

Impulse and Momentum

Honors Physics 2020/21

Change in Momentum = Impulse

1. If momentum changes then either mass or velocity or both changes.
2. If momentum changes but mass stays the same then velocity must change.
3. If velocity changes then an object is accelerating.
4. If an object accelerates then a Force must be acting on the object.
5. The greater the force the greater the velocity change and in turn the greater the momentum change.
6. But if a small force acts on an object over a long time you will also have a large momentum change.
7. So increasing Force or time will increase momentum change
8. Use Newton's second law to show how force and time affect change in momentum.

$$F = m \cdot a \quad \text{but} \quad a = \frac{\Delta v}{t}$$

$$F = m \cdot \frac{\Delta v}{t} \quad \text{we can multiply by time}$$

$$F \cdot t = m \cdot \Delta v = \Delta p$$

Force x time is what we call impulse

Impulse changes momentum

Like work changes energy

Which one has the least force of impact? They both come to a stop.

WHY is it better to hit a haystack than a brick wall? $\Delta p = m \cdot \Delta v$

$$\Delta p = m \cdot \Delta v = 1000 \cdot (20 - 0) = 20,000 \text{Ns}$$



time to stop = 0.25 seconds.

Use impulse to find force

$$F \cdot t = \Delta p$$

$$F \cdot (0.25) = 20,000$$

$$F = \frac{20000}{0.25} = 80,000 \text{N}$$

$$F \cdot t$$

time to stop = 3 seconds

$$F \cdot (3.0) = 20,000$$

$$F = \frac{20000}{3} = 6,667 \text{N}$$

$$F \cdot t$$

The force of impact hitting the haystack is reduced by the increased time of contact

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Impulse Mania

1. Explain why in terms of impulse and force of impact why now most new cars have air bags.

The air bags allow you to come to a stop over a longer time than if your face hit the steering which reduces the force of impact.

2. Explain why in terms of impulse, change in momentum, and velocity why tennis players, golfers, and baseball players "follow through" when hitting the ball.

By following through, you increase the contact time, therefore the force acts over a longer time and you have a greater change in momentum of the ball resulting in a higher velocity.

By not following through, the momentum change is less i.e. a bunt in baseball

3. Arnold Palmer strikes a resting golf ball (ball mass = .2kg) with his club. After impact, the ball takes off with a velocity of 50 m/s.

- a. What is the change in momentum of the golf ball? (10 kg m/s.)

$$p = m \cdot v = 0.2 \cdot 50 = 10 \cdot \text{Kg} \cdot \frac{\text{m}}{\text{s}}$$

- b. If Arnold applied 160N of force, how long was the time of contact between the ball and the club? 0.0625 s

since the ball started from rest where momentum was zero

Using impulse we know $F \cdot t = \Delta p$ $\Delta p =$ final momentum of the ball 10

$$160 \cdot t = 10 \quad t = \frac{10}{160} = 0.0625 \text{ s}$$

4. A 110 kg Dennis Rodman "The Worm" lands on a wooden gym floor at 15m/s. It took 0 .089 seconds to come to a complete stop after making contact with the floor.

- a. calculate the change in momentum:

Since we come to a stop $\Delta p = m \cdot \Delta v$

$$\Delta p = 110(15 - 0) = 1,650 \text{ Kg} \cdot \frac{\text{m}}{\text{s}}$$

- b. calculate the force of impact:

$$F \cdot (0.089) = 1,650$$

Using impulse $F \cdot t = \Delta p$

$$F = \frac{1650}{0.089} = 18,540 \cdot \text{N}$$

This time "The Worm" lands on a concrete floor. It takes him .041 seconds to come to a complete stop once he makes contact with the floor.

- c. calculate the force of impact:

$$F \cdot t = \Delta p$$

$$F \cdot 0.041 = 1,650$$

$$F = \frac{1650}{0.041} = 40,240 \cdot \text{N}$$

- d. Explain in terms of impulse and force why basketball courts are made of wood.

Basketballs are made of wood or other materials so that the force if impact on the players is less. The floor has a little "give" to it which increases the stopping time when landing and reduces the force. You should also notice that the track outside is made of a soft material to reduce impact for the runners.