Unit Title: Shake, Rattle and Roll **Date Developed/Last Revised:** 7/2/13 **Unit Author(s):** Liane Tanigawa	**Grade Level:** 4 **Time Frame:** 1 Quarter **Primary Content Area:** Engineering Design Process

UNIT DESCRIPTION:
This STEM unit focuses on the Engineering Design Process (EDP) and should be implemented at the end of an Earth Science unit.

As structural engineers, students will understand the importance of engineering safe structures that can protect humans from the potential dangers of various natural disasters such as earthquakes. They will collaborate with partners and use the engineering design process to create a unique two-story building that will be able to withstand earthquakes.

Big Ideas (Student Insights that Will Be Developed Over the Course of the Unit):

- Many people live in The Ring of Fire where many fast processes like earthquakes often occur. Engineers design structures that will withstand earthquakes in order to keep people safe from harm.

Essential Questions (Questions that Will Prompt Students to Connect to the Big Ideas):

- How do engineers design and build structures to withstand the forces of an earthquake?

	BENCHMARKS/STANDARDS/LEARNING GOALS
Science	Supporting Science Standards: SC.4.8.1 Describe how slow processes sometimes shape and reshape the surface of the Earth. SC.4.8.2 Describe how fast processes (e.g., volcanoes, earthquakes) sometimes shape and reshape the surface of the Earth.
Technology	CTE Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
Engineering	CTE Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
Mathematics	Supporting Math Standards: CCSS.Math.Content.4.MD.A.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. *For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...*

English Language Arts and Literacy	Supporting ELA Standards: CCSS.ELA-Literacy.W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
STEM Competencies	• Indicator 2:2: Collaborates with, helps and encourages others in group situations • Indicator 3.3: Generates new and creative ideas and approaches to developing solutions

Prior Background Knowledge Needed for Earth Science

- The earth is divided into three layers: the crust, mantle, and core.
- Fast processes include earthquakes, volcanoes, tsunamis, and landslides.
- Slow processes include plate tectonics, weathering, and erosion.
- The theory of plate tectonics – the earth's crust is broken into 6 –13 major plates that move on the upper mantle; these movements cause earthquakes and volcanoes.
- The Pacific Plate interacting with other plates causes the Ring of Fire.
- The hot spot theory explains the formation of the Hawaiian island chain.
- Waves, wind, water, and ice change the shape of the earth.
- Natural landforms in Hawaii are primarily the result of volcanic activity, erosion, and sea level change.

LESSON SEQUENCE

	Lesson Title/Description	Learning Goals (What Students Will Know and Be Able to Do)	Assessments	Time Frame
1	Center of Gravity	Students will know… • The center of gravity needs to be over the base of support • The closer the center of gravity is to the base of support, the easier it is to balance • When body parts extend to one side beyond the base of support, the body needs to make a corresponding extension in the opposite direction to achieve counterbalance Students will be able to… • Use a wooden craft stick, pipe cleaner, and two metal hex nuts to create a system with a center of gravity that can balance on one finger • Explain the relationship between a wide base of support, the center of gravity, and the use of counterbalance to create a stable system of balance	Formative • Teacher Observations/Discussions	1 hour
2	Engineering an Earthquake-Proof Tower	Students will know…. • Six steps of the Engineering Design Process Students will be able to… • Use the Engineering Design Process to design and build a tower that can withstand the effects of a simulated earthquake	Formative: • Teacher Observations/Discussions Summative: • Earthquake-Proof Tower Engineering Design Process Journal • Engineering Design Process Summative Assessment	3-5 45- minute sessions

Suggested Lessons To Teach Prior to the Engineering Design Process (EDP) Performance Task

Go to http://www.livebinders.com/play/play?id=860666 to access more resources for this unit.

Hook –Journey to the Center of the Earth:

If we were to drill a hole to the center of the earth, what would we observe? Describe the layers of the earth using a hard-boiled egg as a model.

From *The Amazing Earth Model Book, "Earth Layers"* (pages 10 – 14)

- The crust is mostly rock approx. 25 miles thick. Under the ocean it's 3-6 miles thick. No one has yet drilled to the bottom of the crust.
- The mantle is very hot. Scientists think the top and bottom parts are rigid rock, but are so hot they flow like thick syrup. The mantle is 1,789 miles thick.
- Because gravity pulls things to the center of the earth, the increased pressure makes the center of the earth solid or the inner core, solid. The outer core is made of liquid iron and nickel.

Geology Lesson 1: Keynotes slideshow with videos and Exploration activities from Discovery Education

Go to http://www.livebinders.com/play/play?id=860666 to access this slideshow.

- Earth Layers Video (4:41)
- Plate Tectonics Video (2:00)
- Folding (1:00)
- Volcanoes (1:00)
- Earthquakes (1:00)
- Exploration – The Earth's Layers

Geology Lesson 2: Keynotes slideshow with videos and Exploration activity from Discovery Education

Go to http://www.livebinders.com/play/play?id=860666 to access this slideshow.

- The Earth's Interior and Crust (4:10)
- Earth Changes Slowly (2:32)
- Earth Changes Quickly (3:38)
- Exploration – Erosion and Deposition
- Exploration – Glaciers
- Exploration – Earthquakes
- Exploration – Volcanoes

Lesson 3: Activity: "Moving Plates"

- Read: *The Amazing Earth Model Book*, pages 110 – 117
- Students create a model of what happens when the earth's plates move and then infer that most volcanic eruptions and earthquakes occur where they do because of plate tectonic interaction.

Lesson 4: Ring of Fire – Students read a short informational passage on the Ring of Fire and color a map

- Deery, Ruth. *Earthquakes & Volcanoes*. New Jersey: Good Apple, Inc., 1985.

Lesson 5: Video – Exploring the Islands

- "Volcanoes on Stage" --Moanalua Gardens Foundation with 'Ohia Project.
- http://www.mgf-hawaii.org/HTML/Television/dlprogramguide.htm
- Video available through DOE TeleSchool website: http://wetserver.net/teleschool/pages/express/index.jsp
- **Formative Assessment** – Students produce a podcast that describes the stages of Hawaiian volcanoes.

END: Teacher-made summative assessment on fast and slow processes

Unit Title: Shake, Rattle and Roll **Lesson Title:** Center of Gravity **Date Developed/Last Revised:** 7/2/13 **Unit Author(s):** Liane Tanigawa	**Lesson #:** 1 **Grade Level:** 4 **Primary Content Area:** Science **Time Frame:** 1 hour

PLANNING (Steps 1, 2, & 3)

Standards/Benchmarks and Process Skills Assessed in this Lesson:

- This lesson does not directly address any grade-level benchmarks, but it is important for the understanding of related concepts within the unit.

2A. Criteria- What Students Should Know and Be Able to Do:

What students should **KNOW**

- The center of gravity needs to be over the base of support
- The closer the center of gravity is to the base of support, the easier it is to balance
- When body parts extend to one side beyond the base of support, the body needs to make a corresponding extension in the opposite direction to achieve counterbalance

What student should be able to **DO**

- Use a wooden craft stick, pipe cleaner, and two metal hex nuts to create a system with a center of gravity that can balance on one finger
- Explain the relationship between a wide base of support, the center of gravity, and the use of counterbalance to create a stable system of balance

2B. Assessment Tools/Evidence:

Formative:

- Teacher Observations/Discussions

3. Learning Experiences (Lesson Plan)

Materials: (per student)

- wooden craft stick
- pipe cleaner
- 2 metal hex nuts

Handouts:

- Balance - Center of Gravity Activity

Other Resources:

- *The Amazing Earth Model Book, Easy-To-Make, Hands-On Models That Teach,* p. 1-24
  - By Donald M. Silver, Patricia J. Wynne

Background Knowledge Needed:

- The earth is divided into three layers; the crust, mantle, and core.
- The theory of plate tectonics – the earth's crust is broken into 6 –13 major plates that move on

the upper mantle; these movements cause earthquakes and volcanoes.
- The Pacific Plate interacting with other plates causes the Ring of Fire.
- The hot spot theory explains the formation of the Hawaiian island chain.
- Waves, wind, water, and ice change the shape of the earth.
- Natural landforms in Hawaii are primarily the result of volcanic activity, erosion, and sea level change.

Procedure:

1. Hook –Journey to the Center of the Earth

- Question: If we were to drill a hole to the center of the earth, what would we observe?
- Describe the layers of the earth using a hard-boiled egg as a model.
- Resource: *The Amazing Earth Model Book*, "Earth Layers" (pages 10 – 14)
- Optional Resource: http://www.teachersdomain.org/resource/oer08.sci.phys.maf.gravitynsn/
    - *Gravity at Earth's Center*: investigate the hypothetical scenario of a person falling into a hole through the center of Earth.
        - (1m 46s video adapted from *NOVA scienceNOW*)

REVIEW FACTS:

- The crust is mostly rock approximately 25 miles thick. Under the ocean it is 3-6 miles thick. No one has yet drilled to the bottom of the crust.
- The mantle is very hot. Scientist think the top and bottom parts are rigid rock but are so hot they flow like thick syrup. The mantle is 1,789 miles thick.
- Because gravity pulls things to the center of the earth and the increased pressure makes the center of the earth solid or the inner core, solid. The outer core is made of liquid iron and nickel.
- Fast processes like earthquakes and volcanic eruptions often occur. Engineers design structures that will withstand these types of natural disasters in order to keep people safe from harm.

2. **Stability/Bases of Support**: Students experiment with their bodies to learn about stability and bases of support.

- Find one base of support - students balance on one base of support – teacher pushes on student to display balance and stability
- Find – 2, 3, 4, 5 bases of support
- More background information
    - http://www.sportnz.org.nz/Documents/Young People/K_5620-3_SPC_A4_3_stability-ff_WEB_balance.pdf
        - *Balance* – a variety of activities that focus on balance and movement skills
    - http://www.algarcia.org/AnimationPhysics/BalanceTutorial.pdf
        - *Physics of Balance & Weight Shift* – explore the center of gravity, locating center of gravity by suspension/support, human center of gravity, human base of support and more!

3. Class Discussion

- What is the body position that would be the most stable, so that you don't topple over?

- Discuss the following concepts:
  - Balance is attained when the center of gravity is over the base of support.
  - The closer the center of gravity is to the base of support, the easier it is to balance.
  - When body parts extend to one side beyond the base of support, the body needs to make a corresponding extension in the opposite direction to achieve counterbalance.

4. Balance/Center of Gravity activity – (see attached handout below)

- Give students the materials and have them explore ways to make a balance stick that would balance on their fingers.
- Option: students create a balance stick following the picture procedures in the handout.
- Students practice balancing the stick on their fingers.
- Discuss the concepts of balancing and the center of gravity.
- Students will use this information on the center of gravity when creating their earthquake tower.

5. Formative Assessment: Class Discussion

- What did we learn from this?
- How will this knowledge help your design your building?

Assessment Option

- Write an explanation about the relationship between a wide base of support, the center of gravity, and the use of counterbalance to create a stable system of balance.

TEACHING & ASSESSMENT (Steps 4, 5, 6, &7) **Completed by teacher after instruction has taken place**
4. Teaching and Collecting of Evidence of Student Learning: Teacher Notes:
5. Analysis of Student Products/Performances - Formative: Teacher Notes:
6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson): Teacher Notes:
7. Teacher Reflection: Replanning, Reteaching, Next Steps: Teacher Notes:

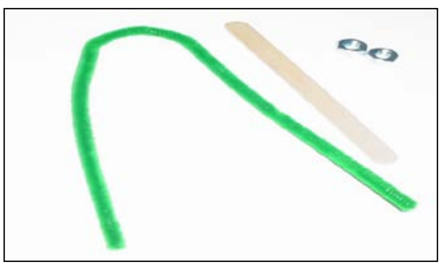
Balance – Center of Gravity Activity

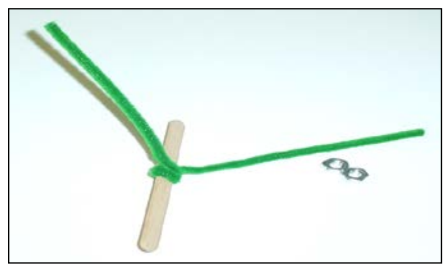
Materials: wooden craft stick, pipe cleaner, 2 metal hex nuts

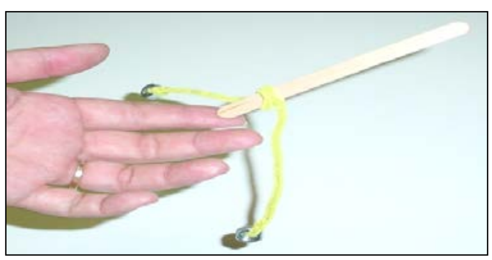
1. Bend the pipe cleaner in half; wrap it around the craft stick two times and twist to hold, ending up with two ends of the pipe cleaner about the same length.

2. Attach a hex nut to each end of the pipe cleaner.

3. Try balancing the system on a fingertip; if it tips over and falls, move the location of the washers or the attachment location.







Kimura, Art. "Brushbot Teacher Workshop." Letry Robot Workshop. Honolulu Community College, Honolulu. 4 May 2012. Lecture.

Unit Title: Shake, Rattle and Roll Lesson Title: Engineering an Earthquake-Proof Tower Date Developed/Last Revised: 7/2/13 Unit Author(s): Liane Tanigawa	Lesson #: 2 Grade Level: 4 Primary Content Area: Science, Engineering Time Frame: 3 one-hour sessions+

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

- CTE Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems

STEM Competencies

- Indicator 2.2: Collaborates with, helps and encourages others in group situations
- Indicator 3.3: Generates new and creative ideas and approaches to developing solutions

2A. Criteria- What Students Should Know and Be Able to Do:

Students will know…

- Six steps of the Engineering Design Process

Students will be able to…

- Use the Engineering Design Process to design and build a tower that can withstand the effects of a simulated earthquake

2B. Assessment Tools/Evidence:

Formative:

- Teacher Observations/Discussions

Summative:

- Earthquake-Proof Tower Engineering Design Process Journal
- Engineering Design Process Summative Assessment

3. Learning Experiences (Lesson Plan)

Materials:

Each group of students needs:

- 1 cardboard base (approximately 25 cm by 25 cm)
- 30 straws
- 100 paper clips (one box) (used as connectors for the straws)
- 20 straight pins
- 2 meters of string

The class needs:

- 10-20 sandbags consisting of 250 grams sand in a sandwich-sized Ziploc bag. The bag should be taped into a sausage- shaped cylinder for rigidity and ease of mounting onto the towers.
- 1 shake table (also called an earthquake table)
- seismometer to record the magnitude size of the earthquake
  Go to: https://itunes.apple.com/us/app/iseismometer/id304190739?mt=8

Handouts/Other Resources:

- Earthquake-Proof Towers Engineering Design Process Journal
- Engineering Design Process Summative Assessment
- Engineering Design Process Rubric
- iSeismometer app https://itunes.apple.com/us/app/iseismometer/id304190739?mt=8

Additional Resources:

- A great, very accessible resource on structural engineering principles with projects that can be adapted for the classroom is the book *The Art of Construction: Projects and Principles for Beginning Engineers and Architects* by Mario Salvadori, Chicago Review Press (1981). http://www.amazon.com/Art-Construction-Principles-Engineers-Architects/dp/1556520808/ref=si3_rdr_bb_product/104-5471696-9833564?ie=UTF8

- This Earthquake Proof Tower was taken and adapted from *A MyScienceBox Lesson Plan* by Irene Salter. This work is licensed under the Creative Commons Attribution-NonCommercial License. To view a copy of this license, visit http://creativecommons.org/licenses/by-nc/2.5/ or send a letter to Creative Commons, 559 Nathan Abbott Way, Stanford, California 94305, USA. http://www.mysciencebox.org

- Optional: Career Awareness
  - Architect Danny Forster discusses the Hoover Dam Overpass, a bridge that will span the Colorado River near the Hoover Dam (Discovery Education)

Teacher Preparation:

- Prepare 10-20 sand bags.

- Make a shake table.

  Marble Design Type
  For instructions, go to: http://www.ehow.com/how_6932544_make-earthquake-shaker-table.html

  Trampoline Design Type
  This activity was inspired by the WGBH production of "Structures", produced and narrated by Bebe Nixon. In this video designed to introduce teachers to inquiry-based teaching methods, students build towers and bridges out of drinking straws to see the maximum amount of weight each tower or bridge can hold. I adapted this lesson as a complement to the plate tectonics unit.

  To create your own very simple earthquake table that is more like a trampoline than a standard, motor-controlled earthquake table:

  1. Cut a piece of board or plywood into a 12" square. If you wish, create a raised edge for your platform by nailing lengths of 1/2" square dowel on top of each of the sides.

  2. Mount wood screws on the underside of the plywood at each corner and at the center of each side. Don't screw the screws in all the way; make sure at least 1/4" sticks up so you can loop a rubber band around it.

3. Construct a frame out of 2” x 4”s that fits around the wood square with around 1/2” clearance between the outer edge of the square and the inside edge of the frame. Make sure the 2” x 4”s are oriented so that the frame is 4” high.

4. Mount wood screws on the top edge of the frame at each corner and at the center of each side. Again, don’t screw in the screws all the way.

5. Loop a rubber band around each pair of screws so that the plywood square is suspended like a trampoline within the frame.

   Powered by an electric drill: Go to http://www.jclahr.com/science/earth_science/shake/

Procedure:

1. Hook: How do fast processes that shape the earth affect our lives?
   - Go to http://www.livebinders.com/edit/index/860666 to access the video
     - Earthquake Towers > Earthquake Restless Planet
     - Earthquake Destruction – National Geographic (0:47)
     - Earthquake 8.9 in Japan Market (1:43)

2. Class Discussion
   - What did you notice about the three different videos?
   - Did the people in Northern California react the same way as the people in Japan?
   - Was the damage the same in both countries? Why or why not?
   - Go back to a Pacific Rim Map showing the plates. Why do you think there are more earthquakes in Japan vs. California? Notice how three plates are interacting near the islands of Japan.

3. Share videos to build students’ background knowledge of structures:
   - Earthquake Resistant Buildings (3:39) Architects for the new San Francisco Oakland Bay Bridge needed to design a structure that could withstand intense earthquakes.

     DragonflyTV: Snow Structures and Straw House: Structures Twin Cities Public Television, 2002. Full Video. *Discovery Education*. Web. 24 May 2013. <http://www.discoveryeducation.com/>.

   - Light Structure (2:04) - Engineers and builders use the least amount of materials to build structures with sound designs.

     Structure Distribution Access, 1999. Full Video. *Discovery Education*. Web. 24 May 2013. <http://www.discoveryeducation.com/>.

<u>Engineering Design Process</u>

- Distribute and explain Earthquake-Proof Towers Engineering Design Process Journal.

  Note: The class will go through each step of the process together. Stop after each step to discuss what the students did and the criteria needed. Teacher may refer to the Engineering Design Process Rubric to help guide discussions. Do the amount of steps you feel your students can handle in the time allotted. It may take one day or many days to go through and understand these steps. Don’t worry… it’s the process that’s important.

- Assign students to engineering teams.

  Note: Although students are part of a team, each student is responsible for completing each part of their own engineering design process journal. The team is there to help brainstorm, share ideas, and create one product, but each student must participate and contribute their individual to help the group.

- Read performance task to students.

  You have been hired as the structural engineer in charge of designing a new 2-story building. Here are the building codes you must follow:
    - *Each floor of the building must support at least 250 grams of weight.*
    - *The building must be able to withstand earthquakes of various magnitudes.*

  An earthquake may be happening soon and many lives will be at stake. People are counting on you to help keep them safe!

Step 1: Ask

- Read the criteria/constraints to the students.
- Show students the materials available to create their Earthquake-Proof Towers. Consider keeping all of the materials on a "materials table" for easy access.
- Have students identify and write in their journals:
    - the problem of the performance task
    - what they are creating
- Have students:
    - write further questions they may have about constructing this Earthquake-Proof Tower
    - share questions with the class for teacher to answer

Stop and go over the criteria for the "Ask" section of the process. The teacher monitors student learning by recording observations of the questions that students are asking. (See Engineering Design Process Rubric.)

Step 2: Imagine

- Instruct students to independently brainstorm ideas for building an Earthquake-Proof Tower and draw or write out ideas in their journal.
- After each student had the chance to express their own ideas, encourage them to discuss their ideas with the rest of the engineering team. Students should defend their reasons for using specific ideas from their prototype. (Ex. I made a wide base so the top would be balanced.)
- Tell students that each engineering team may then decide on ONE person's design to use, or create ONE new hybrid idea incorporating all the differing ideas.

Stop and go over the criteria for the "Imagine" section of the process. The teacher monitors student learning by recording observations of the ideas that students are generating. (See Engineering Design Process Rubric.)

Step 3: Plan

- Designate one person to sketch a diagram of the team's Earthquake-Proof Tower prototype onto a piece of paper. This sketch should include labels for each of the parts and possible measurements. The sketcher must be sure to incorporate all the agreed upon ideas into the design. Students then list all possible materials that will be needed to create the prototype.

- Inform students that when all team members are satisfied with the prototype design, each member should copy this diagram of the tower onto their own journals.
- Instruct team members to check with each other to see if all drawings and labels are completed and everyone has the same plan to follow.

Stop and go over the criteria for the "Plan" section of the process. The teacher monitors students learning by recording observations of the plan that students are creating. (See Engineering Design Process Rubric.)

Step 4: Create
Students build their Earthquake-Proof Tower

- Instruct students to follow their team plan as closely as possible when building their prototype. If students are modifying their original model to make it work, then each person should add these modifications to their own journal diagram plans as well.

Ask teams to share their prototype to the large group, stating what modifications were made to the plan and why.

Stop and go over the criteria for the "Create" section of the process. The teacher monitors student learning by recording observations to see if students are following/modifying their plans (See Engineering Design Process Rubric.)

Step 5: Experiment Test it out!

1. Bring your Earthquake-Proof Tower to the shake table.
2. Teacher will place sand bags onto your tower.
3. Teacher will shake the table for 10 seconds.
4. Students log data onto EDP journals.
5. Students have 1 minute to repair their tower if needed to get it ready for the next testing situation.
6. Repeat steps 2-5 until all sandbags on the different levels have been tested. (See data table on journal.)

Have teams share out their data and the reasons for their results to the class. Teacher may chart the results on a class data table for all students to see and compare. (Students will be learning from each other and using other people's ideas, as well as their own, as they are improving upon their prototype.)

Stop and go over the criteria for the "Experiment" section of the process. The teacher monitors student learning by recording observations of how students collected and analyzed their data. (See Engineering Design Process Rubric.)

Step 6: Improve

- Have each team review the results of their data.
- Repeat the EDP to optimize the product. Students continue to record the following in their journal:
    - Ask: What worked? What didn't work? Why?
      Fill in "Things to consider" part of the journal. This helps the students to think about certain

aspects of their tower that they may not have thought of that they may want to change in the redesign. Students write their ideas on how they are going to modify their towers.

- Imagine: Which variables will they change to make their tower withstand the forces of the earthquake? What is the rationale for the changes?
- Plan: Draw the diagram of the team's 2nd prototype. Label the parts with measurement.
- Create: Build your second prototype following your team's design. Keep to the plan.
- Experiment:
  1. Bring your Earthquake-Proof Tower to the shake table.
  2. Teacher will place sand bags onto your tower.
  3. Teacher will shake the table for 10 seconds.
  4. Students log data onto EDP journals.
  5. Students have 1 minute to repair their tower if needed to get it ready for the next testing situation.
  6. Repeat steps 2-5 until all sandbags on the different levels have been tested. (see data table on journal)
  7. Log data onto student journals.
  8. Write 3 facts comparing the data tables for prototypes 1 and 2.
  9. Do a data analysis and explain the results that you find.

Note: You may go through this EDP cycle many times to get an optimized product that is wanted. It all depends on the amount of time you have available.

Summary and Conclusions:

- Have each team share their earthquake-proof tower, how they modified their tower, a rationale for their changes, and the results. Students may also share what they learned about earthquakes and how people need to prepare themselves for these types of natural disasters.
- Discuss what students have learned about the Engineering Design Process.
- Complete EDP Journal.
- Have students complete EDP Summative Assessment (Use EDP Rubric).

TEACHING & ASSESSMENT (Steps 4, 5, 6, &7)
Completed by teacher after instruction has taken place

4. Teaching and Collecting of Evidence of Student Learning:
Teacher Notes:

5. Analysis of Student Products/Performances - Formative:
Teacher Notes:

6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson):
Teacher Notes:

7. Teacher Reflection: Replanning, Reteaching, Next Steps:
Teacher Notes:

Name ___________________________

Date __________________ #________

Earthquake-Proof Towers Engineering Design Process Journal

A MyScienceBox Lesson Plan by Irene Salter (http://www.mysciencebox.org)

Performance Task

You have been hired as the structural engineer in charge of designing a new two-story building. Here are the building codes you must follow:

- *Each floor of the building must support at least 250 grams of weight.*
- *The building must be able to withstand earthquakes of various magnitudes.*

An earthquake may be happening soon and many lives will be at stake. People are counting on you to help keep them safe!

What is the problem? ____
____
____

What is the task? ____
____
____

Criteria

- The building must fit on the base. Attach your building to the base using pins, paper clips, or string.
- Your building must be at least 36 cm tall.
- Your building has 2 stories that are each at least 18 cm tall (approximately the height of 1 straw).
- Each story must support the weight of at least 1 sand bag (250 grams) without collapsing.
- A construction drawing with measurements and analysis must be submitted before earthquake testing.

- To survive an earthquake test, the building must not collapse for 10 seconds after the earthquake begins. The weights must stay on the building. You have 1 minute to repair any damage to your building in between trials.

Step 1: ASK: Ask questions that pertain to completing the performance task.

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Step 2: IMAGINE: Use your background knowledge to design a tower prototype that is one story and will be able to hold 1 sand bag (250 g). Draw your possible designs and label the parts. Be sure to include your measurements. Be ready to share and discuss your design and explain the rational for your design choices.

Step 3: PLAN: Draw out a diagram of your group's prototype. Remember to label your parts, state the type of material you will be using for that part, and include measurements.

Side View:
Top View:

STEP 4: CREATE: Build your prototype tower following your group's design. Keep to the plan.

STEP 5: EXPERIMENT

Data Table 1 – Test Trials of Earthquake Towers

	Mild Earthquake		Major Earthquake	
	Standing? Yes or No	iSeismograph Reading	Standing? Yes or No	iSeismograph Reading
Tower with 1 sand bag on the first floor				
Tower with 1 sand bag on the 1st floor and 1 sandbag on the 2nd floor				
Tower with 2 sand bags on the 1st floor and 1 sandbag on the 2nd floor				
Tower with 2 sand bags on the 1st floor and 2 sandbags on the 2nd floor				

STEP 6: IMPROVE:

ASK: Looking at your data, answer the following questions:

- What worked? Why?
- What didn't work? Why?

Things to Consider	Did it work?	Why or why not?
Securing the structure to the foundation	Yes A little No	
The length of the tower base	Yes A little No	
Geometric shapes used in the design	Yes A little No	
Was your structure symmetrical or asymmetrical?	Yes A little No	
Sturdiness of your tower	Yes A little No	

IMAGINE: Which variable(s) of your tower will you change to keep it standing after the next series of earthquakes?

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PLAN: Draw out a diagram of your group's 2nd prototype. Remember to label your parts, state the type of material you will be using for that part, and include measurements.

Side View:
Top View:

CREATE: Build your prototype tower following your group's design. Keep to the plan.

EXPERIMENT:

Data Table 2 – Test Trials of Earthquake Towers

	Mild Earthquake		Major Earthquake	
	Standing? Yes or No	iSeismograph Reading	Standing? Yes or No	iSeismograph Reading
Tower with 1 sand bag on the first floor				
Tower with 1 sand bag on the 1st floor and 1 sandbag on the 2nd floor				
Tower with 2 sand bags on the 1st floor and 1 sandbag on the 2nd floor				
Tower with 2 sand bags on the 1st floor and 2 sandbags on the 2nd floor				

Write three facts comparing data tables 1 and 2

Fact 1	
Fact 2	
Fact 3	

Data Analysis: Compare the data from prototype 1 and prototype 2.

1. Which earthquake-proof tower was most effective? __________

2. Conclusions: What changes did you make to your prototype? What effects did those changes make to your final earthquake-proof tower design? (cause/effect)

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3. Do you think your earthquake-proof tower was successful? Why or why not?

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4. If you had more time and materials, what would you do to optimize your tower even more? Explain your thinking.

STEM Competency Rubrics

Community Collaborator

GLO Indicator 2:2 -- Collaborates with, helps and encourages others in group situations

An effective community contributor who is STEM literate will

- Collaborate and make positive contributions to the group toward identifying and achieving task goals
- Consistently assess the group's progress and encourage others to use scientific investigation, a mathematical approach, appropriate technology, and engineering principles towards achieving their goal.

Masterful 5	Skilled 4	Able 3	Apprentice 2	Novice 1
Masterfully collaborates with the group, demonstrating flexibility and efficiency. Fluently adjusts understanding in diverse and difficult contexts to make positive contributions toward identifying and achieving task goals.		Ably collaborates with the group, performing well with knowledge and skill in key contexts. Although lacking flexibility, able to make positive contributions to the group toward identifying and achieving task goals.		Requires ongoing coaching and reminders or highly scripted approaches to collaborate and make contributions to the group toward identifying and achieving task goals.
Provides an insightful assessment of the group's progress characterized by a penetrating and novel viewpoint.		Provides a reasonably critical and comprehensive assessment of the group's progress by considering all points in context.		Unaware of differing points of view or overlooks / ignores other perspectives. Assessment of group's progress is uncritical or tends to be egocentric.
Masterfully encourages others to flexibly and efficiently use scientific investigations, mathematical approaches, appropriate technology, and engineering principles towards achieving their goal.		Ably encourages others to perform well in the use scientific investigations, mathematical approaches, appropriate technologies, and engineering principles towards achieving their goal.		Relies on highly scripted approach to perform scientific investigation, mathematical approach, appropriate technology, and engineering principles towards achieving group goals.

GLO Indicator 3.3: --Generates new and creative ideas and approaches to developing solutions

An complex thinker contributor who is STEM literate

- Examines a broad span of information, recognizes patterns, and narrows the information to reach a diagnosis to the problem
- Uses creativity to generate new and innovative solutions, integrating seemingly unrelated information and considering alternative solutions
- Applies knowledge of science, technology, engineering, and mathematics to identify and solve problems, using systems thinking, modeling, and analysis

Masterful 5	Skilled 4	Able 3	Apprentice 2	Novice 1
Effectively and efficiently examines a broad span of information, recognizes patterns, and narrows the information to develop an insightful and effective critique of information to reach an effective diagnosis to the problem in novel, diverse and/or difficult contexts.		Ably examines a broad span of information, recognizes patterns, and narrows the information to develop a reasonably critical and comprehensive critique of information to reach a plausible diagnosis to the problem in a few key contexts, with limited repertoire, flexibility or adaptability to diverse contexts.		Relies on coaching or highly scripted algorithmic skills, procedures, or approaches to examine information. Is unaware of different points of view and/or prone to overlook/ignore other perspectives in critique of information to reach a scripted diagnosis of the problem.
Provides a powerful and illuminating solution by analyzing and integrating seemingly unrelated information and deeply considers alternate solutions and the significance of all issues involved. Effectively applies knowledge of science, technology, engineering, and mathematics to identify and solve problems using systems thinking, modeling and analysis.		Provides a helpful solution by analyzing and integrating important information and considers solutions and the usefulness of issues involved. Ably applies knowledge of science, technology, engineering, and to identify and solve problems using systems thinking, modeling and analysis.		Provides a simplistic solution by decoding information with little or no sense of wider importance or significance of issues involved, with coaching and/or heavy reliance on highly scripted / algorithmic procedures to apply knowledge of science, technology, engineering, and mathematics.

Name: ______________________________________ Date: ________________

Engineering Design Process Summative Assessment

1. Write the letter (a-f) that matches each of the Engineering Design Process steps.

1. Ask: ________________ 2. Imagine: ____________ 3. Plan: _______________ 4. Create: _____________ 5. Experiment: _________ 6. Improve: ___________	a. Test out prototype and collect data. b. Brainstorm ideas of possible solutions. c. Identify the problem and get more information about that problem. d. From your possible solutions, chose the best idea and draw a prototype. e. Review data and redesign your product to make it better. f. Follow the plan and make your design.

2. Explain what you did in this project for each step of the Engineering Design Process.

Ask: ____

____

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Imagine: ____

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Plan: ____

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Create: ____

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Experiment: ____

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Improve: ____

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3) What did you learn about the Engineering Design Process?

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Engineering Design Process Rubric

	Advanced (ME)	Proficient (M)	Partially Proficient (DP)	Novice (WB)
ASK	☐ Clarifies the problem clearly ☐ Forms the conditions and limitations on their own ☐ Obtains information from prior knowledge and other sources with citation by self	☐ Clarifies the problem ☐ States all the conditions and limitations ☐ Obtains information from prior knowledge by self	☐ Needs more clarification of the problem ☐ States most conditions and limitations ☐ Obtains information from prior knowledge (drawn out by teacher)	☐ Problem is unclear ☐ States few (or no) conditions and limitations ☐ Information given by teacher
IMAGINE	☐ Brainstorms a variety of innovative ideas ☐ Innovative ideas are relevant to the problem	☐ Brainstorms a complete idea ☐ Idea is relevant to the problem	☐ Brainstorms an incomplete idea ☐ Idea is somewhat relevant to the problem	☐ Unable to brainstorm ideas, teacher assistance needed ☐ Brainstormed ideas have little relevance to the problem
PLAN	☐ Chooses the best possible idea that is testable ☐ Draws a useable and accurate prototype design with more than 2 views to scale ☐ Lists all materials needed that are affordable, obtainable, and safe	☐ Chooses one idea that is testable ☐ Draws a useable prototype design with multiple views to scale ☐ Lists all materials needed	☐ Chooses an idea that may be testable ☐ Draws a somewhat useable prototype design with multiple views with inaccurate or incomplete measurements ☐ Most materials needed are listed	☐ Chooses an idea that is not testable ☐ Draws an unusable prototype design with one or more views ☐ Incomplete or inaccurate lists of materials (assistance needed)
CREATE	☐ Able to follow their design plan accurately ☐ Able to improve original design to optimize performance	☐ Able to follow their design plan, with some inaccuracies ☐ Able to add to the original design to make the design work	☐ Able to follow most of their design plan with multiple inaccuracies ☐ Able to add to the original design, but design may still not work	☐ Unable to follow their design plan ☐ Sticks to original design although it may not work
EXPERIMENT	☐ Collects and records detailed data accurately and completely ☐ Analyzes data by comparing patterns and relationships accurately with logic	☐ Collects and records data accurately and completely ☐ Analyzes data by showing patterns or relationships accurately	☐ Collects and records data. Some data may be incomplete or inaccurate. ☐ States obvious patterns or relationships	☐ Data collection inaccurate and incomplete ☐ States obvious patterns or relationships with assistance
IMPROVE	☐ Reviews data to make logical decisions to optimize product ☐ Repeats process until an optimized product is reached with greatly improved data	☐ Reviews data to make decisions to redesign product ☐ Repeats process to optimize a product. Data may/may not show improvement	☐ Reviews data to make decisions to redesign product with assistance ☐ Repeats process to improve product with some assistance	☐ Unable to review data to make decisions to redesign product (assistance needed) ☐ Does not repeat process to improve product or repeats process with much assistance