TABERNACLE TOWNSHIP PUBLIC SCHOOLS

iSTEM: GRADES K-4

Revised: July 2017

Board Adopted: August, 21st, 2017

TABERNACLE TOWNSHIP SCHOOL DISTRICT
MISSION STATEMENT

The mission of the Tabernacle School District is to create and maintain a safe and secure learning environment that ensures that all students in grades Pre K-8 attain success in mastering the ***New Jersey Student Learning Standards***. The home, the school, and the community working together will provide effective learning experiences that foster the academic, personal, intellectual, physical, social, and emotional growth necessary for students to become responsible, productive members of a diverse and global society. We commit to a comprehensive system of support to assure these outcomes.

Glenn Robbins, Superintendent
Barry Saide, Director of Curriculum and Instruction

Steering Committee:
Brittany Murro, iSTEM Teacher

<u>iSTEM Belief Statements and Purpose</u>

The engineering design process removes the stigma from failure; instead, failure is an important part of the problem-solving process and a positive way to learn. It is equally important that there's no single “right” answer in engineering; one problem can have many solutions. When classroom instruction includes engineering, all students can see themselves as successful.

Hands-on, project-based learning is the essence of engineering. As groups of students work together to answer questions like, “How large should I make the canopy of this parachute?” or, “What material should I use for the blades of my windmill?” they collaborate, think critically and creatively, and communicate with one another.

The iSTEM curriculum is designed with the following parameters:

- Every unit uses a field of engineering as a unifying theme.
- Units can stand alone and be introduced in any order
- Lessons are flexibly adaptable to grade band and student readiness
- Lessons are scaffolded—they build logically to the final engineering design challenge.
- All activities focus on materials elementary students come in contact with on a regular basis

iSTEM is taught utilizing a social constructivist view of learning. This includes:

- Contextual Learning and Problem Solving
- Collaborative Learning and Teamwork
- Communication
- Project-Based Learning

Contextual Learning and Problem Solving: iSTEM design challenges show students how what they learn in school connects with the world around them.

Collaborative Learning and Teamwork: Most iSTEM activities involve small-group work that encourages students to consider more than one solution or idea and work collaboratively.

Communication: All iSTEM curricula develop students’ communication skills and encourage them to share ideas in several ways: speaking, writing, drawing, and building.

Project-based Learning: iSTEM design challenges engage students in inquiry. As they analyze their own data and make decisions about their designs, students engage with content, hone their critical-thinking skills, and take ownership of their learning.

The engineering design process in iSTEM uses a five-step problem solving approach:

- Ask
- Imagine
- Plan
- Create
- Improve

Ask: What is the problem? How have others approached it? What are your constraints?

Imagine: What are some solutions? Brainstorm ideas. Choose the best one.

Plan: Draw a diagram. Make lists of materials you will need.

Create: Follow your plan and create something. Test it out!

Improve: What works? What doesn't? What could work better? Modify your design to make it better. Test it out!

Our curriculum is designed to help students foster an understanding of iSTEM from kindergarten through fourth grade. The performance expectations in each grade develops ideas and skills over time that will allow students to explain more complex engineering design problem solving tasks as they progress to fifth grade, middle school, and high school.

Tabernacle School District

UNIT PLAN

Adopted from *Understanding by Design* (Wiggins and McTighe, 2005)

Unit Title	A Slick Solution: Cleaning an Oil Spill	**Unit Length**	Up to 25 Collaborations
DESIRED RESULTS: STAGE ONE			
Standards Addressed			

- ITEEA National Standards and Benchmarks
  - 1B: All people use tools and techniques (technology) to help them do things.
  - 1D: Tools materials, and skills are used to make things and carry out tasks.
  - 2A: Some systems are found in nature, and some are made by humans.
  - 2C: Tools are simple objects that help humans complete tasks.
  - 2D: Different materials are used in making things.
  - 2E: People plan in order to get things done.
  - 2J: Materials have many different properties.
  - 3A: The study of technology uses many of the same ideas and skills as other subjects.
  - 4A: The use of tools and machines can be helpful or harmful.
  - 4B: When using technology, results can be good or bad.
  - 4C: The use of technology can have unintended consequences.
  - 5B: Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment.
  - 5C: The use of technology affects the environment in good and bad ways.
  - 8A: Everyone can design solutions to a problem (brainstorming is important; everyone's ideas should be considered).
  - 8C: The design process is a purposeful method of planning practical solutions to problems.
  - 8D: Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.
  - 9A: The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.
  - 9B: Expressing ideas to others verbally and through sketches and models is an important part of the design process.
  - 9C: The engineering design process involves designing a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
  - 9D: When designing an object, it is important to be creative and consider all ideas.
  - 9E: Models are used to communicate and test design ideas and processes.
  - 10A: Asking questions and making observations helps a person to figure out how things (technologies) work.
  - 10E: The process of experimentation, which is common in science, can also be used to solve technological problems.
  - 11E: The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.
  - 11F: Test and evaluate the solutions for the design problem.
  - 11G: Improve the design solutions.
- 21st Century Skills

- 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.
- 9.3.12.ED.1 Apply communication skills with students, parents and other groups to enhance learning and a commitment to learning.
- 9.3.12.ED.2 Demonstrate effective oral, written and multimedia communication in multiple formats and contexts.

Overall Understanding(s) *(Students will understand that...)*	**Essential Question(s)** *(The open-ended question(s) that help frame inquiry)*
• There are various fields of engineering. • Nearly everything in the human world has been touched by engineering. • Troubleshooting and learning from failure are integral to the learning process. • Materials and their properties are important in engineering solutions. • Engineering problems have multiple solutions. • Society influences and is influenced by engineering. • Technology affects the world. • Engineers are from all races, ethnicities, and genders.	• How do environmental engineers use their knowledge of soil and water to investigate environmental problems? • How might an oil spill affect an ecosystem and what are some materials, tools, and methods we can use to clean it? • How can we use what we have learned about ecosystems, materials, and tools to help us design a process to clean an oil spill so that it has the least impact on an ecosystem?

Knowledge & Skills: Part 1
(Students will be able to...)

- Explore the field of environmental engineering
- Explore parts of an ecosystem
- Examine and discuss some connections between parts of an ecosystem
- Investigate some of the problems plaguing plants and animals
- Test the pH of soil and water from certain areas
- Compare current pH data from select sites with historical pH data to locate possible sources of pollution
- Observe a demonstration of how water moves through soil and discuss connections between parts of the environment
- Present their findings concerning possible pollution sources
- Create a model to represent the connections between the different components of a river ecosystem
- Brainstorm ways that the ecosystem might be affected by an oil spill and use the model they create to study how the ecosystem might be impacted
- Use a controlled experiment to examine different materials and methods used to clean oil spills and discuss the advantages and disadvantages of each
- Use the Engineering Design Process to design, implement, evaluate, and improve a process for cleaning an oil spill so that the oil has the least impact on the surrounding ecosystem

Knowledge & Skills: Part 2
(Students learn that...)

- Environmental engineers help to solve problems related to the environment and lessen impacts on local ecosystems
- If one area of an ecosystem is affected, it is likely that many other areas of that ecosystem will eventually be affected
- The Engineering Design Process is a tool that can be used to help solve problems
- Environmental problems are almost never isolated because all parts of the ecosystem are connected
- Many parts of an ecosystem (including animals, plants, water, and soil) can indicate the presence of pollution in the environment
- The sources of pollution may not be readily visible
- Through testing, environmental engineers can help to identify sources of pollution
- Pollution found in one part of an ecosystem can affect all other parts of that ecosystem
- Engineers often use models to make predictions about how something might impact the environment
- Some materials work better than others to absorb and/or contain an oil spill in a body of water
- There are several methods for cleaning oil spills
- Engineers use a series of steps, called the Engineering Design Process, to design and improve technologies
- A process is a kind of technology
- Even small amounts of pollution have a negative impact on an ecosystem

Differentiation	Performance Task(s)
Overview: Universal Design for Learning Differentiation is inherent in Universal Design for Learning (UDL), a design philosophy with the underlying premise that meeting students' individual needs is best accomplished when lesson design is flexible, and instruction moves each student's thinking, learning, and skills forward from wherever he or she begins, in a manner that does not assume one size fits all. Engineering is Elementary lessons often provide activities for reinforcement and practice, for extension that goes beyond the classroom activity, or for adding artistic expression to lessons. Elements may be used or not, or adapted according to the teacher's assessment of his or her students' prior knowledge and their needs as a class and as individuals. The three primary components of UDL, multiple means of engagement, multiple means of representation, and multiple means of expression, are addressed in each lesson, providing all students—even those at the ends of the learning continuum, or those with unique learning requirements—opportunities to learn in a way that they learn best. **Engagement** Research reveals the importance of engagement as it links to interest, motivation, and achievement. In the	**Assessments/Observations** *Daily:* The students will record daily progress through journaling. The teacher will make observations and keep anecdotal records regarding student use of materials, demonstration of conceptual understanding, and classroom citizenship, and will provide direct and specific feedback to students. *Unit/Final:* These assessments cover key concepts and information introduced in each unit and help teachers to as student comprehension through creating. **Teacher/Student Conferences** The teacher will facilitate learning and meet with groups consistently. The students and the teacher will keep anecdotal records of group engagement and collaboration, teamwork, and work ethic. Strategies teacher will use are as follows: ● Use of Open-Ended & Metacognitive Questioning ● Pushing for Explanation/Elaboration ● Revoicing/Reframing *(restating what the student says)* ● Summarizing/Clarifying Ideas *(ask a student to summarize)* ● Soliciting Ideas/Generating & Evaluating Hypotheses **Peer work**

Engineering is Elementary units, students manipulate materials in hands-on activities, read informational text, participate in discussion, and write, draw, or create in every lesson. Students develop models to represent phenomenon, and use their models to explain how and why things happen. In some lessons, students watch videos, explore websites, or play games. The teacher might choose to add others, as appropriate for the students' learning, and as different modes of technology provide access to new material every day. A variety of ways to engage with the concepts and ideas, beginning with images and discussion that activates prior knowledge, provide all students with entry points into the content and ways to explore and investigate it. Students engage in their learning as a whole class and in collaborative teams or pairs, and have independent time to read, write, draw, or create. **Student Interaction** Students bring to the classroom a range of experiences, as well as varied degrees of interest in learning the skills and concepts covered in this unit.. As they test ideas, collect data, and articulate what they have discovered, learning becomes personal. Groups and pairs may be configured to address reading needs, individual interests, or learning strengths. Consider Think-Pair-Share and Heads-Together techniques to allow time for student reflection prior to answering questions, starting a discussion, writing, or creating so that all students have an opportunity to process information before being called upon to use it. **Representation** ● Visual – Lessons incorporate numerous photographs and illustrations. The student readers contain photographs, charts and graphs, diagrams, and other images so that students can encounter science content in a variety of ways. ● Auditory – Teachers may read aloud or have students do paired reading of the informational texts in the lesson. Discussion— speaking and listening—are core elements Engineering is Elementary. Teamwork provides opportunities for	Working in teams is an essential component of learning. Lessons and activities are often carried out with students in "teams" or "partners" and materials are shared. The teachers should use their knowledge of the class to select productive student groups and spend time modeling and discussing constructive group behavior. The term "partners" refers to two students, while "team" refers to two sets of partners or any grouping of three or more.

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- student-to-student talk as they share ideas and challenge one another's evidence for claims and conclusions.
- Kinesthetic – Every lesson has students interacting with and manipulating materials.
- Use of Technology – Various modes of technology will be incorporated into each part of the learning process.

Expression
Students write, draw, and/or create in every lesson as ways in which they express, demonstrate, and record their developing understandings. This work, done through journaling and projects, provides the teacher with ongoing opportunities to assess learning formatively and adjust classroom experiences, as needed. Rich discussion also enables teachers to assess understanding as students express their ideas and communicate orally.

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<tr><th colspan="2">LEARNING PLAN: STAGE THREE</th></tr>
<tr><th>Lesson Topics & Sequence of Learning Activities</th><th>Materials and Resources</th></tr>
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Pre-assessment:

- **Students will learn to...**
  - Discover how and why everyday objects made by people are technology
  - Identify the problem that a particular object solves
  - Identify the materials used to make an object
  - Identify that objects are designed as a solution to a problem
  - Identify engineers as the people who design objects
- **Lesson Breakdown (up to 4 collaborations):**
  - Introduce the following questions:
    - What do you think an engineer is and does?
    - What do you think technology is and what is it used for?
  - Discuss both topics as a class, infusing video clips and Google slides as enhancements to the discussion.
  - Follow the "Introduction" and "Activity" directions on TG pgs. 34-36.

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MATERIALS:

- Samples of "engineered objects" (examples: toothbrush, flashlight, plastic container, sponge, paper clip, stapler, scissors, pen, CD, slippers, pencil sharpener, glue stick, eraser, plastic bag, nail clippers, hair brush, ec.)
- Opaque bag or container (one for each group)

VOCABULARY:

- Engineering
- Material
- Problem
- Solution
- Technology

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○ Follow the "Reflection" directions on TG pg. 37. ○ Facilitate the "Breakdown of Technology" Lab to engage students in applying what they know about technology. ● **Assessment** ○ Administer appropriate the Pre-Assessment (found in Appendix A) ● **Extension** ○ Invite students to explore the different technologies in the classroom and use them to create their Ceiling Tile Projects. During this project, introduce and use the steps of the Engineering Design Process so that the students become familiar with them. Provide a visual of the steps of this process, as seen in TG 4-1 and 4-2.	
Lesson 1-Tehya's Pollution Solution ● **Students will learn to...** ○ Explore the work of environmental engineers and their role in cleaning up pollution ○ Describe some parts of an ecosystem ○ Explain how one change in an ecosystem may be related to other changes ○ Explain how the Engineering Design Process can be used to help solve problems ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Read/present an abridged version of *Tehya's Pollution Solution* ○ Follow the steps listed in TG pgs. 43-51 (Students will explore ecosystems and some problems that they may face.) ● ***Assessments*** ○ Teachers will complete the Lesson 1 Rubric (1-10) about each student.	**MATERIALS FOR LESSON 1:** ● *Tehya's Pollution Solution* text ● Chart paper ● Washington state marked on a classroom map **VOCABULARY FOR LESSON 1:** ● Ecosystem ● Engineer ● Engineering Design Process ● Environmental engineer ● Food web ● Pollution ● Technology

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- ***Extensions***
  - Have students keep an Ecosystem Journal and encourage them to write and/or draw what they observe and learn about the ecosystem in their own neighborhood

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Lesson 2-An Enviro-Mystery

PLEASE NOTE: *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 58-60.*

- **Students will learn to...**
  - Explain how changes in soil and water pH can affect the health of an ecosystem
  - Compare historical soil and water data to current data
  - Discuss connectedness within an ecosystem, particularly the connections between soil and water and the spread of pollution
  - Act as environmental engineers to present the findings of their pollution study
- ***Lesson Breakdown (up to 4 collaborations)***
  - Follow the steps listed in TG pgs. 61-72 (Students will perform a series of tests on soil and water samples in order to figure out the cause(s) of pollution.)
- ***Assessments***
  - Teachers will complete the Lesson 2 Rubric (2-14) about each student.
- ***Extensions***
  - Have students try planting three of the same types of plants in three different pots, each with a different soil pH (one with neutral soil, one more acidic, and one more basic). Students should observe the plants over the course of several days or weeks and record their observations.

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MATERIALS FOR LESSON 2:

- Chart paper
- 3 clear, plastic sample vials, approx. 5 dram, and 1 additional vial for each group of students
- 1 roll of cellophane tape
- 13 teaspoons of lemon juice
- 11 teaspoons of ammonia-based window cleaner
- pH color chart
- 16 pH paper strips and 3 additional pH paper strips for each group of students
- 7 teaspoons of distilled water
- 4 cups of tap water
- Teaspoon measure
- 1 glass or plastic pan, approx. 8"x8"
- 6 cups of sand
- 8 teaspoons of soil
- Food coloring
- Watering can
- Markers
- Scissors
- Safety goggles for all students

VOCABULARY FOR LESSON 2:

- Acid
- Base
- Environmental engineer
- Neutral
- pH
- Pollution

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Lesson 3-A Slick Idea Part 1

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MATERIALS FOR LESSON 3 PART 1:

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	PLEASE NOTE: *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 77.* ● **Students will learn to...** ○ Use a model to identify and explain how different parts of a given ecosystem might be affected by an oil spill ○ Explain how a model of connections between living and nonliving things in an ecosystem is useful, but also limited in representing the possible effects of an oil spill ○ Conduct controlled experiments to evaluate materials, methods, and tools available for containing and cleaning an oil spill ○ Evaluate the different materials for use in containing an oil spill based on their observations and experimental results ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 78-91 (Students will explore the connections between the different parts of an ecosystem and create/study a food web for that ecosystem.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-18) about each student.	● Chart paper ● A skein of yarn (orange or yellow) ● A spool of blue ribbon, approximately 15 yards ● Cellophane tape ● Markers ● Crayons ● Single hole punch ● Scissors ● 24" length of yarn or string, any color, for each student **VOCABULARY FOR LESSON 3 PART 1:** ● Absorb ● Boom ● Consumer ● Contain ● Decomposer ● Ecosystem ● Environmental engineer ● Food web ● Material ● Method ● Model ● Organism ● Pollution ● Process ● Producer
	Lesson 3-A Slick Idea Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 94-95.* ● **Students will learn to...** ○ Use a model to identify and explain how different parts of a given ecosystem might be affected by an oil spill ○ Explain how a model of connections between living and nonliving things in an ecosystem is	**MATERIALS FOR LESSON 3 PART 2:** ● Chart paper ● Clock or stopwatch ● ½ teaspoon measure ● Liquid measuring cup ● 1 teaspoon of an oil-based, black food coloring ● 1 cup vegetable oil ● 10 index cards, any size ● Cellophane tape ● Newsprint or tablecloths for covering work surfaces

	useful, but also limited in representing the possible effects of an oil spill ○ Conduct controlled experiments to evaluate materials, methods, and tools available for containing and cleaning an oil spill ○ Evaluate the different materials for use in containing an oil spill based on their observations and experimental results ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 96-106 (Students will test various materials, methods, and tools for cleaning up oil spills.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-18) about each student. ● ***Extensions*** ○ Have students research and test out other methods for cleaning up oil spills, such as using dispersants	● 1 plastic, sandwich-size bag for each group of students ● 9 cups of water for each group of students ● 9 clear, plastic deli containers or cups (at least 16 oz.) for each group of students ● 1 large cotton ball for each group of students ● 12" length of yarn for each group of students ● 1 round, paper coffee filter (8-12 cup) for each group of students ● 1 kitchen sponge, approximately 2"x2", for each group of students ● Nylon, light-color pantyhose, cut into approx. 2"x2" squares for each group of students ● Felt, cut into approx. 2"x2" squares, for each group of students ● Rubber bands for each group of students ● Pipettes for each group of students ● Plastic spoons for each group of students ● White paper, at least 4"x4", for each group of students ● 1 plastic bowl (approx. 8 oz.) for each group of students ● Smocks or aprons for each student **VOCABULARY FOR LESSON 3 PART 2:** ● Absorb ● Boom ● Consumer ● Contain ● Decomposer ● Ecosystem ● Environmental engineer ● Food web ● Material ● Method ● Model ● Organism ● Pollution ● Process ● Producer
	Lesson 4-Cleaning an Oil Spill Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 114-115.* ● **Students will learn to...** ○ Identify and implement each step of the Engineering Design Process	**MATERIALS FOR LESSON 4 PART 1:** ● Chart paper ● Aluminum pan, approx. 8"x8"x1.5" ● Dry measuring cup (1-cup) ● 2 liquid measuring cups (2-cup) ● 1 cup aquarium gravel ● 1.5 cups water

	○ Utilize prior knowledge of how well various materials and tools work to contain or remove oil to inform their designs ○ Evaluate their clean-up processes using established criteria and connect results to impacts on an ecosystem ○ Improve their clean-up process designs, taking into account evaluation of their prior designs ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 116-124 (Students will review the goal of the design challenge: designing a process to clean an oil spill in a model river. Students will learn how their designs will be evaluated and review what they have already learned and how it might help them with this challenge. Students will imagine several different processes and then decide on one design to plan. Students will create their materials/tools lists and check to see if their process is under budget. Students will detail each step of their oil spill cleaning process on their plan.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-13) about each student.	● ½ tablespoon black-colored vegetable oil ● ½ tablespoon measure ● Scissors ● Cellophane tape ● 2 overhead transparencies, approx. 8.5"x11" ● 1 brown paper bag, cut into approx. 3"x7" rectangles ● Colander ● Dish soap ● 1 plastic, sandwich-size bag for each group of students ● 1 cotton ball for each group of students ● Plastic spoons for each group of students ● Pipettes for each group of students ● Felt, cut into approx. 2"x2" squares, for each group of students ● Nylon, light-color pantyhose, cut into approx. 2"x2" squares for each group of students ● 1 kitchen sponge, approximately 2"x2", for each group of students ● 1 round, paper coffee filter for each group of students ● 12" length of yarn for each group of students ● Rubber bands ● Jumbo craft sticks **VOCABULARY FOR LESSON 4 PART 1:** ● Budget ● Contain ● Design ● Engineering Design Process ● Environmental engineer ● Goal ● Impact ● Problem ● Process ● Redesign ● Solution ● Teamwork ● Test
	Lesson 4-Cleaning an Oil Spill Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 127-128.* ● **Students will learn to...** ○ Identify and implement each step of the Engineering Design Process	**MATERIALS FOR LESSON 4 PART 2:** ● 1 teaspoon of black, oil-based food coloring ● ½ teaspoon measure ● 1 cup vegetable oil ● ½ tablespoon measure ● Buckets (totaling a volume of 5 liters) ● Colander

	○ Utilize prior knowledge of how well various materials and tools work to contain or remove oil to inform their designs ○ Evaluate their clean-up processes using established criteria and connect results to impacts on an ecosystem ○ Improve their clean-up process designs, taking into account evaluation of their prior designs ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 129-138 (Students will receive a model river setup and collect the necessary tools and materials for their oil spill cleaning process. Following their plans, students will implement their oil spill cleaning process and evaluate their design based on how much oil is left on the surface of the water and how much oil has reached the shore. Students will calculate the total scores for their first designs by also taking their cost into consideration.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-13) about each student.	● Dish soap ● 2 liquid measuring cups (2-cup) ● Dry measuring cup (1-cup) ● 50 cotton balls ● 10 pipettes ● 10 plastic spoons ● 5 kitchen sponges ● 4 sheets of light-colored felt, approx. 8.5”x11” ● 1 pair of light-colored, nylon pantyhose ● 25 round, paper coffee filters (8-12 cup) ● 25 rubber bands ● 1 skein yarn ● Newsprint or tablecloths for covering work surfaces ● Aluminum pan, approx. 8”x8”x1.5”, for each group of students ● 1 cup aquarium gravel for each group of students ● 1.5 cups water for each group of students ● Scissors ● 1 brown paper bag, cut into approx. 3”x7” rectangles, for each group of students ● Oil Evaluator Tool for each group of students ● 1 plastic bowl, approx. 8 oz., for each group of students ● Smock or old t-shirt for each student **VOCABULARY FOR LESSON 4 PART 2:** ● Budget ● Contain ● Design ● Engineering Design Process ● Environmental engineer ● Goal ● Impact ● Problem ● Process ● Redesign ● Solution ● Teamwork ● Test
	Lesson 4-Cleaning an Oil Spill Part 3 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the “Preparation” steps listed on TG pgs. 141-142.* ● **Students will learn to...** ○ Identify and implement each step of the Engineering Design Process	**MATERIALS FOR LESSON 4 PART 3:** ● Buckets (totaling a volume of 5 liters) ● Colander ● Dish soap ● 2 liquid measuring cups (2-cup) ● Dry measuring cup (1-cup) ● ½ teaspoon of black, oil-based food coloring

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- Utilize prior knowledge of how well various materials and tools work to contain or remove oil to inform their designs
- Evaluate their clean-up processes using established criteria and connect results to impacts on an ecosystem
- Improve their clean-up process designs, taking into account evaluation of their prior designs

- ***Lesson Breakdown (up to 3 collaborations)***
  - Follow the steps listed in TG pgs. 143-149 (Students will work to improve one or more of their scores by redesigning their processes. Students will implement and evaluate their improved oil spill cleaning processes.)
- ***Assessments***
  - Teachers will complete the Lesson 4 Rubric (4-13) about each student.
- ***Extensions***
  - Encourage students to brainstorm ways that they can use the Engineering Design Process to help minimize other negative impacts on their local ecosystems.

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- ½ teaspoon measure
- ½ tablespoon measure
- ½ cup vegetable oil
- 50 cotton balls
- 10 pipettes
- 10 plastic spoons
- 5 kitchen sponges
- 4 sheets of light-colored felt, approx. 8.5”x11”
- 1 pair of light-colored, nylon pantyhose
- 25 round, paper coffee filters (8-12 cup)
- 25 rubber bands
- 1 skein yarn
- Newsprint or tablecloths for covering work surfaces
- Aluminum pan, approx. 8”x8”x1.5”, for each group of students
- 1 brown paper bag, cut into approx. 3”x7” rectangles, for each group of students
- 1 cup aquarium gravel for each group of students
- 1.5 cups water for each group of students
- Scissors
- Oil Evaluator Tool for each group of students
- 1 plastic bowl, approx. 8 oz., for each group of students
- Smock or old t-shirt for each student

VOCABULARY FOR LESSON 4 PART 3:

- Budget
- Contain
- Design
- Engineering Design Process
- Environmental engineer
- Goal
- Impact
- Problem
- Process
- Redesign
- Solution
- Teamwork
- Test

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Post-Assessment:
Administer appropriate the Post-Assessment (found in Appendix A).

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<td colspan="3">Notes/Reflections</td>
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UNIT PLAN

Adopted from *Understanding by Design* (Wiggins and McTighe, 2005)

Unit Title	An Alarming Idea: Designing Alarm Circuits	**Unit Length**	Up to 25 Collaborations
DESIRED RESULTS: STAGE ONE			
Standards Addressed			

- ITEEA National Standards and Benchmarks
  - 2D: Different materials are used in making things.
  - 2E: People plan in order to get things done.
  - 2J: Materials have many different properties.
  - 3A: The study of technology uses many of the same ideas and skills as other subjects.
  - 6A: Products are made to meet individual needs and wants.
  - 8A: Everyone can design solutions to a problem (brainstorming is important; everyone's ideas should be considered).
  - 8B: Design is a creative process.
  - 8C: The design process is a purposeful method of planning practical solutions to problems.
  - 8D: Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.
  - 9A: The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.
  - 9B: Expressing ideas to others verbally and through sketches and models is an important part of the design process.
  - 9C: The engineering design process involves designing a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
  - 9D: When designing an object, it is important to be creative and consider all ideas.
  - 9E: Models are used to communicate and test design ideas and processes.
  - 10A: Asking questions and making observations helps a person to figure out how things (technologies) work.
  - 10C: Troubleshooting is a way of finding out why something does not work so that it can be fixed.
  - 11B: Build or construct an object using the design process.
  - 11F: Test and evaluate the solutions for the design problem.
  - 11G: Improve the design solutions.
  - 12D: Follow step-by-step directions to assemble a product.
  - 12G: Use common symbols such as numbers to communicate key ideas.
  - 16A: Energy comes in many forms.
  - 16C: Energy comes in different forms.
  - 16D: Tools, machines, products, and systems use energy in order to do work.

- 17G: Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations.

- 21st Century Skills
  - 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.
  - 9.3.12.ED.1 Apply communication skills with students, parents and other groups to enhance learning and a commitment to learning.
  - 9.3.12.ED.2 Demonstrate effective oral, written and multimedia communication in multiple formats and contexts.

Overall Understanding(s) *(Students will understand that...)*	**Essential Question(s)** *(The open-ended question(s) that help frame inquiry)*
• There are various fields of engineering. • Nearly everything in the human world has been touched by engineering. • Troubleshooting and learning from failure are integral to the learning process. • Materials and their properties are important in engineering solutions. • Engineering problems have multiple solutions. • Society influences and is influenced by engineering. • Technology affects the world. • Engineers are from all races, ethnicities, and genders.	• What are technologies and who designs them? • How do the technologies that we use every single day use and transform electrical energy? • How can schematic diagrams be used to communicate information about different electrical circuits? • How can knowledge of conductors, circuits, schematic diagrams, and the Engineering Design Process be used to design an alarm circuit that someone else can build?

Knowledge & Skills: Part 1 *(Students will be able to...)*
• Examine everyday examples of technology • Explore the field of electrical engineering • Recognize that understanding science concepts helps inform engineering design • Identify the electrical technologies they use in a given time period • Sort the electrical technologies they identified by their function and relate their findings to energy transformation • Explore energy and electricity • Examine open and closed circuits using wires, bulbs, batteries, and switches • Utilize symbols in schematic diagrams • Create schematic diagrams of several circuits • Build a circuit from a schematic diagram • Use the steps of the Engineering Design Process to design an alarm circuit

Knowledge & Skills: Part 2 *(Students learn that...)*

- Electrical engineers use their knowledge of science and math, along with their creativity, to solve problems
- Science and engineering are closely linked
- Electricity is one of many forms of energy
- Energy can be transformed
- Humans can harness electrical energy to do useful things
- Energy can be defined as what it takes to make a change happen
- A circuit must be closed in order for electricity (current) to move through it
- Schematic diagrams are used to plan circuits and communicate information about them
- The different elements of a circuit have specific schematic diagram symbols
- It is important to have a common language for communicating ideas
- A switch can be used to control whether a circuit is closed or open
- Engineers use a series of steps called the Engineering Design Process to design solutions to problems
- Electrical engineers use schematic diagrams to plan circuits and communicate information about them
- A switch can be used to control when a circuit is complete or incomplete
- Electricity moves readily through some materials (conductors) and does not move readily through other materials (insulators)

Differentiation	Performance Task(s)
Overview: Universal Design for Learning Differentiation is inherent in Universal Design for Learning (UDL), a design philosophy with the underlying premise that meeting students' individual needs is best accomplished when lesson design is flexible, and instruction moves each student's thinking, learning, and skills forward from wherever he or she begins, in a manner that does not assume one size fits all. Engineering is Elementary lessons often provide activities for reinforcement and practice, for extension that goes beyond the classroom activity, or for adding artistic expression to lessons. Elements may be used or not, or adapted according to the teacher's assessment of his or her students' prior knowledge and their needs as a class and as individuals. The three primary components of UDL, multiple means of engagement, multiple means of representation, and multiple means of expression, are addressed in each lesson, providing all students—even those at the ends of the learning continuum, or those with unique learning requirements—opportunities to learn in a way that they learn best. **Engagement** Research reveals the importance of engagement as it links to interest, motivation, and achievement. In the	**Assessments/Observations** *Daily:* The students will record daily progress through journaling. The teacher will make observations and keep anecdotal records regarding student use of materials, demonstration of conceptual understanding, and classroom citizenship, and will provide direct and specific feedback to students. *Unit/Final:* These assessments cover key concepts and information introduced in each unit and help teachers to as student comprehension through creating. **Teacher/Student Conferences** The teacher will facilitate learning and meet with groups consistently. The students and the teacher will keep anecdotal records of group engagement and collaboration, teamwork, and work ethic. Strategies teacher will use are as follows: ● Use of Open-Ended & Metacognitive Questioning ● Pushing for Explanation/Elaboration ● Revoicing/Reframing *(restating what the student says)* ● Summarizing/Clarifying Ideas *(ask a student to summarize)* ● Soliciting Ideas/Generating & Evaluating Hypotheses **Peer work**

Engineering is Elementary units, students manipulate materials in hands-on activities, read informational text, participate in discussion, and write, draw, or create in every lesson. Students develop models to represent phenomenon, and use their models to explain how and why things happen. In some lessons, students watch videos, explore websites, or play games. The teacher might choose to add others, as appropriate for the students' learning, and as different modes of technology provide access to new material every day. A variety of ways to engage with the concepts and ideas, beginning with images and discussion that activates prior knowledge, provide all students with entry points into the content and ways to explore and investigate it. Students engage in their learning as a whole class and in collaborative teams or pairs, and have independent time to read, write, draw, or create. **Student Interaction** Students bring to the classroom a range of experiences, as well as varied degrees of interest in learning the skills and concepts covered in this unit.. As they test ideas, collect data, and articulate what they have discovered, learning becomes personal. Groups and pairs may be configured to address reading needs, individual interests, or learning strengths. Consider Think-Pair-Share and Heads-Together techniques to allow time for student reflection prior to answering questions, starting a discussion, writing, or creating so that all students have an opportunity to process information before being called upon to use it. **Representation** ● Visual – Lessons incorporate numerous photographs and illustrations. The student readers contain photographs, charts and graphs, diagrams, and other images so that students can encounter science content in a variety of ways. ● Auditory – Teachers may read aloud or have students do paired reading of the informational texts in the lesson. Discussion— speaking and listening—are core elements Engineering is Elementary. Teamwork provides opportunities for	Working in teams is an essential component of learning. Lessons and activities are often carried out with students in "teams" or "partners" and materials are shared. The teachers should use their knowledge of the class to select productive student groups and spend time modeling and discussing constructive group behavior. The term "partners" refers to two students, while "team" refers to two sets of partners or any grouping of three or more.

student-to-student talk as they share ideas and challenge one another's evidence for claims and conclusions. ● Kinesthetic – Every lesson has students interacting with and manipulating materials. ● Use of Technology – Various modes of technology will be incorporated into each part of the learning process. **Expression** Students write, draw, and/or create in every lesson as ways in which they express, demonstrate, and record their developing understandings. This work, done through journaling and projects, provides the teacher with ongoing opportunities to assess learning formatively and adjust classroom experiences, as needed. Rich discussion also enables teachers to assess understanding as students express their ideas and communicate orally.	
LEARNING PLAN: STAGE THREE	
Lesson Topics & Sequence of Learning Activities	**Materials and Resources**
Pre-assessment: ● **Students will learn to...** ○ Discover how and why everyday objects made by people are technology ○ Identify the problem that a particular object solves ○ Identify the materials used to make an object ○ Identify that objects are designed as a solution to a problem ○ Identify engineers as the people who design objects ● **Lesson Breakdown (up to 4 collaborations):** ○ Introduce the following questions: ■ What do you think an engineer is and does? ■ What do you think technology is and what is it used for? ○ Discuss both topics as a class, infusing video clips and Google slides as enhancements to the discussion. ○ Follow the "Introduction" and "Activity" directions on TG pgs. 34-36.	**MATERIALS:** ● Samples of "engineered objects" (examples: toothbrush, flashlight, plastic container, sponge, paper clip, stapler, scissors, pen, CD, slippers, pencil sharpener, glue stick, eraser, plastic bag, nail clippers, hair brush, ec.) ● Opaque bag or container (one for each group) **VOCABULARY:** ● Engineering ● Material ● Problem ● Solution ● Technology

◦ Follow the "Reflection" directions on TG pg. 37. ◦ Facilitate the "Breakdown of Technology" Lab to engage students in applying what they know about technology. • **Assessment** ◦ Administer appropriate the Pre-Assessment (found in Appendix A) • **Extension** ◦ Invite students to explore the different technologies in the classroom and use them to create their Ceiling Tile Projects. During this project, introduce and use the steps of the Engineering Design Process so that the students become familiar with them. Provide a visual of the steps of this process, as seen in TG 4-1 and 4-2.	
Lesson 1-A Reminder for Emily • **Students will learn to...** ◦ Recognize the role of electrical engineers in designing and improving technology having to do with electricity ◦ Identify how an understanding of electrical conductors, technology, and the field of electrical engineering can help inform a design ◦ Explain how the events in the story represent the steps in the Engineering Design Process • ***Lesson Breakdown (up to 3 collaborations)*** ◦ Read/present an abridged version of *A Reminder for Emily* ◦ Follow the steps listed in TG pgs. 43-51 (Students will explore how electrical conductors, technology, and the field of electrical engineering can help inform a design to solve a problem.) • ***Assessments***	**MATERIALS FOR LESSON 1:** • *A Reminder for Emily* text • Chart paper • Australia marked on a classroom map **VOCABULARY FOR LESSON 1:** • Anchors • Battery • Biscuit • By jingoes • Circuit • Clapped out • Conductor • Electrical engineer • Electricity • Engineer • Engineering Design Process • Generator • Jillaroo • Kilometer • Onya • Schematic diagram • Station • Technology

<table>
<tr><td></td><td>Teachers will complete the Lesson 1 Rubric (1-7) about each student.
Extensions
Have students research several types of alternative energy, such as solar power, wind power, and water power, and explore how these methods of generating electricity differ from traditional power plants</td><td></td></tr>
<tr><td></td><td>Lesson 2-"It's Electric!" Part 1
Students will learn to...
Identify technologies that use electricity and explain how these technologies use electricity to function
Identify the energy transformations that occur in electrical technologies
Recognize that energy is the ability to make change happen and identify some examples of these changes
Lesson Breakdown (1 collaboration)
Follow the steps listed in TG pgs. 56-57 (Students will discover and explore different technologies that use electricity.)
Assessments
Teachers will complete the Lesson 2 Rubric (2-2) about each student.
Extensions
Have students explore their homes for additional items that use electricity</td><td>MATERIALS FOR LESSON 2 PART 1:
"Electricity Scavenger Hunt" Recording Sheets
VOCABULARY FOR LESSON 2 PART 1:
Electricity
Energy
Mechanical
Technology
Transform</td></tr>
<tr><td></td><td>Lesson 2-"It's Electric!" Part 2
Students will learn to...
Identify technologies that use electricity and explain how these technologies use electricity to function
Identify the energy transformations that occur in electrical technologies
Recognize that energy is the ability to make change happen and</td><td>MATERIALS FOR LESSON 2 PART 2
15-20 index cards and 5 additional cards for each student
1 roll of cellophane or masking tape
Markers
Chart paper
VOCABULARY FOR LESSON 2 PART 2:
Electricity
Energy
Mechanical
Technology</td></tr>
</table>

	identify some examples of these changes ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 59-68 (Students will sort different technologies that use electricity into various categories.) ● ***Assessments*** ○ Teachers will complete the Lesson 2 Rubric (2-2) about each student. ● ***Extensions*** ○ Work with students to do some research about where their city or town gets its electrical energy (power plants, generators, solar panels, wind turbines, etc.)	● Transform
	Lesson 3-Representing Circuits Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 73.* ● **Students will learn to...** ○ Identify and distinguish between closed and open circuits using both schematic diagrams and actual circuit materials ○ Explain why standard symbol systems, like schematic diagrams, are important ○ Create schematic diagrams of circuits that include batteries, bulbs, wires, and open and closed switches ○ Build a simple series circuit from a schematic diagram ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 74-78 (Students will investigate open and closed circuits and explore the symbols used in schematic diagrams.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-9) about each student.	**MATERIALS FOR LESSON 3 PART 1** ● 1 test lead (insulated wire with alligator clips on each end) or one 8" length of insulated wire with both ends stripped for the model and 1 for each group ● 1 bulb (1.5-5.0 volts) and one additional bulb for each group ● 1 bulb holder and one additional bulb holder for each group ● 1 buzzer (1.5-6.0 volts) ● 1 D-cell battery and one additional D-cell battery for each group ● 1 battery holder and one additional battery holder for each group ● 1 switch ● 3 pieces of cellophane tape ● Markers ● Plastic, resealable bags (sandwich-size) ● 1 piece of paper for each student (8.5"x11") ● Crayons ● Rulers **VOCABULARY FOR LESSON 3 PART 1:** ● Circuit ● Current ● Represent ● Schematic diagram ● Switch ● Symbol

	Lesson 3-Representing Circuits Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 80.* ● **Students will learn to...** ○ Identify and distinguish between closed and open circuits using both schematic diagrams and actual circuit materials ○ Explain why standard symbol systems, like schematic diagrams, are important ○ Create schematic diagrams of circuits that include batteries, bulbs, wires, and open and closed switches ○ Build a simple series circuit from a schematic diagram ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 81-87 (Students will build a circuit with a switch using a schematic diagram.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-9) about each student. ● ***Extensions*** ○ Have students explore parallel circuits and the role of switches in parallel circuits (see TG pgs. 86-87)	**MATERIALS FOR LESSON 3 PART 2** ● 4 pieces of cellophane tape ● Markers or chalk ● 1 D-cell battery for each group ● 1 battery holder for each group ● 1 bulb (1.5-5.0 volts) for each group ● 1 bulb holder (for each group) ● 1 switch (for each group) ● 3 test leads (insulated wire with alligator clips on each end) or three 8" lengths of insulated wire with both ends stripped for each group ● Plastic, resealable bags (sandwich-sized) ● Rulers **VOCABULARY FOR LESSON 3 PART 2:** ● Circuit ● Current ● Represent ● Schematic diagram ● Switch ● Symbol
	Lesson 4-Designing an Alarm Circuit Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 98-99.* ● **Students will learn to...** ○ Identify the steps of the Engineering Design Process ○ Imagine ideas for an alarm circuit and select one idea to build and test ○ Draw a detailed plan of the alarm circuit, including a schematic diagram and a labeled diagram of their switch connection	**MATERIALS FOR LESSON 4 PART 1** ● 3-5 oz. cup of "water" (e.g.: beads, marbles, pennies, etc.) ● Masking tape ● Permanent markers ● Trough for each group made from the following: ○ Cardboard sheet (9"x2.5") ○ Metal brad/paper fastener ○ Film canister, or other cylindrical object that can act as a fulcrum or pivot point ○ Paper cup (3-4 oz.) ○ Counterweight, approx. 12 grams (e.g.: large washer, flat glass marble, stone, wooden block, etc.)

	○ Construct the alarm circuit and switch connection designed by another group by following that group's plan ○ Test and analyze the success of their own alarm circuit designs ○ Brainstorm ways to improve their designs ○ Implement some of their improvement ideas ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 100-104 (Students will be introduced to the design challenge: designing an alarm circuit to light a bulb when the trough is empty. Students will imagine different ideas for their circuits and switch connection points.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-11) about each student.	● Electricity Parts Kit for each group containing the following: ○ Plastic, resealable container (approx. 24 oz.) ○ 2 D-cell batteries ○ 2 battery holders ○ 1 bulb (1.5-5.0 volts) ○ 1 bulb holder ○ 8 test leads ● Switch Parts Bag (resealable) for each group containing at least four items from the "Conductors" list and two items from the "Insulators" list (see the table on TG pg. 97) **VOCABULARY FOR LESSON 4 PART 1:** ● Circuit ● Conductor ● Contractor ● Design ● Engineering Design Process ● Goal ● Insulator ● Material ● Problem ● Redesign ● Solution ● Switch ● Teamwork ● Test ● Trough
	Lesson 4-Designing an Alarm Circuit Part 2 ● **Students will learn to...** ○ Identify the steps of the Engineering Design Process ○ Imagine ideas for an alarm circuit and select one idea to build and test ○ Draw a detailed plan of the alarm circuit, including a schematic diagram and a labeled diagram of their switch connection ○ Construct the alarm circuit and switch connection designed by another group by following that group's plan ○ Test and analyze the success of their own alarm circuit designs	**MATERIALS FOR LESSON 4 PART 2** ● Electricity Parts Kit (from Part 1) for each group ● Switch Parts Bag (from Part 1) for each group ● Trough assembly (from Part 1) for each group ● 1 roll of cellophane tape (for each group) ● Scissors ● Paper (11"x17") ● Cardboard (11"x17") ● Markers/crayons ● Rulers **VOCABULARY FOR LESSON 4 PART 2:** ● Circuit ● Conductor ● Contractor ● Design ● Engineering Design Process

	○ Brainstorm ways to improve their designs ○ Implement some of their improvement ideas ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 106-108 (Student groups will decide on one alarm circuit design to plan. Students will create a schematic diagram and a detailed, labeled diagram of their switch connection point, including a materials list.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-11) about each student.	● Goal ● Insulator ● Material ● Problem ● Redesign ● Solution ● Switch ● Teamwork ● Test ● Trough
	Lesson 4-Designing an Alarm Circuit Part 3 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 109.* ● **Students will learn to...** ○ Identify the steps of the Engineering Design Process ○ Imagine ideas for an alarm circuit and select one idea to build and test ○ Draw a detailed plan of the alarm circuit, including a schematic diagram and a labeled diagram of their switch connection ○ Construct the alarm circuit and switch connection designed by another group by following that group's plan ○ Test and analyze the success of their own alarm circuit designs ○ Brainstorm ways to improve their designs ○ Implement some of their improvement ideas ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 110-112 (Students will switch	**MATERIALS FOR LESSON 4 PART 3** ● Electricity Parts Kit (from Part 1) for each group ● Switch Parts Bag (from Part 1) for each group ● Trough assembly (from Part 1) for each group ● 1 roll of cellophane tape (for each group) ● Cardboard (11"x17") and attached paper schematic diagram for each group ● 3-5 oz. cup of "water" (e.g.: beads, marbles, pennies, etc.) for each group **VOCABULARY FOR LESSON 4 PART 3:** ● Circuit ● Conductor ● Contractor ● Design ● Engineering Design Process ● Goal ● Insulator ● Material ● Problem ● Redesign ● Solution ● Switch ● Teamwork ● Test ● Trough

	their plan, electricity parts kit, and switch parts bag with another group. Each group will work as "contractors" to build the circuit and switch connection point as specified in another group's plan. "Contractors" will have the opportunity to give feedback to the group whose circuit and switch they built. Fully constructed alarm circuits will be returned to the original "engineer" group for testing.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-11) about each student.	
	Lesson 4-Designing an Alarm Circuit Part 4 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 114.* ● **Students will learn to...** ○ Identify the steps of the Engineering Design Process ○ Imagine ideas for an alarm circuit and select one idea to build and test ○ Draw a detailed plan of the alarm circuit, including a schematic diagram and a labeled diagram of their switch connection ○ Construct the alarm circuit and switch connection designed by another group by following that group's plan ○ Test and analyze the success of their own alarm circuit designs ○ Brainstorm ways to improve their designs ○ Implement some of their improvement ideas ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 115-123 (Students will complete	**MATERIALS FOR LESSON 4 PART 4** ● Electricity Parts Kit (from Part 1) for each group ● Switch Parts Bag (from Part 1) for each group ● Trough assembly (from Part 1) for each group ● 3-5 oz. cup of "water" (e.g.: beads, marbles, pennies, etc.) for each group ● 1 buzzer (1.5-6.0 volts) for each group, if using Option 2 **VOCABULARY FOR LESSON 4 PART 4:** ● Circuit ● Conductor ● Contractor ● Design ● Engineering Design Process ● Goal ● Insulator ● Material ● Problem ● Redesign ● Solution ● Switch ● Teamwork ● Test ● Trough

	the "Improve" step of this process, following either Option 1 or Option 2. Option 1 includes troubleshooting and improving upon students' first designs. Option 2 is slightly more advanced and involves adding a buzzer to the circuit.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-11) about each student.	
	Post-Assessment: Administer appropriate the Post-Assessment (found in Appendix A).	

Notes/Reflections

Tabernacle School District

UNIT PLAN

Adopted from *Understanding by Design* (Wiggins and McTighe, 2005)

Unit Title	Catching the Wind: Designing Windmills	**Unit Length**	Up to 25 Collaborations
DESIRED RESULTS: STAGE ONE			
Standards Addressed			

- ITEEA National Standards and Benchmarks
  - 1C: Things that are found in nature differ from things that are human-made in how they are produced and used.
  - 1D: Tools materials, and skills are used to make things and carry out tasks.
  - 1E: Creative thinking and economic and cultural influences shape technological development.
  - 2D: Different materials are used in making things.
  - 2E: People plan in order to get things done.
  - 2J: Materials have many different properties.
  - 2K: Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing.
  - 3A: The study of technology uses many of the same ideas and skills as other subjects.
  - 3B: Technologies are often combined.
  - 6B: Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes.
  - 7A: The way people live and work has changed throughout history because of technology.
  - 8A: Everyone can design solutions to a problem (brainstorming is important; everyone's ideas should be considered).
  - 8B: Design is a creative process.
  - 8C: The design process is a purposeful method of planning practical solutions to problems.
  - 8D: Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.
  - 9A: The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.
  - 9B: Expressing ideas to others verbally and through sketches and models is an important part of the design process.
  - 9C: The engineering design process involves designing a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
  - 9D: When designing an object, it is important to be creative and consider all ideas.
  - 10A: Asking questions and making observations helps a person to figure out how things (technologies) work.
  - 10E: The process of experimentation, which is common in science, can also be used to solve technological problems.
  - 11B: Build or construct an object using the design process.
  - 11C: Investigate how things are made and how they can be improved.
  - 11F: Test and evaluate the solutions for the design problem.
  - 11G: Improve the design solutions.

○ 16A: Energy comes in many forms. ○ 16D: Tools, machines, products, and systems use energy in order to do work. ● 21st Century Skills ○ 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues. ○ 9.3.12.ED.1 Apply communication skills with students, parents and other groups to enhance learning and a commitment to learning. ○ 9.3.12.ED.2 Demonstrate effective oral, written and multimedia communication in multiple formats and contexts.	
Overall Understanding(s) *(Students will understand that...)*	**Essential Question(s)** *(The open-ended question(s) that help frame inquiry)*
● There are various fields of engineering. ● Nearly everything in the human world has been touched by engineering. ● Troubleshooting and learning from failure are integral to the learning process. ● Materials and their properties are important in engineering solutions. ● Engineering problems have multiple solutions. ● Society influences and is influenced by engineering. ● Technology affects the world. ● Engineers are from all races, ethnicities, and genders.	● How do mechanical engineers observe and think about machines? ● What properties of a sail affect how well it catches the wind? ● How can we use what we know about materials and their properties, our creativity, and the Engineering Design Process to design windmill blades that catch the wind?
Knowledge & Skills: Part 1 *(Students will be able to...)*	
● Explore the work of mechanical engineers ● Identify objects that catch the wind ● Describe common objects that are machines ● Observe and analyze the motions involved in the functioning of different machines ● Investigate the advantages and disadvantages of common machines ● Discuss the role of mechanical engineers in designing machines ● Predict which materials will catch the wind the best when used as a sail ● Observe and describe how different materials and shapes catch the wind when used as sails ● Test different sail designs by measuring how far down a track they move when blown by a fan ● Discuss the properties of materials used to make sails and how those properties affect how well the sails catch the wind ● Design and construct windmill blades ● Use wind energy to do work (turn the blades of a windmill that will lift weights) ● Test and improve their blade designs	
Knowledge & Skills: Part 2 *(Students learn that...)*	

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- Engineers solve problems by designing solutions
- Wind has energy
- Wind energy can do useful work, such as generating electricity or powering machines
- Windmills use the energy of the wind to do useful work
- The Engineering Design Process can be used to help solve problems
- Mechanical engineers study the motion of machines in order to design machines that work effectively and efficiently
- Mechanical engineers design entire machines and/or parts of machines
- Machines are instruments that change or use energy in order to do work
- Moving one part of a machine can affect the other parts of a machine
- A problem can be solved in many different ways using different materials
- The properties of a material make it a good or poor choice for certain uses
- Conducting tests helps determine which materials are the best choice for a given use
- The wind can be harnessed to do work
- Windmills use the energy of wind to do useful work
- Testing and redesigning can improve the performance of any engineered object
- Engineers use a series of steps, called the Engineering Design Process, to design solutions to problems

</td></tr>
<tr><th>Differentiation</th><th>Performance Task(s)</th></tr>
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Overview:
Universal Design for Learning Differentiation is inherent in Universal Design for Learning (UDL), a design philosophy with the underlying premise that meeting students' individual needs is best accomplished when lesson design is flexible, and instruction moves each student's thinking, learning, and skills forward from wherever he or she begins, in a manner that does not assume one size fits all. Engineering is Elementary lessons often provide activities for reinforcement and practice, for extension that goes beyond the classroom activity, or for adding artistic expression to lessons. Elements may be used or not, or adapted according to the teacher's assessment of his or her students' prior knowledge and their needs as a class and as individuals. The three primary components of UDL, multiple means of engagement, multiple means of representation, and multiple means of expression, are addressed in each lesson, providing all students—even those at the ends of the learning continuum, or those with unique learning requirements—opportunities to learn in a way that they learn best.

Engagement
Research reveals the importance of engagement as it links to interest, motivation, and achievement. In the Engineering is Elementary units, students

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Assessments/Observations
Daily: The students will record daily progress through journaling. The teacher will make observations and keep anecdotal records regarding student use of materials, demonstration of conceptual understanding, and classroon citizenship, and will provide direct and specific feedback to students.
Unit/Final: These assessments cover key concepts and information introduced in each unit and help teachers to as student comprehension through creating.

Teacher/Student Conferences
The teacher will facilitate learning and meet with groups consistently. The students and the teacher will keep anecdotal records of group engagement and collaboration, teamwork, and work ethic. Strategies teacher will use are as follows:

- Use of Open-Ended & Metacognitive Questioning
- Pushing for Explanation/Elaboration
- Revoicing/Reframing *(restating what the student says)*
- Summarizing/Clarifying Ideas *(ask a student to summarize)*
- Soliciting Ideas/Generating & Evaluating Hypotheses

Peer work
Working in teams is an essential component of learning. Lessons and activities are often carried out with students

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manipulate materials in hands-on activities, read informational text, participate in discussion, and write, draw, or create in every lesson. Students develop models to represent phenomenon, and use their models to explain how and why things happen. In some lessons, students watch videos, explore websites, or play games. The teacher might choose to add others, as appropriate for the students' learning, and as different modes of technology provide access to new material every day. A variety of ways to engage with the concepts and ideas, beginning with images and discussion that activates prior knowledge, provide all students with entry points into the content and ways to explore and investigate it. Students engage in their learning as a whole class and in collaborative teams or pairs, and have independent time to read, write, draw, or create.

Student Interaction
Students bring to the classroom a range of experiences, as well as varied degrees of interest in learning the skills and concepts covered in this unit.. As they test ideas, collect data, and articulate what they have discovered, learning becomes personal. Groups and pairs may be configured to address reading needs, individual interests, or learning strengths. Consider Think-Pair-Share and Heads-Together techniques to allow time for student reflection prior to answering questions, starting a discussion, writing, or creating so that all students have an opportunity to process information before being called upon to use it.

Representation

- Visual – Lessons incorporate numerous photographs and illustrations. The student readers contain photographs, charts and graphs, diagrams, and other images so that students can encounter science content in a variety of ways.
- Auditory – Teachers may read aloud or have students do paired reading of the informational texts in the lesson. Discussion— speaking and listening—are core elements Engineering is Elementary. Teamwork provides opportunities for student-to-student talk as they share ideas

in "teams" or "partners" and materials are shared. The teachers should use their knowledge of the class to select productive student groups and spend time modeling and discussing constructive group behavior. The term "partners" refers to two students, while "team" refers to two sets of partners or any grouping of three or more.

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● Kinesthetic – Every lesson has students interacting with and manipulating materials.
● Use of Technology – Various modes of technology will be incorporated into each part of the learning process.

Expression
Students write, draw, and/or create in every lesson as ways in which they express, demonstrate, and record their developing understandings. This work, done through journaling and projects, provides the teacher with ongoing opportunities to assess learning formatively and adjust classroom experiences, as needed. Rich discussion also enables teachers to assess understanding as students express their ideas and communicate orally.
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<th>Lesson Topics & Sequence of Learning Activities</th>
<th>Materials and Resources</th>
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Pre-assessment:
● Students will learn to...
○ Discover how and why everyday objects made by people are technology
○ Identify the problem that a particular object solves
○ Identify the materials used to make an object
○ Identify that objects are designed as a solution to a problem
○ Identify engineers as the people who design objects
● Lesson Breakdown (up to 4 collaborations):
○ Introduce the following questions:
■ What do you think an engineer is and does?
■ What do you think technology is and what is it used for?
○ Discuss both topics as a class, infusing video clips and Google slides as enhancements to the discussion.
○ Follow the "Introduction" and "Activity" directions on TG pgs. 34-36.
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MATERIALS:
● Samples of "engineered objects" (examples: toothbrush, flashlight, plastic container, sponge, paper clip, stapler, scissors, pen, CD, slippers, pencil sharpener, glue stick, eraser, plastic bag, nail clippers, hair brush, ec.)
● Opaque bag or container (one for each group)

VOCABULARY:
● Engineering
● Material
● Problem
● Solution
● Technology
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	○ Follow the "Reflection" directions on TG pg. 37. ○ Facilitate the "Breakdown of Technology" Lab to engage students in applying what they know about technology. ● **Assessment** ○ Administer appropriate the Pre-Assessment (found in Appendix A) ● **Extension** ○ Invite students to explore the different technologies in the classroom and use them to create their Ceiling Tile Projects. During this project, introduce and use the steps of the Engineering Design Process so that the students become familiar with them. Provide a visual of the steps of this process, as seen in TG 4-1 and 4-2.	
	Lesson 1-Leif Catches the Wind ● **Students will learn to...** ○ Define engineer ○ Identify the different uses of windmills and wind turbines ○ Describe how wind energy can be harnessed to do useful work ○ Recognize the role of mechanical engineers ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Read/present an abridged version of *Leif Catches the Wind* ○ Follow the steps listed in TG pgs. 44-50 (Students will explore how the wind can do useful work.) ● ***Assessments*** ○ Teachers will complete the Lesson 1 Rubric (1-8) about each student.	**MATERIALS FOR LESSON 1:** ● *Leif Catches the Wind* text ● Chart paper ● Denmark marked on a classroom map **VOCABULARY FOR LESSON 1:** ● Anemometer ● Beaufort scale ● Energy ● Engineer ● Engineering Design Process ● Fisk ● Mechanical engineering ● Technology ● Vejr ● Wind ● Windmill ● Wind turbine
	Lesson 2-Who are Mechanical Engineers? **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 55.* ● **Students will learn to...**	**MATERIALS FOR LESSON 2:** ● Egg beater, hand-operated ● Chart paper ● 5 glue sticks ● 5 mechanical pencils ● 5 can openers with interlocking gears

	○ Identify and describe common objects that are machines ○ Identify and describe moving parts of a machine ○ Recognize how they move a machine (put energy in) and how the machine (or part of the machine) moves in response ○ Recognize the role of mechanical engineers in designing and improving machines ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 56-63 (Students will examine how different machines work and explore their advantages and disadvantages) ● ***Assessments*** ○ Teachers will complete the Lesson 2 Rubric (2-5) about each student. ● ***Extensions*** ○ *Activity A-Inefficient Machines:* Introduce students to Rube Goldberg machines. Rube Goldberg machines perform simple tasks in very roundabout, complex ways. Have students write or draw a Rube Goldberg-style machine to open a can, mix batter, or sharpen a pencil. ○ *Activity B-Large-Scale Machines:* If possible, take students on a trip to see some large machines, such as a car engine, or the engine room of your school or another building. Encourage students to observe moving parts and how they fit together.	● Markers ● Crayons **VOCABULARY FOR LESSON 2:** ● Action ● Efficient ● Energy ● Machine ● Mechanical engineer ● Motion ● Purpose
	Lesson 3-Testing Sail Designs Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 69-71.* ● **Students will learn to...** ○ Make predictions about which materials will make the best sails	**MATERIALS FOR LESSON 3 PART 1:** ● 5 rulers ● 1 large fan ● 4 pieces of fishing line (15-20 lb. gauge), each 8' to 10' long ● 1 roll of cellophane tape ● 1 roll of masking tape or duct tape

	○ Observe and describe how different materials and shapes catch the wind when used as sails ○ Notice that the material, shape, and size of a sail affect how well the wind can move the boat or raft to which it is attached ○ Compare the performance of different sails and decide which properties have the greatest effect on sail performance ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 72-75 (Students will explore the different properties of various materials and determine which materials would be best for making sails.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-6) about each student.	● 2 foam trays (each at least 4"x6") ● 2 plastic, non-flexible drinking straws ● Chart paper ● 1 craft stick for each group of students ● 1 coffee stirrer for each group of students ● 1 index card (3"x5") for each group of students ● Copy paper (8.5"x11") for each group of students ● Tissue paper (approx. 12"x12") for each group of students ● 1 paper cup (3 or 5 oz.) for each group of students ● Aluminum foil (approx. 12"x12") for each group of students ● Wax paper (approx. 12"x12") for each group of students ● Felt sheet (approx. 9"x12") for each group of students ● 1 plastic grocery bag for each group of students **VOCABULARY FOR LESSON 3 PART 1:** ● Mast ● Material ● Predict ● Property ● Sail ● Test
	Lesson 3-Testing Sail Designs Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 77.* ● **Students will learn to...** ○ Make predictions about which materials will make the best sails ○ Observe and describe how different materials and shapes catch the wind when used as sails ○ Notice that the material, shape, and size of a sail affect how well the wind can move the boat or raft to which it is attached ○ Compare the performance of different sails and decide which properties have the greatest effect on sail performance ● ***Lesson Breakdown (up to 4 collaborations)*** ○ Follow the steps listed in TG pgs.	**MATERIALS FOR LESSON 3 PART 2:** ● Sailboat rafts and tracks prepared in Part 1 ● Chart paper ● Rulers ● 1 roll of masking or duct tape ● 150 index cards, any size ● 150 craft sticks ● 150 coffee stirrers ● ½ ream (approx. 250 sheets) of paper (8.5"x11") ● 35 paper cups (3 or 5 oz.) ● Aluminium foil (50 square feet) ● Wax paper (50 square feet) ● 25 felt sheets (approx. 9"x12") ● 15 plastic grocery bags ● scissors **VOCABULARY FOR LESSON 3 PART 2:** ● Mast ● Material ● Predict ● Property

	78-83 (Students will design and create their sails.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-6) about each student.	● Sail ● Test
	Lesson 4-Designing a Windmill Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 91-92.* ● **Students will learn to...** ○ Implement each step of the Engineering Design Process ○ Use what they have learned about materials, their properties, and how they work to catch the wind to inform their windmill blade designs ○ Imagine several ideas for designing blades for a windmill ○ Create a detailed plan for making windmill blades that includes a materials list and labeled diagrams ○ Create their blade designs and test them ○ Analyze their designs for strengths and weaknesses, and imagine ways that they could improve their designs ○ Implement some of their improvement ideas ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 93-97 (Students will be introduced to their challenge: design windmill blades that are able to spin a rotor and lift weights. The class will use juice carton "windmill bases" for which they will design their blades. Students will explore materials and shapes useful for catching the wind, using what the learned about sail design. Students will imagine several different blade designs. Each pair	**MATERIALS FOR LESSON 4 PART 1:** ● 1 craft stick ● 1 index card, any size ● Pens ● Scissors ● 1 roll of masking or duct tape ● 1 juice carton (half gallon) for each group of students ● Pennies, sand or water to weigh down the juice carton (approx. 2 cups) for each group of students ● 1 dowel (12" long and approximately ¼" in diameter) for each group of students ● 1 washer (large enough to fit around the dowel) for each group of students ● String (15") for each group of students ● 1 paper cup (3 or 5 oz.) for each group of students ● 1 hard, foam ball (3" in diameter) for each group of students **VOCABULARY FOR LESSON 4 PART 1:** ● Blade ● Design ● Engineering Design Process ● Goal ● Hub ● Mechanical engineer ● Problem ● Redesign ● Rotor ● Solution ● Teamwork ● Test ● Windmill ● Wind turbine

	of students will select one blade design that the would like to build and test. They will draw a plan for their blade design.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-13) about each student.	
	Lesson 4-Designing a Windmill Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 99.* ● **Students will learn to...** ○ Implement each step of the Engineering Design Process ○ Use what they have learned about materials, their properties, and how they work to catch the wind to inform their windmill blade designs ○ Imagine several ideas for designing blades for a windmill ○ Create a detailed plan for making windmill blades that includes a materials list and labeled diagrams ○ Create their blade designs and test them ○ Analyze their designs for strengths and weaknesses, and imagine ways that they could improve their designs ○ Implement some of their improvement ideas ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 100-108 (Student pairs will create their blades according to their plans from Part 1. Each student pair will then test their blades by attaching them to the hub (foam ball) of the windmill and placing the windmill in front of a fan. If a pair's windmill blades rotate with ease, they should then test to	**MATERIALS FOR LESSON 4 PART 2:** ● 150 index cards, any size ● 150 craft sticks ● 150 coffee stirrers ● ½ ream (approx. 250 sheets) of paper (8.5"x11") ● Tissue paper (25 square feet) ● 50 paper cups (3 or 5 oz.) ● Aluminium foil (50 square feet) ● Wax paper (50 square feet) ● 25 felt rectangles (approx. 9"x12") ● 15 plastic grocery bags ● 10 rolls of cellophane tape ● 1 large fan ● Crayons ● Markers ● 3 textbooks to raise the windmills ● 485 washers, inner diameter ⅜", for use as weights for windmills to lift ● 1 windmill base for each group of students, as prepared in Part 1 ● 1 hard, foam ball for each group of students, in addition to the one already on the windmill ● Scissors ● Rulers **VOCABULARY FOR LESSON 4 PART 12** ● Blade ● Design ● Engineering Design Process ● Goal ● Hub ● Mechanical engineer ● Problem ● Redesign ● Rotor ● Solution ● Teamwork ● Test ● Windmill

	determine the maximum number of weights the windmill can lift. After testing, the class will discuss what parts of their blades did and did not work well. Students will have the opportunity to improve and re-test their blades.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-13) about each student. ● ***Extensions*** ○ Guide students to think about changes in the direction of motion that take place as their windmills spin. Have students draw a diagram showing the fan and their windmill. Then, instruct students to draw arrows to show the motion of each part of the system (see TG pg. 107).	● Wind turbine
	Post-Assessment: Administer appropriate the Post-Assessment (found in Appendix A).	

Notes/Reflections

Tabernacle School District

UNIT PLAN

Adopted from *Understanding by Design* (Wiggins and McTighe, 2005)

Unit Title	Lighten Up: Designing Lighting Systems	**Unit Length**	Up to 30 Collaborations

DESIRED RESULTS: STAGE ONE

Standards Addressed

- ITEEA National Standards and Benchmarks
  - 2B: Systems have parts or components that work together to accomplish a goal.
  - 2D: Different materials are used in making things.
  - 2E: People plan in order to get things done.
  - 2J: Materials have many different properties.
  - 2L: Requirements are the limits to designing or making a product or system
  - 2S: Trade-off is a decision process recognizing the need for careful compromises among competing factors.
  - 6A: Products are made to meet individual needs and wants.
  - 8A: Everyone can design solutions to a problem (brainstorming is important; everyone's ideas should be considered).
  - 8C: The design process is a purposeful method of planning practical solutions to problems.
  - 8D: Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.
  - 9A: The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.
  - 9B: Expressing ideas to others verbally and through sketches and models is an important part of the design process.
  - 9C: The engineering design process involves designing a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
  - 9D: When designing an object, it is important to be creative and consider all ideas.
  - 10A: Asking questions and making observations helps a person to figure out how things (technologies) work.
  - 11E: The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.
  - 11F: Test and evaluate the solutions for the design problem.
  - 11G: Improve the design solutions.
  - 12D: Follow step-by-step directions to assemble a product.
  - 12E: Select and safely use tools, products, and systems for specific tasks.
  - 17B: Technology enables people to communicate by sending and receiving information over a distance.
- 21st Century Skills
  - 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.
  - 9.3.12.ED.1 Apply communication skills with students, parents and other groups to enhance learning and a commitment to learning.

- ○ 9.3.12.ED.2 Demonstrate effective oral, written and multimedia communication in multiple formats and contexts.

Overall Understanding(s) *(Students will understand that...)*	**Essential Question(s)** *(The open-ended question(s) that help frame inquiry)*
● There are various fields of engineering. ● Nearly everything in the human world has been touched by engineering. ● Troubleshooting and learning from failure are integral to the learning process. ● Materials and their properties are important in engineering solutions. ● Engineering problems have multiple solutions. ● Society influences and is influenced by engineering. ● Technology affects the world. ● Engineers are from all races, ethnicities, and genders.	● How does light interact with different materials and how do optical engineers use this knowledge in their work? ● How does light travel and how can we measure its intensity? ● How can we use our creativity and what we have learned about how light travels, reflection, and intensity to design a lighting system for the inside of a tomb?

Knowledge & Skills: Part 1
(Students will be able to...)

- Explore the field of optical engineering
- Identify examples of light being reflected
- Explore how light interacts with a variety of different materials
- Use the terms transmit, reflect, and absorb to describe how materials interact with light
- Connect their findings to the work of optical engineers
- Explore how light travels in a straight line until it comes in contact with another medium
- Experiment with reflecting light using mirrors to determine the law of reflection
- Explore the relationship between the distance of an object from a light source and the intensity of light on that object
- Discuss how their findings might influence their lighting system design
- Use the Engineering Design Process to design a lighting system to light the hieroglyphs in a tomb
- Evaluate their designs in terms of the intensity of light on each hieroglyph and the total cost of their lighting system designs

Knowledge & Skills: Part 2
(Students learn that...)

- Optical engineers solve problems related to light
- Light interacts with materials in different ways, including being reflected and absorbed
- The intensity of light depends on the distance over which it travels
- The Engineering Design Process is a tool that can be used to help solve problems
- Light interacts with different materials in different ways, based on each material's properties
- Optical engineers use what they know about math, science, materials, and their creativity to solve problems that involve light
- Optical engineers select materials for their designs based on how those materials interact with light
- Light travels from a source in straight lines until it hits another medium
- When light strikes a reflective surface, the angle of incidence is always equal to the angle of reflection
- The greater the distance between an object and a light source, the less intense the light is on the object
- Engineers use a series of steps, called the Engineering Design Process, to design solutions to problems
- Optical engineers design and improve technologies that involve light
- A system is a type of technology

Differentiation	Performance Task(s)
Overview: Universal Design for Learning Differentiation is inherent in Universal Design for Learning (UDL), a design philosophy with the underlying premise that meeting students' individual needs is best accomplished when lesson design is flexible, and instruction moves each student's thinking, learning, and skills forward from wherever he or she begins, in a manner that does not assume one size fits all. Engineering is Elementary lessons often provide activities for reinforcement and practice, for extension that goes beyond the classroom activity, or for adding artistic expression to lessons. Elements may be used or not, or adapted according to the teacher's assessment of his or her students' prior knowledge and their needs as a class and as individuals. The three primary components of UDL, multiple means of engagement, multiple means of representation, and multiple means of expression, are addressed in each lesson, providing all students—even those at the ends of the learning continuum, or those with unique learning requirements—opportunities to learn in a way that they learn best. **Engagement** Research reveals the importance of engagement as it links to interest, motivation, and achievement. In the Engineering is Elementary units, students	**Assessments/Observations** *Daily:* The students will record daily progress through journaling. The teacher will make observations and keep anecdotal records regarding student use of materials, demonstration of conceptual understanding, and classroom citizenship, and will provide direct and specific feedback to students. *Unit/Final:* These assessments cover key concepts and information introduced in each unit and help teachers to as student comprehension through creating. **Teacher/Student Conferences** The teacher will facilitate learning and meet with groups consistently. The students and the teacher will keep anecdotal records of group engagement and collaboration, teamwork, and work ethic. Strategies teacher will use are as follows: • Use of Open-Ended & Metacognitive Questioning • Pushing for Explanation/Elaboration • Revoicing/Reframing *(restating what the student says)* • Summarizing/Clarifying Ideas *(ask a student to summarize)* • Soliciting Ideas/Generating & Evaluating Hypotheses **Peer work** Working in teams is an essential component of learning. Lessons and activities are often carried out with students

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Discover how and why everyday objects made by people are technology
Identify the problem that a particular object solves
Identify the materials used to make an object
Identify that objects are designed as a solution to a problem
Identify engineers as the people who design objects
Lesson Breakdown (up to 4 collaborations):
Introduce the following questions:
What do you think an engineer is and does?
What do you think technology is and what is it used for?
Discuss both topics as a class, infusing video clips and Google slides as enhancements to the discussion.
Follow the “Introduction” and “Activity” directions on TG pgs. 34-36.
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MATERIALS:
Samples of “engineered objects” (examples: toothbrush, flashlight, plastic container, sponge, paper clip, stapler, scissors, pen, CD, slippers, pencil sharpener, glue stick, eraser, plastic bag, nail clippers, hair brush, ec.)
Opaque bag or container (one for each group)
VOCABULARY:
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Material
Problem
Solution
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○ Follow the "Reflection" directions on TG pg. 37. ○ Facilitate the "Breakdown of Technology" Lab to engage students in applying what they know about technology. ● **Assessment** ○ Administer appropriate the Pre-Assessment (found in Appendix A) ● **Extension** ○ Invite students to explore the different technologies in the classroom and use them to create their Ceiling Tile Projects. During this project, introduce and use the steps of the Engineering Design Process so that the students become familiar with them. Provide a visual of the steps of this process, as seen in TG 4-1 and 4-2.	
Lesson 1-Omar's Time to Shine ● **Students will learn to...** ○ Explain the work of optical engineers and their role in designing technologies that involve light ○ Identify places where light is reflected ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Read/present an abridged version of *Omar's Time to Shine* ○ Follow the steps listed in TG pgs. 43-51 (Students will explore how light is reflected and places where light is reflected.) ● ***Assessments*** ○ Teachers will complete the Lesson 1 Rubric (1-7) about each student. ● ***Extensions*** ○ Have students do some research on hieroglyphs and try to write their names or a secret message using hieroglyphs	**MATERIALS FOR LESSON 1:** ● *Omar's TIme to Shine* text ● Chart paper ● Egypt marked on a classroom map **VOCABULARY FOR LESSON 1:** ● Absorption ● *Aish* ● Engineer/Engineering ● Engineering Design Process ● Intensity ● *Marhaba* ● Optical engineer ● Reflection ● System ● Technology

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Lesson 2-Think Like an Optical Engineer
PLEASE NOTE: Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 57-59.

Students will learn to...

Observe and describe how light interacts with different materials
Use the terms transmit, reflect, and absorb to describe how materials interact with light
Explain that optical engineers have to think about how light interacts with different materials when designing technologies
Explain what optical engineers do for their work and give examples of technologies they might work on

Lesson Breakdown (up to 3 collaborations)

Follow the steps listed in TG pgs. 60-71 (Students will investigate how different materials interact with light and discuss and record their findings.)

Assessments

Teachers will complete the Lesson 2 Rubric (2-9) about each student.

Extensions

Have students look around the classroom or their homes and identify any other technologies that might have been designed, even in part, by optical engineers

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MATERIALS FOR LESSON 2:

Chart paper
Sharpened pencils
Single hole punch
Clear transparency
Permanent markers
Fiber optic toy
Flashlight with regular bulbs for each group of students
2 white index cards (5"x8") for each group of students
4 medium-sized binder clips for each group of students
1 roll of masking tape for each group of students
1 plastic, resealable bag (quart-size) for each group of students
2 materials from the list below for each group of students:

Black construction paper (¼ sheet)
Black construction paper (¼ sheet with holes punched)
Mylar or aluminum foil (4"x6")
White tissue paper (4"x6")
Mirror (4"x6")

VOCABULARY FOR LESSON 2:

Absorb/Absorption
Interact
Material
Optical engineer
Reflect/Reflection
Transmit/Transmission

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Lesson 3-Shedding Light on It Part 1
PLEASE NOTE: Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 77-79.

Students will learn to...

Explain how the way light travels would affect a lighting system design
Conduct an experiment to explore how light is reflected by a mirror
Analyze data to explain the law of reflection: the angle of incidence is

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MATERIALS FOR LESSON 3 PART 1:

Chart paper
Materials to create one tomb:

1 copy paper box, approx. 17"x12"x9"
Utility knife (for teacher use)
Cellophane tape
Scissors
Permanent markers

1 flashlight with incandescent bulb for each group of students
1 shoe box for each group of students
Rulers

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	always equal to the angle of reflection ○ Explain how the relationship between light intensity and the distance light travels would affect a lighting system design ● ***Lesson Breakdown (up to 4 collaborations)*** ○ Follow the steps listed in TG pgs. 80-90 (Students will explore how light travels and how light can be reflected using mirrors.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-17) about each student.	● 1 mirror, approx. 4”x6”, for each group of students ● 2 mirrors, approx. 2.25”x3.5”, for each group of students **VOCABULARY FOR LESSON 3 PART 1:** ● Absorb ● Angle of incidence ● Angle of reflection ● Constraint ● Criteria ● Engineering Design Process ● Goal ● Intense/Intensity ● Light source ● Optical engineer ● Reflect/reflection ● Trade-off
	Lesson 3-Shedding Light on It Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the “Preparation” steps listed on TG pg. 92.* ● **Students will learn to...** ○ Explain how the way light travels would affect a lighting system design ○ Conduct an experiment to explore how light is reflected by a mirror ○ Analyze data to explain the law of reflection: the angle of incidence is always equal to the angle of reflection ○ Explain how the relationship between light intensity and the distance light travels would affect a lighting system design ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 93-101 (Students will investigate the intensity of light in different situations.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-17) about each student.	**MATERIALS FOR LESSON 3 PART 2:** ● Chart paper ● Scissors ● Utility knife (for teacher use) ● Cellophane tape ● Permanent markers ● 1 copy paper box, approx. 17”x12”x9”, for each group of students (for the tomb) ● 1 flashlight with incandescent bulb for each group of students **VOCABULARY FOR LESSON 3 PART 2:** ● Absorb ● Angle of incidence ● Angle of reflection ● Constraint ● Criteria ● Engineering Design Process ● Goal ● Intense/Intensity ● Light source ● Optical engineer ● Reflect/reflection ● Trade-off

	Lesson 4-Designing a Lighting System Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 109.* ● **Students will learn to...** ○ Identify and implement each step of the Engineering Design Process ○ Use what they have learned about how light travels, light intensity, and the law of reflection to inform their design of a lighting system for the inside of a tomb ○ Evaluate their designs using established criteria ○ Improve their lighting system designs, taking into account the evaluation of a prior design ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 110-116 (Students will review the goal of the design challenge: designing a lighting system for a tomb. They will also review criteria and constraints and how their designs will be evaluated. Students will imagine several different ways to design a lighting system and think about the advantages and disadvantages of each idea. Students will select one lighting system design and make a plan, including a detailed diagram.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-14) about each student.	**MATERIALS FOR LESSON 4 PART 1:** ● Chart paper ● Model tomb (from Lesson 3) for each group of students ● 1 plastic, resealable bag (quart-size for each group of students ● 1 mirror, approx. 2"x3.5", for each group of students ● 1 mirror, approx. 4"x6", for each group of students ● 1 pipe cleaner for each group of students ● 1 index card (3"x5") for each group of students ● 6" of string or yarn for each group of students ● 1 craft stick for each group of students ● 1 medium binder clip for each group of students **VOCABULARY FOR LESSON 4 PART 1:** ● Constraint ● Criteria ● Design ● Engineering Design Process ● Goal ● Intensity ● Optical engineer ● Problem ● Redesign ● Solution ● System ● Teamwork ● Technology ● Test ● Trade-off
	Lesson 4-Designing a Lighting System Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 118.* ● **Students will learn to...** ○ Identify and implement each step of the Engineering Design Process	**MATERIALS FOR LESSON 4 PART 2:** ● 50 mirrors, approx. 2"x3.5" ● 20 mirrors, approx. 4"x6" ● 90 index cards (3"x5") ● 90 pipe cleaners ● 10 rolls of cellophane tape ● 275 feet of string

	○ Use what they have learned about how light travels, light intensity, and the law of reflection to inform their design of a lighting system for the inside of a tomb ○ Evaluate their designs using established criteria ○ Improve their lighting system designs, taking into account the evaluation of a prior design ● ***Lesson Breakdown (up to 6 collaborations)*** ○ Follow the steps listed in TG pgs. 119-126 (Students will create their lighting systems by following their plans and calculate the cost of their designs. Students will test their designs by turning on the light source (flashlight) and evaluating the intensity of light on each of the hieroglyphs using the Light Intensity Meters. Students will score their designs and analyze them for strengths and weaknesses. Students will brainstorm ways to improve their designs and then implement and evaluate their improved lighting system designs. Students will prepare to be interviewed by the documentary host about their lighting system designs by answering a series of interview questions.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-14) about each student. ● ***Extensions*** ○ Using a video camera or a computer with a built-in camera, have student groups take turns presenting their lighting system designs as if they were in a	● 90 craft sticks ● 50 medium binder clips ● 1 model tomb for each group of students ● 1 flashlight with incandescent bulb for each group of students ● Scissors ● Light Intensity Meters (from Lesson 3) **VOCABULARY FOR LESSON 4 PART 2:** ● Constraint ● Criteria ● Design ● Engineering Design Process ● Goal ● Intensity ● Optical engineer ● Problem ● Redesign ● Solution ● System ● Teamwork ● Technology ● Test ● Trade-off

	documentary.	
	Post-Assessment: Administer appropriate the Post-Assessment (found in Appendix A).	

Notes/Reflections

Tabernacle School District

UNIT PLAN

Adopted from *Understanding by Design* (Wiggins and McTighe, 2005)

Unit Title	Marvelous Machines: Making Work Easier	**Unit Length**	Up to 25 Collaborations

DESIRED RESULTS: STAGE ONE

Standards Addressed

- ITEEA National Standards and Benchmarks
    - 1B: All people use tools and techniques to help them do things.
    - 1D: Tools materials, and skills are used to make things and carry out tasks.
    - 1E: Creative thinking and economic and cultural influences shape technological development.
    - 2C: Tools are simple objects that help humans complete tasks.
    - 2E: People plan in order to get things done.
    - 2F: A subsystem is a system that operates as a part of another system.
    - 2K: Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing.
    - 3A: The study of technology uses many of the same ideas and skills as other subjects.
    - 3B: Technologies are often combined.
    - 6A: Products are made to meet individual needs and wants.
    - 7A: The way people live and work has changed throughout history because of technology.
    - 8A: Everyone can design solutions to a problem (brainstorming is important; everyone's ideas should be considered).
    - 8B: Design is a creative process.
    - 8C: The design process is a purposeful method of planning practical solutions to problems.
    - 8D: Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.
    - 9B: Expressing ideas to others verbally and through sketches and models is an important part of the design process.
    - 9C: The engineering design process involves designing a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.

- 9D: When designing an object, it is important to be creative and consider all ideas.
    - 10A: Asking questions and making observations helps a person to figure out how things (technologies) work.
    - 10E: The process of experimentation, which is common in science, can also be used to solve technological problems.
    - 11B: Build or construct an object using the design process.
    - 11C: Investigate how things are made and how they can be improved.
    - 11F: Test and evaluate the solutions for the design problem.
    - 11G: Improve the design solutions.
    - 12D: Follow step-by-step directions to assemble a product.
    - 12E: Select and safely use tools, products, and systems for specific tasks.
    - 19A: Manufacturing systems produce products in quantity.
- 21st Century Skills
    - 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.
    - 9.3.12.ED.1 Apply communication skills with students, parents and other groups to enhance learning and a commitment to learning.
    - 9.3.12.ED.2 Demonstrate effective oral, written and multimedia communication in multiple formats and contexts.

Overall Understanding(s) *(Students will understand that...)*	**Essential Question(s)** *(The open-ended question(s) that help frame inquiry)*
• There are various fields of engineering. • Nearly everything in the human world has been touched by engineering. • Troubleshooting and learning from failure are integral to the learning process. • Materials and their properties are important in engineering solutions. • Engineering problems have multiple solutions. • Society influences and is influenced by engineering. • Technology affects the world. • Engineers are from all races, ethnicities, and genders.	• Is is always most efficient to work alone? • How do simple machines make a job easier? • How can we use our knowledge of simple machines and the Engineering Design Process to design and improve a factory subsystem that makes work easier?

Knowledge & Skills: Part 1
(Students will be able to...)

- Investigate various simple machines
- Explore the work of industrial engineers
- Compare the advantages and disadvantages of working independently and working in an assembly line
- Test simple machines, including a lever, an inclined plane, a pulley, a double pulley, and a cart with wheels and axles, using a spring scale to determine how much force is needed to move a standard load
- Observe if and how each simple machine changes the amount of force needed to move a standard load and comment on the ergonomics of each simple machine

● Use the steps of the Engineering Design Process to create a factory subsystem that uses simple machines to make work easier ● Test and analyze the performances of their subsystems ● Use their analyses to brainstorm ways to improve their subsystem designs ● Implement some improvement ideas and retest their designs
Knowledge & Skills: Part 2 *(Students learn that...)*
● Engineers solve problems by designing solutions ● Simple machines can be used to make work easier ● Different simple machines can be used to solve different types of problems ● Industrial engineers work to improve systems and processes used by people who work in various industries ● Performing many steps in a process on your own can sometimes be very time consuming ● Assembly lines can be designed to shorten production time to shorten production time and make a process more efficient ● Factories can benefit from having each worker master just one step in the production of a product ● Technology can be a process or system ● There are advantages and disadvantages to using an assembly line to make a product ● The force needed to move an object can be measured (in units called Newtons) using a spring scale ● Different simple machines make work easier in different ways ● Engineers conduct experiments, much as scientists do, to collect data that will help them design and improve technologies. ● There are practical ways in which simple machines can be used to make manufacturing systems run smoothly ● Engineers use a series of steps, called the Engineering Design Process, to design solutions to problems ● Ergonomics are important to consider when designing a technology for human use

Differentiation	Performance Task(s)
Overview: Universal Design for Learning Differentiation is inherent in Universal Design for Learning (UDL), a design philosophy with the underlying premise that meeting students' individual needs is best accomplished when lesson design is flexible, and instruction moves each student's thinking, learning, and skills forward from wherever he or she begins, in a manner that does not assume one size fits all. Engineering is Elementary lessons often provide activities for reinforcement and practice, for extension that goes beyond the classroom activity, or for adding artistic expression to lessons. Elements may be used or not, or adapted according to the teacher's assessment of his or her students' prior knowledge and their needs as a class and as individuals. The three primary components of UDL, multiple means of engagement, multiple means of representation, and multiple means of expression, are addressed in each lesson, providing all	**Assessments/Observations** *Daily:* The students will record daily progress through journaling. The teacher will make observations and keep anecdotal records regarding student use of materials, demonstration of conceptual understanding, and classroon citizenship, and will provide direct and specific feedback tc students. *Unit/Final:* These assessments cover key concepts and information introduced in each unit and help teachers to as student comprehension through creating. **Teacher/Student Conferences** The teacher will facilitate learning and meet with groups consistently. The students and the teacher will keep anecdotal records of group engagement and collaboration, teamwork, and work ethic. Strategies teacher will use are as follows: ● Use of Open-Ended & Metacognitive Questioning ● Pushing for Explanation/Elaboration

students—even those at the ends of the learning continuum, or those with unique learning requirements—opportunities to learn in a way that they learn best.

Engagement

Research reveals the importance of engagement as it links to interest, motivation, and achievement. In the Engineering is Elementary units, students manipulate materials in hands-on activities, read informational text, participate in discussion, and write, draw, or create in every lesson. Students develop models to represent phenomenon, and use their models to explain how and why things happen. In some lessons, students watch videos, explore websites, or play games. The teacher might choose to add others, as appropriate for the students' learning, and as different modes of technology provide access to new material every day. A variety of ways to engage with the concepts and ideas, beginning with images and discussion that activates prior knowledge, provide all students with entry points into the content and ways to explore and investigate it. Students engage in their learning as a whole class and in collaborative teams or pairs, and have independent time to read, write, draw, or create.

Student Interaction

Students bring to the classroom a range of experiences, as well as varied degrees of interest in learning the skills and concepts covered in this unit.. As they test ideas, collect data, and articulate what they have discovered, learning becomes personal. Groups and pairs may be configured to address reading needs, individual interests, or learning strengths. Consider Think-Pair-Share and Heads-Together techniques to allow time for student reflection prior to answering questions, starting a discussion, writing, or creating so that all students have an opportunity to process information before being called upon to use it.

Representation

- Visual – Lessons incorporate numerous photographs and illustrations. The student readers contain photographs, charts and graphs, diagrams, and other images so that

- Revoicing/Reframing *(restating what the student says)*
- Summarizing/Clarifying Ideas *(ask a student to summarize)*
- Soliciting Ideas/Generating & Evaluating Hypotheses

Peer work

Working in teams is an essential component of learning. Lessons and activities are often carried out with students in "teams" or "partners" and materials are shared. The teachers should use their knowledge of the class to select productive student groups and spend time modeling and discussing constructive group behavior. The term "partners" refers to two students, while "team" refers to two sets of partners or any grouping of three or more.

students can encounter science content in a variety of ways. ● Auditory – Teachers may read aloud or have students do paired reading of the informational texts in the lesson. Discussion— speaking and listening—are core elements Engineering is Elementary. Teamwork provides opportunities for student-to-student talk as they share ideas and challenge one another's evidence for claims and conclusions. ● Kinesthetic – Every lesson has students interacting with and manipulating materials. ● Use of Technology – Various modes of technology will be incorporated into each part of the learning process. **Expression** Students write, draw, and/or create in every lesson as ways in which they express, demonstrate, and record their developing understandings. This work, done through journaling and projects, provides the teacher with ongoing opportunities to assess learning formatively and adjust classroom experiences, as needed. Rich discussion also enables teachers to assess understanding as students express their ideas and communicate orally.	
LEARNING PLAN: STAGE THREE	
Lesson Topics & Sequence of Learning Activities	**Materials and Resources**
Pre-assessment: ● **Students will learn to...** ○ Discover how and why everyday objects made by people are technology ○ Identify the problem that a particular object solves ○ Identify the materials used to make an object ○ Identify that objects are designed as a solution to a problem ○ Identify engineers as the people who design objects ● **Lesson Breakdown (up to 4 collaborations):** ○ Introduce the following questions: ■ What do you think an engineer is and does?	**MATERIALS:** ● Samples of "engineered objects" (examples: toothbrush, flashlight, plastic container, sponge, paper clip, stapler, scissors, pen, CD, slippers, pencil sharpener, glue stick, eraser, plastic bag, nail clippers, hair brush, ec.) ● Opaque bag or container (one for each group) **VOCABULARY:** ● Engineering ● Material ● Problem ● Solution ● Technology

- What do you think technology is and what is it used for? ○ Discuss both topics as a class, infusing video clips and Google slides as enhancements to the discussion. ○ Follow the "Introduction" and "Activity" directions on TG pgs. 34-36. ○ Follow the "Reflection" directions on TG pg. 37. ○ Facilitate the "Breakdown of Technology" Lab to engage students in applying what they know about technology. ● **Assessment** ○ Administer appropriate the Pre-Assessment (found in Appendix A) ● **Extension** ○ Invite students to explore the different technologies in the classroom and use them to create their Ceiling Tile Projects. During this project, introduce and use the steps of the Engineering Design Process so that the students become familiar with them. Provide a visual of the steps of this process, as seen in TG 4-1 and 4-2.	
Lesson 1-Aisha Makes Work Easier ● **Students will learn to...** ○ Define engineer ○ Identify and describe simple machines ○ Identify and describe the problems solved by simple machines ○ Investigate why some simple machines are better solutions for specific problems than others ○ Explore the work of industrial engineers ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Read/present an abridged version of *Aisha Makes Work Easier* ○ Follow the steps listed in TG pgs. 45-53 (Students will explore how	**MATERIALS FOR LESSON 1:** ● *Aisha Makes Work Easier* text ● Chart paper ● Boston, Massachusetts marked on a classroom map **VOCABULARY FOR LESSON 1:** ● Engineer ● Engineering Design Process ● Inclined plane ● Industrial engineering ● Lever ● Process ● Pulley ● Screw ● Simple machine ● Subsystem ● Technology

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and why simple machines were used in this story.)
Assessments
Teachers will complete the Lesson 1 Rubric (1-7) about each student.
Extensions
Go on a Simple Machines Scavenger Hunt, in which students will search for, identify, and describe simple machines around their classroom and school building.
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Wedge
Wheel and axle
Work
</td></tr>
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Lesson 2-Assembly Lines
PLEASE NOTE: Prior to the start of this lesson, the teacher must complete the “Preparation” steps listed on TG pg. 59.
Students will learn to...
Define process in an engineering context
Identify a process as a kind of technology
Identify an assembly line as a process and a technology
Explain how an assembly line works
Explain how an assembly line can make a process more time efficient
Explain at least one advantage and one disadvantage of using an assembly line
Explore the role of industrial engineers in designing processes
Lesson Breakdown (up to 3 collaborations)
Follow the steps listed in TG pgs. 60-70 (Students will create folders independently and in an assembly line and compare and contrast the efficiency of each process and how each process could be improved.)
Assessments
Teachers will complete the Lesson 2 Rubric (2-4) about each student.
Extensions
Activity 1: Have students implement some of their ideas
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MATERIALS FOR LESSON 2:
Chart paper
Clock or stopwatch
Staples
20 pieces of construction paper for each group of 5 students
5 pieces of copy or scrap paper (8.5”x11”) for each group of 5 students
1 stapler for each group of 5 students
1 roll of cellophane tape for each group of 5 students
60 pieces of construction paper for each group of 10 students
15 pieces of copy or scrap paper (8.5”x11”) for each group of 10 students
2 staplers for each group of 10 students
1 rolls of cellophane tape for each group of 10 students
Pencils
Markers
Rulers
VOCABULARY FOR LESSON 2:
Assembly line
Horizontal
Process
Production
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	about how to improve the assembly line and determine whether the class is able to produce more folders using the improved assembly line. ○ *Activity 2:* Students can (1) calculate the rate at which they made the folders on their own and the rate at which they made folders in an assembly line.	
	Lesson 3-Using Simple Machines **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 76-79.* ● **Students will learn to...** ○ Observe and describe the performances of five different simple machines-a lever, an inclined plane, a pulley, a double pulley, and a wheel and axle-for moving a load ○ Analyze the performance of five kinds of simple machines for moving a standard load ○ Discuss the ergonomics of each simple machine as well as if and how each simple machine changes the direction of the applied force ○ Analyze the trade-offs of using each simple machine in a given situation ● ***Lesson Breakdown (up to 4 collaborations)*** ○ Follow the steps listed in TG pgs. 80-92 (Students will rotate through simple machine stations to investigate how each type of simple machines works.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-20) about each student. ● ***Extensions*** ○ Have students complete the additional "Wheel and Axle" activity (see TG pgs. 89-92)	**MATERIALS FOR LESSON 3:** ● 1 roll of masking tape ● Rulers ● Scissors ● 1 Lever Station (see TG pg. 74) ● 1 Inclined Plane Station: Long Board (see TG pg. 74) ● 1 Inclined Plane Station: Short Board (see TG pg. 74) ● 1 Pulley Station: Single Pulley (see TG pg. 74) ● 1 Pulley Station: Double Pulley (see TG pg. 74) ● 1 Wheel and Axle Station: Cart, No Wheels (see TG pg. 74) ● 1 Wheel and Axle Station: Cart With Wheels (see TG pg. 74) **VOCABULARY FOR LESSON 3:** ● Double pulley ● Effort ● Ergonomics ● Fulcrum ● Inclined plane ● Lever ● Load ● Newton ● Pulley ● Simple machine ● Test ● Trade-off ● Wheel and axle

	Lesson 4-Improving a Factory Subsystem Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 99.* ● **Students will learn to...** ○ Implement each step of the Engineering Design Process ○ Utilize their knowledge of how simple machines make work easier (both by reducing forces and by giving an ergonomic advantage) when designing their factory subsystems ○ Imagine ideas for using simple machines to improve a factory subsystem and choose one idea to plan, build, and test ○ Create a plan for their improved factory subsystem that includes a materials list and labeled diagram ○ Create and test a prototype from their plan ○ Compare the force required to move the load by hand to the force required to move the load using their subsystem ○ Compare the ergonomic advantages and disadvantages of moving the load with and without their factory subsystem designs ○ Imagine ways to improve their designs and implement some of their improvement ideas ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 100-105 (Students will review what they learned about simple machines and ergonomics in Lesson 3 and establish a need for creating an improved factory subsystem. Working in small groups, students will be assigned one simple machine to use in their subsystem designs. Groups can then imagine several designs that	**MATERIALS FOR LESSON 4 PART 1:** ● 1 spring scale, measuring 10 Newtons ● 12" masking tape ● 1 desk ● Markers ● Pens ● Load, approx. 1-2 pounds, such as a filled 0.50-liter water bottle ● 1 plastic grocery bag ● 1 index card for each group of students **VOCABULARY FOR LESSON 4 PART 1:** ● Design ● Engineering Design Process ● Ergonomics ● Goal ● Industrial engineering ● Prototype ● Redesign ● Solution ● Subsystem ● Teamwork ● Test

	include both their assigned simple machines as well as one or two additional machines. Each group will select one subsystem design and draw a detailed plan that includes a labeled diagram and a materials list.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-10) about each student.	
	Lesson 4-Improving a Factory Subsystem Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 107.* ● **Students will learn to...** ○ Implement each step of the Engineering Design Process ○ Utilize their knowledge of how simple machines make work easier (both by reducing forces and by giving an ergonomic advantage) when designing their factory subsystems ○ Imagine ideas for using simple machines to improve a factory subsystem and choose one idea to plan, build, and test ○ Create a plan for their improved factory subsystem that includes a materials list and labeled diagram ○ Create and test a prototype from their plan ○ Compare the force required to move the load by hand to the force required to move the load using their subsystem ○ Compare the ergonomic advantages and disadvantages of moving the load with and without their factory subsystem designs ○ Imagine ways to improve their designs and implement some of their improvement ideas ● ***Lesson Breakdown (up to 3 collaborations)***	**MATERIALS FOR LESSON 4 PART 2:** ● 10 feet of rope/clothesline ● 20 feet of string/mason line ● 100 paper clips ● 10 rolls of masking tape ● Spring scale, measuring 10 Newtons ● Load, approx. 1-2 pounds, such as a filled 0.50-liter water bottle ● 1 plastic grocery bag ● Assembled simple machines from previous lesson ● Scissors **VOCABULARY FOR LESSON 4 PART 2:** ● Design ● Engineering Design Process ● Ergonomics ● Goal ● Industrial engineering ● Prototype ● Redesign ● Solution ● Subsystem ● Teamwork ● Test

	○ Follow the steps listed in TG pgs. 108-111 (Students will build their factory subsystems based on their plans. Students will also test their subsystems by measuring the force required to move the load and analyzing the subsystem's ergonomics. Students will record their testing data and share their results and designs with the class.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-10) about each student.	
	Lesson 4-Improving a Factory Subsystem Part 3 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 113.* ● **Students will learn to...** ○ Implement each step of the Engineering Design Process ○ Utilize their knowledge of how simple machines make work easier (both by reducing forces and by giving an ergonomic advantage) when designing their factory subsystems ○ Imagine ideas for using simple machines to improve a factory subsystem and choose one idea to plan, build, and test ○ Create a plan for their improved factory subsystem that includes a materials list and labeled diagram ○ Create and test a prototype from their plan ○ Compare the force required to move the load by hand to the force required to move the load using their subsystem ○ Compare the ergonomic advantages and disadvantages of moving the load with and without their factory subsystem designs	**MATERIALS FOR LESSON 4 PART 3:** ● 10 feet of rope/clothesline ● 20 feet of string/mason line ● 100 paper clips ● 10 rolls of masking tape ● Spring scale, measuring 10 Newtons ● Load, approx. 1-2 pounds, such as a filled 0.50-liter water bottle ● 1 plastic grocery bag ● Assembled simple machines from previous lesson ● Scissors **VOCABULARY FOR LESSON 4 PART 3:** ● Design ● Engineering Design Process ● Ergonomics ● Goal ● Industrial engineering ● Prototype ● Redesign ● Solution ● Subsystem ● Teamwork ● Test

	◦ Imagine ways to improve their designs and implement some of their improvement ideas ● ***Lesson Breakdown (up to 3 collaborations)*** ◦ Follow the steps listed in TG pgs. 113-118 (Students will brainstorm ways to improve their subsystem designs and implement some of their improvement ideas. Students will also write a letter to the president of the potato chip factory that identifies the problem, details their final factory subsystem design, and explains why the potato chip factory should use their group's subsystem design.) ● ***Assessments*** ◦ Teachers will complete the Lesson 4 Rubric (4-10) about each student. ● ***Extensions*** ◦ Go on a class trip to visit a factory in the area. Have students look for different simple machines in the factory and try to identify different ways that the factory used ergonomics to make work easier for its employees.	
	Post-Assessment: Administer appropriate the Post-Assessment (found in Appendix A).	

Notes/Reflections

Tabernacle School District

UNIT PLAN

Adopted from *Understanding by Design* (Wiggins and McTighe, 2005)

Unit Title	Now You're Cooking: Designing Solar Ovens	**Unit Length**	Up to 30 Collaborations

DESIRED RESULTS: STAGE ONE

Standards Addressed

- ITEEA National Standards and Benchmarks
    - 1B: All people use tools and techniques (technology) to help them do things.
    - 1C: Things that are found in nature differ from things that are human-made in how they are produced and used.
    - 1D: Tools materials, and skills are used to make things and carry out tasks.
    - 1E: Creative thinking and economic and cultural influences shape technological development.
    - 2D: Different materials are used in making things.
    - 2H: Resources are things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.
    - 2J: Materials have many different properties.
    - 2S: Trade-off is a decision process recognizing the need for careful compromises among competing factors.
    - 5A: Some materials can be reused and/or recycled.
    - 5B: Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment.
    - 5C: The use of technology affects the environment in good and bad ways.
    - 6C: Individual, family, community, and economic concerns may expand or limit the development of technologies.
    - 8A: Everyone can design solutions to a problem (brainstorming is important; everyone's ideas should be considered).
    - 8C: The design process is a purposeful method of planning practical solutions to problems.
    - 8D: Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.
    - 9A: The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.
    - 9C: The engineering design process involves designing a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
    - 9D: When designing an object, it is important to be creative and consider all ideas.
    - 10A: Asking questions and making observations helps a person to figure out how things (technologies) work.
    - 10E: The process of experimentation, which is common in science, can also be used to solve technological problems.
    - 11B: Build or construct an object using the design process.
    - 11C: Investigate how things are made and how they can be improved.
    - 11E: The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.

- 11F: Test and evaluate the solutions for the design problem.
  - 11G: Improve the design solutions.
  - 13D: Investigate and assess the influence of a specific technology on the individual, family, community, and environment.
  - 16B: Energy should not be wasted.
  - 16C: Energy comes in different forms.
  - 16D: Tools, machines, products, and systems use energy in order to do work.
- 21st Century Skills
  - 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.
  - 9.3.12.ED.1 Apply communication skills with students, parents and other groups to enhance learning and a commitment to learning.
  - 9.3.12.ED.2 Demonstrate effective oral, written and multimedia communication in multiple formats and contexts.

Overall Understanding(s) *(Students will understand that...)*	**Essential Question(s)** *(The open-ended question(s) that help frame inquiry)*
• There are various fields of engineering. • Nearly everything in the human world has been touched by engineering. • Troubleshooting and learning from failure are integral to the learning process. • Materials and their properties are important in engineering solutions. • Engineering problems have multiple solutions. • Society influences and is influenced by engineering. • Technology affects the world. • Engineers are from all races, ethnicities, and genders.	• What are technologies and who designs them? • How do life cycle assessments help green engineers analyze the environmental impacts of a technology? • What materials are good thermal insulators and also have a low impact on the environment? • How can we use our knowledge of thermal properties and environmental impact of materials, the Engineering Design Process, and our creativity to design a solar oven with minimal environmental impact?

Knowledge & Skills: Part 1
(Students will be able to...)

- Examine everyday examples of technology
- Explore the field of green engineering
- Ask and answer questions that help determine the environmental impact of a technology
- Identify materials as thermal conductors or thermal insulators
- Examine the life cycle of paper
- Identify and explain resources required for and the environmental impacts resulting from the manufacture and use of paper
- Collect and analyze data regarding their class' paper usage
- Brainstorm ways to reduce the environmental impacts of using paper
- Conduct a controlled experiment to determine how well different materials perform as thermal insulators
- Explore how changing the configuration of a material (by shredding it) affects its performance as a thermal insulator

- Analyze different materials in terms of their environmental impacts
- Explain how their findings might influence their solar oven designs
- Use the Engineering Design Process to design a solar oven
- Use knowledge of thermal properties of materials and the environmental impact of materials to inform their solar oven designs

Knowledge & Skills: Part 2

(Students learn that...)

- Green engineering involves analyzing the resources used to make a technology and any environmental impacts resulting from a technology
- When a technology is engineered to be green, it is designed to have minimal impact on the environment
- Some materials are thermal insulators and others are thermal conductors
- The life cycle of a technology involves many steps, including manufacturing, transportation, use, and disposal
- Many resources are required to create a product
- The environmental impacts of a product include the pollution created throughout the product's life cycle
- Reducing, reusing, and recycling are ways to decrease the environmental impact of a product
- Some materials conduct heat energy more readily than other materials
- Heat energy is always transferred from warmer areas to cooler areas
- Many factors are taken into account when analyzing the environmental impact of a material
- Waste management is one way of decreasing the environmental impact of a design
- Engineers use a series of steps, called the Engineering Design Process, to *ask* questions about, *imagine*, *plan*, *create*, and *improve* technologies
- Engineers often have to balance several variables when designing a technology
- Increasing the performance of a design for one variable can decrease its performance for other variables

<table>
<tr><th>Differentiation</th><th>Performance Task(s)</th></tr>
<tr><td>Overview:
Universal Design for Learning Differentiation is inherent in Universal Design for Learning (UDL), a design philosophy with the underlying premise that meeting students' individual needs is best accomplished when lesson design is flexible, and instruction moves each student's thinking, learning, and skills forward from wherever he or she begins, in a manner that does not assume one size fits all. Engineering is Elementary lessons often provide activities for reinforcement and practice, for extension that goes beyond the classroom activity, or for adding artistic expression to lessons. Elements may be used or not, or adapted according to the teacher's assessment of his or her students' prior knowledge and their needs as a class and as individuals. The three primary components of UDL, multiple means of engagement, multiple means of representation, and multiple means of expression, are addressed in each lesson, providing all students—even those at the ends of the learning</td><td>Assessments/Observations
Daily: The students will record daily progress through journaling. The teacher will make observations and keep anecdotal records regarding student use of materials, demonstration of conceptual understanding, and classroon citizenship, and will provide direct and specific feedback tc students.
Unit/Final: These assessments cover key concepts and information introduced in each unit and help teachers to as student comprehension through creating.

Teacher/Student Conferences
The teacher will facilitate learning and meet with groups consistently. The students and the teacher will keep anecdotal records of group engagement and collaboration, teamwork, and work ethic. Strategies teacher will use are as follows:
● Use of Open-Ended & Metacognitive Questioning
● Pushing for Explanation/Elaboration
● Revoicing/Reframing (restating what the student says)</td></tr>
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continuum, or those with unique learning requirements—opportunities to learn in a way that they learn best.

Engagement
Research reveals the importance of engagement as it links to interest, motivation, and achievement. In the Engineering is Elementary units, students manipulate materials in hands-on activities, read informational text, participate in discussion, and write, draw, or create in every lesson. Students develop models to represent phenomenon, and use their models to explain how and why things happen. In some lessons, students watch videos, explore websites, or play games. The teacher might choose to add others, as appropriate for the students' learning, and as different modes of technology provide access to new material every day. A variety of ways to engage with the concepts and ideas, beginning with images and discussion that activates prior knowledge, provide all students with entry points into the content and ways to explore and investigate it. Students engage in their learning as a whole class and in collaborative teams or pairs, and have independent time to read, write, draw, or create.

Student Interaction
Students bring to the classroom a range of experiences, as well as varied degrees of interest in learning the skills and concepts covered in this unit.. As they test ideas, collect data, and articulate what they have discovered, learning becomes personal. Groups and pairs may be configured to address reading needs, individual interests, or learning strengths. Consider Think-Pair-Share and Heads-Together techniques to allow time for student reflection prior to answering questions, starting a discussion, writing, or creating so that all students have an opportunity to process information before being called upon to use it.

Representation
- Visual – Lessons incorporate numerous photographs and illustrations. The student readers contain photographs, charts and graphs, diagrams, and other images so that

- Summarizing/Clarifying Ideas *(ask a student to summarize)*
- Soliciting Ideas/Generating & Evaluating Hypotheses

Peer work
Working in teams is an essential component of learning. Lessons and activities are often carried out with students in "teams" or "partners" and materials are shared. The teachers should use their knowledge of the class to select productive student groups and spend time modeling and discussing constructive group behavior. The term "partners" refers to two students, while "team" refers to two sets of partners or any grouping of three or more.

students can encounter science content in a variety of ways. ● Auditory – Teachers may read aloud or have students do paired reading of the informational texts in the lesson. Discussion— speaking and listening—are core elements Engineering is Elementary. Teamwork provides opportunities for student-to-student talk as they share ideas and challenge one another's evidence for claims and conclusions. ● Kinesthetic – Every lesson has students interacting with and manipulating materials. ● Use of Technology – Various modes of technology will be incorporated into each part of the learning process. **Expression** Students write, draw, and/or create in every lesson as ways in which they express, demonstrate, and record their developing understandings. This work, done through journaling and projects, provides the teacher with ongoing opportunities to assess learning formatively and adjust classroom experiences, as needed. Rich discussion also enables teachers to assess understanding as students express their ideas and communicate orally.	

LEARNING PLAN: STAGE THREE	
Lesson Topics & Sequence of Learning Activities	**Materials and Resources**
Pre-assessment: ● **Students will learn to...** ○ Identify everyday objects made by people as technology. ○ Identify the problem that a particular object solves. ○ Identify the materials used to make an object. ○ Identify that objects are designed as a solution to a problem. ○ Identify engineers as the people who design objects. ● **Lesson Breakdown (up to 4 collaborations):** ○ Introduce the following questions: ■ What do you think an engineer is and does?	**MATERIALS:** ● Samples of "engineered objects" (examples: toothbrush, flashlight, plastic container, sponge, paper clip, stapler, scissors, pen, CD, slippers, pencil sharpener, glue stick, eraser, plastic bag, nail clippers, hair brush, ec.) ● Opaque bag or container (one for each group) **VOCABULARY:** ● Engineering ● Material ● Problem ● Solution ● Technology

■ What do you think technology is and what is it used for? ○ Discuss both topics as a class, infusing video clips and Google slides as enhancements to the discussion. ○ Follow the "Introduction" and "Activity" directions on TG pgs. 34-36. ○ Follow the "Reflection" directions on TG pg. 37. ○ Facilitate the "Breakdown of Technology" Lab to engage students in applying what they know about technology. ● **Assessment** ○ Administer appropriate the Pre-Assessment (found in Appendix A) ● **Extension** ○ Invite students to explore the different technologies in the classroom and use them to create their Ceiling Tile Projects. During this project, introduce and use the steps of the Engineering Design Process so that the students become familiar with them. Provide a visual of the steps of this process, as seen in TG 4-1 and 4-2.	
Lesson 1-Lerato Cooks Up a Plan ● **Students will learn to...** ○ Explain the work of green engineers in designing technologies that have minimal impact on the environment ○ Identify several resources needed to make a technology ○ Identify and explain some of the environmental impacts of a technology ○ Define the terms *thermal insulator* and *thermal conductor* and explain how they are different ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Read/present an abridged version of *Lerato Cooks Up a Plan*	**MATERIALS FOR LESSON 1:** ● *Lerato Cooks Up a Plan* text ● Chart paper ● Botswana marked on a classroom map **VOCABULARY FOR LESSON 1:** ● Conductor ● Energy ● Engineer ● Engineering Design Process ● Green engineering ● Insulator ● Life cycle assessment ● Maize porridge ● Nata ● Rondavel ● Technology ● Thermal

	○ Follow the steps listed in TG pgs. 41-54 (Students will explore the environmental impacts of technologies and explore how a variety of materials can be thermal conductors or thermal insulators.) ● ***Assessments*** ○ Teachers will complete the Lesson 1 Rubric (1-7) about each student. ● ***Extensions*** ○ **Activity 1:** Have students use their learning in this lesson to draw/design what they imagine as the ultimate sustainable home for their town that would help the people and the environment. The same activity could be completed for their school. The teacher will facilitate ways that some of their ideas could actually be used/created/instituted in their town/at their school. ○ **Activity 2:** Have students choose a technology that they use in their classroom. Students will think of ways to make that technology more green. Students will explore the potential of using greener materials to create that technology.	● Tikologo ● Transfer
	Lesson 2-The Good Life Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 59.* ● **Students will learn to...** ○ Utilize a life cycle assessment to analyze the environmental impact of paper ○ Identify some of the basic resources required for and the environmental impacts created by the manufacturing and use of paper ○ Quantify the paper consumption for their class	**MATERIALS FOR LESSON 2 PART 1:** ● Chart paper **VOCABULARY FOR LESSON 2 PART 1:** ● Consumer ● Energy ● Environmental impact ● Green engineering ● Life cycle assessment ● Pollution ● Product ● Recycle ● Reduce ● Resource ● Reuse ● Technology ● Waste management

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○ Explore ways to decrease the environmental impact of a product, including reducing, reusing, and recycling

Lesson Breakdown (1 collaboration)
○ Follow the steps listed in TG pgs. 60-64 (Students will create a way to track and monitor how much paper they use in one day.)
Assessments
○ Teachers will complete the Lesson 2 Rubric (2-11) about each student.

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Lesson 2-The Good Life Part 2
PLEASE NOTE: Prior to the start of this lesson, the teacher must complete the “Preparation” steps listed on TG pg. 66.

Students will learn to...

○ Utilize a life cycle assessment to analyze the environmental impact of paper
○ Identify some of the basic resources required for and the environmental impacts created by the manufacturing and use of paper
○ Quantify the paper consumption for their class
○ Explore ways to decrease the environmental impact of a product, including reducing, reusing, and recycling

Lesson Breakdown (up to 3 collaborations)

○ Follow the steps listed in TG pgs. 67-75 (Students will explore ways that they can reduce their paper usage and track the environmental impact of each way they identify.)
○ Students will create recycled paper use a “base” recipe, and then recreate their recipes to optimize their paper to make it stronger.

Assessments
○ Teachers will complete the Lesson 2 Rubric (2-11) about each student.

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MATERIALS FOR LESSON 2 PART 1:

Chalk or dry erase markers (3 different colors)
“Environmental Impacts” chart from Part 1
“Resources” Chart from Part 1

VOCABULARY FOR LESSON 2 PART 1:

Consumer
Energy
Environmental impact
Green engineering
Life cycle assessment
Pollution
Product
Recycle
Reduce
Resource
Reuse
Technology
Waste management

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	• ***Extensions*** ○ Have students research the recycling/reuse programs in other countries and compare and contrast them to their local recycling program (Students may be able to connect with students from other countries for this activity using Google Hangout)	

	Lesson 3-What's Hot & What's Not Part 1
	PLEASE NOTE: *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 84-86.*
	• **Students will learn to...**
	  ○ Conduct a controlled experiment testing how different materials perform as thermal insulators
	  ○ Analyze class data and draw conclusions, ranking each material based on how well it worked as a thermal insulator
	  ○ Explain how changing the configuration of a material (by shredding it) affects its performance as a thermal insulator
	  ○ Evaluate materials based on established criteria to determine their environmental impact
	• ***Lesson Breakdown (up to 3 collaborations)***
	  ○ Follow the steps listed in TG pgs. 87-99 (Students will study and record the properties of materials and test their abilities to be thermal insulators.)
	• ***Assessments***
	  ○ Teachers will complete the Lesson 1 Rubric (3-17) about each student.
		MATERIALS FOR LESSON 3 PART 1:
		• Aluminium Foil (5 sheets, approximately 8.5"x11")
		• 1 plastic resealable bag (1 gallon)
		• 2 plastic grocery bags
		• 1 plastic basin, approximately 15"x12"x4")
		• 1 bowl (paper or deli container), approximately 10 ounces
		• 4 sheets of craft foam
		• 12 clear plastic cups (10 ounces) and an additional cup for every group of students
		• 4 sheets of felt or other fabric
		• Glue/spray adhesive (for teacher use)
		• 48 ice cubes
		• 1 index card
		• 1 knife (for teacher use)
		• 1 clear plastic lid to fit on a 10 oz. cup and an additional lid for every group of students
		• Markers
		• Modeling clay (0.5 lbs)
		• 4 sheets of newspaper
		• 1 pitcher
		• 1 sheet of medium grit sandpaper
		• Scissors
		• 1 shoe box
		• 1 tube of silicone adhesive sealant (waterproof)
		• Stopwatch
		• 1 roll of masking tape
		• 1 roll of packing tape
		• Glass thermometer
		• 4 liters of cold water
		
		VOCABULARY FOR LESSON 3 PART 1:
		• Conductor
		• Criteria
		• Green
		• Heat energy
		• Insulator

		• Material • Natural • Processed • Property • Recycle • Reduce • Reuse • Test • Thermal • Trade-off • Transfer • Waste management
	Lesson 3-What's Hot & What's Not Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 101.* • **Students will learn to...** ◦ Conduct a controlled experiment testing how different materials perform as thermal insulators ◦ Analyze class data and draw conclusions, ranking each material based on how well it worked as a thermal insulator ◦ Explain how changing the configuration of a material (by shredding it) affects its performance as a thermal insulator ◦ Evaluate materials based on established criteria to determine their environmental impact • ***Lesson Breakdown (up to 3 collaborations)*** ◦ Follow the steps listed in TG pgs. 102-109 (Students will explore how poor thermal insulators can be good thermal conductors by testing a variety of materials.) • ***Assessments*** ◦ Teachers will complete the Lesson 1 Rubric (3-17) about each student.	**MATERIALS FOR LESSON 3 PART 2:** • Chart paper • 10 index cards • Markers • Masking tape **VOCABULARY FOR LESSON 3 PART 2:** • Conductor • Criteria • Green • Heat energy • Insulator • Material • Natural • Processed • Property • Recycle • Reduce • Reuse • Test • Thermal • Trade-off • Transfer • Waste management

	Lesson 3-What's Hot & What's Not Part 3 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 111.* ● **Students will learn to...** ○ Conduct a controlled experiment testing how different materials perform as thermal insulators ○ Analyze class data and draw conclusions, ranking each material based on how well it worked as a thermal insulator ○ Explain how changing the configuration of a material (by shredding it) affects its performance as a thermal insulator ○ Evaluate materials based on established criteria to determine their environmental impact ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 112-122 (Students will begin planning which materials they want to use to design their solar ovens and why they want to use them.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-17) about each student.	**MATERIALS FOR LESSON 3 PART 3:** ● Chart paper ● 5 index cards ● Red and green markers ● Masking tape ● A small sample of each of the following materials: ○ Aluminum foil ○ Felt or other fabric (matching what was tested in Part 1) ○ Foam sheet ○ Plastic grocery bag ○ Newspaper ○ Other materials brainstormed during Parts 1-2 **VOCABULARY FOR LESSON 3 PART 3:** ● Conductor ● Criteria ● Green ● Heat energy ● Insulator ● Material ● Natural ● Processed ● Property ● Recycle ● Reduce ● Reuse ● Test ● Thermal ● Trade-off ● Transfer ● Waste management
	Lesson 4-Designing a Solar Oven Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 131-133.* ● **Students will learn to...** ○ Implement the steps of the Engineering Design Process ○ Use prior analyses of the thermal properties and environmental impact of materials to inform solar oven designs ○ Test their designs by placing them in direct sunlight and recording how much warmer they get	**MATERIALS FOR LESSON 4 PART 1:** ● 1 bowl (paper or shallow deli container), approximately 10 ounces, and one additional bowl for each group of students ● Glue/spray adhesive (for teacher use) ● Rulers ● Scissors ● 1 roll of packing tape ● 1 utility knife (for teacher use) ● 2-3 dry measuring cups (1 cup each) ● Extra bowls or cups for gathering materials ● Insulation materials as follows: ○ Aluminum foil ○ Newspaper

	compared to a solar oven with no insulation ○ Evaluate their solar oven designs using established criteria ○ Improve their solar oven designs, taking into account the evaluation of a prior design ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 134-140 (Students will review what they have already learned about the thermal properties and environmental impact of different materials. First individually, and then in small groups, students "imagine" several different ways to insulate their solar oven designs and think about the advantages and disadvantages of each idea. Groups select one solar oven design and make a "plan", including a detailed materials list. Students will "Create their insulated solar ovens and calculate their impact score based on established criteria.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-12) about each student.	○ Felt ○ Foam sheets ○ Plastic grocery bags ○ Gravel ○ Rocks ○ Leaves, fresh or dried ○ Hay/straw ○ Soil ○ Sand ○ T-shirts or other fabric scraps ○ Cotton balls ○ Magazines ○ Foam packing peanuts ○ Construction paper ○ Paper scraps ● 1 index card for each group of students ● 1 clear, plastic, resealable bag for each group of students (1 gallon) ● 1 shoe box (for each group of students) **VOCABULARY FOR LESSON 4 PART 1:** ● Advantage ● Criteria ● Constraint ● Design ● Disadvantage ● Engineering Design Process ● Goal ● Green ● Insulate ● Material ● Problem ● Redesign ● Solution ● Teamwork ● Test ● Thermal ● Trade-off
	Lesson 4-Designing a Solar Oven Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 142.* ● **Students will learn to...** ○ Implement the steps of the Engineering Design Process ○ Use prior analyses of the thermal properties and environmental	**MATERIALS FOR LESSON 4 PART 2:** ● 1 bowl (paper or shallow deli container), approximately 10 ounces, and one additional bowl for each group of students ● Control solar oven (from Part 1) ● Pens and pencils ● Rulers ● 2 glass thermometers ● Stopwatch

	impact of materials to inform solar oven designs ○ Test their designs by placing them in direct sunlight and recording how much warmer they get compared to a solar oven with no insulation ○ Evaluate their solar oven designs using established criteria ○ Improve their solar oven designs, taking into account the evaluation of a prior design ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 143-149 (Groups will test their solar ovens by placing them in direct sunlight and measuring their internal temperature over time. Groups will then close the reflectors of their solar ovens, move them out of direct sunlight, and measure the internal temperature to see how long their solar ovens stay warm. Then, groups will assess the environmental impact of the materials used in their design, and they will score their designs and analyze them for strengths and weaknesses.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-12) about each student.	**VOCABULARY FOR LESSON 4 PART 2:** ● Advantage ● Criteria ● Constraint ● Design ● Disadvantage ● Engineering Design Process ● Goal ● Green ● Insulate ● Material ● Problem ● Redesign ● Solution ● Teamwork ● Test ● Thermal ● Trade-off
	Lesson 4-Designing a Solar Oven Part 3 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 151.* ● **Students will learn to...** ○ Implement the steps of the Engineering Design Process ○ Use prior analyses of the thermal properties and environmental impact of materials to inform solar oven designs	**MATERIALS FOR LESSON 4 PART 3:** ● 1 bowl (paper or shallow deli container), approximately 10 ounces, and one additional bowl for each group of students for use as a cooking pot ● Control solar oven (from Parts 1-2) ● Pens and pencils ● Rulers ● 2 glass thermometers ● Stopwatch ● Additional materials for students to use to insulate their solar oven designs (the same

	○ Test their designs by placing them in direct sunlight and recording how much warmer they get compared to a solar oven with no insulation ○ Evaluate their solar oven designs using established criteria ○ Improve their solar oven designs, taking into account the evaluation of a prior design ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 152-157 (Students will brainstorm ways to "improve" one or more of their scores. Groups will implement some of their improvement ideas and test their solar ovens again.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-12) about each student. ● ***Extensions*** ○ Not all solar ovens are box-shaped. Have the students try designing a different kind of solar oven, such as a funnel-shaped solar oven.	materials from Parts 1-2 or students can bring in additional materials) **VOCABULARY FOR LESSON 4 PART 3:** ● Advantage ● Criteria ● Constraint ● Design ● Disadvantage ● Engineering Design Process ● Goal ● Green ● Insulate ● Material ● Problem ● Redesign ● Solution ● Teamwork ● Test ● Thermal ● Trade-off
	Post-Assessment: Administer appropriate the Post-Assessment (found in Appendix A).	
Notes/Reflections		

Tabernacle School District

UNIT PLAN

Adopted from *Understanding by Design* (Wiggins and McTighe, 2005)

Unit Title	Taking the Plunge: Designing Submersibles	Unit Length	Up to 25 Collaborations
DESIRED RESULTS: STAGE ONE			
Standards Addressed			

- ITEEA National Standards and Benchmarks
  - 1B: All people use tools and techniques (technology) to help them do things.
  - 1D: Tools materials, and skills are used to make things and carry out tasks.
  - 2E: People plan in order to get things done.
  - 2J: Materials have many different properties.
  - 2K: Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing.
  - 2S: Trade-off is a decision process recognizing the need for careful compromises among competing factors.
  - 3C: Various relationships exist between technology and other fields of study.
  - 6A: Products are made to meet individual (people's) needs and wants.
  - 7A: The way people live and work has changed throughout history because of technology.
  - 7B: People have made tools (developed, abandoned, and improved technologies over time) to provide food, to make clothing, and to protect themselves (for many purposes).
  - 8A: Everyone can design solutions to a problem (brainstorming is important; everyone's ideas should be considered).
  - 8C: The design process is a purposeful method of planning practical solutions to problems.
  - 9A: The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.
  - 9B: Expressing ideas to others verbally and through sketches and models is an important part of the design process.
  - 9C: The engineering design process involves designing a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
  - 9D: When designing an object, it is important to be creative and consider all ideas.
  - 10E: The process of experimentation, which is common in science, can also be used to solve technological problems.
  - 11B: Build or construct an object using the design process.
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  - 9.3.12.ED.2 Demonstrate effective oral, written and multimedia communication in multiple formats and contexts.

Overall Understanding(s) *(Students will understand that...)*	**Essential Question(s)** *(The open-ended question(s) that help frame inquiry)*

• There are various fields of engineering. • Nearly everything in the human world has been touched by engineering. • Troubleshooting and learning from failure are integral to the learning process. • Materials and their properties are important in engineering solutions. • Engineering problems have multiple solutions. • Society influences and is influenced by engineering. • Technology affects the world. • Engineers are from all races, ethnicities, and genders.	• What are technologies and who designs them? • What are some technologies ocean engineers have designed to help scientists study the ocean floor and how are these technologies useful? • How does the mass and volume of an object affect whether it sinks or floats in water? • How can we use our knowledge of floating and sinking and the Engineering Design Process to design a submersible that meets specific criteria?

Knowledge & Skills: Part 1
(Students will be able to...)

- Examine everyday examples of technology
- Explore how pieces of technology were designed to solve problems
- Explore the work of ocean engineers
- Explore the concept of density
- Begin to understand submersibles and some of the instruments that might be used in an underwater mission
- Use sound pole technology to generate data about about a model ocean floor
- Utilize information gathered through sounding pole technology and identify missing information
- Begin to understand sonar technology and explore additional information gained by using sonar (as compared to information gained with a sounding pole)
- Explain some of the advantages of using various technologies to explore the ocean floor
- Predict and test whether vials filled with various materials sink or float in water
- Conduct a controlled experiment to observe how changes in mass and volume affect whether an object floats or sinks water
- Formulate hypotheses as to why some vials sink and some float
- Analyze and discuss their hypotheses with the class
- Use the Engineering Design Process to design a submersible
- Use the data they collected and their knowledge of floating and sinking to help inform their submersible designs

Knowledge & Skills: Part 2
(Students learn that...)

- Almost all of the objects we use every single day are examples of technology
- Technology can be made of many different kinds of materials
- Engineers design technology to solve problems
- Ocean engineers solve problems related to the ocean environment
- Submersibles and the instruments they carry are technologies designed by engineers

- Density in the word used to describe how packed something is--if there is a lot of matter packed into a space, it is considered “dense”
- The Engineering Design Process is a tool that can be used to help solve problems
- Different technologies have advantages and limitations for exploring the ocean floor
- Sounding poles help collect information about the ocean floor, primarily related to depth
- Sonar technology also collects information about the ocean floor, including depth, substrate, and shape of objects
- Engineers and scientists decide what technologies to design and use based on what problem they are trying to solve
- Mass and volume are important factors that affect an object’s ability to sink or float in a fluid
- Density is a term that describes how much mass there is in a given volume
- The larger an object’s volume, the more mass it can support before sinking
- Engineers use a series of steps, called the Engineering Design Process, to design solutions to problems
- Sometimes increasing the performance of a design for some variables decreases its performance for other variables
- There can be multiple solutions to a problem
- The density of an object affects its sinking and floating behavior

<table>
<tr><th>Differentiation</th><th>Performance Task(s)</th></tr>
<tr>
<td>
Overview:
Universal Design for Learning Differentiation is inherent in Universal Design for Learning (UDL), a design philosophy with the underlying premise that meeting students’ individual needs is best accomplished when lesson design is flexible, and instruction moves each student’s thinking, learning, and skills forward from wherever he or she begins, in a manner that does not assume one size fits all. Engineering is Elementary lessons often provide activities for reinforcement and practice, for extension that goes beyond the classroom activity, or for adding artistic expression to lessons. Elements may be used or not, or adapted according to the teacher’s assessment of his or her students’ prior knowledge and their needs as a class and as individuals. The three primary components of UDL, multiple means of engagement, multiple means of representation, and multiple means of expression, are addressed in each lesson, providing all students—even those at the ends of the learning continuum, or those with unique learning requirements—opportunities to learn in a way that they learn best.

Engagement
Research reveals the importance of engagement as it links to interest, motivation, and achievement. In the Engineering is Elementary units, students
</td>
<td>
Assessments/Observations
Daily: The students will record daily progress through journaling. The teacher will make observations and keep anecdotal records regarding student use of materials, demonstration of conceptual understanding, and classroon citizenship, and will provide direct and specific feedback tc students.
Unit/Final: These assessments cover key concepts and information introduced in each unit and help teachers to as student comprehension through creating.

Teacher/Student Conferences
The teacher will facilitate learning and meet with groups consistently. The students and the teacher will keep anecdotal records of group engagement and collaboration, teamwork, and work ethic. Strategies teacher will use are as follows:

Use of Open-Ended & Metacognitive Questioning
Pushing for Explanation/Elaboration
Revoicing/Reframing (restating what the student says)
Summarizing/Clarifying Ideas (ask a student to summarize)
Soliciting Ideas/Generating & Evaluating Hypotheses

Peer work
Working in teams is an essential component of learning. Lessons and activities are often carried out with students i
</td>
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</table>

manipulate materials in hands-on activities, read informational text, participate in discussion, and write, draw, or create in every lesson. Students develop models to represent phenomenon, and use their models to explain how and why things happen. In some lessons, students watch videos, explore websites, or play games. The teacher might choose to add others, as appropriate for the students' learning, and as different modes of technology provide access to new material every day. A variety of ways to engage with the concepts and ideas, beginning with images and discussion that activates prior knowledge, provide all students with entry points into the content and ways to explore and investigate it. Students engage in their learning as a whole class and in collaborative teams or pairs, and have independent time to read, write, draw, or create.

Student Interaction

Students bring to the classroom a range of experiences, as well as varied degrees of interest in learning the skills and concepts covered in this unit.. As they test ideas, collect data, and articulate what they have discovered, learning becomes personal. Groups and pairs may be configured to address reading needs, individual interests, or learning strengths. Consider Think-Pair-Share and Heads-Together techniques to allow time for student reflection prior to answering questions, starting a discussion, writing, or creating so that all students have an opportunity to process information before being called upon to use it.

Representation

- Visual – Lessons incorporate numerous photographs and illustrations. The student readers contain photographs, charts and graphs, diagrams, and other images so that students can encounter science content in a variety of ways.
- Auditory – Teachers may read aloud or have students do paired reading of the informational texts in the lesson. Discussion— speaking and listening—are core elements Engineering is Elementary. Teamwork provides opportunities for student-to-student talk as they share ideas

"teams" or "partners" and materials are shared. The teache should use
their knowledge of the class to select productive student gr and spend time modeling and discussing constructive grou behavior. The term "partners" refers to two students, whil "team" refers to two sets of partners or any grouping of thr more.

<table>
<tr><td>and challenge one another's evidence for claims and conclusions.
● Kinesthetic – Every lesson has students interacting with and manipulating materials.
● Use of Technology – Various modes of technology will be incorporated into each part of the learning process.

Expression
Students write, draw, and/or create in every lesson as ways in which they express, demonstrate, and record their developing understandings. This work, done through journaling and projects, provides the teacher with ongoing opportunities to assess learning formatively and adjust classroom experiences, as needed. Rich discussion also enables teachers to assess understanding as students express their ideas and communicate orally.</td><td></td></tr>
<tr><th colspan="2">LEARNING PLAN: STAGE THREE</th></tr>
<tr><th>Lesson Topics & Sequence of Learning Activities</th><th>Materials and Resources</th></tr>
<tr><td>Pre-assessment:
● Students will learn to...
○ Discover how and why everyday objects made by people are technology
○ Identify the problem that a particular object solves
○ Identify the materials used to make an object
○ Identify that objects are designed as a solution to a problem
○ Identify engineers as the people who design objects
● Lesson Breakdown (up to 4 collaborations):
○ Introduce the following questions:
■ What do you think an engineer is and does?
■ What do you think technology is and what is it used for?
○ Discuss both topics as a class, infusing video clips and Google slides as enhancements to the discussion.
○ Follow the "Introduction" and "Activity" directions on TG pgs. 34-36.</td><td>MATERIALS:
● Samples of "engineered objects" (examples: toothbrush, flashlight, plastic container, sponge, paper clip, stapler, scissors, pen, CD, slippers, pencil sharpener, glue stick, eraser, plastic bag, nail clippers, hair brush, ec.)
● Opaque bag or container (one for each group)

VOCABULARY:
● Engineering
● Material
● Problem
● Solution
● Technology</td></tr>
</table>

○ Follow the "Reflection" directions on TG pg. 37. ○ Facilitate the "Breakdown of Technology" Lab to engage students in applying what they know about technology. ● **Assessment** ○ Administer appropriate the Pre-Assessment (found in Appendix A) ● **Extension** ○ Invite students to explore the different technologies in the classroom and use them to create their Ceiling Tile Projects. During this project, introduce and use the steps of the Engineering Design Process so that the students become familiar with them. Provide a visual of the steps of this process, as seen in TG 4-1 and 4-2.	
Lesson 1-Despina Makes a Splash ● **Students will learn to...** ○ Discuss the work of ocean engineers and their role in designing technologies for the ocean environment ○ Discuss the concept of density and why it is important for ocean engineers to consider ○ Identify the characteristics of the ocean, including: size, salt, temperature, and presence of animal life ○ Trace the use of the Engineering Design Process ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the "Introduction" directions on TG pg. 43. ○ Ask the "Pre-Reading Questions" found on TG pg. 45, and begin to read/present an abridged version of *Despina Makes a Splash* ○ When the term "density" appears in the story, students will participate in a live-action version	**MATERIALS FOR LESSON 1:** ● *Despina Makes a Splash* text ● Chart paper ● Greece marked on a classroom map ● *Despina and the Engineering Design Process* as an activity **VOCABULARY FOR LESSON 1:** ● Baba ● Density ● Engineer/Engineering ● Engineering Design Process ● GPS ● Mass ● Name Day ● Ocean Current ● Ocean Engineer ● Remotely Operated Vehicle (ROV) ● Soulakia ● Submersible ● Technology ● Thia ● Volume

	of the "Pack Your Cooler" activity. ○ Complete the reading/presentation of the abridged version of *Despina Makes a Splash*, stopping to ask additional questions as necessary (refer to the questions on TG pg. 48) ○ Together as a class, complete the steps listed in the "Reflection" on TG pg. 49 (NOTE: The "Despina and the Engineering Design Process" activity will be completed as a class through a SmartBoard activity). ○ Ask/discuss the "Post-Reading Questions" (on TG pg. 51) ○ Students will complete Activity 1-7. ● ***Assessments*** ○ Teachers will complete the Lesson 1 Rubric (1-9) about each student. ● ***Extensions*** ○ Students will research different types of submersibles and draw pictures/make diagrams of what they find. Students will discuss the similarities and differences between each type of submersible.	
	Lesson 2-Into the Deep ***PLEASE NOTE:*** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 58-60. It may be helpful to create multiple copies of the "Ocean Floor" so that students can work in smaller groups instead of as a class.* ● **Students will learn to...** ○ Explain how ocean exploration involves close collaboration between scientists and engineers ○ Use a sounding pole to map a model of the ocean floor ○ Identify findings and remaining unknowns after collecting data using a sounding pole ○ Compare the advantages and disadvantages of using sounding	**MATERIALS FOR LESSON 2:** ● Copy paper box with lid, minimum dimensions 16"x12"x6" ● Chart Paper ● Ruler ● Tape ● Glue ● 8-10 river rocks ● Screwdriver (for teacher use) ● 2 boxes, each approximately 3.5"x2"x3" ● 2 tennis balls ● 1 table tennis ball ● Utility Knife (for teacher use) ● Bottle Cap, from 2 liter bottle ● 2 paper cups (8 oz.) ● Wooden dowel (12"x1/4") ● Flashlight with batteries ● Markers ● Crayons

	pole technology to gather data about the ocean floor ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the "Introduction" directions on TG pg. 61-65 (consolidated into a SmartBoard presentation) ○ Follow the "Activity" directions listed on TG pgs. 66-72, infusing real-life video clips from sonar imaging. ○ Follow the "Reflection" steps listed on TG pgs. 73-74 ● ***Assessments*** ○ Teachers will complete the Lesson 2 Rubric (2-13) about each student.	**VOCABULARY FOR LESSON 1:** ● Advantage ● Depth ● Model ● Ocean ● Ocean Engineer ● Shallow ● Sonar ● Sounding ● Technology ● Topography
	Lesson 3-A Sinking Feeling Part 1 ***PLEASE NOTE:*** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 81-82.* ● **Students will learn to...** ○ Conduct controlled tests to collect data about the properties (mass, volume, density) and behavior (floating and sinking) of vials filled with different materials ○ Make predictions about the properties of floating/sinking behavior of a variety of vials ○ Compare the properties (mass, volume, density) and floating/sinking behavior of a variety of vials ○ Analyze data from controlled tests and use it to explain why objects sink or float in water ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the "Introduction" directions on TG pgs. 83-85 (consolidated into a SmartBoard presentation) ○ Follow the "Activity" directions listed on TG pgs. 86-93, where students will investigate which	**MATERIALS FOR LESSON 3 PART 1:** ● Chart paper ● 3 markers (each a different color) ● 1 clear, plastic deli container (32 ounces and about 6" high) for each group ● 1 clear, plastic tank (14.5 gallons and approximate dimensions of 12"x12"x20") ● 18 mini glass marbles, approximately 0.4", for each group ● Pitcher ● 45 plastic pony beads, approximately 0.4", for each group ● 4.5 teaspoons of sand for each group ● Teaspoon measure ● Paper or cloth towels ● Two-pan balance ● 6 clear plastic vials, approximately 18.5mL, for each group ● Permanent markers ● Rubber bands ● Water **VOCABULARY FOR LESSON 3 PART 1:** ● Density ● Engineering Design Process ● Float ● Hypothesis ● Instrument ● Mass

	vials of materials will sink or float and why ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-8) about each student.	● Ocean engineer ● Sink ● Submersible ● Volume
	Lesson 3-A Sinking Feeling Part 2 ***PLEASE NOTE:*** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 95-96* ● **Students will learn to...** ○ Conduct controlled tests to collect data about the properties (mass, volume, density) and behavior (floating and sinking) of vials filled with different materials ○ Make predictions about the properties of floating/sinking behavior of a variety of vials ○ Compare the properties (mass, volume, density) and floating/sinking behavior of a variety of vials ○ Analyze data from controlled tests and use it to explain why objects sink or float in water ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the "Introduction" directions on TG pgs. 97-98 (consolidated into a SmartBoard presentation) ○ Follow the "Activity" directions listed on TG pgs. 99-102, where students will investigate which vials of materials with greater mass will sink or float and why ○ Follow the "Reflection" steps listed on TG pgs. 103-105 ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-8) about each student. ● ***Extensions*** ○ Students will test the same vials used in this lesson in other media so they can observe how the	**MATERIALS FOR LESSON 3 PART 2:** ● 1 clear, plastic tank (14.5 gallons and approximate dimensions of 12"x12"x20") ● 1 clear, plastic deli container (32 ounces and about 6" high) for each group ● 42 mini glass marbles, approximately 0.4", for each group ● Paper or cloth towels ● Pitcher ● 115 plastic pony beads, approximately 0.4", for each group ● 9 teaspoons of sand for each group ● Teaspoon measure ● Two-pan balance ● 9 clear plastic vials, approximately 44.4mL, for each group ● 2 "Video Camera" vials from Part 1 ● 2 "Lights" vials from Part 1 ● 2 "Battery" vials from Part 1 **VOCABULARY FOR LESSON 3 PART 2:** ● Density ● Engineering Design Process ● Float ● Hypothesis ● Instrument ● Mass ● Ocean engineer ● Sink ● Submersible ● Volume

	density of the medium affects an object's ability to sink or float in that medium.	
	Lesson 4-Designing a Submersible Part 1 ***PLEASE NOTE:*** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 116-117.* ● **Students will learn to...** ○ Identify and implement each step of the Engineering Design Process ○ Use their knowledge of density, sinking, and floating gained earlier in the unit to inform their submersible designs ○ Evaluate their designs using established criteria and use their evaluation to inform improvements ○ Identify and discuss trade-offs associated with their submersible designs ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the "Introduction" directions on TG pgs. 118-123 (consolidated into a SmartBoard presentation) and follow the "Activity" directions listed on TG pgs. 124-125. For this part of the lesson, students will review the goals of the design challenge as well as how their submersible designs will be evaluated. The class will review the questions they asked during Lesson 3 and the information they gathered on how the density of an object affects its floating and sinking behavior. Students will "imagine" several different ideas for their submersible designs, and groups will select one submersible design to "plan" and make a labeled diagram and list the instruments they will include in their submersible. ○ Follow the "Reflection" steps listed	**MATERIALS FOR LESSON 4 PART 1:** ● Chart Paper ● 1 clear, plastic tank (14.5 gallons and approximate dimensions of 12"x12"x20") ● Scissors or utility knife (for teacher use) ● Rubber band ● 1 roll of masking tape ● Subset of vials from Lesson 3 Demonstration Set ○ "Suction Sampler": large vial filled with marbles ○ "Sound Recorder": small vial half-filled with marbles ○ "Manipulator Arm": small vial half-filled with sand ○ "Video Camera": small vial filled with beads ○ "Lights": small vial filled with marbles ○ "Battery": small vial filled with sand ○ "Sonar": large vial half-filled with marbles ○ "Camera": large vial half-filled with sand ○ "Sample Box": large vial filled with beads ○ "Salt Sensor": large vial filled with sand ● 17 ring/disc magnets, approximately 1" diameter ● Water, approximately 7.5 gallons ● 10-12 river rocks ● 1 clear, plastic cup (8 oz.) ● 2 clear, plastic deli containers (32 ounces and about 6" high) for each group ● 1 plastic container with lid, approximately 2"x2"x2" ● 1 plastic container with lid, approximately 3"x3"x3" ● 1 plastic container with lid, approximately 4"x4"x4" ● 3 clear plastic vials, approximately 18.5mL, for each group ● 6 teaspoons of aquarium gravel ● Permanent markers **VOCABULARY FOR LESSON 4 PART 1:** ● Criteria ● Density ● Design ● Engineering Design Process

	on TG pgs. 133-134 ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-10) about each student.	● Goal ● Instrument ● Mass ● Ocean Engineer ● Problem ● Redesign ● Solution ● Submersible ● Teamwork ● Technology ● Test ● Trade-off ● Volume
	Lesson 4-Designing a Submersible Part 2 ***PLEASE NOTE:*** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 127.* ● **Students will learn to...** ○ Identify and implement each step of the Engineering Design Process ○ Use their knowledge of density, sinking, and floating gained earlier in the unit to inform their submersible designs ○ Evaluate their designs using established criteria and use their evaluation to inform improvements ○ Identify and discuss trade-offs associated with their submersible designs ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the "Introduction" directions on TG pg. 128 (consolidated into a SmartBoard presentation) and follow the "Activity" directions listed on TG pgs. 129-132. For this part of the lesson, student groups will "create" their submersibles and test and score their designs. Groups will analyze their designs, the trade-offs involved, and how they might "improve" their designs. Groups will implement some of their improvement ideas	**MATERIALS FOR LESSON 4 PART 2:** ● "Small" Volume Score Box (prepared in Part 1) ● "Medium" Volume Score Box (prepared in Part 1) ● "Large" Volume Score Box (prepared in Part 1) ● Tank (set up in Part 1) ● Permanent markers ● 1 roll of masking tape ● "Lights": small vial filled with marbles ● "Battery": small vial filled with sand ● "Pressure Sensor": large vial half-filled with beads ● 1 magnet with tape marking (1 for the teacher and 1 for each group) ● Rubber bands ● Subset of vials from Lesson 3 Demonstration Set (for each group) ○ "Suction Sampler": large vial filled with marbles ○ "Sound Recorder": small vial half-filled with marbles ○ "Manipulator Arm": small vial half-filled with sand ○ "Video Camera": small vial filled with beads ○ "Lights": small vial filled with marbles ○ "Battery": small vial filled with sand ○ "Sonar": large vial half-filled with marbles ○ "Camera": large vial half-filled with sand ○ "Sample Box": large vial filled with beads ○ "Salt Sensor": large vial filled with sand **VOCABULARY FOR LESSON 4 PART 2:** ● Criteria ● Density

	and retest and score their designs. ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-10) about each student. Teachers may also use the Student Group Design Chart (4-9) to help track and monitor group progress. ● ***Extensions*** ○ Students will reflect on their use of the Engineering Design Process throughout this unit by discussing the following questions: ■ How might we use the Engineering Design Process to solve other problems?	● Design ● Engineering Design Process ● Goal ● Instrument ● Mass ● Ocean Engineer ● Problem ● Redesign ● Solution ● Submersible ● Teamwork ● Technology ● Test ● Trade-off ● Volume
	Post-Assessment: Administer appropriate the Post-Assessment (found in Appendix A).	
Notes/Reflections		

Tabernacle School District

UNIT PLAN

Adopted from *Understanding by Design* (Wiggins and McTighe, 2005)

Unit Title	The Attraction is Obvious: Designing Maglev Systems	**Unit Length**	Up to 25 Collaborations
DESIRED RESULTS: STAGE ONE			
Standards Addressed			

- ITEEA National Standards and Benchmarks
  - 2B: Systems have parts or components that work together to accomplish a goal.
  - 2E: People plan in order to get things done.
  - 2J: Materials have many different properties.
  - 3C: Various relationships exist between technology and other fields of study.
  - 6A: Products are made to meet individual needs and wants.
  - 8A: Everyone can design solutions to a problem (brainstorming is important; everyone's ideas should be considered).
  - 8B: Design is a creative process.
  - 9A: The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.

- 9B: Expressing ideas to others verbally and through sketches and models is an important part of the design process.
- 9C: The engineering design process involves designing a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
- 9D: When designing an object, it is important to be creative and consider all ideas.
- 9E: Models are used to communicate and test design ideas and processes.
- 10A: Asking questions and making observations helps a person to figure out how things (technologies) work.
- 11B: Build or construct an object using the design process.
- 11C: Investigate how things are made and how they can be improved.
- 11F: Test and evaluate the solutions for the design problem.
- 11G: Improve the design solutions.
- 13A: Collect information about everyday products and systems by asking questions.
- 13C: Compare, contrast, and classify collected information in order to identify patterns.
- 18A: A transportation system has many parts that work together to help people travel.
- 18B: Vehicles move people or goods from one place to another in water, air or space, and on land.
- 18D: The use of transportation allows people and goods to be moved from place to place.

- 21st Century Skills
  - 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.
  - 9.3.12.ED.1 Apply communication skills with students, parents and other groups to enhance learning and a commitment to learning.
  - 9.3.12.ED.2 Demonstrate effective oral, written and multimedia communication in multiple formats and contexts.

Overall Understanding(s) *(Students will understand that...)*	**Essential Question(s)** *(The open-ended question(s) that help frame inquiry)*
• There are various fields of engineering. • Nearly everything in the human world has been touched by engineering. • Troubleshooting and learning from failure are integral to the learning process. • Materials and their properties are important in engineering solutions. • Engineering problems have multiple solutions. • Society influences and is influenced by engineering. • Technology affects the world. • Engineers are from all races, ethnicities, and genders.	• What types of problems do transportation engineers solve and what are some factors they work to balance? • How can we use the properties of magnets to help us design a maglev transportation system? • How can we use our knowledge of the properties of magnets, the Engineering Design Process, and our creativity to design a maglev transportation system?

Knowledge & Skills: Part 1
(Students will be able to...)

- Explore the field of transportation engineering
- Investigate magnets and the role that magnets play in maglev transportation systems
- Model a four-way intersection

- Modify the four-way intersection in a way that balances the safety and efficiency needs of both the motorists and pedestrians who use the intersection
- Use observations to help inform safety decisions when modifying the intersection
- Explore the properties of magnets
- Participate in activities involving magnets
- Investigate how some of the properties of magnets could help them design a maglev transportation system
- Use the steps of the Engineering Design Process to design a maglev transportation system

Knowledge & Skills: Part 2
(Students learn that...)

- Transportation engineers are concerned with the safety and efficiency of systems that are used to move people or objects from one place to another
- Maglev transportation systems take advantage of the magnetic force of repulsion
- Intersection design requires balancing the needs of multiple parties
- An increase in safety can often lead to a decrease in efficiency
- The effects of transportation engineering are all around us
- Magnets have poles
- The like poles of magnets repel, while opposite poles attract
- Magnets are surrounded by magnetic fields
- The magnetic forces of attraction and repulsion can be intensified by increasing the magnetic field
- Magnetic fields are not affected by non-magnetic materials
- Engineers use a series of steps, called the Engineering Design Process, to design solutions to problems
- Transportation engineers are often concerned with designing systems rather than objects
- A system is a type of technology

Differentiation	Performance Task(s)
Overview: Universal Design for Learning Differentiation is inherent in Universal Design for Learning (UDL), a design philosophy with the underlying premise that meeting students' individual needs is best accomplished when lesson design is flexible, and instruction moves each student's thinking, learning, and skills forward from wherever he or she begins, in a manner that does not assume one size fits all. Engineering is Elementary lessons often provide activities for reinforcement and practice, for extension that goes beyond the classroom activity, or for adding artistic expression to lessons. Elements may be used or not, or adapted according to the teacher's assessment of his or her students' prior knowledge and their needs as a class and as individuals. The three primary components of UDL, multiple means of engagement, multiple means of	**Assessments/Observations** *Daily:* The students will record daily progress through journaling. The teacher will make observations and keep anecdotal records regarding student use of materials, demonstration of conceptual understanding, and classroon citizenship, and will provide direct and specific feedback tc students. *Unit/Final:* These assessments cover key concepts and information introduced in each unit and help teachers to as student comprehension through creating. **Teacher/Student Conferences** The teacher will facilitate learning and meet with groups consistently. The students and the teacher will keep anecdotal records of group engagement and collaboration, teamwork, and work ethic. Strategies teacher will use are as follows: ● Use of Open-Ended & Metacognitive Questioning

representation, and multiple means of expression, are addressed in each lesson, providing all students—even those at the ends of the learning continuum, or those with unique learning requirements—opportunities to learn in a way that they learn best. **Engagement** Research reveals the importance of engagement as it links to interest, motivation, and achievement. In the Engineering is Elementary units, students manipulate materials in hands-on activities, read informational text, participate in discussion, and write, draw, or create in every lesson. Students develop models to represent phenomenon, and use their models to explain how and why things happen. In some lessons, students watch videos, explore websites, or play games. The teacher might choose to add others, as appropriate for the students' learning, and as different modes of technology provide access to new material every day. A variety of ways to engage with the concepts and ideas, beginning with images and discussion that activates prior knowledge, provide all students with entry points into the content and ways to explore and investigate it. Students engage in their learning as a whole class and in collaborative teams or pairs, and have independent time to read, write, draw, or create. **Student Interaction** Students bring to the classroom a range of experiences, as well as varied degrees of interest in learning the skills and concepts covered in this unit.. As they test ideas, collect data, and articulate what they have discovered, learning becomes personal. Groups and pairs may be configured to address reading needs, individual interests, or learning strengths. Consider Think-Pair-Share and Heads-Together techniques to allow time for student reflection prior to answering questions, starting a discussion, writing, or creating so that all students have an opportunity to process information before being called upon to use it. **Representation** ● Visual – Lessons incorporate numerous photographs and illustrations. The student	● Pushing for Explanation/Elaboration ● Revoicing/Reframing *(restating what the student says)* ● Summarizing/Clarifying Ideas *(ask a student to summarize)* ● Soliciting Ideas/Generating & Evaluating Hypotheses **Peer work** Working in teams is an essential component of learning. Lessons and activities are often carried out with students in "teams" or "partners" and materials are shared. The teachers should use their knowledge of the class to select productive student groups and spend time modeling and discussing constructive group behavior. The term "partners" refers to two students, while "team" refers to two sets of partners or any grouping of three or more.

readers contain photographs, charts and graphs, diagrams, and other images so that students can encounter science content in a variety of ways. ● Auditory – Teachers may read aloud or have students do paired reading of the informational texts in the lesson. Discussion— speaking and listening—are core elements Engineering is Elementary. Teamwork provides opportunities for student-to-student talk as they share ideas and challenge one another's evidence for claims and conclusions. ● Kinesthetic – Every lesson has students interacting with and manipulating materials. ● Use of Technology – Various modes of technology will be incorporated into each part of the learning process. **Expression** Students write, draw, and/or create in every lesson as ways in which they express, demonstrate, and record their developing understandings. This work, done through journaling and projects, provides the teacher with ongoing opportunities to assess learning formatively and adjust classroom experiences, as needed. Rich discussion also enables teachers to assess understanding as students express their ideas and communicate orally.	
LEARNING PLAN: STAGE THREE	
Lesson Topics & Sequence of Learning Activities	**Materials and Resources**
Pre-assessment: ● **Students will learn to...** ○ Discover how and why everyday objects made by people are technology ○ Identify the problem that a particular object solves ○ Identify the materials used to make an object ○ Identify that objects are designed as a solution to a problem ○ Identify engineers as the people who design objects ● **Lesson Breakdown (up to 4 collaborations):** ○ Introduce the following questions:	**MATERIALS:** ● Samples of "engineered objects" (examples: toothbrush, flashlight, plastic container, sponge, paper clip, stapler, scissors, pen, CD, slippers, pencil sharpener, glue stick, eraser, plastic bag, nail clippers, hair brush, ec.) ● Opaque bag or container (one for each group) **VOCABULARY:** ● Engineering ● Material ● Problem ● Solution ● Technology

■ What do you think an engineer is and does? ■ What do you think technology is and what is it used for? ○ Discuss both topics as a class, infusing video clips and Google slides as enhancements to the discussion. ○ Follow the "Introduction" and "Activity" directions on TG pgs. 34-36. ○ Follow the "Reflection" directions on TG pg. 37. ○ Facilitate the "Breakdown of Technology" Lab to engage students in applying what they know about technology. ● **Assessment** ○ Administer appropriate the Pre-Assessment (found in Appendix A) ● **Extension** ○ Invite students to explore the different technologies in the classroom and use them to create their Ceiling Tile Projects. During this project, introduce and use the steps of the Engineering Design Process so that the students become familiar with them. Provide a visual of the steps of this process, as seen in TG 4-1 and 4-2.	
Lesson 1-Hikaru's Toy Troubles ● **Students will learn to...** ○ Identify and explain the role of transportation engineers in designing and improving transportation systems ○ Identify and define a system ○ Identify the parts of a maglev system and explain their functions ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Read/present an abridged version of *Hikaru's Toy Troubles* ○ Follow the steps listed in TG pgs. 45-53 (Students will explore the work of transportation engineers	**MATERIALS FOR LESSON 1:** ● *Hikaru's Toy Troubles* text ● Chart paper ● Japan marked on a classroom map **VOCABULARY FOR LESSON 1:** ● Cram school ● Engineer ● Engineering Design Process ● *Genkan* ● *Han* group ● *Kotatsu* ● Levitate ● Maglev train ● Magnet ● *Miso katsu*

	and the importance of magnets to maglev transportation systems.) ● ***Assessments*** ○ Teachers will complete the Lesson 1 Rubric (1-8) about each student. ● ***Extensions*** ○ Have students look at home or around the classroom for toys that include or use magnets and examine them for how the magnets are used	● *Randoseru* ● Repel ● Sashimi ● *Sensei* ● *Tatami* ● Technology ● Transportation engineer ● *Wagashi*
	Lesson 2-Steering Clear of Danger **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 59.* ● **Students will learn to...** ○ Identify intersection hazards and inefficiencies ○ Demonstrate and explain safe intersection behavior ○ Identify and explain intersection changes that will improve safety and/or efficiency ○ Explain the role that transportation engineers play in designing and improving safe and efficient intersections ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 60-72 (Students will transform into transportation engineers and explore an intersection. Students will discuss the positive aspects and negative aspects of this intersection.) ● ***Assessments*** ○ Teachers will complete the Lesson 2 Rubric (2-8) about each student. ● ***Extensions*** ○ Have students conduct their own studies of local intersections (with adult supervision).	**MATERIALS FOR LESSON 2:** ● Painter's tape or sidewalk chalk **VOCABULARY FOR LESSON 2:** ● Efficiency/Efficient ● Engineering ● Intersection ● Model ● Observe ● Pedestrian ● Safety ● Transportation engineer
	Lesson 3-A Magnetic Personality Part 1	**MATERIALS FOR LESSON 3 PART 1:** ● Chart paper ● Scissors

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PLEASE NOTE: *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 79-81.*

- **Students will learn to...**
  - Experiment with magnets, recording observations in words and drawings
  - Identify and explain several properties of magnets
  - Use observations as evidence to explain the properties of magnets
  - Imagine how properties of magnets can help to design a maglev transportation system
- ***Lesson Breakdown (up to 3 collaborations)***
  - Follow the steps listed in TG pgs. 82-86 (Students will investigate the properties of magnets by rotating through various station activities.)
- ***Assessments***
  - Teachers will complete the Lesson 3 Rubric (3-15) about each student.

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- 1 cardboard box (12"x3"x3")
- 1 manila file folder
- 5 "Levitating Magnets" stations (see TG pg. 77)
- 5 "Find the Poles" stations (see TG pg. 77)
- 5 "Magnetic Sailing" stations (see TG pg. 78)

VOCABULARY FOR LESSON 3 PART 1:

- Attract
- Levitate
- Maglev
- Magnet
- Magnetic field
- Pole
- Predict
- Repel

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Lesson 3-A Magnetic Personality Part 2

PLEASE NOTE: *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 87.*

- **Students will learn to...**
  - Experiment with magnets, recording observations in words and drawings
  - Identify and explain several properties of magnets
  - Use observations as evidence to explain the properties of magnets
  - Imagine how properties of magnets can help to design a maglev transportation system
- ***Lesson Breakdown (up to 3 collaborations)***
  - Follow the steps listed in TG pgs. 88-89 (Students will finish rotating through the station activities from Part 1. Then,

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MATERIALS FOR LESSON 3 PART 2:

- Chart paper
- 5 "Levitating Magnets" stations (see TG pg. 77)
- 5 "Find the Poles" stations (see TG pg. 77)
- 5 "Magnetic Sailing" stations (see TG pg. 78)

VOCABULARY FOR LESSON 3 PART 2:

- Attract
- Levitate
- Maglev
- Magnet
- Magnetic field
- Pole
- Predict
- Repel

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	students will report out on their findings from each station.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-15) about each student.	
	Lesson 3-A Magnetic Personality Part 3 ● **Students will learn to...** ○ Experiment with magnets, recording observations in words and drawings ○ Identify and explain several properties of magnets ○ Use observations as evidence to explain the properties of magnets ○ Imagine how properties of magnets can help to design a maglev transportation system ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 91-101 (Students will explore and test the strength of different types of magnets.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-15) about each student. ● ***Extensions*** ○ Have students complete one or all of the following activities: Magnetic Fishing, Magnets Through a Maze, and Magnet Detective (all activities are described on TG pgs. 99-101)	**MATERIALS FOR LESSON 3 PART 3:** ● 1 bar magnet, approximately 1"in length ● 1 ring magnet, approximately 1" in outer diameter with a hole diameter large enough to fit over a pencil ● 1 disc magnet, approximately ¾" in diameter ● 1 piece of magnet, approximately ½" wide and 3" long ● 3 paper clips **VOCABULARY FOR LESSON 3 PART 3:** ● Attract ● Levitate ● Maglev ● Magnet ● Magnetic field ● Pole ● Predict ● Repel
	Lesson 4-Designing a Maglev System Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 109.* ● **Students will learn to...** ○ Implement each step of the Engineering Design Process ○ Use prior analyses of the properties of magnets to inform their design of a maglev transportation system	**MATERIALS FOR LESSON 4 PART 1:** ● Sample track box and insert created in Lesson 3 ● Scissors ● 3-5 weights, non-magnetic and uniform (e.g.: pennies or glass beads) ● 1 clear, plastic, resealable bag for each group of students ● 2 bar magnets with poles labeled, approximately 1"in length, for each group of students

	○ Evaluate a maglev transportation system design using established criteria ○ Improve a maglev transportation system design, taking into account the evaluation of a prior design ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 110-116 (Students will review their design challenge: designing a maglev transportation system, comprised of a vehicle and track, that can safely and efficiently carry weights from one end of a track to the other. Students will review the properties of magnets and discuss how they might be used in designing a maglev transportation system. The students will also be introduced to the materials available to them for use in their designs. Students will imagine several possible designs for their maglev tracks and vehicles. Students will choose one design to fully develop into a plan.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-9) about each student.	● 2 ring magnets, approximately 1" in outer diameter with a hole diameter large enough to fit over a pencil, for each group of students ● 2 disc magnets, approximately ¾" in diameter, for each group of students ● 1 piece of magnet, approximately ½" wide and 12" long or as long as the track box, for each group of students ● 2 squares of manila folder, approximately 2"x2", for each group of students ● 2 foam tray squares, approximately 2"x2", for each group of students ● 2 paper cups (3 or 5 oz.) for each group of students **VOCABULARY FOR LESSON 4 PART 1:** ● Design ● Engineering Design Process ● Goal ● Levitate ● Maglev ● Model ● Problem ● Redesign ● Solution ● System ● Teamwork ● Test
	Lesson 4-Designing a Maglev System Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 118.* ● **Students will learn to...** ○ Implement each step of the Engineering Design Process ○ Use prior analyses of the properties of magnets to inform their design of a maglev transportation system ○ Evaluate a maglev transportation system design using established criteria	**MATERIALS FOR LESSON 4 PART 2:** ● 10 rolls of masking tape ● 30 manila folders, approximately 9"x12" ● 30 foam trays, approximately 6"x8" ● 40 bar magnets with poles labeled, approximately 1"in length ● 50 ring magnets, approximately 1" in outer diameter with a hole diameter large enough to fit over a pencil ● 45 disc magnets, approximately ¾" in diameter ● 40 pieces of magnet, approximately ½" wide and 12" long or as long as the track box ● 250 weights, non-magnetic and uniform (e.g.: pennies or glass beads)

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- Improve a maglev transportation system design, taking into account the evaluation of a prior design

- ***Lesson Breakdown (up to 4 collaborations)***
  - Follow the steps listed in TG pgs. 119-124 (Students will create and test their maglev transportation system designs. Students will note aspects of their designs that work well, or do not work well, and brainstorm possible ways to improve their designs. Students will redesign, create, and retest their maglev transportation systems based on their initial test results.)
- ***Assessments***
  - Teachers will complete the Lesson 4 Rubric (4-9) about each student.

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- 20 paper cups (3 or 5 oz.)
- 1 utility knife (for teacher use)
- 10 overhead transparencies
- Scissors
- Rulers
- 1 cardboard box, approximately 12”x3”x3”, for each group of students
- 1 manila file folder, approximately 12”x3”, for each group of students

VOCABULARY FOR LESSON 4 PART 2:

- Design
- Engineering Design Process
- Goal
- Levitate
- Maglev
- Model
- Problem
- Redesign
- Solution
- System
- Teamwork
- Test

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Post-Assessment:
Administer appropriate the Post-Assessment (found in Appendix A).

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<tr><td colspan="3">Notes/Reflections</td></tr>
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Tabernacle School District

UNIT PLAN

Adopted from *Understanding by Design* (Wiggins and McTighe, 2005)

Unit Title	To Get to the Other Side: Designing Bridges	**Unit Length**	Up to 25 Collaborations
DESIRED RESULTS: STAGE ONE			
Standards Addressed			
- ITEEA National Standards and Benchmarks 2E: People plan in order to get things done.			

- 8A: Everyone can design solutions to a problem (brainstorming is important; everyone's ideas should be considered).
- 8B: Design is a creative process.
- 8C: The design process is a purposeful method of planning practical solutions to problems.
- 8D: Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.
- 9A: The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.
- 9B: Expressing ideas to others verbally and through sketches and models is an important part of the design process.
- 9C: The engineering design process involves designing a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
- 9D: When designing an object, it is important to be creative and consider all ideas.
- 10A: Asking questions and making observations helps a person to figure out how things (technologies) work.
- 10E: The process of experimentation, which is common in science, can also be used to solve technological problems.
- 11B: Build or construct an object using the design process.
- 11F: Test and evaluate the solutions for the design problem.
- 11G: Improve the design solutions.
- 20B: The type of structure determines how the parts are put together.

- 21st Century Skills
  - 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.
  - 9.3.12.ED.1 Apply communication skills with students, parents and other groups to enhance learning and a commitment to learning.
  - 9.3.12.ED.2 Demonstrate effective oral, written and multimedia communication in multiple formats and contexts.

Overall Understanding(s) *(Students will understand that...)*	**Essential Question(s)** *(The open-ended question(s) that help frame inquiry)*
• There are various fields of engineering. • Nearly everything in the human world has been touched by engineering. • Troubleshooting and learning from failure are integral to the learning process. • Materials and their properties are important in engineering solutions. • Engineering problems have multiple solutions. • Society influences and is influenced by engineering. • Technology affects the world. • Engineers are from all races, ethnicities, and genders.	• What are some of the forces that act on structures and how do civil engineers design structures that can withstand these forces? • How does the structure of a bridge affect its strength and how can we use different materials in our bridge designs? • How can we use our knowledge of materials and their properties, different bridge types, and the Engineering Design Process to design a strong, stable bridge?

Knowledge & Skills: Part 1

(Students will be able to...)

- Learn about various types of bridges
- Explore what civil engineers do for their jobs
- Become familiar with the Engineering Design Process
- Examine several different structures and observe how each is affected by a force
- Brainstorm and implement some engineering solutions to prevent forces from causing a structure to fail
- Explore how civil engineers work to counteract the forces (pushes and pulls) on a structure in order to make it stronger and more stable
- Create three different types of bridges (beam, arch, and deep beam) out of index cards
- Test each type of bridge to see how much weight it can support and how adding weight affects the structure of the bridge
- Examine the materials available to them for designing their bridges and brainstorm how they might use each material in their bridges
- Use the Engineering Design Process to design a bridge made from paper and other materials
- Test and improve their bridges using the evaluation criteria of strength and stability

Knowledge & Skills: Part 2

(Students learn that...)

- Depending on the criteria and constraints of a given problem, one or more bridge types may be the best design choice
- Engineers must consider criteria and constraints when solving a problem
- Bridges are a type of technology
- Anyone can use the Engineering Design Process
- Forces act on structures in many different directions
- Two equivalent forces acting on a structure in opposite directions will balance one another
- Civil engineers need to understand the forces acting on a structure in order to make it safe and stable
- Different bridge types, with unique shapes, can support different amounts of weight
- Controlled experiments can help to determine the strengths and weaknesses of different bridge designs
- Materials can be used in different ways to accomplish different design tasks
- Sheets of paper can be modified and reinforced to make a strong, stable bridge
- Testing and redesigning can improve the performance of any technology

Differentiation	Performance Task(s)
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Representation

collaboration, teamwork, and work ethic. Strategies teacher will use are as follows:

- Use of Open-Ended & Metacognitive Questioning
- Pushing for Explanation/Elaboration
- Revoicing/Reframing *(restating what the student says)*
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● **Lesson Breakdown (up to 4 collaborations):** ○ Introduce the following questions: ■ What do you think an engineer is and does? ■ What do you think technology is and what is it used for? ○ Discuss both topics as a class, infusing video clips and Google slides as enhancements to the discussion. ○ Follow the "Introduction" and "Activity" directions on TG pgs. 34-36. ○ Follow the "Reflection" directions on TG pg. 37. ○ Facilitate the "Breakdown of Technology" Lab to engage students in applying what they know about technology. ● **Assessment** ○ Administer appropriate the Pre-Assessment (found in Appendix A) ● **Extension** ○ Invite students to explore the different technologies in the classroom and use them to create their Ceiling Tile Projects. During this project, introduce and use the steps of the Engineering Design Process so that the students become familiar with them. Provide a visual of the steps of this process, as seen in TG 4-1 and 4-2.	
Lesson 1-Javier Builds a Bridge ● **Students will learn to...** ○ Identify the technologies discussed in the story ○ Discuss some of the problems, criteria, constraints, and solutions associated with designing bridges ○ Recognize the role of civil engineers in designing structures ○ Identify and utilize the steps of the Engineering Design Process ● ***Lesson Breakdown (up to 3 collaborations)***	**MATERIALS FOR LESSON 1:** ● *Javier Builds a Bridge* text ● Chart paper **VOCABULARY FOR LESSON 1:** ● Abutment ● Arch bridge ● Beam bridge ● Civil engineering ● Constraint ● Criteria ● Engineer ● Engineering Design Process

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Read/present an abridged version of Javier Builds a Bridge
Follow the steps listed in TG pgs. 43-51 (Students will explore how building different types of bridges can solve different kinds of problems.)

Assessments
Teachers will complete the Lesson 1 Rubric (1-7) about each student.
Extensions
Have students research other types of bridges, such as pontoon, cable stay, and truss bridges

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Masa
Pier
Problem
Prototype
Span
Suspension bridge
Tamale
Technology

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Lesson 2-Pushes and Pulls
PLEASE NOTE: Prior to the start of this lesson, the teacher must complete the “Preparation” steps listed on TG pgs. 58-60.

Students will learn to...

Identify some of the forces (pushes and pulls) that act on a structure
Explain that applying a new force (push or pull) in the opposite direction of an existing force (push or pull) can increase the strength and/or stability of a structure
Describe the role of civil engineering in identifying and addressing the forces acting on a structure

Lesson Breakdown (up to 2 collaborations)
Follow the steps listed in TG pgs. 61-79 (Students will investigate how different forces can act on a structure.)
Assessments
Teachers will complete the Lesson 2 Rubric (2-6) about each student.
Extensions
Ask students to design and build the tallest tower they can using index cards, cellophane tape, and string. Encourage students to use what they learned in this lesson to think about the forces that act on

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MATERIALS FOR LESSON 2:

Chart paper
Markers
Crayons
Table fan
4 plastic, non-flexible drinking straws
8 small paper clips
8 index cards (5”x8”) and 1 additional index card for each student
Rulers
Scissors
1 roll of cellophane tape
36” of string or mason line
10 weights, appox. 0.6 oz.
Modeling clay (enough to make 4 balls about a half inch in diameter)

VOCABULARY FOR LESSON 2:

Action
Civil engineering
Effect
Equilibrium
Force
Problem
Stable
Strong
Structure

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	their towers and how they can build the strongest, most stable tower they can. Test each tower by adding weights to the top and by blowing air on it with the fan. The teacher may want to videotape the testing of each tower so that the students can watch in slow motion how their towers reacted to the forces.	
	Lesson 3-Bridging Understanding Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 86-87.* ● **Students will learn to...** ○ Conduct a controlled experiment to determine and compare the strength of three different bridge types (beam, arch, and deep beam) ○ Analyze testing data and draw conclusions about how the shape and structure of a bridge affect how much weight it can support ○ Recognize that under different criteria and constraints, different bridge types are the best design choice ○ Brainstorm how they might use different materials and ways that they might change the shape of a material (rolling, folding, etc.) in a bridge design ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 88-97 (Students will build and test different bridge designs.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-9) about each student.	**MATERIALS FOR LESSON 3 PART 1:** ● Markers ● 12 index cards (5"x8") and 12 additional cards for each group of students ● 12 blocks or textbooks, smallest dimension approx. 1.5", all the same size and 4 additional blocks or textbooks for each group of students ● 45 standard weights, approx. 0.6 oz. each (e.g.: nuts, bolts, or washers) ● 3 paper or plastic cups (8 oz.) and 2 additional cups for each group of students **VOCABULARY FOR LESSON 3 PART 1:** ● Abutment ● Arch bridge ● Balance ● Beam bridge ● Civil engineering ● Criteria ● Engineering Design Process ● Failure ● Force ● Material ● Pier ● Property ● Span ● Test
	Lesson 3-Bridging Understanding Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 99.* ● **Students will learn to...** ○ Conduct a controlled experiment to determine and compare the	**MATERIALS FOR LESSON 3 PART 2:** ● Chart paper ● Markers ● 1 index card (5"x8") and 1 additional card for each group of students ● 1 sheet of copy paper or scrap paper, 8.5"x11", and 1 additional sheet for each group of students

	strength of three different bridge types (beam, arch, and deep beam) ○ Analyze testing data and draw conclusions about how the shape and structure of a bridge affect how much weight it can support ○ Recognize that under different criteria and constraints, different bridge types are the best design choice ○ Brainstorm how they might use different materials and ways that they might change the shape of a material (rolling, folding, etc.) in a bridge design ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 100-106 (Students will test out various materials and how effective each material would be if it were used in a bridge design.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-9) about each student. ● ***Extensions*** ○ Use poster board or cardstock to create larger beam, arch, and deep beam bridges together as a class. Use stacks of textbooks or other sturdy, rectangular objects as abutments. Test these bridges in the same manner that students tested their index card bridges. Heavier weights will be needed to collapse these larger bridges	● 1 craft stick and 1 additional craft stick for each group of students ● 1 plastic, non-flexible drinking straw and 1 additional straw for each group of students ● 1 jumbo paper clip and 1 additional paper clip for each group of students ● String or mason line, approx. 12" length, and 1 additional string for each group of students ● 1 roll of cellophane tape ● 1 plastic, resealable bag for each group of students **VOCABULARY FOR LESSON 3 PART 2:** ● Abutment ● Arch bridge ● Balance ● Beam bridge ● Civil engineering ● Criteria ● Engineering Design Process ● Failure ● Force ● Material ● Pier ● Property ● Span ● Test
	Lesson 4-Designing a Bridge Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 113.* ● **Students will learn to...** ○ Identify and implement the steps of the Engineering Design Process ○ Utilize what they have learned about different bridge types and the properties of different	**MATERIALS FOR LESSON 4 PART 1:** ● Chart paper ● 6 blocks or textbooks, smallest dimension approx. 1.5", all equal in size ● Plastic container, cardboard box, or block approximately 7.5"x5"x2" ● Standard weights (e.g.: nuts, bolts, washers), approx. 0.6 oz. each ● Sample materials bags from Lesson 3, Part 2 for each group of students

	materials to inform their bridge designs ○ Test the strength and stability of their bridge designs and analyze test results ○ Improve their bridge designs, based on testing results and analyses ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 114-118 (Students will review what they have already learned about different bridge types, the materials from which they can build their bridges, and the work of civil engineers. Students will discuss why engineers use prototypes when designing a technology. Students will review the criteria and constraints for their bridge designs as well as how they will test their bridges. Finally, students will create a detailed plan for their bridge designs, which will include a labeled diagram and a list of the materials they will use.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-13) about each student.	**VOCABULARY FOR LESSON 4 PART 1:** ● Abutment ● Civil engineering ● Constraint ● Criteria ● Design ● Engineering Design Process ● Force ● Goal ● Prototype ● Redesign ● Solution ● Stability ● Strength ● Teamwork ● Test
	Lesson 4-Designing a Bridge Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 120.* ● **Students will learn to...** ○ Identify and implement the steps of the Engineering Design Process ○ Utilize what they have learned about different bridge types and the properties of different materials to inform their bridge designs	**MATERIALS FOR LESSON 4 PART 2:** ● 1 ream (500 sheets) of copy paper (8.5"x11") ● 150 index cards (5"x8"), collected from Lesson 3 Part 1 ● 200 craft sticks ● 200 plastic, non-flexible drinking straws ● String or mason line (25 yards) ● 200 jumbo paper clips ● 10 rolls of cellophane tape ● Rulers ● Scissors

	○ Test the strength and stability of their bridge designs and analyze test results ○ Improve their bridge designs, based on testing results and analyses ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 121-126 (Students will create their bridge prototypes based on their plans from Part 1. Students will test the stability of their bridge prototypes by pushing a toy car across the bridge's span and observing its trajectory. Students will then test the strength of their bridge prototypes by placing weights on the center of the bridge's span until it sinks below a designated "failure" level. Based on their observations during testing, students will brainstorm ways to improve their bridge designs. Once they have decided on their improvement ideas, students will build new bridge prototypes and test them again. ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-13) about each student.	● 675 standard weights (e.g.: nuts, bolts, washers), approx. 0.6 oz. each ● 5 paper or plastic cups (8 oz.) ● Plastic container, cardboard box, or block approximately 7.5"x5"x2" ● 6 blocks or textbooks, smallest dimension approx. 1.5", all equal in size ● 1 small toy car (pull-back type and spring-loaded) for each group **VOCABULARY FOR LESSON 4 PART 2:** ● Abutment ● Civil engineering ● Constraint ● Criteria ● Design ● Engineering Design Process ● Force ● Goal ● Prototype ● Redesign ● Solution ● Stability ● Strength ● Teamwork ● Test
	Post-Assessment: Administer appropriate the Post-Assessment (found in Appendix A).	
Notes/Reflections		

Tabernacle School District

UNIT PLAN

Adopted from *Understanding by Design* (Wiggins and McTighe, 2005)

Unit Title	Water, Water Everywhere: Designing Water Filters	**Unit Length**	Up to 20 Collaborations
DESIRED RESULTS: STAGE ONE			
Standards Addressed			

- ITEEA National Standards and Benchmarks
  - 1A: The natural world and human-made world are different.
  - 1D: Tools materials, and skills are used to make things and carry out tasks.
  - 2D: Different materials are used in making things.
  - 2E: People plan in order to get things done.
  - 3A: The study of technology uses many of the same ideas and skills as other subjects.
  - 4A: The use of tools and machines can be helpful or harmful.
  - 4B: When using technology, results can be good or bad.
  - 4C: The use of technology can have unintended consequences.
  - 5B: Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment.
  - 5C: The use of technology affects the environment in good and bad ways.
  - 6A: Products are made to meet individual needs and wants.
  - 6C: Individual, family, community, or economic concerns may expand or limit the development of technologies.
  - 8A: Everyone can design solutions to a problem (brainstorming is important; everyone's ideas should be considered).
  - 8B: Design is a creative process.
  - 8C: The design process is a purposeful method of planning practical solutions to problems.
  - 8D: Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.
  - 9A: The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.
  - 9B: Expressing ideas to others verbally and through sketches and models is an important part of the design process.
  - 9C: The engineering design process involves designing a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
  - 9D: When designing an object, it is important to be creative and consider all ideas.
  - 10A: Asking questions and making observations helps a person to figure out how things (technologies) work.
  - 10E: The process of experimentation, which is common in science, can also be used to solve technological problems.
  - 11B: Build or construct an object using the design process.
  - 11F: Test and evaluate the solutions for the design problem.
  - 11G: Improve the design solutions.

- 21st Century Skills
  - 9.3.12.AC-DES.2 Use effective communication skills and strategies (listening, speaking, reading, writing and graphic communications) to work with clients and colleagues.
  - 9.3.12.ED.1 Apply communication skills with students, parents and other groups to enhance learning and a commitment to learning.
  - 9.3.12.ED.2 Demonstrate effective oral, written and multimedia communication in multiple formats and contexts.

Overall Understanding(s) *(Students will understand that...)*	**Essential Question(s)** *(The open-ended question(s) that help frame inquiry)*
• There are various fields of engineering. • Nearly everything in the human world has been touched by engineering. • Troubleshooting and learning from failure are integral to the learning process. • Materials and their properties are important in engineering solutions. • Engineering problems have multiple solutions. • Society influences and is influenced by engineering. • Technology affects the world. • Engineers are from all races, ethnicities, and genders.	• What types of problems do environmental engineers address and what are sources of those problems? • Which materials work the best for filtering different types of contaminated water? • How can we use our knowledge of how different filter materials work, our creativity, and the Engineering Design Process to design and improve a water filter that cleans contaminated "Mystery Water"?

Knowledge & Skills: Part 1
(Students will be able to...)

- Explore environmental engineering and the idea that engineers design solutions to problems
- Identify some sources of pollution and possible solutions
- Identify some common uses of air, water, and soil in a mural of a community
- Identify sources of air, water, and soil contamination in a mural of a community and explain why the contaminants are a problem
- Brainstorm ways in which one environmental contamination problem might be addressed through engineering
- Investigate the properties of different materials used for filtering water
- Conduct a controlled experiment to compare various filter materials' effects on different kinds of non-toxic contaminated water
- Use the steps of the Engineering Design Process to design a water filter to clean non-toxic contaminated water

Knowledge & Skills: Part 2
(Students learn that...)

- Engineers design technologies to solve problems
- Some environmental engineers work on solving problems related to the quality of drinking water
- Water quality is a problem that affects everyone, but especially people in areas where there is insufficient water treatment and purification

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The Engineering Design Process is a series of steps that can be used to solve problems
Environmental engineers, in their work, address problems of air, water, and soil contamination
Contaminants can be natural or artificial
Human activities can lead to air, water, and soil contamination
The problem of contamination can be addressed using a variety of approaches, some of which are designed by environmental engineers
Some filter materials work better than others for cleaning different kinds of contaminated water
How well or poorly a filter materials works depends on both the properties of the material and the properties of the contaminants in the water
By conducting controlled experiments, students can determine which filter materials will work best for cleaning different types of contaminated water
A good design will meet all of the criteria for solving a problem (in this case, speedy filtration, removal of particles and color, and low cost) to some degree
Sometimes increasing the performance of a design on some criteria (e.g.: making cleaner, clearer water) will decrease its performance on other criteria (e.g.: cost)

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<tr><th>Differentiation</th><th>Performance Task(s)</th></tr>
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Overview:
Universal Design for Learning Differentiation is inherent in Universal Design for Learning (UDL), a design philosophy with the underlying premise that meeting students' individual needs is best accomplished when lesson design is flexible, and instruction moves each student's thinking, learning, and skills forward from wherever he or she begins, in a manner that does not assume one size fits all. Engineering is Elementary lessons often provide activities for reinforcement and practice, for extension that goes beyond the classroom activity, or for adding artistic expression to lessons. Elements may be used or not, or adapted according to the teacher's assessment of his or her students' prior knowledge and their needs as a class and as individuals. The three primary components of UDL, multiple means of engagement, multiple means of representation, and multiple means of expression, are addressed in each lesson, providing all students—even those at the ends of the learning continuum, or those with unique learning requirements—opportunities to learn in a way that they learn best.

Engagement
Research reveals the importance of engagement as it links to interest, motivation, and achievement. In the Engineering is Elementary units, students manipulate materials in hands-on activities, read informational text, participate in discussion, and
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Assessments/Observations
Daily: The students will record daily progress through journaling. The teacher will make observations and keep anecdotal records regarding student use of materials, demonstration of conceptual understanding, and classroom citizenship, and will provide direct and specific feedback to students.
Unit/Final: These assessments cover key concepts and information introduced in each unit and help teachers to as student comprehension through creating.

Teacher/Student Conferences
The teacher will facilitate learning and meet with groups consistently. The students and the teacher will keep anecdotal records of group engagement and collaboration, teamwork, and work ethic. Strategies teacher will use are as follows:

Use of Open-Ended & Metacognitive Questioning
Pushing for Explanation/Elaboration
Revoicing/Reframing (restating what the student says)
Summarizing/Clarifying Ideas (ask a student to summarize)
Soliciting Ideas/Generating & Evaluating Hypotheses

Peer work
Working in teams is an essential component of learning. Lessons and activities are often carried out with students in "teams" or "partners" and materials are shared. The
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write, draw, or create in every lesson. Students develop models to represent phenomenon, and use their models to explain how and why things happen. In some lessons, students watch videos, explore websites, or play games. The teacher might choose to add others, as appropriate for the students' learning, and as different modes of technology provide access to new material every day. A variety of ways to engage with the concepts and ideas, beginning with images and discussion that activates prior knowledge, provide all students with entry points into the content and ways to explore and investigate it. Students engage in their learning as a whole class and in collaborative teams or pairs, and have independent time to read, write, draw, or create. **Student Interaction** Students bring to the classroom a range of experiences, as well as varied degrees of interest in learning the skills and concepts covered in this unit.. As they test ideas, collect data, and articulate what they have discovered, learning becomes personal. Groups and pairs may be configured to address reading needs, individual interests, or learning strengths. Consider Think-Pair-Share and Heads-Together techniques to allow time for student reflection prior to answering questions, starting a discussion, writing, or creating so that all students have an opportunity to process information before being called upon to use it. **Representation** ● Visual – Lessons incorporate numerous photographs and illustrations. The student readers contain photographs, charts and graphs, diagrams, and other images so that students can encounter science content in a variety of ways. ● Auditory – Teachers may read aloud or have students do paired reading of the informational texts in the lesson. Discussion— speaking and listening—are core elements Engineering is Elementary. Teamwork provides opportunities for student-to-student talk as they share ideas and challenge one another's evidence for claims and conclusions.	teachers should use their knowledge of the class to select productive student groups and spend time modeling and discussing constructive group behavior. The term "partners" refers to two students, while "team" refers to two sets of partners or any grouping of three or more.

● Kinesthetic – Every lesson has students interacting with and manipulating materials. ● Use of Technology – Various modes of technology will be incorporated into each part of the learning process. **Expression** Students write, draw, and/or create in every lesson as ways in which they express, demonstrate, and record their developing understandings. This work, done through journaling and projects, provides the teacher with ongoing opportunities to assess learning formatively and adjust classroom experiences, as needed. Rich discussion also enables teachers to assess understanding as students express their ideas and communicate orally.	
LEARNING PLAN: STAGE THREE	
Lesson Topics & Sequence of Learning Activities	**Materials and Resources**
Pre-assessment: ● **Students will learn to...** ○ Discover how and why everyday objects made by people are technology ○ Identify the problem that a particular object solves ○ Identify the materials used to make an object ○ Identify that objects are designed as a solution to a problem ○ Identify engineers as the people who design objects ● **Lesson Breakdown (up to 4 collaborations):** ○ Introduce the following questions: ■ What do you think an engineer is and does? ■ What do you think technology is and what is it used for? ○ Discuss both topics as a class, infusing video clips and Google slides as enhancements to the discussion. ○ Follow the “Introduction” and “Activity” directions on TG pgs. 34-36. ○ Follow the “Reflection” directions on TG pg. 37.	**MATERIALS:** ● Samples of “engineered objects” (examples: toothbrush, flashlight, plastic container, sponge, paper clip, stapler, scissors, pen, CD, slippers, pencil sharpener, glue stick, eraser, plastic bag, nail clippers, hair brush, ec.) ● Opaque bag or container (one for each group) **VOCABULARY:** ● Engineering ● Material ● Problem ● Solution ● Technology

○ Facilitate the "Breakdown of Technology" Lab to engage students in applying what they know about technology. ● **Assessment** ○ Administer appropriate the Pre-Assessment (found in Appendix A) ● **Extension** ○ Invite students to explore the different technologies in the classroom and use them to create their Ceiling Tile Projects. During this project, introduce and use the steps of the Engineering Design Process so that the students become familiar with them. Provide a visual of the steps of this process, as seen in TG 4-1 and 4-2.	
Lesson 1-Saving Salila's Turtle ● **Students will learn to...** ○ Define engineer ○ Identify possible sources of pollution ○ Explore some of the problems and engineering solutions associated with improving water quality ○ Recognize the role of environmental engineers in helping to address problems of air, water, and soil contamination ○ Identify the steps of the Engineering Design Process ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Read/present an abridged version of *Saving Salila's Turtle* ○ Follow the steps listed in TG pgs. 43-51 (Students will explore water pollution and possible water contaminants. Students will begin discussing how these environmental issues can be solved.) ● ***Assessments*** ○ Teachers will complete the Lesson	**MATERIALS FOR LESSON 1:** ● *Saving Salila's Turtle* text ● Chart paper ● India marked on a classroom map **VOCABULARY FOR LESSON 1:** ● Bacteria ● CContaminanthlorine ● ● Engineer ● Engineering Design Process ● Environment ● Environmental engineer ● Evaporation ● Filter ● Glacier ● *Kachua* ● Microbes ● Monsoon ● *Paneer* ● *Sari* ● Technology ● Ultraviolet light ● Water purification ● Water vapor

	1 Rubric (1-7) about each student. ● ***Extensions*** ○ Have students write a letter asking for information about local sources of water and how Tabernacle's water is treated and purified	
	Lesson 2-Who are Environmental Engineers? **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pg. 57.* ● **Students will learn to...** ○ Identify multiple human uses for air, water, and soil ○ Identify multiple ways that air, water, and soil become contaminated ○ Explore some problems and engineering solutions associated with air, water, and soil contamination ○ Recognize the role of environmental engineers in helping to address the problems of air, water, and soil contamination ● ***Lesson Breakdown (up to 2 collaborations)*** ○ Follow the steps listed in TG pgs. 58-63 (Students will explore ways people use air, water, and soil and how those areas can become contaminated.) ● ***Assessments*** ○ Teachers will complete the Lesson 2 Rubric (2-7) about each student. ● ***Extensions*** ○ Have students find and discuss articles in the newspaper or magazines that discuss current issues and debates concerning pollution	**MATERIALS FOR LESSON 2:** ● Masking tape ● Markers ● 1 blank sheet of paper (for each group) **VOCABULARY FOR LESSON 2:** ● Artificial ● Contaminant ● Contamination ● Environment ● Natural ● Pollution
	Lesson 3-Exploring Filter Materials **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the "Preparation" steps listed on TG pgs. 70-73.* ● **Students will learn to...**	**MATERIALS FOR LESSON 3:** ● Tea leaves, approx. 4 tablespoons or the loose tea from 8-10 tea bags ● Potting soil, approx. 4 tablespoons ● Cornstarch, approx. 4 tablespoons

	○ Make predictions about the efficacy of different filter materials based on their properties ○ Conduct a controlled experiment ○ Observe, analyze, and compare the performance of filter materials when used to filter contaminated water ○ Decide which materials and/or combination of materials will be good choices for use in a water filter design ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 74-84 (Students will test a variety of materials that can be used in water filters and investigate how well each material filters contaminated water.) ● ***Assessments*** ○ Teachers will complete the Lesson 3 Rubric (3-8) about each student. ● ***Extensions*** ○ Set up a testing station where students can test other filter materials, such as cotton balls, nylon stockings, cheesecloth, etc.. Students should conduct testing in exactly the same manner as the other items in Lesson 3.	● Paper towels or rags ● 1 empty, clear, plastic bottle (2-liter) and 1 additional bottle for each group ● 1 bottle cap for each 2-liter plastic bottle, with a hole drilled through it (or size 4 rubber stopper with drip hole) ● Hammer and nail or drill (for teacher use, if not using rubber stopper with drip hole) ● Aquarium gravel (fine, uncolored), approx. ½ cup, and an additional ½ cup for each group ● Art sand (washed, uncolored), approx. ½ cup, for the model and an additional ½ cup for each group ● 34-42 cups of warm water ● 1 utility knife (for teacher use) ● Utility gloves ● Liquid measuring cup (able to hold at least 1 cup) ● Timer ● Clear packing tape ● Masking tape ● Permanent markers ● Chart paper ● Tablespoon measure ● Teaspoon measure ● Funnel, to be used with the 2-liter plastic bottles ● 1 empty, clear, plastic bottle (1-liter) for each group ● 6 clear, plastic cups (16 oz.) for each group ● 1 pan/basin, approx. 20”x12”x3” (for each group) ● 1 fine, nylon screen, cut into a 10”x12” piece (for each group) ● 5 round, paper coffee filters (for each group) **VOCABULARY FOR LESSON 3:** ● Criteria ● Data ● Filter ● Material ● Particle
	Lesson 4-Designing a Water Filter Part 1 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the “Preparation” steps listed on TG pgs. 91-92.* ● **Students will learn to...** ○ Identify and implement the steps of the Engineering Design Process	**MATERIALS FOR LESSON 4 PART 1:** ● 2 clear, plastic 2-liter bottles (uncut, with caps) ● Funnel (to be used with the 2-liter plastic bottle) ● Masking tape ● Permanent markers ● 5 clear, plastic 1-liter bottles (with caps) and 1 additional bottle for each group

	○ Use prior analyses of filter materials to inform their water filter designs ○ Imagine ideas for making a water filter, and choose one idea to build and test ○ Make a detailed plan of their water filter design that includes a materials list, a labeled diagram, and calculated cost ○ Create their water filters and observe the results of testing ○ Test and analyze a water filter design for strengths and weaknesses ○ Improve their designs based on earlier analyses ● ***Lesson Breakdown (up to 3 collaborations)*** ○ Follow the steps listed in TG pgs. 93-96 (Working in small groups, students will imagine several different water filter designs. Students will plan their water filter designs and calculate the cost of their designs.) ● ***Assessments*** ○ Teachers will complete the Lesson 4 Rubric (4-14) about each student.	● Tea leaves , approx. 14 tablespoons, or tea from 18-20 bags ● Potting soil, approx. 14 tablespoons ● Cornstarch, approx. 14 tablespoons ● Tablespoon measure ● Teaspoon measure ● Liquid measuring cup (able to hold at least 1 cup) ● 16 liters of warm water ● 1 filter holder for each group ● 2-liter bottle cap with a hole drilled through it (or size 4 rubber stopper with drip hole) for each group ● 1 fine, nylon screen, cut into a 10”x12” piece (for each group) ● 1 jumbo size cotton ball (for each group) ● 1 cheesecloth piece cut into 10”-12” piece (for each group) ● 1 round, paper coffee filter (for each group) ● Art sand (washed, uncolored), approx. ½ cup (for each group) ● Aquarium gravel (fine, uncolored), approx. ½ cup (for each group) ● 2 clear, plastic cups (16 oz.) for each group **VOCABULARY FOR LESSON 4 PART 1:** ● Constraint ● Criteria ● Data ● Design ● Engineering Design Process ● Goal ● Problem ● Redesign ● Requirement ● Solution ● Teamwork ● Test
	Lesson 4-Designing a Water Filter Part 2 **PLEASE NOTE:** *Prior to the start of this lesson, the teacher must complete the “Preparation” steps listed on TG pg. 98.* ● **Students will learn to...** ○ Identify and implement the steps of the Engineering Design Process ○ Use prior analyses of filter materials to inform their water filter designs	**MATERIALS FOR LESSON 4 PART 2:** ● 10-20 pieces of fine, nylon screen, cut into 10”-12” pieces ● 100 round, paper coffee filters ● 400 jumbo size cotton balls ● 25-30 cheesecloth squares, approx. 10”x12” pieces ● 20 clear, plastic cups (16 oz.) ● Art sand (washed, uncolored), approx. 15 cups

- Imagine ideas for making a water filter, and choose one idea to build and test
- Make a detailed plan of their water filter design that includes a materials list, a labeled diagram, and calculated cost
- Create their water filters and observe the results of testing
- Test and analyze a water filter design for strengths and weaknesses
- Improve their designs based on earlier analyses

- ***Lesson Breakdown (up to 3 collaborations)***
  - Follow the steps listed in TG pgs. 99-105 (Students will create and test their water filters, scoring them on established criteria. Students will also improve their water filter designs based on the results of testing and their final score.)
- ***Assessments***
  - Teachers will complete the Lesson 4 Rubric (4-14) about each student.
- ***Extensions***
  - As a class, study and take apart a commercial water filter (such as the pitcher filters that are kept in the refrigerator or the small filters that attach to a faucet). Help students to identify the different parts of the filter and what material each part is made of. Then, have the students predict and discuss what they think each part of the filter does in the process of cleaning the water. NOTE: There is often activated charcoal or carbon in these filters, which should not be ingested.

- Aquarium gravel (fine, uncolored), approx. 15 cups
- Clear packing tape
- Masking tape
- Liquid measuring cup (able to hold at least 1 cup)
- Timer
- Paper towels or rags
- 1 filter holder for each group
- 2-liter bottle cap with a hole drilled through it (or size 4 rubber stopper with drip hole) for each group
- 1-liter bottle filled with "Mystery Water" (from Part 1) for each group
- 1 pan/basin, approx. 20"x12"x3" (for each group)
- 1 clear, plastic cups (16 oz.) marked at ¼ cup for each group
- 1 clear, plastic cups (16 oz.) marked at 1 cup for each group

VOCABULARY FOR LESSON 4 PART 2:

- Constraint
- Criteria
- Data
- Design
- Engineering Design Process
- Goal
- Problem
- Redesign
- Requirement
- Solution
- Teamwork
- Test

	Post-Assessment: Administer appropriate the Post-Assessment (found in Appendix A).	

Notes/Reflections