Name:______________________________ Class:__________________ Date:__________________

Momentum and Collisions

Problem F

KINETIC ENERGY IN PERFECTLY INELASTIC COLLISIONS

PROBLEM

Alaskan moose can be as massive as 8.00×10^2 kg. Suppose two feuding moose, both of which have a mass of 8.00×10^2 kg, back away and then run toward each other. If one of them runs to the right with a speed of 8.0 m/s and the other runs to the left with a speed of 6.0 m/s, what amount of kinetic energy will be dissipated after their inelastic collision?

SOLUTION

Given: m_1 = mass of first moose = 8.00×10^2 kg

m_2 = mass of second moose = 8.00×10^2 kg

$\mathbf{v_{1,i}}$ = initial velocity of first moose = 8.0 m/s to the right

$\mathbf{v_{2,i}}$ = initial velocity of second moose = 6.0 m/s to the left

= −6.0 m/s to the right

Unknown: $\Delta KE = ?$

Use the equation for a perfectly inelastic collision.

$$m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} = (m_1 + m_2)\mathbf{v_f}$$

$$(8.00 \times 10^2 \text{ kg})(8.0 \text{ m/s}) + (8.00 \times 10^2 \text{ kg})(-6.0 \text{ m/s}) = (2)(8.00 \times 10^2 \text{ kg})\mathbf{v_f}$$

$$6.4 \times 10^3 \text{ kg}\bullet\text{m/s} - 4.8 \times 10^3 \text{ kg}\bullet\text{m/s} = (16.0 \times 10^2 \text{ kg})\mathbf{v_f}$$

$$\mathbf{v_f} = \frac{1.6 \times 10^3 \text{ kg}\bullet\text{m/s}}{16.0 \times 10^2 \text{ kg}} = 1.0 \text{ m/s to the right}$$

Use the equation for kinetic energy to calculate the kinetic energy of each moose before the collision and the final kinetic energy of the two moose combined.

Initial kinetic energy:

$$KE_i = KE_{1,i} + KE_{2,i} = \frac{1}{2}m_1 v_{1,i}^{\,2} + \frac{1}{2}m_2 v_{2,i}^{\,2}$$

$$KE_i = \frac{1}{2}(8.00 \times 10^2 \text{ kg})(8.0 \text{ m/s})^2 + \frac{1}{2}(8.00 \times 10^2 \text{ kg})(-6.0 \text{ m/s})^2$$

$$KE_i = 2.6 \times 10^4 \text{ J} + 1.4 \times 10^4 \text{ J} = 4.0 \times 10^4 \text{ J}$$

Final kinetic energy:

$$KE_f = KE_{1,f} + KE_{2,f} = \frac{1}{2}(m_1 + m_2)v_f^{\,2}$$

$$KE_f = \frac{(2)(8.00 \times 10^2 \text{ kg})(1.0 \text{ m/s})^2}{2}$$

$$KE_f = 8.0 \times 10^2 \text{ J}$$

Change in kinetic energy:

$$\Delta KE = KE_f - KE_i = 8.0 \times 10^2 \text{ J} - 4.0 \times 10^4 \text{ J} = -3.9 \times 10^4 \text{ J}$$

By expressing ΔKE as a negative number, we indicate that the energy has left the system to take a form other than mechanical energy.

1. The hog-nosed bat is the smallest mammal on Earth: it is about the same size as a bumblebee and has an average mass of 2.0 g. Suppose a hog-nosed bat with this mass flies at 2.0 m/s when it detects a bug with a mass of 0.20 g flying directly toward it at 8.0 m/s. What fraction of the total kinetic energy is dissipated when it swallows the bug?
2. The heaviest wild lion ever measured had a mass of 313 kg. Suppose this lion is walking by a lake when it sees an empty boat floating at rest near the shore. The curious lion jumps into the boat with a speed of 6.00 m/s, causing the boat with the lion in it to move away from the shore with a speed of 2.50 m/s. How much kinetic energy is dissipated in this inelastic collision.
3. The cheapest car ever commercially produced was the *Red Bug Backboard*, which sold in 1922 in the United States for about $250. The car’s mass was only 111 kg. Suppose two of these cars are used in a stunt crash for an action film. If one car’s initial velocity is 9.00 m/s to the right and the other car’s velocity is 5.00 m/s to the left, how much kinetic energy is dissipated in the crash?
4. In 1986, four high school students built an electric car that could reach a speed of 106.0 km/h. The mass of the car was just 60.0 kg. Imagine two of these cars used in a stunt show. One car travels east with a speed of 106.0 km/h, and the other car travels west with a speed of 75.0 km/h. If each car’s driver has a mass of 50.0 kg, how much kinetic energy is dissipated in the perfectly inelastic head-on collision?
5. The Arctic Snow Train, built for the U.S. Army, has a mass of 4.00×10^5 kg and a top speed of 32.0 km/h. Suppose such a train moving at its top speed is hit from behind by another snow train with a mass of 1.60×10^5 kg and a speed of 45.0 km/h in the same direction. What is the change in kinetic energy after the trains’ perfect inelastic collision?
6. There was a domestic cat in Australia with a mass of 21.3 kg. Suppose this cat is sitting on a skateboard that is not moving. A 1.80×10^{-1} kg treat is thrown to the cat. When the cat catches the treat, the cat and skateboard move with a speed of 6.00×10^{-2} m/s. How much kinetic energy is dissipated in the process? Assume one-dimensional motion.
7. In 1985, a spider with a mass of 122 g was caught in Surinam, South America. (Recall that the smallest dog in the world had a smaller mass.) Suppose a spider with this mass runs at a certain unknown speed when it collides inelastically with another spider, which has a mass of 96.0 g and is at rest. Find the fraction of the kinetic energy that is dissipated in the perfect inelastic collision. Assume that the resting spider is on a low-friction surface. Do you need to know the first spider’s velocity to calculate the fraction of the dissipated kinetic energy?