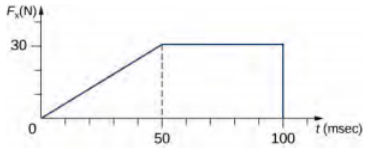
2.5: Particles and Interactions (Exercises)

2.5.1: Conceptual Questions

1. An object that has a small mass and an object that has a large mass have the same momentum. Which object is moving faster?
2. An object that has a small mass and an object that has a large mass are moving with the same speed. Which mass has the largest momentum?
3. Is it possible for a small force to produce a larger impulse on a given object than a large force? Explain.
4. Why is a 10-m fall onto concrete far more dangerous than a 10-m fall onto water?
5. What external force is responsible for changing the momentum of a car moving along a horizontal road?
6. A piece of putty and a tennis ball with the same mass are thrown against a wall with the same velocity. Which object experiences a greater force from the wall or are the forces equal? Explain.

2.5.2: Problems

1. (a) Calculate the momentum of a 2000-kg elephant charging a hunter at a speed of 7.50 m/s. (b) Compare the elephant's momentum with the momentum of a 0.0400-kg tranquilizer dart fired at a speed of 600 m/s. (c) What is the momentum of the 90.0-kg hunter running at 7.40 m/s after missing the elephant?
2. A skater of mass 40 kg is carrying a box of mass 5 kg. The skater has a speed of 5 m/s with respect to the floor and is gliding without any friction on a smooth surface. (a) Find the momentum of the box with respect to the floor. (b) Find the momentum of the box with respect to the floor after she puts the box down on the frictionless skating surface.
3. A car of mass 2000 kg is moving with a constant velocity of 10 m/s due east. What is the momentum of the car?
4. The mass of Earth is 5.97×10^{24} kg and its orbital radius is an average of 1.50×10^{11} m. Calculate the magnitude of its average linear momentum.
5. If a rainstorm drops 1 cm of rain over an area of 10 km^2 in the period of 1 hour, what is the momentum of the rain that falls in one second? Assume the terminal velocity of a raindrop is 10 m/s.
6. What is the average momentum of an avalanche that moves a 40-cm-thick layer of snow over an area of 100 m by 500 m over a distance of 1 km down a hill in 5.5 s? Assume a density of 350 kg/m^3 for the snow.
7. What is the average momentum of a 70.0-kg sprinter who runs the 100-m dash in 9.65 s?
8. A tennis ball of mass 0.06 kg is thrown at a wall with a speed of 15 m/s. The ball bounces back from the wall with a speed of 12 m/s. What is the change in momentum and impulse of the ball due to the collision with the wall?
9. A 5 kg cannonball is shot out of a cannon at 400 m/s on the Gettysburg Battlefield. The cannon has a mass of 1,200 kg.
    1. What is the impulse that was delivered to the cannonball by the cannon?
    2. What is the impulse that is delivered to the cannon?
    3. What is the final speed of the cannon?
10. One hazard of space travel is debris left by previous missions. There are several thousand objects orbiting Earth that are large enough to be detected by radar, but there are far greater numbers of very small objects, such as flakes of paint. Calculate the force exerted by a 0.100-mg chip of paint that strikes and sticks to a spacecraft window at a relative speed of 4.00×10^3 m/s, given the collision lasts 6.00×10^{-8} s.
11. Calculate the final speed of a 110-kg rugby player who is initially running at 8.00 m/s but collides head-on with a padded goalpost and experiences a backward force of 1.76×10^4 N for 5.50×10^{-2} s.
12. Water from a fire hose is directed horizontally against a wall at a rate of 50.0 kg/s and a speed of 42.0 m/s. Calculate the force exerted on the wall, assuming the water's horizontal momentum is reduced to zero.
13. A 300 g scoop of ice cream fall from a cone. It falls for 2 seconds.
    1. What was the impulse that was delivered to the ice cream cone by the Earth?
    2. What was the impulse that was delivered to the Earth by the ice cream cone?
    3. If the ice cream started from rest, how fast is the ice cream going now?
    4. If the Earth started from rest, how fast is it moving towards the ice cream now?
14. The x-component of a force on a 46-g golf ball by a 7-iron versus time is plotted in the following figure:
    a. Find the x-component of the impulse during the intervals (i) [0, 50 ms], and (ii) [50 ms, 100 ms].
    b. Find the change in the x-component of the momentum during the intervals (iii) [0, 50 ms], and (iv) [50 ms, 100 ms].



2.5.3: Additional Problems

15. Which has a larger magnitude of momentum: a 3000-kg elephant moving at 40 km/h or a 60-kg cheetah moving at 112 km/h?
16. A driver applies the brakes and reduces the speed of her car by 20%, without changing the direction in which the car is moving. By how much does the car's momentum change?
17. You friend claims that momentum is mass multiplied by velocity, so things with more mass have more momentum. Do you agree? Explain.
18. Dropping a glass on a cement floor is more likely to break the glass than if it is dropped from the same height on a grass lawn. Explain in terms of the impulse.
19. Your 1500-kg sports car accelerates from 0 to 30 m/s in 10 s. What average force is exerted on it during this acceleration?
20. A 5.0-g egg falls from a 90-cm-high counter onto the floor and breaks. What impulse is exerted by the floor on the egg?
21. You are coasting on your 10-kg bicycle at 15 m/s and a 5.0-g bug splatters on your helmet. The bug was initially moving at 2.0 m/s in the same direction as you. If your mass is 60 kg, (a) what is the initial momentum of you plus your bicycle? (b) What is the initial momentum of the bug? (c) What is your change in velocity due to the collision with the bug? (d) What would the change in velocity have been if the bug were traveling in the opposite direction?
22. A 100-kg astronaut finds himself separated from his spaceship by 10 m and moving away from the spaceship at 0.1 m/s. To get back to the spaceship, he throws a 10-kg tool bag away from the spaceship at 5.0 m/s. How long will he take to return to the spaceship?
23. You friend wonders how a rocket continues to climb into the sky once it is sufficiently high above the surface of Earth so that its expelled gasses no longer push on the surface. How do you respond?
24. To increase the acceleration of a rocket, should you throw rocks out of the front window of the rocket or out of the back window?

Contributors and Attributions

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