FACT SHEET

Module 2.1 How Seat Belts Work

Crash Concepts

The basic idea of a seatbelt is very simple: It keeps you from flying through the windshield or hurdling toward the dashboard when your car comes to an abrupt stop. But why would this happen in the first place? In short, because of inertia. Inertia is an object's tendency to keep moving until something else works against this motion. To put it another way, inertia is every object's resistance to changing its speed and direction of travel. Things naturally want to keep going.

If a car is speeding along at 50 miles per hour, inertia wants to keep it going 50 mph in one direction. Air resistance and friction with the road are constantly slowing it down, but the engine's power compensates for this energy loss.

Anything that is in the car, including the driver and passengers, has its own inertia, which is separate from the car's inertia. The car **accelerates** riders to its speed. Imagine that you're coasting at a steady 50 miles per hour. Your speed and the car's speed are pretty much equal, so you feel like you and the car are moving as a single unit.

But if the car were to crash into a telephone pole, it would be obvious that your inertia and the car's were absolutely independent. The force of the pole would bring the car to an abrupt stop, but your speed would remain the same. Without a seatbelt, you would either slam into the steering wheel at 50 miles per hour or go flying through the windshield at 50 miles per hour. Just as the pole slowed the car down, the dashboard, windshield or the road would slow you down by exerting a tremendous amount of force.

It is a given that no matter what happens in a crash, *something* would have to exert force on you to slow you down. But depending on where and how the force is applied, you might be killed instantly or you might walk away from the damage unscathed.

If you hit the windshield with your head, the stopping power is concentrated on one of the most vulnerable parts of your body. It also stops you very quickly, since the glass is a hard surface. This can easily kill or severely injure a person.

A seatbelt applies the stopping force to more durable parts of the body over a longer period of time. In the next section, we'll see how this reduces the chances of major injury.

Taking a Hit

In the last section, we saw that any time a car comes to a sudden stop, a passenger comes to a sudden stop as well. A seatbelt's job is to **spread the stopping force** across sturdier parts of your body in order to minimize damage.

A typical seatbelt consists of a **lap belt**, which rests over your pelvis, and a **shoulder belt**, which extends across your chest. The two belt sections are tightly secured to the frame of the car in order to hold passengers in their seats.

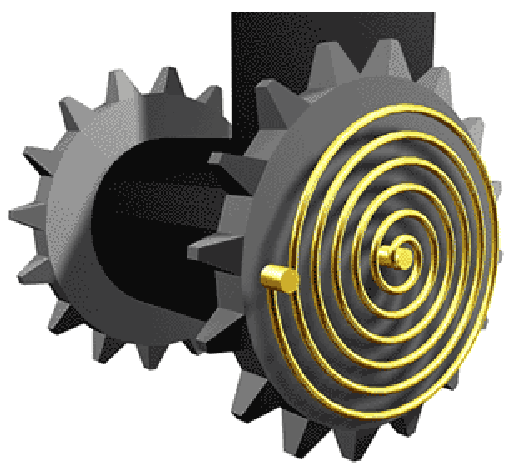
When the belt is worn correctly, it will apply most of the stopping force to the rib cage and the pelvis, which are relatively sturdy parts of the body. Since the belts extend across a wide section of your body, the force isn't concentrated in a small area, so it can't do as much damage. Additionally, the seatbelt **webbing** is made of more flexible material than the dashboard or windshield. It stretches a little bit, which means the stop isn't quite so abrupt. The seatbelt shouldn't give more than a little, however, or you might bang into the steering wheel or side window. Safe seatbelts will only let you shift forward slightly.

A car's **crumple zones** do the real work of softening the blow. Crumple zones are areas in the front and rear of a car that collapse relatively easily. Instead of the entire car coming to an abrupt stop when it hits an obstacle, it absorbs some of the impact force by flattening, like an empty soda can. The car's cabin is much sturdier, so it does not crumple around the passengers. It continues moving briefly, crushing the front of the car against the obstacle. Of course, crumple zones will only protect you if you move with the cab of the car -- that is, if you are secured to the seat by your seatbelt.

The simplest sort of seatbelt, found in some roller coasters, consists of a length of webbing bolted to the body of the vehicle. These belts hold you tightly against the seat at all times, which is very safe but not particularly comfortable.
Car seatbelts have the ability to **extend and retract** -- you can lean forward easily while the belt stays fairly taut. But in a collision, the belt will suddenly tighten up and hold you in place. In the next section, we'll look at the machinery that makes all this possible.

Extend and Retract

In a typical seatbelt system, the belt webbing is connected to a **retractor mechanism**. The central element in the retractor is a spool, which is attached to one end of the webbing. Inside the retractor, a spring applies a rotation force, or **torque**, to the spool. This works to rotate the spool so it winds up any loose webbing.

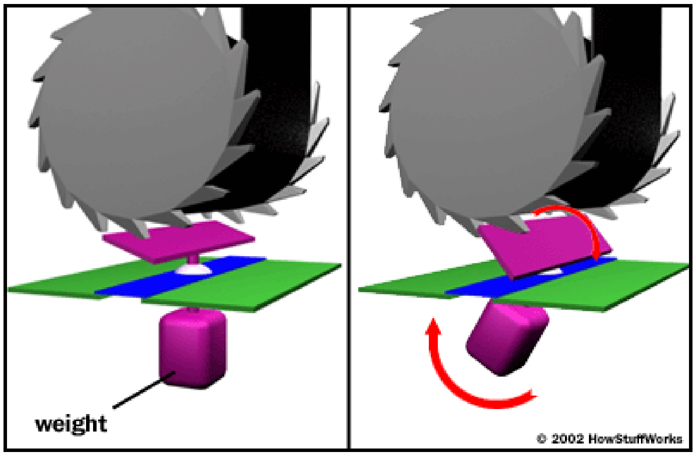


When you pull the webbing out, the spool rotates counter-clockwise, which turns the attached spring in the same direction. Effectively, the rotating spool works to **untwist** the spring. The spring wants to return to its original shape, so it resists this twisting motion. If you release the webbing, the spring will tighten up, rotating the spool clockwise until there is no more slack in the belt.

The retractor has a **locking mechanism** that stops the spool from rotating when the car is involved in a collision. There are two sorts of locking systems in common use today:

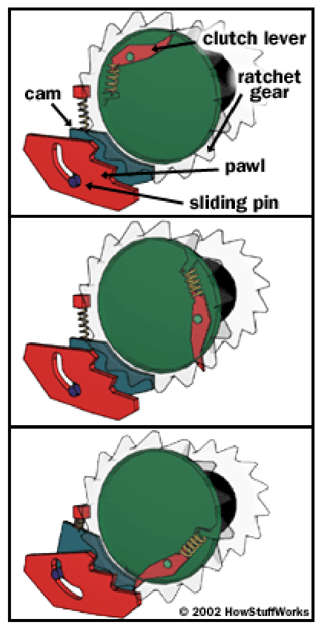
- systems **triggered by the car's movement**
- systems **triggered by the belt's movement**

The first sort of system locks the spool when the car rapidly **decelerates** (when it hits something, for example). The diagram below shows the simplest version of this design.



The central operating element in this mechanism is a **weighted pendulum**. When the car comes to a sudden stop, the inertia causes the pendulum to swing forward. The **pawl** on the other end of the pendulum catches hold of a toothed **ratchet gear** attached to the spool. With the pawl gripping one of its teeth, the gear can't rotate counter-clockwise, and neither can the connected spool. When the webbing loosens again after the crash, the gear rotates clockwise and the pawl disengages.

The second kind of system locks the spool when something **jerks the belt webbing**. The activating force in most designs is the speed of the spool rotation. The diagram shows a common configuration.



The central operating element in this design is a **centrifugal clutch** -- a weighted pivoting lever mounted to the rotating spool. When the spool spins slowly, the lever doesn't pivot at all. A spring keeps it in position. But when something yanks the webbing, spinning the spool more quickly, **centrifugal force** drives the weighted end of the lever outward.

The extended lever pushes a **cam** piece mounted to the retractor housing. The cam is connected to a pivoting pawl by a sliding pin. As the cam shifts to the left, the pin moves along a groove in the pawl. This pulls the pawl into the spinning ratchet gear attached to the spool. The pawl locks into the gear's teeth, preventing counter-clockwise rotation.

In some newer seatbelt systems, a **pretensioner** also works to tighten the belt webbing.

Source: http://auto.howstuffworks.com/