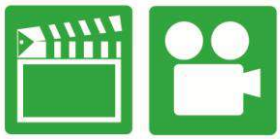
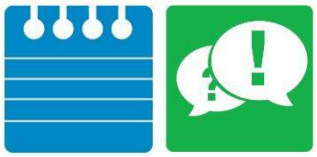
Automotive Electrical & Engine Performance 7/E

Chapter 32 Oxygen Sensors

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	**This course or class covers Automotive Electrical & Engine Performance. 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 this session or class.	Explain the chapter learning objectives to the students. 1. Prepare for ASE Engine Performance (A8) certification test content area "E" (Computerized Engine Controls Diagnosis and Repair). 2. Discuss how oxygen sensors (O2S) work. 3. List the methods that can be used to test oxygen sensors. 4. Describe how a wide-band oxygen sensor works. 5. List how to test narrow- and wide-band oxygen sensors
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 7/E Chapter Images found on Jim's web site @ www.jameshalderman.com
LINK CHP 32: Chapter Images

ICONS	Ch32 Oxygen Sensors
	**1. SLIDE 1 CH32 Oxygen Sensors**
	**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 32-1** Many oxygen sensors are located in exhaust manifold near its outlet so that the sensor can detect the presence or absence of oxygen in the exhaust stream for all cylinders that feed into the manifold
	**DEMONSTRATION: PUT OBD-II VEHICLE ON A LIFT, SHOW STUDENTS THE OXYGEN SENSORS. POINT OUT AND EXPLAIN UPSTREAM AND DOWNSTREAM SENSORS TO THEM. FIGURE 32-1**
	**DISCUSSION: HAVE THE STUDENTS DISCUSS OXYGEN SENSORS. HOW DO O_2 SENSORS HELP ACHIEVE CORRECT AIR-FUEL RATIO?**
	**DEMONSTRATION: SHOW CONVENTIONAL O_2 SENSOR THAT USES ZIRCONIUM DIOXIDE. FIGURE 32-1**
	**3. SLIDE 3 EXPLAIN Figure 32.2A** When exhaust is **lean**, output of a zirconia oxygen sensor is **below 450 mV**. **4. SLIDE 4 EXPLAIN Figure 32.2B** When exhaust is **rich**, output of a zirconia oxygen sensor is **above 450 mV** **5. SLIDE 5 EXPLAIN Figure 32-3** Most conventional Zirconia oxygen sensors and some wide-band oxygen sensors use the cup (finger) type of design

ICONS	Ch32 Oxygen Sensors
	6. **SLIDE 6 EXPLAIN Figure 32.4** A typical heated zirconia oxygen sensor, showing the sensor signal circuit that uses the outer (exhaust) electrode as the negative and the ambient air side electrode as the positive.
	7. **SLIDE 7 EXPLAIN Figure 32-5** oxygen sensor provides a quick response at stoichiometric air–fuel ratio of 14.7:1
	**DISCUSSION: DISCUSS CUTAWAY VIEWS OF OXYGEN SENSORS IN FIGURES 32–2, 3, & 4. CALL THEIR ATTENTION TO ATMOSPHERE TAG IN FIGURES 32–3 4. OXYGEN SENSORS HAVE TO "BREATHE" IN ORDER TO WORK.**
	**DISCUSSION: DISCUSS 1-, 2-, 3-, & 4-WIRE OXYGEN SENSORS. WHAT IS THE SAME ABOUT THESE SENSORS, AND WHAT IS DIFFERENT?**
	8. **SLIDE 8 EXPLAIN FIGURE 32–6** Number and label designations for oxygen sensors. Bank 1 is the bank where cylinder number 1 is located
	**DEMONSTRATION: USE SCAN TOOL TO SHOW BIAS VOLTAGE. HAVE THEM WATCH DATA STREAM WHEN VEHICLE IS STARTED TO SEE HOW LONG IT TAKES FOR OXYGEN SENSOR TO OVERRIDE BIAS VOLTAGE FIGURE 32-5**
	**DISCUSS FREQUENTLY ASKED QUESTION**
	**DISCUSS REAL WORLD FIX**
	**DISCUSS FREQUENTLY ASKED QUESTION**
	**DISCUSSION: DISCUSS WIDE BAND SENSOR AND ITS OPERATING CHARACTERISTICS. HOW IS IT DIFFERENT FROM ZIRCONIA SENSOR?**
	**DEMONSTRATION: SHOW LOCATIONS OF OXYGEN SENSORS. SHOW THEM NUMBER 1, NUMBER 2, UPSTREAM, AND DOWNSTREAM SENSORS, IF APPLICABLE. FIGURE 32-6**

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         	**DISCUSS REAL WORLD FIX** **IT MAY BE NECESSARY TO ACCESS TUNE-UP SPECS & DIAGRAMS TO ACCURATELY IDENTIFY BANK 1 ON DIFFERENT V6 & V8 ENGINES.** 9. **SLIDE 9 EXPLAIN FIGURE 32–7** The OBD-II catalytic converter monitor compares the signals of the upstream and downstream oxygen sensor to determine converter efficiency **DISCUSSION: HAVE THE STUDENTS DISCUSS OPEN-LOOP & CLOSED-LOOP ENGINE OPERATION. WILL AN ENGINE THAT RUNS WELL IN OPEN LOOP ALSO RUN WELL IN CLOSED LOOP?** **DISCUSSION: HAVE STUDENTS TALK ABOUT HOW PCM USES THE OXYGEN SENSOR TO TEST OTHER SYSTEMS. WHAT HAPPENS WITH OTHER SYSTEMS IF A FAULT OCCURS WITH AN OXYGEN SENSOR? FIGURE 32-7** **DISCUSSION: HAVE THE STUDENTS DISCUSS THE NECESSITY OF INSPECTING AN OLD OXYGEN SENSOR. WHAT CAN BE DETERMINED BY CONDITION OF SENSOR?** **DISCUSS REAL WORLD FIX** 10. **SLIDE 10 EXPLAIN Figure 32-8** Testing oxygen sensor using DMM set on DC volts. With engine operating in closed loop, oxygen voltage should read over 800 mV & < 200 mV & be constantly fluctuating. **DEMONSTRATION: SHOW EXAMPLES OF OXYGEN SENSORS THAT HAVE FAILED DUE TO OTHER PROBLEMS. ASK THEM TO IDENTIFY CAUSE OF FAILURE. WORK WITH STUDENTS TO TEST AN OXYGEN SENSOR WITH DMM. FIGURE 32-8** **DISCUSSION: DISCUSS THE CONDITIONS THAT CAN CAUSE A FALSE RICH INDICATION BY THE OXYGEN SENSOR. COULD ANYTHING ELSE BE CAUSE OF A FALSE INDICATION?**

ICONS	Ch32 Oxygen Sensors
	**DEMONSTRATION: SHOW EXAMPLES OF OXYGEN SENSORS THAT HAVE FAILED**
	**DISCUSSION: HAVE THE STUDENTS DISCUSS THE CONDITIONS THAT CAN CAUSE A FALSE LEAN INDICATION BY THE OXYGEN SENSOR. COULD ANYTHING ELSE BE CAUSE OF A FALSE INDICATION?**
	**HANDS-ON TASK: HAVE STUDENTS SELECT AND MONITOR OXYGEN SENSOR MIN-MAX VOLTAGE WITH A DMM. HAVE THEM CHART MINIMUM AND MAXIMUM READINGS OBSERVED ON SENSORS DURING A RUN CYCLE. GRADE STUDENTS ON PROPER OPERATION OF DMM MIN AND MAX FUNCTIONS AS WELL AS THE VOLTAGE READINGS OBSERVED. FIGURE 32-8**
	11. **SLIDE 11 EXPLAIN Figure 32-9** Using a digital multimeter to test an oxygen sensor using the MIN/MAX record function of the meter
	**EXPLAIN TECH-TIP**
	**DISCUSS CHART 32–1** test results of using DMM set to read minimum and maximum values while testing a narrow-band oxygen sensor. Check for an exhaust leak upstream from O_2S or ignition misfire that can cause a false lean indication before further diagnosis
	**DISCUSSION: DISCUSS MIN-MAX TEST RESULTS IN CHART 32–1. IS IT POSSIBLE FOR A DEFECTIVE SENSOR TO WORK WELL ENOUGH THAT IT DOESN'T SET A DTC?**
	**DEMONSTRATION: SHOW HOW TO MONITOR OXYGEN SENSOR DATA WITH A SCAN TOOL. ASK THEM TO IDENTIFY THE LOCATION OF THE SENSORS TESTED.**
	**DISCUSSION: HAVE STUDENTS DISCUSS FREQUENCY AT WHICH AN OXYGEN SENSOR SWITCHES. WHAT HAPPENS IF THE SENSOR SWITCHES TOO SLOWLY?**

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	**DISCUSS REAL WORLD FIX**
	EXPLAIN TECH-TIP
	**12. SLIDE 12 EXPLAIN Figure 32-10** Connecting a handheld digital storage oscilloscope to an oxygen sensor signal wire. Check the instructions for the scope as some require the use of a filter to be installed in the test lead to reduce electromagnetic interference that can affect the oxygen sensor waveform.
	**DEMONSTRATION: SHOW HOW TO USE A SCOPE TO TEST AN OXYGEN SENSOR. HAVE THEM IDENTIFY THE HIGH AND LOW VOLTAGE READINGS ON THE SCOPE. FIGURE 32-10**
	**13. SLIDE 13 EXPLAIN Figure 32-11** waveform of a good oxygen sensor as displayed on a **digital storage oscilloscope (DSO).** Note that the maximum reading is above 800 mV and minimum reading is < 200 mV.
	**O2 SENSOR VOLT CHECK**
	**DEMONSTRATION: SHOW DATA STREAM ON A DOWNSTREAM OXYGEN SENSOR. COMPARE IT TO READING ON AN UPSTREAM SENSOR. PERFORM ALL DEMONSTRATIONS AHEAD OF TIME TO BE SURE THE RESULTS ARE APPROPRIATE FOR THE DEMONSTRATION.**
	**DISCUSSION: STUDY FIGURE 32–12 AND COMPARE NORMAL (GOOD CONVERTER) & ABNORMAL (BAD CONVERTER) AFTER CONVERTER OXYGEN SENSOR READINGS. COULD THIS TEST BE USED TO DIAGNOSE ANY OTHER PROBLEMS?**
	FIGURES 32-11 & 12
	**DISCUSSION: HAVE THE STUDENTS DISCUSS TESTING DOWNSTREAM OXYGEN SENSOR. WHAT DOES THIS SENSOR REALLY DO?**

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	**14. SLIDE 14 EXPLAIN Figure 32-12** post catalytic converter oxygen sensor should display very little activity if the catalytic converter is efficient
	**EXPLAIN TECH-TIP**
	**DISCUSS REAL WORLD FIX**
	**15. SLIDE 15 EXPLAIN FIGURE 32–13** conventional Zirconia oxygen sensor can only reset to exhaust mixtures that are richer or leaner than 14.7:1 (lambda 1.00).
	**DISCUSS FREQUENTLY ASKED QUESTION**
	**16. SLIDE 16 EXPLAIN FIGURE 32-14** planar design Zirconia oxygen sensor places all of the elements together, which allows the sensor to reach operating temperature quickly.
	**DISCUSSION: DISCUSS PLANAR DESIGN OF THE WIDE-BAND OXYGEN SENSOR. WHAT IS THE MAIN ADVANTAGE OF THIS DESIGN? FIGURE 32-14**
	**17. SLIDE 17 EXPLAIN FIGURE 32–15** reference electrodes are shared by Nernst cell and pump cell.
	18. SLIDE 18 EXPLAIN FIGURE 32–16 When the exhaust is rich, the PCM applies a negative current into the pump cell
	**DISCUSSION: HAVE THE STUDENTS TALK ABOUT ULEV AND SULEV EMISSIONS SYSTEMS. WHY DO THESE EMISSIONS RATINGS REQUIRE MORE PRECISE FUEL MANAGEMENT STRATEGIES?**
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	**DISCUSSION: ASK THE STUDENTS TO DISCUSS THE DUAL CELL, PLANAR-TYPE, WIDE-BAND OXYGEN SENSOR. IN WHAT MAJOR WAY DOES CONSTRUCTION OF THIS SENSOR DIFFER FROM THAT OF A CONVENTIONAL SENSOR?**
	19. **SLIDE 19 EXPLAIN FIGURE 32-17** When exhaust is lean, PCM applies a positive current into the pump cell.
	**DISCUSSION: ASK THE STUDENTS TO DISCUSS STOICHIOMETRIC READING IN THE EXHAUST AND FACT THAT THE OXYGEN SENSOR CALCULATES THIS AIR-FUEL RATIO AT 14.7:1. FIGURE 32-17**
	**DISCUSSION: DISCUSS NUMBER OF WIRES NEEDED FOR AN OXYGEN SENSOR TO OPERATE. THEY CAN USE WIRING DIAGRAMS OF SINGLE-, THREE-, FOUR-, FIVE-, OR SIX-WIRE SENSORS.**
	**EXPLAIN CHART 32–2** comparison showing what a factory scan tool and a generic OBD-II scan tool might display at various air-fuel ratios
	**DISCUSSION: ASK STUDENTS TO LOOK AT CHART 32–2. WHAT IS NOTICEABLE ABOUT FACTORY AND GENERIC SETTINGS? POINT OUT DIRECT CORRELATION BETWEEN THE VOLTAGE READINGS IN FACTORY & GENERIC SETTINGS. CHART 32–2.**
	**DISCUSSION: HAVE THE STUDENTS DISCUSS STEPS FOR TESTING A WIDE-BAND OXYGEN SENSOR. WHY IS IT NECESSARY TO CHECK SERVICE INFORMATION FIRST?**
	20. **SLIDE 20 EXPLAIN FIGURE 32-18** Testing dual cell wide-band oxygen sensor can be done using a voltmeter or a scope. The meter reading is attached to Nernst cell and should read stoichiometric (450 mV) at all times. Scope is showing activity to pump cell with commands from PCM to keep Nernst cell at 14.7:1 air-fuel ratio
	**DEMONSTRATION: IF AVAILABLE, SHOW STUDENTS DATA STREAM READINGS USING FACTORY SCAN TOOL AND GENERIC SCAN TOOL. HAVE THEM OBSERVE DIFFERENCE IN READINGS,**

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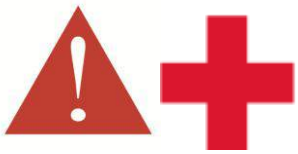
	**IF THEY ARE DIFFERENT. FIGURE 32-18 EXPLAIN WHAT A BREAKOUT BOX IS. ASK THEM TO DECIDE WHETHER A BREAKOUT BOX WOULD BE BENEFICIAL IN TESTING DUAL CELL WIDE-BAND OXYGEN SENSOR SHOWN IN FIGURE 32-18**
	21. **SLIDE 21 EXPLAIN Figure 32-19** single cell wide-band oxygen sensor has four wires with two for heater and two for sensor itself. The voltage applied to sensor is 0.4 V (3.3 − 2.9 = 0.4) across two leads of sensor.
	**DISCUSSION: HAVE THE STUDENTS DISCUSS SINGLE CELL WIDEBAND OXYGEN SENSORS. HOW ARE THEY SIMILAR TO OTHER SENSORS?**
	**SAFETY DISCUSS IMPORTANCE OF USING PROPER TERMINALS WHEN TESTING ANY SENSOR, ESPECIALLY WHEN BACK-PROBING CONNECTORS. EXPLAIN THAT PIERCING WIRES THAT WILL BE EXPOSED TO ELEMENTS IS NOT AN ACCEPTED TESTING PROCEDURE.**
	**DISCUSSION: HAVE THE STUDENTS DISCUSS FACT THAT A WIDE-BAND OXYGEN SENSOR CAN CAUSE AN ENGINE TO OPERATE EXTREMELY LEAN, BUT STILL FAIL TO TRIGGER A DTC. WHY MIGHT UNPLUGGING A SENSOR CAUSE THE ENGINE TO OPERATE CORRECTLY?**
	22. **SLIDE 22 EXPLAIN FIGURE 32–20** The scan tool can display various voltage but will often show 3.3 volts because the PCM is controlling the sensor by applying a low current to the sensor to achieve balance.
	**ON-VEHICLE NATEF TASK INSPECT AND TEST OXYGEN O_2 SENSOR USING GMM)/(DSO); PERFORM NECESSARY ACTION**
	**ON-VEHICLE NATEF TASK INSPECT AND TEST WIDE-BAND OXYGEN O_2 SENSOR USING GMM)/(DSO); PERFORM NECESSARY ACTION**