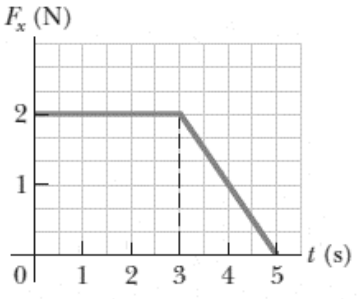
AP Physics 1 Name: _____

Unit 4 Test: Momentum

Multiple Choice - Choose the answers that best answers the questions below (if an exact answer is not present, chose the closest available answer). Answer on the lines next to each question. (4 pts each)

1. _____ In which case is the total momentum of a system ***not*** conserved?
   A) When an elastic collision occurs in the system.
   B) When an inelastic collision occurs in the system.
   C) When an outside force acts on the system.
   D) When an explosion occurs in a system.
   E) None of the above. The total momentum of a system is always conserved.

2. _____ A variable force acts on an object for a period of time as shown in the graph on the right. Analysis of the graph indicates that the momentum of the object:
   A) increased during the first three seconds, and then decreased during the last two seconds.
   B) did not change over the five seconds.
   C) did not change during the first three seconds, then decreased during the last two seconds.
   D) increased over the five seconds.



3. _____ A golf ball, initially at rest, is struck by a club so that it acquires a speed v. A force F is exerted on the ball for a time t. Which of the following gives an expression for the mass of the golf ball?

A) $\frac{v}{Ft}$ B) $\frac{v^2}{2Ft}$ C) $\frac{Ft}{v}$ D) Fvt E) $\frac{Fv}{2t}$

4. _____ A small car and a heavy pickup truck are both out of gas. The truck has twice the mass of the car. After you push both the car and the truck for the same amount of time with the same force, what can you say about the momentum and speed of the car and the truck?
   A) They have the same momentum and the same velocity.
   B) The car has more momentum and a higher velocity than the truck.
   C) The truck has more momentum and higher velocity than the car.
   D) They have the same momentum, but the car has a higher velocity than the truck.

5. _____ A boat travels down a river with a momentum of p and a kinetic energy of K. As it passes under a bridge, Westin drops a crate of Anime memorabilia on the boat. If the crate has the same mass as the boat, which of the following gives the momentum and kinetic energy of the boat after the crateis dropped on it?

A) p, K B) $\frac{1}{2}\mathrm{p}, \mathrm{K}$ C) $\mathrm{p}, \frac{1}{2}\mathrm{K}$ D) $\mathrm{p}, \frac{1}{4}\mathrm{K}$

6. _____ Two identical blocks with mass 5.0 kg each are connected to the opposite ends of a compressed spring. The blocks initially slide together on a frictionless surface with a velocity 2 m/s to the right. The spring is then released by remote control. At some instant later, the left block is moving to the left at 1 m/s, and the other block is moving to the right. What is the speed of the center of mass of the system at that instant?

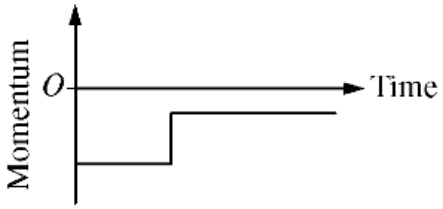
A) 4 m/s B) 3 m/s C) 2 m/s D) 0 m/s

7. _____ 2 carts are released from rest as shown. A 20 kg cart is released from a height of 5 m and travels to the right and a 10 kg cart is released from a height of 10 m and travels left. The two carts collide on the horizontal surface in a perfectly inelastic collision. Which way do the carts move after colliding?

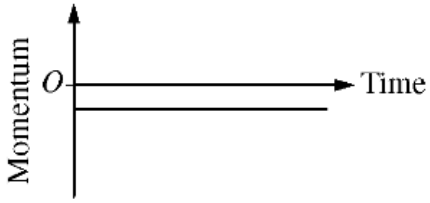
A) The carts move to the right since the 20 kg cart has more momentum at the time of the collision.
B) The carts move to the left since the 10 kg cart has more momentum at the time of the collision.
C) The carts stop after the collision since the have equal but opposite momenta.
D) The two carts go to Best Buy for Black Friday shopping.

8. _____ Two carts, of mass $2m$ and m, approach each other head-on with the same speed v, as shown in the figure above. When the carts collide, they hook together. Assuming positive momentum is to the right, which of the following best represents the momentum of the cart of mass m as a function of time before and after the collision?

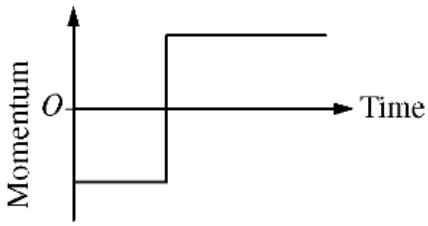
A)



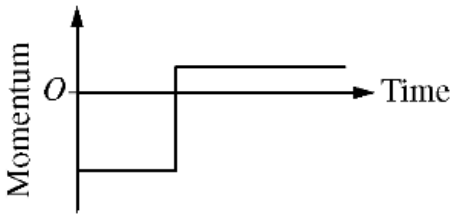
C)



B)



D)



9. _____ A cue ball is traveling at 12 m/s directly to the right when it hits an eight ball, which has identical mass. After the two collide, the cue ball travels at 6 m/s, 60° below the horizontal. What is the magnitude and direction of the eight ball?

A) 10.4 m/s, 60° above the horizontal
B) 6 m/s 30 above the horizontal
C) 6 m/s, 30° below the horizontal
D) 10.4 m/s, 30° above the horizontal

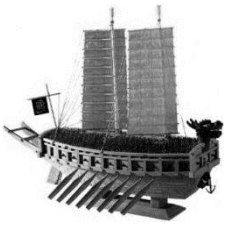
10. _____ The data in the table below were recorded during an experiment in which two carts on a frictionless track collide head-on.

	Mass	Average Force on Cart	Change in Momentum	Average Acceleration
Cart 1	5 kg	15 N	0.3 kg m/s	3 m/s^2
Cart 2	1 kg	15 N	Δp_2	a_2

What are the values of the magnitude of the change in momentum Δp_2 of cart 2 and the magnitude of its average acceleration a_2 during the collision?

A) $\Delta p_2 = 0.3\ kg\ m/s$ $a_2 = 3\ m/s^2$
B) $\Delta p_2 = 0.3\ kg\ m/s$ $a_2 = 15\ m/s^2$
C) $\Delta p_2 = 1.5\ kg\ m/s$ $a_2 = 3\ m/s^2$
D) $\Delta p_2 = 1.5\ kg\ m/s$ $a_2 = 15\ m/s^2$

11. (10 points) a) Korean Naval Admiral Yi Sun-Shin sails his legendary turtle ship in the waters off the coast of Korea. The ship is propelled by a constant current. As the ship sails, a heavy rain falls upon the ship and water accumulates on the deck of the ship. Describe what will happen to the ships i) velocity and ii) kinetic energy as the water accumulates onboard.



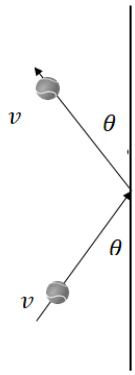
i. Velocity:

ii. Kinetic energy:

b) The Korean turtle ship attacked enemy ships by ramming into them. A Japanese naval vessel travels due east fleeing from the turtle ship, but the turtle pursues it at a faster speed(also due east) and rams into the back of the Japanese naval ship. After the collision, the Japanese vessel breaks into 2 pieces. One fragment of the Japanese travels northwest while the turtle ship comes to rest after the collision. Describe the motion of the other fragment of the Japanese ship after the collision.

c) Specify which direction the center of mass of the turtle ship/fragment system travels after the collision.

12. (13 points) A tennis ball of mass m travelling at v collides with a wall at an angle θ and then rebounds at the same angle and speed as shown.



a) What is the direction of the impulse of the ball on the wall?

b) Was energy conserved when the ball bounced off the wall? Justify your answer.

c) Another tennis ball of mass m = 0.2 kg is traveling at 10 m/s when it collides horizontally with a wall and bounces off at 5 m/s.

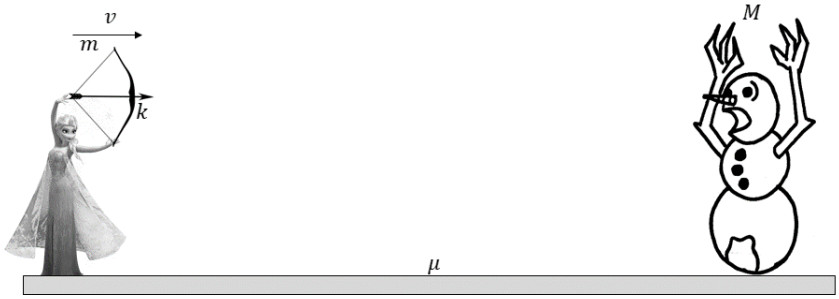
i. Calculate the impulse of the wall on the ball.

ii. How would the final speed of the ball compare if it were in contact with the wall for a shorter time?

_____Greater than 5m/s _____Less than 5 m/s _____Equal to 5 m/s

Justify your answer.

13. (20 points) Do you want to shoot a snowman? Elsa wields a bow, which can be treated as an ideal spring. She takes an arrow of mass m=0.2 kg and pulls the bow back a distance of 0.5 m before she lets it go, can't hold it back anymore. The arrow leaves the bow traveling at 40 m/s. It travels straight horizontally and hits and become embedding in a snowman of mass M = 10.0 kg, which is set up on ice.



a) Determine the spring constant, k, of the bow.

b) Find the impulse Elsa's bow exerts on the arrow.

c) Find the velocity of the snowman after the arrow is embedded in it.

d) After the arrow becomes embedded in it, the snowman slides backwards. The coefficient between the snowman and ice is $\mu = 0.10$. Find the distance the snowman slides before stopping.

Question continued on next page →

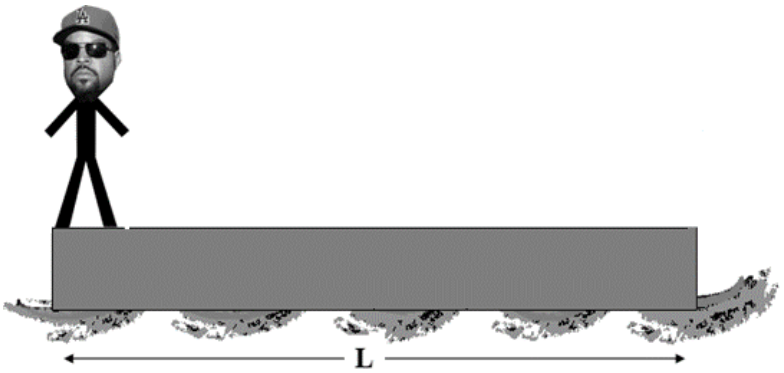
e) Suppose the arrow goes straight throw the snowman instead of being embedded in it. Would the velocity of the snowman after the collision be greater than, less than, or equal your answer from c)? Justify your answer.

14. (14 points) Tired of Mario stealing all the glory, Luigi decides to just go and rear-end Mario on a go-kart track. Mario has a total mass of 2M and a is traveling at speed v east while Luigi, with mass of M, travels east at $6v$. Luigi collides with Mario. After the collision, Luigi's cart travels to the west at $2v$.

a) Find the direction and speed of Mario's motion after the collision.

b) Was the collision elastic or inelastic? Justify you answer

c) Mario's cart exerts a force F on Luigi's cart. Determine an expression for the time of the collision.



15. (7 points) Today was not a good day. Rapper Ice Cube (O'Shea Jackson) is stranded at sea on top of a long rectangular floating ice cube of length L = 10 m. The floating ice cube has a mass of M = 300 kg and O'Shea Jackson has a mass of m = 100 kg. Suppose O'Shea Jackson is initially at rest on the far left end of the ice cube and then walks to the far right end of the ice cube.

a) Specify the direction the ice cube goes as O'Shea Jackson walks across.

b) Determine an expression for how far the ice cube moves when O'Shea Jackson reaches the right end of the ice cube.

Bonus: Waluigi shoots a bullet bill of mass m at a speed of $10v$ to the right as shown. The bullet passes through a block of mass $5m$, which is initially at rest. The bullet passes through the block. After the bullet passes completely through the block, the bullet's velocity has dropped to $5v$. What is the maximum height the block travels up the incline?