CONSERVATION OF ENERGY
PHYSICS 221: CLASSICAL PHYSICS I

Name: _____

Lab Date: _____ Due Date: _____

Lab Partner(s): _____

Part 1 Conservation of Kinetic Energy: Elastic Collisions

Introduction

Momentum is always conserved in collisions that are isolated from external forces. Energy is also conserved, but energy conservation is much harder to demonstrate since the energy can change forms: energy of motion (kinetic energy) may be changed into heat energy, gravitational potential energy. In the air track glider collisions you will be investigating, the total energy before the collision is simply the kinetic energy of the gliders:

$$E_k = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

In this experiment you will examine the kinetic energy before and after a collision to determine if kinetic energy is conserved in air track collision.

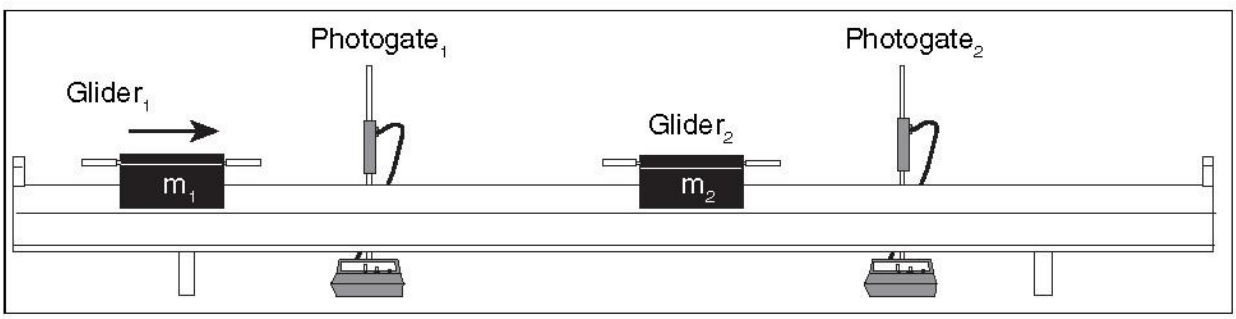

Fig.1 Equipment Setup

Procedure

1. Set up the air track and photogates as shown in Fig.1, using bumpers on the gliders to provide an *elastic collision*. **Carefully level the track**.
2. Measure m_1 and m_2, the masses of the two gliders to be used in the collision. Record your results in the Table.
3. Measure and record L_1 and L_2, the length of the flags of the gliders.
4. Set both photogate Timers to GATE mode, and press the RESET buttons. Press the RESET button.

5. Place glider 2 at rest between the photogates. Give glider 1 a gentle push toward the end of the air track. After the rebound it will collide with the glider 2.
   Record four time measurements in Table as follows:
   t_{1i} = the time that glider 1 blocks photogate before the collision.
   t_{2i} = the time that glider 2 blocks photogate before the collision.
   (In this case, there is no t_{2i} since glider 2 begins at rest.)
   t_{1f} = the time that glider 1 blocks photogate after the collision.
   t_{2i} = the time that glider 2 blocks photogate after the collision.
   IMPORTANT: the collision must occur after glider 1 has passed completely through photogate1 and after the collision; the gliders must be fully separated before either glider interrupts a photogate.
   NOTE: Use the memory function to store the initial times while the final are being measured. Immediately after the final times are recorded, the gliders must be stopped to prevent them from triggering the photogate again due to rebounds.
   MEMORY FEATURE: When two measurements must be made in rapid succession, such as measuring the pre- and post-collision velocities of an air track glider, use the memory function. It can be used in either Gate or Pulse mode.
   To use the memory:
   a. Turn the MEMORY switch ON.
   b. Press RESET.
   c. Run the experiment.
      1. When the first time (t_1) is measured, it will be immediately displayed. The second time (t_2) will be automatically measured by the timer, but it will not be shown on the display.
   d. Record t_1, then push the MEMORY switch to READ. The display will show the TOTAL time, t_1+t_2. Subtract t_1 from the displayed time to determine t_2.
6. Repeat the experiment several times, varying the mass of one or both gliders and varying the initial velocity of glider1.
7. Try collisions in which the initial velocity of glider 2 is not zero. You may need to practice a bit to coordinate the gliders so the collision takes place completely between the photogates.

Part 2 Inelastic Collision

Design and conduct an experiment to investigate conservation of kinetic energy in an inelastic collision in which the two gliders, instead of bouncing of each other, stick together so that they move off with identical final velocities. Replace the bumpers with the wax and needle.

Data and Calculations

1. For each time that you measured, calculate the corresponding glider velocity.
   (e.g., $\mathbf{v}_{1i}=\pm L_1/t_{1i}$, where the velocity is positive when the glider moves to the right and negative when it moves to the left.)
2. Use your measured values to calculate E_{ki} and E_{kf}, the combined kinetic energy of the gliders before and after the collision. Record your results in the table.

Table 1. Data and Calculations

L_1=_____ **L_2=_____**

m_1	m_2	t_{1i}	t_{2i}	t_{1f}	t_{2f}	v_{1i}	v_{2i}	v_{1f}	v_{2f}	E_{ki}	E_{kf}

Part 3 Conservation of Mechanical Energy

Introduction

In this experiment you will examine the transformation of energy that occurs as an air track glider slides down on inclined track. Since there are no objects to interfere with the motion and there is minimal friction between the track and glider, the loss in gravitational potential energy as the glider slides down the track should be equal to the gain in kinetic energy.

$$\Delta E_k = \Delta(mgh) = mg\Delta h$$

where ΔE_k is the change in kinetic energy of the glider [$\Delta E_k = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$] and $\Delta(mgh)$ is the change in its gravitational potential energy (m is the mass of the glider, g is the acceleration due gravity, and Δh is the change in the vertical position of the glider).

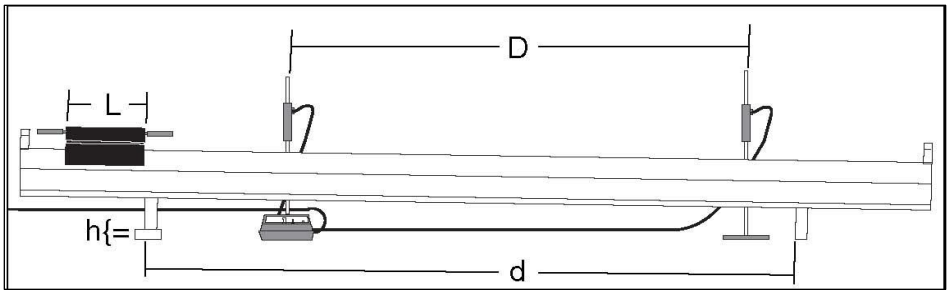

Fig.2 Equipment Setup

Procedure

1. Measure d, the distance between the air track support legs.
   Record this distance in Table 2.
2. Place a block of known thickness under the support leg of the track. For the best accuracy, the thickness of the block should be measured with calipers. Record the thickness of the block as h in Table 2.
3. Measure and record D, the distance the glider moves on the air track from where it first triggers the first photogate, to where it first triggers the second photogate.
4. Measure and record m, the mass of the glider.
5. Set the photogate timer to GATE mode and press the RESET button.
6. Hold the glider steadily near the top of the air track, and then release it so it glides freely through the photogates. Record t_1, the time during which the glider blocks the first photogate, and t_2, the time during which it blocks the second photogate. Record your data in the Table 2.
7. Change the mass of the glider by adding weights and repeat steps 4 through 6.

Table 2. Data and Calculations

d = _____ h = _____ D = _____ L = _____

m	θ	t_1	t_2	v_1	v_2	E_{ki}	E_{kf}	E_{kf} - E_{ki}	Δ(mgh)

Data and Calculations

1. Calculate θ, the angle of incline for the air track, using the equation θ = arctan (h/d).

2. Divide L by t_1 and t_2 to determine v_1 and v_2, the velocities of the glider as it passed through each photogate.
3. Use the equation $E_k = (1/2)mv^2$ to calculate the kinetic energy.
4. Calculate the change in kinetic energy, $\Delta E_k = E_{kf} - E_{ki}$.
5. Calculate Δh, the distance through which the glider dropped in passing between the two photogates ($\Delta h = D\sin\theta$, where $\theta = \arctan(h/d)$).
6. Compare the kinetic energy gained with the loss in gravitational potential energy.

Questions

1. In Part 1 was kinetic energy conserved in each of your collisions?
2. In Part 2 was kinetic energy conserved in your collisions? If not, where did the energy go?
3. In Part 3 was mechanical energy conserved? Explain any discrepancies you found.

Turn in

(a) This sheet of instructions with data and calculations.
(b) The answers to the questions.