Inelastic Collisions

Apparatus: Air track gliders (2 per track), air tracks, air supplies, air supply hoses & power cords, air track accessories kit, photogate stands, photogate heads, photogate interface cables, PASCO Science Workshop 750 Interface & Power Supplies.

Theory: Inelastic collisions on an air track will be studied in today's experiment. According to theory

$$\vec{p_i} = \vec{p_f}$$

where $\vec{p_i}$ and $\vec{p_f}$ are respectively the combined initial and final momenta of all objects involved in the collision.

For a perfectly inelastic collision the objects will stick together and form a single object with a mass equivalent to the sum of the masses of the colliding object. This can be written as

$$m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = (m_1 + m_2)\vec{v}_f$$

where the *m*'s are glider masses and the *v*'s are glider velocities. Don't forget that velocities can be positive or negative (they are vectors).

For a 1D problem, the vector sign can be dropped (assuming one uses +#'s for forward momentum and -#'s for backward momentum). The percent change in momentum can then be calculated using the following formula:

$$\%\Delta p = \frac{(p_f - p_i)}{p_i} \times 100\%$$

Similarly the percent change in kinetic energy can be written as

$$\%\Delta K = \frac{(K_f - K_i)}{K_i} \times 100\%$$

where $K_i = \frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2$ and, for inelastic collisions only $K_f = \frac{1}{2}(m_1 + m_2)v_f^2$.

Check your textbook to see if energy, momentum, or both are to be conserved for this experiment**. If a physical quantity is conserved, what should be the percent change in that physical quantity? The answer to that question is the hypothesis of today's lab.**

Set-up for inelastic collisions:

- Set up the glider with bumpers on each end.
- Remove the small glider attachment that has a piece of cork on it. Remove the cork and don't poke your eye out.
- Attach this needle attachment to one end of a glider. On the opposite side of the glider attach a metal fin to keep the glider balanced.
- On the other glider, attach the attachment filled with wax. On the opposite side of the glider attach a metal fin to keep the glider balanced.
- Set the two gliders on the air track in such a way that the needle will penetrate the wax when the two gliders collide. The gliders should also be set up so that the metal fins on each glider make contact with the bumpers.
- Put flags on each glider. You can measure the length of the flag using the ruler on the airtrack.
- Set up photogates to act as timers for each glider. Use the appendix on Data Studio to set up the photogates properly.
- Be sure to enter the correct length of the flag on the constants tab…see the appendix to learn how.
- **Turn on the air supply and verify it is level.** The gliders should stay relatively motionless.

Perform the following inelastic collision experiments:

- 1D inelastic collision with two objects of equal mass, one initially at rest. **Be sure to mass the gliders with all the attachments on them or you will get inaccurate results!**
- 1D inelastic collision with two objects of unequal mass, one initially at rest. First try a heavy glider hitting a stationary light glider. **Be sure to symmetrically weight the glider.**
- 1D inelastic collision with two objects of unequal mass, one initially at rest. Now try a light glider hitting a stationary heavy glider. **Be sure to symmetrically weight the glider.**

For each experiment record the mass of each glider and the velocity for each photogate. **Be sure to mass the gliders with all the attachments on them or you will get inaccurate results!**

Once you have the initial and final momenta and kinetic energies you can calculate the percent change in momentum and percent change in energy. The results might surprise you.

To find the theoretical change in kinetic energy you should do the following:

- Assume that your initial speed is known (given by v_1) as well as your two masses.
- Do a conservation of momentum problem to figure out what v_f should be.
- Use this theoretical v_f to determine what K_f should be. Write this answer in terms of the masses and v_1.
- Determine the $\%\Delta K$ using

$$\%\Delta K = \frac{\left(K_f - K_i\right)}{K_i} \times 100\%$$

You should show that

$$\%\Delta K = -\frac{m_2}{m_{total}}$$

Conclusion:

1. The air tracks are not completely frictionless. Obviously both measurements are lowered by friction. Since we don't really care about what initial speed is used, it really only impacts the second measurement in our system. Will friction make $\%\Delta p_{exp}$ more positive or more negative? Will it make $\%\Delta K_{exp}$ more positive or more negative?
2. During the collision of a heavy mass with a stationary light mass state which object:
   - has the greater force acting on it
   - has the longer collision time
   - has the largest acceleration
   - has the largest change in momentum
3. How do your answers to the above question change if it is a stationary heavy mass that is hit by a moving light mass?
4. According to theory, what is $\%\Delta p$ for an inelastic collision? Assuming 5% precision, did each experiment match theory?
5. According to theory, what is $\%\Delta K$ for each inelastic collision? Assuming 5% precision, did each experiment match theory?
6. According to theory, which collision should lose the most energy? Even if you have large %differences, does your data qualitatively support this aspect of the theory?
7. Energy is conserved in the universe. Our experiments in the lab always show a slight loss of energy. Where does the "lost energy" go in these problems?
8. Suppose your collision was not perfectly inelastic but actually elastic. What are the theoretical values of $\%\Delta p$ and $\%\Delta K$ for this elastic collision?