Total Equilibrium

Objects sink or float in liquids based on the net force acting on that object. By layering two liquids of different densities, therefore applying different magnitudes of buoyant force, an object can become suspended between two layers.

Objectives

* Investigate buoyant force and density.
* Use a Force Sensor to measure the net force on an object in air, fresh water, and salt water.
* Use the results to explain why objects sink or float.

Materials

Vernier data-collection software (e.g., Logger *Pro* or Graphical Analysis)

Vernier data-collection interface (not necessary if using Go Direct sensors)

computer, Chromebook, **or** mobile device

Go Direct Force and Acceleration **or** Dual-Range Force Sensor

500 mL beaker

1 L of distilled water

180 g NaCl

stirring rod

1 L graduated cylinder

large ring stand

right-angle clamp

metal rod (included with the sensor)

thread

golf ball with hook attached

Procedure

1. Make approximately 500 mL of saturated sodium chloride solution by adding 180 g of solid NaCl to 500 mL of water in a beaker. Stir until no more solid will dissolve.

2. Add the sodium chloride solution to a 1 L graduated cylinder.

3. Hold the graduated cylinder at a 45° angle and very slowly add 500 mL of fresh water. Be as gentle as possible to minimize mixing.

4. Attach the Force Sensor to the ring stand using the metal rod and right-angle clamp.

5. Cut a piece of thread approximately 30 cm long and tie a loop on each end. **Note**: The finished thread should be long enough that it will let the ball reach the fresh/salt interface, yet short enough that the ball can be suspended in air above the water.

6. Use the thread to suspend the ball from the hook on the Force Sensor and position the ball just above the water.

7. Prepare the data-collection equipment.

1. Launch the data-collection software.
2. Connect the sensor to your computer, Chromebook, or mobile device (use an interface if necessary).

8. Set up the data-collection mode.

1. Change the Mode to Event Based.
2. Enter **Position** as the Event Name and **cm** as the Units.

9. You are now ready to collect force and position data.

1. Start data collection.
2. Click or tap Keep and enter **0**, the distance you have moved the sensor (in cm).

10. Lower the sensor by 1 cm. Click Keep or Keep Point and enter **–1**, the distance you have moved the sensor (in cm). The distance should be reported as negative because of the downward direction of movement.

11. Repeat Step 10, entering the total distance moved with each data point, until the ball has stopped moving and the string is no longer supporting the ball.

12. Stop data collection.

13. (Optional) Reverse the graph axes so that the position of the sensor is on the vertical axis and the force is on the horizontal axis.

Questions

1. Calculate the mass of the golf ball in units of grams, assuming that 1 kg weighs 9.8 N in air. Show your work.

2. Determine the volume of the golf ball in units of cm3. Show your work if calculated, or explain your procedure if measured by the water displacement method.

3. Calculate the density of the golf ball. Show your work.

4. Explain why the golf ball became suspended in the water. Include the density of the object in your discussion.