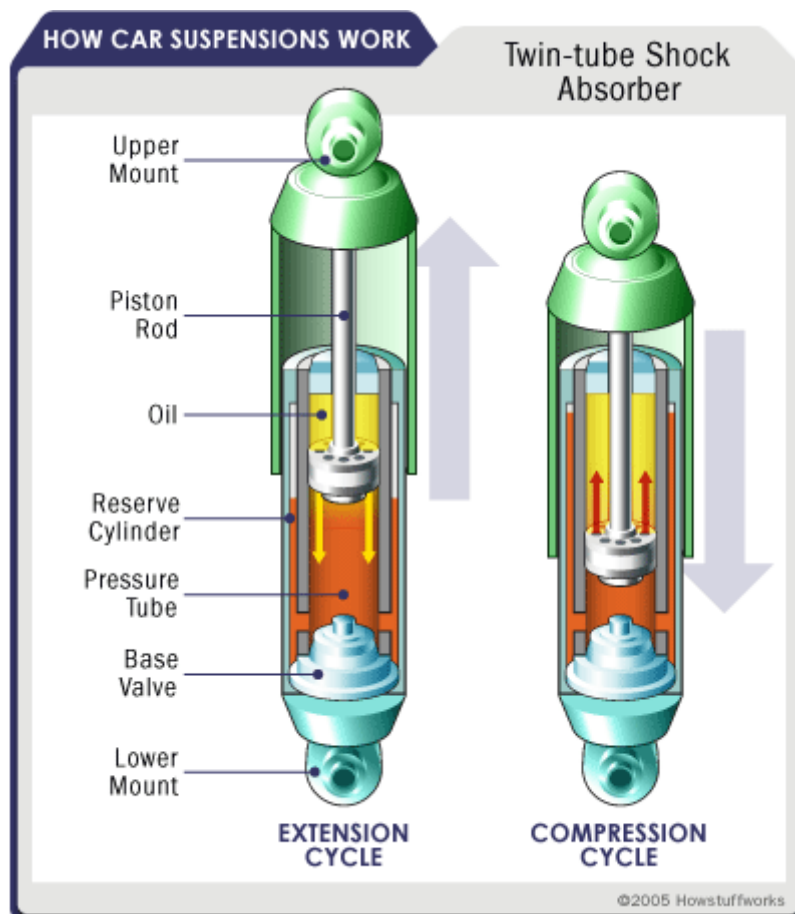


Dampers: Shock Absorbers

by William Harris

Unless a dampening structure is present, a car spring will extend and release the energy it absorbs from a bump at an uncontrolled rate. The spring will continue to bounce at its natural frequency until all of the energy originally put into it is used up. A suspension built on springs alone would make for an extremely bouncy ride and, depending on the terrain, an uncontrollable car.

Enter the shock absorber, or snubber, a device that controls unwanted spring motion through a process known as dampening. Shock absorbers slow down and reduce the magnitude of vibratory motions by turning the kinetic energy of suspension movement into heat energy that can be dissipated through hydraulic fluid. To understand how this works, it's best to look inside a shock absorber to see its structure and function.



A shock absorber is basically an oil pump placed between the frame of the car and the wheels. The upper mount of the shock connects to the frame (i.e., the sprung weight), while the lower mount connects to the axle, near the wheel (i.e., the unsprung weight). In a twin-tube design, one of the most common types of shock absorbers, the upper mount is connected to a piston rod, which in turn is connected to a piston, which in turn sits in a tube filled with hydraulic fluid. The inner tube is known as the pressure tube, and the outer tube is known as the reserve tube. The reserve tube stores excess hydraulic fluid.

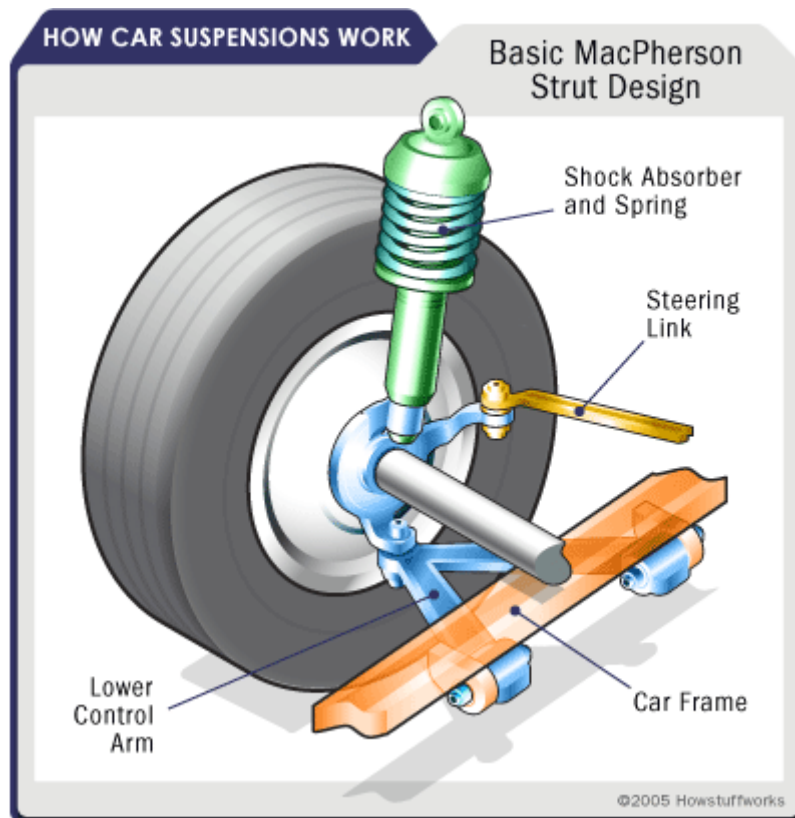
When the car wheel encounters a bump in the road and causes the spring to coil and uncoil, the energy of the spring is transferred to the shock absorber through the upper mount, down through the piston rod and into the piston. Orifices perforate the piston and allow fluid to leak through as the piston moves up and down in the pressure tube. Because the orifices are relatively tiny, only a small amount of fluid, under great pressure, passes through. This slows down the piston, which in turn slows down the spring.

Shock absorbers work in two cycles -- the compression cycle and the extension cycle. The compression cycle occurs as the piston moves downward, compressing the hydraulic fluid in the chamber below the piston. The extension cycle occurs as the piston moves toward the top of the pressure tube, compressing the fluid in the chamber above the piston. A typical car or light truck will have more resistance during its extension cycle than its compression cycle. With that in mind, the compression cycle controls the motion of the vehicle's unsprung weight, while extension controls the heavier, sprung weight.

All modern shock absorbers are velocity-sensitive -- the faster the suspension moves, the more resistance the shock absorber provides. This enables shocks to adjust to road conditions and to control all of the unwanted motions that can occur in a moving vehicle, including bounce, sway, brake dive and acceleration squat.

Dampers: Struts and Anti-sway Bars

Another common dampening structure is the strut -- basically a shock absorber mounted inside a coil spring. Struts perform two jobs: They provide a dampening function like shock absorbers, and they provide structural support for the vehicle suspension. That means struts deliver a bit more than shock absorbers, which don't support vehicle weight -- they only control the speed at which weight is transferred in a car, not the weight itself.



Common strut design

Because shocks and struts have so much to do with the handling of a car, they can be considered critical safety features. Worn shocks and struts can allow excessive vehicle-weight transfer from side to side and front to back. This reduces the tire's ability to grip the road, as well as handling and braking performance.

Anti-sway Bars

Anti-sway bars (also known as anti-roll bars) are used along with shock absorbers or struts to give a moving automobile additional stability. An anti-sway bar is a metal rod that spans the entire axle and effectively joins each side of the suspension together.

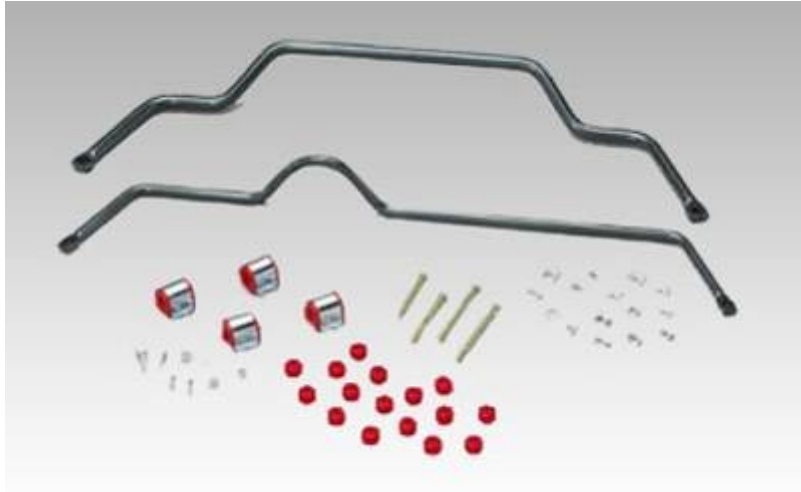


Photo courtesy HSW Shopper
Anti-sway bars

When the suspension at one wheel moves up and down, the anti-sway bar transfers movement to the other wheel. This creates a more level ride and reduces vehicle sway. In particular, it combats the roll of a car on its suspension as it corners. For this reason, almost all cars today are fitted with anti-sway bars as standard equipment, although if they're not, kits make it easy to install the bars at any time.

Suspension Types: Front

So far, our discussions have focused on how springs and dampers function on any given wheel. But the four wheels of a car work together in two independent systems -- the two wheels connected by the front axle and the two wheels connected by the rear axle. That means that a car can and usually does have a different type of suspension on the front and back. Much is determined by whether a rigid axle binds the wheels or if the wheels are permitted to move independently. The former arrangement is known as a dependent system, while the latter arrangement is known as an independent system. In the following sections, we'll look at some of the common types of front and back suspensions typically used on mainstream cars.

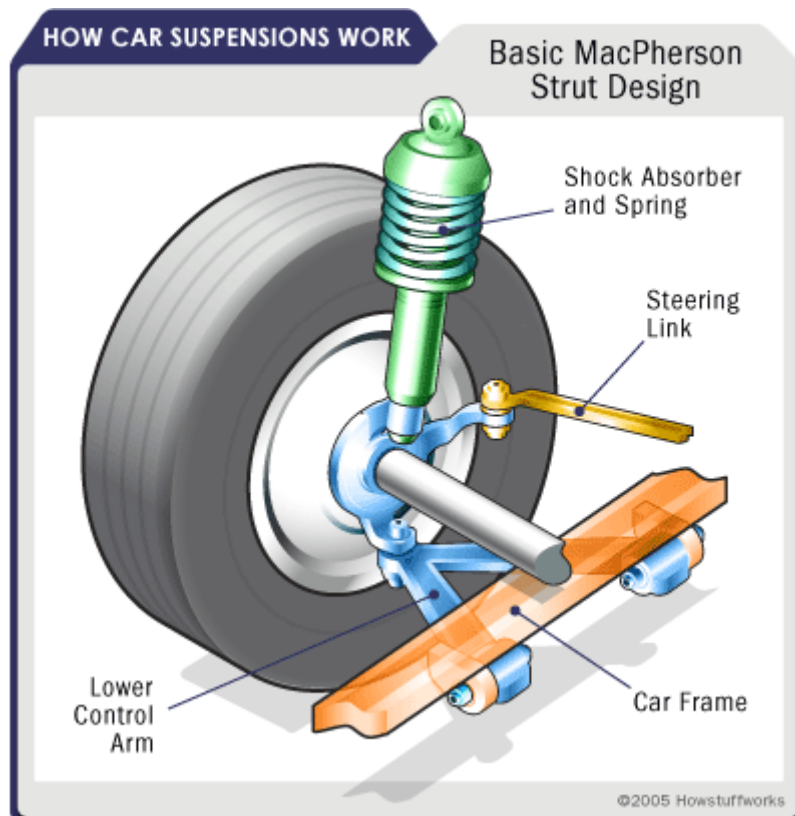
Dependent Front Suspensions

Dependent front suspensions have a rigid front axle that connects the front wheels. Basically, this looks like a solid bar under the front of the car, kept in place by leaf springs and shock

absorbers. Common on trucks, dependent front suspensions haven't been used in mainstream cars for years.

Independent Front Suspensions

In this setup, the front wheels are allowed to move independently. The MacPherson strut, developed by Earle S. MacPherson of General Motors in 1947, is the most widely used front suspension system, especially in cars of European origin.



The MacPherson strut combines a shock absorber and a coil spring into a single unit. This provides a more compact and lighter suspension system that can be used for front-wheel drive vehicles.

The double-wishbone suspension, also known as an A-arm suspension, is another common type of front independent suspension.



Photo courtesy Honda Motor Co., Ltd.

Double-wishbone suspension on Honda Accord 2005 Coupe

While there are several different possible configurations, this design typically uses two wishbone-shaped arms to locate the wheel. Each wishbone, which has two mounting positions to the frame and one at the wheel, bears a shock absorber and a coil spring to absorb vibrations. Double-wishbone suspensions allow for more control over the camber angle of the wheel, which describes the degree to which the wheels tilt in and out. They also help minimize roll or sway and provide for a more consistent steering feel. Because of these characteristics, the double-wishbone suspension is common on the front wheels of larger cars.

Now let's look at some common rear suspensions.

Suspension Types: Rear

Dependent Rear Suspensions

If a solid axle connects the rear wheels of a car, then the suspension is usually quite simple -- based either on leaf spring or a coil spring. In the former design, the leaf springs clamp directly to the drive axle. The ends of the leaf springs attach directly to the frame, and the shock absorber is attached at the clamp that holds the spring to the axle. For many years, American car manufacturers preferred this design because of its simplicity.



Photo
courtesy HowStuffWorks
Shopper
Leaf spring

The same basic design can be achieved with coil springs replacing the leaves. In this case, the spring and shock absorber can be mounted as a single unit or as separate components. When they're separate, the springs can be much smaller, which reduces the amount of space the suspension takes up.

Independent Rear Suspensions

If both the front and back suspensions are independent, then all of the wheels are mounted and sprung individually, resulting in what car advertisements tout as "four-wheel independent suspension." Any suspension that can be used on the front of the car can be used on the rear, and versions of the front independent systems described in the previous section can be found on the rear axles. Of course, in the rear of the car, the steering rack -- the assembly that includes the pinion gear wheel and enables the wheels to turn from side to side -- is absent. This means that rear independent suspensions can be simplified versions of front ones, although the basic principles remain the same.