TODAY'S TECHNICIAN™

# AUTOMOTIVE BRAKE SYSTEMS

7

Shop Manual

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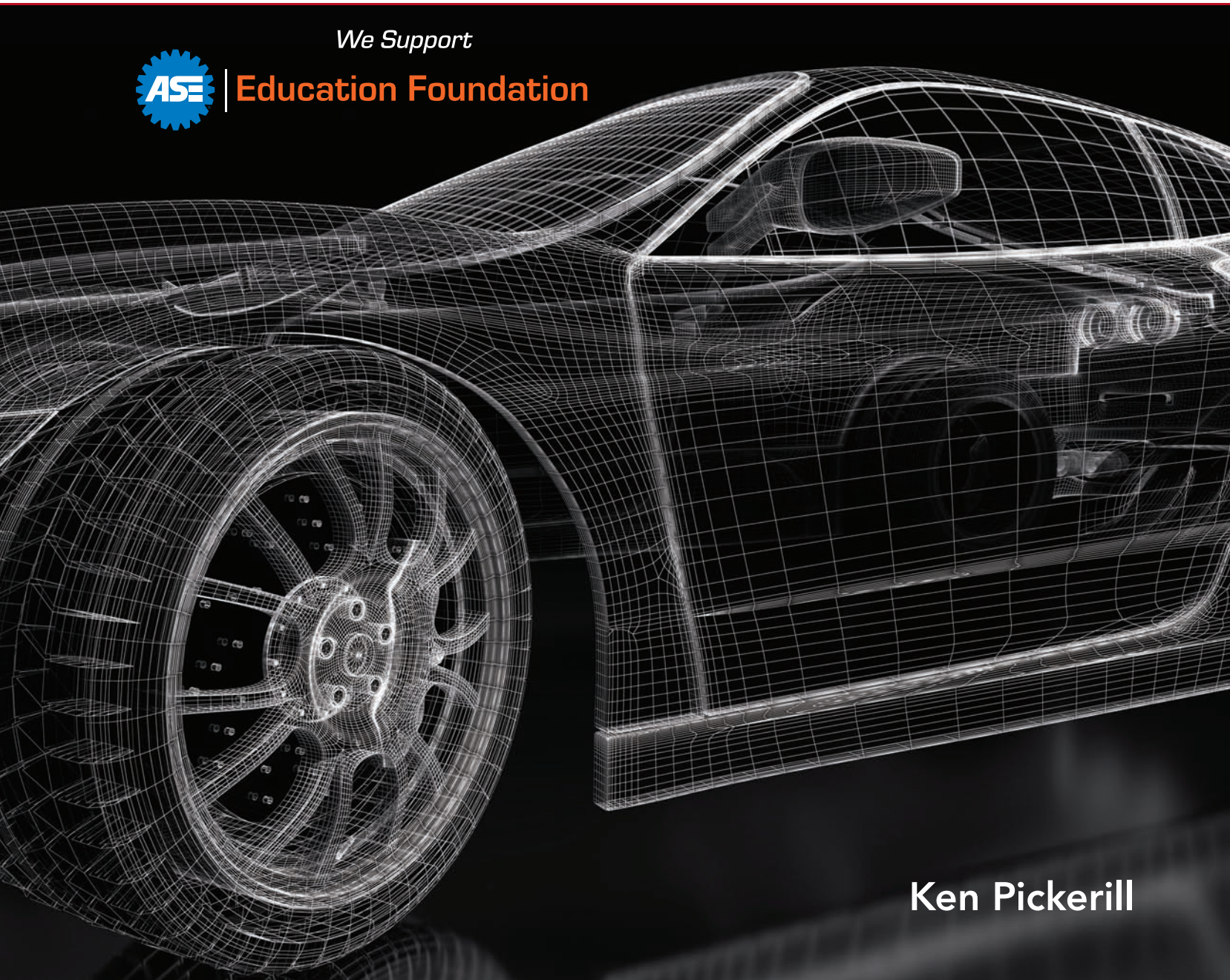

Ken Pickerill

TODAY'S TECHNICIAN™

# SHOP MANUAL

For Automotive Brake Systems

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# SHOP MANUAL

## For Automotive Brake Systems

SEVENTH EDITION

Ken Pickerill

CENGAGE

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**Today's Technician: Automotive Brake Systems, Seventh Edition**

**Ken Pickerill**

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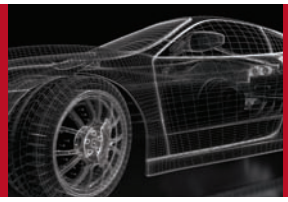
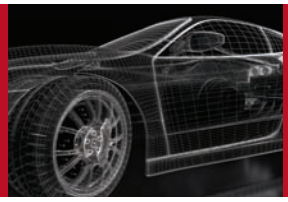


# CONTENTS



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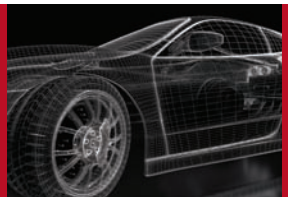
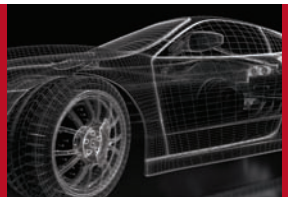


# JOB SHEETS



# PREFACE

The *Today's Technician*™ series features textbooks and digital learning solutions that cover all mechanical and electrical systems of automobiles and light trucks. The content corresponds to the 2017 ASE Education Foundation program accreditation requirements. They are specifically correlated to the Task Lists contained in each level of program accreditation; Maintenance and Light Repair (MLR), Automotive Service Technology (AST), and Master Service Technology (MAST).

Additional titles include remedial skills and theories common to all of the certification areas and advanced or specific subject areas that reflect the latest technological trends. *Today's Technician: Automotive Electricity & Electronics, 7e* is designed to give students a chance to develop the same skills and gain the same knowledge that today's successful technician has. This edition also reflects the most recent changes in the guidelines established by the ASE Education Foundation.

The purpose of the ASE Education Foundation program accreditation is to evaluate technician training programs against standards developed by the automotive industry and recommend qualifying programs for accreditation. Programs can earn accreditation upon the recommendation of ASE Education Foundation. These national standards reflect the skills that students must master. ASE Education Foundation accreditation ensures that certified training programs meet or exceed industry-recognized, uniform standards of excellence.

## HIGHLIGHTS OF THIS NEW EDITION—CLASSROOM MANUAL

The text and figures of this edition are updated to show modern brake technology and its applications, including the integration of stability control and active braking systems. The Classroom Manual covers the complete mechanical-hydraulic automotive braking theories. It introduces the reader to basic brake systems as well as advanced electronics utilized in stability control systems. The following chapters cover basic brake physics theories: discussion of newer components and materials, including a section on electric parking brakes, and any braking functions required for passenger cars and light trucks. The reader is introduced to fundamental information on trailer brakes, DOT requirements for trailer brakes, and a brief introduction to air brakes. Chapter 10, Electrical Braking Systems (EBS), simplifies the discussion on traditional antilock brake systems (ABS) while retaining the information for a complete understanding of ABS. Included in this chapter is a detailed discussion of electro-hydraulic brakes, including the Teves Mk60/70, Delphi DBC-7 and the newer Bosch 9.0 are introduced in Chapter 10. Advanced Braking Systems, Chapter 11, goes more into stability control and its relationship with some of the ancillary systems that work with stability control. This chapter also explains some of the ancillary systems that make stability control work more effectively, such as electro-hydraulic and fully electric steering, and tire pressure monitoring systems. The very latest technologies, such as active braking and intelligent cruise control systems, are introduced. Lastly, the chapter examines regenerative braking systems in use on the latest hybrid vehicles in production today. The Classroom Manual guides the reader from traditional hydraulic brake to the brake system of the future.

## HIGHLIGHTS OF THIS NEW EDITION—SHOP MANUAL

Safety information remains in the first chapter of the Shop Manual, placing this critical subject next to the tasks to be accomplished. Chapter 2, Brake Service Tools and Equipment, covers basic tools with more information on brake special tools and equipment. Figures and technical information have been added to cover the use of common shop tools such as on-car brake lathes. Some of the safety information that is pertinent to a particular piece of equipment is still in the chapter, so safety issues are presented just prior to the operation of the equipment. In keeping with typical shop diagnostic procedures and curriculum sequence, Chapter 3 retains the information on related systems that may have a direct impact on the braking system. Updated information on diagnosing electric parking brakes and electric braking systems has been added to this edition. To clarify the diagnosis and repair procedures for electric braking, three major ABS/TCS brands, Delphi DBC-7 and Bosch ABS 9.0 and Teves Mk 60/70, are retained for discussion instead of an individual discussion on all industry ABS offerings. This helps the reader better understand the technical diagnosing and repairing for all ABS/ TCS. This edition of the Shop Manual will guide the student/technician through all the basic tasks in brake system repair and presents a look into the near-term future of electric brakes and vehicle stability systems. The Shop Manual has several additions in the Advanced Braking Systems chapter, Chapter 11. This chapter deals with the diagnosis and repair of stability control systems and the surrounding technologies, such as electric steering, tire pressure monitoring systems, active braking, and intelligent cruise control.

# SHOP MANUAL

To stress the importance of safe work habits, the Shop Manual also dedicates one full chapter to safety. Other important features of this manual include:


CHAPTER 1
BRAKE SAFETY

Upon completion and review of this chapter, you should be able to:

- Explain the need and methods for maintaining a safe working area.
- List and discuss safety precautions when dealing with
- Explain so
- Wear pr
- Explain
- Expla

- List the safety requirements for working with brake fluid.
- Describe the hazards of asbestos materials.
- Explain the safety concerns with sol-
- other chemicals.

Basic Tools
Safety glasses or goggles
Respirator
Vacuum with HEPA filter
Wet-clean system
Carbon monoxide vent system
extinguisher(s)

Master Cylinder and Brake Fluid Service 135

Figure 4-2 Checking stop lamp operation.

BRAKE PEDAL MECHANICAL CHECK

Classroom Manual page 74

Special Tools
Coworker

PEDAL TRAVEL AND FORCE TEST

Special Tools
Brake pedal effort gauge
Tape measure
Service manual

Terms To Know
Bench bleeding
Bleeder screw
Brake bleeding
Gravity bleeding
Integral ABS
Manual bleeding
Non-integral ABS
Pressure bleeding
Specific gravity
Surge bleeding
Vacuum bleeding

BRAKE SYSTEM ROAD TEST

133

## Basic Tools Lists

Each chapter begins with a list of the basic tools needed to perform the tasks included in the chapter.

## Performance-Based Objectives

These objectives define the contents of the chapter and define what the student should have learned on completion of the chapter.

## Special Tools Lists

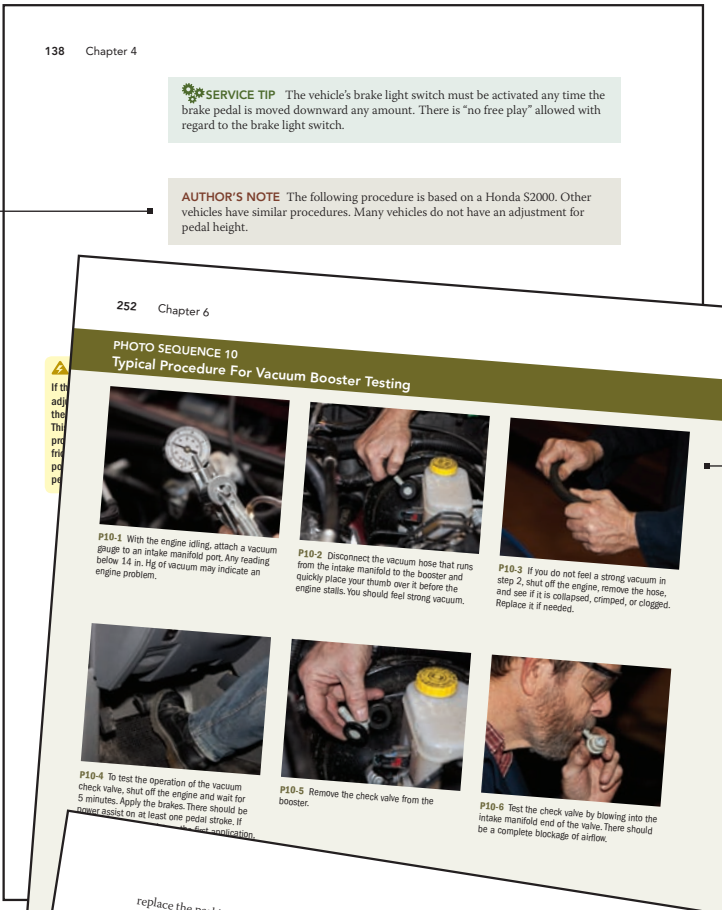
Whenever a special tool is required to complete a task, it is listed in the margin next to the procedure.

## Terms To Know List

Terms in this list are also defined in the Glossary at the end of the manual.

## Author's Notes

This feature includes simple explanations, stories, or examples of complex topics. These are included to help students understand difficult concepts.



138 Chapter 4

SERVICE TIP The vehicle's brake light switch must be activated any time the brake pedal is moved downward any amount. There is "no free play" allowed with regard to the brake light switch.

AUTHOR'S NOTE The following procedure is based on a Honda S2000. Other vehicles have similar procedures. Many vehicles do not have an adjustment for pedal height.

252 Chapter 6

PHOTO SEQUENCE 10
Typical Procedure For Vacuum Booster Testing

P10-1 With the engine idling, attach a vacuum gauge to an intake manifold port. Any reading below 14 in. Hg of vacuum may indicate an engine problem.

P10-2 Disconnect the vacuum hose that runs from the intake manifold to the booster and quickly place your thumb over it before the engine stalls. You should feel strong vacuum.

P10-3 If you do not feel a strong vacuum in step 2, shut off the engine, remove the hose, and see if it is collapsed, crimped, or clogged. Replace it if needed.

P10-4 To test the operation of the vacuum check valve, shut off the engine and wait for 5 minutes. Apply the brakes. There should be power assist on at least one pedal stroke. If

P10-5 Remove the check valve from the booster.

P10-6 Test the check valve by blowing into the intake manifold end of the valve. There should be a complete blockage of airflow.

Hydraulic Line, Valve, and Switch Service 223

replace the parking brake switch. If the lamp is still off, find and repair the open circuit in the wiring harness between the body control computer and the switch.

### Brake Fluid Level Switch Test

With the ignition on and the brake fluid level switch closed, the brake warning lamp lights to alert the driver of a low-fluid condition in the master cylinder. Some switches are built into the reservoir body; others are attached to the reservoir cap. Test principles are similar for both types.

Begin by ensuring that the fluid level is at or near the full mark on the reservoir. Turn the ignition on and observe the warning lamp. If it is lit, disconnect the wiring connector at the switch. If the lamp then goes out, replace the switch. If the lamp does not go out, find and repair the short circuit between the switch and the lamp.

To verify that the warning lamp will light when the fluid level is low, manually depress the switch float or remove the cap with an integral switch and let the float drop. If the lamp does not light with the switch closed, check for an open circuit between the switch and the lamp. If circuit continuity is good, replace the switch.

As a final check, disconnect the wiring harness from the switch, and connect a jumper wire between the two terminals in the harness connector. The warning lamp should light. If it does not, find and repair the open circuit between the switch and the body control computer.

### Electrical Wiring Repair

Wire size is determined by the amount of current, the length of the circuit, and the voltage drop allowed. Wire size is specified in either the **American Wire Gauge (AWG)** system or in metric cross-sectional area. The higher the number in AWG the smaller the conductor. A 20 gauge is much smaller than a 12 gauge.

When replacing a wire, the correct size wire must be used as shown on applicable wiring diagrams or in parts books. Each harness or wire must be held securely in place to prevent chafing or damage to the insulation due to vibration. Always use **rosin flux solder** to splice a wire, and use insulating tape or **heat-shrink tubing** to cover all splices or bare wires. Rosin flux cleans the connection during soldering without eroding the material as does acid-based flux. Applying heat to shrink tubing causes the tubing to contract and completely seal the wiring and connections. Utility companies used heat-shrink tubing to seal underground electrical supply cables.

Many electrical system repairs require replacing damaged wires. It is important to make these repairs in a way that does not increase the resistance in the circuit or lead to shorts or grounds in the repaired area. Several methods are used to repair damaged wire with many factors influencing the choice. These factors include the type of repair required accessibility of the wiring, the type of conductor and size of wire needed, and the circuit requirements. The three most common repair methods are:

1. Wrapping the damaged insulation with electrical tape (in cases where the insulation is damaged and the wiring is unharmed)
2. Crimping the connections with a solder-less connector
3. Soldering splices

When deciding where to cut a damaged wire, avoid points close to other splices or connections. As a rule, do not have two splices or connections within 1.5 inches (40 mm) of each other. Use a wire of the same size or larger than the wire being replaced.

**Crimping.** A solderless connection uses a compressed junction to connect two conductors. Some manufacturers require the use of self-sealing solderless connections on all repairs. Crimping selfsealing solder less connections is an acceptable way to splice wire,

An **American wire gauge** (AWG) is a system for specifying wire size (conductor cross-sectional area) by a series of gauge numbers; the lower the number, the larger the wire cross section.

**Caution** Never replace a wire with one of a smaller size. Using the incorrect size could cause repeated failure and damage to the vehicle electrical system.

**Rosin flux solder** is solder used for electrical repairs.

**Heat-shrink tubing** is plastic tubing that shrinks in diameter when exposed to heat.

## Photo Sequences

Many procedures are illustrated in detailed Photo Sequences. These photographs show the students what to expect when they perform particular procedures. They also familiarize students with a system or type of equipment that the school might not have.

## Margin Notes

The most important terms to know are highlighted and defined in the margin. Common trade jargon also appears in the margins and gives some of the common terms used for components. This feature helps students understand and speak the language of the trade, especially when conversing with an experienced technician.

## Service Tips

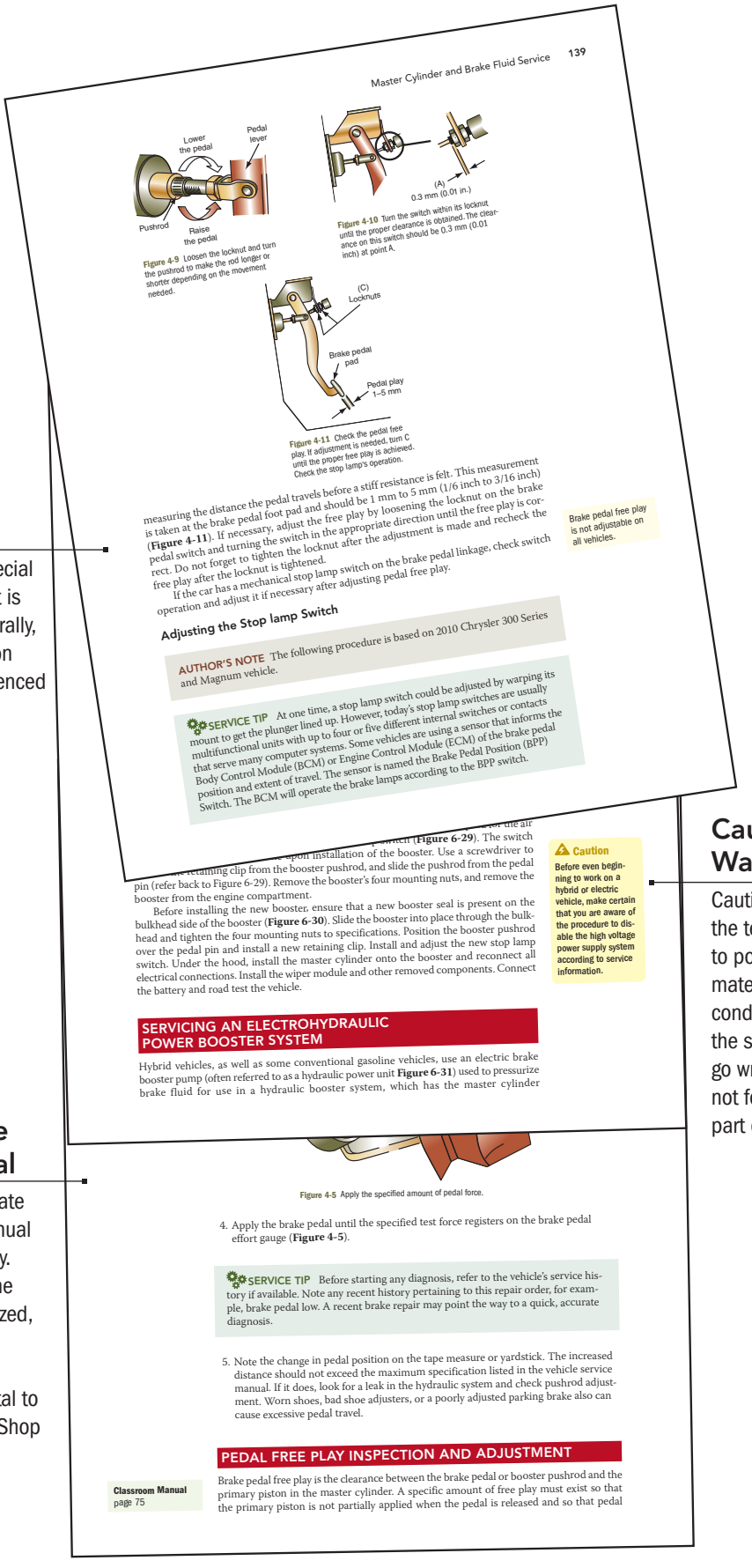
Whenever a shortcut or special procedure is appropriate, it is described in the text. Generally, these tips describe common procedures used by experienced technicians.

## References to the Classroom Manual

References to the appropriate page in the Classroom Manual appear whenever necessary. Although the chapters of the two manuals are synchronized, material covered in other chapters of the Classroom Manual may be fundamental to the topic discussed in the Shop Manual.

## Cautions and Warnings

Cautions appear throughout the text to alert the reader to potentially hazardous materials or unsafe conditions. Warnings advise the student of things that can go wrong if instructions are not followed or if an incorrect part or tool is used.



Master Cylinder and Brake Fluid Service 139



Figure 4-9 Loosen the locknut and turn the pushrod to make the rod longer or shorter depending on the movement needed.



Figure 4-10 Turn the switch within its locknut until the proper clearance is obtained. The clearance on this switch should be 0.3 mm (0.01 inch) at point A.



Figure 4-11 Check the pedal free play. If adjustment is needed, turn C until the proper free play is achieved. Check the stop lamp's operation.

measuring the distance the pedal travels before a stiff resistance is felt. This measurement is taken at the brake pedal foot pad and should be 1 mm to 5 mm (1/6 inch to 3/16 inch) (**Figure 4-11**). If necessary, adjust the free play by loosening the locknut on the brake pedal switch and turning the switch in the appropriate direction until the free play is correct. Do not forget to tighten the locknut after the adjustment is made and recheck the free play after the locknut is tightened.

If the car has a mechanical stop lamp switch on the brake pedal linkage, check switch operation and adjust it if necessary after adjusting pedal free play.

Brake pedal free play is not adjustable on all vehicles.

### Adjusting the Stop lamp Switch

**AUTHOR'S NOTE** The following procedure is based on 2010 Chrysler 300 Series and Magnum vehicle.

**SERVICE TIP** At one time, a stop lamp switch could be adjusted by warping its mount to get the plunger lined up. However, today's stop lamp switches are usually multifunctional units with up to four or five different internal switches or contacts that serve many computer systems. Some vehicles are using a sensor that informs the Body Control Module (BCM) or Engine Control Module (ECM) of the brake pedal position and extent of travel. The sensor is named the Brake Pedal Position (BPP) Switch. The BCM will operate the brake lamps according to the BPP switch.

**Caution**
**Before even beginning to work on a hybrid or electric vehicle, make certain that you are aware of the procedure to disable the high voltage power supply system according to service information.**

switch (**Figure 6-29**). The switch ... upon installation of the booster. Use a screwdriver to ... retaining clip from the booster pushrod, and slide the pushrod from the pedal pin (refer back to Figure 6-29). Remove the booster's four mounting nuts, and remove the booster from the engine compartment.

Before installing the new booster, ensure that a new booster seal is present on the bulkhead side of the booster (**Figure 6-30**). Slide the booster into place through the bulkhead and tighten the four mounting nuts to specifications. Position the booster pushrod over the pedal pin and install a new retaining clip. Install and adjust the new stop lamp switch. Under the hood, install the master cylinder onto the booster and reconnect all electrical connections. Install the wiper module and other removed components. Connect the battery and road test the vehicle.

### SERVICING AN ELECTROHYDRAULIC POWER BOOSTER SYSTEM

Hybrid vehicles, as well as some conventional gasoline vehicles, use an electric brake booster pump (often referred to as a hydraulic power unit **Figure 6-31**) used to pressurize brake fluid for use in a hydraulic booster system, which has the master cylinder

Figure 4-5 Apply the specified amount of pedal force.

4. Apply the brake pedal until the specified test force registers on the brake pedal effort gauge (**Figure 4-5**).

**SERVICE TIP** Before starting any diagnosis, refer to the vehicle's service history if available. Note any recent history pertaining to this repair order, for example, brake pedal low. A recent brake repair may point the way to a quick, accurate diagnosis.

5. Note the change in pedal position on the tape measure or yardstick. The increased distance should not exceed the maximum specification listed in the vehicle service manual. If it does, look for a leak in the hydraulic system and check pushrod adjustment. Worn shoes, bad shoe adjusters, or a poorly adjusted parking brake also can cause excessive pedal travel.

### PEDAL FREE PLAY INSPECTION AND ADJUSTMENT

**Classroom Manual** page 75

Brake pedal free play is the clearance between the brake pedal or booster pushrod and the primary piston in the master cylinder. A specific amount of free play must exist so that the primary piston is not partially applied when the pedal is released and so that pedal

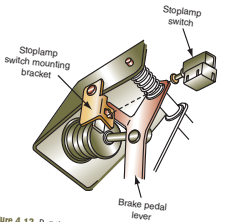



**Figure 4-12** Pull the switch plunger all the way out before installation. The pedal should be locked down and not released until the switch is installed.

Use a brake pedal depressor to hold the brake pedal down (check the alignment machine for a depressor). Rotate the stop lamp switch approximately 30 degrees counterclockwise and pull rearward on the switch. It should separate from its mount (**Figure 4-12**). Using hand force only, pull the switch plunger out to its fully extended position. Low clicks should be heard as the plunger ratchets out.

Ensure the brake pedal is down as far as it will go and is firmly held in place. Align the switch's index key to the notch in the bracket and push the switch into place. Rotate the switch about 30 degrees clockwise until it locks.

Apply foot force to the brake pedal and remove the pedal depressor. Allow the pedal to gently rise until it stops. Using gentle hand force, pull up on the brake pedal until it stops moving. This will ratchet the switch plunger to the correct position. The switch adjustment is initially checked by having an assistant observe the brake lights as the brake pedal is depressed and released. However, the final check requires a road test on a road where the cruise control can be safely used. During the road test, engage the cruise control at a safe speed. Once the system is stabilized, depress the brake slightly. The cruise control should turn off. If not, then the switch must be checked and readjusted as needed.

**Caution**
Do not release the brake pedal by pulling the depressor out and letting the pedal slam up to its stop. The stop lamp switch will not adjust properly and may be damaged.

**CUSTOMER CARE** A customer's only contact, literally, with the brake system in his or her car is through the brake pedal. Customers tend to judge brake performance by "pedal feel." It is always a good idea to evaluate the feel and action of the brake pedal before starting any brake job. Then when you deliver the finished job, pedal feel should be noticeably improved. The biggest cause of spongy or low brake pedal action is air in the system, so careful bleeding of the system will do a lot to ensure customer confidence.

### Brake Pedal Position Switch

Many late-model vehicles use a BPP sensor to inform the body control module (BCM) of the brake pedal position (**Figure 4-13**). The BPP sensor is a potentiometer. The BCM



**Name** _____ **Date** _____

JOB SHEET 36

## DIAGNOSING DRUM BRAKE PROBLEMS

Upon completion of this job sheet, you will be able to diagnose poor stopping, noise, pulling, grabbing, dragging or pedal pulsation problems.

**ASE Education Foundation Correlation**

This job sheet addresses the following **MLR** task:

**C.4.** Inspect wheel cylinders for leaks and proper operation; remove and replace as needed. **(P-2)**

This job sheet addresses the following **AST/MAST** tasks:

**C.1.** Diagnose poor stopping, noise, vibration, pulling, grabbing, dragging or pedal pulsation concerns; determine necessary action. **(P-1)**

**C.5.** Inspect wheel cylinders for leaks and proper operation; remove and replace as needed. **(P-2)**

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**Tools and Materials**
- Basic hand tools

**Protective Clothing**
Goggles or safety glasses with side shields

**Describe the vehicle being worked on:**
Year _____ Make _____ Model _____ VIN _____
Engine type and size _____

**Procedure**

1. Begin the inspection of the drum brake system by checking the tires for excessive or unusual wear or improper inflation. What did you find?
2. Wheels for bent or warped rims. What did you find?
3. Wheel bearings for looseness or wear. What did you find?
4. Suspension system for worn or broken components. What did you find?
5. Brake fluid level in the master cylinder. What did you find?
6. Signs of leakage at the master cylinder, in brake lines or hoses, at all connections, and at each wheel. What did you find?

## Customer Care

This feature highlights those little things a technician can do or say to enhance customer relations.

## Job Sheets

Located at the end of each chapter, the Job Sheets provide a format for students to perform procedures covered in the chapter. A reference to the ASE Education Foundation task addressed by the procedure is included on the Job Sheet.

## ASE Challenge Questions

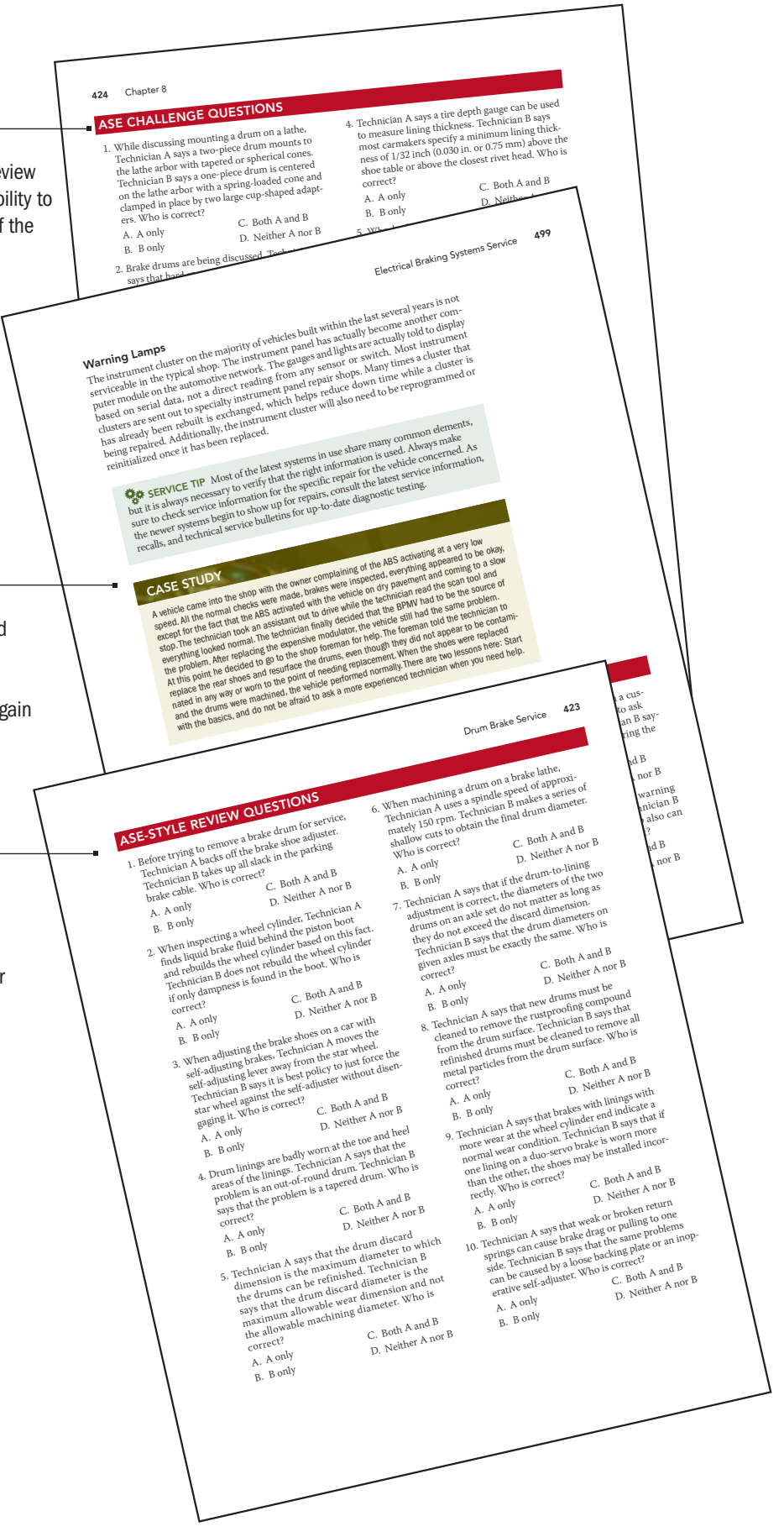
Each technical chapter ends with five ASE challenge questions. These are not mere review questions; rather, they test the students' ability to apply general knowledge to the contents of the chapter.

## Case Studies

Each chapter ends with a Case Study describing a particular vehicle problem and the logical steps a technician might use to solve the problem. These studies focus on system diagnosis skills and help students gain familiarity with the process.

## ASE–Style Review Questions

Each chapter contains ASE-style review questions that reflect the performance objectives listed at the beginning of the chapter. These questions can be used to review the chapter as well as to prepare for the ASE certification exam.



424 Chapter 8

ASE CHALLENGE QUESTIONS

1. While discussing mounting a drum on a lathe, Technician A says a two-piece drum mounts to the lathe arbor with tapered or spherical cones. Technician B says a one-piece drum is centered on the lathe arbor with a spring-loaded cone and clamped in place by two large cup-shaped adapters. Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

2. Brake drums are being discussed. Technician A says that hard

4. Technician A says a tire depth gauge can be used to measure lining thickness. Technician B says most carmakers specify a minimum lining thickness of 1/32 inch (0.030 in. or 0.75 mm) above the shoe table or above the closest rivet head. Who is correct?
A. A only C. Both A and B
B. B only

Electrical Braking Systems Service 499

Warning Lamps

The instrument cluster on the majority of vehicles built within the last several years is not serviceable in the typical shop. The instrument panel has actually become another computer module on the automotive network. The gauges and lights are actually told to display based on serial data, not a direct reading from any sensor or switch. Most instrument clusters are sent out to specialty instrument panel repair shops. Many times a cluster that has already been rebuilt is exchanged, which helps reduce down time while a cluster is being repaired. Additionally, the instrument cluster will also need to be reprogrammed or reinitialized once it has been replaced.

SERVICE TIP Most of the latest systems in use share many common elements, but it is always necessary to verify that the right information is used. Always make sure to check service information for the specific repair for the vehicle concerned. As the newer systems begin to show up for repairs, consult the latest service information, recalls, and technical service bulletins for up-to-date diagnostic testing.

CASE STUDY

A vehicle came into the shop with the owner complaining of the ABS activating at a very low speed. All the normal checks were made, brakes were inspected, everything appeared to be okay, except for the fact that the ABS activated with the vehicle on dry pavement and coming to a slow stop. The technician took an assistant out to drive while the technician read the scan tool and everything looked normal. The technician finally decided that the BPMV had to be the source of the problem. After replacing the expensive modulator, the vehicle still had the same problem. At this point he decided to go to the shop foreman for help. The foreman told the technician to replace the rear shoes and resurface the drums, even though they did not appear to be contaminated in any way or worn to the point of needing replacement. When the shoes were replaced and the drums were machined, the vehicle performed normally. There are two lessons here: Start with the basics, and do not be afraid to ask a more experienced technician when you need help.

Drum Brake Service 423

ASE-STYLE REVIEW QUESTIONS

1. Before trying to remove a brake drum for service, Technician A backs off the brake shoe adjuster. Technician B takes up all slack in the parking brake cable. Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

2. When inspecting a wheel cylinder, Technician A finds liquid brake fluid behind the piston boot and rebuilds the wheel cylinder based on this fact. Technician B does not rebuild the wheel cylinder if only dampness is found in the boot. Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

3. When adjusting the brake shoes on a car with self-adjusting brakes, Technician A moves the self-adjusting lever away from the star wheel. Technician B says it is best policy to just force the star wheel against the self-adjuster without disengaging it. Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

4. Drum linings are badly worn at the toe and heel areas of the linings. Technician A says that the problem is an out-of-round drum. Technician B says that the problem is a tapered drum. Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

5. Technician A says that the drum discard dimension is the maximum diameter to which the drums can be refinished. Technician B says that the drum discard diameter is the maximum allowable wear dimension and not the allowable machining diameter. Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

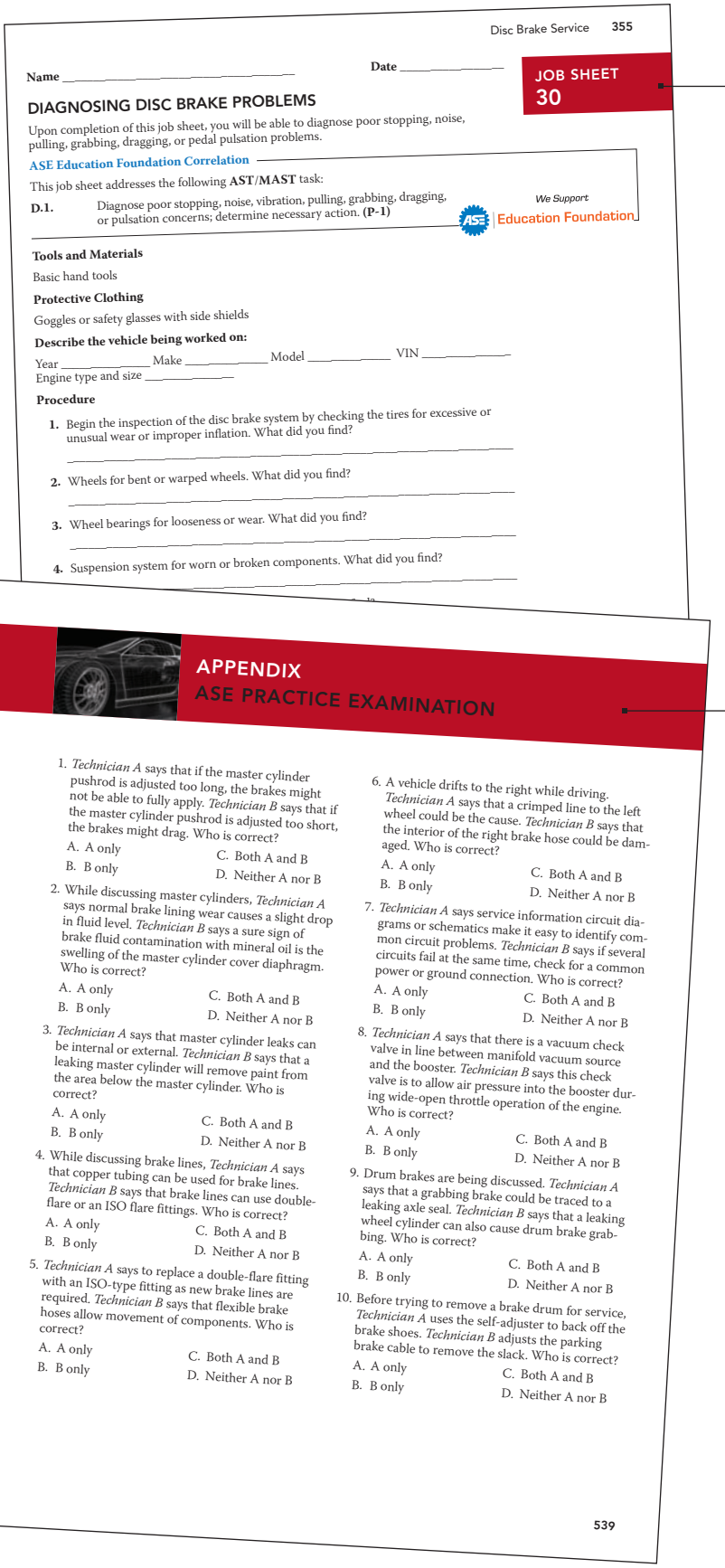
6. When machining a drum on a brake lathe, Technician A uses a spindle speed of approximately 150 rpm. Technician B makes a series of shallow cuts to obtain the final drum diameter. Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

7. Technician A says that if the drum-to-lining adjustment is correct, the diameters of the two drums on an axle set do not matter as long as they do not exceed the discard dimension. Technician B says that the drum diameters on given axles must be exactly the same. Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

8. Technician A says that new drums must be cleaned to remove the rustproofing compound from the drum surface. Technician B says that refinished drums must be cleaned to remove all metal particles from the drum surface. Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

9. Technician A says that brakes with linings with more wear at the wheel cylinder end indicate a normal wear condition. Technician B says that if one lining on a duo-servo brake is worn more than the other, the shoes may be installed incorrectly. Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

10. Technician A says that weak or broken return springs can cause brake drag or pulling to one side. Technician B says that the same problems can be caused by a loose backing plate or an inoperative self-adjuster. Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B



Disc Brake Service 355

Name _____ Date _____

JOB SHEET 30

DIAGNOSING DISC BRAKE PROBLEMS

Upon completion of this job sheet, you will be able to diagnose poor stopping, noise, pulling, grabbing, dragging, or pedal pulsation problems.

ASE Education Foundation Correlation

This job sheet addresses the following **AST/MAST** task:

**D.1.** Diagnose poor stopping, noise, vibration, pulling, grabbing, dragging, or pulsation concerns; determine necessary action. **(P-1)**

We Support Education Foundation

**Tools and Materials**

Basic hand tools

**Protective Clothing**

Goggles or safety glasses with side shields

**Describe the vehicle being worked on:**

Year _____ Make _____ Model _____ VIN _____

Engine type and size _____

**Procedure**

1. Begin the inspection of the disc brake system by checking the tires for excessive or unusual wear or improper inflation. What did you find?

2. Wheels for bent or warped wheels. What did you find?

3. Wheel bearings for looseness or wear. What did you find?

4. Suspension system for worn or broken components. What did you find?

APPENDIX

ASE PRACTICE EXAMINATION

1. *Technician A* says that if the master cylinder pushrod is adjusted too long, the brakes might not be able to fully apply. *Technician B* says that if the master cylinder pushrod is adjusted too short, the brakes might drag. Who is correct?
   A. A only C. Both A and B
   B. B only D. Neither A nor B

2. While discussing master cylinders, *Technician A* says normal brake lining wear causes a slight drop in fluid level. *Technician B* says a sure sign of brake fluid contamination with mineral oil is the swelling of the master cylinder cover diaphragm. Who is correct?
   A. A only C. Both A and B
   B. B only D. Neither A nor B

3. *Technician A* says that master cylinder leaks can be internal or external. *Technician B* says that a leaking master cylinder will remove paint from the area below the master cylinder. Who is correct?
   A. A only C. Both A and B
   B. B only D. Neither A nor B

4. While discussing brake lines, *Technician A* says that copper tubing can be used for brake lines. *Technician B* says that brake lines can use double-flare or an ISO flare fittings. Who is correct?
   A. A only C. Both A and B
   B. B only D. Neither A nor B

5. *Technician A* says to replace a double-flare fitting with an ISO-type fitting as new brake lines are required. *Technician B* says that flexible brake hoses allow movement of components. Who is correct?
   A. A only C. Both A and B
   B. B only D. Neither A nor B

6. A vehicle drifts to the right while driving. *Technician A* says that a crimped line to the left wheel could be the cause. *Technician B* says that the interior of the right brake hose could be damaged. Who is correct?
   A. A only C. Both A and B
   B. B only D. Neither A nor B

7. *Technician A* says service information circuit diagrams or schematics make it easy to identify common circuit problems. *Technician B* says if several circuits fail at the same time, check for a common power or ground connection. Who is correct?
   A. A only C. Both A and B
   B. B only D. Neither A nor B

8. *Technician A* says that there is a vacuum check valve in line between manifold vacuum source and the booster. *Technician B* says this check valve is to allow air pressure into the booster during wide-open throttle operation of the engine. Who is correct?
   A. A only C. Both A and B
   B. B only D. Neither A nor B

9. Drum brakes are being discussed. *Technician A* says that a grabbing brake could be traced to a leaking axle seal. *Technician B* says that a leaking wheel cylinder can also cause drum brake grabbing. Who is correct?
   A. A only C. Both A and B
   B. B only D. Neither A nor B

10. Before trying to remove a brake drum for service, *Technician A* uses the self-adjuster to back off the brake shoes. *Technician B* adjusts the parking brake cable to remove the slack. Who is correct?
    A. A only C. Both A and B
    B. B only D. Neither A nor B

539

## Job Sheets

Located at the end of each chapter, the Job Sheets provide a format for students to perform procedures covered in the chapter. A reference to the ASE Education Foundation task addressed by the procedure is included on the Job Sheet.

## ASE Practice Examination

A 50-question ASE practice exam, located in the Appendix, is included to test students on the content of the complete Shop Manual.

# CLASSROOM MANUAL

Features of the Classroom Manual include the following:

## Cognitive Objectives

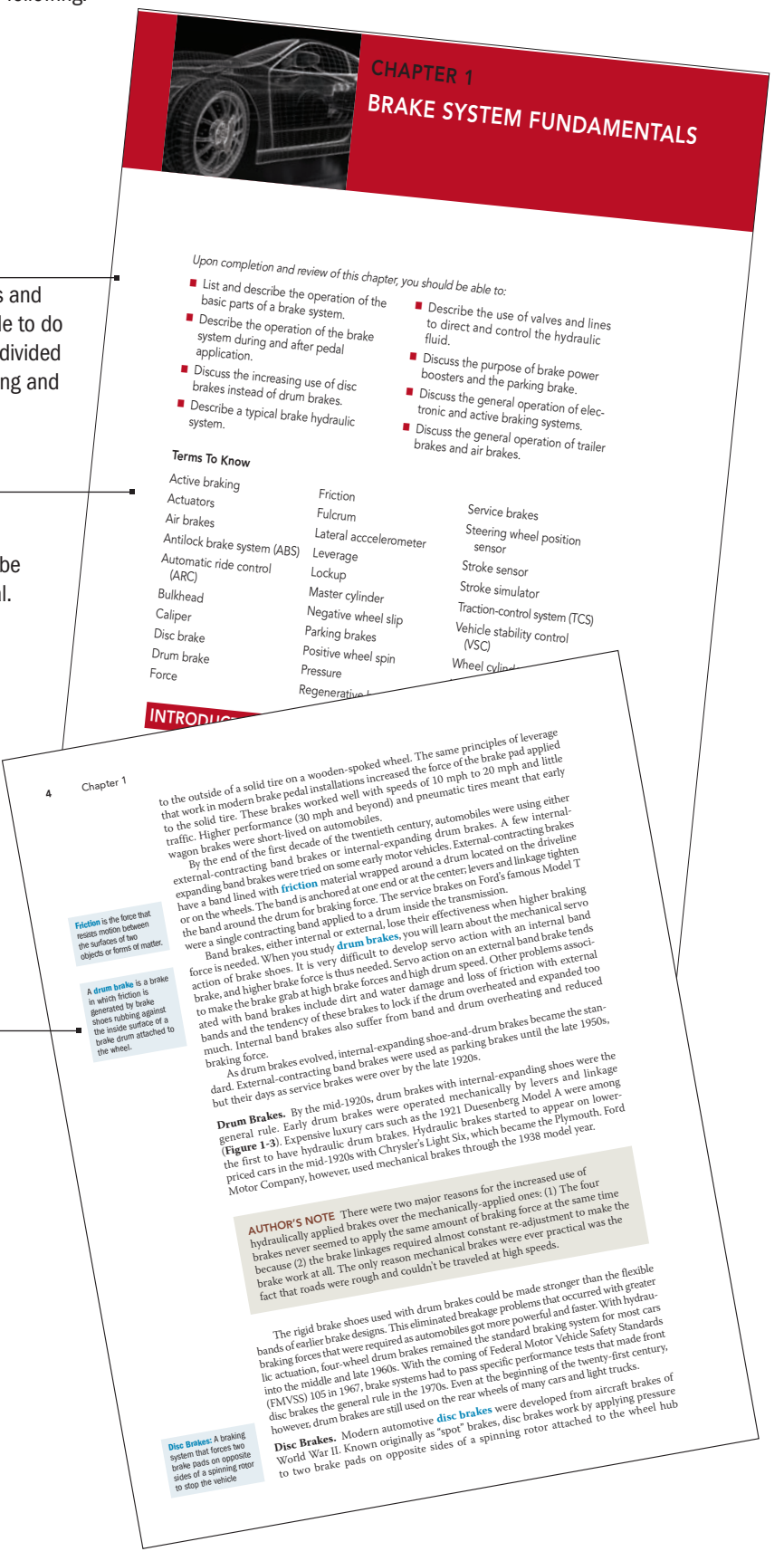
These objectives outline the chapter's contents and identify what students should know and be able to do upon completion of the chapter. Each topic is divided into small units to promote easier understanding and learning.

## Terms To Know List

A list of key terms appears in the beginning of the chapter. Students will see these terms discussed in the chapter. Definitions can also be found in the Glossary at the end of the manual.

## Margin Notes

The most important terms to know are highlighted and defined in the margin. Common trade jargon also appears in the margin and gives some of the common terms used for components. This helps students understand and speak the language of the trade, especially when conversing with an experienced technician.



CHAPTER 1

BRAKE SYSTEM FUNDAMENTALS

*Upon completion and review of this chapter, you should be able to:*

- List and describe the operation of the basic parts of a brake system.
- Describe the operation of the brake system during and after pedal application.
- Discuss the increasing use of disc brakes instead of drum brakes.
- Describe a typical brake hydraulic system.
- Describe the use of valves and lines to direct and control the hydraulic fluid.
- Discuss the purpose of brake power boosters and the parking brake.
- Discuss the general operation of electronic and active braking systems.
- Discuss the general operation of trailer brakes and air brakes.

**Terms To Know**

Active braking
Actuators
Air brakes
Antilock brake system (ABS)
Automatic ride control (ARC)
Bulkhead
Caliper
Disc brake
Drum brake
Force
Friction
Fulcrum
Lateral acccelerometer
Leverage
Lockup
Master cylinder
Negative wheel slip
Parking brakes
Positive wheel spin
Pressure
Service brakes
Steering wheel position sensor
Stroke sensor
Stroke simulator
Traction-control system (TCS)
Vehicle stability control (VSC)

4 Chapter 1

to the outside of a solid tire on a wooden-spoked wheel. The same principles of leverage that work in modern brake pedal installations increased the force of the brake pad applied to the solid tire. These brakes worked well with speeds of 10 mph to 20 mph and little traffic. Higher performance (30 mph and beyond) and pneumatic tires meant that early wagon brakes were short-lived on automobiles.

By the end of the first decade of the twentieth century, automobiles were using either external-contracting band brakes or internal-expanding drum brakes. A few internal-expanding band brakes were tried on some early motor vehicles. External-contracting brakes have a band lined with **friction** material wrapped around a drum located on the driveline or on the wheels. The band is anchored at one end or at the center; levers and linkage tighten the band around the drum for braking force. The service brakes on Ford's famous Model T were a single contracting band applied to a drum inside the transmission.

Band brakes, either internal or external, lose their effectiveness when higher braking force is needed. When you study **drum brakes**, you will learn about the mechanical servo action of brake shoes. It is very difficult to develop servo action with an internal band brake, and higher brake force is thus needed. Servo action on an external band brake tends to make the brake grab at high brake forces and high drum speed. Other problems associated with band brakes include dirt and water damage and loss of friction with external bands and the tendency of these brakes to lock if the drum overheated and expanded too much. Internal band brakes also suffer from band and drum overheating and reduced braking force.

As drum brakes evolved, internal-expanding shoe-and-drum brakes became the standard. External-contracting band brakes were used as parking brakes until the late 1950s, but their days as service brakes were over by the late 1920s.

**Drum Brakes.** By the mid-1920s, drum brakes with internal-expanding shoes were the general rule. Early drum brakes were operated mechanically by levers and linkage (**Figure 1-3**). Expensive luxury cars such as the 1921 Duesenberg Model A were among the first to have hydraulic drum brakes. Hydraulic brakes started to appear on lower-priced cars in the mid-1920s with Chrysler's Light Six, which became the Plymouth. Ford Motor Company, however, used mechanical brakes through the 1938 model year.

**AUTHOR'S NOTE** There were two major reasons for the increased use of hydraulically applied brakes over the mechanically-applied ones: (1) The four brakes never seemed to apply the same amount of braking force at the same time because (2) the brake linkages required almost constant re-adjustment to make the brake work at all. The only reason mechanical brakes were ever practical was the fact that roads were rough and couldn't be traveled at high speeds.

The rigid brake shoes used with drum brakes could be made stronger than the flexible bands of earlier brake designs. This eliminated breakage problems that occurred with greater braking forces that were required as automobiles got more powerful and faster. With hydraulic actuation, four-wheel drum brakes remained the standard braking system for most cars into the middle and late 1960s. With the coming of Federal Motor Vehicle Safety Standards (FMVSS) 105 in 1967, brake systems had to pass specific performance tests that made front disc brakes the general rule in the 1970s. Even at the beginning of the twenty-first century, however, drum brakes are still used on the rear wheels of many cars and light trucks.

**Disc Brakes.** Modern automotive **disc brakes** were developed from aircraft brakes of World War II. Known originally as "spot" brakes, disc brakes work by applying pressure to two brake pads on opposite sides of a spinning rotor attached to the wheel hub

**Friction** is the force that resists motion between the surfaces of two objects or forms of matter.

A **drum brake** is a brake in which friction is generated by brake shoes rubbing against the inside surface of a brake drum attached to the wheel.

**Disc Brakes:** A braking system that forces two brake pads on opposite sides of a spinning rotor to stop the vehicle

Related Systems: Tires, Wheels, Bearings, and Suspensions 45

springs. Any of these components can create braking problems if they are not in proper working order. This chapter outlines the key relationships between brake systems and the related systems of wheels, tires, wheel bearings, and suspensions.

TIRE FUNDAMENTALS

Brake systems are engineered in relation to many vehicle factors of weight, size, and performance. Among these factors are the construction, size, and tread design of the tires and the amount of traction or friction expected to be available between the tires and the road. For the best and most reliable brake performance, tires at all four wheels should be identical in construction, size, and tread pattern.

Shop Manual page 98

Carmakers' Recommendations

Most passenger cars and light trucks built since 1968 have a tire information placard on a door, on a door pillar, or inside the glove compartment (**Figure 3-1**). The tire information placard lists the manufacturer's original equipment tire size and any recommended optional sizes. It also lists the recommended cold front and rear inflation pressures, and maximum front and rear **gross vehicle weight rating (GVWR)**. Brake systems are engineered to work most efficiently with the tire sizes and pressures listed on the placard.

A few carmakers install different sized wheels and tires at the front and rear of some vehicles, but this practice is reserved for a small percentage of high-performance sports cars like the Porsche 911. More than 99 percent of the vehicles on the road are originally

**Gross vehicle weight rating (GVWR)** is the total weight of a vehicle plus its maximum rated

22 Chapter 2

BRAKE SYSTEM ENERGY

All brake systems work according to a few principles or "laws" of physics, and the concept of energy is a basic part of physical science. Energy is the ability to do work and comes in many familiar forms: chemical energy, mechanical energy, heat energy, and electrical energy are among the most obvious forms in all automotive systems.

A brake system converts one form of physical energy to another. To slow and stop a moving vehicle, the brakes change the **kinetic energy** of motion to heat energy through the application of friction. When the brakes change one form of energy to another, they are doing work. Work is the result of releasing or using energy.

**Kinetic energy** is the energy of mechanical work or motion.

AUTHOR'S NOTE It is impossible at this time to create or destroy energy. However, it can be converted from one form to another. The master cylinder is one place this happens: the mechanical energy of the brake pedal is converted into hydraulic energy in the master cylinder bore. It is later converted back to mechanical energy at the wheels.

Kinetic Energy, Mass, Weight, and Speed

Kinetic energy is the energy of mechanical work or motion. When an automobile starts, accelerates, decelerates, and stops, kinetic energy is at work. The amount of kinetic energy at work at any moment is determined by a v[illegible]'s mass (weight), speed, and the rate at which speed is changing.

The terms "mass" and "weight" can be [illegible] the surface of the Earth, but the two terms [illegible] surement of the number of molecules that [illegible] of the effect of gravity on that mass. All [illegible] quart of hydraulic fluid to the air in an air [illegible] science of physics, it can be said that the [illegible] the more complex the molecules are, th[illegible] dense it is. The effect of gravity on the [illegible]

**Mass** is the measure of the inertia of an object or form of matter or its resistance to acceleration; it also is the molecular density of an object.

The basic difference between mass [illegible] space shuttle, which weighs about 1[illegible] When the shuttle is in orbit, outside [illegible] mass stays the same, however.

The combined effects of weight [illegible] much greater effect than weight. T[illegible] lated with this formula, which is q[illegible]

$$\frac{mv^2}{29.9} = Ek$$

where

$m$ = mass (weight) in pou[illegible]
$v$ = velocity (speed) in m[illegible]
$Ek$ = kinetic energy in fo[illegible]

Consider two cars, bo[illegible] pounds; the other weighs 4[illegible]

Related Systems: Tires, Wheels, Bearings, and Suspensions 45

springs. Any of these components can create braking problems if they are not in proper working order. This chapter outlines the key relationships between brake systems and the related systems of wheels, tires, wheel bearings, and suspensions.

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Shop Manual page 98

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A few carmakers install different sized wheels and tires at the front and rear of some vehicles, but this practice is reserved for a small percentage of high-performance sports cars like the Porsche 911. More than 99 percent of the vehicles on the road are originally fitted with wheels and tires of the same size at each corner. Although manufacturers may recommend one or two optional tire sizes at the rear that are larger than the front original equipment size, a large variation from the carmaker's recommendation can lead to braking problems, as well as problems with other vehicle systems.

For example, an extreme difference in tire diameters from front to rear may produce unequal speed signals from the wheel speed sensors of ABSs. Tires much larger than those recommended by the vehicle maker may produce inaccurate vehicle speed-sensor signals to the PCM or the ABS control module. This same problem exists if all four tires are larger or smaller than the manufacturer's recommendations.

**Gross vehicle weight rating (GVWR)** is the total weight of a vehicle plus its maximum rated payload, including passengers and full fuel tank.

A BIT OF HISTORY

When radial tires were first introduced in the 70s, there was a lot of resistance by drivers to using the new design. Complaints ranged from "feels funny when driving" to "they don't have enough air in them." Some drivers even went so far as to remove radial tires from a brand-new vehicle and to install bias tires. Two major characteristics of the radial tire overcame this die-hard resistance: a much smoother ride and increased fuel mileage. Lower-profile tires of today have also eliminated most of the comments about the tires "appearing underinflated."



Figure 3-1 This placard is located on the driver door and lists recommended tire size and cold inflation pressure.

## Cross-References to the Shop Manual

References to the appropriate page in the Shop Manual appear whenever necessary. Although the chapters of the two manuals are synchronized, material covered in other chapters of the Shop Manual may be fundamental to the topic discussed in the Classroom Manual.

## Author's Notes

This feature includes simple explanations, stories, or examples of complex topics. These are included to help students understand difficult concepts.

## A Bit of History

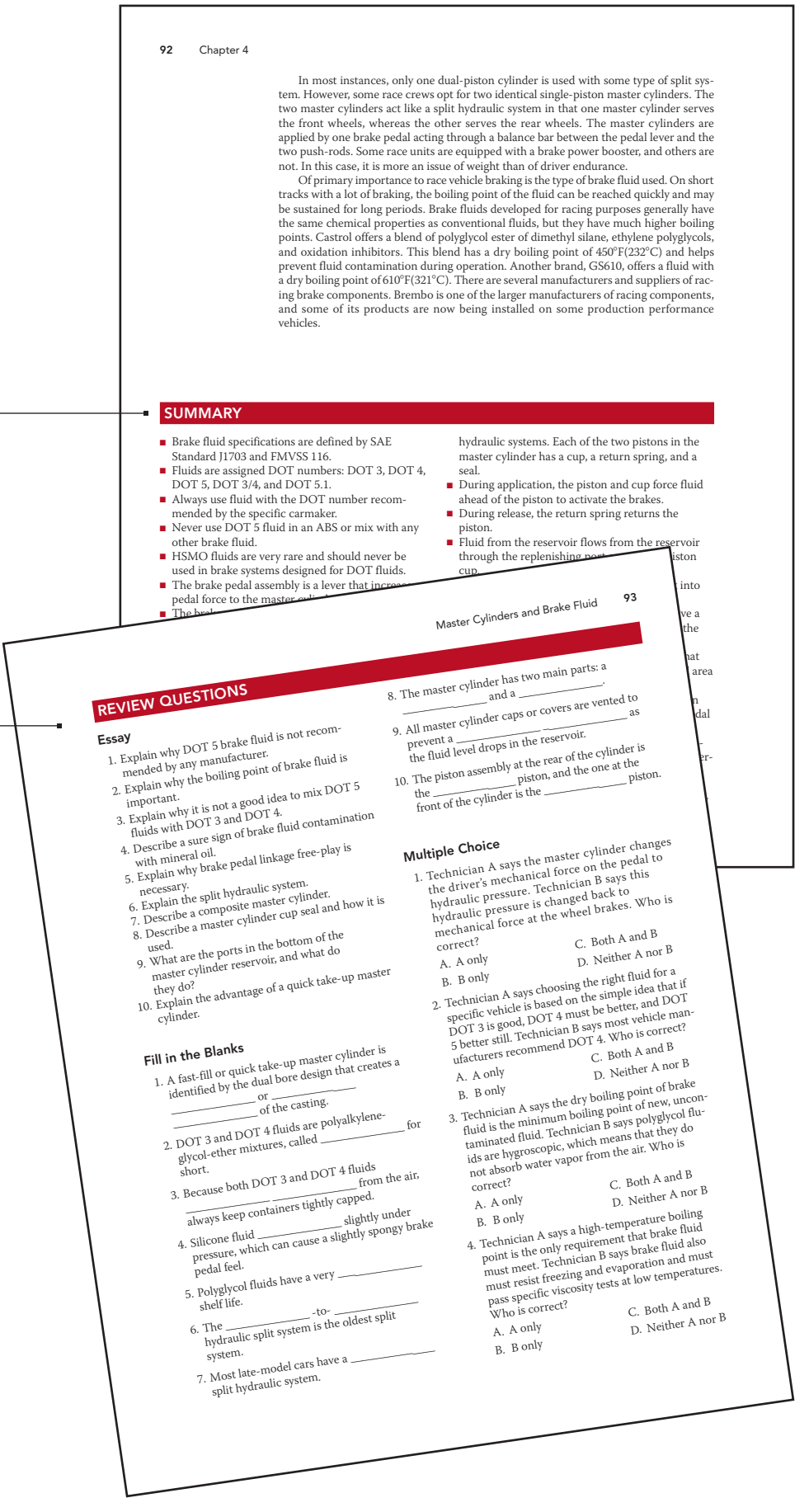
This feature gives the student a sense of the evolution of the automobile. This feature not only contains nice-to-know information, but also should spark some interest in the subject matter.

## Summary

Each chapter concludes with summary statements that contain the important topics of the chapter. These are designed to help the reader review the contents.

## Review Questions

Short-answer essay, fill in the blank, and multiple-choice questions follow each chapter. These questions are designed to accurately assess the student's competence in the stated objectives at the beginning of the chapter.



92 Chapter 4

In most instances, only one dual-piston cylinder is used with some type of split system. However, some race crews opt for two identical single-piston master cylinders. The two master cylinders act like a split hydraulic system in that one master cylinder serves the front wheels, whereas the other serves the rear wheels. The master cylinders are applied by one brake pedal acting through a balance bar between the pedal lever and the two push-rods. Some race units are equipped with a brake power booster, and others are not. In this case, it is more an issue of weight than of driver endurance.

Of primary importance to race vehicle braking is the type of brake fluid used. On short tracks with a lot of braking, the boiling point of the fluid can be reached quickly and may be sustained for long periods. Brake fluids developed for racing purposes generally have the same chemical properties as conventional fluids, but they have much higher boiling points. Castrol offers a blend of polyglycol ester of dimethyl silane, ethylene polyglycols, and oxidation inhibitors. This blend has a dry boiling point of 450°F(232°C) and helps prevent fluid contamination during operation. Another brand, GS610, offers a fluid with a dry boiling point of 610°F(321°C). There are several manufacturers and suppliers of racing brake components. Brembo is one of the larger manufacturers of racing components, and some of its products are now being installed on some production performance vehicles.

SUMMARY

- Brake fluid specifications are defined by SAE Standard J1703 and FMVSS 116.
- Fluids are assigned DOT numbers: DOT 3, DOT 4, DOT 5, DOT 3/4, and DOT 5.1.
- Always use fluid with the DOT number recommended by the specific carmaker.
- Never use DOT 5 fluid in an ABS or mix with any other brake fluid.
- HSMO fluids are very rare and should never be used in brake systems designed for DOT fluids.
- The brake pedal assembly is a lever that increases pedal force to the master cylinder.
- The brake pedal assembly is a lever that increases pedal force to the master cylinder.
- Fluid from the reservoir flows from the reservoir through the replenishing port [illegible] piston cup.

Master Cylinders and Brake Fluid 93

REVIEW QUESTIONS

**Essay**

1. Explain why DOT 5 brake fluid is not recommended by any manufacturer.
2. Explain why the boiling point of brake fluid is important.
3. Explain why it is not a good idea to mix DOT 5 fluids with DOT 3 and DOT 4.
4. Describe a sure sign of brake fluid contamination with mineral oil.
5. Explain why brake pedal linkage free-play is necessary.
6. Explain the split hydraulic system.
7. Describe a composite master cylinder.
8. Describe a master cylinder cup seal and how it is used.
9. What are the ports in the bottom of the master cylinder reservoir, and what do they do?
10. Explain the advantage of a quick take-up master cylinder.

**Fill in the Blanks**

1. A fast-fill or quick take-up master cylinder is identified by the dual bore design that creates a _____ or _____ of the casting.
2. DOT 3 and DOT 4 fluids are polyalkylene-glycol-ether mixtures, called _____ for short.
3. Because both DOT 3 and DOT 4 fluids _____, always keep containers tightly capped.
4. Silicone fluid _____ from the air, pressure, which can cause a slightly spongy brake pedal feel.
5. Polyglycol fluids have a very _____ slightly under shelf life.
6. The _____ -to- _____ hydraulic split system is the oldest split system.
7. Most late-model cars have a _____ split hydraulic system.
8. The master cylinder has two main parts: a _____ and a _____.
9. All master cylinder caps or covers are vented to prevent a _____ as the fluid level drops in the reservoir.
10. The piston assembly at the rear of the cylinder is the _____ piston, and the one at the front of the cylinder is the _____ piston.

**Multiple Choice**

1. Technician A says the master cylinder changes the driver's mechanical force on the pedal to hydraulic pressure. Technician B says this hydraulic pressure is changed back to mechanical force at the wheel brakes. Who is correct?
   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B
2. Technician A says choosing the right fluid for a specific vehicle is based on the simple idea that if DOT 3 is good, DOT 4 must be better, and DOT 5 better still. Technician B says most vehicle manufacturers recommend DOT 4. Who is correct?
   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B
3. Technician A says the dry boiling point of brake fluid is the minimum boiling point of new, uncontaminated fluid. Technician B says polyglycol fluids are hygroscopic, which means that they do not absorb water vapor from the air. Who is correct?
   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B
4. Technician A says a high-temperature boiling point is the only requirement that brake fluid must meet. Technician B says brake fluid also must resist freezing and evaporation and must pass specific viscosity tests at low temperatures. Who is correct?
   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B

# SUPPLEMENTS

## Instructor Resources

The *Today's Technician* series offers a robust set of instructor resources, available online at Cengage's Instructor Resource Center and on DVD. The following tools have been provided to meet any instructor's classroom preparation needs:

- An Instructor's Guide provides lecture outlines, teaching tips, and complete answers to end-of-chapter questions.
- Power Point presentations include images, videos, and animations that coincide with each chapter's content coverage.
- Cengage Learning Testing Powered by Cognero® delivers hundreds of test questions in a flexible, online system. You can choose to author, edit, and manage test bank content from multiple Cengage Learning solutions and deliver tests from your LMS, or you can simply download editable Word documents from the DVD or Instructor Resource Center.
- An Image Gallery includes photos and illustrations from the text.
- The Job Sheets from the Shop Manual are provided in Word format.
- End-of-Chapter Review Questions are also provided in Word format, with a separate set of text rejoinders available for instructors' reference.
- To complete this powerful suite of planning tools, a pair of correlation guides map this edition's content to the NATEF tasks and to the previous edition.

## MindTap for Today's Technician: Automotive Brake Systems, 7e

MindTap is a personalized teaching experience with relevant assignments that guide students to analyze, apply, and improve thinking, allowing you to measure skills and outcomes with ease.

- Personalized Teaching: Becomes yours with a Learning Path that is built with key student objectives. Control what students see and when they see it. Use it as-is or match to your syllabus exactly—hide, rearrange, add, and create your own content.
- Guide Students: A unique learning path of relevant readings, multimedia, and activities that move students up the learning taxonomy from basic knowledge and comprehension to analysis and application.
- Promote Better Outcomes: Empower instructors and motivate students with analytics and reports that provide a snapshot of class progress, time in course, engagement and completion rates.

# REVIEWERS

The author and publisher would like to extend special thanks to the following instructors for reviewing the draft manuscript:

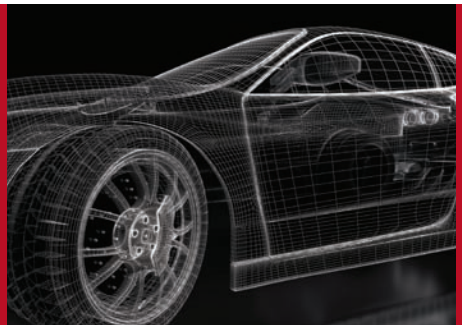
**Rodney Batch**
University of Northwestern Ohio
Lima, OH

**Christopher J. Marker**
University of Northwestern Ohio
Lima, OH

**Tim Pifer**
Midlands Technical College
Columbia, SC

**Larry Stanley**
Arizona Western College
Yuma, AZ

**Claude F. Townsend**
Oakland Community College
Bloomfield Hills, MI



# CHAPTER 1
# BRAKE SAFETY

*Upon completion and review of this chapter, you should be able to:*

- Explain the need and methods for maintaining a safe working area.
- List and discuss some safety issues dealing with vehicle operation in the shop.
- Explain some of the commonsense rules for working with power equipment.
- Wear proper clothing and equipment in a shop.
- Explain the first aid step to remove chemicals from the eyes.
- Explain the purpose for government regulations of brake performance and standards.
- List the safety requirements for working with brake fluid.
- Describe the hazards of asbestos materials.
- Explain the safety concerns with solvents and other chemicals.
- Explain the general functions of the safety and environmental agencies of the United States and Canada.
- Discuss the principles of hazardous communications.
- Discuss some of the safety concerns associated with antilock brake and air bag systems.
- Discuss technician training and certification.

**Basic Tools**

Safety glasses or goggles
Respirator
Vacuum with HEPA filter
Wet-clean system
Carbon monoxide vent system
Fire extinguisher(s)

**Terms To Know**

Asbestos
Asbestosis
Canadian Center for Occupational Health and Safety (CCOHS)
Carbon monoxide
Chlorinated hydrocarbon solvents
Department of Transportation (DOT)
Environmental Canada
Environmental Protection Agency (EPA)
Extraction Procedures (EP)
Federal Motor Vehicle Safety Standards (FMVSS)
Material safety data sheet (MSDS)
Occupational Safety and Health Administration (OSHA)
Phosgene
Supplemental inflatable restraint system (SIRS)
Tetrachloroethylene
1,1,1-Trichloroethane
Trichloroethylene
Workplace Hazardous Materials Information Sheet

## INTRODUCTION

Personal protection from injury involves not only what the technician is wearing, but also making and keeping the work area safe. The twofold advantage here is if one technician is protecting himself by wearing personal protection equipment *and* keeping the shop clean and safe, then all the other employees or visitors stand a good chance of avoiding accidents or injury. This chapter discusses those practices and equipment that will provide overall and personal safety.

## Housekeeping

Good housekeeping is a safety issue. A cluttered shop is a dangerous shop. Each employee is responsible for keeping the work area and the rest of the shop clean and safe.

All surfaces must be kept clean, dry, and orderly. Any oil, coolant, or grease on the floor can cause slips that could result in injury. Use commercial oil absorbent to clean up oil or brake fluid spills (**Figure 1-1**). Oily rags must be stored in a sealed metal container until disposed of properly. Keep all water off the floor; remember that water is a conductor of electricity. A serious shock hazard will result if a live wire falls into a puddle in which a person is standing.

Some oil dry or absorbent compounds have to be treated as hazardous waste after being used. They should not be thrown in the trash bin.

When a vehicle is raised with a hand-operated jack, always set the car down on safety stands and remove the jack (**Figure 1-2**). Do not leave the jack handle sticking out from under the car where someone can trip over it.

**Figure 1-1** Use a commercial absorbent to soak up a spill.

**Figure 1-2** Support a vehicle on safety stands such as these and move the jack out of the way.

Creepers also must be used and stored safely. When not in use, stand the creeper on end against a wall. Pushing it completely under the vehicle gets it out of the way, but it is easy to forget that it is there and drive over it after the job is completed.

Air hoses and power extension cords should be neatly coiled and hung. Do not leave a tangled mess in walkways or on the shop floor.

Check air hoses and power cords for signs of damage. A leaking or bulging air hose should be immediately disconnected and replaced. Power cords should be inspected before each use and replaced if frayed or damaged.

Keep all exits open. A blocked exit violates fire codes and leaves the shop liable to legal action if people become trapped in a fire or dangerous situation. Memorize the route to the nearest exit in case of a fire or hazardous material spill.

## Vehicle Operation

**WARNING: Use extra caution when moving a vehicle that requires brake repairs. The brakes may be poor or completely inoperative. Damage to the vehicle or shop or injury to yourself or others could result.**

It is a good idea to never reach inside the vehicle to start a vehicle in the shop. There have been several instances in which technicians have started a car that immediately "took off" and crashed through a garage door, walls, and even people! Do not be that technician! Always get inside the vehicle to start the engine.

Test the brakes on the car to make sure they work before you start the engine. Push the car into the shop if it has a complete brake failure. After completing a brake repair and before moving the vehicle, always check the service brakes. There have been several small but embarrassing and expensive incidents where brakes were replaced but not seated. The first time the brakes were applied, there were no brakes. When new brake pads are installed in a disc brake system, always apply the brakes several times to move the brake pads out against the rotor before putting the vehicle into gear. It will take a few seconds to get pedal back to normal after replacing the pads.

Be very careful when driving a car in the shop. Be watchful of other workers or customers. Drive slowly and carefully, and get someone to act as a guide if visibility is blocked. Leave a window cranked down so instructions from someone outside the car can be heard.

Once the car is in the service area, place the automatic transmission shift lever in PARK. If the car has a manual transmission, put it in reverse gear with the engine off. Engage the parking brake by pulling the lever or setting the parking brake pedal.

The engine must often be operated in the shop to check for problems and to check your repairs. Several safety precautions should be followed when working on a running engine:

- Use wheel blocks to block the front and back of one of the wheels (**Figure 1-3**).
- Never get under a car when someone else is working on it or when the engine is running.
- Do not stand in front of or behind an automobile when the engine is running.
- Be careful of hot manifolds and moving engine parts if working under the hood.
- Many cars use electric cooling fans. Keep hands, tools, and test equipment clear of electric fans because they can start up at any time, even when the engine is not running.

## Carbon Monoxide

Running an engine inside a shop can be very hazardous. Engine exhaust contains large amounts of **carbon monoxide**, a deadly gas that is odorless and colorless. Carbon monoxide poisoning begins with headaches and drowsiness. High exposure can lead to coma and death. Never run an engine in the shop without properly venting the exhaust fumes to the outside or to a dedicated ventilation system for exhaust gas (**Figure 1-4**), and make sure the ventilation system is working properly.

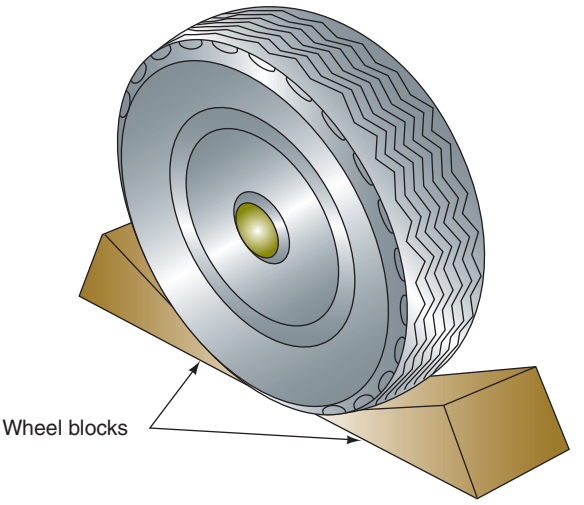



**Figure 1-3** Block at least one wheel both in front and behind before raising the other end of the vehicle.

**Figure 1-4** When running an engine in a shop, always connect the exhaust to the ventilation system.

The most easily prevented injury is an eye injury—always wear safety glasses in the shop.

## Housekeeping and Brake Dust

There are special tools and equipment designed to be used to collect and contain brake dust. This special equipment is discussed in detail in Chapter 2 of this manual, but some common sense should always be used when working on and around vehicles undergoing brake service.

The first and probably most critical is to *never* use compressed air to blow dust from the braking components. This, obviously, moves and suspends the dust in the air. Use only the equipment or their equivalents listed in Chapter 3 to clean the brake components and surrounding area.

A second commonsense rule is the wearing of safety glasses and gloves. As discussed earlier in this chapter, brake fluid and cleaning solvents are hazardous materials and can cause injuries. If a vacuum cleaner is not available to clean the floor around the work area, mop the floor with water. When the mop is rinsed, the rinse water and the material it collects must be stored and treated as hazardous waste. This may seem to present some work problems, but like many things in the automotive repair business it must be done to protect the employees, the environment, and the community in general. Smokers or persons with some type of respiratory problems must be considered when dealing with brake

dust. Even with so-called clean air, those individuals may suffer an extreme reaction to what we technicians consider everyday conditions. A technician should make every attempt to prevent the spread of brake dust while working on a vehicle.

**CAUTION**

**Do not use compressed air to clean brake components. Brake dust will be present and can be blown into the eyes, embedded into the skin, and, at least, will contaminate the surrounding air. Use only authorized low-pressure washers or vacuum-cleaner-type equipment.**

## Eye and Face Protection

The most frequent causes of eye injuries are flying objects, corrosive chemical splash, dangerous light rays, and poisonous gas or fumes.

**WARNING: Grinding and cutting tools can be dangerous, even to a person not in the immediate area of the work. Ensure that the area is cleared of personnel as much as possible before metal-shaping work.**

The best way to prevent eye injuries is to wear the correct type of eye protection. When you are performing jobs such as grinding metal, cutting metal, or driving a punch or chisel, the eyes are at risk from flying objects.

Occupational safety glasses (**Figure 1-5**) are the best protection against flying objects. These safety glasses are especially designed to provide the most protection. The glass or plastic lens provides maximum protection against an impact to the eye. The frames are constructed to prevent the lens from being pushed out of the frame during impact. They must have side shields to prevent objects from entering the eye from the side. They are available in prescriptions for people who need corrective lenses.

**WARNING: Wear occupational safety glasses when working in the shop, especially when performing any grinding or cutting operations. Ordinary prescription dress glasses are made to standards that provide impact protection, but the impact protection and the frame strength of dress glasses are much lower than occupational safety glasses.**

The face shield **(Figure 1-6**) provides protection for the entire face and is a good choice when the danger is from flying objects or splashing liquids. Goggles can be used for nearly every type of eye hazard, and they can be used over ordinary dress glasses. Goggles have another advantage over occupational safety glasses because they fit against the head, which allows them to distribute an impact better. Clear-cover goggles provide protection against flying objects or liquid splash. Some goggles have vents and baffles on top to prevent harmful vapors or fumes from getting into the eyes. When you wear goggles, do not over tighten the straps. They need only be taut enough to hold the goggles in

**Figure 1-5** Occupational safety glasses provide protection from flying objects that ordinary eyeglasses do not.

**Figure 1-6** A face shield protects your entire face.

place. As with all other clothing, they have to be worn for a while for you to adapt to their weight and viewing area. When taking off goggles or a face shield, close the eyes. Small particles of sharp metal may have attached themselves to the outside of the goggles or face shield and may drop into the eyes.

## Initial First Aid

Most shops and all schools require an accident report to be completed and filed.

Make sure the location and contents of the shop's first aid kit are known. There should be eyewash solution or eyewash stations in the shop so the eyes can be rinsed thoroughly should hydraulic fluid, battery acid, asbestos dust, or other irritants enter them (**Figure 1-7**). See **Photo Sequence 1** for details. After eye washing, seek medical attention. Find out if there is a resident nurse in the shop or at the school, and locate the nurse's office. If there are specific first aid rules in the school or shop, find out what they are and abide by them. In a school, a report is required to be filed for any injuries to a student.


**Figure 1-7** An eyewash solution will flush contaminants from your eyes.

If someone is overcome by carbon monoxide, move the person to fresh air immediately. Rinse burns immediately in cold water or apply an ice pack. To stop bleeding from a deep cut or puncture wound, apply pressure on or around the wound and get medical help. Never move someone you suspect has broken bones or a back injury unless the person is in danger from another hazard such as fire or carbon monoxide gas. Call for medical assistance.

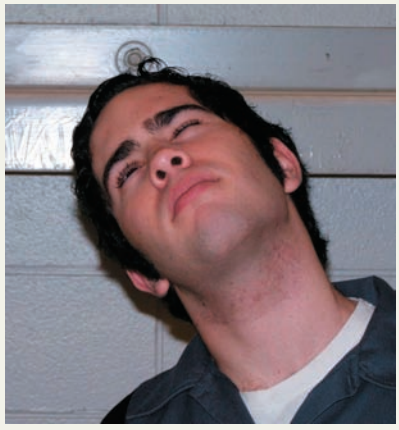
## Hand Protection

Hands are one of the most frequently injured parts of the body. This fact is not surprising when you think of how often the hands are used doing automotive repair. There are two parts to protecting the hands. One is to keep hands out of dangerous areas. Rotating parts, such as the belts on the front of an engine, are hand danger areas. Make an effort to keep the hands out of those areas as much as possible.

## PHOTO SEQUENCE 1
## Using Eye Wash

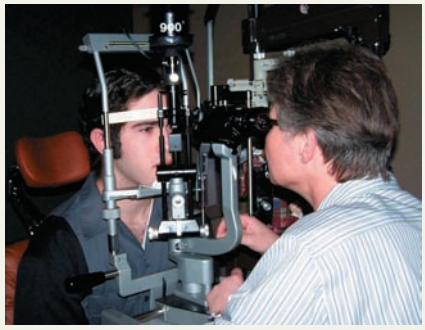
**P1-1** Remove the eyewash bottle from the wall holder. The injured person may require assistance.


**P1-2** Open the bottle. Attempt not to touch the mouth of the bottle once it is opened. The injured person may require assistance.



**P1-3** Tilt the head back and over so the injured eye is lower than the other eye.

**P1-4** Pour the water so the flow goes from the nose bridge, over the eye, and down the cheek. Keep both eyes open and looking upward during the flushing. The injured person may require assistance.



**P1-5** The injured eye should be examined by an ophthalmologist for injuries that may not be immediately apparent.

The second part of hand safety is to wear hand protection when necessary. Special protective gloves are available for many jobs that require hand protection. There are heavy work gloves for metal working, rubber gloves for electrical shock protection, and nitrile gloves for handling used oil, brake fluid, and chemicals such as those used to clean parts. Always use the correct type of gloves for the hand hazards in the work area.

Do not wear a wristwatch or jewelry while working. Watches can get caught in rotating machinery. Necklaces or rings can get caught in machinery or provide a path for an electrical shock. Long hair can get caught in rotating machinery. Many serious injuries have been caused by the hair pulling the face into a rotating part. Always tie up long hair or wear a hat over it.

Always wear safety shoes in the shop. Safety shoes have metal or fiberglass protection over the toe to prevent an injury if a heavy object falls on your foot. Safety shoes should at least have oil-resistant soles that grip slippery floors better than casual dress shoes.

## Lifting and Carrying

If you lose control of a lifted object, do not attempt to catch it. Step back and let the object drop.

The back is one of the most often injured parts of the body. The most common kind of back injury at work is caused by improper lifting. Not all back injuries are caused by lifting too much weight but by lifting relatively small, light objects. The problem occurs while lifting the object and twisting the body or lifting when the load is unbalanced. Most back injuries can be prevented by following these 10 simple rules:

1. Do not lift any heavy object by yourself. Get someone to share the load or get some equipment such as a chain hoist to do the lifting.
2. Study the load before you attempt to lift it. Use your head before you use your back.
3. Place your body close to the object as shown in **Figure 1-8**. Keep your legs close to the load and positioned for good balance.
4. Bend your legs, not your back.
5. Get a strong grip on the object with your hands.
6. Lift with your legs, keeping your back as straight as possible.
7. Keep the load close to your body as you lift it up.
8. Keep a tight grip on the object and do not try to change your grip while lifting.

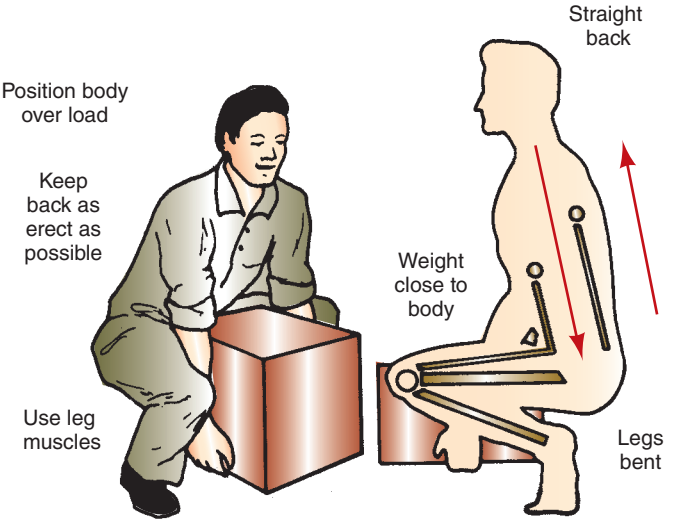



**Figure 1-8** Keep your back straight and bend your legs to lift heavy objects safely.

9. Do not twist your body to change direction. Move your feet in the new direction.
10. When you are ready to set the load down, do not bend forward. Keep the load close to your body and lower it by bending your legs. When placing the object on a shelf, place the edge of the load on the surface of the shelf and slide it forward. When setting an object on the floor, lower it by bending your knees and keeping your back straight. Bending forward strains your back muscles.

Having the body out of position can lead to painful injury even if nothing is being lifted. The most common muscle sprain or injury happens when the person is lifting a small weight but the body is twisted off center.

## BRAKE SYSTEM SAFETY REGULATIONS

In the United States, brake systems are regulated by Part 571 of the **Federal Motor Vehicle Safety Standards (FMVSS)**. These regulations are established and enforced by the U.S. **Department of Transportation (DOT)**. The standards that relate to brake systems are:

- FMVSS 105 Hydraulic Brake Systems
- FMVSS 106 Brake Hoses
- FMVSS 108 Lamps, Reflective Devices, and Associated Equipment
- FMVSS 116 Motor Vehicle Brake Fluids
- FMVSS 121 Air Brake Systems
- FMVSS 122 Motorcycle Brake Systems
- FMVSS 211 Wheel Nuts, Wheel Discs, and Hub Caps

**Department of Transportation (DOT)** is the U.S. government executive department that establishes and enforces safety regulations for motor vehicles and for federal highway safety and oversees, inspects, and regulates all interstate transportation including road, rail, and water facilities; commercial operators training/certification; and commercial vehicles. They are assisted by state-funded transportation departments.

Many U.S. states and Canadian provinces also have regulations that govern the brakes' safety, condition, and operation. Several of the federal standards apply to specific components included in this text. General performance requirements for service brakes and parking brake systems are governed by FMVSS 105. This standard became effective in 1967, was revised significantly in 1976, and has undergone several smaller changes since then. FMVSS 105 spells out the "requirements for hydraulic service brake and associated parking brake systems to ensure safe braking performance under normal and emergency conditions for passenger cars, multipurpose passenger vehicles, trucks, and buses with hydraulic service brakes."

FMVSS 105 does not prescribe the design of brake systems; it establishes brake performance requirements. By so doing, however, it also establishes the baseline for system safety. The standard regulates four major features of brake systems: instrument panel warning lamps, the fluid reservoir and its labeling, automatic adjustment, and mechanically operated friction parking brakes.

Although FMVSS does not dictate brake system hardware and design, one of its first major effects that car owners saw was the introduction of dual-chamber master cylinders and split hydraulic systems on 1967 model-year cars. Also, the increased performance requirements in the 1976 revision made it impractical to use drum brakes on the front wheels of cars. The standard did not specify front disc brakes, but discs were the most practical way to meet the performance requirements.

Brake systems are not designed just to meet minimum legal standards, however. They are designed in relation to the performance and intended use of a vehicle. Trucks have larger brakes than passenger cars, for example, to stop a vehicle with a heavier payload. A high-performance car will have high-performance brakes, but an economy compact car will not. Every vehicle has a brake system that meets motor vehicle safety requirements and matches the performance capabilities and intended use of that vehicle. Thus, brake systems reflect both safety regulations and sound engineering practices.