Automotive Technology 6th Edition
Chapter 63 Heating & Air-Conditioning Components & Operation: 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 on NEXT SLIDE. 1. Describe how an automotive heating, ventilation, and air-conditioning system works. 2. Describe the parts and operation of the heating system. 3. Explain the air-conditioning refrigeration cycle. 4. Describe the operation of expansion valve systems, orifice tube systems, and thermostatic control systems. 5. Discuss the refrigerants used and their impact on the environment. 6. Explain the function of refrigerant oils, condensers, and evaporators. 7. Explain the function of receiver-dryers, accumulators, refrigerant lines and hoses, thermostatic expansion valves, and fixed-orifice tubes. 8. Explain the operation of a compressor and its controls.
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 63 Chapter Images: From

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

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

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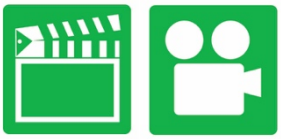
	**1. SLIDE 1 Chapter 63 HEATING & AIR-CONDITIONING** **2. SLIDE 2 EXPLAIN Figure 62-1** Water is a substance that can be found naturally in solid, liquid, and vapor states.
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE IS CONSTANTLY UPDATED**
	**http://www.jameshalderman.com/automotive_principles.html** **DOWNLOAD** **Crossword Puzzle (Microsoft Word) (PDF)** **Word Search Puzzle (Microsoft Word) (PDF**
	**Videos**
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***Why is Liquid Sprayed from a Can Cold?*** **If you spray a can of liquid continuously, the can becomes cold, and the liquid being sprayed becomes cold. The can becomes cold because the pressure in the can is reduced while spraying, allowing liquid propellant inside can to boil and absorb heat. The liquid being sprayed has also been cooled by the liquid propellant. The propellant vapor is further cooled as it decompresses when it hits open air. Rapid decompression results in a rapid temperature drop.**
	**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.**
	Conduction (View) (Download) Convection (View) (Download) Heat Transfer & Boiling (View) (Download) Heat Transfer (View) (Download) Heat Transfer Through Latent Heat (View) (Download)

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	HVAC Functions (View) (Download) Radiant Heat (View) (Download)
	3. **SLIDE 3 EXPLAIN Figure 63-2** extra heat required to change a standard amount of water at its boiling point to a vapor is called **latent heat of vaporization**. 4. **SLIDE 4 EXPLAIN Figure 63-3** 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 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.**
	5. **SLIDE 5 EXPLAIN Figure 63-4** A sling psychrometer is used to measure relative humidity.
	**DEMONSTRATION: Borrow either a hygrometer or a psychrometer (FIGURE 63-4) from your school's science lab, and show students how they are used to measure relative humidity.**
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***What is an Auxiliary Electric Water Pump?*** **Some vehicles are equipped with an auxiliary electric water pump. The purpose and function of this pump is to *help warm the interior of the vehicle by circulating coolant from the engine through the heater core when the engine is at idle speed.* At idle speed, the water pump does not circulate a sufficient quantity of coolant**

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	through the heater core to warm interior in freezing weather.
	6. **SLIDE 6 EXPLAIN Figure 63-5** 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. Use this on the radiator hoses to check for a thermostat opening. Also, INFRARED temperature guns are available to check temperatures.**
	7. **SLIDE 7 EXPLAIN Figure 63-6** A typical heater core as installed in an HVAC housing 8. **SLIDE 8 EXPLAIN Figure 63-7** evaporator removes heat from the air that enters a vehicle by transferring it to the vaporizing refrigerant. 9. **SLIDE 9 EXPLAIN FIGURE 63-8** The compressor provides mechanical force needed to pressurize the refrigerant 10. **SLIDE 10 EXPLAIN Figure 63-9** condenser changes the **refrigerant vapor into a liquid** by transferring heat from the refrigerant to the air stream that flows between the condenser fins
	**DISCUSS FREQUENTLY ASKED QUESTION: *How Does the Inside of the Vehicle Get Cooled?* The underlying principle involved in air-conditioning or refrigeration is that "cold attracts heat." *Heat always flow from the warmer to the colder object*. Therefore, a cool evaporator attracts the hot air inside the vehicle. Heat always travels toward cold and, when the hot air passes through cold evaporator, heat is absorbed by cold evaporator, which lowers temperature of air. The cooled air is then forced into passenger compartment by blower through air-conditioning vents.**
	**DEMONSTRATION: USE LAB VEHICLE Show students the parts of an automotive heating system, including heater hoses & heater core. Also show them blower motor that sends heated air into**

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	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.**
	**DEMONSTRATION: Show students an expansion valve, describe its purpose, and explain how it works**
	**11. SLIDE 11 EXPLAIN Figure 63-10** A 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
	**Conduction (View) (Download)** **Convection (View) (Download)** **Heat Transfer & Boiling (View) (Download)** **Heat Transfer (View) (Download)** **Heat Transfer Through Latent Heat (View) (Download)** **HVAC Functions (View) (Download)** **Radiant Heat (View) (Download)**
	**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 temperature? FIGURE 63-10**
	**12. SLIDE 12 EXPLAIN Figure 63-11** A typical automotive air-conditioning system that uses a cycling clutch and an orifice tube. **13. SLIDE 13 EXPLAIN Figure 63-12** 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 63-12**

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	**14. SLIDE 14 EXPLAIN Figure 63-13** A cutaway of an air-conditioning compressor electromagnetic clutch
	**15. SLIDE 15 EXPLAIN Figure 63-14** R-134a is available in 12 oz cans as well as larger 30-lb containers
	16. SLIDE 16 EXPLAIN Figure 63-15 A depletion of the ozone layer allows more ultraviolet radiation from the sun to reach Earth's surface.
	**DISCUSSION: Ask students to talk about the requirements of automotive technicians stemming from Section 609 of the Clean Air Act of 1990. FIGURE 63-15**
	**17. SLIDE 17 EXPLAIN Figure 63-16** Chlorofluorocarbon molecules break apart in the atmosphere
	18. SLIDE 18 EXPLAIN FIGURE 63–17 Due to the cost of **R-1234yf**, most shops will purchase 10 or 20 pound containers compared to the normal 30 pound container that most shops purchased for R-134a.
 	**DISCUSS CHART 63-1 Refrigerant fitting sizes must be unique for each type of refrigerant to help prevent cross–contamination.**
	All cars since 1990s use HFC-134a as a refrigerant because it is less harmful to ozone layer than CFC-12. DISCUSS why we are going to R1234yf. HFO-1234yf is a new class of refrigerants acquiring a global warming potential (GWP) rating 335 times < R-134a (only 4 X higher than carbon dioxide, which can also be used as a refrigerant but has significantly different properties to R134A, especially requiring operation at around 5 times higher pressure) and an atmospheric lifetime of about 400 times shorter. It was developed to meet the European directive 2006/40/EC that went into effect in 2011 requiring that all new car platforms for sale in Europe use a refrigerant in its AC system with a GWP below 150.

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	**DISCUSS FREQUENTLY ASKED QUESTION:** ***Will R-134a Systems be Required to be Retrofitted to R-1234yf?*** ***No*****. Currently there is no mandate to retrofit existing systems with R-1234yf. If a vehicle came from the factory with R-1234yf, then this refrigerant, of course, should be used when servicing the vehicle and requires a special machine. R-134a is primary refrigerant for most vehicles and there is no need or legal requirement to replace it with any other refrigerant at this time.**
	**DEMONSTRATION: Show students the tester for identifying refrigerants**
	**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.**
 	**DISCUSSION: discuss why carbon dioxide (CO2) is not a good automotive refrigerant.**
	**19. SLIDE 19 EXPLAIN Figure 63-18** 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. **20. SLIDE 20 EXPLAIN Figure 63-19** Ester refrigerant oils are often specified for use when retrofitting an R-12 system to R-134a by companies who supply refit kits. Ester refrigerant oil is not recommended by many vehicle or air-conditioning compressor manufacturers. Always

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	use the recommended refrigerant oil for the vehicle and system being serviced. 21. **SLIDE 21 EXPLAIN Figure 63-20** The condenser serves the same function for both the orifice-tube and the expansion valve–type air-conditioning system, and that is to remove the heat from the refrigerant and cause the hot refrigerant vapors to condense into a hot liquid. **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. These systems use 200 volts to drive compressor rather than driving it with a belt.** **EXPLAIN TECH TIP: *Broken Condenser Line? Check the Engine Mounts!* Most air-conditioning systems use aluminum and flexible rubber lines between the compressor and the condenser. Because compressor is mounted on and driven by engine and the condenser is mounted to the body, these lines can break if the engine mounts are defective. The rubber hoses attached between the aluminum fittings of the compressor and condenser are designed to absorb normal engine movement. Worn engine mounts allow the engine to move too much. Aluminum lines cannot stand to be flexed without crushing and breaking. Therefore, the wise technician carefully inspects and replaces any and all worn engine mounts if a broken aluminum condenser line is discovered to prevent a premature failure of a replacement condenser. • SEE FIGURE 63–21.** 22. **SLIDE 22 EXPLAIN FIGURE 63-21** A repaired condenser refrigerant line.

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	**DEMONSTRATION:** Show students **Condenser** on an automotive A/C system. Describe its purpose and how it works
	**DEMONSTRATION:** Show students a **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 and how it works
	**DISCUSSION:** Ask students to discuss how an evaporator helps remove moisture from the air and lower humidity.
	23. **SLIDE 23 EXPLAIN Figure 63-22** 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 the passenger compartment.
	**DEMONSTRATION:** Show students **Receiver-Drier** in an automotive A/C system and describe its purpose and function
	**DISCUSSION:** Ask students to talk about the role of the desiccant in the drier. What would happen if it were omitted?
	24. **SLIDE 24 EXPLAIN FIGURE 63-23** 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. 25. **SLIDE 25 EXPLAIN Figure 63-24** typical accumulator used on a cycling clutch orifice-tube (CCOT) system
	**DEMONSTRATION:** Show students the **Accumulator** on an orifice tube system (**FIGURE 63-24**). Describe its purpose and how it works
	26. **SLIDE 26 EXPLAIN Figure 63-25** Rigid lines and flexible hoses are used throughout the air-conditioning system. The line to and from the compressor must be

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	flexible because it is attached to the engine, which moves on its mounts during normal vehicle operation.
	**DISCUSSION:** **Ask students to discuss how refrigerant lines and hoses differ from radiator cooling system hoses.**
	**27. SLIDE 27 EXPLAIN Figure 63-26** A 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
	**28. SLIDE 28 EXPLAIN Figure 63-27** A 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 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 63-27**
	**29. SLIDE 29 EXPLAIN Figure 63-28** The sensing bulb is attached to the evaporator outlet tube. Refrigerant inside the bulb expands or contracts in response to the evaporator temperature.
	30. SLIDE 30 EXPLAIN Figure 63-29 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.
	**DISCUSSION:** **Ask students to talk about how sensing bulb, capillary tube, & diaphragm inside expansion valve work together to regulate flow of refrigerant into evaporator.**
	**31. SLIDE 31 EXPLAIN Figure 63-30** An H-valve (H-block) combines the temperature-sensing and pressure-regulating functions into a single assembly.
	32. SLIDE 32 EXPLAIN Figure 63-31 An H-valve as used on a Chrysler minivan
	33. SLIDE 33 EXPLAIN Figure 63-32 In this Chrysler system, a low-pressure cutoff switch and a cycling-clutch switch are mounted on the H-valve.

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	**DEMONSTRATION:** Show students an example of an H-Valve from a Chrysler vehicle and describe how it works. FIGURES 63-30 & 31
	**34. SLIDE 34 EXPLAIN Figure 63-33** orifice tube is usually located at the inlet tube to the evaporator
	**DISCUSSION:** Ask students to 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? FIGURE 63-33
	**DEMONSTRATION:** Show students an example of a thermo, icing, or defrost switch (thermostat), & describe how it works.
	**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.
	**35. SLIDE 35 EXPLAIN Figure 63-34** 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 students an example of a positive displacement piston compressor and how it works FIGURE 63-34
	**36. SLIDE 36 EXPLAIN Figure 63-35** A reed valve is a one-way check valve that flaps away from the valve plate to open, and toward the valve plate to close.

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     	**DEMONSTRATION:** Show students an example of a reed valve (FIGURE 63-35) inside a compressor and discuss how it functions. 37. **SLIDE 37 EXPLAIN Figure 63-36** The swash plate, attached to the crankshaft at an angle, converts the pulley's rotary motion to axial motion, which drives the pistons in a reciprocating motion **DEMONSTRATION:** Show students a swash plate in a compressor and discuss how it operates. FIGURE 63-36 **DISCUSSION:** Ask students to discuss how a variable displacement compressor works and how it differs from a positive-displacement piston compressor. **DISCUSSION:** Ask students to talk about how an electromagnetic clutch works to control the compressor. **EXPLAIN TECH TIP:** The Radio "POP" Trick Most air-conditioning compressor clutch circuits contain a diode that is used to suppress the high-voltage spike that is generated whenever the compressor clutch coil is disengaged (turned off). If this diode were to fail, a high voltage (up to 400 volts!) could damage sensitive electronic components in vehicle, including electronic air-Conditioning compressor clutch control unit (if so equipped). Another thing that can occur is that the radio often turns off and then back on whenever electronics inside radio detect a high-voltage spike. This can create a "pop" in radio that is very intermittent because it only occurs when air-conditioning compressor clutch cycles off. To check this diode, simply tune radio to a weak AM station near 1,400 Hz and cycle air-conditioning compressor on and off. If a "pop" is heard from the radio speaker(s), then diode is defective and must be replaced. **NOTE:** While some A/C compressor diodes can be replaced separately, some of these air-conditioning

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    	**compressor clutch diodes** **DEMONSTRATION: Show students how to perform the radio pop trick.** 38. **SLIDE 38 EXPLAIN FIGURE 63-37** V-5 variable displacement compressor 39. **SLIDE 39 EXPLAIN Figure 63-38** 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. **DISCUSSION: Ask students to describe 3 types of switches that must be functional to engage compressor clutch and how each functions.** **DISCUSS CASE STUDY *What Throttle Switch?*** **A service technician was tracing cause of an inoperative air compressor on a Saab. The service manual showed a schematic of the air-conditioning compressor that indicated number of switches that had to be closed for compressor clutch to be supplied with battery voltage. Besides the low-pressure switch (to assure that the system is charged so as not to damage the compressor), a throttle switch was shown on the schematic. Obviously, someone else had worked on the vehicle because the throttle switch was missing entirely—just two wires remained to indicate that anything had been installed. Connecting the two wires together provided voltage to the air-conditioning compressor clutch. The customer decided not to replace the throttle switch after learning that its purpose was to disconnect (open circuit) air-conditioning compressor when the throttle was at wide open positive to allow maximum power for passing.**

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 	**Summary:** • **Complaint—The air conditioning system was inoperative.** • **Cause—throttle switch was missing and the wiring, being opened, prevented the compressor from operating.** • **Correction—wiring was connected to restore the operation of A/C compressor:** **ON-VEHICLE ASEEDUCATION TASK Locate and interpret vehicle and major component identification numbers.**