Lesson 1 - Basic Heat Pump Theory (Part 1)
Objectives:

- Describe the basic operation of a heat pump.
- Explain the function of various heat pump controls.
- Interpret the wiring diagrams and performance data provided by heat pump manufacturers.
- Determine and evaluate the coefficient of performance (COP) of a heat pump.

Lesson 2 - Basic Heat Pump Theory (Part 2)
Objectives:

- Explain the operation of a four-way reversing valve.
- Describe the proper installation and replacement of reversing valves.
- Describe the various types of applications in which reversing valves are used.
- Diagnose and troubleshoot reversing valve malfunctions.

Lesson 3 - Water-Source Heat Pumps
Objectives:

- Describe how outdoor conditions affect the perimeter load of a building.
- Explain the basic principles of operation of water-to-air heat pumps.
- Determine the best location and method of installation for individual heat recovery units.
- Explain how large vertical units are installed and piped.
- Diagnose water-source heat pump malfunctions and suggest corrective procedures.

Lesson 4 - Computer Room Environmental Control
Objectives:

- Describe the effects of humidity in computer rooms.
- Explain the reasons for using raised floors in computer rooms.
- Discuss the advantages of using packaged units specifically designed for computer room applications.
- Describe the operation of temperature and humidity recorders.
- List and identify the tools necessary for providing efficient service.
- Explain the different types of head pressure controls.

Lesson 5 - Economizer Systems (Part 1)
Objectives:

- Explain the purpose of an economizer system.
- Describe the economizer's damper positions during each of its cycles of operation.
- Explain the basic operating sequence of a packaged economizer.

Lesson 6 - Economizer Systems (Part 2)
Objectives:

- Describe the operating cycle of a typical rooftop economizer.
- Explain the difference between *integrated* and *non-integrated* economizers.
- Discuss the basic principles of operation of various economizer controls and components, including
- dampers, motors, outdoor-air thermostats, enthalpy controls, mixed-air thermostats, and minimum position potentiometers.
- Describe the proper installation of a rooftop economizer.
- Identify the symptoms of various economizer problems, and describe possible causes and corrective actions.

Lesson 7 - Fans and Blowers (Part 1)
Objectives:

- Name the three types of axial fans.
- Identify the three most common centrifugal impeller designs.
- Explain how the characteristics of an air distribution system are represented by a parabolic curve on a graph.
- Explain how fan speed, air volume flow rate, air density, static pressure, and motor horsepower are related to each other.

- Apply the appropriate fan laws to determine how a change in one variable will affect the others.
- Interpret fan performance curves, and explain what is meant by a *point of operation*.
- Describe the operating characteristics of various types of fans.

Lesson 8 - Fans and Blowers (Part 2)
Objectives:

- Interpret the data provided by the rpm/torque graph of a motor.
- Demonstrate good maintenance practices for fan drives and bearings.
- Describe various methods of fan motor speed control.
- Use the fan law calculator to solve fan performance problems involving changes in any of four variables.

Lesson 9 - Air Filters and Electrostatic Cleaning
Objectives:

- Explain the function of an air filter, and describe the different processes used to accomplish this function.
- Identify various types of mechanical air filters.
- Explain the operation of electronic air filters.
- Demonstrate basic maintenance procedures for air filters.

Lesson 10 - Air Distribution (Part 1)
Objectives:

- Explain the general principles of room air distribution, including typical air flow patterns and stratification.
- Describe the effects of air movement on human comfort.
- Describe the performance characteristics of the various types of supply air outlets.
- Select proper air outlets for maximum comfort and efficiency.
- Explain where the return intakes should be located for a given application, and why.
- Describe the methods of air delivery through a variety of terminal air-handling units.

Lesson 11 - Air Distribution (Part 2)
Objectives:

- Use and understand duct system terminology.
- List and explain the various factors that affect resistance to air flow in a duct system.
- Identify and describe duct system designs.

Lesson 12 - Air Distribution (Part 3)
Objectives:

- Explain how *equivalent length* (EL) values are determined, and why they are important in laying out a duct system.
- Identify various types of duct fittings, and describe the purpose of each.
- Use duct sizing tables.
- Determine the duct approach to an outlet that will provide the best air distribution.

Lesson 13 - Evaporative Condensers and Cooling Towers
Objectives:

- Determine which condensing method should be used for applications in which plenty of cool water is available.
- Explain how an evaporative condenser works.
- Identify the factors that must be considered when you install an evaporative condenser.
- Describe the operational characteristics of an evaporative condenser water pump.
- Explain how a cooling tower operates.

Lesson 14 - Water Treatment (Part 1)
Objectives:

- Determine why water treatment is necessary.
- Identify the basic causes of corrosion.
- Define *pH*.
- Explain galvanic action.

- Discuss the importance of condensing temperature.
- Describe procedures for field testing water.
- List safety precautions for using scale removers.
- Describe cleaning procedures.

Lesson 15 - Water Treatment (Part 2)
Objectives:
- Explain why preventive maintenance is necessary for condensers and cooling towers.
- Add different types of algaecides to water-cooled equipment.
- Discuss the methods of scale prevention.

Lesson 16 - Closed-Circuit Water Coolers
Objectives:
- Explain the difference between a closed-circuit water cooler and an evaporative condenser.
- Discuss the factors that should be considered in selecting a closed-circuit water cooler.
- Describe how to regulate the capacity of a closed-circuit water cooler.
- Determine the location of louvers in a cold-climate application.
- Define the terms *cooling range*, *approach*, and *temperature difference*.

Lesson 17 - Air-Cooled Condensing Unit Room Requirements
Objectives:
- Explain why the majority of supermarkets use air-cooled condensing units.
- Describe the basis on which wall opening area is calculated for intake air in the condensing unit room.
- Determine factors governing the unit room planning.

Lesson 18 - Heat Transfer Coils
Objectives:
- Describe the design characteristics that apply to heating and cooling coils.
- Identify problems that cause improper performance of coils.
- Discuss important features to be considered in the selection of piping coils.

Lesson 19 - Multiple Rack Systems
Objectives:
- Explain the operating principles of multiple rack refrigeration systems.
- Describe the various components of rack refrigeration systems in general.

Lesson 20 - Hydronics (Part 1)
Objectives:
- Explain the basic operation of liquid chillers.
- Describe both the refrigerant circuit and the water circuit in a typical liquid chiller.
- Explain why it is so important to keep the liquid being chilled from freezing.
- Determine causes of common chiller problems and suggest corrective steps.

Lesson 21 - Hydronics (Part 2)
Objectives:
- Describe the different types of piping systems, including loop, single-main, and two-pipe systems.
- Trace flow circuits and paths.
- Explain how piping is sized for a given system.
- Describe the configuration of a primary-secondary piping system, and of a three-pipe system.
- List some of the considerations that must be taken into account in the installation of a hydronic piping system.
- Explain the operation of various balancing test devices.

Lesson 22 - Hydronics (Part 3)
Objectives:

- Describe the performance characteristics of a typical centrifugal pump.
- Explain how temperature rise affects pump capacity requirements.
- Interpret the information provided by pump curves.
- Establish the operation point of a pump connected to a specific piping system.
- Calculate the total head of a system.
- Evaluate pump performance by taking gauge readings.
- Explain the advantages of parallel, series, and combination pumping arrangements.

Lesson 23 - Troubleshooting (Part 1)
Objectives:

- Diagnose typical problems that may occur in condensers and cooling towers, and describe the related troubleshooting procedures.
- Diagnose typical problems that may occur in piping systems, and describe the related troubleshooting procedures.
- Explain the proper application of various HVAC/R accessories.

Lesson 24 - Troubleshooting (Part 2)
Objectives:

- Identify the causes of common problems in pumping systems.
- Follow a logical, step-by-step approach in troubleshooting control systems.
- Isolate the causes of malfunctions in chiller systems.
- Observe proper application procedures in electric heating applications.
- Identify the causes of common problems in fan installations.

Lesson 25 - Control Components and Variables
Objectives:

- Describe the functions of an HVAC/R control system.
- Identify the comfort range for relative humidity.
- Explain why maintaining a slight positive pressure in a building is desirable.
- State the goal of air distribution.
- Convert temperatures from Fahrenheit degrees to Celsius degrees, and vice versa.
- Convert temperatures from Fahrenheit degrees to Rankine degrees, and vice versa.
- Explain the Perfect Gas Law.
- Explain how gauge pressure differs from absolute press.
- Describe how barometers, U-tube manometers, and Magnehelic® manometers are used.
- Define the following terms: *specific heat*, *sensible heat*, *latent heat*, *heat of fusion*, and *heat of vaporization*.
- Name the four basic elements of control systems and describe their functions.
- Identify the six basic functions of fully automatic control equipment.
- Explain how electric, pneumatic, and electronic controllers differ from each other.
- Describe the operation of the various types of temperature and humidity sensors.
- Describe the operation of pneumatic and electronic modulating controllers.

Lesson 26 - Types of Control Systems
Objectives:

- List the advantages and the disadvantages of electric controls.
- List the advantages and the disadvantages of pneumatic controls.
- List the advantages and the disadvantages of electronic analog controls.
- List the advantages and the disadvantages of electronic digital controls.
- Define the following terms: *two-position control*, *offset*, *timed two-position control*, and *floating control*.
- Describe proportional pneumatic control.
- Describe proportional plus integral (P.I.) control.
- Describe proportional plus integral plus derivative (P.I.D.) control.

Lesson 27 - Specifications
Objectives:
- Name the 16 CSI specification divisions.
- Identify Division 15 mechanical broad-scope specifications.
- Discuss automatic temperature control specifications in detail.

Lesson 28 - Sensors
Objectives:
- Describe the various types of disturbance-sensing elements and their properties.
- Discuss the application of these sensors, including those that respond to changes in pressure, temperature, and relative humidity, in automatic HVAC/R control systems.
- Explain the two steps of converting a mechanical signal to an electrical signal.
- Describe the advantages and disadvantages of electrical pressure transducers, potentiometric pressure transducers, and capacitive pressure transducers.

Lesson 29 - Basic Control Theory
Objectives:
- Describe the functions of an HVAC/R control system.
- Convert temperatures from Fahrenheit degrees to Celsius degrees, and vice versa.
- Convert temperatures from Fahrenheit degrees to Rankine degrees, and vice versa.
- Explain the Perfect Gas Law.
- Explain how gauge pressure differs from absolute pressure.
- Define the following terms: *specific heat*, *sensible heat*, *latent heat*, *heat of fusion*, and *heat of vaporization*.
- Name the four basic elements of control systems and describe their functions.
- Identify the six basic functions of fully automatic control equipment.
- Define the following terms used in HVAC/R controls: *setpoint*, *control point*, *offset*, *deviation*, and *differential*.
- Explain what terms “controller throttling range” and “proportional band” mean.

Lesson 30 - Air Supply Equipment (Part 1)
Objectives:
- Describe the characteristics and operating principles of various types of air compressors.
- Size and specify the air supply equipment necessary for a pneumatic temperature control system.

Lesson 31 - Air Supply Equipment (Part 2)
Objectives:
- Describe common maintenance procedures for air supply systems.
- Identify the various components that make up an air supply system.
- Adjust and troubleshoot a typical air supply system.

Lesson 32 - Thermostats and Controllers (Part 1)
Objectives:
- Explain how controllers are classified.
- Describe the design, construction, and operation of various types of thermostats and controllers.
- Define the terms *throttling range*, *proportional band*, and *differential* as they apply to controllers.

Lesson 33 - Thermostats and Controllers (Part 2)
Objectives:
- Describe the design, construction, and operation of high-capacity single-temperature thermostats.
- Explain the operation of the valve unit in a high-capacity thermostat.
- Describe the design, construction, and operation of high-capacity dual-temperature thermostats.
- Describe the design, construction, and operation of high-capacity heating/cooling thermostats.

Lesson 34 - Pneumatic Relays
Objectives:

- Describe the function and operation of various types of switching, reversing, volume-amplifying, and positive positioning pneumatic relays.
- Explain the difference between high-pressure selecting relays and low-pressure selecting relays.
- Explain how electric-pneumatic and pneumatic-electric relays are used in control systems.
- Give examples of the types of control applications in which manual switches are used.
- Describe the function and operation of integral reset relays.

Lesson 35 - Typical Control Applications
Objectives:

- Explain how the temperature of the discharge air is controlled in basic air-handling systems.
- Explain the differences between single-zone and multizone control systems.
- Describe the operation of mixed air and economizer controls.
- Explain how and why unit ventilator controls are used.
- Describe the operation of hot deck and cold deck control systems.

Lesson 36 - Control System Maintenance
Objectives:

- Explain the maintenance procedures necessary to ensure the proper operation of a pneumatic control system.
- Describe the steps necessary to set up a scheduled maintenance program for a pneumatic control system.