Automotive Engines
Chapter 31 Crankshafts, Balance Shafts, & Bearings
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 ASE Engine Repair (A1) certification test content area "C" (Engine Block Diagnosis and Repair). 2. Describe the purpose and function of a crankshaft. 3. Discuss how to measure crankshafts. 4. Explain how crankshafts are machined and polished. 5. Discuss the purpose and function of balance shafts. 6. Discuss engine bearing construction and installation procedures.
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.

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	CH31 CRANKSHAFTS, BALANCE SHAFTS, BEARINGS **2. SLIDES 2-3 EXPLAIN Objectives & KEY TERMS**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE IS UPDATED REGULARLY** **4. SLIDE 4 EXPLAIN** Crankshaft **5. SLIDE 5 EXPLAIN FIGURE 31-1** Typical crankshaft with main journals that are supported by main bearings in the block. Rod journals are offset from the crankshaft centerline. **6. SLIDE 6 EXPLAIN FIGURE 31-2** crankshaft rotates on main bearings. Longitudinal (end-to-end) movement is controlled by the thrust bearing
	**Show ANIMATION: CRANKSHAFT COMPONENTS www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A1_Animation/Chapter31_Fig_31_1/index.htm
	**DEMONSTRATION: Show all components of crankshaft and describe function of each component.**
	**7. SLIDE 7 EXPLAIN FIGURE 31-3** ground surface on one of the crankshaft cheeks next to a main bearing supports thrust loads on the crank. **8. SLIDE 8 EXPLAIN FIGURE 31-4** distance from the crankpin centerline to the centerline of the crankshaft determines the stroke, which is the leverage available to turn the crankshaft.
	**DEMONSTRATION: Show location of thrust bearing and explain effect of thrust loads on the crankshaft.**
	**9. SLIDE 9 EXPLAIN** Crankshaft Construction & **EXPLAIN FIGURE 31-5** Wide separation lines of a forged crankshaft. **10. SLIDE 10 EXPLAIN FIGURE 31-6** Cast crankshaft showing the bearing journal overlap and a straight, narrow cast mold parting line. The amount of overlap determines the strength of the crankshaft.

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	**DISCUSSION: Have students discuss why crankshaft surfaces are ground to highly smooth finishes.**
	**DEMONSTRATION: Show separation line on a forged crankshaft and discuss its purpose.**
	11. **SLIDE 11** EXPLAIN **FIGURE 31-7** billet crankshaft showing how it is machined from a large round roll of steel, usually 4340 steel, at the right and the finished crankshaft on the left.
	**DISCUSSION: Ask students to discuss why NODULAR cast IRON crankshafts are used in most production automotive engines today. What are the benefits of using a cast crankshaft? ANS: COST**
	**DEMONSTRATION: Show students rod bearing journals and discuss how rod bearing offset determines stroke of the engine.**
	**DEMONSTRATION: Show billet crankshaft and how it differs from a forged or cast crankshaft.**
	12. **SLIDE 12** EXPLAIN Crankshaft Oiling Holes & EXPLAIN **FIGURE 31-8** Crankshaft sawed in half, showing drilled oil passages between the main and rod bearing journals. 13. **SLIDE 13** EXPLAIN **FIGURE 31-9** Typical chamfered hole in crankshaft bearing journal
	**DEMONSTRATION: Show differences in oiling between a normally drilled crankshaft & cross-drilled crankshaft.**
	14. **SLIDE 14** EXPLAIN Engine Crankshaft Types
	15. **SLIDE 15** EXPLAIN FREQUENTLY ASKED QUESTION

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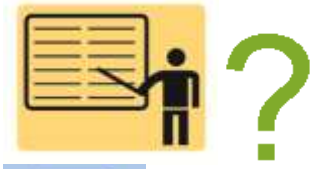	**16. SLIDE 16** EXPLAIN FREQUENTLY ASKED QUESTION **FIGURE 31-10** cross-drilled crankshaft is used on some production engines and is a common racing modification.
	**17. SLIDE 17** EXPLAIN REAL WORLD FIX
	**18. SLIDE 18** EXPLAIN **FIGURE 31-11** splayed crankshaft design is used to create an even-firing 90-degree V-6
	**DISCUSSION: (FIGURE 31-11) Have students explain differences between odd-firing & even firing 90-degree V-6 engine crankshafts. Is either configuration preferable? If so, why? Is there any advantage to a 60-degree V-6 engine crankshaft?**
	**19. SLIDE 19** EXPLAIN Counterweights & EXPLAIN **FIGURE 31-12** fully counterweighted 4-cylinder crankshaft
	**20. SLIDE 20** EXPLAIN FREQUENTLY ASKED QUESTION
	**21. SLIDE 21** EXPLAIN FREQUENTLY ASKED QUESTION **FIGURE 31-13** crank throw is halfway down on the power stroke. The piston on the left without an offset crankshaft has a sharper angle than the engine on the right with an offset crankshaft.
	**22. SLIDE 22** EXPLAIN **FIGURE 31-14** A crankshaft broken as a result of using the wrong torsional vibration damper. **23. SLIDE 23** EXPLAIN **FIGURE 31-15** hub of the harmonic balancer is attached to the front of the crankshaft. The elastomer (rubber) between the inertia ring and the center hub allows the absorption of crankshaft firing impulses.
	**DEMONSTRATION: Show crankshaft counterweights & discuss their purpose.**

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	**DEMONSTRATION: Show results of crankshaft vibration. Show damaged parts of the crankshaft & bearings.**
 	**DISCUSSION: (FIGURE 31-14) Ask students to discuss the causes of crankshaft vibrations and suggest ways of eliminating it.**
	**DEMONSTRATION: Show examples of a torsional vibration damper or harmonic balancer. Explain how it works to reduce the twisting vibrations of crankshaft.**
	**DEMONSTRATION: Show examples of balance shafts used in GM 4-cylinder engines. Why are 2 balance shafts used in a 4-cylinder engine?**
	**24. SLIDE 24 EXPLAIN TECH TIP**
 	**25. SLIDE 25 EXPLAIN TECH TIP FIGURE 31-16** GM high-performance balancer used on race engine.
 	**ON-VEHICLE NATEF TASK: Remove, inspect or replace crankshaft vibration damper (harmonic balancer) PAGE 158**
	**26. SLIDE 26 EXPLAIN EXTERNALLY AND INTERNALLY BALANCED ENGINES** **27. SLIDE 27 EXPLAIN FIGURE 31-17** In a 4-cylinder engine, the two outside pistons move upward at the same time as the inner pistons move downward, which reduces primary unbalance. **28. SLIDE 28 EXPLAIN FIGURE 31-18** Primary and secondary vibrations in relation to piston position
	**Show ANIMATION: BALANCING SHAFTS www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A1_Animation/Chapter31_Fig_31_19/index.htm
	**29. SLIDE 29 EXPLAIN** Balance Shafts & **EXPLAIN FIGURE 31-19** Two counter rotating balance shafts used to counterbalance the vibrations of a 4-cylinder engine **30. SLIDE 30 EXPLAIN FIGURE 31-20** GM 4-cylinder engine uses two balance shafts driven by a chain at the

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	rear of the crankshaft. 31. **SLIDE 31** EXPLAIN **FIGURE 31-21** Many 90-degree V-6 engines use a balance shaft to reduce vibrations & effectively cancel rocking motion (rocking couple) that causes engine to rock front to back
	**OPTIONAL SEARCH INTERNET: Have students use Internet to research balance shafts, including how they are designed to eliminate engine vibration, how they are driven, where they are located, and their benefits to 4-cylinder and V-6 engine operation.**
	32. **SLIDE 32** EXPLAIN Crankshaft Service 33. **SLIDE 33** EXPLAIN **FIGURE 31-22** Scored connecting rod bearing journal. 34. **SLIDE 34** EXPLAIN Crankshaft Service 35. **SLIDE 35** EXPLAIN **FIGURE 31-23** All crankshaft journals should be measured for diameter as well as taper and out-of-round. 36. **SLIDE 36** EXPLAIN **FIGURE 31-24** Check each journal for taper and out-of-round 37. **SLIDE 37** EXPLAIN **FIGURE 31-25** The rounded fillet area of the crankshaft is formed by the corners of the grinding stone. 38. **SLIDE 38** EXPLAIN **FIGURE 31-26** An excessively worn crankshaft can be restored to useful service by welding the journals, and then machining them back to the original size. EXPLAIN **FIGURE 31-27** All crankshafts should be polished after grinding. Both the crankshaft and the polishing cloth are being revolved 39. **SLIDE 39** EXPLAIN **FIGURE 31-28** Crankshafts should be stored vertically to prevent possible damage or warpage. This clever bench mounted tray for crankshafts not only provides a safe place to store crankshafts but is also out of the way and cannot be accidentally tipped.
	**ON-VEHICLE NON-NATEF TASK: Inspect crankshaft for straightness, journal damage, keyway damage; determine necessary action.**
	**Store crankshafts vertically to prevent damage and warping. This is also a safety procedure that prevents the crankshaft from falling on someone's foot if it is kicked**

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	**or knocked over, SEE FIGURE 31-28** **HANDS-ON TASK: Have students perform a visual inspection of a worn crankshaft. Remind students that they should be looking for warping, cracks, nicks, pits, and scoring of bearing journals.**
	**DISCUSSION: Ask students to discuss the causes for wear to the crankshaft bearing journals.**
	**DEMONSTRATION: Show how to use an outside micrometer to measure crankshaft main and rod journals for diameter, taper, & out-of-round wear.**
	**HANDS-ON TASK: Have students take measurements with an outside micrometer on crankshaft for which proper specifications for the rod and main journals are available. Have students compare their measurements to OEM specifications**
	**DEMONSTRATION: Show fillet area of a crankshaft. Why is this, the area of greatest stress? How is crankshaft stress relieved?**
	**40. SLIDE 40** EXPLAIN Engine Bearings **41. SLIDE 41** EXPLAIN **FIGURE 31-29** The two halves of a plain bearing meet at the parting faces. **42. SLIDE 42** EXPLAIN **FIGURE 31-30** Bearing wall thickness is not same from center to parting line. This is called eccentricity and is used to help create an oil wedge between the journal and the bearing. **43. SLIDE 43** EXPLAIN **FIGURE 31-31** Typical two- and three-layer engine bearing inserts showing the relative thickness of the various materials.
	**DEMONSTRATION: Show examples of crankshaft rod, main, and thrust bearings. Show the two halves of the bearing together with the matching parting faces and tabs. Show one bearing half with the oiling groove and one without the groove. Demonstrate how to fit each bearing half into main journal and connecting rod correctly.**

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	**44. SLIDE 44 EXPLAIN FIGURE 31-32** Typical bearing shell types found in modern engines: (a) half-shell thrust bearing, (b) upper main bearing insert, (c) lower main bearing insert, (d) full round-type camshaft bearing.
	**45. SLIDE 45 EXPLAIN FIGURE 31-33** Bearings are often marked with an undersize dimension. This bearing is used on a crankshaft with a ground journal that is 0.020 in. smaller in diameter than the stock size.
	**DEMONSTRATION: (Figure 31-32) Show standard size markings on a rod bearing and a main bearing, then show bearings marked with undersize dimensions. Ask them why they are called undersize bearing dimensions.**
	**HANDS-ON TASK: FIGURE 31-32 Have students measure the thickness of a rod bearing and a main bearing in several places on the bearing— lower side parting edge, and halfway between the lower side parting edge and the top middle crown of the bearing. Note the sizes. Why aren't they the same? Explain why.**
	**46. SLIDE 46 EXPLAIN FIGURE 31-34** Work hardened bearing material becomes brittle and cracks, leading to bearing failure.
	**DISCUSSION: 31-34 Ask students to discuss property of bearings that allows them to embed foreign particles and not allow them to score the crankshaft journal surface. Ask the students to talk about scoring & corrosion resistance properties of bearings.**
	**47. SLIDE 47 EXPLAIN FIGURE 31-35** Bearing material covers foreign material (Dirt) as it embeds into bearing
	**ON-VEHICLE NATEF TASK (A1A2) Connecting Rod Specification Measurement: Research applicable vehicle & service information (P-1) PAGES 16 & 20**

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	**HANDS-ON TASK:** Have students visually compare good bearings with those that have various amounts of wear. Have students note the wear and the bearing colors. Have them associate the colors with materials used to make bearings.
	**ON-VEHICLE NON-NATEF TASK:** Inspect main and connecting rod bearings for damage and wear; determine necessary action.
	**ON-VEHICLE NON-NATEF TASK:** Inspect auxiliary (balance, intermediate, idler, counter balance or silencer) shaft(s); inspect; determine necessary action.
	48. **SLIDE 48** EXPLAIN **Bearing Clearance &** EXPLAIN **FIGURE 31-36** Bearing spread and crush.
	**DEMONSTRATION: FIGURE 31-36** Use a new rod and main bearing to show what bearing spread and crush are. Compare used rod and main bearings with new ones. Explain that it is necessary to note size and shape of bearings as you install and replace used bearings with new ones.
	DISCUSSION why you need to have bearing spread and crush
	49. **SLIDE 49** EXPLAIN **Bearing Clearance &** EXPLAIN **FIGURE 31-37** Bearings are thinner at the parting line faces to provide crush relief.
	50. **SLIDE 50** EXPLAIN **FIGURE 31-38** Spun bearing. The lower cap bearing has rotated under the upper rod bearing.
	51. **SLIDE 51** EXPLAIN **FIGURE 31-39** tang & slot help index bearing in the bore. EXPLAIN **FIGURE 31-40** Many bearings are manufactured with a groove down the middle to improve the oil flow around the main journal
	**DEMONSTRATION: FIGURE 31-39:** Show students the tang & slot of a bearing. Explain why they are designed to fit together.
	52. **SLIDE 52** EXPLAIN TECH TIP

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	53. **SLIDE 53** EXPLAIN Camshaft Bearings & EXPLAIN **FIGURE 31-41** Cam-in-block engines support the camshaft with sleeve-type bearings. 54. **SLIDE 54** EXPLAIN **FIGURE 31-42** Camshaft bearings must be installed correctly so that oil passages are not blocked. 55. **SLIDE 55** EXPLAIN **FIGURE 31-43** Some overhead camshaft engines use split bearing inserts.
	**DISCUSSION: 31-41 Ask students to discuss cam bearings' shape and design. Ask them to discuss why it is important to put the right numbered bearing into right camshaft journal. Ask them to discuss why it is important to align oil passage holes during installation.**
	**DEMONSTRATION: Show difference between OHC bearings and in the cam-in-block full round bearings. Show different types of overhead cam engines and the types of bearings used on each.**
	**ON-VEHICLE NON-NATEF TASK: Check camshaft for wear, damage, and out-of-round; determine necessary action.**
	**ON-VEHICLE NON-NATEF TASK: Inspect camshaft bearing surface for wear, damage, out-of-round, and alignment; determine necessary action.**
	**ON-VEHICLE NON-NATEF TASK: Inspect and measure camshaft bearings; determine necessary action.**
	**ON-VEHICLE NON-NATEF TASK: Install engine covers, using gaskets and seals as required**
	**Talk through SUMMARY and questions**
	**HOMEWORK: complete Ch31 crossword puzzle: http://www.jameshalderman.com/links/book_engine_theory_serv_7/cw/crossword_ch_31.pdf**