Names _____

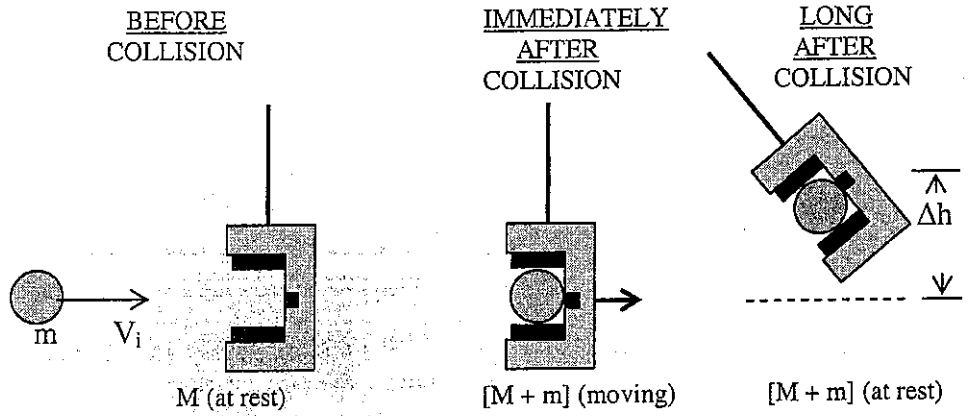
Physics Lab **THE BALLISTIC PENDULUM** HWW/FM

A. Objectives: The objectives of this lab are to study conservation of momentum for a system of objects before and after a collision and conservation of energy of those objects moving in a gravitational field after collision.

B. Equipment Required: Ballistic Pendulum apparatus, 25-cm ruler, a meter stick, a 2-m stick, balance scale, and cardboard.

C. Set-Up/Theory

1. A metal ball of mass m is "shot" horizontally with speed V_i toward a hollow cavity in a pendulum of mass M, which is suspended by a free-swinging frame. The pendulum captures the ball. The pendulum and ball rise and come to rest a height Δh above the pendulum's initial resting position. V is the velocity of pendulum and ball immediately after collision.



Momentum	$m V_i$	$(M + m) V$	0
Kinetic Energy	$\frac{1}{2} m V_i^2$	$\frac{1}{2} (M + m) V^2$	0
Potential Energy	0	0	$(M + m) g \Delta h$

Physics: Through the collision, total momentum is conserved: P_{after} (immediately) = P_{before}. After the collision total energy, E = KE + PE, is conserved throughout the subsequent motion of the pendulum.

Application of these two principles allows one to solve for the initial velocity of the bullet in terms of the other variables, which can be measured in the lab:

$$V_i = \frac{m+M}{m}\sqrt{2 g \Delta h} \qquad (1)$$

2. To verify the result from part 1, the ball will be shot horizontally with the pendulum out of the way. The ball will fall to the floor in **projectile motion**. The height, y, of the ball above the floor and the horizontal distance traveled, x, can be measured. Using the equations of kinematics, V_i can be determined:

$$V_i = x\sqrt{\frac{g}{2y}} \qquad (2)$$

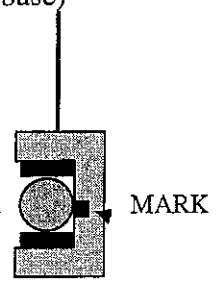
D. Procedure—Part 1

1. "Fire" the "bullet" as instructed.

2. Determine as accurately as possible the change in vertical position, $\Delta h = h_f - h_i$, that the **mark on the "catcher,"** the pendulum, (opposite the center of the ball) rose from its initial height, h_i, to its new height, h_f. Record h_i here and h_f in the table below.

   $h_i =$ _____ cm (above the instrument's base)

3. Repeat for a total of 5 trials.



TRIAL	h_f (cm)
1	
2	
3	
4	
5	
Average	

4. Calculate Δh: $\Delta h = h_f - h_i =$ _____ cm - _____ cm = _____ cm = _____ m.

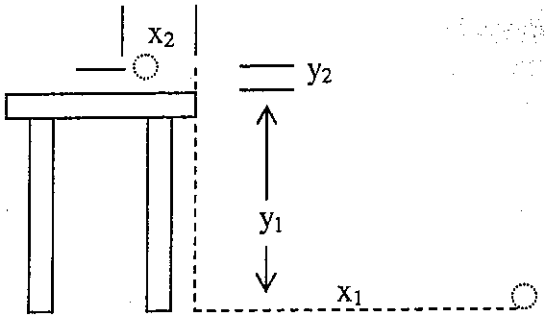
E. Procedure—Part 2

1. Place cardboard on the floor and position the pendulum up out of the "line of fire" as instructed.

2. Shoot the ball out onto the cardboard <u>three</u> times. Note and measure as distance, x_1, the <u>middle</u> distance the ball traveled **horizontally** from the front of the table. Record that distance only <u>to the nearest</u> cm.

   $x_1 =$ _____ cm

3. Measure also the distance, x_2, from the end of the guide rod to the front of the table in order to get the total horizontal distance traveled by the ball.



   $x_2 =$ _____ cm; $x = x_1 + x_2 =$ _____ cm = _____ m

4. Measure the vertical distances, y_1 and y_2 as pictured above to determine the total distance the **bottom** of the ball fell in its projectile motion.

   $y_1 =$ _____ cm; $y_2 =$ _____ cm;

   (From which part of the ball are you going to make your measurement for y_2 ? Did that part of the ball strike the floor.)

   $y = y_1 + y_2 =$ _____ cm = _____ m.

5. Measure the mass of the ball by weighing; and record the given (effective) mass of the pendulum. The latter is recorded somewhere on the ballistic pendulum apparatus.

Mass of ball = _____ g = _____ Kg. Mass of pendulum = _____ g = _____ Kg

F. Calculations

1. Using Equation 1 (derived from principles of conservation of momentum through the collision and conservation of total energy after the collision), calculate the initial speed of the ball.

2. Using Equation 2 (derived from kinematics of projectile motion), calculate the initial speed of the ball.

3. Compare your two results by calculating the percentage difference. (Use as the accepted value the one you consider most trustworthy.)

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