Physics 12

Momentum Quiz Solutions

1.	a. ☐	b. ☒		
2.	a. ☒	b. ☐		
3.	a. ☒	b. ☐		
4.	a. ☒	b. ☐	c. ☐	d. ☐
5.	a. ☐	b. ☐	c. ☒	d. ☐
6.	a. ☒	b. ☐	c. ☐	d. ☐
7.	a. ☐	b. ☐	c. ☒	d. ☐
8.	a. ☐	b. ☐	c. ☐	d. ☒
9.	a. ☐	b. ☐	c. ☐	d. ☒
10.	a. ☒	b. ☐	c. ☐	d. ☐
11.	a. ☐	b. ☒	c. ☐	d. ☐
12.	a. ☐	b. ☐	c. ☒	d. ☐

1. **Problem**
   True or false? Kinetic energy is conserved when two objects collide and stick together.

   a. True
   b. False

   Solution
   False. Kinetic energy is not conserved during an inelastic collision.

2. **Problem**
   True or false? Momentum is conserved when two objects collide and stick together.

   a. True
   b. False

   Solution
   True. Momentum is conserved in all collisions.

3. **Problem**
   True or false? Momentum is conserved in a completely inelastic collision.

   a. True
   b. False

   Solution
   True. Momentum is conserved in any collision.

4. **Problem**
   In a game of pool, the white cue ball hits the #2 ball and stops, while the #2 ball moves away with the same velocity as the cue ball had originally. Both balls have the same mass. The type of collision is

   a. elastic
   b. inelastic
   c. completely inelastic
   d. any of the above, depending on the mass of the balls

   Solution
   The collision described conserves kinetic energy. Therefore, it is an elastic collision.

5. **Problem**
   What is the SI unit of impulse?

   a. $\mathrm{kg\,m/s^2}$
   b. $\mathrm{J\,s}$
   c. $\mathrm{N\,s}$
   d. $\mathrm{kg\,m/s}$

   Solution
   The newton-second ($\mathrm{N\,s}$) is the SI unit of impulse.

6. **Problem**
A rubber ball and a lump of putty have equal mass. They are both thrown with equal speed at a wall. The rubber ball bounces back with nearly the same speed with which it hit the wall. The putty sticks to the wall. Which object experiences the greater momentum change?

   a. The ball.
   b. The putty.
   c. Both experience the same momentum change.
   d. Cannot be determined from the information given.

   Solution
   The ball experiences the greater momentum change. The ball's change in velocity is double the putty's and so the ball experiences double the momentum change.

   For the ball, the final velocity is nearly its initial velocity, but in the opposite direction:

$$\Delta v = v_f - v_i = -v_i - v_i = -2vi$$

   For the putty, the final velocity is zero:

$$\Delta v = v_f - v_i = 0 - v_i = -v_i$$

7. **Problem**
A very light ball rolling with speed v collides with a very heavy ball at rest. If the collision is elastic, then the light ball's speed after the collision is approximately

   a. 0
   b. $v/2$
   c. v
   d. $2v$

   Solution
   Conservation of momentum and kinetic energy with $v_2 = 0$ gives the velocity of the light ball after the collision

$$v_1{}' = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) v_1$$

   When $m_1 \ll m_2$, the factor $(m_1 - m_2)/(m_1 + m_2)$ is approximately -1, which means that the ball bounces back with the same velocity v.

8. **Problem**
A very light ball and a very heavy ball move in opposite directions toward each other with the same speed v. If the balls hit each other head on and the collision is elastic, the speed of the lighter ball after the collision is approximately

   a. 0
   b. v
   c. $2v$
   d. $3v$

   Solution
   Conservation of momentum and kinetic energy gives the general result for an elastic collision in 1 dimension

$$v_1{}' = \frac{(r-1)v_1 + 2v_2}{r+1}$$

where $r = m_1/m_2$. Let m_1 be the mass of the very light ball and let $v_1 = v$ its velocity before the collision. Then $v_2 = -v$ and $m_2 \gg m_1$. This means that $r \approx 0$ and the above expression becomes $-3v$. Therefore, the speed of the lighter ball after the collision is approximately $3v$.

9. **Problem**
A ball of mass 5 kg rolls with speed v towards another ball of mass 2 kg at rest. If the collision is completely inelastic, what is the speed of the combined mass after the collision?

   a. $0.29v$
   b. $0.5v$
   c. $0.4v$
   d. $0.71v$

   Solution
   Conservation of momentum gives

$$v' = \left(\frac{m_1}{m_1 + m_2}\right) v_1 = \left(\frac{5}{5+2}\right) v = 0.71v$$

10. **Problem**
A 141 g baseball is thrown towards a batter at 35 m/s. The batter hits the ball back along the same path, and at the same speed. If the bat was in contact with the ball for 1.9 ms, the average force exerted by the bat was

   a. 5190 N
   b. 1.52×10^6 N
   c. 5.19×10^6 N
   d. 2520 N

   Solution
   The impulse is equal to the change in momentum

$$F\Delta t = m\Delta v$$

   Solving for F

$$F = \frac{m\Delta v}{\Delta t} = \frac{(0.141\,\text{kg})(35\,\text{m/s} - -35\,\text{m/s})}{0.0019\,\text{s}} = 5190\,\text{N}$$

11. **Problem**
Consider two balls of equal mass moving at different speeds. Ball 1 has double the kinetic energy of ball 2. How does the momentum of ball 1, p_1, compare to the momentum of ball 2, p_2?

    a. $p_1 = p_2$
    b. $p_1 = \sqrt{2}p_2$
    c. $p_1 = 2p_2$
    d. $p_1 = 4p_2$

    Solution
    Momentum is proportional to the square root of kinetic energy.

$$p = \sqrt{2mE_k}$$

12. **Problem**
A ball of mass 641 g, moving horizontally with speed 24 m/s strikes a wall and rebounds at 17 m/s. What is the magnitude of the change in momentum of the ball?

    a. 22 400 kg m/s
    b. 4.49 kg m/s
    c. 26.3 kg m/s
    d. 15 000 kg m/s

    Solution
    The change in momentum is

$$\Delta p = m\Delta v = 26.3\,\mathrm{kg\,m/s}$$