The Pennsylvania State University
Workforce Education and Development

Lesson Plan Template

Name of Instructor: Brian Stevens
Program Title: Automobile/Automotive Mechanics Technology/Technician
Course Title:Automotive Mechanics
Unit Title: Brakes Overview
Lesson Title: Brake System Fundamentals
Lesson Performance Objective: Given information on the purpose of the braking system,Friction and heat, and how they effect braking.How weight and speed effect stopping.
Time (length of lesson): 30-45 min.
Equipment and Materials needed:Information package and question sheet.
Technical Standard(s): 602
Academic Standard(s): CIP 47.0604 Follow information on how transforming kinetic energy into heat energy and how friction is the principle that make automotive brakes work.
Introduction Student will read and answer questions pertaining to brake system fundamentals and base brake components.

Body: General information on brake system fundamentals,how braking is the transfer of kinetic energy to heat energy. Information about how heat is used to stop a vehicle when friction occurs, and brake subsystems.

Summary: Given information on brake system fundamentals that will help students understand basic brake operation.`

Student Assessment:

Formative Assessment(s)

Summative Assessment:

Universal Design for Learning (UDL)

Multiple Means of Engagement:

Multiple Means of Representation:

Multiple Means of Expression:

UNIT 1: BRAKES OVERVIEW

The following topics are addressed in this unit:

BRAKE SYSTEM FUNDAMENTALS

- Introduction
- Friction
- Tire Footprint
- Heat
- Weight and Speed
- Service Brakes and Parking Brakes
- Base Brake Components
- Brake Subsystems

BRAKE DIAGNOSIS PROCEDURES

- Work Orders
- Brake Diagnosis - Initial Steps
- Fluid Levels and Leaks
- Detailed Visual Inspection
- Test Drive (Road Testing)
- Removing Brake Dust
- Vehicle Lifting

BRAKE SYSTEM FUNDAMENTALS

Automotive brakes are designed to slow and stop a vehicle by transforming **kinetic energy** (motion energy) into **heat energy**.

INTRODUCTION

The purpose of the braking system is to slow or stop the vehicle in a controlled manner, without pulling to one side or the other, without making noise or vibration, and without causing any single tire to lock up and skid. It must do all this while requiring very little pedal pressure.

The main type of brake system in use since the early 2000s is a power-assisted four-wheel disc brake system. Prior to that, the most common systems were power-assisted front disc, rear drum systems. Nearly all service performed today will be on one of these two types of systems. Hybrid and electric vehicles have regenerative braking systems, but this is not considered a third braking system type within this chapter. These systems work on the principle of magnetic repulsion and therefore do not require adjustments or serviceable components. All vehicles with regenerative braking also have either disc/disc or disc/drum systems that work in combination with the regenerative braking.

Braking systems operate on the principle of friction. As increased pressure, in the form of friction, is applied to a rotating object, the rotating object will slow or come to a full stop. This process generates a significant amount of heat.

The basic operation of the braking system is as follows. A driver applies pressure to a pedal. The pedal pushrod activates a brake booster, which multiplies the force applied by the driver. The booster then pushes a rod that is connected to a double piston within a hydraulic master cylinder. Each piston within the cylinder splits the force into one of two separate circuits. The master cylinders are divided with either a front rear split, or a diagonal split. The movement of the piston forces hydraulic fluid under pressure to the individual wheels. The hydraulic pressure moves a small piston at each wheel, transferring the pressure to mechanical movement of the piston that forces the brake pads against a rotating device called a brake rotor, or forces brake shoes against a rotating device called a brake drum. The mechanical pressure creates friction that acts upon the rotating rotor or drum until the vehicle slows or stops.

Components in the system include:

- Brake pedal assembly
- Vacuum and hydraulic assist boosters
- Master cylinder, lines, and flexible brake hoses
- Disc brakes: brake rotors, brake pads, brake calipers
- Drum brakes: brake drums, brake shoes, return springs and hardware, and wheel cylinders
- Anti-lock brake (ABS) components including sensors, computers, wiring, hydraulic valves, and solenoids
- Parking brake components: both mechanical and electrically-activated

Brake system service carries a liability concern for the technician. When performing diagnosis, replacement or adjustment, proper procedures are critical to safety of the vehicle's occupants and surrounding vehicles. There are specific Federal Motor Vehicle Safety Standards (FMVSS) that govern brake system design and service.

FRICTION

Friction is the fundamental principle that makes automotive Brake Systems work. It is defined as "a resistance to movement that results from two objects moving or contacting each other". There are two types of friction: **Kinetic** and **Static.**

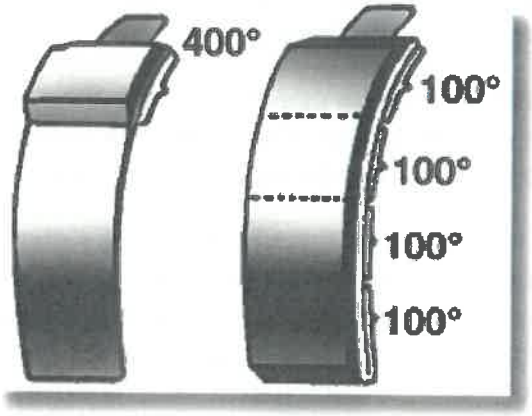
Kinetic friction occurs between two objects that are sliding against each other. Kinetic friction produces Heat and is used to actually stop a vehicle when the Brake Pedal is pressed (Rub your hands together and feel the heat!).

Static friction occurs between two objects that are in contact with each other but not moving. Static friction does not produce heat, but is used in automotive braking systems to hold a vehicle in place after it has stopped.

Various factors affect the amount of friction created between two surfaces but, generally, the rougher a surface is, the more friction it will produce. Extremely rough surfaces will therefore naturally create the most friction, but they also tend to wear down quickly. As a result, automotive brake systems use relatively smooth surfaces to avoid rapid wear. However, in order to compensate for the reduced friction of their smooth surfaces, automotive brakes must be applied with a greater amount of pressure to work properly.

As a rule, the greater the pressure between two surfaces, the more friction they will produce. Therefore, the greater the pressure applied to the brakes, the greater their stopping power will be.

Brake Shoe Friction Distribution



The greater the contact area of a brake shoe or pad, the less heat the shoe or pad generates per square inch.

Just as an increase in pressure will increase the friction between two surfaces, an increase in the amount of contact area between two surfaces will also increase the friction between them. Braking systems are therefore designed to use the largest contact area possible. As a result of the greater contact area between a brake shoe/pad and its drum/rotor, the amount of friction needed to stop a vehicle can be generated while also creating less heat. Producing less heat helps the brakes be more efficient.

On **drum brake** systems, **brake shoes** are applied to brake drums to create friction while **disc brake** systems apply **brake pads** to rotors to create friction.

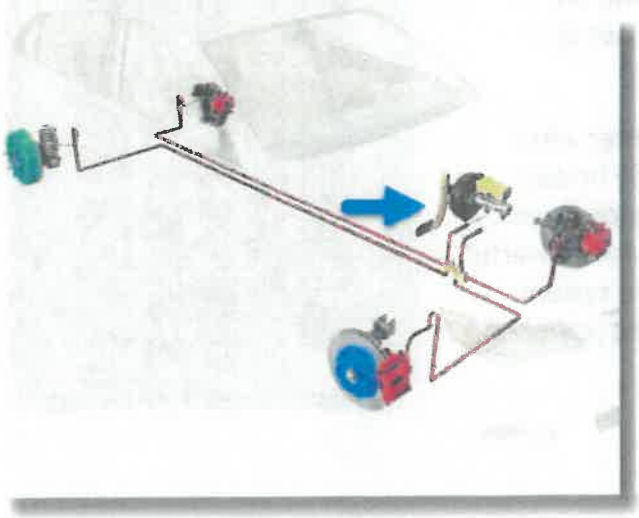
One of the friction surfaces used on brake systems is the **brake lining**, which is mounted on either a brake shoe or brake pad. Brake linings produce friction by directly contacting either a brake drum or disc (rotor).

Brake lining material must be somewhat softer than the brake drums or discs to ensure that the shoes and/or pads wear instead of the drums or discs. Currently, most brake linings are ceramic, metallic, or organic. These linings are metallic, ceramic, or organic.

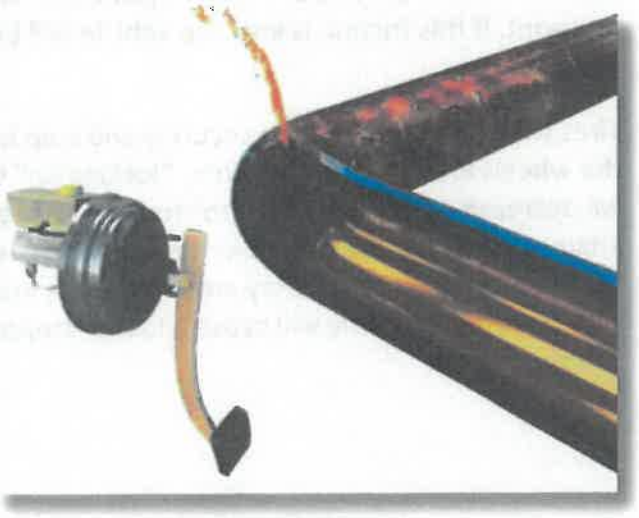
Note: For years, asbestos was commonly used to make brake linings. However, since asbestos has now been classified as a cancer-causing substance, federal law prohibits its use in brake systems.When a brake lining is applied to a drum or disc, it is important that the proper amount of friction is produced in order to ensure the brakes' effectiveness. Consider the following:

- If the amount of friction is too great, the brakes may be "grabby" or overly sensitive. Overly sensitive brakes can cause a vehicle to skid.
- If the amount of friction is too low, brake application will require excessive pressure. Applying the brakes using excessive pressure can create excessive heat that could result in brake failure.

Brake System



Brakes Applied



Rusted Brake Lines

Tire Footprint

The point where a vehicle's tire contacts the road is called the **tire footprint** or **contact patch**. This "footprint" is the only place where there is braking friction between the tire and the road. In general, the larger a tire's footprint, the greater its stopping ability. Changes in the friction of a footprint due to tiresize, tire condition (including tire pressure), road surface condition, or substances on the surface (water, ice, snow, dirt, etc) will affect a vehicle's ability to stop.

Typical Tire Footprint

Typically, the wider a tire is, the larger its footprint will be and the more stopping power it will have. However, the wider a tire is, the more braking power will be needed to stop the vehicle.

Note: As a general rule, wider tires require larger Brakes.

Unlike wider tires, taller tires with a larger diameter do not necessarily have a larger footprint. Still, the greater a tire's diameter is, the more braking power will be needed to stop the vehicle.

Tire Footprint From Wider Tire

Note: Because larger diameter tires have more rotational mass, they require more braking power.

Excessive vehicle weight and/or incorrectly inflated tires can distort a tire's footprint and reduce its hold on the road. Tires that cannot hold the road will reduce a vehicle's ability to stop.

Note: To control a vehicle, friction must occur at the tire footprint. If this friction is lost, the vehicle will be out of control.

Tires will grip the road more securely and stop better when the wheels are turning. Therefore, "locking up" the brakes wil decrease a vehicle's ability to stop. As such, automotive engineers avoid designing brake systems that are too powerful for the vehicles in which they are installed. A brake system that locks up too easily will cause a loss of stopping power and vehicle control.

HEAT

It is the friction of converting kinetic energy to heat energy that makes vehicles stop. But what do we do with all of the heat once it is created?

The reason we want reduced heat in brake systems is that the hotter the surface is between two objects, the less stopping friction will be produced. Too much heat in a brake system will reduce the amount of friction produced, which will reduce the stopping ability of the brakes. This phenomenon is called **brake fade**.

To prevent brake fade, all of the heat a brake system creates must dissipate as quickly as it is created. Since brake systems can store little or no heat, their friction surfaces must be made of materials that can dissipate heat easily. Braking system components that produce friction (brake shoes or brake pads) are also designed so that the passing air will cool them.

Therefore, the brake lining material and the surfaces it contacts must have the following characteristics:

- Brake drums or discs must conduct heat easily,
- Hold their shape under extremely high heat,
- Withstand rapid temperature changes,
- Resist warping and distortion,
- Wear well in general

Because of those factors, brake drums and discs typically consist of aluminum combined with iron or steel.

Remember the following:

- If brakes create more heat than they can dissipate, braking effectiveness will be reduced.
- Excessive heat can also cause the bonding agents in a lining to melt and flow to the surface of a shoe or pad. Those bonding agents can then produce a "glaze" on the lining surface, which will further reduce the brake's effectiveness and cause brake fading. Brake application will then require more pressure, which will create more heat and more glazing.

Weight and Speed

Vehicle Weight

The more weight a moving vehicle has, the more kinetic energy it possesses. Recall that brake systems convert kinetic energy into heat energy, so any increase in vehicle weight puts a greater demand on the brakes.

How much does weight affect a vehicle's braking? If a vehicle's weight doubles, the amount of kinetic energy the brakes must convert to heat energy also doubles.

Because of the effect of weight on braking, never overload any vehicle, especially a truck. Exceeding the weight limit of any vehicle is actually overloading the brakes.

Note: Pulling a trailer essentially has the same effect on vehicle braking as increasing the weight of the vehicle itself. The exception to this would be if the trailer has its own brake system. This is just one reason why you should always slow down when towing.

Vehicle Speed

Vehicle speed also affects braking, but to a much greater degree than weight. When the speed of a vehicle doubles, the brakes must convert **four times** the amount of kinetic energy into heat energy.

A combination of high speed and excessive weight could easily push a vehicle's brake system beyond its performance limit, resulting in a serious loss of stopping power.

Service Brakes and Parking Brakes

Automotive brake systems fall into two major categories: **service brakes** (hydraulically-operated) and **parking brakes** (cable or electrically-operated).

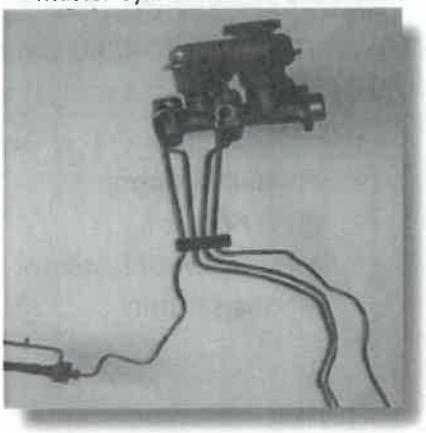
Service brakes are designed to stop a vehicle that is in motion while a parking brake is intended to hold the vehicle while it is parked.

Note: A parking brake isn't designed to stop a moving vehicle and is **not** an emergency brake.

Note: Parking brakes often -- but not always -- use the same friction surfaces as the service brakes.

Base Brake Components

Master Cylinder and Brake Lines



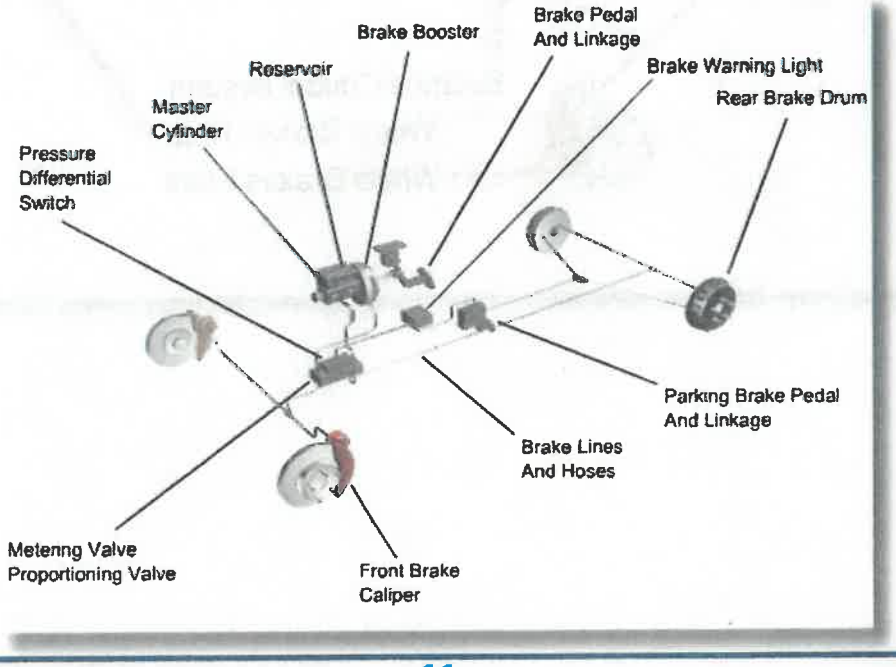
These base brake components include those parts that make up the hydraulic brake system found on all vehicles. The term "base brakes" does not include anti-lock brake or traction control systems.

Base Brake components include:

- Brake pedal and linkage
- Power brake boost system (vacuum or hydraulic)
- Master cylinder, lines, and hoses
- Brake rotors and pads
- Brake drums and shoes
- Brake balance controls (proportioning valves and metering valves, if equipped)
- Red brake warning and other warning light systems
- Parking brake pedal and linkage(s)

Brake Light

Brake System Components

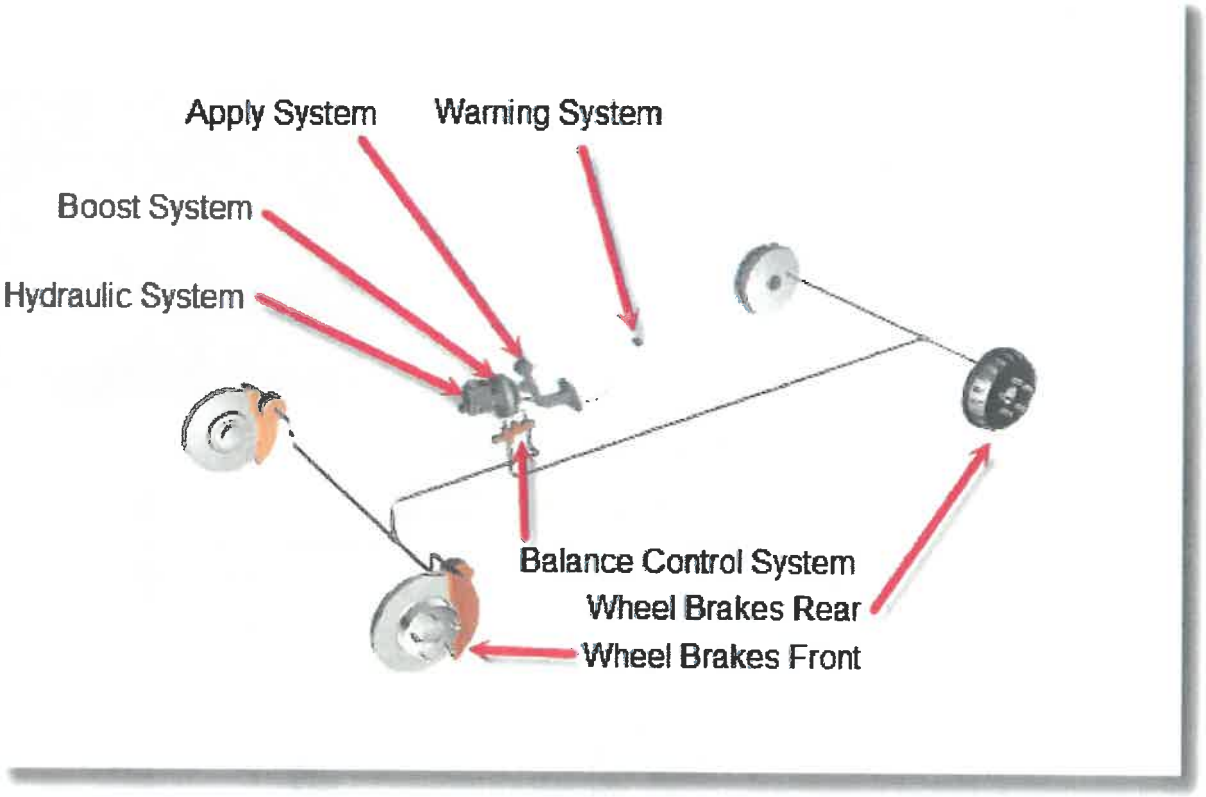


Brake Subsystems

Automotive Brake Systems can be broken down into several different sub-systems:

- Apply system
- Boost system
- Hydraulic system
- Wheel brakes
- Balance control system
- Warning system

Subsystem Names andTheir Components



Brake System Fundamentals Name _____

1. Automotive brakes are designed to slow and stop a vehicle by transforming _____ energy into _____ energy.
2. Brake systems operate on the principle of _____.
3. Friction generates a significant amount of _____.
4. What are the two types of friction? _____ and _____
5. _____ friction occurs between two objects that are sliding against each other.
6. _____ friction occurs between two objects that are in contact with each other but not moving.
7. One of the friction surfaces used on brake systems is the brake _____, which is mounted on either a brake shoe or brake pad.
8. The point where a vehicle's tire contacts the road is called the tire_____ _____.
9. A combination of _____ speed and _____ weight could easily push a vehicle's brake system beyond its performance limit.
10. A _____ brake isn't designed to stop a vehicle and is not an emergency brake.