Mike Holt's

ELECTRICAL APPRENTICESHIP PROGRAM

Based on the 2026 NEC®

ABOUT MIKE HOLT ENTERPRISES

Mike's passion for the electrical industry and educating others on the *National Electrical Code* began in 1972 while studying for a local electrical exam. His inability to find material that was well-written or properly illustrated gave him the idea to start a school that would be devoted to electrical training.

In 1975 Mike Holt Enterprises was created with very clear principles of making electrical training more effective, and providing books that were straightforward and easy to understand. This desire to create books to help electricians pass exams grew into the nation's largest "electrical-only" publisher that specializes in books, videos, online training, school curriculum, and seminars—changing the way the *NEC* and electrical training is taught.

Forty years later, these standards continue to guide us. Our products are designed for student success:

- **Easy to Understand**. Our text simplifies difficult technical topics and includes clear, step-by-step, detailed explanations.
- **Visual**. We include full-color, detailed, instructional graphics that help students visualize what's being taught.
- **Effective**. Our instructor resources are designed to save teachers time and give them tools to be more successful in reaching their students.

Our primary goal as a company is to change the lives of electrical professionals through our products. We genuinely care about helping our instructors and schools prepare the next generation of electrical professionals with the skills and knowledge they need to succeed.

We're here to help you every step of the way and encourage you to contact us, so we can be a part of your success.

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ABOUT THIS LESSON PLAN

Mike Holt's Electrical Apprenticeship Program Based on the 2026 NEC® has been developed with the goal of providing the knowledge required to become a competent journeyman electrician. The training resources used throughout this program have been selected to provide the most comprehensive education possible. Supplemented with Mike's instructional support material (such as presentations, videos, and practice exams), the program is tailored to meet the needs of different types of learners.

THE SCOPE OF THIS LESSON PLAN

This program is organized into hourly study increments that are designed to deliver a logical flow of the material and adaptable to any personal or institutional calendar. Whether your course delivery is one, two, or even five days per week, this lesson plan can accommodate your schedule. From day one, and maintained throughout the program, strong emphasis is placed on safe work practices. In addition, the program covers the *National Electrical Code (NEC)* and Construction Safety (as prescribed by OSHA) in a manner relevant to today's apprentices, preparing them for their journeyman's exam and the jobsite.

Level 1 Level 1 begins with the study of OSHA's construction safety rules and introduces apprentices to the principles associated with electricity, electrical theory, and the basics of electrical systems. These basic fundamentals are necessary in understanding complex *NEC* requirements covered throughout the program. Digital multimeter principles will also be covered. Early on students will learn a bit about how to use the NEC and then be introduced to some of the fundamental requirements of the *National Electrical Code*.

Level 2 Level 2 continues the study of OSHA's construction safety rules and students will be introduced to some of the fundamental calculations used throughout the NEC. This level also focuses on the first three chapters of the *NEC*. Some equipment specific to alternating current will be introduced. Residential and commercial wiring methods and practices will also be covered in depth during Level 2.

Level 3 Level 3 covers additional OSHA construction safety rules, an in depth look at Article 250–Grounding and Bonding, and Chapter 4 of the *NEC* along with common industrial applications, methods, and requirements. While motors and motor controls are a major area of focus, hazardous locations, special applications, an extensive look at Solar PV and interconnected Power Systems is also included.

Level 4 Level 4 of the program covers advanced *Code* calculations in great detail and extensive journeyman/master electrician exam preparation and practice exams. Electrical estimating is covered as well as a review of electrical theory and motor controls. Additional OSHA construction safety rules will also be covered along with some career development in the form of leadership skills.

The anticipated hours of study for the 2026 Apprenticeship Program are as follows:

Level 1 156 hours

Level 2 156 hours

Level 3 156 hours

Level 4 156 hours

Total 624 total program hours

HOW TO USE THIS LESSON PLAN

These lesson plans take into account that not all students and institutions operate on the same calendar schedule. It is organized hour-by-hour and should be used as a guide for personal or class scheduling. This flexibility will successfully guide both classroom instructors and self-paced online learners through this course regardless of individual calendars. References to slide and video presentations for classroom instruction are included along with the references to online presentations in the online Capacitor®.

Each individual and each class is unique. As such, the flow of this course will vary accordingly. Some parts of this course will move more quickly than the time suggested, while other parts may require all of the time allotted. It's important to remember that this plan is flexible. Time overlap is expected and will balance out a student's learning pace to ensure that all course outcomes and objectives are met.

Note: Please make notes during the semester and provide us feedback in order to improve this schedule each year. Instructor-led course quizzes or assessments are at the instructor's discretion, or as mandated by individual institution requirements.

We all learn differently, and the same methods of presentation and study don't necessarily bring the same results for each student. Instructors should be aware of the differences in learning styles when presenting this material to the class. Some students learn better visually and need to see diagrams and illustrations; others learn better audibly such as lectures and class group discussions.

Hands-on learning is an important component of education, and most of it will be done on the jobsite rather than in the classroom. However, when it's feasible, bring equipment and material in to show the class. Just a little "show and tell" of components that your students haven't yet used, like motor control pushbuttons (start-stop-stations) or AFCI breakers, can help add understanding to a lesson. When possible, try to supplement classroom instruction with field trips to view live construction projects showcasing the material being studied.

We recommend the lesson material be presented in the form of lecture and include visual aids when possible. Slide and video presentations using a large screen can be very beneficial, but it's understood that this type of equipment isn't always available. In some cases, what is available may limit the presentation to the use of student textbooks and whiteboards.

Self-paced learners should be sure to take advantage of our online Capacitor® and make full use of all included presentations, videos, and extra links as part of their learning experience. These tools will enhance comprehension and reinforce retention of the material.

Instructors should involve the students as much as possible. An example is how you would handle the questions that are assigned in the books. After completing the questions, have the students take turns reading the question and their answers so they're involved in the process. Don't just read the answers to your students—and don't just post them. Do what you can to interact with your students in discussion and allow their input. Another example is to incorporate a discussion of what some students might already be doing in the field with the rest of the class.

Answer questions honestly, and don't be afraid to tell your students if you don't know an answer. Of course, do take time to look it up, and explain that you can't always know all the answers, but you're there to help them in the learning process. Make sure your students understand their responsibility in the learning process. They need to do their part by reading and studying the information in their textbooks and participating in discussions. Remind them that learning is a life-long process, and there are always new things to learn in the electrical field.

Instructors will be most successful if you remember that we all started not knowing what's involved in the electrical trade. Provide encouragement and reassurance while they strive to achieve their personal goals. Help them develop a respect for the electrical profession and a love for learning—essential to a successful career in our ever-changing industry. Self-paced learners should also maintain the same perspective and try not to let yourself feel overwhelmed. Keep focused on achieving your career goals and the rewards that follow!

LEVEL 1 OUTLINE

LEVEL 1 RESOURCES

Mike Holt's Apprenticeship Training Program is designed to use textbooks, slide presentations, videos, labs/activities, review questions, and exams designed to enhance learning, comprehension, and retention of the material presented.

Self-paced learners should be sure to take advantage of our online Capacitor® and make full use of all included presentations, videos, and extra links as part of their learning experience. These tools will enhance comprehension and reinforce retention of the material.

Videos

The instruction package includes videos that can be played along with the textbooks, or viewed in their entirety, to provide a practical viewpoint of the material covered. If something isn't understood or misinterpreted, stop, go back, and play that section again until the topic is clear.

Mike and a panel of industry experts are featured on these videos. They carefully examine the topics in a way that's both educational and entertaining. You'll hear stories, discussions, and opinions that aren't covered in the textbooks thereby making them an invaluable practical source of information.

Presentations

Included in this instruction package are presentations containing hundreds of slides that are synchronized with the textbooks. These presentations are sorted by individual article or unit resulting in much smaller, less cumbersome files and make it easier to follow along side by side with the textbook.

Labs/Activities/Worksheets

One of the most enjoyable parts of learning is "hands on" learning of mechanical parts such as meters, wire, magnets, coils, light bulbs, switches, fuses, circuit breakers, receptacles, GFCIs, AFCIs—basically anything that can be broken!

Include worksheets as handouts that give students repeated practice with calculations, including voltage drop, ampacity adjustment, temperature correction, range calculations, and similar tasks. This repetition is one of the most effective ways to embed the formulas, methods, and procedures into permanent memory.

We strongly suggest you find or create labs that match the topic being studied as a hands-on experience to help students understand the material being covered. Seeing a mechanical concept in action makes it easier to understand the lesson being taught.

NOTE: Check out https://www.electriclab.org/ for some lab ideas.

Assessments

Student assessments are an important aspect of the learning process. Studies have shown that regardless of the result, students who are required to mentally recall a subject upon review, are more likely to remember the content than those who didn't have this opportunity. Our program includes different options for assessment including textbook review questions and exams. Online quizzes and exams are available in the blended and online programs in our Capacitor® platform.

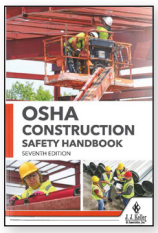
Textbook Questions. Our textbooks contain review questions and exams designed to reinforce the learning process when the online testing tools aren't used. We encourage you to have your students complete the textbook tests before taking the online tests to further reinforce their learning process.

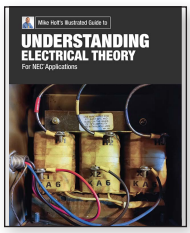
Online Testing. Our online testing program has been specifically designed to take advantage of today's blended or self-paced learning environments and reinforce the material that's been covered.

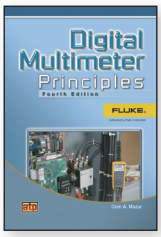
Books

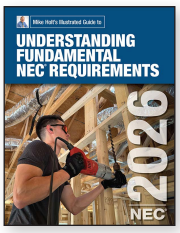
In Level 1, you'll be using the following books and we suggest you take a few moments to review the layout of each. Pay attention to the table of contents, the layout of the units and chapters, and the review questions.

- *OSHA Construction Safety Training Handbook, 7th Edition*
  J.J. Keller & Associates
  ISBN 979-8-88912-483-2, 2024
- *Mike Holt's Illustrated Guide to Understanding Electrical Theory for NEC Applications*
  Mike Holt Enterprises
  ISBN 978-1-950431-68-7, 2022
- *Digital Multimeter Principles, 4th Edition*
  American Technical Publishers
  ISBN 978-0-8269-1506-1, 2010
- *Mike Holt's Illustrated Guide to Understanding Fundamental NEC Requirements*
  Mike Holt Enterprises
  ISBN 978-1-960005-50-2, 2026



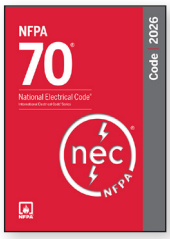






Suggested Additional Resources*

- *National Electrical Code, 2026 Edition*
  National Fire Protection Association
  ISBN 978-145593220-7, 2026



**Sold separately.*

LEVEL 1 LESSON PLANS—AT-A-GLANCE

Hours (Session)	Module I (Term 1)
1-3 (1)	Introduction | Orientation | Tools | Safety *Electrical hazards and safe working practices* OSHA Construction Safety *Electrical Safety and PPE*
4-6 (2)	OSHA Construction Safety Falls | Ladders and Stairs | Scaffolds
7-9 (3)	Electrical Theory—Units 1-2 *Atomic Structure, Electron Theory and Chemical Bonding*
10-12 (4)	Electrical Theory—Units 3-4 *Electrical Circuits and Power Sources, The Electrical System*
13-15 (5)	Electrical Theory—Units 5-6 *Uses and Dangers of Electricity*
16-18 (6)	Electrical Theory—Units 7-9 *Electromagnetism and Magnetism*
19-21 (7)	Digital Multimeter Principles *Chapters 1 through 4*
22-24 (8)	Digital Multimeter Principles *Chapters 5 through 9*
25-27 (9)	Digital Multimeter Principles *Chapter 10*
28-30 (10)	Digital Multimeter Principles *Review and Competency Test*
31-33 (11)	Lab/Activity/Worksheet *3-4-way switching*
34-36 (12)	Module Review
37-39 (13)	Module Quiz

Hours (Session)	Module II (Term 2)
40-42 (1)	Electrical Theory—Unit 10 *Basic Math*
43-45 (2)	Electrical Theory—Unit 11 *Trigonometry*
46-48 (3)	Electrical Theory—Units 12-13 *Ohm's Law, Watt's Law*
49-51 (4)	Electrical Theory—Units 14-15 *Series and Parallel Circuits*
52-54 (5)	Electrical Theory—Units 15-16 *Parallel and Series-Parallel Circuits*
55-57 (6)	Electrical Theory—Units 17-19 *AC Fundamentals, Inductance, Capacitance*
58-60 (7)	Electrical Theory—Unit 20 *True Power, Power Factor, and Apparent Power*
61-63 (8)	Electrical Theory—Unit 20 *True Power, Power Factor, and Apparent Power*
64-66 (9)	Electrical Theory—Unit 21 *Motors*
67-69 (10)	Electrical Theory—Units 22-23 *Generators–Relays*
70-72 (11)	Electrical theory—Unit 24 *Transformers*
73-75 (12)	Module Review
76-78 (13)	Module Quiz

Hours (Session)	Module III (Term 3)
79-81 (1)	Electrical Theory—Unit 25 *Overcurrent Protection*
82-84 (2)	Electrical Theory—Unit 26 *GFCIs, GFPEs, AFCIs, AND SPDs*
85-87 (3)	Electrical Theory—Unit 26 *GFCIs, GFPEs, AFCIs, AND SPDs*
88-90 (4)	Electrical Theory—Unit 27 *Wire Resistance and Voltage Drop*
91-93 (5)	Electrical Theory—Unit 28 *Multiwire Circuits*
94-96 (6)	Electrical Theory—Unit 29 *The Formula Wheel*
97-99 (7)	Electrical Theory—Review *All Theory Material*
100-102 (8)	Electrical Theory—Exam
103-105 (9)	Fundamental *NEC* Requirements *How to Use the NEC*
106-108 (10)	Fundamental *NEC* Requirements *Article 90*
109-111 (11)	Fundamental *NEC* Requirements *Article 110*
112-114 (12)	Module Review
115-117 (13)	Module Quiz

Hours (Session)	Module IV (Term 4)
118-120 (1)	Fundamental *NEC* Requirements *Articles 200, 210*
121-123 (2)	Fundamental *NEC* Requirements *Article 250*
124-126 (3)	Lab/Activity/Worksheet *Grounding Electrodes*
127-129 (4)	Fundamental *NEC* Requirements *Articles 300, 310*
130-132 (5)	Lab/Activity/Worksheet *Conductor Ampacity and Selection*
133-135 (6)	Fundamental NEC Requirements *Articles 312, 314*
136-138 (7)	Lab/Activity/Worksheet *Box Fill*
139-141 (8)	Fundamental *NEC* Requirements *Articles 320, 330, 334, 336, 338, 340*
142-144 (9)	Fundamental *NEC* Requirements *Articles 342, 344, 348, 350, 352, 358,*
145-147 (10)	Fundamental *NEC* Requirements *Articles 356, 362, 376, 380, 386, 392*
148-150 (11)	Fundamental *NEC* Requirements *Articles 404, 406, 408, 410, 422*
151-153 (12)	Level 1 Review
154-156 (13)	Level 1 Exam

LEVEL 1 OBJECTIVES

The primary goal of Level 1 is for students to possess the knowledge necessary to safely and proficiently perform the job duties and responsibilities expected of a first-year apprentice. They'll have built a foundation of knowledge about construction safety, electrical safety, and electrical theory that's necessary to understand the *National Electrical Code (NEC)*. They'll be introduced to the *Code* rules that are related to general wiring requirements, outlet box sizing, raceway sizing, and bonding and grounding. In addition, they'll learn how a multimeter is used in the field and receive a multimeter competency certification.

LEVEL 1—MODULE I (Hours 1–39)

At the completion of each section, students should be able to master the concepts as listed below:

OSHA—Construction Safety

NOTE: As you proceed through this program you'll find that safety related topics are presented in Module I of each Level of the program. Safety should be at the forefront of everything we do in the field BEFORE we do it!

- Identify the general hazards that may be present on a construction site.
- Demonstrate or describe the safe handling and use of ladders and scaffolding.
- List safety precautions necessary to prevent falls on a construction site.
- Identify the hazards specific to the installation, maintenance, and servicing of electrical equipment.
- Identify and describe the levels (Categories) of arc-flash hazards.
- Identify and apply the level of personal protective equipment (PPE) required for each Category of arc-flash hazard.

Understanding Electrical Theory—Units 1-9

Unit 1—Atomic Structure

- Describe the structure of an atom.
- Define the subatomic particles of an atom.
- Exhibit an understanding of positive and negative electrostatic charges of an atom.
- Identify some of the hazards of a high-voltage electrostatic discharge.
- Explain the cause and effect of a lightning strike.
- Describe what can be done to mitigate the effects of a lightning strike.
- Explain the intent of a lightning protection system.

Unit 2—Electron Theory and Chemical Bonding

- Exhibit an understanding of electron theory.
- Describe the relationship between electrons and protons.
- Explain what makes a good conductor and why.
- Explain how the negative charge of electron movement participates in the creation of electricity.
- Describe the differences between conductors, semiconductors, and insulators.
- Explain what chemical bonding is and how it can change the electrical characteristic of an atom.

Unit 3—Electrical Circuits and Power Sources

- Define what an electrical circuit is.
- Describe what components make up an electrical circuit.
- Explain the two theories of electron current flow.
- Describe the different types of power sources that force electrons to move.

Unit 4—The Electrical System

- Describe how electricity is generated at the utility generating plant.
- Explain step-up and step-down substation transmission and distribution voltages.
- Explain how electricity goes from utility distribution transformers to a customer's premises.

Unit 5—Uses of Electricity

- Describe how electricity is used for electro-plating.
- Describe the function of electromagnetism in motors, generators, relays, and transformers.
- Explain about (PV) photovoltaic systems.
- Explain how and why electricity produces heat.
- Describe the uses of different types of lighting systems.

Unit 6—Dangers of Electricity

- Explain the purpose of the *National Electrical Code*®.
- Describe how electrical fires are created.
- Describe electric shock and electrocution.
- Explain what arc flashes and arc blasts are.

Unit 7—Basics of Magnetism

- Describe the law of attraction and repulsion of magnets.
- Explain why some metals are easily magnetized and how to demagnetize metals.
- Describe the difference between permanent and temporary magnets.
- Illustrate the magnetic field around a magnet.

Unit 8—Electromagnetism

- Explain how electromagnetism in a wire is produced.
- Describe electromagnetic field intensity.
- Explain how an electromagnetic field is influenced by the shape of the wire.

Unit 9—Uses of Electromagnetism

- List some common uses of electromagnetism for motors, generators, relays, and transformers.

Digital Multimeter Principles

- Demonstrate the safe handling, storage, and use of a DMM (digital multimeter.)
- Define and explain the various displays, abbreviations, symbols, and terminology associated with a digital multimeter.
- Define and explain the application of the extended features of a typical digital multimeter.
- Demonstrate the proper settings and technique for measuring AC and DC voltages.
- Demonstrate the proper settings and technique for determining continuity, resistance, and AC and DC current.
- Apply Ohm's Law and power formulas to determine the missing variable when two of the formula values are known.
- Explain how changes in frequency affect the operation of electrical equipment.
- Explain how to determine frequency and duty cycle using a digital multimeter (DMM).
- Demonstrate a working knowledge of all aspects of a DMM.
- Satisfactorily complete the DMM competency test.

Module I—Exam

- Successfully pass the module quiz within the program completion requirements.

LEVEL 1—MODULE II (Hours 40-78)

At the completion of each section, students should be able to master the concepts as listed below:

Understanding Electrical Theory—Units 10-24

Unit 10—Basic Math

- Explain the difference between whole numbers and fractional numbers.
- Describe the various ways fractional numbers can be expressed.
- Demonstrate how to convert a percentage into a decimal to use as a multiplier.
- Explain the differences between a reciprocal, a square root, and squaring a number.

Unit 11—Trigonometry

- Describe what right triangles are.
- Explain what the Pythagorean Theorem is.
- Describe the terms sine, cosine, and tangent.

Unit 12—Ohm's Law

- Describe electromotive force, intensity, and resistance.
- Demonstrate what voltmeters, ammeters, and ohmmeters are used for.
- Demonstrate how to use the Ohm's Law formula.

Unit 13—Watt's Law

- Describe what Watt's Law is.
- Demonstrate how to use Watt's Law.
- Explain what a wattmeter is.

Unit 14—Series Circuits

- Explain the relationship between resistance, current, and voltage in series circuits.
- Describe how voltage is affected in a series-connected power supply.
- Explain what series circuits are and their practical uses in the electrical industry.
- Perform calculations involving series circuits.

Unit 15—Parallel Circuits

- Explain relationship between resistance, current, and voltage in parallel circuits.
- Describe how voltage is affected in a parallel-connected power supply.
- Describe how parallel circuits are used for the electrical wiring of receptacles, lighting, appliances, and equipment.
- Perform calculations involving parallel circuits.
- Explain any advantages of parallel circuits and how they differ from series circuits.

Unit 16—Series-Parallel Circuits

- Describe a series-parallel circuit.
- Identify which portions of a circuit are in series and which portions are in parallel.
- Demonstrate how to calculate total circuit resistance for series-parallel circuits.

Unit 17—Alternating Current Fundamentals

- Explain the advantages (and disadvantages) of alternating current compared to direct current.
- Describe some of the uses for alternating current.
- Explain how alternating current is generated.

- Explain that a waveform is a mathematical representation on a graph that can be used to visualize the level and direction of current or voltage in a circuit.
- Describe the difference(s) between a "sinusoidal waveform" and a "nonsinusoidal waveform."
- Analyze an ac waveform.
- Explain the difference(s) between "leading" and "lagging" waveforms.
- Define the various values associated with an ac waveform.

Unit 18—Inductance

- Define self-inductance and mutual inductance.
- Explain the electrical characteristics of induction and how inductive reactance is calculated.
- Describe the relationship between induced voltage and current
- Describe the benefits of induction as it relates to electrical power.

Unit 19—Capacitance

- Explain that "capacitance" is the ability of a device to store and release electrical energy.
- Describe the purpose of a capacitor and the precautions that should be taken where they are used.
- Show common uses of capacitors
- Explain how capacitive reactance is calculated

Unit 20—True Power, Power Factor, and Apparent Power

- Explain the concept of "true power vs. "apparent power" and their units of measure.
- Correctly apply power factor formulas to determine "true power" and "apparent power."
- Describe the effects of power factor as it relates to the efficiency of electrical circuits.
- Explain how the efficiency rating of utilization equipment effects power factor.
- Outline how true power is determined and its effects on the cost of the electricity to operate the equipment.
- Describe how the effects of power factor can influence sizing transformers and or branch circuits.
- Identify and apply the formulas necessary to determine the power loss(es) and efficiency of utilization equipment.

Unit 21—Motors

- Explain the basics principles and theory behind how motors convert electrical energy into mechanical work.
- Describe the primary components of a motor and their function.
- Define how the output of a motor is rated.
- Calculate the output of a motor in the appropriate unit of measure.
- Explain how input power relates to output power of a motor.
- Describe motor current ratings.
- Calculate the full-load ampere rating of a given single- or three-phase motor.

- Explain the difference(s) between a motor's starting current versus its running current.
- Describe how motors are protected from overcurrent.
- Explain the difference(s) between "overload" protection of a motor and its short-circuit/ground-fault protection.

Unit 22—Generators

- Explain the basic concept and theory behind how a generator produces electricity.
- Describe the primary difference between a dc and an ac generator.
- Describe the differences between single- and three-phase generators.
- Explain how to calculate generator output volt-amperes and amperes.

Unit 23—Relays

- Describe how relays operate.
- Explain normally open (NO) and normally closed (NC) contacts.

Unit 24—Transformers

- Describe the benefits of transforming voltage and the theory by which this process occurs.
- Explain the difference(s) between the primary and secondary windings of a transformer.
- Apply the necessary formulas to predict the input and/or output voltages and currents of a transformer.
- Explain how true and apparent power relate to transformers.
- List various types of transformers and their applications.
- Describe how the efficiency rating of a transformer affects its output.
- Calculate and predict the output of a transformer based on its efficiency rating.
- Calculate the primary and/or secondary line current based on a set of known values.

Module II—Exam

- Successfully pass the module quiz within the program completion requirements.

LEVEL 1—MODULE III (Hours 79-117)

At the completion of each section, students should be able to master the concepts as listed below:

Understanding Electrical Theory—Units 25-29

Unit 25—Overcurrent Protection

- Explain the primary function of an overcurrent protective device.

- List and describe the conditions that will cause an overcurrent protection device to function.
- Describe the differences and similarities between a short-circuit and a ground-fault.
- Explain the concept of a "time-current curve".
- List the most common types of overcurrent protective devices.
- Describe the differences between overcurrent, overload, and fault current protection.
- Explain the concept of an improper neutral to case connection and its potential hazards.

Unit 26—GFCIs, GFPEs, AFCIs, AND SPDs

- Explain the importance of "ground-fault circuit interrupter" (GFCI) protection.
- Describe the condition(s) that will cause a GFCI device to function.
- Describe the importance of and how to confirm a GFCI device is properly functioning.
- Define the term "arc-fault" and describe a series-arc vs. a parallel-arc.
- Describe how an (AFCI) arc-fault circuit interrupter functions.
- Reference the *National Electrical Code* to identify the requirements for AFCI protection.
- Describe the difference between GFCI protection and (GFPE) ground-fault protection of equipment.
- Describe what a surge protection device (SPD) is.

Unit 27—Wire Resistance and Voltage Drop

- Describe what is included in direct-current wire resistance.
- Describe what is included in alternating-current wire resistance.
- Demonstrate how to calculate voltage drop in a wire using Ohm's Law.

Unit 28—Multiwire Circuits

- Describe the purpose of a "balanced" electrical system.
- Describe a multiwire branch circuit.
- Justify the advantages in the use of multiwire branch circuits.
- Evaluate the effects on the neutral conductor when employing multiwire branch circuits.
- Demonstrate and correctly calculate voltage drop for various multiwire branch circuits.
- Explain the hazards involved when using multiwire branch circuits and how they are to be avoided.
- Identify and apply the *NEC* requirements regarding the use of multiwire branch circuits.

Unit 29—The Formula Wheel

- Explain how The Formula combines both Ohm's and Watt's Laws.
- Explain the relationship between Ohm's Law and Watt's (Power) Law.
- Demonstrate how to perform calculations using the Formula Wheel.

Understanding Electrical Theory— Exam

- Review all Theory related material.
- Successfully pass the Electrical Theory Exam within the program completion requirements.

Fundamental *NEC* Requirements

Mike Holt's Illustrated Guide to Understanding Fundamental *NEC*® Requirements, based on the 2026 *NEC* is intended to provide students with an introduction to the *Code* rules they'll need in order to be an effective electrician. The majority of installations share a common set of *Code* rules and this material will introduce you to many of those.

How to Use the *National Electrical Code*

- Explain the layout and format the *NEC*.
- Describe the structural hierarchy of the *NEC*.
- Identify key words that identify mandatory and permissive rules.
- Explain "mandatory" versus "permissive" rules in the *NEC*.
- Identify "keywords" and phrases that may help to locate specific rules and requirements.
- Understand how *NEC* rules are interpreted and by whom.
- Describe how the *NEC* revision cycles occur and who can contribute to what is contained within.

Article 90—Introduction

- Explain the history of the *NEC*—when it was established and how it's updated.
- Understand the purpose of the *NEC*, practical safeguarding, adequacy, and intention.
- Describe the scope of the *NEC*, including what is and isn't covered.

Article 110—Requirements for Electrical Installations

- Explain how equipment is approved.
- Describe how to determine when or where equipment can be used.
- Describe how to arrange equipment so it is safe to operate and maintain.
- Describe how to identify the characteristics of the systems being installed so future alterations, service, or maintenance can be completed safely.
- Explain how electrical splices, connections, and terminations are made and why proper torquing is so crucial.
- Describe the rule pertaining to a lockable disconnecting means and why it is such a critical safety factor.
- Explain and understand spaces about electrical equipment.
- Discuss working depth in relation to voltage and conditions as shown in Table 110.26(A)(1) Working Space.

Module III—Exam

- Successfully pass the module quiz within the program completion requirements.

LEVEL 1—MODULE IV (Hours 118-156)

At the completion of each section, students should be able to master the concepts as listed below:

Fundamental *NEC* Requirements (cont)

Article 200—Use and Identification of Grounded [Neutral] Conductors

- Discuss and demonstrate proper methods of identification for grounded conductors.
- Describe the permitted uses of reidentifying the white or gray conductor in cables.

Article 210— Branch Circuits

- Describe the requirements for branch circuits and AFCI and GFCI protection.
- Explain receptacle and lighting outlet requirements.

Article 250—Grounding and Bonding

- Explain the differences between the grounding and bonding of electrical systems and equipment.
- Describe the grounding electrode system, permitted grounding electrodes, and grounding electrode installation methods.
- Explain the requirements for equipment grounding conductors, such as identification, receptacle bonding, and metal box bonding.

Article 300—General Requirements for Wiring Methods and Materials

- Explain the general rules for wiring methods and materials for power and lighting.
- Describe the installation methods of cables and raceways for protection against physical damage.
- Explain the requirements for underground installations, securing and supporting, and minimum conductor length at boxes.

Article 310—Conductors for General Wiring

- Describe the minimum conductor size and conductor material code requirements.
- Explain the requirements for connecting conductors in parallel and installation characteristics.

Article 312—Cabinets, Cutout Boxes, and Meter Socket Enclosures

- Describe the requirements for installing cabinets and meter enclosures in wet locations.

- Discuss the rules for the installation of cabinets and meter enclosures in non-combustible/combustible materials.
- Explain the rules on how to terminate cables into cabinets and meter enclosures.

Article 314—Outlet, Device, Pull, and Junction Boxes, Conduit Bodies, and Handhole Enclosures

- Describe the requirements for installing cabinets and meter enclosures in wet locations.
- Discuss how to size outlet and device boxes based on conductor volume fill.
- Explain the requirements for supporting and securing boxes.

Articles 320-340—Cable Types

- Describe the uses permitted and not permitted for various cable wiring methods.
- Explain the rules for exposed work and installation in accessible attic spaces.
- Describe the securing and supporting intervals or other requirement(s) for various cable wiring methods.

Articles 404-422—Switches, Wiring Devices, Panelboards, Luminaires, Appliances

- Explain how “general-use” switches (Article 404) differ from “general-use snap” switches (Article 406).
- Describe the basic requirements pertaining to general-use switches such as:
  - considerations for switch enclosures
  - locating in damp and/or wet locations
  - indicating “on” and “off”
  - accessibility and grouping of switches
- List the various devices included in Article 406–Wiring Devices.
- Describe the basic requirements for the use and installation of such devices.
- Define what is meant by the term “panelboard”. (Article 408)
- Describe various considerations pertaining to the installation of panelboards.
- Describe various consideration for the installation and locations for luminaires. (Article 410)
- Describe the various considerations regarding the installation of typical appliances. (Article 422)

Module IV—Exam

- Successfully pass the module quiz within the program completion requirements.

Level I—Exam

- Successfully pass the Level 1 Exam within the program completion requirements.

LEVEL 2 OUTLINE

LEVEL 2 RESOURCES

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Self-paced learners should be sure to take advantage of our online Capacitor® and make full use of all included presentations, videos, and extra links as part of their learning experience. These tools will enhance comprehension and reinforce retention of the material.

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Include calculation worksheets as handouts that give students repeated practice with critical calculations, including voltage drop, ampacity adjustment, temperature correction, range calculations, and similar tasks. This repetition is one of the most effective ways to embed the formulas, methods, and procedures into permanent memory.

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Online Testing. Our online testing program has been specifically designed to take advantage of today's blended or self-paced learning environments and reinforce the material that's been covered.

Books

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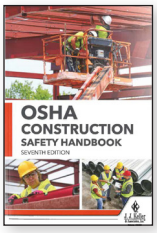
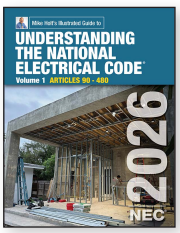
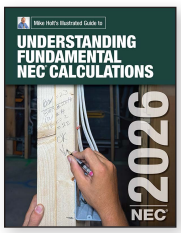
- *OSHA Construction Safety Training Handbook, 7th Edition*
  J.J. Keller & Associates
  ISBN 979-8-88912-483-2, 2024
- *Mike Holt's Understanding the National Electrical Code, Volume 1*
  Mike Holt Enterprises
  ISBN 978-1-950431-77-9, 2026
- *Mike Holt's Illustrated Guide to Fundamental NEC Calculations*
  Mike Holt Enterprises
  ISBN 978-1-960005-02-1, 2026

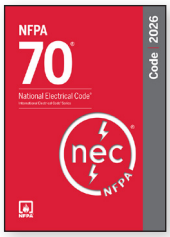






Suggested Additional Resources*

- *National Electrical Code, 2026 Edition*
  National Fire Protection Association
  ISBN 978-145593220-7, 2026



**Sold separately.*

LEVEL 2 LESSON PLANS—AT-A-GLANCE

Hours (Session)	Module I (Term 1)
1-3 (1)	**Introduction | Orientation | Tool Safety** *Level 2*
4-6 (2)	**OSHA Construction Safety** *Electrical Safety and PPE*
7-9 (3)	**OSHA Construction Safety** *Confined Space, Emergency Response, and Lockout/Tagout*
10-12 (4)	**Fundamental *NEC* Calculations** *NEC Chapters 1 and 2*
13-15 (5)	**Fundamental *NEC* Calculations** *NEC Chapters 2 and 3*
16-18 (6)	**Fundamental *NEC* Calculations** *NEC Chapters 4*
19-21 (7)	**Flex Training** *Institution/Instructor Choice*
22-24 (8)	***NEC*—Article 110** *Requirements for Electrical Installations 1*
25-27 (9)	***NEC*—Article 110** *Requirements for Electrical Installations 2*
28-30 (10)	***NEC*—Article 120** *Branch-Circuit, Feeder, and Service Load Calculations 1*
31-33 (11)	***NEC*—Article 120** *Branch-Circuit, Feeder, and Service Load Calculations 2*
34-36 (12)	**Module Review**
37-39 (13)	**Module Quiz**

Hours (Session)	Module II (Term 2)
40-42 (1)	***NEC*—Article 130** *Energy Management Systems*
43-45 (2)	***NEC*—Articles 200, 206** *Use and Identification of Grounded [Neutral] Conductors, Remote-Control and Signaling Circuits*
46-48 (3)	**Flex Training** *Institution/Instructor Choice*
49-51 (4)	***NEC*—Article 210** *Branch Circuits 1*
52-54 (5)	***NEC*—Article 210** *Branch Circuits 2*
55-57 (6)	***NEC*—Article 210** *Branch Circuits 3*
58-60 (7)	***NEC*—Article 215** *Feeders*
61-63 (8)	***NEC*—Article 225** *Outside Branch Circuits and Feeders*
64-66 (9)	***NEC*—Article 230** *Services 1*
67-69 (10)	***NEC*—Article 230** *Services 2*
70-72 (11)	**Flex Training** *Institution/Instructor Choice*
73-75 (12)	**Module Review**
76-78 (13)	**Module Quiz**

Hours (Session)	Module III (Term 3)
79-81 (1)	***NEC*—Article 240** *Overcurrent Protection 1*
82-84 (2)	***NEC*—Article 240** *Overcurrent Protection 2*
85-87 (3)	***NEC*—Article 242** *Overvoltage Protection (SPDs)*
88-90 (4)	***NEC*—Article 300** *General Requirements for Wiring Methods and Materials*
91-93 (5)	***NEC*—Article 300** *General Requirements for Wiring Methods and Materials*
94-96 (6)	***NEC*—Article 310** *Conductors for General Wiring*
97-99 (7)	**Lab/Activity/Worksheet** *Conductor Adjustment and Corrections*
100-102 (8)	***NEC*—Article 312** *Cabinets, Cutout Boxes, and Meter Socket Enclosures*
103-105 (9)	***NEC*—Article 314** *Boxes; Conduit Bodies; and Handhole Enclosures*
106-108 (10)	***NEC*—Article 314** *Boxes; Conduit Bodies; and Handhole Enclosures*
109-111 (11)	***NEC*—Articles 320 and 330** *Armored Cable (Type AC) and Metal-Clad Cable (Type MC)*
112-114 (12)	**Module Review**
115-117 (13)	**Module Quiz**

Hours (Session)	Module IV (Term 4)
118-120 (1)	***NEC*—Articles 334, 336** *Cable Types NM, TC*
121-123 (2)	***NEC*—Articles 338, 340** *Cable Types SE and USE, UF*
124-126 (3)	***NEC*—Articles 342, and 344** *Conduit Types, IMC and RMC*
127-129 (4)	***NEC*—Articles 348, 350, 352, 356** *Conduits Types FMC, LFMC, and LFNC*
130-132 (5)	**Lab/Activity/Worksheet** *Raceway Sizing Calculations*
133-135 (6)	***NEC*—Article 352** *PVC*
136-138 (7)	***NEC*—Article 358** *Electrical Metallic Tubing (EMT)*
139-141 (8)	**Lab/Activity/Worksheet** *Conduit Bending*
142-144 (9)	***NEC*—Articles 362 and 376** *Raceway Type ENT and Metal Wireways*
145-147 (10)	***NEC*—Articles 380, 386, and 392** *Multioutlet Assemblies, Surface Metal Raceways, and Cable Trays*
148-150 (11)	**Flex Training** *Institution/Instructor Choice*
151-153 (12)	**Level 2 Review**
154-156 (13)	**Level 2 Exam**

LEVEL 2 OBJECTIVES

Upon the completion of Level 2, students will possess the knowledge necessary to safely and proficiently perform the job duties and responsibilities expected of a second-year apprentice. The student will develop a further knowledge of construction safety, electrical safety, and Chapters 1–3 of the *National Electrical Code*.

As the student studies the rules in the first three chapters of the *NEC,* they will have a greater understanding of the purpose of the *Code*'s general wiring methods, materials, and different types of protection along with developing a deeper understanding of residential and commercial wiring systems.

LEVEL 2—MODULE I (Hours 1-39)

At the completion of each section, students should be able to master the concepts as listed below:

Tool Safety

- Demonstrate the safe and proper usage of various hand tools.
- Explain and demonstrate the safe usage, storage, and pre-use inspection of various power tools.*
- *NOTE: Check out this site MikeHolt.com/ToolVideos for some useful videos.

OSHA Construction Safety

- List some electrical hazards and explain safe electrical practices.
- Explain the importance of PPE and why it's considered "your last line of defense against injury."
- Define what is meant by a "confined space" relative to working conditions.
- Describe how to get in and out of confined spaces safely.
- Describe an "emergency response" protocol and how you might deal with an incident on a jobsite.
- Outline the "lockout/tagout" procedure and how to control exposure to hazardous electrical energy.

Fundamental *NEC* Calculations

- Mike Holt's Illustrated Guide to Fundamental *NEC*® Calculations, based on the 2026 *NEC*, is designed to teach basic single-step *NEC* calculations. It provides a short but complete explanation for each calculation and how it relates to the *Code*.
- Chapter 1—Size conductors based on load, ampacity, and temperature rating of terminal .

- Chapter 2—Determine load calculations, conductor sizing, and overcurrent protection for branch circuits, feeders, and services.
- Chapter 3—Dwelling Services and Feeders, Ampacity Tables, NM Cable Conductor Ampacity, and Metal Wireway.
  - ☐ Correctly size service and feeder conductors for dwelling units.
  - ☐ Make conductor ampacity adjustments and/or temperature corrections where required.
  - ☐ Determine the correct ampacity for Type NM Cable based on conditions of use.
- Chapter 4—Appliances, Electric Space Heating, Air-Conditioning Marking.
  - ☐ Size branch circuits and overcurrent protection for appliances and electric space heating
  - ☐ Explain the rules for "small conductors" as described in Article 240.
  - ☐ Explain the effect A/C equipment nameplate ratings have on conductor and protection sizing.
  - ☐ Calculate branch circuit and conductor sizing for A/C equipment

Article 110—Requirements for Electrical Installations

- Describe the significance of the listing and labeling of electrical equipment.
- Discuss interrupting ratings of overcurrent devices.
- Explain short-circuit current and short-circuit current ratings of electrical equipment.
- Describe the effects of deteriorating agents and mechanical execution of work.
- Thoroughly explain electrical connections focusing on temperature limitations and equipment provisions.
- Explain the requirements for high-leg identification and flash protection warning signs.
- Properly select an enclosure for a given installation condition.
- Explain and understand spaces about electrical equipment.
- Discuss working depth in relation to voltage and conditions as shown in Table 110.26(A)(1) Working Space.
- Explain the significance of maintaining proper working width, height, and clear spaces.
- Lay out electrical equipment with proper clearances along with adequate entrance/egress.
- Explain the requirements for foreign systems in dedicated electrical space.

Article 120—Branch-Circuit, Feeder, and Service Load Calculations

- Calculate branch-circuit loads.
- Select proper overcurrent protection devices (OCPD) for branch circuits.
- Select minimum conductor size for branch circuits.
- Calculate service/feeder loads and selection ampacities.
- Select proper OCPD for service/feeder loads.
- Select minimum conductor size for service/feeders.

Module I—Exam

- Successfully pass the module quiz within the program completion requirements.

LEVEL 2—MODULE II (Hours 40-78)

At the completion of each section, students should be able to master the concepts as listed below:

Understanding the *National Electrical Code*, Volume 1

Article 130—Energy Management Systems

- Define "energy management system" and "power control system".
- Explain what is meant by "load shedding" and some of its restrictions.
- Explain the "PCS" of an energy management systems and its function(s).
- Explain how energy management systems including PCS affect electrical service sizing.

Article 200—Use and Identification of Grounded (Neutral) Conductors

- Demonstrate knowledge of the requirements for the use and identification of the grounded conductor which (in most cases) is the neutral conductor.
- Identify and apply the *Code* requirements for re-identifying white conductors within multi-conductor cables.
- Explain how neutral terminals are identified.
- Describe the dangers of reverse polarity relative to neutral terminals or conductor leads.

Article 206—Non-Power-Limited Remote-Control and Signaling Circuits

- Describe the scope of Article 206.
- List the requirements for mixing non-power-limited remote control and signaling circuits and power conductors in enclosures and raceways.

Article 210—Branch Circuits

- Identify and apply the requirements for specific branch circuits where necessary.
- Explain how a branch circuit rating is determined.
- Identify and apply the requirements for "multiwire branch circuits."
- Identify and apply the requirements for branch circuits specific to dwelling units.
- Explain the requirements for branch circuits such as conductor sizing, identification, and AFCI and GFCI protection.
- Describe outlet device ratings for branch circuits and cord-and-plug connected loads.
- Identify and apply the *Code* sections on permissible loads, multiple occupancies, and required outlets general requirements.
- Outline how the *NEC* defines "wall space" as it pertains to the location of "general-use" receptacle outlets within dwelling occupancies.
- Outline how the *NEC* defines "countertop space" as it pertains to the location of receptacles served by small-appliance branch circuits.

- Identify and apply the *Code* requirements for receptacle placement in dwelling unit bathrooms, garages, basements, outdoors, and hallways.
- Identify and apply the *Code* requirements for guest rooms, suites, dormitories, and similar occupancies with respect to receptacle placement for permanent furniture layout.

Article 215—Feeders

- Discuss the requirements for the installation of feeders and calculate their ampacities.
- Discuss the requirements for identifying feeder conductors based on nominal system voltage.

Article 225—Outside Branch Circuits and Feeders

- Outline the requirements for wiring methods located outside (both overhead and underground) including feeders that run on or between buildings, poles, and other structures which may be present on the premises and used to feed equipment.

Article 230—Services

- Demonstrate knowledge of the terminology and definitions related to services such as where an electrical service begins and ends when applying the requirements for services.
- Outline the installation requirements for service conductors and equipment.
- Explain the service disconnect requirements as related to grouping and limitations.
- Identify and apply the service disconnect requirements specific to one- and two-family dwellings.

Module I—Exam

- Successfully pass the module quiz within the program completion requirements.

LEVEL 2—MODULE III (Hours 79-117)

At the completion of each section, students should be able to master the concepts as listed below:

Understanding the *National Electrical Code*, Volume 1

Article 240—Overcurrent Protection

- Explain the purpose and function of various OCPDs.
- List the more common standard OCPD current ratings.
- Identify the different types of circuit breakers and fuses and apply the *Code* rules for each.
- Explain the difference between an OCPD "rated" current and "fault" current rating and the purpose of each.
- Describe the requirements for where an OCPD is to be located in a given circuit.
- Identify and apply the *Code* rules for "tap conductors."

Article 242—Overvoltage Protection

- Describe the purpose of a surge protective device (SPD).
- Describe how SPDs functions.
- List the different "types" of SPD devices and where they might be located in an electrical system.
- Explain the general installation and connection requirements for SPDs permanently installed on both the line side and load side of service disconnects.

Article 300—General Requirements for Wiring Methods and Materials

- Identify and apply the general requirements for conductors and raceways such as:
  - protection against physical damage
  - minimum "cover" requirements for underground installations
  - raceways exposed to different temperatures and wet locations
  - electrical and mechanical continuity of raceways
  - mechanical and electrical continuity of conductors, splices, and pigtails
  - number and size of conductors in a raceway, vertical support, and conductor jamming
  - induced current in a non-ferrous raceway
- Identify and apply the *Code* rules to prevent the spread of fire, and the requirements for wiring in ducts and plenums.

Article 310—Conductors for General Wiring

- List the requirements for conductors installed in parallel including minimum size.
- Identify locations and corrosive conditions affecting conductor selection.
- Explain conductor insulation types and uses.
- Select the appropriate conductor ampacity for a single-family dwelling service or feeder.
- Identify and apply correct conductors sizes based on the Ampacity Table 310.16.
- Demonstrate proficiency in determining conductor ampacity subject to correction or adjustment.

Article 312—Cabinets, Cutout Boxes, and Meter Socket Enclosures

- Select the equipment necessary for installation in damp or wet locations.
- Describe the *Code* rules for enclosure installations recessed in wall cavities.
- Explain conductor protection when entering or leaving an enclosure.
- Identify and apply the requirements relative to wire bending space.
- Explain when and if an enclosure is permitted to be used as a raceway.

Article 314—Outlet, Device, Pull, and Junction Boxes; Conduit Bodies; and Handhole Enclosures

- Identify and apply the *Code* rules for both metallic and non-metallic boxes.
- Identify and apply the requirements relative to "box-fill" calculations.
- Identify and apply the formulas necessary to determine the power losses and efficiency of utilization equipment.
- Identify and apply the requirements for sizing pull-boxes based on raceway sizes and type of pull.

Cable Articles—Articles 320, 330

- Select which cables are appropriate for a given type of electrical installation and outline the rules for their installation.
- Explain that the *NEC* includes rules pertaining to which types of cables are suitable for underground installations.
- Identify and apply the *Code* rules for the uses permitted, securing, supporting, and protection of various cable types.

Module III—Exam

- Successfully pass the module quiz within the program completion requirements.

LEVEL 2—MODULE IV (Hours 118-156)

At the completion of each section, students should be able to master the concepts as listed below:

Understanding the *National Electrical Code*, Volume 1

Wiring Methods and Raceway Articles—Articles 334 through 392

- Select which wiring methods and raceways are appropriate for a given type of electrical installation and outline the rules for their installation.
- Explain that the *NEC* includes rules pertaining to which types of raceways are suitable for underground installations and exposure to corrosive environments.
- Identify and apply the *Code* rules for the uses permitted and/or "not" permitted, securing, supporting, and protection of various raceways.

Module IV—Exam

- Successfully pass the module quiz within the program completion requirements.

Level II—Exam

- Successfully pass the Level 2 Exam within the program completion requirements.

LEVEL 3 OUTLINE

LEVEL 3 RESOURCES

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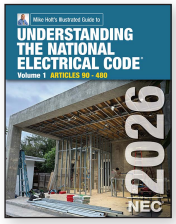
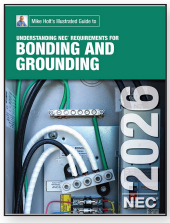
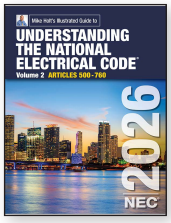
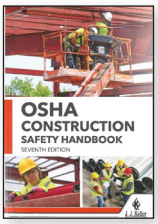
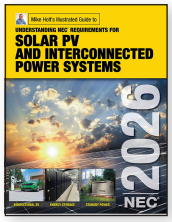
  Mike Holt Enterprises
  ISBN 978-1-960005-59-5, 2026
- *Mike Holt's Understanding NEC Requirements for Bonding and Grounding*
  Mike Holt Enterprises
  ISBN 978-1-960005-61-8, 2026
- *Mike Holt's Understanding the National Electrical Code, Volume 2*
  Mike Holt Enterprises
  ISBN 978-1-960005-60-1, 2026
- *OSHA Construction Safety Training Handbook, 7th Edition*
  J.J. Keller & Associates
  ISBN 979-8-88912-483-2, 2024
- *Mike Holt's Understanding NEC Requirements for Solar PV and Interconnected Power Systems*
  Mike Holt Enterprises
  ISBN 978-1-960005-55-7, 2026
- *Mike Holt's Understanding Basic Motor Controls*
  Mike Holt Enterprises
  ISBN 978-0-9992038-4-2, Revised Edition







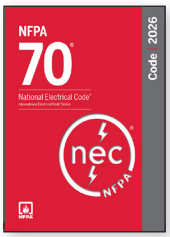




Suggested Additional Resources*

- *National Electrical Code, 2026 Edition*
  National Fire Protection Association
  ISBN 978-145593220-7, 2026

**Sold separately.*



LEVEL 3 LESSON PLANS—AT-A-GLANCE

Hours (Session)	Module I (Term 1)
1-3 (1)	Introduction | Orientation | Tool Safety *Level 3*
4-6 (2)	OSHA Construction Safety *Electrical Safety and PPE*
7-9 (3)	OSHA Construction Safety *Excavation/Motor Vehicles/Tool Safety*
10-12 (4)	*NEC*—Article 400 *Flexible Cords*
13-15 (5)	*NEC*—Articles 404 and 406 *Switches and Wiring Devices*
16-18 (6)	*NEC*—Article 408 *Switchboards and Panelboards*
19-21 (7)	*NEC*—Articles 410 and 411 *Luminaires and Low-Voltage Lighting*
22-24 (8)	*NEC*—Articles 410 and 411 *Luminaires and Low-Voltage Lighting*
25-27 (9)	*NEC*—Article 422 *Appliances*
28-30 (10)	*NEC*—Articles 424 and 440 *Electric Space-Heating and AC Equipment*
31-33 (11)	*NEC*—Articles 445 and 450 *Generators, Transformers*
34-36 (12)	Module Review
37-39 (13)	Module Quiz

Hours (Session)	Module II (Term 2)
40-42 (1)	Bonding and Grounding—Electrical Theory *Units 1–4, 6, and 25*
43-45 (2)	Bonding and Grounding—*NEC* *Article 250–Part I*
46-48 (3)	Bonding and Grounding—*NEC* *Article 250–Part II*
49-51 (4)	Bonding and Grounding—*NEC* *Article 250–Part III*
52-54 (5)	Bonding and Grounding—*NEC* *Article 250–Part IV*
55-57 (6)	Bonding and Grounding—*NEC* *Article 250–Part V*
58-60 (7)	Bonding and Grounding—*NEC* *Article 250–Parts VI, VII*
61-63 (8)	*NEC*—Articles 500-502, 511, and 514 *Hazardous Locations, Commercial Garages, and Motor Fuel Dispensing*
64-66 (9)	*NEC*—Articles 517, 518, and 547 *Health Care Facilities, Assembly Occupancies, Agricultural Buildings*
67-69 (10)	*NEC*—Article 555 *Marinas, Boatyards, and Docking*
70-72 (11)	*NEC*—Article 590 *Temporary Installations*
73-75 (12)	Module Review
76-78 (13)	Module Quiz

Hours (Session)	Module III (Term 3)
79-81 (1)	***NEC*—Articles 600 and 620** *Electric Signs, Elevators*
82-84 (2)	***NEC*—Articles 630, 640 and 645** *Electric Welders, Audio Signal Processing, Information Technology Equipment*
85-87 (3)	***NEC*—Article 680 and 695** *Swimming Pools, Spas, and Hot Tubs, Fire Pumps*
88-90 (4)	***NEC*—Articles 700 and 701** *Emergency, Legally Required Standby Systems*
91-93 (5)	***NEC*—Articles 720, 722, 723** *Limited-Energy Wiring Methods, Limited Energy Cables, Raceways and Routing Assemblies*
94-96 (6)	***NEC*—Articles 724, 725, 726, 750** *Class 1 and 2 Power-Limited Circuits, Class 4 Fault-Managed Power Systems, Grounding and Bonding of Limited-Energy Systems*
97-99 (7)	***NEC*—Article 760** *Fire Alarm Systems*
100-102 (8)	***NEC*—Articles 624, 625, 690** *Self-Propelled Vehicle Power Transfer Systems, Electric Vehicle Power Transfer Systems, Solar Photovoltaic (PV) Systems 1*
103-105 (9)	***NEC*—Article 690, 691** *Solar Photovoltaic (PV) Systems 2, Large Scale Solar Photovoltaic (PV) Systems*
106-108 (10)	***NEC*—Article 702 and 705** *Interconnected Electric Power Production Sources (IEPPS), Optional Standby Systems*
109-111 (11)	***NEC*—Articles 480, 706, 710** *Stationary Batteries, Energy Storage Systems (ESS), Stand Alone Systems*
112-114 (12)	**Module Review**
115-117 (13)	**Module Quiz**

Hours (Session)	Module IV (Term 4)
118-120 (1)	**Motor Controls—Units 1-3** *Introduction to Motor Controls*
121-123 (2)	**Motor Controls—Units 4-8** *Motor Controls and Schematics 1*
124-126 (3)	**Motor Controls—Units 9-10** *Motor Controls and Schematics 2*
127-129 (4)	**Motor Controls—Units 11-12** *Reversing Controls 1*
130-132 (5)	**Motor Controls—Units 13-14** *Reversing Controls 2*
133-135 (6)	**Motor Controls—Units 15-16** *Controls for Multiple Motors*
136-138 (7)	**Motor Controls—Units 17-20** *Miscellaneous Requirements*
139-141 (8)	***NEC*—Article 430** *Parts I–V*
142-144 (9)	***NEC*—Article 430** *Parts VI, VII, IX, X, XIV*
145-147 (10)	**Lab/Activity/Worksheet** *Motor Tables 430.248, 430.250*
148-150 (11)	**Flex Training** *Institution/Instructor Choice*
151-153 (12)	**Level 3 Review**
154-156 (13)	**Level 3 Exam**

LEVEL 3 OBJECTIVES

Upon the completion of Level 3, students will possess the knowledge necessary to safely and proficiently perform the job duties and responsibilities expected of a third-year apprentice. The student will continue building a foundation of knowledge about construction safety, electrical safety, and the *National Electrical Code*.

LEVEL 3—MODULE I (Hours 1-39)

At the completion of each section, students should be able to master the concepts as listed below:

Tool Safety

- Demonstrate the safe and proper usage of various hand tools.
- Explain and demonstrate the safe usage, storage, and pre-use inspection of various power tools. *
- *NOTE: Check out this site MikeHolt.com/ToolVideos for some useful videos.

OSHA—Construction Safety

- List some electrical hazards and explain safe electrical practices.
- Explain the importance of PPE and why it's considered "your last line of defense against injury."
- Demonstrate an understanding of excavation safety in and around the site.
- Demonstrate an understanding of construction vehicle operations and safety protocols.

Understanding the *National Electrical Code*, Volume 1

Article 400—Flexible Cords and Cables

- Identify and apply ampacity ratings for various cords and cables.
- Describe some of the more commonly used types of cords and cables.
- Explain the application and purpose of "strain relief" where cords or cables are the wiring method.

Article 404—Switches

- Explain the primary function of a general-use switch and describe various types of switches and their applications.
- Select the appropriate switching equipment based on location and rating.
- Commit to memory the maximum mounting height for switches.

Article 406—Wiring Devices

- Demonstrate the proper snap switch connections for 3- and 4-way switches.
- Identify and apply the acceptable methods for the bonding of metal snap switch plates or covers.
- Describe various receptacle types and their applications.
- Explain the concept of receptacle ratings and the reason for various NEMA configurations.
- List the criteria for the replacements of non-grounding type receptacles.
- Identify and apply the *Code* rules for attachment plugs and cord connectors.

Article 408—Switchboards and Panelboards

- Define the terms, "switchboard," and "panelboard."
- Explain the "phase" arrangement with respect to the high-leg of a Delta-type electrical system.
- Identify and apply the *Code* rules pertaining to panel directories.
- List types of enclosures suitable for installing panelboards in damp and wet locations.
- Demonstrate proper termination of conductors in panelboards.
- List the proper percent fill for panelboard enclosures when used as raceways and for splices.

Article 410—Luminaires

- Describe the definitions associated with luminaries, lampholders, and lamps.
- Identify and apply the requirements for luminaires installed near combustibles.
- Identify and apply the *Code* rules for luminaires installed in clothes closets.
- Identify and apply the *Code* rules for luminaires installed in bathtub and shower spaces.
- Describe the proper support of luminaires
- Explain the requirements for the disconnecting means for luminaires.
- Describe the unique considerations for the installation of horticultural ("grow") lighting.

Article 411—Low-Voltage Lighting Systems

- Outline the requirements for the installation of low-voltage lighting systems and their associated components, as well as their ac/dc voltage limitations.

Article 422—Appliances

- Identify and apply the requirements specific to the branch circuit ratings and overcurrent protection for various appliances.
- Identify and apply the *Code* rules for proper appliance disconnecting means and types.
- List instances where ground-fault circuit interrupter (GFCI) protection is required for specific appliances.
- Describe the permitted uses of flexible cords for appliances.
- Identify equipment to properly assemble cord-and-plug connections for appliances.

Article 424—Fixed Electric Space-Heating Equipment

- Recognize that heating equipment includes heating cable, unit heaters, boilers, central systems, and other fixed electric space-heating equipment.
- Describe the requirements that cover fixed electric equipment used for space heating.
- Describe fixed electric equipment branch circuit ratings, overcurrent protection, and disconnect requirements.
- Understand that Article 424 does not apply to process heating and room air-conditioning.
- Explain requirements for heating conductors installed in concrete and other masonry floors.

Article 440—Air-Conditioning and Refrigeration Equipment

- Explain the significance of equipment nameplate ratings.
- Describe requirements of disconnecting means.
- Explain the determination of short-circuit and ground-fault protection.
- Describe the requirements for "room air-conditioners."

Article 445—Generators

- Explain the *NEC* requirements for the installation of generators.
- Discuss some of the hazards involved in the use of generators.

Article 450—Transformers

- Explain referencing and applying information from Article 450.
- Calculate overcurrent protection for transformers applying the values and rules from Table 450.5(B).

Module I—Exam

- Successfully pass the module quiz within the program completion requirements.

LEVEL 3—MODULE II (Hours 40-78)

At the completion of each section, students should be able to master the concepts as listed below:

Understanding *NEC* Requirements for Bonding and Grounding

Electrical Theory Units 1-4, and Units 6 and 25

- Describe and or explain the following fundamental theory topics:
  - Unit 1—Atomic Structure
  - Unit 2—Electron Theory and Chemical Bonding
  - Unit 3—Electrical Circuits and Power Sources
  - Unit 4—The Electrical System
  - Unit 6—Dangers of Electricity
  - Unit 25—Overcurrent Protection

Article 250—Grounding and Bonding

Part I—General Requirements

- Demonstrate a thorough understanding of the terminology used throughout Article 250.
- Explain the difference between grounding and bonding.
- Identify the various grounding terminations, their locations and performance requirements, in a solidly grounded (ac) system.
- Explain the significant hazards created when an electrical system is not properly grounded.
- Define, and explain the importance of, an "effective ground-fault-current path."
- List the components of an electrical system that make up an effective ground-fault current path.
- Explain the importance of ensuring the electrical continuity of all noncurrent-carrying metal parts of an electrical system.
- Describe how grounding does not remove touch potential and why this is such a dangerous misconception.

Part II—System Grounding and Bonding

- Explain what is meant by an "ungrounded system.
- Define the term objectionable current and explain the hazards involved.
- List and apply the *Code* rules regarding objectionable current.
- List the permitted methods for making bonding and grounding connections.
- Identify the following and their respective locations in an electrical system:
  - main bonding jumper (MBJ)
  - system bonding jumper (SBJ)
  - supply-side bonding jumper (SSBJ)

- Describe where the service neutral conductor must be grounded AND bonded.
- Explain when a neutral must be insulated and why.
- Define a “separately derived system.”
- Explain the rules for the grounding of permanently installed generators.
- Correctly size a supply-side bonding jumper and neutral conductor originating from a separately derived system.
- Explain the rules for neutral conductors installed in parallel.

Part III—Grounding Electrode System and Grounding Electrode Conductor

- Correctly size the grounding electrode conductor (GEC).
- Describe the difference between a GEC and an equipment grounding conductor (EGC).
- List various types of grounding electrodes and explain what may be used as a grounding electrode.
- Apply the requirements for supplemental ground rods.
- Define an “auxiliary grounding electrode.”
- Explain the requirements for grounding electrode conductors and their installation.
- Demonstrate the ability to correctly size grounding electrode conductors.

Part IV—Enclosure, Raceway, and Service Cable Connections

- List the components of a service that must be bonded.

Part V—Bonding

- Identify and apply the requirements for the bonding of:
  - equipment containing service conductors
  - communications systems
  - other enclosures
  - 277/480V circuits
  - loosely jointed metal raceways
- Apply the values in Table 250.102(C)(1) to correctly size neutral conductors and bonding jumpers.
- Identify and apply the requirements for the bonding of metal piping systems.

Part VI—Equipment Grounding and Equipment Grounding Conductors

- Identify and apply the rules for equipment grounding and equipment grounding conductors for:
  - metal enclosures and cord-and-plug connected equipment
  - the types and identification of equipment grounding conductors
  - the installation and restricted use of equipment grounding conductors
  - the sizing of equipment grounding conductors

Part VII—Equipment Grounding Conductor Connections

- Identify and apply the rules for the connections of equipment grounding conductors for:
  - permanent wiring methods and equipment secured to metal supports
  - cord-and-plug connected equipment and the frames of ranges, ovens, and dryers
  - using the neutral conductor to provide an effective ground-fault current path
  - continuity and attachment to metal boxes

Understanding the *National Electrical Code*, Volume 2

Articles 500-502—Hazardous (Classified) Locations

- List general requirements applicable to all hazardous (classified) locations.
- Explain that a hazardous (classified) location is an area where the possibility of fire or explosion exists due to the presence of flammable or combustible liquid-produced vapors, flammable gases, combustible dusts, or easily ignitable fibers/flyings.
- Explain that a Class I hazardous (classified) location is an area where flammable or combustible liquid-produced vapors or flammable gases may present the hazard of a fire or explosion.
- Describe the Class I divisions and identify the appropriate wiring methods for such locations.
- Explain that a Class II hazardous (classified) location is an area where the possibility of fire or explosion may exist due to the presence of combustible dust.
- Describe the Class II divisions and identify the appropriate wiring methods for such locations.
- Explain that Class III hazardous (classified) locations are hazardous because fire or explosion risks may exist due to easily ignitible fibers/flyings. Identify the locations that may produce fibers from materials such as cotton and rayon which are found in textile mills and clothing manufacturing plants.
- Explain that these locations can also include establishments and industries such as sawmills and woodworking plants.
- Describe the Class III divisions and identify the appropriate wiring methods for such locations.

Article 511—Commercial Garages, Repair, and Storage

- Outline that commercial garages used for repair and storage are locations used for service and repair operations in connection with self-propelled vehicles including (but not limited to) passenger automobiles, buses, trucks, and tractors in which flammable liquids or flammable gases are used for fuel or power. Identify the appropriate wiring methods for such locations.

Article 514—Motor Fuel Dispensing Facilities

- Explain that motor fuel dispensing facilities are gasoline dispensing and service stations where gasoline or other volatile liquids are transferred to the fuel tanks of self-propelled vehicles.
- Outline the wiring and equipment requirements for the area of service and repair rooms of service stations in compliance with the installation requirements in Article 514.

Article 517—Health Care Facilities

- Describe the *Code* requirements which apply to electrical wiring in human health care facilities such as hospitals, nursing homes, limited-care facilities, clinics, medical and dental offices, and ambulatory care—whether permanent or movable.

Article 518—Assembly Occupancies

- Apply the *NEC* requirements which apply to assembly occupancies.
- Explain that these rules apply to buildings or portions of buildings specifically designed or intended for the assembly of 100 or more persons.

Article 525—Carnivals, Circuses, Fairs, and Similar Events

- Apply the *NEC* requirements electrical installations at these types of events.

Article 547—Agricultural Buildings

- Apply the *NEC* requirements that apply to these types of installations.
- Describe the rules for and the importance of equipotential planes.

Article 555—Marinas, Boatyards, and Commercial and Non-Commercial Docking Facilities

- Apply the general requirements and wiring methods for electrical installations in and about marinas.
- Describe electrical shock hazards related to marinas and the importance and methods of current leakage detection.
- Describe electric shock drowning (ESD) and the warning signage required.
- Disseminate between GFPE and GFCI requirements in and about marinas and boatyards.
- Apply the rules for bonding and the equipment grounding conductor in and about marinas.

Article 590—Temporary Installations

- Define temporary power and lighting for construction, remodeling, maintenance, repair, demolitions, and decorative lighting. List the general requirements for temporary electrical installations and explain their time limitations.

Module II—Exam

- Successfully pass the module quiz within the program completion requirements.

LEVEL 3—MODULE III (Hours 79-117)

At the completion of each section, students should be able to master the concepts as listed below:

Understanding the *National Electrical Code*, Volume 2

Article 600—Electric Signs

- Identify and apply the electrical installation requirements for the conductors and equipment for electric signs and outline lighting as defined in Article 100.
- Explain that all products and installations utilizing neon tubing such as signs, decorative elements, skeleton tubing, or art forms are included.
- Define the process of, and identify the rules that apply to, retrofitting existing lighting installations.

Article 604—Manufactured Wiring Systems

- Identify and apply the *Code* requirements for field-installed manufactured wiring systems used for branch circuits, remote-control circuits, signaling circuits, and communications circuits in accessible areas.
- Explain that the components of a listed manufactured wiring system can be assembled at the jobsite.

Article 620—Elevators

- List the *NEC* requirements for the installation of electrical equipment and wiring used in connection with elevators, dumbwaiters, escalators, moving walks, wheelchair lifts, and stairway chair lifts.
- Identify and apply the *Code* rules for wiring and equipment located in the elevator pit.
- Identify and apply the *Code* rules for electrical installations in the elevator machine room.

Article 630—Electric Welders

- Apply the *Code* requirements for the wiring of electric arc welding and resistance welding apparatus, and other similar welding equipment connected to an electrical supply system.
- Accurately perform branch circuit, feeder, and overcurrent protection calculations for electric welders.

Article 645—Information Technology Equipment

- Discuss the *Code* requirements that apply to equipment, power-supply wiring, equipment interconnecting wiring, and grounding of information technology equipment and systems (including terminal units) in an information technology equipment room.
- Define underfloor wiring and list the approved wiring methods for these areas.

Article 680—Swimming Pools, Spas, Hot Tubs, Fountains, and Similar Installations

- Explain the significance of correctly applying the *NEC* requirements for the installation of bonding and grounding devices and the electric wiring and equipment that supply swimming, wading, therapeutic and decorative pools, fountains, hot tubs, spas, hydromassage bathtubs, and powered pool lifts whether permanently installed or storable.
- Describe equipotential bonding as applied to swimming pools.

Article 700—Emergency Standby Systems

- Describe how the requirements of Article 700 apply only to the wiring methods for “emergency systems” that are essential for safety to human life and required by federal, state, municipal, or other regulatory codes.

- Explain that according to the *NEC*, when normal power is lost, emergency systems must be capable of supplying emergency power in 10 seconds or less and be able to run loads for at least 2 hours on gasoline and 90 minutes on a battery.

Article 701—Legally Required Standby Systems

- Define "legally required standby systems" as those that provide electrical power to aid in firefighting, rescue operations, control of health hazards, and similar operations and are required by federal, state, municipal, or other regulatory *code*s.
- Explain that according to the *Code*, when normal power is lost, legally required standby systems must be capable of automatically supplying standby power in 60 seconds or less and be able to run loads for at least 2 hours on gasoline and 90 minutes on a battery.

Article 702—Optional Standby Systems

- Define "optional standby systems" as those intended to protect public or private facilities or property where life safety does not depend on the performance of the system.
- Explain that these systems are typically installed to serve loads that, when stopped during any power outage, can cause discomfort, serious interruption of a process, or damage to a product or process.
- Explain that optional standby systems are intended to supply onsite generated power, either automatically or manually, to loads selected by the customer.
- Explain the difference between emergency, legally required, and optional standby systems.

Article 720—Limited-Energy System Wiring Methods and Materials

- Explain rules for installing, protecting, securing, and supporting limited-energy wiring.
- Serves a role similar to Article 300, but specifically for limited-energy wiring.
- Consolidates limited-energy system requirements previously scattered throughout Articles 725, 760, and 800.

Article 722—Limited-Energy System Cables

- Describe limited-energy cable construction, listing, identification, and marking requirements.
- Explain the scope Article 722 and what limited-energy cable can be used and where it is permitted to be installed.
- List where different cable types and ratings are permitted, such as plenum, riser, and general-purpose cables.

Article 723—Limited-Energy System Raceways

- List the *NEC* compliant raceways, cable routing assemblies, and cable trays used with limited-energy wiring.
- Describe the rules for permitted and non-permitted uses of limit-energy raceways based on applications.

Article 724—Class 1 Power-Limited Circuits

- Identify and apply the *NEC* requirements for Class 1 Power-Limited Circuits:
  - ☐ circuit identification
  - ☐ power source(s)
  - ☐ overcurrent protection and location of same

- wiring methods
- conductors of different circuits in same cable or raceway
- number of conductors in raceways

Article 725—Class 2 Power-Limited Circuits

- Identify and apply the *NEC* requirements for Class 2 Power-Limited Circuits:
  - safety control equipment
  - power source(s)
  - supply-side wiring methods
  - load-side wiring methods
  - separation from power conductors
  - conductors of different circuits in same cable or raceway
  - power and data cable bundling

Article 726—Class 4 Fault-Managed Power Systems

- Identify and apply the *NEC* requirements for Class 4 Fault-Managed Systems:
  - listing requirements
  - Class 4 marking requirements
  - terminals and connectors for Class 4 systems

Article 750—Grounding and Bonding of Limited-Energy Systems

- Identify and apply the *NEC* requirements for Grounding and Bonding of Limited-Energy Systems:
  - listing requirements
  - metal antenna systems bonding or grounding
  - antenna systems bonding and grounding electrode conductors

Article 760—Fire Alarm Systems

- Identify and apply the *Code* requirements for the installation of wiring of fire alarm systems.

Chapter 8—Communications Systems

Chapter 8 covers the outside wiring requirements for communications circuits such as hard-wired telephones, radio/TV antennas, satellite dishes, and CATV systems. This is not within the scope of this textbook.

Understanding the *NEC* Requirements for Solar PV and Energy Storage Systems

Article 624— Electric Self-Propelled Vehicle Power Transfer Systems

- Explain the differences between the purpose of Articles 624 vs Article 625
- List some of the types of vehicles to which Article 624 is applied.

Article 625—Electric Vehicle Power Transfer System

- Define an "electric vehicle power transfer system."
- List the requirements for the electrical equipment needed to charge automotive-type electric and hybrid vehicles including cars, bikes, and buses.
- Explain the concept of "bi-directional power transfer."

Article 690—Solar Photovoltaic (PV) Systems

- Describe the electrical hazards that may arise from installing and operating a solar photovoltaic (PV) system.
- State the definitions of some of the equipment terminology that is specific to PV systems and their purposes.
- Paraphrase the wiring and installation requirements for PV systems.
- Explain that the requirements of the *NEC* Chapters 1–4 apply to these installations, except as specifically modified in Article 690.

Article 691—Large Scale Solar Photovoltaic (PV) Electric Supply Stations

- Discuss the *Code* rules that apply to large-scale solar photovoltaic (PV) electric supply stations with a generating capacity of 5,000 kW or more and not under exclusive utility control.

Article 705—Interconnected Electric Power Production Sources (IEPPS)

- Understand that interconnected electric power production sources (IEPPS) are alternate power sources (such as generator, solar or energy storage) that run in parallel with a primary utility source and need particular consideration and requirements.
- Apply the *NEC* requirements when connecting such systems.

Article 480—Stationary Batteries

- Explain the requirements and safety considerations for the installation of stationary batteries.

Article 706—Energy Storage Systems

- Explain what an energy storage systems (ESS) can be connected to.
- Identify the requirements of energy storage system disconnecting means, conductor and protection sizing.
- Confirm how Article 706 correlates with other articles in the *Code* such as Articles 480, 690, and 705.

Article 710—Stand Alone Systems

- Define a "stand-alone system" as an electrical system that is self-sufficient and a completely "off the grid" source of electrical energy such as solar or wind.
- Explain that a stand-alone system may be connected to a utility supply as part of an interconnected system and how Article 710 specifically addresses these systems.

Article 750—Bonding and Grounding for Limited-Energy Systems

- List the grounding and bonding requirements for limited-energy systems.
- Describe the requirements for the bonding of cable shields, metallic sheaths, and equipment, and limited-energy system protectors.
- List some of the requirements for grounding and bonding conductors, connection points, and intersystem bonding terminations.

Module III—Exam

- Successfully pass the module quiz within the program completion requirements.

LEVEL 3—MODULE IV (Hours 118-156)

At the completion of each section, students should be able to master the concepts as listed below:

Motor Controls

Motor Controls—Units 1-3, Introduction

- Explain the basic concepts of motor controls, concentrating on how specialized electrical symbols, words, and line diagrams are used to convey information about motor control circuits.
- Describe the purpose of various types of motor circuit diagrams such as:
  - ladder diagrams (these are also called line diagrams or elementary diagrams)
  - connection diagrams (also called wiring diagrams)
  - pictorial diagrams
- Recognize and explain various definitions, abbreviations, and graphic symbols used on motor control diagrams.
- Identify and explain the purposes of various types of common motor control devices including auxiliary contacts, control relays, pushbutton stations, solenoids and solenoid valves, flow switches, pressure switches, limit switches, and timing relays.

Motor Controls—Units 4-10, Motor Controls and Schematics

- Interpret the information found in a motor control schematic called a "ladder diagram" (also called an "elementary diagram" or "line diagram"). Explain how this type of diagram is used to illustrate a simple 2-wire control circuit used with small single-phase motors, and a similar circuit with a mechanical automatic control device (in this case, a float switch for controlling a pump).
- Describe the concept of magnetic motor control, and how it's used for the remote control of both single-phase and three-phase motors. Define the concept of "mechanically held contactors." Exhibit a satisfactory knowledge of the following concepts:
  - Circuit types classified by power source (common control circuits, transformer control wiring, and separate control wiring)
  - Control devices (solenoids, relays, and contactors, both mechanically held and electrically held)
  - Remote-control circuits
  - Using control circuits and magnetic devices to control 480V loads
- Describe the operation and use of magnetic motor starters. Explain in detail, motor overload protection devices, auxiliary contacts, and motor starter add-on accessories.
- Explain the differences between 2-wire and 3-wire control schemes and related concepts such as:
  - Holding circuits (also called sealing circuits)
  - Low-voltage protection with 3-wire control circuits and how this improves safety
  - Reading motor control wiring (connection) diagrams
  - Pilot devices such as start-stop pushbuttons
- Explain the importance of providing overcurrent protection for motor control circuits.
- Identify the *Code* rules that apply to motor control circuits that are tapped from motor power supply circuits.
- Demonstrate the ability to correctly select conductor, control transformer, and fuse sizes.
- Explain some of the uses for pilot (indicator) lights and illuminated pushbuttons in motor control circuits.
- Describe the purposes of various types, colors, typical applications of, and symbols for pilot lights and illuminated pushbuttons.
- Explain some of the uses for two- and three-position selector switches.
- Describe how to read a "truth table" to determine what the contacts do in each position of the selector switch.
- Demonstrate the use of a selector switch on a 2-wire circuit for a hand-off-auto (HOA) application.

Motor Controls—Units 11-14, Reversing Controls

- Describe the basic concepts, components, and schematic diagrams used with reversing controls for three-phase motors.
- Describe how combining mechanical interlocking with electrical interlocking provides a greater degree of safety.
- Explain how pilot (indicator) lights are used with reversing.
- Explain the use of limit switches in reversing motor control circuits, control schematics, and the wiring of pushbutton stations.
- Explain reversing controls for single-phase motors making the important point that manufacturer's instructions should always be followed when reversing single-phase motors.

Motor Controls—Units 15-16, Controls for Multiple Motors

- Explain the concept of "sequence" controls for multiple motors. Recognize that these motor control concepts are logical extensions of typical motor control circuits involving industrial machinery with hundreds of wires and many contactors and relays, and that the control of the sequencing functions is typically handled by computers.
- Explain the purpose of, and how to implement, a master stop function for multiple motors. Describe how motor overload units (OLs) can be connected in series so that if any motor stops due to an overload condition, all related motors will stop.

Motor Controls—Units 17-20, Miscellaneous Requirements

- Identify and apply the *NEC* requirements for disconnecting means used with motor and motor controllers. Explain that the pushbutton (PB) controls aren't usually the actual motor controller or disconnect.
- Explain how control relays and selector switch PBs are used to expand the capability of a basic 2- or 3-wire motor control circuit by combining equipment used for motor control.
- Explain wiring configurations for different types of three-phase motors and how to reverse three-phase motors by interchanging the L1 and L3 power leads.
- Describe different ways to wire doorbell circuits. Recognize the importance of using the manufacturer's wiring diagrams to wire the controls for heating and cooling equipment.

Article 430—Motors

- Demonstrate knowledge of the specific requirements for conductor sizing, overcurrent protection, control circuit conductors, motor controllers, and disconnecting means covered in Article 430.
- Recognize the difference between motor FLA and FLC ratings.
- Reference values from all *NEC* motor related tables necessary for *Code* compliant installations
- Calculate the minimum conductor required, maximum overload protection rating, and maximum branch-circuit OCPD ratings for motor branch circuits.
- Calculate maximum overcurrent protection for motor feeders.

Module IV—Exam

- Successfully pass the module quiz within the program completion requirements.

Level III—Exam

- Successfully pass the Level III—Exam within the program completion requirements.

LEVEL 4 OUTLINE

LEVEL 4 RESOURCES

Mike Holt's Apprenticeship Training Program is designed to use textbooks, slide presentations, videos, labs/activities, review questions, and exams designed to enhance learning, comprehension, and retention of the material presented.

Self-paced learners should be sure to take advantage of our online Capacitor® and make full use of all included presentations, videos, and extra links as part of their learning experience. These tools will enhance comprehension and reinforce retention of the material.

Videos

The instruction package includes videos that can be played along with the textbooks, or viewed in their entirety, to provide a practical viewpoint of the material covered. If something isn't understood or misinterpreted, stop, go back, and play that section again until the topic is clear.

Mike and a panel of industry experts are featured on these videos. They carefully examine the topics in a way that's both educational and entertaining. You'll hear stories, discussions, and opinions that aren't covered in the textbooks thereby making them an invaluable practical source of information.

Presentations

Included in this instruction package are presentations containing hundreds of slides that are synchronized with the textbooks. These presentations are sorted by individual article or unit resulting in much smaller, less cumbersome files and make it easier to follow along side by side with the textbook.

Labs/Activities/Worksheets

One of the most enjoyable parts of learning is "hands on" learning of mechanical parts such as meters, wire, magnets, coils, light bulbs, switches, fuses, circuit breakers, receptacles, GFCIs, AFCIs—basically anything that can be broken!

Include calculation worksheets as handouts that give students repeated practice with critical calculations, including voltage drop, ampacity adjustment, temperature correction, range calculations, and similar tasks. This repetition is one of the most effective ways to embed the formulas, methods, and procedures into permanent memory.

We strongly suggest you find or create labs that match the topic being studied as a hands-on experience to help students understand the material being covered. Seeing a mechanical concept in action makes it easier to understand the lesson being taught.

NOTE: Check out https://www.electriclab.org/ for some lab ideas.

Assessments

Student assessments are an important aspect of the learning process. Studies have shown that regardless of the result, students who are required to mentally recall a subject upon review, are more likely to remember the content than those who didn't have this opportunity. Our program includes different options for assessment including, textbook review questions and exams. Online quizzes and exams are available in the blended and online programs in our online Capacitor®.

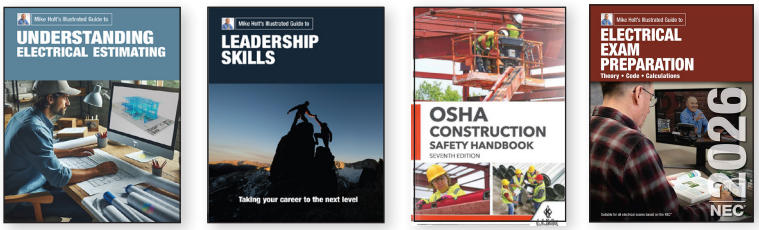
Textbook Questions. Our textbooks contain review questions and exams designed to reinforce the learning process when the online testing tools aren't used. We encourage you to have your students complete the textbook tests before taking the online tests to further reinforce their learning process.

Online Testing. Our online testing program has been specifically designed to take advantage of today's blended or self-paced learning environments and reinforce the material that's been covered.

Books

You'll be using the following books or textbooks and we suggest you take a few moments to review the layout of each. Pay attention to the table of contents, the layout of the units/chapters, and the review questions.

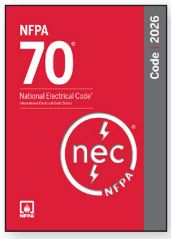
- *Mike Holt's Guide to Understanding Electrical Estimating*
  Mike Holt Enterprises
  ISBN 978-1-960005-40-3, 2024
- *Mike Holt's Leadership Skills*
  Mike Holt Enterprises
  ISBN 978-0-9975452-2-7, 2016
- *OSHA Construction Safety Training Handbook, 7th Edition*
  J.J. Keller & Associates
  ISBN 979-8-88912-483-2, 2024
- *Mike Holt's Guide to Electrical Exam Preparation*
  Mike Holt Enterprises
  ISBN 978-1-960005-53-3, 2026



Suggested Additional Resources*

- *National Electrical Code, 2026 Edition*
  National Fire Protection Association
  ISBN 978-145593220-7, 2026

**Sold separately.*



LEVEL 4 LESSON PLANS—AT-A-GLANCE

Hours (Session)	Module I (Term 1)
1-3 (1)	**Introduction | Orientation | Tool Safety** *Level 4*
4-6 (2)	**OSHA Construction Safety** *Electrical Safety and PPE*
7-9 (3)	**OSHA Construction Safety** *Hazard Communication/Jobsite Exposures/ Work Zone Safety*
10-12 (4)	**Electrical Estimating—Chapters 1 and 2** *Introduction to Estimating, Qualities of an Estimator*
13-15 (5)	**Electrical Estimating—Chapter 3** *The Estimating Process*
16-18 (6)	**Electrical Estimating—Chapter 4** *The Takeoff*
19-21 (7)	**Electrical Estimating—Chapter 5** *Determining Labor Cost*
22-24 (8)	**Electrical Estimating—Chapters 6 and 7** *Unit Pricing, Determining Break-even Cost*
25-27 (9)	**Lab/Activity/Worksheet** *Blueprint Takeoff*
28-30 (10)	**Leadership Training, Part 1** *Leadership Skills*
31-33 (11)	**Leadership Training, Part 2** *Leadership Skills*
34-36 (12)	**Module Review**
37-39 (13)	**Module Quiz**

Hours (Session)	Module II (Term 2)
40-42 (1)	**Exam Prep Module I—Fundamentals Review** *Basic Math, Ohms' Law, Watt's Law*
43-45 (2)	**Exam Prep Module I—Fundamentals Review** *Series, Parallel, Series-Parallel Circuits*
46-48 (3)	**Exam Prep Module I—Fundamentals Review** *AC Current, True and Apparent Power, Power Factor*
49-51 (4)	**Exam Prep Module I—Fundamentals Review** *Motors, Generators*
52-54 (5)	**Exam Prep Module I—Fundamentals Review** *Relays, Transformers*
55-57 (6)	**Exam Prep Module I—Fundamentals Review** *Overcurrent Protection*
58-60 (7)	**Exam Prep Module I—Fundamentals Review** *The Formula Wheel*
61-63 (8)	**Exam Prep Module II—*Code* Review** *Article 90, NEC Chapters 1 and 2*
64-66 (9)	**Exam Prep Module II—*Code* Review** *NEC Chapters 3, 4, and 5*
67-69 (10)	**Exam Prep Module II—*Code* Review** *NEC Chapters 6,7, and 8*
70-72 (11)	**Exam Prep Module III—Calculations** *Unit 1—Raceway Calculations*
73-75 (12)	**Module Review**
76-78 (13)	**Module Quiz**

Hours (Session)	Module III (Term 3)
79-81 (1)	**Exam Prep Module III—Calculations** *Unit 2—Box Calculations Part A*
82-84 (2)	**Exam Prep Module III—Calculations** *Unit 2—Box Calculations Part B*
85-87 (3)	**Exam Prep Module III—Calculations** *Unit 3—Conductor Sizing and Protection Calculations*
88-90 (4)	**Exam Prep Module III—Calculations** *Unit 4 Motor, Air-Conditioning, and Transformer Calculations*
91-93 (5)	**Exam Prep Module III—Calculations** *Unit 5—Voltage-Drop Calculations*
94-96 (6)	**Exam Prep Module III—Calculations** *Unit 6—Dwelling Unit Calculations*
97-99 (7)	**Exam Prep Module III—Calculations** *Unit 6—Dwelling Unit Calculations*
100-102 (8)	**Exam Prep Module III—Calculations** *Unit 6—Review Questions (57)*
103-105 (9)	**Exam Prep Module IV—Advanced Calculations** *Unit 7—Multifamily Dwelling Calculations*
106-108 (10)	**Exam Prep Module IV—Advanced Calculations** *Unit 7—Multifamily Dwelling Calculations*
109-111 (11)	**Lab/Activity/Worksheet** *Fire Alarm Systems*
112-114 (12)	**Module Review**
115-117 (13)	**Module Quiz**

Hours (Session)	Module IV (Term 4)
118-120 (1)	**Exam Prep Module IV—Advanced Calculations** *Unit 8—Commercial Calculations*
121-123 (2)	**Exam Prep Module IV—Advanced Calculations** *Unit 8—Commercial Calculations*
124-126 (3)	**Exam Prep Module IV—Advanced Calculations** *Review and Practice Exam (25 Questions*
127-129 (4)	**Exam Prep Module II—*NEC* Review Questions** *Practice Exam*
130-132 (5)	**OSHA Construction Safety Handbook** *Review safety rules and practices*
133-135 (6)	**Electrical Theory Review** *All Theory related material*
136-138 (7)	**Exam Part 1—Electrical Theory** *Journeyman Practice Exam, Electrical Theory*
139-141 (8)	***National Electrical Code*** *Review*
142-144 (9)	**Exam Part 2—*National Electrical Code*** *Journeyman Practice Exam, National Electrical Code*
145-147 (10)	**Electrical Calculations** *Review*
148-150 (11)	**Exam Part 3—Electrical Calculations** *Journeyman Practice Exam, Electrical Calculations*
151-153 (12)	**Exam(s) Results** *Review Test Results and Questions*
154-156 (13)	**Processing, Graduation Documents**

LEVEL 4 OBJECTIVES

Upon the completion of Level 4, students will possess the knowledge necessary to safely and proficiently perform the job duties and responsibilities expected of a Journeyman Electrician. They'll develop a further knowledge of construction safety, electrical safety, and the *NEC* in preparation for their exam. Your students will also gain an understanding of some basic leadership principals necessary to excel on the job, and to be introduced to fire alarm system basics.

LEVEL 4—MODULE I (Hours 1-39)

At the completion of each section, students should be able to master the concepts as listed below:

Tool Safety

- Demonstrate complete knowledge in the safe and proper usage of various hand and power tools. *
- *NOTE: Check out this site MikeHolt.com/ToolVideos for some useful videos.

OSHA—Construction Safety

- List some electrical hazards and explain safe electrical practices.
- Explain the importance of PPE and why it's considered "your last line of defense against injury."
- Demonstrate an understanding of jobsite physical, chemical, and health hazards.
- Demonstrate an understanding of jobsite hazards and the protective measures that should be taken.

Electrical Estimating

Chapter 1—Introduction to Estimating

- Describe the purpose of an estimate
- List various types of estimates
- Understand what goes into developing and estimating system
- Explain difference between estimating and bidding
- Describe how the market can affect estimating

Chapter 2—Qualities of an Estimator

- Describe the qualities of a good estimator and their responsibilities.
- Explain the importance of field experience.

Chapter 3—The Estimating Process

- Describe the importance of an adequate estimating workspace and its components.
- Recognize what might affect the accuracy of an estimate
- List and explain various estimating techniques

Chapter 4—The Takeoff

- Recognize how and why the takeoff is the foundation for everything that follows in developing an accurate estimate.
- Describe and explain the following processes used when performing a take-off:
  - the takeoff sequence
  - takeoff systems
  - the bill of material (BOM)
  - determining and pricing labor and material
- Explain how historical data can promote more accurate estimating

Chapter 5—Determining Labor Cost

- D escribe and explain the following processes used when determining the cost of labor:
  - how labor units are expressed and why
  - what makes up a labor unit
  - the benefits of labor unit manuals
  - what adjustments might be necessary
  - labor unit variables

Chapter 6—Unit Pricing

- Explain “unit pricing” and how it is applied

Chapters 7—Determining Break-Even Cost

- Explain what is meant by “break-even cost”.
- List common expenses that might contribute to the break-even cost on any given job.

Leadership Training

- Outline the concept of “personal branding” and the factors that contribute to it.
- Describe the development of the basic skills that make-up an effective career path.
- Explain some of the strategies involved in the advancement of your career.

- Recognize that an effective leader is one who not only manages, but also mentors others to become leaders.
- Outline some of the ways to remain a healthy, knowledgeable, and effective leader.

Module I—Exam

- Successfully pass the module quiz within the program completion requirements.

LEVEL 4—MODULE II (Hours 40-78)

At the completion of each section, students should be able to master the concepts as listed below:

Electrical Exam Preparation—Review

Module I—Electrical Fundamentals

Unit 10—Basic Math

- Revisit and practice basic math functions necessary to perform electrical calculations.

Unit 12—Ohm's Law

- Practice the application of Ohm's Law formulas to calculate electrical circuits.

Unit 13—Watt's Law

- Practice applying Watt's Law to various electrical calculations.

Unit 14—Series Circuits

- Practice calculating the values of the variables when analyzing series circuits.

Unit 15—Parallel Circuits

- Practice calculating the values of the variables when analyzing parallel circuits.

Unit 16—Series-Parallel Circuits

- Practice calculating the resistance when analyzing series-parallel circuits.

Unit 17—Alternating Current

- Explain how ac waveforms are used
- Explain the relationship(s) between voltage and current in an ac waveform
- Practice calculating Peak and RMS values

Unit 20—True Power, Power Factor, and Apparent Power

- Explain the relationship between true power and apparent powe
- Practice calculating true power when the apparent power is known
- Explain power factor and practice calculating power requirements where power factor is a consideration

Unit 21—Motors

- Explain the differences between motor start-up, running, and locked-rotor currents
- Practice motor calculations involving horsepower vs nameplate ratings
- Recognize which tables need to be used for motor calculations

Unit 22—Generators

- Practice calculating generator output current.

Unit 23—Relays

- Practice recognizing normally open vs normally closed relays, and which might be used in certain applications.

Unit 24—Transformers

- Review calculating transformer ratios when given the necessary variables
- Practice calculating primary and secondary voltages and currents when given the necessary variables
- Practice sizing transformers for a given load or demand
- Review tap rules for secondary conductors

Unit 25—Overcurrent Protection

- Recognize the importance of overcurrent protection for electrical circuits and equipment
- Explain the differences and similarities between circuit breakers and fuses
- Explain the role of "supplementary" protection for an electrical circuit
- Understand the differences between overcurrent and interrupting ratings of circuit breakers and fuses
- Practice calculating short-circuit current

Unit 29—The Formula Wheel

- Apply various formulas from the Power Wheel to solve electrical calculations.

Module II—*NEC* Review Questions

- Practice navigating the *NEC* by answering the Chapter review questions taking the time to highlight the *Code* book for future reference.

Module III—*NEC* Calculations

- Unit 1, Raceway Calculations—Practice sizing various raceways for conductor fill applying *NEC* requirements and referencing *NEC* Tables where necessary.

Module II—Exam

- Successfully pass the module quiz within the program completion requirements.

LEVEL 4—MODULE III (Hours 79-117)

At the completion of each section, students should be able to master the concepts as listed below:

Electrical Exam Preparation—Review (cont)

Module III—*NEC* Calculations

Unit 2, Box Calculations

- Part A, Outlet Box Sizing—Practice sizing outlet boxes applying *NEC* requirements and referencing *NEC* Tables where necessary.
- Part B, Pull and Junction Boxes—Practice sizing pull and junction boxes applying *NEC* requirements and referencing *NEC* Tables where necessary.

Unit 3, Conductor Sizing and Protection Calculations

- Part A, Conductor Insulation, Terminals, and Overcurrent Protection—Practice sizing conductors and overcurrent protection taking into consideration temperature limitations for terminations applying *NEC* requirements and referencing *NEC* Tables where necessary.
- Part B, Conductor Ampacity and Protection—Practice sizing conductors and overcurrent protection considering factors such as, ampacity adjustment and temperature correction, continuous vs non-continuous loads, branch circuit requirements, and feeder tap rules.

Unit 4, Motor, Air-Conditioning, and Transformer Calculation

- Part A, Motor Calculations—Practice sizing motor conductors, overcurrent, and motor overload protection applying *NEC* requirements and referencing *NEC* Tables where necessary.
- Part B, Air-Conditioning Calculations—Practice sizing conductors, and overcurrent protection for transformers applying *NEC* requirements and referencing *NEC* Tables where necessary.

Unit 5, Voltage-Drop Calculations

- Part A, Conductor Resistance Calculations—Practice calculating conductor resistance referencing *NEC* Tables where necessary.
- Part B, Voltage-Drop Calculations—Practice calculating voltage drop for various circuits using the voltage drop formula.

Unit 6, Dwelling Unit Calculations

- Part A, Optional Method—Practice calculating the service load for dwelling units applying *NEC* requirements for the Optional Method.
- Part B, Standard Method—Practice calculating the service load for dwelling units applying *NEC* requirements for the Standard Method.
- Part C, Neutral Load Calculations—Apply reductions to neutral demand loads for dryers and ranges where permitted. Practice calculating the service load neutral for dwelling units applying *NEC* requirements.

Module IV—Advanced *NEC* Calculations

Unit 7, Multifamily Dwelling Calculations

- Part A, Optional Method—Practice calculating the service load for multifamily dwellings using the Optional Method.
- Part B, Standard Method—Practice calculating the service load for multifamily dwellings using the Standard Method.
- Part C, Neutral Load Calculations—Practice calculating the service load neutral for multifamily dwellings.

Module III—Exam

- Successfully pass the module quiz within the program completion requirements.

LEVEL 4—MODULE IV (Hours 118-156)

At the completion of each section, students should be able to master the concepts as listed below:

Electrical Exam Preparation—Review (cont)

Module IV—Advanced *NEC* Calculations (cont)

Unit 8, Commercial Calculations

- Part A, General Commercial Demand Loads—Practice calculating common demand loads found in commercial occupancies applying *NEC* requirements and demand factors where necessary.
- Part B, Office, Mobile Home, Kitchen, Restaurants, and School Examples—Practice calculating service demand loads unique to various commercial occupancies applying *NEC* requirements and demand factors where necessary.
- Part C, Welder Calculations—Practice calculating service demand loads for single and groups of electric welders applying *NEC* requirements and demand factors where necessary.
- Part D, Light Industrial Calculations—Practice calculating service demand loads unique to various industrial buildings applying *NEC* requirements and demand factors where necessary.

NEC—Practice Exam

- Complete the Module II (100 question) Practice Exam as a timed exam using only the *NEC* to answer the questions.

OSHA Construction Safety Handbook

- Demonstrate advanced knowledge of construction safety in preparation for obtaining an OSHA 10 certification.

Journeyman Review and Exams—Part I

Electrical Theory—Review

- Demonstrate as second nature, common knowledge of the concepts of basic electrical theory and Ohm's Law calculations, to the extent of correctly answering questions that may appear on a licensing exam.

Journeyman Review and Exams—Part 2

Electrical Theory

- Successfully pass the theory section of the Journeyman Practice Exam within the program completion requirements.

National Electrical Code—Review and Exam

- Review all material pertaining to understanding the *NEC* to prepare for the *Journeyman Practice Exam*.
- Successfully pass the *Code* section of the *Journeyman Practice Exam* within the program completion requirements.

Journeyman Review and Exams—Part 3

Electrical Calculations—Review

- Demonstrate an advanced ability to complete all calculations that may be required to correctly answer questions that may appear on a Journeyman Licensing Exam.

Electrical Calculations—Part 3 Exam

- Successfully pass the calculations section of the *Journeyman Practice Exam* within the program completion requirements.

Exams Review

- Review the graded exams.
- Identify and focus upon any weaknesses that may have impeded students' ability to take and pass a timed Journeyman Licensing Exam.