**APPLYING PHYSICAL CONCEPTS IN ENGINEERING DESIGN**

**THE RESEARCH REQUIRED:**

**Archimedes Principle** is described mathematically using the formula:

FB is the *buoyant force*,

∆ is the *displacement* of water in lbs,

ρ is the *density of water* in lb-s2/ft4,

g is the *acceleration due to gravity* in ft/s2, and V is the *submerged volume of the object* in ft3.

On earth, g = 32 ft/s2 and in freshwater, ρ = 1.94 lb-s2/ft4.

This formula can also be rewritten as

 **V = ∆/(ρg)**.

According to Archimedes Principle, an object partially or fully submerged in a fluid will

https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-process-steps

experience a vertical force, the buoyant force FB , pushing up on it equal to the weight of the volume of fluid displaced (∆) by the object. The buoyant force on the object is equal to the weight of the volume of water displaced by the object. When the weight of the object submerged is equal to the upward buoyant force exerted by the water, the object is neutrally buoyant so it neither sinks or floats, instead it hovers or flinks in the fluid.

**DESIGN CHALLENGE: Based on what you know now about buoyancy, use the engineering design process to design and build a small scale International Space Station National Laboratory to submerge in water similar to the scenario at the National Buoyancy Lab.**

**Keep a design log of your trials, noting which parameter has been varied and the results.**

**Be consistent in changing parameters (amount of weight, position of weight added, for example).**

**Collect materials that would be waterproof or resistant to water.**

**Take a picture of your best design to submit with your design log.**

**Challenge your students to use the least amount of supplies as possible.**

**Neutral Buoyancy Engineering Design Challenge**

**What types of materials do you have laying around?**

You could use pencils or Popsicle sticks for the longer parts.

Experiment with materials and let students be creative.

* Foil, pipe cleaners, background image/poster, small pieces for spacecraft.
* Change bottom surface for terrestrial training with rocks and minifigures.
* Small toy car could represent rover for astronauts or robotic vehicle.

**Materials using leftover SeaPerch parts:**

* PVC pipe piece(s)
	+ 3 - three sided corner joints
	+ 4 - two sided corner joints
	+ 2 - six inch pieces (holds solar arrays)
	+ 1 - three inch piece (ISS)
	+ 6 - four inch pieces (base)
* 8 wooden skewers
* Duct tape (blue, black, or silver)
* Scissors, flashlight, and pitcher for water.
* 1 large clear tub (approx.  23 ¾” L x 16” W x 13 ½” H)

Power tool required:

* Drill (drill bit 3/16 used here), pipe cutter, vice to hold pipes, safety glasses.

**Build Your Own Neutral Buoyancy Lab Chamber for Space Simulations in 1/6g Microgravity!**

Create a model of the International Space Station using PVC pipe as the main structure. I was able to use the remaining parts from a SeaPerch Kit.

1. Layout the pieces in the material list.
2. Assemble base using the picture as a guide. Suggested materials: SeaPerch kit mesh for payload area.
3. Drill 4 holes on 2 lengths of  6” pipe to create solar panel extensions. Space holes XX” apart so tape doesn’t overlap
4. Cut approx. 16  3 ½”  links of duct tape to represent the 16 solar panels. Attach 8 to ends of the 8 skewers with each skewer placed so tape is  folded in half and skewer is centered between folded tape.
5. Thread each wooden skewer through the drilled holes down the pipe.
6. Add tape to opposite ends of skewers to make solar panels. Secure skewer with additional tape as needed.
7. Place the structure in the clear tub. Using pitcher, fIll tub with water to cover model. Water line in the container should be 2-3” above the top of the model.

Additional Ideas:

A picture of the ISS or a telescope image of a constellation can be taped to one side of the tub for an added dimensional effect.

Exploration of neutral buoyancy and simulating ⅙ microgravity:

* Students create a table in their engineering notebook and list materials for weight (washers, rocks, marbles, coins).
* Place weights (5g, 10g, 15g, of rocks or marbles) to achieve a neutral buoyant ISS lab in the chamber. Discuss the effects of weight distribution. Note placement and weigh the attachments needed.
* Next, students will attach the structure to the floor or tape with duct tape. Place a floating representation of the moon, earth, and sun.
* Use a flashlight to represent the direction of the solar radiation. Adjust the solar panels for maximum angle for receiving the longest light exposure. Document constraints on maximizing exposure, simulating process required to achieve optimal exposure.

Other STEM Connections:

Science - Consider waterproof materials and adhesives for your models, test items before using for absorption rate, degradation based on hours in water.

Technology - Innovation, Evolution or Explosion? Make a historical timeline representing the development of the NBL and major space milestones.

Engineering Design - Make model spacecraft from your extra materials. Create terrain “lunar surface” scenarios to replicate actual mission requirements by weighting models on the “floor” of your NBL mockup.

Math - Use ratios to calculate additional dimensions for a model (such as a space capsule) based on length of your ISS model (actual compared to model). Quantify buoyant forces. Quantify optimal volume per weight allowed.

Art - Use recycled materials to create environmental scenarios, backdrops, for use in water experiments. Use different media, colors, textures to create realistic effects. Create an audio recording that mimics an underwater environment.

Social Studies - How did technology impact history? Identify significant events on the space timeline, during the Space Race and research the politics and economics of the time.