

Conceptual Questions

1. A car accelerates from rest. In doing so the absolute value of the car's momentum changes by a certain amount and that of the Earth changes by
 - a) a larger amount.
 - b) the same amount.
 - c) a smaller amount.
 - d) The answer depends on the interaction. ¹

2. Consider these situations:
 - (i) a ball moving at speed v is brought to rest;
 - (ii) the same ball is projected from rest so that it moves at speed v ;
 - (iii) the same ball moving at speed v is brought to rest and then projected backward to its original speed.
 In which case(s) does the ball undergo the largest change in momentum?
 - a) (i)
 - b) (i) and (ii)
 - c) (i), (ii), and (iii)
 - d) (ii)
 - e) (ii) and (iii)
 - f) (iii) ²

3. Consider two carts, of masses m and $2m$, at rest on an air track. If you push first one cart for 3 s and then the other for the same length of time, exerting equal force on each, the momentum of the light cart is
 - a) four times
 - b) twice
 - c) equal to
 - d) one-half
 - e) one-quarter
 the momentum of the heavy cart. ³

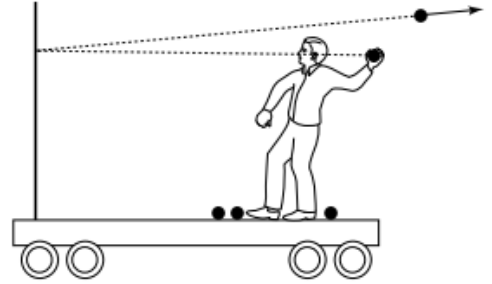
4. Suppose a ping-pong ball and a bowling ball are rolling toward you. Both have the same momentum, and you exert the same force to stop each. How do the time intervals to stop them compare?
 - a) It takes less time to stop the ping-pong ball.
 - b) Both take the same time.
 - c) It takes more time to stop the ping-pong ball. ⁴

¹ Peer Instruction – A User's Guide, Mazur, Inertial mass, momentum, collisions CT 4

² Peer Instruction – A User's Guide, Mazur, Inertial mass, momentum, collisions CT 10

³ Peer Instruction – A User's Guide, Mazur, Inertial mass, momentum, collisions CT 11

5. Suppose you are on a cart, initially at rest on a track with very little friction. You throw balls at a partition that is rigidly mounted on the cart. If the balls bounce straight back as shown in the figure, is the cart put in motion?
- Yes, it moves to the right.
 - Yes, it moves to the left.
 - No, it remains in place.⁵



6. We claim that momentum is conserved, yet most moving objects eventually slow down and stop. Explain.⁶
7. Cars used to be built as rigid as possible to withstand collisions. Today, though, cars are designed to have “crumple zones” that collapse upon impact. What is the advantage of this new design? Explain.⁷

Problems

8. An atomic nucleus initially moving at 420 m/s emits an alpha particle in the direction of its velocity, and the remaining nucleus slows to 350 m/s. If the alpha particle has a mass of 4.0 u and the original nucleus has a mass of 222 u, what speed does the alpha particle have when it is emitted?⁸
9. A lumberjack ($m = 98$ kg) is standing at rest on one end of a floating log ($m = 230$ kg) that is also at rest. The lumberjack runs to the other end of the log, attaining a velocity of + 3.6 m/s relative to the shore, and then hops onto an identical floating log that is initially at rest. Neglect any friction and resistance between the logs and the water. (a) What is the velocity of the first log just before the lumberjack jumps off? (b) Determine the velocity of the second log if the lumberjack comes to rest on it.⁹

⁴ Peer Instruction – A User’s Guide, Mazur, Inertial mass, momentum, collisions CT 13

⁵ Peer Instruction – A User’s Guide, Mazur, Inertial mass, momentum, collisions CT 23

⁶ Physics 6th Edition, Giancoli, Chapter 7 Questions, #1

⁷ Physics 6th Edition, Giancoli, Chapter 7 Questions, #7

⁸ Physics 6th Edition, Giancoli, Chapter 7 Problems, #11

⁹ Physics, 7th Edition, Cutnell & Johnson, Chapter 7 Problems, #17

10. A 975-kg two-stage rocket is travelling at a speed of 5.80×10^3 m/s with respect to Earth when a pre-designed explosion separates the rocket into two sections of equal mass that then move at a speed of 2.20×10^3 m/s relative to each other along the original line of motion. What are the speed and direction of each section (relative to Earth) after the explosion? ¹⁰
11. Two people are standing on a 2.0-m-long platform, one at each end. The platform floats parallel to the ground on a cushion of air, like a hovercraft. One person throws a 6.0-kg ball to the other, who catches it. The ball travels nearly horizontally. Excluding the ball, the total mass of the platform and people is 118 kg. Because of the throw, this 118-kg mass recoils. How far does it move before coming to rest again? ¹¹
12. A 1.0×10^3 -kg plane is trying to make a forced landing on the deck of a 2.0×10^3 -kg barge at rest on the surface of a calm sea. The only frictional force to consider is between the plane's wheels and the deck; this braking force is constant and is equal to one-quarter of the plane's weight. What must the minimum length of the barge be for the plane to stop safely on deck, if the plane touches down just at the rear end of the deck with a velocity of 5.0×10^1 m/s toward the front of the barge? ¹²
13. A rocket of total mass 3180 kg is travelling in outer space with a velocity of 115 m/s. To alter its course by 35.0° , its rockets can be fired briefly in a direction perpendicular to its original motion. If the rocket gases are expelled at a speed of 1750 m/s, how much mass must be expelled? ¹³

¹⁰ Physics 6th Edition, Giancoli, Chapter 7 Problems, #13a

¹¹ Physics, 7th Edition, Cutnell & Johnson, Chapter 7 Problems, #23

¹² Physics 12, Nelson Education, Chapter 5 Review, #32

¹³ Physics 6th Edition, Giancoli, Chapter 7 Problems, #14

14. Two hockey pucks of equal mass undergo a collision on a hockey rink. One puck is initially at rest, while the other is moving with a speed of 5.4 m/s. After the collision, the velocities of the pucks make angles of 33° and 46° relative to the original velocity of the moving puck.
- Draw a diagram showing the initial and final situations. Make sure that the geometry of your diagram is such that momentum is conserved.
 - Determine the speed of each puck after the collision. ¹⁴
15. Two subatomic particles collide. Initially, the more massive particle (**A**) is at rest and the less massive particle (**B**) is moving. After the collision, the velocities of **A** and **B** make angles of 67.8° and 30.0° , respectively, to the original direction of **B**'s motion. The ratio of the final speeds of the particles v_B/v_A is 3.30. What is the ratio of the masses of the particles m_B/m_A ? ¹⁵
16. Two rolling golf balls of the same mass collide. The velocity of one ball is initially 2.70 m/s [E]. After the collision, the velocities of the balls are 2.49 m/s [62.8° N of W] and 2.37 m/s [69.2° S of E]. What are the magnitude and direction of the unknown initial velocity? ¹⁶
17. A 50.0-kg skater is traveling due east at a speed of 3.00 m/s. A 70.0-kg skater is moving due south at a speed of 7.00 m/s. They collide and hold on to each other after the collision, managing to move off at an angle θ south of east, with a speed of v_f . Find (a) the angle θ and (b) the speed v_f , assuming that friction can be ignored. ¹⁷

¹⁴ Physics 12, Nelson Education, Chapter 5 Review, #16

¹⁵ Physics 12, Nelson Education, Chapter 5 Review, #17

¹⁶ Physics 12, Nelson Education, Chapter 5 Review, #18

¹⁷ Physics, 7th Edition, Cutnell & Johnson, Chapter 7 Problems, #35