NATIONAL MUSEUM OF THE UNITED STATES AIR FORCE

NEUTRAL BUOYANCY

Students practice observation and math skills while learning about astronaut training .
Adapted from a lesson plan provided by NASA

LESSON PLAN

Introduction
Neutral buoyancy is the term used to describe something that has an equal tendency to float as it does sink. Articles that are configured to be neutrally buoyant (which is accomplished with a combination of weights and flotation devices) seem to "hover" under water and large, neutrally buoyant items can be easily manipulated much like in orbit. This is similar to how it feels to be in the microgravity of space. Astronauts train in NASA's Neutral Buoyancy Lab to simulate working in space. Extra-vehicular Activities (EVAs) or space walks and many additional tasks related to the Space Shuttle Orbiter and the International Space station are rehearsed in the Neutral Buoyancy Lab (NBL). However, there are two important differences. First, a suited astronaut in the NBL is not truly weightless; while it is true the suit/ astronaut combination is neutrally buoyant, the astronauts feel their weight while in the suit (they are lying or standing in the suit depending on its orientation; that is one reason why suit fit is so critical). Second, water drag acts to hinder motion; this makes some things easier to do in the NBL than on orbit and some things more difficult. Both effects are unlike the conditions of space and must be recognized during EVA training. However, even with these limitations, neutral buoyancy is currently the best available method for EVA training.

Lesson Objective
In this lesson, students will learn about neutral buoyancy while experimenting with various weights in a large container of water. Students will weigh their containers, adjust the weights and graph their results as they achieve neutral buoyancy.

Learning Objectives

The students will
- Learn about neutral buoyancy.
- Learn about density
- Learn about Archimedes' Principle
- Learn why astronauts train for EVAs in neutral buoyancy
- Investigate neutral buoyancy through experimentation
- Calculate the volume of the canister
- Work cooperatively in teams to select weights, weigh canisters and graph their results

Grade Level: 6—8

National Math Standards:
Number and Operations, Algebra, Geometry, Measurement, Problem Solving, Communications and Connections.

National Science Education Standards:
Unifying Concepts and Processes, Science as Inquiry, Physical Science, Earth and Space Science, Science and Technology, Science in Personal and Social Perspective, History and Nature of Science.

Materials Required:
- Large aquarium or other clear container
- Film canisters or small air-tight plastic containers
- Variety of stainless steel nuts, bolts and washers
- Calculators
- Pencils
- Rulers
- Drawing paper or graph paper
- Digital scale or triple beam balance
- Fish net (optional)

Preparation for activity:

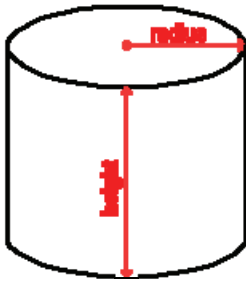
The teacher will collect or instruct students to bring from home the film canisters or small plastic containers and various stainless steel nuts, bolts and washers.

Procedures:

- The students will work in teams of 2 to 3 students.
- Begin by showing the Brain bites video from NASA of astronauts training in the Neutral Buoyancy Lab.
- Discuss/Present:
  - What is density?
  - What determines whether or not an object will float in water?
  - What is Archimedes' Principle?
  - What is NASA's Neutral Buoyancy Laboratory (NBL)?
  - What is the advantage of working in a neutrally buoyant environment?
  - How does training the this environment prepare astronauts for working in space?
  - Does the NBL duplicate the working environment of space?

- Explain to the students that each team will be investigating neutral buoyancy using a film canister or small plastic container and the various nuts, bolts and washers as the weights. Students will calculate the volume of their canister.

  Volume of a cylinder = $\boldsymbol{\pi}$ **r**^{2} x **h**



- Students will weigh the empty canister, and drop it (with the lid on) in the aquarium. Then the students remove the canister from the aquarium, add weight, re-weigh and drop in the aquarium, repeating until the canister achieves neutral buoyancy.

- Students will graph their results and compare their results with the entire class and determine the average weight needed for like-sized canisters to become neutrally buoyant.

Extension:

- If you have access to a swimming pool and your students can swim, have the students experiment with various weights until their bodies neither rise to the surface nor sink. Once they have successfully simulated the experience of a neutrally buoyant astronaut, then give them the tasks of fitting together pieces of PVC pipe according to a pre-determined structure to give the students a simulated astronaut training session. Always practice water safety!

Resources:

- NASA (National Aeronautics and Space Administration)

  http://brainbites.nasa.gov/#/astronauts-practice-underwater

  http://www.nasa.gov/pdf/379064main_Neutral_Bouyancy.pdf

  http://www.grc.nasa.gov/WWW/K-12?WindTunnel/Activities/buoy_Archimedes.html

  http://quest.nasa.gov/neuron/teachers/stellar/Neutral.html

NEUTRAL BUOYANCY WORKSHEET

Volume of canister_____

Weight of empty canister_____

Trial 1—Weight _____ Observation _____Float/Sink/Neutral

Trial 2—Weight _____ Observation _____Float/Sink/Neutral

Trial 3—Weight _____ Observation _____Float/Sink/Neutral

Trial 4—Weight _____ Observation _____Float/Sink/Neutral

Trial 5—Weight _____ Observation _____Float/Sink/Neutral

Trial 6—Weight _____ Observation _____Float/Sink/Neutral

Trial 7—Weight _____ Observation _____Float/Sink/Neutral

Trial 8—Weight _____ Observation _____Float/Sink/Neutral

Trial 9—Weight _____ Observation _____Float/Sink/Neutral

Trial 10—Weight _____ Observation _____Float/Sink/Neutral

Trial 11—Weight _____ Observation _____Float/Sink/Neutral

Trial 12—Weight _____ Observation _____Float/Sink/Neutral

Trial 13—Weight _____ Observation _____Float/Sink/Neutral

Trial 14—Weight _____ Observation _____Float/Sink/Neutral

Trial 15—Weight _____ Observation _____Float/Sink/Neutral

Trial 16—Weight _____ Observation _____Float/Sink/Neutral

Trial 17—Weight _____ Observation _____Float/Sink/Neutral

Trial 18—Weight _____ Observation _____Float/Sink/Neutral

Trial 19—Weight _____ Observation _____Float/Sink/Neutral

Trial 20—Weight _____ Observation _____Float/Sink/Neutral

How many trials were needed to achieve neutral buoyancy? _____