PLTW Curriculum Framework – Design and Modeling
Lesson 1 Introduction to Design

Meaning
***Essential Questions**: Students will keep considering…* • EQ1.1 How is a design process used to effectively develop a design solution that solves a problem or addresses a design opportunity? • EQ1.2 Why is communication of design ideas with teams and with stakeholders important throughout the design process? • EQ1.3 How are sketches used to document and communicate design ideas with accuracy? • EQ1.4 What role do team norms play in making a collaborative team more successful? • EQ1.5 Why are accurate measurement, precise dimensioning, and thorough documenting necessary for both mechanical dissection and creative problem solving?

Meaning	*Acquisition*	
Domains/Understandings	***Transfers/Learning Objectives***	***Knowledge and Skills***
Domains are key understandings and long-term takeaways that go beyond factual knowledge into broader and more conceptual comprehensions. *Domains are areas of expertise that an employer in a specific field may seek.* ***"I will be able to address real-world challenges because I understand…"***	*Objectives articulate what skills students need to be able to do. (The learning objectives will become targets of assessment.)* *Objectives are functions that directly relate to the workplace or in an applied academic setting.* ***"In the workplace or academic setting, I will need to know and be able to…"***	*Knowledge and skills include the essential facts and basic concepts that a student should know and be able to recall in order to perform the competency.* *Knowledge and skill statements are foundational to the performance of a skill.* ***"After I learn the information, I will be able to use my knowledge and skills to…"***

D1.1: Mindset Ethics, analytical thinking, creativity, persistence, iteration, and the positive role of failure are important mindsets and habits of action. They are developed over time in problem solving processes, inquiry, and computational thinking.	LO1.1A: Describe and/or analyze moments within a problem solving process where persistence, iteration, and the positive aspect of failure played an important role in gaining understanding about a problem or unexpected observation.	KS1.1A1: Understand that problem solving and experimentation are cyclical, meaning steps are repeated as many times as needed.
D1.2: Problem Solving Process and/or Design Process Many disciplines, including engineering, computer science, and biomedical science, use an iterative problem solving process or engineering design process.	LO1.2A: Apply an iterative process to solve a problem or create an opportunity that can be justified.	KS1.2A1: Recall that the goal of any design process is to create solutions and opportunities for people and society, while justifying the cost and effort involved. KS1.2A3: Recognize that all solution attempts should be realistic and based on identified design requirements, which include specifications, constraints, desired features, and testable parameters. KS1.2A6: Create multiple solution options and evaluate those options with tools such as a decision matrix to justify a data-driven path forward.
	LO1.2B: Analyze and describe design functionality by observation of an artifact.	KS1.2B1: Describe reverse engineering as a process that allows designers to gain understanding about the functionality of an artifact, component, assembly, or system. KS1.2B2: Deconstruct an artifact to gain understanding about its functionality. KS1.2B3: Recognize that designers must be unbiased in reflecting and presenting their design process. The process only has validity through stakeholder and peer review. KS1.2B5: Illustrate how the context in which an artifact is used determines the correctness, usability, functionality, and suitability of the artifact.

D2.1: Modeling Designing and creating models are essential to the engineering design and problem solving processes. Models are used to represent an artifact or a system to better understand its attributes and/or behavior. Models can be physical, mathematical, computer-generated, and/or simulated.	LO2.1D: Create a physical model or prototype.	KS2.1D1: Construct a prototype based on design documentation. KS2.1D2: Conduct prototype testing to identify design flaws or additional needs. KS2.1D3: Analyze and interpret testing data collected and make modifications to optimize the design or process.
D2.2: Measurement and Estimation A common measurement system is essential to design accuracy for sketches, models, and prototypes. Measuring and dimensioning objects using appropriate tools are critical to effectively communicate and collaborate on design solutions.	LO2.2A: Measure and present values appropriate to standards of accuracy and precision.	KS2.2A1: Identify the proper tool to use to measure and dimension with accuracy and precision. KS2.2A2: Identify the appropriate equation for area and volume problems. KS2.2A3: Measure objects to create accurate design sketches.
D2.3: Spatial Visualization Sketching allows designers to quickly communicate ideas with accurate dimensions and details. Using technology, two-dimensional sketches can be represented in a three-dimensional solid model. Solid models allow designers to view multiple aspects and perspectives of a design.	LO2.3A: Translate and interoperate between 2D and 3D design representations.	KS2.3A1: Differentiate between two-dimensional and three-dimensional models including the strengths and limitations of each. KS2.3A2: Interpret multiview drawings, specifications, dimensions, and annotations.
	LO2.3B: Sketch and/or interpret perspective, isometric, and multiview drawings with adequate attention to standards and critical annotations.	KS2.3B1: Recognize perspective, thumbnail, isometric, and multiview sketches. KS2.3B2: Recognize that isometric drawings of an object are used to provide information that a perspective drawing may not be able to show. KS2.3B3: Summarize the reasoning for using sketching as a communication tool. KS2.3B4: Apply dimensions on a multiview sketch following the guidelines of dimensioning. KS2.3B5: Create a rapid, accurate sketch to communicate ideas.

D3.1 Collaboration Effective problem solving, experimentation, and/or design are most often conducted within teams.	LO3.1A: Collaborate effectively on a diverse and multi-disciplinary team.	KS3.1A2: Identify and value the contributions of each team member. KS3.1A3: Illustrate successful collaboration through effective communication and constructive feedback. KS3.1A4: Apply team norms to encourage productivity and define how a team will function and measure its success. KS3.1A5: Identify and evaluate positive and negative behaviors that impact the team's effectiveness. KS3.1A6: Recognize individual strengths when defining roles and responsibilities.
D3.2: Communication Communication can often be categorized as technical communication or professional communication.	LO3.2A: Communicate effectively for specific purposes and settings.	KS3.2A2: Distinguish technical communication artifacts that capture a process, including but not limited to engineering notebooks, laboratory journals, technical presentations, sketches, technical drawings, design briefs, design reviews, laboratory reports, and code. KS3.2A3: Demonstrate best practices that are widely accepted by professionals when they communicate such as how to present visual media, oral presentations, and professional correspondence. KS3.2A4: Communicate to meet the needs of the audience and be appropriate to the situation. KS3.2A5: Demonstrate proper elements of written and electronic communication (spelling, grammar and formatting) at all times when communicating with a team or stakeholder in a process. KS3.2A6: Use accurate terminology when communicating about systems and processes.

	LO3.2B: Document a process according to professional standards.	KS3.2B1: Present data and information through a variety of accepted means such as: graphs, charts, images, video, schematics, code, 3D models, and simulations.
D3.4 Career Awareness It is important to prepare a flexible education plan that matches your interests, knowing that you can change or modify that plan as you discover more about career opportunities.	LO3.4B: Describe the role, connections between disciplines, and impact of engineering, biomedical science, and computer science on society.	KS3.2B1: Present data and information through a variety of accepted means such as: graphs, charts, images, video, schematics, code, 3D models, and simulations. KS3.4B2: Recognize that engineering, biomedical science, and computer science fields impact various career paths, industries, and our society.

PLTW Curriculum Framework – Design and Modeling
Lesson 2 Modeling and Statistical Analysis

Meaning
***Essential Questions**: Students will keep considering…* • EQ2.1 How is a design process used to effectively develop a design solution that solves a problem or addresses a design opportunity? • EQ2.2 Why would a designer choose to communicate a solid object design with two-dimensional sketches rather than a three-dimensional model. • EQ2.3 How has the evolution of rapid prototyping tools impacted design fabrication? • EQ2.4 How is design testing data used to improve design solutions? • EQ2.5 How does using a CAD application benefit an engineer? • EQ2.6 Why is it important for an engineer to be aware of the criteria and the constraints when designing a project? • EQ2.7 How does documentation play a critical role in each step of the design process? • EQ2.8 How can mathematical modeling help designers understand a design? • EQ2.9 How can computational thinking be applied when developing an engineering solution? • EQ2.10 What is the role of statistical analysis in the design process?

Meaning	*Acquisition*

Domains/Understandings *Domains are key understandings and long-term takeaways that go beyond factual knowledge into broader and more conceptual comprehensions.* *Domains are areas of expertise that an employer in a specific field may seek.* ***"I will be able to address real-world challenges because I understand…"***	***Transfers/Learning Objectives*** *Objectives articulate what skills students need to be able to do. (The learning objectives will become targets of assessment.)* *Objectives are functions that directly relate to the workplace or in an applied academic setting.* ***"In the workplace or academic setting, I will need to know and be able to…"***	***Knowledge and Skills*** *Knowledge and skills include the essential facts and basic concepts that a student should know and be able to recall in order to perform the competency.* *Knowledge and skill statements are foundational to the performance of a skill.* ***"After I learn the information, I will be able to use my knowledge and skills to…"***
D1.1: Mindset Ethics, analytical thinking, creativity, persistence, iteration, and the positive role of failure are important mindsets and habits of action. They are developed over time in problem solving processes, inquiry, and computational thinking.	LO1.1A: Describe and/or analyze moments within a problem solving process where persistence, iteration, and the positive aspect of failure played an important role in gaining understanding about a problem or unexpected observation.	KS1.1A1: Understand that problem solving and experimentation are cyclical, meaning steps are repeated as many times as needed. KS1.1A2: Recognize that identifying complex problems, defining them clearly, and proposing solutions can be difficult and requires persistence and iteration. KS1.1A3: Describe how failure can produce positive outcomes by improving understanding.
	LO1.1C: Analyze problems or artifacts when developing solutions.	KS1.1C1: Demonstrate analytical thinking when evaluating a proposed solution, locating and correcting errors, explaining how something functions, gaining understanding through experimentation, and/or justifying the appropriateness of a solution, model, or artifact.
	LO1.1E: Recognize that models are used to make predictions and/or learn about a phenomenon, situation, or design.	KS1.1E1: Identify various models that may be used, which include but are not limited to physical models (prototypes), mathematical models, simulations, schematics, code, and 3D and 2D representations. KS1.1E2: Compare and contrast the various types of models used when designing a solution.

D1.2: Problem Solving Process and/or Design Process Many disciplines, including engineering, computer science, and biomedical science, use an iterative problem solving process or engineering design process.	LO1.2A: Apply an iterative process to solve a problem or create an opportunity that can be justified.	KS1.2A3: Recognize that all solution attempts should be realistic and based on identified design requirements, which include specifications, constraints, desired features, and testable parameters.
D1.3: Computational Thinking Computational thinking is used to solve problems or create solutions based on an identified need or an opportunity. Common concepts of computational thinking include: the use of algorithms, abstraction, problem decomposition, and data analysis and processing. Computational thinking can support solving problems across many disciplines including math, science, humanities, engineering, and computer science.	LO1.3A: Apply computational thinking to solve problems.	KS1.3A1: Recognize that computational thinking can be applied in all domains. KS1.3A3: Apply logical reasoning by organizing the steps of an algorithm into the correct sequence. KS1.3A4: Understand that different algorithms can be used to solve the same problem.
D2.1: Modeling Designing and creating models are essential to the engineering design and problem solving processes. Models are used to represent an artifact or a system to better understand its attributes and/or behavior. Models can be physical, mathematical, computer-generated, and/or simulated.	LO2.1A: Apply a mathematical model to represent an authentic situation.	KS2.1A1: Recognize that mathematical equations can be used to create models through tables, charts, and simulations.
	LO2.1C: Construct a computer-generated solid model.	KS2.1C1: Develop solid models using two-dimensional geometric shapes and three-dimensional geometric primitives. KS2.1C2: Construct new solid models using geometric primitives with additive and subtractive methods. KS2.1C3: Apply geometric and dimensional constraints to solid model designs.

	LO2.1D: Create a physical model or prototype.	KS2.1D1: Construct a prototype based on design documentation. KS2.1D2: Conduct prototype testing to identify design flaws or additional needs. KS2.1D3: Analyze and interpret testing data collected and make modifications to optimize the design or process.
D2.2: Measurement and Estimation A common measurement system is essential to design accuracy for sketches, models, and prototypes. Measuring and dimensioning objects using appropriate tools are critical to effectively communicate and collaborate on design solutions.	LO2.2A: Measure and present values appropriate to standards of accuracy and precision.	KS2.2A1: Identify the proper tool to use to measure and dimension with accuracy and precision. KS2.2A2: Identify the appropriate equation for area and volume problems.
D2.3: Spatial Visualization Sketching allows designers to quickly communicate ideas with accurate dimensions and details. Using technology, two-dimensional sketches can be represented in a three-dimensional solid model. Solid models allow designers to view multiple aspects and perspectives of a design.	LO2.3A: Translate and interoperate between 2D and 3D design representations.	KS2.3A1: Differentiate between two-dimensional and three-dimensional models including the strengths and limitations of each. KS2.3A2: Interpret multiview drawings, specifications, dimensions, and annotations.
	LO2.3B: Sketch and/or interpret perspective, isometric, and multiview drawings with adequate attention to standards and critical annotations.	KS2.3B3: Summarize the reasoning for using sketching as a communication tool. KS2.3B4: Apply dimensions on a multiview sketch following the guidelines of dimensioning. KS2.3B5: Create a rapid, accurate sketch to communicate ideas.

D2.4 Tools and Technology There are a variety of tools and technology used during the different stages of an engineering design or problem-solving process. They include, but are not limited to, measuring tools, drawing tools, software applications including computer-aided design (CAD), computer algebra system (CAS) applications, modeling and simulation, data representation, and online resources.	LO2.4A: Select and apply tools and technology appropriately to develop solutions, create artifacts, and/or conduct investigations into engineering, biomedical science, and computational problems/needs.	KS2.4A1: Recognize the existence of various tools and technology that can be used when developing solutions or artifacts or conducting experiments. KS2.4A2: Select the appropriate tools and technology based on the needs of the project and the team.
D3.1 Collaboration Effective problem solving, experimentation, and/or design are most often conducted within teams.	LO3.1A: Collaborate effectively on a diverse and multi-disciplinary team.	KS3.1A1: Describe how diverse perspectives in collaboration typically produce the best results in a process. KS3.1A4: Apply team norms to encourage productivity and define how a team will function and measure its success.
D3.2: Communication Communication can often be categorized as technical communication or professional communication.	LO3.2A: Communicate effectively for specific purposes and settings.	KS3.2A3: Demonstrate best practices that are widely accepted by professionals when they communicate such as how to present visual media, oral presentations, and professional correspondence.
	LO3.2C: Construct and communicate informed decisions supported by evidence.	KS3.2C2: Use current and accurate research and testing documentation.

Meaning
***Essential Questions**: Students will keep considering…* • EQ3.1 Why is it important to engage stakeholders during the design process? • EQ3.2 Why are teams of people more successful than an individual when solving problems? • EQ3.3 Why is brainstorming, research, and testing important when creating, modifying, or improving a design solution?

Meaning	*Acquisition*	
Domains/Understandings	***Transfers/Learning Objectives***	***Knowledge and Skills***
Domains are key understandings and long-term takeaways that go beyond factual knowledge into broader and more conceptual comprehensions. *Domains are areas of expertise that an employer in a specific field may seek.*	*Objectives articulate what skills students need to be able to do. (The learning objectives will become targets of assessment.)* *Objectives are functions that directly relate to the workplace or in an applied academic setting.*	*Knowledge and skills include the essential facts and basic concepts that a student should know and be able to recall in order to perform the competency.* *Knowledge and skill statements are foundational to the performance of a skill.*
"I will be able to address real-world challenges because I understand…"	***"In the workplace or academic setting, I will need to know and be able to…"***	***"After I learn the information, I will be able to use my knowledge and skills to…"***

D1.1: Mindset Ethics, analytical thinking, creativity, persistence, iteration, and the positive role of failure are important mindsets and habits of action. They are developed over time in problem solving processes, inquiry, and computational thinking.	LO1.1A: Describe and/or analyze moments within a problem solving process where persistence, iteration, and the positive aspect of failure played an important role in gaining understanding about a problem or unexpected observation.	KS1.1A1: Understand that problem solving and experimentation are cyclical, meaning steps are repeated as many times as needed. KS1.1A2: Recognize that identifying complex problems, defining them clearly, and proposing solutions can be difficult and requires persistence and iteration. KS1.1A3: Describe how failure can produce positive outcomes by improving understanding.
	LO1.1B: Demonstrate creativity and courage to take risks in proposing designs.	KS1.1B2: Generate ideas or build upon other ideas to innovate. KS1.1B3: Develop solutions employing non-traditional techniques; novel combinations of artifacts, tools, techniques; and exploration of personal curiosities throughout a creative process.
	LO1.1C: Analyze problems or artifacts when developing solutions.	KS1.1C1: Demonstrate analytical thinking when evaluating a proposed solution, locating and correcting errors, explaining how something functions, gaining understanding through experimentation, and/or justifying the appropriateness of a solution, model, or artifact.
	LO1.1E: Recognize that models are used to make predictions and/or learn about a phenomenon, situation, or design.	KS1.1E1: Identify various models that may be used, which include but are not limited to physical models (prototypes), mathematical models, simulations, schematics, code, and 3D and 2D representations. KS1.1E2: Compare and contrast the various types of models used when designing a solution.

	LO1.1F: Identify ethical considerations that must be considered when creating solutions or opportunities.	KS1.1F1: Recognize that ethical considerations include but are not limited to safety, impact on future generations (sustainability), and recognizing the work of others (intellectual property). KS1.1F2: Explain how universal design considers the broadest possible spectrum of human ability in the design of products, environments and information systems.
D1.2: Problem Solving Process and/or Design Process Many disciplines, including engineering, computer science, and biomedical science, use an iterative problem solving process or engineering design process.	LO1.2A: Apply an iterative process to solve a problem or create an opportunity that can be justified.	KS1.2A1: Recall that the goal of any design process is to create solutions and opportunities for people and society, while justifying the cost and effort involved. KS1.2A2: Identify a problem and justify the pursuit of a solution to the problem. KS1.2A3: Recognize that all solution attempts should be realistic and based on identified design requirements, which include specifications, constraints, desired features, and testable parameters. KS1.2A4: Define the problem or opportunity identified through research and stakeholder engagement prior to any solution attempt. This includes examining prior solution attempts. KS1.2A5: Evaluate, define, and/or prioritize realistic design requirements including specifications, constraints, desired features, and testable parameters. KS1.2A6: Create multiple solution options and evaluate those options with tools such as a decision matrix to justify a data-driven path forward. KS1.2A7: Create and execute an iterative testing plan to provide evidence that a solution meets the design requirements.

	LO1.2B: Analyze and describe design functionality by observation of an artifact.	KS1.2B3: Recognize that designers must be unbiased in reflecting and presenting their design process. The process only has validity through stakeholder and peer review. KS1.2B4: Evaluate the validity of a testing plan and conclusions drawn from a process. KS1.2B5: Illustrate how the context in which an artifact is used determines the correctness, usability, functionality, and suitability of the artifact.
	LO1.3B: Organize, process, and analyze data to understand a real-world situation.	KS1.3B3: Collect and process data to facilitate the creation of knowledge. KS1.3B4: Interpret data to gain insight on a problem and draw conclusions.
	LO2.1C: Construct a computer-generated solid model.	KS2.1C1: Develop solid models using two-dimensional geometric shapes and three-dimensional geometric primitives. KS2.1C2: Construct new solid models using geometric primitives with additive and subtractive methods. KS2.1C3: Apply geometric and dimensional constraints to solid model designs.
	LO2.1D: Create a physical model or prototype.	KS2.1D1: Construct a prototype based on design documentation. KS2.1D2: Conduct prototype testing to identify design flaws or additional needs. KS2.1D3: Analyze and interpret testing data collected and make modifications to optimize the design or process.

D2.2: Measurement and Estimation A common measurement system is essential to design accuracy for sketches, models, and prototypes. Measuring and dimensioning objects using appropriate tools are critical to effectively communicate and collaborate on design solutions.	LO2.2A: Measure and present values appropriate to standards of accuracy and precision.	KS2.2A1: Identify the proper tool to use to measure and dimension with accuracy and precision. KS2.2A3: Measure objects to create accurate design sketches.
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D2.4: Tools and Technology There are a variety of tools and technology used during the different stages of an engineering design or problem-solving process. They include, but are not limited to, measuring tools, drawing tools, software applications including computer-aided design (CAD), computer algebra system (CAS) applications, modeling and simulation, data representation, and online resources.	LO2.4A: Select and apply tools and technology appropriately to develop solutions, create artifacts, and/or conduct investigations into engineering, biomedical science, and computational problems/needs.	KS2.4A2: Select the appropriate tools and technology based on the needs of the project and the team.

D3.1: Collaboration Effective problem solving, experimentation, and/or design are most often conducted within teams.	LO3.1A: Collaborate effectively on a diverse and multi-disciplinary team.	KS3.1A1: Describe how diverse perspectives in collaboration typically produce the best results in a process. KS3.1A2: Identify and value the contributions of each team member. KS3.1A3: Illustrate successful collaboration through effective communication and constructive feedback. KS3.1A4: Apply team norms to encourage productivity and define how a team will function and measure its success. KS3.1A5: Identify and evaluate positive and negative behaviors that impact the team's effectiveness. KS3.1A6: Recognize individual strengths when defining roles and responsibilities.

D3.2: Communication Communication can often be categorized as technical communication or professional communication.		KS3.2A2: Distinguish technical communication artifacts that capture a process, including but not limited to engineering notebooks, laboratory journals, technical presentations, sketches, technical drawings, design briefs, design reviews, laboratory reports, and code. KS3.2A3: Demonstrate best practices that are widely accepted by professionals when they communicate such as how to present visual media, oral presentations, and professional correspondence. KS3.2A4: Communicate to meet the needs of the audience and be appropriate to the situation. KS3.2A5: Demonstrate proper elements of written and electronic communication (spelling, grammar and formatting) at all times when communicating with a team or stakeholder in a process. KS3.2A6: Use accurate terminology when communicating about systems and processes.
	LO3.2B: Document a process according to professional standards.	KS3.2B1: Present data and information through a variety of accepted means such as: graphs, charts, images, video, schematics, code, 3D models, and simulations.
	LO3.2C: Construct and communicate informed decisions supported by evidence.	KS3.2C1: Recognize that the validity of sources will provide credibility to one’s arguments.

		KS3.2C2: Use current and accurate research and testing documentation.
D3.3: Project Management The discipline of carefully projecting or planning, organizing, motivating and controlling resources to achieve specific goals and meet specific success criteria.	LO3.3A: Demonstrate the ability to manage multiple resources throughout a project.	KS3.3A1: Identify resources managed in a project to include time, capital, energy, information, materials, people, tools, and machines. KS3.3A2: Create and execute a plan to manage and use resources.
	LO3.3B: Justify decisions and provide rationales when making tradeoffs between resources.	KS3.3B1: Recognize that processes involve tradeoffs when weighing the need against effort and resources available. KS3.3B2: Demonstrate sound judgement when making decisions regarding resources and their potential tradeoffs.