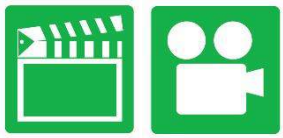
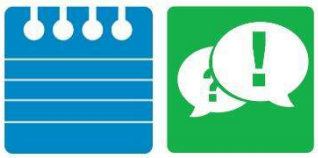
Automotive Electrical & Engine Performance 7/E

Chapter 43 Fuel Cells & Advanced Technologies

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 learning objectives to students as listed on NEXT SLIDE. 1. Understand the technology of fuel cells. 2. Explain fuel-cell vehicle systems. 3. Discuss hydraulic hybrid storage systems. 4. Explain homogeneous charge compression ignition (HCCI). 5. Discuss plug-in hybrid electric vehicles (PHEVs)
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 43:Chapter Images

ICONS	Ch43Fuel Cells & Advanced Technologies
	**1. SLIDE 1 CH43 FUEL CELLS AND ADVANCED TECHNOLOGIES**
	**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. SLIDE2EXPLAINFigure 43-1** Ford Motor Company has produced a number of demonstration fuel-cell vehicles based on the Ford Focus. **3. SLIDE 3EXPLAINFigure 43-2** Hydrogen does not exist by itself in nature. Energy must be expended to separate it from other, more complex materials.
	**DISCUSSION:Have the students compare and contrast operation of internal combustion engine vehicles, fuel-cell vehicles, fuel-cell hybrid vehicles, and hybrid electric vehicles. What are advantages of powering vehicles with a fuel cell?** **FIGURES 43-1 & 3**
	**DISCUSSION:Have the students talk about fuel cell technology. As a fuel, how does hydrogen compare to fossil fuel? FIGURE 43-2**
	**4. SLIDE 4EXPLAINFigure 43-3** Mercedes-Benz B-Class fuel-cell car was introduced in 2005. **5. SLIDE 5EXPLAINFigure 43-4**Toyota FCHV is based on the Highlander platform and uses much of Toyota's Hybrid Synergy Drive (HSD) technology in its design

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	**DISCUSSION:Have the students discuss types of fuel cells. Which type of fuel cell is best suited to automotive applications? CHART 42-1**
	**DISCUSSION:Have the students talk about the current generated by a fuel cell. Why does a fuel cell generate direct current electricity?**
	**EXPLAIN TECH TIP**
	**6. SLIDE 6EXPLAINFigure 43-5polymer electrolyte membrane** only allows H^+_ ions (protons) to pass through it. This means that electrons must follow the external circuit and pass through load to perform work
	**HANDS-ON TASK: Have the students explain the PEM fuel-cell process. Have them use FIGURE 43–5 in their explanation. Grade students on their understanding of the process.**
	**7. SLIDE7EXPLAINFigure 43-6** fuel-cell stack is made up of hundreds of individual cells connected in series
	**DISCUSSION:Have the students discuss fuel-cell stacks. How is the total voltage of a fuel-cell stack determined? FIGURE 43–6**
	**8. SLIDE 8EXPLAINFigure 43-7**direct methanol fuel cell uses a methanol/water solution for fuel instead of hydrogen gas.
	**DISCUSS FREQUENTLY ASKED QUESTION**
	**9. SLIDE 9EXPLAINFigure 43-8** A direct methanol fuel cell can be refueled similar to a gasoline-powered vehicle
	**DISCUSSION:Have the students talk about the way hydrogen is stored onboard a vehicle. What are the pros and cons of methanol for fuel cells? Are methanol fuel cells likely to be used in automotive applications? FIGURES43–7 & 8**

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	**DISCUSSION:Have the students discuss fuel purity in PEM fuel cells. What happens if the hydrogen stream being fed to PEM anode is not pure? Why is this a concern for usage in vehicles?**
	**10. SLIDE 10 EXPLAINFigure 43-9** Powertrain layout in a Honda FCX fuel-cell vehicle. Note the use of a humidifier behind the fuel-cell stack to maintain moisture levels in the membrane electrode assemblies
	**DISCUSSION:Review with students purpose of having moisture in contact with electrolyte membrane in a PEM fuel cell. Use FIGURE 43–9 to highlight humidifier used in Honda FCX fuel-cell vehicle. What is purpose of the humidifier?**
	**11. SLIDE 11EXPLAINFigure 43-10** The Honda FCX uses one large radiator for cooling fuel cell, and two smaller ones on either side for cooling drive train components.
	**DISCUSSION:Have the students discuss waste heat and low-grade heat. How do the conditions of low-grade heat affect heat transfer? How is heat generated by fuel cells dealt with in an FCHV? FIGURE 43–10**
	**HANDS-ON TASK: Have students explain why it is important to keep electrolyte membrane cool in a PEM fuel cell. What can be done to control its temperature? Grade students on their understanding of heat issues in PEM fuel cells.**
	**12. SLIDE 12EXPLAINFigure 43-11** Space is limited at the front of the Toyota FCHV engine compartment, so an auxiliary heat exchanger is located under the vehicle to help cool the fuel-cell stack
	**DISCUSSION:Have the students discuss hybridization of fuel-cell vehicles. What is the purpose of an electrical storage device in a hybrid vehicle? FIGURE 43–11**
	**DISCUSS FREQUENTLY ASKED QUESTION**

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	**13. SLIDE 13EXPLAINFigure 43-12** secondary battery in a fuel-cell hybrid vehicle is made up of many individual cells connected in series, much like a fuel-cell stack **14. SLIDE 14EXPLAINFigure 43-13** Honda ultracapacitor module & construction of individual cells.
	**DISCUSSION:Have students talk about secondary batteries and ultracapacitors. Why are ultracapacitors suited to electric assist applications in fuel-cell hybrid vehicles? FIG 43–12 & 13**
	**15. SLIDE `5EXPLAINFigure 43-14** An ultracapacitor can be used in place of a highvoltage battery in a hybrid electric vehicle. This example is from the Honda FCX fuel-cell hybrid vehicle
	**DISCUSSION:Have the students discuss advantages & disadvantages of ultracapacitors in current use. What is major downside of ultracapacitors? FIGURE 43–14**
	**16. SLIDE 16EXPLAINFigure 43-15** Drive motors in fuel-cell hybrid vehicles often use stator assemblies similar to ones found in Toyota hybrid electric vehicles. The rotor turns inside the stator and has permanent magnets on its outer circumference
	**DISCUSSION:Have the students talk about electric traction motors. Why is the typical drive motor used in FCHVs and HEVs so reliable? FIGURE 43–15**
	**17. SLIDE 17EXPLAINFigure 43-16** The General Motors "Skateboard" concept uses a fuel-cell propulsion system with wheel motors at all four corners **18. SLIDE 18EXPLAINFigure 43-17** The electric drive motor and transaxle assembly from a Toyota FCHV. Note the three orange cables, indicating that this motor is powered by high-voltage three-phase alternating current.
	**DISCUSSION:Have the students discuss transaxles used in fuel-cell hybrid vehicles. How do these transaxles compare to transmissions required for vehicles powered by internal combustion engines? FIGURE 43–17**

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	**19. SLIDE 19EXPLAINFigure 43-18** The power control unit (PCU) on a Honda FCX fuel-cell hybrid vehicle is located under the hood. **20. SLIDE 20EXPLAINFigure 43-19** Toyota's FCHV uses a power control unit that directs electrical energy flow between the fuel cell, battery, and drive motor.
	**DISCUSSION:Have students talk about power control units (PCU) in fuel-cell hybrid vehicles. Why does an FCHV need an inverter? What are other functions of PCU? FIGURES43–18 & 19**
	**HANDS-ON TASK: Have students compare the benefits of electric motors with those of internal combustion engines. Grade students on their understanding of the operation of both electric motors and internal combustion engines as well as the comparison.**
	**21. SLIDE 21EXPLAINFigure 43-20** This GM fuel-cell vehicle uses compressed hydrogen in three high-pressure storage tanks **22. SLIDE 22EXPLAINFigure 43-21** The Toyota FCHV uses high-pressure storage tanks that are rated at 350 bar. This is the equivalent of 5,000 pounds per square inch.
	**DISCUSSION:Have the students review and discuss regenerative braking systems. How does the electric drive motor function during regenerative braking?**
	**DISCUSSION:Have the students discuss the issue of hydrogen storage in fuel-cell hybrid vehicles. Review physical density with students. How does physical density affect hydrogen storage capacity? FIGURES43–20 & 21**
	**23. SLIDE 23EXPLAINFigure 43-22** The high-pressure fitting used to refuel a fuel-cell hybrid vehicle. **24. SLIDE 24EXPLAINFigure 43-23** Note that high-pressure hydrogen storage tanks must be replaced in 2020
	**DISCUSSION:Have students discuss how compressed hydrogen gas is stored &how tanks are rated. How does use of multiple small storage tanks further reduce hydrogen storage**

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	capacity on fuel-cell HEVS? **FIGURE 43-22 &23** **25. SLIDE 25EXPLAINFigure 43-24** GM's Hydrogen3 has a range of 249 miles when using liquid hydrogen. **26. SLIDE 26EXPLAINFigure 43-25** Refueling a vehicle with liquid hydrogen
	**DISCUSSION:Have the students discuss liquid hydrogen and its properties and requirements. How does energy content of liquid hydrogen compare to that of gasoline? FIGURE 43-24 &25**
	**DISCUSSION:Have students review hydrogen gas, liquid hydrogen, & solid storage of hydrogen. What advantages as a fuel does hydrogen have over hydrocarbons? FIGURE 43-24 &25**
	**EXPLAIN TECH TIP**
	**27. SLIDE 27EXPLAIN FIGURE43-26** Carbon deposits, such as these, are created by incomplete combustion of a hydrocarbon fuel.
	**28. SLIDE 28EXPLAINFigure 43-27** Both diesel and conventional gasoline engines create exhaust emissions due to high peak temperatures created in the combustion chamber. The lower combustion temperatures during HCCI operation result in high efficiency with reduced emissions
	**29. SLIDE 29EXPLAINFigure 43.28** After Chevrolet Volt has been charged, it uses electrical power stored in the high-voltage battery to propel the vehicle and provide heating and cooling for 25 to 50 miles (40 to 80 km).
	**DISCUSSION:Have the students talk about the homogeneous charge compression ignition process. Have them use FIGURE 43–27 to compare HCCI system to diesel and gasoline engines. What are the current downsides to the HCCI system?**
	**30. SLIDE 30EXPLAINFigure 43-29A** The Chevrolet Volt is charged using standard SAE 1772 connector using either 110 or 220 volts.
	**DISCUSSION:Have the students discuss plug-in hybrid electric vehicles. What is the main advantage of PHEVs? How can these plug-in**

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	**hybrids achieve zero emissions?** **DISCUSSION:Have the students talk about the factors affecting the future of electric vehicles. How is the rising cost of fossil fuels affecting consumers' ability to continue with ICE vehicles? How might this factor spur the development of EVs?**
	31. **SLIDE 31EXPLAINFigure 43-29B** After connecting the charging plug, a light on the top of the dash turns green and the dash display shows the estimated time when the high-voltage battery will be fully charged and the estimated current range using battery power alone. 32. **SLIDE 32EXPLAINFigure 43-30** The SAE J 1772 plug is used on most electric and plug-in hybrid electric vehicles and is designed to work with Level 1 (110 to 120 volt) and Level 2 (220 to 240 volt) charging.
	**DISCUSSION:Have the students discuss weather concerns for electric vehicles. How do both cold and hot weather affect electrical power needs for electric vehicles?**
	**ON-VEHICLE NATEF TASK: Electric/Fuel Cell Vehicle Identification: Identify high-voltage circuits of electric vehicles and related safety precautions**
	**DISCUSS FREQUENTLY ASKED QUESTION**
	33. **SLIDE 33EXPLAINFIGURE 43-31** Nissan Leaf electric vehicle charging ports located at the front of the vehicle under a hinged door for easy access. 34. **SLIDE 34EXPLAIN Figure 43-32** Wind power capacity by area 35. **SLIDE 35EXPLAINFigure 43-33**The Hoover Dam in Nevada/Arizona is used to create electricity for use in the southwest United States
	**DISCUSSION:Have the students discuss wind power. How is electricity generated from wind power? What are its advantages? Why can't wind farms be placed in more locations?**

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 	**DISCUSSION:Have the students talk about hydroelectric power. How is hydroelectric power generated? What is the advantage of hydroelectric power over wind power?** **DISCUSSION:Have the students discuss drag racing for electric-powered vehicles.How is power of the electric powered vehicles increased? What are NEDRA's reasons for promoting electric drag racing? FIGURE 43-31**