

Student's Name/Initials

/

Date

Teacher's Initials

Date

ELECTRICITY 1, 2, 3, and 4

DIRECTIONS: Evaluate the student using the applicable rating scales below and check the appropriate box to indicate the degree of competency. The ratings 3, 2, 1, and N are not intended to represent the traditional school grading system of A, B, C, and D. The description associated with each of the ratings focuses on the level of student performance or cognition for each of the competencies listed below.

PERFORMANCE RATING

- 3 - Skilled--can perform task independently with no supervision
 2 - Moderately skilled--can perform task completely with limited supervision
 1 - Limitedly skilled--requires instruction and close supervision
 N - No exposure--has no experience or knowledge of this task

COGNITIVE RATING

- 3 - Knowledgeable--can apply the concept to solve problems
 2 - Moderately knowledgeable--understands the concept
 1 - Limited knowledge--requires additional instruction
 N - No exposure--has not received instruction in this area

NCCER CONTREN® CORE MODULES**MODULE A:****BASIC SAFETY**

3 2 1 N

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|---|
| ☐ | ☐ | ☐ | ☐ | 1. Identify the responsibilities and personal characteristics of a professional craftsman. |
| ☐ | ☐ | ☐ | ☐ | 2. Explain the role that safety plays in the construction crafts. |
| ☐ | ☐ | ☐ | ☐ | 3. Describe what job-site safety means. |
| ☐ | ☐ | ☐ | ☐ | 4. Explain the appropriate safety precautions around common job-site hazards. |
| ☐ | ☐ | ☐ | ☐ | 5. Demonstrate the use and care of appropriate personal protective equipment. |
| ☐ | ☐ | ☐ | ☐ | 6. Follow safe procedures for lifting heavy objects. |
| ☐ | ☐ | ☐ | ☐ | 7. Describe safe behavior on and around ladders and scaffolds. |
| ☐ | ☐ | ☐ | ☐ | 8. Explain the importance of the HazCom (Hazard Communication Standard) requirement and MSDs (Material Safety Data Sheets). |
| ☐ | ☐ | ☐ | ☐ | 9. Describe fire prevention and fire fighting techniques. |
| ☐ | ☐ | ☐ | ☐ | 10. Define safe work procedures around electrical hazards. |
| ☐ | ☐ | ☐ | ☐ | 11. Complete 10-hour OSHA course/assessment and receive card. (SDE Requirement) |

MODULE B:**BASIC MATH**

3 2 1 N

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|--------------------------|--------------------------|--------------------------|--------------------------|---|
| ☐ | ☐ | ☐ | ☐ | 1. Add, subtract, multiply, and divide whole numbers, with and without a calculator. |
| ☐ | ☐ | ☐ | ☐ | 2. Use a standard ruler and a metric ruler to measure. |
| ☐ | ☐ | ☐ | ☐ | 3. Add, subtract, multiply, and divide fractions. |
| ☐ | ☐ | ☐ | ☐ | 4. Add, subtract, multiply, and divide decimals, with and without a calculator. |
| ☐ | ☐ | ☐ | ☐ | 5. Convert decimals to percents and percents to decimals. |
| ☐ | ☐ | ☐ | ☐ | 6. Convert fractions to decimals and decimals to fractions. |
| ☐ | ☐ | ☐ | ☐ | 7. Explain what the metric system is and how it is important in the construction trade. |
| ☐ | ☐ | ☐ | ☐ | 8. Recognize and use metric units of length, weight, volume, and temperature. |
| ☐ | ☐ | ☐ | ☐ | 9. Recognize some of the basic shapes used in the construction industry and apply basic geometry to measure them. |

MODULE C:**INTRODUCTION TO HAND TOOLS**

3 2 1 N

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|--------------------------|--------------------------|--------------------------|--------------------------|--|
| ☐ | ☐ | ☐ | ☐ | 1. Recognize and identify some of the basic hand tools used in the construction trade. |
|--------------------------|--------------------------|--------------------------|--------------------------|--|

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|--------------------------|--------------------------|--------------------------|--------------------------|--|
| ☐ | ☐ | ☐ | ☐ | 2. Use these tools safely. |
| ☐ | ☐ | ☐ | ☐ | 3. Describe the basic procedures for taking care of these tools. |

MODULE D:**INTRODUCTION TO POWER TOOLS**

3 2 1 N

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|--------------------------|--------------------------|--------------------------|--------------------------|--|
| ☐ | ☐ | ☐ | ☐ | 1. Identify commonly used power tools of the construction trade. |
| ☐ | ☐ | ☐ | ☐ | 2. Use power tools safely. |
| ☐ | ☐ | ☐ | ☐ | 3. Explain how to maintain power tools properly. |

MODULE E:**INTRODUCTION TO BLUEPRINTS**

3 2 1 N

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|---|
| ☐ | ☐ | ☐ | ☐ | 1. Recognize and identify basic blueprint terms, components, and symbols. |
| ☐ | ☐ | ☐ | ☐ | 2. Relate information on blueprints to actual locations on the print. |
| ☐ | ☐ | ☐ | ☐ | 3. Recognize different classifications of drawings. |
| ☐ | ☐ | ☐ | ☐ | 4. Interpret and use drawing dimensions. |

MODULE F:**BASIC RIGGING (Optional)**

3 2 1 N

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|---|
| ☐ | ☐ | ☐ | ☐ | 1. Explain how ropes, chains, hoists, loaders, and cranes are used to move material and equipment from one location to another on a job site. |
| ☐ | ☐ | ☐ | ☐ | 2. Describe inspection techniques and load-handling safety practices. |

- — — — 3. Explain the American National Standards Institute (ANSI) hand signals.

MODULE G: BASIC COMMUNICATION SKILLS
(SDE Requirement)

- 3 2 1 N
— — — — 1. Explain techniques for communicating effectively with coworkers and supervisors.
— — — — 2. Demonstrate verbal and written communication skills necessary in the workplace.
— — — — 3. Demonstrate telephone and e-communication skills necessary in the workplace.

MODULE H: BASIC EMPLOYABILITY SKILLS
(SDE Requirement)

- 3 2 1 N
— — — — 1. Identify the roles of individuals and companies in the construction industry.
— — — — 2. Explain the importance critical thinking and problem solving skills in the workplace.
— — — — 3. Describe computer systems and their industry applications.
— — — — 4. Explain interpersonal relationship skills, self-presentation, and key workplace issues such as sexual harassment, stress, and substance abuse.

ELECTRICITY 1, 2, 3, and 4

UNIT A: ELECTRICAL SAFETY

- 3 2 1 N
— — — — 1. Demonstrate safe working procedures in a construction environment.
— — — — 2. Explain the purpose of OSHA and how it promotes safety on the job.
— — — — 3. Identify electrical hazards and how to avoid or minimize them in the workplace.
— — — — 4. Explain safety issues concerning lockout/tagout procedures, personal protection using assured grounding and isolation programs, confined space entry, respiratory protection, and fall protection

systems.

UNIT B: HAND BENDING

- 3 2 1 N
— — — — 1. Identify the methods of hand bending conduit.
— — — — 2. Identify the various methods used to install conduit.
— — — — 3. Use math formulas to determine conduit bends.
— — — — 4. Make 90° bends, back-to-back bends, offsets, kicks, and saddle bends using a hand bender.
— — — — 5. Cut, ream, and thread conduit.

UNIT C: FASTENERS AND ANCHORS

- 3 2 1 N
— — — — 1. Identify and explain the use of threaded fasteners.
— — — — 2. Identify and explain the use of non-threaded fasteners.
— — — — 3. Identify and explain the use of anchors.
— — — — 4. Demonstrate the correct applications for fasteners and anchors.
— — — — 5. Install fasteners and anchors.

UNIT D: ELECTRICAL THEORY ONE

- 3 2 1 N
— — — — 1. Recognize what atoms are and how they are constructed.
— — — — 2. Define voltage and identify the ways in which it can be produced.
— — — — 3. Explain the difference between conductors and insulators.
— — — — 4. Define the units of measurement that are used to measure the properties of electricity.
— — — — 5. Explain how voltage, current, and resistance are related to each other.
— — — — 6. Using the formula for Ohm's Law, calculate an unknown value.
— — — — 7. Explain the different types of meters used to measure voltage, current, and resistance.
— — — — 8. Using the power formula, calculate the amount of power used by a circuit.

UNIT E: ELECTRICAL THEORY TWO

- 3 2 1 N
— — — — 1. Explain the basic characteristics of a series circuit.
— — — — 2. Explain the basic characteristics of a parallel circuit.
— — — — 3. Explain the basic characteristics of a series-parallel circuit.
— — — — 4. Calculate, using Kirchoff's Voltage Law, the voltage drop in series, parallel, and series-parallel circuits.
— — — — 5. Calculate, using Kirchoff's Current Law, the total current in parallel and series-parallel circuits.
— — — — 6. Find the total amount of resistance in a series circuit.
— — — — 7. Find the total amount of resistance in a parallel circuit.
— — — — 8. Find the total amount of resistance in a series-parallel circuit.

UNIT F: ELECTRICAL TEST EQUIPMENT

- 3 2 1 N
— — — — 1. Explain the operation of and describe the following pieces of test equipment:
Ammeter
Voltmeter
Ohmmeter
Volt-ohm-milliammeter (VOM)
Wattmeter
Megohmmeter
Frequency meter
Power factor meter
Continuity tester
Voltage tester
Recording instruments
Cable-length meters
— — — — 2. Explain how to read and convert from one scale to another using the above test equipment.
— — — — 3. Explain the importance of proper meter polarity.
— — — — 4. Define frequency and explain the use of a frequency meter.
— — — — 5. Explain the difference between digital and analog meters.

UNIT G: INTRODUCTION TO THE NATIONAL ELECTRICAL CODE®

- 3 2 1 N
— — — — 1. Explain the purpose and history of

- — — — 2. Describe the layout of the NEC®.
- — — — 3. Explain how to navigate the NEC®.
- — — — 4. Describe the purpose of the National Electrical Manufacturers' Association (NEMA) and the National Fire Protection Association (NFPA).
- — — — 5. Explain the role of testing laboratories.

UNIT H: RACEWAYS, BOXES, AND FITTINGS

- | 3 | 2 | 1 | N | |
|---|---|---|---|--|
| — | — | — | — | 1. Describe various types of cable trays and raceways. |
| — | — | — | — | 2. Identify and select various types and sizes of raceways. |
| — | — | — | — | 3. Identify and select various types and sizes of cable trays. |
| — | — | — | — | 4. Identify and select various types of raceway fittings. |
| — | — | — | — | 5. identify various methods used to install raceways. |
| — | — | — | — | 6. Demonstrate knowledge of NEC® raceway requirements. |
| — | — | — | — | 7. Describe procedures for installing raceways and boxes on masonry surfaces. |
| — | — | — | — | 8. Describe procedures for installing raceways and boxes on concrete surfaces. |
| — | — | — | — | 9. Describe procedures for installing raceways and boxes in a metal stud environment. |
| — | — | — | — | 10. Describe procedures for installing raceways and boxes in a wood frame environment. |
| — | — | — | — | 11. Describe procedures for installing raceways and boxes on drywall surfaces. |
| — | — | — | — | 12. Recognize safety precautions that must be followed when working with boxes and raceways. |

UNIT I: CONDUCTORS

- | | | | | |
|---|---|---|---|---|
| 3 | 2 | 1 | N | |
| — | — | — | — | 1. Explain the various sizes and gauges of wire in accordance with American Wire Gauge standards. |
| — | — | — | — | 2. Identify insulation and jacket types according to conditions and applications. |

3. Describe voltage ratings of conductors and cables.
4. Read and identify markings on conductors and cables.
5. Use the tables in the NEC® to determine the ampacity of a conductor.
6. State the purpose of stranded wire.
7. State the purpose of compressed conductors.
8. Describe the different materials from which conductors are made.
9. Describe the different types of conductor insulation.
10. Describe the color coding of insulation.
11. Describe instrumentation control wiring.
12. Describe the equipment required for pulling wire through conduit.
13. Describe the procedure for pulling wire through conduit.
14. Install conductors in conduit.
15. Pull conductors in a conduit system.

UNIT J: INTRODUCTION TO ELECTRICAL BLUEPRINTS

- | 3 | 2 | 1 | N | |
|---|---|---|---|---|
| — | — | — | — | 1. Explain the basic layout of a blueprint. |
| — | — | — | — | 2. Describe the information included in the title block of a blueprint. |
| — | — | — | — | 3. Identify the types of lines used on blueprints. |
| — | — | — | — | 4. Identify common symbols used on blueprints. |
| — | — | — | — | 5. Understand the use of architect's and engineer's scales. |
| — | — | — | — | 6. Interpret electrical drawings, including site plans, floor plans, and detail drawings. |
| — | — | — | — | 7. Read equipment schedules found on electrical blueprints. |
| — | — | — | — | 8. Describe the type of information included in electrical specifications. |

UNIT K: WIRING: COMMERCIAL AND INDUSTRIAL

- | 3 | 2 | 1 | N | |
|---|---|---|---|---|
| — | — | — | — | 1. Identify and state the functions and ratings of single-pole, double-pole, three-way, four-way, dimmer, special, and safety switches. |
| — | — | — | — | 2. Explain NEMA classifications as |

- they relate to switches and enclosures.
3. Explain the NEC® requirements concerning wiring devices.
 4. Identify and state the functions and ratings of straight blade, twist lock, and pin and sleeve receptacles.
 5. Identify and define receptacle terminals and disconnects.
 6. Identify and define ground fault circuit interrupters.
 7. Explain the box mounting requirements in the NEC®.
 8. Use a wire stripper to strip insulation from a wire.
 9. Use a solderless connector to splice wires together.
 10. Identify and state the functions of limit switches and relays.
 11. Identify and state the function of switchgear.

UNIT L: WIRING: RESIDENTIAL

- | 3 | 2 | 1 | N | |
|---|---|---|---|---|
| — | — | — | — | 1. Describe how to determine electric service requirements for dwellings. |
| — | — | — | — | 2. Explain the grounding requirements of a residential electric service. |
| — | — | — | — | 3. Calculate and select service-entrance equipment. |
| — | — | — | — | 4. Select the proper wiring methods for various types of residences. |
| — | — | — | — | 5. Explain the role of the NEC® in residential wiring. |
| 3 | — | — | — | 6. Compute branch circuit loads and explain their installation requirements. |
| — | — | — | — | 7. Explain the types and purposes of equipment grounding conductors. |
| — | — | — | — | 8. Explain the purpose of ground fault circuit interrupters and tell where they must be installed. |
| — | — | — | — | 9. Size outlet boxes and select the proper type for different wiring methods. |
| — | — | — | — | 10. Describe rules for installing electric space heating and HVAC equipment. |
| — | — | — | — | 11. Describe the installation rules for electrical systems around swimming pools, spas, and hot tubs. |
| — | — | — | — | 12. Explain how wiring devices are selected and installed. |
| — | — | — | — | 13. Describe the installation and control |

of lighting fixtures.

ELECTRICITY – ADVANCED

For schools with more classroom instructional hours, choose from the list of advanced standards for your second and third year students. The first priority in adding standards would be to include industrial motor controls to your customized list.

ADVANCED UNIT A: ALTERNATING CURRENT

3 2 1 N

- | | | |
|---------|-----|--|
| — — — — | 1. | Calculate the peak and effective voltage or current values for an AC waveform. |
| — — — — | 2. | Calculate the phase relationship between two AC waveforms. |
| — — — — | 3. | Describe the voltage and current phase relationship in a resistive AC circuit. |
| — — — — | 4. | Describe the voltage and current transients that occur in an inductive circuit. |
| — — — — | 5. | Define inductive reactance and state how it is affected by frequency. |
| — — — — | 6. | Describe the voltage and current transients that occur in a capacitive circuit. |
| — — — — | 7. | Define capacitive reactance and state how it is affected by frequency. |
| — — — — | 8. | Explain the relationship between voltage and current in the following types of AC circuits:
RL circuit
RC circuit
LC circuit
RLC circuit |
| — — — — | 9. | Describe the effect that resonant frequency has on impedance and current flow in a series or parallel resonant circuit. |
| — — — — | 10. | Define bandwidth and describe how it is affected by resistance in a series or parallel resonant circuit. |
| — — — — | 11. | Explain the following terms as they relate to AC circuits:
True power
Apparent power
Reactive power
Power factor |
| — — — — | 12. | Explain basic transformer action. |

ADVANCED UNIT B: MOTORS: THEORY AND APPLICATION

3 2 1 N

- | | | |
|---------|-----|---|
| — — — — | 1. | Define the following terms:
Ampacity
Branch circuit
Circuit breaker
Controller
Duty
Equipment
Full-load amps
Ground fault circuit interrupter
Interrupting rating
Motor circuit switch
NEMA design letter
Nonautomatic
Overcurrent
Overload
Power factor
Rated full-load speed
Rated horsepower
Remote control circuit
Thermal cutout
Thermal protector
Service factor |
| — — — — | 2. | Describe the various types of motor enclosures. |
| — — — — | 3. | Describe how the rated voltage of a motor differs from the system voltage. |
| — — — — | 4. | Describe the basic construction and components of a three-phase squirrel cage induction motor. |
| — — — — | 5. | Explain the relationships among speed, frequency, and the number of poles in a three-phase induction motor. |
| — — — — | 6. | Describe how torque is developed in an induction motor. |
| — — — — | 7. | Explain how and why torque varies with rotor reactance and slip. |
| — — — — | 8. | Define percent slip and speed regulation. |
| — — — — | 9. | Explain how the direction of a three-phase motor is reversed. |
| — — — — | 10. | Describe the component parts and operating characteristics of a three-phase wound-rotor induction motor. |
| — — — — | 11. | Describe the component parts and operating characteristics of a three-phase synchronous motor. |
| — — — — | 12. | Define torque, starting current, and armature reaction as they apply to DC motors. |

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|---------|-----|--|
| — — — — | 13. | Explain how the direction of rotation of a DC motor is changed. |
| — — — — | 14. | Describe the design and characteristics of a DC shunt, series, and compound motor. |
| — — — — | 15. | Describe dual-voltage motors and their applications. |
| — — — — | 16. | Describe the methods for determining various motor connections. |
| — — — — | 17. | Describe general motor protection requirements as delineated in the NEC®. |

ADVANCED UNIT C: GROUNDING

3 2 1 N

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|---------|-----|--|
| — — — — | 1. | Explain the purpose of grounding and the scope of NEC Article 250. |
| — — — — | 2. | Distinguish between a short circuit and a ground fault. |
| — — — — | 3. | Define the NEC® ground-related terms. |
| — — — — | 4. | Distinguish between system grounding and equipment grounding. |
| — — — — | 5. | Use NEC Table 250.66 to size the grounding electrode conductor for various AC systems. |
| — — — — | 6. | Explain the NEC® requirements for the installation and physical protection of grounding electrode conductors. |
| — — — — | 7. | Explain the function of the grounding electrode system and determine which grounding electrodes must be used. |
| — — — — | 8. | Define electrodes and explain the resistance requirements for electrodes using NEC Section 250.56. |
| — — — — | 9. | Use NEC Table 250.122 to size the equipment grounding conductor for raceways and equipment. |
| — — — — | 10. | Explain the function of the main bonding jumper in the grounding system and size the main bonding jumper for various applications. |
| — — — — | 11. | Size the main bonding jumper for a service utilizing multiple service disconnecting means. |
| — — — — | 12. | Explain the NEC® requirements for bonding of enclosures and equipment. |
| — — — — | 13. | Explain the NEC® requirements for |

- — — — grounding of enclosures and equipment.
- — — — 14. Explain effectively grounded and its importance in clearing ground faults and short circuits.
- — — — 15. Explain the purposes of the grounded conductor (neutral) in the operation of overcurrent devices.
- — — — 16. Explain the NEC® requirements for grounding separately-derived systems, including transformers and generators.
- — — — 17. Explain the NEC® requirements for grounding at more than one building.
- — — — 18. Explain the NEC® grounding requirements for systems over 600 volts.

ADVANCED UNIT D: CONDUIT BENDING

- 3 2 1 N
- — — — 1. Describe the process of conduit bending using power tools.
- — — — 2. Identify all parts of popular electric and hydraulic benders.
- — — — 3. Avoid excessive waste when working with conduit systems.
- — — — 4. Bend offsets, kicks, saddles, segmented, and parallel bends.
- — — — 5. Explain the requirements of the NEC® for bending conduit.
- — — — 6. Compute the radius, degrees in bend, developed length, and gain for conduit up to six inches.
- — — — 7. Explain how to correct damaged conduit and modify existing bends.

ADVANCED UNIT E: BOXES AND FITTINGS

- — — — 1. Describe the different types of nonmetallic and metallic boxes.
- — — — 2. Understand the NEC® requirements for box fill.
- — — — 3. Calculate the required box size for any number and size of conductors.
- — — — 4. Explain the NEC® regulations for volume required per conductor in outlet boxes.
- — — — 5. Properly locate, install, and support boxes of all types.
- — — — 6. Describe the NEC® regulations governing pull and junction boxes.
- — — — 7. Explain the radius rule when installing conductors in pull boxes.

- — — — 8. Understand the NEC® requirements for boxes supporting lighting fixtures.
- — — — 9. Describe the purpose of conduit bodies and Type FS boxes.
- — — — 10. Install the different types of fittings used in conjunction with boxes.
- — — — 11. Describe the installation rules for installing boxes and fittings in hazardous areas.
- — — — 12. Explain how boxes and fittings are selected and installed.
- — — — 13. Describe the various types of box supports.

ADVANCED UNIT F: CONDUCTOR INSTALLATIONS

- 3 2 1 N
- — — — 1. Describe the various methods of installing conductors in conduit.
- — — — 2. Plan and set up for a cable pull.
- — — — 3. Understand the importance of selecting the proper location for cable pulls.
- — — — 4. Describe how cable reels are transported to the pulling site.
- — — — 5. Set up reel stands and spindles for a wire-pulling installation.
- — — — 6. Explain how mandrels, swabs, and brushes are used to prepare conduit for conductors.
- — — — 7. Properly install a pull line for a cable-pulling operation.
- — — — 8. Explain the operation of power fish tape systems.
- — — — 9. Prepare the ends of conductors for pulling.
- — — — 10. Describe the types of cable pullers.
- — — — 11. Describe the process of high-force cable pulling.
- — — — 12. Explain how to support conductors in vertical conduit runs.
- — — — 13. Describe the installation of cables in cable trays.
- — — — 14. Explain the importance of communication during a cable-pulling operation.
- — — — 15. Calculate the probable stress or tension in cable pulls.

ADVANCED UNIT G: CABLE TRAY

- 3 2 1 N
- — — — 1. Describe the components that make up a cable tray assembly
- — — — 2. Explain the methods used to hang

- — — — and secure cable tray.
- — — — 3. Describe how cable enters and exits cable tray.
- — — — 4. Select the proper cable tray fitting for the situation.
- — — — 5. Explain the NEMA standards for cable tray installations.
- — — — 6. Explain the NEC® requirements for cable tray installations.
- — — — 7. Select the required fittings to ensure equipment grounding continuity in cable tray systems.
- — — — 8. Interpret electrical working drawings showing cable tray fittings.
- — — — 9. Size cable tray for the number and type of conductors contained in the system.
- — — — 10. Select rollers and sheaves for pulling cable in specific cable tray situations.
- — — — 11. Designate the required locations of rollers and sheaves for a specific cable pull.

ADVANCED UNIT H: CONDUCTOR TERMINATIONS AND SPLICES

- 3 2 1 N
- — — — 1. Describe how to make a good conductor termination.
- — — — 2. Prepare cable ends for terminations and splices.
- — — — 3. Install lugs and connectors onto conductors.
- — — — 4. Train cable at termination points.
- — — — 5. Explain the role of the NEC® in making cable terminations and splices.
- — — — 6. Explain why mechanical stress should be avoided at cable termination points.
- — — — 7. Describe the importance of using proper bolt torque when bolting lugs onto busbars.
- — — — 8. Describe crimping techniques.
- — — — 9. Select the proper lug or connector for the job.
- — — — 10. Describe splicing techniques.
- — — — 11. Explain how to use hand and power crimping tools.

ADVANCED UNIT I: INSTALLATION OF ELECTRIC SERVICES

3 2 1 N

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|---------|-----|---|
| — — — — | 1. | Describe various types of electric services for commercial and industrial installations. |
| — — — — | 2. | Read electrical blueprints and diagrams describing service installations. |
| — — — — | 3. | Calculate and select service-entrance equipment. |
| — — — — | 4. | Explain the role of the NEC® in service installations. |
| — — — — | 5. | Install main disconnect switches, panelboards, and overcurrent protection devices. |
| — — — — | 6. | Identify the circuit loads, number of circuits required, and installation requirements for distribution panels. |
| — — — — | 7. | Explain the types and purposes of service grounding. |
| — — — — | 8. | Explain the purpose and required location(s) of ground fault circuit interrupters |
| — — — — | 9. | Describe single-phase service connections. |
| — — — — | 10. | Describe both wye- and delta-connected three-phase services. |

ADVANCED UNIT J: CIRCUIT BREAKERS AND FUSES

3 2 1 N

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|---------|----|---|
| — — — — | 1. | Explain the necessity of overcurrent protection devices in electrical circuits. |
| — — — — | 2. | Define the terms associated with fuses and circuit breakers. |
| — — — — | 3. | Describe the operation of a circuit breaker. |
| — — — — | 4. | Select the most suitable overcurrent device for the application. |
| — — — — | 5. | Explain the role of the NEC® in specifying overcurrent devices. |
| — — — — | 6. | Describe the operation of single-element and time-delay fuses. |
| — — — — | 7. | Explain how ground fault circuit interrupters (GFCIs) can save lives. |
| — — — — | 8. | Calculate short circuit currents. |
| — — — — | 9. | Describe troubleshooting and maintenance techniques for overcurrent devices. |

ADVANCED UNIT K: CONTACTORS AND RELAYS

3 2 1 N

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|---------|-----|--|
| — — — — | 1. | Describe the operating principles of contactors and relays. |
| — — — — | 2. | Select contactors and relays for use in specific electrical systems. |
| — — — — | 3. | Explain how mechanical contactors operate. |
| — — — — | 4. | Explain how solid-state contactors operate. |
| — — — — | 5. | Install contactors and relays according to the NEC® requirements. |
| — — — — | 6. | Select and install contactors and relays for lighting control. |
| — — — — | 7. | Read wiring diagrams involving contactors and relays. |
| — — — — | 8. | Describe how overload relays operate. |
| — — — — | 9. | Connect a simple control circuit. |
| — — — — | 10. | Test control circuits |

ADVANCED UNIT L: ELECTRIC LIGHTING

3 2 1 N

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| — — — — | 1. | Explain how the human eye works. |
| — — — — | 2. | Describe the characteristics of light. |
| — — — — | 3. | Recognize the different kinds of lamps and explain the advantages and disadvantages of each type:
Incandescent
Halogen
Fluorescent
High-intensity discharge (HID) |
| — — — — | 4. | Properly select and install lamps into lighting fixtures. |
| — — — — | 5. | Recognize and install various types of lighting fixtures:
Surface-mounted
Recessed
Suspended
Track-mounted |

ADVANCED UNIT M: LOAD CALCULATORS-BRANCH AND FEEDER CIRCUITS

3 2 1 N

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| — — — — | 1. | Calculate loads for single-phase and three-phase branch circuits. |
| — — — — | 2. | Size branch circuit overcurrent protection devices (circuit breakers and fuses) for noncontinuous duty and continuous duty circuits. |

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|---------|----|---|
| — — — — | 3. | Apply derating factors to size branch circuits. |
| — — — — | 4. | Calculate ampacity for single-phase and three-phase loads. |
| — — — — | 5. | Use load calculations to determine branch circuit conductor sizes. |
| — — — — | 6. | Use NEC Table 220.55 to calculate residential cooking equipment loads. |
| — — — — | 7. | Select branch circuit conductors and overcurrent protection devices for electric heat, air conditioning equipment, motors, and welders. |

ADVANCED UNIT N: CONDUCTOR SELECTION AND CALCULATIONS FITTING FILL REQUIREMENTS

3 2 1 N

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|---------|----|---|
| — — — — | 1. | Select electrical conductors for specific applications. |
| — — — — | 2. | Calculate voltage drop in both single-phase and three-phase applications. |
| — — — — | 3. | Apply NEC® regulations governing conductors to a specific application. |
| — — — — | 4. | Calculate and apply NEC® tap rules to a specific application. |
| — — — — | 5. | Size conductors for the load. |
| — — — — | 6. | Derate conductors for fill, temperature, and voltage drop. |
| — — — — | 7. | Select conductors for various temperature ranges and atmospheres. |

ADVANCED UNIT O: OVERCURRENT PROTECTION FITTING FILL REQUIREMENTS

3 2 1 N

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| — — — — | 1. | Apply the key NEC® requirements regarding overcurrent protection. |
| — — — — | 2. | Check specific applications for conformance to NEC® sections that cover short circuit current, fault currents, interrupting ratings, and other sections relating to overcurrent protection. |
| — — — — | 3. | Determine let-through current values (peak and rms) when current-limiting overcurrent devices are used. |
| — — — — | 4. | Select and size overcurrent. |

ADVANCED UNIT P: RACEWAY, BOX, AND FITTING FILL REQUIREMENTS

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1. Size raceways according to conductor fill and NEC installation requirements.
 2. Size outlet boxes according to NEC® installation requirements.
 3. Size and select pull and junction boxes according to NEC® installation requirements.
 4. Calculate conduit fill using a percentage of the trade size conduit inside diameter (ID).
 5. Calculate the required bending radius in boxes and cabinets.

ADVANCED UNIT Q: WIRING DEVICES

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1. Select wiring devices according to the National Electrical Manufacturers' Association (NEMA) classifications.
 2. Size wiring devices in accordance with NEC® requirements.
 3. Discuss the NEMA enclosure classifications.
 4. Follow NEC® regulations governing the installation of wiring devices.
 5. Explain the types and purposes of grounding wiring devices.
 6. Determine the maximum load allowed on specific wiring devices.

ADVANCED UNIT R: DISTRIBUTION EQUIPMENT

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1. Describe the purpose of switchgear.
 2. Describe the four general classifications of circuit breakers and list the major circuit breaker ratings.
 3. Describe switchgear construction, metering layouts, wiring requirements, and maintenance.
 4. List NEC® requirements pertaining to switchgear.
 5. Describe the visual and mechanical inspections and electrical tests associated with low-voltage and medium-voltage cables, metal-enclosed busways, and metering and instrumentation.

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6. Describe a ground fault relay system and explain how to test it.

ADVANCED UNIT S: DISTRIBUTION SYSTEM TRANSFORMERS

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1. Describe transformer operation.
 2. Explain the principle of mutual induction.
 3. Describe the operating characteristics of various types of transformers.
 4. Connect a multi-tap transformer for the required secondary voltage.
 5. Explain NEC® requirements governing the installation of transformers.
 6. Compute transformer sizes for various applications.
 7. Explain types and purposes of grounding transformers.
 8. Connect a control transformer for a given application.
 9. Size the maximum load allowed on open delta systems.
 10. Describe how current transformers are used in conjunction with watt-hour meters.
 11. Apply capacitors and rectifiers to practical applications.
 12. Calculate the power factor of any given electrical circuit.

ADVANCED UNIT T: LAMPS, BALLASTS, AND COMPONENTS

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1. Recognize incandescent, fluorescent, and high-intensity discharge (HID) lamps and describe how each type of lamp operates.
 2. Recognize ballasts and describe their purpose for use in fluorescent and HID lighting fixtures.
 3. Explain the relationship of Kelvin temperature to the color of light produced by a lamp.
 4. Recognize basic occupancy sensors, photoelectric sensors, and timers used to control lighting circuits and describe how each device operates.
 5. Use troubleshooting checklists to troubleshoot fluorescent and HID lamps and lighting fixtures.

ADVANCED UNIT U: MOTOR CALCULATIONS

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1. Size branch circuits and feeders for electric motors.
 2. Size and select overcurrent protective devices for motors.
 3. Size and select overload relays for electric motors.
 4. Size and select devices to improve the power factor at motor locations.
 5. Size motor short circuit protectors.
 6. Size multi-motor branch circuits.
 7. Size motor disconnects.

ADVANCED UNIT V: MOTOR MAINTENANCE, PART ONE

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1. Properly store motors and generators.
 2. Test motors and generators.
 3. Make connections for specific types of motors and generators.
 4. Clean open-frame motors.
 5. Lubricate motors that require this type of maintenance.
 6. Collect and record motor data.
 7. Select tools for motor maintenance.
 8. Select instruments for motor testing.

ADVANCED UNIT W: MOTOR CONTROLS

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1. Identify contactors and relays both physically and schematically and describe their operating principles.
 2. Identify pilot devices both physically and schematically and describe their operating principles.
 3. Interpret motor control wiring, connection, and ladder diagrams.
 4. Select and size contactors and relays for use in specific electrical motor control systems.
 5. Select and size pilot devices for use in specific electrical motor control systems.
 6. Connect motor controllers for specific applications according to NEC® requirements.

ADVANCED UNIT X: HAZARDOUS LOCATIONS

3 2 1 N

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| — — — — | 1. | Define the various classifications of hazardous locations. |
| — — — — | 2. | Describe the wiring methods permitted for branch circuits and feeders in specific hazardous locations. |
| — — — — | 3. | Select seals and drains for specific hazardous locations. |
| — — — — | 4. | Select wiring methods for Class I, Class II, and Class III hazardous locations. |
| — — — — | 5. | Follow NEC® requirements for installing explosion proof fittings in specific hazardous locations. |

ADVANCED UNIT Y: LOAD CALCULATIONS – FEEDERS AND SERVICES

3 2 1 N

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| — — — — | 1. | Size feeders and services in accordance with NEC requirements. |
| — — — — | 2. | Calculate loads and ampacities for single-phase and three-phase feeders. |
| — — — — | 3. | Understand and apply derating factors to size feeders. |
| — — — — | 4. | Size feeder overcurrent protection devices (circuit breakers and fuses) for non-continuous duty and continuous duty loads. |
| — — — — | 5. | Understand and apply tap rules. |
| — — — — | 6. | Calculate loads for a retail store with a show window. |
| — — — — | 7. | Calculate loads for an office building. |
| — — — — | 8. | Calculate loads for both single-family and multi-family dwellings. |
| — — — — | 9. | Calculate loads for a restaurant. |
| — — — — | 10. | Calculate loads for hotels and motels. |
| — — — — | 11. | Calculate loads for schools and other institutional projects. |
| — — — — | 12. | Perform feeder and service calculations for farms. |
| — — — — | 13. | Calculate the power and supply feeders for marinas and boatyards. |
| — — — — | 14. | Calculate electric motor loads on feeders. |

ADVANCED UNIT Z: PRACTICAL APPLICATIONS OF LIGHTING

3 2 1 N

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| — — — — | 1. | Explain how the lighting terms lumen, candlepower, and footcandle relate to one another. |
| — — — — | 2. | Classify lighting fixtures by layout, location, fixture type, and type of service. |
| — — — — | 3. | Identify the basic design configurations of incandescent, fluorescent, and HID lighting fixtures and describe the general lighting pattern (direct, indirect, etc.) produced by each type. |
| — — — — | 4. | Identify the main lighting requirements associated with lighting systems used in selected applications such as office buildings, schools, theaters, etc. |
| — — — — | 5. | Identify the special wiring and dimming system components used with incandescent, fluorescent, and HID lighting systems. |
| — — — — | 6. | Use manufacturer's lighting fixture catalogs to select the appropriate lighting fixtures for specific lighting applications. |

ADVANCED UNIT AA: STANDBY AND EMERGENCY SYSTEMS

3 2 1 N

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| — — — — | 1. | Explain the basic differences between emergency systems, legally required standby systems, and optional standby systems. |
| — — — — | 2. | Describe the operating principles of an engine-driven standby AC generator. |
| — — — — | 3. | Describe the different types and characteristics of standby and emergency generators. |
| — — — — | 4. | Recognize and describe the operating principles of both automatic and manual transfer switches. |
| — — — — | 5. | Recognize the different types of storage batteries used in emergency and standby systems and explain how batteries charge and discharge. |
| — — — — | 6. | For selected types of batteries, describe their characteristics, applications, maintenance, and |

testing.

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| — — — — | 7. | Recognize double-conversion and single-conversion types of uninterruptible power supplies (UPSs) and describe how they operate. |
| — — — — | 8. | Describe the NEC® requirements that pertain to the installation of standby and emergency power systems. |

ADVANCED UNIT BB: BASIC ELECTRONIC THEORY

3 2 1 N

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| — — — — | 1. | Identify electronic system components. |
| — — — — | 2. | Describe the electrical characteristics of solid-state devices. |
| — — — — | 3. | Describe the basic materials that make up solid-state devices. |
| — — — — | 4. | Describe and identify the various types of transistors, and explain how they operate. |
| — — — — | 5. | Interpret electronic schematic diagrams. |
| — — — — | 6. | Describe and connect diodes. |
| — — — — | 7. | Describe and connect light-emitting diodes (LEDs). |
| — — — — | 8. | Describe and connect silicon-controlled rectifiers (SCRs). |
| — — — — | 9. | Identify the leads of various solid-state devices. |

ADVANCED UNIT CC: FIRE ALARM SYSTEMS

3 2 1 N

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| — — — — | 1. | Understand the unique terminology associated with fire alarm systems. |
| — — — — | 2. | Describe the relationship between fire alarm systems and life safety. |
| — — — — | 3. | Identify and explain the role that various codes and standards play in both commercial and residential fire alarm applications. |
| — — — — | 4. | Describe the characteristics and functions of various fire alarm system components. |
| — — — — | 5. | Explain and describe the different types of circuitry that connect fire alarm system components. |
| — — — — | 6. | Describe the theory behind conventional, addressable, and analog fire alarm systems and |

explain how these systems function.

ADVANCED UNIT DD: SPECIALTY TRANSFORMERS

3 2 1 N

- — — — 1. Identify power transformer connections.
- — — — 2. Identify specialty transformers.
- — — — 3. Size and select buck-and-boost transformers.
- — — — 4. Connect current and potential transformers.
- — — — 5. Calculate and install overcurrent protection for specialty transformers.
- — — — 6. Ground specialty transformers according to NEC® requirements.
- — — — 7. Size, install, and connect control, shielded, constant-current, and other specialty transformers.
- — — — 8. Check additive and subtractive polarities.
- — — — 9. Derate transformers to account for the effects of harmonics.

ADVANCED UNIT EE: ADVANCED MOTOR CONTROLS

3 2 1 N

- — — — 1. Select and install solid-state relays for specific applications in motor control circuits.
- — — — 2. Install non-programmable/programmable motor circuit protectors (solid-state overload relays) in accordance with the manufacturer's instructions.
- — — — 3. Select and install electromechanical and solid-state timing relays for specific applications in motor control circuits.
- — — — 4. Recognize the different types of reduced-voltage starting motor controllers and describe their operating principles.
- — — — 5. Connect and program adjustable frequency drives to control a motor in accordance with the manufacturer's instructions.
- — — — 6. Demonstrate and/or describe the special precautions used when handling and working with solid-state motor controls.
- — — — 7. Recognize common types of motor

braking and explain the operating principles of motor brakes.

- — — — 8. Perform preventive maintenance and troubleshooting tasks in motor control circuits.

ADVANCED UNIT FF: HVAC CONTROLS

3 2 1 N

- — — — 1. Identify the major mechanical components common to all HVAC systems.
- — — — 2. Explain the function of a thermostat in an HVAC system.
- — — — 3. Describe different types of thermostats and explain how they are used.
- — — — 4. Demonstrate the correct installation and adjustment of a thermostat using proper siting and wiring techniques.
- — — — 5. Explain the basic principles applicable to all control systems.
- — — — 6. Identify the various types of electromechanical and electronic HVAC controls, and explain their function and operation.
- — — — 7. State the NEC® requirements applicable to HVAC controls.

ADVANCED UNIT GG: HEAT TRACING AND FREEZE PROTECTION

3 2 1 N

- — — — 1. Identify and describe the purpose for electric heat tracing equipment used with pipelines and vessels.
- — — — 2. Select, size, and install electric heat tracing equipment on selected pipelines and vessels in accordance with the manufacturer's instructions and NEC® requirements.
- — — — 3. Identify and describe the purpose for electric heating equipment used with roof, gutter, and downspout e-icing systems.
- — — — 4. Select, size, and install selected roof, gutter, and downspout de-icing systems in accordance with the manufacturer's instructions and NEC® requirements.
- — — — 5. Identify and describe the purpose for electric heating equipment used with snow-melting and anti-icing systems.
- — — — 6. Select, size, and install selected snow melting and anti-icing systems

in accordance with the manufacturer's instructions and NEC® requirements.

- — — — 7. Identify and describe the purpose for electric heat tracing equipment used with domestic hot-water temperature maintenance systems.
- — — — 8. Select, size, and install selected electric heat traced domestic hot-water systems in accordance with the manufacturer's instructions and NEC® requirements.
- — — — 9. Identify and describe the purpose for electric floor heating/warming systems.
- — — — 10. Select, size, and install selected electric floor heating/warming systems in accordance with the manufacturer's instructions and NEC® requirements.

ADVANCED UNIT HH: MOTOR MAINTENANCE, PART TWO

3 2 1 N

- — — — 1. Test motor winding resistance.
- — — — 2. Select and use motor testing equipment.
- — — — 3. Clean and test open frame motors.
- — — — 4. Clean, dry, and test motors that have been subjected to water damage.
- — — — 5. Troubleshoot and repair electric motors.

ADVANCED UNIT II: HIGH VOLTAGE TERMINATIONS/SPLICES

3 2 1 N

- — — — 1. Select proper materials and tools for high-voltage terminations and splices
- — — — 2. Prepare high-voltage cable for terminations and splices.
- — — — 3. Complete cable assemblies with terminations and splices.
- — — — 4. Inspect and test high-voltage terminations and splices.