

# **Construction Technologies Career Field Commercial and Industrial Construction Electrical Systems**

Subject Code: 178009

## **Outcome & Competency Descriptions**

### **Course Description:**

Students will plan and install electrical systems in commercial settings. Students learn worksite safety and understand permitting requirements. Students interpret plans and job specifications and calculate loads and service requirements. Students install, test and repair receptacle outlet, lighting and equipment circuits. They will understand circuit protection concepts and be able to install entrance panels. Specialty commercial circuit installation will be addressed. Students apply operating principles to the installation and troubleshooting of motors and controls.

### **Strand 1. Business Operations/21st Century Skills**

Learners apply principles of economics, business management, marketing and employability in an entrepreneur, manager and employee role to the leadership, planning, developing and analyzing of business enterprises related to the career field.

### **Outcome 1.1. Employability Skills**

Develop career awareness and employability skills (e.g., face-to-face, online) needed for gaining and maintaining employment in diverse business settings.

### **Competencies**

- 1.1.1. Identify the knowledge, skills and abilities necessary to succeed in careers.
- 1.1.2. Identify the scope of career opportunities and the requirements for education, training, certification, licensure and experience.
- 1.1.3. Develop a career plan that reflects career interests, pathways and secondary and postsecondary options.
- 1.1.4. Describe the role and function of professional organizations, industry associations and organized labor and use networking techniques to develop and maintain professional relationships.
- 1.1.5. Develop strategies for self-promotion in the hiring process (e.g., filling out job applications, résumé writing, interviewing skills, portfolio development).
- 1.1.6. Explain the importance of work ethic, accountability and responsibility and demonstrate associated behaviors in fulfilling personal, community and workplace roles.
- 1.1.7. Apply problem-solving and critical-thinking skills to work-related issues when making decisions and formulating solutions.
- 1.1.8. Identify the correlation between emotions, behavior and appearance and manage those to establish and maintain professionalism.
- 1.1.9. Give and receive constructive feedback to improve work habits.
- 1.1.10. Adapt personal coping skills to adjust to taxing workplace demands.
- 1.1.11. Recognize different cultural beliefs and practices in the workplace and demonstrate respect for them.
- 1.1.12. Identify healthy lifestyles that reduce the risk of chronic disease, unsafe habits and abusive behavior.

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**Outcome 1.2. Leadership and Communications**

Process, maintain, evaluate and disseminate information in a business. Develop leadership and team building to promote collaboration.

**Competencies**

- 1.2.1. Extract relevant, valid information from materials and cite sources of information.
- 1.2.2. Deliver formal and informal presentations.
- 1.2.3. Identify and use verbal, nonverbal and active listening skills to communicate effectively.
- 1.2.4. Use negotiation and conflict-resolution skills to reach solutions.
- 1.2.5. Communicate information (e.g., directions, ideas, vision, workplace expectations) for an intended audience and purpose.
- 1.2.6. Use proper grammar and expression in all aspects of communication.
- 1.2.7. Use problem-solving and consensus-building techniques to draw conclusions and determine next steps.
- 1.2.8. Identify the strengths, weaknesses and characteristics of leadership styles that influence internal and external workplace relationships.
- 1.2.9. Identify advantages and disadvantages involving digital and/or electronic communications (e.g., common content for large audience, control of tone, speed, cost, lack of non-verbal cues, potential for forwarding information, longevity).
- 1.2.10. Use interpersonal skills to provide group leadership, promote collaboration and work in a team.
- 1.2.11. Write professional correspondence, documents, job applications and résumés.
- 1.2.12. Use technical writing skills to complete forms and create reports.
- 1.2.13. Identify stakeholders and solicit their opinions.
- 1.2.14. Use motivational strategies to accomplish goals.

**Outcome 1.3. Business Ethics and Law**

Analyze how professional, ethical and legal behavior contributes to continuous improvement in organizational performance and regulatory compliance.

**Competencies**

- 1.3.1. Analyze how regulatory compliance affects business operations and organizational performance.
- 1.3.2. Follow protocols and practices necessary to maintain a clean, safe and healthy work environment.
- 1.3.3. Use ethical character traits consistent with workplace standards (e.g., honesty, personal integrity, compassion, justice).
- 1.3.4. Identify how federal and state consumer protection laws affect products and services.
- 1.3.5. Access and implement safety compliance measures (e.g., quality assurance information, safety data sheets [SDSs], product safety data sheets [PSDSs], United States Environmental Protection Agency [EPA], United States Occupational Safety and Health Administration [OSHA]) that contribute to the continuous improvement of the organization.

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- 1.3.6. Identify deceptive practices (e.g., bait and switch, identity theft, unlawful door-to-door sales, deceptive service estimates, fraudulent misrepresentations) and their overall impact on organizational performance.
- 1.3.7. Identify the labor laws that affect employment and the consequences of noncompliance for both employee and employer (e.g., harassment, labor, employment, employment interview, testing, minor labor laws, Americans with Disabilities Act, Fair Labor Standards Acts, Equal Employment Opportunity Commission [EEOC]).
- 1.3.8. Verify compliance with computer and intellectual property laws and regulations.
- 1.3.9. Identify potential conflicts of interest (e.g., personal gain, project bidding) between personal, organizational and professional ethical standards.

### **Outcome 1.4. Knowledge Management and Information Technology**

Demonstrate current and emerging strategies and technologies used to collect, analyze, record and share information in business operations.

#### **Competencies**

- 1.4.1. Use office equipment to communicate (e.g., phone, radio equipment, fax machine, scanner, public address systems).
- 1.4.2. Select and use software applications to locate, record, analyze and present information (e.g., word processing, e-mail, spreadsheet, databases, presentation, Internet search engines).
- 1.4.3. Verify compliance with security rules, regulations and codes (e.g., property, privacy, access, accuracy issues, client and patient record confidentiality) pertaining to technology specific to the industry pathway.
- 1.4.4. Use system hardware to support software applications.
- 1.4.5. Use information technology tools to maintain, secure and monitor business records.
- 1.4.6. Use an electronic database to access and create business and technical information.
- 1.4.7. Use personal information management and productivity applications to optimize assigned tasks (e.g., lists, calendars, address books).
- 1.4.8. Use electronic media to communicate and follow network etiquette guidelines.

### **Outcome 1.5. Global Environment**

Evaluate how beliefs, values, attitudes and behaviors influence organizational strategies and goals.

#### **Competencies**

- 1.5.1. Describe how cultural understanding, cultural intelligence skills and continual awareness are interdependent.
- 1.5.2. Describe how cultural intelligence skills influence the overall success and survival of an organization.
- 1.5.3. Use cultural intelligence to interact with individuals from diverse cultural settings.
- 1.5.4. Recognize barriers in cross-cultural relationships and implement behavioral adjustments.
- 1.5.5. Recognize the ways in which bias and discrimination may influence productivity and profitability.

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- 1.5.6. Analyze work tasks for understanding and interpretation from a different cultural perspective.
- 1.5.7. Use intercultural communication skills to exchange ideas and create meaning.
- 1.5.8. Identify how multicultural teaming and globalization can foster development of new and improved products and services and recognition of new opportunities.

**Outcome 1.12. Cyber Hygiene**

Apply digital information security principles to keep information secure.

**Competencies**

- 1.12.1. Identify the purpose and practices of Cyber Hygiene.
- 1.12.2. Differentiate between appropriate and inappropriate information.
- 1.12.3. Interpret security policies through job specific training and training updates.
- 1.12.4. Apply secure password behavior.
- 1.12.5. Apply physical and virtual situational awareness (e.g., clean desk policies, shoulder surfing, social engineering, tailgating).

**Strand 2. Safety, Tools, and Equipment**

Learners apply principles of protection, prevention and mitigation to create and maintain safe working conditions at construction sites. Knowledge and skills may be applied in all aspects of personal site safety to meet all applicable standards.

**Outcome 2.1. Site Safety**

Handle materials, prevent accidents and mitigate hazards.

**Competencies**

- 2.1.1. Use Occupational Safety and Health Administration (OSHA)-defined procedures for identifying employer and employee responsibilities, working in confined spaces, managing worker safety programs, using ground fault circuit interrupters (GFCIs), maintaining clearance and boundaries and labeling.
- 2.1.2. Identify and rectify or mitigate construction hazards (e.g., thresholds, slippery surfaces, lighting and workplace clutter).
- 2.1.3. Identify and apply load factors for constructing scaffolding, railings, ladders and temporary structures.
- 2.1.6. Identify the source of electrical hazards and use shutdown and established lock-out/tag-out procedures.
- 2.1.7. Identify procedures for the handling, storage and disposal of hazardous materials.
- 2.1.8. Identify the location of emergency flush showers, eyewash fountains, Safety Data Sheets (SDSs), fire alarms and exits.
- 2.1.9. Select and operate fire extinguishers based on the class of fire.
- 2.1.10. Create a hazardous materials safety plan (e.g., liquid and airborne materials).
- 2.1.11. Describe the interactions of incompatible substances when measuring and mixing chemicals.

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**Outcome 2.2. Personal Safety**

Practice personal safety in construction.

**Competencies**

- 2.2.1. Interpret personal safety rights according to the employee Right-to-Know plan.
- 2.2.2. Describe how working under the influence (e.g., drugs, alcohol and stimulants/caffeine) increases the risk of accident, lowers productivity, raises insurance costs, and reduces profits.
- 2.2.3. Select, use, store, maintain and dispose of personal protective equipment (PPE) appropriate to job tasks, conditions and materials.
- 2.2.4. Identify workplace risk factors associated with lifting, operating and moving heavy objects and establish an ergonomics process.
- 2.2.5. Identify, inspect and use safety equipment appropriate for the task.
- 2.2.6. Demonstrate first aid and cardiopulmonary resuscitation (CPR).
- 2.2.7. Identify and describe hazards associated with using electronic devices on the job site.
- 2.2.8. Identify and describe hazards associated with improper clothing and poor hygiene.
- 2.2.9. Describe trenching and excavation hazards (e.g. soil types, cave in, utilities, underground obstacles).
- 2.2.10. Describe the process for identifying and locating existing site utilities.

**Outcome 2.4. Equipment and Machinery Preventative Maintenance**

Clean, maintain and perform planned preventative maintenance (PPM) on equipment and machinery.

**Competencies**

- 2.4.1. Lubricate machinery and equipment.
- 2.4.2. Ensure the presence and functionality of safety systems and hardware.
- 2.4.3. Service electrical systems (e.g., fuses, bulbs).
- 2.4.4. Perform machine adjustments (e.g., belts, drive chains).
- 2.4.5. Service filtration systems.
- 2.4.6. Identify, select and maintain fluid levels.
- 2.4.7. Maintain instrument, machinery and equipment cleanliness, appearance and safety devices.
- 2.4.8. Inspect and maintain fluid conveyance and storage components (e.g., hoses, lines, valves, nozzles).
- 2.4.9. Inspect and maintain tooling and implements.
- 2.4.10. Document and log equipment maintenance records.

**Strand 4. Electrical**

Learners apply principles of electricity and knowledge of building codes to construct systems to generate and deliver power in residential, commercial and industrial applications. Knowledge and skill may be applied to rough-in and finish wiring, motors and power wiring, specialized low-voltage systems, alternative power systems, power transmission, plant operations and coal equipment.

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**Outcome 4.2. Circuits**

Analyze and evaluate direct current (DC) circuits and alternating current (AC) circuits.

**Competencies**

- 4.2.2. Describe the purpose of and common methods used for grounding and bonding.
- 4.2.3. Analyze wiring schematics and diagrams to troubleshoot circuits.
- 4.2.6. Determine voltage, current, frequency and phase.
- 4.2.7. Identify common types and uses of transformers.
- 4.2.8. Calculate service load demands and branch circuit load demands.
- 4.2.9. Identify types of capacitors and common usages for each.
- 4.2.10. Identify methods of varying capacitance.
- 4.2.11. Identify types of inductors and explain the purposes of different core materials.
- 4.2.12. Identify the characteristics of inductors and capacitors in series and parallel circuits.
- 4.2.13. Calculate true power, apparent power, reactive power and power factor.

**Outcome 4.3. Codes and Regulations**

Explain and apply the National Electrical Code (NEC) and other building codes.

**Competencies**

- 4.3.1. Describe the role of Nationally Recognized Testing Laboratories (e.g. Underwriters Laboratory (UL), Canadian Standards Association (CSA) and Intertek Testing Service/Edison Testing Laboratory (ITS/ETL)).
- 4.3.2. Locate and apply the information in articles of the NEC and other relevant codes and explain how they impact job requirements (e.g., service conductors, feeders, branch circuits, overload protection, grounding and bonding requirements, low voltage).
- 4.3.3. Utilize National Fire Protection Association (NFPA) procedures for NFPA 70E-arc flash boundaries, current-limiting fuses, live work power permits, electrically safe work conditions, emergency worker safety programs, scheduling, energized circuits and training.

**Outcome 4.4. Electrical Wiring**

Install above and in-ground wiring in residential, commercial, and industrial settings.

**Competencies**

- 4.4.1. Select materials and lay out rough-in wiring runs according to specifications, drawings and code requirements.
- 4.4.2. Identify and install fasteners, anchors, and fire stop systems.
- 4.4.3. Locate and mount electrical boxes in exterior and interior applications.
- 4.4.4. Verify the location of and install service entrance systems.
- 4.4.5. Install service panels, meter apparatus, grounding electrode systems, subpanels and over current protective devices.
- 4.4.6. Identify and label a panel directory to reflect devices and circuits installed on each circuit.



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- 4.4.7. Lay out and install conduit or cable runs, raceways and cable systems (e.g., electrical metallic tubing [EMT], galvanized rigid conduit [GRC], intermediate metal conduit [IMC], polyvinyl chloride [PVC], electrical nonmetallic tubing [ENT or ENMT], armored cable [AC], metal clad cable [MC]).
- 4.4.8. Install rough-in wiring following specifications, drawings and code requirements.
- 4.4.9. Install, service, and troubleshoot low-voltage systems (e.g., communication systems, telephone systems, control systems, lighting systems, security systems, fire alarm systems).
- 4.4.10. Install lighting fixtures, wiring devices and covers.
- 4.4.11. Install equipment grounding and bonding systems.
- 4.4.12. Make conductor terminations.
- 4.4.13. Connect electrical appliances and equipment in accordance with NEC and manufacturer's instructions.
- 4.4.14. Check and test installation.

### **Outcome 4.5. Motors and Power**

Install motors and power wiring in accordance with the National Electrical Code (NEC).

#### **Competencies**

- 4.5.1. Identify types and components of single-phase, split-phase and three-phase motors.
- 4.5.2. Calculate the branch circuit size of the motor based on nameplate information and specifications.
- 4.5.3. Determine motor rotation needed for the installed load and explain the process for reversing rotation (i.e., three-phase, single-phase).
- 4.5.4. Interpret schematics and control diagrams for building a motor circuit.
- 4.5.5. Wire single-phase, split-phase and three-phase circuits and install motor control devices (i.e., contactors, starters, variable frequency and motor speed controls).
- 4.5.6. Explain the starting sequence of motor components within a given circuit.
- 4.5.7. Troubleshoot and repair motor starting systems to verify operation according to schematics and control diagrams.
- 4.5.8. Describe how programmable controllers can be used in single-phase, split-phase and three-phase circuits.

### **Outcome 4.6. Alternative Power and Renewable Energy Systems**

Describe specialized power systems and components.

#### **Competencies**

- 4.6.1. Compare renewable energy systems.
- 4.6.2. Identify and describe the functions of standby power systems (i.e., generator, uninterrupted power supplies [UPS] systems).
- 4.6.3. Identify and describe the functions of electric storage systems.
- 4.6.4. Describe battery maintenance functions (e.g., cleaning, checking electrolyte quality and level and battery status) and disposal methods.

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### **Strand 6. Construction Management and Jobsite Maintenance**

Learners apply principles of business, facility and site operations and project management to build and operate residential, commercial and industrial facilities. Knowledge and skill may be applied in managing and supervising site operations; developing work sequences for tasks and units of work; coordinating material and equipment delivery; planning building stages and the build environment; and providing facility management, and maintenance services.

#### **Outcome 6.1. Construction Math**

Apply math and measurement principles to complete construction projects.

##### **Competencies**

- 6.1.1. Calculate surface area and volume for three-dimensional objects, accurate to a specified level of precision.
- 6.1.2. Apply measurement scales to layout length, width, and angle measurements.
- 6.1.3. Apply algebraic procedures and geometric concepts to reading construction documents.
- 6.1.4. Use proportional reasoning and apply indirect measurement techniques (e.g., right triangle trigonometry, properties of similar triangles).
- 6.1.5. Select and use measurement tools (i.e., grade rod, ruler, tape measure, measuring cups, builder's level).
- 6.1.6. Perform calculations and conversions with fractions, decimals, and percentages.
- 6.1.7. Perform unit conversions.

#### **Outcome 6.2. Construction Drawings**

Read and interpret plans and diagrams within a construction drawing set (i.e., topographical, grading and drainage, architectural, structural, plumbing, mechanical, electrical) to organize a project work sequence.

##### **Competencies**

- 6.2.2. Read and interpret a site plan.
- 6.2.3. Use architect's and engineer's scales to read and interpret construction drawings for material calculations and installation at the jobsite.
- 6.2.4. Read, interpret, and organize construction drawings, models, specifications and other contractual documents.