PLTW Introduction to Engineering Design Course Framework

PLTW Framework - Overview

PLTW Frameworks are representations of the knowledge, skills, and understandings that empower students to thrive in an evolving world. The PLTW Frameworks define the scope of learning and instruction within the PLTW curricula. The framework structure is organized by four levels of understanding that build upon each other: Knowledge and Skills, Objectives, Domains, and Competencies.

The most fundamental level of learning is defined by course Knowledge and Skills statements. Each Knowledge and Skills statement reflects specifically what students will know and be able to do after they've had the opportunity to learn the course content. Students apply Knowledge and Skills to achieve learning Objectives, which are skills that directly relate to the workplace or applied academic settings. Objectives are organized by higher-level Domains.

Domains are areas of in-demand expertise that an employer in a specific field may seek; they are key understandings and long-term takeaways that go beyond factual knowledge into broader, conceptual comprehension.

At the highest level, Competencies are general characterizations of the transportable skills that benefit students in various professional and academic pursuits. As a whole, the PLTW Frameworks illustrate the deep and relevant learning opportunities students experience from PLTW courses and demonstrate how the courses prepare students for life, not just the next grade level.

To thrive in an evolving world, students need skills that will benefit them regardless of the career path they choose. PLTW Frameworks are organized to showcase alignment to in-demand, transportable skills. This alignment ensures that students learn skills that are increasingly important in the rapidly advancing, innovative workplace.

Competencies, Domains, Objectives, Knowledge and Skills

Transportable Knowledge and Skills

Core workplace skills that students and workers need to acquire, that can be used across all stages of a career, and that, because of their universal utility, are transportable from job to job, from employer to employer, across the economy.

Career Readiness (CAR):

STEM professionals use professional skills and knowledge to pursue opportunities and create sustainable solutions to improve and enhance the quality of life of individuals and society.

CAR-A. Demonstrate awareness of the education and skills required for professional practice in an engineering field.

CAR-A.1 Define engineering as the creation of solutions, such as new and improved products, technologies, systems and processes), to meet the needs of people and society.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CAR-A.2 Identify technical and nontechnical skills common to all engineering disciplines that are gained from specialized and intense education, training, and experience, including problem-solving, the design process, data processing and interpretation, handling uncertainty, systems thinking, and modeling.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CAR-B. Analyze the role of engineering professionals in society.

CAR-B.1 Describe the discipline of mechanical engineering and a variety of sub-disciplines and technical roles related to mechanical engineering

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CAR-B.2 Identify and describe contemporary engineering issues of local, global and cultural significance.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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Communication (COM):

Successful engineering professionals demonstrate effective communication with a variety of audiences using multiple modalities.

COM-A. Communicate effectively with an audience based on audience characteristics.

COM-A.1 According to best practices, effectively document engineering or scientific work in an organized notebook so someone unfamiliar with the work can follow and understand the process.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COM-A.2 Use sketches, tables, charts, and graphs when appropriate to clearly communicate information and in making arguments and claims in oral, written, and visual presentations.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COM-A.3 Initiate and participate in a range of open and effective interactions (one-on-one, in groups, and teacher-led) with diverse participants and across cultures, building on others' ideas and expressing one's own clearly and persuasively.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COM-A.4 Present information, findings, and supporting evidence clearly, concisely, and logically in writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COM-A.5 Present information, findings, and supporting evidence clearly, concisely, and logically, such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COM-A.6 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence, and to add interest.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COM-A.7 Practice active listening.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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Collaboration (COL):

Successful engineering professionals demonstrate an ability to function on multidisciplinary teams.

COL-A. Facilitate an effective team environment to promote successful goal attainment.

COL-A.1 Develop and follow team norms.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-A.2 Monitor, solicit, negotiate, and balance diverse views and beliefs to reach shared understanding, common ground and workable solutions. Identify basic resolution strategies and employ those strategies as necessary and appropriate.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-A.3 Develop ideas and create products through positive interdependence among all teammates.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-B. Contribute individually to overall collaborative efforts.

COL-B.1 Describe one's individual role and expectations of performance within the team, including communication protocol and rules of engagement per the team norms.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-B.2 Support other team members, prompting and offering assistance, if needed, to meet team goals.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-B.3 Present all work to be/being done individually in a timely manner to the team to gather feedback, inform revision, and gain consensus.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-B.4 Critically and realistically self-evaluate personal contributions and collaboration effectiveness within a team. [ongoing]

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-C. Analyze and evaluate the work of others to provide helpful feedback.

COL-C.1 Describe the purpose and positive outcomes of a peer review process.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-C.2 Provide effective feedback to peers.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-A. Analyze a consumer product using reverse engineering techniques to document visual, functional, and structural aspects of the design.

COL-A.1 Describe the processes and purposes of reverse engineering.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-A.2 Perform a visual analysis of a natural or man-made object and describe the apparent visual principles and elements of design.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-A.3 Perform a functional analysis of a product or system to determine the purpose, inputs and outputs, and operation of a product or system.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-A.4 Perform a structural analysis of a product or system to determine the materials used, the form of component parts, as well as the configuration and interaction of component parts when assembled (if applicable).

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-A.5 Describe methods to rigidly join parts of an assembly (including press fits, special joints, adhesives, mechanical fasteners)

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-A.6 Identify joints that allow movement between interfacing parts in an assembly and the degrees of freedom that it removes from the movement between parts (including slots, hinges, ball and socket, rotating knobs).

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-B. Optimize performance of a mechanical part or assembly.

COL-B.1 Apply the principles of design for manufacturability and assembly of mechanical products.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-B.2 Define basic fabrication processes and analyze if a product can be built as designed.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-B.3 Use computer-aided engineering tools (e.g. generative design and shape optimization) to optimize design performance of a mechanical part or assembly.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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COL-B.4 Describe how design quality concepts such as performance, usability, accessibility, reliability, safety, etc. impact product development.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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Competencies, Domains, Objectives, Knowledge and Skills

Ethical Reasoning and Mindset (ERM):

Successful engineering professionals exhibit personal and professional characteristics and behaviors that involve considerations of the impact of their work on individuals, society, and the natural world.

ERM-A. Apply personal and professional ethical standards as they relate to the habits and characteristics of an engineering professional.

ERM-A.1 Explain that engineers have a responsibility to serve the public interest, their clients, and the profession with a high degree of honesty, integrity, and accountability. This responsibility is defined in professional codes of ethics.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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ERM-A.2 Acknowledge and respect the local, national and international perspectives and ideas of others. Demonstrate respect and empathy for teammates, mentors, employers/teachers, clients and other professional contacts, and those impacted by engineering decision

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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ERM-B. Consider the impact of potential engineering solutions on future generations to inform the development of sustainable solutions.

ERM-B.1 Explain that different engineering solutions can have significantly different impacts on individuals, society, and the natural world.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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ERM-B.2 Describe the life cycle of a product or service.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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ERM-B.3 Evaluate a solution to a complex, real-world problem and identify the need for trade-offs to address a range of criteria and constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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ERM-B.4 Take action for collective well-being and sustainable development using an ethical decision-making process. (This includes using natural resources effectively and efficiently, and considering the safety of those affected by a product and the potential effects on individual and public health.)

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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Competencies, Domains, Objectives, Knowledge and Skills

Critical and Creative Problem-Solving (CCP):

The skills necessary for students to generate ideas and solutions to problems.

CCP-A. Demonstrate independent thinking and self-direction in pursuit of accomplishing a goal.

CCP-A.1 Explain the limitations of one's knowledge and skills in pursuit of accomplishing a goal.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-A.2 Plan and use time effectively in pursuit of accomplishing a goal without direct oversight.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-A.3 Make and execute a plan to gain additional knowledge and learning to accomplish a goal.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-B. Demonstrate curiosity, creativity, flexibility, and adaptability to change.

CCP-B.1 Ask new probing questions to expand and build upon an idea and explore personal curiosities throughout a creative process.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-B.2 Seek out and use feedback to improve work and positively influence one's personal and professional development.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-B.3 Reflect critically on past experiences to inform future progress.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-B.4 Successfully adjust to changes that impact work. Adapt to varied roles, job responsibilities, and schedules.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-C. Persevere to solve a problem or achieve a goal.

CCP-C.1 Demonstrate risk taking in engineering, scientific, or computational processes.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-C.2 Demonstrate persistence in accomplishing a difficult challenge.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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Competencies, Domains, Objectives, Knowledge and Skills

CCP-D. Make judgments and decisions based on evidence.

CCP-D.1 Find relevant data in credible sources such as literature, databases, and policy documents.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-D.2 Collect, analyze, and interpret information relevant to the problem or opportunity at hand to support engineering decisions.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-D.3 Evaluate point of view, reasoning, and use of evidence and rhetoric, in oral or written communication and identify deficiencies, limitations and biases.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-D.4 Draw valid conclusions based on supporting evidence while acknowledging the limitations, opposing views, and biases.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-E. Apply an iterative design process to creatively address a need or solve a problem.

CCP-E.1 Synthesize an ill-formed problem into a meaningful, well-defined problem using relevant information.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-E.2 Define measurable visual, functional, and structural design requirements (criteria) and realistic constraints against which solution alternatives can be evaluated and optimized. [Note that criteria and constraints should include considerations of cost, safety, reliability, manufacturability, and aesthetics, as well as possible social, cultural, and environmental impacts.]

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☑	☑	☑	☑	☐	☐	☑	☑	☐	☐	☑	☐	☑

CCP-E.3 Apply effective techniques and appropriate guidelines to generate multiple creative ideas and potential solutions to a problem.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☑	☑	☑	☐	☑	☑	☐	☑	☑	☐	☑

CCP-E.4 Carry out a plan to compare competing solution ideas and justify the selection of a solution path with respect to design requirements and constraints.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☑	☑	☑	☑	☐	☐	☑	☑	☑	☑	☑	☐	☑

CCP-E.5 Develop a potential solution and implement a plan to test and evaluate the solution with respect to design criteria and constraints.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☐	☑	☐	☐	☑	☑	☑	☑	☑	☐	☑

CCP-E.6 Identify design flaws of and potential enhancements to a proposed design solution.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☑	☑	☐	☑	☑	☐	☑	☑	☐	☑	☑	☐	☑

CCP-E.7 Strategically iterate steps of the design process to improve and optimize a solution.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☑	☑	☐	☐

CCP-F. Design and perform an experimental protocol to investigate a phenomenon and/or gain knowledge.

CCP-F.1 Develop a testable hypothesis, experimental controls and important variables (independent and dependent) address a problem or answer a question.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☑	☐	☐	☐	☑	☐	☐	☑	☐	☑	☑	☐	☐

CCP-F.2 Identify best strategies and appropriate tools for data collection, documentation, and analysis.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☑	☑	☐	☐

CCP-F.3 Summarize the objective and relevancy of an experiment.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☑	☐	☐

CCP-F.4 Read and accurately follow established protocols and instructions.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☑	☐	☐

CCP-F.5 Identify possible sources of errors, if they exist, redesign and repeat the experiment when appropriate.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☑	☐	☐

CCP-G. Use appropriate statistical methods and visualization techniques to justify claims based on evidence.

CCP-G.1 Graphically represent experimental data for a single count or measurement with charts and/or plots on the real number line, such as dot plots, box plots and histograms.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☑	☐

CCP-G.2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range) of two or more different data sets. Interpret differences in shape, center, and spread in the context of the data sets.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

CCP-G.3 Apply inferential reasoning to make and/or support claims about populations based on data.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☑	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐

CCP-G.4 Draw conclusions related to the hypothesis and support conclusions using experimental data.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	☐	☐

CCP-H. Apply project management tools when designing and developing a solution to successfully deliver a product using available resources.

CCP-H.1 Define the project deliverables and constraints, such as scope, time, cost, quality, resources, and risk.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☐	☐	☐	☐	☑	☐	☑	☐	☐	☐	☑

CCP-H.2 Develop a project schedule (with the critical path identified when appropriate), allocate tasks among team members, and track progress for successful completion of the project.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☐	☐	☐	☐	☐	☐	☑	☐	☑	☐	☐

CCP-H.3 Select and use collaborative tools, such as cloud-based tools, document sharing, and video and text functions, to successfully complete a project.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☑	☐	☐	☐	☑

CCP-I. Apply systems thinking to consider how an engineering problem and its solution may be thought of as containing subsystems and as being a sub-system of a larger system.

CCP-I.1 Describe a system in terms of its components and/or subsystems and their interactions. For example, describe the components of an electronic circuit, including source, path, and load; describe how an electronic circuit provides power to a larger system to produce mechanical motion; describe the subsystems of a building, including power system, communication system, lighting system, ventilation system, water system, sewer system, safety system, social system, transportation system, structural system, and so on; describe how the water system and sewer system interact in your home. Predict what the effect of making a change to a component of a system will have on the system as a whole.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☐	☐	☐	☑	☑	☑	☐	☑	☑

CCP-I.2 Describe a system using a black box model indicating inputs and outputs, boundaries

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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CCP-I.3 Predict the local and global risks and impacts of an engineering decision/solution (e.g., society, the economy, the environment), including some that were not anticipated.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☐	☐	☐	☐

CCP-J. Assess the sustainability of an engineering solution based on the impacts (within the system or interrelated systems) that result from implementation of the solution.

CCP-J.1 Define sustainability, and identify principles that help guide development of sustainable solutions (e.g. generative design and life cycle assessment)

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☐	☐	☐	☐

CCP-J.2 Explain the benefits of human-centered design and apply principles to align product design with intended use.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

Technical Knowledge and Skills

Every career field requires technical literacy and career-specific knowledge and skills to support professional pratice.

Algorithms and Programming (AAP):

Computational thinking is a critical part of a problem-solving process that supports the ability to interpret complex, open-ended problems across all disciplines.

AAP-A. Apply problem decomposition skills to break down data, problems, and processes into manageable parts.

AAP-A.1 Separate a complex process into multiple subprocesses that can be implemented in an organized way to complete the larger process.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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AAP-B. Use algorithms to create a solution with or without the use of a computer program.

AAP-B.1 Use existing correct algorithms as building blocks for constructing a new algorithm to help ensure the new algorithm is correct.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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AAP-B.2 Write a set of ordered instructions (with or without a computer) involving multiple discrete steps to accomplish a complex task or achieve a desired result.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☐	☐	☑	☑	☑	☐	☑	☐	☐

AAP-C. Formulate solutions that use automation to solve a problem.

AAP-C.1 Automate a human-powered device using a mechanical and/or electrical system.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐

AAP-D. Collect, organize, and analyze data to help define and/or solve a problem.

AAP-D.1 Populate a spreadsheet application with data and organize the data to be useful in accomplishing a specific goal.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☐	☐	☐	☐	☐	☑	☐	☑	☑	☑	☐

AAP-D.2 Use the functions and tools within a spreadsheet application to manipulate, analyze, and present data in a useful way, including graphs, regression analyses, and descriptive statistical analyses.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☑	☑	☑	☐

AAP-E. Apply abstraction to generalize problems and solutions.

AAP-E.1 Identify what has been made more general by an abstraction and what details have been hidden or removed.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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Engineering Tools and Technology (ETT):

The practice of engineering requires the application of mathematical principles and common engineering tools, techniques, and technologies.

ETT-A. Using a variety of measuring devices, measure and report quantities accurately and to a precision appropriate for the purpose.

ETT-A.1 Explain that all measurements are an approximation of the true value of a quantity.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☑	☐	☐	☐	☐	☐	☑	☐	☑	☑	☐	☐	☐

ETT-A.2 Describe the accuracy and precision of a measurement or measuring device and differentiate between the two.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☑	☐	☑	☐	☑	☐	☐	☐	☑	☐	☐	☐	☐

ETT-A.3 Use dimensional analysis and unit conversions to transform data to consistent units or to units appropriate for a particular purpose or model.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☑	☐	☐	☐	☑	☐	☐	☐	☑	☐	☐	☐	☐

ETT-A.4 Choose a measurement device based on the level of precision and accuracy needed.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☑	☐	☑	☐	☑	☐	☐	☐	☑	☑	☑	☑	☐

ETT-B. Apply scientific knowledge related to frictional forces, to solve a problem or design a physical system.

ETT-B.1 Explain that friction is a force that opposes motion.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐

ETT-B.2 Determine the coefficient of friction between two surfaces.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐

ETT-B.3 Identify the force of friction between two interacting components in a mechanism, explain how the frictional force impacts the function and efficiency of the mechanism, and recommend design revisions to improve performance.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☑

Competencies, Domains, Objectives, Knowledge and Skills

ETT-C. Apply basic materials science concepts to inform a design process.

ETT-C.1 Describe different types of materials and their common usages in product design.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☐	☑	☐	☐	☐	☐	☐	☐

ETT-C.2 List material properties that are important to design, including mechanical, chemical, electrical, and magnetic properties.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☐	☑	☑	☐	☐	☑	☐	☐

ETT-C.3 Conduct non-destructive tests (e.g. hardness, flexure, conductivity) on different material types to investigate material properties.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☑	☐	☐

ETT-C.4 Explain how design criteria and constraints (e.g. cost, performance, safety, risk, aesthetics, environmental impact) often limit the material choices available for a given design.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☐	☑	☐	☑	☐	☐	☐	☐

ETT-C.5 Select and justify the use of materials for prototyping and manufacturing products.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☐	☑	☑	☐	☑	☑	☑	☐

ETT-D. Understand how different machine elements influence motion of a mechanical system.

ETT-D.1 Describe different types of motion (e.g. rotary, oscillating, linear, reciprocating, intermittent, and irregular).

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐

ETT-D.2 Explain how cams and followers can be used to move objects in periodic or irregular motion.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐

ETT-D.3 Select and use simple mechanisms (e.g. cams, gears, pulleys and belts, sprockets and chains, springs, levers) to create and control motion to solve a problem.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐	☑

ETT-D.4 Use mechanisms in a design to transform a motion without changing its type (e.g. slow to fast rotary motion, magnifying linear movement, or changing axis of motion)

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑

Competencies, Domains, Objectives, Knowledge and Skills

ETT-E. Integrate an electrical circuit with a machine to solve a problem.

ETT-E.1 Calculate circuit resistance, current, and voltage within a circuit.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐

ETT-E.2 Design and build an electrical circuit that includes a motor, a switch and variable resistance to power and control the speed of a mechanism.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑

Modeling (MOD):

Modeling is used to represent ideas and simulate objects, processes, or systems to help us understand, evaluate, and predict the behavior of real phenomena.

MOD-A. Develop models and simulations to represent information, processes, and/or objects to an appropriate level of abstraction for the intended purpose.

MOD-A.1 Recognize that models use abstraction to represent a simplified version of a complex phenomenon and there is no guarantee that the Recognize that models use abstraction to represent a simplified version of a complex phenomenon and there is no guarantee that the model accurately represents the real object or phenomenon. List differences (potential or real) between model behavior and the behavior of the real object, system, or process that it represents, and identify limitations of the model. (Limitations may include specific characteristics being studied, accuracy, precision, range of conditions, and so on.)

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☑	☑	☐	☐	☑	☑	☐	☑	☐	☐	☐	☑	☐	☐

MOD-A.2 Develop a model to accurately represent information or important characteristics of an object, data, process, or design idea for an intended purpose. [Notes on scope: the intended purpose may vary and could include organizing information to show relationships; providing a visual representation of the object/design to demonstrate how the object might “look”; a functional model to demonstrate the operation; a prototype of a specific component to test fit, performance, durability, or compatibility with other components in a system; and so on. The model could be a conceptual model, a mathematical model, a computer/virtual model, or a physical model, as appropriate for the testing scenario.]

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑

Competencies, Domains, Objectives, Knowledge and Skills

MOD-B. Apply mathematical (including graphical) models and interpret the output of models to test ideas or make predictions.

MOD-B.1 Build and/or use a mathematical model (algorithm, table of values, equation, graph) to represent data, describe relationships, describe processes, and to make predictions in the context of the problem. For example: create displacement/time graphs (Cartesian); create polar graphs to describe displacement caused by a cam (and cam shape).

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☑	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	☑	☑	☐

MOD-B.2 Represent data for two quantitative variables on a scatter plot, and describe how the variables are related.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☐

MOD-B.3 Fit a function to the data and use the function to solve problems and/or make predictions in the context of the data.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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MOD-B.4 In mathematical models, interpret the rate of change (slope) and the y-intercept (constant term) in the context of the data.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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MOD-B.5 Use mathematical modeling to optimize design criteria.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐	☑	☐	☐	☐

MOD-C. Use engineering graphics to represent physcial objects.

MOD-C.1 Identify three-dimensional objects generated by rotation of a two-dimensional object.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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MOD-C.2 Build a physical representation of an object or system based on graphical representations of the object or system. (Includes building solid objects, electrical circuits, mechanical devices, and complex systems according to technical drawings.)

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☑	☐	☑	☐	☐	☐	☑	☐	☐	☐	☑	☑	☑	☑

MOD-C.3 Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, pictorial view of the object, or set of orthographic projections.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐

MOD-C.4 Identify errors and omissions in orthographic projections and multiview drawings (including errors in line locations, line types, Identify errors and ommissions in orthographic projections and multiview drawings (including errors in line locations, line types, number of views, scale, dimensioning, and view orientation) to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial and isometric view of the object.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐

MOD-C.5 Identify errors and omissions in a full- or half-section view (including errors in line locations, line types, location of cutting plane line, scale, dimensioning, and view orientation) to fully detail an object or part.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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MOD-C.6 Identify necessary/appropriate views to fully detail a part or assembly.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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MOD-C.7 Read and interpret a hole note to identify the size and type of hole specified.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

MOD-D. Apply appropriate engineering tolerances to specify the allowable variation, size of individual features, and orientation and location between features of an object.

MOD-D.1 Identify and differentiate among a limit dimension, unilateral tolerance, and bilateral tolerance.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

MOD-D.2 Determine the specified dimension, tolerance, upper limit, and lower limit for any given dimension and related tolerance (or any distance that is dependent on the given dimensions) show on a technical drawing.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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MOD-D.3 Determine the allowance between two mating parts of an assembly based on dimensions given on a technical drawing.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
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MOD-D.4 Identify the need for and specify appropriate dimensions to create a clearance fit or interference fit where appropriate.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☑	☑	☐	☑	☐	☐	☐	☑	☑	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

MOD-E. Create and interpret a computer model or simulation of simple objects, assemblies, or systems to inform engineering decisions and solve problems.

MOD-E.1 Create a computer model to represent an object or conceptual idea and inform design decisions.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☑	☑	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	☐	☑

MOD-E.2 Correctly build and constrain a three-dimensional solid computer model to accurately represent the physical characteristics and behaviors of a design idea or real object. Scope: This could include the appropriate application of geometric (horizontal, vertical, parallel, perpendicular, tangent, concentric) and dimensional constraints, as well as modeling other physical properties (density, color, texture, and so on).

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☑	☑	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	☐	☑

MOD-E.3 Create relationships among part features and dimensions using parametric formulas

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☑	☑	☐	☑

MOD-E.4 Correctly apply joints to constrain multi-component models and/or simulate realistic relative motion of the component parts.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☑	☑	☐	☐	☐	☑	☐	☑	☑	☐	☑

MOD-F. Create technical drawings using 3D computer-aided design (CAD) software to document a design according to standard engineering practices.

MOD-F.1 Generate an annotated multiview technical drawing using CAD software to fully describe a simple part.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☑	☑	☑	☑	☐	☐	☑	☐	☐	☑	☑	☑	☐	☐

MOD-F.2 Apply appropriate and sufficient annotation (including dimensioning) methods to a drawing to fully describe an object or system using accepted technical drawing techniques.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☑	☑	☑	☑	☑	☐	☑	☑	☐	☑	☐	☑	☐	☑

MOD-F.3 Generate an assembly drawing using CAD software to identify component parts and show details of assembly using part identification numbers, a parts list, and other annotations, as appropriate.

Lesson	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☑	☑	☐	☑	☐	☐	☐	☐	☑	☐	☑