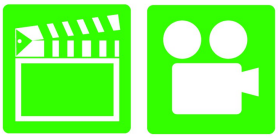
Automotive Maintenance and Light Repair, 1ST Edition

Chapter 37 Heating & Air Conditioning Components & Operations

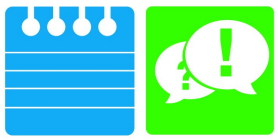
Opening Your Class

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 ASE Heating and Air-conditioning (A7) certification test content area "A" (Air Conditioning System Diagnosis and Repair) and content area "C" (Heating and Engine Cooling Systems Diagnosis and Repair). ⁀ Describe how the heater functions ⁀ Describe how the refrigeration cycle functions. ⁀ List the parts of a typical air-conditioning system. ⁀ Explain how the air-conditioning system removes heat from the passenger compartment.
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	Ch37 Heating & A/C Components & OP
	**1. SLIDE 1 CH37 Heating & Air Conditioning Components & Operations**
	2. SLIDES 2-3 EXPLAIN OBJECTIVES
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/**
	WEB SITE REGULARLY UPDATED
	**4. SLIDE 4 EXPLAIN Purpose and Function**
	5. SLIDE 5 EXPLAIN Figure 37-1 Water is a substance that can be found naturally in solid, liquid, and vapor states.
	**DISCUSSION: ASK STUDENTS TO DISCUSS THE THREE STATES OF WATER AND HOW THEY RELATE TO AUTOMOTIVE HEATING AND AIR-CONDITIONING SYSTEMS. EXPLAIN HOW MOLECULES OF WATER ARE MOVING AT DIFFERENT STATES. ASK WHY THERE HAS TO BE AN UNBALANCED FORCE FOR THE MOLECULES TO TRANSFER HEAT.**
	**6. SLIDES 6-22 EXPLAIN Purpose and Function**
	**LATENT HEAT OF EVAPORATION WWW.MYAUTOMOTIVELAB.COM** HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET_MYAUTOMOTIVELAB_2/ANIMATIONS/A77_ANIMATION/CHAPTER48_FIG_48_2/INDEX.HTM
	**23. SLIDE 23 EXPLAIN Figure 37-2** extra heat required to change a standard amount of water at its boiling point to a vapor is called **latent heat of vaporization**.
	24. SLIDE 24 EXPLAIN Figure 37-3 latent heat of vaporization that water vapor stores is given off when vapor condenses to a liquid. The temperature stays same.
	**DISCUSSION: ASK STUDENTS TO TALK ABOUT THE DIFFERENCES BETWEEN KINETIC AND POTENTIAL ENERGY. HAVE THEM GIVE EXAMPLES OF EACH IN BOTH AUTOMOTIVE AND NON-AUTOMOTIVE APPLICATIONS.**
	**DISCUSSION: ASK STUDENTS TO DISCUSS WHY AEROSOL CANS BECOME COLD WHEN SPRAYED CONTINUOUSLY AND WHY A CAN OF**

ICONS	Ch37 Heating & A/C Components & OP
	NONFLAMMABLE REFRIGERANT CAN EXPLODE WHEN HEATED BY FIRE. HINT: HAVE THEM FOCUS ON RELATIONSHIP BETWEEN PRESSURE AND TEMPERATURE FOR A VAPOR.
	**DISCUSSION: ASKS STUDENTS TO DISCUSS THE RELATIONSHIPS BETWEEN PRESSURE AND TEMPERATURE IN AN HVAC SYSTEM.**
	**25. SLIDES 26-37 EXPLAIN** Purpose and Function **38. SLIDE 38 EXPLAIN Figure 37-4** A sling psychrometer is used to measure relative humidity.
	**DEMONSTRATION: BORROW EITHER A HYGROMETER OR A PSYCHROMETER (FIGURE 37-4) FROM YOUR SCHOOL'S SCIENCE LAB, AND SHOW STUDENTS HOW THEY ARE USED TO MEASURE RELATIVE HUMIDITY.**
	**39. SLIDES 39-41 EXPLAIN** Purpose and Function **42. SLIDES 42-43 EXPLAIN** Heating System **44. SLIDE 44 EXPLAIN Figure 37-5** Typical flow of air through an automotive heat, ventilation, and air-conditioning system when placed in the heat position
	**SOME DMMS COME WITH A TEMPERATURE PROBE FOR CHECKING TEMPERATURES. USE THIS ON THE RADIATOR HOSES TO CHECK FOR A THERMOSTAT OPENING. ALSO, INFRARED TEMPERATURE GUNS ARE AVAILABLE TO CHECK TEMPERATURES.**
	**45. SLIDE 45 EXPLAIN** Heating System **46. SLIDE 46 EXPLAIN Figure 37-6** A typical heater core as installed in an HVAC housing
	47. SLIDES 47-49 EXPLAIN Air-Conditioning Refrigeration Cycle
	**50. SLIDE 50 EXPLAIN Figure 37-7** evaporator removes heat from the air that enters a vehicle by transferring it to the vaporizing refrigerant. **51. SLIDES 51 EXPLAIN** Air-Conditioning Refrigeration Cycle **52. SLIDES 52 EXPLAIN Figure 37-8** compressor provides mechanical force needed to pressurize refrigerant.

ICONS	Ch37 Heating & A/C Components & OP
	53. **SLIDES 53 EXPLAIN** Air-Conditioning Refrigeration Cycle 54. **SLIDE 54 EXPLAIN Figure 37-9** condenser changes the refrigerant vapor into a liquid by transferring heat from the refrigerant to the air stream that flows between the condenser fins. 55. **SLIDES 55-56 EXPLAIN** Air-Conditioning Refrigeration Cycle
	**DEMONSTRATION: USE LAB VEHICLE SHOW PARTS OF AN AUTOMOTIVE HEATING SYSTEM, INCLUDING HEATER HOSES & HEATER CORE. ALSO SHOW THEM BLOWER MOTOR THAT SENDS HEATED AIR INTO PASSENGER COMPARTMENT. USE AN INFRARED THERMOMETER TO SHOW TEMPERATURE DIFFERENCES ON HIGH AND LOW SIDES OF AC SYSTEM & HEATING SYSTEM.**
	**DEMONSTRATION: SHOW STUDENTS THE PARTS OF AN AUTOMOTIVE COOLING SYSTEM. POINT OUT THE COMPRESSOR AND EXPLAIN HOW IT WORKS.**
	**DISCUSSION: ASK STUDENTS TO TALK ABOUT HOW HEAT IS ABSORBED BY AN AUTOMOTIVE A/C SYSTEM.**
	**SHOW ANIMATION: REFRIGERANT FLOW WWW.MYAUTOMOTIVELAB.COM** HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET_MYAUTOMOTIVELAB_2/ANIMATIONS/A77_ANIMATION/CHAPTER48_FIG_48_22/INDEX.HTM
	**DEMONSTRATION: SHOW STUDENTS AN EXPANSION VALVE, DESCRIBE ITS PURPOSE, AND EXPLAIN HOW IT WORKS**
	57. **SLIDES 57-58 EXPLAIN** Expansion Valve Systems 59. **SLIDE 59 EXPLAIN Figure 37-10** typical air-conditioning system that uses an expansion valve. A temperature sensor bulb is attached to the outlet of the evaporator to control the amount of refrigerant allowed to flow into the evaporator
	**DISCUSSION: ASK STUDENTS TO DISCUSS HOW THERMOSTATIC CONTROL IS USED TO PREVENT THE TEMPERATURE OF THE EVAPORATOR FROM DROPPING BELOW 32°F (0°C). WHAT WOULD BE THE RESULT IF IT DID FALL BELOW THIS**

ICONS	Ch37 Heating & A/C Components & OP
	**TEMPERATURE? FIGURE 37-10** 60. **SLIDES 60-62 EXPLAIN** Orifice Tube Systems 63. **SLIDE 63 EXPLAIN Figure 37-11** A typical automotive air-conditioning system that uses a cycling clutch and an orifice tube. 64. **SLIDE 64 EXPLAIN Figure 37-12** Typical orifice tube.
	**DEMONSTRATION: SHOW STUDENTS AN ORIFICE TUBE, DESCRIBE ITS PURPOSE, AND EXPLAIN HOW IT WORKS. SHOW THEM SPECIAL TOOL REQUIRED TO REMOVE ORIFICE TUBE FROM SYSTEM FIGURE 37-12**
	65. **SLIDES 65-66 EXPLAIN** Thermostatic Control 67. **SLIDE 67 EXPLAIN Figure 37-13** A cutaway of an air-conditioning compressor electromagnetic clutch. 68. **SLIDES 68-69 EXPLAIN** Thermostatic Control
	70. **SLIDES 70-71 EXPLAIN** Refrigerants 72. **SLIDE 72 EXPLAIN Figure 37-14** R-134a is available in 12 oz cans as well as larger 30-lb containers. 73. **SLIDES 73-74 EXPLAIN** Refrigerants 75. **SLIDE 75 EXPLAIN** Refrigerants and the Environment 76. **SLIDE 76 EXPLAIN Figure 37-15** A depletion of the ozone layer allows more ultraviolet radiation from the sun to reach Earth's surface.
 QUESTION	**DISCUSSION: ASK STUDENTS TO TALK ABOUT THE REQUIREMENTS OF AUTOMOTIVE TECHNICIANS STEMMING FROM SECTION 609 OF THE CLEAN AIR ACT OF 1990. FIGURE 37-15**
	77. **SLIDE 77 EXPLAIN** Refrigerants & Environment 78. **SLIDE 78 EXPLAIN Figure 37-16** Chlorofluorocarbon molecules break apart in atmosphere
	**ALL CARS SINCE 1990S USE HFC-134A AS REFRIGERANT BECAUSE IT IS LESS HARMFUL TO OZONE THAN ITS PREDECESSOR, CFC-12. DISCUSS WHY THIS IS SO IMPORTANT.**
	**SHOW ANIMATION: OZONE DEPLETION WWW.MYAUTOMOTIVELAB.COM** HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET_MYAUTOMOTIVELAB_2/ANIMATIONS/A77_ANIMATION/CHAPTER48_FIG_48_15/INDEX.HTM

ICONS	Ch37 Heating & A/C Components & OP
DEMO	**DEMONSTRATION: SHOW TESTER FOR IDENTIFYING REFRIGERANT GASES**
	79. **SLIDES 79-81 EXPLAIN** Refrigerants and the Environment
QUESTION	**DISCUSSION: ASK STUDENTS TO TALK ABOUT THE TYPES OF REFRIGERANTS THAT HAVE BEEN USED IN AUTOMOTIVE SYSTEMS AND IN RESIDENTIAL HOME AC SYSTEMS. HOW DO THESE REFRIGERANTS WORK? WHY IS CFC-12 NO LONGER USED?**
	RESIDENTIAL HOME REFRIGERANTS CAN'T BE USED IN AUTOMOTIVE SYSTEMS, EXCEPT IN BUSES.
QUESTION	**DISCUSSION: ASK STUDENTS TO DISCUSS WHY CARBON DIOXIDE (CO_2) IS NOT A GOOD REFRIGERANT**
	82. **SLIDES 82-85 EXPLAIN** Refrigerant Oils
	86. **SLIDES 86-87 EXPLAIN** condenser
	88. **SLIDE 88 EXPLAIN Figure 37-17** label on a Toyota Fuel Cell Hybrid Vehicle (FCHV) showing that CO_2 is being used as the refrigerant.
	89. **SLIDE 89 EXPLAIN Figure 37-18** PAG oil used in Chrysler vehicles equipped with HFC-134a refrigerant. Notice that different oils are used for different systems depending primarily on the manufacturer of the compressor. Also notice that both PAG oils are in metal cans. PAG oil absorbs moisture so readily that it can even absorb moisture that is in the air through plastic—that is why metal containers are used.
	90. **SLIDE 90 EXPLAIN** condenser
	91. **SLIDES 91-93 EXPLAIN** EVAPORATOR
	94. **SLIDE 94 EXPLAIN Figure 37-19** A repaired condenser refrigerant line

ICONS	Ch37 Heating & A/C Components & OP
	**DISCUSSION: ASK STUDENTS TO TALK ABOUT ROLE OF REFRIGERANT OILS IN LUBRICATING COMPRESSOR. WHAT ARE THE TYPES OF REFRIGERANT OIL AND THEIR CHARACTERISTICS? HYBRID VEHICLES OFTEN USE SPECIAL OIL THAT IS NONCONDUCTIVE. USING WRONG OIL COULD CAUSE DEATH OR INJURY FROM ELECTRICAL SHOCK. SYSTEMS USE 200 VOLTS TO DRIVE COMPRESSOR RATHER THAN A BELT.**
	
	95. **SLIDE 95 EXPLAIN Figure 37-20** evaporator serves the same function for both the orifice-tube and the expansion valve–type air-conditioning system, and that is to allow the liquid refrigerant to evaporate and absorb heat from passenger compartment.
	**DEMONSTRATION: SHOW STUDENTS CONDENSER ON AN AUTOMOTIVE A/C SYSTEM. DESCRIBE ITS PURPOSE AND HOW IT WORKS**
	**DEMONSTRATION: SHOW CONDENSER & EXPLAIN ITS PURPOSE AND FUNCTION. USE A CONDENSER THAT HAS A CUT-THROUGH AREA TO SHOW THAT THE TUBES ARE HOLLOW**
	**DEMONSTRATION: SHOW STUDENTS' EVAPORATOR IN AN AUTOMOTIVE A/C SYSTEM. DESCRIBE ITS PURPOSE & HOW IT WORKS**
	**DISCUSSION: ASK STUDENTS TO DISCUSS HOW AN EVAPORATOR HELPS REMOVE MOISTURE FROM THE AIR AND LOWER HUMIDITY.**
	96. **SLIDE 96 EXPLAIN Figure 37-21** Expansion-valve systems store excess refrigerant in a receiver-drier, which is located in high-side liquid section of system, whereas orifice-tube systems store excess refrigerant in accumulator located in low-side vapor section of system 97. **SLIDES 97-101 EXPLAIN** Receiver-Drier
	**DEMONSTRATION: SHOW STUDENTS RECEIVER-DRIER IN AN AUTOMOTIVE A/C SYSTEM AND DESCRIBE ITS PURPOSE AND FUNCTION**

ICONS	Ch37 Heating & A/C Components & OP
	**DISCUSSION: ASK STUDENTS TO TALK ABOUT THE ROLE OF THE DESICCANT IN THE DRIER. WHAT WOULD HAPPEN IF IT WERE OMITTED?**
	**102. SLIDES 102-103 EXPLAIN** Accumulator **104. SLIDE 104 EXPLAIN Figure 37-22** typical accumulator used on a cycling clutch orifice-tube (CCOT) system
	**DEMONSTRATION: SHOW STUDENTS THE ACCUMULATOR ON AN ORIFICE TUBE SYSTEM (FIGURE 37-22). DESCRIBE ITS PURPOSE AND HOW IT WORKS**
	**105. SLIDES 105-106 EXPLAIN** Refrigerant Lines and Hoses
	**107. SLIDE 107 EXPLAIN Figure 37-23** Rigid lines and flexible hoses are used throughout the air-conditioning system. The line to and from the compressor must be flexible because it is attached to the engine, which moves on its mounts during normal vehicle operation. **108. SLIDE 108 EXPLAIN** Refrigerant Lines and Hoses
	**DISCUSSION: ASK STUDENTS TO DISCUSS HOW REFRIGERANT LINES AND HOSES DIFFER FROM RADIATOR COOLING SYSTEM HOSES.**
	**109. SLIDES 109-110 EXPLAIN** Thermostatic Expansion Valves **111. SLIDE 111 EXPLAIN Figure 37-24** typical expansion valve which uses an inlet and outlet attachment for the evaporator, and a temperature-sensing bulb that is attached to evaporator outlet tube. **112. SLIDE 112 EXPLAIN** Thermostatic Expansion Valves
	**SHOW ANIMATION: EXPANSION VALVE OP WWW.MYAUTOMOTIVELAB.COM** HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET_MYAUTOMOTIVELAB_2/ANIMATIONS/A77_ANIMATION/CHAPTER48_FIG_48_29/INDEX.HTM
	**113. SLIDE 113 EXPLAIN Figure 37-25** slot cut in the ball seat inside the expansion valve permits a small amount of refrigerant and oil to pass through at all times, even when the valve is closed. This flow of oil through the system is necessary to make sure that the compressor

ICONS	Ch37 Heating & A/C Components & OP
	receives the oil it needs for lubrication.
	**DISCUSSION: ASK STUDENTS TO DISCUSS HOW A PINTLE VALVE IS USED TO OPERATE THE VARIABLE ORIFICE IN AN EXPANSION VALVE SYSTEM: FIGURE 37-25**
	**114. SLIDE 114 EXPLAIN** Thermostatic Expansion Valves **115. SLIDE 115 EXPLAIN Figure 37-26** sensing bulb is attached to the evaporator outlet tube. Refrigerant inside the bulb expands or contracts in response to the evaporator temperature. **116. SLIDE 116 EXPLAIN** Thermostatic Expansion Valves **117. SLIDE 117 EXPLAIN Figure 37-27** Pressure from the capillary tube pushes on the spring-loaded diaphragm to open the expansion valve. As the pressure in the capillary tube contracts, the reduced pressure on the diaphragm allows the valve to close. **118. SLIDES 118-124 EXPLAIN** Thermostatic Expansion Valves
	**DISCUSSION: DISCUSS HOW SENSING BULB, CAPILLARY TUBE, & DIAPHRAGM INSIDE EXPANSION VALVE WORK TOGETHER TO REGULATE FLOW OF REFRIGERANT INTO EVAPORATOR**
	**125. SLIDE 125 EXPLAIN Figure 37-28** H-valve (H-block) combines the temperature-sensing and pressure-regulating functions into a single assembly. **126. SLIDE 126 EXPLAIN Figure 37-29** H-valve as used on a Chrysler minivan. **127. SLIDES 127-128 EXPLAIN Thermostatic Expansion Valves** **129. SLIDE 129 EXPLAIN Figure 37-30** In this Chrysler system, a low-pressure cutoff switch and a cycling-clutch switch are mounted on the H-valve.
	**DEMONSTRATION: SHOW STUDENTS AN EXAMPLE OF H-VALVE FROM CHRYSLER VEHICLE AND DESCRIBE HOW IT WORKS. FIGURES 37-28, 29, & 31**

ICONS	Ch37 Heating & A/C Components & OP
	130. SLIDE 130 EXPLAIN Fixed-Orifice Tubes 131. SLIDE 131 EXPLAIN Figure 37-31 orifice tube is usually located at the inlet tube to the evaporator 132. SLIDES 132-133 EXPLAIN Fixed-Orifice Tubes
	**DISCUSSION: DISCUSS HOW ORIFICE TUBES SEPARATE THE HIGH-PRESSURE & LOW-PRESSURE SIDES OF THE A/C SYSTEM. HOW DOES THIS METHOD DIFFER FROM THE ONE USED IN AN EXPANSION VALVE SYSTEM? FIG 37-31**
	**DEMONSTRATION: SHOW EXAMPLE OF A THERMO, ICING, OR DEFROST SWITCH (THERMOSTAT), & DESCRIBE HOW IT WORKS.**
	134. SLIDES 134-138 EXPLAIN Compressors
	**DISCUSSION: ASK STUDENTS TO DISCUSS THE PURPOSE AND FUNCTION OF AN A/C COMPRESSOR.**
	**DEMONSTRATION: SHOW STUDENTS AN A/C COMPRESSOR ELECTROMAGNETIC CLUTCH & DESCRIBE ITS PURPOSE & FUNCTION. SHOW CLUTCH ENGAGING. EXPLAIN HOW DIODE PREVENTS A VOLTAGE SPIKE THAT COULD CAUSE DAMAGE TO PCM.**
	139. SLIDE 139 EXPLAIN Figure 37-32 In a positive-displacement compressor, the descending piston creates a drop in pressure inside the cylinder. The resulting pressure differential allows low-side pressure to force the suction valve open. Refrigerant then flows into the cylinder. On the piston's discharge stroke, the pressure caused by the ascending piston closes the intake valve and forces the refrigerant out the discharge valve
	**DEMONSTRATION: SHOW POSITIVE DISPLACEMENT PISTON COMPRESSOR AND HOW IT WORKS FIGURE 37-32**
	140. SLIDES 140-155 EXPLAIN Compressors

ICONS	Ch37 Heating & A/C Components & OP
	156. SLIDES 156-166 EXPLAIN Compressor Controls
	**DEMONSTRATION: SHOW REED VALVE INSIDE A COMPRESSOR AND DISCUSS HOW IT FUNCTIONS.**
	**COMPRESSOR REED VALVE OPERATION WWW.MYAUTOMOTIVELAB.COM** HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET_MYAUTOMOTIVELAB_2/ANIMATIONS/A77_ANIMATION/CHAPTER48_FIG_48_34/INDEX.HTM
	**DEMONSTRATION: SHOW STUDENTS A SWASH PLATE IN A COMPRESSOR AND DISCUSS HOW IT OPERATES**
	**SHOW ANIMATION: SWASH PLATE COMPRESSOR OPERATION WWW.MYAUTOMOTIVELAB.COM** HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET_MYAUTOMOTIVELAB_2/ANIMATIONS/A77_ANIMATION/CHAPTER48_FIG_48_36/INDEX.HTM
	**DISCUSSION: DISCUSS HOW AN ELECTROMAGNETIC CLUTCH WORKS TO CONTROL THE COMPRESSOR**
	185. SLIDE 185 EXPLAIN Figure 37-38 Typical air-conditioning pressure switches. A service manual would be needed to determine the function of each switch. One switch could be the low-pressure switch and the other a high-pressure switch.
	186. SLIDES 186-191 EXPLAIN Compressor Controls
	**DEMONSTRATION: SHOW STUDENTS HOW TO PERFORM THE RADIO POP TRICK.**
	**DISCUSSION: ASK STUDENTS TO DESCRIBE 3 TYPES OF SWITCHES THAT MUST BE FUNCTIONAL TO ENGAGE COMPRESSOR CLUTCH AND HOW EACH FUNCTIONS.**
	**NATEF TASK MLR TASK A7A1 RESEARCH APPLICABLE VEHICLE & SERVICE INFORMATION, VEHICLE SERVICE HISTORY, SERVICE PRECAUTIONS, & TECHNICAL SERVICE BULLETINS.**

ICONS	Ch37 Heating & A/C Components & OP
	**NATEF TASK MLR TASK A7B2 IDENTIFY HYBRID VEHICLE A/C SYSTEM ELECTRICAL CIRCUITS AND THE SERVICE/SAFETY PRECAUTIONS.**