Silicon Valley
Career Technical Education

Mechatronics Engineering

Course Outline

Course Description

Mechatronics is a year-long, 519-hour Laboratory Science course focusing on the scientific principles of physics, energy conservation, electronic sensing, computerized data acquisition, and automated process control. This Mechatronics Engineering course is designed to introduce students to the growing field of mechatronics. Mechatronics is a blending of electrical and mechanical engineering & design. It is a study of the design of "intelligent" systems in which mechanization and control, requiring sensing, actuation, and computation are combined to achieve improved product quality and performance.

In this inquiry-grounded, project-based learning course, students act as engineers, designing, analyzing, and building systems that automate industrial processes. Students will engage in interdisciplinary learning of Science, Technology, Engineering, Art, and Math (STEAM) through a hands-on, project-based approach. Students who complete this curriculum will have the understanding of mechanical and electronic systems. Students will learn how to analyze and debug mechanical assemblies, motors and control systems. Students will learn the function of programmable logic controllers (PLC) and other programmable devices. Students will receive introductory level exploratory instruction on topics including proper use of hand tools, machinery tools, print reading, robotics, pneumatics, electrical control, basic concepts of mechanical and electrical engineering, computer-aided design (CAD), and real world applications of these concepts. Depth of knowledge will be demonstrated through a series of projects starting with research and initial design and culminating with the completion of a build project that is geared toward solving real-world problems. Class projects will include robotics, industrial automation, industrial process control, pneumatics, and electro-mechanical systems. Essentially, activities in this course include work-based learning that connects students to industry and the local community.

The focus of this program is to educate and train a new generation of students who understand both mechanical and electrical systems that make up an industrial manufacturing and robotic infrastructure. Mechatronics is designed to prepare students for employment in the manufacturing industry. Upon completion, students may be employed in Mechatronics and Electronics related career paths, in engineering, industrial packaging, maintenance, and robotic systems.

Course Details

Length of Program and Academic Credits Earned / Internships	CTE Classification / Certifications & State Tests
Length of Program and Academic Credits Earned: Year-long 3 hour course = 519 hours (~261/semester) 30 total credits (15/ semester): ● 10 UC "d" Integrated Science credits (5/semester) ● 20 non-a–g elective credits (10/semester) **Pre-Requisites:** ● High School Junior or Senior, or 16 years or older	**CTE Classification:** ● **Industry Sector:** Engineering & Architecture ● **Industry Pathway:** Engineering Technology ● **CA Basic Education Data System (CBEDS) Code:** 5782
Internships: Limited opportunities will be provided to selected students based on academic capability and industry partner needs, but this is not currently part of the class curriculum	**Certifications & State Tests:** ● SVCTE Certificate of Completion awarded with "C" or better average for both semesters. ● Fanuc Robot operator certification

Possible Education & Career Pathways

For more career information: www.onetonline.org

College & Career Pathways:	Career Opportunities	O*NET Codes
Post-Secondary: Students with a high school diploma and having successfully completed this course have a number of entry-level career opportunities, as well as continuing their education.	● Robotics Technicians ● PLC programmer & operator ● Electrical and Electronic Equipment Assemblers ● Electro-Mechanical Technicians ● Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	17-3024.00 15-1122 .00 51-2022 .00 17-3024 .00 41-4011 .00
Continuing Education: Including Community College, Training Programs, Certifications, etc: ● AA or AS in Mechatronics, Electronics Engineering, or related Industrial Engineering.	● Computer User Support Specialist ● Automotive Engineering Technicians ● Computer-Controlled Machine Tool Operators ● Electrical and Electronic Engineering Technicians ● Electrical and Electronics Drafters ● Electrical and Electronics Repairers ● Electronic Equipment Motor Vehicles	15-1151.00 17-3027.01 51-4011 .00 17-3023.00 17-3012.00 49-2094.00 49-2096.00

	• Industrial Engineering Technicians 17-3026.00 • Mechanical Engineering Technicians 17-3027.00 • Environmental Engineering Technicians 17-3025.00
University Majors & Degrees: • BA or BS in Mechatronics, Mechanical Engineering, Electronics Technology, Electrical Engineering, Computer Science or a closely related field degree in Engineering Computer Science.	• Robotics Engineers 17-2199.08 • Aerospace Engineers 17-2011.00 • Biomedical Engineers 17-2031.00 • Computer Hardware Engineers 17-2061.00 • Electromechanical Engineering Technologists 17-3029.03 • Electrical Engineers 17-2071.00 • Mechanical Engineers 17-2141.00 • Mechatronics Engineers 17-2199.05 • Wind Energy Engineers 17-2199.10
Post-Baccalaureate Degrees: • Masters or Doctorate in Mechatronics, Mechanical Engineering, Electronics Technology, Electrical Engineering, Computer Science or a closely related field degree in Engineering Computer Science.	• Robotics Engineers 17-2199.08 • Aerospace Engineers 17-2011.00 • Biomedical Engineers 17-2031.00 • Electrical Engineers 17-2071.00 • Mechanical Engineers 17-2141.00 • Mechatronics Engineers 17-2199.05

Unit 1: Introduction to Mechatronics and Industrial Safety — 15 hours

Students will explore the importance of maintaining personal and occupational safety when working with industrial systems, robotic equipment and hardware.

- Emergency Procedures
- Safety hazard reporting
- Cyber ethics, cyber safety, and cyber security
- General shop safety rules and procedures
- Types of hazardous waste, safety issues, and proper handling and disposal procedures
- Personal safety practices to and from the job
- Procedure for reporting a work-related hazard or injury
- Effects of substance abuse in the workplace
- Immediate, potential, and hidden hazards
- Housekeeping tasks related to maintaining a safe work environment
- Safety test with a perfect score prior to operating equipment
- Proper safe use of tools and equipment
- Identify safety color codes and their uses
- Lock-out and tag-out procedures (LOTO)

Standards Alignments:

CCSS: LS 11-12.1, LS 11-12.2; **RSIT** 11-12.2, 11-12.7; **RLST** 11-12.2, 11-12.4, 11-12.7, 11-12.10; **WS** 11-12.1, 11-12.2, 11-12.4, 11-12.5, 11-12.6, 11-12.7, 11-12.8; **WHSST** 11-12.2, 11-12.5, 11-12.6, 11-12.7, 11-12.8
NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** In groups students will explore the Mechatronics lab investigating and recording all forms of staged violations. Students will then present and defend to the class their suggested corrective actions. In the same groups as above, students will perform all necessary repairs to bring the shop up to safety standards and reinforce their knowledge of lab standard to the instructor through inspection. Students will be required to pass safety procedural test and quiz . **Assessment:** peer and self-assessment, written report, public presentation, rubric, safety test, observation, visual inspection	2.1, 2.2, 2.3, 2.4, 2.5, 5.0, 6.0, 8.0, 10.2, 11.1	B 1.0, B 7.0

✓ **Key Assignment:** Students will work individually to investigate and research a topic of their choice related to waste management, recycling, or other environmental issues. Students will produce a written report, multimedia presentation or infographic to inform the public of their findings. Students will present their project to an audience for feedback. **Assessment:** peer and self-assessment, written report, public presentation, rubric	2.4, 2.5, 6.0, 10.0	B 1.0, B 9.0
✓ **Key Assignment:** Students will analyze and research an industrial safety topic and use a T-chart or similar graphic organizer to formulate an opinion and through a verbal and slide presentation, support their position through oral defense. Students must respond thoughtfully to diverse perspectives, as well as synthesize comments, claims and evidence made on all sides of the issue while resolving contradictions when possible, and determine what additional information or research is required to deepen the investigation. **Assessment:** peer and self-assessment, slide presentation & oral presentation	2.4, 2.5, 6.0, 10.0	B 7.0, B 9.0, B 10, B 11
✓ **Key Assignment:** Students will research and write an essay on how laws and ethics shape policy in regards to industrial systems and robotic applications and protocols. They must draw evidence from informational texts to support their analysis, reflection, and research. **Assessment:** written report, public presentation, portfolio check	2.2, 2.3, 8.0	B 1.0, B 9.0, B 10, B 11

Unit 2: Hardware & IT Fundamentals — 15 hours

Students will explore the hardware used in standard PCs, Servers and Network equipment

- Identify the names, purpose, and characteristics of key components and system modules common to a PC.
- Identify the names and performance characteristics of common ports, associated connectors, cabling and the peripherals that use them.
- Demonstrate basic procedures for upgrading or replacing common field replaceable modules including CPU, RAM, drives and add-on cards.
- Demonstrate the procedures for installing/replacing a new device including loading and configuring device drivers.
- Networks configurations

Standards Alignments:

CCSS: LS 11-12.1, LS 11-12.2; **RSIT** 11-12.2, 11-12.7; **RLST** 11-12.2, 11-12.4, 11-12.7, 11-12.10; **WS** 11-12.1, 11-12.2, 11-12.4, 11-12.5, 11-12.6, 11-12.7, 11-12.8; **WHSST** 11-12.2, 11-12.5, 11-12.6, 11-12.7, 11-12.8;
NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8

Key Assignments	CTE Anchor Standards	CTE Pathway Standards

✓ **Key Assignment:** Students will compare and contrast the characteristics of popular CPU architecture, RAM form factor and chart their relationship to various operating system bit structures, while gathering relevant information from multiple authoritative print and digital sources, using advanced searches effectively to identify established patterns, and predict emerging technologies. Students will log their completed work and issue resolution in their interactive notebook. **Assessment:** rubric, observation, peer and self-assessment, written ticket report, notebook review	2.4, 2.5, 10.0	B 1.0, B 2.0, B 3.0, B 4.0, B 7.0
✓ **Key Assignment:** Student teams will take part in hand-on labs to demonstrate that they understand how to assemble the components of a PC, re-image a new operating system, install and update software. Students will build, install software and demonstrate a working PC that is connected properly to a network. They will log their procedures and self-reflection in their interactive notebooks. **Assessment:** quiz, test, observation, peer and self-assessment, public presentation/demo of working system	2.4, 2.5, 4.5, 5.0, 10.0	B 1.0, B 2.0, B 3.0, B 4.0, B 7.0, B 9.0
✓ **Key Assignment:** In teams of 2-3, students will reimage a PC system and install service packs and updates to maintain device drivers, and system security. Upon completion they will install, configure and share the PC on the student class network. Teams will quality check each other's PC and complete a checklist verifying that all components are working and/or will suggest corrective action in a brief written statement. Those teams who do not have a working systems will brainstorm with those teams who possess a functioning system to submit to correct their errors and production and functioning PC. **Assessment:** test, observation, peer and self-assessment, written report, gallery walk, public presentation/demo of working system	2.4, 2.5, 4.5, 5.0, 10.0	B 1.0, B 2.0, B 3.0, B 4.0, B 7.0, B 9.0

Unit 3: AC/DC Electronic Fundamentals — 60 hours

Students will explore the Fundamentals of Electronics, the basic principles and hands-on skills of electronics, such as voltage, current and resistance/reactance relationships in AC and DC circuits; theory of operation and industrial applications of transistors and integrated circuits, as well as learn to use test and measurement equipment (voltmeters, oscilloscopes, in-line and clamp-on ammeters, etc.).

- Electronics 101
- Electricity and Magnetism - How are waves used to transfer energy and to send and store information?

- Voltage, current and resistance, signals, capacitors and AC circuits, inductors and transformers, diodes and diode circuits, impedance and reactance
- Basic transistor circuits, amplifier building blocks, negative feedback, typical transistor circuits, field-effect transistors, FET linear circuits, JFETs, FET switches, Power MOSFETs, MOSFETs in linear applications
- Introduction to op-amps, basic op-amp circuits, typical op-amp circuits, feedback , differential, and instrumentation amplifiers
- Passive and active-filter circuits
- Oscillators and timers
- Low-noise techniques

Standards Alignments:

CCSS: LS 11-12.1, LS 11-12.2; **RSIT** 11-12.7; **RLST** 11-12.4, 11-12.7, 11-12.10; **WS** 11-12.2, 11-12.4, 11-12.6; **WHSST** 11-12.2, 11-12.5, 11-12.6; **A-CED** 1, 2, 3, 4

NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **PS** 2.A, 3.A, 3.B, 3.C, 3.D, 4.A, 4.B, 4.C; **ETS** 1.A, 1.B, 1.C, 2.0, 2.A, 2.B; **CC** 2, 3, 4, 5, 6

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Lab-Electricity and Magnetism:** Students will demonstrate the ability to describe an analogy between water flowing through pipes and current flowing through circuits. Students will describe the characteristics of simple series and parallel circuits in terms of voltage, current, and resistance. The student will demonstrate the ability to describe the causes of magnetism, the interaction of magnets, and electromagnetic effects. Students will conduct lab experiments and document their findings in their interactive notebooks. **Assessment:** rubric, quiz, test, recitation and memorization competence, peer and self-assessment, written report	4.0, 5.0, 10.0	B 1.0, B 2.0, B 3.0, B 4.0
✓ **Lab-Electricity and Magnetism:** Students will build and test AC/DC circuits, demonstrating series and parallel implementations on breadboards and PCBs. Students will maintain notes in their interactive logbook and document their understanding and demonstrate their ability to identify kinds of electric charges, analyze interactions between two charged objects, and describe electric fields. Students will also draw/label series and parallel circuits in their interactive notebook. **Assessment:** rubric, quiz, test	4.0, 5.0, 10.0	B 2.0, B 3.0, B 4.0, B 5.0
✓ **Lab-Electricity and Magnetism:** Students will work in collaborative teams to build a power amplifier circuit including an H-Bridge to drive motors. They will submit a working circuit and written report which describes their process for the build, a labeled illustration and journal entry reflecting on the process.	4.0, 5.0, 10.0	B 2.0, B 3.0, B 4.0, B 5.0

Assessment: quiz, test, observation, peer and self-assessment, written report		
✓ **Key Assignment:** Students will build differential amplifier circuits including driver for servo control to servo-motor model. They will submit a working circuit and written report. **Assessment:** quiz, test, observation, peer and self-assessment, written report	4.0, 5.0, 10.0	B 2.0, B 3.0, B 4.0, B 5.0
✓ Students will demonstrate an understanding of test equipment, and show through a hands on demonstration they understand the use of DMMs, oscilloscopes, and other test equipment. Students will show competency through hands on demo to instructor and written quiz and tests. **Assessment:** quiz, test, observation, peer and self-assessment, hands on demonstration	4.0, 5.0, 10.0	B 2.0, B 3.0, B 4.0, B 5.0, B 7.0
✓ **Lab-Electricity and Magnetism:** The student will demonstrate the ability to describe the causes of magnetism, the interaction of magnets, and electromagnetic effects. Students will build an electromagnet and compete to see whose magnet can lift the largest weight. **Assessment:** rubric, quiz, test, recitation and memorization competence, peer and self-assessment, written report	4.0, 5.0, 10.0	B 1.0, B 2.0, B 3.0, B 4.0
✓ **Lab-Electricity and Magnetism:** Students will individually create, secure, label and draw wave behavior/characteristics including reflection, refraction, diffraction, interference, and the Doppler Effect. In teams, students will reinforce their scientific knowledge about waves and work collaboratively to demonstrate wave theory using a Rubens Tube. Student teams will demonstrate their project implementation on the Rubens Tube to the class and/or public audience and identify their procedural steps used to build it; discuss how they solved any problems they encountered along the way, and describe the scientific principles associated with their Rubens Tube. Peers in the audience will complete rubrics to provide feedback. **Assessment:** rubric, quiz, test, recitation and memorization competence, entry/exit ticket, observation, peer and self-assessment, written report, gallery walk, public presentation, portfolio check	2.4, 2.5, 4.0, 5.0, 10.0	B 1.0, B 2.0, B 3.0, B 4.0, B 11.0

Unit 4: Digital Electronic Fundamentals — 60 hours

Students will explore the fundamentals of digital electronics, the basic principles of digital logic, Boolean and binary systems, combinatorial logic, as well as learn to use test and measurement equipment (logic probes, logic analyzers, protocol testers, signal generators, etc.).

- Basic logic concepts, digital integrated circuits, combinational logic, sequential logic, typical digital circuits,
- CMOS and TTL logic interfacing, probing digital signals, comparators, optoelectronics emitters and detectors, optocouplers and relays, fiber-optic digital links, digital signals and long wires, driving cables
- Digital meets analog

- Digital-to-analog converters, analog-to-digital converters, phase-locked loops, pseudorandom bit sequences and noise generation
- Computers, controllers, and data links
- Intro to programmable logic devices
- Logic interfacing

Standards Alignments:
CCSS: LS 11-12.1, LS 11-12.2; **RSIT** 11-12.7; **RLST** 11-12.4, 11-12.7, 11-12.10; **WS** 11-12.2, 11-12.4, 11-12.6; **WHSST** 11-12.2, 11-12.5, 11-12.6; **A-CED** 1, 2, 3, 4
NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **PS** 2.A, 3.A, 3.B, 3.C, 3.D, 4.C; **ETS** 1.A, 1.B, 1.C; **CC** 2, 3, 4, 6

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Students will demonstrate the ability to apply the concepts of digital and Boolean logic in analyzing digital circuits. Students will convert and apply decimal, binary and hexadecimal expressions using basic arithmetic functions, exponent relations, or algebraic fundamentals, complete labs and worksheets **Assessment:** rubric, observation, peer and self- assessment, quiz, tests	2.4, 2.5, 4.0, 5.0, 10.0	B 2.0, B 6.0, B 8.0, B 11.0
✓ **Key Assignment:** Students will work in teams to build logic circuits to emulate counters and adder logic. Students will record all steps in their interactive notebook, incorporate pictures of their circuits with annotated notes, hyperlink relevant websites and complete study guides in preparation for unit quiz/test. **Assessment:** rubric, peer review, graded written reports, instructor observation and unit quiz	2.4, 2.5, 4.0, 5.0, 10.0	B 2.0, B 6.0, B 8.0, B 11.0
✓ **Key Assignment:** Students will build logic circuits to implement state machines logic. Students will record all steps in their interactive notebook, incorporate pictures of their lab work with annotated notes, hyperlink relevant websites and complete study guides in preparation for unit quiz/test. **Assessment:** rubric, peer review, graded written reports, instructor observation and unit quiz	2.4, 2.5, 4.0, 5.0, 10.0	B 2.0, B 6.0, B 8.0, B 11.0

Unit 5: Programing, Coding and Hardware Applications — 75 hours

Students will explore C++ and Python programing languages, coding methods, and have an introduction to microprocessors & microcontrollers.

- **CPA C++ Programing Essentials and programing the Arduino Microcontroller:** The Arduino is a microcontroller in which C++ code is implemented on hardware. Students will learn how to configure hardware and software, develop their own sketches, work with built-in and custom Arduino libraries, and explore the Internet of Things.
    - Basics of programming in the C++ programming language

- Fundamental concepts and techniques used in object-oriented programming
- Help prepare students for the CPA–C++ Certified Associate Programmer certification exam.

- **Python Programing and the Raspberry Pi Microcomputer:**
  - Learn an open source software Python language
  - Develop scripting tasks to solve engineering tasks
  - Create incentive programs and fun coding design projects
  - Control hardware using the Python programing language on the Raspberry Pi microcomputer

Standards Alignments:

CCSS: LS 11-12.1, LS 11-12.2; **RSIT** 11-12.7; **RLST** 11-12.4, 11-12.7, 11-12.10; **WS** 11-12.2, 11-12.4, 11-12.6; **WHSST** 11-12.2, 11-12.5, 11-12.6; **A-CED** 1, 2, 3, 4

NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **ETS** 1.A, 1.B, 1.C

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Students will work individually and in teams to integrate knowledge of basic programing constructs, including: the use of expressions, variables, conditionals, loops, character and string manipulation, functions, objects and standard input/output to develop code. This will include programs that interact with Websites, servers and local hardware. Assignments will include code that shows that the student understand the basic building blocks of the language. Coding projects will be evaluated as individual lab assignments, as well as more encompassing team projects. Students will demonstrate working code and present their code development process. During this unit, students will turn in daily lab assignments, demonstrating their understanding of the coding assignment. **Assessment:** rubric, observation, peer and self- assessment	2.7, 4.2, 5.1, 5.2, 5.7, 5.8, 5.9, 5.11	B 1.0, B 2.0, B 6.0, B 8.0, B 11.0
✓ **Key Assignment:** In teams of 2-3, students will build on their coding experience and deliver C++ code running on an Arduino microcontroller. The team delivery will be an Arduino hardware implementation that receives a physical or electronic sensor inputs, process the inputs with the microcontroller, and then pass either a physical or electronic control signal to the next team, which will control motors, actuators, servos or other electromechanical device. This culminates in a whole class sequential collaborative event where each team's hardware implementation feeds subsequent hardware implementations. **Assessment:** rubric, observation, peer and self- assessment, written report,public presentation	1.0, 2.1, 2.5, 2.7, 4.1, 4.2, 4.3, 5,1, 5.2, 5.4, 5.7, 5.8, 5.9,5.11 6.3, 6.6, 9.2, 9.7	B 1.0, B 2.0, B 6.0, B 8.0, B 11.0

✓ **Key Assignment:** Students individually and in teams will develop Python scripts to control and manage electronic and mechanical systems. Students will produce Python scripts with documentation comments, and through the submission of code that will demonstrates working examples of hardware interactions. Students will peer edit code and provide feedback for revision. **Assessment:** rubric, grading form sheet, observation, peer and self- assessment, instructor graded assignments	1.0, 2.1, 2.5, 2.6, 2.7 4.1, 4.2, 4.3, 5.1, 5.2, 5.4, 5.7, 5.8, 5.9. 5.11 6.3, 6.6, 8.2, 8.4, 8.7, 8.8, 9.2, 9.7, 10.1, 10.5	B 1.0, B 2.0, B 6.0, B 8.0, B 11.0

Unit 6: Programming Programmable Logic Controller — 45 hours

Students will explore and demonstrate their understanding of and their ability to integrate the elements of process control. Students are challenged to design and build an automated system. Given specific economic, physical space, and component parameters students are challenged to design, install, and test an efficient automated systems using a PLC.

- PLC programming
- Ladder logic
- Control systems include two-step, continuous, proportional, integral, and PID
- Open and closed loop system design and implementation
- Implement capstone projects with automated closed-loop control circuits

Standards Alignments:

CCSS: LS 11-12.1, LS 11-12.2; **RSIT** 11-12.7; **RLST** 11-12.4, 11-12.7, 11-12.10; **WS** 11-12.2, 11-12.4, 11-12.6; **WHSST** 11-12.2, 11-12.5, 11-12.6; **A-CED** 1, 2, 3, 4

NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **ETS** 1.A, 1.B, 1.C

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Students design and functionally simulate several automated closed-loop control systems. They produce a written report of the different tradeoffs of the systems. Students will build a logic control loop implemented in the PLC that includes an emergency stop, inputs from limit switches, and at least 2 other physical sensors, that will control the movement of at least 1 motor. **Assessment:** rubric, entry/exit ticket, written report, public presentation	2.4, 2.5, 4.0, 5.0, 10.0	B 1.0, B 2.0, B 6.0, B 8.0, B 11.0
✓ **Key Assignment:** Student teams are challenged to design and code a PLC implementation to control an automated fill level water system. Students first study a process description to understand what the system should be able to do within the parameters established by the assignment. Students then plan, install, and run the system. Students provide electrical and	2.4, 2.5, 4.0, 5.0, 10.0	B 1.0, B 2.0, B 6.0, B 8.0, B 11.0

mechanical circuit diagrams of their projects. Once electrical and mechanical components are built and tested, students automate the system using PLC controllers. Automation includes measurement of pressure and flow using electronic sensors, pump control, and controlling fill level. Students are challenged to demonstrate fill level control using a pneumatic actuator, two-step controller, continuous controller, proportional controller, integral controller, and proportional-integral controller. Deliverables are a written report, slide presentation, schematics and source code for the PLC. **Assessment:** rubric, peer and self-assessment, written report, public presentation, hardware demo, interactive notebook review		
✓ **Key Assignment:** Students teams will design and code a PLC implementation to control an automated assembly line component sorting system. Students first study a process description to understand what the system should be able to do within the parameters established by the assignment. Students then plan, install, and commission the system. Students provide electrical and mechanical circuit diagrams of their projects. Once electrical and mechanical components are built and tested, students automate the system using PLC controllers. Automation includes limit switches, electronic sensors, machine vision. Students are challenged to demonstrate fill level control using a pneumatic actuator, two-step controller, continuous controller, proportional controller, integral controller, and proportional-integral controller. Deliverables are a written report, slide presentation, schematics, entries into their interactive notebook and source code for the PLC. **Assessment:** rubric, peer/self-assessment, written report, public presentation, hardware demo, interactive notebook review	2.4, 2.5, 4.0, 5.0, 10.0	B 1.0, B 2.0, B 6.0, B 8.0, B 11.0

Unit 7: Programmable Logic Devices — 30 hours

Students will explore programmable logic with the Xilinx Pynq Programmable FPGA: PYNQ uses a new open-source framework that enables embedded programmers to exploit the capabilities of Xilinx Zynq All Programmable SoCs (APSoCs) without having to design programmable logic circuits. Instead, the APSoC is programmed using Python and the code is developed and tested directly on the PYNQ-Z1. The programmable logic circuits are imported as hardware libraries and programmed through their APIs in essentially the same way that the software libraries are imported and programmed.

- Web server hosting the Jupyter Notebooks design environment
- Learn the IPython kernel and packages
- Computer vision
- Industrial control
- The Internet of things (IoT)
- Encryption
- Embedded computing acceleration

- Implement code to run on Linux
- Base hardware library and API for the FPGA
- Drones
- Real-time processing

Standards Alignments:

CCSS: LS 11-12.1, 11-12.2; **RSIT** 11-12.7; **RLST** 11-12.4, 11-12.7, 11-12.10; **WS** 11-12.2, 11-12.4, 11-12.6; **WHSST** 11-12.2, 11-12.5, 11-12.6; **A-CED** 1, 2, 3, 4

NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **ETS** 1.A, 1.B, 1.C

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Similar to the programming assignments, students will learn and execute a number of labs designed to teach VHDL and digital logic. Assignments will be implemented on Xilinx programmable logic boards (CPLD and PINQ). Students will turn in completed labs and lab reports. The labs are implemented on the hardware CPLD and PINQ boards, and students will show working results that interface to a hardware test system. **Assessment:** quiz, peer and self-assessment, hardware demonstrations, portfolio check	2.4, 2.5, 4.0, 5.0, 10.0	B 1.0, B 2.0, B 6.0, B 8.0, B 11.0
✓ **Key Assignment:** Students will re-implement a PLC system using Programmable logic FPGA hardware. Deliverables will be a hardware design that is plug in compatible with PLC labs. Students will complete labs and lab reports in their interactive lab books. The labs are implemented on the hardware CPLD and PINQ boards, and students will show working results that interface to a hardware test system. **Assessment:** peer and self-assessment, written report, demo in hardware implementation, public presentation, portfolio check	2.4, 2.5, 4.0, 5.0, 10.0	B 1.0, B 2.0, B 6.0, B 8.0, B 11.0

Unit 8: Linux, Cygwin, Command Line Scripting — 15 hours

Students will explore command line scripting and command line tools, learning both Windows and Linux command line features.

- Demonstrate how to use the command-line interface including UNC paths and proper syntax.
- Use batch programming to automate system administrative tasks.
- Use VB.Net to create custom programs and utilities for system administration.
- Demonstrate how to apply Windows syntax to invoke Cmdlets and scripts

Standards Alignments:

CCSS: LS 11-12.1, 11-12.2; **RSIT** 11-12.7; **RLST** 11-12.4, 11-12.7, 11-12.10; **WHSST** 11-12.2, 11-12.5, 11-12.6; **A-CED** 1, 2, 3, 4

NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **ETS** 1.A, 1.B, 1.C

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Students will complete a large compilation of command line labs designed to test their knowledge. Students will work in teams and use a checklist to complete all labs. **Assessment:** quiz, test, observation, peer and self- assessment	2.4, 2.5, 4.0, 5.0, 10.0	B 1.0, B 2.0, B 6.0, B 8.0, B 11.0

Unit 9: Mechanical 3D design and Mechanical Drawing Standards 45 hours

Students will gain an understanding of mechanical design and mechanical drawing standards and processes for the mechanical, mechatronic, and manufacturing industries. Introduction to engineering graphics, including the following: orthographic projection, auxiliary views, isometric views, dimensioning, tolerancing, drawing standards, working standards, and solids modeling. Students will also learn principles and connections of design for sustainable engineering and manufacturing.

Standards Alignments:

CCSS: LS 11-12.1, 11-12.2; **RSIT** 11-12.7; **RLST** 11-12.4, 11-12.7, 11-12.10; **WHSST** 11-12.2, 11-12.5, 11-12.6; **A-CED** 1, 2, 3, 4; **A-REI** 1, 2, 3, 4, 5 ,6 ,7; **F-IF** 1, 7a, 7b, 7c, 7d, 7e; **F-TF** 1, 2, 5, 6; **G-CO** 12;
NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8

Key Assignments	Anchor Standards	Pathway Standards
✓ **Key Assignment:** Given a 3D object, students will work individually to accurately and thoroughly measure the object, sketch from multiple views and enter all measurements into a 3D CAD modeling tool such as Solidworks to produce a schematic. Students will use these CAD drawings to replicate their object using a 3D printer. **Assessment:** sketch, interactive notebook, observation, calculations check, visual inspection, self reflection, gallery walk	4.0, 5.0, 10.0, 11.0	B 1.0, B 6.0, B 7.0, B 8.0, B 9.0, B 10.0, B 11.0
✓ **Key Assignment:** Students will work individually to design and fabricate a small 3D logo or nameplate (Extrude Boss/Base) of their choice. Students will produce flat plane sketches then enter all measurements into a 3D CAD modeling tool such as Solidworks to produce a schematic. Students will use these CAD drawings to replicate their logo/nameplate using a	4.0, 5.0, 10.0, 11.0	B 1.0, B 6.0, B 7.0, B 8.0, B 9.0, B 10.0, B 11.0

3D printer. Students will be encouraged to consider solid design and aesthetic principles when initially planning their project. **Assessment:** sketch, interactive notebook, observation, calculations check, visual inspection, self reflection, gallery walk		
✓ **Lab:**Teams will work collaboratively to create a cascading Rube Goldberg contraption. Each team will produce (from sketch to fabrication) one component of the final contraption. Teams will work together to make sure that each component triggers the next segment via a physical object or electronic symbol. See an example of Rube Goldberg Machines. **Assessment:** sketch, interactive notebook, observation, calculations check, visual inspection, self reflection,working model	4.0, 5.0, 10.0, 11.0	B 1.0, B 6.0, B 7.0, B 8.0, B 9.0, B 10.0, B 11.0

Unit 10: Robotic Theory and Application — 75 hours

Students will explore Industrial Robots and applications

- Learn how motors work
- Learn how to debug a motor electrical control system
- Train on a Fanuc industrial Robot and qualify to earn an industry certification
- Learn to program and control industrial robots and robot simulators

Standards Alignments:

CCSS: LS 11-12.1, LS 11-12.2; **RSIT** 11-12.7; **RLST** 11-12.4, 11-12.7, 11-12.10; **WHSST** 11-12.2, 11-12.5, 11-12.6; **A-CED** 1, 2, 3, 4; **A-REI** 1, 2, 3, 4, 5 ,6 ,7; **F-IF** 1, 7a, 7b, 7c, 7d, 7e; **F-TF** 1, 2, 5, 6; **G-CO** 12

NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **PS** 2.A, 3.A, 3.B, 3.C, 3.D, 4.A, 4.B, 4.C; **ETS** 1.A, 1.B, 1.C, 2.0, 2.A, 2.B; **CC** 2, 3, 4, 5, 6

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Lab-Two-Dimensional Motion, and Gravity:** Students will work in pairs to build a mechanical system that utilizes gears, pulleys, counterweights and various other gravitational perceptions. They will draw conclusion in respect to how one can explain and predict interactions between objects and within systems of an object. They will demonstrate their mechanical systems to peers and instructor and explain all of the physics concepts at work in their project. Students will record observations, process and self reflection in their interactive notebook. Topics to include: • Newton's three laws of motion • Vector concepts and vector math • Projectile path using motion equations and vector components	1.0, 2.0, 5.0, 10.0, 11.0	B 1.0, B 3.0, B 4.0, B 5.1, B 5.2, B 5.3, B 5.4, B 5.5, B 6.0, B 11.0

• Uniform circular motion • Law of universal gravitation **Assessment:** rubric, quiz, test, observation, peer and self-assessment, written report, gallery walk, public presentation, interactive notebook check		
✓ **Lab-Energy and Momentum:** Students will determine how is energy transferred and conserved. Students will demonstrate the ability to apply the concepts of momentum, impulse, conservation, and system to describe and numerically solve simple collision and explosion problems. Using a small wheeled robot, students will calculate the needed motive power needed for the drive motors to navigate an obstacle course, as they consider factors like momentum, friction, and torque. They will demonstrate their mechanical systems to peers and instructor and explain all of the physics concepts at work in their project. Students will record observations, process and self reflection in their interactive notebook. Topics to include: • Explain the relationships between work and energy • Discuss how energy in a system is transferred from one form to another, or from one object to another, and use the conservation of energy to solve simple problems **Assessment:** rubric, quiz, test, recitation and memorization competence, entry/exit ticket, observation, peer and self-assessment, written report, gallery walk, public presentation, portfolio check	1.0, 2.0, 5.0, 10.0, 11.0	B 1.0, B 3.0, B 4.0, B 5.1, B 5.2, B 5.3, B 5.4, B 5.5, B 6.0, B 11.0
✓ **Key Assignment:** Students will program a 6-axis servo robotic to be able to pick up an object from point "A" and move it to point "B." Students will, through demonstration, show that they can follow safety protocols and properly program and run applications on the robots. **Assessment:** team project rubric, observation, peer and self- assessment, instructor graded assignments	1.0, 2.0, 5.0, 10.0, 11.0	B 1.0, B 3.0, B 4.0, B 6.0, B 10.0, B 11.0
✓ **Key Assignment:** Students will program and control a Fanuc Industrial Robot Trainer. Students will actively demonstrate that they can follow safety protocols and properly program and run applications on the robot. Team project will be graded on how efficient the robot motion and movement is to accomplish a series of lab challenges. Upon successful completion of this module students will have fulfilled the requirements for a Fanuc Robot Operator certificate. **Assessment:** team project rubric, observation, memorization competence, peer and self-assessment, instructor graded assignments	1.0, 2.0, 5.0, 10.0, 11.0	B 1.0, B 3.0, B 4.0, B 6.0, B 10.0, B 11.0

Unit 11: Pneumatics Systems 27 hours

Students will explore how to operate and install basic pneumatic systems, analyze performance, and design basic pneumatic circuits. Pneumatic power is a foundation of industry used in applications across fields like agriculture, pharmaceuticals, automation, and many more. Students will learn how to specify, select and connect basic pneumatics components, pneumatic hoses and fittings. Students will be exposed to industrial quality components and will be prepared for what they will encounter on the job. Students will use these components to study major topic areas such as: pneumatic power systems, basic pneumatic circuits, principles of pneumatic pressure and flow, and pneumatic speed control circuits.

- Introduction to pneumatics circuits
- Pneumatic power systems
- Single & double acting cylinder circuits
- Pneumatic: pressure, volume, flow & speed control
- Pneumatic speed control
- Calculating the force output of a cylinder under varying conditions and loads
- Project based learning including pneumatics

Standards Alignments:

CCSS: LS 11-12.1, LS 11-12.2; **RSIT** 11-12.7; **RLST** 11-12.4, 11-12.7, 11-12.10; **WHSST** 11-12.2, 11-12.5, 11-12.6; **A-CED** 1, 2, 3, 4;
NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **PS** 3.B, 3.C, 4.C; **ETS** 1.A, 1.B, 1.C; **CC** 2, 3, 4, 5

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Students design and functionally simulate several automated open and closed-loop pneumatic control systems. Students will produce a graphic organizer comparing/contrasting passive, active and feedback control and produce a written report comparing both the open and close-loop system. **Assessment:** rubric, entry/exit ticket, written report, public presentation.	1.0, 2.0, 5.0, 10.0, 11.0	B 1.0, B 4.0, B 5.0, B 7.0, B 8.0, B 9.0, B 10.0, B 11.0

Unit 12: Current Events in Mechatronics, Industry and Engineering — 15 hours

Students will explore industrial automation, engineering and mechatronics topics. Students will research and produce mechatronic current events presentations. The purpose of this unit is to focus student learning on newsworthy current events, but also on written and oral presentation skills.

Standards Alignments:

CCSS: LS 11-12.1, 11-12.2; **RSIT** 11-12.2, 11-12.7; **RLST** 11-12.2, 11-12.4, 11-12.7, 11-12.10; **WS** 11-12.1, 11-12.2, 11-12.4, 11-12.5, 11-12.6, 11-12.7, 11-12.8; **WHSST** 11-12.2, 11-12.5, 11-12.6, 11-12.7, 11-12.8;
NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Students will produce an individual bi-weekly slide presentation on a current event topic related to current technological and engineering trends following a rubric	1.0, 2.0, 5.0, 10.0, 11.0	B 1.0, B 6.0, B 8.0, B 9.0, B 10.0, B 11.0

of required components. Students will have an opportunity to present 2-3 times per semester. Each presentation will be evaluated and critiqued by both student peers and the instructor. **Assessment:** rubric, observation, peer and self- assessment, public critiqued oral presentation		

Unit 13: Mathematics for Technology — 15 hours

Students will learn and apply the math needed in the field of Mechatronics.

- Proper technical notations when calculating rates and capacities of specific computer components and technologies
- Convert and apply decimal binary and hexadecimal expressions using basic arithmetic functions, exponent relations, or algebraic fundamentals
- Electronic formulas for series and parallel circuits
- Pneumatic formulas for pressure and force circuits
- Formulas for gear ratios, fulcrum, and other physics equations
- Formulas for wave propagation, signal transmission, and other electromagnetic equation

Standards Alignments:

CCSS: A-CED 1, 2, 3, 4; **A-REI** 1, 2, 3, 4, 5 ,6 ,7; **F-IF** 1, 7a, 7b, 7c, 7d, 7e; **F-TF** 1, 2, 5, 6; **G-CO** 12;
NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **PS** 2.A, 3.A, 3.B, 3.C, 3.D, 4.A, 4.B, 4.C; **ETS** 1.A, 1.B, 1.C, 2.0, 2.A, 2.B; **CC** 2, 3, 4, 5, 6

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Students will complete lab worksheets, convert decimal and binary to and from base 10 and base 2. Demonstrate the understanding of the relationship between Base 2 and Base 16. **Assessment:** worksheet, rubric, quiz, test, recitation and memorization competence, entry/exit ticket, observation, peer and self-assessment, written report, gallery walk, public presentation, portfolio	1.0, 2.0, 5.0, 10.0	B 1.0, B 2.0,
✓ **Key Assignment:** Students will show proficiency in math formulas, equations, and processes related to electricity and electronic circuits. **Assessment:** worksheet, rubric, quiz, test, recitation and memorization competence, observation, peer and self-assessment	1.0, 2.0, 5.0, 10.0	B 1.0, B 2.0, B 3.0
✓ **Key Assignment:** Students will show proficiency in math formulas, equations, and processes related to gear ratios, fulcrum, and motors. **Assessment:** worksheet, rubric, quiz, test, recitation and memorization competence, observation, peer and self-assessment	1.0, 2.0, 5.0, 10.0	B 1.0, B 2.0, B 3.0, B 5.0

✓ **Key Assignment:** Students will show proficiency in math formulas, equations, and processes related to industrial automation. Students will be access through quiz, test, and worksheets. **Assessment:** worksheet, rubric, quiz, test, recitation and memorization competence, observation, peer and self-assessment	1.0, 2.0, 5.0, 10.0	B 1.0, B 2.0, B 4.0

Unit 14: Career Readiness & Professionalism — 27 hours

Students will develop personal and professional skills in the classroom that will transfer to the workplace.

- Time management and organization
- Interpersonal skills
- Work with a variety of technology
- Creative thinking and problem solving
- Job search skills including: resume, job applications and effective interview skills
- Communication Skills
- Interpersonal Skills
- Employability Skills

Standards Alignments:

CCSS: LS 11-12.1, LS 11-12.2; **RSIT** 11-12.2, 11-12.7; **RLST** 11-12.2, 11-12.4, 11-12.7, 11-12.10; **WS** 11-12.1, 11-12.2, 11-12.4, 11-12.5, 11-12.6, 11-12.7, 11-12.8; **WHSST** 11-12.2, 11-12.5, 11-12.6, 11-12.7, 11-12.8; **A-CED** 1, 2, 3, 4; **A-REI** 1, 2, 3, 4, 5 ,6 ,7; **F-IF** 1, 7a, 7b, 7c, 7d, 7e; **F-TF** 1, 2, 5, 6; **G-CO** 12; **NGSS: SEP** 1, 2, 3, 4, 5, 6, 7, 8; **PS** 2.A, 3.A, 3.B, 3.C, 3.D, 4.A, 4.B, 4.C; **ETS** 1.A, 1.B, 1.C, 2.0, 2.A, 2.B; **CC** 2, 3, 4, 5, 6

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Students will participate in mock interviews with industry professionals, peers and instructors to increase their communication, interpersonal and employability skill-set. **Assessment:** rubric, observation of role playing, peer and self- assessment	2.0, 3.0, 7.0, 8.0, 9.0	B 1.0, B 2.0, B 7.0, B 8.0, B 11.0
✓ **Key Assignment:** Students will prepare a portfolio including a cover letter and resume through workshop, self and peer editing, teacher instruction and demonstration. **Assessment:** rubric, observation, peer and self- assessment	2.0, 3.0, 7.0, 8.0, 9.0	B 1.0, B 2.0, B 7.0, B 8.0, B 11.0
✓ **Key Assignment:** Students will create and organize a portfolio consisting of classroom material, projects and interactive notebook entries to demonstrate their acquired skills to improve their job performance. **Assessment:** rubric, grading form sheet, interactive notebook, student documentation	2.0, 3.0, 7.0, 8.0, 9.0	B 1.0, B 2.0, B 7.0, B 8.0, B 11.0

✓ Students will analyze a security issue whose ethics are questionable, then form an opinion and through a verbal and slide presentation, defend their position. Students must respond thoughtfully to diverse perspectives, synthesize comments, claims and evidence made on all sides of the issue. Students will be able to resolve contradictions when possible, and determine what additional information or research is required to deepen the investigation. **Assessment:** peer and self-assessment, slide presentation	2.0, 3.0, 7.0, 8.0, 9.0	B 1.0, B 2.0, B 7.0, B 8.0, B 11.0

Instructional Materials

Textbooks:	Electronic Media/Supplemental Print Materials/Online Resources:
Programming Arduino 2nd edition Simon Monk – McGraw Hill © 2016 ISBN: 978-1-25-964163-3 ***Programming the Raspberry Pi*** 2nd edition Simon Monk – McGraw Hill © 2016 ISBN: 978-1-25-958740-5 ***Physics*** Raymond A. Serway, Jerry S. Faughn – Holt, Rinehart and Winston © 2006 ISBN: ISBN 0-03-073548-3	**Supplemental Print Materials:** ***Programming C++*** Bjarne Stroustrup – Addison-Wesley © 2009 ISBN: 978-0-321-54372-1 ***Automate The Boring Stuff With Python*** 5th edition Al Sweigart – No Starch Press © 2016 ISBN: 13-978-1-59327-599-0 ***Electronic Projects*** 2nd edition Walt Bregach – Tab Books © 1983 ISBN: 0-8306-1544-9 **Online Resources:** ● **Cousera** (www.coursera.org/) ● **Udemy** (www.udemy.com/) ● **Instructables** (www.instructables.com/classes/) Class units

Standards Assessed in this Course

CTE Anchor Standards:

1.0 Academics: Academics standards are aligned to pathways; see below.

2.0 Communications: Acquire and use accurately sector terminology and protocols at the career and college readiness level for communicating effectively in oral, written, and multimedia formats.

3.0 Career Planning and Management: Integrate multiple sources of career information from diverse formats to make informed career decisions, solve problems, and manage personal career plans.

4.0 Technology: Use existing and emerging technology, to investigate, research, and produce products and services, including new information, as required in the sector workplace environment.

5.0 Problem Solving and Critical Thinking: Conduct short, as well as more sustained, research to create alternative solutions to answer a question or solve a problem unique to the sector using critical and creative thinking, logical reasoning, analysis, inquiry, and problem-solving techniques.

6.0 Health and Safety: Demonstrate health and safety procedures, regulations, and personal health practices and determine the meaning of symbols, key terms, and domain-specific words and phrases as related to the sector workplace environment.

7.0 Responsibility and Flexibility: Initiate, and participate in, a range of collaborations demonstrating behaviors that reflect personal and professional responsibility, flexibility, and respect in the sector workplace environment and community settings.

8.0 Ethics and Legal Responsibilities: Practice professional, ethical, and legal behavior, responding thoughtfully to diverse perspectives and resolving contradictions when possible, consistent with applicable laws, regulations, and organizational norms.

9.0 Leadership and Teamwork: Work with peers to promote divergent and creative perspectives, effective leadership, group dynamics, team and individual decision making, benefits of workforce diversity, and conflict resolution.

10.0 Technical Knowledge and Skills: Apply essential technical knowledge and skills common to all pathways in the sector following procedures when carrying out experiments or performing technical tasks.

Engineering & Architecture Sector — Engineering Technology CTE pathway Standards:

B1.0 Communicate and interpret information clearly in industry-standard visual and written formats.

B1.1 Explain the classification and use of various components, symbols, abbreviations, and media common to technical drawings.

B1.2 Describe the current industry standards for illustration and layout.

B1.3 Draw flat layouts of a variety of objects by using the correct drafting tools, techniques, and media.

B1.4 Organize and complete an assembly drawing using information collected from detailed drawings.

B1.5 Create reports and data sheets for writing specifications.

B2.0 Demonstrate the sketching process used in concept development.

B2.1 Understand the process of producing proportional two- and three-dimensional sketches and designs.

B2.2 Apply sketching techniques to a variety of architectural and engineering models.

B2.3 Present conceptual ideas, analysis, and design concepts using freehand graphic communication techniques.

B3.0 Identify the fundamentals of the theory, measurement, control, and applications of electrical energy, including alternating and direct currents.

B3.1 Understand the characteristics of alternating current (AC) and how it is generated; the characteristics of the sine wave; and of AC, tuned, and resonant circuits; and the nature of the frequency spectrum.

B3.2 Analyze relationships between voltage, current, resistance, and power related to direct current (DC) circuits.

B3.3 Calculate, construct, measure, and interpret both AC and DC circuits.

B3.4 Understand how electrical control and protection devices are used in electrical systems.
B3.5 Calculate loads, currents, and circuit-operating parameters.
B3.6 Classify and use various electrical components, symbols, abbreviations, media, and standards of electrical drawings.
B3.7 Analyze, repair, or measure electrical and electronic systems, circuits, or components using appropriate electronic instruments.
B3.8 Predict the effects of circuit conditions on the basis of measurements and calculations of voltage, current, resistance, and power.

B4.0 Understand the concepts of physics that are fundamental to engineering technology.

B4.1 Describe Newton's laws and how they affect and define the movement of objects.
B4.2 Explain how the laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.
B4.3 Compare the effects and applications of heat transfer and thermal dynamic processes.
B4.4 Explore the fundamentals and properties of waveforms and how waveforms may be used to carry energy.
B4.5 Analyze how electric and magnetic phenomena are related and know common practical applications.

B5.0 Understand how the principles of force, work, rate, power, energy, and resistance relate to mechanical, electrical, fluid, and thermal engineering systems.

B5.1 Differentiate between scalars and vectors.
B5.2 Solve problems by using the concept of vectoring to predict resultants.
B5.3 Compare and explore the six simple machines and their applications.
B5.4 Evaluate how energy is transferred and predict the effects of resistance in mechanical, electrical, fluid, and thermal systems.
B5.5 Formulate and solve problems by using the appropriate units applied in mechanical, electrical, fluid, and thermal engineering systems.

B6.0 Employ the design process to solve analysis and design problems.

B6.1 Understand the steps in the design process.
B6.2 Determine what information and principles are relevant to a problem and its analysis.
B6.3 Choose between alternate solutions in solving a problem and be able to justify the choices made in determining a solution.
B6.4 Translate word problems into mathematical statements when appropriate.
B6.5 Demonstrate the process of developing multiple details, within design constraints, into a single solution.
B6.6 Construct a prototype from plans and test it.
B6.7 Evaluate and redesign a prototype on the basis of collected test data.

B7.0 Understand industrial engineering processes, including the use of tools and equipment, methods of measurement, and quality assurance.

B7.1 Know the structure and processes of a quality assurance cycle.
B7.2 Describe the major manufacturing processes.
B7.3 Use tools, fasteners, and joining systems employed in selected engineering processes.
B7.4 Estimate and measure the size of objects in both Standard International and United States units.
B7.5 Apply appropriate geometric dimensioning and tolerancing (GD&T) practices.
B7.6 Calibrate precision measurement tools and instruments to measure objects.

B8.0 Understand fundamental control system design and develop systems that complete pre-programmed tasks.

B8.1 Identify the elements and processes necessary to develop a controlled system that performs a task.
B8.2 Demonstrate the use of sensors for data collection and process correction in controlled systems.
B8.3 Perform tests, collect data, analyze relationships, and display data in a simulated or modeled system using appropriate tools and technology.
B8.4 Program a computing device to control systems or process.
B8.5 Use motors, solenoids, and similar devices as output mechanisms in controlled systems.
B8.6 Assemble input, processing, and output devices to create controlled systems capable of accurately completing a preprogrammed task.

B9.0 Understand the fundamentals of systems and market influences on products as they are developed and released to production.

B9.1 Understand the process of product development.
B9.2 Understand decision matrices and the use of graphic tools in illustrating the development of a product and the processes involved.

B10.0 Design and construct a culminating project effectively using engineering technology.

B10.1 Use methods and techniques for employing all engineering technology equipment appropriately.
B10.2 Apply conventional engineering technology processes and procedures accurately, appropriately, and safely.
B10.3 Apply the concepts of engineering technology to the tools, equipment, projects, and procedures of the Engineering Technology Pathway.

B2.0 Understand the methods of creating both written and digital portfolios.

B11.1 Develop a binder or digital portfolio representative of student work for presentation.
B11.2 Give an effective oral presentation of a portfolio.

Common Core Language Standards:

Language Standards – LS – (Standard Area, Grade Level, Standard #)

LS 11-12.1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
LS 11-12.2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

Reading Standards for Informational Text – RSIT – (Standard Area, Grade Level, Standard #)

RSIT 11-12.2. Determine two or more central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to provide a complex analysis; provide an objective summary of the text.
RSIT 11-12.7. Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.

Reading Standards for Literacy in Science and Technical Subjects – RLST – (Standard Area, Grade Level, Standard #)

RLST 11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
RLST 11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
RLST 11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

RLST 11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades text complexity band independently and proficiently.

Writing Standards – WS – (Standard Area, Grade Level, Standard #)

WS 11-12.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

WS 11-12.2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.

WS 11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WS 11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WS 11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

WS 11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

WS 11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation including footnotes and endnotes.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects – WHSST

WHSST 11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHSST 11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHSST 11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

WHSST 11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

WHSST 11-12.8.	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
Algebra – A-CED – Creating Equations	
A-CED 1.	Create equations and inequalities in one variable including ones with absolute value and use them to solve problems in and out of context, including equations arising from linear functions.
A-CED 1.1	Judge the validity of an argument according to whether the properties of real numbers, exponents, and logarithms have been applied correctly at each step. (CA Standard Algebra II - 11.2)
A-CED 2.	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
A-CED 3.	Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.
A-CED 4.	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.
Algebra – A-REI – Reasoning with Equations and Inequalities	
A-REI 1.	Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.
A-REI 2.	Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.Solve equations and inequalities in one variable
A-REI 3.	Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.
A-REI 3.1	Solve equations and inequalities involving absolute value. (CA Standard Algebra I - 3.0 and CA Standard Algebra II - 1.0)
A-REI 4.	Solve quadratic equations in one variable.
A-REI 4.a.	Use the method of completing the square to transform any quadratic equation in x into an equation of the form (x - p)2 = q that has the same solutions. Derive the quadratic formula from this form.
A-REI 4.b.	Solve quadratic equations by inspection (e.g., for x2 = 49), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as a ± bi for real numbers a and b.
A-REI 5.	Prove that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.
A-REI 6.	Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

A-REI 7.	Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. For example, find the points of intersection between the line y = -3x and the circle x2 + y2 = 3.
Functions – F-IF – Interpreting Functions	
F-IF 1.	Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then f(x) denotes the output of f corresponding to the input x. The graph of f is the graph of the equation y = f(x).
F-IF 7.	Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
F-IF 7. a.	Graph linear and quadratic functions and show intercepts, maxima, and minima.
F-IF 7. b.	Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.
F-IF 7. c.	Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior.
F-IF 7. d.	(+) Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior.
F-IF 7. e.	Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.
Functions – F-TF – Trigonometric Functions	
F-TF 1.	Understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle.
F-TF 1.1	Understand the notion of angle and how to measure it, in both degrees and radians. Convert between degrees and radians. (CA Standard Trigonometry - 1.0)
F-TF 2.	Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle.
F-TF 5.	Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline.
F-TF 6.	(+) Understand that restricting a trigonometric function to a domain on which it is always increasing or always decreasing allows its inverse to be constructed.
F-TF 6.1	Know the definitions of the inverse trigonometric functions and graph the functions. (CA Standard Trigonometry - 8.0)
Geometry – G-CO – Congruence	
G-CO 12.	Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.

Next Generation Science Standards:

Scientific and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
		CC 2. Cause and effect: Mechanism and

SEP 1	Asking questions (for science) and defining problems (for engineering)	PS 4	Waves and Their Applications in technologies for Information Transfer		explanation
SEP 2	Developing and using models	PS 2.A	Forces and Motion	CC 3.	Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
SEP 3	Planning and carrying out investigations	PS 3.A	Definitions of Energy		
SEP 4	Analyzing and interpreting data	PS 3.B	Conservation of Energy and Energy Transfer		
SEP 5	Using mathematics and computational thinking	PS 3.C	Relationship Between Energy and Forces		
SEP 6	Constructing explanations (for science) and designing solutions (for engineering)	PS 3.D	Energy in Chemical Processes		
SEP 7	Engaging in argument from evidence	PS 4.A	Wave Properties		
SEP 8	Obtaining, evaluating, and communicating information	PS 4.B	Electromagnetic Radiation		
		PS 4.C	Information Technologies and Instrumentation	CC 4.	Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
		ETS 1.A	Defining and Delimiting Engineering Problems		
		ETS 1.B	Developing Possible Solutions		
		ETS 1.C	Optimizing the Design Solution		
		ETS 2.0	Links Among Engineering, Technology, Science, and Society		
		ETS 2.A	Interdependence of Science, Engineering, and Technology	CC 5.	Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
		ETS 2.B	Influence of Engineering, Technology, and Science on Society and the Natural World		
				CC 6.	Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.