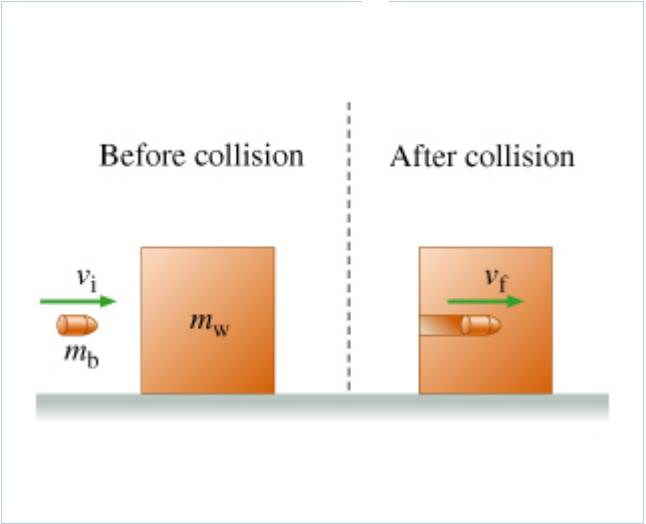
#22 Conservation of Momentum Pre-class

Due: 11:00am on Monday, October 15, 2012

Note: You will receive no credit for late submissions. To learn more, read your instructor's Grading Policy

A Bullet Is Fired into a Wooden Block

A bullet of mass m_b is fired horizontally with speed v_i at a wooden block of mass m_w resting on a frictionless table. The bullet hits the block and becomes completely embedded within it. After the bullet has come to rest within the block, the block, with the bullet in it, is traveling at speed v_f.



Part A

Which of the following *best* describes this collision?

Hint 1. Types of collisions

An inelastic collision is a collision in which kinetic energy is not conserved. In a *partially* inelastic collision, kinetic energy is lost, but the objects colliding do not stick together. From this information, you can infer what completely inelastic and elastic collisions are.

ANSWER:

- perfectly elastic
- partially inelastic
- perfectly inelastic

Correct

Part B

Which of the following quantities, if any, are conserved during this collision?

Hint 1. When is kinetic energy conserved?

Kinetic energy is conserved only in perfectly elastic collisions.

ANSWER:

- kinetic energy only
- momentum only
- kinetic energy and momentum
- neither momentum nor kinetic energy

Correct

Part C

What is the speed of the block/bullet system after the collision?

Express your answer in terms of v_i, m_w, and m_b.

Hint 1. Find the momentum after the collision

What is the total momentum p_total of the block/bullet system after the collision?

Express your answer in terms of v_f and other given quantities.

ANSWER:

$p_\mathrm{total} = (m_w + m_b)\, v_f$

Hint 2. Use conservation of momentum

The momentum of the block/bullet system is conserved. Therefore, the momentum before the collision is the same as the momentum after the collision. Find a second expression for p_total, this time expressed as the total momentum of the system before the collision.

Express your answer in terms of v_i and other given quantities.

ANSWER:

$p_\mathrm{total} = m_b v_i$

ANSWER:

$v_\mathrm{f} = \dfrac{m_\mathrm{b}}{m_\mathrm{b}+m_\mathrm{w}} v_\mathrm{i}$

Correct

Conservation of Momentum in Inelastic Collisions

Learning Goal:

To understand the vector nature of momentum in the case in which two objects collide and stick together.

In this problem we will consider a collision of two moving objects such that after the collision, the objects stick together and travel off as a single unit. The collision is therefore completely inelastic.

You have probably learned that "momentum is conserved" in an inelastic collision. But how does this fact help you to solve collision problems? The following questions should help you to clarify the meaning and implications of the statement "momentum is conserved."

Part A

What physical quantities are conserved in this collision?

ANSWER:

- the magnitude of the momentum only
- (•) the net momentum (considered as a vector) only
- the momentum of each object considered individually

Correct

Part B

Two cars of equal mass collide inelastically and stick together after the collision. Before the collision, their speeds are v_1 and v_2. What is the speed of the two-car system after the collision?

Hint 1. How to approach the problem

Think about how you would calculate the final speed of the two cars with the information provided and using the idea of conservation of momentum. Better yet, try the calculation out. What do you get?

ANSWER:

- $v_1 + v_2$
- $v_1 - v_2$
- $v_2 - v_1$
- $\sqrt{v_1 v_2}$
- $\frac{v_1 + v_2}{2}$
- $\sqrt{{v_1}^2 + {v_2}^2}$
- The answer depends on the directions in which the cars were moving before the collision.

Correct

Part C

Two cars collide inelastically and stick together after the collision. Before the collision, the magnitudes of their momenta are p_1 and p_2. After the collision, what is the magnitude of their combined momentum?

Hint 1. How to approach the problem

Think about how you would calculate the final momentum of the two cars using the information provided and the idea of conservation of momentum. Better yet, try the calculation out. What do you get? Keep in mind that momentum is a vector, but you are asked about the magnitude of the momentum, which is a scalar.

ANSWER:

- $p_1 + p_2$
- $p_1 - p_2$
- $p_2 - p_1$
- $\sqrt{p_1 p_2}$
- $\frac{p_1 + p_2}{2}$
- $\sqrt{{p_1}^2 + {p_2}^2}$
- (selected) The answer depends on the directions in which the cars were moving before the collision.

Correct

Part D

Two cars collide inelastically and stick together after the collision. Before the collision, their momenta are $\vec{p}_1$ and $\vec{p}_2$. After the collision, their combined momentum is $\vec{p}$. Of what can one be certain?

Hint 1. Momentum is a vector

Momentum is a vector quantity, and conservation of momentum holds for two-dimensional and three-dimensional collisions as well as for one-dimensional collisions.

ANSWER:

- $\vec{p} = \vec{p_1} + \vec{p_2}$
- $\vec{p} = \vec{p_1} - \vec{p_2}$
- $\vec{p} = \vec{p_2} - \vec{p_1}$

Correct

You can decompose the vector equation that states the conservation of momentum into individual equations for each of the orthogonal components of the vectors.

Part E

Two cars collide inelastically and stick together after the collision. Before the collision, the magnitudes of their momenta are p_1 and p_2. After the collision, the magnitude of their combined momentum is p. Of what can one be certain?

Hint 1. How to approach the problem mathematically

Momentum is a vector quantity. It is impossible to make exact predictions about the direction of motion after a collision if nothing is known about the direction of motion before the collision. However, one can put some bounds on the values of the final momentum. Start with the expression for $\vec{p}$ from Part D:

$$\vec{p} = \vec{p_1} + \vec{p_2}.$$

Therefore,

$$|p| = |\vec{p_1} + \vec{p_2}| = \sqrt{|p_1|^2 + |p_2|^2 + 2\vec{p_1} \cdot \vec{p_2}} = \sqrt{|p_1|^2 + |p_2|^2 + 2|p_1||p_2| \cos\theta},$$

where θ is the angle between $\vec{p_1}$ and $\vec{p_2}$. (To derive the above, you would have to break each vector into components.) So the value of $|p|$ is controlled by θ.

Hint 2. How to approach the problem empirically

Consider the directions for the initial momenta that will give the largest and smallest final momentum.

ANSWER:

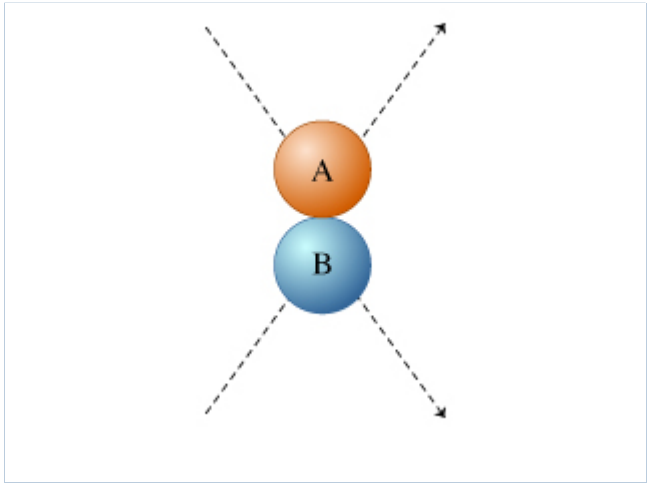
- $p_1 + p_2 \geq p \geq \sqrt{p_1 p_2}$
- $p_1 + p_2 \geq p \geq \frac{p_1 + p_2}{2}$
- $p_1 + p_2 \geq p \geq |p_1 - p_2|$
- $p_1 + p_2 \geq p \geq \sqrt{{p_1}^2 + {p_2}^2}$

Correct

When the two cars collide, the magnitude of the final momentum will always be at most $p_1 + p_2$ (a value attained if the cars were moving in the same direction before the collision) and at least $|p_1 - p_2|$ (a value attained if the cars were moving in opposite directions before the collision).

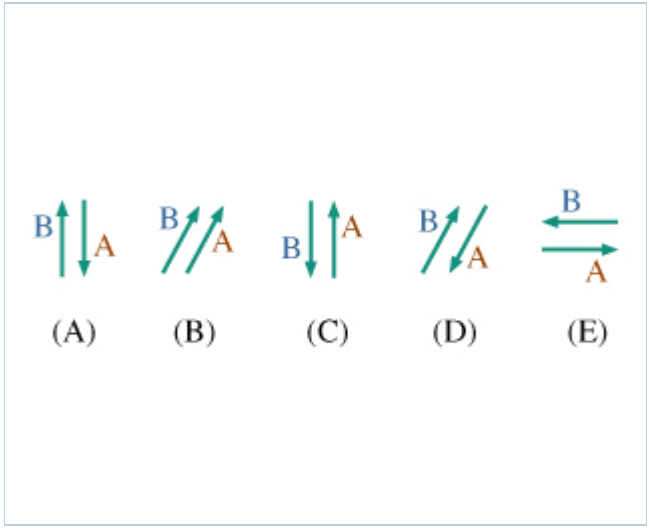
Colliding Balls

Balls A and B roll across a table, then collide and bounce off each other. The paths of the two balls are pictured (viewed from above) in the diagram.



Part A

Which set of arrows best represents the change in momentum for balls A and B?



Hint 1. Consider the components of the momentum vector

Recall that momentum is a vector quantity. It is helpful to consider the horizontal and vertical components of the momenta separately. How do the vertical components of the momenta change during the collision? How do the horizontal components change? (*Do* the horizontal components

of the momenta change?)

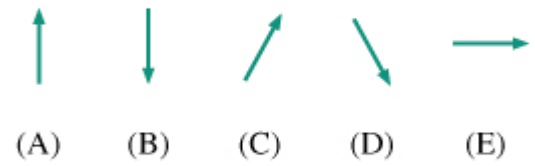
ANSWER:

- A
- B
- C
- D
- E

Correct

Part B

Which of the following arrows indicates the direction of the impulse applied to ball A by ball B?



Hint 1. Definition of impulse

Impulse is defined as the change in momentum. How does the momentum of ball A change during the collision? (If you get stuck, try looking back at part A. There, you found the change in momenta for each of the balls.)

ANSWER:

- (•) A
- ( ) B
- ( ) C
- ( ) D
- ( ) E

Correct

Score Summary:

Your score on this assignment is 94.5%.
You received 14.17 out of a possible total of 15 points.