**Course Description**

Students will apply the knowledge and skills necessary for installing, maintaining and safely troubleshooting modern industrial machinery. Students will learn about pneumatic, hydraulic, mechanical and electrical systems. They will learn to solve practical maintenance problems, read and interpret drawings and maintenance manuals and understand manufacturing process quality practices. Students will troubleshoot electrical controls, sensors and actuators for automated machinery and manufacturing processes.

**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.

**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).

1.3.5. Access and implement safety compliance measures (e.g. quality assurance information, safety data sheets [SDSs], product safety data sheets [PSDSs], U.S. Environmental Protection Agency [EPA], United States Occupational Safety and Health Administration [OSHA]) that contribute to the continuous improvement of the organization.

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, copyright 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**

1.4.2. 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.

**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.

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.

**Strand 2. Electrical/Electronics**

Learners apply principles of electricity and electronics related to electronic theory, alternating and direct current, electronic components, electronic skills, digital electronics and power supplies. Knowledge and skills may be applied to fundamentals of electricity, analyzing and evaluating circuits, assembling components into electrical circuits, creating circuits to perform tasks and operations, wiring components to construct a communications system and providing power to an electrical system.

**Outcome 2.1. Electrical and Electronic Theory:** Explain electrical and electronic principles and theory.

**Competencies**

2.1.1. Describe the structure of atoms and their relationship to electricity.

2.1.2. Compare electrical properties and electromagnetic effect.

2.1.3. Explain methods of producing electrical current.

2.1.5. Compare alternating current (AC) and direct current (DC).

2.1.6. Define the units of measurement for voltage, current, power and resistance.

2.1.7. Describe the relationships between voltage, current, resistance and power in circuits.

2.1.8. Determine voltage, current, resistance and power in circuits using Ohm’s Law, Kirchhoff’s Law and Watt’s Law.

2.1.9. Describe the purpose of grounding and common methods used for grounding.

**Outcome 2.3. Codes and Regulations**: Explain and apply the National Electrical Code (NEC) and other building codes.

**Competencies**

* + 1. Explain the role of Underwriters Laboratory (UL), Canadian Standards Association (CSA), and Intertek Testing Service/Edison Testing Laboratory (ITS/ETL).
    2. Identify information in the National Electrical Code (NEC) and other applicable codes.
    3. Apply applicable codes to installation of electrical equipment.
    4. Use National Fire Protection Association (NFPA) NFPA 70E procedures to create a safety working environment.

**Outcome 2.7. Cabling and Wiring:** Connect components to construct low-voltage, data and communication systems using coaxial or fiber optic cables and twisted pair or balanced wires.

**Competencies**

* + 1. Describe the types, purposes and uses of cables and wires.
    2. Identify the construction, impedance characteristics and use of cables and wires.
    3. Explain how the characteristics of cables and wires cause impedance.
    4. Select methods for splicing and terminating cables and wires (e.g. terminal strips and crimp connectors.
    5. Splice and terminate cables and wires.
    6. Test cables and wires.

**Outcome 2.8. Power Supplies:** Provide power to electrical circuits.

**Competencies**

2.8.1. Identify the differences between transformer-powered supplies and line-connected supplies.

2.8.2. Select a battery based on composition, environment and circuit characteristics.

2.8.5. Select and install fuses and circuit breakers.

**Outcome 2.9. Motors and Power:** Install motors, variable-frequency drives (VFD), and power wiring.

**Competencies**

2.9.1. Identify types and components of single phase and three phase motors.

2.9.2. Interpret motor nameplate information and motor specifications.

2.9.3. Calculate motor loads.

2.9.4. Determine motor rotation needed for the installed load and explain the process for reversing rotation (i.e. three phase and single phase).

2.9.5. Interpret schematics and control diagrams for building a motor circuit.

2.9.6. Wire single phase and three phase circuits and install motor control devices (e.g. contactors, starters, variable-frequency drive (VFD) and motor speed controls).

2.9.7. Explain the starting sequence of motor components within a given circuit.

2.9.8. Troubleshoot and repair motor starting systems to verify operation according to schematics and control diagrams.

2.9.9. Describe how programmable controllers can be used to control single speed motors and variable speed motor applications.

**Strand 3. Computer Integrated Manufacturing**

Learners apply the principles of computer integrated manufacturing related to computer numerical control, robotics, programmable logic controllers and power systems.

**Outcome 3.1. Robotic Fundamentals:** Apply robotics fundamentals.

**Competencies**

3.1.1. Identify the components of a robot system and explain their roles in the robot's operation cycle.

3.1.2. Maintain robot components and controllers.

3.1.3. Select type of industrial robot to meet specific applications.

3.1.4. Use job specifications to create programs for robot operations, sensors and feeder systems.

3.1.5. Plan, program and test a robot using teach pendant and simulation software.

3.1.6. Identify the robot's payload and identify the concepts of payload weight and moment of inertia to select an appropriate robot.

3.1.7. Use robot speed specifications to calculate estimated cycle times for sample tasks.

3.1.8. Direct robot to home position using absolute and incremental coordinates.

3.1.9. Compare robotic applications and processes (e.g. palletizing, vision, pick and place, welding).

3.1.10. Identify the robot's work envelope and apply the concepts of reach and articulation to evaluate whether a robot is suited to an application.

3.1.11. Analyze the performance and troubleshoot the operation of a robot.

**Outcome 3.4. Power Technologies:** Install, maintain and troubleshoot power systems.

**Competencies**

3.4.1. Calculate fluid pressure and flow and describe how it relates to the functioning of hydraulic and pneumatic actuator.

3.4.2. Describe the relationship between force, pressure and power.

3.4.3. Calculate the efficiency of system components and energy loss due to friction, slippage and leakage.

3.4.4. Determine the effect of energy storage on efficiency and size of power units.

3.4.5. Predict the performance of an actuator under meter-in and meter-out conditions.

3.4.6. Read and interpret hydraulic, pneumatic and vacuum schematics and model codes.

3.4.7. Select a fluid power system based on project needs (e.g. pressure, flow, temperature, dissipation, filtration, fluid, maintenance).

3.4.8. Explain the fundamental principles of pneumatics, hydraulics and vacuum technology.

3.4.9. Troubleshoot power loss within a system.

3.4.10. Select the O-ring size, material and oil capacity for a specified application.

3.4.11. Use directional and proportional controls.

3.4.12. Compare electromechanical, pneumatic and hydraulic actuation.

3.4.13. Perform general maintenance on pneumatic, hydraulic and vacuum systems.

3.4.14. De-energize pneumatic, hydraulic and vacuum systems.

3.4.15. Compare types and functions of compressors.

**Outcome 3.5. Pumping Systems:** Install, maintain and troubleshoot pumps and pumping systems.

**Competencies**

3.5.1. Compare types of positive and non-positive displacement pumps and their respective functions.

3.5.2. Calculate flow, head/pressure and efficiency.

3.5.3. Interpret pump curves.

3.5.4. Align precision and non-precision couplings.

3.5.5. Disassemble and assemble pumping stations.

3.5.6. Troubleshoot pump system failure conditions (e.g. cavitation).

**Outcome 3.6. Mechanical Drives Systems:** Install, maintain and monitor mechanical drives systems.

**Competencies**

3.6.1. Compare types of gears, couplings, belts and chains and describe their uses.

3.6.2. Perform shaft alignment on rotating equipment.

3.6.3. Select bearings for specific applications.

3.6.4. Calculate or obtain speed and torque ratios for belt and chain drives per design specifications.

3.6.5. Install and align power transmissions systems.

3.6.6. Perform power transmissions systems maintenance.

3.6.7. Monitor power transmissions systems.

3.6.8. Troubleshoots for power transmission systems problems and inefficiencies.

**Outcome 3.7. Programmable Logic** **Controllers (PLCs):** Program, install and monitor digital computers used for automation of electromechanical processes to perform tasks.

**Competencies**

3.7.1. Describe the use of Programmable Logic Circuits (PLC) in manufacturing automation.

3.7.2. Identify programmable logic controller (PLC) components.

3.7.6. Design a motor control program using manual and automatic modes.

3.7.7. Monitor and troubleshoot a network and hardwired system with a programmable logic controller (PLC).

3.7.8. Monitor and troubleshoot programmable logic controller (PLC) operation.

3.7.9. Install and maintain programmable logic controllers (PLCs).

**Strand 6. Precision and Advanced Machining**

Learners apply principles of precision machining to measuring work pieces, drawing interpretation, inspection, bench work and layout, power saws, drilling machines, lathes and turning machines, milling machines and grinding machines.

**Outcome 6.1. Measurement and Interpretation:** Interpret drawings and documentation and perform measurements.

**Competencies**

6.1.3. Identify measuring systems and convert between systems.

6.1.4. Identify information and symbols provided in drawings and specifications.

**Outcome 6.11.** **Quality:** Apply quality processes.

**Competencies**

6.11.1. Identify quality control systems (e.g. Statistical Process Control (SPC), Six Sigma, Total Quality Management (TQM), Lean Management, “Plan‐Do‐Check‐Act” and International Organization of Standardization standards, especially ISO 9001 for manufacturers).

6.11.2. Troubleshoot manufacturing defects.

6.11.3. Tag and segregate non‐conforming material.

6.11.4. Use statistical methods to ensure quality.

6.11.5. Maintain customer interaction to ensure quality.

**Strand 7. Industrial Maintenance and Safety**

Learners apply principles of protection, prevention and mitigation to create and maintain safe working conditions at manufacturing 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 and using personal protective equipment.

**Outcome 7.1. Site Safety:** Handle materials, prevent accidents and mitigate hazards.

**Competencies**

7.1.1. 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.

7.1.2. Identify and rectify or mitigate hazards associated with walking surfaces, working surfaces and lighting.

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

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

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

7.1.6. Identify source of electrical and mechanical hazards and use shut-down and established lock out/tag-out procedures.

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

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

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

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

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

7.1.12. Create a hazardous materials safety plan.

7.1.13. Set up for ergonomic workflow.

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

**Outcome 7.2 Personal Safety:** Practice personal safety.

**Competencies**

7.2.1. Interpret personal safety rights according to the Employee Right to Know plan.

7.2.2. Describe how working under the influence of drugs and alcohol increases the risk of accident, lowers productivity, raises insurance costs and reduces profits.

7.2.3. Select, use, store, maintain and dispose of personal protective equipment (PPE) appropriate to job tasks, conditions and materials.

7.2.4. Identify workplace risk factors associated with lifting, operating and moving heavy objects and establish an ergonomics process.

7.2.5. Identify, inspect and use safety equipment appropriate for a task.

7.2.6. Use safe practices when working with electrical, mechanical, or other equipment.

7.2.7. Create and distribute training materials.

7.2.8. Safely operate manual, electrical‐powered and pneumatic tools.

**Outcome 7.3 Industrial Maintenance Safety:** Plan, develop and ensure industrial maintenance safety.

**Competencies**

7.3.1. Safely operate machinery and equipment.

7.3.2. Follow equipment shutdown procedures.

7.3.3. Perform leak checks on equipment.

7.3.4. Report and document unsafe machinery conditions.

7.3.5. Safely operate platforms, man lifts and ladders.

7.3.6. Identify tools and equipment requiring safety certification.

7.3.7. Use environmental data systems.

7.3.8. Monitor equipment for unsafe conditions.

7.3.9. Identify the benefits of cross‐training.

7.3.10. Deliver set‐up and operational procedures.

**Outcome 7.4 Industrial Maintenance Installation and Repair:** Inspect, maintain and repair industrial equipment.

**Competencies**

7.4.1. Identify installation techniques using manuals, checklists and regulations.

7.4.2. Identify equipment alarms.

7.4.3. Maintain inspection processes and records.

7.4.4. Calibrate and adjust manufacturing equipment.

7.4.5. Inspect and correct machine malfunctions.