

RSES & Elsevier eLearning – Course Outline

Electricity for the HVACR Technician

Course Title: Electricity for the HVACR Technician

A thorough introduction to the concepts of electricity and magnetism, description of basic electrical devices that use these concepts, the concepts of alternating current and related devices, and the basic explanation of electrical schematics.

- Utah CEUs: 12
- User can stop and start the material at any point (e.g., after 20 minutes), bookmark where they leave off, and repeat all material as many times as desired.
- Price – Full course: \$225, \$150 for RSES members (£112 / £75; €150 / €100)
- Course uses Inch-Pound (I-P) units of measure.
- NATE CEHs: 36 - NATE-recognized for NATE recertification

Designed For:

- Service technicians

After Completing This Course, You Will Understand:

- The concepts of electricity and magnetism
- The fundamentals of alternating currents
- The functioning of basic electrical devices and circuit protection devices
- The electrical schematics

Course Description:

- On-demand, interactive course of 12 modules (“short courses”)
- Online course reader with easy-to-print PDFs
- Online self-assessment

Modules:

- 1) Terminology and Units of Measurement
- 2) Electronics—History and Concepts
- 3) Series Circuits, Parallel Circuits, and Power
- 4) Magnetism and Transformers
- 5) Magnetic Attraction, Repulsion, and Shielding
- 6) Transformers
- 7) Relays, Contactors and Starters
- 8) Fundamentals of Alternating Current
- 9) Alternating Current: Reactance, Impedance & Power Factor
- 10) Circuit Protection Devices: Fuses
- 11) Circuit Protection: Circuit Breakers & Overload Protection
- 12) Understanding Electrical Schematics

Every Module Includes:

- Reading assignment
- Learning activities

- Lesson summary
- Module exam

Outcomes: The 12 online modules help you to understand:

- Introduction to the various terminologies and the units of measurement used in the study of electricity.
- The basic concepts of electronics, especially as used in the HVACR industry.
- The two basic ways in which two circuit components can be connected and the concept of power, its calculations and how the power consumed by the two types of circuits is different.
- The principles that define magnetism, the various types of magnets available today, the methods used to produce magnets, and the various theories on the nature of magnetism.
- The concepts of magnetic fields and lines of force.
- The components that make up a transformer, how transformers are rated, and the different types of transformers in use today.
- Troubleshooting techniques for relays, contactors, and starters used in the HVACR field.
- The fundamentals of alternating current and the reason why it can be used in the power distribution system.
- Calculation of the different resistance introduced in an ac circuit by capacitors, inductors, and resistors and the concept of power factor.
- The different types of fuses, their usage and rating, and how they are tested.
- The circuit-breakers as circuit-protection devices and the concepts of internal and external overloads.
- The symbols and conventions commonly used in schematic diagrams.

How This Course Relates to Existing RSES Training:

This online course is a great complement to the instructor-led trainings being offered by RSES Chapters.

The modules that make up the **Electricity for the HVACR Technician** course most directly resemble content within the first few Lessons of the, "Electricity for HVACR Technicians," manual as well as various lessons covered throughout the Electricity Unit manuals, however, because the eLearning courses are available in short, segmented, module format, you can also choose to use any of the independent modules to supplement nearly any course in which further study or explanation is needed in a given topic area.

Module 1: Terminology and Units of Measurement

Description:

Introduction to the various terminologies and the units of measurement used in the study of electricity

Learning Outcome:

Upon the completion of this module, you will understand

1. Describe how the basic “building blocks” of matter—elements, compounds, molecules, atoms—are related to each other
2. Explain how atomic structure is related to the study of electricity
3. Define the coulomb, volt, ampere, and ohm
4. Identify how to use these units of measurement properly
5. State Ohm’s Law
6. Use the equations commonly derived from Ohm’s Law to calculate voltage, current, resistance, and power in electric circuits

Topic 1: Particles of Matter

- Topic Introduction and Objectives
- History of Electrons
- Terminology
- Terminology: The Atom
- Check-Point Question
- Check-Point Question
- The Electron and its Importance to Electricity
- Topic Summary

Topic 2: Units of Measurement

- Topic Introduction and Objectives
- The Coulomb
- Check-Point Question
- Electromotive Force or Voltage
- Relationship Between Amperes and Coulomb
- Unit of Measurement for Resistance
- Check-Point Question
- Topic Summary

Topic 3: Ohm’s Law

- Topic Introduction and Objectives
- Expression for Ohm’s Law
- Using the Equations from Ohm’s Law
- Effect of Increasing Resistance on Current
- Equation Wheel for Ohm’s Law

- Check-Point Question
- Topic Summary
- Assessment

Module 2: Electronics—History and Concepts

Description:

Introduction to the basic concepts of electronics, especially as used in the HVACR industry

Learning Outcome:

Upon the completion of this module, you will be able to:

1. Define “electronics”
2. Explain why solid-state electronic devices have become the primary components for controls used in the HVACR industry
3. Define resistance
4. Explain how resistors work
5. Define capacitance
6. Explain how capacitors work
7. Define inductance
8. Explain how inductors work

Topic 1: A Definition for Electronics

- Topic Introduction and Objectives
- “Electronic” and “Electric”
- Understanding Electronic Control Equipment
- Developments in Electronic Equipment
- Checkpoint Question
- Checkpoint Question
- Topic Summary

Topic 2: Solid-State Controls and Control Systems

- Topic Introduction and Objectives
- 8 Reasons for Using Solid-State Devices
- Checkpoint Question
- Topic Summary

Topic 3: Resistance and Resistors

- Topic Introduction and Objectives
- What is “Resistance?”
- How Resistors are used
- Selecting the Right Resistor
- Check Point Questions
- Check Point Questions
- Topic Summary

Topic 4: Capacitance and Capacitors

- Topic Introduction and Objectives
- Defining “Capacitance” and “Capacitor”
- Explaining Capacitance
- Capacitive Reactance

- Schematic Symbol for Capacitor
- Types of Capacitors
- Value of Capacitance
- Uses of Capacitors
- Check Point Questions
- Check Point Questions
- Topic Summary

Topic 5: Inductance and Inductors

- Topic Introduction and Objectives
- Defining “Inductance” and “Inductors”
- Inductive Reactance
- Inductance of a Coil
- Inductive Resistance
- Uses of Inductors
- Check Point Question
- Topic Summary
- Assessment

Module 3: Series Circuits, Parallel Circuits and Power

Description:

Explanation of the two basic ways in which two circuit components can be connected and the concept of power, its calculations and how the power consumed by the two types of circuits is different

Learning Outcome:

Upon the completion of this module, you will be able to:

1. Explain a series circuit
2. State the three rules that govern the behavior of a series circuit
3. Explain a parallel circuit
4. State the three rules that govern the behavior of a parallel circuit
5. Define power (P)
6. State the equation for power (P) and use it to calculate voltage and current

Topic 1: Series Circuits

- Topic Introduction and Objectives
- Three Rules for a Series Circuit
- Check-Point Question
- Topic Summary

Topic 2: Parallel Circuits

- Topic Introduction and Objectives
- Three Rules for a Parallel Circuit
- Calculating Total Current in a Circuit
- Check-Point Question
- Topic Summary

Topic 3: Power

- Topic Introduction and Objectives
- The Equation for Power
- Equation Wheel for Power
- Calculating Power in a Series Circuit
- Calculating Power in a Parallel Circuit
- Ohm's Law Wheel
- Check-Point Question
- Check-Point Question
- Topic Summary
- Assessment

Module 4: Magnetism and Transformers

Description:

An introduction to the principles that define magnetism, the various types of magnets available today, the methods used to produce magnets, and the various theories on the nature of magnetism

Learning Outcome:

Upon the completion of this module, you will be able to:

1. Describe the concept of magnetism
2. List the different types of magnets
3. Distinguish between “permanent” and “temporary” magnet
4. State the two basic theories of magnetism

Topic 1: Magnetism and Types of Magnets

- Topic Introduction and Objectives
- Magnetic Poles
- Magnetic Fields and Circuits
- Check-Point Question
- Types of Magnets
- Natural Magnets
- Artificial Magnets
- Methods of Producing Artificial Magnets
- High and Low Permeability
- Check-Point Question
- Topic Summary

Topic 1: Nature of Magnetism

- Topic Introduction and Objectives
- Molecular Theory
- Magnetic Poles of a Broken Magnet
- Further Evidence for the Molecular Theory
- Domain Theory
- Domains and Magnetic Fields
- Check-Point Question
- Topic Summary
- Assessment

Module 5: Magnetic Attraction, Repulsion, and Shielding

Description:

The explanation of the concepts of magnetic fields and lines of force

Learning Outcome:

Upon the completion of this module, you will be able to:

1. Define magnetic lines of force.
2. Explain magnetic fields.
3. Define magnetic flux.
4. Calculate flux density.
5. State the laws of magnetic attraction and repulsion.
6. Explain how the earth's magnetic field works.
7. Explain the term "magnetic shielding."
8. Explain the term "electromagnetism."
9. Explain the term "self inductance."
10. Explain the term "mutual induction."
11. Explain the term "electromotive force."

Topic 1: Magnetic Fields and Lines of Force

- Topic Introduction and Objectives
- Line of Direction of Magnetic Force
- Magnetic Line of Force
- Magnetic Fields and Magnetic Flux
- Check-Point Question
- Check-Point Question
- Magnetic Field Around a Magnet
- Topic Summary

Topic 2: Laws of Attraction and Repulsion

- Topic Introduction and Objectives
- First Two Laws of Magnetic Attraction and Repulsion
- Flux Patterns
- Third Law of Magnetic Attraction and Repulsion
- Check-Point Question
- Topic Summary

Topic 3: Earth's Magnetism

- Topic Introduction and Objectives
- Magnetic Polarities of Earth
- Early Compass Users
- Earth's Lines of Force
- Angle of Variation
- Check-Point Question
- Topic Summary

Topic 4: Magnetic Shielding

- Topic Introduction and Objectives
- Insulator for Magnetic Flux?
- Electric Instruments and Magnetic Shields
- Check-Point Question
- Topic Summary

Topic 5: Concepts in Magnetism

- Topic Introduction and Objectives
- Electromagnetism
- Self Inductance
- Mutual Induction
- Counter Electromotive Force
- Check-Point Question
- Check-Point Question
- Topic Summary
- Assessment

Module 6: Transformers

Description:

Explanation of the components that make up a transformer, how transformers are rated, and the different types of transformers in use today

Learning Outcome:

Upon the completion of this module, you will be able to:

1. Explain the purpose of a transformer.
2. Describe the components of a transformer.
3. List the common defects you may encounter when working with transformers.
4. Explain how the power-handling capacity of a transformer is measured.
5. Describe the features of residential transformers.
6. Describe the two types of fuses in transformers.
7. Explain the procedure for testing residential transformers.
8. Define open circuit voltage (OCV).
9. Describe multi-tapped transformers.
10. Explain the procedure for testing multi-tapped transformers.
11. Describe the features of commercial transformers.
12. Explain how multi-voltage commercial transformers can be used.

Topic 1: Components of a Transformer and Transformer Ratings

- Topic Introduction and Objectives
- Basic Components of a Transformer
- Common Defects
- Transformer Ratings
- Check-point Question
- Check-point Question
- Check-point Question
- Topic Summary

Topic 2: Residential Transformers

- Topic Introduction and Objectives
- Features of Residential Transformers
- Transformer Fusing
- Testing the Transformers
- Testing the Transformers: A Short in the Secondary
- Check-Point Question
- Check-Point Question
- Topic Summary

Topic 3: Multi-Tapped Primary Transformers

- Topic Introduction and Objectives
- Multi-Tapped Primaries
- Testing the Transformers
- Check-Point Question
- Check-Point Question
- Topic Summary

Topic 4: Commercial Transformers

- Topic Introduction and Objectives
- Features of Commercial Transformers
- VA Ratings of Commercial Transformers
- Multi-Voltage Commercial Transformers
- Uses of Multi-Voltage Commercial Transformers
- Testing Commercial Transformers
- Calculating Current Draw of a Transformer
- Check-Point Question
- Check-Point Question
- Topic Summary
- Assessment

Module 7: Relays, Contactors and Starters

Description:

Explanation of troubleshooting techniques for relays, contactors, and starters used in the HVACR field

Learning Outcome:

Upon the completion of this module, you will be able to:

1. Describe the basic components of a relay.
2. Identify the four common faults you may encounter when working with relays.
3. Explain the procedure for testing pilot-duty relays.
4. Describe the features of a line-duty relay.
5. Explain the procedure for testing line-duty relays.
6. Describe the features of a contactor.
7. Explain the procedure for testing contactors.
8. Describe the features of a starter and a potential relay.
9. Explain the procedure for testing starters and potential relays.
10. Describe the features of current relays and time-delay relays.
11. Explain the procedure for testing current relays and time-delay relays.

Topic 1: Relays

- Topic Introduction and Objectives
- Basic Components of a Relay
- Common Faults
- Check-Point Question
- Topic Summary

Topic 2: Testing Pilot-Duty Relays

- Topic Introduction and Objectives
- Testing the Contacts
- Testing for an "Open" Coil
- Testing for a "Shorted" Coil
- Calculating Current Draw of Pilot-Duty Relay
- Check-Point Question
- Topic Summary

Topic 3: Testing Line-Duty Relays

- Topic Introduction and Objectives
- Features of a Line-Duty Relay
- Testing the Contacts
- Testing for an "Open" Coil
- Testing for a "Shorted" Coil
- Check-Point Question
- Topic Summary

Topic 4: Contactors

- Topic Introduction and Objectives

- Features of a Contactor
- When to Replace a Contactor
- Testing Contactors
- Testing the Contacts
- Testing for an “Open” Coil
- Testing for a “Shorted” Coil
- Check-Point Question
- Topic Summary

Topic 5: Starters and Potential Relays

- Topic Introduction and Objectives
- Features of a Starter
- Testing Magnetic Starters
- Check-Point Question
- Potential Relays
- Potential Relays: Connecting the Terminals
- Testing a Potential Relay
- Testing the Coil of a Potential Relay
- Using a Relay Tester
- Testing the Relay in Operation
- Check-Point Question
- Check-Point Question
- Topic Summary

Topic 6: Current Relays and Time-Delay Relays

- Topic Introduction and Objectives
- Features of a Current Relay
- Connecting the Terminals on a Current Relay
- Testing Current Relays
- Features of a Time-Delay Relay
- Testing a Delay-On-Make Relay
- Testing a Delay-On-Break Relay
- Check-Point Question
- Check-Point Question
- Topic Summary
- Assessment

Module 8: Fundamentals of Alternating Current

Description:

The fundamentals of alternating current and the reason why it can be used in the power distribution system

Learning Outcome:

Upon the completion of this module, you will be able to:

1. Explain alternating current.
2. Explain sine waves
3. Define peak-to-peak, RMS, and average voltage values.
4. Explain the sine wave relationships in resistive, inductive, and capacitive circuits.

Topic 1: Alternating Current Theory

- Topic Introduction and Objectives
- Nature of a Sine Wave
- Sine Wave in a Simple AC Generator
- How AC Works
- Frequency of Voltage
- Check-Point Question
- Topic Summary

Topic 2: Components of a Sine Wave

- Topic Introduction and Objectives
- Peak-to-Peak, RMS, and Average
- Check-Point Question
- Topic Summary

Topic 3: Using Sine Waves and Vector Diagrams

- Topic Introduction and Objectives
- Sine Wave Relationships in Resistive Circuits
- A Mnemonic for Sine Wave Relationships
- Sine Wave Relationships in a Three-Phase Circuit
- Check-Point Question
- Vector or Phasor Diagrams
- Equation for Calculating Total Current
- Calculating Total Current: An Example
- Connecting Vectors to Form a Triangle
- Using Triangles to Solve AC Problem
- Check-Point Question
- Check-Point Question
- Topic Summary
- Assessment

Module 9: Alternating Current: Reactance, Impedance, and Power Factor

Description:

Calculation of the different resistance introduced in an ac circuit by capacitors, inductors, and resistors and the concept of power factor

Learning Outcome:

Upon the completion of this module, you will be able to:

1. Calculate the capacitive reactance of a circuit, given the value of the capacitor, frequency, and voltage.
2. Describe the relation between capacitive reactance and frequency.
3. Calculate the inductive reactance of a circuit, given the value of the inductor, frequency, and voltage.
4. Describe the relation between inductive reactance and frequency.
5. Calculate the impedance of a circuit, given the values of the inductive and capacitive reactance, and the resistance.
6. Explain the term "Power Factor."
7. Define "apparent" power and the "true" or "actual" power of a circuit.
8. Calculate the power factor.
9. Explain three-phase power.

Topic 1: Reactance

- Topic Introduction and Objectives
- Three Forms of Reactance
- Capacitive Reactance: Equation
- Calculating Capacitive Reactance: Example
- Calculating Reactance at Higher Frequency
- Inductive Reactance: Equation
- Calculating Inductive Reactance: Example
- Calculating Inductive Reactance at Higher Frequency
- Check-Point Question
- Topic Summary

Topic 2: Impedance

- Topic Introduction and Objectives
- Impedance: Equation
- Calculating Impedance
- Calculating Impedance for an AC Solenoid Coil
- Check-Point Question
- Topic Summary

Topic 3: What Is Power Factor?

- Topic Introduction and Objectives
- Apparent Power Versus Actual Power
- The Iron Effect
- Topic Summary

Topic 4: High and Low Power Factors

- Topic Introduction and Objectives
- Ratio of Actual Power to Apparent Power
- Three Reasons Low Power Factor is Costly
- Understanding Apparent Power and Actual Power
- Calculating Power Factor Percentage
- Check-Point Question
- Topic Summary

Topic 5: Three-Phase Power

- Topic Introduction and Objectives
- Sine Waves for Three-Phase Circuit
- Check-Point Question
- Topic Summary
- Assessment

Module 10: Circuit Protection Devices: Fuses

Description:

Introduction to the different types of fuses, their usage and rating, and how they are tested

Learning Outcome:

Upon the completion of this module, you will be able to:

1. Discuss the conditions under which circuit protection is needed.
2. Describe the different types of fuses.
3. Explain fuse ratings.
4. Describe the fuse ratings for different types of fuses.
5. Describe the features of renewable fuses.
6. Describe the features of dual-element fuses.
7. Describe the different types of fuse holders.
8. Explain how to test for open fuses.

Topic 1: Fuses

- Topic Introduction and Objectives
- Types of Fuses
- Plug Fuses
- Features of Plug Fuses
- Cartridge Fuses
- Check-Point Question
- Check-Point Question
- Topic Summary

Topic 2: Fuse Ratings

- Topic Introduction and Objectives
- Current and Voltage Ratings
- Ratings for Different Fuses
- MCA and MOCP
- Check-Point Question
- Check-Point Question
- Topic Summary

Topic 3: Renewable and Dual-Element Fuses

- Topic Introduction and Objectives
- Features of Renewable Fuses
- Dual-Element Fuses
- Check-Point Question
- Topic Summary

Topic 4: Fuse Holders

- Topic Introduction and Objectives
- Clip-Type Fuse Holders
- Post-Type Fuse Holders
- Fuse Blocks

- Check-Point Question
- Topic Summary

Topic 5: Testing Fuses

- Topic Introduction and Objectives
- Checking for an Open Fuse
- Continuity Test
- Safety Precautions
- Check-Point Question
- Topic Summary
- Assessment

Module 11: Circuit Protection Devices: Circuit Breakers and Overload Protection

Description:

An introduction to the circuit-breakers as circuit-protection devices and the concepts of internal and external overloads

Learning Outcome:

Upon the completion of this module, you will be able to:

1. List the main components of a circuit breaker.
2. Explain the basic function of a circuit breaker.
3. Describe the different types of external overloads.
4. Describe the different types of internal overloads.

Topic 1: Circuit Breakers

- Topic Introduction and Objectives
- What is a Circuit Breaker?
- Components of a Circuit Breaker
- Arc Extinguishers
- Check-Point Question
- Topic Summary

Topic 2: Motor Overload Protection

- Topic Introduction and Objectives
- Motor Overload: Causes and Protection
- External Overloads
- Check-Point Question
- Internal Overloads
- Solid State Motor Protection
- Other Protection Devices
- Check-Point Question
- Check-Point Question
- Topic Summary
- Assessment

Module 12: Understanding Electrical Schematics

Description:

Detailed look at the symbols and conventions commonly used in schematic diagrams

Learning Outcome:

Upon the completion of this module, you will be able to:

1. Describe how wiring diagrams can be read.
2. Identify different types of wiring diagrams used in the HVACR industry.
3. List the five basic components to any schematic.
4. Identify the electrical symbols used in schematic diagrams, and the components that they represent.
5. Identify the “line” side and the “load” side of a schematic diagram.
6. Explain the difference between the “line” side and the “load” side.
7. Explain how to use the line-numbering system included in many schematic diagrams.
8. Describe the different switch symbols used in schematic diagrams.
9. Study a complicated wiring diagram for a packaged gas/electric system.
10. Identify the various machine functions depicted in the wiring diagram.

Topic 1: Wiring Diagrams and Their Types

- Topic Introduction and Objectives
- Reading a Wiring Diagram
- Five Components of a Wiring Diagram
- Basic Types of Wiring Diagrams
- The Ladder Diagram
- The Line Diagram
- The Installation Diagram
- Check-Point Question
- Topic Summary

Topic 2: Symbols Used in Schematics

- Topic Introduction and Objectives
- Power Supplies
- Wiring
- Variations in Practices
- Switches
- Loads
- Schematic Symbols used in the HVACR Industry
- Check-Point Question
- Topic Summary

Topic 3: Understanding Electrical Schematics

- Topic Introduction and Objectives
- Side-by-Side Configuration
- Up-and-Down Configuration
- Check-Point Question
- Topic Summary

Topic 4: Locators, Legends, and Switch Symbols

- Topic Introduction and Objectives
- The Line Numbering System
- Legends
- Switch Symbols
- Single-Pole, Single-Throw and Single-Pole, Double-Throw Switches
- Double-Pole, Double-Throw Switches
- Temperature and Pressure Controls
- SPDT Limit Switch
- Relays
- Contactors
- Check-Point Question
- Topic Summary

Topic 5: Locators. the Basic Diagram

- Topic Introduction and Objectives
- Schematic of a packaged heating/cooling unit
- Equipment
- Relays: Locating the Control Relay
- Circuits: Series Circuits
- Circuits: Parallel Circuits
- Series Parallel Circuits and Pressure Controls
- Connections and Wiring
- Non-Replaceable Controls or Relays
- Legends
- Check-Point Question
- Topic Summary
- Assessment