Minds•On Physics Activity

77

Reasoning with Impulse and Momentum Ideas

Purpose and Expected Outcome

Even though we often do not know very much about the forces between interacting objects, we can still understand much of their behavior using momentum ideas. In this activity, you will examine situations in which objects interact. You will use either the Impulse–Momentum Theorem or the principle of Conservation of Momentum to analyze and reason about the problem situations.

Prior Experience / Knowledge Needed

You should know the definitions of momentum and impulse, and you should be familiar with how these ideas are used to describe the interaction between pairs of objects. You should be familiar with the Impulse–Momentum Theorem, as well as the conditions under which the total momentum of a system of objects is conserved.

Explanation of Activity

This activity contains two parts. Answer each of the questions below, and provide an explanation of how you used momentum and impulse ideas to find your answer.

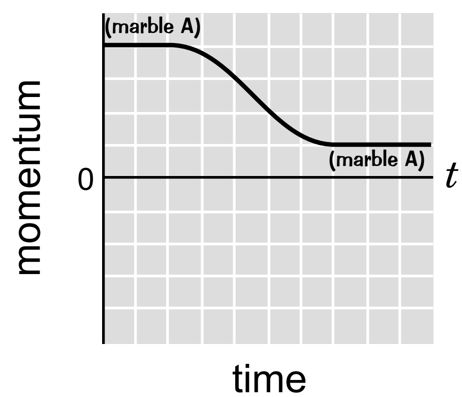
PART A: Motion in One Dimension

A1. Two identical cars are found after having collided on a slippery road. The cars are stationary, and their bumpers are locked together. There are no signs that either car skidded before or after the collision. What can you conclude about the accident? What additional evidence could you look for to support your analysis? Explain.

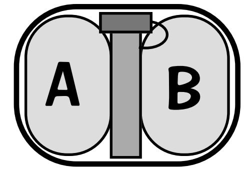
A2. A golf ball, a softball, and a basketball are dropped at the same instant from a fourth-story window. One second later, which ball has the largest speed? Which has the largest momentum? Which has the smallest momentum? Explain.

A3. An object collides with a second object at rest. Is it possible for resulting momentum of the second object to be larger than the initial momentum of the first object? If not, explain why it is not possible for this to happen. If it is possible, give an example.

A4. A marble rolls along a straight horizontal track at constant speed and collides with a second marble at rest. The plot on the right shows how the momentum of the first marble changes with time. On a copy of this graph, sketch how the momentum of the other marble changes with time. Explain how you made your sketch.



PART B: Motion in Two Dimensions

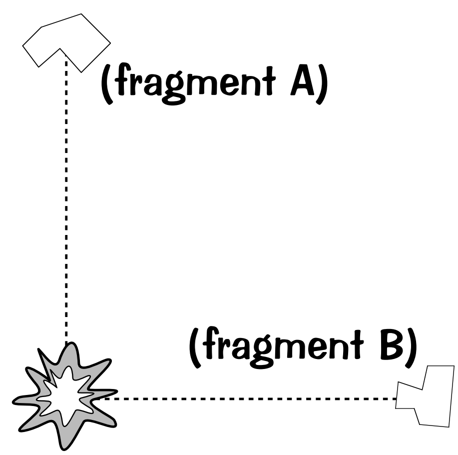


B1. An explosive device is made up of two moderately heavy canisters of material, one on each side of a lightweight explosive as shown. The device is programmed to explode the instant it reaches its maximum height, and is weighted so that the canisters will be projected horizontally by the explosion. The device is launched straight up into the air and explodes. Later, canister *A* is found on the ground 30m from the launch site, and canister *B* is found 40m from the launch site. What can you conclude based on these observations? Explain.

B2. The nucleus of fermium-256 has a mass of about 256amu, and is radioactively unstable. A Fm-256 nucleus is traveling to the right with a speed of 30km/s when it decays into a uranium-238 nucleus and an oxygen-18 nucleus. Is it possible for the oxygen nucleus to travel in a direction perpendicular to the initial direction of the Fm nucleus? If not, explain why not, and if so, indicate how it is possible.

B3. A truck having a mass of 2000kg and a speed of 25mph (about 11m/s) is traveling toward an intersection in which a small car is stuck in a pool of oil. The truck driver tries to stop but the brakes have no effect on the truck's motion. After the collision, the truck moves with a speed of 10mph (about 4.5m/s) at an angle of 30° from its initial direction. What can be determined about the car involved in the collision? (For example, can we determine its mass? its final speed? its direction of motion? its momentum? a component of its momentum?)

B4. A spy satellite has escaped earth's gravitation and is at rest in space. To prevent it from being captured by a hostile government, it must be destroyed. The resulting explosion creates three fragments. Two of the fragments travel along the paths shown, and are equidistant from the explosion site at the instant shown.



(a) What can you say about the velocities of these two fragments after the explosion? Are they constant or changing with time?

(b) Explain why the path of the third fragment (*C*) <u>must</u> lie in the plane formed by the paths of the other two.

(c) What is the path of *C* when the masses of *A* and *B* are equal.

(d) On a copy of this figure, indicate the range of possible paths for fragment *C*, and label your possible paths according to which fragment, *A* or *B*, is heavier.

Reflection

All the questions in this activity could be answered using either Conservation of Momentum or the Impulse–Momentum Theorem. In this Reflection, you should consider the factors that lead you to choose one over the other.

R1. For which questions did you use the principle of Conservation of Momentum? For which did you use the Impulse–Momentum Theorem? For which could you have used both? What caused you to choose one method over the other?

R2. In part A, how many separate relationships does momentum conservation provide? In part B? How does the number of relationships compare to the number of dimensions in each part?

R3. Create a situation in which momentum is conserved in one direction but not another. How do you know that momentum is not conserved in one of the directions?