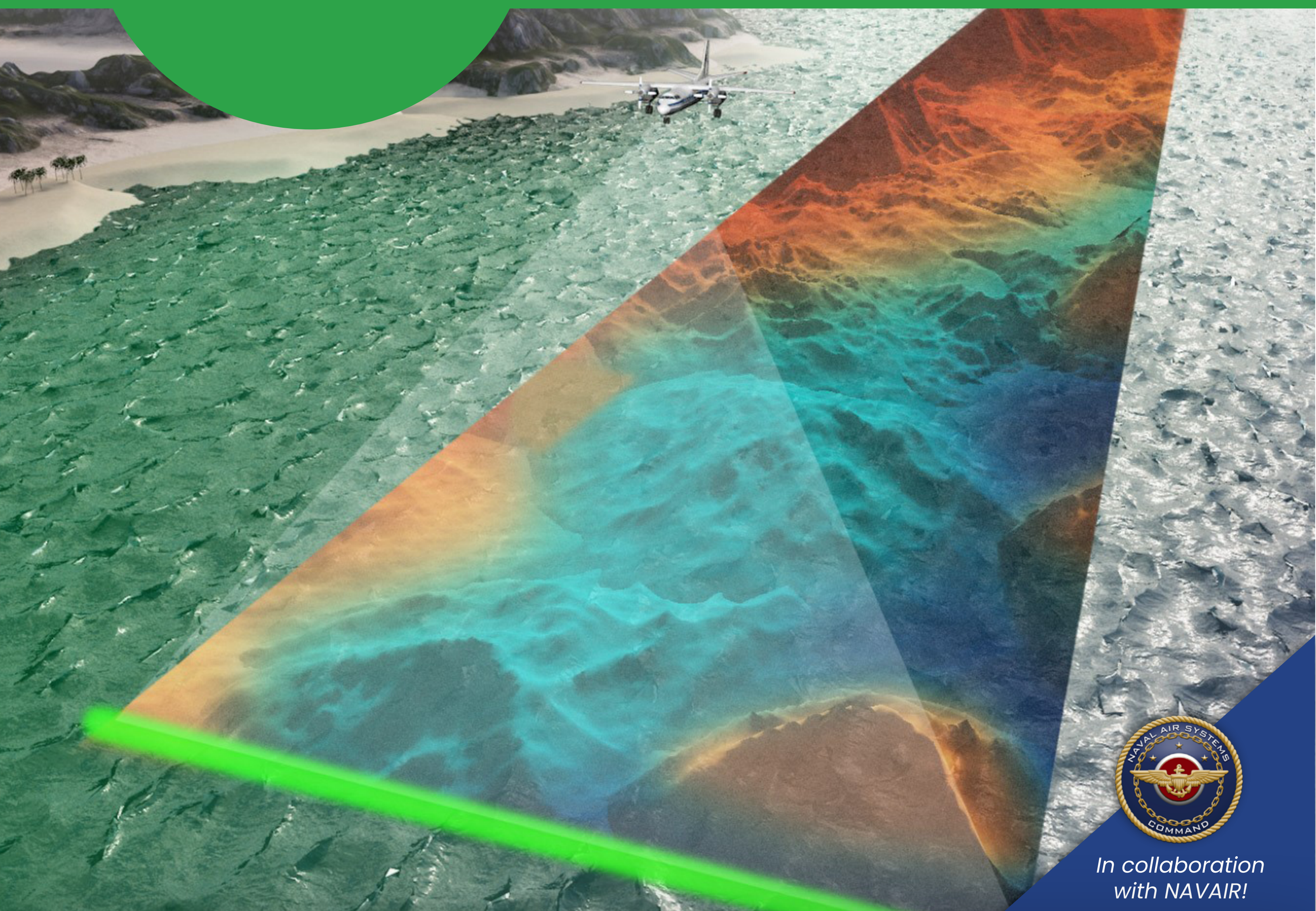
#SeaworthySTEM

Hues in Harmony

An Exploration of COLOR

Grades 6-8

Teacher Guide



In collaboration with NAVAIR!

Seaworthy STEM™ in a Box Series

Hues in Harmony

An Exploration of COLOR

Teacher Guide for 6-8

#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: Artist's illustration of the Fugro RAMMS hydrographic mapping capability, now being used to inform maritime domain awareness for the US Navy. *Photo from LIDAR Magazine*

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title:

Hues in Harmony

An Exploration in COLOR

Time:

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

Student Objectives:

1. Understand the principles of laser technology in underwater communication.
2. Apply the engineering design process to construct a functional and efficient optical communication kit.
3. Test and evaluate their optical communication kit's performance through various colored water samples.
4. Collaborate with peers to solve real-world engineering challenges.

Lesson Overview:

In this high school engineering challenge, students will embark on an adventure to build their own #SeaWorthySTEM communication kits using lasers and a limited set of materials. Students will be building an optical communication kit and performing experiments with it. This demonstration will help students to understand how different educational concepts are relevant to US Navy LIDAR technology. In order to assemble the kit and understand the activity, students will learn background information on the properties of light, basic electronics, and various
Navy technologies.

Next Gen Science Standards (NGSS):

NGSS Standard: MS-PS4-2
Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

NGSS Standard: MS-PS4-3
Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signal.

Notes

Materials and Equipment List

Section One: Light Demonstrations

Part A: M&M's Inquiry Demonstration

- Small Pack of M&M's per student (or group)
- 1 set of Green, Blue, Red Filtered Lenses per group (or shared by class)
- Diffraction lenses

Part B: Gummy Bear Inquiry Demonstration

- Small Pack of Gummy Bears per student (or group)
- One finger LED per student (or group)

Section Two: Building the Circuit System (Transmitter & Receiver)

Part A: Transmitter

- 3 slot AA battery holder
- Mini breadboard
- 3 AA batteries
- 10 male-to-male breadboard jumper wires (less are needed, but its good to have a couple extra in each kit)
- 3.5mm mono audio plug to alligator clip cable (not always needed, but can be used)
- Aluminum laser mount
- 3.5mm audio jack to alligator clip cable
- 600:600 Ohm audio transformer
- 5mW laser diode
- 10k Ohm potentiometer

Part B: Receiver

- 3 slot AA battery holder
- Mini breadboard
- Photoresistor
- 3 AA batteries

- 10 male-to-male breadboard jumper wires
- 10k Ohm resistor
- 4 Ohm 3 Watt speaker
- Adafruit STEMMA Audio Amp- PAM8302
- STEMMA JST 2mm 3-pin to Male header cable
- 2mm flat head screwdriver

Section Three: COLOR Activity Testing

- 4 Small plastic containers with lids, 5oz
- 2 -12 oz food containers
- 1 oz liquid antacid
- Red, green, and blue food coloring
- Double-sided tape
- Water to fill the 4 small plastic containers

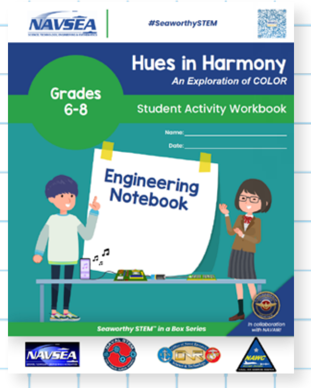
Other Materials

- Stopwatch or timer
- Paper Towels
- Teacher access to the internet (YouTube needs to be available)
- Student access to an internet compatible device
- Computer with attached projector
- Student Worksheets & Writing Utensil

Teacher can include any other materials available if choosing to do

Student Activity Sheets/Handouts:

Student Activity Worksheet:
Hues in Harmony



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 do you know about lasers?
2. What do you know about electrical circuits?
3. What do you know about structure and function?

2 Pre-Activity:

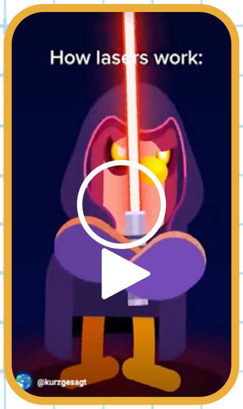
Have the students answer these questions in the "Think about..." section of their engineering notebook. The teacher can post the questions below for the class to reference when answering.

Tell the students to "Think of what they already know about lasers" then answer the following questions:

1. Why would the Navy want to use lasers?
2. Specifically underwater, what factors could affect lasers?

3 Hook:

YouTube:



Show this video of how lasers work: https://www.youtube.com/shorts/RzwaiFvyN6s?si=NbCCITCf-99Ih8Qc

4 Background Research- Information Research Sheets:

Have the students complete the following research sheets:

1. Optical Communications Research Sheet
2. Electronics Research Sheet

5 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.

6 Engineering Design Challenge:

Discuss lasers and share Navy examples and explain the upcoming design engineering challenge.

Some examples are included below:

1. **Communication:** The Navy uses lasers like a flashlight to send messages between ships and planes. It's similar to using a beam of light to talk to each other quickly and without using traditional radio signals.
2. **Targeting:** Think of lasers like a precise pointer. The Navy can use lasers to point at things, like targets in the sky or in the water, to aim their weapons more accurately.
3. **Navigation:** Lighthouses can help ships navigate to locations. Similarly, lasers can help the Navy navigate as well. They create a light path for naval vessels to follow, helping them stay on course.
4. **Defense:** The Navy uses lasers to target adversaries that may present a threat to our military.
5. **Detecting Objects:** The Navy can use lasers to help them locate items. Lasers can be used to locate objects or movement. This can be in the sea or in the air.

Part 2: Engineering Design Challenge

Background Information:

The US Navy operates both above and below the surface of the water. Technologies such as SONAR, RADAR, and LIDAR are used for navigation, detection, and ranging. In the underwater domain, LIDAR has some distinct advantages over SONAR and RADAR.

Advantages (+) and Disadvantages (-) of RADAR
RADAR - RA(dio) D(etection) A(nd) R(anging)

+ Uses electromagnetic waves - does not need medium to propagate like SONAR

+ Good transmission through different weather and lighting conditions

+ Shorter wavelength - high resolution

- High absorption in water - can only detect surface objects

Advantages (+) and Disadvantages (-) of SONAR
SONAR - SO(und) N(avigation) A(nd) R(anging)

+ Sound travels long distances in water due to water being a being a dense medium

+ SONAR can be passive and active

- Broad beam transmission

- Lower resolution

- Can't transmit through air - sea interface

Advantages (+) and Disadvantages (-) of LIDAR
LIDAR - LI(ight) D(etection) A(nd) R(anging)

+ Wide bandwidth

+ Covert

+ Transmits at the speed of light

+ Transmits wirelessly

+ Can penetrate Air-Sea Interface

- Performance limited by absorption and scattering

The Engineering Design Challenge:

You have explored the background of light and optics. The Navy has tasked your design team with creating a circuit system that connects a transmitter to a receiver. You will be using a laser to explore communication, light transmission and potential water properties. The goal of your challenge is to correctly assemble a transmitter-receiver circuit. After this device has been constructed you will be able to test multiple variables about lasers. Your team must be creative in using what you already know, what you learned during the research phase and what you observe during the build phase to draw conclusions about laser technology.

Procedure:

Section One: Light Demonstrations

Part A: M&M's Inquiry Demonstration

Materials:

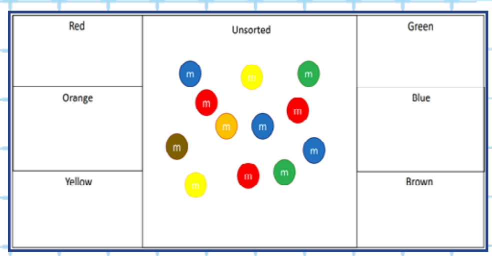
- ☑ Small Pack of M&M's per student (or group)
- ☑ 1 set of Green, Blue, Red Filtered Lenses per group (or shared by class)
- ☑ Diffraction lenses

Procedure:

1. Look through the diffraction lenses to see how white light can be broken up into its base components.
2. Choose a pair of red, blue, or green filtered lenses and put them on.
3. Open up a pack of M&Ms and place them in the center of the activity sheet.
4. Sort the M&Ms into their respective color box.
5. Take off the glasses to see how you did.

You can cover up the picture of the M&M's, it is there to show you an example!

Activity Sheet Example



Part B: Gummy Bear Inquiry Demonstration

Materials:

- ☑ Small Pack of Gummy Bears per student (or group)
- ☑ One finger LED per student (or group)

Procedure:

1. Collect the materials from the teacher for the demonstration, perform the procedure and fill in the following data table.

Gummy Bear	Which LED would show best from behind the gummy bear?	Why?
Red		
Green		
Blue		
	Which LED (ON) shows best from behind the gummy bear?	Why?
Red		
Green		
Blue		

Section Two: Building the Circuit System (Transmitter & Receiver)

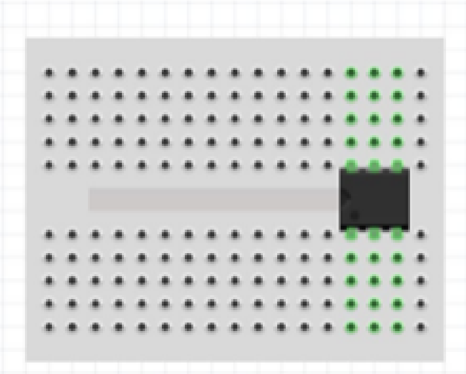
Part A: Transmitter

Materials:

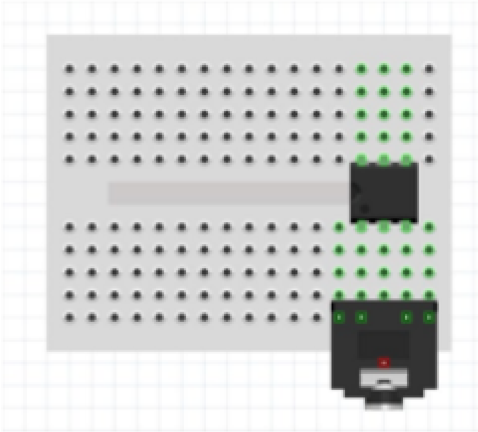
- [x] 3 slot AA battery holder
- [x] Mini breadboard
- [x] 3 AA batteries
- [x] 10 male-to-male breadboard jumper wires (less are needed, but its good to have a couple extra in each kit)
- [x] 3.5mm mono audio plug to alligator clip cable (not always needed, but can be used)
- [x] Aluminum laser mount
- [x] 3.5mm audio jack to alligator clip cable
- [x] 600:600 Ohm audio transformer
- [x] 5mW laser diode
- [x] 10k Ohm potentiometer

Procedure:

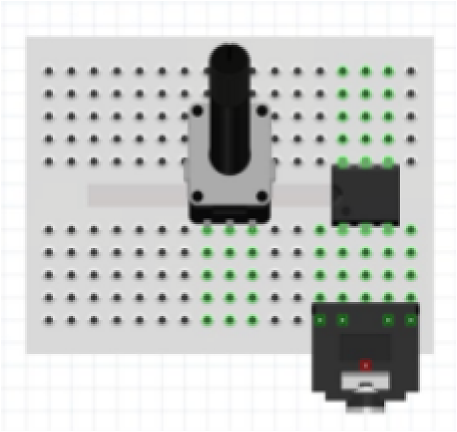
1. Place your transformer (here represented by an IC chip) so that it bridges the gap between the top and bottom sections of the breadboard. You will need to determine which is the primary side of the transformer. It may be labeled with a “P”. This side should be facing the upper portion of the breadboard.



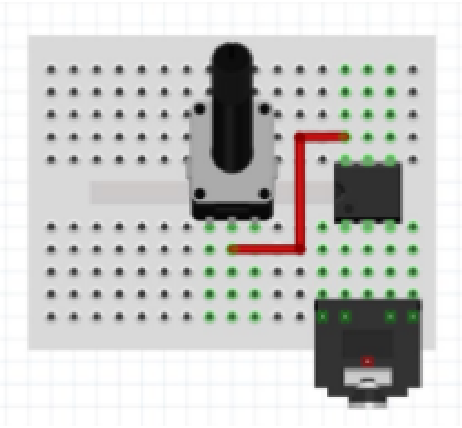
2 Connect your audio jack to the outer bottom pins of the transformer. The positive (white) wire should be on the left and the negative (black) wire should be on the right. Remember that any components that are in the same column are electrically connected!



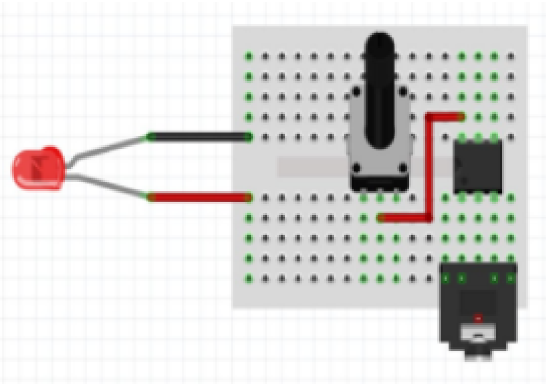
3 Place the potentiometer in the center of the breadboard.



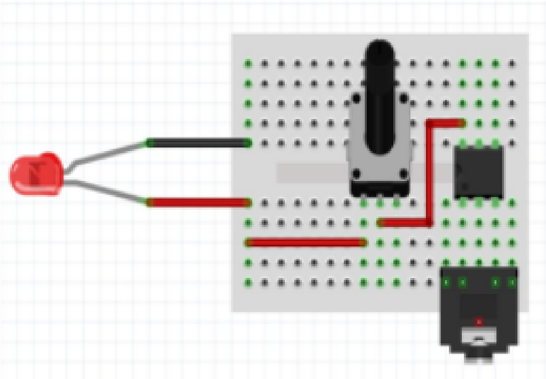
4 Connect the upper left pin of the transformer to the center (wiper) pin of the potentiometer.



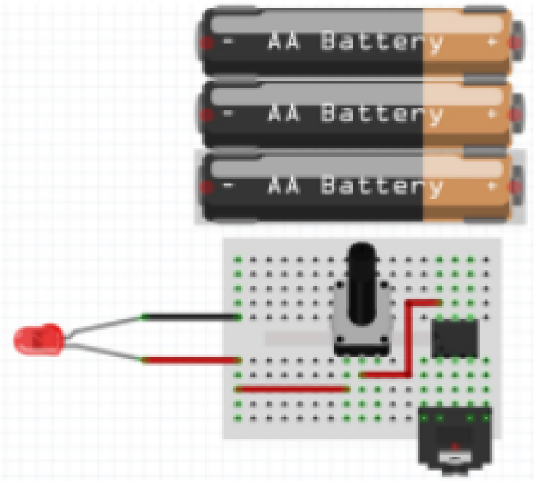
5 Connect your red laser (here represented by the red LED) to the breadboard. Ensure that the ground (black) wire is connected to the upper portion of the breadboard on the leftmost side, and the positive (red) wire is connected to the lower portion of the breadboard.



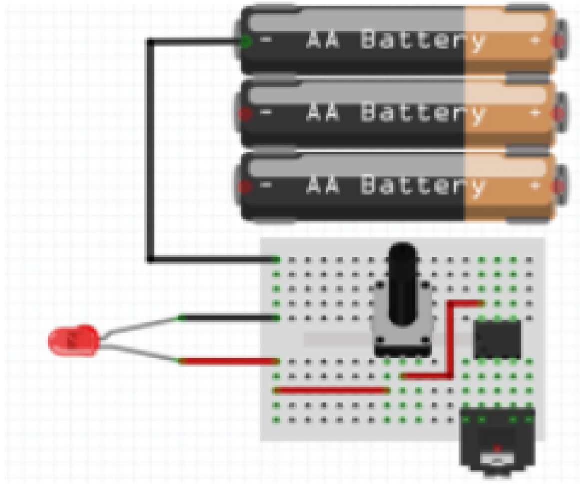
6 Connect the leftmost pin on the potentiometer to the positive (red) wire of the laser.



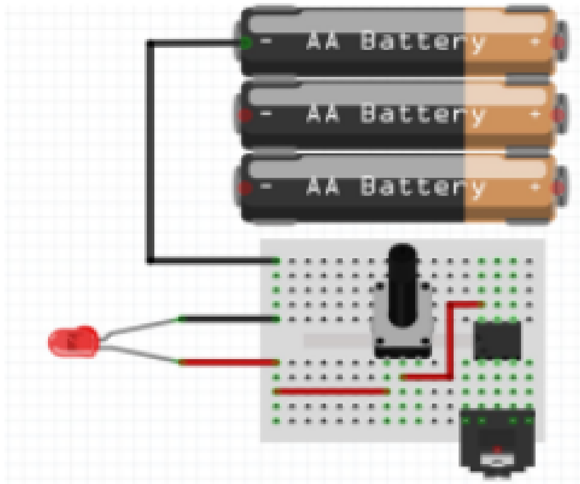
7 Place your 3 AA batteries in the holder above the breadboard. We will soon power the circuit.



8 Connect the negative (black) wire of the batteries to the ground (black) wire of the laser.



9 Connect the positive(red) wire of the battery to the center pin on the upper half of the transformer. Your circuit is now powered up. Press the button on the battery holder to turn it on. **BE CAREFUL TO NEVER POINT A LASER IN YOUR EYES OR THE EYES OF ANYONE ELSE!!!**



Section Two: Building the Circuit System (Transmitter & Receiver)

Part B: Receiver

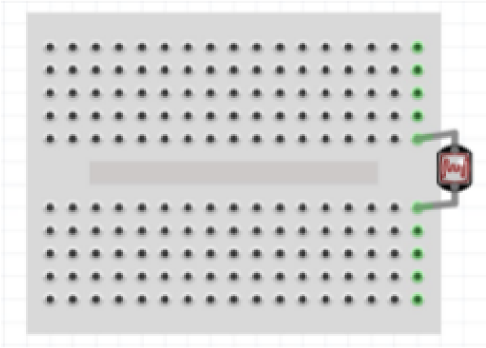
Materials:

- ☑ 3 slot AA battery holder
- ☑ Mini breadboard
- ☑ Photoresistor

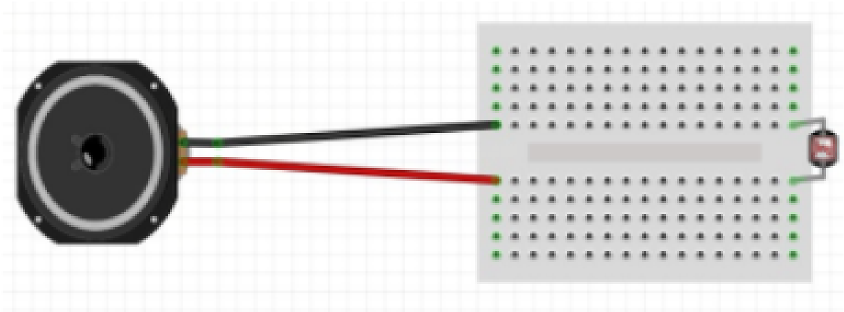
- 3 AA batteries
- 10 male-to-male breadboard jumper wires
- 10k Ohm resistor
- 4 Ohm 3 Watt speaker
- Adafruit STEMMA Audio Amp- PAM8302
- STEMMA JST 2mm 3-pin to Male header cable
- 2mm flat head screwdriver

Procedure:

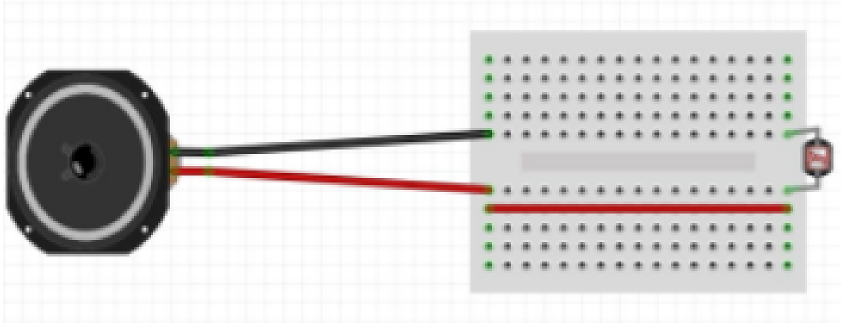
1. Use the photoresistor to bridge the gap between the two sides of the breadboard.



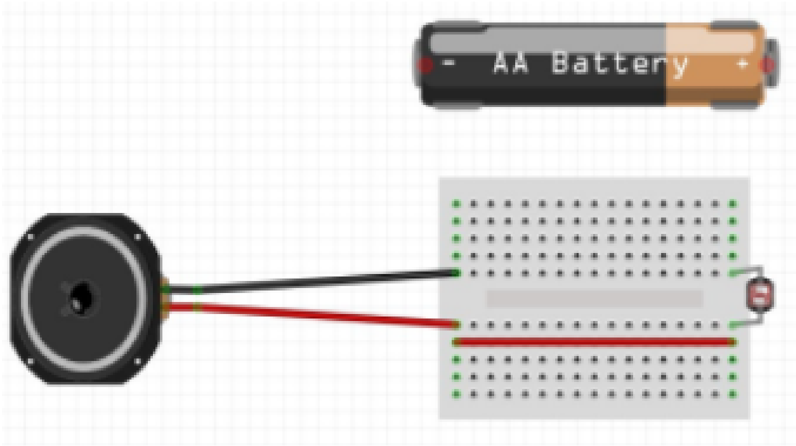
2. Plug the speaker in on the opposite side of the board, bridging the gap between the two sides of the breadboard. The positive (red) wire should be on the bottom half of the breadboard.



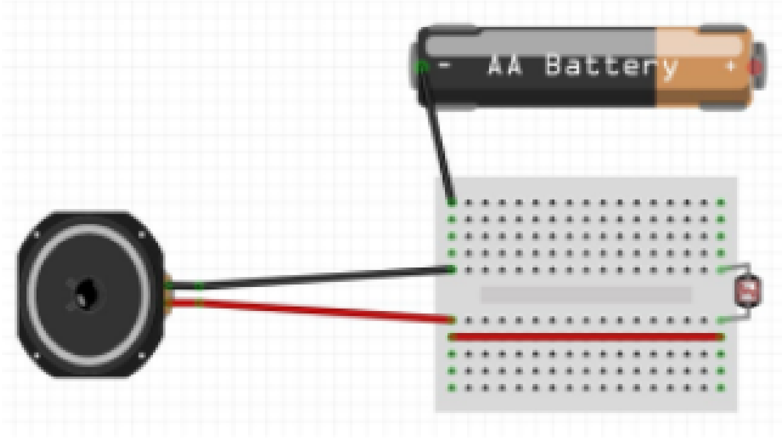
3. Connect the output of the photoresistor (bottom leg) to the input (red wire) of the speaker. Remember, anything in the same column on the breadboard as your wire will be electrically connected!



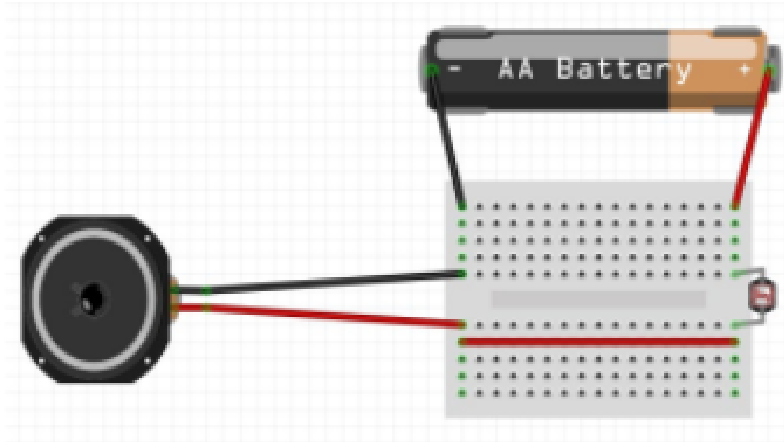
4 Position AA battery and holder above the top of the breadboard. The negative side of the battery should be facing the speaker, and the positive should be facing the photoresistor.



5 Connect the negative (black) side of the battery to the ground (black) wire of the speaker.

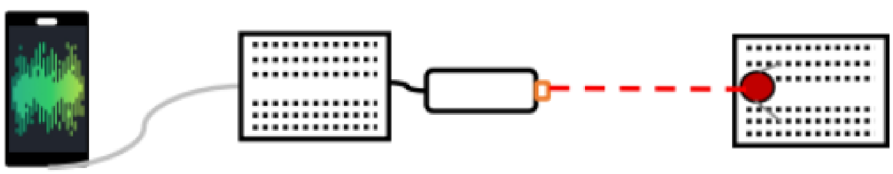


6. Connect the positive (red) side of the battery to the input (upper leg) of the photoresistor. Your circuit is now powered up and you should be able to hear quiet crackling from the speaker.



Section Three: COLOR Activity Testing

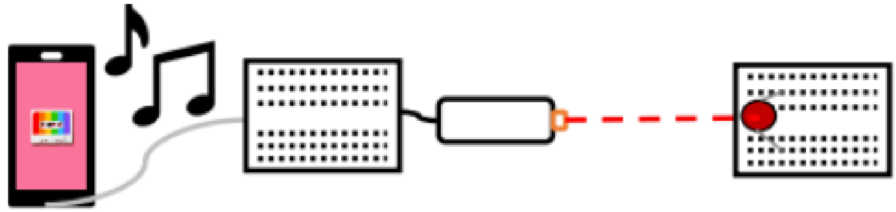
Part A: Testing Transmitter- Laser Power



Directions: Collect the materials from the teacher for the demonstration, perform the procedure and answer the questions as you work.

1. Connect phone to 3.5 mm audio jack.
2. Transmit audio in 10-20Hz range using tone generator app.
3. Adjust potentiometer and verify that laser output power changes. Why does this happen?
4. Illuminate the photoresistor with the laser.
5. Try changing the audio tone frequency.
6. Does the audio coming out of the speaker change when you change the frequency?

Part B: Testing Transmitter- Tone Frequency



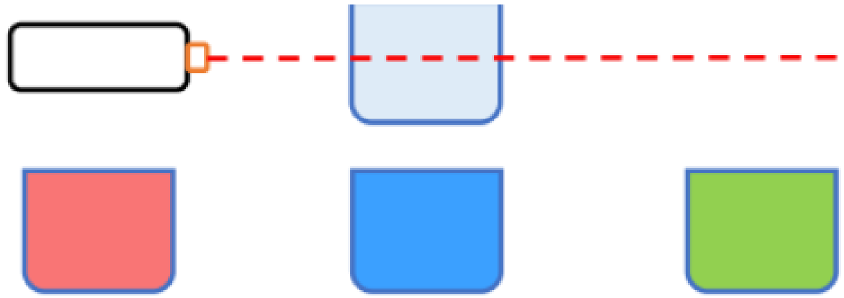
Directions: Collect the materials from the teacher for the demonstration, perform the procedure and answer the questions as you work.

1. Send music from the smartphone instead of the audio tone.
2. Illuminate photoresistor with laser.
3. Can you find a volume/laser power setting that optimizes the audio quality of the music from the speaker?

Part C: Testing Water Colors- Laser Power & Scattering Agent

Directions: Collect the materials from the teacher for the demonstration, perform the procedure and answer the questions as you work.

1. Place a clear water cell between the transmitter and receiver, then align the laser to hit the center of the photoresistor.
2. Which color of water do you think the light will transmit through best? Record the word best under the photo below and explain.



3 Try adding different colored dyes to the water one at a time to test how well they transmit light.

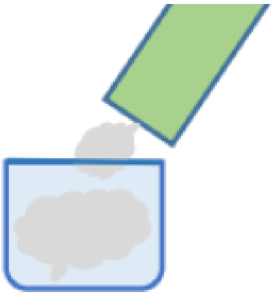
4 Use 20 drops food coloring per ½ cup water.

5 Was your prediction about which color would have the best transmission correct? Record why or why not under the color below and discuss what happened.

6 Your experiment should show that the red laser light transmits best through the red water. When you attempt to transmit the red laser light through the blue or green water, the red light from that laser tends to be absorbed.

7 What color of light would work best for transmitting light through blue or green water? Explain.

8 Add ½ to 1 tsp per ½ cup water of scattering agent (antacid) to clean water.



9 What happens to the laser beam and sound?

10 Why do you think this happens?

11 How could you use lasers if you were an Environmental Engineer knowing what you know now?

Conclusion to reiterate to students:

1. Scattering agent (antacid) acts like an obstacle for the light transmitting through the water.

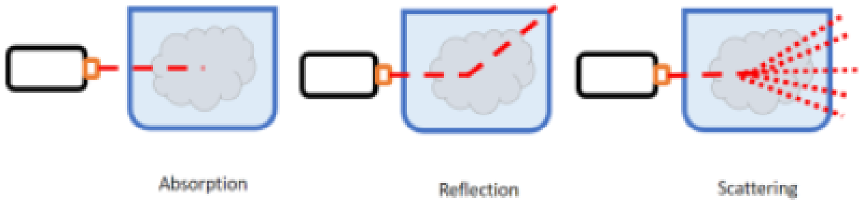
2. When the light collides with the particles of a scattering agent, it can bounce off in various directions.

3. This scattering leads to some of the light not making it to the photoresistor receiver.

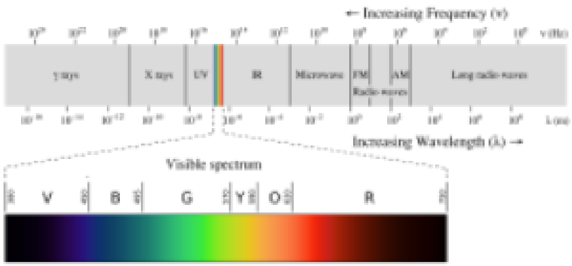
4. The result of this is reduced volume coming out of the speaker at the receiver.

Teacher Background Information / Notes:

When light strikes an object, it can be absorbed, transmitted, or reflected.



Electromagnetic waves have a characteristic wavelength and frequency. Visible light is an electromagnetic wave with a wavelength between 400-700 nm.



Optical communication is:

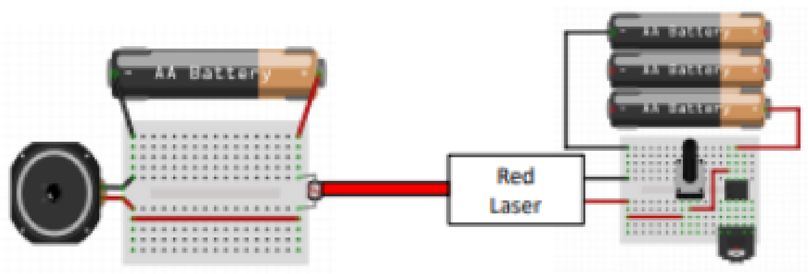
1. One of the many technologies that make use of light.

2. Used by fiber optic cables that serve as the information highways for the internet.

3. Optical communication can also be conducted through air or water without a fiber optic cable.

4. Doing this requires a transmitter such as a laser to send the light. It also requires a receiver to collect and process the light to understand the information it is transmitting.

Overall:
Students will be building the optical communication kit shown below. Before building the kit, they will need to complete the research to discuss the electronic components that are used in the kit and go over some basic electronics concepts.



Vocabulary Terms:

- **LIDAR**
- **SONAR**
- **RADAR**
- **Optics**
- **Electromagnetic**
- **Transmitter**
- **Receiver**
- **Electronics**
- **Voltage**
- **Current**
- **Resistance**
- **Breadboards**
- **Resistors**
- **Photoresistors**
- **Potentiometers**
- **Transformers**

STEM Related Careers:

- **Electronics Engineer:** Works to create and test electrical and optical systems, including those with lasers.
- **Physicist:** Does research into the mathematics behind physical phenomena, such as how light and water interact.
- **Mechanical Engineer:** Creates physical systems and studies how materials and objects interact. Works on various mechanical systems, including those in marine applications.
- **Environmental Engineer:** Focuses on water quality and conservation.

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.

#SeaworthySTEM

Hues in Harmony Teacher Guide

Seaworthy STEM™ in a Box Series