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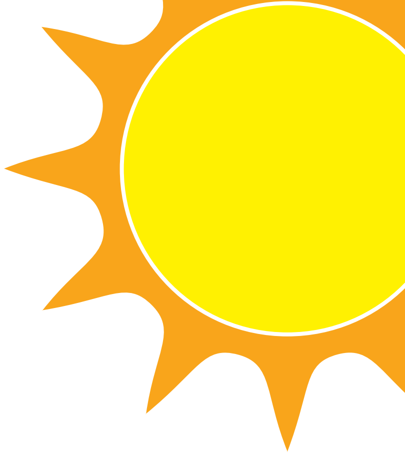


Solar Tube

EI Item #SLR-222

60 Feet Long
72 Inch Circumference

Educational Innovations, Inc.®

Solar Tube

Bigger and Better Than Ever!

A black plastic tube is filled with air, sealed, and tethered. After a few minutes, the tube 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

Procedure:

1. On a cool but sunny, non-windy day, determine the mass of the Solar Tube.

2. Bring your class outside with the Solar Tube, a roll of kite string, scissors, a meter stick, and a roll of 2-inch cellophane packing tape.

3. Unroll the Solar Tube in the shade, away from trees and bushes to avoid tears, and measure its flat dimensions.

4. Open the Solar Tube and run to fill it with the cool air near the ground*. Tie off the open end. If the Solar Tube should tear, use a small amount of packing tape to repair the hole.
   **Alternatively on hot days, use a fan to fill the tube with air from inside, then bring the filled tube outside.*

5. Tie kite string to the tied off end of the Solar Tube, move it into direct sunlight, and hold the other end of the kite string.

6. Observe the Solar Tube becoming rigid as the air inside expands with the absorbed heat from the sun. Just before lift-off, measure the temperature of the surrounding air and the Solar Tube's temperature. (Note: The Educational Innovations Infra-Red Thermometer, # IR-100 is perfect for this.)

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

Warning: Do not release the Solar Tube 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:

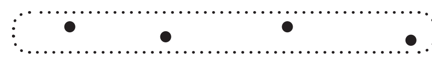
1. Consider a large, helium filled balloon with a volume of 24.5 liters and a mass of 14 grams. The displaced 24.5 liters of air has a mass of 30 grams. Since the mass of the balloon is less than the mass of the air displaced, the balloon will float.

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 Tube initially sink and then float in air?

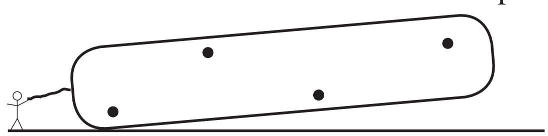
1. At first, the Tube containing the cool air weighs more than the air displaced. It sinks to the ground.

Inside Air + Tube = 1000 g

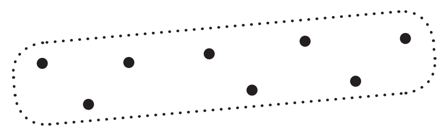


Displaced Air = 500 g

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

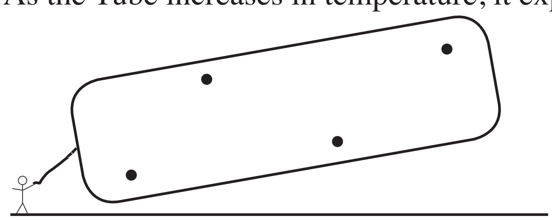


Inside Air + Tube = 1000 g

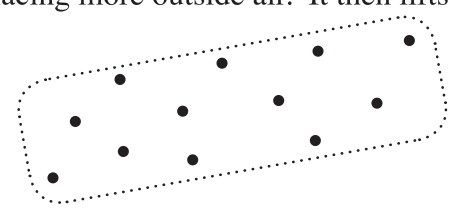


Displaced Air = 1000 g

3. As the Tube 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 Tube: ________
Width of the flat Tube: ________
Length of the flat Tube: ________
Outside air temperature: ________
Tube temperature at lift-off: ________

Calculations:

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

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

3. Use the answer to question #1 along with the density of air at 25° to be 1.2 g/L to calculate the mass of air inside the Solar Tube at lift off.

4. How does the mass of displaced air compare to the filled Solar Tube:
   a. Initially
   b. At lift off, and
   c. Floating in the air.

Challenge Questions:

1. The angle that the tethered string makes with the ground is a function of wind speed and temperature difference. Can you quantify this?

2. The amount of lift of the Solar Tube is a function of the difference in temperature between the cooler external temperature of the surroundings and the warmer internal temperature of the Tube. Can you quantify this?

3. What is the minimum Solar Tube temperature to allow the Tube to rise when the ground temperature is: 20^oC? 25^oC? 30^oC?

4. How does a change in the external temperature affect the buoyancy?

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