Rich Mathematical Task – Algebra II – *Drone's Best Friend*

Task Overview/Description/Purpose:
- In this task, students will explore a system of linear-quadratic equations that models the physical distance between a drone and a dog.   - This task would be used at the end of a unit to assess student's understanding of solving systems of linear-quadratic equations using multiple methods.

Standards Alignment: Strand – *Functions*

Primary SOL:

AII.4   The student will solve systems of linear-quadratic and quadratic-quadratic equations, algebraically and graphically.

Related SOL: A.4de, MA.14

Learning Intention(s):

- **Content** - I am learning to solve systems of linear-quadratic equations.
- **Language** - I am learning explain my thinking using mathematical vocabulary.
- **Social** - I am learning to work with my peers to solve a practical problem.

Success Criteria (Evidence of Student Learning):

- I can solve a linear-quadratic system of two equations in two variables graphically.
- I can solve a linear-quadratic system of two equations in two variables algebraically.

Mathematics Process Goals

Problem Solving	Students will apply mathematical concepts and skills and the relationships among them and choose an appropriate strategy to solve a problem.
Communication and Reasoning	- Students will explain their reasoning using mathematical vocabulary. - Students will provide work to show how they used their strategy to reach their solution.
Connections and Representations	Students will provide one or more representations of the situation: drawing, table, graph, and/or equation.

Task Pre-Planning

Approximate Length/Time Frame: 55 minutes

Grouping of Students: If using this task as a summative assessment, you might choose to have students work independently or in a partner/small group with a group work reflection.

Materials and Technology:	**Vocabulary:**
- White board - Markers - Graph Paper - Waxed string other manipulative for modeling graphs of equations - Graph paper - Desmos Graphing Calculator (see list of tutorials below) - Desmos Version of Drone's Best Friend	- System of Equations - Linear-Quadratic System - Graphically - Algebraically

Desmos Tutorials

Teachers may want to familiarize themselves with features of Desmos they have not used previously. As students progress through the task, if they are requesting assistance with these features, the tutorials could be shared at the teacher's discretion.

- Graph Settings
- Restricting Domains
- Uploading Images
- Sliders and Animations
- Tables

Go to this graph to see a finished product:

https://www.desmos.com/calculator/vjrzkjphlj

Anticipate Responses: See the Planning for Mathematical Discourse Chart (columns 1-3).

Task Implementation (Before) *5 - 10 minutes*

Task Launch:

- Consider sharing the learning intentions and success criteria prior to the task as long as it will not give away a specific strategy for students to use during the task.
- If using as an introductory task, have a class discussion about all of their background knowledge about lines, parabolas, and systems of equations.
- Present this task as a problem for students to solve in any manner that makes sense to them.
- Make sure students have access to a variety of materials.
- Use strategic grouping of students if using as a collaborative task.
- Allow students to pursue different strategies, and do not lead them to using a particular method unless that is what they think of doing on their own.
- If using this as a cumulative task, you should expect students to move to solving algebraically, but have them share their process of for all solution methods they use.

Task Implementation (During) *35 minutes*

Directions for Supporting Implementation of the Task

- Monitor – Teacher will listen and observe students as they work on task and ask assessing or advancing questions (see chart on next page).
- Select – Teacher will decide which strategies or thinking that will be highlighted (after student task implementation) that will advance mathematical ideas and support student learning.
- Sequence – Teacher will decide the order in which student ideas will be highlighted (after student task implementation).
- Connect – Teacher will consider ways to facilitate connections between different student responses.

Suggestions For Additional Student Support

May include, among others:
- Possible use of sentences frames to support student thinking
  - Another idea I had was…
  - I was confused (wondering) about…
  - How or why did you…?
  - I agree (disagree) because…
  - Your answer/strategy reminds me of…
  - Can you explain more about…?
  - I would like to add on…

- Provide highlighters to assist students in interacting with text
- Provide oral instructions
- Allow students to provide oral explanations
- Possible problem solving strategies questions for non-starters:
    - Can you try some graphs by hand?
    - Can you verbally describe a movement you might like to create?

Task Implementation (After) *15 - 20 minutes*

Connecting Student Responses (From Anticipating Student Response Chart) and Closure of the Task:

- Based on the actual student responses, sequence and select particular students to present their mathematical work during a whole class discussion. Some possible big mathematical ideas to highlight could include:
    - A common misconception
    - Trajectory of sophistication in student ideas (i.e. concrete to abstract; graphical to algebraic solutions)
    - Connection between multiplication and division (could both operations provide the same outcome?)
- Connect different students' responses and connect the responses to the key mathematical ideas to bring closure to the task. Possible questions and sentence frames to connect student strategies:
    - How are these strategies alike? How are they different?
    - _____'s strategy is similar to _____'s strategy because _____
    - How do these connect to our Learning Intentions?
    - Why is this important?
- Highlight student strategies to show the connections, either between different ideas for solutions or to show the connection between levels of sophistication of student ideas (connect strategies according to the different strategies for solution). Allow students to ask clarifying questions.
- Consider ways to ensure that each student will have an equitable opportunity to share his/her thinking during task discussion.
    - Students can participate in a Gallery Walk to view all strategies prior to coming together to discuss selected strategies.
    - Students can "Think, Pair, Share" strategies for creating transformations that have the desired effect
    - Close the lesson by returning to the success criteria. Have students reflect on their progress toward the criteria.

Teacher Reflection About Student Learning:

- Were the instructional objectives met?
- Did the task address the process goals?
- Were students able to explain and justify their thinking?
- What was the level of student engagement during the task?
- Are their strategies that may need additional development with students?
- Are there additional supports that may have further helped students with implementation of the task?
- What common errors/misconceptions did students have that were not expected?
- How might lack of prior knowledge be addressed when implementing this task again?

Rich Mathematical Task – Algebra II – *Drone's Best Friend*

Planning for Mathematical Discourse

Mathematical Task: ___Drone's Best Friend___   Content Standard(s): ___AII.4___

Teacher Completes Prior to Task Implementation			Teacher Completes During Task Implementation	
Anticipated Student Response/Strategy *Provide examples of possible correct student responses along with examples of student errors/misconceptions*	**Assessing Questions** *Teacher questioning that allows student to explain and clarify thinking*	**Advancing Questions** *Teacher questioning that moves thinking forward*	**List of Students Providing Response** *Who? Which students used this strategy?*	**Discussion Order - sequencing student responses** *Based on the actual student responses, sequence and select particular students to present their mathematical work during class discussion* *Connect different students' responses and connect the responses to the key mathematical ideas* *Consider ways to ensure that each student will have an equitable opportunity to share his/her thinking during task discussion*
Anticipated Student Response: Student uses guess and check.	- How did you find your solution? - What evidence do you have to support your solution?	- What is another way you could represent your solution? - What other ways could you solve this problem? - Does your solution make sense in the context of the problem?		
Anticipated Student Response: Student solves graphically.	- How did you find your solution? - What evidence do you have to support your solution?	- What is another way you could represent your solution? - What other ways could you solve this problem? - Does your solution make sense in the context of the problem?		
Anticipated Student Response: Student solves the problem algebraically: factoring.	- How did you find your solution? - What evidence do you have to support your solution?	What is another way you could represent your solution?		

Rich Mathematical Task – Algebra II – *Drone's Best Friend*

| Teacher Completes Prior to Task Implementation			Teacher Completes During Task Implementation	
Anticipated Student Response/Strategy *Provide examples of possible correct student responses along with examples of student errors/misconceptions*	**Assessing Questions** *Teacher questioning that allows student to explain and clarify thinking*	**Advancing Questions** *Teacher questioning that moves thinking forward*	**List of Students Providing Response** *Who? Which students used this strategy?*	**Discussion Order - sequencing student responses** *Based on the actual student responses, sequence and select particular students to present their mathematical work during class discussion* *Connect different students' responses and connect the responses to the key mathematical ideas* *Consider ways to ensure that each student will have an equitable opportunity to share his/her thinking during task discussion*
		- In what other ways could you solve this problem? - Does your solution make sense in the context of the problem?		
Anticipated Student Response: Student solves the problem algebraically: Quadratic Formula.	- How did you find your solution? - What evidence do you have to support your solution?	- What is another way you could represent your solution? - In what other ways could you solve this problem? - Does your solution make sense in the context of the problem?		

Name_____ Date_____

Drone's Best Friend

Drones have become very popular in recent years, but dogs have been beloved pets for centuries. What happens when the two come together? If you search the internet, you can see images of drones walking dogs, dogs chasing drones, and even drones and dogs working together for search and rescue.

In the image below, a dog is chasing a drone, beginning a jump towards the drone. The x-axis represents the horizontal distance traveled by the drone and dog and the y-axis represents the vertical distance traveled by the drone and dog.

If the path of the drone can be modeled by the line, $y = \frac{1}{2}x + \frac{5}{2}$ and the path of the dog can be modeled by the parabola, $y = -\frac{3}{4}x^2 + \frac{7}{2}x + \frac{1}{4}$, will the dog catch the drone?

If so, at what point? What does this represent in the context of the situation?

Make sure you have solved the problem both algebraically and graphically to justify your answer.
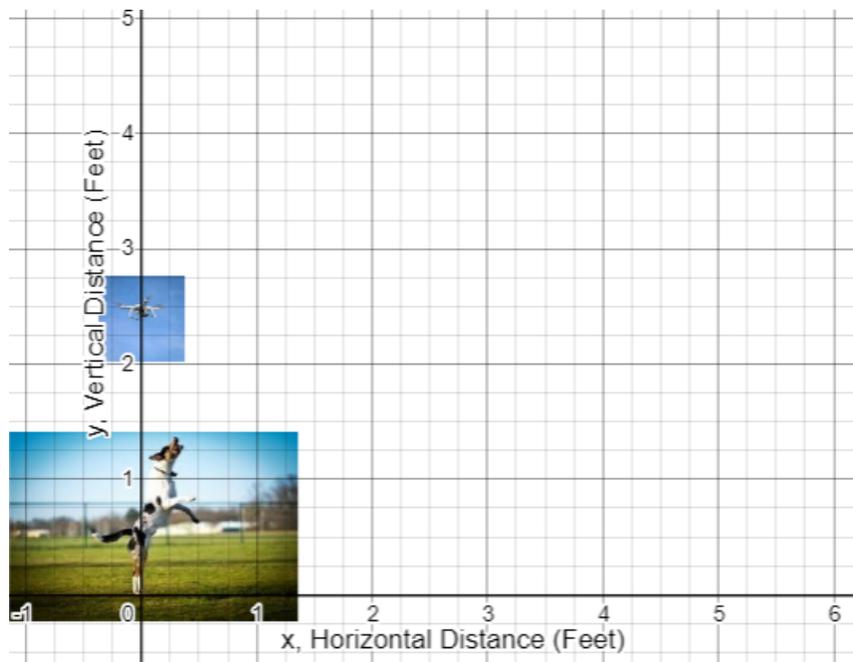
Rich Mathematical Task – Algebra II – *Drone's Best Friend*

Rich Mathematical Task Rubric

	Advanced	Proficient	Developing	Emerging
Mathematical Understanding	Proficient Plus: • Uses relationships among mathematical concepts or makes mathematical generalizations	• Demonstrates an understanding of concepts and skills associated with task • Applies mathematical concepts and skills which lead to a valid and correct solution	• Demonstrates a partial understanding of concepts and skills associated with task • Applies mathematical concepts and skills which lead to an incomplete or incorrect solution	• Demonstrates no understanding of concepts and skills associated with task • Applies limited mathematical concepts and skills in an attempt to find a solution or provides no solution
Problem Solving	Proficient Plus: • Problem solving strategy is well developed or efficient	• Problem solving strategy displays an understanding of the underlying mathematical concept • Produces a solution relevant to the problem and confirms the reasonableness of the solution	• Problem solving strategy displays a limited understanding of the underlying mathematical concept • Produces a solution relevant to the problem but does not confirm the reasonableness of the solution	• A problem solving strategy is not evident • Does not produce a solution that is relevant to the problem
Communication and Reasoning	Proficient Plus: • Reasoning or justification is comprehensive • Consistently uses precise mathematical language to communicate thinking	• Demonstrates reasoning and/or justifies solution steps • Supports arguments and claims with evidence • Uses mathematical language to communicate thinking	• Reasoning or justification of solution steps is limited or contains misconceptions • Provides limited or inconsistent evidence to support arguments and claims • Uses limited mathematical language to partially communicate thinking	• Provides no correct reasoning or justification • Does not provide evidence to support arguments and claims • Uses no mathematical language to communicate thinking
Representations and Connections	Proficient Plus: • Uses representations to analyze relationships and extend thinking • Uses mathematical connections to extend the solution to other mathematics or to deepen understanding	• Uses a representation or multiple representations, with accurate labels, to explore and model the problem • Makes a mathematical connection that is relevant to the context of the problem	• Uses an incomplete or limited representation to model the problem • Makes a partial mathematical connection or the connection is not relevant to the context of the problem	• Uses no representation or uses a representation that does not model the problem • Makes no mathematical connections