Maryland CTE Programs of Study

Engineering III (2025)

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Introduction. 2

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. 2.A

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 solutions and processes in manufacturing, utilizing modern technologies and engineering principles. 2.B

C The Engineering program of study emphasizes careers and educational pathways related to the design, development, and optimization of engineering solutions 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 (used as a structured, iterative framework throughout projects), computational thinking, materials science, manufacturing techniques, and solutions analysis. Students engage in advanced projects that integrate scientific, technical, and ethical reasoning to address real- world engineering challenges. The program also emphasizes the societal, environmental, and ethical implications of engineering innovations and prepares students for careers across industries with the skills to lead responsibly and innovatively. Students will continue to examine societal impacts of engineering decisions, understand the role of ethics in effective decision- making, and develop essential professional skills such as communication and technical writing. 2.C

D Students engage in hands-on projects which can include, but are not limited to, circuit design, energy systems, and heat transfer, integrating mechanical and electrical components. Emphasizing creativity, teamwork, and project management, the course reinforces the systematic use of the engineering design process to solve complex problems. Students are also introduced to computational modeling, algorithmic design thinking, and human-centered engineering, developing both technical depth and ethical awareness. The course

Skip to main content

prepares students for advanced engineering topics, industry certifications, and critical engagement with global engineering issues. 2.D

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.** 2.E

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.** 2.F

Knowledge and Skills. 3

A **The student demonstrates the necessary skills for career development, maintenance of employability, and successful completion of course outcomes. The student is expected to:** 3.A

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. 3.A.1
2. Demonstrate initiative and critical thinking when solving complex engineering challenges, using innovative approaches and creative problem-solving. 3.A.2
3. Prepare and present professional-level technical documentation, including comprehensive engineering reports, project proposals, and presentations, consistent with industry standards. 3.A.3
4. Solve complex engineering problems by applying advanced critical thinking techniques, such as design thinking, systems thinking, and simulation modeling. 3.A.4
5. Exhibit leadership skills in leading interdisciplinary engineering projects, including managing diverse teams, setting goals, and guiding projects through completion. 3.A.5
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. 3.A.6
7. Understand and apply ethical decision-making principles in the context of engineering design, ensuring that projects meet social, environmental, and regulatory standards. 3.A.7
8. Demonstrate advanced time-management skills, prioritizing tasks efficiently, managing long-term projects, and meeting deadlines in a professional engineering context. 3.A.8
9. Apply computational thinking strategies, such as abstraction, decomposition, and algorithmic reasoning, to develop efficient engineering solutions. 3.A.9
10. Reflect on the societal consequences of engineering design decisions, using real-world case studies to inform ethical leadership in project development. 3.A.10

Skip to main content

The student identifies various advanced career pathways in the engineering field. The student is expected to: 3.B

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. 3.B.1
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.B.2
3. Demonstrate advanced communication skills for high-level engineering roles, emphasizing project management experience, technical expertise, and teamwork in professional settings. 3.B.3
4. Research and evaluate the ethical, environmental, and technological challenges facing emerging fields such as autonomous solutions, biotechnology, and climate-resilient infrastructure, connecting them to personal career interests. 3.B.4

C The student develops advanced technology and digital literacy skills. The student is expected to: 3.C

1. Use technology as a tool for research, organization, communication, and problem-solving. 3.C.1
2. Use digital tools, including computers, mobile devices, collaboration platforms, and cloud services, to access, manage, and create information. 3.C.2
3. Demonstrate proficiency in emerging technologies relevant to high-level engineering, such as Internet of Things (IoT), artificial intelligence (AI), machine learning, and smart manufacturing systems. 3.C.3
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. 3.C.4
5. Use computational tools to model, simulate, and visualize engineering systems and optimize designs based on data. 3.C.5
6. Evaluate the implications of automation, AI, and machine learning in engineering practice, including concerns about workforce disruption, algorithmic bias, and transparency. 3.C.6

D The student integrates core academic skills into engineering practices. The student is expected to: 3.D

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. 3.D.1
2. Apply concepts from various mathematics disciplines, such as algebra, geometry, and trigonometry, in the analysis and design of engineering solutions, including stress analysis, material properties, and system optimization 3.D.2
3. Apply scientific principles in designing, testing, and refining engineering solutions. 3.D.3
4. Use computational models and simulations to analyze solutions behavior, test hypotheses, and guide data-driven decisions in engineering projects. 3.D.4

Skip to main content

5 Analyze the historical, societal, and cultural contexts of major engineering innovations, exploring how they have shaped and been shaped by the needs of communities. 3.D.5

6 Solve authentic engineering problems involving community stakeholders and create scalable and sustainable solutions 3.D.6

E The student demonstrates the necessary skills to design, manage, and implement complex engineering systems. The student is expected to: 3.E

1 Design and implement advanced engineering solutions, such as autonomous robots, smart city infrastructure, or integrated mechatronics systems, using a structured, iterative engineering design process grounded in performance criteria, stakeholder feedback, and design constraints. 3.E.1

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.E.2

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. 3.E.3

4 Apply advanced prototyping techniques such as 3D printing, CNC machining, simulation, and virtual prototyping to quickly develop, test, and refine engineering designs. 3.E.4

5 Apply computational simulations and real-time data analysis to test and refine designs during the prototyping phase, ensuring solutions meet functional, environmental, and safety requirements. 3.E.5

F The student demonstrates the necessary skills to integrate and manage multi-disciplinary engineering systems. The student is expected to: 3.F

1 Integrate multiple engineering disciplines (e.g., mechanical, electrical, software, civil) into cohesive, high-functioning solutions, ensuring interoperability between subsystems and optimizing overall system performance. 3.F.1

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.F.2

3 Utilize advanced simulation tools for virtual testing of solutions, such as predictive maintenance simulations, energy efficiency simulations, and system stress testing. 3.F.3

4 Evaluate and implement ethical frameworks (e.g., equity-centered engineering, universal design, stakeholder inclusion) when integrating diverse technologies in public-facing solutions. 3.F.4

G The student demonstrates the necessary skills to assess and improve sustainability and ethical practices in engineering. The student is expected to: 3.G

. Design engineering solutions with sustainability in mind, incorporating renewable energy technologies, low-impact materials, and energy-efficient designs to reduce environmental footprint. 3.G.1

Skip to main content

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.G.2

3 Design solutions 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. 3.G.3

4 Evaluate regulatory compliance and ethical considerations regarding environmental protection, safety standards, and corporate social responsibility (CSR) in advanced engineering projects. 3.G.4

5 Incorporate systems thinking to analyze how engineering solutions interact with environmental, economic, and societal systems, identifying both intended and unintended consequences. 3.G.5

6 Use design-for-impact approaches to solve community-based challenges, ensuring equitable access, social value, and cultural sensitivity in final solutions. 3.G.6

H The student demonstrates the necessary skills to assess and improve engineering system reliability and safety. The student is expected to: 3.H

1 Conduct reliability testing on engineering solutions, including stress testing, failure analysis, and fault-tolerant design to ensure system integrity under varying conditions. 3.H.1

2 Design and implement predictive maintenance systems using sensor data, machine learning algorithms, and remote monitoring tools to prevent system failures before they occur. 3.H.2

3 Ensure product safety and performance by conducting rigorous testing and compliance with industry safety standards, such as ISO 9001, UL certification, and CE marking. 3.H.3

4 Apply computational tools for predictive modeling (e.g., machine learning or statistical analysis) to forecast failures and increase system resilience. 3.H.4

5 Evaluate human factors engineering principles to reduce risks associated with system misuse, operator error, or unclear design interfaces. 3.H.5

I The student integrates core academic skills into advanced engineering practices. The student is expected to: 3.I

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. 3.I.1

2 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. 3.I.2

3 Evaluate the societal impact of new and emerging technologies, such as nanotechnology, biomedical devices, and AI systems, through the lens of public health, equity, and global sustainability. 3.I.3