Curriculum Overview

Notes

Engineering: Design & Build focuses on investigating engineering. Student led teams conceptualize, build, test and acquire knowledge while becoming familiar with the engineering design process. Using an open-ended inquiry approach students are able to foster their creativity. Students learn to apply multiple skills and develop the habits of innovators.

Students are encouraged to think about needs, requirements, and alternatives as they progress throughout the curriculum. Additionally, students consider materials, energy, inputs and outputs. Unit lessons combine generative, analytical, synthesis, and evaluative thinking to allow students to finalize their design choice and initiate construction.

Curriculum Objectives

The students will:

- identify a problem, materials and constraints
- brainstorm solutions
- research and share solutions
- design and construct a prototype
- modify and retest a design
- reflect and discuss results

Logistics

Class age/size: All lessons are designed for twenty 4th-5th grade students.

Materials: See insert for each individual activity within this unit.

Time: See individual activities for suggested times.

Location: All activities may be taught in a classroom. There may be a few instances where it may be advantageous to take a walking tour of the school. Water will be used in the Build-A-Boat lesson.

Notes

Standards

Next Generation Science Standards Scientific and Engineering Practices

1. Asking questions and defining problems (SEP1)
2. Developing and using models (SEP2)
3. Planning and carrying out investigations (SEP3)
4. Analyzing and interpreting data (SEP4)
5. Using mathematics and computational thinking (SEP5)
6. Constructing explanations and designing solutions (SEP6)
7. Engaging in argument from evidence (SEP7)
8. Obtaining, evaluating, and communicating information (SEP8)

Next Generation Science Standards

4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.
3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Notes

Common Core State Standards Mathematical Practices

MP1 Make sense of problems and persevere in solving them.
MP2 Reason abstractly and quantitatively.
MP4 Model with mathematics.
MP5 Use appropriate tools strategically.
MP6 Attend to precision.

Common Core State Standards

4.MD. A2 Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.
5.G.A.2 Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.
6.NS.C.5 Understand a rational number as a point on the number line. Extend number line diagrams and coordinate axes familiar from previous grades to represent points on the line and in the plane with negative number coordinates.
6.RP.A2 Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in the context of a ratio relationship. *For example, "This recipe has a ratio of 3 cups of flour to 4 cups of sugar, so there is 3/4 cup of flour for each cup of sugar." "We paid $75 for 15 hamburgers, which is a rate of $5 per hamburger."*[1]
6.RP.A3.B Solve unit rate problems including those involving unit pricing and constant speed. *For example, if it took 7 hours to mow 4 lawns, then at that rate, how many lawns could be mowed in 35 hours? At what rate were lawns being mowed?*
6.SP.A3 Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number.
6.SP.B5.C Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered
8.SP.A.1 Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.
RI.5.4 Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 5 topic or subject area*.
RI.5.10 By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 4-5 text complexity band independently and proficiently.

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W.5.10 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.
W.6.1 Write arguments to support claims with clear reasons and relevant evidence.
SL.5.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 5 topics and texts*, building on others' ideas and expressing their own clearly.
RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
RST.6-8.7 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).

Unit Summaries and Objectives

Notes

The ***Introductory Activity*** gets at students perceptions and understanding of the field of engineering, what engineers do at work, and what tools they use.

Build-A-Boat is a lesson that focuses on the scientific inquiry process. Students experience the concept of buoyancy. They explain why some objects sink and other objects float. Ultimately, they design and build an aluminum foil boat to hold a maximum load.
The students will:

- **understand and practice scientific inquiry: questioning, predicting, observing, recording and interpreting data, and communicating results**
- **experience the concept of buoyancy**
- **explain in their own words why some objects sink and other objects float**
- **design and construct an aluminum foil boat to hold a maximum load**

You've Got Mail is designed to enhance students' problem solving skills and team work. This lesson specifically focuses on the understanding of package design: planning, construction, testing and evaluation. Students play the role of "engineers" as they design and safely ship a package.
The students will:

- **gain knowledge of product planning**
- **practice the engineering design process**
- **explore and experiment with ideas, materials, technologies and techniques**
- **assess solutions to a design challenge**
- **experience working in groups and problem solving**

Hot Rod Hamster is a lesson that focuses on the scientific inquiry process. Students become familiar with the engineering design process by using it to brainstorm solutions to a problem and then build, test, and refine their prototype.
The students will:

- **become familiar with the design process by using it to brainstorm solutions to a problem and then build, test, and refine their prototype**
- **communicate design strategies for efficient, gravity powered cars including size, mass, and speed**
- **be financially responsible and purchase materials for their car within predetermined budget constraints**

Let It Roll is a lesson where students design and build a ski jump to launch a ball that will travel a maximum distance to a target. In addition, students design and build a foam insulation roller coaster track that demonstrates the laws of motion.
The students will:

- **design and build a ski jump to launch a ball that will travel a maximum distance to a target**
- **design and build a foam insulation roller coaster track that demonstrates the laws of motion**
- **differentiate energy as potential or kinetic**

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Catapult Wars is a lesson where students design and build a catapult. Students test, evaluate and discuss possible improvements to their designs. This lesson focuses on student understanding of motion and forces. In addition, students become aware of accuracy and precision. Ultimately, students will understand that a catapult is a type of simple machine called a first-class lever.

The students will:

- **design and build a catapult**
- **test and evaluate effectiveness of their designs**
- **discuss possible improvements to their designs**
- **communicate experimental results**
- **understand motion and forces**
- **become aware of accuracy and precision**
- **understand that a catapult is a type of simple machine called a first class lever**

FUSION Five engages participants in a case study. A series of engineering challenges to be solved with limited supplies await students.

The students will:

- **identify relationships among the concepts of lever, fulcrum, load, and effort**
- **use simple machines to solve problems**
- **understand air resistance**
- **work in groups to design solutions to problems**

Something Borrowed explores a different aspect of engineering. Students test and assess materials' capabilities to repel water and stains while learning about the inspiration for these ideas – nature. After learning about biomimicry, students develop a new product.

The students will:

- **understand the concept of hydrophobic**
- **be introduced to the field of biomimetics**
- **preform water resistance and stain resistance tests**
- **design a nature inspired product**

In the culmination activity, ***Applications of Engineering Design***, students apply what they have learned about simple machines and engineering design to build a Rube Goldberg machine.

The students will:

- **apply what has been learned about simple machines and engineering design to build a Rube Goldberg machine**

Notes

For those wishing to extend the curriculum, ***Wheeling the Weight Around*** is a lesson where students physically construct a scale model of a working block and tackle system. They develop a deeper understanding of the way force can be multiplied at the expense of distance. Students use what was learned through simulation to answer challenging questions.

The students will:

- **physically construct a scale model that simulates the workings of a real block and tackle system**
- **develop a deeper understanding of the way force can be multiplied at the expense of distance**
- **use what was learned through simulation to answer the challenge question**

Another opportunity to extend learning is ***Topsy Turvy***--a lesson where students find the center of mass of a meter stick. In addition, students explore the use of a lever as a simple machine. Finally, students apply the dynamics of levers in real-world situations.

The students will:

- **find the center of mass of a meter stick**
- **explore the use of a lever as a simple machine**
- **apply the dynamics of levers in real-world situations**