7–6 Inelastic Collisions

Collisions in which kinetic energy is not conserved are called *inelastic collisions*. Some of the initial kinetic energy is transformed into other types of energy, such as thermal or potential energy, so the total kinetic energy after the collision is less than the total kinetic energy before the collision. The inverse can also happen when potential energy (such as chemical or nuclear) is released, in which case the total kinetic energy after the interaction can be greater than the initial kinetic energy. Explosions are examples of this type.

Completely inelastic collision

Typical macroscopic collisions are inelastic, at least to some extent, and often to a large extent. If two objects stick together as a result of a collision, the collision is said to be **completely inelastic**. Two colliding balls of putty that stick together or two railroad cars that couple together when they collide are examples of completely inelastic collisions. The kinetic energy in some cases is all transformed to other forms of energy in an inelastic collision, but in other cases only part of it is. In Example 7–3, for instance, we saw that when a traveling railroad car collided with a stationary one, the coupled cars traveled off with some kinetic energy. In a completely inelastic collision, the maximum amount of kinetic energy is transformed to other forms consistent with conservation of momentum. Even though kinetic energy is not conserved in inelastic collisions, the total energy is always conserved, and the total vector momentum is also conserved.

EXAMPLE 7–9 Railroad cars again. For the completely inelastic collision of two railroad cars that we considered in Example 7–3, calculate how much of the initial kinetic energy is transformed to thermal or other forms of energy.

APPROACH The railroad cars stick together after the collision, so this is a completely inelastic collision. By subtracting the total kinetic energy after the collision from the total initial kinetic energy, we can find how much energy is transformed to other types of energy.

SOLUTION Before the collision, only car A is moving, so the total initial kinetic energy is

$$\tfrac{1}{2} m_{\mathrm{A}} v_{\mathrm{A}}^2 = \tfrac{1}{2}(10{,}000\,\mathrm{kg})(24.0\,\mathrm{m/s})^2 = 2.88 \times 10^6\,\mathrm{J}.$$

After the collision, both cars are moving with a speed of 12.0 m/s, by conservation of momentum (Example 7–3). So the total kinetic energy afterward is

$$\tfrac{1}{2}(20{,}000\,\mathrm{kg})(12.0\,\mathrm{m/s})^2 = 1.44 \times 10^6\,\mathrm{J}.$$

Hence the energy transformed to other forms is

$$\left(2.88 \times 10^6\,\mathrm{J}\right) - \left(1.44 \times 10^6\,\mathrm{J}\right) = 1.44 \times 10^6\,\mathrm{J},$$

which is just half the original kinetic energy.

Ballistic pendulum

EXAMPLE 7–10 Ballistic pendulum. The *ballistic pendulum* is a device used to measure the speed of a projectile, such as a bullet. The projectile, of mass m, is fired into a large block (of wood or other material) of mass M, which is suspended like a pendulum. (Usually, M is somewhat greater than m.) As a result of the collision, the pendulum and projectile together swing up to a maximum height h, Fig. 7–17. Determine the relationship between the initial horizontal speed of the projectile, v, and the maximum height h.

APPROACH We can analyze the process by dividing it into two parts or two time intervals: (1) the time interval from just before to just after the collision itself, and (2) the subsequent time interval in which the pendulum moves from the vertical hanging position to the maximum height h.