

Automobile Safety



Millions of people die or are injured in vehicle accidents every year.

Automobile Crashes

Worldwide, almost 1.3 million people die in road accidents a year, which comes out to an average of 3,287 deaths per day. In the United States alone, more than 37,000 people die in traffic accidents. Automobile crashes injure or disable a further 20-50 million people worldwide and 2.35 million in the United States annually. While those are large numbers,

they would be larger without airbags and seat belts, which prevent additional deaths and injuries. Moving vehicles are dangerous because of the amount of **momentum** they possess.

What is Momentum?

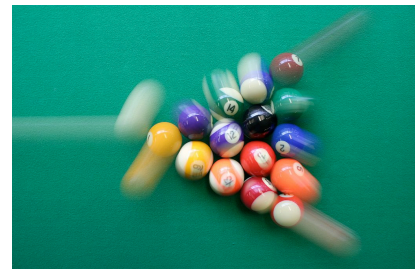
Momentum is a **vector quantity**, meaning that it has both **magnitude** (size) and direction. Simply put, it is the movement of **mass** (stuff) in a direction. Any object that is made of stuff and is moving has momentum. How much momentum an object possesses is determined by its mass and **velocity** (speed in a direction). In fact, momentum (p) is the product of mass (m) and velocity (v):

$$p = m \times v$$

A larger moving object has more momentum than a smaller moving object. However, a smaller moving object has more momentum than a stationary larger object. According to Newton's first law, unless an outside force acts upon a moving object, it will continue moving at the same speed and in the same direction (the same velocity). So, until a force acts on a moving object, it will keep its momentum.

When a moving object collides with another object, the force of the impact changes the velocity, and thus the momentum, of the moving object. However, the momentum of the moving object - we'll call it object A - combines with that of the other object - object B - because momentum is conserved. This means that the total momentum of the two objects doesn't change, but the individual momentums of each object do. So, if object A is a 1000-kg car traveling east at 20 m/s and object B is a 1000-kg car traveling west at 20 m/s, their momentums will combine to fully stop both cars. Thus, in an isolated system (one on which no external forces act):

$$p_{A1} + p_{B1} = p_{A2} + p_{B2}$$



The cue ball's momentum is transferred to the other balls when breaking at the beginning of a pool game.

The concept of conservation of momentum is used in pool as well as Newton's cradle desktop toys.

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How Do Airbags and Seat Belts Protect Passengers?

In order to minimize force, both airbags and seat belts lengthen the time over which the force is experienced. They accomplish this in different ways.

Airbags are nylon sacks coated with powder and folded into a compartment in the center of the steering wheel and the passenger-side dashboard. Some cars have additional side airbags in the seat and door. One end of the bag is attached to a small chamber with an explosive chemical and a heating element. An electrical circuit connects the heating element with a sensor that detects the vehicle's speed, and, by extension, any sudden deceleration. It is programmed to trigger the heating element when the vehicle decelerates at the rate it would upon impact with a brick wall from a speed of 16-24 km/hr (10-15



Airbags are inflatable nylon sacks.

mi/hr). The heating element ignites the explosive chemical, which blasts gas into the bag, rapidly inflating it. Airbags inflate at up to 322 km/hr (200 mi/hr), forcing off the plastic compartment cover and ballooning out in front of the steering wheel. Impact to inflation takes about 1/25 of a second. As mentioned previously, an object will remain in motion unless something stops it. When a vehicle crashes into something and stops, everything within the vehicle that isn't strapped down will continue moving at the original velocity of the vehicle. This includes passengers' heads. When a person hits the airbag, tiny holes in the fabric allow gas to escape slowly, lengthening the duration of the impact and reducing the force the person feels.

Seat belts

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How Effective Are Airbags and Seat belts?

A 2015 estimate suggests that frontal airbags save 29% of drivers and 30% of front-seat passengers (13 and older) in vehicle crashes. Seat belts reduce the likelihood of death by 45%. The combination of airbags and seat belts raises this number to 51%. It is estimated that frontal airbags had prevented 44,869 deaths by 2015. Side airbags saved 2,252 lives by 2012 and are most effective (in terms of reducing death risk) in sport utility vehicles (SUVs).

Reading Comprehension Questions:

1. How
2. How many people are injured or disabled in traffic accidents worldwide each year?
3. What is momentum?
4. What
5. What does Newton's first law tell us about momentum?
6. What
7. What
8. Simply, how do airbags and seat belts minimize force?
9. What
10. How do airbags lengthen the duration of impact?
11. What
12. By what

Extension Questions

13. Imagine you have a friend who doesn't like to wear their seat belt. What would you tell them? How would you explain the importance of seat belts? Use physics!
14. Think
15. Create a

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TWF READING

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