Name: ______________________________ Section: __________ Date: ____________

Worksheet - Exp 7: Conservation of Energy and Linear Momentum

Objective:
This experiment uses principles of conservation to determine the velocity of a ball as is leaves the ballistic pendulum.

Theory: Energy is always conserved in one form or another. However, there are many forms of energy, and one form of energy may be transformed into another kind of energy. Thus, the mechanical energy studied in this experiment might not always be conserved. Relevant energies for this experiment are kinetic energy and gravitational potential energy:

$KE = \frac{1}{2}mv^2$ A mass, m, has energy due to its velocity, v.
$PE_{grav} = mgh$ An object has energy due to gravity, g, and its elevation, h.

Momentum is always conserved in an isolated system, i.e. - one in which all forces are considered. Linear momentum is given by $\vec{\mathbf{p}} = m\vec{\mathbf{v}}$. Momentum and velocity are both vector quantities, and their direction must be considered when adding the motion of multiple objects.

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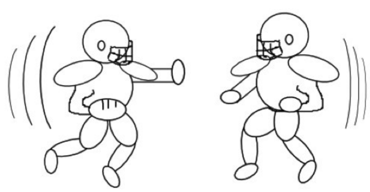
1. A running back weighing **100 kg** runs headlong into a defender weighing **120 kg**. The two players are moving at **7 m/s** and **5 m/s**, respectively. Calculate the total momentum and the total kinetic energy of the system. [Calculations including velocity should reflect direction of travel.]



$p_i =$ ______________ (2 pts)

$KE_i =$ ______________ (2 pts)

$p_f =$ ______________ (2 pts)

$KE_f =$ ______________ (2 pts)

The two players collide and continue moving to the right. Calculate the momentum and kinetic energy of the system after the collision. [Hint: Assume the two players are an isolated system.]

2. Which of the above quantities is/are conserved? (4 pts) What kind of collision is this? (3 pts)

Procedure:

3. Measure the mass of the ball (m) and catcher arm (M). [Unscrew the knurled nut to remove the arm; screw it back when finished.] (4 pts)

$m =$ ________________ $M =$ ________________

4. Measure the radius to the center of mass of the ball/pendulum system. The center of mass is the top of the opening of the ball catcher.

$r =$ ________________

5. Fire the ball into the catcher and calculate the change in height of the ball/pendulum system.
$\Delta h = r - r\cos\Theta$

6. Record Δh for 3 trials at the first detent (short range). Calculate the average Δh for this detent. Record it in the table provided. Repeat for detent 2 (medium range) and detent 3 (long range).

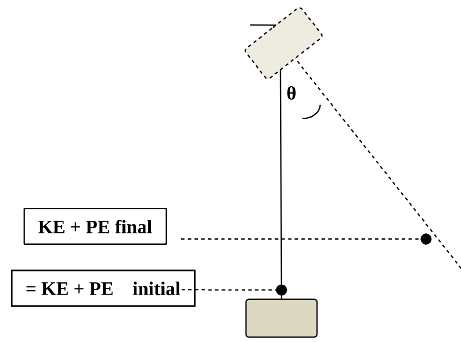
	Detent #1	Detent #2	Detent #3
Trial #1			
Trial #2			
Trial #3			
Average Δh			

7. As the pendulum arm rises, its energy changes from one form to another. a) Describe this transformation of energy. (5 pts) b) How can this process be visually observed? (5 pts)

8. Considering the average Δh during this process, how much gravitational potential energy is being stored in the ball + pendulum with each fire?

$PE_1 =$ ________________ (6 pts) $PE_2 =$ ________________ (6 pts) $PE_3 =$ ________________ (6 pts)

9. Conservation of energy dictates that the total energy remains constant throughout the motion of the pendulum [the force of friction is ignored]. Use this knowledge of energy conservation to determine the velocity of the ball + pendulum just after collision. Show work below and record in the table.



10. Consider the collision of the ball and pendulum that resulted in the motion described above. Are both momentum and energy conserved in this inelastic process? (6 pts) You may wish to refer to the example on the first page.

11. Write an equation relating the value of the conserved quantity (or quantities) before and after the collision. (5 pts) Calculate the initial velocity of the ball before collision, v_i. Show work below and record in the table.

	Average Δh (3 pts ea.)	v_{b+p} After collision (5 pts ea.)	v_i Firing Velocity (4 pts ea.)
Detent #1			
Detent #2			
Detent #3			

12. When fired from the first detent, what percent of the ball's initial energy remains in the ball/pendulum system after the collision? (6 pts) Where did the dissipated energy go? (6 pts)

13. Imagine that the ball, fired from the first detent, transfers 100% of its kinetic energy to the pendulum. How high would the pendulum swing with this extra energy, given that it is not carrying the mass of the ball? Solve using energy equations only. (6 pts)