

Construction Technologies Career Field
Mechanical, Electrical and Plumbing Systems
Subject Code: 178002
Outcome & Competency Descriptions

Course Description:

Students learn physical principles and fundamental skills across mechanical systems in construction. Students will select materials, assemble, and test basic electrical circuits. Students will select materials and assemble simple copper and plastic plumbing applications for both supply and drains. They will perform simple maintenance of electric motors, electric fixtures and plumbing fixtures. Students will be able to select and install basic ductwork components and learn the operation and maintenance of heating and cooling equipment.

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 2.3. Equipment Operation

Operate equipment used to move materials, earth and other heavy materials.

Competencies

- 2.3.1. Select the equipment and attachments needed to complete the task.
- 2.3.2. Follow the manufactures' recommendations for safety, maintenance, limitations and use.
- 2.3.3. Perform pre- and post-operation inspections and adjustments and report malfunctions.
- 2.3.4. Operate levers, pedals or valves to activate power equipment.
- 2.3.5. Drive and maneuver equipment with and without trailers.

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.

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- 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.

Outcome 4.1. Electrical Theory

Summarize electrical principles and theories.

Competencies

- 4.1.1. Describe atomic structure and its relationship to electricity.
- 4.1.2. Compare the relationship between electrical and electromagnetic effect.
- 4.1.3. Identify methods of producing electrical current.
- 4.1.4. Describe the differences between alternating current (AC) and direct current (DC).
- 4.1.5. Compare and contrast conductors and insulators.
- 4.1.6. Describe the relationships between voltage, current, resistance and power in circuits.

Outcome 4.2. Circuits

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

Competencies

- 4.2.1. Identify electrical, electromechanical and solid-state controls.
- 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.
- 4.2.4. Explain the uses of series, parallel and series-parallel circuits.
- 4.2.5. Construct and test series, parallel and series-parallel circuits.

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.

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- 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.
- 4.4.12. Make conductor terminations.

Strand 5. Environmental Systems and Plumbing

Learners apply principles of physics and thermodynamics to install and maintain heating, ventilation and air conditioning (HVAC) and plumbing systems in residential, commercial, industrial, and utility applications.

Outcome 5.1. Refrigeration

Apply physical principles of refrigeration to the installation and maintenance of heating, ventilation and air conditioning (HVAC) systems.

Competencies

- 5.1.2. Describe heat, heat transfer, energy and energy conversion.

Outcome 5.2. Heating, Ventilation, Air Conditioning/Refrigeration (HVAC/R) Systems Installation

Install refrigeration, air conditioning, and heating systems.

Competencies

- 5.2.1. Identify the basic components of a self-contained air conditioning unit.
- 5.2.2. Identify and install a central air conditioning system.
- 5.2.3. Identify and install an air-to-air heat pump.

Outcome 5.3. Service Maintenance

Perform service maintenance (SM) and repair on environmental controls technology equipment (e.g., electric heating equipment, air handler, air filtration equipment, humidifier/dehumidifier, air conditioner, heat pump).

Competencies

- 5.3.1. Perform routine cleaning and inspection of system and components.
- 5.3.2. Inspect and replace filters, belts and fluids.

Outcome 5.6. Sheet Metal

Fabricate and install ductwork systems.

Competencies

- 5.6.1. Identify the components of a duct system.
- 5.6.2. Select materials to fabricate ductwork based on job specifications.

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- 5.6.5. Seal and insulate ductwork.
- 5.6.6. Fasten and hang ductwork.
- 5.6.8 Describe the impact of modifying structural members of duct work without weakening the structure.
- 5.6.9 Take field measurements and translate them to sketch for shop fabrication

Outcome 5.7. Drainage

Rough in drainage systems following plumbing codes and standards in interior and exterior applications.

Competencies

- 5.7.1. Locate drainage system entry points, walls, and chases.
- 5.7.2. Identify components of a drainage system and describe their functions.
- 5.7.3. Describe how waste moves from a fixture through the drain system to the environment.
- 5.7.5. Estimate and compute length, angle of measurement, area, surface area and volume to calculate pipe legs and pipe sizes.
- 5.7.10. Join pipe, pipefittings and valves of similar and dissimilar materials using solvents and mechanical means of joining.
- 5.7.11. Identify and explain the installation of plumbing fixtures and appliances to a drain system.
- 5.7.12. Test the drainage system for leaks.
- 5.7.14. Describe the design, basic operation and care of a septic system.

Outcome 5.8. Water Systems

Rough in water systems following plumbing codes and standards, in interior and exterior applications.

Competencies

- 5.8.3. Prevent freezing and mechanical damage to pipes.
- 5.8.4. Describe how water moves from the source through the water distribution system to the fixture.
- 5.8.7. Estimate and compute length, angle of measurement, area, surface area and volume to calculate pipe legs and pipe sizes.
- 5.8.8. Locate water supply system entry points, walls and chases.
- 5.8.9. Describe the function of the pipe, pipefittings, valves and fixtures that comprise a water supply system.
- 5.8.10. Select water supply components based on their application for a given purpose.
- 5.8.12. Join water supply pipe, pipefittings and valves of similar and dissimilar materials using solder, brazing, solvents and mechanical means of joining.
- 5.8.13. Connect water supply to plumbing fixtures and appliances.
- 5.8.14. Test a water supply system for leaks and pressure using soap, inert gas, electronic sensors and fluorescent dye.
- 5.8.15. Perform maintenance on water supply components of plumbing fixtures and appliances.

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Outcome 5.9. Fuel Piping

Construct fuel piping systems following codes and standards for interior and exterior applications.

Competencies

- 5.9.1. Identify the types of fuel systems and describe the advantages and disadvantages of each.
- 5.9.2. Describe the physical properties and potential hazards associated with different fuel types.
- 5.9.3. Describe the pipe, fittings, and valves used in fuel piping systems and describe their functions.
- 5.9.4. Join pipe, fittings, and valves used in a piping system that transfers fuel.
- 5.9.5. Connect appliances to fuel piping systems.
- 5.9.6. Describe fuel piping testing methods and perform leak tests.

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.

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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.
- 6.2.6. Identify and interpret aspects of sustainable design and construction techniques in construction drawings and specifications.
- 6.2.7. Identify and interpret aspects of the Americans with Disabilities Act (ADA) in construction drawings and specifications.

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