Collisions

An object in motion has both kinetic energy and momentum. The kinetic energy is given by $KE = \frac{1}{2}mv^2$ and does not depend on direction. The momentum is given by $p = mv$ and it has both magnitude and direction.

Kinetic energy is just one of many possible forms of energy. While energy can change forms and be transferred from one system to another, the total energy remains constant. Likewise, momentum can be transferred, but the total momentum of a closed system is always constant.

<u>Preliminary Questions</u>

A linebacker makes a running tackle of a quarterback who is initially at rest.

1. The total momentum of the two players is the same just before and just after the tackle.

   (a) true (b) false (c) depends on their mass and speed

2. The total kinetic energy of the players is the same just before and just after the tackle.

   (a) true (b) false (c) depends on their mass and speed

3. A golfer hits a golf ball with his driver. Which of the following is conserved? (may be more than one)

   (a) momentum (b) kinetic energy (c) total energy

4. A soldier standing on a slippery frozen lake fires a gun which is pressed against his shoulder. Which has the greatest momentum just after the gun is fired?

   (a) bullet (b) gun + soldier

5. Which has the greater kinetic energy?

   (a) bullet (b) gun + soldier

Collision Simulations

Open the PhET Collision Lab at http://phet.colorado.edu/en/simulation/collision-lab.

Before running the simulation, make a prediction. A 1-kg ball moving at 1 m/s makes a head-on collision with a 1-kg ball initially at rest. The "elasticity" of the balls is 100%. Predict what will happen after the collision.

Now run the simulation and compare the results with your prediction. Is momentum conserved? Is kinetic energy conserved?

Now set the elasticity to 0 %. Again predict what will happen.

Run the simulation and compare with your predictions. Is momentum conserved? Is kinetic energy conserved?

Repeat with the elasticity set to 50%. Do you expect the balls to stick together? Can we say that kinetic energy is always conserved if objects bounce apart when they collide?

Inelastic Collision Experiment

Now you will explore collisions using Pasco low friction carts. Note that the carts have Velcro on one end and magnets on the other end. With the Velcro ends facing each other they will stick together when they collide. This would be an "inelastic collision". With the magnet ends facing each other they will bounce apart when they collide. This would be a nearly "elastic" collision. Play around with the carts and see if they behave as illustrated in the PhET simulation.

Now make some measurements. Add a weight to one of the carts so their masses are different. Start with an inelastic collision with one of the carts initially at rest. Position the motion sensor at one end of the track and measure the speed of the moving cart before and after the collision. (We will show you how to use the motion sensor with a laptop and the Data Studio software to measure the speed.)

From your measurements, calculate the momentum of each cart before and after the collision. Is momentum conserved? Is this what you expect?

What about kinetic energy? Is it conserved? If kinetic energy was not conserved, where did it go?

Nearly Elastic Collision Experiment (if time allows)

Now orient the carts to produce a collision with the magnet ends facing each other. Since the carts will bounce apart, you will need to measure two different speeds after the collision. This can be done by placing a motion sensor at each end of the track.

Run the collision and measure the initial speed of the launched cart and the final speeds of both carts. Use the measurements to calculate the initial and final momenta and initial and final kinetic energies.

Is total momentum conserved? Explain.

Is total kinetic energy conserved? Explain.