**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.

**Competency (C), Domain (D), Objectives (O), Knowledge and Skills (KS)**

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C1 Problem Solving and Process Thinking

Strategic and systematic design and inquiry processes guide the development of an effective solution to the problem.

D1 Engineering Mindset

Successful engineers exhibit specific personal and professional characteristics that lend themselves to the creative, collaborative, and solution-driven nature of the profession.

O1.1 Demonstrate independent thinking and self-direction in pursuit of accomplishing a goal.

KS1.1.1 Plan and use time in pursuit of accomplishing a goal without direct oversight.

O1.2 Demonstrate flexibility and adaptability to change.

KS1.2.1 Adapt to varied roles, job responsibilities, schedules, and contexts.

KS1.2.2 Use praise, setbacks, and feedback to positively influence one's professional development.

O1.3 Persevere to solve a problem or achieve a goal.

KS1.3.1 Reflect critically on past experiences to inform future progress.

O1.4 Use spatial visualization to create and interpret graphical communication of two- and three-dimensional objects.

KS1.4.1 Match a set of orthographic projections of a three-dimensional object with pictorial representations of the same object.

KS1.4.2 Match pictorial representations of a three-dimensional object with other pictorial representations that illustrate the same object from different points of view.

KS1.4.3 Identify the shapes of two-dimensional cross-sections of three-dimensional objects.

KS1.4.4 Identify three-dimensional objects generated by rotation of a two-dimensional object.

KS1.4.5 Create and identify flat patterns that can be folded into specified three-dimensional shapes, and identify three-dimensional shapes that are represented by specified flat patterns.

D2 Design Process

An engineering design process is an iterative, systematic approach to problem solving.

O2.1 Explain and justify an engineering design process.

KS2.1.1 Explain that there are many versions of a design process that describe essentially the same process.

KS2.1.2 Describe major steps of a design process and identify typical tasks involved in each step.

KS2.1.3 Identify the step in which an engineering task would fit in a design process.

KS2.1.4 Outline how iterative processes inform engineering decisions, improve solutions, and inspire new ideas.

KS2.1.5 Document a design process in an engineering notebook according to best practices.

O2.2 Collect, analyze, and interpret information relevant to the problem or opportunity at hand to support engineering decisions.

KS2.2.1 Explain the role of research in the process of design.

KS2.2.2 Find relevant data in credible sources such as literature, databases, and policy documents.

O2.3 Synthesize an ill-formed problem into a meaningful, well-defined problem.

KS2.3.1 Explain the importance of carefully and specifically defining a problem or opportunity, design criteria, and constraints, to develop successful design solutions.

KS2.3.2 Identify and define visual, functional, and structural design requirements with realistic constraints, against which solution alternatives can be evaluated.

KS2.3.3 List potential constraints that may impact the success of a design solution. Examples include economic (cost), environmental, social, political, ethical, health and safety, manufacturability, technical feasibility, and sustainability.

O2.4 Generate multiple potential solution concepts.

KS2.4.1 Describe multiple techniques and appropriate guidelines used to generate ideas.

KS2.4.2 Represent concepts using a variety of visual tools, such as sketches, graphs, and charts, to communicate details of an idea.

O2.5 Develop models to represent design alternatives and generate data to inform decision making, test alternatives, and demonstrate solutions.

KS2.5.1 Define various types of models that can be used to represent products, processes, or designs, such as physical prototypes, mathematical models, and virtual representations. Explain the purpose and appropriate use of each.

KS2.5.2 Produce a physical model using hand tools and simple construction techniques.

O2.6 Select a solution path from many options to successfully address a problem or opportunity.

KS2.6.1 Explain that there are often multiple viable solutions and no obvious best solution. Trade-offs must be considered and evaluated consistently throughout an engineering design process.

KS2.6.2 Develop and carry out a justifiable scheme to compare and evaluate competing solution paths. A decision matrix is one tool used to compare and evaluate competing solutions based on design criteria.

O2.7 Make judgements and decisions based on evidence.

KS2.7.1 Explain that a conclusion is valid if the evidence supports the conclusion while acknowledging the limitations, opposing views, and biases.

KS2.7.2 Evaluate evidence and arguments to identify deficiencies, limitations, and biases or appropriate next steps in the pursuit of a better solution.

D3 Engineering Tools and Technology

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

O3.1 Using a variety of measuring devices, measure and report quantities accurately and to a precision appropriate for the purpose.

KS3.1.1 Explain that all measurements are an approximation of the true value of a quantity.

KS3.1.2 Explain and differentiate between the accuracy and precision of a measurement or measuring device.

KS3.1.3 Use dimensional analysis and unit conversions to transform data to consistent units or to units appropriate for a particular purpose or model.

O3.2 Use a spreadsheet application to help identify and/or solve a problem.

KS3.2.1 Populate a spreadsheet application with data and organize the data to be useful in accomplishing a specific goal.

KS3.2.2 Use the functions and tools within a spreadsheet application to manipulate, analyze, and present data in a useful way, including regression analyses and descriptive statistical analyses.

O3.3 Interpret and analyze data for a single count or measurement variable for example, quality control data.

KS3.3.1 Represent data for a single count or measurement with plots on the real number line, such as dot plots and histograms.

KS3.3.2 Use statistics appropriate to the shape of the data distribution to determine the center (median, mean) and spread (interquartile range, standard deviation) of a data set and/or compare data sets.

KS3.3.3 Use the mean and standard deviation of a data set to fit it to a normal distribution and use the Empirical Rule to estimate population percentages.

O3.4 Apply mathematical (including graphical) models and interpret the output of models to test ideas or make predictions.

KS3.4.1 Represent data for two quantitative variables on a scatter plot, and describe how the variables are related.

KS3.4.2 Fit a function to the data; use linear functions fitted to data to solve problems in the context of the data.

KS3.4.3 In linear models, interpret the rate of change (slope) and the intercept (constant term) in the context of the data.

KS3.4.4 Distinguish between sample statistics and population statistics and know appropriate applications of each.

KS3.4.5 Use a free-body diagram and a mathematical model to represent the static equilibrium of an object.

KS3.4.6 Develop a graphical model (function) that describes a relationship between two quantities given a description of a relationship (e.g. motion graph).

C2 Technical Knowledge and Skills

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

D4 Technical Sketching and Drawing

Exploring, visualizing and communicating engineering designs and technical information is often accomplished through technical sketches and drawings.

O4.1 Read and interpret technical drawings.

KS4.1.1 Identify line types used in technical drawing and the purpose and interpretation of each, including construction lines, object lines, hidden lines, and center lines.

KS4.1.2 Identify and describe the proper use of each technical drawing representation, including isometric, orthographic, oblique, section, and auxiliary views.

KS4.1.3 Use scale drawings to solve problems, including computing actual lengths, areas, and volumes related to the drawn object.

O4.2 Create technical drawings to fully detail an object or part.

KS4.2.1 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.

KS4.2.2 Hand sketch 1-point and 2-point perspective pictorial views of a simple object or part given the object, a detailed verbal description of the object, pictorial view of the object, oblique, and/or set of orthographic projections.

KS4.2.3 Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings.

KS4.2.4 Determine the minimum number and types of views necessary to fully detail a part.

KS4.2.5 Hand sketch orthographic projections at a given scale and in the correct 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.

KS4.2.6 Hand sketch a full- or half-section view at a given scale in the correct orientation to fully detail an object or part.

O4.3 Properly dimension technical drawings of simple objects or parts according to a set of dimensioning standards and accepted practices.

KS4.3.1 Identify general rules for dimensioning on technical drawings used in standard engineering practice.

KS4.3.2 Based on a set of dimensioning guidelines and standard engineering practice, identify and correct errors and omissions in the dimensions applied in a technical drawing.

KS4.3.3 Identify and correctly apply chain dimensioning methods to a technical drawing.

KS4.3.4 Identify and correctly apply datum dimensioning methods to a technical drawing.

KS4.3.5 Compare the effect of chain dimensioning and datum dimensioning on the tolerance of a particular specified dimension.

KS4.3.6 Read and interpret a hole note to identify the size and type of hole specified.

O4.4 Apply appropriate engineering tolerances to specify the allowable variation, size of individual features, and orientation and location between features of an object.

KS4.4.1 Identify and differentiate among a limit dimension, unilateral tolerance, and bilateral tolerance.

KS4.4.2 Determine the specified dimension, tolerance, upper limit, and lower limit for any given dimension and related tolerance (or any distance that is dependent on given dimensions) shown on a technical drawing.

KS4.4.3 Identify and differentiate between clearance and interference fit.

KS4.4.4 Determine the allowance between two mating parts of an assembly based on dimensions given on a technical drawing.

D5 Computer-Aided Design (CAD) Software

Engineers use computer-aided design software to facilitate the design, documentation, and communication of solutions to engineering problems.

O5.1 Create a solid part model using 3D computer-aided design (CAD) software to represent an object.

KS5.1.1 Identify and differentiate geometric constructions and constraints (such as horizontal lines, vertical lines, parallel lines, perpendicular lines, collinear points, tangent lines, tangent circles, and concentric circles) and the results, when applied to sketch features within a 3D solid modeling environment.

KS5.1.2 Differentiate between additive and subtractive 3D modeling techniques.

KS5.1.3 Compare the efficiency of creating a 3D computer model using different combinations of additive and subtractive modeling techniques.

KS5.1.4 Apply geometric and dimensional constraints within a CAD program to model an object.

KS5.1.5 Model through, clearance, blind, counter bore, and countersink holes.

KS5.1.6 Assign a specific material (included in the software library) to a part model and use the capabilities of the CAD software to determine the mass, volume, and surface area of the part.

KS5.1.7 Create a new material (not included in the software library), assign a density value to the new material), and apply the material to a part.

KS5.1.8 Create relationships among part features and dimensions using parametric formulas.

O5.2 Create an assembly model using 3D computer-aided design (CAD) software to represent an assembly of parts.

KS5.2.1 Explain each assembly constraint (including mate, flush, insert, and tangent), its role in an assembly model, and the degrees of freedom that it removes from the movement between parts.

KS5.2.2 Apply appropriate assembly constraints to model the realistic operation of an assembly of parts.

O5.3 Create a set of working drawings using 3D computer-aided design (CAD) software to document a design according to standard engineering practices.

KS5.3.1 Generate an annotated multiview technical drawing using CAD software, to fully describe a simple part according to standard engineering practice.

KS5.3.2 Generate an assembly drawing using CAD software of an assembly of parts.

KS5.3.3 Identify and detail components of an assembly using identification numbers on an assembly view and a parts list.

D6 Physical Properties

The success of a problem solution that includes a physical object or system often depends (in whole or in part) on physical properties of the object or system components.

O6.1 Determine physical properties associated with an object.

KS6.1.1 Define the term “physical property” and identify length, volume, mass, weight, density, and surface area as physical properties.

KS6.1.2 Measure mass with accuracy using a balance and report the measurement using an appropriate level of precision.

KS6.1.3 Distinguish between the meanings of the terms “weight” and “mass”.

KS6.1.4 Measure volume with accuracy and report the measurement using an appropriate level of precision.

KS6.1.5 Calculate a physical property indirectly using available data or perform appropriate measurements to gather the necessary data (for example, determine area or volume using linear measurements or determine density using mass and volume measurements).

O6.2 Apply physical properties in a design process (for example, design an object or structure to satisfy physical constraints or minimize cost).

KS6.2.1 Solve real-world and hypothetical mathematical problems involving area and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, right prisms, cylinders, and spheres.

KS6.2.2 Solve volume problems using volume formulas for rectangular solids, cylinders, pyramids, cones, and spheres.

KS6.2.3 Solve real-world and hypothetical mathematical problems involving density, weight and/or mass.

KS6.2.4 Solve real-world and hypothetical mathematical problems involving center of gravity and static equilibrium as is applied to tipping an object about a point.

D7 Reverse Engineering

Engineers analyze the visual, functional, and structural elements of existing products for many reasons, including knowledge attainment, product or process improvement, and failure analysis.

O7.1 Analyze a consumer product using reverse engineering techniques to document visual, functional, and structural aspects of the design.

KS7.1.1 Describe the processes and purposes of reverse engineering.

KS7.1.2 Describe visual principles and elements of design apparent in a natural or man-made object.

KS7.1.3 Explain how the visual elements and principles of design affect the aesthetics and commercial success of a product.

KS7.1.4 Perform a visual analysis of a product that incorporates simple machines.

KS7.1.5 Perform a functional analysis of a product that incorporates simple machines to determine the purpose, inputs and outputs, and operation of a product or system.

KS7.1.6 Perform a structural analysis of a product to determine the materials used, the form of component parts, as well as the configuration and interaction of component parts when assembled (if applicable).

C3 Professional Practices and Communication

Professional practice is guided by professional ethics and standards and requires effective communication and collaboration.

D8 Career Awareness

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

O8.1 Understand the educational, professional, and technical skills required for professional engineering practice.

KS8.1.1 Identify the technical and non-technical 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.

O8.2 Describe the role of engineers in society.

KS8.2.1 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.

O8.3 Describe and distinguish among the different disciplines of engineering.

KS8.3.1 Describe the historically traditional disciplines of engineering, including civil, electrical, mechanical, and chemical.

O8.4 Discuss and analyze some of the persistent global engineering challenges to sustain growing populations and improve lives.

KS8.4.1 Identify and describe some of the “Grand Challenges” as defined by the National Academy of Engineering as current global engineering challenges, and describe their implications on society.

D9 Professionalism and Ethics

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.

O9.1 Assess an engineering ethical dilemma.

KS9.1.1 Explain that engineering solutions can have significantly different impacts on an individual, society, and the natural world.

O9.2 Strive to create sustainable solutions to meet the needs of society, without compromising the ability of future society to meet their needs.

KS9.2.1 Describe the life cycle of a product or service.

D10 Collaboration

Demonstrate an ability to function on multidisciplinary teams.

O10.1 Facilitate an effective team environment to promote successful goal attainment.

KS10.1.1 Describe the importance of team norms and develop those norms for a team.

KS10.1.2 Solicit, negotiate, and balance diverse views and beliefs to reach workable solutions.

KS10.1.3 Identify, describe, and justify a diverse composition of engineering (and other) disciplines that might work together to address challenges (including the Grand Challenges of Engineering).

O10.2 Contribute individually to overall collaborative efforts.

KS10.2.1 Describe one’s individual role and expectations of performance within the team.

KS10.2.2 Critically and realistically self-evaluate personal contributions and collaboration effectiveness within a team.

O10.3 Analyze and evaluate the work of others to provide helpful and effective feedback.

KS10.3.1 Describe the purpose and positive outcomes of a peer review process.

O10.4 Manage project timelines and resources as part of an engineering design process.

KS10.4.1 Develop a project plan using a project planning tool such as a Gantt chart.

KS10.4.2 Select and use a system of collaborative tools, such as cloud-based tools, document sharing, and video and text functions, to successfully complete a project.

D11 Communication

Engineering practice requires effective communication with a variety of audiences using multiple modalities.

O11.1 Communicate effectively with an audience based on audience characteristics.

KS11.1.1 Communicate effectively with an audience based on audience characteristics.

KS11.1.2 Follow acceptable formats for technical writing and professional presentations.

KS11.1.3 Properly cite references for all communication in an accepted format.

KS11.1.4 Clearly label tables and figures with units and explain the information presented in context.

KS11.1.5 Describe characteristics important to oral delivery of information (volume, tempo, eye contact, articulation, and energy). Vary these elements of delivery to convey and emphasize information and engage the audience.