Exam

Name_____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) What is the SI unit of momentum?
A) N·s B) N/s C) N·m D) N/m

Answer: A

2) When a cannon fires a cannonball, the cannon will recoil backward because the
A) momentum of the cannon is greater than the energy of the cannonball.
B) momentum of the cannonball and cannon is conserved.
C) energy of the cannon is greater than the energy of the cannonball.
D) energy of the cannonball and cannon is conserved.

Answer: B

3) A freight car moves along a frictionless level railroad track at constant speed. The car is open on top. A large load of coal is suddenly dumped into the car. What happens to the velocity of the car?
A) It decreases.
B) It increases.
C) It remains the same.
D) cannot be determined from the information given

Answer: A

4) A child falls sideways off a sled while sledding on frictionless ice. What happens to the velocity of the sled?
A) It decreases.
B) It remains the same.
C) It increases.
D) cannot be determined from the information given

Answer: B

5) A rubber ball and a lump of putty have equal mass. They are thrown with equal speed against a wall. The ball bounces back with nearly the same speed with which it hit. The putty sticks to the wall. Which objects experiences the greater momentum change?
A) the putty
B) the ball
C) Both experience the same momentum change.
D) cannot be determined from the information given

Answer: B

6) A sailboat of mass m is moving with a momentum p. How would you represent its kinetic energy in terms of these two quantities?
A) mp B) 1/2 mp^2 C) $p^2/(2m)$ D) mp/2

Answer: C

7) If you pitch a baseball with twice the kinetic energy you gave it in the previous pitch, the magnitude of its momentum is
A) doubled.
B) 1.41 times as much.
C) the same.
D) 4 times as much.

Answer: B

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

8) State Newton's second law in terms of momentum.

Answer: The rate of change of momentum of an object is equal to the net force applied to it.

9) State the law of conservation of momentum.

Answer: The total momentum of an isolated system of objects remains constant.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

10) The area under the curve on a Force versus time (F vs. t) graph represents

A) momentum. B) kinetic energy. C) impulse. D) work.

Answer: C

11) Which of the following is an accurate statement?

A) The momentum of a projectile is constant.
B) If an object is acted on by a non-zero net external force, its momentum will not remain constant.
C) The momentum of a moving object is constant.
D) If the kinetic energy of an object is doubled, its momentum will also double.

Answer: B

12) A small car meshes with a large truck in a head-on collision. Which of the following statements concerning the magnitude of the average collision force is correct?

A) The truck experiences the greater average force.
B) The small car and the truck experience the same average force.
C) The small car experiences the greater average force.
D) It is impossible to tell since the masses and velocities are not given.

Answer: B

13) Two equal mass balls (one red and the other blue) are dropped from the same height, and rebound off the floor. The red ball rebounds to a higher position. Which ball is subjected to the greater magnitude of impulse during its collision with the floor?

A) It's impossible to tell since the time intervals and forces are unknown.
B) Both balls were subjected to the same magnitude impulse.
C) the blue ball
D) the red ball

Answer: D

14) A Ping-Pong ball moving east at a speed of 4 m/s, collides with a stationary bowling ball. The Ping-Pong ball bounces back to the west, and the bowling ball moves very slowly to the east. Which object experiences the greater magnitude impulse during the collision?

A) Neither; both experienced the same magnitude impulse.
B) the Ping-Pong ball
C) the bowling ball
D) It's impossible to tell since the velocities after the collision are unknown.

Answer: A

15) Two objects collide and bounce off each other. Linear momentum
A) is definitely conserved.
B) is conserved only if the environment is frictionless.
C) is conserved only if the collision is elastic.
D) is definitely not conserved.

Answer: A

16) A 3.0-kg object moves to the right at 4.0 m/s. It collides head-on with a 6.0-kg object moving to the left at 2.0 m/s. Which statement is correct?
A) The total momentum both before and after the collision is 24 kg·m/s.
B) The total momentum both before and after the collision is zero.
C) The total momentum before the collision is 24 kg·m/s, and after the collision is 0 kg·m/s.
D) None of the above is true.

Answer: B

17) A 100-kg football linebacker moving at 2.0 m/s tackles head-on an 80-kg halfback running 3.0 m/s. Neglecting the effects due to digging in of cleats,
A) the halfback will drive the linebacker backward.
B) the linebacker will drive the halfback backward.
C) this is a simple example of an elastic collision.
D) neither player will drive the other backward.

Answer: A

18) In an elastic collision, if the momentum is conserved, then which of the following statements is true about kinetic energy?
A) Kinetic energy is also conserved.
B) Kinetic energy is lost.
C) Kinetic energy is gained.
D) none of the above

Answer: A

19) When is kinetic energy conserved?
A) in inelastic collisions
B) in elastic collisions
C) in any collision in which the objects do not stick together
D) in all collisions

Answer: B

20) In a game of pool, the white cue ball hits the #5 ball and stops, while the #5 ball moves away with the same velocity as the cue ball had originally. The type of collision is
A) completely inelastic.
B) elastic.
C) inelastic.
D) any of the above, depending on the mass of the balls.

Answer: B

21) When a light beach ball rolling with a speed of 6.0 m/s collides with a heavy exercise ball at rest, the beach ball's speed after the collision will be, approximately,
A) 12 m/s.
B) 0.
C) 3.0 m/s.
D) 6.0 m/s.

Answer: D

22) A golf ball traveling 3.0 m/s to the right collides in a head-on collision with a stationary bowling ball in a friction-free environment. If the collision is almost perfectly elastic, the speed of the golf ball immediately after the collision is

A) slightly greater than 3.0 m/s. B) equal to 3.0 m/s.
C) much less than 3.0 m/s. D) slightly less than 3.0 m/s.

Answer: D

23) A rubber ball with a speed of 5.0 m/s collides head-on elastically with an identical ball at rest. What is the speed of the initially stopped ball after the collision?

A) zero B) 5.0 m/s C) 1.0 m/s D) 2.5 m/s

Answer: B

24) A very heavy object moving with speed v collides head-on with a very light object at rest. The collision is elastic, and there is no friction. The heavy object barely slows down. What is the speed of the light object after the collision?

A) nearly v B) nearly 3v C) nearly 2v D) nearly infinite

Answer: C

25) A very light object moving with speed v collides head-on with a very heavy object at rest, in a frictionless environment. The collision is almost perfectly elastic. The speed of the heavy object after the collision is

A) slightly greater than v. B) equal to v.
C) much less than v. D) slightly less than v.

Answer: C

26) A red ball with a velocity of +3.0 m/s collides head-on with a yellow ball of equal mass moving with a velocity of -2.0 m/s. What is the velocity of the yellow ball after the collision?

A) -2.0 m/s B) +5.0 m/s C) zero D) +3.0 m/s

Answer: D

27) A very heavy object moving with velocity v collides head-on with a very light object moving with velocity -v. The collision is elastic, and there is no friction. The heavy object barely slows down. What is the speed of the light object after the collision?

A) nearly 2v B) nearly v C) nearly 3v D) nearly infinite

Answer: C

28) In an inelastic collision, if the momentum is conserved, then which of the following statements is true about kinetic energy?

A) Kinetic energy is lost. B) Kinetic energy is gained.
C) Kinetic energy is also conserved. D) none of the above

Answer: A

29) Two objects collide and stick together. Kinetic energy

A) is definitely not conserved.
B) is conserved only if the environment is frictionless.
C) is conserved only if the collision is elastic.
D) is definitely conserved.

Answer: A

30) A 3.0-kg object moves to the right at 4.0 m/s. It collides in a perfectly inelastic collision with a 6.0 kg object moving to the left at 2.0 m/s. What is the total kinetic energy after the collision?

A) 24 J B) 36 J C) 72 J D) 0 J

Answer: D

31) A small object collides with a large object and sticks. Which object experiences the larger magnitude of momentum change?

A) the small object
B) the large object
C) Both objects experience the same magnitude of momentum change.
D) cannot be determined from the information given

Answer: C

32) In a game of pool, the white cue ball hits the #9 ball and is deflected at a 35° angle to the original line of motion. What is the angle of deflection below the original line of motion for the #9 ball?

A) 75° B) 35° C) 55° D) 90°

Answer: C

33) Consider two unequal masses, M and m. Which of the following statements is false?

A) It is possible for the center of mass to lie within one of the objects.
B) If a uniform rod of mass m were to join the two masses, this would not alter the position of the center of mass of the system without the rod present.
C) The center of mass lies on the line joining the centers of each mass.
D) The center of mass is closer to the larger mass.

Answer: B

34) Which of the following is a false statement?

A) The center of gravity of an object may be thought of as the "balance point."
B) For an object on the surface of the Earth, the center of gravity and the center of mass are the same point.
C) The center of mass of an object must lie within the object.
D) For a uniform symmetric object, the center of mass is at the center of symmetry.

Answer: C

35) Tightrope walkers walk with a long flexible rod in order to

A) allow both hands to hold onto something. B) lower their center of mass.
C) increase their total weight. D) move faster along the rope.

Answer: B

36) A plane, flying horizontally, releases a bomb, which explodes before hitting the ground. Neglecting air resistance, the center of mass of the bomb fragments, just after the explosion

A) moves vertically. B) is zero.
C) moves along a parabolic path. D) moves horizontally.

Answer: C

37) Two cars collide head-on on a level friction-free road. The collision was completely inelastic and both cars quickly came to rest during the collision. What is true about the velocity of this system's center of mass?

A) It was never zero. B) It was not zero, but ended up zero.
C) It was always zero. D) none of the above

Answer: C

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

38) State Newton's second law for a system of particles.

Answer: The sum of all forces acting on the system is equal to the total mass of the system times the acceleration of its center of mass.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

39) What is the momentum of a 2000-kg truck traveling at 35 m/s?

A) 3.5×10^4 kg·m/s B) 7.0×10^4 kg·m/s C) 57 kg·m/s D) 7.0×10^5 kg·m/s

Answer: B

40) A 1200-kg ferryboat is moving south at 20 m/s. What is the magnitude of its momentum?

A) 2.4×10^4 kg·m/s B) 1.7×10^{-3} kg·m/s C) 6.0×10^2 kg·m/s D) 2.4×10^3 kg·m/s

Answer: A

41) A ball of mass 0.10 kg is dropped from a height of 12 m. Its momentum when it strikes the ground is

A) 2.4 kg·m/s. B) 4.8 kg·m/s. C) 1.8 kg·m/s. D) 1.5 kg·m/s.

Answer: D

42) Two identical 1500-kg cars are moving perpendicular to each other. One moves with a speed of 25 m/s due north and the other moves at 15 m/s due east. What is the total momentum of the system?

A) 6.0×10^4 kg·m/s at 59° N of E B) 4.4×10^4 kg·m/s at 59° N of E

C) 6.0×10^4 kg·m/s at 31° N of E D) 4.4×10^4 kg·m/s at 31° N of E

Answer: B

43) A handball of mass 0.10 kg, traveling horizontally at 30 m/s, strikes a wall and rebounds at 24 m/s. What is the change in the momentum of the ball?

A) 0.60 kg·m/s B) 1.2 kg·m/s C) 72 kg·m/s D) 5.4 kg·m/s

Answer: D

44) A 0.060-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 in momentum of the ball?

A) 1.8 kg·m/s B) 0.72 kg·m/s C) 0.36 kg·m/s D) 1.1 kg·m/s

Answer: A

45) A 50-kg pitching machine (excluding the baseball) is placed on a frozen pond. The machine fires a 0.40-kg baseball with a speed of 35 m/s in the horizontal direction. What is the recoil speed of the pitching machine? (Assume negligible friction.)

A) 4.4×10^3 m/s B) 0.14 m/s C) 0.70 m/s D) 0.28 m/s

Answer: D

46) A 70-kg astronaut is space-walking outside the space capsule and is stationary when the tether line breaks. As a means of returning to the capsule he throws his 2.0-kg space hammer at a speed of 14 m/s away from the capsule. At what speed does the astronaut move toward the capsule?

A) 1.5 m/s B) 0.40 m/s C) 3.5 m/s D) 5.0 m/s

Answer: B

47) A small object with momentum 5.0 kg·m/s approaches head-on a large object at rest. The small object bounces straight back with a momentum of magnitude 4.0 kg·m/s. What is the magnitude of the large object's momentum change?
A) 9.0 kg·m/s B) 4.0 kg·m/s C) 1.0 kg·m/s D) 5.0 kg·m/s
Answer: A

48) You (50-kg mass) skate on ice at 4.0 m/s to greet your friend (40-kg mass), who is standing still, with open arms. As you collide, while holding each other, with what speed do you both move off together?
A) 2.2 m/s B) 5.0 m/s C) 23 m/s D) zero
Answer: A

49) A car of mass 1000 kg moves to the right along a level, straight road at a speed of 6.0 m/s. It collides directly with a stopped motorcycle of mass 200 kg. What is the total momentum after the collision?
A) 2000 kg·m/s to the right B) 10,000 kg·m/s to the right
C) 6000 kg·m/s to the right D) zero
Answer: C

50) A 1000-kg car traveling at 25 m/s runs into the rear of a stopped car that has a mass of 1500 kg and they stick together. What is the speed of the cars after the collision?
A) 5.0 m/s B) 20 m/s C) 10 m/s D) 15 m/s
Answer: C

51) A railroad freight car, mass 15,000 kg, is allowed to coast along a level track at a speed of 2.0 m/s. It collides and couples with a 50,000-kg second car, initially at rest and with brakes released. What is the speed of the two cars after coupling?
A) 0.60 m/s B) 0.46 m/s C) 1.8 m/s D) 1.2 m/s
Answer: B

52) A railroad car, of mass 200 kg, rolls with negligible friction on a horizontal track with a speed of 10 m/s. A 70-kg stunt man drops straight down a distance of 4.0 m, and lands in the car. How fast will the car be moving after this happens?
A) 10 m/s B) 4.7 m/s C) 2.8 m/s D) 7.4 m/s
Answer: D

53) A 60-kg person walks on a 100-kg log at the rate of 0.80 m/s (with respect to the log). With what speed does the log move, with respect to the shore?
A) 0.48 m/s B) 0.30 m/s C) 0.24 m/s D) 0.60 m/s
Answer: B

54) A 4.0-N force acts for 3.0 s on an object. The force suddenly increases to 15 N and acts for one more second. What impulse was imparted by these forces to the object?
A) 15 N·s B) 27 N·s C) 19 N·s D) 12 N·s
Answer: B

55) A constant 9.0-N net force acts for 2.0 s on a 6.0-kg object. What is the object's change of velocity?
A) 3.0 m/s B) 9.0 m/s C) 110 m/s D) 27 m/s
Answer: A

56) A 2000-kg car, traveling to the right at 30 m/s, collides with a brick wall and comes to rest in 0.20 s. What is the average force the car exerts on the wall?

A) 12,000 N to the right
B) 60,000 N to the right
C) 300,000 N to the right
D) none of the above

Answer: C

57) A 2.0-kg softball is pitched to you at 20 m/s. You hit the ball back along the same path, and at the same speed. If the bat was in contact with the ball for 0.10 s, what is the magnitude of the average force the bat exerted?

A) 400 N
B) zero
C) 40 N
D) 800 N

Answer: D

58) A 0.10-kg ball is dropped onto a table top. The speeds of the ball right before and right after hitting the table top are 5.0 m/s and 4.0 m/s, respectively. If the collision between the ball and the table top lasts 0.15 s, what is the magnitude of the average force exerted on the ball by the table top?

A) 3.0 N
B) 6.0 N
C) 0.67 N
D) 1.3 N

Answer: B

59) A machine gun, of mass 35.0 kg, fires 50.0-gram bullets, with a muzzle velocity of 750 m/s, at the rate of 300 rounds per minute. What is the average force exerted on the machine gun mount?

A) 188 N
B) 219 N
C) 94.0 N
D) 438 N

Answer: A

60) A fire hose is turned on the door of a burning building in order to knock the door down. This requires a force of 1000 N. If the hose delivers 40 kg per second, what is the minimum velocity of the stream needed, assuming the water doesn't bounce back?

A) 30 m/s
B) 25 m/s
C) 15 m/s
D) 20 m/s

Answer: B

61) Water runs out of a horizontal drainpipe at the rate of 120 kg per minute. It falls 3.20 m to the ground. Assuming the water doesn't splash up, what average force does it exert on the ground?

A) 19.6 N
B) 15.8 N
C) 6.20 N
D) 12.0 N

Answer: B

62) A toy rocket, of mass 0.12 kg, achieves a velocity of 40 m/s after 3.0 s, when fired straight up. What average thrust force does the rocket engine exert?

A) 1.6 N
B) 2.8 N
C) 1.2 N
D) 4.4 N

Answer: B

63) Two astronauts, of masses 60 kg and 80 kg, are initially at rest in outer space. They push each other apart. What is their separation after the lighter astronaut has moved 12 m?

A) 21 m
B) 15 m
C) 24 m
D) 18 m

Answer: A

64) A 3.0-kg object moves to the right with a speed of 2.0 m/s. It collides in a perfectly elastic collision with a 6.0-kg object moving to the left at 1.0 m/s. What is the total kinetic energy after the collision?

A) 6.0 J
B) 3.0 J
C) 9.0 J
D) 0 J

Answer: C

65) A 0.10-kg object with a velocity of 0.20 m/s in the +x direction makes a head-on elastic collision with a 0.15 kg object initially at rest. What is the final velocity of the 0.10-kg object after collision?

A) -0.040 m/s B) +0.040 m/s C) +0.16 m/s D) -0.16 m/s

Answer: A

66) A 10.0-g bullet moving at 300 m/s is fired into a 1.00-kg block at rest. The bullet emerges (the bullet does not get embedded in the block) with half of its original speed. What is the velocity of the block right after the collision?

A) 3.00 m/s B) 273 m/s C) 1.50 m/s D) 2.97 m/s

Answer: C

67) A proton, of mass m, at rest, is struck head-on by an alpha-particle (which consists of 2 protons and 2 neutrons) moving at speed v. If the collision is completely elastic, what speed will the alpha-particle have after the collision? (Assume the neutron's mass equals the proton's mass.)

A) 2v/3 B) 3v/5 C) 5v/3 D) zero

Answer: B

68) A 50-gram ball moving +10 m/s collides head-on with a stationary ball of mass 100 g. The collision is elastic. What is the speed of each ball immediately after the collision?

A) -3.3 m/s and +6.7 m/s B) +6.7 m/s and -3.3 m/s

C) -6.7 m/s and +3.3 m/s D) +3.3 m/s and -6.7 m/s

Answer: A

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

69) A ball of mass 400 g moving toward the east with a speed of 3.70 m/s collides head-on with a 200 g ball sitting at rest. The collision is perfectly elastic.

(a) Determine the velocity of the first ball after the collision.

(b) Determine the velocity of the second ball after the collision.

(c) Is kinetic energy conserved in this collision?

Answer: (a) 1.2 m/s toward the east

(b) 4.9 m/s toward the east

(c) Yes, it is an elastic collision.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

70) A 2.0-kg mass moves with a speed of 5.0 m/s. It collides head-on with a 3.0 kg mass at rest. If the collision is perfectly inelastic, what is the speed of the masses after the collision?

A) 2.5 m/s B) 2.0 m/s

C) 10 m/s D) 0, since the collision is inelastic

Answer: B

71) A 2.0-kg mass moving to the east at a speed of 4.0 m/s collides head-on in a perfectly inelastic collision with a stationary 2.0-kg mass. How much kinetic energy is lost during this collision?

A) 8.0 J B) zero C) 4.0 J D) 16 J

Answer: A

72) A car of mass m, traveling with a velocity v, strikes a parked station wagon, who's mass is 2m. The bumpers lock together in this head-on inelastic collision. What fraction of the initial kinetic energy is lost in this collision?

A) 1/3 B) 1/4 C) 2/3 D) 1/2

Answer: C

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

73) A 15-g bullet traveling 213 m/s in a vertical direction buries itself in a 2.4-kg block of wood at rest directly above it. As a result, the bullet/block combination moves vertically upward.

(a) Determine the velocity of the bullet/block combination at the point of impact.

(b) Determine the maximum height reached by the bullet/block combination.

(c) Is kinetic energy conserved in this collision?

Answer: (a) 1.3 m/s

(b) 0.089 m

(c) No, this is an inelastic collision.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

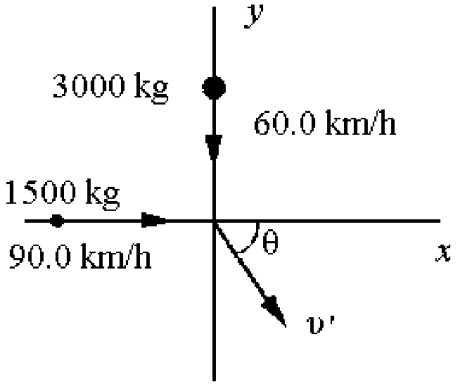


FIGURE 7-1

74) A 1500-kg car traveling at 90.0 km/h east collides with a 3000-kg car traveling at 60.0 km/h south. The two cars stick together after the collision. (See Fig. 7-1.) What is the speed of the cars after collision?

A) 8.33 m/s B) 21.7 m/s C) 17.4 m/s D) 13.9 m/s

Answer: D

75) A 1500-kg car traveling at 90.0 km/h east collides with a 3000-kg car traveling at 60.0 km/h south. The two cars stick together after the collision. (See Fig. 7-1.) What is the direction of motion of the cars after collision?

A) 36.9° S of E B) 36.9° E of S C) 53.1° E of S D) 53.1° S of E

Answer: D

76) Two objects move on a level frictionless surface. Object A moves east with a momentum of 24 kg·m/s. Object B moves north with momentum 10 kg·m/s. They make a perfectly inelastic collision. What is the magnitude of their combined momentum after the collision?

A) 26 kg·m/s

B) 34 kg·m/s

C) 14 kg·m/s

D) cannot be determined without knowing masses and velocities

Answer: A

77) A small bomb, of mass 10 kg, is moving toward the North with a velocity of 4.0 m/s. It explodes into three fragments: a 5.0-kg fragment moving west with a speed of 8.0 m/s; a 4.0-kg fragment moving east with a speed of 10 m/s; and a third fragment with a mass of 1.0 kg. What is the velocity of the third fragment? (Neglect air friction.)

A) 40 m/s south B) 40 m/s north C) zero D) none of the above

Answer: B

78) A 4.00-kg mass sits at the origin, and a 10.0-kg mass sits at x = + 21.0 m. Where is the center of mass on the x-axis?

A) +15.0 m B) +14.0 m C) +7.00 m D) +10.5 m

Answer: A

79) The center of mass of a two-particle system is at the origin. One particle is located at (3.0 m, 0) and has a mass of 2.0 kg. What is the location of the second mass of 3.0 kg?

A) (2.0 m, 0) B) (-3.0 m, 0) C) (3.0 m, 0) D) (-2.0 m, 0)

Answer: D

80) Three masses are positioned as follows: 2.0 kg at (0, 0), 2.0 kg at (2.0, 0), and 4.0 kg at (2.0, 1.0). Determine the coordinates of the center of mass.

A) (1.5, 0.50) B) (2.5, 1.5) C) (0.50, 1.5) D) (2.5, 0.50)

Answer: A

81) Three masses, 1.0 kg, 2.0 kg, and 3.0 kg, are located at (0, 0), (1.0 m, 1.0 m), and (2.0 m, -2.0 m), respectively. What is the location of the center of mass of the system?

A) (1.3 m, 0.67 m) B) (-1.3 m, -0.67 m) C) (-1.3 m, 0.67 m) D) (1.3 m, -0.67 m)

Answer: D

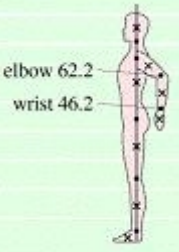
82) A 3.0-kg mass is positioned at (0, 8.0), and a 1.0-kg mass is positioned at (12, 0). What are the coordinates of a 4.0-kg mass which will result in the center of mass of the system of three masses being located at the origin, (0, 0)?

A) (-3.0, -6.0) B) (-6.0, -3.0) C) (3.0, 6.0) D) (-12, -8.0)

Answer: A

TABLE 7–1 Center of Mass of Parts of Typical Human Body
(full height and mass = 100 units)

Distance Above Floor of Hinge Points (%)	Hinge Points (•) (Joints)	Center of Mass (×) (% Height Above Floor)		Percent Mass
91.2	Base of skull	Head	93.5	6.9
81.2	Shoulder joint	Trunk and neck	71.1	46.1
		Upper arms	71.7	6.6
	elbow 62.2	Lower arms	55.3	4.2
	wrist 46.2	Hands	43.1	1.7
52.1	Hip joint	Upper legs (thighs)	42.5	21.5
28.5	Knee joint			
		Lower legs	18.2	9.6
4.0	Ankle joint	Feet	1.8	3.4
		Body CM =	58.0	100.0



83) Use Table 7-1 to calculate the position of the CM of a whole leg including the foot when the leg is stretched straight out. Assume the person is 1.60 m tall.

A) 0.32 m above the bottom of the foot
B) 0.54 m above the bottom of the foot
C) 0.20 m above the bottom of the foot
D) 0.51 m above the bottom of the foot

Answer: D

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

84) When a person jumps from a tree to the ground, what happens to the momentum of the person upon striking the ground?

Answer: Consider this problem as a very light object hitting and sticking to a very heavy object. The large object - small object combination (Earth + jumper) would have some momentum after the collision, but due to the very large mass of the Earth, the velocity of the combination is so small that it is not measurable. Thus the jumper lands on the Earth, and nothing more happens.

85) It is said that in ancient times a rich man with a bag of gold coins froze to death while stranded on a frozen lake. Because the ice was frictionless. he could not push himself to shore. What could he have done to save himself had he not been so miserly?

Answer: If the rich man would have faced away from the shore and thrown the bag of coins directly away from the shore, he would have acquired a velocity towards the shore by conservation of momentum. Since the ice is frictionless, he would slide all the way to the shore.

86) 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 tis new design?

Answer: "Crumple zones" are similar to air bags in that they increase the time of interaction during a collision, and therefore lower the average force required for the change in momentum that the car undergoes in the collision.

87) Why is the CM of a 1-m length of pipe at its mid-point, whereas this is not true for your arm or leg?

Answer: The 1-m length of pipe is uniform—it has the same density throughout, and so its CM is at its geometric center, which is its midpoint. The arm and leg are not uniform—they are more dense where there is muscle, primarily in the parts that are closest to the body. Thus the CM of the arm or leg is closer the body than the geometric center. The CM is located closer to the more massive part of the arm or leg.

88) A rocket following a parabolic path through the air suddenly explodes into many pieces. What can you say about the motion of this system of pieces?

Answer: The motion of the center of mass of the rocket will follow the original parabolic path, both before and after explosion. Each individual piece of the rocket will follow a separate path after the explosion, but since the explosion was internal to the system (consisting of the rocket), the center of mass of all the exploded pieces will follow the original path.

FIGURE 7-31

89) A child in a boat throws a 6.40-kg package out horizontally with a speed of 10.0 m/s, Fig. 7-31. Calculate the velocity of the boat immediately after, assuming it was initially at rest. The mass of the child is 26.0 kg, and that of the boat is 45.0 kg. Ignore water resistance.

Answer: -0.901 m/s

90) A 9300-kg boxcar traveling at 15.0 m/s strikes a second boxcar at rest. The two stick together and move off with a speed of 6.0 m/s. What is the mass of the second car?

Answer: 1.4×10^4 kg

91) A 3800-kg open railroad car coasts along with a constant speed of 8.60 m/s on a level track. Snow begins to fall vertically and fills the car at a rate of 3.50 kg/min. Ignoring friction with the tracks, what is the speed of the car after 90.0 min?

Answer: 7.9 m/s

92) A 975-kg two stage rocket is traveling 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. (a) What are the speed and direction of each section (relative to Earth) after the explosion? (b) How much energy was supplied by the explosion? [*Hint*: What is the change in KE as a result of the explosion?]

Answer: (a) 6.9×10^3 m/s, away from the Earth; 4.7×10^3 m/s, away from the Earth
(b) 5.9×10^8 J

93) A 12-kg hammer strikes a nail at a velocity of 8.5 m/s and comes to rest in a time interval of 8.0 ms. (a) What is the impulse given to the nail? (b) What is the average force acting on the nail?

Answer: (a) 1.0×10^2 kg m/s
(b) 1.3×10^4 N

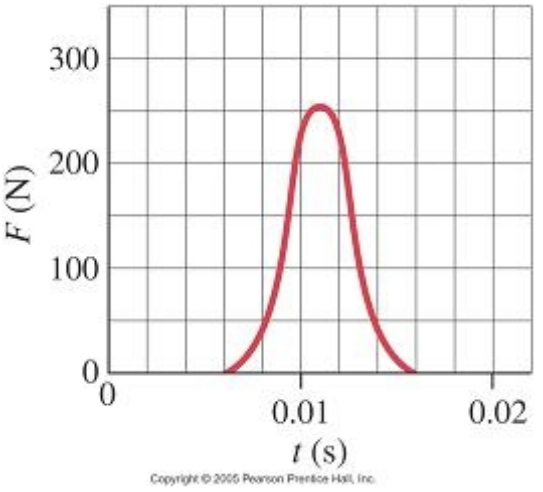


FIGURE 7-33

94) Suppose the force acting on a tennis ball (mass 0.060 kg) points in the +*x* direction and is given by the graph of Fig. 7-33 as a function of time. Use graphical methods to estimate (a) the total impulse given the ball, and (b) the velocity of the ball after being struck, assuming the ball is being served so it is nearly at rest initially.

Answer: (a) 1.25 N s
(b) 21 m/s

95) A ball of mass 0.440 kg moving east (+*x* direction) with a speed of 3.30 m/s collides head-on with a 0.220 kg ball at rest. If the collision is perfectly elastic, what will the speed and direction of each ball after the collision?

Answer: 1.10 m/s, east; 4.40 m/s east

96) Two billiard balls of equal mass undergo a perfectly elastic head-on collision. If one ball's initial speed was 2.00 m/s, and the other's was 3.00 m/s in the opposite direction, what will be their speeds after the collision?

Answer: -3.00 m/s, 2.00 m/s

97) A 0.060-kg tennis ball, moving with a speed of 2.50 m/s, collides head-on with a 0.090-kg ball initially moving away from it at a speed of 1.15 m/s. Assuming a perfectly elastic collision, what are the speed and direction of each ball after the collision?

Answer: 0.88 m/s, 2.23 m/s, Both balls move in the direction of the tennis ball's initial motion.

98) A 28-g rifle bullet traveling 230 m/s buries itself in a 3.6-kg pendulum hanging on a 2.8-m long string, which makes the pendulum swing upward in an arc. Determine the vertical and horizontal components of the pendulum's displacement.

Answer: 0.16 m, 0.94 m

99) A 920-kg sports car collides into the rear end of a 2300-kg SUV stopped at a red light. The bumpers lock, the brakes are locked, and the two cars skid forward 2.8 m before stopping. The police officer, knowing that the coefficient of kinetic friction between tires and road is 0.80, calculates the speed of the sports car at impact. What was that speed?

Answer: 23 m/s

100) A 15.0-kg object moving in the +x direction at 5.5 m/s collides head-on with a 10.0-kg object moving in the -x direction at 4.0 m/s. Find the final velocity of each mass if: (a) the objects stick together; (b) the collision is elastic; (c) the 15.0-kg object is at rest after the collision; (d.) the 10.0-kg object is at rest after the collision; (e) the 15.0-kg object has a velocity of 4.0 m/s in the -x direction after the collision. Are the results in (c), (d), and (e) "reasonable"? Explain.

Answer: (a) 1.7 m/s
(b) -2.1 m/s, 7.4 m/s
(c) 4.3 m/s, Since the system has lost kinetic energy and the directions are possible, this interaction is "reasonable".
(d) 2.8 m/s, This answer is not reasonable because it has A moving in its original direction while B has stopped. Thus A has somehow passed through B. If B has stopped, A should have rebounded in the negative direction.
(e) 10.3 m/s The directions are reasonable, in that each object rebounds. However, the speed of both objects is larger than its speed in the perfectly elastic case (b). Thus the system has gained kinetic energy, and unless there is some other source adding energy, this is not reasonable.

101) Billiard ball A of mass m_A = 0.400 kg moving with speed v_A = 1.80 m/s strikes ball B, initially at rest, of mass m_B = 0.500 kg. As a result of the collision, ball A is deflected off at an angle of 30.0° with a speed v'_A = 1.10 m/s. (a) Taking the *x* axis to be the original direction of motion of ball A, write down the equations expressing the conservation of momentum for the components in the *x* and *y* directions separately. (b) Solve these equations for the speed v'_B and θ'_B of ball B. Do not assume the collision is elastic.

Answer: (a) p_X: $m_A v_A = m_A v'_A \cos\theta'_A + m_B v'_B \cos\theta'_B$
p_Y: $0 = m_A v'_B \sin\theta'_A - m_B v'_B \sin\theta'_B$
(b) -33.0°, 0.808 m/s

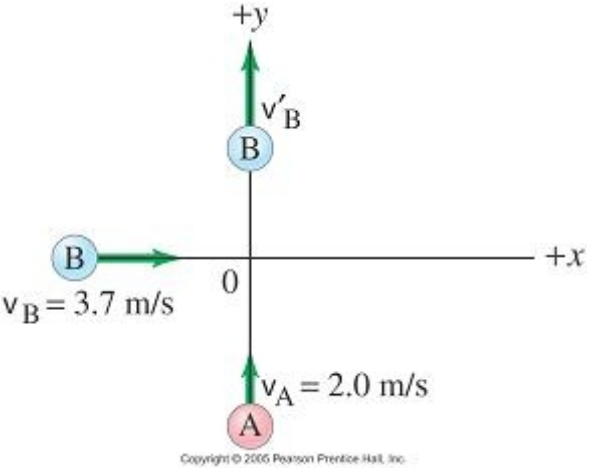


FIGURE 7-37

102) Two billiard balls of equal mass move at right angles and meet at the origin or an *xy* coordinate system. Ball A is moving upward along the *y* axis at 2.0 m/s, and ball B is moving to the right along the *x* axis with speed 3.7 m/s. After the collision, assumed elastic, ball B is moving along the positive *y* axis (Fig. 7-37). What is the final direction of ball A and what are their two speeds?

Answer: The final direction of A is the *x* direction. 3.7 m/s, 2.0 m/s

103) A square uniform raft, 18 m by 18 m, of mass 6800 kg, is used as a ferryboat. If three cars, each of mass 1200 kg, occupy its NE, SE, and SW corners, determine the CM of the loaded ferryboat.

Answer: x_{CM} = 1.04 m, y_{CM} = -1.04 m

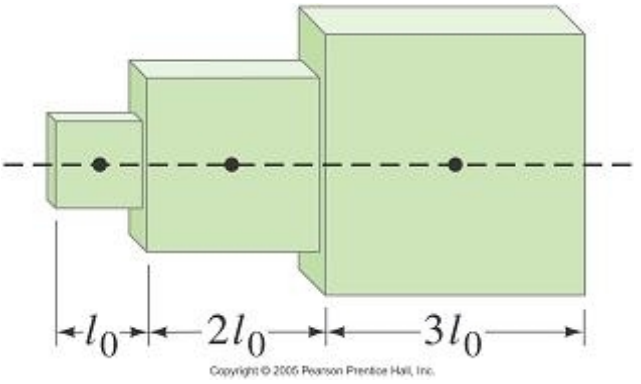


FIGURE 7-39

104) Three cubes of sides l_0, $2l_0$, $3l_0$, are placed next to one another (in contact) with their centers along a straight line and the $l = 2l_0$ cube in the center (Fig. 7-39). What is the position, along this line, of the CM of this system? Assume the cubes are made of the same uniform material.

Answer: 3.8 l_0 from the left edge of the smallest cube

TABLE 7–1 Center of Mass of Parts of Typical Human Body
(full height and mass = 100 units)

Distance Above Floor of Hinge Points (%)	Hinge Points (•) (Joints)		Center of Mass (×) (% Height Above Floor)		Percent Mass
91.2	Base of skull		Head	93.5	6.9
81.2	Shoulder joint		Trunk and neck	71.1	46.1
		elbow 62.2	Upper arms	71.7	6.6
			Lower arms	55.3	4.2
		wrist 46.2	Hands	43.1	1.7
52.1	Hip joint		Upper legs (thighs)	42.5	21.5
28.5	Knee joint				
			Lower legs	18.2	9.6
4.0	Ankle joint		Feet	1.8	3.4
			Body CM =	58.0	100.0

105) Use Table 7-1 to calculate the position of the CM of an arm bent at a right angle. Assume that the person is 155 cm tall.

Answer: x_{CM} = 21.7 cm, y_{CM} = 7.6 cm

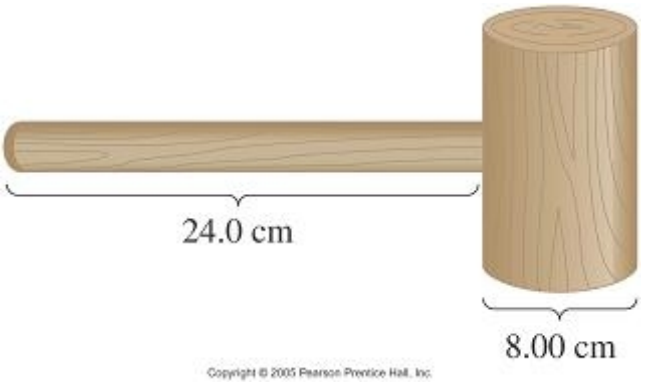


FIGURE 7-42

106) A mallet consists of a uniform cylindrical head of mass 2.00 kg and a diameter 0.0800 m mounted on a uniform cylindrical handle of mass 0.500 kg and length 0.240 m, as shown in Fig. 7-42. If this mallet is tossed, spinning, into the air, how far above the bottom of the handle is the point that will follow a parabolic trajectory?

Answer: 24.8 cm from the left hand end of the mallet