2026

CTECS
CONNECTICUT TECHNICAL EDUCATION AND CAREER SYSTEM

# CTECS 9-12 Electrical Curriculum©

CTECS 9TH-12TH GRADE ELECTRICAL CURRICULUM©

CTECS: CIARLEGLIO, PASQUALE (CO)

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## CTECS Instructional Model

CTECS uses the Marzano Compendium to guide research-based instructional strategies that differentiate learning and promote access, engagement, and success for all students. Teachers apply these strategies to support diverse learners (including multilingual learners, students with disabilities, and students with varied academic or technical backgrounds) through scaffolds, modeling, guided practice, and multiple ways to participate and show understanding. This approach ensures every student can work toward proficiency in the Priority Standards and the competencies outlined in the CTECS Vision of a Graduate.

| Feedback | Content | Context |
|---|---|---|
| **Providing and Communicating Clear Learning Goals**<br>1. Providing scales and rubrics<br>2. Tracking student progress<br>3. Celebrating success<br>**Using Assessments**<br>4. Using informal assessments of the whole class<br>5. Using formal assessments of individual students | **Conducting Direct Instruction Lessons**<br>6. Chunking content<br>7. Processing content<br>8. Recording and representing content<br>**Conducting Practicing and Deepening Lessons**<br>9. Using structured practice sessions<br>10. Examining similarities and differences<br>11. Examining errors in reasoning<br>**Conducting Knowledge Application Lessons**<br>12. Engaging students in cognitively complex tasks<br>13. Providing resources and guidance<br>14. Generating and defending claims<br>**Using Strategies That Appear in All Types of Lessons**<br>15. Previewing strategies<br>16. Highlighting critical information<br>17. Reviewing content<br>18. Revising knowledge<br>19. Reflecting on learning<br>20. Assigning purposeful homework<br>21. Elaborating on information<br>22. Organizing students to interact | **Using Engagement Strategies**<br>23. Noticing and reacting when students are not engaged<br>24. Increasing response rates<br>25. Using physical movement<br>26. Maintaining a lively pace<br>27. Demonstrating intensity and enthusiasm<br>28. Presenting unusual information<br>29. Using friendly controversy<br>30. Using academic games<br>31. Providing opportunities for students to talk about themselves<br>32. Motivating and inspiring students<br>**Implementing Rules and Procedures**<br>33. Establishing rules and procedures<br>34. Organizing the physical layout of the classroom<br>35. Demonstrating withitness<br>36. Acknowledging adherence to rules and procedures<br>37. Acknowledging lack of adherence to rules and procedures<br>**Building Relationships**<br>38. Using verbal and nonverbal behaviors that indicate affection for students<br>39. Understanding students' backgrounds and interests<br>40. Displaying objectivity and control<br>**Communicating High Expectations**<br>41. Demonstrating value and respect for reluctant learners<br>42. Asking in-depth questions of reluctant learners<br>43. Probing incorrect answers with reluctant learners |

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## Curriculum Introduction

This curriculum document outlines the essential learning for this trade program and provides a clear structure for planning, instruction, and assessment. It includes the components required by NEASC Standard 2.2a, along with elements that reflect the unique nature of CTECS technical programs. The curriculum is organized to show what students learn in each course, how learning progresses across grade levels, and how instruction supports both technical skill development and the CTECS Vision of a Graduate.

Teachers should use this document to:

- Understand the overall structure and expectations of the course sequence
- Reference the Course Map to see the scope and sequence of Priority Standards and the alignment to District Summative Assessments (DSAs)
- Use the Priority Standards and Units of Study to guide daily, weekly, and cycle-based planning
- Integrate Big Ideas, Essential Questions, Skills/Learning Outcomes, vocabulary, and resources during lesson design
- Identify required safety, industry, and technical content expectations
- Plan and implement formative assessments to monitor progress and guide instruction
- Prepare students for the District Summative Assessments, ensuring alignment with the Course Map
- Maintain consistency of technical and professional practice instruction across campuses while adapting to student needs and industry-based opportunities

## Curriculum Components

### Course Map

A Course Map serves as the scope and sequence for this course by outlining the progression of instructional units and the standards that guide teaching and assessment. While each campus will have individual student needs, cycle schedules, and industry-based opportunities, all instructors are expected to teach the standards outlined in the Course Map. Using the Course Map below, teachers will intentionally plan learning experiences that prepare students to meet the identified standards within the designated assessment windows.

### Priority Standards (Units of Study)

Priority Standards identify the most essential learning in the trade program. They reflect the core technical competencies, safety practices, and industry-aligned skills that require the greatest instructional focus and appear on program assessments. In CTE programs, each Priority Standard also functions as a Unit of Study, because it includes the required components such as big ideas, essential questions, content topics, and skills/learning outcomes aligned to assessments.

### Vertical Alignment

Vertical alignment shows how Priority Standards and instructional expectations progress from grade to grade within the trade program. It provides a clear pathway of skill development, increasing complexity, and technical proficiency across the four-year sequence.

### Learning Outcomes

Learning outcomes are what students will know (Concepts) and be able to do (Skills).

Concepts identify the major content topics within the Priority Standard (Unit of Study). They appear in the left column of the Learning Outcomes table and follow a similar coding structure as the Priority Standard.

Skills are learning objectives that describe the measurable actions students must be able to perform to demonstrate proficiency. They appear in the right column of the Learning Outcomes table and show the progression of learning evidence in the Priority Standard.

**Vocabulary**

Essential vocabulary includes the technical and academic terms students must understand and use accurately to engage in trade-specific learning and demonstrate proficiency on assessments. Vocabulary is foundational to safety, technical precision, and industry communication, and should be a primary initial focus within each unit and taught explicitly through modeling, demonstration, and repeated application.

**Resources**

Resources include the tools, equipment, texts, materials, and digital tools that support learning within each unit and reflect industry standards.

**Assessment Practices**

Teachers use ongoing formative assessments—such as questioning, checks for understanding, performance demonstrations, reflections, and teacher observation—to monitor progress, guide instruction, and support all learners in mastering the Priority Standards.

Each program also includes District Summative Assessments (DSAs), which measure proficiency on the Priority Standards identified in the Course Map. DSAs provide consistent evidence of student learning across campuses and ensure alignment to industry expectations, safety requirements, and program outcomes. Teachers should reference the Course Map and Units of Study when planning instruction to ensure students have opportunities to practice and demonstrate the skills and knowledge assessed on the DSA.

## Proficiency Scale Alignment

### Mastery by Design: Aligning to Marzano Proficiency Scales

To ensure every student reaches high-level learning, our curriculum utilizes **Marzano-aligned Proficiency Scales** directly embedded within each **Priority Standard**. Rather than a simple "pass/fail" metric, these scales provide a clear, consistent roadmap for growth, moving from foundational knowledge to complex application.

By placing these scales at the point of use within the curriculum, we bridge the gap between planning and instruction.

### Why This Alignment Matters

- **Clarity of Expectation:** Teachers and students share a common language for what "Level 3.0" (Target Mastery) looks like versus "Level 4.0" (Exceeding the Standard).
- **Instructional Precision:** With scales linked to specific Priority Standards, you can instantly identify prerequisite skills (Level 2.0) to support struggling learners or provide enrichment for those ready to go beyond.
- **Scaffolded Success at Level 2:** To support foundational understanding, Level 2.0 includes explicitly aligned and tiered vocabulary required for each priority standard, ensuring students have the linguistic building blocks needed for mastery.
- **Data-Driven Feedback:** Grading becomes more objective and transparent, focusing on the evidence of learning rather than points earned.

### The 4-Point Structure at a Glance

- 4.0: Exceeding: In-depth inferences and applications that go beyond what was taught.
- 3.0: The Target: Mastery of the specific Priority Standard as defined by the curriculum.
- 2.0: Foundational: Understanding of tiered vocabulary and basic processes related to the standard.

- 1.0: Emerging: Success with help or partial understanding of the 2.0 and 3.0 content.

**Integrated for Ease of Access:** When you open a Priority Standard in your curriculum docs, the specific success criteria and required vocabulary are right there, ready for your daily lesson plan or assessment design.

**A link to the CTECS Proficiency Scales aligned to this curriculum is located below:**

CTECS Electrical Proficiency Scales

**A more comprehensive guide to implementation can be found by clicking on the link below:**

VANGUARD Trades PS Implementation Guide

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## CTECS Electrical Math Integration & Competency Crosswalks

To fully illustrate the rigorous mathematical foundations embedded within the ***CTECS Electrical*** curriculum, we have developed a comprehensive integration guide. While the priority standards within this document include specific embedded examples of math applications, a more exhaustive resource is available for instructional use. This guide features detailed mathematics competency crosswalks designed to bridge technical skills with academic standards. You can access the complete ***CTECS Electrical Math Integration Guide*** on the Licensed Trades website or by clicking the link below:

**Embedded Math**

- **Point-of-Use Integration**: Each Priority Standard contains specific ***"Trade Math Crossover"*** sections that align mathematical concepts; such as Ohm's Law, ladder ratios, and conduit fill percentages; directly to the technical task at hand.
- **Marzano-Aligned Scales**: Every standard is linked to a Marzano-aligned Proficiency Scale, providing a clear 4-point roadmap from foundational vocabulary (Level 2.0) to target mastery (Level 3.0) and advanced application (Level 4.0).
- **Cross-Over Tables**: Detailed tables in the curriculum and ***appendix*** sections provide a crosswalk between technical skills and apprenticeship standards, ensuring students meet the requirements for CT-DOL related instruction.

**Additional Resources**

For those seeking more in-depth information, a more comprehensive guide to implementation and the full ***Math Integration Guide*** and ***Electrical Math/SAT/NEC Guide*** can be found on the **Licensed Trades website**.

[Access the Electrical Math Integration Guide]

[Access the Electrical Math/SAT/NEC Guide]

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## CTECS Electrical Philosophy

The ***Electrical*** course of studies is designed to create an appreciation of the industry and to develop entry-level skills within the electrical construction trade. Opportunities to develop skills for personal use and to make a successful transition from school to the workplace or post-secondary institutions will be presented to students enrolled in this course.

The ***Electrical*** course is designed to provide Level I apprenticeship theory content within the trade. Practical experience will be gained within the school, through outside production experience, and through optional Work Based Learning, employed by a licensed electrical contractor or wholesale company.

## Program Description

Students enrolled in the ***CTECS Electrical*** career program The course of study prepares individuals to apply technical knowledge and skills to install, operate, maintain, and repair electric apparatus and systems such as residential, commercial, and industrial electric-power, and DC and AC motors, controls and electrical distribution panels. Low voltage wiring including CAT 6 is taught and practiced, along with instruction and use of test equipment. The student will learn safe use of the hand/portable tools and materials of the trade; proper use of materials, theory for planning, layout, fabrication, and integration of electrical installation; theory for DC, AC and poly-Phase current transformers, transmission and their application, control and protective devices; safe use of ladders, staging, and scaffolds and national, state and local standards and codes including state licensing requirements. The CTECS Electrical curriculum has been vetted by the CT-DOL-Office of Apprenticeship Training, and has been approved to deliver up to 720 hours of related instruction towards an approved apprenticeship program. Students may be able to receive 1500 hours towards a career affiliated apprenticeship upon graduation* (*Upon Employer

Acceptance). Students reaching an acceptable level of proficiency may be eligible for Work Based Learning (WBL).

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## CTECS Electrical Goals

The ***Electrical*** Program will create an awareness of opportunities within the vast trade areas that comprise the Electrical Construction Industry. The program incorporates new developments and practices related to electrical installation in residential, commercial and industrial construction.

**Program Goals**

As a result of education in the Electrical Program grades 9-12 students will:

- Demonstrate safe work habits with hand and portable power tools.
- Demonstrate the ability to apply O.S.H.A 1926 Text
- Demonstrate ability in installation of low voltage wiring and termination
- Demonstrate knowledge of different building materials and fasteners.
- Demonstrate use of metering and testing equipment.
- Application of trade related subjects
- Demonstrate AC/DC theory principles and applications
- Identification and installation of various electrical equipment and components
- Apply related building codes and standards
- Demonstrate the ability to research and apply the National Electrical Code for a safe and acceptable installation.
- Calculate and install a complete residential wiring system according to N.E.C.
- Apply learned knowledge in the installation of equipment and material on inside and outside production jobs.
- Demonstrate maintenance and troubleshooting skills and techniques.
- Demonstrate installation of raceways, wire ways and systems.
- Demonstrate the installation of motors, controllers, control devices and systems
- Demonstrate installing various power distribution systems and networks.
- Present a Student Portfolio that is a purposeful collection of work that documents the student’s efforts, progress or achievements in the Electrical trade during their four (4) Years in the CTECS

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## Program Standards

- Demonstrate Safety for both On and Off Campus production work
- OSHA 10 / OSHA 30 credentialing
- First Aid/CPR/AED credentialing
- Understand career opportunities in the electrical career
- Demonstrate proficiency in career related mathematics, reading, writing, vocabulary, and science
- Understand electrical processes and materials
- Demonstrate safe hand and portable tool uses.
- Operates stationery equipment used in the electrical field.
- Demonstrate basic electrical construction blueprint reading and sketching
- Demonstrate skills for high quality residential/light commercial electrical construction
- Understand and apply National Electrical Code and State of Connecticut Building Codes
- Perform residential and commercial construction projects for customers off-campus
- Demonstrate the ability to complete a job application and interview and to perform entry-level job readiness and electrical career skills

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## Program Locations in CT

**CTECS Electrical:**

- A.I. Prince Technical High School, **Hartford**
- Bullard-Havens Technical High School, **Bridgeport**
- E.C. Goodwin Technical High School, **New Britain**
- Eli Whitney Technical High School, **Hamden**
- Emmett O'Brien Technical High School, **Ansonia**
- Ella T. Grasso Technical High School, **Groton**
- H.C Wilcox Technical High School, **Meriden**
- Harvard H. Ellis Technical High School, **Danielson**
- Henry Abbott Technical High School, **Danbury**
- Howell Cheney Technical High School, **Manchester**
- J.M.Wright Technical High School, **Stamford**
- Norwich Technical High School, **Norwich**
- Oliver Wolcott Technical High School, **Torrington**
- Platt Technical High School, **Milford**
- Vinal Technical High School, **Middletown**
- W.F. Kaynor Technical High School, **Waterbury**
- Windham Technical High School, **Willimantic**

Connecticut Technical Education and Career System

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**CT-DOL Program Approval**

**The CTECS Electrical Curriculum is fully approved by the CT-DOL Office of Apprenticeship Training.**

**A CTECS Electrical graduate who *successfully completes* the program is entitled to 720 hours of related instruction training* towards a E-2 apprenticeship.**

**(*Contingent upon student receiving OSHA 30 certification)**



| **Curriculum Legend** | |
|---|---|
| **Bold** | **Powered-Need to know** |
| Non-Bold | Nice to Know |
| **Green Font** | **Green Technology Alignment** |
| **Red Font** | **Common Core Technical Standards Alignment** |
| **Blue Font** | **Alignment to the CTECS Vision of a Graduate Standards** |

## CTECS Vision of a Graduate

**The CTECS Vision of the Graduate: A Roadmap for Instructional Excellence**

The ***CTECS Vision of the Graduate (VOG)*** represents the collective voice of our stakeholders, capturing the essential traits, attitudes, and skills our students need to excel both in our classrooms and in their future careers. More than just a list of aspirations, the VOG serves as a framework to help you deliver purposeful, high-quality instruction that prepares every student for the demands of the modern workforce.

**How to Use This Document:** To help you bridge the gap between curriculum standards and real-world application, we have integrated the VOG directly into your teaching tools:

**Integrated Standards:** Each Priority Standard within this curriculum has been intentionally aligned with the CTECS VOG. To make these connections easy to identify at a glance, all VOG-aligned standards are denoted in ***blue font*** throughout this document.

**Teacher Support Tools:** We have developed a comprehensive resource site to support your daily instruction. This hub provides the materials and strategies needed to bring these VOG traits to life in your shop or classroom.

**Access your teaching resources here:** CTECS Licensed Trades VOG Resource Site

**The following page has a pictograph that depicts the six CTECS VOG traits we strive to adhere to:**

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*CTECS VOG 1*

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## CTECS Electrical Course Map

### Grade 9: Semester 1

- 9.1 Shop and Site Safety

### Grade 9: Semester 2

- 9.1 Shop and Site Safety
- 9.2 Electrical Fundamentals
- 9.3 Uses and Dangers of Electricity
- 9.4 Basic Electrical Circuits
- 9.5 Motors, Generators and Transformers
- 9.6 Protective Devices
- 9.7 Electrical Wiring and Devices
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the exam)

### Grade 10: Semester 1

- 10.1 Shop and Site Safety
- 10.2 Intro to Code
- 10.3 Residential Layout
- 10.4 Residential Installation
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the exam)

### Grade 10: Semester 2

- 10.1 Shop and Site Safety (OSHA 10 Training)
- 10.5 Residential Services
- 10.6 Residential Finishes
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the exam)

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### Grade 11: Semester 1

- 11.1 Shop and Site Safety (OSHA 10 Training)
- 11.2 Grounding, Bonding and Overcurrent Protection
- 11.3 Cable, Conduits and Raceways
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the exam)

### Grade 11: Semester 2

- 11.1 Shop and Site Safety
- 11.4 Equipment
- 11.5 Special Occupancies
- 11.6 Pools, Hot Tubs and Spas
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the exam)

### Grade 12: Semester 1

- 12.1 Shop and Site Safety
- 12.2 Transformers
- 12.3 Motor Branch Circuits
- 12.4 Motor Control Circuits
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the exam)

### Grade 12: Semester 2

- 12.1 Shop and Site Safety
- 12.5 Fire Alarm
- 12.6 Telecommunications
- 12.7 Solar PV
- 12.8 Exam Prep
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the exam)

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# ELECTRICAL

# Grade 9

| **Priority Standard 9.1 - Shop, and Personal Safety** | |
|---|---|
| **Big Idea(s):**<br>Work safely in the shop following all OSHA, school and shop regulations | |
| **Essential Question(s):**<br>1. What would a jobsite look like without safety standards to follow? | |
| **Learning Outcomes** | |
| *Students will know:* | *As evidenced by: (oral, written, or performance)* |
| **1.1 Follow shop and school safety rules** | • **Explain what OSHA stands for**<br>• **Identify Electrical and school shop safety rules**<br>• **Obtain safety credentials assigned by shop instructor**<br>• **Wear proper PPE for shop**<br>• **Demonstrate how to properly operate power tools**<br>• **Demonstrate how to safely use all types of ladders and scaffolding**<br>• **Pass shop safety test with a 100% accuracy**<br>• **Maintain safe work habits and clean, orderly work area**<br>• **Demonstrate awareness of safety hazards and how to avoid them**<br>• **Models a strong work ethic (VOG-Work Ready).** |
| **Link to Proficiency Scale** | |

**Tiered Vocab**- Electrical students build a professional vocabulary, we have broken down the terms into three tiers based on the standard educational model:

- **Tier 1:** Common, everyday words (Basic communication).
- **Tier 2:** High-frequency academic words (Used across various subjects/trades).
- **Tier 3:** Low-frequency, domain-specific technical terms (The "Language of the Trade").

| **Tier 1 (Everyday)** | **Tier 2 (Academic)** | **Tier 3 (Technical/Trade)** |
|---|---|---|
| • Rules,<br>• safety, | • Regulation,<br>• credentials, | • OSHA,<br>• Focus Four, |

| | | |
|---|---|---|
| • wear,<br>• clean,<br>• tools. | • awareness,<br>• hazard,<br>• ethics | • PPE,<br>• GFCI,<br>• LO/TO (Lock-Out/Tag-Out),<br>• Z87.1,<br>• EPO (Emergency Power Off),<br>• Bloodborne Pathogens. |

**Trade Math Crossover:** 4:1 ladder ratio, Ex. a ladder placed 16 feet high must have its base at 4 feet from the structure.

**Resources to compliment learning- OSHA** 1926, shop and school safety

**Crossover to Apprenticeship Standards:** OSHA 30 A0099

**VOG Portfolio Collection Examples:**

- **Work Ready- Possess the knowledge and skills for industry areas: Students are assigned to create safety plans for each power tool they will use.**
- **Critical Thinker: Students will have the ability to develop a Fire Evacuation plan with proper egress and exits**
- **Respectful: Students work in pairs to conduct safety "audits" of each other's work areas. They must ensure that all hand tools are properly stored and that personal protective equipment (PPE) is being used correctly. The focus is on demonstrating respect for the physical safety of their peers and the shop environment by providing constructive, kind, and firm feedback to prevent accidents.**

| **Priority Standard 9.2 - Electrical Fundamentals** | |
|---|---|
| **Big Idea(s):** Electricity is a predictable system of moving electrons that flows from generation to the home through a structured network of transmission and distribution. | |
| **Essential Question(s):** 1. How far does an electron travel in a conductor and what direction? 2. Select either conventional or electron theory and prove it. | |
| **Learning Outcomes** | |
| *Students will know:* | *As evidenced by: (oral, written, or performance)* |
| **2.1 Diagram and Explain how the Electrical System (Electricity) gets to their homes from the Generation Plant, Transmission Lines and the Distribution Lines** | • **Explaining the structure of an Atom, Protons, Neutrons and Electrons**<br>• **Explain Valence Electrons and the Orbital Shell**<br>• **Explain the difference between Conductors and Insulators**<br>• **Explain what an electrical circuit is and the electrical current flow**<br>• **List the different electrical power sources**<br>• **Explain what an Electrical System is and how it works**<br>• **List the different voltages for each phase of an Electrical System** |
| **Link to Proficiency Scale** | |
| Tiered Vocab- Electrical students build a professional vocabulary, we have broken down the terms into three tiers based on the standard educational model:<br>• **Tier 1:** Common, everyday words (Basic communication).<br>• **Tier 2:** High-frequency academic words (Used across various subjects/trades).<br>• **Tier 3:** Low-frequency, domain-specific technical terms (The "Language of the Trade"). | |

| **Tier 1 (Everyday)** | **Tier 2 (Academic)** | **Tier 3 (Technical/Trade)** |
|---|---|---|
| • Power,<br>• home,<br>• flow,<br>• circle, | • Structure,<br>• system,<br>• theory,<br>• distribution, | • Atom,<br>• Proton,<br>• Neutron,<br>• Electron, |

| Priority Standard 9.2 - Electrical Fundamentals | | |
|---|---|---|
| • source | • transmission. | • Valence Electrons,<br>• Conductors,<br>• Insulators,<br>• Step-up Transmission Voltage,<br>• High Voltage Transmission Lines,<br>• Primary/Secondary<br>• Distribution Voltage. |

**Trade Math Crossover**: Ohm's Law I x R=E, using ohm's law to find different missing values of an electrical circuit using addition, multiplication, division and square root, rounding decimals up to a whole number.

**Resources to compliment learning-** Mike Holt *Understanding Electrical Theory* - Unit 1-4

**Crossover to Apprenticeship Standards:** Electrical Algebra w/Trig A0005

**VOG Portfolio Collection Examples**:

- **Critical Thinker**-Students create a list of rules to follow when solving for the missing value in both series, parallel and combination circuits.
- **Critical Thinker:** Students are presented with an AI-generated explanation that contains a scientific error regarding the relationship between Resistance and Current (Ohm's Law). Students must act as a critical thinker to identify the error, build a physical series circuit to prove the law of physics, and write a "Correction Memo" to verify the real-world data against the digital output.

| **Priority Standard 9.3 - Uses and Dangers of Electricity** | |
|---|---|
| **Big Idea (s):**<br>Electrical safety requires a proactive mastery of environmental hazards (Arc-Flash) and rigorous adherence to physical protection protocols (LOTO and PPE) to prevent injury. | |
| **Essential Question (s):**<br>1. What is the purpose of using different lighting color temperature (Kelvin Scale) for various task and ambiance?<br>2. How can I help protect myself and others from electrical fires and hazards | |
| **Learning Outcomes** | |
| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
| **3.1 Layout a Residential Lighting Project based on the different types of lighting used and the different Kelvins used in each room of a home.** | ● **Explain what electromagnetism is**<br>● **Explain what Photoelectricity is**<br>● **List the different types of lighting color temperature (Kelvin Scale) used in lighting** |
| **3.2 Demonstrate Arc Flash requirements and use in the industry** | ● **List the causes of electrical fires**<br>● **Explain the difference of Electric Shock vs Electrocution**<br>● **Explain Let Go Current**<br>● **Explain the difference of Arc Flash vs Arc Blast** |
| **3.3 Perform a Lock Out / Tag Out procedure** | ● **Explain Lock Out / Tag Out**<br>● **Identify proper PPE**<br>● **Identify different types of Lock Out / Tag Out Devices** |
| **Link to Proficiency Scale** | |
| Tiered Vocab- Electrical students build a professional vocabulary, we have broken down the terms into three tiers based on the standard educational model:<br><br>• **Tier 1:** Common, everyday words (Basic communication).<br>• **Tier 2:** High-frequency academic words (Used across various subjects/trades).<br>• **Tier 3:** Low-frequency, domain-specific technical terms (The "Language of the Trade"). | |

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| **Tier 1 (Everyday)** | **Tier 2 (Academic)** | **Tier 3 (Technical/Trade)** |
|---|---|---|
| • Light,<br>• fire,<br>• shock,<br>• boundary,<br>• danger. | • Requirements,<br>• procedure,<br>• potential,<br>• category,<br>• scale. | • Electromagnetism,<br>• Photoelectricity,<br>• Incandescent,<br>• Fluorescent,<br>• LED,<br>• Kelvin Scale,<br>• Let Go Current,<br>• Arc Flash,<br>• Arc Blast,<br>• Limited Approach Boundary. |

**Trade Math Crossover:** Calculate Arc potential, Milli Amperes effects on human body

**Resources to compliment learning-** Mike Holt *Understanding Electrical Theory* - Unit 5-6, 26

**Crossover to Apprenticeship Standards:** A0904, OSHA 30 A0099

**VOG Portfolio Collection Examples:**

- **Work Ready-** Possess the knowledge and skills for industry areas. Students are assigned to create safety plans for potential electrical hazards.
- **Work Ready**: Students are assigned to create a comprehensive safety plan for a residential setting, focusing on preventing arc-flashes and grounding hazards. To demonstrate being work ready, students must identify proper Lock Out/Tag Out (LOTO) devices and explain the "Let Go Current" to a mock client, showing they possess the professional knowledge required for industry-standard safety protocols.

## Priority Standard 9.4 - Basic Electrical Circuits

**Big Idea (s):**

The mathematical relationships between voltage, current, and resistance (Ohm's Law) are the universal "rules" that govern how every electrical circuit function, regardless of complexity.

**Essential Question (s):**

1. How will learning to calculate series, parallel and complex circuits carry over to your electrical career?
2. Why is mastering basic math functions important if I can find the same answer using an app on my phone or computer?

**Learning Outcomes**

| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
|---|---|
| **4.1 Calculate values for voltage, amperage, resistance and power in a series DC circuit** | ● **List and explain the rules for a series circuit**<br>● **Define Voltage, Current, Resistance, Wattage**<br>● **Explain the difference between a Series and Parallel Circuit** |
| **4.2 Calculate values for voltage, amperage, resistance and power in a Parallel AC/DC Circuit** | ● **List and explain the rules for a parallel circuit**<br>● **Define Voltage, Current, Resistance, Wattage**<br>● **Explain the reciprocal formula**<br>● **Explain the difference between a Series and Parallel Circuit** |
| **4.3 Demonstrate the use of Ohms Law in various electrical circuit / equipment installations** | ● **Identify the Ohms law Wheel and what each letter represents**<br>● **Explain how to use the Ohms Law Wheel** |

**Link to Proficiency Scale**

Tiered Vocab- Electrical students build a professional vocabulary, we have broken down the terms into three tiers based on the standard educational model:

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|

| | | |
|---|---|---|
| • Loop<br>• Path<br>• Break<br>• Flow<br>• Bright / Dim | • Calculate<br>• Identify<br>• Relationship<br>• Value<br>• Formula<br>• Define | • Series Circuit<br>• Parallel Circuit<br>• Combination Circuit<br>• Ohm's Law<br>• Voltage (Volt)<br>• Current (Amperage / Amp)<br>• Resistance (Ohm)<br>• Wattage (Watt)<br>• Reciprocal Formula |

**Trade Math Crossover:** Ohm's Law I x R=E, using ohm's law to find different missing values of an electrical circuit using addition, multiplication, division and square root, rounding decimals up to a whole number.

**Resources to compliment learning-** Mike Holt *Understanding Electrical Theory* - Unit 12-16, 28-29

**Crossover to Apprenticeship Standards:** Electrical Algebra w/Trigonometry A0005

**VOG Portfolio Collection Examples:**

- **Critical Thinker**-Students create a list of rules to follow when solving for the missing value in both series, parallel and combination circuits.
- **Problem Solver**-Students create a list of rules to solve series, parallel and complex circuits.
- **Problem Solver**- Students are given a scenario where a building owner has a high electric bill despite "turning everything off". As a problem solver, the student must calculate values for voltage, amperage, and resistance in complex circuits to locate the "ghost load." They must create a list of rules and steps used to solve the circuit math to prove their troubleshooting logic.

| **Priority Standard 9.5 - Motors, Generators and Transformers** | |
|---|---|
| **Big Idea (s):**<br>The invisible force of electromagnetism is the primary driver of modern mechanical work, allowing us to convert electrical energy into motion (motors) or mechanical motion back into electricity (generators). | |
| **Essential Question (s):**<br>1. What is the law of attraction and repulsion of magnets?<br>2. How is electromagnetism in a wire produced? | |
| **Learning Outcomes** | |
| *Students will know:* | *As evidenced by: (oral, written, or performance)* |
| **5.1 Identify horsepower of a motor using the nameplate of a motor** | ● **Explain Magnetism**<br>● **Explain magnetic lines of force and the law of attraction and repulsion of magnets**<br>● **Explain electromagnetism in a wire**<br>● **List the different uses of electromagnetism in motors**<br>● **Identify the different parts of a motor**<br>● **List electrical industry voltages** |
| **5.2 Calculate output watts of a motor based on nameplate horsepower** | ● **Explain Magnetism**<br>● **Explain magnetic lines of force and the law of attraction and repulsion of magnets**<br>● **Explain electromagnetism in a wire**<br>● **List the different uses of electromagnetism in motors**<br>● **Identify the different parts of a motor**<br>● **List electrical industry voltages** |
| **5.3 Calculate output current of a generator** | ● **Explain Magnetism**<br>● **Explain magnetic lines of force and the law of attraction and repulsion of magnets**<br>● **Explain electromagnetism in a wire**<br>● **List the different uses of electromagnetism in generators**<br>● **List Prime Movers used in Generators**<br>● **List electrical industry voltages** |

| | |
|---|---|
| **5.4 Calculate transformer Primary / Secondary Voltage based on the Turns Rati** | ● **Explain Magnetism**<br>● **Explain magnetic lines of force and the law of attraction and repulsion of magnets**<br>● **Explain electromagnetism in a wire**<br>● **List the different uses of electromagnetism in transformers**<br>● **List electrical industry voltages**<br>● **List the different types of transformers**<br>● **Explain Primary vs Secondary**<br>● **Explain Turns Ratio**<br>● **Explain kVA rating** |
| **Link to Proficiency Scale** | |

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Pull<br>• Spin<br>• Power<br>• Source<br>• Connection | • Calculate<br>• Identify<br>• Output<br>• Rating<br>• Ratio<br>• Attraction<br>• Repulsion | • Magnetism<br>• Lines of Force<br>• Electromagnetism<br>• Electron Current Flow<br>• Motor<br>• Motor Shaft<br>• Windings<br>• Coil<br>• Horsepower<br>• FLA (Full Load Amperage)<br>• Generator<br>• Prime Mover<br>• Single Phase<br>• Three Phase<br>• Transformer<br>• Primary |

| | | |
|---|---|---|
| | | • Secondary<br>• Turns Ratio<br>• kVA Rating |

**Trade Math Crossover:** Horsepower to watts conversion, Ratio of transformer primary to secondary windings

**Resources to compliment learning-** Mike Holt *Understanding Electrical Theory* - Unit 7-9, 21-22, 24

**Crossover to Apprenticeship Standards:** Electrical Theory 1 A0901, Electrical Code 1 A0904

**VOG Portfolio Collection Examples:**

- **Work Ready** - Students identify the important information located on an electric motor nameplate
- **Critical Thinker** - Students find proper voltage and current of transformers and generators
- **Effective Communicator**: Students must explain the "Law of Attraction and Repulsion" and how magnetic lines of force create motion in a motor. They will prepare a visual aid (such as a diagram of a motor's windings and coil) and present a 3-minute "Safety Briefing" to the class, translating complex electromagnetic theory into clear instructions for a new apprentice.

## Priority Standard 9.6 - Protective Devices

**Big Idea (s):**

1. Overcurrent protective devices (fuses and breakers) are the "weakest link" by design; they sacrifice themselves to protect conductors and equipment from the destructive thermal effects of shorts and overloads

2. A Ground Fault Circuit Interrupter (GFCI) is a life-safety "watchdog" that monitors the balance of current; if even a tiny amount of electricity "leaks" from the path, the device trips in milliseconds to prevent electrocution.

**Essential Question (s):**

1. What device is used to protect wires and equipment from damage?
2. How do we protect ourselves when using electricity around water?
3. What are the dangers of curtains or beds overhanging electrical duplex receptacles and how do we protect our homes and ourselves from this danger?

**Learning Outcomes**

| *Students will know:* | *As evidenced by: (oral, written, or performance)* |
|---|---|
| **6.1Install a circuit breaker in a panel board** | ● **Explain the purpose of Overcurrent Protection**<br>● **Explain the differences between Overload, Short Circuit and Ground Fault**<br>● **List Standard OCPD sizes**<br>● **Explain the difference between a circuit breaker and a fuse**<br>● **List the different types of circuit breakers and fuses**<br>● **Explain short circuit current and Interrupting rating** |
| **6.2 Install a GFCI receptacle loaded to a duplex** | ● **Explain the use of GFCI to people and equipment**<br>● **Explain how GFCI work**<br>● **List where GFCI are required in a home**<br>● **Explain Line and Load on a GFCI** |
| **6.3 Install a GFCI and AFCI breaker** | ● **Explain the use of AFCI**<br>● **Explain how AFCI work**<br>● **List where AFCI are required in a home**<br>● **Explain the difference between GFCI and AFCI breakers** |

**Link to Proficiency Scale**

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Trip<br>• Blow<br>• Safety<br>• Switch<br>• Reset | • Fault<br>• Sensitivity<br>• Interrupt<br>• Overload<br>• Protection<br>• Detection | • Circuit Breaker<br>• Fuse<br>• GFCI (Ground Fault Circuit Interrupter)<br>• AFCI (Arc Fault Circuit Interrupter)<br>• Short Circuit<br>• Overcurrent<br>• Time-Delay Fuse<br>• Non-Time-Delay Fuse<br>• Interrupting Rating<br>• Trip-Free |

**Trade Math Crossover:** Using known values of a circuit in homes to determine the correct overcurrent protective devices. Using a torque screwdriver to apply the correct inch/pounds of force to a terminal.

**Resources to compliment learning-** Mike Holt *Understanding Electrical Theory* - Unit 25

**Crossover to Apprenticeship Standards:** Electrical Code 1 A0904, Electrical Theory 1 A0901

**VOG Portfolio Collection Examples:**

- **Critical Thinker-**Students compare and contrast the different types of overcurrent protective devices.
- **Work Ready:** Students will wire and test electrical projects in wooden booths and on boards
- **Effective Communicator:** Students must explain to a "client" (the instructor) why they cannot simply replace a 15-amp breaker with a 30-amp breaker to stop it from tripping. They must translate technical concepts; like **ampacity** and **conductor insulation breakdown**—into a professional, non-technical explanation that ensures the client understands the fire hazard involved.

<table>
<tr><th colspan="2">Priority Standard 9.7 - Electrical Wiring and Devices</th></tr>
<tr><td colspan="2">Big Idea (s):<br>1. Proper device installation and wire termination are the "critical connections" of the trade; a secure, code-compliant connection ensures circuit continuity and prevents the thermal failure (fires) caused by loose or improper joints<br><br>2. Systematic layout and "rough-in" precision are essential for workforce readiness; following blueprints and NEC spacing requirements (like the 6/12 rule) ensures that electrical systems are both functional for the user and safe for the structure.</td></tr>
<tr><td colspan="2">Essential Question (s):<br>1. Today's wiring connectors that were not available to electricians in the past, why are they better?<br>2. If you were to design your own home with today’s technology, what state of the art devices and systems would you install.</td></tr>
<tr><td colspan="2">Learning Outcomes</td></tr>
<tr><td>Students will:</td><td>As evidenced by: (oral, written, or performance)</td></tr>
<tr><td>7.1 Construct a wiring diagram / schematic for Residential Wiring Projects</td><td>• Explain the difference between a wiring Diagram and Schematic<br>• List the different electrical symbols used on diagrams and schematics</td></tr>
<tr><td>7.2 Install Residential Wiring Projects including Single Pole, 3 ways, 4ways, Duplex, Split Duplex and GFI</td><td>• Demonstrate stripping, splicing and terminating of conductors<br>• Identify proper colors of Hots, Neutrals and grounds<br>• Identify terminals on devices<br>• Identify different types of devices used in wiring<br>• Identify different types of conductors and cables used in electrical wiring<br>• List different fasteners used for devices and boxes (6/32, 8/32)</td></tr>
<tr><td>7.3 Complete various blueprint scaling projects using Architectural Ruler and Tape Measure</td><td>• Explain Architectural ruler and scales used on blueprints</td></tr>
<tr><td colspan="2">Link to Proficiency Scale</td></tr>
<tr><td colspan="2">Tiered Vocab- Electrical students build a professional vocabulary, we have broken down the terms into three tiers based on the standard educational model:</td></tr>
</table>

**CTECS ELECTRICAL**

- **Tier 1:** Common, everyday words (Basic communication).
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- **Tier 3:** Low-frequency, domain-specific technical terms (The "Language of the Trade").

| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Plug<br>• Wire<br>• Box<br>• Screw<br>• Light | • Installation<br>• Identification<br>• Termination<br>• Configuration<br>• Orientation<br>• Standardized | • Duplex Receptacle<br>• Single-Pole Switch<br>• Three-Way Switch<br>• Four-Way Switch<br>• Yoke<br>• Terminal<br>• Polarity<br>• Grounding Screw<br>• Traveler<br>• Common Terminal<br>• Non-Metallic Sheathed Cable (NM-B)<br>• Conductor Color Coding (Black, White, Red, Green)<br>• Device Box |

**Trade Math Crossover:** Using known values of appliances in homes to determine the correct conductor. Using percentages to install correct numbers of cables in a drilled hole. Using a torque screwdriver to apply the correct inch/pounds of force to a terminal.

Students apply these terms when calculating "Box Fill" to determine the number of conductors allowed in a specific device box volume according to NEC standards.

**Resources to compliment learning-** N/A

**Crossover to Apprenticeship Standards:** Electrical Code 1 A0904

**VOG Portfolio Collection Examples:**

- **Critical Thinker:** Students create a material list with standard parts for their electrical wiring projects.
- **Effective Communicator:** Students must act as a Lead Electrician explaining a proposed wiring layout to a homeowner. They must clearly describe where switches and receptacles

will be placed and why certain devices (like GFCIs) are required in specific areas. The goal is to translate technical installation plans into a clear, professional conversation that builds client trust.

CTECS

CONNECTICUT TECHNICAL EDUCATION AND CAREER SYSTEM



# ELECTRICAL

# Grade 10

| **Priority Standard 10.1 - OSHA & Safe Working Practices.** | |
|---|---|
| **Big Idea (s):**<br>Safety on a job site is a personal and collective responsibility; strictly following OSHA standards and interpreting SDS data is the only way to mitigate the inherent risks of chemicals, heights, and high-voltage equipment | |
| **Essential Question (s):**<br>1. What are common electrical chemicals used by electricians? What should you know about each one?<br>2. What is the most dangerous power tool you expect to use on a job site, why?<br>3. What is the maximum height you feel comfortable working at, will you be expected to work higher, what PPE would you have on?<br>4. Why is working in a clean work environment so important? | |
| **Learning Outcomes** | |
| *Students will know:* | *As evidenced by: (oral, written, or performance)* |
| **1.1 Shop Safety and OSHA Regulations review.** | • **Demonstrate proper uniforms, footwear, eye protection, and no jewelry policy.**<br>• **Required to have their parents including themselves read and sign the schools and shop safety policy.**<br>• **Required to comply with school, shop, industry and OSHA safety standards.**<br>• **Compile a list of the OSHA standards that would be used in both shop and out on production jobs.**<br>• **Health and safety: Follow safety guidelines and manage personal health.**<br>• **Identify types of PPE commonly used in construction.**<br>• **Identify and list potential hazardous materials found on job sites**<br>• **Explain what SDS is and its importance**<br>• **Gather information from SDS and interpret data presented in these sheets.**<br>• **Explain working conditions, and work practices.**<br>• **Explain what the "Right to Know "rule is.**<br>• **Establish a list of equipment in the shop that requires the use of tagout / lockout requirements and Arc Flash Requirements.** |

| | |
|---|---|
| | • **Required to complete a written assessment with a 100% accuracy rate**<br>• **Properly identify and perform the OSHA, Conn OSHA and industry standards. when working on energized equipment.**<br>• **Explain the reason for having recognized test laboratories.**<br>• **List various testing laboratories that are responsible for establishing electrical standards.**<br><br>Reference NABCEP 1.7 – 1.9<br>○ Identify and implement appropriate codes and standards concerning worker and public safety.<br>○ Identify personal safety hazards associated with PV installations.<br>○ Identify environmental hazards associated with PV installations |
| **1.2 Power Tool Safety Review and Metering Equipment.** | • **Identify various electrical symbols associated with testing instruments.**<br>• **Select the proper meter reading, and apply their applications.**<br>• **Recognize various meter readings, and apply their applications.**<br>• **Required to perform various tasks, taking meter reading using several testing instruments.**<br>• **Demonstrate how to properly inspect a hand/power tool.**<br>• **Demonstrate the safe operation of hand tools and power tools, such as but not limited to Hole Hawg, Band Saw, Pistol Drill, Sawzall and Hammer Drill.** |
| **1.3 Safe work habits when using ladders and scaffolding.** | • **Identify ladder ratios and types of ladders used in construction.**<br>• **Demonstrate how to properly use various types of ladders.**<br>• **Identify ladder ratings and types.**<br>• **Proper use of tools while on a ladder.**<br>• **Explain the importance of daily inspection** |

| | |
|---|---|
| | **before use of a ladder.**<br>• **List OSHA requirements for installing and using scaffolding.**<br>• **Identify and create a procedure to perform various tasks of lifting different types and sizes of objects.** |
| **1.4 Importance of a clean work environment and hazards associated with electrical construction.** | • **Describe why it is necessary to have a clean work environment.**<br>• **Explain the types of hazards associated with electrical construction and how to prevent these from happening.**<br>• **Demonstrate keeping a clean work area in shop and production jobs.**<br>Reference NABCEP 1.1 |
| **Link to Proficiency Scale** | |

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Ladder,<br>• shoes,<br>• wood,<br>• jewelry,<br>• height. | • Implementation,<br>• environmental,<br>• inspection,<br>• procedure,<br>• assessment. | • OSHA,<br>• Lock Out/Tag Out,<br>• Scaffolding,<br>• Extension Ladders,<br>• GFCI, Ladders (aluminum, wood and fiberglass),<br>• Duty Rating,<br>• Polarity,<br>• Step Ladder,<br>• Podium Ladder,<br>• Scaffolding,<br>• Planking,<br>• Toe Board, |

| | | |
|---|---|---|
| | | • Bracing,<br>• Rivets,<br>• Rung,<br>• Casters,<br>• Outriggers,<br>• Guardrails,<br>• SDS,<br>• OSHA Focus 4,<br>• "Right to Know",<br>• Electrocution,<br>• Picograms,<br>• GHS,<br>• Dust Control. |

**Trade Math Crossover:** 4:1 ladder ratio, milli amperes effects on human body. Ex. a ladder placed 16 feet high must have its base at 4 feet from the structure.

**Resources to compliment learning-** OSHA Link

**Crossover to Apprenticeship Standards:** OSHA 30 A0099

**VOG Portfolio Collection Examples:**

- **Problem Solver:** Students create a poster of their electrical shop and identify the hazardous areas that are present, students create an action plan for all the hazards they identified.
- **Problem Solver:** Students take a series of photos of their current shop environment and conduct a mock safety audit. As a problem solver, they must identify potential hazards (e.g., improper ladder placement, disorganized workspaces, or blocked exits) and create a formal, written "Action Plan" to mitigate these risks in compliance with OSHA standards

**Priority Standard 10.2 - Intro to Code**

**Big Idea (s):**

1. The National Electrical Code (NEC) is not a set of suggestions, but a minimum safety standard designed to prevent electrical fires and electrocution by regulating how electricity is physically installed.

2. Mastery of the NEC "Index and Table of Contents" is more important than memorization; a professional electrician is a "Code Detective" who knows how to quickly locate and interpret specific articles to solve on-site installation disputes.

**Essential Question (s):**

1. What is the purpose of the NEC and how is it organized?
2. What is the process to add or change a code article in the NEC?
3. Why are places and industries not covered by the NEC?

**Learning Outcomes**

| *Students will know:* | *As evidenced by: (oral, written, or performance)* |
|---|---|
| **2.1 NEC and identify important terminology** | • **Explain why parts are highlighted**<br>• **Locate specific code articles.**<br>• **Recall how the NEC is structured**<br>• **Interpret why articles are highlighted**<br>• **Explain an FPN** |
| **2.2 Uses permitted and uses not permitted** | • **Recognize real-world examples of code violations and their implications.**<br>• **Identify common electrical practices and installations that are prohibited by the National Electrical Code.** |
| **2.3 What is covered and not covered in the NEC** | • **Compare accessible and readily accessible**<br>• **List areas not covered in the NEC**<br>• **Explain the AHJ and their role** |

Link to Proficiency Scale

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Book<br>• Law<br>• Rule<br>• Safety<br>• Chapter<br>• Index | • Reference<br>• Standardized<br>• Compliance<br>• Mandatory<br>• Interpretation<br>• Article<br>• Annotation | • National Electrical Code (NEC)<br>• NFPA 70<br>• AHJ (Authority Having Jurisdiction)<br>• Listed/Labeled<br>• Shall (Mandatory Language)<br>• Shall be Permitted (Permissive Language)<br>• Informational Note<br>• Scope<br>• Definition (Article 100)<br>• General Requirements (Article 110)<br>• Table of Contents<br>• Annex |

**Trade Math Crossover:** Students apply these terms when navigating the **NEC Index** and **Table of Contents** to locate specific technical tables (e.g., Table 310.16 for allowable ampacities) used for system calculations.

**Resources to compliment learning-** Understanding the NEC Vol.#1, Article 90,100

**Crossover to Apprenticeship Standards:** Electrical Code 1 A0904

**VOG Portfolio Collection Examples:**

- **Critical Thinker-**Students create a layout of what common information is in a code article.
- **Effective Communicator:** Students are given a list of real-world scenarios (e.g., "How many receptacles are allowed on a 15-amp circuit in a dwelling unit?"). They must find the specific NEC article, section, and table, then explain their findings in a 60-second "Safety Briefing" to their peers, articulating exactly why the code exists to protect the end-user.

| **Priority Standard 10.3 - Residential Layout** | |
|---|---|
| **Big Idea (s):**<br>1. A code-compliant residential layout is a balance of safety and accessibility; spacing receptacles according to the "6/12 Rule" ensures that no point along a wall is more than six feet from a power source, reducing the hazardous use of extension cords.<br>2. The blueprint is the electrician's "roadmap"; translating two-dimensional symbols into a three-dimensional physical installation requires precise measurement and an understanding of structural obstacles like engineered beams. | |
| **Essential Question (s):**<br>1. How do Ground Fault Circuit Interrupters (GFCIs) and Arc Fault Circuit Interrupters (AFCIs) enhance electrical safety in homes?<br>2. How do adjustment and correction factors impact the selection and performance of conductors in various electrical installations?<br>3. How do environmental conditions and application requirements influence the selection of the appropriate wire method for different electrical installations?<br>4. What factors must be considered when calculating and selecting the appropriate overcurrent protection devices to ensure safety and reliability in electrical systems?<br>5. How has electricity changed in homes from the past?<br>6. How does the correct use of an architectural scale ruler enhance accuracy and efficiency in interpreting and creating architectural drawings? | |
| **Learning Outcomes** | |
| *Students will know:* | *As evidenced by: (oral, written, or performance)* |
| **3.1 Identify and place AFCI and GFCI devices in a dwelling unit.** | • **Recall and list areas where GFCI and AFCI protection is required.**<br>• **Describe how to provide GFCI and AFCI protection.**<br>• **Identify line and load on GFCI and AFCI devices.**<br>• **Explain how a GFCI device works.**<br>• **Explain how a AFCI device works.**<br>• **Explain different ways to provide GFCI and AFCI protection.** |

| | |
|---|---|
| **3.2 Calculate ampacity adjustments and corrections in dwelling units.** | ● **Demonstrate ability to adjust more than three current carrying conductors in conduit and cable using 310 tables.**<br>● **Demonstrate ability to correct conductors for ambient temperature + or -.**<br>● **Explain and count current carrying conductors**<br>● **Explain why conductors are rated less when installed with over three current carrying conductors.**<br>● **Explain why conductor ampacity is higher or lower when the ambient temperature is higher or lower than 78-86 degrees Fahrenheit.** |
| **3.3 Determine correct wire method for specific locations in dwelling units** | ● **Use ampacity tables to find current rating for wet or dry locations on dual temperature rated wire.**<br>● **Use article 310 to find specific information related to insulation types, temperature rating of terminals, usage statement, thickness, AWG range, insulation description.**<br>● **Identify conductor and cable listings.**<br>● **Use ampacity tables to find current rating for wet or dry locations on dual temperature rated wire** |
| **3.4 Calculate and select OCPD from article 240.6 when selecting overcurrent devices**. | ● **Locate and record nameplate data**<br>● **Calculate full load amps when watts or VA are given**<br>● **Demonstrate ability to apply the 80% rule,125% adjustment, and other derating factors.**<br>● **Apply voltage drop calculation to determine minimum CMA for wire, K rating =12.9 CU, 21.2 AL**<br>● **Calculate wire size and ampacity based on Article 310**<br>● **Calculate connected load of branch circuits**<br>● **Calculate overcurrent protection for branch circuits** |

| | |
|---|---|
| **3.5 Design and layout device and lighting boxes in dwelling units.** | ● **Demonstrate and layout receptacle, switches and lighting in a dwelling unit, following the NEC for spacing requirements.**<br>● **Demonstrate and layout receptacles, switches and lighting in a kitchen, following the NEC for spacing requirements.**<br>● **Identify what is a wall and counter in a dwelling unit.** |
| **3.6 Correctly use an architectural scale ruler.** | ● **Identify and use an architect's scale correctly.**<br>● **Convert fractions to feet using ⅛" and ¼" scales.**<br>● **Locate scale used on blueprints.** |
| **Link to Proficiency Scale** | |

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Wall<br>• Floor<br>• Distance<br>• Center<br>• Mark<br>• Diameter | • Layout<br>• Design<br>• Placement<br>• Requirement<br>• Specifications<br>• Dimension<br>• Conductor<br>• Ambient Temperature<br>• Bundling | • Dwelling Unit<br>• Rough-In<br>• Blueprint<br>• Scale<br>• Luminaire<br>• Receptacle Spacing<br>• Small-Appliance Branch Circuit<br>• AHJ (Authority Having Jurisdiction)<br>• Wall Space<br>• Bored Holes<br>• Firestopping<br>• Current Carrying Conductor |

| | | |
|---|---|---|
| | | |

**Trade Math Crossover:**

Calculate ampacities of conductors in various installations using adding, subtracting, division and finding percentages.

Students apply these terms when using a tape measure to find the proper box layout for the center of a room and calculating the percentage of bored holes allowed in framing members to ensure they do not exceed NEC requirements.

**Resources to compliment learning-** Understanding the NEC Vol.#1, Article 210, 310, 240.6

**Crossover to Apprenticeship Standards: Electrical Code 1 A0904**

**VOG Portfolio Collection Examples:**

- **Critical Thinker:** Students find the correct size conductor for various situations that they will encounter on a job site, using both number of conductors and ambient temperature.
- **Problem Solver:** Students are given a floor plan with "blocked" areas (like large windows or floor-to-ceiling cabinets) that make standard receptacle spacing difficult. As a problem solver, they must re-design the circuit path to ensure they maintain NEC-compliant spacing (e.g., 6-foot/12-foot rules) while minimizing total wire usage.

## Priority Standard 10.4 - Residential Installation

**Big Idea (s):**

A high-quality "rough-in" requires a master-level understanding of both architectural blueprints and physical constraints (like "no-drill" zones) to ensure a code-compliant path for every circuit.

**Essential Question (s):**

1. Before you begin drilling out holes in a house, what should you think about, what local, national codes and manufacturer specifications might apply.
2. What would occur if you install too many conductors in an electrical box?
3. Explain the various ways to secure cables to wood members?
4. Explain what can happen to electrical terminations when they are over or under torqued.

**Learning Outcomes**

| *Students will know:* | *As evidenced by: (oral, written, or performance)* |
|---|---|
| **4.1 Layout and drill framing members.** | ● **Use hole hawg correctly to drill holes.**<br>● **Select and change wood boring bits in a hole hawg.**<br>● **Identify "no drill" engineered wood members**<br>● **Mark-out intended drilling route with attention to drill/no-drill framing members.**<br>● **Explain and demonstrate correct location of bored holes.**<br>● **Identify terms relating to firestopping.**<br>● **Identify locations that require firestopping.**<br>● **Install fire caulk in holes with cables correctly per manufacturer specifications.** |
| **4.2 Calculate and Install device boxes.** | • **Count and calculate the number of conductors in device and junction boxes.**<br>• **Identify the size of conductors.**<br>• **Identify wiring method sizes.**<br>• **Demonstrate rough wiring per NEC for a dwelling unit.**<br>● **Demonstrate proper box layout using the NEC in all areas of a dwelling.**<br>● **Demonstrate how to support cables in a dwelling unit per NEC.** |

| | |
|---|---|
| **4.3 Install and secure cables** | • **Locate article 334 in the NEC.**<br>• **Demonstrate how to support cables in a dwelling unit per NEC.**<br>• **Install wire methods following the 1-¼" rule.**<br>• **Follow the blueprint to install and wire device boxes.**<br>• **Install steel plates where required by the NEC.**<br>• **Show proper techniques for unrolling cables.** |
| **4.4 Identify Common screws and hardware used in residential construction.** | • **Recall common screws used in residential construction.**<br>• **Identify screw sizes 6-32, 8-32.**<br>• **Locate torque requirements on wiring devices.** |

**Link to Proficiency Scale**

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Wall<br>• Hole<br>• Screw<br>• Staple<br>• Roll / Unroll | • Layout<br>• Design<br>• Location<br>• Route<br>• Requirement<br>• Technique<br>• Specifications | • Bored Holes,<br>• Engineered Beams,<br>• Fire Block,<br>• Junction Box,<br>• Yoke,<br>• Box Fill,<br>• Equipment Grounding Conductor,<br>• Fan Box,<br>• Nonmetallic-Sheathed Cable (NM-B),<br>• Torque. |

| |
|---|
| **Trade Math Crossover:**<br><br>Addition, subtraction and percentages.<br>Ex. Using a tape measure to find proper box layout for the center of the room and lighting fixture center mark locations, using percentage of bored holes to not exceed cable ampacity requirements.<br><br>Students apply these terms when using a tape measure to find the center mark for lighting fixtures and when performing **Box Fill calculations** to determine if the number of conductors in a junction box exceeds NEC limits |
| **Resources to compliment learning-** Understanding the NEC Vol.#1, Article 300.4, 314.16,334 |
| **Crossover to Apprenticeship Standards:** Electrical Code 1 A0904 |
| **VOG Portfolio Collection Examples:**<br>• **Work Ready:** Students wire electrical projects in wooden booths using provided blueprints, students mount boxes and drill holes per local and national codes, instructor reviewed.<br>• **Critical Thinker**: Students act as a critical thinker to review an AI-generated work plan that contains code violations regarding wire gauge (14 AWG vs. 12 AWG for kitchen circuits) and support intervals. Students must produce a "Correction List" citing specific NEC sections, then perform the physical "staple and fold" technique in the shop to demonstrate code-compliant installation. |

<table>
<tr><th colspan="2">Priority Standard 10.5 - Residential Services</th></tr>
<tr><td colspan="2">Big Idea (s):<br>The main electrical service is the heart of a home’s power; sizing it requires precise load calculations to balance demand factors and ensure the Grounding Electrode system can safely handle a surge or fault.</td></tr>
<tr><td colspan="2">Essential Question (s):<br>1. What are the key National Electrical Code (NEC) and utility requirements for installing a 100 amp or 200-amp electrical service, and how do these standards ensure the safety and efficiency of the electrical system?<br>2. How do you determine the minimum size of a residential electrical service according to the National Electrical Code (NEC), and what factors must be considered to ensure safety and adequacy for the household's power needs?<br>3. What are the requirements and procedures for installing a Grounding Electrode and Grounding Electrode Conductor according to the National Electrical Code (NEC), and how do these components contribute to the overall safety and effectiveness of an electrical system?</td></tr>
<tr><td colspan="2">Learning Outcomes</td></tr>
<tr><td>Students will know:</td><td>As evidenced by: (oral, written, or performance)</td></tr>
<tr><td>5.1 Install a 100- or 200-amp service to the NEC and Utility requirements.</td><td>● Identify Overhead / Underground Services.<br>● Identify differences between SEU and PVC Services.<br>● Identify Fittings used for Residential Services.</td></tr>
<tr><td>5.2 Size a minimum size residential service per the NEC.</td><td>● Identify the differences between a Service, Feeder and Branch Circuit.<br>● Identify NEC requirements for sizing a Residential Service (Square Footage, Small Appliance, Laundry, Demand Factor, Dryer, Range, Fixed Appliance, Non-Coincidental Load, Motor). (VOG-Critical Thinker)</td></tr>
<tr><td>5.3 Install a Grounding Electrode and Grounding Electrode Conductor to the NEC.</td><td>● Identify Grounding Electrode and Grounding Electrode Conductors per NEC.<br>● Identify the Main Bonding Jumper.<br>● Use NEC to size a GEC.</td></tr>
<tr><td colspan="2">Link to Proficiency Scale</td></tr>
</table>

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Meter<br>• Pipe<br>• Ground<br>• Panel<br>• Mast | • Service<br>• Capacity<br>• Requirement<br>• Minimum<br>• Adequacy<br>• Efficiency | • Service Entrance<br>• Service Entrance Conductor<br>• Service Lateral<br>• Main Service Disconnect<br>• Overhead Service<br>• Underground Service<br>• Meter Socket<br>• Grounding Electrode<br>• Grounding Electrode Conductor (GEC)<br>• Bonding Jumper<br>• 100-Amp / 200-Amp Service<br>• Utility Requirements<br>• Load Calculation |

**Trade Math Crossover:**

Addition of multiple numbers, using percentages.

Example: Adding the total VA from the minimum receptacle load, small appliance and laundry loads, you take the first 3000 VA @100% and the remaining VA @35%.

Students apply these terms when determining the minimum size of a residential service by performing **Load Calculations** according to the National Electrical Code (NEC) to ensure the system meets the household's power needs.

**Resources to compliment learning-** Mike Holt Resource: Understanding the NEC Vol.#1, Article 215, 220, 225, 230, 242, 250.50, 250.52, 250.53, 250.54, 250.64. 250.66, 250.94, 408

**Crossover to Apprenticeship Standards:** A0905 - Electrical Code II

**VOG Portfolio Collection Examples:**

- **Work Ready:** Students complete a 100-amp service for residential dwelling units.
- **Effective Communicator:** Students perform load calculations for a residential project based on square footage, appliances, and demand factors. They must then present these findings to a "homeowner" (the instructor), explaining the difference between service, feeder, and branch circuits, and why a specific service size is required for household safety.

## Priority Standard 10.6 - Residential Finishes

**Big Idea (s):**

1. The "Finish" phase is the final validation of system integrity; precise device termination, proper polarity, and mechanical "plumb and level" installation are essential for both electrical safety and professional craftsmanship.

2. A professional finish requires "Mechanical Execution of Work" (NEC 110.12); ensuring devices are flush to the finished wall surface and plates are level prevents structural gaps that could allow sparks to escape a box during a fault.

**Essential Question (s):**

1. How do wiring receptacles, switches, dimmers, and fan controls function together to create an efficient and safe electrical system in residential homes?
2. What are the different types of switches and dimmers, and how do their unique features and functionalities impact their application in various lighting and electrical systems?
3. In what situations are Tamper-Resistant (TR) and Weather-Resistant (WR) devices required, and how do their specific features enhance safety and functionality in various environments?

**Learning Outcomes**

| *Students will know:* | *As evidenced by: (oral, written, or performance)* |
|---|---|
| **6.1 Wire receptacles, switches, dimmers and fan controls with correct operation.** | • **Complete material list for receptacles, switches, dimmers and fan controls based on blueprints.**<br>• **Follow wiring diagrams for switch and receptacle placement and functions.**<br>• **Locate accessibility and grouping per NEC 404.8.**<br>• **Recall common screw sizes for finish installations.**<br>• **Recall common lighting fixtures used in dwelling units.**<br>• **Use blueprints to place lighting fixtures.**<br>• **Install finish plates for wiring devices.** |
| **6.2 Identify types of switches and dimmers.** | • **Describe receptacles, switches, fan controls and dimmers.**<br>• **Locate voltage and amperage on receptacles, switches, fan controls and dimmers.**<br>• **Identify toggle and decora devices.** |

| | |
|---|---|
| **6.3 Identify where WR and TR devices are required.** | • **Find requirements for Tamper-Resistant (TR), Weather-Resistant (WR) devices.**<br>• **Identify Tamper-Resistant (TR), Weather-Resistant (WR) devices.** |

**Link to Proficiency Scale**

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|---|---|---|
| • Cover<br>• Plate<br>• Bulb<br>• Trim<br>• Clean | • Finish<br>• Aesthetic<br>• Alignment<br>• Flush<br>• Sequence<br>• Integrity | • Device Plate<br>• Jumbo Plate<br>• Wall Wash<br>• Luminaire<br>• Recessed Can<br>• Trim Ring<br>• Baffle<br>• Dimmer Switch<br>• Occupancy Sensor<br>• Pendant Light<br>• Sconce<br>• Snap Switch<br>• Grounding Clip<br>• Plumb |

**Trade Math Crossover:**

Addition and multiplication of material list for dwelling units. Division of layout for lighting placement.

Students apply these terms when calculating the Center-to-Center distance for recessed lighting layouts and ensuring that the protrusion of device boxes does not exceed the 1/4 inch maximum allowed by the NEC for non-combustible finishes.

| |
|---|
| **Resources to compliment learning-** Mike Holt Resource: Understanding the NEC Vol.#1, Article 404,410 |
| **Crossover to Apprenticeship Standards:** Electrical Code 1 A0904 |
| **VOG Portfolio Collection Examples:**<br>• **Critical Thinker:** Types of Electrical Finishes: Investigate various finishes such as:<br>    • Standard vs. decorative outlets and switches<br>    • Dimmers and smart controls<br>    • Cover plates and face plates<br>• **Effective Communicator:** Students are provided with a designer's request for specific decorative lighting and smart-switch placement. As the electrician, the student must explain the technical limitations (e.g., box-fill requirements or compatibility with existing dimmers) to the "designer." This project develops the ability to communicate technical NEC constraints to non-technical stakeholders without sacrificing professional courtesy. |

CONNECTICUT TECHNICAL EDUCATION AND CAREER SYSTEM



# ELECTRICAL

# Grade 11

## Priority Standard 11.1 Workplace Safety

**Big Idea (s):**

1. The "Qualified Person" status is an earned responsibility; it requires the ability to interpret NFPA 70E tables to determine Limited and Restricted Approach Boundaries, ensuring that both the worker and bystanders are protected from "Unsafe Energy Releases."
2. In industrial environments, safety is not just a habit but a legal mandate; establishing an "Electrically Safe Work Condition" through Lockout/Tagout (LOTO) and the use of the "Test-Before-Touch" method is the only acceptable defense against the lethal energy of arc-flash and electrocution.

**Essential Question (s):**

1. How would you handle being asked to work in an unsafe condition?
2. Are tools designed to make them safer to use, or just complete a task?
3. What type of jobsite do you think will have the most safety concerns?

**Learning Outcomes**

| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
|---|---|
| **1.1 Follow OSHA regulations on production sites** | • **Obtain OSHA 10 certification**<br>• **Wear proper PPE for shop, production and WBL sites**<br>• **Demonstrate how to safely use all types of ladders and scaffolding**<br>• **Demonstrate how to properly operate power tools** |
| **1.2 Follow shop and school safety rules** | • **Obtain safety credentials assigned by shop instructor**<br>• **Pass shop safety test with a 100% accuracy**<br>• **Maintain safe work habits and clean, orderly work area**<br>• **Demonstrate awareness of safety hazards and how to avoid them**<br>• **Identify and explain SDS sheets** |

**Link to Proficiency Scale**

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Hardhat<br>• Gloves<br>• Safety<br>• Danger<br>• Harm | • Compliance<br>• Regulation<br>• Mitigation<br>• Assessment<br>• Implementation<br>• Intervention | • OSHA 10 / OSHA 30<br>• PPE (Personal Protective Equipment)<br>• LOTO (Lock-Out/Tag-Out)<br>• NFPA 70E<br>• Arc Flash Boundary<br>• Arc Blast<br>• Energized Electrical Work Permit (EEWP)<br>• Qualified Person<br>• Limited Approach Boundary<br>• Restricted Approach Boundary<br>• JHA (Job Hazard Analysis)<br>• SDS (Safety Data Sheet) |

**Trade Math Crossover:**

Students apply these terms when calculating **Approach Boundaries** and determining the **4:1 ladder ratio** (e.g., a ladder placed 16 feet high must have its base 4 feet from the structure) to ensure safe physical setup on a job site.

**Resources to compliment learning-** OSHA 1926, osha.gov, shop / school safety rules

**Crossover to Apprenticeship Standards:** A0099 - OSHA 30

**VOG Portfolio Collection Examples:**

**Critical Thinker:** Students create a layout of their shop, highlighting the safety hazards, exit doors and fire evacuation path.

**Effective Communicator:** Students are assigned a specific piece of industrial machinery. They must use NFPA 70E tables to determine the "Limited Approach Boundary" and the "Restricted Approach Boundary." They must then deliver a verbal safety briefing to a mock "maintenance team," clearly communicating the specific PPE requirements (Category 1-4) required to work on that equipment.

## Priority Standard 11.2 - Grounding and Bonding and Overcurrent Protection

**Big Idea (s):**

1. Grounding (connecting to earth) and Bonding (connecting metal parts together) serve two distinct masters: Grounding protects the system from lightning and surges, while Bonding creates the low-impedance path necessary to "force" a breaker to trip during a fault.

2. Overcurrent protection is the "Safety Valve" of a commercial system; sizing a breaker is not just about the load, but about ensuring the "Interrupting Rating" (AIC) exceeds the available fault current to prevent the device from exploding during a short circuit.

**Essential Question (s):**

1. Why do we install grounding and bonding conductors?
2. Which grounding electrode system is the most effective?
3. Is a fuse a better overcurrent protective device than a circuit breaker?

**Learning Outcomes**

| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
|---|---|
| **2.1 Calculate and install the proper size GE and GEC for a commercial service** | • **Explain the difference between grounding and bonding**<br>• **Identify grounding electrodes and installation methods based on the NEC**<br>• **Identify grounding electrode conductors and installation methods based on the NEC**<br>• **Explain how to size GEC based on the NEC** |
| **2.2 Calculate and install the proper size EGC for a commercial installation** | • **Identify equipment grounding conductors**<br>• **Explain how to size an EGC based on the NEC** |
| **2.3 Calculate and install the proper size circuit breakers for various residential and commercial installations** | • **Explain Overcurrent protection and how OCPD work**<br>• **Identify Circuit Breaker sizes based on the NEC**<br>• **Identify the difference between Residential and Commercial circuit breakers** |

**Link to Proficiency Scale**

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**CTECS ELECTRICAL**

| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Earth<br>• Path<br>• Break<br>• Green (Wire)<br>• Static | • Effective<br>• Continuous<br>• Sizing<br>• Termination<br>• Potential (Difference)<br>• Redundant | • Grounding Electrode<br>• Grounding Electrode Conductor (GEC)<br>• Main Bonding Jumper<br>• System Bonding Jumper<br>• Grounded Conductor (Neutral)<br>• Equipment Grounding Conductor (EGC)<br>• Overcurrent Protection Device (OCPD)<br>• Inverse Time Circuit Breaker<br>• Instantaneous Trip<br>• Short-Circuit Current Rating (SCCR)<br>• Effective Ground-Fault Current Path<br>• Intersystem Bonding Termination |

**Trade Math Crossover:**

Percentages – Calculating 125% of a continuous load

Students apply these terms when using NEC Table 250.66 to size the Grounding Electrode Conductor based on the size of the service entrance conductors, and Table 250.122 for sizing Equipment Grounding Conductors based on the rating of the overcurrent device.

**Resources to compliment learning-** *Mike Holt Bonding and Grounding Article 250*

**Crossover to Apprenticeship Standards:** A0905 - Electrical Code II

**VOG Portfolio Collection Examples:**

- **Work Ready -** Students compare and contrast the different types of overcurrent protective devices.

- **Effective Communicator:** Students must create a visual presentation that explains the difference between the System Grounded Conductor (neutral) and the Equipment Grounding Conductor (ground). They must present a "Safety Talk" to the class explaining how a properly bonded system provides a low-impedance path to trip a breaker, using professional terminology from NEC Article 250.

| Priority Standard 11.3 - Electrical Cables, Conduit and Raceways | |
|---|---|
| **Big Idea (s):**<br>1. A raceway is a continuous, protective "envelope" for conductors; the integrity of the system depends on the "Mechanical Execution of Work," ensuring every bend, fitting, and support complies with the NEC to prevent physical damage and facilitate future wire pulling.<br>2. Conduit bending is a marriage of geometry and physical skill; using "Shrink" and "Gain" constants allows an electrician to navigate structural obstacles with mathematical precision, ensuring the final installation is both functional and "level and plumb." | |
| **Essential Question (s):**<br>1. Why is bending conduit considered an art?<br>2. What situations could arise from over filling a conduit? | |
| **Learning Outcomes** | |
| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
| **3.1 Perform conduit bending tasks to specific measurements.** | **● Identify the different types of conduit and fittings**<br>**● Identify a 90, Offsets and Saddle Bends**<br>**● Bend a 90 bend, Offset and Saddle Bends** |
| **3.2 Calculate Conduit Fill** | **● Identify derating factors for conductors to size conduit** |
| **3.3 Supporting raceways using various products per NEC requirements** | **● Use the NEC to identify supporting requirements for various conduits** |
| **3.4 Calculate size and install wireways** | **● Identify wireways**<br>**● Identify factors for sizing wireways** |
| **3.5 Install MC cable rough-in for a commercial application per NEC** | **● Properly identify different types of MC cable and fittings.**<br>**● Properly install MC cable into boxes.**<br>**● Explain Architectural ruler and scales used on blueprints** |
| **Link to Proficiency Scale** | |
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**CTECS ELECTRICAL**

| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Pipe<br>• Bend<br>• Fill<br>• Support<br>• Route | • Adjustment<br>• Correction<br>• Factor<br>• Application<br>• Measurement<br>• Specifications | • 90-Degree Bend<br>• Box Offset<br>• Back-to-Back Bend<br>• Saddle Bend<br>• Conduit Fill<br>• Derating Factors<br>• Raceways<br>• Wireways<br>• MC Cable (Metal-Clad)<br>• Fitting<br>• Architectural Ruler<br>• Scale |

**Trade Math Crossover:**

**Percentages -** Calculate conductor size by derating

Students apply these terms when calculating **Conduit Fill** (using NEC Chapter 9, Tables 4 and 5) and determining the **Take-up and Deduct** measurements required to bend conduit to specific physical dimensions.

**Resources to compliment learning-** Mike Holt *Understanding the NEC Vol 1* - Art 330, 344, 348, 350, 352, 358, 376

**Crossover to Apprenticeship Standards:** A0905 Electrical Code II

**VOG Portfolio Collection Examples:**

- **Critical Thinker -** Students layout the correct process to bend an offset using 30-degree bend with a hand bender.
- **Problem Solver:** Students act as a Lead Installer to audit a foreman's (AI) faulty conduit bending plan. They must correct the math for offsets, cite the NEC 360-degree rule for bends, and physically execute a precise offset in the shop to demonstrate that bending is a predictable science, not guesswork.

## Priority Standard 11.4 - Equipment

**Big Idea (s):**

1. Industrial equipment is engineered for high-demand "Continuous Loads"; sizing branch circuits and feeders for this equipment requires a 125% safety factor to ensure that the heat generated by constant operation does not degrade the conductor's insulation or cause nuisance tripping of the breaker.

2. The "Nameplate" is the legal document of the equipment; interpreting data such as **Minimum Circuit Ampacity (MCA)** and **Maximum Overcurrent Protective Device (MOCP)** is the only way to ensure the equipment operates within its UL-listed safety parameters.

**Essential Question (s):**

1. How do we determine the appropriate branch circuit requirements to ensure safe and efficient operation of various household and commercial appliances?
2. What are the key considerations in designing and implementing disconnect requirements to ensure safety, compliance, and reliability for appliances, heating equipment, and AC/refrigerating equipment?
3. What are the different types of heating systems commonly used in commercial buildings, and how do we determine the most suitable system based on factors such as efficiency, cost, and building requirements?
4. How do we accurately calculate the rating and interrupting capacity of AC/refrigerating equipment to ensure optimal performance and adherence to safety standards?

**Learning Outcomes**

| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
|---|---|
| **4.1 Identify Branch circuit requirements for appliances.** | • **Recognize how appliances differ between residential and commercial.**<br>• **Identify common appliances used in commercial kitchens.**<br>• **Identify GFCI Requirements for appliances.**<br>• **Find nameplates for appliances.** |
| **4.2 Design and Recall disconnect requirements for appliances, heating equipment and AC/Refrigerating Equipment.** | • **Locate and interpret relevant NEC articles, such as article 422 (Appliances), article 424 (Fixed Electric Space-Heating Equipment), and Article 440 (Air-Conditioning and Refrigerating Equipment).**<br>• **Identify different types of disconnects and ratings.**<br>• **Identify NEC disconnect requirements for safety, accessibility and proper installation.** |

| | |
|---|---|
| **4.3 Identify various types of heating systems commonly used in commercial buildings.** | • **Recognize fixed electric space heating equipment**<br>• **Identify AC and Refrigeration equipment**<br>• **List and explain the principal components and operation of different heating systems such as forced hot air, radiant heating, hydronic heating and heat pumps.** |
| **4.4 Calculate rating and interrupting capacity of AC/Refrigerating equipment.** | • **Calculate the electrical rating of AC/Refrigerating equipment based on the equipment's specifications and NEC guidelines.**<br>• **Locate nameplate on AC/Refrigerating equipment and interrupt conductor and OCPD sizes**<br>• **Calculate the interrupting capacity needed for circuit breakers and fuses to handle potential fault currents safely.** |
| **Link to Proficiency Scale** | |

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Power<br>• Tool<br>• Heavy<br>• Mount<br>• Hook-up | • Classification<br>• Modification<br>• Maintenance<br>• Integrity<br>• Specification<br>• Operational | • Switchgear<br>• Switchboard<br>• Panelboard<br>• Disconnect Switch<br>• Motor Control Center (MCC)<br>• Transfer Switch<br>• Enclosure Type (NEMA Ratings)<br>• Busbar<br>• Phase Arrangement<br>• Overcurrent Protection |

| | | |
|---|---|---|
| | | • Pilot Light<br>• Nameplate Data |

**Trade Math Crossover:**

**Calculate:** Resistance Values.

Students apply these terms when calculating **Working Space Clearances** (NEC 110.26) to ensure there is sufficient depth, width, and height provided and maintained about all electrical equipment.

**Resources to compliment learning-** Understanding the National Electrical Code Volume 1

**Crossover to Apprenticeship Standards:** A0910 - Electrical Code IV

**VOG Portfolio Collection Examples:**

- **Critical Thinking:** Evaluate the design, functionality, and efficiency of the equipment. Consider the pros and cons.
- **Skilled Socially:** Students work in "commissioning teams" to install a piece of heavy equipment (like a commercial compressor). This requires being **skilled socially** as they must coordinate with "mechanical contractors" (other students) to ensure the electrical disconnect is mounted in a code-compliant, accessible location that does not interfere with the equipment's maintenance clearances.

## Priority Standard 11.5 - Special Occupancies

**Big Idea (s):**

1. Special Occupancies are defined by their unique environmental hazards; in these locations, the NEC mandates specialized equipment (like explosion-proof fittings or isolated grounds) to ensure that the electrical system itself does not become an ignition source or a point of failure for life-support systems.

2. The "Classification" of a space (Class, Division, and Group) is the foundation of industrial safety; misidentifying a hazardous atmosphere can lead to catastrophic system failure, making the ability to interpret Article 500 "Hazardous Location" tables a non-negotiable skill for the commercial electrician.

**Essential Question (s):**

1. Explain where you would find examples of hazardous locations?
2. How many power systems are present at a hospital? How are they identified?
3. Why do we need temporary wiring systems on construction sites?

**Learning Outcomes**

| *Students will know:* | *As evidenced by:* |
|---|---|
| **5.1 Identify various hazardous locations per the NEC requirements** | • **Explain the 3 classes and 2 divisions of hazardous locations**<br>• **List the types of material and equipment to be used in hazardous locations** |
| **5.2 Install a hazardous location project using rigid conduit** | • **List the types of material and equipment to be used in hazardous locations** |
| **5.3 Install a rough in for a Hospital Patient Care Room using MCap and / or conduit per NEC** | • **Identify hospital grade and isolated ground receptacles**<br>• **Explain what MCap cable is** |
| **5.4 Demonstrate proper wiring / GFI use at ALL times concerning temporary installations** | • **Explain what temporary installation are**<br>• **Explain wiring and receptacle requirements for temporary installations** |
| **5.5 Calculate the size for a Residential Generator with an Automatic Transfer Switch** | • **Explain the use of emergency systems and Life Safety**<br>• **Explain the difference between a Manual and Automatic Transfer Switch** |

**Link to Proficiency Scale**

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Gas<br>• Dust<br>• Theater<br>• Clinic<br>• Garage<br>• Pool | • Classification<br>• Hazardous<br>• Atmosphere<br>• Temporary<br>• Critical<br>• Public | • Class I, II, III Locations<br>• Division 1 / Division 2<br>• Intrinsically Safe<br>• Explosion-Proof Enclosure<br>• Dust-Ignition-Proof<br>• Seal-Off Fitting<br>• Patient Care Space<br>• Hospital Grade Receptacle<br>• Isolated Ground<br>• Equipotential Plane<br>• Emergency System<br>• Legally Required Standby System |

**Trade Math Crossover:**

**Fractions -** Converting fractions to a known scale on a blueprint

Students apply these terms when calculating the **Voltage Drop** for long temporary power runs at construction sites and determining the required **Stray Current** voltage thresholds for equipotential planes in agricultural or pool environments according to NEC Article 680.

**Resources to compliment learning-** Mike Holt *Understanding NEC Vol 2 - Art 500, 517, 590, 700-712;* Mike Holt *Understanding NEC Vol 1 - Art 445*

**Crossover to Apprenticeship Standards:** A0910 - Code IV

**VOG Portfolio Collection Examples:**

- **Work Ready -** Students diagram each class and division for hazardous locations.
- **Effective Communicator:** Students are assigned a specific "Class and Division" environment (e.g., a spray-paint booth or a grain silo). They must create a visual safety board and present a

briefing to the class explaining why standard wiring methods are prohibited and describing the specific "Explosion-Proof" fittings required to contain an internal spark.

- **Critical Thinker:** Students act as a **critical thinker** to evaluate an AI-generated equipment list for a commercial kitchen that uses propane. They must determine if the AI correctly distinguished between "Dust-Ignition Proof" (Class II) and "Explosion-Proof" (Class I) equipment, writing a correction report that explains why using the wrong type of protection would result in a catastrophic failure.

| **Priority Standard 11.6: Pools, Hot Tubs and Spas.** | |
|---|---|
| **Big Idea (s):**<br>1. In a pool environment, water is a conductor and the human body is the path of least resistance; "Equipotential Bonding" is the primary life-safety mechanism that eliminates voltage differences between all metal parts and the water, ensuring a "Zero-Voltage Zone" for swimmers.<br>**2.** Corrosive environments require specialized wiring methods; standard residential materials will deteriorate in the presence of chlorine or salt, making the use of Insulated Equipment Grounding Conductors and Liquid-Tight raceways a mandatory requirement for long-term system integrity. | |
| **Essential Question (s):**<br>1. Why do pools, hot tubs and spas have their own NEC article?<br>2. What are the major differences between wiring an above ground pool versus an inground pool?<br>3. Why is grounding and bonding so important for pools? | |
| **Learning Outcomes** | |
| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
| **8.1 Explain NEC requirements to wire a pool, hot tub, spas or fountain.** | • **Differentiate between a permanent pool and storable pool.**<br>• **Explain the difference between a hot tub and hydromassage tub.**<br>• **Cite the requirements for receptacles and lighting around pools**<br>• **Identify limitations and clearances for conductors passing over pools.**<br>• **Identify NEC requirements for spa and hot tub installations.** |
| **8.2 Explain bonding and grounding requirements for pools, hot tubs, spas and fountains.** | • **Explain equipotential bonding**<br>• **List all components that are required to be bonded at various types of pools.**<br>• **Explain NEC requirements for bonding various types of pools.** |
| **[Link to Proficiency Scale]** | |
| **Tiered Vocab-** Electrical students build a professional vocabulary, we have broken down the terms into three tiers based on the standard educational model:<br>• **Tier 1:** Common, everyday words (Basic communication). | |

- **Tier 2:** High-frequency academic words (Used across various subjects/trades).
- **Tier 3:** Low-frequency, domain-specific technical terms (The "Language of the Trade").

| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Pool<br>• Water<br>• Pipe<br>• Shock<br>• Ladder<br>• Light | • Proximity<br>• Perimeter<br>• Maintenance<br>• Accessibility<br>• Clearance<br>• Duration | • Equipotential Bonding<br>• Bonding Grid<br>• Stray Current<br>• Forming Shell<br>• Wet-Niche Luminaire<br>• Dry-Niche Luminaire<br>• No-Niche Luminaire<br>• Hydromassage Bathtub<br>• Self-Contained Spa<br>• Packaged Spa Equipment<br>• Low-Voltage Contact Limit<br>• Solid Copper Conductor (8 AWG) |

**Trade Math Crossover:**

Students apply these terms when measuring **Horizontal and Vertical Clearances** (NEC Table 680.9) to ensure overhead power lines are a safe distance from diving platforms and water levels, and when calculating the **5-foot to 20-foot zones** for receptacle placement.

**Resources to compliment learning-** Mike Holt: NEC Vol 2 (Art. 680), Grounding and Bonding (Art. 680)

**Crossover to Apprenticeship Standards:** A0910 - Electrical Code IV

**VOG Portfolio Collection Examples:**

- **Work Ready -** Students design an inground pool, highlighting all the electrical requirements. Students will fill out a permit and find their local town pool requirements along with required documents the building inspector will ask for.
- **Problem Solver:** In a simulated scenario where a swimmer feels a "tingle" in the water, the student must act as a **problem solver.** They will use a sensitive voltmeter to test for stray

voltage and inspect the **Equipotential Bonding Grid** to identify a broken or corroded connection that is failing to keep all metal parts at the same electrical potential.

- **Respectful:** Students demonstrate **respect** for the trade by performing monthly testing procedures on pool-rated GFCI breakers and "Dead-Front" GFCI devices. They must treat these devices as the primary line of defense against drowning, documenting their findings with meticulous care to show respect for the lives of future pool users.

CTECS
CONNECTICUT TECHNICAL EDUCATION AND CAREER SYSTEM

# ELECTRICAL

# Grade 12

<table>
<tr><td colspan="2">Priority Standard 12.1: Workplace safety</td></tr>
<tr><td colspan="2">Big Idea (s):<br>Being "Qualified" is a legal status, not just a skill level; it requires the ability to perform a Flash Hazard Analysis and determine the exact Limited and Restricted Approach Boundaries to prevent Arc-Blast fatalities.</td></tr>
<tr><td colspan="2">Essential Question (s):<br>1. What is the difference between the OSHA 10 and OSHA 30 training? When are each required on a jobsite?<br>2. If you are asked to use a power tool that is not in proper working order, what would you do or say?</td></tr>
<tr><td colspan="2">Learning Outcomes</td></tr>
<tr><td>Students will know:</td><td>As evidenced by:(oral, written, or performance)</td></tr>
<tr><td>1.1 Follow OSHA regulations on production sites</td><td>● Obtain OSHA 10 certification<br>● Wear proper PPE for shop, production and WBL sites<br>● Demonstrate how to safely use all types of ladders and scaffolding<br>● Demonstrate how to properly operate power tools<br>Reference NABCEP 1.1 – 1-4<br>● Maintain safe work habits and clean, orderly work area<br>● Demonstrate safe and proper use of required tools and equipment<br>● Demonstrate awareness of safety hazards and how to avoid them</td></tr>
<tr><td>1.2 Follow shop and school safety rules</td><td>● Obtain safety credentials assigned by shop instructor<br>● Pass shop safety test with a 100% accuracy<br>● Maintain safe work habits and clean, orderly work area<br>● Demonstrate awareness of safety hazards and how to avoid them<br>● Identify and explain SDS sheets</td></tr>
<tr><td colspan="2">Link to Proficiency Scale</td></tr>
<tr><td colspan="2">Tiered Vocab- Electrical students build a professional vocabulary, we have broken down the terms into three tiers based on the standard educational model:<br>• Tier 1: Common, everyday words (Basic communication).<br>• Tier 2: High-frequency academic words (Used across various subjects/trades).<br>• Tier 3: Low-frequency, domain-specific technical terms (The "Language of the Trade").</td></tr>
</table>

**CTECS ELECTRICAL**

| **Tier 1 (Everyday)** | **Tier 2 (Academic)** | **Tier 3 (Technical/Trade)** |
|---|---|---|
| • Boss<br>• Checklist<br>• Harm<br>• Watch<br>• Clean | • Supervision<br>• Documentation<br>• Liability<br>• Mitigation<br>• Oversight<br>• Precaution | • Qualified Person<br>• Competent Person<br>• NFPA 70E (Standard for Electrical Safety in the Workplace)<br>• Energized Electrical Work Permit (EEWP)<br>• Flash Hazard Analysis<br>• Shock Hazard Analysis<br>• Incident Energy<br>• Cal/cm$^2$ (Calories per centimeter squared)<br>• Arc-Rated (AR) Clothing<br>• Voltage-Rated Gloves (Class 00 through 4)<br>• Dielectric Strength<br>• Boundary Distances (Prohibited, Restricted, Limited) |

**Trade Math Crossover: Ratios -** Extension ladder 4:1 Ratio

Students apply these terms when calculating **Incident Energy** levels to determine the appropriate **PPE Category** (1 through 4) and when performing **minimum approach distance** calculations to ensure safety boundaries are physically marked on-site.

**Resources to compliment learning-** OSHA 1926 textbook, osha.gov, shop/school safety rules

**Crossover to Apprenticeship Standards:** A0099 - OSHA 30

**VOG Portfolio Collection Examples:**

- **Effective Communicator -** Students create safety videos and assessments for all power tools in the electrical shop.
- **Critical Thinker:** Students act as a Safety Officer to audit an AI-generated proposal that suggests

performing "live" work without proper training or permits. Students must use NFPA 70E and OSHA 1910.269 to define the legal requirements for a "Qualified Person," draft a formal Energized Electrical Work Permit (EEWP), and explain why an outage (LOTO) is the only professional solution.

## Priority Standard 12.2: Transformers

**Big Idea (s):**

A transformer is a separately derived system; professional installation requires precise calculations of **Primary/Secondary overcurrent protection** and the selection of the correct **System Bonding Jumper** to ensure a low-impedance path to ground.

**Essential Question (s):**

1. How does a transformer reduce or increase voltage, is there a physical connection between the primary and secondary sides of a transformer?
2. How do we protect the primary and secondary sides of a transformer, what information do we need to do this and where is it found?
3. Why do we install transformers in electrical rooms of a commercial building?

**Learning Outcomes**

| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
|---|---|
| **2.1 Calculate primary protection, conductors and raceway sizes** | ● **Explain KVA**<br>● **Define separately derived system**<br>● **Explain the formula for calculating primary current of a transformer**<br>● **Define Delta and Wye transformer winding connections**<br>● **Identify NEC tables to calculate conductor size**<br>● **Identify NEC tables for transformer overcurrent percentages** |
| **2.2 Calculate secondary protection, conductors and raceway sizes** | ● **Explain KVA**<br>● **Define separately derived system**<br>● **Explain the formula for calculating secondary current of a transformer**<br>● **Define Delta and Wye transformer winding connections**<br>● **Use NEC tables to calculate conductor size**<br>● **Identify NEC tables for transformer overcurrent percentages** |
| **2.3 Calculate Grounding electrode conductor and system bonding jumper size for a transformer** | ● **Define Grounding electrode conductor**<br>● **Define system bonding jumper**<br>● **Identify NEC articles to size grounding electrode conductor**<br>● **Identify NEC articles to size system bonding conductor** |

[Link to Proficiency Scale]

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Wind<br>• Step-up<br>• Step-down<br>• Noise (Hum)<br>• Heat | • Efficiency<br>• Ratio<br>• Induction<br>• Derivation<br>• Transformation<br>• Isolation | • Primary Winding<br>• Secondary Winding<br>• Turns Ratio<br>• kVA Rating<br>• Mutual Inductance<br>• Delta Connection (D)<br>• Wye Connection (Y)<br>• Tap Changer<br>• Control Transformer<br>• Current Transformer (CT)<br>• Potential Transformer (PT)<br>• Autotransformer<br>• Buck-Boost Transformer<br>• System Bonding Jumper |

**Trade Math Crossover: Percentages –**

Calculate transformer overcurrent protection using the percentages given in the NEC.

Students apply these terms when calculating **Transformer Turns Ratios** (Voltage Primary / Voltage Secondary) and determining the **Full-Load Current** of a transformer to properly size overcurrent protection and conductors according to NEC Article 450.

**Resources to compliment learning-** Mike Holt: Basic Electrical Theory (Unit 22) NEC Vol. 1 (Art. 450), Exam Prep (Unit 7), Grounding and Bonding (Art. 450)

**Crossover to Apprenticeship Standards:** A0917 - Power Distribution and Load Calculations

**VOG Portfolio Collection Examples:**

- **Work Ready -** Students will create a step-by-step process to find the correct overcurrent protective device for a transformer's primary and secondary conductors including conductor and grounding/bonding sizes.

- **Problem Solver:** Students act as a Lead Electrical Technician to correct an AI's flawed troubleshooting advice for an industrial "brownout". Instead of just "upsizing a fuse," students must demonstrate how to adjust internal transformer taps to tune the output voltage and calculate the correct FLA and conductor sizes to fix the system correctly.

## Priority Standard 12.3: Motor Branch Circuits

**Big Idea (s):**

1. Motor circuits are unique because of "Inrush Current"; the National Electrical Code (**NEC Article 430**) allows overcurrent protection to be sized up to 250% of the motor's full-load current to prevent the breaker from tripping during the initial "startup surge."

2. The **Motor Nameplate** is the source of truth for protection, but the **NEC Tables (430.248/250)** are the source of truth for wire sizing; an electrician must know when to use the "Actual Amps" vs. the "Table Amps" to ensure a legal and safe installation.

**Essential Question (s):**

1. Where do we see electric motors in the electrical field?
2. What would happen if an electric motor is fed with an undersized conductor?
3. Why are motor circuits treated differently than a traditional electrical circuit?

**Learning Outcomes**

| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
|---|---|
| **3.1 Calculate motor(s) short circuit/ground fault protection per the NEC** | • **Identify the FLA of the motor**<br>• **Explain locked rotor current**<br>• **Explain when to use the FLA on the nameplate of the motor or the NEC table**<br>• **Identify NEC articles for short circuit/ground fault percentages.** |
| **3.2 Calculate conductor size for a single motor and multiple motors.** | • **Locate and explain information from the nameplate of various electric motors.**<br>• **Identify and explain NEC articles that pertain to motor conductor sizing**<br>• **Identify and explain NEC articles for conductor ampacities** |
| **3.3 Explain how a dual voltage motor works** | • **Identify windings and connections on a dual voltage motor**<br>• **Explain when to wire the windings in parallel or series.** |

**Link to Proficiency Scale**

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Start<br>• Stop<br>• Run<br>• Spin<br>• Heavy | • Criteria<br>• Rating<br>• Protection<br>• Sequence<br>• Multiple<br>• Adjustment | • FLA (Full Load Amps)<br>• LRC (Locked Rotor Current)<br>• Service Factor<br>• Inverse Time Circuit Breaker<br>• Instantaneous Trip Circuit Breaker<br>• Non-Time Delay Fuse<br>• Motor Overload Protection (Heaters)<br>• Short-Circuit and Ground-Fault Protection<br>• Disconnecting Means<br>• Motor Controller<br>• Duty Cycle<br>• Nameplate Data |

**Trade Math Crossover:**

Horsepower to Watts conversion.

Students apply these terms when performing **Motor Calculations** (using NEC Article 430). This includes multiplying the FLA by **125%** to size branch circuit conductors and using **Table 430.52** to determine the maximum percentage allowed for various overcurrent protective devices.

**Resources to compliment learning-** Mike Holt: Basic Electrical Theory (Unit 20), NEC Vol. 1 (Art. 430), Exam Prep (Unit 7)

**Crossover to Apprenticeship Standards:** A0907 Motor and Generator Theory

**VOG Portfolio Collection Examples:**

- **Work Ready -** Students highlight the important information located on an electric motor nameplate.
- **Effective Communicator:** Students must present a "Motor Start-Up Briefing" to their peers. They must explain why motor circuits require 125% conductor sizing and up to 300% fuse sizing to handle

"inrush current" without nuisance tripping, using clear, professional language that demonstrates they understand the difference between continuous and non-continuous loads.

## Priority Standard 12.4: Basic Motor Controls and Relays

**Big Idea (s):**

1. Motor control is the "Brain" of industrial automation; by separating the **Control Circuit** (low current) from the **Power Circuit** (high current), we can safely automate heavy machinery using small switches and sensors.
2. The "Ladder Diagram" is the universal language of automation; translating a vertical flow of logic into a physical horizontal wiring layout is the core competency of an industrial electrician.

**Essential Question (s):**

1. How can we control a large motor with small control devices?
2. What is the purpose of a motor starter?
3. What scenarios would you need to reverse a motor?
4. How do you think we can control all of the parking lot lights from 1 switch?
5. How do we control the temperature of separate rooms of a commercial building?

**Learning Outcomes**

| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
|---|---|
| **4.1 Explain, interpret and draw line diagrams** | ● **Identify basic line diagram symbols**<br>● **Explain normally closed and normally open.**<br>● **Explain how start and stop buttons are wired.**<br>● **Explain the purpose of memory contacts.**<br>● **Draw simple ladder logic diagrams** |
| **4.2 Install motor control projects per line diagrams** | ● **Explain how a motor starter works and identify its parts**<br>● **Explain the purpose of momentary contacts.**<br>● **Explain how to size a motor starter**<br>● **Identify typical colors of push buttons**<br>● **Explain the function of a coil.**<br>● **Explain the purpose of overloads/heaters.**<br>● **Explain how to reverse a three phase motor**<br>● **Install various control circuits to control a motor(s)** |
| **4.3 Identify and install a lighting contactor with control devices.** | ● **Explain the difference between a lighting contactor and motor starter**<br>● **identify control devices for lighting**<br>● **Explain how to size a lighting contactor** |
| **4.4 Identify and install HVAC and/or boiler controls** | ● **Explain how a control relay works with a thermostat.**<br>● **Identify a RIB relay and explain how it functions** |

**Link to Proficiency Scale**

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Button<br>• Switch<br>• Coil<br>• Spring<br>• Remote | • Logic<br>• Sequence<br>• Schematic<br>• Interlock<br>• Automatic<br>• State (Open/Closed) | • Magnetic Motor Starter<br>• Contactors<br>• Control Relay<br>• Normally Open (NO)<br>• Normally Closed (NC)<br>• Holding Circuit (Seal-in Circuit)<br>• Overload Relay<br>• Pilot Device<br>• Line Diagram (Ladder Logic)<br>• Wiring Diagram<br>• Auxiliary Contact<br>• Two-Wire Control<br>• Three-Wire Control<br>• Selector Switch |

**Trade Math Crossover:**

Students apply these terms when calculating **Control Transformer VA** ratings to ensure the control circuit has enough power to pull in the magnetic coils of multiple contactors and relays without dropping voltage**.**

**Resources to compliment learning-** Mike Holt: Basic Motor Controls (Units 1-11), Apprentice Resources (Basic Motor Controls)

**Crossover to Apprenticeship Standards:** A0906 - Motor Controls

**VOG Portfolio Collection Examples:**

- **Critical Thinker -** Students complete wiring diagrams for motor controls and construct projects from their diagrams.

- **Effective Communicator:** Students are required to draw and present a "Ladder Diagram" for a Start/Stop station with a holding circuit. They must clearly explain the flow of current through the **control circuit** versus the **power circuit** to a non-technical peer, ensuring the listener understands how the relay coil energizes the contacts to "latch" the motor.
- **Skilled Socially:** In teams, students are tasked with wiring a multi-step conveyor belt system where one motor must start *only* after a previous one is running. This project requires being **skilled socially** as the team must coordinate the placement of interlocks and auxiliary contacts, communicating clearly to ensure the wiring remains organized and maintainable for future inspections.

## Priority Standard 12.5: Fire Alarm

**Big Idea (s): Grade**

1. A Fire Alarm system is a "Supervised Circuit"; its primary function is to monitor its own integrity so that any break in the wire (open) or loss of power is immediately identified before an emergency occurs.

2. "Voltage Drop" is the limiting factor of life safety; every foot of wire adds resistance (R), and if the voltage at the last strobe falls below the manufacturer's "operating window," the device will fail to fire during an alarm.

**Essential Question (s):**

1. How does the electrical design of a "Supervised Circuit" differ from a standard lighting circuit, and why is this distinction critical for a building's survival?
2. Why is it that a strobe light might work perfectly during a single-device test but fail completely when the entire system is activated in an emergency?
3. In a catastrophic event, how does the NEC/NFPA 72 requirement for "Power-Limited" (FPL) cabling and specific circuit "Pathways" (Class A vs. Class B) ensure that a single wire break doesn't leave an entire floor of a building unprotected?

**Learning Outcomes**

| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
|---|---|
| **5.1 Identify and install common devices of a residential fire alarms system and explain their function.** | • **Identify various types of smoke and carbon monoxide detectors**<br>• **Explain NEC and International Building Code requirements for residential fire alarm systems**<br>• **Explain NEC and International Building Code requirements for multifamily dwellings.** |
| **5.2 Identify and install common devices of a commercial fire alarms system and explain their function.** | • **Explain the difference between an addressable and non-addressable fire alarm system.**<br>• **Identify various types of initiating devices.**<br>• **Identify various annunciating devices.**<br>• **Define EOL.**<br>• **Explain how the fire alarms system interacts with other systems in a commercial building.** |

**Link to Proficiency Scale**

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| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Sound<br>• Smoke<br>• Heat<br>• Siren<br>• Alert | • Notification<br>• Initiation<br>• Supervised<br>• Integration<br>• Redundant<br>• Verification | • FACP (Fire Alarm Control Panel)<br>• Initiating Device Circuit (IDC)<br>• Notification Appliance Circuit (NAC)<br>• Addressable System<br>• Conventional System<br>• End-of-Line Resistor (EOLR)<br>• Pull Station<br>• Annunciator Panel<br>• Photoelectric Sensor<br>• Ionization Sensor<br>• Intelligent Device<br>• Power-Limited Tray Cable (FPLP/FPLR)<br>• Monitoring Station |

**Trade Math Crossover:**

Students apply these terms when calculating **Voltage Drop** on long NAC circuits to ensure that the last horn-strobe on the line still receives the minimum operating voltage required by the manufacturer's specifications

**Resources to compliment learning-** Mike Holt: NEC Vol. 2 (Art. 760), Apprentice Resources (Fire Alarm Systems)

**Crossover to Apprenticeship Standards:** A0927, A0928

**VOG Portfolio Collection Examples:**

- **Critical Thinker - Students complete diagrams for fire alarm and construct projects from their diagrams**.
- **Effective Communicator:** Students must present a "Fire Safety Schematic" to a mock building owner.

They must clearly explain the difference between **Initiating Devices** (smoke detectors, pull stations) and **Notification Appliances** (horns, strobes), and why the system's "supervision" circuits are vital for ensuring the system is always ready to activate.

- **Problem Solver:** In a large building, notification appliances at the end of a long wire run may not have enough voltage to "fire" during an emergency. As a **problem solver**, students must calculate the **Voltage Drop** using Ohm's Law and wire resistance to determine if the system will function at the end-of-line (EOL). If it fails, they must redesign the circuit (e.g., adding power boosters) to ensure compliance.

<table>
<tr><th colspan="2">Priority Standard 12.6 Telecommunications</th></tr>
<tr><td colspan="2">Big Idea (s):<br>In telecommunications, "Physical Geometry is Signal Integrity"; maintaining the correct Bend Radius and minimizing Decibel (dB) loss is the only way to ensure that high-speed data arrives at its destination without corruption or latency.</td></tr>
<tr><td colspan="2">Essential Question (s):<br>1. What systems in a dwelling unit use coaxial cable?<br>2. Explain how to terminate CAT5E cable?<br>3. Why is fiber optic cable now being installed in neighborhoods?</td></tr>
<tr><td colspan="2">Learning Outcomes</td></tr>
<tr><td>Students will know:</td><td>As evidenced by:(oral, written, or performance)</td></tr>
<tr><td>6.1 Installation of coaxial cables and equipment.</td><td>● Identify coaxial cable and explain the uses of coaxial cable<br>● Terminate coaxial cable ends and test<br>● Identify and explain grounding requirements for coaxial cable<br>● Identify NEC installation requirements for coaxial cable</td></tr>
<tr><td>6.2 Identify and install category cables used for phone and networking systems and explain the NEC requirements associated with such cables.</td><td>● Describe wire management.<br>● Demonstrate how to test Category cables.<br>● Explain demarcation point.<br>● Demonstrate punch down 110/66.<br>● Identify NEC installation requirements for category cables used for phone and networking<br>● Explain EIA/TIA standards<br>● Explain T568A and T568B color codes.<br>● Terminate RJ45 ends</td></tr>
<tr><td>6.3 Identify fiber optic cables</td><td>● Explain how fiber optic cables work<br>● Explain the different types of fiber optic cable<br>● Explain the different types of terminations for fiber optic cables.</td></tr>
<tr><td colspan="2"><u>Link to Proficiency Scale</u></td></tr>
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**CTECS ELECTRICAL**

| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Internet<br>• Cable<br>• Jack<br>• Phone<br>• Speed | • Transmission<br>• Termination<br>• Interference<br>• Performance<br>• Topology<br>• Infrastructure | • Twisted Pair (UTP/STP)<br>• Category Cable (Cat 5e, Cat 6, Cat 6A)<br>• Fiber Optics (Single-mode/multi-mode)<br>• RJ-45 Connector<br>• Punch Down Block (66 Block / 110 Block)<br>• Patch Panel<br>• Cross-Connect<br>• Crosstalk (NEXT/FEXT)<br>• Attenuation<br>• Decibel (dB)<br>• T568A / T568B Wiring Standards<br>• Structured Cabling System (SCS)<br>• Backbone Cabling |

**Trade Math Crossover:**

Students apply these terms when calculating **Maximum Link Length** (typically 90 meters for horizontal cabling) and determining the **Bend Radius** of fiber optic or high-speed copper cables to prevent signal loss or physical damage to the media.

**Resources to compliment learning- Mike Holt:** NEC Vol. 2 (Art. 725, 770, 800, 805, 810, 820)

**Crossover to Apprenticeship Standards:** A0924, A0925, A0928

**VOG Portfolio Collection Examples:**

- **Effective Communicator:** Students must prepare a technical briefing for a commercial client explaining the impact of "dB loss" (decibels) on high-speed data transmission. They must explain why exceeding the maximum run length or bending a fiber-optic cable beyond its minimum radius degrades the signal, using clear language to justify the need for high-quality installation practices.

- **Problem Solver:** Students are given a floor plan for a large office building and must design a "Data Backbone" layout. As a **problem solver**, they must calculate the optimal placement for Intermediate Distribution Frames (IDFs) to ensure no horizontal cable run exceeds the 90-meter limit, minimizing signal loss and ensuring code-compliant cable support.
- **Skilled Socially:** In teams, students must assemble a server rack, including patching, labeling, and cable management. This project requires being skilled socially as the team must coordinate the "dressing" of hundreds of cables; one student manages the cable pathway while another terminates the patch panel, requiring constant communication to ensure the rack is clean, accessible, and organized for future maintenance.

| **Priority Standard 12.7: Solar PV** | |
|---|---|
| **Big Idea (s):** Solar PV systems are unique because they have **multiple power sources**; safe installation requires understanding the chemistry of the modules and the strict NEC labeling requirements to ensure firefighters and technicians can safely de-energize the array. | |
| **Essential Question (s):** 1. Do you think every home or business will have a PV system one day, support your thoughts? 2. Why are there so many solar farms being installed in CT? 3. What are the differences between a residential PV system and a commercial PV system | |
| **Learning Outcomes** | |
| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
| **7.1 Explain how a residential photovoltaic system works and demonstrate how to install a photovoltaic system per NEC requirements** | Reference NABCEP 6.3 thru 6.8<br>• Visually inspect and quick test PV modules<br>• Assemble modules, panels and support structures as specified by module manufacturer or design<br>• Install module array interconnect wiring, implement measures to disable array during installation<br>• Complete final assembly, structural attachment and weather sealing of array to building or other support mechanism<br>• Install and provide required labels on inverters, controls, disconnects and overcurrent devices, surge suppression and grounding equipment, junction boxes, batteries and enclosures, conduit and other electrical hardware<br>• Label, install and terminate electrical wiring; verify proper connections, voltages and phase/polarity relationships |
| **7.2 Explain how a commercial photovoltaic system works and demonstrate how to install a photovoltaic system per NEC requirements** | Reference NABCEP 6.3 thru 6.8<br>• Visually inspect and quick test PV modules<br>• Assemble modules, panels and support structures as specified by module manufacturer or design<br>• Install module array interconnect wiring, implement measures to disable array during installation<br>• Complete final assembly, structural attachment and weather sealing of array to building or other support mechanism<br>• Install and provide required labels on inverters, |

| | |
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| | controls, disconnects and overcurrent devices, surge suppression and grounding equipment, junction boxes, batteries and enclosures, conduit and other electrical hardware<br>• Label, install and terminate electrical wiring; verify proper connections, voltages and phase/polarity relationships |

**Link to Proficiency Scale**

**Tiered Vocab**- Electrical students build a professional vocabulary, we have broken down the terms into three tiers based on the standard educational model:

- **Tier 1:** Common, everyday words (Basic communication).
- **Tier 2:** High-frequency academic words (Used across various subjects/trades).
- **Tier 3:** Low-frequency, domain-specific technical terms (The "Language of the Trade").

| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Sun<br>• Panel<br>• Roof<br>• Battery<br>• Power | • Generation<br>• Conversion<br>• Interconnection<br>• Renewable<br>• Efficiency<br>• Inversion | • PV Module<br>• Photovoltaic Array<br>• Inverter (String vs. Micro-inverter)<br>• DC Optimizer<br>• Rapid Shutdown System (RSS)<br>• Combiner Box<br>• Grid-Tied vs. Off-Grid<br>• Island Mode<br>• Maximum Power Point Tracking (MPPT)<br>• Irradiance<br>• PV Output Circuit<br>• Charge Controller<br>• Net Metering |

**Trade Math Crossover:**

Converting KWH to watts.

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| Students apply these terms when calculating **Maximum System Voltage** (using NEC 690.7), which requires adjusting the module's Open-Circuit Voltage (Voc) based on the **lowest expected ambient temperature** of the installation site to prevent equipment damage. |
| **Resources to compliment learning-** Mike Holt: NEC Vol. 2 (Art. 690), Grounding and Bonding (Art. 690), Solar Photovoltaic Systems (Chapters 1-7) |
| **Crossover to Apprenticeship Standards:** A0910 |
| **VOG Portfolio Collection Examples:**<br>• **Work Ready -** Students will Assemble modules, panels and support structures as specified by module manufacturer or design<br>• **Work Ready:** To prove they are work ready, students must perform a commissioning checklist on a simulated Solar PV system. They must verify array interconnect wiring, implement de-energization measures, and—crucially—install all required NEC warning labels (such as "Photovoltaic Power Source") so that first responders can safely shut down the system in an emergency. |

| **Priority Standard 12.8: Exam Preparation** | |
|---|---|
| **Big Idea (s):**<br><br>1. A Journeyman's license is a "License to Think"; passing the exam requires mastering the **Language of the Code** to quickly navigate 800+ pages of legal/technical text to find the single correct safety standard for any given installation.<br><br>2. The **Standard Dwelling Load Calculation** is the ultimate test of an electrician's mathematical literacy; it requires the precise application of **Demand Factors** and "Non-Coincident Load" rules to ensure a building's service is neither dangerously undersized nor wastefully oversized. | |
| **Essential Question (s):**<br>1. When is it more advantageous for a designer to use the **Optional Calculation (Article 220, Part IV)** instead of the **Standard Calculation**, and how does this choice impact the physical size of the service entrance conductors?<br>2. Why does the NEC require the use of "Demand Factors" rather than simply adding up the connected wattage of every appliance in a building?<br>3. How does understanding the organizational "architecture" of the NEC allow an electrician to solve a unique installation problem that isn't explicitly named in the Index? | |
| **Learning Outcomes** | |
| *Students will know:* | *As evidenced by:(oral, written, or performance)* |
| **8.1 Calculate box fill for residential and commercial applications** | ● **Identify NEC requirements for box size and fill.**<br>● **Calculate residential box fill for various switch, receptacle and junction boxes.**<br>● **Calculate commercial box sizes with various conduit sizes and scenarios** |
| **8.2 Calculate voltage drop for various scenarios** | ● **Explain the voltage drop formula**<br>● **Calculate voltage drop for 120 volt circuits**<br>● **Calculate voltage drop for 240 volt circuits**<br>● **Calculate voltage drop for 3 phase circuits** |
| **8.3 Calculate residential and commercial service calculations** | ● **Identify NEC requirements for service calculations**<br>● **Calculate lighting load of a dwelling unit**<br>● **Calculate the minimum number of circuits for a dwelling unit using the square footage.**<br>● **Calculate heating and A/C loads of a dwelling unit**<br>● **Calculate motor loads of a dwelling unit**<br>● **Calculate minimum service conductor size of a dwelling unit**<br>● **Calculate feeder size**<br>● **Calculate minimum size service for a commercial building** |

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| **8.4 Calculate conductor and breaker size for Motors, Air Conditioning units and Transformers** | ● **Calculate the minimum conductor size for a motor and multiple motors on a branch circuit.**<br>● **Calculate short circuit/ground fault protection for a motor and multiple motors on a branch circuit**<br>● **Calculate minimum circuit ampacity of a Heat Pump/Condenser**<br>● **Calculate maximum fuse size for a Heat Pump/Condenser**<br>● **Calculate conductor size, conduit size and overcurrent protection for the primary and secondary of a transformer.** |

**Link to Proficiency Scale**

**Tiered Vocab-** Electrical students build a professional vocabulary, we have broken down the terms into three tiers based on the standard educational model:

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- **Tier 3:** Low-frequency, domain-specific technical terms (The "Language of the Trade").

| Tier 1 (Everyday) | Tier 2 (Academic) | Tier 3 (Technical/Trade) |
|---|---|---|
| • Test<br>• Question<br>• Time<br>• Answer<br>• Grade | • Analysis<br>• Synthesis<br>• Evaluation<br>• Competency<br>• Proficiency<br>• Interpretation | • NEC Index<br>• Keyword Identification<br>• Table of Contents Navigation<br>• Cross-Reference<br>• Annexes (A through J)<br>• Informational Note<br>• Mandatory vs. Permissive Language<br>• Tabbed Code Book<br>• Calculations (Load, Conduit Fill, Ampacity)<br>• Theoretical Knowledge<br>• Applied Sciences<br>• Industry Standards |

**Trade Math Crossover:**

Students apply these terms by performing **Comprehensive Load Calculations** for a dwelling unit (NEC

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| Article 220), which requires totaling the Volt-Amps (VA) for general lighting, small appliance circuits, and laundry, then applying demand factors to determine the final service size. |
| **Resources to compliment learning-** Mike Holt: Exam Prep (Units 1-11) |
| **VOG Portfolio Collection Examples:**<br>• **Work Ready** - Students will create an electrical contracting business, with a logo. Students will create an estimate and scope of work from an instructor provided project.<br>• **Respectful:** Students write a final reflection on their four-year journey, detailing how their understanding of the NEC has evolved. They must explicitly discuss the importance of **respecting** the code not just as a set of rules, but as a commitment to the safety of every person who will occupy the buildings they wire. |

## Appendix

[Link to NABCEP Standards for Solar PV]

[Link to CTECS Licensed Trade VOG Guides & Resources]

[Link to Instructional Guidebook Resources]

## Grade 9 Math/Trade Crossover

| Priority Standard | Math Domain | Real-World Application | NEC Reference / Formula |
|---|---|---|---|
| **9.1 Hand & Power Tools** | **Fractions & Decimals** | Reading tape measures to 1/16" and converting to decimals for digital calipers. | 1/16" = 0.0625 |
| **9.2 Electrical Theory** | **Algebraic Equations** | Calculating the "Big Three": Voltage, Current, and Resistance. | **Ohm's Law:** E = I \times R |
| **9.2 Electrical Theory** | **Power Calculations** | Determining total wattage consumed by a circuit to avoid tripping breakers. | **Watt's Law:** P = I \times E |
| **9.3 Blueprint Reading** | **Ratios & Proportions** | Converting paper measurements to actual foot-and-inch room dimensions. | **Scaling:** 1/4" = 1'0" |
| **9.4 Residential Wiring** | **Volume & Addition** | Summing up "volume allowances" for wires, clamps, and devices. | **NEC Table 314.16(B)** |
| **9.4 Residential Wiring** | **Linear Measurement** | Ensuring cable is supported within 12" of a box and every 4.5'. | **NEC 334.30** |
| **9.5 Fasteners** | **Physics & Load** | Calculating the sheer and tensile strength needed to hang heavy fixtures. | **Weight / Capacity** |

**Theory Tip:** Remind students that if they know any **two** values, they can always find the third. This is the foundation of all electrical troubleshooting.

**Tool Tip:** Precision at this stage prevents "short-wire" syndrome. In Grade 9, we focus on the rule: *"Measure twice, cut once."*

**Wiring Tip:** This is the first time students use the **NEC (Table 314.16B)**. They must learn that a 14 AWG wire takes up 2.00 cubic inches, while a 12 AWG wire takes up 2.25.

**CTECS ELECTRICAL**

## Grade 10 Math/Trade Crossover

| Priority Standard | Math Domain | Real-World Application | NEC Reference / Formula |
|---|---|---|---|
| **10.1 Workplace Safety** | **Ratios & Proportions** | Determining the safe angle for extension ladders using the 1:4 rule. | **4:1 Ratio** (H \div 4) |
| **10.2 Service Entrance** | **Area & Multiplication** | Calculating the Square Footage of a dwelling to determine the General Lighting Load. | **NEC 220.12** (3 VA per sq. ft.) |
| **10.3 Rough-in Wiring** | **Addition & Volume** | Calculating box fill for multi-gang boxes and deep device 12/2 and 14/2 NM cables. | **NEC Table 314.16(B)** |
| **10.4 Device Wiring** | **Algebraic Balance** | Balancing loads across Phase A and Phase B in a residential breaker panel. | **Load Balancing** |
| **10.5 Specialized Apps** | **Geometry** | Layout of recessed lighting ("Can lights") to ensure even overlapping "cones" of light. | **Spacing = 2 \times distance from wall** |
| **10.6 Residential Finishes** | **Measurement** | Ensuring trim plates are level and flush within 1/4" of non-combustible surfaces. | **NEC 314.20** |

**Visualizing the Grade 10 Math**

**Service Tip:** Remind students that when calculating square footage for the NEC, they must use the **outside dimensions** of the house and subtract open porches or unused spaces.

**Panel Tip:** A "Balanced Panel" prevents excessive current on the neutral wire. If Leg A has 40 Amps and Leg B has 38 Amps, the neutral only carries 2 Amps.

**Layout Tip:** To avoid "hot spots" or dark corners, the distance between two lights should be double the distance from the first light to the wall.

**CTECS ELECTRICAL**

## Grade 11 Math/Trade Crossover

| Priority Standard | Math Domain | Real-World Application | NEC Reference / Formula |
|---|---|---|---|
| **11.1 Workplace Safety** | **Ratios & Geometry** | Calculating safe approach boundaries and fall protection clearances. | **4:1 Ladder Ratio** |
| **11.2 Grounding & Bonding** | **Table Linear Interpolation** | Sizing conductors based on the largest ungrounded service conductor. | **NEC Table 250.66** |
| **11.3 Cables & Raceways** | **Trigonometry** | Using "Multipliers" to calculate the distance between bends (Offsets/Saddles). | **Cosecant (csc) of Angle** |
| **11.3 Cables & Raceways** | **Area & Percentages** | Calculating 40% cross-sectional area for conduit fill with 3+ wires. | **NEC Chapter 9, Table 1** |
| **11.4 Equipment** | **Measurement** | Calculating minimum clear working space depth (Condition 1, 2, or 3). | **NEC Table 110.26(A)(1)** |
| **11.5 Special Occupancies** | **Percentages** | Calculating "Sealing" requirements and voltage drop for long temp runs. | **3% Max Voltage Drop** |
| **11.6 Pools & Spas** | **Radial Geometry** | Measuring the 5-foot and 10-foot "Perimeter" zones for bonding. | **NEC 680.26(B)(2)** |

**Visualizing the Grade 11 Math**

**Bending Tip:** Remind students that the "Multiplier" is the hypotenuse of the triangle. For a 30-degree offset, the multiplier is 2.0. If they need a 4"rise, they mark their pipe at 8"( 4 X 2).

**Fill Tip:** This is "Math by Table." Students must find the square-inch area of their specific wire insulation (like THHN) in Table 5, then ensure the total doesn't exceed the 40% column in Table 4.

**Grounding Tip:** Students often confuse the Grounding Electrode Conductor (Table 250.66) with the Equipment Grounding Conductor (Table 250.122). Math mastery here means knowing which table to look at based on the "Overcurrent Device" vs. "Service Wire."

## Grade 12 Math/Trade Crossover

| Priority Standard | Math Domain | Real-World Application | NEC Reference / Formula |
|---|---|---|---|
| **12.1 Workplace Safety** | **Standard Units ($Cal/cm^2$)** | Determining the Incident Energy of an arc flash to select PPE. | **NFPA 70E Tables** |
| **12.2 Transformers** | **Ratios & Roots** | Calculating Voltage/Current changes and 3-Phase power factors. | P = V  x I x sqrt 3 |
| **12.3 Motor Circuits** | **Percentages** | Sizing branch circuits at 125% and fuses up to 300% of FLA. | **NEC 430.22 / 430.52** |
| **12.4 Motor Controls** | **Load Totals** | Sizing control transformers based on the "inrush" VA of magnetic coils. | **VA Rating Calculation** |
| **12.5 Fire Alarm** | **Voltage Drop** | Ensuring notification appliances (horns/strobes) have enough V to fire. | **I \times R (End of Line)** |
| **12.6 Telecom** | **Geometry & Decibels** | Calculating "Bend Radius" and signal loss (dB) over distance. | **Radius = 4 x Cable Dia.** |
| **12.7 Solar PV** | **Temperature Coefficients** | Adjusting Voc based on lowest record ambient temperature. | **NEC 690.7** |
| **12.8 Exam Prep** | **Advanced Algebra** | Comprehensive dwelling load calcs with demand factors. | **NEC Article 220** |

**Visualizing the Grade 12 Math**

**Industrial Tip:** In Grade 12, students must understand that not all power is "useful." They use the **Power Triangle** to understand how motors (inductive loads) create a lag that requires power factor correction.

**Motor Tip:** Students learn that they never use the "Amps" on the motor nameplate for circuit sizing; the NEC requires them to use the **FBC (Full-Load Current)** tables (430.247-250) for consistency and safety.

**Safety Tip:** The math here is about **Distance**. As the distance from the energized source increases, the incident energy drops exponentially. Students calculate where the "Limited Approach Boundary" begins.