Physics 2204
Unit 2: Dynamics
Worksheet 12: Impulse Momentum Theorem

Student Name:_____

The Impulse Momentum Theorem states that the impulse applied by the net force on a system is equal to the change in momentum on the system. This theorem can be written numerous ways

$$\vec{J} = \Delta \vec{p}$$

$$\vec{F} \bullet t = \vec{p}_2 - \vec{p}_1$$

$$\vec{F} \bullet t = m\vec{v}_2 - m\vec{v}_1$$

$$\vec{F} \bullet t = m\left(\vec{v}_2 - \vec{v}_1\right)$$

Note that a N •s = Kg •m/s

Example 1:

If the impulse on a 20 kg rock is 15.2 N • s, what is the change in momentum of the rock?

Example 2:

A force of 500.0 N is applied to a stationary 50.0 kg toboggan for a time of 3.0 s. What is the final velocity of the toboggan? .

Example 3:

If a force sensor indicates that your glove exerts a force of -52 N to stop a 190 g puck in 0.09 s, with what speed did the puck hit the glove?

Example 4:

If a 180 g hockey puck hits your glove at 75 km/hr and stops in 0.1 s, what average force does the puck exert on the glove?

Example 5:

Why it is easier to drive a nail with a steel hammer than with a rubber mallet?

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Example 6:

Would you rather be in a head on collision with an identical car, traveling at the same speed as you, or a brick wall?

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PART A: MULTIPLE CHOICE

Instructions: Shade the letter of the correct answer on the computer scorable answer sheet provided

1. Which quantity is defined as the change in an object's momentum?

   (A) Gravity
   (B) Impulse
   (C) Inertia
   (D) Linear momentum

2. What is impulse equivalent to?

   (A) Change in mass of an object.
   (B) Change in time of an object.
   (C) Change in momentum of the object
   (D) Original momentum of the object.

3. A driver accelerates a 240.0 kg snowmobile from 6.0 m/s to 28.0 m/s. What is the impulse on the snowmobile?

   (A) 1440 kg·m/s
   (B) 5280 kg·m/s
   (C) 6720 kg·m/s
   (D) 8160 kg·m/s

4. Which of the following units is equivalent to a 1 N•s

   (A) Kg • m/s
   (B) Kg • m/s^2
   (C) Kg / m/s
   (D) Kg/ m/s^2

5. If the impulse on a 55 g golf ball is 2.2 N•s, what is the change in momentum of the golf ball?

(A) 0.040 kg•m/s
(B) 2.2 kg•m/s
(C) 25 kg•m/s
(D) 120 kg•m/s

6. The change in momentum is 1.52 kg•m/s for a ball that strikes the floor for 1.05×10^{-2} s. What was the force applied to the ball?

(A) 1.60×10^{-2} N
(B) 1.60 N
(C) 23.8 N
(D) 145 N

7. A boxer quickly learns to move his head backward when he sees he is going to receive a jab to the head. What does this head motion accomplish?

(A) It increases the momentum and decreases the force
(B) It increases the contact time which decreases the force
(C) It decreases the contact time which decreases the force
(D) It causes confusion on the opponent.

8. Guardrails along roadsides collapse (bend and crumple) when a car runs into them. Why is this done?

(A) Decrease the contact time and decrease the crash force
(B) Decrease the momentum and decrease the crash force
(C) Increase the contact time and decrease the crash force
(D) Increase the momentum and decrease the crash force

9. How would a person reduce the "sting" in catching a hard ball?

(A) Increases momentum change
(B) Increases the contact force
(C) Increases the impulse
(D) Increase the contact time

10. If a force is exerted on an object, which statement is true?

(A) A large force always produces a large change in the object's momentum.
(B) A large force produces a large change in the object's momentum only if the force is applied over a very short time interval.
(C) A small force applied over a long time interval can produce a large change in the object's momentum.
(D) A small force always produces a large change in the object's momentum.

11. Why are airbags used by stunt people when they fall off buildings?

(A) Change the impulse
(B) Change the momentum
(C) Change the amount of forced exerted
(D) Change the speed you hit the mat

12. A lynx with a mass of 18.0 kg is stalking its prey at 1.50 m/s. It speeds up to 6.50 m/s to catch the prey. What is the change in momentum of the lynx?

(A) 1.50 kg•m/s
(B) 3.60 kg•m/s
(C) 90.0 kg•m/s
(D) 117 kg•m/s

13. A 0.20 kg hockey puck is sliding along the ice with an initial speed of 12 m/s when a player strikes it with his stick, causing it to reverse its direction and giving it a speed of 23 m/s. What is the impulse the stick applies to the puck ?

(A) - 2.2 N• s
(B) - 4.6 N• s
(C) - 7.0 N• s
(D) - 5.5 x 10^{1} N• s

14. A gun fires a 0.25 kg projectile which acquires a velocity of 300 m/s. If the projectile takes 0.0050 seconds to travel the length of the barrel, what is the force exerted by the gun on the projectile?

(A) $3.8x10^{-1}$ N
(B) $7.5\ x10^{1}$ N
(C) $1.50\ x10^{4}$ N
(D) $6.0\ x10^{4}$ N

15. A baseball has a weight of 0.42 kg and is pitched to the batter at 43 m/s and hit back by the batter at 22 m/s. If the ball and bat were in contact for 0.0040 seconds, what force was exerted by the bat on the ball?

(A) -2.7 x 10^{2} N
(B) -4.0 x 10^{2} N
(C) $-2.2\ x10^{3}$ N
(D) $-6.8\ x10^{3}$ N

16. A braking force is applied to a 355 kg motorcycle to reduce its speed from 108 km/h to 34.2 km/h in 3.00 sec. What is the impulse?

(A) -3.3 x 10^{3} N• s
(B) -7.3 x 10^{3} -N• s
(C) -1.1 x 10^{4} N• s
(D) -1.4 x 10^{4} N• s

17. A net force of 4.5 N causes a in change in momentum of a stationary toy car with a mass of 1.15 kg. What will be the velocity of the cart after 2.5 s?

(A) 0.64 m/s
(B) 9.8 m/s
(C) 16 m/s
(D) 21m/s

18. A 0.15 kg snowball traveling at 20.0 m/s [Left] hits you in the head and stops in 0.10 s. What force does the snowball exert on your skull?

(A) 7.5 x 10^{-4} N
(B) 3.0 x 10^{-1} N
(C) 3.0 x 10^{1} N
(D) 1.3 x 10^{2} N

19. A 100.0 g golf ball leaves the tee at 100.0 m/s. If the club exerted a force of 500.0 N on the ball, determine how long the club was in contact with the ball.

(A) 0.020 s
(B) 0.40 s
(C) 0.50 s
(D) 4.0 s

20. A 740 kg car traveling 19 m/s comes to a complete stop in 2.0 s. What is the force exerted on the car during this stop?

(A) -8.5×10^{1} N
(B) -8.50×10^{2} N
(C) -7.0×10^{3} N
(D) -9.2×10^{3} N

PART B: WRITTEN RESPONSE

1. Provide a real life example to explain the Impulse Momentum Theorem? (MUST DO)

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2. A pool ball rolls towards a cushion at 3.0 m/s and rebounds straight back at 3.0 m/s. If the mass of the ball is 250 g, what is its change in momentum?

3. A 7.0 kg bicycle with a 50.0 kg cyclist is moving at uniform motion when the cyclist pushes the pedals, causing it to speed up to 5.0 m/s in 1.0 s without changing direction. If the average force exerted on the pedals was 80.0 N, what was the bicycles initial velocity?

4. A force of 30.0 N is applied to a 50.0 kg sled for a time of 2.0 s. The speed changes from 2.0 m/s to 3.2 m/s.
(a) Calculate the impulse delivered to the sled.

(b) Calculate the change in momentum of the sled.

(c) What do you notice about the answers to parts (a) and (b)?

5. A 1250 kg car, initially traveling at 28 m/s is brought to a stop in a time of 3.1 s. What was the braking force?

6. An accelerating force of +850 N is applied for 5.0 s to a 1250 kg car initially moving at +16 m/s. What will be the final speed?

7. A net force of 3.5 N is applied to a stationary dynamic cart with a mass of 0.95 kg. What will be the velocity of the cart after 1.5 s?

8. A car, initially moving at 10 m/s is slowed down by a braking force of 500.0 N for 2.0s. The car has a mass of 1200 kg. What will be its final velocity?

9. A 70.0 kg downhill skier goes off the trail travelling at 20.0 m/s. The skier is fortunate and land in a newly designed safety fence that exerts a constant force of 352 N. How long after impacting the fence does it take the skier to come to a complete stop?\

10. A soccer player estimates that her foot was in contact with the ball for about 0.010 sec when it was kicked. If the ball has a mass of 1.4 kg and goes off with a speed of 22.1 m/s, what must have been the accelerating force?

11. Rockin Ronny, who has a mass of 60.0 kg, is driving at a speed of 25.0 m/s in his sorts car when he must suddenly slam on the brakes to avoid hitting a neon green three-legged dog crossing the road. Ron's brakes fail, and though he misses the dog, he hits a big rock. As a result, the car's air bag is activated, which brings Ron's body to a stop in 0.400 s. What average force does the seat belt exert on him?

12. If Ron had not been wearing his seat belt and not had an air bag, then the windshield would have stopped his head in 0.001 s. What average force would the windshield have exerted on him?

13. A hockey player applies an average force of 80.0 N to a 0.25 kg hockey puck for a time of 0.10 seconds. Determine the impulse experienced by the hockey puck.

14. Use the concept of Impulse Momentum to explain each of the following situations:

    a) When you jump from a height, you should always bend your knees as you land.

    b) Boat owners often use plastic buoys hung over the sides of their boat when they are tied to a wharf.

    c) Automotive air bags increase safety during a collision.