Automotive Engines
Chapter 18 Ignition System Operation & Diagnosis
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 learning objectives to students. 1. Prepare for ASE Engine Performance (A8) certification test content area "B" (Ignition System Diagnosis and Repair). 2. Explain how ignition coils create 40,000 volts. 3. Describe the operation of distributor, waste-spark and coil-on-plug ignition systems. 4. Explain how to inspect and replace spark plugs. 5. Discuss what to inspect and look for during a visual inspection of the ignition system.
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	Ch18 Ignition System OP & Diagnosis
	**1. SLIDE 1 Ch18 Ignition System OP & Diagnosis** **2. SLIDES 2-3 EXPLAIN OBJECTIVES & KEY TERMS** **4. SLIDES 4-5 EXPLAIN IGNITION SYSTEM**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE IS UPDATED REGULARLY**
	**6. SLIDE 6 EXPLAIN FIGURE 18-1** high-voltage pulse is sent to spark plug to ignite air–fuel mixture in cylinder
	**DEMONSTRATION: Show a point-type distributor. Review its major components & SHOW HOW TO SET AIR GAP. Show major components of a distributor ignition system.**
	**7. SLIDE 7 EXPLAIN FIGURE 18-2** Some ignition coils are electrically connected, called married (top figure), whereas others use separate primary and secondary windings, called divorced (lower figure). The polarity (positive or negative) of a coil is determined by the direction in which the coil is wound.
	**DISCUSSION: Have the students talk about ignition coil operation. What process does an ignition use to produce a high-voltage spark from an ignition coil?**
	**8. SLIDE 8 EXPLAIN FIGURE 18-3** The steel lamination used in an **E coil** helps increase the magnetic field strength, which helps the coil produce higher energy output for a more complete combustion in the cylinders **9. SLIDE 9 EXPLAIN FIGURE 18–4** The primary windings are inside the secondary windings on this General Motors coil
	**DISCUSSION: Have the students discuss the construction of an ignition coil. What is at the core of an ignition coil? What is the purpose of core?**

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	**HANDS-ON TASK:** Have students **disassemble old coils**. Have them identify internal components and point out electrical connections. **OPTION:** students draw or describe the primary and secondary circuits.
	**10. SLIDE 10** EXPLAIN **FIGURE 18-4** The primary windings are inside the secondary windings on this General Motors coil
	**DEMONSTRATION:** Using ignition **oscilloscope**, show students typical connecting procedure for obtaining ignition patterns.
	**You should not check for spark by pulling plug wire on running engine. In addition to risking personal injury, you could damage or shorten electronic ignition components life. Method of checking for cylinder firing was used on older systems.**
	**11. SLIDE 11** EXPLAIN WARNING
	**Show ANIMATION: IGNITION OPERATION www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A16_Animation/Chapter56_Fig_56_4/index.htm
	**12. SLIDE 12** EXPLAIN IGNITION SWITCHING & TRIGGERING **13. SLIDE 13** EXPLAIN **FIGURE 18–6** Operation of a typical pulse alternator (pickup coil). At bottom is a line drawing of a typical scope pattern of the output voltage of a pickup coil. The module receives this voltage from pickup coil and opens ground circuit to ignition coil when the voltage starts down from its peak (just as the reluctor teeth start moving away from the pickup coil)
	**DISCUSSION:** Have the students talk about the **primary & secondary ignition circuits**. How do the 2 circuits function independently and how do

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	they interact? **DISCUSSION: Using an ignition system wiring diagram, have the students locate triggering device. How does this triggering device work?**
	14. **SLIDE 14 EXPLAIN FIGURE 18–7 magnetic sensor uses a permanent magnet** surrounded by a coil of wire. The notches of the crankshaft (or camshaft) create a variable magnetic field strength around the coil. When a metallic section is close to the sensor, the magnetic field is stronger because metal is a better conductor of magnetic lines of force than air
	**Show ANIMATION: SIGNAL GENERATION FORM PERMANENT MAGNET www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A1_Animation/Chapter18_Fig_18_7/index.htm
	15. **SLIDE 15 EXPLAIN FIGURE 18–8 Hall-effect sensor** produces an on-off voltage signal whether it is used with a blade or a notched wheel 16. **SLIDE 16 EXPLAIN FIGURE 18–9** Some **Hall-effect sensors look** like magnetic sensors. This Hall-effect camshaft reference sensor and crankshaft position sensor have an electronic circuit built in that creates a 0 to 5 volt signal as shown at the bottom. These Hall-effect sensors have three wires: a power supply (8 volts) from computer (controller), a signal (0 to 5 volts), and a signal ground 17. **SLIDE 17 EXPLAIN FIGURE 18–10** (a) Typical optical distributor. (b) Cylinder I slit signals computer the piston position for cylinder I. The 1-degree slits provide accurate engine speed information to the PCM
	18. **SLIDE 18 EXPLAIN TECH TIP**
	19. **SLIDE 19 EXPLAIN OPTICAL DISTRIBUTORS FIGURE 18–11** A light shield being installed before the rotor is attached
	20. **SLIDE 20 EXPLAIN TECH TIP**

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	**21. SLIDE 21 EXPLAIN DI Distributor Ignition**
	22. SLIDE 22 EXPLAIN DI Distributor Ignition & FIRING ORDER FIGURE 18–12 The firing order is cast or stamped on the intake manifold on most engines that have a distributor ignition
	**HANDS-ON TASK: Have students identify Proper Firing Order for a selected vehicle in the shop. Then have them verify the spark plug wire routing. Grade them on their understanding of where to find the firing order and location of the spark plug wires**
	**DEMONSTRATION: Review importance of camshaft & crankshaft timing. Use opened timing cover to emphasize timing markings and what is happening to piston & and valve positions**
	**23. SLIDE 23 EXPLAIN WASTE SPARK IGNITION SYSTEMS & FIGURE 18–13** A waste-spark system fires one cylinder while its piston is on the compression stroke and into paired or companion cylinders while it is on the exhaust stroke. In a typical engine, it requires only about 2 to 3 kV to fire the cylinder on the exhaust stroke. The remaining coil energy is available to fire the spark plug under compression (typically about 8 to 12 kV)
	**24. SLIDE 24 EXPLAIN FREQUENTLY ASKED QUESTION**
	**Show ANIMATION: WASTE SPARK www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A16_Animation/Chapter56_Fig_56_21/index.htm
	**Waste Spark Ignition System** **Show ANIMATION: WASTE SPARK**
	**DEMONSTRATION: DEMO WASTE-SPARK IGNITION SYSTEM OPERATION**

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	**DISCUSSION: Have the students talk about WASTE-SPARK IGNITION SYSTEMS. Review reverse polarity that is occurring in a DIS. What is the path of the current?**
	**DISCUSSION: Have the students review the purpose of a crankshaft sensor (CKP). Why is there adjustment on some engines?**
	**25. SLIDE 25 EXPLAIN TECH TIP**
	**26. SLIDE 26 EXPLAIN FIGURE 18–14** Typical wiring diagram of a V-6 **waste-spark ignition system**
	27. SLIDE 27 EXPLAIN waste-spark ignition system & FIGURE 18–15 The slight (5 microsecond) difference in the firing of the companion cylinders is enough time to allow the PCM to determine which cylinder is firing on the compression stroke
	**28. SLIDE 28 EXPLAIN Coil-On-Plug Ignition & FIGURE 18–16** A typical coil-on-plug ignition system showing the triggering and the switching being performed by the PCM from input from the crankshaft position sensor
	**Show ANIMATION: COIL-ON-PLUG OPERATION www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A1_Animation/Chapter18_Fig_18_16_b/index.htm
	**29. SLIDE 29 EXPLAIN Figure 18-17** overhead camshaft engine equipped with variable valve timing on both the intake and exhaust camshafts and the coil-on-plug ignition
	30. SLIDE 30 EXPLAIN Coil-On-Plug Ignition
	**31. SLIDE 31 EXPLAIN SAFETY TIP**
	**DISCUSSION: What does the coil-on-plug (COP) ignition system eliminate?**

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	**DEMONSTRATION: Show the students COP ignition systems with 2 & 3 primary wires and explain the differences.**
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	32. **SLIDE 32 EXPLAIN Coil-On-Plug Ignition & FIGURE 18–18** A Chrysler Hemi V-8 that has two spark plugs per cylinder. The coil on top of one spark fires that plug plus, through a spark plug wire, fires a plug in the companion cylinder 33. **SLIDE 33 EXPLAIN Coil-On-Plug Ignition & FIGURE 18–19** A DC voltage is applied across the spark plug gap after the plug fires and the circuit can determine if the correct air-fuel ratio was present in the cylinder and if knock occurred. The applied voltage for ion-sensing does not jump the spark plug gap, but determines the conductivity of the ionized gases left over from the combustion process
	**HANDS-ON TASK: Have students draw wiring diagrams of 2 & 3 wire COP primary ignition systems. Grade them on accuracy**
	**DEMONSTRATION: Show how to replace Crankshaft (CKP)/camshaft position sensors (CMP) make adjustments using gauging tool. Show how to monitor crankshaft/camshaft position sensors using scan tool**
	34. **SLIDE 34 EXPLAIN KNOCK SENSORS & FIGURE 18–20** typical knock sensor on side of the block. Some are located in the "V" of a V-type engine and are not noticeable until the intake manifold has been removed 35. **SLIDE 35 EXPLAIN KNOCK SENSORS & FIGURE 18–21** A typical waveform from a knock sensor during a spark knock event. This signal is sent to the computer which in turn retards the ignition timing. This timing retard is accomplished by an output command from the computer to either a spark advance control unit or directly to the ignition module

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	**36. SLIDE 36** EXPLAIN REAL WORLD FIX
	**DISCUSSION: Discuss what to inspect and look for during a visual inspection of the ignition system**
	**37. SLIDE 37** EXPLAIN **IGNITION SYSTEM DIAGNPSIS** & EXPLAIN **FIGURE 18-22** spark tester looks like a regular spark plug with an alligator clip attached to the shell. This tester has a specified gap that requires at least 25,000 volts (25 kV) to fire
	**38. SLIDE 38** EXPLAIN **IGNITION SYSTEM DIAGNPSIS & FIGURE 18-23** A close-up showing the recessed center electrode on a spark tester. It is recessed 3/8 in. into the shell and the spark must then jump another 3/8 in. to the shell for a total gap of 3/4 in
	39. SLIDE 39 EXPLAIN **IGNITION SYSTEM DIAGNPSIS &FIGURE 18–24** Checking an ignition coil using a multimeter set to read ohms
	**DEMONSTRATION: Show how to properly use a Spark Tester to check for spark**
	**40. SLIDE 40** EXPLAIN TECH TIP
	**DISCUSSION: DISCUSS spark color. How can spark color be used to determine spark quality?**
	**ON-VEHICLE NATEF TASK A6A2** **Spark Plug Specifications: Research applicable vehicle and service information, such as engine management system operation, vehicle service history, service precautions, and TSBs. PAGES 16 & 20**
	**41. SLIDE 41** EXPLAIN **FIGURE 18–25** Measuring the resistance of an HEI pickup coil using a digital multimeter set to the ohms position. The reading on the face of the meter is 0.796 kΩ or 796 ohms in the middle of the 500 to 1,500 ohm specifications

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	42. SLIDE 42 EXPLAIN FIGURE 18–26 The connection required to test a Hall-effect sensor. A typical waveform from a Hall-effect sensor
	43. SLIDE 43 EXPLAIN FIGURE 18–27 (a) The low-resolution signal has the same number of pulses as the engine has cylinders. (b) A dual-trace pattern showing both the low-resolution signal and the high-resolution signals that usually represent 1 degree of rotation.
	**44. SLIDE 44 EXPLAIN TECH TIP**
	**45. SLIDE 45 EXPLAIN TECH TIP**
	**46. SLIDE 46 EXPLAIN FIGURE 18–28** A track inside an ignition coil is not a short, but a low-resistance path or hole that has been burned through from the secondary wiring to the steel core
	**47. SLIDE 47 EXPLAIN Spark Plug Wire Inspection**
	48. SLIDE 48 EXPLAIN FIGURE 18–29 Corroded terminals on a waste-spark coil can cause misfire diagnostic trouble codes to be set
	49. SLIDE 49 EXPLAIN FIGURE 18–30 This spark plug boot on an overhead camshaft engine has been arcing to the valve cover causing a misfire to occur
	50. SLIDE 50 EXPLAIN FIGURE 18–31 Measuring the resistance of a spark plug wire with a multimeter set to the ohms position. The reading of 16.03 kΩ (16,030 ohms) is okay because the wire is about 2 ft long. Maximum allowable resistance for a spark plug wire this long would be 20 kΩ (20,000 ohms)
	**51. SLIDE 51 EXPLAIN TECH TIP**
	**52. SLIDE 52 EXPLAIN Figure 18-32** Spark plug wire boot pliers are a handy addition to any tool box
	**53. SLIDE 53 EXPLAIN TECH TIP**
	**54. SLIDE 54 EXPLAIN FIGURE 18–33** Always take the time to install spark plug wires back into the original holding brackets (wiring combs).

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	**HANDS-ON TASK: Have students use ohmmeter to test spark plug wires for continuity and compare collected values to specifications to determine condition.**
	**55. SLIDE 55 EXPLAIN Spark Plugs & EXPLAIN FIGURE 18-34** Parts of spark plug **56. SLIDE 56 EXPLAIN Spark Plugs & FIGURE 18–35** The heat range of a spark plug is determined by distance the heat flows from the tip to the cylinder head
	**DISCUSSION: Have students discuss spark plug heat range & how it affects engine operation and emissions. Is it ever acceptable or beneficial to vary from OEM recommendations?**
	**Be sure to check the reach of any new spark plugs being installed. Installing spark plugs with the wrong reach into an engine may cause severe engine damage.**
	**57. SLIDE 57 EXPLAIN FIGURE 18–36** When removing spark plugs, it is wise to arrange them so that they can be compared and any problem can be identified with a particular cylinder.
	**DISCUSSION: discuss importance of keeping spark plugs in correct order during removal. How can the spark plugs help to diagnose engine operating condition? FIGURE 18-36**
	**58. SLIDE 58 EXPLAIN FIGURE 18–37** spark plug thread chaser is a low-cost tool that hopefully will not be used often, but is necessary in order to clean the threads before installing new spark plugs
	**DISCUSSION: Have the students talk about the steps for replacing spark plugs. Why should the engine be allowed to cool before removing spark plugs?**
	**59. SLIDE 59 EXPLAIN Spark Plugs & FIGURE 18–38** A normally worn spark plug that uses a tapered platinum-tipped center electrode. **FIGURE 18–39** Spark plug removed from an engine after a 500 mile race. Note the

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	clipped side (ground) electrode. The electrode design and narrow (0.025 in.) gap are used to ensure that a spark occurs during extremely high engine speed operation. The color and condition of the spark plug indicate that near-perfect combustion has been occurring.
	**60. SLIDE 60** EXPLAIN **Spark Plugs & FIGURE 18–40** Typical worn spark plug. Notice the rounded center electrode. The deposits indicate a possible oil usage problem. **FIGURE 18–41** New spark plug that was fouled by an overly rich air-fuel mixture. The engine from which this spark plug came had a defective (stuck partially open) injector on this one cylinder only
	61. SLIDE 61 EXPLAIN **CHART 18-1**
	**62. SLIDE 62** EXPLAIN **TECH TIP**
	**63. SLIDE 63** EXPLAIN **FIGURE 18–42 Ignition timing** marks are found on the harmonic balancers on engines equipped with distributors that can be adjusted for timing
	64. SLIDE 64 EXPLAIN **FIGURE 18–43** The initial (base) timing is where the spark plug fires at idle speed. The PCM then advances the timing based primarily on engine speed
	65. SLIDE 65 EXPLAIN **FIGURE 18–44** (a) Typical SPOUT connector as used on many Ford engines equipped with distributor ignition (DI). (b) connector must be opened (disconnected) to check and/or adjust ignition timing. On DIS/EDIS systems, the connector is called SPOUT/SAW (spark output/spark angle word)
	**66. SLIDE 66** EXPLAIN **IGNITION SYSTEM DIAGNOSIS CHART**
	**DEMONSTRATION: Review with students how to use a hand-held oscilloscope (GMM), including setup and interpreting waveform patterns. Then show them how to check pickup on an electronic ignition system using an oscilloscope**

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	**Show VIDEO: 5 MINUTES RANDOM MISFIRE DETECTION www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_mylabs/akamai/template/video640x480.php?title=Case%20Study%203%20Random%20Misfire%20Detected&clip=pandc/chet/2012/automotive/OBD2_Ford/ST15_CS3.mov&caption=chet/chet_mylabs/akamai/2012/automotive/OBD2_Ford/xml/ST15_CS3.xml
	**Show VIDEO: 8 MINUTES DTC P0300 MISFIRE DIAGNOSIS www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_mylabs/akamai/template/video640x480.php?title=Case%20Study%201%20Diagnosing%20&%20Engine%20Misfire%20PO300&clip=pandc/chet/2012/automotive/OBD2_GM/CS1.mov&caption=chet/chet_mylabs/akamai/2012/automotive/OBD2_GM/xml/CS1.xml
	**Show VIDEO: 6 MINUTES SINGLE CYLINDER MISFIRE DIAGNOSIS www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_mylabs/akamai/template/video640x480.php?title=Case%20Study%203%20Single%20Cylinder%20Misfire&clip=pandc/chet/2012/automotive/OBD2_Chrysler_Corp/ST16CS3.mov&caption=chet/chet_mylabs/akamai/2012/automotive/OBD2_Chrysler_Corp/xml/ST16CS3.xml
	**ON-VEHICLE NATEF TASK (A8A2)** Research applicable vehicle and service information, such as **Ignition System Identification PAGES 16 & 20**
	**Talk through SUMMARY and questions**
	**HOMEWORK: complete Ch18 crossword puzzle:** http://www.jameshalderman.com/links/book_engine_theory_serv_7/cw/crossword_ch_18.pdf