Name:_____Class:_____ Date:_____

Momentum and Collisions

Problem E

PERFECTLY INELASTIC COLLISIONS

PROBLEM

An arrow is fired into a small target at rest on a frictionless surface. The arrow's mass is 20.0 g and the target's mass is 2.50 kg. If the speed of the arrow and target combined is 0.67 m/s, what is the arrow's initial speed?

SOLUTION

Given: m_1 = mass of arrow = 20.0 g

m_2 = mass of target = 2.50 kg

$v_{2,i}$ = initial speed of target = 0 m/s

v_f = final speed of target and arrow = 0.67 m/s

Unknown: $v_{1,i}$ = initial speed of arrow =?

Use the equation for a perfectly inelastic collision and rearrange it to solve for $v_{1,i}$.

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

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

$$v_{1,i} = \frac{(20.0 \times 10^{-3}\ \text{kg} + 2.50\ \text{kg})(0.67\ \text{m/s}) - (2.50\ \text{kg})(0\ \text{m/s})}{20.0 \times 10^{-3}\ \text{kg}}$$

$$v_{1,i} = \frac{(2.52\ \text{kg})(0.67\ \text{m/s})}{20.0 \times 10^{-3}\ \text{kg}}$$

$$v_{1,i} = \boxed{84\ \text{m/s}}$$

ADDITIONAL PRACTICE

1. A 1550 kg torpedo strikes a 770 kg target that is initially at rest. If the combined torpedo and target move forward with a speed of 9.44 m/s, what is the initial velocity of the torpedo? Assume that no resistance is provided by the water.
2. An ice hockey puck with a mass of 0.17 kg collides inelastically with a0.75 kg snowball that is sliding to the left with a speed of 0.50 m/s. The combined puck and snowball slide along the ice with a velocity of 4.2 m/s to the right. What is the velocity of the hockey puck before the collision?
3. A clay ball with a mass of 45 g is attached to a long string to make a pendulum. The ball is pulled back so that the string is horizontal to the ground, and is then released. At the bottom of the ball's path is another clay ball that has a mass of 75 g and is at rest. The two balls collide inelastically, so that they follow the path of the first ball beyond the point of collision.

What must the speed of the first ball be just before the collision so that the combined balls rise to a height of 8.0 cm above the point of collision? How high must the first ball be raised for it to have this speed at the bottom of its path?

4. A 5.00×10^2 kg log collides inelastically with a second log with the same mass. These combined logs then collide with a third log with a mass of 5.00×10^2 kg. The final speed of the three combined logs is 3.67 m/s. If the speed of the third log before collision was 3.00 m/s, and the speed of the second log before collision was 3.50 m/s, what was the speed of the first log before collision?
5. A railway car with a mass of 8500 kg and a velocity of 4.5 m/s to the right collides inelastically with a railway car with a mass of 9800 kg and a velocity of 3.9 m/s to the left. What is the final velocity of the combined cars?
6. A 1400 kg automobile heading north at 45 km/h collides inelastically with a 2500 kg truck traveling east at 33 km/h. What is the final velocity of the combined vehicles?
7. Four velcro-lined air-hockey disks collide with each other in a perfect inelastic collision. The first disk has a mass of 50.0 g and a velocity of 0.80 m/s to the west, the second disk has a mass of 60.0 g and a velocity of 2.50 m/s to the north, the third disk has a mass of 100.0 g and a velocity of 0.20 m/s to the east, and the fourth disk has a mass of 40.0 g and a velocity of 0.50 m/s to the south. What is the final velocity of the disks after the collision?
8. A 25.0 kg sled carrying a 42.0 kg child is moving with a speed of 3.50 m/s when it collides with a snowman that is initially at rest. If the speed of the snowman, sled, and child is 2.90 m/s, what is the snow-man's mass?
9. A remora is a type of fish that uses suckers underneath its head to attach itself to other fish, notably sharks (for this reason it is also called the "sharksucker"). Suppose a remora swimming with a velocity of 5.0 m/s to the right attaches itself to a 150.0 kg shark that is swimming to the left with a speed of 7.00 m/s. If the remora collides inelastically with the shark, the velocity of the two fish combined is 6.25 m/s to the left. From this information, calculate the mass of the remora.
10. A proposed method for removing small but hazardous debris in orbit around Earth involves a large ball composed of a type of gum or putty. This soft ball would orbit Earth and collide inelastically with small particles of debris, sweeping them up in the process. Suppose this putty ball moves in an orbit containing a stream of debris. The ball has a velocity of 8.0×10^3 m/s to the right, while the particles of debris have a velocity of 8.0×10^3 m/s to the left. Each particle of debris has an average mass of 2.5 g. If the putty ball sweeps up 5,000 particles before the velocity of the ball and debris is 90.0 percent of the ball's initial velocity, what is the ball's mass?