is similar, this command:

```
xList=numpy.linspace(-10,10,100)
```

makes a list of 100 evenly spaced x values between -10 and 10.

Then we calculate the y values for each x value:

```
yList=a*xList**2+b*xList+c
```

Finally, this block of code puts the points we just created on a graph:

```
pyplot.plot(xList,yList)      #plots all points
pyplot.xlabel('x value')      #labels x axis
pyplot.ylabel('y value')      #labels y axis
pyplot.title('Parabola')      #labels graph
pyplot.grid(True)             #shows grid
pyplot.show()                       #tells computer to show the graph on the screen
```

What does the graph look like if you only do 10 evenly spaced points between -10 and 10?

What would you change if you wanted to graph between 0 and 1 instead of -10 to 10?

What would you change if you wanted to graph a straight line instead of a quadratic?

Algebra I Name _____

Date _____ Period ___

Graphing Exploration for Quadratics

Standard form of a Quadratic Equation $y = ax^2 + bx + c$	Standard form of a Quadratic Function $f(x) = ax^2 + bx + c$

1. To graph the function $f(x) = x^2 + x + 1$ you need to enter a=1, b=1, and c=1
   What does the graph look like?

2. Before changing the values, try to predict what will happen (Hint: try evaluating the value of the function for the same value of x but slightly changing the value of the number that is represented by the slider bar.

   a) What happens when you change a to a positive number, 0, a negative number?
   Try the following values $a = 2$, $a = 0$, $a = -2$ (don't forget b=1 and c=1 still).

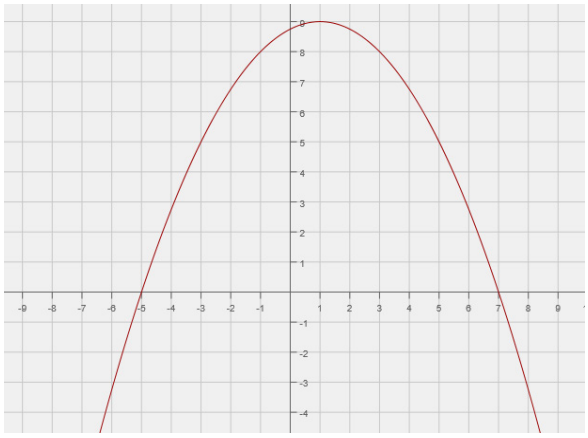
   b) What happens when you change b to a positive number, 0, a negative number?
   Try the following values $b = 2$, $b = 0$, $b = -2$ (don't forget a=1 and c=1 still).

   c) What happens when you change c to a positive number, 0, a negative number?
   Try the following values $c = 2$, $c = 0$, $c = -2$ (don't forget a=1 and b=1 still).

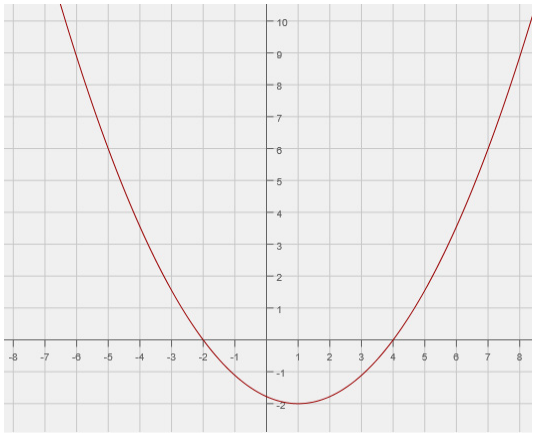
Warm-up: Find the Zeros

1. What are the x-intercepts of the four graphs below?

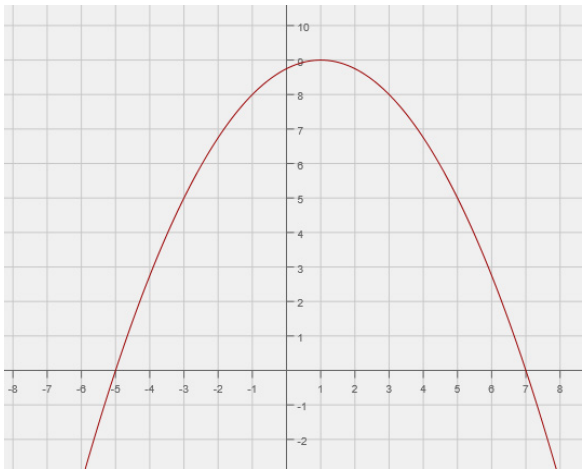
Graph A



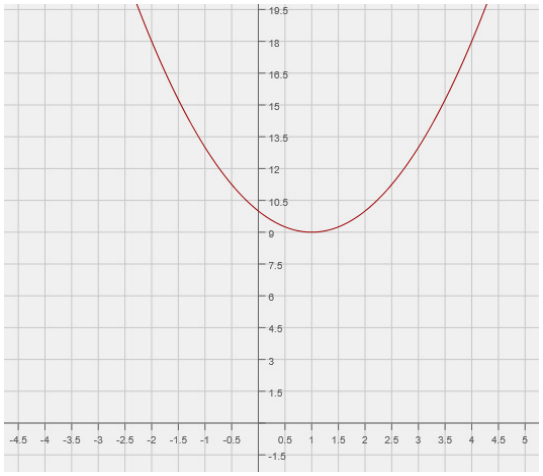
Graph B



Graph C



Graph D



a.

b.

c.

d.

Workshop: Quadratic Formula

Lesson Summary

The quadratic formula, $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$, is derived by completing the square on the general form of a quadratic equation: $ax^2 + bx + c = 0$, where $a \neq 0$. The formula can be used to solve any quadratic equation, and is especially useful for those that are not easily solved using any other method (i.e., factoring or completing the square).

Problem Set

Use the quadratic formula to solve each equation.

1. Solve for z: $z^2 - 3z - 8 = 0$.

2. Solve for q: $2q^2 - 8 = 3q$

3. Solve for m: $\frac{1}{3}m^2 + 2m + 8 = 5$.

Worksheet: Quadratic Formula

Lesson 15: Using the Quadratic Formula

Classwork

Opening Exercise

Solve:

1. $4x^2 + 5x + 3 = 2x^2 - 3x$

2. $c^2 - 14 = 5c$

Exercises 1–5

Solve the following equations using the quadratic formula.

1. $x^2 - 2x + 1 = 0$

2. $3b^2 + 4b + 8 = 0$

3. $2t^2 + 7t - 4 = 0$

4. $q^2 - 2q - 1 = 0$

5. $m^2 - 4 = 3$

Warm-up: How Many Solutions?

Lesson Summary

You can use the sign of the discriminant, $b^2 - 4ac$, to determine the number of real solutions to a quadratic equation in the form $ax^2 + bx + c = 0$, where $a \neq 0$. If the equation has a positive discriminant, there are two real solutions. A negative discriminant yields no real solutions and a discriminant equal to zero yields only one real solution.

Problem Set

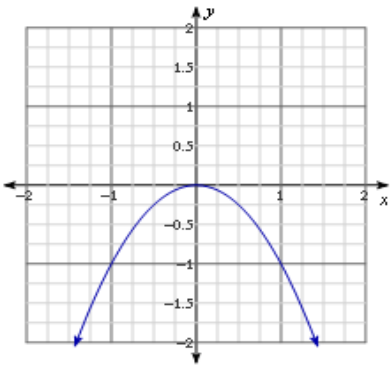
Without solving, determine the number of real solutions for each quadratic equation.

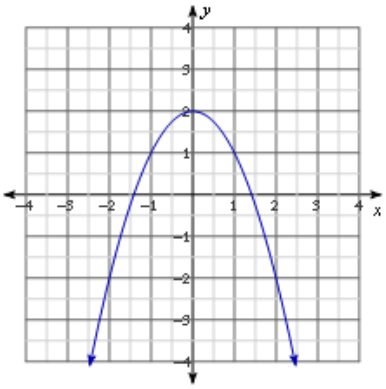
1. $b^2 - 4b + 3 = 0$

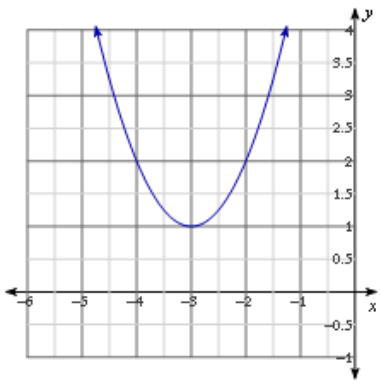
2. $2n^2 + 7 = -4n + 5$

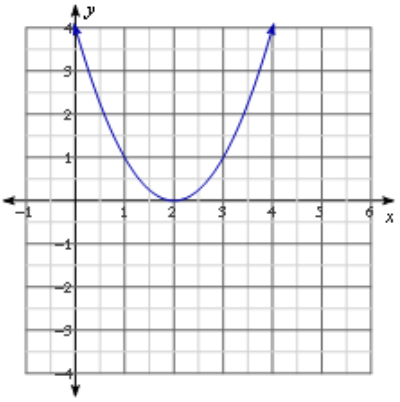
3. $x - 3x^2 = 5 + 2x - x^2$

4. $4q + 7 = q^2 - 5q + 1$

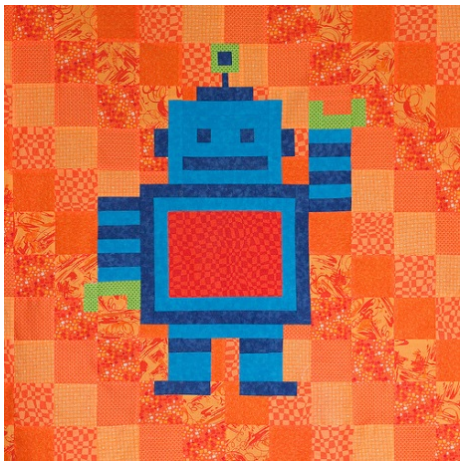
5. 

7. 

6. 

7. 

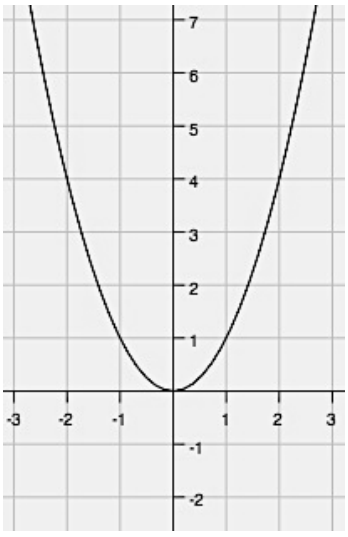
Warm-up: Axis of Symmetry



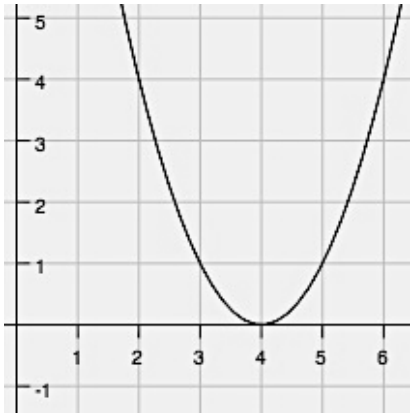
Ready Topic: Finding key features in the graph of a quadratic equation

Make a point on the **vertex** and draw a dotted line for the **axis of symmetry**.
Label the coordinates of the vertex and state whether it's a **maximum** or a **minimum.**
Write the **equation for the axis of symmetry**.

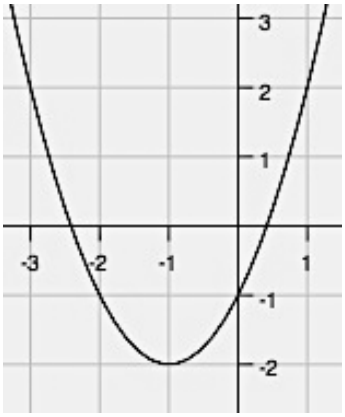
1.



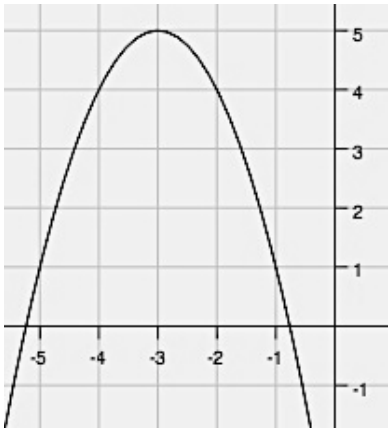
2.



3.



4.



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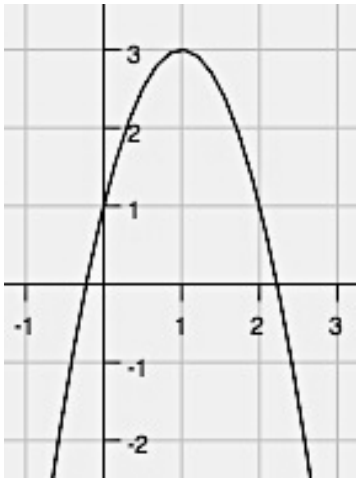
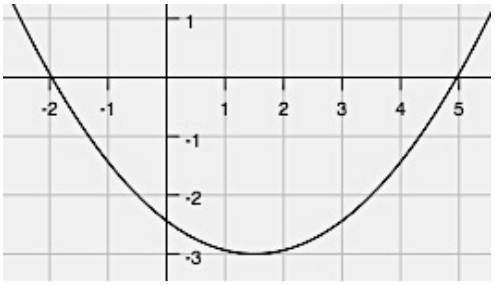
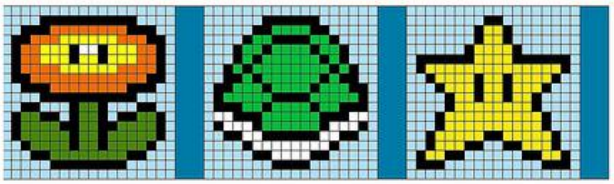


6.



2.3 Building the Perfect Square

A Solidify Understanding Task



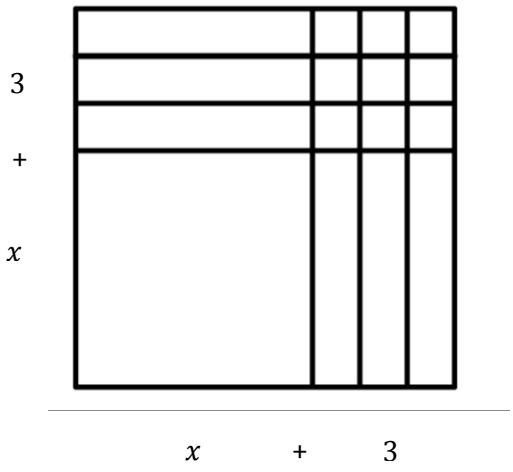
Exploration: Completing the Square

Part 1: Quadratic Quilts

Optima has a quilt shop where she sells many colorful quilt blocks for people who want to make their own quilts. She has quilt designs that are made so that the can be sized to fit any bed. She bases her designs on quilt squares that can vary in size, so she calls the length of the side for the basic square x, and the area of the basic square is the function $A(x) = x^2$. In this way, she can customize the designs by making bigger squares or smaller squares.

1. If Optima adds 3 inches to the side of the square, what is the area of the square?

When Optima draws a pattern for the square in problem #1, it looks like this:



2. Use both the diagram and the equation, $A(x) = (x + 3)^2$ to explain why the area of the quilt block square, $A(x)$, is also equal to the $x^2 + 6x + 9$.

The customer service representatives at Optima's shop work with customer orders and write up the orders based on the area of the fabric needed for the order. As you can see from problem #2 there are two ways that customers can call in and describe the area of the quilt block. One way describes the length of the sides of the block and the other way describes the areas of each of the four sections of the block.

For each of the following quilt blocks, draw the diagram of the block and write two equivalent equations for the area of the block.

3. Block with side length: $x + 2$.

4. Block with side length: $x + 1$.

5. What patterns do you notice when you relate the diagrams to the two expressions for the area?

6. Optima likes to have her little dog, Clementine, around the shop. One day the dog got a little hungry and started to chew up the orders. When Optima found the orders, one of them was so chewed up that there were only partial expressions for the area remaining. Help Optima by completing each of the following expressions for the area so that they describe a perfect square. Then, write the two equivalent equations for the area of the square.

   a. $x^2 + 4x$

   b. $x^2 + 6x$

   c. $x^2 + 8x$

   d. $x^2 + 12x$

7. If $x^2 + bx + c$ is a perfect square, what is the relationship between b and c? How do you use b to find c, like in problem 6?

   Will this strategy work if b is negative? Why or why not?

   Will the strategy work if b is an odd number? What happens to c if b is odd?

Sometimes a customer orders more than one quilt block of a given size. For instance, when a customer orders 4 blocks of the basic size, the customer service representatives write up an order for $A(x) = 4x^2$.

8. What would they write if the order was for 2 blocks that are 1 inch longer than the basic block? Write the area function in two equivalent forms. Verify your algebra using a diagram.

Exploration: Completing the Square

Part 2: Quilts and Quadratic Graphs

Optima's niece, Jenny works in the shop, taking orders and drawing quilt diagrams. When the shop isn't too busy, Jenny pulls out her math homework and works on it. One day, she is working on graphing parabolas and notices that the equations she is working with look a lot like an order for a quilt block. For instance, Jenny is supposed to graph the equation: $y = (x - 3)^2 + 4$. She thinks, "That's funny. This would be an order where the length of the standard square is reduced by 3 and then we add a little piece of fabric that has as area of 4. We don't usually get orders like that, but it still makes sense. I better get back to thinking about parabolas. Hmmm…"

9. Fully describe the parabola that Jenny has been assigned to graph.

10. Jenny returns to her homework, which is about graphing quadratic functions. Much to her dismay, she finds that she has been given: $y = x^2 - 6x + 9$. "Oh dear", thinks Jenny. "I can't tell where the vertex is or any of the transformations of the parabola in this form. Now what am I supposed to do?"

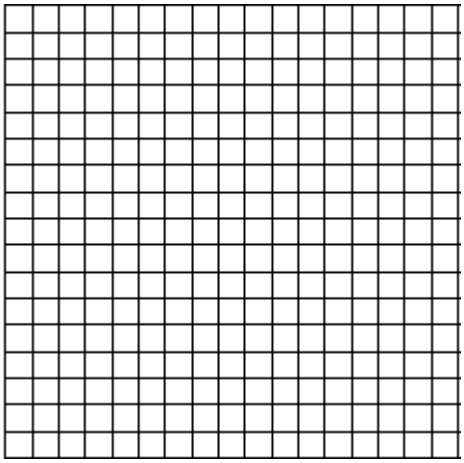
    "Wait a minute—is this the area of a perfect square?" Use your work from Part 1of this task to answer Jenny's question and justify your answer.

11. Jenny says, "I think I've figured out how to change the form of my quadratic equation so that I can graph the parabola. I'll check to see if I can make my equation a perfect square." Jenny's equation is: $y = x^2 - 6x + 9$. Change the form of the equation, find the vertex, and graph the parabola.

    a. $y = x^2 - 6x + 9$ New form of the equation: _____

    b. Vertex of the parabola: _____

    c. Graph (with at least 3 accurate points on each side of the line of symmetry):

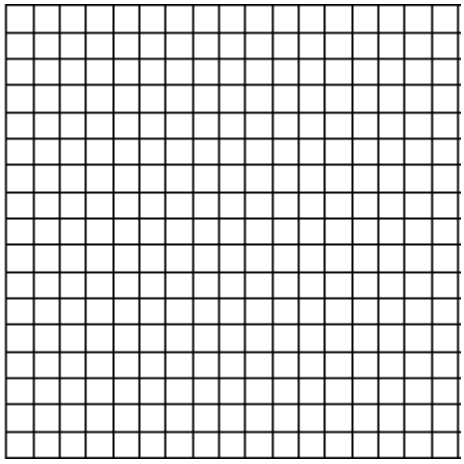


12. The next quadratic to graph on Jenny's homework is $y = x^2 + 4x + 2$. Does this expression fit the pattern for a perfect square? Why or why not?

a. Use an area model to figure out how to complete the square so that the equation can be written in vertex form, $y = a(x - h)^2 + k$.

b. Is the equation you have written equivalent to the original equation? If not, what adjustments need to be made? Why?

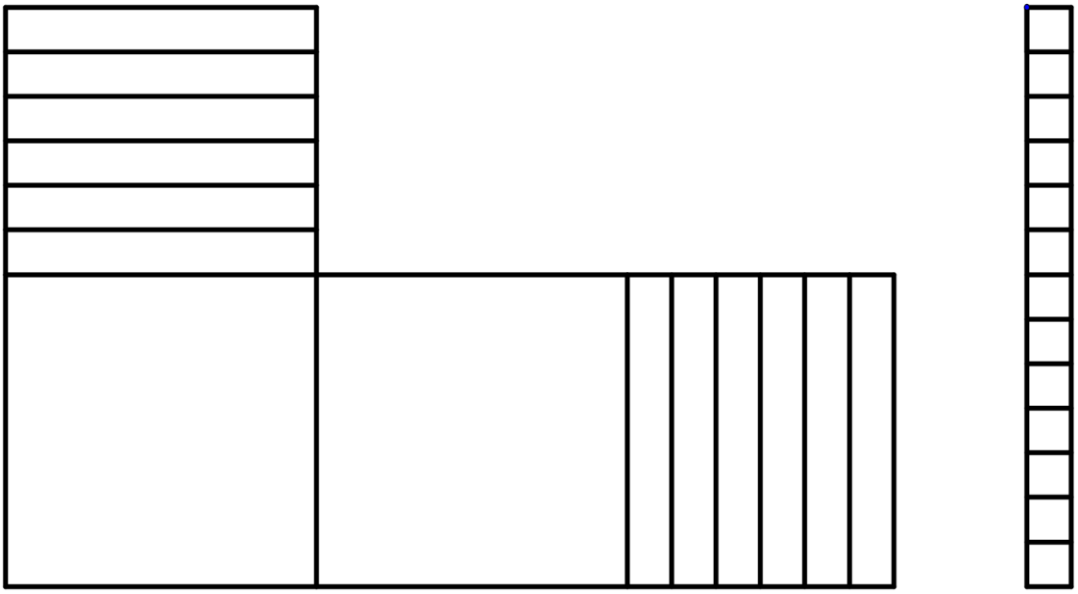
c. Identify the vertex and graph the parabola with three accurate points on both sides of the line of symmetry.



13. Jenny hoped that she wasn't going to need to figure out how to complete the square on an equation where b is an odd number. Of course, that was the next problem. Help Jenny to find the vertex of the parabola for this quadratic function:

$g(x) = x^2 + 7x + 10$

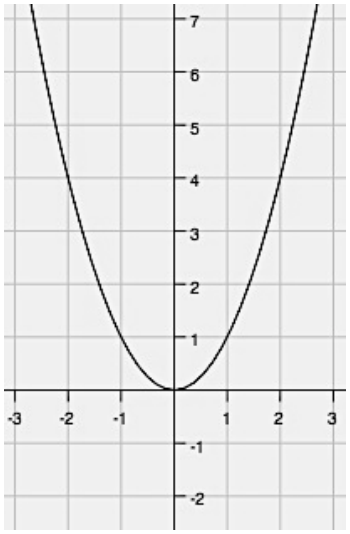
14. Jenny's last quadratic function to graph is $f(x) = 2x^2 + 12x + 13$. She draws the following diagram and says, "I'm not sure how this helps me. I don't see how to make this a square." Help Jenny to complete the square and find the vertex of the parabola using either the diagram or the equation.



Warm-up: Vertex (Qs 7-8)

Ready Topic: Finding key features in the graph of a quadratic equation

1.



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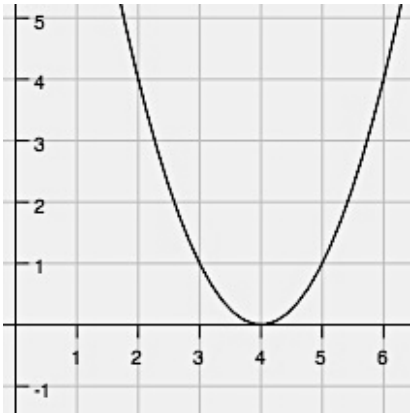

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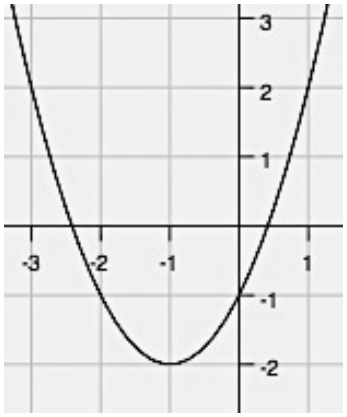

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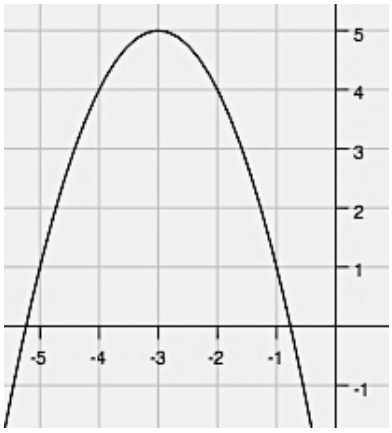
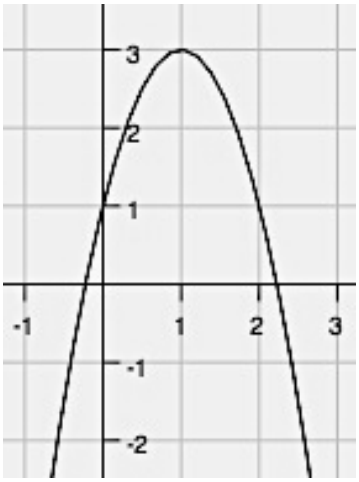
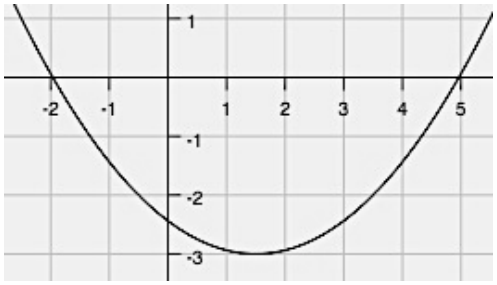


5.



6.



7. What connection exists between the coordinates of the vertex and the equation of the axis of symmetry?

8. Look back at #6. Try to find a way to find the ***exact*** value of the coordinates of the vertex. Test your method with each vertex in 1 - 5. Explain your conjecture.

Will it Hit the Hoop?

Dan Meyer, 3-Act Task
Group Quiz

Act 1:

1. **<u>On your own</u>**:

a.

Is he going to make it? Can you draw me the path of a shot that will make it? That will miss it?

b.

How about now? Can you draw me the path of a shot that will make it? That will miss it?

c.

How about now? Can you draw me the path of a shot that will make it? That will miss it?

2. **Work with a Partner or Team**:
Watch the video. Which shots will go in the hoop? If your answer is "no", predict why the ball won't go in. Will the ball be short, long, or something else entirely?
A.

B.

C.

D.

E.

F.

G.

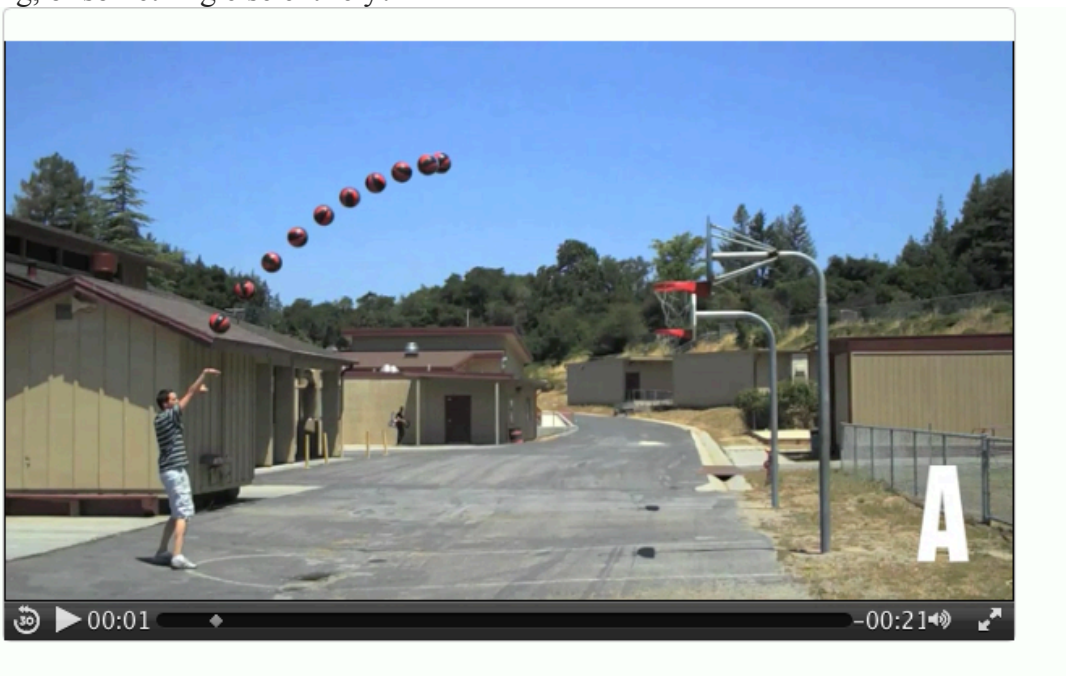
3. **Discuss**: What information/action would help you be surer of your answer?

Act 2: Analyzing the Data and Mathematical Modeling

4. **Frozen Strobes**: Which shots A. – G. will go in the hoop?

For each of the following still photographs, create a quadratic function model for each situation and use it to help you answer each question.

A. **Yes or No?** If your answer is "no", predict why the ball won't go in. Will the ball be short, long, or something else entirely?



B. **Yes or No?** If your answer is "no", predict why the ball won't go in. Will the ball be short, long, or something else entirely?

C. **Yes or No?** If your answer is “no”, predict why the ball won't go in. Will the ball be short, long, or something else entirely?

D. **Yes or No?** If your answer is “no”, predict why the ball won't go in. Will the ball be short, long, or something else entirely?

E. **Yes or No?** If your answer is “no”, predict why the ball won't go in. Will the ball be short, long, or something else entirely?

F. **Yes or No?** If your answer is “no”, predict why the ball won't go in. Will the ball be short, long, or something else entirely?

G. **Yes or No?** If your answer is “no”, predict why the ball won't go in. Will the ball be short, long, or something else entirely?

Act 3: **Conclusion**

Once everyone submits their quiz we'll watch the “answers” to shots A. – G.

Which ones were you right about?

For the ones you got wrong, how did you get them wrong?

CRITICAL FRIENDS PEER REVIEW

This peer evaluation activity can be used as either a midway feedback opportunity for longer projects or as a final assessment for shorter projects. The process forces students to practice their listening skills and provides a safe means for peer evaluation. Each phase can take from 5-10 minutes so plan accordingly. Form teams of 3 or 4 groups who will present to each other.

PHASE ONE: Presentation

Presenting Group: Describe their product, standards and phases of their project.

Critical Friends: Friends remain silent. They are not allowed to ask clarifying or follow up questions. They should be taking notes to evaluate the product as it is presented.

PHASE TWO: Critique

Presenting Group: Presenter(s) remain silent and are not allowed to respond to the comments of the "Friends."

Critical Friends: Friends talk amongst themselves about the project as if the presenters were not in the room and use the phrases below to start each topic. Start by focusing on the strengths, then on suggestions for improvement, and lastly, ideas for "next steps."

I like the fact that...

I wonder if...

A next step might be...

PHASE THREE: Response

Open discussion period for presenter(s) to respond to the comments of the "Friends" and to follow up on ideas or suggestions.

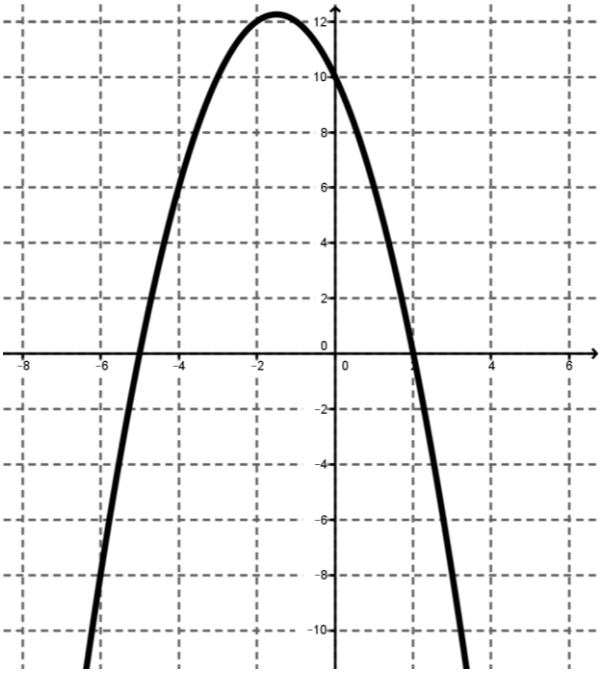
Quadratics Assessment

For each problem below, you are given a piece of information that tells you a lot. Use what you know about that information to fill in the rest.

1.	You get this:	Fill in this:
	$y = x^2 - x - 12$	Vertex form on the equation: Graph of the equation:

2.	You get this:	Fill in this:
	$y = x^2 - 6x + 3$	Vertex form of the equation: Graph of the equation:

3.	You get this:	Fill in this:
		Vertex form of the equation: Standard form of the equation:

4. You get this:	Fill in this:
	Vertex form of the equation:
	Standard form of the equation:

5. You get this:	Fill in this:
$y = -x^2 - 6x + 16$	Either form of the equation other than standard form.
	Vertex of the parabola
	x-intercepts and *y*-intercept

6.	You get this:	Fill in this:
	$y = 2x^2 + 12x + 13$	Either form of the equation other than standard form.
		Vertex of the parabola
		x-intercepts and *y*-intercept

7.	You get this:	Fill in this:
	$y = -2x^2 + 14x + 60$	Either form of the equation other than standard form.
		Vertex of the parabola
		x-intercepts and *y*-intercept

Mini-Project C: Project Euler Problem 42 - Coded Triangle Numbers

The n^{th} term of the sequence of triangle numbers is given by, t_n = ½n(n+1); so the first ten triangle numbers are:

1, 3, 6, 10, 15, 21, 28, 36, 45, 55, ...

By converting each letter in a word to a number corresponding to its alphabetical position and adding these values we form a word value. For example, the word value for SKY is 19 + 11 + 25 = 55 = t_{10}. If the word value is a triangle number then we shall call the word a triangle word.

Using words.txt (right click and 'Save Link/Target As...'), a 16K text file containing nearly two-thousand common English words, how many are triangle words?

Support: Students will need to learn/know: if statements, for loops, and how to read data from a file.

Standard addressed: A-REI 4. Solve quadratic equations in one variable.

The Big Race Calendar (90 min block)

Week	Mon	Tues	Wed	Thur	Fri
1	- Group intro activity - Group contracts - Entry Doc - K/NTK/NS	- Do Now: Linear vs non-linear - Function Lab Part 1 - py code - ch code	- Function Lab Part 2 - py code - ch code	- Do Now: Linear Functions - Write code for linear function	- Test linear function code with robots - Record results
2	- Do Now: Quadratic Functions - Write code for quad. function	- Test quad. function code with robots - Record results	- Do Now: Exponential Functions - Write code for exponential function	-Test exp. function code with robots - Record results	- Do Now: Lin Quad Exp Quiz
3	-Do Now: Comparison worksheet - Review results for linear, quadratic and exponential code for robots - Twist*	- Students present results, justify why their graph represents the function they claim it is - Grading Rubric	- Lab: Students compete to see who can make robot go furthest in 6 seconds		

*Twist: After 6 seconds restart speed to 10 deg/sec then accelerate using a different model for 6 more seconds.

"Desert Survival" Team Building Exercise

It is 1:00 p.m. on a Saturday afternoon at the end of May. You and your teammates have just finished a two-day training in Casablanca, Morocco. You are all on board a chartered, twin-engine plane that is destined for Dakhla, Morocco, a small town on the coast of the North Atlantic Ocean, approximately 1000 miles from Casablanca. At the beginning of the flight the Captain came on the overhead speaker and invited you to sit back and relax during the two-hour flight. The first fifty minutes of the flight were fine. Around this time the pilot comes back on the speaker to let you know that you are currently flying over the Sahara Desert and that weather reports showed a temperature high of 115 degrees. Approximately one hour and ten minutes into the flight, you hear a loud blast and the plane nosedives. Within minutes you realize that the cabin is losing pressure. When you look outside the windows, you notice that is dessert below is growing larger as the plane rapidly descends toward the ground. You notice that the only things you can see out of your window are some large boulders and miles and miles of sand. The pilot comes on once again to let you know that the plane has blown an engine and is therefore, indisputably, going to crash and so all on board should prepare for a turbulent, possibly fatal, crash landing. Within minutes the planes crashes and smoke and flames fill the cabin. All surviving passengers and crew members scramble to exit the plane before it explodes. Seven minutes after the crash, the plane explodes in a fiery ball that reduces it to rubble. With the exception of the airplane's captain and one crew member, you, your teammates, one flight crew member, and the co-captain have all survived the crash. Now you must decide how to work together to survive the desert

climate and terrain, get help, and hopefully make it out of the desert alive. On your way of the plane, in the few minutes before it exploded, you and your teammates were able to salvage the items in the list below. It is May and you and your teammates are dressed in business casual for the hot summer months of Africa. With only the clothes on your back and the items pulled from the wreckage, how will you survive?

Rank the items below in order of importance and develop an action plan to help you get out alive.

1 Book of matches
3 Airplane blankets
20 Feet of nylon rope
1 Sewing kit
2 50 kg Tanks of oxygen
20 Cans of soda
1 Life raft
1 Bottle opener
1 Magnetic compass
1 Single-blade pocketknife
15 Gallons of water
3 Signal flares
1 First aid kit
1 Snakebite kit
25 Mini bags of pretzels
55 Mini bags of peanuts
1 Safety razor blade
4 Airplane pillows

Survival Game Lesson Plan

Overview:

Students, in the role of plane crash survivors, are given an interesting problem about prioritizing actions and equipment to ensure continued survival. They are given time to come up with an action plan, and must present as a group. However, during presentation, the teacher ignores issues of the problem, and asks students questions only about the group process. This opens the door to a conversation about what is the best way for groups to work, and can lead directly into new ideas for contract writing, and also a foundation for norms.

The idea is to use this activity as a way to get students to Need To Know how to make groups work best. If you let the students see what kind of group interaction they might naturally fall into, then the need to know will certainly arise. Hence, it is a good idea *not* to tell the students that you are going to do a "team building" exercise, or a "group work" exercise. Rather, you can pose the activity as a "critical thinking" exercise, or something like it.

This can create a rather rich conversation, and if you set it up correctly, you can have students move seamlessly into contract writing or norm-setting, depending upon your classroom needs at the time.

Expect the activity, with debrief, to take about an hour.

Below is a suggested way to carry out the activity, though it is certainly not the only use of the document. Experimentation, as always, is encouraged.

Introducing the Activity

As mentioned, we recommend introducing it as a critical thinking exercise. (Indeed, you could assign a critical thinking grade to this, if the students generate a document.) Inform students that…

- They will have about 10-15 minutes to come up with an action plan, so they will need to work relatively quickly.
- They will need to present their plan to the rest of the class, and that they will have no more than 4 minutes to present.

During group discussion

As students are discussing, make sure to observe the conversations, and take note (to yourself) of how they are negotiating the group dynamic. Are they coming to decisions? How? Is one person dominating? Are any students "hanging back"? Is there any

negotiating going on? Is there any conflict? How are they dealing with it? This kind of observation will be helpful to share during the debrief. If you see some particularly interesting interactions during the group processing, you might want to call up that group.

During Presentations

Students will begin to present, and you might let them go through their whole presentation. At the end, you can ask them a variety of questions about process, like,

"What are the names of all the people in your group?"
"How did you come to a decision about your final list?"
"What did (name of someone in the group) contribute to the list?"
"Did anyone in the group NOT speak?"
"Was there disagreement in your group? How did you deal with it?"
"Did someone take charge right away? What was the reaction of the rest of the group?"

… and so on. You might tailor some of the questions for observations you made during the group work time.

Gap Analysis

On the board, or on a ppt, you might have three columns for recording student response. The columns might look like so:

Characteristics of an ideal group.	Characteristics of the Survival groups you were just in	Characteristics of groups in our class, during projects

Hopefully, your penetrating questions during the presentation will create some good thoughts about what an ideal group might look like.

Once you have the columns filled out, there will be differences between the ideal and actual. Send the students back to groups, and have them brainstorm some strategies for bringing the actual closer to the ideal. You might phrase this, "Describe at least ___

strategies that we might use in the class to help groups in projects to come closer to what an ideal group looks like."

Students can work on that, and submit to a Discussion Forum, or present.

The whole list of strategies should be synthesized… and then they can become an integral part of the next group contract, OR, part of a template for contracts for the rest of the year in your class.

rEVOLUTIONary thinkers Group Contract

Group Member Name Phone Number Preferred E-mail

Part I: Displaying Core Values in our Group:

Trust: We trust each other. The following are three ways that we will show each other we are capable of trusting and being trusted:
I.

II.

III.

Responsibility: We take responsibility for both our individual contributions and the product as a whole. The following are three ways that we will show we are responsible:
I.

II.

III.

Respect: We show ourselves and others respect. The following are three ways that we will demonstrate respect:
I.

II.

III.

Integrity: We are people who do the right thing. The following are three ways that we will demonstrate our personal integrity:
I.

II.

III.

Perseverance: We do not give up, even when things are difficult. The following are three ways that we can demonstrate our commitment to follow through:
I.

II.

III.

Part II: Project Roles.

_____ will be our Editor. He/She will take responsibility for ensuring the written part of our project is held to a consistent and high standard. This role requires attending a workshop on Science writing and ensuring all text on the poster is of high quality.

_____will be our Designer. He/She will take responsibility for ensuring the visual and aesthetic part of our project is held to a consistent and high standard. This role requires attending a workshop on Scientific posters and ensuring that the layout and execution of the poster is of a high quality.

Part III: Group Consequences

We understand that our primary goal in class is to learn. If we do not hold our group members accountable to their commitments, we not only do an unfair share of work, but we also are allowing a group member to get by without learning. In order to avoid this, we will enforce our contract.

*The first time a group member fails to complete a task, they receive a warning.

*The second time a group member fails to complete a task, they receive a warning and the group must conference with the teacher.

*The third time a group member fails to complete a task, they are fired.

All warnings must be documented with the teacher and signed by the warned individual.

Part IV: Commitment

We agree to uphold _____ core values to the best of our ability. We also understand that we are responsible for the information contained in the rubric and the project calendar, and we will meet all due dates to the best of our ability.

_____ _____

_____ _____

The Big Race:

Dear Students,

We have had a lot of fun learning how to use these robots and maybe a little math along the way. Previously, we've had a race to tie, but we haven't yet had a race to win… until now. The rules of the race are simple:

1. Your Linkbot may not move for longer than six seconds.
2. The initial speed for the first second will be 10 degrees/second.
3. For the remaining seconds you must ***accelerate*** so the graph of your Linkbot's motion matches one of the three models: linear, exponential, ***or*** quadratic.
4. Your final speed shall be no greater than 200 degrees/second.
5. The car that travels the furthest during the 6 seconds will be the winner.

Sincerely,
Your Teacher

Know	Need to Know	

Warm-up: Linear vs Non-Linear

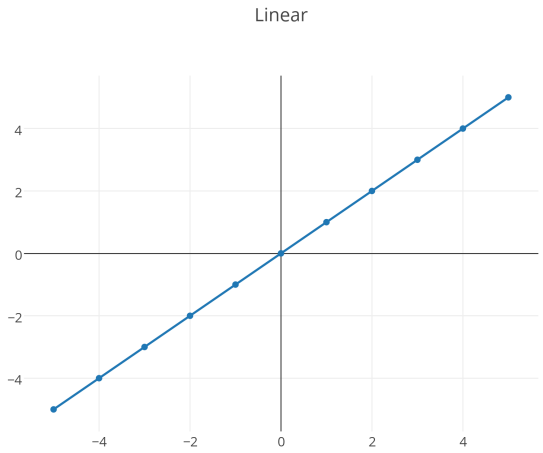
Name _____

Date _____ Period _____

Linear Equation : y = x

x	y=x	y
-5		
-4		
-3		
-2		
-1		
0		
1		
2		
3		
4		
5		

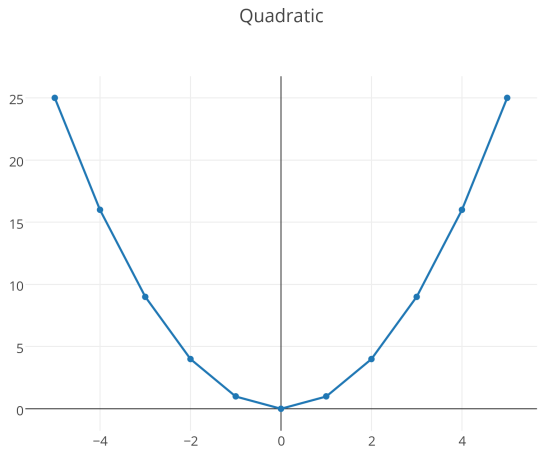
Linear Function f(x) = x



Quadratic Equation : $y = x^2$

x	$y = x^2$	y
-5		
-4		
-3		
-2		
-1		
0		
1		
2		
3		
4		

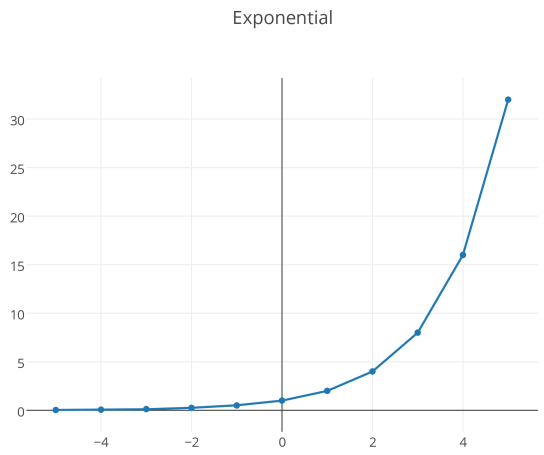
Quadratic Function : $f(x) = x^2$



Exponential Equation : $y = 2^x$

x	$y = 2^x$	y
-5		
-4		
-3		
-2		
-1		
0		
1		
2		
3		
4		
5		

Exponential Function : $f(x) = 2^x$

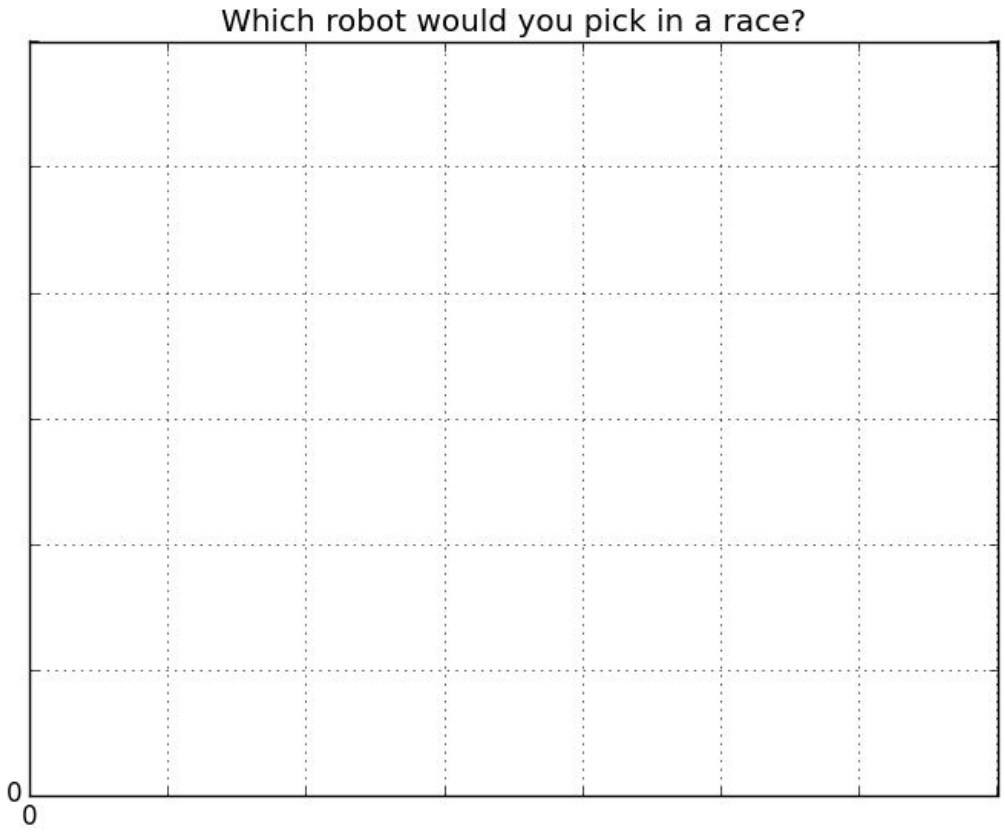


Function Lab: Part 1

Get together with another group (you will need four robots for this). Attach one of the robots to your computer and label the other three as follows: one should be labeled *Linear*, the next *Quadratic*, and the third *Exponential*. Once they are all lined up about six inches apart, run the program called functionLab.py and make sure to enter the correct Linkbot for each label.

As you watch the Linkbots move look for similarities and differences. Which one(s) start off slow and then get faster? Which one(s) move at a mostly constant speed? Which one would you like to have in a race?

Notes:



After the Linkbots have finished moving a graph will appear on your screen. Sketch the graph below (use a different color for each Linkbot).

Use the graph to fill in the table below for the bots:

Seconds	Average Speed (deg/s): Linear	Average Speed (deg/s): Quadratic	Average Speed (deg/s): Exponential
0-1			
1-2			
2-3			
3-4			
4-5			
5-6			

What do you notice about the speed of Linkbot whose graph was linear?
What do you notice about the speed of Linkbot whose graph was quadratic?
What do you notice about the speed of Linkbot whose graph was exponential?

Add a row for 6-7 seconds and predict what the average speed will be for each.

Which graph would you like your Linkbot to match? Why?

Function Lab: Part 2

Share your predictions for 6-7 seconds with your group, record them below:

Name:					Group Average
Linear					
Quadratic					
Exponential					

Use your Group Average and the graph to figure out where each bot will be at the end of the race to 7 seconds.

	Degrees at 6 seconds	Predicted degrees traveled from 6-7 seconds	Degrees predicted at 7 seconds
Linear			
Quadratic			
Exponential			

For each Linkbot put a point using the appropriate shape on your graph from part 1, does it fit with the existing points?

How far from the starting line will the point you put on your graph be?

Linear	
Quadratic	
Exponential	

Place a dot where you think each Linkbot will reach at the end of 7 seconds.

After 7 second run:

How far were your predictions from the actual resting place?
For your prediction that was the furthest away from the actual resting place, how would you adjust it? Does that change anything about how you were thinking about the different speeds?

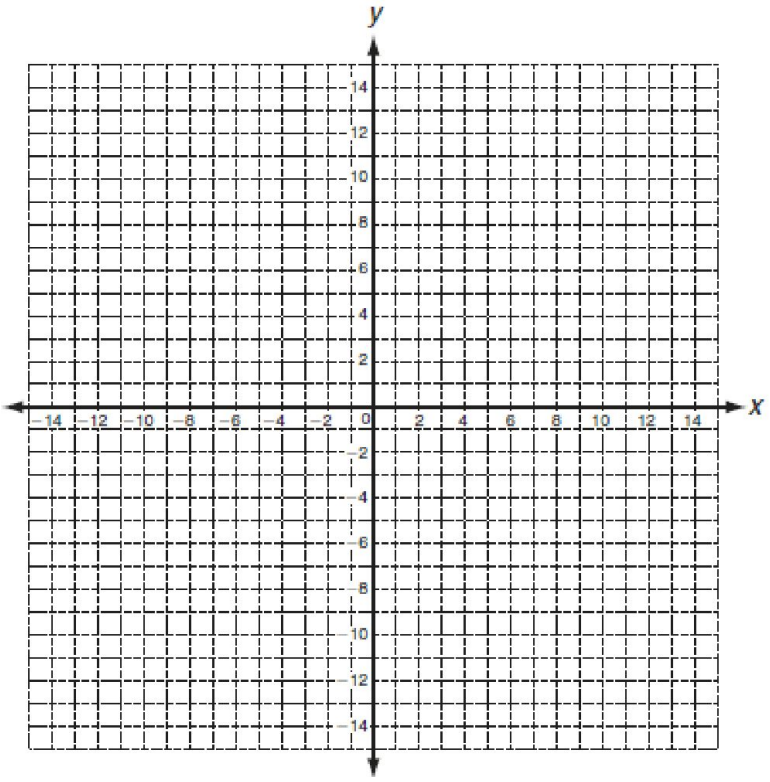
Which graph would you like your Linkbot to match? Why?

Warm-up: Linear Functions

Complete the table for each linear function, and then graph the line.

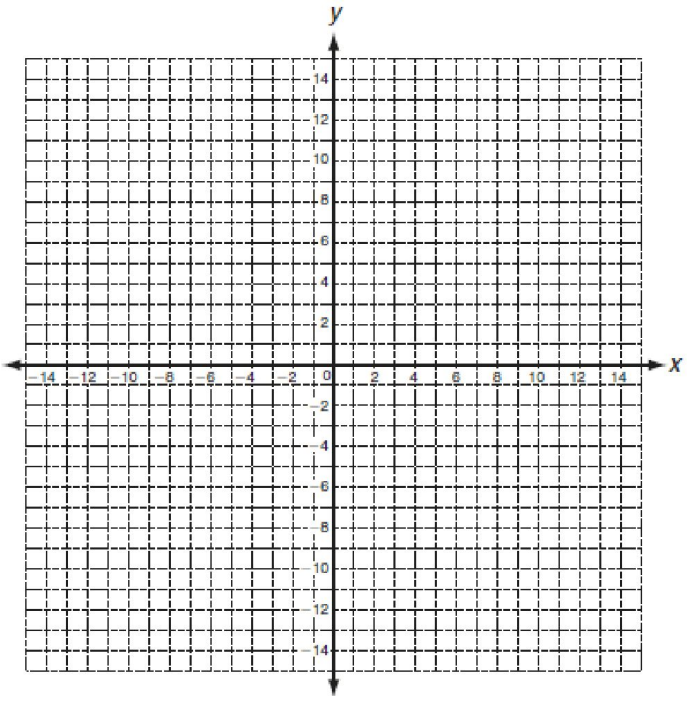
A.) $y = x$

x	y
8	
4	
2	
0	
-2	
-4	
-8	



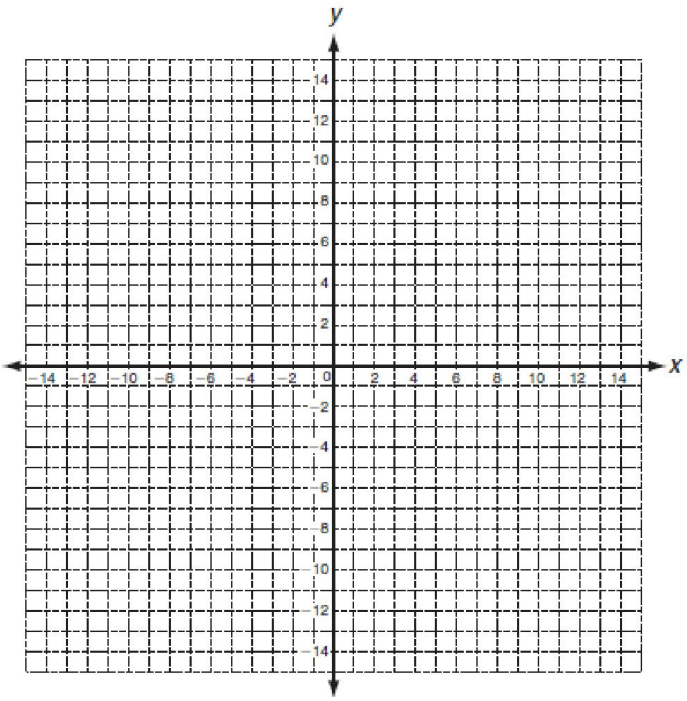
B.) $y = 3x - 4$

x	$3x-4$	y
6		
4		
2		
0		
-1		
-2		
-3		



c.) $y = -2x + 3$

x		y
8		
4		
2		
0		
-2		
-4		
-6		



1. At what value does each graph cross the y-axis?

   Graph A: _____ Graph B: _____ Graph C: _____

2. Do you see this "y-intercept" value in each corresponding equation?

3. If so, where?

4. As you move left to right on each of the graphs, how does the steepness of each line behave?

   Graph A: _____ Graph B: _____ Graph C: _____

5. Which value on each equation do you think affects the "slope" of each line?

6. What is the slope of each graph?

   Graph A: _____ Graph B: _____ Graph C: _____

7. Identify the slope and y-intercept of : $y = mx + b$.

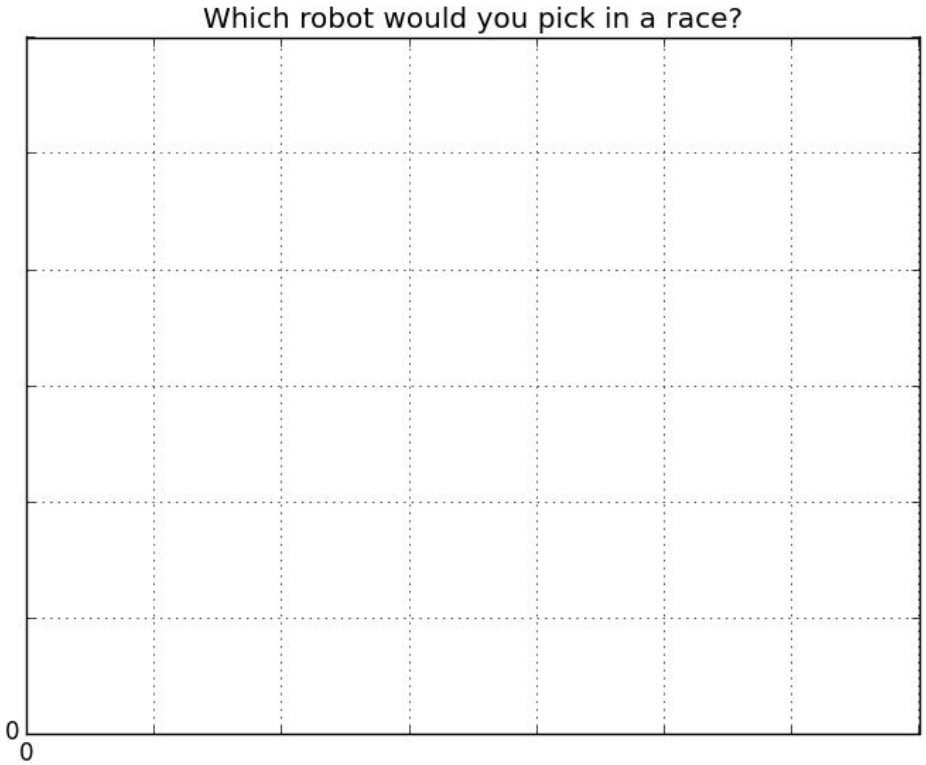
The Big Race Results: Linear

Function type: _____

Time (seconds)	Distance Travelled (cm)	Average Speed (degrees/sec)	Average Speed (cm/sec)
1			
2			
3			
4			
5			
6			

Total Distance Traveled: _____

1. Graph the ordered pairs with "Time" as your independent variable and "Distance Travelled (cm)" as your dependent variable.



The Big Race Results: Linear

2. Describe the characteristics of the graph.

3. Write an equation of the graph.

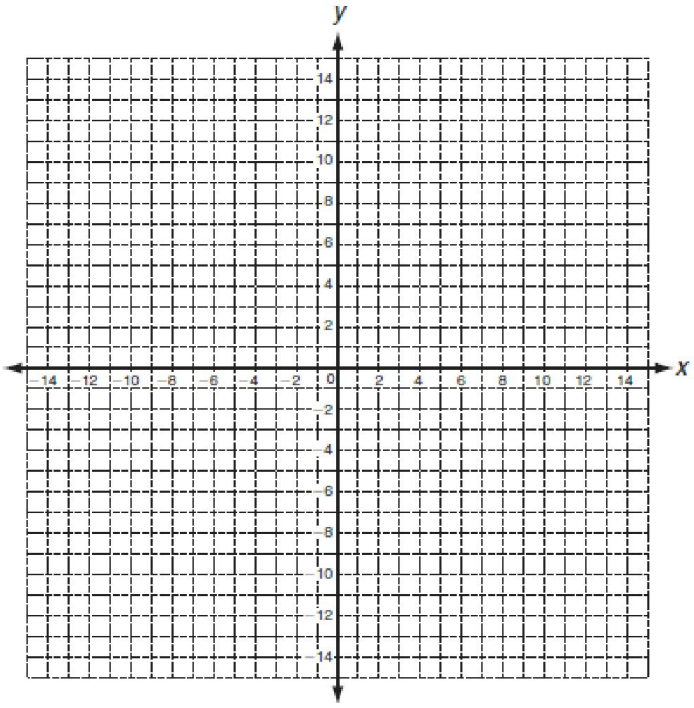
4. Save your results for comparison with different function graphs.

Warm-up: Quadratic Functions

Complete the table for each quadratic function, and then graph the parabola.

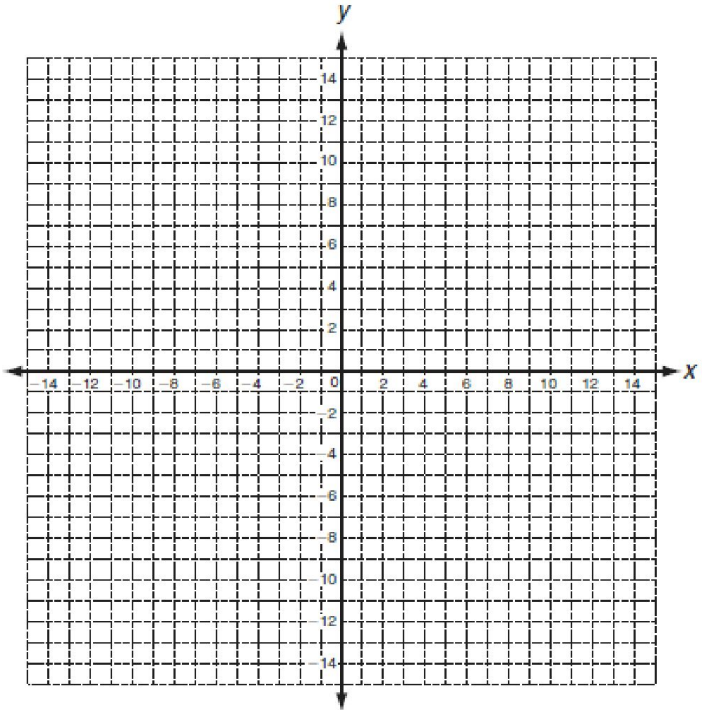
A.) $y = x^2$

x	x^2	y
3		
2		
1		
0		
-1		
-2		
-3		



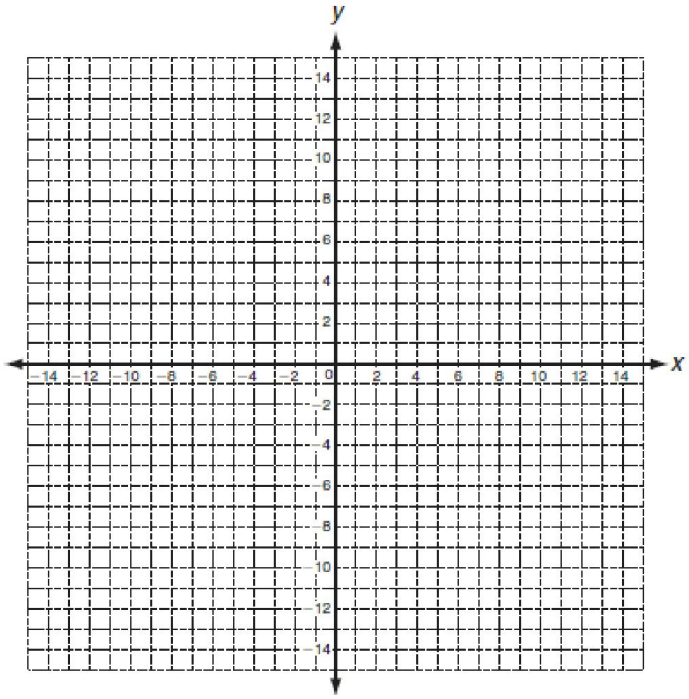
B.) $y = 2x^2 - 4$

x	$2x^2 - 4$	y
3		
2		
1		
0		
-1		
-2		
-3		



c.) $y = -\frac{1}{2}x^2 + 3$

x		y
6		
4		
2		
0		
-2		
-4		
-6		



1. At what value does each graph cross the y-axis?

   Graph A: _____ Graph B: _____ Graph C: _____

2. Do you see this "y-intercept" value in each corresponding equation?

3. If so, where?

4. In which direction does each graph "open"?

   Graph A: _____ Graph B: _____ Graph C: _____

5. Which value on each equation do you think determines the direction a graph opens?

6. What is the "leading coefficient" of each equation?

   Equation A: _____ Equation B: _____ Equation C: _____

7. Identify the leading coefficient and y-intercept of : $y = ax^2 + bx + c$.

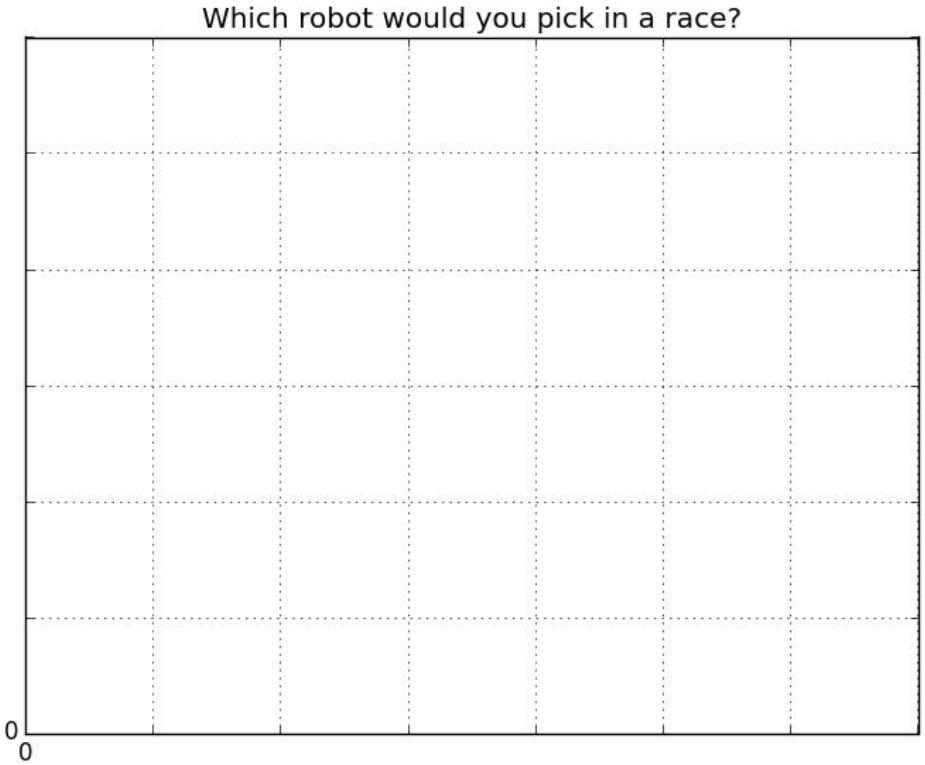
The Big Race Results: Quadratic

Function type: _____

Time (seconds)	Distance Travelled (cm)	Average Speed (degrees/sec)	Average Speed (cm/sec)
1			
2			
3			
4			
5			
6			

Total Distance Traveled: _____

1. Graph the ordered pairs with "Time" as your independent variable and "Distance Travelled (cm)" as your dependent variable.



The Big Race Results: Quadratic

2. Describe the characteristics of the graph.

3. Write an equation of the graph.

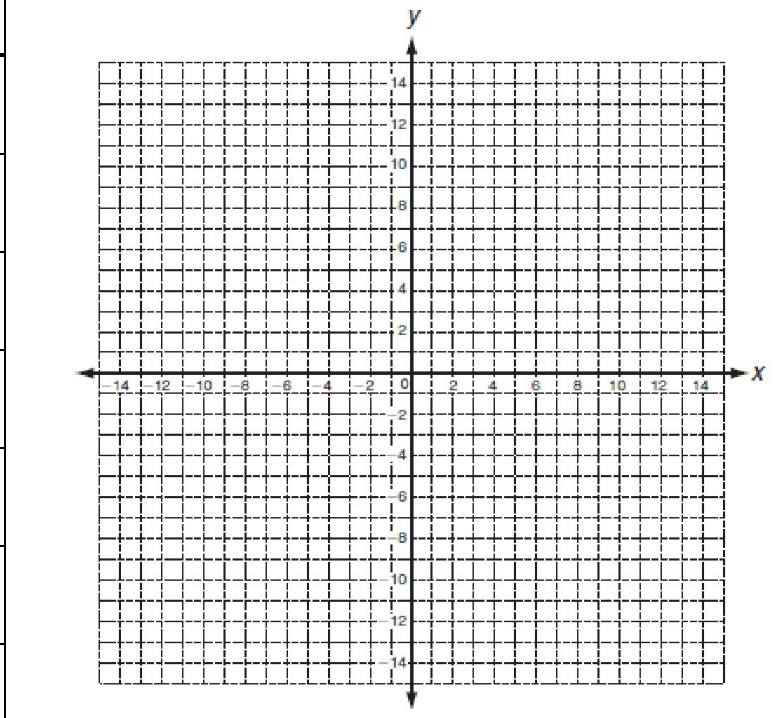
4. Save your results for comparison with different function graphs.

Warm-up: Exponential Functions

Complete the table for each exponential function, and then graph the exponential curve.

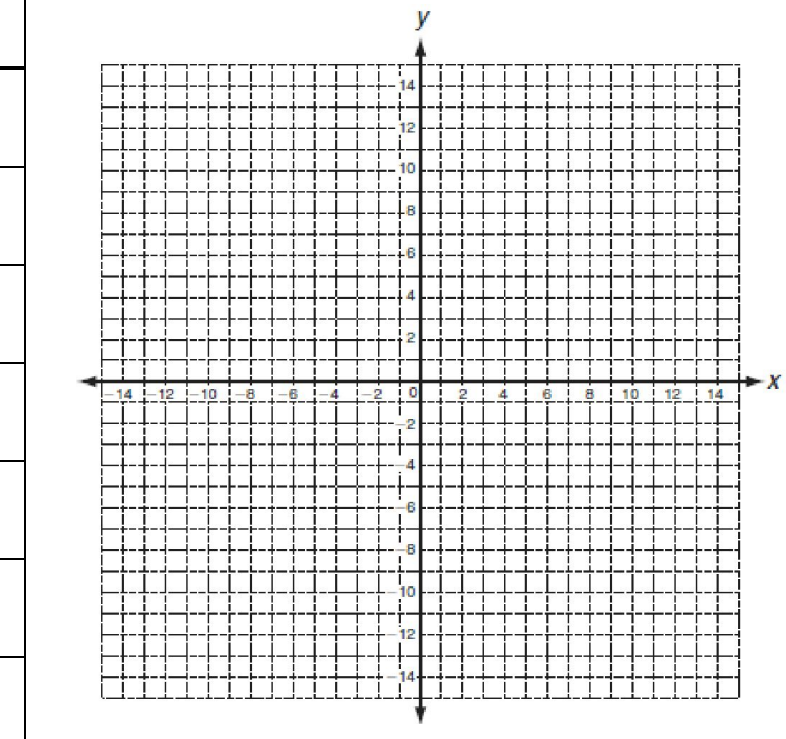
A.) $y = 2^x$

x	2^x	y
3		
2		
1		
0		
-1		
-2		
-3		



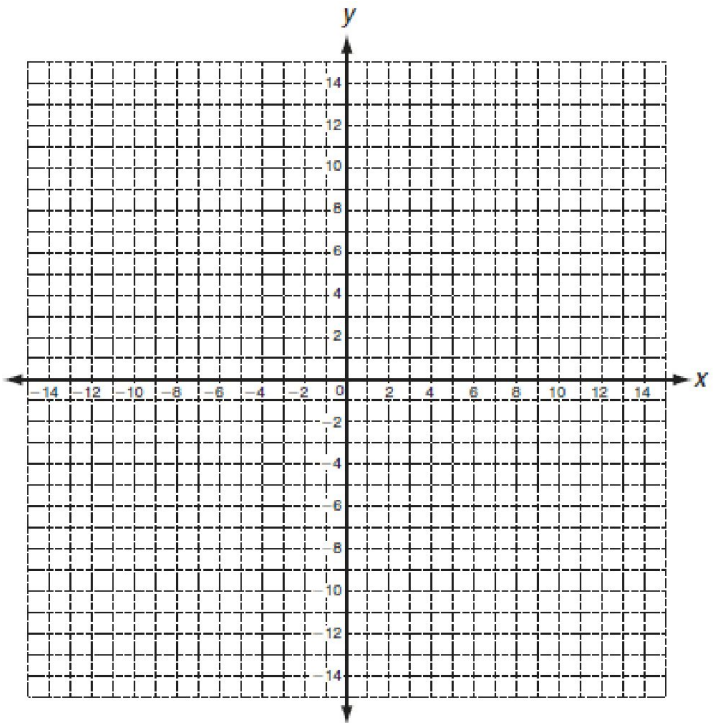
B.) $y = 2(2^x) - 4$

x	$2(2^x) - 4$	y
3		
2		
1		
0		
-1		
-2		
-3		



c.) $y = -\frac{1}{2}(2^x) + 3$

x		y
5		
3		
1		
0		
-1		
-2		
-3		



1. What value does each graph appear to approach as it begins to "flatten out"?

   Graph A: _____ Graph B: _____ Graph C: _____

2. Do you see this "asymptote" value in each corresponding equation?

3. If so, where?

4. In which direction does each graph "open"?

   Graph A: _____ Graph B: _____ Graph C: _____

5. Which value on each equation do you think determines the direction a graph opens?

6. What is the "leading coefficient" of each equation?

   Equation A: _____ Equation B: _____ Equation C: _____

7. Identify the leading coefficient and asymptote of : $y = a(b^x) + c$.

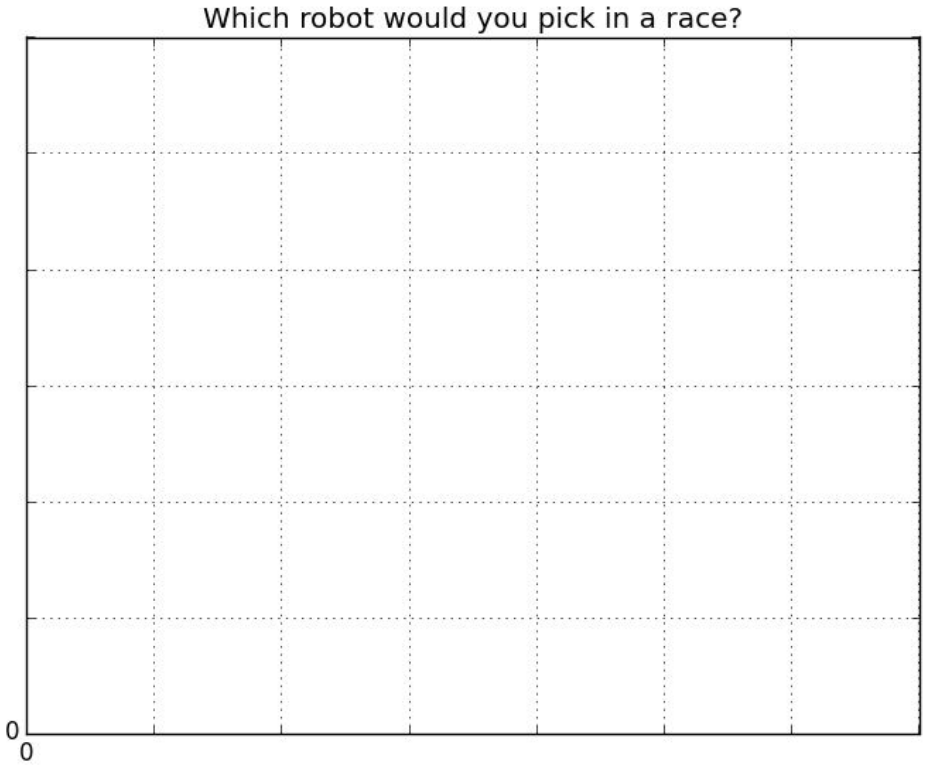
The Big Race Results: Exponential

Function type: _____

Time (seconds)	Distance Travelled (cm)	Average Speed (degrees/sec)	Average Speed (cm/sec)
1			
2			
3			
4			
5			
6			

Total Distance Traveled: _____

1. Graph the ordered pairs with "Time" as your independent variable and "Distance Travelled (cm)" as your dependent variable.



The Big Race Results: Exponential

2. Describe the characteristics of the graph.

3. Write an equation of the graph.

4. Save your results for comparison with different function graphs.

Name _____

Algebra 1 Date _____ Period _____

The Big Race Quiz
Comparing Equation/Function Types

Fill in the blank below to correctly label the equation. Then complete the table below the equation to correctly represent the data from the equation.

_____ Equation : y = 2x+1

x	y=x	y
-5		
-4		
-3		
-2		
-1		
0		
1		
2		
3		
4		
5		

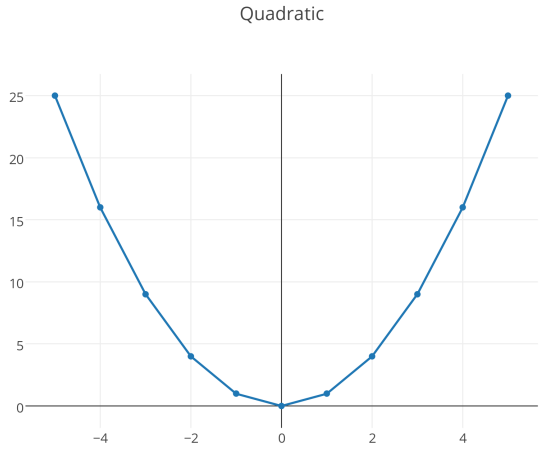
Fill in the data table below with the data generated by the equation below.

Quadratic Equation : $y = x^2$

x	$y = x^2$	y
-5		
-4		
-3		
-2		
-1		
0		
1		
2		
3		
4		

Fill in blanks to correctly represent the graph below. Then fill in the table below the graph with the correct data from the graph.

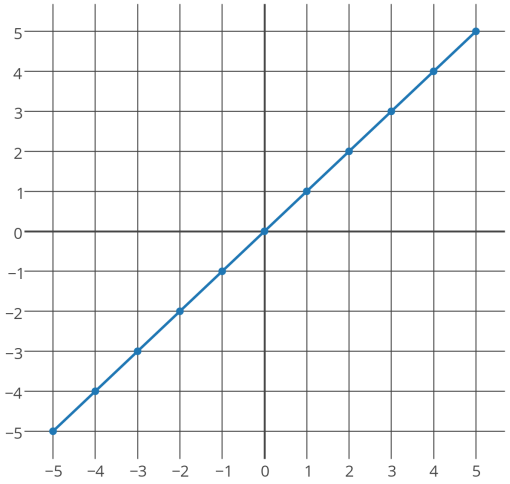
_____ Function : f(x) = ____



x		y
-5		
-4		
-3		
-2		
-1		
0		
1		
2		
3		
4		

Label the function type below based on the graph below. Then fill in the data table.

_____ Function f(x) = x

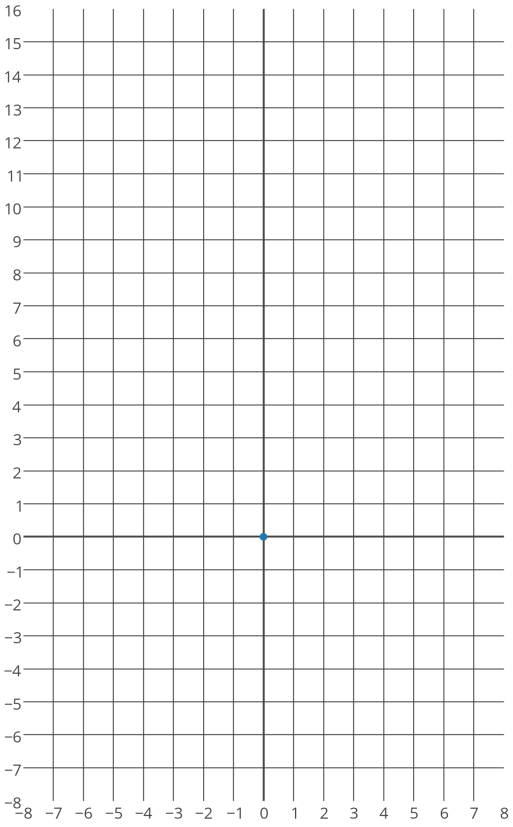


x		y
-5		
-4		
-3		
-2		
-1		
0		
1		
2		
3		
4		

Label the equation type below. Then fill in the table and the graph based on the equation.

_____ Equation : $y = 2^x$

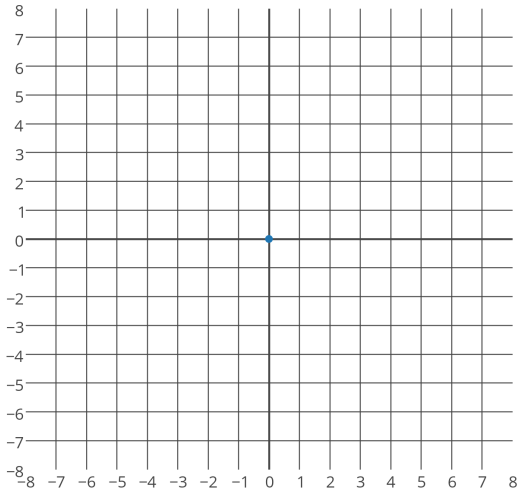
x	$y = 2^x$	y
-5		
-4		
-3		
-2		
-1		
0		
1		
2		
3		
4		
5		



Create your own function of any type then label the function, fill in the data table below and graph the function on the graph below.

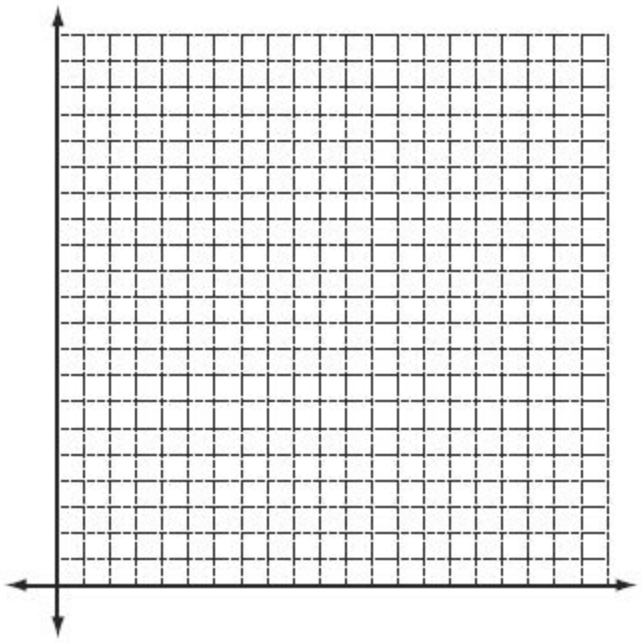
_____ Function _____

x		y



Comparing Function Lab Results

Using the results from the previous labs for this project, graph *time vs. speed* of each type of movement (linear, quadratic and exponential) onto the same coordinate plane. Afterwards, answer the questions that follow.



What do you notice about the speed of Linkbot whose graph was linear?
What do you notice about the speed of Linkbot whose graph was quadratic?
What do you notice about the speed of Linkbot whose graph was exponential?

Add a row for 7 seconds and predict what the average speed will be for each.

Which graph would you like your Linkbot to match? Why?

Share your predictions for 7 seconds with other groups and record them below:

Name:					Group Average
Linear					
Quadratic					
Exponential					

Use your Group Average and the graph to figure out where each bot will be at the end of the race to 7 seconds.

	Degrees at 6 seconds	Predicted degrees traveled from 6-7 seconds	Degrees predicted at 7 seconds
Linear			
Quadratic			
Exponential			

For each Linkbot put a point using the appropriate shape on your graph from the beginning of this worksheet; does it fit with the existing points?

How far from the starting line will the point you put on your graph be?

Linear	
Quadratic	
Exponential	

Place a dot where you think each Linkbot will reach at the end of 7 seconds.

After 7 second run:

How far were your predictions from the actual resting place?

For your prediction that was the furthest away from the actual resting place, how would you adjust it? Does that change anything about how you were thinking about the different speeds?

Which graph would you like your Linkbot to match? Why?

RUBRIC The Big Race	STUDENT: _____ EVALUATOR: _____ DATE: _____		
CRITERIA	**APPROACHING PROFICIENT** (Below Performance Standards)	**PROFICIENT** (Meets Standards)	**ADVANCED** (Demonstrates Exceptional Performance)
Construct and compare linear, quadratic and exponential models and solve problems. Alg. 1: F-LE 1 *20 pts*	Students are unable to distinguish the differences between linear and non-linear situations. Students choose an incorrect function type to model the situation.	Student can choose the correct function (linear or exponential) to model a situation.	**In addition to meeting the PROFICIENT criteria...** Students can correctly explain the reason for their choice of function.
	0 - - - - - - - - - - - - 8 - - - - - - - - - - - - 10	11 - - - - - - - - - - - - 13 - - - - - - - - - - - - 16	17 - - - - - - - - - - - - 19 - - - - - - - - - - - - 20
Alg. 1: F-LE 1a *20 pts*	Students are unable to differentiate the patterns shown in the graphs and tables of different functions.	Students understand that linear functions change by equal amounts over equal intervals, and that exponential functions change by equal factors over equal intervals.	**In addition to meeting the PROFICIENT criteria ...** Students understand that 2nd level differences are the same for quadratic functions and that 1st level differences are constant for linear functions.
	0 - - - - - - - - - - - - 8 - - - - - - - - - - - - 16	17 - - - - - - - - - - - - 19 - - - - - - - - - - - - 21	23 - - - - - - - - - - - - 24 - - - - - - - - - - - - 25
Alg. 1: F-LE 1b *20 pts*	Student does not use table ***and*** graph to determine correct function type (linear, exponential or quadratic).	Student uses table ***and*** graph to determine whether the data represents a linear and exponential (***or*** quadratic) function..	**In addition to meeting the PROFICIENT criteria ...** Student uses table ***and*** graph to determine whether the data represents a linear, exponential ***and*** quadratic function.
	0 - - - - - - - - - - - - 8 - - - - - - - - - - - - 16	17 - - - - - - - - - - - - 19 - - - - - - - - - - - - 21	23 - - - - - - - - - - - - 24 - - - - - - - - - - - - 25
Alg. 1: F-LE 3 *20 pts*	Students are unable to recognize patterns in tables and graphs to distinguish differences in the behavior of functions..	Students use tables and graphs to observe that exponential functions eventually change at a greater rate than linear ***or*** quadratic functions.	**In addition to meeting the PROFICIENT criteria...** Students use tables and graphs to observe that exponential functions eventually change at a greater rate than linear ***and*** quadratic functions.
Project Presentation *20 pts*	Student's Linkbot does not accurately represent the linear and exponential (***or*** quadratic) graph (***or*** table).	Student's Linkbot accurately represents the linear and exponential (***or*** quadratic) graph (***or*** table).	**In addition to meeting the PROFICIENT criteria ...** Student's Linkbot accurately represents the linear and exponential (***and*** quadratic) graph (***and*** table).
	0 - - - - - - - - - - - - 8 - - - - - - - - - - - - 16	17 - - - - - - - - - - - - 19 - - - - - - - - - - - - 21	23 - - - - - - - - - - - - 24 - - - - - - - - - - - - 25

COMMENTS:

Mini-Project D: Project Euler Problem 2 - Even Fibonacci Numbers

Each new term in the Fibonacci sequence is generated by adding the previous two terms. By starting with 1 and 2, the first 10 terms will be:

1, 2, 3, 5, 8, 13, 21, 34, 55, 89, ...

By considering the terms in the Fibonacci sequence whose values do not exceed four million, find the sum of the even-valued terms.

Support: Students will need to learn/know: if statements and while loops.

Standard addressed: F-IF3. Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. *For example, the Fibonacci sequence is defined recursively by $f(0) = f(1) = 1$, $f(n + 1) = f(n) + f(n − 1)$ for $n \geq 1$.*

Light Graphing Calendar (90 min blocks)

Week	Mon	Tues	Wed	Thur	Fri
1	- Entry Doc - Intro to Light Photography	- Complete Phase 1: Light Graph a line - Begin Phase 2: Slope vs Angle investigation	- Continue Phase 2 and fill in the table - Create a grid of square inches to help you measure your robot's motion	- Complete Phase 2 - Begin Phase 3 Light Graph a line with any slope	- Complete Phase 3
2	- Do Now: Linear Absolute Value Graphs - Begin Phase 4 Light Graph an absolute value function with any slope	- Do Now: Stretching Absolute Value Graphs - Continue Phase 4. - Twist*	- Do Now: Shifting Absolute Value Graphs - Finish Phase 4 and Begin Reflections	Catch-Up day: Finalize all materials and Complete Reflection	
3					

*Twist: Be able to change the vertex as well.

Possible student solution
- py code
- ch code

eritech Violins

Dear Designer,

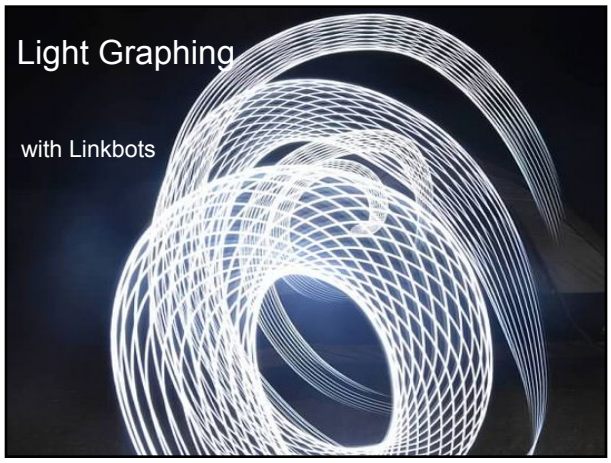
We at Veritech Violins make the most technologically interesting violins you have ever seen. Verruca Veritas, our new CEO, thinks her father's old V logo is holding the company back from entering the hipster ironic violin market. She wants to attach a light to a robot and use a long exposure picture to capture her new hi tech V. She also likes the idea of using the graph of an absolute value function to represent the V, she thinks it will *absolutely* send the right message.

She doesn't know how steep the sides of the V are going to be, but she does want the picture to span ten inches in width. Your task is to write a program that will draw her a V to match the slope of the absolute value function she enters and send her an example V to show that it works.

Sincerely,
Vincent Vanderbilt
Communications Specialist

Know	Need to Know	Next Steps

Fancy V from: https://pixabay.com/p-33685/?no_redirect



What is Light Photography

Why do these pictures look different?

How does Shutter Speed affect a picture?

Which is a longer interval of time 1/800th of a second or 1/15th of a second?

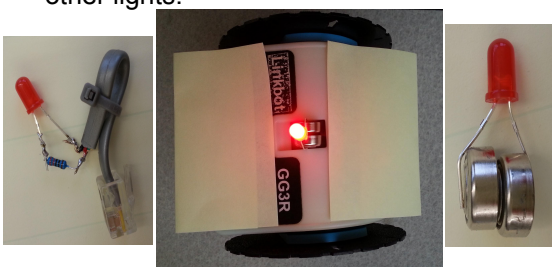
1/800 1/15

In this image the shutter was open for 1/800th of a second

In this image the shutter was open for 1/15th of a second

Light Add-on

This works best if you have a light directly on top of the phone jack and tape over the other lights.



Download the free version of the Long Exposure App

- Pick a partner and install the app
- Let's get Started on the Entry Doc

Phase 1: Light Graph a Line[1]

A) Download the Long Exposure App and practice taking some pictures of the Linkbot's Light. Try to hold the camera as still as possible.

B) Now program the robot to move along the line y=x with the domain 0<x<5. Once that program works, use the Long Exposure App to take a picture of the graph you make.

C) What would change if the line you were graphing had a different slope? y-intercept?

D) Show your teacher your pictures and move on to the next phase after they approve your picture by signing below.

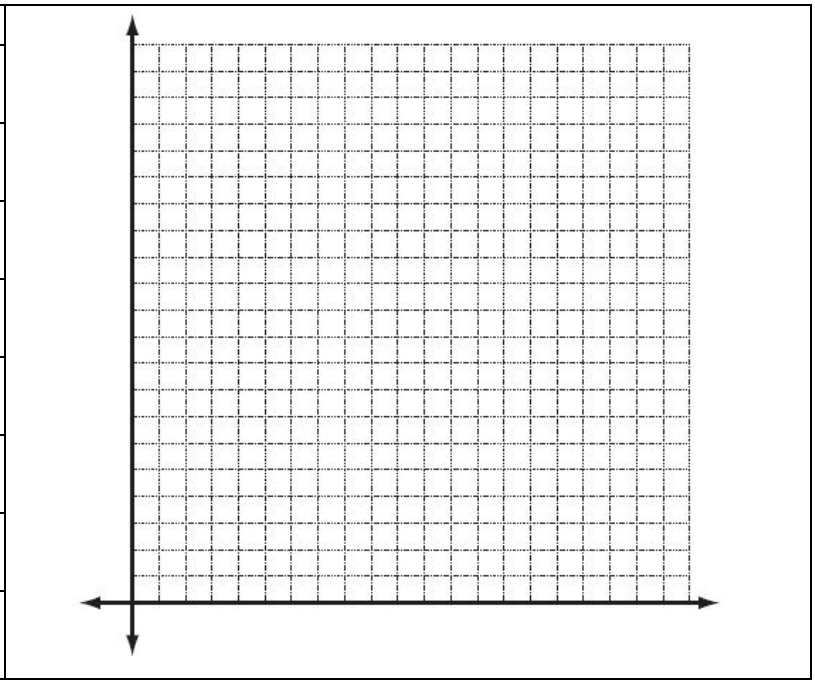
E) Attach your picture below…

Teacher Approval:_____

[1] Polya's How to Solve It, "Can you solve a simpler problem first?"

Phase 2: Slope/Angle Investigation
In this table record the number of degrees a Linkbot has to turn in order to travel a specific slope.

Slope	Angle
1/4	
1/3	
1/2	
3/4	
1	
2	
3	
6	



Observations:

1) Note any patterns that you observe from your data and graph above.

2) What is the relationship between the slope and the angle the bot has to turn?

3) Would any of the functions we have studied so far fit this?

4) What other important things did you learn or notice?

Phase 3: Graph any Slope

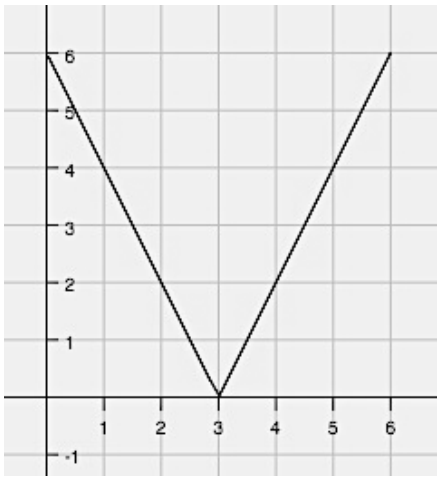
Part 1: Using math.atan() that we just learned, program your bot to graph any positive slope.

Attach a picture of your robot's successful graph of y=1.73x on the domain 0<x<5 below:

Part 2: Negative Slopes
How far does your bot have to turn to graph a line with a negative slope? Add negative slopes to your program and attach a picture of the graph of y=-0.58x on the domain -5<x<0.

Warm-up:
Linear Absolute Value Graphs

Michelle likes riding her bike to and from her favorite lake on Wednesdays. She created the following graph to represent the distance she is away from the lake while biking.



1. Interpret the graph by writing three observations about Michelle's bike ride.

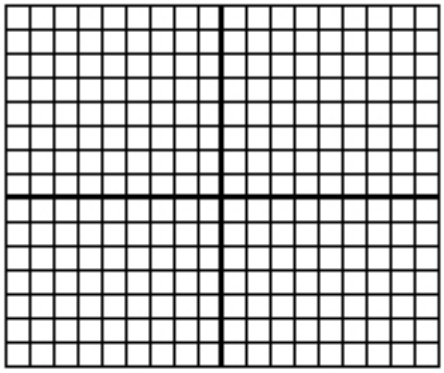
2. Write a piece-wise function for this situation, with each linear function being in point-slope form using the point (3,0). What do you notice?

3. This particular piece-wise function is called a linear absolute value function. What are the traits you are noticing about linear absolute value functions?

Part II

In this part of the task, you will solidify your understanding of piece-wise and use your knowledge of transformations to make sense of absolute value functions. Follow the directions and answer the questions below.

1. Graph the linear function $f(x) = x$



2. On the same set of axes, graph $g(x) = |f(x)|$.

3. Explain what happens graphically from $f(x)$ *to* $g(x)$.

4. Write the piece-wise function for $g(x)$. Explain your process for creating this piece-wise function and how it connects to your answer in question 3.

5. Create a table of values from [-4, 4] for *f(x)* and *g(x).* Explain how this connects to your answer in questions 3 and 4.

x	*f(x)*	*g(x)*
-4		
-3		
-2		
-1		
0		
1		
2		
3		
4		

Phase 4 - Make a V

Adapt your program to graph an absolute value function with any slope.

Attach a picture of your robot’s successful path below:

Warm-up: Stretching Absolute Value Graphs

Exploratory Challenge

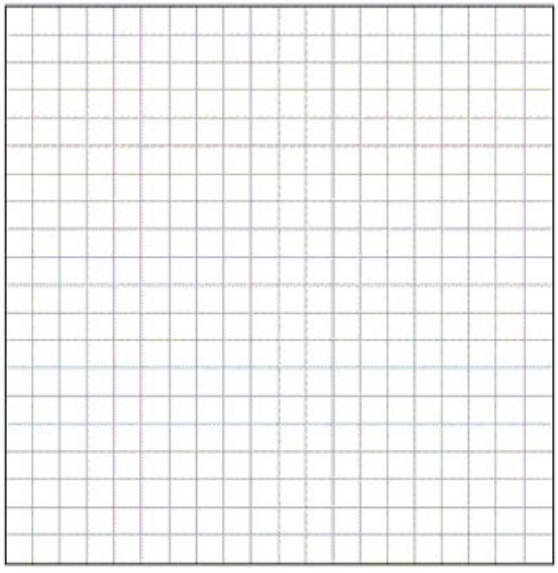
Complete the following to review Module 3 concepts:

a. Consider the function $f(x) = |x|$. Complete the table of values for $f(x)$. Then, graph the equation $y = f(x)$ on the coordinate plane provided for part (b).

x	$f(x)$
-4	
-2	
0	
2	
4	

b. Complete the following table of values for each transformation of the function f. Then, graph the equations $y = g(x)$, $y = h(x)$, $y = j(x)$, *and* $y = k(x)$ on the same coordinate plane as the graph of $y = f(x)$. Label each graph.

x	$f(x)$	$g(x) = 3f(x)$	$h(x) = 2f(x)$	$j(x) = 0.5f(x)$	$k(x) = -2f(x)$
-4					
-2					
0					
2					
4					



c. Describe how the graph of $y = kf(x)$ relates to the graph of $y = f(x)$ for each case.

i. $k > 1$

ii. $0 < k < 1$

iii. $k = -1$

iv. $-1 < k < 0$

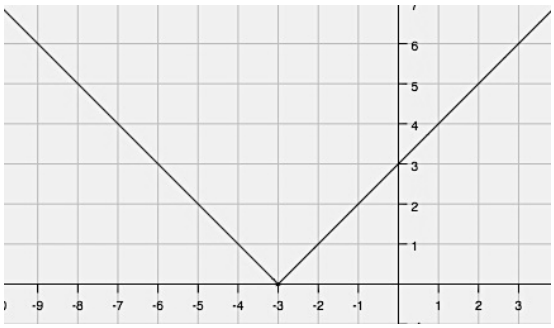
v. $k < -1$

d. Describe the transformation of the "graph" of f that results in the "graphs" of g and h.

$f(x)$ $g(x)$ $h(x)$

Warm-up: Shifting Absolute Value Graphs

6. The graph below is another example of an absolute value function. The equation of this function can be written two ways:

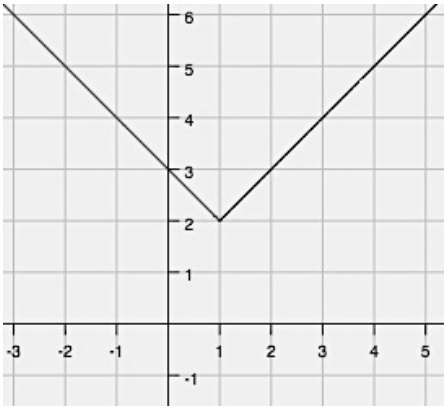


as an absolute value function: $f(x) = |x + 3|$

or as a piece-wise: $f(x) = \begin{cases} -(x+3), & x < -3 \\ (x+3), & x \geq -3 \end{cases}$

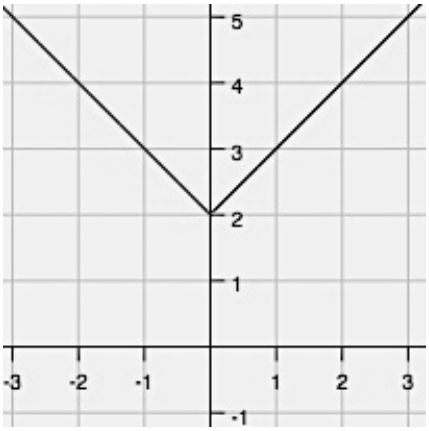
How do these two equations relate to each other?

Below are graphs and equations of more linear absolute value functions. Write the piece-wise function for each. See if you can create a strategy for writing these equations.

7. 

Abolute value: $f(x) = |x - 1| + 2$

Piece-wise: $f(x) =$

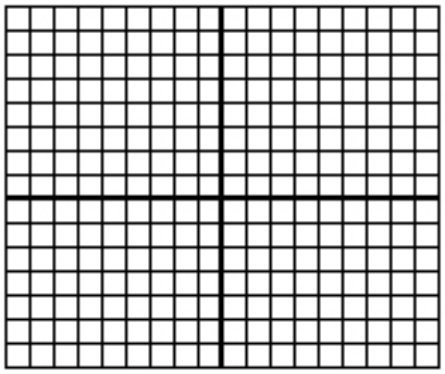
8. 

Abolute value: $f(x) = |x| + 2$

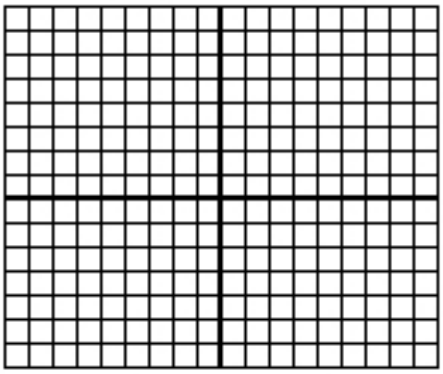
Piece-wise: $f(x) =$

Graph the following linear absolute value piece-wise functions.

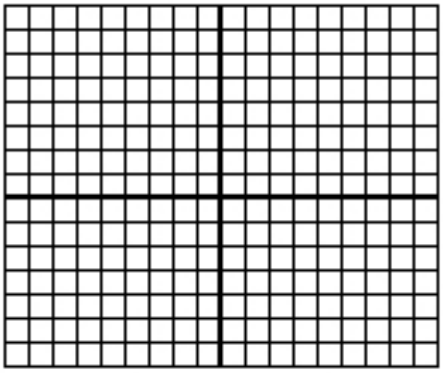
9. $f(x) = |x - 4| = \begin{cases} -(x-4), & x < 4 \\ (x-4), & x \geq 4 \end{cases}$



10. $f(x) = |x| + 1 = \begin{cases} -(x)+1, & x < 0 \\ (x)+1, & x \geq 0 \end{cases}$



11.



Piece-wise: $f(x) = \begin{cases} -3(x+2)+1, & x < -2 \\ 3(x+2)+1, & x \geq -2 \end{cases}$

Absolute Value: $f(x) =$

12. Explain your method for doing the following:

a) Writing piecewise linear absolute value functions from a graph.
b) Writing piecewise linear absolute value functions from an absolute value function.
c) Graphing absolute value functions (from either a piecewise or an absolute value equation).

Reflection Sheet:

1. What were the most challenging parts of this activity? Why?

2. How did you use Algebra and Graphing to find a relationship between the slope and the angle?

3. What was your favorite part of the activity?

4. What did you teach your partner and did they teach you?

Mini-Project E: Project Euler Problem 99 - Largest Exponential

Comparing two numbers written in index form like 2^{11} and 3^7 is not difficult, as any calculator would confirm that $211 = 2048 < 3^7 = 2187$.

However, confirming that $632382^{518061} > 519432^{525806}$ would be much more difficult, as both numbers contain over three million digits.

Using base_exp.txt (right click and 'Save Link/Target As...'), a 22K text file containing one thousand lines with a base/exponent pair on each line, determine which line number has the greatest numerical value.

NOTE: The first two lines in the file represent the numbers in the example given above.

Support: Students will need to learn/know: if statements, for loops, and how to read information from a text file.

Standard addressed: A-SSE3. Write expressions in equivalent forms to solve problems. [Quadratic and exponential] Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

Radioactivebots Calendar (90 min blocks)

Week	Mon	Tues	Wed	Thur	Fri
1	- Radioactivebots Entry Doc - K/NTK/NS	- Do now: Fractional Exponent Exploration with Bacteria - Planning Document	- Do now: Sequences - Use planning document to write code.	- Do now: Fill in tables - Finish and test code	- Do now: More tables - Run simulation (>=3 times) - Record data
2	- Do now: Function from graph - Analyze data	- Do now: Simplify exponents - Twist: Simulation without Robots	- Finish Twist - Record and Analyze Data	- Review	- Test
3					

Example original program: - python - ch
Example twist program: - python - ch

Radioactivebots

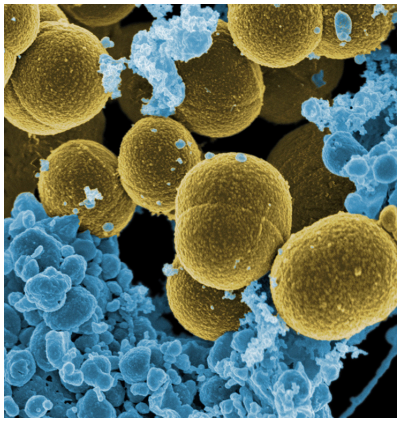
Dear Students,

I found this sign in my storage shed on top of a large and beautiful diamond (it weighs 0.5g). I have reason to believe it is contaminated with carbon-10 which is a radioactive isotope of carbon. I would like to know when it will be safe to give the diamond to my spouse without subjecting them to radiation poisoning.

To figure this out we will be running a simulation with the robots where they decay or not each second in the same way that the carbon isotopes do. Once we take data using the simulation, we will use the graph and equation to predict how long it takes for all of the carbon-10 atoms be gone.

Thanks,
Your Teacher

Warm-up: Fractional Exponent Exploration with Bacteria



Travis and Miriam are studying bacterial growth. They were surprised to find that the population of the bacteria doubled every hour.

1. Complete the following table and plot the data on the graph at the end of this task.

Hours into the study	0	1	2	3	4
Bacteria population (in thousands)	4				

2. Write an equation for P, the population of the bacteria, as a function of time, t, and verify that it produces correct populations for t = 1, 2, 3, and 4 hours.

Travis and Miriam want to create a table with more entries; specifically, they want to fill in the population at each half hour. Unfortunately, they forgot to make these measurements so they decide to estimate the values.

Travis makes the following claim:

> "If the population doubles in 1 hour, then half that growth occurs in the first half-hour and the other half in the second half-hour. So for example, we can find the population at t = ½ by finding the average of the populations at t = 0 and t = 1."

3. Fill in the parts of the table below that you've already computed, and then decide how you might use Travis' strategy to fill in the missing data. Also plot Travis' data on the graph at the end of the task.

Hours into the study	0	½	1	3/2	2	5/2	3	7/2	4
Bacteria population (in thousands)	4								

4. Comment on Travis' idea. How does it compare to the table generated in problem 1? For what kind of function would this reasoning work?

Miriam suggests they should fill in the data in the table in the following way:

> "To make the estimates, I noticed that the population increases by the same factor each hour, and I think that this property should hold over each half-hour interval as well."

4. Fill in the parts of the table below that you've already computed in problem 1, and then decide how you might use Miriam's new strategy to fill in the missing data. As in the table in problem 1, each entry should be multiplied by some constant factor in order to produce consistent results. Use this constant multiplier to complete the table. Also plot Miriam's data on the graph at the end of this task.

Hours into the study	0	$\frac{1}{2}$	1	$\frac{3}{2}$	2	$\frac{5}{2}$	3	$\frac{7}{2}$	4
Bacteria population (in thousands)	4								

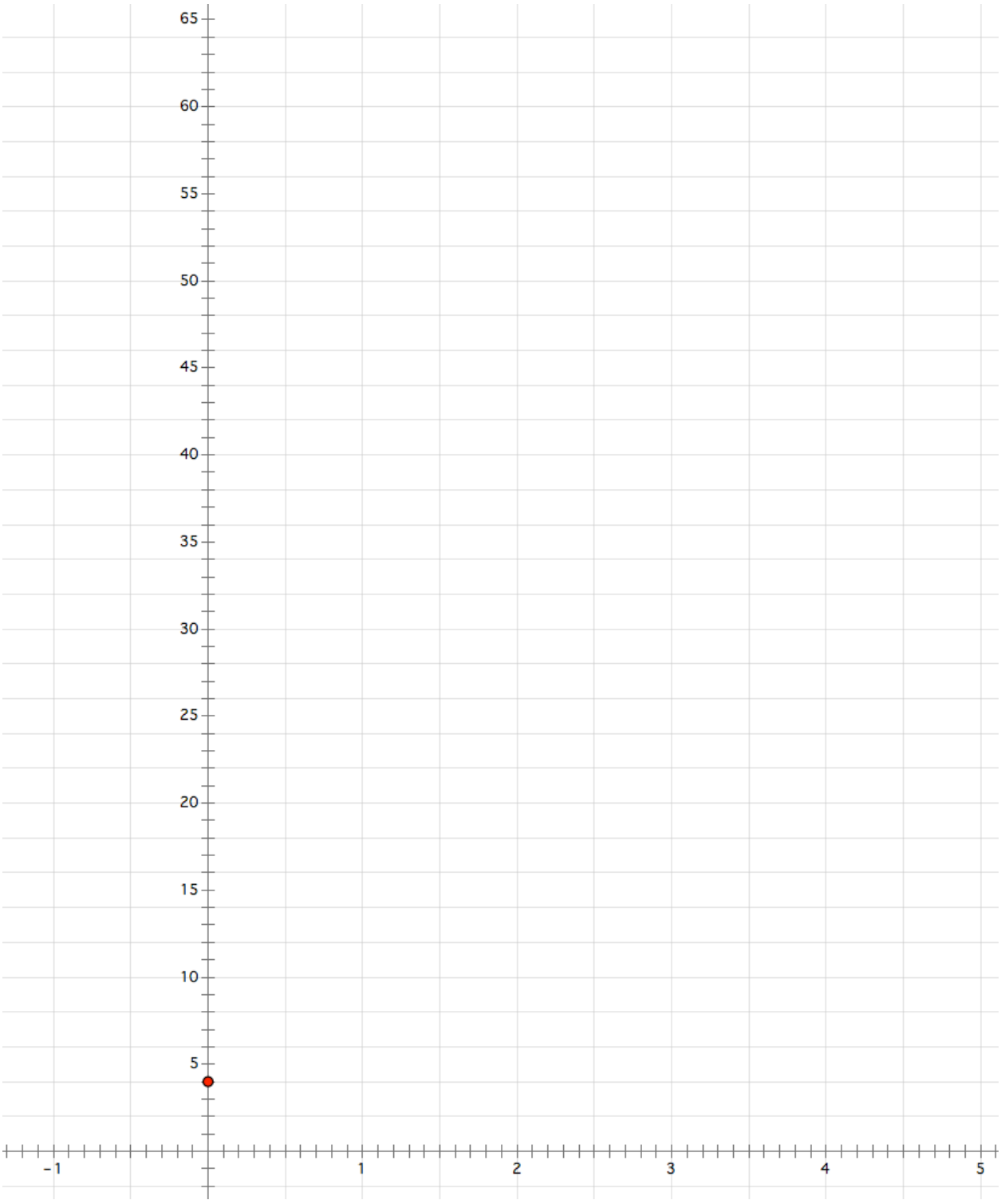
5. What if Miriam wanted to estimate the population every 20 minutes instead of every 30 minutes? What multiplier would she use for every third of an hour to be consistent with the population doubling every hour? Use this multiplier to complete the following table.

Hours into the study	0	$\frac{1}{3}$	$\frac{2}{3}$	1	$\frac{4}{3}$	$\frac{5}{3}$	2	$\frac{7}{3}$	$\frac{8}{3}$	3
Bacteria population (in thousands)	4									

6. What number did you use as a multiplier to complete the table in problem 4?

7. What number did you use as a multiplier to complete the table in problem 5?

8. Give a detailed description of how you would estimate the population, P, at $t = \frac{5}{3}$ hours.



Planning Document

Chance of decay:

The half life of carbon-10 is _____ seconds. That means after that many seconds, fifty percent of the atoms will still be carbon-10 and the other half will have decayed into boron.

What percent of atoms remain after one second?

What are the chances your bot will remain carbon each second?

Pseudo-Random numbers:

You will need to generate a random number each second to check if your radioactivebot has decayed or not. After you “import random” you have a choice of “decimal=random.random()” which returns 0 <= decimal < 1 or “integer=random.randint(a,b)” which returns a <= integer <= b.

Which will you use?

How will you use the number that is generated along with the percent of atoms that remain after each second to check to see if your bot has decayed or not?

Program considerations:

What could you add to your program so that it waits until the class is ready (and you hit enter)?

How will you know how many seconds have passed before it decays?

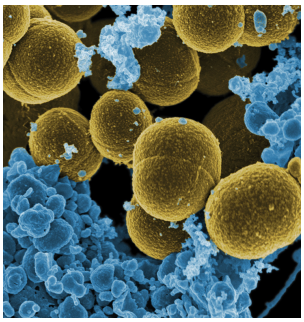
How will the bot show you it still is carbon? How will it show you it has decayed into boron?

How will your radioactivebot behave while it is still radioactive?

NAME

Solving Quadratic and Other Equations | 3.1

Warm-up: Sequences



Ready

Topic: Comparing additive and multiplicative patterns.

The sequences below exemplify either an additive (arithmetic) or a multiplicative (geometric) pattern. Identify the type of sequence, fill in the missing values on the table and write an equation.

1.

Term	1st	2nd	3rd	4th	5th	6th	7th	8th
Value	2	4	8	16	32			

Type of Sequence: **Equation:**

2.

Term	1st	2nd	3rd	4th	5th	6th	7th	8th
Value	66	50	34	18				

Type of Sequence: **Equation:**

3.

Term	1st	2nd	3rd	4th	5th	6th	7th	8th
Value	-3	9	-27	81				

Type of Sequence: **Equation:**

4.

Term	1st	2nd	3rd	4th	5th	6th	7th	8th
Value	160	80	40	20				

Type of Sequence: **Equation:**

5.

Term	1st	2nd	3rd	4th	5th	6th	7th	8th
Value	-9	-2	5	12				

Type of Sequence: **Equation:**

NAME

Solving Quadratic and Other Equations | 3.1

Set

Topic: Evaluate the expressions with rational exponents.

Fill in the missing values of the table based on the growth that is described.

12.

The growth in the table is triple at each whole year.

Years	0	½	1	3/2	2	5/2	3	7/2	4
bacteria	2		6						

13.

The growth in the table is triple at each whole year.

Years	0	1/3	2/3	1	4/3	5/3	2	7/3	8/3
bacteria	2			6					

14.

The values in the table grow by a factor of four at each whole year.

Years	0	½	1	3/2	2	5/2	3	7/2	4
bacteria	2		8						

Go

Topic: Simplifying exponents

Simplify the following expressions using exponent rules and relationships, write your answers in exponential form. (For example: $2^2 \cdot 2^5 = 2^7$)

15. $3^2 \cdot 3^5$

16. $\frac{5^3}{5^2}$

17. 2^{-5}

18. 17^0

19. $\frac{7^5}{7^2} \cdot \frac{7^3}{7^4}$

20. $\frac{3^{-2} \cdot 3^5}{3^7}$

NAME

Solving Quadratic and Other Equations | 3.2

Warm-up: Fill in Tables

Set

Topic: Finding arithmetic and geometric means and making meaning of rational exponents.

You may have found arithmetic and geometric means in your prior work. Finding arithmetic and geometric means requires finding values of a sequence between given values from non-consecutive terms. In each of the sequences below determine the means and show how you found them.

Find the *arithmetic* means for the following, show your work.

10.

x	1	2	3
y	5		11

11.

x	1	2	3	4	5
y	18				-10

12.

x	1	2	3	4	5	6	7
y	12						-6

Find the *geometric* means for the following, show your work.

13.

x	1	2	3
y	3		12

14.

x	1	2	3	4
y	7			875

15.

x	1	2	3	4	5	6
y	4					972

NAME

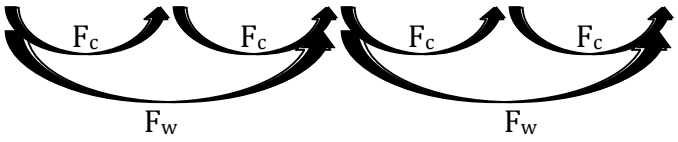
Solving Quadratic and Other Equations | 3.2

Warm-up: More Tables

16.
Fill in the table of values and find the factor used to move between whole number values, F_w, as well as the factor, F_c, used to move between each column of the table.

x	0	½	1	¾	2
y	4 €		16 €		

$F_w =$
$F_c =$



17.
Fill in the table of values and find the factor used to move between whole number values, F_w, as well as the factor, F_c, used to move between each column of the table.

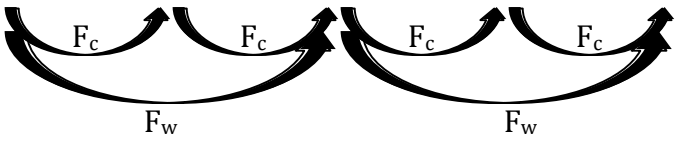
x	0	½	1	¾	2
y	4 €		8 €		

$F_w =$
$F_c =$

18.
Fill in the table of values and find the factor used to move between whole number values, F_w, as well as the factor, F_c, used to move between each column of the table.

x	0	½	1	¾	2
y	5 €		15 €		

$F_w =$
$F_c =$



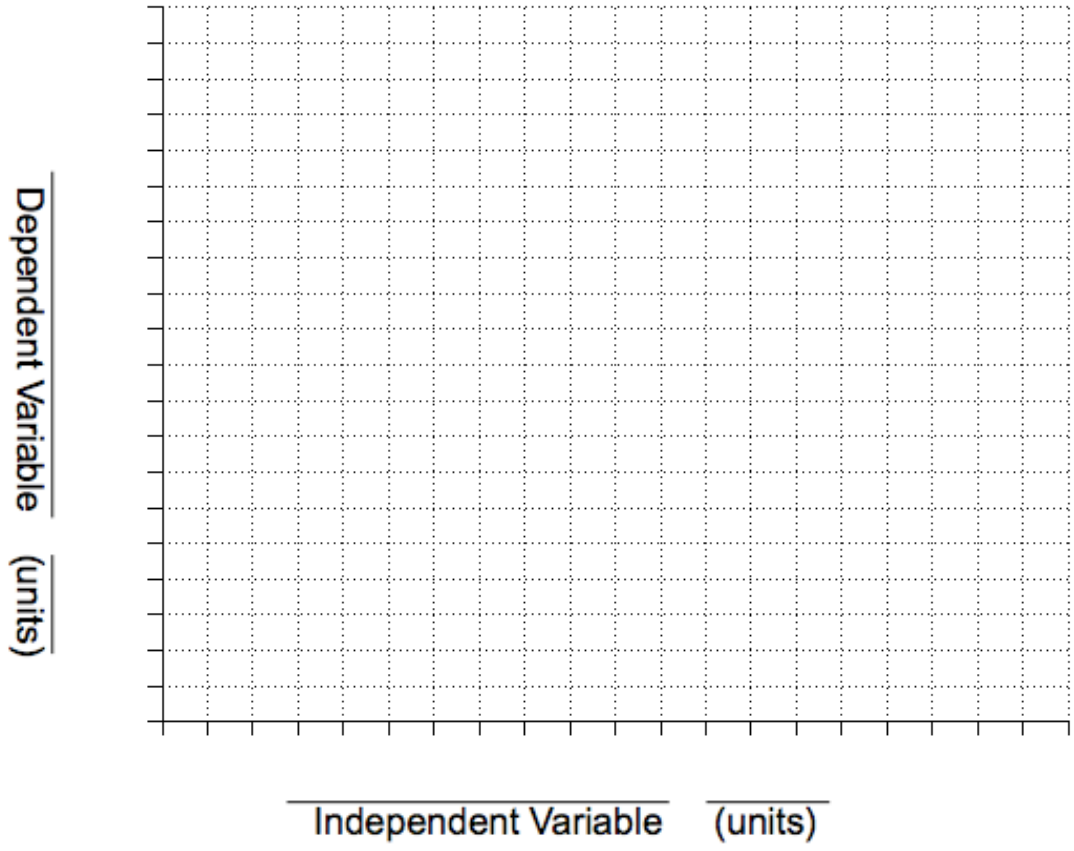
Radioactivebots Data

1. Data Collection: Collect data from your experiment. Be sure to include title, labels, and units.

Table 1: _____

Independent Variable:	**Dependent Variable:**			
	Trial #1 ( )	Trial #2 ( )	Trial #3 ( )	Average ( )

2. Graph: Make a graph of the data below. Be sure to include all 5 parts of a graph (<u>title, IV and DV, units, scales, and data</u>)



Adapted from Jordan Pasqualin's *Helicopter Lab* by Jim Town

3. Claim: What cause and effect relationship have you discovered?

As the _____ increases the _____ _____
(Independent Variable) (Dependent Variable) (Increases, Decreases, or Stays Constant)

4. Evidence: Explain what data you based your claim on.

5. Reasoning: Explain how your *evidence* proves your *claim*?

6. Extend: Find a function that fits your data.

Why does the type of function you chose fit the situation we are modeling?

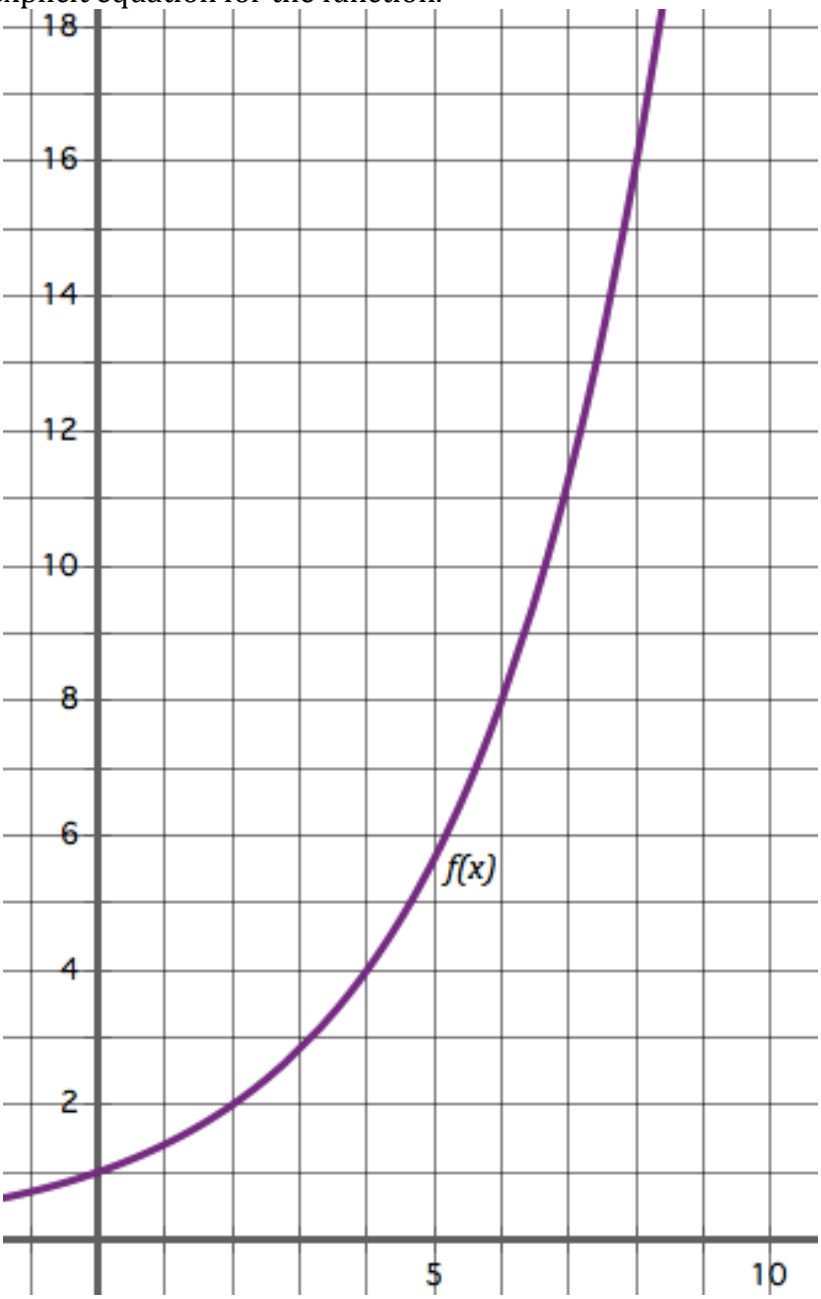
What do the parameters in the function mean in the situation we are modeling? Are they the values you expected them to be? What might have caused differences in the expected value vs the measured value?

NAME

Solving Quadratic and Other Equations | 3.1

Warm-up: Function from Graph

Use the graph of the function to find the desired values of the function. Also create an explicit equation for the function.



6. Find the value of *f(2)*

7. Find where *f(x) = 4*

8. Find the value of *f(6)*

9. Find where *f(x) = 16*

10. What do you notice about the way that inputs and outputs for this function relate? (Create an in-out table if you need to.)

11. What is the explicit equation for this function?

NAME

Solving Quadratic and Other Equations | 3.3

Warm-up: Simplify Exponents

Set

Topic: Finding equivalent expressions and functions.

Determine whether the expressions or functions in each problem below are equivalent. Justify why or why they are not equivalent.

7. $5(3^{x-1})$ $15(3^{x-2})$ $\frac{3}{5}(3^x)$

8. $64\ (2^{-x})$ $\frac{64}{2^x}$ $64\left(\frac{1}{2}\right)^x$

9. 3(x-1)+4 3x - 1 3(x-2) +7

10. $50(2^{x+2})$ $25(2^{2x+1})$ $50(4^x)$

11. $30(1.05^x)$ $30\left(1.05^{\frac{1}{7}}\right)^{7x}$ $30\left(1.05^{\frac{x}{2}}\right)^2$

12. $20\ (1.1^x)$ $20\ (1.1^{-1})^{-1x}$ $20\left(1.1^{\frac{1}{5}}\right)^{5x}$

NAME

Solving Quadratic and Other Equations | 3.3

Go

Topic: Using rules of exponents

Simplify each expression.

13. $7^3 \cdot 7^5 \cdot 7^2$

14. $(3^4)^5$

15. $(5^3)^4 \cdot 5^7$

16. $x^3 \cdot x^5$

17. x^{-b}

18. $x^a \cdot x^b$

19. $(x^a)^b$

20. $\frac{y^a}{y^b}$

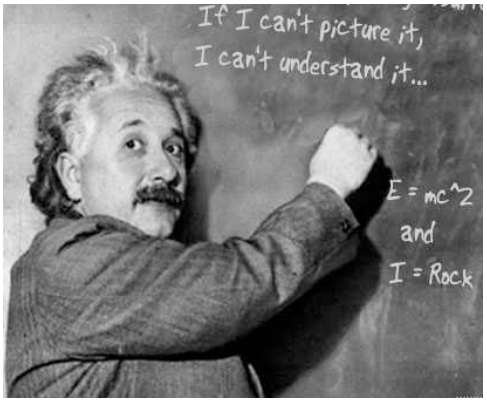
21. $\frac{(y^a)^c}{y^b}$

22. $\frac{(3^4)^6}{3^7} =$

23. $\frac{r^5 s^3}{rs^2} =$

24. $\frac{x^5 y^{12} z^0}{x^8 y^9} =$

Exponents Review



Now that Tia and Tehani know that $a^{m/n} = \left(\sqrt[n]{a}\right)^m$ they are wondering which form, radical form or exponential form, is best to use when working with numerical and algebraic expressions.

Tia says she prefers radicals since she understands the following properties for radicals (and there are not too many properties to remember):

If *n* is a positive integer greater than 1 and both *a* and *b* are positive real numbers then,

1. $\sqrt[n]{a^n} = a$
2. $\sqrt[n]{ab} = \sqrt[n]{a} \cdot \sqrt[n]{b}$
3. $\sqrt[n]{\frac{a}{b}} = \frac{\sqrt[n]{a}}{\sqrt[n]{b}}$

Tehania says she prefers exponents since she understands the following properties for exponents (and there are more properities to work with):

1. $a^m \cdot a^n = a^{m+n}$
2. $\left(a^m\right)^n = a^{mn}$
3. $(ab)^n = a^n \cdot b^n$
4. $\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}$
5. $\frac{a^m}{a^n} = a^{m-n}, \quad a \neq 0$
6. $a^{-n} = \frac{1}{a^n}$

DO THIS: Illustrate with examples and explain, using the properties of radicals and exponents, why $a^{1/n} = \sqrt[n]{a}$ and $a^{m/n} = \left(\sqrt[n]{a}\right)^m$ are true identities.

Using their preferred notation, Tia might simplify $\sqrt[3]{x^8}$ as follows:

$$\sqrt[3]{x^8} = \sqrt[3]{x^3 \cdot x^3 \cdot x^2} = \sqrt[3]{x^3} \cdot \sqrt[3]{x^3} \cdot \sqrt[3]{x^2} = x \cdot x \cdot \sqrt[3]{x^2} = x^2 \cdot \sqrt[3]{x^2}$$

(Tehani points out that Tia also used some exponent rules in her work.)

On the other hand, Tehani might simplify $\sqrt[3]{x^8}$ as follows:

$$\sqrt[3]{x^8} = x^{8/3} = x^{2+2/3} = x^2 \cdot x^{2/3} \text{ or } x^2 \cdot \sqrt[3]{x^2}$$

For each of the following problems, simplify the expression in the ways you think Tia and Tehani might do it.

Original expression	**What Tia and Tehani might do to simplify the expression:**
$\sqrt{27}$	Tia's method
	Tehani's method
$\sqrt[3]{32}$	Tia's method
	Tehani's method
$\sqrt{20x^7}$	Tia's method
	Tehani's method
$\sqrt[3]{\frac{16xy^5}{x^7y^2}}$	Tia's method
	Tehani's method

The Twist

Well, it turns out it is actually carbon-11 which has a much longer half life so using the robots to simulate it is not feasible. Your new task is to update your program to run the simulation without the robots. You should run at least 10 trials with a sample size of at least 100 atoms.

Chance of decay:

The half life of carbon-11 is _____ seconds. That means after that many seconds, fifty percent of the atoms will still be carbon-11 and the other half will have decayed into boron.

What percent of atoms remain after one second?

What are the chances each atom will remain carbon each second?

Program considerations:

How will you keep track of time?

How will you keep track of the trials?

How will you show your results?

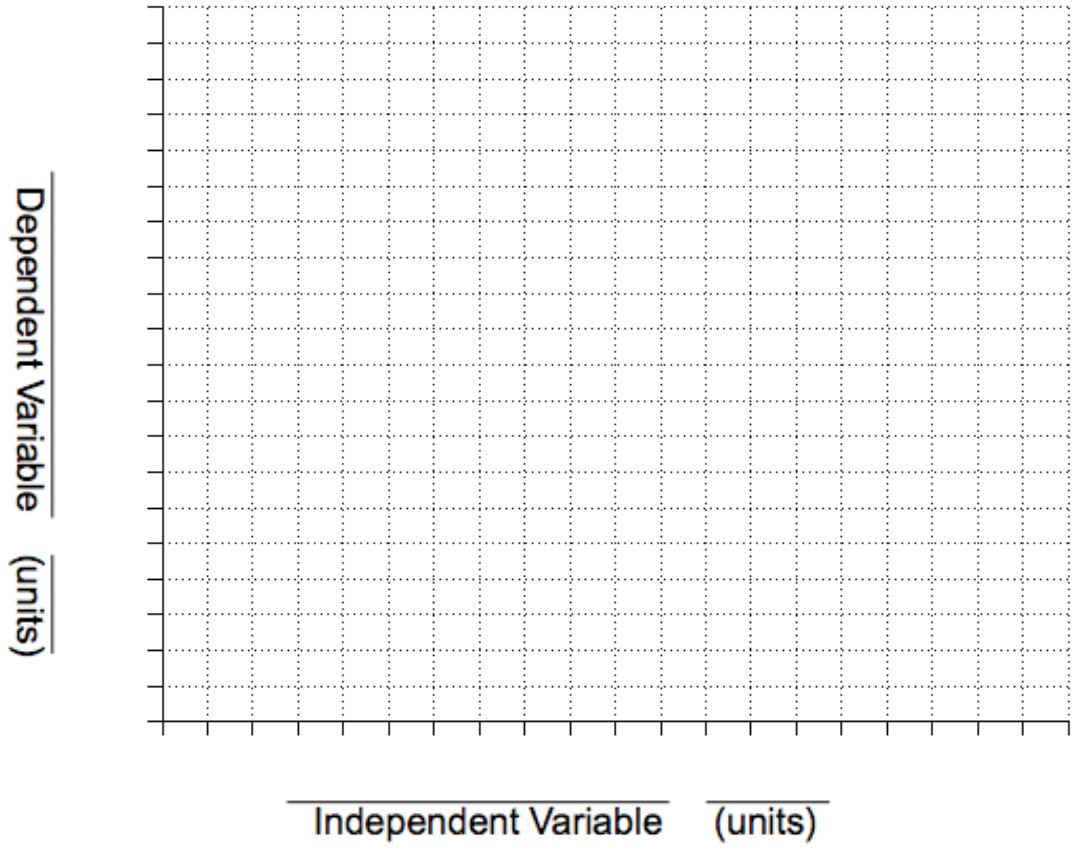
Radioactivebots Twist Data

1. Data Collection: Collect data from your experiment. Be sure to include title, labels, and units.

Table 1: _____

Independent Variable:	**Dependent Variable:**			
	Trial #1 ( )	Trial #2 ( )	Trial #3 ( )	Average ( )

2. Graph: Make a graph of the data below. Be sure to include all 5 parts of a graph (<u>title, IV and DV, units, scales, and data</u>)



Adapted from Jordan Pasqualin's *Helicopter Lab* by Jim Town

3. Claim: What cause and effect relationship have you discovered?

As the _____ increases the _____ _____
(Independent Variable) (Dependent Variable) (Increases, Decreases, or Stays Constant)

4. Evidence: Explain what data you based your claim on.

5. Reasoning: Explain how your *evidence* proves your *claim*?

6. Extend: Find a function that fits your data.

Why does the type of function you chose fit the situation we are modeling?

What do the parameters in the function mean in the situation we are modeling? Are they the values you expected them to be? What might have caused differences in the expected value vs the measured value?

Exponents Assessment

Name _____ Date _____

1. Use properties of exponents to explain why it makes sense to define $16^{\frac{1}{4}}$ as $\sqrt[4]{16}$.

2. Use properties of exponents to rewrite each expression as either an integer or as a quotient of integers $\frac{p}{q}$ to show the expression is a rational number.

   a. $\sqrt[4]{2}\,\sqrt[4]{8}$

   b. $\frac{\sqrt[3]{54}}{\sqrt[3]{2}}$

c. $16^{\frac{3}{2}} \cdot \left(\frac{1}{27}\right)^{\frac{2}{3}}$

5. A scientist is studying the growth of a population of bacteria. At the beginning of her study, she has 800 bacteria. She notices that the population is quadrupling every hour.

   a. What quantities, including units, need to be identified to further investigate the growth of this bacteria population?

   b. The scientist recorded the following information in her notebook, but she forgot to label each row. Label each row to show what quantities, including appropriate units, are represented by the numbers in the table, and then complete the table.

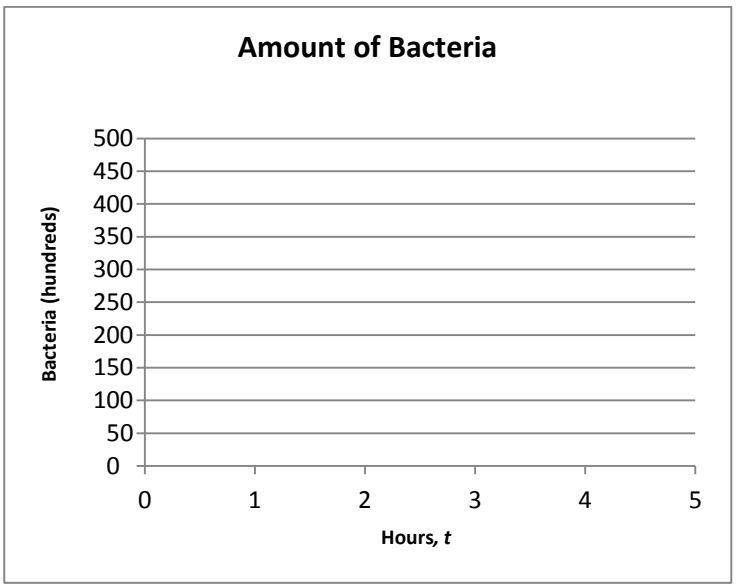
	0	1	2	3	4
	8	32	128		

c. Write an explicit formula for the number of bacteria present after t hours.

d. Another scientist studying the same population notices that the population is doubling every half an hour. Complete the table, and write an explicit formula for the number of bacteria present after x half hours.

Time, t (hours)	0	$\frac{1}{2}$	1	$\frac{3}{2}$	2	$\frac{5}{2}$	3
Time, x (half hours)	0	1	2	3	4	5	6
Bacteria (hundreds)	8	16	32				

e.



f. A scientist calculated the average rate of change for the bacteria in the first three hours to be 168. Which units should the scientist use when reporting this number? Explain how you know.

Find the time, in hours, when there will be 5,120,000 bacteria. Express your answer as a logarithmic expression.