Automotive Technology 6th Edition
Chapter 92 HYBRID HIGH-VOLTAGE BATTERIES
Opening Your Class

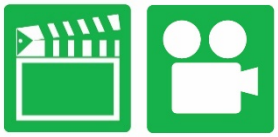
KEY ELEMENT	EXAMPLES
Introduce Content	This Automotive Technology 6th text provides complete coverage of automotive components, operation, design, and troubleshooting. It correlates material to task lists specified by ASE and ASEEducation (NATEF) and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Case Studies, Videos, Animations, and ASEEducation (NATEF) Task Sheets.
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 below: 1. State the purpose of the auxiliary battery in a hybrid vehicle. 2. Explain the types of high-voltage batteries used in most hybrid electric vehicles. 3. Describe the purpose of the high-voltage battery monitor. 4. List the steps for servicing a high-voltage battery. 5. Discuss high-voltage battery charging and safety precautions.
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: Lesson plan is based on 6th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

DOWNLOAD Chapter 91 Chapter Images: From

http://www.jameshalderman.com/automotive_principles.html

NOTE: You can use Chapter Images or possibly Power Point files:

ICONS	Ch 91 HYBRID HIGH-VOLTAGE BATTERIES
	**1. SLIDE 1 CH91 HYBRID HIGH-VOLTAGE BATTERIES**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE IS CONSTANTLY UPDATED** **http://www.jameshalderman.com/automotive_principles.html** **DOWNLOAD** **Crossword Puzzle (Microsoft Word) (PDF)** **Word Search Puzzle (Microsoft Word) (PDF** **Videos**
	
	**SAFETY TIP:** **Have students access SDS 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 SDS and share their work with class.**
	**EXPLAIN TECH TIP: The Hybrid Electric Vehicle *Does Not Start If Auxiliary Battery Is Discharged* If 12-volt auxiliary battery is discharged or defective, it cannot power electronic controller used to start vehicle. Gasoline engine does not start, nor does vehicle move, under high-voltage battery power. If "nothing happens" when the vehicle is attempted to be started, *always start the diagnosis with the state-of-charge and condition of the auxiliary 12-volt battery.***
	**DISCUSS FREQUENTLY ASKED QUESTION: *Can Hybrid Electric Vehicles Be Jump Started? Yes*. When the auxiliary 12-volt battery is discharged, vehicle does not move under battery power from high-voltage battery and the gasoline engine does not start and run. The auxiliary battery is needed to power electronics so that controller can start gasoline engine and control flow of electrical**

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	power to drive (traction) motors. If 12-volt battery is discharged, then it can be jump-started and charged the same as any other vehicle equipped with a 12-volt battery. **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?
	2. **SLIDE 2 EXPLAIN FIGURE 91–1** high-voltage battery and motor controls are located behind the rear passenger's seat in a Honda Civic. 3. **SLIDE 3 EXPLAIN FIGURE 91–2** NiMH cell. The unique element in a nickel-metal hydride cell is negative electrode, which is a 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.
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***Why Do Higher Voltage Motors Draw Less Current?*** Keep in mind that an electric motor is powered by wattage. Every electric motor is rated according to amount of power (in watts) it consumes. ***Power is calculated using the following formula: P = I × E or Power in watts = Current (in amperes) × Voltage (in volts)*** An electric motor rated at 144 watts consumes 12 amperes at 12 volts of applied voltage (12 volts × 12 amperes = 144 watts). If this same motor was powered with 6 volts, it would draw 24 amperes to achieve same power output. This increase in current draw would require a

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	much bigger cable to efficiently transmit electric current and minimize voltage drop. The motor windings would also have to be much heavier to handle this increased current. Imagine that we power this same motor with a144-volt battery. Now we require only 1 ampere of electrical current to operate the motor (144 volts × 1 ampere = 144 watts). The cable required to transmit this current could be sized much smaller and it is now much easier to run the cables over the length of car without significant power loss. Also, the electric motor can be made much smaller and more efficient when less current is needed to power it. Some hybrid systems have motors that operate at up to 650 volts in an effort to increase system efficiency.
	**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.
	4. **SLIDE 4 EXPLAIN FIGURE 92-3** Chemical reactions inside NiMH cell. Charging & discharging both involve exchange of hydrogen ions between 2 electrodes. 5. **SLIDE 5 EXPLAIN FIGURE 92-4** Cylindrical type NiMH batteries are made with stainless steel housing.

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	6. **SLIDE 6 EXPLAIN FIGURE 92-5** prismatic NiMH cell. Prismatic cells are built with flat plates & separators similar to conventional lead–acid batteries. 7. **SLIDE 7 EXPLAIN FIGURE 92-6** 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.
	**DISCUSSION: Ask students to talk about release of hydrogen & oxygen (gassing) during charging. Why might gassing be dangerous when working around an automotive battery?**
	**DEMONSTRATION: Use AA batteries & voltmeter to demonstrate battery construction. Show students how voltage increases when batteries are connected in series versus parallel.**
	**DEMONSTRATION: Show students different types of automotive batteries, focusing on characteristics that may be used to distinguish one from another.**
	**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.**
	8. **SLIDE 8 EXPLAIN FIGURE 92-7** 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. 9. **SLIDE 9 EXPLAIN FIGURE 92-8** 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 *How Is SOC of NiMH Battery Determined?* The state of charge (SOC) of a NiMH battery cannot be measured using cell voltage alone. Instead, SOC is determined using a complex calculation**

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	based on battery temperature, output current, and cell voltage. Accurate SOC measurements are critical for maximizing NiMH battery performance and service life. **DISCUSS FREQUENTLY ASKED QUESTION How *Many Types of Lithium-ion Batteries Are There*?** There are numerous types of lithium-ion batteries, and list is growing. While every component of battery is under development, primary difference between various designs is the materials used for positive electrode or cathode. The original Li-ion cell design used lithium cobalt oxide for its cathode, which has good energy storage characteristics, but suffers chemical breakdown at relatively low temperatures. This failure results in release of heat and oxygen, which often leads to a fire or explosion as the electrolyte ignites. In order to make lithium-ion batteries safer and more durable, a number of alternative cathode materials have been formulated. One of the more promising cathode designs for automotive applications is lithium iron phosphate (LiFePO4), which is stable at higher temperatures and releases less energy when it does suffer breakdown. Other lithium-ion cathode designs include the following: • Lithium nickel cobalt oxide (LNCO) • Lithium metal oxide (LMO) • Nickel cobalt manganese (NCM) • Nickel cobalt aluminum (NCA) • Manganese oxide spinel (MnO) Research and development continues on not only cathode design, but also anodes, separator materials, and electrolyte chemistry.

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	**10. SLIDE 10 EXPLAIN FIGURE 92-9** 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. **11. SLIDE 11 EXPLAIN FIGURE 92-10** 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.
	**12. SLIDE 12 EXPLAIN FIGURE 92–11** A Tesla Model S charge port is located at the left rear behind a door and uses a unique plug that is only used by Tesla.
	**DISCUSS FREQUENTLY ASKED QUESTION *What Were the Causes of Lithium-ion Battery Failure?* Three major factors are responsible for failure of lithiumion batteries. • Operating the cells outside their required voltage range (2 to 4 volts)** • **Operating the cells outside their required temperature range of 32° to 176°F (0o to 80o C)** • **• Short circuits (internal or external) For these reasons, lithium-ion battery packs in automotive applications require precise battery management using specialized cooling and safety systems.**
	**13. SLIDE 13 EXPLAIN FIGURE 92–12** Construction of a cylindrical lithium-ion cell. Note pressure relief valve and exhaust gas hole that relieves internal battery pressure if it gets too hot.. **14. SLIDE 14 EXPLAIN FIGURE 92-13** One advantage of a lithium-ion cell is that it **produces 3.6 volts,** where **NiMH cell produces only 1.2 volts.**
	**EXPLAIN FREQUENTLY ASKED QUESTION *How Is an Alkaline Battery Different from a Lead–Acid Battery?* Lead–acid batteries use sulfuric acid as the electrolyte, which acts as medium between battery positive and negative electrodes. Acids have a pH that is below 7,**

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	and pure water has a pH of exactly 7. If electrolyte from a lead–acid battery is spilled, it can be neutralized using a solution of baking soda and water (an alkaline solution). Alkaline batteries use an electrolyte, such as potassium hydroxide, which has a pH greater than 7. This means that the electrolyte solution is basic, which is opposite of acidic. If an alkaline battery electrolyte is spilled, it can be neutralized using a solution of vinegar and water (vinegar is acidic). Both nickel-cadmium (Ni-Cd) and nickel-metal hydride (NiMH) batteries are alkaline-battery designs.
	15. **SLIDE 15 EXPLAIN FIGURE 92–14** HV battery pack SOC is maintained in a relatively narrow range to prevent overheating and maximize service life.
	16. **SLIDE 16 EXPLAIN FIGURE 92-15** 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. 17. **SLIDE 17 EXPLAIN FIGURE 92-16** 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. 18. **SLIDE 18 EXPLAIN FIGURE 92-17** Snap-on Solus scan tool displays the state of change of the high-voltage battery under the heading of "HV ECM" 19. **SLIDE 19 EXPLAIN FIGURE 92-18** 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).
 	**DISCUSS CHART 92-1 Secondary-type battery comparison showing specifications and limitations.** **EXPLAIN TECH TIP:** ***Check State of Charge First*** **If a hybrid vehicle owner complains of a lack of power on acceleration, check the state of charge**

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	**(SOC) first. There may be nothing wrong with the traction motor or its controller. It may be simply that the HV battery pack is not within a normal state of charge, usually due to a fault with battery pack or related electrical connections.** **DISCUSS CASE STUDY: *Case of Broken Prius:*** **Owner of a 2003 Prius complained that "the engine never shuts off" and fuel economy has dropped to as low as 25 MPG, instead of the normal 40+ MPG. By "never shuts off," the customer means that idle stop (auto start/stop function) is suspended. The master warning light was also on, indicating a serious problem has been detected. The technician used a scan tool and retrieved the following DTCs.** **• P0A80—The difference in voltage between two of blocks in the battery pack is too high** **• P3006—Uneven state of charge Scan tool data showed battery block voltages reading ranging from 4.65 to 15.01 volts. Generally, if a battery block is under 7.5 volts, it cannot be restored to useful service. Even if it can be charged, the module has a short service life. The shop recommended, and customer approved, a replacement reconditioned battery pack supplied by a nationally known company. Battery pack was replaced and vehicle was restored to normal operation and fuel economy.** **Summary:** • **Complaint—customer started that the engine never seems to shut off and the fuel economy is lower than usual.** • **Cause—high-voltage battery had under equal voltage blocks causing the setting of two diagnostic trouble codes.**

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 	• **Correction—high voltage battery was replaced which restored proper hybrid vehicle operation and fuel economy.** **20. SLIDE 20 EXPLAIN FIGURE 92–19** A battery service warning label from a Honda hybrid electric**.** **21. SLIDES 21-33 HV BATTERY PACK SERVICE SLIDE SHOW: 12 slides**