Automotive Technology 6th Edition
Chapter 32 CAMSHAFTS & VALVE TRAINS
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 as listed: 1. Describe the purpose and function of camshafts. 2. Discuss camshaft drives and camshaft movement. 3. Discuss rocker arms and pushrods. 4. Explain overhead camshaft valve trains and camshaft specifications. 5. Explain lifters or tappets, valve train lubrication, and valve train problem diagnosis. 6. Explain the procedure for camshaft removal, measuring camshafts, and selecting a camshaft. 7. Explain variable valve timing, and variable lift and cylinder deactivation systems.
Establish the Mood or Climate	Provide a ***WELCOME,*** Avoid put downs and bad jokes.
Complete Essentials	Restrooms, breaks, registration, tests, etc.
Clarify and Establish Knowledge Base	Do a round robin of the class by going around the room and having each student give their backgrounds, years of experience, family, hobbies, career goals, or anything they want to share.

NOTE: This lesson plan is based on the 6th Edition Chapter Images found on Jim's web site @
www.jameshalderman.com

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http://www.jameshalderman.com/automotive_principles.html
NOTE: You can use Chapter Images or possibly Power Point files:

ICONS	Ch32 Camshaft/Valve Train
	**1. SLIDE 1 CH32 CAMSHAFTS & VALVE TRAINS** **2. SLIDE 2 EXPLAIN Figure 32-1** high-performance camshaft has a lobe that opens valve quickly and keeps it open for a long time. **3. SLIDE 3 EXPLAIN Figure 32-2** In many engines, camshaft drives the distributor and oil pump through a shaft from the end of the distributor. **4. SLIDE 4 EXPLAIN Figure 32-3** camshaft rides on bearings inside the engine block above the crankshaft on a typical cam-in-block engine. **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** **VALVE & SEAT SERVICE** **ON-VEHICLE ASEEDUCATION TASK Research CAMSHAFT SPECS** **5. SLIDE 5 EXPLAIN Figure 32-4** Parts of a cam and camshaft terms (nomenclature). **6. SLIDE 6 EXPLAIN Figure 32-5** 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. **7. SLIDE 7 EXPLAIN Figure 32-6** Worn camshaft with two lobes worn to the point of being almost round. **8. SLIDE 8 EXPLAIN FIGURE 32–7** camshaft powers the high-pressure fuel pump on engines equipped with gasoline direct injection. **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**

ICONS	Ch32 Camshaft/Valve Train
	DISCUSSION: **Ask the students what advantages overhead camshaft has as opposed to cam-in-block design.** **DEMONSTRATION:** **Show examples of steel and composite camshafts.** **DEMONSTRATION:** **Show example of a camshaft with excessive lobe wear.** 9. **SLIDE 9 EXPLAIN Figure 32-8** timing chain hydraulic tensioner. 10. **SLIDE 10 EXPLAIN FIGURE 32–9** By making the camshaft gear twice as large as the crankshaft gear, the camshaft rotates one revolution for every two of the crankshaft.. **Camshaft & Flat Lifter (View) (Download)** **Camshaft & Roller Lifter (View) (Download)** **VVT Operation (View) (Download)** **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, starts to break off in small pieces.** 11. **SLIDE 11 EXPLAIN Figure 32-10** replacement silent chain and sprockets. Original camshaft sprocket was aluminum with nylon teeth to control noise. This replacement set will not be noticeably louder than original and give many of miles of useful service. 12. **SLIDE 12 EXPLAIN Figure 32-11** 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 the chain. However, it is best to replace the timing chain and gear anytime the camshaft is replaced or the engine is disassembled for repair or overhaul.

ICONS	Ch32 Camshaft/Valve Train
	13. **SLIDE 13 EXPLAIN FIGURE 32–12** A typical overhead camshaft engine showing location of tensioner, water pump, and chain guide & timing marks. 14. **SLIDE 14 EXPLAIN FIGURE 32–13** This dual overhead camshaft (DOHC) engine uses one chain from the crankshaft to the intake cam and secondary chain to rotate the exhaust camshaft**.** 15. **SLIDE 15 EXPLAIN Figure 32-14** 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 the recommended interval of 60,000 miles. 16. **SLIDE 16 EXPLAIN Figure 32-15** typical timing belt that also drives the water pump **DISCUSSION: Ask the students to explain the difference between a free-wheeling engine design & interference engine design. Figures 32-14/15** 17. **SLIDE 17 EXPLAIN Figure 32-16** Many engines are of the interference design. If the timing belt (or chain) breaks, the piston still moves up and down in the cylinder while the valves remain stationary. With a freewheeling design, nothing is damaged, but in an interference engine, the valves are often bent. 18. **SLIDE 18 EXPLAIN Figure 32-17** 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. **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 Figure 32-18** slight angle and the curve on the bottom of a flat bottom lifter cause the lifter and the pushrod to rotate during normal operation. 20. **SLIDE 20 EXPLAIN Figure 32-19** lobe lift is amount 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 32-20** 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.

DEMONSTRATION: DEMONSTRATE Show some examples of worn and/or broken timing belts.

EXPLAIN TECH TIP: *Best to Warn the Customer*

A technician replaced a timing chain and gears on a high mileage Chevrolet V-8. The repair was accomplished correctly, yet after starting, the engine burned an excessive amount of oil. Before timing chain replacement, oil consumption was minimal. The replacement timing chain restored proper operation of the engine by restoring proper cam and valve timing, which increased engine vacuum. Increased vacuum can draw oil from the crankcase past worn piston rings and through worn valve guides during the intake stroke. Similar increased oil consumption problems occur if a valve job is performed on a high-mileage engine with worn piston rings and/or cylinders. To satisfy the owner of the vehicle, the technician had to disassemble and refinish the cylinders and replace rings. You should warn customers that increased oil usage might result from almost any engine repair to a high-mileage engine.

22. **SLIDE 22 EXPLAIN Figure 32-21** 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.

23. **SLIDE 23 EXPLAIN Figure 32-22** 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.

Rocker Arm Ratio (View) (Download)

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	24. **SLIDE 24 EXPLAIN Figure 32-23** 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. **DISCUSS FREQUENTLY ASKED QUESTION: *Are the Valves Adjustable?* If the stud has the same diameter for its whole length, the rockers are adjustable and the nut is the "interference" type (lock-type nut). *If stud has a shoulder of different diameter, rockers are nonadjustable* and the nut does not have interference threads.**
	**EXPLAIN TECH TIP: *Rocker Arm Shafts Can Cause Sticking Valves:* As oil oxidizes, it forms a varnish. Varnish buildup is particularly common on hot upper portions of the engine, such as rocker arm shafts. The varnish restricts clean oil from getting into and lubricating the rocker arms. The cam lobe can easily force the valves open, but the valve springs often do not exert enough force to fully close the valves. The result is an engine miss, which may be intermittent. Worn valve guides and/or weak valve springs can also cause occasional rough idle, uneven running, or an engine misfire.** 25. **SLIDE 25 EXPLAIN Figure 32-24** typical stud-mounted rocker arm. 26. **SLIDE 26 EXPLAIN Figure 32-25** Pushrod guide plates are bolted to the head and help stabilize the valve train, especially at high engine speeds. 27. **SLIDE 27 EXPLAIN Figure 32-26** 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. **DISCUSSION: Ask the students to explain the advantages of roller rocker arms.**

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Education Foundation	**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 ASEEDUCATION TASK** Inspect pushrods, rocker arms, rocker arm pivots and shafts for wear, bending, cracks, looseness, and blocked oil passages; determine necessary action (P-2) 28. **SLIDE 28 EXPLAIN Figure 32-27** Overhead valve engines are also known as pushrod engines because of long pushrod that extends from lifter to rocker arm. 29. **SLIDE 29 EXPLAIN Figure 32-28** 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.** 30. **SLIDE 30 EXPLAIN FIGURE 32–29** Hardened pushrods should be used in any engine that uses pushrod guides (plates). To determine if pushrod is hardened, simply try to scratch side of pushrod with a pocket knife. **EXPLAIN TECH TIP:** ***Scratch Test*: All pushrods used with guide plates must be hardened on the sides and on the tips. To easily determine if a pushrod is hardened, simply use a sharp pocketknife to scrape the wall of the pushrod. A heat-treated pushrod does not scratch. • SEE FIGURE 32–29.**

ICONS	Ch32 Camshaft/Valve Train
	31. SLIDE 31 EXPLAIN FIGURE 32–30 Older engines used flat-bottom lifters, whereas all engines since the 1990s use roller lifters. **32. SLIDE 32 EXPLAIN FIGURE 32–31** All roller lifters must use some method to keep the lifter straight and not rotating. **33. SLIDE 33 EXPLAIN FIGURE 32–32** A 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. **DISCUSSION: Ask the students how oil viscosity may affect operation of hydraulic lash adjusters.** **DEMONSTRATION: Show examples of hydraulic lash adjusters.** **34. SLIDE 34 EXPLAIN FIGURE 32–33** An exploded view of a hydraulic roller lifter.. **35. SLIDE 35 EXPLAIN FIGURE 32–34** Hydraulic lifters may be built into bucket type lifters on some overhead camshaft engines. **36. SLIDE 36 EXPLAIN FIGURE 32–35** use of cam followers allows use of hydraulic lifters with an overhead camshaft design. **37. SLIDE 37 EXPLAIN FIGURE 32–36** Hydraulic lash adjusters (HLA) are built into rocker arm on some OHC engines. Sometimes HLAs may not bleed down properly if the wrong viscosity (SAE rating) oil is used. **38. SLIDE 38 EXPLAIN FIGURE 32–37** 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.  **EXPLAIN TECH TIP: *The Rotating Pushrod Test*** **To quickly and easily test whether the camshaft is okay, observe if the pushrods are rotating when the engine is running. This test works on any overhead valve pushrod engine that uses flat-bottom lifters. Due to the slight angle on the cam lobe and lifter offset, the lifter (and pushrod) should rotate**

ICONS	Ch32 Camshaft/Valve Train
	**whenever the engine is running. To check, simply remove the rocker arm cover and observe the pushrods when the engine is running. If one or more pushrods are not rotating, this camshaft and/or the lifter for that particular valve is worn and needs to be replaced.** **DISCUSS CASE STUDY: *The Noisy Camshaft*** **The owner of an overhead cam 4-cylinder engine complained of a noisy engine. After taking the vehicle to several technicians and getting high estimates to replace the camshaft and followers, the owner tried to find a less expensive solution. Finally, another technician replaced serpentine drive belt on front of the engine and "cured" "camshaft" noise for a fraction of previous estimates. Many engines have been disassembled and/or overhauled because of a noise that was later determined to be from one of the following:** • **Loose or defective accessory drive belt(s)** • **Loose torque converter-to-flex plate (drive plate) bolts (nuts)** • **Defective mechanical fuel pump (if equipped)** **Summary:** **Complaint—Vehicle owner complained about an noisy engine.** **Cause—A defective accessory drive belt was found to be the cause of the noise.** **Correction—The accessory drive belt was replaced.** **39. SLIDE 39 EXPLAIN FIGURE 32–38** 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. **40. SLIDE 40 EXPLAIN FIGURE 32–39** Graphic representation of a typical camshaft showing relationship between intake and exhaust valves. The shaded area represents overlap period of 100 degrees. **DISCUSSION: Ask the students to define valve overlap.**

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	**HANDS-ON TASK:** Have the students use service information to look up the valve overlap on a particular engine. 41. **SLIDE 41 EXPLAIN FIGURE 32–40** 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 32–41** Typical cam timing diagram. **DISCUSS CHART 32-1** Changing lobe separation angle has major effect on engine operation. **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. **DEMONSTRATION:** Show disassembled hydraulic lifter **DEMONSTRATION:** Show some examples of solid and hydraulic lifters. **DEMONSTRATION:** On an engine with roller lifters, show the proper installation of the roller lifter and retaining guides.

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Education Foundation	**When installing new lifters, immerse them in clean oil and pump them up manually to eliminate the air from the lifter.** **ON-VEHICLE ASEEDUCATION TASK Inspect valve lifters; determine needed action.** **HANDS-ON TASK: Have students use service information to determine how the camshaft, camshaft bearings, and lifters receive their lubrication.** 43. **SLIDE 43 EXPLAIN FIGURE 32–42** 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 degrees. Because intake and exhaust valve specifications are different, the camshaft grind is called asymmetrical. 44. **SLIDE 44 EXPLAIN FIGURE 32–43** Typical camshaft valve timing diagram with same specifications as those shown in **Figure 32–42.** **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.** **HANDS-ON TASK: For a specific engine, have the students use service information to look up service procedure for removing and replacing camshaft.** 45. **SLIDE 45 EXPLAIN FIGURE 32-44** A dial indicator being used to measure cam lobe height. **DEMONSTRATION: Show how to measure the cam lobe height using a dial indicator.**

ICONS	Ch32 Camshaft/Valve Train
	HANDS-ON TASK: For a specific engine, have the students measure the cam lobe height using a dial indicator **DEMONSTRATION:** DEMONSTRATE Show how to measure the lift of camshaft and compare it to service specifications. **HANDS-ON TASK:** measure lift of camshaft and determine if it meets specifications. **ON-VEHICLE ASEEDUCATION TASK** Check camshaft for wear, damage, and out-of-round; determine needed action.
Education Foundation	
	ON-VEHICLE ASEEDUCATION TASK Inspect camshaft bearing surface for wear, damage, out-of-round, and alignment; determine needed action
Education Foundation	
	**DISCUSS CHART 32-2:** comparison showing valve timing & lift effects on performance.
	**DISCUSS CHART 32-3:** varying cam timing includes providing for more engine torque & power over a wide engine speed & load 46. **SLIDE 46 EXPLAIN Figure 32-45** Camshaft rotation during advance and retard. 47. **SLIDE 47 EXPLAIN Figure 32-46** The camshaft is rotated in relation to the crankshaft by the PCM to provide changes in valve timing. 48. **SLIDE 48 EXPLAIN Figure 32-47** Spline cam phaser assembly 49. **SLIDE 49 EXPLAIN Figure 32-48 S**pline phaser.
	**DISCUSS CHART 32-4: Changing exhaust cam timing mainly helps reduce exhaust emissions, whereas changing the intake cam timing mainly helps engine produce increased power and torque.**

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	**DEMONSTRATION:** **Show an example of a camshaft position actuator oil control valve.** **EXPLAIN TECH TIP:** ***Check the Screen on the Control Valve If There Are Problems*****: If a NOx emission failure at a state inspection occurs or a diagnostic trouble code is set related to the cam timing, remove the control valve and check for a clogged oil screen. A lack of regular oil changes can cause the screen to become clogged, thereby preventing proper operation. A rough idle is a common complaint because the spring may not be able to return the camshaft to the idle position after a long highway trip. • SEE FIGURE 32–49.** **Control solenoid screen can become plugged if the oil is not changed regularly. Changes in performance and emissions.** **50. SLIDE 50 EXPLAIN FIGURE 32-49** The screen(s) protect the solenoid valve from dirt and debris that can cause the valve to stick **51. SLIDE 51 EXPLAIN Figure 32-50** vane phaser is used to move camshaft, using changes in oil pressure from the oil control valve. **52. SLIDE 52 EXPLAIN Figure 32-51** magnetically controlled vane phaser. **53. SLIDE 53 EXPLAIN Figure 32-52** A camshaft position actuator used in a cam-in-block engine. **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.** **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.**

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	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. **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.)