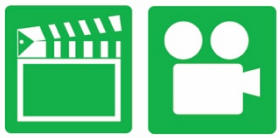
Hybrids & Alternative Fuel Vehicles 4/E
Chapter 8 Hybrid Batteries and Battery Service
Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers operation and service of **Hybrid and Alternative Fueled Vehicles**. 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 Electrical/Electronic Systems (A6) certification test content area "B" (Battery Diagnosis and Service). 2. Describe how auxiliary 12-volt and high-voltage hybrid vehicle batteries work. 3. List battery ratings. 4. Describe deep cycling. 5. List the safety precautions necessary when working with batteries. 6. Explain how to safely charge a battery. 7. Describe how to perform a battery load test. 8. Explain how to perform a conductance test. 9. Discuss how to jump start a vehicle safely. 10. Discuss hybrid electric vehicle auxiliary batteries. 11. Explain the types of high-voltage batteries used in most hybrid electric vehicles.
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 Hybrids 4th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com
LINK CHP 8: Chapter Images

ICONS	Ch08 Hybrid Batteries & Battery Service
	**1. SLIDE 1 Hybrid Batteries & Battery Service**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE IS CONSTANTLY UPDATED**
	**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**
	EXPLAIN TECH TIP
	**2. SLIDE 2 EXPLAIN FIGURE 8.1** Batteries are constructed of plates grouped into cells and installed in a plastic case. **3. SLIDE 3 EXPLAIN FIGURE 8.2** A grid from a battery used in both positive and negative plates
	**SAFETY TIP: HAVE STUDENTS ACCESS MSDS FOR AN AUTOMOTIVE BATTERY TO FIND SAFE HANDLING INSTRUCTIONS, FIRST AID PROCEDURES, REACTIVITY DATA, AND SO FORTH. ASK STUDENTS TO WRITE A SUMMARY OF PROPERTIES AND PROCEDURES DETAILED IN MSDS AND SHARE THEIR WORK WITH CLASS.**
	DISCUSS FREQUENTLY ASKED QUESTION
	**4. SLIDE 4 EXPLAIN FIGURE 8.3** Two groups of plates are combined to form a battery element. **5. SLIDE 5 EXPLAIN FIGURE 8.4** cutaway battery showing the connection of the cells to each other through the partition.
	**DISCUSSION: ASK STUDENTS TO TALK ABOUT RELEASE OF HYDROGEN & OXYGEN (GASSING) DURING CHARGING. WHY MIGHT GASSING BE DANGEROUS WHEN WORKING AROUND AN AUTOMOTIVE BATTERY?**

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	**DEMONSTRATION:** **USE AA BATTERIES & VOLTMETER TO DEMONSTRATE BATTERY CONSTRUCTION. SHOW STUDENTS HOW VOLTAGE INCREASES WHEN BATTERIES ARE CONNECTED IN SERIES VERSUS PARALLEL.**
	6. **SLIDE 6 EXPLAIN FIGURE 8.5** Chemical reaction for a lead-acid battery that is fully charged being discharged by the attached electrical load. 7. **SLIDE 7 EXPLAIN FIGURE 8.6** Chemical reaction for a lead-acid battery that is fully discharged being charged by the attached alternator.
	**EXPLAIN CAUTION**
	**DEMONSTRATION:** **SHOW STUDENTS DIFFERENT TYPES OF AUTOMOTIVE BATTERIES, FOCUSING ON CHARACTERISTICS THAT MAY BE USED TO DISTINGUISH ONE FROM ANOTHER.**
	8. **SLIDE 8 EXPLAIN FIGURE 8.7** Pressure relief valve from a VRLA battery. This valve stays closed during normal operating conditions and prevents gases from entering or leaving the battery case. 9. **SLIDE 9 EXPLAIN FIGURE 8.8** battery has a rating of 1,000 cold amperes (CA) and 900 amperes using the cold-cranking amperes (CCA) rating system.
	**DISCUSSION:** **DISCUSS DIFFERENCE BETWEEN CCA & CA RATINGS. WHAT FACTORS AFFECT BATTERY'S CCA AND CA RATINGS? DISCUSS WHY NORMAL AUTOMOTIVE BATTERIES ARE NOT DESIGNED FOR REPEATED DEEP CYCLING. WHAT VEHICLES ARE LIKELY TO USE DEEP CYCLE BATTERIES?**
	**HANDS-ON TASK:** **HAVE STUDENTS LOCATE & RECORD DIFFERENT BATTERY RATINGS. DISCUSS HOW THOSE RATINGS CAN BE USED TO PROVIDE TESTING DATA, OR TO DETERMINE SPECIFICATIONS FOR REPLACEMENT BATTERIES.**
	**DISCUSS FREQUENTLY ASKED QUESTION**

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	10. **SLIDE 10 EXPLAIN FIGURE 8.9A** voltage reading of 12.28 volts indicates that the battery is not fully charged and should be charged before testing. 11. **SLIDE 11 EXPLAIN FIGURE 8.9B** battery that measures 12.6 volts or higher after the surface charge has been removed is 100% charged 12. **SLIDE 12 EXPLAIN FIGURE 8.10** This battery has cold-cranking amperes (CCA) of 550 A, cranking amperes (CA) of 680 A, and load test amperes of 270 A listed on the top label. Not all batteries have this complete information 13. **SLIDE 13 EXPLAIN FIGURE 8.11** alternator regulator battery starter tester (ARBST) automatically loads battery with fixed load for 15 seconds to remove surface charge, then removes load for 30 seconds to allow battery to recover, and then reapplies the load for another 15 sec. The results of the test are then displayed. 14. **SLIDE 14 EXPLAIN FIGURE 8.12** conductance tester is very easy to use and has proved to accurately determine battery condition if the connections are properly made. Follow the instructions on the display exactly for best results.
	**DEMONSTRATION: SHOW STUDENTS HOW TO PROPERLY TEST A BATTERY USING CONDUCTANCE TESTER**
	**DISCUSSION: HAVE STUDENTS TALK ABOUT IMPORTANCE OF USING LEATHER GLOVES OVER INSULATED GLOVES. REMIND THEM THAT WHEN PURCHASING LEATHER GLOVES, THEY MUST BE LARGE ENOUGH TO FIT OVER INSULATED SAFETY GLOVES. WHAT SHOULD BE DONE BEFORE EACH USE OF GLOVES?**
	**SAFETY HAVE STUDENTS TALK ABOUT NEED FOR SAFETY PRECAUTIONS WHEN WORKING AROUND & WITH HYBRID ELECTRIC VEHICLES. BOTH HYBRID ELECTRIC VEHICLES & ALL-ELECTRIC VEHICLES USE HIGH-VOLTAGE CIRCUITS THAT CANNOT BE TOUCHED WITHOUT PROTECTION.**

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	**15. SLIDE 15 EXPLAIN FIGURE 8.13** typical industrial battery charger. Be sure that ignition switch in vehicle is in off position before connecting any battery charger. Connect the cables of the charger to the battery before plugging the charger into the outlet. This helps prevent a voltage spike and spark that could occur if the charger happened to be accidentally left on. Always follow the battery charger manufacturer's instructions.
	**DEMONSTRATION: SHOW STUDENTS JUMP STARTING PROCEDURES ON HEV. REVIEW SAFETY PROCEDURES FOR CONNECTING & DISCONNECTING JUMPER CABLES. CAN JUMP BOX OR JUMPER CABLE FROM ANOTHER VEHICLE BE USED ON HIGH-VOLTAGE HV BATTERY PACK?**
	**DISCUSSION: DISCUSS CAT III-RATED DMM. WHY IS A CAT III-CERTIFIED DMM REQUIRED FOR TAKING MEASUREMENTS ON HEVS?**
	**DEMONSTRATION: USING A CAT III DMM, SHOW STUDENTS HOW TO CHECK A FLOATING GROUND TO IDENTIFY A HIGH-VOLTAGE LEAK**
	**16. SLIDE 16 EXPLAIN FIGURE 8.14** This mini clamp-on digital multimeter is being used to measure the amount of battery electrical drain that is present. In this case, a reading of 20 mA (displayed on the meter as 00.02 A) is within the normal range of 20 to 30 mA. Be sure to clamp around all of the positive battery cable or all of the negative battery cable, whichever is easiest to get the clamp around. **17. SLIDE 17 EXPLAIN FIGURE 8.15** After connecting the shut-off tool, start the engine and operate all accessories. Stop the engine and turn off everything. Connect the ammeter across the shutoff switch in parallel. Wait 20 minutes. This time allows all electronic circuits to "time out" or shut down. Open the switch—all current now will flow through the ammeter. A reading greater than specified (usually greater than 50 mA, or 0.05 A) indicates a problem that should be corrected. **18. SLIDE 18 EXPLAIN FIGURE 8.16** The 12-volt auxiliary AGM battery for this Camry hybrid was located in the trunk under a covering panel.

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	**DISCUSS FREQUENTLY ASKED QUESTION**
	**DEMONSTRATION: DEMO DE-POWERING PROCEDURE ON HYBRID ELECTRIC VEHICLE**
	**USE A COOKING TIMER WITH A BELL ALARM OR SOME OTHER AUDIBLE SIGNAL AS A WAY TO KNOW WHEN THE 10-MINUTE WAITING PERIOD FOR HV BATTERY SHUTDOWN HAS PASSED.**
	**DISCUSSION: HAVE STUDENTS TALK ABOUT WHEN HIGH VOLTAGE SYSTEM NEEDS TO BE DE-POWERED & WHEN IT DOESN'T. WHEN SERVICING A SYSTEM THAT MAY CONTAIN HIGH VOLTAGE, HOW CAN YOU BE SURE OF WHETHER OR NOT IT NEEDS TO BE DE-POWERED?**
	**HANDS-ON TASK: SUPERVISE STUDENTS AS THEY DE-POWER VEHICLE.**
	**19. SLIDE 19 EXPLAIN FIGURE 8.17** The high-voltage battery and motor controls are located behind the rear passenger's seat in a Honda Civic.
	**20. SLIDE 20 EXPLAIN FIGURE 8.18** NiMH cell. The unique element in a nickel-metal hydride cell is the negative electrode which is hydrogen absorbing alloy. The positive electrode is nickel hydroxide. The electrolyte does not enter into the chemical reaction and is able to maintain a constant conductivity regardless of the state-of-charge of the cell
	**21. SLIDE 21 EXPLAIN FIGURE 7.19** Chemical reactions inside NiMH cell. Charging & discharging both involve exchange of hydrogen ions between 2 electrodes.
	22. SLIDE 22 EXPLAIN FIGURE 8.20 Cylindrical type NiMH batteries are made with stainless steel housing.
	23. SLIDE 23 EXPLAIN FIGURE 8.21prismatic NiMH cell. Prismatic cells are built with flat plates & separators similar to conventional lead–acid batteries.

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	**24. SLIDE 24 EXPLAIN FIGURE 8.22** Each cell has 1.25 volts and a group of six as shown has 7.5 volts. These sections are then connected to other sections to create the high-voltage battery pack. **25. SLIDE 25 EXPLAIN FIGURE 8.23** prismatic NiMH module from a Toyota Prius HV battery pack. Battery posts are located on left & right sides of module. A self-resealing vent is located on top right for venting hydrogen gas if module overheats. **26. SLIDE 26 EXPLAIN FIGURE 8.24** Toyota Camry Hybrid high-voltage battery pack with a total of 34 battery modules connected in series. Each module was rated at 7.2 volts, making 7.2 × 34 = 244 volts of battery output.
	**DISCUSS FREQUENTLY ASKED QUESTION**
	**27. SLIDE 27 EXPLAIN FIGURE 8.25** battery cooling system for a Toyota hybrid SUV. All production hybrid HV battery packs are air cooled. Note the air intake vents located under the seats. **28. SLIDE 28 EXPLAIN FIGURE 8.26** HV battery cooling system from a Ford Escape Hybrid. Ford uses outside air to cool the battery pack, then increases cooling with a separate zone in the A/C system when necessary.
	**29. SLIDE 29 EXPLAIN FIGURE 8.27** Tesla roadster uses 6,800 small Li-ion cells that are slightly larger than an AA battery to power this high-performance sports car. The 375-volt battery pack can supply up to 900 amperes of current to the 3-phase AC induction motor to deliver 295 lbs-ft of torque to the rear drive wheels.
	**DISCUSS FREQUENTLY ASKED QUESTION**
	**30. SLIDE 30 EXPLAIN FIGURE 8.28** Construction of a cylindrical lithium-ion cell. Note the pressure relief valve and exhaust gas hole that will relieve internal battery pressure if it gets too hot. **31. SLIDE 31 EXPLAIN FIGURE 8.29** One advantage of a lithium-ion cell is that it **produces 3.6 volts,** where **NiMH cell produces only 1.2 volts.**

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    	**EXPLAIN NOTE & FREQUENTLY ASKED QUESTION** **32. SLIDE 32 EXPLAIN FIGURE 8.30** The HV battery pack SOC is maintained in a relatively narrow range to prevent overheating and maximize service life. **DISCUSS FREQUENTLY ASKED QUESTION** **33. SLIDE 33 EXPLAIN FIGURE 8.31** Zinc-air batteries are recharged by replacing the zinc anodes. These batteries are also considered to be a type of fuel cell, because the positive electrode is oxygen taken from atmospheric air. **34. SLIDE 34 EXPLAIN FIGURE 8.32** Sodium-metal-chloride batteries are also known as **ZEBRA** batteries. These batteries are lightweight (40% of the weight of lead-acid) and have a high energy density. **35. SLIDE 35 EXPLAIN FIGURE 8.33** Snap-on Solus scan tool displays the state of change of the high-voltage battery under the heading of "HV ECM" **36. SLIDE 36 EXPLAIN FIGURE 8.34** internal resistance of the battery blocks are available on the data stream as shown using an aftermarket scan tool. The internal resistance should be between 15 and 40 milliohms (0.015 to 0.040 Ohms). **37. SLIDE 37 EXPLAIN FIGURE 8.35 A**ppropriate personal protective equipment (PPE) must be worn whenever working on or around a hybrid vehicle high-voltage system. **38. SLIDE 38 EXPLAIN FIGURE 8.36** battery service warning label from a Honda hybrid electric vehicle **39. SLIDES 39-50 HV BATTERY PACK SERVICE SLIDE SHOW**