Solar Bag

P6-7300

BACKGROUND:

A black plastic bag is filled with air, sealed, and tethered. After a few minutes, the bag slowly rises into the air.

WHAT DOES IT TEACH?

1. Hot air is less dense than cool air.
2. Black objects absorb heat faster than the lighter colored surroundings.
3. Gases expand when heated.
4. Volume and temperature are directly related. As one increases, the other increases.
5. Archimedes' Principle and Buoyancy.

KIT CONTENTS:

Includes: 60'x72" bag and kite string

ALSO UTILIZES:

Meterstick (P1-1070), Infrared Thermometer (68-6505 or 68-6500), scissors, and 2-inch roll cellophane packing tape

PROCEDURE:

1. On a cool but sunny, non-windy day, determine the mass of the Solar Bag.
2. Bring your class outside with the Solar Bag, kite string, scissors, a meter stick, and a roll of 2-inch cellophane packing tape.
3. Unroll the Solar Bag in the shade, away from trees and bushes to avoid tears, and measure its flat dimensions.
4. Open the Solar Bag and run to fill it with the cool air near the ground*. Tie off the open end. If the Solar Bag should tear, use a small amount of packing tape to repair the hole.

   **Alternatively on hot days, use a fan to fill the bag with cool air from inside, and then bring the filled bag outside.*
5. Tie kite string to the tied off end of the Solar Bag, move it into direct sunlight, and hold the other end of the kite string.

6. Observe the Solar Bag becoming rigid as the air inside expands with the absorbed heat form the sun. Just before lift-off, measure the temperature of the surrounding air and the Solar Bag's temperature.

7. When finished, reel in the Solar Bag, cut off the knot, and roll up the bag so that it can be used again.

WARNING:

Do not release the Solar Bag into the air. At higher altitudes it would become an aviation hazard!

EXPLANATION:

Why do some objects float and others sink?

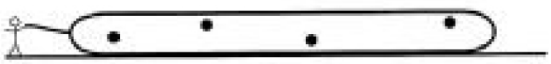
Archimedes discovered that an object is buoyed upward with a force equal to the weight of the fluid displaced. An object displaces or takes the place of an equal volume of fluid: air, water, milk, etc. An object will float in a fluid whenever its mass is less than the mass of the fluid displaced; otherwise, it will sink. For example.

1. Consider a large, helium filled balloon with a volume of 24.5 liters and a mass of 14 grams. The displaced 24.5 liters of air has a mass of 30 grams. Since the mass of the balloon is less than the mass of the air displaced, The balloon will float.

2. Consider a piece of aluminum metal with a volume of 10.0 cm^3 and a mass of 27.0 grams. The displaced 10.0 cm^3 of water has a mass of 10.0 grams. Since the mass of the aluminum is more than the mass of the water displaced, the aluminum will sink.

Why does the Solar Bag initially sink and then float in the air?

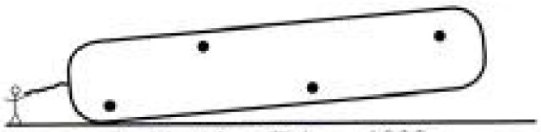
1. At first, the bag containing the cool air weighs more than the air displaced. It sinks to the ground.



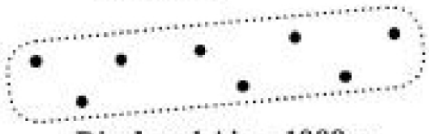
Inside Air + Tube = 1000 g

Displaced Air = 500 g

2. As the black bag absorbs heat from the sun, the air inside expands, displacing more outside air. When the mass of the bag with warm air displaces an equal mass of outside cool air, the bag starts to float.

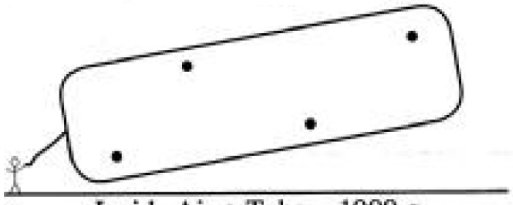


Inside Air + Tube = 1000 g

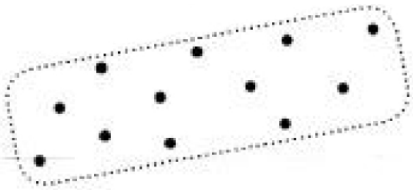


Displaced Air = 1000 g

3. As the bag increases in temperature, it expands, displacing more outside air. It then lifts off into the air.



Inside Air + Tube = 1000 g



Displaced Air = 1500 g

DATA:

Mass of the empty rolled bag: _____

Width of the flat bag: _____

Length of the flat bag: _____

Outside air temperature: _____

Bag temperature at lift-off: _____

CALCULATIONS:

1. Consider the completely inflated bag a cylinder. Calculate its volume.

2. Use the bag lift-off temperature and the air ground temperature to calculate the percent the Solar Bag was initially filled with air.

3. Use the answer to questions #1 along with the density of air at 25^{o} to be 1.2 g/L to calculate the mass of air inside the Solar Bag at lift off.

4. How does the mass of displaced air compare to the filled Solar Bag:

   a. Initially

   b. At lift off, and

   c. Floating in the air.