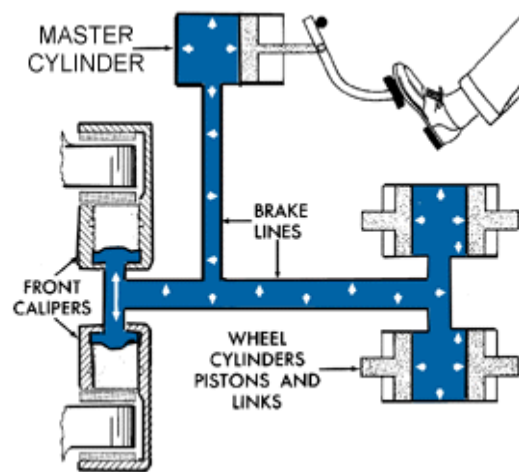
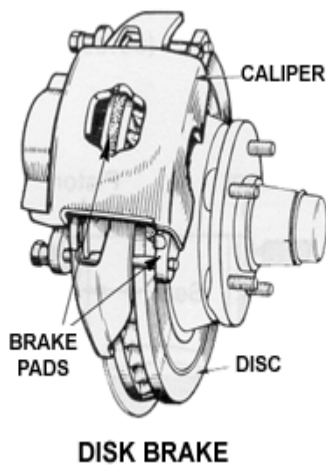
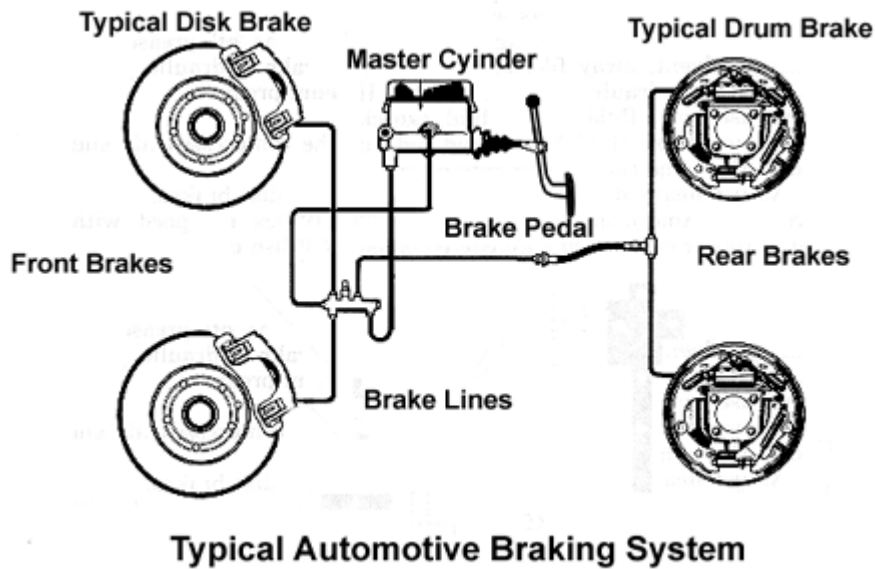


A SHORT COURSE ON BRAKES



The modern automotive brake system has been refined for over 100 years and has become extremely dependable and efficient.

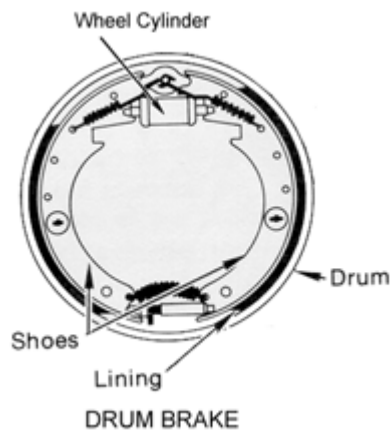
The typical brake system consists of Disk Brakes in front and either **disk** or Drum Brakes in the rear connected by a system of tubes and hoses that link the brake at each wheel to the master cylinder. Other systems that are connected with the brake system include the parking brake, power brake booster and the anti-lock system.

When you step on the brake pedal, you are actually pushing against a plunger in the master cylinder which forces hydraulic oil (brake fluid) through a series of tubes and hoses to the braking unit at each wheel. Since hydraulic fluid (or any fluid for that matter) cannot be compressed, pushing fluid through a pipe is just like pushing a steel bar through a pipe. Unlike a steel bar, however, fluid can be directed through many twists and turns on its way to its destination, arriving with the exact same motion and pressure that it started with. It is very important that the fluid is pure liquid and that there are no air bubbles in it. Air can compress, which causes a sponginess to the pedal and severely reduced braking efficiency. If air is suspected, then the system must be bled to remove the air. There are "bleeder screws" at each wheel cylinder and caliper for this purpose.

On a disk brake, the fluid from the master cylinder is forced into a caliper where it presses against a

piston. The piston, in-turn, squeezes two brake pads against the disk (rotor) which is attached to the wheel, forcing it to slow down or stop.

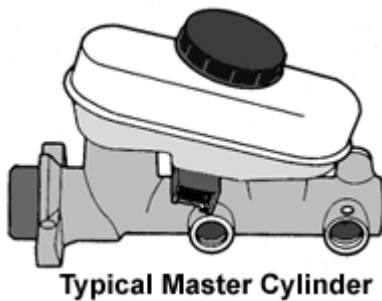
This process is similar to a bicycle brake where two rubber pads rub against the wheel rim creating friction.



With drum brakes, fluid is forced into the wheel cylinder which pushes the brake shoes out so that the friction linings are pressed against the drum which is attached to the wheel, causing the wheel to stop.

In either case, the friction surfaces of the pads on a disk brake system, or the shoes on a drum brake convert the forward motion of the vehicle into heat. Heat is what causes the friction surfaces (linings) of the pads and shoes to eventually wear out and require replacement.

Let's take a closer look at each of the components in a brake system and see where other problems can occur...



Master Cylinder

The master cylinder is located in the engine compartment on the firewall, directly in front of the driver's seat. A typical master cylinder is actually two completely separate master cylinders in one housing, each handling two wheels. This way if one side fails, you will still be able to stop the car. The brake warning light on the dash will light if either side fails, alerting you to the problem. Master cylinders have become very reliable and rarely malfunction; however, the most common problem that they experience is an internal leak.

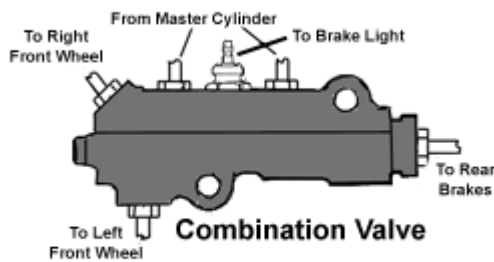
This will cause the brake pedal to slowly sink to the floor when your foot applies steady pressure. Letting go of the pedal and immediately stepping on it again brings the pedal back to normal height.

Brake Fluid

Brake fluid is a special oil that has specific properties. It is designed to withstand cold temperatures without thickening as well as very high temperatures without boiling. (If the brake fluid should boil, it will cause you to have a spongy pedal and the car will be hard to stop.) Brake fluid must meet standards that are set by the Department of Transportation(DOT). The current standard is DOT-3 which has a boiling point of 460° F. But check your owners manual to see what your vehicle manufacturer recommends.

The brake fluid reservoir is on top of the master cylinder. Most cars today have a transparent reservoir so that you can see the level without opening the cover. The brake fluid level will drop slightly as the brake pads wear. This is a normal condition and no cause for concern. If the level drops noticeably over a short period of time or goes down to about two thirds full, have your brakes checked as soon as possible. Keep the reservoir covered except for the amount of time you need to fill it and never leave a can of brake fluid uncovered. Brake fluid must maintain a very high boiling point .Exposure to air will cause the fluid to absorb moisture which will lower that boiling point.

NEVER PUT ANYTHING BUT APPROVED BRAKE FLUID IN YOUR BRAKES. ANYTHING ELSE CAN CAUSE SUDDEN BRAKE FAILURE! Any other type of oil or other fluid will react with the brake fluid and very quickly destroy the rubber seals in the brake system.



Brake Lines

The brake fluid travels from the master cylinder to the wheels through a series of steel tubes and reinforced rubber hoses. Rubber hoses are only used in places that require flexibility, such as at the front wheels, which move up and down as well as steer. The rest of the system uses non-corrosive seamless steel tubing with special fittings at all attachment points. If a steel line requires a repair, the best procedure is to replace the complete line. If this is not practical, a line can be repaired using special splice fittings that are made for brake system repair.

You must **never** use brass "compression" fittings or copper tubing to repair a brake system. They are dangerous and illegal.

Other Components in the Hydraulic System

- Proportioning valve or Equalizer Valve**
 These valves are mounted between the master cylinder and the rear wheels. They are designed to adjust the pressure between the front and rear brakes depending on how hard you are stopping. The shorter you stop, the more of the vehicle's weight is transferred to the front wheels, in some cases, causing the rear to lift and the front to dive. These valves are designed to direct more pressure to the front and less pressure to the rear the harder you stop. This minimizes the chance of premature lockup at the rear wheels.
- Pressure Differential Valve**
 This valve is usually mounted just below the master cylinder and is responsible for turning the brake warning light on when it detects a malfunction. It measures the pressure from the two sections of the master cylinder and compares them. Since it is mounted ahead of the proportioning or equalizer valve, the two pressures it detects should be equal. If it detects a difference, it means that there is probably a brake fluid leak somewhere in the system.
- Combination Valve**
 The Combination valve is simply a proportioning valve and a pressure differential valve that is combined into one unit.

Disk Brakes



Brake Pads
(Disc Brakes)

The disk brake is the best brake we have found so far. Disk brakes are used to stop everything from cars to locomotives and jumbo jets. Disk brakes wear longer, are less affected by water, are self adjusting, self cleaning, less prone to grabbing or pulling and stop better than any other system around. The main components of a disk brake are the **Brake Pads**, **Rotor**, **Caliper** and **Caliper Support**

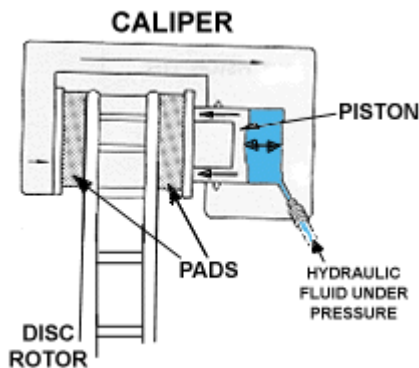
Brake Pads

There are two brake pads on each caliper. They are constructed of a metal "shoe" with the lining riveted or bonded to it. The pads are mounted in the caliper, one on each side of the rotor. Brake linings used to be made of asbestos because of its heat absorbing properties and quiet operation; however, due to health risks, asbestos has been so new materials are now being used. Brake pads wear out with use and must be replaced periodically. There are many types and qualities of pads available. The differences have to do with brake life (how long the new pads will last) and noise (how quiet they are when you step on the brake). Harder linings tend to last longer and stop better under heavy use but they may produce an irritating squeal when they are applied. Technicians that work on brakes usually have a favorite pad that gives a good compromise that their customers can live with.

Brake pads should be checked for wear periodically. If the lining wears down to the metal brake shoe, then you will have a "Metal-to-Metal" condition where the shoe rubs directly against the rotor causing severe damage and loss of braking efficiency. Some brake pads come with a "brake warning sensor" that will emit a squealing noise when the pads are worn to a point where they should be changed. This noise will usually be heard when your foot is **off** the brake and disappear when you step **on** primarily of asbestos because of its heat absorbing properties and quiet operation; however, due to health risks, asbestos has been so new materials are now being used. Brake pads wear out with use and must be replaced periodically. There are many types and qualities of pads available. The differences have to do with brake life (how long the new pads will last) and noise (how quiet they are when you step on the brake). Harder linings tend to last longer and stop better under heavy use but they may produce an irritating squeal when they are applied. Technicians that work on brakes usually have a favorite pad that gives a good compromise that their customers can live with.

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Rotor

The disk rotor is made of iron with highly machined surfaces where the brake pads contact it. Just as the brake pads wear out over time, the rotor also undergoes some wear, usually in the form of ridges and grooves where the brake pad rubs against it. This wear pattern exactly matches the wear pattern of the pads as they seat themselves to the rotor. When the pads are replaced, the rotor must be machined smooth to allow the new pads to have an even contact surface to work with.

Only a small amount of material can be machined off of a rotor before it becomes unusable and must be replaced. A minimum thickness measurement is stamped on every rotor and the technician doing the brake job will measure the rotor before and after machining it to make sure it doesn't go below the legal minimum. If a rotor is cut below the minimum, it will not be able to handle the high heat that brakes normally generate. This will cause the brakes to "fade," greatly reducing their effectiveness to a point where you may not be able to stop!

Caliper & Support

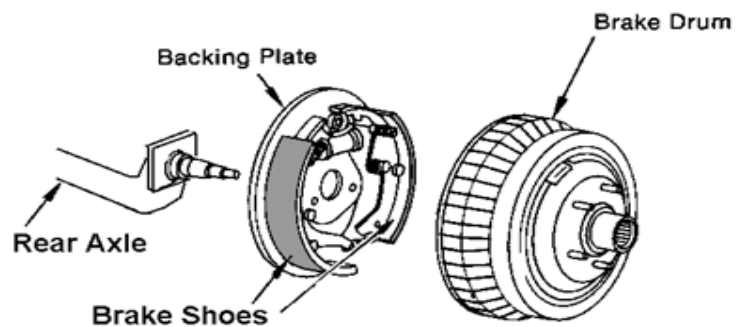
There are two main types of calipers: Floating calipers and fixed calipers. There are other configurations but these are the most popular. Calipers must be rebuilt or replaced if they show signs of leaking brake fluid.

Single Piston Floating Calipers are the most popular and also least costly to manufacture and service. A floating caliper "floats" or moves in a track in its support so that it can center itself over the rotor. As you apply brake pressure, the hydraulic fluid pushes in two directions. It forces the piston against the inner pad which in turn pushes against the rotor. It also pushes the caliper in the opposite direction against the outer pad, pressing it against the other side of the rotor. Floating calipers are also available on some vehicles with two pistons mounted on the same side. Two piston floating calipers are found on more expensive cars and can provide an improved braking "feel".

Four Piston Fixed Calipers are mounted rigidly to the support and are not allowed to move. Instead, there are two pistons on each side that press the pads against the rotor. Four piston calipers have a better feel and are more efficient, but are more expensive to produce and cost more to service. This type of caliper is usually found on more expensive luxury and high performance cars.

Drum Brakes

So if disk brakes are so great, how come we still have cars with drum brakes? The reason is cost. While all vehicles produced for many years have disk brakes on the front, drum brakes are cheaper to produce for the rear wheels. The main reason is the parking brake system. On drum brakes, adding a parking brake is the simple addition of a lever, while on disk brakes,



we need a complete mechanism, in some cases, a complete mechanical drum brake assembly inside the disk brake rotor! Parking brakes must be a separate system that does not use hydraulics. It must be totally mechanical, but more on parking brakes later.

Drum brakes consist of a **backing plate, brake shoes, brake drum, wheel cylinder, return springs** and an **automatic or self-adjusting system**. When you apply the brakes, brake fluid is forced, under pressure, into the wheel cylinder which, in turn, pushes the brake shoes into contact with the machined surface on the inside of the drum. When the pressure is released, return springs pull the shoes back to their rest position. As the brake linings wear, the shoes must travel a greater distance to reach the drum. When the distance reaches a certain point, a self-adjusting mechanism automatically reacts by adjusting the rest position of the shoes so that they are closer to the drum.

Brake Shoes

Like the disk pads, brake shoes consist of a steel shoe with the friction material or lining riveted or bonded to it. Also like disk pads, the linings eventually wear out and must be replaced. If the linings are allowed to wear through to the bare metal shoe, they will cause severe damage to the brake drum.

Backing Plate

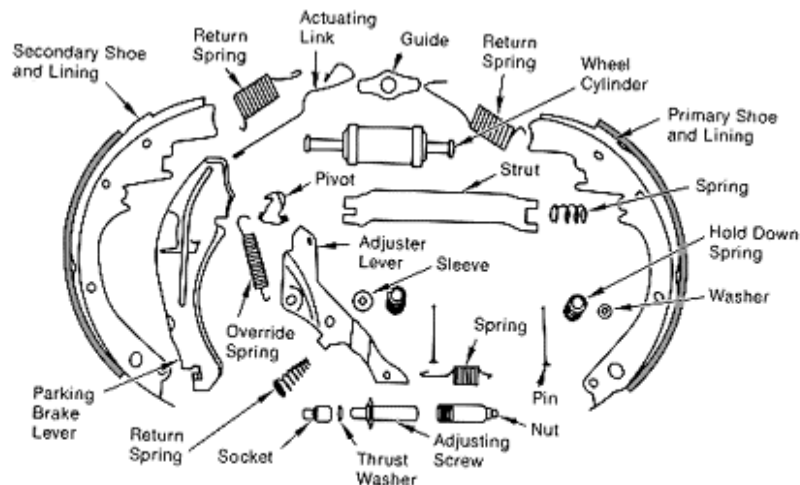
The backing plate is what holds everything together. It attaches to the axle and forms a solid surface for the wheel cylinder, brake shoes and assorted hardware. It rarely causes any problems.

Brake Drum

Brake drums are made of iron and have a machined surface on the inside where the shoes make contact. Just as with disk rotors, brake drums will show signs of wear as the brake linings seat themselves against the machined surface of the drum. When new shoes are installed, the brake drum should be machined smooth. Brake drums have a maximum diameter specification that is stamped on the outside of the drum. When a drum is machined, it must never exceed that measurement. If the surface cannot be machined within that limit, the drum must be replaced.

Wheel Cylinder

The wheel cylinder consists of a cylinder that has two pistons, one on each side. Each piston has a rubber seal and a shaft that connects the piston with a brake shoe. When brake pressure is applied, the pistons are forced out pushing the shoes into contact with the drum. Wheel cylinders must be rebuilt or replaced if they show signs of leaking.



Typical Drum Brake Parts

Return Springs

Return springs pull the brake shoes back to their rest position after the pressure is released from the wheel cylinder. If the springs are weak and do not return the shoes all the way, it will cause premature lining wear because the linings will remain in contact with the drum. A good technician will examine the springs during a brake job and recommend their replacement if they show signs of fatigue. On certain vehicles, the technician may recommend replacing them even if they look good as inexpensive insurance.

- **Self Adjusting System**

The parts of a self adjusting system should be clean and move freely to insure that the brakes maintain their adjustment over the life of the linings. If the self adjusters stop working, you will notice that you will have to step down further and further on the brake pedal before you feel the brakes begin to engage. Disk brakes are self adjusting by nature and do not require any type of mechanism. When a technician performs a brake job, aside from checking the return springs, he will also clean and lubricate the self adjusting parts where necessary.

Parking Brakes

The parking brake (a.k.a. emergency brake) system controls the rear brakes through a series of steel cables that are connected to either a hand lever or a foot pedal. The idea is that the system is fully mechanical and completely bypasses the hydraulic system so that the vehicle can be brought to a stop even if there is a total brake failure.

On **drum brakes**, the cable pulls on a lever mounted in the rear brake and is directly connected to the brake shoes. This has the effect of bypassing the wheel cylinder and controlling the brakes directly.

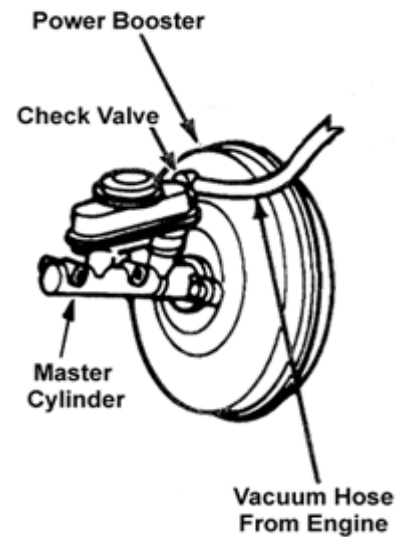
Disk brakes on the rear wheels add additional complication for parking brake systems. There are two main designs for adding a mechanical parking brake to rear disk brakes. The first type uses the existing rear wheel caliper and adds a lever attached to a mechanical corkscrew device inside the caliper piston. When the parking brake cable pulls on the lever, this corkscrew device pushes the piston against the pads, thereby bypassing the hydraulic system, to stop the vehicle. This type of system is primarily used with single piston floating calipers, if the caliper is of the four piston fixed type, then that type of system can't be used. The other system uses a complete mechanical drum brake unit mounted inside the rear rotor. The brake shoes on this system are connected to a lever that is pulled by the parking brake cable to activate the brakes. The brake "drum" is actually the inside part of the rear brake rotor.

On cars with automatic transmissions, the parking brake is rarely used. This can cause a couple of problems. The biggest problem is that the brake cables tend to get corroded and eventually seize up causing the parking brake to become inoperative. By using the parking brake from time to time, the cables stay clean and functional. Another problem comes from the fact that the self adjusting mechanism on certain brake systems uses the parking brake actuation to adjust the brakes. If the parking brake is never used, then the brakes never get adjusted.

Power Brake Booster

The power brake booster is mounted on the firewall directly behind the master cylinder and, along with the master cylinder, is directly connected with the brake pedal. Its purpose is to amplify the available foot pressure applied to the brake pedal so that the amount of foot pressure required to stop even the largest vehicle is minimal. Power for the booster comes from engine vacuum. The automobile engine produces vacuum as a by-product of normal operation and is freely available for use in powering accessories such as the power brake operation and is freely available for use in powering accessories such as the power brake booster. Vacuum enters the booster through a check valve on the booster. The check valve is connected to the engine with a rubber hose and acts as a one-way valve that allows vacuum to enter the booster but does not let it escape. The booster is an empty shell that is divided into two chambers by a rubber diaphragm. There is a valve in the diaphragm that

remains open while your foot is off the brake pedal so that vacuum is allowed to fill both chambers. When you step on the brake pedal, the valve in the diaphragm closes, separating the two chambers and another valve opens to allow air in the chamber on the brake pedal side. This is what provides the power assist. Power boosters are very reliable and cause few problems of their own, however, other things can contribute to a loss of power assist. In order to have power assist, the engine must be running. If the engine stalls or shuts off while you are driving, you will have a small reserve of power assist for two or three pedal applications but, after that, the brakes will be extremely hard to apply and you must put as much pressure as you can to bring the vehicle to a stop.



Anti-Lock Brakes (ABS)

The most efficient braking pressure takes place just before each wheel locks up. When you slam on the brakes in a panic stop and the wheels lock up, causing a screeching sound and leaving strips of rubber on the pavement, you do not stop the vehicle nearly as short as it is capable of stopping. Also, while the wheels are locked up, you lose all steering control so that, if you have an opportunity to steer around the obstacle, you will not be able to do so. Another problem occurs during an extended skid is that you will burn a patch of rubber off the tire which causes a "flat spot" on the tread that will produce an annoying thumping sound as you drive.

Anti-lock brake systems solve this lockup problem by rapidly pumping the brakes whenever the system detects a wheel that is locked up. In most cases, only the wheel that is locked will be pumped, while full braking pressure stays available to the other wheels. This effect allows you to stop in the shortest amount of time while maintaining full steering control even if one or more wheels are on ice. The system uses a computer to monitor the speed of each wheel. When it detects that one or more wheels have stopped or are turning much slower than the remaining wheels, the computer sends a signal to momentarily remove and reapply or pulse the pressure to the affected wheels to allow them to continue turning. This "pumping" of the brakes occurs at ten or more times a second, far faster than a human can pump the brakes manually. If you step on the brakes hard enough to engage the anti-lock system, you may feel a strong vibration in the brake pedal. This is a normal condition and indicates that the system is working, however, it can be disconcerting to some people who don't expect it. If your vehicle has anti-lock brakes, read your owner's manual to find out more about it.

The system consists of an electronic control unit, a hydraulic actuator, and wheel speed sensors at each wheel. If the control unit detects a malfunction in the system, it will illuminate an ABS warning light on the dash to let you know that there is a problem. If there is a problem, the anti-lock system will not function but the brakes will otherwise function.