Ohio

Construction Technologies

CAREER FIELD TECHNICAL CONTENT STANDARDS

2013

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Ohio | Department of Education

Table of Contents

Foreword ii
Acknowledgements iii
Philosophy and Principles for Implementation iv
Ohio Career Field Initiative iv
Career Pathways v
Structure and Format vi
Development of Construction Technologies Career Field Technical Content Standards vii
Research and Development vii
Futuring Panel vii
Validation Panel viii
Postsecondary Alignment viii
Futuring Panel Contributors ix
Development Contributors xi
Validation Panel Contributors xiii
Career Pathway Definitions xv
Design xv
Mechanical, Electrical, Plumbing xv
Structural xvi
Strand/Outcome Pathway Chart xvii
STRANDS 1-7 1
Strand 1. Business Operations/21st Century Skills 2
Strand 2. Safety, Tools, and Equipment 12
Strand 3. Structural Construction 15
Strand 4. Electrical 20
Strand 5. Environmental Systems and Plumbing 25
Strand 6. Planning and Design 31
Strand 7. Construction and Facility Management 35

Foreword

The Career Field Technical Content Standards serve as the curricular framework for Ohio's career-technical education pathway programs as outlined in Ohio Administrative Code 3301-61-03 (Criteria for Secondary Workforce Development Programs).

Career Field Technical Content Standards outline the knowledge and skills needed for success in careers across multiple pathways. Validated by Ohio business and industry representatives in conjunction with Ohio educators, these standards form the basis for developing educational programming in Ohio secondary schools. The standards also serve as the framework for developing strong career pathways that connect secondary education with postsecondary education systems and the workplace.

This version of Career Field Technical Content Standards is intended to support the ongoing evolution of career technical education pathway programs. The standards tend to be somewhat broader than previous versions and are not repeated for individual pathways or occupational areas. The broader and non-duplicated statements are intended to capture the knowledge and skills that can be applied across any number of occupations in a pathway rather than focusing on the requirement of a single occupation. After all, the intent of a pathway program is to prepare a student for a range of educational and career opportunities following high school.

Pathway programs prepare students to combine broad knowledge, insight and understanding of business processes, academic attainment and workplace readiness with depth of knowledge and expertise in a technical area. Knowing that many careers will require some level of postsecondary education, the content standards also delineate the knowledge and skills necessary to seamlessly transition to postsecondary educational programs.

This document seeks to provide the basis for educational programming that will provide the employee with fundamental skill-sets that employers demand. This ensures that Ohio's workforce of tomorrow is competitive in a global environment. An environment that requires knowledge and skills can be applied in a broader context, aimed at innovation to support new products and services in an ever-changing economy.

In addition to the extensive engagement of secondary and postsecondary educators and business/industry professionals, development of these standards represents a collaborative effort of the following professional partners: the Ohio Department of Education's Office of Career-Technical Education; the Ohio Board of Regents Secondary Career-Technical Alignment Initiative; and CETE, known as the Center on Education and Training for Employment, at The Ohio State University.

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Acknowledgements

A number of individuals contributed their time and expertise to this development. Special thanks go to all the business representatives and educators named in this document.

Further acknowledgement is due to:

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Those listed above provided vision and implementation support for the Construction Technologies Career Field Technical Content Standards and Ohio's Construction Technologies educational programs.

Philosophy and Principles for Implementation

Ohio Career Field Initiative

The overarching framework for Ohio career-technical education is outlined in the Ohio Revised Code and subsequent administrative rules, which specify career-technical programming based on 16 career fields. To view the full text of Administrative Rule 3301-61-03 (Criteria for Secondary Workforce Development Programs), go to: http://education.ohio.gov/Topics/Career-Tech/Career-Development-OCIS/CTE-Administrative-Rules-Update. These 16 fields provide the framework for an Ohio career field initiative that seeks to foster the educational shift necessary to respond to the needs of a rapidly changing global environment.

A career field is a "group of occupations and broad industries based on common characteristics" (see www.careertech.org). Career fields are the basis for developing both broad and specialized technical content standards that serve as a framework for curriculum, instruction, assessment and program design, addressing the needs of an entire industry and business sector. Ohio's 16 career fields align with national efforts to broaden career-technical education, integrate career-technical with academic study and reflect the workforce needs of today and tomorrow. For today's students to be adequately prepared for tomorrow's workforce, they must have an education that:

- **Incorporates a broad, long-term conception of work in combination with the depth of specialization skills;**
  Employees need a comprehensive understanding beyond a single occupational area. Career-technical programming needs to be provided in a larger context, so students can generalize learning, make connections between education and work and adapt to changes in their careers. Workplace knowledge and skills are needed to prepare employees for collaborating and problem solving while contributing to the broader business process.
- **Emphasizes the acquisition of strong academic knowledge and skills; and**
  Academic skills provide the foundation for career success. The integration of academic content standards with career field technical content standards helps to contextualize learning for students, making English language arts, mathematics, social studies and science relevant to students as a means to an important end—success at work and in life.
- **Facilitates high-school-to-postsecondary transitions.**
  A lifetime of change means a lifetime of learning, including postsecondary education. Students need knowledge and skills for success in a variety of postsecondary options, including apprenticeships, industry credentialing through adult education, two- and four-year college degree programs and graduate school.

Career Pathways

A key component of the Ohio Career Field Initiative is a career pathway, which is a coherent, articulated sequence of rigorous academic and career-technical coursework commencing in the ninth grade and leading to an associate degree, baccalaureate degree and beyond–an industry-recognized certificate and/or licensure. Pathways facilitate a seamless transition from high school to postsecondary education (including apprenticeships, adult education, two- and four-year colleges and graduate school) and from postsecondary education to the workplace. The career pathway is developed, implemented and maintained in partnership among secondary and postsecondary education, business and employers. Career pathways are available to all students, including adult learners and lead to rewarding careers.

To effectively facilitate the transition from secondary to postsecondary education and a career, high school career pathways should encompass:

1. Challenging technical coursework in a chosen career field based on career field technical content standards;
2. Rigorous academics that meet Ohio's academic content standards and grade-level expectations;
3. Electives that relate to career objectives;
4. Instructional enhancements such as experiential and authentic learning opportunities (e.g., work-based learning, mentorships, internships) and career-technical student organization participation;
5. Opportunities (when appropriate) for program and student certification and licensure;
6. Preparation for transition to further study that includes college readiness and opportunities to earn college credit while in high school;
7. Preparation for transition to employment with advancement opportunities;
8. Performance targets that include high school academic and technical testing/exit and postsecondary entry/placement requirements;
9. Various sector(s) within an industry or encompass a function that crosses industry sectors;
10. The scope of opportunities in the related industry and available college programs;
11. Opportunities to prepare for a range of careers, including
    a. multiple employment opportunities after high school and
    b. opportunities for students to enter and succeed in postsecondary and continuing education programs;
12. Transferable skills required for employment in the range of occupations aligned to the pathway; and
13. Opportunities to learn skills across the pathway as well as in specialized areas.

For additional information on the Career Field Initiative, including Ohio Career Field Technical Content Standards and Career Pathways, go to http://education.ohio.gov/Topics/Career-Tech/Career-Fields.

Structure and Format

The Career Field Technical Content Standards document is composed of a series of strands comprised of outcomes that each contain a set of competencies.

- A strand is a large content area under which multiple outcomes are organized, regardless of the pathway. It includes a title and a concise description with statements that capture multiple, broad areas of learner knowledge and skills expected across all outcomes in the strand. There are approximately six strands of content per career field. Strand 1, Business Operations/21st Century Skills (employability skills, leadership and communications, business ethics and law, knowledge management and information technology, global environment, business literacy, entrepreneurship/entrepreneurs, operations management, financial management, sales and marketing and principles of business economics), is the same for all career-technical education career fields.
- An outcome is an overarching statement that summarizes the knowledge and skills described in a set of individual competencies to be learned by the end of the 12th grade. There are usually 5–15 outcomes within a strand, depending on the breadth of content to be addressed.
- A competency is a specific statement of essential knowledge or skill to be learned in the pathway program. There are usually 5–12 competencies under an outcome.

Each set of outcomes and competencies is included in one or more pathways in the career field. Outcomes and competencies form the basis for developing secondary courses, programs, instruction and assessment, facilitating transition from one educational level to the next and to the workplace. This supports career readiness and long-term career success by:

- Providing the basis for effective collaboration, teamwork and communication across pathways;
- Laying the groundwork for successful transfer of knowledge and skills across pathways, thereby facilitating horizontal and vertical career success and
- Equipping students and workers with the skills needed to transition to new and emerging careers throughout a working lifetime.

All outcomes and competencies in the Career Field Technical Content Standards have been verified as essential by business and labor representatives within the pathway or pathways specified.

These essential outcomes and competencies specify industry-based knowledge or hands-on skills that CTE students need by the end of the 12th grade to be successful in their selected career pathway and on-going learning (such as college, apprenticeships and military opportunities).

Development of Construction Technologies Career Field Technical Content Standards

The process for the development of the Construction Technologies Career Field Technical Content Standards began in February 2012 and culminated in June 2013. Over the course of 2012–2013, numerous business and industry representatives as well as secondary and postsecondary educators from across the state of Ohio took part in the formal development process. The following summarizes the various stages of the development process.

Research and Development

The involvement of subject matter experts, including educators, was critical to the completion of the draft revision of the document. Development was also informed by consulting the following sources of information:

- National Association of State Directors of Career Technical Education Consortium (NASDCTEc) Common Career Technical Core (CCTC) standards and Programs of Study;
- Industry-based certifications/standards;
    - National Center for Construction Education and Research (NCCER);
    - HVAC Excellence;
    - Air Conditioning Heating and Refrigeration Institute (ACRI);
- Ohio Home Builders Association (OHBA);
- Apprenticeship programs;
- Department of Education, Office of Career-Technical Education in North Carolina, Oklahoma, Texas and Utah;
- SkillsUSA;
- Partnership for 21st Century Skills;
- Career-Technical Transfer Assurance Guides (CTAGs);
- University System of Ohio Academic Program Guide; and
- Ohio Industry Employment Projections Report, 2008-18.

Futuring Panel

On February 23, 2012, the Construction Technologies futuring panel brought together key business and industry representatives from across the state to advise the Ohio Department of Education on trends impacting the Construction Technologies career field. The participants were asked to share their perceptions on changes in the workplace, employment trends, changes in technical skill requirements, needed workplace readiness skills and available industry-recognized standards and credentials. This feedback was used to develop and streamline the standards document into what is most demanded by the labor market.

Validation Panel

On October 25, 2012, and January 23, 2013, a diverse group of Ohio business and industry representatives participated in panels to validate and rate the importance of the work-related competencies in the draft standards document. Drawn from various sectors and regions of the state, the panels identified what employees should know and be able to do in the three Construction Technologies pathways. Secondary and postsecondary education representatives participated on the panels to gain an understanding of the standards development process as well as to provide their perspective to the business representatives, when needed.

Postsecondary Alignment

The goal of the Secondary Career-Technical Alignment Initiative (SCTAI) was to develop new statewide Career-Technical Assurance Guides (CTAGs) for secondary career-technical institutions using the combined process of the Ohio Board of Regents' CTAG development process with the Ohio Department of Education's Career Field Technical Content Standards development process. The result of this collaboration was a tighter alignment between secondary career-technical and postsecondary content and the development of pathways that encourage college-going and increase statewide postsecondary options for career technical students. For more information on CTAGs and opportunities for statewide postsecondary articulated transfer credit, visit https://student-transfer.ohiohighered.org.

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Career Pathway Definitions

The Construction Technologies Career Field prepares students for careers in designing, planning, managing, building and maintaining commercial, industrial and residential structures and infrastructures. Students in the Construction Technology career field may continue into registered apprenticeship or traditional postsecondary programs. Apprenticeship opportunities may be found at the Ohio State Apprenticeship Council website (http://jfs.ohio.gov/apprenticeship/index.stml).

Design

Design program areas will prepare students for careers dealing with construction design, facility maintenance, construction management and site safety and heavy equipment operations.

Careers for which this pathway prepares students include:

Architectural Designer
Civil Drafting Engineering
Custodian
Facility Maintenance Technician/Manager
Heavy Equipment Operator
Interior Designer
Project Manager
Site Manager
Site Safety Coordinator
Surveyor

Postsecondary majors for which this pathway prepares students include:

Architectural Drafting
Building/Construction Site Management/Manager
Construction Management
Heavy/Industrial Maintenance Equipment Technologies Interior Design

Mechanical, Electrical, Plumbing

Mechanical, electrical and plumbing program areas will prepare students for careers in electrical, plumbing, sheet metal and Environmental control installation and maintenance.

Careers for which this pathway prepares students include:

Electrician
Facility Maintenance Technician
HVAC Technician
Plumber
Power Line Technician
Sheet Metal Fabricator
Telecommunications Technician

Postsecondary majors for which this pathway prepares students include:

Building Construction Technology
Construction Trades
Electrical and Power Transmission Installation Installer
Electrical/Electronic Technology
Energy Management Technology
Environmental Engineering Management Technology

HVAC Technology
Pipefitter and Sprinkler Fitter Technology
Plumber
Sheet Metal Technology

Structural

Structural program areas will prepare students for careers in occupations related to Carpentry and Masonry construction and maintenance.

Careers for which this pathway prepares students include:

Brick, Block and Cement Mason
Carpenter
Drywall Technician
Flooring Specialists
General Contractor
Remodeler
Roofer

Postsecondary majors for which this pathway prepares students include:

Building Construction Technology
Cabinetmaking and Millwork
Construction Trades
Structural Engineering

Strand/Outcome Pathway Chart

An “X” indicates that the pathway applies to the outcome.

Strand/Outcome	Pathway		
	Design	Mechanical, Electrical, Plumbing	Structural
Strand 1: Business Operations/21st Century Skills page 2			
Outcome 1.1: Employability Skills	X	X	X
Outcome 1.2: Leadership and Communications	X	X	X
Outcome 1.3: Business Ethics and Law	X	X	X
Outcome 1.4: Knowledge Management and Information Technology	X	X	X
Outcome 1.5: Global Environment	X	X	X
Outcome 1.6: Business Literacy	X	X	X
Outcome 1.7: Entrepreneurship/Entrepreneurs	X	X	X
Outcome 1.8: Operations Management	X	X	X
Outcome 1.9: Financial Management	X	X	X
Outcome 1.10: Sales and Marketing	X	X	X
Outcome 1.11: Principles of Business Economics	X	X	X
Strand 2: Safety, Tools, and Equipment page 12			
Outcome 2.1: Site Safety	X	X	X
Outcome 2.2: Personal Safety	X	X	X
Outcome 2.3: Equipment Operation	X	X	X
Outcome 2.4: Equipment and Machinery Preventative Maintenance	X	X	X
Strand 3: Structural Construction page 15			
Outcome 3.1: Brick, Block and Concrete	X		X
Outcome 3.2: Site Management	X	X	X
Outcome 3.3: Excavation	X		X
Outcome 3.4: Floor Framing			X
Outcome 3.5: Wall Framing			X
Outcome 3.6: Roof Framing			X
Outcome 3.7: Exterior Finish Work	X		X
Outcome 3.8: Stairs	X		X
Outcome 3.9: Interior Finish Work	X		X
Outcome 3.10: Remodeling	X		

Strand/Outcome	Pathway		
	Design	Mechanical, Electrical, Plumbing	Structural
Strand 4: Electrical page 20			
Outcome 4.1: Electrical Theory		X	X
Outcome 4.2: Circuits		X	X
Outcome 4.3: Codes and Regulations	X	X	
Outcome 4.4: Low Voltage Systems		X	
Outcome 4.5: Electrical Wiring		X	
Outcome 4.6: Motors and Power		X	
Outcome 4.7: Alternative Power Systems	X	X	X
Strand 5: Environmental Systems and Plumbing page 25			
Outcome 5.1: Refrigeration		X	
Outcome 5.2: Heating, Ventilation, Air Conditioning/Refrigeration (HVAC/R) Systems Installation		X	
Outcome 5.3: Service Maintenance	X	X	
Outcome 5.4: Energy Audit	X	X	
Outcome 5.5: Boiler Systems	X	X	
Outcome 5.6: Sheet Metal		X	
Outcome 5.7: Drainage	X	X	
Outcome 5.8: Water Systems	X	X	
Outcome 5.9: Fuel Piping	X	X	
Strand 6: Planning and Design page 31			
Outcome 6.1: Proposals	X		
Outcome 6.2: Community Planning	X	X	
Outcome 6.3: Drafting	X		
Outcome 6.4: Construction Drawings	X	X	X
Outcome 6.5: Construction Math	X	X	X
Strand 7: Construction and Facility Management page 35			
Outcome 7.1: Construction Scheduling	X	X	
Outcome 7.2: Field Organization	X		X
Outcome 7.3: Floor Maintenance	X		
Outcome 7.4: Custodial Operations	X		
Outcome 7.5: Maintenance Operations	X		
Total Outcomes by Pathway:	40	36	30
Total Outcomes:	51		

CONSTRUCTION TECHNOLOGIES

CAREER FIELD
TECHNICAL CONTENT STANDARDS

STRANDS 1-7

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.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

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, resumé 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.

Outcome 1.2. Leadership and Communications

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

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

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 resumés.
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.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

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.

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.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

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.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

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.
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 1.6. Business Literacy

Develop foundational skills and knowledge in entrepreneurship, financial literacy and business operations.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

Competencies

1.6.1. Identify business opportunities.
1.6.2. Assess the reality of becoming an entrepreneur, including advantages and disadvantages (e.g., risk versus reward, reasons for success and failure).
1.6.3. Explain the importance of planning your business.
1.6.4. Identify types of businesses, ownership and entities (i.e., individual proprietorships, partnerships, corporations, cooperatives, public, private, profit, not-for-profit).
1.6.5. Describe organizational structure, chain of command, the roles and responsibilities of the organizational departments and interdepartmental interactions.
1.6.6. Identify the target market served by the organization, the niche that the organization fills and an outlook of the industry.
1.6.7. Identify the effect of supply and demand on products and services.
1.6.8. Identify the features and benefits that make an organization's product or service competitive.
1.6.9. Explain how the performance of an employee, a department and an organization is assessed.
1.6.10. Describe the impact of globalization on an enterprise or organization.
1.6.11. Describe how all business activities of an organization work within the parameters of a budget.
1.6.12. Describe classifications of employee benefits, rights, deductions and compensations.

Outcome 1.7. Entrepreneurship/Entrepreneurs

Analyze the environment in which a business operates and the economic factors and opportunities associated with self-employment.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

Competencies

1.7.1. Compare and contrast the four types of business ownership (i.e., individual proprietorships, partnerships, corporations, cooperatives).
1.7.2. Explain the role of profit as the incentive to entrepreneurs in a market economy.
1.7.3. Identify the factors that contribute to the success and failure of entrepreneurial ventures.
1.7.4. Assess the roles of nonprofit and for-profit businesses.
1.7.5. Develop a business plan.
1.7.6. Describe life cycles of an entrepreneurial business and an entrepreneur.
1.7.7. Create a list of personal strengths, weaknesses, skills and abilities needed to be successful as an entrepreneur.
1.7.8. Explain pathways used to become an entrepreneur.
1.7.9. Conduct a self-assessment to determine entrepreneurial potential.
1.7.10. Describe techniques for obtaining experience (e.g., apprenticeship, co-operative [co-op] education, work placement, internship, job shadowing) related to an entrepreneurial objective.
1.7.11. Identify initial steps in establishing a business (e.g., limited liability company [LLC], tax ID, permits, insurance, licensing).
1.7.12. Identify resources available to entrepreneurs (e.g., Small Business Administration, mentors, information resources, educational opportunities).
1.7.13. Protect intellectual property and knowledge (e.g., copyright, patent, trademark, trade secrets, processes).

Outcome 1.8. Operations Management

Plan, organize, and monitor an organization or department to maximize contribution to organizational goals and objectives.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

Competencies

1.8.1. Forecast future resources and budgetary needs using financial documents (e.g., balance sheet, demand forecasting, financial ratios).

1.8.2. Select and organize resources to develop a product or a service.

1.8.3. Analyze the performance of organizational activities and reallocate resources to achieve established goals.

1.8.4. Identify alternative actions to take when goals are not met (e.g., changing goals, changing strategies, efficiencies).

1.8.5. Use inventory and control systems to purchase materials, supplies and equipment (e.g., Last In, First Out [LIFO]; First In, First Out [FIFO]; Just in Time [JIT]; LEAN).

1.8.6. Identify the advantages and disadvantages of carrying cost and Just-in-Time (JIT) production systems and the effects of maintaining inventory (e.g., perishable, shrinkage, insurance) on profitability.

1.8.7. Collect information and feedback to help assess the organization's strategic planning and policymaking processes.

1.8.8. Identify routine activities for maintaining business facilities and equipment.

1.8.9. Develop a budget that reflects the strategies and goals of the organization.

1.8.10. Analyze how business management and environmental management systems (e.g., health, safety) contribute to continuous improvement and sustainability.

Outcome 1.9. Financial Management

Use financial tools, strategies and systems to develop, monitor and control the use of financial resources to ensure personal and business financial well-being.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

Competencies

1.9.1. Create, analyze, and interpret financial documents (e.g., budgets, income statements).
1.9.2. Identify tax obligations.
1.9.3. Review and summarize savings, investment strategies and purchasing options (e.g., cash, lease, finance, stocks, bonds).
1.9.4. Identify credit types and their uses in order to establish credit.
1.9.5. Identify ways to avoid or correct debt problems.
1.9.6. Explain how credit ratings and the criteria lenders use to evaluate repayment capacity affect access to loans.
1.9.7. Review and summarize categories (types) of insurance and identify how insurances can reduce financial risk.
1.9.8. Identify income sources and expenditures.
1.9.9. Compare and contrast different banking services available through financial institutions.
1.9.10. Identify the role of depreciation in tax planning and liability.

Outcome 1.10. Sales and Marketing

Manage pricing, place, promotion, packaging, positioning and public relations to improve quality customer service.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

Competencies

1.10.1. Identify how the roles of sales, advertising and public relations contribute to a company's brand.
1.10.2. Determine the customer's needs and identify solutions.
1.10.3. Communicate features, benefits and warranties of a product or service to the customer.
1.10.4. Identify the company policies and procedures for initiating product and service improvements.
1.10.5. Monitor customer expectations and determine product/service satisfaction by using measurement tools.
1.10.6. Discuss the importance of correct pricing to support a product's or service's positioning in the marketing mix.
1.10.7. Describe the importance and diversity of distribution channels (i.e., direct, indirect) to sell a product.
1.10.8. Use promotional techniques to maximize sales revenues (e.g., advertising, sales promotions, publicity, public relations).
1.10.9. Describe how product mix (e.g., product line, product items) maximizes sales revenues, market, share and profit margin.
1.10.10. Demonstrate sales techniques.

Outcome 1.11. Principles of Business Economics

Examine and employ economic principles, concepts and policies to accomplish organizational goals and objectives.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

Competencies

1.11.1. Identify the economic principles that guide geographic location of an industry's facilities (e.g., relative scarcity, price, quantity of products and services).

1.11.2. Identify the difference between monetary and nonmonetary incentives and explain how changes in incentives cause changes in behavior.

1.11.3. Use economic indicators to identify economic trends and conditions (e.g., inflation, interest rate fluctuations, unemployment rates).

1.11.4. Determine how the quality, quantity and pricing of goods and services are affected by domestic and international competition in a market economy.

1.11.5. Analyze factors that affect currency and exchange rates.

1.11.6. Explain how financial markets and government policies influence interest rates (credit ratings/debt ceiling), trade deficits, and unemployment.

1.11.7. Describe how economic performance and culture are interdependent.

1.11.8. Identify the relationships between economy, society and environment that lead to sustainability.

1.11.9. Describe how laws and regulations influence domestic and international trade.

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 and site safety, including handling materials, using tools and equipment, working with and around electricity, using personal protective equipment and operating heavy equipment.

Outcome 2.1. Site Safety

Handle materials, prevent accidents and mitigate hazards.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

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 associated with thresholds, slippery surfaces and lighting.

2.1.3. Calculate an example of load factors for constructing scaffolding, railings, ladders and temporary structures.

2.1.4. Apply inspection, rejection criteria, hitch configurations and load-handling practices to slings and rigging hardware.

2.1.5. Demonstrate the proper use of American National Standards Institute (ANSI) hand signals.

2.1.6. Identify the source of electrical hazards and use shutdown and established lock-out/tag-out procedures.

2.1.7. Identify and eliminate worksite clutter in accordance with standards for cleanliness and safety.

2.1.8. Identify procedures for the handling, storage and disposal of hazardous materials.

2.1.9. Identify the location of emergency flush showers, eyewash fountains, Safety Data Sheets (SDSs), fire alarms and exits.

2.1.10. Select and operate fire extinguishers based on the class of fire.

2.1.11. Identify the components of a hazardous materials safety plan.

2.1.12. Create a hazardous materials safety plan.

2.1.13. Set up for ergonomic workflow.

2.1.14. Describe the interactions of incompatible substances when measuring and mixing chemicals.

Outcome 2.2. Personal Safety

Practice personal safety in construction.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

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 of drugs and alcohol 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).

Outcome 2.3. Equipment Operation

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

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

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.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

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. Calibrate metering, monitoring, and sensing equipment.
2.4.10. Inspect and maintain tooling and implements.

Strand 3. Structural Construction

Learners apply principles of architectural engineering to erect residential, commercial and industrial buildings. Knowledge and skills may be applied in constructing footings and foundations; framing floors, walls, ceilings, roofs and stairs; completing exterior and interior finishes; and repairing, restoring or remodeling existing structures.

Outcome 3.1. Brick, Block, and Concrete

Mix and pour concrete and lay brick and block.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X		X

Competencies

3.1.1. Complete layout calculations.
3.1.2. Set grades and establish benchmark.
3.1.3. Construct foundations, footings and retaining walls.
3.1.4. Lay brick and block with mortar.
3.1.5. Lay out and erect forms and stair forms and install reinforcing material.
3.1.6. Lay out and install anchor bolts in concrete.
3.1.7. Install mortar joints.
3.1.8. Install concrete masonry units (CMUs).
3.1.9. Cast and finish concrete.
3.1.10. Demonstrate knowledge of specialty finishes to concrete.
3.1.11. Level base material.
3.1.12. Compare and contrast foundation types and materials.

Outcome 3.2. Site Management

Analyze site management operations.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

Competencies

3.2.1. Identify topographical and existing features of areas (i.e., property lines, utilities, streets, setbacks) on survey maps (parcel map, survey plat).
3.2.2. Interpret features of a site plan.
3.2.3. Apply conventional engineering and field measurement processes to survey for site development.
3.2.4. Demonstrate an understanding of applicable building codes.

Outcome 3.3. Excavation

Perform excavation activities from clearing and grubbing to finish grading in accordance with excavation specifications on prints and in local building codes.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X		X

Competencies

3.3.1. Describe excavation, trenching, and shoring designs.
3.3.2. Compare and contrast how soil properties, profiles and types affect construction and describe fill placement processes (e.g., lifts, geomat fabrics, compaction, density, moisture content).
3.3.3. Collect samples and explain the environmental impact of contaminated soil and water on the worksite.
3.3.4. Explain disposal procedures for contaminated soil, water and waste.
3.3.5. Describe procedures to control water runoff and drainage.
3.3.6. Identify the actual location and elevation and determine variance.
3.3.7. Check alignment and elevations.
3.3.8. Clear and grub land to prepare site for grading.
3.3.9. Explain the types of grade (e.g., subgrade, finished grade).
3.3.10. Identify the types of stakes and describe their functions.
3.3.11. Describe fill materials, their appropriateness and their functions.
3.3.12. Lay out stakes in sequence and set grade.

Outcome 3.4. Floor Framing

Install floor framing systems.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
		X

Competencies

3.4.1. Identify, describe, and assemble materials for floor framing.
3.4.2. Construct and install sills and sill sealer.
3.4.3. Erect girders, beams and columns.
3.4.4. Lay out, cut and install floor joists.
3.4.5. Frame floor openings.
3.4.6. Install bridging (e.g., wood, metal).
3.4.7. Install subflooring using adhesives and fasteners.

Outcome 3.5. Wall Framing

Construct wall and ceiling framing.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
		X

Competencies

3.5.1. Identify platform and balloon framing.
3.5.2. Lay out walls and rough openings.
3.5.3. Compare and contrast metal and wood framing.
3.5.4. Locate partitions, determine stud layout and strike wall lines.
3.5.5. Describe wall framing techniques used in masonry construction.
3.5.6. Cut and assemble wood and metal wall framing components (e.g., corner posts, T-posts, door openings, window openings, headers, cripples, king studs, trimmers, common studs).
3.5.7. Erect and plumb partitions and walls with top and bottom plates.
3.5.8. Brace exterior walls and install wind bracing.
3.5.9. Install exterior wall sheathing and house wrap.
3.5.10. Lay out, cut, and install ceiling joists and bracing.

Outcome 3.6. Roof Framing

Construct roof framing.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
		X

Competencies

3.6.1. Compare and contrast roof types and materials.
3.6.2. Identify, describe and assemble materials for roof framing.
3.6.3. Lay out, cut and install ridge boards and common rafters.
3.6.4. Lay out, cut and install hip rafters and install valley rafters and jack rafters.
3.6.5. Lay out, cut and install gable-end studs and lookouts.
3.6.6. Frame roof openings, dormers and chimney saddles.
3.6.7. Install roof sheathing.
3.6.8. Install prefabricated roof trusses with required hardware.
3.6.9. Install drip edges, eaves flashing and roof vents.
3.6.10. Install underlayment (ice and water barriers) and shingles.
3.6.11. Lay out and install shingles and other roof finishes (e.g., fiberglass, asphalt, wood, valley material, felt paper, starter strip, hip and ridge caps).

Outcome 3.7. Exterior Finish Work

Complete exterior finish.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X		X

Competencies

3.7.1. Compare and contrast types and characteristics of doors and windows.
3.7.2. Identify, describe, and assemble materials for exterior finishing.
3.7.3. Install exterior door and window units and hardware.
3.7.4. Install weather stripping and apply caulking and sealant.
3.7.5. Install fascia and soffits with backing.
3.7.6. Cut and install molding and frieze board.
3.7.7. Case exterior openings.
3.7.8. Install exterior siding or covering.
3.7.9. Install exterior trim accessories (e.g., gutters, downspouts, louvers, shutters, posts, railings, decorative moldings).
3.7.10. Install draft stopping.

Outcome 3.8. Stairs

Construct open riser, utility, circular and geometric stairs.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X		X

Competencies

3.8.1. Describe stairway types and their components.
3.8.2. Calculate rise and run and design stairway risers, treads, stringers and clearances.
3.8.3. Lay out, cut, and install stair components.
3.8.4. Install stair finish trim components (e.g., skirt boards, handrails, balusters, newels, volutes, balustrade systems).
3.8.5. Install prefabricated stairs and drop-down stair units (e.g., attic stairs).

Outcome 3.9. Interior Finish Work

Complete interior finish for residential, industrial and commercial facilities.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X		X

Competencies

3.9.1. Describe the different types and characteristics of drywall and finishing materials.
3.9.2. Lay out the drywall installation and nail or screw pattern and install drywall and corner accessories.
3.9.3. Describe the effects insulation, vapor barriers and ventilation can have on controlling moisture.
3.9.4. Install insulation and vapor barriers for wall and ceiling finishes.
3.9.5. Install drywall board.
3.9.6. Finish drywall board.
3.9.7. Lay out and install a suspended ceiling.
3.9.8. Prepare subfloor, install building paper and cut and install underlayment.
3.9.9. Lay out and install finished flooring (e.g., vinyl, carpet, wood, ceramic).
3.9.10. Install door units (e.g., prehung, double hung, folding, sliding) and door and builder's hardware.
3.9.11. Install interior door and window trim (e.g., stools, sills, jamb extensions, casing, mullions, aprons).
3.9.12. Apply common drywall finishing compounds.
3.9.13. Apply finish coatings (e.g., paint, stains, varnishes, texturing, wallpaper).
3.9.14. Install baseboard and moldings (e.g., standard, crown, built-up moldings).
3.9.15. Install cabinetry, shelving and related hardware.

Outcome 3.10. Remodeling

Repair, restore, or remodel existing structures.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X		X

Competencies

3.10.1. Identify customer needs and develop a plan for a remodeling or restoration project.
3.10.2. Identify damage, diagnose cause of damage and plan repair.
3.10.3. Diagnose problems and plan deconstruction and preparation for repairs and/or restoration.
3.10.4. Match materials selected to the original structure.
3.10.5. Design and construct temporary bracing and shoring and install safety and security devices during construction.

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

Explain electrical principles and theories.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
	X	X

Competencies

4.1.1. Explain atomic structure and its relationship to electricity.
4.1.2. Describe the relationship between electrical effect and electromagnetic effect.
4.1.3. Explain 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.
4.1.7. Calculate voltage, current, resistance, impedance and power in circuits using Ohm's Law, Kirchhoff's Law and Watt's Law.

Outcome 4.2. Circuits

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

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
	X	X

Competencies

4.2.1. Identify electrical, electromechanical and solid state controls.
4.2.2. Describe the purpose of grounding and common methods used for grounding.
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 troubleshoot series, parallel and series-parallel circuits.
4.2.6. Determine voltage, current, frequency and phase.
4.2.7. Identify common types of transformers and list uses for each.
4.2.8. Explain step-up/step-down voltage methods.
4.2.9. Identify the types of motors and uses for each.
4.2.10. Identify types of capacitors and common usages for each.
4.2.11. Identify methods of varying capacitance.
4.2.12. Identify types of inductors and explain the purposes of different core materials.
4.2.13. Identify the characteristics of inductors and capacitors in series and parallel circuits.
4.2.14. 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.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	

Competencies

4.3.1. Explain the role of 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 applicable codes (i.e., Building Officials and Code Administrators [BOCA], Ohio Building Code [OBC], Life Safety Codes) and explain how they impact job requirements (e.g., service conductors, feeders, branch circuits, overload protection, grounding and bonding requirements).
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. Low Voltage Systems

Describe specialized low-voltage systems and components.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
	X	

Competencies

4.4.1. Identify and describe types of data and communication systems.

4.4.2. Identify and describe local, state and National Electrical Code (NEC) requirements for the installation of security and fire alarm systems.

4.4.3. Identify and describe energy management systems.

4.4.4. Identify and describe smart house systems.

4.4.5. Identify and describe installation techniques for specialized low voltage systems in accordance with Electronic Industries Alliance/Telecommunications Industry Association (EIA/TIA) standards.

Outcome 4.5. Electrical Wiring

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

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
	X	

Competencies

4.5.1. Select materials and lay out rough-in wiring runs according to specifications, drawings and code requirements.
4.5.2. Identify and install fasteners, anchors, and fire stop systems.
4.5.3. Locate and mount boxes.
4.5.4. Verify the location of and install service entrance systems.
4.5.5. Install service panels, meter apparatus, grounding electrode systems, subpanels and over current protective devices.
4.5.6. Identify and label a panel directory to reflect devices and circuits installed on each circuit.
4.5.7. 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]).
4.5.8. Install rough-in wiring following specifications, drawings and code requirements. 4.5.9. Identify the pull needed for conductors according to specifications, drawings and code requirements.
4.5.10. Install and service low-voltage systems (e.g., communication systems, telephone systems, control systems, lighting systems).
4.5.11. Install lighting fixtures, wiring devices and covers.
4.5.12. Install equipment grounding and bonding systems.
4.5.13. Make conductor terminations.
4.5.14. Connect appliances.
4.5.15. Check and test installation.

Outcome 4.6. Motors and Power

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

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
	X	

Competencies

4.6.1. Identify types and components of single-phase, split-phase and three-phase motors.
4.6.2. Interpret motor nameplate information and motor specifications.
4.6.3. Calculate motor loads.
4.6.4. Determine motor rotation needed for the installed load and explain the process for reversing rotation (i.e., three-phase, single-phase).
4.6.5. Interpret schematics and control diagrams for building a motor circuit.
4.6.6. Wire single-phase, split-phase and three-phase circuits and install motor control devices (i.e., contactors, starters, variable frequency and motor speed controls).
4.6.7. Explain the starting sequence of motor components within a given circuit.
4.6.8. Troubleshoot and repair motor starting systems to verify operation according to schematics and control diagrams.
4.6.9. Describe how programmable controllers can be used in single-phase, split-phase and three-phase circuits.

Outcome 4.7. Alternative Power Systems

Describe specialized power systems and components.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

Competencies

4.7.1. Identify and describe the functions of photovoltaic (PV) systems.
4.7.2. Identify and describe the functions of wind power technologies.
4.7.3. Identify and describe the functions of standby power systems (i.e., generator, uninterrupted power supplies [UPS] systems).
4.7.4. Identify and describe the functions of electric storage systems.
4.7.5. Perform battery maintenance functions (e.g., cleaning, checking electrolyte quality and level and battery status).

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 and industrial applications. HVAC may include mobile and fixed refrigeration and heating equipment, including environmental controls, boiler systems and ductwork; plumbing may include drainage, water supply, fuel piping, fixtures and appliances.

Outcome 5.1. Refrigeration

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

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
	X	

Competencies

5.1.1. Record, analyze, and interpret temperature and pressure measurements and their relationship.
5.1.2. Describe heat, heat transfer, energy and energy conversion.
5.1.3. Differentiate between sensible, latent and total heat.
5.1.4. Describe the thermodynamic cycle in the refrigeration process.
5.1.5. Compare and contrast the functions of evaporators, condensers, compressors and metering devices of the basic refrigeration cycle.
5.1.6. Compare and contrast the characteristics of refrigerants.
5.1.7. Describe, calculate, and record superheating and subcooling.
5.1.8. Calculate and record the saturation temperature of a refrigerant.

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

Install refrigeration, air conditioning, and heating systems.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
	X	

Competencies

5.2.1. Identify the basic components of a self-contained air conditioning unit.
5.2.2. Identify and explain the installation of a central air conditioner with heat pump.
5.2.3. Identify and explain the installation of a refrigeration condensing unit with a remote evaporator.
5.2.4. Identify and explain the installation of a distribution system.
5.2.5. Identify and explain the installation of natural gas, propane gas, electric and oil heating units.
5.2.6. Identify and explain the installation of an air-to-air heat pump.
5.2.7. Identify the components of a geothermal system.

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).

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	

Competencies

5.3.1. Perform routine cleaning and inspection of system and components.
5.3.2. Inspect and replace filters, belts and fluids.
5.3.3. Recover, recharge and reclaim refrigerant from refrigeration and air conditioning equipment according to Environmental Protection Agency (EPA) regulations.
5.3.4. Troubleshoot and service refrigeration and air conditioning equipment.
5.3.5. Troubleshoot and service heating systems.

Outcome 5.4. Energy Audit

Implement principles and guidelines needed to carry out effective energy audits in accordance with the Building Energy Efficiency Ordinance.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	

Competencies

5.4.1. Identify the requirements of an energy audit.
5.4.2. Conduct a walk-through inspection and a detailed energy audit and identify energy management opportunities (EMOs).
5.4.3. Calculate the energy and cost savings due to improvement in electrical, mechanical and plumbing systems performance and power quality.

Outcome 5.5. Boiler Systems

Describe and monitor the operation of hydronic and steam boiler systems.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	

Competencies

5.5.1. Compare and contrast the use and components of hydronic and steam boiler systems.
5.5.2. Observe and test system operations and safety controls.
5.5.3. Perform service maintenance and repair procedures for hydronic and steam boiler systems.

Outcome 5.6. Sheet Metal

Fabricate and install ductwork systems.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
	X	

Competencies

5.6.1. Identify the components of a duct system.
5.6.2. Select materials to fabricate ductwork based on job specifications.
5.6.3. Lay out, cut and shear ductwork and fittings.
5.6.4. Bend, fold, form and assemble a ductwork system.
5.6.5. Seal and insulate ductwork.
5.6.6. Fasten and hang ductwork.
5.6.7. Install cleats and drives in ductwork.

Outcome 5.7. Drainage

Rough in drainage systems following plumbing codes and municipal building standards.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	

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.
5.7.4. Describe factors that are considered when planning and installing a wastewater drainage system.
5.7.5. Estimate and compute length, angle of measurement, area, surface area and volume to calculate pipe legs and pipe sizes.
5.7.6. Calculate the slope required for drainage components.
5.7.7. Select drainage components based on their application for a given purpose.
5.7.8. Explain the impact of modifying structural members for drainage lines without weakening the structure.
5.7.9. Identify and explain the installation of pipe sleeves or thimbles through walls, ceilings or floors.
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.
5.7.13. Locate cleanout access points and clear obstructions from lavatories, water closets and sinks.
5.7.14. Describe the design, basic operation and care of a septic system.
5.7.15. Determine the location and type of sewer drainpipes and storm drains.
5.7.16. Identify and explain the installation of sewer drainpipes, septic tanks and storm drains.

Outcome 5.8. Water Systems

Rough in water systems following plumbing codes and municipal building standards.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	

Competencies

5.8.1. Compare and contrast sources of contamination in water supplies and methods of disinfecting water.
5.8.2. Explain the types and applications of pumps and pump controls used in water supplies.
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.
5.8.5. Describe ways in which a water supply system can become contaminated and prepare a water sample for analysis by a testing laboratory.
5.8.6. Describe factors to consider when planning and installing a water distribution system.
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.
5.8.11. Explain the impact of modifying structural members for water supply lines without weakening the structure.
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.

Outcome 5.9. Fuel Piping

Construct fuel piping systems following code and municipal building standards.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	

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. Planning and Design

Learners apply principles of architectural and civil engineering, drawing and construction with current technology to develop, present and use construction proposals, plans and schematics. Knowledge and skill may be applied throughout the project from preconstruction design through all stages of building in residential, commercial and industrial applications.

Outcome 6.1. Proposals

Develop and present a design, proposal, or concept.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X		

Competencies

6.1.1. Collect and analyze data to identify required deliverables (e.g., reports, studies, building designs, drawings) based on client specifications.

6.1.2. Create a visualization of a proposed project using data from relevant materials according to client specifications and in compliance with building codes.

6.1.3. Incorporate building structural systems, environmental systems, safety systems, building envelope systems and building service systems into the design.

6.1.4. Incorporate the Americans with Disabilities Act (ADA) Standards for Accessible Design.

6.1.5. Develop a narrative to describe the project.

6.1.6. Differentiate between residential, commercial, industrial and institutional construction segments.

6.1.7. Present the comprehensive proposal.

Outcome 6.2. Community Planning

Compare and contrast construction planning in urban and rural areas.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	

Competencies

6.2.1. Identify components necessary to managing municipal functions.

6.2.2. Describe the roles of city governments.

6.2.3. Examine problems of mass movement and spatial reorganization generated by expanding populations.

6.2.4. Apply appropriate implementation tools for orderly, efficient and equitable development and arrangement of land (i.e., zoning, development regulations, capital improvement programs).

6.2.5. Discuss appropriate health and social programs to improve the standard of living for those lacking in resources and/or opportunities.

6.2.6. Examine the preservation of historic buildings, neighborhoods and sites to implement a cultural appreciation of architecture and geographic heritage through the protection of the physical representations of that heritage.

6.2.7. Compare the community goals and objectives to the coordination of the transportation network.

6.2.8. Analyze housing problems and opportunities.

6.2.9. Identify economic development resources (e.g., policy development) for attracting and retaining industries.

6.2.10. Integrate environmental values (e.g., preservation of wetlands, air quality strategies, protection of natural areas) into land use and other community plans.

6.2.11. Merge the harmonious design (e.g., culture, related buildings and areas, aesthetics) of urban areas with urban policy.

6.2.12. Examine the strategies for regional and national development (i.e., modernization and urbanization, transportation, rural development patterns, sustainable development, related strategies of economic development).

6.2.13. Examine the economic factors that determine whether and where development, restoration and other investments occur.

Outcome 6.3. Drafting

Design residential, industrial, civil and commercial plans in accordance with the American National Standards Institute (ANSI) Y14.5M-2009 graphics standards.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X		

Competencies

6.3.1. Construct site plans in accordance with the ANSI Y14.5M-2009 graphics standards (e.g., zoning, property lines, utilities, building line, setback).

6.3.2. Construct scaled orthographic drawings to illustrate floor plans with appropriate adjacencies, traffic patterns, orientation of spaces and section views (e.g., stairway section, wall, cabinet elevations, building corners, elevation) in accordance with the ANSI Y14.5M-2009 graphics standards.

6.3.3. Construct foundation and roof plans in accordance with the ANSI Y14.5M-2009 graphics standards.

6.3.4. Construct mechanical, electrical and plumbing plans and schematics in accordance with the ANSI Y14.5M-2009 graphics standards.

6.3.5. Incorporate public spaces and cultural aesthetics in commercial structures.

6.3.6. Calculate a rating for energy responsiveness using a sustainable building guideline.

Outcome 6.4. 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.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

Competencies

6.4.1. Collect and analyze project information to determine resources and tasks required to complete a project.

6.4.2. Read and interpret a site plan.

6.4.3. Use architect's and engineer's scales to read and interpret construction drawings for material calculations and installation at the jobsite.

6.4.4. Read, interpret, and organize construction drawings, specifications and other contractual documents.

6.4.5. Describe various building sections, wall sections and other architectural details of residential, commercial and highway construction.

Outcome 6.5. Construction Math

Calculate materials needed to complete construction projects.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	X

Competencies

6.5.1. Find surface area and volume for three-dimensional objects, accurate to a specified level of precision.

6.5.2. Apply measurement scales to layout length, width, and angle measurements.

6.5.3. Apply algebraic procedures and geometric concepts to reading construction documents.

6.5.4. Use proportional reasoning and apply indirect measurement techniques (e.g., right triangle trigonometry, properties of similar triangles).

Strand 7. Construction and Facility Management

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, maintenance and custodial services.

Outcome 7.1. Construction Scheduling

Organize material and equipment delivery to maximize productivity.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X	X	

Competencies

7.1.1. Describe the delivery schedule of materials and equipment and its effect on employer cash flow and construction economics.

7.1.2. Prescribe material and equipment storage needs and location on different types of job sites (e.g., access, delivery, protection from the elements, security).

7.1.3. Describe the importance of a synchronized delivery schedule with multiple vendors.

7.1.4. Describe the impact of expediting the delivery of materials according to scheduled work assignments.

7.1.5. Prepare and process unused material inventory for return credit.

Outcome 7.2. Field Organization

Investigate and understand the sequence of building stages, systems and inspection processes within a build environment.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X		X

Competencies

7.2.1. Identify the Critical Path Method (CPM) to select and sequence the appropriate building stages and explain their relationships in completing a construction project.

7.2.2. Identify the various material testing techniques (e.g., hardness, tensile strength, bearing capacity, wear resistance).

7.2.3. Complete the commissioning and/or recommissioning process for a facility and its mechanical equipment.

7.2.4. Perform a walkthrough orientation and inspection to obtain assurance that the project has been completed in reasonably close conformity with plans, specifications and authorized change orders.

7.2.5. Generate a final inspections order to obtain certificate of occupancy.

7.2.6. Complete the sustainable building evaluation and certification process.

7.2.7. Identify the roles and goals of construction professionals within a given delivery system (e.g., owners, architects, engineers, suppliers, general and trade contractors, consultants, regulators).

Outcome 7.3. Floor Maintenance

Care for porous and nonporous floor surfaces (e.g., wood, laminate, stone, ceramic, terrazzo, marble, concrete, epoxy, vinyl composition tile [VCT], vinyl asbestos tiling [VAT], sheet goods).

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X		

Competencies

7.3.1. Identify types of surface material (porous/nonporous) to determine processes and chemicals needed to clean and maintain floors using manufacturers' recommendations.

7.3.2. Identify type of carpet (e.g., fibers, styles, construction methods) and associated processes and procedures used for cleaning.

7.3.3. Perform interim maintenance (e.g., vacuuming, encapsulation, spotting, bonnet, deep cleaning extractions) used in extending the life of the carpet.

7.3.4. Identify procedures, chemicals and equipment needed to clean, maintain and restore stone, marble, granite, ceramic, concrete, and terrazzo flooring found in facilities.

7.3.5. Identify hard, resilient, and wood floor coverings and use procedures (e.g., scrubbing, stripping, buffing, high-speed burnishing, screening, sealing), chemicals and equipment needed to maintain and extend the life of the flooring.

Outcome 7.4. Custodial Operations

Provide housekeeping and sanitation to maintain a safe and healthy environment.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X		

Competencies

7.4.1. Describe sustainable, healthy, and high-performance cleaning.

7.4.2. Develop and implement a custodial care plan (i.e., custodial duties and frequency; routine, renovation, supervisory, management activities) that provides a safe and healthy environment for a facility and analyzes efficiency based on hours and square footage.

7.4.3. Select procedures and processes needed to clean, sanitize and disinfect office spaces, public spaces, restrooms and kitchens.

7.4.4. Wash and clean windows and window treatments in accordance with manufacturers' recommendations.

7.4.5. Maintain and make aesthetically presentable permanently fixed audio and visual accessories.

7.4.6. Select procedures and processes needed to clean, disinfect and maintain wall surfaces (e.g., painted, tiled, papered, plastered).

7.4.7. Clean and disinfect lavatories and kitchen fixtures in accordance with health and safety guidelines.

7.4.8. Replenish consumable supplies and maintain levels of inventory.

7.4.9. Collect and dispose solid and hazardous waste in accordance with local codes and green initiatives.

7.4.10. Develop a green cleaning program that identifies cleaning procedures, services, equipment, and supplies that provide improvements in ergonomics and reduce the effect on human health without harming the environment.

Outcome 7.5. Maintenance Operations

Provide maintenance, repair and renovations to maintain the long-term conservation and protection of facility buildings and grounds.

An "X" indicates that the pathway applies to the outcome.

Design	Mechanical, Electrical, Plumbing	Structural
X		

Competencies

7.5.1. Schedule preventative maintenance, repair, and renovation to maintain a safe and healthy environment using computer-aided facilities management programs as appropriate.

7.5.2. Develop and implement a waste management and recycling plan that reduces costs based on local codes and regulations.

7.5.3. Develop and implement an integrated pest management plan that reduces environmental impact and reduces cost.

7.5.4. Develop a water conservation and management plan.

7.5.5. Compare and contrast green and traditional practices in the selection of materials, chemicals and equipment.

7.5.6. Develop and implement a facility walkthrough schedule to monitor environmental and security systems that assure a safe and comfortable environment.

7.5.7. Schedule labor and equipment to prepare for special events and functions.

7.5.8. Establish a cleaning schedule for grounds maintenance and landscaping using sustainable procedures and high productivity methods.