

## Crosswalk to PAHRA/NATE Competencies and Tasks

The following PAHRA/NATE competencies and tasks are covered in this publication. Only the covered competencies and tasks are listed. The first column identifies the competency by name and number. The second column identifies the exact location in this MAVCC publication where that competency or task is covered.

PAHRA/NATE Tasks, Competencies and Objectives	MAVCC Objectives and Tasks
<b>III. Safety</b>	
<b>Subtopic III.A. Personal Safety and Work Practices</b>	
<b>Tasks:</b> <ol style="list-style-type: none"> <li>1. Wear appropriate clothing.</li> <li>2. Use safety equipment (e.g., footwear, hearing protection, hardhat, goggles, gloves).</li> <li>3. Demonstrate good housekeeping practices in the lab.</li> </ol>	<p>All job sheets All job sheets</p> <p>All job sheets</p>
<b>IV. Tools and Equipment</b>	
<b>Subtopic IV.A. Hand Tools and Accessories</b>	
<b>Knowledge:</b> <ol style="list-style-type: none"> <li>1. Identify basic tools.               <ol style="list-style-type: none"> <li>a. Lineman pliers (sidecutters)</li> <li>b. Wire strippers</li> <li>c. Solder gun</li> </ol> </li> </ol>	<p>Unit 2, Objective 2—Tools Unit 2, Objective 2—Tools Unit 2, Objective 2—Tools</p>
<b>Subtopic IV.B. Electrical Testing Devices/ Meters</b>	
<b>Knowledge:</b> <ol style="list-style-type: none"> <li>1. Define watts.</li> <li>2. Demonstrate understanding of the basic types of electrical measurement.</li> </ol>	<p>Unit 3, Objective 9—Watt's Law Unit 2, Objective 7—Test instrument characteristics Unit 2, Objective 8—Reading test instruments Unit 2, Objective 9—Using voltmeters and voltage testers Unit 2, Objective 10—Using ohmmeters Unit 2, Objective 11—Using an ohmmeter to check motors Unit 2, Objective 12—Checking a hermetic compressor motor with an ohmmeter Unit 2, Objective 13—Using ammeters Unit 2, Objective 14—Using test accessories</p>

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<b>PAHRA/NATE Tasks, Competencies and Objectives</b>	<b>MAVCC Objectives and Tasks</b>
<p><b>Tasks:</b></p> <ol style="list-style-type: none"> <li>1. Measure voltage with digital and analog voltmeters.</li> <li>2. Measure AC current with a clamp-on ammeter.</li> <li>3. Measure resistance with an ohmmeter.</li> <li>5. Check voltage with a voltage tester.</li> <li>6. Use a continuity tester to determine whether an open circuit or dead short exists.</li> <li>7. Use a capacitance meter to measure capacitance of run and start capacitors.</li> <li>8. Calculate capacitance.</li> <li>9. Wire and measure resistance of different types of circuits:               <ol style="list-style-type: none"> <li>a. Series</li> <li>b. Parallel</li> <li>c. Unequal</li> <li>d. Series-parallel</li> </ol> </li> </ol>	<p>Located throughout this publication</p> <p>Unit 2, Assignment Sheet 3—Read an ammeter Unit 2, Job Sheet 7—Use digital and analog ammeters to read start and run amperage of a motor</p> <p>Located throughout this publication Located throughout this publication</p> <p>Unit 15, Job Sheet 1—Troubleshoot series electrical circuits on selected HVACR equipment Unit 15, Job Sheet 2—Troubleshoot parallel electrical circuits on selected HVACR equipment Unit 15, Job Sheet 3—Troubleshoot series-parallel electrical circuits on selected HVACR equipment</p> <p>Unit 11, Job Sheet 1—Check capacitors with an analog ohmmeter Unit 11, Job Sheet 2—Check capacitors with a capacitor analyzer Unit 11, Assignment Sheet 1—Calculate ratings of grouped capacitors</p> <p>Located throughout this publication Located throughout this publication Located throughout this publication Located throughout this publication</p>
<b>VI. Electricity</b>	
<b>Subtopic VI.A. Basic Electricity</b>	
<p><b>Knowledge:</b></p> <ol style="list-style-type: none"> <li>1. Define watts.</li> <li>2. Define and compare single- and three-phase voltage and current.</li> <li>3. Identify types of electrical loads (i.e., capacitive, inductive, and resistive).</li> </ol>	<p>Unit 3, Objective 9—Watt’s Law Unit 3, Objective 5—Types of power supplies Unit 14, Objective 5—Troubleshooting three-phase motors Unit 1, Objective 10—Electrical loads Unit 11, Objective 2—Capacitors in HVACR circuit applications Unit 11, Objective 3—Effects of inductive loads on current/voltage relationships Unit 11, Objective 4—Capacitor construction and operation</p>

<b>PAHRA/NATE Tasks, Competencies and Objectives</b>	<b>MAVCC Objectives and Tasks</b>
<p>4. Analyze applications of magnetism in electricity.</p> <p>5. Apply magnetic principles to electrical theory.</p> <p>6. Compare conducting and insulating materials.</p> <p>7. Identify principles of solid-state switching devices.</p>	<p>Unit 1, Objective 3—Sources of electricity and their characteristics.            Unit 6, Objective 2—How a transformer works            Unit 6, Objective 5—Relay components and uses            Unit 8, Objective 4—Basic DC motor operation            Unit 8, Objective 5—Basic AC motor operation            Unit 8, Objective 6—Single-phase AC motor starting</p> <p>Unit 1, Objective 3—Sources of electricity and their characteristics            Unit 6, Objective 2—How a transformer works            Unit 6, Objective 5—Relay components and uses            Unit 8, Objective 4—Basic DC motor operation            Unit 8, Objective 5—Basic AC motor operation            Unit 8, Objective 6—Single-phase AC motor starting</p> <p>Unit 1, Objective 7—Insulators, semiconductors, and conductors.            Unit 5, Objective 8—Electronic switching</p>
<p><b>Tasks:</b></p> <p>1. Demonstrate proper use of ammeter, ohmmeter, voltmeter, and wattmeter.</p> <p>2. Use Ohm’s Law to solve circuit problems and calculate circuit loads.</p> <p>3. Use appropriate meters to check basic electrical components.</p>	<p>Located throughout this publication</p> <p>Unit 1, Assignment Sheet 2—Use Ohm’s Law to determine unknown values in resistive circuits            Unit 2, Job Sheet 3—Use digital and analog voltmeters to check power sources            Unit 2, Job Sheet 4—Use digital and analog ohmmeters to check continuity of fuses            Unit 2, Job Sheet 5—Use digital and analog ohmmeters to determine resistance of resistors            Unit 2, Job Sheet 6—Use digital and analog ohmmeters to identify terminals and electrical condition of a hermetic compressor            Unit 2, Job Sheet 7—Use digital and analog ammeters to read start and run amperage of a motor            Unit 4, Job Sheet 1—Draw pictorials, fabricate working models, and draw ladder schematics for basic series and parallel circuits            Unit 4, Job Sheet 2—Draw pictorials, fabricate working models, and draw ladder schematics for series-parallel circuits            Unit 4, Job Sheet 3—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with varied loads and switching</p>

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<p>4. Determine the electrical characteristics of both series and parallel circuits.</p>	<p>Unit 5, Job Sheet 1—Draw pictorials, fabricate working models, and draw ladder schematics for shunt circuits with one SPST switch</p> <p>Unit 5, Job Sheet 2—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with 3-way switches</p> <p>Unit 5, Job Sheet 3—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with 3-way and 4-way switches</p> <p>Unit 5, Job Sheet 4—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with safety switches</p> <p>Unit 5, Job Sheet 5—Draw pictorials, fabricate working models, and draw ladder schematics for a basic small refrigeration unit circuit</p> <p>Unit 6, Job Sheet 1—Check current relays with an ohmmeter</p> <p>Unit 6, Job Sheet 2—Check potential relays with an ohmmeter</p> <p>Unit 6, Job Sheet 3—Check current relays with an ammeter and a voltmeter</p> <p>Unit 6, Job Sheet 4—Check a potential relay with an ammeter and a voltmeter</p> <p>Unit 6, Job Sheet 5—Install a solid-state, time-delay relay</p> <p>Unit 6, Job Sheet 6—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with basic relays</p> <p>Unit 6, Job Sheet 7—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with dual relays</p> <p>Unit 6, Job Sheet 8—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with special applications</p> <p>Unit 6, Job Sheet 9—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with multiple relays</p> <p>Unit 1, Objective 13—The three types of circuits</p> <p>Unit 1, Objective 19—Using Ohm’s Law to find unknown values</p> <p>Unit 1, Objective 20—Using Ohm’s Law to determine values in a series circuit</p> <p>Unit 1, Objective 21—Using Ohm’s Law to determine values in a parallel circuit</p>

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<p>5. Demonstrate math skills.</p> <p>6. Determine the equivalent resistance in a parallel and series circuit.</p> <p>7. Determine the equivalent capacitance in a parallel and series circuit.</p> <p>8. Construct and analyze:</p> <p style="padding-left: 20px;">a. Series circuit</p> <p style="padding-left: 20px;">b. Parallel circuit</p> <p style="padding-left: 20px;">c. Series-parallel circuit</p>	<p>Unit 1, Assignment Sheet 1—Convert electrical measurements to basic units</p> <p>Unit 1, Assignment Sheet 2—Use Ohm’s Law to determine unknown values in resistive circuits</p> <p>Unit 3, Assignment Sheet 1—Use Watt’s Law to determine power</p> <p>Unit 8, Assignment Sheet 2—Use a pulley selection chart and pulley selection formula</p> <p>Unit 11, Assignment Sheet 1—Calculate ratings of grouped capacitors</p> <p>Unit 1, Assignment Sheet 2—Use Ohm’s Law to determine unknown values in resistive circuits</p> <p>Unit 11, Assignment Sheet 1—Calculate ratings of grouped capacitors</p> <p>Unit 4, J.S. 1—Draw pictorials, fabricate working models, and draw ladder schematics for basic series and parallel circuits</p> <p>Unit 4, J.S. 1—Draw pictorials, fabricate working models, and draw ladder schematics for basic series and parallel circuits</p> <p>Unit 4, J.S. 2—Draw pictorials, fabricate working models, and draw ladder schematics for series-parallel circuits</p>
<b>Subtopic VI.B. Electrical Generation and Distribution</b>	
<p><b>Knowledge:</b></p> <p>1. Explain basic generator principle.</p> <p>2. Explain how electricity is produced and distributed.</p> <p>3. Define Wye (Y) and Delta (<math>\Delta</math>) distribution systems.</p>	<p>Unit 1, Objective 9—Alternating current</p> <p>Unit 3, Objective 2—Characteristics of electrical power</p> <p>Unit 3, Objective 3—Transformers</p> <p>Unit 3, Objective 4—Power distribution</p> <p>Unit 3, Objective 5—Types of power supplies</p> <p>Unit 3, Objective 6—Delivery systems</p> <p>Unit 3, Objective 7—Problems with power delivery</p> <p>Unit 3, Objective 8—Power consumption</p> <p>Unit 3, Student Supplement 1—Electrical transmission</p> <p>Unit 3, Objective 5—Types of power supplies</p> <p>Unit 3, Objective 6—Delivery systems</p>

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PAHRA/NATE Tasks, Competencies and Objectives	MAVCC Objectives and Tasks
<p><b>Tasks:</b></p> <ol style="list-style-type: none"> <li>1. Draw and identify power transformer types.</li> <li>2. Use electrical meters appropriately to test and identify voltages in both single- and three-phase systems.</li> <li>6. Determine whether existing load centers are adequate to supply desired load addition.</li> </ol>	<p>Unit 3, Objective 5—Types of power supplies            Unit 2, Job Sheet 3—Use digital and analog voltmeters to check power sources</p> <p>Unit 3, Objective 6—Delivery systems</p>
<p><b>Subtopic VI.C. Electrical Components</b></p>	
<p><b>Knowledge:</b></p> <ol style="list-style-type: none"> <li>2. Define and explain the use or function of:               <ol style="list-style-type: none"> <li>b. Capacitors</li> <li>e. Current relays</li> <li>n. Relays</li> </ol> </li> </ol>	<p>Unit 11, Objective 1—Terms and definitions            Unit 11, Objective 2—Capacitors in HVACR circuit applications            Unit 11, Objective 3—Effects of inductive loads on current/voltage relationships            Unit 11, Objective 4—Capacitor construction and operation            Unit 11, Objective 5—Types of capacitors            Unit 11, Objective 6—Guidelines for capacitor replacement            Unit 11, Objective 7—Grouping capacitors            Unit 12, Objective 1—Terms and definitions            Unit 12, Objective 2—Applications of capacitors to motors            Unit 12, Objective 3—CS motor characteristics and applications            Unit 12, Objective 4—PSC motor characteristics and applications            Unit 12, Objective 5—CSR motor characteristics and applications            Unit 12, Objective 6—Troubleshooting capacitor motors            Unit 12, Objective 7—Troubleshooting capacitor motor start components            Unit 6, Objective 10—Motor starting current relay operations            Unit 6, Objective 11—Motor starting current relay specifications            Unit 6, Objective 5—Relay components and uses</p>



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<p>2. Explain operation and application of:</p> <p>a. Capacitor start induction run motor (CSIR)</p> <p>b. Capacitor start capacitor run motor (CSCR)</p> <p>c. Electronically controlled motors (ECM)</p>	<p>Unit 8, Objective 7—Basic AC electric motor parts and their functions</p> <p>Unit 8, Objective 8—Types of motor construction</p> <p>Unit 8, Objective 9—Types of motor mounts and typical applications</p> <p>Unit 8, Objective 10—Motor data plates</p> <p>Unit 8, Objective 11—Pulleys and belts</p> <p>Unit 8, Objective 12—Pulley selection</p> <p>Unit 8, Objective 13—Sizing and selecting V-belts</p> <p>Unit 8, Objective 14—Troubleshooting electric motors</p> <p>Unit 12, Objective 2—Applications of capacitors to motors</p> <p>Unit 12, Objective 3—CS motor characteristics and applications</p> <p>Unit 12, Objective 6—Troubleshooting capacitor motors</p> <p>Unit 12, Objective 7—Troubleshooting capacitor motor start components</p> <p>Unit 12, Objective 2—Applications of capacitors to motors</p> <p>Unit 12, Objective 5—CSR motor characteristics and applications</p> <p>Unit 12, Objective 6—Troubleshooting capacitor motors</p> <p>Unit 12, Objective 7—Troubleshooting capacitor motor start components</p> <p>Unit 13, Objective 1—Terms and definitions</p> <p>Unit 13, Objective 2—Characteristics and applications of Electronically Commutated Motors (ECM)</p> <p>Unit 13, Objective 3—ECM motor construction and programming</p> <p>Unit 13, Objective 4—Controlling airflow with an ECM motor</p> <p>Unit 13, Objective 5—Benefits and limits of ECM motors</p> <p>Unit 13, Objective 6—Power connections for a typical ECM</p> <p>Unit 13, Objective 7—Modes of communication</p> <p>Unit 13, Objective 8—ECM motors and Electromagnetic Interference (EMI)</p>



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<p>i. Three-phase motor</p> <p>3. Describe starting components associated with single-phase and three-phase motors.</p> <p>4. Explain the significance of power factor.</p>	<p>Unit 14, Objective 1—Terms and definitions</p> <p>Unit 14, Objective 2—Characteristics and applications of three-phase motors</p> <p>Unit 14, Objective 3—Three-phase motor construction</p> <p>Unit 14, Objective 4—Wiring connections for three-phase motors</p> <p>Unit 14, Objective 5—Troubleshooting three-phase motors</p> <p>Unit 10, Objective 4—Split-phase motor starting mechanisms</p> <p>Unit 14, Objective 3—Three-phase motor construction</p> <p>Unit 9, Objective 7—Using power factor for watt/amp amp/watt conversions</p>
<p><b>Tasks:</b></p> <p>1. Demonstrate proper use of testing equipment for motors</p>	<p>Unit 9, Job Sheet 1—Wire shaded-pole motors to AC voltage</p> <p>Unit 9, Job Sheet 2—Disassemble, inspect, clean, reassemble, and check operation of a shaded-pole motor</p> <p>Unit 10, Job Sheet 1—Wire a single-voltage, split-phase motor to an AC power source</p> <p>Unit 10, Job Sheet 2—Wire a dual-voltage, split-phase motor for 120 VAC</p> <p>Unit 10, Job Sheet 3—Wire a dual-voltage, split-phase motor for 208/240 VAC</p> <p>Unit 10, Job Sheet 4—Disassemble, inspect, clean, reassemble, and check operation of a split-phase motor</p> <p>Unit 12, Job Sheet 1—Wire a CS compressor with a current relay</p> <p>Unit 12, Job Sheet 2—Wire a PSC motor</p> <p>Unit 12, Job Sheet 3—Wire a CSR compressor motor</p> <p>Unit 12, Job Sheet 4—Disassemble, inspect, clean, reassemble, and check operation of a PSC fan motor</p> <p>Unit 12, Job Sheet 5—Use a hermetic analyzer to start, reverse, and check operation of a PSC compressor motor</p> <p>Unit 12, Job Sheet 6—Install a hard start kit</p> <p>Unit 12, Job Sheet 7—Troubleshoot a CSR compressor with an ammeter</p>

<b>PAHRA/NATE Tasks, Competencies and Objectives</b>	<b>MAVCC Objectives and Tasks</b>
<ol style="list-style-type: none"> <li>2. Determine physical conditions of motor bearings and rotors.</li>   <li>4. Draw and explain the starting and run circuit for a single-phase CSIR compressor using a current type starting relay.</li>   <li>5. Draw and explain the starting and run circuit for a single-phase CSCR compressor using a potential (metage) starting relay.</li>   <li>6. Draw and explain the circuit for a PSC compressor</li> </ol>	<p>Unit 9, Job Sheet 2—Disassemble, inspect, clean, reassemble, and check operation of a Shaded-Pole Motor</p> <p>Unit 10, Job Sheet 4—Disassemble, inspect, clean, reassemble, and check operation of a split-phase motor</p> <p>Unit 12, Job Sheet 4—Disassemble, inspect, clean, reassemble, and check operation of a PSC fan motor</p> <p>Unit 12, Assignment Sheet 1—Draw connecting wiring for a CS Motor with a start capacitor and a current relay</p> <p>Unit 16, Assignment Sheet 1—Draw wiring diagrams for a small refrigeration unit with a coil-type current relay</p> <p>Unit 12, Assignment Sheet 3—Draw connecting wiring for a CSR motor</p> <p>Unit 12, Job Sheet 3—Wire a CSR compressor motor</p> <p>Unit 12, Assignment Sheet 2—Draw connecting wiring for a PSC motor</p> <p>Unit 12, Job Sheet 4—Disassemble, inspect, clean, reassemble, and check operation of a PSC fan motor</p> <p>Unit 12, Job Sheet 5—Use a hermetic analyzer to start, reverse, and check operation of a PSC compressor motor</p>
<b>Subtopic VI.E. Electrical Circuits and Controls</b>	
<p><b>Knowledge:</b></p> <ol style="list-style-type: none"> <li>1. Interpret detailed instructions for wiring circuits.</li> </ol>	<p>Located throughout this publication.</p>
<p><b>Tasks:</b></p> <ol style="list-style-type: none"> <li>1. Draw electrical circuits that conform to standard industry logic and symbols using appropriate loads and controls.</li> <li>2. Wire actual electrical circuits from wiring diagrams.</li> <li>3. Demonstrate use and understanding of basic electrical meters in actual wiring and testing of circuits.</li> <li>4. Identify and draw all electrical symbols used by the HVACR industry in diagrams.</li> </ol>	<p>Located throughout this publication.</p> <p>Located throughout this publication.</p> <p>Located throughout this publication.</p> <p>Located throughout this publication.</p>

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PAHRA/NATE Tasks, Competencies and Objectives	MAVCC Objectives and Tasks
<b>VII. Controls</b>	
<b>Subtopic VII.C. Residential Control Systems—Heating/Cooling</b>	
<p><b>Knowledge:</b></p> <ol style="list-style-type: none"> <li>1. Identify residential heating and cooling thermostats.</li> <li>2. Identify controls for heating and cooling.</li> <li>3. Explain heat and cooling anticipators.</li> </ol>	<p>Unit 7, Objective 1—Terms and definitions            Unit 7, Objective 2—Thermostat types and their applications            Unit 7, Objective 5—Major components of a heating/cooling thermostat            Unit 6, Objective 7—Control relays and contactors            Unit 6, Assignment Sheet 1—Identify selected relays            Unit 7, Objective 3—Temperature sensors            Unit 7, Objective 4—Electrical contacts            Unit 7, Objective 5—Major components of a heating/cooling thermostat            Unit 7, Objective 6—Heating thermostat anticipation            Unit 7, Objective 7—Cooling thermostat anticipation</p>
<p><b>Tasks:</b></p> <ol style="list-style-type: none"> <li>1. Program a programmable thermostat for heating, cooling and heat pump operation including set-up and set back.</li> <li>2. Set heat anticipator on system thermostat.</li> <li>3. Install residential heating and cooling thermostats.</li> </ol>	<p>Unit 7, Job Sheet 3—Program a programmable thermostat             Unit 7, Job Sheet 1—Install a wall thermostat and determine heat anticipation            Unit 7, Job Sheet 1—Install a wall thermostat and determine heat anticipation            Unit 7, Job Sheet 2—Replace a standard thermostat with an electronic programmable thermostat.</p>
<b>VIII. Solid-State Electronics</b>	
<b>Subtopic VIII.A. Solid-State Components</b>	
<p><b>Knowledge:</b></p> <ol style="list-style-type: none"> <li>1. Explain the function and/or application in HVACR circuits and controls of rectifiers.</li> </ol>	<p>Unit 6, Objective 4—Providing DC power</p>