Worksheet 13: Collisions

Objective

- Evaluate the mechanics of elastic, inelastic, and totally inelastic collisions.

Summary

Collisions

Momentum is conserved in all collisions. $\sum \vec{p}_{t_1} = \sum \vec{p}_{t_2}; \sum m_i \vec{v}_{i,t_1} = \sum m_i \vec{v}_{i,t_2}$. The center of mass of a system at $\vec{r}_{\text{CM}} = \sum m_i \vec{r_i} / \sum m_i$ always maintains a constant velocity.

Totally inelastic collisions

The colliding bodies stick together after the collision, so that their final velocities are identical at $\vec{v}_{t_2}$. Their final momentum is simply$(m_1 + m_2)v_{t_2}$, where $v_{t_2} = \sum m_i \vec{v_i} / \sum m_i$.

Elastic collisions

Kinetic energy is conserved in elastic collisions. $\sum K_{t_2} = \sum K_{t_1}; \sum m_i v_{i,t_2}^2 = \sum m_i v_{i,1}^2$. The bodies have the same relative speeds before and after the collision.

Inelastic collisions

The bodies rebound from each other, but not as fast as in the elastic case. Some kinetic energy is lost.

Spring-aparts

Bodies may convert potential energy to kinetic energy in a collision, rebounding with greater kinetic energy than before. These behave like inelastic or totally inelastic collisions in reverse.

Problems

1. A 1050-kg sports car is moving westbound at 15.0 m/s when it collides head-on with a 6320-kg truck driving east on the same road at 10.0 m/s. The two vehicles remain locked together after the collision.

   a. What kind of collision is this?

   b. What is the velocity of the two vehicles just after collision?

   c. If the coefficient of friction between the cars and the road is 0.70, how far do they skid after the collision?

2. Two pucks collide on frictionless ice. Before the collision, one puck, with a mass of 4.00 kg, is traveling with a velocity of $(5.00\ \hat{\imath} + 2.00\ \hat{\jmath})$ m/s, and the other puck, with a mass of 3.00 kg, is traveling with a velocity of $(-2.00\ \hat{\imath} + 2.00\ \hat{\jmath})$ m/s. After the collision, the 4.00-kg puck travels with a velocity of $(3.30\ \hat{\imath} + 2.75\ \hat{\jmath})$ m/s.

   a. What is the velocity of the 3.00-kg puck after the collision?

   b. What type of collision is this?

3. A hockey player skates into the boards, coming to a stop.

   a. What type of collision is this?

   b. Is momentum conserved in this collision? If so, how? If not, how is that possible?

5. Find the final velocities of particles 1 and 2 for these special cases of **elastic** collisions in one dimension. Draw before-and-after diagrams to describe the collisions.

   a. $v_{2i} = -v_{1i}$; $m_2 = m_1 = m$

   b. $v_{2i} = 0$

   c. $v_{2i} = 0$; $m_2 = m_1 = m$

   d. $v_{2i} = 0$; $m_2 \gg m_1$

   e. $v_{2i} = 0$; $m_2 \ll m_1$