GRADES 6-12

Revised 06.04.2024

USS CLEVELAND LEGACY FOUNDATION STEAM STARS

MODULE 3 LESSON GUIDE // U.S. NAVY SUBMARINES

USS CLEVELAND LEGACY FOUNDATION STEAM STARS PROGRAM

LESSON OVERVIEW

This module introduces students to U.S. Navy submarines, beginning with brief mention of the U.S.S. COD in Cleveland and the history of hull design and technology. This lesson engages students with facts about the U.S. Navy's history and present use of dolphins and their tie to submariners, and inspires diversity and women in STEM fields. Throughout the presentation, students will learn STEAM concepts in a fun way, with videos and hands-on activities. Students will take part in a Cartesian Diver experiment to learn how submarines use ballast tanks to affect buoyancy in order to dive and navigate underwater and discuss submarine technologies such as SONAR.

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LESSON TITLE

U.S. Navy Submarines

TIME

60 min

LEARNING OBJECTIVES

Students will:

- Understand how submarines dive and resurface in the ocean
- Discover that dolphins influenced early submarine technology and design, and some of the ways they are used by the Navy today
- Learn what buoyancy is, then conduct an experiment to test a method similar to ballast tanks used by submarines
- Use a Cartesian diver and interpret how it works by using terminology such as density, buoyancy and pressure

NEXT GEN SCIENCE STANDARDS (NGSS)

This lesson helps students prepare for these Next Generation Science Standards Performance Expectations:

> HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. (Grades 9 - 12)

MODULE 3 PLAN // U.S. NAVY SUBMARINES

USS CLEVELAND LEGACY FOUNDATION STEAM STARS PROGRAM

MATERIALS AND EQUIPMENT LIST

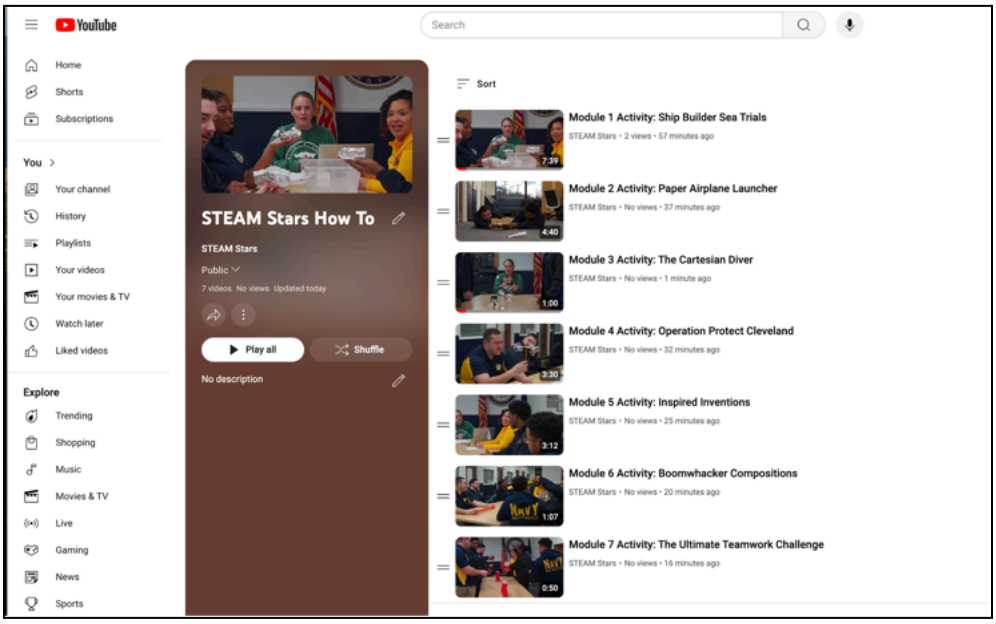
- ☐ Module 3 Presentation (U.S. Navy Submarines)
- ☐ The Cartesian Diver Classroom Activity
  Divide class into teams of 2-6 students. Materials needed for each team:
  - ☐ Access to water source - or - pitcher of water
  - ☐ 1 Clear 1.5 to 2 liter plastic water bottle (without label) - filled with water
  - ☐ 1 Small Glass Eye Dropper

TECHNOLOGY TOOLS

- ☐ Digital display projector with internet access
- ☐ Ability to project and play Google Slides and YouTube videos with sound

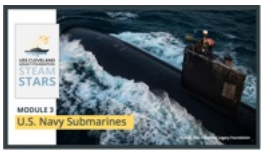
PREP WORK

- ☐ Test slide deck, embedded videos.
- ☐ Pre-fill plastic bottles with water and have ready (1 per team).
- ☐ Pre-sort materials.
- ☐ Recommended: Pre-fill a pitcher of water and have it available to all teams at the front of the class. This should be less messy for dipping the eye droppers into to get water.
- ☐ Go to the @USSCLF-STEAMStars YouTube to watch helpful How-To videos!



PROCEDURE PART 1: PRESENTATION

Module 3 - U.S. Navy Submarines

Slide 1. 	
Slide 2. 	Here's a submarine some of you may already be familiar with. It's the U.S.S. COD, and it's here in Cleveland. **Who here has been to see the U.S.S. COD before? Have you been inside for a tour?** The U.S.S COD SS-224 is a Gato class submarine that served in World War II. One thing you may notice is how it looks more like a ship at first glance. Doesn't really look like the subs we are used to seeing in movies, right? That's because prior to WW2, submarines used to spend most of their time on the surface. So since they had to be able to move fast above water, the design of the hull was optimized for speed on the surface of the ocean, and it really only had limited endurance while submerged. Which leads us to our Submarine Navy Fun Fact ...
Slide 3. 	Did you know that the U.S. Navy looked at dolphins as inspiration for modern submarine design? And that they still use dolphins in the Navy today? During the cold war, the U.S. Navy began studying dolphins for ways to improve their submarine technology so that they could move faster and stealthier underwater. But the program yielded several other surprising discoveries, from their use of fins and echolocation for navigation, to their intelligence for tracking and hunting prey. Dolphins naturally possess the most sophisticated sonar known to science. Since 1959, the Navy has trained dolphins to help guard against explosives and other threats underwater. Because of their superior abilities, they can go into small harbors, coastal areas or deep into the open sea to find objects. They can also find enemy divers that threaten national security or Navy ships, and are great at marking the location of undersea mines. Dolphins have excellent low light vision and underwater directional hearing that allow them to detect and track undersea targets, even in dark or murky waters.

	They can dive hundreds of feet below the surface, without risk of decompression sickness or "the bends" like human divers. While the Navy has also begun to use unmanned underwater drones, the technology is no match for dolphins! Dolphins are special to the Submarine Force. When a submariner qualifies, as in they meet the qualifications to serve on a sub, they are pinned and it's called the day they "earned their dolphins."
Slide 4. 	Did you know that women used to not be allowed to serve on submarines? The U.S. Navy lifted their ban in 2010 to allow female officers to serve on board subs. Then enlisted female sailors were allowed to serve a few years after that. Today, retention rates of female submariners are as high as their male counterparts. Yeoman Suraya Mattocks, pictured on the left, is a trailblazer, one of the very first women to ever serve on board a submarine. Kayla Barron, pictured on the right, served on a submarine as well, and then was inspired by her experience, explaining that being in a submarine sounded a lot like being in a spaceship. She went on to become an astronaut with NASA. Wow! Have you ever thought of the ocean being similar to space? What do you think about a Submariner being like an astronaut? Let's hear a quick clip from Kayla Barron speaking from space herself!
Slide 5. 	(Clip Run Time: 1:23 min. - from 6:52 to 8:15)
Slide 6. 	Much like the space shuttle you saw in the last video, the modern submarine is full of systems that are critical to maintain even the most basic functions of life, like breathing, eating, and generating fresh drinking water. There are systems for communication, warfare, protection, and navigation, and also things like cleaning the air from bad odors, and flushing human waste. In a previous lesson, we learned how large ships stay afloat and even tested what can make them sink. But submarines need a way to control their buoyancy and density to dive in and out of the water. And once they're under the ocean, they use technology to navigate. Let's see how they do it...
Slide 7.	(Clip Run Time: 2:18)

	
Slide 8. 	Now let's test what we've learned with an experiment called the Cartesian Diver.

PROCEDURE PART 2: ACTIVITY

The Cartesian Diver

To begin, divide the class into teams of 2 or more. Each team will need their own set of materials. Let the class know that you'll all go through the steps together. As you guide the students through the activity, keep Slide 8 up for reference.

Each team will need:
1 Clear 1 to 2 liter plastic water bottle (without label)
1 Small Eye Dropper

First, fill your bottle with water, all the way to the top.

Now take some water with the eye dropper, but leave just a little air pocket inside the eye dropper.

When you put the eye dropper into the bottle, it should bob at the top, and the water level should still be all the way full. Add water, if needed.

Now, close the bottle tightly. Do not shake or tip the bottle.

Try gently squeezing the bottle to add pressure. Did your submarine (the eye dropper) sink? Now release your grip on the bottle. Did your submarine rise back up to the top? Try adding and taking away pressure to control your submarine. Let your partner try as well!

Slide 8. 	**Closing Discussion** **Did it work? Why?** **In what way does this experiment explain how submarines are able to navigate in and out of the water?** (Refer to the illustrations at the bottom of the slide) Submarines have ballast tanks between their inner and outer hulls. When the submarine is on the surface, the ballast tanks are filled with air and the submarine floats, like our divers. You can see the pocket of air inside that keeps our diver, or submarine, afloat. To dive, vents are opened on the bottom of the submarine to allow seawater into the ballast tanks. As the water rushes in, the air is forced out through vents in the upper hull. The change in weight causes the submarine to submerge. When you applied pressure to the bottle by squeezing the sides, you compressed the air inside, causing the diver to fill up with water, making it denser than the water, less buoyant, and causing it to sink, or go down. To surface, air is pumped back into the ballast tanks, which forces the sea water out through the bottom vents. The submarine rises as it becomes lighter. For our diver, by releasing the pressure, the air is returned, the diver is now less dense than the water it's in, and it can now float back to the surface. In scientific terms... An object in water experiences a downward force of gravity,

	as well as an upward buoyant force. Pressure of the water increases with depth, causing the upward buoyant force to be greater than the downward force on the object. The buoyant force is equal to the weight of the fluid displaced by the object. Sinking of an object will occur when the object density is greater than the density of the water.
	GO DEEPER **Discussion Question For Further Exploration** What is the difference between SONAR and Echolocation? Both are systems that use sound waves to navigate location. But SONAR transmissions are man made, and echolocation are natural sound wave transmissions made by animals. Echolocation is a natural sound wave transmission and detection method used by animals to accomplish the same goal of object detection. Though sometimes referred to as sonar in casual conversation, echolocation requires no human-made device to function and is used both above and below water. Animals use echolocation by sending out sound waves in the air or water before them. They can then determine information about objects in their path through the echoes produced when those sounds are reflected. Echolocation can be utilized by any animal with sound-producing and sensing capabilities. Humans have been known to develop methods of systematically tapping canes or clicking their tongues to produce the sounds needed for echolocation. However, echolocation is more generally associated with the use of ultrasound by non-human animals. Ultrasound is sound that has a mechanical wave frequency higher than the human ear can detect though they operate the same as audible sound waves. On a ship or sub, Sonar Rooms are full of screens that visually show sound waves. Sonar Technicians are the submarine's eyes and ears, listening and watching for contacts. Once a contact is detected, automated trackers are assigned, and algorithms attempt to determine the contact's course, speed, and range. Sonar Techs get to be really good at reading patterns on screen to know what noises such as ship rudders, whales, and even other submarines “look” like, so they can easily spot what is friendly and what is an enemy!