Lesson 3 Multi-Step Momentum Questions

April 26, 2020 12:27 PM

$\Delta\vec{p} = \vec{F}_{net}\,t$ $\Delta\vec{p} = \vec{p}_f - \vec{p}_i$ $\Delta\vec{p} = m\vec{v}_f - m\vec{v}_i$

Physics 11 Unit 6 Momentum Name:

$\Delta\vec{p} = m\,\Delta\vec{v}$

Lesson 3 Multi-Step Momentum Questions $\Delta = f - i$

Ex. 1. A force of 8.0 N acts on an object for 10.0 s. The mass of the object is 4.0 kg. F t m

(a) What is the magnitude of the object's change in momentum?

$\Delta\vec{p} = \vec{F}t = 8(10) = 80.0 \text{ N}\cdot\text{s}$

b) What is the magnitude of the object's impulse?

$\Delta\vec{p} = 80 \text{ N}\cdot\text{s}$

(c) What is its change in velocity? $\Delta\vec{v}$

$\Delta\vec{p} = m\Delta\vec{v} \rightarrow \Delta\vec{v} = \frac{\Delta\vec{p}}{m} = \frac{80}{4} = +20 \text{ m/s}$

(d) If the final velocity was 12 m/s North, what was its initial velocity?

$v_i = 8 \text{ m/s South}$

Ex. 2. A snow scooter has a mass of 350.0 kg. A constant force acts upon it for 60.0 s. The scooter's initial velocity is 2.5 m/s and its final velocity is 18 m/s.

(a) What change in momentum does it undergo? $\Delta\vec{p} = m\Delta\vec{v}$

$\Delta\vec{p} = m\vec{v}_f - m\vec{v}_i = (350)(18) - 350(2.5)$

$\Delta\vec{p} = 5430 \text{ kg m/s}$

(b) What is the magnitude of the force which acts upon it?

$\Delta\vec{p} = \vec{F}\Delta t \rightarrow \vec{F} = \frac{\Delta\vec{p}}{t} = \frac{5425}{60} = 90.4 \text{ N}$

Ex. 3. A rocket of mass 2.6×10^4 kg starting from rest ($v_i = 0$) is acted upon by a net force of 2.3×10^4 N for 120 s. What is the final velocity of the rocket?

$$m\vec{v}_f - m\vec{v}_i = \vec{F}t$$

$$m\vec{v}_f = \frac{\vec{F}t}{m} = \frac{(2.3 \times 10^4)(120)}{2.6 \times 10^4} = 106 \text{ m/s}$$

Ex. 4. A car of mass 1600 kg moves at 32 m/s. What braking force is needed to bring the car to a halt in 1.6 s?

$$\vec{F}t = m\vec{v}_f - m\vec{v}_i$$

$$\vec{F} = \frac{-m\vec{v}_i}{t} = \frac{-(1600)(32)}{1.6} = -32000 \text{ N}$$

in opp. direction of v_i

Ex. 5. A 2.50 kg rock falls from the top of a 40.0 m high building and strikes the ground below. What is the force (magnitude and direction) of the ground acting on the rock if it comes to a stop in 0.350 seconds?

Ground

$$\vec{F}t = m\vec{v}_f - m\vec{v}_i$$

$$\vec{F} = \frac{-m\vec{v}_i}{t}$$

$$\vec{F} = \frac{-(2.5)(-28)}{.35} = 200 \text{ N}$$

Freefall

$v_f = ?$ $a = -9.8$ $v_i = 0$ $d = -40$

$$v_f^2 = v_i^2 + 2ad$$

$$v_f = \sqrt{2(-9.8)(-40)} = -28 \text{ m/s}$$

Ex. 6. A 4.20 kg ball moving at +4.65 m/s East hits a wall. The wall exerts a force on the ball of −350.0 N to the West for 0.0750 seconds. Find the final velocity (magnitude and direction) of the ball.

$\vec{F}t = m\vec{v}_f - m\vec{v}_i$

$\frac{\vec{F}t + m\vec{v}_i}{m} = \vec{v}_f$

$\vec{v}_f = \frac{(-350)(.075) + 4.2(4.65)}{4.2}$

$\vec{v}_f = -1.6 \text{ m/s} = 1.6 \text{ m/s West}$

Ex. 7. A rifle accelerates ~~12.0 gram~~ .012 kg bullets from rest to 250. m/s. The rifle barrel is about .85 metres long. Find a) the impulse acting on the bullet b) the force on the bullet

a) $\Delta\vec{p} = m\vec{v}_f - m\vec{v}_i = (.012)(250) = 3.0 \text{ kg m/s}$

b) ~~$\Delta\vec{p} = \vec{F}\Delta t$~~ $a = ?\ v_i = 0\ v_f = 250\ d = .85$

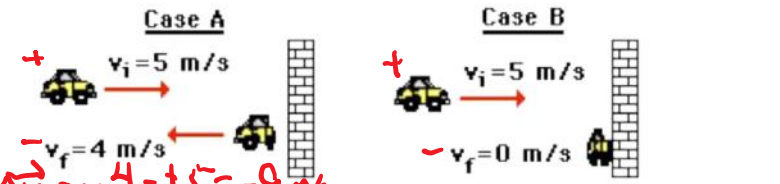
$v_f^2 = v_i^2 + 2ad$

$a = \frac{v_f^2 - v_i^2}{2d} = \frac{250^2 - 0^2}{2(.85)} = 36800 \text{ m/s}^2$

$\vec{F} = ma = (.012)(36800) = 441 \text{ N}$

Ex. 8. Consider the diagram at the right for the next three questions. The diagram depicts initial and final velocities of an 800-kg car in two different collisions with a wall. In case A, the car rebounds upon collision. In case B, the car hits the wall, crumples up and stops. Assume that the collision time for each collision is the same.

$\Delta\vec{p} = m\,\Delta\vec{v}$



$\Delta\vec{v} = -4 - 5 = -9$ m/s

$\Delta v = 0 - 5 = -5$ m/s

i.) In which case does the car experience the greatest momentum change?

a. Case A b. Case B c. Both the same d. Insufficient information

ii.) In which case does the car experience the greatest impulse?

a. Case A b. Case B c. Both the same d. Insufficient information

iii.) The impulse encountered by the 800-kg car in case A has a magnitude of ___ N·s.

800×-9

a. 0 b. 800 c. 3200 d. 4000 e. 7200

f. Not enough information to determine.

Ex. 9) Which type of collision is worse for a passenger? Assume the initial velocities and the time of impact are the same in each situation.

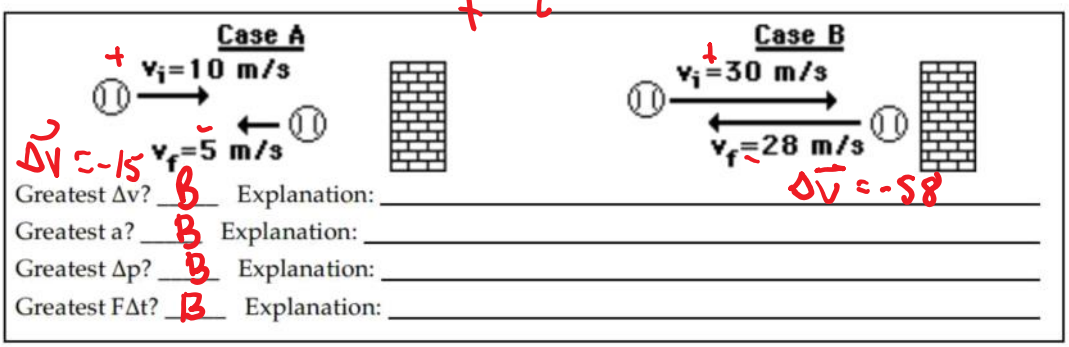
Some i) a head-on collision in which the two cars stick together

Some ii) a head-on collision in when the two cars rebound apart on impact

Explain your answer using principles of physics.

Situation (ii) has a larger change in velocity

Ex. 10) The diagram below depicts the changes in velocity of a ball that undergoes a collision with a wall. Indicate which case (A or B) has the greatest change in velocity, greatest acceleration, greatest momentum change, and greatest impulse. Support each answer. $\Delta\vec{v} = \vec{v}_f - \vec{v}_i$



Greatest Δv? B Explanation: _____

Greatest a? B Explanation: _____

Greatest Δp? B Explanation: _____

Greatest FΔt? B Explanation: _____

$a = \frac{\Delta\vec{v}}{t}$

Lesson 3 Homework:

A car with a mass of 1000 kg is at rest at a stoplight. When the light turns green, it is pushed forward by a net force of 2000 N for 10 s. For this question, assume **forwards = positive** and **backwards = negative**.

1. What is the value of the acceleration that the car experiences?

2. What is the value of the change in velocity that the car experiences?

3. What is the value of the impulse on the car?

4. What is the value of the change in momentum that the car experiences?

5. What is the final velocity of the car at the end of 10 seconds?

The car continues at this same speed for a while.

6. What is the value of the change in momentum the car experiences as it continues at this constant velocity?

7. What is the value of the impulse on the car as it continues at this constant velocity?

The brakes are applied to the car, causing it to come to rest in 4 s.

8. What is the value of the change in momentum that the car experiences?

9. What is the value of the impulse on the car?

10. What is the value of the force (average) that causes the car to stop?

11. What is the acceleration of the car as it stops?

(ans: 2 m/s^2, 20 m/s, 20000 Ns, 20000 kg m/s, 20 m/s, 0, 0, -20000 kg m/s, 20000 Ns backwards, 5000 N backwards, 5.0 m/s^2 backwards)

12. A 0.80-kg soccer ball experiences an impulse of 25 N•s in 0.25 s. Determine the momentum change of the soccer ball. (25 kg m/s)

13. A 1200-kg car is brought from 25 m/s to 10 m/s over a time period of 5.0 seconds. Determine the force experienced by the car. (3600 N backwards)

14. A 90-kg tight end moving at 9.0 m/s encounters a 400 N•s impulse. Determine the velocity change of the tight end. (4.44 m/s)

15. A 0.10-kg hockey puck decreases its speed from 40 m/s to 0 m/s in 0.025 s. Determine the force that it experiences. (160 N backwards)

16. Nasty! A 0.10-kg hockey puck is at rest. It encounters a force of 20 N East for 0.2 seconds that sets it into motion. Over the next 2.0 seconds, it encounters 0.4 Newtons of resistance force. Finally, it encounters a final force of 24 N for 0.05 seconds in the direction of motion. What is the final velocity of the hockey puck?

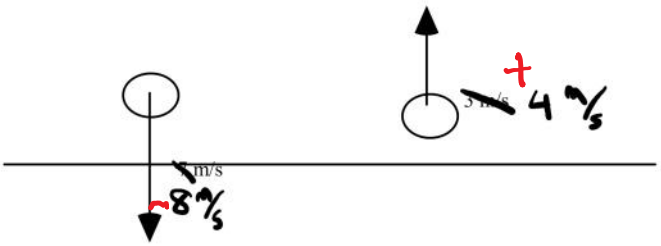
(44 m/s East)

17. (a) A 70.0 kg skier, moving at 20.0 m/s lets go of a towline. What impulse is needed to bring him to rest? (b) If the impulse is provided by the water, exerting an average force of 280 N on the skier, how long should this force act?
(1400 Ns backwards, 5.0 s)

18. How do seatbelts and air-bags protect car drivers in a collision?
(it's all about increasing t, so F decreases)

19. A rifle accelerates 15.0 gram bullets from rest to 200. m/s. The rifle barrel is about 1.20 metres long. Find a) the impulse acting on the bullet (3.00 kg m/s)
b) the force on the bullet (250 N)

20. Nasty! 75 marbles <u>per minute</u> roll off of a table and fall to the floor as shown below. When they hit the floor the 35.0 gram marbles are moving **<u>downwards</u>** at 8.00 m/s. They rebound **<u>upwards</u>** at 4.00 m/s. Find the force that the floor exerts on the marbles.



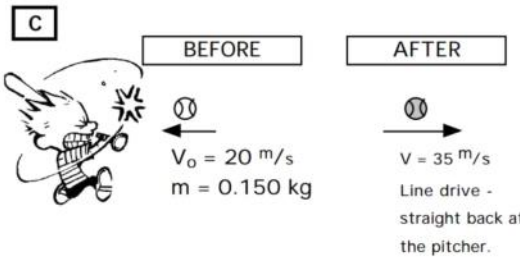
(0.525 N)

21. Find the impulse for each of the following situations:

B

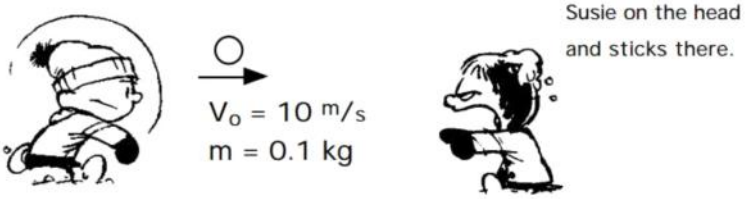
(ans: 4.5 kg m/s UP)

C



(ans: 8.25 kg m/s right)

D



(ans: 1.0 kg m/s LEFT)

22. A 0.095 kg tennis ball is traveling 40 m/s when it bounces of a wall and travels in the opposite direction it came from, with a speed of 30 m/s. A)What is the change in momentum of the ball? B) If the impact lasted 0.050 s, what is the average force the wall exerted on the ball? (ans: 6.65 kg m/s, 133 N)

23. A hockey puck is hit by a hockey player at the goalie. The puck is hit with a 3200 newton force. The stick made contact for 0.08 seconds. A) What impulse was given to the puck? B) If a goalie stopped it with a force that acts for 0.25 seconds, then what force did the goalie apply? (ans: 256 Ns, 1024 N)

I will email out solutions on Wednesday, and I'll include another "Whoa Wednesday" YouTube optional bonus assignment.

To access MyClass, email "myclass@sd42.ca" from your school district email address, and they can reset your password.