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Diving Bell Demonstration
#DIVBL

Warning:

- **Not a toy; use only in a laboratory or educational setting.**
- **Contains latex.**
- **California Proposition 65 Warning: This product can expose you to chemicals including lead, styrene, and nickel, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to www.P65Warnings.ca.gov.**

Introduction

With the help of the **Diving Bell Demonstration** you can explore how **buoyancy** works by learning about **Archimedes' Principle.**

Archimedes' Principle states:

> **"When a solid object is partially or completely immersed in fluid (gas or liquid), the apparent loss in weight will be equal to the weight of the displaced liquid."**

This principle explains the **buoyancy forces,** or the upward force exerted by a fluid on an object, work. Buoyancy can be seen at work with any object in water, whether it be you swimming in a pool, a multi-ton boat floating on a lake, or a fish swimming in a river.

Our **Diving Bell Demonstration** works similarly to how a submarine works. By manipulating the density of the diving bell with the syringe while it is in the water, Archimedes' principle and buoyancy can be observed. You can verify Archimedes' principle by comparing the density of the Diving Bell at a neutrally buoyant state to the density of the water it is displacing.

Additional Supplies

You will need the following supplies to experiment with your device:

- 1 Large Container for Water
- 1 Laboratory Balance (0.1g Scale)
- 1 Beaker, 500ml

How to Use

The Diving Bell Demonstration can be used to do two experiments, one that mimics the operation of a submarine and one that verifies the claims of Archimedes' principle. They are as follows:

Basic Submarine Experiment

1. Fill your large container with water.
2. Attach the tubing to the diving bell and syringe. **(Note:** Make sure the plunger to the syringe is fully pressed down before attaching the tubing.**)**
3. Place the diving bell in the water. The diving bell should float, with approximately half the ball in the water and half of it outside the water. We can say the diving bell here has **positive buoyancy.**
4. Slowly pull on the the plunger of the syringe to extract air out of the diving bell. When the diving bell starts to sink just to water level, stop pulling the syringe. At this point, your diving bell has **neutral buoyancy.**
5. Continue pulling slowly until the syringe handle is pulled up as far as it can. The diving bell will sink. At this point, the diving bell has **negative buoyancy**.
6. Push the plunger on the syringe back down. The diving bell will rise again.

Verifying Archimede's Principle

1. Remove the rubber tubing from the diving bell.
2. Use a laboratory balance to record the mass of the empty Diving Bell ($\mathbf{m}_{\text{empty Bell}}$).
3. Record the mass of an empty 500ml beaker ($\mathbf{m}_{\text{beaker}}$).
4. Fill a large container with water and record the temperature in C° with a thermometer ($\mathbf{t}$).
5. Reattach the rubber hose to the top of the Diving Bell and place it in the water.
6. Press down on the syringe plunger to purge any air from the syringe before attaching it to the diving bell.
7. Pull out the syringe plunger slowly until the top of the Diving Bell just slips under the surface of the water.
8. Remove the partially filled bell from the water quickly and place it into the 500ml beaker.
9. Remove the rubber tubing and record the mass of the neutrally buoyant bell in the beaker ($\mathbf{m}_{\text{Bell + beaker}}$). It is alright if the water leaks from the bell into the beaker.
10. Measure the diameter of the bell and divide it by 2 to obtain the radius ($\mathbf{r}$).
11. Calculate the volume ($\mathbf{v}_{\text{Bell}}$) displaced by the sphere using the formula: $\mathbf{v = 4/3\ \pi r^3}$.
12. Calculate the density ($\boldsymbol{\rho}$)of the neutrally buoyant sphere using the formula: $\boldsymbol{\rho} \mathbf{= m/v}$.
13. Compare you density value to the standard density of water (found in the table below) to verify Archimedes principle:

Temperature (t) (°C)	Standard Density of Water (ρ) (g/cm³)
100	0.9584
80	0.9718
60	0.9832
40	0.9922
30	0.9956
25	0.9970
22	0.9977
20	0.9982
15	0.9991
10	0.9997
4	0.9999
0	0.9998

Calculations for Verifying Archimede's Principle

1. Mass of the empty Bell:

   $m_{empty\ Bell}$ = ______ (g)

2. Mass of the empty beaker:

   m_{beaker} = ______ (g)

3. Mass of the partially filled Bell and beaker at neutral buoyancy:

   $m_{Bell\ +\ beaker}$ = ______ (g)

4. Subtract the mass of the beaker to obtain just the mass of the neutrally buoyant Bell:

   $m_{Bell\ +\ beaker} - m_{beaker} = m_{neutral\ Bell}$ ______ (g)

5. Measure the radius of the Bell:

   r = ______ (cm)

6. Calculate the volume of the Bell using the following formula:

   $v = 4/3\ \pi r^3$ = ______ (cm^3)

7. Use the density formula **$\rho = m/v$** to determine the density of the partially filled ball at neutral buoyancy:

   $\rho = m_{neutral\ Bell}/v$ = ______ (g/cm^3)

8. Use the table to determine the approximate density of your water at a given temperature:

   t = ______ (g)

9. Compare the density of your water at temperature (t), to that of the partially filled ball to verify Archimedes' principle.

Possible Sources for Experimental Errors when Verifying Archimedes' Principle

- **Tap water:** Tap water may contain impurities which will alter the density slightly. Distilled water should be used for more accuracy.
- **Volume calculation:** Volume calculation is based on a spherical Bell. This does not account for the top and bottom plugs. A more accurate calculation may be achieved by plugging the top and bottom vents and submersing in a graduated cylinder to find the volume.