611-2100 (30-160) Density Rod Instructions

How to Teach with Density Rod:

Concepts: Density; buoyancy; flotation-sinking; specific gravity.
Curriculum Fit: Grades 6 - 8.

Introduction:

The purpose of this device is to seek out a position in a fluid of predetermined density and remain with the liquid wherever it goes. Also called a submerged float or density float, it is used in the real world to trace ocean currents.

The density of water is not constant but depends upon mineral content, temperature and pressure. Since mineral content and temperature depend upon solar heat, the surface density of the sea varies widely - some areas of the sea surface are continually sinking due to high mineral content. Later - sometimes in thousands of years - this water will return to the surface by undergoing another change in density caused by temperature.

How To Use:

Additional Materials Needed:

- Graduate cylinder or other transparent container
- Water of varying temperatures

1. Fill a graduated cylinder with hot water at a temperature of aproximately 40°. Since air bubbles cling to the Density Rod and cause erratic operation, use deaerated water if you can. Previously boiled water is good. Place the rod in the warm water and observe the results. It will sink to the bottom and stay until water cools.

At a certain temperature, the density of water will become greater than the rod and the rod will rise to the surface.

2. Half fill a graduate cylinder with cold water on the bottom and pour hot water on top. Insert the rod and observe the results. It will sink through the hot water and be buoyed up by the cold water. The rod will remain suspended at the boundary between hot and cold water.

3. Partly fill a graduate cylinder with water at room temperature. Insert the rod and observe the results. The rod will float at the surface.

Add a quantity of 10% alcohol 90% water mixture and observe the results again. The rod will remain floating between the two liquids. When the liquid is stirred, the two layers gradually mix and the rod sinks to the bottom. Add a few grams of salt. The density of the mixture increases and the rod starts to rise.

4. Partly fill a graduate cylinder with water at room temperature. Add a few cc of alcohol and stir. Place the rod in the water and observe the results. At the start the rod will sink to the bottom of the graduate cylinder. Place a few grams of solid salt in the bottom of the graduate cylinder.

Leave the experiment standing. Over a period of days, the rod will rise as the dissolved salt diffuses upwards increasing the density of water.

Since mixing takes place only by diffusing, this is a good way to observe the rate at which diffusion progresses.

Large slow-moving molecules such as sugar would diffuse more slowly.

Theory:

Temperature and Water Density

The density of pure water depends upon temperature. Its maximum density occurs at a temperature of 3.98° C. The gram was originally defined as 1 cubic centimeter of water at this temperature. When accuracy of measurement improved, it was discovered that 1 cubic cm of water actually weighed .99973 grams but it was too late to make any changes in the metric system. There is very little change in density between 1 and 10° C but above 10° C the density declines as temperature increases, becoming about 4% less at 100°.

Dissolved Minerals and Water Density

The addition of soluble minerals increases the density of water to a degree depending upon the amount and nature of the mineral. A liter of sea water contains about 32 grams of mineral, 90% of it being common salt.

The average density of sea water is about 2.1% denser than water alone, but at the poles and tropics, the salt content is somewhat higher due to the removal of water by evaporation or freezing. Sea water frozen or evaporated to remove half of the water as ice or vapor would have a density about 4.2% greater than pure water.

Effects of Pressure On Water

Usually we think of water as an incompressible liquid. This is primarily but not completely true. If you were to start with a cubic centimeter of water at atmospheric pressure and apply a pressure of 100 lbs per square inch, the volume would decrease a mere .033%. However, in the deep

ocean where pressure is 15,000 lbs. per square inch, the volume decreases almost 5%. This results in approximately a 5% increase in density.
If water were really incompressible, the oceans would be 100 feet deeper!

Construction of the Density Float

You need to know the location of the density float you are using to conduct ocean research. The float carries a sounding device that sends out sound signals at intervals. You locate the float by the direction of the signals. Surface craft can then follow.

Since pressure increases the density of water, it follows that the volume of the float would change under pressure. This is true but can be allowed for by using the right materials. Metals change volume very little under the effect of pressure. Thin-walled vessels are more compressible than thick ones. By the proper choice of metal thickness and metal type, the float may have almost the same compressibility as water.

temperature, 3.98° C. This is the temperature of most of the ocean.

Sea water at 3.98° C has a density of 1.02 g/cm^3, neglecting compressibility for the moment. The volume of water decreases under pressure according to the equation:

$V = V \times 4.8 \times 10^{-11}$ p

where V is the decrease in volume, V_0 is the original volume of water in cubic cm and p is the added pressure (above atmospheric pressure) in dynes per square centimeter caused by the depth of water (a one cm depth of water produces a pressure of 1 gram per cm^3 or 980 dynes per cm^2.) The figure 4.8×10^{-11} is the compressibility of water in square cm per dyne.

At a depth of 1000 meters (3200 feet) 1 ml of sea water is compressed thus: P =

(1) (1000 m) 100cm x 1.021g x 980dynes
$= 1.01 \times 10^{8}$ dynes/cm^2

Floating at Constant Depth

If you need a float at a fixed position beneath the ocean surface, you must calculate the density of the water at this location. The following formulae are approximate but are shown to illustrate the procedure.

Assume that at the depth desired, that water is at its maximum density
Volume decrease

$= 4.8 \times 10^{-11} \times 1.01 \times 10^{8}$
$= 4.85 \times 10^{-3}$ cm^3

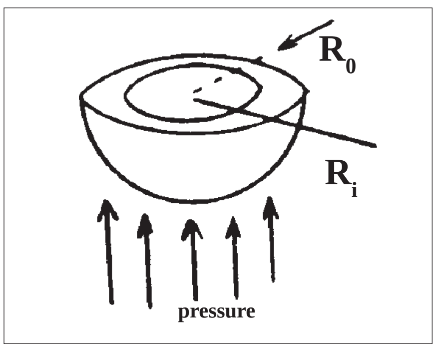
per cm^3 original volume.

The density of sea water at this point is:

$$\frac{1.021}{1.000485 \times .99515} = 1.026 \text{ g/cm}^3$$

If a float of density 1.026 g/cm^3 is placed in sea water of surface density 1.021 g/cm^3, it continues to sink until it reaches a level where density is 1.026 g/cm^3. Since the float sinks very slowly, it is generally lowered to the correct depth by artificial means and released there to begin its journey following the current.

***Note:** You may find the necessary data for calculating density of water at various temperatures and pressures by consulting **Handbook of Chemistry and Physics.** The data will be listed under the index headings water, compressibility and bulk modulus.*



Compression of the Metal

Consider a metal sphere of radius R_o. If sliced in half and subjected to pressure, the two halves would be pressed together by a force equal to pressure times area or R_0^2 P. If the sphere is hollow, the whole force would be applied to the metal surface $R_0^2 - R_i^2$. If we assume now that the sphere is made of aluminum and R_i is 7/8 of R_o the pressure applied to the metal becomes **Force/Area =**

$$\left(\frac{R_0 2P}{R_0^2 - (7/8R_0)^2} \right) P$$

Cancelling we get:
P (1 - 49/64) or 64/15 P = 4.267P.

The metal of the sphere will experience 4.267 times the pressure of the outside surface. The bulk modulus of a hollow vessel is 1/3 the elastic modulus or about 2×10^{11} dynes/cm^2 for aluminum. The volume of the hollow ball would then decrease:

(4.267P) 2×10^{11} or
2.13×10^{-11}P.

This is less than half the compressibility of water.

Related Products:

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- **611-2105 Reverse Density Rod -** This rod of high density polyethylene behaves exactly the opposite as the aluminum density rod. The instructions tell why.
- **611-2085 Overflow Can -** with angled plastic molded spout.
- **611-2055 Specific Gravity Specimens -** 10 unique items, each about the same volume with varying densities. Instructions.

Warranty:

We replace all defective or missing parts free of charge. We accept Master Card and Visa, school P.O's. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse, or normal wear and tear.

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