Advanced Automotive Electricity & Electronics

Chapter 29 Fuel Cells & Advanced Technologies

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers operation and service of **Advanced Automotive Electricity & Electronics.** 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. Explain how a fuel cell generates electricity. 2. Discuss the advantages and disadvantages of fuel cells. 3. List the types of fuel cells. 4. Explain how ultracapacitors work. 5. Describe the advantages and disadvantages of electric vehicles. 6. Discuss alternative energy sources.
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.

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	1. SLIDE 1 CH29 FUEL CELLS AND ADVANCED TECHNOLOGIES
	**Show ANIMATION: FUEL CELL ENGINE ID www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/AX_Animations/Chapter66_Fig_66_27/index.htm
	2. SLIDE 2 EXPLAIN **Fuel-Cell Technology** 3. SLIDE 3 EXPLAIN **Figure 29-1** Ford Motor Company has produced a number of demonstration fuel-cell vehicles based on the Ford Focus. 4. SLIDE 4 EXPLAIN **Figure 29-2** 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 29-1 & 3**
	**DISCUSSION: Have the students talk about fuel cell technology. As a fuel, how does hydrogen compare to fossil fuel? FIGURE 29-2**
	5. SLIDE 5 EXPLAIN **Figure 29-3** The Mercedes-Benz B-Class fuel-cell car was introduced in 2005. 6. SLIDE 6 EXPLAIN **Figure 29-4** The Toyota FCHV is based on the Highlander platform and uses much of Toyota's Hybrid Synergy Drive (HSD) technology in its design. 7. SLIDE 7 EXPLAIN **CHART 29–1** Fuel cell types and their temperature operating range. 8. SLIDE 8 EXPLAIN **PEM-Cell Technology** 9. SLIDE 9 EXPLAIN NOTE
	**DISCUSSION: Have the students discuss types of fuel cells. Which type of fuel cell is best suited to automotive applications? CHART 29-1**

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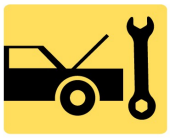
	**DISCUSSION: Have the students talk about the current generated by a fuel cell. Why does a fuel cell generate direct current electricity?**
	**10. SLIDE 10 EXPLAIN Figure 29-5 polymer electrolyte membrane** only allows H^+_ ions (protons) to pass through it. This means that electrons must follow the 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 29–5 in their explanation. Grade students on their understanding of the process.**
	**11. SLIDE 11 EXPLAIN** PEM Fuel Cells
	12. SLIDE 12 EXPLAIN Figure 29-6 A 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 29–6**
	**13. SLIDE 13 EXPLAIN Figure 29-7** A direct methanol fuel cell uses a methanol/water solution for fuel instead of hydrogen gas.
	14. SLIDE 14 EXPLAIN Figure 29-8 A direct methanol fuel cell can be refueled similar to a gasoline-powered vehicle
	15. SLIDE 15 EXPLAIN NOTE
	16. SLIDE 16 EXPLAIN PEM Fuel Cells
	**17. SLIDE 17 EXPLAIN TECH TIP**
	18. SLIDE 18 EXPLAIN FREQUENTLY ASKED QUESTION
	**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? FIGURES 29–7 & 8**

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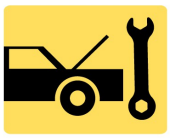
	**DISCUSSION: Have the students discuss fuel purity in PEM fuel cells. What happens if the hydrogen stream being fed to PEM anode is not pure? Why is this a concern for usage in vehicles?**
	**19. SLIDE 19 EXPLAIN** Fuel-Cell Vehicle Systems
	20. SLIDE 20 EXPLAIN Figure 29-9 Powertrain layout in a Honda 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 29–9 to highlight humidifier used in Honda FCX fuel-cell vehicle. What is purpose of the humidifier?**
	**21. SLIDE 21 EXPLAIN Figure 29-10** 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 29–10**
	22. SLIDE 22 EXPLAIN FREQUENTLY ASKED QUESTION
	**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.**
	**23. SLIDE 23 EXPLAIN Figure 29-11** 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 29–11**

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	**24. SLIDE 24 EXPLAIN** Fuel-Cell Vehicle Systems **25. SLIDE 25 EXPLAIN Figure 29-12** secondary battery in a fuel-cell hybrid vehicle is made up of many individual cells connected in series, much like a fuel-cell stack **26. SLIDE 26 EXPLAIN Figure 29-13** 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 29–12 & 13**
	**27. SLIDE 27 EXPLAIN Figure 29-14** An ultracapacitor can be used in place of a high voltage 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 29–14**
	**28. SLIDE 28 EXPLAIN Figure 29-15** 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 29–15**
	**29. SLIDE 29 EXPLAIN Figure 29-16** The General Motors "Skateboard" concept uses a fuel-cell propulsion system with wheel motors at all four corners
	30. SLIDE 30 EXPLAIN Figure 29-17 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 29–17**

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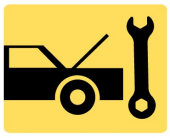
	**31. SLIDE 31 EXPLAIN Figure 29-18** The power control unit (PCU) on a Honda FCX fuel-cell hybrid vehicle is located under the hood. **32. SLIDE 32 EXPLAIN Figure 29-19** Toyota's FCHV uses a power control unit that directs electrical energy flow between the fuel cell, battery, and drive motor.
	**DISCUSSION: 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? FIGURES 29–18 & 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.**
	**33. SLIDE 33 EXPLAIN** Fuel-Cell Vehicle Systems **34. SLIDE 34 EXPLAIN Figure 29-20** This GM fuel-cell vehicle uses compressed hydrogen in three high-pressure storage tanks **35. SLIDE 35 EXPLAIN Figure 29-21** 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? FIGURES 29–20 & 21**
	**36. SLIDE 36 EXPLAIN Figure 29-22** The high-pressure fitting used to refuel a fuel-cell hybrid vehicle. **37. SLIDE 37 EXPLAIN Figure 29-23** Note that high-pressure hydrogen storage tanks must be replaced in 2020

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	**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 capacity on fuel-cell HEVS? FIGURE 29-22 & 23**
	**38. SLIDE 38 EXPLAIN Figure 29-24** GM's Hydrogen3 has a range of 249 miles when using liquid hydrogen.
	39. SLIDE 39 EXPLAIN Figure 29-25 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 29-24 & 25**
	**DISCUSSION: Have students review hydrogen gas, liquid hydrogen, & solid storage of hydrogen. What advantages as a fuel does hydrogen have over hydrocarbons? FIGURE 29-24 & 25**
	**40. SLIDE 40 EXPLAIN TECH TIP**
	**41. SLIDE 41 EXPLAIN FIGURE 29-26** Carbon deposits, such as these, are created by incomplete combustion of a hydrocarbon fuel.
	42. SLIDE 42 EXPLAIN Hydraulic Hybrid Storage System
	**43. SLIDE 43 EXPLAIN** HCCI
	44. SLIDE 44 EXPLAIN Figure 29-27 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
	**DISCUSSION: Have the students talk about the homogeneous charge compression ignition process. Have them use FIGURE 29–27 to compare HCCI system to diesel and gasoline engines. What are the current downsides to the HCCI system?**
	**45. SLIDE 45 EXPLAIN** Plug-In Hybrid Electric Vehicles
	46. SLIDE 46 EXPLAIN The Future for Electric Vehicles

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	47. **SLIDE 47 EXPLAIN Figure 29-28** A typical electric vehicle charging station on the campus of a college in southern California
	**DISCUSSION: Have the students discuss plug-in hybrid electric vehicles. What is the main advantage of PHEVs? How can these plug-in hybrids achieve zero emissions? FIGURE 29-28**
	**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? FIGURES 29-28 & 29**
	48. **SLIDE 48 EXPLAIN VEHICLE CHARGING**
	49. **SLIDE 49 EXPLAIN Figure 29-29** A conductive-type charging connector. This type of battery charging connector is sometimes called an AVCON connector, named for the manufacturer.
	50. **SLIDE 50 EXPLAIN Figure 29-30** An inductive-type electric vehicle battery charger connector. This type of connector fits into a charging slot in the vehicle, but does not make electrical contact
	**DISCUSSION: Have the students discuss weather concerns for electric vehicles. How do both cold and hot weather affect electrical power needs for electric vehicles?**
	**DISCUSSION: Have the students talk about electric vehicle range, charging, & recharging. What are factors that affect EVs' range? How has California addressed range of EVs? FIGURE 29-30**
	**ON-VEHICLE NATEF TASK: Electric/Fuel Cell Vehicle Identification: Identify high-voltage circuits of electric vehicles and related safety precautions**
	51. **SLIDE 51 EXPLAIN FREQUENTLY ASKED QUESTION**

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	**52. SLIDE 52 EXPLAIN FIGURE 29.31** (a) The motor in a compact electric drag car. This 8-inch-diameter motor is controlled by an electronic controller that limits the voltage to 170 volts to prevent commutator flash-over yet provides up to 2,000 amperes. This results in an amazing 340,000 watts or 455 Hp. (b) Batteries used for compact drag car include twenty 12-volt absorbed glass mat (AGM) batteries connected in series to provide 240 volts **53. SLIDE 53 EXPLAIN** Wind Power **54. SLIDE 54 EXPLAIN Figure 29-32** Wind power capacity by area **55. SLIDE 55 EXPLAIN Figure 29-33** typical wind generator that is used to generate electricity
	**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?**
	**56. SLIDE 56 EXPLAIN** Hydroelectric Power **57. SLIDE 57 EXPLAIN Figure 29-34** The Hoover Dam in Nevada/Arizona is used to create electricity for use in the southwest United States
	**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 29-31**