Engineering Design

Course Syllabus

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1. INTRODUCTION

The intent of this syllabus is to provide a practical guide that educators can follow for a seventh grade quarter-long course of engineering. This course provides exposure to engineering disciplines, design challenges and the creation of an invention. Students will follow a design process using the Engineering Design Process (EDP) along with peer feedback. The culminating project involves students designing, creating, testing, and refining an invention of his/her choice that is practical and usable in everyday experiences. This Project Based Learning (PBL) project will provide students with the opportunity to work through the design phase to learn about each engineering discipline.

Differentiation will be addressed through pre-assessment and student need while working through the EDP. Voice and choice will give students the option to choose the problem, criteria and constraints for the culminating project. This is scaffolded so students begin researching engineering disciplines, practicing the EDP through design challenges of each discipline, and then creating an invention combining the core areas of STEM (Technical Skills, Collaboration Skills, Engineering Design Process, Innovation/Problem Solving, Growth Mindset, and Professional Competencies).

Engineering logbooks provide a location for students to record information obtained during the course. The logbooks will provide a structure to record struggles, strengths, questions, sketches, ideas and general thoughts. Information recorded will follow the EDP and be detailed enough that another peer could pick up the logbook and recreate the product. Logbook entries will be assessed on a weekly or biweekly basis. A rubric will assess each section of the logbook entries for completeness and accuracy of information.

Formative assessment monitors student learning using student prototypes, reflections, observations, weekly check-ins, peer critique, and logbook entries. Summative assessments include quizzes and the culminating project. Quizzes cover terms and physical use of the EDP to show mastery.

Students will be assessed on core areas of STEM: Technical Skills, Collaboration Skills, Engineering Design Process (EDP), Innovation/Problem Solving, Growth Mindset, and Professional Competencies. These core areas of STEM will be evaluated through observations, rubrics, quizzes/tests, reflective logbook entries, self-evaluation and peer evaluations.

1. **Technical Skills**: Exhibit skills learned during projects using technology, tools, and programming.
2. **Collaboration Skills**: Helps peers, open to ideas and comments from peers and teachers, and demonstrates inclusion of all peers.
3. **Engineering Design Process (EDP)**: Ability to identify each step of the EDP and understand how each step is interrelated. Able to explain how each step is utilized while working on a project. Steps of EDP:

1. Identify Problem/Challenge
2. Criteria & Constraints
3. Research/Design
4. Build Prototype
5. Test
6. Refine

4. **Innovation/Problem Solving**: Ability to sustain attention to solve problems and take risks while solving problems.
5. **Growth Mindset**: Accept difficult or challenging activities with a positive and encouraging attitude with peers to identify and solve problems while working on a project.
6. **Professional Competencies**: Goal setting, organization, conflict resolution, flexibility, critical thinking, and leadership.

In order to allow students to progress at their own pace, the classroom will need to have a visible question board. This tool provides a central location for the students to ask questions, get answers, and obtain assignments and rubrics. This way the students can become more independent learners by checking the board, then a peer, and lastly the teacher. A collaborative culture is necessary for students to work and this process of using a class question board encourages collaboration. The board will also provide students with assignments to work at their own pace.

Students will have the opportunity to continue class discussions or ask classmates questions using an online discussion board. This can be accomplished using https://classroom.google.com. It will provide an additional format for seeking out assistance from peers since the students can post questions or comments for peers to respond.

1.1. MATERIALS

- Engineering Logbook
- Laptop

2. SYLLABUS

The course provides an entry-level experience using the engineering design process and an introduction to engineering disciplines. Course concepts include problem solving techniques, professional competencies, growth mindset, engineering design process, collaboration skills and technical skills. The purpose of the course is to introduce students to engineering disciplines and help students understand the Engineering Design Process (EDP).

This course is divided into two sections to reinforce the EDP.

Section 1:

- Introduction to engineering disciplines

Section 2:

- Design challenges

The course ends with a student choice PBL project using the design process to create an invention.

Goals of this course:

1. Introduce students to the EDP.
2. Help students feel confident in understanding the steps of the EDP and how the steps are interrelated.
3. Prepare 7th grade students for entry into the engineering pathway in 8th grade.
4. Introduce and practice the process of reflecting through journal entries.

Upon completion of this course students will be able to do the following:

1. Explain the Engineering Design Process and how it is fluid and steps interact.
2. Think critically about how to solve a problem.
3. Recognize the core areas of STEM: Technical Skills, Collaboration Skills, Engineering Design Process, Innovation/Problem Solving, Growth Mindset, and Professional Competencies.
4. Create a PBL project.

2.1. RESOURCES

Computers with accessibility to the Internet. The resources used during this course are downloadable from the Internet. Students use the assigned resources providing the opportunity to extend learning through research.

2.2. DAILY ACTIVITIES

The flow of the daily activities is flexible based on student progress and needs.

Day 1 **Class Activity** – Civil Engineering Design Challenge

Instruction – *Problem:* Build a free-standing structure as tall as possible. *Criteria* & *Constraints:* Students will have 5 minutes to build the tower. The constructed tower must be able to stand on the table without being attached to the table or being held upright by any team member. It should stand for at least 25 seconds. Measurements are made after the time is up. The focus of this activity is to build a structure out of simple materials that can stand for 25 seconds, while collaborating with a partner.

Material(s) – List of materials for each group of two students.

- 1 index card
- 1 mailing label
- 2 straws
- 2 paper clips

Question(s) – What were some of the challenges when constructing your tower? What were the stress points of the design? What engineering discipline would this activity identify with most?

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Core Area of STEM – *Introduction to Collaboration.*

Day 2

Class Activity – Agricultural Engineering Design Challenge

Instruction – *Problem:* Build a device out of a sheet of paper that can generate enough wind to create energy.
Criteria & Constraints: Students are given 20 minutes to create a device that can be used to generate wind. The device must be moved in a circular motion by blowing on the device or using a finger to spin it. Allow students to label the sections of the paper with consecutive numbers. Start the numbering on the top left side of the paper with number 1. The top right side should be 2. The bottom right should be 3 and bottom left should be 4. The center of the paper should have the number 5. All materials given must be used. Each group will demonstrate their device after the 20 minute build section.

Material(s) – List of materials for each group of two students.

- Sheet of paper with an X extending through the entire sheet
- A sharpened pencil or 2 popsicle/craft sticks
- 1 straight pin
- Scissors
- Glue or tape (use this step only if you are using the sticks)

Question(s) – How is your device using mechanical power? How is the kinetic energy being generated? What engineering discipline does this activity identify with?

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Core Area of STEM – *Introduction to Innovation/Problem Solving*

Day 3 **Class Activity** – Mechanical Engineering Design Challenge

Instruction – *Problem:* Move various objects into a container from a marked area without touching the objects or putting any part of your body into the marked area.
Criteria & Constraints: Students will have 4 minutes to use their imagination to plan how to use the materials provided. Brainstorm ways to move the objects out of the larger marked area into the container. The containers and objects cannot be damaged or modified. Students can practice during part one, but must return objects into the container in the center of the smaller marked area. In part two students have 4 minutes to move the objects from the larger marked area one at a time without touching the objects.
EDP Focus: EDP (steps 1-6).

Material(s) – List of materials for each group of four students.

- 1 envelope
- 2 straws
- 5 toothpicks
- 1 golf ball
- 2 pipe cleaners
- 2 rubber bands
- 6 pieces of spaghetti
- 1 sheet of paper
- 2 paper clips
- 1 paper cup
- 2 adhesive labels
- 2 balloons

Question(s) – Does the device meet the expectation of the activity? How many objects were you able to move? To which engineering discipline does this relate?

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Core Area of STEM – *Introduction to Engineering Design Process*

Day 4-5 **Class Activity** – Civil Engineering Design Challenge

Instruction – *Problem:* Identify how a windup toy functions.
Criteria & Constraints: Put students in groups of 2 and give each group one windup toy, a set of small screwdrivers, and a Disassembly Chart. Tell the students to sketch and label the windup toy on the Disassembly Chart. Label all parts of the toy providing dimensions and the view (5 minutes). Then have students open the toy to see the internal working parts. On the second page

have students sketch the internal parts of the toy. This will provide the students with a key for putting the parts back together. Tell students to number the parts and put that number with the part in the chart. Then write down how each part that helps the toy function. Once finished disassembling the toy and identifying each piece, ask the students to think of suggestions for making the toy function better. Write down the suggestions at the bottom of the Disassembly Chart.
EDP Focus: research/design (step 3) and build prototype (step 5).

Material(s) – List of materials for each group of two students.

- Windup toy
- Set of small screwdrivers
- Closeable bag to store screws and parts
- Disassembly Chart
- Pencil

Question(s) – What does reverse engineering mean? How will taking apart a toy help us understand the EDP? How is the power transferred in the toy? What is the function of the gears?

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Core Area of STEM – *Introduction to Growth Mindset*

Day 6

Class Activity – Introduction to Engineering Logbook

Instruction – Review care and use of logbook and introduce rubric. Handout Engineering Logbook template and review with students. Create a Table of Contents in the composition notebook and then glue in the template and the rubric on pages 1 and 2 respectively. Explain to students that daily entries will include a date, setting a goal, detailed explanation of work and explanation of core areas of STEM. Other portions of the template will be filled out based on the daily activity. Set daily goals and provide an explanation of work (5-7 minutes). Goals need to be set at the beginning of each class and assessed at the end of each class. Provide time for students to write down the Engineering Design Process on page 3 of the logbook. This will serve as a reference for students. Any new pages entered into the logbook will require an entry in the Table of Contents.

Material(s) – List of materials for each student.

- Engineering Logbook
- Engineering Logbook Template

- Pencil
- Glue

Day 7-8 **Class Activity** – Introduction to Engineering Disciplines

Instruction – Introduce website for researching different engineering disciplines. Approximately 2 days to research each field and record information based on seven questions in the Engineering Disciplines graphic organizer. Optional: At the end of each week, check for understanding by having students write a one page, double spaced, size 12 font (Calibri/New Times Roman) reflective summary using the information learned (problem, prototypes, materials, safety, testing and education) section as a guide.

Material(s) – List of materials for each student.

- Engineering Logbook
- Engineering Disciplines graphic organizer
- Pencil
- 1 sheet of paper

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Resources – Website for types of engineering disciplines: http://www.nacme.org/types-of-engineering

Day 9 **Class Activity** – Bioengineering Design Challenge

Instruction – *Problem:* Dissect and redesign a plant or flower to harness energy.
Criteria & Constraints: Part 1: Create a design to harness energy or heat with inspiration from nature by dissecting a flower/plants using their genetic design sign for a blue print.
EDP Focus: research (step 3).

Question(s) – What type of design is currently being used for harnessing energy? How could an engineer use your design to develop energy? Can this design be used in the real world?

Material(s) – List of materials for each group of two students.

- 1-2 flowers (lilies or sunflowers work best)
- Tools to reverse engineer the flower, such as toothpicks, tweezers, cutting tools
- Magnifying glass
- 1 sheet of blank paper

- Markers or colored pencils
- 1 plastic bag to store the flower components if the activity is completed over more than one day

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 10 **Class Activity** – Audio Engineering Design Challenge

Instruction – *Problem:* Create two instruments using the materials provided. *Criteria & Constraints:* Students are to build two instruments using basic materials. Part one: The completed instruments are to have sounds and playable by both students. Student should take 5 minutes to come up with ideas. Student should take 20 minutes to build and test instrument. Part two: students have 2 minutes to demonstrate the instrument and its sound. *EDP Focus*: design of instrument (step 3).

Question(s) – Which instruments produced high frequencies? Which instruments will produce a pleasant sound vs. noise?

Material(s) – List of materials for each group of two students.

- Plastic plate
- 6 rubber bands
- Flat stick
- Glue gun with sticks
- Egg carton, toilet paper roll or paper towel roll
- Rice
- Beans
- Buttons
- Beads
- Tape (duct tape)
- Scissors
- Markers
- Construction paper
- Pipe cleaner
- Hole puncher (hand held)
- Marker

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class

period (5 minutes).

Day 11 **Class Activity** – Environmental Engineering Design Challenge

Instructions – *Problem:* Build a water tower that holds up a tank of water.
Criteria & Constraints: Part one: As the team begin to build the tower remember not to damage the ball or attach anything to it or the table. The tower must stand at least 12 inches high. The tower must be measured by the instructor. Part two: Take an additional 2 minutes to make modifications if the tower is not 12 inches high. The instructor will say when the rubber ball can placed on the tower. The tower must withstand the rubber on top of it for 5 seconds without falling down.
EDP Focus: design (step 3).

Question(s) – Did your water tower survive the challenge? If so, why? What world problem can be solved by using this type of ingenuity?

Material(s) – List of materials for group of four students.

- 1 cardboard tube
- 1 Styrofoam cup
- 6 toothpicks
- 4 paper clips
- 2 drinking straws
- 2 mailing labels
- 1 piece of aluminum foil
- 1 small rubber ball that cannot be damaged or have anything attached to it
- 1 ruler that is used only for measuring

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 12 **Class Activity** – BioMedical Engineering Design Challenge

Instruction – *Problem:* Design and create a cast to mend broken bones. Put the sketch of the cast in the logbook including labels of materials, measurements and view of design.
Criteria & Constraints: Students will use only provided materials. The cast must fit snugly on a student's arm. The length should extend from the wrist to the bend of the elbow. The thickness should be no more than two layers of materials. Upon completion, create a PowerPoint slide inclusive of design, and picture of prototype with sketch of design.
EDP Focus: design (step 3) and prototype (step 4).

Question(s) – What is the problem you are trying to solve? What were the results of your brainstorming session? What are possible solutions to your problem?

Material(s) – List of materials for group of four students.

- Boxes to hold recyclable materials
- Half a container of Play-Doh™
- 4 Popsicle™ sticks
- 6 to 8 recyclable materials: fabric, cotton batting, egg cartons, toilet paper or paper towel rolls, toothpicks, plastic bottles, milk cartons cut in pieces, rubber bands, straws, plastic tubing
- PowerPoint slide
- Markers

Resources – **Teach Engineering:**
https://www.teachengineering.org/activities/view/bones_sue

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 13

Class Activity – Mechanical Engineering Challenge

- **Instructions –** *Problem:* Build a transportation device and use that transportation device to move 10 lost kittens to Kitten Paradise. *Criteria & Constraints:* In the center of the room is a bucket. This bucket is the Lost and Found, and there are 10 lost kittens inside it. One the other side of the room is another bucket. This bucket is for Kitten Paradise. Part 1 (5 minutes): Using the materials provided, build a transportation device. The transportation device should be able to move the kittens from the Lost and Found Kitten Paradise without letting the kittens touch the ground. Part 2 (3 minutes): Using your transportation device, move the lost kittens from Lost and Found to Kitten Paradise one at a time. If a kitten touches the ground, you must return it to the Lost and Found before you can try to move it again. Each team member should try to move at least one kitten.
  EDP Focus: identify problem (step 1) and criteria & constraints (step 2).

Question(s) – What materials will help you create a transportation device that will hold the kittens? What problems do you see happening when the device is

moving with the kittens?

Material(s) – List of materials for group of four students.

- 2 sheets of paper
- 4 mailing labels
- 1 plastic spoon
- 2 note cards
- 4 paper clips
- 2 Chenille stems (pipe cleaners)
- 1 paper cup
- Several markers to decorate your device

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 14-15 **Class Activity** – Ceramic & Materials Design Challenge

Instruction – Students will test various compositions of construction material to determine durability of various compositions of concrete.
Problem: Each group of 2 students will make 4 different types of "concrete" to test.
Criteria & Constraints: Create concrete using materials provided. Make 4 types of concrete. Make 4 types of student chosen concrete (1 class period). Allow one day for the concrete to cure. Test: Drop each sample from the same height (10 feet). Determine and record the outcome in the logbook. Compare results with other teams and identify the sturdiest "concrete" (1 class period).
EDP Focus: build prototype (step 4) and test (step 5).

Material(s) – List of materials for group of two students.

- 4 paper bowls
- Sandwich size baggie of straw
- Snack size baggie of nails
- Gallon size baggie of sand
- Gallon size baggie of rocks
- Gallon size bag of ground gypsum
- Ladder
- 4 plastic spoons
- 2 sets of plastic gloves
- 1 black sharpie
- 1 container for 24 oz. of water

Question(s) – What is concrete made out of? How did you determine what to

put into each concrete mixture? Describe the failure type of each concrete. Did each concrete sample fracture in the same way? How can we reinforce the concrete? What is ductile concrete? How does it strengthen the concrete?

Logbook Entry – Set goal, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 16 **Class Activity** – Chemical Engineering Design Challenge

Instruction – *Problem*: Change the recipe of gummy candy to be chewier.
Criteria & Constraints: Amount of ingredients will be student choice. Size of candy should be same as sample. Provide pre-made gummy candies to test. Make changes to amounts of ingredients to make the candy chewier (15 minutes). Remake the recipe again to determine if candy can be chewier than first candy (10 minutes).
EDP Focus: test (step 5) and refine (step 6).

Material(s) – List of materials for groups of 2 students. Provide enough to test 2-3 times.

- Small paper cereal bowl
- Measuring teaspoon
- Popsicle sticks (4)
- 1 cup 100% juice (apple, or other juice types)
- 2 tablespoons gelatin
- Paper towels
- 1 rubber ice cube mold (animal or plant design)

Question(s) – Does it change the state of "chewiness" if you vary the amounts of gelatin and volume of juice? If you change the order in adding ingredients, does it change the consistency? How much do you mix the 2 ingredients? Will a change in temperature impact the chemical reaction? What changes to the recipe did you make?

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 17 **Class Activity** – Civil Engineering Design Challenge

Instruction – *Problem*: Design and build frame traps (device/structure) to capture bugs for a population study.
Criteria & Constraints: Collect bugs from a designated 3x5 foot rectangular area.

The bugs are moving (blow dryer) while being caught. Use materials provided. The frame trap needs to collect the bugs without human intervention. Frame traps may not be attached to the floor. Bugs will be considered "trapped" if within the frame trap or touching the frame trap (15 minutes to design and build).
EDP Focus: research & design (step 3) and build prototype (step 4).

Material(s) – List of materials for group of two students.

- 10 straws
- 5 chenille stems
- 5 craft sticks
- Scissors
- 36 inches of yarn
- 6 mailing labels
- 10 toothpicks
- 1 paper cup
- 1 plastic spoon
- 10 creatures (plastic bugs, ping pong balls, etc.)
- Blow dryer
- Painters tape to block off 3x5 inch grid

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 18 **Class Activity** – Computer Engineering Design Challenge

Instruction – *Problem*: Design a flowchart giving directions to stack cups in a pyramid.
Criteria & Constraints: Use flowchart symbols given by teacher. Include a repeat (loop) of one or more steps. The pyramid must include a base that is at least 3 cups wide. Width of the pyramid is not specified. Can use a stencil or ruler to create flowchart symbols (15 minutes). Switch flowcharts with another group and follow the "commands" in the flowchart (5-7 minutes).
EDP Focus: research & design (step 3) and build prototype (step 4).

Material(s) – List of materials for group of two students.

- Pencil
- Paper
- Reference chart of flowchart symbols
- 10 Solo cups (same size cups)
- Stencil of flowchart shapes (optional)

Question(s) – What symbols are used for a flowchart? What do the different symbols mean? How can you make a loop or repeat steps? Is there a place in your flowchart that repeats? How will the person know to stop building the pyramid?

Logbook Entry – Set goal, glue in flowchart, enter Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 19 **Class Activity** – Geological & Geophysical Engineering Design Challenge

Instruction – *Problem*: Look at layers of soil and determine what is the best way to layer the soil to build a foundation for a high-rise apartment. Students will look at gravel, silt, sand, crushed stone and determine the best system for layering the soil to build the foundation (12 minutes). The second part is to determine the type of foundation needed to build on these layers of soil (15 minutes).

Material(s) – List of materials for group of 2 students.

- Sandwich baggie of sand
- Sandwich baggie of clay
- Sandwich baggie of gravel
- Sandwich baggie of hummus
- Sheet of plastic to place on tables
- Hand shovel
- Small clear plastic container to place soil & build high rise apartment

Question(s) – How quickly do different types of soils allow water to flow through? Why is this important? Which soil do you think is the sturdiest? Why? What test can you perform to determine solidity of soil for a building structure? What material(s) should the high-rise apartment be made of to withstand testing for earthquake, rain, landslide, and heat?

Logbook Entry – Set goal, sketch layers of soil and design of high-rise apartment, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 20 **Class Activity** – Industrial/Manufacturing Engineering Design Challenge

Instruction – *Problem*: Refine the design of a drinking cup to be sustainable and renewable. Create a cup out of materials that are sustainable and renewable (15 minutes).

Criteria & Constraints: Cup can hold between 8 and 10 oz. of liquid. Cup has to be made out of renewable materials.
EDP Focus: test (step 5) and refine (step 6).

Material(s) – List of materials for group of two students.

- Recycled paper
- Recycled cardboard
- Aluminum foil
- Recycled plastic
- Fabric
- 10 oz. of water

Question(s) – What materials can I use that hold liquid? How can I design a cup that keeps the liquid inside without spilling out?

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 21 **Class Activity** – Mechanical Engineering Design Challenge

Instruction – *Problem*: Design and build a mechanical creature that can move forward (20 minutes). Research mechanical toys (5-7 minutes). Choose materials to build a toy based on a sketch.
Criteria & Constraints: Toy must move forward at least 2 feet. Any supplies from list can be used to create the toy. The power for moving the toy cannot come from a student. The toy needs to move from beginning taped line on the floor to the next taped line. Share toys with entire class. Write in engineering logbook new ideas for refining the design based on ideas from other groups.
EDP Focus: criteria & constraints (step 2) and research & design (step 3).

Material(s) – List of materials for group of two students.

- 2 paper clips
- 2 small gears
- 4 toothpicks
- 1 piece of cardstock
- 2 toothbrushes
- 2 empty tape dispenser rolls
- Variety of small screws
- 1 screwdriver
- 2 empty toilet paper rolls
- 2 bottle caps
- 1 empty soda bottle

- Hot glue
- Hot glue gun
- 2 rubber bands
- 2 magnets

Question(s) – What parts make a toy move? How can a toy move without electricity? How do gears work in a toy?

Logbook Entry – Set goal, include sketch, Explanation of Work and core area of STEM.

Resources – Website for hand crank mechanical toy: https://www.instructables.com/id/Hand-Crank-Mechanical-Toy/

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 22

Class Activity – Nuclear Engineering Design Challenge

Instruction – *Problem*: Create a shut off valve to contain the steam in a nuclear reactor. Sketch a design for a container and shut off valve that contains steam within a holding unit (7-9 minutes). Build the container and shut off valve out of given material (15 minutes). Steam will be created from a wet sponge that is microwaved to create steam. Discussion on containers and how to open containers. For safety, use tongs to transfer the wet sponge from the microwave to the container.
Criteria & Constraints: The container needs to hold a 3x1x4 inch sponge. The "shut off valve" is attached to the container. Some type of mechanism opens and shuts the valve.
EDP Focus: research & design (step 3) and build prototype (step 4).

Material(s) – List of materials for group of two students.

- Cardboard (4x10 inches)
- Hot glue
- Hot glue gun
- Pencil
- 5 paper clips
- 2 plastic cups
- 1 sheet of tin foil
- 3 popsicle sticks
- 2 screws (any size)
- 2 sheets of cardstock
- Microwave oven

Question(s) – What type of container can hold steam? How do you open a container? How can you create a seal for your container that keeps the steam

from escaping? What mechanism will allow the steam to escape when desired?

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 23 **Class Activity** – Petroleum Engineering Design Challenge

Instruction – *Problem*: Design an oil storage tank that allows oil to flow to a different storage tank. Sketch includes labels for measurements, materials and view of design (10 minutes). Build a prototype of this design thinning of the viscosity of the oil. Consider weight of oil, thickness of walls, height of storage tank, diameter of the pipes, and pressure from oil on tank and pipes (15 minutes).
Criteria & Constraints: Oil storage tank and pipes need to fit inside of large plastic tub. Use only provided materials. Share group designs as a whole class and discuss the pros and cons of each design.
EDP Focus: design (step 3), build prototype (step 4) and test (step 5).

Material(s) – List of materials for group of two students.

- Corn syrup (oil)
- Large plastic tub to hold tank in case of spillage
- Paper towels
- 10 straws
- 5 plastic grocery bags
- 5 skewers
- Hot glue
- Hot glue gun
- 1 sheet of cardstock
- 5 index cards (3x5)
- 3 balloons
- 6 inches of plastic wrap
- 6 inches of wax paper
- 6 inches of aluminum foil
- Pencil

Question(s) – How does the weight of the oil change the structure of the storage tank? How can you get the oil to transfer from the tank through the pipes? How can gravity transfer the oil from the tank to the pipe? What type of mechanism will transfer the oil from the tank to the pipe? What do you need to think about to keep the oil flowing?

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of

STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 24 **Class Activity** – Aerospace Engineering Design Challenge

Instruction – *Problem:* Design and build a rocket that will launch 5 feet or higher in the air. Use any given materials to build the rocket (7 minutes). Test the rocket and make modifications. Remember to make changes to the sketch in a different colored pencil (7 minutes). *Criteria & Constraints*: Rocket must launch 5 feet into the air. Use only 5 materials from the given list. Rocket has to launch without human touch (example: throw rocket in air). Launch rockets as a whole class and record height of launch. Compare designs and height of launch to determine best design for 5 foot height. Refine design and relaunch (7 minutes).
EDP Focus: build prototype (step 4) and test (step 5).

Material(s) – List of materials for group of two students.

- Yardstick
- Launch area marked off in painters tape (3x3 inches)
- 2 rubber bands
- 2 empty toilet paper rolls
- ½ sheet cardstock
- 2 bottle caps
- 2 straws
- Sandwich bag
- 1 pencil
- Hot glue
- Hot glue gun
- ½ sheet of foam board (4 x 5 inches)
- Masking tape for launch area

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 25 **Class Activity** – Electrical Engineering Design Challenge

Instruction – *Problem*: Design and create a light up card that explains one of the steps of the Engineering Design Process (15 minutes).
Criteria & Constraints: Use one sheet of cardstock. Can use up to 1.5 feet of conductive adhesive copper tape.
EDP Focus: problem (step 1) and criteria & constraints (step 2).

Material(s) – List of materials for group of two students.

- 1 LED
- Conductive Adhesive Copper tape
- 1 sheet of Cardstock
- Various colors of sharpies or markers
- 1 coin battery
- 1 AAAA battery
- 1 set of alligator clips

Question(s) – How can we make a card that will light up? What materials should we consider for this design challenge? What type of circuit can you use to make the card light up?

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 26

Class Activity – Marine and Ocean Engineering Design Challenge

Instruction – *Problem*: Build a transportation device to move stranded whales from a lower level of water to the deeper ocean.
Criteria & Constraints: Build a floating device to transport beached whales to a deeper section of the ocean (15 minutes). The whales may not be damaged in order to continue living in the ocean. The transportation device must float and cannot touch the bottom of the ocean. The whales must be transported from the "beached" area to the deeper ocean marked by an X on the bottom of the ocean. Test each device for buoyancy and ability to transfer the 4 whales (5 minutes). Share out as a class the strengths and weaknesses of the devices. Then refine the design (7 minutes) and retest.
EDP Focus: build prototype (step 4), test (step 5), and refine (step 6).

Material(s) – List of materials for group of two students.

- 2 sheets of paper
- 3 mailing labels
- 2 note cards
- 2 rubber bands
- 1 balloon
- 2 chenille stems
- 4 paper clips
- 4 plastic whales
- Gallon size baggie of sand
- Container to hold water (no smaller than 16x10x11 inches with one end

raised to 1 inch of water level using sand)

Questions(s) – What do you need to include in your design to contain the whale? What kinds of water transportation devices already exist? How will you change your design based on test results? What kind of movement do you do with your hands when you pick up something? How can you use this movement to help you design your transportation device?

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 27

Class Activity – Mining Engineering Design Challenge

Instruction – *Problem*: Extract mineral deposits from earth. Design and build a mechanism to extract minerals out of sand (20 minutes. Research earth movers.
Criteria & Constraints: Mechanism cannot be larger than 3x5 inches. Mechanism must extract the mineral out of the sand without a student touching the mineral. Adhesives may not be attached to mineral to extract from sand. Use any or all materials to build the mechanism.
EDP Focus: research & design (step 3) and build prototype (step 4).

Material(s) – List of materials for group of two students.

- 1 9/16 inch aluminum foil baking pan
- 1 gallon size baggie of sand
- 5-8 Plastic jewels or minerals in varying size
- Plastic sheeting
- 3 craft sticks
- 2 rubber bands
- 3 mailing labels
- 1 piece of paper
- Scissors to use as a tool
- 4 straws

Question(s) – How will you design a mechanism to dig something out of the sand? How can your digging mechanism also pick up the mineral(s)? What mechanisms are in existence that you could use ideas from the design?

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

Day 28 **Class Activity** – Engineering Safety

Instruction – Safety: Create a list on collaboration boards and then share out. Teacher will review list on board and make additions. For the safety of engineers, make lists of rules/procedures for workers to follow to keep them safe. Examine unsafe situations, identify problems and write rules to be safe.

Material(s) – List of materials for group of four students.

- Pictures of unsafe practices
- White boards or large poster boards
- Markers

Question(s) – What safety rules should be followed by engineers? What do we need to keep in mind when working with tools? How can engineers be safe in their daily tasks?

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Day 29 **Class Activity** – Comparing Engineering Disciplines

Instruction – What do all of these disciplines have in common? Discussion and writing about similarities and differences of engineering fields. (Students create diagrams on collaborative boards and then share as whole class while teacher shares on white board). They all follow the engineering design process. Explain how in small groups and then whole group.

Material(s) – List of materials for group of four students.

- White boards or large poster board
- Markers

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Day 30-37 **Class Activity** – Project Based Learning Invention

Instruction – Student groups of two will apply knowledge learned from each engineering discipline to design and create an invention to use at school or home. The Engineering Design Process will guide the project. Provide a Driving Question for the students to answer with their invention.
Problem: How can we design and build an invention for daily use?
Criteria & Constraints: All materials must be approved by the instructor and based on need for invention. No power tools or machines used within the design. Invention size is dependent on the need for the invention. Label view, measurements and materials on sketch. Initial design (3-5 days). Testing and

refining design (2-3 days). Presentation of invention as a class and invite engineers to review (1 day).
EDP Focus: Engineering Design Process (steps 1-6).

Material(s) – Student choice based on invention design chosen.

Logbook Entry – Set goal, enter findings, Explanation of Work and core area of STEM.

Team Assessment – Groups will fill out Team Assessment at the end of the class period (5 minutes).

2.3 RESOURCES

Tall Tower Lesson: http://www.cre8iowa.org/wp-content/uploads/2010/07/Tall-Tower1.pdf

Create Wind Energy (Pinwheel template): https://www.teachengineering.org/content/cub_/activities/cub_earth/cub_earth_lesson04_activity2_template.pd

Out of my Way!: http://www.cre8iowa.org/wp-content/uploads/2010/07/Out-of-My-Way.pdf

Website for types of Engineering Disciplines: http://www.nacme.org/types-of-engineering

You Inspire Me: https://www.teachengineering.org/activities/view/cub_lifescience_lesson03_activity2

Water Tower: http://www.cre8iowa.org/wp-content/uploads/2012/09/Water-Tower.pdf

Ouch it Hurts (materials): https://www.teachengineering.org/activities/view/bones_sue

Cat Frame Corral: http://www.cre8iowa.org/wp-content/uploads/2012/09/Cat-Frame-Corral.pdf

Website for hand crank mechanical toy: https://www.instructables.com/id/Hand-Crank-Mechanical-Toy/