

NAVAL HISTORY STEM-H LESSON PLAN

TEACHER HELP GUIDE

LESSON PLAN: SNAP, CRACKLE, POP: Submarine Buoyancy, Compression, and Rotational Equilibrium

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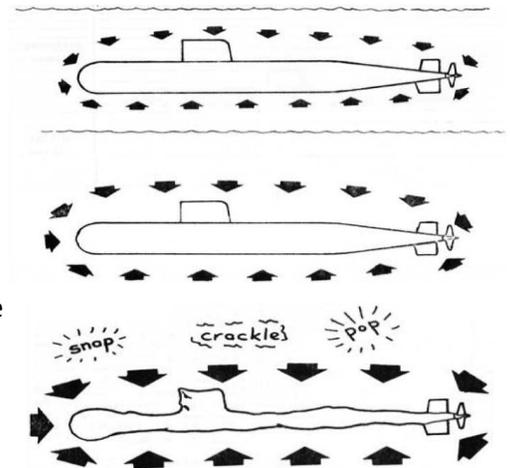
2012 Naval Historical Foundation STEM-H Teacher Fellowship

INSTRUCTIONAL GOAL: Explain and perform calculations regarding the buoyant force on a submarine, how the buoyant force on a submarine varies as its hull compresses, and how a submarine can maintain neutral buoyancy and rotational equilibrium by pumping water from tank to tank and on/off the boat. In an extension activity, students can calculate the deformation of the submarine due to water pressure at various depths.

BACKGROUND:

There are three Activities included with this lesson plan.

- Activity 1: Encompasses a number of concepts and thus could be used as an end of term review activity, or broken up and used during the chapters in which each topic is covered.
 - Fluid Pressure vs Depth and Absolute Pressure
 - Comparing Air Pressure to Water Pressure
 - Density and Buoyancy
 - Equilibrium, Linear Kinematics
 - Boyle's Law (Pressure vs Volume)
- Activity 2: Focuses solely on Bulk Deformation and how the hull of a submarine is compressed as it proceeds deeper into the ocean.
 - Calculations involving a Styrofoam cup taken far below the surface of the ocean
- Activity 3: Explores Linear and Rotational Equilibrium as they apply to keeping the submarine level as well as neutrally buoyant.
 - Two ways to control the vertical position of a submarine
 - adjust its own density and thus the net vertical force it experiences by pumping water from its tanks into the ocean, or allowing some ocean water into its tanks.
 - changing some of its horizontal motion into vertical motion by angling its "planes".
- The activities are conceptual, but involve a lot of calculations. They are only partially inquiry based.



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RESOURCES:

The movies *Das Boot* and *U-571* have relatively realistic depictions of World War II submarines at war. Several weeks in advance, you could recommend that one of these be watched, or possibly show some clips in class.

[How A Submarine Submerges - Video](#) This clip “Buoyancy: Take ‘Er Down” and many others are available on the [US Navy History Museum's You Tube Channel](#)

STANDARDS:

Learning Objectives for AP Physics, © 2012 The College Board

<http://apcentral.collegeboard.com/apc/public/repository/ap-physics-course-description.pdf>

The following objectives apply to both AP Physics B and AP Physics C Mechanics.

I. NEWTONIAN MECHANICS

E. Circular Motion and Rotation

2. Torque and rotational statics

a) Students should understand the concept of torque, so they can:

- (1) Calculate the magnitude and direction of the torque associated with a given force.
- (2) Calculate the torque on a rigid object due to gravity.

b) Students should be able to analyze problems in statics, so they can:

- (1) State the conditions for translational and rotational equilibrium of a rigid object.
- (2) Apply these conditions in analyzing the equilibrium of a rigid object under the combined influence of a number of coplanar forces applied at different locations.

The following objectives apply to AP Physics B, but not AP Physics C

II. FLUID MECHANICS AND THERMAL PHYSICS

A. Fluid Mechanics

1. Hydrostatic pressure

Students should understand the concept of pressure as it applies to fluids, so they can:

- a) Apply the relationship between pressure, force, and area.
- b) Apply the principle that a fluid exerts pressure in all directions.
- c) Apply the principle that a fluid at rest exerts pressure perpendicular to any surface that it contacts.
- f) Apply the relationship between pressure and depth in a liquid, $\Delta P = \rho g h$.

2. Buoyancy

Students should understand the concept of buoyancy, so they can:

- a) Determine the forces on an object immersed partly or completely in a liquid.
- b) Apply Archimedes' principle to determine buoyant forces and densities of solids and liquids

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Virginia Standards of Learning

http://www.doe.virginia.gov/testing/sol/standards_docs/science/courses/stds_physics.doc

- PH.4 The student will investigate and understand how applications of physics affect the world. Key concepts include
- a) examples from the real world; and
 - b) exploration of the roles and contributions of science and technology.
- PH.7 The student will investigate and understand properties of fluids. Key concepts include
- a) density and pressure;
 - b) variation of pressure with depth;
 - c) Archimedes' principle of buoyancy;

INSTRUCTIONAL PROCEDURES FOR LESSON: None

INSTRUCTIONAL PROCEDURES FOR ACTIVITIES: None