



TENNESSEE DEPARTMENT OF

EDUCATION

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Fundamentals of Construction

Primary Career Cluster:	Architecture & Construction
Consultant:	Rachel Allen, (615) 532-2835, Rachel.Allen@tn.gov
Course Code(s):	6073
Prerequisite(s):	None
Credit:	1
Grade Level:	9
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
Programs of Study and Sequence:	This is the first course in the <i>Residential & Commercial Construction</i> , <i>Structural Systems</i> , and <i>Mechanical, Electrical, & Plumbing Systems</i> programs of study.
Necessary Equipment:	Refer to the Teacher Resources page.
Aligned Student Organization(s):	SkillsUSA: http://tnskillsusa.com/ Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/work_based_learning.shtml .
Available Student Industry Certifications:	NCCER Core Curriculum
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	501, 502, 522, 523, 524, 527, 532, 553, 554, 555, 556, 567, 575, 580, 584, 585, 592, 598
Required Teacher Certifications/Training:	None
Teacher Resources:	http://www.tn.gov/education/cte/ArchitectureConstruction.shtml

Course Description

Fundamentals of Construction is a foundational course in the Architecture & Construction cluster covering essential knowledge, skills, and concepts required for careers in construction. Upon completion of this course, proficient students will be able to describe various construction fields and outline the steps necessary to advance in specific construction careers. Students will be able to employ tools safely

and interpret construction drawings to complete projects demonstrating proper measurement and application of mathematical concepts. Standards in this course also include an overview of the construction industry and an introduction to building systems and materials. Students will begin compiling artifacts for inclusion in their portfolios, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects, Tennessee State Standards in Mathematics, and the National Center for Construction Education and Research (NCCER) Curriculum.*

Program of Study Application

This is the foundational course in the *Residential & Commercial Construction, Structural Systems, and Mechanical, Electrical, & Plumbing Systems* programs of study. For more information on the benefits and requirements of implementing these programs in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

Course Standards

Safety

- 1) Identify safety hazards on a jobsite and demonstrate practices for safe working conditions. Accurately read and interpret safety rules, including but not limited to 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. (TN Reading 3, 4, 6)
- 2) Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, equipment safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy. (TN Reading 3, 4)
- 3) Follow procedures to work safely around materials. Adhere to responsibilities for employees in material safety as outlined by the Hazard Communication Standard (HazCom), such as locating and interpreting material safety data sheets (MSDS). Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. (TN Reading 3, 4)

History of Architecture & Construction

- 4) Investigate the evolution of architecture and construction across a variety of civilizations throughout history. Identify major architectural innovations, such as technological advances in materials or construction processes. Create an annotated timeline or visual graphic illustrating significant time periods in the development of construction. (TN Reading 2, 4, 7; TN Writing 2, 9)



Introduction to the Construction Industry

- 5) Drawing on resources from textbooks, websites, and research centers such as the National Center for Construction Education and Research (NCCER), analyze the organization of the modern construction industry. Distinguish among the various personnel involved in the industry and explain the roles of each in the construction process, including but not limited to the owner, developer, architects, engineers, building officials, contractors, suppliers, unions, and professional craftsmen. For example, create a written report or infographic describing the basic steps of traditional building delivery for a construction project (from pre-design to post-construction), outlining who and what is involved in each step. (TN Reading 1, 2, 4, 5, 7; TN Writing 2)
- 6) Research basic regulations affecting today's construction industry.
 - a. Investigate and report on the process for securing a building permit for a selected location in the community. (TN Reading 2, 3, 4; TN Writing 2)
 - b. Explain what a building code is and where to find published local building codes. Write persuasively to defend why a particular building code is necessary. (TN Reading 2, 3, 4; TN Writing 1)
- 7) Investigate the social, economic, and environmental impact of construction work at the local, national, and global levels. Analyze current and emerging trends in the construction industry such as LEED certification and green building design. For example, write an informative essay on how the implementation of green construction practices (such as preventing waste and recycling waste) affects the environment and cost of a project. (TN Reading 2, 4; TN Writing 2, 9)

Career Exploration

- 8) Research the major professions and trades within construction, such as construction manager, cost estimator, carpenter, mason, electrician, and HVAC technician. Produce a chart or other graphic detailing the aptitudes and training needed for at least three careers of interest. For example, outline the typical steps needed to become a journeyman electrician, such as completing postsecondary training and obtaining on-the-job training through an apprenticeship, and devise a tentative career plan to reach employment goals. (TN Reading 1, 2, 4, 7; TN Writing 2, 9)
- 9) Evaluate jobs data and employment projections in the construction industry from sources such as O*Net OnLine. Determine areas of largest growth and discuss the significance of construction to the national and global economy. Articulate why construction is considered a STEM field, citing the specific knowledge, skills, and abilities required to be successful in a variety of construction occupations. (TN Reading 1, 2, 4, 7; TN Writing 9; TN Math S-ID)

Introduction to Measurement

- 10) Use physical measurement devices typically employed in construction to complete accurate field measurements. Determine the appropriate units and record accurate measurements of lengths and angles. Tools should include, but are not limited to: fractional rule, metric rule, measuring tape, architect's scale, engineer's scale, dial caliper, micrometer, protractor, and square. (TN Reading 3; TN Math N-Q)



- 11) Interpret given linear and angular dimensions to accurately set up layouts to complete a project. For example, use an architect's scale to measure distance on a construction drawing, and then use a measuring tape to lay out cuts in dimensional lumber to an accuracy of 1/16 inch. (TN Reading 2, 3; TN Math N-Q)

Construction Math

- 12) Apply mathematics concepts to solve construction problems, distinguishing which principles apply to a given construction problem. Concepts should include, but are not limited to:
- Operating with whole numbers, fractions, and decimals. (TN Math N-Q)
 - Performing conversions between fractions, decimals, and percent. For example, convert a decimal to a fraction to prepare a unit for measurement on a fractional scale to the precision of 1/16 of an inch. (TN Math N-Q)
 - Working with units such as feet, inches, meters, centimeters, and millimeters, and determining appropriate units for a given construction task. For example, determine how many pieces of 2 ft. 4 in. PVC pipe may be cut from a 10 ft. piece and how much pipe will be left over. (TN Math N-Q)
 - Calculating the area of two-dimensional spaces. Calculating surface area and volume for three-dimensional objects employing related geometric terminology. (TN Math G-GMD, G-MG)
 - Performing proportionate reasoning to estimate quantities. (TN Math N-Q)
 - Using basic rules of right triangles, such as the Pythagorean Theorem, to find missing lengths. (TN Math G-SRT)

Tools & Equipment

- 13) Accurately identify a wide range of hand and power tools used in the construction trades, such as striking tools, cutting tools, torque producing tools, leveling and squaring tools, grinding and shaping tools, clamping tools, and pulling and lifting tools. Explain when each is used and describe the characteristics that make each appropriate for a given task. (TN Reading 2, 3, 4)
- 14) Assess a variety of situations requiring the use of hand tools, power tools, and equipment. Select the proper tool and accessories, critique the readiness of the tool, use the tool to accomplish the desired task, and then return the tool and accessories to their proper storage. For example, demonstrate the ability to safely use a crosscut saw to cut a straight square to specified dimensions on dimensional lumber. (TN Reading 3; TN Math N-Q)

Introduction to Building Systems and Materials

- 15) Compare and contrast the properties and uses of basic construction materials employed in building construction processes, such as aggregates, asphalt, concrete, steel, wood, and masonry materials. (TN Reading 4)
- 16) Distinguish between the various types of fasteners commonly used in construction, such as nails, screws, and bolts, by creating a visual display outlining the properties and uses of each type. Demonstrate the ability to accurately select and install the appropriate fastener in a variety of situations. (TN Reading 2, 4, 7)



- 17) Using graphic illustrations and supporting text, identify and describe major building systems (i.e. foundation, structural, mechanical, electrical, and plumbing systems) to establish a basic knowledge of their purpose, structure, and function. Discriminate between the different types of construction drawings related to these systems and the common symbols used in each. (TN Reading 2, 4, 5, 7, 9)

Construction Drawings

- 18) Inspect and interpret construction drawings, diagrams, and written specifications for construction projects. Explain how pictorial representations relate to a physical layout. Use an architect's scale and the given dimensions on a construction document to determine an unknown dimension. For example, interpret electrical schedules and single-pole or three-way light switch symbols in electrical plans to determine the types, quantities, and exact physical locations of the light switches to be installed in a construction project. (TN Reading 1, 2, 4, 6, 7)
- 19) Investigate and explain the relationship between a plan, elevation, section, and detail drawing. For example, explain how a floor plan, elevation, and detail drawing may all be used to inform the reader about the layout and material of a given building component, such as a cabinet layout or an exterior wall. (TN Reading 1, 2, 4, 5, 6, 7)
- 20) Create two-dimensional scale drawings using accepted dimensioning rules and measurement systems. For example, as part of a project to build a simple structure, develop the complete drawings that specify the dimensional details for each step of the construction process, annotating all drawings such that another person could replicate the work. (TN Reading 3, 4; TN Math N-Q, G-MG)

Course Project

- 21) Interpret construction drawings to determine the correct materials, tools, and equipment needed to complete a basic construction project. Plan and implement the steps needed to complete the project, employing safe practices throughout. For example, read and interpret a technical document to build a simple tool box. (TN Reading 1, 2, 4, 6, 7)

Portfolio

- 22) Compile important artifacts to create a portfolio connecting personal career preparation to concepts learned in this course. (TN Writing 4)

Standards Alignment Notes

*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 9-10 Students (page 62).



- Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 8 and 10 at the conclusion of the course.
- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 9-10 Students (pages 64-66).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3, 5, 6, 7, 8, and 10 at the conclusion of the course.
- TN Math: [Tennessee State Standards for Mathematics](#); Math Standards for High School: Number and Quantity, Geometry, Statistics and Probability (pages 58-83).
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative, geometric, and statistical reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- NCCER Curriculum: [National Center for Construction Education and Research](#)
 - Students who are engaging in activities outlined above will be prepared to pursue certification in the NCCER Core Curriculum module.
- 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.





TENNESSEE DEPARTMENT OF

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Residential & Commercial Construction I

Primary Career Cluster:	Architecture & Construction
Consultant:	Rachel Allen, (615) 532-2835, Rachel.Allen@tn.gov
Course Code(s):	TBD
Prerequisite(s):	<i>Fundamentals of Construction</i>
Credit:	1
Grade Level:	10
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
Programs of Study and Sequence:	This is the second course in the <i>Residential & Commercial Construction</i> program of study.
Necessary Equipment:	Refer to the Teacher Resources page.
Aligned Student Organization(s):	SkillsUSA: http://tnskillsusa.com/ Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/work_based_learning.shtml .
Available Student Industry Certifications:	Modules may count towards NCCER Construction Technology.
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	580
Required Teacher Certifications/Training:	TBD
Teacher Resources:	http://www.tn.gov/education/cte/ArchitectureConstruction.shtml

Course Description

Residential & Commercial Construction I is the second course in the *Residential & Commercial Construction* program of study intended to prepare students for careers in construction by developing an understanding of the different phases of a construction project from start to finish. Upon completion of this course, proficient students will be able to demonstrate knowledge and skill in the earlier phases of building construction, including site layout, foundation systems, concrete, framing systems, and

electrical systems. Students will be able to perform concrete work; frame walls, ceilings, and floors of a structure; and install proper wiring while safely employing tools and interpreting construction drawings to complete projects. Emphasis is placed on demonstrating proper measurement and application of mathematical concepts. Standards in this course also include principles of the construction industry and business and project management. Students will continue compiling artifacts for inclusion in their portfolios, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects, Tennessee State Standards in Mathematics, Tennessee Physical Science Standards, and the National Center for Construction Education and Research (NCCER) Curriculum.*

Program of Study Application

This is the second course in the *Residential & Commercial Construction* program of study. For more information on the benefits and requirements of implementing this program in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

Course Standards

Safety

- 1) Identify safety hazards on a jobsite and demonstrate practices for safe working conditions. Accurately read and interpret safety rules, including but not limited to 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. Perform a hazard assessment for a given task such as changing the light bulbs in a classroom. Explain the steps necessary to safely perform the task, outlining procedures to follow in the case of an emergency. (TN Reading 3, 4, 6; TN Writing 2)
- 2) Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, equipment safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy. (TN Reading 3, 4)
- 3) Follow procedures to work safely around materials. Adhere to responsibilities for employees in material safety as outlined by the Hazard Communication Standard (HazCom), such as locating and interpreting material safety data sheets (MSDS). Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. (TN Reading 3, 4)

Tools & Equipment

- 4) For each of the systems covered in this course, identify and select the proper tools and accessories, critique the readiness of the tools, use the tools to accomplish the desired tasks, and then return the tools and accessories to their proper storage locations. For example,



demonstrate the ability to safely use a darby or bullfloat to level a concrete surface and effectively clean and store the tool. (TN Reading 3; TN Math N-Q)

Career Exploration

- 5) Referencing data from U.S. Department of Labor and other sources, explain an apprenticeship. Write persuasively to describe the benefits of the apprenticeship approach of on-the job training paired with related training for individuals seeking construction careers. Use a variety of sources to gather data, cite each source, and briefly describe why the chosen source is reliable. (TN Reading 1, 7, 8; TN Writing 1, 8)
- 6) Research apprenticeships and postsecondary institutions (colleges of applied technology, community colleges, and four-year universities) in Tennessee and other states that offer construction-related programs. Write an informative paper or develop an infographic identifying entry requirements for a specific apprenticeship or postsecondary program of study, and the secondary courses that will prepare students to be successful in the program. (TN Reading 1, 3; TN Writing 4)

Construction Industry Principles

- 7) Investigate and report on the process for determining the zoning regulations for a particular building site. Describe how zone designation and regulations such as setbacks, ground coverage, and maximum height impact the design and placement of a building on a given site. (TN Reading 2, 3, 4; TN Writing 2)
- 8) Explain inspection procedures used to enforce building codes during the construction of a residential or commercial building, outlining the roles and responsibilities of the building inspector and the contractor and the intervals at which inspections are performed. (TN Reading 2, 3, 4)

Site Layout

- 9) Read and interpret a site drawing to determine the steps, personnel, equipment, and materials needed to prepare a site for construction. Relate the site features labeled on the plan to the layout and topography on the actual site. Develop a timeline and action steps needed to complete a site layout. (TN Reading 1, 2, 4, 6, 7)
- 10) Apply the appropriate mathematical principles, tools, equipment, and procedures to accurately lay out a site, including:
 - a. Estimating distances by employing pacing techniques. (TN Math N-Q)
 - b. Completing precise measurements with manual or electronic equipment, using mathematical concepts as necessary, such as converting decimal feet to feet and inches or applying right triangle rules such as the 3-4-5 rule. For example, in the process of staking the corners of a building using taping procedures, calculate the diagonal of the building by plugging the length and width of the building into the Pythagorean Theorem. Then, use the diagonal value to locate the third corner and check the completed layout for accuracy. (TN Reading 3; TN Math N-Q, G-SRT)



- c. Describing the tools, equipment, and procedures involved in establishing elevations on a site. For example, use a builder's level to determine site and building elevations. (TN Math N-Q)
- d. Annotating site layout data using proper field note techniques. (TN Writing 2)

Foundation Systems and Properties of Concrete

- 11) Draw on construction texts and other technical documents to compare and contrast types of foundation systems and footings. Create a written report or visual description outlining the structure and properties of each type. Describe the conditions, costs, and other factors that influence the decision to use each type of system. (TN Reading 2, 4, 5, 7; TN Writing 2)
- 12) Describe the composition of concrete by listing the materials used to make concrete. Analyze the factors that impact the compression strength of concrete, such as the water-cement ratio. Identify additional materials used in concrete construction, such as reinforcement materials and forms. For example, create a comparison chart outlining the materials, forms, and reinforcement used in concrete for a sidewalk versus a bridge. (TN Reading 2, 4, 5, 7; TN Writing 2, 9; TN Math N-Q)
- 13) Calculate the total volume of concrete and the specific materials necessary for a given project based on construction drawings and specifications. Use the information to estimate the amount of each material needed to mix concrete for the project. (TN Reading 4, 6; TN Math N-Q, G-GMD, G-MG)
- 14) Analyze factors influencing the curing of concrete, such as the weather, moisture, and the use of control joints. For example, write an explanatory text outlining the procedures necessary to ensure concrete cures properly for a given date and location, including procedures to prevent cracking and recommendations for the spacing of control joints. (TN Reading 2, 3, 4, 5; TN Writing 2, 4; TN Math N-Q)
- 15) Apply the appropriate tools, equipment, and procedures to safely place concrete and cleanup after a concrete project. Work in teams to safely and properly employ tools and personal protective equipment (PPE), and follow procedures to construct a simple concrete form, place concrete into the form, and strike-off (screed), level, smooth, edge, and joint concrete to finish the project. (TN Reading 3, 4)

Framing Systems Overview

- 16) Distinguish among the basic types of wood framing systems, such as platform frames, balloon frames, and post-and-beam frames. Create a chart to define and compare the pros and cons of each, citing examples of when each is used. (TN Reading 1, 2, 7)

Floor Framing Systems

- 17) Identify the components which make up a floor frame, analyzing the purpose of and interrelationships among each component and explaining the sequence in which each is constructed. (TN Reading 2, 3, 4, 5)



- 18) Read and interpret construction drawings to determine floor system requirements such as the proper girder and joist size for a given span and floor load, and estimate the amount of material needed to frame a floor assembly. (TN Reading 1, 4, 7; TN Math N-Q)
- 19) Describe the procedures necessary to fasten sills to the foundation and construct a floor assembly. Apply the appropriate tools, equipment, and procedures to build a floor assembly. Work in teams to install girders, lay out and install floor joists, install bridging and blocking, and apply subflooring. (TN Reading 3)

Wall and Ceiling Framing Systems

- 20) Explain the procedure to lay out a wood frame wall, defining and describing the components such as plates, studs, partitions, door and window openings, bracing, and other components. (TN Reading 3, 4)
- 21) Read and interpret drawings to determine wall and ceiling frame requirements for a given residential or commercial structure. For example, calculate the length of a stud and estimate the amount of material needed to frame a wall and ceiling assembly. (TN Reading 4; TN Math N-Q)
- 22) Work in teams to construct a wall frame and ceiling assembly by implementing required safety techniques, tools, and equipment. Accurately measure and lay out the frame; accurately level and plumb the walls. (TN Reading 3; TN Math N-Q)
- 23) Compare and contrast the different tools, procedures, and fastening methods used in steel wall framing versus wood wall framing in building construction. Outline the major similarities and differences in each and write persuasively to provide a recommendation to a client for a specific project. (TN Reading 2, 3, 4; TN Writing 1, 4, 9)

Electrical Systems

- 24) Describe how different levels of electrical shock affect the human body. Research current OSHA standards and other regulations specific to electrical systems to identify methods and equipment to reduce the risk of injury due to electrical shock. Drawing on evidence from textbooks and OSHA standards, apply lockout/tagout procedures to ensure safe working conditions. For example, perform a lockout/tagout to prepare to work on an electrical device. (TN Reading 1, 2, 3, 4; TN Writing 9)
- 25) Citing technical data, explain the interrelationships among sources of current, voltage, resistance, and power in electric circuits and the units to quantify each (amperes, volts, ohms and watts). Demonstrate understanding of the operation of electrical circuits (series, parallel, and series-parallel circuits) and relate it to the physical laws, such as Ohm's law and Kirchhoff's law, that govern the behavior of electrical circuits and devices such as the function of resistors in electrical circuits. Accurately apply these physical laws to solve problems. For example, use Ohm's law to calculate the current flow of a circuit for an electric dryer with a given voltage and resistance. (TN Reading 2, 3, 4, 5; TN Math N-Q, A-SSE, A-CED; TN Physical Science 2)



Business and Project Management

- 26) Describe strategies used to promote collaboration, trust, and clear communication among internal and external parties on a job site. Practice effective verbal, nonverbal, written, and electronic communication skills for working with colleagues, employers, clients, and other personnel while demonstrating the ability to: listen attentively, speak courteously and respectfully, resolve obstacles in construction, and respond to criticism. For example, assume the roles of a construction business owner and a potential client, listen to the needs of the potential client, and respond to the potential client by email; explain the services provided by the company and the next steps needed to begin the project. Other role playing could include a construction business owner and a potential subcontractor. (TN Reading 2, 3; TN Writing 2, 4)
- 27) Describe the components and purpose of a basic contract document for a residential project. Recognize the relationship and responsibilities of various parties to a contract. Write a basic contract for a construction job, such as a carpenter's contract to complete a deck addition for a residential client. (TN Reading 2, 3, 4, 5)
- 28) Interpret construction drawings to determine the correct materials, tools, and equipment needed to complete a construction project. Plan and implement the steps needed to complete the project, adhering to inspection procedures and employing safe practices throughout. Draw from print and electronic examples to create a material list, cost estimation, construction schedule, and inspection checklist for a project, applying the components of the documents to the given project. (TN Reading 2, 3; TN Writing 4)
- 29) Log daily activities completed during a construction project over an extended period of time. Document important facts concisely in a daily report as would a project manager on a jobsite, including daily progress, equipment and materials used, personnel involved, and other work-related activities. (TN Reading 3; TN Writing 2, 5, 10)

Portfolio

- 30) Update materials from coursework to add to the portfolio started in *Fundamentals of Construction*. Continually reflect on coursework experiences and revise and refine the career plan generated in the prior course. Include photographs or illustrations and written descriptions of sequential progress in construction projects. (TN Writing 2, 4)

Standards Alignment Notes

*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 9-10 Students (page 62).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 9 and 10 at the conclusion of the course.



- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 9-10 Students (pages 64-66).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3 and 6 at the conclusion of the course.
- TN Math: [Tennessee State Standards for Mathematics](#); Math Standards for High School: Number and Quantity, Algebra, Geometry (pages 58-83).
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative, algebraic, and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- TN Physical Science: Tennessee Science: [Physical Science](#) standard 2 may provide additional insight and activities for educators.
- NCCER Curriculum: [National Center for Construction Education and Research](#)
 - Students who are engaging in activities outlined above will be able to complete modules working toward certification in NCCER Construction Technology.
- 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.





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Residential & Commercial Construction II

Primary Career Cluster:	Architecture & Construction
Consultant:	Rachel Allen, (615) 532-2835, Rachel.Allen@tn.gov
Course Code(s):	TBD
Prerequisite(s):	<i>Fundamentals of Construction, Residential & Commercial Construction I</i>
Credit:	1-2 credits (see Recommended Credit below)
Grade Level:	11
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
Programs of Study and Sequence:	This is the third course in the <i>Residential & Commercial Construction</i> program of study.
Necessary Equipment:	Refer to the Teacher Resources page.
Aligned Student Organization(s):	SkillsUSA: http://tnskillsusa.com/ Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/work_based_learning.shtml .
Available Student Industry Certifications:	Modules may count towards NCCER Construction Technology.
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	580
Required Teacher Certifications/Training:	TBD
Teacher Resources:	http://www.tn.gov/education/cte/ArchitectureConstruction.shtml

Course Description

Residential & Commercial Construction II is the third course in the *Residential & Commercial Construction* program of study intended to prepare students for careers in construction by developing an understanding of the different phases of a construction project from start to finish. Upon completion of this course, proficient students will be able to demonstrate knowledge and skill in the later phases of building construction including roofing systems, exterior finishing, stair framing systems, masonry

systems, and plumbing systems. Students will be able to perform masonry work; frame roofs; install shingles on roofs; apply exterior finishes; and install proper piping for plumbing systems while safely employing tools and interpreting construction drawings to complete projects. Emphasis is placed on demonstrating proper measurement and application of mathematical concepts. Standards in this course also include an introduction to heating, ventilation, and air conditioning systems, principles of the construction industry, and business and project management. Students will continue compiling artifacts for inclusion in their portfolios, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects, Tennessee State Standards in Mathematics, Tennessee Physical Science Standards, Tennessee Physics Standards, and the National Center for Construction Education and Research (NCCER) Curriculum.*

Program of Study Application

This is the third course in the *Residential & Commercial Construction* program of study. Flexibility is built in to offer this course for either one or two credits, depending on school capacity and teacher background. Whether offered for one credit or two credits, this course can feed into a fourth-level *Construction Practicum* course in which students can apply the skills learned throughout the program of study toward the completion of an in-depth, semester- or year-long work-based learning (WBL) apprenticeship or internship. For more information on the benefits and requirements of implementing this program in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

Recommended Credit

If all standards in the course are covered, the course is recommended for two credits. If only one credit is to be offered, the following two options are recommended:

1 Credit- Option A

Content	Standards
Safety	1, 2, 3
Tools & Equipment	4
Construction Industry Principles	5, 6
Roofing Systems	6, 7, 8, 9, 10, 11, 12
Exterior Finishing	13, 14, 15, 16
Basic Stair Framing Systems	17, 18
Introduction to Masonry	19, 20
Business & Project Management	32, 33, 34, 35
Portfolio	36

1 Credit- Option B

Content	Standards
Safety	1, 2, 3
Tools & Equipment	4
Construction Industry Principles	5, 6
Plumbing Systems	21, 22, 23, 24, 25, 26
Principles of Electrical Systems	27, 28, 29
Introduction to HVAC	30, 31
Business & Project Management	32, 33, 34, 35
Portfolio	36



Course Standards

Safety

- 1) Identify safety hazards on a jobsite and demonstrate practices for safe working conditions. Accurately read and interpret safety rules, including but not limited to 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. Recognize and employ universal construction signs and symbols such as colors, flags, stakes, and hand signals that apply to construction workplace situations. Research and evaluate construction company safety plans from local industry. Explain the need for jobsite security to prevent liability. Drawing from examples, create and implement a jobsite safety program in the class to ensure safe practices and procedures including jobsite security procedures. (TN Reading 3, 4, 6; TN Writing 2, 4)
- 2) Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, equipment safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy. (TN Reading 3, 4)
- 3) Follow procedures to work safely around materials. Adhere to responsibilities for employees in material safety as outlined by the Hazard Communication Standard (HazCom), such as locating and interpreting material safety data sheets (MSDS). Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. (TN Reading 3, 4)

Tools & Equipment

- 4) For each of the systems covered in this course, identify and select the proper tools and accessories, critique the readiness of the tools, use the tools to accomplish the desired tasks, and then return the tools and accessories to their proper storage. Research a new technology recently developed for the construction industry. Write persuasively to convince an employer how the use of the technology could benefit the company, citing evidence from resources. For example, describe how a new power tool could improve efficiency and reduce muscle fatigue for a construction team. (TN Reading 2, 3, 4; TN Writing 1)

Construction Industry Principles

- 5) Locate and assess the Tennessee Contractor's Licensing Board's website and analyze the policies and requirements for construction work in Tennessee. Explain how such policies impact local construction businesses. (TN Reading 2, 3, 4)
- 6) Describe alternatives to traditional project delivery methods, such as the design-build and construction management-related methods, distinguishing among the roles and relationships of



various construction personnel in each scenario. Examine the project delivery method of an actual company. Develop a company profile with supporting graphics the company could share with a client describing the services provided and explaining the building delivery method used by the company. (TN Reading 2, 3, 4, 5, 7; TN Writing 2, 4)

Roofing Systems

- 7) Define and describe the framing components of gable and hip roofs such as the ridgeboard, plates, and types of rafters. For example, create a graphic illustration showing the roles of each component and how they work together in a roof framing system. (TN Reading 3, 4, 7)
- 8) Read and interpret drawings to determine roof framing requirements, such as calculating the length of a rafter based on the desired pitch and estimating the materials needed to frame and sheath a roof. For example, use a speed square to lay out a common rafter on a piece of lumber. (TN Reading 2, 3, 4; TN Math N-Q, G-SRT)
- 9) Work in teams to construct a roof frame assembly by implementing required safety techniques, tools, and equipment to accurately measure, lay out, construct, and sheath a roof frame. For example, frame a gable roof with an opening. (TN Reading 3; TN Math N-Q)
- 10) Compare and contrast different procedures to frame a roof. For example, describe the benefits of using prefabricated trusses in place of framing with rafters on site. Outline the major similarities and differences in each and write persuasively to provide a recommendation to a client for a specific project. (TN Reading 2, 3, 4; TN Writing 1, 4, 9)
- 11) Compare and contrast the materials, methods, and procedures for roofing with fiberglass shingles with other roofing materials such as wood shingles. Perform a cost analysis for a client to help the client choose between two roofing materials for a specific project given the site location, project budget, environmental considerations, and other factors. (TN Reading 2, 3, 4)
- 12) Apply the appropriate tools, equipment, and procedures to safely install shingles on a roof including strategies for watertight installation, using quantitative reasoning and geometric formulas where applicable. For example, interpret construction documents to estimate the roofing materials needed to install fiberglass shingles on a gable roof. After preparing the roof with underlayment, flashing, and other preparation materials, install fiberglass shingles. (TN Reading 3; TN Math N-Q)

Exterior Finishing

- 13) Examine a wall section drawing for a specific building. Identify, define, and explain the function of each component including wall insulation, flashing, and the structure of the cornice. Draw from textbooks and other resources to annotate the wall section drawing with notes explaining the purpose of each component. (TN Reading 1, 2, 3, 4, 5, 7; TN Writing 2, 4, 9)
- 14) Interpret wall section drawings to safely construct a cornice. For example, accurately measure materials, employ tools, and follow procedures to build a box cornice, checking for accuracy in each step. (TN Reading 3; TN Math N-Q)



- 15) Analyze various finish systems used to sheath a building, including but not limited to wood siding, fiber-cement siding, vinyl siding, metal siding, stucco, and masonry veneer finishes. Perform a case study of three different buildings in the community which are sheathed in different ways, hypothesizing why the different materials and methods were selected for each. (TN Reading 2, 3, 4)
- 16) Estimate the siding materials needed to cover a building utilizing mathematical principles such as area formulas and quantitative reasoning. Utilize the appropriate procedures, tools, and materials to install various types of siding. For example, identify three siding methods that are commonly used in the area and demonstrate the ability to plan the installation of and install each. (TN Reading 3; Math N-Q)

Basic Stair Framing Systems

- 17) Analyze the components of a stair system. Read and interpret construction drawings to determine stair system requirements such as the total rise, number and size of risers, and number and size of treads. Based on stated requirements, estimate the amount of material needed to frame a stair assembly. (TN Reading 2, 3, 4, 5, 7; TN Math N-Q)
- 18) Apply the appropriate tools, equipment, and procedures to safely build a small stair unit, demonstrating proper procedures for laying out and cutting stringers, risers, and treads. (TN Reading 3; TN Math N-Q)

Introduction to Masonry Systems

- 19) Describe the materials and methods used in modern masonry. Distinguish between masonry units made of clay products (i.e. brick) and masonry units made of concrete (i.e. block), analyzing the composition and structure of common units. Differentiate between the types of masonry construction, such as solid masonry walls, cavity walls, and veneer walls, citing examples of when each is used. Apply the knowledge to examine two different masonry constructions found in the school or community. Create a visual display with supporting text comparing the composition and construction methods of each. (TN Reading 1, 2, 3, 4, 5, 7; TN Writing 2)
- 20) Describe the procedures and techniques of basic bricklaying, including preparing mortar, laying a mortar bed, and laying bricks. Apply the appropriate tools, equipment, and procedures to safely mix mortar and properly use a trowel to spread and furrow bed joints and butter head joints. (TN Reading 3, 4)

Plumbing Systems

- 21) Study a schematic plan of a typical community sewer system. Citing evidence from a technical description or actual observation of a system, explain how waste moves through a drain, waste, and vent system from the fixture to the environment. Create a graphic illustration to represent the movement of waste from one component to the others in the system. For example, create a basic diagram of how the waste generated by a clean-up sink in the classroom travels to the local sewage treatment plant. (TN Reading 2, 3, 4, 7)



- 22) Demonstrate understanding of the specific roles of various plumbing components in a drain, waste, and vent system by sketching a system model. Label the components, and include a written description of the function of each. Be able to describe the physical principles involved such as gravity and pressure. (TN Reading 2, 3, 4, 5, 7; TN Writing 2; TN Physical Science 1)
- 23) Analyze the function of a trap by examining a drain, waste, and vent system whose trap has lost its seal. Diagnose and explain the cause and determine the appropriate solution, citing evidence from textbooks or technical manuals in order to justify why the chosen solution is preferable or more effective than another. (TN Reading 1, 2, 4, 5; TN Writing 2, 9)
- 24) Determine common requirements found in plumbing codes and explain why the codes are necessary; include the importance of proper plumbing on human health. Examine a case in which poor plumbing contributed to the outbreak of disease in a community. Write an explanatory text to illustrate the problem and describe how it could have been prevented with proper plumbing applications. (TN Reading 2, 4, 5; TN Writing 2)
- 25) Compare and contrast the material properties and uses of the various types of plastic and copper piping, including storing and handling, safety issues, and types of fitting and hanging equipment. Describe the factors influencing the decision to use plastic or copper piping in a residence. Demonstrate the ability to select the correct materials, tools, and PPE to complete both plastic and copper piping projects by creating a list of the items needed for a specific installation. For example, for a residential bathroom sink drain, create a list of the materials, tools, and equipment needed to install the drain. (TN Reading 2, 3, 4, 7; TN Writing 4, 9)
- 26) Employ tools and procedures to safely measure, cut, ream, and join plastic and copper piping and fittings. For example, accurately measure PVC pipe, use a miter box and handsaw to cut pieces of pipe, ream and chamfer the ends, and join the pipe using solvent cement. (TN Reading 3, 4; TN Math N-Q)

Principles of Electrical Systems

- 27) Evaluate and recommend proper electrical hardware for a residential building. For example, for a residential dwelling with a given floor plan and schedule of major appliances, determine the size of the electrical service by referring to the National Electrical Code to select the service-entrance equipment, such as conductors, panelboard, and protective devices. Steps should include: calculating the load for lighting, small appliances, and large appliances; and determining the number of branch circuits required. Describe the installation rules pertaining to dedicated circuits as applied to various equipment such as ranges, dryers, and HVAC systems. (TN Reading 2, 3, 4, 7; TN Math N-Q; TN Physical Science 2)
- 28) Utilize the proper tools, equipment, and procedures to select and safely perform basic installation of device boxes according to drawings, specifications, and code requirements. (TN Reading 3, 4, 6, 9)



- 29) Utilizing test equipment such as a voltmeter, inspect and test an electrical wiring system for compliance according to drawings, specifications, and code requirements. (TN Reading 3, 4, 6; TN Math N-Q; TN Physical Science 2; TN Physics 5)

Introduction to Heating, Ventilation, and Air Conditioning Systems (HVAC)

- 30) Demonstrate understanding of the principles of heating, ventilation and air conditioning systems. Use graphic illustrations and supporting text to describe the structure and function of each system. (TN Reading 2, 3, 4, 5, 7; TN Writing 2)
- 31) Examine the regulations which impact the work of HVAC technicians, such as the Clean Air Act and EPA guidelines. Create a brochure to inform an individual contemplating beginning an HVAC business of these regulations, explaining key considerations and citing resources. (TN Reading 1, 2, 4; TN Writing 2, 4, 9)

Business & Project Management

- 32) Demonstrate advanced understanding of contract documents. Examine the components of a subcontract and explain the function of each component. For example, explain the responsibility of subcontractor if damages are incurred due to delays caused by the subcontractor. (TN Reading 2, 4, 6)
- 33) Establish and implement specific goals to manage project assignments in a timely manner, including organizing teams to effectively manage assignments, monitoring and reporting on project progress, and evaluating a completed project according to client requirements. For example, inspect and critique a team member's work, providing constructive feedback for improvement. Similarly, respond to constructive feedback from a team member to improve project outcomes and meet project goals. (TN Reading 2, 6; TN Writing 2)
- 34) Perform estimating and scheduling techniques for a long-term project, including calculating material quantities and cost (including tax) and labor cost to complete a bid sheet; scheduling construction activities using a flow chart; and determining amounts to be charged to the client at various intervals throughout the project. (TN Reading 3, 7; TN Math N-Q)
- 35) Utilize technology to write and share periodical reports (weekly, monthly, etc.) to provide others with information about progress during construction activities as would a project manager to a supervisor. Summarize activities in a narrative form including overall progress in relationship to a previously planned schedule. (TN Reading 3; TN Writing 2, 4, 6, 10)

Portfolio

- 36) Update materials from coursework to add to the portfolio started in *Fundamentals of Construction* and *Residential & Commercial Construction I*. Continually reflect on coursework experiences and revise and refine the career plan generated in prior courses. Include photographs or illustrations and written descriptions of sequential progress in construction projects. (TN Writing 2, 4)



Standards Alignment Notes

*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 11-12 Students (page 62).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 8 and 10 at the conclusion of the course.
- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 11-12 Students (pages 64-66).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3, 5, 7, and 8 at the conclusion of the course.
- TN Math: [Tennessee State Standards for Mathematics](#); Math Standards for High School: Number and Quantity, Geometry (pages 58-83).
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- TN Physical Science: Tennessee Science: [Physical Science](#) standard 2 may provide additional insight and activities for educators.
- TN Physics: Tennessee Science: [Physics](#) standard 5 may provide additional insight and activities for educators.
- NCCER Curriculum: [National Center for Construction Education and Research](#)
 - Students who are engaging in activities outlined above will be able to complete modules working toward certification in NCCER Construction Technology.
- 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.





Structural Systems I

Primary Career Cluster:	Architecture & Construction
Consultant:	Rachel Allen, (615) 532-2835, Rachel.Allen@tn.gov
Course Code(s):	TBD
Prerequisite(s):	<i>Fundamentals of Construction</i>
Credit:	1
Grade Level:	10
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
Programs of Study and Sequence:	This is the second course in the <i>Structural Systems</i> program of study.
Necessary Equipment:	Refer to the Teacher Resources page.
Aligned Student Organization(s):	SkillsUSA: http://tnskillsusa.com/ Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/work_based_learning.shtml .
Available Student Industry Certifications:	Modules may count towards NCCER Carpentry.
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	522, 575, 580, 592
Required Teacher Certifications/Training:	TBD
Teacher Resources:	http://www.tn.gov/education/cte/ArchitectureConstruction.shtml

Course Description

Structural Systems I prepares students for careers in residential and commercial carpentry. Upon completion of this course, proficient students will be able to demonstrate knowledge and skill in framing buildings. Students will be able to frame floors, walls, ceilings, roofs, and stairs while safely employing tools and interpreting construction drawings to complete projects. Emphasis is placed on demonstrating proper measurement and application of mathematical concepts. Standards in this course also include

principles of the construction industry and business and project management. Students will continue compiling artifacts for inclusion in their portfolios, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects, Tennessee State Standards in Mathematics, Tennessee Physical Science Standards, Tennessee Physics Standards, and the National Center for Construction Education and Research (NCCER) Curriculum.*

Program of Study Application

This is the second course in the *Structural Systems* program of study. For more information on the benefits and requirements of implementing these programs in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

Course Standards

Safety

- 1) Identify safety hazards on a jobsite and demonstrate practices for safe working. Accurately read and interpret safety rules, including but not limited to 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. Perform a hazard assessment for a given task such as working on a ladder to install roof framing components. Explain the steps necessary to safely perform the task, outlining steps to take in case of an emergency. (TN Reading 3, 4, 6; TN Writing 2)
- 2) Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, equipment safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy. (TN Reading 3, 4)
- 3) Follow procedures to work safely around materials. Adhere to responsibilities for employees in material safety as outlined by the Hazard Communication Standard (HazCom), such as locating and interpreting material safety data sheets (MSDS). Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. (TN Reading 3, 4)

Career Exploration

- 4) Research career opportunities within the carpentry trade, such as a journeyman carpenter, master carpenter, foreman, supervisor, and more. Produce a chart or other graphic detailing the skills, responsibilities, and personal characteristics of a successful carpenter. (TN Reading 2, 4, 5, 7; TN Writing 2)



Construction Industry Principles

- 5) Investigate and report on the process for determining the zoning regulations of a building site. Describe how zone designation and regulations such as setbacks, ground coverage, and maximum height impact the design, placement, and use of a building on a given site. Read and interpret zoning ordinances and other regulations impacting a given site (city, county, historic district, subdivision regulations, etc.). (TN Reading 2, 3, 4; TN Writing 2)
- 6) Explain inspection procedures used to enforce building codes during the construction of a residential or commercial building, outlining the roles and responsibilities of the building inspector and the contractor and the intervals at which inspections are performed. (TN Reading 2, 3, 4)

Types of Structural Systems

- 7) Compare and contrast types of structural framing systems, including wood light-frame, structural steel, and reinforced concrete, analyzing the factors influencing the selection of a structural system for given building functions. Using textbooks, online resources, or examples in the community, select three buildings with different framing types and explain why each type was used for the building's function. (TN Reading 1, 2, 4, 5; TN Writing 2, 9)

Materials and Methods of Light-Frame Wood Construction

- 8) Distinguish among the basic types of wood framing systems, such as platform frames, balloon frames, and post-and-beam frames. Create a chart to define and compare the pros and cons of each type, citing examples of when each is used. (TN Reading 1, 2, 4, 5, 7; TN Writing 2, 9)
- 9) Analyze the characteristics and uses of various types of wood products used in light frame construction.
 - a. Categorize types of wood as hardwood or softwood.
 - b. Identify grades of lumber, common lumber defects, and differences in treated and untreated lumber.
 - c. Explain the difference between actual and nominal lumber sizes.
 - d. Distinguish among the properties and uses of engineered wood products such as plywood, hardboard, particleboard, oriented strand board, mineral fiberboard, engineered lumber, glulam lumber, and wood I-beams.

Drawing on resources such as textbooks and wood product retailers' catalogs, examine actual wood product samples and create a written description of each, identifying the type and grade of the product, noticing and naming any defects, and explaining common uses of the product. (TN Reading 1, 2, 4, 5, 7; TN Writing 2, 9)

Tools & Equipment

- 10) Accurately identify hand and power tools used in carpentry, describing the safe use and maintenance of each. Hand tools include levels, squares, planes, clamps, and hand saws. Power tools include power saws, drill presses, routers, laminate trimmers, portable power planes, power metal shears, and pneumatic and cordless nailers and staplers. For each of the systems covered in this course, identify and select the proper tools and accessories, critique the



readiness of the tools, use the tools to accomplish the desired tasks, and then return the tools and accessories to their proper storage. (TN Reading 2, 3, 4)

Construction Drawings & Specifications

- 11) Inspect and interpret construction drawings related to structural systems, including foundation plans, floor plans, elevation views, section views, details, and schedules. Describe the purpose and organization of written specifications; be able to read and interpret written specifications to complete projects. Evaluate the construction drawings and specifications for a framing system. In a written narrative, explain how the drawings and specifications work together to inform the carpenter for a particular project, citing specific examples from the text. (TN Reading 1, 4, 5, 6, 7, 9; TN Writing 2, 9)

Floor Framing Systems

- 12) Implement geometric principles to square a building layout. For example, in the process of staking the corners of a building, check the layout for squareness by using the 3-4-5 rule based on right triangles and the Pythagorean Theorem. (TN Reading 3; TN Math N-Q, G-SRT)
- 13) Identify the components which make up a floor frame, analyzing the purpose of and interrelationships among each component and explaining the sequence in which each is constructed. (TN Reading 2, 3, 4, 5)
- 14) Read and interpret construction drawings to determine floor system requirements, such as the proper girder and joist size for a given span and floor load, and estimate the amount of material needed to frame a floor assembly. (TN Reading 1, 4, 7; TN Math N-Q)
- 15) Describe the procedures necessary to fasten sills to the foundation and construct a floor assembly. Apply the appropriate tools, equipment, and procedures to build a floor assembly. Work in teams to install girders, lay out and install floor joists, install bridging and blocking, and apply subflooring. (TN Reading 3)

Wall and Ceiling Framing Systems

- 16) Explain the procedure to lay out a wood frame wall, defining and describing the components such as plates, studs, partitions, door and window openings, bracing, and other components. (TN Reading 3, 4)
- 17) Read and interpret drawings to determine wall and ceiling frame requirements for a given residential or commercial structure. For example, calculate the length of a stud and estimate the amount of material needed to frame a wall and ceiling assembly. (TN Reading 4; TN Math N-Q)
- 18) Work in teams to construct a wall frame and ceiling assembly by implementing required safety techniques, tools, and equipment. Accurately measure and lay out the frame; accurately level and plumb the walls. (TN Reading 3; TN Math N-Q)



Roof Framing Systems

- 19) Define and describe the framing components of gable and hip roofs such as the ridge board, plates, and types of rafters. Create a graphic illustration showing the roles of each component and how they work together in a roof framing system. (TN Reading 3, 4, 7)
- 20) Read and interpret drawings to determine roof framing requirements, such as calculating the length of a rafter based on the desired pitch and estimating the materials needed to frame and sheath a roof. For example, use a speed square to lay out a common rafter on a piece of lumber. (TN Reading 2, 3, 4; TN Math N-Q, G-SRT)
- 21) Work in teams to construct a roof frame assembly by implementing required safety techniques, tools, and equipment to accurately measure, lay out, construct, and sheath a roof frame. For example, frame a gable roof with an opening. (TN Reading 3; TN Math N-Q)
- 22) Compare and contrast different procedures to frame a roof. For example, describe the benefits of using prefabricated trusses in place of framing with rafters on site. Outline the major similarities and differences in each and write persuasively to provide a recommendation to a client for a specific project. (TN Reading 2, 3, 4; TN Writing 1, 4, 9)

Introduction to Building Envelope Systems

- 23) Analyze the components of a building envelope system, including building wrap and various types of windows and exterior doors. Describe how the various components affect the energy efficiency of the building. For example, explain the impact the glass type in a window has on the energy efficiency of the building. (TN Reading 2, 4, 5; TN Physical Science 2; TN Physics 2)
- 24) Describe the procedures necessary to prepare a rough opening and install windows and doors. Apply the appropriate tools, equipment, and procedures to prepare rough openings for proper window and door installation. Properly install a lockset in an exterior door. (TN Reading 3; TN Math N-Q)

Basic Stair Framing Systems

- 25) Analyze the components of a stair system. Read and interpret construction drawings to determine stair system requirements such as the total rise, number and size of risers, and number and size of treads. Based on stated requirements, estimate the amount of material needed to frame a stair assembly. (TN Reading 2, 3, 4, 5, 7; TN Math N-Q)
- 26) Apply the appropriate tools, equipment, and procedures to safely build a small stair unit, demonstrating proper procedures for laying out and cutting stringers, risers, and treads. (TN Reading 3; TN Math N-Q)

Business and Project Management

- 27) Describe strategies used to promote collaboration, trust, and clear communication among internal and external parties on a job site. Practice effective verbal, nonverbal, written, and



electronic communication skills for working with colleagues, employers, clients, and other personnel while demonstrating the ability to: listen attentively, speak courteously and respectfully, resolve obstacles in construction, and respond to criticism. For example, assume the roles of a construction business owner and a potential client, listen to the needs of a potential client, and respond to the potential client by email; explain the services provided by the company and the next steps needed to begin the project. Other role playing could include a construction business owner and a potential subcontractor. (TN Reading 2, 3; TN Writing 2, 4)

28) Describe the components and purpose of a basic contract document for a residential project. Recognize the relationship and responsibilities of various parties to a contract. Write a basic contract for a construction job, such as a carpenter's contract to complete a deck addition for a residential client. (TN Reading 2, 3, 4, 5)

29) Interpret construction drawings to determine the correct materials, tools, and equipment needed to complete a construction project. Plan and implement the steps needed to complete the project, adhering to inspection procedures and employing safe practices throughout. Draw from print and electronic examples to create a materials list, cost estimation, construction schedule, and inspection checklist for a project, applying the components of the documents to the given project. (TN Reading 2, 3; TN Writing 4)

30) Log daily activities completed during a construction project over an extended period of time. Document important facts concisely in a daily report as would a project manager on a jobsite, including daily progress, equipment and materials used, personnel involved, and other work-related activities. (TN Reading 3; TN Writing 2, 5, 10)

Portfolio

31) Update materials from coursework to add to the portfolio started in *Fundamentals of Construction*. Continually reflect on coursework experiences and revise and refine the career plan generated in the prior course. Include photographs or illustrations and written descriptions of sequential progress in construction projects. (TN Writing 2, 4)

Standards Alignment Notes

*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 9-10 Students (page 62).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 8 and 10 at the conclusion of the course.
- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 9-10 Students (pages 64-66).



- Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3, 6, 7, and 8 at the conclusion of the course.
- TN Math: [Tennessee State Standards for Mathematics; Math Standards for High School: Number and Quantity, Geometry](#) (pages 58-83).
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- TN Physical Science: Tennessee Science: [Physical Science](#) standard 2 may provide additional insight and activities for educators.
- TN Physics: Tennessee Science: [Physics](#) standard 2 may provide additional insight and activities for educators.
- NCCER Curriculum: [National Center for Construction Education and Research](#)
 - Students who are engaging in activities outlined above will be able to complete modules working toward certification in NCCER Carpentry.
- 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.





Structural Systems II

Primary Career Cluster:	Architecture & Construction
Consultant:	Rachel Allen, (615) 532-2835, Rachel.Allen@tn.gov
Course Code(s):	TBD
Prerequisite(s):	<i>Fundamentals of Construction, Structural Systems I</i>
Credit:	1-2 credits (see Recommended Credit below)
Grade Level:	11-12
Graduation Requirements:	This course satisfies one or two of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
Programs of Study and Sequence:	This is the third course in the <i>Structural Systems</i> program of study.
Necessary Equipment:	Refer to the Teacher Resources page.
Aligned Student Organization(s):	SkillsUSA: http://tnskillsusa.com/ Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/work_based_learning.shtml .
Available Student Industry Certifications:	Modules may count towards NCCER Carpentry.
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	522, 575, 580, 592
Required Teacher Certifications/Training:	TBD
Teacher Resources:	http://www.tn.gov/education/cte/ArchitectureConstruction.shtml

Course Description

Structural Systems II is an advanced-level course that builds on the introductory skills learned in the *Fundamentals of Construction* and *Structural Systems I* courses. This course will explore advanced framing, the physics of structural loads, and the coverings and finishes of structural systems. Upon completion of this course, proficient students will be able to install interior and exterior finishing, including roofing, siding, thermal and moisture protection components, drywall, doors, and trim.

Throughout the course, students will interpret construction drawings to complete projects, implementing material estimating procedures and safe working practices. Standards in this course also expand on principles of the construction industry and delve deeper into business and project management strategies. Students will continue compiling artifacts for inclusion in their portfolios, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects, Tennessee State Standards in Mathematics, Tennessee Physical Science Standards, Tennessee Physics Standards, and the National Center for Construction Education and Research (NCCER) Curriculum.*

Program of Study Application

This is the third course in the *Structural Systems* program of study. Flexibility is built in to offer this course for either one or two credits, depending on school capacity and teacher background. Whether offered for one or two credits, this course can feed into a fourth-level *Construction Practicum* course in which students can apply the skills learned throughout the program of study toward the completion of an in-depth, semester- or year-long work-based learning (WBL) apprenticeship or internship. For more information on the benefits and requirements of implementing this program in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

Recommended Credit

If all standards in this course are covered, the course is recommended for two credits. If only one credit is to be offered, the following option is recommended:

1 Credit Option

Content	Standards
Safety	1, 2, 3
Tools & Equipment	4
Career Exploration	5, 6
Construction Industry Principles	7, 8
Structural Systems Loads	9, 10
Cold-Formed Steel Framing	11, 12
Exterior Finishing	13, 14, 15, 16
Thermal & Moisture Protection	17, 18, 19, 20
Roofing Applications	21, 22
Business & Project Management	34, 35, 36, 37
Portfolio	38



Course Standards

Safety

- 1) Identify safety hazards on a jobsite and demonstrate practices for safe working. Accurately read and interpret safety rules, including but not limited to 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. Recognize and employ universal construction signs and symbols such as colors, flags, stakes, and hand signals that apply to construction workplace situations. Research and evaluate construction company safety plans from local industry. Explain the need for jobsite security to prevent liability. Drawing from examples, create and implement a jobsite safety program in the class to ensure safe practices and procedures including jobsite security procedures. (TN Reading 3, 4, 6; TN Writing 2, 4)
- 2) Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, equipment safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy. (TN Reading 3, 4)
- 3) Follow procedures to work safely around materials. Adhere to responsibilities for employees in material safety as outlined by the Hazard Communication Standard (HazCom), such as locating and interpreting material safety data sheets (MSDS). Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. (TN Reading 3, 4)

Tools & Equipment

- 4) For each of the systems covered in this course, identify and select the proper tools and accessories, critique the readiness of the tools, use the tools to accomplish the desired tasks, and then return the tools and accessories to their proper storage. Research a new technology recently developed for the construction industry. Write persuasively to convince an employer how the use of the technology could benefit the company, citing evidence from resources. For example, describe how a new power tool could improve efficiency and reduce muscle fatigue for a construction team. (TN Reading 1, 2, 3, 4; TN Writing 1, 4, 9)

Career Exploration

- 5) Referencing data from U.S. Department of Labor and other sources, explain an apprenticeship. Write persuasively to describe the benefits of the apprenticeship approach of on-the job training paired with related training for individuals seeking construction careers. Use a variety of sources to gather data; cite each source, and briefly describe why the chosen source is reliable. (TN Reading 7, 8; TN Writing 1, 8)



- 6) Research apprenticeships and postsecondary institutions (colleges of applied technology, community colleges, and four-year universities) in Tennessee and other states that offer carpentry-related programs. Write an informative paper or develop an infographic identifying entry requirements for a specific apprenticeship or postsecondary program of study, and the secondary courses that will prepare students to be successful in the program. (TN Reading 2, 3, 4; TN Writing 2)

Construction Industry Principles

- 7) Locate and assess the Tennessee Contractor's Licensing Board's website and analyze the policies and requirements for construction work in Tennessee. Explain how such policies impact local construction businesses. (TN Reading 2, 3, 4)
- 8) Describe alternatives to traditional project delivery methods, such as the design-build and construction management-related methods, distinguishing among the roles and relationships of various construction personnel in each scenario. Examine the project delivery method of an actual company. Develop a company profile with supporting graphics the company could share with a client describing the services provided and explaining the project delivery method used by the company. (TN Reading 2, 3, 4, 5, 7; TN Writing 2, 4)

Structural System Loads

- 9) Categorize and describe the structural loads that act on a building, including vertical loads (such as dead loads, live loads, and rain loads) and lateral loads (such as wind and earthquakes). Drawing on textbooks and other resources, create a visual display with supporting text to explain how the various loads act on a building's structural system. (TN Reading 2, 4, 5, 7; TN Writing 2; TN Physics 1)
- 10) Distinguish among the types of structural failures that can occur in a structural system, including compressive failures, tensile failures, and buckling failures. Explain how specific components of a structural system prevent structural failures based on descriptions in texts and through classroom experiments, synthesizing information gathered from both to illustrate concepts. For example, explain how blocking between studs in a wood frame wall prevents the buckling of studs. (TN Reading 2, 4, 5, 7, 8, 9; TN Writing 2)

Cold-Formed Steel Framing

- 11) Examine the components, fasteners, tools, and procedures used in cold-formed steel framing; compare and contrast cold-formed steel framing with wood framing in building construction. Outline the major similarities and differences in each and write persuasively to provide a recommendation to a client for a specific project. (TN Reading 2, 3, 4; TN Writing 1, 4, 9)
- 12) Demonstrate the ability to build steel frame components including back-to-back, box, and L-headers. Work in teams to lay out and install steel stud walls (both structural and non-structural) with openings to include bracing and blocking by implementing required safety techniques, tools, and equipment. (TN Reading 3; TN Math N-Q)



Exterior Finishing

- 13) Examine a wall section drawing for a specific building. Identify, define, and explain the function of each component including wall insulation, flashing, and the structure of the cornice. Draw from textbooks and other resources to annotate the wall section drawing with notes explaining the purpose of each component. (TN Reading 1, 2, 3, 4, 5, 7; Writing 2, 4, 9)
- 14) Interpret wall section drawings to safely construct a cornice. For example, accurately measure materials, employ tools, and follow procedures to build a box cornice, checking for accuracy in each step. (TN Reading 3; TN Math N-Q)
- 15) Analyze various finish systems used to sheath a building, including but not limited to wood siding, fiber-cement siding, vinyl siding, metal siding, stucco, and masonry veneer finishes. Perform a case study of three different buildings in the community which are sheathed in different ways, hypothesizing why the different materials and methods were selected for each. (TN Reading 2, 3, 4)
- 16) Estimate the siding materials needed to cover a building utilizing mathematical principles such as area formulas and quantitative reasoning. Utilize the appropriate procedures, tools, and materials to install various types of siding. For example, identify three siding methods that are commonly used in the area and demonstrate the ability to plan the installation of and install each. (TN Reading 3; Math N-Q)

Thermal & Moisture Protection

- 17) Explain the impact of heat transfer in a building, including heat loss during cold temperatures and heat gain during warm temperatures. Describe how building components such as insulation work to resist the transfer of heat in a structure. Interpret charts and graphs in building codes to determine the recommended r-values of insulation in a given location. (TN Reading 2, 4, 5; TN Physical Science 2; TN Physics 2)
- 18) Categorize the various types of insulation based on their characteristics and installation method. Summarize the key properties and installation procedures of each insulation type in a visual display. (TN Reading 2, 3, 4, 7)
- 19) Describe the materials and methods used in a structure for moisture control, waterproofing, and ventilation. In a written narrative, explain how a vapor barrier protects an interior from moisture and describe the permeability rating necessary for a material to be considered a vapor retarder. Write guidelines for a builder or architect to use as reference when selecting appropriate vapor barriers for a specific location based on the climate and other factors, citing evidence from textbooks and other resources. (TN Reading 1, 2, 4; TN Writing 2, 4, 9)
- 20) Interpret construction drawings and building codes to select and estimate the thermal and moisture protection materials needed to complete a project utilizing mathematical principles such as area formulas and quantitative reasoning. Utilize the appropriate procedures, tools, and materials to install blanket insulation in a wall, a vapor barrier on a wall, and building wraps. (TN Reading 2, 3, 4; TN Math N-Q)



Roofing Applications

- 21) Compare and contrast the materials, methods, and procedures for roofing with fiberglass shingles with other roofing materials such as wood shingles. Perform a cost analysis for a client to help the client choose between two roofing materials for a specific project given the site location, project budget, environmental considerations, and other factors. (TN Reading 2, 3, 4; TN Math N-Q)
- 22) Apply the appropriate tools, equipment, and procedures to safely install shingles on a roof including strategies for watertight installation, using quantitative reasoning and geometric formulas where applicable. For example, interpret construction documents to estimate the roofing materials needed to install fiberglass shingles on a gable roof. After preparing the roof with underlayment, flashing, and other preparation materials, install fiberglass shingles, install a cricket or saddle, and install ridge caps. (TN Reading 3; TN Math N-Q, G-SRT)

Doors and Door Hardware

- 23) Analyze the parts of a door frame, including sills, jambs, and casings, and describe different interior door types. Read and interpret door schedules and other construction documents to determine the type of door and door hardware required for a project. (TN Reading 2, 4)
- 24) Apply the appropriate tools, equipment, and procedures to safely install a door, including checking the plumb and square of a door frame and installing a prehung door unit. Demonstrate proper procedures to work with door hardware, including laying out and cutting hinges in a wooden door and installing door closers and locksets. (TN Reading 3; TN Math N-Q)

Drywall Installation & Finishing

- 25) Describe the various components involved in drywall installation, including the types of drywall, drywall fasteners and adhesives, and drywall accessories. Explain the procedure to install drywall, noting the proper tools involved. Describe the role drywall plays in sound isolation and fireproofing, outlining how fire-rated walls are constructed. (TN Reading 3, 4, 5)
- 26) Read and interpret drawings to select the type and thickness of drywall required for a specific installation. Utilize quantitative reasoning to estimate the amount of drywall, fasteners, and finishing materials needed for a project. (TN Reading 2, 4, 6; TN Math N-Q)
- 27) Install gypsum drywall panels on stud walls and ceilings using different types of fastening systems, including nails, screws, and adhesives. Perform single-layer and multi-layer installations by implementing required safety techniques, tools, and equipment. Describe the differences in procedures for installing gypsum panels on steel wall frames. (TN Reading 2, 3; TN Math N-Q)

Drywall Finishing

- 28) Describe the procedures, tools, and materials used in drywall finishing, indicating the purpose of each material. Read and interpret industry standards regarding drywall finish such as the *Recommended Levels of Gypsum Board Finish*. Observe finished drywall and determine the level



of finish, citing evidence from industry standards documents. (TN Reading 1, 2, 3, 4, 6, 7; TN Writing 9)

- 29) Implement the proper procedures, tools, and materials to finish drywall. Procedures include preparing compounds, taping joints, applying joint compounds, sanding, spotting fastener heads, and finishing corners. (TN Reading 3)
- 30) Diagnose the cause and determine the appropriate solution for problems that occur in drywall finishing, citing evidence from textbooks or technical manuals in order to justify why the chosen solution is appropriate. Implement the proper tools and procedures to patch damaged drywall. (TN Reading 1, 2, 3, 4; TN Writing 9)

Window, Door, Floor, and Ceiling Trim

- 31) Distinguish among the different types of standard trim, including base, wall, ceiling, window, and door trim. Utilize the proper tools, equipment, and procedures to make square cuts, miter cuts, and coped joint cuts in trim. (TN Reading 2, 3, 4)
- 32) Apply the appropriate tools, fasteners, and procedures to install window, door, floor, and ceiling trim. Estimate the quantities of different trim materials needed for a given room. (TN Reading 3; TN Math N-Q)

Cabinet Installation

- 33) Identify the components which make up a basic set of cabinets, analyzing the purpose of and interrelationships among each component and explaining the sequence in which each is constructed. Components include wall cabinets, base cabinets, countertops, and cabinet hardware. Read and interpret drawings and technical manuals to determine the steps, equipment, and materials needed to lay out and install a basic set of cabinets. Develop a timeline and action steps needed to complete a cabinet installation. For example, narrate the steps in an explanatory text that a peer could use to install a set of cabinets. (TN Reading 1, 2, 3, 4, 5, 7; TN Writing 2, 4)

Business & Project Management

- 34) Demonstrate advanced understanding of contract documents. Examine the components of a subcontract and explain the function of each component. For example, explain the responsibility of a subcontractor if damages are incurred due to delays caused by the subcontractor. (TN Reading 2, 4, 6)
- 35) Establish and implement specific goals to manage project assignments in a timely manner, including organizing teams to effectively manage assignments, monitoring and reporting on project progress, and evaluating a completed project according to client requirements. For example, inspect and critique a team member's work, providing constructive feedback for improvement. Similarly, respond to constructive feedback from a team member to improve project outcomes and meet project goals. (TN Reading 2, 6; TN Writing 2)



- 36) Perform estimating and scheduling techniques for a long-term project, including calculating material quantities and cost (including tax) and labor cost to complete a bid sheet; scheduling construction activities using a flow chart; and determining amounts to be charged to the client at various intervals throughout the project. (TN Reading 3, 7; TN Math N-Q)
- 37) Utilize technology to write and share periodical reports (weekly, monthly, etc.) to provide others with information about progress during construction activities as would a project manager to a supervisor. Summarize activities in a narrative form including overall progress in relationship to a previously planned schedule. (TN Reading 3; TN Writing 2, 4, 6, 10)

Portfolio

- 38) Update materials from coursework to add to the portfolio started in *Fundamentals of Construction* and *Structural Systems I*. Continually reflect on coursework experiences and revise and refine the career plan generated in prior courses. Include photographs or illustrations and written descriptions of sequential progress in construction projects. (TN Writing 2, 4)

Standards Alignment Notes

*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 11-12 Students (page 62).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 8 and 10 at the conclusion of the course.
- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 11-12 Students (pages 64-66).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3, 5, 6, and 8 at the conclusion of the course.
- TN Math: [Tennessee State Standards for Mathematics; Math Standards for High School: Number and Quantity, Geometry](#) (pages 58-83).
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- TN Physical Science: Tennessee Science: [Physical Science](#) standard 2 may provide additional insight and activities for educators.
- TN Physics: Tennessee Science: [Physics](#) standards 1 and 2 may provide additional insight and activities for educators.
- NCCER Curriculum: [National Center for Construction Education and Research](#)



- Students who are engaging in activities outlined above will be able to complete modules working toward certification in NCCER Carpentry.
- 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.





TENNESSEE DEPARTMENT OF

EDUCATION

FIRST TO THE TOP

Mechanical, Electrical, & Plumbing Systems I

Primary Career Cluster:	Architecture & Construction
Consultant:	Rachel Allen, (615) 532-2835, Rachel.Allen@tn.gov
Course Code(s):	TBD
Prerequisite(s):	<i>Fundamentals of Construction</i>
Credit:	1
Grade Level:	10
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
Programs of Study and Sequence:	This is the second course in the <i>Mechanical, Electrical, and Plumbing (MEP) Systems</i> program of study.
Necessary Equipment:	Refer to the Teacher Resources page.
Aligned Student Organization(s):	SkillsUSA: http://tnskillsusa.com/ Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/work_based_learning.shtml .
Available Student Industry Certifications:	Modules may count towards NCCER Curriculum.
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	TBD
Required Teacher Certifications/Training:	TBD
Teacher Resources:	http://www.tn.gov/education/cte/ArchitectureConstruction.shtml

Course Description

Mechanical, Electrical, and Plumbing Systems I prepares students for electrical, plumbing, and HVAC careers by introducing students to the physical principles of these systems and the fundamental skills needed to work with them. Upon completion of this course, proficient students will be able to implement safety procedures and tools to perform basic operations with device boxes, electrical test equipment, and electrical conduits, demonstrating understanding in fundamental concepts of electricity

such as Ohm's Law. Students will be able to explain how drain, waste, and vent systems work and apply proper tools and procedures to perform basic operations with plastic and copper piping, including measuring, cutting, and joining pipe. Furthermore, students will examine the regulations that impact electrical, plumbing, and HVAC work, including building codes. Standards in this course also include principles of the construction industry and business and project management. Students will continue compiling artifacts for inclusion their portfolios, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects, Tennessee State Standards in Mathematics, Tennessee Physical Science Standards, Tennessee Physics Standards, and the National Center for Construction Education and Research (NCCER) Curriculum.*

Program of Study Application

This is the second course in the *Mechanical, Electrical, & Plumbing (MEP) Systems* program of study. For more information on the benefits and requirements of implementing these programs in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

Course Standards

Safety

- 1) Identify safety hazards on a jobsite and demonstrate practices for safe working. Accurately read and interpret safety rules, including but not limited to 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. Perform a hazard assessment for a given task such as working on a ladder to install electrical components. Explain the steps necessary to safely perform the task, outlining steps to take in case of an emergency. (TN Reading 3, 4, 6; TN Writing 2)
- 2) Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, equipment safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy. (TN Reading 3, 4)
- 3) Follow procedures to work safely around materials. Adhere to responsibilities for employees in material safety as outlined by the Hazard Communication Standard (HazCom), such as locating and interpreting material safety data sheets (MSDS). Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. (TN Reading 3, 4)

Tools & Equipment

- 4) For each of the systems covered in this course, identify and select the proper tools and accessories, critique the readiness of the tools, use the tools to accomplish the desired tasks,



and then return the tools and accessories to their proper storage. For example, demonstrate the ability to safely use a deburring tool to ream a pipe end and effectively clean and store the tool. (TN Reading 3; TN Math N-Q)

Career Exploration

- 5) Explain what an apprenticeship is, referencing data from the U.S. Department of Labor and other sources. Write persuasively to describe the benefits of the apprenticeship approach of on-the-job training paired with related training for individuals seeking construction careers. Use a variety of sources to gather data, cite each source, and briefly describe why the chosen source is reliable. (TN Reading 1, 7, 8; TN Writing 1, 8)
- 6) Research apprenticeships and postsecondary institutions (colleges of applied technology, community colleges, and four-year universities) in Tennessee and other states that offer construction-related programs. Write an informative paper or develop an infographic identifying entry requirements for a specific apprenticeship or postsecondary program of study, and the secondary courses that will prepare students to be successful in the program. (TN Reading 1, 3; TN Writing 4)

Construction Industry Principles

- 7) Examine how the roles and responsibilities among construction trades and professions work in relationship to completing a project. Describe how electricians, plumbers, and HVAC technicians coordinate work with other construction personnel to complete the construction of a project, including submitting bids for subcontracted work and requesting clarification through a RFI (request for information) process. (TN Reading 2, 3, 4; TN Writing 2)
- 8) Explain inspection procedures used to enforce building codes during the construction of a residential or commercial building, outlining the roles and responsibilities of the building inspector and the contractor and the intervals at which inspections are performed. (TN Reading 2, 3, 4)

Electrical Systems

- 9) Describe how different levels of electrical shock affect the human body. Research current OSHA standards and other regulations specific to electrical systems to identify methods and equipment to reduce the risk of injury due to electrical shock. Drawing on evidence from textbooks and OSHA standards, apply lockout/tagout procedures to ensure safe working conditions. For example, perform a lockout/tagout to prepare to work on an electrical device. (TN Reading 1, 2, 3, 4; TN Writing 9)
- 10) Citing technical data, explain the interrelationships among sources of current, voltage, resistance, and power in electric circuits and the units to quantify each (amperes, volts, ohms and watts). Demonstrate understanding of the operation of electrical circuits (series, parallel, and series-parallel circuits) and relate it to the physical laws, such as Ohm's law and Kirchhoff's law, which govern the behavior of electrical circuits and devices such as the function of resistors in electrical circuits. Accurately apply these physical laws to solve problems including calculating



equivalent resistance and calculating voltage and/or current through elements within a circuit. For example, use Ohm's law to calculate the current flow of a circuit for an electric dryer with a given voltage and resistance. (TN Reading 2, 3, 4, 5; TN Math N-Q, A-SSE, A-CED; TN Physical Science 2)

- 11) Assemble basic series and parallel circuits according to electrical diagrams using a transformer or battery, wires, and selected load devices. Use the proper instrument to measure voltage, current, and resistance, and check circuit continuity in an energized circuit. Test and correct the performance of the circuits using electrical test instruments appropriately. (TN Reading 3, 4, 5; TN Math N-Q; TN Physical Science 2)
- 12) Describe the purpose and layout of the National Electrical Code (NEC[®]). Create a chart to illustrate what is and is not covered by the NEC[®], citing evidence from *NEC[®] Article 90*. Navigate, read, and interpret the NEC[®] to determine requirements for a given electrical installation. For example, interpret the NEC[®] to compare and contrast the box requirements for a device box to support a wall receptacle with those for a box to support a lighting fixture. (TN Reading 1, 2, 4, 6, 7; TN Writing 2, 9)
- 13) Analyze the composition and properties of conductors. Explain how the markings on a conductor relate to the physical properties of the conductor, including the insulation and jacket material, conductor size and type, number of conductors, temperature rating, voltage rating, and permitted uses of the conductor. Inspect electrical charts and tables to determine the ampacity of a given conductor and to draw conclusions about the relationship between the physical properties of a conductor, such as size and ampacity. Explain how color coding is used to distinguish among conductor purposes. Create a visual display a beginning electrician might use to interpret the meaning of color and markings on conductors. (TN Reading 2, 3, 4, 5, 7; TN Writing 2, 4)
- 14) Utilize the proper tools, equipment, and procedures to select and safely perform basic installation of device boxes according to drawings, specifications, and code requirements. Steps should include identifying the proper box type and size; and determining the minimum size pull or junction box for conduit entering and exiting for a straight pull and at an angle. (TN Reading 3, 4, 6, 9)
- 15) Utilizing test equipment such as a voltmeter, inspect and test an electrical wiring system for compliance according to drawings, specifications, and code requirements. (TN Reading 3, 4, 6; TN Math N-Q; TN Physical Science 2; TN Physics 5)
- 16) Describe the procedures, techniques, and tools for hand bending and installing conduit. Implement geometric principles to plan and use a hand bender to make 90 degree bends, back-to-back bends, offsets, kicks, and saddle bends. For example, use trigonometric ratios of right triangles to determine the offset angle of an offset bend and use the calculation to accurately create the bend. (TN Reading 3, 4; TN Math N-Q, G-RST)
- 17) Apply the appropriate tools, equipment, and procedures to safely cut, ream, and thread conduit. For example, ream the inside edge of a piece of conduit using a hand reamer. (TN Reading 3, 4)



Plumbing Systems

- 18) Study a schematic plan of a typical community sewer system. Citing evidence from a technical description or actual observation of a system, explain how waste moves through a drain, waste, and vent system from the fixture to the environment. Create a graphic illustration to represent the movement of waste from one component to the others in the system. For example, create a basic diagram of how the waste generated by a clean-up sink in the classroom travels to the local sewage treatment plant. (TN Reading 2, 3, 4, 7)
- 19) Demonstrate understanding of the specific roles of various plumbing components in a drain, waste, and vent system by sketching a system model. Label the components, and include a written description of the function of each. Be able to describe the physical principles involved such as gravity and pressure. (TN Reading 2, 3, 4, 5, 7; TN Writing 2; TN Physical Science 1, 4)
- 20) Analyze the function of a trap by examining a drain, waste, and vent system whose trap has lost its seal. Diagnose and explain the cause and determine the appropriate solution, citing evidence from textbooks or technical manuals in order to justify why the chosen solution is preferable or more effective than another. (TN Reading 1, 2, 4, 5; TN Writing 2, 9)
- 21) Determine common requirements found in plumbing codes and explain why the codes are necessary; include the importance of proper plumbing on human health. Examine a case in which poor plumbing contributed to the outbreak of disease in a community. Write an explanatory text to illustrate the problem and describe how it could have been prevented with proper plumbing applications. (TN Reading 2, 4, 5; TN Writing 2)
- 22) Compare and contrast the material properties and uses of the various types of plastic and copper piping, including storing and handling, safety issues, and types of fitting and hanging equipment. Describe the factors influencing the decision to use plastic or copper piping in a residence. Demonstrate the ability to select the correct materials, tools, and PPE to complete both plastic and copper piping projects by creating a list of the items needed for a specific installation. For example, for a residential bathroom sink drain, create a list of the materials, tools, and equipment needed to install the drain. (TN Reading 2, 3, 4, 7; TN Writing 4, 9)
- 23) Employ tools and procedures to safely measure, cut, ream, and join plastic and copper piping and fittings. For example, accurately measure PVC pipe, use a miter box and handsaw to cut pieces of pipe, ream and chamfer the ends, and join the pipe using solvent cement. (TN Reading 3, 4; TN Math N-Q)

Introduction to Heating, Ventilation, and Air Conditioning Systems (HVAC)

- 24) Demonstrate basic understanding of the principles of heating, ventilation, and air conditioning systems, such as heat transfer and the mechanical refrigeration cycle. Use graphic illustrations and supporting text to describe the structure and function of each system. (TN Reading 2, 3, 4, 5, 7; TN Writing 2)
- 25) Examine the regulations which impact the work of HVAC technicians, such as the Clean Air Act and EPA guidelines. Use technology to create a brochure to inform an individual contemplating



beginning an HVAC business of these regulations, explaining key considerations and citing resources. (TN Reading 1, 2, 4; TN Writing 2, 4, 6, 9)

Business and Project Management

- 26) Describe strategies used to promote collaboration, trust, and clear communication among internal and external parties on a job site. Practice effective verbal, nonverbal, written, and electronic communication skills for working with colleagues, employers, clients, and other personnel while demonstrating the ability to: listen attentively, speak courteously and respectfully, resolve obstacles in construction, and respond to criticism. For example, assume the roles of a construction business owner and a potential client, listen to the needs of a potential client, and respond to the potential client by email; explain the services provided by the company and the next steps needed to begin the project. Other role playing could include a construction business owner and a potential subcontractor. (TN Reading 2, 3; TN Writing 2, 4)
- 27) Describe the components and purpose of a basic contract document for a residential project. Recognize the relationship and responsibilities of various parties to a contract. Write a basic contract for a construction job, such as an electrical service agreement for wiring work done for a residential client. (TN Reading 2, 3, 4, 5)
- 28) Interpret construction drawings to determine the correct materials, tools, and equipment needed to complete a construction project. Plan and implement the steps needed to complete the project, adhering to inspection procedures and employing safe practices throughout. Draw from print and electronic examples to create a material list, cost estimation, construction schedule, and inspection checklist for a project, applying the components of the documents to the given project. (TN Reading 2, 3; TN Writing 4)
- 29) Log daily activities completed during a construction project over an extended period of time. Document important facts concisely in a daily report as would a project manager on a jobsite including daily progress, equipment and materials used, personnel involved, and other occurrences. (TN Reading 3; TN Writing 2, 5, 10)

Portfolio

- 30) Update materials from coursework to add to the portfolio started in *Fundamentals of Construction*. Continually reflect on coursework experiences and revise and refine the career plan generated in the prior course. Include photographs or illustrations and written descriptions of sequential progress in construction projects. (TN Writing 2, 4)

Standards Alignment Notes

*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 9-10 Students (page 62).



- Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 10 at the conclusion of the course.
- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 9-10 Students (pages 64-66).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3 and 7 at the conclusion of the course.
- TN Math: [Tennessee State Standards for Mathematics; Math Standards for High School: Number and Quantity, Algebra, Geometry](#) (pages 58-83).
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative, algebraic, and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- TN Physical Science: Tennessee Science: [Physical Science](#) standards 1, 2, and 4 may provide additional insight and activities for educators.
- TN Physics: Tennessee Science: [Physics](#) standard 5 may provide additional insight and activities for educators.
- NCCER Curriculum: [National Center for Construction Education and Research](#)
 - Students who are engaging in activities outlined above will be able to complete modules working toward certification in NCCER Electrical, Plumbing, and HVAC.
- 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.





TENNESSEE DEPARTMENT OF

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FIRST TO THE TOP

Mechanical, Electrical, & Plumbing Systems II

Primary Career Cluster:	Architecture & Construction
Consultant:	Rachel Allen, (615) 532-2835, Rachel.Allen@tn.gov
Course Code(s):	TBD
Prerequisite(s):	<i>Fundamentals of Construction and Mechanical, Electrical, & Plumbing Systems I</i>
Credit:	1-2 credits (see Recommended Credit below)
Grade Level:	11-12
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
Programs of Study and Sequence:	This is the third course in the <i>Mechanical, Electrical, & Plumbing Systems</i> program of study.
Necessary Equipment:	Refer to the Teacher Resources page.
Aligned Student Organization(s):	SkillsUSA: http://tnskillsusa.com/ Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/work_based_learning.shtml .
Available Student Industry Certifications:	Modules may count towards NCCER Curriculum.
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	TBD
Required Teacher Certifications/Training:	TBD
Teacher Resources:	http://www.tn.gov/education/cte/ArchitectureConstruction.shtml

Course Description

Mechanical, Electrical, and Plumbing Systems II is an advanced-level course that builds on the introductory skills learned in the earlier courses, focusing on installation techniques and systems analyses to prepare students for electrical, plumbing, and HVAC careers. Upon completion of this course, proficient students will be able to implement safety procedures and tools to perform operations

with raceway systems and conductors, and calculate residential loads to recommend electrical hardware. Students will be able to explain how water distribution systems and plumbing fixtures work and apply proper tools and procedures to perform advanced operations with plumbing piping, including measuring, cutting, joining, supporting, and hanging pipe. Students will read and interpret drawings, specifications, and diagrams to determine materials needed to complete a project. Students will explain the functions and components of heating, cooling, and air distribution systems and demonstrate basic techniques to prepare copper tubing for HVAC systems. Standards in this course also expand on principles of the construction industry, delving deeper into business and project management, and introduce basic troubleshooting procedures and alternate power systems. Students will continue compiling artifacts for inclusion in their portfolios, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects, Tennessee State Standards in Mathematics, and Tennessee State Standards in Chemistry I, Physics, Physical Science, and Environmental Science, as well as the National Center for Construction Education and Research (NCCER) Curriculum.*

Program of Study Application

This is the third course in the *Mechanical, Electrical, & Plumbing Systems* program of study. Flexibility is built in to offer this course for either one or two credits, depending on school capacity and teacher background. Whether offered for one credit or two credits, this course can feed into a fourth-level *Construction Practicum* course in which students can apply the skills learned throughout the program of study toward the completion of an in-depth, semester- or year-long work-based learning (WBL) apprenticeship or internship. For more information on the benefits and requirements of implementing these programs in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

Recommended Credit

If all standards in this course are covered, the course is recommended for two credits. If only one credit is to be offered, two options are recommended. Option A focuses more on electrical and plumbing systems while Option B is tailored for programs with a specific interest in or access to HVAC systems.

1 Credit- Option A

Content	Standards
Safety	1, 2, 3
Tools & Equipment	4
Construction Industry Principles	5, 6
Electrical Systems	7, 8, 9, 10, 11, 12
Plumbing Systems	13, 14, 15, 16, 17
Basic Maintenance & Repair Process	31, 32
Alternate Power Systems	33
Business & Project Management	34, 35, 36, 37
Portfolio	38

1 Credit- Option B

Content	Standards
Safety	1, 2, 3
Tools & Equipment	4
Construction Industry Principles	5, 6
HVAC Systems	18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30
Basic Maintenance & Repair Process	31, 32
Alternate Power Systems	33
Business & Project Management	34, 35, 36, 37
Portfolio	38



Course Standards

Safety

- 1) Identify safety hazards on a jobsite and demonstrate practices for safe working. Accurately read and interpret safety rules, including but not limited to 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. Recognize and employ universal construction signs and symbols such as colors, flags, stakes, and hand signals that apply to construction workplace situations. Research and evaluate construction company safety plans from local industry. Explain the need for jobsite security to prevent liability. Drawing from examples, create and implement a jobsite safety program in the class to ensure safe practices and procedures including jobsite security procedures. (TN Reading 3, 4, 6; TN Writing 2, 4)
- 2) Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, equipment safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy. (TN Reading 3, 4)
- 3) Follow procedures to work safely around materials. Adhere to responsibilities for employees in material safety as outlined by the Hazard Communication Standard (HazCom), such as locating and interpreting material safety data sheets (MSDS). Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. Describe hazards involved with HVAC work including working around refrigerants, oils, and gases. (TN Reading 3, 4)

Tools & Equipment

- 4) For each of the systems covered in this course, identify and select the proper tools and accessories, critique the readiness of the tools, use the tools to accomplish the desired tasks, and then return the tools and accessories to their proper storage. Research a new technology recently developed for the construction industry. Write persuasively to convince an employer how the use of the technology could benefit the company, citing evidence from resources. For example, describe how a new power tool could improve efficiency for a technician. (TN Reading 2, 3, 4; TN Writing 1)

Construction Industry Principles

- 5) Locate and assess the Tennessee Contractor's Licensing Board's website and analyze the policies and requirements for construction work in Tennessee. Explain how such policies impact local construction businesses. (TN Reading 2, 3, 4)



- 6) Describe alternatives to traditional project delivery methods, such as the design-build and construction management-related methods, distinguishing among the roles and relationships of various construction personnel in each scenario. Examine the project delivery method of an actual company. Develop a company profile with supporting graphics the company could share with a client, describing the services provided and explaining the project delivery method used by the company. (TN Reading 2, 3, 4, 5, 7; TN Writing 2, 4)

Electrical Systems

- 7) Explain the function of raceway systems, including acting as a grounding conductor. Distinguish among the various types of raceways, fittings, and conduit bodies available for raceway systems. Analyze a given environment and select the appropriate materials and installation methods for a raceway system, citing evidence from textbooks and codes. For example, recommend the appropriate raceway materials and installation method for a wood frame building of given parameters, drawing on evidence from codes such as the National Electrical Code (NEC®). (TN Reading 2, 3, 4, 6, 9; TN Writing 2, 9)
- 8) Outline the methods and procedures used to install various raceway systems, including terminating conduit. Accurately connect conduit to a box according to code requirements, explaining the need for a proper connection based on grounding requirements and protection of the wires. Apply the appropriate tools and procedures to install flexible raceway systems. (TN Reading 2, 3, 4, 6)
- 9) Describe the proper methods and procedures for installing conductors in a raceway system, noting potential hazards that exist when conductors are installed incorrectly. Employ tools and procedures to safely install conductors in a raceway system and verify the installation is performed according to code requirements. (TN Reading 2, 3, 4, 6; TN Writing 2, 9)
- 10) Distinguish among the various types and uses of electrical devices such as switches, receptacles, and lighting fixtures. Read and interpret technical documents to safely and properly install electrical devices. For example, install a duplex receptacle in a device box. (TN Reading 2, 3, 4)
- 11) Read and interpret electrical drawings and specifications, including detail drawings and equipment schedules, to create a list of materials needed for a given electrical project. For example, analyze a lighting plan, light fixture schedule, and specifications for a residence to determine the materials needed to install the lighting system. (TN Reading 2, 3, 4, 6, 7; TN Writing 2, 9; TN Math N-Q)
- 12) Evaluate and recommend proper electrical hardware for a residential building. For example, for a residential dwelling with a given floor plan and schedule of major appliances, determine the size of the electrical service by referring to the National Electrical Code® to select the service-entrance equipment, such as conductors, panelboard, and protective devices. Steps should include: calculating the load for lighting, small appliances, and large appliances; and determining the number of branch circuits required. Describe the installation rules pertaining to dedicated circuits as applied to various equipment such as ranges, dryers, and HVAC systems. (TN Reading 2, 3, 4, 7; TN Math N-Q; TN Physical Science 2)



Plumbing Systems

- 13) Analyze the parts of a pipe fitting including the face, center, and back. Determine fitting allowances by using measuring and calculating techniques and by consulting manufacturer's tables. Calculate the length of pipe needed for a given application by implementing common pipe measuring techniques. (TN Reading 3, 4; TN Math N-Q)
- 14) Distinguish among different types of plumbing pipe, fittings and valves, and select the correct support and spacing for plumbing piping. Compare and contrast the tools, hazards, and procedures for cutting and joining various types of plumbing pipe, including plastic, copper, cast-iron, steel, and PEX pipe. Employ tools and procedures to safely measure, cut, and join advanced piping and fittings such as steel and cast-iron piping. (TN Reading 2, 3, 4; TN Math N-Q)
- 15) Describe the features and operating principles of various types of plumbing fixtures, including sinks, lavatories, faucets, bathtubs, showers, and water closets. Analyze the operational procedures of two different water closets, such as a siphon-action water closet and a blow-out water closet. Compare and contrast the functions and benefits of each, citing resources to make a recommendation for a client based on the specific needs of a project. (TN Reading 1, 2, 3, 4, 7; TN Writing 2, 4, 9; TN Physical Science 2)
- 16) Study a schematic plan of a typical municipal water distribution system. Citing evidence from a technical description or actual observation of a system, explain how water travels from a water treatment plant to a fixture in a residence. Create a graphic illustration to represent the movement of water from one component to the others in the system. For example, sketch an isometric drawing of a simple water distribution system and label its components. (TN Reading 1, 2, 3, 4, 7; TN Writing 2, 9)
- 17) Read and interpret construction drawings including, detail drawings and equipment schedules, to create a list of materials needed for a given plumbing project. For example, analyze plumbing plans and isometric drawings to determine the materials needed to install a water supply system. (TN Reading 2, 3, 4, 6, 7; TN Writing 2, 9)

Heating, Ventilation, and Air Conditioning (HVAC) Systems Overview

- 18) Describe the functions of electrical components used in HVAC systems. Examine an electrical diagram of an HVAC system and interpret symbols to describe the system, distinguishing between load devices and control devices. For example, annotate a basic HVAC electrical diagram to explain the purpose and function of each component in the overall system to an entry-level HVAC technician. (TN Reading 2, 3, 4, 6, 7; TN Writing 2, 4)

Heating Systems

- 19) Explain the fundamental concepts of heating and combustion, including describing the processes by which heat is transferred. Illustrate the differences in heat transfer by conduction, convection, and radiation by performing experiments and relating the types of heat transfer to various types of heating equipment. (TN Reading 2, 3, 4, 5; TN Physical Science 2; TN Physics 2)



- 20) Analyze various types of gas furnaces and explain how they operate. Describe the equipment and controls involved, the concept of combustion, the various gas fuels, and their combustion characteristics. Explain the proper procedures for installing and maintaining gas furnaces. Perform basic maintenance tasks on a gas furnace, including replacing air filters and measuring temperature. (TN Reading 2, 3, 4; TN Chemistry I 2)
- 21) Compare and contrast gas furnaces, hydronic heating systems, and electric heating systems by analyzing the operating procedures and pros and cons of each system. Write a recommendation for a heating system for a client with a given location and building type. Cite evidence from retail catalogues, manufacturers' specifications, and energy ratings to justify the recommendation, defending why the selected system is a better choice than an alternative solution given. (TN Reading 1, 2, 3, 4, 5, 9; TN Writing 1, 9)

Cooling Systems

- 22) Describe the relationship between temperature and pressure and relate it to use of refrigerant in cooling systems. Summarize the processes involved in the basic mechanical refrigeration cycle, including the changes of state that occur and the basic patterns of the refrigerant flow. Analyze the major components of cooling systems and how they function, including compressors, condensers, evaporators, and controls. Draw evidence from textbooks, professional journals, and online sites to produce an explanation of the refrigerant cycle and the functioning processes of cooling systems in a written narrative with supporting graphics. (TN Reading 1, 2; TN Writing 2, 4, 6, 8, 9; TN Physical Science 1; TN Physics 2)
- 23) Utilize common measurement instruments including thermometers and gauge manifolds to measure temperature and pressure in an operating cooling system. Demonstrate the ability to calibrate a set of refrigerant gauges and thermometers, connect a refrigerant gauge manifold, and properly calculate subcooling and superheat on an operating system using a temperature probe. (TN Reading 3, 4; TN Math N-Q; TN Physical Science 1; TN Physics 2)
- 24) Distinguish among the various types of refrigerant, identifying the properties and cylinder color codes of each type. Describe the safety precautions and regulations impacting the handling of refrigerant established by the EPA, OSHA, and the U.S. Department of Transportation. (TN Reading 2, 3, 4)

Air Distribution Systems

- 25) Describe the physical principles involved in air distribution systems, including pressure, velocity, and volume. Analyze the design of a simple air distribution system (i.e., as found in a typical residence) and explain how the system functions, noting where physical principles can be observed. Create a visual display with supporting text to explain the functions of the system. (TN Reading 2, 3, 4, 5, 7; TN Writing 2, 9; TN Physical Science 1)
- 26) Recognize the various types and properties of mechanical equipment that make up an air distribution system, including various blowers, fans, duct materials, grilles, registers, and dampers. Relate the physical laws that apply to these systems, such as the Fan Laws, and



demonstrate how they work, as though leading a training or tutorial for fellow employees. (TN Reading 2, 3, 4, 5; TN Physical Science 1)

- 27) Illustrate how the design and proper installation of an air distribution system impacts the energy efficiency of the system. Drawing on observations and supporting technical manuals, recommend an air distribution layout for a given climate and describe the installation techniques to ensure efficient functioning of the system, such as properly sealing the ducts, dampers, and vent locations. (TN Reading 2, 3, 4, 5; TN Physical Science 1)
- 28) Utilize test equipment including tachometers, manometers, and velometers to analyze the performance of an air distribution system and make calculations. For example, collect measurements with a velometer, apply the information to calculate the airflow volume in a duct, and report the findings using appropriate units. Read and interpret duct system charts to determine required duct sizes for a given air volume. (TN Reading 2, 3, 4; TN Math N-Q; TN Physical Science 1)

HVAC Tubing

- 29) Building on knowledge gained from working with copper piping for plumbing systems, demonstrate how to measure, cut, and bend copper tubing for HVAC systems while preparing the tubing to be joined. Describe common fittings, hangers, and supports used in copper tubing. Demonstrate techniques for mechanically joining copper tubing, including flared connections and compression connections. (TN Reading 2, 3, 4; TN Math N-Q)
- 30) Describe and implement procedures to safely prepare, solder, and braze copper tubing using various fittings. Safely set up and shut down oxyacetylene equipment and an acetylene single tank. (TN Reading 2, 3, 4)

Basic Maintenance & Repair Process

- 31) Identify and demonstrate basic troubleshooting strategies appropriate for evaluating mechanical, electrical, and plumbing systems and devices. For example, in electrical systems, develop and implement a troubleshooting strategy to test and remedy an electrical fault. (TN Reading 3)
- 32) Identify routine maintenance procedures that should be performed on mechanical, electrical, and plumbing systems for a given building. Create a timeline of recommended maintenance procedures for a client, justifying why each procedure is necessary by highlighting its preventive or cost-efficient characteristics. (TN Reading 2, 3, 4, 7; TN Writing 4)

Alternate Power Systems

- 33) Analyze typical electric power systems in a region by explaining how electricity is generated and distributed from a power plant to a given location. Research alternate electric power systems, including but not limited to photovoltaic systems and wind power technologies. Describe the functions of the systems and analyze their use in regions across the country. Compare and contrast at least three types of power generation systems in a written text, chart, or visual display. (TN Reading 2, 3, 4, 7; TN Writing 2; TN Math N-Q; TN Environmental Science 5)



Business & Project Management

- 34) Examine the components of a subcontract and explain the function of each component. For example, explain the responsibility of subcontractor if damages are incurred due to delays caused by the subcontractor. (TN Reading 2, 4, 6)
- 35) Establish and implement specific goals to manage project assignments in a timely manner, including organizing teams to effectively manage assignments, monitoring and reporting on project progress, and evaluating a completed project according to client requirements. For example, inspect and critique a team member's work, providing constructive feedback for improvement. Similarly, respond to constructive feedback from a team member to improve project outcomes and meet project goals. (TN Reading 2, 6; TN Writing 2)
- 36) Perform estimating and scheduling techniques for a long-term project, including calculating material quantities and cost (including tax) and labor cost to complete a bid sheet; scheduling construction activities using a flow chart; and determining amounts to be charged to the client at various intervals throughout the project. (TN Reading 3, 7; TN Math N-Q)
- 37) Utilize technology to write and share periodical reports (weekly, monthly, etc.) to provide others with information about progress during construction activities as would a project manager to a supervisor. Summarize activities in a narrative form including overall progress in relationship to a previously planned schedule. (TN Reading 3; TN Writing 2, 4, 6, 10)

Portfolio

- 38) Update materials from coursework to add to the portfolio started in *Fundamentals of Construction and Mechanical, Electrical, & Plumbing Systems I*. Continually reflect on coursework experiences and revise and refine the career plan generated in prior courses. Include photographs or illustrations and written descriptions of sequential progress in construction projects. (TN Writing 2, 4)

Standards Alignment Notes

*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 11-12 Students (page 62).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 10 at the conclusion of the course.
- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 11-12 Students (pages 64-66).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 3 at the conclusion of the course.



- TN Math: [Tennessee State Standards for Mathematics; Math Standards for High School: Number and Quantity, Geometry](#) (pages 58-83).
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- TN Chemistry I: Tennessee Science: [Chemistry I](#) standard 2 may provide additional insight and activities for educators.
- TN Physics: Tennessee Science: [Physics](#) standard 2 may provide additional insight and activities for educators.
- TN Physical Science: Tennessee Science: [Physical Science](#) standards 1 and 2 may provide additional insight and activities for educators.
- TN Environmental Science: Tennessee Science: [Environmental Science](#) standard 5 may provide additional insight and activities for educators.
- NCCER Curriculum: [National Center for Construction Education and Research](#)
 - Students who are engaging in activities outlined above will be able to complete modules working toward certification in NCCER Electrical, Plumbing, and HVAC.
- 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.





TENNESSEE DEPARTMENT OF

EDUCATION

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Architectural & Engineering Design I

Primary Career Cluster:	Architecture & Construction
Consultant:	Rachel Allen, (615) 532-2835, Rachel.Allen@tn.gov
Course Code(s):	6037
Prerequisite(s):	None
Credit:	1
Grade Level:	9
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
Programs of Study and Sequence:	This is the first course in the <i>Architectural & Engineering Design</i> program of study.
Necessary Equipment:	Refer to the Teacher Resources page.
Aligned Student Organization(s):	SkillsUSA: http://tnskillsusa.com/ Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov Technology Student Association (TSA): http://www.tntsa.org Amanda Hodges, (615) 532-6270, Amanda.Hodges@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/work_based_learning.shtml .
Available Student Industry Certifications:	Autodesk Certified User or ADDA Apprentice Drafter
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	070, 230, 470, 477, 531, 551, 552, 553, 554, 555, 556, 584, 585, 595, 596, or any other Occupational License endorsement.
Required Teacher Certifications/Training:	ADDA Certified Drafter or Autodesk Certified Professional or NOCTI Technical Drafting
Teacher Resources:	http://www.tn.gov/education/cte/ArchitectureConstruction.shtml

Course Description

Architectural & Engineering Design I is a foundational course in the Architecture & Construction cluster for students interested in a variety of engineering and design professions. Upon completion of this course, proficient students will be able to create technical drawings of increasing complexity, and utilize

these skills to complete the design process and communicate project outcomes. Students will build foundational skills in freehand sketching, fundamental technical drawing, and related measurement and math. Standards in this course also include career exploration within the technical design industry, as well as an overview of the history and impact of architecture and engineering. In addition, students will begin compiling artifacts for inclusion in a portfolio, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects and Tennessee State Standards in Mathematics.*

Program of Study Application

This is the foundational course in the *Architectural & Engineering Design* program of study. For more information on the benefits and requirements of implementing this program in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

Course Standards

Safety

- 1) Accurately read and interpret safety rules, including but not limited to rules published by the Occupational Safety and Health Administration (OSHA), and state and national code requirements. Be able to distinguish between the rules and explain why certain rules apply. (TN Reading 3, 4, 6)
- 2) Identify and explain the intended use of safety equipment available in the classroom. 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. (TN Reading 3, 4)

Introduction to Architecture & Engineering Design

- 3) Investigate the evolution of architecture and engineering across a variety of civilizations throughout history. Identify major innovations, such as technological advances in materials or construction processes. Synthesize research from textbooks and other resources to create an annotated timeline or visual graphic illustrating significant time periods in the development of architecture and engineering. (TN Reading 2, 4, 7; TN Writing 2, 4)
- 4) Research and summarize in a clear and coherent informational artifact (e.g., a brochure, poster, fact sheet, narrative, or presentation) the influences and contributions of a selected architect or engineer. Cite resources and examples of the individual's completed work to illustrate their impact on society. (TN Reading 2, 4; TN Writing 2, 4)
- 5) Investigate the social, economic, and environmental impact of decisions made by architects and engineers at the local, national, and global levels. Provide a detailed description of the impacts of a specific discipline, citing links to relevant websites to illustrate the ideas presented. For example, describe how structural engineers design structural systems in buildings to protect



occupants from earthquakes and tornadoes, and illustrate how the materials selected by the engineer impact the environment and economy. (TN Reading 1, 2, 5; TN Writing 2, 4, 6, 9)

- 6) Research the principles of sustainable design. Examine a case study of an energy efficient building and explain how the principles of sustainable design are illustrated in the design of the building. (TN Reading 2, 4; TN Writing 2, 9)

Career Exploration

- 7) Research the major professions in architecture and engineering, such as a civil engineer, mechanical engineer, industrial engineer, electrical engineer, engineering technician, architect, and more. Cite supporting evidence from multiple sources (such as interviews with design professionals retrieved from industry magazines). Produce a chart or other graphic detailing the aptitudes and training needed for at least three careers of interest. For example, outline the typical requirements needed to become a civil engineer, including personal aptitudes, secondary and postsecondary training, and licensing. Devise a tentative career plan to reach employment goals. (TN Reading 1, 2, 3, 4, 7; TN Writing 2, 9)
- 8) Compile and analyze real-time and projected labor market data from public sources such as the U.S. Bureau of Labor Statistics to investigate local and regional occupational opportunities and trends in architectural and engineering careers. Synthesize collected data to develop a graphic illustration comparing occupations by job availability, salaries, and benefits. (TN Reading 2, 4, 7; TN Writing 9; TN Math S-ID)

Design Process

- 9) Research design processes used by architects and engineers. Drawing on resources, explain the steps to the design process in a written narrative. Explain why it is an iterative process and always involves refinement. (TN Reading 3, 4, 5; TN Writing 2, 4)
- 10) Evaluate an existing design created by architects and/or engineers using the design process such as a building, landscape, bridge, or product. Produce a report on the chosen design, describing how the design team likely progressed through each step of the design process citing examples from design magazines and other resources. Examples should include design constraints encountered by the design team and criteria for measuring the effectiveness of the design. (TN Reading 1, 2, 3, 4, 6; TN Writing 2, 9)

Sketching

- 11) Investigate the use of sketching in the creative design process. Drawing from resources, explain the tools and techniques used and when architects and engineers apply sketching in the design process. (TN Reading 3, 4, 5, 7; TN Writing 4; TN Math G-MG)
- 12) Create freehand sketches, including rough and refined sketches, demonstrating techniques for sketching freehand lines and circles while attending to accurate proportion. Produce pictorial sketches applying shading techniques. Simulate sketching techniques used by engineers and architects on jobsites by sketching live objects to create field sketches. Utilize hand lettering



techniques to neatly add notes to the sketches. (TN Reading 3, 4, 7; TN Writing 4; TN Math G-GMD, G-MG)

- 13) Develop conceptual design ideas using freehand sketching. For example, for a given design problem, generate, analyze, and refine sketches to develop design solutions. Use the sketches to further develop a chosen design and create refined drawings. (TN Reading 3, 4, 7; TN Writing 4, 5, 9; TN Math G-GMD)

Fundamental Technical Drawing

- 14) Interpret a technical narrative to understand the steps and tools needed to create geometric constructions such as bisecting a line, angle, or arc; using lines, circles, and arcs to draw a polygon such as a pentagon or hexagon; and constructing tangent and perpendicular relationships. Use geometric terms, illustrations, and supporting texts to describe the steps of creating a geometric construction with accuracy. (TN Reading 3, 4, 5, 7; TN Writing 4; TN Math G-CO, G-C, G-MG)
- 15) Create accurate manual single-view scale drawings of advancing complexity, incorporating symbols, notes, and dimensions, using appropriate layout within title blocks, drawing composition (including line weight and line type), geometric construction techniques, and lettering techniques. For example, create a drawing of a metal plate at half scale using an engineer's scale and other tools. After more practice, create a floor plan of the classroom at quarter scale using an architect's scale and other tools. (TN Reading 3, 4, 5, 7; TN Writing 4; TN Math G-CO, N-Q, G-MG)
- 16) Interpret and apply dimensioning rules to accurately label dimensions on drawings including arranging dimensions, using various dimension styles (such as aligned and angular), and avoiding redundancy. Drawing on evidence from textbooks and industry standards (such as the American National Standards Institute and the American Society of Mechanical Engineers), create an infographic an engineer or architect could use as a guide to appropriately employ basic dimensioning rules. (TN Reading 2, 3, 4, 5, 7; TN Writing 2, 4)
- 17) Create accurate multi-view scale drawings of objects of advancing complexity using orthographic projection. Incorporate symbols, notes, dimensions, and different types of lines (such as hidden lines to show internal or hidden features). Demonstrate procedures to establish a principle view of an object and project from an existing view to create additional views. (TN Reading 3, 4, 5, 7; TN Writing 4; TN Math G-MG)
- 18) Building on the knowledge of a single view and multi-view drawing, create simple isometric drawings, properly using lines, labels, and dimensioning techniques. (TN Reading 3, 4, 5, 7; TN Writing 4; TN Math G-GMD, G-MG)
- 19) Define the differences in technique among freehand sketching, manual drafting, and computer-aided drafting (CAD). Describe the skills required for each and how each type is used in industry. Create a visual display with accompanying text comparing and contrasting at least two techniques. (TN Reading 2, 3, 4, 5; TN Writing 2, 4)



- 20) Interpret instructional material to use CAD software to create simple two-dimensional drawings, accurately incorporating symbols, dimensioning, and line types. Instructional material may include textbooks, manuals, websites, video tutorials, and more. Perform basic operations such as creating files, saving files, opening files, storing files, and printing. Set up the drawing environment by inserting title blocks, applying settings (ortho, snap, etc.), and assigning line weights, line types, and colors. (TN Reading 3, 4, 5, 7; TN Writing 4; TN Math G-MG)
- 21) Demonstrate the ability to refine drawings based on critique from peers, instructors, and self-evaluation. Drawing on evidence from textbooks and other resources, evaluate the effectiveness of a drawing based on industry standards for technical drawing. Interpret and incorporate feedback when refining drawings. (TN Reading 2, 3, 4, 6, 7; TN Writing 5, 9)

Measurement & Math

- 22) Apply mathematics concepts to create drawings and solve design problems in this course, distinguishing which principles apply to a given design problem. Concepts should include, but are not limited to:
- Determining and applying the equivalence between fractions and decimals. For example, convert a decimal to a fraction to prepare a unit for measurement on a fractional scale to the precision of $\frac{1}{16}$ of an inch. (TN Math N-Q)
 - Working with units such as feet, inches, meters, centimeters, and millimeters, and determining appropriate units for a given construction task. For example, convert a dimension from centimeters to inches. (TN Math N-Q)
 - Calculating perimeter, area, volume, and surface areas of objects employing related geometric terminology. (TN Math G-GMD, G-MG)
 - Performing proportionate reasoning to estimate quantities, such as determining the appropriate scale for a drawing and a given sheet size. (TN Math N-Q)
 - Using basic rules of right triangles, such as the Pythagorean Theorem, to find missing lengths. (TN Math G-SRT)
- 23) Use customary and metric measurement systems to complete accurate field measurements. Determine the appropriate units and record accurate measurements of lengths and angles using proper tools. Tools should include, but are not limited to: fractional rule, metric rule, measuring tape, architect's scale, engineer's scale, dial caliper, and protractor. (TN Reading 3; TN Math N-Q)
- 24) Use field measurements to create a drawing, accurately representing the true layout. For example, create a scale drawing of a simple mechanical device by taking field measurements of the device, determining the appropriate scale, and using an engineer's scale to accurately draw the device. (TN Reading 3, 4; TN Writing 2, 4; TN Math N-Q, G-MG)

Design Project

- 25) Use the design process to create a solution for a given design problem, selecting and creating appropriate drawings to explain the solution, including sketches and multiple views of two-dimensional scale drawings. Prepare an informative narrative to explain how each step of the design process was followed to complete the project. Emphasize the key characteristics of the



design which make it an appropriate solution for the given constraints. (TN Reading 3, 4, 5, 7; TN Writing 2, 4; TN Math N-Q, G-MG)

Portfolio

- 26) Compile important artifacts to create a portfolio connecting personal career preparation to concepts learned in this course, including written descriptions of drawing types and learning outcomes. (TN Writing 4, 9)

Standards Alignment Notes

*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 9-10 Students (page 62).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 8, 9, and 10 at the conclusion of the course.
- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 9-10 Students (pages 64-66).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 1, 3, 7, 8, and 10 at the conclusion of the course.
- TN Math: [Tennessee State Standards for Mathematics](#); Math Standards for High School: Number and Quantity, Geometry, and Statistics (pages 58-83).
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative, geometric, and statistical reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- 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.





TENNESSEE DEPARTMENT OF

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Architectural & Engineering Design II

Primary Career Cluster:	Architecture & Construction
Consultant:	Rachel Allen, (615) 532-2835, Rachel.Allen@tn.gov
Course Code(s):	6039
Prerequisite(s):	<i>Architectural & Engineering Design I, Algebra I</i>
Credit:	1
Grade Level:	10
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
Programs of Study and Sequence:	This is the second course in the <i>Architectural & Engineering Design</i> program of study.
Necessary Equipment:	Refer to the Teacher Resources page.
Aligned Student Organization(s):	SkillsUSA: http://tnskillsusa.com/ Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov Technology Student Association (TSA): http://www.tntsa.org Amanda Hodges, (615) 532-6270, Amanda.Hodges@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/work_based_learning.shtml .
Available Student Industry Certifications:	Autodesk Certified User or ADDA Apprentice Drafter
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	070, 230, 470, 477, 531, 551, 552, 553, 554, 555, 556, 584, 585, 595, 596, or any other Occupational License endorsement.
Required Teacher Certifications/Training:	ADDA Certified Drafter or Autodesk Certified Professional or NOCTI Technical Drafting
Teacher Resources:	http://www.tn.gov/education/cte/ArchitectureConstruction.shtml

Course Description

Architectural & Engineering Design II is the second course in the *Architectural & Engineering Design* program of study. Students in this course build their skills in developing and representing design ideas using technical drawing and modeling techniques, and apply the design process to solve design

problems. Upon completion of this course, proficient students will be able to use CAD software to create multi-view, sectional view, auxiliary view, and three-dimensional drawings using industry standard dimensioning and notation. Students will connect drawings with actual physical layouts by building models based on drawings, creating drawings based on objects and other physical layouts, and using software to create basic three-dimensional models. In addition, students will continue compiling artifacts for inclusion in a portfolio, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects and Tennessee State Standards in Mathematics.*

Program of Study Application

This is the second course in the *Architectural & Engineering Design* program of study. For more information on the benefits and requirements of implementing this program in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

Course Standards

Safety

- 1) Accurately read and interpret safety rules, including but not limited to rules published by the Occupational Safety and Health Administration (OSHA), and state and national code requirements. Be able to distinguish between the rules and explain why certain rules apply. (TN Reading 3, 4, 6)
- 2) Identify and explain the intended use of safety equipment available in the classroom. 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. (TN Reading 3, 4)

Career Exploration

- 3) Research the postsecondary institutions (colleges of applied technology, community colleges, and four-year universities) in Tennessee and other states that offer architecture or engineering programs. Write an informative paper or develop an infographic identifying admissions criteria, the postsecondary programs of study, and the secondary courses that will prepare individuals to be successful in a postsecondary architecture or engineering program. Evaluate the tentative career plan developed in the introductory course in light of these findings, and update the career plan to reflect any new discoveries, citing evidence from the research. (TN Reading 1, 2, 3, 5; TN Writing 4, 7, 9)

Advanced Technical Drawing

- 4) Use CAD software to create two-dimensional drawings of advancing complexity, accurately incorporating symbols, notes, dimensioning, and line types to design drawings. Perform software operations such as utilizing sheets/layouts for printing, scaling viewports in sheets/layouts for printing, printing drawings to proper scale, outputting drawings to electronic



and paper media, and overlaying drawings on externally-referenced drawings. (TN Reading 3, 4; TN Math G-MG)

- 5) Use CAD software to create accurate multi-view drawings of objects of advancing complexity using orthographic projection, incorporating symbols, notes, dimensions, and line type (such as hidden lines to show internal or hidden features). (TN Reading 3, 4; TN Math G-MG)
- 6) Use CAD software to create pictorial drawings of advancing complexity, such as isometric, oblique, and perspective drawings. Attend to detail by using proper angles and ensuring holes, cylinders, prisms, and other features are in proper alignment and relationship to each other. Incorporate symbols, notes, dimensions, and line type according to industry standards. (TN Reading 3, 4; TN Math G-GMD, G-MG)
- 7) Create accurate sectional view drawings of advancing complexity (such as full, half, offset, broken-out, removed, and revolved sections), incorporating symbols, notes, and dimensions, using appropriate layout within title blocks, and appropriate drawing composition (including line weight and line type). For example, create a full section drawing of a mechanical part, hatching appropriate surfaces and using notation to indicate the cutting plane. (TN Reading 3, 4; TN Math G-GMD, G-MG)
- 8) Create accurate auxiliary view drawings of advancing complexity including depth, height, or width auxiliary views; partial auxiliary views; and auxiliary section views. (TN Reading 3, 4; TN Math G-GMD, G-MG)
- 9) Draw detailed, schematic, and simplified drawings of various types of threads and fasteners, including unified, square, and acme threads. Demonstrate the ability to accurately interpret industry-standard thread notes to calculate the thread pitch as well as lay out and construct the drawing. (TN Reading 3, 4; TN Math N-Q, A-CED, G-GMD, G-MG)
- 10) In teams, produce a complete set of project drawings including a completed assembly drawing and an exploded assembly drawing. Supplement assembly drawings with appropriate representations of individual components and a bill of materials as needed for the project type. Fully describe the design by selecting the most appropriate drawing type for the given component, including plan, section, and three-dimensional drawings. (TN Reading 3, 4; TN Math G-MG)
- 11) Demonstrate the ability to refine drawings based on critique from peers, instructors, and self-evaluation. Drawing on evidence from textbooks and other resources, evaluate the effectiveness of a drawing based on industry standards for technical drawing. Interpret and incorporate feedback when refining drawings. (TN Reading 2, 3, 4, 6, 7; TN Writing 5, 9)

Dimensioning

- 12) Interpret industry standards to accurately apply dimensions, notes, and symbols on CAD drawings, including arranging dimensions, using various dimension styles and symbols, and avoiding redundancy. Demonstrate the ability to adjust annotation styles and sizes based on the



drawing type and scale. Define tolerance and give examples of general methods for noting tolerances on drawings. (TN Reading 3, 4; TN Math G-MG)

- 13) Research the American National Standards Institute (ANSI) and describe the goals of the organization and the impact it has on technical drawing, particularly for dimensioning a drawing. (TN Reading 2, 3, 4, 5, 7)

Introduction to Three-Dimensional Modeling

- 14) Use three-dimensional modeling software to create a simple three-dimensional model. Interpret instructional materials to perform basic operations using three-dimensional modeling software. Instructional materials may include textbooks, instructional manuals, websites, video tutorials, and more. (TN Reading 2, 3, 4, 6, 7; TN Math G-GMD, G-MG)

Applications of Technical Drawing

- 15) Understand how designs are communicated through different types of two-dimensional and three-dimensional drawings, physical models, and virtual three-dimensional models within various disciplines, such as architectural, civil, mechanical, electrical, and industrial design. Interpret symbols and notations within the context of each type. Use technology to create a visual display with supporting text to compare and contrast how different drawing types covered in the coursework are implemented in a variety of disciplines, drawing from examples in textbooks, industry journals, drawings created during the coursework, and other resources. For example, illustrate how the plan, orthographic projections, and section drawings of a residence compare with those of a machine part. (TN Reading 1, 2, 4, 7; TN Writing 2, 6, 9)
- 16) Interpret technical drawings to build a physical model of a design. Select and use the appropriate materials and tools to safely measure components and construct the model. Upon completion, use the technical drawings to check the model for accuracy. (TN Reading 2, 3, 4, 6, 7; TN Math N-Q; G-GMD, G-MG)
- 17) Building on techniques practiced in the introductory course, continue to measure, record, and use field measurements to create drawings of increasingly complex objects and layouts. For example, create an accurate half section drawing of an actual mechanical gear by measuring and examining the physical object in order to visualize and draw the section. (TN Reading 3, 4; TN Writing 2, 4; TN Math N-Q, G-MG)
- 18) Create two-dimensional plans for a simple three-dimensional object utilizing drawing techniques learned in the course, such as auxiliary drawing. Use the plans to build a rough study model of the object. Evaluate the model and revise the design on the basis of collected test data. For example, create a two-dimensional drawing of three-dimensional sheet metal design or package design as if the object were unfolded. Print the drawing on paper and construct a paper model of the object. Evaluate the model for inaccuracies and identify opportunities to improve efficiency of materials or construction. Use these conclusions to refine the design. (TN Reading 3, 4; TN Math N-Q; G-GMD, G-MG)



Technology

- 19) Identify and demonstrate basic troubleshooting strategies related to fundamental hardware and software problems. Evaluate electronic media to diagnose and fix hardware and software problems encountered during the coursework. For example, consult software forums, tutorial videos, and other instructional materials to diagnose and correct a drawing that prints on paper differently than intended. (TN Reading 2, 3, 4, 5, 9)
- 20) Explain how technology has changed design throughout history, and identify current transitions occurring in design media, technique, and focus. Read and interpret trade journals, assessing the usefulness of each source, to describe the impact technology has had on a particular design discipline. For example, cite evidence from trade journals to explain the impact of three-dimensional printing on industrial engineering practices or the impact of building information modeling software on structural engineering practices. (TN Reading 1, 2, 3, 4, 5; TN Writing 2, 8, 9)

Projects

- 21) Develop a project plan and use the design process to create a solution for moderately complex problem sets, utilizing both simple three-dimensional modeling techniques and detailed technical two-dimensional and three-dimensional scale drawings. Prepare a persuasive narrative to justify the design, describing the constraints of the design and defending how the design solves the identified problem(s). At the completion of the design process, present the design to an audience, receive feedback, and critique the designs of other classmates. (TN Reading 3, 4, 5, 7; TN Writing 1, 4; TN Math N-Q, G-MG)
- 22) Choose between alternate design solutions for a given design problem and justify the choices. Make a written case for selecting one design over another, highlighting the design features of each and citing resources to validate claims. Demonstrate the ability to pitch the idea to the client in a presentation, defending the design by pointing to specific features that meet the client's specifications. (TN Reading 1, 2, 4, 6, 7, 8; TN Writing 1, 4, 9)

Portfolio

- 23) Update materials from coursework to add to the portfolio begun in the introductory course. Continually reflect on coursework experiences and revise and refine the career plan generated in the introductory course. Include written descriptions of drawing types and learning outcomes. (TN Writing 4, 5, 7, 9)

Standards Alignment Notes

*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 9-10 Students (page 62).



- Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 10 at the conclusion of the course.
- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 9-10 Students (pages 64-66).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3 and 10 at the conclusion of the course.
- TN Math: [Tennessee State Standards for Mathematics](#); Math Standards for High School: Number and Quantity, Algebra, and Geometry (pages 58-83).
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative, algebraic, and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- 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.





TENNESSEE DEPARTMENT OF

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Architectural & Engineering Design III

Primary Career Cluster:	Architecture & Construction
Consultant:	Rachel Allen, (615) 532-2835, Rachel.Allen@tn.gov
Course Code(s):	5927
Prerequisite(s):	<i>Architectural & Engineering Design I, Architectural & Engineering Design II, Algebra I, Geometry</i>
Credit:	1-2 credits (see Recommended Credit below)
Grade Level:	11-12
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
Programs of Study and Sequence:	This is the third course in the <i>Architectural & Engineering Design</i> program of study.
Necessary Equipment:	Refer to the Teacher Resources page.
Aligned Student Organization(s):	SkillsUSA: http://tnskillsusa.com/ Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov Technology Student Association (TSA): http://www.tntsa.org Amanda Hodges, (615) 532-6270, Amanda.Hodges@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/work_based_learning.shtml .
Available Student Industry Certifications:	Autodesk Certified User or ADDA Apprentice Drafter
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	070, 230, 470, 477, 531, 551, 552, 553, 554, 555, 556, 584, 585, 595, 596, or any other Occupational License endorsement.
Required Teacher Certifications/Training:	ADDA Certified Drafter or Autodesk Certified Professional or NOCTI Technical Drafting
Teacher Resources:	http://www.tn.gov/education/cte/ArchitectureConstruction.shtml

Course Description

Architectural & Engineering Design III is the third course in the *Architectural & Engineering Design* program of study. In this advanced course, students will apply technical drawing and design skills

developed in the previous courses to specific architectural and mechanical design projects and contexts. In the process, students will expand their problem-solving and critical-thinking skills by assessing the requirements of a project alongside the available resources in order to accomplish realistic planning. Upon completion of this course, proficient students will be able to employ methods of data collection and analysis to provide others with appropriate information for projects and to develop their own designs. Students will also be able to engage with industry-specific technology to create visual representations of project outcomes. In addition, students will continue compiling artifacts for inclusion in a portfolio, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects and Tennessee State Standards in Mathematics.*

Program of Study Application

This is the third course in the *Architectural & Engineering Design* program of study. Flexibility is built in to offer this course for either one or two credits, depending on school capacity and teacher background. Whether offered for one credit or two credits, this course can feed into a fourth-level *Engineering Practicum* course in which students can apply the skills learned toward the completion of an in-depth, semester- or year-long project. For more information on the benefits and requirements of implementing this program in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

Recommended Credit

If all standards in the course are covered, the course is recommended for two credits. If only one credit is to be offered, the following two options are recommended:

1 Credit- Option A

Content	Standards
Safety	1, 2
Architectural Design	3, 4, 5, 6, 7, 8, 9, 10
Research Project	16
Design Project	17, 18, 19
Project Management	20, 21, 22
Portfolio	23

1 Credit- Option B

Content	Standards
Safety	1, 2
Mechanical Design	11, 12, 13, 14, 15
Research Project	16
Design Project	17, 18, 19
Project Management	20, 21, 22
Portfolio	23

Course Standards

Safety

- 1) Accurately read and interpret safety rules, including but not limited to rules published by the Occupational Safety and Health Administration (OSHA), and state and national code



requirements. Be able to distinguish between the rules and explain why certain rules apply. (TN Reading 3, 4, 6)

- 2) Identify and explain the intended use of safety equipment available in the classroom. 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. (TN Reading 3, 4)

Architectural Design

- 3) Interpret civil drawings used to describe a site, including recognizing symbols used to describe topography. For example, in teams, interpret a topographic survey drawing to construct a model (physical or virtual) of a building site. Use the model to influence the design of the building and the building's placement on the site. (TN Reading 3, 4, 5, 6; TN Math N-Q, G-GMD, G-MG)
- 4) Perform a site analysis to make design decisions for a building plan, including interpreting existing site conditions and evaluating site surroundings. Determine the impact environmental factors such as climate, wind patterns, and the movement of the sun have on the design and site placement of the building. Summarize site analysis findings with drawings and supporting text. (TN Reading 2, 3, 4, 5, 7; TN Writing 2, 9)
- 5) Synthesize the various constraints affecting a building's design to make and justify design decisions. Items to consider should include:
 - a. Evaluating the building's program based on client need. For example, appraise the requirements of the client such as total square footage and list of desired features (number of bedrooms, bathrooms, etc.).
 - b. Accommodating the needs of people of all ages and physical abilities in compliance with the Americans with Disabilities Act (ADA).
 - c. Interpreting applicable building codes based on the project type. For example, determine the minimum number and spacing of exit doors for a given building occupancy size.(TN Reading 2, 4, 6)
- 6) Research planning and diagramming techniques used by designers. Implement planning and diagramming techniques such as bubble diagrams and traffic flow patterns to design a schematic site plan and floor plan for a given building program. (TN Reading 2, 3, 4, 7)
- 7) Create a properly scaled model of a building (physical or virtual) and study the model in the context of the site layout. Present the model along with supporting sketches and diagrams to an audience (such as the instructor and peers), explaining and justifying design ideas in a logical, coherent narrative. Gather feedback and use it to refine the design. (TN Reading 3, 4, 7; TN Writing 2, 4, 5, 9)
- 8) Incorporate schematic design sketches, models, and peer feedback to further develop a building's design. Communicate details of the design through appropriate drawing types, utilizing industry-standard drawing conventions and software. Create a comprehensive set of drawings including the following drawing types:
 - a. Site plan



- b. Floor plan
 - c. Interior and exterior building elevations
 - d. Foundation plan
 - e. Roof plan
 - f. Building system plans (such as an electrical plan)
 - g. Door and window schedules
 - h. Three-dimensional renderings (interior and exterior)
- (TN Reading 3, 4, 7; TN Math N-Q, G-GMD, G-MG)

- 9) Research sustainable design solutions and practices; then provide recommendations for a given design. Calculate a rating for energy responsiveness using a sustainable building guideline. (TN Reading 2, 3, 4, 6; TN Writing 2, 9)
- 10) Examine a wall section drawing for a specific building. Identify, define, and explain the function of each component, including wall insulation, flashing, and the structure of the cornice. Draw from textbooks and other resources to annotate the wall section drawing with notes explaining the purpose of each component. (TN Reading 1, 2, 3, 4; TN Writing 2, 4, 9)

Mechanical Design

- 11) Create three-dimensional models of machine parts of increasing complexity utilizing parametric modeling software. Perform software operations including:
- a. Utilizing basic software tools such as extruding and cutting, and navigating around the object.
 - b. Applying and modifying geometric constraints and dimensions to capture and alter the design geometry of a part.
 - c. Creating drawing layouts with dimensioned views of parametric solids, arranging a drawing sheet according to industry standards.
 - d. Printing drawing layouts at appropriate scales.
 - e. Preparing multi-sheet working drawings and assembly drawings according to industry standards.
- (TN Reading 2, 3, 4; TN Math N-Q, G-GMD, G-MG)
- 12) Building on techniques practiced in prior courses, continue to measure, record, and use field measurements to create drawings of increasingly complex objects and layouts. For example, create an accurate three-dimensional model of an actual screw and fastener by first measuring and examining the physical object in order to visualize and create the model. (TN Reading 3, 4; TN Writing 2, 4; TN Math N-Q, G-MG)
- 13) Compile parametric models of individual machine parts to create a model of a simple assembly. Perform advanced software operations such as animating the model to illustrate how the assembly operates. (TN Reading 3, 4; TN Math N-Q, G-GMD, G-MG)
- 14) Utilize the design process to create a schematic design solution for a mechanical design problem. Identify the criteria and constraints and produce a virtual or physical model of the solution, utilizing software tools where appropriate. Test and evaluate the solution by performing an analysis of the model and gathering feedback from peers. (TN Reading 2, 3, 4; TN Math N-Q, G-GMD, G-MG)



- 15) Incorporate schematic design models, peer feedback, and test results to further develop a design. Communicate details of the design through appropriate drawing types, utilizing industry standard drawing conventions and software. Derive working drawings (detail and assembly drawings including parts lists) from the three-dimensional models created using parametric modeling software. Attend to details when explaining the design, including:
- Specifying and depicting threads, fasteners, and other hardware involved in a mechanical assembly.
 - Applying appropriate geometric dimensioning and tolerancing based on industry standards, including understanding tolerance relationships between mating parts, interpreting geometric tolerancing symbols in a drawing, and using tolerancing in drawings.
 - Selecting and creating appropriate section drawings, noting tolerances, hidden surfaces, and other mechanical details.

(TN Reading 2, 3, 4, 7; TN Math N-Q, G-GMD, G-MG)

Research Project

- 16) Employ basic methods of data collection and analysis to compile information for projects. Use available research methods when project planning and problem solving. Synthesize research to present appropriate precedents for development of a project and articulate logical rationale for the use of chosen precedents. Create a detailed presentation or written report, citing evidence from research. Examples include a proposal for how a specific plot of land should be developed to meet the needs of a given neighborhood; or a proposal for a new product based on consumer market data for a target audience. (TN Reading 1, 2, 4, 6, 9; TN Writing 2, 4, 8, 9)

Design Project

- 17) Use the design process to create schematic designs employing discipline-appropriate representational media (such as sketches, technical drawings, and preliminary models) for a given problem set. Prepare and present schematic designs to peers and others, citing research to justify design solutions. Note constructive feedback received and use it to refine the design. (TN Reading 1, 2, 3, 4, 7, 8, 9; TN Writing 1, 4, 5, 9; TN Math N-Q, G-GMD, G-MG)
- 18) Drawing on results from the schematic design phase, create discipline-appropriate drawings based on industry standards, a three-dimensional model of the design, and presentation boards. Present final design conclusions to members of the profession as well as peers; justify design decisions as would an architect or engineer delivering a pitch to a prospective client. (TN Reading 2, 3, 4, 9; TN Writing 1, 4, 5, 9; TN Math N-Q, G-GMD, G-MG)
- 19) Compile working drawings in a comprehensive set, including a bill of materials with allowable material alternatives. Demonstrate the ability to properly select the drawing scale, select the views, lay out drawings, and organize the drawing set according to industry standards. (TN Reading 2, 3, 4; TN Math N-Q, G-GMD, G-MG)

Project Management



- 20) Examine how architects and engineers conduct project management processes, including but not limited to setting interim goals, tracking progress, and coordinating with construction professionals and clients. Compare and contrast components of project management models gathered from textbooks, online resources, and actual case studies of major or local design professionals. (TN Reading 7, 9; TN Writing 4, 8)
- 21) Utilize project management strategies to create and implement a work plan to complete projects according to schedule. Use technology to periodically document project status and progress in written reports. (TN Reading 3, 4; TN Writing 2, 4, 6)
- 22) Create a written report or infographic describing the basic steps of traditional project delivery, outlining who and what is involved in each step. Compare texts to describe alternatives to traditional project delivery methods, such as the design-build method used in construction. (TN Reading 1, 2, 4, 5, 7; TN Writing 2)

Portfolio

- 23) Update the portfolio to reflect the cumulative total of all projects undertaken across the program of study. Continually reflect on coursework experiences and revise and refine the career plan generated in the introductory course. Include written descriptions of drawing types and learning outcomes. (TN Writing 4, 5, 7, 9)

Standards Alignment Notes

*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 11-12 Students (page 62).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 10 at the conclusion of the course.
- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 11-12 Students (pages 64-66).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3 and 10 at the conclusion of the course.
- TN Math: [Tennessee State Standards for Mathematics](#); Math Standards for High School: Number and Quantity, Geometry (pages 58-83).
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.



- 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.





TENNESSEE DEPARTMENT OF
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Construction Practicum

Primary Career Cluster:	Architecture & Construction
Consultant:	Rachel Allen, (615) 532-2835, Rachel.Allen@tn.gov
Course Code:	TBD
Prerequisite(s):	Minimum of 3 credits in an Architecture & Construction program of study.
Credit:	1
Grade Level:	12
Graduation Requirement:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
Programs of Study and Sequence:	This is the fourth course in the <i>Residential & Commercial Construction</i> , <i>Structural Systems</i> , and <i>Mechanical, Electrical, and Plumbing Systems</i> programs of study.
Necessary Equipment:	Refer to the Teacher Resources page.
Aligned Student Organization(s):	SkillsUSA: http://tnskillsusa.com/ Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/work_based_learning.shtml .
Available Student Industry Certifications:	TBD
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	TBD
Required Teacher Certifications/Training:	TBD
Teacher Resources:	http://www.tn.gov/education/cte/ArchitectureConstruction.shtml

Course Description

Construction Practicum is a capstone course intended to provide students with the opportunity to apply the skills and knowledge learned in previous Architecture & Construction courses within a professional, working environment. In addition to developing an understanding of the professional and ethical issues

encountered by tradesmen and contractors in the workplace, students learn to refine their skills in problem solving, communication, teamwork, and project management in the completion of a course-long project. Due to the importance of on-the-job training in the construction industry, a principle aim of the practicum is to assist students with pre-apprenticeship placements, where available, so they can begin to log hours on a worksite and gain experience prior to entering the job market. Additionally, students are exposed to the great range of postsecondary opportunities in today's construction fields as well, in order to prepare them to make an informed decision regarding their post-high school plans. The course is highly customizable to meet local system needs. Instruction may be delivered through school laboratory training or through work-based learning arrangements such as internships, cooperative education, service learning, mentoring, and job shadowing. Upon completion of the practicum, proficient students will be prepared to pursue further study in architecture or construction, or seek additional training and employment with the aid of a portfolio documenting student work completed throughout high school. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects, Tennessee State Standards in Mathematics, and the National Center for Construction Education and Research (NCCER) Curriculum.*

Note: Practicum activities may take the form of work-based learning opportunities (such as internships, cooperative education, service learning, and job shadowing) or industry-driven project-based learning. As such, this course must be taught by a teacher with an active WBL Certificate issued by the Tennessee Department of Education and follow policies outlined in the Work-Based Learning Policy Guide available online at http://www.tn.gov/education/cte/work_based_learning.shtml.

Program of Study Application

This is the fourth course in the *Residential & Commercial Construction, Structural Systems, and Mechanical, Electrical, and Plumbing Systems* programs of study. For more information on the benefits and requirements of implementing these programs in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

Course Standards

Safety

- 1) Identify safety hazards on a jobsite and demonstrate practices for safe working. Accurately read and interpret safety rules, including but not limited to 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. Recognize and employ universal construction signs and symbols such as colors, flags, stakes, and hand signals that apply to construction workplace situations. (TN Reading 3, 4, 6; TN Writing 2, 4)
- 2) Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, equipment safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy. (TN Reading 3, 4)



- 3) Follow procedures to work safely around materials. Adhere to responsibilities for employees in material safety as outlined by the Hazard Communication Standard (HazCom), such as locating and interpreting material safety data sheets (MSDS). Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. (TN Reading 3, 4)
- 4) Research state and national laws governing workplace injuries, particularly those common to the construction industry. In preparation for a future career in construction, outline the necessary procedures to follow if an injury is sustained on the job; in particular, explain the responsibilities of managers, supervisors, and the injured parties in the event of an emergency, including incident reporting after the event. Practice explaining the process of securing workers compensation benefits as if assisting a co-worker or subordinate.

Postsecondary and Career Preparation

- 5) Research the range of credentials one can earn with advanced study of construction at the postsecondary level (i.e., apprenticeship, technical certification, BA, BS, MBA, etc.). Investigate both in-state and out-of-state postsecondary programs in a variety of construction fields, including but not limited to construction management, construction science, architecture, landscape design, civil engineering, and more. Synthesize research conducted in previous Architecture & Construction courses to update the portfolio career plan to achieve post-high school goals. (TN Reading 5, 7, 9; TN Writing 2, 4, 6, 8)
- 6) Research and select a company or organization for a work-based learning project in a construction field. Cite specific textual evidence from the organization's literature, as well as independent news articles, to summarize:
 - a. The mission and history of the organization
 - b. Headquarters and organizational structure
 - c. Products or services provided
 - d. Credentials required for employment and how they are obtained and maintained
 - e. Policies and procedures
 - f. Reports, newsletters, and other documents published by the organization
 - g. Website and contact information(TN Writing 4, 7)
- 7) Search for the resumes of construction professionals retrieved from the websites of companies, organizations, or professional networks. Discuss what is typically included in the resumes of these professionals, compare and contrast several examples, and create a personal resume modeled after elements identified in the search. (TN Reading 1, 4, 5, 6; TN Writing 4)
- 8) Simulate the experience of conducting a job search by researching local employment options. In preparation for a future career in construction, complete an authentic job application form and compose a cover letter following guidelines specified in the vacancy announcement. (TN Reading 7; TN Writing 4)
- 9) Participate in a mock interview. Prior to the interview, research tips on dress and grooming, most commonly asked interview questions, appropriate conduct during an interview, and



recommended follow-up procedures. Highlight sample work compiled in the portfolio that illustrates mastery of specific skills attained in the program of study. Upon completion of the interview, write a thank you letter to the interviewer in a written or email format. (TN Reading 2; TN Writing 2, 4, 7, 9)

Transferring Course Concepts to Practicum

10) Apply skills and knowledge from previous courses in an authentic work-based learning internship, job shadow, or classroom-based project. Where appropriate, develop, practice, and demonstrate skills outlined in previous courses. (TN Reading 2, 3)

11) As part of a course project, develop a comprehensive project plan to guide all work. The plan should include at minimum the following:

- a. Material list
- b. Cost estimation/Mock bid package
- c. Criteria and constraints
- d. Construction schedule
- e. Inspection checklist
- f. Applicable contracts
- g. Minutes from project meetings and other documentation
- h. Contingency plan in case of delay or emergency
- i. Justification for major design and budgeting decisions made

Collaboratively update the plan to reflect unexpected changes in conditions or capacity. For example, demonstrate the ability to reschedule an activity if there is a delay in the arrival of materials. (TN Reading 3, 4, 7, 9; TN Writing 2, 5, 7)

12) Create and continually update a personal journal to document skills learned during the practicum and draw connections between the experience and previous course content by reflecting on:

- a. Tasks accomplished and activities implemented
- b. Positive and negative aspects of the experience
- c. How challenges were addressed
- d. Team participation in a learning environment
- e. Comparisons and contrasts between classroom and work environments
- f. Interactions with colleagues and supervisors
- g. Personal career development
- h. Personal satisfaction

(TN Writing 2, 4)

Business Skills and Project Management

13) In teams, develop and successfully implement a suite of project management tools and processes to aid in the completion of the course project. (If participating in a work-based learning experience, apply tools and processes to satisfy placement requirements.) Demonstrate the ability to divide roles and responsibilities among team members, track progress toward goals, and satisfy client specifications as would a construction manager or contractor. For example, assign tasks and monitor deliverables using a Gantt chart or other tracker.



Portfolio

- 14) Update materials from coursework to add to the portfolio started in *Fundamentals of Construction* to illustrate mastery of skills and knowledge outlined in the previous courses and applied in the practicum. The portfolio should reflect thoughtful assessment and evaluation of the progression of work involving the application of project management skills specific to the construction industry. The following documents will reside in the career portfolio:
- The career plan developed and revised in prior courses
 - Resume
 - List of responsibilities undertaken through the course
 - Examples of visual materials used during the course (such as diagrams, schematics, and site plans) and artifacts of project outcomes (such as photographs of various stages of a construction project)
 - Periodic journal entries reflecting on tasks and activities
 - Feedback from instructor and/or supervisor based on observations
 - Transcripts or other evidence of certifications obtained throughout the program of study

(TN Writing 4, 5)

Communication of Project Results

- 15) Apply all steps of the construction process to successfully build a structure and/or install a system(s) as outlined in the course project plan. Demonstrate the ability to communicate results over the course of the project's duration. Produce a technical report documenting the progress of the project and evaluating the final product. (TN Reading 1, 2, 3, 4, 5, 7, 8, 9; TN Writing 1, 2, 4, 5, 6, 7, 8, 9)
- 16) Upon completion of the practicum, develop a technology-enhanced presentation showcasing highlights, challenges, and lessons learned from the experience. The presentation should be delivered orally, but supported by relevant graphic illustrations, such as diagrams, drawings, videos, photographs, and/or guided tours of the finished structure or product. Throughout the presentation, justify construction decisions and assess the quality of the work. Prepare the presentation in a format that could be presented to both a technical and a non-technical audience, as well as for a career and technical student organization (CTSO) competitive event. (TN Reading 1, 3, 7, 9; TN Writing 2, 4, 5, 6, 9)

Standards Alignment Notes

*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 11-12 Students (page 62).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 10 at the conclusion of the course.



- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 11-12 Students (pages 64-66).
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- TN Math: [Tennessee State Standards for Mathematics](#); Math Standards for High School: Numbers and Quantity, Algebra, Geometry.
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project-based activities or collaborate on lesson planning. While not aligned to one specific conceptual category, students who are engaging in the activities outlined above should be able to demonstrate quantitative, algebraic, and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- NCCER Curriculum: [National Center for Construction Education and Research](#)
 - Students who are engaging in activities outlined above will be able to complete modules working toward certification in NCCER Construction Technology.
- 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.

