Name: _____ Period: _____

Elastic Collisions: Conservation of Momentum

In this activity, you will observe collisions between two gliders on a frictionless air track.

Procedure:

1. Launch Internet Explorer
2. Go to www.explorelearning.com
3. Click on Login.
4. Enter the Username: orange0910 Password: black0910
5. Search for **Air Track**
6. Select **Air Track**
7. Click on Gizmo Tab to open the **Air Track** Gizmo

1. In the Gizmo™, check that the Elasticity is set to 1.0, and that the masses of both gliders (m_1 and m_2) are set to 2.0 kg. For Glider 1, be sure that the velocity (v_1) is 5.0 m/s. For Glider 2, set the velocity (v_2) to 0.0 m/s. (To quickly set a slider to a certain number, type the number into the field to the right of the slider and hit **Enter**.) Click on Glider 2 and drag it to the middle of the air track. Click Play ( ). After the gliders collide, click Pause ( ).
    a. Which direction was Glider 1 moving before the collision? _____
    b. Which direction did each glider move after the collision? _____
    c. Turn on the Show numerical data checkboxes for both gliders. What is the relationship between the velocity of Glider 1 *before* the collision and the velocity of Glider 2 *after* the collision? _____
    d. What is the relationship between the velocity of Glider 2 before the collision and the velocity of Glider 1 after the collision? _____
2. Click Reset ( ). Set v_2 to -2.0 m/s and turn on the Show velocity vectors checkbox. Notice the purple arrow on each glider. Velocity is a vector quantity; it has a magnitude and a direction. The length of the purple arrow represents how fast each glider is moving, and the direction of the arrow indicates the direction the glider is moving. Click Play, wait for the collision, and then click Pause.
    a. What do you notice about the velocity vectors before and after the collision?
    _____
    _____
    b. What is the relationship between the velocity of Glider 1 before the collision and the velocity of Glider 2 after the collision? _____
    c. What is the relationship between the velocity of Glider 2 before the collision and the velocity of Glider 1 after the collision? _____
    d. Write a general rule to describe the velocity of each glider before and after the collision.
    _____
    _____
    _____
    Test your rule with several other combinations of starting velocities.

e. Change the mass of one of the gliders. Does your rule work when the gliders do not have the same mass? Explain.

_____

_____

_____

3. Momentum (p) is the product of an object's mass and velocity, $p = m \cdot v$. Like velocity, momentum is a vector quantity. It has both size and direction. Click Reset and turn off the Show numerical data checkboxes. Set v_1 to 8.0 m/s, m_1 to 1.0 kg, v_2 to -4.0 m/s, and m_2 to 3.0 kg.
   a. Calculate the momentum of each glider. Be sure to include a positive or negative sign to indicate direction. Turn on the Show numerical data checkboxes to check your answers.
   b. What is the sum of the momentum of Glider 1 and Glider 2 before the collision? (Remember that Glider 2 has negative momentum.) _____
   c. Click Play, wait for the collision, and then click Pause. What is the velocity and momentum of each glider after the collision?

      _____

      _____

   d. What is the total momentum after the collision? _____
   e. Try several other combinations of starting velocities and masses for Glider 1 and Glider 2. In each experiment, find the total momentum before the collision and after the collision. What do you notice?

      _____

      _____

      _____

   f. When there are no external forces (such as friction) acting on the system, the total momentum is constant. This is the law of conservation of momentum. Write an expression for conservation of momentum given the mass and velocity of each glider before and after the collision.

4. Click Reset. The energy of each moving glider is expressed as kinetic energy (KE), which is calculated as $KE = mv^2/2$.
   a. Based on the current mass and initial velocity settings, calculate the initial kinetic energy (KE) of each glider. Check your answers on the Show numerical data chart. What is the total kinetic energy of the two gliders combined?

      _____

   b. Click Play, wait for the collision, and then click Pause. What is the kinetic energy of each glider after the collision? _____
   c. What is the combined kinetic energy of both gliders after the collision?

      _____

d. Did the total kinetic energy of the system stay the same? Explain your answer.
_____
_____
_____

5. There is a third interesting relationship between the before-and-after velocities of the two gliders. Click Reset, and set the initial masses to any values you like. Set v_1 to 6.0 m/s, and v_2 to -4.0 m/s.
    a. How quickly will the two gliders approach each other? To calculate this, subtract the velocity of Glider 2 from the velocity of Glider 1.
    _____
    b. Click Play, wait for the collision, and then click Pause. How quickly will the two gliders separate from one another? (Subtract the current velocity of Glider 1 from the velocity of Glider 2).
    _____
    c. What do you notice about the approach velocity compared to the separation velocity?
    _____
    _____
    d. To see if this is always the case, try other velocity and mass settings. Does the relationship hold? _____

Elastic and Inelastic Collisions

So far, you have only looked at perfectly elastic collisions, in which the objects bounce cleanly off one another like two billiard balls. But what happens when the objects are deformed and mash together in the collision?

1. Click Reset. Set m_1 and m_2 to 1.0 kg. Set v_1 to 5.0 m/s, and v_2 to -5.0 m/s. Set the Elasticity to 0.0. Click Play wait for the collision, and then click Pause.
    a. What happens to the two gliders when they collide this time?
    _____
    b. Is total momentum conserved in this collision? Explain why or why not.
    _____
    _____
    c. Is kinetic energy conserved in this collision? Explain why or why not.
    _____
    _____
    d. What do you think happens to the energy that is "lost"?
    _____
    _____