Unit 8: Using Engineering Design with Force and Motion Systems

Content Area: **Science**
Course(s):
Time Period: **Generic Time Period**
Length: **3 weeks**
Status: **Published**

Essential Questions

Specific NGSS: 4-PS3-4, 3-5-ETS1-1, 3-5-ETS1-2, and 3-5-ETS1-3

Essential Unit Question:

- How can scientific ideas be applied to design, test, and regine a device that converts engery from one form to another?

Guiding Questions:

- What is the relationship between the speed of an object and its energy?

Objectives:

- SWBAT apply scientific ideas to design, test, and regine a device that converts energy from one form to another.
- SWBAT define a simple design problem reflecting a need or want thatincludes specified criteria for success and constraints on materials, time, or cost.
- SWBAT generate and compare multople possible solutions to a problem based on how well each is likely to meet the criteria and constraints of a problem.
- SWBAT 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.

Concepts that will be taught...

1. Science affects everyday life.
2. Most scientists and engineers work in teams.
3. Engineers improve existing technologies or develop new ones.
4. People’s needs and wants change over time, as do their demands for new and improved technologies.
5. Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.
6. Energy can be transferred in various ways and between objects.
7. Energy can also be transferred from place to place by electric currents, which can then be used locally to

produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.

8. The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use.
9. Possible solutions to a problem are limited by available materials and resources (constraints).
10. The success of a designed solution is determined by considering the desired features of a solution (criteria).
11. Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.
12. Research on a problem should be carried out before beginning to design a solution.
13. Testing a solution involves investigating how well it performs under a range of likely conditions.
14. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead toimproved designs.
15. Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.
16. Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints

Disciplinary Core Ideas

Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

Developing Possible Solutions

- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that

need to be improved

Optimizing the Design Solution

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

SCI.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.
SCI.3-5-ETS1	Engineering Design
SCI.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.
SCI.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.

Learning Activities

Note: In the prior unit of study, students observed objects in motion in order to understand the relationship between the speed of an object and its energy, and they investigated the transfer of energy from one object to another, as well as from one form to another. In this unit, students will apply scientific ideas about force, motion, and energy in order to design, test, and refine a device that converts energy from one form to another. Through this process, students will learn that science affects everyday life and that engineers often work in teams, using scientific ideas, in order to meet people's needs for new or improved technologies.

- To begin the **engineering design process**, students must be presented with the problem of designing a device that converts energy from one form to another. This process should include the following steps:
- As a class, students should create a list of all the concepts that they have learned about force, motion, and energy.
- The faster a given object is moving, the more energy it possesses.
- Energy is present whenever there are moving objects, sound, light, or heat.
- Energy can be transferred in various ways and between objects.
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.
- When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
- When objects collide, the contact forces transfer energy so as to change the objects' motions.
- Have students brainstorm examples of simple devices that convert energy from one form to another. As

students give examples, the teacher should draw one or two and have students describe how each device converts energy from one form to another.

- Next, the teacher can present a "Design Challenge" to students: Design and build a simple device that converts energy from one form to another. Please note that teachers should limit the devices to those that convert motion energy to electric energy or that use stored energy to cause motion or produce light or sound.
- Small groups of students should conduct research, using several sources of information, to build understanding of "stored energy." Students can look for examples of objects that have stored energy. Stretched rubber bands, compressed springs, wound or twisted rubber bands, batteries, wind-up toys, and objects at the top of a ramp or held at a height above the ground all have stored energy.
- As a class, determine criteria and possible constraints on the design solutions. For example, devices are only required to perform a single energy conversion (i.e., transfer energy from one form to another), and devices must transfer stored energy to motion, light, or sound. Constraints could include the use of materials readily available in the classroom or provided by the teacher. (An assortment of materials can be provided, including batteries, wires, bulbs, buzzers, springs, string, tape, cardboard, balls, rubber tubing, suction cups, rubber bands of various sizes, construction paper, craft sticks, wooden dowels or skewers, buttons, spools, glue, brads, paper clips, plastic cups, paper plates, plastic spoons, straws, Styrofoam, and cloth.) A time constraint could also be set, if desired. All criteria and constraints should be posted on chart paper so that groups can refer to them as needed.
- Students should work in small, collaborative groups to design and build their device. Examples of possible devices could include:
    - A simple rubber band car that converts the stored energy in a twisted rubber band into motion energy.
    - A simple roller coaster that converts the stored energy in a marble held at the top of the roller coaster into motion energy.
    - A whirly bird that converts stored energy (in a student's muscles) into motion energy.
    - A ball launcher that converts stored energy in a compressed spring, compressed suction cup, or stretched rubber band into motion energy when the ball is launched.
- Students should create a poster that includes a diagram of the device and a description of how the device transfers energy from one form to another. Every group should have the opportunity to present their device and explain how it works.
- As a class, students compare each of the design solutions based on how well they meet criteria and constraints, giving evidence to support their thinking. When giving feedback to the groups, students should identify which criteria were/were not met, and how the design might be improved.
- Small groups should then have the opportunity to refine their designs based on the feedback from the class.
- At every stage, communicating with peers is an important part of the design process, because shared ideas can lead to improved designs. It is also important that students describe the ways in which energy is transferred

between objects and from one form to another.

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Assessments

Science Textbook

- Chapter Review
- Chapter Test

Mystery Science

- Individual Mystery Assessments
- Summative Assessment
- Informal Observation during explorations & activities

Teacher-Made Assessments

- Quizzes
- Tests
- Classwork
- Homework
- Projects

Materials & Resources

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(batteries, wires, bulbs, buzzers, springs, string, tape, cardboard, balls, rubber tubing, suction cups, rubber bands of various sizes, construction paper, craft sticks, wooden dowels or skewers, buttons, spools, glue, brads, paper clips, plastic cups, paper plates, plastic spoons, straws, Styrofoam, and cloth.)

Accommodations & Modifications

- Large print textbooks
- Additional time for assignments
- Review of directions
- Have student restate information
- Provision of notes or outlines
- Concrete examples
- Adaptive writing utensils
- Support auditory presentations with visuals
- Weekly home-school communication tools (notebook, daily log, phone calls or email messages)
- Space for movement or breaks
- Extra visual and verbal cues and prompts
- Books on tape
- Graphic organizers
- Quiet corner or room to calm down and relax when anxious
- Preferential seating
- Alteration of the classroom arrangement

- Reduction of distractions
- Answers to be dictated
- Hands-on activities
- Use of Manipulatives
- Follow a routine/schedule
- Alternate quiet and active time
- Teach time management skills
- Rest breaks
- Verbal and visual cues regarding directions and staying on task
- Daily check-in special education teacher
- Visual daily schedule
- Varied reinforcement procedures
- Immediate feedback
- Personalized examples