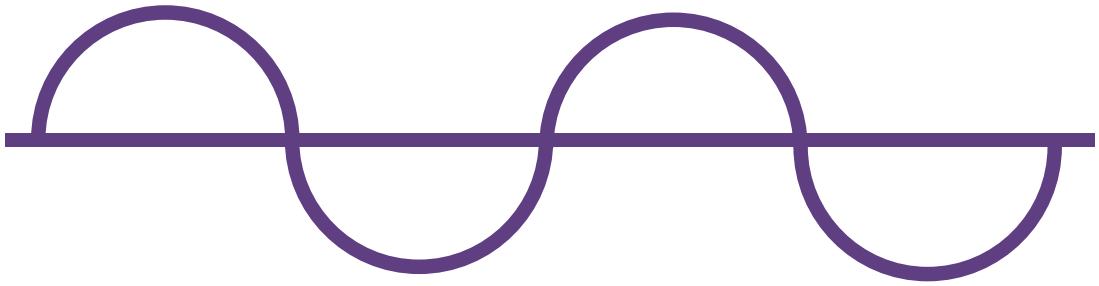
Digital Vs. Analog Signals

Look at the difference between two types of signals

Analog signals are sent in a continuous wave. These signals can be interrupted by interference, such as an electronic signal. For example, on an airplane, electronic devices must be turned off, or they can cause the airplane's electronics to malfunction!



Digital signals transmit the same information, but in a series of steps. The information is coded in numbers, or pulses of information, instead of a continuous wave.

SCIENCE CAREER ADVENTURES

Space Exploration and Fiber Optic Cables

Fiber optic cables are used as part of space exploration. Here are a few examples of how the cables are used:

To transport people to and from the Moon:

NASA is planning to use fiber optic cables on spacecraft to bring people safely back from the Moon to Earth. The fiber optic cables will send digital signals about how the material on the outside of the spaceship is holding up during different parts of the trip. For example, the signals will send information about how the spaceship is holding up in very hot or very cold temperatures.

To learn about Mars

Fiber optic cables can be used as part of spectrometers to analyze chemicals on Mars. Spectrometers work by heating up chemicals so that they give off light. The light travels through fiber optic cables to be analyzed by a computer. By analyzing light given off by chemicals on Mars, scientists can figure out what Mars is made of and how humans can live there. For example, the Mars' Rover uses three miniature fiber optic spectrometers.

To explore Europa

Europa is one of Jupiter's moons. It has a thick icy shell surrounding it! In most places, the shell is 10 miles thick! Scientists think that life could live in a liquid ocean below the icy shell. To study the liquid ocean, NASA wants to send a robot through the ice. The robot will use a fiber optic cable to send signals back out for scientists to study!

Teacher Demonstration

You will be using a flashlight (without the fiber optic rod) to show the difference between analog and digital signals.

First, show what binary code looks like.

1. Turn off lights in the room and shine a flashlight on the ceiling or the wall.
    1. Explain that while the flashlight is on, it represents a "1."
    2. Turn the flashlight off and explain that when the flashlight is off, it represents a "0."

2. Tell students that you are going to use the flashlight to send 1 signal every 3 beats.
    1. As a class count "1, 2, 3" then turn the flashlight on while saying on.
    2. Immediately turn the flashlight off and as a class count "1, 2, 3" and then leave the flashlight off while saying off.
    3. This process should sound like "1, 2, 3, on. 1, 2, 3, off."

Next, have students decode binary signals.

1. On the board, write the number 1 next to the word "on" and the number 0 next to the word "off."
2. Explain to students that computers read these "on" and "off" signals to decode the message being sent.
3. Practice having students decode a longer message by using the flashlight to flash the following: "1, 2, 3", "on", "1, 2, 3", "on" "1, 2, 3", "off", "1, 2, 3", "off" "1, 2, 3", "on", "1, 2, 3", "off" (to create the message 1 1 0 0 1 0)
4. Explain to students that when a digital signal is interrupted, it can often still be read. For instance, if the battery is running low, the light will be dimmer, but still readable. Demonstrate this by putting your hand over half of the flashlight so that only half the light comes out.
    1. With the flashlight half covered, show the students a short message; "1, 2, 3, off. 1, 2, 3, on" (to create the message 0 1)
    2. Ask students if only seeing half the light made it harder to figure out the signal. Students should say that it was a little harder to see the light, but it was still easy to figure out the message.
    3. Explain that digital signals are very reliable for transmitting information. It is simple to see whether there is a light or isn't a light. This is how a digital code works. There is an input, or there isn't.

Now, show an analog signal.

1. Explain to students that now you are going to ask them to decide on a scale of 1 to 5 how bright the flashlight is to send a signal.
    1. Shine the flashlight on the ceiling and tell students this represents the brightest light so it is a 5.
    2. Now put one finger over the end of the flashlight and shine it on the ceiling and tell students this is the second brightest so it is a 4.
    3. Now put two fingers over the end of the flashlight and shine it on the ceiling and tell students this is the third brightest so it is a 3.
    4. Now put 3 fingers over the end of the flashlight and shine it on the ceiling and tell students this is the fourth brightest so it is a 2.
    5. Now put four fingers over the end of the flashlight and shine it on the ceiling and tell students this is the fifth brightest so it is a 1.

Next, have students decode analog signals.

1. Tell students that you are going to use the flashlight to send 1 signal every 3 beats.
    1. As a class count “1, 2, 3” then turn the flashlight on with no fingers covering the end and ask students what number it represents. Accept all answers and then tell students that it was a 5.
    2. Turn the flashlight off and as a class count “1, 2, 3” and then turn the flashlight on with 3 fingers covering the end and ask students what number it represents. Accept all answers and then tell students that it was a 3.
    3. Explain to students that it is much harder to determine an analog code, it is hard to decide exactly how bright the light is. It is much easier to figure out a digital code. The flashlight is clearly either on or off.

Exploring Europa

As a fiber optic cable engineer, you have been recruited by NASA to help build a device that will collect data on and below the surface of Europa. NASA needs to design and build a space craft that can:

- Tunnel through the ice to get to the ocean.
- Test the ice as it tunnels through and test the ocean when it gets all the way through.
- Send test results back up to the surface above the ice using fiber optic cables.
    - Because of the large change in temperature that can occur, fiber optic cables are much more reliable than other kinds of wire or cables. The digital signals that will be sent through the fiber optics are also more reliable than analog signals because there is less interference.

It is your job to build a device that is capable of entering the ice on Europa. Your device will have fiber optic cables that can transmit signals from the device to a computer at the surface of the ice. Then, the signals will be interpreted by scientists to determine if there is liquid water beneath the icy shell of Europa.

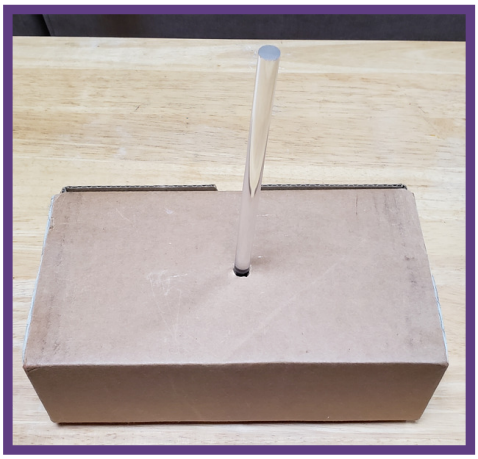
Steps to Build Your Device

Follow the steps to build your device!

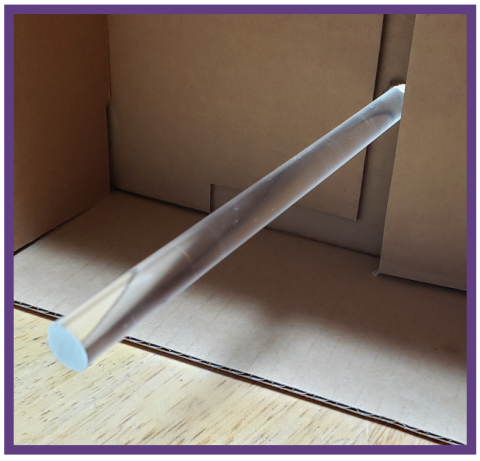
Step 1: Build Europa

- Cut a small hole in the cardboard box provided by your teacher. This hole should be small enough to ensure that the plastic rod is secure and won't fall out. The cardboard box represents the icy shell found on Europa.

- Insert the plastic rod through the hole in the box. The plastic rod represents the fiber optic cable that the two halves of your device will use to communicate with each other.



- Practice sending light through the rod from inside the shell of Europa to outside the shell of Europa. To do this, hold the flashlight up to the end of the rod that is inside the box. Turn on the flashlight and look to see if you can see the light traveling through the rod to the outside of the box.



Step 2: Build Your Device

Your device will have two parts. One part will enter into the ice on Europa to try to reach the liquid ocean beneath the surface. The second part will stay at the surface of the ice on Europa. The second part of the device will "decode" the information from the fiber optic cable.

1. Build the part of the device that drills through the ice to get to the liquid ocean. This part of your device should meet the following requirements:
    - Have a way to travel through the ice to get to the ocean beneath the surface.
    - Have space for testing equipment. Your device will need to take samples of the material it finds along the way.
    - Connect to the fiber optics cable (plastic rod) so it can send results back to the surface through a digital signal.
        - You will need to be able to use a flashlight to send light from one end of your fiber optic rod to the other end of your fiber optic rod.

2. Build the decoding part of your device. The decoding part of your device will sit on the surface of Europa and interpret the data that has been delivered by the drilling portion. The decoding device should meet the following requirements:
    - Receive transmissions from the lower half (allow light to shine through).
    - Have an area to hold the technology that will decode the messages.
        - Connect to the fiber optics cable (plastic rod) so it can receive results from the tunneling part of the device through a digital signal.

3. Connect each part of your device to one end of the fiber optics cable (plastic rod).

Step 3: Practice Sending Signals

- Have one group member use a flashlight to send light from inside Europa to the surface.
- Try different locations to see what position works best for transmitting your signal.

Creating a Code

It is time to test if your prototype can transmit data through your fiber optic plastic rod. To do this, you will create a coded message to send through your prototype.

Step 1: Look at the binary code alphabet and get familiar with the letters.

A	00001	N	01110
B	00010	O	01111
C	00011	P	10000
D	00100	Q	10001
E	00101	R	10010
F	00110	S	10011
G	00111	T	10100
H	01000	U	10101
I	01001	V	10110
J	01010	W	10111
K	01011	X	11000
L	01100	Y	11001
M	01101	Z	11010

Lesson: Installing Fiber optic Cables

SCIENCE CAREER ADVENTURES

Step 2: Write your binary code

- You must separate each signal with 3 beats.
- Your message will be a series of 1s and 0s.
- Write your code out below:

Step 3: Practice sending your message with your group

- Hold a flashlight to one end of the fiber optic rod in your prototype.
- Have a member of your group read the code at the other end of the fiber optic rod, on the other side of the box.

Step 4: Read another group's signal

- Pair up with another group and try to read each other's signals.
- As you read the other groups signal, write down the signals that you see.
- Write down the message that the other group was sending and check to see if you are right!
- Now switch and have the other group try to read your signal.