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# Age Levels:

* Grades 11-12
* Subjects: Environmental Science, Engineering Design Development

# Total Time Required:

### (10) 50 minute classes

* (18) 90 minute classes

# Prepared by:

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# Unit Objectives:

Students will be able to:

* Describe the locations and potential life-threatening conditions of areas that are likely to be hit by natural disasters such as hurricanes, earthquakes, volcanoes, tornadoes and fires.
* Describe the ways that arthropods design their homes that are well suited to their habitats using specific shapes, materials and architecture.
* Design, build, and test an apparatus to reduce the turbidity of water as a preliminary step in preparation of water for human consumption.
* Experiment with solar power, wind power and hydropower; building an understanding of how these alternative energy sources may be implemented in times of crisis.
* Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

# Science Standards and Standards for Technology Literacy:

**Environmental Science**

**Env.2.4** Recognize and describe the different sources of energy, including fossil fuels, nuclear, and alternative sources of energy provided by water, wind, geothermal, biomass/biofuels, and the sun.

**Env.2.8** Cite examples of how all fuels, renewable and nonrenewable, have advantages and disadvantages that society must question when considering the trade-offs among them, such as how energy use contributes to the rising standard of living in the industrially developing nations.

**Engineering Design and Development**

**STL 5** Students will develop an understanding of the effects of technology on the environment.

**STL 6** Students will develop an understanding of the role of society in the development and use of technology.

**STL 10** The role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

**STL 13** Student will develop abilities to apply the design process.

**STL 16** Students will develop an understanding of energy and power technologies.

**STL 20** Student will develop an understanding of construction technologies.

## **Standards for Technology Literacy**

**11-12.LST.1.1:** Read and comprehend science and technical texts within a range of complexity appropriate for grades 11-CCR independently and proficiently by the end of grade 12.

**11-12.LST.2.2:** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

**11-12.LST.4.3:** Synthesize information from a range of sources (e.g., *texts, experiments, simulations*) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

**11-12.LST.7.1:** Conduct short as well as more sustained research assignments and tasks to answer a question (including a self-generated question), test a hypothesis, or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

# Recommended Instructor Preparation

Lesson Plan: Natural Disasters – Locations and Impacts

# Lesson Focus:

Students should be able to describe the types of life-threatening conditions people have to endure in natural disaster-prone locales.

# Total Time Required:

* (1) 50 min. period
* (1) 90 min. period

# Lesson Objectives:

Students will be able to:

* Describe the locations and potential life-threatening conditions of areas that are likely to be hit by natural disasters such as hurricanes, earthquakes, volcanoes, tornadoes and fires.

# Equipment and Materials

|  |  |
| --- | --- |
| Tools and Materials | Quantity Needed |
| Internet access | per group |
| Electronic poster resources | per group |

## Special Notes on Materials:

**Lesson Procedures:**

1. Natural Disasters
   1. Organize students into groups of four and have them discuss the following questions to consider the impacts of natural disasters and what locations are most likely to experience severe weather conditions around the world.
      1. What are seven most common natural disasters that impact a large amount of the population today?
      2. What types of loss do people experience when impacted by natural disasters?
      3. What are some of the major needs that people have following natural disasters?
      4. When a large portion of a community or city is negatively impacted by natural disaster, what help from the federal government is available?
      5. What are the most common resources that are supplied by organizations during natural disaster relief efforts?
      6. What are some resources that are not supplied that would benefit survivors during the relief process?
      7. What would be your biggest personal challenges if you were to experience a catastrophic event resulting from a natural disaster?
   2. Provide opportunity for classroom discussion based upon the guiding questions and have each group provide feedback from their small group discussions.
2. Research
   1. Have students research common locations of the following natural disasters:

Hurricanes

Earthquakes

Tornadoes

Volcanoes

Forest fires

Tsunamis

Flood/Monsoons

b. Have students research the major challenges that would be faced in each of the above listed locations that could be impacted by natural disasters.

c. Have students select three of the seven catastrophic events and highlight the main points of their research in an electronic infographic.

d. Have students submit their infographic via electronic submission or per teacher discretion.

3. Closing Questions

1. What is one thing you were most surprised by from your research about natural disasters?
2. What role do local organizations play in the disaster relief effort even though they may also have suffered losses?

*Note:*

# Student Resources:

Electronic Infographic Resources:

[www.canva.com/create/posters](http://www.canva.com/create/posters)

[www.piktochart.com/formats/posters](http://www.piktochart.com/formats/posters)

[www.postermywall.com](http://www.postermywall.com/)

# Student Worksheets:

Lesson Plan: Nature Inspired Design

# Lesson Focus:

Students should be able to discuss how nature provides a basis for design inspiration and how it improves how we design products.

# Total Time Required:

* (1) 90 min. period

# Lesson Objectives:

Students will be able to:

* Describe the ways that arthropods design their homes that are well suited to their habitats using specific shapes, materials and architecture.

# Equipment and Materials

|  |  |
| --- | --- |
| Tools and Materials | Quantity Needed |
| Internet access | per group |
| Microsoft word | per group |

## Special Notes on Materials:

**Lesson Procedures:**

1. Biomimicry
   1. Research various examples of biomimicry found in products in the real world.
   2. Biomimicry lesson from TRAILS can be used here.
   3. Use the table below to document the research you find regarding biomimicry inspiration, descriptions with rationale for using biomimicry, and photo examples in nature and the product inspired by the design in nature. Submit the assignment via teacher discretion.

|  |  |  |  |
| --- | --- | --- | --- |
| **Biomimicry Inspiration Organism** | **Biomimicry Inspiration Photo** | **Product Description with Rationale** | **Product Photo** |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

2. Closing Questions

1. What was the most obscure example of biomimicry that you found in your research? Why did it surprise you?
2. Was there an example of biomimicry that you already knew about prior to this lesson?
3. Give one example of nature inspired design that could benefit your community.

*Note:*

# Student Resources:

Biomimicry Resources

<http://www.momtastic.com/webecoist/2010/12/31/inspired-by-insects-10-creepy-crawly-biomimetic-designs/>

<https://biomimicry.org/>

<http://www.bbc.com/earth/story/20150913-nine-incredible-buildings-inspired-by-nature>

<https://www.independent.co.uk/news/architects-inspired-by-engineers-of-insect-world-1080524.html>

<https://inhabitat.com/tag/insect-inspired-architecture/>

# Student Worksheets:

Lesson Plan: Water Purification Device

# Lesson Focus:

Students should be able to discuss how we determine the quality of water that is deemed safe for human use and consumption.

# Total Time Required:

* (2) 50 min. period
* (4) 90 min. period

# Lesson Objectives:

Students will be able to:

* Define potable water and how natural disasters may affect it
* Define turbidity and what factors will increase or decrease it
* Design a portable filtration system that increases the potability of water after natural disasters

# Equipment and Materials

|  |  |
| --- | --- |
| Tools and Materials | Quantity Needed |
| Turbidity Bottles | 1 per group |
| Vernier Turbidity Sensor | 1 per group |
| Various materials to build filtration system |  |

## Special Notes on Materials:

**Lesson Procedures:**

1. Potable Water
   1. Organize a class discussion about what activities require potable water other than for consumption.
   2. Note that natural disasters tend to cause many issues with contamination of fresh water and flooding and other disasters can damage drinking water wells and lead to well contamination from livestock waste, human sewage, chemicals, and other impurities.
   3. Obtain a sample of water that has been “contaminated” to show students what a poor representation of turbidity in a water source would look like. Turbidity is a measure of the lack of clarity (cloudiness) of water and is one key test of water quality. Turbidity is apparent when light reflects off of particles in the water. Sources of turbidity include soil erosion, waste discharge, urban runoff, events that stir up sediments, humic acids and other organic compounds that result from decay of leaves and plants, and algal growth.
   4. Communicate to students that this water sample will be used as the focus of their work in creating a water purification device to reduce the turbidity. Note that turbidity is measured in Nephelometric Turbidity Units (NTU) and the standard for drinking water is 0.5 NTU to 1.0 NTU. Having an abundant supply of potable water is a huge concern for those in disaster ravaged areas and they are developing this device to use in this type of setting.
2. Filtration System Building
   1. Stress to students the focus of this lesson is not only create a device to reduce the turbidity but is also should be an exercise in proper documentation of the engineering design process in their engineering notebooks. Advise students to take pictures often and record all notes and daily activities in their engineer’s notebook. Make sure to follow the best practices for engineering notebook documentation. The best way to ensure proper documentation of the design process is to fully document the activities performed in each stage of the design process.
   2. Outline the criteria and constraints that the students will need to consider as they design and build their water purification device:
   3. Designs that will be considered well performing will:

· Be constructed from easily acquired inexpensive/free materials

· Significantly reduce the turbidity of the contaminated water

· Purify 100 ml of water in the least amount of time

· Be durable and require the least amount of maintenance

· Be easily assembled

· Be designed to attach to a bucket or other device that will be used as the clean collection container

d. Allow the students to periodically test the turbidity of their filtered water sample using the following equipment:

· Vernier Turbidity Sensor

· Turbidity Standard (included with Vernier Turbidity Sensor)

· Turbidity curvette (included with Vernier Turbidity Sensor)

· LabQuest Mini

Logger Pro software

e. Note the following testing procedures to students:

a. Calibrate the turbidity sensor using the instructions provided with the equipment.

b. Use the Turbidity Sensor, LabQuest Mini, and Logger Pro to measure, collect, and record the turbidity of contaminated sample and the purified water. You may want to investigate the advantages of running the water through your system more than once.

c. After handling contaminated water, be sure to thoroughly clean your area and wash your hands.

f. Students may continue to test and redesign their device as needed for the duration of this lesson.

g. At the end of the lesson, students will demonstrate their functioning prototype and submit their engineering notebooks for evaluation.

*Note:*

# Student Resources:

# Student Worksheets:

Lesson Plan: Alternative Energy Solutions

# Lesson Focus:

Students should be able to discuss how alternative energy solutions generate power and their benefits and tradeoffs.

# Total Time Required:

* (1) 50 min. period
* (2) 90 min. period

# Lesson Objectives:

Students will be able to: (list 2-3 that apply directly to the lesson)

* Experiment with solar power, wind power and hydropower; building an understanding of how these alternative energy sources may be implemented in times of crisis.

# Equipment and Materials

|  |  |
| --- | --- |
| Tools and Materials | Quantity Needed |
| Power House Kit | 1 per group |
| Hydropower Kit | 1 per group |
| Alternative Energy Experiments Check-Off Sheet | 1 per group |

## Special Notes on Materials:

**Lesson Procedures:**

1. Alternative Energies
   1. Students will be placed into groups of four for this lesson. Each group will receive (1) Power House kit and (1) Hydropower kit in order to complete a series of experiments that are outlined in the experiment manuals. These kits are from the company Thames & Kosmos and come with experiment manuals.
   2. Students will complete the following experiments from the kits in the order they choose:

**Hydropower Kit**

· Water Wheel (pg. 6)

· Water Wheel with Generator (pg. 27)

**Power House Kit**

· Experiment 2 Polystyrene Foam Stops Noise (pg. 6)

· Experiment 3 Captured Heat (pg. 7)

· Experiment 21 Natural Climate Control (pg. 18)

· Experiment 22 Home Water Heater (pg. 19)

· Experiment 46 Drinking Water from Salt Water (pg. 32)

· Experiment 63 Generating Electricity on the Roof (pg. 42)

· Experiment 64 Solar Current Powers the Motor (pg. 42)

· Experiment 69 Clouds in Front of the Sun (pg. 46)

· Experiment 78 Weather Vane Shows the Wind Direction (pg. 50)

· Experiment 80 A Wind Power Plant for your House (pg. 52)

· Experiment 83 Homemade Wind Turbine (pg. 54)

· Experiment 84 At the Right Angle (pg. 54)

· Experiment 85 Will Fewer Blades Work Too? (pg. 55)

· Experiment 87 Solar-Powered Blower (pg. 56)

c. Have a check-off list of the experiments and as you observe, have students demonstrate or notify you as they complete each experiment. Having a single question or list of follow-up questions after each experiment as a formative check for their learning.

2. Closing questions

1. What are three things that you learned during these activities using the hydropower and powerhouse experiment kits that you would like to see implemented in homes or shelters?
2. Describe one product using solar power that could be implemented in a developing nation, when camping, or when the power is out from storms?

*Note:*

# Student Resources:

# Student Worksheets:

Lesson Plan: Temporary Sanctuary

# Lesson Focus:

Students should be able to demonstrate how biomimicry and alternative energy can be integrated to create a shelter for people in need after the events of a natural disaster.

# Total Time Required:

* (1) 50 min. period
* (2) 90 min. period

# Lesson Objectives:

Students will be able to:

* Design a habitat for someone affected by a natural disaster that incorporates water filtration, and element of biomimicry, and an alternative source of energy

# Equipment and Materials

## Special Notes on Materials:

Materials needed will be decided as students begin the construction of their sanctuaries. Some element of the sanctuary will need to be 3D printed so that material will need to be made available.

**Lesson Procedures:**

1. Temporary Sanctuary
   1. After discussing the design brief, provide a list of criteria and constraints that the students will have for the project:
      1. Choose a site that has a high chance of being negatively impacted by a natural disaster and provide proper justification for your site selection
      2. Must communicate and consider the number of occupants with FEMA recommended square footage for long-term stay
      3. 40 square feet per person (satisfies recommended square footage for persons with special needs)
      4. Minimum wall length must be at least 4 feet
      5. The prototype must be able to fit within a 20”x 20” footprint and be no taller than 20” for displaying to possible clients (recommended scale: 1” = 1’)
      6. The prototype model will include the shelter and site design in which it is to be implemented
      7. Must be a standalone shelter (intended for single family occupancy) as defined by FEMA
      8. It may be sited away from potential debris hazards.
      9. It will be structurally and mechanically separate from any building and therefore not vulnerable to being weakened if part of an adjacent structure collapses or if a CBRE event occurs in the adjacent building.
      10. The design must include a biomimicry element involving a habitat inspired by arthropod-built structures
      11. Must have at least one 3D printed part in the final solution
      12. The design must include a low-cost method of water purification
      13. Must have at least one alternative energy source to provide power such as solar, wind, or hydroelectric
      14. Must be easy to transport and able to be moved to areas of need
      15. Must be easy to assemble and disassemble
      16. Must provide adequate shielding from the elements such as rain, harsh sun, wind, and pests
      17. Must be low cost while considering balance for structural stability and quality
   2. Have students review the design brief and complete the Define the Problem section on the Temporary Sanctuary Submission Form to review the elements of the design brief.
   3. Without the aid of Internet searches, students will brainstorm possible concepts of possible design solutions. Provide students with a sheet of large paper and markers to sketch and provide ideas for brainstorming. Each group needs to compile at least 10 brainstormed ideas for an adequate session.
   4. Students will need to discuss and evaluate the brainstormed ideas and select three possibilities to explore. From the three ideas selected, students will complete a decision matrix using the criteria and constraints to provide an unbiased evaluation to determine the “best” solution.
   5. Students will document the initial design solution by sketching an isometric pictorial of the solution with annotations, signatures, and dates.
   6. Model the initial design using Autodesk Inventor or Autodesk Revit and create working drawings of the parts required to build your solution.
   7. Students will begin constructing and testing their prototypes for the design problem, modifying and completing redesign as needed throughout the allotted time.
   8. Students will prepare a testable prototype for an initial round of testing and all groups will test to evaluate the performance of the design solution.
   9. Students will be given time to redesign and modify the solution in preparation for final testing.
   10. Students will test their revised solution and complete a final evaluation of their design solution. Students will complete a final design solution isometric sketch of the design with annotations, signatures, and dates
   11. Update the initial design using Autodesk Inventor or Autodesk Revit and create working drawings of the parts required to build your solution. Students will submit completed working drawings for evaluation.
   12. Students will present their solution and complete the Temporary Sanctuary Submission Form for grading.

*Note:*

# Student Resources:

# Student Worksheets:



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Any opinions, and findings expressed in this material are the authors and do not necessarily reflect the views of NSF.