Name_________________________________ Period_________ Date_________

CONCEPTUAL PHYSICS | **Experiment**

9.7 Energy: Conservation of Energy

DROPPING THE BALL

Purpose

In this experiment, you will lift a ball and drop it. You will determine and compare the potential energy of the ball before it's dropped to the kinetic energy of the ball after right before it hits the ground.

Required Equipment and Supplies

acrylic tube (1.0-inch diameter, about 4 feet in length)
steel ball, about 16 mm
small rare-earth magnet (neodymium or equivalent)
2 photogates and timers
table clamp
support rod
2 three-finger clamps or buret clamps
meterstick
sponge (optional for noise suppression)

SAFETY NOTE: Use caution when handling the magnet to avoid pinching. Keep it away from computers, sensitive electronic devices, and magnetic storage media such as computer disks.

Discussion

When an object is lifted, the work done to lift the object is transformed into potential energy. If the object is then dropped, the potential energy is transformed to kinetic energy as it falls. In this experiment, we will determine the potential energy of a lifted object. We will also determine the kinetic energy of a dropped object. We will then compare the potential energy that an object has when it is lifted to a certain height to the kinetic energy it has after it has fallen from that height.

Procedure

Step 1: Arrange the apparatus as shown in Figures 1 and 2. The upper photogate (gate 1) should be about 5 cm above the lower photogate (gate 2). Connect both gates to the timer. Place the optional sponge at the bottom of the tube.

Step 2: Configure the photogate timer to read the time between the two gates (that is, the timer starts when the beam of the first photogate is interrupted and stops when the beam of the second photogate is interrupted).

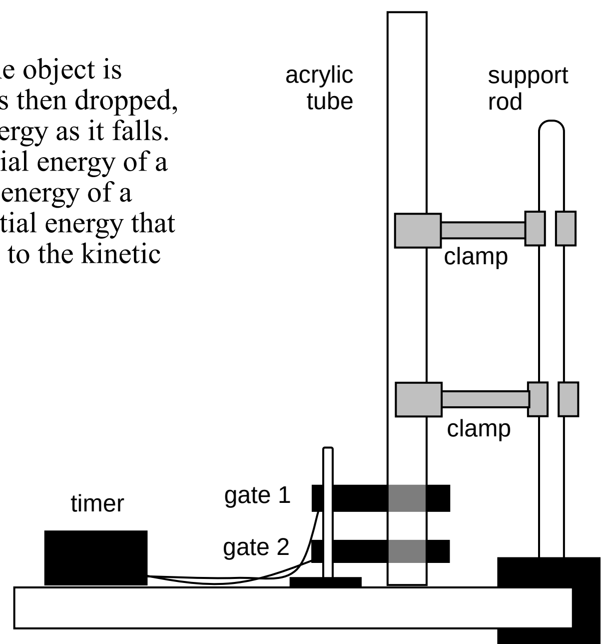

Figure 1

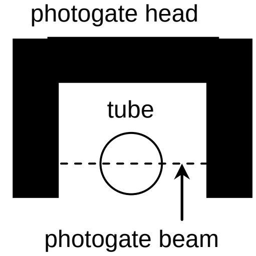

Figure 2. Top View
Make sure the photogate beam passes through the diameter of the tube.

Step 3: Measure the distance between the photogate beams as shown in Figure 3. **Be very careful in this measurement.** Record the distance in centimeters and convert it to meters.

Distance between photogate beams:

d = ______________ cm

= ________________ m

Step 4: Determine the mass of the ball. Record its mass in grams and kilograms.

Mass of steel ball:

m = _________________ g

= ___________________ kg

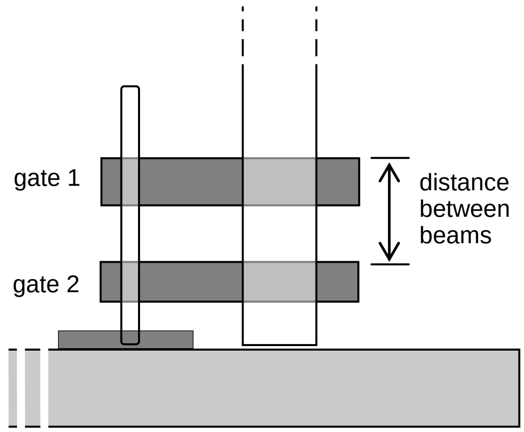

Figure 3

Step 5: Set the ball inside the tube. Use the magnet to lift the ball up through the tube so that the bottom of the ball is 40 cm above the upper photogate as shown in Figure 4. Be careful: the bottom of the ball must be 40 cm above the **upper photogate**, not 40 cm above the **table**.

Step 6: Clear or "arm" the photogate timer so that it is prepared to make a measurement.

Step 7: Carefully remove the magnet from the side of the tube. Doing so will release the ball to fall to the bottom of the tube. When the ball passes through the photogate beams, a measurement will be made and displayed on the timer. The goal is to release the ball from rest, so take care not to give the ball upward or downward motion when you release it.

Step 8: If the trial went well, record the time value. Repeat the process until you have three reliable time values. (If you make a mistake during a trial, do not record the result. Simply repeat the process until you have a good trial.)

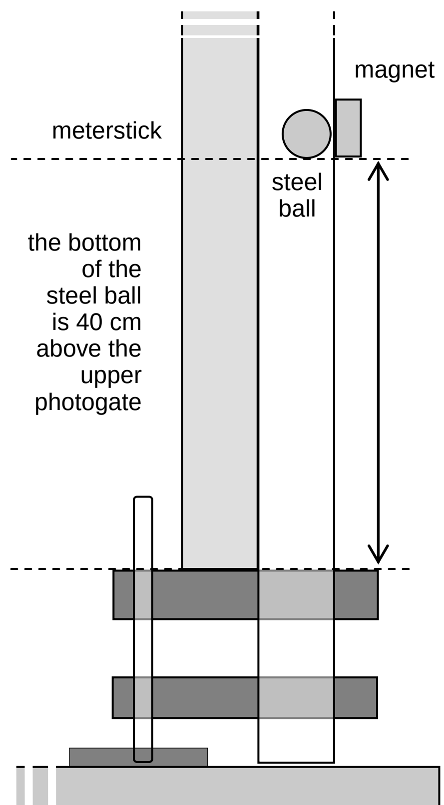

Figure 4

Time values: ___________________

___________________ ___________________

Step 9: Determine the average of the three values and record it on the data table.

Step 10: Repeat the process for drops from 60 cm, 80 cm, and 100 cm. Record the results on the data table.

Data and Calculations

Drop Height h (meters)	Photogate Time t (seconds)	Speed v (m/s)	Potential Energy PE (J)	Kinetic Energy KE (J)
0	—	0	0	0
0.40				
0.60				
0.80				
1.00				

1. Calculate the potential energy of the ball when it was 40 cm above the photogate using the equation $PE = mgh$ (m is the mass of the ball, g is 9.8 m/s^2, and h is 0.40 m). Show your work and your solution. (The value should be between 0.050 J and 0.100 J.) Record your solution in the data table as well.

2. Calculate the potential energy of the ball at the other heights and record your solutions in the data table.

3. Calculate the speed of the ball after it fell 40 cm using the equation $v = d/t$ (d is the distance between the photogates and t is the time it took the ball to pass between the photogates). Show your work and your solution. (The value should be between 2.50 m/s and 3.00 m/s.) Record your solution to the data table.

4. Calculate the speed of the ball after falling from the other drop heights and record your solutions on the data table.

5. Calculate the kinetic energy of the ball after it fell 40 cm using the equation $KE = 1/2mv^2$ (m is the mass of the ball and v is the speed of the ball). Show your work and your solution. (The value should be between 0.050 and 0.100 J.) Record your solution to the data table.

6. Calculate the kinetic energy of the ball after falling from the other drop heights and record your solutions on the data table.

Summing Up

1. When the drop height doubles from 40 cm to 80 cm, which of the following quantities also doubles (approximately)?
   ___ speed after the fall
   ___ potential energy at the drop height
   ___ kinetic energy after the fall

2. Which statement best describes the relationship between the potential energy at the drop height to the kinetic energy after the fall?
   ___ The potential energy is always significantly higher than the kinetic energy.
   ___ The kinetic energy is always significantly higher than the potential energy.
   ___ The potential energy and kinetic energy are about the same.
   (A significant difference in this experiment would be a difference of 20% or more.)

3. Use your findings to predict the following values for a trial involving dropping the ball from 160 cm.
   a. Potential energy = ________________________________

   b. Kinetic energy = ________________________________

   c. Speed after falling = ________________________________
   Hint: By what factor was the "80-cm ball" faster than the "40-cm ball?" Use this factor to determine how much faster the "160-cm ball" will be compared to the "80-cm ball."

Going Further

When the ball was released from a particular height, its potential energy was transformed to kinetic energy as it fell. This type of energy transformation happens on a roller coaster as well. Potential energy that the roller coaster has at the top of the first hill is transformed to kinetic energy as it rolls downward. In an ideal roller coaster (with no frictional losses), the kinetic energy at the bottom of the hill would be equal to the potential energy at the top.

Consider an ideal roller coaster. The first hill has a certain height. When the roller coaster reaches the bottom of the hill, it is traveling at a certain speed.

1. How much higher would the hill have to be so that the roller coaster had twice as much **kinetic energy** at the bottom of the hill?

---

2. How much higher would the hill have to be so that the roller coaster had twice as much **speed** at the bottom of the hill? (The answer to this question is not the same as the answer to the previous question.)

---

3. In real-world roller coasters, each hill is shorter than the hill before it. Why do you suppose that is?
