Discussion 8: Collisions

Summary

Collisions

Collisions are interactions between moving objects. When the objects do not receive significant net forces from beyond the system (each other), total momentum is conserved.

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

It is convenient to categorize collisions as totally inelastic, inelastic, and elastic.

Totally inelastic collisions

In a totally inelastic collision, the objects cling together after the collision. Thus, they have the same final velocity: $v_{1f} = v_{2f} = v_f$. Because momentum is conserved,

$$v_f = \frac{m_1 v_{1i} + m_2 v_{2i}}{m_1 + m_2}$$

Elastic collisions

In elastic collisions, total kinetic energy is conserved as well as total momentum. In one dimension, the final velocities of the colliding particles are

$$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i} + \frac{2m_2}{m_1 + m_2} v_{2i}; \quad v_{2f} = \frac{m_2 - m_1}{m_1 + m_2} v_{2i} + \frac{2m_1}{m_1 + m_2} v_{1i}$$

In an elastic collision, the departure speed of the particles after the collision is equal to their approach speed before the collision.

Inelastic collisions

In inelastic collisions, the particles do not cling together after the collision, but kinetic energy is not conserved. To find the final velocities after an inelastic collision, you need additional information beyond the masses and initial velocities.

Problems

1. Two vehicles collide at a right-angle intersection and remain stuck together after the collision. Before the collision, vehicle 1, with a mass of 1320 kg, was traveling east at a speed of 14.0 m/s, and vehicle 2, with a mass of 1700 kg, was traveling north at a speed of 12.0 m/s.
   a. What is the speed and heading of the coupled vehicles immediately after the collision?
   b. Suppose both vehicles have a coefficient of kinetic friction against the pavement of 0.65. Where do they come to a stop after the collision? Express in terms of distance and direction from where the impact occurred.

2. A dynamics cart on a frictionless track overtakes and collides perfectly elastically with another cart. The first cart has a mass of 250. g and an initial speed of 2.00 m/s. The second

cart has a mass of 500. g and an initial speed of 0.500 m/s (in the same direction). What are the velocities of the two carts after the collision?

3. A moving particle collides with a particle that is initially stationary. The initially moving particle has a mass of 2.000 kg and an initial velocity of 4.00 m/s in the $+x$ direction. After the collision, its velocity is 2.88 m/s in the direction of 56.3° counterclockwise of the $+x$ direction (it was deflected to the left by an angle of 56.3° in the collision). The initially stationary particle has a mass of 3.000 kg. What is its velocity (speed and direction) after the collision?