

Conservation of Momentum Practice Solutions

Part B: Momentum Practice

3. A 5.0 kg ball is launched with a speed of 2.0 m/s. Find the momentum of the ball.
 - $p = mv$
 - $p = (5.0 \text{ kg}) \cdot (2.0 \text{ m/s})$
 - $p = 10. \text{ kg} \cdot \text{m/s}$
4. A 500. kg car is driving with a speed of 4.00 m/s. Find the momentum of the car.
 - $p = mv$
 - $p = (500. \text{ kg}) \cdot (4.00 \text{ m/s})$
 - $p = 2000 \text{ kg} \cdot \text{m/s}$
5. Two students are running in a cross country race. One has a mass of 60 kg, while the other has a mass of 68kg. If they are both running with a speed of 7 m/s, which has more momentum? Why?

The student with more mass has more momentum. If the speeds are the same, then more mass means more momentum.
6. Which has more momentum, a car with a mass of 5000 kg moving at a speed 10 m/s or a boat with a mass of 2000 kg moving at a speed of 40 m/s?
 - Car: $p = mv = (5000 \text{ kg}) \cdot (10 \text{ m/s}) \quad p = 50\,000 \text{ kg} \cdot \text{m/s}$
 - Boat: $p = mv = (2000 \text{ kg}) \cdot (40 \text{ m/s}) \quad p = 80\,000 \text{ kg} \cdot \text{m/s}$
 - The boat has more momentum
7. How fast would a 0.40 kg football have to be thrown to have a momentum of 8 kg m/s?
 - $p = mv \rightarrow v = p/m$
 - $v = (8 \text{ kg} \cdot \text{m/s}) / (0.40 \text{ kg})$
 - $v = 20 \text{ m/s}$
8. A pitcher claims he can throw a baseball with as much momentum as a 0.001kg bullet moving with a speed of 1500 m/s. If a baseball has a mass of 0.15kg, how fast must he throw the ball?
 - Bullet: $p = mv = (0.001 \text{ kg}) \cdot (1500 \text{ m/s}) \quad p = 1.5 \text{ kg} \cdot \text{m/s}$
 - $p = mv \rightarrow v = p/m$
 - Baseball: $v = (1.5 \text{ kg} \cdot \text{m/s}) / (0.15 \text{ kg})$
 - $v = 10 \text{ m/s}$

Part C: Conservation of Momentum

9. Someone throws a heavy ball to you when you are standing on roller skates. You catch it and roll backwards. How does your speed compare to the speed of the ball, and why?

You would have less speed because you have more mass and the total momentum must remain constant.
10. A prospector finds himself holding his bag of gold and standing in the middle of a large pond of frictionless ice. How can he get to the side before he freezes?

He could throw the bag of gold. While at rest, the momentum is zero. So if he throws the bag, he must move in the opposite direction so that the total momentum will remain constant (equal to zero).
11. What is the velocity of the "8" ball after the elastic collision below?



The pool balls have the same mass. Because the cue ball stops, that mean the 8 ball moves forward with the original speed of the cue ball. So the speed is $v = 2.0 \text{ m/s}$ after the collision.

12. A 110 kg football player runs at 8 m/s and plows into an 80 kg referee standing on the field causing the referee to fly forward at 5.0 m/s.
 - a. What is the momentum of the football player before the collision?
 - $p = mv$
 - $p = (110 \text{ kg}) \cdot (8 \text{ m/s})$
 - $p = 880 \text{ kg} \cdot \text{m/s}$
 - b. What is the momentum of the referee before the collision?
 - $p = mv$

$$p = (80 \text{ kg}) \cdot (0 \text{ m/s})$$

$$p = 0 \text{ kg} \cdot \text{m/s}$$

- c. What is the total momentum before the collision? (hint: add the two above together)

$$p(\text{total}) = p(\text{football player}) + p(\text{referee})$$

$$p(\text{total}) = 880 \text{ kg} \cdot \text{m/s} + 0 \text{ kg} \cdot \text{m/s}$$

$$p(\text{total}) = 880 \text{ kg} \cdot \text{m/s}$$

- d. What is the momentum of the referee after the collision?

$$p = mv$$

$$p = (80 \text{ kg}) \cdot (5 \text{ m/s})$$

$$p = 400 \text{ kg} \cdot \text{m/s}$$

- e. What must the momentum of the football player be after the collision?

$$p = p(\text{total}) - p(\text{referee}) \text{ because the total momentum has to stay the same}$$

$$p = 880 \text{ kg} \cdot \text{m/s} - 400 \text{ kg} \cdot \text{m/s}$$

$$p = 480 \text{ kg} \cdot \text{m/s}$$

- f. Find the football player's speed after the collision.

$$p = mv \rightarrow v = p/m$$

$$v = (480 \text{ kg} \cdot \text{m/s}) / (110 \text{ kg})$$

$$v = 4.4 \text{ m/s}$$

13. An 80.0-kg fisherman jumps from a dock into a 100.0-kg rowboat which is not moving. If the velocity of the fisherman is 4.00 m/s when he jumps into the boat, what is the final velocity of the fisherman and the boat?

This is an elastic collision, so we use the elastic collision equation. $(m_1v_1 + m_2v_2)_{\text{before}} = (m_1 + m_2)v_{\text{after}}$

Solve for $v(\text{after})$: $(m_1v_1 + m_2v_2)_{\text{before}} / (m_1 + m_2) = v_{\text{after}}$

$$v(\text{after}) = (80.0 \text{ kg} \cdot 4.00 \text{ m/s} + 0 \text{ kg} \cdot \text{m/s}) / (80.0 \text{ kg} + 100.0 \text{ kg})$$

$$v(\text{after}) = 320 \text{ kg} \cdot \text{m/s} / 180 \text{ kg}$$

$$v(\text{after}) = 1.8 \text{ m/s}$$

14. A train car, which has a mass of 2000 kg, is rolling along with a speed of 20 m/s. It strikes a stationary car, which also has a mass of 2000 kg, and they stick together. What is their combined speed after the collision?

Same steps as #11

$$v(\text{after}): (m_1v_1 + m_2v_2)_{\text{before}} / (m_1 + m_2) = v_{\text{after}}$$

$$v(\text{after}) = (2000 \text{ kg} \cdot 20.00 \text{ m/s} + 0 \text{ kg} \cdot \text{m/s}) / (2000 \text{ kg} + 2000 \text{ kg})$$

$$v(\text{after}) = 40000 \text{ kg} \cdot \text{m/s} / 4000 \text{ kg}$$

$$v(\text{after}) = 10 \text{ m/s}$$

15. A 1200 kg car is stopped at a traffic light. A 3000 kg truck moving at 8.0 m/s hits the car from behind. If bumpers lock, how fast will the two vehicles move?

Same steps as #11 and #12

$$v(\text{after}): (m_1v_1 + m_2v_2)_{\text{before}} / (m_1 + m_2) = v_{\text{after}}$$

$$v(\text{after}) = (3000 \text{ kg} \cdot 8.0 \text{ m/s} + 0 \text{ kg} \cdot \text{m/s}) / (3000 \text{ kg} + 1200 \text{ kg})$$

$$v(\text{after}) = 24000 \text{ kg} \cdot \text{m/s} / 4200 \text{ kg}$$

$$v(\text{after}) = 5.7 \text{ m/s}$$