OREGON DEPARTMENT OF EDUCATION

HIGHER EDUCATION COORDINATING COMMISSION

OREGON CAREER AND TECHNICAL EDUCATION STATEWIDE FRAMEWORKS

Engineering Technology Career Cluster

Resource Guide

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Statewide Framework for **Engineering Technology**

Well-designed career and technical education (CTE) programs help high school and college students make successful educational transitions and find employment in high-wage, high-skill, in-demand careers. **Oregon's State Plan for CTE: 2020–2024** lays out a comprehensive strategy for ensuring all Oregonians have equitable access to high-quality CTE programming. This entails designing instructional coursework that is sequenced within and across educational levels, grounded on rigorous academic knowledge and technical skills, and aligned with industry needs. It also requires building and sustaining quality relationships, experiences, and interactions among learners, educators, business partners, and community members.

OREGON'S VISION FOR CTE

Reimagine and transform learner experiences to enhance their future prospects, empower communities, and ensure equitable access to an inclusive, sustainable, innovation-based economy.

This document provides information and resources related to the ***Statewide Framework in the Engineering Technology Career Cluster,*** which falls within the Industrial and Engineering Systems career area. Engineering Technology is one of 17 Career Clusters used to organize and deliver CTE programming in Oregon. The cluster includes a range of careers that fall into three Focus Areas profiled in this document: (1) Electrical Systems, (2) Manufacturing Systems, and (3) Mechanical Systems.

Oregon's CTE state plan calls for the development of Statewide Frameworks to guide program design. The goal is to *improve instructional quality* by aligning technical skills to the needs of employers in high-wage, high-skill, in-demand careers; *promote equity* by ensuring that all learners have access to consistent, high-quality programming; *strengthen career pathways* by intentionally connecting secondary and postsecondary coursework that culminates in an industry-recognized credential or certificate, or associate or baccalaureate degree; and *expand student access to dual and concurrent enrollment credits* to reduce tuition costs and the time required to earn a postsecondary credential.

While secondary and postsecondary CTE providers have considerable flexibility in designing curriculum and assessments, state approval is required to qualify programs for federal and/or state funding. This includes aligning offerings with labor market needs; meeting state-defined criteria for size, scope, and quality; addressing Oregon's core elements of a Program of Study; and continuously improving CTE offerings through the use of the **High Quality CTE Program of Study Rubric.**

In Oregon, the CTE Program of Study is the cornerstone of CTE programming at the secondary and postsecondary levels. A CTE Program of Study is a progressive, nonduplicative sequence of courses, developed by a partnering secondary school district and postsecondary institution, to prepare students

to seamlessly transition across education levels and into the workforce. Coursework integrates rigorous academic knowledge with industry-validated employability and technical skills and culminates in the award of an industry-recognized credential or certificate or an associate or baccalaureate degree. High school students may also have options to earn credit that may be applied toward their postsecondary studies.

Within each Career Cluster, CTE Programs of Study may be offered at the Career Cluster or Focus Area level. Career Cluster-level Programs of Study offer students broad exposure to multiple careers in the field, along with cross-cutting skills valued by all industry employers. Focus Area-level Programs of Study offer students more occupationally specific training with a higher level of statewide content standardization.

The new Statewide CTE Frameworks provide updated Knowledge and Skill Statements to inform CTE program development. The updated skill statements incorporate: 1) employability skills commonly found in all jobs in all Career Clusters; 2) cross-cutting technical skills applicable to all jobs in a specific Career Cluster; and 3) Focus Area skills applicable to a specific occupation. Each skill statement includes an optional set of Suggested Performance Indicators, which are intended to help educators develop curriculum and assessments to teach specific skills.

Projected Labor Market Demand

Occupational projections published by the State of Oregon Employment Department indicate that while jobs in the Engineering Technology field will expand over the coming decade, a subset will experience significant demand. These occupational titles, their projected demand, and associated wage and educational expectations of entry-level employees are detailed in table 1.

Table 1. Occupational Employment Projections in Oregon, 2021–2031

Standard Occupational Classification (SOC)* code	Occupational title	Total job openings	Percent change	2022 median annual wage	Entry-level education
11-9041	**Architectural and Engineering Managers**	3,075	13.5%	$155,958	Bachelor's degree
17-2051	**Civil Engineers**	4,061	16.3%	$94,224	Bachelor's degree
17-2061	**Computer Hardware Engineers**	966	3.9%	$132,288	Bachelor's degree
17-2071	**Electrical Engineers**	2,329	18.9%	$103,750	Bachelor's degree
17-2072	**Electrical Engineers, Except Computer**	3,792	13.0%	$100,173	Bachelor's degree
17-2112	**Industrial Engineers**	3,806	20.7%	$102,918	Bachelor's degree
17-2141	**Mechanical Engineers**	2,660	13.6%	$99,008	Bachelor's degree

Standard Occupational Classification (SOC)* code	Occupational title	Total job openings	Percent change	2022 median annual wage	Entry-level education
17-2199	Engineers, All Other	2,532	14.0%	$100,776	Bachelor's degree
17-3011	Architectural and Civil Drafters	1,558	14.3%	$61,464	Postsecondary training (non-degree)
17-3019	Drafters, All Other	970	17.9%	$52,478	Postsecondary training (non-degree)
17-3022	Civil Engineering Technologists and Technicians	1,205	13.0%	$77,438	Associate's degree
17-3023	Electrical and Electronic Engineering Technologists and Technicians	2,605	10.7%	$62,650	Associate's degree
17-3026	Industrial Engineering Technologists and Technicians	–	–	$62,525	Associate's degree
17-3031	Surveying and Mapping Technicians	1,337	16.1%	$52,790	Bachelor's degree
17-3098	Calibration and Engineering Technologists and Technicians	1,115	11.4%	–	High school diploma or equivalent
49-2022	Telecommunications Equipment Installers and Repairers	1,638	-5.1%	$63,690	Postsecondary training (non-degree)
49-2098	Security and Fire Alarm Systems Installers	904	25.6%	$67,350	Postsecondary training (non-degree)

Note: Adapted from ***State of Oregon Employment Department: High-Wage, High-Demand, and High-Skill Occupations (Projections 2021-2031)***

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Among occupations that are considered high-wage and high-demand,[1] the largest occupational growth rate in Oregon is projected for Security and Fire Alarm Systems Installers, with opportunities expected to increase by nearly 26 percent between 2021 and 2031. This will lead to 904 projected job openings, including new and replacement workers. Relatively large numbers of job openings are anticipated in other high-wage and high-demand occupations that are associated with programs of study commonly found in Oregon high schools, community colleges, and 4-year colleges and universities. These include Civil Engineers with 4,061 projected openings, Industrial Engineers with 3,806 projected openings, and Electronic Engineers with 3,792 projected openings. Due to the complexity of the subject matter,

[1] High-wage occupations are those paying more than the all-industry median wage for a particular area. High-demand occupations are those having more than the statewide median number of total openings (growth plus replacement) for a particular area.

most entry-level careers require a bachelor's degree; however, several are projected to require a high school diploma or some postsecondary training. These include Surveying and Mapping Technicians, Architectural and Civil Drafters, Drafters generally, and Calibration and Engineering Technologists and Technicians.

Jobs in the Engineering Technology field typically pay relatively high wages. Median annual wages in 2022 for the two highest paying jobs were $155,958 for Architectural and Engineering Managers and $132,288 for Computer Hardware Engineers. While wages were somewhat lower in occupations requiring less than a bachelor's degree for entry-level employment, nearly all fields are projected to offer relatively high levels of compensation. Since career advancement in this Career Cluster will likely require both on-the-job training and advanced educational credentials and/or degrees, participation in a CTE Program of Study can offer students important insights into the types of careers that exist, and the education and training necessary to advance in their career.

Statewide Program of Study Framework

Programs of Study in the Engineering Technology Career Cluster prepare students for entry-level employment in a range of careers central to Oregon's economic base and/or to pursue advanced postsecondary educational studies. When proposing programming, secondary and postsecondary CTE providers collaborate to offer coursework leading to an industry recognized certificate and/or an associate or baccalaureate degree. High school students also may be offered the opportunity to earn college credit that may be applied towards their certificate or degree objective.

In winter 2023, the Oregon Department of Education launched a statewide effort to update and revalidate the skills and indicators used to define the Engineering Technology Career Cluster. An advisory group composed of eight Oregon employers and educators was seated to identify the skills desired of entry-level workers and high school graduates completing a CTE Program of Study in the field. Membership included eight employers representing individual firms or professional associations, and 17 district and community college educators. Based on their work, an updated set of skills and indicators was developed.

Following updates to the list, a statewide survey of district CTE Program of Study leaders and community college faculty was conducted. Individuals were asked to rate the importance of the employer-vetted Knowledge and Skill Statements and Suggested Performance Indicators. A total of 26 high school instructors and 11 community college faculty responded to one or more sections of the survey.

Community college faculty were asked to provide feedback on each Knowledge and Skill Statement and rate the importance of Suggested Performance Indicators using the following scale:

- **Critically important.** This skill would be expected of students entering a community college after having completed a CTE Program of Study at the high school level
- **Somewhat important.** This skill would be useful but not necessary for students entering a community college after having completed a CTE Program of Study at the high school level
- **Not important.** This skill would not be expected of students entering a community college after having completed a CTE Program of Study at the high school level (i.e., it will be taught at the college level)

High school CTE instructors were asked to rate the importance of high school graduates in related CTE Programs of Study mastering these skills upon completing their secondary CTE studies.

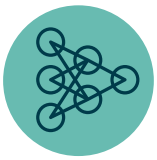
Feedback from survey respondents was analyzed to produce a core set of Knowledge and Skill Statements and Suggested Performance Indicators that secondary educators should consider when designing CTE programs and formulating their CTE program approval applications.

Knowledge and Skill Statements

Knowledge and Skill Statements describe the learning expectations of students in CTE programs. Ideally, skills marked as Foundational will be taught during a student's high school CTE Program of Study experience, with educators determining how and when instruction occurs. The CTE Statewide Framework for Hospitality, Tourism, and Recreation is organized around three levels of skills

Employability Knowledge and Skills – *Applicable to all Career Clusters—Foundational*

All learners are expected to master these basic skills to function in the workplace. These cross-cutting abilities, found in all jobs in all industries, encompass a broad range of communication, critical thinking, interpersonal, and organizational skills considered imperative for career success.



Career Cluster Knowledge and Skills – *Applicable to all careers in the Engineering Technology Cluster*

All workers in the industry are expected to have a broad understanding of the field. These cross-cutting skills prepare workers to succeed in a range of jobs in the cluster. High school students mastering these skills are prepared to enter community college or the workforce with an understanding of their career options and training needs.

Focus Area Knowledge and Skills – *Applicable to a specific career*

Field-specific knowledge that an entry-level worker would be expected to possess. High school students mastering these skills are prepared to enter employment or enroll in a community college to pursue advanced training. Postsecondary graudates would be prepared to enter employment with a credential, certificate, or degree.

These skills have been classified based on their level of knowledge required for their mastery:

- ***Foundational Skills*** describe technical skills that all high school students completing a Program of Study would be expected to master. Ideally, these skills would be taught within a high school CTE Program of Study (or in collaboration with a postsecondary partner if it is not feasible within high school).
- ***Intermediate Skills*** describe more technically advanced skills that high school instructors are encouraged to teach, though some might be taught by community college faculty due to equipment or time constraints.
- ***Advanced Skills*** describe highly technical skills that high school instructors may choose to teach with the understanding that, due to their complexity, most will be taught by community college faculty as part of the postsecondary component of a CTE Program of Study.

Overarching descriptions of the Knowledge and Skill statements for new Statewide Frameworks in (1) Electrical Systems, (2) Manufacturing Systems, and (3) Mechanical Systems are listed in Figure 1. Each Knowledge and Skill Statement includes a list of Suggested Performance Indicators that illustrate how students might demonstrate their understanding or abilities relating to each statement (see Appendix A). These examples are intended to provide educators with guidance in establishing program standards and assessments and designing curriculum and instructional activities. These skills also have been classified based on their level of difficulty, ranging from foundational to intermediate to advanced.

Suggested Performance Indicators are offered as an optional, industry-suggested, community college faculty-vetted way to demonstrate the Knowledge and Skill Statements. They are not required. Educators may choose to select from these indicators and/or design other means for students to show skill mastery in their CTE Program of Study. It is anticipated that secondary and postsecondary educators will collaborate in selecting the number, type, and technical specificity of skills and indicators, as well as the educational level at which they will be taught.

Figure 1. Knowledge and Skill Statements for the Statewide Framework for Engineering Technology Cluster

EMPLOYABILITY

Cross-cutting, same for all Career Clusters

- Workplace practices
- Personal responsibility and accountability
- Teamwork and conflict resolution
- Communication
- Technology in the workplace
- Planning and organizing
- Career planning

CAREER CLUSTER

- Describe the engineering industry and its role within society and the economy
- Demonstrate an understanding of basic concepts and safe working practices
- Describe government policies and industry standards
- Apply design principles and life-cycle methodology to create products, systems, and processes
- Use technology to solve engineering problems
- Demonstrate an understanding of machine control systems, logic, and devices
- Understand industrial engineering processes, methods of measurement, and quality assurance
- Understand concepts and use applied mathematics, science, and physics
- Identify the fundamentals of the theory, measurement, control, and applications of electrical energy
- Demonstrate an understanding of basic economic systems and financial management practices and procedures

FOCUS AREAS

Electrical Systems

- Understanding of electrical symbols and images
- Safety hazards and precautions
- Use of electrical equipment and materials
- Electrical and electronic theory and laws
- Circuit concepts and analysis techniques
- Soldering, electronic components and wiring
- Power sources and power supplies
- Communication system concepts
- System integration and amplification
- Motors, variable-frequency drives, and power wiring

Manufacturing Systems

- Manufacturing processes and their effect on materials
- Material science in manufacturing engineering
- Planning and logistics requirements
- Product development and design
- Precision manufacturing and automation
- Computer-aided manufacturing, drafting, modeling
- Quality assurance and continuous improvement
- Basics of supply chain management
- Packaging within manufacturing
- Sustainability and environmentally friendly processes

Mechanical

- Principles of machine theory and design
- Product development and design
- Computer-aided drafting and modeling
- Principles of mechanical and power systems
- Fundamental automating manufacturing systems
- Fluid dynamics
- Thermal dynamics
- Statics and dynamics in mechanical systems
- Material strength
- Quality assurance and continuous improvement

Program of Study Design Options

Educators have two options in designing a Program of Study using a Statewide Framework. They can pursue a Career Cluster-level Program of Study or a Focus Area-level Program of Study. The distinction between a Cluster and Focus Area Program of Study relates to the scope of Knowledge and Skill Statements covered in the Program of Study and level of secondary to postsecondary alignment.

There are two primary distinctions between the two options:

1. Educators choosing to offer a **Career Cluster Programs of Study** are encouraged to cover all the employability skills and Cluster-level skills identified and draw on the foundational skills included in one or more Focus Areas.
2. **Focus Area Programs of Study** are more occupationally specific with a higher level of content standardization. Educators are encouraged to cover all the employability skills, Cluster-level skills, and foundational skills identified within a Focus Area. Intermediate and advanced skills also may be addressed, either at the high school level or in collaboration with a postsecondary partner.

Career Cluster Program of Study Option

A Career Cluster-level Program of Study provides high school students with a broad overview of the Engineering Technology field to prepare them to specialize in an area of their choosing at the postsecondary level. With this option, educators may choose to offer a broad range of courses that address different aspects of the field, drawing on skills included in each of the identified Focus Areas.

To qualify as a concentrator at the Career Cluster-level, high school students must earn at least two credits in a state-approved Program of Study sequence, with one of these credits awarded as part of the second or third course in a sequence. High school graduates concentrating their studies in the Engineering Technology Career Cluster would have the option of continuing their studies at an affiliated community college, where they could pursue related training that culminates in the award of a credential, certificate, or associate degree.

Focus Area Program of Study Option

Focus Area-level Programs of Study are intended to align with specific certificate and associate degree options offered at the postsecondary level. Where appropriate, districts and colleges can negotiate dual credit agreements so that high school students can earn college credit that may be applied toward a postsecondary certificate or degree, expediting the time it takes to complete.

The new statewide Program of Study option requires:

- Offering a minimum of three credits at the secondary level and 36 credits at the postsecondary level
- Covering all the employability, Career Cluster, and foundational Focus Area skills as part of the high school component of a CTE Program of Study or in collaboration with a postsecondary partner
- Concentrators to earn two credits in the Program of Study, including at least one credit awarded as part of the second or third course in a sequence
- Providing a sequenced, progressive set of courses, including an introductory or survey course, and two courses offering more technically advanced skills
- Exhibiting secondary-postsecondary standards alignment that is clearly defined and communicated to all stakeholders
- Offering or potentially offering dual credit opportunities
- Integrating career-related learning experiences, career-connected learning, and work-based learning in meaningful ways

High school graduates concentrating their studies in the Engineering Technology field would have the option of continuing their studies at an affiliated community college, where they could seek advanced training in the Focus Area or pursue training in a related field that culminates in the award of a credential, certificate, or associate degree.

Statewide Framework Programs of Study align course standards to industry-validated skills so that students throughout the state have access to consistent, high-quality CTE with opportunities to gain college credit and skills in in-demand occupations.

Course Scope and Sequence

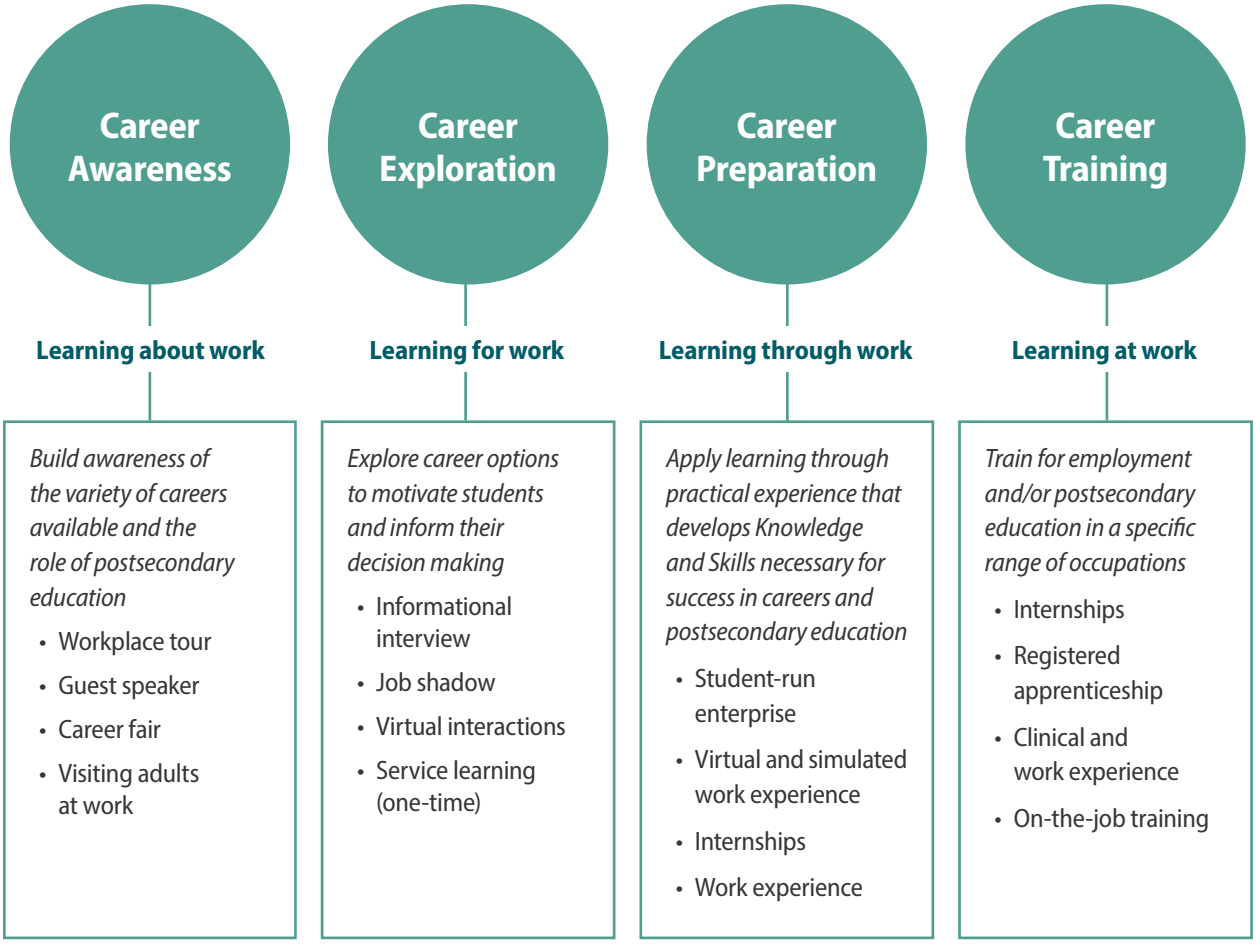
It is anticipated that CTE students will begin their course sequence with an introductory/survey course that opens a range of more technically advanced course options. An example of how a Program of Study might be configured for each Focus Area is provided in Table 2. *Note that course sequences and titles are provided for illustrative purposes only—it is up to secondary and postsecondary partners to determine course titles and sequences; course content, curriculum, and assessments, including when and how Knowledge and Skill Statements are addressed; and whether dual credit or industry certifications may be awarded.*

Table 2. Sample Scope and Sequence for Cluster-level and Focus Area-level Program of Study

Course level	Grade	Course
Course 1	Grades 9 or 10	**Cluster Level.** Introduction to Drafting and Design
		Focus Area Level. Introduction to Electricity; Survey of Manufacturing and Engineering; Mechatronics 1
Course 2	Grades 10 or 11	**Cluster Level.** Computer Programming
		Focus Area Level. Electrical Engineering 1; Manufacturing & Engineering 1 or Engineering Robotics 1; Mechatronics 2
Course 3	Grades 11 or 12	**Cluster Level.** Engineering and Design
		Focus Area Level. Electrical Engineering 2; Manufacturing & Engineering 2 or Engineering Robotics 2; Mechatronics 3
Capstone	Grades 12	**Cluster Level.** Advanced Principles of Engineering and Design or work-based learning experience
		Focus Area Level. Advanced Principles of Electrical Engineering 3 or work-based learning experience; Manufacturing & Engineering 3 or work-based learning experience; Mechatronics 4 or work-based learning experience

Additionally, all Programs of Study are expected to integrate a full range of **Career Connected Learning Experiences** that advance progressively, as indicated in Figure 2.

Figure 2. Career Connected Learning Experiences



Developing a CTE Program of Study for State Approval

To meet Oregon's definition of a High-Quality Program of Study, a CTE Program of Study must be built around five core elements. These elements and supporting components, which align to the Association for Career and Technical Education's (ACTE's) High-Quality CTE Program of Study Framework, are detailed in Table 3.

Table 3. Elements and Supporting Components of a High-Quality CTE Program of Study

Element	Components
Standards and Content	***Rigorous Integrated Content:*** Appropriately licensed secondary teachers and postsecondary instructors integrate rigorous technical and academic content.
	Engaged Learning: Students are engaged through instructional strategies that are relevant and authentic, and meet the needs and interests of all students.
	Coherent Curriculum: Aligned to industry-identified standards and sequenced to prepare students for their next steps.
Alignment and Articulation	***Partnerships:*** Actively engages employer and educator partners to develop, enhance and support the CTE program in a manner that is sustainable.
	Credentials: Links instruction to meaningful college credit or industry credentials that can lead to high-wage, high-skill, and in-demand occupations.
	Facilities and Equipment: Provides students with safe access to facilities and equipment appropriate to the type of instruction and reflective of workforce needs.
Accountability and Evaluation	***Continuous Improvement:*** Revisions to the Program of Study are based on student performance, economic demand, and employer requirements.
Student Support Services	***Equity and Access:*** Provides all students and their families with appropriate knowledge and experiences to help make informed education and career decisions.
	Career Connected Learning: Provides quality, accurate and timely information and support that will help students identify, pursue, transition to, and complete pathways to future careers. Career Connected Learning should include activities and opportunities within the four domains of Awareness, Exploration, Preparation and Training.
Professional Development	***Professional Development:*** Promotes instructional long-term growth that aligns with long-term program goals.

Educators are encouraged to consult the **High Quality CTE Program of Study Rubric** and accompanying **Quick Guide to Using the High Quality CTE Program of Study Rubric** to assess their existing CTE Programs of Study and create goals for continuous improvement.

CTE Licensure Requirements.
Engineering Technology

Educators seeking to teach in the Engineering Technology Career Cluster must possess a valid Oregon CTE endorsement. See **CTE Licensure in Oregon** for an overview of licensing requirements and the steps to be taken to receive an endorsement. Contact **Muhammad Rahman** (Muhammad.Rahman@ode.oregon.gov) for more information.

Student Leadership

Learning is enhanced when students can apply academic, technical, and employability skills in an authentic setting. Career and Technical Student Organizations (CTSOs) are extracurricular groups that offer youth the ability to practice and enhance their classroom learning, while developing personal skills and leadership abilities, through participation in activities, events, and competitions.

In the Engineering Technology field, there are several active CTSOs in Oregon in which students may participate:

SkillsUSA (https://www.skillsusaoregon.org/) prepares preparing student leaders for careers in trade, technical, and skilled service occupations.

Technology Student Association (https://www.oregontsa.org/) accelerates student achievement and leadership and supports teachers by providing engaging opportunities for students to develop STEM skills.

Appendix A. Engineering Technology Career Cluster Knowledge and Skill Statements and Suggested Performance Indicators

Overview

This document details the Knowledge and Skill Statements comprising the Programs of Study for: (1) Electrical Systems, (2) Manufacturing Systems, and (3) Mechanical Systems. These statements, developed with input by employers, define the career readiness expectations of entry-level workers.

Community college faculty were asked to provide feedback on each Knowledge and Skill Statement and rate the importance of each Suggested Performance Indicator using the following scale:

- **Critically important.** This skill would be expected of students entering a community college after having completed a CTE Program of Study at the high school level
- **Somewhat important.** This skill would be useful but not necessary for students entering a community college after having completed a CTE Program of Study at the high school level
- **Not important.** This skill would NOT be expected of students entering a community college after having completed a CTE Program of Study at the high school level (i.e., it will be taught at the college level)

To gather district perspectives, high school CTE instructors with approved programs were asked to rate the importance of high school graduates in related CTE programs of study mastering these skills upon completing their secondary CTE studies.

Feedback from survey respondents was analyzed to produce a core set of Knowledge and Skill Statements and Suggested Performance Indicators that secondary educators should consider when designing CTE programs and formulating their CTE program approval applications.

These Knowledge and Skill Statements and Suggested Performance Indicators are intended to provide educators with guidance in establishing program standards and assessments and designing curriculum and instructional activities. *Performance indicators are offered as suggestions, not requirements, for addressing the Knowledge and Skill Statements comprising a Program of Study.*

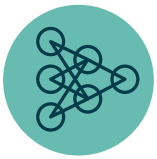
How to Use This Document

Educators offering a CTE Program of Study in the Engineering Technology Career Cluster should review the Knowledge and Skill statements and Suggested Performance Indicators in this document. Ideally, skills marked as Foundational will be taught during a student's high school CTE Program of Study experience, with educators determining how and when instruction occurs. Three types of skills and indicators are provided:

Three types of skills and indicators are provided:

Employability Knowledge and Skills – *Applicable to all Career Clusters*

All learners are expected to master these basic skills to function in the workplace. These cross-cutting abilities, found in all jobs in all industries, encompass a broad range of communication, critical thinking, interpersonal, and organizational skills considered imperative for career success.



Career Cluster Knowledge and Skills – *Applicable to all careers in the Engineering Technology Cluster*

All workers in the Engineering Technology industry are expected to have a broad understanding of the field. These cross-cutting skills prepare workers to succeed in a range of jobs in the cluster. High school students mastering these skills are prepared to enter community college or the workforce with an understanding of their career options and training needs.

Focus Area Knowledge and Skills – *Applicable to a specific career*

Field-specific knowledge that an entry-level worker would be expected to possess. High school students mastering these skills are prepared to enter employment or enroll in a community college to pursue advanced training. Postsecondary graduates would be prepared to enter employment with a credential, certificate, or degree.

These skills have been classified based on their level of knowledge required for their mastery:

- ***Foundational Skills*** describe technical skills that all high school students completing a Program of Study would be expected to master. Ideally, these skills would be taught within a high school CTE Program of Study (or in collaboration with a postsecondary partner if it is not feasible within high school).
- ***Intermediate Skills*** describe more technically advanced skills that high school instructors are encouraged to teach, though some might be taught by community college faculty due to equipment or time constraints.

- ***Advanced Skills*** describe highly technical skills that high school instructors may choose to teach with the understanding that, due to their complexity, most will be taught by community college faculty as part of the postsecondary component of a CTE Program of Study.

Engineering Technology Career Cluster
Knowledge and Skill Statements

Employability Knowledge and Skills

These Knowledge and Skill statements apply to all Career Clusters in Oregon.

Code number	Knowledge and Skill Statement
E-01	Adhere to workplace practices
E-02	Exhibit personal responsibility and accountability
E-03	Practice cultural competence
E-04	Demonstrate teamwork and conflict resolution
E-05	Communicate clearly and effectively
E-06	Employ critical thinking to solve problems
E-07	Demonstrate creativity and innovative thinking
E-08	Demonstrate fluency in workplace technologies
E-09	Plan, organize, and manage work
E-10	Make informed career decisions

Career Cluster-Level Knowledge and Skills

These Knowledge and Skill statements apply to all Engineering Technology Programs of Study in Oregon.

Code number	Knowledge and Skill Statement
CC-EN01	Describe the engineering industry and its role within society and the economy
CC-EN02	Demonstrate an understanding of basic concepts in the engineering technology field
CC-EN03	Demonstrate an understanding of and adherence to safe working practices
CC-EN04	Describe government policies and industry standards that apply to the engineering technology field
CC-EN05	Exhibit integrity and professionalism in engineering cluster occupations
CC-EN06	Apply design principles and life-cycle methodology to create products, systems, and processes using appropriate technology
CC-EN07	Use technology such as computers and design software to solve engineering problems
CC-EN08	Demonstrate an understanding of machine control systems, logic, and devices

Code number	Knowledge and Skill Statement
CC-EN09	Understand industrial engineering processes, including the use of tools and equipment, methods of measurement, and quality assurance
CC-EN10	Understand and use applied mathematics and science for engineering cluster careers
CC-EN11	Describe the concepts of physics that are fundamental to engineering technology
CC-EN12	Identify the fundamentals of the theory, measurement, control, and applications of electrical energy, including alternating and direct currents
CC-EN13	Develop a career plan within the engineering cluster occupations
CC-EN14	Demonstrate an understanding of basic economic systems, financial management practices, and procedures

Focus Area Level Knowledge and Skills

These are updated Knowledge and Skill Statements for the three Focus Area Programs of Study in the Engineering Technology Career Cluster.

ELECTRICAL SYSTEMS

Code number	Knowledge and Skill Statement
FA-ENES01	Understand and communicate using electrical symbols and images
FA-ENES02	Demonstrate knowledge of safety hazards and precautions in using electrical equipment
FA-ENES03	Demonstrate the proper use of electrical equipment and materials commonly used in the field
FA-ENES04	Understand and apply electrical and electronic theory and laws
FA-ENES05	Understand and apply circuit concepts and analysis techniques
FA-ENES06	Demonstrate knowledge of circuits
FA-ENES07	Demonstrate knowledge and application of electronic components
FA-ENES08	Understand and apply digital concepts and circuitry
FA-ENES09	Connect components to construct low-voltage, data, and communications systems using coaxial, fiber optic, and twisted pair cables
FA-ENES10	Demonstrate knowledge of power sources and power supplies
FA-ENES11	Demonstrate knowledge of communication systems
FA-ENES12	Understand and perform skills for system integration and amplification
FA-ENES13	Understand and install motors, variable-frequency drives, and power wiring

MANUFACTURING SYSTEMS

Code number	Knowledge and Skill Statement
FA-ENMN01	Describe differing manufacturing processes and their effect on materials
FA-ENMN02	Use knowledge of material science in manufacturing engineering
FA-ENMN03	Demonstrate knowledge of planning and logistics requirements in manufacturing engineering
FA-ENMN04	Apply product development and design process from problem identification to final presentation
FA-ENMN05	Demonstrate knowledge of manufacturing principles to ensure precision
FA-ENMN06	Demonstrate knowledge of fundamental automating manufacturing systems
FA-ENMN07	Apply principles of computer-aided manufacturing technology relating to mechatronics and robotics
FA-ENMN08	Use computer-aided drafting and modeling to illustrate the design of projects and components
FA-ENMN09	Demonstrate an understanding of quality assurance and continuous improvement
FA-ENMN10	Understand and apply basics of supply chain management
FA-ENMN11	Demonstrate basic knowledge of packaging within manufacturing
FA-ENMN12	Describe issues of sustainability and environmentally friendly processes in the manufacturing industry

MECHANICAL SYSTEMS

Code number	Knowledge and Skill Statement
FA-ENMS01	Understand and use principles of machine theory
FA-ENMS02	Demonstrate knowledge of machine design
FA-ENMS03	Apply product development and design process from problem identification to final presentation
FA-ENMS04	Use computer-aided Drafting and Modeling to illustrate the design of projects and components
FA-ENMS05	Understand fundamental principles of basic mechanical and power systems
FA-ENMS06	Demonstrate knowledge of fundamental automating manufacturing systems
FA-ENMS07	Demonstrate knowledge of fluid dynamics
FA-ENMS08	Demonstrate knowledge of thermal dynamics
FA-ENMS09	Demonstrate knowledge of statics and dynamics in mechanical systems
FA-ENMS10	Analyze the strengths of materials
FA-ENMS11	Demonstrate an understanding of quality assurance and continuous improvement

Employability Knowledge and Skill Statements with Suggested Performance Indicators

● **Foundational -** *Basic skills that **should be taught** within high school or, if not feasible, at a partnering college*

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational
E-01 ***Adhere to workplace practices***	A. Explain and follow workplace standards, rules, and regulations B. Show up on time and prepared to work C. Demonstrate the ability to take direction, be proactive, and work independently	●
E-02 ***Exhibit personal responsibility and accountability***	A. Apply professional and ethical standards of the industry to personal conduct B. Maintain integrity and promote personal and professional integrity in co-workers C. Take responsibility and carry out work assignments	●
E-03 ***Practice cultural competence***	A. Demonstrate awareness of issues related to diversity, equity, and inclusion B. Work effectively with colleagues of differing abilities, cultures, and backgrounds C. Describe issues relating to workplace harassment D. Model behaviors that are respectful and sensitive of others	●
E-04 ***Demonstrate teamwork and conflict resolution***	A. Demonstrate the ability to collaborate and contribute to the work of a diverse team B. Explain when it is appropriate to lead and when to follow another's lead C. Demonstrate strategies for resolving issues with coworkers	●
E-05 ***Communicate clearly and effectively***	A. Listen attentively, and speak and write clearly to convey information correctly B. Interpret information and instructions presented in verbal and written form C. Demonstrate effective communication with colleagues, supervisors, customers, and suppliers D. Demonstrate the ability to communicate verbally, in writing, and using electronic communication tools	●

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational
E-06 ***Employ critical thinking to solve problems***	A. Recognize problems in the workplace and diagnose their root causes B. Develop well-reasoned plans to solve identified challenges C. Apply and follow through on plans to ensure that problems are resolved	●
E-07 ***Demonstrate creativity and innovative thinking***	A. Develop ideas to solve problems in new and different ways B. Investigate one's own and others' ideas to find those with greatest applicability C. Develop and deploy plans to implement new ideas in the workplace	●
E-08 ***Demonstrate fluency in workplace technologies***	A. Demonstrate knowledge and application of general technology skills, including hardware and software commonly used in the industry B. Use online communication, networking tools and social networks to access, manage, evaluate, and create information to successfully function in a knowledge economy C. Describe and demonstrate a fundamental understanding of the ethical, legal, and security issues surrounding access to and use of information technologies	●
E-09 ***Plan, organize, and manage work***	A. Identify an intended project outcome including available inputs, materials, labor, timeline for producing work, and job-site obligations B. Effectively plan, monitor, and complete projects on time and within budget using available resources and materials C. Demonstrate ability to write coherent reports and project summaries to communicate the progress of project work and its adherence to schedule	●
E-10 ***Make informed career decisions***	A. Identify job and entrepreneurial opportunities in the industry and the required education and credentials to obtain employment B. Set short- and long-term career goals based on personal interests and aptitudes C. Maintain a project portfolio D. Develop a professional resume E. Explain and demonstrate how to cultivate and maintain a professional presence in an online environment, including the appropriate use of social media and networking platforms	●

Engineering Technology Career Cluster Knowledge and Skill Statements with Suggested Performance Indicators

- ● **Foundational -** *Basic skills that **should be taught** within high school or, if not feasible, at a partnering college*
- ■ **Intermediate -** *Advanced skills **encouraged to be taught** within high school, with some offered at a partnering college*
- ▲ **Advanced -** *Highly technical skills that **may be taught** within high school, with most offered at a partnering college*

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
CC-EN01 ***Describe the engineering industry and its role within society and the economy***	A. Describe how the use of engineered products and systems impact global, environmental, and social contexts B. Describe the type of companies that exist in the industry and how they work independently and in collaboration with other companies to produce products C. Describe how engineering businesses and the products they produce contribute to improving people's lives and strengthening the economy D. Describe how transferring technology from one society to another can cause cultural, social, economic, and political changes		A. ■ B. ■ C. ■ D. ■	
CC-EN02 ***Demonstrate an understanding of basic concepts in the engineering technology field***	A. Analyze various careers and their job descriptions and the educational requirements and certifications to find entry-level employment B. Define and use industry-standard terminology to communicate information C. Explain how products are designed and the various professions involved (e.g., engineers, designers, fabricators, suppliers) D. Identify relevant artifacts and experiences for an effective engineering portfolio E. Identify the professional associations that exist in the field and the purposes that they serve	A. ● B. ●	C. ■ D. ■ E. ■	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
CC-EN03 ***Demonstrate an understanding of and adherence to safe working practices***	A. Describe the importance of a safety culture B. Identify safety hazards and follow correct procedures when using appropriate safety techniques, equipment, and procedures in the workplace C. Demonstrate the use of and care for personal protective equipment D. Demonstrate awareness of common industry hazards and the steps needed to correct them	A. ● B. ● C. ● D. ●		
CC-EN04 ***Describe government policies and industry standards that apply to the engineering technology field***	A. Describe how to apply quality control and assurance procedures within the industry and why they are important B. State the purpose of regulations and certification requirements C. Describe how the Americans with Disabilities Act applies in the workplace D. Describe requirements related to handling and disposal of environmentally hazardous materials in accordance with the material safety data sheet (MSDS), the Occupational Safety and Health Administration (OSHA), and the Environmental Protection Agency (EPA) regulations E. Explain the types of governmental regulations and federal, state, and local regulations that apply in the industry and how the professions engage with them F. Describe how government agencies ensure compliance with environmental regulations and the consequences that organizations suffer when they fail to comply		A. ■ B. ■ C. ■ D. ■ E. ■	F. ▲

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
CC-EN05 ***Exhibit integrity and professionalism in engineering cluster occupations***	A. Adhere to ethical and legal standards and requirements for the treatment of people in the engineering workplace and while performing engineering tasks B. Comply with ethical standards (code of ethics) and follow requirements of regulatory agencies in the engineering fields C. Demonstrate advocacy and professional collaboration in engineering. D. Exhibit cultural sensitivity in the engineering workplace E. Understand how gender-bias, racial-bias, and other forms of stereotyping and discrimination can adversely affect communications within an engineering team F. Demonstrate knowledge of federal and state health and safety regulations to support a safe working environment in engineering	A. B. C.	D. E. F.	
CC-EN06 ***Apply design principles and life-cycle methodology to create products, systems, and processes using appropriate technology***	A. Use scientific and mathematical models to communicate and test design ideas and processes B. Apply a structured approach to solving problems including defining a problem, brainstorming, researching, and generating ideas, identifying criteria and constraints, exploring possibilities, making a model or prototype, and evaluating the design using specifications C. Understand and apply the engineering design process to create a product, system, or process D. Identify and apply individual and group brainstorming techniques during the design process and in the solution of design problems E. Apply knowledge of science, technology, engineering, and mathematics to define, analyze, and solve problems F. Demonstrate the relationship between a scientific method and engineering design process G. Consider factors, including reliability, safety, production, manufacturability, aesthetics, ergonomics, and human interaction in the design process H. Understand and apply the life-cycle methodology of analysis, design, construction, and implementation	A. B. C. D. E.	F. G. H.	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
CC-EN07 ***Use technology such as computers and design software to solve engineering problems***	A. Apply contemporary engineering tools, including software, to define, analyze, analyze, and synthesize engineering systems data, and model and prototype solutions to engineering problems B. Use modeling, simulation, and prototype techniques to solve engineering problems C. Apply information technology tools and techniques for gathering, storing, and transferring engineering systems data D. Write and execute a simple program (e.g., Python, Java, C++, etc.) E. Use modeling, simulation, and visualization to efficiently analyze, synthesize and communicate engineering information F. Use technology to create, manipulate, organize, manage, and distribute engineering information, including electronically G. Apply current computer programming languages to engineering development H. Use statistical tools to analyze engineering data I. Understand the difference between object-oriented programs and procedural programs	A. ● B. ● C. ● D. ●	E. ■ F. ■ G. ■ H. ■	I. ▲
CC-EN08 ***Demonstrate an understanding of machine control systems, logic, and devices***	A. Choose appropriate inputs and outputs devices based on the need of a technological system B. Create detailed flow charts utilizing a computer software application C. Create control system operating programs utilizing computer software D. Design and create a control system based on given needs and constraints E. Create system control programs that utilize flowchart logic F. Judge between open and closed loop systems and choose the most appropriate system for a given technological problem	A. ●	B. ■ C. ■ D. ■ E. ■ F. ■	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
CC-EN09 ***Understand industrial engineering processes, including the use of tools and equipment, methods of measurement, and quality assurance***	A. Estimate and measure the size of objects in both Standard International and United States units B. Apply appropriate geometric dimensioning and tolerancing (GD&T) practices C. Use tools, fasteners, and joining systems employed in selected engineering processes D. Describe the major manufacturing processes E. Calibrate precision measurement tools and instruments to measure objects F. Know the structure and processes of a quality assurance cycle	A. ●	B. ■ C. ■ D. ■ E. ■ F. ■	
CC-EN10 ***Understand and use applied mathematics and science for engineering cluster careers***	A. Apply the concepts and processes using the guiding principles and standards of mathematics, such as algebraic, geometric, and trigonometric relationships to solve engineering problems B. Understand the impact of assumptions, initial conditions, boundary conditions, and other constraints on problem solutions C. Apply scientific method in qualitative and quantitative analysis, data gathering, direct and indirect observation, predictions, and problem identification D. Demonstrate the ability to select, apply, and convert systems of measurement to solve problems E. Understand science constructs including conclusions, conflicting data, controls, data, inferences, limitations, questions, sources of errors, and variables F. Apply fundamental laws and principles relevant to engineering and technology G. Apply scalar and vector quantities as applied to physical systems, such as the relationship between position, velocity, and acceleration H. Apply appropriate data collection, statistical analysis methods, and the means of displaying data to make decisions	A. ● B. ● C. ● D. ● E. ● F. ● G. ●	H. ■	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
CC-EN11 ***Describe the concepts of physics that are fundamental to engineering technology***	A. Describe and practice real world applications of physical laws (e.g., Newton's Law, Pascal's Principle, Ohm's Law, Watt's Law, Bernoulli's principle, mass and energy balances) B. Compare the effects and applications of heat transfer and thermal dynamic processes C. Analyze how electric and magnetic phenomena are related and know common practical applications D. Formulate and solve problems by using the appropriate units applied in mechanical, electrical, fluid, and thermal engineering systems E. Evaluate how energy is transferred and predict the effects of resistance in mechanical, electrical, fluid, and thermal systems F. Explore the fundamentals and properties of waveforms and how waveforms may be used to carry energy		A. ■ B. ■ C. ■ D. ■ E. ■ F. ■	
CC-EN12 ***Identify the fundamentals of the theory, measurement, control, and applications of electrical energy, including alternating and direct currents***	A. Predict the effects of circuit conditions based on measurements and calculations of voltage, current, resistance, and power B. Analyze relationships between voltage, current, resistance, and power related to direct current (DC) circuits C. Classify and use various electrical components, symbols, abbreviations, media, and standards of electrical drawings D. Understand how electrical control and protection devices are used in electrical systems E. Calculate, construct, measure, and interpret both AC and DC circuits F. 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 G. Calculate loads, currents, and circuit-operating parameters		A. ■ B. ■ C. ■ D. ■ E. ■ F. ■ G. ■	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
CC-EN13 ***Develop a career plan within the engineering cluster occupations***	A. Understand the career opportunities in engineering and differentiate among different disciplines B. Identify relevant artifacts and experiences for an effective engineering portfolio C. Engage in continuous self-assessment and goals modification for personal and professional growth D. Develop skills and knowledge for career growth in engineering E. Identify and participate in continuous engineering education opportunities	A. ● B. ●	C. ■ D. ■ E. ■	
CC-EN14 ***Demonstrate an understanding of basic economic systems and financial management practices and procedures***	A. Explain the concept of profit margin and how it affects project and production decisions B. Explain the purpose of a budget and differentiate between revenues and expenses C. Describe basic economic principles that apply in the engineering cluster (e.g., supply and demand, the production of goods and services) D. Describe what key performance indicators (KPIs) are, how they are used in different industries, and how they are tracked (e.g., daily, weekly, monthly, annually) E. Describe purchasing activities to obtain business supplies, equipment, and services (e.g., sourcing and procurement)	A. ● B. ●	C. ■ D. ■ E. ■	

Electrical Systems Knowledge and Skill Statements with Suggested Performance Indicators

- ● **Foundational -** *Basic skills that **should be taught** within high school or, if not feasible, at a partnering college*
- ■ **Intermediate -** *Advanced skills **encouraged to be taught** within high school, with some offered at a partnering college*
- ▲ **Advanced -** *Highly technical skills that **may be taught** within high school, with most offered at a partnering college*

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENES01 ***Understand and communicate using electrical symbols and images***	A. Understand symbols used in electrical engineering including electronic symbols, flowcharting symbols, science symbols, and telecommunication symbols B. Use graphical symbols on electronic drawings, diagrams, and charts C. Use schematics to locate components and wiring failures in electronic products D. Use block diagrams for troubleshooting and maintenance of electronic products E. Identify electronic components and draw their schematic symbols (e.g., AC power supply, relay switch, transformer) F. Describe the current industry standards for illustration and layout	A. ●	B. ■ C. ■ D. ■ E. ■	F. ▲
FA-ENES02 ***Demonstrate knowledge of safety hazards and precautions in using electrical equipment***	A. Describe first aid treatment for individuals who have experienced a shock B. Describe conductors and insulators and how they are used C. Understand shock hazards when servicing power supplies in electronic equipment D. Demonstrate safety hazards associated with servicing electrical equipment and precautions that can be taken to alleviate dangers E. Describe the effects of electricity on the human body	A. ● B. ● C. ●	D. ■ E. ■	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENES03 ***Demonstrate the proper use of electrical equipment and materials commonly used in the field***	A. Understand the proper configuration, handling, and storage of voltmeters, ammeters, ohm meters, and bench power supplies B. Demonstrate understanding of circuit boards and their uses C. Describe the operation of and procedure for testing various electronic components (e.g., resistors and capacitors) in both a series and in parallel circuit D. Use curve tracers, oscilloscopes, and multi-meters E. Use function generators in the process of repairing electronic equipment F. Understand the use and application of current and voltage probes G. Demonstrate proper selection of materials used for insulation H. Explain the purpose and use of pulsers and logic probes	A. ● B. ●	C. ■ D. ■ E. ■ F. ■	G. ▲ H. ▲
FA-ENES04 ***Understand and apply electrical and electronic theory and laws***	A. Describe the units of electrical charge, voltage, current, power, resistance, capacitance, and inductance B. Understand fundamentals of direct current (DC) and alternating current (AC) circuit theory and clearly distinguish between them C. State Ohm's Law and use related formulas for current, voltage, resistance, and power to solve electrical systems problems D. Understand and apply the basic methods of using electricity to operate a motor E. State Watt's Law, graph the relationship between voltage, current, and power in circuits, and use formulas to solve problems involving Watt's Law F. Understand fundamentals of electrical properties and electromagnetic effect G. Understand atomic theory, the atomic structure of matter, and its relationship to electricity		A. ■ B. ■ C. ■ D. ■ E. ■ F. ■	G. ▲

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENES05 ***Understand and apply circuit concepts and analysis techniques***	A. Construct, measure, and test a variety of simple series and parallel resistive circuits B. Explain the uses of series, parallel, and series-parallel circuits, and construct and troubleshoot their function C. Analyze wiring schematics and diagrams for accuracy and function D. Understand basic microelectronic circuit concepts E. Use fundamental electric-circuit techniques such as Kirchhoff's Laws, impedance, superposition, phasor transforms, transformers, filters, Fourier-series methods, and 3-phase power to solve electrical systems problems F. Build and test half-wave rectifiers, LED circuits, inverting and non-inverting op amp circuits G. Understand reasons for using rheostats and isolation transformers. H. Use small-signal and large-signal techniques to analyze and design transistor circuits		A. ■ B. ■ C. ■ D. ■	E. ▲ F. ▲ G. ▲ H. ▲
FA-ENES06 ***Demonstrate knowledge of circuits***	A. Demonstrate knowledge of soldering and desoldering principles. B. Demonstrate the use of solder and solder removers. C. Demonstrate appropriate use of heat sinks on solid state components. D. Describe aspects of soldering techniques such as tinning, physical connections, temperature selection, and cleaning		A. ■ B. ■ C. ■ D. ■	
FA-ENES07 ***Demonstrate knowledge and application of electronic components***	A. Determine the values for electronic components from their markings and physical characteristics B. Describe the purpose of and operation of optical interface devices (e.g., light emitting diodes (LEDs), liquid crystal displays (LCDs) C. Describe the purpose and operation of photovoltaic cells, photoresistors, photodiodes, and phototransistors D. Understand, build, and test transistor switching and amplifier circuits E. Know the various types of transistors and diodes and how they are used		A. ■ B. ■ C. ■ D. ■	E. ▲

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENES08 ***Understand and apply digital concepts and circuitry***	A. Describe the purpose and use of logic gates (e.g., discrete and medium scale integration [MSI] gates, latches, flip-flops) B. Identify the numbering systems, codes, arithmetic operations, Boolean operations and simplification methods used in digital electronics C. Describe the purpose and use of digital-to-analog and analog-to-digital circuits D. Describe the purpose and operation of programmable logic devices (PLDs) and complex programmable logic devices (CPLDs) E. Understand ASCII code F. Explain the purpose and use of basic digital concepts including asynchronous and synchronous counters, digital bus, and display circuitry G. Convert number systems (e.g., binary coded decimal (BCD) to decimal, and decimal to BCD) H. Design, construct and test a digital circuit based on schematics using simulations and simulation test benches I. Utilize memory in a control system J. Determine fan-out and propagation delays		A. ■ B. ■ C. ■ D. ■ E. ■ F. ■ G. ■ H. ■	I. ▲ J. ▲
FA-ENES09 ***Connect components to construct low-voltage, data, and communications systems using coaxial, fiber optic, and twisted pair cables***	A. Describe the types, purposes and uses of cables and wires B. Splice and terminate cables and wires C. Select methods for splicing and terminating cables and wires (e.g., terminal strips, and crimp connectors) D. Test cables and wires E. Explain how the characteristics of cables and wires cause impedance F. Identify the construction, impedance characteristics and use of cables and wires		A. ■ B. ■ C. ■ D. ■ E. ■ F. ■	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENES10 ***Demonstrate knowledge of power sources and power supplies***	A. Understand fusing and circuit breaker rules and reasons for different types of fuses B. Identify the various battery supplies, their common usages, and recharging principles C. Understand the differences between transformer-powered supplies and line-connected supplies D. Select and install power conditioning, isolation transformers, surge suppressors, and uninterruptible power supplies E. Identify common filter types F. Construct and install regulated power supplies		A. ■ B. ■	C. ▲ D. ▲ E. ▲ F. ▲
FA-ENES11 ***Demonstrate knowledge of communication systems***	A. Understand design of communication networks including network protocol, security, privacy, routing and congestion control, Internet, local area networks, wireless services, and multimedia services B. Understand basic concepts of digital communication modulation and reception C. Understand basic concepts of information theory and its application		A. ■ B. ■ C. ■	
FA-ENES12 ***Understand and perform skills for system integration and amplification***	A. Describe the use of common amplifier devices B. Understand grounding, proper and improper methods, and the results of power source mismatch C. Understand frequency response of an amplifier circuit and why it is important D. Recognize causes of distortion in amplifiers and reduce or eliminate it E. Understand expected circuit signal levels for various common electronics products or test equipment F. Understand anticipated signal or voltage levels for output circuits in audio and video equipment G. Demonstrate knowledge of each component in an amplifier circuit H. Use techniques to overcome loading problems in amplifiers		A. ■ B. ■ C. ■ D. ■ E. ■ F. ■	G. ▲ H. ▲

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENES13 ***Understand and install motors, variable-frequency drives, and power wiring***	A. Interpret motor nameplate information and motor specifications B. Identify types and components of single-phase and three-phase motors C. Calculate motor loads D. Interpret schematics and control diagrams for building a motor circuit E. Wire single phase and three phase circuits and install motor control devices (e.g., contactors, starters, variable-frequency drive (VFD) and motor speed controls) F. Describe how programmable controllers can be used to control single speed motors and variable speed motor applications G. Explain the starting sequence of motor components within a given circuit H. Troubleshoot and repair motor starting systems to verify operation according to schematics and control diagrams I. Determine motor rotation needed for the installed load and explain the process for reversing rotation (i.e., three phase and single phase)	A. ● B. ●	C. ■ D. ■ E. ■	F. ▲ G. ▲ H. ▲ I. ▲

Manufacturing Systems Knowledge and Skill Statements with Suggested Performance Indicators

● **Foundational -** *Basic skills that **should be taught** within high school or, if not feasible, at a partnering college*

■ **Intermediate -** *Advanced skills **encouraged to be taught** within high school, with some offered at a partnering college*

▲ **Advanced -** *Highly technical skills that **may be taught** within high school, with most offered at a partnering college*

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMN01 ***Describe differing manufacturing processes and their effect on materials***	A. Describe how differing processes impact quality of products, price, and schedule B. Explain advanced manufacturing and how it applies information, automation, computation, software, sensing and networking to make traditional processes more efficient C. Describe recent trends in manufacturing and why they matter including digital manufacturing, industrial robots, biomanufacturing, nanomanufacturing, sustainable manufacturing etc. D. Distinguish between primary and secondary processes involved in the manufacture of industrial goods and finished products E. Demonstrate knowledge of manufacturing processing techniques (e.g., casting and molding, forging, separating, assembling, digital and additive manufacturing, stamping, etc.) for materials such as metals, plastics, wood, concrete, glass, and ceramics	A. ● B. ● C. ●	D. ■ E. ■	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMN02 ***Use knowledge of material science in manufacturing engineering***	A. Identify and describe the wide range of materials used in manufacturing and how and why they are selected for differing processes (e.g., function, appearance, use) B. Explain the major material properties: physical, mechanical, chemical, thermal, electrical/magnetic, acoustical, and optical C. Describe how differing manufacturing processes influence material properties and apply mechanical testing processes to solid materials D. Demonstrate understanding of material strengths and basic concepts of stress, strain, internal forces, and structural analysis E. Select and defend a material for use in a product, explaining material properties and characterization (based upon manufacturing processes, chemical composition, internal defects, temperature, previous loading, dimensions, and other factors)		A. ■ B. ■ C. ■ D. ■ E. ■	
FA-ENMN03 ***Demonstrate knowledge of planning and logistics requirements in manufacturing engineering***	A. Demonstrate an ability to plan effectively utilizing space, time, and materials effectively B. Explain practices and procedures for planning, organizing, and controlling the resources for the manufacturing of quality products C. Describe rapid prototyping and just in time manufacturing D. Understand resource planning systems for manufacturing including materials and capacity, requirement planning, production scheduling, shop floor control and scheduling, inventory control, and manufacturing databases E. Distinguish the difference between custom and industrial production	A. ● B. ● C. ●	D. ■ E. ■	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMN04 ***Apply product development and design process from problem identification to final presentation***	A. Understand and apply various ideation techniques to develop ideas and concepts, test the effects of various parameters, and assess the efficiency and effectiveness of production B. Apply various two-dimensional (2-D) graphic and/or three-dimensional (3-D) modeling techniques to develop concepts C. Understand and apply research methodologies to identify a need, problem, or opportunity for a new product, product line, system design, or service D. Conduct model documentation of the process of recording details such as size and the material development process E. Apply technology to create a preliminary design of a product concept utilizing drawing, computer software (graphic or CAD), and/or conceptual model fabrication techniques F. Document final design, optimization, and final presentation of a product	A. B.	C. D. E. F.	
FA-ENMN05 ***Demonstrate knowledge of manufacturing principles to ensure precision***	A. Identify and demonstrate proper use of measuring tools including tape rule, machinist's rule, bench rule, caliper, divider, micrometer etc. B. Inspect and interpret blueprints, schematic diagrams, and writing specifications for manufacturing devices and systems C. Explain why proper layout is critical to making parts correctly D. Apply principles of trigonometry, Cartesian geometry, and/or polar geometry, distinguishing which principles apply to a given machining tool and when E. Explain the difference between freehand sketching, manual drafting, and computer-aided drafting (CAD) and describe the skills needed for each F. Demonstrate understanding of the set-up and operation of manual and CNC wood and/or metalworking machines	A. B. C. D. E.	F.	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMN06 ***Demonstrate knowledge of fundamental automating manufacturing systems***	A. Define industry standard vocabulary (i.e., CAD, CAM, CIM, CNC) B. Differentiate between digital and analog devices C. Identify components needed to integrate computer controls for an automated system D. Interface output devices to a computer, microcontroller, or programmable logic controller E. Choose appropriate machine control inputs and outputs, based on the need of a technological system F. Plan, design, and construct an automated system, using computer hardware and software G. Define open and closed loop systems and their uses to solve a technological problem H. Demonstrate ability to program using timers, counters, and loops I. Identify and explain various types of electrical motors	A. B.	C. D. E. F. G. H. I.	
FA-ENMN07 ***Apply principles of computer-aided manufacturing technology relating to mechatronics and robotics***	A. Demonstrate an understanding of the impact of robotics on the manufacturing process B. Identify the components of a robot system and explain their roles in the robot's operation cycle C. Define mechatronics and its use in advanced manufacturing D. Explain the skills associated with mechatronics E. Describe the main components of a typical mechatronic system (e.g., actuators, sensors, digital control devices, input device, output devices, graphical displays) F. Describe the various file types used for import/export of 3D data and upload and download data between robotic simulation and a real robot G. Compare robotic applications and processes (e.g., pick and place, welding) H. Plan, program, and test a robot using appropriate software		A. B. C. D. E. F. G. H.	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMN08 ***Use computer-aided drafting and modeling to illustrate the design of projects and components***	A. Create and interpret auxiliary views, orthographic projections, isometric drawings, oblique drawings, and perspective drawings B. Apply tolerancing techniques and dimensioning to the computer-aided design process C. Perform part manipulation during the creation of an assembly model D. Analyze assembly, successfully construct an assembly drawing, and use libraries and subassemblies effectively during the assembly modeling process E. Compare conceptual, physical, and mathematical design models used to check design F. Evaluate a sketch and generate a model utilizing three-dimensional modeling G. Evaluate a model for design imperfections and the accuracy of mass properties calculations H. Add technical elements (e.g., parts lists, titles, finishes, tolerances, specifications, hidden surfaces) to drawings. I. Translate a three-dimensional drawing or model into corresponding orthographic J. Apply manufacturing processes to computer-aided modeling (e.g., casting, molding, forming, separating, conditioning, assembling, finishing, rapid prototyping, 3-D printing)	A. B. C. D. E. F. G. H. I.	J.	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMN09 ***Demonstrate an understanding of quality assurance and continuous improvement***	A. Understand principle of total quality control for maximization of product effectiveness B. Measure, weigh, and visually inspect machine parts, using the appropriate instrumentation to measure tolerances as required in the engineering drawings C. Describe the three different types of data that are important to controlling the manufacturing of a product (i.e., product output data, quality control data, labor data) D. Define, understand, and apply concepts of quality control, statistical process control, statistical methods for continuous improvement, reliability theories, assessment, and prediction E. Discuss quality control standards (e.g., Six Sigma, TQM, ISO, ANSI, etc.) F. Understand inspection sampling, human factors in quality control, quality cost analysis, and quality audits G. Explain how corrective action plans address quality problems and how functions of process management and quality assurance relate to one another	A. B. C.	D. E. F. G.	
FA-ENMN10 ***Understand and apply basics of supply chain management***	A. Understand the role of employees, customers, and suppliers and the possible effects on the sequencing of work events B. Define supply chains and how they function from the supplier to the customer and describe common supply chain issues C. Understand the flow of products, information, and financial resources that result from supply chain transactions D. Design a supply chain as a complete system using mathematical techniques	A. B. C.	D.	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMN11 ***Demonstrate basic knowledge of packaging within manufacturing***	A. Understand rules, standards, and laws in packaging relating to the quality of products and safety in consumption and transportation B. Understand and apply basic business and entrepreneurial principles and identify potential markets and/or other business opportunities for distribution of the product C. Produce a package design concept for a product or line of products based on consumer's need D. Understand and apply packaging graphic strategies that effectively communicate and influence the purchasing of products E. Understand the functions and significance of packages and describe basic principles relating to materials, systems, and methods in packaging F. Conduct test on package durability and compatibility for physical distribution G. Understand the effects and prevention of drop, impact, and vibration on packages		A. ■ B. ■ C. ■ D. ■ E. ■ F. ■ G. ■	
FA-ENMN12 ***Describe issues of sustainability and environmentally friendly processes in the manufacturing industry***	A. Describe the types of pollution and environmental hazards that are a product of the manufacturing industry and traditional manufacturing processes B. Describe sustainability practices that may be adopted in the manufacturing industry (e.g., recycling, conducting energy audits, reducing pollution byproducts, updating machinery and equipment) C. Define environmentally conscious design and manufacturing and the benefits that it offers D. Describe the difference between green and sustainable manufacturing		A. ■ B. ■ C. ■ D. ■	

Mechanical Systems Knowledge and Skill Statements with Suggested Performance Indicators

- **Foundational -** *Basic skills that **should be taught** within high school or, if not feasible, at a partnering college*
- **Intermediate -** *Advanced skills **encouraged to be taught** within high school, with some offered at a partnering college*
- **Advanced -** *Highly technical skills that **may be taught** within high school, with most offered at a partnering college*

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMS01 ***Understand and use principles of machine theory***	A. Demonstrate an understanding of machines and mechanism structure and principles of motion B. Identify and explain basic principles of internal combustion engines. C. Explain basic principles of kinematics and dynamics of mechanisms D. Explain synthesis of linkage E. Apply knowledge of kinematics and dynamics of mechanisms to linkage systems, reciprocating engines, and industrial machinery		A. B. C. D. E.	
FA-ENMS02 ***Demonstrate knowledge of machine design***	A. Identify different machine elements (e.g., gears, cam mechanisms, linkages, belt drives) in motion and their components B. Identify machine elements (e.g., springs, flywheels, clutches, brakes) that absorb and store energy C. Understand and utilize ISO Drawing standards for machine components and assembly D. Calculate mechanical advantage of screws and bolts using thread, pitch, and diameter E. Design, build and test a machine utilizing multiple machine elements and components that also meets safety requirements F. Install and align power transmission systems and troubleshoot for problems and inefficiencies	A. B.	C. D. E.	F.

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMS03 ***Apply product development and design process from problem identification to final presentation***	A. Apply technology to create a preliminary design of a product concept utilizing drawing, computer software (graphic or CAD), and/or conceptual model fabrication techniques B. Document final design, optimization, and final presentation of a product C. Compare conceptual, physical and mathematical design models used to check design D. Understand and apply research methodologies as a means to identify a need, problem, or opportunity for a new product, product line, system design, or service E. Understand and apply various ideation techniques to develop ideas and concepts, test the effects of various parameters, and assess the efficiency and effectiveness of production F. Apply various two-dimensional (2-D) graphic and/or three-dimensional (3-D) modeling techniques to development concepts G. Conduct model documentation of the process of recording details such as size and the material development process	A. B. C. D. E. F.	G.	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMS04 ***Use computer-aided Drafting and Modeling to illustrate the design of projects and components***	A. Apply manufacturing processes to computer-aided modeling (e.g., casting, molding, forming, separating, conditioning, assembling, finishing, rapid prototyping, 3-D printing) B. Evaluate a sketch and generate a model utilizing three-dimensional modeling C. Translate a three-dimensional drawing or model into corresponding orthographic D. Create and interpret auxiliary views, orthographic projections, isometric drawings, oblique drawings, and perspective drawings E. Perform part manipulation during the creation of an assembly model F. Compare conceptual, physical and mathematical design models used to check design G. Analyze assembly, successfully construct an assembly drawing, and use libraries and subassemblies effectively during the assembly modeling process H. Apply tolerancing techniques and dimensioning to the computer aided design process I. Add technical elements (e.g., parts lists, titles, finishes, tolerances, specifications, hidden surfaces) to drawings J. Evaluate a model for design imperfections and the accuracy of mass properties calculations	A. B. C. D. E. F.	G. H. I. J.	
FA-ENMS05 ***Understand fundamental principles of basic mechanical and power systems***	A. Distinguish between the six simple machines, their attributes, and components B. Calculate work, power, and torque C. Define terminology used to describe machines (e.g., work, power, torque, horsepower, watts, etc.) and demonstrate the ability to perform basic calculations D. Define different types of energy (i.e., potential and kinetic) and categorize the major forms it may take, such as thermal, radiant, nuclear, chemical, electrical, mechanical, fluid). Determine efficiency in a mechanical system and calculate mechanical advantage and drive ratios	A.	B. C. D.	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMS06 ***Demonstrate knowledge of fundamental automating manufacturing systems***	A. Define industry standard vocabulary (i.e., CAD, CAM, CIM, CNC) B. Differentiate between digital and analog devices C. Identify and explain various types of electrical motors D. Demonstrate ability to program using timers, counters, and loops E. Interface output devices to a computer, microcontroller, or programmable logic controller F. Choose appropriate machine control inputs and outputs, based on the need of a technologic system G. Plan, design, and construct an automated system, using computer hardware and software H. Identify components needed to integrate computer controls for an automated system I. Define open and closed loop systems and their uses to solve a technologic problem	A. B. C.	D. E. F. G. H. I.	
FA-ENMS07 ***Demonstrate knowledge of fluid dynamics***	A. Identify the advantages and disadvantages of using fluid power systems and the safety concerns of working with liquids and gasses under pressure B. Identify and define the components of fluid systems C. Define fluid systems (e.g., hydraulic, pneumatic, vacuum, etc.) and understand basic concepts of the science of fluids in motion D. Demonstrate proper setup and adjustment of a fluid power system E. Calculate velocity, pressure, density, and temperature as functions in space and time F. Analyze and solve mechanical engineering problems in solid and fluid mechanics and dynamics	A.	B. C. D. E. F.	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMS08 ***Demonstrate knowledge of thermal dynamics***	A. Understand concepts of conservation of energy in processes, direction of spontaneous change, limited efficiency in converting heat into useful power, and trade-offs between equilibrium thermodynamics and kinetics when designing processes B. Understand and apply the First Law of Thermodynamics to mechanical systems engineering applications C. Understand and apply the Second Law of Thermodynamics to mechanical systems engineering applications D. Understand how to estimate the thermodynamic properties under various process conditions E. Use equation of state to model fluids and calculate thermodynamic properties of fluids		A. ■ B. ■ C. ■ D. ■ E. ■	
FA-ENMS09 ***Demonstrate knowledge of statics and dynamics in mechanical systems***	A. Create free-body diagrams to analyze forces on a rigid body. Calculate the support reactions on a two or three-dimensional rigid body B. Use the method of joints and the method of sections to solve for the internal forces in members of a truss C. Use force and acceleration methods to analyze motion of a rigid body D. Use work and energy methods to analyze motion of a rigid body E. Use impulse and momentum methods to analyze motion of a rigid body		A. ■ B. ■ C. ■ D. ■ E. ■	
FA-ENMS10 ***Analyze the strengths of materials***	A. Describe the various forms of stress (i.e., compression, tension, torque, and shear) B. Differentiate between scalar and vector quantities; determine the magnitude, direction, and sense of a vector; and calculate the X and Y components and determine the resultant vector C. Calculate material properties relating to a stress strain curve D. Analyze the principles of statics and dynamics to calculate the strength of various engineering materials used to build a structure E. Calculate moment forces given a specified axis F. Use equations of static equilibrium to calculate unknown forces		A. ■ B. ■ C. ■ D. ■ E. ■ F. ■	

Code and Knowledge and Skill Statement	Suggested Performance Indicators	Foundational	Intermediate	Advanced
FA-ENMS11 ***Demonstrate an understanding of quality assurance and continuous improvement***	A. Understand principle of total quality control for maximization of product effectiveness B. Explain how corrective action plans address quality problems and how functions of process management and quality assurance relate to one another C. Understand inspection sampling, human factors in quality control, quality cost analysis, and quality audits D. Measure, weigh, and visually inspect machine parts, using the appropriate instrumentation to measure tolerances as required in the engineering drawings E. Describe and explain the three different types of data that are important to controlling the manufacturing of a product (i.e., product output data, quality control data, labor data) F. Define, understand, and apply concepts of quality control, statistical process control, statistical methods for continuous improvement, reliability theories, assessment, and prediction G. Discuss quality control standards (e.g., Six Sigma, TQM, ISO, ANSI, etc.)	A.	B. C. D. E. F. G.	