



STEM II: Applications

Primary Career Cluster:	Science, Technology, Engineering, and Mathematics (STEM)
Course Contact:	CTE.Standards@tn.gov
Course Code(s):	C21H16
Prerequisite(s):	<i>STEM I: Foundations</i> (C21H15); <i>Algebra I</i> (G02X02, G02H00); and <i>Physical Science</i> (G03H00) or <i>Biology</i> (G03H03)
Credit:	1
Grade Level:	10
Focus Elective Graduation Requirement:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other <i>STEM</i> 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 second course in the <i>STEM Education</i> 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, visit https://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/

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** | Invite an industry representative to discuss occupations within the Science and Engineering career field.
- **Standards 2-4** | Do a project that is useful to a local employer based on each STEM path.
- **Standards 5-7** | Visit a work site to introduce students scientific modeling.
- **Standards 8-9** | Work with an industry partner on a real project.
- **Standards 10-12** | Invite a math teacher to discuss how math is essential to Science and Engineering.
- **Standards 14** | Invite a scientific writing specialist to give a seminar.
- **Standards 15-16** | Invite a science and engineering rep to discuss safety protocols related to each profession.

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

Course Description

STEM II: Applications is a project-based learning experience for students who wish to further explore the dynamic range of STEM fields introduced in *STEM I: Foundation*. Building on the content and critical thinking frameworks of *STEM I*, this course asks students to apply the scientific inquiry and engineering design processes to a course-long project selected by the instructor with the help of student input. Instructors design a project in one of two broad pathways (traditional sciences or engineering) that reflects the interest of the class as a whole; the students then apply the steps of the scientific inquiry or the engineering design process throughout the course to ask questions, test hypotheses, model solutions, and communicate results. In some cases, instructors may be able to design hybrid projects that employ elements of both the scientific inquiry and the engineering design process. Upon completion of this course, proficient students will have a thorough understanding of how scientists and engineers research problems and methodically apply STEM knowledge and skills; and they will be able to present and defend a scientific explanation and/or an engineering design solution to comprehensive STEM-related scenarios.

Note: Standards in this course are presented sequentially according to the traditional steps followed in the scientific inquiry or engineering design process. While instructors may tailor the order of course standards to their specifications, it is highly recommended that they maintain fidelity to the overall process. In addition, instructors opting for either the Science Path or the Engineering Path do not have to teach to both sets of standards; they are presented in parallel fashion here for ease of comparison, should teachers wish to combine elements of each.

Program of Study Application

This is the second 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

The Roles of Scientists and Engineers

Science Path	Engineering Path
1) Determine the scientist's role in explaining why phenomena occur in the natural world, justified by historical and current science knowledge. Research a known scientist and present in an informative paper, oral presentation, or other format his/her contributions to scientific knowledge. Include an outline of how the scientific inquiry process was used in his/her work.	1) Determine the engineer's role in developing solutions to design problems that are justified by scientific knowledge. Research a known engineer and present in an informative paper, oral presentation, or other format his/her designs and explain how they influenced technology in his/her field. Include an outline of how the design process was used in his/her work.

Questioning and Defining Problems

Science Path	Engineering Path
2) Engage in scientific inquiry by brainstorming for questions to understand how a certain phenomenon in the natural world works, to understand why a phenomenon occurs, or to determine the validity of a theory.	2) Ask clear, relevant questions that lead to defining a design problem. For example, questions should be testable and explore the requirements of a problem solution, but not define the methodology to solve the problem.
3) Research various sources (e.g., articles, end-uses, textbooks) and identify one or more questions that will guide a scientific investigation. For example, questions should be relevant, testable, and based on current scientific knowledge.	3) Brainstorm for several problem solutions, then conduct research using various sources (e.g., articles, end-uses, textbooks) to generate more solution ideas. Justify ideas using evidence from the sources.
4) Develop an original proposal as would a natural or social scientist that will guide the scientific inquiry and follow responsible ethical practices. For example, the proposal should outline the reason for the research interest, hypothesis, methodology, data analysis, importance of study, and deliverables.	4) Develop a design brief that will guide a design process and follow responsible ethical practices. For example, the design brief should outline a problem definition, design statement, criteria, constraints, and deliverables.

Modeling

Science Path	Engineering Path
5) Create models to illustrate questions and represent processes or systems that are justified by scientific evidence. For example, models can be diagrams, drawings, or scaled down physical representations.	5) Create models to illustrate design criteria and represent processes, mechanisms, or systems. For example, models can be drawings, mathematical representations, or computer simulations.
6) Use mathematics and technology to develop multiple models to predict an occurrence in the natural world. Compare and contrast the recorded observations from each model. For example, computer modeling can be used to analyze current atmospheric conditions to predict the weather in days ahead.	6) Identify and sketch at least three alternative solutions, to a problem, that consider analyses such as mechanical and electrical systems. For example, computer modeling can be used to analyze the effect of stress and strain on a beam.

7) Analyze results from modeling and appropriately determine when it is necessary to revise questions. Justify revisions with evidence.	7) Conduct iterations of modeling a solution to a design problem, demonstrate that design criteria are met, and select a reliable design approach.
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Planning & Investigating

Science Path	Engineering Path
8) Make a hypothesis that explains a scientific question, plan and conduct a simple investigation, and record observations (e.g., data) in a manner easily retrievable by others.	8) Develop a design proposal to create prototypes for testing. The proposal should provide details such as drawings with dimensions, materials, and construction process.
9) Identify the independent variables and dependent variables in an investigation. Demonstrate the effects of a changing independent variable on a dependent variable, and observe and record results.	9) Outline testing procedures that identify type of data (e.g., number of trials, cost, risk, and time) that is needed to produce reliable measurements and the specifications (e.g., effectiveness, efficiency, and durability) to determine whether a design has exceeded or failed expectations.

Data Analysis & Interpretation

Science Path	Engineering Path
10) Use mathematics to represent and solve scientific questions. For example, simple limit cases can be used to determine if a model is realistic.	10) Use mathematics to represent and solve engineering problems. For example, simple limit cases can be used to determine if a model is realistic.
11) Evaluate data and identify any limitations of data analysis. Using this information, determine whether to make scientific claims from data or revise an investigation and collect more data.	11) Evaluate data and identify any limitations of data analysis. Using this information, determine whether a design solution is optimal or should be refined and tested again.
12) Compare and contrast the data results from multiple iterations of a scientific investigation. For example, consider how well each explanation is supported by evidence, prior research, and scientific knowledge.	12) Compare and contrast the data results from testing multiple design solutions. For example, consider how well each design solution meets the design criteria and constraints.

Problem Solutions & Scientific Explanations

Science Path	Engineering Path
13) Develop an explanation to a scientific question that is logically consistent, peer reviewed, and justified by data analysis and scientific knowledge.	13) Develop an optimal design solution that is justified by data analysis and scientific knowledge, and meets ethical and design criteria and constraints.

Communicating Solutions & Explanations

Science Path	Engineering Path
14) Develop a technical report to communicate and defend a scientific explanation and justify its merit and validity with scientific information. Consider the ethical implications of the findings. The report can include tables, diagrams, graphs, procedures, and methodology. For example, conduct a STEM forum, present scientific research, and provide evidence to support arguments for or against scientific solutions.	14) Develop a design document to communicate the final design solution and how well it meets the design criteria and constraints. For example, the design document can include charts, graphs, calculations, engineering drawings, as well as information regarding marketing, distribution, and sales. For example, conduct a STEM forum, present engineering design briefs, and provide evidence to support arguments for or against design solutions.

Safety

- 15) 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.
- 16) 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.

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.