NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

#SeaworthySTEM

StyroGlide Lab

Designing Table Top Hovercrafts

Grades 9-12

Teacher Guide

Seaworthy STEM™ in a Box Series

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Office of Naval Research
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StyroGlide Lab

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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: 220523-N-OM737-1156 NORFOLK, VA. (May 23, 2022) - Landing Craft, Air Cushion 84 prepares to enter the welldeck of the amphibious assault ship USS Bataan (LHD 5) May 23, 2022. Bataan is underway in the 2nd fleet area of operations. Bataan is homeported at Naval Station Norfolk. (U.S. Navy photo by Mass Communication Specialist 3rd Class Bradley Rickard)

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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:

StyroGlide Lab

Designing Table Top Hovercrafts

Time:

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

Student Objectives:

1. Understand the principles of air cushion vehicles (hovercraft) and their applications.
2. Design and build a functional hovercraft using Styrofoam and other materials.
3. Apply the engineering design process to solve real-world problems.
4. Collaborate effectively in a team and communicate their design process and findings.

Lesson Overview:

In this lesson, high school students will explore the principles of hovercraft technology and engage in a hands-on engineering challenge to design and build a #SeaWorthySTEM styrofoam hovercraft. They will apply the principles of physics and engineering to create a vehicle that can glide smoothly over a variety of surfaces using an air cushion.

Next Gen Science Standards (NGSS):

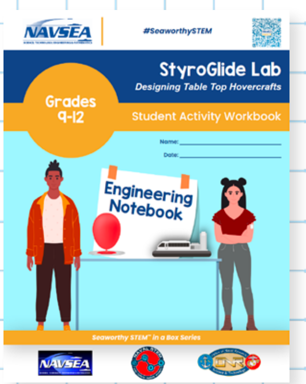
HS-PS2-6
Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

HS-PS3-3
Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Notes

Materials and Equipment List

- ☑ Styrofoam plate
- ☑ Duct tape
- ☑ Balloon inflator
- ☑ Balloons
- ☑ Circular plastic tablecloths or garbage bags
- ☑ Ruler
- ☑ Scissors
- ☑ Utility knife
- ☑ Markers
- ☑ Stopwatch
- ☑ Small objects for testing (e.g., small weights or marbles)
- ☑ DC motor with propeller
- ☑ Battery pack or power source
- ☑ Hot glue
- ☑ Wires
- ☑ Sandpaper
- ☑ Soldering iron (optional)



Student Activity Sheets/Handouts:

Student Activity Worksheet:
StyroGlide Lab- Designing Table Top Hovercrafts

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. Describe key features and technologies you would use in your hovercraft design and why?
2. What do you know about structure and function of a hovercraft?
3. Explain the scientific principles, from your perspective, that hovering requires.

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 Boat's Structure" then answer the following questions:

1. What are the parts of a hovercraft?
2. Do you think the type of material used to construct a hovercraft matters?
3. What are some examples of hovercrafts types that you know of?
4. Are all hovercrafts the same?
5. Sketch at least one hovercraft that you have previous knowledge about. Even if it is not an actual "craft", but an object that uses the same scientific principles.

3 Hook:

Show this video and have students reference questions from the journal and pre-activity section. (Note: Video is lengthy but can be skipped around to find diverse hovercraft footage.)
https://www.youtube.com/watch?v=wnk7h3aHivk

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: "**Type of Hovercrafts Research Sheets**"

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 hovercraft design and share Navy examples and explain the upcoming design engineering challenge.

Here are some examples of hovercrafts used by various navies around the world:

1. **LCAC (Landing Craft Air Cushion)**: Used by the United States Navy, the LCAC is a high-speed air-cushioned landing craft capable of carrying personnel, vehicles, and supplies from ship to shore.

Part 2: Engineering Design Challenge

Background Information:

Hovercrafts are vehicles that combine designs from both boats and airplanes, enabling them to glide over a variety of surfaces, including water, land, mud, and ice. These machines operate on the concept of an air cushion, created by a fan that pushes air underneath the craft. This trapped air lifts the hovercraft, reducing friction and allowing it to travel over surfaces that would impede other vehicles. Hovercrafts are used in both military and civilian sectors, such as search and rescue missions, transportation over difficult landscapes, and recreational activities.

Check out the different hovercrafts here: https://www.discoverhover.org/infoinstructors/guide1.htm

The Engineering Design Challenge:

The Navy has tasked your design team with creating a new table top hovercraft. Your craft must be able to carry "sailors" while gliding across the table. The goal of your design is to hold as many sailors as possible. Your team must be creative in determining what type of boat 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.

1 What is the Problem?

- Have the students discuss the basic scientific principles associated with the lab: friction, lift and thrust..
- Introduce the engineering challenge:
    - ***Design and build a hovercraft that can carry as many sailors* as possible, while continuing to hover.***
- 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.

Examples

Source: https://www.steampoweredfamily.com/diy-hovercraft-project/

Source: https://www.flitetest.com/articles/hovercraft-and-snowball-project

Source: https://www.pinterest.com/pin/284571270190072578/

- 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.
  - Budget Constraints
  - Material Constraints

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. Placing it on a large flat surface.

  B. Turn on the power source. The craft must initially hover for it to count.

  C. Add sailors* one by one until the hovercraft does not move.

  D. Record the number of sailors the hovercraft carries successfully.

  E. 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 <u>Findings</u>? 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 <u>Redesign</u> 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:

Hovercrafts are vehicles that utilize a cushion of air to glide over various surfaces. The concept of the hovercraft dates back to the early 20th century, with engineers experimenting with different designs. By the 1950s and 1960s, hovercraft models were developed and used for their ability to navigate across terrains that were previously inaccessible to traditional boats or vehicles. One of the key components of a hovercraft is the skirt, which traps the air underneath the vehicle, creating an air cushion that reduces friction and allows the craft to hover above the surface.

Misconceptions:
Some students might hold misconceptions about hovercrafts, such as assuming that they operate solely on the basis of air propulsion similar to helicopters or airplanes. They might not fully grasp the role of the air cushion in supporting the hovercraft's weight and reducing friction. Additionally, some students might believe that hovercrafts are only designed for water travel, overlooking their ability to navigate on land, ice, and other terrains.

Vocabulary Terms:

- **Hovercraft**
- **Air cushion vehicle**
- **Engineering design process**
- **Friction**
- **Air pressure**
- **Thrust**
- **Iteration**
- **Prototype**
- **Lift**
- **Drag**
- **Buoyancy**
- **Force**

STEM Related Careers:

- Mechanical Engineer
- Aerospace Engineer
- Civil Engineer
- Marine Engineer
- Physics Researcher

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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