STEM Curriculum Planning Guide

This instructional design guide serves as the template for the design and development of STEM units of instruction at the Dayton Regional STEM Center in Dayton, Ohio. The guide is anchored to the *STEM Education Quality Framework* also developed at the Dayton Regional STEM Center.

STEM Unit Title	**Launch Into Energy Transformations**
Economic Cluster	Air Vehicles/Air Systems
Targeted Grades	6-7
STEM Disciplines	Science Technology Engineering Mathematics
Non-STEM Disciplines	English Language Arts

Section I: STEM Unit Overview

Unit Overview

Students assume the role of propulsion engineers and aerodynamicists on collaborative Air Vehicle teams. They are challenged to employ the iterative nature of the engineering design process to design, build, and test a nose cone system for a air pressurized-air and water fueled soda bottle rocket. Students will conduct research based on their role, utilize complete research to choose a team prototype design plan, and sketch a schematic of their plan. While testing, students will collect data regarding kinetic and potential energy and calculate the potential energy of their system. Students will then label and explain energy transformations that take place during rocket launches.

Essential Question

How can you effectively utilize kinetic and potential energy transformations to design a nose cone for a rocket system that is able to reach a maximum altitude while maintaining stability?

Enduring Understanding

All energy is categorized as one of two forms, kinetic or potential; it can be transformed from one form to another, but the total amount of energy remains the same.

Technical writing is an effective method for examining a topic and conveying ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Real-life problems can be modeled through the use of algebraic expressions that represent quantitative relationships, so that data can be used to make sense of the quantitative relationships.

Engineering Design Challenge

Student Air Vehicle teams of aerodynamicists and propulsion engineers are challenged to research and develop and improved rocket nose cone designs that will increase a rocket's stability as it reaches high altitudes. Students will use the engineering design process to plan, build, and modify a prototype nose cone for a soda bottle rocket fueled by pressurized-air and water. They will first investigate transformations between potential and kinetic energy, and research effective methods for designing a nose cone. Upon completion of building, testing and analyzing, each Air Vehicle team member will prepare and submit a rocket nose cone design proposal.

Time and Activity Overview

Day	Time Allotment	Actvities
1	40-50 minutes	Pre-Test and Introduction
2	40-50 minutes	Kinetic vs. Potential Energy and Introduction to Engineering Design Challenge
3	40-50 minutes	Propulsion and Aerodynamics Research
4	40-50 minutes	Initial Design Plan
5	80-90 minutes	Design Construction and Launch Plan
6	40-50 minutes	Launch and Redesign
7	40-50 minutes	Final Launch and Design Submission Proposal
8	40-50 minutes	Post-Test and Design Submission Proposal

Pre-requisite Knowledge & Skill

Metric Conversions
Research Methods
Substitution in an Algebraic Formulas
Labeling Units
Recording Qualitative and Quantitative Data

Academic Content Standards

Add Standard	Mathematics
Grade/Conceptual Category	6
Domain	Expressions and Equations
Cluster	Reason about and solve one-variable equations and inequalities.
Standards	Understand solving an equation or inequality as a process of answering a question: which values from a specified set, if any, make the equation or inequality true? Use substitution to determine whether a given number in a specified set makes an equation or inequality true. Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

Add Standard	Mathematics
Grade/Conceptual Category	7
Domain	Expressions and Equations
Cluster	Solve real-life and mathematical problems using numerical and algebraic expressions and equations.
Standards	Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. a. Solve word problems leading to equations of the form px + q = r and p(x + q) = r, where p, q, and r are specific rational numbers. Solve equations of these forms fluently. Compare an algebraic solution to an arithmetic solution, identifying the sequence of the operations used in each approach. For example, the perimeter of a rectangle is 54 cm. Its length is 6 cm. What is its width? b. Solve word problems leading to inequalities of the form px + q > r or px + q < r, where p, q, and r are specific rational numbers. Graph the solution set of the inequality and interpret it in the context of the problem. For example: As a salesperson, you are paid $50 per week plus $3 per sale. This week you want your pay to be at least $100. Write an inequality for the number of sales you need to make, and describe the solutions.

Add Standard	Mathematics
Grade	
Standard	
Benchmark	
Indicator	

Add Standard	English Language Arts
Grade	6
Strand	Writing
Topic	Text Types and Purposes
Standard	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Add Standard	English Language Arts
Grade	7
Strand	Writing
Topic	Text Types and Purposes
Standard	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Add Standard	English Language Arts
Grade	
Standard	
Benchmark	
Indicator	

Add Standard	Social Studies
Grade	
Theme	
Strand (pk-8 only)	
Topic	
Content Standard	

Add Standard	Social Studies
Grade	
Standard	
Benchmark	
Indicator	

Add Standard	Science	Ohio
Grade	6	
Theme	Order and Organization	
Topic	Matter and Motion	
Content Standard	There are two categories of energy: kinetic and potential. Objects and substances in motion have kinetic energy. Objects and substances can have energy as a result of their position (potential energy). Note: Kinetic and potential energy should be introduced at the macroscopic level for this grade. Chemical and elastic potential energy should not be included at this grade; this is found in PS grade 8	

Add Standard	Science	Ohio
Grade	7	
Theme	Order and Organization	
Topic	Conservation of Mass and Energy	
Content Standard	Energy can be transformed or transferred but is never lost. When energy is transferred from one system to another, the quantity of energy before transfer equals the quantity of energy after transfer. When energy is transformed from one form to another, the total amount of energy remains the same.	

Add Standard	Science	Ohio
Grade	7	
Theme	Order and Organization	
Topic	Conservation of Mass and Energy	
Content Standard	Energy can be transferred through a variety of ways. Mechanical energy can be transferred when objects push or pull on each other over a distance.	

Add Standard	Science
Strand	
Course Content	
Content Elaboration	

Add Standard	Science
Grade	
Standard	
Benchmark	
Indicator	

Add Standard	Fine Arts
Grade	
Subject	
Standard	
Benchmark	
Indicator	

Add Standard	Technology
Grade	6
Standard	Nature of Technology
Benchmark	Analyze information relative to the characteristics of technology and apply in a practical setting.
Indicator	Suggest alternative technological solutions for everyday problems that occur in the school or classroom.

Add Standard	Technology
Grade	6
Standard	Nature of Technology
Benchmark	Analyze the relationships among technologies and explore the connections between technology and other fields of study.
Indicator	Recognize that knowledge from other fields of study impacts the development of technological systems and products.

Add Standard	Technology
Grade	7
Standard	Nature of Technology
Benchmark	Apply the core concepts of technology in a practical setting.
Indicator	Identify parameters that may be placed on the development of a product or system (e.g., cost, time, size).

Add Standard	Technology
Grade	7
Standard	Nature of Technology
Benchmark	Analyze information relative to the characteristics of technology and apply in a practical setting.
Indicator	Develop technological solutions to problems.

Assessment Plan

What evidence will show that students have acquired the enduring understandings for this STEM unit?

Performance Task, Projects	Engineering Logbook Design Proposal Submission Engineering Design Challenge
Quizzes, Tests, Academic Prompts	Pre-Test Post Test Engineering Logbook Engineering Design Proposal Submission Rubric Engineering Logbook Rubric
Other Evidence (e.g. observations, work samples, student artifacts, etc.)	Engineering Logbook Design Proposal Submission Engineering Design Challenge Rubric
Student Self- Assessment	Engineering Logbook Engineering Design Proposal Submission Rubric Engineering Logbook Rubric

Technology Integration

ADISC Technology Integration Model*

	Type of Integration	Application(s) in this STEM Unit
A	Technology tools and resources that support students and teachers in ***adjusting, adapting, or augmenting*** teaching and learning to meet the needs of individual learners or groups of learners.	-Computer -Projector -Interactive Whiteboard
D	Technology tools and resources that support students and teachers in ***dealing effectively with data***, including data management, manipulation, and display.	-Altitrak- Altitude Finder
I	Technology tools and resources that support students and teachers in conducting ***inquiry***, including the effective use of Internet research methods.	-Computer -Altitrak- Altitude Finder -Launch Pad
S	Technology tools and resources that support students and teachers in ***simulating*** real world phenomena including the modeling of physical, social, economic, and mathematical relationships.	-Water Rocket Fun: A Water Rocket Simulator for Fun & Science Studies: http://www.seeds2lrn.com/rocketSoftware.html -Ohio 4H: Rockets Away: http://www.ag.ohio-state.edu/~rockets/cgi-bin/design_zone.cgi -NASA: RocketModeler II Version 2.1f http://exploration.grc.nasa.gov/education/rocket/rktsim.html -NASA: Bottle Rocket http://exploration.grc.nasa.gov/education/rocket/BottleRocket/bottleold/br2d_b.swf
C	Technology tools and resources that support students and teachers in ***communicating and collaborating*** including the effective use of multimedia tools and online collaboration.	-Computer
	**The ADISC Model was developed by James Rowley PhD, Executive Director of the Institute for Technology-Enhanced Learning at the University of Dayton*	

Career Connections

Career Description

Aerospace Engineering is the design, construction, and study of aircraft, rockets, and spacecraft. Ultimately, these complex vehicles are the product of various technical and engineering disciplines such as aerodynamics, propulsion, avionics, materials science, structural analysis, and manufacturing. The interaction of all these technologies encompasses the field of aerospace engineering. Two of these technological specialties that are pertinent to this lesson are discussed below.

Aerodynamicist

Aerodynamics is the study of airflow around an object and the forces that are generated by the air on that object. To be more precise, it is really the study of gas flow around a body, but air is the most common gas that we usually care about. When designing a nosecone for a rocket that will be used within the earth's atmosphere, the biggest design driver is usually aerodynamic drag. By designing a nosecone with the lowest drag, you can help increase the range of the rocket. However, there are other considerations that may be important. Maneuverability, internal heating, sound wave reduction, and material selection may all be important as well. Aerodynamicists will typically have to work with complex trade-offs to meet overall design requirements.

When most people think about aerodynamics, they immediately think of airplanes and rockets, and aerodynamicists are routinely employed in large numbers in these industries. There are many types of jobs within the aerospace industry that need these skills. For example, Modeling and Simulation Engineers typically work with computer codes called Computational Fluid Dynamics (CFD), where they will simulate the performance of an object before it is built. Modelers will typically be needed to build smaller scale test models (usually wood or plastic) that will be placed in a wind tunnel to measure the forces on the design. If everything is promising up to this point, the full scale item will be built and Test Engineers will measure the performance throughout flight testing at a variety of speeds, temperature, altitudes, and even weather.

There are many other design projects that need a strong understanding of aerodynamics to create an effective design. Automobile designers are always concerned about reducing drag because this improves handling and increases gas mileage. Ship and submarine designers are concerned about the aerodynamic forces imposed by a different fluid, in this case water. Architects are concerned about forces imposed by the wind on their buildings and bridges. In fact, one famous bridge at Tacoma Narrows in Washington State was actually destroyed by winds creating a natural harmonic frequency throughout the entire structure until it buckled from violent swaying. Many sports are also dependent on aerodynamics; golf ball and golf club design, wind surfer design, boat sail design, bicycle and bike helmet design, and even hang glider design.

Propulsion Engineer

Propulsion engineers are primarily concerned with the design, construction, testing, and performance of the engines used on the aircraft or rocket. The engine design includes design of the individual components such as the inlet, compressors, combustion chambers, turbines, and exhaust nozzles. Even more importantly, propulsion engineers also study and test the chemistry of fuel and oxidizer choices that are ignited in the engine which causes the propulsive thrust for the vehicle. Here again, there are numerous fuel choices and design trade-offs that must be balanced against each other; reactive thrust, operating pressures, flow rates, ignition temperature, material melting points, material strength, and pollution byproducts.

Once again, propulsion engineers can work in any industry that uses engines. This includes internal combustion engines used in automobiles, farm equipment, and even lawn mowers; turbine engines used in aircraft, helicopters, windmills, oil refineries, natural gas pipelines, or hydroelectric dams; rocket engines used in missiles and the space shuttle; and even ramjet or scramjet engines to be used in future spacecraft designs.

Section II: STEM Lesson Plan

Title of Lesson **Day 1 - Introduction and Hook**

Time Required 40-50 minutes

Materials
Appendix A: Pre-test (1 per student)
Appendix B: Fin Design and Construction (1 per class)
Appendix C: Engineering Logbook (1 per student)
Rocket Launch Pad (1 per class)
2-liter Soda Bottles (3 per class)
40 psi Bicycle Pump (1 per class)
Water (1200 mL per class)
Washers (3 per class)

Objectives
Students will be able to measure and record preliminary mass and altitude data of a rocket in order to draw conclusions regarding effective launch methods and rocket nose cone designs.

Instructional Process
1. Administer the Pre-test.
2. Divide the class into Air Vehicle teams consisting of four students each.
3. Instruct students to record data and preliminary findings on Introduction: Day 1 in their Engineering Logbook as they observe the teacher demonstration three separate water and air fueled 2-liter bottle rocket launches.
4. Peel the labels off of three 2-liter soda bottles, mark each of them with either an A, B, or C.
5. Refer to Fin Design and Construction Instructions and attach three fins to each 2-liter bottle.
6. Fill each 2-liter bottle with 400 mL of water.
7. Model the affect the mass of a nose cone has on a rocket: Bottle A - no modifications; Bottle B - attach on heavy washer in place of a nose cone; Bottle C - attach two or three washer in place of a nose cone.
8. Place one bottle at a time on the launch pad and pump 40 psi of into the the rocket with the bicycle pump.
9. Launch each bottle rocket as students compile data.

Differentiation
In order to serve all learner needs, the Pre-test and data recording methods can be adapted to reflect varying abilities.

Assessments	Teachers should use the Pre-test as a tool for determining students' prior knowledge of the content. Pretest data should be used as a guide for making necessary modifications to the unit as needed in order to meet the specific needs of your students. Teachers should use the Engineering Logbook as a formative assessment tool throughout the lesson. Monitoring student responses can provide additional opportunities for scaffolding.

Section II: STEM Lesson Plan

Title of Lesson **Day 2 - Potential vs. Kinetic Energy**

Time Required 40-50 minutes

Materials

Appendix C: Engineering Logbook (1 per student)
Hoodwinks video: http://www.youtube.com/watch?v=qZ4FFWvZtyo
Calculators (1 per student or group)
Available materials for nose cone assembly:
Washers (approx. 100)
Cardboard (approx. 2 square meters)
Posterboard (approx. 1 per team)
Flex-Foam-It V (1 gallon per class)
Modeling Clay (4-8 sticks)
Duct Tape or Clear Packing Tape (4 rolls per class)
Foam Core Posterboard (2 sheets per class)
Packing Peanuts (1 bag per class)
Floral Foam (optional)
Plastic Cups (package per class)
Hot Glue (with extra glue sticks)

Objectives

Students will be able to define and identify gravitational potential energy, kinetic energy and elastic potential energy.

Students will be able to apply the principles of mechanical energy to new situations.

Students will be able to calculate gravitational potential energy after measuring the mass and altitude of a rocket.

Instructional Process

1. Show Hoodwinks video clip and prompt students to follow the questions in their Logbooks.

Teacher's note: It may be beneficial to show the video twice so that the students have ample time to view and record their thoughts.

2. Allow time for students to complete the questions in the Logbook.
3. Model calculation of gravitational potential energy for Rocket A. Use of a document camera or SMART Board is suggested.
4. Allow students time to complete the calculations for Rockets B and C.
5. Prompt students to view the Engineering Design Challenge (in Logbook) and the Engineering Design Process diagram.
6. Students should complete the Engineering Design Challenge page of the Engineering Logbook.

7. Allow students to view available materials for the Engineering Design Challenge.
8. For homework, students should brainstorm ways to utilize the materials to build a nose cone design.

Differentiation

In order to serve all learner needs, the lesson can be adapted to reflect varying abilities. Mathematical computations can be altered by increasing teacher modeling of the potential energy calculations. Additional challenge can be added by asking students to determine the relative kinetic and potential energies throughout the flight path of the rocket. Additionally, velocity can be calculated utilizing the mass and relative kinetic energies at various positions along the flight path.

Assessments

Teachers should use the Engineering Logbook as a formative assessment tool throughout the lesson. Monitoring student responses can provide additional opportunities for scaffolding.

Section II: STEM Lesson Plan

Title of Lesson	**Day 3 - Propulsion Engineer and Aerodynamicist Research**
Time Required	40-50 minutes
Materials	Appendix C: Engineering Logbook (1 per student) Computers (1 per student) Available materials for nose cone assembly: Washers (approx. 100) Cardboard (approx. 2 square meters) Posterboard (approx. 1 per team) Flex-Foam-It V (1 gallon per class) Modeling Clay (4-8 sticks) Duct Tape or Clear Packing Tape (4 rolls per class) Foam Core Posterboard (2 sheets per class) Packing Peanuts (1 bag per class) Floral Foam (optional) Plastic Cups (package per class) Hot Glue (with extra glue sticks)
Objectives	Students will prepare for discussion, decision-making, and design having researched rocket propulsion and rocket nose cone design. Students will be able to synthesize effective use of kinetic and potential energy transformations and relate them to relevant real-world careers and systems.
Instructional Process	1. Prompt students to read the Propulsion Engineer Research and Aerodynamicist Research pages in the Engineering Logbook. 2. Guide Air Vehicle teams to collaborate in order and assign two team members to assume the career position each: propulsion engineer and aerodynamicist. 3. Allow time for students to individually complete the appropriate research page matching their assumed career position. Throughout the research process, they may (and should) collaborate with the other member of their Air Vehicle team with the same career position. However, they should each record findings and ideas unique to them.
Differentiation	In order to serve all learner needs, the lesson can be adapted to reflect varying abilities. Additional prompting, scaffolding can be added to the research documentation sheets as needed.

Assessments

Teachers should use the Engineering Logbook as a formative assessment tool throughout the lesson. Monitoring student responses can provide additional opportunities for scaffolding.

STEM Center

Section II: STEM Lesson Plan

Title of Lesson	**Day 4 - Initial Design Plan**
Time Required	40-50 minutes
Materials	Appendix C: Engineering Logbook (1 per student) Available materials for nose cone assembly: Washers (approx. 100) Cardboard (approx. 2 square meters) Posterboard (approx. 1 per team) Flex-Foam-It V (1 gallon per class) Modeling Clay (4-8 sticks) Duct Tape or Clear Packing Tape (4 rolls per class) Foam Core Posterboard (2 sheets per class) Packing Peanuts (1 bag per class) Floral Foam (optional) Plastic Cups (package per class) Hot Glue (with extra glue sticks)
Objectives	Students will be able to apply their understanding of propulsion and aerodynamics to collaboratively create a team design plan that will optimize altitude and stability of their rocket. Students will be able to conceptually manipulate materials and ideas to create a schematic drawing of their nose cone system for use on their rockets. Students will be able to compose technical writing pieces that illustrate the engineering design process and content mastery.
Instructional Process	1. Instruct Air Vehicle teams to share and discuss their research findings with their team. 2. Guide teams to draw from knowledge gained through assuming specific career positions and researching in order to thoughtfully analyze and discuss pros and cons of each team member's suggested design ideas. 3. Instruct teams to collaboratively complete the Schematic of Team Design Plan page in the Engineering Logbook, basing the design on their shared research and discussion. 4. Introduce the Design Proposal Submission Requirements and Rubric found in the Logbook and students can begin preliminary work.

Differentiation	In order to serve all learner needs, the lesson can be adapted to reflect varying abilities. Additional prompting, scaffolding can be added to the research documentation sheets as needed.
Assessments	Teachers should use the Engineering Logbook as a formative assessment tool throughout the lesson. Monitoring student discussions and responses can provide additional opportunities for scaffolding.

Section II: STEM Lesson Plan

Title of Lesson	**Day 5 - Design Construction and Launch Plan**
Time Required	80-90 minutes
Materials	Appendix B: Fin Design and Construction Instructions (1 per student team) Appendix C: Engineering Logbook (1 per student) 2-liter bottle (one per student team) Washers (approx. 100) Cardboard (approx. 2 square meters) Posterboard (approx. 1 per team) Flex-Foam-It V (1 gallon per class) http://www.smooth-on.com/Rigid-and-Flexible/c10_1121/index.html?catdepth=1 Modeling Clay (4-8 sticks) Duct Tape or Clear Packing Tape (4 rolls per class) Foam Core Posterboard (2 sheets per class) Packing Peanuts (1 bag per class) Floral Foam (optional) Plastic Cups (package per class) Hot Glue (with extra glue sticks) E-xacto Blades (4 per class) Heavy Duty Scissors (1 per class) Cutting Boards (4 per class)

Objectives

Students will be able to apply their understanding of propulsion and aerodynamics to create a design that will optimize altitude and stability of their rocket.

Students will be able to use the schematic drawing of their nose cone system to create a tactile design for use on their rockets.

Students will be able to manipulate materials to create their nose cone system.

Students will be able to compose technical writing pieces that illustrate the engineering design process and content mastery.

Instructional Process

1. Guide students to use the results from their propulsion and aerodynamics research to finalize their nose cone system design.
2. Guide teams through the assembly of fins based upon the design template in Appendix B.
3. Instruct teams to construct their design using the available materials.
4. Upon completion of the construction of their design, teams should create their

Launch Plan for use on Launch Day.

5. If time permits, have students work on their Design Proposal Submissions.

Differentiation	In order to provide opportunity for all students to learn, teachers can pre-cut materials to expedite assembly. Additionally, alternate materials can be used to increase student interest in the design and creation.
Assessments	Teachers should utilize the Engineering Logbook to review student research and schematic drawings as a formative assessment tool. Immediate feedback and scaffolding can be provided to improve student results.

Section II: STEM Lesson Plan

Title of Lesson	**Day 6 - Launch Day and Redesign**
Time Required	40-50 minutes
Materials	Appendix C: Engineering Logbooks (1 per student) Student designed rocket systems (1 per student team) Launch Pad (1 per class) Altitrak Altitude Finder (1 per class) Scale (large enough to measure rocket full of water) Materials for Redesign: Washers (approx. 100) Cardboard (approx. 2 square meters) Posterboard (approx. 1 per team) Flex-Foam-It V (1 gallon per class) Modeling Clay (4-8 sticks) Duct Tape or Clear Packing Tape (4 rolls per class) Foam Core Posterboard (2 sheets per class) Packing Peanuts (1 bag per class) Floral Foam (optional) Plastic Cups (package per class) Hot Glue (with extra glue sticks) (2-4 per class) E-xacto Blades (4 per class) Heavy Duty Scissors (1 per class) Cutting Boards (4 per class)
Objectives	Students will be able to use their Launch Plan to execute a launch of their rocket. Students will be able to record the mass in kilograms, the altitude in meters and the stability in qualitative terms. Students will be able to analyze their data and calculate the gravitational potential energy.
Instructional Process	1. Instruct each team to execute their Launch Plan. 2. Establish an order of team launches to ensure time efficiency. 3. Using the results of the launch, have students return to their materials and redesign the nose cone structure. 4. Prompt students to reconstruct fins after deformation during the launch.

Differentiation	Modifications can be made to the Launch Documentation sheets in the Engineering Logbook. For students that may require additional prompting, scaffolding can be added. Calculators can be provided to students as needed for computations.
Assessments	The Engineering Logbooks should be used as a formative assessment tool. Teachers should prompt students to utilize the Engineering Design Process Rubric as a self assessment tool.

Section II: STEM Lesson Plan

Title of Lesson	**Day 7 - Final Launch & Proposal**
Time Required	40-50 minutes
Materials	Appendix C: Engineering Logbooks (1 per student) Student designed rocket systems (1 per student team) Launch Pad (1 per class) Altitrak Altitude Finder (1 per class) Scale (large enough to hold rocket full of water)

Objectives	Students will be able to use their Launch Plan to execute a launch of their rocket. Students will be able to record the mass in kilograms, the altitude in meters and the stability in qualitative terms. Students will be able to analyze their data and calculate the gravitational potential energy. Students will be able to compose technical writing pieces that illustrate the engineering design process and content mastery.
Instructional Process	1. Prompt each team should execute their Launch Plan. 2. Establish an order of team launches to ensure time efficiency. 3. Instruct students to record data for the rocket's altitude, mass and stability. 4. Following the launch, have students work on the Nose Cone Design Proposal Submission assignment found in the Engineering Logbook. Be sure to emphasize that individual students will submit a proposal. 5. Assign the proposal completion for homework.
Differentiation	Modifications can be made to the Launch Documentation sheets in the Engineering Logbook. For students that may require additional prompting, scaffolding can be added. Calculators can be provided to students as needed for computations.
Assessments	The Engineering Logbooks should be used as a formative assessment tool. Teachers should prompt students to utilize the Engineering Logbook Rubric and Nose Cone Design Proposal Submission Rubric as self assessment tools.

Section II: STEM Lesson Plan

Title of Lesson	**Day 8 - Post-Test & Design Submission Proposal**
Time Required	40-50 minutes
Materials	Appendix A: Post-test (1 per student) Appendix C: Engineering Logbook (1 per student)
Objectives	Students will demonstrate mastery of potential and kinetic energy transformations, solving algebraic expressions, and the engineering design process through completion of both formative and summative assessments.
Instructional Process	1. Collect Engineering Logbooks and Nose Cone Design Proposal Submissions for scoring on the rubrics provided found in Engineering Logbooks. 2. Administer Post-test.
Differentiation	Modifications can be made to the Launch Documentation sheets in the Engineering Logbook as well as to the Post-test. For students that may require additional prompting, scaffolding can be added. Calculators can be provided to students as needed for computations.
Assessments	Modifications can be made to the Launch Documentation sheets in the Engineering Logbook as well as to the Post-test. For students that may require additional prompting, scaffolding can be added. Calculators can be provided to students as needed for computations. The Engineering Logbooks should be used as a formative assessment tool. The Post-test should be used as a summative assessment tool.

Section III: Unit Resources

Materials and Resource Master List

Resources to be Copied:
Pre-Test (one per student)
Engineering Logbook (one per student)
Fin Design and Construction Instructions (one per student team)
Post-Test (one per student)

Unit Materials:
2-liter bottle (one per student team)
Launch Pad (1 per class)
Altitrak Altitude Finder (1 per class)
Scale (large enough to measure rocket full of water)
Materials for redesign of nose cone systems and fin construction:
Washers (approx. 100)
Cardboard (approx. 2 square meters)
Posterboard (approx. 1 per team)
Flex-Foam-It V (1 gallon per class)
Modeling Clay (4-8 sticks)
Duct Tape or Clear Packing Tape (4 rolls per class)
Foam Core Posterboard (2 sheets per class)
Packing Peanuts (1 bag per class)
Floral Foam (optional)
Plastic Cups (package per class)
Hot Glue (with extra glue sticks) (2-4 per class)
E-xacto Blades (4 per class)
Heavy Duty Scissors (1 per class)
Cutting Boards (4 per class)

Classroom Resources:
Computers with Internet Access (1 per student pair)
Projector for Hoodwinks video

Key Vocabulary

Aerodynamics
the study of airflow around an object and the forces that are generated by the air on that object

Conservation of Energy
energy cannot be create or destroyed; it can only be transferred or transformed

Decision Analysis Matrix
a tool used to rank and score criteria to determine a best solution

Energy Transfer
the movement of energy from one object to another

Energy Transformation
the process of changing from one form of energy to another

Rocket Fin
a part of a rocket that provides stability and promotes aerodynamics

Friction
the force that opposes the motion of the rocket moving

Kinetic Energy
the energy of motion

Mass
a measure of the amount of matter

Nose Cone
the tip of the rocket that promotes greater aerodynamics

Potential Energy
stored energy

Propulsion
the force moving a rocket forward or upward

Prototype
a model built to test an idea or concept

PSI
pounds per square inch- a unit of pressure

Qualitative Data
data that is descriptive and does not include numbers or quantities

Quantitative Data
data that is expressed numerically

Schematic
a diagram or drawing

Weight
the force of gravity acting on an object

Technical Brief

Rockets can be thought of as a type of internal combustion engine like we have in our cars. Rocket engines mix fuel with an oxidizer (a mix of oxygen and other combustible gases) to burn the fuel in their combustion chamber. The reason that rockets bring their own internal mix of oxygen for combustion is their performance would decrease as rockets ascend in the atmosphere because the atmosphere becomes thinner and the oxygen molecules become rarer. Eventually, when rockets reach space, there is no air for the fuel to burn unless the rockets bring it along in their own internal tanks. The burning of rocket fuel under high pressure in the combustion chamber creates a rapid expansion of combustion gases that generate high exhaust velocities out the exhaust nozzle that propel the rocket. Because of this, rockets follow Newton's Third Law of Motion; for every action there is an equal and opposite reaction. The reaction of the exhaust out the back of a rocket pushes the engine in the opposite direction, in this case forward. In rocket engines, high temperatures and high pressures give rise to better thermodynamic efficiency which translates into improved thrust.

There are many types of rockets and liquid rockets have been used as an example up to this point. This is a type of rocket that uses one or more liquid propellants stored in tanks prior to combustion. There are also solid propellant rocket motors, hybrid rockets using both liquids and solids, and even thermal rockets where the propellant is heated by an external power source. In this lesson, we are using a simplified water rocket design that never burns anything. Instead, thrust is created using Newton's Third Law by pressurizing the bottle and expelling water out of the rocket nozzle. As in normal rocket engines, higher pressures will generate higher thrust. Because the thrust is calculated from the mass and speed of the water stream, using more water will also generate higher total thrust.

By using aerodynamic principles, the body of a rocket can be designed to minimize the atmospheric drag on the rocket while also creating stability. Both the nosecone and fins on a rocket use aerodynamics to generate lift and maintain stability. Similar to cars, lower body drag means that more of the thrust is converted into higher speeds and longer travel distances given a fixed amount of fuel.

Rockets also represent a good example of energy transformation. Energy transformation is the process of changing one form of energy into another. When the rocket is sitting on the launch pad ready for takeoff, the fuel has its highest state of chemical energy. As the rocket travels thru the atmosphere, the chemical energy is converted into kinetic energy. When the rocket attains its maximum speed, its kinetic energy is at a maximum. As the rocket slows down, its kinetic energy decreases.

Something that we have not discussed until this point is the effect of gravity. The gravitational force exerted on an object can be calculated as a function of the distance from the center of the Earth. As the rocket launches upward into the atmosphere or even all the way into space, the gravitational forces exerted by the Earth decrease. In the above example, when the rocket is sitting on the launch pad, both its kinetic energy and potential energy will be zero. As the rocket lifts off, its potential energy due to gravitational effects will gradually increase as it climbs. When it reaches its highest point, or apogee, the gravitational potential energy will be at a maximum. If the rocket burns out and returns to Earth, the chemical energy, potential energy, and kinetic energy will all go back to zero. Throughout the flight of the rocket, the chemical energy is converted to heat and sound and is dissipated in the Earth's atmosphere.

Safety and Disposal

Set up the launch pad as directed by manufacturer in a large open area. Students not involved in a launch should stand at least 5 meters from the launch pad. Safety goggles should be worn by all students and adults during launch days. Rockets should only be pressurized up to 50 psi to prevent bursting. All spectator students should have ample notice that a rocket is launching and to prepare for its return to the ground.

During construction, care must be taken with the use of E-xacto knives and other sharp devices. Safety goggles should be worn when using E-xacto knives, etc. The use of parent volunteers as leaders of a cutting station is recommended.

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Curriculum Developers

Philip Bottelier: Materials Consultant
Ann Drake: Contributing Author
Jeanette McNally: Contributing Author, Editor
Carly Monfort: Contributing Author, Editor
Bruce Preiss: Contributing Author
Sandra Preiss: Contributing Author, Editor

Section IV: Appendices

Appendix A: Pre-Test/Post-Test

Appendix B: Fin Design and Construction Instructions

Appendix C: Engineering Logbook:
Engineering Logbook Rubric
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Potential vs. Kinetic Energy
Engineering Design Challenge
Engineering Design Process
Propulsion Engineer Research
Aerodynamicist Research
Schematic of Team Design Plan
Launch Documentation
Nose Cone Design Proposal Submission Requirements
Nose Cone Design Proposal Submission Rubric