Automotive Engines
Chapter 17 Starting & Charging System
Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This engine systems course or class provides complete coverage of the components, operation, design, and troubleshooting. It correlates material to task lists specified by ASE and NATEF and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Real World Fixes, Videos, Animations, and NATEF Task Sheet references.
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 Engine Performance (A8) certification test content area "F" (Engine Electrical Systems Diagnosis and Repair). 2. Discuss methods that can be used to check the condition of a battery. 3. Describe how to perform a battery drain test and how to isolate the cause. 4. Explain how to test the condition of the starter. 5. List the steps necessary to perform a voltage drop test. 6. Explain how to test the alternator.
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.

ICONS	Chapter 17 Starting & Charging System
	1. TITLE SLIDE 1 CHAPTER 17 STARTING & CHARGING SYSTEM 2. SLIDES 2-3 EXPLAIN OBJECTIVES & KEY TERMS
	Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/ WEB SITE IS CONSTANTLY UPDATED
	4. SLIDE 4 EXPLAIN PURPOSE & FUNCTION OF BATTERY 5. SLIDE 5 EXPLAIN Battery Ratings 6. SLIDE 6 EXPLAIN FIGURE 17–1 This battery shows a large "1000" on the front panel but this is the CA rating and not the more important CCA rating. Always compare batteries with the same rating
	7. SLIDE 7 EXPLAIN FREQUENTLY ASKED QUESTION 8. SLIDE 8 EXPLAIN FREQUENTLY ASKED QUESTION 9. SLIDE 9 EXPLAIN FREQUENTLY ASKED QUESTION
	DEMONSTRATION: Use AA batteries & voltmeter to demonstrate battery construction. Show students how voltage increases when batteries are connected in series versus parallel.
	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.
	10. SLIDE 10 EXPLAIN Battery Service Safety Considerations
	DEMONSTRATION: Show students proper procedure for removing a surface charge. Load battery with fixed load for 15 sec. to remove surface charge, using AVR.

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	**DEMONSTRATION: Using a voltmeter, demonstrate how to find corroded or poor connections by measuring voltage drop.**
	**11. SLIDE 11 EXPLAIN Battery Visual Inspection & FIGURE 17-2** Corrosion on a battery cable could be an indication that battery itself is either being overcharged or is sulfated, creating a lot of gassing of the electrolyte
	**12. SLIDE 12 EXPLAIN FIGURE 17-3** visual inspection on this battery shows the electrolyte level was below the plates in all cells.
	13. SLIDE 13 EXPLAIN Battery Voltage Test & FIGURE 17–4 Using a DMM to measure the open-circuit voltage of a battery
	14. SLIDE 14 EXPLAIN Battery Voltage Test & FIGURE 17-4 (a) A voltage reading of 12.28 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
	**15. SLIDE 15 EXPLAIN TECH TIP**
	**16. SLIDE 16 EXPLAIN FIGURE 17–6** Using a scan tool to check battery voltage
	**17. SLIDE 17 EXPLAIN FIGURE 17–7** Bear Automotive starting and charging tester. This tester automatically loads the battery for 15 seconds to remove the surface charge, waits 30 seconds to allow the battery to recover, and then loads the battery again. The LCD indicates the status of the battery
	18. SLIDE 18 EXPLAIN FIGURE 17–8 This shows a typical battery load tester hookup
	19. SLIDE 19 EXPLAIN conductance testing
	20. SLIDE 20 EXPLAIN FIGURE 17–9 electronic battery tester. 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.
	**21. SLIDE 21 EXPLAIN FREQUENTLY ASKED QUESTION**

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	**DEMONSTRATION: Show students how to load test battery. Typically done at ½ CCR.**
	**DISCUSSION: Have students 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 charge. Why might a technician prefer one or the other?**
	**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**
	**SHOW 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
	**Students complete A6 NATEF Task Sheet Perform battery state-of-charge (conductance) test; determine necessary action.** **A6 Perform battery capacity test; confirm proper battery capacity for vehicle application; determine necessary action.**
	**22. SLIDE 22 EXPLAIN** Jump starting
	**23. SLIDE 23 EXPLAIN FIGURE 17–10 Jumper cable usage guide.** Jumper cable usage guide. Note that the last connection should be the engine block of the disabled vehicle to help prevent the spark that normally occurs from igniting the gases from the battery. **24. SLIDE 24 EXPLAIN** Battery Charging & **FIGURE 17-11** 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

25. **SLIDE 25 EXPLAIN CHART 17-1** Battery voltage can indicate the state of charge (SOC) of a battery after the surface charge has been removed

DEMONSTRATION: Use two bar magnets to show the students how like magnetic charges repel while opposite charges attract.

DISCUSSION: Have the students discuss the principles of magnetism. What causes a stronger magnetic field?

SHOW VIDEO: Battery Removal

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

26. **SLIDE 26 EXPLAIN** Battery Service
27. **SLIDE 27 EXPLAIN BATTERY ELECTRICAL DRAIN TEST**
28. **SLIDE 28 EXPLAIN FREQUENTLY ASKED QUESTION**
29. **SLIDE 29 EXPLAIN TECH TIP**
30. **SLIDE 30 EXPLAIN FIGURE 17–13** (a) Memory saver. The part numbers represent components from Radio Shack®. (b) A schematic drawing of the same memory saver
31. **SLIDE 31 EXPLAIN TECH TIP**
32. **SLIDE 32 EXPLAIN BATTERY ELECTRICAL DRAIN TESTING USING AN AMMETER**
33. **SLIDES 33-34 EXPLAIN Procedure For Battery Electrical Drain Test**
35. **SLIDE 35 EXPLAIN Procedure For Battery Electrical Drain Test & FIGURE 17–14** This mini clamp-on DMM is being used to measure the amount of

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	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 cables or all of the negative battery cables, whichever is easiest to clamp
	**36. SLIDE 36 EXPLAIN Procedure For Battery Electrical Drain Test & FIGURE 17–15** After connecting shutoff tool, start engine and operate all accessories. Stop engine and turn off everything. Connect 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 ammeter. A reading greater than specified, usually greater than 50 mA (0.05 A), indicates a problem that should be corrected. **FIGURE 17–16** battery was replaced in this Acura and the radio displayed "code" when replacement battery was installed. Thankfully, owner had five-digit code required to unlock radio
	**37. SLIDE 37 EXPLAIN Finding Source of the Drain**
	**38. SLIDE 38 EXPLAIN When Battery Drain Exists After All Fuses are Disconnected** **DEMONSTRATION: Show how to use service information to look up starting system control circuit. Have them help you identify different components of starting system control circuit.**
	**39. SLIDE 39 EXPLAIN CRANKING CIRCUIT** **40. SLIDE 40 EXPLAIN CRANKING CIRCUIT** **FIGURE 17–17** A typical ignition switch showing all of the electrical terminals after the connector has been removed. **FIGURE 17–18** Some column-mounted ignition switches act directly on the contact points, whereas others use a link from the lock cylinder to the ignition switch
	**Starter Circuit Animation** **Show Starting System Animation**
	**DISCUSSION: Have the students discuss difference between engine cranking and engine starting. What is required for an engine to start?**

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       	**HANDS-ON TASK:** Have half the students locate and label system components with numbers. Have other half identify the components by number. **ON-VEHICLE TASK:** Use Vocabulary Scavenger Hunt Task Sheet to identify parts on vehicle related to Starting System that correspond with letter on the task sheet & describe purpose of each part. 41. **SLIDE 41 EXPLAIN Figure 17-19** typical solenoid-operated starter. 42. **SLIDE 42 EXPLAIN DIAGNOSING STARTER PROBLEMS USING VISUAL INSPECTION** 43. **SLIDE 43 EXPLAIN DIAGNOSING STARTER PROBLEMS USING VISUAL INSPECTION FIGURE 17–20** Carefully inspect all battery terminals for corrosion 44. **SLIDE 44 EXPLAIN STARTER TESTING ON VEHICLE** 45. **SLIDE 45 EXPLAIN STARTER TESTING ON VEHICLE FIGURE 17–21** When connecting a starter tester such as a Sun VAT 45 to the vehicle, make certain that the inductive probe is placed over all of the cables or wires from the battery. **FIGURE 17–22** Always check the battery, using a conductance or load tester. A battery showing a green charge indicator does not mean that the battery is good. 46. **SLIDE 46 EXPLAIN REAL WORLD FIX** 47. **SLIDE 47 EXPLAIN REAL WORLD FIX** 48. **SLIDE 48 EXPLAIN TESTING STARTER WITH SCAN TOOL** 49. **SLIDE 49 EXPLAIN TECH TIP** 50. **SLIDE 50 EXPLAIN VOLTAGE DROP TESTING** 51. **SLIDE 51 EXPLAIN VOLTAGE DROP TESTING & FIGURE 17–23** Voltmeter hookups for voltage drop testing of a GM-type cranking circuit

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	**52. SLIDE 52 EXPLAIN VOLTAGE DROP TESTING & FIGURE 17–24** Voltmeter hookups for voltage drop testing of a Ford-type cranking circuit **53. SLIDE 53 EXPLAIN VOLTAGE DROP TESTING & FIGURE 17–25** Using the voltmeter leads from a starting and charging test unit to measure the voltage drop between the battery terminal (red lead) and the cable end (black lead). The engine must be cranked to cause current to flow through this connection
	**54. SLIDE 54 EXPLAIN VOLTAGE DROP TESTING & FIGURE 17–26 starter diagnosis chart** **55. SLIDE 55 EXPLAIN TECH TIP**
	**56. SLIDE 56 EXPLAIN STARTER DRIVE-TO-FLYWHEEL CLEARANCEFIGURE 17–27** shim (or half shim) may be needed to provide the proper clearance between the flywheel teeth of the engine and the pinion teeth of the starter
	**57. SLIDE 57 EXPLAIN Charging Circuit** **Charging System Animation** **Show Charging System Animation** **AC, Alternating Current Animation**
	**58. SLIDE 58 EXPLAIN Charging Circuit & FIGURE 17–28 Cutaway view of a typical AC alternator**
	**59. SLIDE 59 EXPLAIN FREQUENTLY ASKED QUESTION**
	**60. SLIDE 60 EXPLAIN TECH TIP**
	**61. SLIDE 61 EXPLAIN TECH TIP**
	**62. SLIDE 62 EXPLAIN CHECKING CHARGING SYSTEM VOLTAGE FIGURE 17–29** digital multimeter should be set to read DC volts and the red lead connected to battery positive (+) terminal and black meter lead connected to negative (-) battery terminal
	**63. SLIDE 63 EXPLAIN TECH TIP**

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	**64. SLIDE 64 EXPLAIN FIGURE 17–30** A simple and easy-to-use tester can be made from a lighter plug and double banana plug that fits the "COM" and "V" terminals of most digital meters. By plugging the lighter plug into the lighter, the charging circuit voltage can be easily measured **65. SLIDE 65 EXPLAIN TESTING AN ALTERNATOR USING A SCAN TOOL**
	**66. SLIDE 66 EXPLAIN TECH TIP**
	**67. SLIDE 67 EXPLAIN TECH TIP**
	**68. SLIDE 68 EXPLAIN TECH TIP**
	**69. SLIDE 69 EXPLAIN AC RIPPLE VOLTAGE CHECK** **70. SLIDE 70 EXPLAIN AC RIPPLE VOLTAGE CHECK & FIGURE 17–31** AC ripple at the output terminal of battery is more accurate than testing at battery due to the resistance of the wiring between alternator and battery. Set meter to read AC volts. The reading shown on meter is only 78 mV (0.078 V), far below what reading would be if a diode were defective **71. SLIDE 71 EXPLAIN current check & FIGURE 17–32** A mini clamp-on digital multimeter can be used to measure alternator output and unwanted AC current by switching the meter to read DC amperes **72. SLIDE 72 EXPLAIN CHARGING SYSTEM VOLTAGE DROP TESTING** **73. SLIDE 73 EXPLAIN FIGURE 17–33** Voltmeter hookup to test the voltage drop of the charging circuit
	**HANDS-ON TASK: Have the students locate the sticker or stamp that shows the alternator amperage rating on several different alternators.**
	**DEMONSTRATION: Show how to perform a quick check on a charging system by checking static and dynamic voltages with a DMM. Engine OFF, 12.6 volts. Engine Running at 1500 RPM: 14.5 volts.**
	**74. SLIDE 74 EXPLAIN TECH TIP**

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	**75. SLIDE 75 EXPLAIN ALTERNATOR OUTPUT TEST** **76. SLIDE 76 EXPLAIN ALTERNATOR OUTPUT TEST & FIGURE 17–34 Typical hookup of a starting and charging tester** **77. SLIDE 77 EXPLAIN ALTERNATOR OUTPUT TEST & FIGURE 17–35** The output on this alternator is printed on a label.
	**DEMONSTRATION: Demonstrate ways to do an Alternator Output Test. Show students how to perform carbon pile test with AVR or equivalent tool. Have students interpret results by comparing them to OEM specifications.**
	**78. SLIDE 78 EXPLAIN REAL WORLD FIX**
	**79. SLIDE 79 EXPLAIN REAL WORLD FIX**
	**80. SLIDE 80 EXPLAIN FIGURE 17–36** Normal alternator scope pattern. This AC ripple is on top of a DC voltage line. The ripple should be less than 0.50 V high
	81. SLIDE 81 EXPLAIN FIGURE 17–37 Alternator pattern indicating a shorted diode **82. SLIDE 82 EXPLAIN FIGURE 17–38** Alternator pattern indicating an open diode
	**79. SLIDE 79 EXPLAIN REAL WORLD FIX**
	**Students complete NATEF Task Sheet A6A2, Research applicable vehicle and service information, such as electrical/electronic system operation, vehicle service history, service precautions, and technical service bulletins: PAGE 16 & 20**
	**Students complete A6 NATEF Task Sheet: Inspect, clean, fill, and/or replace battery, battery cables, connectors, clamps, and hold-downs.**

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	**Students complete A6 NATEF Task Sheet: Perform battery charge.**
	**Students complete A6 NATEF Task Sheet: Start a vehicle using jumper cables or an auxiliary power supply**
	**Students complete A6 NATEF Task Sheet: Perform charging system output test; determine necessary action.**
	**HOMEWORK: Ask students to research history of starter motor on the Internet. Ask them to identify the first car company to offer electric start, and when it was offered. Ask students to present their findings to the class.**
	**Talk through SUMMARY and questions**
	**HOMEWORK: complete Ch17 crossword puzzle: http://www.jameshalderman.com/links/book_engine_theory_serv_7/cw/crossword_ch_17.pdf**