Elastic and Inelastic Collisions

- Momentum is conserved in <u>all</u> collisions
- A collision may be defined as *elastic* or *inelastic* based on whether the total kinetic energy of the system is conserved or not
- **Elastic collisions** occur when the *total kinetic energy* of the system is conserved

$$\sum E_k = \sum E_k' \quad \text{or} \quad E_{k,\,total} = E_{k',\,total}$$

  - Elastic collisions really only occur at a subatomic level (protons, electrons, and neutrons colliding)

- **Inelastic collisions** occur when the *total kinetic energy* of the system is ***not*** conserved

$$\sum E_k \neq \sum E_k' \quad \text{or} \quad E_{k,\,total} \neq E_{k',\,total}$$

  - Kinetic energy is lost due to bending, crumpling, breaking, or any deformation
  - All collisions at a macroscopic level are considered to be inelastic

- The conservation of energy still applies to inelastic collision because inelastic only means that kinetic energies are not conserved. The conservation of energy accounts for the energies converted into heat, deformation, etc.

- Momentum is still conserved in both elastic and inelastic collisions
  - Elastic and inelastic strictly relates to the total kinetic energy of the objects and makes no statement on the momentum of the system!

EXAMPLES:

1. An argon atom with a mass of 6.63×10^{-26}kg travels at 17m/s, right and strikes another identical argon atom dead centre travelling at 20m/s, left. The first atom rebounds at 20 m/s, left while the second atom moves at 17 m/s, right. Determine if the collision is elastic.

$$E_{k,total} = E'_{k,total}$$

$$\tfrac{1}{2}mv_1^2 + \tfrac{1}{2}mv_2^2 = \tfrac{1}{2}mv_1'^2 + \tfrac{1}{2}mv_2'^2$$

$$\tfrac{1}{2}m\,(v_1^2 + v_2^2) = \tfrac{1}{2}m\,(v_1'^2 + v_2'^2)$$

$$v_1^2 + v_2^2 = (v_1')^2 + (v_2')^2$$

$$(17\,m/s)^2 + (20\,m/s)^2 = (20\,m/s)^2 + (17\,m/s)^2$$

$$689 = 689 \checkmark$$

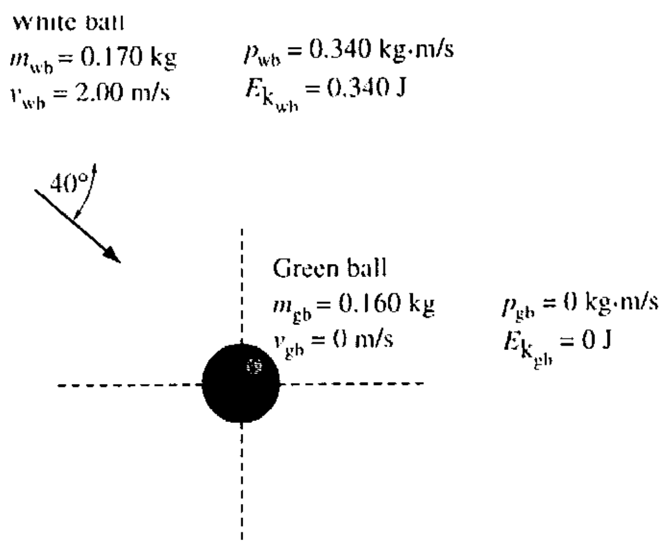
∴ collision is *elastic*!

* no need to put direction in for speed b/c energy is scalar!

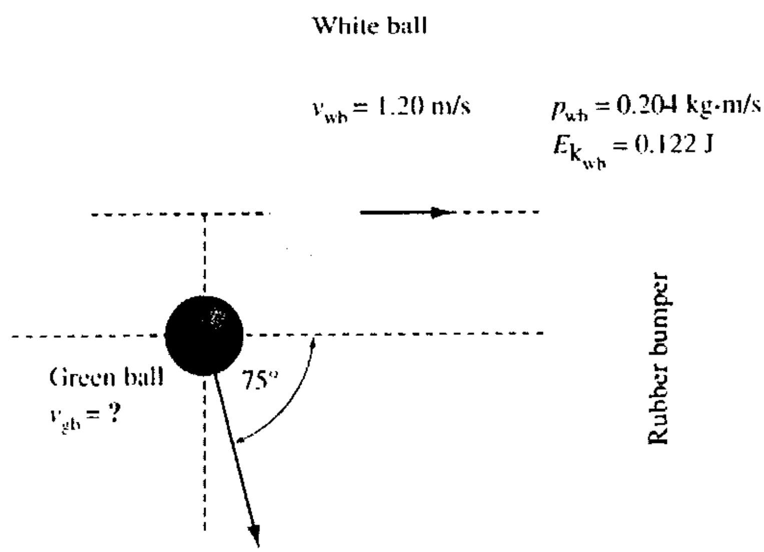
Use the following information to answer the next question.

A white billiard ball has a mass of 0.170 kg. A green billiard ball has a mass of 0.160 kg. A collision involving a white ball and a green ball is described in the Before and After diagrams below.

Before the White Ball–Green Ball Collision



After the White Ball–Green Ball Collision



Immediately after the collision with the green ball, the white ball collided with the rubber bumper along the edge of the billiard table. The white ball's velocity before the ball hit the bumper was 1.20 m/s, right, and immediately after the ball hit the bumper it was 1.00 m/s, left.

2. The white ball-green ball collision is classified as
    a. elastic
    b. inelastic
    c. isolated
    d. non-isolated

Now try pg. 66 # 4, Practice Problems (intermediate), 6a,b (excellence)

Practice Problems

1. A Calgary company, Cerpro, is a world leader in ceramic armour plating for military protection. The ceramic structure of the plate transmits the kinetic energy of an armour-piercing bullet throughout the plate, reducing its penetrating power. Explain if this type of collision is elastic or inelastic.

2. Two masses collide head-on and come to a stop. Explain what has happened in terms of
    a. each mass's original momentum.

    b. the elasticity of the collision.

3. Does all kinetic energy need to be lost for a collision to be considered inelastic?

4. Explain how an inelastic collision does not violate the law of conservation of energy.

5. Give an example of elastic collision.

Answers

1. This is an inelastic collision because the total kinetic energy after the collision will be less than before the collision because the plate transmits the kinetic energy throughout the plate in some other form of energy (ie. deformation of the plate upon impact of bullet).

2.
   a. Momentum will be conserved. They had equal and opposite momenta.
   b. Since both masses come to a stop after the collision, the total kinetic energy after the collision is less than before; therefore, the collision is inelastic.

3. No, as long as some kinetic energy is lost, the collision is considered inelastic.

4. An inelastic collision is defined when the total kinetic energy of the system is not conserved. Since this definition does not include all types of energies involved in the collision, the conservation of energy is not violated.

5. An atomic/subatomic collision. For example, a proton colliding with a gold atom.