Automotive Technology 6th Edition
Chapter 131 FWD & AWD
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 learning objectives to students as listed below: 1. Explain the operation of four-wheel-drive and all-wheel-drive systems. 2. Describe the components of a transfer case. 3. Discuss the purpose and function of an interaxle differential. 4. Describe the different types of four-wheel-drive axles. 5. Describe the procedure to diagnose and service transfer cases and locking hubs
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

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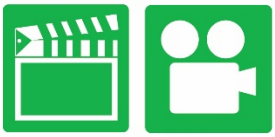
NOTE: You can use Chapter Images or possibly Power Point files:

ICONS	Chapter 131 FWD & AWD Systems
	1. **SLIDE 1 Chapter 126: FWD & AWD**
	**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**
	**Videos**
	
	**DEMONSTRATION: Show FWD vehicle on the hoist. Point out the two differentials and the transfer case**
	**DEMONSTRATION: Show FWD selector in a vehicle and procedure in its owner's manual for changing from FWD to two-wheel-drive.**
	2. **SLIDE 2 EXPLAIN FIGURE 131–1** Four-wheel-drive vehicles can be achieved by using an existing rear-wheel-drive arrangement and adding a transfer case, or a front-wheel-drive arrangement with the addition of rear axle output shaft and center differential assembly. 3. **SLIDE 3 EXPLAIN Figure 131-2** Cutaway of a manually-operated locking hub. 4. **SLIDE 4 EXPLAIN Figure 131-3** Manual locking hubs require that the hubs be rotated to the locked position by hand to allow torque to be applied to the front wheels. Automatic locking hubs enable the driver to shift into four-wheel drive from inside the vehicle.
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***What Is the Difference Between Four-Wheel Drive (4WD) and All-Wheel Drive (AWD)?*** **The major difference between four-wheel drive and AWD is that 4WD units contain a transfer case with a low range. Most all-wheel-drive vehicles do not have low range and are in high**

four-wheel drive all time. Both use a center (interaxle) differential and both usually use a viscous coupling or an electronically controlled clutch to control (lock) center differential.

DEMONSTRATION: Show the students an example of a locking hub assembly. Demonstrate the inner workings of the hub: **FIGURE 131-2, 3**

DISCUSSION: Ask the students to discuss the path the torque follows through the center of the hub, through the locking device, and out to wheel.

HANDS-ON-TASK: Have the students inspect a locking hub assembly. Have them determine which parts are the locking system and which are the drive components. **FIGURE 131-2, 3**

EXPLAIN TECH TIP: ***How to Tow a Four-Wheel-Drive Vehicle Without Doing Harm***. If any of drive wheels are on ground, wheels are turning axles. Depending on exact type of 4WD vehicle being towed, this rotation of wheels can cause severe wear; therefore most experts suggest following options:

- Placing vehicle on a flatbed or trailer. This keeps all four wheels off the ground and is the safest method for transporting a four-wheel-drive (or all-wheel-drive) vehicle without doing any harm.
- Hoisting front wheels off ground and placing rear wheels on a dolly. This procedure also keeps all wheels off the ground and therefore prevents any damage being done to the powertrain as a result of towing. • **SEE FIGURE 131–4.** Always check with vehicle specific information for exact towing procedures.

5. **SLIDE 5 EXPLAIN FIGURE 131-4** If a four-wheel-drive vehicle must be towed, it should be either on (a) a flatbed truck or (b) a dolly.
6. **SLIDE 6 EXPLAIN Figure 131-5** When turning a corner, each wheel takes a slightly different path and rotates at a slightly different speed. Unlike a part-time

ICONS	Chapter 131 FWD & AWD Systems
     	four-wheel-drive system, which when engaged locks the front and rear axles together, a full-time system uses a center differential that allows for any speed differences between the front and rear axles. It can therefore be activated on any surface—slippery or dry. **DISCUSSION: Ask the students to discuss why some vehicles have FWD. Discuss when FWD would be needed** **DISCUSSION: Ask the students to discuss the differences between part-time and full-time four-wheel-drive** **HANDS-ON-TASK: Have the students' research automotive careers that require the ability to repair and troubleshoot 4WD vehicles. DISCUSS in class career opportunities, their advantages & disadvantages, & compensation levels.** Active 4WD (View) (Download) Active 4WD Transfer Case (View) (Download) AWD Differentials (View) (Download) Transfer Case, Chain Drive (View) (Download) 7. **SLIDE 7 EXPLAIN Figure 131-6** viscous coupling is a sealed unit containing many steel discs. One-half of them are splined to the input shaft, with every other disc splined to the output shaft. Surrounding these discs is a thick (viscous) silicone fluid that expands when hot and effectively locks the discs together. 8. **SLIDE 8 EXPLAIN Figure 131-7** typical four-wheel-drive vehicle that uses a longitudinal engine and a transfer case to send engine torque to both the front and rear wheel. **DISCUSS FREQUENTLY ASKED QUESTION:** ***What Is Brake-Actuated Traction Control?*** **The engine torque of a full-time four-wheel-drive vehicle (with the center differential unlocked) is split into four nearly equal parts. One quarter of the torque is applied to each wheel. If a brake is applied to a spinning wheel, torque to that wheel is increased, which will increase torque to all of other wheels. The**

increased torque applied to wheels that have contact with a surface that has some traction will enable the vehicle to proceed. This is principle involved in brake-controlled traction control such as is used on the Mercedes M4 sport utility vehicle (SUV).

DEMONSTRATION: Show the students a viscous coupling. Demonstrate how the coupling locks up as speed increases.

DISCUSSION: Ask the students to discuss the operation of a viscous coupling

An example of a dilatant fluid similar to that used in a viscous coupler is Silly Putty. Under low shear force, such as pulling it apart slowly, Silly Putty is somewhat fluid. Pulling it apart fast (high shear force) causes it to become structurally less fluid, and it snaps apart. This is why Silly Putty bounces. Another viscous coupler found on rear-wheel-drive cars is the clutch that holds the fan to the front of the engine. As engine heats up, the fluid becomes stiffer, causing fan to engage.

9. **SLIDE 9 EXPLAIN Figure 131-8** center differential is the heart of a typical all-wheel-drive system. AWD systems do not use a low range, and therefore the vehicle may not be able to go off-road like a vehicle equipped with a four-wheel drive with a low range.

DEMONSTRATION: Show an AWD vehicle, including the lack of controls in the driver's compartment. With vehicle on a hoist, point out 2 differentials & viscous coupler, if one is present.

DISCUSSION: Ask the students to discuss use of AWD. Have them discuss the advantages and disadvantages associated with AWD

DISCUSSION: Have students discuss **front and rear gear ratios of an AWD vehicle.** Ask them to discuss why there would be a problem if both gear ratios were exactly same. What if the rear ratio was higher than the front?

ICONS	Chapter 131 FWD & AWD Systems
	**DEMONSTRATION:** Show example of a drive chain transfer case. Demonstrate change in output as transfer case shifts between modes and ranges
	10. **SLIDE 10 EXPLAIN Figure 131-9** typical transfer case is attached to the output of the transmission and directs engine torque to rear or to front and rear differentials. 11. **SLIDE 11 EXPLAIN Figure 131-10** exploded view of New Venture 241 transfer case
	**DISCUSSION:** Ask the students to discuss the torque flow through a chain-type transfer case like the one in FIGURE 131–10
	**HANDS-ON-TASK:** Have the students' research operational flaws of chain drive. Ask them to DISCUSS their findings, making sure to include a discussion of torque loss, roller chains, and the use of belts rather than chains.
	12. **SLIDE 12 EXPLAIN Figure 131-11 (a)** When one axle shaft is disconnected, both front wheels can rotate independently, reducing excessive tire wear. 13. **SLIDE 13 EXPLAIN Figure 131-11 (b)** In four-wheel-drive mode, vacuum is applied to the front part and the opposite side is vented to atmospheric pressure retracting the shift motor stem. The shift fork and collar move into engagement with both axle shaft gears. Engine torque from the front differential can now be applied to both front axles. When transfer case is placed in two-wheel drive, vacuum is applied to the other side of the diaphragm and shift collar moves, unlocking front axles.
	**SEARCH INTERNET:** Have students use Internet to research viscous fluids. Ask them to describe to the class how such a fluid becomes stiffer under conditions such as the two ends of a viscous coupler moving at different speeds.
	**DEMONSTRATION:** Show examples of transfer case shifting options, including manual floor, vacuum-operated, and electric
	**DISCUSSION:** Ask students to discuss operation and service concerns related to each of the three engagement options: manual floor, vacuum-operated, and electric

ICONS	Chapter 131 FWD & AWD Systems
  	**DISCUSSION:** **Ask the students to discuss the difference between mode shift and range shift** **DISCUSSION:** **Ask the students to discuss when four-wheel low range would be appropriate** **14. SLIDE 14 EXPLAIN FIGURE 131-12** General Motors sport utility vehicle front axle showing the electric axle disconnect actuator. **15. SLIDE 15 EXPLAIN FIGURE 131-13** range shift selector on a Hummer H1 sport utility vehicle**.** **16. SLIDE 16 EXPLAIN Figure 131-14** A typical planetary gear set used in a transfer case. **17. SLIDE 17 EXPLAIN Figure 131-15** Cutaway of a planetary gear set transfer case.
	**DEMONSTRATION:** **Show the students an example of a planetary gear transfer case. Demonstrate the mode and range shifts and how they affect the output of the transfer case.**
 	**DISCUSSION:** **Have students discuss how gear reduction is achieved with a planetary gear set** **18. SLIDE 18 EXPLAIN Figure 131-16** Two-wheel-drive/high-range torque flow in a NV231 transfer case. The sliding range clutch is shifted to the forward position by the range lever and fork, which connects the input gear to the output shaft and rear axle. The mode synchronizer sleeve is moved out of engagement from the drive sprocket to remove torque from the front axle. **19. SLIDE 19 EXPLAIN Figure 131-17** Four-wheel-drive/high-range torque flow in a NV231 transfer case. The range clutch position remains the same as in two-wheel drive/high-range, but the synchronizer sleeve is moved rearward and engages the drive sprocket clutch teeth. This action connects the drive sprocket to the rear output shaft, thereby applying equal torque to both front and rear output shafts. **20. SLIDE 20 EXPLAIN Figure 131-18** Four-wheel-drive/low-range torque flow in a NV231 transfer case. The mode synchronizer assembly remains engaged and the range clutch is moved to the rearward position. The

annulus (ring) gear is fixed to the case and the input (sun) gear drives the pinion gears, which walk around the stationary annulus gear and drive the planetary carrier and output shaft at a speed lower than the input gear.

DEMONSTRATION: Show the students how the chain drive sprocket is engaged for all-wheel drive and how the planetary set is engaged for low-range drive in the figures for the NV231 transfer case.

FIGURE 131–16, 17

Active 4WD Transfer Case (View) (Download)

Transfer Case, Chain Drive (View) (Download)

ON-VEHICLE ASEEDUCATION: F1. Inspect, adjust, and repair shifting controls (mechanical, electrical, and vacuum), bushings, mounts, levers, and brackets.

DEMONSTRATION: Show the students an example of an interaxle differential. Demonstrate how the differential is similar to a rear differential in that it has pinion gears, a ring gear, and a drive pinion gear.

21. **SLIDE 21 EXPLAIN Figure 131-19** bevel gear-type interaxle differential.
22. **SLIDE 22 EXPLAIN Figure 131-20** A viscous coupling. Note that the unit is attached to the output shaft between the transfer case (or transaxle) and the rear differential. A typical viscous coupling in a sealed unit is serviced as a complete assembly.

DEMONSTRATION: When differential is shifted, it locks front axle and sends torque to that axle. Show students that when the front axle is shifted out, it is free-turning with no torque applied. Note that there is no provision for four-wheel low

HANDS-ON-TASK: Have the students rotate input shaft and observe the torque flow and then shift into all wheel and see how torque flow changes to both shafts

ICONS	Chapter 131 FWD & AWD Systems
	**HANDS-ON-TASK:** Have the students use an interaxle differential and determine the gear ratio of the front and rear axles in all-wheel drive. Have them determine the gear ratio of front axle when the differential is in rear-wheel drive
	**DISCUSSION:** Ask the students to discuss the advantages and disadvantages of front axles with Cardan U-joints and CV joints **FIGURE 131–21**
	23. **SLIDE 23 EXPLAIN FIGURE 131-21A** standard Cardan U-joint used on the output driveshaft from the transfer case to the front differential assembly. 24. **SLIDE 24 EXPLAIN FIGURE 131-21B** Cardan-type U-joint at the front drive wheels on a Jeep Wrangler.
	**DEMONSTRATION:** Show procedure for removing a **Cardan U-joint axle shaft**. Demonstrate how to check seals and bearings in the axle tubes. Show the students how to replace a Cardan U-joint
	**HANDS-ON-TASK:** Have the students' remove the locking or automotive hub assembly, remove the Cardan U-joint drive axle, and inspect the U-joint and determine if it needs to be replaced. Have them reassemble the axle and hub assembly and check for smooth operation. Grade students on their ability to complete the task, following proper procedures and all applicable safety precautions
	25. **SLIDE 25 EXPLAIN Figure 131-22** Constant velocity (CV) joints are used on the front axles of many four-wheel-drive vehicles like this Chevrolet Blazer.
	**HANDS-ON-TASK:** Have the students research the cost of a replacement transfer case for a vehicle. Ask them to include cost of labor to replace it. Have them role play, presenting their findings to the class the way an automotive technician would report findings to a customer.
	**SEARCH INTERNET:** Have students search Internet to research the available vehicles with true all-wheel-drive capability. Ask them to be prepared DISCUSS the vehicles and indicates whether the all-wheel drive is standard or an option.

ICONS	Chapter 131 FWD & AWD Systems
	**26. SLIDE 26 EXPLAIN Figure 131-23** Most transfer cases use an internal oil pump to force the lubricant throughout the unit. Using the correct lubricant is critical to the proper operation of the transfer case.
	**DEMONSTRATION: Show student how to drain and refill transfer case. Discuss the importance of using the correct fluid in all transfer cases**
	**DISCUSSION: Ask the students to discuss why some transfer cases use automatic transmission fluid and some use gear lube**
	**HANDS-ON-TASK: Have the students drain and refill a transfer case**
	**ON-VEHICLE ASEEDUCATION TASK F3: Check for leaks at drive assembly and transfer case seals; check vents; check fluid level; use proper fluid type per OEM specification**
	**Transfer case & differential vents on FWD should be located as high as possible. Be certain there tubing has no kinks in it & vents are not routed near hot/moving parts**
	
	**27. SLIDE 27 EXPLAIN Figure 131-24A** pin and rocker-type chain, which is also called a rocker joint-type chain, is used in transfer cases because of low noise and high efficiency, which improves fuel economy
	28. SLIDE 28 EXPLAIN FIGURE 131-24B rocker pin-type chain used in a transfer case.
	**DEMONSTRATION: Show the students how to properly visually inspect a transfer case before disassemble. Check for end play and runout of input and output shafts. Check for case cracks and deformities**
	**It may be more expensive to repair major problems with a transfer case than to just replace the entire assembly**

ICONS	Chapter 131 FWD & AWD Systems
	**HANDS-ON-TASK:** Have the students do pre-disassembly inspections on several transfer cases. Have them tag the transfer cases with a list of concerns about each unit
	**DEMONSTRATION:** Show the students how to identify a transfer case before disassembly
	**ON-VEHICLE TASK:** Remove and install transfer case.
	29. **SLIDE 29 EXPLAIN Figure 131-25 (a)** transfer case shift forks attach to the synchronizer sleeve. 30. **SLIDE 30 EXPLAIN Figure 131-25 (b)** sleeve, hub, and inserts are similar in design except larger than those used in a manual transmission/transaxle.
	**EXPLAIN TECH TIP:** ***Please Install Snap Rings Correctly.*** **Many snap rings are tapered at their opening, as shown in • FIGURE 131–26. This allows snap ring pliers to grasp points of snap ring so that it can be expanded and easily removed. If points are facing down, it is very difficult for snap-ring pliers to grasp end of snap ring. Therefore, to make it easier to disassemble a transfer case later, always install snap rings as they were designed to be installed.**
	31. **SLIDE 31 EXPLAIN FIGURE 131-26** When reassembling a transfer case (or another automotive component) that includes a snap ring, always be sure that the upper opening is tapered from the top to allow snap-ring pliers room to get a grip on open end.
	**Before disassembling a transfer case for service, make sure parts are available for that particular type**
	**EXPLAIN TECH TIP:** ***Keep the Differential Vents Clear.*** **All differentials are vented to allow for expansion and contraction of differential lubricant in all temperature ranges. Typically, these vents are shielded openings near top of differential. Most**

ICONS	Chapter 131 FWD & AWD Systems
	trucks, especially 4WD vehicles, use an extended vent hose to prevent water from getting into differential if the vehicle is driven in deep water. If mud gets into vent, pressure can build up inside differential and cause lubricant leakage past rear axle seals. Therefore, whenever replacing rear axle seals, always check to make sure that differential vent is clear. Remember that 4WD use two differentials and that both the front and rear vents plus the vent on transfer case should be checked. **DISCUSS CASE STUDY: *Differential Lubricant Story.* 4WD vehicle was serviced and both differentials were drained and refilled as recommended by OEM. The owner returned shortly after picking up vehicle and complained that vehicle drove as if the parking brake was still applied. The vehicle lacked power and would decelerate rapidly whenever accelerator pedal was released. Careful inspection of parking brake revealed that everything was functioning correctly. Because all that was done was differential fluid service, fluid level was checked and again, level was correct and not overfull. Then technician checked container of gear lubricant that was used and discovered that parts store had accidentally sent SAE 80W-140 instead of the requested, and more commonly used, SAE 80W-90. Both lubricants were listed GL-5 meaning that they were acceptable for differentials. The container of lubricant had been installed in portable lubricating dispenser when it was delivered, and therefore label on container was not visible to technician. The correct lower viscosity lubricant was installed in differential and normal vehicle performance was restored. The technician and parts store learned to double-check product before shipping/using it.**

ICONS	Chapter 131 FWD & AWD Systems
	Summary: • **Complaint—customer complained of poor performance after the differential fluid was replaced.** • **Cause—incorrect fluid was used.** • **Correction—correct viscosity fluid was used which restored proper vehicle performance.**
	**HANDS-ON-TASK: Have students list the steps in disassembling, inspecting, and reassembling the transfer case they have been assigned. Grade them on the completeness of the list**
	**ON-VEHICLE ASEEDUCATION TASK F2: Inspect locking hubs; determine needed action.**
	
	**ON-VEHICLE ASEEDUCATION TASK F4. Identify concerns related to variations in tire circumference and/or final drive ratios.**
	
	**ON-VEHICLE ASEEDUCATION TASK F6: . Diagnose, test, adjust, and/or replace electrical/electronic components of four-wheel drive/all-wheel drive systems..**
	
	32. **SLIDE 32 EXPLAIN Figure 131-27** (a) exploded view of a Dualmatic® manual locking hub. (b) A Warn® manual locking hub
	**HANDS-ON-TASK: Have students disassemble and reassemble a locking hub front axle. Grade them on their ability to complete the task, following all applicable safety procedures.**
	**ON-VEHICLE ASEEDUCATION TASK F7: Disassemble, service, and reassemble transfer case and components..**
	

ICONS	Chapter 131 FWD & AWD Systems
	**SEARCH INTERNET:** Have students search the Internet research and report on the NP203 doubler. Have them include the process for building a doubler and the advantages of doubling up a transfer case.
	**ON-VEHICLE ASEEDUCATION TASK F5:** Diagnose noise, vibration, and unusual steering concerns; determine needed action.
	
	**33. SLIDES 33-53 OPTIONAL 20 SLIDES TO EXPLAIN NV-242 TRANSFER CASE SERVICE**