Department of Education | College, Career and Technical Education

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Engineering Design II

Primary Career Cluster:	Science, Technology, Engineering, and Mathematics (STEM)
Course Contact:	CTE.Standards@tn.gov
Course Code(s):	C21H06
Prerequisite(s):	*Engineering Design I* (C21H05) and *Biology* (G03H03) or *Chemistry* (G03H12)
Credit:	1
Grade Level:	11
Focus Elective Graduation Requirement:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other *STEM* courses. In addition, this course satisfies one credit of laboratory science required for graduation.
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 third course in the *Engineering* 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, 413, 414, 415, 416, 417, 418, 230, 232, 233, 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

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 1-4**| Invite an industry representative to discuss safety protocols and career opportunities.
- **Standards 5-6**| Invite an ethics professor to discuss ethics in engineering.
- **Standards 7-9** | Invite a local scientist to discuss scientific foundations.
- **Standards 10-12** | Invite a scientist to provide an interactive example of control systems.
- **Standards 13-14** | Invite a materials engineer to speak.
- **Standards 15-16** |Work on trajectory problem with an engineer.
- **Standards 17-19** |Invite a mathematician to discuss statistics and economics.
- **Standards 20-21** |Do a project that is used by a local industry and evaluated by industry experts.

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

Course Description

Engineering Design II is an applied course in the STEM career cluster for students interested in further developing their skills as future engineers. This course covers knowledge, skills, and concepts required for postsecondary engineering and technology fields of study. Upon completion of this course, proficient students are able to explain the differences between scientists and engineers, understand the importance of ethical practices in engineering and technology, identify components of control systems, describe differences between laws related to fluid power systems, explain why material and mechanical properties are important to design, create simple free body diagrams, use measurement devices employed in engineering, conduct basic engineering economic analysis, follow the steps in the engineering design process to complete a team project, and effectively communicate design solutions to others.

Note: Students are expected to use engineering notebooks to document procedures, design ideas, and other notes for all projects throughout the course.

Program of Study Application

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

Course Standards

Safety

1) 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.

2) 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.

Career Exploration

3) In teams, research various sources to determine the differences between engineers and scientists. Create a brochure that would be appealing to middle school students to educate them on the differences between the roles and activities of engineers and scientists. As an extension activity, prepare a presentation, using the brochures, to present to local middle school students.

4) Research various engineering job responsibilities (such as research engineer, development engineer, testing engineer, design engineer, analysis engineer, systems engineer, manufacturing engineer, operations and maintenance engineer, technical support engineer, sales engineer, and engineering manager) and present the characteristics of each. Also,

describe how these job responsibilities are applied in industry. Use a variety of sources to gather data, cite each source, and briefly explain why each source is reliable.

Engineering Ethics

5) Write an explanatory text defining ethics in the context of engineering practice, comparing and contrasting ethical standards with morals, personal standards, and legal standards. Include reasons and examples why ethical standards take precedence over personal and legal standards in engineering.

6) Research print and electronic media to identify an issue related to ethics and engineering (for example, the decision to launch the space shuttle Challenger in cold temperatures). As a team, use the National Society of Professional Engineers (NSPE) Code of Ethics as a framework and develop a presentation displaying arguments on multiple sides of the selected issue or product. Teams should present their findings to the class and other audience members.

Control Systems

7) Prepare an explanatory text defining a system and identifying the components of a system (i.e., input, output, process, feedback) using a specific example such as: if an automobile is a system, the driver provides the input by turning the steering wheel to the left; the car converts input to process; the car then delivers the output by changing direction from straight to left. Convert the description to an illustration of the system.

8) Define, compare, and contrast processors and controllers; further, define, compare, and contrast microcontrollers, computer-based controllers, and programmable logic controllers, citing examples of how each is used.

9) Define, compare, and contrast open-loop and closed-loop systems. Use responsible internet searches to find examples of both open- and closed-loop system diagrams, and explain why they are either open- or closed-loop. Use an online editing tool to develop an informational paper or infographic illustrate the difference between open- and closed-loop systems, supplying examples for each.

Fluid Power Systems

10) Define fluid power; define, compare, and contrast the two categories of fluid power: pneumatic and hydraulic. Compare and contrast hydrostatics and hydrodynamics. Compare and contrast fluid flow rate and fluid velocity. Compare and contrast the three types of air pressure: atmospheric, gauge, and absolute. Demonstrate the use of the appropriate formulae for each concept.

11) Using various sources such as the internet and textbooks, research various applications of Bernoulli’s principle and identify specific examples to demonstrate the principle. Develop and lead a lab activity to teach Bernoulli’s principle to the class.

12) Given a confined gas, explain the differences between the following laws: Boyle's, Charles', Avogadro's and Gay-Lussac's. Identify an online demonstration or prepare a demonstration of one (or more) of these laws and document each step of the law(s). Use an online editing tool to create a single written informative text with links to virtual demonstrations.

Materials and Mechanical Properties

13) Define the following and describe differences among terms dealing with strength and testing of materials (e.g., ductility, brittleness, hardness, elasticity, electrical conductivity, thermal conductivity, stress, strain, and shear stress). Explain why each factor is important to consider in a design. Research various sources and identify a demonstration of a design or material failing due to one of these characteristics; write an introduction to the topic and include the link to the video or demonstration.

14) As a team, use an online editing tool to develop an informational paper or infographic illustrating how raw materials are processed to make products and systems, and how each of these materials or products are used in society. Students should identify milestone developments (e.g., cast iron, paper, battery, and fiberglass) made possible after specific materials were developed. Metals, ceramics, polymers, and composites should be included. Select a material that is one of the most valuable materials ever discovered or manufactured, and use the online editing tool to prepare a persuasive paper supporting the claim.

Statics, Kinematics and Trajectory Motion

15) Define a projectile. Define, compare, and contrast kinematics and kinetics. Explain why a projectile travels along a parabolic curve. Solve fundamental projectile motion problems such as the initial horizontal velocity, initial vertical velocity, time for projectile to reach maximum height, maximum height reached by projectile, total flight time of projectile, distance projectile will travel horizontally, and firing angle. For example, given initial horizontal and vertical velocity of a projectile, use a graphical tool (i.e., Microsoft Excel or MATLAB) to graph the path of the projectile by programming equations defining the path.

16) Given a scenario of a stationary object with forces applied, construct a simple free body diagram, graphically illustrating the magnitude and direction of all forces acting upon the object. Demonstrate that the sum of the force vectors is equal to 0 for a stationary object. If the sum of the force vectors does not equal zero, explain the resulting motion of the object.

Introduction to Statistics and Quality

17) Given a dataset, calculate mean, mode, median, standard deviation, and range using algebraic/statistical reasoning and engineering software such as Microsoft Excel. Generate a graphical representation of the dataset including results of these statistics in a format suitable for a technical report.

18) In teams, prepare an informative report on the importance of quality management in the context of product design, process planning, and manufacturing implementation. For example, research and describe, through class discussion, the aspects of Joseph Juran's

trilogy of quality planning, quality control, and quality improvement; sampled inspection during manufacturing and the use of the Taguchi method to minimize sampling; or the concept of 6-sigma in manufacturing. Prepare and deliver a presentation to the class, and incorporate visuals and information from print and electronic resources.

Engineering Economics

19) Assess the impact of materials costs and manufacturing/construction costs in the development and determination of the best design solution. Apply techniques of engineering economics to guide design decisions. For example, understand how to use value and interest; cash flow diagrams; cash flow patterns; equivalence of cash flow patterns; unusual cash flows; and interest periods to make design solution decisions.

Projects

20) Explore how teams are formed in order to design solutions to engineering problems. Using a scholarly database such as the Education Resources Information Center (ERIC), or searching on the websites of research institutions or other organizations, investigate a well-known team of engineers (for example, the team that raised the Costa Concordia shipwreck) and report to the class on how they collaborated to solve an engineering problem.

21) As a team, identify a problem in the school or community; draft a problem statement to guide a project incorporating engineering concepts from at least three of the content sections outlined above (engineering economics **must** be included). Follow the engineering design process to solve the problem. Each team member will develop a paper following the format of a typical technical report (see components of the report below). Upon completion of the report, create and deliver a presentation for a CTSO event using appropriate citation conventions. Then, each team member will refine his/her report, incorporating feedback from the presentation.
The written report should include, but is not limited to:
    a. Background
    b. Problem definition
    c. Design constraints
    d. Methodology
    e. Data analysis (e.g., charts, graphs, calculations)
    f. Cost analysis (using engineering economics concepts)
    g. Results/Problem solution (including engineering drawings)
    h. Conclusions and recommendations for future research

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.
- National Society of Engineers (NSPE) Code of Ethics. (2014). http://www.nspe.org/resources/ethics/code-ethics.