Automotive Electrical & Engine Performance 8/E

Chapter 29 Ignition System Components & Operation

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This Automotive Electrical & Engine Performance 8th edition provides complete coverage of automotive areas pertaining vehicle electrical systems and engine performance. 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, and Animations that are listed in this Lesson Plan. This Lesson Plan also references ASEEducation (NATEF) Task Sheets available from Jim's web site.
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. 1. Explain how the ignition system and ignition coils work. 2. Discuss crankshaft position sensor and pickup coil operation. 3. Discuss knock sensors and ignition control circuits. 4. Describe the operation of distributor ignition. 5. Describe the operation of waste-spark and coil-on-plug ignition systems. **This chapter will help you prepare for Engine Repair (A8) ASE certification test content area "B" (Ignition System Diagnosis and Repair).**
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 Automotive Electrical & Engine Performance 8th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

DOWNLOAD Chapter 29 Chapter Images: From http://www.jameshalderman.com/books_a8.html#anchor2

ICONS	Ch29 Ignition System Components & OP
         	**1. SLIDE 1 CH29 Ignition System Components & Operation** **Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE REGULARLY UPDATED** **Videos 1** **Videos** **Videos 2** **At the beginning of this class, you can download the crossword puzzle & Word Search from Jim's web site to familiarize your class with terms in this chapter & then discuss them, see below:** **HTTP://WWW.JAMESHALDERMAN.COM/BOOKS_A8.HTML#ANCHOR2** **DOWNLOAD** **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 THE POINT-TYPE DISTRIBUTOR & HAVE STUDENTS SET AIR GAP** **3. SLIDE 3 EXPLAIN FIGURE 29–2** 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 THE PRIMARY & SECONDARY IGNITION**

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	**CIRCUITS. HOW DO THE 2 CIRCUITS FUNCTION INDEPENDENTLY AND HOW DO THEY INTERACT?** 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 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 THE PRIMARY AND SECONDARY CIRCUITS.**
	**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 OSCILLOSCOPE: DEMO DSO**
	**DSO USES ADVANCED OBD II DIAGNOSTIC CAPABILITIES INCLUDING DOMESTIC & ASIAN IMPORT VEHICLE COMMUNICATION SOFTWARE, PLUS FAST-TRACK TROUBLESHOOTER. INTEGRATES EXPERIENCE-BASED INFORMATION WITH SCAN TOOL INSTRUMENTATION. 4-CHANNEL LAB SCOPE WITH MULTIPLE SECONDARY IGNITION CAPABILITIES & GMM BUILT INTO A**

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   	**COMMON ARCHITECTURE WITH EXPANDABLE PORTS.** **DISCUSSION: USING AN IGNITION SYSTEM WIRING DIAGRAM, HAVE THE STUDENTS LOCATE TRIGGERING DEVICE. HOW DOES THIS TRIGGERING DEVICE WORK?** 7. **SLIDE 7 EXPLAIN FIGURE 29–6** Hall-effect sensor produces a digital on-off voltage signal whether it is used with a blade or a notched wheel. **DEMONSTRATION: USING OSCILLOSCOPE SHOW WAVEFORM PATTERN OF A PULSE GENERATOR. COMPARE PATTERN WITH** **DISCUSS FREQUENTLY ASKED QUESTION:** ***HOW DOES THE COMPUTER CONTROL THE IGNITION?*** **PCM plays a key role in final functioning of ignition circuits. PCM receives signals from all of the engine sensors and, based on this information, uses an algorithm (computer program) to determine best time to fire spark plugs. For example, the sensors and how they could affect when spark occurs include:** **ENGINE COOLANT TEMPERATURE (ECT)—the colder the engine, more spark advance may be needed to achieve the highest possible engine output torque with lowest exhaust emissions.** **THROTTLE POSITION (TP) SENSOR—PCM uses TP sensor information to not only determine where the accelerator position is located, but also at what rate it is changing. If the accelerator pedal is rapidly being depressed, then spark timing may be delayed (retarded slightly) to help prevent spark knock.** **MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR—MAP sensor is used to detect engine load. During a heavy load, less spark advance is needed to help prevent spark knock,**

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	**whereas more spark advance is needed under light load conditions for the engine to achieve maximum fuel economy and the lowest possible exhaust emissions.** 8. **SLIDE 8 EXPLAIN FIGURE 29–7** 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 the computer (controller); a signal (0 to 5 volts); and a signal ground 9. **SLIDE 9 EXPLAIN FIGURE 29–8** A 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. 10. **SLIDE 10 EXPLAIN FIGURE 29–9** A typical magnetic crankshaft position sensor.
	**EXPLAIN TECH TIP:** ***Tachometer Trick.*** **When diagnosing a no-start or intermittent misfire condition, *check operation of the tachometer*. If tachometer does not indicate engine speed (no-start condition) or drops toward zero (engine misfire), problem is due to a defect in primary ignition circuit. The tachometer gets its signal from the pulsing of primary winding of ignition coil or crankshaft position (CKP) sensor. The following components in primary circuit could cause tachometer to not work when engine is cranking:** • **Pickup coil** • **Crankshaft position sensor** • **Ignition module (igniter)** • **Coil primary wiring** **If the vehicle is not equipped with a tachometer, connect a scan tool and monitor engine RPM. Remember the following:** • **No tachometer reading means the problem is in primary ignition circuit.**

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      	• **Tachometer reading okay means the problem is in the secondary ignition circuit or is a fuel-related problem.** **DEMONSTRATION: USING AN DSO SHOW WAVEFORM PATTERNS OF MAGNETIC SENSOR & HALL-EFFECT SENSOR. COMPARE THESE SCOPE PATTERNS WITH FIGURES 29–7 & 29–8** **DISCUSSION: DISCUSS HALL EFFECT. HOW IS HALL-EFFECT SWITCH DIFFERENT FROM MAGNETIC PULSE GENERATOR?** 11. **SLIDE 11 EXPLAIN FIGURE 29–10** (a) A cutaway of a Ford distributor showing Hall-effect shutter blade that is used to trigger the ignition control module and the rotor. (b) A rotor from a GM HEI system. **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:** **DEMONSTRATION: SHOW HOW TO INSPECT A TORQUE CONVERTER DRIVE PLATE. HIGHLIGHT IMPORTANCE OF A THOROUGH INSPECTION TO AVOID A DRIVEABILITY CONDITION.** **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**

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	12. **SLIDE 12 EXPLAIN FIGURE 29–11** firing order is cast or stamped on intake manifold on most engines that have a distributor ignition.. 13. **SLIDE 13 EXPLAIN FIGURE 29–12** typical General Motors HEI coil installed in distributor cap. When the coil or distributor cap is replaced, check that ground clip is transferred from the old distributor cap to the new. Without proper grounding, coil damage is likely. There are two designs of HEI coils. One uses red and white wire as shown, and the other design, which has reversed polarity, uses red and yellow wire for the coil primary.
	**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.**
	14. **SLIDE 14 EXPLAIN FIGURE 29–13** This distributor ignition system uses a remotely mounted ignition coil**.**
	**DEMONSTRATION: DEMO WASTE-SPARK IGNITION SYSTEM OPERATION**
	15. **SLIDE 15 EXPLAIN FIGURE 29–14** Wiring diagram of a typical Ford electronic ignition. 16. **SLIDE 16 EXPLAIN FIGURE 29–15** Chrysler electronic ignition distributor. This unit is equipped with a vacuum advance mechanism that advances ignition timing under light engine load conditions**.**
	Hall Effect Sensor (View) (Download) Waste Spark Ignition System 1 (View) (Download) Waste Spark Ignition System 2 (View) (Download) Cylinder Deactivation System (View)
	**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?**

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	**HANDS-ON TASK: OPTIONAL DIS TRAINER**
	**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.**
	17. **SLIDE 17 EXPLAIN FIGURE 29–16 waste-spark system** fires one cylinder while its piston is on compression stroke and into paired or companion cylinders while it is on exhaust stroke. In a typical engine, it requires only about 2 to 3 kV to fire cylinder on the exhaust strokes. Remaining coil energy is available to fire spark plug under compression (typically about 8 to 12 kV). 18. **SLIDE 18 EXPLAIN FIGURE 29–17** left-hand rule states that if a coil is grasped with the left hand, the fingers point in the direction of current flow and thumb points toward the north pole.
	**EXPLAIN TECH TIP:** ***Odds Fire Straight*** **Waste-spark ignition systems fire two spark plugs at same time. Most vehicle manufacturers use a waste spark system that fires the odd-numbered cylinders (1, 3, and 5) by straight polarity (current**

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   	**flow from the top of spark plug through gap and to the ground electrode). Even-numbered cylinders (2, 4, and 6) are fired reverse polarity, meaning that the spark jumps from the side electrode to center electrode. Some OEMS equip their vehicles with platinum plugs with expensive platinum alloy only on one electrode as follows:** • **On odd-numbered cylinders (1, 3, 5), the platinum is on the center electrode.** • **On even-numbered cylinders (2, 4, 6), the platinum is on ground electrode.** **Replacement spark plugs use platinum on both electrodes (double platinum) and can, therefore, be placed in any cylinder location.** **Coil-On-Plug Ignition System (View) (Download)** **Cylinder Deactivation System (View)** **DISCUSSION: HAVE STUDENTS STUDY AND DISCUSS FIGURE 29–18. WHAT DOES THE COIL-ON-PLUG (COP) IGNITION SYSTEM ELIMINATE?** **WARNING: Never Disconnect a Spark Plug Wire When Engine Is Running! Ignition systems produce a high-voltage pulse necessary to ignite a lean air–fuel mixture. If you disconnect a spark plug wire when engine is running, this high-voltage spark could cause personal injury or damage to the ignition coil and/or ignition module.** 19. **SLIDE 19 EXPLAIN FIGURE 29–18** 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 processed by PCM, which then determines which cylinder is on the compression stroke.

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	20. **SLIDE 20 EXPLAIN FIGURE 29–19** Typical wiring diagram of a V-6 distributorless (direct fire) ignition system. 21. **SLIDE 21 EXPLAIN FIGURE 29–20** typical two-wire coil-on-plug ignition system showing the triggering and switching being performed by PCM from input from the crankshaft position sensor. 22. **SLIDE 22 EXPLAIN FIGURE 29–21** An overhead camshaft engine equipped with variable valve timing on both the intake and exhaust camshafts and coil-on-plug ignition. 23. **SLIDE 23 EXPLAIN FIGURE 29-22** 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.**
	**HANDS-ON TASK: HAVE STUDENTS DRAW WIRING DIAGRAMS OF 2 & 3 WIRE COP PRIMARY IGNITION SYSTEMS. GRADE THEM ON ACCURACY**
	**DISCUSSION: STUDY FIGURE 71–21 DISCUSS ION-SENSING IGNITION SYSTEMS. WHAT IS THE PURPOSE OF MEASURING ELECTRICITY CONDUCTED BY THE IONIZED COMBUSTION FLAME?**
	**DISCUSSION: 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?**
	**HANDS-ON TASK: HAVE THE STUDENTS TEST KNOCK SENSORS ON SHOP VEHICLES USING DSO OR GMM & SCAN TOOL). HAVE THEM DRAW WAVEFORMS THEY DETECT TO START BUILDING A LIBRARY OF KNOWN-GOOD KNOCK SENSOR WAVEFORMS.**

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	24. **SLIDE 24 EXPLAIN FIGURE 29–23** DC voltage is applied across the spark plug gap after plug fires and circuit can determine the correct air–fuel ratio was present in the cylinder and if knock occurred. 25. **SLIDE 25 EXPLAIN FIGURE 29–24** initial timing is where spark plug fires at idle speed. Computer then advances timing based on engine speed and other factors. 26. **SLIDE 26 EXPLAIN FIGURE 29–25** Ignition timing marks are found on the harmonic balancers that are equipped with distributor ignition.
	**DEMONSTRATION: SHOW LOCATION OF KNOCK SENSOR AND DEMONSTRATE TESTING PROCEDURE. DISCUSS KNOCK SENSOR'S PURPOSE. FIGURE 71–26 USE LAB VEHICLE OR TRAINER**
	27. **SLIDE 37 EXPLAIN FIGURE 29–26** knock sensor that is used by the powertrain control module (PCM) to detect engine detonation.
	**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?**
	28. **SLIDE 28 EXPLAIN FIGURE 29–27** 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.
	29. **SLIDE 29 EXPLAIN FIGURE 29–28** Parts of a typical spark plug.
	30. **SLIDE 30 EXPLAIN FIGURE 29–29** The heat range of a spark plug is determined by the distance the heat has to flow from the tip to the cylinder head**.**

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	ASEEDUCATION TASK TASK A1 RESEARCH APPLICABLE VEHICLE AND SERVICE INFORMATION, SUCH AS IGNITION SYSTEM IDENTIFICATION