Digital Electronics
PLTW Framework
Course Level

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 (C), Domains (D), Objectives (O), Knowledge and Skills (KS)

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.

KS1.1.2 Plan how to gain additional knowledge and learning to accomplish a goal.

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 Describe why persistence is important when identifying a problem and/or pursuing solutions.

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 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.

O2.4 Generate multiple potential solution concepts.

KS2.4.1 Represent concepts using a variety of visual tools, such as sketches, graphs, and charts, to communicate details of an idea.

O2.5 Choose and develop models to represent design alternatives and scenarios in order to generate data to inform decision making, test alternatives, and demonstrate solutions.

KS2.5.1 Describe the use of a model to accurately represent the key aspects of a physical system. Include the identification of constraints, such as cost, time, or expertise that may influence the selection of a model.

KS2.5.2 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.

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. Tradeoffs must be considered and evaluated consistently throughout an engineering design process.

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

O3.2 Construct physical objects using hand tools and shop tools.

KS3.2.1 Identify basic hand tools and shop tools and describe their function.

KS3.2.2 Describe a process to build a physical object based on a conceptual communication such as a drawing or description.

KS3.2.3 Demonstrate use of hand tools and shop tools.

KS3.2.4 Produce a physical model using electronic components.

O3.3 Apply computational thinking to generalize and solve a problem using a computer.

KS3.3.1 Interact with content-specific models and simulation to support learning and research.

KS3.3.2 Use modeling and simulation to represent and understand natural phenomena.

KS3.3.3 Analyze data and identify patterns through modeling and simulation.

KS3.3.4 Develop an algorithm (step-by step-process) for solving a problem.

KS3.3.5 Identify, test, and implement possible solutions to a problem using a computer.

C2 Technical Knowledge and Skills

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

D4 Foundations in Mathematics and Science

All digital circuits are created from base 2 mathematics. Knowledge of number systems and mathematical relationships of analog circuits are fundamental to understanding and creating circuits.

O4.1 Solve complex calculations using appropriate notation.

KS4.1.1 Select the most appropriate notation.

KS4.1.2 Convert any number to/from engineering notation.

KS4.1.3 Convert any number between the International System of Units, SI, prefixes.

O4.2 Use mathematical processes to convert any value between any two number systems.

KS4.2.1 Count from 0 to 15 in binary.

KS4.2.2 Convert numbers between the binary and decimal number systems.

KS4.2.3 Convert numbers between the decimal, binary, octal, and hexadecimal number systems.

KS4.2.4 Convert numbers between the binary coded decimal and the decimal number systems.

O4.3 Calculate voltage, current, and/or resistance for components in a circuit.

KS4.3.1 Identify parts and distinguish between characteristics of a circuit that are in series.

KS4.3.2 Identify parts and characteristics of a circuit that are in parallel.

KS4.3.3 Calculate total resistance for a circuit by applying Kirchhoff's Voltage Law and Kirchhoff's Current Laws.

KS4.3.4 Solve for unknown values in a circuit by applying Ohm's law.

O4.4 Simplify algebraic expressions.

KS4.4.1 Apply Boolean algebra theorems and De Morgan's theorems to simplify expressions.

KS4.4.2 Apply the Karnaugh mapping technique to simplify Boolean expressions.

O4.5 Add and subtract in the binary number system.

KS4.5.1 Describe and/or apply the two's complement arithmetic process and relate the process to decimal number systems without the use of negative numbers.

D5 Foundations in Electronics

Electronics requires specific knowledge related to working safely, the tools, and the electrical components used within the field.

O5.1 Demonstrate and apply appropriate safety procedures when working with electronics in a classroom.

KS5.1.1 Identify potential electrical hazards that might cause damage to the human body.

O5.2 Identify and describe the characteristics of common components and logic gates.

KS5.2.1 Explain that the transistor is the most fundamental digital logic component.

KS5.2.2 Demonstrate that digital components, such as transistors, and analog components, such as resistors and capacitors, can be used to create logic gates.

KS5.2.3 Identify resistor component values from color codes.

KS5.2.4 Identify a capacitor's nominal value by reading its labeled nomenclature.

KS5.2.5 Know that common logic gates are designed to fit in Integrated Circuits (ICs) for easier use in design. These ICs are most often found in two styles: Small Scale Integration (SSI) and Medium Scale Integration (MSI).

KS5.2.6 Identify, implement, and/or describe integrated circuits' properties from their part number, schematic symbol, and/or data sheet.

KS5.2.7 Identify integrated circuits wiring diagram from a data sheet.

KS5.2.8 Identify a logic gate from a truth table or write a truth table representing a logic gate.

KS5.2.9 Implement a seven-segment display into a circuit design to display alphanumeric values using seven-segment display drivers.

KS5.2.10 Select the correct current-limiting resistor and/or properly wire both common cathode and common anode seven-segment displays.

KS5.2.11 Describe how Programmable Logic Devices (PLDs) allow designers to bypass breadboarding and test designs on devices, such as a Field Programmable Gated Array (FPGA), reducing the time needed in design.

O5.3 Select and apply the appropriate components, tools, and technology when creating or characterizing a design.

KS5.3.1 Troubleshoot circuits (mechanics of circuit and logic of circuit).

KS5.3.2 Properly solder and de-solder components to printed circuit boards according to best practices.

KS5.3.3 Measure current, voltage, and/or resistance within a circuit or across a component using a digital multimeter (DMM).

KS5.3.4 Measure frequency, period, and duty cycle of a clock signal using an oscilloscope.

KS5.3.5 Design a circuit, simulate a circuit, and verify a measurement and/or hand calculation using circuit design software (CDS).

O5.4 Clock signals trigger events in circuits.

KS5.4.1 Select and apply components in a design to produce a desired waveform, frequency, period, and/or duty cycle.

KS5.4.2 Analyze and interpret the amplitude, period, frequency, and duty cycle of analog and digital signals based on instrumentation and calculations.

KS5.4.3 Interpret and/or modify the analog components of a 555 timer oscillator circuit to affect the wave generated.

O5.5 Interpret and/or modify a full adder and half adder to predict outputs given specific inputs when adding or subtracting numbers.

KS5.5.1 (same as KS4.5.1) Describe and/or apply the two's complement arithmetic process and relate the process to decimal number systems without the use of negative numbers.

KS5.5.2 Predict outputs given specific inputs when adding or subtracting numbers.

KS5.5.3 Describe the design of an adder/subtractor circuit related to the carry out and use of XOR/XNOR gates.

O5.6 Create, interpret, and/or modify a multiplexed or de-multiplexed circuit to make it more efficient.

KS5.6.1 Interpret and/or modify a multiplexed or de-multiplexed circuit to make it more efficient.

D6 Combinational Logic

Create specific outputs in a circuit based on specific inputs.

O6.1 Create, interpret, and/or modify an AOI combinational logic circuit based on design requirements according to a systematic process for designing a combinational logic circuit.

KS6.1.1 Translate design requirements into Boolean expressions and/or a truth table.

KS6.1.2 Translate Boolean expressions into truth tables and truth tables into unsimplified Boolean expressions.

KS6.1.3 Translate circuit schematics into Boolean expressions or truth tables and Boolean expressions or truth tables into circuit schematics.

KS6.1.4 Interpret and/or modify an AOI circuit based on design requirements.

KS6.1.5 Create an AOI circuit on a breadboard from a schematic.

O6.2 Simplify an AOI circuit design by applying mathematics, K-Mapping, and/or universal gates.

KS6.2.1 (same as KS4.4.1) Apply Boolean algebra theorems and De Morgan's theorems to simplify expressions.

KS6.2.2 (same as KS4.4.2) Apply the Karnaugh mapping technique to simplify Boolean expressions.

KS6.2.3 Translate a set of design specifications into a functional NAND or NOR combinational logic circuit, determine when NAND only or NOR only implementations are the most efficient design, and implement effectively into a circuit.

D7 Sequential Logic

The foundation of digital circuits based on the use of memory.

O7.1 Design, interpret, and/or modify common sequential logic circuits, such as counters, event detectors, and shift registers, using flip-flops based on given design requirements.

KS7.1.1 Draw or analyze detailed timing diagrams for the D or J/K flip-flop's Q output in response to a variety of synchronous and asynchronous input conditions.

KS7.1.2 Analyze and/or design introductory flip-flop applications, such as latches, event detection circuits, data synchronizers, shift registers, and frequency dividers.

KS7.1.3 Describe the advantages and disadvantages of counters using an asynchronous counter design or synchronous counter design.

O7.2 Design, interpret, and/or modify asynchronous counter circuits based on specific design requirements using SSI and/or MSI to count up/down, hold/rest, and start/stop counts according to any desired range.

KS7.2.1 Describe the ripple effect of an asynchronous counter.

KS7.2.2 Analyze and/or design up, down, and modulus asynchronous counters using discrete D and J/K flip-flops.

KS7.2.3 Analyze and/or design up, down, and modulus asynchronous counters using medium-scale integrated (MSI) circuit counters.

KS7.2.4 Describe where a count starts and where a count stops/repeats on a modulus asynchronous counter.

D8 State Machines

Allow circuits to make decisions on the next action based on the current state.

O8.1 Design, interpret, and/or modify a state machine based on specific design requirements to communicate the design.

KS8.1.1 Identify, create, interpret, or modify a state machine design based on design requirements according to a systematic process.

KS8.1.2 Describe the components and structure of a state machine.

KS8.1.3 Draw or interpret a state graph and construct or interpret a state transition table for a state machine.

KS8.1.4 Derive a state machine's Boolean equations from its state transition table.

D9 Programming Logic

There are a wide range of tools that allow designers to create logic on a larger scale and faster.

O9.1 Create, interpret, and/or modify a program to manage inputs and outputs of a microcontroller.

KS9.1.1 Select appropriate hardware and translate a set of design requirements into a program that completes a task.

O9.2 Create logic using a programming language.

KS9.2.1 Create, interpret, or modify a program to control inputs and outputs.

KS9.2.2 Create, interpret, or modify a program to control a servo’s speed and/or position.

C3 Professional Practices and Communication

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

D10 Communication

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

O10.1 Communicate effectively with an audience based on audience characteristics.

KS10.1.1 Adhere to established conventions of written, oral, and electronic communications (grammar, spelling, usage, and mechanics).

KS10.1.2 Follow acceptable formats for technical writing and professional presentations.