Lesson Title: The Launch of The New Shepard Mission to Space

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Topic: Functions / Data Analysis

Targeted Grade Level: 8th grade

Time Needed: 3 days

Subject Integration:

- Math - Collection, graphing, analalying, and interpreting data from rocket launch. Describe qualitatively the functional relationship between two quantities by analyzing a graph. Comparison of data from various graphs.
- Science - Authentic data integration from space launch data including speed/velocity and altitude, along with discussion of advances in space exploration. Students will calculate the force needed to launch the New Shepherd launch using the formula for Newton's 2nd Law.
- Engineering - engineering careers (mechanical, aerospace, chemical, materials). Also compare data from rocket launches of different designs.
- ELA - Conduct short research projects to answer a question (including self-generated questions), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
- Social Studies - timeline of evolution and history behind rocket development and design.

Justification:

- **Math** - This lesson is designed to be implemented within an 8th grade math classroom with functions & data analysis as the focal point. Students will collect authentic data from the New Shepard NS-18 Mission via a LIVE Webcast recording. From there, students will graph the data and describe the functional relationship between two quantities by analyzing a graph and describe what it means. Students will have an opportunity to compare similar data from the LADEE launch to the moon from September 6, 2013.
- **Science** - by utilizing data from an authentic source and event they watched LIVE will give these students an opportunity to see relevance in what they are learning and how it is utilized in a real world setting. Students will be exposed to various science concepts including space exploration and processes, Newton's Law, the Karman Line,

The flight profile references a few key points within the flight: Liftoff, MAXQ, MECO (main engine cutoff), Separation, Zero G, Karman, APOGEE) which are also referenced in the LIVE launch recording.

- **Engineering** - students will be exposed to roles that engineering design plays into the history of space exploration. The video discusses rocket design and functionality in the mission. Students will have an opportunity to explore various engineering careers involved in space exploration and rocket design including mechanical, aerospace, chemical and materials.
- **ELA** - Students will conduct a short research extension to answer a self-generated question prompted by an observation or inquiry of a classmate.
- **Social Studies** - Students will be exposed to and have the opportunity to explore the evolution and history behind rocket development and design and create a timeline of what they consider to be milestones in history of rocket development.

Standards:

NGSS Performance Expectations: MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. (Grades 6-8)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. ● Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be	**PS2.A: Forces and Motion** ● The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. ● All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame	**Stability and Change** ● Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. Additional Concepts: Patterns: ● Graphs, charts, and images can be used to identify patterns in data.

recorded, and how many data are needed to support a claim. - ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** ● Science knowledge is based upon logical and conceptual connections between evidence and explanations. Additional Practices: Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. ● Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and non-linear relationships. Mathematical and computational thinking at the 6-8 level builds on K-5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. ● Apply mathematical concepts and/or processes (such as ratio, rate, percent,	and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.	● Patterns in rates of change and other numerical relationships can provide information about natural systems.

basic operations, and simple algebra) to scientific and engineering questions and problems.		

Common Core State Standards:

Math:

- CCSS.MATH.PRACTICE.MP4 - Model with mathematics.
- CCSS.MATH.PRACTICE.MP2 - Reason abstractly and quantitatively.
- CCSS.MATH.CONTENT.8.F.B.5 - Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

ELA:

- WHST.6-8.7 - Conduct short research projects to answer a question (including self-generated questions), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

ITEEA Standards

Transportation vehicles are made up of subsystems, such as structural propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively. (Grades 6 - 8)

Other Standards *(as needed)*

Measurable Student Learning Objectives:

- Students will be able to collect data from an authentic source.
- Students will be able to display data in a way that exhibits the relationship between various quantities.
- Students will be able to analyze data and establish connections between variables – reason abstractly and quantitatively
- Students will be able to extend their understanding of a topic through research based on their own inquiries.

Nature of STEM:

- **Nature of Mathematics** - The 4th CCSS Mathematical Practice - ***Model with Mathematics*** asks students to apply their mathematical knowledge to real-world situations. Also the 2nd CCSS Mathematical Practice - ***Reason Abstractly and Quantitatively*** asks students to make sense of quantities and their relationships in problem situations. In this lesson, students will be tasked with collecting, analyzing, and interpreting authentic data from a modern day rocket launch.
- **Nature of Science** - In Appendix H of the Next Generation Science Standards, it states that "Scientific Knowledge is Based on Empirical Evidence" which means that science is based upon logical and conceptual connections between evidence and explanations. The use of this authentic data will help students to make that connection between real-time evidence collected and making sense of what they are observing. It also states that "students should develop an understanding of the enterprise of science as a whole - the wondering, investigating, questioning, data collecting and analyzing" which will often require quantitative data and mathematical computation of data. In this lesson, students will be involved in authentic data collection and analyzing to see firsthand comparisons between rocket launches and how they compare and why.
- **Nature of Engineering** - Students will observe, compare performance of rockets of different resign and purpose. Students will have an opportunity to look into engineering careers associated with space exploration.
- **Nature of Technology** - As stated in the Standards for Technology Literacy: Content for the Study of Technology, "Technology is closely linked to creativity, which has resulted in innovation". Students are looking at how technology has impacted the evolution and development of space exploration to current opportunities in space tourism.

Engaging Context/Phenomena:

Students will watch the October 13, 2021 New Shepard Mission NS-18 LIVE Webcast - **https://www.youtube.com/watch?v=uEhdIIor-do**. (Launch begins at about 2:23:00 into the video).

This particular launch gained a lot of media attention as it was the second successful crewed spaceflight designed for space tourism. Aboard this flight was Canadian actor, William Shatner, who famously played Capt. Kirk in the original "Star Trek" television series, is now the oldest person to fly into space, at 90.

Data Integration: Students will be collecting and analyzing data in this lesson. Students will be collecting authentic launch data from the recent New Shepard Mission launched by Blue Origin on October 13, 2021 that was streamed LIVE via Webcast at **https://www.youtube.com/watch?v=uEhdIIor-do**. Students will graph the data, calculate the slope/rate of change, interpret the data and share what it represents (vertical speed of the rocket, horizontal speed of the rocket, and average acceleration of the rocket). Also, students will use the newly calculated horizontal and vertical speeds along with their knowledge of the Pythagorean Theorem to find the total speed of the rocket. Students will also be provided with real data from the LADEE (Lunar Atmosphere and Dust Environment Explorer) launch to the moon from September of 2013 to analyze in a similar way as the New Shepard Mission. The data for the LADEE launch is provided from The SpaceMath@NASA assignment, **The Launch of LADEE to the Moon** which inspired the tasks for using the New Shepard Data.

Differentiation of Instruction: There are a few places within the lesson that can be differentiated for different learners.

- During the data collection phase students will be collecting authentic data from a prerecorded LIVe webcast of the New Shepard launch where they will need to stop the video at 10 second intervals to collect data, but this could be differentiated by providing an Edpuzzle that stops the video at the appropriate time to ensure proper data collection or even have the data provided for students on the chart already for students who may struggle with this task.
- Students will be asked to create graphs of the data to analyze. Some students struggle with setting up their graphs properly. This could be differentiated by having the graph set up for them to plot their data on before analysis.

- Students will be asked to research a topic further based on their own inquiry at the end of the lesson. This could be differentiated by providing teacher generated topics ahead of time for students to choose from.

Real-life Connection: This assignment will utilize authentic data from a LIVE rocket launch watched together in class. Students will see firsthand where space has advanced to during modern times. Students will get an opportunity to extend their learning through an inquiry-based extension activity driven by student curiosity that focuses on student-generated questions which are then used as an anchor for further exploration / learning.

Possible Misconceptions:

- Students may assume that graphs would be linear. Are there any previous ideas or thoughts you anticipate students having about this concept? List them here as it will help you consider ideas to include in your lesson.

Lesson Procedure:

5E Model	5E Objectives
Engage *Introduce the lesson with an anchoring phenomenon. Facilitate student questions, discussion, etc. as appropriate. Learn about what students already know and want to know.*	**Procedure:** 1. Students will watch the October 13, 2021 New Shepard Mission NS-18 LIVE Webcast - https://www.youtube.com/watch?v=uEhdIlor-do. (Launch begins at about 2:23:00 into the video). This particular launch gained a lot of media attention as it was the second successful crewed spaceflight designed for space tourism. Aboard this flight was Canadian actor, William Shatner, who famously played Capt. Kirk in the original “Star Trek” television series, is now the oldest person to fly into space, at 90. 2. Teacher will stop the video at different points to draw students attention to different concepts throughout the video. For example, during the Flight model to discuss how the launch will operate and the different phases that will occur. This will be helpful for students to understand what they are watching during the actual launch and during the data collection

	phase later in the lesson. Other science/ vocabulary concepts the teacher may want to draw attention to would be **Modifications:** 1. To ensure students' understanding of what they are watching, the teacher will facilitate a class discussion while watching the video that addresses some key concepts, diagrams, & launch procedures. The teacher will ask the students to recall prior knowledge about what they know about space exploration, Karman Line, launch procedures & traditions. The flight profile references a few key points within the flight: Liftoff, MAXQ, MECO (main engine cutoff), Separation, Zero G, Karman, APOGEE). Draw attention to diagrams demonstrating launch path & live data tracking during launch including velocity & altitude. During data collection, students will need to pay close attention to the following o the video: Velocity, Altitude, and time (T+). 2. For students learning on a virtual platform, the teacher could create a screencastify or Edpuzzle video that includes clarification and focus drawn to key points in the launch video. **Standards Addressed** ● **ITEEA** - Transportation vehicles are made up of subsystems, such as structural propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively. (Grades 6 - 8) **Formative/Summative Assessments:** ● Observations made during class discussion. Topics and questions that arise during this time can be addressed by the teacher or noted as possible extension topics to be utilized at the end of the lesson. **Resources:** ● **https://youtu.be/uEhdIIor-do** - October 13, 2021 LIVE Stream launch of Blue Origin's New Shepard

	● https://www.nasaspaceflight.com/2018/07/blue-origin-new-shepard-nine-test/ - New Shepard Flight Profile
Explore *Plan for students to engage in hands-on activities that are designed to facilitate conceptual change.*	**Procedure:** 1. Students will work through **The Launch of New Shepard Mission to Space** activity. a. Teacher will read through the background information about the New Shepard NS-18 Mission Launch aloud with the students. b. Students will utilize the New Shepard Mission launched by Blue Origin on October 13, 2021 Replay that was streamed LIVE via Webcast at **https://www.youtube.com/watch?v=uEhdIlor-do**. While watching, they will collect real-time launch data about the altitude & velocity on the chart provided. (Teacher note: due to the speed of the rocket launch, the student collected data may vary from student to student due to when the video is paused. To avoid this, a teacher created Edpuzzle video designed to stop the video every 10 seconds could be utilized to ensure all students have consistent and accurate data, or the data could be provided on the worksheet upfront). c. Using the collected data, students will graph, analyze, and interpret the information to make connections and describe the functional relationship between quantities. Students will compare the rate of change in the altitude and the time to represent the vertical speed of the launch. Students will also compare the speed of the rocket over time to determine the average acceleration. d. Using the data, students will calculate the force needed for the launch during the formula for Newton's Second Law. **Modifications:** ● For some students, being able to collect data from the video may be difficult in terms of stopping the video at various points. For this reason, a teacher created Edpuzzle video designed to stop the video every 10 seconds could be utilized to ensure all students have consistent and accurate data, or the data could be provided on the worksheet upfront.

	Standards Addressed: ● CCSS.MATH.PRACTICE.MP4 - Model with mathematics. ● CCSS.MATH.CONTENT.8.F.B.5 - Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally. ● NGSS.MS-PS2-2 - Plan and investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. ○ PS2.A: Forces and Motion ■ The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. ■ All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. **Formative/Summative Assessments:** ● Problems 1-4 of **The Launch of New Shepard Mission to Space** activity. **Resources:** ● **The Launch of New Shepard Mission to Space** student activity handout. ● New Shepard Mission launched by Blue Origin on October 13, 2021 Replay that was streamed LIVE via Webcast at **https://www.youtube.com/watch?v=uEhdIlor-do**.

Explain *Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts.*	**Procedure:** 1. Students will then discuss their findings with other students in the class and make any modifications to their findings as a result of their Think-Pair-Share. 2. Class discussion will follow allowing students/groups to share their findings and address any misconceptions. **Modifications:** ● The teacher may want to have planned questions to ask about the analysis of the data. For example: ○ Is the relationship a functional relationship? Why or why not? ○ Is the relationship linear or nonlinear? What are contributing factors for the graph to be this way? **Standards Addressed:** ● CCSS.MATH.PRACTICE.MP4 - Model with mathematics. ● CCSS.MATH.PRACTICE.MP2 - Reason abstractly and quantitatively. ● CCSS.MATH.CONTENT.8.F.B.5 - Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally. ● NGSS.MS-PS2-2 - Plan and investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. ○ PS2.A: Forces and Motion ■ The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. ■ All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

	Formative/Summative Assessments: ● Problems 1-4 of **The Launch of New Shepard Mission to Space** activity. ● Class Discussion. **Resources:** ● **The Launch of New Shepard Mission to Space** student activity handout.
Elaborate *Provide applications of concepts and opportunities to challenge and deep ideas; build on or extend understanding and skills.*	**Procedure:** 1. Students will work through **The Launch of LADEE to the Moon** activity. a. Teacher will read through the background information about the LADEE launch aloud with the students. b. Using the collected data, students will graph, analyze, and interpret the information to make connections and describe the functional relationship between quantities. Students will compare the rate of change in the altitude and the time to represent the vertical speed of the launch. Students will also compare the speed of the rocket over time to determine the average acceleration. **Modifications:** ● This part of the lesson could be modified or differentiated if needed due to ability level or students or time allotment. The completed graphs could already be provided for students of the LADEE launch in order to go straight to the analysis and comparison of the two launches. **Standards Addressed:** ● CCSS.MATH.PRACTICE.MP4 - Model with mathematics. ● CCSS.MATH.CONTENT.8.F.B.5 - Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing,

	linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally. **Formative/Summative Assessments:** ● Problems 1-3 of **The Launch of LADEE to the Moon** activity. ● Class discussion of the comparison and interpretation between the two launches. **Resources:** ● **The Launch of New Shepard Mission to Space** student activity handout. ● **The Launch of LADEE to the Moon** activity - The Launch of LADEE to the Moon - https://spacemath.gsfc.nasa.gov/weekly/10Page66.pd, from **Space Math @NASA, https://spacemath.gsfc.nasa.gov/**
Evaluate *Assess students knowledge, skills and abilities.*	**Procedure:** ● Students will then compare their finding from the LADEE launch with their finding from the New Shepard launch and draw conclusions about their vertical speed and average acceleration between the two different launches. ● Lead students through discussion as to why the differences in the two launches exist. (For example, the average acceleration of the LADEE rocket is about '6 Gs' which would be very unpleasant for humans if it had been a manned flight). **Modifications:** ● Teacher developed questions to guide class discussion. For example: ○ How do the vertical speed ofthe 2 launches compare? ○ How do the graphs compare? What may have caused this? ○ How do the slopes of the accelerations of ricket compare? ○ How might the design or purpose for each rocket influence their differences? **Standards Addressed:**

	● CCSS.MATH.PRACTICE.MP4 - Model with mathematics. ● CCSS.MATH.PRACTICE.MP2 - Reason abstractly and quantitatively. ● CCSS.MATH.CONTENT.8.F.B.5 - Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally. **Formative/Summative Assessments:** ● Class discussion of the comparison and interpretation between the two launches. **Resources:** ● The Launch of New Shepard Mission to Space student activity handout. ● The Launch of LADEE to the Moon activity - The Launch of LADEE to the Moon - https://spacemath.gsfc.nasa.gov/weekly/10Page66.pd, from **Space Math @NASA, https://spacemath.gsfc.nasa.gov/**
Extend / Elaborate / Evaluate II	**Procedure:** 1. Students will get an opportunity to utilize their knowledge obtained in the activity to extend their learning through an inquiry-based research study that is driven by student curiosity and directed by student-generated questions which are then used as an anchor for further exploration/learning. a. Students will be given a **K-W-L chart** to organize and focus their ideas for extension activity. They will begin by listing things they have learned in this activity in the "KNOW" portion of the K-W-L chart.

	b. Students will then jot down questions they have in the “WHAT” sections of their K-W-L chart describing “What do you want to know about this topic?” Students can share their questions with their classmates using the “Think-Pair-Share” strategy. c. The teacher will then have pairs of students share out some questions they have listed on the K-W-L chart and organize them on the board. The teacher may want to organize similar questions by topic on the board. The teacher may want to pull from the comments and questions noted from class discussion during the initial viewing of the New Shepard Launch at the beginning of this lesson. d. From here, students will need to choose a topic and/or category to research and investigate further to extend their learning and make plans to report back to the class. Some ideas may include: ● What does it take to be a participant on the New Shepard? ● Engineering Careers involved in space explorations. ● The evolution and history behind rocket development & design as described in A Pictorial History of Rockets at https://www.nasa.gov/sites/default/files/atoms/files/rockets-guide-20-history.pdf create a timeline. ● Data analysis of an addition space rocket launch of their choice ● Competitors in the Space Tourism industry. e. Students will utilize their “LEARNED” section of their K-W-L chart. Here they will record what they have learned and check off the questions they had listed in the “WHAT” column that were answered. Students can share anything they found interesting or surprising and identify any misconceptions they might have from the “KNOW” column. **Modifications:**

	● Teachers can make the research study as formal or informal as they wish. Teachers may want to require a completed project or simply have them spend a little time researching and report back their findings after so much class time is given. ● Teachers may want to provide students with a choice board or list of topics/projects to choose from for their research study and/or suggested links to use in their research. For example: ○ Use the Pictorial History of Rockets at https://www.nasa.gov/sites/default/files/atoms/files/rockets-guide-20-history.pdf to create a timeline of at least 10 significant events in their evoluvtion and history of rocket development. ○ Create a travel brochure designed to encourage civilians to plan vacations to space. **Standards Addressed:** ● WHST.6-8.7 - Conduct short research projects to answer a question (including self-generated questions), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. ● Science nquiry & Research **Formative/Summative Assessments:** ● Student reporting of finding based on their chosen topics. **Resources** : ● **K-W-L chart** ● A Pictorial History of Rockets - **https://www.nasa.gov/sites/default/files/atoms/files/rockets-guide-20-history.pdf**

Teacher Background:

- Blue Origin Official Website. - https://www.blueorigin.com/new-shepard/ - offers information about the company who owns The New Shepard and information about their rockets and program.

- Be familiar with the New Shepard Mission NS-18 LIVE Webcast - https://www.youtube.com/watch?v=uEhdlIor-do. Launch begins at about 2:23:00 into the video.
- Be familiar with the The Launch of LADEE to the Moon assignment form SpaceMath@NASA
- Be familiar with the use of a K-W-L chart