



Physics in the crumple zone demonstrate how less stiff materials, like plastic, can help prevent injury and save lives

plastics & autos

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- Crumple zones are structural areas in the front and sometimes rear of a vehicle that are designed to absorb energy upon impact in a predictable way.¹
- Crash test results from the National Highway Traffic Safety Administration's New Car Assessment Program (NCAP) indicate that occupant injury and fatality risk can be reduced by designing vehicles with softer front end structures resulting in larger "maximum crush," provided there is no intrusion.²
- Newton's first law states that an object in motion will stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force. As a result, if a vehicle is going 50mph, the bodies inside are as well, and if the vehicle hits a solid wall and comes to a stop immediately, the bodies will want to continue going in the same direction at 50mph.¹
- Passengers will continue to move forward at the same speed until they come in contact with a part of the automobile or another human being, causing injury. Even after a human body comes to a stop in an accident, its internal organs continue to move, slamming against each other because of the impact, often causing serious injury or death.³
- Newton's second law of motion, force = mass x acceleration, conveys that as the time it takes for an automobile to come to rest or change direction is increased, the force experienced by the automobile (and its occupants) is decreased. Conversely too, if the time to stop is shorter, the force experienced is greater.⁴ Crumple zones add time to the crash by absorbing energy.
- Crumple zones allow the front of the vehicle to crush like an accordion, absorbing some of the impact of the collision and giving some off in the form of heat and sound. The front of the vehicle effectively acts as a cushion that slows the time it takes for the vehicle to come to a complete stop, applying less force on passengers, which could help save their lives.¹
- When used in crumple zones, lightweight plastic components can help absorb energy and save vehicle weight at the same time. Located in the front crumple zone, the plastic fan/shroud reservoir of the 2000 Dodge Dakota and Durango saved 1.1 lbs./vehicle, while the plastic bumper beam of the Saturn VUE saved 2.5 lbs. in vehicle weight.⁵



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The front of this vehicle crumples to spread the force of the impact over a longer period of time. This energy absorption can keep passengers from experiencing the full force of the impact at once, protecting them from potentially serious injuries.

	<p>Solid Steel Block vs. Aluminum Can with Crumple Zone</p> <p>As the solid steel block collides with the wall, the wall exerts an equal and opposite force on the block, causing the car to rebound in an elastic manner, regaining nearly all of its initial kinetic energy and consequently experiencing a large force.⁴ For more detail on the crash pulse, see the next page.</p>
	<p>As an aluminum soda can (or a car with crumple zones) collides with a wall, it does not regain all of its initial kinetic energy. Instead, some of the kinetic energy is transferred into heat and sound energy, resulting in a smaller force experienced by the can. The action of crumple zones lessens the amount of force experienced by the can.⁴</p>



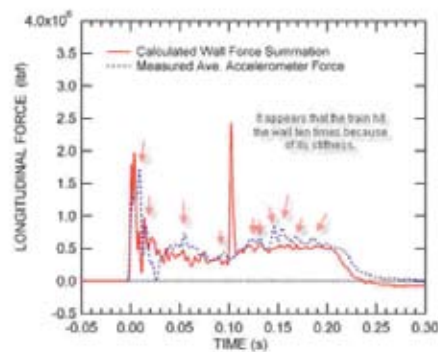
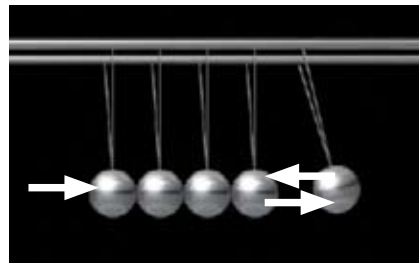
Energy absorption of a front crumple zone

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Additional Information

- “Prior to 1959, people believed the stronger the structure, the safer the car. But in actuality, such construction proved deadly to passengers, because the force from impact went straight inside the vehicle and onto the passenger.”⁶
- “Crumple zones with rigid cabs are now the standard in every car made throughout the world.”⁶
- A 1999 study by the Society of Automotive Engineers found that light trucks with 4 and 5 star ratings (lower risk of severe injury) have more maximum crush, lower maximum deceleration, and longer duration crash pulses than those with 1 and 2 star ratings (higher risk of severe injury).²
- In 1967, the Mercedes Heckflosse was the first production car in the world with “crumple zone” safety features including a safety cage with crumple zones and a trunk that had been made almost 50% bigger.¹

This illustration demonstrates how a force creates an equal and opposite force on this set of swinging balls.



These two illustrations show how an equal and opposite force can act in a collision, such as this train against this wall. Notice that although we think of a train in our experience as hitting the wall just once, by the measurements taken from the accelerometer once can see how the wall pushed back almost ten times during the collision event though it appears to stand still. This back and forth motion in a vehicle crash is called the crash pulse. The crash pulse shakes a crash dummy and from mechanical readings in a dummy we can infer the stress and damage a human body will sustain.

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Pictures

Crumple zone crash test: <http://www.k12.nf.ca/gc/Science/Physics3204/Projects2003/SlotA/ProjectA2/link20.htm>

Crash force diagram. Reproduced by Lindsay Pack. Original idea: <http://autoracing1.com/MarkC/2001/0226CrumpleZones.htm>

Crumple zone see-through: <http://www.blonnet.com/iw/2005/01/16/stories/2005011600081500.htm>

Newton's cradle: http://www.6moons.com/audioreviews/equarack2/equarack__2.html

Train and crash force graph: http://www.ara.com/arasvo/crash_figs1.htm

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