Program of Study Guide: Engineering - DRAFT

Comprehensive guidelines and course standards for the Engineering pathway

Office of College and Career Readiness

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Table of Contents

Document Control Information

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DOCUMENT HISTORY

Document Version	Date	Summary of Change
1.0	October 2024	Initial Document
1.1	January 2025	Standards Reviewed by OCCP Leadership. Course descriptions reviewed and shortened. LMI data verified and updated. IRC selections reviewed and confirmed.

Purpose

The purpose of this document is to communicate the required Career and Technical Education (CTE) academic standards for the Engineering Program of Study. The academic standards in this document are theoretical and performance based. The standards contain content from multiple state departments of education, the College Board, and The Standards for Technological and Engineering Literacy (STEL) and have been reviewed and vetted by members of the Maryland business and industry community.

In addition to academic standards, the Maryland State Department of Education (MSDE) has incorporated into this document Labor Market Information (LMI) definitions and explanations for the Program of Study; program aligned Industry Recognized Credentials; and Work-Based Learning resources and requirements by course level.

This document is intended for use by educational administrators and practitioners. A similar document is available for each state-approved CTE Program of Study.

Standards Sources

These sources collectively guide the standards for Engineering I-III Course Standards, ensuring alignment with national education frameworks, industry-recognized certifications, and security standards essential for developing a skilled cybersecurity workforce.

1. **Standards for Technological and Engineering Literacy (STEL)**
   A. **Source:** International Technology and Engineering Educators Association (ITEEA)
   B. **Purpose:** The Standards for Technological and Engineering Literacy distills this broad field into a set of essential knowledge, skills, and abilities (the eight core disciplinary standards and associated benchmarks) that are widely applicable across a range of technology and engineering contexts and that incorporate acknowledged technology and engineering practices. These are described more fully in the five chapters of STEL.
   C. **Relevance:** The Standards for Technological and Engineering Literacy presents the information that students should know and be able to do in order to achieve a high level of technological and engineering literacy. In other words, the standards prescribe the outcomes for the study of technology and engineering in Grades PreK-12.
   D. **Access:** Standards for Technological and Engineering Literacy: STEL

2. **Autodesk Certifications**
   A. **Source:** Autodesk
   B. **Purpose:** Autodesk certifications: ACU (Autodesk Certified User in Inventor, Autodesk Certified User in AutoCAD, Autodesk Certified User in Revit, Autodesk Certified User in Fusion 360) provide industry-standard benchmarks for technical skills in 3D design for engineering and alignment with current job roles and practices in the field.
   C. **Relevance:** Engineering I and II course standards align with Autodesk Certified User in Inventor and AutoCAD, ensuring students gain foundational skills in the 3D design and the Engineering Design Process. Engineering III and IV align with advanced certifications such as Autodesk Certified User in Revit and Fusion 360, providing higher-level skills in design, layout, and manufacturing.
   D. **Access:** Autodesk Certifications: https://www.autodesk.com/certification/overview

3. **National Career Cluster Framework – Advanced Manufacturing Cluster**
   A. **Source:** Advance CTE
   B. **Purpose:** The National Career Cluster Framework provides a structure for organizing career and technical education (CTE) around 14 clusters, including Advanced Manufacturing, to promote skill development for specific industry sectors.
   C. **Relevance:** The Advanced Manufacturing Career Cluster blends innovative technologies and practices to enhance design and production. It covers areas such as engineering, research and development, automation and artificial intelligence, equipment maintenance, safety protocols, and quality control. This Cluster aims to increase efficiency, reduce waste, ensure safety, and produce high-quality goods, driving the industry’s growth and adapting to modern demands.
   D. **Access:** Advance CTE Career Clusters: https://careertech.org/career-clusters

4. **Certified CAD Design Associate/Certified SolidWorks Associate (CWSA)**
   A. **Source:** SolidWorks
   B. **Purpose:** The Certified SolidWorks Associate (CSWA) certification serves as a foundational credential for individuals new to CAD software, particularly SolidWorks. It assesses essential

skills in part and assembly modeling, 2D sketching, and the application of geometric and dimensional constraints. This certification is designed to validate a candidate's ability to navigate and utilize SolidWorks tools effectively, providing a solid basis for further exploration and learning in the field of engineering design.

C. **Relevance:** For engineering students, the CSWA certification is highly relevant as it enhances their technical skill set and makes them more competitive in the job market. By earning this credential, students demonstrate their commitment to mastering CAD software, which is widely used in various engineering disciplines. Furthermore, the CSWA serves as a steppingstone to more advanced certifications, such as the Certified SolidWorks Professional (CSWP), helping students build a robust portfolio that aligns with industry expectations and improves their prospects for internships and employment opportunities in engineering.

D. **Access:** SolidWorks Certifications: https://www.solidworks.com/certifications/mechanical-design-cswa-mechanical-design

Course Descriptions

Course Level	Course Information	Description
Required Core: Course 1	**Engineering I** **SCED:** <XX> **Grades:** 9-12 **Prerequisite:** None **Credit:** 1	Engineering I introduces students to core engineering principles, focusing on the design process, computer-aided design (CAD) with Autodesk Inventor, materials science, and basic manufacturing. Through hands-on projects and real-world problem-solving, students gain CAD proficiency, explore engineering careers, and build employability skills. The course integrates academic concepts into practical applications, preparing students for industry certifications like the Autodesk Certified User in Inventor.
Required Core: Course 2	**Engineering II** **SCED:** <XX> **Grades:** 10-12 **Prerequisite:** Engineering I **Credit:** 1	Engineering II builds on Engineering I, delving into advanced mechanics, statics, dynamics, and materials analysis. Students tackle complex projects, create and test 3D models using advanced CAD software, and develop problem-solving and analytical skills. Emphasizing teamwork and real-world challenges, the course includes interdisciplinary projects and prepares students for industry-recognized certifications to enhance career readiness.
Optional Flex: Course 1	**Engineering III** **SCED:** <XX> **Grades:** 11-12 **Prerequisite:** Engineering II **Credit:** 1	Engineering III explores specialized fields like electrical systems, thermodynamics, and integrated design. Students engage in hands-on projects involving circuit design, energy systems, and heat transfer, integrating mechanical and electrical components. Emphasizing creativity, teamwork, and project management, the course prepares students for advanced engineering topics and industry certifications.
Optional Flex: Course 3	**Career Connected Learning I** **SCED:** <XX> **Grades:** 11-12	This flexible, work-based learning course introduces students to real-world applications of classroom knowledge and technical skills through on-the-job experiences and reflective practice.

Course Level	Course Information	Description
	Prerequisite: None **Credits:** 1-3	Students engage in career exploration, skill development, and professional networking by participating in youth apprenticeships, registered apprenticeships, pre-apprenticeships, internships, capstone projects, or other approved career-connected opportunities. Variable credit (1–3) accommodates the required on-the-job training hours and related instruction. By integrating industry standards, employability skills, and personalized learning goals, Career Connected Learning I equips students to make informed career decisions, develop a professional portfolio, and build a strong foundation for success in postsecondary education, training, or the workforce.
Optional Flex: Course 4	**Career Connected Learning II** **SCED:** <XX> **Grades:** 11-12 **Prerequisite:** Career Connected Learning I **Credits:** 1-3	Building on the foundational experiences of Career Connected Learning I, this advanced work-based learning course provides students with deeper on-the-job practice, leadership opportunities, and refined career exploration. Students continue to enhance their technical and professional skills, expanding their industry networks and aligning personal goals with evolving career interests. Variable credit (1–3) remains aligned with the required training hours and related instruction. Through elevated responsibilities and skill application, Career Connected Learning II prepares students to confidently transition into higher-level postsecondary programs, apprenticeships, or the workforce.

Dual Enrollment and Career Connected Learning Experiences Must be Aligned to the CTE Core.

Industry-Recognized Credentials and Work-Based Learning

Industry-Recognized Credentials: The standards in this document are aligned to the following certifications:
By the end of Engineering I: Autodesk Certified User in Inventor **By the end of Engineering II:** Autodesk Certified User in AutoCAD, Revit, or Fusion 360 **By the end of Engineering III:** Optional Credentials (via the Flex Course options): Certified SolidWorks Associate

Work-based Learning Resources		
Engineering I: **Career Awareness**	**Engineering II:** **Career Preparation**	**Flex Courses:** **Career Preparation**
• Industry Visits • Guest Speakers • Participation in Career and Technical Student Organizations • Postsecondary Visits – Program Specific Site Tours • Mock Interviews	• All of Career Awareness plus the following: • Job Shadow • Paid and Unpaid Internships	• Paid and Unpaid Internships • Youth Apprenticeships • Registered Apprenticeships

Labor Market Information: Definitions and Data

Labor market information (LMI) plays a crucial role in shaping Career and Technical Education (CTE) programs by providing insights into industry demands, employment trends, and skills gaps. This data helps education leaders assess the viability of existing programs and identify opportunities for new offerings. By aligning CTE programs with real-time labor market needs, schools can better prepare students for in-demand careers and ensure that resources are effectively utilized to support pathways that lead to high-quality, sustainable employment.

Standard Occupational Code (SOC) and Aligned Industry:

Indicator	Definition	Pathway Labor Market Data
High Wage[1]	Those occupations that have a 25th percentile wage equal to or greater than the most recent MIT Living Wage Index for one adult in the state of Maryland, and/or leads to a position that pays at least the median hourly or annual wage for the DC-VA-MD-WV Metropolitan Statistical Area (MSA). *Note: A 25th percentile hourly wage of $24.74 or greater is required to meet this definition.*	**Standard Occupational Classification (SOC) Code** 11-9041 - Architectural and Engineering Managers 17-2051 - Civil Engineers 17-3022 - Civil Engineering Technologists and Technicians 17-2071 - Electrical Engineers 17-2081 - Environmental Engineer **Hourly Wage/Annual Salary:** 25th Percentile: $44.36 / $92,258.51 50th Percentile: $57.30 / $119,187.25 75th Percentile: $67.20 / $139,777.98
High Skill	Those occupations located within the DC-VA-MD-WV Metropolitan Statistical Area (MSA) with the following education or training requirements: completion of an apprenticeship program; completion of an industry-recognized certification or credential; associate's degree, bachelor's degree, or higher.	**Typical Entry-Level Education:** Bachelor's degree in engineering or a related field (e.g., mechanical, civil, electrical, chemical engineering). **Additional Requirements**: Many positions may require a Professional Engineer (PE) license, which necessitates passing the Fundamentals of Engineering (FE) exam and gaining relevant work experience.
In-Demand	Annual growth plus replacement, across all Maryland occupations, is 405 openings between 2024-2029.	**Annual Openings:** 1,142

[1] Living Wage Calculator: https://livingwage.mit.edu/states/24

Labor Market Information Data Source

Lightcast Q4 2024 Data Set. Lightcast occupation employment data are based on final Lightcast industry data and final Lightcast staffing patterns. Wage estimates are based on Occupational Employment Statistics (QCEW and Non-QCEW Employees classes of worker) and the American Community Survey (Self-Employed and Extended Proprietors). Occupational wage estimates are also affected by county-level Lightcast earnings by industry. Foundational data for the state of Maryland is collected and reported by the Maryland Department of Labor.

Methodology for High Wage Calculations

To combine labor market data across multiple Standard Occupational Classifications (SOCs), a weighted average approach was used to ensure accurate representation of the marketplace. Median wages for each SOC were weighted based on their respective employment levels, reflecting the relative demand for each occupation. This method ensures that occupations with higher employment contribute proportionately to the overall wage calculation. Additionally, job openings from all relevant SOCs were summed to determine the total projected demand. For example, if Mechanical Engineers account for 67% of total employment and Electrical Engineers for 33%, their respective wages are weighted accordingly, and job openings are aggregated to provide a comprehensive view of labor market opportunities. This approach delivers a balanced and accurate representation of both wages and employment demand for the program.

Methodology for In-Demand Calculations

The baseline for annual job openings, taking into account new positions and replacement positions, was determined by taking the average of all annual job openings between 2024 and 2029 across all 797 career sectors at the 5-digit SOC code level. For the 2024-2029 period, average job openings (growth + replacement) is 405.

Course Standards: Engineering I

1. **General requirements.** This course is recommended for students in Grades 9-12. Students shall be awarded one credit for successfully completing this course.

2. **Introduction.**
   A. Career and Technical Education (CTE) instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions.
   B. The Advanced Manufacturing Cluster emphasizes developing a skilled workforce in manufacturing and engineering fields. This cluster prepares students for careers that involve designing, creating, and maintaining systems and processes in manufacturing, utilizing modern technologies and engineering principles.
   C. The Engineering program of study emphasizes careers and educational pathways related to the design, development, and optimization of engineering systems and processes. This includes disciplines such as mechanical, electrical, civil, and industrial engineering. The Engineering program of study covers essential topics such as the engineering design process, materials science, manufacturing techniques, and systems analysis. Students will engage in projects that involve problem-solving and critical thinking to address real-world challenges in engineering, preparing them for careers in various industries and equipping them with the skills needed to innovate and improve engineering solutions.
   D. Engineering I introduces students to core engineering principles, focusing on the design process, computer-aided design (CAD) with Autodesk Inventor, materials science, and basic manufacturing. Through hands-on projects and real-world problem-solving, students gain CAD proficiency, explore engineering careers, and build employability skills. The course integrates academic concepts into practical applications, preparing students for industry certifications like the Autodesk Certified User in Inventor.
   E. Students will participate in at least two Career-Connected Education and Work-Based Learning experiences in this course, which might include informational interviews or job shadowing relevant to the program of study.
   F. Students are encouraged to participate in extended learning experiences through aligned Career and Technical Student Organizations (CTSOs). CTSOs are a cocurricular requirement in the Carl D. Perkins Act, and alignment to CTSO activities is an expectation for CTE programs in the state of Maryland.

3. **Knowledge and Skills.**
   A. **The student demonstrates the necessary skills for career development, maintenance of employability, and successful completion of course outcomes. The student is expected to:**
      1. Identify and demonstrate positive work behaviors that enhance employability and job advancement, such as regular attendance, promptness, proper attire, maintenance of a clean and safe work environment, and pride in work.
      2. Demonstrate positive personal qualities such as flexibility, open-mindedness, initiative, active listening, and a willingness to learn.
      3. Employ effective reading, writing, and technical documentation skills.
      4. Solve problems using critical thinking techniques and structured troubleshooting methodologies.
      5. Demonstrate leadership skills and collaborate effectively as a team member.

6. Implement safety procedures, including proper handling of equipment and following engineering guidelines.
7. Exhibit an understanding of legal and ethical responsibilities in the engineering field, following intellectual property laws and best practices for engineering and design.
8. Demonstrate time-management skills and the ability to prioritize tasks in a technical setting.

B. **The student identifies various career pathways in the engineering field. The student is expected to:**
1. Develop a career plan that includes the necessary education, certifications, job skills, and experience for specific roles in engineering design.
2. Create a professional resume and portfolio that reflect skills, projects, certifications, and recommendations.
3. Demonstrate effective interview skills for roles in engineering and technology.

C. **The student develops technology and digital literacy skills. The student is expected to:**
1. Use technology as a tool for research, organization, communication, and problem-solving.
2. Use digital tools, including computers, mobile devices, collaboration platforms, and cloud services, to access, manage, and create information.
3. Demonstrate proficiency in using emerging and industry-standard technologies, including data visualization tools, CAD software, robotics and other hardware, and programming applications.
4. Understand ethical and legal considerations for technology use, including the principles of data protection, copyright, and responsible technology use.

D. **The student integrates core academic skills into engineering practices. The student is expected to:**
1. Demonstrate the use of clear communication techniques, both written and verbal, that are consistent with industry standards.
2. Apply mathematical concepts such as scale-drawing, isometric and geometric drawings, spatial recognition, and standard algebraic techniques.
3. Use scientific principles, such as the engineering design process, position, speed, acceleration principles, and sustainability practices.

E. **The student demonstrates the necessary skills to understand and operate engineering systems. The student is expected to:**
1. Identify and describe the functions of key engineering system components, including mechanical parts (gears, motors), electrical components (resistors, capacitors, ICs), and software interfaces (CAD, simulation tools).
2. Perform basic installation, configuration, and troubleshooting of engineering systems in line with industry standards, including setting up design software, testing equipment, and machine tools.
3. Demonstrate the ability to install and configure relevant software and firmware, focusing on updates, calibration, and compatibility testing for engineering systems.
4. Explain the importance of and perform regular maintenance and upgrades on engineering systems, including hardware (e.g., mechanical tools) and software (e.g., simulation or design software), to ensure optimal performance and reliability.

F. **The student demonstrates the necessary skills to design, configure, and manage engineering systems and environments. The student is expected to:**

1. Understand basic engineering principles such as force, motion, and energy, and apply this knowledge to system design and troubleshooting.
2. Configure and troubleshoot mechanical, electrical, and software systems used in engineering applications, adhering to safety standards and operational protocols.
3. Apply fundamental principles of engineering system security, including safety protocols, equipment safeguards, and ensuring system reliability through design.
4. Demonstrate the ability to set up and secure engineering environments, including laboratory setups, ensuring equipment safety, and applying industry best practices for efficient system performance.

G. **The student demonstrates the necessary skills to implement fundamental engineering practices for protecting systems and data. The student is expected to:**

1. Describe common risks and vulnerabilities in engineering systems, including equipment failure, material degradation, and design flaws, and apply mitigation strategies.
2. Implement basic security measures for engineering systems, such as physical safeguards for equipment, secure design protocols, and redundancy planning.
3. Demonstrate knowledge of access controls and system permissions for engineering software, design files, and collaborative platforms used in engineering projects.
4. Conduct basic risk assessments and apply strategies to prevent failures and ensure operational continuity in engineering systems, using hazard analysis and fault tolerance methods.

H. **The student demonstrates the necessary skills to manage and troubleshoot engineering system issues in a professional environment. The student is expected to:**

1. Identify and troubleshoot common engineering system issues (mechanical, electrical, software) using systematic diagnostic methods, including tests, simulations, and real-time observations.
2. Document technical issues, troubleshooting steps, and solutions in professional reports, adhering to industry documentation practices such as technical drawings, schematic updates, and logbooks.
3. Demonstrate using technical support tools, such as diagnostic equipment (multimeters, oscilloscopes) and simulation software, to resolve engineering system issues.
4. Apply professional communication skills in troubleshooting and customer support scenarios, practicing clear reporting, teamwork, and problem-solving in an engineering context.

I. **The student integrates core academic skills into engineering practice. The student is expected to:**

1. Demonstrate clear communication techniques, both written and verbal, consistent with industry standards, including technical reports, presentations, and collaboration in team settings.
2. Apply mathematical concepts such as algebra, trigonometry, and calculus in system analysis, design, and troubleshooting, including force, power, voltage, and material stress calculations.
3. Use scientific principles, such as thermodynamics, fluid dynamics, and materials science, to design, test, and optimize engineering systems and components.

Course Standards: Engineering II

1. **General requirements.** This course is recommended for students in Grades 9-12. Students shall be awarded one credit for successfully completing this course.

2. **Introduction.**
   A. Career and Technical Education (CTE) instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions.
   B. The Advanced Manufacturing Cluster emphasizes developing a skilled workforce in manufacturing and engineering fields. This cluster prepares students for careers that involve designing, creating, and maintaining systems and processes in manufacturing, utilizing modern technologies and engineering principles.
   C. The Engineering program of study emphasizes careers and educational pathways related to the design, development, and optimization of engineering systems and processes. This includes disciplines such as mechanical, electrical, civil, and industrial engineering. The Engineering program of study covers essential topics such as the engineering design process, materials science, manufacturing techniques, and systems analysis. Students will engage in projects that involve problem-solving and critical thinking to address real-world challenges in engineering, preparing them for careers in various industries and equipping them with the skills needed to innovate and improve engineering solutions.
   D. Engineering II builds on Engineering I, delving into advanced mechanics, statics, dynamics, and materials analysis. Students tackle complex projects, create and test 3D models using advanced CAD software, and develop problem-solving and analytical skills. Emphasizing teamwork and real-world challenges, the course includes interdisciplinary projects and prepares students for industry-recognized certifications to enhance career readiness.
   E. Students will participate in at least two Career-Connected Education and Work-Based Learning experiences in this course, which might include informational interviews or job shadowing relevant to the program of study.
   F. Students are encouraged to participate in extended learning experiences through aligned Career and Technical Student Organizations (CTSOs). CTSOs are a cocurricular requirement in the Carl D. Perkins Act, and alignment to CTSO activities is an expectation for CTE programs in the state of Maryland.

3. **Knowledge and Skills.**
   A. **The student demonstrates the necessary skills for career development, maintenance of employability, and successful completion of course outcomes. The student is expected to:**
      1. Identify and demonstrate positive work behaviors that enhance employability and job advancement, such as regular attendance, promptness, professional attire, and maintenance of a clean and safe work environment.
      2. Demonstrate positive personal qualities such as initiative, flexibility, teamwork, active listening, and a willingness to learn in engineering contexts.
      3. Employ effective written and verbal communication skills, including technical documentation, project reports, and design presentations consistent with industry standards.
      4. Solve engineering problems using critical thinking and structured troubleshooting methodologies, focusing on complex systems and processes.
      5. Demonstrate leadership skills in managing engineering projects, including team coordination, task delegation, and collaborative problem-solving.

6. Implement safety procedures related to mechanical, electrical, and software tools, ensuring adherence to safety protocols, including proper equipment handling and use of personal protective equipment (PPE).
7. Exhibit an understanding of legal and ethical responsibilities in engineering, including adherence to industry regulations, intellectual property rights, and environmental impact assessments.
8. Demonstrate time-management skills and the ability to prioritize tasks efficiently, especially when working on multi-phase engineering projects.

B. **The student identifies various career pathways in the engineering field. The student is expected to:**
   1. Develop a career plan that includes the necessary education, certifications, job skills, and experience for specific roles in engineering design, manufacturing, or system integration.
   2. Create a professional resume and portfolio that reflects engineering projects, certifications, skills, and academic achievements, showcasing technical proficiency and hands-on experience.
   3. Demonstrate effective interview skills for engineering roles, including preparation, articulation of project work, and communication of technical expertise.

C. **The student develops technology and digital literacy skills. The student is expected to:**
   1. Use technology as a tool for research, organization, communication, and problem-solving.
   2. Use digital tools and platforms, including cloud-based services, simulation software, and engineering applications, to access, manage, and create engineering designs and project documentation.
   3. Demonstrate proficiency in using emerging and industry-standard technologies relevant to engineering fields, such as robotics, automation, additive manufacturing (3D printing), and IoT (Internet of Things) systems.
   4. Use advanced CAD tools (e.g., SolidWorks, Fusion 360) for 3D modeling, assembly design, and simulation, applying digital technology to solve engineering problems.
   5. Understand ethical and legal considerations for technology use, including data protection, design ownership, and the environmental implications of engineering projects.

D. **The student integrates core academic skills into networking practices. The student is expected to:**
   1. Demonstrate the use of clear communication techniques, both written and verbal, that align with engineering project standards, including technical reports, design presentations, and project documentation.
   2. Apply mathematical concepts such as calculus, linear algebra, and geometry in the analysis and design of engineering systems, including stress analysis, material properties, and system optimization
   3. Use scientific principles, including thermodynamics, fluid mechanics, and electrical principles, in the design and analysis of engineering systems and projects

E. **The student demonstrates the necessary skills to design, manage, and implement advanced engineering systems. The student is expected to:**
   1. Design and implement complex engineering systems, such as automation systems, advanced robotics, and integrated mechanical-electrical systems, to solve real-world engineering challenges.

2. Configure and troubleshoot sophisticated systems by applying advanced engineering principles, including control systems, electrical circuits, and embedded systems, to ensure system efficiency and performance.
3. Utilize advanced materials and manufacturing techniques, such as composite materials, CNC machining, and rapid prototyping, to create functional prototypes and finished products. Apply techniques for optimizing network performance and securing network traffic.
4. Apply optimization techniques for system performance, efficiency, and cost-effectiveness, including energy management and resource allocation.

F. **The student demonstrates the necessary skills to integrate and manage engineering systems. The student is expected to:**

1. Integrate multiple engineering disciplines (mechanical, electrical, software) into cohesive, functioning systems that meet design specifications and operational requirements.
2. Configure and troubleshoot complex systems such as PLCs (Programmable Logic Controllers), automation networks, and sensor systems, adhering to industry standards.
3. Use advanced project management software to plan, track, and manage engineering projects, ensuring deadlines, budgets, and quality standards are met.
4. Apply techniques for improving system integration, ensuring seamless interaction between hardware, software, and user interfaces.

G. **The student demonstrates the necessary skills to implement and assess the sustainability of engineering solutions. The student is expected to:**

1. Design engineering solutions that minimize environmental impact, incorporating sustainable materials, energy-efficient processes, and waste reduction techniques.
2. Apply lifecycle analysis to assess the environmental and economic sustainability of engineering projects, including sourcing, manufacturing, usage, and disposal stages.
3. Integrate renewable energy solutions into engineering designs, exploring solar, wind, and other green technologies for reducing carbon footprints.
4. Analyze regulatory compliance and implement sustainable practices in accordance with industry standards, such as LEED (Leadership in Energy and Environmental Design) certification and ISO environmental standards.

H. **The student demonstrates the necessary skills to assess and improve engineering system reliability. The student is expected to:**

1. Conduct reliability analysis on engineering systems, using methods like Failure Modes and Effects Analysis (FMEA) and fault tree analysis (FTA).
2. Implement strategies to enhance system reliability, such as redundancy, fault-tolerant design, and predictive maintenance technologies.
3. Apply statistical methods such as regression analysis and quality control techniques (e.g., Six Sigma) to improve system performance and reduce failures.
4. Design and implement testing protocols for validating the reliability of engineering systems and products, including stress testing, performance testing, and environmental testing.

I. **The student integrates core academic skills into advanced engineering practices. The student is expected to:**

1. Demonstrate effective communication skills in documenting and presenting engineering solutions, including detailed reports, project proposals, and design reviews.
2. Apply advanced mathematical and computational techniques such as optimization, numerical methods, and simulations to solve complex engineering problems.

3. Use scientific and experimental methods in engineering research, including hypothesis testing, experimental design, and data analysis, to inform system improvements and innovations.

Course Standards: Engineering III

1. **General requirements.** This course is recommended for students in Grades 9-12. Students shall be awarded one credit for successfully completing this course.

2. **Introduction.**
   A. Career and Technical Education (CTE) instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions.
   B. The Advanced Manufacturing Cluster emphasizes developing a skilled workforce in manufacturing and engineering fields. This cluster prepares students for careers that involve designing, creating, and maintaining systems and processes in manufacturing, utilizing modern technologies and engineering principles.
   C. The Engineering program of study emphasizes careers and educational pathways related to the design, development, and optimization of engineering systems and processes. This includes disciplines such as mechanical, electrical, civil, and industrial engineering. The Engineering program of study covers essential topics such as the engineering design process, materials science, manufacturing techniques, and systems analysis. Students will engage in projects that involve problem-solving and critical thinking to address real-world challenges in engineering, preparing them for careers in various industries and equipping them with the skills needed to innovate and improve engineering solutions.
   D. Engineering III explores specialized fields like electrical systems, thermodynamics, and integrated design. Students engage in hands-on projects involving circuit design, energy systems, and heat transfer, integrating mechanical and electrical components. Emphasizing creativity, teamwork, and project management, the course prepares students for advanced engineering topics and industry certifications.
   E. Students will participate in at least two Career-Connected Education and Work-Based Learning experiences in this course, which might include informational interviews or job shadowing relevant to the program of study.
   F. Students are encouraged to participate in extended learning experiences through aligned Career and Technical Student Organizations (CTSOs). CTSOs are a cocurricular requirement in the Carl D. Perkins Act, and alignment to CTSO activities is an expectation for CTE programs in the state of Maryland.

3. **Knowledge and Skills.**
   A. **The student demonstrates the necessary skills for career development, maintenance of employability, and successful completion of course outcomes. The student is expected to:**
      1. Identify and demonstrate advanced work behaviors that enhance employability and job advancement, such as leadership in team settings, conflict resolution, effective decision-making, and ethical professionalism in engineering.
      2. Demonstrate initiative and critical thinking when solving complex engineering challenges, using innovative approaches and creative problem-solving.
      3. Prepare and present professional-level technical documentation, including comprehensive engineering reports, project proposals, and presentations, consistent with industry standards.
      4. Solve complex engineering problems by applying advanced critical thinking techniques, such as design thinking, systems thinking, and simulation modeling.

5. Exhibit leadership skills in leading interdisciplinary engineering projects, including managing diverse teams, setting goals, and guiding projects through completion.
6. Adhere to strict safety protocols in both physical and digital environments, including safe handling of advanced machinery, tools, and adherence to cybersecurity measures in collaborative engineering platforms.
7. Understand and apply ethical decision-making principles in the context of engineering design, ensuring that projects meet social, environmental, and regulatory standards.
8. Demonstrate advanced time-management skills, prioritizing tasks efficiently, managing long-term projects, and meeting deadlines in a professional engineering context.

B. **The student identifies various advanced career pathways in the engineering field. The student is expected to:**
   1. Develop a detailed career plan that outlines the necessary education, certifications, work experience, and skills required for specific engineering roles, such as systems engineer, automation specialist, or manufacturing manager.
   2. Create a polished professional resume and portfolio, highlighting in-depth project work, leadership experience, industry certifications, and specific technical skills developed throughout their engineering education.
   3. Demonstrate advanced interview skills for high-level engineering roles, emphasizing project management experience, technical expertise, and teamwork in professional settings.

C. **The student develops advanced technology and digital literacy skills. The student is expected to:**
   1. Use technology as a tool for research, organization, communication, and problem-solving.
   2. Use digital tools, including computers, mobile devices, collaboration platforms, and cloud services, to access, manage, and create information.
   3. Demonstrate proficiency in emerging technologies relevant to high-level engineering, including Internet of Things (IoT), artificial intelligence (AI), machine learning, and smart manufacturing systems.
   4. Understand ethical and legal considerations for technology use in advanced engineering, including data privacy, intellectual property rights, and the environmental impact of emerging technologies.

D. **The student integrates core academic skills into engineering practices. The student is expected to:**
   1. Apply advanced communication techniques, both written and verbal, that are consistent with industry standards, including drafting clear technical specifications, user manuals, and formal presentations to diverse audiences.
   2. Apply mathematical concepts such as calculus, linear algebra, and geometry in the analysis and design of engineering systems, including stress analysis, material properties, and system optimization
   3. Apply scientific principles in designing, testing, and refining engineering systems, focusing on advanced materials science, thermodynamics, and electromagnetism to enhance system performance and efficiency.

E. **The student demonstrates the necessary skills to design, manage, and implement complex engineering systems. The student is expected to:**
   1. Design and implement advanced engineering systems, such as autonomous robots, smart cities infrastructure, or integrated mechatronics systems, addressing specific engineering challenges with multi-disciplinary approaches.
   2. Optimize system performance by applying advanced principles of system integration, design for manufacturability (DFM), and design for assembly (DFA), ensuring projects meet both functional and budgetary constraints.
   3. Manage complex projects using project management methodologies like Agile, Scrum, or Lean, including the use of Gantt charts, risk analysis, and project tracking tools to ensure timely and efficient delivery of engineering solutions.
   4. Apply advanced prototyping techniques such as 3D printing, CNC machining, and virtual prototyping to quickly develop, test, and refine engineering designs.

F. **The student demonstrates the necessary skills to integrate and manage multi-disciplinary engineering systems. The student is expected to:**
   1. Integrate multiple engineering disciplines (e.g., mechanical, electrical, software, civil) into cohesive, high-functioning systems, ensuring interoperability between subsystems and optimizing overall system performance.
   2. Apply systems engineering methodologies to manage the design, development, and lifecycle of complex engineering projects, from initial concept to final deployment and operation.
   3. Utilize advanced simulation tools for virtual testing of systems, including predictive maintenance simulations, energy efficiency simulations, and system stress testing.

G. **The student demonstrates the necessary skills to assess and improve sustainability and ethical practices in engineering. The student is expected to:**
   1. Design engineering solutions with sustainability in mind, incorporating renewable energy technologies, low-impact materials, and energy-efficient designs to reduce environmental footprint.
   2. Apply lifecycle analysis tools to assess and optimize the environmental, economic, and social impacts of engineering designs and processes, including waste reduction and sustainable resource usage.
   3. Design systems for circularity, ensuring products are designed for reuse, recycling, or repurposing at the end of their life cycle, aligning with the principles of a circular economy.
   4. Evaluate regulatory compliance and ethical considerations regarding environmental protection, safety standards, and corporate social responsibility (CSR) in advanced engineering projects.

H. **The student demonstrates the necessary skills to assess and improve engineering system reliability and safety. The student is expected to:**
   1. Conduct reliability testing on engineering systems, including stress testing, failure analysis, and fault-tolerant design to ensure system integrity under varying conditions.
   2. Apply advanced safety engineering techniques, including hazard analysis (HAZOP), failure modes effects analysis (FMEA), and the development of emergency response plans for high-risk systems.

3. Design and implement predictive maintenance systems using sensor data, machine learning algorithms, and remote monitoring tools to prevent system failures before they occur.
4. Ensure product safety and performance by conducting rigorous testing and compliance with industry safety standards, such as ISO 9001, UL certification, and CE marking.

I. **The student integrates core academic skills into advanced engineering practices. The student is expected to:**
   1. Demonstrate advanced communication skills in documenting, presenting, and defending engineering solutions to both technical and non-technical audiences, including clients, stakeholders, and industry professionals.
   2. Apply advanced mathematical modeling and optimization techniques, such as Monte Carlo simulations, multi-objective optimization, and control theory, to solve complex engineering problems.
   3. Use scientific principles to inform and guide the development of new technologies, including material science innovations, advancements in nanotechnology, and cutting-edge aerospace or biomedical engineering research.

Career Connected Learning I and II

Career connected learning is an educational approach that integrates classroom instruction with real-world experiences, enabling high school students to explore potential careers and develop relevant skills before graduation. By participating in work-based learning opportunities—such as apprenticeships, internships, capstone projects, and school-based enterprises—students apply academic concepts in authentic settings, gain practical industry knowledge, and build professional networks. This hands-on engagement helps students connect their studies to future career paths, strengthens their problem-solving and communication skills, and supports a smoother transition into college, vocational programs, or the workforce.

All Career and Technical Education Programs of Study include aspects of work-based learning, and almost all of the programs include two Career Connected Learning (CCL) courses. The CCL standards can be found via this link: