Automotive Engines
Chapter 28 CAMSHAFTS & VALVE TRAINS
Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This engine systems course or class provides complete coverage of the components, operation, design, and troubleshooting. It correlates material to task lists specified by ASE and NATEF and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Real World Fixes, Videos, Animations, and NATEF Task Sheet references.
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 as listed on the NEXT SLIDE. 1. Prepare for the ASE Engine Repair (A1) certification test content area "B" (Cylinder Head and Valve Train Diagnosis and Repair). 2. Describe how the camshaft and valve train function. 3. Discuss valve train noise and its causes. 4. Explain how a hydraulic lifter works. 5. Describe the purpose and function of variable valve timing.
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.

ICONS	Ch28 Camshaft/Valve Train
	1. SLIDE 1 CH28 CAMSHAFTS & VALVE TRAINS 2. **SLIDES 2-4** EXPLAIN **Objectives & KEY TERMS**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE IS UPDATED REGULARLY**
	5. **SLIDES 5** EXPLAIN Camshaft 6. **SLIDE 6** EXPLAIN **FIGURE 28-1** This high-performance camshaft has a lobe that opens the valve quickly and keeps it open for a long time. 7. **SLIDE 7** EXPLAIN **FIGURE 28-2** In many engines, the camshaft drives the distributor and the oil pump through a shaft from the end of the distributor. 8. **SLIDE 8** EXPLAIN **Camshaft &** EXPLAIN **FIGURE 28-3** camshaft rides on bearings inside the engine block above the crankshaft on a typical cam-in-block engine**.**
	**ON-VEHICLE NATEF TASK (A1A2)** Research CAMSHAFT SPECS PAGES 16 & 20
	9. **SLIDE 9** EXPLAIN Camshaft Design & EXPLAIN **FIGURE 28-4** Parts of a cam and camshaft terms (nomenclature). 10. **SLIDE 10** EXPLAIN **FIGURE 28-5** composite camshaft is lightweight and yet flexible, because hollow tube can absorb twisting forces & lobes are hard enough to withstand the forces involved in opening valves. 11. **SLIDE 11** EXPLAIN **FIGURE 28-6** Worn camshaft with two lobes worn to the point of being almost round. 12. **SLIDE 12** EXPLAIN **FIGURE 28-7** fuel pump rocker arm rides on the camshaft eccentric.
	**DEMONSTRATION: Show camshaft and point out intake and exhaust lobes as well as the distributor drive gear and the fuel pump eccentric, if the cam has them**
	**DISCUSSION: Ask the students what advantages overhead camshaft has as opposed to cam-in-block design.**

ICONS	Ch28 Camshaft/Valve Train
	**DEMONSTRATION: Show examples of steel and composite camshafts.**
	**DEMONSTRATION: Show example of a camshaft with excessive lobe wear.**
	13. **SLIDE 13** EXPLAIN Camshaft Drives & EXPLAIN **FIGURE 28-8** timing chain hydraulic tensioner. 14. **SLIDE 14** EXPLAIN **FIGURE 28-9** The larger camshaft gear is usually made from fiber and given a helical cut to help reduce noise. By making the camshaft gear twice as large as the crankshaft gear, the camshaft rotates one revolution for every two of the crankshaft.
	**Show ANIMATION: CAMSHAFT COMPONENTS www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A1_Animation/Chapter28_Fig_28_4/index.htm
	**DEMONSTRATION: Show the students an example of a steel camshaft gear and a composite camshaft gear.**
	**Composite camshaft gears have a nylon coating on the teeth to provide quiet operation. With age this nylon gets brittle and starts to break off in small pieces.**
	15. **SLIDE 15** EXPLAIN **FIGURE 28-10** replacement silent chain and sprockets. The original camshaft sprocket was aluminum with nylon teeth to help control noise. This replacement set will not be noticeably louder than the original and should give owner many thousands of miles of useful service. EXPLAIN **FIGURE 28-11** industry standard for when to replace a timing chain and gears is when 1/2 in. (13 mm) or more of slack is measured in chain. However, it is best to replace the timing chain and gear anytime camshaft is replaced or the engine is disassembled for repair or overhaul. 16. **SLIDE 16** EXPLAIN **FIGURE 28-12** replacement high-performance double roller chain. Even though a bit noisier than a flat-link chain, a roller chain does not stretch as much and will therefore be able to maintain accurate valve timing for a long time. EXPLAIN **FIGURE 28-13** This dual overhead camshaft (DOHC)

engine uses one chain from the crankshaft to the intake cam and a secondary chain to rotate exhaust camshaft.

17. **SLIDE 17** EXPLAIN **FIGURE 28-14** A timing belt failed when the teeth were sheared off. This belt failed at 88,000 miles because the owner failed to replace it at recommended interval of 60,000 miles. EXPLAIN **FIGURE 28-15** This timing belt broke because an oil leak from one of camshaft seals caused oil to get into and weaken belt. Most experts recommend replacing all engine seals in front of engine anytime a timing belt is replaced. If the timing belt travels over water pump, the water pump should also be replaced as a precaution.

DISCUSSION: Ask the students to explain the difference between a free-wheeling engine design & interference engine design.

18. **SLIDE 18** EXPLAIN **FIGURE 28-16** Many engines are of the interference design. If the timing belt (or chain) breaks, piston still moves up and down in cylinder while the valves remain stationary. With a freewheeling design, nothing is damaged, but in an interference engine, the valves are often bent. EXPLAIN **FIGURE 28-17** head from a Mercedes showing bent valves when timing chain stretched and skipped over crankshaft sprocket. When this happened, piston kept moving and bent valves.

Show VIDEO: CHECKING TIMING CHAIN SLACK: 1.16 Minutes
www.myautomotivelab.com
http://media.pearsoncmg.com/ph/chet/chet_mylabs/akamai/template/video640x480.php?title=Checking%20Timing%20Chain%20Slack&clip=pandc/chet/2012/automotive/Engines/A1T7.mov&caption=chet/chet_mylabs/akamai/2012/automotive/Engines/xml/A1T7.xml

DEMONSTRATION: Show proper procedure for checking a timing chain for excessive wear and looseness.

HANDS-ON TASK: Have the students measure the slack of a timing chain installed on an engine.

19. **SLIDE 19** EXPLAIN Camshaft Movement & EXPLAIN **FIGURE 28-18** slight angle and the curve on the bottom of a flat bottom lifter cause the lifter and the pushrod to rotate during normal operation.

ICONS	Ch28 Camshaft/Valve Train
	**20. SLIDE 20 EXPLAIN FIGURE 28-19** The lobe lift is the amount the cam lobe lifts the lifter. The blue circle is called the base circle. Because the rocker arm adds to this amount, the entire valve train has to be considered when selecting a camshaft that has the desired lift and duration. **21. SLIDE 21 EXPLAIN FIGURE 28-20** The ramps on the cam lobe allow the valves to be opened and closed quickly yet under control to avoid damaging valve train components, especially at high engine speeds
	**22. SLIDE 22 EXPLAIN TECH TIP**
	**DEMONSTRATION: DEMONSTRATE Show some examples of worn and/or broken timing belts.**
	**23 SLIDE 23 EXPLAIN ROCKER ARMS** **24. SLIDE 24 EXPLAIN FIGURE 28-21** A 1.5:1 ratio rocker arm means that dimension A is 1.5 times the length of dimension B. Therefore, if the pushrod is moved up 0.4 in. by the camshaft lobe, the valve will be pushed down (opened) 0.4 in. × 1.5, or 0.6 in. **25. SLIDE 25 EXPLAIN FIGURE 28-22** high-performance aluminum roller rocker arm. Both pivot & tip that contacts the stem of the valve are equipped with rollers to help reduce friction for more power and better fuel economy.
	**26. SLIDE 26 EXPLAIN FIGURE 28-23** Some engines today use rocker shafts to support rocker arms such as the V-6 engine with a single overhead camshaft located in the center of the cylinder head. **27. SLIDE 27 EXPLAIN FIGURE 28-24** typical stud-mounted rocker arm. **EXPLAIN FIGURE 28-25** Pushrod guide plates are bolted to the head and help stabilize the valve train, especially at high engine speeds.
	**28. SLIDE 28 EXPLAIN FREQUENTLY ASKED QUESTION**
	**29. SLIDE 29 EXPLAIN FIGURE 28-26** A pedestal-type rocker arm design that used one bolt for each rocker arm and is nonadjustable. If valve lash needs to be adjusted, different length pushrod(s) must be used.

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	**DISCUSSION: Ask the students to explain the advantages of roller rocker arms.**
	**DEMONSTRATION: Show examples of roller rocker arms as opposed to cast non-roller rocker arms.**
	**DEMONSTRATION: On an engine with adjustable rocker arms, the proper procedure for adjusting rocker arms**
	**HANDS-ON TASK: On an engine with adjustable rocker arms, have the students use the service information to look up the correct adjustment procedure. If this type of engine is not available just have them look up and print out the procedure**
	**ON-VEHICLE NATEF TASK: Inspect pushrods, rocker arms, rocker arm pivots and shafts for wear, bending, cracks, looseness, and blocked oil passages; determine necessary action. PAGES 132 & 133**
	**30. SLIDE 30 EXPLAIN TECH TIP**
	**31. SLIDE 31 EXPLAIN** Pushrods & **EXPLAIN FIGURE 28-27** Overhead valve engines are also known as pushrod engines because of long pushrod that extends from lifter to rocker arm. **32. SLIDE 32 EXPLAIN FIGURE 28-28** When timing chain broke, valves stopped moving up and down but pistons kept moving and hit valves causing pushrods to bend.
	**DEMONSTRATION: Show how to check for bent pushrods by rolling them across a flat surface.**
	**Some engines such as GM 2.8 L & 3.1 L use different lengths for intake and exhaust pushrods. Make sure not to mix pushrods up when disassembling these engines.**
	**33. SLIDE 33 EXPLAIN TECH TIP**

ICONS	Ch28 Camshaft/Valve Train
	**34. SLIDE 34** EXPLAIN TECH TIP
	**35. SLIDE 35** EXPLAIN **FIGURE 28–29** Hardened pushrods should be used in any engine that uses pushrod guides (plates). To determine if the pushrod is hardened, simply try to scratch the side of the pushrod with a pocketknife
	36. SLIDE 36 EXPLAIN **OVERHEAD CAMSHAFT VALVE TRAINS**
	37. SLIDE 37 EXPLAIN **FIGURE 28-30** Hydraulic lifters may be built into bucket-type lifters on some overhead camshaft engines. EXPLAIN **FIGURE 28-31** The use of cam followers allows the use of hydraulic lifters with an overhead camshaft design.
	38. SLIDE 38 EXPLAIN **FIGURE 28-32** Hydraulic lash adjusters (HLA) are built into the rocker arm on some OHC engines. Sometimes hydraulic lash adjusters may not bleed down properly if the wrong viscosity (SAE rating) oil is used.
	**DISCUSSION: Ask the students how oil viscosity may affect operation of hydraulic lash adjusters.**
	**DEMONSTRATION: Show examples of hydraulic lash adjusters.**
	**39. SLIDE 39** EXPLAIN Camshaft Specifications
	40. SLIDE 40 EXPLAIN **FIGURE 28-33** Graphic representation of a typical camshaft showing the relationship between the intake and exhaust valves. The shaded area represents the overlap period of 100 degrees.
	41. SLIDE 41 EXPLAIN **FIGURE 28-34** As the lobe center angle decreases, the overlap increases, with no other changes in the lobe profile lift and duration.
	42. SLIDE 42 EXPLAIN **FIGURE 28-35 Typical cam timing diagram.**
	43. SLIDE 43 EXPLAIN **CHART 28-1** Changing lobe separation angle has a major effect on engine operation.
	44. SLIDE 44 EXPLAIN **FIGURE 28-36** Typical high-performance camshaft specifications on a straight-line graph. Intake valve duration = 39 + 180 + 71 = 290 degrees. Exhaust valve duration = 7 + 180 + 47 = 234

ICONS	Ch28 Camshaft/Valve Train
	degrees. Because intake and exhaust valve specifications are different, the camshaft grind is called asymmetrical.
	45. SLIDE 45 EXPLAIN **FIGURE 28-37** Typical camshaft valve timing diagram with the same specifications as those shown in **FIGURE 28–36**
	**DISCUSSION: Ask the students to define valve overlap.**
	**HANDS-ON TASK: Have the students use service information to look up the valve overlap on a particular engine.**
	**DISCUSSION: Ask the students why some dual overhead cam engines may have a different camshaft profile for each of the intake valves and exhaust valves. (Answer: This creates an engine that is able to produce a high torque over a broader engine speed range.)**
	**Installing a high performance camshaft on a newer vehicle can have a significant impact on vehicle emissions.**
	**DISCUSSION: Ask the students why intake valve should open slightly before the piston reaches top dead center**
	**HANDS-ON TASK: Have the students calculate the lobe separation angle using camshaft data.**
	**46. SLIDE 46** EXPLAIN Lifters or Tappets
	47. SLIDE 47 EXPLAIN **FIGURE 28-38** Older engines used flat-bottom lifters, whereas all engines since the 1990s use roller lifters.
	48. SLIDE 48 EXPLAIN **FIGURE 28-39** All roller lifters must use some method to keep lifter straight and not rotating
	**DEMONSTRATION: Show disassembled hydraulic lifter**

ICONS	Ch28 Camshaft/Valve Train
	**DEMONSTRATION: Show some examples of solid and hydraulic lifters.**
	**49. SLIDE 49** EXPLAIN **FIGURE 28-40** cutaway of a flat-bottom solid lifter. Because this type of lifter contains a retaining ring and oil holes, it is sometimes confused with a hydraulic lifter that also contains additional parts. The holes in this lifter are designed to supply oil to the rocker arms through a hollow pushrod. **50. SLIDE 50** EXPLAIN **FIGURE 28-41** exploded view of a hydraulic roller lifter.
	**DEMONSTRATION: On an engine with roller lifters, show the proper installation of the roller lifter and retaining guides.**
	**When installing new lifters, immerse them in clean oil and pump them up manually to eliminate the air from the lifter.**
	**ON-VEHICLE NON-NATEF TASK: Inspect valve lifters; determine necessary action.**
	SEARCH INTERNET: Have the students search Internet and find a calculator program for calculating valve overlap. Have them share their findings with the class.
	**51. SLIDE 51** EXPLAIN Valve Train Lubrication
	**HANDS-ON TASK: Have the students use service information to determine how the camshaft, camshaft bearings, and lifters receive their lubrication.**
	**52. SLIDE 52** EXPLAIN Valve Train Problem Diagnosis & EXPLAIN **FIGURE 28-42** The cause of a misfire diagnostic trouble code was discovered to be a pushrod that had worn through the rocker arm on a General Motors 3.1 liter V-6 engine. **53. SLIDE 53** EXPLAIN **FIGURE 28-43** Shaft-mounted rocker arms are held in position by an assortment of

springs, spacers, and washers, which should be removed so that the entire shaft can be inspected for wear.

Lifters are noisy, always check oil level first. One of first signs of low oil level is noisy lifters because they pick up air. Excessively high oil level can also cause this noise.

DISCUSSION: Ask the students to discuss the possible causes of abnormal valve train noise.

54. **SLIDE 54** EXPLAIN TECH TIP

55. **SLIDE 55** EXPLAIN REAL WORLD FIX

56. **SLIDE 56** EXPLAIN TECH TIP

57. **SLIDE 57** EXPLAIN **Camshaft Removal**

HANDS-ON TASK: For a specific engine, have the students use service information to look up service procedure for removing and replacing camshaft.

58. **SLIDE 58** EXPLAIN **FIGURE 28-44** A dial indicator being used to measure cam lobe height.

DEMONSTRATION: Show how to measure the cam lobe height using a dial indicator.

HANDS-ON TASK: For a specific engine, have the students measure the cam lobe height using a dial indicator

Show VIDEO: MEASURING LOB LIFT: 1 MINUTE www.myautomotivelab.com

http://media.pearsoncmg.com/ph/chet/chet_mylabs/akamai/template/video640x480.php?title=Measuring%20Lobe%20Lift&clip=pandc/chet/2012/automotive/Engines/A1T8.mov&caption=chet/chet_mylabs/akamai/2012/automotive/Engines/xml/A1T8.xml

ICONS	Ch28 Camshaft/Valve Train
	**DEMONSTRATION: DEMONSTRATE Show how to measure the lift of camshaft and compare it to service specifications.**
	**HANDS-ON TASK: Have the students measure the lift of camshaft and determine if it meets specifications.**
	**ON-VEHICLE NON-NATEF TASK: Check camshaft for wear, damage, and out-of-round; determine necessary action.**
	**ON-VEHICLE NON-NATEF TASK: Inspect and replace camshaft and drive belt/chain; includes checking drive gear wear and backlash, end play, sprocket and chain wear, overhead cam drive sprocket(s), drive belt(s), belt tension, tensioners, camshaft reluctor ring/tone-wheel, and valve timing components; verify correct camshaft timing. PAGE 136**
	**59. SLIDE 59 EXPLAIN Chart 28-2** A comparison showing the effects of valve timing and lift on engine performance.
	**60. SLIDE 60 EXPLAIN** Variable Valve Timing **61. SLIDE 61 EXPLAIN CHART 28-3** purpose for varying cam timing includes providing for more engine torque and power over a wide engine speed and load range. **62. SLIDE 62 EXPLAIN FIGURE 28-45** Camshaft rotation during advance and retard. **63. SLIDE 63 EXPLAIN FIGURE 28-46** The camshaft is rotated in relation to the crankshaft by the PCM to provide changes in valve timing. **64. SLIDE 64 EXPLAIN Chart 28-4** Changing the exhaust cam timing mainly helps reduce exhaust emissions, whereas changing the intake cam timing mainly helps the engine produce increased power and torque. **65. SLIDE 65 EXPLAIN FIGURE 28-47** Spline cam phaser assembly

ICONS	Ch28 Camshaft/Valve Train
	**DEMONSTRATION: Show an example of a camshaft position actuator oil control valve.**
	**HANDS-ON TASK: Have students search service information to determine what controls camshaft position actuator oil control valve.**
	**DISCUSSION: Ask the students to discuss the advantages of intake and exhaust camshaft phasing.**
	**The control solenoid screen can become plugged if the oil is not changed regularly. This can cause changes in performance and emissions.**
	**66. SLIDE 66** EXPLAIN **FIGURE 28-48** Spline phaser.
	**67. SLIDE 67** EXPLAIN TECH TIP
	**68. SLIDE 68** EXPLAIN Variable Valve Timing & **FIGURE 28–49** The screen(s) protect the solenoid valve from dirt and debris that can cause the valve to stick. This fault can set a P0017 diagnostic trouble code (crankshaft position/camshaft position correlation error). **69. SLIDE 69** EXPLAIN **FIGURE 28-50** vane phaser is used to move the camshaft, using changes in oil pressure from the oil control valve. EXPLAIN **FIGURE 28-51** magnetically controlled vane phaser. **70. SLIDE 70** EXPLAIN **FIGURE 28-52** A camshaft position actuator used in a cam-in-block engine.
	**DEMONSTRATION: Using a scan tool and vehicle equipped with variable valve timing, show the students what variable valve timing data can be observed using the scan tool.**
	**HANDS-ON TASK: For a vehicle that uses variable valve timing, have the students use service information to read a description of the variable valve timing and how it is controlled on that vehicle.**

ICONS	Ch28 Camshaft/Valve Train
	**DEMONSTRATION: Show an example of a vane phaser system, if one is available.**
	**HANDS-ON TASK: Have the students use service information to research the role that the PCM plays in activation of the variable valve controls.**
	**ON-VEHICLE NATEF TASK: Establish camshaft position sensor indexing. PAGE 137**
	**Show ANIMATION: VARIABLE VALVE TIMING** **www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A1_Animation/Chapter28_Fig_28_48/index.htm
	**71. SLIDE 71 EXPLAIN FIGURE 28-53** A plastic mockup of a Honda VTEC system that uses two different camshaft profiles—one for low-speed engine operation and the other for high speed. **72. SLIDE 72 EXPLAIN FIGURE 28-54** Engine oil pressure is used to switch cam lobes on a VTEC system. **73. SLIDE 73 EXPLAIN FIGURE 28-55** Oil pressure applied to the locking pin causes the inside of the lifter to freely move inside the outer shell of the lifter, thereby keeping the valve closed. **74. SLIDE 74 EXPLAIN FIGURE 28-56** Active fuel management includes many different components and changes to the oiling system, which makes routine oil changes even more important on engines equipped with this system.
	**HANDS-ON TASK: For a vehicle with variable timing, have students' list PCM codes that are associated with the variable valve timing system.**
	**DEMONSTRATION: Using a scan tool, show how PWM is used to control the actuator solenoid.**
	**HANDS-ON TASK: Have students use service information to research VTEC system used by Honda.**

ICONS	Ch28 Camshaft/Valve Train
	**DEMONSTRATION:** Show some examples of camshaft position sensors.
	**DEMONSTRATION:** Show some examples, if available, of cylinder deactivation controls used by various OEMS.
	**DISCUSSION:** Ask the students to discuss the main purpose of cylinder deactivation. (Answer: Fuel economy.)
	**SEARCH INTERNET:** Have students search the Internet and discover the benefits of variable valve timing. Have them discuss their findings in class.
	**Talk through SUMMARY and questions**
	**HOMEWORK:** complete Ch28 crossword puzzle: http://www.jameshalderman.com/links/book_engine_theory_serv_7/cw/crossword_ch_28.pdf