Engineering Design and Problem Solving (2021)

Implementation. The provisions of this section shall be implemented by school districts beginning with the 2022-2023 school year. A

1 No later than August 31, 2022, the commissioner of education shall determine whether instructional materials funding has been made available to Texas public schools for materials that cover the essential knowledge and skills identified in this section. A.1

2 If the commissioner makes the determination that instructional materials funding has been made available, this section shall be implemented beginning with the 2022-2023 school year and apply to the 2022-2023 and subsequent school years. A.2

3 If the commissioner does not make the determination that instructional materials funding has been made available under this subsection, the commissioner shall determine no later than August 31 of each subsequent school year whether instructional materials funding has been made available. If the commissioner determines that instructional materials funding has been made available, the commissioner shall notify the State Board of Education and school districts that this section shall be implemented for the following school year. A.3

General requirements. This course is recommended for students in Grades 11 and 12. Prerequisites: Algebra I, Geometry, and at least one credit in a Level 2 or higher course in the science, technology, engineering, and mathematics career cluster. This course satisfies a high school science graduation requirement. Students shall be awarded one credit for successful completion of this course. B

b General requirements. This course is recommended for students in Grades 11 and 12. Prerequisites: Algebra I, Geometry, and at least one credit in a Level 2 or higher course in the science, technology, engineering, and mathematics career cluster. This course satisfies a high school science graduation requirement. Students shall be awarded one credit for successful completion of this course. B

Introduction. C

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.** C.1

2 **The STEM Career Cluster focuses on planning, managing, and providing scientific research and professional and technical services, including laboratory and testing services, and research and development services.** C.2

3 **The Engineering Design and Problem Solving course is the creative process of solving problems by identifying needs and then devising solutions. The solution may be a product, technique, structure, or process depending on the problem. Science aims to understand the natural world, while engineering seeks to shape this world to meet human needs and wants. Engineering design takes into consideration limiting factors or "design under constraint." Various engineering disciplines address a broad spectrum of design problems using specific concepts from the sciences and mathematics to derive a solution. The design process and problem solving are inherent to all engineering disciplines.** C.3

4 **Engineering Design and Problem Solving reinforces and integrates skills learned in previous mathematics and science courses. This course emphasizes solving problems, moving from well-defined toward more open-ended, with real-world application. Students will apply critical-thinking skills to justify a solution from multiple design options. Additionally, the course promotes interest in and understanding of career opportunities in engineering.** C.4

5 **This course is intended to stimulate students' ingenuity, intellectual talents, and practical skills in devising solutions to engineering design problems. Students use the engineering design process cycle to investigate, design, plan, create, and evaluate solutions. At the same time, this course fosters awareness of the social and ethical implications of technological development.** C.5

6 **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.** C.6

7 **Scientific hypotheses and theories. Students are expected to know that:** C.7

- 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 C.7.A
- 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. C.7.B

8 **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.** C.8

- 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. C.8.A
- B Engineering practices. Students should be able to identify problems and design solutions using appropriate tools and models. C.8.B

9 **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).** C.9

10 **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.** C.10

11 **Students are encouraged to participate in extended learning experiences such as career and technical student organizations and other leadership or extracurricular organizations.** C.11

12 **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.** C.12

Knowledge and skills. D

1 **The student demonstrates professional standards/employability skills as required by business and industry. The student is expected to:** D.1

- A demonstrate knowledge of how to dress appropriately, speak politely, and conduct oneself in a manner appropriate for the profession; D.1.A
- B how the ability to cooperate, contribute, and collaborate as a member of a group in an effort to achieve a positive collective outcome; D.1.B
- C present written and oral communication in a clear, concise, and effective manner; D.1.C
- D demonstrate time-management skills in prioritizing tasks, following schedules, and performing goal-relevant activities in a way that produces efficient results; and D.1.D
- E demonstrate punctuality, dependability, reliability, and responsibility in performing assigned tasks as directed. D.1.E

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:** D.2

- A ask questions and define problems based on observations or information from text, phenomena, models, or investigations; D.2.A
- B apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems; D.2.B
- C use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards; D.2.C
- D use appropriate tools such as dial caliper, micrometer, protractor, compass, scale rulers, multimeter, and circuit components; D.2.D
- E collect quantitative data using the International System of Units (SI) and United States customary units and qualitative data as evidence; D.2.E
- F organize quantitative and qualitative data using spreadsheets, engineering notebooks, graphs, and charts; D.2.F
- G develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and D.2.G
- H distinguish between scientific hypotheses, theories, and laws. D.2.H

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:** D.3

A identify advantages and limitations of models such as their size, scale, properties, and materials; D.3.A

B analyze data by identifying significant statistical features, patterns, sources of error, and limitations; D.3.B

C use mathematical calculations to assess quantitative relationships in data; and D.3.C

D evaluate experimental and engineering designs. D.3.D

4 **The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to:** D.4

A develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories; D.4.A

B communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and D.4.B

C engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence. D.4.C

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:** D.5

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; D.5.A

B relate the impact of past and current research on scientific thought and society, including research methodology, cost-benefit analysis, and contributions of diverse scientists and engineers as related to the content; and D.5.B

C research and explore resources such as museums, libraries, professional organizations, private companies, online platforms, and mentors employed in a STEM field. D.5.C

6 **The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:** D.6

A communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials; and D.6.A

B draw inferences based on data related to promotional materials for products and services. D.6.B

7 The student applies knowledge of science and mathematics and the tools of technology to solve engineering design problems. The student is expected to: D.7

- A select appropriate mathematical models to develop solutions to engineering design problems; D.7.A
- B integrate advanced mathematics and science skills as necessary to develop solutions to engineering design problems; D.7.B
- C judge the reasonableness of mathematical models and solutions; D.7.C
- D investigate and apply relevant chemical, mechanical, biological, electrical, and physical properties of materials to engineering design problems; D.7.D
- E identify the inputs, processes, outputs, control, and feedback associated with open and closed systems; D.7.E
- F describe the difference between open-loop and closed-loop control systems; D.7.F
- G evaluate different measurement tools such as dial caliper, micrometer, protractor, compass, scale rulers, and multimeter, make measurements with accuracy and precision, and specify tolerances; and D.7.G
- H use conversions between measurement systems to solve real-world problems. D.7.H

8 The student communicates through written documents, presentations, and graphic representations using the tools and techniques of professional engineers. The student is expected to: D.8

- A communicate visually by sketching and creating technical drawings using established engineering graphic tools, techniques, and standards; D.8.A
- B read and comprehend technical documents, including specifications and procedures; D.8.B
- C prepare written documents such as memorandums, emails, design proposals, procedural directions, letters, and technical reports using the formatting and terminology conventions of technical documentation; D.8.C
- D organize information for visual display and analysis using appropriate formats for various audiences, including technical drawings, graphs, and tables such as file conversion and appropriate file types, in order to collaborate with a wider audience; D.8.D
- E evaluate the quality and relevance of sources and cite appropriately; and D.8.E
- F defend a design solution in a presentation. D.8.F

9 The student recognizes the history, development, and practices of the engineering professions. The student is expected to: D.9

- A identify and describe career options, working conditions, earnings, and educational requirements of various engineering disciplines such as those listed by the Texas Board of Professional Engineers; D.9.A
- B recognize that engineers are guided by established codes emphasizing high ethical standards; D.9.B
- C explore the differences, similarities, and interactions between engineers, scientists, and mathematicians; D.9.C
- D describe how technology has evolved in the field of engineering and consider how it will continue to be a useful tool in solving engineering problems; D.9.D
- E discuss the history and importance of engineering innovation on the U.S. economy and quality of life; and D.9.E
- F describe the importance of patents and the protection of intellectual property rights. D.9.F

10 The student creates justifiable solutions to open-ended real-world problems using engineering design practices and processes. The student is expected to: D.10

- A identify and define an engineering problem; D.10.A
- B formulate goals, objectives, and requirements to solve an engineering problem; D.10.B
- C determine the design parameters associated with an engineering problem such as materials, personnel, resources, funding, manufacturability, feasibility, and time; D.10.C
- D establish and evaluate constraints pertaining to a problem, including health, safety, social, environmental, ethical, political, regulatory, and legal; D.10.D
- E identify or create alternative solutions to a problem using a variety of techniques such as brainstorming, reverse engineering, and researching engineered and natural solutions; D.10.E
- F test and evaluate proposed solutions using methods such as creating models, prototypes, mock-ups, or simulations or performing critical design review, statistical analysis, or experiments; D.10.F
- G apply structured techniques to select and justify a preferred solution to a problem such as a decision tree, design matrix, or cost-benefit analysis; D.10.G
- H predict performance, failure modes, and reliability of a design solution; and D.10.H
- I prepare a project report that clearly documents the designs, decisions, and activities during each phase of the engineering design process. D.10.I

11 The student manages an engineering design project. The student is expected to: D.11

- A participate in the design and implementation of a real-world or simulated engineering project using project management methodologies, including initiating, planning, executing, monitoring and controlling, and closing a project; D.11.A
- B develop a plan and project schedule for completion of a project; D.11.B
- C work in teams and share responsibilities, acknowledging, encouraging, and valuing contributions of all team members; D.11.C
- D compare and contrast the roles of a team leader and other team member responsibilities; D.11.D
- E identify and manage the resources needed to complete a project; D.11.E
- F use a budget to determine effective strategies to meet cost constraints; D.11.F
- G create a risk assessment for an engineering design project; D.11.G
- H analyze and critique the results of an engineering design project; and D.11.H
- I maintain an engineering notebook that chronicles work such as ideas, concepts, inventions, sketches, and experiments. D.11.I