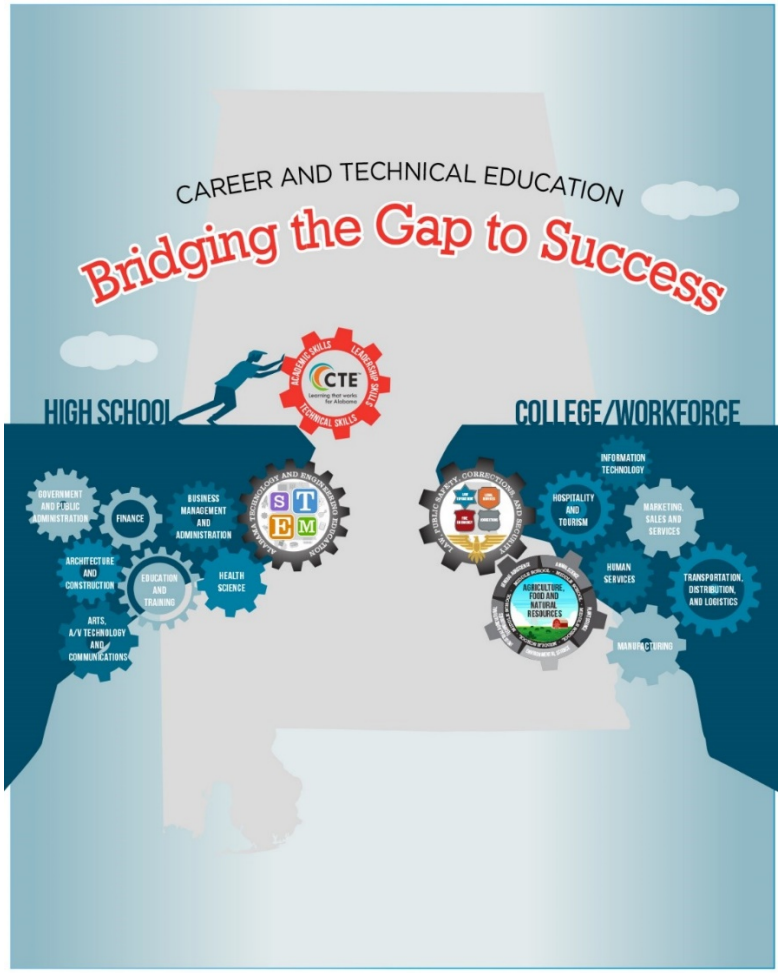
2020 Alabama Course of Study

Career and Technical Education



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Alabama State Department of Education

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2020 Alabama Course of Study
Career and Technical Education

Eric G. Mackey
State Superintendent of Education

STATE SUPERINTENDENTOF EDUCATION MESSAGE

Dear Alabama Educator:

Society and the workplace require that Alabama students receive a solid foundation of knowledge, skills, and understanding in science, technology, engineering, and mathematics (STEM). The *2020 Alabama Course of Study: Career and Technical Education, Science, Technology, Engineering, and Mathematics* presents standards designed to prepare students for the career and technical demands of the future, both in the workplace and in the postsecondary education setting. This document contains a set of challenging standards designed to promote students' engagement and interest in STEM fields. I encourage each system to use the document in developing local curriculum guides that determine how local school students will achieve and even exceed these standards.

The *2020 Alabama Course of Study: Career and Technical Education, Science, Technology, Engineering, and Mathematics* was developed by educators and business and community leaders to provide a foundation for building quality STEM programs across the state. Implementing the content of this document through appropriate instruction will promote students' exploration and engagement in STEM content and enhance preparation for STEM career fields.

Eric G. Mackey
State Superintendent of Education

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Science, Technology, Engineering, and Mathematics (STEM)
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2020 Alabama Course of Study:
Science, Technology, Engineering, and Mathematics

PREFACE

The *Alabama Course of Study: Career Technical Education, Science, Technology, Engineering, and Mathematics* provides the framework for Grades 6-12 science, technology, engineering, and mathematics (STEM) instruction in Alabama's public schools. Content standards in this document are minimum and required (Code of Alabama, 1975, §16-35-4), fundamental and specific, but not exhaustive. When developing local curriculum, school systems may include additional content standards to reflect local needs and philosophies and may add implementation guidelines, resources, and activities.

In developing the minimum required content for STEM education, the 2019-2020 Career and Technical Education Course of Study Committee and Task Force made use of previous Alabama career and technical education courses of study as well as national standards documents and certification standards.

In addition, Committee and Task Force members reviewed information found in professional journals, Internet sites, and similar documents from other states. The Committee and Task Force attended state and national conferences, listened to and read suggestions from interested individuals and STEM industry advisors throughout Alabama, considered suggestions from independent reviewers, sought input from advisory councils, and thoroughly discussed each issue and standard among themselves. The Committee and Task Force reached consensus and developed what members believe to be the best Science, Technology, Engineering, and Mathematics Course of Study for students in Alabama's public schools.

Alabama Course of Study: Career and Technical Education
Science, Technology, Engineering, and Mathematics
2020

This document was developed by the Science, Technology, Engineering, and Mathematics (STEM) Course of Study Committee and Task Force of the 2020 Alabama Career and Technical Education Course of Study Committee and Task Force, composed of middle school, high school, and college educators appointed by the State Board of Education and business and professional persons appointed by the Governor (Code of Alabama, 1975,§16-35-1). The Committee and Task Force began work in March 2019 and submitted the document to the State Board of Education for adoption at the April 2020 meeting.

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2020 Alabama Course of Study: Career and Technical Education

GENERAL INTRODUCTION

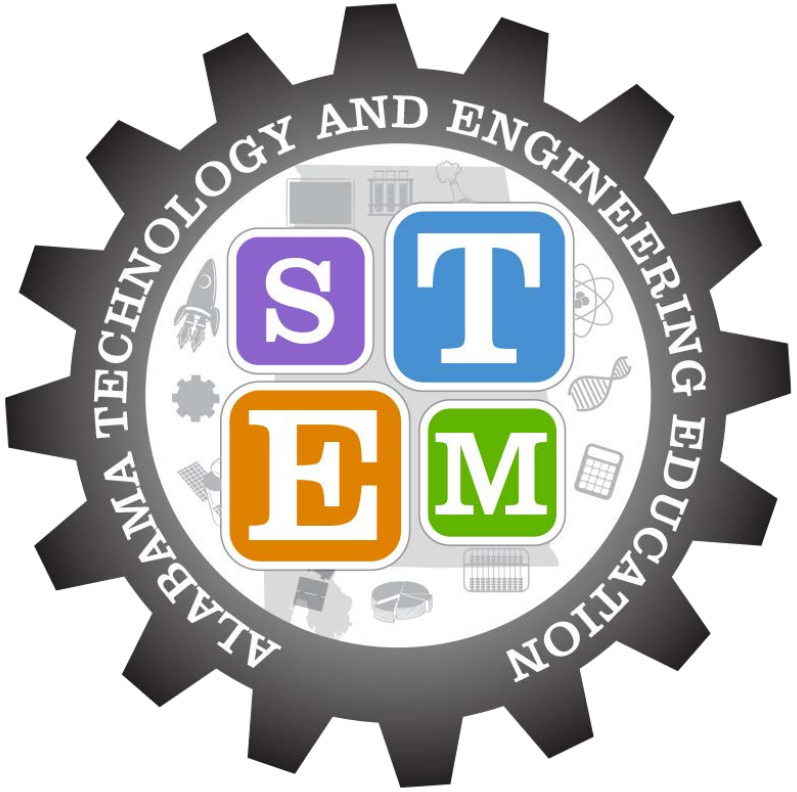
Alabama's Career and Technical Education programs empower students with the workplace-readiness skills necessary for success in the 21st Century. As a result, students are productive citizens who are prepared with the necessary knowledge and skills for postsecondary education and employment. Career and technical education provides opportunities for students to combine core academic content with rigorous and relevant technical knowledge and skills.

The 2020 *Alabama Course of Study: Career and Technical Education* is intended for all students in Grades 6-12. Alabama's career and technical education programs promote students' career awareness through engaging career exploration and development activities. Career and Technical Education programs focus on providing students with the knowledge and skills that reinforce attainment of academic core content through hands-on experiential learning. These programs are organized into the sixteen national career clusters identified by the United States Department of Education, which arrange instruction into groups of similar occupations. Within the sixteen national career clusters, separate course content standards have been developed for more than fifty career pathways.

Alabama's Career and Technical Education programs are designed to keep abreast of the rapid changes in business and industry and be responsive to the current and future workforce demands. Rigor in each course of study is derived from core academic content and industry-specific knowledge and skills required for students to achieve, maintain, and advance in employment in a particular career pathway. The level of academic and workplace rigor determines the degree to which each Alabama Career and Technical Education program prepares students for high-skill, high-wage, and in-demand careers. For each career and technical education program, industry-recognized credentials of value and certifications have been established that validate the rigor of the curriculum to students, parents, and members of business and industry. In addition, articulation agreements, in partnership with the Alabama Community College System, are developed to allow for a seamless transition for students to further their education.

Alabama's growing economy has created the demand for more highly-skilled workers. Alabama's Career and Technical Education programs, through the implementation of each career cluster's course of study, equip students with the employability skills and technical knowledge necessary to meet current and future workforce demands by preparing them for lifelong learning.

2020 Alabama Course of Study:
Science, Technology, Engineering, and Mathematics (STEM)
Conceptual Framework



2020 Alabama Course of Study: Science, Technology, Engineering, and Mathematics (STEM)

CONCEPTUAL FRAMEWORK

STEM is the acronym for Science, Technology, Engineering, and Mathematics. The gear denotes the inventive and industrial nature of the human mind, includes the STEM acronym, and represents STEM's ability to interlock and to set other parts of the Career and Technical Education programs into motion.

In the STEM letters superimposed shaded map of Alabama, the "T" and "E" are larger because of the cluster's focus on technology and engineering. These two fields go hand in hand, using and applying knowledge of science and mathematics. This cluster guides students to a deeper understanding of the nature of technology and of the processes used in engineering.

The background images represent some of the diverse products, endeavors, and technical fields which require a working knowledge of science, technology, engineering, and mathematics. Because STEM disciplines are at the forefront of scientific progress, holding the promise of advancements in manufacturing, food production, medicine, education, transportation, and every other field of inquiry, they are an integral part of Career and Technical Education.

whil POSITION STATEMENTS

STEM EDUCATION

Classroom and Laboratory Environment

The effective career and technical education classroom is equipped with current and emerging technologies and other supplies and materials representative of the content area. In such a classroom, students and teachers utilize equipment to enhance a variety of classroom instruction and learning activities. The career and technical education classroom environment is unlimited and encompasses more than the traditional four walls of the classroom. Students and teachers should have access to laboratory environments on and off campus that provide students with practical and real-world experiences in the industry represented.

Technology, Equipment, and Facilities

Adequate classroom equipment must be available, maintained, and upgraded according to a regularly scheduled plan. In addition, other classroom supplies and materials such as textbooks, reference materials, and software should be readily available for student use to support instruction, including access to classroom libraries, reading and research areas, and material centers. Maintaining up-to-date technology enhances students' learning and readies them for future career opportunities. Sufficient funds must be allocated to support the technology and materials necessary for a superior career and technical education program. Facilities include but are not limited to computer laboratories, general construction laboratories, and flexible multi-purpose makerspaces.

Safety

Student safety is a prime consideration in any location of the learning environment. A written safety plan is an essential part of planning, implementing, and evaluating each career and technical education program. An effective plan may include federal, state, local, school, and program guidelines. Students are required to pass safety tests with one-hundred per cent accuracy.

Professional Development

As technology and instructional methods continue to change, it is essential for teachers to take advantage of professional development and technical training opportunities to stay abreast of current trends and methods pertaining to their content area and the industry represented. Teachers who continually expand their knowledge and skills are able to adjust the learning environment to reflect current and emerging trends in teaching methods and learning styles. Regular assessment by students, educators, administrators, and business and industry also strengthens the instructional program and enhances professional development.

Administrative Support

Administrative support is essential in providing the necessary components for a successful career and technical education program. Administrators should recruit highly qualified teachers who possess appropriate credentials. Time must be provided for professional development activities and for planning for integration of academic content areas into the CTE STEM program. Funding must be secured for professional development programs and for industry certification for teachers. In addition, administrators should actively participate in marketing the career and technical education programs within the school and within the community.

Instructional Model

In the career and technical education classroom, it is imperative that students apply knowledge, skills, and ideas to solve problems and make decisions. The CTE STEM course of study is designed to address the challenges of a changing, technological, diverse, and global society. Students develop their abilities to analyze, communicate, manage, and lead. The CTE STEM curriculum is project-based, process-oriented, and work-based.

The rigorous content standards contained in this document require students to use creative and innovative, critical-thinking skills. Utilization of this document requires teachers to identify the issue or concern addressed in a specific content standard and then to plan appropriate learning experiences. These experiences should be project-based and require higher-order thinking, communication, management, and leadership skills.

The CTE STEM curriculum should emphasize the integration of academics. To achieve the solution to a given problem, students must possess an adequate foundation in communication skills for reading, writing, speaking, listening, viewing, and presenting; knowledge and skills in mathematics, science, and social studies; and knowledge of current and emerging technologies.

The CTE STEM curriculum should emphasize the integration of workplace demands, essential, and/or soft skills where students' individual learning styles and interests require the use of various instructional strategies. Individual needs of students must be determined by a variety of assessments that evaluate interests, aptitudes, and abilities. Once individual needs have been determined for special populations, a support service program should be planned cooperatively with the career and technical education teacher and other appropriate personnel. Individual education plans are more effective when developed with career and technical education instructors. Courses and equipment may be tailored to ensure equal access to the full range of learning experiences and skill development in the STEM curriculum.

Student Organizations

Nationally affiliated student organizations such the Technology Student Association (TSA) and SkillsUSA are an integral part of classroom instruction in the STEM career cluster of the career and technical education program. SkillsUSA and TSA enhance personal development, leadership and career opportunities in STEM, whereby members apply and integrate these concepts through intra-curricular activities, competitions and related programs. The focus of these organizations is to help students develop an understanding of all aspects of industry and technology in the program areas while learning teamwork and leadership skills. Goals of student organizations include:

- developing individual potential;
- developing effective leadership and citizenship skills through social, economic, scholastic, and civic activities;
- increasing knowledge and understanding of an ever-changing society;
- assisting in the exploration of occupational choices and the development of essential workplace skills;
- participating in career development events; and
- serving the school and community through service projects.

Business-Industry-School Relationships

Certification

Maintaining relationships with local businesses and industries is vital to the Career and Technical Education program certification process as well as to federal funding through the Carl D. Perkins legislation. Certain elements of program certification require local industries to participate in the Career and Technical Education program's adoption of industry standards. Representatives from local businesses and industries interact with school programs to address the ever-changing needs of the competitive global economy. From

this interaction, program structure is reviewed to ensure that needs are being met through lesson plans, instructional techniques, facilities, professional development, technical updates, equipment, and implementation of CTSOs.

Student Work Experience

As students begin to plan careers, they must have opportunities to visit, tour, and work at local industries and businesses. Real-world experiences such as cooperative education, internships, apprenticeships, and job shadowing are beneficial to enhance classroom learning. Continuous feedback from students and supervisors provides further assessment of the program and facilitates changes necessary to satisfy industry needs.

Advisory Councils and Partnerships

In accordance with Alabama Department of Education guidelines, each career and technical education program has an advisory council that will provide opportunities to establish partnerships as a means for professional input regarding equipment needs, curriculum emphasis, technical updates, and problem solving. This external support is a necessary link to business and industry for the potential acquisition of equipment, resource materials, community support, and qualified speakers. These resources include judges for student career development events, program sponsors, financial support, scholarships, field trip sites, and other program needs.

Community Involvement and Service

There are many ways students and teachers become involved with community and service projects. Mentoring activities may include teacher-to-teacher, teacher-to-student, student-to-student, student-to-community resident, and community member-to-students-and-teacher. Local organizations such as community civic clubs, professional educational organizations, youth organizations, and community adult education organizations are valuable resources for career and technical education programs. Open houses, tours, and presentations provide families and other interested citizens with opportunities to become more involved in the education environment.

Postsecondary and Higher Education Credit

Postsecondary and higher education articulation is a significant element in a student's career cluster. Secondary and postsecondary instructors must communicate on a regular basis to ensure a smooth transition for students and to ensure students are aware of articulation opportunities. Articulation may occur through program alignment with postsecondary programs, early college enrollment, or dual enrollment programs. Students benefit in a variety of ways when cooperation exists between secondary and postsecondary institutions. One of the benefits is the earning of postsecondary credit in conjunction with work completed while the student is still in secondary

school. Postsecondary teachers offer additional benefits by serving as guest speakers, donating equipment, sharing expertise through professional development activities, and addressing other needs appropriate for the school community.

Dual Enrollment for Dual Credit is an enrichment opportunity allowing eligible high school students to earn high school and college credits for courses taken through an Alabama Community College System (ACCS) institution while still enrolled in high school.

Credit is awarded when a student enrolls in a post-secondary institution that has an articulation agreement with that student's participating school.

Directions for Interpreting Standards

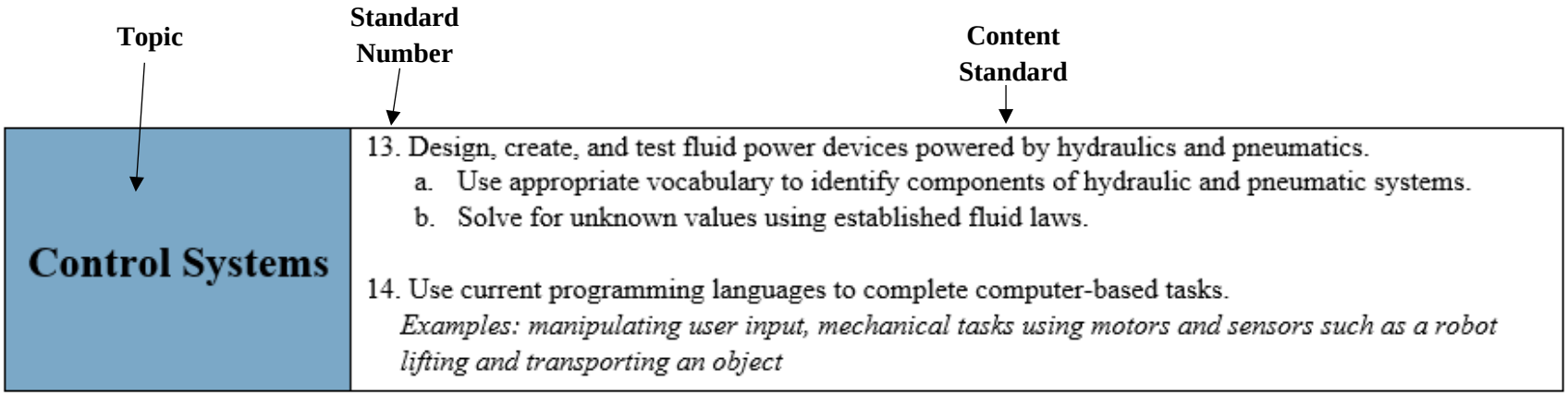
The 2020 *Alabama Course of Study: Science, Technology, Engineering, and Mathematics* is organized around foundational standards, topics, and content standards.

Foundational standards are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership and take advantage of the opportunities afforded by Career and Technical Student Organizations, learn and practice essential digital skills, and participate in supervised projects which allow them to put into practice the skills and knowledge acquired in the classroom.

Topics group related content standards. In the example below, the topic is "Control Systems." Standards from different topics may be closely related.

Content Standards contain the minimum required content and define what students should know or be able to do at the conclusion of a course. Some have sub-standards, indicated with a, b, c, d, which are extensions of the content standards and are also required. Some standards are followed by italicized examples, which are not required to be taught. Each content standard completes the stem *"Students will..."*

The course of study does not dictate curriculum, teaching methods, or sequence. Each local education authority should create its own curriculum and pacing guide based on the Course of Study. LEAs may add standards to meet local needs and incorporate local resources. The order in which standards are listed within a course or grade is not intended to convey a progression for instruction. Even though one topic may be listed before another, the first topic does not have to be taught before the second. A teacher may choose to teach the second topic before the first; to teach both at the same time to highlight connections; or to select a different topic that leads to students reaching the standards for both topics.


Topic
Standard Number
Content Standard
Control Systems
13. Design, create, and test fluid power devices powered by hydraulics and pneumatics.
a. Use appropriate vocabulary to identify components of hydraulic and pneumatic systems.
b. Solve for unknown values using established fluid laws.
14. Use current programming languages to complete computer-based tasks.
Examples: manipulating user input, mechanical tasks using motors and sensors such as a robot lifting and transporting an object

2020 Alabama Course of Study:
Science, Technology, Engineering, and Mathematics (STEM)
Cluster Overview

The standards in each course are to be used as a minimal framework and should encourage innovation.

The Science, Technology, Engineering, and Mathematics (STEM) cluster contains one pathway – Engineering and Technology. This cluster introduces students to foundational principles of engineering and technological literacy in the middle school grades. The high school courses provide students with opportunities to gain experience with general engineering design and application and to acquire discipline-specific knowledge that allows them to make informed career choices.

In this pathway, students discover the relationship of mathematics and science to engineering and technological disciplines and apply mathematical and scientific principles throughout the courses. These challenging standards involve practical applications of engineering principles and technological literacy.

The primary purpose of the Engineering and Technology pathway is to prepare students for engineering-related careers in a world of rapidly expanding technology. This pathway will also provide broad exposure to the many aspects of digital security while encouraging socially responsible choices and ethical behavior. It will require students to participate in structured decision-making and critical thinking through the engineering design process.

There are three middle school courses, which can be taught individually or sequentially. The high school courses begin with Foundations of Engineering and progress to Applications of Engineering. Students who progress through the STEM career cluster may opt to take advantage of the specialized courses: Capstone of Engineering, Career Pathways Project in STEM, and/or CTE Lab in STEM.

STEM classrooms and laboratories provide safe and appropriate settings for student exploration and learning. The engaging, structured environment encourages teamwork, stimulates students' creativity, and fosters the essential skills needed for future employment.

Students in this pathway affiliate with the Technology Student Association (TSA) and/or SkillsUSA as the co-curricular Career and Technical Student Organizations (CTSOs). TSA and SkillsUSA provide additional opportunities that enhance classroom instruction, develop leadership skills, and further career development.

Courses in this pathway include the following foundational standards:

1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and following protocols for fire and electrical safety.

2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork.

3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing.

4. Demonstrate digital literacy by using digital and electronic tools appropriately, safely, and ethically.

5. Participate in a Career Technical Student Organization (CTSO) to increase technical knowledge and essential workplace skills.

STEM Technologies I

Course duration (to be determined by LEA)	6 weeks (24 hours) OR 9 weeks (35 hours) OR 1 semester (70 hours) OR 1 year (140 hours)
Grade Level(s)	6-8
Prerequisite(s)	N/A

STEM Technologies I provides students with knowledge and processes needed to begin their attainment of technological literacy and awareness of careers in science, technology, engineering, and mathematics. Students gain knowledge and skills in the application, design, production, and assessment of products, services, and systems in a variety of areas.

Foundational standards, shown in the chart below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, learn and practice essential digital literacy skills, develop leadership, and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs). Students in this course may be affiliated with the Technology Student Association (TSA). The foundational standards are to be incorporated throughout the course.

Foundational Standards	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and following protocols for fire and electrical safety. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Demonstrate digital literacy by using digital and electronic tools appropriately, safely, and ethically. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

STEM Technologies I Content Standards

Each content standard completes the stem *"Students will…"*

Scope of Technology	1. Describe the development of technology as a human activity that is the result of creatively meeting individual or collective needs. 2. Explain the close link between technology and creativity and how it results in innovation. 3. Describe technological systems, including input, processes, output, and feedback. 4. Explain how technological systems can be connected to one another. 5. Identify the difference between open loop and closed loop systems.
Technology and Society	6. Identify positive and negative ways the use of technology affects humans. 7. Investigate the management of waste produced by technological systems as a societal issue. 8. Describe how technologies can be used to repair damage caused by natural disasters and to break down waste from various products and systems. 9. Describe the development of a technology from the demands, values, and interests of employers. 10. Identify inventions and innovations that have evolved through slow and methodical processes of testing and refinement.
Design Process	11. Utilize the design process to produce products and systems. 12. Identify the steps of an engineering design process.

	13. Identify criteria and constraints in a design. 14. Describe how the design process is used to develop solutions for a problem. 15. Describe the importance of documentation and how it is used to communicate ideas. 16. Model designs to transform ideas into practical solutions. 17. Obtain, evaluate, and share information to support the assertion that there is no perfect design. 18. Practice brainstorming as a group problem-solving design process in which each person in the group presents ideas in an open forum. 19. Identify two-dimensional and three-dimensional representations of the design solution.

Digital Literacy	20. Describe the permanence of digital data and the importance of managing one's digital identity and reputation. 21. Engage in positive, safe, legal, and ethical behaviors when using technology, including during social interactions online and when using networked devices. 22. Identify research strategies to locate information and other resources for their intellectual and/or creative pursuits. 23. Identify information from digital resources, using a variety of tools and methods to create a collection of artifacts that demonstrates meaningful connections or conclusions. 24. Identify real-world issues, develop ideas, and pursue solutions to address the issues.

STEM Technologies II

Course duration (to be determined by LEA)	6 weeks (24 hours) OR 9 weeks (35 hours) OR 1 semester (70 hours) OR 1 year (140 hours)
Grade Level(s)	6-8
Prerequisite(s)	n/a

STEM Technologies II provides students with knowledge and processes needed to further their attainment of technological literacy and awareness of careers in science, technology, engineering, and mathematics. Students gain skills in the application, design, production, and assessment of products, services, and systems in a variety of areas.

Foundational standards, shown in the chart below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, learn and practice essential digital literacy skills, develop leadership, and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs). Students in this course may be affiliated with the Technology Student Association (TSA). The foundational standards are to be incorporated throughout the course.

Foundational Standards	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and following protocols for fire and electrical safety. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Demonstrate digital literacy by using digital and electronic tools appropriately, safely, and ethically. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

STEM Technologies II Content Standards

Each content standard completes the stem *"Students will…"*

Scope of Technology	1. Investigate how technological systems can be connected to one another. 2. Explore different technologies that involve different sets of processes. 3. Gather and present information about ways corporations may create demand for a product by bringing it onto the market and advertising it.
Technology and Society	4. Differentiate between positive and negative effects of technology usage on human beings, including their safety, comfort, choices, and attitudes about technology's development and use. 5. Analyze the management of waste produced by technological systems as a societal issue. 6. Research and communicate how technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems. 7. Identify ethical issues associated with the development and use of technology. 8. Describe how social and cultural priorities and values are reflected in technological devices. 9. Explain how meeting societal expectations can be a driving force behind the acceptance and use of products and systems.
Design Process	10. Design a plan to produce products and systems. 11. Create criteria and constraints in a design. 12. Use the design process to develop solutions for a problem. 13. Employ brainstorming in a group problem-solving setting where each person presents design process related ideas in an open forum as part of the design process. 14. Model two-dimensional and three-dimensional solutions of a design.

	15. Test and modify designs to transform ideas into practical solutions. 16. Accurately identify different resources used in projects. 17. Make a product or system to solve a problem and document the solution.

Digital Literacy	18. Create and maintain a digital identity and reputation, demonstrating an awareness of the permanence of one's actions in the digital world. 19. Demonstrate an understanding of and respect for the rights and obligations of using and sharing intellectual property. 20. Manage their personal data to maintain digital privacy and security. 21. Create strategies to locate information and other resources for their intellectual or creative pursuits. 22. Generate ideas about real-world issues and problems and pursue answers and solutions to them.

STEM Technologies III

Course duration (to be determined by LEA)	6 weeks (24 hours) OR 9 weeks (35 hours) OR 1 semester (70 hours) OR 1 year (140 hours)
Grade Level(s)	6-8
Prerequisite(s)	n/a

STEM Technologies III provides students with knowledge and processes needed to extend their attainment of technological literacy and awareness of careers in science, technology, engineering, and mathematics. Students gain skills in the application, design, production, and assessment of products, services, and systems in a variety of areas.

Foundational standards, shown in the chart below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, learn and practice essential digital literacy skills, develop leadership, and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs). Students in this course may be affiliated with the Technology Student Association (TSA). The foundational standards are to be incorporated throughout the course.

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and following protocols for fire and electrical safety. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Demonstrate digital literacy by using digital and electronic tools appropriately, safely, and ethically. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

STEM Technologies III Content Standards

Each content standard completes the stem *"Students will…"*

Scope of Technology	1. Design a technological system that can be connected to another system. 2. Design a variety of technologies that involve different sets of processes. 3. Demonstrate how every part of a system relates to another. 4. Analyze malfunctions of any part of a system that may affect the system's function and quality. 5. Compare and contrast trade-offs as a decision process and describe the need for careful compromises among competing factors. 6. Perform basic maintenance on systems within the program.
Technology and Society	7. Analyze the ways, both positive and negative, that the use of technology affects humans, including their safety, comfort, choices, and attitudes about technology's development and use. 8. Critique the management of waste produced by technological systems as a societal issue. 9. Design a solution to alleviate and/or repair the damage caused by various disasters. 10. Make decisions about the development and use of technologies that put environmental and economic concerns in direct competition with one another.
Design Process	11. Develop a plan to produce products and systems. 12. Critique criteria, constraints, and tradeoffs in a design. 13. Synthesize elements of the design process to develop solutions for a problem. 14. Analyze results of solutions to problems using the steps in the design process.

	15. Design two-dimensional and three-dimensional representations of a design solution. 16. Evaluate designs to transform ideas into practical solutions. 17. Critique a product or system and document the evaluation. 18. Apply a design process to solve problems in and beyond the classroom. 19. Test, evaluate, and modify a design in relation to criteria and constraints.

Digital Literacy	20. Cultivate a digital identity and reputation, demonstrating an awareness of the permanence of one's actions in the digital world. 21. Manage their personal data to maintain digital privacy and security, demonstrating awareness of data-collection technology used to track their navigation online. 22. Employ research strategies to locate information and other resources for their intellectual or creative pursuits. 23. Evaluate the accuracy, perspective, credibility, and relevance of information, media, data, or other resources. 24. Curate information from digital resources using a variety of tools and methods to create a collection of artifacts that demonstrate meaningful connections or conclusions. 25. Develop solutions to real-world issues by analyzing ideas and solutions.

Foundations of Engineering and Technology

Course Credit	1.0
Grade Level(s)	9-12
Prerequisite(s)	None

Foundations of Engineering and Technology offers students an exploratory view of the engineering profession and the fundamental skills utilized in the field. Students investigate various engineering disciplines and related career paths. Students will develop leadership and teamwork skills through creativity, collaboration, communication, and critical thinking. Additionally, students will increase their understanding of science, technology, engineering, and mathematics (STEM) principles used in problem-solving as they use the engineering design process. Upon completion of this course students may be ready to earn a credential in a Computer-Aided Design (CAD) software such as Autodesk Inventor, SolidWorks, or SolidEdge.

Foundational standards, shown in the chart below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, learn and practice essential digital literacy skills, develop leadership, and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs). Students in this course may be affiliated with the Technology Student Association (TSA) or Skills USA. The foundational standards are to be incorporated throughout the course.

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and following protocols for fire and electrical safety. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Demonstrate digital literacy by using digital and electronic tools appropriately, safely, and ethically. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

Foundations of Engineering Content Standards

Each content standard completes the stem *"Students will…"*

Safety	1. Describe and follow appropriate safety and health procedures for engineering classroom and laboratory situations. a. Utilize tools and equipment safely. b. Identify environmental safety requirements for specific applications. *Examples: proper storage of chemicals, disposal of used materials*
Essential Skills	2. Exhibit essential skills required by business and industry in the engineering field. a. Communicate effectively through writing, speaking, listening, and reading. b. Show appropriate interpersonal skills, punctuality, work habits, ethical behavior, and work-appropriate attire. c. Create a resume and digital portfolio and participate in a mock interview. 3. Connect leadership and teamwork skills from CTSO activities with engineering practices. a. Use standard technical knowledge and skills during CTSO activities. b. Exhibit leadership and teamwork skills. c. Demonstrate effective collaboration in a diverse group to define and solve engineering problems.
Careers	4. Compare and investigate various aspects of jobs in STEM disciplines and the engineering field, including education requirements, job responsibilities, and potential earnings. a. Investigate current and future engineering job opportunities. b. Analyze positive and negative impacts of engineering on society. c. Critique significant contributions of leaders in engineering fields. d. Differentiate among engineering, technology, and science. e. Identify and discuss the various tools utilized by individuals in STEM disciplines, including engineering.

Standard Practices	5. Apply standard engineering practices and skills to solve problems. a. Use a variety of appropriate tools throughout the engineering design process. *Examples: hand tools, power tools, software programs, and other appropriate engineering instruments* b. Present a research-based solution to an engineering problem in a professional manner. c. Use terminology and vocabulary relevant to the field of engineering. 6. Cite evidence and document the steps in an engineering design process. a. Construct an engineering notebook based upon industry standard best practices. b. Display clear standard technical knowledge and skills when categorizing and classifying engineering practices. c. Record ideas, sketches, calculations, observations, and summaries of activities. d. Compare and contrast the methods of creating written and digital portfolios. 7. Demonstrate the use of analog and digital precision measuring instruments utilized in engineering. *Examples: micrometers, calipers, indicators, rulers, protractors, multimeters, digital data collection devices* a. Compare and convert between customary and metric measurement systems. b. Apply conversion factors of customary and metric measurements. c. Perform measurements using significant digits. 8. Create basic engineering drawings, including sketches and computer-aided designs (CAD). a. Produce multi-view sketches and drawings. b. Create two-dimensional and three-dimensional appropriate sketches. 9. Differentiate among components of engineering drawings. *Examples: cross sections, dimensions, line weights* 10. Create models and prototypes using CAD techniques and/or appropriate manufacturing tools.

Application	11. Utilize real-world STEM principles to investigate a variety of engineering disciplines. *Example: Use project-based learning to investigate and solve problems related to engineering.* a. Research and investigate engineering challenges in today's world. b. Apply the systems model of input, process, output, feedback, and impact to the engineering design process. c. Analyze an engineering design brief. d. Collaborate with team members to observe, identify, and modify individual solutions to engineering problems. e. Design and/or test a prototype using an engineering design process. 12. Generate code to solve challenges using appropriate languages.

Applications of Engineering and Technology

Course Credit	1.0
Grade Level(s)	10-12
Prerequisite(s)	Foundations of Engineering and Technology; Algebra I with Probability

Applications of Engineering and Technology offers students an investigative view of the engineering profession and the fundamental skills utilized in the field. Students continue investigating engineering disciplines and related career paths. Students will expand leadership and teamwork skills through creativity, collaboration, communication, and critical thinking. Additionally, students will increase their understanding of science, technology, engineering, and mathematics (STEM) principles used in problem-solving through the engineering design process.

Foundational standards, shown in the chart below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, learn and practice essential digital literacy skills, develop leadership, and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs). Students in this course may be affiliated with the Technology Student Association (TSA) or Skills USA. The foundational standards are to be incorporated throughout the course.

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and following protocols for fire and electrical safety. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Demonstrate digital literacy by using digital and electronic tools appropriately, safely, and ethically. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

Applications of Engineering and Technology Content Standards

Each content standard completes the stem *"Students will…"*

Standard Practices	1. Apply the design process to problems that can be solved using methods of engineering. 2. Create a project scope which includes, but is not limited to, a Gantt chart, a budget, and a materials list.
Energy and Power	3. Design, create, test, and perform calculations on simple machines, gear trains, and sprockets. 4. Investigate the application of multiple energy sources to a variety of systems. 5. Describe the features of and explain the differences between series and parallel circuits. a. Use Ohms Law to calculate current, voltage, resistance, and power in series and parallel circuits. 6. Use a multimeter to measure current, voltage, and/or resistance to diagnose and correct problems within a series or parallel circuit.
Communication Technologies	7. Analyze properties and functionalities of communication technologies. *Examples: terrestrial communication technology with analog or digital data; satellite communication technology including satellite ground station, remote sensing, navigation, geocentric orbit (low earth orbit, medium earth orbit, high earth orbit); Global Positioning Systems (GPS); geostationary satellites (GEOs); polar satellites; Nano satellites; CubeSats; SmallSats* 8. Analyze properties and functionalities of laser and fiber optic technologies.

Materials and Structures	9. Calculate unknown forces using vectors. a. Construct free-body diagrams. b. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes. 10. Calculate weight, density, mass, volume, and surface area of common items. 11. Design, create, test, and perform calculations on structural members using real models and computerized simulations. *Examples: beams, trusses* 12. Use 3D modeling software to examine properties and functionality of objects.
Control Systems	13. Design, create, and test fluid power devices powered by hydraulics and pneumatics. a. Use appropriate vocabulary to identify components of hydraulic and pneumatic systems. b. Solve for unknown values using established fluid laws. 14. Use current programming languages to complete computer-based tasks. *Examples: manipulating user input, mechanical tasks using motors and sensors such as a robot lifting and transporting an object*
Statistics	15. Construct the five-number summary for a set of data. a. Perform measures of central tendency, variance, and standard deviation. b. Use the normal curve, when appropriate, to compute probabilities concerning a data set, and relate the normal curve to applications of quality control in manufacturing. 16. Calculate the probability of single, sequential, and simultaneous events if they are independent, dependent, mutually exclusive and non-mutually exclusive, using tools such as tables and trees and implementing logical operators such as *and, or,* and *not.*

Kinematics	17. Solve problems involving linear motion, projectiles, and objects in free-fall using kinematics. a. Design, create, and test a mechanism to launch a projectile in the field. b. Analyze mathematically relevant components of a parabola.

Capstone of Engineering and Technology

Course Credit	1.0
Grade Level(s)	11-12
Prerequisite(s)	Foundations of Engineering and Technology, Applications of Engineering and Technology; Geometry with Data Analysis, Algebra I with Probability

Capstone of Engineering and Technology allows students to expand and apply previous knowledge to solve engineering problems. In this course, students will conduct research and develop solutions to complete a capstone project in the engineering field. Project-based learning reinforces the application of science, technology, engineering, and mathematics (STEM) concepts and skills. Technology applications are utilized in this course to enable students to visualize, model, prototype, solve, and report on comprehensive design problems. Collaboration and teamwork are vital components of the producing the capstone project.

Foundational standards, shown in the chart below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, learn and practice essential digital literacy skills, develop leadership, and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs). Students in this course may be affiliated with the Technology Student Association (TSA) or Skills USA. The foundational standards are to be incorporated throughout the course.

Foundational Standards	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and following protocols for fire and electrical safety. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Demonstrate digital literacy by using digital and electronic tools appropriately, safely, and ethically. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

Capstone of Engineering and Technology Content Standards

Each content standard completes the stem *"Students will…"*

Research	1. Research and explain professional, legal, and ethical responsibilities in the field of engineering, including the need for a diverse, equitable, and inclusive workforce. 2. Use industry standard best practices to document observations, ideas, sketches, calculations, and summaries of activities pertaining to the capstone project in an engineering notebook. 3. Conduct independent technological research throughout the process of an engineering project. a. Investigate past and current engineering practices related to an engineering project to develop a solution to a problem. b. Analyze research and draw conclusions to apply to problems in an engineering project.
Project Proposal	4. Create a formal, narrative proposal for a rigorous and relevant project in the field of engineering. a. Apply concepts of an engineering design process to a project in the field of engineering. b. Describe design constraints, criteria, and trade-offs for a project in the field of engineering in regard to a variety of conditions. *Examples: technology, cost, safety, society, environment, time, human resources, manufacturability* c. Use an engineering design brief to assist in the creation of a proposal. d. Communicate ideas clearly using effective writing practices in a project in the field of engineering.
Evaluation	5. Apply appropriate design methodologies by using various computer-aided design (CAD) programs to produce plans, diagrams, and working drawings for the construction of models, prototypes, and final products. 6. Demonstrate proper use and selection of tools, materials, procedures, and equipment in the construction of models, prototypes, and final products.

Report	7. Create a report explaining the engineering project, using industry-recognized guidelines to describe it from initiation to completion.

Presentation and Portfolio	8. Design and present a multimedia presentation describing the capstone project to an appropriate audience. 9. Construct a project portfolio that incorporates all project-related documentation, including the project proposal, research, engineering design notebook, project report, and presentation documentation.

Computer Engineering and Technology

Course Credit	1.0
Grade Level(s)	11-12
Prerequisite(s)	Applications of Engineering and Technology

Computer Engineering and Technology is designed to explore the process of taking a software idea and turning it into a profitable product. Students will gain knowledge of the phases of a software life-cycle (planning, design, implementation, testing, deployment, and maintenance). Technology will be introduced by exposing students to industry standard tools for implementing the System Development Life Cycle (SDLC) process. This course will be focused on the SDLC but will expose the students to the various architectures used for a successful project. While not required, it is recommended that students have some prior knowledge of programming languages, databases, operating systems, and platforms.

Foundational standards, shown in the chart below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, learn and practice essential digital literacy skills, develop leadership, and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs). Students in this course may be affiliated with the Technology Student Association (TSA) or Skills USA. The foundational standards are to be incorporated throughout the course.

Foundational Standards	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and following protocols for fire and electrical safety. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Demonstrate digital literacy by using digital and electronic tools appropriately, safely, and ethically. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

Computer Engineering and Technology Content Standards

Each content standard completes the stem *"Students will…"*

Planning and Methodology	1. Analyze the various software development methodologies and describe the pros and cons of each one. *Examples: agile, waterfall, spiral, rapid prototype* 2. Collect, document, and decompose all requirements for the completed software system. *Examples: user stories, project requirements document (PRD)* 3. Identify characteristics of a sound financial model to ensure a project can be developed within the projected budget. *Examples: cost, schedule, performance*
Design	4. Analyze various infrastructure options including cloud and in-house hosting for the product. *Examples: cloud, web, mobile, cross platform* 5. Describe software architecture within applications that makes them vulnerable to cyber-attacks. a. Design strategies to counter possible threats to software security. 6. Develop configuration management plans and analyze technologies to manage all work products in designing software. *Examples: software products, documentation, customer feedback*
Implementation	7. Implement scheduling techniques that will ensure adequate time and resources are allocated to deliver a software project on schedule and on budget. 8. Develop metrics and procedures that will ensure all requirements are fully implemented to customer's quality standards. *Examples: peer reviews, QA audits, defect tracking*

Testing	9. Analyze various testing strategies and design test procedures to ensure desired functionality of software products. *Examples: unit testing, regression testing, 508 compliance testing*
Deployment	10. Develop strategies for deploying end products to consumers. *Examples: DevOps, continuous integration*
Maintenance	11. Describe methodologies for tracking defects and planning bug-fix releases. *Examples: Bugzilla, Jira*

Environmental Engineering

Course Credit	1.0
Grade Level(s)	9-12
Prerequisite(s)	None

Environmental Engineering is designed to offer students an overview of environmental sustainability. It allows students to explore training, education, and career opportunities related to environmental engineering. Students will investigate and design solutions in response to real-world challenges related to clean and abundant drinking water, food supply, and renewable energy. Applying their knowledge through hands-on activities and simulations, students research and design potential solutions to these real-life challenges. And finally, students will describe the careers associated with environmental engineering and what roles they play in society.

Foundational standards, shown in the chart below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, learn and practice essential digital literacy skills, develop leadership, and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs). Students in this course may be affiliated with the Technology Student Association (TSA) or Skills USA. The foundational standards are to be incorporated throughout the course.

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and following protocols for fire and electrical safety. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Demonstrate digital literacy by using digital and electronic tools appropriately, safely, and ethically. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

Environmental Engineering Content Standards

Each content standard completes the stem, *"Students will…"*

Water Security in Society	1. Examine environmental and physical factors related to safe drinking water. a. Analyze the relationship between population growth and water resources. b. Obtain, evaluate, and share information on ways human health is affected by the quality of drinking water sources. c. List the characteristics of clean water. d. Explain why clean water is necessary for survival. e. Describe common sources of drinking water contamination.
Water Security Systems	2. Identify appropriate wastewater treatment processes and designs to eliminate common wastewater contaminants. a. Explain how water quality is quantitatively measured using chemically and/or biologically based testing processes. b. Outline the stages of sewage water treatment used in treatment facilities. c. Explain how water treatment plants remove nitrates from contaminated water. d. Use an engineering design process to create a water filtration system. e. Design and conduct a scientific experiment to test a variable affecting bacteria's ability to decompose oil.
Food Security in Society	3. Describe applications that engineers use to manipulate DNA to improve the quality, quantity, and reliability of food resources. a. Analyze environmentally and socially sustainable and unsustainable food production methods. b. Research the meaning and importance of food security. c. Describe the structure and function of DNA. d. Apply scientific techniques used in molecular biology to observe and/or experiment with plants, analyze results, and create plans that might increase the quality and quantity of food crops. e. Justify an argument for or against the use of genetic recombination methods as a means of improving food security.

Alternative Fuels	4. Analyze how engineers maximize the use and efficiency of renewable fuels and use results of the analysis to design alternative fuel sources. a. Demonstrate a working knowledge of various sources of energy and their environmental and economic impacts. b. Apply stoichiometric principles to the process of photosynthesis to predict and compare the experimental results of oxygen/carbon dioxide production and consumption. c. Conduct simulations of real-world situations to predict possible solutions. d. Debate the positive and negative aspects of using algae and biological free stocks as a fuel source. e. Demonstrate efficient fuel production methods from renewable sources. f. Plan various upstream and downstream processing methods to design an effective biofuels manufacturing plant.

Careers	5. Use professional engineering skills and knowledge to pursue opportunities and create sustainable solutions to improve and enhance the quality of life of individuals and society. a. Explain the educational, professional, and technical skills required for professional engineering practice. b. Discuss engineering as a means to create new and improved products, technologies, systems and processes to meet the needs of people and society. *Examples: plant, animal, microbial, forensic, and marine biotechnology* c. Explain how genetics has influenced engineering disciplines, new interdisciplinary fields, or sub-disciplines. *Examples: biomedical engineering, zoology, biochemistry, microbiology, medical science, and chemistry* d. Explain how engineering challenges are persistent. *Examples: providing growing populations with access to clean water, a sustainable food supply, energy, sanitation, and health care* e. Explain the engineer's responsibility to serve the public interest, his/her clients, and the profession with a high degree of honesty, integrity, and accountability.

Robotic Systems

Course Credit	1.0
Grade Level(s)	9-12
Prerequisite(s)	N/A

Robotic Systems is designed to offer students an overview of robotics. It allows students to explore training, educational, and career opportunities related to the automation of robotics in industry. Students will investigate and create a plan to achieve industry certifications, incorporate proper ethics in submitted projects, demonstrate basic technical skills necessary for following safety precautions, utilize engineering principles and fundamental physics, and demonstrate the technological product design processes and methodologies of systems.

Foundational standards, shown in the chart below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, learn and practice essential digital literacy skills, develop leadership, and take advantage of the opportunities afforded by Career and Technical Student Organizations (CTSOs). Students in this course may be affiliated with the Technology Student Association (TSA) or Skills USA. The foundational standards are to be incorporated throughout the course.

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining tools and machinery; handling materials; utilizing personal protective equipment; maintaining a safe work area; and following protocols for fire and electrical safety. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field of Robotics and investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Demonstrate digital literacy by using digital and electronic tools appropriately, safely, and ethically. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

Robotic Systems Content Standards

Each content standard completes the stem *"Students will…"*

Robotic Systems Project Planning	1. Develop a project management plan to include initiating, executing, monitoring, controlling, and closing a robotic systems project. a. Identify and select methodologies and skills for managing a robotics project. b. Participate in the organization and operation of a robotic system engineering project. c. Develop a project schedule of work according to established criteria for completing a robotics project.
Robotic Systems Teamwork	2. Apply principles of problem-solving through collaboration and conflict resolution using positive attitudes to produce effective teamwork. a. Participate in team projects in various roles. b. Apply principles of effective problem-solving in teams to collaborate and to resolve conflict.
Robotic Mechanical Design	3. Utilize STEM concepts in the engineering design process to solve problems in robotic mechanical design. a. Apply the systems model of input, process, output, feedback, and impact to solve problems in mechanical design. b. Use precision measuring instruments to analyze systems and prototypes in mechanical design projects. c. Calculate Newton's Laws as they apply to robotics. *Examples: rotational dynamics, torque, weight, friction, and traction factors required for the operation of robotic systems* 4. Demonstrate knowledge of motors, gears, gear ratios, and gear trains used in robotic systems.

Robotic Systems Process	5. Build, test, and present a robotic system. a. Identify the characteristics and functions of manipulators, accumulators, and end effectors required for a robotic or automated system to function. b. Use feedback to refine the design of a robotic or automated system to ensure the quality, efficiency, and manufacturability of the final product. c. Present a completed robotic system, including a design, materials, procedure, prototype, and reflection summary, using a variety of media.
Robotic Systems Programming Applications	6. Use current software applications to program robot behavior and complete tasks. a. Program robotic systems to complete an automated task using various sensors. b. Create robotic system programs that use variables to store and modify data. c. Create robotic system programs that utilize control statement loops and/or conditionals. d. Test and debug errors in an algorithm or program that includes sequences and simple loops.
Robotics and Automation in Industry	7. Describe the utilization of programmable control devices and data transfer in automated systems. a. Identify the systems, components, and processes of a technological system. b. Generate a device control flow chart or schematic for an automated manufacturing system. c. State the advantages and disadvantages of utilizing various control devices, including those for pressure, heat, volume control, color, weight and timing. d. Discuss the various architectures used in developing a programmable logic-controlled system.

Career Pathway Project in STEM

Course Credit	1.0
Grade Level(s)	11-12
Prerequisite(s)	Successful completion of any two courses in the STEM cluster

Career Pathway Project (CPP) for STEM is a capstone course designed for students who have completed two or more career and technical education courses in Science, Technology, Engineering, and Mathematics. This course allows students to utilize their secondary coursework through an experience that showcases their learning. It provides an opportunity for a student to choose an area of interest and engage in an in-depth exploration of the area while demonstrating problem-solving, decision-making, and independent-learning skills. The CPP contributes to an educational plan of challenging courses and practical experiences that prepares students for the workplace or for pursuing further education.

During the CPP, the student works with his or her coordinating teacher, academic teachers, and with a product or process mentor who has expertise in the student's field of study. At the conclusion of the CPP, the student presents or demonstrates knowledge gained to an audience consisting of the coordinating teacher, academic teachers, the product or process mentor, peers, and community and business representatives.

Foundational standards, shown in the chart below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership and take advantage of the opportunities afforded by Career and Technical Student Organizations, learn and practice essential digital skills, and participate in supervised projects which allow them to put into practice the skills and knowledge acquired in the classroom, shop, and lab. The foundational standards are to be incorporated throughout the course.

Foundational Standards	
	1. Incorporate safety procedures in handling, operating, and maintaining equipment; utilizing materials and protective equipment; maintaining a safe work area; and handling hazardous materials and forces.

	2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field, investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Demonstrate digital literacy by using digital and electronic tools appropriately, safely, and ethically. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

Career Pathway Project in STEM
Content Standards

Each content standard completes the stem *"Students will…"*

Project Proposal	1. Create a formal, narrative proposal that communicates a specific concept, process, or product related to STEM. *Examples: "Effects of Artificial Intelligence, on Teen Spending," "The Pros and Cons of Nanotechnology," "Internship for Becoming an Engineer," "Developing a Plan for a Solving Traffic Congestion in a Small City"*

Research	2. Conduct independent research related to a selected project concept. *Examples: Internet research, related readings, original research*

Project Report	3. Write a detailed report on the chosen project, demonstrating correct usage of standard writing format.

Presentation	4. Produce an original multimedia presentation based upon project results. *Examples: producing a digital presentation and oral explanation, creating a documentary, presenting a project model and explanation*

Portfolio	5. Design a project portfolio that includes documentation of components of the project and demonstrates the validity of the process. *Examples: components—abstract, table of contents, project proposal, signature sheets, journal entries, research, formal timeline, self-assessment, mentor assessments*

CTE Lab in STEM	
Course Credit	1.0
Grade Level(s)	11-12
Prerequisite(s)	Successful completion of any two courses in the STEM Cluster

CTE Lab in STEM enhances the student's general understanding and mastery of the cluster. This course is designed as a learning laboratory to support students' individual interests and goals. This laboratory may take place in a traditional classroom, in an industry setting, or in a virtual learning environment.

Foundational standards, shown in the chart below, are an important part of every course. Through these standards, students learn and apply safety concepts, explore career opportunities and requirements, practice the skills needed to succeed in the workplace, develop leadership and take advantage of the opportunities afforded by Career and Technical Student Organizations. The foundational standards are to be incorporated throughout the course.

Foundational Standards	1. Incorporate safety procedures in handling, operating, and maintaining equipment; utilizing materials and protective equipment; maintaining a safe work area; and following protocols for fire and electric safety. 2. Demonstrate effective workplace and employability skills, including communication, awareness of diversity, positive work ethic, problem-solving, time management, and teamwork. 3. Explore the range of careers available in the field, investigate their educational requirements, and demonstrate job-seeking skills including resume-writing and interviewing. 4. Demonstrate digital literacy by using digital and electronic tools appropriately, safely, and ethically. 5. Participate in a Career and Technical Student Organization (CTSO) to increase knowledge and skills and to enhance leadership and teamwork.

CTE Lab in STEM
Content Standards

Each content standard completes the stem *"Students will…"*

Occupational Expertise	1. Demonstrate expertise in a specific occupation within the career cluster. a. Meet benchmarks selected by the instructor from the appropriate curriculum frameworks, based upon the individual student's assessed needs.
Research and Presentation	2. Conduct investigative research on a selected topic related to STEM using approved research methodology; interpret findings; and prepare presentation to defend results. a. Select an investigative study referencing prior research and knowledge. b. Collect, organize, and analyze data accurately and precisely. c. Design procedures to test the research. d. Report, display, and defend the results of investigations to audiences that may include professionals and technical experts. 3. Demonstrate higher order critical thinking and reasoning skills appropriate for the selected program of study. a. Use mathematical and/or scientific skills to solve problems encountered in the chosen occupation. b. Read and interpret information related to the chosen occupation. c. Locate and evaluate key elements of oral and written information. d. Analyze and apply data and/or measurements to solve problems and interpret documents. e. Construct charts, tables, or graphs using functions and data.

	4. Apply enhanced leadership and professional career skills. a. Develop and present a professional presentation offering potential solutions to a current issue. b. Practice leadership and career skills through work-based learning including job placement, job shadowing, entrepreneurship, internship, or by obtaining an industry-recognized credential of value. c. Participate in leadership development opportunities available through the appropriate student organization and/or other professional organizations. d. Demonstrate written and oral communication skills through presentations, public speaking, live/virtual interviews, and/or an employment portfolio.

Resources

CTE CTSO Resources:

TSA (Technology Student Association)
https://tsaweb.org/

SkillsUSA
https://www.skillsusa.org/

Robotics Resources:

VEX EDR and VEX IQ
https://www.roboticseducation.org/robotics-curriculum/

Carnegie Mellon
https://www.cmu.edu/roboticsacademy/

Professional Resources:

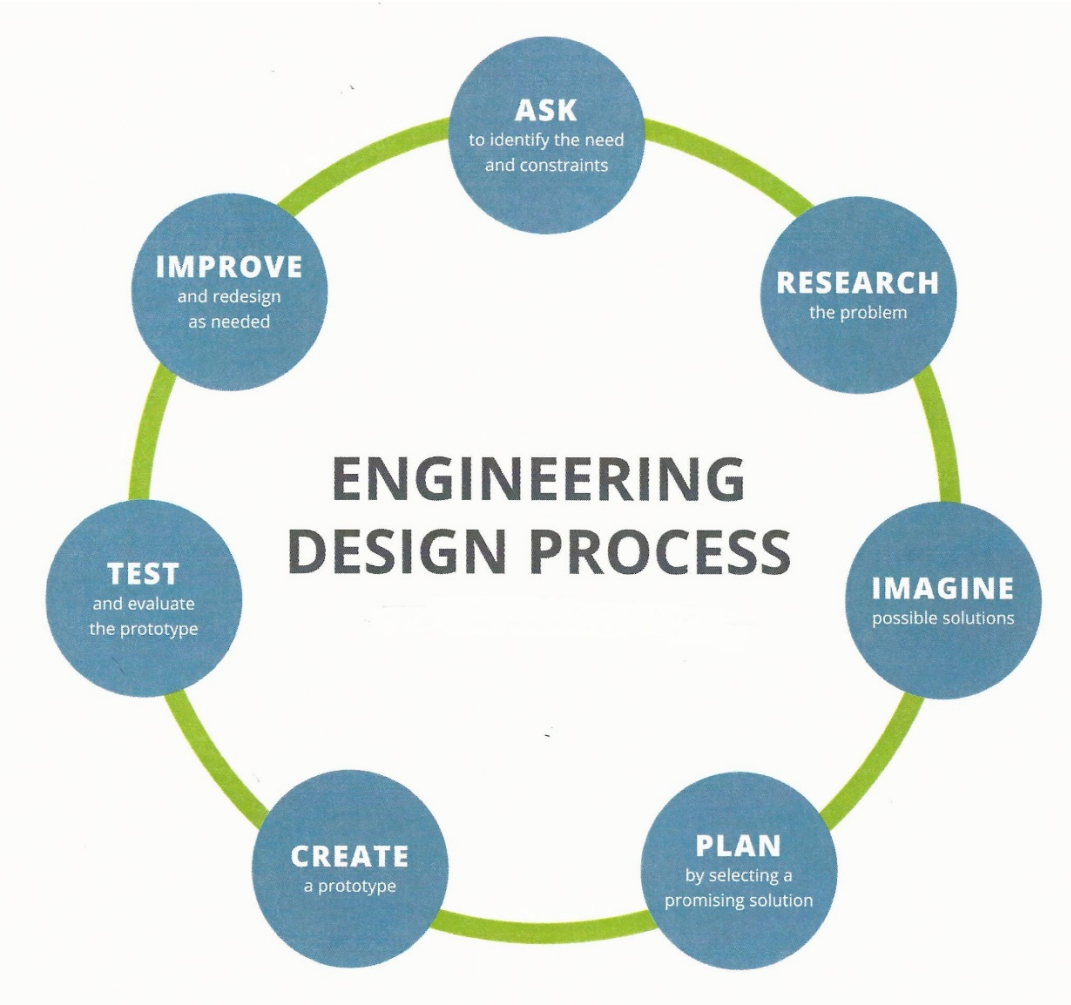
ITEEA (International Technology and Engineering Educators Association)
https://www.iteea.org/

PLTW (Project Lead The Way)
https://www.pltw.org/

ISTE (International Society for Technology in Education)
https://www.iste.org/

Engineering Design Process

https://www.teachengineering.org/activities/view/cub_creative_activity1


ENGINEERING
DESIGN PROCESS
ASK
to identify the need
and constraints
RESEARCH
the problem
IMAGINE
possible solutions
PLAN
by selecting a
promising solution
CREATE
a prototype
TEST
and evaluate
the prototype
IMPROVE
and redesign
as needed

ALABAMA HIGH SCHOOL GRADUATION REQUIREMENTS

Effective for students in the ninth grade in the 2013-2014 school year, all students shall earn the required credits for the Alabama High School Diploma. A local board of education may establish requirements for receipt of diplomas and endorsements, but any diploma or endorsement shall include the requirements of the Alabama High School Diploma. The Alabama courses of study shall be followed in determining minimum required content in each discipline.		
	COURSE REQUIREMENTS	
English Language Arts	**Four credits to include:**	**Credits**
	English 9	**1**
	English 10	**1**
	English 11	**1**
	English 12	**1**
	Equivalent options may include: Advanced Placement/International Baccalaureate/postsecondary equivalent courses	
	English Language Arts Total Credits	**4**
Mathematics	**Three credits to include:**	**Credits**
	Algebra I or its equivalent	**1**
	Geometry or its equivalent	**1**
	Algebra II w/Trigonometry or Algebra II, or its equivalent	**1**
	One credit from:	
	Alabama Course of Study: Mathematics or *Career and Technical Education*/Advanced Placement/International Baccalaureate/postsecondary equivalent courses	**1**
	Mathematics Total Credits	**4**
Science	**Two credits to include:**	**Credits**
	Biology	**1**
	A physical science (Chemistry, Physics, Physical Science)	**1**
	Two credits from:	
	Alabama Course of Study: Science or *Career and Technical Education/Advanced Placement/International Baccalaureate/postsecondary equivalent courses*	**2**
	Science Total Credits	**4**
Social Studies	**Four credits to include:**	**Credits**
	World History	**1**
	United States History I	**1**
	United States History II	**1**
	United States Government	**0.5**
	Economics	**0.5**
	Equivalent options may include: Advanced Placement/International Baccalaureate/postsecondary equivalent courses	
	Social Studies Total Credits	**4**
Physical Education	Lifelong Individualized Fitness Education (LIFE)	**1**
Health Education		**0.5**
Career Preparedness		**1**
Career and Technical Education and/or Foreign Language and/or Arts Education		**3**
Electives		**2.5**
Local boards shall offer foreign languages, arts education, physical education, wellness education, career and technical education, and driver education as electives.		
	Total Credits	**24**

GUIDELINES AND SUGGESTIONS FOR LOCAL TIME REQUIREMENTS AND HOMEWORK

Total Instructional Time

The total instructional time of each school day in all schools and at all grade levels shall be not less than 6 hours or 360 minutes, exclusive of lunch periods, recess, or time used for changing classes (*Code of Alabama,* 1975, §16-1-1).

Suggested Time Allotments for Grades 1 – 6

The allocations below are based on considerations of a balanced educational program for Grades 1-6. Local school systems are encouraged to develop a general plan for scheduling that supports interdisciplinary instruction. Remedial and/or enrichment activities should be a part of the time scheduled for the specific subject area.

Subject Area	**Grades 1-3**	**Grades 4-6**
Language Arts	150 minutes daily	120 minutes daily
Mathematics	60 minutes daily	60 minutes daily
Science	30 minutes daily	45 minutes daily
Social Studies	30 minutes daily	45 minutes daily
Physical Education	30 minutes daily*	30 minutes daily*
Health	60 minutes weekly	60 minutes weekly
Technology Education (Computer Applications)	60 minutes weekly	60 minutes weekly
Character Education	10 minutes daily**	10 minutes daily**

Arts Education

Dance Music Theatre Visual Arts	*Daily instruction with certified arts specialists in each of the arts disciplines is the most desirable schedule. However, schools unable to provide daily arts instruction in each discipline are encouraged to schedule in Grades 1 through 3 two 30- to 45-minute arts instruction sessions per week and in Grades 4 through 6 a minimum of 60 minutes of instruction per week. Interdisciplinary instruction within the regular classroom setting is encouraged as an alternative approach for scheduling time for arts instruction when certified arts specialists are not available.*

*Established by the Alabama State Department of Education in accordance with *Code of Alabama*, 1975, §16-40-1

**Established by the Alabama State Department of Education in accordance with *Code of Alabama*, 1975, §16-6B-2(h)

Kindergarten

In accordance with *Alabama Administrative Code* r. 290-5-1-.01(5) Minimum Standards for Organizing Kindergarten Programs in Alabama Schools, the daily time schedule of the kindergartens shall be the same as the schedule of the elementary schools in the systems of which they are a part since kindergartens in Alabama operate as full-day programs. There are no

established time guidelines for individual subject areas for the kindergarten classroom. The emphasis is on large blocks of time that allow children the opportunity to explore all areas of the curriculum in an unhurried manner.

It is suggested that the full-day kindergarten program be organized utilizing large blocks of time for large groups, small groups, center time, lunch, outdoor activities, snacks, transitions, routines, and afternoon review. Individual exploration, small-group interest activities, interaction with peers and teachers, manipulation of concrete materials, and involvement in many other real-world experiences are needed to provide a balance in the kindergarten classroom.

Grades 7-12

One credit may be granted in Grades 9-12 for required or elective courses consisting of a minimum of 140 instructional hours or in which students demonstrate mastery of Alabama course of study content standards in one credit courses without specified instructional time (*Alabama Administrative Code* r. 290-3-1-.02 (9)(a)).

In those schools where Grades 7 and 8 are housed with other elementary grades, the school may choose the time requirements listed for Grades 4-6 or those listed for Grades 7-12.

Character Education

For all grades, not less than 10 minutes instruction per day shall focus upon the students' development of the following character traits: courage, patriotism, citizenship, honesty, fairness, respect for others, kindness, cooperation, self-respect, self-control, courtesy, compassion, tolerance, diligence, generosity, punctuality, cleanliness, cheerfulness, school pride, respect of the environment, patience, creativity, sportsmanship, loyalty, and perseverance.

Homework

Homework is an important component of every student's instructional program. Students, teachers, and parents should have a clear understanding of the objectives to be accomplished through homework and the role it plays in meeting curriculum requirements. Homework reflects practices that have been taught in the classroom and provides reinforcement and remediation for students. It should be student-managed, and the amount should be age-appropriate, encouraging learning through problem-solving and practice.

At every grade level, homework should be meaning-centered and mirror classroom activities and experiences. Independent and collaborative projects that foster creativity, problem-solving abilities, and student responsibility are appropriate. Parental support and supervision reinforce the quality of practice or product as well as skill development.

Each local board of education shall establish a policy on homework consistent with the Alabama State Board of Education resolution adopted February 23, 1984 (Action Item #F-2).

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ITEEA Standards | *International Technology Engineering Education Association*, www.iteeeaconnect.org.

VEX EDR STEM Labs, education.vex.com/eduvex/edr/stem-labs/.

GLOSSARY

Accumulator: A robot mechanism designed to pick up a large number of similar objects.

Agile methodology: A project management methodology characterized by building products for consumers using short work cycles that allow for quick production and constant revision.

Analog data: Data that is represented in a physical way and stored in physical media such as the grooves of vinyl records, tape of VCR cassette, and/or other non-digital media.

CAD (Computer-Aided Design): A technology that designs and documents the product and process.

Caliper: A precision measuring device used to measure linear dimensions, thickness, or diameter.

Closed loop system: A system that records and modifies the output and does not encounter external or internal disturbances; also called a feedback control system.

Configuration management plan: A plan developed to define, document, control, implement, account for, and audit changes to components of a project.

CRI (color rendering index): A measure of a light source's ability to show realistic and natural colors.

CTSO (Career and Technical Student Organizations): Affiliation of national career and technical student organizations that serve student and teachers in career clusters.

CubeSats: A class of nanosatellites that use a standard size and form factor from "1 unit" or "1U" measuring 4 inches x 4 inches x 4.5 inches up to "12 units" or "12u" in size used for educational research, space exploration, new technology demonstrations and advanced mission concepts through a collaborative effort of academia including high schools and colleges, government, and industry.

Digital data: Data that is represented using specific machine language systems and interpreted by different technologies.

Feedback: A system's output used as input into the system as part of a chain reaction.

Free-body diagram: A representation of an object with all the forces that act on it. The external environment (other objects, the floor on which the object sits, etc.), as well as the forces that the object exerts on other objects are omitted.

Genetic recombination: The exchange of genetic material between two different chromosomes or between different regions within the same chromosome.

Geocentric orbit: An orbit that goes around the earth; our moon and most man-made satellites follow a geocentric orbit.

Geostationary satellite: A tool used by scientists to monitor and observe the earth's atmosphere from an altitude of 22,300 miles above the earth, moving at 7,000 mph in order to maintain its orbit; they are named geostationary based on how they move.

High Earth Orbit (HEO): A circular orbit beyond a geostationary orbit at an altitude of 22,236 miles above the earth traveling at speeds of 17,895 mph, taking longer than 24 hours to circle the earth.

Indicator: A mechanical device that provides a visual perspective of the state of a component.

Input: A component that allows information to be given to a computer.

Intellectual property: A product of the human intellect that the law protects from unauthorized users.

Low Earth Orbit (LEO): A circular orbit normally at an altitude of 99 to 621 miles above the earth traveling at speeds of 17,448 mph, taking approximately 90 minutes to circle the earth.

Manipulator: Component that provides a robot with the ability to interact with its environment.

Medium Earth Orbit (MEO): A circular orbit at an altitude of 1,242-22,232 miles above the earth, traveling at speeds of 16,329 mph, taking 12 hours to circle the earth.

Micrometer: A device used to measure small objects precisely; it can measure depth, length, and thickness of objects that fit between the anvil and spindle.

Multimeter or **multitester**: A device used for measuring current, resistance, and voltage in an electrical circuit.

The National Career Clusters: Framework providing structure for CTE instruction and learning.

Open loop system: A system that takes input and does not react on the feedback for output; also called a non-feedback control system.

OSHA (Occupational Safety and Health Administration): Federal agency created to ensure safe and healthy working conditions by setting standards and providing training, outreach, education, and assistance.

Output: A component that receives information from a computer.

PRD (Product Requirements Document): Specifications checklist to ensure all requirements from stakeholders are met.

Process: A sequence of instructions that are executed by a computer.

Rapid-prototype methodology: The act of creating a low-fidelity object for testing purposes.

SDLC: (System Development Life Cycle): Process used in the design, development, and testing of software.

Significant digits: Number of digits in a figure that expresses the precision of a measurement instead of its magnitude. In a measurement, commonly the in-between (embedded) zeros are included but leading and trailing zeros are ignored. Non-zero digits, and leading zeros to the right of a decimal point, are always significant.

SkillsUSA: A partnership of students, teachers, and industry that work together to prepare for skilled workforce.

SmallSats: Small satellites or miniature satellites small in mass and size, usually under 1,100 pounds.

Spiral methodology: A software development process where each iteration builds on the previous.

STEM: Science, Technology, Engineering, and Math

Stoichiometry: In chemistry, the relationship between reactants and/or products in a chemical reaction used to determine data.

3D modeling software: A type of computer graphics software that enables the design, development and production of 3-D graphics and animations. 3-D software allows users to visualize, design, and control an object, environment, or any graphical element within a three-dimensional scope. 3-D software includes computer-aided design (CAD) programs and animation packages.

TSA (Technology Student Association): A student organization created to enhance personal development, leadership, and career opportunities in STEM.

QA (Quality Assurance): A process used to establish whether product specifications and expectations are met.

Waterfall methodology: A linear management approach where a sequential project plan is devised based on the requirements of the stakeholder and customer.