Automotive Chassis Systems 7th Edition

Chapter 5 Brake Hydraulic Systems

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers operation and service of **Automotive Chassis Systems.** It correlates material to task lists specified by ASE and NATEF.
Motivate Learners	Explain how the knowledge of how something works translates into the ability to use that knowledge to figure why the engine does not work correctly and how this saves diagnosis time, which translates into more money.
State the learning objectives for the chapter or course you are about to cover and explain this is what they should be able to do as a result of attending this session or class.	Explain the chapter learning objectives to the students. 1. Discuss the energy principles that apply to brakes. 2. Discuss the mechanical principles that apply to brakes. 3. Discuss the friction principles that apply to brakes. 4. Describe how brakes can fade due to excessive heat. 5. Describe how deceleration rate are measured. **This chapter will help prepare for ASE Brakes (A5) certification test**
Establish the Mood or Climate	Provide a *WELCOME,* Avoid put downs and bad jokes.
Complete Essentials	Restrooms, breaks, registration, tests, etc.
Clarify and Establish Knowledge Base	Do a round robin of the class by going around the room and having each student give their backgrounds, years of experience, family, hobbies, career goals, or anything they want to share.

NOTE: This lesson plan is based on Automotive Chassis Systems 7th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

LINK CHP 5: Chapter Images

ICONS	Ch05 Brake Hydraulic Systems
	**1. SLIDE 1 BRAKE HYDRUALIC SYSTEMS**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE IS CONSTANTLY UPDATED** **Videos**
	**At the beginning of this class, you can download the crossword puzzle & Word Search from the links below to familiarize your class with the terms in this chapter & then discuss them**
	**Crossword Puzzle (Microsoft Word) (PDF)** **Word Search Puzzle (Microsoft Word) (PDF)**
	2. **SLIDE 2 EXPLAIN Figure 5-1** Hydraulic brake lines transfer the brake effort to each brake assembly attached to all four wheels. 3. **SLIDE 3 EXPLAIN Figure 5-2** Because liquids cannot be compressed, they are able to transmit motion in a closed system. 4. **SLIDE 4 EXPLAIN Figure 5-3** Hydraulic system must be free of air to operate properly. If air is in system, air is compressed when brake pedal is depressed and brake fluid does not transmit the force to wheel brakes.
	**Brake Fluid Level Check (View) (Download)** **Brake Hydraulic System (View) (Download)** **Pascal's Law, Area (View) (Download)** **Pascal's Law, Force (View) (Download)** **PASCAL'S LAW, PRESSURE (VIEW) (DOWNLOAD)**
	**DISCUSSION: DISCUSS GENERAL PRINCIPLES OF HYDRAULICS OR THE MECHANICAL PROPERTIES OF FLUIDS. INVITE STUDENTS TO NAME A VARIETY OF APPLICATIONS OF HYDRAULICS.**
	**DEMONSTRATION: SHOW THAT PISTONS CANNOT COMPRESS LIQUIDS IN CLOSED SYSTEM. ASK THEM TO EXPLAIN HOW AIR CAN**

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	**CONTAMINATE HYDRAULIC SYSTEM & WHAT PROBLEMS RESULT FROM SUCH CONTAMINATION** 5. **SLIDE 5 EXPLAIN Figure 5-4** one-pound force exerted on a small piston in a sealed system transfers the pressure to each square inch throughout the system. In this example, the 1-lb force is able to lift a 100-lb weight because it is supported by a piston that is 100 times larger in area than the small piston. 6. **SLIDE 6 EXPLAIN Figure 5-5** amount of force (F) on the piston is the result of pressure (P) multiplied by the surface area (A). In this example, the driver is applying a force of 150 pounds but through the mechanical advantage of the brake pedal (3.3 to 1 ratio), the force is increased to 500 pounds into master cylinder. 7. **SLIDE 7 EXPLAIN Figure 5-6** Drum brake illustrating the typical clearance between the brake shoes (friction material) and the rotating brake drum represented as the outermost black circle. 8. **SLIDE 8 EXPLAIN Figure 5-7** brake pad (friction material) is pressed on both sides of the rotating rotor by the hydraulic pressure of the caliper. 9. **SLIDE 9 EXPLAIN FIGURE 5–8** Mechanical force and the master cylinder piston area determine the hydraulic pressure in the brake system 10. **SLIDE 10 EXPLAIN Figure 5-9** Hydraulic pressure is the same throughout a closed system and acts with equal force on equal areas. 11. **SLIDE 11 EXPLAIN Figure 5-10** Differences in brake caliper and wheel cylinder piston area have a major effect on brake application force. 12. **SLIDE 12 EXPLAIN Figure 5-11** The increase in application force created by the large brake caliper piston is offset by a decrease in piston travel.
	
	**DEMONSTRATION: show application of Pascal's law by demonstrating that a force applied to a piston in a sealed system displaces equal amounts of force in every direction. Use single master cylinder & 2 wheel cylinders with different piston area measurements. Ask students to interpret results using Pascal's law. How does this demonstration correspond to operation of a braking system?**

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	**DISCUSSION:** TALK ABOUT PASCAL'S LAW AND HOW IT IS THE CENTRAL PRINCIPLE UPON WHICH HYDRAULIC SYSTEMS WORK.
	**DISCUSSION:** ASK STUDENTS TO TALK ABOUT THE RELATIONSHIP BETWEEN HYDRAULIC PRESSURE AND PISTON SIZE. WHY DOES INCREASING THE PISTON SIZE REDUCE THE HYDRAULIC PRESSURE ACHIEVED?
	USING CLEAR MEDICAL SYRINGES AND CLEAR PLASTIC TUBING CAN HELP STUDENTS VISUALIZE HYDRAULIC PRINCIPLES
	**DISCUSSION:** DISCUSS WHY, ALTHOUGH MECHANICAL FORCE AVAILABLE TO APPLY DISC BRAKES IS GREATER, AMOUNT OF HYDRAULIC ENERGY CONVERTED INTO MECHANICAL MOTION IS LESS. WHAT ARE IMPLICATIONS OF THIS FACT FOR DISC-BRAKE DESIGN?
	**HANDS-ON TASK:** USING EQUATION BELOW & TEXTBOOK PAGES 1027-1031, HAVE STUDENTS CALCULATE THE MOVEMENT OF A DISC-BRAKE CALIPER WHEN THE AREA OF THE MASTER-CYLINDER PISTON IS 0.95 SQ. IN., THE AREA OF THE WHEEL CYLINDER OR CALIPER PISTON IS 3.75 SQ. IN., AND THE MASTER CYLINDER PISTON STROKE LENGTH IS 0.9 IN. (***ANSWER***: 0.228 IN.) $d_1 \cong \frac{A_2}{A_1} d_2 \quad \frac{.95}{3.75} \cong .9 \cong 0.228$
	**DISCUSSION:** ASK STUDENTS TO TALK ABOUT THE IMPLICATIONS OF HYDRAULICS FOR BRAKE-SYSTEM DESIGN. HAVE THEM FOCUS ON SELECTION OF CORRECT PISTON SIZE TO PROVIDE DRIVER WITH PROPER BRAKE-PEDAL FEEL.
	13. **SLIDE 13 EXPLAIN Figure 5-12** Typical master cylinder showing reservoir and associated parts. The reservoir diaphragm lays directly on top of brake fluid, which helps keep air from the surface of brake fluid because brake fluid easily absorbs moisture from air. 14. **SLIDE 14 EXPLAIN FIGURE 5–13** Master cylinder with brake fluid level at the "min" (minimum) line 15. **SLIDE 15 EXPLAIN FIGURE 5–14** The typical brake

pedal is supported by a mount and attached to the pushrod by a U-shaped bracket. The pin used to retain the clevis to the brake pedal is usually called a clevis pin.

16. **SLIDE 16 EXPLAIN FIGURE 5–15** The composite master cylinder is made from two different materials—aluminum for the body and plastic materials for the reservoir and reservoir cover. This type of reservoir feeds both primary and secondary chambers, and therefore uses a fluid level switch that activates the red dash warning lamp if the brake fluid level drops.
17. **SLIDE 17 EXPLAIN FIGURE 5–16** Note the various names for the vent port (front port) and the replenishing port (rear port). Names vary by vehicle and brake component manufacturer. The names vent port and replenishing port are the terms recommended by SAE
18. **SLIDE 18 EXPLAIN FIGURE 5–17** vent ports must remain open to allow brake fluid to expand when heated by friction material and transferred to the caliper and/or wheel cylinder. As brake fluid increases in temperature, it expands. The heated brake fluid can expand and flow back into the reservoir through the vent ports.

19. **SLIDE 19 EXPLAIN FIGURE 5–18** As brake pedal is depressed, the pushrod moves primary piston forward, closing off the vent port. As soon as the port is blocked, pressure builds in front of the primary sealing cup, which pushes on the secondary piston. The secondary piston also moves forward, blocking the secondary vent port and building pressure in front of the sealing cup.

20. **SLIDE 20 EXPLAIN FIGURE 5–19** The purpose of the replenishing port is to keep the volume behind the primary piston filled with brake fluid from the reservoir as the piston moves forward during a brake application
21. **SLIDE 21 EXPLAIN FIGURE 5–20** When the brake pedal is released, the master cylinder piston moves rearward. Some of the brake fluid is pushed back up through the replenishing port, but most of the fluid flows past the sealing cup. Therefore, when the driver pumps the brake pedal, the additional fluid in front of the pressure-building sealing cup is available quickly

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	22. **SLIDE 22 EXPLAIN Figure 5-21** Rear-wheel-drive vehicles use a dual split master cylinder. 23. **SLIDE 23 EXPLAIN Figure 5-22** primary outlet is the outlet closed to the pushrod end of the master cylinder and the secondary outlet is closest to the nose end of the master cylinder. 24. **SLIDE 24 EXPLAIN Figure 5-23** In the event of a primary system failure, no hydraulic pressure is available to push the second piston forward. As a result, the primary piston extension rod contacts the secondary piston and pushes on the secondary piston mechanically rather than hydraulically. The loss of pressure in the primary system is usually noticed by the driver by a lower-than-normal brake pedal and the lighting of the red brake warning lamp.
	**BRAKE HYDRAULIC SYSTEM (VIEW) (DOWNLOAD)**
	**DEMONSTRATION: SHOW STUDENTS MASTER CYLINDER OF A VEHICLE, AND ASK THEM TO DESCRIBE HOW IT WORKS. WHY IS THE MASTER CYLINDER THE HEART OF THE BRAKING SYSTEM? SHOW STUDENTS THE SEE-THROUGH RESERVOIR OF A MASTER CYLINDER, AND POINT OUT THE MINIMUM AND MAXIMUM FILL MARKINGS**
	**DISC BRAKE APPLY & RELEASE**
	**NEVER FILL THE MASTER CYLINDER HIGHER THAN THE RECOMMENDED FULL MARK TO ALLOW FOR BRAKE-FLUID EXPANSION.**
	**DEMONSTRATION: SHOW MASTER CYLINDER WHEN BRAKES ARE NOT APPLIED, OR IN THE AT-REST POSITION. DISCUSS HOW BRAKE-FLUID EXPANSION AND CONTRACTION CAN OCCUR WITH CHANGES IN TEMPERATURE. SHOW WHAT CHANGES OCCUR WITHIN THE MASTER CYLINDER WHEN BRAKES ARE APPLIED, AND ASK THEM TO EXPLAIN THE RESULTS. SHOW STUDENTS WHAT CHANGES OCCUR WITHIN MASTER CYLINDER WHEN BRAKES ARE RELEASED & RETURNED TO AT-REST POSITION. WHAT IS IMPACT OF PUMPING BRAKES?**

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	**IF MINERAL BASED FLUIDS (MOTOR OIL OR HYDRAULIC FLUID) HAVE BEEN INTRODUCED TO THE BRAKE SYSTEM THE RUBBER DIAPHRAGM WILL SWELL OVER SIZED. THIS WILL SHOW THAT THERE ARE EXTENSIVE REPAIRS TO BE MADE.**
	**DISCUSSION: DISCUSS PURPOSE AND FUNCTION OF VENT AND REPLENISHING PORTS IN THE MASTER CYLINDER. HOW IS OUTSIDE AIR AND MOISTURE PROHIBITED FROM ENTERING THE MASTER CYLINDER THROUGH THESE VENTS?**
	25. **SLIDE 25 EXPLAIN Figure 5-24** FWD vehicles use a diagonal split master cylinder. In this design one section of the master cylinder operates the right front and the left rear brake and the other section operates the left front and right rear. In the event of a failure in one section, at least one front brake will still function.
	**DEMONSTRATION: SHOW AN EXAMPLE OF A DIAGONAL-SPLIT MASTER CYLINDER, DISCUSS HOW IT ENABLES FRONT AND REAR BRAKING ACTION IN EVENT OF FAILURE OF ONE CYLINDER**
	**DISCUSSION: WHAT % OF BRAKING THAT WOULD BE SUPPLIED IN EVENT THAT ½ OF A DIAGONALLY SPLIT BRAKE SYSTEM FAILS.**
	**WHEN HYDRAULIC SWITCH TURNS LIGHT ON DURING ½ OF SYSTEM FAILURE LIGHT SWITCH MAY HAVE TO BE RE-CENTERED TO GET LIGHT OFF**
	26. **SLIDE 26 EXPLAIN Figure 5-25** Quick take-up master cylinder can be identified by the oversize primary low-pressure chamber. 27. **SLIDE 27 EXPLAIN FIGURE 5–26** brake pedal depressor like this can be used during brake service to block the flow of brake fluid from the master cylinder during service work on the hydraulic system**.**
	**OPTIONAL DEMONSTRATION: SHOW STUDENTS AN EXAMPLE OF A QUICK TAKE-UP MASTER CYLINDER IF ONE IS AVAILABLE.**
	28. **SLIDE 28 EXPLAIN Figure 5-27** Some seepage is normal when a trace of fluid appears on the vacuum booster shell. Excessive leakage, however, indicates a leaking secondary (end) seal

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 	**DEMONSTRATION: SHOW STUDENT HOW TO CHECK FOR PROPER FLUID MOVEMENT IN THE MASTER CYLINDER RESERVOIR.** **HANDS-ON TASK: HAVE STUDENTS PERFORM A VISUAL INSPECTION OF A MASTER CYLINDER. HAVE STUDENTS CHECK POSITION & OPERATION OF BRAKE PEDAL FOLLOWING INSPECTION. SELECT A STUDENT TO PRESENT RESULTS OF INSPECTION TO CLASS, IDENTIFYING ANY PROBLEMS & SUGGESTING POSSIBLE CAUSES & SOLUTIONS.**
	29. **SLIDE 29 EXPLAIN Figure 5-28** Pedal height is usually measured from the floor to the top of the brake pedal. Some vehicle manufacturers recommend removing the carpet and measuring from the asphalt matting on the floor for an accurate measurement. Always follow the manufacturer's recommended procedures and measurements. 30. **SLIDE 30 EXPLAIN Figure 5-29** Brake pedal free play is distance between the brake pedal fully released and position of brake pedal when braking resistance is felt. 31. **SLIDE 31 EXPLAIN Figure 5-30** Brake pedal reserve is usually specified as the measurement from the floor to the top of the brake pedal with the brakes applied. A quick-and-easy test of pedal reserve is to try to place your left toe underneath the brake pedal while the brake pedal is depressed with your right foot. If your toe will not fit, then pedal reserve may not be sufficient.
     	**DEMONSTRATION: SHOW STUDENTS HOW TO CHECK BRAKE PEDAL FREE PLAY. EXPLAIN THE IMPORTANCE OF THIS SPECIFICATION.** **ON-VEHICLE NATEF TASK MEASURE BRAKE PEDAL HEIGHT; DETERMINE NECESSARY ACTION** **BRAKE FLUID IS HIGHLY CORROSIVE. ALWAYS USE FENDER COVERS TO PROTECT THE VEHICLE'S FINISH FROM CONTACT WITH BRAKE FLUID.** 32. **SLIDE 32 EXPLAIN Figure 5-31** Using a prybar to remove the reservoir from the master cylinder. 33. **SLIDE 33 EXPLAIN FIGURE 5–32** Whenever disassembling a master cylinder, note the exact order of

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	parts as they are removed. Master cylinder overhaul kits (when available) often include entire piston assemblies rather than the individual seals. **34. SLIDE 34 EXPLAIN Figure 5-33** Piston assembly. **35. SLIDE 35 EXPLAIN Figure 5-34** To reinstall the reservoir onto a master cylinder, place the reservoir on a clean flat surface and push the housing down onto the reservoir after coating the rubber seals with brake fluid
	**36. SLIDE 36 EXPLAIN Figure 5-35** Bleeding a master cylinder before installing it on the vehicle. The master cylinder is clamped into a bench vise while using a rounded end of a dowel rod to push on the pushrod end with bleeder tubes down into the brake fluid. Master cylinders should be clamped on the mounting flange as shown to prevent distorting the master cylinder bore.
	37. SLIDES 37 EXPLAIN Figure 5-36 Installing a master cylinder. Always tighten the retaining fastener and brake lines to factory specifications.
	**DISCUSSION: ask students to discuss how to diagnose and correct spongy brake pedal. Ask how to test & fix a lower-than-normal brake pedal. Ask students to discuss how to diagnose and correct a problem that would cause a brake pedal to go all the way to the floor. Ask students to talk about the phenomenon of bypassing, or internal leak within the master cylinder. How can a technician determine an external leak within braking system versus bypassing within master cylinder?**
	**DEMONSTRATION: SHOW STUDENTS HOW TO BENCH BLEED A MASTER CYLINDER.**
	**HANDS-ON TASK: HAVE STUDENTS BENCH BLEED A MASTER CYLINDER WITH THE PROPER BYPASS TUBING AND PUNCH.**
	**ON-VEHICLE NATEF TASK CHECK MASTER CYLINDER FOR EXTERNAL AND INTERNAL LEAKS AND PROPER OPERATION; REMOVE, BENCH BLEED, AND REINSTALL MASTER CYLINDER.**

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	**ON-VEHICLE NATEF TASK** IDENTIFY AND INTERPRET BRAKE SYSTEM CONCERN AND DETERMINE NECESSARY ACTION