PLANNED INSTRUCTION

A PLANNED COURSE FOR:

Engineering 2: Principles of Engineering

Curriculum writing committee:
Robert Curtis

Grade Level:
10-12

Date of Board Approval: ___2024__________

Course Weighting: Engineering 2: Principles of Engineering

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

Curriculum Map

Overview:
Principles of Engineering is a full-year course designed to be a high school student's second exposure to the PLTW Engineering program and is appropriate for students in grades 10-12. In Principles of Engineering, students explore a broad range of engineering disciplines, careers, and design and solve real-world engineering problems. This course introduces students to engineering concepts that are applicable to a variety of engineering disciplines and empowers them to develop technical skills using engineering tools such as 3-D modeling software, hands-on prototyping equipment, programming software, and robotics hardware to bring their solutions to life. Students apply the engineering design process to solve real-world problems across a breadth of engineering fields such as mechanical, robotics, infrastructure, environmental sustainability, and product design and development. Using PLTW's activity-, project-, problem-based (APB) instructional approach, students advance from completing structured activities to solving open-ended projects and problems that provide opportunities to develop planning and technical documentation skills, as well as in-demand, transportable skills such as problem solving, critical thinking, collaboration, communication, and ethical reasoning. The last is particularly important as the course encourages students to consider the impacts of engineering decisions. Through individual and collaborative team activities, projects, and problems, students create solutions to problems as they practice common engineering design and development protocols, such as experimental design, testing, project management, and peer review.

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: Mechanical Design
   - Lesson 1.1 Simple and Compound Machines (18 days)
     - Activity 1.1.1 Over-Easy Engineering
     - Activity 1.1.2 What's Simple About a Combine?
     - Activity 1.1.3 Mechanical System Efficiency
     - Activity 1.1.4 Powerful Pulleys
     - Activity 1.1.5 Top Gear
     - Activity 1.1.6 Maximizing Power
     - Project 1.1.7 Tug-of-War
   - Lesson 1.2 Mechanisms (12 days)
     - Activity 1.2.1 A-door-able Hens
     - Activity 1.2.2 Converting Types of Motion
     - Project 1.2.3 Motion Conversion Challenge
   - Lesson 1.3 Agricultural Solutions (15 days)
     - Problem 1.3.1 Fix Fran's Farm

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

   Unit 2: Application of Robotics
   - Lesson 2.1 Introduction to Robotics (4 days)
     - Activity 2.1.1 Silly Walks
     - Activity 2.1.2 A Robotic Revolution
   - Lesson 2.2 Robotics in Action (16 days)
     - Activity 2.2.1 Going the Distance
     - Activity 2.2.2 Chain Reaction
     - Activity 2.2.3 Moving with Color
     - Project 2.2.4 Biomimicry
   - Lesson 2.3 Artificial Intelligence (10 days)
     - Activity 2.3.1 AI Robotic Greetings
     - Activity 2.3.2 Ethics in AI
     - Project 2.3.3 Robots for Good: Assistive Robotics
   - Lesson 2.4 An Electronic Ensemble (15 days)
     - Problem 2.4.1 Robotic Symphony

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

   Unit 3: Energy in Action
   - Lesson 3.1 Electrical Circuits (12 days)
     - Activity 3.1.1 Illumination Creation
     - Activity 3.1.2 Ohm's Law Lab

    - Activity 3.1.3 Series vs. Parallel Circuits
    - Activity 3.1.4 Equivalent Resistance
    - Activity 3.1.5 Kirchhoff's Laws Lab
    - Project 3.1.6 Project 3.1.6
- Lesson 3.2 Fluid Power (10 days)
    - Activity 3.2.1 Under Pressure
    - Activity 3.2.2 Mathematics of Pressure
    - Project 3.2.3 Pressurized Power
- Lesson 3.3 Kinematics (8 days)
    - Activity 3.3.1 Gravitate to Greatness
    - Activity 3.3.2 Horizontal Projectile Motion
    - Project 3.3.3 Application of Kinematics
- Lesson 3.4 Integration of Circuits, Fluid Power, and Kinematics (15 days)
    - Problem 3.4.1 Auto Golf

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

Unit 4: Designing Infrastructure and Developing Sustainability

- Lesson 4.1 Statics (21 days)
    - Activity 4.1.1 Cantilever Design Challenge
    - Activity 4.1.2 Beam Deflection
    - Activity 4.1.3 Free Body Diagrams and Force Vectors
    - Activity 4.1.4 Stressed and Strained
    - Activity 4.1.5 Tensile Testing
    - Activity 4.1.6 Moments
    - Activity 4.1.7 Method of Joints
    - Project 4.1.8 Designing with Trusses
- Lesson 4.2 Renewable Energy (7 days)
    - Activity 4.2.1 Endless Energy
    - Project 4.2.2 Waterwheel Design
- Lesson 4.3 Transportation (7 days)
    - Activity 4.3.1 Traffic Flow Rate
    - Activity 4.3.2 What's the Optimal Speed Limit?
    - Activity 4.3.3 Intersection Design
    - Project 4.3.4 Lend a Helping Hand
- Lesson 4.4 Infrastructure Redesign (10 days)
    - Problem 4.4.1 Sustainability, Structures, and Transportation

Textbook and Supplemental Resources:

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

Handley, Brett A, et al. *Principles of Engineering.* 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

Principles of Engineering | Course Outline

Explore how modern engineers are helping improve the world through diverse engineering fields such as product design, robotics, mechanical design, infrastructure, and sustainability. Learn the principles of engineering as well as the cutting-edge tools of robotics, 3-D modeling, programming, and prototyping that engineers are using to solve problems today and for the future!

Principles of Engineering is a full-year course designed to be a high school student's second exposure to the PLTW Engineering program and is appropriate for students in grades 9-12. In Principles of Engineering, students explore a broad range of engineering disciplines, careers, and design and solve real-world engineering problems.

This course introduces students to engineering concepts that are applicable to a variety of engineering disciplines and empowers them to develop technical skills through the use of engineering tools such as 3-D modeling software, hands-on prototyping equipment, programming software, and robotics hardware to bring their solutions to life. Students apply the engineering design process to solve real-world problems across a breadth of engineering fields such as mechanical, robotics, infrastructure, environmental sustainability, and product design and development.

Using PLTW's activity-, project-, problem-based (APB) instructional approach, students advance from completing structured activities to solving open-ended projects and problems that provide opportunities to develop planning and technical documentation skills, as well as in-demand, transportable skills such as problem solving, critical thinking, collaboration, communication, and ethical reasoning. The last is particularly important as the course encourages students to consider the impacts of engineering decisions.

Through individual and collaborative team activities, projects, and problems, students create solutions to problems as they practice common engineering design and development protocols, such as experimental design, testing, project management, and peer review.

The following is a summary of the units of study that are included in the course. The course requires a rigorous pace and contains more material than a skilled teacher new to the course will be able to complete in the first iteration. Giving students exposure to various engineering disciplines, developing their enthusiasm for engineering, and understanding the role, impact, and practice of engineering are primary goals of the course.

Principles of Engineering Unit Summary

Unit 0	Introduction to Product Design and Development
Unit 1	Mechanical Design
Unit 2	Application of Robotics
Unit 3	Energy in Action
Unit 4	Designing Infrastructure and Developing Sustainability

Unit 0: Introduction to Product Design and Development

This optional introductory unit creates space for schools who begin their PLTW Engineering pathway with Introduction to Engineering Design or Engineering Essentials to quickly review familiar topics and challenge students to reach new levels of understanding and application. It also allows schools that are new to the pathway to build upon strong fundamental skills. In the unit, students explore different careers while applying modern collaborative modeling tools to create new products that meet real needs. Student teams take on the role of a product development team using the engineering design process to solve problems and create value for others.

Students gain enduring understandings to key principles of engineering such as modeling, material selection, statistics, tolerance analysis, as well as testing design and analysis. Through these challenges, students apply and develop project management, communication, and other pivotal transportable skills to solve problems.

Product Design and Development

Lesson 0.1 Engineering Design Process
Lesson 0.2 Collaborative Modeling and Modern Product Design
Lesson 0.3 Material Choice and Testing
Lesson 0.4 Designing A Shoe For You

Lesson 0.1 Engineering Design Process
In Lesson 0.1, students review and apply their understanding of the engineering design process to design a shoe to meet the specific needs of a customer. They use information gathered in interviews to learn about their client, develop a detailed problem statement, apply different brainstorming techniques, visualize their solution through concept sketches, and create a decision matrix to select the best solution for their client's needs. Students build a prototype and create a testing plan, to test and iterate their design and share their results in a detailed presentation.

Lesson 0.2 Collaborative Modeling and Modern Product Design
In Lesson 0.2 students use a 3-D modeling software to learn different tools used to develop a detailed solution and are introduced to basic manufacturing techniques and practices. Students use a 3-D modeling software to modify an existing shoe model. Students learn manufacturing techniques and apply their knowledge to optimize a shoe design process.

Lesson 0.3 Material Choice and Testing
In Lesson 0.3 students experiment with different material options to determine which material properties are best paired with specific use cases and why. They design a test to gather meaningful data for a material that can be replicated consistently to cause an object to fail or break in a consistent manner. Students also model a shoe sole custom sized for their foot and choose a material that best meets the needs of a desired shoe application of their choice.

Lesson 0.4 Designing a Shoe For You
In the final lesson, students apply their knowledge gained through the entire unit to identify a client with a specific footwear need to design and develop a solution. They interview their client, document their engineering design process, create a 3-D model, develop a physical prototype, and iterate with their client to design a shoe tailored to their needs.

Unit 1: Mechanical Design

In Unit 1, students explore the foundational elements that make up complex mechanical devices and systems. They work collaboratively to solve real-world problems using their understanding of mechanical designs and motion to develop complex mechanisms. Students end the unit by working collaboratively and applying their knowledge to solve a real-world agricultural problem.

Students gain understanding of mechanical engineering concepts such as simple machines, energy, work, power, and mechanisms and apply them to solve engineering problems. Students continue to apply their project management, collaboration, communication, and additional key transportable skills throughout the unit. They continue to explore future career opportunities by conducting a professional interview of a professional of their choice.

Mechanical Design

Lesson 1.1 Simple and Compound Machines
Lesson 1.2 Mechanisms
Lesson 1.3 Agricultural Solutions

Lesson 1.1 Simple and Compound Machines

In Lesson 1.1 students explore simple machines, where they are found, how they are used, and why they are the foundation of mechanical devices. They will explore the fundamentals of energy, work, and power then apply their understanding to maximize efficiency and power. Students then investigate the factors that impact pulley systems, how to maximize the efficiency of pulleys, and design their own pulley system in a simulation. Students discover the benefits and drawbacks of different gears and gear trains as well as how to optimize speed or torque through gear ratios. Finally, students use force and acceleration sensors as well as their understanding of simple machines to design a robot that can pull with the greatest force.

Lesson 1.2 Mechanisms

Students begin Lesson 1.2 by examining the four types of motion as well as their application in different mechanical devices. They apply their understanding of motion by designing and building a latch mechanism to fix a broken door. Students continue their understanding of motion by creating a variety of different mechanisms and explore how they convert one type of motion to another. The lesson ends with a motion conversion challenge where students work collaboratively to design, build, and test individual segments of a machine and combine their machines to make a large-scale device to solve a problem.

Lesson 1.3 Agricultural Solutions

In this unit problem, students apply their understanding of simple machines, compound machines, mechanisms, and motion to choose a real-world agricultural problem then design, test, and build a compound machine that solves the identified problem. They then pitch their solution to a team of potential investors in an informative and persuasive presentation.

Unit 2: Application of Robotics

In Unit 2, students explore the world of robotics and programming. They use their understanding of mechanical design, robotics, and programming to work collaboratively to develop solutions to real-world-problems. Students continue their career exploration through investigating different pathways to higher education and determine their best course of action to make themselves good candidates for postsecondary education opportunities.

Students learn concepts such as programming, using and applying sensors, and artificial intelligence. Students utilize their collaboration, communication, project management, and additional transportable skills throughout the unit to solve in-depth problems.

Application of Robotics

Lesson 2.1 Introduction to Robotics
Lesson 2.2 Robotics in Action
Lesson 2.3 Artificial Intelligence
Lesson 2.4 An Electronic Ensemble

Lesson 2.1 Introduction to Robotics

In this lesson, students begin their introduction to robotics by creating their own robot that moves forward without the use of wheels. They then investigate what constitutes a robot compared to other programmable mechanical devices. Students conclude this lesson with detailed research in the history of robotics and predict opportunities for the future of the field.

Lesson 2.2 Robotics in Action

In lesson 2.2 students develop best coding practices, differentiate between open and closed loop systems, apply conditional statements, utilize a variety of different sensors, and apply their understanding to solve a problem. Students build and program a simple robot vehicle that can drive as close as possible to an obstacle without the use of sensors. Students are then introduced to bumper and limit switches, a potentiometer, a servo motor, and optical sensors and program each device to solve different problems. They conclude this unit by applying their understanding of programming to design and build a robot that replicates an animal's behavior.

Lesson 2.3 Artifical Intelligence

Students continue their exploration of robotics with artificial intelligence and machine learning. They design and build a robot, using a supervised machine learning algorithm, a distance sensor, and a bumper switch to train their robot to give a physical greeting. Students then investigate ethical concerns involved in the implementation of artificial intelligence and conduct research to determine the best course of action in a given scenario. To finish this unit, students apply their understanding of artificial intelligence to design and build a robot that can help someone.

Lesson 2.4 An Electronic Ensemble
In this unit problem, students create a robotic system that can perform a piece of music. They research different instruments from around the world, construct a functional prototype of their chosen instrument, then design, build, and program a robot that can play their instrument. Students coordinate and collaborate with their individual robots and each other to create a system of robots that can play a piece of music.

Unit 3: Energy in Action

In this unit students explore energy more deeply and useful applications of it through electrical circuits, fluids, and kinematics. They begin the unit by exploring the relationships between circuit components, derive formulas, and apply their understanding to solve problems. Students then move into the world of fluids, the deep mathematical principles that govern them, and apply their knowledge to design their own fluid power system. They end the unit implementing their understanding of energy in motion through kinematics. Students also continue their career exploration journey by examining the financial aspects of attending a postsecondary institution.

Energy in Action

Lesson 3.1 Electrical Circuits
Lesson 3.2 Fluid Power
Lesson 3.3 Kinematics
Lesson 3.4 Integration of Circuits, Fluid Power, and Kinematics

Lesson 3.1 Electrical Circuits
In Lesson 3.1, students explore the basic components of electrical circuits and model them through a hands-on introduction. They then explore the basic elements of electricity and electrical circuits and build simple circuits with breadboards and online simulations. Students collect data to derive the formula for Ohm's Law then apply their understanding of Ohm's Law to solve problems. They then move into a comparison between series and parallel circuits and explore their similarities and differences. Students continue hands-on breadboarding and simulations to derive Kirchhoff's voltage and current laws. They end the lesson with a final project that applies all the skills acquired to design and build their own functional safe.

Lesson 3.2 Fluid Power
In this lesson, students learn the fundamentals of hydraulic and pneumatic fluid power. They begin by exploring the differences between hydraulic and pneumatic systems as well as common mathematical formulas that support fluid power engineering. Students the apply these concepts to complete a problem set surrounding fluid power mathematics. This lesson concludes with students designing and building their own working hydraulic system.

Lesson 3.3 Kinematics

In Lesson 3.3, students explore the physics of moving objects. They begin by experimentally measuring the gravitational constant. Then, students consider motion vertical and horizontal directions and derive the equations that govern horizontal projectile motion. This lesson culminates with an engineering design challenge where students are challenged to design and build a zipline and calculate where an object will land when dropped.

Lesson 3.4 Integration of Circuits, Fluid Power, and Kinematics

In this unit problem, students will combine their knowledge of electrical circuits and kinematics to design and build an automated golfer and a golf course. Students will also create two targets that trigger an LED to illuminate and another to produce a sound. This problem requires deep understanding of series and parallel circuits, fluid power, as well as horizontal and vertical motion.

Unit 4: Designing Infrastructure and Developing Sustainability

They investigate methods of designing infrastructure as well as various techniques to develop sustainable practices for the future. Students work collaboratively in teams to develop solutions to structural design problems, sustainable approaches, and transportation design needs that have a lasting impact on local and global communities.

Students gain an understanding of in-depth mathematical approaches to infrastructure design for static systems as well as apply statistical analysis and rigorous calculations to traffic and intersection design. They explore a variety of energy sources and a life cycle analysis to measure trade-offs in environmental dilemmas. Students continue to refine their project management, collaboration, communication, and additional key transportable skills to understand the impact of design choices on a large scale. Students conclude their career exploration by examining the future of different careers and how they will be affected by the adoption of artificial intelligence.

Designing Infrastructure and Developing Sustainability

4.1 Statics
4.2 Renewable Energy
4.3 Transportation
4.4 Infrastructure Redesign

Lesson 4.1 Statics

In Lesson 4.1, students explore various aspects of static structures and apply mathematical approaches to solve structural problems. They begin the lesson by applying an engineering design process to design and test a cantilever beam. Students then compare materials and their properties that impact beam deflection; they also use 3-D modeling software to analyze and investigate factors that impact beam deflection and solve an engineering design problem. Students analyze and solve systems through the use of free body diagrams, force vectors, moment calculations, and method of joints. They will also explore internal forces in materials and the relationship between stress and strain. Students culminate their understanding to design their own bridge truss to support a given load at the lowest cost.

Lesson 4.2 Renewable Energy

In lesson 4.2, students discover various sources of energy and research their effects on social, environmental, political, and economic systems to develop assertions and debate important environmental topics. They apply an engineering design process to design, construct, and test a device that converts the mechanical energy of falling water into electrical energy.

Lesson 4.3 Transportation

In lesson 4.3, students examine and apply various mathematical tools to analyze traffic flow, capacity, and speed limit to solve transportation problems. They use hands on experiments and spreadsheets to determine maximum traffic density, traffic flow rate, and calculate optimal speed limit. Students also model traffic flow at various intersections and use critical lane volume to improve an existing intersection. Students conclude the lesson by applying an engineering design process to solve a transportation need for a client with different abilities.

Lesson 4.4 Infrastructure Redesign

In the unit problem, students determine a building that needs to be remodeled with a renewable energy source, a structural element, and a new intersection that serves the building. They calculate how much energy they can gather from their chosen renewable energy source and determine if it is sufficient to replace existing energy sources for their building. Students identify a structure to model with a free body diagram and calculate the forces of each member of their chosen structure. Students analyze a map of their chosen building location to determine the most effective renewable energy source. Finally, they redesign an intersection based on an increased flow rate traveling to and from their remodeled building.

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.

Design Process Experience

- Solve a problem using an iterative engineering design process
- Work collaboratively on a team to design a product or solve a problem
- Document in detail the engineering design process used to solve a problem or design a product
- Develop a detailed and comprehensive design brief
- Brainstorm to generate creative ideas and potential solutions to a problem
- Carry out a plan to compare alternate solutions and select the best solution path
- Evaluate a design solution with respect to design requirements

Experimental Design and Testing Experience

- Design an experimental protocol to investigate a phenomenon
- Develop a test plan to compare alternate solutions
- Collect and analyze data to draw conclusions
- Accurately represent experimental data using visualization techniques and statistical models

Modeling Experience

- Create concept sketches to represent ideas
- Create technical drawings to represent solutions
- Create hand-drawn and scaled technical drawings
- Create and/or modify 3-D solid computer models
- Develop models (including conceptual, graphical, mathematical, physical, and computer) and simulations to represent information, objects, systems, and processes.
- Use CAD software to develop parametric models, calculate beam deflection, determine life cycle and assessments, and analyze a pulley system.

Computational and Analytical Skills

- Use data to inform decisions and make predictions
- Apply abstraction to generalize a problem and solutions
- Collect, organize, and analyze data to help define a problem
- Use algorithms to create solutions
- Write programming code for a project involving a sequence or system of tasks
- Use a variety of methods for identifying and correcting errors in a program code

Project Management Experience

- Project scheduling and collaboration
- Act as a project lead to solve an engineering problem

Transportable Skills

- Team collaboration
- Peer review and feedback
- Project management
- Problem-solving
- Oral communication and presentation
- Technical writing
- Ethical reasoning

COURSE KNOWLEDGE

Careers
- Engineering career research
- STEM careers related to engineering
- Awareness of education and skills required for professional practice
- Professional understanding of the need for multidisciplinary solutions to complex global challenges
- Financial considerations of post-secondary education
- Technology advancements and implications of AI in the workforce
- Professional ethics

Product Design
- Technical Drawings and Modeling
- Manufacturing techniques and optimization
- Tolerance Analysis

Material Choice and Testing
- Material analysis
- Failure testing
- Statistics
- Materials Choice

Energy
- Energy, work, and power fundamentals
- Maximizing efficiency
- Maximizing power
- Energy sources and application

Simple and Compound Machines
- Mechanisms and simple machines
- Mechanical advantage
- Gear ratio
- Compound gears
- Types of motion
- Converting types of motion

Programming
- Open and closed loop systems
- Potentiometer, bumper and limit switch, distance sensor, servo motor, and optical sensors
- Artificial intelligence and machine learning

Electrical Circuits
- Ohms Law
- Parallel and series circuits
- Equivalent Resistance
- Kirchhoff’s Law

Fluid Power

- Hydraulic systems
- Pneumatic systems
- Flow Rate
- Pascal's Law
- Fluid power
- Flow velocity
- Bernoulli's Principle
- Absolute power
- Absolute temperature
- Boyle's Law
- Charles' Law
- Gay-Lussac's Law

Kinematics

- Displacement
- Velocity
- Acceleration
- Vertical motion
- Horizontal projectile motion

Statics

- Beam deflection
- Free body diagrams
- Force vectors
- Stress and Strain
- Tensile Testing
- Moments
- Method of joints
- Material properties

Transportation

- Flow rate
- Roadway capacity
- Optimal speed limit
- Critical lane volume

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	How do engineers quantify the mechanical advantage of a system?
1.1 - 2	How do engineers apply their knowledge of simple machines to solve problems?
1.1 - 3	How do engineers quantify energy, work, and power?
1.1 - 4	How do engineers apply their knowledge of energy, work, and power to solve problems?
1.2 - 1	How are mechanisms used to convert one type of motion to another?
1.2 - 2	How do engineers manipulate motion to solve design problems?
1.3 - 1	How can you apply your understanding of machines and mechanisms to solve an authentic problem?

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:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☑

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

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☑	☐	☐	☐	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

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

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☑	☐	☐	☐	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

CAR-A.7 Reflect upon knowledge gained to monitor professional progress and individual growth.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☑	☐	☐	☐	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

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:

1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
☑	☐	☐	☐	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

COM-A.3 Properly cite references for all communication in an accepted format.

APB:

1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
☑	☐	☐	☐	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☑

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 Describe the various individual roles and interdependencies of a collaborative team.

APB:

1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
☐	☐	☐	☐	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☑

COL-A.3 Solicit, negotiate, and balance diverse views and beliefs to reach workable solutions.

APB:

1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
☐	☐	☐	☐	☐	☐	☐	☑

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☑	☐

COL-A.4 Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.

APB:

1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
☐	☐	☐	☐	☐	☐	☐	☑

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☑	☐

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. Explain and justify an engineering design process.

CCP-A.2 Document a design process in an engineering notebook according to best practices.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☐

	1.2.1	1.2.2	1.2.3	1.3.1
	☐	☐	☑	☑

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

CCP-C.2 List potential constraints that may impact the success of a design solution. Examples include economic (cost), environmental, social, political, ethical, health and safety, manufacturability, technical feasibility, and sustainability.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☐

	1.2.1	1.2.2	1.2.3	1.3.1
	☐	☐	☐	☑

CCP-D. Generate multiple potential solution concepts.

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

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☑	☐

	1.2.1	1.2.2	1.2.3	1.3.1
	☐	☐	☐	☑

CCP-E. Develop models to represent design alternatives and generate data to inform decision making, test alternatives, and demonstrate solutions.

CCP-E.1 Define various types of models that can be used to represent products, processes, or designs, such as physical prototypes, mathematical models, and virtual representations. Explain the purpose and appropriate use of each.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☑	☑	☐	☐	☐	☐	☐

	1.2.1	1.2.2	1.2.3	1.3.1
	☐	☐	☑	☐

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

CCP-F.1 Explain that there are often multiple viable solutions and no obvious best solution. Trade-offs must be considered and evaluated consistently throughout an engineering design process.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☑	☐	☐	☐	☐	☐	☐
	1.2.1	1.2.2	1.2.3		1.3.1			
	☐	☐	☐		☑			

CCP-G. Plan and execute an investigation to collect valid quantitative data to serve as a basis for evidence and to inform decisions.

CCP-G.1 Identify the data needed to answer a research question and the appropriate tools necessary to collect, record, analyze, and evaluate the data.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☐
	1.2.1	1.2.2	1.2.3		1.3.1			
	☐	☐	☐		☑			

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

CCP-H.1 Plan and use time in pursuit of accomplishing a goal without direct oversight.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☑	☐	☐	☐	☐	☐	☑
	1.2.1	1.2.2	1.2.3		1.3.1			
	☐	☐	☐		☑			

CCP-I. Demonstrate flexibility and adaptability to change.

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

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☑	☐	☐	☐	☐	☐	☐
	1.2.1	1.2.2	1.2.3		1.3.1			
	☐	☐	☐		☐			

Competencies, Domains, Objectives, Knowledge and Skills

CCP-K. Design and carry out an experiment that investigates a research question.

CCP-K.1 Develop a testable hypothesis and design an experimental protocol that evaluates its validity.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐
	1.2.1	1.2.2	1.2.3		1.3.1			
	☐	☐	☐		☐			

CCP-K.2 Distinguish between the independent and dependent variables.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐
	1.2.1	1.2.2	1.2.3		1.3.1			
	☐	☐	☐		☐			

CCP-K.3 Identify and explain the purpose and importance of experimental controls.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐
	1.2.1	1.2.2	1.2.3		1.3.1			
	☐	☐	☐		☐			

CCP-K.4 Maintain a detailed repeatable account of the experiment in a physical or digital laboratory notebook.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐
	1.2.1	1.2.2	1.2.3		1.3.1			
	☐	☐	☐		☐			

CCP-K.6 Identify possible source of errors, then redesign and repeat the experiment when appropriate.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐
	1.2.1	1.2.2	1.2.3		1.3.1			
	☐	☐	☐		☐			

CCP-K.7 Communicate the findings of the experiment in oral and written (including digital) form.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐

	1.2.1	1.2.2	1.2.3	1.3.1
	☐	☐	☐	☐

CCP-K.8 Describe why experimental design is a continual process.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐

	1.2.1	1.2.2	1.2.3	1.3.1
	☐	☐	☐	☐

CCP-L. Collect and analyze experimental data to draw conclusions.

CCP-L.2 Draw logical conclusions from experimental data.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐

	1.2.1	1.2.2	1.2.3	1.3.1
	☐	☐	☐	☐

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.

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:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☑

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

ETT-B. Use a spreadsheet application to help identify and/or solve a problem.

ETT-B.2 Populate a spreadsheet application with data and organize the data to be useful in accomplishing a specific goal.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

ETT-B.3 Use the functions and tools within a spreadsheet application to manipulate, analyze, and present data in a useful way, including regression analyses and descriptive statistical analyses.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

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

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

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☑	☐	☐	☑	☑	☑

1.2.1	1.2.2	1.2.3	1.3.1
☑	☑	☑	☑

ETT-E.2 Demonstrate use of hand tools and shop tools.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☑	☐	☐	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

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

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

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

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

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

ETT-F.4 Identify, test, and implement possible solutions to a problem using a computer.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

Foundations in Math and Engineering Science (FMS):

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

FMS-A. Identify appropriate applications and examples of each of the six simple machines.

FMS-A.1 Describe the attributes and components of each of the six simple machines.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☑	☐	☐	☐	☐	☐
	1.2.1	1.2.2	1.2.3		1.3.1			
	☐	☐	☐		☑			

FMS-A.2 Distinguish between the six simple machines.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☑	☐	☐	☐	☐	☐
	1.2.1	1.2.2	1.2.3		1.3.1			
	☐	☐	☐		☑			

FMS-A.3 Design a solution that incorporates several simple machines.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☐
	1.2.1	1.2.2	1.2.3		1.3.1			
	☐	☐	☑		☑			

FMS-B. Measure forces and distances and calculate mechanical advantage, work, power, and efficiency in mechanical systems.

FMS-B.1 Identify the equations to solve for mechanical advantage, work, and power.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☑	☐	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

FMS-B.2 Measure forces and distances related to mechanisms.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☑	☐	☑

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☑

FMS-B.3 Calculate mechanical advantage and drive ratios of mechanisms.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☑	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☑

FMS-B.4 Identify the equations for work and power.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☑	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

FMS-B.5 Calculate work and power in mechanical systems.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☑	☐	☐	☐	☑

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

FMS-B.6 Determine efficiency in a mechanical system.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☑	☐	☐	☑	☑

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

FMS-B.7 Identify the equation for calculating the efficiency of a system.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☑	☐	☐	☑	☑

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

FMS-B.8 Calculate the mechanical power developed when lifting an object.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☑	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

FMS-B.9 Design, build, and test a machine that efficiently channels mechanical energy when friction and limited input energy are significant constraints.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☑

FMS-B.10 Differentiate between types of motion and design systems to convert types of motion.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☑	☐	☐	☑

FMS-B.11 Apply knowledge of simple machines to construct complex mechanisms and machines.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☐

1.2.1	1.2.2	1.2.3	1.3.1
☑	☐	☐	☑

Competencies, Domains, Objectives, Knowledge and Skills

Algorithms and Programing (AAP):

Algorithms are used to develop and express solutions to computational problems. Algorithms are fundamental to even the most basic everyday task.

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

AAP-C.2 Create, interpret, and/or modify a program to manage inputs and outputs of a microcontroller.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☑

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

Robotics and Automation (RA):

The interaction and use of mechanical systems, energy transfer, machine automation, and computer control systems to solve problems.

RA-A. Design a robotic system that solves an engineering design problem and meets required constraints and criteria.

RA-A.3 Construct a robot that meets design requirements.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☑

1.2.1	1.2.2	1.2.3	1.3.1
☐	☐	☐	☐

Product Design (PD):

The process of identifying a market opportunity, imagining a product that meets the market's needs, and working to create a valid solution.

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

PD-A.1 Develop a model to accurately represent information or important characteristics of an object, data, process, or design idea for an intended purpose.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☑	☐	☐	☐	☑	☐	☑

1.2.1	1.2.2	1.2.3	1.3.1
☐	☑	☐	☐

PD-B. Use spatial visualization to interpret graphical representations of physical objects.

PD-B.1 Build a physical representation of an object, system, or environment. (Includes building solid objects, electrical circuits, mechanical devices, and complex systems according to technical drawings.)

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☐

	1.2.1	1.2.2	1.2.3	1.3.1
	☐	☑	☐	☐

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

PD-D.1 Correctly build and constrain a three-dimensional solid computer model to accurately represent the physical characteristics and behaviors of a design idea or real object. [Scope: This could include the appropriate application of geometric (horizontal, vertical, parallel, perpendicular, tangent, concentric) and dimensional constraints, as well as modeling other physical properties (i.e., density, color, texture, and so on)]

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☐

	1.2.1	1.2.2	1.2.3	1.3.1
	☐	☑	☐	☐

PD-F. Design a product with consideration to how it will be manufactured.

PD-F.1 Create a prototype.

APB:	1.1.0	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7
	☐	☐	☐	☐	☐	☐	☐	☑

	1.2.1	1.2.2	1.2.3	1.3.1
	☐	☐	☐	☐

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	What characteristics define a robot?
2.2 - 1	What practices do programmers use to write effective code?
2.2 - 2	How do engineers use sensors to solve design problems?
2.3 - 1	What is artificial intelligence, and how do engineers use it to solve problems?
2.3 - 2	What are some of the ethical implications of artificial intelligence?
2.4 - 1	How can you apply your understanding of mechanics and programming to solve a design problem?

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:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☑	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☐

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

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☑	☐	☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☐

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

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☑	☐	☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☐

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

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☑	☐	☑	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☑	☐	☑

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

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☑	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☑	☐	☑

COM-A.3 Properly cite references for all communication in an accepted format.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☑	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☑	☐	☑

COM-A.5 Use characteristics important to oral delivery of information (volume, tempo, eye contact, articulation, and energy). Vary these elements of delivery to convey and emphasize information and engage the audience.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☑	☐	☑	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☑	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

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 Describe the various individual roles and interdependencies of a collaborative team.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☑	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☑

COL-A.2 Describe the importance of team norms and how to develop those norms for a team.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☑

COL-A.3 Solicit, negotiate, and balance diverse views and beliefs to reach workable solutions.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☑	☐	☑	☐	☑

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☑

COL-A.4 Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☑	☐	☑

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☑

COL-B. Contribute individually to overall collaborative efforts.

COL-B.1 Describe one's individual role and expectations of performance within the team.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☑

Ethical Reasoning and Mindset (ERM):

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

ERM-A. 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:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☐	☐	☑

2.3.1	2.3.2	2.3.3	2.4.1
☐	☑	☑	☐

Critical and Creative Problem-Solving (CCP):

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

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

CCP-A.2 Document a design process in an engineering notebook according to best practices.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☑	☑

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

CCP-C.1 Explain the importance of carefully and specifically defining a problem or opportunity, design criteria, and constraints, to develop successful design solutions.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☑	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☑	☐	☐

CCP-C.2 List potential constraints that may impact the success of a design solution. Examples include economic (cost), environmental, social, political, ethical, health and safety, manufacturability, technical feasibility, and sustainability.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☑	☑

CCP-D. Generate multiple potential solution concepts.

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

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☑	☑

CCP-E. Develop models to represent design alternatives and generate data to inform decision making, test alternatives, and demonstrate solutions.

CCP-E.1 Define various types of models that can be used to represent products, processes, or designs, such as physical prototypes, mathematical models, and virtual representations. Explain the purpose and appropriate use of each.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☑	☐	☑

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☐

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

CCP-F.1 Explain that there are often multiple viable solutions and no obvious best solution. Trade-offs must be considered and evaluated consistently throughout an engineering design process.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☑	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☑

CCP-G. Plan and execute an investigation to collect valid quantitative data to serve as a basis for evidence and to inform decisions.

CCP-G.1 Identify the data needed to answer a research question and the appropriate tools necessary to collect, record, analyze, and evaluate the data.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☑

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

CCP-H.1 Plan and use time in pursuit of accomplishing a goal without direct oversight.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☑	☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☑

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.

Engineering Tools and Technology (ETT):

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

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

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

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☑	☑	☑	☑

2.3.1	2.3.2	2.3.3	2.4.1
☑	☐	☑	☑

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

ETT-F.5 Automate a solution using algorithmic thinking.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☑	☑	☑	☑

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☑

Control Systems (CSY):

A control system is integrated into a larger system as a means to coordinate input and output devices.

CSY-A. Distinguish between digital and analog data, and the inputs and outputs of a computational system.

CSY-A.1 Distinguish between digital and analog data, and between the inputs and outputs of a computational system.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☑	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☐

CSY-B. Describe differences and advantages of open- and closed-loop systems.

CSY-B.1 Distinguish between open- and closed-loop systems based on whether decisions are made using time delays or sensor feedback.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☑	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☐

CSY-B.2 Identify the relative advantage of an open-loop or closed-loop control system for a given technological problem.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☑	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☐

CSY-C. Create a flowchart, pseudocode, and computer program to implement an algorithm.

CSY-C.4 Create a computer program to implement an algorithm, including conditional statements and iterations.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☑	☑	☑

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☑	☑

CSY-D. Predict the behavior of a control system and use a variety of methods for finding, identifying, and correcting bugs in a program.

CSY-D.1 Based on given needs and constraints, design and create a control system, including the inputs, computer program, and outputs.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☑	☑	☑

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☑	☑

CSY-D.2 Predict the behavior of a control system by examining the program it is going to execute.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☑	☑	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☐

CSY-D.3 Evaluate algebraic and logical expressions involving programming variables.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☐	☑	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☐

Algorthms and Programing (AAP):

Algorithms are used to develop and express solutions to computational problems. Algorithms are fundamental to even the most basic everyday task.

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

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

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☑	☑	☑

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☑	☑

AAP-B. Use algorithms to create a solution with or without the use of a computer program.

AAP-B.1 Write a set of ordered instructions (with or without a computer) involving multiple discrete steps to accomplish a complex task or achieve a desired result.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☑	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☑	☑

AAP-B.2 Implement and analyze algorithms using conditional logic.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☑	☑

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

AAP-C.1 Interpret simple computer code within various applications to describe the intended function of the code.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☐	☑	☑

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☐

AAP-C.2 Create, interpret, and/or modify a program to manage inputs and outputs of a microcontroller.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☑	☑	☑

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☑	☑

AAP-C.3 Create programs by writing and testing code in a modular, incremental approach.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☑	☑

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

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

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☐	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☑

Robotics and Automation (RA):

The interaction and use of mechanical systems, energy transfer, machine automation, and computer control systems to solve problems.

RA-A. Design a robotic system that solves an engineering design problem and meets required constraints and criteria.

RA-A.1 Identify and explain basic components and functions of a robot

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☑	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☐	☐	☑

RA-A.2 Program a robot to execute a desired behavior using inputs and outputs

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☑	☐	☐	☐	☑	☑

2.3.1	2.3.2	2.3.3	2.4.1
☑	☐	☑	☑

RA-A.3 Construct a robot that meets design requirements.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☑	☐	☐	☐	☑	☑

2.3.1	2.3.2	2.3.3	2.4.1
☑	☐	☑	☑

RA-B. Describe the purpose of automation and robotics and its effect on society.

RA-B.1 Summarize ways that robots are used in today’s world and the impact of their use on society.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☑	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☑	☑	☐

RA-B.2 Describe positive and negative effects of automation and robotics on humans in terms of safety, economics, and ethics

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☑	☐	☐	☐	☐

2.3.1	2.3.2	2.3.3	2.4.1
☐	☑	☑	☐

Product Design (PD):

The process of identifying a market opportunity, imagining a product that meets the market's needs, and working to create a valid solution.

PD-F. Design a product with consideration to how it will be manufactured.

PD-F.1 Create a prototype.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☑	☐	☐	☐	☐
	2.3.1	2.3.2	2.3.3	2.4.1			
	☐	☐	☐	☐			

PD-F.4 Describe how a product changes over time.

APB:	2.1.0	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.2.4
	☐	☐	☑	☐	☐	☐	☐
	2.3.1	2.3.2	2.3.3	2.4.1			
	☐	☐	☐	☐			

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 do you differentiate between circuit types?
3.1 - 2	How do you model electrical circuits?
3.1 - 3	How do you test circuit parameters?
3.1 - 4	What are the mathematical relationships between circuit parameters?
3.1 - 5	Why are Kirchhoff's Laws important to engineers and designers of electrical circuits?
3.2 - 1	What impact does fluid power have on our everyday lives?
3.2 - 2	What devices or systems might be improved with the use of fluid power?
3.2 - 3	What are the similarities and differences of mechanical advantage in simple machines?
3.2 - 4	Why are Pascal's Law, the perfect gas laws, Bernoulli's Principle, and other similar rules important to engineers and designers of fluid power systems?
3.3 - 1	How do we graph and analyze motion?
3.3 - 2	What equations govern how objects move?
3.3 - 3	How do we predict where projectiles will land?

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.8 List financial considerations of postsecondary education pathways.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☑	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☐

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:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☑	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

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

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☑	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

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 Describe the various individual roles and interdependencies of a collaborative team.

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

COL-A.2 Describe the importance of team norms and how to develop those norms for a team.

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

COL-A.3 Solicit, negotiate, and balance diverse views and beliefs to reach workable solutions.

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

COL-A.4 Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

COL-B. Contribute individually to overall collaborative efforts.

COL-B.1 Describe one’s individual role and expectations of performance within the team.

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

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. Explain and justify an engineering design process.

CCP-A.2 Document a design process in an engineering notebook according to best practices.

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

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

CCP-C.1 Explain the importance of carefully and specifically defining a problem or opportunity, design criteria, and constraints, to develop successful design solutions.

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

CCP-D. Generate multiple potential solution concepts.

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

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

CCP-E. Develop models to represent design alternatives and generate data to inform decision making, test alternatives, and demonstrate solutions.

CCP-E.1 Define various types of models that can be used to represent products, processes, or designs, such as physical prototypes, mathematical models, and virtual representations. Explain the purpose and appropriate use of each.

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

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

CCP-F.1 Explain that there are often multiple viable solutions and no obvious best solution. Trade-offs must be considered and evaluated consistently throughout an engineering design process.

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

CCP-G. Plan and execute an investigation to collect valid quantitative data to serve as a basis for evidence and to inform decisions.

CCP-G.1 Identify the data needed to answer a research question and the appropriate tools necessary to collect, record, analyze, and evaluate the data.

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☑	☐	☐	☐	☑	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☑	☑	☐	☐	☑

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

CCP-H.1 Plan and use time in pursuit of accomplishing a goal without direct oversight.

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☑	☑

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☑	☐	☐	☐	☑

CCP-I. Demonstrate flexibility and adaptability to change.

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

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☐	☑

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

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

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

APB:

3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

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.

Engineering Tools and Technology (ETT):

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

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

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

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☑	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☐

ETT-E.2 Demonstrate use of hand tools and shop tools.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☑

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☐

Foundations in Math and Engineering Science (FMS):

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

FMS-B. Measure forces and distances and calculate mechanical advantage, work, power, and efficiency in mechanical systems.

FMS-B.10 Differentiate between types of motion and design systems to convert types of motion.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☑

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☐

FMS-B.11 Apply knowledge of simple machines to construct complex mechanisms and machines.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☑

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☐

FMS-C. Analyze parallel and series circuits resistance, current, and voltage using Ohm's law.

FMS-C.1 Identify the equations to calculate the resistance, current, and voltage of simple circuits.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☑	☑	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☐

FMS-C.2 Calculate electrical power developed in a circuit.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☑	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

FMS-C.3 Calculate circuit resistance, current, and voltage using Ohm's law, including circuits with elements in series and/or parallel.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☑	☐	☐	☑

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☑

FMS-C.4 Compare and contrast the behavior of electrical circuits with parallel and series circuit designs.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☑	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☐

FMS-F. Describe free-fall motion.

FMS-F.1 Describe free-fall motion of a projectile as having constant velocity in the horizontal direction and uniformly accelerating motion in the vertical direction.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☑	☐	☐	☑

FMS-G. Calculate distance, displacement, speed, velocity, and acceleration from data.

FMS-G.1 Calculate acceleration due to gravity given data from a free-fall trajectory.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☑	☐	☐	☑

FMS-G.2 Determine the angle needed to launch a projectile a specific range given vthe projectile’s initial velocity.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☑	☐	☑

FMS-G.3 Calculate distance, displacement, speed, velocity, and acceleration from data.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☑	☑

FMS-H. Describe the location of a projectile in motion as a function of time.

FMS-H.1 Identify formulas related to motion of a projectile.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☑	☑

FMS-H.2 Calculate the location of a projectile at a specified time.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☑	☑

Control Systems (CSY):

A control system is integrated into a larger system as a means to coordinate input and output devices.

CSY-E. Describe the advantages of hydraulic and pneumatic systems relative to each other.

CSY-E.1 Identify devices that use hydraulic and pneumatic power.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☑	☐	☐	☐	☐	☐	☐

CSY-E.2 Distinguish between hydrodynamic and hydrostatic systems.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☑	☐	☐	☐	☐	☐	☐

CSY-E.3 Identify the advantages of hydraulic and pneumatic systems relative to each other.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☑	☐	☐	☐	☐	☐	☐

CSY-F. Design a hydraulic and pneumatic device, calculating design parameters using Pascal's Law.

CSY-F.1 Design, create, and test a fluid powered device.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☑	☐	☑	☐	☐	☐	☑

CSY-F.2 Calculate flow rate, flow velocity, power, and mechanical advantage in a fluid power system.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☑	☑	☐	☐	☐	☐

CSY-F.3 Identify and explain basic components and functions of fluid power devices.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☑	☑	☐	☐	☐	☐

CSY-F.4 Calculate values in a pneumatic system using the ideal gas laws.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☑	☐	☐	☐	☐	☐

CSY-F.5 Calculate design parameters in a fluid power system utilizing Pascal's Law.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☑	☐	☐	☐	☐	☐

CSY-F.6 Distinguish between pressure and absolute pressure.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☑	☐	☐	☐	☐	☐

CSY-F.7 Distinguish between temperature and absolute temperature.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☐

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☑	☐	☐	☐	☐	☐

Product Design (PD):

The process of identifying a market opportunity, imagining a product that meets the market's needs, and working to create a valid solution.

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

PD-A.1 Develop a model to accurately represent information or important characteristics of an object, data, process, or design idea for an intended purpose.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☑

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☐

PD-B. Use spatial visualization to interpret graphical representations of physical objects.

PD-B.1 Build a physical representation of an object, system, or environment. (Includes building solid objects, electrical circuits, mechanical devices, and complex systems according to technical drawings.)

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☑

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☐

PD-F. Design a product with consideration to how it will be manufactured.

PD-F.1 Create a prototype.

APB:	3.1.0	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
	☐	☐	☐	☐	☐	☐	☑

3.2.1	3.2.2	3.2.3	3.3.1	3.3.2	3.3.3	3.4.1
☐	☐	☐	☐	☐	☐	☐

PLTW Principles of Engineering
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	What factors impact beam deflection?
4.1 - 2	Why is the value of beam deflection useful?
4.1 - 3	What are the properties of structural members and why are they useful?
4.1 - 4	What is a centroid and how is it applied in structural members?
4.1 - 5	Why is it crucial for designers and engineers to construct accurate free body diagrams of the parts and structures that they design?
4.1 - 6	Why must designers and engineers calculate forces acting on bodies and structures?
4.1 - 7	What are the differences between stress and strain?
4.1 - 8	Why are stress and strain important factors to consider when designing?
4.1 - 9	How does the stress-strain curve help engineers during tensile testing?
4.1 - 7	What is a moment and how does it help solve problems in static structures?
4.1 - 8	When solving truss forces, why is it important to know that the structure is statically determinate?
4.1 - 9	How is the method of joints used to determine internal forces in trusses?
4.1 - 10	How do material properties affect structural stability, internal forces, and cost?
4.2 - 1	What are renewable and nonrenewable resources and how do humans use them?
4.2 - 2	In what innovative ways could the efficiency of electricity production using solar cells be maximized throughout the day?
4.3 - 1	What factors affect the rate of flow on a roadway?
4.3 - 2	How is the optimum speed limit determined for a roadway?
4.3 - 3	In your opinion, what type of intersection is prone to the most accidents? What can be done to maximize safety at this type of intersection?
4.4 - 1	What role does creativity have in the engineering design process?
4.4 - 2	What do engineers do to clearly document and communicate their work? Why is this important?
4.4 - 3	How are different elements of infrastructure related?
4.4 - 4	How do mass, friction, and gears

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

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☑	☐	☐	☐	☐	☐	☐	☐	☐

CAR-A.7 Reflect upon knowledge gained to monitor professional progress and individual growth.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☑	☐	☐	☐	☐	☐	☐	☐	☐

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

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☑

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

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☑

COM-A.3 Properly cite references for all communication in an accepted format.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☑

COM-A.4 Clearly label tables and figures with units and explain the information presented in context.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☑

COM-A.5 Use characteristics important to oral delivery of information (volume, tempo, eye contact, articulation, and energy). Vary these elements of delivery to convey and emphasize information and engage the audience.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☑

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 Describe the various individual roles and interdependencies of a collaborative team.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☑

COL-A.2 Describe the importance of team norms and how to develop those norms for a team.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☑

COL-A.3 Solicit, negotiate, and balance diverse views and beliefs to reach workable solutions.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☐

COL-A.4 Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☐

COL-B. Contribute individually to overall collaborative efforts.

COL-B.1 Describe one’s individual role and expectations of performance within the team.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☑

Ethical Reasoning and Mindset (ERM):

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

ERM-A. 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:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☑	☐	☑	☑	☐

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. Explain and justify an engineering design process.

CCP-A.2 Document a design process in an engineering notebook according to best practices.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☑

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

CCP-C.2 List potential constraints that may impact the success of a design solution. Examples include economic (cost), environmental, social, political, ethical, health and safety, manufacturability, technical feasibility, and sustainability.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☑

CCP-D. Generate multiple potential solution concepts.

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

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☑

CCP-E. Develop models to represent design alternatives and generate data to inform decision making, test alternatives, and demonstrate solutions.

CCP-E.1 Define various types of models that can be used to represent products, processes, or designs, such as physical prototypes, mathematical models, and virtual representations. Explain the purpose and appropriate use of each.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☑

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

CCP-F.1 Explain that there are often multiple viable solutions and no obvious best solution. Trade-offs must be considered and evaluated consistently throughout an engineering design process.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☑

CCP-G. Plan and execute an investigation to collect valid quantitative data to serve as a basis for evidence and to inform decisions.

CCP-G.1 Identify the data needed to answer a research question and the appropriate tools necessary to collect, record, analyze, and evaluate the data.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☑

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

CCP-H.1 Plan and use time in pursuit of accomplishing a goal without direct oversight.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☑	☐	☑	☐	☐	☐	☐	☑

CCP-I. Demonstrate flexibility and adaptability to change.

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

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☐

CCP-K. Design and carry out an experiment that investigates a research question.

CCP-K.1 Develop a testable hypothesis and design an experimental protocol that evaluates its validity.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

CCP-K.2 Distinguish between the independent and dependent variables.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

CCP-K.3 Identify and explain the purpose and importance of experimental controls.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

CCP-K.4 Maintain a detailed repeatable account of the experiment in a physical or digital laboratory notebook.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

CCP-K.6 Identify possible source of errors, then redesign and repeat the experiment when appropriate.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

CCP-K.7 Communicate the findings of the experiment in oral and written (including digital) form.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

CCP-K.8 Describe why experimental design is a continual process.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

CCP-L. Collect and analyze experimental data to draw conclusions.

CCP-L.2 Draw logical conclusions from experimental data.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

Technical Knowledge and Skills

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

Engineering Tools and Technology (ETT):

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

ETT-B. Use a spreadsheet application to help identify and/or solve a problem.

ETT-B.1 Use dimensional analysis and unit conversions to transform data to consistent units or to units appropriate for a particular purpose or model.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☑	☐	☐	☐

ETT-B.2 Populate a spreadsheet application with data and organize the data to be useful in accomplishing a specific goal.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☑	☐	☐

ETT-B.3 Use the functions and tools within a spreadsheet application to manipulate, analyze, and present data in a useful way, including regression analyses and descriptive statistical analyses.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☑	☐	☐

ETT-D. Apply system thinking to consider how an engineering problem and its solution fit into broader systems.

ETT-D.1 List realistic considerations that constrain solutions within the broader system. Examples include economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☑	☐	☐	☑	☐

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

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

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

ETT-E.2 Demonstrate use of hand tools and shop tools.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☑	☐	☐	☐	☐	☐	☐	☐

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

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

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☑	☑	☐	☐

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

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☑	☑	☐	☐

ETT-F.3 Develop an algorithm (step-by-step process) for solving a problem.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

ETT-F.4 Identify, test, and implement possible solutions to a problem using a computer.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

ETT-G. Determine the traffic flow rate for roadways.

ETT-G.1 Calculate average flow rate.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☑	☐	☐	☑

ETT-G.2 Determine the optimal speed limit for a given roadway.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☑	☐	☐

ETT-G.3 Calculate Critical Lane Volume (CLV) for an intersection.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☑	☐

ETT-G.4 Use data to redesign an intersection.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☑	☐

Foundations in Math and Engineering Science (FMS):

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

FMS-B. Measure forces and distances and calculate mechanical advantage, work, power, and efficiency in mechanical systems.

FMS-B.9 Design, build, and test a machine that efficiently channels mechanical energy when friction and limited input energy are significant constraints.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☑	☐	☐	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

Materials and Structures (MAS):

The integrity of physical systems is dependent on their material properties and structural design.

MAS-A. Draw free body diagrams of objects, identifying all forces acting on the object.

MAS-A.1 Differentiate between scalar and vector quantities.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

MAS-A.2 Identify the magnitude, direction, and sense of a vector.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

MAS-A.4 Understand how Newton’s Laws are applied to determine the forces acting on an object.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

MAS-A.5 Create free body diagrams of objects, identifying all forces acting on the object.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☑

MAS-A.6 Calculate the x and y components of a given vector.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

MAS-B. Calculate moment of inertia, beam deflection, and moments or torques.

MAS-B.1 Define a cantilver as a projecting beam fixed at only one end.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☑	☐	☐	☐	☐	☐	☐	☐

MAS-B.2 Define moment as the tendency to cause an object to rotate.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

MAS-B.3 Calculate moment given force and distance.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

MAS-B.4 Know that beam deflection is related to cross-sectional geometry and material properties.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

MAS-B.5 Know that the moment of inertia is related to cross-sectional geometry.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

MAS-B.6 Know that the modulus of elasticity defines the stiffness of an object related to material and chemical properties.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

MAS-B.7 Mathematically locate the centroid of structural members.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

MAS-B.8 Calculate the area moment of inertia of structural members.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

MAS-B.9 Calculate the deflection of a center-loaded beam from the beam’s geometry and material properties.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

MAS-B.10 Calculate moments or torques given a force and a point of application relative to a specified axis.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

MAS-C. Analyze and solve for the external and internal forces on a truss.

MAS-C.1 Use equations of equilibrium to calculate unknown external forces on a truss.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☑

MAS-C.2 Use the method of joints to calculate tension and compression forces in the members of a statically determinate truss.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☑

MAS-C.3 Construct and destructively test a truss, and relate observations to calculated predictions.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

MAS-E. Describe how the formulas are applied to material loaded with a tensile force.

MAS-E.1 Describe how formulas for stress and strain are applied to a material loaded with a tensile force.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

MAS-E.2 Describe how elastic and plastic deformation occurs in a material loaded with a tensile force.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

MAS-E.3 Describe the modulus of elasticity.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☑	☐	☐	☐	☐	☐	☐

MAS-F. Use axial force experiments to create a stress-strain curve describing intrinsic material properties.

MAS-F.1 Measure axial force and elongation data of material samples and create stress-strain diagrams describing the intrinsic properties of the materials.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

MAS-F.2 Calculate minimum or maximum design parameters to ensure a safe or reliable product using material strength properties.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

MAS-F.3 Identify and calculate test sample material properties using a stress-strain curve.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☐

Energy Sources (ESO):

Energy sources are used to generate power for humanity. Non-renewable sources include coal, oil, and natural gas, while renewable sources include wind, solar, hydroelectric, and geothermal.

ESO-A. Explore and document different energy sources and their uses.

ESO-A.1 Describe different energy sources.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☑

ESO-A.2 Explain positive and negative effects of different energy sources.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☑	☐	☐	☐	☐	☐

Product Design (PD):

The process of identifying a market opportunity, imagining a product that meets the market's needs, and working to create a valid solution.

PD-C. Create technical drawings.

PD-C.1 Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, pictorial view of the object, or set of orthographic projections.

APB:	4.1.0	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.3.2	4.3.3	4.4.1
	☐	☐	☐	☐	☐	☐	☐	☐	☑