

Submarine Force Museum Lesson Plan

Developed by 2015 Submarine Force Library and Museum STEM –H Teacher Fellow
Ted Allen, Science Teacher, Ledyard Middle School, Ledyard, CT

Lesson Name Pressure & Buoyancy **Number of minutes in the Lesson** 90

Intended Audience Grade three through eight

Content Standards: Identify state CCSS content and literacy standards (when applicable) and national curricular standards this lesson is designed to help students attain. Also include state and district standards as well as the Technology Standards and CCSS Math Standards when applicable.

- MS-PS2-2 Motion and Stability: Forces and Interactions (Next Generation Science Standards)
- CCSS.ELA-Literacy.RST.6-8.9 (Common Core State Standards for Literacy in Science and Technical Subjects)

Pre-Visit Materials/Activities: Describe the students' prior knowledge or skill related to the learning objective(s) and the content of this lesson, using data from pre-assessment as appropriate. What background knowledge or skills do you want students' to come to the museum prepared with, and what materials will you provide to groups ahead of time so they are prepared for this lesson?

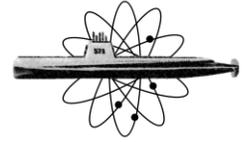
1. <http://www.youtube.com/watch?v=JrU0bYq7KPQ&list=PLFD9B22F33A5FBDCB> Watch the one minute video on U.S. Navy YouTube Channel.
2. Read about buoyancy at <http://hyperphysics.phy-astr.gsu.edu/hbase/pbuoy.html> or view a video at <https://www.khanacademy.org/science/physics/fluids/buoyant-force-and-archimedes-principle/v/fluids-part-5> .
3. To learn more about how a submarine operates surfaced (positive buoyancy) and submerged (neutral buoyancy) see <https://www.youtube.com/watch?v=yb3e4IegeJ0> .
4. To learn more about the history of the U.S. Submarine Force take a virtual tour at www.usnautilus.org/virtualTour/index.shtml .

Set up Before the Lesson Begins: Describe any preparation that is necessary before the lesson.

Charles's law states that if a given quantity of gas is held at a constant pressure, its volume is directly proportional to the absolute temperature.

Boyle's law states that if the pressure of a gas is inversely proportional to the volume.

Archimedes' principle indicates that the upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces.



Submarine Force Museum Lesson Plan

Materials

1. Water available
2. Medicine droppers
3. 10 water bottles
4. Balloons
5. 2 liter bottle
6. Submarine model (2 liter bottle or other)
7. Pressure demonstration (two liter bottle)
8. Steel ink can (Charles Law) demo
9. Hot plate
10. Laptop and projector for Power Point

Content Objective(s): Identify specific and measurable learning objectives for this lesson. Remember only one for a 45 minute class, two for a 90 minute class.

1. That fluid pressure is a force caused by the weight of the column of fluid above you and increases with depth (in both air and water)
2. This pressure can exert noticeable forces inwards on objects (crushing them) and upward (buoyancy).

Initiation: Briefly describe how you will initiate the lesson. (Set expectations for learning; articulate to learners what they will be doing and learning in this lesson, how they will demonstrate learning, and why this is important)

- Exhibit of Bushnell on museum first floor, on virtual tour at: <http://www.submarinemuseum.org/virtualTour/mainexhibit.shtml> .
David Bushnell (1754-1824), of Westbrook, Connecticut, was an American inventor and a veteran of the Revolutionary War. He is credited with creating the first submarine ever used in combat, while studying at Yale College in 1775. He called it the *Turtle* because of its look in the water. His idea of using water as ballast for submerging and raising his submarine is still in use, as is the screw propeller, which was used in the *Turtle*.

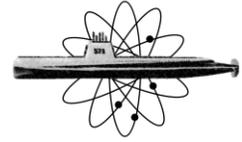
Just as David Bushnell had to, modern submarines must reckon with the fluid pressures that are exerted on them and they must adjust their densities to submerge and rise.

Lesson Development: (Add a Time for Each Segment of the Lesson)

Copies of each page of the Power Point which sequences with the Activities is included at the end of this lesson plan.

Activity 1: (To be done while discussing Initiation) Fill Ink Can with 0.5 inches water and place on hot plate on high. 5 Minutes

Activity 2: Demonstrate how pressure changes with depth by poking 3 tiny holes Push pin sized) in a two liter bottle, one near the bottom, one 1/3rd of the way up, and the last 2/3rds of the way up, all one above the other. Fill the bottle with water and observe the pressure of the streams of water from each hole.



Submarine Force Museum Lesson Plan

Activity 1 (Revisited-can be done after Cartesian Dive if steel can's water is not hot enough yet)

Ask the group if they can feel the pressure around them? (Usual answer is no) Explain that the pressure of just the air can crush the steel can.

(Conclusion) Remove can and seal rapidly, either watch as it slowly crushes as it cools (best with younger groups as the anticipation and sounds it makes work best), or dip into an ice bath deep enough to submerge it in to collapse it rapidly. This works as the pressure of a hot gas has more pressure than a cooler gas in the same volume (Charles Gas Law), once the gasses in the can cool the outside air pressure crushes the can.

Activity 3: Hand out procedure (at end of lesson plan) for making a Cartesian Diver, monitor as group completes. For low level discuss as simply density changing, for older students discuss Boyle's Gas Law showing as the pressure increases (squeezing the bottle) the volume of a gas decreases (the air bubble in the diver shrinking). This change in volume affects buoyancy and is comparable to how a submarine adjusts its depth.

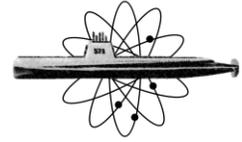


*Allow group to play and challenge them to achieve neutral buoyancy. Questions at that point can revolve around forces and whether they are balanced or unbalanced. 15 Minutes

Activity 4: Place Submarine Model in water. Inflate the balloons causing submarine to rise. Questions at this point are;

1. Why does the submarines rise? (It's lighter, it has less water etc....)
2. Why is it lighter? (The balloons force the water out)
3. How is this similar to how a submarine works? (Ballast water)

Continue with groups about Archimedes Principle explanations to why things float. Lead the group towards the correct answer as needed. 15 Minutes



Submarine Force Museum Lesson Plan

Closure: Briefly describe how you will close the lesson and help students understand the purpose of the lesson. (Interact with learners to elicit evidence of student understanding of purpose(s) for learning and mastery of objectives)

Post-Visit Materials/Activities: Provide additional materials if they would reinforce a good learning experience after leaving the museum. If materials allow have students take their Cartesian Diver with them.

Technology: Please explain the technology used: why you will use it, how you will use it and how you will assess the results of using this technology.

Key Vocabulary: Words students need to know in order to reach the objectives.

Buoyancy	Pressure	*Boyles Gas Law
Archimedes Principle	Force	
Density	*Charles Gas Law	*For higher level

Extension: What do you have in place in case during the lesson you finish early, run out of time or need to accommodate students who complete the class work before other students, or your technology fails?

Finish Early: Heavy mil large garbage bag, duct tape, and a shop vac. Tear hole in garbage bag near bottom. Use duct tape to seal hole with shop vac hose in it. Have a volunteer get in the bag and kneel. Hold the top of the bag in a loose seal around neck of volunteer. Turn on shop vac. The removal of air will cause the bag to press in (harmlessly) on the volunteer but it will press their arms to their body with about half an atmosphere of pressure, preventing them from raising their arms. To be honest, everybody will want to try this once shown, just tell them it is not who can tear the bag, but who can lift their arm.

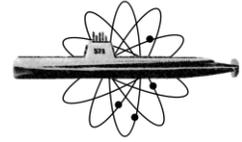
Run out of time: Each of the demonstrations/activities stands alone and as long as the Cartesian Diver and steel can are completed the rest of it is merely continued expansion on the theme.

Technology Fails: With the exception of the hot plate (which rarely fails) there is no technology included. Unless using the Power Point.

Materials: List the materials you will use in each learning activity.

1. Water available
2. Medicine droppers
3. 10 water bottles
4. Balloons
5. 2 liter bottle
6. Submarine model (2 liter bottle or other)
7. Pressure demonstration (two liter bottle)
8. Steel ink can (Charles Law) demo
9. Hot plate
10. Laptop and projector for Power Point

Resources: Include any resources you may use such as textbooks and any technological resources.



Cartesian Diver Procedure

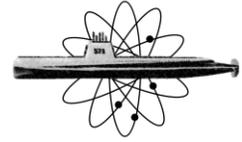
Materials Needed:

Water, a one liter or smaller water bottle, and an eye dropper/medicine dropper.

- ◆ Fill the plastic soda bottle to the VERY top with water.
- ◆ Fill the glass eyedropper 1/4 full with water.
- ◆ Place the eye dropper into the soda bottle.
- ◆ Cap the bottle.
- ◆ Squeeze the sides of the bottle and notice how the eyedropper (called a diver) sinks. Unsqueeze.
- ◆ Squeeze again and observe closely the water level in the eyedropper (it goes **up**). Unsqueeze.
- ◆ What is happening? Why?



Submarine Force Museum Lesson Plan



To begin

- ◆ Lets put this steel can, with a bit of water, on the heat to boil. We will return to this later.

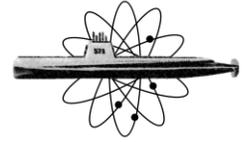


Pressure

Historic Ship *Nautilus*
& Submarine Force Museum



Submarine Force Museum Lesson Plan

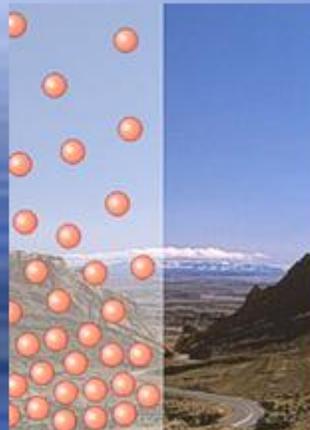


What is Fluid Pressure?

- ◆ Pressure is exerted in all directions by a fluid, (liquids and gasses) dependent upon the weight of the column of fluid directly above the measurement point.

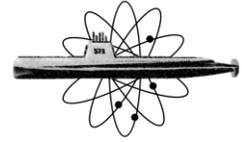
or, it is air or water pushing in on an object.

The deeper you go, in air or water, the greater the pressure.





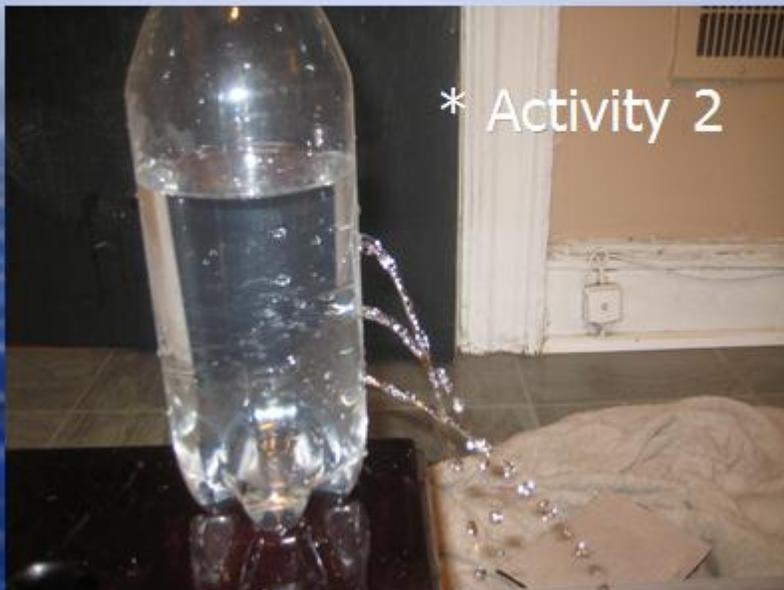
Submarine Force Museum Lesson Plan



Pressure and depth

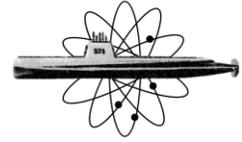
- ◆ Lets see how quickly pressure can change with water depth.

* Activity 2



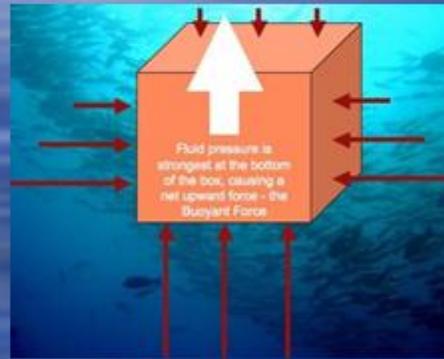


Submarine Force Museum Lesson Plan



Buoyancy

- ◆ the ability or tendency to float in water, air, or some other fluid.
- ◆ Buoyant Force

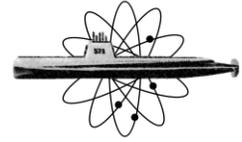


Activity 3: We can show this using a Cartesian Diver!

- ◆ Fill the plastic soda bottle to the VERY top with water.
- ◆ Fill the glass eyedropper 1/4 full with water.
- ◆ Place the eyedropper into the soda bottle.
- ◆ Squeeze the sides of the bottle and notice how the eyedropper (called a diver) sinks.
- ◆ Squeeze again and observe the water level in the eyedropper (it goes up).



Submarine Force Museum Lesson Plan



So how does all of this relate
to submarines?

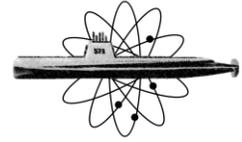
◆ Lets see.....

Virtual Activity 3 Diver

◆ [http://argofloats.wikispaces.com/Cartesian
+Divers](http://argofloats.wikispaces.com/Cartesian+Divers)



Submarine Force Museum Lesson Plan



Now, back to the steel can

- ◆ What happened here?

Activity 4: Submarine Operations