44 Geometric Physics

Purpose

To investigate ratios of surface area to volume.

Required Equipment/Supplies

Styrofoam (plastic foam) balls of diameter 1", 2", 4", 8"
4 sheets of paper
stopwatch or clock with second hand
50-mL beaker
hot plate
2 200-mL beakers
400-mL beaker
800-mL beaker
water
10 g granulated salt
10 g rock salt
2 stirrers
thermometer or
 computer
 2 temperature probes with interface
 printer

Discussion

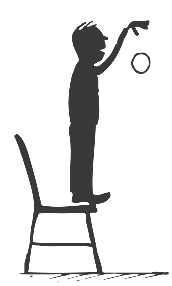
Why do elephants have big ears? Why does a chunk of coal burn, while coal dust explodes? Why are ants not the size of horses? This activity will give you insights into some secrets of nature that may at first appear to have no direct connection to physics.

Part A

Procedure

Step 1: Drop pairs of different-size Styrofoam balls from a height of about 3 m. Drop the balls at the same moment with no push or retardation. Compare their falling times by observing when one ball strikes the ground relative to another. Summarize your observations in Data Table A.

Drop Styrofoam balls.



FALLING TIME	BALL DIAMETER
HITS THE GROUND 1ST	
HITS THE GROUND 2ND	
HITS THE GROUND 3RD	
HITS THE GROUND LAST	

Data Table A

1. Describe any regularity you observe.

Analysis

2. Which size Styrofoam ball had the greatest average speed when dropped?

3. Which size Styrofoam ball had the least average speed when dropped?

4. Which size Styrofoam ball has the greatest surface area?

5. Which size Styrofoam ball has the greatest volume?

6. Which size Styrofoam ball has the greatest ratio of surface area to volume?

7. Which size Styrofoam ball has the smallest ratio of surface area to volume?

8. A Styrofoam ball falling through the air has two forces acting on it. One is the downward force due to gravity—its weight. The weight of the ball is proportional to its volume. The other force is the upward force of air resistance—drag—which opposes the fall. Drag is proportional to the surface area of the ball.

a. To what is the upward force due to drag proportional?

b. Which size Styrofoam ball should have experienced the greatest upward force due to drag?

c. Which size Styrofoam ball should have experienced the greatest *net* downward force per unit mass (due to gravity *and* drag)—that is, which should show the greatest acceleration?

d. Does your answer to (c) agree with your observations?

9. Predict which will fall to the ground faster—a heavier raindrop or a lighter one. Why?

Part B

Procedure

Dissolve salt in water.

Step 2: Record the number of seconds it takes to dissolve 10 g of granulated salt in 100 mL of water at room temperature that is being stirred vigorously. Repeat, substituting 10 g of rock salt for the granulated salt.

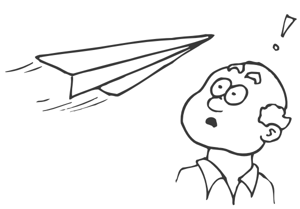
time for granulated salt = ________

time for rock salt = ________

Analysis

10. Which salt dissolved more quickly—the granulated salt or the rock salt? Why?

11. Suggest a relationship for predicting dissolving times for salt granules of different size, such as rock salt and table salt.



Part C

Procedure

Step 3: Make similar paper airplanes from whole, half, and quarter sheets of paper. Record which one flies the farthest.

airplane that flies farthest: ____________

Analysis

12. Which paper airplane generally traveled farthest? Why?

Name Period Date

Part D

Procedure

Step 4: Heat 500 mL of water to 40°C. Then pour 50 mL into a 50-mL beaker and 400 mL into a 400-mL beaker. Allow the beakers to cool down by themselves on the lab table. Measure the temperature of both every 30 seconds, using either a thermometer or temperature probes connected to a computer. (If you are using the computer, use two temperature probes to monitor the temperatures of the two beakers of water. Save your data, and print a copy of your graph; include it with your lab report.) Record your findings in Data Table B.

Monitor cooling water.

Data Table B

TIME (s)	TEMPERATURE (°C)	
	50 mL	400 mL
0		
30		
60		
90		
120		
150		
180		
210		
240		
270		
300		

Analysis

13. Which beaker of warm water cooled faster?

____

____

14. Which beaker has more surface area?

____

____

15. Which beaker has the greater volume?

16. Which beaker has the larger ratio of surface area to volume?

17. Which beaker has the smaller ratio of surface area to volume?

18. The cooling of a beaker of warm water takes place at the surface. The total amount of heat that must leave the water for it to cool to room temperature depends on the volume. Therefore, on what ratio does the rate of cooling (the temperature drop with time) depend?

19. Suppose that a small wading pool is next to a swimming pool. Predict which pool will heat up faster during the day. Why?