











# Automotive Maintenance and Light Repair, 1<sup>ST</sup> Edition

## Chapter 29 BATTERIES

### Opening Your Class

| KEY ELEMENT   | EXAMPLES   |
|---|--|
| Introduce Content   | This course or class covers <b>Automotive Maintenance and Light Repair</b> . 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. | <p>Explain the chapter learning objectives to the students.</p> <ul style="list-style-type: none"><li>— Prepare for ASE Electrical/Electronic Systems (A6) certification test content area “B” (Battery Diagnosis and Service).</li><li>— Describe how a battery works.</li><li>— List battery ratings.</li><li>— Describe deep cycling.</li><li>— List safety precautions necessary when working with batteries.</li><li>— Explain how to safely charge a battery.</li><li>— Discuss how to perform a battery drain test.</li><li>— Describe how to perform a battery load test.</li><li>— Explain how to perform a conductance test.</li><li>— Discuss how to jump start a vehicle safely.</li><li>— Discuss hybrid electric vehicle auxiliary batteries.</li><li>— Explain the types of high-voltage battery used in most hybrid electric vehicles.</li></ul> |
| Establish the Mood or Climate   | Provide a <i>WELCOME</i> , 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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| <br> <br><br> <br>  <p data-bbox="350 1398 456 1423">QUESTION</p><br><br> | <p data-bbox="630 302 1094 331"><b>1. SLIDE 1 C29 BATTERIES</b></p> <p data-bbox="636 348 1192 378"><b>2. SLIDES 2-4 EXPLAIN OBJECTIVES</b></p> <p data-bbox="630 432 1430 550"><b>Check for ADDITIONAL VIDEOS &amp; ANIMATIONS @ <a href="http://www.jameshalderman.com/">http://www.jameshalderman.com/</a> WEB SITE REGULARLY UPDATED</b></p> <p data-bbox="623 575 1198 604"><b>5. SLIDE 5 EXPLAIN INTRODUCTION</b></p> <p data-bbox="623 621 1370 651"><b>6. SLIDE 6 EXPLAIN: BATTERY CONSTRUCTION</b></p> <p data-bbox="623 667 1370 764"><b>7. SLIDE 6 EXPLAIN Figure 29-1 Batteries are constructed of plates grouped into cells &amp; installed in a plastic case</b></p> <p data-bbox="584 781 1406 1041"><b>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.</b></p> <p data-bbox="623 1092 1416 1159"><b>8. SLIDE 8 EXPLAIN Figure 29-2 grid from a battery used in both positive and negative plates.</b></p> <p data-bbox="623 1171 1360 1201"><b>9. SLIDE 9 EXPLAIN BATTERY CONSTRUCTION</b></p> <p data-bbox="623 1218 1403 1285"><b>10. SLIDE 10 EXPLAIN Figure 29-3 two groups of plates are combined to form a battery element.</b></p> <p data-bbox="584 1297 1341 1474"><b>DISCUSSION: ASK STUDENTS TO TALK ABOUT RELEASE OF HYDROGEN &amp; OXYGEN (GASSING) DURING CHARGING. WHY MIGHT GASSING BE DANGEROUS WHEN WORKING AROUND AN AUTOMOTIVE BATTERY?</b></p> <p data-bbox="584 1486 1409 1663"><b>DEMONSTRATION: USE AA BATTERIES &amp; VOLTMETER TO DEMONSTRATE BATTERY CONSTRUCTION. SHOW STUDENTS HOW VOLTAGE INCREASES WHEN BATTERIES ARE CONNECTED IN SERIES VERSUS PARALLEL.</b></p> <p data-bbox="623 1680 1338 1789"><b>11. SLIDE 11 EXPLAIN Figure 29-4 cutaway battery showing connection of cells to each other through partition</b></p> |

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- 12. SLIDE 12 EXPLAIN: HOW BATTERY WORKS
- 13. SLIDE 13 EXPLAIN Figure 29-5 Chemical reaction for a lead-acid battery that is fully charged being discharged by the attached electrical load.
- 14. SLIDE 14 EXPLAIN: HOW BATTERY WORKS
- 15. SLIDE 15 EXPLAIN Figure 29-6 Chemical reaction for a lead-acid battery that is fully discharged being charged by the attached generator.



**DEMONSTRATION: LEMON BATTERY: USE A LEMON AND TWO DISSIMILAR METALS TO SHOW BATTERY CELL OPERATION. SEE HOW MANY CELLS IT TAKES TO LIGHT A BULB. DID YOU HAVE TO WIRE THE CELLS IN SERIES OR PARALLEL?**



**ACADEMIC TASK: CROSS-CURRICULAR ACTIVITY: SCIENCE: HAVE STUDENTS RESEARCH CHEMICAL STRUCTURE OF A SULFURIC ACID MOLECULE. HAVE STUDENTS DISCUSS HOW THE ELECTROLYTE USED IN A BATTERY CHANGES AS THE BATTERY IS DISCHARGED AND CHARGED.**



**HANDS-ON TASK: STUDENTS LOCATE AND READ THE CHARGE INDICATOR ON A BATTERY TO DETERMINE STATE-OF CHARGE. HAVE STUDENTS EXPLAIN THE VALIDITY OF CHARGE INDICATORS IN DETERMINING BATTERY STATE-OF-CHARGE.**



**DISCUSSION: DISCUSS WITH STUDENTS HOW SPECIFIC GRAVITY MEASUREMENT IS BASED ON A GRAVITY READING AT A SPECIFIC TEMPERATURE. HOW COULD CHANGES IN TEMPERATURE AFFECT A BATTERY'S SPECIFIC GRAVITY MEASUREMENT?**



- 16. SLIDE 16 EXPLAIN: VALVE REGULATED LEAD-ACID BATTERIES
- 17. SLIDE 17 EXPLAIN Figure 29-9 Absorbed glass mat battery is totally sealed and is more vibration resistant than conventional lead-acid batteries.



**DEMONSTRATION: SHOW STUDENTS DIFFERENT TYPES OF AUTOMOTIVE BATTERIES, FOCUSING ON CHARACTERISTICS THAT MAY BE USED TO DISTINGUISH ONE FROM ANOTHER.**



- 18. SLIDE 18 EXPLAIN: BATTERY RATINGS
- 19. SLIDE 19 EXPLAIN FIGURE 29-8 battery has a rating of 1,000 amperes using cold cranking rating and 900 amperes using the CCA (cold-cranking method)

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QUESTION



QUESTION

**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.

20. SLIDE 20 EXPLAIN: Battery Service Safety Precautions

**DEMONSTRATION:** USING A VOLTMETER, DEMONSTRATE HOW TO FIND CORRODED AND/OR POOR CONNECTIONS BY MEASURING VOLTAGE DROP

**DEMONSTRATION:** SHOW PROPER PROCEDURE FOR REMOVING SURFACE CHARGE. LOAD BATTERY WITH FIXED LOAD FOR 15 SEC. TO REMOVE SURFACE CHARGE, USING AVR FIGURE 18-3

**SHOW VIDEO: BATTERY REMOVAL VIDEO**

[HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET\\_MYLABS/AKAMAI/TEMPLATE/VIDEO640X480.PHP?TITLE=BATTERY%20REMOVAL&CLIP=PANDC/CHET/2012/AUTOMOTIVE/AUTO\\_SHOP\\_SAFETY/CLIP15BATTREMOV1.MOV&CAPTION=CHET/CHET\\_MYLABS/AKAMAI/2012/AUTOMOTIVE/AUTO\\_SHOP\\_SAFETY/XML/CLIP15BATTREMOV1.XML](http://media.pearsoncmg.com/ph/chet/chet_myLABS/akamai/template/video640x480.php?title=battery%20removal&clip=pandc/chet/2012/automotive/auto_shop_safety/clip15battremov1.mov&caption=chet/chet_myLABS/akamai/2012/automotive/auto_shop_safety/xml/clip15battremov1.xml)

21. SLIDE 21 EXPLAIN Battery Voltage Test

22. SLIDE 22 EXPLAIN FIGURE 29-9 (a) Voltage reading of 12.229 volts indicates that the battery is not fully charged and should be charged before testing. (b) A battery that measures 12.6 volts or higher after the surface charge has been removed is 100% charged.

**DEMONSTRATION:** DEMO OPEN CIRCUIT VOLTAGE (OCV) TEST FIGURE 29-9

**DISCUSSION:** DISCUSS CORRELATION BETWEEN SPECIFIC GRAVITY, OPEN-CIRCUIT VOLTAGE, & BATTERY STATE OF CHARGE. HOW DO YOU DETECT DEFECTIVE BATTERY? TALK ABOUT DIFFERENCES BETWEEN OPEN-CIRCUIT VOLTAGE AND SPECIFIC GRAVITY WHEN DETERMINING BATTERY STATE OF

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### CHARGE. WHY MIGHT A TECHNICIAN PREFER ONE OR THE OTHER?

23. SLIDE 23 EXPLAIN CHART 29-1

24. SLIDE 24 EXPLAIN: BATTERY LOAD TESTING

25. SLIDE 25 EXPLAIN FIGURE 29-10 This battery has cold-cranking amperes (CCA) of 550 A, cranking amperes (CA) of 6290 A, and load test amperes of 270 A listed on the top label. Not all batteries have this complete information



**DEMONSTRATION: SHOW STUDENTS HOW TO LOAD TEST BATTERY. TYPICALLY DONE AT 1/2 CCR.**



### VIDEO: BATTERY LOAD TESTING

[HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET\\_MYLABS/AKAMAI/TEMPLATE/VIDEO640X480.PHP?TITLE=LOAD%20TESTING%20THE%20BATTERY&CLIP=PANDC/CHET/2012/AUTOMOTIVE/STARTING\\_CHARGING ELECT/A6T3.MOV&CAPTION=CHET/CHET\\_MYLABS/AKAMAI/2012/AUTOMOTIVE/STARTING\\_CHARGING ELECT/XML/A6T3.XML](http://media.pearsoncmg.com/ph/chet/chet_my labs/akamai/template/video640x480.php?title=load%20testing%20the%20battery&clip=pandc/chet/2012/automotive/starting_charging_elect/a6t3.mov&caption=chet/chet_my labs/akamai/2012/automotive/starting_charging_elect/xml/a6t3.xml)



26. SLIDE 26 EXPLAIN Figure 29-11 alternator regulator battery starter tester (ARBST) automatically loads the battery with a fixed load for 15 sec. to remove the surface charge, then removes the load for 30 sec. to allow the battery to recover, and then reapplies the load for another 15 sec. The results of test are then displayed.

27. SLIDE 27 EXPLAIN: ELECTRONIC CONDUCTANCE TESTING



28. SLIDE 28 EXPLAIN Figure 29-12 conductance tester is very easy to use and has proved to accurately determine battery condition if the connections are properly made. Follow instructions on the display exactly for best results



**DISCUSSION: HAVE STUDENTS DISCUSS DIFFERENCE BETWEEN BATTERY LOAD TESTING AND CONDUCTANCE TESTING. WHAT ARE PROS & CONS OF EACH?**



**DEMONSTRATION: SHOW STUDENTS HOW TO PROPERLY TEST A BATTERY USING CONDUCTANCE TESTER FIGURE 29-12 CONDUCTANCE TESTING**

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### 29. SLIDE 29 EXPLAIN BATTERY CHARGING

30. SLIDE 30 EXPLAIN CHART 29-2 Battery charging guidelines based on the state-of-charge of the battery and the charging rate

31. SLIDE 31 EXPLAIN Figure 29-13 typical industrial battery charger. Be sure that the ignition switch is in the 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 HOW TO PROPERLY DISABLE HIGH-VOLTAGE BATTERY TO DECREASE RISK OF INJURY/DEATH WHEN WORKING AROUND HIGH VOLTAGE SYSTEMS.**

32. SLIDE 32: EXPLAIN BATTERY ELECTRICAL DRAIN TEST

33. SLIDE 33 EXPLAIN Figure 29-14 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.

34. SLIDE 34 EXPLAIN Figure 29-15 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 shut-off 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.

### PARASITIC DRAW TEST VIDEO

[HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET\\_MYLABS/AKAMAI/TEMPLATE/VIDEO640X480.PHP?TITLE=MEASURING%20PARASITIC%20DRAW&CLIP=PANDC/CHET/2012/AUTOMOTIVE/STARTING\\_CHARGING\\_ELECT/A6T1.MOV&CAPTION=CHET/CHET\\_MYLABS/AKAMAI/2012/AUTOMOTIVE/STARTING\\_CHARGING\\_ELECT/XML/A6T1.XML](http://media.pearsoncmg.com/PH/CHET/CHET_MYLABS/AKAMAI/TEMPLATE/VIDEO640X480.PHP?TITLE=MEASURING%20PARASITIC%20DRAW&CLIP=PANDC/CHET/2012/AUTOMOTIVE/STARTING_CHARGING_ELECT/A6T1.MOV&CAPTION=CHET/CHET_MYLABS/AKAMAI/2012/AUTOMOTIVE/STARTING_CHARGING_ELECT/XML/A6T1.XML)

**DEMONSTRATION: SHOW STUDENTS HOW TO PERFORM A PARASITIC DRAW TEST USING AN AMMETER WITH AN INDUCTIVE LEAD.**

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**DEMO**



**DEMONSTRATION: SHOW THE STUDENTS HOW TO PERFORM A PARASITIC DRAW TEST USING AN AMMETER HOOKED UP IN SERIES.**

35. **SLIDE 35 EXPLAIN** Figure 29-16 battery was replaced in this Acura and the radio displayed “code” when the replacement battery was installed. Thankfully, the owner had the five-digit code required to unlock the radio.
36. **SLIDE 36 EXPLAIN BATTERY ELECTRICAL DRAIN TESTING**

**Jump Box Usage**

**Jump Starting Hybrids**

**Jumper Cable Usage**

37. **SLIDE 37 EXPLAIN** Hybrid Auxiliary Batteries
38. **SLIDE 38 EXPLAIN CHART 29-3** summary chart showing where the 12-volt and high-voltage batteries and shut-off switch/plugs are located. Only the auxiliary 12-volt batteries can be serviced or charged.
39. **SLIDE 39 EXPLAIN CHART 29-3 CONTINUED**
40. **SLIDE 40 EXPLAIN** Jump Starting
41. **SLIDE 41 EXPLAIN FIGURE 29.17** Jump starting a 2001–2003 Toyota Prius using a 12-volt supply to boost the 12-volt auxiliary battery in the trunk
42. **SLIDE 42 EXPLAIN Hybrid and Electric Vehicle Batteries**
43. **SLIDE 43 EXPLAIN FIGURE 29-18** NiMH cell. The unique element in a nickel metal hydride cell is the negative electrode. Note that the electrolyte does not enter into chemical reaction and is able to maintain a constant conductivity regardless of state-of-charge of cell.
44. **SLIDE 44 EXPLAIN Hybrid and Electric Vehicle Batteries**
45. **SLIDE 45 EXPLAIN FIGURE 29-19** One advantage of a lithium-ion cell is that it produces 3.6 volts, whereas an NiMH or Ni-Cd cell only produces 1.2 volts
46. **SLIDES 46-47 EXPLAIN** Other High-Voltage Battery Types
48. **SLIDE 48 EXPLAIN FIGURE 29-20** Zinc-air batteries are recharged by replacing the zinc anodes. These batteries are also considered to be a type of fuel cell,



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because the positive electrode is oxygen taken from atmospheric air

- 49. **SLIDE 49 EXPLAIN FIGURE 29-21** 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
- 50. **SLIDE 50 EXPLAIN** Other High-Voltage Battery Types
- 51. **SLIDE 51 EXPLAIN CHART 29-4** Secondary-type battery comparison showing specifications and limitations.

**NATEF MLR TASK A6B1 PERFORM BATTERY STATE-OF-CHARGE TEST; DETERMINE NECESSARY ACTION.**

**NATEF MLR TASK A6B2 CONFIRM PROPER BATTERY CAPACITY FOR VEHICLE APPLICATION; PERFORM BATTERY CAPACITY TEST; DETERMINE NECESSARY ACTION.**

**NATEF MLR TASK A6B3 MAINTAIN OR RESTORE ELECTRONIC MEMORY FUNCTIONS.**

**NATEF MLR TASK A6B4 INSPECT AND CLEAN BATTERY; FILL BATTERY CELLS; CHECK BATTERY CABLES, CONNECTORS, CLAMPS, AND HOLD-DOWNS.**



**NATEF MLR TASK A6B5 PERFORM SLOW/FAST BATTERY CHARGE ACCORDING TO MANUFACTURER'S RECOMMENDATIONS.**

**NATEF MLR TASK A6B6 JUMP-START VEHICLE USING JUMPER CABLES AND A BOOSTER BATTERY OR AN AUXILIARY POWER SUPPLY.**

**NATEF MLR TASK A6B7 IDENTIFY HIGH-VOLTAGE CIRCUITS OF ELECTRIC OR HYBRID ELECTRIC VEHICLE AND RELATED SAFETY PRECAUTIONS.**

**NATEF MLR TASK A6B8 IDENTIFY ELECTRONIC MODULES, SECURITY SYSTEMS, RADIOS, AND OTHER ACCESSORIES THAT REQUIRE REINITIALIZATION OR CODE ENTRY AFTER RECONNECTING VEHICLE BATTERY.**



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|  |  | <b><u>NATEF MLR TASK A6B9</u> IDENTIFY HYBRID VEHICLE AUXILIARY (12V) BATTERY SERVICE, REPAIR, AND TEST PROCEDURES.</b> |
|  |  | <b><u>NATEF MLR TASK A6A8</u>. MEASURE KEY-OFF BATTERY DRAIN (PARASITIC DRAW).</b>                                      |