Archimedes' Principle–Buoyant Force

Fluid mechanics: Archimedes' principle, buoyant force, volume	GLX setup file: **buoyancy**

Qty	Equipment and Materials	Part Number
1	PASPORT Xplorer GLX	PS-2002
1	PASPORT Force Sensor	PS-2104
1	Basic Calorimetry Set (metal objects)	TD-8557
1	Large Base and Support Rod	ME-9355
1	Rod, 45 cm	ME-8736
1	Double Rod Clamp	ME-9873
1	Overflow Can	SE-8568
1	Balance	SE-8723
0.3 m	Braided Physics String	SE-8050
1	Beaker, 250 mL (or equivalent)	
1 L	Water at room temperature	
1 mL	Liquid detergent	

Purpose

The purpose of this activity is to investigate the relationship between the buoyant force on objects immersed in water and the amount of the water the objects displace when submerged.

Background

You know from experience that some objects float in water and other objects sink. Many people say that 'heavy' objects sink, while 'light' objects float. However, a heavy supertanker floats, while a light penny sinks to the bottom of a bowl of water. There must be more to the reason why some objects float and others sink than just the weight of the object.

Archimedes

Archimedes (287 to 211 B.C.) lived in Syracuse on the island of Sicily, and is considered to be one of the greatest mathematicians of all time. One of his discoveries is that an object submerged in a fluid displaces a volume of the fluid that is equal to the volume of the object.

When an object is submerged in a fluid, the fluid applies a buoyant force on the object. If the object weighs less than the buoyant force on it, it rises. If the object weighs more than the buoyant force, it sinks.

Archimedes discovered a relationship between the weight of the liquid displaced by the submerged object, and the amount of buoyant force on the object.

Prediction

How would the buoyant force on a fully submerged object compare to the weight of the water displaced by the object?

Preview

Use a Force Sensor to measure the buoyant force on a fully submerged object. Use the Xplorer GLX to record and display the force. Measure the weight of the water displaced by the submerged object, and compare the buoyant force to the weight of the displaced water.

Safety Precaution

- Follow all directions for using the equipment.

Procedure

GLX Setup

1. Turn on the GLX (⏻) and open the GLX setup file labeled **buoyancy**. (Check the Appendix at the end of this activity.)

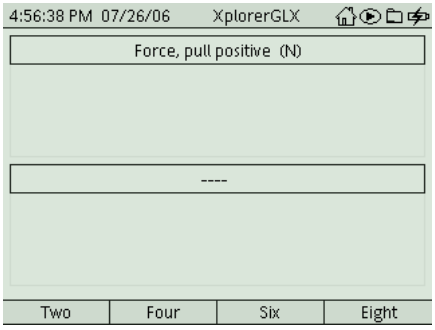


Fig. 1: 'Force, pull positive'

- The file is set to measure force at 10 times per second (10 Hz). The file has a Digits display of Force, pull positive (N) and shows the force with three digits to the right of the decimal point.

2. Open the Digits screen. Press ⌂ to go to the Home Screen. Use the arrow keys to select Digits and press ✓ to activate your choice.

- The Digits screen shows Force, push positive (N).

3. Plug a PASCO Force Sensor into a sensor port on the top of the Xplorer GLX.

Equipment Setup

1. Mount the Force Sensor so its hook is down. Tie a piece of string to the first object.
2. Set up the beaker below the spout of the overflow can. Fill the overflow can with room temperature water until it begins to overflow into the beaker. Add a few drops of liquid detergent to reduce the water's surface tension.
3. Wait for the dripping from the overflow spout to stop and then empty and dry the beaker.


Fig. 2: Equipment setup

Record Data

- NOTE: The procedure is easier if one person handles the equipment and a second person handles the Xplorer GLX.
- Measure and record the mass of the empty beaker and place the beaker under the spout of the overflow can.

First Object

1. Press the ZERO button on the Force Sensor to zero the sensor.
2. Hang the first object from the sensor's hook. Press Start (▶) on the GLX to start recording data.
3. Record the dry weight of the first object in the Data Table in the Lab Report.
4. Rearrange the Force Sensor and object so the object is fully submerged in the water.

- Be sure that the displaced water is caught in the beaker that is below the spout on the overflow can.

5. Wait for the water to stop dripping from the spout and the record the wet weight of the object in the Data Table. Press ▶ to stop data recording.
6. Measure and record the mass of the beaker plus the displaced water.
7. Lift the object from the overflow can and remove the object from the sensor.
8. Empty the beaker and dry it.

Other Objects

1. Refill the overflow can as before.
2. Press the ZERO button on the Force Sensor to zero the sensor. Hang the new object from the sensor's hook.
3. Repeat the data recording procedure for each new object.

Analysis

Calculate the buoyant force for each object. The buoyant force is the weight of the object in air minus the weight of the object when it is submerged in water.

Calculate the mass of the displaced water by subtracting the mass of the empty beaker from the mass of the beaker plus the displaced water.

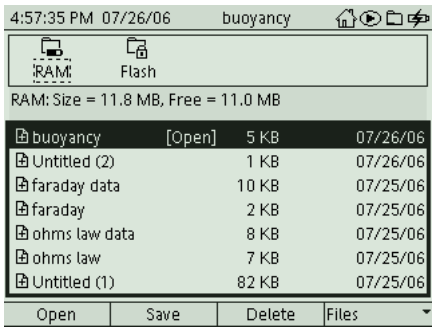
Calculate the weight of the displaced water by multiplying the mass, in kilograms, by 9.8 newtons per kilogram (9.8 N/kg).

Note: Press ⌂ to return to the Home Screen and press F3 to open the Calculator. You can use the Calculator to calculate the weight of the water.

Record your results and answer the questions in the Lab Report section.

Appendix: Opening a GLX File

To open a specific GLX file, go to the Home Screen (⌂). In the Home Screen, select Data Files and press ✓ to activate your choice. In the Data Files screen, use the arrow keys to navigate to the file you want. Press F1 to open the file. Press the Home button to return to the Home Screen. Press F1 to open the Graph.



Lab Report – Activity 29: Archimedes' Principle–Buoyant Force

Name _____ Date _____

Prediction

How would the buoyant force on a fully submerged object compare to the weight of the water displaced by the object?

Data Table

Item	Value
Mass of empty beaker	

Run	Dry Weight (N)	Wet Weight (N)	Buoyant Force (N)	Mass of Water (kg)	Weight of Water (N)	Percent Difference
1						
2						
3						

Calculations

Calculate the mass of water by subtracting the mass of the empty beaker from the mass of the displaced water.

Calculate the weight of the water by multiplying the water by 9.8 N/kg.

Calculate the percent difference between the buoyant force and the weight of displaced water.

$$\%diff = \left| \frac{Wt.\ of\ water - Buoyant\ Force}{Buoyant\ Force} \right| \times 100$$

Questions

1. For each object, why is there a difference between the dry weight and the wet weight?

2. For each run, how does the weight of the displaced water compare to the buoyant force? Explain why you think this happens.

3. Archimedes' Principle of Floating Objects is as follows:

   The buoyant force on an object is equal to the weight of the displaced fluid.

   How do your results compare to this statement?

4. Do your results support your prediction?