Automotive Technology 5th Edition
Chapter 76 OXYGEN SENSORS
Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This 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 as listed on NEXT SLIDE. 1. Discuss how O2S sensors work. 2. List the methods that can be used to test oxygen sensors. 3. Describe the symptoms of a failed OS2 sensor. 4. Explain the operation of wide-band oxygen sensors. 5. Compare dual cell wide-band sensors to single cell wide-band sensors. 6. Describe wide-band oxygen pattern failures and interpret oxygen sensor-related diagnostic trouble codes.
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 the 5th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

LINK CHP 76: ATE5 Chapter Images

ICONS	Chapter 76 OXYGEN SENSORS

1. **SLIDE 1 Chapter 76 Oxygen Sensors**

Check for ADDITIONAL VIDEOS & ANIMATIONS @
http://www.jameshalderman.com/
WEB SITE IS CONSTANTLY UPDATED

Videos

2. **SLIDE 2 EXPLAIN Figure 76-1** 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 an OBD-II vehicle on a LIFT and show students the oxygen sensors. Point out and explain upstream and downstream sensors to them. FIGURE 76-1

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 76-1

3. **SLIDE 3 EXPLAIN Figure 76-2 (a)** exhaust is lean, the output of a Zirconia oxygen sensor is below 450 mV.
4. **SLIDE 4 EXPLAIN Figure 76-2 (b)** exhaust is rich, the output of a Zirconia oxygen sensor is above 450 mV.
5. **SLIDE 5 EXPLAIN Figure 76-3** Most conventional Zirconia oxygen sensors and some wide-band oxygen sensors use the cup (finger) type of design.
6. **SLIDE 6 EXPLAIN Figure 76-4** 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

DISCUSSION: Have students discuss cutaway views of oxygen sensors in FIGURES 76–2, 76–3, & 76–4. Call their attention to atmosphere tag in FIGURES 76–3 & 76–4. Oxygen sensors have

to "breathe" in order to work.

DISCUSSION: **Have the students talk about 1-, 2-, 3-, & 4-wire oxygen sensors. What is the same about these sensors, and what is different?**

7. **SLIDE 7 EXPLAIN Figure 76-5** The oxygen sensor provides a quick response at the stoichiometric air-fuel ratio of 14.7:1.s

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 76-5

Dual Cell O2 Sensor Voltage Check (View) (Download)
O2 Sensor Volt Check (View) (Download)
Test O2 Sensor (View) (Download)
Wide Band O2 Sensor (View) (Download)

DISCUSSION: **Ask the students to discuss the Titania Oxygen Sensor and its operating characteristics. How is it different from Zirconia sensor?**

It may be necessary to access tune-up specs & diagrams to accurately identify bank 1 on different V6 & V8 engines.

DEMONSTRATION: **Show the typical locations of oxygen sensors on a vehicle. Show them number 1, number 2, upstream, and downstream sensors, if applicable. FIGURE 76-6**

8. **SLIDE 8 EXPLAIN FIGURE 76-6** Number and label designations for oxygen sensors.
9. **SLIDE 9 EXPLAIN FIGURE 76-7** OBD-II catalytic converter monitor compares signals of 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?**

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	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 76-7**
	DISCUSSION: **Have the students discuss the necessity of inspecting an old oxygen sensor. What can be determined by condition of sensor?**
	10. **SLIDE 10 EXPLAIN Figure 76-8** Testing an oxygen sensor using a DMM set on DC volts. With the engine operating in closed loop, the oxygen voltage should read over 800 mV and lower than 200 mV and be constantly fluctuating.
	DEMONSTRATION: **Show examples of oxygen sensors that have failed due to other problems with the vehicle. Ask them to identify cause of failure. Work with students to test an oxygen sensor with DMM. FIGURE 76-8**
	DISCUSSION: **Have the students discuss the conditions that can cause a false rich indication by the oxygen sensor. Could anything else be cause of a false indication?**
	DEMONSTRATION: **Show examples of oxygen sensors that have failed. Try to show examples that demonstrate the specific failure causes**
	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 76-8**
	11. **SLIDE 11 EXPLAIN Figure 76-9** Using a digital multimeter to test an oxygen sensor using the MIN/MAX record function of the meter.

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	DISCUSSION: DISCUSS min-max test results in Chart 76–1. 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?
	12. **SLIDE 12 EXPLAIN Figure 76-10** 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 the students how to use a scope to test an oxygen sensor. Have them identify the high and low voltage readings on the scope. FIGURE 76-10
	13. **SLIDE 13 EXPLAIN Figure 76-11** 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.
	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: discuss testing downstream oxygen sensor. What does this sensor really do?
	14. **SLIDE 14 EXPLAIN Figure 76-12** The post catalytic converter oxygen sensor should display very little activity if the catalytic converter is efficient
	DISCUSSION: study Figure 76–12 compare normal (good converter) & abnormal (bad converter) after converter oxygen sensor readings. Could this test be used to diagnose other problems? FIGURES 76-11 & 12

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	15. **SLIDE 15 EXPLAIN Figure 76-13** A conventional Zirconia oxygen sensor can only reset to exhaust mixtures that are richer or leaner than 14.7:1 (lambda 1.00).
	DISCUSSION: Have the students talk about wide-band oxygen sensors. What does "wide-band" mean?
	DISCUSSION: Explain to the students operation of conventional oxygen sensors on a 14.7:1 air-fuel ratio. Is this ratio accurate enough? **FIGURE 76-13**
	16. **SLIDE 16 EXPLAIN Figure 76-14** A planar design Zirconia oxygen sensor places all of the elements together, which allows the sensor to reach operating temperature quickly.
	DISCUSSION: Have the students discuss the planar design of the wide-band oxygen sensor. What is the main advantage of this design? **FIGURE 76-14**
	17. **SLIDE 17 EXPLAIN Figure 76-15** reference electrodes are shared by Nernst cell and 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?
	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?
	18. **SLIDE 18 EXPLAIN Figure 76-16** When exhaust is rich, PCM applies a negative current into the pump cell. 19. **SLIDE 19 EXPLAIN Figure 76-17** When exhaust is lean, the PCM applies a positive current into 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 76-16

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	DISCUSSION: Ask the students to discuss the **number of wires needed** for an oxygen sensor to operate. They can use wiring diagrams of single-, three-, four-, five-, or six-wire sensors.
	DISCUSSION: Ask students to look at **Chart 76–2.** What is noticeable about factory and generic settings? Point out direct correlation between the voltage readings in factory & generic settings. **Chart 76–2.**
	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 76-18** Testing a dual cell wide-band oxygen sensor can be done using a voltmeter or a scope. Meter reading is attached to Nernst cell and should read stoichiometric (450 mV) at all times. The 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, if they are different. **FIGURE 76-18**
	Explain to the students 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 76–18.
	21. **SLIDE 21 EXPLAIN Figure 76-19** single cell wide-band oxygen sensor has 4 wires with two for 4 heater and two for the sensor itself. The voltage applied to 4 sensor is 0.4 V (3.3 − 2.9 = 0.4) across the two leads of 4 sensor
	DISCUSSION: Have the students discuss **single cell** wideband oxygen sensors. How are they similar to other sensors? **FIGURE 76-19**
	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.

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	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? **ON-VEHICLE NATEF TASK:** Inspect and test **OXYGEN O_2 Sensor** using GMM)/(DSO); perform necessary action. **Page 242** **ON-VEHICLE NATEF TASK (A8-B-5)** Inspect and test **WIDE-BAND OXYGEN O_2 Sensor** using GMM)/(DSO); perform necessary action. **Page 243** **Crossword Puzzle (Microsoft Word) (PDF)** **Word Search Puzzle (Microsoft Word) (PDF)**