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#SeaworthySTEM

Amplify This!

Unleashing the Power of Sound

Grades 9-12

Teacher Guide

Seaworthy STEM™ in a Box Series

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Seaworthy STEM™ in a Box Educator Kit description:

Seaworthy STEM™ in a Box activities are a Navy initiative to provide enhanced Naval-relevant, standards aligned, hands-on activities to K-12 teachers and students. Components of this program include, curated sets of classroom activities that aim to build deep conceptual understanding in Naval-relevant content areas. The kits also includes comprehensive lesson plans, material lists, scientific background information, STEM related literacy books, and student activity sheets. The **Seaworthy STEM™ in a Box** program is designed to support teachers as they select content, acquire materials, and implement more hands-on STEM activities in their classrooms. Increasing student access to hands-on STEM activities, also increases awareness of STEM career paths, engage students in STEM, and support development of student's abilities in STEM content.

The **Seaworthy STEM™ in a Box** kits were designed to guide students through the scientific inquiry-based theory and the engineering design process. The content and Naval-relevant activities are aligned with the Next Generation Science Standards. The topics and content covered within the lessons are connected and scaffolded based on distinct grade bands (K-2nd, 3rd-5th, 6th-8th, and 9th-12th).

Photo on the Cover: 230121-N-TV933-2681 PHILIPPINE SEA (January 21, 2023) Sonar Technician (Surface) Third Class Kiera Taylor interprets and logs sonar information in the Sonar Control Room aboard Ticonderoga-class guided-missile cruiser USS Antietam (CG 54) during a submarine familiarization exercise with allied forces. (U.S. Navy photo by Ensign William Stricklett).

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Introduction

Welcome to an innovative curriculum designed to engage students in the world of engineering, problem-solving, and creative thinking. This curriculum is structured around three fundamental components, each carefully crafted to provide students with a comprehensive learning experience. In this curriculum, each lesson is divided into three parts: Journal Entry, Part 1, and Part 2.

Parts of Each Lesson

Journal Entry

The first part of every lesson serves as a bridge between what students already know and what they are about to learn. The Journal Entry is an opportunity for students to reflect on their prior knowledge and experiences related to the topic. These questions will stimulate critical thinking and prime students for the exploration of new concepts. The teacher can mold these questions into a format that best fits their class. This entries can be done in the student workbook, a separate journal notebook or another location determined by the educator.

Part 1: Introduction & Research

Following the Journal Entry, Part 1 of each lesson is dedicated to research and in-depth exploration. The students will delve into the subject matter, investigate key concepts, and gather valuable information. This phase is essential in providing the foundation for the Engineering Design Challenge, ensuring that students have the necessary background knowledge and skills to approach real-world problems effectively. Do not feel as though you have to strictly follow these instructions. Use the tools that are necessary for your students. This could include adding teaching strategies, word banks or other differentiation techniques to the lessons.

Part 2: Engineering Design Challenge

The culmination of each lesson is the Engineering Design Challenge. This is where students put their newfound knowledge and research skills to the test. They will work through the engineering design process, applying their problem-solving abilities to develop practical solutions. The challenges are crafted to mimic real-world scenarios, allowing students to experience the fulfillment of creatively designing their own products. Engineering education can be enriched by infusing elements of business-style competitions into your lessons. This approach not only deepens students' technical understanding but also hones their teamwork, critical thinking, and real-world problem-solving skills. This can be done by using the team dynamics page as a "business" team page. Remember, as the teacher you create your materials pricing list from what you have. This will allow you to have more control over the outcome of the lesson. The educator becomes the customer while the students incorporate regular pitch sessions as part of the final presentation. Play with the style of the lesson and build students up to feel the business dynamic that unfolds through the engineering process.

Here We Go!

By the end of this curriculum, students will have the tools and confidence to address real-world challenges in a systematic way. This curriculum is designed to provide the basics and help organize a young engineers thought patterns. Teaching students how to map out their thinking is essential in the development of world changing solutions. We are excited to embark on this educational journey with you! Let's get ready to journal, research, and create as we embark on a #SeaWorthySTEM learning adventure!

Table of Contents

Lesson Title:

Amplify This!

Unleashing the Power of Sound

Time:

Average learning time is 4-5, 50 minute class periods

Student Objectives:

1. Understand the basic principles of sound amplification and directionality.
2. Design and build a functional acoustic device using affordable materials.
3. Analyze and interpret the effects of different materials on sound amplification.
4. Apply critical thinking and problem-solving skills to optimize the performance of the acoustic device.

Lesson Overview:

In this lesson, students will delve into the world of acoustics. They will explore the principles of sound amplification and directionality by designing and building their own #SeaWorthySTEM acoustic devices using household materials. Through experimentation and analysis, students will determine how different materials affect sound propagation and amplification.

Next Gen Science Standards (NGSS):

HS-PS4-1
Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

HS-ETS1-2
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Notes

Materials and Equipment List

- ☑ Disposable plastic cups
- ☑ Balloons
- ☑ Rubber bands
- ☑ String
- ☑ Cardboard tubes (if available)
- ☑ Scissors
- ☑ Tape

Student Activity Sheets/Handouts:

Student Activity Worksheet:
Amplify This! Unleashing the Power of Sound

Technology Tools:

Computer

Internet access

Part I: Background Research

1 Pre-Assessment Activity:

The student journal response can be used as a pre-assessment for this unit. Have the students answer these questions in the "Journal Entry" section of their engineering notebook.

Sample Journal Prompts:

1. What situations benefit from sound amplification?
2. What examples from the real-world do you know that focus on sound amplification?

2 Pre-Activity:

Have the students answer these questions in the "Think about..." section of their engineering notebook. The teacher can post the questions below for the class to reference when answering.

Tell the students to "Think of a speaker's structure" then answer the following questions:

1. What are the parts of a speaker?
2. Do you think the type of material used to construct a speaker matters?
3. What are some examples of speaker types that you know of?
4. Are all speakers the same?
5. Sketch speakers that you have previous knowledge about.

3 Hook:

Show this video of the evolution of speakers: https://www.youtube.com/watch?v=cZhsMGAFSzE

YouTube:

4 Background Research- Primary Sources:

Research Artifacts:

- Have students complete the: "**Let's Explore Primary Sources & Research**"

5 Background Research- Information:

Research Sheets:

- Have the students complete the: "**Types of Sound Amplification Devices Sheet**"

6 Student Discussion:

After the students complete their research, use the information within both research sections to review with the students. Class discussions, share outs, partner shares or gallery walks are effective methods of communicating findings.

7 Engineering Design Challenge:

Discuss the different types of sounds amplification devices, share Navy examples and explain the upcoming design engineering challenge. Some examples of sound amplification devices used by the navy include:

1. **Sonobuoys:** These are expendable sonar systems that are dropped from aircraft or ships to detect and track submarines or other underwater targets.
2. **Hydrophones:** These are sensors used to detect sound underwater. They are often used to enhance the detection of submarines and other naval vessels.
3. **Sonar systems:** These use various types of sound-based detection for underwater navigation, communication, and target detection.

Part 2: Engineering Design Challenge

Background Information:
Acoustics is the science that deals with the study of mechanical waves in gases, liquids, and solids. This includes things like vibration, sound, ultrasound, and infrasound. It includes a wide range of topics, such as the production and transmission of sound. From the sounds of musical instruments to the design of concert halls, acoustics plays an important role in understanding properties of sound. The field of acoustics can be found in areas such as music, architecture, engineering, medicine, and environmental science.

Sound comes from the movement of particles that go through a medium, usually air. It is characterized by its frequency and amplitude, which cause the auditory sounds we hear. The study of sound is important to understanding its impact on human life and the environment. From noise pollution in urban areas to the hearing capabilities of marine life, sound research is helps us understand the connections of life. The manipulation of sound waves has led to technological advancements in the fields of telecommunications, ultrasound imaging, and sonar systems.

The Engineering Design Challenge:

The Navy has tasked your design team with creating a new sea acoustic device. Your vessel must be able to amplify sound. The goal of your design is to make the sound of some item louder than its original capacity. Your team must be creative in determining what type of structure and features should be included for success.

Procedure:

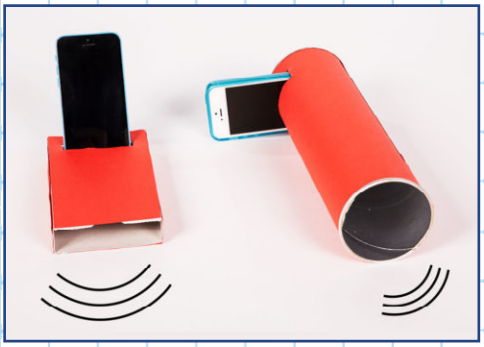
Pre-Activity: Students will fill out a Team Dynamics page to review expectations and goals of the challenge.

I **What is the Problem?**

- Have the students discuss the basic scientific principles associated with the lab: sound amplification and directionality.

Examples

Source: https://kidminds.org/engineering-easy-amplifier/



Source: https://learning.sciencemuseumgroup.org.uk/resources/tune-booster/

- Introduce the engineering challenge:
    - ***Design and build an acoustic device and collect data on its effectiveness***
- Form small teams and distribute the materials. Note: If allowing students to choose materials at random, create a materials home-base (a large box or storage container) designated for hand-selected materials.
- Have the students formulate a problem (in question form) from the scenario provided.

2 What are the Criteria and Constraints?

- Have the students list out the criteria and constraints for the lab.
- Constraints: Provide your students with a list of constraints for the engineering design challenge.
- Discuss budget constraints (a limited number of materials per team).
- Have the students fill out the budget form for their design.

Possible ideas are listed below:

- You will have (pre-determined number) of class periods to design, build and test your project.
- Structural ideas:
    - Material limitations
    - Size restrictions
    - Weight restrictions
    - Accuracy requirements

3 How can we Brainstorm and construct the Prototype?

- Have the student brainstorm multiple designs for their prototype.

- Students will choose one design, justify their choice in the writing section and build their models according to their designs.
- Emphasize teamwork, creativity, and adherence to budget.

4 How can we Test and Data Collection?

- Each team tests their prototype by:
  - A. Take two plastic cups and cut a small hole at the bottom of each cup.
  - B. Cut off the neck of one balloon and stretch it over one of the cups, securing it tightly with a rubber band around the edges.
  - C. Cut the cardboard tube in half, lengthwise.
  - D. Use tape to attach one half of the cardboard tube to the open end of the cup covered with the balloon, making sure it forms a funnel-like shape.
  - E. Use string to tie the other cup upside down onto the open end of the cardboard tube.
  - F. Cut the other balloon's neck and stretch it over the open end of the second cup, securing it with a rubber band.
  - G. Make sure the balloons are taut but not too tight.
  - H. Now, the sound amplification device is complete. Test it by speaking into the open end of the first cup and listening to the amplified sound from the second cup.
  - I. Determine how you will collect data about your device.

Note teachers are encouraged to have students create their own step-wise procedures as well. Students may develop different models then the ones listed above, allow for experimentation and flexibility in data collection.

5 What are our Findings? Data Analysis and Reflection

- Team present their findings by creating a data chart, graph and reflection statement to discuss the findings of their prototype.
- Teams discuss what worked and what did not in their design.
- Reflect on the engineering design process by answering the following questions:
  A. Does my prototype meet the requirements of the design challenge?
  B. Can I improve the design from its original specifications?
  C. How can I reduce the cost of my final prototype without sacrificing quality?

6 Let's Improve it! Class Discussion, Team Redesign Conclusion

- Discuss the most successful designs and strategies.
- Relate the activity to real-world applications in naval engineering and design.

7 Peer Evaluation of Teamwork

- Students will be providing feedback of teammates and collaboration.

Teacher Background Information / Notes:

Acoustics is the study of sound and how it behaves in various environments. It explores how sound is produced, transmitted, and received, as well as its interactions with different mediums. Acoustics also includes the properties of sound waves, including their frequency, amplitude, and wavelength. Acoustics helps us figure out how it all works together. Through the study of acoustics we can learn about the development of noise-canceling technology, and the impact of sound on human health or the environment.

In the topic of acoustics students often form misconceptions such as viewing sound as a substance that can be created or destroyed rather than a wave that propagates through a medium. Misconceptions may also arise regarding the relationship between frequency and pitch, leading to confusion about how different frequencies contribute to sound.

Vocabulary Terms:

- Ocean Currents
- Sound amplification
- Acoustics
- Directionality
- Resonance
- Sound propagation

STEM Related Careers:

- Acoustic Engineer
- Sound Designer
- Audio Technician
- Media Producer
- Architectural Acoustics Specialist


Notes

The Seaworthy STEM™ in a Box curricula was developed through collaborative efforts of a team of individuals at the Naval Surface Warfare Center Carderock Division and Albert Einstein Distinguished Educator Fellows via an inter-agency agreement with the U.S. Department of Energy for the Albert Einstein Distinguished Educator Fellowship (AEF) Program. We are grateful to the following Content Specialists who contributed their knowledge and expertise by researching and writing on selected topics: Suzanne Otto, Stephanie Klixbull, Thomas Jenkins and Melissa Thompson. We'd also like to acknowledge the contributions of AEF participant Ms. Deborah Reynolds, the inaugural AEF Educator at Carderock that helped inspire the design of Seaworthy STEM™ in a Box content. Special thanks to Albert Einstein Fellow Melissa Thompson, for the creation of a collaborative high school engineering curriculum and supplemental additions to the early grade bands; career portfolios, workforce trading cards, and in-house short story publications. Gratitude to Carderock Outreach Specialist Ashlee Floyd, STEM Program Manager, Charlotte George, and Media Specialist Kristin Behrle for the creation and support of this naval endeavor that showcases the diversity of NAVSEA Sites.

It is the goal of the Seaworthy STEM™ Curriculum to embrace NAVSEA technologies from sites nationwide to empower the youth of our nation to purse STEM-centric career pathways. The views and opinions of the Content Specialists expressed herein do not necessarily state or reflect those of the AEF Program, the U.S. Department of Energy, or the U.S. Government. Reference herein to any specific commercial product, process, or service by trade name, trademark, service mark, manufacturer, or otherwise does not constitute or imply endorsement, recommendation, or favoring by the AEF Program, the U.S. Department of Energy, or the U.S. Government.

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