Unit 6 Momentum Review

Momentum/Impulse Formulas:

$$p = mv \qquad \vec{F}\Delta t = \Delta\vec{p} = m\Delta\vec{v}$$

Law of Conservation of Momentum: $p_{before} = p_{after}$ or $\sum \vec{p}_i = \sum \vec{p}_f$

$m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = m_1\vec{v}_{1f} + m_2\vec{v}_{2f}$ With two objects that collide and separate (elastic)

$m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = (m_1 + m_2)\vec{v}_f$ With two objects that collide and stick together (inelastic)

Answer the following on a separate piece of paper.

1. A person can survive a feet-first impact at a speed of about 12 m/s on concrete; 15 m/s on soil; and 34 m/s on water. Why the different values for different surfaces?

2. When catching a foul ball at a baseball game, why is it important to extend your bare hands upward so they can move downward as the ball is being caught?

3. Automobiles were previously manufactured to be as rigid as possible, whereas today's autos are designed to crumple upon impact. Why?

~~4. In terms of impulse and momentum, why is it important that helicopter blades deflect air **downward**?~~

5. A lunar vehicle is tested on Earth at a speed of 5 m/s. When it travels just as fast on the Moon, is its momentum on the moon more, less, or the same as on earth?

6. You may have seen large yellow containers on the highways at exit ramps. These containers are filled with sand or water. Newer containers have a loose top half resting on a bottom. These containers are designed to protect cars that would otherwise hit solid concrete barriers. How does physics explain how these containers (called 'impact attenuators) work?

7. A skateboarder has a mass of 90 kg. A car has a mass of 900 kg. Explain how it is possible for both of them to have the same momentum.

~~8. Why are the impulses that colliding objects exert on each other equal and opposite?~~

~~9. A boxer can punch a heavy bag for more than an hour without tiring, but will tire quickly when boxing with an opponent for a few minutes. Why? (Hint: When the boxer's fist is aimed at the bag, what supplies the impulse to stop the punches? When the boxer's fist is aimed at the opponent, what or who supplies the impulse to stop the punches that don't connect?)~~

10. You are at the front of a floating canoe near a dock. You jump forwards, expecting to land on the dock easily. Instead you land in the water. How does physics explain why this happens?

11. If a large bus and a small car have a head-on collision, which vehicle will experience (a) the greater force of impact? (b) The greater impulse? (c) The greater change in momentum? (d) The greater deceleration?

~~12. A force of 6.0 N acts on an object for 10.0 s. The mass of the object is 3.0 kg.~~

~~(a) What is the object's change in momentum?~~
~~(b) What is its change in velocity?~~

13. A snow scooter has a mass of 250.0 kg. A constant force acts upon it for 60.0 s. The scooter's initial velocity is 6.0 m/s and its final velocity is 28 m/s.
(a) What change in momentum does it undergo?
(b) What is the magnitude of the force which acts upon it?

~~14. A rocket of mass 2.0×10^4 kg starting from rest is acted upon by a net force of 1.5×10^5 N for 15 s. What is the final velocity of the rocket?~~

15. A car weighing 15680 N and moving at 20.0 m/s is acted upon by a 640 N braking force until it is brought to a stop.
(a) What is the car's mass?
(b) What is its initial momentum?
(c) What change in the car's momentum does the force bring about?
(d) How long does the braking force act on the car to bring it to a halt?

16. A car of mass 1100 kg moves at 22 m/s. What braking force is needed to bring the car to a halt in 20.0 s?

17. When a bat hits a baseball, the change in momentum of the bat is (less than, greater than, equal to) the change in momentum of the ball.

18. When a bat hits a baseball, the change in velocity of the bat is (less than, greater than, equal to) the change in velocity of the ball.

19. A 3.20 kg mass moving at 4.00 m/s <u>west</u> hits a wall. The wall exerts a force of 250.0 N to the <u>east</u> for 0.0700 seconds. Find the final speed and direction of the mass. (1.47 m/s East)

~~20. A rifle accelerates 15.0 gram bullets from rest to 250. m/s. The rifle barrel is about 0.80 metres long. Find a) the impulse acting on the bullet, and b) the force on the bullet.~~

21. A 55 gram pinball moving at 0.60 m/s hits a bumper and **<u>rebounds</u>** at 0.75 m/s. If the impact takes 0.12 seconds, find the magnitude of force that acted on the pinball.

22. A sandbag is mounted on a cart that is at rest on a horizontal frictionless surface. The mass of the cart and sandbag combined is 4.5 kg. What will be the velocity of the cart and sandbag if a bullet of mass 2.0 g is fired into the sandbag with a horizontal velocity of 550 m/s? Assume the collision is inelastic.

23. Two boys of mass 45 kg and 60 kg, respectively, are sitting on two separate 15 kg wagons (so their total masses are 60 kg and 75 kg), facing each other and holding a rope taut between them. The lighter boy pulls on the rope and acquires a velocity of 2.0 m/s west. What is the velocity of the other boy?

24. Two train cars approach each other, one of mass 113 000 kg traveling at 1.20 m/s, the other of mass 75 000 kg traveling at 2.30 m/s. The collision is inelastic.

(a) What is the momentum of the heavier car?

(b) What is the momentum of the lighter car?

(c) What is the velocity of the cars after the collision?

25. A child's ball of mass 560 g rolls east along the ground at 7.6 m/s towards a stationary bowling ball of mass 4.5 kg. After the collision, the bowling ball travels east at 1.5 m/s. What is the velocity of the child's ball?

26. Two train cars approach each other, one mass 76 000 kg traveling at 3.5 m/s, the other of mass 95000 kg traveling at 1.9 m/s. The collision is elastic, with the lighter one reversing its direction after the collision and traveling with a speed of 0.42 m/s. What is the velocity of the other train car?

27. A car of mass 1500 kg traveling at 15.6 m/s east loses its brakes and collides with the rear end of the car in front of it, which has a mass of 1020 kg and is traveling **in the same direction** at 12.5 m/s. If the smaller car is given a speed of 15.3 m/s east by the collision, what is the speed of the larger car after the collision?

28. What will the recoil velocity be if a 3.2 kg rifle fires a 0.036 kg bullet with a velocity of 290 m/s?

Answers:

1. Concrete will stop a person in much less time. Since $\Delta\vec{p} = \vec{F}\Delta t = m\Delta\vec{v}$, smaller t means much larger force unless the change in velocity is smaller, larger force means much larger acceleration, and large acceleration is what causes damage.

2. Since $\Delta\vec{p} = \vec{F}\Delta t = m\Delta\vec{v}$, this allows the catcher to increase time, lowering force.

3. Increasing the time of impact lowers the force of impact.

4. Since momentum is conserved, a downward momentum on the air will result in an upward momentum on the blades.

5. The same (since the mass and velocity are not different on the moon)

6. Increasing the time of impact lowers the force of impact.

7. If the skateboarder travels at 10 m/s, and the car travels at 1 m/s.

8. Since momentum is conserved, and positive momentum lost by the first object will be transferred to the second object. Assuming the collision is head on, the second object already had negative momentum, so it will gain the positive momentum lost by the first object.

9. The punching bag normally supplies the impulse to stop a punch. In a boxing match, the boxer has to supply the impulse to stop any punch that misses its target. This is tiring.

10. The initial momentum of the system is zero, so the final momentum must be zero. When you jump forwards, the canoe must move backwards. Also, since the canoe has a smaller mass than you, it will move with a higher speed than you. So . . . splash!

11. a) same (Newton's 3rd) b) same (same force, same time of impact, so same impulse) c) same (change in momentum and impulse are the same thing)
d) the car (this is why a smaller vehicle is worse off in a collision)

12. a) 60 Ns b) 20 m/s

13. a) 5500 kg m/s b) 91.7 N

14. 112.5 m/s

15. a) 1600 kg b) 32000 kg m/s c) -32000 kg m/s d) 50 s

16. 1210 N (in the opposite direction of initial velocity)

17. equal to

18. less than

19. 1.47 m/s East

20. a) 3.75 kg m/s b) t= 0.0064 s, so F=586 N

21. F=0.62 N (in the direction of the rebound, but I didn't ask for direction)

22. 0.244 m/s

23. 1.6 m/s East.

24. a) +135600 kg m/s b) -172500 kg m/s c) -0.196 m/s

25. -4.45 m/s

26. +1.24 m/s (in the opposite direction from its initial velocity)

27. 13.7 m/s

28. -3.26 m/s