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	**Space Age Strength: Achieving Unbendable Strength in Tense Situations**
Economic Cluster	Advanced Manufacturing & Materials Air Vehicles/Air Systems
Targeted Grades	7
STEM Disciplines	Science Technology Engineering Math
Non-STEM Disciplines	English Language Arts Social Studies Visual Arts

Section I: STEM Unit Overview

Unit Overview

In October 2012, a parachute jumper took a leap of science and stepped off a platform from an altitude of close to 24 miles above the Earth's surface, breaking the 1959 space jump record. The parachute jumper's team helped him to reach these heights with a helium balloon attached to a space gondola/capsule. Because air density and temperature vary greatly with altitude in our atmosphere, the engineering team had to consider both the mass and strength of the materials used in construction of the entire high-altitude balloon. These materials needed to be safe and lightweight, and also be able to perform well in extreme cold conditions.

This unit's focus is the design of the balloon capsule and student teams are challenged to create a composite material that is capable of surpassing the space jump record due to its superior strength to mass ratio. Knowledge gained through research of both properties of the atmosphere and properties of composite materials are synthesized and applied while designing and creating sample composite materials. Through the use of a testing fixture, the teams will subject their composite materials to extreme conditions in order to test the material's ability to withstand force under tensile and bending conditions. Teams record and analyze the test results, calculate strength to mass ratios, and determine the composite's percent of change under these test conditions. Finally, teams compose a marketing proposal to persuade a potential sponsor company to fund the next potentially record-breaking space jump in order boost awareness and sales of its products. This world record will be possible because the company is being offered the use of the student team's test results and improved composite material recommendations for the gondola/ capsule. Students are required to support claims made in the letter with scientific evidence based on research and testing results gathered throughout this design challenge.

Essential Question

How can we design a composite material that is able to achieve an optimum strength to mass ratio for surviving extreme conditions of high-altitude flight?

How can we represent relationships between variables to construct patterns for guidance in analyzing properties of materials and designing a composite material that achieves an optimum strength to mass ratio to survive the extreme conditions of high altitude space flight?

Enduring Understanding

Matter has specific physical properties (including density, volume, and mass), and consists of atoms that may be arranged in regular geometric patterns. Density can be defined as the amount of matter that is in a particular amount of space. If two objects have equal volume, but unequal mass, the one with greater mass is denser. If two objects have equal strength, but unequal mass, the material with the lower mass will have a greater strength to mass ratio, and therefore will have higher material performance.

The atmosphere has defined layers, each having distinct properties of air density, air pressure, temperature, and gas mixtures.

Ratios compare portions of changing quantities to other portions or to entire entities. Conversions allow cross-cultural and quantifiable relationships to excel with defined, universally accepted ratios. Use of equations can lead to graphical representations, connecting realistic comparisons with hypothetical and abstract knowledge.

Engineering Design Challenge

Student teams are challenged to create a composite material with a superior strength to mass ratio capable of surpassing the space jump record. Teams decide which material combination will create an optimal composite for use in creating components of a stratospheric capsule. In this case, we have simplified the challenge and are focusing on the material selection for the floor of the capsule. Student teams will analyze the properties of fibers in tension to draw conclusions regarding their ability to withstand forces. They then create a composite material by combining the material of their choice with a given epoxy resin. Students test their cured composites for tensile and bending strength. Testing is completed at both room temperature and under extreme cold conditions (as created by dry ice). The students will learn that their materials become more brittle at lower temperatures, and therefore designing for room temperature is very different than designing for high-altitude conditions. The test fixture will be provided for the students and will help them measure the forces that their composite should be able to withstand for a successful design.

Students use the engineering design process to design, build, and test composite materials from a choice of either classroom provided materials or those that they supply themselves. As they test and find the breaking point, they may use other team's testing results as a guide for redesigning, rebuilding, and retesting. The end goal is to find the best strength to mass ratio in order to conclude which combinations of materials yield the strongest, lightest composite material. Finally, students use research and gathered data to support their scientific claims and communicate these findings in the form a marketing proposal to a company of their choice.

Time and Activity Overview

Day	Time Allotment	Actvities
1	50 minutes	Pretest Introduce Composites Video Clip: "Carbon Fiber " Video Clip: "The Newsreel of Joseph Kittinger's 19.5-Mile Jump" Video Clip: "The World's Biggest Jump" Engineering Design Challenge & Marketing Proposal Requirements Homework: Find Material, Analyze Ancient Rome's Buildings
2	50 minutes	Team Career Positions Team Code of Cooperation Observe Composite Examples Video Clip: "Atomic Structure of Carbon Fibers" Video Clip: "Concrete Atoms" Homework: Sponsor Company Research, Career Research
3	80-100 minutes	Physical Composition of Composites Introduce Test Fixture and Function Homework: Analyze Composite Polygons, Opposing Forces
4	80-100 minutes	Continue Investigative Rotations Composite Connections to Aerospace Choose a Material Formulate Plan for Team Composite Homework: Original Space Jump Inferences, Proposal Tasks
5	50 minutes	Create Composite Specimen Specific Strength
6	80-100 minutes	Composite Bend Testing Record and Analyze Each Team's Data Exit Slip Homework: Proportional Relationships
7	50 minutes	Analyze Results Brainstorm Redesign Ideas (continue individually for HW)
8	50 minutes	Share Brainstorming Ideas Plan and Construct Redesign
9	80-100 minutes	Test and Analyze Redesigned Composite Measure, Record, Plot and Analyze Physical Properties of Composite Test Winning Team's Composite for Tension Strength Under Extreme Cold Continue Marketing Proposal
10	50 minutes	Finalize Data Plots Compare Class Results Concluding Analysis
11	50 minutes	Connect Results to Previous Research Finalize Proposal (complete for homework)
12	50 minutes	Unit Wrap-Up / Class Discussion Post-Test

Pre-requisite Knowledge & Skill

Students know how to set up a proportion to solve for a unit rate.

Students can write and solve equations with variables.

Students can distinguish between area and surface area of figures.

Students can analyze and interpret data in order to develop a conclusion.

Students can identify the different properties of matter.

Students comprehend that all matter is made of atoms.

Students understand and can give examples of transformations of energy.

Students know the different parts of a formal written letter.

Academic Content Standards

Add Standard	Mathematics
Grade/Conceptual Category	Grade 7 - Developing Understanding of and Applying Proportional Relationships
Domain	Ratios and Proportional Relationships
Cluster	Analyze proportional relationships and use them to solve real-world and mathematical problems.
Standards	1. Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measure in like or different units. 2. Recognize and represent proportional relationships between quantities. a. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin. b. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships. c. Represent proportional relationships by equations. For example, if total cost t is proportional to the number n of items purchased at a constant price p, the relationship between the total cost and the number of items can be expressed as $t = pn$. 3. Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.

Add Standard	Mathematics
Grade/Conceptual Category	Grade 7 - Solving Problems Involving Scale Drawings and Informal Geometric Constructions
Domain	Geometry
Cluster	Draw, construct, and describe geometrical figures and describe the relationships between them.
Standards	1. Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale. 3. Describe the two-dimensional figures that result from slicing three-dimensional figures, as in plane sections of right rectangular prisms and right rectangular pyramids.

Add Standard	Mathematics
Grade/Conceptual Category	Grade 7 - Working with Two- and Three-Dimensional Shapes to Solve Problems Involving Area, Surface Area, and Volume
Domain	Geometry
Cluster	Solve real-life and mathematical problems involving angle measure, area, surface area, and volume
Standards	6. Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms

Add Standard	Mathematics
Grade/Conceptual Category	Grade 7 - Drawing Inferences about Populations Based on Samples
Domain	Statistics and Probability
Cluster	Draw informal comparative inferences about two populations.
Standards	3. Informally assess the degree of visual overlap of two numerical data distributions with similar variabilities, measuring the difference between the centers by expressing it as a multiple of a measure of variability. 4. Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations.

Add Standard	English Language Arts
Grade	6 - 8
Strand	Reading Standards for Literacy in Science and Technical Subjects 6–12
Topic	Key Ideas and Details
Standard	1. Cite specific textual evidence to support analysis of science and technical texts. 2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. 3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Add Standard	English Language Arts	
Grade	6 - 8	
Strand	Reading Standards for Literacy in Science and Technical Subjects 6–12	
Topic	Craft and Structure	
Standard	4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics. 5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic. 6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.	

Add Standard	English Language Arts	
Grade	6 - 8	
Strand	Reading Standards for Literacy in Science and Technical Subjects 6–12	
Topic	Integration of Knowledge and Ideas	
Standard	5. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). 6. Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. 7. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	

Add Standard	**English Language Arts**	Ohio
Grade	6 - 8	
Strand	Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects 6–12	
Topic	Texts Types and Purpose	
Standard	1. Write arguments focused on discipline-specific content. a. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically. b. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence. d. Establish and maintain a formal style. e. Provide a concluding statement or section that follows from and supports the argument presented. 2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. a. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension. b. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. c. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to inform about or explain the topic. e. Establish and maintain a formal style and objective tone. f. Provide a concluding statement or section that follows from and supports the information or explanation presented.	

Add Standard	**English Language Arts**	Ohio
Grade	6 - 8	
Strand	Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects 6–12	
Topic	Productions and Distribution of Writing	
Standard	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. 5. With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. 6. Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.	

Add Standard	English Language Arts
Grade	6 - 8
Strand	Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects 6–12
Topic	Research to Build and Present Knowledge
Standard	7. Conduct short research projects to answer a question, drawing on several sources and generating additional related, focused questions for further research and investigation. 8. Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. 9. Draw evidence from literary or informational texts to support analysis, reflection, and research.

Add Standard	English Language Arts
Grade	6 - 8
Strand	Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects 6–12
Topic	Range of Writing
Standard	10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Add Standard	English Language Arts	
Grade	7	
Strand	Speaking and Listening	
Topic	Comprehension and Collaboration	
Standard	1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly. a. Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. b. Follow rules for collegial discussions, track progress toward specific goals and deadlines, and define individual roles as needed. c. Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed. d. Acknowledge new information expressed by others and, when warranted, modify their own views. 2. Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study. 3. Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence.	

Add Standard	English Language Arts	
Grade	7	
Strand	Language	
Topic	Vocabulary Acquisition and Use	
Standard	6. Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.	

Add Standard	**Social Studies**	Ohio
Grade	7	
Theme	World Studies from 750 B.C. to 1600 A.D.: Ancient Greece to the First Global Age	
Strand (pk-8 only)	History	
Topic	Historical Thinking: Historical thinking begins with a clear sense of time – past, present and future – and becomes more precise as students progress. Historical thinking includes skills such as locating, researching, analyzing and interpreting primary and secondary sources so that students can begin to understand the relationships among events and draw conclusions.	
Content Standard	1. Historians and archaeologists describe historical events and issues from the perspectives of people living at the time in order to avoid evaluating the past in terms of today's norms and values.	

Add Standard	**Social Studies**	Ohio
Grade	7	
Theme	World Studies from 750 B.C. to 1600 A.D.: Ancient Greece to the First Global Age	
Strand (pk-8 only)	History	
Topic	Early Civilizations: The eight features of civilizations include cities, well-organized central governments, complex religions, job specialization, social classes, arts and architecture, public works and writing. Early peoples developed unique civilizations. Several civilizations established empires with legacies influencing later peoples.	
Content Standard	2. The civilizations that developed in Greece and Rome had an enduring impact on later civilizations. This legacy includes governance and law, engineering and technology, art and architecture, as well as literature and history. The Roman Empire also played an instrumental role in the spread of Christianity.	

Add Standard	Science	Ohio
Grade	7	
Theme	Order and Organization	
Topic	Cycles and Patterns of Earth and the Moon	
Content Standard	The atmosphere has different properties at different elevations and contains a mixture of gases that cycle through the lithosphere, biosphere, hydrosphere and atmosphere. The atmosphere is held to the Earth by the force of gravity. There are defined layers of the atmosphere that have specific properties, such as temperature, chemical composition and physical characteristics. Gases in the atmosphere include nitrogen, oxygen, water vapor, carbon dioxide and other trace gases. Biogeochemical cycles illustrate the movement of specific elements or molecules (such as carbon or nitrogen) through the lithosphere, biosphere, hydrosphere and atmosphere. Note: The emphasis is on why the atmosphere has defined layers, not on naming the layers.	

Add Standard	Science	Ohio
Grade	7	
Theme	Order and Organization	
Topic	Conservation of Mass and Energy	
Content Standard	The properties of matter are determined by the arrangement of atoms. Elements can be organized into families with similar properties, such as highly reactive metals, less-reactive metals, highly reactive nonmetals and some gases that are almost completely nonreactive. Substances are classified according to their properties, such as metals and acids. When substances interact to form new substances, the properties of the new substances may be very different from those of the old, but the amount of mass does not change. Note: This is the conceptual introduction of the Periodic Table of Elements. Note: Acids and bases are included in this topic. Note: It is important to emphasize that most changes in the properties of matter have some combination of chemical and physical change (at different levels). Nonmetals are poor conductors of heat and electricity, are usually gases at room temperature and, as solids, tend to be dull and brittle. Chemical and physical changes occur on a continuum and no distinct lines separate the two. In many cases when objects, substances or materials undergo change, there may be a combination of chemical and physical changes occurring. Under these standards, classifying specific changes as chemical or physical is not appropriate. For any change in a closed system, the number and type of atoms stays the same, even if the atoms are rearranged. Therefore, the mass remains constant. Note: Appropriate background knowledge such as graphics representing the atomic composition of the substances involved or descriptions of how the matter can be formed, decomposed or separated, should accompany questions asking to classify matter as an element, compound or mixture. The nature of chemical bonding is not appropriate at this grade. Note: While mass is always conserved, this is not the case for volume. Mixing alcohol with water results in a volume that is less than the sum of the volumes. Boiling liquid results in a significant increase in volume. Note: The idea of reversibility of changes is not a criterion for classifying changes as chemical or physical. Some changes cannot be reversed, like tearing paper. As students progress farther in chemistry, they will learn about equilibrium, which involves many chemical changes that are reversible. Dissolving an ionic substance is an example of a process that is not clearly chemical or physical since bonds are broken.)	

Add Standard	Science
Strand	
Course Content	
Content Elaboration	

Add Standard	Fine Arts
Grade	7
Subject	Visual Arts (2012, Revised)
Standard	Cognitive & Creative Learning Processes: Perceiving/Knowing
Benchmark	N/A
Indicator	Content Statements: 1PE Explore how personal experiences, interest, cultural heritage and gender influence an artist's style and choice of subject matter. 2PE Identify professions that use artistic skills and problem-solving. 5PE Examine designed objects and identify the processes and decisions made to produce them with attention to purpose, aesthetics, social issues and cultural and personal meaning. 6PE Connect various art forms to their social, cultural or political purposes and include regional examples.

Add Standard	**Technology**
Grade	7
Standard	Technology and Society Interaction
Benchmark	A: Analyze technologically responsible citizenship.
Indicator	Technology and Citizenship 1. Classify how new technologies have resulted from the demands, values and interests of individuals, businesses, industries and societies. 2. Relate ways that the uses of inventions and innovations have led to changes in society and the creation of new needs and wants.

Add Standard	**Technology**
Grade	7
Standard	Technology and Society Interaction
Benchmark	C: Describe how design and invention have influenced technology throughout history.
Indicator	Technology and History 1. Explain how the design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.

Assessment Plan

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

Performance Task, Projects	Engineering Design Challenge: Design, Create, and Test a Composite
Quizzes, Tests, Academic Prompts	Pre/Post-Test Inferences Regarding Observations of Provided Composite Materials
Other Evidence (e.g. observations, work samples, student artifacts, etc.)	Composite Material Nature of Team Collaboration Observations Nonfiction Article Analysis; Supporting Claims with Evidence Data Tables and Plots Synthesis and Application of Gathered and Plotted Data
Student Self- Assessment	Reflections Based on Rubrics Exit/Entrance Slips

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.	Teacher will use a Smartboard or LCD projector to view a youtube video of the Red Bull Stratos Live Jump. Teacher will use Smartboard or LCD projector to view examples of gondolas.
D	Technology tools and resources that support students and teachers in ***dealing effectively with data***, including data management, manipulation, and display.	Students may use a graphing calculator to solve mathematical concepts and plot data. Students may use an excel spreadsheet to record data of their testing materials.
I	Technology tools and resources that support students and teachers in conducting ***inquiry***, including the effective use of Internet research methods.	Students will use the Flow Model Research template or the Sequence Model Research template to organize their research. Students will use search engines to conduct research.
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.	Students will use an Excel spreadsheet to determine the rate of change of the temperature and breaking point of their material. Students will use youtube videos to view examples of composites during their redesign process. Students and teachers will view the redbull.com - Stratos live jump video to demonstrate the physical properties of breaking the sound barrier.
C	Technology tools and resources that support students and teachers in ***communicating and collaborating*** including the effective use of multimedia tools and online collaboration.	Students will use a word document to write a persuasive letter to a company convincing them to use their composite. Students and teachers will use Google Docs to collaborate and communicate ideas with group members.
	**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

Structural Engineers-
Structural engineers commonly design and analyze buildings and structures for any use. In addition to buildings, structural engineers also commonly design machinery and all types of vehicles (cars, ships, planes, and spacecraft) where the structural material and design are important to the item's operation or safety throughout its intended lifetime. Any object is constantly subjected to the stresses and pressures of everyday use, and it is the responsibility of the structural engineer to ensure the item does not bend, twist, collapse, or vibrate excessively. The structural engineer is responsible for ensuring that the object remains strong and secure throughout its use even under extreme design conditions such as weather.

Structural engineers have a role in designing the building you teach in, the desks and chairs that students use, and even many science laboratory instruments. Everything is designed with a purpose in mind to be both safe and effective. There are many common objects that people use all the time that may not have obvious structural engineer involvement. For example, sporting equipment is designed to withstand unique stresses for that sport. Material selection is critical to provide unique combinations of light weight, high strength, practical safety, and reasonable cost. Common examples are football pads, basketball backboards, baseball bats, tennis rackets, golf clubs and golf balls, and even snow and water skis. Structural engineers are critical team members for the design of any of these products. Especially as composite materials are more commonly used for these items, structural engineers provide the necessary expertise to tailor the selection of polymer-matrix and reinforcement materials to determine the correct mechanical properties and weight ratios in the design.

Structural engineers are often needed within the Air Force Research Laboratory. The most common position is within the Materials and Manufacturing Directorate where engineers develop new materials, processes and manufacturing technologies for use in aerospace applications. These applications include aircraft, spacecraft, missiles, and rockets. The material selection and design includes the structural, electronic, and electromagnetic components that are used in these systems. AFRL researchers are commonly called on to provide quick reaction support to solve materials related concerns and problems that often occur within daily Air Force operations. The directorate is also responsible for the Air Force technology programs that address environmental issues, and they provide materials expertise for airbase assets such as runways, buildings, and infrastructure, and technologies for deployed forces.

Materials Scientists/Engineers

Materials science is an interdisciplinary field applying the properties of matter to various areas of science and engineering. This scientific field investigates the relationship between the structure of materials at atomic or molecular scales and their macroscopic properties. It incorporates elements of applied physics and chemistry. With significant media attention focused on nanoscience and nanotechnology in recent years, materials science has been propelled to the forefront at many universities. It is also an important part of forensic engineering and failure analysis. Materials science also deals with fundamental properties and characteristics of materials.

Materials engineers are often needed within the Air Force Research Laboratory. The most common position is within the Materials and Manufacturing Directorate where engineers develop new materials, processes and manufacturing technologies for use in aerospace applications.

Mechanical Engineers

Mechanical engineering is the discipline of designing, developing, building, and testing mechanical devices such as tools, engines, machinery, vehicles, and thermal systems. Mechanical engineers often apply principles from and work with individuals from several engineering disciplines when selecting or integrating materials, developing a design for a particular system, manufacturing products, or testing new designs. Mechanical engineering requires a fundamental understanding of several concepts including mechanics, kinematics, thermodynamics, materials science, structural analysis, and electricity.

Mechanical engineering is one the oldest engineering disciplines, with its foundation being traced back several thousand years around the world with in civilizations such as ancient Greece and the Roman Empire. This engineering discipline emerged with the 18th century European industrial revolution and 19th century advancements in the field of physics, and has continued to develop with advancements in technology.

As one of the broadest engineering fields, mechanical engineering is used widely within the Air Force Research Laboratory. This discipline is needed in almost every directorate involved in the development of materials, hardware, and weapon systems.

Aerospace Engineers

Aerospace engineers design aircraft, spacecraft, satellites, and missiles. In addition, they test prototypes to make sure that they function according to design. Aerospace engineers may develop new technologies for use in aviation, defense systems, and spacecraft. They often specialize in areas such as aerodynamic fluid flow; structural design; guidance, navigation, and control; instrumentation and communication; robotics; or propulsion and combustion.

Aerospace engineers can specialize in designing different types of aerospace products, such as commercial and military airplanes and helicopters; remotely piloted aircraft and rotorcraft; spacecraft, including launch vehicles and satellites; and military missiles and rockets. Aerospace engineers often become experts in one or more related fields: aerodynamics, thermodynamics, celestial mechanics, flight mechanics, propulsion, acoustics, and guidance and control systems.

Aerospace engineering is used widely within the Air Force Research Laboratory. This discipline is needed in almost every directorate involved in the development of aircraft, spacecraft, and weapon systems.

Section II: STEM Lesson Plan

Title of Lesson — **Day 1: Pre-Test, Introduction to Composites**

Time Required — 50 minutes

Materials

Computer with Internet Access and Video Projection Capabilities (one per class)
Composite-Based Toys/Tools (ex. snowboard, ball bat, construction tools)
Appendix A: Pre-Tests (one per student)
Appendix B: Pre-Test Answer Key (one per teacher)
Appendix C: Engineering Logbook (one copy of entire appendix packet per student-used throughout unit)
  Engineering Design Challenge
  Engineering Design Challenge Rubric
  Marketing Proposal Outline
  Marketing Proposal Rubric
  "The Secrets of Ancient Rome's Buildings," by Erin Wayman, Analysis
Appendix D: Engineering Logbook (one per teacher)
Appendix E: Bell Ringer: Let the Units Lead You

Video Clip: "Carbon Fiber" from "Greatest Inventions with Bill Nye" (4m): http://player.discoveryeducation.com/views/hh_httpView.cfm?guidAssetId=eefc8075-bd9f-4568-8de9-23e8c8d25d25 (video begins at 19m5s)

Video Clip: "The Newsreel of Joseph Kittinger's 19.5-Mile Jump From Space (1960)" (2m4s):
http://www.theatlantic.com/video/index/263390/

Video Clip: "Felix Baumgartner Breaks the Speed of Sound" (1m30s):
http://www.redbullstratos.com/gallery/?mediaId=media1900707044001

Objectives

Students will demonstrate prior knowledge regarding properties of matter, properties of atmospheric layers, units of measure, and ratios through completion of a pre assessment and class discussion.

Student will explore and be able to explain the properties of composite materials while making connections to their personal experiences.

In order to effectively evaluate informational articles, students will be able to cite pieces of textual evidence to support analysis of what a text says explicitly as well as inferences drawn from a scientifically-based historical article.

Instructional Process

Bell-ringer: Let the Units Lead You

1. Administer Pre-Test
   Note: Pre-Test scores can are useful for guidance in modifying the unit to suit your particular students' needs.
2. Break students into teams of four.
3. Distribute Engineering Logbook and discuss reasons for Keeping a logbook. For an example and further explanation, see the following: http://www.bio-link.org/GMP/Labnote.pdf
4. Introduce the concept of a composite - define/discuss what a composite is in its most basic form. Connect to the basic definition of a ratio.
5. Show and discuss the video clip "Carbon Fiber" excerpt from "Greatest Inventions with Bill Nye."
6. Show video clip: "The Newsreel of Joseph Kittinger's 19.5-Mile Jump From Space (1960)"
7. Show video clip: "The World's Biggest Jump"

8. Instruct teams to discuss and record notes regarding:
   a. ways in which they think composites are used in space capsule designs such as the ones they viewed in the video clips
   b. how materials have changed from the time of Kittenger's space jump to the time of Baumgaartner's jump.
9. Assign Homework:
   a, Find a material (fiber) at home that can be used for testing on day three and bring to class the following day.
   b. Analyze Ancient Rome's Buildings article contained in logbook by completing Analysis pages.

Differentiation

Materials can be geared toward those in which students are most familiar.
Choice of video clips was selected and could be changed in order to reflect local careers and/or objects with which students can identify.

Assessments

Students will take a pretest to establish baseline understanding of where (in the world) composite may be used, and the calculations necessary to build and test them. Results should be used to modify the remainder of this unit as necessary for specific classes and individuals.

Students will make qualitative observations/connections based on the movie clip (at least four).

Bell Ringer (used as a formative assessment)

Section II: STEM Lesson Plan

Title of Lesson

Day 2: Explore Properties of Commonly Known Composites

Time Required

50 minutes

Materials

Computer with Internet Access and Video Projection Capabilities (one per class)
Computers with Internet (at least one per team)
Composite-Based Toys/Tools (examples: cell phone cover, lap top case, corrugated pizza box)
(*advanced composite examples, if available: drywall/cement board piece, tool handles, sporting equipment)
Appendix C: Engineering Logbook:
Team Career Positions
Team Code of Cooperation
"The Secrets of Ancient Rome's Buildings," by Erin Wayman, Analysis (completed homework)
Potential Sponsorship Company Research
Appendix E: Bell Ringer: Prop Up the Proportionality

Video Clip: "How to Explore the Atomic Structure of a Carbon Fiber: Zoom into Carbon Fibers" (3m18s)
https://www.youtube.com/watch?v=Vjyjdj-5S5E

Video Clip: "How to Explore the Atomic Composition of Concrete: Zoom into Concrete" (3m1s)
https://www.youtube.com/watch?v=UUcQSw7oO0k

Objectives

Student will collaboratively explore, discuss, and be able to explain the properties of composite materials while making connections to their personal experiences.

Students will classify relationships between two quantities as proportional or non-proportional and complete a table of values for both sets of numerical patterns.

In order to effectively evaluate informational articles, students will be able to cite pieces of textual evidence to support analysis of what a text says explicitly as well as inferences drawn from a scientifically based historical article.

Instructional Process

Bell Ringer: Prop Up the Proportionality

1. Instruct teams to choose individual careers and create a Team Code of Cooperation.
2. Display and discuss the construction and application of common composite items, including ways in which the ratios of composite items must be proportionate, depending necessary quantities.
   *possible easily accessible examples: cell phone cover, lap top case, corrugated pizza box
   *advanced composite examples, if available: drywall/cement board piece, tool handles, sporting equipment
3. Discuss "The Secrets of Ancient Rome's Buildings" article analysis and ways in which knowledge gained could be beneficial completing the design challenge.
4. Instruct students to complete Atomic Structure of Carbon Fibers and Atomic Composition of Concrete pages as the corresponding video clips are are played. Discuss knowledge gained from videos to check for understanding. Discuss connections to ancient Rome's buildings.
5. Discuss instructions on the Potential Sponsorship Company Research page of Engineering Logbook. Allow time for teams to discuss companies that could benefit from attempting to break space jump records
6. Assign Homework:
   a. Continue research of potential sponsorship companies, and record notes for presenting to the team. Teams will choose a company based on research findings and notes.
   c. Begin career research as instructed on the bottom of Team Career Position page.

Differentiation

Materials can be geared toward those in which students are most familiar.
Bell-ringer may contain fewer problems or have guided notes added to the document to visualize patterns.

Assessments

Bell-ringer (used as a formative assessment)

Section II: STEM Lesson Plan

Title of Lesson

Days 3 and 4: Physical Composition of Composites, Team Investigative Rotations, Formulate a Plan

Time Required

160-200 minutes (80-100 minutes per day)

Materials

Computer with Internet Access and Video Projection Capabilities (one per class)
Computer (at least one - each team will use during investigative rotations)
Composite Materials Testing Fixture (one per class)
Various Cut-Away Specimens of Materials Accessible to Teacher
(possible examples: fiberglass, acrylic based pieces, construction materials such as drywall)
Appendix C: Engineering Logbook:
"U.S. Air Force Fact Sheet: Excelsior Gondola" Analysis
"U.S. Air Force Fact Sheet: Stargazer Gondola" Analysis
Exploring Atmospheric Properties of a Space Dive: Red Bull® Interactive
"Red Bull Stratos Fact Sheet" Analysis
Engineering Design Process
Appendix E: Bell Ringer: Just the Way You Slice It
Appendix E: Bell Ringer: The Mind-Manipulating of Misused Data

Video Clip: "Concret" Excerpt from "Greatest Inventions with Bill Nye"
http://player.discoveryeducation.com/views/hh_httpView.cfm?guidAssetId=eefc8075-bd9f-4568-8de9-23e8c8d25d25 (video starts at 5m40s)

Objectives

Students will utilize test equipment correctly to explain the physical composition of and methods by which composite materials are created as well as determine and analyze the results of the strength of composite materials by correctly labeling a diagram. They will apply the concept of inverse operations towards tension and compressive forces within a strength test to record net force.

Students will identify misuses of numerical scales within charts and graphs that are used to misrepresent data and explain how the change reflects these inaccuracies.

Students will utilize information from their design process to persuade a potential client using knowledge of mathematical models to convey an appealing argument in a marketing proposal format.

Through use of an interactive simulation, students will be able to explain properties of the atmosphere as related to high-altitude flight missions.

Instructional Process

Day 3 - Bell Ringer: Just the Way You Slice It - Geometric Polyhedrons: may be analyzed to determine cross-section of a polyhedron.

Day 4 - Bell Ringer: The Mind-Manipulating of Misused Data

1. Introduce students to the physical composition of a composite material. This should involve a display of the cross section of a composite materials or even materials that are fully broken into parts. They will rotate to analyze this as described below.
2. Hold a class discussion regarding reasons why a composite is vital to certain aerospace missions (high strength, lower weight, temperature resistance, insulating properties). Instruct teams to refer to yesterday's team discussion notes regarding use of composites. Have teams add ideas to the notes.
3. View "Concrete" excerpt about the creation of a composite material, from "Greatest Inventions with Bill Nye."
4. Demonstrate testing fixture; use a piece of material that is not easily broken to create suspense that will be

broken later in this unit. Be sure to focus on use of equipment throughout demonstration. Introduce new vocabulary while demonstrating, including compressive and opposing forces. Connect opposing forces to inverse operations mathematically pulling in opposite directions.

5. Inform teams that they will be rotating today and tomorrow to in order to:
   • Test each team member's material (brought from home) for tension strength following Student Testing Procedures Tension Strength instruction in Engineering Logbook.
   • View and record observations from teacher provided composite material samples.
   • Discuss Potential Sponsorship Company Research homework, choose one company to whom you will market, and complete research company to fill in information on the chart.
   • Research & support need for extreme testing as related to properties of atmospheric layers by analyzing all 3 space flight fact sheets contained in logbook by breaking down the text on the Analysis pages.
   • Collaboratively complete "Exploring Atmospheric Properties of a Space Dive: Red Bull® Interactive" on the Internet.
   • Complete "Ask" and "Think" "Plan, Test, Think Again" sections of the Engineering Design Process contained in the Engineering Logbook.
   • If teams finish any rotation and are waiting to use test fixture or complete computer interactive, they should begin drafting marketing proposal (components that can be written prior to testing --how competing with Red Bull® is a beneficial marketing strategy, etc.).
6. Have teams complete the Choose a Material section of the Engineering Design Process.
7. Assign homework:

   Day 3 -

   a. Pick 3-5 composite materials from home and analyze the polygon involved with the cross section of the given material.
   b. Connect opposing forces to another physical example involved in the movement of an object or living creature. Assign the forces positive and negative values to determine which "motion" wins the battle of inverse operations.

   Day 4 -

   a. "Inside the Original Space Dive: Joseph Kittinger on 1960 Jump" pages of Engineering Logbook.
   b. Individual marketing proposal tasks (teams should keep in mind this is due on Day 12 and manage their time by dividing tasks among team members as needed).

Differentiation

Sample specimens and discussion focuses can be chosen to connect to students experiences and prior knowledge. Guided notes may be created to allow all to participate in the idea generation stage of brainstorming and selecting a material for their composite.

Video clips can be changed if necessary for different audiences (maturity of discussion and/or topics).

Bell-ringer may be shortened or expanded; manipulatives may be used to visualize the cross section of a polyhedron.

Final company selection may require a list of competitors including local businesses seeking exposure. Students with special education needs may need a guide to frame their marketing plan.

Assessments

Observation of the using mathematics of opposing forces to make connection to inverse operations
Bell Ringer: Just the Way You Slice It
Bell Ringer: The Mind-Manipulating of Misused Data (for use of math models in Marketing Proposal)
Completion of investigative rotations
Team plan for creating a composite
Marketing Proposal draft - per rubric

Section II: STEM Lesson Plan

Title of Lesson — **Day 5: Create Team Composite**

Time Required — 50 minutes

Materials

Appendix C: Engineering Logbook:
- Engineering Design Process
- Testing Data Sheet

Test Fixture (one per class)
Materials for Composite Construction (chosen by individual teams)
Epoxy Resin for use in Composite Material Building (see Appendix F: Teacher Resources)
Appendix E: Bell Ringer: Put the Proportions in Place

Objectives

Based on results from day two, students will draw from knowledge gained regarding properties of matter and arrangement of atoms as well as properties of the atmosphere to construct a composite material from supplied epoxy resin and choice matrix.

Students will explain through a written summary how constraints or introductory values affect a relationship's ability to maintain proportionality.

Students will practice use of a specific strength equation and be able to apply it to their composite testing results.

Instructional Process

Bell-ringer - Proportional relationships through graphs

1. Discuss importance of following the Epoxy Resin Use Instructions. Have teams review the document and sign page 2 to verify they understand.
2. Explain how teams will obtain resin from the teacher and use the other material (chosen by team) to create their composite specimen for testing.
3. If a team finishes construction of their composite, they should continue drafting their marketing proposal (teams should keep in mind this is due on Day 12 and manage their time by dividing tasks among team members as needed).
4. Discuss specific strength of materials (see Finding a Material's Specific Strength) and have teams collaboratively complete the Specific Strength - Student Guide.
5. Assign homework:
   Individual marketing plan tasks (as determined by team)

Differentiation

Coordinate grids may be provided with scales intact to assist with the Bell-ringer

Assessments

Assessed for accuracy in the analysis of tested composites' specific strength.

Section II: STEM Lesson Plan

Title of Lesson

Day 6: Testing Composites, Analyzing And Recording Data

Time Required

80-100 minutes

Materials

Composite Materials Test Fixture (one per class)
Common Resin for use in Composite Material Building
Specimen Materials for Composite Building (from home-see day 1)
Appendix C: Engineering Logbook:
  Engineering Design Process
Dry Ice (one block)
Appendix E: Bell Ringer: Edge into Equations for Proportionality

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Objectives

Students will observe and analyze physical properties of their composite specimens and record testing data to determine and compare and contrast the strength of the specimens by applying the specific strength equation.

Students will match linear equations, tables and graphs with each other in the context of authentic applications of composite projects launched during historical and contemporary events.

Instructional Process

Bell Ringer: Edge into Equations for Proportionality

1. Explain that members of each team will measure physical properties of composite specimens and record on the data sheet.
2. Instruct teams to measure and record their composite specimen's preload measurements on Composite Bend Testing Results page of Engineering Design Process.
3. Discuss the Student Testing Procedures for Bend Strength instructions. Remind students to observe each team tests as they main gain ideas for their team's redesigned composite.
4. Have teams take turns mounting specimens in the test fixture and testing for bend failure, while recording and analyzing data.
5. Allow time for teams to continue recording and analyzing testing results.
6. Exit Slip - How does the challenge of mass restrictions to your composite adversely affect your ability to produce a high strength yield? Additionally, do you find the strength of your specimen to be proportionally related to any other variables identified through this engineering design process?
7. Assign homework:
   Individual marketing plan tasks (teams should keep in mind this is due on Day 12 and manage their time by dividing tasks among team members as needed).

Differentiation

Teams may be guided as needed during the test (use of testing fixture).
Some students may need modified data sheet if they struggle to keep pace with the class.
Mathematical glossaries may need to be provided to assist with the vocabulary matching

Assessments

Assessed for accuracy in the analysis of tested composites' specific strength.
Bell-ringer – second day of graphing proportional relationships
Exit Slip: Mass Restrictions & Proportionality

Section II: STEM Lesson Plan

Title of Lesson

Day 7: Analyze Results, Plan Redesign

Time Required

50 minutes

Materials

Composite Materials Test Fixture (one per class)
Appendix C: Engineering Logbook:
Engineering Design Process
Appendix E: Bell Ringer: Sample Space Has Its Place

Objectives

Students will observe and analyze physical properties of their composite specimens and record testing data to determine and compare and contrast the strength of the specimens by applying the specific strength equation.

Students will collaborate to categorize data in a format that is useful for informing redesign, emphasizing comparative specimen spaces.

Instructional Process

Bell-ringer: Specimen Space

1. Instruct teams to complete Analyze Results, Think Again, Improve, Test section of the Engineering Design Process.
2. Guide teams through Testing Analysis questions to form graphs and comparative conclusions based on their recorded data.
3. Instruct teams to begin a brainstorming session for a redesign based on the collected data.
4. As time runs out teams should be assigned to bring 5-10 redesign ideas for their homework.
5. Math Match - As teams continue to redesign and test, have students match mathematical vocabulary with authentic applications
6. Assign homework:
   Individual marketing plan tasks (teams should keep in mind this is due on Day 12 and manage their time by dividing tasks among team members as needed).

Differentiation

Some teams may need guidance and/or a template to graph collected data.
Some teams may also need a guide for doing their brainstorming (certain criteria to look to change).

Assessments

Students plot a graph and record analysis questions that accurately portrays differences in team testing of composite materials.

Section II: STEM Lesson Plan

Title of Lesson — **Day 8: Composite Redesign**

Time Required — 50 minutes

Materials

Common Resin for use in Composite Material Building
Sample Specimens for Composite Building (from home-see day 1)
Appendix C: Engineering Logbook
Appendix E: Bell Ringer: The Price is Prickly – Percent of Change

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Objectives

Students will follow the engineering design process and in order to reengineer a composite material based on analysis of calculated percent of change from initial testing results.

Students will determine the slope of a proportional relationship and analyze the slope to discover its authentic meaning within the specific strength scenario

Instructional Process

Bell Ringer: The Price is Prickly – Percent of Change

1. Instruct teams to share brainstorming ideas and create a plan for redesigning their composite specimen.
2. Allow time for students to follow their plan and construct a second iteration of a composite specimen.
3. Be sure teams include percent of change scenarios within experimentation to contextualize the formulas introduced in the Bell-ringer.
4. Have students continue to add to their marketing plan as they redesign a composite with proposed improvements (continue letter for homework).
5. Assign homework:
   Individual marketing plan tasks (teams should keep in mind this is due on Day 12 and manage their time by dividing tasks among team members as needed).

Differentiation

Some teams may need to be shown template of which ways to plug in their brainstorms for redesign.
Formulate guided notes for percent change problems as need for specific students.

Assessments

Brainstorming session
Calculation of percent of change within the Bell-ringer questions

Section II: STEM Lesson Plan

Title of Lesson

Day 9: Test Redesign, Analyze Results and Test Winning Design

Time Required

80-100 minutes

Materials

Redesigned Composite Specimens
Composite Testing Fixture
Appendix C: Engineering Logbook:
Engineering Design Process
Dry Ice (one block for the day)
Appendix E: Bell Ringers: Putting Pennies on the Price – Percent of Change Creation

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Objectives

Students will test and analyze the specific strength of the redesigned material and calculate the percent of change between the specific strength of the two specimens.

Students will plot data based on test failure and specific strength to compare graphs based on different specimens and assume proportionality for mass production of these specimens. They will analyze graphs to determine why certain trends emerged/based on previous research.

Instructional Process

Bell Ringer: Putting Pennies on the Price – Percent of Change Creation

1. Have members of each team measure physical properties of composite specimens and record on the data sheet.
2. Instruct teams to take turns mounting specimens in the test fixture and testing for bend failure while recording and analyzing data regarding mass, failure rate, and specific strength.
3. Have students plot redesign strength results in order to determine the strongest composite.
4. Instruct teams to analyze data in order to determine which composite has the best specific strength.
5. Perform tension testing on the “winning” team's composite only under extreme cold conditions by subjecting it to dry ice.
6. Assign homework:
   Individual marketing plan tasks (teams should keep in mind this is due on Day 12 and manage their time by dividing tasks among team members as needed).

Differentiation

Some teams may need guidance and/or a template to graph collected data.
Rational numbers used within percent of change or the length of the percent of change
Bell-ringer may need to be modified.

Assessments

Plotted graph that accurately portrays differences in team testing of composite materials
Students will determine that the slope of a comparison graph represents the tensile strength of a composite
Use of proportional relationships to solve percent of change problems in preparation for data recording.

Section II: STEM Lesson Plan

Title of Lesson — **Day 10: Finalize Data Plots and Compare Class Results**

Time Required — 50 minutes

Materials

Redesigned Composite Specimens
Composite Testing Fixture
Appendix C: Engineering Logbook
Graph paper for plotting results
Appendix C: Engineering Logbook:
  Comparison/Connection: Concluding Analysis
Appendix E: Bell Ringers: Scandalous Scale Models

Objectives

Students will plot data based on test failure and specific strength to compare graphs based on different specimens and assume proportionality for mass production of these specimens. They will analyze graphs to determine why certain trends emerged/based on previous research.

Students will determine missing side lengths within similar figures and apply or calculate scale factors between these figures.

Students will be able to complete a concluding analysis which draws from knowledge gained throughout the unit as well as researched evidence to compare / make connections to creating and testing composites.

Instructional Process

Bell Ringer: Scandalous Scale Models

1. Provide the students opportunity to finish plotting data from final testing.
2. Present volunteered graphs to the class, working together to analyze trends with specimens and their strength
3. Model for the students how to complete Comparison/Connection: Concluding Analysis:
   -First, they will pick two successes/failures from their own material testing graphs.
   -Next, they will record one success/failure and connect each one to previous trials and/or research. (They need to write what they knew going in and/or changes that they made as a result)
   -Finally, model ways in which students can compare their chosen success/failure to that of another team. (Where did other teams have similar or opposite strengths/weaknesses)
4. Provide time for students to trade and/or observe each others' graphs.
5. Assign homework:
   a. Complete Connections/Comparisons for homework if needed.
   b. Individual marketing plan tasks (teams should keep in mind this is due on Day 12 and manage their time by dividing tasks among team members as needed).

Differentiation

Guided proportions may be provided on the Bell-ringer.
Comparison/Connection graphic organizer will assist to organize student’s qualitative observations regarding the engineering design process, allowing for smooth transfer of observations to their marketing proposal.

Assessments

Analysis of trends in data regarding specimens and their strengths
Concluding analysis with the appropriate connections and comparisons
Bell Ringer: Scale Models

Section II: STEM Lesson Plan

Title of Lesson — **Day 11: Finalize Marketing Proposal**

Time Required — 50 minutes

Materials

Computer Access- Word Processing Program, Printer, Internet, and E-Mail
Appendix C: Engineering Logbook:
  Marketing Proposal Outline and Rubric
Appendix E: Bell Ringer: Mix up the Math Models for Marketing

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Objectives

Students will analyze mathematical models to describe positive and negative characteristics regarding the usage in different contexts.

Students will utilize information from their design process and knowledge of mathematical models to convey an appealing argument in a marketing proposal. They will work with peers and the teacher to revise and edit their proposal for publication.

Instructional Process

Bell Ringer: Mix up the Math Models for Marketing

1. Discuss results and their connection to previous research. Remind students to include these connections in their marketing proposals.
2. Provide time for students to assemble individual marketing proposal tasks into a complete marketing proposal.
3. Guide students to revise and edit their compilations to prepare for final draft.
4. Provide or ensure access to technology for final proposals.
5. Assign homework:
   Ccomplete final copy of persuasive marketing proposal and E-mail or print for submission as determined by teacher.

Differentiation

Students will use technology as needed (graphic organizers/electronic media) to organize thoughts in a manner acceptable for cooperative compilation.

Persuasive marketing proposal template provides a model for students to create their own.

Matching of mathematical models allows students to construct positive and negative characteristics of their testing results stemming from those discussed in Bell-ringer.

Assessments

Presentation of final marketing proposals, correctly presenting a proposal and following the correct conventions for publication and distribution.

Section II: STEM Lesson Plan

Title of Lesson

Day 12: Post-Test

Time Required

50 Minutes

Materials

Appendix A: Post-Test (one per student)
Appendix B: Post-Test Answer Key (one per teacher)
Appendix C: Engineering Logbook
Graphs of Testing Results
Video Clips of Teams' Conducting Tests
Appendix E: Bell Ringer: Single Out the Summary

Objectives

Students will demonstrate knowledge and growth based on a post-test measuring the academic standards outlined previously in the lesson.
Students will discuss and analyze lessons learned and testing successes/failures.

Instructional Process

Bell Ringer: Single out the Summary

1. Administer post test.
2. As students finish, play video clips of material testing time.
3. Discuss new knowledge gained regarding composites: surprises and confirmations
4. As discussing, students will submit two ideas (each) for future creation and testing of composites.

Differentiation

Provide testing accommodations as needed for students.
Class discussion and individual submissions of ideas for future composite creation and testing.

Assessments

Score post-tests and compare to pretest.
Collect and review student suggestions for future building and testing.

Section III: Unit Resources

Materials and Resource Master List

Appendix A: Pre/Post-Test (one per student)
Appendix B: Pre/Post-Test Answer Key (one per teacher)
Appendix C: Engineering Logbook (one copy of entire appendix packet per student-used throughout unit)
Appendix D: Engineering Logbook Answer Keys (one per teacher)
Appendix E: Bell Ringers(one per student)
Appendix F: Teacher Resources
  Testing Fixture Assembly Directions
  Epoxy Resin and Caliper Suggestions
Computer with internet access and video projection capabilities (one per class)
Student computers to use for marketing proposal and various online student activities
Composite-based toys/tools
  (ex: snowboard, ball bat, construction tools)
Various cut-away samples of materials accessible to teacher
  (possible ideas: fiberglass, acrylic based pieces, construction materials such as drywall)
Geometric polyhedrons that may be analyzed to determine cross-sections
Dry ice (one block)
Video recorder to record team testing
Caliper - millimeter (one per class, see Appendix F: Epoxy Resin and Caliper Suggestions)

Epoxy Resin Material List: per team

- Epoxy Resin Parts A and B (see list in Printable Resources for suggested epoxy resins)
- MSDS
- Reinforcement materials
- Flat glass or metal sheet (approximately12 inch x 12 inch) – referred to as the "curing plate"
- Parchment paper
- Popsicle sticks or tongue depressors
- Mass scale
- Scotch (or similar) tape
- Cups (for mixing resin)
- Paper Towels
- Scissors
- Nitrile or latex gloves
- Safety goggles

-Testing Fixture (one per class)
-Testing Fixture Assembly Directions

Video clips:
  "Felix Baumgartner Breaks the Speed of Sound " (1m30s):
    http://www.redbullstratos.com/gallery/?mediaId=media1900707044001
  Supersonic jump (4m25s):
    http://www.redbullstratos.com/the-mission/world-record-jump/
  "How to Explore the Atomic Structure of a Carbon Fiber: Zoom into Carbon Fibers" (3m18s):
    http://science.wonderhowto.com/how-to/explore-atomic-structure-carbon-fiber-160131/
  "How to Explore the Atomic Composition of Concrete: Zoom into Concrete" (3m1s):
    http://science.wonderhowto.com/how-to/zoom-into-concrete-161995/
  "The Newsreel of Joseph Kittinger's 19.5-Mile Jump from Space (1960)" (2m4s):
    http://www.theatlantic.com/video/index/263390/
  "Carbon Fiber" (4m):
    http://player.discoveryeducation.com/views/hh_httpView.cfm?guidAssetId=eefc8075-bd9f-4568-8de9-23e8c8d25d25
  "Concrete Except" (4m32s):
    http://player.discoveryeducation.com/views/hh_httpView.cfm?guidAssetId=eefc8075-bd9f-4568-8de9-23e8c8d25d25

Key Vocabulary

altitude
a distance measurement usually in the vertical or "up" direction (Creative Common Attribution-ShareAlike License (Ed.), 2013)

atmosphere
the gaseous envelope surrounding the earth; the air (Littman, 2012)

atoms
the smallest unit of an element (MsC2, 2012)

breaking point
the point when an object or structure collapses under stress (breaking point, n.d.)

chemical change
a change that causes one kind of matter to become a different kind of matter (Littman, 2012)

coefficient
the number factor of a term that contains a decimal (Carter, Cuevas, Day, Malloy, Kersaint, Luchin, ... & Willard, 2013)

composite
something composed of separate parts; compound (composite, n.d.)

constant
a term that does not contain a variable (Carter, Cuevas, Day, Malloy, Kersaint, Luchin, ... & Willard, 2013)

convert
the process to change (something) into a different form or properties (convert, n.d.)

corrosion
process where a solid is eaten away and changed by a chemical action (amsy999, 2012)

dimensional analysis
the process of including units of measurement when you compute (Carter et al., 2013)

dry ice
solid form of carbon dioxide that is mainly used as a cooling agent (Creative Common Attribution-ShareAlike License (Ed.), 2013)

engineering design process
the formulation of a plan to help an engineer build a product with a specified performance goal. This process involves a number of steps, and parts of the process may need to be repeated many times before production of a final product can begin. (Engineering design process, 2013)

equation
a mathematical sentence that contains an equals sign, =, stating that two quantities are equal (Carter et al., 2013)

expression
the manner or form in which a thing is expressed in words (expression, n.d.)

fiber
a string or rope used as a component of composite materials, or matted into sheets to make products such as paper or felt. Fibers are often used in the manufacture of other materials (Creative Common Attribution-ShareAlike License (Ed.), 2013)

force
push or pull of any kind (Littman, 2012)

gondola
an open payload platform suspended beneath an unpowered hot air or gas balloon

law of conservation of mass
mass cannot be created nor destroyed (Littman, 2012)

Technical Brief

See Printable Resources, Appendix C: Engineering Design Challenge - Engineering Technical Brief

Safety and Disposal

Students should wear safety goggles at all times when working in lab.
If teacher permitted, students must wear heavy duty gloves and use tongs when working with dry ice.

Students should wear protective gloves when working with epoxies, and should always wash hands with soap and water after use. Unused epoxy resin should be left to solidify and cool before disposing.

Dry ice should never be disposed of in sewers, sinks, sewers, or garbage cans. Instead, allow dry ice to evaporate in a well ventilated area so that a buildup of carbon dioxide doesn't occur.

Students should only use the testing apparatus under teacher supervision.

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Section IV: Appendices

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- "U.S. Air Force Fact Sheet: Excelsior Gondola" Analysis
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