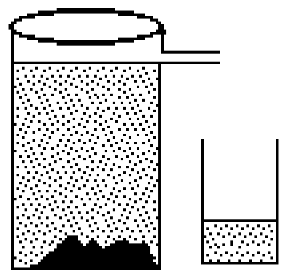
# FLOATING OBJECTS

## PROBLEM PRESENTATION / EXPLORATION

A. Predict which things will float in water

1. At each station place various objects. Make sure that at least one of them is a piece of paraffin or a candle. Have students predict, by just looking at them, whether they will float or not. Record the consensus in the appropriate column in the chart on the transparency or on the board.
2. Now have the students find the mass of each object. Let them once again predict whether each object will float or not. Record.
3. Have each object carefully placed into an overflow can and catch the displaced water in a graduated cylinder. Record whether it floated or not. (If a couple of drops of liquid detergent have been mixed in with the water in the can, there will not be as much trouble with the water not flowing smoothly. The detergent lowers the surface tension of the water.)



4. The mass of the dry cylinder should be determined before the experiment begins. The mass of the cylinder + water displaced should be measured.
5. The volume of displaced water can be read directly from the graduations on the graduated cylinder.

| Object | Predict if it Will Float or Not | | Did it Float? | Mass of Object | Volume of Water in Cylinder | Mass of Empty Cylinder | Mass of Cylinder + Water | Mass of Water |
|---|---|---|---|---|---|---|---|---|
| | After Inspection Only | After Weighing | | | | | | |
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## CLASS RESPONSE / CONCEPT INVENTION

A. What consistent relationship is there for those objects that floated?

1. Care must be taken to insure that the mass of the dry object and the mass of the displaced water are determined accurately. The reason for weighing the graduated cylinder dry and then weighing it after the displaced water had been collected was so that the mass of the water could be determined by difference rather that transferring the water and taking the chance of losing some of it.
2. **<u>For all the objects that floated, the mass of the water displaced is equal to the mass of the object.</u>**
3. Would this be true if the objects were dropped into a different liquid than water? Try it in rubbing alcohol.

| Object | Did it Float? | Mass of Object | Volume of Alcohol in Cylinder | Mass of Cylinder | Mass of Cylinder + Alcohol | Mass of Alcohol |
|---|---|---|---|---|---|---|
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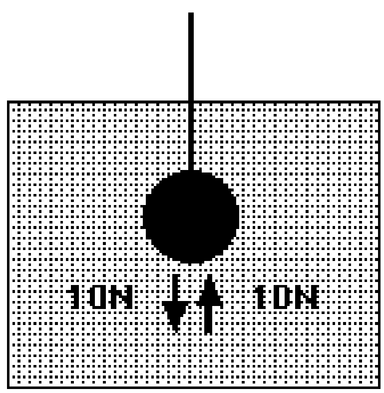
4. Note that this relationship holds true in the alcohol as well as in the water.
5. Depending on the objects that are being tested, there might be one or more that floated in water but sank in alcohol. (The paraffin or candle falls into this category.) The relationship about the mass of the displaced fluid and the mass of the object only refer to those objects that floated.

B. What consistent relationship is there for those objects that sank?
1. **For all the objects that sank, either in water or alcohol, the mass of the fluid displaced was less than the mass of the object.**
2. For even those objects that floated in water and sank in alcohol, comparing the mass of the fluid displaced and the mass of the dry object gives consistent results with the above two generalizations (**A2 & B1**).

C. The conclusions that we came to in A2 & B1 are know as **Archimedes' Principle**.

D. How do we explain why some objects float and some sink?
1. Do all heavy objects sink? [No] Do all light objects float? [No].
2. Lets consider what happens when an object is placed into a fluid. The object by being placed into the fluid takes up space and pushes the fluid out of the way. As we learned in Newton's Third Law, the fluid that is pushed out of the way in effect pushes back on the submerged object. For example, if the object pushes a volume of water with a weight of 10 Newtons out of its way, then the water reacts by pushing back on the object with a force of 10 Newtons. We then say that the object is buoyed upward with a force of 10 Newtons. In other words 10 Newtons of the downward force of gravity is being counteracted by the upward buoyant force.




3. Use a spring scale to determine the mass of a rock or piece of pipe. Now submerge the object with the spring balance still attached. What does it read now? Lighter, heavier, or the same as out of the water? How much buoyancy is the rock experiencing?

weight of object in air = __________
apparent weight of object in water = __________
buoyant force on object = __________

4. Refill an overflow can with water. Tape a marble or other object in the beaker so that it will float upright in the overflow can. This will allow you to measure the volume of water that the beaker system displaces. Now ask students to predict what will happen when 50.0 g of sand is added to the beaker floating in the overflow can. Assuming the beaker doesn't sink, what will be the increase in buoyancy? Will it be more than, less than, or equal to 50.0 g more? [Equal to 50.0 g]

| Mass of Empty Beaker | Volume of Water Displaced | Mass of Dry Cylinder | Mass of Water + Cylinder | Mass of Water Displaced | Buoyant force |
|---|---|---|---|---|---|
| | | | | | |

| Mass of Beaker + 50 g. of Sand | Volume of All Water Displaced | Mass of Dry Cylinder | Mass of All Water Displaced + Cylinder | Mass of All Water Displaced | Buoyant force |
|---|---|---|---|---|---|
| | | | | | |

5. What needs to be emphasized here is that, as we saw earlier, **the buoyant force for floating objects is equal to the weight of the displaced fluid**, and the total weight of the displaced fluid will equal the weight of the object (beaker + sand).

**CONCEPT EXTENSION**

A. Give each group of students an empty 35 mm film canister, one penny (minted after 1982), a balance, a graduated cylinder, an overflow can, and some water. Ask them to find out the greatest number of pennies that they could put into the film canister and not sink it. The only limitation to this investigation is that they can not arrive at their answer by trial and error by adding pennies one at a time until it sinks. They can, however, use the materials to do individual experiments, but they can never put the pennies in the film canister to see if it will float or sink. **[This is a direct application of determining the buoyant force and its relationship to the mass of the object. First the volume of water that the film canister would displace if it was submerged must be determined. The mass of this displaced water is the buoyant force. This mass is the maximum mass that the canister + pennies can have. Subtract the mass of the empty canister from this and you have the maximum mass of the pennies. Divide the mass of one penny into this mass and the number of pennies is determined.]**

B. What will happen if you drop a ball of clay into a graduated cylinder of water? What will happen if you shape the same clay into a boat? Calculate the buoyant force on first the ball of clay and then on the clay boat. Why do you get different buoyant forces for the same mass of clay? **[The boat displaces a larger amount of water, in other words, has a larger buoyant force.]**

C. Consider a rowboat loaded with sand in a swimming pool. If the sand is thrown overboard into the pool, will the water level in the pool rise, fall, or remain unchanged? What will happen to the water line on the boat? Will it be higher up on the boat, lower on the boat, or the same level on the boat when the sand is thrown out?

1. Lets use a large graduated cylinder for our lake, and lets use a large test tube for our boat.
2. Float the test tube in the cylinder by putting sand into it so that at least 3/4 of the testtube is submerged.
3. With a grease pencil mark on the testtube the water level on the "boat". Also

mark on the cylinder the level in the "lake".

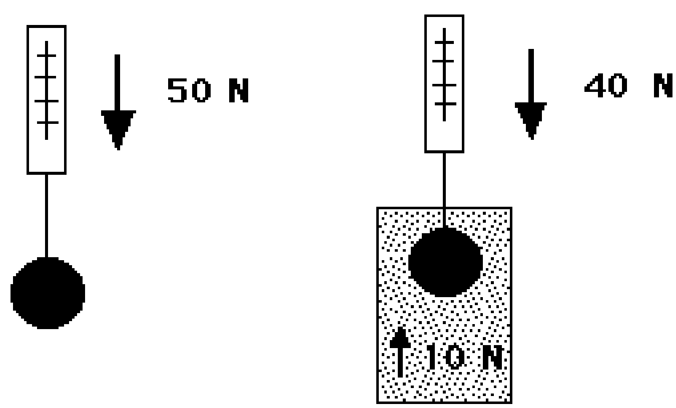
4. Now have the students predict what will happen to the level in the tube if half of the sand is poured out into a clean and dry beaker.
5. Have them predict what will happen to the level in the cylinder when the sand is poured into the clean and dry beaker.
6. Pour half of the sand into the clean and dry beaker. Note the water level on the testtube and on the graduated cylinder.
7. Now, pour the sand into the cylinder. Where did the final level in the cylinder come in relation to the original level before the sand was taken out ?
8. **The water level in the cylinder will fall, because the sand will displace less water submerged than when floating. When floating it displaces its weight of water. When submerged it displaces only its volume (remember, this will be less because sand is more dense than water.)**

D. How could we determine the density of a block of wood that floats in water without measuring its mass?

1. To check our results lets first determine the density of the block.
2. Measure the mass on a balance.
3. Measure the length, width, and height with a ruler.
4. The volume is equal to length x width, x height.
5. The density is equal to mass/volume.
6. Now that we know the density of the block, how could we find it without ever measuring the mass?
7. Students should have seen by now that the mass of the displaced fluid is equal to the mass of the floating object. Since the density of water is 1 g/mL the volume in mL is the same as the mass in grams. Therefore, the volume of the displaced water expressed in grams is the mass of the block of wood. To get the density, the mass need only to be divided by the volume of the block. This volume can be obtained by either measuring length x height x width, or by simply submerging the entire block under water and collecting the volume of water displaced by the entire block.

E. Find the density of an object that sinks without measuring the volume of the object. The only materials that can be used are a balance, a piece of string, and a glass of water.

1. This is probably the toughest task in this whole activity, but it will indicate whether the concept of buoyancy and Archimedes' Principle are thoroughly understood.
2. Weigh the object in air.
3. Weigh the object submerged in the glass of water.




4. Since the buoyant force equals the mass of water displaced this is the difference between the two weights.
5. Because the density of water is 1 g/mL, the mass of water displaced also equals the volume of the object in mL.
6. Now the density is simply the mass of object divided by the difference in the

two weights of the object. Remember, this difference in the air weight and the submerged weight is the buoyant force of the water.