Mike Holt's

ELECTRICAL APPRENTICESHIP PROGRAM

Based on the 2020 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 2020 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* 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. In the latter part of Level 1, students will be introduced to, and begin utilizing, the *National Electrical Code*.

Level 2 Level 2 continues the study of OSHA's construction safety rules and then 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, Chapter 4 of the *NEC*, and common industrial applications, methods, and requirements. While motors and controls are the major focus area, hazardous locations, special applications, and Solar (PV) Photovoltaic and Energy Storage Systems, are also introduced.

Level 4 Level 4 of the program covers advanced *Code* calculations in great detail. Electrical estimating is covered as well as a review of electrical theory and motor controls. Additional OSHA construction safety rules will also be covered.

The anticipated hours of study for the 2020 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 of 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 here and empathize with your students. 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 to not 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.

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

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!

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.

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®.

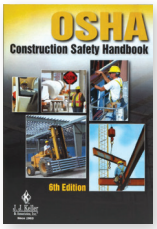
Textbook Questions. Our textbooks contain review questions and exams designed to reinforce the learning process when the online testing tools aren't used. We encourage you to have your students complete the textbook tests before taking the online tests to further reinforce their learning process.

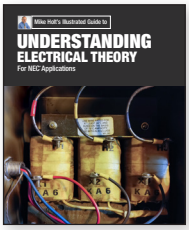
Online Testing. Our online testing program has been specifically designed to take advantage of today's blended or self-paced learning environments and reinforce the material that's been covered.

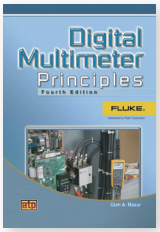
Books

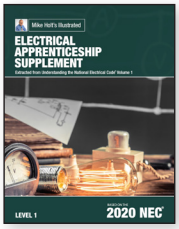
In Level 1, you'll be using the following books and we suggest you take a few moments to review the layout of each. Pay attention to the table of contents, the layout of the units and chapters, and the review questions.

- *OSHA Construction Safety Training Handbook, 6th Edition*
  J.J. Keller & Associates
  ISBN 978-1-60287-891-4, 2010
- *Mike Holt's Understanding Electrical Theory*
  Mike Holt Enterprises
  ISBN 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 Apprenticeship Supplement Level 1*
  Mike Holt Enterprises
  ISBN 978-1-950431-25-0, 2020









Suggested Additional Resources*

- *National Electrical Code, 2020 Edition*
  National Fire Protection Association
  ISBN 978-145592297-0, 2019

**Sold separately.*

LEVEL 1 LESSON PLANS–AT A GLANCE

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

Hours	Content
40-42	**Electrical Theory–Unit 10** *Basic Math*
43-45	**Electrical Theory–Unit 11** *Trigonometry*
46-48	**Electrical Theory–Units 12–13** *Ohm's Law, Watt's Law*
49-51	**Electrical Theory–Units 14–15** *Series and Parallel Circuits*
52-54	**Electrical Theory–Units 15–16** *Parallel and Series-Parallel Circuits*
55-57	**Electrical Theory–Units 17–19** *AC Fundamentals, Inductance, Capacitance*
58-60	**Electrical Theory–Unit 20** *True Power, Power Factor, and Apparent Power*
61-63	**Electrical Theory–Unit 20** *True Power, Power Factor, and Apparent Power*
64-66	**Electrical Theory–Unit 21** *Motors*
67-69	**Lab/Activity** *Instructor/Institution Choice*
70-72	**Flex Training** *Instructor/Institution Choice*
73-75	**Content Review**
76-78	**Content Exam**

Hours	Content
79-81	**Electrical Theory–Unit 22** *Generators*
82-84	**Electrical Theory–Unit 23** *Relays*
85-87	**Electrical Theory–Unit 24** *Transformers*
88-90	**Electrical Theory–Unit 25** *Overcurrent Protection*
91-93	**Electrical Theory–Unit 26** *GFCIs, GFPEs, AFCIs, AND SPDs*
94-96	**Electrical Theory–Unit 26** *GFCIs, GFPEs, AFCIs, AND SPDs*
97-99	**Electrical Theory–Unit 27** *Wire Resistance and Voltage Drop*
100-102	**Electrical Theory–Unit 28** *Multiwire Circuits*
103-105	**Electrical Theory–Unit 29** *The Formula Wheel*
106-108	**Lab/Activity** *Box Fill*
109-111	**Lab/Activity** *Box Fill*
112-114	**Content Review**
115-117	**Content Exam**

Hours	Content
118-120	**Apprenticeship Supplement** *How to Use the NEC (Video)*
121-123	**Apprenticeship Supplement** *Articles 90 and 100*
124-126	**Apprenticeship Supplement** *Article 110*
127-129	**AC/DC Fundamentals** *Review*
130-132	**Apprenticeship Supplement** *Grounding and Bonding*
133-135	**Apprenticeship Supplement** *Grounding and Bonding*
136-138	**Apprenticeship Supplement** *Grounding and Bonding*
139-141	**Lab/Activity** *Conductor Ampacity*
142-144	**Lab/Activity** *Conductor Ampacity*
145-147	**Content Review**
148-150	**Content Exam**
151-153	**Level 1 Review**
154-156	**Level 1 Final 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 (HOURS 1–39)

At the completion of the following content, students should be able to:

OSHA–Construction Safety

- 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 and how to mitigate these hazards.
- 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 chemical bonding is and how it can change the electrical characteristic of an atom.
- Explain how the negative charge of electron movement participates in the creation of electricity.
- Describe the differences between conductors, semiconductors, and insulators.
- Explain what makes a good conductor and why.

Unit 3–Electrical Circuits and Power Sources

- Define what an electrical circuit is.
- Describe what components makeup an electrical circuit.
- 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 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 what electric shock/electrocution are.
- 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.

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.

Level 1, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

LEVEL 1 (HOURS 40–78)

At the completion of the following content, students should be able to:

Understanding Electrical Theory–Units 10–21

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 circuit.
- 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 circuit.
- 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.
- Perform calculations involving 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 what is meant by “induction” and explain its various types.
- Explain the electrical characteristics of induction.
- 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.

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.

Level 1, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

LEVEL 1 (HOURS 79–117)

At the completion of the following content, students should be able to:

Understanding Electrical Theory–Units 14–22

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.

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.

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.

Level 1, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

LEVEL 1 (HOURS 118–156)

At the completion of the following content, students should be able to:

Apprenticeship Supplement–Introduction to the *National Electrical Code*

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 100–Definitions

- Explain and comprehend the importance of understanding the language and terminology of the *Code* and the meaning of the terms contained within the *NEC*'s Article 100–Definitions.

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.

AC/DC Fundamentals–Review

- Review and demonstrate retained knowledge specific to alternating and direct currents covered in Level 1, *Understanding Electrical Theory*.

Apprenticeship Supplement–Grounding and Bonding

- Describe the scope of *NEC* Article 250–Grounding and Bonding.
- Identify and apply the *Code* rules for grounding and bonding connections and their protection from physical damage.
- Explain the importance of "clean surfaces" where a bonding or grounding connection is made.
- Identify and apply the *Code* rules pertaining to a "Grounding Electrode System."
- List various types of grounding electrodes permitted by the *Code*.
- Describe the installation requirements for grounding electrodes.
- Explain the importance of a reliable connection to an "effective ground-fault current path."
- Identify and apply the *Code* requirements for various types of equipment grounding conductors (EGC) and their terminations.

Level 1, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

Level 1, Final Exam

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

LEVEL 2 OUTLINE

LEVEL 2 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.

Videos

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Labs/Activities

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!

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.

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®.

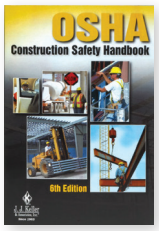
Textbook Questions. Our textbooks contain review questions and exams designed to reinforce the learning process when the online testing tools aren't used. We encourage you to have your students complete the textbook tests before taking the online tests to further reinforce their learning process.

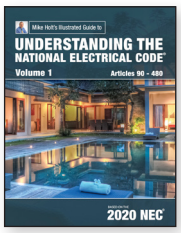
Online Testing. Our online testing program has been specifically designed to take advantage of today's blended or self-paced learning environments and reinforce the material that's been covered.

Books

In Level 2, 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.

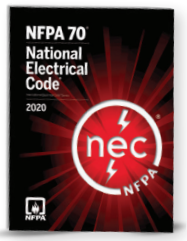
- *OSHA Construction Safety Training Handbook, 6th Edition*
  J.J. Keller & Associates,
  ISBN 978-1-60287-891-4, 2010
- *Mike Holt's Understanding the National Electrical Code, Volume 1*
  Mike Holt Enterprises
  ISBN 978-1-950431-07-6, 2020





Suggested Additional Resources*

- *National Electrical Code, 2020 Edition*
  National Fire Protection Association
  ISBN 978-145592297-0, 2019



**Sold separately.*

LEVEL 2 LESSON PLANS–AT A GLANCE

Hours	Content
1-3	**Introduction | Orientation | Tool Safety** *Level 2*
4-6	**OSHA Construction Safety** *Electrical Safety and PPE*
7-9	**OSHA Construction Safety** *Confined Space, Emergency Response, and Lockout/Tagout*
10-12	***NEC*–Article 90** *Introduction*
13-15	***NEC*–Article 100** *Definitions*
16-18	***NEC*–Article 110** *Requirements for Electrical Installations 1*
19-21	***NEC*–Article 110** *Requirements for Electrical Installations 2*
22-24	***NEC*–Article 200** *Use and Identification of Grounded [Neutral] Conductors*
25-27	***NEC*–Article 210** *Branch Circuits 1*
28-30	***NEC*–Article 210** *Branch Circuits 2*
31-33	***NEC*–Article 210** *Branch Circuits 3*
34-36	**Content Review**
37-39	**Content Exam**

Hours	Content
40-42	***NEC*–Article 215** *Feeders*
43-45	***NEC*–Article 220** *Branch-Circuit, Feeder, and Service Calculations 1*
46-48	***NEC*–Article 220** *Branch-Circuit, Feeder, and Service Calculations 2*
49-51	***NEC*–Article 225** *Outside Branch Circuits and Feeders*
52-54	***NEC*–Article 230** *Services 1*
55-57	***NEC*–Article 230** *Services 2*
58-60	***NEC*–Article 240** *Overcurrent Protection 1*
61-63	***NEC*–Article 240** *Overcurrent Protection 2*
64-66	***NEC*–Article 250** *Grounding and Bonding*
67-69	**Lab** *GFCI Devices*
70-72	**Flex Training** *Institution/Instructor Choice*
73-75	**Content Review**
76-78	**Content Exam**

Hours	Content
79-81	***NEC*–Article 242** *Surge-Protective Devices (SPDs)*
82-84	***NEC*–Article 300** *General Requirements for Wiring Methods and Materials 1*
85-87	***NEC*–Article 300** *General Requirements for Wiring Methods and Materials 2*
88-90	***NEC*–Article 310** *Conductors for General Wiring 1*
91-93	***NEC*–Article 310** *Conductors for General Wiring 2*
94-96	***NEC*–Article 312** *Cabinets, Cutout Boxes, and Meter Socket Enclosures*
97-99	***NEC*–Article 314** *Outlet, Device, Pull, and Junction Boxes; Conduit Bodies; and Handhole Enclosures 1*
100-102	***NEC*–Article 314** *Outlet, Device, Pull, and Junction Boxes; Conduit Bodies; and Handhole Enclosures 2*
103-105	***NEC*–Articles 320 and 330** *Armored Cable (Type AC) and Metal-Clad Cable (Type MC)*
106-108	**Lab/Activity** *Voltage-Drop Calculations*
109-111	**Flex Training** *Institution/Instructor Choice*
112-114	**Content Review**
115-117	**Content Exam**

Hours	Content
118-120	***NEC*–Articles 334, 336, and 338** *Cables Types, NM, NMC, TC, SE, and USE)*
121-123	***NEC*–Articles 340, 342, and 348** *Cable Type UF, Conduits Types, IMC and FMC*
124-126	***NEC*–Articles 350, 352, and 356** *Conduits Types LFMC, PVC, and LFNC*
127-129	***NEC*–Articles 344 and 358** *Conduits Types, RMC and EMT*
130-132	***NEC*–Articles 362 and 376** *Conduit Type ENT and Metal Wireways*
133-135	***NEC*–Articles 380, 386, and 392** *Multioutlet Assemblies, Surface Metal Raceways, and Cable Trays*
136-138	**Lab/Activity** *Conduit Bending*
139-141	**Lab/Activity** *Raceway Sizing Calculations*
142-144	**Flex Training** *Institution/Instructor Choice*
145-147	**Content Review**
148-150	**Content Exam**
151-153	**Level 2 Review**
154-156	**Level 2 Final 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 (HOURS 1–39)

At the completion of the following content, students should be able to:

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.

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.

Understanding the *National Electrical Code*, Volume 1

Article 90–Introduction

- Explain the intent and purpose of the *NEC.*
- List what is and is not covered by the rules in the *NEC.*
- List the general articles and how they can be modified by other articles relative to Chapters 1–4.
- Identify key words that identify mandatory and permissive rules.

Article 100–Definitions

- Explain and comprehend the importance of understanding the language and terminology of the *Code* and the meaning of the terms contained within the *NEC*'s Article 100–Definitions.
- Identify and apply more common definitions from memory.

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 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 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.

Level 2, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

LEVEL 2 (HOURS 40–78)

At the completion of the following content, students should be able to:

Understanding the *National Electrical Code*, Volume 1

Article 215–Feeders

- Discuss the requirements for the installation of feeders and calculate their ampacities.
- Discuss the requirements for calculating the required sizes for branch circuits, feeders, and services. Accurately determine the mandatory number of branch circuits and the required number of receptacles on each.
- 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 220–Branch-Circuit, Feeder, and Service 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.

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.

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 250–Grounding and Bonding

- Demonstrate a thorough understanding of the terminology used throughout Article 250.
- Define what is meant by the "bonding" of electrical equipment.
- Define what is meant by "grounding" an electrical system.
- Explain the significance of distinguishing between grounding and bonding.
- Apply the grounding requirements for providing a path to the Earth to reduce overvoltage from lightning.
- Define an "effective ground-fault current path."
- Explain the bonding requirements necessary to maintain a low-impedance fault current path necessary to facilitate the operation of overcurrent protective devices in the event of a ground fault.
- Identify and apply the requirements for the installation of a grounding electrode.
- Correctly size the grounding electrode conductor (GEC) for a separately derived system.
- Identify and apply the rules for equipment grounding and equipment grounding conductors.
- Correctly size an equipment grounding conductor for a given application.

Level 2, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

LEVEL 2 (HOURS 79–117)

At the completion of the following content, students should be able to:

Understanding the *National Electrical Code*, Volume 1

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 how each is rated.
- 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 limitations and the letter designators used for the identification of these limitations.
- Select the appropriate conductor ampacity for a single-family dwelling service or feeder.
- Demonstrate proficiency in determining conductor ampacity subject to correction or adjustment–or both.
- Identify and apply correct conductors sizes based on the Ampacity Table 310.16.

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 through 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.

Level 2, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

LEVEL 2 (HOURS 118–156)

At the completion of the following content, students should be able to:

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, securing, supporting, and protection of various raceways.

Level 2, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

Level 2, Final Exam

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

LEVEL 3 OUTLINE

LEVEL 3 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.

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

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!

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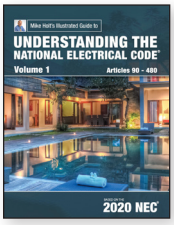
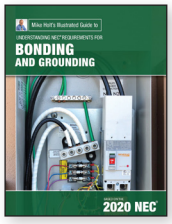
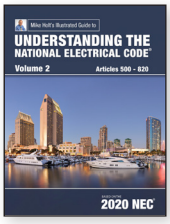
Books

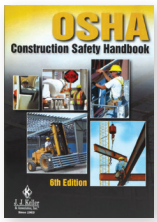
You'll be using the following books or textbooks and we suggest you take a few moments to review the layout of each. Pay attention to the table of contents, the layout of the units and chapters, and the review questions.

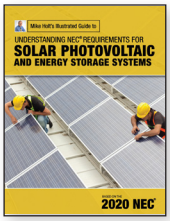
- *Mike Holt's Understanding the National Electrical Code, Volume 1*
  Mike Holt Enterprises
  ISBN 978-1-950431-07-6, 2020
- *Mike Holt's Understanding NEC Requirements for Bonding and Grounding*
  Mike Holt Enterprises
  ISBN 978-1-950431-03-8, 2020
- *Mike Holt's Understanding the National Electrical Code, Volume 2*
  Mike Holt Enterprises
  ISBN 978-1-950431-08-3, 2020
- *OSHA Construction Safety Training Handbook, 6th Edition*
  J.J. Keller & Associates,
  ISBN 978-1-60287-891-4, 2010
- *Mike Holt's Understanding NEC Requirements for Solar Photovoltaic (PV) and Energy Storage Systems*
  Mike Holt Enterprises
  ISBN 978-1-950431-05-2, 2020
- *Mike Holt's Understanding Basic Motor Controls*
  Mike Holt Enterprises
  ISBN 978-0-9992038-4-2, Revised Edition





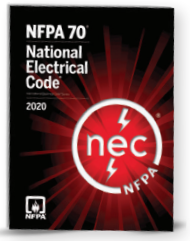






Suggested Additional Resources*

- *National Electrical Code, 2020 Edition*
  National Fire Protection Association
  ISBN 978-145592297-0, 2019



**Sold separately.*

LEVEL 3 LESSON PLANS–AT A GLANCE

Hours	Content
1-3	**Introduction | Orientation | Tool Safety** *Level 3*
4-6	**OSHA Construction Safety** *Electrical Safety and PPE*
7-9	**OSHA Construction Safety** *Excavation/Motor Vehicles/Tool Safety*
10-12	***NEC*–Articles 400 and 402** *Flexible Cords and Cables, and Fixture Wires*
13-15	***NEC*–Articles 404 and 406** *Switches and Receptacles*
16-18	***NEC*–Article 408** *Switchboards, Switchgear, and Panelboards*
19-21	***NEC*–Articles 410 and 411** *Luminaires and Low-Voltage Lighting Systems*
22-24	***NEC*–Article 422** *Appliances*
25-27	***NEC*–Article 424** *Fixed Electric Space-Heating Equipment*
28-30	***NEC*–Article 430** *Motors, Motor Circuits, and Controllers 1*
31-33	***NEC*–Article 430** *Motors, Motor Circuits, and Controllers 2*
34-36	**Content Review**
37-39	**Content Exam**

Hours	Content
40-42	**Lab/Activity** *Lighting–Ballasts and Transformers*
43-45	***NEC*–Articles 440, 445, and 450** *Air-Conditioning/Refrigeration Equipment and Transformers*
46-48	**Bonding and Grounding–Fundamentals** *Units 1, 2, 3, and 4*
49-51	**Bonding and Grounding–*NEC*** *Articles, 90, 100, and 110*
52-54	**Bonding and Grounding–*NEC*** *Article 250*
55-57	**Bonding and Grounding–*NEC*** *Article 250*
58-60	**Bonding and Grounding–*NEC*** *Article 250*
61-63	***NEC*–Articles 500-503, 511, and 514** *Hazardous Locations, Commercial Garages, and Motor Fuel Dispensing*
64-66	***NEC*–Articles 517, 518, 550, and 590** *Health Care Facilities, Assembly Occupancies, Mobile/Manufactured Homes, and Temporary Installations*
67-69	***NEC*–Articles 600, 604, and 620** *Electric Signs, Manufactured Wiring Systems, and Elevators*
70-72	**Flex Training** *Institution/Instructor Choice*
73-75	**Content Review**
76-78	**Content Exam**

Hours	Content
79-81	***NEC*–Articles 625 and 630** *Electric Vehicle Charging System and Electric Welders*
82-84	***NEC*–Articles 640 and 645** *Audio Signal Processing and Information Technology Equipment*
85-87	***NEC*–Article 680** *Swimming Pools, Spas, Hot Tubs, Fountains, and Similar Installations*
88-90	***NEC*–Articles 700, 701, and 702** *Emergency, Legally Required, and Optional Standby Systems*
91-93	***NEC*–Article 725** *Remote-Control, Signaling, and Power-Limited Circuits*
94-96	***NEC*–Articles 760, 770, 800, 805, 810, and 820** *Fire Alarm Systems, Optical Fiber Cables and Raceways, Communications Circuits, Radio and Television Equipment, and CATV and Radio Distribution Systems.*
97-99	***NEC*–Article 690** *Solar Photovoltaic (PV) Systems 1*
100-102	***NEC*–Article 690** *Solar Photovoltaic (PV) Systems 2*
103-105	***NEC*–Articles 480, 691, and 705** *Storage Batteries, Large-Scale Solar Photovoltaic (PV) Electric Supply Stations, and Interconnected Electric Power Production Sources (IEPPS)*
106-108	***NEC*–Articles 705 and 706** *Interconnected Electric Power Production Sources (IEPPS) and Energy Storage Systems*
109-111	***NEC*–Articles 706 and 710** *Energy Storage and Stand-Alone Systems*
112-114	**Content Review**
115-117	**Content Exam**

Hours	Content
118-120	**Motor Controls–Units 1–3** *Introduction to Motor Controls*
121-123	**Motor Controls– Units 4–8** *Motor Controls and Schematics 1*
124-126	**Motor Controls–Units 9–10** *Motor Controls and Schematics 2*
127-129	**Motor Controls– Units 11–12** *Reversing Controls 1*
130-132	**Motor Controls–Units 13–14** *Reversing Controls 2*
133-135	**Motor Controls–Units 15–16** *Controls for Multiple Motors*
136-138	**Motor Controls–Units 17–20** *Miscellaneous Requirements*
139-141	**Lab/Activity** *Instructor/Institution Choice*
142-144	**Flex Training** *Institution/Instructor Choice*
145-147	**Content Review**
148-150	**Content Exam**
151-153	**Level 3 Review**
154-156	**Level 3 Final 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 (HOURS 1–39)

At the completion of the following content, students should be able to:

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.

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 402–Fixture Wires

- Demonstrate the ability to properly select fixture wires for a given ampacity.
- List where the use of fixture wires is permitted.

Article 404–Switches

- Explain the primary function of a 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.
- Demonstrate the proper switch connections for 3- and 4-way switches.
- Identify and apply the acceptable methods for the bonding of metal switch plates or covers.

Article 406–Receptacles

- 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, Switchgear, and Panelboards

- Define the terms, "switchboard," "switchgear," 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.

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

- Describe the requirements that cover fixed electric equipment used for space heating.
- Recognize that heating equipment includes heating cable, unit heaters, boilers, central systems, and other fixed electric space-heating equipment.
- Understand that Article 424 does not apply to process heating and room air-conditioning.

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.
- Competently calculate the minimum conductor required, maximum overload protection rating, and maximum branch-circuit OCPD ratings for motor branch circuits.
- Competently calculate maximum OCPD for motor feeders.

Level 3, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

LEVEL 3 (HOURS 40–78)

At the completion of the following content, students should be able to:

Understanding the *National Electrical Code*, Volume 1

Article 440–Air Conditioning and Refrigeration Equipment

- Describe the requirements pertaining to electrically driven air-conditioning and refrigeration equipment with motorized hermetic refrigerant motor compressors.
- Demonstrate the ability to size the appropriate conductors based on the equipment demand load.
- Determine the equipment overcurrent protection as required.
- Identify and apply the branch circuit requirements pertaining to “room” air conditioners.

Article 445–Generators

- Outline the electrical installation requirements for generators and other requirements such as where they can be installed, their nameplate markings, conductor ampacity, and disconnecting means.

Article 450–Transformers

- Explain the general requirements for the installation of transformers, calculating overcurrent protection, and when it is necessary.
- Identify and apply the requirements for transformer primary and secondary overcurrent protection.

Bonding and Grounding–Fundamentals

Unit 1–Matter

- 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 and how to mitigate these hazards.
- 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

- Exhibit an understanding of electron theory.
- Describe the relationship between electrons and protons.
- Explain the characteristics of electrons relative to conductive and insulative properties of an element.
- Explain what makes a good conductor and why.

Unit 3–Sources, Uses, and Dangers of Electricity

- List common sources of electrical power.
- Describe electrical current flow.
- Describe how photoelectricity is produced in a PV system.
- List the dangers inherent with the use of electricity.
- Explain the intent of the *NEC* with regard to the use of electricity.

Unit 4–Circuit Protective Devices

- 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 difference between overload and fault current protection.
- Explain the importance of ground-fault circuit interrupter (GFCI) protection.
- Describe the conditions that will cause a GFCI device to function.
- Describe the importance of how to confirm a GFCI device is properly functioning.

Bonding and Grounding–*NEC*

Article 90–Introduction to the *National Electrical Code*

- Explain the intent and purpose of the *NEC.*
- List what is and is not covered by the rules in the *NEC.*
- Understand the arrangement of the *NEC.*
- Explain by whom and how the rules in the *NEC* are enforced.
- Identify key words that identify mandatory and permissive rules.

Chapter 1–General Rules

- Explain and comprehend the importance of understanding the language and terminology of the *Code* and the meaning of the terms contained within the *NEC*'s Article 100–Definitions.
- Reference and apply the *Code* rules for the examination, identification, installation, use, and product listing (certification) of equipment.
- Describe the rules regarding conductor material.
- List the standards that express conductor sizes.
- List and describe the effects of deteriorating agents, and the rules that apply to wiring methods in these environments.
- Identify and apply the rules for conductor splicing.
- Thoroughly explain and apply the rules relating to conductor material and terminations, and electrical connections with regard to temperature limitations and proper torquing.

Bonding and Grounding–Article 250

Part I–General Requirements

- Demonstrate a thorough understanding of the terminology used throughout Article 250.
- Define what is meant by the "bonding" of electrical equipment.
- Define what is meant by "grounding" an electrical system.
- Explain the significance of distinguishing 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 what components of an electrical system must be connected together to maintain electrical continuity.
- Explain the importance of ensuring the electrical continuity of all noncurrent-carrying metal parts of an electrical system.
- Describe how Earth grounding does not remove touch potential and why this is such a dangerous misconception.
- Apply the grounding requirements for providing a path to the Earth to reduce overvoltage from lightning, and the bonding requirements for the low-impedance fault current path necessary to facilitate the operation of overcurrent protective devices in the event of a ground fault.

Part II–System Grounding and Bonding

- Explain what is meant by an "ungrounded system" and why such systems must be grounded.
- 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.
- Apply the surface contact requirements for effective grounding and/or bonding connections.
- Identify (ac) systems that are required to be grounded.
- 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 service or feeder neutral must be insulated and why.
- Describe the requirements for bonding and grounding at the supply side of the service disconnect.
- Define a "separately derived system."
- Explain the bonding and grounding requirements for a separately derived system.
- 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) for a separately derived system.
- Define both a "common grounding electrode" and "common grounding electrode conductor."
- Explain the rules for grounding relative to buildings supplied by a feeder.
- Distinguish between, and describe the intent of, a GEC and an equipment grounding conductor (EGC).
- Explain the rules for the grounding of generators.
- Define a "high-impedance (or high-resistance) system" and explain the rules for grounding of such systems.
- Explain what is meant by a "grounding electrode system."
- List various types of grounding electrodes and explain what may be used as a grounding electrode.
- Apply the requirements for the installation of, and connections to, various type of grounding electrode conductors.
- Apply the requirements for supplemental ground rods.
- Define an "auxiliary grounding electrode."
- Identify and apply the requirements for grounding electrode conductors and their installation.
- Demonstrate the ability to correctly size grounding electrode conductors.
- Identify fittings listed for grounding electrode conductor terminations.

Part IV–Enclosure, Raceway, and Service Cable Connections

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

Part V–Bonding for Fault Current

- 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–Methods of 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
  - receptacle grounding terminals
  - continuity and attachment to metal boxes

Understanding the *National Electrical Code*, Volume 2

Articles 500–503–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 511.

Article 517–Health Care Facilities

- Apply 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 550–Mobile Home, Manufactured Homes, and Mobile Home Parks

- Outline the *NEC* requirements for the installation of electrical conductors and equipment within or on mobile and manufactured homes, conductors that connect mobile and manufactured homes to the electrical supply, and the installation of electrical wiring, luminaires, and electrical equipment in or on mobile and manufactured homes.

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.

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.

Level 3, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

LEVEL 3 (HOURS 79–117)

At the completion of the following content, students should be able to:

Understanding the *National Electrical Code*, Volume 2

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 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 640–Audio Signal Processing

- Explain the *NEC* requirements that apply to equipment and wiring for audio signal generation, recording, processing, amplification and reproduction, distribution of sound, public address, speech input systems, temporary audio system installations, and electronic musical instruments such as electric organs, electric guitars, and electronic drums/percussion.

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 695–Fire Pumps

- Recite the wiring considerations specific to the reliable operation of fire pumps.
- Explain the *NEC* rules as they apply to the electric power sources and interconnecting circuits for electric motor-driven fire pumps and switching and control equipment dedicated to fire pump drivers.

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.
- List who might determine that a standby system is legally required.
- Apply the Article 701 requirements when connecting such systems.

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 legally required and optional standby systems.
- Apply the Article 702 requirements when connecting such systems.

Article 725–Remote-Control, Signaling, and Power-Limited Circuits

- Identify and apply the *NEC* requirements for remote-control, signaling, and power-limited circuits that are not an integral part of a device or appliance.
- Define a "remote-control circuit" as a circuit that controls others through a relay or solid-state device.
- Define a "signaling circuit" as a circuit that supplies energy to an appliance or device that gives a visual and audible signal. List examples of signaling circuits.

Article 760–Fire Alarm Systems

- Identify and apply the *Code* requirements for the installation of wiring and equipment for fire alarm systems.
- Explain that these requirements apply to fire detection and alarm notification, voice communications, guard's tour, sprinkler waterflow, and sprinkler supervisory systems.

Article 770–Optical Fiber Cables and Raceways

- List and define the various types of optical fiber cables. Identify and apply the *NEC* requirements for the installation of optical fiber cables.
- Explain that optical fiber cables are those cables that transmit signals using light for control, signaling, and communications.
- Identify and apply the installation requirements for raceways that contain optical fiber cables, and the rules for composite cables (often called "hybrid" cables in the field) that combine optical fibers with current-carrying metallic conductors.

Article 800–Communications Systems

- List and describe the general requirements for the installation of communications systems.
- Explain that these requirements can be modified by Articles 805 or 820.
- Describe how these communications circuits fit into the premises electrical grounding system.
- List and describe the installation requirements for communications circuits and equipment related to telephone wiring and other telecommunications purposes such as computer local area networks (LANs) and outside wiring for fire and burglar alarm systems connected to central monitoring stations.
- Describe how these communications systems fit into the premises electrical grounding system.

Article 805–General Requirements For Communications Systems

- List and describe the installation requirements for communications circuits and equipment related to telephone wiring and other telecommunications purposes such as computer local area networks (LANs) and outside wiring for fire and burglar alarm systems connected to central monitoring stations.
- Describe how these communications systems fit into the premises electrical grounding system.

Article 810–Radio and Television Antenna Equipment

- Identify the requirements that apply to antenna systems for radio and television receiving equipment, amateur radio transmitting and receiving equipment, and certain features of transmitter safety.
- Explain that these requirements also include antennas such as multi-element, vertical rod and dish, and the wiring and cabling that connects them to the equipment.
- Describe how these different components fit into the premises electrical grounding system.

Article 820–CATV Radio Distribution Systems (Coaxial Cable)

- Identify the requirements that apply to the installation of coaxial cables that distribute limited-energy high-frequency signals for television, cable TV, and closed-circuit television (CCTV) which is often used for security purposes.
- Explain that these requirements also apply to the premises wiring of satellite TV systems where the dish antenna is outside and covered by Article 810.
- Describe how these cable systems fit into the premises electrical grounding system.

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 480–Storage Batteries

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

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 solar or wind turbines) that run in parallel with a primary utility source and need particular consideration and requirements.
- Apply the *NEC* requirements when connecting such systems.

Article 706–Energy Storage Systems

- Explain that energy storage systems (ESS) can be (and usually are) connected to other energy sources, such as the local utility distribution system and that there can be more than one source of power connected to an ESS.
- Identify the requirements of Article 705 which covers installation of one or more interconnected electric power production sources operating in parallel with a utility source of electricity.
- Confirm how Article 706 correlates with other articles in the *Code* such as Articles 480, 690, 692, and 694.

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.

Level 3, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

LEVEL 3 (HOURS 118–156)

At the completion of the following content, students should be able to:

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 120V 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 and apply the *Code* rules for motor control circuits that are tapped from motor power supply circuits in accordance with Article 725. Demonstrate the ability to correctly select conductor sizes, control transformers, and fuses. Explain the *NEC* requirements for motor control circuits that involve fire pump motors and why they are less stringent.
- Explain some of the uses for pilot (indicator) lights and illuminated pushbuttons in motor control circuits. Describe the purposes of various types and colors of lamps, typical applications of pilot lights and illuminated pushbuttons, symbols used on wiring diagrams, and the "push-to-test" safety application.
- 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. Explain how a selector switch can be used on a 3-wire control circuit in a jogging (inching) application.
- 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. Explain that reversing motor controls are basically a variation of 3-wire control circuits, even though they may have four or five conductors. Describe how combining mechanical interlocking with electrical interlocking provides a greater degree of safety by reducing the possibility of phase-to-phase shorts.
- Explain how pilot (indicator) lights are used with reversing controls for three-phase motors. Outline a motor reversing control circuit to include, control schematics, motor starter auxiliary contacts, and the additional conductors needed to add pilot (indicator) lights for these circuits.
- Explain the use of limit switches in reversing motor control circuits, control schematics, and the wiring of pushbutton stations. Describe the use of microswitches for control applications such as raising and lowering garage doors. Draw a simple reversing control schematic using 2-wire circuits.
- Explain reversing controls for single-phase motors making the important point that manufacturer's instructions should always be followed when reversing single-phase motors. Recognize that there are variations in making the connections, and that dual-voltage motors, or those from different manufacturers or different countries, may not use the same schemes for identifying the motor leads.

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.

Level 3, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

Level 3, Final Exam

- Successfully pass the Level 3 Final 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.

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

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!

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.

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®.

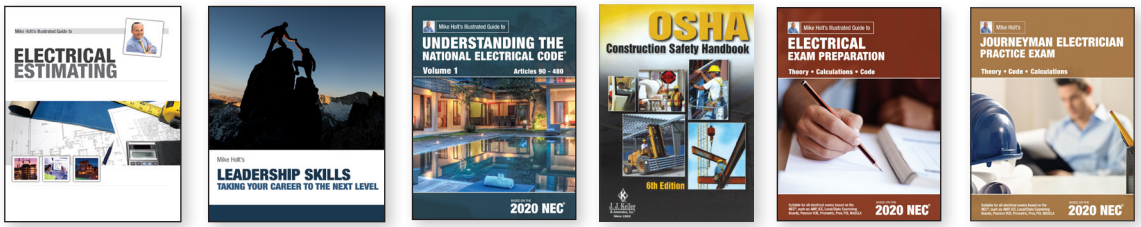
Textbook Questions. Our textbooks contain review questions and exams designed to reinforce the learning process when the online testing tools aren't used. We encourage you to have your students complete the textbook tests before taking the online tests to further reinforce their learning process.

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

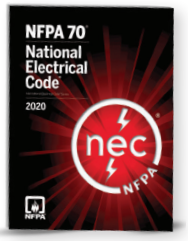
You'll be using the following books or textbooks and we suggest you take a few moments to review the layout of each. Pay attention to the table of contents, the layout of the units/chapters, and the review questions.

- *Mike Holt's Guide to Electrical Estimating, 2nd Edition*
  Mike Holt Enterprises
  ISBN 978-1-932685-50-3, 2012
- *Mike Holt's Leadership Skills*
  Mike Holt Enterprises
  ISBN 978-0-9975452-2-7, 2016
- *Mike Holt's Understanding the National Electrical Code, Volume 1*
  Mike Holt Enterprises
  ISBN 978-1-950431-07-6, 2020
- *OSHA Construction Safety Training Handbook, 6th Edition*
  J.J. Keller & Associates,
  ISBN 978-1-60287-891-4, 2010
- *Mike Holt's Guide to Electrical Exam Preparation*
  Mike Holt Enterprises
  ISBN 978-0-9992038-7-3, 2020
- *Mike Holt's Journeyman Practice Exam*
  Mike Holt Enterprises
  ISBN 978-0-9992038-8-0, 2020



Suggested Additional Resources*

- *National Electrical Code, 2020 Edition*
  National Fire Protection Association
  ISBN 978-145592297-0, 2019



**Sold separately.*

LEVEL 4 LESSON PLANS–AT A GLANCE

Hours	Content
1-3	**Introduction | Orientation | Tool Safety** *Level 4*
4-6	**OSHA Construction Safety** *Electrical Safety and PPE*
7-9	**OSHA Construction Safety** *Hazard Communication/Jobsite Exposures/ Work Zone Safety*
10-12	**Electrical Estimating–Chapters 1 and 2** *Introduction and About Estimating*
13-15	**Electrical Estimating–Chapter 3** *Understanding Labor Units*
16-18	**Electrical Estimating–Chapter 4** *The Estimating Process*
19-21	**Electrical Estimating–Chapter 5** *Determining Break-Even Cost*
22-24	**Electrical Estimating–Chapters 6 and 7** *The Bid Process and Unit Pricing*
25-27	**Lab/Activity** *Blueprint Takeoff*
28-30	**Leadership Training, Part 1** *Leadership Skills*
31-33	**Leadership Training, Part 2** *Leadership Skills*
34-36	**Content Review**
37-39	**Content Exam**

Hours	Content
40-42	***Code* Review** *Articles 90 through 110 and 200 through 240*
43-45	***Code* Review** *Articles 300 through 314*
46-48	***Code* Review** *Articles 400 through 480*
49-51	**Fundamentals Review–Unit 1** *Electrician's Math and Basic Electrical Formulas*
52-54	**Fundamentals Review–Unit 2** *Series, Parallel, and Multiwire Circuits*
55-57	**Fundamentals Review–Unit 3** *Understanding Alternating Current*
58-60	**Fundamentals Review–Unit 4** *Motor Basics*
61-63	**Fundamentals Review–Unit 4** *Transformers*
64-66	**Fundamentals Final Review** *Units 1–4*
67-69	**Flex Training** *Institution/Instructor Choice*
70-72	***NEC* Calculations–Unit 5** *Raceway and Box Calculations*
73-75	**Content Review**
76-78	**Content Exam**

Hours	Content
79-81	***NEC*** **Calculations–Unit 6, Part A** *Conductor Sizing and Protection Calculations 1*
82-84	***NEC*** **Calculations–Unit 6, Part B** *Conductor Sizing and Protection Calculations 2*
85-87	***NEC*** **Calculations–Unit 7, Parts A and B** *Motor and Air-Conditioning Calculations 1*
88-90	***NEC*** **Calculations–Unit 7, Parts B and C** *Air-Conditioning Calculations–Transformers 2*
91-93	***NEC*** **Calculations–Unit 8, Parts A and B** *Voltage-Drop Calculations*
94-96	***NEC*** **Calculations–Unit 9, Parts A and B** *Dwelling Unit Calculations 1*
97-99	***NEC*** **Calculations–Unit 9, Parts B and C** *Dwelling Unit Calculations 2*
100-102	**Lab/Activity** *Dwelling Unit Calculations*
103-105	***NEC*** **Calculations–Unit 10, Parts A and B** *Multifamily Dwelling Calculations 1*
106-108	***NEC*** **Calculations–Unit 10 Parts B and C** *Multifamily Dwelling Calculations 2*
109-111	**Lab/Activity** *Fire Alarm Systems*
112-114	**Content Review**
115-117	**Content Exam**

Hours	Content
118-120	***NEC*** **Calculations–Unit 11, Parts A and B** *Commercial Calculations 1*
121-123	***NEC*** **Calculations–Unit 11, Parts B and C** *Commercial Calculations 2*
124-126	***NEC*** **Practice Quiz 16** *Sections 90.1–680.25*
127-129	***NEC*** **Practice Quiz 17** *Sections 680.26–701.12*
130-132	**OSHA Construction Safety Handbook** *Review safety rules and practices*
133-135	**Electrical Theory Review** *All Theory related material*
136-138	**Final Exam Part 1–Electrical Theory** *Journeyman Practice Exam, Electrical Theory*
139-141	***National Electrical Code*** *Review*
142-144	**Final Exam Part 2–*National Electrical Code*** *Journeyman Practice Exam, National Electrical Code*
145-147	**Electrical Calculations** *Review*
148-150	**Final Exam Part 3–Electrical Calculations** *Journeyman Practice Exam, Electrical Calculations*
151-153	**Final Exam** *Review Test Results and Questions*
154-156	**Final 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, 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 (HOURS 1–39)

At the completion of the following content, students should be able to:

Tool Safety

- Demonstrate complete knowledge in the safe and proper usage of various hand and power tools.

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

- Describe the differences between estimating and bidding.
- Develop an estimating system.
- Explain the objectives and purpose of an electrical contractor and some of the pitfalls contractors face.
- Describe the importance of proper job management and its effects on profit and loss.
- Outline how knowledge of the electrical market both locally, and in general, has a direct effect on job pricing and what role negotiating might play in determining the final price for a given project.

Chapter 2–About Estimating

- Describe the qualities of a good estimator and the role they play in overall project management.
- Describe various types of bids , bidding methodology, and outline the concept of the detailed estimate.
- List what goes into the accuracy of an estimate.
- Recognize the advantages and disadvantages of manual, software or using a service to produce an estimate.

Chapter 3–Labor Units

- Explain how work experience effects labor unit accuracy and help develop your own labor units.
- Determine labor units for various job components. Research and list some labor unit manuals.
- Explain what is, and what isn't, included in a labor unit.
- Describe the role labor units play in the competitive bidding process.
- List some variables that can affect labor units.

Chapter 4–The Estimating Process

- Explain how to determine whether a job or project is a good fit for submitting a proposal.
- List the steps involved in the preparation of an accurate estimate.

Chapter 5–Determining Break-Even Cost

- Define what is meant by the "break-even cost" of a job or project.
- Outline the steps necessary for determining the break-even cost of a job or project.
- Define "overhead" and the role it plays the estimating process, and how it's determined.

Chapter 6–The Bid Process

- List the benefits of an accurate bid and explain the concept of both a winning and losing bid.
- List some of the more common mistakes made when preparing a bid and explain the process and benefits of bid analysis.

Chapters 7–Unit Pricing

- Define "unit pricing" and explain its advantages and disadvantages.
- Outline an example of unit pricing.

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.

Level 4, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

LEVEL 4 (HOURS 40–78)

At the completion of the following content, students should be able to:

Code–Review

- Demonstrate and advanced ability to identify and apply *Code* requirements located throughout *NEC* Chapters 1–2.

Exam Preparation–Review

Understanding Electrical Theory–Review

- Review and commit to memory, the concepts of basic electrical theory and calculations using the Ohm's and Watt's Formula Wheel.

NEC–Calculations, Unit 5

- Demonstrate and advanced ability to identify and apply *Code* requirements relative to raceways, box fill, and box selection.

Level 4, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

LEVEL 4 (HOURS 79–117)

At the completion of the following content, students should be able to:

Exam Preparation

NEC–Calculations, Unit 6–10

- Demonstrate an advanced ability to identify and apply *Code* requirements for calculations relative to conductor sizing and protection.
- Demonstrate an advanced ability to identify and apply *Code* requirements for calculations relative to motors, air-conditioning equipment, and transformers.

- Demonstrate an advanced ability to identify and apply *Code* requirements for calculations relative to voltage drop.
- Demonstrate an advanced ability to identify and apply *Code* requirements for calculations relative to dwelling units.
- Demonstrate an advanced ability to identify and apply *Code* requirements for calculations relative to multifamily dwellings.

Level 4, Content Exam

- Successfully pass the covered content exam within the program completion requirements.

LEVEL 4 (HOURS 118–156)

At the completion of the following content, students should be able to:

Exam Preparation

NEC–Calculations, Unit 11

- Demonstrate and advanced ability to identify and apply *Code* requirements for calculations relative to commercial spaces.

NEC–Practice Quizzes

- Demonstrate an advanced ability to identify and apply *Code* requirements for questions.

OSHA Construction Safety Handbook

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

Review and Final Exams

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.

Electrical Theory–Part 1 Final Exam

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

Final Exams–Part 2

National Electrical Code–Review

- Confidently navigate the requirements of the *NEC* to the extent of correctly answering questions that may appear on a licensing exam.

National Electrical Code–Part 2 Final Exam

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

Final 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 Final Exam

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

Final Exams Review

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