Dropping the Ball [Experiment]

This experiment can provide a hands-on, quantitative support for the principle of conservation of energy. More than most activities and experiments in this manual, this experiment demands that careful attention be paid to the setup and to distance measurements. Of particular concern is measured distance between the photogate beams. If this measurement bears significant error, so will the results. It will appear as if energy is *not* conserved! But when carried out with deliberate concern for accuracy and precision, the results are impressive.

Equipment notes: Acrylic tube can be found a plastics supply companies. Neodymium "supermagnets" (disc-shaped: ~13 mm dia. x ~5 mm thick) and steel balls (16 mm ball bearings) can be found at scientific supply companies.

Some specific values will vary depending on available equipment; the values provided below assume a 16-g ball and a 5.0-cm photogate beam separation. Student values will vary.

To determine whether or not the difference between two values is significant, have students use this formula: Percent Difference = $|a - b| / (a + b) \times 200$. Notice that this is not a percent error calculation—neither value is more reliable than the other. Rather, this formula compares the difference between the two values to the average of the two values.

Answers to Procedure Questions

1. $PE = mgh = 0.016 \text{ kg} \cdot 9.8 \text{ m/s}^2 \cdot 0.40 \text{ m} = 0.063 \text{ J}$
2. $v = d/t = 0.050\text{m} / 0.0178 \text{ s} = 2.8 \text{ m/s}$
5. $KE = (1/2)mv^2 = (1/2) \cdot 0.016 \text{ kg} \cdot (2.8 \text{ m/s})^2 = 0.063 \text{ J}$

Answers to Summing Up Questions

1. The potential energy at the drop height and the kinetic energy after falling.
2. The potential energy and the kinetic energy are about the same.
3. a. $PE = 0.25 \text{ J}$
   b. $KE = 0.25 \text{ J}$
   c. $v = 5.6 \text{ m/s}$ [This determination is the trickiest; expect a range of answers.]

Answers to Going Further Questions

1. Double the height
2. Quadruple the height (doubling the height won't double the speed!)
3. Energy from the roller coaster is transferred to the environment through friction and air resistance.