

# Engineering Design and Problem Solving (IMRA26)

Subject: Career Development and Career and Technical Education

Grade: 12

Expectations: 75

Breakouts: 336

Career and Technical Education Employability Skills Introduction.

(a) Implementation. The provisions of this section shall be implemented by school districts beginning with the 2025-2026 school year.

(b) General requirements. These standards may not be offered as a standalone course. These standards shall be offered together with the essential knowledge and skills for career and technical education (CTE) courses in this chapter.

(c) Introduction.

- (1) CTE instruction provides content aligned with challenging academic standards, industry-relevant technical knowledge, and college and career readiness skills for students to further their education and succeed in current and emerging professions.
- (2) The goal of the employability skills standards is to ensure that students develop essential skills for effective performance in the workplace, regardless of the occupation.
- (3) These standards are required to be addressed in their entirety as part of each CTE course based on the level of the course in a CTE program of study.
- (4) CTE courses identified as Level 1 or Level 2 courses in a CTE program of study must address the employability skills standards identified in subsection (d)(1) of this section.
- (5) CTE courses identified as Level 3 or Level 4 courses in a CTE program of study must address the employability skills standards identified in subsection (d)(2) of this section.
- (6) Statements that contain the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

Engineering Design and Problem Solving

(a) Implementation.

- (1) The provisions of this section shall be implemented by school districts beginning with the 2025-2026 school year.
- (2) School districts shall implement the employability skills student expectations listed in §127.15(d)(2) of this chapter (relating to Career and Technical Education Employability Skills) as an integral part of this course.

(b) General requirements. This course is recommended for students in Grade 12. Prerequisites: Algebra I, Geometry, and at least one credit in a Level 2 or higher course in the Engineering Career Cluster. Recommended prerequisites or corequisites: Engineering Science, chemistry, or physics. This course satisfies a high school science graduation requirement. Students shall be awarded one credit for successful completion of this course.

(c) Introduction.

- (1) Career and technical education instruction provides content aligned with challenging academic standards, industry-relevant technical knowledge, and college and career readiness skills for students to further their education and succeed in current and emerging professions.
- (2) The Engineering Career Cluster focuses on planning, designing, testing, building, and maintaining machines, structures, materials, systems, and processes using empirical evidence and science, technology, and math principles. This career cluster includes occupations ranging from mechanical engineer and drafter to electrical engineer and mapping technician.
- (3) The Engineering Design and Problem Solving course extends students' problem solving skills by identifying needs and then devising solutions using scientific and engineering practices. Students apply prior knowledge to develop a multi-system product or solution for a complex problem. Students demonstrate project management skills by collaborating as part of a team, conducting research, and analyzing data that culminates in a comprehensive report and presentation. Technical drawings, models, and prototypes are created using the appropriate tools, materials, and techniques. Structured decision-making processes are used to select and justify a preferred, multi-system solution to an authentic problem. Students develop, implement, and document repeated trials of experiments and tests using scientific and engineering practices to determine whether a prototype meets design requirements.
- (4) Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable.
- (5) Scientific hypotheses and theories. Students are expected to know that:
  - (A) hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power that have been tested over a wide variety of conditions are incorporated into theories; and
  - (B) scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established and highly reliable explanations, but they may be subject to change as new areas of science and new technologies are developed.
- (6) Scientific inquiry is the planned and deliberate investigation of the natural world using scientific and engineering practices. Scientific methods of investigation are descriptive, comparative, or experimental. The method chosen should be appropriate to the question being asked. Student learning for different types of investigations include descriptive investigations, which involve collecting data and recording observations without making comparisons; comparative investigations, which involve collecting data with variables that are manipulated to compare results; and experimental investigations, which involve processes similar to comparative investigations but in which a control is identified.
  - (A) Scientific practices. Students should be able to ask questions, plan and conduct investigations to answer questions, and explain phenomena using appropriate tools and models.
  - (B) Engineering practices. Students should be able to identify problems and design solutions using appropriate tools and models.
- (7) Scientific decision making is a way of answering questions about the natural world involving its own set of ethical standards about how the process of science should be carried out. Students should be able to distinguish between scientific decision-making methods (scientific methods) and ethical and social decisions that involve science (the application of scientific information).

- (8) Science consists of recurring themes and making connections between overarching concepts. Recurring themes include systems, models, and patterns. All systems have basic properties that can be described in space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested, while models allow for boundary specification and provide a tool for understanding the ideas presented. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment.
- (9) Students are encouraged to participate in extended learning experiences such as career and technical student organizations and other organizations that foster leadership and career development in the profession such as student chapters of related professional associations.
- (10) Statements that contain the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(d) Knowledge and Skills Statements

- (0) Employability skills--Levels 3 and 4. In a CTE course identified as a Level 3 or Level 4 course in a CTE program of study, the student demonstrates professional standards/employability skills as required by business and industry. The student is expected to:
  - (A) demonstrate dressing appropriately, speaking politely, and conducting oneself in a manner appropriate for the profession and work site
    - (i) demonstrate dressing appropriately for the profession
    - (ii) demonstrate speaking politely for the profession
    - (iii) demonstrate conducting oneself in a manner appropriate for the profession
    - (iv) demonstrate dressing appropriately for the work site
    - (v) demonstrate speaking politely for the work site
    - (vi) demonstrate conducting oneself in a manner appropriate for the work site
  - (B) analyze how teams can produce better outcomes through cooperation, contribution, and collaboration from members of the team;
    - (i) analyze how teams can produce better outcomes through cooperation from members of the team
    - (ii) analyze how teams can produce better outcomes through contribution from members of the team
    - (iii) analyze how teams can produce better outcomes through collaboration from members of the team
  - (C) present written and oral technical communication in a clear, concise, and effective manner for a variety of purposes and audiences, including explaining and justifying decisions;
    - (i) present written technical communication in a clear manner for a variety of purposes, including explaining decisions
    - (ii) present written technical communication in a concise manner for a variety of purposes, including explaining decisions
    - (iii) present written technical communication in a[n] effective manner for a variety of purposes, including explaining decisions

- (iv) present written technical communication in a clear manner for a variety of audiences, including explaining decisions
- (v) present written technical communication in a concise manner for a variety of audiences, including explaining decisions
- (vi) present written technical communication in a[n] effective manner for a variety of audiences, including explaining decisions
- (vii) present written technical communication in a clear manner for a variety of purposes, including justifying decisions
- (viii) present written technical communication in a concise manner for a variety of purposes, including justifying decisions
- (ix) present written technical communication in a[n] effective manner for a variety of purposes, including justifying decisions
- (x) present written technical communication in a clear manner for a variety of audiences, including justifying decisions
- (xi) present written technical communication in a concise manner for a variety of audiences, including justifying decisions
- (xii) present written technical communication in a[n] effective manner for a variety of audiences, including justifying decisions
- (xiii) present written oral communication in a clear manner for a variety of purposes, including explaining decisions
- (xiv) present written oral communication in a concise manner for a variety of purposes, including explaining decisions
- (xv) present written oral communication in a[n] effective manner for a variety of purposes, including explaining decisions
- (xvi) present written oral communication in a clear manner for a variety of audiences, including explaining decisions
- (xvii) present written oral communication in a concise manner for a variety of audiences, including explaining decisions
- (xviii) present written oral communication in a[n] effective manner for a variety of audiences, including explaining decisions
- (xix) present written oral communication in a clear manner for a variety of purposes, including justifying decisions
- (xx) present written oral communication in a concise manner for a variety of purposes, including justifying decisions
- (xxi) present written oral communication in a[n] effective manner for a variety of purposes, including justifying decisions
- (xxii) present written oral communication in a clear manner for a variety of audiences, including justifying decisions

- (xxiii) present written oral communication in a concise manner for a variety of audiences, including justifying decisions
  - (xxiv) present written oral communication in a[n] effective manner for a variety of audiences, including justifying decisions
- (D) use time-management skills independently and in groups to prioritize tasks, follow schedules, and tend to goal-relevant activities in a way that optimizes efficiency and results;
- (i) use time-management skills independently to prioritize tasks in a way that optimizes efficiency
  - (ii) use time-management skills independently to prioritize tasks in a way that optimizes results
  - (iii) use time-management skills independently to follow schedules in a way that optimizes efficiency
  - (iv) use time-management skills independently to follow schedules in a way that optimizes results
  - (v) use time-management skills independently tend to goal-relevant activities in a way that optimizes efficiency
  - (vi) use time-management skills independently tend to goal-relevant activities in a way that optimizes results
  - (vii) use time-management skills in groups to prioritize tasks in a way that optimizes efficiency
  - (viii) use time-management skills in groups to prioritize tasks in a way that optimizes results
  - (ix) use time-management skills in groups to follow schedules in a way that optimizes efficiency
  - (x) use time-management skills in groups to follow schedules in a way that optimizes results
  - (xi) use time-management skills in groups tend to goal-relevant activities in a way that optimizes efficiency
  - (xii) use time-management skills in groups tend to goal-relevant activities in a way that optimizes results
- (E) describe the importance of and demonstrate punctuality, dependability, reliability, and responsibility in reporting for duty and performing assigned tasks as directed;
- (i) describe the importance of punctuality in reporting for duty
  - (ii) describe the importance of dependability in reporting for duty
  - (iii) describe the importance of reliability in reporting for duty
  - (iv) describe the importance of responsibility in reporting for duty
  - (v) describe the importance of punctuality in performing assigned tasks as directed
  - (vi) describe the importance of dependability in performing assigned tasks as directed
  - (vii) describe the importance of reliability in performing assigned tasks as directed
  - (viii) describe the importance of responsibility in performing assigned tasks as directed
- (F) demonstrate respect for differences in the workplace;
- (i) demonstrate respect for differences in the workplace
- (G) identify the importance and benefits of meritocracy, a hard work ethic, and equal opportunity in the workplace;
- (i) identify the importance of meritocracy in the workplace

- (ii) identify the importance of a hard work ethic in the workplace
  - (iii) identify the importance of equal opportunity in the workplace
  - (iv) identify the benefits of meritocracy in the workplace
  - (v) identify the benefits of a hard work ethic in the workplace
  - (vi) identify the benefits of equal opportunity in the workplace
- (H) identify consequences relating to discrimination and harassment;
- (i) identify consequences relating to discrimination
  - (ii) identify consequences relating to harassment
- (I) demonstrate knowledge of personal and occupational health and safety, applicable regulations, and first aid in the workplace and discuss why it is critical for employees and employers to maintain a safe work environment;
- (i) demonstrate knowledge of personal health in the workplace
  - (ii) demonstrate knowledge of personal safety in the workplace
  - (iii) demonstrate knowledge of occupational health in the workplace
  - (iv) demonstrate knowledge of occupational safety in the workplace
  - (v) demonstrate knowledge of applicable regulations in the workplace
  - (vi) demonstrate knowledge of first aid in the workplace
  - (vii) discuss why it is critical for employees to maintain a safe work environment
  - (viii) discuss why it is critical for employers to maintain a safe work environment
- (J) compare skills and characteristics of managers and leaders in the workplace; and
- (i) compare skills and characteristics of managers in the workplace
  - (ii) compare skills and characteristics of leaders in the workplace
- (K) identify career development opportunities in the field: education and training; credentialing; internships and apprenticeships; and entrepreneurship opportunities; and
- (i) identify career development opportunities in the field: education
  - (ii) identify career development opportunities in the field: training
  - (iii) identify career development opportunities in the field: credentialing
  - (iv) identify career development opportunities in the field: internships
  - (v) identify career development opportunities in the field: apprenticeships
  - (vi) identify career development opportunities in the field: entrepreneurship opportunities
- (L) demonstrate an understanding of legal and ethical responsibilities in relation to the field.
- (i) demonstrate an understanding of legal responsibilities in relation to the field
  - (ii) demonstrate an understanding of ethical responsibilities in relation to the field

- (1) The student researches and describes ethics pertaining to engineering. The student is expected to explain how engineering ethics as defined by the Texas Board of Professional Engineers and Land Surveyors apply to engineering practice.
  - (A) explain how engineering ethics as defined by the Texas Board of Professional Engineers and Land Surveyors apply to engineering practice.
    - (i) explain how engineering ethics as defined by the Texas Board of Professional Engineers and Land Surveyors apply to engineering practice
- (2) The student, for at least 40% of instructional time, asks questions, identifies problems, and plans and safely conducts classroom, laboratory, and field investigations to answer questions, explain phenomena, or design solutions using appropriate tools and models. The student is expected to:
  - (A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations;
    - (i) ask questions based on observations or information from text, phenomena, models, or investigations
    - (ii) define problems based on observations or information from text, phenomena, models, or investigations
  - (B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems;
    - (i) apply scientific practices to plan descriptive investigations
    - (ii) apply scientific practices to plan comparative investigations
    - (iii) apply scientific practices to plan experimental investigations
    - (iv) apply scientific practices to conduct descriptive investigations
    - (v) apply scientific practices to conduct comparative investigations
    - (vi) apply scientific practices to conduct experimental investigations
    - (vii) use engineering practices to design solutions to problems
  - (C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards;
    - (i) use appropriate safety equipment during laboratory investigations as outlined in Texas Education Agency-approved safety standards
    - (ii) use appropriate safety equipment during classroom investigations as outlined in Texas Education Agency-approved safety standards
    - (iii) use appropriate safety equipment during field investigations as outlined in Texas Education Agency-approved safety standards
    - (iv) use appropriate practices during laboratory investigations as outlined in Texas Education Agency-approved safety standards
    - (v) use appropriate practices during classroom investigations as outlined in Texas Education Agency-approved safety standards
    - (vi) use appropriate practices during field investigations as outlined in Texas Education Agency-approved safety standards

- (D) use appropriate tools such as dial caliper, micrometer, protractor, compass, scale rulers, multimeter, and circuit components;
    - (i) use appropriate tools
  - (E) collect quantitative data using the International System of Units (SI) and United States customary units and qualitative data as evidence;
    - (i) collect quantitative data using the International System of Units (SI) as evidence
    - (ii) collect quantitative data using the United States customary units as evidence
    - (iii) collect qualitative data as evidence
  - (F) organize quantitative and qualitative data using spreadsheets, engineering notebooks, graphs, and charts;
    - (i) organize quantitative data using spreadsheets
    - (ii) organize quantitative data using engineering notebooks
    - (iii) organize quantitative data using graphs
    - (iv) organize quantitative data using charts
    - (v) organize qualitative data using spreadsheets
    - (vi) organize qualitative data using engineering notebooks
    - (vii) organize qualitative data using graphs
    - (viii) organize qualitative data using charts
  - (G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and
    - (i) develop models to represent phenomena, systems, processes, or solutions to engineering problems
    - (ii) use models to represent phenomena, systems, processes, or solutions to engineering problems
  - (H) distinguish between scientific hypotheses, theories, and laws.
    - (i) distinguish between scientific hypotheses, theories, and laws
- (3) The student analyzes and interprets data to derive meaning, identify features and patterns, and discover relationships or correlations to develop evidence-based arguments or evaluate designs. The student is expected to:
- (A) identify advantages and limitations of models such as their size, scale, properties, and materials;
    - (i) identify advantages of models
    - (ii) identify limitations of models
  - (B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;
    - (i) analyze data by identifying significant statistical features
    - (ii) analyze data by identifying patterns
    - (iii) analyze data by identifying sources of error
    - (iv) analyze data by identifying limitations
  - (C) use mathematical calculations to assess quantitative relationships in data; and

- (i) use mathematical calculations to assess quantitative relationships in data
- (D) evaluate experimental and engineering designs.
  - (i) evaluate experimental designs
  - (ii) evaluate engineering designs
- (4) The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to:
  - (A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories;
    - (i) develop explanations supported by data
    - (ii) develop explanations supported by models
    - (iii) develop explanations consistent with scientific ideas
    - (iv) develop explanations consistent with scientific principles
    - (v) develop explanations consistent with scientific theories
    - (vi) propose solutions supported by data
    - (vii) propose solutions supported by models
    - (viii) propose solutions consistent with scientific ideas
    - (ix) propose solutions consistent with scientific principles
    - (x) propose solutions consistent with scientific theories
  - (B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and
    - (i) communicate explanations individually in a variety of settings
    - (ii) communicate explanations individually in a variety of formats
    - (iii) communicate explanations collaboratively in a variety of settings
    - (iv) communicate explanations collaboratively in a variety of formats
    - (v) communicate solutions individually in a variety of settings
    - (vi) communicate solutions individually in a variety of formats
    - (vii) communicate solutions collaboratively in a variety of settings
    - (viii) communicate solutions collaboratively in a variety of formats
  - (C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence.
    - (i) engage respectfully in scientific argumentation using applied scientific explanations
    - (ii) engage respectfully in scientific argumentation using empirical evidence
- (5) The student knows the contributions of scientists and engineers and recognizes the importance of scientific research and innovation on society. The student is expected to:

- (A) analyze, evaluate, and critique scientific explanations and solutions by using empirical evidence, logical reasoning, and experimental and observational testing so as to encourage critical thinking by the student;
- (i) analyze scientific explanations by using empirical evidence to encourage critical thinking by the student
  - (ii) analyze scientific explanations by using logical reasoning to encourage critical thinking by the student
  - (iii) analyze scientific explanations by using experimental testing to encourage critical thinking by the student
  - (iv) analyze scientific explanations by using observational testing to encourage critical thinking by the student
  - (v) analyze scientific solutions by using empirical evidence to encourage critical thinking by the student
  - (vi) analyze scientific solutions by using logical reasoning to encourage critical thinking by the student
  - (vii) analyze scientific solutions by using experimental testing to encourage critical thinking by the student
  - (viii) analyze scientific solutions by using observational testing to encourage critical thinking by the student
  - (ix) evaluate scientific explanations by using empirical evidence to encourage critical thinking by the student
  - (x) evaluate scientific explanations by using logical reasoning to encourage critical thinking by the student
  - (xi) evaluate scientific explanations by using experimental testing to encourage critical thinking by the student
  - (xii) evaluate scientific explanations by using observational testing to encourage critical thinking by the student
  - (xiii) evaluate scientific solutions by using empirical evidence to encourage critical thinking by the student
  - (xiv) evaluate scientific solutions by using logical reasoning to encourage critical thinking by the student
  - (xv) evaluate scientific solutions by using experimental testing to encourage critical thinking by the student
  - (xvi) evaluate scientific solutions by using observational testing to encourage critical thinking by the student
  - (xvii) critique scientific explanations by using empirical evidence to encourage critical thinking by the student
  - (xviii) critique scientific explanations by using logical reasoning to encourage critical thinking by the student
  - (xix) critique scientific explanations by using experimental testing to encourage critical thinking by the student
  - (xx) critique scientific explanations by using observational testing to encourage critical thinking by the student
  - (xxi) critique scientific solutions by using empirical evidence to encourage critical thinking by the student
  - (xxii) critique scientific solutions by using logical reasoning to encourage critical thinking by the student
  - (xxiii) critique scientific solutions by using experimental testing to encourage critical thinking by the student
  - (xxiv) critique scientific solutions by using observational testing to encourage critical thinking by the student
- (B) relate the impact of past and current research on scientific thought and society, including research methodology, cost-benefit analysis, and contributions of various scientists and engineers as related to the content; and
- (i) relate the impact of past research on scientific thought, including research methodology as related to the content
  - (ii) relate the impact of past research on scientific thought, including cost-benefit analysis as related to the content

- (iii) relate the impact of past research on scientific thought, including contributions of various scientists as related to the content
- (iv) relate the impact of past research on scientific thought, including contributions of various engineers as related to the content
- (v) relate the impact of past research on society, including research methodology as related to the content
- (vi) relate the impact of past research on society, including cost-benefit analysis as related to the content
- (vii) relate the impact of past research on society, including contributions of various scientists, as related to the content
- (viii) relate the impact of past research on society, including contributions of various engineers, as related to the content
- (ix) relate the impact of current research on scientific thought, including research methodology as related to the content
- (x) relate the impact of current research on scientific thought, including cost-benefit analysis as related to the content
- (xi) relate the impact of current research on scientific thought, including contributions of various scientists, as related to the content
- (xii) relate the impact of current research on scientific thought, including contributions of various engineers, as related to the content
- (xiii) relate the impact of current research on society, including research methodology as related to the content
- (xiv) relate the impact of current research on society, including cost-benefit analysis as related to the content
- (xv) relate the impact of current research on society, including contributions of various scientists, as related to the content
- (xvi) relate the impact of current research on society, including contributions of various engineers, as related to the content

(C) research and explore resources such as museums, libraries, professional organizations, private companies, online platforms, and mentors employed in a science, technology, engineering, and mathematics (STEM) field.

- (i) research resources
- (ii) explore resources

(6) The student understands how to implement an engineering design process to develop a multi-system product or solution for a complex problem. The student is expected to:

- (A) implement the stages of an engineering design process to construct a model of a multi-system product or solution;
  - (i) implement the stages of an engineering design process to construct a model of a multi-system product or solution
- (B) explain how factors, including complexity, scope, resources, ethics, regulations, manufacturability, maintainability, and technology, affect stages of the engineering design process;
  - (i) explain how factors, including complexity, affect stages of the engineering design process

- (ii) explain how factors, including scope, affect stages of the engineering design process
  - (iii) explain how factors, including resources, affect stages of the engineering design process
  - (iv) explain how factors, including ethics, affect stages of the engineering design process
  - (v) explain how factors, including regulations, affect stages of the engineering design process
  - (vi) explain how factors, including manufacturability, affect stages of the engineering design process
  - (vii) explain how factors, including maintainability, affect stages of the engineering design process
  - (viii) explain how factors, including technology, affect stages of the engineering design process
- (C) explain how interested parties affect an engineering design process; and
- (i) explain how interested parties affect an engineering design process
- (D) discuss how lessons learned from failure is often an essential component of the engineering design process.
- (i) discuss how lessons learned from failure is often an essential component of the engineering design process
- (7) The student explores and implements the methods and aspects of project management for complex, multi-phase, multi-system projects. The student is expected to:
- (A) research and explain the process and phases of project management, including initiating, planning, executing, and closing;
- (i) research the process of project management, including initiating
  - (ii) research the process of project management, including planning
  - (iii) research the process of project management, including executing
  - (iv) research the process of project management, including closing
  - (v) research the phases of project management, including initiating
  - (vi) research the phases of project management, including planning
  - (vii) research the phases of project management, including executing
  - (viii) research the phases of project management, including closing
  - (ix) explain the process of project management, including initiating
  - (x) explain the process of project management, including planning
  - (xi) explain the process of project management, including executing
  - (xii) explain the process of project management, including closing
  - (xiii) explain the phases of project management, including initiating
  - (xiv) explain the phases of project management, including planning
  - (xv) explain the phases of project management, including executing
  - (xvi) explain the phases of project management, including closing
- (B) explain the roles and responsibilities of team members, including project managers and leads;

- (i) explain the roles of team members, including project managers
  - (ii) explain the roles of team members, including project leads
  - (iii) explain the responsibilities of team members, including project managers
  - (iv) explain the responsibilities of team members, including project leads
- (C) create a resource-loaded project schedule for an engineering project;
- (i) create a resource-loaded project schedule for an engineering project
- (D) maintain a resource-loaded project schedule for the life of an engineering project;
- (i) maintain a resource-loaded project schedule for the life of an engineering project
- (E) develop and implement a system for the organization of project documentation such as file naming conventions, document release control, and version control;
- (i) develop a system for the organization of project documentation
  - (ii) implement a system for the organization of project documentation
- (F) describe how project requirements, constraints, and deliverables affect the project schedule and influence and are influenced by an engineering design;
- (i) describe how project requirements affect the project schedule
  - (ii) describe how project requirements influence an engineering design
  - (iii) describe how project requirements are influenced by an engineering design
  - (iv) describe how project constraints affect the project schedule
  - (v) describe how project constraints influence an engineering design
  - (vi) describe how project constraints are influenced by an engineering design
  - (vii) describe how project deliverables affect the project schedule
  - (viii) describe how project deliverables influence an engineering design
  - (ix) describe how project deliverables are influenced by an engineering design
- (G) create a budget that includes materials, equipment, and labor for an engineering project;
- (i) create a budget that includes materials for an engineering project
  - (ii) create a budget that includes equipment for an engineering project
  - (iii) create a budget that includes labor for an engineering project
- (H) describe the importance of management of change (MOC) and how MOC applies throughout the life of an engineering project;
- (i) describe the importance of management of change (MOC)
  - (ii) describe how MOC applies throughout the life of an engineering project
- (I) create and implement a project management plan for an engineering project; and
- (i) create a project management plan for an engineering project

- (ii) implement a project management plan for an engineering project
- (J) describe how techniques such as Monte Carlo simulation, risk matrices, and tornado diagrams are used to evaluate risk.
  - (i) describe how techniques are used to evaluate risk
- (8) The student conducts research and analyzes data to create a problem statement in the engineering design process. The student is expected to:
  - (A) create an organized engineering notebook to record research and findings for an engineering project;
    - (i) create an organized engineering notebook to record research for an engineering project
    - (ii) create an organized engineering notebook to record findings for an engineering project
  - (B) select an open-ended real-world problem that can be solved using scientific and engineering practices and the engineering design process;
    - (i) select an open-ended real-world problem that can be solved using scientific practices
    - (ii) select an open-ended real-world problem that can be solved using engineering practices
    - (iii) select an open-ended real-world problem that can be solved using the engineering design process
  - (C) collect, organize, analyze, and summarize scientific and technical articles, data, and information to support the development of a problem statement;
    - (i) collect scientific articles to support the development of a problem statement
    - (ii) collect technical articles to support the development of a problem statement
    - (iii) collect data to support the development of a problem statement
    - (iv) collect information to support the development of a problem statement
    - (v) organize scientific articles to support the development of a problem statement
    - (vi) organize technical articles to support the development of a problem statement
    - (vii) organize data to support the development of a problem statement
    - (viii) organize information to support the development of a problem statement
    - (ix) analyze scientific articles to support the development of a problem statement
    - (x) analyze technical articles to support the development of a problem statement
    - (xi) analyze data to support the development of a problem statement
    - (xii) analyze information to support the development of a problem statement
    - (xiii) summarize scientific articles to support the development of a problem statement
    - (xiv) summarize technical articles to support the development of a problem statement
    - (xv) summarize data to support the development of a problem statement
    - (xvi) summarize information to support the development of a problem statement
  - (D) define and use relevant scientific and engineering vocabulary as it relates to the problem statement;

- (i) define relevant scientific vocabulary as it relates to the problem statement
  - (ii) define relevant engineering vocabulary as it relates to the problem statement
  - (iii) use relevant scientific vocabulary as it relates to the problem statement
  - (iv) use relevant engineering vocabulary as it relates to the problem statement
- (E) evaluate information from sources for quality, accuracy, completeness, and reliability and conduct additional research as appropriate in the context of an iterative design process; and
- (i) evaluate information from sources for quality
  - (ii) evaluate information from sources for accuracy
  - (iii) evaluate information from sources for completeness
  - (iv) evaluate information from sources for reliability
  - (v) conduct additional research as appropriate in the context of an iterative design process
- (F) create a problem statement that is concise, specific, and measurable.
- (i) create a problem statement that is concise
  - (ii) create a problem statement that is specific
  - (iii) create a problem statement that is measurable
- (9) The student identifies potential solutions and uses structured techniques to select and justify a preferred solution using scientific and engineering practices and the engineering design process. The student is expected to:
- (A) identify or create alternative solutions to a problem using a variety of techniques such as sketching, brainstorming, reverse engineering, and researching engineered and natural solutions;
- (i) identify or create alternative solutions to a problem using a variety of techniques
- (B) select a preferred solution to a problem by applying structured techniques such as a decision tree, design matrix, or cost-benefit analysis;
- (i) select a preferred solution to a problem by applying structured techniques
- (C) evaluate whether the preferred solution meets the requirements of the problem statement in the context of an iterative design process;
- (i) evaluate whether the preferred solution meets the requirements of the problem statement in the context of an iterative design process
- (D) identify material properties that are important to the solution design such as physical, mechanical, chemical, electrical, and magnetic properties and explain how material properties affect material selection;
- (i) identify material properties that are important to the solution design
  - (ii) explain how material properties affect material selection
- (E) explain how different engineering solutions can have significantly different effects on individuals, society, and the natural world; and
- (i) explain how different engineering solutions can have significantly different effects on individuals

- (ii) explain how different engineering solutions can have significantly different effects on society
- (iii) explain how different engineering solutions can have significantly different effects on the natural world
- (F) document concepts, solutions, findings, and structured decision-making techniques in the engineering notebook.
  - (i) document concepts in the engineering notebook
  - (ii) document solutions in the engineering notebook
  - (iii) document findings in the engineering notebook
  - (iv) document structured decision-making techniques in the engineering notebook

(10) The student creates technical drawings, models, and prototypes using the appropriate tools, materials, and techniques. The student is expected to:

- (A) determine and explain the type of technical drawing that best represents the solution;
  - (i) determine the type of technical drawing that best represents the solution
  - (ii) explain the type of technical drawing that best represents the solution
- (B) create a technical drawing(s) that includes dimensions, scale, views, annotations, tolerances, legends, symbols, and material specifications;
  - (i) create a technical drawing(s) that includes dimensions
  - (ii) create a technical drawing(s) that includes scale
  - (iii) create a technical drawing(s) that includes views
  - (iv) create a technical drawing(s) that includes annotations
  - (v) create a technical drawing(s) that includes tolerances
  - (vi) create a technical drawing(s) that includes legends
  - (vii) create a technical drawing(s) that includes symbols
  - (viii) create a technical drawing(s) that includes material specifications
- (C) create a mathematical or physical model(s) to make predictions, identify limitations, and optimize design criteria;
  - (i) create a mathematical or physical model(s) to make predictions
  - (ii) create a mathematical or physical model(s) to identify limitations
  - (iii) create a mathematical or physical model(s) to optimize design criteria
- (D) create a prototype for testing;
  - (i) create a prototype for testing
- (E) evaluate the successes and failures of the prototype(s) in the context of an iterative design process; and
  - (i) evaluate the successes of the prototype(s) in the context of an iterative design process
  - (ii) evaluate the failures of the prototype(s) in the context of an iterative design process
- (F) revise technical drawings, models, and prototype(s) as the solution evolves to better meet objectives.

- (i) revise technical drawings as the solution evolves to better meet objectives
- (ii) revise models as the solution evolves to better meet objectives
- (iii) revise prototype(s) as the solution evolves to better meet objectives

(11) The student develops, implements, and documents repeated trials of experiments and tests using scientific and engineering practices to determine whether a prototype meets design requirements. The student is expected to:

- (A) design and conduct experiments and tests to determine whether the prototype meets the requirements of the problem statement;
  - (i) design experiments to determine whether the prototype meets the requirements of the problem statement
  - (ii) design tests to determine whether the prototype meets the requirements of the problem statement
  - (iii) conduct experiments to determine whether the prototype meets the requirements of the problem statement
  - (iv) conduct tests to determine whether the prototype meets the requirements of the problem statement
- (B) document and evaluate quantitative and qualitative data obtained through experiments and tests of the prototype in the engineering notebook;
  - (i) document quantitative data obtained through experiments of the prototype in the engineering notebook
  - (ii) document quantitative data obtained through tests of the prototype in the engineering notebook
  - (iii) document qualitative data obtained through experiments of the prototype in the engineering notebook
  - (iv) document qualitative data obtained through tests of the prototype in the engineering notebook
  - (v) evaluate quantitative data obtained through experiments of the prototype in the engineering notebook
  - (vi) evaluate quantitative data obtained through tests of the prototype in the engineering notebook
  - (vii) evaluate qualitative data obtained through experiments of the prototype in the engineering notebook
  - (viii) evaluate qualitative data obtained through tests of the prototype in the engineering notebook
- (C) create and analyze charts, data tables, or graphs to organize information collected during experiments on the prototype;
  - (i) create charts, data tables, or graphs to organize information collected during experiments on the prototype
  - (ii) analyze charts, data tables, or graphs to organize information collected during experiments on the prototype
- (D) determine acceptable limits of error in data from experiments and tests of the prototype;
  - (i) determine acceptable limits of error in data from experiments of the prototype
  - (ii) determine acceptable limits of error in data from tests of the prototype
- (E) explain the purpose of regression analysis as a method to model and investigate relationships between independent and dependent variables from experiments and tests of the prototype;

- (i) explain the purpose of regression analysis as a method to model relationships between independent and dependent variables from experiments
  - (ii) explain the purpose of regression analysis as a method to model relationships between independent and dependent variables from tests of the prototype
  - (iii) explain the purpose of regression analysis as a method to investigate relationships between independent and dependent variables from experiments
  - (iv) explain the purpose of regression analysis as a method to investigate relationships between independent and dependent variables from tests of the prototype
- (F) identify linear and nonlinear relationships in data and situations where regression is appropriate;
- (i) identify linear relationships in data where regression is appropriate
  - (ii) identify nonlinear relationships in data where regression is appropriate
  - (iii) identify linear relationships in situations where regression is appropriate
  - (iv) identify nonlinear relationships in situations where regression is appropriate
- (G) identify sources of random error and systematic error and differentiate between both types of error from experiments and tests of the prototype; and
- (i) identify sources of random error
  - (ii) identify sources of systematic error
  - (iii) differentiate between [random error and systematic error] from experiments
  - (iv) differentiate between [random error and systematic error] from tests of the prototype
- (H) evaluate and determine whether the prototype meets the requirements of the problem statement by analysis of data collected in the context of an iterative design process.
- (i) evaluate whether the prototype meets the requirements of the problem statement by analysis of data collected in the context of an iterative design process.
  - (ii) determine whether the prototype meets the requirements of the problem statement by analysis of data collected in the context of an iterative design process.
- (12) The student develops and presents a comprehensive report that describes the problem, research and information collected and analyzed, concepts and solutions considered, prototypes developed and tested, and final results. The student is expected to:
- (A) create and present the comprehensive report in a professional manner to an appropriate audience such as peers, educators, potential clients, potential employers, community members, or engineering professionals;
    - (i) create the comprehensive report in a professional manner [for] an appropriate audience
    - (ii) present the comprehensive report in a professional manner to an appropriate audience
  - (B) solicit and evaluate feedback from the audience on the comprehensive report and presentation;
    - (i) solicit feedback from the audience on the comprehensive report
    - (ii) solicit feedback from the audience on the presentation [of the comprehensive report]

- (iii) evaluate feedback from the audience on the comprehensive report
- (iv) evaluate feedback from the audience on the presentation [of the comprehensive report]
- (C) present learning experiences such as essential skills gained, areas of personal growth, and challenges and solutions encountered throughout the design process; and
  - (i) present learning experiences encountered throughout the design process
- (D) predict the local and global impacts or risks of an engineering solution to segments of the society such as the economy or the environment.
  - (i) predict the local impacts or risks of an engineering solution to segments of the society
  - (ii) predict the global impacts or risks of an engineering solution to segments of the society