| **Wood: The Ultimate Building Material**  Author: Dan Bollock ASEC 545 | | |
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| **Unit Overview** | | |
| **Target Audience:**  Middle school (grade 6-8) | **Est. Time:** Three 55-minute class periods | **Content Area(s):** Science, Environmental Science |
| **Abstract:**  Wood is an amazing building material. It is strong, lightweight, and grows on trees. Wood is the only building material that is biodegradable, renewable, and recyclable. In this mini unit students will learn about the buoyancy, density, specific gravity, and strength of different wood species, then they will design and make quarter scale chairs. The chairs will be tested and students will discuss the results. All woods have different properties. Some woods are less dense and some are very dense. Some woods are strong and some are weak. Students will do inquiry and problem-based learning in this mini unit. They will use what they learn about the density and strength of two different wood species in the first two lessons to design and make a chair. Everyone will break their chairs on a test apparatus. STEM will be integrated throughout all three lessons. Students will do several experiments in the first two lessons. They will collect and analyze data. In the third lesson they will use engineering skills to design and make chairs using the information they learned in the first two lessons. After testing the chairs, they will use math and science skills to analyze the results. Students will learn that there are often trade-offs between weight and strength when designing a product. A good design finds the proper balance between the two. | | |
| **Unit Goals/Objectives:**   1. Be able to calculate volume, density, and specific gravity of a material. 2. Be able to predict if a material will sink or float in water given the materials specific gravity. 3. Be able to identify how density and buoyancy are related. 4. Be able to develop and perform tension and bending tests for material strength. 5. Be able to predict the relative strength of different wood species given their densities. 6. Design and make a chair using two different species of wood and different arrangement of parts. | | |
| **Lesson Summaries:**  Lesson 1: *Wood Density and Buoyancy*  Students will apply an Inquiry-based learning approach to calculate volume, density, the specific gravity of objects, and predict buoyancy from the object gravity. Students will explain that different wood species have different properties like density and buoyancy and will articulate how wood responds to changes in humidity.  Lesson 2: *Wood Strength*  Students will apply an Inquiry-based learning approach to explain the three standard tests when assessing the strength of materials, explain that wood strength varies among different wood species, articulate how wood strength properties vary depending on the direction of applied force in relation to the wood grain direction, and explain that wood strength is directly related todensity*.*  Lesson 3: *Design,* m*ake, and break a chair. (Project-based teaching)*  *Students will apply a project-based learning approach to d*esign an object while reducing weight and increasing strength, evaluate a design to determine if it meets certain weight and strength criteria, analyze data from tests and explain why some designs were stronger and some weaker, and create new designs by looking at test results to improve strength and decrease weight. | | |
| **Lesson Timeline:**  **Lesson 1 (55 minutes):**  Introduction: *5 minutes*  Perform sink or swim wood block test: *5 minutes*  Measure and weigh wood and water: *25 minutes*  Perform density and specific gravity calculations: *10 minutes*  Discuss results: *10 minutes*  Teach hygroscopic nature of wood: *5 minutes*  **Lesson 2 (55 minutes):**  Introduction: *5 minutes*  Review: *5 minutes*  Teach about building materials: 5 *minutes*  Teach that wood is recyclable, renewable, and biodegradable: *10 minutes*  Perform bending test: 20 *minutes*  Discuss results and show how density and strength are related: *10 minutes*  **Lesson 3 (55 minutes):**  Introduction: *5 minutes*  Review: *5 minutes*  Teach about the design criteria for designing a chair: *5 minutes*  Design and make chairs: 20 *minutes*  Test the chairs: *15 minutes*  Discuss results: *5 minutes* | | |
| **Standards:**  NGSS Standards for Middle School Engineering Design  Indiana State Standards  Science and Engineering Process Standards (SEPS) | | |
| **STEM Integration within the Unit:**  STEM will be integrated throughout all three lessons. Students will do several experiments in the first two lessons. They will collect and analyze data. In the third lesson they will use engineering skills to design and make chairs using the information they learned in the first two lessons. After testing the chairs, they will use math and science skills to analyze the results. Students will learn that there are often trade-offs between weight and strength when designing a product. A good design finds the proper balance between the two. | | |

| **Lesson 1: *Wood Density and Buoyancy*** | | | |
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| **Est. Time:** 55 minutes | | | |
| **Lesson Learning Goals/Objectives:**   1. Be able to calculate volume, density, and specific gravity of objects. 2. Be able to predict buoyancy given the specific gravity of an object. 3. Explain that different wood species have different properties like density and buoyancy. 4. Articulate how wood responds to changes in humidity. | | **Standards:**  **8.C.1:** Solve real-world problems with rational numbers by using multiple operations.  **8.GM.2:** Solve real-world and other mathematical problems involving volume of cones, spheres, and pyramids and surface area of spheres.  **6.C.3:** Solve real-world problems with positive fractions and decimals by using one or two operations. | |
| **Assessments**  **Pre-Assessment:**  **Formative:**  Student questioning and discussions  **Summative:** | | | |
| **Concept Prerequisites or Background Knowledge Needed:** | | | |
| **Vocabulary:**  Hygroscopic, density, buoyancy, volume | | | |
| **Materials & Technology Needed:**   * One tub of water per group * Three wood blocks per group * Scales and calipers * Calculators * Pencils | | | |
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| **Lesson Component** | **Instructions** | | **Materials** |
| **Introduction**  *5 minutes* | Tell students about the amazing building material that grows on trees. Discuss plans and goals for lessons. Divide students into groups of two or three. | |  |
| **Instructional Activities**  *30 minutes* | **Sink or swim wood block test (5 minutes)**  Ask students:   * Which wood block will sink, and which will float? Why? | | * One tub of water per group * Three wood blocks per group |
| Measure dimensions and weight of wood blocks and a sample of water (25 minutes)   * Explain that digital scales and calipers are used to get accurate data. These are instruments that scientists use. * Students weigh all three blocks of wood. * Students measure the length, width, and height measurements of all three wood blocks. * Students weigh a cup of water. Give students the volume of a cup of water. * Ask students how to calculate volume. Then have students calculate the volume of wood blocks using the formula Volume=height x width x length. * Ask the students how to calculate density. Then have students calculate density of the tree blocks and the water using the formula Volume=weight/volume. * Students calculate the specific gravity of the water and the three wood blocks by using the formula Specific Gravity=Density of object/density of water. | | * Scales and calipers * Calculators * Pencils |
| **Wrap Up,**  **Synthesis/Closure**  *5 minutes* | Ask students:   * Do you see a relationship between buoyancy and specific gravity by looking at the values calculated? * Can the water be altered to change the buoyancy?   Teach about the hygroscopic nature of wood.   * Ask students if the wood can be altered to make it more or less buoyant? | |  |
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| **Resources:** Worksheet | | | |

| **Lesson 2: *Wood Strength*** | | | |
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| **Est. Time:** 55 minutes | | | |
| **Lesson Learning Goals/Objectives:**   1. Explain the three standard tests when assessing the strength of materials. 2. Explain that wood strength varies among different wood species. 3. Articulate how wood strength properties vary depending on the direction of applied force in relation to the wood grain direction. 4. Explain that wood strength is directly related to density. | | **Standards:**  **8.C.1:** Solve real-world problems with rational numbers by using multiple operations.  **8.GM.2:** Solve real-world and other mathematical problems involving volume of cones, spheres, and pyramids and surface area of spheres.  **6.C.3:** Solve real-world problems with positive fractions and decimals by using one or two operations. | |
| **Assessments**  **Pre-Assessment:**  **Formative:**  Review lesson 1, discussion, student records  **Summative:** | | | |
| **Concept Prerequisites or Background Knowledge Needed:**  Density, wood grain, buoyancy | | | |
| **Vocabulary:**  Hygroscopic, density, buoyancy, compression, tension | | | |
| **Materials & Technology Needed:**   * Paper and pencil * Tested wood specimens * Two different species of wood toothpick size specimens * Weights * Two different wood species per group * Tape measure | | | |
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| **Lesson Component** | **Instructions** | | **Materials** |
| **Introduction**  *10 minutes* | **Discuss plan and goals for lesson (5 minutes)**  **Review what students learned in lesson 1 (5 minutes)**  Ask:   * Who can tell me what we did in lesson 1? | |  |
| **Instructional Activities**  *35 minutes* | **Teach about material testing (5 minutes)**  Explain about compression, tension, and bending tests | | * Tested wood specimens |
| **Tensile test activity (15 minutes)**   * Have groups predict how much weight it will take to break the toothpick size sample. * Add weights until it breaks. * Record the data. * Repeat for other species. | | * Two different species of wood toothpick size specimens * Weights |
| **Bending test activity (15 minutes)**   * Each group performs a bending test on both samples * Record the data. | | * Two different wood species per group * Tape measure |
| **Wrap Up,**  **Synthesis/Closure**  *10 minutes* | **Discuss Results**  Ask students if they see a correlation between density and strength | |  |
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| **Resources:** | | | |

| **Lesson 3: *Design, make, and break a chair.*** | | | |
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| **Est. Time:** 55 minutes | | | |
| **Lesson Learning Goals/Objectives:**   1. Design an object while reducing weight and increasing strength. 2. Evaluate a design to determine if it meets certain weight and strength criteria. 3. Analyze data from tests and explain why some designs were stronger and some weaker. 4. Create new designs by looking at test results to improve strength and decrease weight. | | **Standards:**  **8.C.1:** Solve real-world problems with rational numbers by using multiple operations.  **8.GM.2:** Solve real-world and other mathematical problems involving volume of cones, spheres, and pyramids and surface area of spheres.  **6.C.3:** Solve real-world problems with positive fractions and decimals by using one or two operations.  **MS-ETS1-1:** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.  **MS-ETS1-2:** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.  **MS-ETS1-3:** Analyze data from test to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success  **MS-ETS1-4:** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. | |
| **Assessments**  **Pre-Assessment:**  **Formative:**  Review previous lessons, student discussions  **Summative:**  Building and breaking a chair | | | |
| **Concept Prerequisites or Background Knowledge Needed:**  The three standard tests when assessing the strength of materials, wood strength varies among different wood species, wood strength properties vary depending on the direction of applied force in relation to the wood grain direction, wood strength is directly related to density, wood responds to changes in humidity | | | |
| **Vocabulary:**  Hygroscopic, density, buoyancy, compression, tension, apparatus | | | |
| **Materials & Technology Needed:**   * Pencils * Quarter-scale chair parts * Glue * Scale * Test apparatus and weights | | | |
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| **Lesson Component** | **Instructions** | | **Materials** |
| **Introduction**  *10 minutes* | **Discuss plan and goals for lesson (5 minutes)**  **Review what students learned in lesson 1 and 2 (5 minutes)**  Ask:   * Can someone summarize what we learned in lessons 1 and 2 in two sentences? | |  |
| **Instructional Activities**  *30 minutes* | **Build a Chair Activity (20 minutes)**  Introduce activity:   * Tell students about standards for chair strength. * Tell students about my experience as a woodworker. * Today you are going to make a chair and break a chair. * The object is to make the chair light but strong. * We will weigh the chair and measure how much weight it can hold. * Each group will try to have the highest ratio of strength divided by weight. | | * Quarter-scale chair parts * Glue * Scale |
| **Break a Chair Activity (20 minutes)**   * Each group will put their chair on the test apparatus. Weights will be added until failure occurs. * Record the data * Divide the strength weight by the chair weight | | * Test apparatus and weights |
| **Wrap Up,**  **Synthesis/Closure**  *5 minutes* | * Ask what the students learned. * How would they change their designs? | | **•** Pencils |
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| **Resources:** | | | |