Physics Exploration Homework Supplement **P110-8.pdf**

Conservation of Linear Momentum: Collisions on the Air Track

Go to the Physics Exploration Center. Enter through the resource room 311/312 Thaw Hall.

Before you start the exploration assignment, answer the following questions:
(1) Which of these statements best describes the difference between an inelastic collision and an elastic collision?
(a) If colliding objects stick to each other after the collision, the collision is inelastic; otherwise, it is elastic.
(b) If there is external force acting on the system, the collision is inelastic; otherwise, it is elastic.
(c) The potential energy of the system is not conserved in an inelastic collision, but it is conserved in an elastic collision.
(d) The kinetic energy of the system is not conserved in an inelastic collision, but it is conserved in an elastic collision.
(e) The linear momentum of the system is not conserved in an inelastic collision, but it is conserved in an elastic collision.

(2) Two carts with masses m and M sit on a frictionless air track. The cart with mass m is given an initial push towards cart M (which is at rest). If the collision of the carts is elastic and mass M is larger than mass m, then after the collision:
(a) both carts will move in the same direction
(b) the carts will move in opposite direction
(c) the first cart will come to rest and the second cart will move with the same velocity as the first one.
(d) both carts move with the same velocity which is half of the initial velocity of the cart with mass m.
(e) none of the above

This week you will use "air track" demonstration to learn about elastic and inelastic collisions. When the air track is turned on, objects can slide with negligible friction. Attached to the air track are two motion detector sensors which will track the time for a 2.5 cm strip attached to the slider to pass through the sensor. Since the velocity of the slider on a horizontal air track is considered constant, you can find the velocity by dividing the distance (2.5 cm) by the time registered on the computer. Perform the following experiments:
(a) Suppose two carts are on a horizontal frictionless surface. One cart is at rest while the second is moving with an initial velocity v_0 head-on towards the first. Predict whether the velocity of the two carts after a collision in which they stick together will be larger, smaller or the same as v_0.

Justify your answer. Now take the two sliders marked "inelastic" which have equal mass. Add 100 gram mass to one of the sliders and put it at the end of the air track. Put the other slider somewhere in the middle of the track. Give the slider at the end an initial push and let go. The slider will bump into the other one. The collision is completely inelastic and the two will move together as one mass. Calculate the velocity before and after the collision using the time measured for a 2.5 cm strip to pass through the sensor. Use this information to find the mass of the slider.

(b) Predict whether the kinetic energy of the two slider system is conserved in the inelastic collision of part (a). Justify your answer. Now calculate the difference in the kinetic energy of the system before and after the collision from the data in part (a). Is this difference zero? Does it agree with your prediction?

(c) Suppose two carts are on a horizontal frictionless surface. One cart is at rest while the second is moving with an initial velocity v_0 head-on towards the first. Predict what should be the velocities of the carts after an elastic collision. Predict the magnitude and direction of final velocities of the two carts after the elastic collision if the cart which is initially at rest is more massive. Predict the magnitude and direction of final velocities of the two carts after the elastic collision if the cart which is initially at rest is less massive, (d) Now take the two sliders marked "elastic" which have equal mass. Put one of them at the end of the air track and the other one somewhere in the middle. Give an initial push to the slider at the end and let go. What happens to the velocities of the two sliders when they bump into one another? Is this what you predicted in part (c) based upon your knowledge of elastic collision?

(e) Take the two sliders marked "elastic" which have equal mass. Add 100 gram mass to one of the sliders (Note: place 50 grams on each side of the air cart). Put that slider at the end of the air track and the other one somewhere in the middle. Give an initial push to the slider at the end and let go. What happens to the velocities when the two sliders bump into one another? Is this what you predicted in part (c) based upon your knowledge of elastic collision with unequal masses?

(f) How will the final velocity after collision be affected if the 100 gram mass was attached not to the slider that was initially moving in part (c) but the one initially at rest? Discuss your intuition qualitatively (You can actually do the experiment to verify if your intuition is correct.) Is this what you predicted in part (c) based upon your knowledge of elastic collision with unequal masses?

(g) Go back to the two multiple choice questions at the beginning of this assignment and discuss whether you agree with your original answers in the light of your exploration. Also, from what you learned in the class about collisions, justify WHY the momentum of the system is conserved in any collision *(i.e.,* what is necessary for the momentum of the system to be conserved?).