Automotive Technology 6th Edition
Chapter 72 Ignition System Diagnosis & Service
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 learning objectives to students as listed below: 1. Explain the use of a spark tester, the procedure for ignition spark testing and ignition sensor testing. 2. Explain the construction and operation of different types of spark plugs and discuss how to inspect the spark plug wire. 3. List the steps necessary to check and/or adjust ignition timing on engines equipped with a distributor 4. Explain the diagnosis procedure when the engine does not start and the use of ignition scope testing.
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: Lesson plan is based on 6th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

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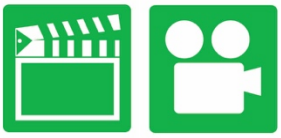
NOTE: You can use Chapter Images or possibly Power Point files:

ICONS	Chapter 72 Ignition System Diagnosis
	**1. SLIDE 1 CH72 IGNITION SYSTEM DIAGNOSIS & SERVICE**
	**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**
	**DISCUSS FREQUENTLY ASKED QUESTION:**
	**2. SLIDE 2 EXPLAIN FIGURE 72-1** adjustable spark tester that can be adjusted and should be set to at least 25,000 volts. The tester is connected to a disconnected spark plug wire or coil and the pigtail clipped to a good chassis ground. Cranking the engine should cause a spark to be seen from the spark tester.
	3. SLIDE 3 EXPLAIN Figure 72-2 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.
	**DEMONSTRATION: Show how to properly use a Spark Tester FIGURE 72-1 & 2 to check for spark**
	**EXPLAIN TECH TIP: *Always Use a Spark Tester*** **A spark tester looks like a spark plug except it has a recessed center electrode and no side electrode. The tester commonly has an alligator clip attached to the shell so that it can be clamped on a good ground connection on engine. A good ignition system should be able to cause a spark to jump this wide gap at atmospheric pressure. Without a spark tester, a technician might assume that**

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  	ignition system is okay, because it can spark across a normal, grounded spark plug. Voltage required to fire a standard spark plug when it is out of engine and not under pressure is about 3,000 volts or less. An electronic ignition spark tester requires a minimum of 25,000 volts to jump the 3/4 inch gap. Therefore, never assume that the ignition system is okay because it fires a spark plug—always use a spark tester. Remember that an intermittent spark across a spark tester should be interpreted as a no-spark condition. **DISCUSSION: DISCUSS spark color. How can spark color be used to determine spark quality?** **ON-VEHICLE ASEEDUCATION TASK** **Meets NATEF Task: (A8-A-3) Spark Plug Specifications: Research applicable vehicle and service information, such as engine management system operation, vehicle service history, service precautions, and TSBs. (P-1)** **DISCUSS CASE STUDY: *Weird Running Chevrolet Truck:* An older Chevrolet pickup truck equipped with V-8 engine was towed into a shop because it would not start. A quick check of ignition system showed that pickup coil had a broken wire below it and ignition control module. Distributor was removed from the engine and distributor shaft was removed, cleaned, and a replacement pickup coil was installed. The engine started but ran rough and hesitated when accelerator pedal was depressed. After an hour of troubleshooting, a careful inspection of new pickup coil showed that time core had six instead of eight points, meaning that new pickup coil was meant for a V-6 instead of a V-8 engine. Replacing pickup coil solved problem.** **Summary:**

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     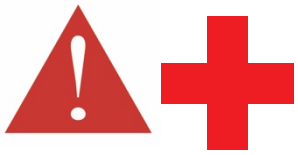  	• **Complaint—Customer stated that the truck would not start.** • **Cause—visual inspection was used to determine that a pickup coil wire was broken and was replaced, but with the wrong part that was in the correct box.** • **Correction—Replacing pickup coil with right part fixed truck.** 4. **SLIDE 4 EXPLAIN FIGURE 72–3** (a) Set digital meter to read ohms and measure between two primary terminals of the coil. Most coils are less than one ohm. (b) To measure secondary winding, connect one meter lead to one of primary terminals and other to secondary terminal. **HANDS-ON TASK: Have students test ignition coils, using ohmmeter to determine coil condition. FIGURE 72-3** **Perform Careful Visual Inspection of coil housing. Inspection will help to locate burn marks or cracks that indicate a faulty coil.** **ON-VEHICLE ASEEDUCATION TASK IGNITION COIL TESTING C2: Inspect and test crankshaft and camshaft position sensor(s); determine needed action.** **SAFETY Have students review hazards of working with electrical components. Explain to reduce chances of being shocked, they should not hold/touch a spark tester while checking for spark.** **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?** 5. **SLIDE 5 EXPLAIN FIGURE 72–4** Measuring resistance of a magnetic crankshaft position (CKP) sensor using an ohmmeter. 6. **SLIDE 6 EXPLAINFIGURE 72–5** Hall Effect sensor produces a square waveform, whereas a magnetic sensor produces an analog waveform, when viewed on scope.

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 	**DISCUSSION:** Have students talk about waveform that shows primary current flow. How will DSO (Digital Storage Oscilloscope), time, voltage, and current settings differ when checking secondary Ignition circuits? **EXPLAIN TECH TIP:** ***Bad Wire? Replace the Coil!*** When performing engine testing (such as a compression test), always ground the coil wire. Never allow the coil to discharge without a path to ground for the spark. High energy electronic ignition systems can produce 40,000 volts or more of electrical pressure. If spark cannot arc to ground, coil energy can (and usually does) arc inside coil itself, creating a low-resistance path to primary windings or steel laminations of coil. • SEE FIGURE 72–6. This low-resistance path is called a track and could cause an engine misfire under load, even though all of remaining component parts of ignition system are functioning correctly. Often, these tracks do not show up on any coil test, including most scopes. Because track is a lower-resistance path to ground than normal, it requires that ignition system be put under a load for it to be detected, and, even then, problem (engine misfire) may be intermittent. Therefore, when disabling an ignition system, perform one of following procedures to prevent possible ignition coil damage: 1. Remove the power source wire from the ignition system to prevent any ignition operation. 2. On distributor-equipped engines, remove the secondary coil wire from the center of the distributor cap and connect a jumper wire between the disconnected coil wire and a good engine ground. This ensures that secondary coil energy is safely grounded and prevents high-voltage coil damage.

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 	7. **SLIDE 7 EXPLAIN FIGURE 72–6** A track inside an ignition coil is not a short, but rather it is a low-resistance path or hole that has been burned through from the secondary wiring to the steel core. **EXPLAIN TECH TIP: *The Magnetic Pickup Tool Test*** **All ignition coils are pulsed on and off by ignition control module or PCM. When coil charges and discharges, the magnetic field around the coil changes. This pulsing of coil can be observed by holding magnetic end of a pickup tool near an operating ignition coil. The magnet at end of the pickup tool moves as magnetic field around coil changes. • SEE FIGURE 72–7.**
	8. **SLIDE 8 EXPLAIN FIGURE 72–7** If coil is working, **end of magnetic pickup tool moves with changes in magnetic field** around the coil.
	9. **SLIDE 9 EXPLAIN FIGURE 72–8** Using a vacuum hose and a grounded test light to ground one cylinder at a time on a DIS. This works on all types of ignition systems and provides a method for grounding out one cylinder at a time without fear of damaging any component. Use a standard 12-volt test light that uses a bulb because if an LED test light is used, high-voltage will harm the electronic circuit inside the test light.
	**DEMONSTRATION: Show how to use a scan tool on LAB VEHICLE to obtain engine RPM.**
	**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: test a magnetic sensor (pickup coil) using an ohmmeter to determine electrical integrity of sensor.**
	**DISCUSSION: Have the students talk about distributor indexing. How does incorrect distributor indexing affect engine operation?**

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	**10. SLIDE 10 EXPLAIN FIGURE 72–9** The relationship between the crankshaft position (CKP) sensor and the camshaft position (CMP) sensor is affected by wear in the timing gear and/or chain. **11. SLIDE 11 EXPLAIN FIGURE 72–10** When checking a coil-on-plug (COP) assembly, check that primary and secondary wiring looks normal and that coil is not discolored from arcing or corrosion.
	**DEMONSTRATION: Show how to test a magnetic sensor (pickup coil) using an AC Voltmeter to determine sensor condition FIGURE 72-10**
	**12. SLIDE 12 EXPLAIN FIGURE 72–11** When checking a waste spark-type ignition system, check that secondary wires are attached to correct coil terminal and that wiring is correctly routed to help avoid cross-fire.
	**DISCUSSION: Have the students talk about scope-testing a waste-spark system. Why is the firing voltage measured across the waste cylinder lower than the voltage measured across power cylinder?**
	**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**
	**13. SLIDE 13 EXPLAIN FIGURE 72–12** Corroded terminals on a waste-spark coil can cause misfire diagnostic trouble codes to be set. **14. SLIDE 14 EXPLAIN FIGURE 72–13** This spark plug boot on an overhead camshaft engine has been arcing to the valve cover, causing a misfire to occur. **15. SLIDE 15 EXPLAIN FIGURE 72–**14 Measuring resistance of a spark plug wire with a multimeter set to ohms position. The reading of 16.03 kO (16.030 ohms) is okay because wire is about 2-feet long. Maximum allowable resistance for a spark plug wire this long is 20 kO (20,000 ohms). High-resistance spark plug wires can cause an engine misfire, especially during acceleration.

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	**EXPLAIN TECH TIP:** ***Spark Plug Wire Pliers Are a Good Investment:*** **Spark plug wires are often difficult to remove. Using a good-quality spark plug wire plier, such as shown in • FIGURE 72–15, saves time and reduces chance of harming the wire during removal..**
	**16. SLIDE 16 EXPLAIN FIGURE 72–15** Spark plug wire boot pliers is 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. FIGURE 70-19/20/21/22**
	**Test Spark Plug Wire (View) (Download)**
	**DISCUSSION: Have students talk about difference between analog & digital signals. Does scope testing use an analog or a digital signal?**
	**17. SLIDE 17 EXPLAIN FIGURE 72–16** Always take the time to install spark plug wires back into the original holding brackets (wiring combs). **18. SLIDE 18 EXPLAIN FIGURE 72–17** 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 spark plugs help to diagnose engine operating condition?**
	**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**

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	**DISCUSSION:** **Have the students discuss the purpose of "suppression" wires. How do they work?**
	19. **SLIDE 19 EXPLAIN FIGURE 72–18** A spark plug thread chaser is a low-cost tool that hopefully is not used often, but is necessary to use to clean threads before new spark plugs are installed. 20. **SLIDE 20 EXPLAIN FIGURE 72–19** Since 1991, GM engines have been equipped with slightly (1/8 inch or 3 mm) longer spark plugs. This requires that a longer spark plug socket be used to prevent possibility of cracking a spark plug during installation. Longer socket is shown next to a normal 5/8 inch spark plug socket.
	**HANDS-ON TASK:** **Have 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**
	21. **SLIDE 21 EXPLAIN FIGURE 72–20** A normally worn spark plug that has a tapered platinum-tipped center electrode. 22. **SLIDE 22 EXPLAIN FIGURE 72–21** A worn spark plug showing fuel and/or oil deposits. 23. **SLIDE 23 EXPLAIN FIGURE 72–22** A spark plug from an engine that had a blown head gasket. The white deposits could be from additives in coolant**.**
	**DISCUSSION:** **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.**
	**DISCUSSION:** **Have the students talk about the steps for replacing spark plugs. Why should the engine be allowed to cool before removing spark plugs?**

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	**HANDS-ON TASK:** Have the students gap a set of spark plugs using proper tools.
	**DISCUSSION:** discuss oil-fouled & fuel- or carbon-fouled spark plugs. Will changing fouled spark plugs provide a long-term cure for drivability complaints?
	24. **SLIDE 24 EXPLAIN FIGURE 72–23** A platinum-tipped spark plug that is fuel soaked, indicating a fault with the fuel system or the ignition system causing the spark plug to not fire. 25. **SLIDE 25 EXPLAIN FIGURE 72–24** A water spray bottle is an excellent diagnostic tool to help find an intermittent engine misfire caused by a break in secondary ignition circuit component.
	26. **SLIDE 26 EXPLAINFIGURE 72–25** Typical timing marks. The numbers of the degrees are on stationary plate and the notch is on the harmonic balancer**.**
	27. **SLIDE 27 EXPLAIN FIGURE 72–26** initial (base) timing is where spark plug fires at idle speed. PCM then advances the timing based primarily on engine speed.
	**DISCUSSION:** discuss how initial timing changes with engine wear. Can changes be made to compensate for wear? How?
	**DISCUSSION:** discuss how firing order can be used to find companion cylinders. Where can firing order be found?
	**HANDS-ON TASK:** Provide the students with a vehicle that has incorrect firing order. Have them use specifications to inspect and correct firing order.
	**EXPLAIN TECH TIP:** ***Turn the Key Test:*** **If ignition timing is correct, a warm engine should start immediately when ignition key is turned to start position. If engine cranks a long time before starting, ignition timing may be retarded. If engine cranks slowly, ignition timing may be too far advanced. However, if the engine starts immediately, ignition timing, although it may not be**

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	**exactly set according to specification, is usually adjusted fairly close to specifications. When a starting problem is experienced, check the ignition timing first, before checking fuel system or cranking system, for a possible problem. This procedure can be used to help diagnose a possible ignition timing problem quickly without tools or equipment.** **EXPLAIN TECH TIP:** ***Two Marks Are the Key to Success:*** **When a distributor is removed from an engine, always mark direction rotor is pointing to ensure that distributor is reinstalled in correct position. Because of helical cut on distributor drive gear, the rotor rotates as distributor is being removed from engine. To help reinstall a distributor without any problems, simply make another mark where the rotor is pointing just as distributor is lifted out of engine. Then to reinstall, simply line up the rotor to the second mark and lower distributor into engine. The rotor should then line up with the original mark as a double check.**
	**DISCUSSION: Have the students discuss why some spark plugs use multiple ground electrodes. How do multiple ground electrodes affect operation and service life?**
	**DISCUSSION: Have the students discuss the difference between BTDC & ATDC. How would changes in ignition timing affect engine operation?**
	**28. SLIDE 28 EXPLAIN FIGURE 72–27** (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 the ignition timing. On DIS/EDIS systems, the connector is called SPOUT/SAW (spark output/spark angle word). **29. SLIDE 29 EXPLAIN FIGURE 72–28** Typical engine analyzer hookup that includes a scope display. (1) Coil wire on top of the distributor cap if integral type of coil; (2) number 1 spark plug connection; (3) negative side of ignition coil; (4) ground (negative) connection of battery.

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	**30. SLIDE 30 EXPLAIN FIGURE 72–29** Clip-on adapters are used with an ignition system that uses an integral ignition coil. **32. SLIDE 32 EXPLAIN FIGURE 72–30** Typical secondary ignition oscilloscope pattern**.** **33. SLIDE 33 EXPLAIN FIGURE 72–31** A single cylinder is shown at the top and a four cylinder engine at the bottom. **34. SLIDE 34 EXPLAIN FIGURE 72–32** Drawing shows what is occurring electrically at each part of scope pattern.
	**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.**
	**HANDS-ON TASK: Have students retrieve timing specifications from VECI or service information. Have them follow procedure to correctly check and adjust ignition timing**
	**35. SLIDE 35 EXPLAIN FIGURE 72–33** Typical secondary ignition pattern. Note the lack of firing lines on superimposed pattern..
	**36. SLIDE 36 EXPLAIN FIGURE 72–34** Raster is best scope position to view spark lines of all cylinders to check for differences. Most scopes display cylinder 1 at the bottom. Other cylinders are positioned by firing order above cylinder 1.
	37. SLIDE 37 EXPLAIN FIGURE 72–35 Display is only position to view firing lines of all cylinders. Cylinder 1 is displayed on the left (except for its firing line, which is shown on right). The cylinders are displayed from left to right by firing order.
	**DISCUSS CASE STUDY: *Technician's Toughie*** **The owner of a Honda Civic complained that 3 engine did not run smoothly and Check Engine light was on. Technician retrieved a P0300 (random misfire detected) as well as P0303 (cylinder number 3 misfire detected). A scope was connected to each of coils, one at a time and secondary pattern looked perfect on all**

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	four cylinders. All four coils and spark plugs were removed, yet they all looked normal. Spark plug for cylinder #3 was moved to cylinder #1, then coils were re-installed and vehicle driven on a test drive. A P0301 was then retrieved, which indicated that problem was due to spark plug itself. Replacing spark plug with a new one solved the misfire problem. The plug was apparently cracked, yet not seen. Scope showed a normal secondary pattern because voltage needed to jump to ground through crack in plug was about same as required to jump gap inside chamber. **Summary:** • Complaint—Customer stated that engine ran poorly. • Cause—Tests confirmed that one spark plug was found to be cracked. • Correction—Replacing spark plug solved engine misfire
	**38. SLIDE 38 EXPLAIN FIGURE 72–36** A downward-sloping spark line usually indicates high secondary ignition system resistance or an excessively rich air–fuel mixture. **39. SLIDE 39 EXPLAIN FIGURE 72–37** An upward-sloping spark line usually indicates a mechanical engine problem or a lean air–fuel mixture..
	**DISCUSS CHART 72-1 Spark line length depends on number of cylinders & engine speed.**
	**DISCUSSION: Have the students discuss the different parts of a typical secondary ignition pattern. What does each section represent?**
	**DISCUSSION: Have the students discuss how firing line analysis can be used to determine secondary ignition system component condition. What are common causes of abnormally high or low firing line voltage?**

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	**DEMONSTRATION:** Show different ignition system patterns (parade, raster, superimposed) and how they can be used to diagnose secondary system condition.
	**DISCUSSION:** Have the students discuss how the display or parade pattern can be used to diagnose secondary ignition system abnormalities. How does a lean mixture compare to rich mixture?
	**HANDS-ON TASK:** Have the students hook up a secondary ignition scope and use different patterns to determine secondary ignition system condition.
	**DISCUSSION:** Have the students talk about the importance of dwell & factors that affect it. How does dwell differ between distributor ignition, waste-spark, and coil-on-plug systems?
	**DISCUSSION:** Have the students discuss how firing voltage affects spark duration. How is required voltage affected by a lean cylinder?
	**HANDS-ON TASK:** Have the students use oscilloscope to perform an acceleration check to determine secondary ignition system condition.
	**HANDS-ON TASK:** Have students hook up a scan tool to see how ignition timing changes as engine speed and 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?
	40. **SLIDE 40 EXPLAIN FIGURE 72–38** relationship between the height of firing line and length of spark line can be illustrated using a rope. Because energy cannot be destroyed, stored energy in an ignition coil must dissipate totally, regardless of engine operating conditions.. 41. **SLIDE 41 EXPLAIN FIGURE 72–39** dual-trace scope pattern showing both the power and the waste spark from the same coil (cylinders 1 and 6). Note that the firing line is higher on the cylinder that is under compression (power); otherwise, both patterns are almost identical.

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	**DEMONSTRATION: Show how to properly hook up an ignition oscilloscope to check secondary ignition patterns. Be sure to discuss how voltage and time divisions can be changed on many scopes.**
	**DEMONSTRATION: Show how to prepare a DSO (Digital Storage Oscilloscope) to obtain primary circuit patterns.**
 	**ON-VEHICLE ASEEDUCATION TASK C4: Remove and replace spark plugs; inspect secondary ignition components for wear and damage.**
	**DISCUSSION: Have the students talk about analysis of waveforms. What should you look for when analyzing waveforms to determine ignition coil condition?**
	**DISCUSSION: Have the students discuss the difference between the terms shorted and open. How do these terms relate to coils?**
	**DISCUSSION: Have the students discuss how scope connection points differ between distributor, waste-spark, and coil on-plug systems. Are any special adapters needed? Are there any difficulties you may face when testing different types of systems?**
	**42. SLIDE 42 EXPLAIN FIGURE 72–40** secondary waveform of a Ford 4.6 liter V-8, showing three sparks occurring at idle speed.
 	**ON-VEHICLE ASEEDUCATION TASK C1: Diagnose (troubleshoot) ignition system related problems such as no-starting, hard starting, engine misfire, poor driveablility, spark knock, power loss, poor mileage, and emissions concerns; determine needed action.**

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	**ON-VEHICLE ASEEDUCATION TASK C3** **Inspect, test, and/or replace ignition control module, powertrain/engine control module; reprogram/initialize as needed.**