

52. Type: M Diff: 2 ANSWER: B
53. Type: M Diff: 2 ANSWER: C
54. Type: M Diff: 2 ANSWER: B
55. Type: M Diff: 2 ANSWER: C
56. Type: M Diff: 2 ANSWER: D
57. Type: M Diff: 3 ANSWER: A
58. Type: M Diff: 3 ANSWER: C
59. Type: M Diff: 2 ANSWER: D
60. Type: M Diff: 2 ANSWER: C

1. A valid unit for momentum is which of the following?
 - a. $\text{kg}\cdot\text{m}/\text{s}^2$
 - b. kg/m^2
 - c. $\text{kg}\cdot\text{m}/\text{s}$
 - d. $\text{N}\cdot\text{m}$
2. The dimensional equivalent of the quantity impulse in terms of the fundamental quantities (mass, length, time) is which of the following?
 - a. MLT^{-1}
 - b. ML^2T^{-2}
 - c. MLT
 - d. MLT^{-2}
3. A 75 kg swimmer dives horizontally off a 500 kg raft. If the diver's speed immediately after leaving the raft is 4 m/s, what is the corresponding raft speed?
 - a. 0.2 m/s
 - b. 0.5 m/s
 - c. 0.6 m/s
 - d. 4.0 m/s
4. A 75 kg swimmer dives horizontally off a 500 kg raft. The diver's speed immediately after leaving the raft is 4 m/s. A micro-sensor system attached to the edge of the raft measures the time interval during which the diver applies an impulse to the raft just prior to leaving the raft surface. If the time interval is read as 0.2 s, what is the magnitude of the average horizontal force by diver on the raft?
 - a. 900 N
 - b. 450 N
 - c. 525 N
 - d. 1500 N

5. During a snowball fight two balls with masses of 0.4 and 0.6 kg, respectively, are thrown in such a manner that they meet head-on and combine to form a single mass. The magnitude of initial velocity for each is 15 m/s. What is the speed of the 1.0 kg mass immediately after collision?
- zero
 - 3.0 m/s
 - 6.0 m/s
 - 9.0 m/s
6. A 1500-kg automobile moving at 15 m/s strikes an automobile stopped at a traffic light from behind, hooking bumpers. The two cars continue to move together at 10 m/s. What was the mass of the struck car?
- 1500 kg
 - 1250 kg
 - 1000 kg
 - 750 kg
7. A 0.06 kg tennis ball, initially moving at a speed of 12 m/s, is struck by a racket causing it to rebound in the opposite direction at a speed of 18 m/s. What is the change of momentum of the ball?
- 0.36 kg m/s
 - 0.72 kg m/s
 - 1.08 kg m/s
 - 1.80 kg m/s
8. A cannon of mass 1500 kg fires a 10 kg shell with a velocity of 200 m/s at an angle of 45° above the horizontal. What is the recoil velocity of the cannon across the level ground?
- 1.33 m/s
 - 0.94 m/s
 - 2.41 m/s
 - 1.94 m/s

9. A billiard ball collides in an elastic head-on collision with a second stationary identical ball. After the collision which of the following conditions applies to the first ball?
- maintains the same velocity as before
 - has one half its initial velocity
 - comes to rest
 - moves in the opposite direction
10. A billiard ball collides in an elastic head-on collision with a second identical ball. What is the kinetic energy of the system after the collision compared to that before collision?
- the same as
 - one fourth
 - twice
 - four times
11. In a two-body collision, if the momentum of the system is conserved, then which of the following best describes the kinetic energy after the collision?
- must be less
 - must also be conserved
 - may also be conserved
 - is doubled in value
12. In a two-body collision, if the kinetic energy of the system is conserved, then which of the following best describes the momentum after the collision?
- must be less
 - must also be conserved
 - may also be conserved
 - is doubled in value

13. The law of conservation of momentum is applicable to systems made up of objects described by which of the following?
- macroscopic
 - microscopic
 - interacting through friction
 - All the above choices are valid.
14. The impulse experienced by a body is equivalent to its change in which of the following quantities?
- velocity
 - kinetic energy
 - momentum
 - None of the above choices are valid.
15. If a two-body collision is not head-on, then which of the following may always be assumed?
- momentum is conserved
 - kinetic energy is conserved
 - neither momentum nor kinetic energy are conserved
 - both momentum and kinetic energy are conserved
16. The dimensional equivalence of the quantity momentum in terms of the fundamental quantities (mass, length, time) is which of the following?
- MLT^{-1}
 - ML^2T^{-2}
 - MLT
 - MLT^{-2}
17. A machine-gun is attached to a railroad flat car that rolls with negligible friction. If the railroad car has a mass of 1.2×10^5 kg, how many bullets of mass 20 grams would have to be fired at 300 m/s off the back to give the railroad car a forward velocity of 1 m/s
- 200
 - 2,000
 - 10,000
 - 20,000

18. A 0.30 kg ball is dropped onto a steel plate. The ball's velocity just before impact is 4.5 m/s, and just after is 4.2 m/s. What is the change in the ball's momentum?
- 0.09 kg-m/s
 - 2.6 kg-m/s
 - 4.0 kg-m/s
 - 116 kg-m/s
19. A 0.30 kg steel ball is dropped onto a steel plate where its speeds just before impact and after are 4.5 m/s and 4.2 m/s, respectively. If the ball is in contact with the plate for 0.03 second, what is the magnitude of the average force applied by the plate on the ball?
- 87 N
 - 133 N
 - 3.0 N
 - 3.5 N
20. A 0.30 kg steel ball is dropped onto a steel plate where its speeds just before impact and after are 4.5 m/s and 4.2 m/s, respectively. If the ball is in contact with the plate for 0.03 seconds, what average force does the ball exert on the plate during impact?
- 87 N
 - 133 N
 - 3.0 N
 - 3.5 N
21. A pitched baseball, of mass 0.2 kg, arrives at home plate with a speed of 40 m/s and is batted straight back to the pitcher with a return speed of 60 m/s. What is the magnitude of change in the ball's momentum?
- 4.0 kg-m/s
 - 8.0 kg-m/s
 - 18 kg-m/s
 - 20 kg-m/s



22. A pitched baseball, of mass 0.2 kg, arrives at home plate with a speed of 40 m/s and is batted straight back to the pitcher with a return speed of 60 m/s. If the bat is in contact with the ball for 0.05 second, what is the impulse experienced by the ball?
- 360 N-s
 - 20 N-s
 - 400 N-s
 - 9.0 N-s
23. A 70 kg astronaut is space walking outside the space capsule when the tether line breaks. As a means of returning to the capsule he throws his 2 kg space wrench at a speed of 14 m/s away from the capsule. At what speed does the astronaut move toward the capsule?
- 5.0 m/s
 - 0.4 m/s
 - 3.5 m/s
 - 7.0 m/s
24. A lead pendulum bob of mass 1 kg is released from a height of 0.25 m above a table. At its lowest point it strikes a 0.5 kg copper block which moves off with all the momentum. What is the velocity of the copper block?
- 1.11 m/s
 - 3.33 m/s
 - 2.21 m/s
 - 4.42 m/s
25. A railroad freight car, mass 15,000 kg, is allowed to coast along a level track at a speed of 2 m/s. It collides and couples with a 50,000 kg loaded second car, initially at rest and with brakes released. What percentage of the initial kinetic energy in the 15,000 kg car is preserved in the two coupled cars after collision?
- 14%
 - 23%
 - 86%
 - 100%

26. A miniature spring loaded, radio controlled gun is mounted on an air puck. The gun's bullet has a mass of 0.005 kg and the gun and puck have a combined mass of 0.120 kg. With the system initially at rest, the radio controlled trigger releases the bullet causing the puck and empty gun to move with a speed of 0.5 m/s. What is the bullet's speed?
- 4.8 m/s
 - 11.5 m/s
 - 48 m/s
 - 12.0 m/s
27. A miniature spring loaded, radio controlled gun is mounted on an air puck. The gun's bullet has a mass of 0.005 kg and the gun and puck have a combined mass of 0.120 kg. With the system initially at rest, the radio controlled trigger releases the bullet causing the puck and empty gun to move with a speed of 0.5 m/s. Of the total kinetic energy of the gun-puck-bullet system, what percentage is in the bullet?
- 4%
 - 50%
 - 96%
 - 100%
28. A model car is propelled by a cylinder of carbon-dioxide gas. The cylinder emits gas at a rate of 4.5 grams/second with an exit speed of 80.0 m/s. The car has a mass of 400 grams, including the CO₂ cylinder. Starting from rest, what is the car's initial acceleration?
- 0.9 m/s²
 - 4.5 m/s²
 - 9.0 m/s²
 - 36.0 m/s²

29. A 1000 kg experimental rocket sled on level frictionless rails is loaded with 50 kg of propellant. It exhausts the propellant in a 20 s "burn." If the rocket, initially at rest, moves with the speed of 150 m/s after the burn, what impulse is experienced by the rocket sled?

- a. $1.1 \times 10^5 \text{ x kg-m/s}$
- b. $1.6 \times 10^5 \text{ x kg-m/s}$
- c. $1.5 \times 10^5 \text{ x kg-m/s}$
- d. $1.9 \times 10^5 \text{ x kg-m/s}$

30. A 1000 kg experimental rocket sled on level frictionless rails is loaded with 50 kg of propellant. It exhausts the propellant in a 20 s "burn." If the rocket, initially at rest, moves with the speed of 150 m/s after the burn, what average force is experienced by the rocket during the burn?

- a. $0.95 \times 10^4 \text{ N}$
- b. $0.75 \times 10^4 \text{ N}$
- c. $0.60 \times 10^4 \text{ N}$
- d. $0.35 \times 10^4 \text{ N}$

31. A helicopter stays aloft by pushing large quantities of air downward every second. What mass of air must be pushed downward at 40 m/s every second to keep a 1000 kg helicopter aloft?

- a. 120 kg
- b. 245 kg
- c. 360 kg
- d. 490 kg

32. A 0.10 kg object moving initially with a velocity of +.20 m/s makes an elastic head-on collision with a 0.15 kg object initially at rest. What is the final velocity of the 0.10 kg object after the collision?

- a. +0.16 m/s
- b. -0.16 m/s
- c. +0.04 m/s
- d. -0.045 m/s

33. A uranium nucleus (mass 238 units) at rest decays into a helium nucleus (mass 4 units) and a thorium nucleus (mass 234 units). If the velocity of the helium nucleus is $6 \times 10^5 \text{ m/s}$, what is the velocity of the thorium nucleus?

- a. 10,250 m/s
- b. $3.04 \times 10^4 \text{ m/s}$
- c. $3.55 \times 10^4 \text{ m/s}$
- d. $4.1 \times 10^4 \text{ m/s}$

34. A 0.10 kg object moving initially with a velocity of +.20 m/s makes an elastic head-on collision with a 0.15 kg object initially at rest. What percentage of the original kinetic energy is retained by the 0.10 kg object?

- a. 5%
- b. -4%
- c. 50%
- d. 96%

35. If the momentum of an object is tripled, its kinetic energy will change by what factor?

- a. zero
- b. one third
- c. three
- d. nine

36. If the kinetic energy of an object is quadrupled, its momentum will change by what factor?

- a. zero
- b. two
- c. eight
- d. four

37. Two billiard balls have velocities of 2.0 m/s and -1.0 m/s when they meet in an elastic head-on collision. What is the final velocity of the first ball after collision?

- a. -2.0 m/s
- b. -1.0 m/s
- c. -0.5 m/s
- d. +1.0 m/s

38. A ball with original momentum +4.0 kg-m/s hits a wall and bounces straight back without losing any kinetic energy. The change in momentum of the ball is

- a. 0
- b. -4.0 kg-m/s
- c. 8.0 kg-m/s
- d. -8.0 kg-m/s

39. Two objects, one less massive than the other, collide and bounce back after the collision. If the two originally had velocities that were equal in size but opposite in direction, then after the collision which one will be moving faster (the collision is partially inelastic)?

- a. The less massive one.
- b. The more massive one.
- c. The speeds will be the same after the collision.
- d. There is no way to be positive with inelastic collisions.

40. A moderate force will break an egg. However, an egg dropped on the road usually breaks, while one dropped on the grass usually doesn't break because for the egg dropped on the grass,

- a. the change in momentum is greater.
- b. the change in momentum is less.
- c. the time interval for stopping is greater.
- d. the time interval for stopping is less.

41. If a glass of water is on a table with a piece of paper under it, it is relatively easy to pull the paper out without disturbing the glass very much if the pull is done very quickly. This is because, with a quick pull,

- a. the force on the glass will be less.
- b. the momentum of the paper will be greater.
- c. the time for the pull will be less.
- d. the coefficient of kinetic friction will be less.

42. A 70 kg man is standing in a 20 kg boat. The man steps to the right thinking he is stepping out onto the dock. However, the following will actually happen (ignore the friction of the water or air on the boat or the man):

- a. The man only moves a short distance to the right while the boat moves a larger distance to the left.
- b. The man actually stays still while the boat moves toward the left.
- c. The boat doesn't move and the man moves to the right.
- d. None of the above.

43. In a partially elastic collision between two objects with unequal mass

- a. the velocity of one will increase by the amount that the velocity of the other decreases.
- b. the momentum of one will increase by the amount that the momentum of the other decreases.
- c. the energy of one increases by the amount that the energy of other decreases.
- d. the total momentum of the system will decrease.

44. A 7-kg bowling ball strikes a 2-kg pin. The pin flies forward with a velocity of 6 m/s, the ball continues forward at 4 m/s. What was the original velocity of the ball?

- a. 4.0 m/s
- b. 5.7 m/s
- c. 6.6 m/s
- d. 3.3 m/s

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45. A billiard ball moving at 5 m/s strikes a stationary ball of the same mass. After the collision, the original ball moves at a velocity of 4.35 m/s at an angle of 30° with respect to its original motion. Find the velocity and angle of the ball that was struck after the collision.

- a. 1.25 m/s @ 30°
- b. 1.44 m/s @ 60°
- c. 2.16 m/s @ 30°
- d. 2.50 m/s @ 60°

46. A 1.00 kg duck is flying overhead at 1.50 m/s when a hunter fires straight up. The 0.010 kg bullet is moving 100 m/s when it hits the duck and stays lodged in the duck's body. What is the speed of the duck and bullet immediately after the hit?

- a. 1.49 m/s
- b. 2.48 m/s
- c. 1.80 m/s
- d. 1.78 m/s

47. A model rocket sits on the launch pad until its fuel is ignited, blasting the rocket upward. During the short time of blast-off, as the ignited fuel goes down, the rocket goes up because

- a. the center of mass of rocket and ignited fuel stay essentially stationary.
- b. the fuel pushes on the ground.
- c. air friction pushes on the escaping fuel.
- d. the downward force of gravity is less than the downward momentum of the fuel.

48. A batter hits a thrown baseball with a bat, knocking the ball back in the direction from which it came in a partially inelastic collision. The bat, which is heavier than the baseball, continues to move in the same direction after the hit as the batter "follows through". Is the ball moving faster before or after it was hit?

- a. The ball was moving faster before it was hit.
- b. The ball was moving faster after it was hit.
- c. The ball was moving at essentially the same speed before and after the hit.
- d. There is insufficient information to answer this problem.

49. A 200 gm meter stick has two objects attached to it, one of 100 gm at the 30 cm mark and the other of 300 gm at the 70 cm mark. At what mark on the meter stick is the center of gravity of the system?

- a. 38 cm
- b. 50 cm
- c. 57 cm
- d. 60 cm

50. A uniform bridge span weighs 50×10^3 N and is 40.0 m long. An automobile weighing 15×10^3 N is parked with its center of gravity located 12.0 m from the right pier. Where is the center of mass of the bridge-automobile combination located as measured from the left pier?

- a. 14 m
- b. 18 m
- c. 22 m
- d. 26 m

51. At liftoff, the engines of the Saturn V rocket consumed 13,000 kg/s of fuel and exhausted the combustion products at 2900 m/s. What was the total upward force (thrust) provided by the engines?

- a. 3.77×10^7 N
- b. 7.54×10^7 N
- c. 1.47×10^8 N
- d. 2.95×10^8 N

52. Two skaters, both of mass 50 kg, are on skates on a frictionless ice pond. One skater throws a 0.2 kg frisbee at 5 m/s to her friend, who catches it and throws it back at 5 m/s. When the first skater has caught the returned frisbee, what is the velocity of each of the two skaters?

- a. 0.02 m/s, moving apart
- b. 0.04 m/s, moving apart
- c. 0.02 m/s, moving towards each other
- d. 0.04 m/s, moving towards each other

53. A 90-kg halfback running north with a speed of 10 m/s is tackled by a 120-kg opponent running south at 4 m/s. The collision is inelastic. Compute the velocity of the two players just after the tackle.

- a. 3 m/s south
- b. 2 m/s south
- c. 2 m/s north
- d. 3 m/s north

54. A neutron in a nuclear reactor makes an elastic head-on collision with a carbon atom initially at rest. (The mass of the carbon atom is 12 times that of the neutron.) What fraction of the neutron's kinetic energy is transferred to the carbon atom?

- a. 14.4%
- b. 28.4%
- c. 41.4%
- d. 56.6%

55. Popeye, of mass 70 kg, has just downed a can of spinach. He accelerates quickly and stops Bluto, of mass 700 kg (Bluto is very dense), who is charging in at 10 m/s. What was Popeye's velocity?

- a. 10 m/s
- b. 31 m/s
- c. 50 m/s
- d. 100 m/s

56. A 10-gram bullet is fired into a 200-gram block of wood at rest on a horizontal surface. After impact, the block slides 8 m before coming to rest. If the coefficient of friction $\mu = 0.4$, find the speed of the bullet before impact.

- a. 106 m/s
- b. 166 m/s
- c. 226 m/s
- d. 286 m/s

57. A baseball infielder, mass 75 kg, jumps up with velocity 3 m/s and catches a 0.15 kg baseball moving horizontally at 50 m/s. What is the final momentum of the system, infielder and baseball?

- a. 225.125 kg-m/s
- b. 227.91 kg-m/s
- c. 230.03 kg-m/s
- d. 232.5 kg-m/s

58. A firehose directs a steady stream of 15 kg/sec of water with velocity 28 m/s against a flat plate. What force is required to hold the plate in place?

- a. 110 N
- b. 420 N
- c. 1100 N
- d. 4116 N

59. How far from the center of the Earth is the center of mass of the Earth-moon system? The moon has 1/81 the mass of the Earth and their center-to-center separation is 384,000 km.

- a. 4,683 km
- b. 4,740 km
- c. 4,800 km
- d. 42,666 km

60. A high-diver of mass 70 kg jumps off a board 10 meters above the water. If, 1 s after entering the water his downward motion is stopped, what average upward force did the water exert?

- a. 100 N
- b. 245 N
- c. 490 N
- d. 980 N

