21252 Materials Science and Engineering

3 2 1 0 1. Identify key participants and events in the science and history of materials science and engineering, including areas of metallurgy, polymers, ceramics, and composite development.

3 2 1 0 2. Identify professional organizations and resources available to provide additional information on materials science.

3 2 1 0 3. Recognize and know how to utilize the MSDS information in the workplace and where to find it.

3 2 1 0 4. Recognize physical properties of materials: solid, liquid, gas, and plasma.

3 2 1 0 5. **(#4 Primary Alternate)** Recognize materials properties(such as but not limited to):

- Mechanical properties
  - Compressive strength
  - Ductility
  - Hardness
  - Specific weight
  - Tensile strength
  - Density
- Electrical properties
  - *Electrical conductivity
  - *Dielectric/Piezoelectric properties
- Thermal properties
  - Thermal conductivity
  - Thermal expansion
  - Heat of vaporization
  - Flammability/FlashPoint/Autoignition Temperature
  - Vapor Pressure
  - Melting point
  - Boiling point
  - Curie point (loss of magnetism by heat)
- Chemical properties
  - pH
  - Reactivity
  - Solubility (ionic vs. covalent)
  - Corrosion resistance
- Magnetic properties
  - Permeability
- Optical properties
  - Absorptivity
  - Reflectivity
  - Refractive index
  - Color
  - Transmittance
  - Scattering
- Acoustical properties
  - Acoustical absorption
  - Speed of sound
- Environmental properties
  - Embodied energy (sustainability … used in LEED)
  - RoHS compliance (Hazardous Materials)
- Atomic properties
  - Atomic number - applies to pure elements only
  - Atomic mass - applies to individual isotopes or specific mixtures of isotopes of a given element (useful in discussion of alloys & composites).
- Manufacturing properties
  - Machining speeds and feeds
  - Machinability rating
  - Hardness
  - Extruding temperature and pressure
  - Castability
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3 2 1 0 4. **(#4 Secondary Alternate)** Recognize key properties of materials: reactivity, toxicity, flammability, stability

3 2 1 0 6. Recognize the various classes of materials, such as <u>crystals</u> (ionic and covalent), <u>metals</u>, intermetallics (<u>alloys</u>), <u>semiconductors</u>, <u>polymers</u>, <u>composite</u> materials, and <u>ceramics</u>/vitreous (glasslike) materials.

3 2 1 0 7. Identify the fundamentals of materials in terms of material structural properties; behaviors under varying conditions, bonding, electrical/magnetic conductivity, chemical reaction, and decomposition behaviors (ie. oxidation/rust/crazing).

3 2 1 0 8. Give examples of specialized usage of materials in industry.

3 2 1 0 9. Identify reasons for particular materials to be chosen over other materials for specific applications.

3 2 1 0 10. Identify various methods for physical bonding of materials.
3 2 1 0 11. Explain appropriate usage/advantage of physical bonds over chemical bonds in various applications.
3 2 1 0 12. Identify various methods for chemical bonding of materials.
3 2 1 0 13. Explain appropriate usage/advantage of chemical bonds over physical bonds in various applications.
3 2 1 0 14. Define tribology and its importance.
3 2 1 0 15. Describe the impact of biomaterials on the industry.
3 2 1 0 16. Identify and describe a material that has recently become available or has recently been adopted for widespread use and how it may impact future design and development.
3 2 1 0 17. Describe manufacturing processes that have changed due to availability of new materials.
3 2 1 0 18. Identify and describe a testing technique for the integrity of a part made from a particular material (examples might be stress/pressure testing, magnaflux, diffraction techniques, x-ray, sonic, etc).

All Engineering and Technology Pathways

A. FOUNDATIONAL ACADEMIC EXPECTATIONS

B. ESSENTIAL KNOWLEDGE AND SKILLS

ACADEMIC FOUNDATIONS: Achieve additional academic knowledge and skills required to pursue the full range of career and postsecondary education opportunities within a career cluster.

3 2 1 0 1. Complete required training, education, and certification to prepare for employment in a particular career field.
   a. Identify training, education and certification requirements for occupational choice.
   b. Participate in career-related training and/or degree programs.
   c. Pass certification tests to qualify for licensure and/or certification in chosen occupational area.
3 2 1 0 2. Demonstrate language arts knowledge and skills required to pursue the full range of post-secondary education and career opportunities.
   a. Model behaviors that demonstrate active listening.
   b. Adapt language for audience, purpose, situation. (i.e. diction/structure, style).
   c. Organize oral and written information.
   d. Compose focused copy for a variety of written documents such as agendas, audio-visuals, bibliographies, drafts, forms/documents, notes, oral presentations, reports, and technical terminology.
   e. Edit copy to create focused written documents such as agendas, audio-visuals, bibliographies, drafts, forms/documents, notes, oral presentations, reports, and technical terminology.
   f. Comprehend key elements of oral and written information such as cause/effect, comparisons/contrasts, conclusions, context, purpose, charts/tables/graphs, evaluation/critiques, mood, persuasive text, sequence, summaries, and technical subject matter.
   g. Evaluate oral and written information for accuracy, adequacy/sufficiency, appropriateness, clarity, conclusions/solutions, fact/opinion, propaganda, relevancy, validity, and relationship of ideas.
   h. Identify assumptions, purpose, outcomes/solutions, and propaganda techniques.
   i. Predict potential outcomes and/or solutions based on oral and written information regarding trends.
   j. Present formal and informal speeches including discussion, information requests, interpretation, and persuasive arguments.
3 2 1 0 3. Demonstrate mathematics knowledge and skills required to pursue the full range of post-secondary education and career opportunities.
   a. Identify whole numbers, decimals, and fractions.
   b. Demonstrate knowledge of basic arithmetic operations such as addition, subtraction, multiplication, and division.
   c. Demonstrate use of relational expressions such as equal to, not equal, greater than, less than, etc.
   d. Apply data and measurements to solve a problem.
   e. Analyze mathematical problem statements for missing and/or irrelevant data.

f. Construct charts/tables/graphs from functions and data.
g. Analyze data when interpreting operational documents.

3 2 1 0 4. Demonstrate science knowledge and skills required to pursue the full range of post-secondary and career education opportunities.
a. Evaluate scientific constructs including conclusions, conflicting data, controls, data, inferences, limitations, questions, sources of errors, and variables.
b. Apply scientific methods in qualitative and quantitative analysis, data gathering, direct and indirect observation, predictions, and problem identification.

COMMUNICATIONS: Use oral and written communication skills in creating, expressing and interpreting information and ideas including technical terminology and information.

3 2 1 0 1. Select and employ appropriate reading and communication strategies to learn and use technical concepts and vocabulary in practice.
a. Determine the most appropriate reading strategy for identifying the overarching purpose of a text (i.e. skimming, reading for detail, reading for meaning or critical analysis).
b. Demonstrate use of content, technical concepts and vocabulary when analyzing information and following directions.
c. Select the reading strategy or strategies needed to fully comprehend the content within a written document (i.e., skimming, reading for detail, reading for meaning or critical analysis).
d. Interpret information, data, and observations to apply information learned from reading to actual practice.
e. Transcribe information, data, and observations to apply information learned from reading to actual practice.
f. Communicate information, data, and observations to apply information learned from reading to actual practice.

3 2 1 0 2. Demonstrate use of the concepts, strategies, and systems for obtaining and conveying ideas and information to enhance communication in the workplace.
a. Employ verbal skills when obtaining and conveying information.
b. Record information needed to present a report on a given topic or problem.
c. Write internal and external business correspondence that conveys and/or obtains information effectively.
d. Communicate with other employees to clarify workplace objectives.
e. Communicate effectively with customers and employees to foster positive relationships.

3 2 1 0 3. Locate, organize and reference written information from various sources to communicate with co-workers and clients/participants.
a. Locate written information used to communicate with co-workers and customers.
b. Organize information to use in written and oral communications.
c. Reference the sources of information.

3 2 1 0 4. Evaluate and use information resources to accomplish specific occupational tasks.
a. Use informational texts, Internet web sites, and/or technical materials to review and apply information sources for occupational tasks.
b. Evaluate the reliability of information from informational texts, Internet Web sites, and/or technical materials and resources.

3 2 1 0 5. Use correct grammar, punctuation and terminology to write and edit documents.
a. Compose multi-paragraph documents clearly, succinctly, and accurately.
b. Use descriptions of audience and purpose when preparing and editing written documents.
c. Use correct grammar, spelling, punctuation, and capitalization when preparing written documents.

3 2 1 0 6. Develop and deliver formal and informal presentations using appropriate media to engage and inform audiences.
a. Prepare oral presentations to provide information for specific purposes and audiences.
b. Identify support materials that will enhance an oral presentation.
c. Prepare support materials that will enhance an oral presentation.
d. Deliver an oral presentation that sustains listeners' attention and interest.
e. Align presentation strategies to the intended audience.
f. Implement multi-media strategies for presentations.

3 2 1 0 7. Interpret verbal and nonverbal cues/behaviors to enhance communication with co-workers and clients/participants.
- a. Interpret verbal behaviors when communicating with clients and co-workers.
- b. Interpret nonverbal behaviors when communicating with clients and co-workers.

3 2 1 0 8. Apply active listening skills to obtain and clarify information.
- a. Interpret a given verbal message/information.
- b. Respond with restatement and clarification techniques to clarify information.

3 2 1 0 9. Develop and interpret tables, charts, and figures to support written and oral communications.
- a. Create tables, charts, and figures to support written and oral communications.
- b. Interpret tables, charts, and figures used to support written and oral communication.

3 2 1 0 10. Listen to and speak with diverse individuals to enhance communication skills.
- a. Apply factors and strategies for communicating with a diverse workforce.
- b. Demonstrate ability to communicate and resolve conflicts within a diverse workforce.

3 2 1 0 11. Exhibit public relations skills to increase internal and external customer/client satisfaction.
- a. Communicate effectively when developing positive customer/client relationships.

PROBLEM-SOLVING AND CRITICAL THINKING: Solve problems using critical thinking skills (analyze, synthesize, and evaluate) independently and in teams. Solve problems using creativity and innovation.

3 2 1 0 1. Employ critical thinking skills independently and in teams to solve problems and make decisions (e.g., analyze, synthesize and evaluate).
- a. Identify common tasks that require employees to use problem-solving skills.
- b. Analyze elements of a problem to develop creative solutions.
- c. Describe the value of using problem-solving and critical thinking skills to improve a situation or process.
- d. Create ideas, proposals, and solutions to problems.
- e. Evaluate ideas, proposals, and solutions to problems.
- f. Use structured problem-solving methods when developing proposals and solutions.
- g. Generate new and creative ideas to solve problems by brainstorming possible solutions.
- h. Critically analyze information to determine value to the problem-solving task.
- i. Guide individuals through the process of recognizing concerns and making informed decisions.
- j. Identify alternatives using a variety of problem-solving and critical thinking skills.
- k. Evaluate alternatives using a variety of problem-solving and critical thinking skills.

3 2 1 0 2. Employ critical thinking and interpersonal skills to resolve conflicts with staff and/or customers.
- a. Analyze situations and behaviors that affect conflict management.
- b. Determine best options/outcomes for conflict resolution using critical thinking skills.
- c. Identify with others' feelings, needs, and concerns.
- d. Implement stress management techniques.
- e. Resolve conflicts with/for customers using conflict resolution skills.
- f. Implement conflict resolution skills to address staff issues/problems.

3 2 1 0 3. Identify, write and monitor workplace performance goals to guide progress in assigned areas of responsibility and accountability.
- a. Write realistic performance goals, objectives and action plans.
- b. Monitor performance goals and adjust as necessary.
- c. Recognize goal achievement using appropriate rewards in the workplace.
- d. Communicate goal achievement with managers and co-workers.

3 2 1 0 4. Conduct technical research to gather information necessary for decision-making.
- a. Align the information gathered to the needs of the audience.
- b. Gather technical information and data using a variety of resources.
- c. Analyze information and data for value to the research objectives.

d. Evaluate information and data to determine value to research objectives.

INFORMATION TECHNOLOGY APPLICATIONS: Use information technology tools specific to the career cluster to access, manage, integrate, and create information.

3 2 1 0 1. Use Personal Information Management (PIM) applications to increase workplace efficiency.
- a. Manage personal schedules and contact information.
- b. Create memos and notes.

3 2 1 0 2. Employ technological tools to expedite workflow.
- a. Use information technology tools to manage and perform work responsibilities.

3 2 1 0 3. Operate communications applications within a workplace.
- a. Share files and documents.
- b. Identify the functions and purpose of communications systems.
- c. Use communications tools within and across organizations.

3 2 1 0 4. Operate Internet applications to perform workplace tasks.
- a. Access and navigate Internet (e.g., use a web browser).
- b. Search for information and resources.
- c. Evaluate Internet resources for reliability and validity.

3 2 1 0 5. Operate writing and publishing applications to prepare business communications.
- a. Prepare simple documents and other business communications.
- b. Prepare reports and other business communications by integrating graphics and other non-text elements.
- c. Prepare complex multi-media publications.

3 2 1 0 6. Operate presentation applications to prepare presentations.
- a. Prepare presentations for training, sales and information sharing.
- b. Deliver presentations with supporting materials.

3 2 1 0 7. Employ spreadsheet applications to organize and manipulate data.
- a. Create a spreadsheet.
- b. Perform calculations and analyses on data using a spreadsheet.

3 2 1 0 8. Employ database applications to manage data.
- a. Manipulate data elements.
- b. Manage interrelated data elements.
- c. Analyze interrelated data elements.
- d. Generate reports showing interrelated data elements.

3 2 1 0 9. Employ collaborative/groupware applications to facilitate group work.
- a. Facilitate group work through management of shared schedule and contact information.
- b. Facilitate group work through management of shared files and online information.
- c. Facilitate group work through instant messaging or virtual meetings.

3 2 1 0 10. Employ computer operations applications to manage work tasks.
- a. Manage computer operations.
- b. Manage file storage.
- c. Compress or alter files.

3 2 1 0 11. Use computer-based equipment (containing embedded computers or processors) to control devices.
- a. Operate computer driven equipment and machines.
- b. Use installation and operation manuals.
- c. Troubleshoot computer driven equipment and machines.
- d. Access support as needed to maintain operation of computer driven equipment and machines.

SYSTEMS: Understand roles within teams, work units, departments, organizations, inter-organizational systems, and the larger environment. Identify how key organizational systems affect organizational performance and the quality of products and services. Understand global context of industries and careers.

3 2 1 0 12. Describe the nature and types of business organizations to build an understanding of the scope of organizations.
   a. List the types and functions of businesses.
   b. Describe the types and functions of businesses.
   c. Explain the functions and interactions of common departments within a business.

3 2 1 0 13. Implement quality control systems and practices to ensure quality products and services.
   a. Describe quality control standards and practices common to the workplace.

SAFETY, HEALTH AND ENVIRONMENTAL: Understand the importance of health, safety, and environmental management systems in organizations and their importance to organizational performance and regulatory compliance. Follow organizational policies and procedures and contribute to continuous improvement in performance and compliance.

3 2 1 0 14. Implement personal and jobsite safety rules and regulations to maintain safe and healthful working conditions and environments.
   a. Assess workplace conditions with regard to safety and health.
   b. Align safety issues with appropriate safety standards to ensure a safe workplace/jobsite.
   c. Identify safety hazards common to workplaces.
   d. Identify safety precautions to maintain a safe worksite.
   e. Select appropriate personal protective equipment as needed for a safe workplace/jobsite.
   f. Inspect personal protective equipment commonly used for selected career pathway.
   g. Use personal protective equipment according to manufacturer rules and regulations.
   h. Employ a safety hierarchy and communication system within the workplace/jobsite.
   i. Implement safety precautions to maintain a safe worksite.

3 2 1 0 15. Complete work tasks in accordance with employee rights and responsibilities and employers obligations to maintain workplace safety and health.
   a. Identify rules and laws designed to promote safety and health in the workplace.
   b. State the rationale of rules and laws designed to promote safety and health.

3 2 1 0 16. Employ emergency procedures as necessary to provide aid in workplace accidents.
   a. Demonstrate knowledge of First Aid procedures.
   b. Demonstrate knowledge of CPR procedures.
   c. Use safety equipment as necessary.

3 2 1 0 17. Employ knowledge of response techniques to create a disaster and/or emergency response plan.
   a. Complete an assessment of an emergency and/or disaster situation.
   b. Create an emergency and/or disaster plan.

LEADERSHIP AND TEAMWORK: Use leadership and teamwork skills in collaborating with others to accomplish organizational goals and objectives.

3 2 1 0 18. Employ leadership skills to accomplish organizational goals and objectives.
   a. Analyze the various roles of leaders within organizations (e.g. contribute ideas; share in building an organization; act as role models to employees by adhering to company policies, procedures, and standards; promote the organization's vision; and mentor others).
   b. Exhibit traits such as empowerment, risk, communication, focusing on results, decision-making, problem solution, and investment in individuals when leading a group in solving a problem.
   c. Exhibit traits such as compassion, service, listening, coaching, developing others, team development, and understanding and appreciating others when acting as a manager of others in the workplace.
   d. Exhibit traits such as enthusiasm, creativity, conviction, mission, courage, concept, focus, principle-centered living, and change when interacting with others in general.

e. Consider issues related to self, team, community, diversity, environment, and global awareness when leading others.
f. Exhibit traits such as innovation, intuition, adaptation, life-long learning and coachability to develop leadership potential over time.
g. Analyze leadership in relation to trust, positive attitude, integrity, and willingness to accept key responsibilities in a work situation.
h. Describe observations of outstanding leaders using effective management styles.
i. Participate in civic and community leadership and teamwork opportunities to enhance skills.

3 2 1 0 19. Employ organizational and staff development skills to foster positive working relationships and accomplish organizational goals.
a. Implement organizational skills when facilitating others' work efforts.
b. Explain how to manage a staff that satisfies work demands while adhering to budget constraints.
c. Describe how staff growth and development to increase productivity and employee satisfaction.
d. Organize team involvement within a group environment.
e. Work with others to develop and gain commitment to team goals.
f. Distribute responsibility and work load fairly.
g. Model leadership and teamwork qualities to aid in employee morale.
h. Identify best practices for successful team functioning.
i. Explain best practices for successful team functioning.

3 2 1 0 20. Employ teamwork skills to achieve collective goals and use team members' talents effectively.
a. Work with others to achieve objectives in a timely manner.
b. Promote the full involvement and use of team members' individual talents and skills.
c. Employ conflict-management skills to facilitate solutions.
d. Demonstrate teamwork skills through working cooperatively with co-workers, supervisory staff, and others, both in and out of the organization, to achieve particular tasks.
e. Demonstrate teamwork processes that provide team building, consensus, continuous improvement, respect for the opinions of others, cooperation, adaptability, and conflict resolution.
f. Develop plans to improve team performance.
g. Demonstrate commitment to and a positive attitude toward team goals.
h. Take responsibility for shared group and individual work tasks.
i. Assist team members in completing their work.
j. Adapt effectively to changes in projects and work activities.
k. Negotiate effectively to arrive at decisions.

3 2 1 0 21. Establish and maintain effective working relationships with all levels of personnel and other departments in order to accomplish objectives and tasks.
a. Build effective working relationships using interpersonal skills.
b. Use positive interpersonal skills to work cooperatively with co-workers representing different cultures, genders and backgrounds.
c. Manage personal skills to accomplish assignments.
d. Treat people with respect.
e. Provide constructive praise and criticism.
f. Demonstrate sensitivity to and value for diversity.
g. Manage stress and control emotions.

3 2 1 0 22. Conduct and participate in meetings to accomplish work tasks.
a. Develop meeting goals, objectives and agenda.
b. Assign responsibilities for preparing materials and leading discussions.
c. Prepare materials for leading discussion.
d. Assemble and distribute meeting materials.
e. Conduct meeting to achieve objectives within scheduled time.
f. Demonstrate effective communication skills in meetings.

g. Produce meeting minutes including decisions and next steps.
h. Use parliamentary procedure, as needed, to conduct meetings.

3 2 1 0 23. Employ mentoring skills to inspire and teach others.
a. Use motivational techniques to enhance performance in others.
b. Provide guidance to enhance performance in others.

ETHICS AND LEGAL RESPONSIBILITIES: Know and understand the importance of professional ethics and legal responsibilities.

3 2 1 0 24. Apply ethical reasoning to a variety of workplace situations in order to make ethical decisions.
a. Evaluate alternative responses to workplace situations based on legal responsibilities and employer policies.
b. Evaluate alternative responses to workplace situations based on personal or professional ethical responsibilities.
c. Identify personal and long-term workplace consequences of unethical or illegal behaviors.
d. Explain personal and long-term workplace consequences of unethical or illegal behaviors.
e. Determine the most appropriate response to workplace situations based on legal and ethical considerations.
f. Explain the most appropriate response to workplace situations based on legal and ethical considerations.

3 2 1 0 25. Interpret and explain written organizational policies and procedures to help employees perform their jobs according to employer rules and expectations.
a. Locate information on organizational policies in handbooks and manuals.
b. Discuss how specific organizational policies and procedures influence a specific work situation.

EMPLOYABILITY AND CAREER DEVELOPMENT: Know and understand the importance of employability skills. Explore, plan, and effectively manage careers. Know and understand the importance of entrepreneurship skills.

3 2 1 0 26. Identify and demonstrate positive work behaviors and personal qualities needed to be employable.
a. Demonstrate self-discipline, self-worth, positive attitude, and integrity in a work situation.
b. Demonstrate flexibility and willingness to learn new knowledge and skills.
c. Exhibit commitment to the organization.
d. Identify how work varies with regard to site, from indoor confined spaces to outdoor areas, including aerial space and a variety of climatic and physical conditions.
e. Apply communication strategies when adapting to a culturally diverse environment.
f. Manage resources in relation to the position (i.e. budget, supplies, computer, etc).
g. Identify positive work-qualities typically desired in each of the career cluster's pathways.
h. Manage work roles and responsibilities to balance them with other life roles and responsibilities.

3 2 1 0 27. Develop a personal career plan to meet career goals and objectives.
a. Develop career goals and objectives as part of a plan for future career direction.
b. Develop strategies to reach career objectives.

3 2 1 0 28. Demonstrate skills related to seeking and applying for employment to find and obtain a desired job.
a. Use multiple resources to locate job opportunities.
b. Prepare a résumé.
c. Prepare a letter of application.
d. Complete an employment application.
e. Interview for employment.
f. List the standards and qualifications that must be met in order to enter a given industry.
g. Employ critical thinking and decision-making skills to exhibit qualifications to a potential employer.

3 2 1 0 29. Maintain a career portfolio to document knowledge, skills and experience in a career field.
a. Select educational and work history highlights to include in a career portfolio.
b. Produce a record of work experiences, licenses, certifications and products.
c. Organize electronic or physical portfolio for use in demonstrating knowledge, skills and experiences.

3 2 1 0 30. Demonstrate skills in evaluating and comparing employment opportunities in order to accept employment positions that match career goals.
- a. Compare employment opportunities to individual needs and career plan objectives.
- b. Evaluate employment opportunities based upon individual needs and career plan objectives.
- c. Demonstrate appropriate methods for accepting or rejecting employment offers.

3 2 1 0 31. Identify and exhibit traits for retaining employment to maintain employment once secured.
- a. Model behaviors that demonstrate reliability and dependability.
- b. Maintain appropriate dress and behavior for the job to contribute to a safe and effective workplace/jobsite.
- c. Complete required employment forms and documentation such as I-9 form, work visa, W-4 and licensures to meet employment requirements.
- d. Summarize key activities necessary to retain a job in the industry.
- e. Identify positive work behaviors and personal qualities necessary to retain employment.

3 2 1 0 32. Identify and explore career opportunities in one or more career pathways to build an understanding of the opportunities available in the cluster.
- a. Locate and identify career opportunities that appeal to personal career goals.
- b. Match personal interest and aptitudes to selected careers.

3 2 1 0 33. Recognize and act upon requirements for career advancement to plan for continuing education and training.
- a. Identify opportunities for career advancement.
- b. Pursue education and training opportunities to acquire skills necessary for career advancement.
- c. Examine the organization and structure of various segments of the industry to prepare for career advancement.
- d. Research local and regional labor (workforce) market and job growth information to project potential for advancement.
- e. Manage employment relations to make career advancements.

3 2 1 0 34. Continue professional development to keep current on relevant trends and information within the industry.
- a. Use self-assessment, organizational priorities, journals, Internet sites, professional associations, peers and other resources to develop goals that address training, education and self-improvement issues.
- b. Read trade magazines and journals, manufacturers' catalogues, industry publications and Internet sites to keep current on industry trends.
- c. Participate in relevant conferences, workshops, mentoring activities and in-service training to stay current with recent changes in the field.

3 2 1 0 35. Examine licensing, certification and credentialing requirements at the national, state and local levels to maintain compliance with industry requirements.
- a. Examine continuing education requirements related to licensing, certification, and credentialing requirements at the local, state and national levels for chosen occupation.
- b. Examine the procedures and paperwork involved in maintaining and updating licensure, certification and credentials for chosen occupation.
- c. Align ongoing licensing, certification and credentialing requirements to career plans and goals.

3 2 1 0 36. Examine employment opportunities in entrepreneurship to consider entrepreneurship as an option for career planning.
- a. Describe the opportunities for entrepreneurship in a given industry.

TECHNICAL SKILLS: Use of technical knowledge and skills required to pursue careers in all career cluster, including knowledge of design, operation, and maintenance of technological systems critical to the career cluster.

3 2 1 0 37. Employ information management techniques and strategies in the workplace to assist in decision-making.
- a. Use information literacy skills when accessing, evaluating and disseminating information.
- b. Describe the nature and scope of information management.
- c. Maintain records to facilitate ongoing business operations.

3 2 1 0 38. Employ planning and time management skills and tools to enhance results and complete work tasks.
- a. Develop goals and objectives.
- b. Prioritize tasks to be completed.

c. Develop timelines using time management knowledge and skills.
d. Use project-management skills to improve workflow and minimize costs.

C. CLUSTER (FOUNDATION) KNOWLEDGE AND SKILLS

ACADEMIC FOUNDATIONS: Achieve additional academic knowledge and skills required to pursue the full range of career and postsecondary education opportunities within a career cluster.

COMMUNICATIONS: Use oral and written communication skills in creating, expressing and interpreting information and ideas including technical terminology and information.

Prepare STEM material in oral, written, or visual formats that provide information to an intended audience to fulfill specific communication need of an audience.

3 2 1 0 1. Use effective methods to communicate concepts of STEM to a broadly represented audience.
a. Report subjective and objective information.
b. Report information with the intent of being persuasive.
c. Report information with the intent of being informational.
d. Report information with the intent of being instructional.
e. Analyze the audience and presentation environment.
f. Explain technical concepts to non-technical audiences
g. Use professional terminology.
h. Identify, select, use appropriate multimedia resources.
i. Discern between various communication techniques and their ability to convey various types of information.
j. Explain various methods of obtaining information.
3 2 1 0 2. Effectively communicate STEM information to a select audience.
a. Explain the various methods of presenting information.
b. Use oral presentation skills to present scientific, technological, engineering, or mathematical reports.
c. Use written presentation skills to present scientific, technological, engineering, or mathematical reports.
d. Use visual presentation skills to present scientific, technological, engineering, or mathematical reports.
e. Use multimedia presentation skills to present scientific, technological, engineering, or mathematical reports.
3 2 1 0 3. Apply the ability to read, interpret, and analyze STEM materials discerning the information and concepts.
a. Use appropriate note-taking methods.
b. Write a report on technical literature; use graphical tools as appropriate.
c. Present a report on technical literature; use graphical tools as appropriate.
d. Discriminate between fact and opinion.

Apply active listening skills to obtain or clarify information pertaining to plans, processes, projects, or designs.

3 2 1 0 4. Interpret messages or information provided that clarifies issues, ideas, plans, projects, or processes.
a. Indicate familiarity of topic being presented.
b. Respond accordingly using appropriate verbal and nonverbal language.
c. Answer questions correctly and be able to provide feedback in own words.
3 2 1 0 5. Respond and/or restate information that will clarify STEM techniques to be used and/or information to be applied to projects, plans, or processes.
a. Ask questions to seek or confirm understanding.
b. Paraphrase and/or repeat information.
c. Record notes and summarize information from written notes.

PROBLEM-SOLVING AND CRITICAL THINKING: Solve problems using critical thinking skills (analyze, synthesize, and evaluate) independently and in teams. Solve problems using creativity and innovation.

Effectively develop and apply the skills inherent in systems engineering where requirements, configuration, integration, project management, quality assurance, and process applications are necessary.

3 2 1 0 1. Apply the skills and abilities in requirements analysis and configuration control while working plans, processes, and projects as assigned.
3 2 1 0 2. Use the skills required in project management to track and assess the progress of a plan, process, or project as assigned.
3 2 1 0 3. Apply the skills in quality assurance as well as those in process management and development for appropriate applications of systems integration techniques to an assigned project.

INFORMATION TECHNOLOGY APPLICATIONS: Use information technology tools specific to the career cluster to access, manage, integrate, and create information.

Effectively use information technology to gather, store, and communicate data in appropriate formats.

3 2 1 0 1. Use IT in support of gathering, storage, and transfer of data or results in appropriate formats to support assigned projects.
   a. Apply different techniques for gathering storing and transferring data.
3 2 1 0 2. Select and use assorted forms of IT to meet the requirements of a plan, process, project, report, issue, or problem.
   a. Write a report based on Internet research, using calculations, graphs, and/or spreadsheets.
   b. Create, organize, manage, and distribute information in electronic format.

Evaluate and use skills relating to the differing technological tools used to manipulate, report, or operate with data acquisition.

3 2 1 0 3. Use IT tools to manipulate data creating reports, plans, processes, or projects from data provided.
   a. Use statistical tools to analyze data.
   b. Query and extract information from data.
   c. Create knowledge from data.
3 2 1 0 4. Use modeling, simulation, or visual reproduction to effectively analyze, create, and/or communicate to others regarding plans, projects, problems, issues or processes.
   a. Apply techniques for modeling systems or problems.
   b. Apply techniques for scientific visualization and animation of complex physical systems or problems.
   c. Test different scenarios to multiple variables.
3 2 1 0 5. Apply a currently applicable computer programming language to a process, project, plan, or issue as assigned.
   a. Write a computer program, e.g., Java, C++.
   b. Execute a computer program, e.g., Java, C++.
3 2 1 0 6. Apply statistical tools that verify the reliability or validity of the data used or collected in the plan, project, process, or problem.
   a. Using a selected statistical tool, compute data reliability.
   b. Select and use the tools to analyze and synthesize data.
   c. Describe the meaning of probability and how it applies to a set of data.
3 2 1 0 7. Apply a technological, scientific, or mathematical concept (use of algorithms) when communicating with others on issues, plans, processes, problems, or concepts.
   a. Select the proper visualization tools.
   b. Use simulation, modeling, prototype techniques to solve problems.
   c. Communicate data visually.

SYSTEMS: Understand roles within teams, work units, departments, organizations, inter-organizational systems, and the larger environment. Identify how key organizational systems affect organizational performance and the quality of products and services. Understand global context of industries and careers.

SAFETY, HEALTH AND ENVIRONMENTAL: Understand the importance of health, safety, and environmental management systems in organizations and their importance to organizational performance and regulatory compliance. Follow organizational policies and procedures and contribute to continuous improvement in performance and compliance.

Apply safety practices in the environment where science, technology, engineering, and/or mathematical principles are appropriate to ensure a safe workplace.

3 2 1 0 1. Apply appropriate safety and health practices when developing plans, projects, processes, or solving complex problems.
   a. Exercise good safety practices.
   b. Follow various regulatory codes, such as EPA, FEMA, UL, OSHA, CSA.
   c. Reference and use material safety data sheets (MSDS).
   d. Encourage others to employ safe practices.

3 2 1 0 2. Use appropriate safety techniques, equipment, and processes in planning and /or project applications.
   a. Demonstrate safe use of tools and equipment.
   b. Develop and implement emergency plans.
   c. Develop and implement workplace lab safety plan.
   d. Follow workplace regulations and record-keeping requirements.
   e. Demonstrate the use of safety equipment in the workplace.
   f. Demonstrate the use of eyewash and safety showers
   g. Accurately interpret safety signs, symbols, and labels.
   h. Demonstrate basic first aid techniques.

Develop an awareness of safety, health, and environmental hazards inherent in the STEM arenas when solving problems, developing plans, processes, or completing projects to be proactive in promoting safety.

3 2 1 0 3. Identify existing or potential hazards to existing or assigned plans, projects, or processes where safety, health, or environment might be in play.
   a. Describe potential safety, health and environmental hazards in various situations.
   b. Identify physical, chemical, toxicological, biological, and radioactive hazards.
   c. Analyze environmental impacts.
   d. Conduct a safety audit.

LEADERSHIP AND TEAMWORK: Use leadership and teamwork skills in collaborating with others to accomplish organizational goals and objectives.

ETHICS AND LEGAL RESPONSIBILITIES: Know and understand the importance of professional ethics and legal responsibilities.

Develop the knowledge and abilities to comprehend ethical and legal standards as they apply to STEM where plans, processes, and projects will be dependent upon them.

3 2 1 0 1. Demonstrate the skill of application to ethical and legal standards as they apply to the plans, processes, and projects as assigned in simulated environments.
   a. Evaluate the pros and cons of current ethical questions and scenarios, for example, environmental stewardship, genetic research, and living subjects in research.
   b. Comply with ethical standards and professional code of ethics.
   c. Follow legal requirements for the treatment of people in the workplace (ADA, EEO).
   d. Follow requirements of regulatory agencies in the scientific, and mathematics, engineering, or technology field (e.g., NFPA. OSHA, EPA, ADA, EOE, FCC).

e. Develop personal ethics for real-life situations and experiences.
f. Evaluate personal, professional, and organizational ethics.
g. Explain fundamentals of patents, trademarks, copyrights, and proprietary information.
h. Recognize and refute misleading information.
i. Evaluate methods for protecting and conserving resources.

EMPLOYABILITY AND CAREER DEVELOPMENT: Know and understand the importance of employability skills. Explore, plan, and effectively manage careers. Know and understand the importance of entrepreneurship skills.

Develop the skills and abilities to research career pathways in STEM.

3 2 1 0 1. Engage experiences in STEM where an individual can identify personal interests and expectations for career and personal development.
   a. List resources for researching funding sources for scientific projects and technology.
   b. List careers that you have investigated, internships that you could apply for, and job shadowing opportunities that you have identified.
   c. Construct and maintain a portfolio of experiences and accomplishments.

TECHNICAL SKILLS: Use the technical knowledge and skills required to pursue the targeted careers for all pathways in the career cluster, including knowledge of design, operation, and maintenance of technological systems critical to the career cluster.

D. PATHWAY KNOWLEDGE AND SKILLS

ACADEMIC FOUNDATIONS

Apply the concepts and processes using the guiding principles and standards of school mathematics to solve STEM problems.

3 2 1 0 1. Apply and create appropriate models, concepts, and processes for an assigned situation, and apply them in solving the problem.
3 2 1 0 2. Explain the impact of assumptions, initial conditions, boundary conditions, and other constraints on problem solutions.

Apply and use algebraic, geometric and trigonometric relationships, characteristics, and properties to solve problems.

3 2 1 0 3. Evaluate mathematical solutions for reasonableness.
3 2 1 0 4. Apply appropriate data collection, statistical analysis methods, and the means of displaying data to make decisions.
3 2 1 0 5. Apply the processes and concepts for science literacy relative to engineering and technology.

Demonstrate the ability to select, apply, and convert systems of measurement to solve problems.

3 2 1 0 6. Apply scalar and vector quantities as applied to physical systems, such as the relationship between position, velocity, and acceleration.
3 2 1 0 7. Apply fundamental laws and principles relevant to engineering and technology.

Demonstrate the ability to use Newton's Laws of Motion to analyze static and dynamic systems with and without the presence of external forces.

3 2 1 0 8. Use the laws of conservation of energy, charge, and momentum, to solve a variety of problems involving mechanical, fluid, chemical, biological, electrical, and thermal systems.
3 2 1 0 9. Use the relationships between energy, work, and power to solve a variety of problems involving mechanical, fluid, electrical, and thermal systems.

Explain relevant physical properties of materials used in engineering and technology.

3 2 1 0 10. Use the principles of ray optics to describe reflection and refraction of light.
3 2 1 0 11. Explain the relationships between amplitude, wavelength, frequency, period, and speed of a wave.

Explain the relationships between scientific theory, scientific principles and laws, in technology, and engineering.

3 2 1 0 12. Develop concepts and processes for the application of technology standards.

COMMUNICATIONS

PROBLEM-SOLVING AND CRITICAL THINKING

Use mathematics, science, and technology concepts and processes to solve problems in projects involving design and/or production (e.g. medical, agricultural, biotechnological, energy and power, information and communication, transportation, manufacturing, and construction).

3 2 1 0 13. Apply the core concepts of technology and recognize the relationships with STEM systems (e.g. systems, resources, criteria and constraints, optimization and trade-off, and controls).
3 2 1 0 14. Develop the active use of information technology applications.
3 2 1 0 15. Use computer applications to solve problems by creating and using algorithms, and through simulation and modeling techniques.

INFORMATION TECHNOLOGY APPLICATIONS

Select and use different forms of communications technology including word processing, spreadsheets, database, presentation software, email to communicate, and use of the internet to search for and display information.

3 2 1 0 16. Select and use information technology tools to collect, analyze, synthesize, and display data to solve problems.
3 2 1 0 17. Read and create basic computer aided engineering drawings.

TECHNICAL SKILLS

Apply concepts and processes for the application of technology to engineering.

3 2 1 0 18. Use knowledge, techniques, skills, and modern tools necessary for engineering practice.
3 2 1 0 19. Describe the elements of good engineering practice (e.g. understanding customer needs, planning requirements analysis, using appropriate engineering tools, prototyping, test, evaluation, and verification).
3 2 1 0 20. Demonstrate the ability to characterize a plan and identify the necessary engineering tools that will produce a technical solution when given a problem statement.
3 2 1 0 21. Effectively use project management techniques (e.g. working in teams, appropriate time management practices, effective organizational skills, conduct analysis of cost, resources, and production capacity, and quality practices with continuous improvement).

Develop processes and concepts for the use of technology which model technical competence.

3 2 1 0 22. Use and calibrate probes, sensors, measuring systems, and devices to collect data using traceable standards.
3 2 1 0 23. Explain the impact of error in measurement, predict the effect of error propagation in calculations, and record data with the correct number of significant digits.
3 2 1 0 24. Safely operate a variety of tools, machines, and equipment (e.g. milling machines, rapid prototyping machines, drill press, band saw, CNC machines, and hand tools).
3 2 1 0 25. Use, handle, and store tools and materials correctly, perform preventative maintenance, understanding the results of negligence and improper maintenance or improper calibration.

DESIGN

Know the elements of the processes and concepts for understanding the design process.

3 2 1 0 26. Explain why and how the contributions of great innovators are important to society.
3 2 1 0 27. Explain the elements and steps of the design process and tools or techniques that can be used for each step.
3 2 1 0 28. Describe design constraints, criteria, and trade-offs in regard to variety of conditions (e.g. technology, cost, safety, society, the environment, time, human resources, manufacturability).

Develop processes and concepts to apply the design process.

3 2 1 0 29. Apply the design process, including understanding customer needs, interpreting and producing design constraints and criteria, planning and requirements analysis, brainstorming and idea generation, using appropriate modeling and prototyping, testing, verification, and implementation.
3 2 1 0 30. Demonstrate the ability to evaluate a design or product and improve the design using testing, modeling, and research.
3 2 1 0 31. Demonstrate the ability to record and organize information and test data during design evaluation.