Automotive Brake Systems

Brake System Operation

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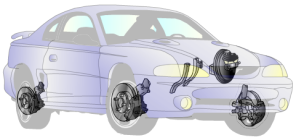
Automotive Brake Systems

Brake System

- Master cylinder
- Brake lines
- Hydraulic valves
- Disc brakes
- Drum brakes
- Power assist unit
- Parking brake
- Antilock system



Automotive Brake Systems

Brake System Functions

- Slow moving vehicle
- Bring vehicle to a stop
  - 30 mph – 57 feet
  - 60 mph – 216 feet
  - 95 mph – 607 feet
  - 100 mph – 673 feet
- Hold vehicle stationary

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Vehicle Energy

- Vehicles operate by converting chemical energy into heat energy and then into kinetic energy
- Kinetic energy is the energy of mechanical work or motion
- Brakes stop the car using friction to convert kinetic energy into heat energy

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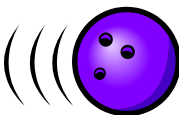
Calculating Kinetic Energy

- What is the kinetic energy of a 4 kilogram ball moving at 10 meters per second?
  - KE = ½ mv^2
  - KE = .5 (4) $(10)^2$
  - KE = (2) (100)
  - KE = 200 joules



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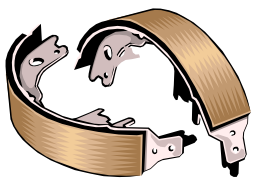
Brake Lining Materials

- A brake's linings coefficient of friction is affected by
  - Surface finish
  - Composition
  - Temperature
- Brake linings must resist fading as temperature increases



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Friction Lining Material Rating

Edge Code	Coefficient of Friction
C	Not over 0.15
D	Over 0.15 but not over 0.25
E	Over 0.25 but not over 0.35
F	Over 0.35 but not over 0.45
G	Over 0.45 but not over 0.55
H	Over 0.55

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Pascal's Law

- Pressure on a confined fluid is transmitted equally in all directions and acts with equal force on all parts
- Force = pressure x area
- Pressure applied to a piston with a larger surface area will generate a greater output force with less travel

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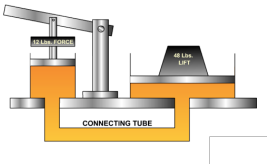
Brake Hydraulics

- Increasing the size of the output piston
  - Increases output force
  - Decreases output travel
- Disc brakes require more output force than drum brakes



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Brake Fluid

- Brake fluid properties
  - High boiling point
  - Low freezing point
  - Non-corrosive to rubber and metal brake parts
  - Ability to lubricate rubber and metal brake system parts
- Most brake fluid is poly glycol or silicone based although a few European manufacturers have used a mineral oil based brake fluid

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Brake Fluid Characteristics

Fluid Grade	DOT 3	DOT 4	DOT 5	DOT 5.1
Fluid Type	Poly Glycol	Poly Glycol	Silicone	Poly Glycol
Boiling Point	401° F	446° F	500° F	518° F

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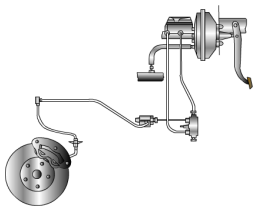
Brake Hydraulic System

- Master cylinder
- Lines and hoses
- Calipers
- Wheel cylinders
- Hydraulic valves
  - Metering
  - Proportioning
  - Pressure differential
  - Residual pressure check valve



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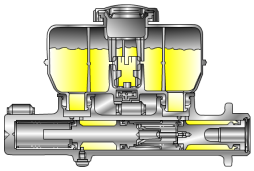
Master Cylinder

- Brake fluid reservoir
  - Plastic
  - Cast iron
- Master cylinder body
  - contains piston assemblies used to generate hydraulic pressure



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Dual Piston Master Cylinder

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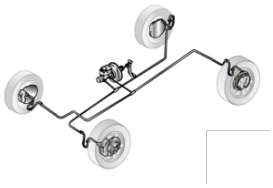
Master Cylinder Operation

- In 1967 DOT required dual-brake systems
- Dual-brake systems utilize two master cylinder pistons
- Brake hydraulic systems are normally split
  - front-rear
  - diagonally



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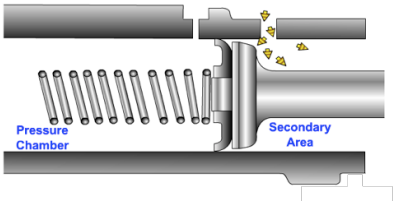
Fill Port



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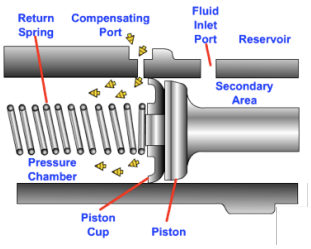
Compensating Port



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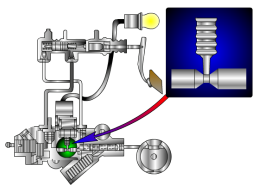
Combination Valve

- Replaces
  - Metering valve
  - Proportioning valve
  - Pressure differential switch
- Some manufacturers have used a two function combination valve that combines only a pressure differential switch and a proportioning or metering valve



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Disc Brakes

- Fade resistant design
  - Heat
  - Water
- Self adjusting
- Brake noise during normal operation
  - Increased with the use of semi-metallic pads

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Disc Brake Parts

- Rotor
  - Solid or ventilated
- Caliper assembly
  - Caliper housing
  - Piston
  - Square cut piston seal
  - Dust boot
  - Bleeder screw
- Brake pads

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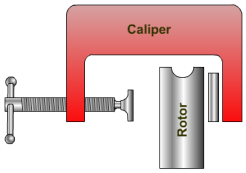
Disc brake Operation

- Hydraulic pressure moves the caliper piston and inner brake pad outward
- The floating caliper assembly then moves inward applying the outer pad and balancing the apply force



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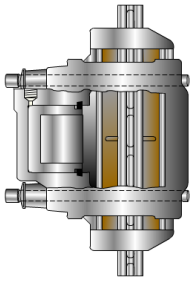
Floating or Sliding Caliper

- The caliper floats on pins or V shaped surfaces allowing the outboard fixed pad to move toward the rotor as the inboard pad is applied



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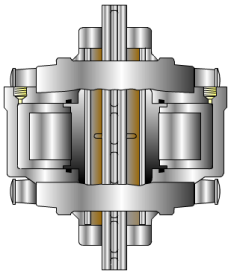
Fixed Caliper

- One or more pistons on each side of the caliper apply the brake pads
- Multiple pistons
  - Increase clamping force
  - Decrease brake pad deflection



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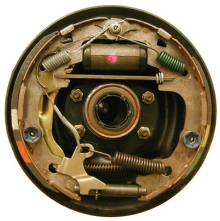
Drum Brakes

- Backing plate
- Wheel cylinder
- Brake shoes
  - Primary and secondary
- Hold down springs
- Brake shoe return springs
- Self-adjuster
- Brake drum



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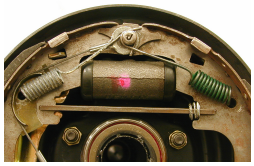
Wheel Cylinders

- Brake system pressure from the master cylinder expands the wheel cylinder's cup seals and forces the pistons outward
- Most wheel cylinders also utilize cup seal expanders to improve sealing when the brake system pressure is not present



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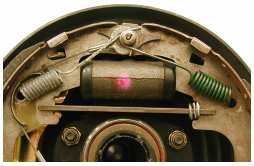
Drum Brake Operation

- Master cylinder pressure moves the wheel cylinder pistons and brake shoes outward
- When the pressure is released the brake return springs move the brake shoes back to their original position



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Drum Brake Operation

- Drum brakes are mechanically self energizing when applied
- Two drum brake designs are common
  - Duo Servo
  - Balanced or leading-trailing

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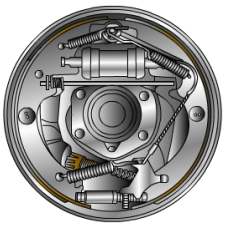
Duo Servo Drum Brakes

- Duo servo drum brakes require the least apply pressure
- Hydraulic pressure moves the wheel cylinder pistons and brake shoes outward
- The shoes contact the rotating drum and the primary shoe forces the secondary shoe into the drum



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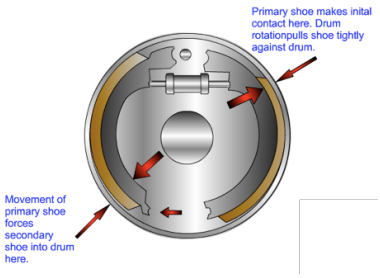
Duo Servo Operation



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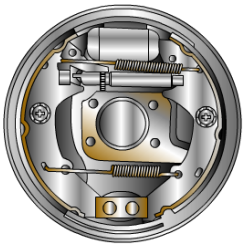
Leading Trailing Drum Brakes

- Hydraulic pressure moves the wheel cylinder pistons and brake shoes outward
- The rotating drum forces the primary shoe into the anchor pin and the secondary shoe is forced into the wheel cylinder apply pin



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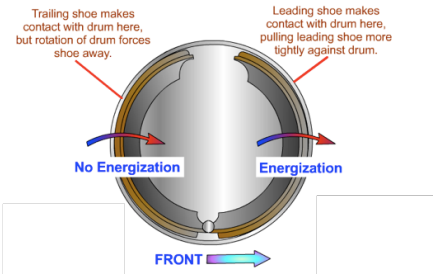
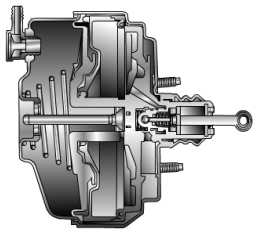
Leading Trailing Operation



Automotive Brake Systems

Power Assist Unit

- The power assist unit decreases the necessary pedal effort to apply the brakes
- Three types of power assist units are common
  - Vacuum
  - Hydro-boost
  - Electro-hydraulic



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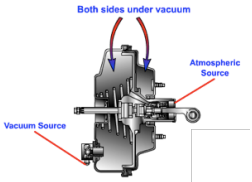
Vacuum Power Assist Unit

- Brakes not applied
- Moderate brake application
- Brakes holding
- Full brake application
- Brakes being released



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Antilock Brakes

- The electronic control unit monitors brake pedal application and wheel speed
- Solenoids are used to limit and/or reduce brake apply pressure

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Antilock Brake Components

- Computer monitors input from wheel speed sensors
- Solenoids limit or reduce hydraulic pressure to slipping wheel(s)
  - Inlet solenoid
  - Outlet solenoid