DRAFT

# Determination of Mass, Volume, and Ballast of a Sea Perch ROV

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**Overview:**
This lab will result in students demonstrating knowledge of mass measurements, volume measurements of an irregularly shaped object, and ballast determination for a Sea Perch ROV. This lesson is to help the students understand the principals behind why a ROV needs to be ballasted and how to determine how much ballast is needed. It will also show them how to determine the volume of an irregularly shaped object.

**Grades:** $7^{th} – 12^{th}$

**Time:** One 45-minute period.

**Objective:**
The students will:

- Determine the mass of an object
- Determine the volume of an irregularly shaped object
- Calculate the density of an irregularly shaped object

**Skills Attained:**

- Develop a method to determine the density of a Sea Perch ROV
- Determine how much ballast a Sea Perch ROV needs
- Develop an understanding of the ballast buoyancy relationship

**National Science Content Standards Addressed:**

- Unifying Concepts and Processes
- Science as an Inquiry
- Physical Science
- Science and Technology for grades 9-12

**Lesson:**
Buoyancy is an upward force exerted on an object by the fluid it is surrounded by. How buoyant an object is, is determined by the weight of fluid an object displaces. To determine how buoyant an object is you need to know the density of the fluid it will be surrounded by. With this information and the known volume of the object, you can determine the buoyant force exerted on the object. This is the force that an ROV would have to supply to submerge itself. A ROV needs to be slightly buoyant so that it will return to the surface if it loses power, but if it is too buoyant, it will take more energy to submerge it or it may not submerge at all. To adjust the buoyancy of a ROV weight known as ballast needs to be added. To calculate the ballast needed to make your ROV neutrally buoyant you need to know the density of the fluid your ROV is submerged in, the density of the ballast weights, as well as the volume and weight of the ROV. Remember that the densities of your weights must be greater than the density of your fluid otherwise they just add more buoyant force to the craft. This is why you use lead or

steel instead of foam, because lead and steel are denser than water and foam is less dense that water.

**Materials:**

- Pool float found in Sea Perch kit
- String to attach weights, also known as ballast, to the float
- Scale that weighs in fractions of an ounce
- One pound coffee can, or uniform cylindrical object that will hold water and that the float will fit into
- Electrical tape
- Measuring tape or ruler accurate to 1/16 of an inch
- Weights (ballast) Washers and lead sinkers work well. Washers are a little easier to calculate the volume for. Lead sinkers are irregularly shaped and you need to figure out the volume of the weight.

**Procedure:**

1. Weigh the pool float and write the weight down.
2. Measure your coffee can diameter and write it down
3. Place ruler or measuring tape into coffee can and tape it to the side with electrical tape
4. Fill coffee can half way up with water
5. Make sure that the ruler is at lest partially submerged and write down the height of water
6. Place pool float into coffee can and submerge. You will have to push the float below the water, take care not to submerge your finger too as this will affect your volume calculation. Write down the height of water with the float submerged
7. Subtract the first measurement from the last measurement and use this as your height to calculate the volume of water displaced.
   Remember: Volume for a cylinder is
   $$V=Pi*r^2*H$$
   This is the volume of your pool float
8. Calculate the density of the float by dividing the weight of the float by the volume of the float
9. Determine the density of the ballast you are going to use.
10. Start adding ballast to the float until it just submerges.
11. Weigh the ballast and see how much it took to make the float neutrally buoyant.

**Assessment:**

- Calculate the density of a 4 inch piece of PVC plastic used in the Sea Perch frame. Will it float?
- What happens if you place tape over the ends of the 4 inch PVC piece so water can't flood the inside?
- Using the principals of what you just learned, devise an experiment to determine the displacement of a Sea Perch using a 5 gallon bucket.
- Determine how much ballast you need for your Sea Perch frame.

$$\text{Mass of Ballast} = \frac{(\text{Density of Water} * \text{Volume of ROV}) - \text{Mass of ROV}}{1 - (\text{Density of Water} / \text{Density of Ballast})}$$

**References:**

http://en.wikipedia.org/wiki/Buoyancy