College, Career and Technical Education

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STEM I: Foundations

Primary Career Cluster:	Science, Technology, Engineering, and Mathematics (STEM)
Course Contact:	CTE.Standards@tn.gov
Course Code(s):	C21H15
Prerequisite(s):	None
Credit:	1
Grade Level:	9
Focus Elective Graduation Requirement:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other *STEM* courses.
Program of Study (POS) Concentrator:	This course satisfies one out of two required courses that meet the Perkins V concentrator definition, when taken in sequence in the approved program of study.
Programs of Study and Sequence:	This is the first course in the *STEM Education* program of study.
Aligned Student Organization(s):	SkillsUSA: http://www.tnskillsusa.com Technology Student Association (TSA): http://www.tntsa.org
Coordinating Work-Based Learning:	Teachers are encouraged to use embedded WBL activities such as informational interviewing, job shadowing, and career mentoring. For information, visithttps://www.tn.gov/education/career-and-technical-education/work-based-learning.html.
Promoted Student Industry Credentials:	Credentials are aligned with post-secondary and employment opportunities and with the competencies and skills that students acquire through their selected program of study. For a listing of promoted student industry credentials, visit https://www.tn.gov/education/career-and-technical-education/student-industry-certification.html
Teacher Endorsement(s):	013, 014, 015, 016, 017, 018, 047, 070, 078, 081, 125, 126, 127, 128, 129, 157, 210, 211, 212, 213, 214, 230, 232, 233, 413, 414, 415, 416, 417, 418, 449, 470, 477, 519, 531, 595, 596, 700, 740, 760, 982
Required Teacher Certifications/Training:	Teachers who have never taught this course must attend training provided by the Department of Education.
Teacher Resources:	https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-stem.html Best for All Central: https://bestforall.tnedu.gov/

Approved April 10, 2015; Amended January 25, 2018; Amended Nov. 2021

Course-At-A-Glance

There is no one way to create meaningful learning experiences for students. There are best practices available that data and students say impact long-term student learning. One of those best practices is to put student learning in context with their experiences.

Career and Technical Student Organizations (CTSOs) provide an opportunity for students to display their learning in the classroom and through regional, state, and/or national competition. Work-based Learning (WBL) consists of sustained and coordinated work-based activities that relate to the course content. These activities should occur at every level through a program of study. Below is a listing of possible CTSO connections and WBL activities for this course. This listing is intended to be an idea starter and not a comprehensive listing.

Using a Career and Technical Student Organization (CTSO) in Your Classroom

Putting the classroom learning into real life experiences is often what creates a meaningful learning experience for students, one that lasts beyond the exam and course. CTSOs are a great resource to create this type of learning for your students. They are also a great resource to showcase your students learning through regional, state, and national competitions. Possible connections for this course include the following. This is not an exhaustive list.

- Participate in CTSO Fall Leadership Conference to engage with peers by demonstrating logical thought processes and developing industry specific skills that involve teamwork and project management
- Participate in contests that highlight job skill demonstration; interviewing skills; community service activities, extemporaneous speaking, and job interview
- Participate in leadership activities such as National Leadership and Skills Conference, National Week of Service, 21st Century Skills

For more ideas and information, visit Tennessee SkillsUSA at http://www.tnskillsusa.com and Technology Student Association (TSA): http://www.tntsa.org

Using Work-based Learning in Your Classroom

Sustained and coordinated activities that relate to the course content are the key to successful work-based learning. Possible activities for this course include the following. This is not an exhaustive list.

- **Standards 1.1-2.3**| Invite an industry representative to discuss occupations and safety protocols within the STEM career field.
- **Standards 3.1-3.4**| Develop a project to be used by a local industry.
- **Standards 4.1-4.4** | Do an integrated project with an industry professional.
- **Standards 5.1-5.3** | Shadow an environmental scientist.
- **Standards 6.1-6.3** | Invite a panel of scientists, engineers and mathematicians to discuss relationships in STEM.

For more ideas and information, visit https://www.tn.gov/education/career-and-technical-education/work-based-learning.html.

Course Description

STEM I: Foundations is a foundational course in the STEM cluster for students interested in learning more about careers in science, technology, engineering and mathematics. This course covers basic skills required for STEM fields of study. Upon completion of this course, proficient students are able to identify and explain the steps in both the engineering design and the scientific inquiry processes. They conduct research to develop meaningful questions, define simple problem scenarios and scientific investigations, develop fundamental design solutions, conduct basic mathematical modeling and data analysis, and effectively communicate solutions and scientific explanations to others.

Note: For clarity, some standards include example applications to science, technology, engineering, and mathematics. Teachers are encouraged to align instruction to one or more of these areas, depending on area of expertise and student interest.

Program of Study Application

This is the first course in the *STEM Education* program of study. For more information on the benefits and requirements of implementing this program in full, please visit the STEM website at https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-stem.html.

Course Standards

1. Safety

1.1 Safety Rules: Accurately **read and interpret safety rules**, including but not limited to rules published by the National Science Teachers Association (NSTA), rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA) guidelines, and state and national code requirements. Be able to distinguish between the rules and explain why certain rules apply.

1.2 Safety Equipment: Identify and explain the **intended use of safety equipment** available in the classroom. For example, demonstrate how to properly inspect, use, and maintain safe operating procedures with tools and equipment. Incorporate safety procedures and complete safety test with 100 percent accuracy.

2. STEM Fields Exploration

2.1 History of STEM: Research the **history of science, math, and engineering related to technology**. Examine how these technologies have evolved, and evaluate their influence on present-day society, citing specific textual evidence from news articles and scholarly journals.

2.2 STEM Occupations: Explore several **occupations within the STEM field** (such as manufacturing, computer science/programming, aviation, forensics, health science, engineering, transportation/ distribution & logistics, actuarial science) and describe the many sources and types of information that these occupations use. Determine how various industries employ different kinds of data to meet their needs.

2.3 STEM Skills and Education: Investigate an **assortment of skills and education required for STEM professionals**. Write an informative text that i**dentifies the typical educational and certification requirements, working environments, and career opportunities** for these occupations. For example, participate in an information-gathering tour of a local organization that uses computer-aided design, and report on the roles and responsibilities of STEM professionals on staff, including the kinds of software and equipment they use.

3. Problem-Resolution Skills

3.1 Engineering Design and Scientific Inquiry: Research the terms engineering design and scientific inquiry. Compare and contrast the **steps of the engineering design process to the steps of the scientific inquiry** in a graphic illustration or presentation.

3.2 Usage of Design Process: Evaluate a question to determine if it is testable and can produce empirical data. Plan an **investigation that outlines the steps of the design process to collect, record, analyze, and evaluate data.** For example:

a. Given a set of symptoms, determine whether there is enough data to diagnose a medical condition as would a physician or nurse practitioner. (Science)
b. Determine the information necessary in order to design a vehicle to carry a specified payload a designated distance in the least amount of time like a mechanical engineer. (Technology/Engineering)
c. Determine what information an actuary would need to know in order to answer a research question about which factors (accident, sickness, disability, etc.) are contributing the most to medical insurance claims in a region. (Mathematics)

3.3 Identifying Solutions: Given a real-world problem, **identify several possible solutions using both the engineering design process and the scientific inquiry**. For example:

a. Research several treatment plans for a severe allergy sufferer as would a biochemist or biophysicist. (Science)
b. Investigate a variety of materials suitable for building structures to withstand earthquakes as would a civil engineer. (Technology/Engineering)
c. Explore commonly used methods to safeguard computer files against accidental or unauthorized alteration, destruction, or disclosure as would an information security analyst. (Technology/Mathematics)

3.4 Critical Factors: Analyze solutions to a real-world problem collaboratively, to i**dentify critical factors of the steps of the design process**. Explain why these factors are critical. For example:

a. Research types of prosthetics and submit a proposal for which one most effectively uses the design process in terms of feasibility, cost, safety, aesthetics, and durability like a biomedical engineer. (Science)
b. Research ways a chemical engineer performs tests and monitors performance of processes throughout the stages of production for manufacturing chemicals and products such as gasoline, synthetic rubber, plastics, detergents, cement, paper, and pulp. Submit a proposal for which one most effectively uses the design process in

terms of factors like mixing, crushing, heat transfer, distillation, and drying. (Technology/Engineering)
   c. Investigate the development and use of models such as diagrams, simulations, graphs, and equations to represent findings from either science or engineering research. Critique others' proposals by providing specific arguments for or against their reasoning and methodology as would a statistician. (Technology/Mathematics)

4. Critical Thinking in Context

4.1 Problem Identification in STEM: Given a real-world STEM scenario, **identify the problem and develop meaningful questions**. Differentiate between necessary and non-essential information as well as needs and wants for applying the scientific method of investigation or the engineering design process. For example, evaluate a STEM scenario related to one of the following:
   a. Environmental scientists perform tests on the quality of water in oceans, lakes, beaches, ponds, rivers, etc. Compare and contrast the pros and cons of using a satellite to provide real time data of water conditions in order to determine its validity as a resource for environmental engineers. (Science)
   b. The organization Engineers Without Borders implements projects worldwide to provide clean drinking water to developing nations. Identify the conditions and information collected in order to provide a sustainable water source to a rural farming community. (Technology/Engineering)
   c. Robots need to be programmed to perform specific tasks in harsh working conditions such as welding parts in an automobile assembly line operation. Compare and contrast the pros and cons of using robots versus humans in a manufacturing facility. (Technology/Mathematics)

4.2 Solution Prototypes: Design and develop several **solution prototypes, conduct feasibility testing, and use the data to justify the solution** selected. For example:
   a. Use a construction set to efficiently build a vehicle at low cost, and to travel a straight path with predictability. (Science)
   b. Using readily available, low cost materials, design a water filter in a soda bottle that lets as much water through as possible, but also removes as much particulate matter as possible as would a civil engineer. (Technology/Engineering)
   c. Design and construct a robot to maneuver through a given obstacle course. Use circumference of the wheels and distance needed to travel to calculate how many rotations the wheels need to make. Justify the solution selected for the robot to maneuver most efficiently through the course. (Technology/Mathematics)

4.3 STEM Problem-based Scenario: Collaborate to write a fictional, yet plausible, **STEM problem-based scenario**. Evaluate possible solutions, **aligning work with the steps of the scientific method or the engineering design process**. Consider possible constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. Sample scenarios might include the following:
   a. A scenario to diagnosis and identify a method of treatment for an illness based on several physical symptoms. (Science)
   b. A scenario that requires the design of a self-sustaining city for humans living on

another planet. (Technology/Engineering)
    c. A scenario that requires calculation of an investment of an inheritance so that its growth is maximized by a certain time. (Mathematics)

4.4 <u>Global Challenges</u>: Conduct research to create a list of **problems that are considered major global challenges**. Choose one to analyze. Evaluate **possible solutions**, aligning work with the steps of the scientific method or the engineering design process. Consider **possible constraints**, including cost, safety, reliability, and aesthetics, as well as possible **social, cultural, and environmental impacts**. Identify trade-offs and defend decisions that were made as a result of those trade-offs. Possible global challenges could include the following:
    a. Scientists work to address the threat of a global pandemic or issues related to food security. (Science)
    b. Engineers work to address issues related to climate change and global warming, global water shortages, and the need for alternative energy sources. (Technology/Engineering)
    c. Statisticians work on projects related to national and international debt, the global population, or workforce imbalances and lack of jobs worldwide. (Mathematics)

5. STEM Field Readiness

5.1 <u>Data Manipulation</u>: Sort and **evaluate data** for its **significance and/or meaning in the process of solving a problem as a STEM professional** would. Examine the data in ways that reveal the relationships, patterns, and trends that can be found within it. Differentiate between quantitative and qualitative data. For example:
    a. Environmental scientists collect, synthesize, analyze, manage, and report environmental data, such as pollution emission measurements, atmospheric monitoring measurements, meteorological or mineralogical information, and soil or water samples. (Science)
    b. Aerospace engineers identify information by categorizing, estimating, recognizing differences or similarities, and detecting changes in circumstances or events. They are also expected to evaluate product data and design from inspections and reports for conformance to engineering principles, customer requirements, and quality standards. (Technology/Engineering)
    c. Economists study economic and statistical data in various areas of specialization, such as finance, labor, or agriculture. They also compile, analyze, and report data to explain economic phenomena and forecast market trends, applying mathematical models and statistical techniques. (Mathematics)

5.2 <u>Data Collection and Forms of Data</u>: Identify multiple **forms of data and list mechanisms for collection** that are essential to solving a problem. Prepare written documentation to **justify findings**.
    a. Statisticians analyze outcomes such as employment and educational attainment by identifying data sources, such as public data sets available from the Census Bureau, or collecting original data from the field, in order to model relationships among variables.
    b. Engineers collect data such as ease of use, operation safety, material properties, and material costs in order to determine an optimal design solution from multiple ideas.

5.3 Using Data for Creation: **Use available data to create an original prototype/solution** to a scenario.

a. Biomedical scientists and biomedical engineers design and construct prototype implants to fill and stabilize a partial bone defect. (Science)
b. Aerospace engineers test a drag device to slow a spacecraft and protect its cargo, as well as calculate the surface area and measure the mass of the spacecraft. (Science/Mathematics)

6. Cause and Effect Relationships in STEM

6.1 Cause and Effect Patterns: Analyze **multiple aspects of a problem scenario to identify cause/effect patterns**. Consider the history of a problem to identify factors such as risks and benefits.

a. Aerospace engineers perform engineering duties in designing, constructing, and testing aircraft, missiles, and spacecraft. They conduct basic and applied research to evaluate adaptability of materials and equipment to aircraft design and manufacture, and recommend improvements in testing equipment and techniques. For example, variations in the nose and fins will result in different behaviors, so construction and testing of multiple designs is necessary. (Engineering)
b. Apply standardized mathematical formulas, principles, and methodology to the solution of technological problems involving projectiles as a mathematical technician would. Use computer software to analyze the critical aspects of parabolic motion, for example: height at any given time, maximum height, maximum distance. (Technology/Mathematics)

6.2 Mathematical Models and Computer Simulations: Explore **mathematical models and/or computer simulations** that are **used** by scientists and engineers to accurately **predict the effect of components of their original prototype design**. Examine a range of resources (e.g. texts, experiments, simulations) to consider which models are likely to be most efficient, economic, and beneficial. Write a justification to support the conclusion.

a. Meteorologists interpret data, reports, maps, photographs, or charts to predict long- or short-range weather conditions, using computer models and knowledge of climate theory, physics, and mathematics. Investigate the use of mathematical or computer models for weather forecasting. (Science)
b. Civil engineers and civil drafters use the computer as a problem-solving tool. They identify locations of forces (tension, compression, torsion, shear, and resonance) in their bridge designs. Investigate the use of software to make modifications to multiple properties and gain immediate access to cost analysis and forces data. (Engineering/Technology)

6.3 Analyzing Data: Analyze data from scientific investigation or prototype testing and accurately **identify the cause of the results**. Examine **constraints** including cost, safety, reliability, and aesthetics. Consider **social, cultural, and environmental impacts**. Summarize findings using tables, functions, graphical representations, and written explanations.

a. Forensic scientists collect, identify, classify, and analyze physical evidence related to criminal investigations. They perform tests on weapons or substances, such as fiber, hair, and tissue, to determine significance to the investigation. (Science)

b. Police frequently use mathematics in the analysis of crime data. Data can be stored and interpreted using wavelets, probability, and statistics. It can be securely transmitted using prime numbers and cryptography. (Mathematics/Technology)

Standards Alignment Notes

*References to other standards include:

- P21: Partnership for 21st Century Skills Framework for 21st Century Learning
    - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.