**Course Description:**

Students will learn the production processes applied across manufacturing operations. Students will be able to demonstrate a broad array of technical skills with an emphasis given to quality practices, measurement, maintenance and safety.

**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).

1.3.4. 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], U.S. Environmental Protection Agency [EPA], United States Occupational Safety and Health Administration [OSHA]) that contribute to the continuous improvement of the organization.

1.3.6. 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, 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**

1.4.1. 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, electronic 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 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 electronic database to access and create business and technical information.

1.4.7. Use personal information management and productivity applications to optimize assigned tasks (e.g. lists, calendars, address books).

1.4.8. Use electronic media to communicate and follow network etiquette guidelines.

**Outcome 1.5. Global Environment:** Evaluate how beliefs, values, attitudes, and behaviors influence organizational strategies and goals.

**Competencies**

1.5.1. Describe how cultural understanding, cultural intelligence skills, and continual awareness are interdependent.

1.5.2. Describe how cultural intelligence skills influence the overall success and survival of an organization.

1.5.3. Use cultural intelligence to interact with individuals from diverse cultural settings.

1.5.4. Recognize barriers in cross-cultural relationships and implement behavioral adjustments.

1.5.5. Recognize the ways in which bias and discrimination may influence productivity and profitability.

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.

**Competencies**

1.6.1. Identify business opportunities.

1.6.2. Assess the reality of becoming an entrepreneur, including advantages and disadvantages (e.g. risk vs. 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 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 1.9. 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.

**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 different banking services available through financial institutions.

1.9.10. Identify the role of depreciation in tax planning and liability.

**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**

* + 1. Compare alternating current (AC) and direct current (DC).

**Outcome 2.2. Circuits:** Construct and analyze alternating current (AC) circuits and direct current (DC) circuits.

**Competencies**

* + 1. Compare conductors and insulators.
    2. Analyze wiring schematics and diagrams for accuracy and function.

**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.

2.3.3. Apply applicable codes to installation of electrical equipment.

**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.

2.8.3. Select and install filters.

2.8.4. Construct and install regulated power supplies.

2.8.5. Select and install fuses and circuit breakers.

2.8.6. Select and construct half-wave, full wave, and bridge rectifiers.

2.8.7. Select and install power conditioning, isolation transformers, surge suppressors, uninterruptible power supplies.

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

**Competencies**

* + 1. Calculate the pressure and flow of a fluid and describe how it relates to the functioning of a hydraulic and pneumatic actuator.
    2. Describe the relationship between force, pressure and power.
    3. Calculate the efficiency of system components and energy loss due to friction, slippage, and leakage.
    4. Determine the effect of energy storage on efficiency and size of power units.
    5. Predict the performance of an actuator under meter-in and meter-out conditions.
    6. Read and interpret hydraulic, pneumatic and vacuum schematics and model codes.
    7. Select a fluid power system based on project needs (e.g. pressure, flow, temperature, dissipation, filtration, fluid, maintenance).
    8. Explain the fundamental principles of pneumatics, hydraulics, and vacuum technology.
    9. Troubleshoot power loss within a system.
    10. Select an O-ring size, material, and oil capacity for a specified application.
    11. Use directional and proportional controls.
    12. Compare electromechanical, pneumatic and hydraulic actuation.
    13. Perform general maintenance on pneumatics, hydraulics, and vacuum systems.
    14. De-energize pneumatics, hydraulics, and vacuum systems.
    15. Compare types and functions of compressors.

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

**Competencies**

* + 1. Compare types of positive and nonpositive displacement pumps and their respective functions.
    2. Calculate flow, head/pressure and efficiency.
    3. Interpret pump curves.
    4. Align precision and non-precision couplings.
    5. Disassemble and assemble pumping stations.
    6. Troubleshoot pump system failure conditions (e.g. cavitation).

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

**Competencies**

* + 1. Compare types of gears, couplings, belts and chains and describe their uses.
    2. Perform shaft alignment on rotating equipment.
    3. Select bearings for specific applications.
    4. Calculate or obtain speed and torque ratios for belt and chain drives per design specifications.
    5. Install and align power transmissions systems.

**Strand 4. Materials Joining**

Learners apply principles of physics and metallurgy to join materials and test joints. Knowledge and skills may be applied to arc welding processes, non‐arc welding processes, testing and inspection and thermal cutting.

**Outcome 4.3. Arc Welding Process:** Perform types of welds in the six positions using arc welding processes.

**Competencies**

4.3.2. Select the types of weld required for product specifications.

4.3.4. Select an arc welding process based on product specifications.

**Outcome 4.4. Non-Arc Material Joining Process:** Perform types of non-arc material joining processes in the six positions.

**Competencies**

4.4.2. Select the types of material joining required for product specifications.

**Outcome 4.7. Fabrication:** Fabricate parts and weldment using fabrication equipment and tools.

**Competencies**

4.7.7. Identify various methods of fastening materials.

**Strand 5. Pre‐Engineering: Design and Development**

Learners apply principles of design and development related to the design process, sketching and visualization, modeling, drafting, materials and production and process design.

**Outcome 5.2. Sketching, Drawing, and Visualization:** Conceptualize, sketch, and draw design projects and components.

**Competencies**

5.2.1. Compare technical sketching and drawing.

5.2.2. Sketch possible solutions to an existing design problem.

5.2.3. Apply tolerancing techniques when dimensioning.

5.2.4. Apply annotations on sketches and drawings.

5.2.5. Create sketches using integration sketching techniques and styles.

5.2.6. Apply coordinate systems (e.g. absolute, relative, user, cylindrical, Cartesian).

5.2.7. Sketch geometric forms and shapes.

5.2.8. Describe geometric constraints (e.g. geometric dimension and tolerancing [GD&T], run out, location, and form).

5.2.9. Select a view to graphically communicate a design solution.

5.2.10. Use reverse engineering to determine the strengths and weaknesses of a design.

**Outcome 5.3. Computer-Aided Drafting and Modeling:** Computer-aided Drafting and Modeling to illustrate the design of projects and components.

**Competencies**

5.3.1. Apply manufacturing processes to computer-aided modeling (e.g. casting, molding, forming, separating, conditioning, assembling, finishing, rapid prototyping, 3-D printing).

5.3.2. Evaluate a sketch and generate a model utilizing three-dimensional modeling.

5.3.3. Compare conceptual, physical and mathematical design models used to check design.

5.3.4. Perform part manipulation during the creation of an assembly model.

5.3.5. Analyze assembly constraints and successfully construct an assembly drawing.

5.3.6. Use part libraries effectively during the assembly modeling process.

5.3.7. Employ subassemblies during the production of assemblies.

5.3.8. Verify drive constraints that simulate the motion of parts in assemblies.

5.3.9. Apply adaptive design concepts during the development of sketches, drawings, features, parts, and assemblies.

5.3.10. Translate a three-dimensional drawing or model into corresponding orthographic drawing views.

5.3.11. Evaluate the accuracy of mass properties calculations.

5.3.12. Evaluate a model for design imperfections.

5.3.13. Create and interpret auxiliary views, orthographic projections, isometric drawings, oblique drawings, and perspective drawings.

5.3.14. Create a sectional view drawing.

5.3.15. Illustrate the types of breaks and symbols used in drawing sectional views.

5.3.16. Produce a reverse-engineered drawing from a solid object.

**Outcome 5.4. Materials:** Select materials for design projects and components.

5.4.1. Compare advantages of materials used in manufacturing based on physical properties.

5.4.2. Identify the production processes used to create materials.

5.4.3. Determine the production processes used to create products from categories of materials (e.g. organic materials, metals, polymers, ceramics and composites).

5.4.4. Evaluate the types and magnitude of stresses and forces.

5.4.5. Analyze material properties by destructive and nondestructive tests.

5.4.6. Select materials for a given application based on specified criteria (e.g. cost, availability, manufacturability).

**Outcome 5.5. Production and Process Design:** Production, process design, and project management.

**Competencies**

5.5.1. Plan and apply manufacturing processes (e.g. casting, molding, forming, separating, conditioning, assembling, finishing, rapid prototyping, 3-D printing).

5.5.2. Use process planning and improvement tools (e.g. flowcharts, diagrams, design for manufacturability [DFM]).

5.5.3. Identify the planning and process procedures for production (e.g. corrective preventive actions, audit documentation, Process Failure Mode Effect Analysis [PFMEA]).

5.5.4. Determine critical characteristics and establish quality controls.

5.5.5. Employ project scheduling techniques (e.g. critical path methodology [CPM], project evaluation and review technique [PERT]).

5.5.6. Identify criteria and constraints and determine how those will affect the design of the production process.

5.5.7. Estimate time, tooling, product packaging and material costs.

5.5.8. Monitor performance and compare to time, tool and material cost estimates.

5.5.9. Set capacity to account for fluctuation in demand.

5.5.10. Adjust the plan as necessary to respond to variations (e.g. process, demand, material).

5.5.11. Evaluate final solutions and communicate observations, processes and results.

5.5.12. Develop a packaging design that prepares a product for shipping.

**Strand 6. Precision 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**

* + 1. Identify measuring tools and gradations used in precision machining and their purposes.
    2. Identify typical measurements in precision machining (e.g. angles, diameter, hardness).
    3. Identify measuring systems and convert between systems.
    4. Identify information and symbols provided in drawings and specifications.
    5. Measure and inspect work pieces according to product specifications.

**Outcome 6.2. Layout and Planning:** Plan a machining process.

**Competencies**

* + 1. Determine product requirements, dimensions, and tolerances from drawing and specifications.
    2. Determine process steps (e.g. cut, drill, turn, mill, grind, heat treat).
    3. Plan individual process steps based on industry standards (e.g. manufacturer’s specifications, machining standards).
    4. Schedule machining equipment as required.

**Outcome 6.8. Maintenance:** Maintain tools and equipment in working condition.

**Competencies**

* + 1. Identify equipment maintenance requirements in the equipment manufacturer’s documentation.
    2. Identify maintenance tasks required (e.g. inspecting, grinding, sharpening, dressing, lubricating, cleaning).
    3. Verify measuring tool accuracy and recalibrate as needed.
    4. Develop a preventive maintenance schedule.
    5. Monitor equipment performance during use.
    6. Repair or replace equipment and accessories as needed.

**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**

* + 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. Identify and rectify or mitigate hazards associated with walking surfaces, working surfaces, and lighting.
    3. Calculate example of load factors for constructing scaffolding, railings, ladders, and temporary structures.
    4. Apply inspection, rejection criteria, hitch configurations, and load-handling practices to slings and rigging hardware.
    5. Demonstrate proper use of American National Standards Institute (ANSI) hand signals.
    6. Identify source of electrical and mechanical hazards and use shut down and established lock-out/tag-out procedures.
    7. Identify and eliminate worksite clutter in accordance with standards for cleanliness and safety.
    8. Identify procedures for handling, storage, and disposal of hazardous materials.
    9. Identify the location of emergency flush showers, eyewash fountains, Safety Data Sheets (SDSs), fire alarms, and exits.
    10. Select and operate fire extinguishers based on the class of fire.
    11. Identify the components of a hazardous materials safety plan.
    12. Create a hazardous materials safety plan.
    13. Set up for ergonomic workflow.
    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 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.