**Part A: Multiple-Multiple Choice**

1. Which of the following statements are true about momentum?

1. Momentum is a vector quantity.
2. The standard unit on momentum is the Joule.
3. An object with mass will have momentum.
4. An object which is moving at a constant speed has momentum.
5. An object can be traveling eastward and slowing down; its momentum is westward.
6. Momentum is a conserved quantity; the momentum of an object is never changed.
7. The momentum of an object varies directly with the speed of the object.
8. Two objects of different mass are moving at the same speed; the more massive object will have the greatest momentum.
9. A less massive object can never have more momentum than a more massive object.
10. Two identical objects are moving in opposite directions at the same speed. The forward moving object will have the greatest momentum.
11. An object with a changing speed will have a changing momentum.

3. Which of the following statements are true about impulse?

1. Impulse is a force.
2. Impulse is a vector quantity.
3. An object which is traveling east would experience a westward directed impulse in a collision.
4. Objects involved in collisions encounter impulses.
5. The Newton is the unit for impulse.
6. The kg•m/s is equivalent to the units on impulse.
7. An object which experiences a net impulse will definitely experience a momentum change.
8. In a collision, the net impulse experienced by an object is equal to its momentum change.
9. A force of 100 N acting for 0.1 seconds would provide an equivalent impulse as a force of 5 N acting for 2.0 seconds.

4. Which of the following statements are true about collisions?

1. Two colliding objects will exert equal forces upon each other even if their mass is significantly different.
2. During a collision, an object always encounters an impulse and a change in momentum.
3. During a collision, the impulse which an object experiences is equal to its velocity change.
4. The velocity change of two respective objects involved in a collision will always be equal.
5. While individual objects may change their velocity during a collision, the overall or total velocity of the colliding objects is conserved.
6. In a collision, the two colliding objects could have different acceleration values.
7. In a collision between two objects of identical mass, the acceleration values could be different.
8. Total momentum is always conserved between any two objects involved in a collision.
9. When a moving object collides with a stationary object of identical mass, the stationary object encounters the greater collision force.
10. When a moving object collides with a stationary object of identical mass, the stationary object encounters the greater momentum change.
11. A moving object collides with a stationary object; the stationary object has significantly less mass. The stationary object encounters the greater collision force.
12. A moving object collides with a stationary object; the stationary object has significantly less mass. The stationary object encounters the greater momentum change.

**Part B: Multiple Choice**

6. Which of the following objects have momentum? Include all that apply.

1. An electron is orbiting the nucleus of an atom.
2. A UPS truck is stopped in front of the school building.
3. A Yugo (a compact car) is moving with a constant speed.
4. A small flea walking with constant speed across Fido's back.
5. The high school building rests in the middle of town.

7. A truck driving along a highway road has a large quantity of momentum. If it moves at the same speed but has twice as much mass, its momentum is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

a. zero b. quadrupled c. doubled d. unchanged

 8. TRUE or FALSE:

A ball is dropped from the same height upon various flat surfaces. For the same collision time, impulses are smaller when the most bouncing take place.

a. True b. False

9. Consider a karate expert. During a talent show, she executes a swift blow to a cement block and breaks it with her bare hand. During the collision between her hand and the block, the \_\_\_.

1. time of impact on both the block and the expert's hand is the same
2. force on both the block and the expert's hand have the same magnitude
3. impulse on both the block and the expert's hand have the same magnitude
4. all of the above.
5. none of the above.

10. It is NOT possible for a rocket to accelerate in outer space because \_\_\_\_. List all that apply.

1. there is no air in space
2. there is no friction in space
3. there is no gravity in outer space
4. ... nonsense! Rockets do accelerate in outer space.

11. In order to catch a ball, a baseball player naturally moves his or her hand backward in the direction of the ball's motion once the ball contacts the hand. This habit causes the force of impact on the players hand to be reduced in size principally because \_\_\_.

1. the resulting impact velocity is lessened
2. the momentum change is decreased
3. the time of impact is increased
4. the time of impact is decreased
5. none of these

12. Suppose that Paul D. Trigger fires a bullet from a gun. The speed of the bullet leaving the muzzle will be the same as the speed of the recoiling gun \_\_\_\_.

1. because momentum is conserved
2. because velocity is conserved
3. because both velocity and momentum are conserved
4. only if the mass of the bullet equals the mass of the gun
5. none of these

 13. Suppose that you're driving down the highway and a moth crashes into the windshield of your car. Which undergoes the greater change is momentum?

a. the moth b. your car c. both the same

 14. Suppose that you're driving down the highway and a moth crashes into the windshield of your car. Which undergoes the greater force?

a. the moth b. your car c. both the same

15. Suppose that you're driving down the highway and a moth crashes into the windshield of your car. Which undergoes the greater impulse?

a. the moth b. your car c. both the same

 16. Suppose that you're driving down the highway and a moth crashes into the windshield of your car. Which undergoes the greater acceleration?

a. the moth b. your car c. both the same

18. In a physics experiment, two equal-mass carts roll towards each other on a level, low-friction track. One cart rolls rightward at 2 m/s and the other cart rolls leftward at 1 m/s. After the carts collide, they couple (attach together) and roll together with a speed of \_\_\_\_\_\_\_\_\_\_\_\_\_. Ignore resistive forces.

a. 0.5 m/s b. 0.33 m/s c. 0.67 m/s d. 1.0 m/s e. none of these

20. The firing of a bullet by a rifle causes the rifle to recoil backwards. The speed of the rifle's recoil is smaller than the bullet's forward speed because the \_\_\_.

a. force against the rifle is relatively small b. speed is mainly concentrated in the bullet

c. rifle has lots of mass d. momentum of the rifle is unchanged e. none of these

 21. Two objects, A and B, have the same size and shape. Object A is twice as massive as B. The objects are simultaneously dropped from a high window on a tall building. (Neglect the effect air resistance.) The objects will reach the ground at the same time but object A will have a greater \_\_\_. Choose all that apply.

a. speed b. acceleration c. momentum d. none of the above quantities will be greater

22. Cars are equipped with padded dashboards. In collisions, the padded dashboards would be safer than non-padded ones because they \_\_\_\_. List all that apply.

a. increase the impact time b. decrease an occupant's impulse

c. decrease the impact force d. none of the above

 23. A 4 kg object has a momentum of 12 kg•m/s. The object's speed is \_\_\_ m/s.

a. 3 b. 4 c. 12 d. 48 e. none of these.

 24. A wad of chewed bubble gum is moving with 1 unit of momentum when it collides with a heavy box that is initially at rest. The gum sticks to the box and both are set in motion with a combined momentum that is \_\_\_.

a. less than 1 unit b. 1 unit c. more than 1 unit d. not enough information

 25. A relatively large force acting for a relatively long amount of time on a relatively small mass will produce a relatively \_\_\_\_\_\_. List all that apply.

a. small velocity change b. large velocity change c. small momentum change

27. A 5-N force is applied to a 3-kg ball to change its velocity from +9 m/s to +3 m/s. This impulse causes the momentum change of the ball to be \_\_\_\_ kg•m/s.

a. -2.5 b. -10 c. -18 d. -45 e. none of these

 28. A 5-N force is applied to a 3-kg ball to change its velocity from +9 m/s to +3 m/s. The impulse experienced by the ball is \_\_\_\_ N•s.

a. -2.5 b. -10 c. -18 d. -45 e. none of these

 29. A 5-N force is applied to a 3-kg ball to change its velocity from +9 m/s to +3 m/s. The impulse is encountered by the ball for a time of \_\_\_\_ seconds.

a. 1.8 b. 2.5 c. 3.6 d. 10 e. none of these

34. A 0.5-kg ball moving at 5 m/s strikes a wall and rebounds in the opposite direction with a speed of 2 m/s. If the impulse occurs for a time duration of 0.01 s, then the average force (magnitude only) acting upon the ball is \_\_\_\_ Newtons.

a. 0.14 b. 150 c. 350 d. 500 e. none of these

 35. If mass and collision time are equal, then impulses are greater on objects which rebound (or bounce).

a. TRUE b. FALSE

36. Consider the head-on collision between a lady bug and the windshield of a high speed bus. Which of the following statements are true? List all that apply.

1. The magnitude of the force encountered by the bug is greater than that of the bus.
2. The magnitude of the impulse encountered by the bug is greater than that of the bus.
3. The magnitude of the momentum change encountered by the bug is greater than that of the bus.
4. The magnitude of the velocity change encountered by the bug is greater than that of the bus.
5. The magnitude of the acceleration encountered by the bug is greater than that of the bus.

38.



System Momentum Before Collision:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

System Momentum After Collision:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

45. Ball 1 which has a mass of 6kg is moving at 10 m/s to the right which collides elastically with Ball 2 who has a mass of 4 kg and is moving in the same direction at 4 m/s initially. After the collision, ball 2 is moving at 10 m/s to the right. What is the final velocity of ball one if they bounce off of each other during the collision?

46. A red ball which has a mass of 4 kg is moving at 8 m/s to the right which collides inelastically with a blue ball who has a mass of 2 kg and is moving in the same direction at 5 m/s initially. What is the velocity of these balls after the collision?

48. A soccer ball with a mass of 4 kg moving to the right at 10 m/s initially collides with a volley ball of mass 4 kg that is moving to the left initially at 12 m/s. After the collision, the soccer ball bounces backwards at a speed of 2 m/s. What is the final velocity of the volley ball?

**Part E: Problem-Solving**

57. A 0.530-kg basketball hits a wall head-on with a forward speed of 18.0 m/s. It rebounds with a speed of 13.5 m/s. The contact time is 0.100 seconds. (a) determine the impulse with the wall, (b) determine the force of the wall on the ball.

60. A 46-gram tennis ball is launched from a 1.35-kg homemade cannon. If the cannon recoils with a speed of 2.1 m/s, determine the muzzle speed of the tennis ball.

67. At an amusement park, twin brothers Tubby (m = 50 kg) and Chubby (m = 62 kg) occupy separate 36-kg bumper cars. Tubby gets his car cruising at 3.6 m/s and collides head-on with Chubby who is moving the opposite direction at 1.6 m/s. After the collision, Tubby bounces backwards at 0.5 m/s. Assuming an isolated system, determine Chubby's post-collision speed.