COLLISIONS-II

PURPOSE: To investigate the conservation of momentum and the conservation of energy in elastic and inelastic collisions.

APPARATUS: ULI, ultrasonic rangers, track, low friction carts

Introduction: Last week we looked at the relationship between change in momentum and impulse. In this week's lab we will investigate conservation of momentum in collisions, and investigate the behavior of kinetic energy in collisions. Momentum of a system is conserved only in the absence of external forces. In the experiment today one very common force will be present: friction. We will attempt to account for the effects of friction in our investigations of conservation of momentum.

We will also study kinetic energy in collisions. Unlike momentum, kinetic energy is not usually conserved. Kinetic energy or the energy of motion of an object is

$$K = \frac{1}{2}mv^2.$$

Notice that this is a <u>scalar</u> quantity. Mechanical energy is the sum of kinetic and potential energies. The law of conservation of energy states that the total energy of a system is always conserved. It does <u>not</u> state that <u>mechanical</u> energy is always conserved. In the collisions we will consider in today's lab there will be no change in potential energy (if the track is properly leveled), so we will ignore it. **A collision in which kinetic energy is conserved is an elastic collision. In an inelastic collision some of the kinetic energy is converted into non-mechanical energy (often heat).** Total energy is still conserved, but mechanical energy is not. Inelastic collisions such as in the example above in which two bodies stick together (sometimes called perfectly inelastic collisions) have a maximum loss of kinetic energy.

EXPERIMENT: In this experiment we will explore momentum, mechanical energy conservation (or non-conservation) in several types of collisions.

You will determine the velocities of several "low-friction" carts with ultrasonic position rangers located on both ends of the 2 meter long aluminum track. The rangers use the `LoggerPro` software which should be already familiar to you. The mass of a cart is 500 g (which you should check with a scale). Each cart will hold one or two additional 500 g weights. Both ends have Velcro pads attached so that if the carts touch, they will stick together. One cart has a spring to allow for collisions that are more nearly elastic.

The lab entails investigating these four different types of collisions:

1. Elastic collision (spring): $m_1 = m_2$ $\mathbf{v_1} > 0$ $\mathbf{v_2} = 0$

2. Inelastic collision (Velcro): $m_1 = m_2$ $\quad \mathbf{v_1} > 0$ $\quad \mathbf{v_2} = 0$
3. Elastic collision (spring): $m_1 = m_2$ $\quad \mathbf{v_1} > 0$ $\quad \mathbf{v_2} \neq 0$
   (one fast, one slow!)
4. Elastic collision (spring): $m_1 < m_2$ $\quad \mathbf{v_1} > 0$ $\quad \mathbf{v_2} = 0$

EXAMPLE ANALYSIS (ELASTIC COLLISION #1)

Compute the total momentum of the system (cart 1 and cart 2) before and after the collision. These are

$$\mathbf{p_i} = m_1\mathbf{v_{1i}} + m_2\mathbf{v_{2i}}$$
$$\mathbf{p_f} = m_1\mathbf{v_{1f}} + m_2\mathbf{v_{2f}}$$

where the subscripts "i" and "f" stand for "initial" and "final." You will calculate the ratio of $\mathbf{p_f}/\mathbf{p_i}$.

Next, compute the kinetic energy of the system before and after the collision. These are:

$$K_i = \frac{1}{2}m_1 v_{1i}^2 + \frac{1}{2}m_2 v_{2i}^2$$
$$K_f = \frac{1}{2}m_1 v_{1f}^2 + \frac{1}{2}m_2 v_{2f}^2$$

Note that the speeds v_{1i}, v_{1f}, etc. are not in bold type because kinetic energy is a scalar quantity. You will calculate the ratio K_f/K_i.

Friction: In each case you will need to make appropriate measurements to determine the amount of friction. Discuss a method for determining the friction. Discuss your method with your instructor before proceeding. Be sure in each case to record enough data to make corrections for friction.

Report: For each case find the total momentum and kinetic energy before and after the collision. List the values with the ratios. Then correct for the change in velocity between when it was measured and the collision time. Recalculate momentum and kinetic energy. Discuss whether momentum was conserved in the collisions. Your report should be typed and written in complete sentences and include a discussion of the following. Some energy is lost in the collisions with the spring. Is the fraction constant? Compare it to the fractional energy loss of the golf ball in last week's experiment. Which collision was most nearly elastic? Describe how you measured the frictional force and corrected for losses due to friction.