Automotive Technology 6th Edition
Chapter 130 DRIVE AXLES & DIFFERENTIALS
Opening Your Class

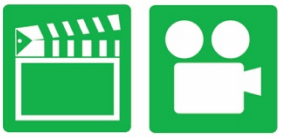
KEY ELEMENT	EXAMPLES
Introduce Content	This Automotive Technology 6th text provides complete coverage of automotive components, operation, design, and troubleshooting. It correlates material to task lists specified by ASE and ASEEducation (NATEF) and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Case Studies, Videos, Animations, and ASEEducation (NATEF) Task Sheets.
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. Describe the operation of a differential and the gear ratios set types. 2. Compare the operation of a standard open differential and a limited slip differential. 3. Describe the components of a differential and the types of bearings used in drive axles. 4. Explain how to identify, determine the axle ratio, diagnose, inspect, and disassemble a differential. 5. Explain how to set the drive pinion depth and replace the pinion shaft bearing. 6. Describe the procedure to check backlash and set the preload for pinion gears and side bearings. 7. Discuss differential lubricants.
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: Lesson plan is based on 6th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

DOWNLOAD Chapter 130 Chapter Images: From

http://www.jameshalderman.com/automotive_principles.html

NOTE: You can use Chapter Images or possibly Power Point files:

ICONS	Ch130 Drive Axles and Differentials
	**1. SLIDE 1 CH130 DRIVE AXLES & DIFFERENTIALS**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE IS CONSTANTLY UPDATED**
	**http://www.jameshalderman.com/automotive_principles.html** **DOWNLOAD** **Crossword Puzzle (Microsoft Word) (PDF)** **Word Search Puzzle (Microsoft Word) (PDF**
	**Drive Axle (41 Links)** **Drive Shaft (27 Links)**
	**2. SLIDE 2 EXPLAIN FIGURE 130-1 differential assembly changes the direction of engine torque and increases the torque to the drive wheels.**
	3. SLIDE 3 EXPLAIN FIGURE 130–2 difference between the travel distance of drive wheels is controlled by the differential..
	**4. SLIDE 4 EXPLAIN FIGURE 130–3 When vehicle turns a corner, the inner wheel slows and outer wheel increases in speed to compensate. This difference in rotational speed causes the pinion gears to "walk" around slower side gear..**
	**5. SLIDE 5 EXPLAIN Figure 130–4** hypoid gear set uses a drive pinion that meshes with the ring gear below the center line of the ring gear.
	6. SLIDE 6 EXPLAIN FIGURE 130–5 A pair of tapered roller bearings called carrier bearings is used to locate the drive pinion gear and the differential case and ring gear. Another pair of bearings locates the drive pinion gear..
	**DEMONSTRATION: SHOW INSIDE WORKINGS OF THE DIFFERENTIAL AND POINT OUT THE MAJOR COMPONENTS.**

ICONS	Ch130 Drive Axles and Differentials
	**DEMONSTRATION:** SHOW COMPLETE DIFFERENTIAL ASM. DEMONSTRATE HOW TURNING PINION TRANSFERS ROTATION OF AXLE SHAFTS 90 DEGREES FROM ROTATION OF PINION.
	**DISCUSSION:** DISCUSS REASON FOR USING A HYPOID GEAR SET AS COMPARED TO A STANDARD BEVELED GEAR ARRANGEMENT
	**DISCUSSION:** DISCUSS THE DESIGN OF RING AND PINION THAT QUALIFIES IT AS A HYPOID GEAR ASSEMBLY.
	7. SLIDE 7 EXPLAIN FIGURE 130–6 relationship among the ring gear and drive pinion as well as side and spider gears. 8. SLIDE 8 EXPLAIN FIGURE 130–7 drive side is convex side of ring gear except for some front axles used in four-wheel vehicles, and they often use concave side on drive side.
	**DISCUSSION:** DISCUSS GEAR RATIOS AND ADVANTAGES AND DISADVANTAGES OF LOW AND HIGH RATIOS.
	**DEMONSTRATION:** SHOW HOW TO ROUGHLY **DETERMINE GEAR RATIO** OF A DIFFERENTIAL AS DESCRIBED IN THE TEXT.
	**DISCUSSION:** DISCUSS THE PROCEDURE FOR DETERMINING GEAR RATIO WITHOUT OPENING THE DIFFERENTIAL. HAVE THEM EXPLAIN WHY THIS MIGHT BE HELPFUL FOR SERVICE
	**DISCUSSION:** DISCUSS ADVANTAGES AND DISADVANTAGES OF HUNTING AND NON-HUNTING GEAR COMBINATION. HAVE THEM DISCUSS WHY NON-HUNTING GEAR SETS HAVE TIMING MARKS.
	**HANDS-ON-TASK:** HAVE THE STUDENTS USE MATHEMATICS TO FIGURE RATIO OF SEVERAL GEAR SETS. GIVE THEM DIAGRAMS OF A DOZEN RING AND PINION SETS. HAVE THEM DETERMINE WHETHER EACH SET IS **HUNTING, NON-HUNTING, PARTIAL NON-HUNTING.**

ICONS	Ch130 Drive Axles and Differentials
	**DEMONSTRATION: SHOW HOW TORQUE FLOWS THROUGH A STANDARD OPEN DIFFERENTIAL. SHOW THEM A STANDARD OPEN DIFFERENTIAL WITH THE COVER OFF. WHILE TURNING PINION FLANGE, HAVE A STUDENT HOLD ONE AXLE. TORQUE FLOWS TO FREE AXLE. AS STUDENT RELEASES HELD AXLE, BOTH WILL BEGIN TO TURN**
	**HANDS-ON-TASK: HAVE STUDENTS DETERMINE GEAR RATIO OF A DIFFERENTIAL WITHOUT OPENING DIFFERENTIAL. HAVE THEM COMPARE THEIR RESULT WITH THE OEM INFORMATION ON THE GEAR RATIO OF THE DIFFERENTIAL**
	9. **SLIDE 9 EXPLAIN FIGURE 130–8 A close-up view of the side gears and spider (pinion) gear. Note the ridges on the gear teeth. These ridges are manufactured into the gear teeth to help retain lubricant so that no metal-to-metal contact occurs.**
	**EXPLAIN TECH TIP: *Change Axle Ratio*** **To increase vehicle performance, replace a high ratio (lower number) rear axle ratio with a lower ratio (higher number) rear axle. For example, Stock rear end = 3.23:1 (drive pinion has 13 teeth and ring gear has 42 teeth) Replacement rear end = 3.73:1 (drive pinion has 11 teeth and the ring gear has 41 teeth)**
	**DEMONSTRATION: SHOW RING GEAR, INCLUDING HEEL, TOE, ROOT, DRIVE SIDE, AND DECELERATION SIDE.**
	10. **SLIDE 10 EXPLAIN FIGURE 130–9 (a) A two-wheel-drive vehicle equipped with an open differential. (b) A two-wheel-drive vehicle equipped with a limited-slip differential..** 11. **SLIDE 11 EXPLAIN FIGURE 130–10 Trac-loc limited-slip differential. This type of limited-slip differential uses the preload force from a spring and torque generated by side gears as two axles rotate at different rates to apply the clutches and limit amount of difference in the speed of two axles.**
	12. **SLIDE 12 EXPLAIN FIGURE 130–11 An Eaton locker differential..**

ICONS	Ch130 Drive Axles and Differentials
	**DEMONSTRATION: SHOW AN EXAMPLE OF A PINION GEAR AND CARRIER ASSEMBLY. SHOW LOCATION OF ALL MAJOR COMPONENTS OF THE CARRIER ASSEMBLY**
	13. SLIDE 13 EXPLAIN FIGURE 130–12 This Eaton design differential uses a torque-limiting disc to prevent the possibility of breaking an axle in the event of a high torque demand. When the disc tangs shear, the differential will continue to function but as an open rather than as a limited-slip differential
	**HANDS-ON-TASK: HAVE THE STUDENTS IDENTIFY THE COMPONENTS OF A TYPICAL DIFFERENTIAL ASSEMBLY.**
	14. SLIDE 14 EXPLAIN FIGURE 130–13 Torsen differential. This type of differential provides torque to both drive wheels even if one tire is on ice. The complex system of gears allows this smooth transfer of torque without use of clutches..
	15. SLIDE 15 EXPLAIN FIGURE 130–14 pinion flange is equipped with a damper weight to help dampen driveline vibrations..
	16. SLIDE 16 EXPLAIN FIGURE 130–15 collapsible spacer-type drive pinion shaft.
	17. SLIDE 17 EXPLAIN FIGURE 130–16 Side bearings are press fit on the differential case.
	18. SLIDE 18 EXPLAIN FIGURE 130–17 Some side bearings use threaded adjusters to adjust preload.
	**DIFFERENTIAL ACTION**
	**DEMONSTRATION: SHOW LIMITED SLIP DIFFERENTIAL ASSEMBLY. SHOW HOW CLUTCHES CONNECT SMALL PINION GEARS TO CASE.**
	19. SLIDE 19 EXPLAIN FIGURE 130–18 (a) axle shaft itself is the inner race if a straight roller bearing is used. (b) The straight roller bearings are lubricated by the rear axle fluid, and a leak at the rear axle seal can cause this fluid to get onto brake components.

ICONS	Ch130 Drive Axles and Differentials
	**EXPLAIN TECH TIP:** ***Don't Spin Those Wheels!*** **While driving on ice or snow-covered roads, it is common to see drivers moving slowly up a hill by simply spinning one drive wheel. However, when one wheel is spinning and other wheel is stationary (or close to stationary), pinion gears are spinning twice as fast as drive wheel. This spinning of drive wheel has been known to completely wear down pinion gear thrust washers in less than one minute!** • **SEE FIGURE 130–19. The same wear can occur if different-size tires are used on same drive axle. Therefore, to prevent expensive repairs, avoid unnecessary tire spinning and check that both tires on same axle are the same size, brand name, and condition.**
	20. SLIDE 20 EXPLAIN **FIGURE 130-19** pinion gear thrust washers can be destroyed by spinning one wheel for an extended period of time. 21. SLIDE 21 EXPLAIN FIGURE 130–20 This differential has obviously been leaking. If differential lubricant is low, wear may have occurred that would require further inspection.
	**EXPLAIN TECH TIP:** ***A Quick-and-Easy Backlash Test.*** **Excessive clearance (lash) between the drive pinion and ring gear can cause driveline clash noise during a gear selector change. To check if the cause is due to differential, simply hoist the vehicle and, while one wheel and driveshaft are being held stationary, use your hand to move opposite wheel. The maximum amount tire should move is 1 inch (2.5 cm) measured at tread of the tire. If backlash is greater than this, then further inspection of differential assembly is required. Beside excessive clearance between drive pinion and ring gear, the wear may also be between the pinion and side gears.**
	22. SLIDE 22 EXPLAIN FIGURE 130–21 (a) Backlash is determined by mounting a dial indicator to differential housing and placing the button of gauge against a tooth of ring gear. Moving ring gear back and forth will indicate on dial indicator amount of

ICONS	Ch130 Drive Axles and Differentials
	backlash. (b) Backlash is the clearance between the drive pinion and the ring gear teeth. 23. SLIDE 23 EXPLAIN FIGURE 130–22 Ring gear runout should be less than 0.002 inch (0.05 mm) as measured by a dial indicator. 24. SLIDE 24 EXPLAIN FIGURE 130–23 Force has to be applied to the ring gear to achieve a proper contact pattern.
DEMO	**DEMONSTRATION:** SHOW SETUP PROCEDURE FOR CHECKING RING GEAR BACKLASH. EXPLAIN IMPORTANCE OF THIS READING
QUESTION	**DISCUSSION:** HOLD A DISCUSSION ON CHECKING RING GEAR BACKLASH AND WHAT IT MEANS
DEMO	**DEMONSTRATION:** SHOW SET-UP AND PROCEDURE FOR CHECKING RING GEAR RUNOUT.
Education Foundation	**HANDS-ON-TASK:** HAVE THE STUDENTS SET UP AND TAKE RING GEAR AND BACKLASH READINGS ON SEVERAL DIFFERENTIALS.
Education Foundation	ASEEDUCATION TASK E1.1 CLEAN AND INSPECT DIFFERENTIAL CASE; CHECK FOR LEAKS; INSPECT HOUSING VENT.
Education Foundation	ASEEDUCATION TASK E1.2 CHECK AND ADJUST DIFFERENTIAL CASE FLUID LEVEL; USE PROPER FLUID TYPE PER MANUFACTURER SPECIFICATION..
Education Foundation	ASEEDUCATION TASK E1.3 DRAIN AND REFILL DIFFERENTIAL CASE; USE PROPER FLUID TYPE PER MANUFACTURER SPECIFICATION

ICONS	Ch130 Drive Axles and Differentials
	25. SLIDE 25 EXPLAIN FIGURE 130–24 Tooth contact pattern. 26. SLIDE 26 EXPLAIN FIGURE 130–25 Mark differential bearing caps before removing them to make sure that they are replaced in the same location.
	27. SLIDE 27 EXPLAIN FIGURE 130–26 Pinion gear and associated parts. The pinion end yoke is also called the pinion flange..
	**DEMONSTRATION: SHOW EXAMPLES OF AXLE SHAFTS WITH TAPERED ROLLER BEARINGS, BALL BEARINGS, AND STRAIGHT ROLLER BEARINGS**
	**DEMONSTRATION: SHOW RING AND PINION AND DEMONSTRATE THE IMPORTANCE OF PROPER DEPTH PLACEMENT OF THE PINION GEAR INTO RING GEAR.**
	**HYPOID RING & PINION GEAR SET**
	**DEMONSTRATION: SHOW THREADED AND SHIMMED ADJUSTMENT FOR PRELOAD ON SIDE BEARINGS**
	28. SLIDE 28 EXPLAIN FIGURE 130–27 pinion on the left uses a collapsible spacer, and the pinion on the right uses shims to provide the necessary preload to the pinion shaft bearings. 29. SLIDE 29 EXPLAIN FIGURE 130–28 ring and pinion gears are a matched set and are marked for correct pinion depth variance. 30. SLIDE 30 EXPLAIN FIGURE 130–29 Special tool kit used for determining the correct pinion shaft shim thickness. 31. SLIDE 31 EXPLAIN FIGURE 130–30 Using an inch-pound torque wrench to check rotating torque of the drive pinion. This procedure is very important if axle uses a collapsible spacer. The drive pinion nut should be gradually tightened and the rotating torque checked to prevent overtightening the nut. If the rotating torque is higher than specifications,

ICONS	Ch130 Drive Axles and Differentials
       	collapsible spacer will require replacement and installation procedure must be repeated.. **WHEN INSTALLING SHIMS, A COATING OF GREASE WILL HELP HOLD THEM IN PLACE.** **Adjust Carrier, Threaded Adjusters** **Adjust Carrier** **Assemble Carrier** **DISCUSSION: HOLD A DISCUSSION ON THE ADVANTAGES OR DISADVANTAGES OF THREADED OR SHIMMED PRELOAD ADJUSTMENT** 32. SLIDE 32 EXPLAIN FIGURE 130–31 I f the ring gear has been removed from differential case or if a new ring gear is being installed, always replace ring gear bolts.. **DEMONSTRATION: SHOW HOW TO DO A TOOTH CONTACT PATTERN TEST ON A DIFFERENTIAL BY USING EITHER IRON OXIDE COMPOUND OR WHITE LITHIUM GREASE.** **WHITE LITHIUM GREASE WORKS WELL ON GEAR TOOTH CONTACT PATTERN TEST** 33. SLIDE 33 EXPLAIN FIGURE 130–32 Backlash should be between 0.005 and 0.008 inch on most differentials. If the backlash is too great, add shim thickness to the ring gear side and subtract shim thickness from opposite side. 34. SLIDE 34 EXPLAIN FIGURE 130–33 (a) Some vehicle manufacturers recommend using a housing spreader tool that fits into round openings on both sides. (b) spreader tool being installed. The housing is spread a specified amount and differential is then installed into housing. **EXPLAIN TECH TIP: *“Click-Click” Is Okay—“Clunk-Clunk” Is Not:* An experienced service technician was observed checking backlash on a differential. Technician was simply turning drive pinion by grasping pinion flange and using wrist action to**

ICONS	Ch130 Drive Axles and Differentials
	quickly rotate it first in one direction and then other. The technician explained that if it made a "click-click" sound, backlash was usually between 0.005 and 0.008 inch, which is usually within specifications for most differentials. If however, sound made was more like a "clunk-clunk," then backlash was greater than 0.010 inch and had to be corrected. To summarize what sounds mean when drive pinion is moved back and forth: • No sound when moved back and forth —too little or no backlash; backlash must be adjusted. • A "click-click" sound —backlash is usually within specifications; double-check with a dial indicator and compare against specifications for the axle being serviced. • A "clunk-clunk" sound —usually too much backlash; correction is required to restore proper backlash.
	35. SLIDE 35 EXPLAIN FIGURE 130–34 (a) Note hex shape the threaded adjuster used to adjust side bearing preload and ring gear backlash on a Dodge Dakota truck. (b) A long handled adjuster tool is needed to turn side bearing adjuster on this truck.
	36. SLIDE 36 EXPLAIN FIGURE 130–35 On many axles, it is necessary to use a special tool to install steel spacers (shims) to achieve specified backlash and side bearing preload
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***What is a spool rear end?*** **A spool is a solid piece of metal that takes place of side gears and pinion gears in a differential assembly** **• SEE FIGURE 130–36. A spool used in drag racing is Not suitable for street driving because spool does not Allow for any differences in speeds of drive wheel during cornering. Obviously, drag vehicles do not turn corners while racing and the spool rear end is**

ICONS	Ch130 Drive Axles and Differentials
	one of reasons they bounce when turning around at end of strip to return to pits.
	37. SLIDE 37 EXPLAIN **FIGURE 130–36** A spool used in a rear end for drag racing only.
	38. SLIDE 38 EXPLAIN FIGURE 130–37 Install axle shaft, being careful to not damage seal
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***WHAT DO I DO ABOUT DRIVE PINION BEARING PRELOAD WHEN I REPLACE JUST THE PINION SEAL?*** **To replace a pinion seal, drive pinion nut and pinion flange must be removed. CAUTION: DO NOT USE AN AIR IMPACT WRENCH ON DRIVE PINION NUT. PINION BEARINGS CAN BE DAMAGED BY IMPACT OF WRENCH. Before nut is removed, make a mark on pinion nut and on axle housing. After new pinion seal is installed, tighten pinion nut to same position it was in before disassembly and then rotate the nut 1/16 inch (1.5 mm) farther. This extra rotation makes sure that collapsible space (crush sleeve) is still able to maintain Proper preload on pinion bearing. Another method is to measure rotating torque of drive pinion using inch-pound beam-type torque wrench after removing both rear wheels and brake drums. After installing replacement pinion shaft seal, tighten drive pinion nut until the rotating torque is 3 to 5 in-lb more than reading obtained before pinion nut was removed.**
	39. SLIDE 39 EXPLAIN FIGURE 130–38 A container of GL-5 SAE 80W-90 gear lubricant.

ICONS	Ch130 Drive Axles and Differentials
	**DISCUSS CASE STUDY: *I DIDN'T KNOW IT WOULD FIT THE WRONG WAY!*** **An automotive student changed differential lubricant by removing housing cover. Cover was reinstalled and then filled with correct lubricant. However, when student drove vehicle it made a grinding sound that was not there before differential service. When cover was removed, it was discovered that cover had been installed with raised area on the right side of housing instead of on left side and ring gear had rubbed a groove in the cover, as shown in FIGURE 130–39 installing cover correctly stopped grinding sound.** **SUMMARY:** • **Complaint—vehicle, made a grinding noise after a differential fluid service procedure was performed.** • **Cause—drive axle hosing cover was installed incorrectly.** • **Correction—cover was removed and installed correctly.**
	**40. SLIDE 40 EXPLAIN FIGURE 130–39 beginning automotive student did not realize that axle housing cover could fit the wrong way. The only problem was that ring gear scraped against cover.**
	**BECAUSE OF CLUTCHES & SPRINGS IN DIFFERENTIAL, YOU CAN USUALLY TELL IF A VEHICLE HAS A LIMITED SLIP DIFFERENTIAL BY ROTATING TIRES WHEN CAR IS LIFTED. IF BOTH TIRES ROTATE IN SAME DIRECTION, CAR HAS A LIMITED SLIP DIFFERENTIAL.**
	**DEMONSTRATION: SHOW DISASSEMBLED LIMITED SLIP DIFFERENTIAL. SHOW THEM HOW COMPRESSION OF THE CLUTCH PACKS LOCKS THE GEARS TO THE CASE**

ICONS	Ch130 Drive Axles and Differentials
	**DEMONSTRATION: SHOW CONE DIFFERENTIALS DISASSEMBLED SO THEY CAN SEE HOW THE CONE IS FORCED INTO ITS SEAT TO MAKE A DIRECT LINK BETWEEN GEAR AND THE CASE**
	**DISCUSSION: DISCUSS THE ADVANTAGES OF THE LIMITED SLIP DIFFERENTIAL IN CERTAIN SITUATIONS.**
 	ASEEDUCATION TASK **E1.4. DIAGNOSE NOISE AND VIBRATION CONCERNS; DETERMINE NEEDED ACTION.**
 	ASEEDUCATION TASK E1.5 **INSPECT AND REPLACE COMPANION FLANGE AND/OR PINION SEAL; MEASURE COMPANION FLANGE RUNOUT.**
 	ASEEDUCATION TASK E1.6 INSPECT RING GEAR AND MEASURE RUNOUT; DETERMINE NEEDED ACTION.
 	ASEEDUCATION TASK E1.7 REMOVE, INSPECT, REINSTALL AND/OR DRIVE PINION AND RING GEAR, SPACERS, SLEEVES, AND BEARINGS
 	ASEEDUCATION TASK E1.8 **MEASURE AND ADJUST DRIVE PINION DEPTH**
 	ASEEDUCATION TASK E1.9 MEASURE AND ADJUST DRIVE PINION BEARING PRELOAD.

ICONS	Ch130 Drive Axles and Differentials
	ASEEDUCATION TASK E1.10.MEASURE AND ADJUST SIDE BEARING PRELOAD AND RING AND PINION GEAR TOTAL BACKLASH AND BACKLASH VARIATION ON A DIFFERENTIAL CARRIER ASSEMBLY (THREADED CUP OR SHIM TYPES).
	ASEEDUCATION TASK E1.11 CHECK RING AND PINION TOOTH CONTACT PATTERNS; PERFORM NEEDED ACTION
	ASEEDUCATION TASK E1.12 DISASSEMBLE, INSPECT, MEASURE, ADJUST, AND/OR REPLACE DIFFERENTIAL PINION GEARS (SPIDERS), SHAFT, SIDE GEARS, SIDE BEARINGS, THRUST WASHERS, AND CASE
	ASEEDUCATION TASK E1.13 REASSEMBLE AND REINSTALL DIFFERENTIAL CASE ASSEMBLY; MEASURE RUNOUT; DETERMINE NEEDED ACTION.
	ASEEDUCATION TASK E2.1. DIAGNOSE NOISE, SLIPPAGE, AND CHATTER CONCERNS; DETERMINE NEEDED ACTION. E2.2. MEASURE ROTATING TORQUE; DETERMINE NEEDED ACTION.