LAB 13: CONSERVATION OF MOMENTUM 2

QUESTION

How does conservation of momentum affect the velocity of dissimilar objects that push off each other?

SAFETY

Do not leave the marbles in a place where someone might step on them or a child might swallow them.

MATERIALS

2 glass marbles, metal marble, plastic ruler with groove, 3 × 5 in. card

PROCEDURE

Momentum is the product of mass and velocity (momentum = [mass][velocity]). In cases where two objects are allowed to move for the same amount of time, distance traveled is directly proportional to speed. A faster object will travel farther than the slower object in equal time. If you compared the momentum of two objects that had traveled for 2 seconds, the 2 seconds would cancel out of both sides of the equation and the only thing that would matter is distance traveled.

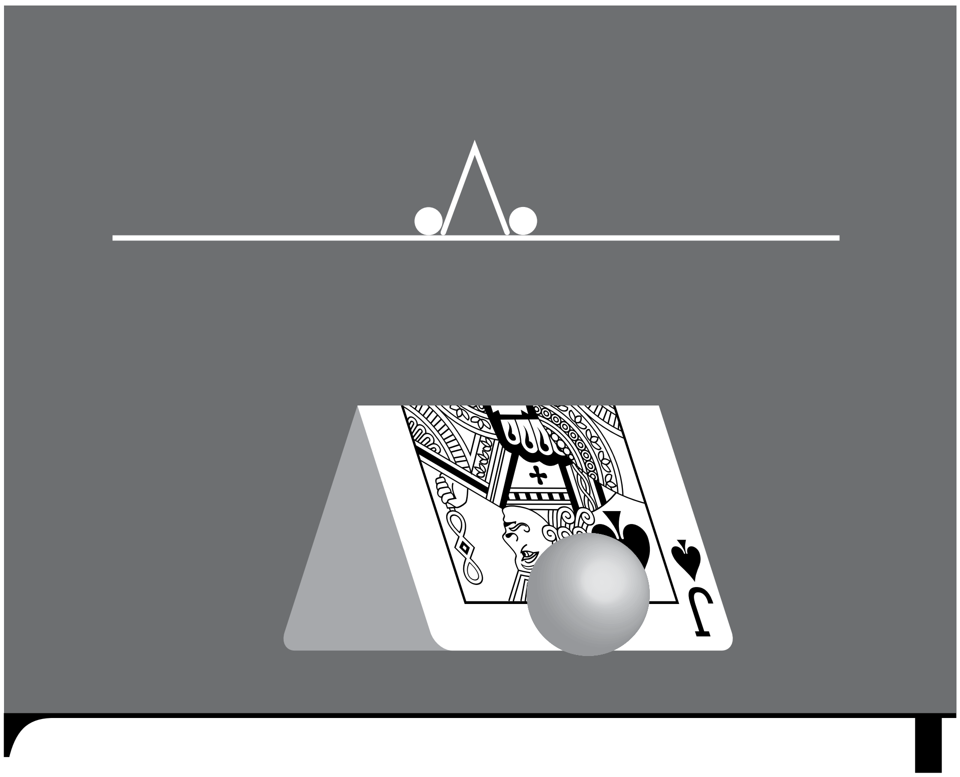
In this lab, you will be rolling two objects by having them push off each other (so that momentum must be conserved) and letting them travel for equal times. If they are allowed to move for the same amount of time, then distance may be substituted for velocity in the equation. Because the marbles begin with zero total momentum, they have to end with zero total momentum. By substituting distance for velocity and setting the sum of their momentum to 0, you will calculate the ratio of their masses.

IMPORTANT: You will need the masses of the marbles to calculate percent error at the end of the lab.

1. Find a flat surface and verify that it is flat by putting the ruler on the surface and placing a marble in the groove. The marble should not move. Tables are not generally level. Floors and countertops work better. You may be able to rotate the ruler around in a circle to find an orientation that is level.
2. Get a 3 × 5 card or playing card and gently fold it in half so that it forms a "V" shape. Notice that when you squeeze the card closed, it springs back open. This is what you will use to launch the marbles (see Figure 13.1).

Figure 13.1

Launching the Marbles



3. To verify that you are operating the launcher correctly, use two of the same marbles and launch them from the center of the ruler. The marbles should reach the ends of the ruler at the same time. This is required to conserve momentum. To add up to 0, they must have equal momentum in opposite directions. If their masses are equal, their velocities must also be equal but in opposite directions.
4. Practice the following procedure several times: Starting with the card in the middle, squeeze the card, put one marble on each side, and release the card. The marbles should take off in opposite directions. Keep in mind these tips as you are practicing:

a. Don't hold the card in your hand, release it. The marbles must push off each other, not your hand.
b. The strength of the launcher doesn't really matter as long as both marbles reach the ends of the ruler.
c. Try to make the marbles touch the card before releasing it. Don't let one marble get a head start.

5. Put the card in the middle of the ruler and release it. Which marble reaches the end of the ruler first?
6. Put the card at the 7.5 cm mark (approximately the one-quarter mark) with the glass marble on the short side of the ruler and the metal marble on the long side of the ruler. Which marble reaches the end of the ruler first?
7. Put the card at the 22.5 cm mark (approximately the three-quarter mark) with the glass marble on the long side of the ruler and the metal marble on the short side of the ruler. Which marble reaches the end of the ruler first?
8. Now move the card back and forth until you find the point at which the two marbles hit the ends of the ruler at the same time. What is the ratio of their distances from their respective ends of the ruler? What is the ratio of the masses of the marbles?

Post-Lab Questions

1. Your teacher will give you the real masses of the marbles. What was the percentage error in your mass ratio?
2. Explain why a person standing on frictionless ice who shoots a bullet at 200 m/s does not fly backward at 200 m/s. Is velocity conserved? Is momentum conserved?
3. Two people are standing near each other on ice. One has a mass of 100 kg and the other has a mass of 50 kg. They push off each other. If the 100 kg person moves backward with a speed of 5 m/s, what is the speed of the 50 kg person?

Extension

Three astronauts of equal mass are floating relatively motionless in space and decide to play a game. Two of the astronauts will push the third one back and forth in a game of catch. How many times can they push the third astronaut before the game ends?