

# IEC ELECTRICAL APPRENTICESHIP CURRICULUM

2023–2024 Edition

## OBJECTIVES FOR YEAR 1

### Lesson 101 - Orientation and Basic Principles

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- 101.1 **DESCRIBE** and **EXPLAIN** the apprenticeship policies and procedures of the IEC chapter sponsoring your training program.
- 101.2 **LIST** and **EXPLAIN** the advantages of being part of the IEC apprenticeship program.
- 101.3 **DESCRIBE** and **EXPLAIN** the IEC 4-year electrical apprenticeship program.
- 101.4 **RECOGNIZE** basic electrical terms.
- 101.5 **RECOGNIZE** basic NEC® definitions (Article 100).

### Lesson 102 - Tools and Fasteners\*

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- 102.1 **RECOGNIZE** hand tools used in the trade by identifying the “do’s and don’ts” of their use and care.\*
- 102.2 **RECOGNIZE** power tools used in the trade by identifying the “do’s and don’ts” of their use and care.
- 102.3 **DESCRIBE** torque wrenches and their use.
- 102.4 **RECALL** and **DEMONSTRATE** knowledge of electrical materials.
- 102.5 **IDENTIFY** hands-on tool activity.

### Lesson 103 - Introduction to Safety, Navigating the NEC® and EWR Plans

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- 103.1 **STATE** and **EXPLAIN** the GHS symbols and requirements.
- 103.2 **RECOGNIZE** requirements of NFPA 70E® on flexible cords and cables, highlighting GFCI protection and electrical hazards.
- 103.3 **STATE** general safety considerations in electrical installations.
- 103.4 **OUTLINE** a basic understanding of the creation and organization of the NEC®.
- 103.5 **DESCRIBE** the components of plans and specifications.

### Lesson 104 - Introduction to Electric Charges and Basic Math

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- 104.1 **RECOGNIZE** the law of electric charges and theories of current flow.
- 104.2 **ILLUSTRATE** knowledge of basic mathematics.

### Lesson 105 - Applied Math, Circuit Theory, Plans & Specs

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- 105.1 **MASTER** whole numbers, decimals, percentages, averages, fractions, and linear measures necessary in solving problems encountered by electricians.
- 105.2 **MASTER** conversions between English and metric units, Fahrenheit and Celsius temperatures; and conduct conversions among metric prefixes.
- 105.3 **POSSESS** a fundamental awareness of resistance, power, and electrical circuits.
- 105.4 **DESCRIBE** the basic information available on the EWR plans and specifications.

### Lesson 106 - Applied Math, Ohm’s Law, Electrical Symbols, and Boxes

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- 106.1 **MASTER** ratios, proportions, squared and square root numbers, area, and volume by applying their uses as a means of solving problems encountered by electricians.
- 106.2 **RECOGNIZE** the relationship between voltage, current, and resistance as demonstrated in Ohm’s Law.
- 106.3 **CONTRAST** results of using different applied voltages and resistances as demonstrated in Ohm’s Law.
- 106.4 **RECOGNIZE** various outlet boxes by identifying each outlet box’s characteristics.
- 106.5 **DESCRIBE** symbols presented within the text.

#### Lesson 107 - Conduit Bending\*

- 107.1 **LABEL** the points on a hand bender and **LIST** terms used in conduit bending.\*
- 107.2 **OUTLINE** mathematical calculations and apply them to bending conduit.
- 107.3 **DEMONSTRATE** conduit bending hands-on activity.

#### Lesson 108 - Dwelling Circuit Requirements, Outlet Locations, and General Lighting Load\*

- 108.1 **DEFINE** circuit requirements in dwellings. **RECOGNIZE** the circuit requirement differences between a dwelling and a non-dwelling.
- 108.2 **DEFINE** outlet locations in dwellings. **RECOGNIZE** the outlet location differences between a dwelling and a non-dwelling.
- 108.3 **OUTLINE** NEC<sup>®</sup> calculation for the general lighting load.

#### Lesson 109 - Conductor Types, Ampacity, Overcurrent Protection, Type NM Cables, and Common Voltage Systems

- 109.1 **STATE** appropriate insulation and material characteristics according to conductor types.
- 109.2 **SELECT** OCPD and conductor size for given loads.
- 109.3 **LIST** nonmetallic cable (NM-B and NM-B-PCS) installation requirements.
- 109.4 **RECOGNIZE** voltages from common voltage systems.

#### Lesson 110 - Voltage Drop, Cable, Conduit, and Tubing\*

- 110.1 **RECOGNIZE** and solve various single-phase voltage drop calculations using the K-method.
- 110.2 **LIST** cable installation requirements for Types AC and MC.
- 110.3 **LIST** conduit and tubing installation requirements.

#### Lesson 111 - Mid-Term Review and Exam

- 111 This lesson will determine your proficiency in the subject matter from the previous lessons.

#### Lesson 112 - Conductor Terminology, Switches, and Receptacles\*

- 112.1 **SELECT** between grounding, grounded, and ungrounded conductors.
- 112.2 **DESCRIBE** the NEC<sup>®</sup> requirements for switches.
- 112.3 **RECOGNIZE** the construction, operation, and connection of switches.\*
- 112.4 **RECOGNIZE** the construction and connection of receptacles by identifying each receptacle and its NEMA designation.
- 112.5 **DESCRIBE** the NEC<sup>®</sup> requirements for receptacles.

#### Lesson 113 - GFCI, AFCI, and Other Special-Purpose Receptacles\*

- 113.1 **RECOGNIZE** the purpose, operation, and installation of GFCI protective devices.\*
- 113.2 **RECOGNIZE** the purpose, operation, and installation of AFCI protective devices.
- 113.3 **RECOGNIZE** the purpose, operation, and installation of TVSS, SPD, IG, hospital grade, and ALCI protective devices.
- 113.4 **DESCRIBE** the NEC<sup>®</sup> requirements for GFCI, AFCI, TVSS, SPD, IG, ALCI, and hospital grade protective devices.
- 113.5 **DESCRIBE** receptacle/GFCI/AFCI functions (referencing EWR plan).

#### Lesson 114 - Luminaires, Ballasts, and Lamps

- 114.1 **RECOGNIZE** the purpose, operation, and installation of a luminaire. **DESCRIBE** thermal protection for luminaires.
- 114.2 **SELECT** ballast and lamp applications for luminaires.
- 114.3 **LIST** basic lighting terminology.
- 114.4 **DESCRIBE** the NEC<sup>®</sup> requirements for luminaires.
- 114.5 **DESCRIBE** the cost benefits of using energy efficient lighting.

#### Lesson 115 - Box Fill and Introduction to Series Circuits (Front Bedroom)

- 115.1 **RECOGNIZE** lighting requirements in clothes closets and storage areas, per NEC®.
- 115.2 Using the EWR plans, **LOCATE** the circuits and outlets in the front bedroom, based on specifications.
- 115.3 **SELECT** Ohm's Law formulas for series circuits.
- 115.4 **OUTLINE** the minimum NEC® requirements for box fill.

#### Lesson 116 - Box Sizing and Series Circuits (Master Bedroom)\*

- 116.1 Using the EWR plans, **LOCATE** the circuits and outlets in the Master Bedroom based on specifications and NEC® requirements.
- 116.2 **SELECT** proper box sizing for receptacle outlet, switch outlet, lighting outlet, and fan outlet. **RECALL** box fill calculations.
- 116.3 **RECOGNIZE** individual and series-connected DC power sources.\*
- 116.4 **LABEL** "unknowns" for series circuits using Ohm's Law formulas.
- 116.5 **RECOGNIZE** and solve various single phase voltage drop calculations using the resistance method.

#### Lesson 117 - Lighting and Small Appliance Branch Circuits

- 117.1 Using the EWR plans, **LOCATE** the circuits and lighting in the bathrooms, hallways, foyer, and porch, based on specifications and NEC® requirements.
- 117.2 **DESCRIBE** installation for all indoor and outdoor lighting fixtures.
- 117.3 **RECOGNIZE** small-appliance branch circuit and receptacle outlet installation based on NEC® requirements.
- 117.4 **DRAW** a wiring diagram of cable layout and requirements for the kitchen small appliance circuits.

#### Lesson 118 - First Semester Final Exam

- 118 This lesson will determine your proficiency in the subject matter from the previous lessons.

#### Lesson 119 - Track Lighting, Dimmers, and Introduction to Parallel Circuits (Living Room)\*

- 119.1 **DESCRIBE** the NEC® requirements for track lighting.
- 119.2 **RECOGNIZE** the operation and connection of dimmers.
- 119.3 **ILLUSTRATE** the layout of the living room and the bedroom/study circuits using specifications and the NEC®.
- 119.4 **RECOGNIZE** parallel-connected DC power sources.\*
- 119.5 **SELECT** Ohm's Law formulas for parallel circuits.

#### Lesson 120 - Laundry and Bathroom Receptacles and Parallel Circuits

- 120.1 **DEFINE** the NEC® circuit and receptacle requirements for electrical clothes dryer outlets.
- 120.2 **DEFINE** the NEC® circuit and receptacle requirements for bathrooms, laundry room receptacles, and the installation requirements for exhaust and attic fans.
- 120.3 **FORMULATE** Ohm's Law while performing circuit calculations for parallel circuits.
- 120.4 **ILLUSTRATE** the layout of the laundry and attic and demonstrate an understanding of the layout using specifications and the NEC®.

#### Lesson 121 - Garage and Garage Door Circuits, Underground Installations, and Parallel Circuit Calculations

- 121.1 **DEFINE** NEC® requirements for branch circuit wiring protection for garages.
- 121.2 **DESCRIBE** underground requirements using conduit and nonmetallic cable.
- 121.3 **DESCRIBE** garage door opener circuitry including power and control wiring.
- 121.4 **SELECT** parallel circuit calculations for voltage, current, and power.

#### Lesson 122 - Appliance and Special Purpose Outlets

- 122.1 **RECOGNIZE** branch circuit installation for special purpose outlets based on NEC® requirements.
- 122.2 **RECOGNIZE** the NEC® requirements for water heaters and their related disconnecting means, grounding, and overcurrent protection.
- 122.3 **RECOGNIZE** the expected voltmeter measurements across open and closed switches.
- 122.4 Using the EWR plans, **LOCATE** the circuits and information concerning the pump and water heater.

#### Lesson 123 - Ranges, Ovens, Counter-Mounted Cooking Units, and Other Kitchen Appliances

- 123.1 **MATCH** circuit and receptacle installation for kitchen ranges, ovens, and counter-mounted cooking equipment based on NEC® requirements.
- 123.2 **MATCH** the NEC® requirements for circuit and receptacle installation for kitchen appliances such as dishwashers and food waste disposals.
- 123.3 **SELECT** between direct (hard-wired/permanent) connections and cord-and-plug connections for kitchen equipment. **DESCRIBE** NEC® requirements for appliance disconnecting means.

#### Lesson 124 - Bathrooms, Exhaust Fans, and Hydromassage Tubs

- 124.1 **RECOGNIZE** the circuit installation for ceiling heat/vent/light units in bathrooms based on NEC® requirements.
- 124.2 **STATE** the control circuit wiring for exhaust fans and hydromassage tubs, and identify the required GFCI protection for each.
- 124.3 Using the EWR plans, **LOCATE** the circuit installation for bathrooms based on NEC® requirements.

#### Lesson 125 - Heating and Air Conditioning

- 125.1 **RECOGNIZE** circuit installation for heating cable, electric furnaces, electric baseboard heaters, heat pumps, and air conditioners based on NEC® requirements.
- 125.2 **STATE** the NEC® requirements for Class 2 control circuit wiring.
- 125.3 **RECOGNIZE** the data located on the nameplate of HVAC equipment.

#### Lesson 126 - Residential Limited Energy Systems\*

- 126.1 **LIST** basic standard installation practices for limited energy residential systems based on NEC® requirements.\*
- 126.2 Using the EWR plans, **LOCATE** the circuits and information concerning low-voltage and fire alarm.

#### Lesson 127 - Mid-Term Review and Exam

- 127 This lesson will determine your proficiency in the subject matter from the previous lessons.

#### Lesson 128 - Multiwire Branch Circuits and Introduction to Combination Circuits (Recreation Room)\*

- 128.1 **RECOGNIZE** the method of installation of multiwire branch circuits according to NEC® standards.
- 128.2 **DEFINE** watt loss, voltage drop, and current flow in two-wire and three-wire circuits.
- 128.3 **SELECT** Ohm's Law formulas for combination circuits.
- 128.4 **DESCRIBE** the advantages of installing multiwire branch circuits and the effects on the connected loads when open neutrals occur.\*
- 128.5 **RECOGNIZE** features and voltage of multiple battery connections.

#### Lesson 129 - Combination Circuits, Conductor Ampacity Correction, and Conduit Fill (Workshop)\*

- 129.1 **FORMULATE** Ohm's Law while performing circuit calculations for combination circuits.
- 129.2 **SELECT** proper conduit size by utilizing tables 4 and 5 in the NEC®.\*
- 129.3 **STATE** conductor ampacity using correction and adjustment factors. **SELECT** maximum ratings of overcurrent protection for conductors.
- 129.4 **RECOGNIZE** requirements for receptacles in a dwelling unit basement.

### Lesson 130 - Services and Service Equipment, and Cost of Electrical Power\*

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- 130.1 **RECOGNIZE** the NEC<sup>®</sup> terminology and requirements for electrical service installations.
- 130.2 **DESCRIBE** the cost of using electricity through calculation.

### Lesson 131 - Grounding and Bonding, Specialty Tools

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- 131.1 **LIST** components of grounding and bonding.
- 131.2 **RECOGNIZE** the installation requirements for grounding and bonding as per the NEC<sup>®</sup>.
- 131.3 **RECOGNIZE** and **DEMONSTRATE** use of specialty tools.

### Lesson 132 - Overcurrent Protection and Circuit Conditions

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- 132.1 **RECOGNIZE** basic overcurrent device type, terminology and operation.
- 132.2 **RECOGNIZE** the NEC<sup>®</sup> requirements for ratings, sizing, and installation requirements of various OCPDs.
- 132.3 **RECOGNIZE** possible circuit conditions (normal, short-circuit, overload, open, ground-fault).
- 132.4 Using the EWR drawing set, **LOCATE** information concerning overcurrent protection.

### Lesson 133 - Service Entrance Calculations

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- 133.1 **SELECT** the size of the electrical service including conductors for a single-family dwelling.
- 133.2 Using the EWR drawing set, **LOCATE** information concerning the service calculation.

### Lesson 134 - Swimming Pools, Spas, and Hot Tubs

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- 134.1 **RECOGNIZE** electrical hazards associated with pools, spas, and hot tubs.
- 134.2 **DESCRIBE** installation of electrical wiring for swimming pools, spas, and hot tubs based on NEC<sup>®</sup> requirements.
- 134.3 **LIST** bonding and grounding requirements for swimming pools, spas, and hot tubs based on information provided during class discussions and education materials.
- 134.4 Using the EWR drawing set, **LOCATE** information concerning the swimming pool.

### Lesson 135 - Home Automation, Standby Power, and Photovoltaic Systems\*

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- 135.1 **RECOGNIZE** structured wiring and wireless technology installations.
- 135.2 **RECOGNIZE** residential standby power systems, the NEC<sup>®</sup> requirements for installation, and the inherent safety issues.
- 135.3 **RECOGNIZE** solar photovoltaic system installation and NEC<sup>®</sup> requirements.

### Lesson 136 - Second Semester Final Exam

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- 136 This lesson will determine your proficiency in the subject matter from the previous lessons.

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\* Additional resources may be found in the back of the book and/or CMS.

## OBJECTIVES FOR YEAR 2

### Apprenticeship Abbreviations and Special Notes

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#### Lesson 201 - Construction Materials

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- 201.1 **RECOGNIZE** structural supports. **DESCRIBE** the uses of steel and metal in construction.
- 201.2 **IDENTIFY** wood construction materials. **DESCRIBE** wood framing types and methods.
- 201.3 **DESCRIBE** foundation types and foundation assembly methods.
- 201.4 **DESCRIBE** masonry types and masonry methods.
- 201.5 **RECOGNIZE** insulation, wall coverings, finishes, and firestopping methods.

#### Lesson 202 - Printreading: Project Design, Development, and Specifications\*

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- 202.1 **DESCRIBE** project origins and construction professionals.
- 202.2 **INTERPRET** the purpose and format of specifications.\*
- 202.3 **INTERPRET** specifications for the Wendy's restaurant project—Documentation
- 202.4 **INTERPRET** specifications for the Wendy's restaurant project—Construction

#### Lesson 203 - Printreading Basics

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- 203.1 **RECOGNIZE** and distinguish different prints: title page, civil, structural, architectural, electrical, mechanical, etc.
- 203.2 **INTERPRET** general notes, key notes, abbreviations, and symbols.
- 203.3 **RECOGNIZE** and **IDENTIFY** project plan lines, scales, and dimensions.
- 203.4 **RECOGNIZE** and distinguish different drawings: elevations, section drawings, detail drawings, and schedules.

#### Lesson 204 - Electrical Part I: Service, Distribution, and Panel Schedules

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- 204.1 **INTERPRET** and **LIST** electrical materials and methods.
- 204.2 **RECOGNIZE** electrical service and distribution components.
- 204.3 **INTERPRET** electrical panel schedules.

#### Lesson 205 - Electrical Part II: Lighting, Power, and Other Associated Drawings

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- 205.1 **INTERPRET** electrical lighting drawings.
- 205.2 **INTERPRET** electrical power drawings.
- 205.3 **INTERPRET** fire-alarm, communications, controls, and security systems.
- 205.4 **INTERPRET** electrical quantity take-off.

#### Lesson 206 - Site/Civil and Structural Drawings

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- 206.1 **LOCATE** and **USE** site, civil, and survey drawings.
- 206.2 **INTERPRET** foundation and structural floor plans.
- 206.3 **INTERPRET** photometric and site lighting plans.

#### Lesson 207 - Mechanical and Plumbing Materials and Drawings

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- 207.1 **INTERPRET** and **LIST** mechanical and plumbing materials and methods.
- 207.2 **INTERPRET** mechanical and plumbing equipment schedules.
- 207.3 **INTERPRET** mechanical drawings.
- 207.4 **INTERPRET** plumbing drawings.
- 207.5 **RECOGNIZE** how roofing types affect electrical installations.

#### Lesson 208 - Architectural Drawings

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- 208.1 **RECOGNIZE** and **ANALYZE** architectural schedules.
- 208.2 **IDENTIFY** and **EXPLAIN** various wall types and their components.
- 208.2 **RECOGNIZE** and **ANALYZE** architectural details.
- 208.4 **DEMONSTRATE** coordination of drawings.

#### Lesson 209 - Midterm Review and Exam

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- 209 This lesson will provide a review of the subject matter from previous lessons and determine your proficiency in the subject matter from previous lessons.

#### Lesson 210 - Code Study: NEC® Intro, Chapter 1, and Chapter 2, Articles 90, 100, 110, and 200

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- 210.1 **IDENTIFY** key concepts and key words in NEC® Article 90.
- 210.2 **IDENTIFY** definitions in NEC® Article 100.
- 210.3 **IDENTIFY** key concepts and key words in NEC® Article 110.
- 210.4 **IDENTIFY** key concepts and key words in NEC® Article 210.

#### Lesson 211 - Code Study: NEC® Chapter 2, Article 210

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- 211.1 **IDENTIFY** key concepts and key words in NEC® Article 210 Part I.
- 211.2 **IDENTIFY** key concepts and key words in NEC® Article 210 Part II.
- 211.3 **IDENTIFY** key concepts and key words in NEC® Article 210 Part III.

#### Lesson 212 - Code Study: NEC® Chapter 2, Articles 215, 220, 225, and 230

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- 212.1 **IDENTIFY** key concepts and key words in NEC® Article 215.
- 212.2 **IDENTIFY** key concepts and key words in NEC® Article 220.
- 212.3 **IDENTIFY** examples in NEC® Informative Annex D and how they relate to Article 220.
- 212.4 **IDENTIFY** key concepts and key words in NEC® Article 225.
- 212.5 **IDENTIFY** key concepts and key words in NEC® Article 230.

#### Lesson 213 - Code Study: NEC® Chapter 2, Articles 240, 242, and 250

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- 213.1 **IDENTIFY** key concepts and key words in NEC® Article 240.
- 213.2 **IDENTIFY** key concepts and key words in NEC® Article 242.
- 213.3 **IDENTIFY** key concepts and key words in NEC® Article 250, specifically equipment grounding conductors.
- 213.4 **IDENTIFY** key concepts and key words in NEC® Article 250, specifically main bonding jumper and grounding electrode system.

#### Lesson 214 - Code Study: NEC® Chapter 3, Articles 300 and 310

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- 214.1 **IDENTIFY** key concepts and key words in NEC® Article 300.
- 214.2 **IDENTIFY** key concepts and key words in NEC® Article 310 Parts I and II.
- 214.3 **IDENTIFY** key concepts and key words in NEC® Article 310 Part III.
- 214.4 **IDENTIFY** Chapter 9, Table 8 and its relationship to conductors.

#### Lesson 215 - Code Study: NEC® Chapter 3, Articles 312 and 314\*

- 215.1 **IDENTIFY** key concepts and key words in NEC® Article 312.
- 215.2 **IDENTIFY** key concepts and key words in NEC® Article 314.
- 215.3 **FORMULATE** volume calculations for outlet, device, and junction boxes.\*
- 215.4 **FORMULATE** calculations for pull box sizing.

#### Lesson 216 - Code Study: NEC® Chapter 3, Articles 320–393\*

- 216.1 **IDENTIFY** code organization and structure standards as contained in NEC® Articles 320–393.
- 216.2 **IDENTIFY** key concepts and key words for cables as used in NEC® Articles 320–340.
- 216.3 **IDENTIFY** key concepts and key words for conduit and tubing as used in NEC® Articles 342–362.
- 216.4 **IDENTIFY** key concepts and key words for other raceway systems as used in NEC® Articles 366–393.
- 216.5 **IDENTIFY** Chapter 9 Tables 1, 4, and 5 and perform conduit fill calculations.\*

#### Lesson 217 - First Semester Exam Review

- 217 This lesson will provide a review of the subject matter from previous lessons.

#### Lesson 218 - First Semester Exam

- 218 This lesson will determine your proficiency in the subject matter from the previous lessons.

#### Lesson 219 - Introduction to AC Theory

- 219.1 **DESCRIBE** and **CHOOSE** the terms used for electrical charges, magnetism, and electromagnetism.
- 219.2 **RECOGNIZE** basics of AC power, AC generation, frequency, voltage, and current.
- 219.3 **DEFINE** inductance and capacitance, and **CHOOSE** symbols and formulas for inductors and capacitors.

#### Lesson 220 - AC Theory: Inductive and Capacitive Reactance

- 220.1 **DEFINE** and compute inductive reactance and capacitive reactance in an AC circuit.
- 220.2 **DESCRIBE** and predict the leading and lagging effects on the voltage and current relationship when inductive reactance and capacitive reactance are present in an AC circuit.

#### Lesson 221 - AC Theory: Impedance and Power Factors\*

- 221.1 **DEFINE** and **COMPUTE** impedance in series and parallel circuits.
- 221.2 **IDENTIFY** the relationship between true power, apparent power, and power factor.\*

#### Lesson 222 - Single-Phase Transformers: Theory, Types, and Calculations\*

- 222.1 **DESCRIBE** the basic transformer terms and theory.
- 222.2 **DESCRIBE** basic transformer types.
- 222.3 **MASTER** calculations and connections for single-phase, single-voltage transformers.\*
- 222.4 **MASTER** calculations and connections for single-phase, dual-voltage transformers.\*

#### Lesson 223 - Power Generation, Transmission, and Distribution; Introduction to Three-Phase Calculations

- 223.1 **RECOGNIZE** methods and components utilized in the generation, transmission, and distribution of power from various types of power plants.
- 223.2 **FORMULATE** power and current in three-phase systems.



#### Lesson 224 - 3Ø Transformers\*

- 224.1 **RECOGNIZE** and **EXPLAIN** three-phase transformers, three-wire, closed-delta secondary outputs, capacities, and connections. Identify proper primary tap connections and perform calculations.\*
- 224.2 **RECOGNIZE** and **EXPLAIN** three-phase, four-wire, closed-delta secondary outputs, capacities, and connections. Perform current and power calculations.
- 224.3 **RECOGNIZE** and **EXPLAIN** three-phase, three-wire and four-wire, open-delta secondary outputs, capacities, and connections. **PERFORM** current and power calculations.
- 224.4 **RECOGNIZE** and explain three-phase, four-wire, wye secondary outputs, capacities, and connections for transformers and connected loads.\*
- 224.5 **PERFORM** current, power, and tap calculations for transformers.

#### Lesson 225 - Buck–Boost Transformers: Single-Phase Connections and Applications\*

- 225.1 **RECOGNIZE** and **EXPLAIN** additive and subtractive polarity and the output voltages of buck-boost transformers.
- 225.2 **RECOGNIZE** and **CHOOSE** applications involving buck-boost transformers. **PERFORM** the calculations for determining the output voltages and capacities of these transformers.
- 225.3 **COMPUTE** the output voltage when supply voltages are other than the table values.

#### Lesson 226 - Balancing Three-Phase Loads, Nonlinear Loads, Three-Phase Fault Currents, and Voltage Drop

- 226.1 **RECOGNIZE** and **EXPLAIN** the terms and solutions associated with balancing loads on wye-connected secondaries.
- 226.2 **RECOGNIZE** and **EXPLAIN** terms, symptoms, and solutions associated with nonlinear loads.
- 226.3 **FORMULATE** three-phase and single-phase bolted-fault currents.
- 226.4 **FORMULATE** three-phase and single-phase voltage drop.

#### Lesson 227 - Mid-Term Review and Exam

- 227 This lesson will provide a review of the subject matter from previous lessons and determine your proficiency in the subject matter from previous lessons.

#### Lesson 228 - Code Study: NEC® Chapter 4, Articles 400–408, 410, 422, and 424\*

- 228.1 **IDENTIFY** key concepts and key words concerning flexible cords, cables, and fixture wires as used in NEC® 400 and 402.\*
- 228.2 **IDENTIFY** key concepts and key words concerning switches, receptacles, switchboards, and panelboards as used in NEC® 404, 406, and 408.
- 228.3 **IDENTIFY** key concepts and key words concerning luminaires as used in NEC® 410.
- 228.4 **IDENTIFY** key concepts and key words as used in NEC® 422 and 424.

#### Lesson 229 - Code Study: NEC® Chapter 4, Articles 430, 440, 445, 450, and 480

- 229.1 **IDENTIFY** key concepts and key words as used in NEC® 430.
- 229.2 **IDENTIFY** key concepts and key words as used in NEC® 440.
- 229.3 **IDENTIFY** key concepts and key words as used in NEC® 445.
- 229.4 **IDENTIFY** key concepts and key words as used in NEC® 450.
- 229.5 **IDENTIFY** key concepts and key words as used in NEC® 480.

**Lesson 230 - Code Study: NEC® Chapter 5, Articles 500–506 and 511–516**

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- 230.1 **IDENTIFY** key concepts and key words as used in NEC® 500, 501, 502, and 503.
- 230.2 **IDENTIFY** key concepts and key words as used in NEC® 504, 505, and 506.
- 230.3 **IDENTIFY** key concepts and key words as used in NEC® 511, 513, 514, and 515.
- 230.4 **IDENTIFY** key concepts and key words as used in NEC® 516.

**Lesson 231 - Code Study: NEC® Chapter 5, Articles 517–590**

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- 231.1 **IDENTIFY** key concepts and key words as used in NEC® 517.
- 231.2 **IDENTIFY** key concepts and key words as used in NEC® 518–540.
- 231.3 **IDENTIFY** key concepts and key words as used in NEC® 545–555.
- 231.4 **IDENTIFY** key concepts and key words as used in NEC® 590.

**Lesson 232 - Code Study: NEC® Chapter 6, Articles 600–604, 620–645, and 680**

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- 232.1 **IDENTIFY** key concepts and key words as used in NEC® 600, 604, and 620.
- 232.2 **IDENTIFY** key concepts and key words as used in NEC® 625, 630, 640, and 645.
- 232.3 **IDENTIFY** key concepts and key words as used in NEC® 680.

**Lesson 233 - Code Study: NEC® Chapter 6, Articles 690 and 695**

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- 233.1 **IDENTIFY** key concepts and key words as used in NEC® 690.
- 233.2 **IDENTIFY** key concepts and key words as used in NEC® 695.

**Lesson 234 - Code Study: NEC® Chapter 7, Articles 700–705, 722, 724, 725, and 760**

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- 234.1 **IDENTIFY** key concepts and key words as used in NEC® 700, 701, and 702.
- 234.2 **IDENTIFY** key concepts and key words as used in NEC® 705.
- 234.3 **IDENTIFY** key concepts and key words as used in NEC® 722, 724, and 725.
- 234.4 **IDENTIFY** key concepts and key words as used in NEC® 760.

**Lesson 235 - Final Exam Review**

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- 235 This lesson will provide a review of the subject matter from previous lessons.

**Lesson 236 - Final Exam**

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- 236 This lesson will determine your proficiency in the subject matter from previous lessons.

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\* Additional resources may be found in the back of the book and/or CMS.

## OBJECTIVES FOR YEAR 3

### Lesson 301 - Test Instruments, OSHA, NFPA 70E®, and Test Instrument Safety

- 301.1 **USE** and correctly **INTERPRET** information on a digital meter display. List examples of electrical test instruments and demonstrate their uses.
- 301.2 **RECALL** the important key safety requirements relative to OSHA and NFPA 70E®.
- 301.3 **DEMONSTRATE** safe test instrument habits by using proper PPE and procedures.

### Lesson 302 - Introduction to Grounding and Bonding; General Requirements

- 302.1 **REVIEW** definitions for grounding and bonding.
- 302.2 **IDENTIFY** the components and explain the effective ground-fault path to facilitate the OCPD operation.
- 302.3 **IDENTIFY** objectionable currents and their effects.

### Lesson 303 - System Grounding: Grounded Conductors, Systems Required to be Grounded, and Systems Not Permitted to be Grounded

- 303.1 **REVIEW** the various common AC voltage systems. Determine which ARE REQUIRED to be grounded, which conductors are to be grounded, and which conductors are to be protected by overcurrent devices.
- 303.2 **EXPLAIN** a separately derived system.
- 303.3 **REVIEW** the various common AC voltage systems. Determine which systems and branch circuits are not required or are not permitted to be grounded.
- 303.4 **DESCRIBE** and **EXPLAIN** installation requirements and properly sized grounded conductors.

### Lesson 304 - System Grounding: Separately Derived Systems, Main Bonding Jumpers, and System Bonding Jumpers\*

- 304.1 **RECALL** and **EXPLAIN** the function, installation requirements, and sizing of main and system bonding jumpers.\*
- 304.2 **ASSESS** grounding and installation requirements for separately derived systems.
- 304.3 **ASSESS** the grounding requirements for two or more buildings or structures supplied by feeders or branch circuits.
- 304.4 **ASSESS** the grounding requirements for portable and vehicle-mounted generators and impedance grounded systems.

### Lesson 305 - Grounding Electrode Systems and Grounding Electrode Conductors\*

- 305.1 **EXPLAIN** general requirements for the grounding electrode system. **CHOOSE** which types of electrodes are permitted and the correct installation of the electrodes.
- 305.2 **REVIEW** requirements for grounding electrode conductors.\*
- 305.3 **REVIEW** sizing for grounding electrode conductors.

### Lesson 306 - Supply-Side and Load-Side Bonding Jumpers

- 306.1 **DEMONSTRATE** the requirements for supply-side bonding jumpers including materials used, installation, and sizing.
- 306.2 **DEMONSTRATE** the requirements for load-side bonding jumpers including materials used, installation, and sizing.

### Lesson 307 - Equipment Grounding and Equipment Grounding Conductors

- 307.1 **IDENTIFY** effective equipment grounding and recognize the difference between short circuit and ground fault.
- 307.2 **REVIEW** grounding requirements for fastened-in-place equipment.
- 307.3 **REVIEW** sizing for equipment grounding conductors.

### Lesson 308 - Grounding of Specific Equipment and Conditions

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- 308.1 **RECOGNIZE** and **LIST** the methods of equipment grounding conductor connections.
- 308.2 **SHOW** the normally non-current-carrying metal parts of equipment and identify the supports that are required to be connected to the equipment grounding conductor of a circuit. **EXPLAIN** why this connection is necessary.
- 308.3 **LOCATE** and **APPLY** the provisions for grounding in Chapter 5 and 6 of the NEC®.

### Lesson 309 - Mid-Term Review and Exam

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### Lesson 310 - DC Motors, AC Single-Phase and Polyphase Motors

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- 310.1 **DESCRIBE** and **EXPLAIN** the operation, construction, and required connections for DC motors.
- 310.2 **DESCRIBE** and **EXPLAIN** the operation, construction, and required connections for single-phase AC motors.
- 310.3 **DESCRIBE** and **EXPLAIN** three-phase operation of wound-rotor, synchronous, and squirrel-cage induction motors.
- 310.4 **RECOGNIZE** and **DEMONSTRATE** proper connections of wye- and delta-wound squirrel-cage induction motors.
- 310.5 **RECOGNIZE** enclosure types and nameplate information for three-phase motors.

### Lesson 311 - Motors: General Knowledge and Sizing Branch Circuit Conductors

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- 311.1 **SELECT** proper size branch circuit conductors for single-phase motors.
- 311.2 **SELECT** proper size branch circuit conductors for three-phase motors.
- 311.3 **SELECT** proper size flexible cord conductors for motors.
- 311.4 **MASTER** adjustment factors for motor branch circuits due to voltage drop, ambient temperature, and/or multiple conductors in a raceway.

### Lesson 312 - Sizing Motor Short-Circuit and Ground-Fault Protection; Locked Rotor Current

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- 312.1 **SELECT** proper size short-circuit and ground-fault protection for single-phase motor branch circuits.
- 312.2 **SELECT** proper size short-circuit and ground-fault protection for polyphase motor branch circuits.
- 312.3 **DESCRIBE** the fundamentals of motor locked rotor current. **COMPUTE** approximate locked rotor current when a motor starts or stalls.
- 312.4 **CONTRAST** the minimum equipment grounding conductor size for motor branch circuit installations and branch circuit installations.

### Lesson 313 - Sizing Motor Overloads and Disconnects

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- 313.1 **DESCRIBE** the purpose and function of motor overloads.
- 313.2 **SELECT** overload protection for installation in a motor starter.
- 313.3 **RECOGNIZE** the devices that can be used as a disconnecting means for a motor.

### Lesson 314 - Motor Feeder Conductors, OCPDs, and Tap Conductors

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- 314.1 **FORMULATE** proper size motor feeder conductors.
- 314.2 **FORMULATE** proper size motor feeder short-circuit and ground-fault protection.
- 314.3 **FORMULATE** proper size motor feeder tap conductors.

### Lesson 315 - Adjustable-Speed Drive Systems, Code, and Introduction to Motor Speed Control Methods

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- 315.1 **DESCRIBE** adjustable-speed drive system technology and **CONTRAST** it to traditional motor circuitry.
- 315.2 **DESCRIBE** and **APPLY** speed control methods for various classifications of motor loads.

### Lesson 316 - AC Equipment, Fire Pumps

- 316.1 **FORMULATE** the minimum size for conductors, safety switches, and OCPDs used for air conditioning and refrigeration equipment branch circuits.
- 316.2 **RECOGNIZE** the NEC® requirements for fire pumps.

### Lesson 317 - First Semester Exam Review

### Lesson 318 - First Semester Exam

### Lesson 319 - Introduction to Ladder Logic, Pushbuttons

- 319.1 **RECOGNIZE** inputs and outputs. **LABEL** various switches and loads as input or output.
- 319.2 **RECOGNIZE** correct symbology and operation for toggle switches, pushbuttons, and basic loads.
- 319.3 **WRITE** simple ladder diagrams. **LABEL** ladder diagrams.

### Lesson 320 - Manual Control Devices, Hands-On Activity\*

- 320.1 **RECOGNIZE** correct symbology and operation for manual control devices (pushbuttons, selector switches, joysticks, and foot switches).
- 320.2 From the work description, **ILLUSTRATE** ladder diagrams, and **CONNECT** manual control devices in the hands-on activity.\*

### Lesson 321 - Automatic Control Devices, Hands-On Activity\*

- 321.1 **RECOGNIZE** correct symbology and operation for automatic control devices (limit, pressure, temperature, float, flow, photocell, and time switches).
- 321.2 From the work description, **ILLUSTRATE** ladder diagrams, and **CONNECT** automatic control devices in the hands-on activity.\*

### Lesson 322 - Relays, Solid-State Relays, Contactors, Hands-On Activities\*

- 322.1 **RECOGNIZE** and **EXPLAIN** the magnetic solenoid action required to operate magnetic control devices. **USE** correct solenoid symbology in ladder logic diagrams
- 322.2 **RECOGNIZE** the purpose and function of contactors and relays. **SHOW** what happens to contacts when the coils are energized.
- 322.3 **IDENTIFY** the basic types of solid-state relays and indicate their characteristics in comparison to electro-mechanical relays.
- 322.4 From the work description, **ILLUSTRATE** ladder diagrams, and **CONNECT** various contactors and relays in the hands-on activity.\*

### Lesson 323 - Holding Circuits, Hands-On Activities\*

- 323.1 **MASTER** the connection of holding circuits for relays and contactors.
- 323.2 From the work description, **ILLUSTRATE** ladder diagrams, and **CONNECT** various scenarios with holding contacts in the hands-on activity.\*

### Lesson 324 - Timing Relays: On-Delay, Interval, and Recycle\*

- 324.1 **CONTRAST** timing relays with non-timing relays. **LIST** the types of timers available, identify timing modes, and recognize the symbols used for timing relay contacts in ladder diagrams.
- 324.2 **SELECT** and **ILLUSTRATE** the operation of on-delay timing relays.
- 324.3 **SELECT** and **ILLUSTRATE** the operation of interval and recycle (repeat) timing relays.
- 324.4 From the work description, **ILLUSTRATE** ladder diagrams, and **CONNECT** various scenarios with 8-pin relays in the hands-on activity.\*

### Lesson 325 - Timing Relays: Off-Delay, One-Shot, and Multifunction; Hands-On Activities\*

- 325.1 **SELECT** and **ILLUSTRATE** the operation of off-delay timing relays.
- 325.2 **SELECT** and **ILLUSTRATE** the operation of one-shot timing relays.
- 325.3 **SELECT** and **ILLUSTRATE** the operation of multifunction timing relays.
- 325.4 From the work description, **ILLUSTRATE** ladder diagrams, and **CONNECT** various scenarios with 11-pin relays in the hands-on activity.\*

### Lesson 326 - Ladder Logic Line Diagram: Critical Thinking Activity

- 326.1 **DEMONSTRATE** an understanding of control concepts and ladder logic line diagrams by creating and explaining a control circuit scenario.

### Lesson 327 - Mid-Term Review and Exam

### Lesson 328 - Magnetic Motor Starters, Control Circuit Overview, Hands-On Activity\*

- 328.1 **RECOGNIZE** the purpose and function of motor starters.
- 328.2 **LABEL** connection terminals on motor starters. **MASTER** connection of motor starters to control circuitry. **SHOW** what happens to contacts when the coils are energized.
- 328.3 **RECALL** the purpose and function of motor overloads.
- 328.4 **IDENTIFY** motor starter components (hands-on activity). \*

### Lesson 329 - Motor Power Connections, NEMA Enclosures, Hands-On Activity\*

- 329.1 **DEMONSTRATE** motor power connections as required for the available circuit voltage.
- 329.2 **REVIEW** NEMA enclosure classifications as they apply to environmental conditions.
- 329.3 From the work description, **ILLUSTRATE** ladder diagrams, and **CONNECT** magnetic motor starters in the hands-on activity. \*

### Lesson 330 - Motor Reversing: Controllers and Connections, Hands-On Activity\*

- 330.1 **DESCRIBE** and **USE** manual methods to reverse the rotation of a three-phase motor.
- 330.2 **DESCRIBE** and **USE** magnetic motor starters to reverse the rotation of a three-phase motor.
- 330.3 From the work description, **ILLUSTRATE** ladder diagrams, and **CONNECT** a reversing magnetic motor in the hands-on activity. \*

### Lesson 331 - Jogging Circuits, Latching Relays, Alternating Relays, Phase-Loss Relays; Hands-On Activity\*

- 331.1 **DESCRIBE** the operation and function of jogging circuits.
- 331.2 **DESCRIBE** the operation and function of latching relays.
- 331.3 **DESCRIBE** the operation and function of alternating relays.
- 331.4 **INDICATE** the effects of phase loss on a motor. **DESCRIBE** the operation and function of a phase loss relay.
- 331.5 From the work description, **ILLUSTRATE** ladder diagrams, and **CONNECT** jogging circuits, latching relays, alternating relays, or phase-loss relays in the hands-on activity.\*

### Lesson 332 - Introduction to Limited Energy/Low-Voltage Systems

- 332.1 **RECOGNIZE** and **EXPLAIN** the basic functions of a structured cabling system as it relates to limited energy / low-voltage systems.
- 332.2 **RECOGNIZE** and **EXPLAIN** types of twisted pair structured cable (UTP), connectors, terminal blocks, terminations, and applications such as POE.
- 332.3 **RECOGNIZE** and **EXPLAIN** types of coaxial cable, connectors, and terminations.
- 332.4 **RECOGNIZE** and **EXPLAIN** types of fiber, fiber connectors, and terminations.

### Lesson 333 - Building the Foundation of the Productive Worker

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- 333.1 **RECOGNIZE** types of motivation.
- 333.2 **LIST** elements of planning skills.
- 333.3 **DESCRIBE** key elements of organization.
- 333.4 **IDENTIFY** ways to increase personal productivity.

### Lesson 334 - Transition to Supervisor

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- 334.1 **IDENTIFY** motivation types as they apply to supervision.
- 334.2 **OUTLINE** steps in task planning.
- 334.3 **LIST** key elements of organization.
- 334.4 **IDENTIFY** key concepts of productivity.

### Lesson 335 - Final Exam Review

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### Lesson 336 - Final Exam

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\* Additional resources may be found in the back of the book and/or CMS.

## OBJECTIVES FOR YEAR 4

### Lesson 401 - Energized Electrical Work Relative to NFPA 70E®\*

- 401.1 **DEMONSTRATE** a broad understanding on working on or near energized electrical equipment as explained by OSHA and NFPA 70E®.

### Lesson 402 - Power Distribution Systems and Phase-Loss Monitors

- 402.1 **EXPLAIN** the transmission and distribution processes, and **SHOW** the equipment required, for the delivery of energy from a generating station to the end user's equipment.
- 402.2 **IDENTIFY** and **ANALYZE** circuit problems that can cause equipment damage. Discuss the features of phase-loss monitors.

### Lesson 403 - Solid-State Relays and Phase-Loss Lab\*

- 403.1 **IDENTIFY** the basic types of solid-state relays and **INDICATE** their characteristics in comparison to electromechanical relays.
- 403.2 **CONSTRUCT** a control panel circuit for a motor protected with a phase-failure relay.

### Lesson 404 - Timing Relays: On-Delay, Interval, and Recycle\*

- 404.1 **CONTRAST** timing relays with non-timing relays. **LIST** the types of timers available, identify timing modes, and recognize the symbols used for timing relay contacts in ladder diagrams.
- 404.2 **SELECT** and **ILLUSTRATE** the operation of ON-DELAY timing relays.
- 404.3 **SELECT** and **ILLUSTRATE** the operation of interval and recycle (repeat) timing relays.

### Lesson 405 - Timing Relays: Practical Application of On-Delay, Recycle, and Interval Timers

- 405.1 **IDENTIFY** circuit components and sequence of operation from the work description.
- 405.2 **ILLUSTRATE** each rung in the diagram.
- 405.3 **ILLUSTRATE** complete ladder diagram by combining rungs.
- LAB **CONSTRUCT** the project. (Those classes without access to physical labs should refer to the special instructions within this section.)

### Lesson 406 - Timing Relays: Off-Delay, One-Shot, and Multifunction\*

- 406.1 **SELECT** and **ILLUSTRATE** the operation of OFF-DELAY timing relays.
- 406.2 **SELECT** and **ILLUSTRATE** the operation of one-shot timing relays.
- 406.3 **SELECT** and **ILLUSTRATE** the operation of multifunction timing relays.

### Lesson 407 - Timing Relays: Practical Application of Off-Delay, One-Shot, and Multifunction Timers

- 407.1 **IDENTIFY** circuit components and sequence of operation from the work description.
- 407.2 **ILLUSTRATE** each rung in the diagram.
- 407.3 **ILLUSTRATE** a complete ladder diagram by combining rungs.
- 407.4 **CONSTRUCT** the project. (Those classes without access to physical labs should refer to the special instructions within this section.)

### Lesson 408 - Counters and Sensors\*

- 408.1 **DESCRIBE** and **DEMONSTRATE** the basic operation and uses for counters.
- 408.2 **LIST** and **DEMONSTRATE** sensors in control circuits.



#### Lesson 409 - Mid-Term Review and Exam

409 This lesson will determine your proficiency in the subject matter from the previous lessons.

#### Lesson 410 - Motor Starting Methods

- 410.1 **RECOGNIZE** and **EXPLAIN** why full-voltage starting methods are not suitable for all motor applications.
- 410.2 **LIST** and **DEMONSTRATE** the various reduced-voltage starting methods.
- 410.3 **DESCRIBE** and **CHOOSE** between various solid-state (including soft start) motor starting methods.

#### Lesson 411 - Motor Drives—Accelerating and Decelerating Methods

- 411.1 **LIST** and **EXPLAIN** the available types and basic operation of motor drives.
- 411.2 **LIST** and **EXPLAIN** the various accelerating and decelerating methods for all motors.
- 411.3 **DESCRIBE** and **APPLY** speed control methods for various classifications of motor loads.

#### Lesson 412 - Introduction to Programmable Controllers\*

- 412.1 **RECOGNIZE** and **EXPLAIN** the basic operation and use of programmable controllers.
- 412.2 **RECOGNIZE** programmable controller components and **EXPLAIN** their operation. **USE** basic programming symbols and logic functions.
- 412.3 **DEMONSTRATE** basic programmable controller applications.
- 412.4 **EXPLAIN** basic troubleshooting steps for programmable controllers.

#### Lesson 413 - Advanced Lab—Automatic Car Wash

- 413.1 **IDENTIFY** circuit components and sequence of operation from the work description.
- 413.2 **ILLUSTRATE** each rung in the diagram.

#### Lesson 414 - Energy Management and Building Automation Including Latching Relays

- 414.1 **LIST** methods utilized to conserve the usage of a facility's electric energy consumption.
- 414.2 **EXPLAIN** building management systems as used for automation, energy conservation, and redundant equipment systems.
- 414.3 **IDENTIFY** and **USE** a mechanically held (latching) relay. **EXPLAIN** how these lighting contactors are used with building automation systems.

#### Lesson 415 - Fire Suppression Systems and Advanced Lab

- 415.1 **IDENTIFY** the purpose, circuit components, and sequence of operation for fire suppression (Ansul) systems.
- 415.2 **ILLUSTRATE** a complete ladder diagram for the fire suppression system.
- 415.3 **CONSTRUCT** the project. (Those classes without access to physical labs should refer to the special LAB instructions within this section).

#### Lesson 416 - Preventive Maintenance and Troubleshooting\*

- 416.1 **OUTLINE** and **EXPLAIN** the purpose and methods utilized for preventive and predictive maintenance systems.
- 416.2 **OUTLINE** and **EXPLAIN** the processes utilized to troubleshoot equipment.
- 416.3 **OUTLINE** and **EXPLAIN** the processes utilized to troubleshoot control circuits.
- 416.4 **OUTLINE** and **EXPLAIN** the processes utilized to troubleshoot power circuits.

#### Lesson 417 - First Semester Exam Review

417 This lesson will provide a review of the subject matter from the previous lessons.

#### Lesson 418 - First Semester Final Exam

418 This lesson will determine your proficiency in the subject matter from the previous lessons.

#### Lesson 419 - Introduction, Definitions, and Boxes

419.1 **REVIEW** the use, format, structure, outline, and practical application of the NEC®.

419.2 **REVIEW** definitions used in the NEC®.

419.3 **REVIEW** NEC® requirements for the use and installation of boxes and enclosures.

419.4 **REVIEW** box-fill and box-sizing calculations.

#### Lesson 420 - Cable Types and Flexible Cords: General Installation Requirements

420.1 **REVIEW** NEC® requirements for the general installation of any cable.

420.2 **REVIEW** NEC® requirements for the use of specific cable wiring methods.

420.3 **REVIEW** NEC® requirements for underground installations.

#### Lesson 421 - Raceways and Conductors

421.1 **REVIEW** NEC® requirements for the general installation of any raceway.

421.2 **REVIEW** NEC® requirements for the use of specific raceway and other wiring methods.

421.3 **REVIEW** raceway fill calculations.

421.4 **REVIEW** NEC® requirements for the general use and installation of any conductor.

421.5 **REVIEW** ampacity correction factor calculations for conductors.

#### Lesson 422 - Dwelling Units: General Provisions

422.1 **REVIEW** NEC® branch circuit ratings in dwellings.

422.2 **REVIEW** NEC® requirements for the location and installation of general receptacles in dwellings.

422.3 **REVIEW** NEC® requirements for the location and installation of general lighting outlets in dwellings.

422.4 **REVIEW** NEC® calculations for general lighting load and general purpose receptacles.

#### Lesson 423 - Dwelling Units: Specific Provisions

423.1 **REVIEW** NEC® circuit ratings and calculations for fixed appliances.

423.2 **REVIEW** NEC® installation requirements for fixed appliances in dwellings.

423.3 **REVIEW** NEC® requirements for specific lighting outlets and luminaires in dwellings.

#### Lesson 424 - Services: Equipment and Working Space

424.1 **REVIEW** NEC® requirements for services and service equipment.

424.2 **REVIEW** NEC® requirements for clearances and working space.

424.3 **REVIEW** NEC® requirements for panelboards, switchboards, transformers, generators, and busways.

424.4 **REVIEW** NEC® requirements for fuses and circuit breakers.

#### Lesson 425 - Commercial Installations

425.1 **PERFORM** voltage drop calculations and other electrical calculations.

425.2 **REVIEW** NEC® requirements for commercial branch circuits and outlets.

425.3 **REVIEW** NEC® requirements for use and installation of commercial luminaires.

#### Lesson 426 - Hazardous Locations and Health Care Facilities

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- 426.1 **REVIEW** NEC® classes and divisions for hazardous locations.
- 426.2 **REVIEW** NEC® requirements for specific hazardous locations.
- 426.3 **REVIEW** NEC® definitions and requirements for health care facilities.
- 426.4 **REVIEW** NEC® requirements for health care electrical systems.
- 426.5 **REVIEW** NEC® requirements for health care equipment.

#### Lesson 427 - Mid-Term Review and Exam

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- 427 This lesson will determine your proficiency in the subject matter from the previous lessons.

#### Lesson 428 - Miscellaneous Occupancies and Special Equipment

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- 428.1 **REVIEW** NEC® requirements for occupancies designated in Articles 518–540.
- 428.2 **REVIEW** NEC® requirements for occupancies designated in Articles 545–590.
- 428.3 **REVIEW** NEC® requirements for swimming pools, spas, and fountains.
- 428.4 **REVIEW** NEC® requirements for special equipment in Articles 600–685 and 695.

#### Lesson 429 - Alternative Energy Sources and Emergency Power Systems

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- 429.1 **IDENTIFY** and **EXPLAIN** the different types of emergency systems.
- 429.2 **RECOGNIZE** and **EXPLAIN** different energy storage systems.
- 429.3 **RECOGNIZE** and **EXPLAIN** NEC® requirements for renewable energy generation.
- 429.4 **RECOGNIZE** and **EXPLAIN** NEC® requirements for interconnection of energy systems.

#### Lesson 430 - Motors and Power Quality

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- 430.1 **CHOOSE** motor branch circuit conductors.
- 430.2 **CHOOSE** motor branch circuit short-circuit and ground-fault protection rating.
- 430.3 **CHOOSE** motor branch circuit overload protection rating. **RECALL** and **EXPLAIN** power quality issues, their causes and effects in electrical systems, and how to reduce their impact.
- 430.4 **REVIEW** hermetic motor installation requirements.
- 430.5 **REVIEW** sources of poor power quality and mitigating solutions.

#### Lesson 431 - Service and Load Calculations

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- 431.1 **REVIEW** NEC® requirements for one-family and multifamily dwelling service calculations.
- 431.2 **REVIEW** NEC® requirements for commercial occupancy service calculations.

#### Lesson 432 - BCES Application and Grounding & Bonding Requirements

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- 432.1 **FIND** information on BCES plans.
- 432.2 **COMPUTE** connected and demanded loads using BCES plans.
- 432.3 **REVIEW** NEC® requirements for grounding and bonding of services and service equipment.

#### Lesson 433 - Fire Alarm Systems—Introduction and Overview

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- 433.1 **DESCRIBE** and **APPLY** the basic functions of a fire alarm system.
- 433.2 **LIST** and **EXPLAIN** the basic types, functions, and proper locations for fire alarm initiation and notification devices.
- 433.3 **LIST** and **EXPLAIN** the wire types used in fire alarm systems.
- 433.4 **LIST** and **EXPLAIN** the different types of fire alarm systems.
- 433.5 **RECOGNIZE** and **EXPLAIN** the safety precautions for working on existing fire alarm systems.

#### Lesson 434 - Introduction to Limited Energy/Low-Voltage Systems

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- 434.1 **RECOGNIZE** and **EXPLAIN** the basic functions of limited energy/low-voltage systems.
- 434.2 **RECOGNIZE** and **EXPLAIN** types of coaxial cable, connectors, and terminations.
- 434.3 **RECOGNIZE** and **EXPLAIN** types of structured cable, connectors, terminal blocks, and terminations.
- 434.4 **RECOGNIZE** and **EXPLAIN** types of fiber, fiber connectors, and terminations.
- 434.5 **REVIEW** NEC® requirements for special conditions and communications systems.

#### Lesson 435 - Final Exam Review

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435 This lesson will provide a review of the subject matter from the previous lessons.

#### Lesson 436 - Second Semester Final Exam

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436 This lesson will determine your proficiency in the subject matter from the previous lessons.

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\* Additional resources may be found in the back of the book and/or CMS.