**Course Description**

In this course, students will be introduced to all aspects of computer-integrated manufacturing. They will learn about robotics and automation, manufacturing processes, computer modeling, manufacturing equipment and flexible manufacturing systems.

**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 resumes.

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.

1.3.6. 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 2.4 Electronic Components:** Describe the functions and purposes of electronic components.

**Competencies**

2.4.3. Identify symbols for electronic components.

**Outcome 2.5 Electronic Connections:** Connect individual components into an electrical circuit.

**Competencies**

2.5.6. Combine components per wiring prints, schematics and block diagrams.

**Outcome 2.6** **Digital Electronics:** Create circuits to perform tasks and operations.

**Competencies**

2.6.13. Design a schematic for a digital circuit.

**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.

2.8.4. Construct and install regulated power supplies.

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

**Competencies**

* + 1. Identify types and components of single phase and three phase motors.
    2. Interpret motor nameplate information and motor specifications.
    3. Calculate motor loads.
    4. Determine motor rotation needed for the installed load and explain the process for reversing rotation (i.e. three phase and single phase).
    5. Interpret schematics and control diagrams for building a motor circuit.

**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.

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

**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.

**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 5.1. The Design Process:** Use the engineering design process and quality assurance principles to analyze and solve design problems.

**Competencies**

* + 1. Describe the role of research, development, and experimentation in design problem solving.
    2. Conduct an investigation to identify customer needs, constraints, and criteria.
    3. Develop multiple solutions and select an approach.
    4. Develop a design proposal and make a model/prototype.
    5. Evaluate and redesign a prototype using collected data.
    6. Use process planning and improvement tools to manage the life cycle of a product.
    7. Identify the potential concept and design flaws (e.g. concept model corrections, audit documentation using Design Failure Mode Effect Analysis [DFMEA]).
    8. Compare design considerations for product recycling or disposal for the end of a product's life cycle.
    9. Document progress and capture ideas during the development phase.

**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. Use 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.

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

**Outcome 5.3** **Computer-Aided Modeling:** Create models 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 proper 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. Utilize 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, 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.

5.3.17. Add technical elements (e.g. parts lists, titles, finishes, tolerances, specifications, hidden surfaces) to drawings.

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

**Competencies**

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).

5.4.7. Analyze the strength of a design using simulation modeling software (e.g. finite element analysis).

5.4.8. Use a material and develop a product.

**Outcome 5.5 Production and Process Design:** Identify and evaluate production and process design.

**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.

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

**Competencies**

6.2.1. Determine product requirements, dimensions, and tolerances from drawing and specifications.

6.2.2. Determine process steps (e.g. cut, drill, turn, mill, grind, heat treat).

6.2.3. Plan individual process steps based on industry standards (e.g. manufacturer’s specifications, machining standards).

6.2.4. Schedule machining equipment as required.

**Outcome 6.5 Turning:** Turn materials.

**Competencies**

6.5.1. Identify the type of material and turning required in product specifications.

6.5.2. Select turning machine, bit, chucks, speeds, and cutting fluids.

6.5.3. Configure the turning equipment.

6.5.4. Prepare work pieces for turning.

6.5.5. Turn the materials.

6.5.6. Inspect the work to meet requirements.

**Outcome 6.6 Milling:** Mill materials.

**Competencies**

6.6.1. Identify the type of material and milling required in product specifications.

6.6.2. Select milling machine, bit, chucks, speeds and cutting fluids.

6.6.3. Configure the milling equipment.

6.6.4. Prepare work pieces for milling.

6.6.5. Mill the materials.

6.6.6. Inspect and deburr the work to meet requirements.

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

**Competencies**

6.8.1. Identify equipment maintenance requirements in the equipment manufacturer’s documentation.

6.8.2. Identify maintenance tasks required (e.g. inspecting, grinding, sharpening, dressing, lubricating, cleaning).

6.8.3. Verify measuring tool accuracy and recalibrate as needed.

6.8.4. Develop a preventive maintenance schedule.

6.8.5. Monitor equipment performance during use.

6.8.6. Repair or replace equipment and accessories as needed.

**Outcome 6.9. Computer Numerical Control (CNC):** Apply standard practices of CNC operations and part inspection.

**Competencies**

* + 1. Maintain CNC milling/turning machine components and controllers.
    2. Plan a CNC production process for jobs in a machining cell.
    3. Create and edit CNC programs (e.g. G-code, computer-aided manufacturing [CAM]) for milling/turning machine operations according to job specifications, dimensions, and tolerances.
    4. Create a tool setup sheet.
    5. Work from a process sheet and part print.
    6. Set up and operate CNC milling/turning machines.
    7. Monitor the operations of a machining cell and troubleshoot problems that arise.
    8. Verify part quality against job specifications.