

Teacher's Name: Lucy Blackford
Topic of Focus: Kinematics
Title of Lesson Plan: Rockets to Mars
Grade Level: 9/10 Grade
Time Needed: 3-4 weeks (for my students)

The lessons are attached and labeled by number. They are each one document per lesson except for the 6th one because it is a variety of different leveled readings. The second lesson plan was not included because it is an experiment with carts to learn more about acceleration and is not directly space related. It still connects to the unit as the students need to learn about acceleration. The unit outcomes are also attached as a separate document.

Rocket to Mars https://www.nasa.gov/sites/default/files/atoms/files/rockets-educator-guide-20.pdf
CONTEXT: We've left one of our own, Mark Watney, on Mars. We need to build and design a rocket to get there. The rocket must carry food supplies for Mark and for the crew.
DURATION: <i>What is the proposed beginning and end date?</i> 3 - 4 weeks <i>My students meet every day for an hour during a typical year. Due to the fact that they are all English Language Learners (ELLs) they have an hour long class. It usually takes them longer to complete activities as they are learning the language at the same time. For non ELLs this unit could probably be done in 2 weeks, but for my students they will need at least 3 weeks and probably more.</i>
ESSENTIAL QUESTION(S): How can I use my knowledge of Newton's Laws to get to Mars? What is the relationship between <i>force</i> , <i>mass</i> , and <i>acceleration</i> ? How can we launch the most amount of mass to a desired location?
PRACTICES: <i>Science and Engineering</i> <ul style="list-style-type: none">- Asking questions (for science) and defining problems (for engineering)- Developing and using models- Planning and carrying out investigations- Analyzing and interpreting data- Using mathematics and computational thinking- Constructing explanations (for science) and designing solutions (for engineering)- Obtaining, evaluating, and communicating information CROSS-CUTTING CONCEPTS: <ul style="list-style-type: none">- Patterns: Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.- Scale, proportion, and quantity: In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or

performance.

- **Systems and system models:** Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

STANDARDS: * See bottom of unit plan.

OUTCOMES:

My school is transitioning to outcomes or standards based grading. It started in the fall of 2019 and has continued throughout the pandemic. I still feel like I am learning about using standards and outcomes especially since we have been in a pandemic and the grading has felt very different this past year. We use a mix of content and language outcomes and sometimes a habit of work outcome that is the same for all disciplines. Language outcomes are incorporated because my students are 100% English Language Learners (ELLs) and the school focuses on teaching them English through the lens of the content. My idea around the outcomes is that we would align them to the Engineering Design Cycle or the Scientific Method depending on the year. This is because my school has a Regents waiver and the students instead have to do graduation worthy projects for every subject. In science we have a choice of using the Engineering rubric or the Science rubric that were created by the [Internationals Network \(https://www.internationalsnetwork.org/\)](https://www.internationalsnetwork.org/). The projects for science are done in the 10th or 11th grade, so they are building towards this. Below are the outcomes that I developed for the Engineering Design Cycle.

My school has a content and a language outcome that is assessed for each lesson. Sometimes we use the same language outcome for many days and oftentimes the language outcomes correspond to what other classes are seeing. For example paraphrase is an outcome that is used in all disciplines. In science it is embedded in the contextualize the design problem outcome.

Engineering Design Cycle Learning Outcomes:

1. I can identify the design problem.
2. I can describe and explain a prototype.
3. I can collect, organize, and present data.
4. I can evaluate the design prototype.

Engineering Design Cycle Language Outcomes

1. I can contextualize the design problem.
2. I can organize and structure a paper according to the engineering design process.

CENTRAL VOCABULARY/GRAMMAR:

Tier I	Tier II	Tier III
Analyze, consist, create, data, define, benefit, estimate, principle, research, require, process,	As the crow flies, bee line, obvious, complex, verify, evidence, advantages, aim, characteristics conclusion,	Kinematics, Vector, Scalar, Position, Time, Distance, Displacement, Speed,

law, travel	conditions, development, diagram, factors.	Velocity, Acceleration, Direction, Free-fall, motion, nosecone, fins, fuselage, launch, apogee, climbing, descending, touch down
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Background Knowledge:

At this point in the year the students will have seen measurement and the basics of science in their first unit. That unit is an introduction to the school, the language, the tools we use in science, and conversions. Then we will move on to constant motion and velocity. This unit is designed to come after learning about velocity. In this unit they will learn about velocity that is not constant (acceleration) and forces are embedded in the unit. They will be learning Newton's laws to build and test a rocket using the engineering design process.

FINAL PROJECT FOR THE UNIT:

Use the Engineering Design Cycle to design and build a rocket. They will be trying to launch as much mass as possible to a specific height. Launch the rocket, record the mass vs. altitude. Analyze forces acting upon the rocket at different times and draw a force diagram. Explain Newton's laws in relation to the rocket.

Based off of *Heavy Lifting* from <https://www.nasa.gov/sites/default/files/atoms/files/rockets-educator-guide-20.pdf>

Skills/Standards:

Human error, rounding/estimates, calculate average, graphing, making tables, accuracy/precision, sample size, unit conversions, prediction vs reality,

Science as Inquiry

- Abilities necessary to do scientific inquiry

Physical Science

- Position and motion of objects
- Motions and forces

Science and Technology

- Abilities of technological design

National Mathematics Content Standards

- Number and Operations
- Data Analysis and Probability

National Mathematics Process Standards

- Problem Solving
- Reasoning and Proof
- Communication
- Connections
- Representations

LENSES

DIFFERENTIATION: *How is the unit and content differentiated for different types of learners.*

I teach at an international transfer school. All of my students are recent arrivals to the country which makes them 100% ELLs (English Language Learners) Many of the students have gaps in their education and are considered SLIFE (Students with Limited or Interrupted Formal Education). Due to this almost all lessons I teach have three different levels to incorporate scaffolds for my students with lower English ability. If it is earlier in the year or a student is brand new, I will provide readings in Spanish or French or Arabic depending on the student. For differentiation the students can self select their level and the levels I use are Explorers

explorers



builders



engineers



, Builders , and Engineers . This corresponds to what other departments are using in their classes, so that students are not learning multiple different ways to identify their levels. Explorers refers to students who are brand new to English and are exploring the language. Their project packets and activities have more scaffolds in them. This includes fill in the blanks and sentence starters. Builders are the students who know some English and are building on their knowledge of the language. Their project packets and activities break down each question into smaller parts to answer. Engineers are fortifying their English and finding new ways to express themselves in English. Project packets and activities for them give a topic and expect them to write more complete sentences and paragraphs. The packets are designed to push their thinking beyond what is being done in the classroom. These students are expected to create and use their own data tables and graphs where explorers have the option to create a graph. We go over this extensively at the beginning of the year. At anypoint a student can choose to go up or down a level. They also might be a builder in one class and an explorer in another class, but it is always open to the student to choose.

RATIONALE: *How is the unit connected to the real world? Why is it valuable for students to study/learn this?*

This unit connects to the real world as we continue to explore about Space. 2021 has been an important year in the exploration of Mars and landing a rover there while other missions to Mars are also in progress. I think travel to Mars is the big science news now and students are interested in learning about the process that goes into getting there.

EMOTION: *In what way is this topic made emotionally relevant to students? How are you going to make students care so much about the issue?*

The introduction to the unit with showing a movie and a person stranded on Mars. This will help set the scene for the need to build a rocket to get there. Students are also excited to learn about space travel and the possibility of visiting Mars. This makes them more interested in exploring the topic.

INQUIRY: *In what way are students using inquiry?*

Drawing conclusions and developing explanations—Students are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses. Students are able to develop, modify, clarify, and explain questions that guide physics investigations of various types. They understand factors that influence the questions they pose.

MATHEMATICS: *In what way are students using mathematics?*

Patterns: Observed patterns in nature guide organization and classification and prompt

questions about relationships and causes underlying them. ■ Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. Scale, Proportion, and Quantity: In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change. ■ The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ■ Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

ENGINEERING: *In what way are students engineering?*

Standard 6

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design. Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems. Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions. Key Idea 6: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Standard 7

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena.

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

CALENDAR

Month: _____

Year: _____

This unit would be 3 - 4 weeks

***I didn't include a lesson**

1. Mars with *The Martian* (1 day)
 - a. How can we save him?
 - b. What if velocity isn't constant?
2. *What is acceleration? *This lesson is done with cars to understand acceleration. It is not connected to space, but it is important to do the experiment to understand more about acceleration and what it is.* (3 days)
 - a. Create and set up an experiment.
 - b. Acceleration lab findings and share out
 - c. Look at distance vs time graphs for acceleration
 - d. Bring back in information from velocity and distance vs time graphs

- e. Newton's 2nd Law
- 3. What is a force? Types of forces (2 days)
 - a. Show demonstrations with discrepant events
 - b. Reading (homework)
 - c. Draw force diagrams
- 4. 3rd Law: action and reaction (1 day)
- 5. 1st Law: with bowling ball (1 day)
- 6. Reading and background on Rockets (2 days)
- 7. Dawn Spacecraft acceleration (2 days)
- 8. Rocket to Mars (5 days)

UNIT REFLECTION

This part is blank because I complete a unit reflection after every unit I teach. This helps me improve the unit each time it is taught. I often teach units again and I update and edit them according to my reflections from the previous teaching of it.

STRENGTHS:

DIFFICULTIES:

WHAT TO CHANGE FOR NEXT TIME:

NGSS Standards:

Students who demonstrate understanding can:

- HS-PS2-1.** Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at nonrelativistic speeds.]
- HS-PS2-2.** Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.]
- HS-PS2-3.** Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.]
- HS-PS2-4.** Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]
- HS-PS2-5.** Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. [Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]

NYS Physics Curriculum:

5.1a	Measured quantities can be classified as either vector or scalar.
5.1b	A vector may be resolved into perpendicular components.
5.1c	The resultant of two or more vectors, acting at any angle, is determined by vector addition.
5.1d	An object in linear motion may travel with a constant velocity* or with acceleration*. <i>(Note: Testing of acceleration will be limited to cases in which acceleration is constant.</i>
5.1e	An object in free fall accelerates due to the force of gravity.* Friction and other forces cause the actual motion of a falling object to deviate from its theoretical motion. <i>(Note: Initial velocities of objects in free fall may be in any direction.)</i>
5.1f	The path of a projectile is the result of the simultaneous effect of the horizontal and vertical components of its motion; these components act independently.
5.1g	A projectile's time of flight is dependent upon the vertical component of its motion
5.1h	The horizontal displacement of a projectile is dependent upon the horizontal component of its motion and its time of flight.
5.1i	When the net force on a system is zero, the system is in equilibrium.
5.1j	According to Newton's First Law, the inertia of an object is directly proportional to its mass. An object remains at rest or moves with constant velocity, unless acted upon by an unbalanced force.
5.1k	According to Newton's Second Law, an unbalanced force causes a mass to accelerate.
5.1q	According to Newton's Third Law, forces occur in action/ reaction pairs. When one object exerts a force on a second, the second exerts a force on the first that is equal in magnitude and opposite in direction.
Process Skills 5.1	(i) construct and interpret graphs of position, velocity or acceleration versus time (ii) determine and interpret slopes and areas of motion graphs (iv) determine the resultant of two or more vectors graphically or algebraically (vi) resolve a vector into perpendicular components both graphically and

	algebraically (vii) sketch the theoretical path of a projectile
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Math Common Core Standards:

Mathematics 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.

HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

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.

HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law $V = IR$ to highlight resistance R . Represent and model with vector quantities.

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 (e.g., v , $|v|$, $\|v\|$, v).

HSN-VM.A.2: Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point.

HSN-VM.A.2: Solve problems involving velocity and other quantities that can be represented by vectors.

HSN-VM.A.4: Add and subtract vectors.

HSN-VM.A.5: Multiply a vector by a scalar.