Data

Juno Spacecraft Launch: August 5, 2011 @ 12:25:00PM - Cape Canaveral

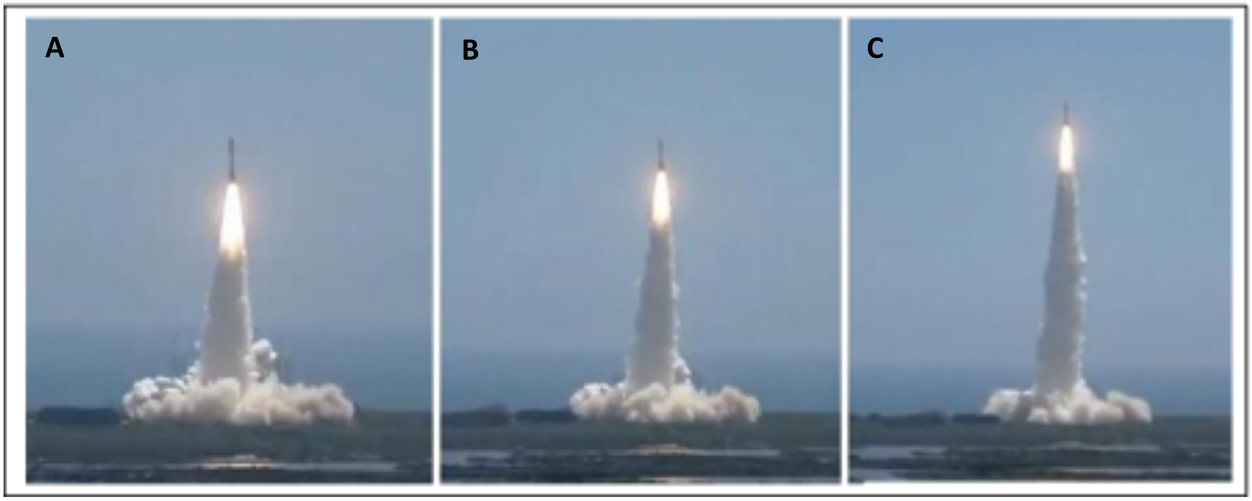

Image A → t = 21 seconds after launch (normal zoom)
Image B → t = 23 seconds after launch (zoomed out - same zoom as image C)
Image A → t = 25 seconds after launch (zoomed out - same zoom as image B)

Rocket Length = 45 meters

How does the data serve as an engaging context for the math concept?

Teaching kinematics in an algebra-based physics class requires the calculation of physical quantities such as distance, time, velocity, and acceleration. It is one thing to create a problem that simulates the motion of a given object, and another to provide real data with real life implications such as the example shown here. The images can be used to determine quantities relating to the motion of the rocket. The activity can be taken further to consider the required velocity of the spacecraft to successfully orbit Jupiter.

For this activity, students will solve both linear and quadratic equations to determine unknown quantities. To make sense of the images and gather useful information, the students must first create a scale for each image based upon the known length of the rocket.

What are the measurable objectives of the activity?

Students will determine:

1) The distance the rocket traveled from t = 0s to t = 21s
2) The distance the rocket traveled from t = 21s to t = 23s
3) The distance the rocket traveled from t = 23s to t = 25s
4) The average velocity of the rocket from t = 0s to t = 21s
5) The average velocity of the rocket from t = 21s to t = 23s
6) The average velocity of the rocket from t = 23s to t = 25s
7) The average acceleration of the rocket from t = 0s to t = 21s
8) The average acceleration of the rocket from t = 21s to t = 23s
9) The average acceleration of the rocket from t = 23s to t = 25s

Common Core State Standards - Math

- CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
- CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.
- CCSS.MATH.PRACTICE.MP4 Model with mathematics.
- CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically.
- CCSS.MATH.CONTENT.HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- CCSS.MATH.CONTENT.HSN.VM.A.1 Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes.
- CCSS.MATH.CONTENT.HSN.VM.A.3 Solve problems involving velocity and other quantities that can be represented by vectors.
- CCSS.MATH.CONTENT.HSN.VM.B.4 Add and subtract vectors.
- CCSS.MATH.CONTENT.HSN.VM.B.5 Multiply a vector by a scalar.
- CCSS.MATH.CONTENT.HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.
- CCSS.MATH.CONTENT.HSA.APR.A.1 Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.
- CCSS.MATH.CONTENT.HSA.CED.A.1 Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.*
- CCSS.MATH.CONTENT.HSA.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
- CCSS.MATH.CONTENT.HSA.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
- CCSS.MATH.CONTENT.HSA.REI.A.1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.
- CCSS.MATH.CONTENT.HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.
- CCSS.MATH.CONTENT.HSA.REI.B.4 Solve quadratic equations in one variable.
- CCSS.MATH.CONTENT.HSF.LE.A.1 Distinguish between situations that can be modeled with linear functions and with exponential functions.
- CCSS.MATH.CONTENT.HSF.LE.B.5 Interpret the parameters in a linear or exponential function in terms of a context.

Evidence regarding the use of data in the classroom

As I am not currently teaching in the traditional classroom and schools in my district have just finished classes I was not able to use this specific activity with students. However, I can speak about student understanding that was gained using a few similar examples.

Like the activity featured in this assignment, I once took a video of a subway car entering and exiting a subway station in New York City where I was teaching. I measured the length of the subway car windows next time I was in a similar train, and the time for each frame on the camera was known. As such, I was able to project the video on the whiteboard and move the video frame by frame for the students to create a length scale and take data on the train's motion.

The students were incredibly engaged by this activity. They talked about taking their own videos of things and I eventually turned that idea into an assignment of it's own. Student understanding was enhanced - this was shown by the excellent problem solving that was demonstrated when they turned in their own video projects.

I can only guess that the increased engagement and competence with the material was a function of the activity and project featuring something that was known to the students. All of my students had ridden in a subway car at some point in their lives. As such, they spoke about the inertial effects of the acceleration when the car was speeding up and slowing down. That connection to something that is familiar made the content more valuable to them.

The Juno Spacecraft launch data is not as familiar to students as I don't know any students who have been in a rocket! However, the notion that something really happened and was not made up by the teacher makes a big difference to students.

I have also videoed a ball being dropped from the ceiling with a measuring tape in the background and done something similar in asking the students to take position and time data to determine the average velocity over small intervals and use those velocities to calculate the average acceleration. The acceleration due to gravity of a freely falling object (in the absence of air resistance) is a known quantity. When students are able to make that calculation themselves, using physical and algebraic principals the knowledge sticks. In the past, I had used a motion sensor to capture that data and show it to the students that the acceleration is constant and near (can't exclude air resistance in the classroom) the expected value - the information was not retained nearly as well. Not only are you allowing students to take ownership of the knowledge, but you are also requiring that they practice the necessary physics and algebra themselves. That process helps to cement the concepts and problem solving skills in such a way that students become more comfortable those tasks. This is particularly important when studying high school physics because kinematics is the first thing that is taught in most physics curricula and it is then used throughout the remainder of the year. As such, it is incredibly important that they are familiar with solving motion problems.