PLANNED INSTRUCTION

A PLANNED COURSE FOR:

Engineering 3: Digital Electronics

Curriculum writing committee:
Robert Curtis

Grade Level:
11-12

Date of Board Approval: ____________________

Course Weighting: Engineering 3: Digital Electronics

Major Assessments	**45%**
Skills Application	**30%**
Skills Practice	**20%**
Participation	**5%**
Total	**100%**

Curriculum Map

Overview:
Digital electronics is the study of electronic circuits that are used to process and control digital signals. In contrast to analog electronics, where information is represented by a continuously varying voltage, digital signals are represented by two discrete voltages or logic levels. This distinction allows for greater signal speed and storage capabilities and has revolutionized the world of electronics.

The major focus of the DE course is to expose students to the design process of combinational and sequential logic design, teamwork, communication methods, engineering standards, and technical documentation.

Utilizing the activity-project-problem-based (APB) teaching and learning pedagogy, students will analyze, design, and build digital electronic circuits. While implementing these designs, students will continually hone their professional skills, creative abilities, and understanding of the circuit design process.

Digital Electronics (DE) is a high school level course that is appropriate for 11th or 12th grade students interested in exploring electronics. Other than their concurrent enrollment in college preparatory mathematics and science courses, this course assumes no previous knowledge.

Time/Credit for the Course: One full year, meeting daily for ~46 minutes / 1 elective credit

Goals:

1. **Marking Period One: Over a 45-day period, students will aim to understand:**

   Unit 1: Foundations in Electronics
   - Lesson 1.1 Introduction to Electronics (23 days)
     - Activity 1.1.1 General Safety in the Electronics Classroom
     - Activity 1.1.2 Investigating Basic Circuits
     - Activity 1.1.3 Scientific and Engineering Notation
     - Activity 1.1.4 Analog Component Identification
     - Activity 1.1.5a Circuit Theory Hand Calculations
     - Activity 1.1.5b Circuit Theory Simulations
     - Activity 1.1.5c Circuit Theory Breadboarding
     - Activity 1.1.6 Digital Component Identification
     - Activity 1.1.7 Datasheets
     - Project 1.1.9 Soldering: Random Number Generator
   - Lesson 1.2 Introduction to Circuit Design (22 days)
     - Activity 1.2.1 Introduction to Combinational Logic Design: Seat Belt Circuit
     - Activity 1.2.2 Analog and Digital Signals
     - Activity 1.2.3 Binary Number System
     - Activity 1.2.4 Introduction to Sequential Logic Design: Counters
     - Activity 1.2.5 Clock Signals Using the 555 Timer
     - Project 1.2.6 Understanding Analog Design: Random Number Generator
     - Project 1.2.7 Understanding Digital Design: Random Number Generator

2. **Marking Period Two: Over a 45-day period, students will aim to understand:**

   Unit 2: Combinational Logic
   - Lesson 2.1 AOI Combinational Logic Circuit Design (12 days)
     - Activity 2.1.1 AOI Design: Truth Tables to Logic Expressions
     - Activity 2.1.2 AOI Logic Analysis: Circuit to Truth Table to Logic Expression
     - Activity 2.1.3 AOI Logic Implementation
     - Activity 2.1.4 Circuit Simplification: Boolean Algebra
     - Activity 2.1.5 Circuit Simplification: De Morgan's Theorems
     - Project 2.1.6 AOI Logic Design: Majority Vote
   - Lesson 2.2 Alternative Design: Universal Gates and K-Mapping (14 days)
     - Activity 2.2.1 Circuit Simplification: Karnaugh Mapping
     - Activity 2.2.2 Universal Gates: NAND
     - Activity 2.2.3 Universal Gates: NOR
     - Activity 2.2.4 Design Tool: Logic Converter
     - Project 2.2.5 Fireplace Control
   - Lesson 2.3 Specific Combinational Logic Designs (10 days)
     - Activity 2.3.1 Hexadecimal and Octal Number Systems

    - Activity 2.3.2 Seven-Segment Display
    - Activity 2.3.3 Multiplexers (MUX) and Demultiplexers (DEMUX)
    - Activity 2.3.4 Two's Complement Arithmetic
    - Activity 2.3.5 Binary Adders: XOR and XNOR
- Lesson 2.4 Introduction to Programmable Logical Devices (PLDs) (9 days)
    - Problem 2.4.1 Combinational Logic Circuit Design: Date of Birth
    - Activity 2.4.2 Introduction to Programmable Logic Devices (PLD) Using PLTW S7
    - Project 2.4.3 PLD Design: Date of Birth Using PLTW S7

3. **Marking Period Three: Over a 45-day period, students will aim to understand:**

Unit 3: Sequential Logic

- Lesson 3.1 Sequential Logic Circuit Design (7 days)
    - Activity 3.1.1 Sequential Logic: D Flip-Flops and J/K Flip-Flops
    - Activity 3.1.2 Flip-Flop Applications: Event Detection
    - Activity 3.1.3 Flip-Flop Applications: Shift Registers Using PLTW S7
- Lesson 3.2 Asynchronous Counters (27 days)
    - Activity 3.2.1 Asynchronous Counters: Small Scale Integration (SSI) Up/Down Counters Using PLTW S7
    - Activity 3.2.2 Asynchronous Counters: Small Scale Integration (SSI) Modulus Counters Using PLTW S7
    - Activity 3.2.3 Asynchronous Counters: Medium Scale Integration (MSI) Suspend/Reset Counts
    - Problem 3.2.4 Asynchronous Counters: Now Serving Display Using PLTW S7
- Lesson 3.3 Synchronous Counters (11 days)
    - Activity 3.3.1 Synchronous Counters: Small Scale Integration (SSI)
    - Activity 3.3.2 Synchronous Counters: Medium Scale Integration (MSI) 74LS163 Up Counter Using PLTW S7

4. **Marking Period Four: Over a 45-day period, students will aim to understand:**

Unit 3: Sequential Logic (continued)

- Lesson 3.3 Synchronous Counters (continued) (16 days)
    - Activity 3.3.3 Synchronous Counters: Medium Scale Integration (MSI) 74LS193 Up/Down Counter Using PLTW S7
    - Problem 3.3.4 Synchronous Counters: Sixty-Second Timer Using PLTW S7

Unit 4: Controlling Real-world Systems

- Lesson VEX – Introduction to State Machines (14 days)
    - Project 4.1.1 Copier Jam Detector Using PLTW S7
    - Activity 4.1.2 State Machines: Phone Number Using PLTW S7

    - Problem 4.1.3 State Machine: Tollbooth Using PLTW S7
- Lesson 4.2 Arduino – Introduction to Microcontrollers (15 days)
    - Activity 4.2.2 Introduction to Microcontrollers
    - Activity 4.2.3 Pulse Width Modulation (PWM)
    - Problem 4.2.4 Microcontrollers: The Tollbooth Revisited

Textbook and Supplemental Resources:

my.pltw.org website: the source for all activities and projects

Dueck, Robert K, et al. *Digital Electronics.* Clifton Park, Ny, Delmar Cengage Learning, 2012.

Curriculum Plan

Please refer to the following Course Outline, Course Resume, and Unit Frameworks for the curriculum plan.

PLTW Engineering
Digital Electronics | Course Outline

Open doors to understanding electronics and foundations in circuit design.

Digital electronics is the foundation of all modern electronic devices such as cellular phones, MP3 players, laptop computers, digital cameras, high definition televisions, etc. Students learn the digital circuit design process to create circuits and present solutions that can improve people's lives.

Learn how advancements in foundational electronic components and digital circuit design processes have transformed the world around you.

Digital electronics is the study of electronic circuits that are used to process and control digital signals. In contrast to analog electronics, where information is represented by a continuously varying voltage, digital signals are represented by two discrete voltages or logic levels. This distinction allows for greater signal speed and storage capabilities and has revolutionized the world of electronics.

The major focus of the DE course is to expose students to the design process of combinational and sequential logic design, teamwork, communication methods, engineering standards, and technical documentation.

Utilizing the activity-project-problem-based (APB) teaching and learning pedagogy, students will analyze, design, and build digital electronic circuits. While implementing these designs, students will continually hone their professional skills, creative abilities, and understanding of the circuit design process.

Digital Electronics (DE) is a high school level course that is appropriate for 10th or 11th grade students interested in exploring electronics. Other than their concurrent enrollment in college preparatory mathematics and science courses, this course assumes no previous knowledge.

The following is a summary of the units of study that are included in the course. Activities, projects, and problems are provided to the teacher in the form of student-ready handouts, teacher notes/lesson planning resources, and supplementary materials, including simulations, instructional videos, and online resources as appropriate.

While many students may have been exposed to basic circuits and electricity in a science course, Digital Electronics is typically a unique experience for students because of its focus on understanding and implementing circuit design skills. The course is planned for a rigorous pace, and it is likely to contain more material than a skilled teacher new to the course will be able to complete in the first iteration. Building enthusiasm for rigorous exploration of electronics and circuit design for students is a primary goal of the course.

DE Unit Summary

Unit 1	Foundations in Electronics
Unit 2	Combinational Logic
Unit 3	Sequential Logic
Unit 4	Controlling Real-World Systems

Unit 1: Foundations in Electronics

In Unit 1 Foundations in Electronics, students will explore the fundamental components, concepts, equipment, and skill sets associated with circuit design. They will learn an engineering design process that can be used to guide the creation of circuits based on a set of design requirements. Throughout the course students will learn about advancements in circuits and circuit design that have shaped the world of digital electronics.

Foundations in Electronics Lesson Summary

Lesson 1.1	Introduction to Electronics
Lesson 1.2	Introduction to Circuit Design

Lesson 1.1 Introduction to Electronics

In Lesson 1.1 Introduction to Electronics, students will learn to distinguish between analog and digital components. They will begin by exploring basic circuits and the measurement tools used to characterize and validate calculations that predict a circuit's behavior. Students will be able to clearly describe electrical circuits, voltage, current, resistance, series and parallel circuits, Ohm's law, and how to use a digital multimeter to measure voltage. Students will be introduced to common components such as resistors, capacitors, light emitting diodes (LEDs), seven-segment displays, combinational logic gates, and sequential logic gates.

Lesson 1.2 Introduction to Circuit Design

In Lesson 1.2 Introduction to Circuit Design, students will explore fundamental circuit designs, manipulate circuits to understand their function, and explore the examples that combine analog, digital combinational logic, and digital sequential logic.

This lesson is meant to serve as a broad overview of circuit design and to expose students to basic designs they will be exploring and incorporating into their own future designs.

Unit 2: Combinational Logic

How do you design a circuit to "do what you want it to do"? The goal of Unit 2 is for students to gain in-depth understanding of the combinational logic circuit design. Student will explore creation of circuits with discrete components and how to simplify these circuits to implement more efficient designs.

Combinational Logic Lesson Summary

Lesson 2.1 AOI Combinational Logic Circuit Design
Lesson 2.2 Alternative Design: Universal Gates and K-Mapping
Lesson 2.3 Specific Combinational Logic Designs
Lesson 2.4 Introduction to Programmable Logic Devices (PLDs)

Lesson 2.1 AOI Combinational Logic Circuit Design
Lesson 2.1 focuses on AND, OR, Inverter (AOI) combinational logic circuit design. Students will reinforce concepts that were introduced in the previous units, including binary number systems, truth tables, and Boolean expressions. They will then expand on these concepts by exploring how mathematics can be used to reduce circuit size, cost, and complexity. Using the systematic approaches of AOI simplification, AOI logic analysis, and AOI implementation, students will learn to take design specifications and translate them into the most efficient circuit possible.

Lesson 2.2 Alternative Design: Universal Gates and K-Mapping
In the first lesson of this unit, students learned how to use a design process to transform design specifications into functional AOI combinational logic. Though the result of this work was a functioning circuit, this process does not address a few issues.

First, Boolean algebra was required to simplify the logic expressions. Though Boolean algebra is an important mathematical process, applying its numerous theorems and laws is not always the easiest task to undertake in simplifying circuits.

Second, AOI circuit implementations are rarely the most cost-effective solutions for combinational logic designs.

After completing a series of guided foundational activities on Karnaugh maps, NAND only logic design, and NOR only logic design, the students will apply the combinational logic design process to develop a Fireplace Control Circuit. This process will walk the students through the steps required to transform a set of written design specifications into a functional combinational logic circuit implemented with either NAND only or NOR only logic.

Lesson 2.3 Specific Combinational Logic Designs
This lesson will address a few fundamental topics related to combinational logic. These topics include hexadecimal and octal number systems, XOR, XNOR, and binary adders, 2's complement arithmetic, and multiplexers/de-multiplexers.

These designs are commonly used in digital circuit designs related to adding/subtracting numbers, the use of seven segment displays in designs, and carrying multiple signals through the same pathway in a circuit.

Lesson 2.4 Introduction to Programmable Logic Devices (PLDs)
In the first three lessons of this unit, students learned how to use a design process to transform design specifications into functional AOI, NAND, and NOR combinational logic circuits. In this lesson students apply all that they have learned to design a circuit in which they define some of the design specifications themselves for the first time.

Students will design, simulate, and breadboard a circuit that displays their unique birthdate. Circuit implementation is then demonstrated at the next level by utilizing a programmable logic device called a Field Programmable Gate Array (FPGA). FPGA is a state-of-the-art programmable device capable of implementing large, sophisticated designs. In this course we have limited our designs to four inputs and circuits that are manageable for breadboarding. The PLD shows us the next evolution of circuit design, allowing us to design more complex circuits in a shorter period of time. Students quickly see the benefit of this new design tool and strategy over designing discrete logic gates.

Unit 3: Sequential Logic

How do you get a circuit to do what you want it to do, when you want it to do it? Sequential logic introduces students to event detection and memory. Sequential logic has two characteristics that distinguish it from combinational logic. First, sequential logic must have a signal that controls the sequencing of events. Second, sequential logic must have the ability to remember past events.

A keypad on a garage door opener is a classic example of an everyday device that utilizes sequential logic. On the keypad, the sequencing signal controls when a key can be pressed. The need to enter the passcode in a specific order necessitates memory of past events.

These characteristics are made possible by a simple device called a flip-flop. The flip-flop is a logic device that is capable of storing a logic level and allowing this stored value to change only at a specific time. For this reason the flip-flop is the fundamental building block for all sequential logic designs.

Sequential Logic Lesson Summary

Lesson 3.1 Sequential Logic Circuit Design
Lesson 3.2 Asynchronous Counters
Lesson 3.3 Synchronous Counters

Lesson 3.1 Sequential Logic Circuit Design

In this lesson students begin the study of sequential logic by examining the basic operation of the two most common flip-flop types, the D and J/K flip-flops. As part of this analysis, they will review the design of four typical flip-flop applications: event detector, data synchronizer, frequency divider, and shift register. In later lessons the application of flip-flops for asynchronous counters, synchronous counters, and state-machines will be studied.

Lesson 3.2 Asynchronous Counters

The ability to count in a digital design application is a fundamental need in most circuits. These counting applications range from the simple Now Serving sign at the neighborhood deli counter to the countdown display used by NASA to launch rockets. A number of techniques are used to design counters, but they all fall into two general categories, each with their own advantages and disadvantages. These two categories are called asynchronous counters and synchronous counters.

The primary design characteristic of asynchronous counters that distinguish them from synchronous counters is that the flip-flop of each stage is clocked by the flip-flop output of the prior stage. Thus, rather than all the flip-flops changing simultaneously, the clock ripples its way from the first flip-flop to the last. This is why asynchronous counters are sometimes referred to as ripple counters.

After completing a series of activities on the process for designing Small Scale Integration (SSI) and Medium Scale Integration (MSI) asynchronous counters, this lesson will conclude with a design problem that requires the students to design, simulate, and create a Now Serving display circuit.

Lesson 3.3 Synchronous Counters
As discussed in the previous lesson of this unit, the two categories of digital counters are asynchronous and synchronous. The analysis and design of synchronous counters is the topic of study of this lesson. The primary design characteristic of synchronous counters is that all of the flip-flops are clocked simultaneously. This simultaneous clocking avoids the rippling effect that is present in asynchronous counters.

After completing a series of activities on the process for designing SSI and MSI synchronous counters, this lesson will conclude with a project that requires the students to design and simulate a Sixty Second Timer circuit.

Unit 4: Controlling Real-World Systems

In Unit 4 students make a final transition to the use of single-board computers used widely today. State machines and computers allow students to integrate sensors and motors. This allows us to create circuits that exist in the world around us.

Controlling Real-World Systems Lesson Summary

Lesson 4.1	Introduction to State Machines
Lesson 4.2	Application of State Machines

Lesson 4.1 Introduction to State Machines
State machines, sometimes called Finite State Machines (FSM), are a form of sequential logic that can be used to electronically control common everyday devices such as traffic lights, electronic keypads, and automatic door openers.

In this lesson students will learn and apply the state machine design process. This design process will be used to implement state machines utilizing the pi-top platform, which is based on the Raspberry Pi.

After completing a foundational activity on state machine design, the lesson introduces students to algorithmic thinking and the use of digital and analog devices to solve a problem. The lesson concludes with a project where students design and build a preemptive traffic light using the pi-top and the Python programming language.

Lesson 4.2 Application of State Machines

This lesson introduces students to more algorithms and programming concepts as they learn to use servo motors and remote communication across pi-top devices. The lesson concludes with a problem in which students use all the knowledge and skills they have learned in the unit to design and implement an escape room using multiple pi-tops.

State machines, the design process, planning, and documentation are threaded throughout the unit as students work in teams and practice transportable skills including communication and collaboration.

Course resumes showcase the technical skills students obtain in each PLTW course. Each resume outlines the computational skills, analytical skills, and knowledge acquired in the course. Course resumes also detail student experience with tools, software, lab work, and engineering design. The detailed skills listed within course resumes illustrate the immediate, applicable contributions that students can make within a workplace.

Computational and Analytical Skills

- Use mathematical processes to convert any value between any number systems
- Calculate voltage, current, and/or resistance for components in a complex circuit
- Translate circuit designs, truth tables, design requirements into logic expressions
- Simplify circuits using Boolean algebra theorems and DeMorgan's theorems
- Simplify a logic expression graphically using the Karnaugh Mapping process
- Use algorithmic thinking to solve a problem computationally

Digital Electronics Design Experience

- Implement the design process to design a circuit
- Design a circuit to meet voltage, current, or resistance design requirements
- Select components in a design to produce a desired waveform
- Implement the best combinational logic circuit design
- Apply knowledge of logic gates to select an appropriate gate for the circuit design
- Troubleshoot the design of a circuit by analysis and comparison to the truth table
- Implement a circuit design based on logic expressions
- Troubleshoot existing circuits based on logic expressions
- Determine when NAND only or NOR only implementations are the most efficient
- Implement a seven segment display into a circuit design
- Determine when a common cathode or common anode seven segment display may perform better in a particular circuit design
- Design a sequential circuit
- Describe the function of XOR/XNOR gates in a circuit design
- Design an adder/subtractor circuit related to the carry out and use on XOR gates
- Design a desired frequency of a clock signal in a 555 timer design
- Design a sequential logic circuit to produce a desired output
- Design synchronous/asynchronous counter circuits based on design requirements
- Design a state machine based on specific design requirements
- Design a circuit with motors as outputs that operate at different voltage levels
- Select and apply the most appropriate design method for circuit implementation

Practical Application Experience

- Solder and de-solder components to printed circuit boards
- Validate circuit design through measurement using a probe/oscilloscope and analysis of timing diagram
- Select and apply the most appropriate technology for circuit implementation
- Implement designs on an FPGA
- Create a program to manage inputs and outputs of a single-board computer

Tools and Software

- Oscilloscope
- DMM
- FPGA Digital Mini System
- Digital Logic Board

Professional Skills

- Team collaboration
- Project management
- Problem-solving
- Communication skills
- Presentation skills
- Technical writing

Course Knowledge

- Foundations in Electronics
  - Introduction to safety, electricity, and components
  - Introduction to common analog and digital circuit designs and applications
- Combinational Logic
  - Designing AOI combinational logic circuits
  - Alternative Design: Universal gates and K-mapping
  - Specific combinational logic designs
  - Introduction to PLD design and circuit prototyping on a PLD
- Sequential Logic
  - Sequential logic circuit design
  - D flip-flops, J/K flip-flops, and flip-flop applications
  - Asynchronous counters
  - Counter design SSI, MSI, and MOD asynchronous counters
  - Synchronous counters
  - Counter design SSI, MSI, and MOD synchronous counters
- Controlling Real World Systems
  - Introduction to state machines
  - Introduction to sensors, motors, and state machine design
  - Introduction to programming with Python

PLTW Framework - Overview

PLTW Unit Frameworks provide an overview of the levels of understanding that each build upon the higher level: 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.

Essential Questions

1.1 - 1 Why are the safety practices important?

1.1 - 2 Why are hand calculations important when a software can perform the same calculations?

1.1 - 3 How are analog and digital components used in products that you use?

1.1 - 4 How can you use your soldering skills beyiond this course?

1.2 - 1 Can a digital and analog circuit be designed to accomplish the same tasks?

1.2 - 2 Why is the understanding of binary and decimal number systems essential to your ability to design combinational logic circuits?

1.2 - 3 How can the engineering design process be adapted to produce a circuit?

1.2 - 4 How can a computer software design (CSD) and measurement tools be applied to an engineering design process?

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):

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.

CAR-A. Identify engineering disciplines and engineering expertise that are critical to the solution of a specific problem.

CAR-A.1 Describe the historically traditional disciplines of engineering, including civil, electrical, mechanical, and chemical.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☑	☐	☐	☐	☐	☐	

CAR-A.2 Explain that engineering disciplines continue to evolve and emerge as new interdisciplinary fields or sub-disciplines to better meet the needs of society. Examples include: Aerospace Engineering, Biomedical Engineering, Environmental Engineering, Computer Engineering, Structural Engineering, and Water Resource Engineering.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☑	☐	☑	☐	☐	☐	☑
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☑	☐	☐	☐	☐	☐	

CAR-A.3 Describe a wide variety of career options and show each career option relates to Science, Technology, Engineering, and Mathematics.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☑	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☑	☐	☐	☐	☐	☐	

CAR-A.4 Match interests, aptitudes, and aspirations to career choices.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☑	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☑	☐	☑	☐	☐	☐	

CAR-A.5 Compare and contrast how education and training decisions may affect career choices.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☑	☐	☑	☐	☐	☐	

CAR-A.6 Identify necessary actions that bridge the gap between high school and postsecondary education.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☑	☐	☑	☐	☐	☐	

Communication (COM):

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

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

COM-A.1 Adhere to established conventions of written, oral, and electronic communications (grammar, spelling, usage, and mechanics).

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☑	☐	☐	☑	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☑	☐	☐	☐	☐	☐	☐	

COM-A.2 Follow acceptable formats for technical writing and professional presentations.

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☑	☐	☐	☑	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☑	☐	☐	☐	☐	☐	☐

Ethical Reasoning and Mindset (ERM):

The skills necessary for students to make decisions between what is considered right and wrong based on evidence, beliefs, values, and emotions.

ERM-A. Assess an engineering ethical dilemma.

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

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☐	☐	☐	☐	☐	☐	☑

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☑	☐	☐	☐	☐	☐	☐

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

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☐	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☑

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☑	☑

CCP-A.2 Plan how to gain additional knowledge and learning to accomplish a goal.

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☐	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☑	☑

CCP-C. Persevere to solve a problem or achieve a goal.

CCP-C.1 Describe why persistence is important when identifying a problem and/or pursuing solutions.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☑	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☐	☐	

CCP-C.2 Accept failure as part of an evolution of individual growth and necessary to the expansion of the engineering profession.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☑	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☐	☐	

CCP-D. Explain and justify an engineering design process.

CCP-D.5 Document a design process in an engineering notebook according to best practices.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☑				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☐	☑	

CCP-F. Generate multiple potential solution concepts.

CCP-F.1 Represent concepts using a variety of visual tools, such as sketches, graphs, and charts, to communicate details of an idea.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☑	☐	☑
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☑	☑	☐	☑	☑	☑	☑	

CCP-H. Make judgements and decisions based on evidence.

CCP-H.1 Explain that a conclusion is valid if the evidence supports the conclusion while acknowledging the limitations, opposing views, and biases.

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☑	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☐	☐

CCP-H.2 Evaluate evidence and arguments to identify deficiencies, limitations, and biases or appropriate next steps in the pursuit of a better solution.

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☑	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☐	☐

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 practice.

Sequential Logic (SLO):

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

SLO-A. 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.

SLO-A.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.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☑	☐	☑	☑	

SLO-A.2 Analyze and/or design introductory flip-flop applications, such as latches, event detection circuits, data synchronizers, shift registers, and frequency dividers.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☑
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☑	☐	☐	☐	

SLO-A.3 Describe the advantages and disadvantages of counters using an asynchronous counter design or synchronous counter design.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☑	☐	☐	☐	

SLO-B. 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.

SLO-B.1 Describe the ripple effect of an asynchronous counter.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☑	☐	☐	☐	

SLO-B.2 Analyze and/or design up, down, and modulus asynchronous counters using discrete D and J/K flip-flops.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☑
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☑	☐	☐	☐	

SLO-B.4 Describe where a count starts and where a count stops/repeats on a modulus asynchronous counter.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☑	☐	☐	☐	

Combinational Logic (CLO):

Create specific outputs in a circuit based on specific inputs.

CLO-A. 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.

CLO-A.1 Translate design requirements into Boolean expressions and/or a truth table.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☑	☐	☐	☐	☐	☐	☐	

CLO-A.2 Translate Boolean expressions into truth tables and truth tables into unsimplified Boolean expressions.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☑	☐	☐	☐	☐	☐	☐	

CLO-A.3 Translate circuit schematics into Boolean expressions or truth tables and Boolean expressions or truth tables into circuit schematics.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☑
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☑	☐	☐	☐	☐	☐	☐	

CLO-A.4 Interpret and/or modify an AOI circuit based on design requirements.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☑	☐	☐	☐	☐	☐	☐	

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

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☑	☐	☑	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☑				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☐	☐	

Competencies, Domains, Objectives, Knowledge and Skills

ETT-B. Construct physical objects using hand tools and shop tools.

ETT-B.1 Identify basic hand tools and shop tools and describe their function.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☑	☐	☑	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☑	☑

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☐	☐

ETT-B.2 Describe a process to build a physical object based on a conceptual communication such as a drawing or description.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☑	☑

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☐	☐

ETT-B.3 Demonstrate use of hand tools and shop tools.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☑	☑

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☐	☐

ETT-B.4 Produce a physical model using electronic components.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☑	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☑	☑

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☑	☑

ETT-C. Apply computational thinking to generalize and solve a problem using a computer.

ETT-C.1 Interact with content-specific models and simulation to support learning and research.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☑	☐	☑

1.1.7	1.1.8	1.1.9
☐	☐	☑

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☐	☐

ETT-C.2 Use modeling and simulation to represent and understand natural phenomena.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☑	☐	☐	☐	☑	☐	☑
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☑	☑	

ETT-C.3 Analyze data and identify patterns through modeling and simulation.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☑	☐	☑
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☐	☐	

Foundations in Mathematics and Science (FMS):

Engineering practice requires an understanding of mathematical principles and scientific phenomena to solve problems.

FMS-A. Solve complex calculations using appropriate notation.

FMS-A.1 Select the most appropriate notation.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☑	☑	☐	☑	☐	☑	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☑	☑	

FMS-A.2 Convert any number to/from engineering notation.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☑	☐	☐	☐	☑	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☐	☐	

FMS-A.3 Convert any number between the International System of Units, SI, prefixes.

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☐	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☑	☑

FMS-B. Use mathematical processes to convert any value between any two number systems.

FMS-B.1 Count from 0 to 15 in binary.

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☐	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☑	☑	☐	☑	☑

FMS-B.2 Convert numbers between the binary and decimal number systems.

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☐	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☑	☑	☐	☐	☐

FMS-C. Calculate voltage, current, and/or resistance for components in a circuit.

FMS-C.1 Identify parts and distinguish between characteristics of a circuit that are in series.

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☑	☐	☐	☑	☑	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☐	☐

FMS-C.2 Identify parts and characteristics of a circuit that are in parallel.

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☑	☐	☐	☑	☑	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☐	☐

FMS-C.3 Calculate total resistance for a circuit by applying Kirchhoff's Voltage Law and Kirchhoff's Current Laws.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☑	☑	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☐	☐	

FMS-C.4 Solve for unknown values in a circuit by applying Ohm's law.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☑	☐	☐	☑	☑	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☐	☐	

Foundations in Electronics (FIE):

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

FIE-A. Demonstrate and apply appropriate safety procedures when working with electronics in a classroom.

FIE-A.1 Identify potential electrical hazards that might cause damage to the human body.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☑	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☑				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☑	☑	

FIE-B. Identify and describe the characteristics of common components and logic gates.

FIE-B.1 Explain that the transistor is the most fundamental digital logic component.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☑	☐	☐	☐	☑
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☐	☐	

FIE-B.2 Demonstrate that digital components, such as transistors, and analog components, such as resistors and capacitors, can be used to create logic gates.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☑	☐	☐	☐	☑

1.1.7	1.1.8	1.1.9
☐	☐	☑

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☑	☑	☑

FIE-B.3 Identify resistor component values from color codes.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☑	☑	☐	☑	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☑

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☑	☑	☑

FIE-B.4 Identify a capacitor’s nominal value by reading its labeled nomenclature.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☑	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☑

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☑	☑

FIE-B.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).

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☑

1.1.7	1.1.8	1.1.9
☐	☐	☑

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☐	☐

FIE-B.6 Identify, implement, and/or describe integrated circuits’ properties from their part number, schematic symbol, and/or data sheet.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☑

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☑	☑	☑

FIE-B.7 Identify integrated circuits wiring diagram from a data sheet.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☑	☐	☑				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☑	☑	☑	

FIE-B.8 Identify a logic gate from a truth table or write a truth table representing a logic gate.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☑
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☐	☐	

FIE-C. Select and apply the appropriate components, tools, and technology when creating or characterizing a design.

FIE-C.1 Troubleshoot circuits (mechanics of circuit and logic of circuit).

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☑	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☐	☐	

FIE-C.2 Properly solder and de-solder components to printed circuit boards according to best practices.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☑	☑				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☐	☐	☐	

FIE-C.3 Measure current, voltage, and/or resistance within a circuit or across a component using a digital multimeter (DMM).

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☑	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☐	☐	☐	☐	☑	☑

FIE-C.4 Measure frequency, period, and duty cycle of a clock signal using an oscilloscope.

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☐	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☑	☐	☐	☐	☑	☑

FIE-C.5 Design a circuit, simulate a circuit, and verify a measurement and/or hand calculation using circuit design software (CDS).

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☐	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☑	☐	☐	☑	☑	☐	☐

FIE-D. Clock signals trigger events in circuits.

FIE-D.1 Select and apply components in a design to produce a desired waveform, frequency, period, and/or duty cycle.

APB:

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
☐	☐	☐	☐	☐	☐	☐	☐

1.1.7	1.1.8	1.1.9
☐	☐	☐

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
☐	☑	☐	☐	☑	☑	☑

FIE-D.2 Analyze and interpret the amplitude, period, frequency, and duty cycle of analog and digital signals based on instrumentation and calculations.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☑	☐	☐	☑	☑	☑	

FIE-D.3 Interpret and/or modify the analog components of a 555 timer oscillator circuit to affect the wave generated.

APB:	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5a	1.1.5b	1.1.5c	1.1.6
	☐	☐	☐	☐	☐	☐	☐	☐
		1.1.7	1.1.8	1.1.9				
		☐	☐	☐				
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	
	☐	☐	☐	☐	☑	☐	☐	

PLTW Framework - Overview

PLTW Unit Frameworks provide an overview of the levels of understanding that each build upon the higher level: 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.

Essential Questions

2.1 - 1 How can a set of design specifications be transformed into a functional combinational logic circuit?

2.1 - 2 How do a truth table, logic expression, and circuit design interrelate?

2.1 - 3 How are all logic expressions, regardless of complexity, simply AND, OR, and INVERTER gates.

2.2 - 1 Why are NAND gates and NOR gates considered universal gates?

2.2 - 2 How can universal gates be used to create a combinational logic design?

2.2 - 3 How are K-mapping and Boolean algebra applied to logic expressions?

2.3 - 1 How can seven-segment displays be integrated into your design process?

2.3 - 2 How are common digital circuits such as binary adders, multiplexers, and de-multiplexers used in common electronic devices?

2.4 - 1 How can Circuit Design Software (CDS) and Programmable Logic Devices (PLDs) be used in an engineering design process?

2.4 - 2 How can a PLD be used to model a complex physcial circuit?

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):

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.

CAR-A. Identify engineering disciplines and engineering expertise that are critical to the solution of a specific problem.

CAR-A.2 Explain that engineering disciplines continue to evolve and emerge as new interdisciplinary fields or sub-disciplines to better meet the needs of society. Examples include: Aerospace Engineering, Biomedical Engineering, Environmental Engineering, Computer Engineering, Structural Engineering, and Water Resource Engineering.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☐

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☐	☐

CAR-A.3 Describe a wide variety of career options and show each career option relates to Science, Technology, Engineering, and Mathematics.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☐

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☐	☐

CAR-A.4 Match interests, aptitudes, and aspirations to career choices.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☐

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☐	☐

CAR-A.5 Compare and contrast how education and training decisions may affect career choices.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☐

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☐	☐

Ethical Reasoning and Mindset (ERM):

The skills necessary for students to make decisions between what is considered right and wrong based on evidence, beliefs, values, and emotions.

ERM-A. Assess an engineering ethical dilemma.

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

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☑

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☐	☐

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

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☑

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☑	☑

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☐	☐

CCP-A.2 Plan how to gain additional knowledge and learning to accomplish a goal.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☑

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☑	☑

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

CCP-D. Explain and justify an engineering design process.

CCP-D.5 Document a design process in an engineering notebook according to best practices.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☑

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☐	☑

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☐	☑

CCP-F. Generate multiple potential solution concepts.

CCP-F.1 Represent concepts using a variety of visual tools, such as sketches, graphs, and charts, to communicate details of an idea.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☑	☐	☐	☑

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☑	☑	☑	☑

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☑	☑	☐	☑

CCP-G. Select a solution path from many options to successfully address a problem or opportunity.

CCP-G.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.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☐

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☐	☐

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 practice.

Combinational Logic (CLO):

Create specific outputs in a circuit based on specific inputs.

CLO-A. 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.

CLO-A.1 Translate design requirements into Boolean expressions and/or a truth table.

APB:	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
	☑	☑	☑	☑	☑	☑
	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	
	☑	☑	☑	☑	☑	
	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	
	☐	☐	☐	☐	☐	

CLO-A.2 Translate Boolean expressions into truth tables and truth tables into unsimplified Boolean expressions.

APB:	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
	☑	☑	☑	☑	☑	☑
	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	
	☑	☑	☑	☑	☑	
	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	
	☐	☐	☐	☐	☐	

CLO-A.3 Translate circuit schematics into Boolean expressions or truth tables and Boolean expressions or truth tables into circuit schematics.

APB:	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
	☑	☑	☑	☑	☑	☑
	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	
	☑	☑	☑	☑	☑	
	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	
	☐	☐	☐	☐	☐	

CLO-A.4 Interpret and/or modify an AOI circuit based on design requirements.

APB:	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
	☑	☑	☑	☑	☑	☑
	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	
	☑	☑	☑	☑	☑	
	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	
	☐	☐	☐	☐	☐	

CLO-A.5 Create an AOI circuit on a breadboard from a schematic.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☑	☑	☑	☑	☑	☑

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☑	☑	☑	☑

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☐	☐

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

CLO-B.1 (same as KS4.4.1) Apply Boolean algebra theorems and De Morgan's theorems to simplify expressions.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☑	☑	☑

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☑	☑	☑	☑	☑

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☐	☐

CLO-B.2 (same as KS4.4.2) Apply the Karnaugh mapping technique to simplify Boolean expressions.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☐

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☑	☑	☑	☑	☑

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☐	☐

CLO-B.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.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☐

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☑	☑	☑	☑

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☑	☑

Competencies, Domains, Objectives, Knowledge and Skills

Foundations in Mathematics and Science (FMS):

Engineering practice requires an understanding of mathematical principles and scientific phenomena to solve problems.

FMS-B. Use mathematical processes to convert any value between any two number systems.

FMS-B.1 Count from 0 to 15 in binary.

APB:	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
	☑	☑	☑	☑	☑	☑
	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	
	☑	☑	☑	☑	☑	
	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	
	☑	☐	☐	☑	☑	

FMS-B.2 Convert numbers between the binary and decimal number systems.

APB:	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
	☑	☑	☑	☑	☑	☑
	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	
	☑	☑	☑	☑	☑	
	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	
	☑	☐	☐	☑	☑	

FMS-B.3 Convert numbers between the decimal, binary, octal, and hexadecimal number systems.

APB:	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
	☐	☐	☐	☐	☐	☐
	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	
	☐	☐	☐	☐	☐	
	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	
	☑	☐	☐	☑	☑	

FMS-B.4 Convert numbers between the binary coded decimal and the decimal number systems.

APB:	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
	☐	☐	☐	☐	☐	☐
	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	
	☐	☐	☐	☐	☐	
	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	
	☑	☐	☐	☑	☑	

Competencies, Domains, Objectives, Knowledge and Skills

FMS-D. Simplify algebraic expressions.

FMS-D.1 Apply Boolean algebra theorems and De Morgan’s theorems to simplify expressions.

APB:						
	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
	☐	☐	☐	☐	☑	☑
	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	
	☑	☑	☐	☐	☐	
	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	
	☑	☑	☐	☐	☐	

FMS-D.2 Apply the Karnaugh mapping technique to simplify Boolean expressions.

APB:						
	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
	☐	☐	☐	☐	☐	☐
	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	
	☑	☑	☐	☐	☐	
	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	
	☐	☐	☐	☐	☐	

FMS-E. Add and subtract in the binary number system.

FMS-E.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.

APB:						
	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
	☐	☐	☐	☐	☐	☐
	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	
	☐	☐	☐	☐	☐	
	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	
	☐	☐	☐	☑	☑	

Foundations in Electronics (FIE):

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

FIE-B. Identify and describe the characteristics of common components and logic gates.

FIE-B.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).

APB:						
	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
	☐	☐	☐	☐	☐	☐
	2.2.1	2.2.2	2.2.3	2.2.4	2.2.5	
	☐	☐	☐	☐	☐	
	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	
	☐	☐	☑	☐	☐	

FIE-B.6 Identify, implement, and/or describe integrated circuits' properties from their part number, schematic symbol, and/or data sheet.

APB:						
	2.1.1 ☐	2.1.2 ☐	2.1.3 ☐	2.1.4 ☐	2.1.5 ☐	2.1.6 ☐
	2.2.1 ☐	2.2.2 ☐	2.2.3 ☐	2.2.4 ☐	2.2.5 ☐	
	2.3.1 ☐	2.3.2 ☐	2.3.3 ☑	2.3.4 ☐	2.3.5 ☐	

FIE-B.7 Identify integrated circuits wiring diagram from a data sheet.

APB:						
	2.1.1 ☐	2.1.2 ☐	2.1.3 ☐	2.1.4 ☐	2.1.5 ☐	2.1.6 ☐
	2.2.1 ☐	2.2.2 ☐	2.2.3 ☐	2.2.4 ☐	2.2.5 ☐	
	2.3.1 ☐	2.3.2 ☐	2.3.3 ☑	2.3.4 ☐	2.3.5 ☐	

FIE-B.9 Implement a seven-segment display into a circuit design to display alphanumeric values using seven-segment display drivers.

APB:						
	2.1.1 ☐	2.1.2 ☐	2.1.3 ☐	2.1.4 ☐	2.1.5 ☐	2.1.6 ☐
	2.2.1 ☐	2.2.2 ☐	2.2.3 ☐	2.2.4 ☐	2.2.5 ☐	
	2.3.1 ☐	2.3.2 ☑	2.3.3 ☑	2.3.4 ☑	2.3.5 ☑	

FIE-B.10 Select the correct current-limiting resistor and/or properly wire both common cathode and common anode seven-segment displays.

APB:						
	2.1.1 ☐	2.1.2 ☐	2.1.3 ☐	2.1.4 ☐	2.1.5 ☐	2.1.6 ☐
	2.2.1 ☐	2.2.2 ☐	2.2.3 ☐	2.2.4 ☐	2.2.5 ☐	
	2.3.1 ☐	2.3.2 ☑	2.3.3 ☑	2.3.4 ☑	2.3.5 ☑	

FIE-C. Select and apply the appropriate components, tools, and technology when creating or characterizing a design.

FIE-C.1 Troubleshoot circuits (mechanics of circuit and logic of circuit).

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☐

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☑	☐	☑	☑

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

FIE-E.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.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☐

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☑	☐

FIE-E.2 Predict outputs given specific inputs when adding or subtracting numbers.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☐

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☑	☐

FIE-E.3 Describe the design of an adder/subtractor circuit related to the carry out and use of XOR/XNOR gates.

APB:

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6
☐	☐	☐	☐	☐	☐

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
☐	☐	☐	☑	☐

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

FIE-F.1 Interpret and/or modify a multiplexed or de-multiplexed circuit to make it more efficient.

APB:						
	2.1.1 ☐	2.1.2 ☐	2.1.3 ☐	2.1.4 ☐	2.1.5 ☐	2.1.6 ☐
	2.2.1 ☐	2.2.2 ☐	2.2.3 ☐	2.2.4 ☐	2.2.5 ☐	
	2.3.1 ☐	2.3.2 ☐	2.3.3 ☑	2.3.4 ☐	2.3.5 ☐	

PLTW Framework - Overview

PLTW Unit Frameworks provide an overview of the levels of understanding that each build upon the higher level: 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.

Essential Questions

3.1 - 1 How can sequential and differential logic circuits be used in a product that you use?

3.1 - 2 How would you explain the function and use of a flip-flop to someone with limited electronics background?

3.1 - 3 What are some of the common applications of flip-flops?

3.2 - 1 How can D flip-flops or J/K flip-flops be arranged to create a desired asynchronous clock signal?

3.2 - 2 How can a small-scale integration (SSI) and medium-scale integration (MSI) be used in a product that you use?

3.2 - 3 Why is it important to have a counter or to start at specific values?

3.3 - 1 How can D flip-flops or J/K flip-flops be arranged to create a desired synchronous clock signal?

3.3 - 2 How can a small-scale integration (SSI) and medium-scale integration (MSI) be used in a produc that you use?

3.3 - 3 How can a synchronous counter be designed to start and stop or repeat a count at the desired values?

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):

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.

CAR-A. Identify engineering disciplines and engineering expertise that are critical to the solution of a specific problem.

CAR-A.4 Match interests, aptitudes, and aspirations to career choices.

APB:				
	3.1.1 ☐	3.1.2 ☐	3.1.3 ☐	
	3.2.1 ☐	3.2.2 ☐	3.2.3 ☐	3.2.4 ☑
	3.3.1 ☐	3.3.2 ☐	3.3.3 ☐	3.3.4 ☐

CAR-A.5 Compare and contrast how education and training decisions may affect career choices.

APB:				
	3.1.1 ☐	3.1.2 ☐	3.1.3 ☐	
	3.2.1 ☐	3.2.2 ☐	3.2.3 ☐	3.2.4 ☑
	3.3.1 ☐	3.3.2 ☐	3.3.3 ☐	3.3.4 ☐

CAR-A.6 Identify necessary actions that bridge the gap between high school and postsecondary education.

APB:				
	3.1.1 ☐	3.1.2 ☐	3.1.3 ☐	
	3.2.1 ☐	3.2.2 ☐	3.2.3 ☐	3.2.4 ☑
	3.3.1 ☐	3.3.2 ☐	3.3.3 ☐	3.3.4 ☐

Competencies, Domains, Objectives, Knowledge and Skills

Communication (COM):

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

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

COM-A.2 Follow acceptable formats for technical writing and professional presentations.

APB:

3.1.1	3.1.2	3.1.3	
☐	☐	☐	
3.2.1	3.2.2	3.2.3	3.2.4
☐	☐	☐	☑
3.3.1	3.3.2	3.3.3	3.3.4
☐	☐	☐	☐

Ethical Reasoning and Mindset (ERM):

The skills necessary for students to make decisions between what is considered right and wrong based on evidence, beliefs, values, and emotions.

ERM-A. Assess an engineering ethical dilemma.

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

APB:

3.1.1	3.1.2	3.1.3	
☑	☐	☐	
3.2.1	3.2.2	3.2.3	3.2.4
☐	☐	☐	☐
3.3.1	3.3.2	3.3.3	3.3.4
☐	☐	☐	☑

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

APB:

3.1.1	3.1.2	3.1.3	
☐	☐	☑	
3.2.1	3.2.2	3.2.3	3.2.4
☐	☐	☐	☑
3.3.1	3.3.2	3.3.3	3.3.4
☐	☐	☐	☑

CCP-A.2 Plan how to gain additional knowledge and learning to accomplish a goal.

APB:

3.1.1	3.1.2	3.1.3	
☐	☐	☑	

3.2.1	3.2.2	3.2.3	3.2.4
☐	☐	☐	☑

3.3.1	3.3.2	3.3.3	3.3.4
☐	☐	☐	☐

CCP-D. Explain and justify an engineering design process.

CCP-D.5 Document a design process in an engineering notebook according to best practices.

APB:

3.1.1	3.1.2	3.1.3	
☐	☐	☑	

3.2.1	3.2.2	3.2.3	3.2.4
☐	☐	☐	☑

3.3.1	3.3.2	3.3.3	3.3.4
☐	☐	☐	☐

CCP-F. Generate multiple potential solution concepts.

CCP-F.1 Represent concepts using a variety of visual tools, such as sketches, graphs, and charts, to communicate details of an idea.

APB:

3.1.1	3.1.2	3.1.3	
☑	☑	☑	

3.2.1	3.2.2	3.2.3	3.2.4
☑	☑	☑	☑

3.3.1	3.3.2	3.3.3	3.3.4
☑	☑	☑	☑

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 practice.

Sequential Logic (SLO):

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

SLO-A. 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.

SLO-A.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.

APB:

3.1.1	3.1.2	3.1.3	
☑	☐	☐	
3.2.1	3.2.2	3.2.3	3.2.4
☑	☑	☑	☑
3.3.1	3.3.2	3.3.3	3.3.4
☑	☐	☐	☐

SLO-A.2 Analyze and/or design introductory flip-flop applications, such as latches, event detection circuits, data synchronizers, shift registers, and frequency dividers.

APB:

3.1.1	3.1.2	3.1.3	
☑	☑	☑	
3.2.1	3.2.2	3.2.3	3.2.4
☑	☑	☑	☑
3.3.1	3.3.2	3.3.3	3.3.4
☑	☐	☐	☐

SLO-A.3 Describe the advantages and disadvantages of counters using an asynchronous counter design or synchronous counter design.

APB:

3.1.1	3.1.2	3.1.3	
☐	☐	☑	
3.2.1	3.2.2	3.2.3	3.2.4
☑	☑	☑	☑
3.3.1	3.3.2	3.3.3	3.3.4
☑	☐	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

SLO-B. 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.

SLO-B.1 Describe the ripple effect of an asynchronous counter.

APB:

3.1.1	3.1.2	3.1.3	
☐	☐	☑	
3.2.1	**3.2.2**	**3.2.3**	**3.2.4**
☑	☑	☑	☑
3.3.1	**3.3.2**	**3.3.3**	**3.3.4**
☐	☐	☐	☐

SLO-B.2 Analyze and/or design up, down, and modulus asynchronous counters using discrete D and J/K flip-flops.

APB:

3.1.1	3.1.2	3.1.3	
☐	☐	☑	
3.2.1	**3.2.2**	**3.2.3**	**3.2.4**
☑	☑	☑	☑
3.3.1	**3.3.2**	**3.3.3**	**3.3.4**
☐	☐	☐	☐

SLO-B.3 Analyze and/or design up, down, and modulus asynchronous counters using medium-scale integrated (MSI) circuit counters.

APB:

3.1.1	3.1.2	3.1.3	
☐	☐	☐	
3.2.1	**3.2.2**	**3.2.3**	**3.2.4**
☐	☐	☑	☑
3.3.1	**3.3.2**	**3.3.3**	**3.3.4**
☐	☐	☐	☐

SLO-B.4 Describe where a count starts and where a count stops/repeats on a modulus asynchronous counter.

APB:

3.1.1	3.1.2	3.1.3	
☐	☐	☑	
3.2.1	**3.2.2**	**3.2.3**	**3.2.4**
☑	☑	☑	☑
3.3.1	**3.3.2**	**3.3.3**	**3.3.4**
☐	☐	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

SLO-C. Design, interpret, and/or modify synchronous 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.

SLO-C.1 Analyze and design up, down, and modulus synchronous counters using discrete D and J/K flip-flops.

APB:				
	3.1.1 ☐	3.1.2 ☐	3.1.3 ☐	
	3.2.1 ☐	3.2.2 ☐	3.2.3 ☐	3.2.4 ☐
	3.3.1 ☑	3.3.2 ☑	3.3.3 ☑	3.3.4 ☑

SLO-C.2 Analyze and design up, down, and modulus synchronous counters using medium-scale integrated (MSI) circuit counters.

APB:				
	3.1.1 ☐	3.1.2 ☐	3.1.3 ☐	
	3.2.1 ☐	3.2.2 ☐	3.2.3 ☐	3.2.4 ☐
	3.3.1 ☑	3.3.2 ☑	3.3.3 ☑	3.3.4 ☑

SLO-C.3 Describe where a count starts and where a count stops/repeats on a modulus synchronous counter.

APB:				
	3.1.1 ☐	3.1.2 ☐	3.1.3 ☐	
	3.2.1 ☐	3.2.2 ☐	3.2.3 ☐	3.2.4 ☐
	3.3.1 ☑	3.3.2 ☑	3.3.3 ☑	3.3.4 ☑

Foundations in Electronics (FIE):

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

FIE-B. Identify and describe the characteristics of common components and logic gates.

FIE-B.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).

APB:				
	3.1.1 ☑	3.1.2 ☐	3.1.3 ☐	
	3.2.1 ☐	3.2.2 ☐	3.2.3 ☐	3.2.4 ☐
	3.3.1 ☐	3.3.2 ☐	3.3.3 ☐	3.3.4 ☐

FIE-B.6 Identify, implement, and/or describe integrated circuits' properties from their part number, schematic symbol, and/or data sheet.

APB:

3.1.1	3.1.2	3.1.3	
☐	☑	☐	
3.2.1	3.2.2	3.2.3	3.2.4
☐	☐	☐	☐
3.3.1	3.3.2	3.3.3	3.3.4
☐	☐	☐	☐

FIE-C. Select and apply the appropriate components, tools, and technology when creating or characterizing a design.

FIE-C.1 Troubleshoot circuits (mechanics of circuit and logic of circuit).

APB:

3.1.1	3.1.2	3.1.3	
☐	☑	☐	
3.2.1	3.2.2	3.2.3	3.2.4
☐	☐	☐	☐
3.3.1	3.3.2	3.3.3	3.3.4
☐	☐	☐	☐

FIE-D. Clock signals trigger events in circuits.

FIE-D.1 Select and apply components in a design to produce a desired waveform, frequency, period, and/or duty cycle.

APB:

3.1.1	3.1.2	3.1.3	
☑	☐	☐	
3.2.1	3.2.2	3.2.3	3.2.4
☐	☐	☐	☐
3.3.1	3.3.2	3.3.3	3.3.4
☐	☐	☐	☐

PLTW Digital Electronics
Unit 4 Framework

PLTW Framework - Overview

PLTW Unit Frameworks provide an overview of the levels of understanding that each build upon the higher level: 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.

Essential Questions

4.1 - 1 How is a state machine design used in electronics?

4.1 - 2 How can a state machine be used in a product that you use?

4.2 - 1 Why are microcontrollers such a valuable tool today in electronics?

4.2 - 2 What are the components and processes associated with programming microcontrollers to control real-world systems?

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.

Communication (COM):

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

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

COM-A.1 Adhere to established conventions of written, oral, and electronic communications (grammar, spelling, usage, and mechanics).

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☑	☑	☑	☑	☑	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☑	☑	☑	☑	☑	☑

COM-A.2 Follow acceptable formats for technical writing and professional presentations.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☐	☐	☐	☐	☐	☐
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☐	☐	☐	☐	☑

Collaboration (COL):

Demonstrate an ability to function on multidisciplinary teams.

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

COL-A.1 Solicit, negotiate, and balance diverse views and beliefs to reach workable solutions.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☐	☐	☐	☐	☐	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☐	☐	☐	☐	☑

Ethical Reasoning and Mindset (ERM):

The skills necessary for students to make decisions between what is considered right and wrong based on evidence, beliefs, values, and emotions.

ERM-A. Assess an engineering ethical dilemma.

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

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☐	☐	☐	☐	☐	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☐	☐	☐	☐	☐

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

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☐	☐	☐	☐	☐	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☐	☐	☐	☑	☑

CCP-A.2 Plan how to gain additional knowledge and learning to accomplish a goal.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☐	☐	☐	☐	☐	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☐	☐	☐	☑	☑

CCP-B. Demonstrate flexibility and adaptability to change.

CCP-B.1 Adapt to varied roles, job responsibilities, schedules, and contexts.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☐	☐	☐	☐	☐	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☑	☐	☐	☐	☑	☑

CCP-B.2 Use praise, setbacks, and feedback to positively influence one’s professional development.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☑	☑	☑	☑	☑	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☑	☑	☑	☑	☑	☑

CCP-C. Persevere to solve a problem or achieve a goal.

CCP-C.1 Describe why persistence is important when identifying a problem and/or pursuing solutions.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☐	☐	☐	☐	☐	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☑	☐	☐	☐	☑	☑

Competencies, Domains, Objectives, Knowledge and Skills

CCP-E. Synthesize an ill-formed problem into a meaningful, well-defined problem.

CCP-E.1 Identify and define visual, functional, and structural design requirements with realistic constraints, against which solution alternatives can be evaluated.

APB:

4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
☐	☐	☑	☐	☑	☑

4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
☐	☑	☑	☑	☑	☑

CCP-F. Generate multiple potential solution concepts.

CCP-F.1 Represent concepts using a variety of visual tools, such as sketches, graphs, and charts, to communicate details of an idea.

APB:

4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
☑	☐	☑	☐	☑	☑

4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
☐	☐	☑	☑	☑	☑

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 practice.

Algorithms and Programming (AAP):

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

AAP-A. Create, interpret, and/or modify a program to manage inputs and outputs of a microcontroller.

AAP-A.1 Select appropriate hardware and translate a set of design requirements into a program that completes a task.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☐	☐	☐	☐	☐	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☑	☐	☑	☑	☑

AAP-B. Create logic using a programming language.

AAP-B.1 Create, interpret, or modify a program to control inputs and outputs.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☑	☑	☑	☑	☑	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☑	☑	☑	☑	☑	☑

AAP-B.2 Create, interpret, or modify a program to control a servo’s speed and/or position.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☐	☐	☐	☐	☐	☐
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☐	☑	☑	☑	☑

Engineering Tools and Technology (ETT):

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

ETT-B. Construct physical objects using hand tools and shop tools.

ETT-B.2 Describe a process to build a physical object based on a conceptual communication such as a drawing or description.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☐	☐	☑	☑	☑	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☑	☑	☑	☑	☑	☑

ETT-B.3 Demonstrate use of hand tools and shop tools.

APB:

4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
☐	☑	☑	☑	☑	☑

4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
☑	☑	☑	☑	☑	☑

ETT-B.4 Produce a physical model using electronic components.

APB:

4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
☐	☑	☑	☑	☑	☑

4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
☑	☑	☑	☑	☑	☑

ETT-C. Apply computational thinking to generalize and solve a problem using a computer.

ETT-C.1 Interact with content-specific models and simulation to support learning and research.

APB:

4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
☐	☑	☑	☑	☑	☑

4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
☑	☑	☑	☑	☑	☑

ETT-C.2 Use modeling and simulation to represent and understand natural phenomena.

APB:

4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
☐	☐	☑	☑	☑	☑

4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
☐	☑	☐	☑	☑	☑

ETT-C.3 Analyze data and identify patterns through modeling and simulation.

APB:

4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
☐	☑	☑	☑	☑	☑

4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
☑	☑	☑	☑	☑	☑

ETT-C.4 Develop an algorithm (step-by step-process) for solving a problem.

APB:

4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
☐	☑	☑	☑	☑	☑

4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
☑	☑	☑	☑	☑	☑

ETT-C.5 Identify, test, and implement possible solutions to a problem using a computer.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☐	☐	☑	☑	☑	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☑	☑	☑	☑	☑	☑

Foundations in Electronics (FIE):

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

FIE-B. Identify and describe the characteristics of common components and logic gates.

FIE-B.1 Explain that the transistor is the most fundamental digital logic component.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☑	☐	☐	☐	☐	☐
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☐	☐	☐	☐	☐

FIE-B.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.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☑	☐	☐	☐	☐	☐
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☐	☐	☐	☐	☐

FIE-C. Select and apply the appropriate components, tools, and technology when creating or characterizing a design.

FIE-C.1 Troubleshoot circuits (mechanics of circuit and logic of circuit).

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☑	☑	☑	☑	☑	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☑	☑	☑	☑	☑	☑

FIE-C.5 Design a circuit, simulate a circuit, and verify a measurement and/or hand calculation using circuit design software (CDS).

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☑	☐	☐	☐	☐	☐
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☐	☐	☐	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

State Machines (SMA):

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

SMA-A. Design, interpret, and/or modify a state machine based on specific design requirements to communicate the design.

SMA-A.1 Identify, create, interpret, or modify a state machine design based on design requirements according to a systematic process.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☑	☐	☑	☐	☑	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☑	☑	☑	☑	☑

SMA-A.2 Describe the components and structure of a state machine.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☑	☐	☑	☐	☑	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☑	☑	☑	☑	☑

SMA-A.3 Draw or interpret a state graph and construct or interpret a state transition table for a state machine.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☑	☐	☑	☐	☑	☑
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☑	☑	☑	☑	☑

SMA-A.4 Derive a state machine's Boolean equations from its state transition table.

APB:	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6
	☑	☐	☐	☐	☐	☐
	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6
	☐	☐	☐	☐	☐	☐