The State Board of Education (SBOE) adopts new §§127.402-127.419, 127.452, and 127.453, concerning Texas Essential Knowledge and Skills (TEKS) for engineering. The new sections are adopted with changes to the proposed text as published in the February 28, 2025 issue of the *Texas Register* (50 TexReg 1571) and will be republished. The adoption adds new courses and updates existing courses that are being moved to this subchapter in the civil engineering, engineering foundations, and mechanical and aerospace design programs of study to ensure the content of the courses remains current and supports relevant and meaningful programs of study.

REASONED JUSTIFICATION: In accordance with statutory requirements that the SBOE identify by rule the essential knowledge and skills of each subject in the required curriculum, the SBOE follows a board-approved cycle to review and revise the essential knowledge and skills for each subject.

During the November 2022 meeting, the SBOE approved a timeline for the review of career and technical education (CTE) courses for 2022-2025. Also at the meeting, the SBOE approved a specific process to be used in the review and revision of the CTE TEKS. The CTE-specific process largely follows the process for TEKS review for other subject areas but was adjusted to account for differences specific to CTE. The 2022-2025 CTE cycle identified two reviews, beginning with the winter 2023 review of a small group of courses in career preparation and entrepreneurship. An abbreviated version of the new CTE TEKS review process was used for the winter 2023 review. The second review in the 2022-2025 CTE TEKS review cycle began in summer 2023. The complete CTE TEKS review process was used for the summer 2023 CTE TEKS review.

Texas Education Agency (TEA) staff began a CTE TEKS review process for engineering in December 2023. Applications to serve on the engineering 2024 CTE TEKS review work groups were collected by TEA from December 2023 through April 2024. TEA staff provided SBOE members with batches of applications for approval to serve on a CTE work group in February, March, and April 2024. Work groups convened to develop recommendations for the CTE courses in May, June, July, and August 2024. Additionally, work groups met for a final time in December 2024 to address feedback from the SBOE and to finalize their recommendations for the new standards.

The adopted new sections ensure the standards for engineering support relevant and meaningful programs of study.

The following changes were made to the rules since published as proposed.

New subsection (a)(2) was added in §§127.402-127.419, 127.452, and 127.453 to reference the employability skills in new §127.15.

Subsection (d)(1) in §§127.402-127.419, 127.452, and 127.453 related to employability skills was deleted since a new section on employability skills is being adopted in §127.15.

Subsection (d)(1) in §§127.402-127.406, 127.408-127.414, 127.417, 127.418, 127.452, and 127.453 related to engineering ethics was added.

Section 127.402(d)(8)(D) was amended by striking the word "the" and adding the phrase "such as structured techniques, design matrix, or cost-benefit analysis" after "criteria."

The section title for §127.404 was amended to remove the roman numeral "I."

Section 127.404(c)(3) was modified by updating the course title.

The section title for §127.405 was amended to read, "Advanced Engineering Design and Presentation."

Section 127.405(b) was modified by striking the Principles of Applied Engineering prerequisite and amending the Engineering Design and Presentation course title.

Section 127.405(c)(3) was modified by updating the course titles.

Section 127.406(b) was modified by adding a recommended prerequisite or corequisite of "chemistry or physics" and striking the specific courses, "Chemistry, Physics, or Physics for Engineering."

Section 127.407(d)(3)(A) was amended by replacing the verb "compare" with the verb "analyze," inserting the word "and" after the word "Act," and striking the phrase "to the code of ethics of other engineering societies such as the American Society of Civil Engineers and the National Society of Professional Engineers to" after the word "Act."

Section 127.407(d)(9)(H) was amended to read, "research and describe emerging contaminants in water and demonstrate understanding of methods of detection, measurement techniques, degradation, assessment of risk, and strategies for mitigation and removal of contaminants."

Section 127.407(d)(10)(A) was amended to read, "explain the differences between and costs of renewable and non-renewable energy sources, providing examples of each."

New §127.407(d)(10)(B) was added to read, "describe energy density, subsidies, raw materials, the impact of energy production on land and animal life, and the environmental and resource demands of mining in relation to renewable and non-renewable energy sources."

New §127.407(d)(10)(F) was added to read, "define and identify types of intermittent and on-demand energy."

Section 127.407(d)(11)(A) was amended by adding "identify innovations and laws which have improved air quality in the United States, including bag houses, water suppression at mines, the catalytic converter, industrial scrubbers, and the Clean Air Act" and striking "describe mitigation techniques and their associated costs for air pollutants and greenhouse gas emissions."

Section 127.407(d)(11)(B) was amended by adding "human habitat and access to energy of climate and extreme weather events such as flooding, freezing temperatures, hurricanes, tornadoes, and thunderstorms" after the phrase "analyze the impact on" and striking the phrase "humans of naturally occurring extreme weather events such as flooding, hurricanes, tornadoes, and thunderstorms."

New §127.407(d)(11)(E) was added to read, "compare and analyze air quality data from different countries around the world, evaluating factors that influence air quality such as laws and use of different types of energy."

Section 127.407(d)(12)(C) was amended to read, "identify and evaluate land conservation, preservation, and restoration measures using industry practice standards, including the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Conservation Practice Standards and the Texas Railroad Commission (TRC) environmental regulations."

Section 127.407(d)(12)(E) was amended by adding "analyze and report positive and negative environmental impacts due to changes in land use, including urbanization over time, mining of rare earth minerals, and precision farming" and striking "analyze and report environmental impacts due to changes in land use such as urbanization over time."

Section 127.407(d)(13)(C) was amended by adding "explain how landfills manage waste decomposition, including the capture and potential use of gases, including methane" and striking "explain the capture and use of methane gas from landfills."

New §127.407(d)(14)(D) was added to read, "explain the role of the TRC in facilitating the restoration of mined land to its original condition."

Section 127.407(d)(15)(C) was amended by adding "identify principles that guide the development of resilient solutions that enhance quality of life, support a high standard of living, and conserve resources" and striking "identify principles that help guide development of solutions with considerations for sustainable development to include people and the planet."

Section 127.408(b) was modified by replacing the "Physics or Chemistry" prerequisite with "physics or chemistry."

Section 127.408(c)(4)-(8) relating to science were added because Fluid Mechanics satisfies a high school science graduation requirement.

Section 127.409(b) and §127.410(b) were modified by replacing "Physics" with "physics."

Section 127.411(b) and §127.413(b) were modified by removing the prerequisite of at least one credit in a course from the Engineering Career Cluster as these are Level 2 CTE courses.

Subsections (d)(2) and (3) in §127.411 and §127.413 were modified by replacing these subsections with the Levels 1 and 2 engineering design process and project management strands since the courses were adjusted to Level 2 CTE courses.

Section 127.411(d)(12)(I) was amended by inserting the phrase "explain the" before "use" and inserting the word "of" after "use."

Section 127.413(d)(11)(B) was modified by replacing the word "mechanical" with the word "aerospace."

Section 127.415(d)(16)(A) was modified by striking the phrase "and other professional organizations such as American Society of Civil Engineers, the National Society of Professional Engineers, the National Council of Examiners for Engineering and Surveying, and the National Institute of Engineering Ethics."

Section 127.415(d)(17)(B) was amended by adding "apply cost-benefit analysis to sustainability standards used throughout the project life cycle to evaluate their economic, environmental, and social trade-offs" and striking "describe sustainability standards used throughout the project life cycle."

Section 127.416(d)(16)(A) was modified by striking the phrase "and Rules" after "Act."

Section 127.418(d)(5)(F) was modified by replacing the word "sustainable" with the word "resilient."

Section 127.419(d)(13)(B) was amended by inserting the phrase "the Texas Engineering Practice Act and rules concerning the practice of engineering and surveying" after the word "by" and striking the phrase "organizations such as the American Society of Civil Engineers, the National Society of Professional Engineers, the Texas Board of Professional Engineers and Land Surveyors, the National Council of Examiners for Engineering and Surveying, and the National Institute of Engineering Ethics."

The SBOE approved the new sections for first reading and filing authorization at its January 31, 2025 meeting and for second reading and final adoption at its April 11, 2025 meeting.

In accordance with Texas Education Code, §7.102(f), the SBOE approved the new sections for adoption by a vote of two-thirds of its members to specify an effective date earlier than the beginning of the 2025-2026 school year. The earlier effective date will allow districts of innovation that begin school prior to the statutorily required start date to implement the proposed rulemaking when they begin their school year. The effective date is August 1, 2025.

SUMMARY OF COMMENTS AND RESPONSES: The public comment period on the proposal began February 28, 2025, and ended at 5:00 p.m. on March 31, 2025. The SBOE also provided an opportunity for registered oral and written comments at its April 2025 meeting in accordance with the SBOE board operating policies and procedures. No public comments were received.

STATUTORY AUTHORITY. The new sections are adopted under Texas Education Code (TEC), §7.102(c)(4), which requires the State Board of Education (SBOE) to establish curriculum and graduation requirements; TEC, §28.002(a), which identifies the subjects of the required curriculum; TEC, §28.002(c), which requires the SBOE to identify by rule the essential knowledge and skills of each subject in the required curriculum that all students should be able to demonstrate and that will be used in evaluating instructional materials and addressed on the state assessment instruments; TEC, §28.002(j), which allows the SBOE to require by rule laboratory instruction in secondary science courses and require a specific amount or percentage of time in a secondary science course that must be laboratory instruction; TEC, §28.025(a),which requires the SBOE to determine by rule the curriculum requirements for the foundation high school graduation program that are consistent with the required curriculum under the TEC, §28.002; and TEC, §28.025(b-2)(2), which requires the SBOE to allow a student by rule to comply with the curriculum requirements for the third and fourth mathematics credits under TEC, §28.025(b-1)(2), or the third and fourth science credits under TEC, §28.025(b-1)(3), by successfully completing a career and technical education (CTE) course designated by the SBOE as containing substantially similar and rigorous content.

CROSS REFERENCE TO STATUTE. The new sections implement Texas Education Code, §§7.102(c)(4); 28.002(a), (c), and (j); and 28.025(a) and (b-2)(2).

<rule>

§127.402. Engineering Design Process (One Credit), Adopted 2025.

(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)(1) 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 Grades 9 and 10. Prerequisite: Algebra I. Recommended prerequisite: Principles of Applied Engineering. 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) Engineering Design Process is an engineering course applicable to all engineering fields. Students use an iterative engineering design process to solve problems, make decisions, and manage a project. Professional practices are addressed, including development of a problem statement, maintenance of documentation, use of an engineering notebook, research, project management, internal and external communication, and creation of technical drawings and prototypes. The student delivers a professional presentation detailing the experience of working through each step of the engineering design process.

(4) 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.

(5) 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.

(1) The student discusses ethics pertaining to engineering. The student is expected to identify and discuss the importance of professionalism, standards of conduct, and ethics as defined by the Texas Engineering Practice Act and rules concerning the practice of engineering and surveying.

(2) The student understands there are different stages of the engineering design process and the importance of working through each stage as part of an iterative process. The student is expected to:

(A) explain the importance of defining an engineering problem as an initial step in the engineering design process;

(B) describe the research stage of the engineering design process;

(C) define and discuss the roles of ideation and conceptualization in innovation and problem solving;

(D) explain the criteria for selecting an idea or concept for detailed prototype design, development, and testing;

(E) explain the purpose of non-technical drawings, technical drawings, models, and prototypes in designing a solution to an engineering problem;

(F) describe the relevance of experimental design, conducting tests, collecting data, and analyzing data to evaluate potential solutions;

(G) explain how the engineering design process is iterative and the role reflection plays in developing an optimized engineering solution; and

(H) explain the purpose of effective communication throughout the entirety of the engineering design process to various audiences.

(3) The student explores and develops skills to solve problems, make decisions, and manage a project. The student is expected to:

(A) discuss strategies for managing time, setting deadlines, and prioritizing to accomplish goals;

(B) identify constraints and describe the importance of planning around constraints, including budgets, resources, and materials;

(C) define milestones and deliverables and explain the advantages of dividing a large project into smaller milestones and deliverables;

(D) identify different types of communication and explain how different types of communication lead to successful teamwork on a shared project in a professional setting; and

(E) identify strategies to solve problems and describe how problem solving is utilized to accomplish personal and team objectives.

(4) The student understands the foundations of occupational safety and health. The student is expected to:

(A) explain and discuss the responsibilities of workers and employers to promote safety and health in the workplace and the rights of workers to a secure workplace;

(B) explain the role industrial hygiene plays in occupational safety and explain various types of industrial hygiene hazards, including physical, chemical, biological, and ergonomic;

(C) identify and explain the appropriate use of types of personal protective equipment used in industry;

(D) demonstrate safe practices for preventing or reducing slips, trips, and falls in the workplace;

(E) describe types of risks of and control methods to prevent electrical hazards in the workplace; and

(F) identify workplace health and safety resources, including emergency plans and Safety Data Sheets, and discuss how these resources are used to make decisions in the workplace.

(5) The student understands the value of maintaining documentation using an engineering notebook. The student is expected to:

(A) explain the purpose and legal value of maintaining an engineering notebook as intellectual property;

(B) describe the proper implementation of an engineering notebook, including notebook type, documentation, signatures, adding external materials, sealing, and dating;

(C) create and maintain an engineering notebook by recording ideas, notes, decisions, findings, deficiencies, and corrections throughout the entire design process; and

(D) communicate progress during the engineering design process at regular intervals using various methods such as written reports, informal presentations, and formal presentations.

(6) The student understands how to conduct research in the engineering design process. The student is expected to:

(A) describe the advantages and disadvantages of emerging technologies and practices in the research process;

(B) explain the importance of identifying and synthesizing information from a variety of sources in the research process;

(C) explain the ethical acquisition and use of digital information;

(D) demonstrate use and citation of source material ethically and appropriately;

(E) define and discuss intellectual property laws such as patent, copyright, and trade secret law and their role in protecting proprietary information in the research process; and

(F) identify limitations in information and research such as outdated, conflicting, proprietary, or limited access.

(7) The student understands the process of creating and refining a problem statement in the engineering design process. The student is expected to:

(A) explain the essential components of a problem statement such as who the problem affects, when it is a problem, where the problem happens, and the magnitude of the problem;

(B) describe different methods for creating and refining a problem statement such as questioning, observation, and client needs;

(C) create a problem statement that is concise, specific, and measurable;

(D) collect, analyze, and interpret information relevant to a problem statement;

(E) modify a problem statement based on information acquired from using processes or various analysis tools such as fishbone charts, root-cause analysis, 80-20 rule, heat maps, survey results, and end-user input;

(F) explain the purpose of a technical document such as a design brief or design basis that compiles the objectives, constraints, data, alternatives, and design solutions in the engineering design process; and

(G) compile a technical document that includes a problem statement, constraints, resources, budget, timeline, deliverables, and solution criteria such as quality, risk, and extent to which problem is solved.

(8) The student understands the importance of conceptualizing a solution in the engineering design process. The student is expected to:

(A) discuss the importance of creativity in engineering, innovation, and problem solving;

(B) explain and use various techniques for idea generation such as brainstorming, mapping, storyboarding, sketching, questioning, reverse engineering, and natural solutions to create solution concepts;

(C) explain the similarities and differences between designing a solution in the classroom versus designing a solution in the real world;

(D) analyze and evaluate solutions using established criteria such as structured techniques, design matrix, or cost-benefit analysis;

(E) explain the importance of capturing client feedback to refine solution concepts; and

(F) explain and use various techniques for gathering end-user input such as focus groups, interviews, and surveys to refine solution concepts.

(9) The student creates technical drawings in the engineering design process. The student is expected to:

(A) explain the role of freehand sketching, freehand modeling, technical drawing, and technical modeling in the development of a prototype or solution;

(B) create nontechnical representations such as sketches, drawings, or models of a solution with relevant annotations;

(C) develop a technical model of the solution using a nontechnical representation of a solution; and

(D) create technical drawings, including single-view projections, multi-view projections, and orthographic views, using industry standards.

(10) The student creates prototypes in the engineering design process. The student is expected to:

(A) identify different types of prototypes and explain the role of a prototype in the development of a solution;

(B) identify and describe the steps needed to produce a prototype;

(C) identify and use appropriate tools, equipment, machines, and materials to produce a prototype; and

(D) present a prototype using presentation software.

(11) The student tests and evaluates a prototype or solution using experiments, data, and end-user feedback. The student is expected to:

(A) explain the purpose of conducting tests on a prototype or solution;

(B) design appropriate protocols for testing a prototype or solution;

(C) analyze, evaluate, and critique a prototype or solution by using observational testing, experimental testing, empirical evidence, and statistical analysis;

(D) collect end-user feedback using appropriate protocols such as focus groups, interviews, and surveys to evaluate a prototype or solution; and

(E) identify the successes and failures of a prototype or solution based on the criteria established in the testing protocols and technical document to determine next steps in the engineering design process.

(12) The student understands the iterative nature of the engineering design process to develop a solution. The student is expected to:

(A) analyze design flaws of a prototype or solution using various tools such as fishbone charts, root-cause analysis, 80-20 rule, heat maps, survey results, and end-user feedback;

(B) iterate steps of the design process, as necessary, to improve and optimize a solution; and

(C) evaluate the potential impact of a solution on the original problem identified during the design process.

(13) The student prepares and delivers a professional presentation detailing the experience of working through each step of the engineering design process to create a viable solution. The student is expected to:

(A) prepare and deliver a presentation detailing the experience of working through each step of the engineering design process to create a viable solution;

(B) solicit and evaluate feedback on implementation of the design process and the presentation; and

(C) present learning experiences such as essential skills gained, areas of personal growth, and challenges encountered throughout the design process.

§127.403. Programming for Engineers (One Credit), Adopted 2025.

(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. Prerequisite: Algebra I and Principles of Applied Engineering, Physics for Engineering, Introduction to Computer-Aided Design and Drafting, or Introduction to Engineering Design. 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) Students enrolled in Programming for Engineers focus on understanding, writing, evaluating, and troubleshooting code to solve engineering problems. Students use the engineering process and computational thinking to write computer programs for real-world solutions. Students explore autonomous systems, sensors, and careers to integrate computational thinking within their engineering mindset. Students spend at least 40% of the instructional time completing hands-on, real-world projects.

(4) 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.

(5) 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.

(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.

(2) The student understands how to implement an engineering design process to develop a product or solution. The student is expected to:

(A) describe and implement the stages of an engineering design process to construct a model;

(B) explain how factors, including complexity, scope, resources, ethics, regulations, manufacturability, maintainability, and technology, impact stages of the engineering design process;

(C) explain how stakeholders impact an engineering design process; and

(D) analyze how failure is often an essential component of the engineering design process.

(3) The student explores the methods and aspects of project management in relation to projects. The student is expected to:

(A) research and explain the process and phases of project management, including initiating, planning, executing, and closing;

(B) explain the roles and responsibilities of team members, including project managers and leads;

(C) research and evaluate methods and tools available for managing a project;

(D) discuss the importance of developing and implementing a system for the organization of project documentation such as file naming conventions, document release control, and version control;

(E) describe how project requirements, constraints, and deliverables impact the project schedule and influence and are influenced by an engineering design;

(F) explain how a project budget, including materials, equipment, and labor, is developed and maintained; and

(G) describe the importance of management of change (MOC) and how MOC applies to project planning.

(4) Computational thinking--foundations. The student explores the core concepts of computational thinking related to engineering solutions, a set of problem-solving processes that involve decomposition, pattern recognition, abstraction, and algorithms. The student is expected to:

(A) decompose real-world engineering problems into structured parts by using visual representation;

(B) analyze and use industry-specific symbols, patterns, and sequences found in visual representations such as flow-charts, pseudocode, concept maps, or other representations of data;

(C) define and practice abstraction in the context of writing a program to solve an engineering problem;

(D) design a plan using visual representation to document a problem, possible solutions, and an expected timeline for the development of a coded engineering solution;

(E) analyze different techniques used in debugging and apply them to an algorithm;

(F) analyze the benefits of using iteration such as code and sequence repetition in algorithms, including loops and functions;

(G) define and analyze Boolean expressions;

(H) define and analyze conditional statements;

(I) write code that uses conditional statements such as (if), (then), (while), and (else);

(J) compare the differences between scripting and programming languages such as interpretation versus compiling; and

(K) identify and demonstrate when to use a compiler and editor for programming design.

(5) Computational thinking--applications. The student applies the fundamentals of programming within the context of engineering. The student is expected to:

(A) analyze how programming parallels iterative design within the engineering design process such as problem solving and critical thinking illustrated in an engineering notebook;

(B) modify previously written code and implement the modified code to develop improved programs;

(C) solve an engineering problem by creating block-based or text-based programs that include sequences, functions, loops, conditionals, and events;

(D) identify and label variables that relate to a program or algorithm;

(E) manipulate and rename variables and describe different data types;

(F) write comments while coding programs for engineering solutions to enhance readability and functionality such as descriptive identifiers, internal comments, white space, spacing, punctuation, indentation, and standardized programming style;

(G) write code that uses comparison operators such as greater than, less than, equal to, and modulus to perform mathematical computations;

(H) write code that uses strings to sort different data types such as Boolean operators, floats, and integers; and

(I) perform user testing on code to assess and improve a program.

(6) The student understands physical computing systems to integrate input and output functions in engineering concepts. The student is expected to:

(A) write programming to process data and control physical devices for efficient and optimized solutions;

(B) apply coding to demonstrate the correct operation of the output device such as motors, video displays, speakers, rapid prototype machines, and lights;

(C) apply coding to demonstrate the correct operation of the input device such as buttons, sensors, and switches;

(D) apply critical problem-solving skills to troubleshoot any errors and miscommunication such as wiring, code, and physical hardware;

(E) apply basic circuit theory as it pertains to ground and power systems for diagramming input and output devices and use tools such as a multimeters, microcontrollers, sensors, and LEDs; and

(F) use script writing to develop engineering solutions such as automatic data collecting, data analysis, programmable logic controllers, power system programming, robotics, and scripting for commercial engineering related software.

(7) The student understands the roles of sensors and programming sensors in engineering. The student is expected to:

(A) describe how sensors were used in the past and are used currently in real-world engineered products, including innovative applications for sensors;

(B) identify the proper input sensors to measure light, distance, sound, and color such as photoresistors, thermistors, sonar, switches, and buttons;

(C) identify the specifications of sensors and other input devices used in engineering problems, including units of measurement, upper limits, lower limits, and errors;

(D) select the proper sensor and defend the choice in developing a solution to an engineering problem;

(E) write code that will control sensors and accurately collect relevant information pertaining to the function of sensors;

(F) debug, asses, and test code to evaluate and improve sensor performance; and

(G) document the steps of sensor integration in an engineering notebook using flowcharts or technical drawings.

(8) The student understands how automation plays a role in engineering and manufacturing. The student is excepted to:

(A) research and explain how automated machines are used in engineering and manufacturing;

(B) research and explain different job roles and required level of education in the field of automation;

(C) compare the roles of engineers, technicians, and technologists in automation;

(D) describe the role of safety and ethics related to the use of automation within engineering; and

(E) convert a manual mechanical system to an automated system using code and hardware.

(9) The student uses appropriate tools and demonstrates safe work habits. The student is expected to:

(A) demonstrate lab safety as prescribed by the instructor in compliance with local, state, and federal regulations;

(B) recognize the classification of hazardous materials and wastes;

(C) dispose of hazardous materials and wastes appropriately;

(D) describe the implications of negligent or improper maintenance of tools in engineering solutions;

(E) demonstrate the use of precision measuring instruments;

(F) analyze a circuit design and identify specific areas where quality, reliability, and safety features can be implemented; and

(G) identify governmental and organizational regulations for health and safety in the workplace related to electronics.

§127.404. Engineering Design and Presentation (One Credit), Adopted 2025.

(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 Grades 10-12. Prerequisite: Algebra I and at least one credit in a course from the Engineering Career Cluster. Recommended prerequisite: Principles of Applied Engineering. 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) Students enrolled in Engineering Design and Presentation demonstrate knowledge and skills of the design process as it applies to engineering fields and project management using multiple software applications and tools necessary to produce and present working drawings, solid model renderings, and prototypes. Through implementation of the design process, students transfer advanced academic skills to component designs. Additionally, students explore career opportunities in engineering, technology, and drafting and learn what is required to gain and maintain employment in these areas.

(4) 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.

(5) 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.

(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.

(2) The student understands how to implement an engineering design process to develop a product or solution. The student is expected to:

(A) describe and implement the stages of an engineering design process to construct a model;

(B) explain how factors, including complexity, scope, resources, ethics, regulations, manufacturability, maintainability, and technology, impact stages of the engineering design process;

(C) explain how stakeholders impact an engineering design process; and

(D) analyze how failure is often an essential component of the engineering design process.

(3) The student understands the value of maintaining documentation using an engineering notebook. The student is expected to:

(A) explain the legal value of maintaining an engineering notebook as intellectual property;

(B) describe the proper implementation of an engineering notebook, including notebook type, documentation, signatures, adding external materials, sealing, and dating; and

(C) create and maintain an engineering notebook by recording ideas, notes, decisions, findings, and corrections.

(4) The student explores the methods and aspects of project management in relation to projects. The student is expected to:

(A) research and explain the process and phases of project management, including initiating, planning, executing, and closing;

(B) explain the roles and responsibilities of team members, including project managers and leads;

(C) research and evaluate methods and tools available for managing a project;

(D) discuss the importance of developing and implementing a system for the organization of project documentation such as file naming conventions, document release control, and version control;

(E) describe how project requirements, constraints, and deliverables impact the project schedule and influence an engineering design;

(F) explain how a project budget, including materials, equipment, and labor, is developed and maintained; and

(G) describe the importance of management of change (MOC) and how MOC applies to project planning.

(5) The student gains knowledge of and demonstrates the skills necessary for success in the engineering workplace. The student is expected to:

(A) describe and compare the roles of an industry technician, engineering technologist, and engineer;

(B) identify educational requirements and career opportunities for engineers, engineering technologists, and industry technicians;

(C) research and describe various engineering disciplines such as mechanical, civil, aerospace, biomedical, chemical civil, computer, electrical, petroleum, and other related and emerging fields;

(D) investigate and describe the requirements of engineering licensure and industry-based certifications;

(E) investigate and describe elements of teamwork critical for success in the engineering and technology industries such as communication, active listening, and time management;

(F) research and describe industry standards and governmental regulations such as health and safety and environmental regulations applicable to a design problem; and

(G) analyze and discuss ethical issues related to engineering and technology.

(6) The student understands the roles and responsibilities of individual team members, how successful teams function, and how to constructively contribute to the team. The student is expected to:

(A) describe the various roles and responsibilities of a project team;

(B) identify the strengths of individual team members to assign roles and distribute tasks within a team; and

(C) describe and demonstrate appropriate behaviors such as active listening and clear communication while serving as a team leader and member on projects.

(7) The student practices safe and proper work habits. The student is expected to:

(A) identify and explain the appropriate use of types of personal protective equipment used in industry;

(B) explain and comply with safety guidelines and procedures as described in relevant manuals, instructions, and regulations;

(C) discuss the importance of safe walking and working surfaces in the workplace and best practices for preventing or reducing slips, trips, and falls in the workplace;

(D) describe the various types of electrical hazards in the workplace and the risks associated with electrical hazards;

(E) describe the various control methods to prevent electrical hazards in the workplace;

(F) identify workplace health and safety resources, including emergency plans and Safety Data Sheets, and explain how emergency plans and Safety Data Sheets are used to make decisions in the workplace;

(G) describe the appropriate disposal of selected hazardous materials and wastes;

(H) perform routine maintenance on selected tools, equipment, and machines;

(I) demonstrate proper handling, use, and storage of tools and materials; and

(J) research and describe the consequences of negligent or improper equipment maintenance.

(8) The student understands how visual and spatial reasoning applies to engineering design. The student is expected to:

(A) describe and compare characteristics and dimensional changes of two-dimensional (2D) and three-dimensional (3D) figures;

(B) draw and manipulate geometric shapes in three dimensions;

(C) create 2D views of a 3D object; and

(D) explain the symmetry of figures through the proportionate transformation of objects.

(9) The student uses sketching and computer-aided design and drafting (CADD) to represent 3D objects in a 2D format needed for manufacturing an object. The student is expected to:

(A) use single and multi-view projections to represent 3D objects in a 2D format;

(B) use appropriate line types in engineering drawings to represent 3D objects in a 2D format;

(C) use orthographic and pictorial views to represent 3D objects in a 2D format;

(D) use auxiliary views to represent 3D objects in a 2D format;

(E) use section views to represent 3D objects in a 2D format;

(F) prepare and revise annotated multi-dimensional production drawings in computer-aided design and drafting to industry standards;

(G) apply best practices for file structure and management to efficiently retrieve and edit files;

(H) use advanced dimensioning techniques, including annotation scale; and

(I) construct and use CADD drawings to develop a model or prototype for presentation.

(10) The student designs products using appropriate engineering design processes and techniques. The student is expected to:

(A) design product components using a variety of technologies;

(B) research and analyze the applications of different types of CADD software for various engineering problems;

(C) create and interpret engineering drawings using industry standards;

(D) describe how quality, reliability, and safety can be designed into specific products;

(E) identify specific requirements of users with special needs and modify a product design to accommodate users with special needs;

(F) research and explain the patenting process and analyze opportunities for potential patents related to a project; and

(G) use multiple software applications for concept presentations.

(11) The student builds a prototype(s) using the appropriate tools, materials, and techniques. The student is expected to:

(A) identify and describe the steps needed to produce a prototype;

(B) identify and use appropriate tools, equipment, machines, and materials to produce the prototype;

(C) present the prototype and explain how the prototype meets the project requirements; and

(D) evaluate the successes and failures of the prototype(s) in the context of an iterative design process.

(12) The student creates justifiable solutions to open-ended real-world problems using engineering design practices and processes. The student is expected to:

(A) identify and define an engineering problem;

(B) formulate goals, objectives, and requirements to solve an engineering problem;

(C) investigate and select appropriate materials for a particular product to be designed;

(D) explain the importance of manufacturability and maintainability when designing a product;

(E) determine design constraints such as personnel, resources, funding, feasibility, and time associated with an engineering problem;

(F) identify requirements, including health, safety, social, environmental, ethical, regulatory, and legal constraints, defining an engineering problem;

(G) identify alternative solutions to a problem using a variety of techniques such as brainstorming, reverse engineering, and researching engineered and natural solutions;

(H) test and evaluate proposed solutions using engineering practices such as experiments, simulations, statistical analysis, and critical design review; and

(I) select and justify a preferred solution to a problem using structured techniques such as a decision tree, design matrix, or cost-benefit analysis.

(13) The student presents a solution derived through the engineering design process. The student is expected to:

(A) present the solution in a professional manner;

(B) solicit and evaluate feedback on the solution and presentation; and

(C) present learning experiences, including essential skills gained, areas of personal growth, challenges, and solutions, encountered throughout the design process.

§127.405. Advanced Engineering Design and Presentation (Two Credits), Adopted 2025.

(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 Grades 11 and 12. Prerequisites: Algebra I, Geometry, and Engineering Design and Presentation. Students shall be awarded two credits 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) Advanced Engineering Design and Presentation is a continuation of knowledge and skills learned in Engineering Design and Presentation. Students enrolled in this course demonstrate advanced knowledge and skills of a system design process as it applies to engineering fields and project management using multiple software applications and tools necessary to produce and present working drawings, solid model renderings, and prototypes. Students expand on the use of a variety of computer hardware and software applications to complete assignments and projects. Through implementation of a system design process, students transfer advanced academic skills to component designs and engineering systems. Emphasis is placed on transdisciplinary and integrative approaches using skills from ideation, prototyping, and project management methods.

(4) 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.

(5) 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.

(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.

(2) The student understands how to implement an engineering design process to develop a product or solution. The student is expected to:

(A) describe and implement the stages of an engineering design process to construct a model;

(B) explain how factors, including complexity, scope, resources, ethics, regulations, manufacturability, maintainability, and technology, impact stages of the engineering design process;

(C) explain how interested parties impact an engineering design process; and

(D) analyze how failure is often an essential component of the engineering design process.

(3) The student explores the methods and aspects of project management in relation to projects. The student is expected to:

(A) research and explain the process and phases of project management, including initiating, planning, executing, and closing;

(B) explain the roles and responsibilities of team members, including project managers and leads;

(C) research and evaluate methods and tools available for managing a project;

(D) discuss the importance of developing and implementing a system for the organization of project documentation such as file naming conventions, document release control, and version control;

(E) describe how project requirements, constraints, and deliverables impact the project schedule, influence an engineering design, and are influenced by an engineering design;

(F) explain how a project budget, including materials, equipment, and labor, is developed and maintained; and

(G) describe the importance of management of change (MOC) and how MOC applies to project planning.

(4) The student practices safe and proper work habits. The student is expected to:

(A) identify and explain the appropriate use of types of personal protective equipment used in industry;

(B) explain and comply with safety guidelines and procedures as described in relevant manuals, instructions, and regulations;

(C) explain the importance of lock out tag out (LOTO) procedures in preventing the release of hazardous energy;

(D) explain the importance of safe walking and working surfaces in the workplace and best practices for preventing or reducing slips, trips, and falls in the workplace;

(E) describe the various types of electrical hazards in the workplace and the risks associated with electrical hazards;

(F) describe the various control methods to prevent electrical hazards in the workplace;

(G) identify workplace health and safety resources, including emergency plans and Safety Data Sheets, and explain how health and safety resources are used to make decisions in the workplace;

(H) describe the appropriate disposal of selected hazardous materials and wastes;

(I) perform routine maintenance on selected tools, equipment, and machines;

(J) handle, use, and store tools and materials correctly; and

(K) research and describe the consequences of negligent or improper equipment maintenance.

(5) The student demonstrates the roles and responsibilities of individual team members, how successful teams function, and how to constructively contribute to the team. The student is expected to:

(A) demonstrate the various roles and responsibilities of a project team;

(B) create a plan to improve team member's skillsets based on strengths of individual team members;

(C) demonstrate appropriate behaviors of a successful team such as active listening, development of consensus, and clear communication while serving as a team leader and member on projects; and

(D) describe and demonstrate the roles and responsibilities specific to team leaders such as assigning roles and responsibilities, facilitating decision making, tracking progress, and soliciting and providing timely feedback to team members.

(6) The student uses and documents engineering design processes. The student is expected to:

(A) use idea generation techniques such as brainstorming, sketching, rapid prototyping, and mind mapping during conceptual stages and for resolving problems of an engineering project;

(B) analyze and evaluate solution constraints;

(C) develop or improve a solution using evidence-based decision-making;

(D) compare solutions using analysis tools such as a decision matrix or paired comparison analysis;

(E) create and maintain an organized engineering notebook to record findings and corrections, including deficiencies in the design process and decisions throughout the entire design process; and

(F) develop an engineering notebook or portfolio to record and justify the final design, construction, and manipulation of finished projects.

(7) The student understands how systems impact the design, integration, and management of engineering solutions. The student is expected to:

(A) analyze and document systems such as electrical, mechanical, or information processes within a product or design concept in engineering;

(B) explain ethical reverse engineering;

(C) reverse engineer a multi-system product and explain how the systems work together; and

(D) modify a system design to meet a newly identified need or to improve performance.

(8) The student demonstrates proficiency using computer-aided design and drafting (CADD) software as part of the engineering design process. The student is expected to:

(A) research and explain the features and benefits of different types of CADD software applications for use in design systems and problem solving;

(B) identify and describe industry graphic standards such as American National Standards Institute (ANSI) and International Organization for Standardization (ISO) standards;

(C) create drawings that meet industry standards using CADD software;

(D) customize CADD software user interface options such as buttons, tabs, and ribbons to match different digital work environments;

(E) prepare and use advanced views such as auxiliary, section, and break-away using CADD software;

(F) draw detailed parts, assembly diagrams, and sub-assembly diagrams using CADD software;

(G) indicate tolerances and standard fittings using appropriate library functions within CADD software;

(H) setup and apply annotation styles by defining fonts, dimension styles, and leader lines using CADD software;

(I) identify and incorporate the use of advanced layout techniques and viewports using paper-space and modeling areas using CADD software;

(J) create and use layers to organize objects in drawings using CADD software;

(K) create and use custom templates using CADD software for advanced project management;

(L) use advanced polar tracking and blocking techniques using CADD software to increase drawing efficiency;

(M) create drawings that incorporate external referencing using CADD software;

(N) create and render objects using parametric modeling tools within CADD software; and

(O) model individual parts or assemblies and produce rendered or animated output using CADD software.

(9) The student builds a prototype using the appropriate tools, materials, and techniques. The student is expected to:

(A) delineate and implement the steps such as defining the problem and generating concepts needed to produce a prototype;

(B) develop a prototype safely using tools, equipment, machines, or precision measuring instruments;

(C) select and justify the use of materials for prototyping and manufacturing;

(D) describe how design quality concepts, including performance, usability, accessibility, reliability, and safe use, affect prototype development;

(E) document quality-control requirements in the design and production of a prototype;

(F) evaluate prototype quality and performance to meet design criteria;

(G) fabricate a prototype using a systems engineering approach to compare the actual prototype performance to the required performance; and

(H) present a prototype and explain how the prototype meets the project requirements.

(10) The student creates justifiable solutions to open-ended real-world problems within a multitude of engineering disciplines using engineering design practices and processes. The student is expected to:

(A) identify and define a multi-system engineering problem requiring a complex solution from different engineering disciplines such as aerospace, biomedical, chemical, civil, electrical, industrial, mechanical, petroleum, robotics, or structural engineering;

(B) formulate and document goals, objectives, and requirements to solve a multi-system engineering problem;

(C) determine the design constraints such as materials, personnel, resources, funding, manufacturability, feasibility, and time associated with a multi-system engineering problem;

(D) identify parameters, including health, safety, social, environmental, ethical, regulatory, and legal constraints, defining a multi-system engineering problem;

(E) identify or create alternative solutions to a multi-system engineering problem using a variety of techniques such as brainstorming, reverse engineering, and researching engineered and natural solutions;

(F) test and evaluate proposed multi-system engineering solutions using tools such as models, prototypes, and mockups and methods such as simulations, critical design review, statistical analysis, and experiments; and

(G) select and justify a preferred solution to a multi-system engineering problem using a structured technique such as a decision tree, design matrix, or cost-benefit analysis.

(11) The student presents a solution derived through the engineering design process. The student is expected to:

(A) develop and deliver a presentation describing the solution to a multi-system engineering problem in a professional manner to an appropriate audience such as peers, educators, potential clients, potential employers, community members, or engineering professionals;

(B) solicit and evaluate feedback from the audience on the multi-system engineering solution and presentation; and

(C) present learning experiences, including essential skills gained, areas of personal growth, challenges, and solutions encountered throughout the design process for a multi-system engineering solution.

§127.406. Engineering Design and Problem Solving (One Credit), Adopted 2025.

(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.

(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.

(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;

(B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and 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;

(D) use appropriate tools such as dial caliper, micrometer, protractor, compass, scale rulers, multimeter, and circuit components;

(E) collect quantitative data using the International System of Units (SI) and United States customary units and qualitative data as evidence;

(F) organize quantitative and qualitative data using spreadsheets, engineering notebooks, graphs, and charts;

(G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and

(H) 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;

(B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;

(C) use mathematical calculations to assess quantitative relationships in data; and

(D) evaluate experimental and 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;

(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and

(C) engage respectfully in scientific argumentation using applied scientific explanations and 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;

(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

(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.

(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;

(B) explain how factors, including complexity, scope, resources, ethics, regulations, manufacturability, maintainability, and technology, affect stages of the engineering design process;

(C) explain how interested parties affect an engineering design process; and

(D) 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;

(B) explain the roles and responsibilities of team members, including project managers and leads;

(C) create a resource-loaded project schedule for an engineering project;

(D) 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;

(F) describe how project requirements, constraints, and deliverables affect the project schedule and influence and are influenced by an engineering design;

(G) create a budget that includes materials, equipment, and 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) create and implement a project management plan for an engineering project; and

(J) describe how techniques such as Monte Carlo simulation, risk matrices, and tornado diagrams 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;

(B) select an open-ended real-world problem that can be solved using scientific and engineering practices and 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;

(D) define and use relevant scientific and 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

(F) create a problem statement that is concise, specific, and 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;

(B) select a preferred solution to a problem by applying structured techniques such as a decision tree, design matrix, or cost-benefit analysis;

(C) 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;

(E) explain how different engineering solutions can have significantly different effects on individuals, society, and the natural world; and

(F) document concepts, solutions, findings, and 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;

(B) create a technical drawing(s) that includes dimensions, scale, views, annotations, tolerances, legends, symbols, and material specifications;

(C) create a mathematical or physical model(s) to make predictions, identify limitations, and optimize design criteria;

(D) create a prototype for testing;

(E) evaluate the successes and failures of the prototype(s) in the context of an iterative design process; and

(F) revise technical drawings, models, and 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;

(B) document and evaluate quantitative and qualitative data obtained through experiments and 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;

(D) determine acceptable limits of error in data from experiments and 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;

(F) identify linear and nonlinear relationships in data and 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

(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.

(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;

(B) solicit and evaluate feedback from the audience on the comprehensive report and presentation;

(C) present learning experiences such as essential skills gained, areas of personal growth, and challenges and solutions encountered throughout the design process; and

(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.

§127.407. Environmental Engineering (One Credit), Adopted 2025.

(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 Grades 10-12. Prerequisites: At least one credit in a course from the Engineering or Energy Career Cluster. 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) In Environmental Engineering, students research, develop, and design solutions related to water, land, and energy problems, with consideration to ethics and regulations. Using technology and the engineering design process, students devise innovative solutions to address current and future engineering challenges.

(4) Students are encouraged to participate in extended learning experiences such as career and technical student organizations, organizations that foster leadership and career development in the profession such as student chapters of related professional associations, and work-based experiences.

(5) 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.

(1) The student understands how to implement an engineering design process to develop a product or solution. The student is expected to:

(A) describe and implement the stages of an engineering design process to construct a model;

(B) explain how factors, including complexity, scope, resources, ethics, regulations, manufacturability, maintainability, and technology, impact stages of the engineering design process;

(C) explain how stakeholders impact an engineering design process; and

(D) analyze how failure is often an essential component of the engineering design process.

(2) The student explores the methods and aspects of project management in relation to projects. The student is expected to:

(A) research and explain the process and phases of project management, including initiating, planning, executing, and closing;

(B) explain the roles and responsibilities of team members, including project managers and leads;

(C) research and evaluate methods and tools available for managing a project;

(D) discuss the importance of developing and implementing a system for the organization of project documentation such as file naming conventions, document release control, and version control;

(E) describe how project requirements, constraints, and deliverables impact the project schedule and influence and are influenced by an engineering design;

(F) explain how a project budget, including materials, equipment, and labor, is developed and maintained; and

(G) describe the importance of management of change (MOC) and how MOC applies to project planning.

(3) Engineering ethics. The student applies ethical consideration to analyze resilient engineered systems. The student is expected to:

(A) analyze the Texas Engineering Practices Act and explain how engineers demonstrate the responsibility they have to serve the public interest, their clients, and the profession with a high degree of honesty, integrity, and accountability;

(B) research the New London school explosion and explain how this event led to the development of the Texas Engineering Practice Act and other regulations such as odorization of natural gas;

(C) evaluate and explain an engineering ethical dilemma between environmental considerations and the needs and wants of society; and

(D) explain how engineering solutions can have significantly different impacts on an individual, society, and the natural world.

(4) Models. The student builds a model using the appropriate tools, materials, and techniques. The student is expected to:

(A) identify and describe the steps needed to produce a model of a system such as hydrological, watershed management, or geospatial analysis models;

(B) identify advantages and limitations of models such as size, scale, properties, and materials;

(C) identify and use appropriate tools, equipment, and materials to produce a model;

(D) describe the use of a model to accurately represent the key aspects of a physical system, including the identification of constraints such as cost, time, or expertise, that may influence the selection of a model;

(E) develop a design proposal using a variety of media to produce a model; and

(F) evaluate the successes and failures of a model in the context of an iterative design process.

(5) Critical and creative problem-solving. The student examines environmental challenges and gathers assumptions to synthesize a meaningful, well-defined problem and ideates multiple solutions. The student is expected to:

(A) collect, analyze, and interpret information relevant to an environmental engineering problem;

(B) document a design process according to best practices in an engineering notebook;

(C) identify and define visual, functional, and design requirements with realistic constraints against which solution alternatives can be evaluated;

(D) list potential appropriate criteria for a defined problem that may impact the success of a design solution such as economic, environmental, ethical, health and safety, technical feasibility, and design;

(E) represent concepts using a variety of visual tools such as sketches, graphs, and charts to communicate the details of an idea;

(F) develop, design, and test alternatives to generate valid quantitative data to inform decision making and demonstrate solutions; and

(G) explain why there are often multiple viable solutions.

(6) Critical and creative problem-solving. The student selects the optimal design solution for real-world environmental problems based on engineering judgement. The student is expected to:

(A) evaluate competing solutions paths using a decision matrix to compare solutions based on design criteria;

(B) formulate a risk analysis matrix using a spreadsheet to evaluate threats and opportunities, including cost, time, and environmental impacts;

(C) identify data needed to address an environmental engineering research question and the appropriate tools necessary to collect, record, analyze, and evaluate the data; and

(D) evaluate evidence and arguments to identify deficiencies, limitations, and biases for appropriate next steps in the pursuit of a better solution.

(7) Engineering tools and technology. The student uses a variety of techniques to measure and report quantities appropriate for an environmental analysis. The student is expected to:

(A) research and determine appropriate units of measure, including acres, miles, and hectares, for environmental analysis;

(B) measure and estimate a large-scale area such as a wetland, streamline, or floodplain using maps or digital resources;

(C) perform dimensional analysis and unit conversions to transform data to units appropriate for a particular purpose or model; and

(D) select and effectively use appropriate tools for accurately measuring specific volumes.

(8) Water resources. The student analyzes environmental factors related to safe drinking water. The student is expected to:

(A) research and describe the Texas State Water Plan, including the sources of water, floodplain management, and recycling;

(B) analyze the relationship between population growth and water resources;

(C) describe how human health is affected by the quality of drinking water sources;

(D) describe and compare the most common sources of drinking water such as desalination, aquifers, surface water, and reclaimed water in developed and developing countries;

(E) explain the characteristics of potable water;

(F) describe common sources of drinking water contamination, including stormwater runoff;

(G) explain contaminant cycling through an ecosystem; and

(H) describe the infrastructure components of private wells and public drinking water systems.

(9) Water quality. The student evaluates water quality and uses a variety of chemical and biological assays to describe water quality. The student is expected to:

(A) research and describe Environmental Protection Agency (EPA) and Texas Commission on Environmental Quality (TCEQ) surface water quality standards for rivers, lakes, and estuaries;

(B) research and describe annual water quality compliance reports and compare water quality between the different reports;

(C) explain how water quality is quantitatively measured using chemical and biologically based testing processes;

(D) perform and analyze a culture assay to detect coliform in water;

(E) collect a water sample and determine water turbidity and pH;

(F) outline the stages of treatment that a typical septic system and modern sewage treatment plant use to treat sewage water;

(G) explain the role of bacteria in wastewater treatment;

(H) research and describe emerging contaminants in water and demonstrate understanding of methods of detection, measurement techniques, degradation, assessment of risk, and strategies for mitigation and removal of contaminants;

(I) describe the interacting roles of bacteria, protozoa, and rotifers in a wastewater treatment ecosystem;

(J) describe and provide examples of how physical, chemical, and biological processes work in the process of purifying contaminated water;

(K) explain how plants remove nitrates from contaminated water;

(L) use the engineering design process to design, build, and test a water filtration system;

(M) design and perform an experiment to use phytoremediation to remove contaminants from water; and

(N) design and conduct a scientific experiment to test a variable affecting the bacteria's ability to decompose oil.

(10) Energy. The student demonstrates a working knowledge of various sources of energy and their environmental and economic impact. The student is expected to:

(A) explain the differences between and costs of renewable and non-renewable energy sources, providing examples of each;

(B) describe energy density, subsidies, raw materials, the impact of energy production on land and animal life, and the environmental and resource demands of mining in relation to renewable and non-renewable energy sources;

(C) identify and measure the amount and types of energy that students use in their daily lives;

(D) compare the fuel efficiency of various fuel sources;

(E) analyze the results of software simulations and models that vary the amounts and types of energy used to predict future energy needs;

(F) define and identify types of intermittent and on-demand energy;

(G) perform a full life cycle assessment (LCA) of material and energy sources; and

(H) identify the variables and the methods for completing an LCA.

(11) Engineering resilient systems. The student understands the environmental impacts to infrastructure systems and the need to support system performance with resilient solutions. The student is expected to:

(A) identify innovations and laws which have improved air quality in the United States, including bag houses, water suppression at mines, the catalytic converter, industrial scrubbers, and the Clean Air Act;

(B) analyze the impact on human habitat and access to energy of climate and extreme weather events such as flooding, freezing temperatures, hurricanes, tornadoes, and thunderstorms;

(C) research and explain how engineering design can be more resilient to environmental impacts to limit additional impacts to the natural environment;

(D) research and explain elements of natural environmental resilience; and

(E) compare and analyze air quality data from different countries around the world, evaluating factors that influence air quality such as laws and use of different types of energy.

(12) Land management. The student understands land management and land management practices. The student is expected to:

(A) explain the value of a healthy ecosystem and the impact of biodiversity on the environment;

(B) research and explain ecological value of the land such as direct products and provisioning, regulating, supporting, and cultural services;

(C) identify and evaluate land conservation, preservation, and restorative measures using industry practice standards, including the United States Department of Agriculture (USDA) National Resources Conservation Services (NRCS) Conservation Practice Standards and the Texas Railroad Commission (TRC) environmental regulations;

(D) research changes in land use and land cover over time using geospatial tools;

(E) analyze and report positive and negative environmental impacts due to changes in land use, including urbanization over time, mining of rare earth minerals, and precision farming; and

(F) explain the role of protected areas and lands to safeguard natural ecosystems.

(13) Waste management. The student understands the role and importance of waste management. The student is expected to:

(A) analyze the impacts of reduction, reuse, and recycling in waste management;

(B) explain the impact of individual practices of waste reduction on resource management;

(C) explain how landfills manage waste decomposition, including the capture and potential use of gases, including methane;

(D) analyze the waste breakdown cycle of various waste products that enter landfills; and

(E) research and describe hazardous waste products and impacts on the environment, including long-term storage needs and pollution.

(14) Regulations. The student understands the role of national and local standards and regulations in environmental design. The student is expected to:

(A) research and describe the functions of the EPA and U.S. Fish and Wildlife Service;

(B) research and describe the functions of the TCEQ and the Texas Parks and Wildlife Department;

(C) describe the relationship between the National Environmental Policy Act, the EPA, and TCEQ; and

(D) explain the role of the TRC in facilitating the restoration of mined land to its original condition.

(15) Future challenges in environmental engineering. The student discusses and analyzes some of the persistent environmental engineering challenges to sustain growing populations and the natural environment and improve quality of life. The student is expected to:

(A) explain why some environmental engineering challenges are persistent such as providing access to clean water, energy, sanitation, and health to growing populations;

(B) create a solution to a current challenge to meet the needs of society without compromising the ability to meet the needs of the future;

(C) identify principles that guide the development of resilient solutions that enhance quality of life, support a high standard of living, and conserve resources;

(D) describe the life cycle of a product or service and identify energy consumption, wastes, and emissions that are produced in the process.

§127.408. Fluid Mechanics (One Credit), Adopted 2025.

(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 Grades 11 and 12. Prerequisite: at least one credit in a course from the Engineering Career Cluster and physics or chemistry. Recommended prerequisite or corequisite: Algebra II. 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) Students enrolled in Fluid Mechanics investigate the behavior and properties of fluids, including liquids and gasses. Through hands-on experiments, simulations, and real-world examples, students learn about concepts such as viscosity, pressure, buoyancy, and flow dynamics. Students explore how fluids interact with solid objects, understanding phenomena like lift and drag, which are critical to the operation of ships, airplanes, and vehicles. Students engage in case studies and problem-solving activities to gain insights into how fluid mechanics shape our everyday lives, technological advancements, and industrial applications. This course prepares students to progress in careers in engineering and scientific disciplines such as aerospace, mechanical, civil, chemical, materials, and physics.

(4) Nature of science. 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 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. 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) Science and social ethics. 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 tools 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.

(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.

(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;

(B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and 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;

(D) use appropriate tools such as dial calipers, protractors, scale rulers, tape measures, load cells, micrometers, scales, tensiometer, multimeter, and thermometers;

(E) collect quantitative data using the System International (SI) and United States customary units and qualitative data as evidence;

(F) organize quantitative and qualitative data using spreadsheets, engineering notebooks, graphs, and charts;

(G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and

(H) 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;

(B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;

(C) use mathematical calculations to assess quantitative relationships in data; and

(D) evaluate experimental and 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;

(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and

(C) engage respectfully in scientific argumentation using applied scientific explanations and 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;

(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

(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.

(6) The student explains the application of fluids in historical and modern applications. The student is expected to:

(A) describe the efficient storage and transportation of fluids, including gravity flow and natural phenomena such as aqueducts, water towers, winds, and currents;

(B) explain the use of fluids in power generation and power transmission such as hydraulics, pneumatics, pumps, compressors, and turbomachinery; and

(C) explain the impact of lift and drag on a moving object.

(7) The student describes basic concepts of fluid mechanics. The student is expected to:

(A) differentiate and compare the properties that distinguish a solid from a fluid;

(B) define the characteristics of a fluid and identify different types of fluids, including gasses, liquids, Newtonian, and non-Newtonian;

(C) define and list examples of compressible and incompressible fluids;

(D) explain the properties of fluids, including density, specific weight, specific gravity, viscosity, and compressibility;

(E) describe methods to measure and calculate the density, specific weight, specific gravity, viscosity, and compressibility of a Newtonian fluid;

(F) calculate density, specific weight, and specific gravity for a variety of fluids from measured data;

(G) explain the appropriate use of material reference frames and spatial reference frames, including boundary conditions, control surfaces, and control volumes;

(H) identify and explain the variables in the ideal gas law and apply the ideal gas law to constructed problems;

(I) explain the laws of conservation of energy and conservation of mass, including the algebraic version of Reynolds transport theorem; and

(J) identify appropriate boundary conditions, including no-slip and ambient pressure boundary conditions in fluid flow.

(8) The student demonstrates an understanding of pressure and hydrostatics and calculates values in a variety of systems. The student is expected to:

(A) describe the relationship between force, area, and pressure;

(B) calculate force proportionalities in hydraulic and pneumatic cylinders using Pascal's law and explain the impact of the cylinders' diameter on the resultant force;

(C) differentiate between atmospheric pressure, gauge pressure, and absolute pressure;

(D) describe the working principles of a pressure gauge and measure fluid pressure using dial gauges and manometers;

(E) calculate the buoyant force of floating and submerged objects according to Archimedes' principle; and

(F) define and calculate hydrostatic pressure.

(9) The student demonstrates an understanding of fluid flows in steady-state pipes, channels, and free jets. The student is expected to:

(A) compare developing, fully developed, and steady-state Newtonian fluid flows in pipes and channels;

(B) compare fluid flow profiles, including uniform and parabolic;

(C) describe experimental measurements of fluid flow field lines, including stream, streak, and pathlines;

(D) calculate volumetric flow rate in a steady state system using the continuity equation and conservation of mass;

(E) explain how Bernoulli's equation relates to the total energy of a steady-state system;

(F) calculate unknown variables in varying conditions, including changes in height, velocity, and cross-sectional area of a steady state system using Bernoulli's equation and the conservation of energy;

(G) derive Torricelli's equation from Bernoulli's equation and calculate the exit velocity and mass flow rates of free jets;

(H) calculate fluid flows in pipes, channels, and free jets using the Reynolds Transport theorem and conservation of mass; and

(I) calculate the resultant force of a free jet at the outlet based on the density of the fluid, cross-sectional area, pressure, and velocity of the fluid.

(10) The student demonstrates an understanding of the effects of an object moving through a fluid. The student is expected to:

(A) differentiate turbulent and laminar flows;

(B) calculate the Reynolds number of given flows to determine if the flows are turbulent or laminar;

(C) define lift and drag as applied to fluid flows;

(D) explain the relationship between viscosity and shear force in a fluid flow;

(E) explain the variables of lift and drag formulas and how the variables relate to fluid flow; and

(F) design an experiment to measure the drag coefficient for a solid body in a fluid flow.

(11) The student understands compressible flow and the relationship between sound transmission through a fluid and fluid compression. The student is expected to:

(A) differentiate between compressible and incompressible fluids and explain the effect of compressibility on the speed of sound through a fluid;

(B) explain how density impacts the speed of sound through a fluid;

(C) calculate and use the Mach number to model a fluid as compressible or incompressible; and

(D) explain the effects on fluid, including shock waves, when the sound barrier is broken.

(12) The student designs and analyzes fluid systems. The student is expected to:

(A) explain the function of weirs in an open channel and describe an application of weirs such as flow control or flow measurement;

(B) calculate the fluid flow in open channels with different shapes, slopes, and weirs;

(C) design an application of hydrostatics using the principle of buoyancy such as a boat, submarine, floating dock, or hot air balloon;

(D) analyze and design a fluid device such as a clepsydra, water tower, pressure regulator, or nozzle using the principles of fluid dynamics;

(E) describe applications and processes of different types of pumps, including centrifugal pumps, peristaltic pumps, gear pumps, and positive displacement pumps;

(F) describe the operation of a centrifugal pump and explain the data presented in a pump curve, including head, flow rate, efficiency, and power;

(G) design a hydraulics system with components, including hydraulic fluid, pump, reservoir, motor, cylinders, valves, and flow controllers;

(H) identify and compare different types of turbomachines, including pumps and turbines;

(I) describe and differentiate the applications of turbomachines, including pumps and turbines; and

(J) explain the concept of tribology and identify the associated variables of tribology such as film thicknesses and pressures.

§127.409. Mechanics of Materials (One Credit), Adopted 2025.

(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 Grades 11 and 12. Prerequisites: at least one credit from the Engineering Career Cluster and physics. Prerequisite or corequisite: Algebra II. This course satisfies a high school science graduation requirement. Students shall be awarded one credit for the 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) Students enrolled in Mechanics of Materials describe the mechanical behavior of engineering materials, including metals, ceramics, polymers, composites, welds, and adhesives, and the applications of load, deformation, stress and strain relationships for deformable bodies, and mechanical elements relevant to engineers. The course includes axially loaded members, buckling of columns, torsional members, beams, and failure.

(4) Nature of science. 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 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. 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) Science and social ethics. 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 tools 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.

(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.

(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;

(B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and 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;

(D) use appropriate tools such as dial calipers, protractors, scale rulers, tape measures, load cells, micrometers, scales, tensometers, multimeters, and thermometers;

(E) collect quantitative data using the System International (SI) and United States customary units and qualitative data as evidence;

(F) organize quantitative and qualitative data using spreadsheets, engineering notebooks, graphs, and charts;

(G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and

(H) 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;

(B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;

(C) use mathematical calculations to assess quantitative relationships in data; and

(D) evaluate experimental and 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;

(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and

(C) engage respectfully in scientific argumentation using applied scientific explanations and 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 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

(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.

(6) The student examines the historical developments that led to the field of mechanics of materials and material science. The student is expected to:

(A) describe the contribution to the field of mechanics by historical scientists such as Pascal, Galileo, Euler, Navier, Lame, Poisson, Hooke, and Young;

(B) describe key historical advancements related to the development of different materials such as bronze, iron, steel, Damascus steel, and Roman concrete;

(C) explain how materials have influenced historical events and products such as the steel in the Titanic, the space race, and smartphones;

(D) evaluate and explain the impact of modern development of materials to manufacturing such as composites, nanotechnology, semi-conductors, and alloys and the effects of processes on materials such as subtractive manufacturing, additive manufacturing, and welding; and

(E) describe the development of shapes in architectural structures such as columns, arches, domes, keystones, and suspension bridges.

(7) The student identifies and measures different properties of an object. The student is expected to:

(A) classify properties of an object as geometric, structural, or material;

(B) identify and describe the application of tools, including rulers, calipers, micrometers, weighing scales, tensile testers (tensometers), and thermometers;

(C) measure common properties of materials, including length, width, height, and mass;

(D) measure and observe intrinsic properties of materials such as hardness, thermal conductivity, and impact resistance;

(E) calculate density, cross-sectional area, specific gravity, thermal expansion, modulus of elasticity, Poisson's ratio, bulk modulus, yield, and ultimate stress using data from a table or graph;

(F) differentiate material properties, including ductility, malleability, resilience, toughness, and reflectivity;

(G) classify material properties as geometric (extrinsic), material (intrinsic), or structural; and

(H) classify types of materials, including metals and alloys, polymers, ceramics, biomaterials, composites, and semiconductors.

(8) The student understands various manifestations of forces acting on solids. The student is expected to:

(A) illustrate forces, including axial, radial, normal, torsional, and shear and identify different units such as newtons, pounds, and kips used in force measurement;

(B) explain force intensity of distributed forces, including forces distributed over a line, area, and volume;

(C) calculate and simplify multiple loads to a single combined load;

(D) distinguish between normal forces and shear forces; and

(E) identify and calculate different types of stress, including axial stress, shear stress, and bending stress.

(9) The student evaluates the effect of temperature on the properties of a material. The student is expected to:

(A) describe engineering applications of thermo-mechanical properties such as thermometers, thermocouples, thermistors, thermostatic valves and controllers, and fuses;

(B) explain the atomic origin of thermal expansion resulting in measurable effects such as building height change and material distortion;

(C) describe potential failure modes due to thermal expansion for kinematically constrained structures;

(D) explain how to accommodate thermal expansion in construction such as buckling of railroad rails, U-runs in piping, and expansion joints; and

(E) explain the effect of temperature on the mechanical properties of materials, including modulus of elasticity, yield strength, ductility, and toughness.

(10) The student determines the material properties from different mechanical material tests and how they are graphically represented. The student is expected to:

(A) describe a tensile test, the various possible shapes of tensile testing specimens, and tensile test measurements, including force, elongation, and change in thickness;

(B) analyze data from a tensile test to calculate engineering stress and strain for various materials such as aluminum, brass, cast iron, steel, and nylon at significantly different temperatures;

(C) plot engineering stress and strain on a two-dimensional graph;

(D) identify regions of a stress-strain curve, including elastic deformation, plastic deformation, resilience, strain hardening, fracture, and tension toughness;

(E) estimate the values from a stress-strain curve, including 0.2% offset, modulus of elasticity, yield stress, ultimate stress, resilience, and tension toughness;

(F) compare and explain differences in testing plots based on differences in specimen geometry and material;

(G) compare different types of material testing, including compression tests, tensile tests, and three-point bending tests;

(H) analyze testing results from compression and three-point bending tests with different specimen geometries, including length, cross-sectional shape, and cross-sectional area; and

(I) describe modern mechanical testing such as digital image correlation, thermography, acoustic emission, and x-ray diffraction.

(11) The student analyzes the impact of the cross-sectional geometry on the second moment of area for beams and shafts. The student is expected to:

(A) calculate the area and the second moment of area for primitive shapes, including rectangles, triangles, circles, and semi-circles;

(B) explain the parallel-axis theorem and use the parallel axis theorem to calculate the second moment of area for complex shapes;

(C) calculate area, centroid, and second moment of area for complex shapes composed of primitive shapes such as an H-beam, square tubes, round tubes, and angle iron; and

(D) hypothesize the best cross-sectional shape for different types of loads such as tension, compression, torsion, bending, and combinations of these loads.

(12) The student represents point and distributed forces on a sketch and calculates the maximum deflection and factor of safety of bars, cables, columns, beams, and shafts using algebraic equations. The student is expected to:

(A) describe the consequences of stresses such as elastic deformation, plastic deformation, and fracture on solid objects with mass;

(B) calculate the maximum deflection of various homogenous prismatic beams, including simply supported, cantilever, and overhang beams, using algebraic formulas;

(C) calculate the factor of safety of various homogenous prismatic beams, including simply supported, cantilever, overhang beams, and columns, using algebraic formulas;

(D) analyze the impact of cross-sectional area and length on the potential for various homogenous prismatic columns to buckle under load;

(E) explain the impact of and the reason for using a tapered object in structural applications; and

(F) describe why pre-stress is used in applications such as shot-peening, tempered glass, wheel spokes, flatbed trailers, and bridges.

(13) Students demonstrate an understanding of stress, strain, and displacement fields throughout a structure, including bars and beams. The student is expected to:

(A) identify compression and tension regions in a bent beam;

(B) describe the kinematics of a bent member, including elongation due to tension, shortening due to compression, the neutral axis, and the linear displacement profile; and

(C) identify regions of compression and tension in digital image correlation data.

(14) The student understands that the mechanics of materials are required to analyze a multi-member structure for strength and stability in real-world applications. The student is expected to:

(A) compare permanent and non-permanent joints, including welding, brazing, soldering, adhesives, bolting, screwing, and riveting joints;

(B) analyze a bolted connection for pre-stress, load, factor of safety, grade, size, yield stress, and applied torque; and

(C) design a structure to support a specified load with materials of adequate properties, size, and geometry and with an appropriate factor of safety.

§127.410. Statics (One Credit), Adopted 2025.

(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 Grades 11 and 12. Prerequisites: at least one credit in a course from the Engineering Career Cluster and physics. Prerequisite or corequisite: Algebra II.

(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) Statics is a gateway course into most engineering majors such as aerospace, mechanical, civil, and biomedical engineering. Students learn the elements of statics that include the forces in structures that are in equilibrium and usually not moving. This includes forces calculated in two dimensions, free-body diagrams, distributed loads, centroids, and friction as applied to cables, trusses, beams, machines, gears, and mechanisms. Students explore scenarios where objects remain stationary, emphasizing the importance of balance and stability in engineering design. This course not only equips students with theoretical knowledge but also empowers them with practical skills that are indispensable in real-world engineering scenarios.

(4) 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.

(5) 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.

(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.

(2) The student describes milestones in structural design and construction throughout history. The student is expected to:

(A) research and evaluate the significance of pioneering structures such as the Eiffel Tower, pyramids, Roman aqueducts, ferris wheel, Sydney Opera House, and St. Louis Bridge to the field of structural design;

(B) analyze how locally available materials and technology have impacted the construction of structures through time;

(C) identify the contributions of structural design pioneers such as Archimedes, Leonardo DaVinci, Galileo, René Descartes, and Albert of Saxony; and

(D) identify careers that use the field of statics and predict the future application of statics.

(3) The student measures and converts units in the System International (SI) units and United States (US) customary systems of measurement. The student is expected to:

(A) measure objects using different units of measurement such as feet, inches, centimeters, meters, pounds force, Newtons, slugs, and kilograms in decimal and fractional measurements;

(B) apply prefixes to units of measure and convert between units in U.S. customary and SI systems such as kilograms and kips; and

(C) identify physical examples of different units of measurement, including one Newton, one pound, and one kip.

(4) The student develops an understanding of point and distributed forces and moments, including torque and couples and their respective units. The student is expected to:

(A) explain how Newton's third law of motion applies to static systems;

(B) explain the purpose and operation of mechanical components, including gears, sprockets, pulleys, and simple machines;

(C) explain how mechanical components, including gears, sprockets, pulley systems, and simple machines, are used in mechanisms;

(D) explain distributed loads and simplify distributed loads to point loads;

(E) compare a two-dimensional distributed load applied over a line to a distributed load applied over an area and a volume;

(F) calculate and use applicable units for forces, torque, distances, and mechanical advantages related to levers, gears, and pulleys;

(G) define and calculate the efficiency of mechanical systems; and

(H) identify and explain couples in a static system.

(5) The student applies vector algebra to calculate the equivalent force and moment vectors. The student is expected to:

(A) differentiate between scalar and vector quantities;

(B) identify properties of a vector, including magnitude and direction;

(C) convert forces represented graphically to vector notation;

(D) represent a force vector in its horizontal and vertical components;

(E) calculate resultant vectors from multiple vectors using a strategy, including vector addition and the parallelogram rule;

(F) simplify free-body diagrams by using strategies, including the principle of transmissibility, couples, and the summation of moments;

(G) calculate moments of a rigid body system using strategies, including multiplying force by the perpendicular distance to a specified axis and the right-hand rule;

(H) calculate moments from component forces using Varignon's principle; and

(I) apply equivalent transformation to simplify external loads in a structural system.

(6) The student locates and applies the geometric centroid and the center of mass of homogenous and heterogeneous objects. The student is expected to:

(A) explain the difference between geometric centroid and center of mass;

(B) locate the geometric centroid of simple and complex shapes using the composite parts method; and

(C) locate the center of mass for two-dimensional and three-dimensional homogeneous and heterogeneous objects.

(7) The student determines the stability of simple and complex objects with a variety of applied forces. The student is expected to:

(A) identify potential pivot points at which objects could potentially rotate leading to a tip-over;

(B) determine the stability of simple and complex objects with only frictional force using the relative location of the center of mass and the object pivot point;

(C) calculate the stability of simple and complex objects with external forces applied at different locations on the object and a reaction force caused by friction; and

(D) describe how the friction reaction forces when combined with applied forces at different locations affect the stability of an object and how to stabilize systems subject to tipping.

(8) The student differentiates supports, including fixed, pin, and roller supports, for structures. The student is expected to:

(A) define and compare the applications of different structural supports, including fixed, pin, and roller supports, and describe which support is utilized in a cantilevered beam;

(B) explain the degrees of freedom for fixed, pin, and roller supports;

(C) describe how fixed, pin, and roller supports affect a structural system; and

(D) describe and sketch the different reaction forces and moments for structural supports, including fixed, pin, and roller supports.

(9) The student constructs free-body diagrams of particles and rigid bodies around various supports and determines the reaction forces of the static body. The student is expected to:

(A) sketch a complete free-body diagram that includes applied and reaction forces for a structure;

(B) define static equilibrium;

(C) formulate translational and rotational static equilibrium equations into a system of algebraic equations; and

(D) solve for unknown forces in a structure using equations of equilibrium.

(10) The student analyzes statically determinant plane trusses. The student is expected to:

(A) test if a plane truss is statically determinant;

(B) apply the method of sections and method of joints to calculate the internal forces of a statically determinant plane truss;

(C) explain the difference between tension and compression forces;

(D) describe capabilities of members, including beams, cables, ropes, bars, and columns, to bear tension, compression, or both tension and compression;

(E) identify internal members as being in tension or compression, the members bearing the maximum loads, and the member most likely to fail; and

(F) design structures such as bridges, tensegrity structures, or trusses to support external loads.

(11) The student recognizes the limitations of a two-dimensional model. The student is expected to:

(A) identify the differences between a two-dimensional and three-dimensional system;

(B) explain the implications of adding a third dimension to a structure and how a two-dimensional analysis is insufficient to model a three-dimensional structure; and

(C) describe how a third dimension can cause instability in a structure.

§127.411. Mechanical Design I (One Credit), Adopted 2025.

(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)(1) 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 Grades 10-12. Prerequisite: Algebra I. Recommended corequisite: Geometry. 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) Students enrolled in Mechanical Design I demonstrate knowledge and skills associated with design and manufacture of mechanical systems. Fundamental mechanisms are introduced such as gears, belts, threaded elements, and four-bar mechanisms. Basic manufacturing processes such as stamping, injection molding, casting, machining, and assembly are explored through reverse engineering. The mechanisms encountered through reverse engineering enable the exploration of product functionality. Students compare engineering choices made for components, materials, and manufacturing processes. Emphasis is placed on team collaboration and professional documentation.

(4) 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.

(5) 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.

(1) The student discusses ethics pertaining to engineering. The student is expected to identify and discuss the importance of professionalism, standards of conduct, and ethics as defined by the Texas Engineering Practice Act and rules concerning the practice of engineering and surveying.

(2) The student understands that there are different stages of the engineering design process and the importance of working through each stage as part of an iterative process. The student is expected to:

(A) explain the importance of defining an engineering problem as an initial step in the engineering design process;

(B) describe the research stage of the engineering design process;

(C) define ideation and conceptualization and discuss the role these processes play in innovation and problem solving;

(D) explain the processes of selecting an idea or concept for detailed prototype design, development, and testing;

(E) describe the purpose of non-technical drawings, technical drawings, models, and prototypes in designing a solution to an engineering problem;

(F) describe the process of relevant experimental design, conducting tests, collecting data, and analyzing data to evaluate potential solutions;

(G) explain how the engineering design process is iterative and the role reflection plays in developing an optimized engineering solution; and

(H) describe the purpose of effective communication of the engineering solution as obtained through the engineering design process to various audiences.

(3) The student explores and develops skills to solve problems, make decisions, and manage a project. The student is expected to:

(A) discuss strategies for managing time, setting deadlines, and prioritizing to accomplish goals;

(B) identify constraints and describe the importance of planning around constraints, including budgets, resources, and materials;

(C) define milestones and deliverables and explain the advantages of dividing a large project into smaller milestones and deliverables;

(D) identify different types of communication and explain how different types of communication lead to successful teamwork on a shared project in a professional setting; and

(E) identify strategies to solve problems and describe how problem solving is utilized to accomplish personal and team objectives.

(4) Collaboration. The student develops teamwork skills. The student is expected to:

(A) discuss principles of critique such as describing, analyzing, interpreting, and evaluating;

(B) identify and demonstrate teamwork skills such as sensemaking where a team member recognizes another team member who requires additional clarity and then addresses the team member by providing clarity;

(C) identify methods for structuring projects such as Gantt charts, work breakdown structure, Agile, and critical path method; and

(D) discuss the importance of contributing to positive and productive group dynamics to enhance teamwork.

(5) Documentation. The student documents information gathered and interpretation developed throughout engineering processes. The student is expected to:

(A) create documents such as executive summaries, reverse engineering forms, test reports, failure documents, system black box models, engineering notebooks, and drawing packages aligned with professional industry standards;

(B) select the document format to communicate essential information to identified stakeholders; and

(C) explain and justify the structure and sequence of how information is presented in engineering documents.

(6) Applications for mechanical design. The student examines domestic, commercial, and industrial applications of mechanical design. The student is expected to:

(A) explain applications of mechanical design in various industries, including medical, aeronautical, automotive, naval, and robotics industries;

(B) research and identify commercial applications for mechanical design such as heating and cooling systems and robotics; and

(C) identify and discuss household items that are impacted by mechanical design such as environmental controls, refrigerators, washing machines, and clothes dryers.

(7) Mechanisms. The student investigates and understands mechanisms that convert motion such as gears, belts, threaded elements, linkages, or linear actuators. The student is expected to:

(A) create virtual models of physical mechanisms using appropriate tools;

(B) predict how different inputs affect the motion of a mechanism such as gears and linkages and compare the predictions with physical models;

(C) classify mechanisms into different types such as gears, belts, threaded elements, linkages, or linear actuators; and

(D) explain how changes in the dimensions of a mechanism influence the relationship between input and output.

(8) Reverse engineering. The student systematically disassembles and analyzes a system to identify the concepts involved in function and manufacture. The student is expected to:

(A) use appropriate simple tools and methods to disassemble consumer products such as can openers, mixers, or drills;

(B) document the reverse engineering process using appropriate documentation tools and methods;

(C) identify mechanisms of a product such as drive systems and gears and how their function contributes to the overall function of the product;

(D) identify elements of a product such as housings, covers, and controls and how their attributes contribute to the product;

(E) use appropriate measurement tools and methods to capture and document information about the sub-assemblies and components in a product;

(F) identify and evaluate the choice of particular materials in the elements of a product;

(G) identify and evaluate the choice of the process used to manufacture the element of a product; and

(H) identify and evaluate the choice of the process to assemble a product.

(9) Manufacturing. The student identifies different manufacturing processes such as stamping, injection molding, casting, sintering, and machining and assembly. The student is expected to:

(A) explain and compare common manufacturing processes such as stamping, casting, injection molding, and machining;

(B) identify and describe stamping manufacturing process elements such as press, tool, and blank and process steps such as shearing, bending, and perforating;

(C) identify and describe injection molding elements such as hopper, heater, platen, and mold and process steps such as heating and injecting;

(D) identify and describe casting elements such as mold, furnace, parting plane, sprue, and gate and process steps such as heating, pouring, cooling, and removal;

(E) identify and describe sintering elements such as mold, furnace, binder, and powder and process steps such as heating, pressing, cooling, and post-processing;

(F) identify and describe material removal elements such as workpiece, tool, jigs, and fixtures; the machine used such as mill, lathe, or drill; and process steps such as holding, locating, and cutting;

(G) identify and describe assembly process elements such as jigs and fixtures, tolerances, fasteners, and tools and related process steps such as locating, holding, joining, and automating; and

(H) identify and explain which material types are appropriate for manufacturing processes such as stamping, injection molding, casting, sintering, material removal, and assembly.

(10) Assembly. The student explores the assembly process. The student is expected to:

(A) explain the purposes of joining methods such as welding, adhesive bonding, fastening, riveting, and snap fitting;

(B) evaluate the choice of joining methods found in a consumer product and generate requirements based on the evaluation; and

(C) compare different assembly strategies such as assembly line, automation versus manual, or batch versus pull.

(11) Design. The student applies appropriate professional design tools. The student is expected to:

(A) define industry relevant terminology, including Failure Modes Effects Analysis (FMEA), Design for Manufacturing (DFM), Design for Assembly (DFA), Lean Manufacturing, Design of Experiments (DOE), benchmarking, reverse engineering, and Life Cycle Analysis (LCA);

(B) use design tools such as FMEA, Quality Functional Deployment (QFD), root cause analysis, five whys, or decision matrices to extract information about a reverse engineered product;

(C) develop an engineering requirements list to justify the selection of materials, processes, parts, and features from a reverse engineered product;

(D) identify opportunities for manufacturing and assembly improvement from a reverse engineered consumer product; and

(E) design and conduct tests to collect information needed to understand the engineers' design decisions, including material, manufacturing process, and mechanism choices, during a reverse engineering project.

(12) Key concepts. The student understands key concepts of mechanical engineering. The student is expected to:

(A) define heat transfer concepts such as conduction, convection, or radiation;

(B) define thermodynamic concepts such as systems boundary, conservation, or entropy;

(C) define mechanics of materials concepts such as strain, stress, elasticity, brittleness, or fatigue;

(D) define dynamics concepts such as vibrations, dampening, or spring coefficients;

(E) define material concepts such as strength, hardness, metallics, polymers, or ceramics;

(F) define fluids concepts such as mass flow rate, viscosity, compressibility, turbulence, or boundary layer;

(G) define statics concepts such as free body diagrams, force, torque, moment, or equilibrium;

(H) define controls concepts such as open loop, closed loop, or systems modeling; and

(I) identify and explain the use of engineering computational tools such as computer-aided design (CAD), finite element analysis (FEA), or computational fluid dynamics (CFD).

§127.412. Mechanical Design II (Two Credits), Adopted 2025.

(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 Grades 11 and 12. Prerequisite: Mechanical Design I. Students shall be awarded two credits 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) Students enrolled in Mechanical Design II demonstrate knowledge and skills associated with the design development and validation of a prototype solution to meet a given set of requirements. Students identify project stakeholders; manage projects; evolve requirements; model system solutions; develop, test, and refine prototypes; and validate project solutions. Emphasis is placed on budget management, professional documentation, conducting project status updates, critiquing design reviews, and team collaboration.

(4) 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.

(5) 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.

(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.

(2) The student understands how to implement an engineering design process to develop a product or solution. The student is expected to:

(A) describe and implement the stages of an engineering design process to construct a model;

(B) explain how factors, including complexity, scope, resources, ethics, regulations, manufacturability, maintainability, and technology, impact stages of the engineering design process;

(C) explain how stakeholders impact an engineering design process; and

(D) analyze how failure is often an essential component of the engineering design process.

(3) The student explores the methods and aspects of project management in relation to projects. The student is expected to:

(A) research and explain the process and phases of project management, including initiating, planning, executing, and closing;

(B) explain the roles and responsibilities of team members, including project managers and leads;

(C) research and evaluate methods and tools available for managing a project;

(D) discuss the importance of developing and implementing a system for the organization of project documentation such as file naming conventions, document release control, and version control;

(E) describe how project requirements, constraints, and deliverables impact the project schedule and influence and are influenced by an engineering design;

(F) explain how a project budget, including materials, equipment, and labor, is developed and maintained; and

(G) describe the importance of management of change (MOC) and how MOC applies to project planning.

(4) Collaboration. The student develops teamwork skills. The student is expected to:

(A) explain and apply sensemaking skills such as recognizing team members who require additional clarity and addressing team members to provide clarity;

(B) apply methods such as Gantt charts, work breakdown structure, Agile, and critical path method to structure a project;

(C) apply principles of critique within the team such as describing, analyzing, interpreting, and evaluating;

(D) develop and present action plans to positively support the team's work relationships;

(E) explain and model how to provide an effective critique of team members on topics such as team performance, test performance, project development, or presentation;

(F) explain and model how to provide an effective critique of other teams on topics such as presentation, problem definition, schedule, and solution justification;

(G) analyze and evaluate critique received from team members and other teams; and

(H) develop a design review presentation to provide status and solicit feedback on the design problem and solution.

(5) Documentation. The student documents information gathered and interpretations developed throughout the applied engineering process. The student is expected to:

(A) generate documents such as executive summaries, reverse engineering forms, test reports, failure documents, system black box models, engineering notebooks, and drawing packages by applying professional standards and templates;

(B) select the appropriate document format for the information being communicated based on the audience;

(C) explain and justify the structure and sequence of how the information is presented in the engineering documents;

(D) create assembly and user manuals for peer review; and

(E) generate a final design report that focuses on the project scope and solution with appendices to capture all relevant design information such as the design process used, requirements compliance matrix, concept reports, and test reports.

(6) Project management. The student reviews and applies basic project management strategies following a proposal-justification-approval process for each significant model considered. The student is expected to:

(A) generate a project management plan that includes time and deliverable estimates;

(B) review and update periodically the project management plan based on appropriate industry standard practices such as stage-gate and Agile Project Management; team structure and formation; and project modeling such as flow charts, Gantt charts, Program Evaluation Review Technique (PERT), critical path method, and work breakdown structures;

(C) create model or test proposals for review; and

(D) compare project management approaches such as stage-gate and Agile.

(7) Stakeholder. The student understands how to engage stakeholders, including end user, consumer, fabricator, maintenance, the design team, and other engineers. The student is expected to:

(A) describe how an engineer's professional responsibility applies to stakeholders;

(B) develop a journey map or equivalent tool to model how the stakeholder interacts with the product; and

(C) explain the importance of maintaining engagement with the stakeholder throughout the project.

(8) Design requirements. The student understands the importance of the role of requirements in the mechanical engineering design process. The student is expected to:

(A) identify and solicit stakeholder requirements;

(B) generate, refine, and document product and project requirements throughout the project;

(C) document requirements in correct format with appropriate standards such as National Aeronautics and Space Administration (NASA), military, and International Council on Systems Engineering (INCOSE);

(D) verify that each requirement can be associated to at least one stakeholder;

(E) verify that each stakeholder can be associated to at least one requirement;

(F) discuss the importance of the relation between requirements and respective stakeholders;

(G) analyze how key mechanical design concepts such as heat transfer, mechanics of materials, statics, or fluids impact the design process, design requirements, and design decisions; and

(H) explain how requirements drive the project.

(9) System modeling. The student generates multiple abstract models of mechanical systems using representations such as schematic diagramming and function structure modeling. The student is expected to:

(A) create models of various mechanical system concepts;

(B) compare different models against the appropriate requirements;

(C) extract new system requirements from the models;

(D) create models to communicate engineering design solutions to stakeholders for a project;

(E) discuss conservation principles of energy, matter, and motion; and

(F) apply conservation principles throughout the system model.

(10) Design space modeling. The student models conceptual design spaces using morphological matrices. The student is expected to:

(A) select the key requirements for the problem;

(B) generate multiple means to address each key requirement to populate a morphological matrix;

(C) generate multiple integrated solutions by selecting means from each requirement for further modeling and refinement; and

(D) calculate the total number of possible solutions captured in the generated morphological matrix.

(11) Concept generation. The student generates multiple systematic concepts using appropriate ideation tools. The student is expected to:

(A) explain the rules of ideation tools such as brainstorming, 6-3-5, Gallery Method, C-Sketch, and concept mapping;

(B) apply ideation tools to generate multiple concepts for a problem; and

(C) compare the ideation tools based on the rules, number of people, representation, and purpose.

(12) Concept pruning. The student prunes sets of concepts using design tools such as decision matrices, pair-wise comparison, and pro-con lists. The student is expected to:

(A) use and explain absolute or relative decision matrices to prune a set of concepts;

(B) use and explain pair-wise comparisons to prune a set of concepts;

(C) use and explain pro-con lists to prune a set of concepts;

(D) explain why it is important to use multiple pruning tools in design; and

(E) explain why the pruning tools are not for selecting concepts.

(13) Prototyping and testing. The student fabricates multiple physical prototypes ranging from parts to subsystems to final integrated prototypes to gather information needed to support mechanical engineering design decision making. The student is expected to:

(A) develop prototyping proposals that include cost, time, and effort estimates; desired information; and testing plans;

(B) use appropriate tools and materials to fabricate prototypes;

(C) evaluate and execute testing plans for each prototype to gather information or check requirement satisfaction;

(D) extract and document new requirements from prototyping and testing; and

(E) justify the purpose for each physical or virtual model constructed against the cost of making the model.

(14) Embodiment and refinement. The student refines design solutions by selecting and sizing components appropriately. Students justify material choices based on the requirements defined. The student is expected to:

(A) construct geometric models and drawings to represent designed system;

(B) justify and use appropriate analytical and simulation tools to correlate the changes in parameters of the models with changes in the performance of the modeled system;

(C) justify design decisions using requirements such as functionality, cost, performance, or time;

(D) use appropriate tools and materials to fabricate a final prototype;

(E) develop final product documents such as bill of materials, assembly models, user manual, and assembly instructions; and

(F) explain the evolution of requirements between earlier and final prototypes.

(15) Solution validation. The student tests and verifies requirements throughout the project. The student understands the importance of discovering new requirements through testing and simulation. The student is expected to:

(A) analyze information gained from testing and simulation to document new or refined requirements;

(B) document simulations or tests using an appropriate report template;

(C) design and execute simulations or tests to validate functional requirements are met;

(D) explain why engineering design processes are iterative; and

(E) discuss how continuous improvement and design iteration are related.

(16) Budget. The student plans, monitors, and updates project budgets throughout the design project. The student is expected to:

(A) create budgets for initial project costs such as raw materials, purchased parts, salvaged parts, hardware, taxes, shipping, and handling categories;

(B) create a Bill of Materials cost report for the final build;

(C) compare and explain any differences between the final product build cost and the project budget;

(D) monitor and update the project budget throughout the duration of the project;

(E) prepare budget status reports that include explanations of spenddown rates and changes to the budget; and

(F) explain the importance of budget tracking in design projects.

§127.413. Aerospace Design I (One Credit), Adopted 2025.

(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)(1) 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 Grades 10-12. Prerequisite: Algebra I. Recommended corequisite: Geometry. 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) Students enrolled in Aerospace Design I demonstrate knowledge and skills associated with the design evolution and emerging trends of aircraft and aerospace systems. Fundamental concepts such as forces of flight, structures, aerodynamics, propulsion, stability and control, and orbital mechanics are introduced as related to design decisions for atmospheric and space flight. These concepts are related to mission requirements and solution approaches.

(4) 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.

(5) 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.

(1) The student discusses ethics pertaining to engineering. The student is expected to identify and discuss the importance of professionalism, standards of conduct, and ethics as defined by the Texas Engineering Practice Act and rules concerning the practice of engineering and surveying.

(2) The student understands that there are different stages of the engineering design process and the importance of working through each stage as part of an iterative process. The student is expected to:

(A) explain the importance of defining an engineering problem as an initial step in the engineering design process;

(B) describe the research stage of the engineering design process;

(C) define ideation and conceptualization and discuss the role these processes play in innovation and problem solving;

(D) explain the processes of selecting an idea or concept for detailed prototype design, development, and testing;

(E) describe the purpose of non-technical drawings, technical drawings, models, and prototypes in designing a solution to an engineering problem;

(F) describe the process of relevant experimental design, conducting tests, collecting data, and analyzing data to evaluate potential solutions;

(G) explain how the engineering design process is iterative and the role reflection plays in developing an optimized engineering solution; and

(H) describe the purpose of effective communication of the engineering solution as obtained through the engineering design process to various audiences.

(3) The student explores and develops skills to solve problems, make decisions, and manage a project. The student is expected to:

(A) discuss strategies for managing time, setting deadlines, and prioritizing to accomplish goals;

(B) identify constraints and describe the importance of planning around constraints, including budgets, resources, and materials;

(C) define milestones and deliverables and explain the advantages of dividing a large project into smaller milestones and deliverables;

(D) identify different types of communication and explain how different types of communication lead to successful teamwork on a shared project in a professional setting; and

(E) identify strategies to solve problems and describe how problem solving is utilized to accomplish personal and team objectives.

(4) Collaboration. The student engages in multiple team projects and activities. The student is expected to:

(A) discuss principles of critique such as describing, analyzing, interpreting, and evaluating;

(B) identify and demonstrate teamwork skills such as sensemaking where a team member recognizes another team member who requires additional clarity and then addresses the team member by providing clarity;

(C) identify methods for structuring projects such as Gantt charts, work breakdown structure, Agile, and critical path method; and

(D) discuss the importance of contributing to positive and productive group dynamics to enhance teamwork.

(5) Documentation. The student documents information and interpretation developed throughout engineering processes. The student is expected to:

(A) use professional standards and templates to generate documents such as executive summaries, test reports, failure documents, system black box models, engineering notebooks, and drawing packages;

(B) select the document format to communicate essential information for identified stakeholders; and

(C) explain and justify the structure and sequence of how the information is presented in the engineering documents.

(6) History of flight. The student understands the history and evolution of human flight, including flight within and outside the Earth's atmosphere. The student is expected to:

(A) identify and discuss successes and failures in human efforts to fly prior to powered flight;

(B) research and discuss innovations in aircraft prior to the jet age and explain how world events impacted these innovations;

(C) research and discuss innovations in aircraft after the beginning of the jet age and explain how world events impacted these innovations;

(D) research and discuss innovations in rockets prior to human spaceflight and explain how world events impacted these innovations;

(E) research and discuss innovations in rockets after the first human spaceflight and explain how world events impacted these innovations; and

(F) discuss the history of regulation of aircraft and the role of the Federal Aviation Administration (FAA).

(7) Introduction to aircraft. The student explains the FAA categories for aircraft and categorizes the different types of aircraft such as airplanes, rotorcraft, lighter-than-air or aerostats, glider, powered-lift, powered parachutes, weight-shift aircraft, ground-effect vehicles (GEV), air-cushion vehicles (ACV), and rockets. The student is expected to:

(A) identify and describe classes of aircraft such as single-engine land (SEL), gyroplane, powered-lift, and glider using the FAA categories;

(B) categorize aircraft by attributes such as piston engine, turboprop, powered or unpowered, and drones or piloted;

(C) compare aircraft categories and use cases for each category; and

(D) research and discuss emerging trends in aircraft such as airships, rotary powered aircraft, and alternative energy powered aircraft.

(8) Atmospheric flight. The student identifies and relates the three axes of an aircraft, the four forces of flight, and the components used for stability and control of the aircraft. The student is expected to:

(A) explain the relationships between atmospheric temperature, pressure, density, and altitude;

(B) identify and describe the motion about the three axes of an aircraft, including yaw, pitch, and roll;

(C) identify and describe ways to control motion about the three axes;

(D) identify and explain the four forces acting on aerospace vehicles in flight, including lift, drag, thrust, and weight;

(E) explain the relationship between weight, mass, gravity, and acceleration and identify their corresponding units such as pounds-force, pound-mass, kilogram, and Newton;

(F) discuss the difference between g-force and weight;

(G) draw the forces of flight for a straight and level flight and a level banked turn;

(H) identify different ways to control the forces that change the pitch, roll, and yaw of an aircraft;

(I) identify and explain the major fixed and movable components of various aircraft to enable stability and control within the atmosphere; and

(J) define and discuss aerodynamics as a subset of aerospace.

(9) Lift and drag. The student explains how lift and drag are generated by an aircraft and how they change during flight. The student is expected to:

(A) explain how an airfoil generates lift;

(B) explain how the angle of attack (AoA) influences lift;

(C) explain how to interpret a "Lift Coefficient (CL) versus AoA" chart;

(D) define and discuss stall for an airfoil;

(E) explain the types of drag, including profile/form, skin friction, interference, trim, and induced;

(F) explain how the AoA influences drag;

(G) explain how to interpret a "Drag Coefficient (CD) versus AoA" chart;

(H) explain how changes in drag during flight impact performance such as range, altitude, and power requirements;

(I) define and discuss Lift-to-Drag (L/D) ratio;

(J) explain how to interpret an L/D chart;

(K) identify the maximum L/D ratio from a chart to determine the optimal glide speed for maximum range;

(L) research and discuss other systems that use airfoils such as windmills, fans, and propelling aircraft; and

(M) explain how a plane can fly without engine power and in some cases can gain altitude to stay aloft for extended time and distance.

(10) Weight and balance. The student recognizes that components have mass, weight, and location resulting in moments that are balanced by control surfaces. The student is expected to:

(A) identify and calculate moments created by the forces of flight;

(B) define and discuss center of gravity (CG);

(C) define and discuss center of pressure (CP);

(D) explain how the locations of the CP and CG influence the stability of an aircraft; and

(E) create a model of an aircraft with variable configurations for CG and CP to determine stability of an aircraft.

(11) Computerized design tools. The student understands that computerized technology is available for design and analysis. The student is expected to:

(A) identify engineering computational tools such as computer-aided design (CAD), finite element analysis (FEA), or computational fluid dynamics (CFD); and

(B) explain the applications of engineering computational tools used in aerospace design.

(12) Mission requirements. The student understands how mission requirements influence the type and form of aircraft. The student is expected to:

(A) analyze a mission to generate a list of atmospheric mission requirements such as payload, range, cruise, take-off length, landing length, climb gradient, altitude, and land or sea;

(B) analyze a mission to generate a list of space mission requirements such as payload, altitude, vibration sensitivity, launch conditions, environmental conditions, and recovery;

(C) explain how the mission requirements are interrelated;

(D) discuss how the mission requirements relate to the aircraft and spacecraft categories;

(E) discuss how mission requirements relate to the overall aircraft design; and

(F) interpret a mission profile and explain how it impacts mission requirements.

(13) Propulsion. The student explains and evaluates different types of propulsion systems such as piston engine, turboprop, jet, and rocket. The student is expected to:

(A) identify and explain how a piston powered aircraft delivers thrust with respect to altitude limits and speed limitations;

(B) identify and explain how a turboprop powered aircraft delivers thrust with respect to design requirements such as cost, operation cost, reliability, power, altitude limits, and speed limitations;

(C) identify and explain how a jet powered aircraft delivers thrust with respect to design requirements such as cost, operation cost, reliability, power, altitude limits, and speed limitations;

(D) explore and explain how a rocket engine is different from a jet engine;

(E) research and discuss the applications for solid-fuel rockets; and

(F) research and discuss the applications for liquid-fuel rockets.

(14) Material selection. The student explains why a particular material is used in an aircraft application, taking into account cost, density, strength, and mission requirements. The student is expected to:

(A) research and discuss material classes used in aerospace design such as woods, composites, metals, and plastics;

(B) explain why specific materials might have been chosen for components on different aircraft;

(C) discuss methods for manufacturing aircraft components such as landing gears, wings, fuselage, or canopies;

(D) explain the impact of material and manufacturing costs on design decisions; and

(E) explain how material requirements relate to mission requirements.

(15) Aerospace structures. The student explains and compares and contrasts types of structures such as truss, semi-monocoque, monocoque. The student is expected to:

(A) identify and discuss truss, semi-monocoque, and monocoque structures;

(B) explain why different structure types are used in various aircraft categories;

(C) discuss how mission requirements impact the selection of the structural types for an aircraft;

(D) identify structural components in the fuselage such as stringers, bulkheads, and skin;

(E) identify structural components in the wings and empennage such as ribs, spars, stringers, and skin; and

(F) compare structures used in atmospheric flight and space flight.

(16) Space flight and orbital mechanics. The student knows properties of orbital mechanics as they relate to space flight and the impact of the space environment on design. The student is expected to:

(A) identify and describe orbits based on the six Keplerian Elements;

(B) explain how changes in Keplerian Elements change the orbit;

(C) explain how mission requirements determine specific orbit types;

(D) describe the unique environmental conditions of operating in space for human or autonomous missions;

(E) research and discuss methods to reach and recover a spacecraft from space; and

(F) research and discuss emerging trends in space flight.

(17) Alternate applications for aerospace design. The student examines alternate applications for aerospace design in various industries, including the automotive, naval, and other commercial industries. The student is expected to:

(A) research and discuss how aerospace engineers contribute to automotive and naval applications to improve performance;

(B) research and identify commercial applications for aerospace design such as heating and cooling systems, building design, and wind turbines; and

(C) identify and discuss items at home that are impacted by aerodynamics such as fans, convection ovens, and heating and cooling systems.

(18) Aircraft systems. The student explores and discusses other aircraft systems such as navigation, communication, entertainment, flight control, actuation, energy storage and management, and propulsion. The student is expected to:

(A) explain basic functionality for aircraft systems such as navigation, communication, entertainment, flight control, and propulsion; and

(B) research and discuss different implementations for aircraft systems such as navigation, communication, entertainment, flight control, and propulsion.

§127.414. Aerospace Design II (Two Credits), Adopted 2025.

(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 Grades 11 and 12. Prerequisites: Geometry and Aerospace Design I. Students shall be awarded two credits 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) Students enrolled in Aerospace Design II demonstrate knowledge and skills associated with the design and prototyping of aerospace systems. Through aerospace projects, students apply fundamental concepts such as managing an engineering project to meet mission requirements, prototyping, testing, and validating requirements. Students explore choices made for propulsion, material, and structural design as well as various ways aircraft can navigate. Emphasis is placed on team collaboration and professional documentation.

(4) 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.

(5) 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.

(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.

(2) The student understands how to implement an engineering design process to develop a product or solution. The student is expected to:

(A) describe and implement the stages of an engineering design process to construct a model;

(B) explain how factors, including complexity, scope, resources, ethics, regulations, manufacturability, maintainability, and technology, impact stages of the engineering design process;

(C) explain how stakeholders impact an engineering design process; and

(D) analyze how failure is often an essential component of the engineering design process.

(3) The student explores the methods and aspects of project management in relation to projects. The student is expected to:

(A) research and explain the process and phases of project management, including initiating, planning, executing, and closing;

(B) explain the roles and responsibilities of team members, including project managers and leads;

(C) research and evaluate methods and tools available for managing a project;

(D) discuss the importance of developing and implementing a system for the organization of project documentation such as file naming conventions, document release control, and version control;

(E) describe how project requirements, constraints, and deliverables impact the project schedule and influence and are influenced by an engineering design;

(F) explain how a project budget, including materials, equipment, and labor, is developed and maintained; and

(G) describe the importance of management of change (MOC) and how MOC applies to project planning.

(4) Collaboration. The student engages in multiple team projects and activities. The student is expected to:

(A) explain and apply sensemaking skills such as recognizing team members who require additional clarity and addressing team members to provide clarity;

(B) apply methods such as Gantt charts, work breakdown structure, Agile, and critical path method to structure a project;

(C) apply principles of critique within the team such as describing, analyzing, interpreting, and evaluating;

(D) develop and present action plans to positively support the team's work relationships;

(E) explain and model how to provide an effective critique of team members on topics such as team performance, test performance, project development, or presentation;

(F) explain and model how to provide an effective critique of other teams on topics such as presentation, problem definition, schedule, and solution justification;

(G) analyze and evaluate critique received from team members and other teams; and

(H) develop a design review presentation to provide status and solicit feedback on the design problem and solution.

(5) Documentation. The student documents information and interpretation developed throughout engineering processes. The student is expected to:

(A) generate documents such as executive summaries, reverse engineering forms, test reports, failure documents, system black box models, engineering notebooks, and drawing packages by applying professional standards and templates;

(B) select the appropriate document format for the information being communicated based on the audience;

(C) explain and justify the structure and sequence of how the information is presented in the engineering documents;

(D) create assembly and user manuals for peer review; and

(E) generate a final design report that focuses on the project scope and solution with appendices to capture all relevant design information such as the design process used, requirements compliance matrix, concept reports, and test reports.

(6) Designing to mission requirements. The student generates conceptual aircraft solutions to meet a set of given requirements. The student is expected to:

(A) analyze given mission requirements such as altitude, speed, and payload to derive sub-requirements;

(B) generate and document additional sub-requirements for the mission considering various factors such as maintainability, producibility, operational cost, and safety;

(C) generate and document conceptual aircraft solutions to address mission and sub-requirements;

(D) classify the generated conceptual aircraft solutions into appropriate categories such as single-engine land (SEL), gyroplane, powered-lift, and glider using the Federal Aviation Agency (FAA) classification system;

(E) select, justify, and document a conceptual solution that addresses the mission and sub-requirements; and

(F) create a model such as a graph or matrix that displays the relationships between the documented requirements.

(7) Managing aerospace engineering projects. The student applies project management techniques to aerospace projects. The student is expected to:

(A) generate a project plan that includes time, deliverable, and cost estimates;

(B) review and update periodically a project plan according to a stage gate process;

(C) document and execute test plans to evaluate prototypes against requirements;

(D) justify and present design choices through periodic design reviews; and

(E) generate a final design report with an executive summary, a body with problem and solution descriptions, and appendices with additional relevant information such as the design process used, requirements compliance matrix, concept reports, and test reports.

(8) Prototyping aerospace vehicles. The student creates a prototype to address a set of mission requirements. The student is expected to:

(A) generate a list of design parameters based on the mission and sub-requirements;

(B) generate and document design concepts to address design parameters;

(C) use appropriate tools such as decision matrices, pro-con lists, and pair-wise comparison to evaluate, downselect, and justify design concepts to prototype;

(D) create and document prototypes to test, validate, and modify design concepts;

(E) use appropriate tools such as decision matrices, pro-con lists, and pair-wise comparison to evaluate, downselect, and justify a prototype to develop as the solution;

(F) evaluate a prototype to identify areas of improvement for iteration;

(G) test, evaluate, and document performance of the revised prototype in meeting project requirements; and

(H) compose and present a project debrief, including lessons learned.

(9) Atmospheric flight. The student relates the three axes of an aircraft, the four forces of flight, and the components used for stability and control. The student is expected to:

(A) research and discuss ways to control motion about the three axes;

(B) calculate and explain changes in motion due to the four forces acting on aircraft during flight;

(C) explain why loads acting on aircraft change during different flight scenarios;

(D) draw and calculate the forces of flight for a straight and level flight and a level banked turn; and

(E) describe which aircraft components control and provide stability with respect to the six degrees of freedom.

(10) Lift and drag. The student explains how lift and drag are generated by an aircraft and how they change during flight. The student is expected to:

(A) explain the lift equation and illustrate the relationships between its variables;

(B) explain the drag equation and illustrate the relationships between its variables;

(C) calculate the changes to lift and drag based on changes to atmospheric conditions such as temperature, density, and pressure;

(D) describe how aircraft control surfaces, including leading edge flaps, trailing edge flaps, ailerons, and spoilers, influence lift;

(E) describe how aircraft control surfaces, including leading edge flaps, trailing edge flaps, ailerons, and spoilers, influence drag;

(F) define and discuss how the stall angle and stall speed can be changed; and

(G) research and present contemporary developments reducing drag such as winglets, boundary layer control, and surface effects.

(11) Weight and balance. The student recognizes that components have mass, weight, and location resulting in moments that are balanced by control surfaces. The student is expected to:

(A) calculate an aircraft's estimated center of gravity throughout a mission profile considering factors such as fuel consumption, payload, and passengers;

(B) estimate the location of an aircraft's center of pressure;

(C) calculate the static margin throughout a flight profile to verify positive stability margin;

(D) generate and document solutions to improve positive static stability in the event of a negative stability margin; and

(E) revise and document static margin calculations reflecting proposed solutions.

(12) Propulsion. The student evaluates various propulsion solutions to downselect the solutions to meet mission requirements. The student is expected to:

(A) evaluate and select a propulsion solution that meets requirements such as piston, jet, turboprop, and rocket;

(B) evaluate and select the number of engines to meet mission and sub-requirements; and

(C) calculate propulsion weight of the selected solution to meet mission and sub-requirements.

(13) Material selection. The student evaluates various materials to meet mission and sub-requirements. The student is expected to:

(A) analyze component material requirements to select materials that meets mission and sub-requirements; and

(B) document the justification for the materials selected to meet component requirements.

(14) Aerospace structures. The student evaluates and selects structure types to meet mission and sub-requirements. The student is expected to:

(A) analyze structural requirements to select structure types that meets mission and sub-requirements; and

(B) document the justification for the structure types selected to meet structural requirements.

(15) Navigation. The student defines and explains types of navigation used for flight. The student is expected to:

(A) explain dead reckoning navigation using an aeronautical chart, compass, clock, and airspeed indicator;

(B) explain navigation using radio radials such as Automatic Direction Finder (ADF) and VHF Omnidirectional Range (VOR);

(C) explain navigation using an Inertial Navigation System (INS); and

(D) explain navigation using Global Positioning Systems (GPS).

§127.415. Civil Engineering I (One Credit), Adopted 2025.

(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)(1) of this chapter (relating to Career and Technical Education Employability Skills) as an integral part of this course.

(b) General requirements. Prerequisite: Algebra I and Introduction to Computer-Aided Design and Drafting or Principles of Applied Engineering. Recommended prerequisite: Geometry. 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) Students in Civil Engineering I are introduced to the basic principles and practices essential to the field of civil engineering. Throughout this course students investigate different career paths in civil engineering, explore the various specializations within the field, and understand the phases and life cycle of civil engineering projects. They also delve into the functional mathematics crucial to the profession. Additionally, the course emphasizes the importance of effective project document structure and project management, ethical considerations, and the impact of civil engineering on the natural and built environment.

(4) 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.

(5) 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.

(1) The student understands that there are different stages of the engineering design process and the importance of working through each stage as part of an iterative process. The student is expected to:

(A) explain the importance of defining an engineering problem as an initial step in the engineering design process;

(B) describe the research stage of the engineering design process;

(C) define ideation and conceptualization and discuss the role these processes play in innovation and problem solving;

(D) explain the processes of selecting an idea or concept for detailed prototype design, development, and testing;

(E) describe the purpose of non-technical drawings, technical drawings, models, and prototypes in designing a solution to an engineering problem;

(F) describe the process of relevant experimental design, conducting tests, collecting data, and analyzing data to evaluate potential solutions;

(G) explain how the engineering design process is iterative and the role reflection plays in developing an optimized engineering solution; and

(H) describe the purpose of effective communication of the engineering solution as obtained through the engineering design process to various audiences.

(2) Students explore and develop skills to solve problems, make decisions, and manage a project. The student is expected to:

(A) discuss strategies for managing time, setting deadlines, and prioritizing to accomplish goals;

(B) identify constraints and describe the importance of planning around constraints, including budgets, resources, and materials;

(C) define milestones and deliverables and explain the advantages of dividing a large project into smaller milestones and deliverables;

(D) identify different types of communication and explain how different types of communication lead to successful teamwork on a shared project in a professional setting; and

(E) identify strategies to solve problems and describe how problem solving is utilized to accomplish personal and team objectives.

(3) The student understands the foundations of occupational safety and health. The student is expected to:

(A) explain and discuss the responsibilities of workers and employers to promote safety and health in the workplace and the rights of workers to a secure workplace;

(B) explain and discuss the importance of Occupational Safety and Health Administration (OSHA) standards and OSHA requirements for organizations, how OSHA inspections are conducted, and the role of national and state regulatory entities;

(C) explain the role industrial hygiene plays in occupational safety and explain various types of industrial hygiene hazards, including physical, chemical, biological, and ergonomic;

(D) identify and explain the appropriate use of types of personal protective equipment used in industry;

(E) discuss the importance of safe walking and working surfaces in the workplace and best practices for preventing or reducing slips, trips, and falls in the workplace;

(F) describe types of electrical hazards in the workplace and the risks associated with these hazards and describe control methods to prevent electrical hazards in the workplace;

(G) analyze the hazards of handling, storing, using, and transporting hazardous materials and identify and discuss ways to reduce exposure to hazardous materials in the workplace;

(H) identify workplace health and safety resources, including emergency plans and Safety Data Sheets, and discuss how these resources are used to make decisions in the workplace;

(I) describe the elements of a safety and health program, including management leadership, worker participation, and education and training;

(J) explain the purpose and importance of written emergency action plans and fire protection plans and describe key components of each such as evacuation plans and emergency exit routes, list of fire hazards, and identification of emergency personnel;

(K) explain the components of a hazard communication program; and

(L) explain and give examples of safety and health training requirements specified by standard setting organizations.

(4) The student investigates different career paths in civil engineering. The student is expected to:

(A) explain the licensing requirements for an engineer in training and a professional engineer;

(B) identify various career options related to civil engineering such as surveyors, architects, construction contractors, urban and regional planners, inspectors, and regulators;

(C) identify and explain the requirements to obtain professional credentials such as certified flood plain manager (CFM), project management professional (PMP), professional engineer (PE), Autodesk certifications, SolidWorks certifications, certified surveying technician (CST), registered professional land surveyor (RPLS), certified quality engineer (CQE), and certified quality inspector (CQI) associated with civil engineering; and

(D) describe sub-disciplines within civil engineering, including water resources, environmental, geotechnical, structural, transportation, material sciences, coastal, land development, urban development, and infrastructure.

(5) The student examines the functional mathematics used in civil engineering. The student is expected to:

(A) calculate the mean, median, and mode of a given data set;

(B) calculate the standard deviation of a given data set;

(C) identify parts of a normal distribution curve;

(D) define the Empirical Rule and analyze the distribution of a data set using the Empirical Rule;

(E) define systematic, gross, and random error;

(F) define accuracy and precision in a data set;

(G) analyze the accuracy and precision of a data set;

(H) identify the types and properties of various polygons;

(I) solve for the parts of a triangle using the Pythagorean theorem, the law of sines, and the law of cosines;

(J) identify the properties of circles;

(K) solve for the measurements of a circle, including diameter, radius, circumference, area, chord, arclength, delta, and tangent;

(L) solve linear functions on a Cartesian Coordinate System using standard form, slope-intercept form, point-slope form, and the distance between two points; and

(M) calculate the volumes of three-dimensional shapes such as cylinders, spheres, and trapezoidal and triangular prisms.

(6) The student understands methods of measurement and associated errors. The student is expected to:

(A) define units of linear measurement, including U.S. survey feet, international feet, chains, rods, miles, fathoms, furlongs, varas, and other metric units commonly used in the surveying and civil engineering industry;

(B) define the different units of angular measurement, including vertical angles, horizontal angles, bearings, azimuths, degrees-minutes-seconds, decimal degrees, seconds of arc, and gradians;

(C) define the different units of volumetric measurement, including cubic feet, cubic yards, tons, and acre-feet;

(D) calculate and define area measurements such as acre, hectare, square feet, square mile, league, or sitio;

(E) convert linear, angular, and area measurements between different units;

(F) determine a change in elevation between two or more points by performing a differential level loop;

(G) measure the distance between two points on a plane using methods such as taping, electronic distance meter, total station, pacing, odometer, tacheometry, and stadia;

(H) compare the errors from two or more methods of calculating distance between two points such as comparing pacing and taping; and

(I) identify and analyze various types of errors associated with survey data.

(7) The student researches civil engineering throughout history. The student is expected to:

(A) describe the significance and development of historic civil engineering projects such as the Panama Canal, Roman aqueducts, and Hadrian's wall;

(B) describe the significance and development of a major Texas civil engineering project; and

(C) describe the significance and development of a major U.S. civil engineering project.

(8) The student understands a civil engineering project life cycle. The student is expected to:

(A) explain the civil engineering project conception, scope, proposal, contract, design planning and development, construction documents, bid and specifications, construction, and closeout phase; and

(B) identify and sequence the phases of a project life cycle.

(9) The student understands and develops a civil engineering project scope of work and proposal. The student is expected to:

(A) identify and describe the importance of potential components in a feasibility report, including soil analysis, existing land entitlements, existing topography, federal emergency management agency (FEMA) floodplain location and elevation, existing utility and locations, environmental studies, and adjacent rights-of-way;

(B) identify and quantify costs and benefits associated with a proposed civil engineering project, including initial investments, operational expenses, and anticipated returns;

(C) conduct a cost-benefit analysis for a small civil engineering project;

(D) identify common risks associated with civil engineering projects, including technical, financial, environmental, and regulatory risks;

(E) describe methodologies for conducting risk analysis such as probability assessment, impact analysis, and risk prioritization;

(F) develop a feasibility report for a small civil engineering project;

(G) explain the purpose of a request for qualifications (RFQ);

(H) evaluate RFQs based on a project's scope;

(I) identify relevant codes and regulations impacting civil engineering projects;

(J) define the fundamental components of a scope of work document, including project description, stakeholders, objectives, deliverables, scope exclusions, milestones, schedule, and signature block; and

(K) develop a scope of work document for a small civil engineering project.

(10) The student understands and develops the components of civil engineering designs. The student is expected to:

(A) identify various conceptual schematic design drawings, sketches, and diagrams that explore design solutions and communicate design concepts;

(B) generate a conceptual schematic design drawing, sketch, or diagram that effectively communicates a design concept;

(C) explain the purpose and application of common civil engineering calculations such as superelevation, flow line, beam analysis, cost amortization, materials testing, plasticity index, and differential leveling;

(D) evaluate engineering plans and specifications using quality control and quality assurance (QCQA) processes; and

(E) prepare a design quantity take-off and estimate of probable construction cost.

(11) The student researches the use and application of technology in civil engineering. The student is expected to:

(A) identify the tools and technology used in civil engineering throughout history such as abacus, compass, scale, measuring tape, slide rule, calculator, computer-aided drafting and design, level, auto-level, grade rod, plumb bob, transit, theodolite, total station, GPS, lidar, and drones;

(B) explain the evolution of technology used in civil engineering; and

(C) explain the uses of design analysis and computer-aided drafting software.

(12) The student understands and researches the components of project closeout processes. The student is expected to:

(A) identify the main stakeholders involved in final inspections such as owner, utility provider(s), designer(s), contractors, municipalities, and regulatory agencies;

(B) develop a punch list that is organized by trade, area, or priority and identifies deficiencies in a substantially completed project; and

(C) evaluate the completed project to identify project successes and deficiencies.

(13) The student understands and navigates civil engineering construction documents. The student is expected to:

(A) identify the sections of a construction document set, including plat, existing conditions, site plan, fire protection plan, dimensional control plan, grading plan, drainage plan, utility plan, paving plan, erosion control plan, and project detail sheets;

(B) research and describe the purpose of a fire protection plan;

(C) describe the components of a paving plan, including pavement sections, material types, and design details;

(D) identify and locate construction specification documents relevant to a given project;

(E) explain and locate the fundamental components of a construction document's legend, including symbols, line types, and typical abbreviations;

(F) explain the process of drafting a construction document to scale;

(G) determine and demonstrate which scale best fits a standard size drawing sheet;

(H) explain the relationship between a construction document's specifications, plans, legend, and scale; and

(I) identify and explain the differences between design drawings and record drawings.

(14) The student applies best practices for effective project document structure and management. The student is expected to:

(A) explain the significance of systematic organizational structure for project documents;

(B) develop a systematic organizational structure for project documents that considers factors such as project phase, discipline, and document type;

(C) develop a consistent naming convention for project documents; and

(D) implement and maintain a uniform naming convention for project documents.

(15) The student describes and exhibits characteristics that lead to a successful civil engineering team. The student is expected to:

(A) research and describe time management techniques such as using Gantt charts, schedules, critical paths, and man-power projections for project management;

(B) demonstrate effective communication skills in written and oral formats to facilitate collaboration in a project team; and

(C) explain how project team dynamics impact project outcomes and member morale.

(16) The student researches and describes ethics pertaining to civil engineering. The student is expected to:

(A) research and identify the fundamental engineering ethics established by the Texas Board of Professional Engineers and Land Surveyors; and

(B) analyze root causes and lessons learned from historical examples or case studies involving ethical misconduct in civil engineering projects.

(17) The student explores the impact of engineering in the natural world and built environment. The student is expected to:

(A) describe the potential impacts, costs, and benefits of sustainable practices on local and global communities, environments, and economies;

(B) apply cost-benefit analysis to sustainability standards used throughout the project life cycle to evaluate their economic, environmental, and social trade-offs;

(C) describe governmental agencies that regulate environmental impact at the federal, state, and local level;

(D) describe the potential impacts of construction on the natural world, including flora, fauna, groundwater, surface water, soil, Earth's atmosphere, air quality, and waterways; and

(E) describe methods used by engineers to mitigate and remediate the effects of construction on the natural world.

(18) The student understands the methods environmental engineers use to supply water, dispose of waste, and control pollution. The student is expected to:

(A) describe methods of population projection for sizing water and wastewater facilities;

(B) describe water quality standards using prescribed units of measure;

(C) research and explain regulations for water quantity design requirements by jurisdiction;

(D) research and explain regulations for wastewater quantity design requirements by jurisdiction;

(E) research and describe methods of water and wastewater treatment;

(F) research and describe methods of solid waste management;

(G) research and describe methods of controlling hazardous waste; and

(H) research and describe methods of measuring and managing air quality.

§127.416. Civil Engineering II (Two Credits), Adopted 2025.

(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 Grades 11 and 12. Prerequisites: Geometry and Civil Engineering I. Recommended prerequisite: Introduction to Computer-Aided Design and Drafting. Students shall be awarded two credits 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) Students in Civil Engineering II apply the principles and practices essential to various subdisciplines within civil engineering. Throughout this course, students develop knowledge and skills essential to the design development and construction of a civil engineering project. The students explore the impacts and constraints on the design of a project. They also delve into the functional mathematics crucial to the profession. Additionally, the course emphasizes the importance of effective project document structure and project management, ethical considerations, and the impact of civil engineering on the natural and built environment.

(4) 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.

(5) 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.

(1) The student understands how to implement an engineering design process to develop a product or solution. The student is expected to:

(A) describe and implement the stages of an engineering design process to construct a model;

(B) explain how factors, including complexity, scope, resources, ethics, regulations, manufacturability, maintainability, and technology, impact stages of the engineering design process;

(C) explain how stakeholders impact an engineering design process; and

(D) analyze how failure is often an essential component of the engineering design process.

(2) The student explores the methods and aspects of project management in relation to projects. The student is expected to:

(A) research and explain the process and phases of project management, including initiating, planning, executing, and closing;

(B) explain the roles and responsibilities of team members, including project managers and leads;

(C) research and evaluate methods and tools available for managing a project;

(D) discuss the importance of developing and implementing a system for the organization of project documentation such as file naming conventions, document release control, and version control;

(E) describe how project requirements, constraints, and deliverables impact the project schedule and influence an engineering design;

(F) explain how a project budget, including materials, equipment, and labor, is developed and maintained; and

(G) describe the importance of management of change (MOC) and how MOC applies to project planning.

(3) The student recognizes project stakeholders and industry organizations in civil engineering. The student is expected to:

(A) describe the roles and objectives of project stakeholders, including engineer, owner, architect, contractor, subcontractors, project manager, end users, regulatory agencies, and the public; and

(B) describe the mission and membership benefits of industry organizations such as the American Society of Civil Engineers, the National Society of Professional Engineers, and the Society of Women Engineers.

(4) The student explores various disciplines within civil engineering. The student is expected to:

(A) describe the essential technical knowledge and functions in a variety of civil engineering subdisciplines, including environmental, geotechnical, transportation, structural, water resources, and construction;

(B) explain how different types of projects within civil engineering subdisciplines, including public works, transportation, urban development, water resources, and utility projects, impact the built environment; and

(C) identify and describe types of civil engineering projects.

(5) The student explores how codes, regulations, and plats impact a civil engineering project. The student is expected to:

(A) research and describe regulations established by the American Disabilities Act relevant to site design;

(B) identify local codes and regulations for a civil engineering project;

(C) describe the potential impacts of local codes and regulations on civil engineering projects; and

(D) describe the purpose of a plat and easements for a civil engineering project.

(6) The student develops a proposal for a civil engineering project such as a park, a parking lot, or a storm drain. The student is expected to:

(A) analyze or develop a feasibility report for a civil engineering project;

(B) develop and analyze the scope of work document for a civil engineering project;

(C) calculate monetary value for engineering efforts on a given project;

(D) revise and archive the draft project proposal for scope of work changes;

(E) develop a client deliverable package that contains a fee proposal, project schedule, organizational chart, exclusions, and an engineering contract;

(F) communicate effectively a final proposal for a civil engineering project; and

(G) identify and evaluate lessons learned from the project proposal process.

(7) The student develops a civil engineering project schedule. The student is expected to:

(A) identify and prioritize project tasks to determine the critical path of a project;

(B) create a project critical path diagram;

(C) evaluate project tasks and the critical path to develop a project schedule;

(D) create a Gantt chart for all the project activities in a project; and

(E) assess a project schedule for opportunities to improve project efficiencies.

(8) The student develops a civil engineering design for a project site. The student is expected to:

(A) create a concept site plan using existing schematics, survey data, and regulatory design manuals;

(B) identify existing and proposed utility providers, including electric, water, sewer, gas, and telecommunications providers, at a project site;

(C) research and identify existing plats and easements for a project site; and

(D) revise and finalize a project site plan to reflect analyzed site data, including utilities, geotechnical, right-of-way, water resources, environmental, survey, and transportation data.

(9) The student explores concepts and calculations for storm water events used by water resources engineers. The student is expected to:

(A) describe storm event probability based on historical models;

(B) describe methods used, including Rational method, Natural Resources Conservation Service (NRCS), Soil Conservation Service (SCS), and unit hydrograph, to calculate flow rate;

(C) analyze existing topography at the project site to determine drainage patterns;

(D) delineate existing and proposed drainage areas impacting a project site to determine the change in stormwater runoff generated by a project design;

(E) research and describe methods of stormwater mitigation and water quality treatment;

(F) calculate the existing flow rates for a 5-year and a 100-year storm event for a project site using the Rational method;

(G) analyze and calculate the proposed flow rates for a 5-year and a 100-year storm event for a project design;

(H) determine the required stormwater remediation techniques for a 100-year storm event by comparing existing and proposed runoff quantities;

(I) describe methods of stormwater conveyance, including channel, culvert, and pipe;

(J) calculate the hydraulics of a stormwater conveyance using the continuity equation, energy equation, and Bernoulli's equation;

(K) design a conveyance system such as a pipe, culvert, or open channel to convey stormwater runoff for a 100-year storm event using the calculated data;

(L) create a plan and profile sheet of a drainage system, including surface elevations, slopes, conveyance system dimensions, material, and pipe invert elevations; and

(M) describe potential impacts of a drainage analysis for a project.

(10) The student explores concepts and calculations used by geotechnical engineers. The student is expected to:

(A) identify and explain the components of a geotechnical report, including boring samples and logs, soil types and classifications, pavement recommendations, foundations recommendations, and soil preparations;

(B) identify and determine the soil classifications at a project site using the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey (WSS);

(C) calculate the plasticity index of soil from a project site;

(D) research and describe methods of soil preparation;

(E) research and explain how geotechnical results impact pavement recommendations used in civil engineering projects;

(F) research and select the most effective pavement section for a project; and

(G) describe the impact of a geotechnical analysis for a project.

(11) The student explores concepts and calculations used by structural engineers. The student is expected to:

(A) identify and analyze the various types of building foundations, including raft, monolithic slab, slab on grade, pier and beam, spread footing, mat footing, drilled piers, pylons, waffle slab, and post-tension slab;

(B) describe the forces common to structural engineering calculations, including gravity, tension, compression, flexure, and torsion;

(C) describe the loads common to structural engineering calculations, including dead load, live load, environmental loads, and other loads such as lateral and concentrated loads;

(D) diagram and explain how applied loads and forces are resisted in a structure and transferred to the Earth;

(E) diagram a simply supported beam subjected to loading conditions to determine reaction forces;

(F) sketch diagrams to determine the maximum shear and moment resulting in the beam;

(G) identify the different types of trusses, including simple, planar, and space frame trusses;

(H) diagram a truss subjected to loading conditions to determine reaction forces and identify the zero force members;

(I) explain why design loads are dictated by building codes; and

(J) describe potential impacts of a structural analysis for a project.

(12) The student explores concepts and calculations used by transportation engineers. The student is expected to:

(A) identify and describe various types of transportation engineering specializations such as rail, aviation, roadway, highway, and marine;

(B) research and explain the benefits of having a professional transportation engineering certification;

(C) research and explain the benefits of membership in a transportation engineering organization such as Institute for Transportation Engineers (ITE), American Society of Highway Engineers (ASHE), American Association of State Highway and Transportation Officials (AASHTO), and WTS International;

(D) determine stopping sight distance of a roadway given the design speed and grade;

(E) research and describe the impacts of transportation design elements, including grades, superelevation, design speed, friction factor, lane widths, vertical curves, horizontal curves, roadway classification, acceleration, and deceleration;

(F) analyze the level of service of a roadway to determine if operating conditions are adequate;

(G) identify and explain the components of a traffic impact analysis (TIA), including data collection summary, trip analysis, turn lane analysis, project phasing, and sight visibility analysis;

(H) research and identify methods of traffic data collection;

(I) collect and calculate traffic count data at a project site and analyze the results of the traffic count to determine peak hour trips and traffic mitigation;

(J) determine the peak hour trips generated by a given land use from a ITE Trip Generation Manual;

(K) research and describe traffic level of service for various roadways;

(L) determine if a turn lane is warranted based on peak hour trips and traffic volume; and

(M) describe potential impacts of a transportation analysis for a project.

(13) The student develops construction documents for a civil engineering project. The student is expected to:

(A) develop project construction documents that includes design plans, specifications, and a cost estimate for a civil engineering project;

(B) develop the analysis reports for a civil engineering project;

(C) generate a demolition sheet that contains existing topography, property lines, easements, utilities, rights-of-way, drainage infrastructure, and structures, and identifies items to be demolished;

(D) develop a fire protection plan for a project;

(E) generate a paving plan that shows the limits and types of pavement necessary for a project;

(F) generate a site plan that labels proposed improvements for a project;

(G) generate a site dimensional control plan containing measurements for all site improvements for a project;

(H) generate a grading plan that documents proposed elevations and topography in comparison to existing topography for a project;

(I) generate drainage plans that document the existing drainage patterns, proposed drainage plan, and drainage infrastructure for a project;

(J) generate a utility plan that documents existing and proposed utility types, locations, and materials for a project;

(K) generate an erosion control plan that identifies erosion control best management practices (BMP) defined by the Texas Commission on Environmental Quality (TCEQ) for a project; and

(L) explain the importance of a quality control review and complete a quality control review of the construction documents of the project.

(14) The student develops documents for support of the construction bid. The student is expected to:

(A) identify components of a bid tabulation, including item description, material quantity, unit measure, unit price, and total price;

(B) compare a project bid tabulation with corresponding construction documents to verify all items are included;

(C) create a project bid tabulation; and

(D) identify and compile the parts of civil engineering project manual.

(15) The student works as an individual and a team member to complete projects. The student is expected to:

(A) track team goals to verify completion of project milestones;

(B) explain various methods to resolve conflict within a project team;

(C) explain how leadership impacts project outcomes and team members; and

(D) evaluate team member performance and effectiveness in a project.

(16) The student researches and understands the code of ethics pertaining to civil engineering. The student is expected to:

(A) research and describe the impact of the State of Texas Engineering Practice Act; and

(B) analyze and discuss ethical case studies using Texas Administrative Code, Title 22, Part 6, Chapter 137, Subchapter C (relating to Professional Conduct and Ethics).

(17) The student understands the fundamental sustainable design approaches and practices in civil engineering projects. The student is expected to:

(A) research and describe sustainable building materials and methods;

(B) identify and explain the programs and certifications that establish design criteria for engineering projects such as Leadership in Energy and Environmental Design (LEED);

(C) explain how sustainable programs and certifications potentially impact the design elements and costs of a project;

(D) explain how design choices potentially impact human health, the environment, and the cost of a project; and

(E) explain how elements of the construction process potentially impact human health and the environment.

§127.417. Engineering Project Management (One Credit), Adopted 2025.

(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)(1) 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 Grades 10-12. Prerequisite: Algebra I. Recommended prerequisite: English II. 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) Students enrolled in Engineering Project Management develop cursory knowledge and essential skills to lead an engineering team through the development and construction of a project. Students assess project documentation for compliance with best management practices. They engage in project planning, risk management, team management, and stakeholder communication to ensure project completion, adherence to safety guidelines, and continuous improvement.

(4) 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.

(5) 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.

(1) The student discusses ethics pertaining to engineering. The student is expected to identify and discuss the importance of professionalism, standards of conduct, and ethics as defined by the Texas Engineering Practice Act and rules concerning the practice of engineering and surveying.

(2) The student understands that there are different stages of the engineering design process and the importance of working through each stage as part of an iterative process. The student is expected to:

(A) explain the importance of defining an engineering problem as an initial step in the engineering design process;

(B) describe the research stage of the engineering design process;

(C) define ideation and conceptualization and discuss the role these processes play in innovation and problem solving;

(D) explain the processes of selecting an idea or concept for detailed prototype design, development, and testing;

(E) describe the purpose of non-technical drawings, technical drawings, models, and prototypes in designing a solution to an engineering problem;

(F) describe the process of relevant experimental design, conducting tests, collecting data, and analyzing data to evaluate potential solutions;

(G) explain how the engineering design process is iterative and the role reflection plays in developing an optimized engineering solution; and

(H) describe the purpose of effective communication of the engineering solution as obtained through the engineering design process to various audiences.

(3) The student explores and develops skills to solve problems, make decisions, and manage a project. The student is expected to:

(A) discuss strategies for managing time, setting deadlines, and prioritizing to accomplish goals;

(B) identify constraints and describe the importance of planning around constraints, including budgets, resources, and materials;

(C) define milestones and deliverables and explain the advantages of dividing a large project into smaller milestones and deliverables;

(D) identify different types of communication and explain how different types of communication lead to successful teamwork on a shared project in a professional setting; and

(E) identify strategies to solve problems and describe how problem solving is utilized to accomplish personal and team objectives.

(4) The student understands the foundations of occupational safety and health. The student is expected to:

(A) explain and discuss the responsibilities of workers and employers to promote safety and health in the workplace and the rights of workers to a secure workplace;

(B) explain and discuss the importance of Occupational Safety and Health Administration (OSHA) standards and OSHA requirements for organizations, how OSHA inspections are conducted, and the role of national and state regulatory entities;

(C) explain the role industrial hygiene plays in occupational safety and explain various types of industrial hygiene hazards, including physical, chemical, biological, and ergonomic;

(D) identify and explain the appropriate use of types of personal protective equipment used in industry;

(E) discuss the importance of safe walking and working surfaces in the workplace and best practices for preventing or reducing slips, trips, and falls in the workplace;

(F) describe types of electrical hazards in the workplace and the risks associated with these hazards and describe control methods to prevent electrical hazards in the workplace;

(G) analyze the hazards of handling, storing, using, and transporting hazardous materials and identify and discuss ways to reduce exposure to hazardous materials in the workplace;

(H) identify workplace health and safety resources, including emergency plans and Safety Data Sheets, and discuss how these resources are used to make decisions in the workplace;

(I) describe the elements of a safety and health program, including management leadership, worker participation, and education and training;

(J) explain the purpose and importance of written emergency action plans and fire protection plans and describe key components of each such as evacuation plans and emergency exit routes, list of fire hazards, and identification of emergency personnel;

(K) explain the components of a hazard communication program; and

(L) explain and give examples of safety and health training requirements specified by standard setting organizations.

(5) The student explores the methods and aspects of project management in relation to engineering projects. The student is expected to:

(A) identify and prioritize engineering tasks for an engineering project plan;

(B) identify and outline the critical path of a set of tasks in an engineering project;

(C) develop a project budget based on billable hours and engineering tasks in a project;

(D) track and maintain time spent on engineering tasks for a given project;

(E) generate a Gantt chart for an engineering project, including project tasks, time to complete tasks, critical path, and schedule of tasks;

(F) develop and implement a systematic folder structure for organizing project documents considering factors such as project phase, discipline, and document type;

(G) apply naming conventions consistently to all project documents to facilitate efficient identification and retrieval;

(H) research and describe best management practices such as quality control and quality assurance, risk management, and project management plan for an engineering project;

(I) evaluate an engineering project for adherence to local, state, and federal regulations;

(J) evaluate an engineering project for adherence to best management practices; and

(K) evaluate an engineering project for implementation of sustainable practices.

(6) The student explores processes involved in the construction phase of an engineering project. The student is expected to:

(A) identify parts of an engineering project manual associated with a construction bid, including bid schedule, bid tabulation, construction plan set, and material specifications;

(B) explain the bid process for a project, including timeline, value engineering, request for information (RFI), request for qualifications (RFQ), request for price (RFP), interview process, bid opening, bid evaluations, and bid award;

(C) develop a quantity take-off for an engineering project; and

(D) identify applicable materials based on the engineering project specifications to conduct a material quantity take-off.

(7) The student researches and identifies methods and divisions of project documentation. The student is expected to:

(A) compare shop drawings and construction documents to identify and rectify variances;

(B) identify and justify applicable material specifications for a given project;

(C) compile and organize material specifications to create a submittal log;

(D) analyze a construction drawing to develop applicable design questions and create an RFI document;

(E) identify and explain the permitting process for an engineering project;

(F) identify permitting stakeholders and explain stakeholder roles in the permitting process;

(G) identify permitting entities and create a permit request;

(H) identify and explain the purpose and parts of a change order for a project;

(I) develop a method of documentation to track project changes, including field changes, design changes, and change orders, and analyze cost and schedule impacts of project changes; and

(J) identify and draft applicable completion documents, including certificate of occupancy, temporary certificate of occupancy, field changes, as-built or plan of record documents, and engineer's certification of substantial completion.

(8) The student explores applicable federal, state, and local regulations as they pertain to engineering projects. The student is expected to:

(A) research federal regulatory agencies and describe the role federal regulatory agencies serve in relation to engineering projects such as the Environmental Protection Agency (EPA), Federal Aviation Administration (FAA), and Army Corps of Engineers;

(B) research state regulatory agencies such as the Texas Department of Transportation (TxDOT), Texas Commission on Environmental Quality (TCEQ), and the Texas Railroad Commission (TRC) and describe the role these agencies serve in relation to engineering projects;

(C) research local regulatory agencies such as cities and counties and describe the role local regulatory agencies serve in relation to engineering projects; and

(D) describe local codes and ordinances affecting construction and development activities.

(9) The student explores methods of risk management and the effects on engineering projects. The student is expected to:

(A) identify and describe various methods of risk management related to engineering projects;

(B) identify and analyze the potential risks in a project with respect to the project stakeholders;

(C) develop and communicate a job hazard analysis (JHA) for a given project task;

(D) identify factors of contingency related to an engineering project;

(E) create a contingency estimate analyzing events that can cause potential losses to a project; and

(F) present a risk management plan for a given project.

(10) The student examines components of value engineering practices in relation to an engineering project. The student is expected to:

(A) describe value engineering;

(B) identify and analyze common areas of engineering projects that are susceptible to value engineering;

(C) analyze an existing project design and cost estimate to identify potential cost saving areas;

(D) describe an opinion of probable cost (OPC) associated with an engineering project;

(E) generate an OPC for an engineering project, including construction mobilization, material cost, material quantities, waste disposal, contingency, and total price; and

(F) create a cost-benefit analysis of an engineering project that compares the monetary cost of the project to the benefit to end user.

(11) The student demonstrates effective leadership and communications skills necessary to manage engineering projects. The student is expected to:

(A) identify and describe the various team roles for an engineering project;

(B) research and describe various project management methodologies;

(C) create a schedule of roles for team members in an engineering project;

(D) conduct an effective kick-off meeting to communicate the project management plan for a given engineering project;

(E) evaluate how project team dynamics impact the successful completion of a project;

(F) prepare and document effective meeting agendas;

(G) record, prepare, and distribute clear and accurate meeting minutes;

(H) research and describe effective leadership qualities;

(I) research and identify examples of effective leadership styles;

(J) identify and describe personal leadership styles and strengths; and

(K) evaluate how student leadership styles impact the success of the project team.

§127.418. Architectural Engineering (Two Credits), Adopted 2025.

(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 Grades 11 and 12. Prerequisite: Civil Engineering I. Students shall be awarded two credits 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) Students enrolled in Architectural Engineering use principles of engineering and design tools to create innovative, functional, and sustainable buildings. Students develop cursory knowledge and essential skills to understand the design of buildings, including the mechanical, electrical, plumbing, and structural systems, while also planning the construction process. They engage in project planning, building and system analysis, site investigation, and the integration of sustainable design and construction practices for an architectural engineering project.

(4) 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.

(5) 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.

(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.

(2) The student understands how to implement an engineering design process to develop a product or solution. The student is expected to:

(A) describe and implement the stages of an engineering design process to construct a model;

(B) explain how factors, including complexity, scope, resources, ethics, regulations, manufacturability, maintainability, and technology, impact stages of the engineering design process;

(C) explain how stakeholders impact an engineering design process; and

(D) analyze how failure is often an essential component of the engineering design process.

(3) The student explores the methods and aspects of project management in relation to projects. The student is expected to:

(A) research and explain the process and phases of project management, including initiating, planning, executing, and closing;

(B) explain the roles and responsibilities of team members, including project managers and leads;

(C) research and evaluate methods and tools available for managing a project;

(D) discuss the importance of developing and implementing a system for the organization of project documentation such as file naming conventions, document release control, and version control;

(E) describe how project requirements, constraints, and deliverables impact the project schedule and influence and are influenced by an engineering design;

(F) explain how a project budget, including materials, equipment, and labor, is developed and maintained; and

(G) describe the importance of management of change (MOC) and how MOC applies to project planning.

(4) The student explores the origin and application of basic building types. The student is expected to:

(A) identify and describe the fundamental parts of a building, including foundations, floors, walls, roof, and utility systems;

(B) identify and describe the visual design elements of various building types, including residential, commercial, institutional, and industrial buildings; and

(C) research and describe the evolution of the built space and development of building forms.

(5) The student understands the properties of common building materials and construction methods. The student is expected to:

(A) identify and describe common building materials such as wood, masonry, concrete, metal, glass, aggregate, and plastic;

(B) identify and describe common roofing materials such as thatch, wood, metal, sod, and asphalt;

(C) describe traditional construction methods such as wood framing, tilt-wall, masonry, and steel;

(D) describe contemporary construction methods such as prefabricated, modular, and additive construction (3D printing);

(E) identify and describe standard building methods such as casting, cutting, drilling, driving, and fastening for the construction of buildings;

(F) research and describe resilient building materials, methods, and costs; and

(G) describe how building material selection is impacted influenced by certifications such as Leadership in Energy and Environmental Design (LEED) or Energy Star.

(6) The student understands the application of codes and regulations to building projects. The student is expected to:

(A) explain the purpose of local building codes, including public health and safety, structural, and utility codes;

(B) describe land use regulations to identify zoning ordinances and allowable uses of real property;

(C) describe how zoning regulations are used to control land use and development;

(D) identify standard accessibility features such as ramps, elevators, parking, handrails, and fire alarm horn strobe as specified in codes and regulations such as the American Disability Act (ADA) and the Texas Accessibility Standards (TAS);

(E) explain how codes and building regulations constrain aspects of building design, including the structure, site design, utilities, and building usage;

(F) explain how codes and building regulations constrain aspects of building construction, including the structure, site construction, utilities, and building usage; and

(G) classify a building according to its use type, occupancy, and construction type using the International Building Code.

(7) The student explores the various building systems. The student is expected to:

(A) identify and describe various building envelopes such as tilt-wall, glazing, brick, and Exterior Insulation Finishing System (EIFS);

(B) describe the components of building envelopes, including foundation, walls, wall openings, roofs, roof penetrations, insulation, and building membranes;

(C) research and describe different types of insulating materials;

(D) describe different types of windows and doors;

(E) identify the main components and describe the purpose of mechanical systems within a building, including heating ventilation and air conditioning (HVAC), air handler, boiler, fire protection and suppression, lift, chilled water equipment, and emergency power systems;

(F) describe how programs and certifications such as LEED potentially impact the selection of building systems;

(G) identify the main components and describe the purpose of electrical systems within a building, including meters, panels, lighting, receptacles, transformers, generators, and low-voltage systems; and

(H) identify the main components and describe the purpose of plumbing systems within a building, including meters, main supply lines, branch lines, sewer lines, traps, risers, fire suppression, appurtenances, and fixtures.

(8) The student examines building foundations and structures. The student is expected to:

(A) identify and analyze the various types of building foundations, including slab on grade, pier and beam, spread footing, mat footing, drilled piers, pylons, waffle slab, and post-tension slab;

(B) classify a soil sample according to grain size and plasticity;

(C) calculate the plasticity index of a soil sample;

(D) determine the united soil classification system designation from a site soil sample analysis;

(E) describe the forces common to structural engineering calculations, including gravity, tension, compression, flexure, and torsion;

(F) describe the loads common to structural engineering calculations, including dead load, live load, environmental, and other load paths such as lateral and concentrated;

(G) diagram and explain how applied loads and forces are resisted in a structure and transferred to the Earth;

(H) diagram a simply supported beam subjected to loading conditions to determine reaction forces;

(I) sketch diagrams to determine the maximum shear and moment resulting in the beam;

(J) identify the different types of trusses, including simple, planar, and space frame trusses;

(K) diagram a truss subjected to loading conditions to determine reaction forces and identify the zero force members;

(L) explain why design loads are dictated by building codes;

(M) identify the composition and describe the ratios of ingredients in different concrete mixtures;

(N) describe the purpose of various concrete admixtures, including air entrainer, reducer, retarder, and accelerator;

(O) explain why various admixtures are selected for a project such as curing time, ambient climate, and permeability;

(P) conduct concrete compression and splitting-tension tests and compare strength and failures in a concrete mixture; and

(Q) analyze a concrete mixture by performing a slump test.

(9) The student designs and develops plans for the building systems. The student is expected to:

(A) develop a stormwater management system for a building that includes roof drainage calculations, roof drain design, and downspout sizing and location;

(B) design ingress and egress for a building that complies with local, state, and federal codes and regulations;

(C) develop building design and engineering plans that incorporate energy conservation techniques;

(D) recommend and defend an appropriate foundation design for a building type;

(E) design, modify, and plan structures using 3D software;

(F) construct building drawings using advanced computer-aided design drafting skills;

(G) create three-dimensional views of a building design;

(H) create three-dimensional solid models of the building;

(I) design and present a final effective building design for critique;

(J) develop preliminary drawings of a building or structural design;

(K) develop a site plan using maximum orientation of the building relative to views, sun, and wind direction;

(L) draw schematic site plans, floor plans, roof plans, building elevations, sections, and perspectives using design development techniques;

(M) draw scaled wall thickness plans, interior elevations, and sections;

(N) develop details, floor and wall sections, ceiling and roof sections, door and window sections, and other sections as required within a building design;

(O) review and revise draft construction documents to incorporate results from structural analysis such as beam, truss, and foundation calculations conducted for the project; and

(P) review and revise draft construction documents to incorporate results from building system analysis such as mechanical, electrical, and plumbing calculations conducted for the project.

(10) The student designs and develops plans for the building site. The student is expected to:

(A) identify and describe various site constraints, including utilities, grading, drainage, transportation access, environmental, regulatory requirement, and rights-of-way constraints;

(B) explain the purpose of low impact development techniques in site development such as to reduce the impact on stormwater runoff quantity and quality;

(C) develop preliminary drawings of a building site design;

(D) develop building site design and engineering plans that integrate solutions to site constraints as appropriate;

(E) describe how soil characteristics impact building design;

(F) determine the type, sizing, and placement of site features, including parking lots, entrance and exits road, pedestrian and handicap access, and storm water facilities, that comply with local codes and regulations;

(G) evaluate a site to appropriately locate and orient a building or structure;

(H) develop site drawings using advanced computer-aided design drafting skills; and

(I) design and present a final effective site design for critique.

(11) The student explores construction phase processes for a building design project. The student is expected to:

(A) calculate quantities of building components such as the total square units of wall covering, the total cubic units of concrete, linear units of wire, and doors and windows;

(B) develop a material quantity take-off for a building project;

(C) develop an Opinion of Probable Cost (OPC) for a building project;

(D) document elements of the building construction that comply with design criteria such as those outlined in LEED;

(E) identify components of a bid tabulation, including item description, material quantity, unit measure, unit price, and total price;

(F) compare a project bid tabulation with corresponding construction documents to verify all items are included;

(G) create a project bid tabulation;

(H) identify and describe the parts of a construction project manual, including invitation to bidders, instruction for bidders, project information, construction contracts, bid tabulation, maintenance bonds, performance bonds, payment bonds, specifications, insurance certificates, and legal requirements; and

(I) develop an organizational chart and Gantt chart for the construction of a project.

§127.419. Surveying and Geomatics (Two Credits), Adopted 2025.

(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)(1) 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 Grades 10-12. Prerequisite: Algebra I. Recommended prerequisites: Geometry and Introduction to Computer-Aided Design and Drafting. Students shall be awarded two credits 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) Students enrolled in Surveying and Geomatics are introduced to the principles and practices essential to the field of surveying. Throughout this course students investigate different tools, applications, and techniques used to capture and process geospatial data. They also use functional mathematics crucial to the profession. Additionally, the course emphasizes the importance of visual representations of data in multiple mediums, ethical considerations, and the legal or regulatory impact of surveying on the community and society.

(4) 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.

(5) 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.

(1) The student understands that there are different stages of the engineering design process and the importance of working through each stage as part of an iterative process. The student is expected to:

(A) explain the importance of defining an engineering problem as an initial step in the engineering design process;

(B) describe the research stage of the engineering design process;

(C) define ideation and conceptualization and discuss the role these processes play in innovation and problem solving;

(D) explain the processes of selecting an idea or concept for detailed prototype design, development, and testing;

(E) describe the purpose of non-technical drawings, technical drawings, models, and prototypes in designing a solution to an engineering problem;

(F) describe the process of relevant experimental design, conducting tests, collecting data, and analyzing data to evaluate potential solutions;

(G) explain how the engineering design process is iterative and the role reflection plays in developing an optimized engineering solution; and

(H) describe the purpose of effective communication of the engineering solution as obtained through the engineering design process to various audiences.

(2) The student explores and develops skills to solve problems, make decisions, and manage a project. The student is expected to:

(A) discuss strategies for managing time, setting deadlines, and prioritizing to accomplish goals;

(B) identify constraints and describe the importance of planning around constraints, including budgets, resources, and materials;

(C) define milestones and deliverables and explain the advantages of dividing a large project into smaller milestones and deliverables;

(D) identify different types of communication and explain how different types of communication lead to successful teamwork on a shared project in a professional setting; and

(E) identify strategies to solve problems and describe how problem solving is utilized to accomplish personal and team objectives.

(3) The student understands the foundations of occupational safety and health. The student is expected to:

(A) explain and discuss the responsibilities of workers and employers to promote safety and health in the workplace and the rights of workers to a secure workplace;

(B) explain and discuss the importance of Occupational Safety and Health Administration (OSHA) standards and OSHA requirements for organizations, how OSHA inspections are conducted, and the role of national and state regulatory entities;

(C) explain the role industrial hygiene plays in occupational safety and explain various types of industrial hygiene hazards, including physical, chemical, biological, and ergonomic;

(D) identify and explain the appropriate use of types of personal protective equipment used in industry;

(E) discuss the importance of safe walking and working surfaces in the workplace and best practices for preventing or reducing slips, trips, and falls in the workplace;

(F) describe types of electrical hazards in the workplace and the risks associated with these hazards and describe control methods to prevent electrical hazards in the workplace;

(G) analyze the hazards of handling, storing, using, and transporting hazardous materials and identify and discuss ways to reduce exposure to hazardous materials in the workplace;

(H) identify workplace health and safety resources, including emergency plans and Safety Data Sheets, and discuss how these resources are used to make decisions in the workplace;

(I) describe the elements of a safety and health program, including management leadership, worker participation, and education and training;

(J) explain the purpose and importance of written emergency action plans and fire protection plans and describe key components of each such as evacuation plans and emergency exit routes, list of fire hazards, and identification of emergency personnel;

(K) explain the components of a hazard communication program; and

(L) explain and give examples of safety and health training requirements specified by standard setting organizations.

(4) The student examines the functional mathematics of surveying. The student is expected to:

(A) calculate central tendencies of a given data set, including mean, median, and mode;

(B) calculate standard deviation of a given data set;

(C) identify parts of a normal distribution curve;

(D) define the Empirical Rule and analyze the distribution of a data set using the Empirical Rule;

(E) define systematic and random error;

(F) identify and describe the relationship between accuracy and precision;

(G) identify the types and properties of various polygons;

(H) solve for the parts of a triangle, including Pythagorean theorem, sine, cosine, tangent, arcsine, arccosine, and arctangent;

(I) identify the properties of circles;

(J) solve for the parts of a unit circle, including diameter, radius, circumference, area, chord, arclength, delta, and tangent;

(K) identify and solve for linear functions, including standard form, slope-intercept form, point-slope form, and the distance between two points, on a Cartesian Coordinate System; and

(L) identify and solve for volumetric calculations of three-dimensional shapes, including a cylinder, sphere, rectangular prisms, trapezoidal prisms, and triangular prisms.

(5) The student researches and understands global positioning systems (GPS) used in surveying. The student is expected to:

(A) identify and explain data terminology related to GPS such as latitude, longitude, datum, ellipsoid, geoid, orthometric height, World Geodetic System 1984, Earth Centered Earth Fixed (ECEF), 3D coordinate geometry, and state plane coordinate system;

(B) explain the different types and applications of GPS surveying, including static, differential, and real-time kinematic (RTK);

(C) tie down a point and derive a geographic latitude and longitude coordinate using GPS;

(D) identify and explain GPS components, including the space segment, control segment, and the user segment;

(E) describe the functions of a GPS satellite;

(F) describe the functions of GPS ground stations;

(G) describe the functions of GPS receivers; and

(H) generate a map using geodetic coordinates.

(6) The student researches and understands the industry standard methods and means of collecting various topographical data used in the civil engineering and construction professions. The student is expected to:

(A) research and explain the components of optomechanical equipment, including vertical and horizontal plates and optics;

(B) explain the types of optomechanical equipment, including theodolite, level, and total station, and their application;

(C) explain methods of remote sensing, including unmanned aerial vehicle (UAV), light detection and ranging (LiDAR), sonar, ground penetrating radar, underwater remotely operated vehicle (ROV), photogrammetry, and gravity satellite;

(D) identify the tools used to make distance measurements, including steel tape, electric distance meter, pacing, odometer, stadia, and estimating;

(E) explain the various methods to measure the distance between two points on the surface of the Earth;

(F) measure the distance between two points on the surface of the Earth using different methods and tools;

(G) compare the data collected from different methods used to measure the distance between two points on the surface of the Earth for accuracy;

(H) identify the tools used to make angular measurements, including protractor, compass, theodolite, total station, and estimating;

(I) explain the various methods to measure the angle between two vectors;

(J) measure the angle between two vectors using different methods and tools;

(K) compare the data collected from different methods used to measure the angles between two vectors for accuracy;

(L) describe the use of control points and National Geodetic Survey (NGS) monuments;

(M) identify the tools used to measure elevation, including level, theodolite, total station, barometer, and estimating;

(N) measure and calculate the height of an object using a theodolite;

(O) establish the elevation of a point assuming the elevation of a relative point is zero using various methods and tools;

(P) compare the data collected from different methods used to measure elevation between two points for accuracy;

(Q) identify and adhere to regulations of UAV piloting and control specified by the Federal Aviation Administration Small UAS Rule (Part A107); and

(R) explain the purposes of specialized surveys used in engineering, including engineering topographic, control, construction, boundary, hydrographic, optical tooling, American Land Title Association (ALTA), photogrammetric, and as-built survey.

(7) The student records meta-data associated with surveying measurements and data collection. The student is expected to:

(A) create and maintain field notes within a comprehensive field book that includes a cover page and field data;

(B) describe the necessary components of a field book cover page, including weather data, project site data, personnel data, equipment data, and type of survey conducted; and

(C) record surveying information in a field book, including differential level notes, collected horizontal and vertical angles, site sketches, and topographic data.

(8) The student researches and understands the industry standard methods and means of analyzing various topographical data used in the civil engineering and construction professions. The student is expected to:

(A) explain the process to generate a control survey;

(B) identify and explain symbols found on survey drawings; and

(C) identify and describe software used to create drawings and analyze survey data.

(9) The student develops and communicates visual representations of topographical data used in civil engineering and construction documentation and presentations. The student is expected to:

(A) explain the process of drafting a construction document to scale;

(B) determine and demonstrate which scale best fits a standard size drawing sheet;

(C) explain the relationship between a construction document's specifications, plans, legend, and scale;

(D) explain the difference between grid and surface distances;

(E) identify the local scale factor that transforms collected grid distances to surface distances for a given survey;

(F) generate a scaled topography map using collected field data;

(G) create a surface profile from a baseline drawn on a topographic map; and

(H) stake out points from design files, maps, or real-property descriptions.

(10) The student explores how a practicing surveyor follows in the footsteps of the original surveyor. The student is expected to:

(A) explain why and how surveyors defer to the work of existing surveys;

(B) define boundary monumentation;

(C) research and explain natural and artificial monuments;

(D) explain the methods to adjust real-property boundaries for the change in natural monuments over time, including riparian and littoral boundaries;

(E) interpret a legal description of a real property;

(F) identify an original survey boundary by conducting land record research using the Texas General Land Office (GLO);

(G) explain the historical significance of land grants in Texas;

(H) explain how a boundary survey protects the public;

(I) create a property boundary drawing using collected field data; and

(J) explain the dignity of calls, including natural objects, artificial objects, courses, distances, and acreage, as specified in Texas Administrative Code, Title 31, Part 1, Chapter 7, §7.5 (relating to Dignity of Calls).

(11) The student understands the different methods of measurements and associated errors. The student expected to:

(A) define the different units of linear measurement, including U.S. feet, international feet, chains, rod, mile, fathom, furlong, varas, and metric units, commonly used in the surveying and civil engineering industry;

(B) define the different units of angular measurement, including vertical angles, horizontal angles, bearings, azimuths, degrees-minutes-seconds, decimal degrees, seconds of arc, and gradians;

(C) define the different units of volumetric measurement, including cubic feet, cubic yards, tons, and acre-feet;

(D) calculate and define area measurements such as acre, hectare, square feet, square mile, league, or sitio;

(E) convert linear, angular, and area measurements between different units;

(F) determine a change in elevation between two or more points by performing a differential level loop;

(G) measure the distance between two or more points using industry acceptable methods such as taping, electronic distance meter, total station, pacing, odometer, tacheometry, GPS, and stadia;

(H) compare the errors from two or more methods of calculating the distance between two or more points; and

(I) calculates various types of errors associated with survey data.

(12) The student researches and understands surveying and geomatics throughout history. The student is expected to:

(A) explain how Eratosthenes first derived the circumference of the Earth;

(B) research and describe the change in methods and precision used to calculate the circumference of the Earth; and

(C) describe the surveying that contributed to great works of civil engineering before and after the Age of Exploration.

(13) The student researches and understands the code of ethics pertaining to civil engineering and surveyors. The student is expected to:

(A) research and identify the legal definitions and descriptions surveyors use to delineate and report survey data; and

(B) research and identify engineering ethics established by the Texas Engineering Practice Act and rules concerning the practice of engineering and surveying.

§127.452. Practicum in Engineering (Two Credits), Adopted 2025.

(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 and Geometry and a minimum of two credits with at least one course in a Level 2 or higher course from the Engineering Career Cluster.

(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) Practicum in Engineering is designed to give students supervised practical application of knowledge and skills. Practicum experiences can occur in a variety of locations appropriate to the nature and level of experiences such as employment, independent study, internships, assistantships, mentorships, or laboratories. To prepare for careers in engineering, students must attain academic knowledge and skills, acquire technical knowledge and skills related to the workplace, and develop knowledge and skills regarding career opportunities, entry requirements, and industry expectations. To prepare for success, students need opportunities to learn, reinforce, apply, and transfer their knowledge and skills and technologies in a variety of settings.

(4) 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.

(5) 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.

(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.

(2) The student understands how a professional engineer serves the local and global community. The student is expected to:

(A) research and identify student and professional engineering organizations and the benefits of membership such as networking platforms, training and educational opportunities, and participating in community initiatives;

(B) explain an engineer's role and how various engineering roles serve the organization, community, and society; and

(C) evaluate how the work of student or professional engineering organizations impact the local or global community such as recommended practices and issuing standards.

(3) The student uses critical thinking and problem solving in the work-based learning experience. The student is expected to:

(A) conduct technical research to gather information, identify gaps, and make decisions in the work-based learning experience;

(B) develop creative and innovative solutions to problems in the work-based learning experience;

(C) analyze and compare alternative designs for an effective solution to a problem in the work-based learning experience; and

(D) evaluate and present solutions to problems in the work-based learning experience.

(4) The student understands and demonstrates how effective leadership and teamwork skills enable the accomplishment of goals and objectives. The student is expected to:

(A) analyze leadership characteristics such as trustworthiness, positive attitude, integrity, and work ethic;

(B) explain and demonstrate effective characteristics of teamwork;

(C) explain and demonstrate responsibility for shared group and individual work tasks in the work-based learning experience;

(D) describe and analyze how strategies such as meeting deadlines, showing respect for all individuals, and communicating clearly and timely contribute to effective working relationships and accomplishing objectives; and

(E) research and identify opportunities to participate in extracurricular engineering activities.

(5) The student demonstrates oral and written communication skills in delivering and receiving information and ideas. The student is expected to:

(A) apply appropriate content knowledge, technical concepts, and vocabulary to analyze information and follow directions;

(B) use professional communication skills such as using technical terminology, email etiquette, and following the organization or team communication plan and hierarchy when delivering and receiving information in the work-based learning experience;

(C) identify and analyze information contained in informational texts, internet sites, or technical materials in the work-based learning experience;

(D) describe and analyze verbal and nonverbal cues and behaviors such as body language, tone, and interrupting to enhance communication in the work-based learning experience; and

(E) apply active listening skills to receive and clarify information in the work-based learning experience.

(6) The student reflects on the work-based learning experience to prepare for postsecondary and employment success. The student is expected to:

(A) assess and evaluate personal strengths and weaknesses in knowledge and skill proficiency and contributions to a project related to the work-based learning experience;

(B) develop and maintain a professional portfolio to include:

(i) attainment of technical skill competencies;

(ii) licensures or certifications;

(iii) recognitions, awards, and scholarships;

(iv) extended learning experiences such as community service and active participation in career and technical student organizations and professional organizations;

(v) abstract of key points of the practicum;

(vi) resume;

(vii) samples of work; and

(viii) evaluation from the practicum supervisor; and

(C) present the professional portfolio to interested stakeholders.

(7) The student develops a presentation describing the culmination of skills and knowledge gained from the work-based learning experience. The student is expected to:

(A) develop a professional presentation to display and communicate the work-based learning experience, including goals and objectives, levels of achievement, skills and knowledge gained, areas for improvement and personal growth, challenges encountered throughout the experience, and a plan for future goals;

(B) identify an appropriate audience and coordinate the presentation of findings related to the work-based learning experience;

(C) present findings in a professional manner using concise language, engaging content, relevant media, and clear speech; and

(D) analyze feedback received from a presentation.

§127.453. Extended Practicum in Engineering (One Credit), Adopted 2025.

(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. The practicum course is a paid or unpaid capstone experience for students participating in a coherent sequence of career and technical education courses in the Engineering Career Cluster. Prerequisites: Algebra I and Geometry and a minimum of two credits with at least one course in a Level 2 or higher course from the Engineering Career Cluster. This course must be taken concurrently with Practicum in Engineering and may not be taken as a stand-alone course. Students shall be awarded one credit for successful completion of this course. A student may repeat this course once for credit provided that the student is experiencing different aspects of the industry and demonstrating proficiency in additional and more advanced knowledge and skills.

(c) Introduction.

(1) Career and technical education instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or 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) Extended Practicum in Engineering is designed to give students supervised practical application of previously studied knowledge and skills. Practicum experiences can occur in a variety of locations appropriate to the nature and level of experience.

(4) 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.

(5) 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.

(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.

(2) The student understands how a professional engineer serves the local and global community. The student is expected to:

(A) research and identify student and professional engineering organizations and the benefits of membership such as networking platforms, training and educational opportunities, and participating in community initiatives;

(B) explain an engineer's role and how various engineering roles serve the organization, community, and society; and

(C) evaluate how the work of student or professional engineering organizations impact the local or global community such as recommended practices and issuing standards.

(3) The student uses critical thinking and problem solving in the work-based learning experience. The student is expected to:

(A) conduct technical research to gather information, identify gaps, and make decisions in the work-based learning experience;

(B) develop creative and innovative solutions to problems in the work-based learning experience;

(C) analyze and compare alternative designs for an effective solution to a problem in the work-based learning experience; and

(D) evaluate and present solutions to problems in the work-based learning experience.

(4) The student understands and demonstrates how effective leadership and teamwork skills enable the accomplishment of goals and objectives. The student is expected to**:**

(A) analyze leadership characteristics such as trustworthiness, positive attitude, integrity, and work ethic;

(B) explain and demonstrate effective characteristics of teamwork;

(C) explain and demonstrate responsibility for shared group and individual work tasks in the work-based learning experience;

(D) describe and analyze how strategies such as meeting deadlines, showing respect for all individuals, and communicating clearly and timely contribute to effective working relationships and accomplishing objectives; and

(E) research and identify opportunities to participate in extracurricular engineering activities.

(5) The student demonstrates oral and written communication skills in delivering and receiving information and ideas. The student is expected to:

(A) apply appropriate content knowledge, technical concepts, and vocabulary to analyze information and follow directions;

(B) use professional communication skills such as using technical terminology, email etiquette, and following the organization or team communication plan and hierarchy when delivering and receiving information in the work-based learning experience;

(C) identify and analyze information contained in informational texts, internet sites, or technical materials in the work-based learning experience;

(D) describe and analyze verbal and nonverbal cues and behaviors such as body language, tone, and interrupting to enhance communication in the work-based learning experience; and

(E) apply active listening skills to receive and clarify information in the work-based learning experience.

(6) The student reflects on the work-based learning experience to prepare for postsecondary and employment success. The student is expected to:

(A) assess and evaluate personal strengths and weaknesses in knowledge and skill proficiency and contributions to a project related to the work-based learning experience;

(B) develop and maintain a professional portfolio to include:

(i) attainment of technical skill competencies;

(ii) licensures or certifications;

(iii) recognitions, awards, and scholarships;

(iv) extended learning experiences such as community service and active participation in career and technical student organizations and professional organizations;

(v) abstract of key points of the practicum;

(vi) resume;

(vii) samples of work; and

(viii) evaluation from the practicum supervisor; and

(C) present the professional portfolio to interested stakeholders.

(7) The student develops a presentation describing the culmination of skills and knowledge gained from the work-based learning experience. The student is expected to:

(A) develop a professional presentation to display and communicate the work-based learning experience, including goals and objectives, levels of achievement, skills and knowledge gained, areas for improvement and personal growth, challenges encountered throughout the experience, and a plan for future goals;

(B) identify an appropriate audience and coordinate the presentation of findings related to the work-based learning experience;

(C) present findings in a professional manner using concise language, engaging content, relevant media, and clear speech; and

(D) analyze feedback received from a presentation.