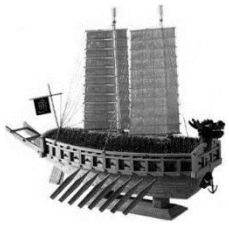
AP Physics 1 Name: _____

Unit 4 Test: Momentum

1. 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.



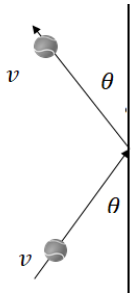
i. Velocity:

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.

2. 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 momentum 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.

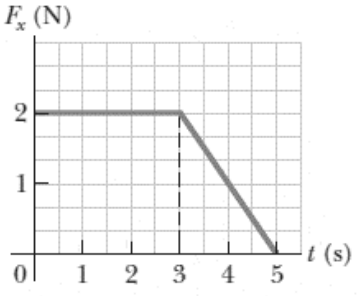
i. Calculate the impulse of the wall on the ball.

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.

3. A 2.0 kg present is moving in the positive direction with a speed of 4.0 m/s when it is acted upon by a force that varies with time according to the graph shown on the right.

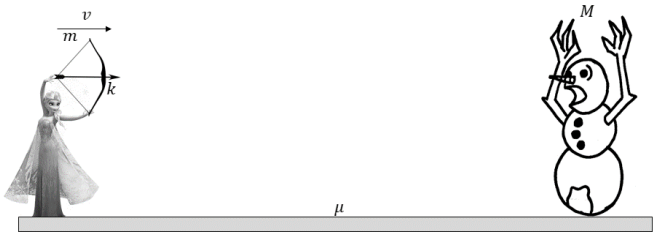


a) At time does the present reach its maximum speed?

b) Determine the change in momentum of the present.

c) Calculate the speed of the present at time t = 5 s.

4. 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.

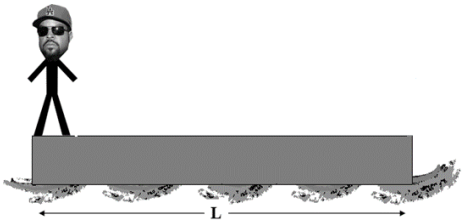


a) Determine the spring constant, k, of the bow.
b) Find the impulse Elsa's bow exerts on the arrow.
c) Find the velocity of the snowman after the arrow is embedded in it.
d) After the arrow becomes embedded in it, the snowman slides backwards. The coefficient between the snowman and ice is $\mu = 0.10$. Find the distance the snowman slides before stopping.
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.

5. 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) The collision lasts for a time t. Specify the force that Luigi exerts on Mario.
d) Is the magnitude of the impulse exerted on Luigi greater than, equal to, or less than the magnitude of the impulse exerted on Mario? Justify your answer.

6. 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 = 8 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 with velocity v.



a) Calculate the velocity of the ice cube 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.
c) Why does the center of mass of person/ice system not move when O'Shea Jackson walks across?