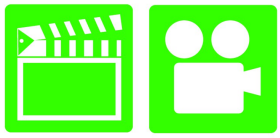
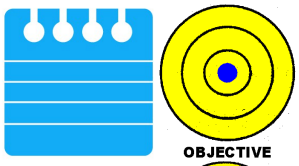
A8 Engine Performance 4th Edition

Chapter 24 Oxygen Sensors

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers operation and service of **Automotive 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 O2S sensors work. 3. List the methods that can be used to test O2S sensors. 4. Describe the symptoms of a failed O2S Sensor. 5. List how the operation of the O2S sensor affects vehicle operation.
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.

ICONS	Ch24 Oxygen Sensors
	1. SLIDE 1 CH24 Oxygen Sensors
	Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/ WEB SITE REGULARLY UPDATED
	POWER POINTS DONE BY INDIVIDUAL LEARNING OBJECTIVES, SO THERE IS POWER POINT FILE FOR EACH LEARNING OBJECTIVE
	2. SLIDE 2 EXPLAIN OBJECTIVE CH24 AEP_LO1 3. SLIDE 3 EXPLAIN Figure 24-1 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
	ANIMATION: OXYGEN SENSOR EXERCISE WWW.MYAUTOMOTIVELAB.COM HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET_MYAUTOMOTIVELAB_2/ANIMATIONS/A16_ANIMATION/CHAPTER55_FIG_55_34/INDEX.HTM
	DEMONSTRATION: PUT OBD-II VEHICLE ON A LIFT, SHOW STUDENTS THE OXYGEN SENSORS. POINT OUT AND EXPLAIN UPSTREAM AND DOWNSTREAM SENSORS TO THEM. FIGURE 24-1
	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 24-1
	4. SLIDES 4-6 EXPLAIN Oxygen Sensors: Construction and Operation
	7. SLIDE 7 EXPLAIN FIGURE 24–2 A cross-sectional view of a typical Zirconia oxygen sensor 8. SLIDE 8 EXPLAIN FIGURE 24–3 difference in oxygen content between the atmosphere and the exhaust gases enables an O2S sensor to generate voltage
	

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	9. **SLIDE 9 EXPLAIN Figure 24-4** oxygen sensor provides a quick response at stoichiometric air–fuel ratio of 14.7:1. 10. **SLIDE 10 EXPLAIN** Oxygen Sensors CONSTRUCTION AND OPERATION
	**DISCUSSION: DISCUSS VIEWS OF O2S SENSORS IN FIGURES 24–2, 3, & 4. CALL THEIR ATTENTION TO ATMOSPHERE TAG IN FIGURES 24–3 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?**
	11. **SLIDE 11 EXPLAIN FIGURE 24–5** A typical Zirconia oxygen sensor. 12. **SLIDE 12 EXPLAIN** Zirconia Oxygen Sensors
	**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 24-5**
	13. **SLIDES 13-15 EXPLAIN Titania Oxygen Sensor**
	**DISCUSSION: ASK THE STUDENTS TO DISCUSS THE TITANIA OXYGEN SENSOR AND ITS OPERATING CHARACTERISTICS. HOW IS IT DIFFERENT FROM ZIRCONIA SENSOR?**
	16. **SLIDE 16 EXPLAIN FIGURE 24–6** Number and label designations for oxygen sensors. Bank 1 is the bank where cylinder number 1 is located 17. **SLIDES 17-19 EXPLAIN CLOSED/OPEN LOOP** 20. **SLIDES 20-23 EXPLAIN** PCM Uses of Oxygen Sensor
	**IT MAY BE NECESSARY TO ACCESS TUNE-UP SPECS & DIAGRAMS TO ACCURATELY IDENTIFY BANK 1 ON DIFFERENT V6 & V8 ENGINES.**

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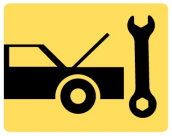
DEMO	**DEMONSTRATION: SHOW THE TYPICAL LOCATIONS OF OXYGEN SENSORS ON A VEHICLE. SHOW THEM NUMBER 1, NUMBER 2, UPSTREAM, AND DOWNSTREAM SENSORS, IF APPLICABLE. FIGURE 15-6**
	24. **SLIDES 24-25 EXPLAIN** Oxygen Sensor Diagnosis Sensor 26. **SLIDE 26 EXPLAIN FIGURE 24–7** The OBD-II catalytic converter 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 24-7**
	**DISCUSSION: DISCUSS THE NECESSITY OF INSPECTING AN OLD OXYGEN SENSOR. WHAT CAN BE DETERMINED BY CONDITION OF SENSOR?**
	27. **SLIDE 27 EXPLAIN** Oxygen Sensor Diagnosis 28. **SLIDE 28 EXPLAIN Figure 24-8** 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.
DEMO	**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 24-8**
	**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	Ch24 Oxygen Sensors
	**DEMONSTRATION: SHOW EXAMPLES OF OXYGEN SENSORS THAT HAVE FAILED. TRY TO SHOW EXAMPLES THAT DEMONSTRATE THE SPECIFIC FAILURE CAUSES LISTED ON PAGE 851.**
	**DISCUSSION: 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 24-8**
	**VIDEO: 1 MIN OXYGEN SENSOR WAVEFORM ANALYSIS WWW.MYAUTOMOTIVELAB.COM** HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET_MYLABS/AKAMAI/TEMPLATE/VIDEO640X480.PHP?TITLE=ANALYZING%20OXYGEN%20SENSOR%20WAVEFORMS&CLIP=PANDC/CHET/2012/AUTOMOTIVE/ADVANCED_DRIVABILITY/L1T6.MOV&CAPTION=CHET/CHET_MYLABS/AKAMAI/2012/AUTOMOTIVE/OBD2_GM/XML/L1T6.XML
	29. **SLIDE 29 EXPLAIN Figure 24-9** Using a digital multimeter to test an oxygen sensor using the MIN/MAX record function of the meter
	**DISCUSSION: DISCUSS MIN-MAX TEST RESULTS IN CHART 24–1. 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?**
	30. **SLIDE 30 EXPLAIN Figure 24-10** Connecting handheld digital storage oscilloscope to an oxygen sensor signal wire. Check scope instructions as some require use of a filter to be installed in the test lead to reduce electromagnetic interference that can affect waveform

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DEMO	**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 15-10**
	31. **SLIDE 31 EXPLAIN Figure 24-11** 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.
DEMO	**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.**
 QUESTION	**DISCUSSION: ASK STUDENTS TO STUDY FIGURE 24–12 AND COMPARE NORMAL (GOOD CONVERTER) & ABNORMAL (BAD CONVERTER) AFTER CONVERTER OXYGEN SENSOR READINGS. COULD THIS TEST BE USED TO DIAGNOSE ANY OTHER PROBLEMS? FIGURES 24-11 & 12**
 QUESTION	**DISCUSSION: HAVE THE STUDENTS DISCUSS TESTING DOWNSTREAM OXYGEN SENSOR. WHAT DOES THIS SENSOR REALLY DO?**
	32. **SLIDE 32 EXPLAIN Figure 24-12** post catalytic converter oxygen sensor should display very little activity if the catalytic converter is efficient 33. **SLIDE 33 EXPLAIN FIGURE 24–13** Using the cursors on the oscilloscope, the high- and low-oxygen sensor values can be displayed on the screen 34. **SLIDE 34 EXPLAIN FIGURE 24–14** When the air–fuel mixture rapidly changes such as during a rapid acceleration, look for a rapid response. The transition from low to high should be less than 100 ms. 35. **SLIDE 35 EXPLAIN FIGURE 24–15** Adding propane to the air inlet of an engine operating in closed loop with a working oxygen sensor causes the oxygen sensor voltage to read high. 36. **SLIDE 36 EXPLAIN FIGURE 24–16** When propane is shut off, the oxygen sensor should read below 200 Mv

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	37. SLIDE 37-38 EXPLAIN OXYGEN SENSOR WAVEFORM ANALYSIS 39. SLIDE 39 EXPLAIN FIGURE 24–17 When the O2S voltage rises above 450 mV, the PCM starts to control the fuel mixture based on oxygen sensor activity. 40. SLIDE 40 EXPLAIN FIGURE 24–18 Normal oxygen sensor frequency is from about one to five times per second.
	41. SLIDES 41-42 EXPLAIN HASH 43. SLIDE 43 EXPLAIN FIGURE 24–19 Significant hash can be caused by faults in one or more cylinders, whereas amplified hash is not as important for diagnosis. 44. SLIDE 44 EXPLAIN FIGURE 24–20 Moderate hash may or may not be significant for diagnosis. 45. SLIDE 45 EXPLAIN FIGURE 24–21 Severe hash is almost always caused by cylinder misfire conditions. 46. SLIDE 46 EXPLAIN FIGURE 24–22 ignition- or mixture-related misfire can cause hash on oxygen sensor waveform. 47. SLIDE 47 EXPLAIN FIGURE 24–23 An injector imbalance can cause a lean or a rich misfire
 	2. SLIDE 2 EXPLAIN OBJECTIVE CH24 AEP_LO2 3. SLIDES 3-5 EXPLAIN NEGATIVE O2S VOLTAGE
	6. SLIDE 6 EXPLAIN FIGURE 24–24 Negative reading oxygen sensor voltage can be caused by several problems
	7. SLIDE 7 EXPLAIN LOW O2S READINGS 8. SLIDES 8-9 EXPLAIN LOW O2S READINGS FALSE/LEAN 10. SLIDES 10-13 EXPLAIN HIGH O2S READINGS 14. SLIDE 14 EXPLAIN POST-CATALYTIC CONVERTER OXYGEN SENSOR TESTING 15. SLIDE 15 EXPLAIN FIGURE 24–25 The post-catalytic converter oxygen sensor should display very little activity if the catalytic converter is efficient. 16. SLIDES 16-17 EXPLAIN OXYGEN SENSOR VISUAL INSPECTION

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	18. **SLIDE 18 EXPLAIN FIGURE 24–26** The target lambda on this vehicle is slightly lower than 1.0 indicating that the PCM is attempting to supply the engine with an air–fuel mixture that is slightly richer than stoichiometric. Multiply the lambda number by 14.7 to find the actual air–fuel ratio
	2. **SLIDE 2 EXPLAIN OBJECTIVE CH24 AEP_LO3** 3. **SLIDE 3 EXPLAIN DIAGNOSTIC TROUBLE CODES**