1. Consider a collision between two blocks of mass 0.25 kg each on a horizontal surface. Suppose that one block is initially going with speed 4 m/s when it hits the second block, which is initially at rest. The blocks then collide elastically along a straight line. Suppose that the two blocks are in contact for approximately 0.05 s.

(a) Find the final speeds of each of the two blocks.

(b) Estimate the average force between the blocks during the collision by assuming that the force is approximately constant during the time they are in contact.

(c) Suppose that there is a coefficient of kinetic friction of $\mu = 0.2$ between the blocks and the ground. Taking into account this frictional force, the momentum of the system of two blocks is no longer conserved in the collision. Find the change in the momentum of the system due to the presence of friction. Does this significantly change your answer in part (a)? Explain.

2. You are a police officer charged with determining the speed of two cars involved in a collision. An SUV of mass 1900 kg collided with a compact car of mass 1300 kg. The cars were travelling at right angles to each other before they collided. The cars stuck together after the collisions, and the combined wreck left skid marks of length 2.2 m before it came to rest. The skid marks make an angle of 32° from the initial direction of the SUV’s motion. Assume that the coefficient of friction between the road and the car tires is $\mu_k = 0.4$. Find the speed of each of the cars just before the collision.
3. (a) A bullet of mass \( m \) has speed \( v \) when it hits a stationary block of mass \( M \) that is hanging from the ceiling. The bullet becomes embedded in the block, and the block swings up to a maximum vertical height \( h \).

![Diagram of bullet and block collision](image)

(a) What fraction of the initial kinetic energy of the bullet is lost in the collision between the bullet and the block? What happens to this fraction for \( m \ll M \)?

(b) Find the height \( h \).

4. On a pool table, the cue ball is initially moving with speed \( v_c \) toward the 8-ball, which is initially at rest. After the collision, the 8-ball moves away at an angle \( \theta_8 \) from the initial direction of the cue ball. Assume that the collision is elastic, and that the cue ball and 8-ball have the same mass. Show that the angle \( \theta_c \) that the cue ball travels after the collision is given by

\[
\tan \theta_c = \cot \theta_8.
\]

Also find formulas for the speed of the cue ball and the 8-ball after the collision. Do your results make sense for \( \theta_8 \simeq \pi/2 \)? What about \( \theta_8 \simeq 0 \)?

![Diagram of cue ball and 8-ball collision](image)

6. (a) Find the moment of inertia of a rod of mass \( M \) and length \( L \) for rotation about one end. Do this by slicing the rod.

(b) Find the moment of inertia of a “slice of pie,” i.e. a wedge with mass \( M \), radius \( R \), and angle \( \theta \) cut out of a thin sheet. Does your answer reduce to the moment of inertia of a disc when \( \theta \to 2\pi \)? If \( \theta \to 0 \) (with \( M \) held fixed), does your answer reduce to the moment of inertia of a rod of length \( L \) rotation about one end? Explain.

7. (a) Find a formula for the volume of a spherical shell with inner radius \( R_1 \) and outer radius \( R_2 \).

(b) Find a formula for the moment of inertia of the spherical shell if it has mass \( M \).

**Study Problems**

Chapter 8, Problems 121, 128, 131, 140
Chapter 9, Problems 52