Department of Education | College, Career and Technical Education

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Electrical Systems

Primary Career Cluster:	Architecture & Construction
Course Contact:	CTE.Standards@tn.gov
Course Code(s):	C17H16
Prerequisite(s):	*Mechanical, Electrical, & Plumbing Systems* (C17H23)
Credit:	1
Grade Level:	11-12
Elective Focus -Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
POS Concentrator:	This course satisfies one out of two required courses that meet the Perkins V concentrator definition, when taken in sequence in the approved program of study.
Programs of Study and Sequence:	This is one of the third-level course options in the *Mechanical, Electrical, & Plumbing (MEP) Systems* program of study.
Aligned Student Organization(s):	SkillsUSA: https://www.skillsusatn.org/
Coordinating Work-Based Learning:	Teachers are encouraged to use embedded WBL activities such as informational interviewing, job shadowing, and career mentoring. For information, visit https://www.tn.gov/content/tn/education/career-and-technical-education/work-based-learning.html.
Promoted Tennessee Student Industry Credentials:	Credentials are aligned with postsecondary and employment opportunities and with the competencies and skills that students acquire through their selected program of study. For a listing of promoted student industry credentials, visit https://www.tn.gov/education/career-and-technical-education/student-industry-certification.html
Teacher Endorsement(s):	523, 532, 567, 580, 592, 701
Required Teacher Certifications/Training:	None
Teacher Resources:	https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-architecture-construction.html Best for All Central: https://bestforall.tnedu.gov/

Approved April 10, 2015; Amended Jan. 31, 2018; Nov. 2021

Course-At-A-Glance

CTE courses provide students with an opportunity to develop specific academic, technical, and 21st century skills necessary to be successful in career and in life. In pursuit of ensuring every student in Tennessee achieves this level of success, we begin with rigorous course standards which feed into intentionally designed programs of study.

Students engage in industry relevant content through general education integration and experiences such as career & technical student organizations (CTSO) and work-based learning (WBL). Through these experiences, students are immersed with industry standard content and technology, solve industry-based problems, meaningfully interact with industry professionals and use/produce industry specific, informational texts.

Using a Career and Technical Student Organization (CTSO) in Your Classroom

CTSOs are a great resource to put classroom learning into real-life experiences for your students through classroom, regional, state, and national competitions, and leadership opportunities. Below are CTSO connections for this course, note this is not an exhaustive list.

- Participate in CTSO Fall Leadership Conference to engage with peers by demonstrating logical thought processes and developing industry specific skills that involve teamwork and project management.
- Participate in contests that highlight job skill demonstration. These include Career Pathways Showcase, Job Interview, Building Maintenance, and Electrical Wiring.

Using a Work-based Learning (WB) in Your Classroom

Sustained and coordinated activities that relate to the course content are the key to successful work-based learning. Possible activities for this course include the following. This is not an exhaustive list.

- **Standards 1.1-1.4** | Include a safety briefing in a visit to an industry partner/job site.
- **Standard 3.1-3.2 |** Visit a local company and discuss construction industry principles with those employees.
- **Standards 4.1-5.2** | Guest speaker.
- **Standards 6.1-8.2** | Do a project or work at a jobsite to be critiqued by the employer.
- **Standards 9.1-9.3** | Ask an industry rep to discuss the impact of construction drawings to an electrician on the job.
- **Standards 11.1-11.2** | Ask an industry rep to discuss the realities of basic troubleshooting.
- **Standards 13.1-13.5** | Do a project that is used by a local industry or evaluated by local industry managers.

Course Description

Electrical Systems prepares students for careers as electricians across a variety of residential and commercial environments. Upon completion of this course, proficient students will be able to implement safety procedures and tools to perform operations with device boxes, conduit, raceway systems conductors, and cable. Students will read and interpret the National Electrical Code, drawings, specifications, and diagrams to determine materials and procedures needed to complete a project. Students will calculate residential loads to recommend electrical hardware. Standards in this course also introduce basic troubleshooting procedures and power systems, and expand on principles of the construction industry, delving deeper into business and project management. Students will continue compiling artifacts for inclusion in their portfolios, which they will carry with them throughout the full sequence of courses in this program of study.

Course Standards

1. Safety

1.1. Safety Hazards: Identify **safety hazards on a jobsite** and demonstrate **practices for safe working.** Accurately read, interpret, and demonstrate **safety rules**, including but not limited to rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA) guidelines, and state and national code requirements. Be able to **distinguish between the rules** and explain **why certain rules apply**. Recognize and employ **universal construction signs and symbols** such as colors, flags, stakes, and hand signals that apply to construction workplace situations. Research and evaluate **construction company safety plans** from local industry. Explain the need for **jobsite security** to prevent liability.

1.2. Safety Records and Industry Practices: Maintain **safety records** and demonstrate **adherence to industry-standard practices** regarding general machine safety, tool safety, equipment safety, electrical safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate **safety procedures** when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy.

1.3. Materials Safety Procedures: Follow procedures to work safely around materials. Adhere to responsibilities for employees in **material safety** as outlined by the **Hazard Communication Standard (HazCom)**, such as locating and interpreting **material safety data sheets (MSDS).** For example, obtain an MSDS for a given material from a supplier in the community. Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment.

1.4. Electricity Hazards: Describe **hazards involved when working with electricity** and determine **procedures to safeguard against them** in the workplace, including ensuring

power load balance, adhering to the appropriate use of ground-fault circuit interrupters (GFCIs) when working with power tools, and performing lockout/tagout procedures.

2. Tools & Equipment

2.1 Tools: Identify and select the **proper tools** and accessories, critique the readiness of the tools, use the tools to **accomplish the desired tasks**, and then return the tools and accessories to their proper storage. Research a **new technology** recently developed for the electrical industry. For example, describe how a new power tool could improve efficiency for a technician.

2.2 Test Equipment: Distinguish among the **various types and uses of electrical test equipment**. Determine the **appropriate test equipment for a given situation and environment** and the **procedures necessary for safe use**. Utilize test equipment to inspect and test the **compliance of an electrical wiring system** according to drawings, specifications, and code requirements.

3. Construction Industry Principles

3.1 Electrical Work: Understand **how electrical work fits into the overall construction project**. Locate and assess **requirements for performing electrical work** including local, state, and national requirements. Interpret **electrical codes** and determine **inspection procedures** and other applicable portions of the law. Visit the **Tennessee Contractor's Licensing Board's website** and analyze its **policies and requirements**. Explain how such policies impact local construction businesses.

3.2 Alternative Project Delivery Methods: Explain a **project delivery method**. Consult a variety of sources to describe **alternatives to traditional project delivery methods**, such as the design-build and construction management-related methods, distinguishing among the roles and relationships of various construction personnel in each scenario. Examine the project delivery method of an actual company.

4. National Electrical Code (NEC©)

4.1 National Electrical Code: Describe the **purpose and layout of the National Electrical Code (NEC©)**. Illustrate **what is and is not covered by the NEC©,** citing evidence from *NEC© Article 90*. Navigate, read, and interpret the NEC© to determine **requirements for a given electrical installation**. For example, interpret the NEC© to compare and contrast the box requirements for a device box to support a wall receptacle with those for a box to support a lighting fixture.

5. Device Boxes

5.1 Identify Device Boxes: Distinguish among the various **types of device boxes**, such as metallic and nonmetallic device boxes. For a variety of given residential and/or commercial applications, **select appropriate device boxes** according to drawings, specifications, and code requirements. Steps should include identifying the proper box type and size; and determining the minimum size pull or junction box for conduit entering and exiting (both for a straight pull and at an angle).

5.2 Install Device Boxes: Utilize the proper tools, equipment, and procedures to safely perform **installation of a variety of device boxes** according to drawings, specifications, and code requirements.

6. Hand Bending

6.1 Hand Bend Conduit: Describe the procedures, techniques, and tools for **hand bending and installing conduit**. Implement **geometric principles to plan and use a hand bender** to make 90 degree bends, back-to-back bends, offsets, kicks, and saddle bends. For example, use trigonometric ratios of right triangles to determine the offset angle of an offset bend and use the calculation to accurately create the bend.

6.2 Cut, Ream, and Thread Conduit: Apply the appropriate tools, equipment, and procedures to safely **cut, ream, and thread conduit**. For example, ream the inside edge of a piece of conduit using a hand reamer.

7. Raceway Systems

7.1 Raceway Systems: Explain the **function of raceway systems**, including acting as a grounding conductor. Distinguish among the **various types of raceways, fittings, and conduit bodies** available for raceway systems**.** Analyze a given environment and select the **appropriate materials and installation methods for a raceway system**, citing evidence from textbooks and codes. For example, recommend the appropriate raceway materials and installation method for a wood frame building of given parameters, drawing on evidence from codes such as the National Electrical Code (NEC©).

7.2 Install Raceway Systems: Outline the **methods and procedures used to install various raceway systems, including terminating conduit.** Accurately **connect conduit to a box** according to code requirements, explaining the need for a proper connection based on grounding requirements and protection of the wires. Apply the **appropriate tools and procedures to install flexible raceway systems.**

8. Conductors & Cables

8.1 Conductor Capacity: Building on knowledge of **conductors** from *Mechanical, Electrical, & Plumbing Systems* course, read and interpret the NEC© and other instructional texts to determine **the allowable ampacity of conductors** for a variety of given applications. Include the insulation and jacket material, conductor size and type, number of conductors, temperature rating, and voltage rating of each. Describe possible **consequences of improper conductor selection or installation**, citing evidence from resources such as textbooks or trade journals.

8.2 Conductors in Raceways: Describe the **proper methods and procedures for installing conductors in a raceway system**, noting potential hazards that exist when conductors are installed incorrectly. Employ **tools and procedures to safely install conductors in a raceway system** and **verify the installation** is performed according to code requirements.

9. Construction Drawings & Specifications

9.1 Read Drawings and Specifications: Building on knowledge of construction drawings and specifications from *Mechanical, Electrical, & Plumbing Systems* course, read and interpret **electrical drawings and specifications**, including detail drawings and equipment schedules, to create a **list of materials needed** for a given electrical project. For example, analyze a lighting plan, light fixture schedule, and specifications for a residence to determine the materials needed to install the lighting system.

9.2 Use Drawings and Specifications: Explain the **relationship between construction drawings and specifications**. For example, describe **how both the construction drawings and specifications provide information about the raceway system** indicated for a given building. Examine construction drawings and specifications to determine **the requirements for a raceway system in a given building.**

9.3 Request for Information: Describe processes by which construction professionals obtain **clarification from architects regarding construction documents**, such as by the use of requests for information (RFI's). **Write a request for information (RFI)** as would a construction professional to an architect to request clarification for a detail of the construction documents, such as the selection of a product.

10. Residential Electrical Services

10.1 Hardware in Residential Construction: Evaluate and recommend **proper electrical hardware for a residential building.** For example, for a residential dwelling with a given floor plan and schedule of major appliances, determine the size of the electrical service by referring to the National Electrical Code© and local code to select the service-entrance equipment, such as conductors, panelboard, and protective devices. Steps should include:

a. calculating the load for lighting,
b. small appliances, and large appliances, and
c. determining the number of branch circuits required.

Describe the **installation rules pertaining to dedicated circuits** as applied to various equipment such as ranges, dryers, and HVAC systems.

11. Basic Maintenance & Repair Process

11.1 Troubleshooting: Identify and demonstrate **basic troubleshooting strategies appropriate for evaluating electrical systems and devices**. For example, in electrical systems, develop and implement a troubleshooting strategy to test and remedy an electrical fault.

11.2 Maintenance Procedures: Identify **routine maintenance procedures that should be performed on electrical systems** for a given building. Create a **timeline of recommended maintenance procedures for a client,** justifying why each procedure is necessary by highlighting its preventive or cost-efficient characteristics. For example, create a schedule of tests to ensure emergency alarms are operating properly.

12. Introduction to Power Systems

12.1 Power Systems: Analyze **typical electric power systems in a region** by explaining how electricity is generated, transmitted, and distributed from a power plant to a given location**.** Describe **different types of traditional power generation** including fossil-fuel generation and nuclear energy. Explain the **basic layout of the power grid** and the function of its components, including substations and transformers.

12.2 Environmental Impacts of Electricity: Discuss the **environmental impacts of generating and distributing electricity.** Research alternate electric power systems, including but not limited to photovoltaic systems and wind power technologies. Describe the **functions of the systems and analyze their use in regions across the country** according to informational texts and technical specs. Compare and contrast at least three **types of power generation systems.**

13. Business & Project Management

13.1 Contract Documents: Describe the **components and purpose of a basic contract document** for a residential project, determining the meaning of **key terms and other industry-specific words**. Recognize the **relationship and responsibilities of various parties to a contract**. Write a **basic contract for a construction job,** such as an electrical service agreement for wiring work done for a residential client.

13.2 Project Management: Establish and implement **specific goals to manage project assignments** in a timely manner, including organizing teams to effectively manage

assignments, monitoring and reporting on project progress, and evaluating a completed project according to client requirements. For example, inspect and critique a team member's work, providing constructive feedback for improvement. Similarly, respond to **constructive feedback from a team member** to improve project outcomes and meet project goals.

13.3 Materials, Tools, and Equipment Lists: Interpret construction drawings and applicable national and local codes to determine **the correct materials, tools, and equipment needed to complete a construction project.** Plan and implement the **steps needed to complete the project**, adhering to inspection procedures and **employing safe practices** throughout. **Create a material list, cost estimation, project schedule, and inspection checklist** for a project, applying the components of the documents to the given project.

13.4 Write an Order: Produce clear and coherent writing for communication in the electrical industry. Create a **service order for a given electrical project.** Explain the service order to a peer, as would a service technician to a client.

13.5 Write a Report: Utilize technology to write and share **periodical reports** (weekly, monthly, etc.) to provide others with **information about progress during electrical projects as would a project manager to a supervisor**. Summarize activities in a narrative form including overall progress in relationship to a previously planned schedule.

14. Portfolio

14.1 Portfolio: Update materials from coursework to add to the portfolio started in *Fundamentals of Construction* and *Mechanical, Electrical, & Plumbing Systems*. Continually reflect on coursework experiences and revise and refine the career plan generated in prior courses. Include photographs or illustrations and written descriptions of sequential progress in construction projects.

Standards Alignment Notes

*References to other standards include:

- NCCER Curriculum: National Center for Construction Education and Research
    - Note: NCCER accreditation is required to offer NCCER credentials to students. Instructors trained through the NCCER Instructor Certification Training Program (ICTP) may use the NCCER curricula to teach the listed standards. By doing so, their students will receive a certificate of completion for NCCER Electrical Level One and be placed in NCCER's National Registry Database.
- P21: Partnership for 21st Century Skills Framework for 21st Century Learning
    - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.