Automotive Technology 6th Edition
Chapter 127 Manual Transmissions/Transaxles
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. Discuss the need for a transmission. 2. Explain the different types of gears and gear ratios. 3. Describe the relationship between torque, speed, and power. 4. Describe the construction of a transmission. 5. Describe the torque flow through a manual transmission. 6. Describe speed gears. 7. Explain the construction and operation of a synchronizer. 8. Describe the torque flow through a five-speed manual transmission. 9. Describe the procedure to diagnose, remove, disassemble, and install manual transmission/transaxle.
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 127 Chapter Images: From

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

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

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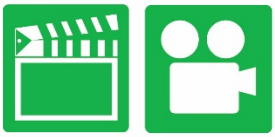
	**1. SLIDE 1 CH127: Manual Transmissions/Transaxles**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE IS CONSTANTLY UPDATED** **http://www.jameshalderman.com/automotive_principles.html** **DOWNLOAD** **Crossword Puzzle (Microsoft Word) (PDF)** **Word Search Puzzle (Microsoft Word) (PDF**
	**Videos**
	**2. SLIDE 2 EXPLAIN Figure 127-1** Spur gears have straight-cut teeth. **3. SLIDE 3 EXPLAIN Figure 127-2** teeth of a helical gear are cut at an angle to the gear axis.
	**DEMONSTRATION: Show the students a vehicle with a transmission and one with a transaxle.**
	**DISCUSSION: Ask the students to advantages & disadvantages of the transaxle design compared to transmission design.**
	**4. SLIDE 4 EXPLAIN Figure 127-3** A spur gear has straight-cut teeth. This design is very strong and is used where strength is important. Spur gears are noisy during operation. Helical-cut gears, on the other hand, operate quietly but create a force in line with the axis of the gears due to the angle of the gear teeth.
	**DISCUSS FREQUENTLY ASKED QUESTION: *What is the Difference Between a Transmission and Transaxle?* A transmission is used on rear-wheel-drive vehicles, whereas a transaxle is usually used on front-wheel-drive vehicles. A vehicle equipped with a transmission uses a separate differential to split the torque equally to the drive wheels. A transaxle includes a**

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	differential assembly. In a transaxle, the differential, sometimes called the final drive unit, is incorporated in the construction of the transmission.
	**DEMONSTRATION: Show a spur gear. Show examples of where they would find spur gears in non-automotive applications. (Examples: boat winches, gear reduction units on machinery, and analog clocks and watches)**
	**DISCUSSION: Ask the students to discuss the difference between spur and helical gears and other places in vehicle where you may find each.**
	5. **SLIDE 5 EXPLAIN Figure 127-4** A pinion gear meshed with an internal ring gear rotates in the same direction around a parallel axis of rotation. 6. **SLIDE 6 EXPLAIN Figure 127-5** When two external gears mesh, they rotate in opposite directions. 7. **SLIDE 7 EXPLAIN Figure 127-6** Bevel gears are often used to change the direction of rotation and are typically used in differentials. 8. **SLIDE 8 EXPLAIN Figure 127-7** differential uses a hypoid gear set to provide a change in direction of torque and for gear reduction (torque increases) to drive wheels.
	**DEMONSTRATION: Show the students an example of a hypoid gear in a differential. Point out how the pinion gear is offset from the ring gear.**
	9. **SLIDE 9 EXPLAIN Figure 127-8** Gear ratio is determined by dividing the number of teeth of the driven (output) gear (24 teeth) by the number of teeth on the driving (input) gear (12 teeth). The ratio illustrated is 2:1. 10. **SLIDE 10 EXPLAIN Figure 127-9** gear combination provides a gear reduction of 3:1. 11. **SLIDE 11 EXPLAIN Figure 127-10** This gear combination provides an overdrive ratio of 0.33:1.
	**DEMONSTRATION: Show the students how using different size combinations of gears changes rotation speed.**

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	**External Gears, 2:1 (View) (Download)** **Internal & External Gear (View) (Download)**
	**DISCUSSION: Ask the students to discuss how gear ratios help when pedaling a multi-speed bike**
	12. **SLIDE 12 EXPLAIN Figure 127-11** Idler gears affect the direction of rotation in a gear train, but not the final drive ratio.
	**Show ANIMATION: Idler Gear Operation** **External Gears With Idler (View) (Download)**
	**DEMONSTRATION: Show the students two gears connected by an idler gear. Explain how idler gear keeps both gears rotating in the same direction.**
	**Good example of an idler gear used in an in-block cam system is a gear called a "bone," which takes place of a timing chain**
	13. **SLIDE 13 EXPLAIN Figure 127-12** Gears apply torque in the same way a wrench applies torque—the force applied multiplied by the distance from the center of the gear equals the torque. 14. **SLIDE 14 EXPLAIN Figure 127-13** lever can be used to multiply torque, but it does so at the expense of distance or speed.
	**DEMONSTRATION: Show the students how a fulcrum and lever can reduce lifting effort. Set a long lever on fulcrum ¼ of way to the load you want to lift. Then move fulcrum to ¼ of distance from the input point. Show students how decreased lift effort increases the length of movement and then opposite happens for other setup.**
	**DISCUSSION: Have students discuss other places on the vehicle where leverage is used to reduce input effort.**

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	**HANDS-ON TASK:** **Have students use several combinations of fulcrums and levers to lift objects so they can experience input force required to lift heavier objects or to move objects longer distance.**
	**15. SLIDE 15 EXPLAIN Figure 127-14** Cross section of a five-speed manual transmission showing the main parts.
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***What is Meant by a 77 mm Transmission?*** **The size (77 mm or about 3 inches) is distance between center of input shaft and center of countershaft. The greater this distance, larger transmission and the more torque it is capable of handling due to the larger gears. • SEE FIGURE 127–15.**
	**16. SLIDE 16 EXPLAIN FIGURE 127–15** torque capacity of a transmission is determined by the size of the gear and bearings used. The greater distance, usually measured in millimeters such as 77 mm, between the main shaft and the countershaft, greater torque capacity.
	**DEMONSTRATION:** **Show examples of manual transmissions. Show difference in construction of each. Show the students internal workings of several manual transmissions. Show locations of major parts.**
	**DISCUSSION:** **Ask students to discuss why the design of manual transmissions varies. Ask them to explain advantage & disadvantage of each design.**
	**DISCUSSION:** **Ask the students to discuss the terms "gear reduction" and "overdrive." In each combination, something is gained and something is lost. (For example, in gear reduction, the number of rotations is lost but torque is increased)**
	**17. SLIDE 17 EXPLAIN Figure 127-16** Notice that the countershaft and the main shaft both use gears of increasing size that mesh together.
	**DEMONSTRATION:** **Show countershaft. Show how gears on shaft are fixed and decrease in size from one end to other. Demonstrate that gears on**

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	countershaft are fixed to shaft and all turn together whenever power comes into the input shaft. Show the main shaft. Show them that only the input gear is fixed to shaft. Show the students how the gears on the main shaft decrease in size in the opposite direction from the countershaft.
	**DEMONSTRATION:** Show an example of a floor shift rod-and-fork shifting mechanism. Show them how moving the shift lever moves the forks and how detents prevent two gears from being shifted at one time.
	**HANDS-ON TASK:** Have the students move the shift lever and watch the action of the forks. Have them observe use of detents to prevent two forks from moving at one time.
	18. **SLIDE 18 EXPLAIN Figure 127-17** typical shift mechanism showing shift detents designed to not only give driver a solid feel when shifting but also to prevent 2 gears from being selected at same time. Shifter also prevents shifting into reverse except from neutral position.
	**Worn detents can cause trans lock-up when 2 gears synchronize at same time**
	**Transmission Interlocks & Detents (View) (Download)**
	19. **SLIDE 19 EXPLAIN Figure 127-18** The shifter fork fits into the groove of the synchronizer sleeve. When a shift is made, the sleeve is moved toward the speed gear. The sleeve presses the stop ring (synchronizer ring) against the cone area of the speed gear. The friction between the stop ring and the speed gear causes the speed of the two to become equal, permitting the sleeve to engage the gear clutch teeth of the speed gear. When this engagement occurs, the shift is complete.
	**DEMONSTRATION:** Show a synchronizer assembly. Show major components of synchronizer and how they fit together. Show the placement of synchronizer in a manual transmission. Show

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   	**students how synchronizer moves between centered positions to speed gear.** **Cutting a 90-degree pie shape out of a synchronizer assembly with a band saw makes it easier to see operation.** **DEMONSTRATION: Show how to inspect components of a synchronizer assembly. Show the students how the back taper works to help engage and hold the synchronizer into the speed gear.** **Show ANIMATION: Synchronizer Operation** **Synchronizer Operation (View) (Download)** 20. **SLIDE 20 EXPLAIN Figure 127-19** Typical synchronizer assembly. 21. **SLIDE 21 EXPLAIN Figure 127-20** Synchronizer keys are attached to the clutch hub and push against the synchronizer ring when the sleeve is being moved during a shift. Notice the grooves on the synchronizer ring. These grooves prevent lubricating oil from becoming trapped between the ring and the cone surface of the speed gear. The grooves also help the ring release from the cone surface when a shift is made out of a gear 22. **SLIDE 22 EXPLAIN Figure 127-21** A shift sequence starts when the shift fork is moved by the driver, (1) applying a force on the sleeve that moves it toward the speed gear. (2) The sleeve and the inserts contact the stop ring (blocking ring). (3) The synchronizer ring (stop ring) engages the cone on the speed gear, causing both assemblies to reach the same speed. (4) The shift is completed when the internal teeth of the sleeve mesh with the gear clutch teeth of the speed gear. 23. **SLIDE 23 EXPLAIN Figure 127-22** Before reassembling the transmission/transaxle, carefully inspect the splines on the synchronizer sleeves for wear. The shape of the splines helps prevent the transmission/transaxle from jumping out of gear during acceleration and deceleration. 24. **SLIDE 24 EXPLAIN FIGURE 127–23** Exploded view of a triple-cone synchronizer. The inner and outer rings rotate with the synchronizer sleeve while middle ring rotates with the speed gear.

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	**DISCUSS FREQUENTLY ASKED QUESTION:** ***What Do the Keys Do?*** **The keys are there to limit amount of rotation of ring from 1/2 tooth misaligned in forward direction, to 1/2 tooth misaligned in "coast" direction so that both upshifts and downshifts can be made. The detent key springs are designed to "push up" on the keys which have a "bump" on them that aligns with a notch in the inside center of sliding sleeve. This upward pressure tends to keep sliding sleeve in neutral position and prevents unwanted movement toward another unwanted gear.**
	**DISCUSSION:** **Have the students discuss the effect of worn synchronizer rings in the assembly.**
	**Transmission Power Flow (View) (Download)**
	**25. SLIDE 25 EXPLAIN Figure 127-24** In neutral, the input shaft and the countershaft are rotating if the clutch is engaged (clutch pedal up), but no torque is being transmitted through the transmission. **26. SLIDE 26 EXPLAIN Figure 127-25** first gear, 1–2 synchronizer sleeve is moved rearward, locking the first speed gear to the output shaft. Torque is transmitted from the input shaft to countershaft and then to output shaft. **27. SLIDE 27 EXPLAIN Figure 127-26** In second gear, the 1–2 synchronizer sleeve is moved forward, which locks the second speed gear to the output shaft. **28. SLIDE 28 EXPLAIN Figure 127-27** To achieve third gear, the shaft linkage first centers the 1–2 synchronizer sleeve and then moves the 3–4 synchronizer sleeve rearward, locking third speed gear to the output shaft. **29. SLIDE 29 EXPLAIN Figure 127-28** In fourth gear, the 3–4 synchronizer sleeve is moved forward, which locks the fourth speed gear to the output shaft. **30. SLIDE 30 EXPLAIN Figure 127-29** To achieve fifth gear, the shift linkage first centers the 3–4 synchronizer

sleeve and then moves the fifth synchronizer sleeve toward the fifth speed gear, locking it to the output shaft.

31. **SLIDE 31 EXPLAIN Figure 127-30** Torque flows through the transmission in reverse gear. Note that the idler gear drives the 1–2 synchronizer sleeve gear, which is splined to the output shaft.
32. **SLIDE 32 EXPLAIN Figure 127-31** Cutaway of T56 6-SPD transmission showing all its internal parts.

6 Speed Transaxle Operation (View) (Download)

DEMONSTRATION: Show students how power flows through a 5-speed transmission, using Figures 122-24 to 122-30. Show how neutral is achieved with centering of all synchronizers.

DEMONSTRATION: Show the students how reverse is achieved with the centering of all synchronizers.

DISCUSSION: Ask the students to discuss what the effect would be on shift quality as the gears and synchronizers begin to wear.

33. **SLIDE 33 EXPLAIN Figure 127-32** Notice that this five-speed transaxle from a Dodge/Plymouth Neon uses synchronizers on both the input and output shafts.
34. **SLIDE 34 EXPLAIN Figure 127-33** Cutaway of a typical manual transaxle showing all of its internal parts including the final drive assembly.

DEMONSTRATION: Show the students an example of a manual transaxle. Show the students the similarities between a transaxle and a rear-wheel-drive manual transmission.

Transaxle, Power Flow (View) (Download)

DISCUSSION: discuss advantages & disadvantages of 2 types of transmissions. Ask them what similarities they see & what differences.

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         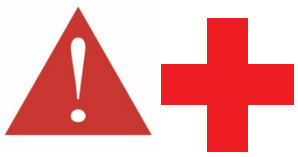 	**ON-VEHICLE ASEEDUCATION TASK:** **Describe the operational characteristics of an electronically controlled manual transmission/transaxle.** **SEARCH INTERNET:** **use Internet to research how helical and hypoid gears are manufactured. Ask them to write a report that describes at least two different manufacturing processes.** 35. **SLIDE 35 EXPLAIN Figure 127-34** When the transmission/transaxle is removed from the vehicle, the engine must be supported. In this case, the engine oil pan is supported with a block of wood to spread the load across the entire oil pan to prevent damage. The block of wood is placed on top of a tall safety stand that allows room for the service technician to work while standing. **DEMONSTRATION:** **Show how to support the engine during transmission removal. Show them how to support engine from below and from above.** **DISCUSSION:** **discuss importance of supporting engine properly. Ask them to discuss damage that can happen to engine if it is not supported properly. Ask students to discuss safety factors involved in properly supporting engine.** 36. **SLIDE 36 EXPLAIN Figure 127-35** A transaxle being removed from underneath a vehicle and being supported by a transmission jack. 37. **SLIDE 37 EXPLAIN Figure 127-36** Typical cable-operated shift linkage used on a FWD transaxle. **SAFETY:** **With cover off of transmission and someone turning output or input shaft, be careful of students getting their fingers pinched between gears.** **HANDS-ON TASK:** **Have students move synchronizers into place to see how the gears are engaged. Have the students place correct synchronizer into place to achieve reverse.**

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 	**ON-VEHICLE ASEEDUCATION TASK: A1** **Identify and interpret drive train concerns; determine needed action**
	**38. SLIDE 38 EXPLAIN Figure 127-37** Drain the fluid into a suitable container and dispose of the old fluid according to local, state, and federal regulations
 	**ON-VEHICLE ASEEDUCATION TASK A3: Check fluid condition; check for leaks; determine needed action.**
 	**ON-VEHICLE ASEEDUCATION TASK A4: Drain and refill manual transmission/transaxle and final drive unit; use proper fluid type per manufacturer specification.**
 	**DEMONSTRATION: ON-VEHICLE ASEEDUCATION TASK C1: Inspect, adjust, lubricate, and/or replace shift linkages, brackets, bushings, cables, pivots, and levers.**
	**SEARCH INTERNET: Have the students use the Internet to research Have the students use the Internet to research M22 GM Muncie transmission known as the Rock Crusher. Ask them to summarize their findings in a report, making sure they discuss the gear ratio and construction characteristics of this muscle-car transmission**
	**DEMONSTRATION: Show proper procedure for disassembling the transmission and inspecting parts for wear.**
	**39. SLIDE 39 EXPLAIN Figure 127-38** Borg-Warner T5 5-speed transmission shown with shifter cover removed. **40. SLIDE 40 EXPLAIN Figure 122-39** cost to replace these gears may exceed the cost of a replacement transmission.

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	41. **SLIDE 41 EXPLAIN Figure 127-40** It often requires 2 people to assemble a transaxle because shaft with the shifter forks needs to be placed into the case as an assembly, as on this unit.
	42. **SLIDE 42 EXPLAIN Figure 127-41 (a)** During the disassembly of any manual transmission/transaxle, carefully check for the location of the snap rings. Often they are hidden. Consult the factory service manual or unit repair manual for information and procedures for the unit being serviced.
	43. **SLIDE 43 EXPLAIN Figure 127-41 (b)** Using snap-ring pliers to remove a snap ring. Many snap rings have an "up" side. Be sure to reinstall any snap rings in the correct direction.
	**EXPLAIN TECH TIP:** ***Manual Transmission Service Tips.*** **A wise technician once told a beginning technician to remember these items when working with transmissions:** • **Always use a brass or plastic hammer when pounding on a steel or aluminum component.** • **If using a steel hammer, always use a brass or aluminum punch or place wood between steel components and hammer.** • **Many parts can be installed in either direction but usually only one way is correct.** • **If you are exerting a lot of force, you are probably doing something wrong.** • **Many drive train parts are pulled or pressed off and pressed or driven on.**
	**DEMONSTRATION: Show the importance of inspection before disassemble. Explain that at times damage as simple as a bad gear can outweigh the cost of a new transmission by time you consider labor for rebuilding. Show students the proper way to remove snap rings. Explain that there is always a correct tool for job.**
	44. **SLIDE 44 EXPLAIN Figure 127-41 (c)** After the snap ring is removed, some components can be simply lifted off the main shaft, while other gears may require the use of a press.
	45. **SLIDE 45 EXPLAIN Figure 127-42a** Many gears require that a hydraulic press be used to separate the

gear(s) from the shaft. After double-checking that all snap ring retainers have been removed and after checking in the service manual to see which gear needs to be pressed off, carefully position the "bearing splitter" as far inward as possible to avoid damaging the teeth during the pressing operation.

DISCUSS CASE STUDY: *Worn Shift Fork Mystery.* A vehicle equipped with a manual transmission had to be repaired several times for worn shift forks. Even though vehicle warranty paid for repair, both customer and service department personnel were concerned about repeated failures. All TSBs were checked to see if there was an updated, improved shift fork. No luck. Even OEM personnel were unable to determine why shift forks were wearing out. After third repair, the service technician rode with customer to see if cause could be determined. As woman driver got into driver's seat, she placed handle of her purse over shifter on floor and allowed purse to hang from shifter. Technician asked owner if she always placed her purse on shifter and when she said yes, technician knew immediately cause of worn shift forks. The purse exerted a force on shifter all time. This force pushed shift forks against synchronizer sleeve. Because sleeve rotates all time the vehicle is in motion, shift forks were quickly worn. The service technician should have determined the root cause of problem after first repair. The customer agreed to find another location for her purse so that transmission problem would not reoccur.

Summary:

- **Complaint—Driver complained of repeated transmission failures.**

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	• **Cause—root cause was found to be that driver was hanging their purse over floor shifter causing wear to occur to forks.** • **Correction—driver found another location for her purse.**
	**46. SLIDE 46 EXPLAIN Figure 127-42b** Use caution when pressing parts onto the main shaft.
 	**ON-VEHICLE ASEEDUCATION TASK C6:.** **Disassemble, inspect clean, and reassemble internal transmission/transaxle components..**
 	**ON-VEHICLE ASEEDUCATION TASK C1:** **Inspect, adjust, lubricate, and/or replace shift linkages, brackets, bushings, cables, pivots, and levers.**
 	**ON-VEHICLE ASEEDUCATION TASK C2:.** **Describe the operational characteristics of an electronically-controlled manual transmission/transaxle.**
	**HOMEWORK: SEARCH INTERNET:** Have students use Internet to research synchronizers and how gears are selected. Ask them to report their findings to the class in a presentation.
 	**ON-VEHICLE ASEEDUCATION TASK C3:** **Diagnose noise concerns through the application of transmission/transaxle powerflow principles.**
 	**ON-VEHICLE ASEEDUCATION TASK C4:** **Diagnose hard shifting and jumping out of gear concerns; determine needed action.**

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	**DISCUSSION:** **Have students discuss importance of using proper fluid for each transmission they are working on. Have them discuss why different fluids are recommended for different transmissions.**
	**47. SLIDE 47 EXPLAIN FIGURE 127–43** dial indicator is set up to measure input shaft endplay as it is lifted and dropped using the pry bar..
	48. SLIDE 48 EXPLAIN Figure 127-44 Some manual transmissions/transaxles require synchromesh transmission fluid
	**ON-VEHICLE ASEEDUCATION TASK C5: Diagnose transaxle final drive assembly noise and vibration concerns; determine needed action.**
	
	**DISCUSSION:** **Ask the students to discuss different wear points and how they would affect transmission performance.**
	**49. SLIDES 49-64 EXPLAIN NV-1500 MANUAL TRANSMISSION**
	**ON-VEHICLE ASEEDUCATION TASK: Inspect and replace manual transmission gaskets and seals.**
	
	**ON-VEHICLE ASEEDUCATION TASK: Remove and replace transaxle final drive.**
	
	**ON-VEHICLE ASEEDUCATION TASK: Inspect and adjust shift cover and fork.**
	

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 	**ON-VEHICLE ASEEDUCATION TASK:** Measure endplay on transmission/transaxle; perform necessary action.
 	**ON-VEHICLE ASEEDUCATION TASK:** Inspect and reinstall synchronizer assembly.
	**DEMONSTRATION:** Show the students how to use a press to remove a bearing from the shaft. Show them how to check bearing for wear and to determine if the bearing is reusable.
	65. SLIDES 65-82 EXPLAIN NV-350 TRANSAXLE SERVICE
	**SEARCH INTERNET:** Have the students use Internet to research the manufacturers of manual transmissions. Ask them to report to the class on three different manufacturers and the advantages or disadvantages of each manufacturer's product. In their reports, have them compare prices of the transmissions.