CHAPTER SIX

Brakes

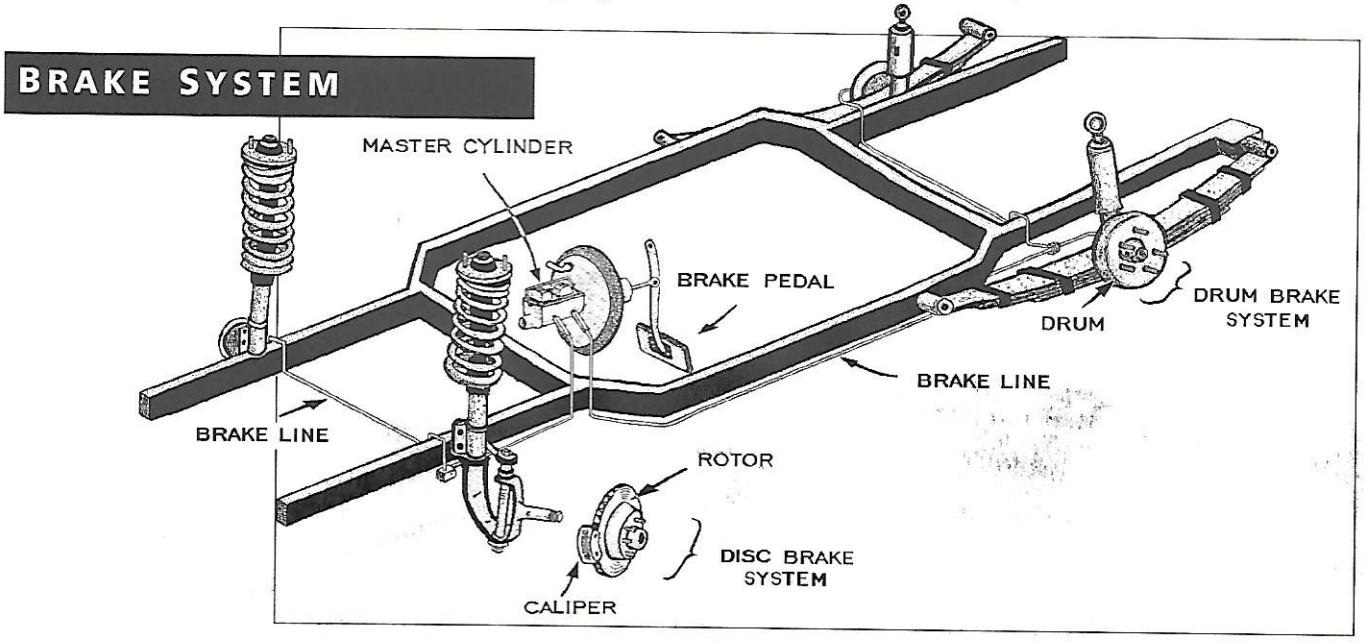
A *braking system* controls how fast, how smooth, and how straight a car slows down. Automobile braking systems use *master cylinders* and *hydraulic fluid* to transfer force from a *brake pedal* to *friction pads* located inside each wheel assembly. These friction pads are forced against metal surfaces in each wheel to create the friction which slows a car; the harder a pedal is pressed, the more friction is applied.

Force from a foot pedal must be equally balanced between all four wheels, delivering the same force at exactly the same time to each wheel. Otherwise, one wheel would slow down sooner than the others, causing a vehicle to swerve or "pull" to the side—or worse, locking a wheel and causing a skid.

There are two types of braking systems:

1. *Disc brakes*, where pads held in *calipers* pinch against the spinning *rotors*
2. *Drum brakes*, where *wheel cylinders* push pads against *brake drums*

Vehicles often use a combination, with discs on the front and drums on the rear. Many modern vehicles employ disc brakes on all four wheels.



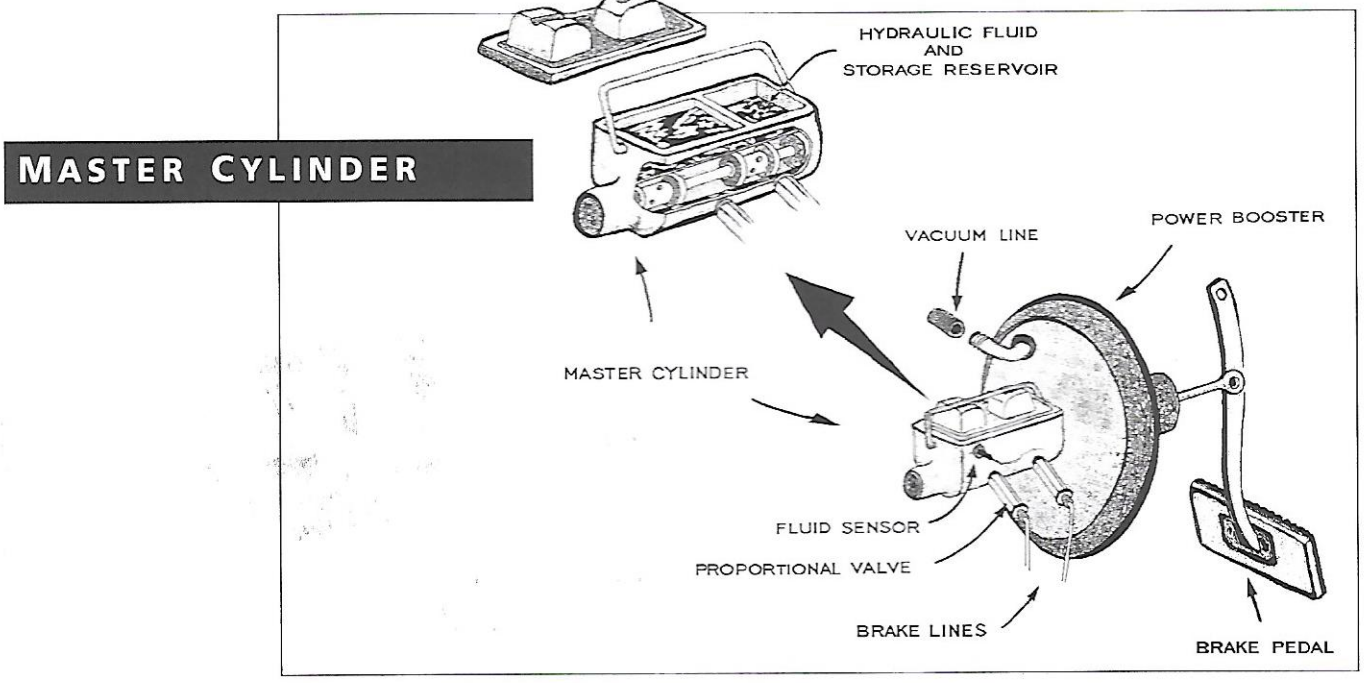
Master Cylinder

A *brake pedal* is a pump handle for a *master cylinder*. Almost all master cylinders are divided into two separate systems. If one fails, the other one will keep at least two brakes working, providing some braking despite the partial hydraulic failure.

Sensitive *pressure regulators* ensure that all friction pads receive the same braking power at exactly the same time. Pressure regulators are located between a master cylinder and the wheels. A *metering valve* coordinates the time when disc and drum brakes engage the wheels. A *proportional valve* balances the pressure between the front and rear brakes. Modern auto makers may use a *combination valve*, which does both jobs.

Larger vehicles use *power brakes* to increase the force from a foot pedal. Two types are used: a vacuum *booster* system (shown below) which uses vacuum from the intake manifold to increase the pedal force, and an *electro-hydraulic* system which uses an electric motor to increase hydraulic force. Pedal force can also be amplified using a system which shares fluid from the nearby power steering system.

A master cylinder provides a reservoir where fluid level is checked and new fluid is added. Most master cylinders have a sensor in the reservoir to signal low fluid and a pressure sensitive switch to turn on the brake lights.

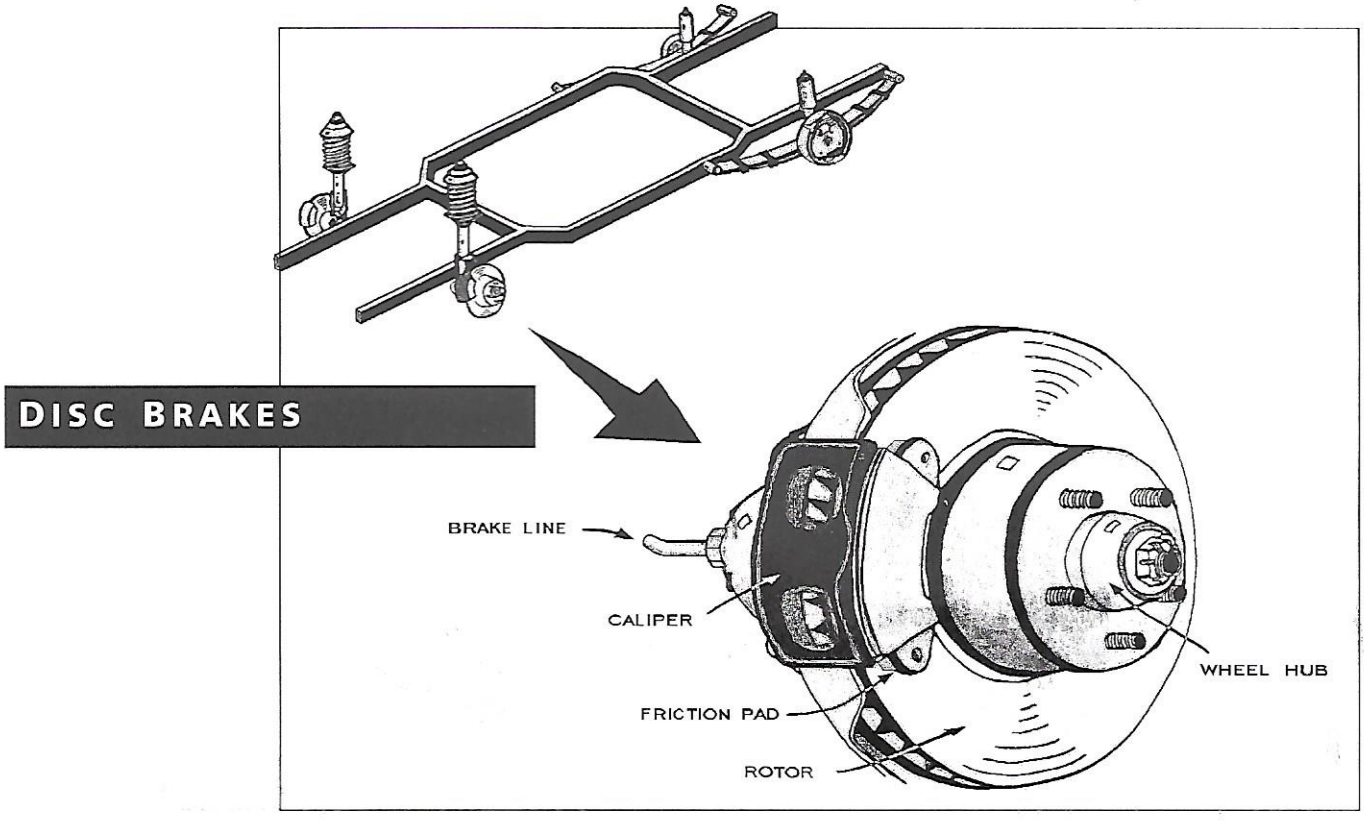


Disc Brakes

A *disc brake* system uses a polished metal disc or *rotor* and *friction pads,* which pinch against the rotor, to slow a car. Typically, each wheel assembly in the disc brake system has a rotor, a *caliper*, and two friction pads, one positioned on each side of the rotor. A *caliper* positions the friction pads and transfers hydraulic force from a master cylinder to the friction pads. A rotor and pads are often partially visible through the wheel *spokes*. Both a tire and a rim bolt to a rotor and all rotate together when a car is moving.

Small metal pipes called *brake lines* carry the hydraulic fluid from a master cylinder to the calipers at each wheel. Friction pads are held inside calipers about one hundredth (.01) of an inch from the rotor. Alignment and timing between all rotors, friction pads and calipers must be precise to avoid vibrations and squeaking when the pads touch the rotors.

Friction from braking creates considerable heat, but the open-air design of the disc system allows rapid heat dispersion.

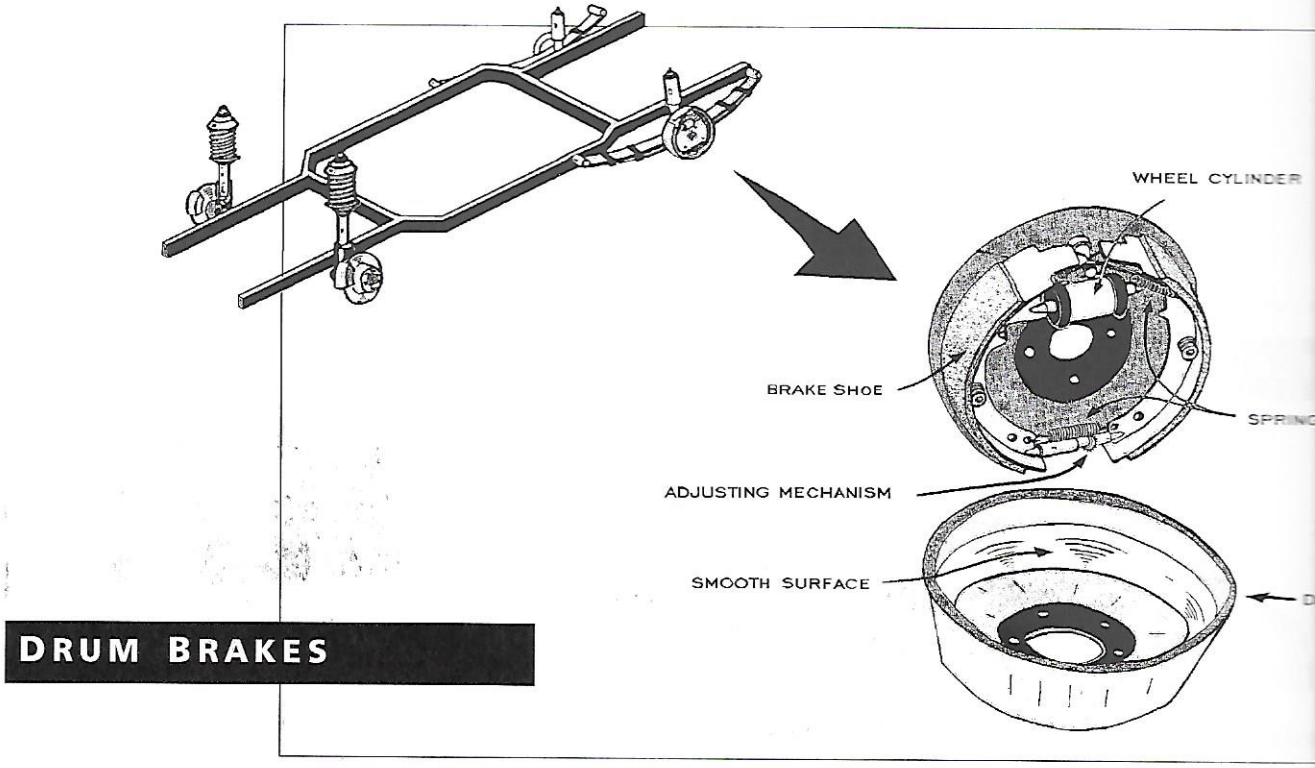


Drum Brakes

In the *drum brake* system, curved friction pads, called *brake shoes*, are pushed out against a *brake drum* when hydraulic fluid from a master cylinder is received at each of the *wheel cylinders*. One wheel cylinder, one brake drum and two brake shoes are located at each drum brake wheel assembly.

A *brake drum* is like a bowl with smooth surfaces on the inner sides. Brake shoes are pushed outward against these surfaces when a brake pedal is pushed. When a pedal is released, strong springs pull the shoes away from the drum, forcing fluid back through the brake lines and into the master cylinder reservoir (see p. 64).

A *wheel cylinder,* located between each pair of shoes, receives and transforms hydraulic fluid from the master cylinder into the mechanical pushing force used to press brake shoes against a drum. Like a disc brake rotor, a brake drum attaches to a vehicle at a wheel hub, spindle, or axle using wheel bearings to reduce friction. Also, like the disc brake rotor, a tire and rim bolt directly to the outside of the wheel drum (see p. 59).



DRUM BRAKES

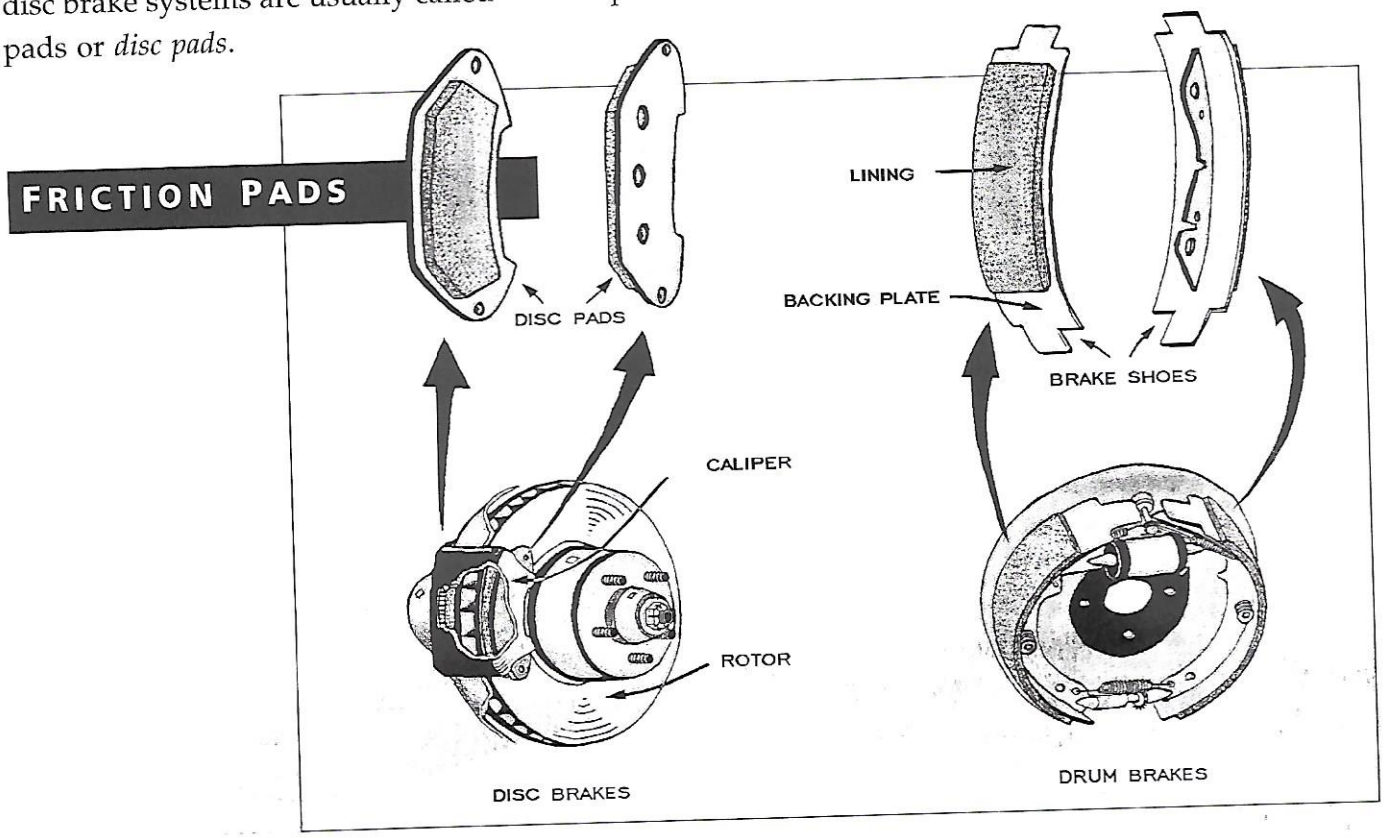
Friction Pads

Friction pads must withstand extreme pressures and temperatures, yet be soft enough to protect the smooth polished surfaces of a wheel drum or rotor. Friction pads must also maintain a similar degree of friction, *the coefficient of friction*, throughout a wide range of temperature and weather conditions. This insures even braking.

Friction pads used in drum brakes are called *brake shoes*. New friction pad material, or brake *linings*, attach to metal *backing plates*. Friction pads in disc brake systems are usually called pads or *disc pads*.

In either system if the pad material wears down completely, the metal backing plate will touch the wheel drum or rotor and scratch, or *score*, the smooth surfaces. In some vehicles a signal warns that friction pads are wearing thin.

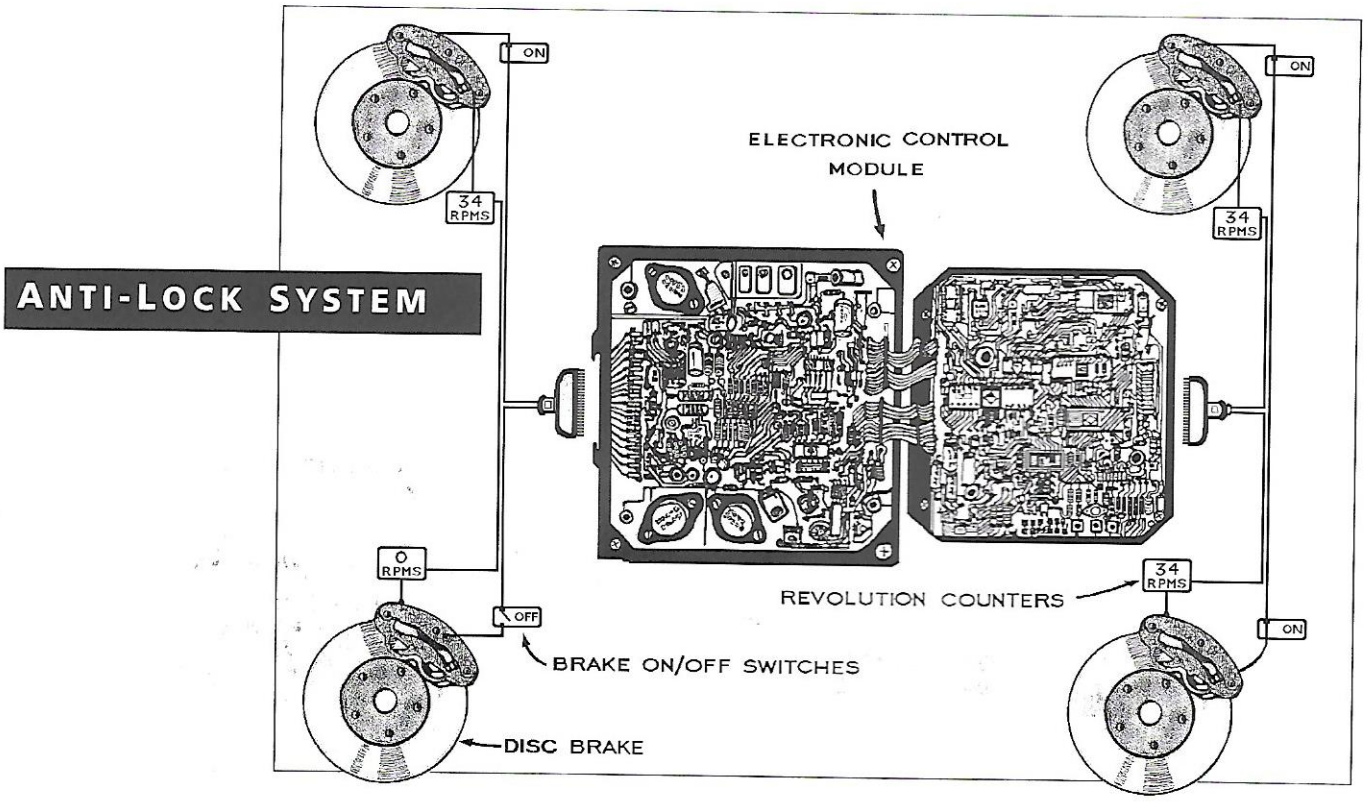
Tremendous heat is generated in the braking process. A stop from 60 mph can heat the brake shoes to 450° F. Disc pads, which require 10 times the force, can heat to 1000° F. Like the heat generated in an engine, the heat from braking dissipates to the surrounding air.



Anti-lock Brake System

The computerized *anti-lock brake system* (ABS) virtually eliminates uncontrolled tire skids. Slamming on regular brakes at highway speed will "lock-up" or completely stop a tire, causing it to skid. The long swerving skid marks on the highway are the result of brakes stopping tires, but not stopping the car. The ABS system prevents this type of skidding.

With ABS, a computer counts each time a wheel makes a revolution. Under normal driving conditions all four wheels turn the same speed. If one wheel locks-up during braking, the wheel count for that wheel will immediately drop to zero. This triggers the release of the brake mechanism for that wheel, allowing it to rotate freely. When the rotation count becomes equal again, the computer will reactivate the braking mechanism for that wheel. During hard braking, this process results in rapid "on-and-off" skidding for each wheel, leaving dotted skid marks down a roadway.

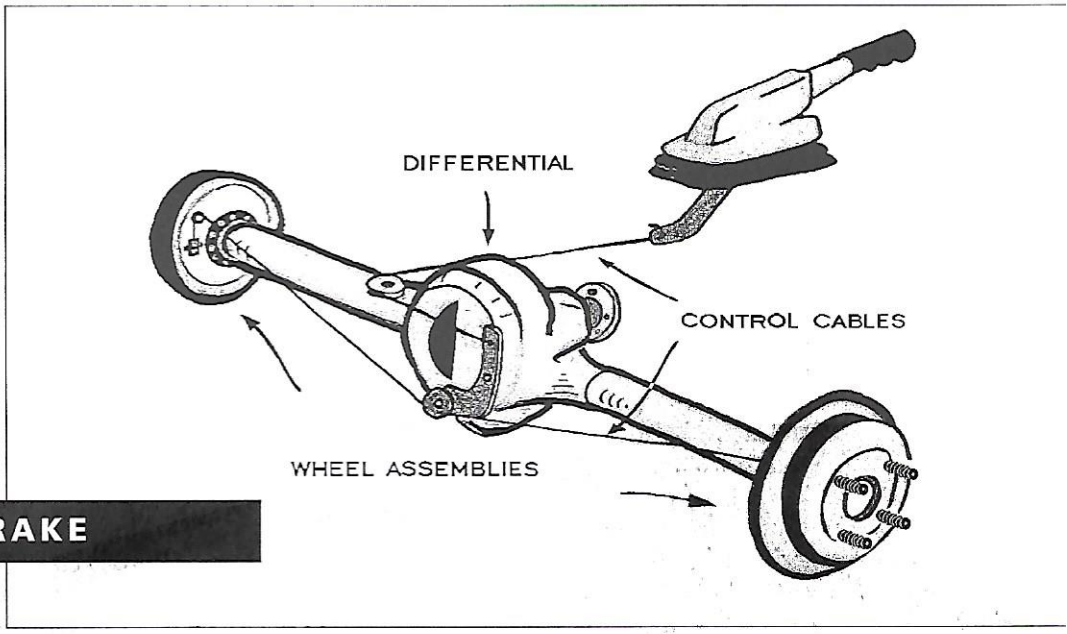


Parking Brake

A *parking brake* stops a car from rolling away when parked. Parking brakes operate either by hand or foot using levers and cables to connect to the wheels; this mechanical linkage is independent of the hydraulic system.

A parking brake system is usually limited to only two wheels. The rear wheels are usually used for the parking brake with rear wheel drive vehicles. Front wheel drive vehicles often use the front two wheels for the parking brake. Parking brake systems usually share the friction pads, drums, or rotors of the regular braking system. Vehicles with disc brakes on all four wheels sometimes use an independent parking brake system, connecting to an axle instead of a wheel.

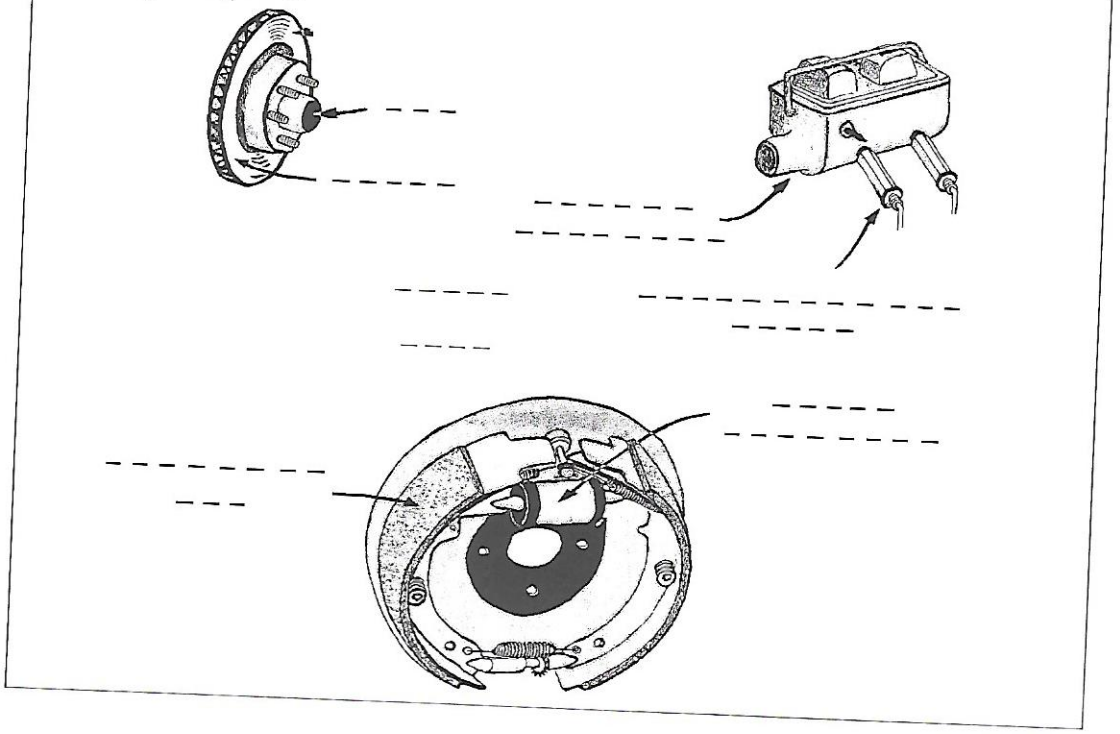
A parking brake may be used as an *emergency brake* to slow a vehicle if complete brake failure occurs.



PARKING BRAKE

BRAKE TEST

Identify the parts:



1. Wheel bearings decrease friction, friction pads increase friction. (T) (F) *(p. 67)*
2. Force from a foot pedal is transferred to the wheels using _____fluid. *(p. 64)*
3. A brake pedal is a _____ for a master cylinder. *(p. 64)*
4. Wheel cylinder : _____ *(p. 66)*
   Caliper : Rotor
5. Vehicles often use _____brakes on the front and _____on the rear. *(p. 63)*
6. With ABS, an ECM counts RPMs.(T) or (F) *(p. 68)*
7. Dotted skid marks on a roadway indicates _____. *(p. 68)*
8. The brakes controls how _____, how_____, and how_____ a car slows down. *(p. 63)*
9. Vibrations occur only as the brakes are applied, what's wrong?_____ *(p. 65)*
10. Loud screeching when the brakes are applied indicates_____. *(p. 65)*
11. What will happen if friction pads get wet?_____ *(p. 67)*
12. When brakes are applied, a car skids and swerves to the left. Explain._____
    _____