NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

#SeaworthySTEM

Flying High with Paper-Jet Airplanes

Grades 9-12

Teacher Guide

Seaworthy STEM™ in a Box Series

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Office of Naval Research
ONR
Science & Technology

Flying High with Paper-Jet Airplanes

Teacher Guide for 9-12

#SeaworthySTEM®

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: 050817-N-3488C-028. An F/A-18C Hornet launches from the flight deck of the aircraft carrier USS Kitty Hawk. (U.S. Navy photo by Photographer's Mate 3rd Class Jonathan Chandler).

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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:

Flying High with Paper-Jet Airplanes

Time:

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

Student Objectives:

1. Understand the importance of data analysis in engineering and problem-solving.
2. Apply mathematical and statistical concepts to real-world challenges.
3. Design, build, and test paper-jets to optimize their flight performance.
4. Collaborate with peers and present findings effectively.

Lesson Overview:

In this lesson, students will engage in a hands-on engineering challenge involving paper-jet airplanes. They will design, build, and test different paper-jet airplane models, collect data on their flight performance, and analyze the data to optimize their designs. Through this project, students will learn about the importance of data analysis in engineering and gain valuable collaboration skills. The students will either A. Change the material the paper is made from, or B. Change the shape of the plane and keep the material consistent.

Next Gen Science Standards (NGSS):

HS-ETS1-3
Engineering Design

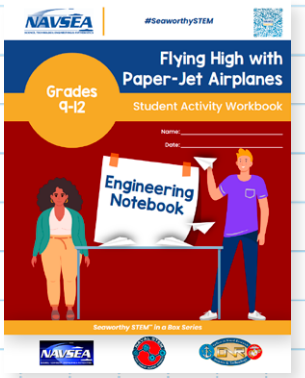
HS-PS2-3
Motion and Stability

HS-PS3-1
Energy and Momentum

Notes

Materials and Equipment List

- ☑ Sheets of paper (8.5 x 11 inches)
- ☑ Rulers and measuring tape
- ☑ Stopwatch or timer
- ☑ Markers and colored pencils
- ☑ Data collection sheets
- ☑ Access to a large open space (e.g., gymnasium or outdoor area)



Student Activity Sheets/Handouts:

Student Activity Worksheet:
Flying High with Paper-Jet Airplanes

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 is the most important part of a Jet and why?
2. What do you know about structure and function?

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 Plane's structure" then answer the following questions:

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

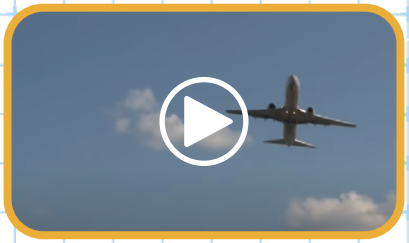
3 Hook:

Show these videos and have students reference questions from the journal and pre-activity section.

https://www.youtube.com/watch?v=xk4LFFm1zAA

https://www.youtube.com/watch?v=d1RfVHK3Vt8

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 Plane Research Sheets**"

6 Student Discussion:

After the students complete their research, use the information within the "Student Background" to review with the students.

7 Engineering Design Challenge:

Discuss the different types of planes, share Navy examples and explain the upcoming design engineering challenge.

Part 2: Engineering Design Challenge

Background Information:

Planes, also known as airplanes or aircraft, are modes of transportation that have revolutionized industry on a global level. Dating back to the Wright brothers' historic flight in 1903, planes have undergone advancements in design, technology, and engineering. These vehicles use the principles of aerodynamics to achieve flight, with wings generating lift and engines creating propulsion. From small private planes to large commercial airliners and even military fighter-jets, the diversity of aircraft types serves various purposes, including travel, transport, surveillance, and national defense.

The Engineering Design Challenge:

The Navy has tasked your design team with creating a far-flying Jet. The teacher will let you know if you can change the paper type, plane design or another

variable. The goal is to create a plane that flies the farthest. Your team must be creative in determining what type of materials 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: stability and motion
- Introduce the engineering challenge:
  - ***Design and build a Plane that can fly as far as possible as well as get as close as possible to the "flight deck".***
- 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.

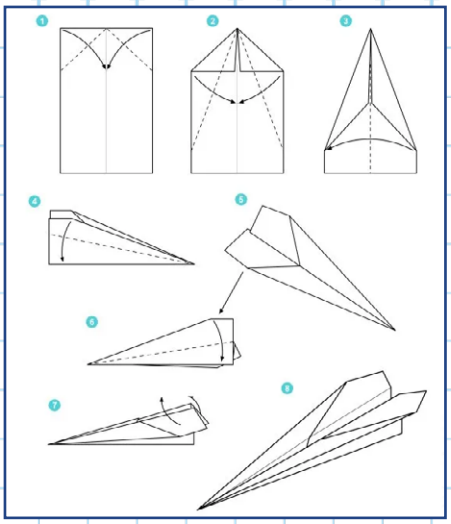
2 What are the Criteria and Constraints?

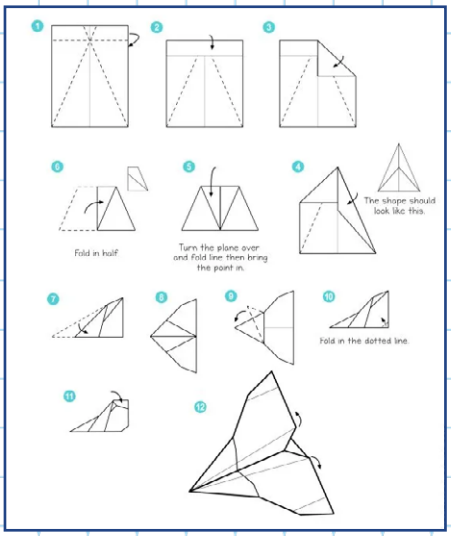
- Have the students list out the criteria and constraints for the lab.
- Constraints: Provide your students with a list of constraints for the engineering design challenge.
- Discuss budget constraints (a limited number of materials per team).
- Have the students fill out the budget form for their design.

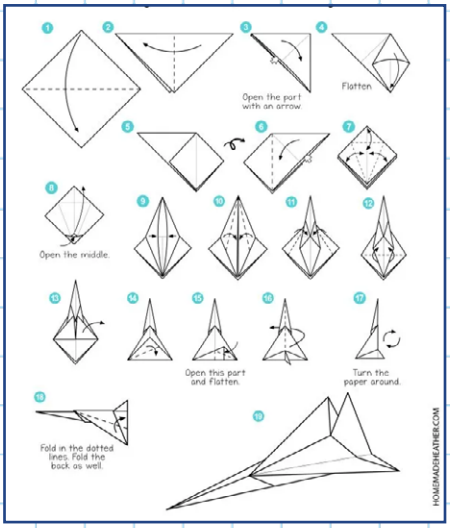
Possible ideas are listed below:

- You will have (pre-determined number) of

Examples







Source: https://homemadeheather.com/free-paper-airplane-printables/

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. Assigning one team mate as the "Pilot". Note: All students will get a chance to fly the plane, but for data purposes, one student will be used to collect data.
  B. Starting at the starting line.
  C. Pull the arm back and provide consistent force for each trial to fly the plane.
  D. Record the distance the plane flies and/or how close it gets to the flight deck.

5 What are our Findings? Data Analysis and Reflection

- Teams 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:

- Familiarize yourself with the principles of buoyancy, stability, and momentum.
    - **Aerodynamics** is the study of how air and other gases interact with objects in motion, particularly how they affect the forces acting on these objects. It focuses specifically on the behavior of air as it flows over and around various structures, such as aircraft, cars, and buildings.
    - **Stability** refers to the ability of an object to stay in its position in the presence of various external forces.
    - **Momentum** is a fundamental concept in physics that describes how much motion an object possesses.
- Understand the basics of the engineering design process.

- Be prepared to facilitate group work and problem-solving among students.
- Research different types of paper airplane designs for reference.

Vocabulary Terms:

- **Data Analysis**
- **Optimization**
- **Aerodynamics**
- **Experimentation**
- **Variables**
- **Statistical Analysis**
- **Hypothesis**
- **Momentum**
- **Design Criteria**

STEM Related Careers:

- Aerospace engineering
- Civil Engineering
- Industrial Design Engineering
- Pilots

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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