Having a Ball with Chemistry

Problem
Will the bowling ball sink or float in water?

Procedure
Obtain a bowling ball. Devise a method to determine whether a bowling ball will sink or float in water. Write your method in the space below so that another person could follow your steps and get the same results. Record all measurements that you make in a data table.

Remember:
\[ C = 2\pi r \quad V_{sphere} = \frac{4}{3}\pi r^3 \quad D = \frac{m}{V} \quad D_{water} = 1.0 \text{ g/mL} \quad 1 \text{ lb} = 453.6 \text{ g} \]

Method:
1. Wrap a string all the way around the middle of the bowling ball. Measure the length of string it takes to go all the way around the ball to find the circumference.
2. Calculate the radius of the ball from the circumference you just measured using \( C = 2\pi r \).
3. Use the radius you calculated to determine the volume of the bowling ball using \( V_{sphere} = \frac{4}{3}\pi r^3 \).
4. Measure the mass of the bowling ball using a balance. [If the balance doesn’t go high enough to measure the mass, students could convert the weight of the 8-lb ball to grams using the conversion factor 1 lb = 435.6 g]
5. Divide the mass of the ball (step 4) by its volume (step 3) to determine the density of the ball.
6. Compare the density of the ball to that of water – if the ball’s density is greater than water’s, it will sink, and if it is lower than water’s, it will float.

Results
Create a data table to record all measurements you need to answer the question posed in the problem.

<table>
<thead>
<tr>
<th>Circumference of bowling ball</th>
<th>68.1 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of bowling ball</td>
<td>3629 g</td>
</tr>
</tbody>
</table>

*As noted in Teacher Notes, if your balance doesn’t go high enough to measure the ball’s mass, it can be calculated from the weight (8 lbs) knowing that 1 lb = 453.6 g.

Calculations
Show all calculations in the space below.

Step 2: \( C = 2\pi r \rightarrow r = \frac{C}{2\pi} = \frac{68.1 \text{ cm}}{2 \times \pi} = 10.8 \text{ cm} \)

Step 3: \( V_{sphere} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi (10.8 \text{ cm})^3 = 5277 \text{ cm}^3 \approx 5280 \text{ cm}^3 \)

Step 4 (if needed): \[ \frac{8 \text{ lb}}{1 \text{ lb}} = \frac{453.6 \text{ g}}{3629 \text{ g}} = 3629 \text{ g} \]

Step 5: \( D = \frac{m}{V} = \frac{3629 \text{ g}}{5280 \text{ cm}^3} = 0.6877 \ldots \text{ g/cm}^3 \approx 0.688 \text{ g/mL} \)
**Analysis**

So will the bowling ball sink or float in water? Explain how you came to this conclusion.

The 8 lb bowling ball will float in water, as it has a lower density than water. We calculated the density of the bowling ball by determining its mass and volume and then compared the density of the ball to that of water. Less dense objects float on top of more dense objects, so since the ball has a density of 0.688 g/mL and water has a density of 1.0 g/mL, the bowling ball will float.

**Conclusion**

Explain why you took the measurements that you did and how they helped you answer the question posed in the problem. Identify two specific sources of experimental error in this activity.

Whether something sinks or floats in water depends on its density, so in order to determine if the bowling ball will sink or float, we first needed to determine its density. If the bowling ball is more dense than water, it sinks, and if it is less dense, it floats. Density, in turn, depends on mass and volume. Density is a ratio of mass to volume, or \( D = \frac{m}{V} \). In order to determine the density, then, we had to find both mass and volume. Mass was determined by placing the bowling ball on the balance and recording its mass [or calculated the mass based on the weight of the ball, if the balance didn’t read high enough to determine the mass of the ball]. To determine the volume, we could use the equation for calculating the volume of a sphere. This requires the radius, which would be challenging to measure directly, so we measured the circumference by measuring the length of a string wrapped around the bowling ball and determined the radius from the circumference and used that in the volume equation. Then, knowing the mass and volume, we could determine the density.

One source of error includes not having the string exactly around the middle of the bowling ball, which would result in an error in the circumference measurement and thus the radius and volume calculations. Another could be not ensuring that the balance was properly tared/calibrated. [If the balance wasn’t used and the mass was calculated, it could be mentioned that we use 8 lb for the weight of the ball, but that only has 1 significant figure which could lead to inaccurate calculation of mass. It could be 7.9 lb or 8.1 lb – without more significant digits, our calculation for mass was not as accurate as it could be.] Another possibility is the slight variation of density with temperature and pressure – water’s density, for instance, might be slightly more or less than 1.0 g/mL depending on temperature and air pressure conditions.