

Engineering and Science Technologies Career Field

Engineering Principles

Subject Code: 175002

Outcome & Competency Descriptions

Course Description:

This course will introduce students to fundamental engineering concepts and scientific principles associated with engineering design applications. Topics include mechanisms, energy statics, materials and kinematics. Additionally, students will learn material properties and electrical, control and fluid power systems. Students will learn to apply problem solving, research and design skills to create solutions to engineering challenges.

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 post-secondary 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.

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- 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.

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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.

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- 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

- 2.1.1. Describe the structure of atoms and their relationship to electricity.
- 2.1.2. Compare electrical properties and electromagnetic effect.

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- 2.1.3. Explain methods of producing electrical current.
- 2.1.4. Explain how batteries store and disperse energy.
- 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.

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

Competencies

- 2.2.1. Compare conductors and insulators.
- 2.2.8. Explain the uses of series, parallel and series-parallel circuits.
- 2.2.9. Construct and troubleshoot series, parallel and series-parallel circuits.
- 2.2.10. 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

- 2.3.1. Explain the role of Underwriters Laboratory (UL), Canadian Standards Association (CSA) and Intertek Testing Service/Edison Testing Laboratory (ITS/ETL).

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

Competencies

- 2.4.1. Identify resistor values from color codes or other marks.
- 2.4.9. Describe the purpose and operation of photovoltaic cells.

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 fluid power systems.

Competencies

- 3.4.1. Calculate fluid pressure and flow and describe how it relates to the functioning of a 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.

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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.
- 5.1.6. 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, 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.

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

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.