Lesson Plan for Implementing NETS•S—Template I
(More Directed Learning Activities)

Template with guiding questions

Teacher(s)
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Grade Level(s): 9-12

Content Area: Mathematics

Time line: Three Weeks

Standards (What do you want students to know and be able to do? What knowledge, skills, and strategies do you expect students to gain? Are there connections to other curriculum areas and subject area benchmarks? ) Please put a summary of the standards you will be addressing rather than abbreviations and numbers that indicate which standards were addressed.

Students will:

1. Perform online research and inquiry on historical background information and modern day applications of quadratic functions (Humanities)
2. Use two-dimensional equations of projectile motion to calculate initial velocity, time in the air, horizontal distance and maximum height. (Algebra)
3. Resolve two-dimensional vectors into its vertical and horizontal components. (Trigonometry)
4. Graph quadratic equation using TI-83 graphing calculator, Desmos, and Microsoft, and find x-intercepts, y-intercepts and vertex.
5. Make predictions of the height of a baseball versus time. (Sports)
6. Make presentations using screen casting, video, or voice thread.

Common Core GPS Standards:

General
1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.
Specific:

MGSE9–12.F.IF.7 Graph functions expressed algebraically and show key features of the graph both by hand and by using technology.
MGSE9–12.F.IF.7a Graph linear and quadratic functions and show intercepts, maxima, and minima (as determined by the function or by context).
MGSE9–12.F.IF.8 Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function.
MGSE9–12.F.IF.8a Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context.

NETS*S Standards:
Students will demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students apply digital tools to gather, evaluate, and use information. Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources

Overview (a short summary of the lesson or unit including assignment or expected or possible products)

The unit is about the quadratic function and its applications in real life. It will be covered in five Lessons. Each lesson will last two ninety minute periods. The objectives of this unit is to enable students to:

- Write and solve quadratic equations representing real life situations.
- Investigate and describe the relationships among solutions of an equation, zeros of a function, x-intercepts of a graph, and factors of a polynomial expression.
- Investigate and analyze functions algebraically and graphically. Key concepts include a) Domain and range, including limited and discontinuous domains and ranges; b) zeros; c) x- and y-intercepts.

To promote differentiation, students will be given choices as to which mathematical process to use to solve quadratic problems. They will be able to use algebraic process, graphs, or tables to solve problems. In drawing graphs, students will be given more choices. They will be able to use a TI-83/84 graphing calculator, an online Desmos software, or Microsoft excel, or by hand. Ongoing formative assessments including two quizzes will be used to check for student understanding. Students will perform a summative assessment comprising two parts. The first is a project involving a catapult. Catapults were used in the past as weapons. In modern day, there are many applications for catapults such as the launching of aircrafts off the aircraft carriers. For this project, students will build a catapult that shoots baseballs as far as it can by applying projectile motion, quadratic functions, and trigonometry. The objective of these launches will be for students to explore how the launch angle of a catapult affects its initial velocity and how the latter in turn affects both the horizontal and vertical distances of the ball. Students will take measurements, present the measurements in a chart and draw graphs. At the end of the project, students will make a presentation using power point or video or screencast. The second part of the summative assessment is an authentic performance task requiring application of the skills they acquired in the unit. To differentiate, there will be two versions of varying difficulty. Students will be given choices as to which method (algebraic, hands-on, and/or visual) to use.
to arrive at a solution. Students will be continuously assessed to check for understanding. The instructional sequence will be as follows:

**Instructional Sequence**

- **Lesson 1**  Graphing quadratic equations
- **Lesson 2**  Solving quadratic equations by graphing
- **Lesson 3**  Solving quadratic equations by Factoring
- **Lesson 4**  Solving quadratic equations by completing the square
- **Lesson 5**  Applications of quadratic functions

**Essential Questions** (What essential question or learning are you addressing? What would students care or want to know about the topic? What are some questions to get students thinking about the topic or generate interest about the topic? Additionally, what questions can you ask students to help them focus on important aspects of the topic? (Guiding questions) What background or prior knowledge will you expect students to bring to this topic and build on?) Remember, essential questions are meant to guide the lesson by provoking inquiry. They should not be answered with a simple “yes” or “no” and should have many acceptable answers.

1. How is a relation determined to be quadratic?
2. How do I choose the most efficient method of solving quadratic equations?
3. How do the factors of a quadratic function yield the zeros for that function?
4. Where is the maximum or minimum value of a quadratic equation located?
5. How is the quadratic formula developed by completing the square?
6. How does the initial velocity of a launched object affect the horizontal and vertical heights of the object?
7. How does the angle of launch of a catapult affects the initial velocity of the tennis ball?
8. How do we determine the maximum height attained by a projectile?
9. How do we apply quadratic equations in real life?

**Assessment** (What will students do or produce to illustrate their learning? What can students do to generate new knowledge? How will you assess how students are progressing (formative assessment)? How will you assess what they produce or do? How will you differentiate products?) You must attach copies of your assessment and/or rubrics. Include these in your presentation as well.
Ongoing formative assessments including two quizzes will be used to check for student understanding. Other formative assessment strategies will include questionings, discussions, reflections, practice assignments, and exit tickets. Students will perform a summative assessment comprising two parts. The first is a project involving a catapult. For this project, students will assemble a catapult that shoots baseballs as far as it can by applying projectile motion, quadratic functions, and trigonometry. The objective of these launches will be for students to explore how the launch angle of a catapult affects its initial velocity and how the latter in turn affects both the horizontal and vertical distances of the ball. Students will take measurements, present the measurements in a chart and draw graphs. At the end of the project, students will make a presentation using power point or video or screencast. The second part of the summative assessment is an authentic performance task requiring an application of the skills they acquired in the unit. To differentiate, there will be two versions of varying difficulty. Students will be given choices as to which method (algebraic, hands-on, and visual) to use to arrive at a solution. Both the project and the Performance task will be scored using a rubric.

Resources (How does technology support student learning? What digital tools, and resources—online student tools, research sites, student handouts, tools, tutorials, templates, assessment rubrics, etc—help elucidate or explain the content or allow students to interact with the content? What previous technology skills should students have to complete this project?)

The three week lesson will require the students to use technology tools, hardware, and other resources.

Technology tools will include:

1. Directions for building catapult
2. A video camera and cell phone camera. Students will use these to make videos of baseball launches from the catapult, and for presentations.
3. Online tool Prezi and Power point for presentations.
4. Moodle, Manga high and Quizizz are online sites where I will have assignments and games posted for students to do.
5. Jing/Camtasia will allow students to screen cast while webcam and voice thread will allow them to make video presentations.
6. Desmos is an online tool that the students will have the option to use in creating graphs.
7. Microsoft excel for creating graphs and solving problems.

Hardware and other resources will include:

8. Catapult kit. In addition to the catapult, the kit also includes:
   a. Three rubber bands, 3 × 1/8 inches
   b. Table tennis (ping pong) ball
   c. Plastic ball with holes
   d. Clamp for attaching the catapult to a surface
9. Surface for mounting catapult (piece of wood on the floor, tabletop, etc.)
10. Optional: paper towels, dish towel, or other padding for protecting the mounting surface from being scratched by the attachment clamp
11. Open area for launching balls with bright lighting (either outside in direct sunlight, or inside with lots of lights)
12. Measuring tapes, Lab notebooks, stop watches
13. Project handout
14. Hard copies of authentic assessment
15. Hard copies of background information on catapults
16. Assessment rubrics
**Instructional Plan**

**Preparation** (What student needs, interests, and prior learning provide a foundation for this lesson? How can you find out if students have this foundation? What difficulties might students have?)

To be successful in this lesson, students will need to have basic knowledge related to the topic as well as basic technological skills. Students will have knowledge of evaluating functions, finding the greatest common factor, solving simple equations, knowledge of natural numbers, integers and fractions, patterns and basic algebra. Because Mathematics is a subject that builds on what is previously learned, students will have acquired this knowledge from preceding unit on polynomials. A diagnostic assessment will be administered to find out what they already know or need to know. The data I will obtain from this assessment will enable me to determine whether or not to include teaching prior knowledge content on the lesson plan.

Students will need to know how to surf the internet, and, have basic skills involving PowerPoints, spreadsheets, digital cameras, and screen casting. Students will need familiarity with the screen casting tool, Jing, Manga high, voice thread, Desmos, and TI-83 graphing calculators. All these skills will be taught to students before the commencement of the lesson.

Students might have difficult using spreadsheet to generate equations and graphs, or using the online tools, Jing and voice thread.

**Management** Describe the classroom management strategies will you use to manage your students and the use of digital tools and resources. How and where will your students work? (Small groups, whole group, individuals, classroom, lab, etc.) What strategies will you use to achieve equitable access to the Internet while completing this lesson? Describe what technical issues might arise during the Internet lesson and explain how you will resolve or trouble-shoot them? Please note: Trouble-shooting should occur prior to implementing the lesson as well as throughout the process. Be sure to indicate how you prepared for problems and work through the issues that occurred as you implemented and even after the lesson was completed.
The class for which the lesson is intended is my regular Algebra 2 class. I have had them since the beginning of the school year. My classroom management style is firmly based on a structured environment and set of expectations and/or procedures. From the onset of the school year, together we came up with a set of rules and procedures guiding acceptable and unacceptable behaviors. I made the students have a voice in formulating these rules so as to achieve a greater acceptability and compliance. Throughout the school year, I have been consistent in implementing these rules. I also built structure in to my lessons. My class commences with a warm up, followed by a warm up review and homework review. The opening activity is the next phase, then the work session, and finally the closure. In this lessons, as students complete one phase, they move to the next without any lapses of time. Thus, there is no time for slacking off. My students are very familiar with the established structure and always know what comes next. The same structure that I have built and the established expectations will be carried over to these lessons as well since they are the same students.

Seating arrangements will be in groups of four or five based on ability levels on the topic. Data will be obtained from formative assessments in the form of quizzes, discussions, observation, guided and practice work, and performance tasks. This seating arrangements will allow for collaboration and peer feedback. During small group instruction which will take place in the last forty of the ninety minutes of class, I will work with struggling students and those needing modifications like my diverse students and those with IEPs. From previous experience, I have noticed that frustrations and misbehaviors set in when students cannot do the given assignments. The small group instruction, the collaboration that will be taking place, and peer feedback will minimize frustrations and misbehaviors. Working with students in small groups will enhance the working relationship between the students and me. With closer relationships, I will achieve greater cooperation from my students.

The activities in this lesson will include completing the square using algebra tiles or online algebra tiles. They will create graphs using a graphing calculator, or the online tool-Desmos graphing calculator, or by hand. They will have a choice regarding which tool to use. They will play games and perform online assignments at Moodle, Mangahigh.com or Quizziz.com. These activities which will take place in the classroom are student centered, and will allow the students to take ownership of their own learning. The major activity, the project, is heavily student centered. It will require them to use webcam, digital cameras, cell phone cameras, screen casting tool Jing, and a catapult. The project which will take place outside of the classroom will involve kinesthetic and visual activities, and continuous communication amongst group members. These student centered activities will generate high student interest and participation.

My school has adopted a BYOD program. About eighty percent of students have school rented laptops that they keep with them always throughout the school year. The digital divide has been greatly minimized by this program. I will reserve a cart of laptops for those few students without their own devices. This lesson is a unit lesson that will span three weeks. I do not envisage any technical issue lasting for that length of time. The two problems that can happen are the internet or online websites mentioned above running down. I will make backup copies of online information they will need for the research on USBs before and throughout the lesson. I will also have in storage the same information in print that students can read. I will have available printed copies of online assignments. Presentations using screen casting will be substituted with power point presentations or videos. I will ensure that I have enough graphing calculators for all as a precaution against running down of the online site, desmos.com. The above stated provisions will be available from the beginning to end of the unit.

I will ensure that all the catapults are in good working condition. I will have two extra catapults already assembled in case of malfunctioning of any one or two.

**Instructional Strategies and Learning Activities** – Describe the research-based instructional strategies you will use with this lesson. How will your learning environment support these activities? What is your role? What are the students’ roles in the lesson? How can you ensure higher order thinking at the analysis, evaluation, or creativity levels of Bloom’s Taxonomy? How can the technology support your teaching? What authentic, relevant, and meaningful learning activities and tasks will your students complete? How will they build knowledge and skills? How will students use digital tools and resources to communicate and collaborate with each other and others? How will you facilitate the collaboration?
The activity is student centered. My role is to facilitate the successful execution of the project, a hands on activity in which students will collaborate, communicate and learn in a group setting. At the initial part of the lesson, before the project, students will investigate the historical and current applications of catapults. The students themselves will choose whether to use print media or internet resources from the media center for their investigations. Students will work in heterogeneous groups of four for collaboration to investigate the height of a of a tennis ball versus time through a series of launches of the ball from a catapult. A member of the group will make a video of the paths of the balls from the catapult through the air until it hits the ground. The choice of a tool for recording will be at the discretion of the students. From the experimental data, they will analyze the effect of the initial velocity of the ball on the horizontal distance travelled by the tennis ball. Initial velocity is varied by varying the launch angle of the catapult. Launch angle sizes will be at the discretion and creativity of the students. They will create graphs by hand, or by a graphing calculator, or by a spreadsheet, or by the online graphing tool, Desmos. The students will be responsible for making their own creative decisions as to which tool to use for the graphs. The students will analyze the graphs for the effect of time on the height of the ball from the ground. From the graphs, they will evaluate the vertex, x-intercept, and y-intercept of the graphs and relate these features to the maximum height of the ball in the air, the time when this occurs, and the time when the ball hits the ground. The final part of the project will be student presentations. They will have the option of using any one of the following tools: Jing for screen casting, Prezi, or PowerPoint for presentations, voice thread or webcam for video presentations.

**Differentiation** (How will you differentiate content and process to accommodate various learning styles and abilities? How will you help students learn independently and with others? How will you provide extensions and opportunities for enrichment? What assistive technologies will you need to provide?)

I teach Algebra 2 to students in grades ten to twelve. On the average, my class comprises sixty percent diverse learners and forty percent native English speakers. In addition to diversity, my students differ in their mode of learning. There are those cognitive learners who understand the lesson just from my modeling. They are able to analyze the characteristics of a quadratic function by converting a given equation from one form to another through algebraic processes of factorization or completing the square. But there are also those who are visual learners who find it difficult with these algebraic processes. To address their needs, I will explain the same concept using graphs, a visual approach. To facilitate learning for my kinesthetic learners, I will teach them how to use algebra tiles to complete the square. This is a hands-on activity. To further enhance the learning experiences of all my students, I will assign to them the catapult project. This is not only a hands-on activity, but one that will allow my visual learners to see at close hand, algebra in action. I use explicit vocabulary instruction, and technology incorporation to address the needs of my diverse learners. They will have the option to use any of the following tools that I will provide: graphing calculator, online Desmos calculator, and spreadsheet. My diverse learners will also benefit from the visual and kinesthetic approaches I will use. My classroom seating arrangement is always in groups of four or five except during testing times. I will use a homogenous seating approach based on how well they will perform on my formative assessments. This will allow for collaboration and peer feedback or peer tutoring. These are differentiation methods backed by research as effective strategies. To provide enrichment opportunities, I will create games at Manga high and Quizziz, online websites with games covering all subjects and grade levels. The project that they will perform also provides an excellent enrichment opportunity. For extension purposes, I will provide them with problem solving questions with connections to Economics and geometry and with a focus on mastery.

**Reflection** (Will there be a closing event? Will students be asked to reflect upon their work? Will students be asked to provide feedback on the assignment itself? What will be your process for answering the following questions?)

- Did students find the lesson meaningful and worth completing?
- In what ways was this lesson effective?
- What went well and why?
- What did not go well and why?
- How would you teach this lesson differently?)
I am exceedingly happy that in designing the unit lesson plan, I took certain characteristics of my students into consideration. Top on the list for such consideration were student interest, motivation, learning style, diversity and special needs.

I think that the approach that was adopted in this unit plan and implemented fully, created the highest level of interest in the students. Because of the student centered nature of the plan and the incorporation of the various differentiation strategies previously described, I think that the lesson was highly effective in imparting maximum benefits to the students and that the objectives of the plan were fully accomplished. I am content that in planning this lesson and in its implementation I completely deviated from the traditional teacher centered approach.

Very often students are not presented with why quadratic functions and equations are important, and why they need to be learned. The very first activity that the students performed, which involved making a research of the real life applications of quadratic functions as well as the very nature of the activities including the project, in my opinion, enabled the students to view the whole unit as meaningful, authentic and worth learning.

In this unit lesson plan in which the needs of diverse students were taken into account, and students were given choices, collaborated with each other, had the opportunity to work outside the classroom, and moved around, caused the students to be highly engaged so that classroom management was not an issue. With great classroom management and full participation from ninety eight percent of the students, the lessons proceeded very well. The only issue that arose were technical issues related to building the catapult. Fortunately, I was around to help overcome that issue since I had equipped myself with the technical skills in building catapults.

Even though I took the needs of diverse learners into consideration in designing and implementing this unit plan, I do not think that I incorporated all the strategies involving diversity. Perhaps if I have to redo the unit lesson over the changes that I think would be made will have to include making it more culturally responsive. To help me bring changes into the unit plan the next time around, I asked my students for their own reflections on the unit. I think asking them for their opinions as to what aspect of the whole unit inspired them the most or least, gave me more insight into what need to be changed to make future delivery of the unit most effective.

Since every lesson has closure, I believe that the closing activity of presentations by students on the project was very appropriate. I can still imagine how some of my students were trying hard to portray themselves as professional reporters. That was fun!

**Closure:** Anything else you would like to reflect upon regarding lessons learned and/or your experience with implementing this lesson. What advice would you give others if they were to implement the lesson? Please provide a quality reflection on your experience with this lesson and its implementation.

As a whole I can say that it was a great experience working with these students on the unit and particularly on the project. My great take way from the project is that students want to be active. As a teacher I will do better for my students by giving them more of such activities. I have heard many students say that Math is boring. This activity has shown me that Math may actually be the most active and interesting subject. As teachers, we just need to know how to deliver it.
Algebra 2, Quiz 2

You have a choice in the process and the product you create to help you answer the questions. You can use factoring to produce a factored form, or you may use completing the square to produce the vertex form of the equation, or you may produce a graph by hand, a TI-83 graphing calculator, a Desmos tool, or a spreadsheet to help you answer the questions.

1. If \( f(x) = 4x^2 + 14x - 8 \), find the:
   A. \( y \)-intercept.
   B. \( x \)-intercepts
   C. vertex
   D. axis of symmetry.

2. If \( y = \frac{3}{2}x + 3x + 12 \), Find:
   A. \( y \)-intercept
   B. \( x \)-intercept
   C. vertex
   D. Maximum Value
   E. axis of symmetry.

3. Complete the square of \( y = x^2 - 8x + 3 \) to find the vertex form \( y = a(x-h)^2 + k \)
4. Complete the square: \( y = x^2 + 4x + 9 \) to find the vertex

5. Find the minimum or maximum value of \( y = x^2 - 12x - 5 \)

**Quiz 1**

<table>
<thead>
<tr>
<th>Student Learning Tasks: Teacher Input</th>
<th>Student Activities: Possible Responses</th>
<th>Teacher's Support and Actions</th>
<th>Assessing the Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>The width of a rectangle is 5cm greater than its length. Could you write this in terms of ( x )?</td>
<td>( x + 5 )</td>
<td>I will: Get the students to draw a diagram of a suitable rectangle.</td>
<td>Do students extending their knowledge of quadratic equation?</td>
</tr>
<tr>
<td>If we know the area is equal to 36cm, write the information we know about this rectangle as an equation.</td>
<td>( A = (\text{length}) (\text{width})x (x + 5) )</td>
<td></td>
<td>Do students understand why ( x = -9 ) was a spurious solution?</td>
</tr>
<tr>
<td>Solve this equation.</td>
<td>( x^2 + 5x - 36 = 0 ) ( (x + 9)(x - 4) = 0 ) ( x = 9 ) or ( x = 4 ) ( (x + 9)(x - 4) = 0 ) True ( x = 4 ) ( (x - 4) = 0 ) True</td>
<td></td>
<td>Do students understand that saying ( x = 4 ) is not a sufficient answer to the question, but that it must be bought back into context of the question?</td>
</tr>
<tr>
<td>What is the length and width of the rectangle?</td>
<td>( x = 9 ) ( -9 ) ( x = 4 ) ( -9 + 9 ) ( x - 4 = 0 ) True ( x = 9 ) ( x - 4 ) = 0 True</td>
<td></td>
<td></td>
</tr>
<tr>
<td>» Is it sufficient to leave this question as ( x = 4 )?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Project Handout**

You have probably seen figures in your physics textbook that show a catapult launching a projectile and then equations that calculate the resulting trajectory. Well, it is a lot more fun if you actually get to use a catapult instead of just doing the calculations! In this science project, you will use a catapult to launch
ping-pong balls and use a video camera to film their trajectory, or path, as they fly through the air. You can also use physics to predict the trajectory of the ball, and then compare this predicted trajectory to the one you measure from video recordings. If the results match, you can conclude that your predictions and the assumptions you used to make them were valid under the circumstances of the test. If they don't match exactly, that's OK. There are many real-world factors that can be difficult to account for in predictions. Part of the scientific process involves figuring out what those factors are so you can make better predictions next time.

Remember your goal is to calculate the initial velocity of the ball. The Equation of the horizontal distance \( X \) travelled by a ball launched from a catapult is given by:

\[
X(t) = V_0 \cos(\theta) \ t \quad \text{where} \quad t \text{ is time in seconds,} \quad V_0 \text{ is initial velocity, and} \quad \theta \text{ is the launch angle.}
\]

The height \( Y \), of the ball from the ground at any time \( t \), is given by:

\[
Y(t) = h + V_0 \ (\theta) \ t - \frac{1}{2}gt^2 \quad \text{where} \quad g \text{ is the acceleration due to gravity and} \quad h \text{ is the height of the baseball above ground.}
\]

You will do the following:

1. You will make 5 launches at different launch angles.
2. You will measure the horizontal distance travelled and the time it takes the ball to hit the ground each time.
3. You will calculate the initial velocity each time using the equation \( x(t) = V_0 \cos(\theta) \ t \) by making \( V_0 \) the subject of the formula, and plot the following graphs:
   i. Initial velocity vs Launch angle
   ii. Horizontal distance vs initial velocity,
   iii. Height vs Initial velocity, and
   iv. Height vs time

You will answer the following questions:

4. How does initial velocity change with launch angle?
5. How does the horizontal distance travelled by the baseball change with initial velocity?
6. How does height of the ball above ground change with initial velocity?
7. How does height of the baseball change with time?
8. You will make a presentation of your findings.
The catapult with all of its parts labeled. The rubber-band-powered catapult is clamped to a table (we used a paper towel to prevent it from scratching the surface). An aluminum disk with tick marks lets students measure the launch-angle and pull-back angle easily.
**FINAL ASSESSMENT Version A**

**“Rocket in Flight” Authentic Task**

Homer H. Hickam Jr. is a coal miner’s son, who lived in West Virginia during the 1950s. After the Russians launched the Sputnik satellite, Homer was inspired to learn about model rocketry. After many tries, Homer and his friends discovered how to launch and control the flight path of their model rockets. Homer went on to college and then worked for NASA.

Cooper is a model rocket fan. Cooper’s model rockets have single engines and, when launched, can rise as high as 1000 ft. depending upon the engine size. After the engine is ignited, it will burn for 3–5 seconds and the rocket will accelerate upward. Once the engine burns out, the rocket will be in free fall, because the only acceleration is due to gravity. The rocket has a parachute that will open as the rocket begins to fall back to Earth. Cooper wanted to track one of his rockets, the Eagle, so that he investigate its time and height while in flight. He installed a device into the nose of the Eagle to measure the time and height of the rocket as it fell back to Earth. The device started measuring when the parachute opened. The data for one flight of the Eagle is shown in the table below.

<table>
<thead>
<tr>
<th>Time Since Parachute Opened (seconds)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (feet)</td>
<td>625</td>
<td>618</td>
<td>597</td>
<td>562</td>
<td>513</td>
<td>450</td>
<td>373</td>
<td>282</td>
<td>177</td>
<td>58</td>
</tr>
</tbody>
</table>

1. Use the data in the table above. Determine whether the height of the Eagle can be modeled by a linear function of time. Explain your reasoning.

2. Create a graph of the data. (by hand, or by a ti-83 calculator, or by Desmos software, or by Microsoft Excel)

3. Write a quadratic function for the height of the eagle above ground level versus time.

4. Use the function from Item 3 to answer these questions.
   
   a. At what time was the rocket’s height 450 ft above Earth? Verify that your result agrees with the data in the table.

   b. After the parachute opened, how long did it take for the rocket to hit Earth?

Cooper wanted to investigate the flight of a rocket from the time the engine burns out until the rocket lands. He set a device in a second rocket, named Spirit, to begin collecting data the moment the engine shut off. Unfortunately, the parachute failed to open. When the rocket began to descend it was in free fall.

5. Graph the data for the height of the Spirit versus time on the grid.
The Spirit

<table>
<thead>
<tr>
<th>Time since the engine burned out (s)</th>
<th>Height (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>512</td>
</tr>
<tr>
<td>1</td>
<td>560</td>
</tr>
<tr>
<td>2</td>
<td>576</td>
</tr>
<tr>
<td>3</td>
<td>560</td>
</tr>
<tr>
<td>4</td>
<td>512</td>
</tr>
<tr>
<td>5</td>
<td>432</td>
</tr>
<tr>
<td>6</td>
<td>320</td>
</tr>
</tbody>
</table>

6. Use the table and graph in Item 5.
   a. How high was the Spirit when the engine burned out?
   b. How long did it take the rocket to reach its maximum height after the engine cut out?
   c. Estimate the time the rocket was in free fall before it reached the earth.

7. Use the table and graph in Item 5.
   a. Write a quadratic $h(t)$ function for the data.
   b. Sketch the graph of the function on the grid in Item 5.

8. Use the function found in Item 7 to verify the height of the Spirit when the engine burned out.
9. Graph the function found in Item 7 on your graphing calculator. Use the graph to approximate the time interval in which the Spirit was in free fall. Explain how you determined your answer.
10. What was the total time that the Spirit was in the air after the engine burned? Factor the equation you found in 7 above or set that equation equal to zero and complete the square.
Homer H. Hickam Jr. is a coal miner’s son, who lived in West Virginia during the 1950s. After the Russians launched the Sputnik satellite, Homer was inspired to learn about model rocketry. After many tries, Homer and his friends discovered how to launch and control the flight path of their model rockets. Homer went on to college and then worked for NASA.

Cooper is a model rocket fan. Cooper’s model rockets have single engines and, when launched, can rise as high as 1000 ft depending upon the engine size. After the engine is ignited, it will burn for 3–5 seconds and the rocket will accelerate upward. Once the engine burns out, the rocket will be in free fall, because the only acceleration is due to gravity. The rocket has a parachute that will open as the rocket begins to fall back to Earth. Cooper wanted to track one of his rockets, the Eagle, so that he investigate its time and height while in flight. He installed a device into the nose of the Eagle to measure the time and height of the rocket as it fell back to Earth. The device started measuring when the parachute opened. The data for one flight of the Eagle is shown in the table below.

<table>
<thead>
<tr>
<th>Time Since Parachute Opened (seconds)</th>
<th>Height (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>625</td>
</tr>
<tr>
<td>1</td>
<td>618</td>
</tr>
<tr>
<td>2</td>
<td>597</td>
</tr>
<tr>
<td>3</td>
<td>562</td>
</tr>
<tr>
<td>4</td>
<td>513</td>
</tr>
<tr>
<td>5</td>
<td>450</td>
</tr>
<tr>
<td>6</td>
<td>373</td>
</tr>
<tr>
<td>7</td>
<td>282</td>
</tr>
<tr>
<td>8</td>
<td>177</td>
</tr>
<tr>
<td>9</td>
<td>58</td>
</tr>
</tbody>
</table>

1. The data in the table above. Determine whether the height of the *Eagle* can be modeled by a linear function of time. Explain your reasoning.

2. Create a graph of the data. (by hand, or by a TI-83 calculator, or by Desmos software, or by Microsoft Excel)

3. The height of the *Eagle* can be modeled by the quadratic function \( h(t) = kt^2 + h_0 \), where \( k \) is a constant and \( h_0 \) is the initial height of the rocket. You can use the table data to find the values of \( k \) and \( h_0 \) in the *Eagle*’s height function.

   **a.** Solve for the value of \( h_0 \) using the point \((0, 625)\). Include the appropriate units for \( h_0 \) in your solution.

   **b.** Use a different ordered pair from the table above Item 1 to find the value of \( k \). Write a function for the height of the rocket as a function of time.

4. Use the function from Item 3 to answer these questions.
a. At what time was the rocket’s height 450 ft above Earth? Verify that your result agrees with the data in the table.

b. After the parachute opened, how long did it take for the rocket to hit Earth?

Cooper wanted to investigate the flight of a rocket from the time the engine burns out until the rocket lands. He set a device in a second rocket, named Spirit, to begin collecting data the moment the engine shut off. Unfortunately, the parachute failed to open. When the rocket began to descend it was in free fall.

5. Graph the data for the height of the Spirit versus time on the grid

<table>
<thead>
<tr>
<th>Time since the engine burned out (s)</th>
<th>Height (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>512</td>
</tr>
<tr>
<td>1</td>
<td>560</td>
</tr>
<tr>
<td>2</td>
<td>576</td>
</tr>
<tr>
<td>3</td>
<td>560</td>
</tr>
<tr>
<td>4</td>
<td>512</td>
</tr>
<tr>
<td>5</td>
<td>432</td>
</tr>
<tr>
<td>6</td>
<td>320</td>
</tr>
</tbody>
</table>

5. Use the table and graph in Item 5.

d. How high was the Spirit when the engine burned out?

e. How long did it take the rocket to reach its maximum height after the engine cut out?

f. Estimate the time the rocket was in free fall before it reached the earth.

6. Use the table and graph in Item 5.

c. **Write** a quadratic \( h(t) \) function for the data.

d. Sketch the graph of the function on the grid in Item 5.

7. Given that the function of the table in item 5 above is \( h(t) = -16t^2 + 64t + 512 \),
Find the height when the time elapsed is 7 seconds.

8. Use the function found in Item 7 to verify the height of the *Spirit* when the engine burned out.

9. Graph the function found in Item 7 on your graphing calculator. Use the graph to approximate the time interval in which the Spirit was in free fall. Explain how you determined your answer.

10. What was the total time that the Spirit was in the air after the engine burned? Factor the equation you found in 7 above. Alternatively, set that equation equal to zero and complete the square.

---

### Final Assessment Rubric

<table>
<thead>
<tr>
<th>Part two</th>
<th>Rubric</th>
</tr>
</thead>
<tbody>
<tr>
<td>**Question #</td>
<td>3 pts</td>
</tr>
<tr>
<td>1</td>
<td>Students response reveals low analytic skills and lack of understanding of linear and quadratic patterns</td>
</tr>
<tr>
<td>2</td>
<td>Students creates low quality graph with incorrect labeling of axes</td>
</tr>
<tr>
<td>3</td>
<td>Student incorrectly writes the function and shows some understanding of the process</td>
</tr>
<tr>
<td>4</td>
<td>Student’s response is incorrect in both subsections but shows some understanding of concept</td>
</tr>
<tr>
<td>5</td>
<td>Students creates low quality graph with incorrect labeling of axes</td>
</tr>
<tr>
<td>6</td>
<td>Student’s response is correct in only one subsection and shows some understanding of concept</td>
</tr>
</tbody>
</table>
| Catapult Project Scoring Rubric  
**Eric Williams** |
|---|

<table>
<thead>
<tr>
<th><strong>25 points</strong></th>
<th><strong>19 points</strong></th>
<th><strong>12 points</strong></th>
<th><strong>7 points</strong></th>
</tr>
</thead>
</table>
| **Use of Time & Initiative**  
25 points possible  
You used your time effectively, and researched thoroughly and a great deal of care and effort is displayed in the project. The project shows that you carefully & thoughtfully made decisions while building/designing  
You worked well and completed the project, but with a little more effort it could have been outstanding.  
You finished the project, but it could have been improved with more effort and a more productive use of time. It appears that you made decisions randomly.  
The project was completed with a minimum of effort and care. Your time could have been spent more effectively.  
**Quality of Work**  
25 points possible  
The implementation of the project requirements was impressive and well done. A strong understanding of project details was demonstrated (how catapults work, how the process works, etc.).  
With a little more effort, the project could have been outstanding. Your work shows an understanding of requirements but lacks the extra panache.  
You showed average craftsmanship and applied catapult methodology with little care. Work is adequate, but not as good as it could have been – a bit careless.  
You showed below average craftsmanship and a lack of pride in the finished work. |
multiple launches without breaking or losing pieces, chose projectile wisely, etc).

<table>
<thead>
<tr>
<th>Fulfills Objectives 25 points possible</th>
<th>The project met or exceeded all requirements of the assignment excellently.</th>
<th>The project satisfactorily met all requirements of the assignment.</th>
<th>The project only fulfilled the minimal objectives of the assignment.</th>
<th>The project only partly fulfilled the objectives of the assignment.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report 25 points possible</td>
<td>The content of your report is detailed and significant. You thoroughly explored catapults, the history of the weapon, made connections to other Medieval topics such as warfare, and presented your report in a neat and orderly fashion.</td>
<td>The content of your report is meaningful. The report shows that you applied the basic skills of researching / writing effectively; showed an awareness of the project requirements.</td>
<td>You did the report adequately, yet it shows a lack of planning and little evidence that the overall report was thought out and researched.</td>
<td>Your project shows little evidence of thought regarding content and the necessary report requirements.</td>
</tr>
</tbody>
</table>