Automotive Technology 6th Edition
Chapter 35 Crankshafts, Balance Shafts, & Bearings
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. Explain the purpose of the crankshaft, crankshaft construction, and crankshaft oiling holes. 2. Discuss the different engine crankshaft types. 3. Explain the purpose and function of counterweights. 4. Discuss engine balance, and explain externally and internally balanced engines. 5. Explain the purpose of balance shafts. 6. Discuss crankshaft service. 7. Describe engine bearings and discuss the importance of bearing clearance. 8. Discuss camshaft bearings.
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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NOTE: You can use Chapter Images or possibly Power Point files:

ICONS	Ch35 Crankshaft/Bearings
	**CH35 CRANKSHAFTS, BALANCE SHAFTS, BEARINGS** 2. **SLIDE 2 EXPLAIN Figure 35-1** Typical crankshaft with main journals that are supported by main bearings in the block. Rod journals are offset from the crankshaft centerline. 3. **SLIDE 3 EXPLAIN Figure 35-2** crankshaft rotates on main bearings. Longitudinal (end-to-end) movement is controlled by the thrust bearing. **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 all components of crankshaft and describe function of each component.** 4. **SLIDE 4 EXPLAIN Figure 35-3** ground surface on one of the crankshaft cheeks next to a main bearing supports thrust loads on the crank. 5. **SLIDE 5 EXPLAIN Figure 35-4** 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.** 6. **SLIDE 6 EXPLAIN Figure 35-5** Wide separation lines of a forged crankshaft. 7. **SLIDE 7 EXPLAIN Figure 35-6** 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. 8. **SLIDE 8 EXPLAIN Figure 35-7** 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. 9. **SLIDE 9 EXPLAIN Figure 35-8** Crankshaft sawed in half, showing drilled oil passages between the main and rod bearing journals. 10. **SLIDE 10 EXPLAIN Figure 35-9** Typical chamfered hole in crankshaft bearing journal **DEMONSTRATION:** Show differences in oiling between a normally drilled crankshaft & cross-drilled crankshaft. **DISCUSS FREQUENTLY ASKED QUESTION:** ***What Does a "Cross-Drilled Crankshaft" Mean?*** **A cross-drilled crankshaft means that there are two, instead of only one, oil hole leading from the main bearing journal to the rod bearing journal. Oil is supplied to the main bearing journals through oil galleries in the block. A cross-drilled crankshaft has 2 outlet holes for oil to reach the drilled passage that supplies**

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	**oil to rod journal. • SEE FIGURE 35–10.** 11. **SLIDE 11 EXPLAIN Figure 35-10** cross-drilled crankshaft is used on some production engines and is a common racing modification. 12. **SLIDE 12 EXPLAIN Figure 35-11** splayed crankshaft design is used to create an even-firing 90-degree V-6. **DISCUSS CASE STUDY: *The Mysterious Engine Vibration*: Buick 3.8 liter V-6 engine vibrated the whole car after a new short block had been installed. The technician who had installed the replacement engine did all of following:** **1. Checked spark plugs** **2. Checked spark plug wires** **3. Disconnected torque converter from flex plate (drive plate) to eliminate possibility of a torque converter or automatic transmission pump problem** **4. Removed all accessory drive belts one at a time** **Yet the vibration still existed.** **Another technician checked the engine mounts and found that the left (driver's side) engine mount was out of location, ripped, and cocked. The transmission mount was also defective. After the technician replaced both mounts and made certain that all mounts were properly set, vibration was eliminated.** **Summary:** **Complaint—Vehicle vibrated after a replacement engine block was installed.** **Cause—Defective engine and transmission mounts.** **Correction—Both mounts were replaced, which corrected the vibration.** **DISCUSSION: 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?** 13. **SLIDE 13 EXPLAIN Figure 35-12** fully counterweighted 4-cylinder crankshaft

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	**DISCUSS FREQUENTLY ASKED QUESTION:** ***What Is an Offset Crankshaft?*** **To reduce side loads, some vehicle manufacturers offset crankshaft from center. For example, if an engine rotates clockwise as viewed from the front, the crankshaft may be offset to left to reduce the angle of the connecting rod during power stroke. • SEE FIGURE 35–13.** **The offset usually varies from 1/16 to 1/2 inch, depending on make and model. Many inline four-cylinder engines used in hybrid electric vehicles use an offset crankshaft.** 14. **SLIDE 14 EXPLAIN Figure 35-13** 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. 15. **SLIDE 15 EXPLAIN Figure 35-14** crankshaft broken as a result of using the wrong torsional vibration damper. 16. **SLIDE 16 EXPLAIN Figure 35-15** 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.** **DEMONSTRATION: Show results of crankshaft vibration. Show damaged parts of the crankshaft & bearings.** **DISCUSSION: 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?**

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	**EXPLAIN TECH TIP:** ***High Engine Speeds Require High-Performance Parts:*** **Do not go racing with stock parts. A stock harmonic balancer can come apart and the resulting vibration can break the crankshaft if engine is used for racing. Check the Internet or race part suppliers for recommended balancer to use. • SEE FIGURE 35–16.** 17. **SLIDE 17 EXPLAIN Figure 35-16** GM high-performance balancer used on race engine. **ON-VEHICLE ASEEDUCATION TASK: Remove, inspect or replace crankshaft vibration damper (harmonic balancer)**
	18. **SLIDE 18 EXPLAIN Figure 35-17** 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. 19. **SLIDE 19 EXPLAIN Figure 35-18** Primary and secondary vibrations in relation to piston position 20. **SLIDE 20 EXPLAIN Figure 35-19** Two counter rotating balance shafts used to counterbalance the vibrations of a 4-cylinder engine 21. **SLIDE 21 EXPLAIN Figure 35-20** GM 4-cylinder engine uses two balance shafts driven by a chain at the rear of the crankshaft. 22. **SLIDE 22 EXPLAIN Figure 35-21** Many 90-degree V-6 engines use a balance shaft to reduce vibrations and effectively cancel a 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. Hold a class discussion during next class on students' findings.**

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	23. SLIDE 23 EXPLAIN Figure 35-22 Scored connecting rod bearing journal. **24. SLIDE 24 EXPLAIN Figure 35-23** All crankshaft journals should be measured for diameter as well as taper and out-of-round. **25. SLIDE 25 EXPLAIN Figure 35-24** Check each journal for taper and out-of-round. **26. SLIDE 26 EXPLAIN Figure 35-25** The rounded fillet area of the crankshaft is formed by the corners of the grinding stone. **27. SLIDE 27 EXPLAIN Figure 35-26** An excessively worn crankshaft can be restored to useful service by welding the journals, and then machining them back to the original size. **ON-VEHICLE ASEEDUCATION TASK Inspect crankshaft for straightness, journal damage, keyway damage; determine needed action.** **28. SLIDE 28 EXPLAIN Figure 35-27** All crankshafts should be polished after grinding. Both the crankshaft and the polishing cloth are being revolved **29. SLIDE 29 EXPLAIN FIGURE 35.28** Crankshafts should be stored vertically to prevent damage or warpage **Store crankshafts vertically to prevent damage and warping. Also a safety procedure that prevents the crankshaft from falling on someone's foot if it is kicked or knocked over, SEE FIGURE 35-28** **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.**

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	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? 30. **SLIDE 30 EXPLAIN Figure 35-29** two halves of a plain bearing meet at the parting faces. 31. **SLIDE 31 EXPLAIN Figure 35-30** 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. 32. **SLIDE 32 EXPLAIN Figure 35-31** 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. 33. **SLIDE 33 EXPLAIN Figure 35-32** 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. 34. **SLIDE 34 EXPLAIN Figure 35-33** 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 35-32)** 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.

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	HANDS-ON TASK: 35-32 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. 35. **SLIDE 35 EXPLAIN Figure 35-34** Work hardened bearing material becomes brittle and cracks, leading to bearing failure. **DISCUSSION: 35-34** 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. 36. **SLIDE 36 EXPLAIN Figure 35-35** Bearing material covers foreign material (Dirt) as it embeds into bearing **ON-VEHICLE ASEEDUCATION TASK** **Connecting Rod Specification Measurement: Research applicable vehicle & service information**
Education Foundation	**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 ASEEDUCATION TASK** Inspect main and connecting rod bearings for damage and wear; determine needed action.
Education Foundation	**ON-VEHICLE ASEEDUCATION TASK** Inspect auxiliary (balance, intermediate, idler, counter balance or silencer) shaft(s); inspect; determine needed action.

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	37. **SLIDE 37 EXPLAIN Figure 35-36** Bearing spread and crush. **DEMONSTRATION: 35-36 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** 38. **SLIDE 38 EXPLAIN Figure 35-37** Bearings are thinner at the parting line faces to provide crush relief. 39. **SLIDE 39 EXPLAIN Figure 35-38** Spun bearing. The lower cap bearing has rotated under the upper rod bearing 40. **SLIDE 40 EXPLAIN Figure 35-39** tang & slot help index bearing in the bore. **DISCUSS FREQUENTLY ASKED QUESTION: *Why Do Some Bearings Have a Tang and Others Do Not?* Many newer engines are being built without a bearing locating tang (lug). The tang is used to place the bearing shell in the correct location over the bearing journal. If an engine does not have tang, the technician needs to carefully locate the bearing to make sure that the oil hole aligns with the housing, as well as to prevent interference between the edge of the bearing and crankshaft (fillet area). Deleting the tang from the bearing and the required notch in the housing reduce amount of machining required, which helps reduce cost of the engine manufacture.** **DEMONSTRATION: 35-39: Show students the tang & slot of a bearing. Explain why they are designed to fit together.**

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	41. **SLIDE 41 EXPLAIN Figure 35-40** Many bearings are manufactured with a groove down the middle to improve the oil flow around the main journal 42. **SLIDE 42 EXPLAIN Figure 35-41** Cam-in-block engines support the camshaft with sleeve-type bearings. 43. **SLIDE 43 EXPLAIN Figure 35-42** Camshaft bearings must be installed correctly so that oil passages are not blocked. 44. **SLIDE 44 EXPLAIN Figure 35-43** Some overhead camshaft engines use split bearing inserts. **DISCUSSION: 35-41 discuss cam bearings' shape and design. Ask 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 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	**ON-VEHICLE ASEEDUCATION TASK** **Establish camshaft position sensor indexing.**
Education Foundation	**ON-VEHICLE ASEEDUCATION TASK Inspect and measure camshaft bearings; determine needed action.**
Education Foundation	

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Education Foundation	ON-VEHICLE ASEEDUCATION TASK Connecting Rod Specification Measurement: Research applicable vehicle & service information ON-VEHICLE ASEEDUCATION TASK Install engine covers, using gaskets and seals as required