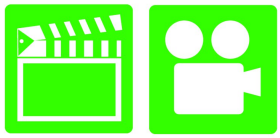
Automotive Maintenance and Light Repair, 1ST Edition

Chapter 19 Cooling System Operation & Diagnosis

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers **Automotive Maintenance and Light Repair.** 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. • Prepare for Engine Repair (A1) ASE certification test content area "D" (Lubrication and Cooling Systems Diagnosis and Repair). • Diagnose high- and low-temperature engine problems. • Describe how coolant flows through an engine. • Discuss the operation of the thermostat. • Explain the purpose and function of the radiator pressure cap. • Describe the operation and service of the water pump. • Describe the various types of antifreeze and how to recycle and discard used coolant. • Inspect and test cooling system, and perform necessary action.
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	Ch19 Cooling System Operation & Diagnosis
	**1. SLIDE 1 CH19 Cooling System Operation & Diagnosis** **2. SLIDES 2-4 EXPLAIN OBJECTIVES**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE REGULARLY UPDATED**
	**5. SLIDE 5 EXPLAIN Figure 21-1** Typical combustion and exhaust temperatures. **6. SLIDE 6 EXPLAIN** LOW-TEMPERATURE ENGINE PROBLEMS **7. SLIDE 7 EXPLAIN** HIGH-TEMPERATURE ENGINE PROBLEMS
	**DISCUSSION: HAVE STUDENTS DISCUSS HEAT GENERATED IN AN ENGINE. ASK: "IF ONE-THIRD OF THE HEAT IS REMOVED THROUGH THE COOLING SYSTEM, AND ONE-THIRD IS REMOVED THROUGH THE EXHAUST SYSTEM, WHAT IS THE OTHER ONE-THIRD USED FOR?" (ANSWER: PUSHING PISTONS DOWN.)**
	**ENGINES THAT DO NOT REACH PROPER OPERATING TEMPERATURE MAY LEAVE WATER IN OIL, WHICH CAN CAUSE ENGINE FAILURES, SUCH AS BEARING FAILURE.**
	**DISCUSSION: DISCUSS WITH STUDENTS HOW IMPROPER COOLANT TEMPERATURE CAN HARM FUEL ECONOMY. WHY DOES TEMPERATURE AFFECT FUEL ECONOMY? (ANS: CHANGES FUEL VAPORIZATION RATE)**
	**8. SLIDE 8 EXPLAIN** Cooling System Design **9. SLIDE 9 EXPLAIN Figure 19-2** Coolant circulates through water jackets in engine block and cylinder head. **10. SLIDE 10 EXPLAIN Figure 19-3** Coolant flow through a typical engine cooling system. **12. SLIDES 12-13 EXPLAIN** Cooling System Design
	**DISCUSSION: HAVE STUDENTS DISCUSS POSSIBLE REASONS THAT OLDER ENGINES WERE LESS LIKELY TO HAVE ENGINE FAILURE FROM OVERHEATING. (THE REASON IS THAT HEAVY**

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    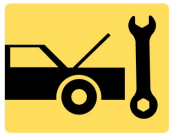 	**STEEL BLOCKS AND HEADS DISPLACED HEAT BETTER AND WERE ABLE TO TAKE HIGHER TEMPERATURES WITHOUT DAMAGE DUE TO AMOUNT OF METAL.)** **DEMONSTRATION: SHOW STUDENTS A BYPASS HOSE AND WHERE IT IS LOCATED ON DIFFERENT ENGINES** **DISCUSSION: DISCUSS WITH STUDENTS WHY THE BYPASS HOSE IS SO IMPORTANT. WHY IS IT IMPORTANT? (ANS: ALLOWS FOR RAPID ENGINE WARM UP)** **ON-VEHICLE NATEF TASK: RESEARCH APPLICABLE VEHICLE AND SERVICE INFO, VEHICLE SERVICE HISTORY, SERVICE PRECAUTIONS, AND TECHNICAL SERVICE BULLETINS: SEE 2013 NATEF TASK CORRELATION CHART** 14. **SLIDES 14-15 EXPLAIN** Thermostats Temperature Control 16. **SLIDE 16 EXPLAIN Figure 19-4** A cross section of a typical wax-actuated thermostat showing the position of the wax pellet and spring. 17. **SLIDE 17 EXPLAIN Figure 19-5 (a)** When the engine is cold, the coolant flows through the bypass. **(b)** When the thermostat opens, the coolant can flow to the radiator. 18. **SLIDE 18 EXPLAIN Chart 19-1** The temperature of the coolant depends on the rating of the thermostat. 19. **SLIDE 19 EXPLAIN Figure 19-6** A thermostat stuck in open position caused engine to operate too cold. If a thermostat is stuck closed, this can cause engine to overheat. 20. **SLIDEs 20-21 EXPLAIN** Thermostat Control Bypass 22. **SLIDE 22 EXPLAIN Figure 19-7** This internal bypass passage in the thermostat housing directs cold coolant to the water pump. 23. **SLIDE 23 EXPLAIN Figure 19-8** cutaway of small block Chevrolet V-8 showing passage from cylinder head through the front of the intake manifold to the thermostat.

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	**REMOVING A THERMOSTAT MAY CAUSE OVERHEATING ISSUES BECAUSE COOLANT FLOWS SO QUICKLY THAT IT CANNOT ABSORB THE HEAT.**
	**24. SLIDE 24 EXPLAIN** Testing Thermostats **25. SLIDE 25 EXPLAIN FIGURE 19–9** Setup used to check the opening temperature of a thermostat **26. SLIDES 26-28 EXPLAIN Thermostat Replacement** **29. SLIDE 29 EXPLAIN Figure 19-10** Some thermostats are integral part of housing. Thermostat & radiator hose housing is serviced as assembly. Some thermostats snap into engine radiator fill tube underneath pressure cap
	**WHEN CHECKING A THERMOSTAT FOR AN OVERHEATING CONDITION, BE SURE THE THERMOSTAT IS INSTALLED CORRECTLY.**
	**DISCUSSION: DISCUSS WITH STUDENTS THE 3 METHODS OF TESTING THERMOSTATS & POSITIVE AND NEGATIVES OF EACH.**
	**DEMONSTRATION: USING THE HOT WATER METHOD, SHOW HOW A THERMOSTAT OPENS AND CLOSES.**
	HANDS-ON TASK: HAVE STUDENTS PERFORM THERMOSTAT TESTING USING AT LEAST ONE OF 3 METHODS LISTED IN THE TEXT
	**WHEN REPLACING THERMOSTAT, BE SURE SENSING PELLET IS FACING ENGINE BLOCK.**
	**AIR POCKETS AROUND THERMOSTAT CAN CAUSE THERMOSTAT TO MALFUNCTION, CAUSING AN OVERHEATING CONDITION.**
	**ON-VEHICLE NATEF TASK: INSPECT, TEST, REMOVE AND REPLACE THERMOSTAT AND GASKET/SEAL. SEE 2013 NATEF TASK CORRELATION CHART**

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	**30. SLIDES 30-31 EXPLAIN Antifreeze/Coolant** **32. SLIDE 32 EXPLAIN FIGURE 19–11** Graph showing the relationship of the freezing point of the coolant to the percentage of antifreeze used in the coolant.
	**33. SLIDE 33 EXPLAIN FIGURE 19–12** Graph showing how the boiling point of the coolant increases as the percentage of antifreeze in the coolant increases. **34. SLIDES 34-35 EXPLAIN Antifreeze Can Freeze** **36. SLIDE 36 EXPLAIN FIGURE 19–13** Checking the freezing and boiling protection levels of the coolant using a hydrometer. **37. SLIDES 37-38 EXPLAIN Recycling Coolant** **39. SLIDES 39-40 EXPLAIN Disposing of Used Coolant**
	**DISCUSSION: DISCUSS PROPER COOLANT DISPOSAL PROCEDURES.**
	**DEMONSTRATION: SHOW STUDENTS PROPER PROCEDURE FOR USING A COOLANT EXCHANGE MACHINE**
	**41. SLIDE 41 EXPLAIN Figure 19-14** tubes and fins of radiator core. **42. SLIDE 42 EXPLAIN Figure 19-15** radiator may be either a down-flow or a crossflow type. **43. SLIDE 43 EXPLAIN FIGURE 19–16** A heavily corroded radiator from a vehicle that was overheating. A visual inspection discovered that the corrosion had eaten away many of the cooling fins, yet did not leak. This radiator was replaced and it solved overheating problem **44. SLIDE 44 EXPLAIN Figure 19-17** Many vehicles equipped with automatic transmission use a transmission fluid cooler installed in one of radiator tanks.
	**OLDER STEEL RADIATORS COULD OFTEN BE REPAIRED. MOST NEWER RADIATORS CANNOT BE REPAIRED, DUE TO COST, & MUST BE REPLACED**
	**DEMONSTRATION: SHOW STUDENTS DIFFERENT STYLES OF RADIATORS.**

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	**DISCUSSION:** DISCUSS THE IMPORTANCE OF HEAT TRANSFER. WHAT ARE THE 3 FORMS OF HEAT TRANSFER FROM PHYSICS CLASS? (ANS: CONDUCTANCE, CONVECTION, & RADIATION. RADIATORS DESPITE THEIR NAME, GENERALLY TRANSFER THE BULK OF THEIR HEAT VIA CONVECTION, NOT BY THERMAL RADIATION. CONVECTION IS TRANSFER OF HEAT FROM ONE PLACE TO ANOTHER BY MOVEMENT OF FLUIDS. CONVECTION IS USUALLY THE DOMINANT FORM OF HEAT TRANSFER IN LIQUIDS AND GASES)
	**DEMONSTRATION:** SHOW WHERE RADIATOR PETCOCK IS LOCATED AND HOW TO PROPERLY OPEN AND CLOSE IT WITHOUT BREAKING IT.
	**ON-VEHICLE NATEF TASK:** REMOVE AND REPLACE RADIATOR: SEE 2013 NATEF TASK CORRELATION CHART
	45. SLIDE 45 EXPLAIN Pressure Caps 46. SLIDE 46 EXPLAIN FIGURE 19–18 The pressure valve maintains the system pressure and allows excess pressure to vent. The vacuum valve allows coolant to return to the system from the recovery tank. 47. SLIDE 47 EXPLAIN FIGURE 19–19 Some vehicles use a surge tank, which is located at the highest level of the cooling system, with a radiator cap. 48. SLIDES 48-49 EXPLAIN Metric Radiator Caps 50. SLIDE 50 EXPLAIN Chart 19-4 Comparison showing the metric pressure as shown on the top of the cap to pounds per square inch (PSI)
 	**SAFETY TIP:** ALWAYS REMOVE PRESSURE CAP SLOWLY USING RAGS OR HEAVY GLOVES FOR PROTECTION. A HOT COOLING SYSTEM CAN SPRAY COOLANT OR STEAM UNDER PRESSURE. EVEN A COLD SYSTEM MAY HAVE PRESSURE THAT CAN SPRAY COOLANT INTO EYES OR DAMAGE PAINT.

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	OVERHEATING TRANSMISSIONS CAN CAUSE ENGINE OVERHEATING ISSUES.
DEMO	**DEMONSTRATION: DEMONSTRATE HOW A PRESSURE CAP VENTS AT THE PRESSURE LISTED.**
	RADIATOR PRESSURE CAP ANIMATION: WWW.MYAUTOMOTIVELAB.COM HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET_MYAUTOMOTIVELAB_2/ANIMATIONS/A1_ANIMATION/CHAPTER14_FIG_14_14/INDEX.HTM 51. **SLIDE 51 EXPLAIN FIGURE 19–20** The level in the coolant recovery system raises and lowers with engine temperature.
DEMO	**DEMONSTRATION: SHOW STUDENTS DIFFERENT TYPES OF COOLANT RECOVERY BOTTLES**
	DISCUSSION: DISCUSS WITH STUDENTS WHY THE RECOVERY BOTTLE IS IMPORTANT TO LONGEVITY OF THE COOLING SYSTEM'S EFFECTIVENESS. 52. **SLIDE 52 EXPLAIN FIGURE 19–21** Pressure testing the cooling system. A typical hand-operated pressure tester applies pressure equal to the radiator cap pressure. The pressure should hold; if it drops, this indicates a leak somewhere in the cooling system. An adapter is used to attach the pump to the cap to determine if the radiator can hold pressure, and release it when pressure rises above its maximum rated pressure setting. 53. **SLIDE 53 EXPLAIN FIGURE 19–22** The pressure cap should be checked for proper operation using a pressure tester as part of the cooling system diagnosis
	COLLAPSED HOSES MAY BE CAUSED BY PRESSURE CAP NOT VENTING CORRECTLY.
We Support ASE NATEF	**ON-VEHICLE NATEF TASK: INSPECT AND REPLACE ENGINE COOLING & HEATER SYSTEM HOSES: SEE 2013 NATEF TASK CORRELATION CHART**

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	**ON-VEHICLE NATEF TASK PERFORM COOLING SYSTEM PRESSURE TESTS; DETERMINE NECESSARY ACTION SEE 2013 NATEF TASK CORRELATION CHART**
	**ON-VEHICLE NATEF TASK IDENTIFY AND INTERPRET ENGINE CONCERN; DETERMINE NECESSARY ACTION SEE 2013 NATEF TASK CORRELATION CHART**
	**54. SLIDE 54 EXPLAIN FIGURE 19–23** Use dye specifically made for coolant when checking for leaks using a black light
	**IF USING A DYE TO LEAK TEST, IT MAY BE NECESSARY TO REMOVE BLOWER RESISTOR TO ACCESS HEATER CORE**
	**DEMONSTRATION: SHOW STUDENTS HOW DYE ILLUMINATES WITH A BLACK LIGHT.**
	**55. SLIDE 55 EXPLAIN FIGURE 19-24** Coolant flow through impeller & scroll of coolant pump for a V-type **56. SLIDE 56 EXPLAIN FIGURE 19–25** A demonstration engine showing the amount of water that can be circulated through the cooling system. **57. SLIDE 57 EXPLAIN Figure 19-26** severely corroded water pump could not circulate enough coolant to keep engine cool. Engine overheated and blew a head gasket. **58. SLIDE 58 EXPLAIN Figure 19-27** bleed weep hole in the water pump allows coolant to leak out of the pump and not be forced into the bearing. If the bearing failed, more serious damage could result. **59. SLIDE 59 EXPLAIN Figure 19-21** A cutaway of a typical water pump showing the long bearing assembly and the seal. The weep hole is located between the seal and the bearing. If the seal fails, then coolant flows out of the weep hole to prevent coolant from damaging bearing.
	**DISCUSSION: DISCUSS WATER PUMP OPERATION WITH STUDENTS**

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DEMO	**DEMONSTRATION: SHOW STUDENTS DIFFERENT VARIATIONS OF WATER PUMP.**
DEMO	**DEMONSTRATION: SHOW STUDENTS WATER PUMP WEEP HOLE.**
	BE SURE TO INSTALL THE SERPENTINE BELT CORRECTLY WHEN REPLACING WATER PUMP; OTHERWISE, PUMP MAY TURN BACKWARDS.
We Support ASE NATEF	**ON-VEHICLE NATEF TASK: INSPECT, TEST, REMOVE, AND REPLACE WATER PUMP: SEE 2013 NATEF TASK CORRELATION CHART**
	DISCUSSION: DISCUSS WITH STUDENTS DIFFERENCES IN COOLANT FLOW SYSTEMS.
DEMO	**DEMONSTRATION: SHOW STUDENTS DIFFERENT HEAD GASKET DESIGNS AND THE COOLANT PASSAGES THROUGH THEM.**
	ON VEHICLES THAT USE A TIMING BELT TO RUN WATER PUMP, IT IS STRONGLY RECOMMENDED THAT WATER PUMP BE REPLACED WHEN TIMING BELT REPLACED.
	60. **SLIDE 60 EXPLAIN FIGURE 19–29** typical engine-driven cooling fan 61. **SLIDE 61 EXPLAIN FIGURE 19–30** A typical electric cooling fan assembly showing the radiator and related components & **FIGURE 19–31** Flexible cooling fan blades change shape as the engine speed changes 62. **SLIDES 62-63 EXPLAIN Thermostatic Fans** 64. **SLIDE 64 EXPLAIN FIGURE 19–32** bimetallic temperature sensor spring controls the amount of silicone that is allowed into the drive unit, which controls the speed of the fan. 65. **SLIDE 65 EXPLAIN FIGURE 19–33** typical electric cooling fan assembly after being removed from vehicle

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	**CLUTCH FAN & HOSES 1.5 MINUTES WWW.MYAUTOMOTIVELAB.COM** HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET_MYLABS/AKAMAI/TEMPLATE/VIDEO640X480.PHP?TITLE=CLUTCH%20FAN%20AND%20HOSES&CLIP=PANDC/CHET/2012/AUTOMOTIVE/AUTO_PARTS_SPECIALIST/EXP5.MOV&CAPTION=CHET/CHET_MYLABS/AKAMAI/2012/AUTOMOTIVE/AUTO_PARTS_SPECIALIST/XML/EXP5.XML
 	**SAFETY: ELECTRICAL COOLING FANS CAN COME ON UNEXPECTEDLY. ALWAYS KEEP HANDS AND OBJECTS CLEAR OF THEM. SPRING-TYPE FANS SHOULD SPIN FREELY ON A COLD ENGINE.**
	**DEMONSTATION: SHOW STUDENTS HOW TO REMOVE AND REPLACE A COOLING FAN ASSEMBLY.**
	**ON-VEHICLE NATEF TASK: INSPECT AND TEXT FANS(S) (ELECTRICAL OR MECHANICAL), FAN CLUTCH, FAN SHROUD, AND AIR DAMS. SEE 2013 NATEF TASK CORRELATION CHART**
	**DEMONSTRATION: SHOW STUDENTS HOW FAN SHROUD HELPS DIRECT AIRFLOW THROUGH RADIATOR.**
	66. **SLIDES 66-67 EXPLAIN** Coolant Temperature Warning Light 68. **SLIDES 68-69 EXPLAIN Common Causes of Overheating** 70. **SLIDE 70 EXPLAIN Figure 19-34** When an engine overheats, often the coolant overflow container boils
	**DISCUSSION: DISCUSS WITH STUDENTS HOW INCORRECT IGNITION TIMING CAN CAUSE OVERHEATING ISSUES (I.E., CAUSE A LEAN CONDITION, WHICH LEADS TO THE ENGINE RUNNING AT HOTTER TEMPERATURES.)**
	**ON-VEHICLE NATEF TASK: IDENTIFY CAUSES OF ENGINE OVERHEATING (SEE 2013 NATEF TASK CORRELATION CHART**
	71. **SLIDE 71 EXPLAIN FIGURE 19–35** (a) Chrysler recommends that the bleeder valve be opened whenever refilling the cooling system. (b) Chrysler also recommends that a clear plastic hose (1/4” ID) be

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	attached to the bleeder valve and directed into a suitable container to keep from spilling coolant onto the ground and on the engine and to allow the technician to observe the flow of coolant for any remaining oil bubbles. 72. **SLIDE 72 EXPLAIN Figure 19-36** All cooling system hoses should be checked for wear or damage 73. **SLIDES 73-75 EXPLAIN** Cleaning the Radiator Exterior
DEMO	**DEMONSTRATION: SHOW STUDENTS DIFFERENT TYPES OF HEATER HOSES.**
	WHEN CHECKING RADIATOR HOSES, REMEMBER THAT BOTTOM HOSE MAY HAVE SPRING INSIDE TO KEEP IT FROM COLLAPSING.
We Support NATEF	**HANDS-ON TASK: HAVE STUDENTS REMOVE AND REPLACE A RADIATOR HOSE.**
DEMO	**DEMONSTRATION: SHOW STUDENTS PROPER PROCEDURE FOR USING A BELT TENSION GAUGE.**
We Support NATEF	**ON-VEHICLE NATEF TASK: INSPECT, REPLACE, AND ADJUST DRIVE BELTS, TENSIONERS AND PULLEYS; CHECK PULLEY AND BELT ALIGNMENT**
	OPTIONAL HOMEWORK (2 HOURS OUTSIDE WORK): HAVE STUDENTS RESEARCH THE INTERNET AND FIND OUR HOW HYBRID VEHICLES KEEP THE ENGINE COOLANT WARM EVEN THOUGH THE ENGINE IS NOT ALWAYS RUNNING. HAVE THEM REPORT THEIR FINDINGS TO THE CLASS.