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Intense Study of the Buoyant Forces

Part I

Ships made of thousands of tons of steel can float on top of water.

Balloons filled with helium will float upward, but balloons filled with regular air will not.

A swimmer floats more in Salt Lake than in a regular freshwater lake.

All of these phenomena are due buoyancy – the capacity for an object to sink, float, or remain neutral in a fluid, including liquids or gasses.

Goal Q: What factors influence buoyancy?

Think of examples of objects that sink or float in water. What could be the differences attributed to their buoyancy in water?

You are given the following materials:
Triple-beam scale
Tub of water
Objects of varying masses, shapes, volumes, and densities. (Of these objects, there will be pairs in which only one variable has been changed (i.e. two spheres of same density and shape, but varying volumes).

Conduct a variety of qualitative experiments to determine what kinds of factors might influence buoyancy.

Draw a force diagram for a floating object in the water.

What is the force that keeps the object from sinking?

How might the value of this force be determined? (Consider attaching a string to a triple-beam balance).

Part II

Goal Q: How do the volume of an object and its buoyancy relate?

Materials: As listed in Part I, but only with sinking objects.

Does a sinking object also have a buoyant force acting upon it?

How can you verify your claim? (Refer back to how to measure the buoyant force of a floating object.)

How do you predict the volume of an object will affect its buoyancy? Why?

How might one calculate the volume of an irregularly shaped object? (Consider the Eureka story of the king's crown!)

Calculate a number of volumes of varying objects.

Find the buoyant force for a number of objects of varying volumes.

Use a computer program to plot the buoyant force (y-axis) versus the volume of the object (x-axis).

What mathematical relationship can be determined from this graph?

Determine the slope of the graph. What does the value of the slope represent?

Part III

Goal Q: How can the density of the liquid affect the buoyancy of an object?

How do you predict the density of the liquid will affect an object's buoyancy? Why?

You are given the following materials:
Tap water
Salt water
Ethyl alcohol
Cooking oil
Honey
Graduated cylinder

Find the density of each liquid. (Consider the definition of density as M/V).

Find the buoyant force of a single object in each of the provided liquids.

Use a computer to plot object's buoyant forces (y-axis) versus the densities of the different liquids (x-axis). What mathematical relationship between buoyancy and liquid density can be derived from this graph?

By combining the results from Parts II and III of this activity, what can you conclude is the mathematical relationship between the buoyant force, object volume, and liquid density?

From the results of Part III, determine the values of k for each trial. Average the values to determine the average value of k. This value of k is very near to what well-known constant in nature?

What is the mathematical relationship between the buoyant force, object volume, liquid density, and the value of k?

Part IV

Goal Q: Where does the buoyant force come from?

What is the definition of pressure?

After evaluating the free-body diagram of a cube floating in water, what is the specific mathematical value of the force pushing down from above the object? Plug this into the equation of the definition of pressure.

How can the mass of the liquid be related to the liquid's density? Plug this into the equation for pressure.

How can the volume of the liquid above the cube be related to the area of the top surface of the cube and the height from the cube up to the surface of the liquid?

How does the pressure on the top of the cube relate to the pressure on the bottom of the cube?

How might the difference between the top and bottom pressures of the cube be related to the buoyant force?