Momentum: Exercises

1. An Olympic diver dives off the high-diving platform. The magnitude of his momentum will be a maximum at point

   (a) A.  
   (b) B.  
   (c) C.  
   (d) D.  
   (e) none of the above.

2. An object with mass number \( m \) and velocity of magnitude \( |\vec{v}| \) directed to the right strikes a wall and rebounds with velocity of magnitude \( |\vec{v}| \) directed to the left. As a result of the collision, the change in the object’s momentum is

   (a) \( 2m |\vec{v}| \) directed to the left  
   (b) \( m |\vec{v}| \) directed to the left  
   (c) zero  
   (d) \( m |\vec{v}| \) directed to the right  
   (e) \( 2m |\vec{v}| \) directed to the right  
   (f) None of the above.

Problems 3 - 5 refer to the figure below:
3. What is the magnitude of the impulse?
   (a) $|\vec{F}_{\text{net}}| (t_2 - t_1)$
   (b) $\vec{F}_{\text{net}}(t_2 - t_1)$
   (c) $\frac{1}{2} |\vec{F}_{\text{net}}| (t_2 - t_1)$
   (d) $\frac{1}{2} \vec{F}_{\text{net}}(t_2 - t_1)$
   (e) None of the above.

4. If the impulse is applied to an object at rest, what will be the magnitude object’s final momentum?
   (a) $|\vec{F}_{\text{net}}| (t_2 - t_1)$
   (b) $\vec{F}_{\text{net}}(t_2 - t_1)$
   (c) $\frac{1}{2} |\vec{F}_{\text{net}}| (t_2 - t_1)$
   (d) $\frac{1}{2} \vec{F}_{\text{net}}(t_2 - t_1)$
   (e) None of the above.

5. If the object has mass number $m$, what will be the magnitude of object’s final velocity?
   (a) $m |\vec{F}_{\text{net}}| (t_2 - t_1)$
   (b) $m \vec{F}_{\text{net}}(t_2 - t_1)$
   (c) $\frac{m}{2} |\vec{F}_{\text{net}}| (t_2 - t_1)$
   (d) $\frac{m}{2} \vec{F}_{\text{net}}(t_2 - t_1)$
   (e) $|\vec{F}_{\text{net}}| (t_2 - t_1)/m$
   (f) $\vec{F}_{\text{net}}(t_2 - t_1)/m$
   (g) $\frac{1}{2m} |\vec{F}_{\text{net}}| (t_2 - t_1)$
   (h) $\frac{1}{2m} \vec{F}_{\text{net}}(t_2 - t_1)$
   (i) None of the above.

Problems 6 - 9 refer to the figure below:
6. What is the magnitude of the impulse?
   (a) $|\vec{F}_{\text{net}}| (t_2 - t_1)$
   (b) $\vec{F}_{\text{net}}(t_2 - t_1)$
   (c) $\frac{1}{2} |\vec{F}_{\text{net}}| (t_2 - t_1)$
   (d) $\frac{1}{2} \vec{F}_{\text{net}}(t_2 - t_1)$
   (e) None of the above.

7. What constant force acting over the same time interval would produce the same impulse?
   (a) $\vec{F}_{\text{net}}$
   (b) $\frac{1}{2} \vec{F}_{\text{net}}$
   (c) $2\vec{F}_{\text{net}}$
   (d) Impossible to tell.
   (e) None of the above.

8. If the impulse is applied to an object at rest, what will be the magnitude of object’s final momentum?
   (a) $|\vec{F}_{\text{net}}| (t_2 - t_1)$
   (b) $\vec{F}_{\text{net}}(t_2 - t_1)$
   (c) $\frac{1}{2} |\vec{F}_{\text{net}}| (t_2 - t_1)$
   (d) $\frac{1}{2} \vec{F}_{\text{net}}(t_2 - t_1)$
   (e) None of the above.

9. If the object has mass number $m$, what will be the magnitude of object’s final velocity?
   (a) $m |\vec{F}_{\text{net}}| (t_2 - t_1)$
   (b) $m\vec{F}_{\text{net}}(t_2 - t_1)$
   (c) $\frac{m}{2} |\vec{F}_{\text{net}}| (t_2 - t_1)$
   (d) $\frac{m}{2} \vec{F}_{\text{net}}(t_2 - t_1)$
   (e) $|\vec{F}_{\text{net}}| (t_2 - t_1)/m$
   (f) $\vec{F}_{\text{net}}(t_2 - t_1)/m$
   (g) $\frac{1}{2m} |\vec{F}_{\text{net}}| (t_2 - t_1)$
   (h) $\frac{1}{2m} \vec{F}_{\text{net}}(t_2 - t_1)$
   (i) None of the above.
10. A railroad car, with mass number $m_r$, traveling at $\vec{v}$ strikes and couples with a caboose, with mass number $m_c$, at rest. What is the velocity of the final combination?

(a) $\vec{v}$.
(b) $(m_r + m_c)\vec{v}$.
(c) $\vec{v}/(m_r + m_c)$.
(d) $m_r \vec{v}/(m_r + m_c)$.
(e) $m_r + m_c \vec{v}$.
(f) None of the above.

11. A railroad car, with mass number $m_r$, traveling at $\vec{v}_r$ strikes and couples with a caboose, with mass number $m_c$, traveling at $\vec{v}_c$ in the opposite direction. What is the velocity of the final combination?

(a) $\vec{v}_r - \vec{v}_c$.
(b) $m_r \vec{v}_r/(m_r + m_c)$.
(c) $m_c \vec{v}_c/(m_r + m_c)$.
(d) $(m_r \vec{v}_r - m_c \vec{v}_c)/(m_r + m_c)$.
(e) $(m_r \vec{v}_r + m_c \vec{v}_c)/(m_r + m_c)$.
(f) None of the above.

12. A billiard ball traveling to the right at $|\vec{v}_1|$ catches up to and strikes center-to-center an identical ball traveling in the same direction at $|\vec{v}_2|$. What is the velocity of the first ball after the collision?

(a) $|\vec{v}_1| - |\vec{v}_2|$ to the right.
(b) $|\vec{v}_1| - |\vec{v}_2|$ to the left.
(c) $|\vec{v}_2|$ to the right.
(d) $|\vec{v}_2|$ to the left.
(e) None of the above.

13. A billiard ball traveling to the right at $|\vec{v}_1|$ catches up to and strikes center-to-center an identical ball traveling in the same direction at $|\vec{v}_2|$. What is the velocity of the second ball after the collision?

(a) $|\vec{v}_2| - |\vec{v}_1|$ to the right.
(b) $|\vec{v}_2| - |\vec{v}_1|$ to the left.
(c) $|\vec{v}_1|$ to the right.
(d) $|\vec{v}_1|$ to the left.
(e) None of the above.
14. A billiard ball traveling to the right at $|\vec{v}_1|$ strikes an identical ball traveling in the opposite direction at $|\vec{v}_2|$. What is the velocity of the first ball after the collision?

(a) $|\vec{v}_1| - |\vec{v}_2|$ to the right.
(b) $|\vec{v}_1| - |\vec{v}_2|$ to the left.
(c) $|\vec{v}_2|$ to the right.
(d) $|\vec{v}_2|$ to the left.
(e) None of the above.

15. A billiard ball traveling to the right at $|\vec{v}_1|$ strikes an identical ball traveling in the opposite direction at $|\vec{v}_2|$. What is the velocity of the second ball after the collision?

(a) $|\vec{v}_2| - |\vec{v}_1|$ to the right.
(b) $|\vec{v}_2| - |\vec{v}_1|$ to the left.
(c) $|\vec{v}_1|$ to the right.
(d) $|\vec{v}_1|$ to the left.
(e) None of the above.

16. Two objects with the same mass number $m$ move initially toward one another and collide. Assuming the initial trajectories to be along the $x$-axis, we observe after the collision that the velocity of one of the objects has a $y$-component $v_{y1}$. What is the $y$-component of the velocity of the other object after the collision?

(a) 0.
(b) $v_{y1}$.
(c) $-v_{y1}$.
(d) Insufficient information to tell.
(e) None of the above.

The following information pertains to problems 17 - 19.

“A target rifle is held horizontally at rest and fired. The bullet has mass number $m$, and the rifle has mass number $M \gg m$.”

17. Compared to the magnitude of the bullet’s velocity, the magnitude of the rifle’s recoil velocity is

(a) equal.
(b) smaller.
(c) larger.
(d) indeterminate.
18. Compared to the magnitude of the bullet’s momentum, the magnitude of the rifle’s recoil momentum is
   (a) equal.
   (b) smaller.
   (c) larger.
   (d) indeterminate.

19. If the mass number of the bullet had been slightly smaller, the magnitude of the sum of the linear momentum of the bullet and the linear momentum of the rifle would have been
   (a) the same.
   (b) larger.
   (c) smaller.
   (d) indeterminate.

The following information pertains to problems 20 and 21.
“A bomb of mass 4m initially at rest explodes into two pieces. One piece, with mass number 3m, moves toward the east with magnitude |\vec{v}|.”

20. The magnitude of the second bomb fragment’s velocity will be
   (a) |\vec{v}|.
   (b) 2 |\vec{v}|.
   (c) 3 |\vec{v}|.
   (d) 4 |\vec{v}|.
   (e) 6 |\vec{v}|.
   (f) none of the above.

21. A second bomb with more powder than the one described, but also initially at rest, explodes into two pieces. The mass numbers of the two pieces are the same as for the first bomb. The magnitude of the total linear momentum of the two bomb fragments for this second bomb is
   (a) equal to the magnitude of the total linear momentum of the bomb fragments in the first explosion.
   (b) more than the magnitude of the total linear momentum of the bomb fragments in the first explosion.
   (c) less than the magnitude of the total linear momentum of the bomb fragments in the first explosion.
   (d) incomparable with the magnitude of the total linear momentum of the bomb fragments in the first explosion.
22. An object at rest explodes into three pieces each with mass number $m$. One piece flies eastward with magnitude $|\vec{v}_1|$; another heads southeastward with magnitude $|\vec{v}_2|$. What is the velocity (magnitude and general direction) of the third piece?

(a) $|\vec{v}_1| + |\vec{v}_2|$ to the north and west.
(b) $|\vec{v}_1| - |\vec{v}_2|$ to the north and west.
(c) $|\vec{v}_1 + \vec{v}_2|$ to the north and west.
(d) $|\vec{v}_1 - \vec{v}_2|$ to the north and west.
(e) None of the above.

23. Two objects with the same mass number $m$ and equal but oppositely directed velocities of magnitude $|\vec{v}|$ collide head-on.

(a) How are the final velocities related to one another?
(b) What is the possible range of these velocities, assuming no initial internal excited states?

24. A block with mass number $m$ slides to the right on a horizontal frictionless plane with a velocity of magnitude $|\vec{v}_i|$. The block collides with a motionless spring, which, upon compressing, slows the block down, reverses its direction, and, a time interval $\Delta t$ after initial contact, sends the block back with a velocity of magnitude $|\vec{v}|$.

(a) What was the average force of the spring on the block?
(b) What impulse (magnitude and direction) did the spring exert on the block?