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| Bridges and Structures   * Grade Four | |
| Focus of Unit:  Earth’s Systems: A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. | |
| Unit Overview:  Students build an understanding of engineering and design principles and learn how engineers construct bridges and structures that can better withstand earthquakes. Examples of these principles include: distribution of mass, center of gravity, compression and tension.  Students learn to value collaboration, teamwork, failure and iteration as integral parts of the design process. | |
| Materials to have on hand for various building challenges and explorations:  -Spaghetti  -Masking Tape  -String  -pipe cleaners  -twist ties  -drinking straws  -copier paper (collect mistakes from the copy machine to use in challenges.)  -washers (square, 1 inch pattern block tiles can be substituted for washers.)  -cardstock paper  -used file folders  -paper lunch bags  -Manila Envelopes  -Ziploc bags - Sandwich size and Gallon size  -scotch tape  -cardboard squares 9” x 9” and 12” x 12”  -elmer’s glue - other kinds of kid friendly glue  -Toothpicks  -Aluminum Foil  -paper towel and toilet paper cardboard tubes  Items like marshmallows and gumdrops will dry out, so they should be purchased shortly before a design challenge that uses them. | |
| C  O  N  T  E  N  T  S  T  A  N  D  A  R  D  S | Core Content:  **Engineering Design:**  Students who demonstrate understanding can:  **3–5-ETS1-1.**  Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.  **3–5-ETS1-2.** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.  **3–5-ETS1-3.** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.  **Earth’s Systems: Processes that Shape the Earth**  **ESS2.E: Biogeology**   * Living things affect the physical characteristics of their regions. (4-ESS2-1)   **ESS3.B: Natural Hazards**   * A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2)   **ETS1.B: Designing Solutions to Engineering Problems**   * Testing a solution involves investigating how well it performs under a range of likely conditions. (secondary to 4-ESS3-2)   Science and Engineering Practices:  **Planning and Carrying Out Investigations**  Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.   * Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)   **Analyzing and Interpreting Data**   * Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. * Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2)   **Constructing Explanations and Designing Solutions**  Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.   * Identify the evidence that supports particular points in an explanation. (4-ESS1-1)   Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2)  Cross-Cutting Concept(s):  **Cause and Effect** (4-ESS2-2)   * Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS2-1),(4-ESS3-2)     **-----------------------------------------------**  ***Connections to Engineering, Technology,***  ***and Applications of Science***    **Influence of Engineering, Technology, and Science on Society and the Natural World**   * Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS3-2)     **-----------------------------------------------**  ***Connections to Nature of Science***    ***Scientific Knowledge Assumes an Order and Consistency in Natural Systems***  Science assumes consistent patterns in natural systems. (4-ESS1-1)  California English Language Development Standards:  <http://www.cde.ca.gov/sp/el/er/documents/sbeeldstdg4c.pdf>   1. Interacting in Meaningful Ways: 2. Collaborative   1. Exchanging information and ideas with others through oral collaborative discussions on a range of social and academic topics  3. Offering and supporting opinions and negotiating with others in communicative exchanges SL.4.1,6; L.4.1,3,6  4. Adapting language choices to various contexts (based on task, purpose, audience, and text type)  B. Interpretive  5. Listening actively to spoken English in a range of social and academic contexts SL.4.1‐3; L.4.3  6. Reading closely literary and informational texts and viewing multimedia to determine how meaning is conveyed explicitly and implicitly through language  C. Productive  9. Expressing information and ideas in formal oral presentations on academic topics SL.4.4‐6; L.4.1,3,6  10. Writing literary and informational texts to present, describe, and explain ideas and information, using appropriate technology W.4.1‐10; L.4.1‐3,6  11. Supporting own opinions and evaluating others’ opinions in speaking and writing W.4.1,4,9‐10; SL.4.4,6; L.4.1‐3,6  12. Selecting and applying varied and precise vocabulary and other language resources to effectively convey ideas W.4.4‐5  Writing Standards:  **W.4.7** Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-ESS1-1),(4-ESS2-1)  **W.4.8** Recall relevant information from experiences or gather relevant information from print and digital sources; take notes, **paraphrase**, and categorize information, and provide a list of sources. **CA** (4-ESS1-1),(4-ESS2-1)  **W.4.9.a,b** Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-ESS1-1)  Math Standards and Practices:  **MP.2** Reason abstractly and quantitatively. (4-ESS1-1),(4-ESS2-1),(4-ESS3-2)  **MP.4** Model with mathematics. (4-ESS1-1),(4-ESS2-1),(4-ESS3-2)  **MP.5** Use appropriate tools strategically. (4-ESS2-1)  **4.MD.A** 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. (4-ESS1-1),(4-ESS2-1)  [**4.MD. 2**](http://www.corestandards.org/Math/Content/4/MD/A/2)Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. (4-ESS2-1),(4-ESS2-2)  **4.OA.1** Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations. (4-ESS3-2) |
| Assessment:  Quantitative data in the form of graphic organizers or student project journal entries can be collected and examined.  Qualitative data in the form of video taped student conversations during explorations, teacher observation notes, debriefing conversations with students; team prepared oral and written reports after activities, students or teams create posters to illustrate project.. | |

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|  | Teacher will…. | Students will…. |
| Introduction: | Provide clear instructions:  Create a large Chart paper document on the wall/board with materials and challenge rules listed, so students can refer back to it as they work in their teams. Key vocabulary may go on this chart.  Tell students:  Where to get materials  How to use materials  How to collaborate in a positive way with their teammates.  Provide key vocabulary and language forms for the lesson: what are the key academic vocabulary and language forms students will need to describe their observations in the exploration?  Teacher should:  Create groups of 2-4 students, depending on the activity  or  set ground rules for how to choose a partner or team so no one in class is excluded. If this option is selected, monitor group selection closely.  Assign roles in teams such as:  **Materials Manager 1-** gets materials  **Materials Manager 2** - puts materials away  **Facilitator** - makes sure every student gets a chance to share his or her ideas with the group.  Makes sure everyone understands and follows the rules of the challenge.  **Reporter -** reports to the class about the group’s work and process.  Optional:  Provide a graphic organizer and have students record:  key vocabulary  materials list  rules and/or steps of the activity  or  Write these into a journal | Listen carefully to instructions  Know where to look for reminders of the design challenge rules and materials  Ask clarifying questions before the challenge time begins.  Respect the teacher’s group and role assignment  or  Choose group mates mindful of the need to include all students.  Optional:  Students write down the key vocabulary, materials needed and activity rules on a graphic organizer provided or in a journal. |
| Student Exploration: | Teacher walks around room  Make sure students are following the rules of the challenge or activity.  Direct students back to the Chart paper for directions and materials reminders.  Make mental or take written note of how students work together and note comments you hear that are good examples of teamwork and collaboration.  Keep track of time to give warnings when 10 minutes and five minutes remain to challenge.  Have students stop in the middle of the time (pause timer) and do a “room walk” to see what other teams are doing. | Follow the rules of the challenge or activity. Including stopping when time is up and stopping if the teacher asks them to stop for a “room walk.”  Fulfill the assigned role  Work cooperatively with the team to complete the challenge.  Get help from teammates.  Ask questions, give ideas, listen to each other, try different ideas.  Learn to accept challenges, “being stuck” and failure as part of the process of learning. |
| Closure/  Summary: | Allow time for students to talk with their team about what they will report about their project  Allow time for teams to report out about their work.  Allow reflection and recording time for students to fill out the graphic organizer or add reflections to a journal. | Talk about what they did and how the team worked together.  Decide what the reporter should share with the class.  Report out to class and discuss.  Reflection time:  Fill out Graphic Organizer or Journal  Draw sketches of results and make notes |
| Thoughts on Academic Language and Vocabulary:  It is important that academic language and vocabulary be explicitly taught and modeled when doing these activities. This is true for Limited English Proficient (LEP) students as well as students considered to be Fully English Proficient (FEP) and even Native English Speakers. Be open to exploring the best way to introduce key vocabulary to your students. Sometimes it works well to allow students time to discover concepts through exploration. Once students have discovered concepts and are struggling to find language to describe their observations, the teacher can introduce language and vocabulary to help them. I try to avoid limiting students with assumptions about what they should learn from the activity that may emerge when learning vocabulary up front. However, I have also found that frontloading, giving students some of the key terms before they begin an exploration, can help them make more in depth observations, using the key terms in their descriptions.  The article linked here is helpful not only for teaching the Next Generation Science Standards to English Language Learners, but really for all kinds of learners. http://blog.colorincolorado.org/2015/02/25/seven-steps-to-using-next-generation-science-standards-with-ells/ | | |

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| Suggested Lesson Order:  Note: Lessons listed below include website links to complete lesson plans. Materials and design challenge rules should be adapted to fit the time, space and materials you have available. |
| 1. **Marshmallow Challenge:**   <http://teachers.egfi-k12.org/marshmallow-design-challenge/>  This activity helps students learn the importance of teamwork and how engineers learn from failures. This activity can be done more than once through the course of the unit, materials and expectations of the challenge can be changed to provide more learning opportunities.  Vocabulary Ideas: (Draft) Angles, triangles, structures, construction, free-standing, weight bearing, connections, iteration  Other building challenges:  **Marshmallow and Toothpick Buildings**  <http://knowitall.scetv.org/careeraisle/resources/related/ccjan10/Marshmallow%20Tower%20Activity.pdf>  Related Video:  <https://youtu.be/y6FmrOS72EA>  Other building challenge ideas:  <http://www.pbs.org/wgbh/buildingbig/educator/act_cha_ho.html> |
| 2) **Center of Mass: Balancing Birds**  <https://www.teachersource.com/downloads/lesson_pdf/CTR-200.pdf>  This activity helps students understand how the center of mass can change depending on how the mass is distributed. Bird can be copied onto cardstock paper. You will need two pennies per bird and some scotch tape for this activity.  Vocabulary Ideas: (draft) Balance, Mass, Gravity, center of mass, center of gravity, distribution of weight, support  Other Center of Gravity/Center of Mass Activities:  <http://www.exploratorium.edu/xref/exhibits/center_of_gravity.html>  <http://visit.exploratorium.edu/events/wp-content/uploads/2009/11/activities/Forks_and_Corks.pdf> |
| 3) **Paper Bridge Building:**  <http://www.pbs.org/wgbh/buildingbig/educator/act_paper_ei.html>  This collaborative building activity supports the understanding that even weak materials can be made stronger given the right design choices. My class used one inch pattern block squares instead of washers or coins. Watch for books or desks that are more or less than the 20 cm or 8 inches apart described in the challenge rules. Weights should only be on the paper over the gap, not on the desks or books. This is a great activity to do multiple times so kids can try different design strategies and learn from success and failure.  Vocabulary Ideas: (draft) models, materials, design, iteration, design considerations  Link to a presentation that you can adapt to show the challenge rules to your class.  <https://docs.google.com/presentation/d/18hIH3p94ox5y8gSapZwEQRMsCEdYyVKcnOZL5TxXfU8/edit?usp=sharing> |
| 4) **Resonance Rings:**  [http://w.exploratorium.edu/snacks/resonant\_rings/ ww](http://www.exploratorium.edu/snacks/resonant_rings/)  This is an activity I did with each student creating his/her own model of the resonance rings. As noted in the activity - This device graphically demonstrates that objects of different sizes and stiffnesses tend to vibrate at different frequencies.  Vocabulary Ideas: (draft) Resonance, materials, vibrations, frequencies, demonstration, model, mass, inertia, force  Related Video  Resonance leads to disaster - The Tacoma Bridge Collapse  <https://youtu.be/XggxeuFDaDU>  Why do buildings fall in earthquakes?  <http://ed.ted.com/lessons/why-do-buildings-fall-in-earthquakes-vicki-v-may> |
| Culminating Activity:  **Strain some Pasta - Seismic Activity**  <http://www.exo.net/~emuller/activities/seismic%20engineering/Strain%20Some%20Pasta-Seismic.pdf>  This activity is designed for grades 6 - 12. In our first iteration only one of six groups in my class had success creating a standing structure with the materials given in this challenge. We adapted the challenge by providing extra materials when needed to avoid student frustration. We also decided to do 3-4 iterations of this specific building challenge. Most groups had increased success in creating free standing structures on the third or fourth attempt. Since we ran out of time to create the earthquake rumble table, we opted to simply display the finished structures at Open House.  Vocabulary Ideas: (draft) free standing, structure, construction, cross-bracing, base, foundation, balance, support, iteration  Here are links to videos we showed our students between iterations to enhance their solution strategies.  <https://www.youtube.com/watch?v=NUzkh_2hS24&feature=youtu.be>  <https://youtu.be/JwapuC2-VlA>  Strongly recommended: make video of the building and destruction phases to allow review and further discussion to enhance learning from these design challenges. These can also be used to assess student learning.  Graphic Organizers created by Gina Tanner and Ed Malaret of Mary E. Silveira school, San Rafael, CA:  https://drive.google.com/file/d/0BxqPOd1j5EjdQld0YWg2LWZJd1k/view?usp=sharing  https://drive.google.com/file/d/0BxqPOd1j5EjdLWY3N3Jka1JlMGc/view?usp=sharing |