**Course Description**

Students will apply the knowledge and skills necessary to safely fabricate parts by cutting, drilling, bending, shaping, forming, edging and assembling stock to drawing dimensions. Students will identify weld types, fasteners and adhesives to join materials.

**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, resume 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 (e.g. medical reports, fitness assessment, medical test results).

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 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.

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.

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

1.3.7. Identify the labor and practice 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], human trafficking) and interpret personal safety rights according to the employee Right‐to‐Know Plan.

1.3.8. Verify compliance with computer and intellectual property laws and regulations.

1.3.9. Identify potential conflicts of interest (e.g. personal gain, project bidding) between personal, organizational and professional ethical standards.

**Outcome 1.4. Knowledge Management and Information Technology:** Demonstrate current and emerging strategies and technologies used to collect, analyze, record and share information in business operations.

**Competencies**

1.4.2. 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 4. Materials Joining**

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

**Outcome 4.1. Physics of Welding:** Apply the physics of arc welding to the process of joining metal.

**Competencies**

4.1.1. Explain how the welding arc produces a weld.

4.1.2. Identify the factors that affect heat transfer.

4.1.3. Identify the factors that affect melting.

4.1.4. Describe the effects of arc length and shielding gases on the arc.

4.1.5. Identify key variables that determine the type of metal transfers.

4.1.6. Identify how metal transfers in different welding processes (i.e. short circuit, globular, spray transfer, pulsed spray transfer).

4.1.7. Explain the characteristics of different transfer modes (i.e. short circuit, globular, spray transfer, pulsed spray transfer).

4.1.8. Describe the relationship between wire feed speed, current and voltage.

4.1.9. Describe types of transfer modes.

4.1.10. Describe the effects of wire size and type on deposition rate and current ranges.

4.1.11. Identify the characteristics of a stable arc, arc voltage and arc length.

4.1.12. Describe the relationship of current and voltage as it applies to constant voltage power sources.

4.1.13. Explain conditions when arc blow occurs and how to reduce arc blow.

4.1.14. Describe how polarity affects the arc welding process.

4.1.15. Explain the effects of high frequency when welding aluminum with the gas tungsten arc welding (GTAW) process.

4.1.16. Compare transformers, rectifiers and inverters in relation to the arc welding process.

**Outcome 4.2. Metallurgy of Welding:** Apply the metallurgy of welding to the processes of joining metal.

**Competencies**

4.2.1. Explain phases of matter and phase changes during solidification.

4.2.2. Explain how the common crystal structure in metallic materials affects welds.

4.2.3. Explain point, line and surface imperfection in metal crystal structure.

4.2.4. Explain the types of weld imperfections and their effects on material properties.

4.2.5. Explain grain boundaries.

4.2.6. Explain allotropic phase changes as a function of temperature.

4.2.7. Explain the production of ferrous and nonferrous alloys.

4.2.8. Explain an equilibrium phase diagram for alloys.

4.2.9. Explain how the constituent structure of eutectoid steel changes when it is slowly cooled from austenite to pearlite and when it is rapidly cooled from austenite to martensite.

4.2.10. Explain the tie line concept for calculating percent of a phase in the two-phase region of equilibrium diagrams.

4.2.11. Identify the phases present in the two-phase pro-eutectoid ferrite region.

4.2.12. Explain transformation strengthening, deformation strengthening and precipitation strengthening.

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

**Competencies**

4.3.1. Identify types of ferrous and nonferrous materials to be joined.

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

4.3.3. Explain electrode and filler metal classification systems and procedures for handling and storing.

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

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

**Competencies**

4.4.1. Identify types of ferrous and nonferrous metals and plastics to be joined.

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

4.4.3. Select non-arc welding processes based on product specifications.

4.4.6. Describe the types and applications of solid state bonding processes.

**Outcome 4.5. Testing and Inspection:** Test and inspect joints and weld structures.

**Competencies**

4.5.1. Identify the factors considered in weld quality.

4.5.2. Conduct a visual defect examination.

4.5.3. Conduct destructive weldment testing.

4.5.4. Conduct dye penetrant examination.

4.5.5. Conduct radiographic examination.

4.5.6. Conduct eddy current examination.

4.5.7. Analyze weld structure test results to determine weld quality.

4.5.8. Describe emerging non-destructive examination process related to quality testing.

**Outcome 4.6. Cutting Processes:** Cut materials using cutting processes.

**Competencies**

4.6.1. Identify types of materials to be cut.

4.6.2. Identify the characteristics of the cut (e.g. bevels, miters, angles) and finish (e.g. machined, grind, rolled).

4.6.3. Select a cutting process based on product specifications.

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

**Competencies**

4.7.1. Evaluate material structures and equipment and plan the method of repair.

4.7.2. Evaluate project design and identify welding type to meet the specifications to plan the method of fabrication.

4.7.3. Lay out and cut materials.

4.7.4. Shape stock through bending, cutting, drilling and filing.

4.7.5. Form and assemble material through cutting and bending.

4.7.6. Edge material through rolling turning, beading and crimping.

4.7.7. Identify various methods of fastening materials.

4.7.8. Fasten material using a range of hardware.

4.7.9. Join material using a range of adhesives.

4.7.10. Process cold metals through tapping, threading, torqueing and smoothing.

4.7.11. Compare surface coatings and apply them under appropriate environmental conditions.

4.7.12. Explain and demonstrate the process of squaring and fixturing.

**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**

5.1.1. Describe the role of research, development and experimentation in design problem solving.

5.1.2. Conduct an investigation to identify customer needs, constraints and criteria.

5.1.3. Develop multiple solutions and select an approach.

5.1.4. Develop a design proposal and make a model/prototype.

5.1.5. Evaluate and redesign a prototype using collected data.

5.1.6. Use process planning and improvement tools to manage the life cycle of a product.

5.1.7. Identify the potential concept and design flaws (e.g. concept model corrections, audit documentation using Design Failure Mode Effect Analysis [DFMEA]).

5.1.8. Compare design considerations for product recycling or disposal for the end of a product's life cycle.

5.1.9. 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. 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, 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**

5.3.2. 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.

5.3.17. 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**

5.4.4. 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).

**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**

6.1.1. Identify measuring tools and gradations used in precision machining and their purposes.

6.1.2. Identify typical measurements in precision machining (e.g. angles, diameter, hardness).

6.1.3. Identify measuring systems and convert between systems.

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

6.1.5. Measure and inspect work pieces according to product 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. manufacturers' specifications, machining standards).

**Outcome 6.3. Cutting:** Cut materials.

**Competencies**

6.3.1. Identify the type of material and cuts required in product specifications.

6.3.6. Inspect the work to meet requirements.

**Outcome 6.4. Drilling:** Drill materials.

**Competencies**

6.4.1. Identify the type of material and apertures required in product specifications.

6.4.6. Inspect the work to meet requirements.

**Outcome 6.7. Grinding:** Grind materials.

**Competencies**

6.7.1. Identify the type of material and grinding required in product specifications.

6.7.6. Inspect the work to meet requirements.

**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.

7.1.6. 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.

7.1.13. Set up for ergonomic workflow.

**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.