#SeaworthySTEM
#AirworthySTEM

Communication Over Lasers in Ocean Research:

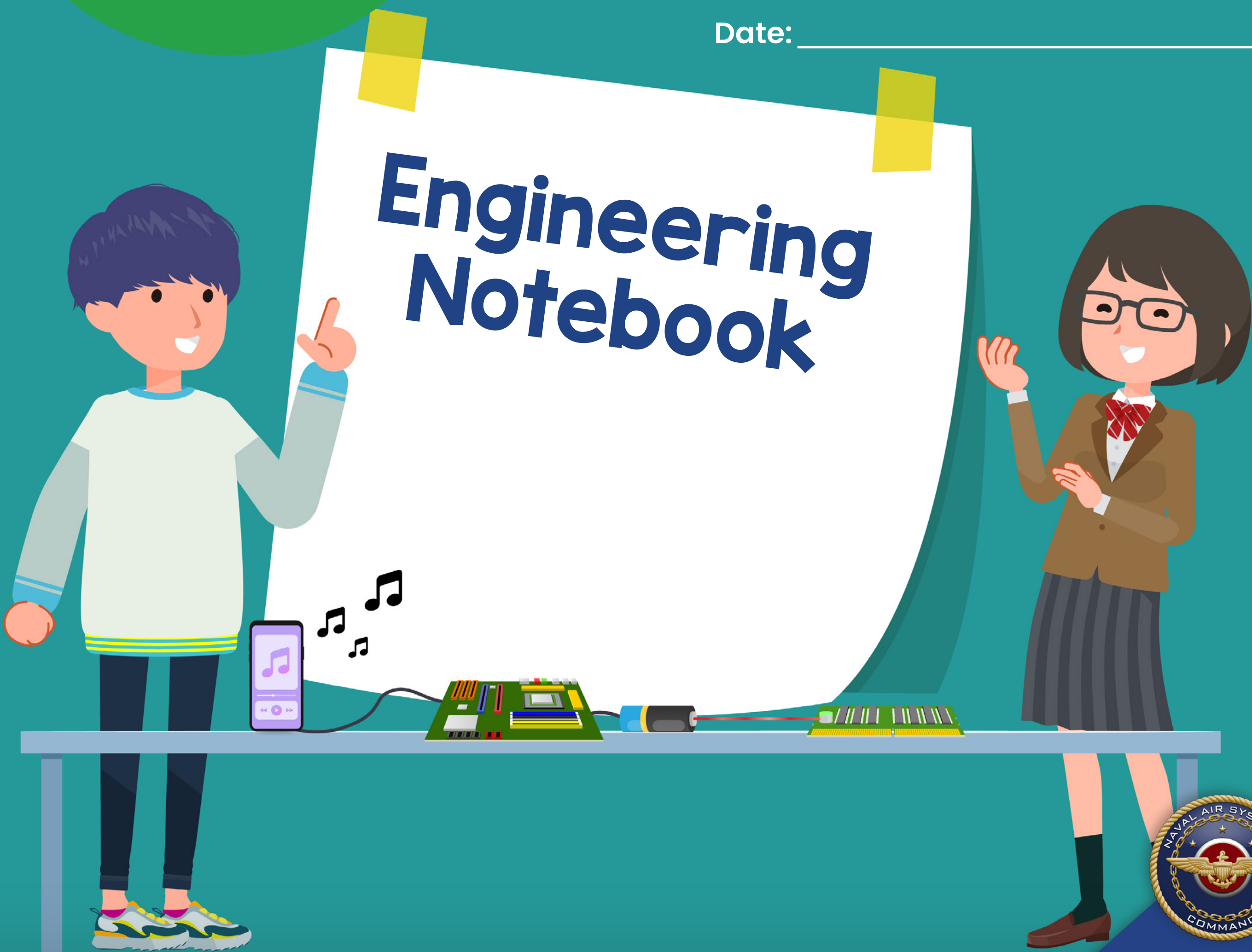
An Exploration of COLOR

Grades 6-8

Student Activity Workbook

Name: ______________________________

Date: ______________________________



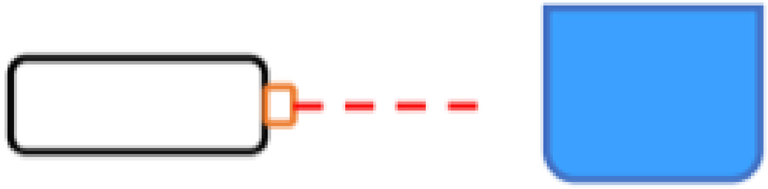
Seaworthy STEM™ in a Box Series

In collaboration with NAVAIR!

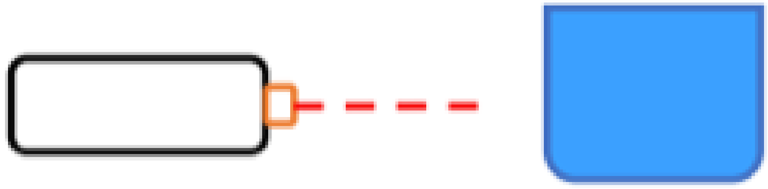
Optical Communications Research Sheet

Directions: Answer the questions below to expand your optical knowledge.

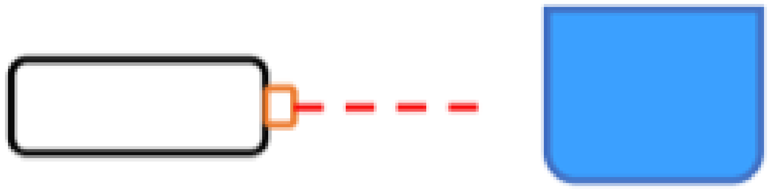
1 What happens to light during **Absorption**? Diagram and Explain below.



2 What happens to light during **Reflection**? Diagram and Explain below.



3 What happens to light during **Scattering**? Diagram and Explain below.



Using your research tools fill in the following:

4 Electromagnetic waves have a characteristic ______________________ and ______________________ .

5 Visible light is an electromagnetic wave with a wavelength between _____ - _____ nm.

6 Create a story for a younger student explaining what Optical Communication is. Use the information below as part of your story:

Optical communication is:

- One of the many technologies that make use of light.
- Used by fiber optic cables that serve as the information highways for the internet.
- Optical communication can also be conducted through air or water without a fiber optic cable.
- Doing this requires:
    - A transmitter such as a laser to send the light.
    - A receiver to collect and process the light to understand the information it is transmitting

Electronics Research Sheet

Directions: Read the following article and answer the questions below to expand your electrical knowledge.

Electronics and their POWER!

A voltage source, such as a battery, is used to push electrons through a material. This flow of electrons is referred to as an electrical current. Different materials allow or resist the flow of electrons. This property is referred to as the resistance of the material. Materials with little resistance are called conductors. An example is the copper wire found in a cable. Materials with high resistance are called insulators. An example is the rubber or plastic sheath around a wire. To better understand electricity, let us pretend we are talking about water. Imagine water moving through a pipe. Voltage is like water pressure. Current is the amount of water in the pipe. Resistance is anything making it harder for the water to flow, like a smaller pipe size or sand within the pipe.

The following units and symbols are used to describe electrical parameters:

- Voltage: V (measured in Volts or V)
- Current: I (measured in Amperes or amps or A)
- Resistance: R (measured in Ohms or Ω).

Breadboards provide a platform, making them a convenient way to build circuits and prototype projects on. They provide electrical connections between components without needing to solder or crimp components together. Voltage sources, such as batteries, have polarity so they have a positive and negative end. The negative is usually the reference to measure other voltages and is referred to as ground.

A circuit is formed when electricity flows out of the positive terminal through the load and back to the negative or ground terminal. A circuit is a closed loop of electrical flow. Connecting both ends of a voltage source without a load is called a short circuit. Don't do this! It is dangerous! Resistors are electronic components that have a specific nominal resistance. They come in different shapes and sizes. The colored stripes across the resistor tell you the nominal resistance value.

Resistors resist or limit the flow of electrical current.

- Photo = light, resistor = resistance

The resistance of the photoresistor changes based on the amount of light it receives.

- More light = less resistance.

Like photoresistors, potentiometers have a changing (variable) resistance. The resistance changes based on the position of the wiper (being the knob you turn). They can create a lot of resistance, very little resistance, or anything between. Transformers manipulate the voltage flowing through parts of a circuit. They are made of two coils of wire, which can increase or decrease a signal.

Questions:

1. What is an example of a voltage source?

2. What is electrical current?

3. What will different materials do to the flow of electrons and what is it called?

4. Compare conductors and insulators. Use examples.

5. Compare and contrast electricity and water.

6. What is a breadboard and what is it used for?

7. What is a circuit and how are they made?

8. What is a resistor and why is it important?

9. What is a photoresistor and why is it important?

10. What is a potentiometer and why is it important?

11. What is a transformer and why is it important?

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

Part A: Transmitter

Materials:

- [x] 3 slot AA battery holder
- [x] Mini breadboard
- [x] 3 AA batteries
- [x] 6 male-to-male breadboard jumper wires
- [x] Rubber grommet with ID 1/4”, OD 9/16”
- [x] 2 alligator clips
- [x] 3.5mm mono audio plug to alligator clip cable
- [x] Aluminum laser mount
- [x] 600:600 Ohm audio transformer
- [x] 5mW laser diode
- [x] 10k Ohm potentiometer
- [x] 2 5.08mm pitch screw terminals
- [x] 2mm flathead screwdriver

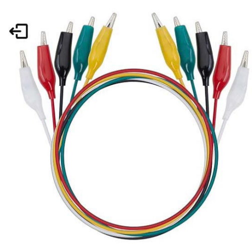
3 slot AA battery holder

Mini breadboard

3 AA batteries

Male-to-male breadboard jumper wires

Rubber grommet with ID 1/4”, OD 9/16”



Alligator clips

3.5mm audio plug to alligator clip cable

Aluminum laser mount

600:600 Ohm audio transformer

5mW laser diode

10k Ohm potentiometer

5.08mm pitch screw terminal

2mm flat head screwdriver

What Do These Components Do?

Mini breadboard: Allows you to create and test circuits on one platform. The columns are connected electrically. The two halves of the board are not connected.

Jumper wires: Allow you to connect two columns on the breadboard. The wires guide the electricity through the circuit. The color of the wires do NOT impact anything.

Rubber grommet: Used here to hold the laser in place in the aluminum mount.

Alligator clips: Grab on tightly to wires. One end clips onto the laser wire, and the other end to a jumper wire, allowing you to connect the laser to the breadboard. The metal part of the alligator clip MUST touch the metal of the wire.

3.5mm audio plug to alligator clip cable: Used to plug your phone or computer into the circuit, so the laser can modulate with the music's information.

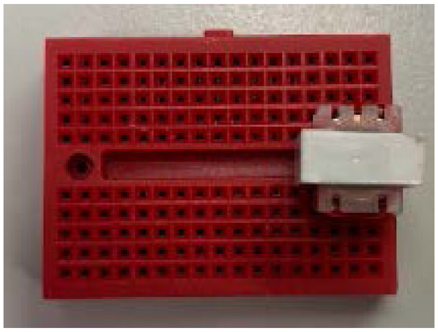
600:600 Ohm audio transformer: Isolates the signal, allowing the "noise" level to be lowered. The noise is any unwanted interference in a signal, like static.

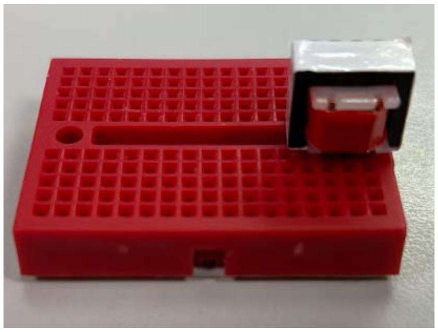
10k Ohm potentiometer: Changes the resistance, and thus the voltage, of your circuit. This allows the laser to be made brighter or dimmer.

5.08mm pitch screw terminals: Unscrew the screws on top, place wires (or a wire) in the slots on the front, and screw the screws back in. This allows you to place wires that are too large or small into the breadboard, like the battery wires.

Procedure:

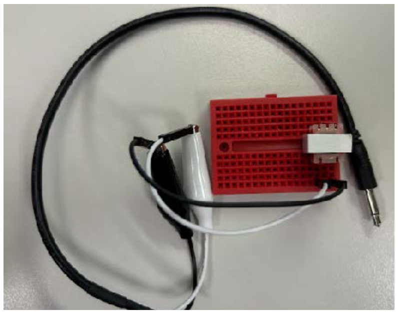
1. Place your transformer (the red, square component) so that it bridges the gap between the top and bottom sections of the breadboard. This means two legs should be on each half of the board. It does not matter which side is facing up or down. Place it on the right side of the board.

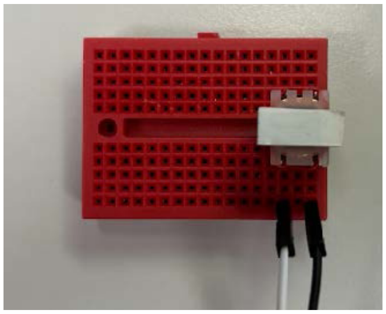




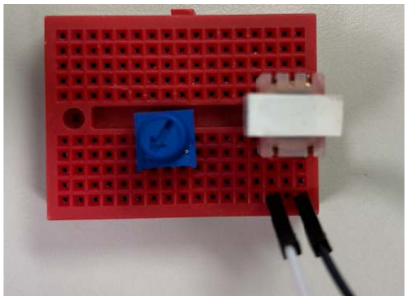
2. Connect your audio jack to the same columns as the bottom pins of the transformer. The positive (usually white) wire should be on the left side and

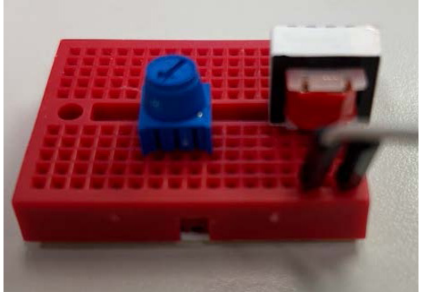
the negative (usually black) wire should be on the right. Remember that any components that are in the same column are electrically connected!



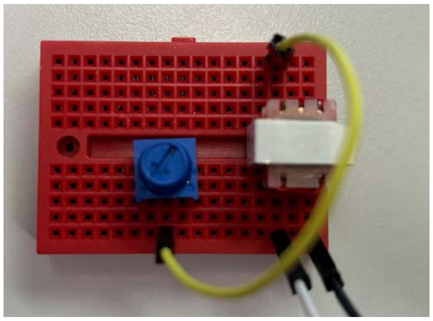


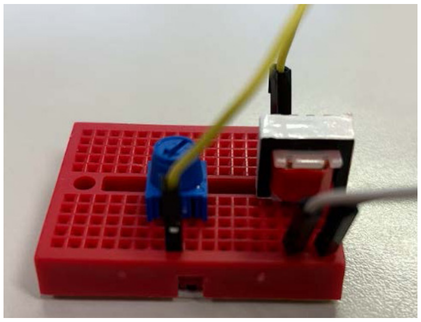
3 Place the potentiometer in the center of the breadboard, so that all three legs are in different columns. The ridges on the potentiometer should be facing you. Turn the potentiometer all the way to the left (counter-clockwise).



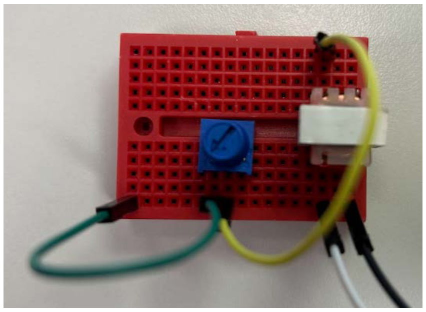


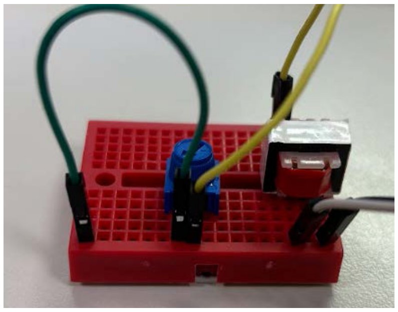
4 Connect the upper left pin of the transformer to the center (wiper) pin of the potentiometer.



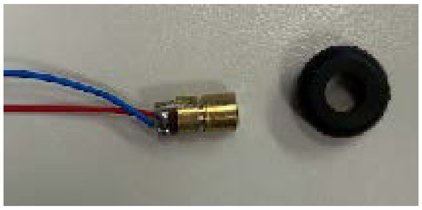
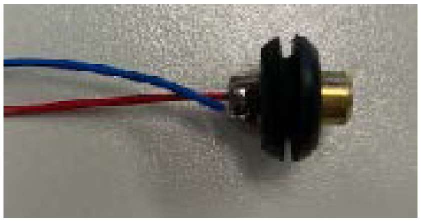
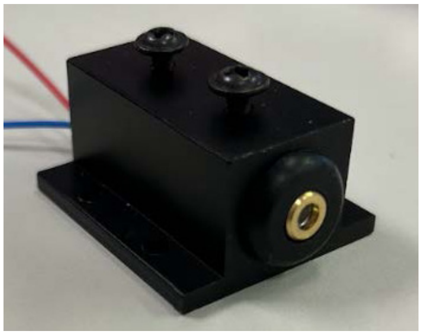


5 Connect a jumper wire from the leftmost pin of the potentiometer to the leftmost column of the breadboard.

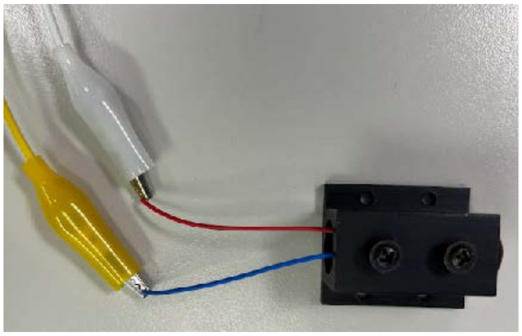




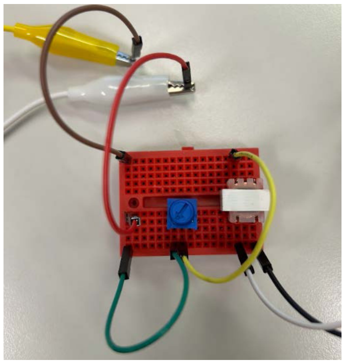
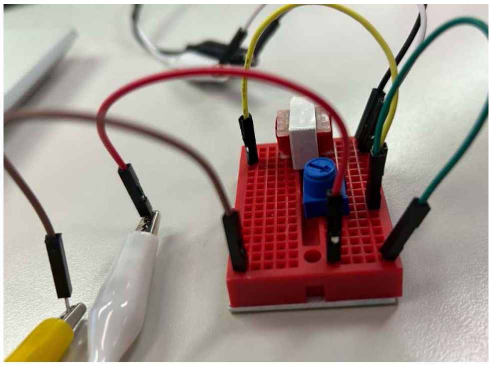
6 Place your laser into the center of the rubber grommet. Then, feed the laser wires backwards through the aluminum laser mount,and squeeze the grommet with the laser into the laser mount. This will keep the laser from moving when you do your experiment.

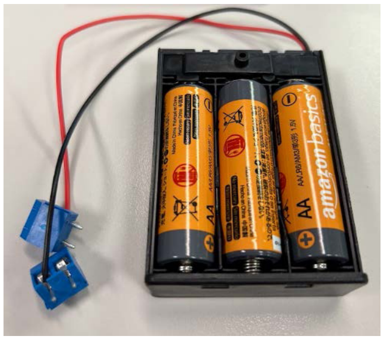
7 Connect your laser to the breadboard. Clip one alligator clip onto each wire of the laser. Clip a wire onto the other end of each alligator clip. The wire connected to the red laser wire (shown here as red) goes in the first bottom column of the breadboard. The wire connected to the blue laser wire (shown here as brown) goes in the first top column of the breadboard.



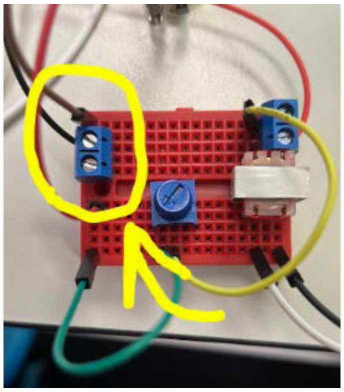
8 Place each battery wire in a blue screw terminal. To do this, unscrew one of the screws on top of the screw terminal. Hold the wire in place in the front slot while you screw the top screw back in. The wire should stay in place in the screw terminal.

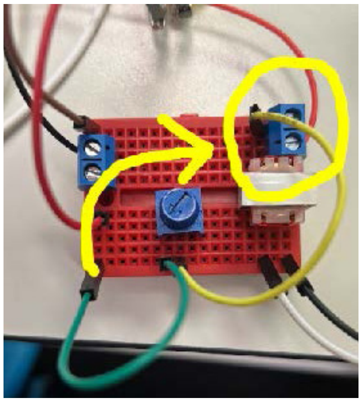
9 Connect the negative (black) battery lead to the first top column of the breadboard. It is in the same column as the wire going to the blue laser wire.



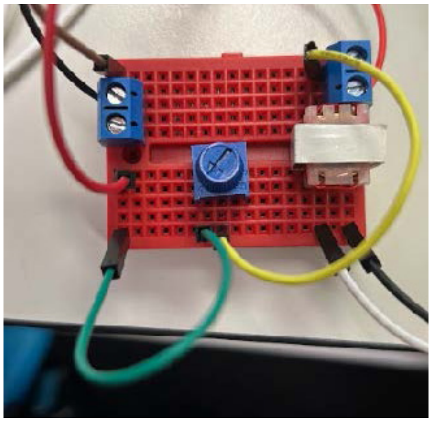
10 Connect the negative (black) battery lead to the first top column of the breadboard. It is in the same column as the wire going to the blue laser wire.

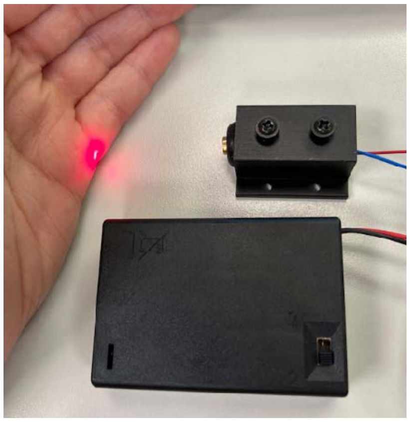


11 Connect the remaining screw terminal to the upper right leg of the transformer.



12 Your laser is now ready to be turned on. Place the batteries in the holder. Make sure that the laser is pointed away from any person, and is preferably pointed at your hand or the kit's container. Flip the switch on the battery holder to turn on your laser. **If you point the laser at your or anyone else's eyes, your kit will be taken away.**





Troubleshooting: My laser won't turn on!

Ten steps to get it working. Try each step and turn on your battery holder after completing it. (Hint: It is okay to ask for help. Even experts do it!)

1. Ensure that the battery holder is switched on.
2. Check the wires connected to each transformer or potentiometer leg- make sure each wire is in the same column as the leg it should be connected to. Ask a teacher to make sure it is wired correctly, or ask another student for help.
3. Make sure that the alligator clips are clipped onto the metal of the laser wires and that each component is pressed down into the breadboard.
4. Make sure that your potentiometer is turned all the way to the left, counterclockwise. The arrow should be pointing towards you and slightly to the left. This will make the laser as bright as possible.
5. Now, we will have to start replacing components. The transformer in this kit is the most commonly broken part. Ask a teacher for a new one.
6. The laser and potentiometer are also commonly broken parts. Ask your teacher for new ones, testing them one at a time.
7. Replace the batteries.
8. It is uncommon for the remaining components to be broken. However, you can try swapping out the wires and alligator clips.
9. By this point, you've pretty much rebuilt the circuit. The problem must be the battery holder or the screw terminals. Replace them.
10. If it is still not working, one of the replacement parts must be broken. Go back to step 5.

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

Part B: Receiver

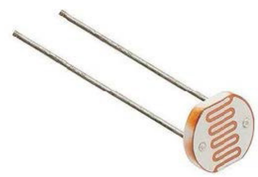
Materials:

- [x] 3 slot AA battery holder
- [x] Mini breadboard
- [x] Photoresistor
- [x] 3 AA batteries
- [x] 5 male-to-male breadboard jumper wires

- 10k Ohm resistor
- One pair of earbuds
- 2mm flat head screwdriver (reused)
- 3.5mm mono audio jack to alligator clip cable
- 2 5.08mm pitch screw terminals
- 2 Alcohol wipes / prep pads
- Phone dongle (USB-C/Lightning to 3.5mm)

3 slot AA
battery holder

Mini breadboard



Photoresistor

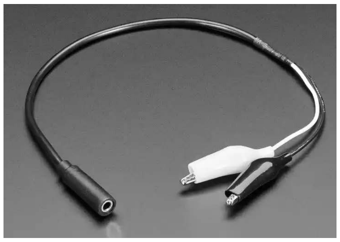
3 AA batteries

Male-to-male
breadboard jumper wires

10k Ohm resistor

One pair of earbuds

2mm flat head screwdriver



3.5mm mono audio jack
to alligator clip cable

5.08mm pitch
screw terminals

Alcohol wipes/ prep pads

Phone dongle

What Do These Components Do?

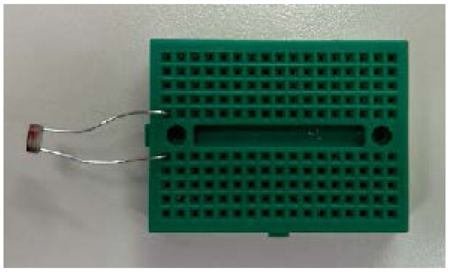
Photoresistor: Changes its voltage value based on how much light it receives. It’s great at accepting laser light, but it will also react to room light, which will cause noise/static in your music.

10k Ohm resistor: They provide resistance to the circuit, which limits the flow of electrons or current. This prevents damage to the components in the circuit.

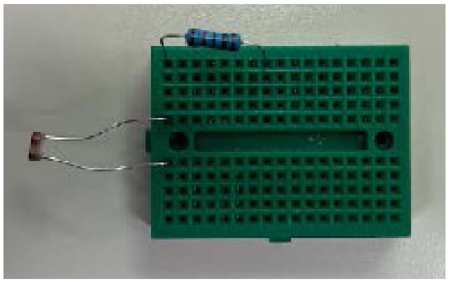
3.5mm mono audio jack to alligator clip cable: Allows you to listen to your music through earbuds plugged into the cable. It is mono, meaning one, so music will only come out of one side of the earbuds.

Procedure:

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

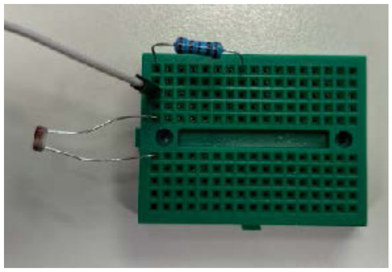


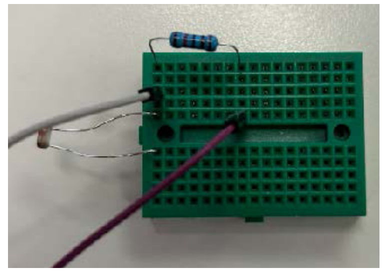
2. Connect a resistor leg to the upper leg of the photoresistor, and the other leg can go in any other column.



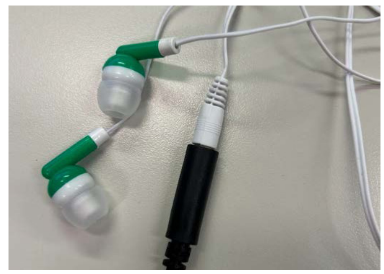
3. Now, we will connect the headphone jack to the circuit. Connect one wire to each alligator clip on the audio jack.

4 One wire (gray, in image) is connected to the white clip. Plug it into the upper leftmost column. The other wire (purple, in image) is connected to the black clip. Plug it into the same column as the far right resistor leg.

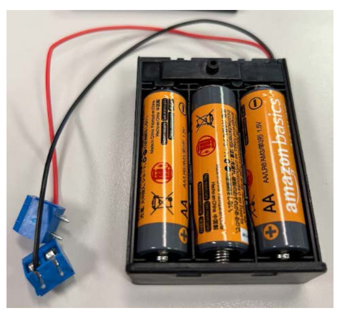




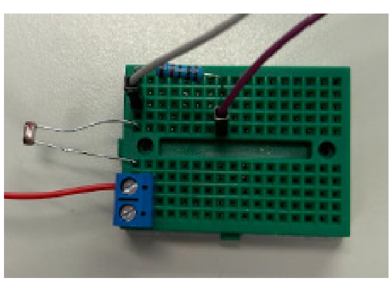
5 Now, we will plug in the earbuds. Use an alcohol wipe to clean off the silicone earbud tips. Plug in your earbuds to the audio jack.

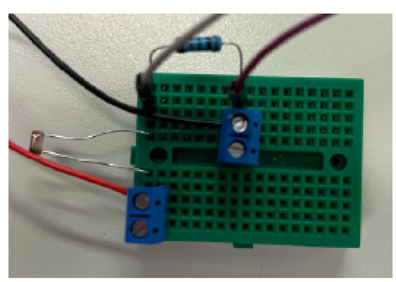


6 To plug in the batteries, first use two screw terminals to house the red and black wires from the batteries. Place the batteries in the holder.

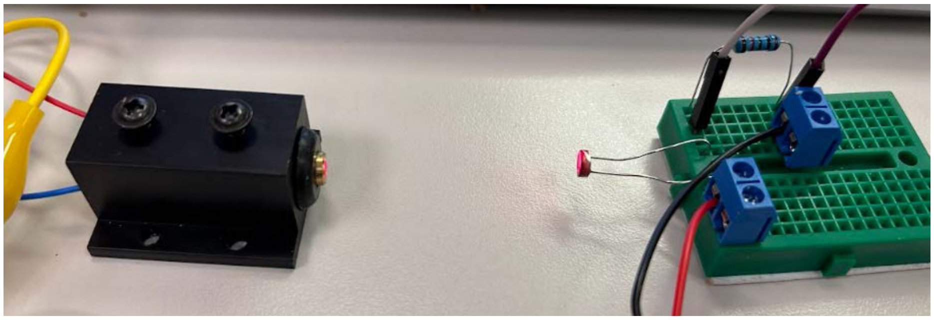


7 Place your battery's red wire in the lower leftmost column on the breadboard. Place the black wire in line with the far right resistor's leg.



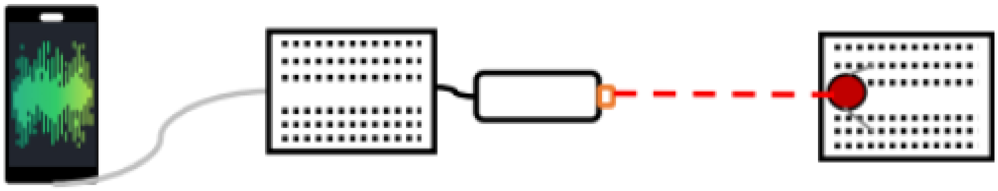


8. Turn on the battery holder. Plug your phone into the transmitter's audio plug, using a dongle, and aim the laser at the photoresistor. Get ready to test your circuit! If your circuits aren't working, go to page 23 for troubleshooting tips.



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?

____

____

____

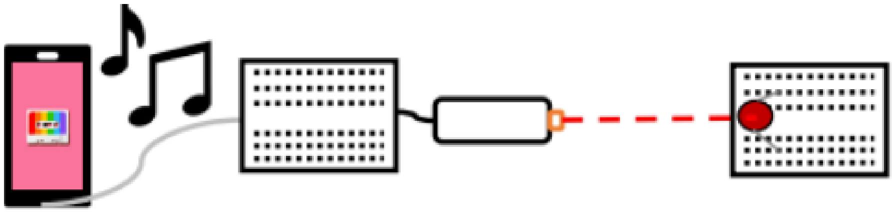
4. Illuminate the photoresistor with the laser.
5. Try changing the audio tone frequency.
6. Does the audio coming out of the speaker change when you change the frequency?

____

____

____

Part B: Testing Transmitter- Tone Frequency



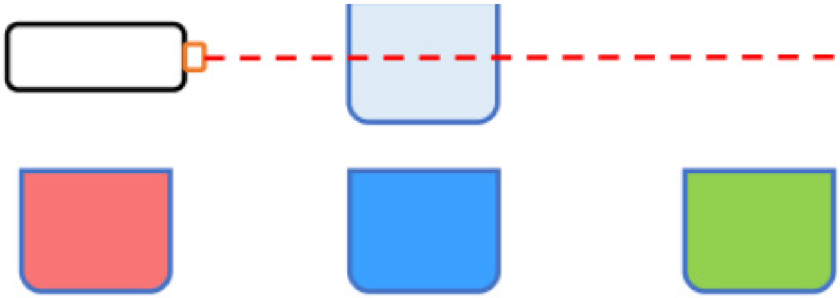
Directions: Collect the materials from the teacher for the demonstration, perform the procedure and answer the questions as you work.

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.

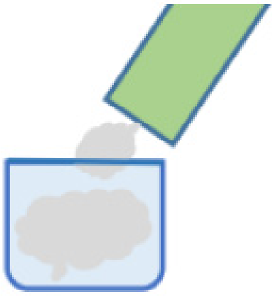
4 Use 4-5 drops food coloring per ½ cup water.

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 1-2 drops 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?

Troubleshooting: My music won't turn on!

Try each step, listen through your earbuds after completing it.

1. Ensure that the battery holders are switched on and the laser is pointing directly at the photoresistor. Turn the potentiometer on the transmitter counterclockwise as far as it will go to make the laser brighter.
2. Put in both earbuds. The music can only come through one side since we are using mono audio.
3. Have a teacher or another student check your wiring. Make sure everything that needs to be connected is in the same column. Make sure that all wires are secure and are pressed down into the breadboard.
4. Use a Tone Generator app to generate a frequency between 10Hz and 20Hz. Is the laser flashing/blinking? If it is NOT, there is a problem with the transmitter (very rarely, it will not flash but still transmit music). Go to page 14.
5. Now we will need to start replacing components. The earbuds are the most fragile piece. Swap them out for a new pair.
6. Swap out the resistor and photoresistor, one at a time, testing in between.
7. It is less likely that the remaining components are broken, but you can swap out the remaining wires and screw terminals if you need to.

Part D: Clean Up!

1. Turn off both of the battery packs.
2. Remove the batteries from the battery holders. This prevents the circuit from powering on while in storage.
3. Use an alcohol wipe to clean off the silicone ear tips of the earbuds.
4. Ask your teacher whether to take the kits apart or put them in the container fully assembled.
5. If you are taking apart the transmitter and/or receiver, make sure that you do not swap parts between the kits. The transmitter container should only have transmitter parts in it. The same goes for the receiver.
6. Carefully place each component into its assigned container. Place the lid on the container.
7. Place the kits in the center of your desk or table.

Congratulations! You have successfully built a laser communication device and completed this assignment.

Real Life STEM! Learn more about actual scientists and engineers.

Dr. Patricia E. Bath (1942 - 2019)

Dr. Bath spent her career working to help people who suffered from blindness through research and ophthalmological work. She invented a new device and method of using lasers to remove cataracts with her laserphaco probe. She co-founded the American Institute for the Prevention of Blindness, an organization that believes eyesight is a basic human right. Dr. Bath worked in Black and low-income communities to serve people who didn't have access to preventative care. In 1983, she was appointed the first woman chair of ophthalmology in the United States at Drew-UCLA. Today, the laserphaco probe is used worldwide to treat those with blindness.

Notes

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