Automotive Fuel and Emissions Control Systems 4/E

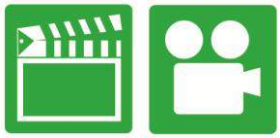
Chapter 29 Ignition System Operation & Diagnosis

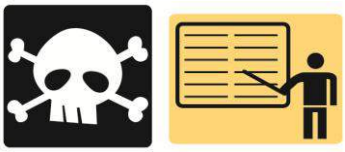
Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers operation and service of **Automotive Fuel and Emissions Control Systems.** It correlates material to task lists specified by ASE and NATEF.
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 session or class.	Explain the chapter learning objectives to the students. 1. Understand how the ignition system and ignition coils work. 2. Discuss crankshaft position sensors and the operation of pickup coils. 3. Explain the operation of waste-spark and coil-on-plug ignition systems. 4. Discuss ignition system diagnosis. 5. Understand the construction and operation of different types of spark plugs and discuss how to inspect spark plug wires. 6. List the steps necessary to check and/ or adjust ignition timing on engines equipped with a distributor.
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 Fuel & Emission Control 4th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

LINK CHP 29: Chapter Images

ICONS	Ch29 Ignition System Operation/Diagnosis
	1. SLIDE 1 CH29 Ignition System Operation & Diagnosis
	Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/ WEB SITE REGULARLY UPDATED VIDEOS
	At the beginning of this class, you can download the crossword puzzle & Word Search from the links below to familiarize your class with the terms in this chapter & then discuss them Crossword Puzzle (Microsoft Word) (PDF) Word Search Puzzle (Microsoft Word) (PDF)
	2. SLIDE 2 EXPLAIN Figure 29-1 point-type distributor from a hot rod being tested on a distributor machine.
	DEMONSTRATION: SHOW A POINT-TYPE DISTRIBUTOR. REVIEW ITS MAJOR COMPONENTS & SHOW HOW TO SET AIR GAP. SHOW MAJOR COMPONENTS OF A DISTRIBUTOR IGNITION SYSTEM.
	HANDS-ON TASK: PASS AROUND POINT-TYPE DISTRIBUTOR & HAVE STUDENTS SET AIR GAP
	3. SLIDE 3 EXPLAIN Figure 29-2 primary ignition system is used to trigger and therefore create the secondary (high-voltage) spark from ignition coil. Some ignition coils are electrically connected, called married (top figure) whereas others use separated primary and secondary windings, called divorced (lower figure).
	DISCUSSION: DISCUSS THE PRIMARY & SECONDARY IGNITION CIRCUITS. HOW DO 2 CIRCUITS FUNCTION INDEPENDENTLY & HOW DO

ICONS	Ch29 Ignition System Operation/Diagnosis
	**THEY INTERACT? FIGURE 29-2** 4. **SLIDE 4 EXPLAIN Figure 29-3** steel laminations 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. 5. **SLIDE 5 EXPLAIN Figure 29-4** primary windings are inside secondary windings on this General Motors coil. 6. **SLIDE 6 EXPLAIN Figure 29-5** primary ignition system is used to trigger and therefore create the secondary (high-voltage) spark from the ignition coil.
	**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?**
	**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?**
	**HANDS-ON TASK: HAVE STUDENTS DISASSEMBLE OLD COILS. HAVE THEM IDENTIFY INTERNAL COMPONENTS AND POINT OUT ELECTRICAL CONNECTIONS. OPTION: STUDENTS DRAW OR DESCRIBE PRIMARY AND SECONDARY CIRCUITS.**
	**EXPLAIN WARNING**
	**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: DEMO SNAP-ON MODUS HERE**
	**DISCUSSION: USING AN IGNITION SYSTEM WIRING DIAGRAM, HAVE THE STUDENTS LOCATE TRIGGERING DEVICE. HOW DOES THIS TRIGGERING DEVICE WORK?**

ICONS	Ch29 Ignition System Operation/Diagnosis
	7. **SLIDE 7 EXPLAIN Figure 29-6** Operation of a typical pulse generator (pickup coil). At bottom is a line drawing of a typical scope pattern of the output voltage of a pickup coil. ICM receives this voltage from pickup coil and opens the ground circuit to the ignition coil when the voltage starts down from its peak (just as the reluctor teeth start moving away from pickup coil).
	**DEMONSTRATION: USING OSCILLOSCOPE, SHOW WAVEFORM PATTERN OF PULSE GENERATOR. COMPARE PATTERN WITH FIG 29–6**
	8. **SLIDE 8 EXPLAIN Figure 29-7** 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. 9. **SLIDE 9 EXPLAIN Figure 29-8** A Hall-effect sensor produces an on-off voltage signal whether it is used with a blade or a notched wheel. 10. **SLIDE 10 EXPLAIN Figure 29-9** 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 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.
	**DEMONSTRATION: USING AN OSCILLOSCOPE SHOW WAVEFORM PATTERNS OF MAGNETIC SENSOR & HALL-EFFECT SENSOR. COMPARE THESE SCOPE PATTERNS WITH FIGURES 29–7 & 8** **HALL EFFECT SENSOR (VIEW) (DOWNLOAD)**
	
 	**DISCUSSION: DISCUSS HALL EFFECT. HOW IS HALL-EFFECT SWITCH DIFFERENT FROM MAGNETIC PULSE GENERATOR? FIG 29-7 & 8**
	11. **SLIDE 11 EXPLAIN Figure 29-10 (a)** Typical optical distributor. 12. **SLIDE 12 EXPLAIN Figure 29-10 (b)** Cylinder I slit

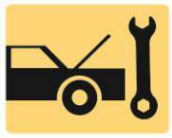
ICONS	Ch29 Ignition System Operation/Diagnosis
	signals the computer the piston position for cylinder I. The 1-degree slits provide accurate engine speed information to the PCM.
	**HANDS-ON TASK: HAVE STUDENTS REMOVE A DISTRIBUTOR FROM A VEHICLE WITH OPTICAL SENSOR, FIRST REVIEW OEM SVC INFO. HAVE THEM IDENTIFY DISTRIBUTOR COMPONENTS & TEST CRANK ANGLE SENSOR. HAVE THEM DISASSEMBLE DISTRIBUTOR, REMOVING SHAFT AND NOTING BUSHING/BEARING & SEAL AREAS: FIGURES 29-9 & 10**
	**DEMONSTRATION: SHOW HOW TO INSPECT A TORQUE CONVERTER DRIVE PLATE. HIGHLIGHT IMPORTANCE OF A THOROUGH INSPECTION TO AVOID A DRIVEABILITY CONDITION. FIGURE 29-9**
	**DEMONSTRATION: SHOW HOW TO REPLACE CRANKSHAFT (CKP)/CAMSHAFT POSITION SENSORS (CMP) & MAKE ADJUSTMENTS USING A GAUGING TOOL. SHOW HOW TO MONITOR CRANKSHAFT/CAMSHAFT POSITION SENSORS USING SCAN TOOL**
	**DEMONSTRATION: REVIEW IMPORTANCE OF CAMSHAFT & CRANKSHAFT TIMING. USE OPENED TIMING COVER TO EMPHASIZE TIMING MARKINGS AND WHAT IS HAPPENING TO PISTON & AND VALVE POSITIONS**
	**13. SLIDE 13 EXPLAIN TECH-TIP & FIGURE 29–11** light shield being installed before the rotor is attached. **EXPLAIN TECH-TIP**
	
	**14. SLIDE 14 EXPLAIN Figure 29-12** firing order is cast or stamped on the intake manifold on most engines that have a distributor ignition

ICONS	Ch29 Ignition System Operation/Diagnosis
	**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. FIGURE 29-12**
	**Waste Spark Ignition System 1** **Waste Spark Ignition System 2**
	**15. SLIDE 15 EXPLAIN Figure 29-13** 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).
	**DEMONSTRATION: DEMO WASTE-SPARK IGNITION SYSTEM OPERATION: FIGURE 29-13**
	**DISCUSS FREQUENTLY ASKED QUESTION**
	**EXPLAIN TECH-TIP**
	**16. SLIDE 16 EXPLAIN Figure 29-14** Typical wiring diagram of V-6 waste-spark ignition system. PCM is in control of ignition timing based on information from various engine sensors including RPM, MAP & engine coolant temperature (ECT). Timing signal is sent to module through electronic spark timing (EST) wire **17. SLIDE 17 EXPLAIN Figure 29-15** 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. The compression sensing ignition (CSI) signal is then processed by the PCM which then determines which cylinder is on the compression stroke.

ICONS	Ch29 Ignition System Operation/Diagnosis
	**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? **FIGURE 29-13, 14, 15**
	**DISCUSSION:** HAVE THE STUDENTS REVIEW THE PURPOSE OF A **CRANKSHAFT SENSOR (CKP)**. WHY IS THERE ADJUSTMENT ON SOME ENGINES?
	**DEMONSTRATION:** USING IGNITION **OSCILLOSCOPE**, SHOW STUDENTS TYPICAL CONNECTING PROCEDURE FOR OBTAINING IGNITION PATTERNS.
	**DEMONSTRATION:** SHOW **LAB VEHICLE** WITH AN **IGNITION MODULE UNDER COIL PACK**. REMOVE IGNITION MODULE & DEMO TESTING PIN LOCATIONS.
	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.
	**COIL-ON-PLUG IGNITION SYSTEM**
	18. **SLIDE 18 EXPLAIN Figure 29-16** A typical coil-on-plug ignition system showing the triggering and the switching being performed by the PCM via input from the crankshaft position sensor.
	**DISCUSSION: HAVE STUDENTS STUDY AND DISCUSS FIGURE 29–16. WHAT COP IGNITION SYSTEM ELIMINATE?**
	**DISCUSSION: HAVE STUDENTS STUDY AND DISCUSS FIGURE 29–16. WHAT DOES THE COIL-ON-PLUG (COP) IGNITION SYSTEM ELIMINATE?**

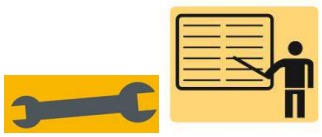
ICONS	Ch29 Ignition System Operation/Diagnosis
	19. **SLIDE 19 EXPLAIN Figure 29-17** An overhead camshaft engine equipped with variable valve timing on both the intake and exhaust camshafts and the coil-on-plug ignition. **EXPLAIN SAFETY-TIP**
	20. **SLIDE 20 EXPLAIN Figure 29-18** Chrysler Hemi V-8 that has two spark plugs per cylinder. The coil on top of one spark plug fires that plug and, through a spark plug wire, fires a plug in the companion cylinder.
	**DEMONSTRATION: SHOW THE STUDENTS COP IGNITION SYSTEMS WITH 2 & 3 PRIMARY WIRES AND EXPLAIN THE DIFFERENCES.**
	**DEMONSTRATION: SHOW THE STUDENTS COP IGNITION SYSTEMS WITH 2 & 3 PRIMARY WIRES AND EXPLAIN THE DIFFERENCES.**
	21. **SLIDE 21 EXPLAIN Figure 29-19** 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 spark plug gap but rather 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**
	**DISCUSSION: HAVE STUDENTS STUDY FIGURE 29–19 AND DISCUSS ION-SENSING IGNITION SYSTEMS. WHAT IS PURPOSE OF MEASURING ELECTRICITY CONDUCTED BY IONIZED COMBUSTION FLAME?**
	22. **SLIDE 22 EXPLAIN Figure 29-20** typical knock sensor on side of block. Some are located in "V" of a V-type engine and are not noticeable until the intake manifold has been removed.
	**DEMONSTRATION: SHOW KNOCK SENSOR AND DEMONSTRATE TESTING PROCEDURE. DISCUSS KNOCK SENSOR'S PURPOSE. FIGURE 29–20**

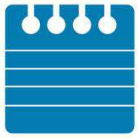
ICONS	Ch29 Ignition System Operation/Diagnosis
	**HANDS-ON TASK: HAVE THE STUDENTS TEST KNOCK SENSORS ON SHOP VEHICLES USING GMM & SCAN TOOL. HAVE THEM DRAW WAVEFORMS THEY DETECT TO START BUILDING A LIBRARY OF KNOWN-GOOD KNOCK SENSOR WAVEFORMS**
	**23. SLIDE 23 EXPLAIN Figure 29-21** typical waveform 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
	**DISCUSSION: HAVE THE STUDENTS TALK ABOUT WHAT HAPPENS WITH SOME ENGINE COMPUTERS WHEN THEY DETECT KNOCK SENSOR SIGNALS AT IDLE SPEED. WHY SHOULD KNOCK SENSORS BE CHECKED AT OFF IDLE IN ORDER TO ISOLATE A TRUE ENGINE KNOCK CONDITION?**
	**DISCUSS REAL WORLD FIX**
	**DISCUSSION: HAVE STUDENTS DISCUSS BYPASS IGNITION CONTROL. WHAT CONTROLS TIMING?**
	**DISCUSSION: DISCUSS UP-INTEGRATED IGNITION CONTROL. WHAT IS DIFFERENCE BETWEEN A BYPASS IGNITION CONTROL CIRCUIT AND UPINTEGRATED IGNITION?**
	**ON-VEHICLE NATEF TASK RESEARCH APPLICABLE VEHICLE AND SERVICE INFORMATION, SUCH AS IGNITION SYSTEM IDENTIFICATION**
	**24. SLIDE 24 EXPLAIN Figure 29-22** A 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. **25. SLIDE 25 EXPLAIN Figure 29-23** 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.

ICONS	Ch29 Ignition System Operation/Diagnosis
	**DEMONSTRATION:** SHOW HOW TO PROPERLY USE A SPARK TESTER FIGURE 29-22 & 23 TO CHECK FOR SPARK
	**DISCUSSION:** DISCUSS SPARK COLOR. HOW CAN SPARK COLOR BE USED TO DETERMINE SPARK QUALITY?
	ON-VEHICLE NATEF TASK MEETS NATEF TASK: SPARK PLUG SPECIFICATIONS: RESEARCH APPLICABLE VEHICLE AND SERVICE INFORMATION, SUCH AS ENGINE MANAGEMENT SYSTEM OPERATION, VEHICLE SERVICE HISTORY, SERVICE PRECAUTIONS, AND TSBS
	EXPLAIN TECH-TIP
	26. SLIDE 26 EXPLAIN Figure 29-24 Checking an ignition coil using a multimeter set to read ohms
	HANDS-ON TASK: HAVE THE STUDENTS TEST IGNITION COILS, USING OHMMETER TO DETERMINE COIL CONDITION. FIGURE 29-24
	PERFORM CAREFUL VISUAL INSPECTION OF COIL HOUSING. INSPECTION WILL HELP TO LOCATE BURN MARKS OR CRACKS THAT INDICATE A FAULTY COIL.
	ON-VEHICLE NATEF TASK: IGNITION COIL TESTING INSPECT AND TEST IGNITION PRIMARY AND SECONDARY CIRCUIT WIRING AND SOLID STATE COMPONENTS; TEST IGNITION COIL (S); PERFORM NECESSARY ACTION.
	DISCUSSION: HAVE THE STUDENTS DISCUSS WHAT RESULTS FROM LOW/NO VOLTAGE TO PRIMARY SIDE OF COIL. HOW DOES LOWER-THAN-NORMAL VOLTAGE IN THE PRIMARY CIRCUIT AFFECT SECONDARY CIRCUIT?

ICONS	Ch29 Ignition System Operation/Diagnosis
	27. **SLIDE 27 EXPLAIN Figure 29.25** Measuring the resistance of an HEI pickup coil using a digital multimeter set to ohms position. Reading on face of meter is 0.796 kΩ, or 796 ohms in middle of 500- to 1,500-ohm spec 28. **SLIDE 28 EXPLAIN Figure 29-26** A waveform showing the primary current flow through the primary windings of an ignition coil 29. **SLIDE 29 EXPLAIN FIGURE 29–27** (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.
	**DISCUSSION: DISCUSS WAVEFORM THAT SHOWS PRIMARY CURRENT FLOW IN FIG 29–26. HOW WILL DSO, TIME, VOLTAGE, AND CURRENT SETTINGS DIFFER WHEN CHECKING SECONDARY IGNITION CIRCUITS?**
	**EXPLAIN TECH-TIPS** 30. **SLIDE 30 EXPLAIN FIGURE 29–28** 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.
	**DEMONSTRATION: SHOW HOW TO PREPARE A DSO (DIGITAL STORAGE OSCILLOSCOPE) TO OBTAIN PRIMARY CIRCUIT PATTERNS.**
	**ON-VEHICLE NATEF TASK SCOPE TESTING: INSPECT AND TEST IGNITION PRIMARY AND SECONDARY CIRCUIT WIRING AND SOLID STATE COMPONENTS; TEST IGNITION COIL**
	**DISCUSSION: HAVE THE STUDENTS TALK ABOUT ANALYSIS OF WAVEFORMS. WHAT SHOULD YOU LOOK FOR WHEN ANALYZING WAVEFORMS TO DETERMINE IGNITION COIL CONDITION?**
	**DEMONSTRATION: SHOW STUDENTS HOW TO USE A SCAN TOOL ON A LAB VEHICLE TO OBTAIN ENGINE RPM.**
	**DISCUSSION: HAVE STUDENTS TALK ABOUT RELATIONSHIP BETWEEN TEMPERATURE & RESISTANCE. HOW DOES TEMPERATURE AFFECT RESISTANCE OF SENSORS AND COILS?**

ICONS	Ch29 Ignition System Operation/Diagnosis
	**HANDS-ON TASK:** PROVIDE THE STUDENTS WITH IGNITION COIL PRIMARY WAVEFORMS. HAVE THE STUDENTS IDENTIFY KEY PARTS OF WAVEFORM THAT CAN BE ANALYZED TO DETERMINE COIL CONDITION.
	**HANDS-ON TASK:** HAVE THE STUDENTS TEST A MAGNETIC SENSOR (PICKUP COIL) USING AN OHMMETER TO DETERMINE ELECTRICAL INTEGRITY OF SENSOR
	**DEMONSTRATION:** SHOW HOW TO TEST A MAGNETIC SENSOR (PICKUP COIL) USING AN AC VOLTMETER TO DETERMINE SENSOR CONDITION
	**DISCUSSION:** HAVE STUDENTS TALK ABOUT CHANGES IN FREQUENCY. HOW DOES AMPLITUDE OF AN AC SIGNAL CHANGE WITH CHANGES IN FREQUENCY?
	**HANDS-ON TASK:** HAVE STUDENTS LOCATE AND INSPECT CKP & CMP IGNITION SENSORS TO DETERMINE TYPES OF SENSORS. CHECK THEM USING A SCAN TOOL
	**DISCUSSION:** HAVE STUDENTS TALK ABOUT DIFFERENCE BETWEEN ANALOG & DIGITAL SIGNALS. DOES SCOPE TESTING USE AN ANALOG OR A DIGITAL SIGNAL?
	**DEMONSTRATION:** USE A DSO TO SHOW DIFFERENT WAVEFORMS GENERATED BY PICKUP COIL, HALL-EFFECT, AND OPTICAL SENSORS
	**DISCUSSION:** HAVE STUDENTS DISCUSS TERM TRACKING. WHAT IS TRACKING? WHAT TYPES OF PROBLEMS DOES IT CAUSE? HOW CAN IT BE FOUND
	**DISCUSSION:** HAVE THE STUDENTS DISCUSS THE PURPOSE OF "SUPPRESSION" WIRES. HOW DO THEY WORK?

ICONS	Ch29 Ignition System Operation/Diagnosis
	31. **SLIDE 31 EXPLAIN Figure 29-29** Corroded terminals on a waste-spark coil can cause misfire diagnostic trouble codes to be set. 32. **SLIDE 32 EXPLAIN Figure 20-30** This spark plug boot on an overhead camshaft engine has been arcing to the valve cover causing a misfire to occur
	**HANDS-ON TASK: HAVE THE STUDENTS REMOVE SPARK PLUG WIRES TO INSPECT FOR EVIDENCE OF SPARK LEAKAGE. MAKE SURE WIRES ARE REINSTALLED CORRECTLY, FOLLOWING PROPER ROUTING & USE OF WIRE SEPARATORS. CHECK FOR CORROSION FIGURE 29-29**
	33. **SLIDE 33 EXPLAIN Figure 29-31** Measuring the resistance of a spark plug wire with a multimeter set to the ohms position. The reading of 16.03 kΩ (16.03 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).
	**Test Spark Plug Wire (View) (Download)**
	**EXPLAIN TECH-TIP** 34. **SLIDE 34 EXPLAIN Figure 29-32** Spark plug wire boot pliers are a handy addition to any tool box
	**HANDS-ON TASK: HAVE STUDENTS USE OHMMETER TO TEST SPARK PLUG WIRES FOR CONTINUITY AND COMPARE COLLECTED VALUES TO SPECIFICATIONS TO DETERMINE CONDITION**
	**EXPLAIN TECH-TIP** 35. **SLIDE 35 EXPLAIN FIGURE 29–33** Always take the time to install spark plug wires back into the original holding brackets (wiring combs)
	36. **SLIDE 36 EXPLAIN Figure 29-34** Parts of spark plug. 37. **SLIDE 37 EXPLAIN Figure 29-35** The heat range of a spark plug is determined by the 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**

ICONS	Ch29 Ignition System Operation/Diagnosis
	**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.**
	**38. SLIDE 38 EXPLAIN Figure 29-36** When removing spark plugs, it is wise to arrange them so that they can be compared & problem can be identified with 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 29-36**
	**39. SLIDE 39 EXPLAIN Figure 29-37** A 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?**
	**HANDS-ON TASK: HAVE THE STUDENTS GAP A SET OF SPARK PLUGS USING PROPER TOOLS.**
	**DISCUSSION: DISCUSS OIL-FOULED SPARK PLUGS & FUEL- OR CARBON-FOULED SPARK PLUGS. WILL CHANGING FOULED SPARK PLUGS PROVIDE A LONG-TERM CURE FOR DRIVABILITY COMPLAINTS?**
	**40. SLIDE 40 EXPLAIN Figure 29-38** normally worn spark plug that uses tapered platinum-tipped center electrode & **41. SLIDE 41 EXPLAIN Figure 29-39** Spark plug removed from an engine after 500-mile race. Note clipped side (ground) electrode. Electrode design and narrow (0.025 in.) gap are used to ensure that a spark occurs during extremely high engine speed operation. **42. SLIDE 42 EXPLAIN Figure 29-40** Typical worn spark plug. Notice the rounded center electrode. The deposits indicate a possible coolant usage problem & **43. SLIDE 43 EXPLAIN Figure 29-41** New spark plug that was fouled by an overly rich air-fuel mixture. The engine

ICONS	Ch29 Ignition System Operation/Diagnosis
	from which this spark plug came had a defective (stuck partially open) injector on this one cylinder only
	**DISCUSSION:** DISCUSS WHY SOME SPARK PLUGS USE MULTIPLE GROUND ELECTRODES. HOW DO MULTIPLE GROUND ELECTRODES AFFECT OPERATION AND SERVICE LIFE?
	EXPLAIN TECH-TIP
	44. **SLIDE 44 EXPLAIN Figure 29-42** Ignition timing marks are found on harmonic balancers on engines equipped with distributors can be adjusted for timing. 45. **SLIDE 45 EXPLAIN Figure 29-43** initial (base) timing is where spark plug fires at idle speed. The PCM then advances timing based primarily on engine speed 46. **SLIDE 46 EXPLAIN FIGURE 29–44** (a) Typical SPOUT connector as used on many Ford engines equipped with distributor ignition (DI). (b) The connector must be opened (disconnected) to check and/or adjust the ignition timing. On DIS/EDIS systems, the connector is called SPOUT/SAW (spark output/spark angle word)
	**DISCUSSION:** DISCUSS THE DIFFERENCE BETWEEN BTDC & ATDC. HOW WOULD CHANGES IN IGNITION TIMING AFFECT ENGINE OPERATION?
	**DEMONSTRATION:** SHOW HOW TO USE A TIMING LIGHT TO CHECK AND/OR ADJUST IGNITION TIMING. DEMONSTRATE FOR STUDENTS HOW TO DETERMINE WHETHER TIMING IS ADJUSTABLE. FIGURE 29-42-43
	**HANDS-ON TASK:** HAVE STUDENTS RETRIEVE TIMING SPECIFICATIONS FROM VECI OR SERVICE INFORMATION. HAVE THEM FOLLOW PROCEDURE TO CORRECTLY CHECK AND ADJUST IGNITION TIMING FIGURE 29-42-43
	**DISCUSSION:** HAVE THE STUDENTS DISCUSS HOW INITIAL TIMING CHANGES WITH ENGINE WEAR. CAN CHANGES BE MADE TO COMPENSATE FOR WEAR? HOW?
	**HANDS-ON TASK:** PROVIDE THE STUDENTS WITH A VEHICLE THAT HAS INCORRECT FIRING ORDER. HAVE THEM USE SPECIFICATIONS TO

ICONS	Ch29 Ignition System Operation/Diagnosis
	INSPECT AND CORRECT FIRING ORDER. HANDS-ON TASK: HAVE STUDENTS HOOK UP A SCAN TOOL TO SEE HOW IGNITION TIMING CHANGES AS ENGINE SPEED & LOAD CHANGE
	DISCUSSION: HAVE THE STUDENTS DISCUSS WHAT CAN CAUSE NO-START CONDITION. HOW DO YOU SYSTEMATICALLY TEST IGNITION SYSTEM COMPONENTS & CIRCUITRY TO DETERMINE CAUSE OF NO-SPARK CONDITION?
	ON-VEHICLE NATEF TASK DIAGNOSE ELECTRONIC IGNITION-RELATED PROBLEMS; DETERMINE NECESSARY ACTION
	ON-VEHICLE NATEF TASK USING SCAN TOOL DIAGNOSE ELECTRONIC IGNITION-RELATED PROBLEMS; DETERMINE NECESSARY ACTION
	ON-VEHICLE NATEF TASK: IGNITION INSPECTION & TESTING: INSPECT AND TEST IGNITION PRIMARY AND SECONDARY CIRCUIT WIRING; PERFORM NECESSARY ACTION.
	ON-VEHICLE NATEF TASK: SPARK PLUG INSPECTION: INSPECT AND TEST SPARK PLUGS
	DEMONSTRATION: SHOW THE STUDENTS HOW TO PERFORM A ROTOR AIR GAP TEST TO CHECK DISTRIBUTOR CAP AND ROTOR CONDITION.
	ON-VEHICLE NATEF TASK INSPECT, TEST, AND/OR REPLACE IGNITION CONTROL MODULE, POWERTRAIN/ENGINE CONTROL MODULE; REPROGRAM AS NECESSARY
	ON-VEHICLE NATEF TASK INSPECT AND TEST CRANKSHAFT AND CAMSHAFT POSITION SENSOR(S); PERFORM NECESSARY ACTION