Lesson 3 Multi-Step Momentum Questions Solutions

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

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?

$a = \frac{F}{m} = \frac{2000}{1000} = 2.0\ m/s^2$ forward

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

$\Delta\vec{v} = \vec{v}_f - \vec{v}_i = 20 - 0 = \boxed{20\ m/s}$ $\left\{ v_f = v_i + at = 0 + 2(10) = 20 \right.$

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

$\Delta\vec{p} = m\Delta\vec{v} = (1000)(20) = 20{,}000\ kg\,m/s$

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

$\Delta\vec{p} = 20{,}000\ kg\,m/s$

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

$v_f = v_i + at = 0 + 2(10) = 20\ m/s$

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?

$\Delta\vec{p} = 0\ kg\,m/s$

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

$\Delta\vec{p} = 0\ kg\,m/s$

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?

$\Delta\vec{p} = \vec{p}_f - \vec{p}_i = 0 - (1000)(20) = -20{,}000\ kg\,m/s$

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

$\Delta\vec{p} = -20000\ kg\,m/s$

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

$\Delta\vec{p} = \vec{F}\Delta t \rightarrow \vec{F} = \frac{\Delta\vec{p}}{t} = \frac{-20000}{4} = -5000\ N$

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

$a = \frac{F}{m} = \frac{-5000}{1000} = -5\ m/s^2 = 5\ m/s$ 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)

$\Delta\vec{p} = 25\ N{\cdot}s$ or $25\ kg\,m/s$

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)

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

$\vec{F}t = m\vec{v}_f - m\vec{v}_i = (1200)(10) - 1200(25) = -3600\ N$

t $\quad 5$

OR 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)

$\frac{\vec{\Delta p}}{m} = \vec{\Delta v} \rightarrow \vec{\Delta v} = \frac{400}{90} = 4.44\ m/s$

~~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)

$\vec{F}t = m\vec{v}_f - m\vec{v}_i = \frac{.1(0) - .1(40)}{.025} = -160\ N$

OR 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)

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

$v_f = \frac{Ft}{m} = \frac{20(.2)}{.1}$

$v_f = 40\ m/s$

$v_i = 40\ m/s \quad t = 2$

$F = -.4\ N$

$Ft = mv_f - mv_i$

$\frac{Ft + mv_i}{m} = v_f$

$v_f = \frac{-.4(2) + (.1)(40)}{.1} = 32\ m/s$

$v_i = 32$

$v_f = \frac{Ft + mv_i}{m}$

$v_f = \frac{(24)(.05) + .1(32)}{.1}$

$v_f = 44\ m/s$ East

17) (a) A 70.0 kg skier, moving at 20.0 m/s (v_i) lets go of a towline. What impulse is needed to bring him to rest (v_f)? (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)

a) $\vec{\Delta p} = m\vec{v}_f - m\vec{v}_i = -70(20) = -1400\ kg\ m/s$

b) $\Delta\vec{p} = \vec{F}\Delta t \rightarrow t = \frac{\Delta\vec{p}}{F} = \frac{-1400}{-280} = 5.0\ s$

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

$\Delta\vec{p} = Ft$ as $t \uparrow$, $F \downarrow$

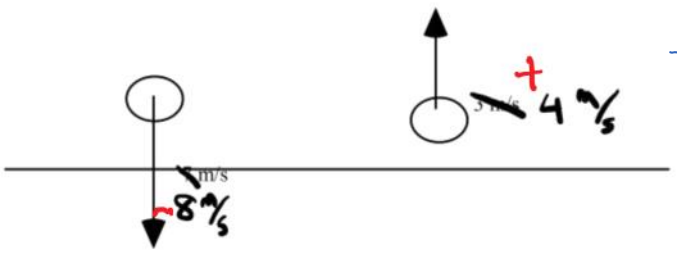
19. A rifle accelerates 15.0 gram bullets from rest to 200. m/s. The rifle barrel is about 1.20 metres long. Find a) the impulse acting on the bullet (3.00 kg m/s)
b) the force on the bullet (250 N)

a) $\Delta\vec{p} = m\vec{v}_f - m\vec{v}_i = (.015)(200) = 3.0\ kg\ m/s$ $\quad v_f^2 = v_i^2 + 2ad$

b) $\Delta p = Ft$ $\quad F = ma$ $\quad \leftarrow a = \frac{v_f^2 - v_i^2}{2d} = \frac{200^2 - 0^2}{2(1.2)} = 1.67 \times 10^4\ m/s^2$

$F = (.015)(1.67 \times 10^4) = 250\ N$

20. Nasty! 75 marbles per minute 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 **downwards** at 8.00 m/s. They rebound **upwards** at 4.00 m/s. Find the force that the floor exerts on the marbles.



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

t

$\vec{F} = \frac{(75 \times .035)(4) - (75 \times .035)(-8)}{60}$

$F = .525\ N$ up

(0.525 N)

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)

a) $\Delta\vec{p} = m\vec{v}_f - m\vec{v}_i = (.095)(30) - (.095)(-40) = 6.65\ kg\ m/s$

b) $Ft = \Delta\vec{p} \rightarrow \vec{F} = \frac{\Delta\vec{p}}{t} = \frac{6.65}{.05} = 133\ N$