84 Decelerating Safely

READING

When a car crashes into something, the driver's and passengers' inertia keeps them moving forward until something stops their motion. Stopping or slowing motion is called **deceleration.** How a person in a car decelerates often determines the seriousness of that person's injuries. Most injuries and deaths occur when internal body parts, such as bones or brains, are decelerated very quickly by a large force.

CHALLENGE

How can a person's deceleration be controlled during a collision?

MATERIALS

For each student

1 Student Sheet 84.1, "Talking Drawing: Safety Features"

1 Student Sheet 84.2, "Three-Level Reading Guide: Decelerating Safely"

READING

Use Student Sheet 84.1, "Talking Drawing: Safety Features" and Student Sheet 84.2, "Three-Level Reading Guide: Decelerating Safely" to prepare yourself for the following reading.

Safety Features

To design safer cars, it is important to understand friction, forces, and deceleration. Many safety features help reduce the speed before impact, and other features help protect passengers during a collision. Automobile safety engineers use their knowledge of forces and motion to develop, and continue to improve, many safety features that help avoid accidents or reduce injuries in accidents.

Before the Accident

Driving on a worn-out tire is dangerous because there isn't enough friction between it and the road.

Two of the most important safety features of a car are its brakes and tires. Good tires and brakes help to avoid accidents by using friction to decelerate a car quickly, yet in a controlled way.

The friction between the tires and the road affects braking distance. The amount of this friction depends mostly on the contact area between the tire and the road, the material and tread design of the tire, the type and condition of the road surface, and the temperature of the tire. All new tires are rated for various aspects of safety.

The disc brakes commonly used on cars, like bicycle brakes, work because brake pads squeeze against the two sides of a rotating wheel. The friction between the brake pads and the wheel slows the rotation of the wheels. The larger the surface area of the brake pads, the more friction and, therefore, the greater the braking power. More braking power, however, is not always better.

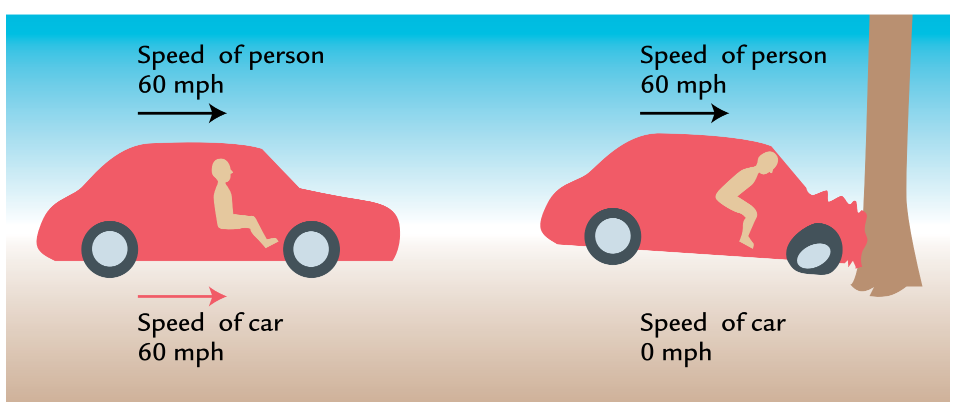
When a car's brakes clamp down so tightly that they "lock" the wheels, the tires stop rolling and begin to slide on the road. When this happens, the car skids, and the driver can lose control. In this situation there is actually less friction between the tires and the road than when the tires roll. To bring the car to a stop as quickly as possible, friction between the tires and road needs to be maximized. Antilock brake systems (sometimes referred to as ABS) automatically engage and release the brakes many times per second. During the moments when the brakes are released, the tires stop skidding and briefly roll. The overall amount of friction during the pulsing of the

A bicycle brake, above, uses friction between the brake pads and the wheel rim to stop or slow down. In the photo on the right, a mechanic inspects a brake. If the parts become too worn, they won't generate enough friction to stop the car quickly.

ABS brake is higher than if the tires were simply skidding. By maximizing the friction between the tire and the road, antilock brakes help a vehicle stop more quickly and with more control.

During the Accident

When a vehicle is moving, everything inside it, including the passengers, is moving at the same speed as the vehicle, as shown below left. When a vehicle collides with a solid object, the car stops quickly, but the inertia of the passengers keeps them moving forward until a force changes their motion and slows them down, as shown below right. If that force is from the steering wheel, dashboard, or windshield, the injuries are often very serious.

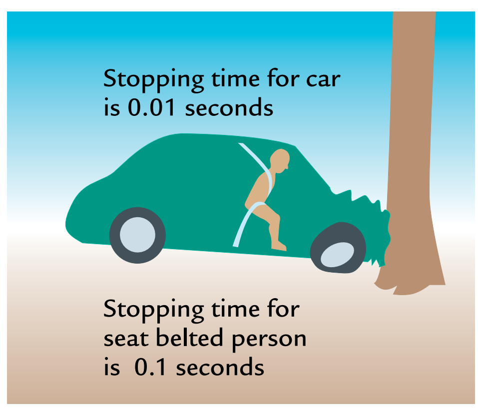


The stopping time of a seat-belted passenger may be up to ten times slower than the stopping time for the car.

Seat belts are designed to reduce the force that a passenger experiences. To reduce the force, seat belts increase the amount of time that it takes to decelerate the passenger. If it takes longer to come to a stop, the deceleration has been reduced. According to Newton's second law, a reduced acceleration (or in this case, deceleration) results in a reduced force:

$F = ma$	$F = ma$
Smaller deceleration (a) results in a smaller force (F)	Larger deceleration (a) results in a larger force (F)

For example, a car that hits a tree may take about 0.01 seconds from the moment of impact until it comes to a full stop. Without a seatbelt it may take the same amount of time for the driver to also stop. If the driver is wearing a seatbelt, the seatbelt will slow her or him down to a complete stop closer to 0.1 seconds. These time intervals may both seem very fast, but the passenger has taken 10 times longer to come to a stop than the car. This can reduce the maximum force between the seatbelt and the passenger to 1/10 that of the force between the car and the tree. If the driver is not wearing a seatbelt, he or she is likely to be decelerated with a force close to that applied to the car by the tree.



Like seatbelts, air bags also reduce the deceleration a person experiences during a collision. Air bags also help by spreading out the deceleration force over a large area. This reduces the pressure, or force per unit area, on the body. When a car hits a tree, if there is no air bag and the driver's forehead hits the steering wheel, the entire force needed to decelerate the driver is applied to the forehead. This pressure could be great enough to break the skull. With an air bag, the same force is needed to decelerate the

driver, but it is spread out evenly over the larger area of the driver's body—head, arms, shoulders, and chest—that hit the air bag. The pressure on any one part is much lower and much less likely to cause injuries. Seatbelts also reduce the pressure on the body by distributing force over the belt, but they have a smaller effect than air bags.

Other Safety Features

A well designed car has a strong occupant compartment, known as the safety cage. The safety cage is important because once it starts to collapse during a collision, the likelihood of injury increases rapidly. Crumple zones are sections in cars that are designed to crumple up when the car collides with something. In a collision, forces are directed to that section of the vehicle instead of being transmitted to the safety cage. Crumple zones increase the damage to the car but reduce the harm done to the occupants. Crumple zones, like air bags and seatbelts, make deceleration more gradual and spread out the area of impact. This can significantly reduce the force felt by the passengers.

Modern steering columns are designed to collapse, as this telescope can.

Cars have not always had as many safety features as today's vehicles. For example, it wasn't until the 1970s that steering wheels were made to be collapsible. Before then, steering wheels were attached to rigid steering columns. If a driver hit the steering wheel with enough force, the rigid steering column could push through the steering wheel and spear the driver. Today's cars have steering columns designed to collapse on impact like a ship captain's telescope. This reduces the chances of being speared. Similarly, headrests, padded dashboards, padded steering wheels, side impact beams, even plastic-covered car keys, and other devices must, by law, be built into new cars.

Safety features in vehicles have come a long way since the automobile was first invented. Although every new generation of cars has better safety features than the previous cars, even the most innovative designs are based on the understanding that passengers are best protected if they decelerate as slowly as possible and if the force is spread over the largest surface possible.

ANALYSIS

1. Choose one of the safety features described in the reading. Use the terms inertia, force, and deceleration to describe how the safety feature helps keep people safe in a collision.

2. As a collision is about to happen, if you had enough time to chose between hitting a large haystack or a telephone pole, which one would you choose to hit? Explain why in terms of force and deceleration.

3. In the accident mentioned in Activity 73, "Choosing a Safe Vehicle," Noah's family car had old tires that were worn down. Explain how this could have contributed to the car accident.

4. **Reflection:** Since the 1920s, the rate of fatalities per billion miles traveled has dropped steadily. However, the rate has been about the same for the past 20 years. Why do you think this is?