Civil Engineering and Architecture

PEIMS Code: N1303747

Abbreviation: CEA

Grade Level(s): 9-12

Award of Credit: 1.0

Approved Innovative Course

- Districts must have local board approval to implement innovative courses.
- In accordance with Texas Administrative Code (TAC) §74.27, school districts must provide instruction in all essential knowledge and skills identified in this innovative course.
- Innovative courses may only satisfy elective credit toward graduation requirements.
- Please refer to TAC §74.13 for guidance on endorsements.

Course Description:

Civil Engineering and Architecture (CEA) is a high school level specialization course in the PLTW Engineering Program. In CEA students are introduced to important aspects of building and site design and development. They apply math, science, and standard engineering practices to design both residential and commercial projects and document their work using 3D architectural design software. Utilizing the activity-project-problem-based (APB) teaching and learning pedagogy, students progress from completing structured activities to solving open-ended projects and problems that require them to develop planning, documentation, communication, and other professional skills.

Through both individual and collaborative team activities, projects, and problems, students problem solve as they practice common design and development protocols such as project management and peer review. Students develop skill in engineering calculations, technical representation, documentation of design solutions according to accepted technical standards, and use of current 3D architectural design and modeling software to represent and communicate solutions.

Essential Knowledge and Skills:

(a) General Requirements. This course is recommended for students in Grade 9-12. It is recommended that students are concurrently enrolled in college preparatory mathematics and science courses and have successfully completed the Introduction to Engineering Design course.

(b) Introduction.

(1) CTE instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions.

(2) The Science, Technology, Engineering, and Mathematics (STEM) Career Cluster focuses on planning, managing and providing scientific research and professional and technical services

(e.g., physical science, social science, engineering) including laboratory and testing services, and research and development services.

(3) Civil Engineering and Architecture students are introduced to important aspects of building and site design and development. They apply math, science, and standard engineering practices to design both residential and commercial projects and document their work using 3D architectural design software. Utilizing the activity-project-problem-based (APB) teaching and learning pedagogy, students progress from completing structured activities to solving open-ended projects and problems that require them to develop planning, documentation, communication, and other professional skills.

(4) Statements that contain the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(c) Knowledge and Skills.

(1) Civil Engineering and Architecture Profession and Employability. The student examines civil engineering and architecture professions and careers, including employability. The student is expected to:

(A) compare the primary duties, responsibilities, and attributes of civil engineers and an architects,

(B) describe the educational preparation required for becoming a civil engineer or architect,

(C) investigate how civil engineers are involved in the design and construction of a diverse array of projects, including structural, environmental, geotechnical, water resources, transportation, construction, and urban planning, and

(D) describe how civil engineering and architecture careers and their specialties offer creative job opportunities for individuals with a wide variety of backgrounds and goals.

(2) Researching and Resources for Civil Engineering and Architecture. The student analyzes existing resources related to a civil engineering and architecture problem or solution. The student is expected to:

(A) explain how a legal description of property is used to identify real estate in a legal transaction and can be found in a deed, mortgage, plat or other purchase documents,

(B) explain the purpose of building and construction codes including public health and safety, structure location, utilities, construction, and landscape,

(C) demonstrate how the selection of a site and the project being planned are interrelated,

(D) identify the criteria for commercial property/project viability,

(E) research Land Use regulations to identify zoning designations and allowable uses of property,

(F) examine the legal, physical, and financial conditions as well as the needs of the surrounding community when determining the viability of a project,

(G) identify and interpret codes, zoning ordinances, and regulations to determine the applicable requirements for a project,

(H) identify project criteria and constraints and gather information to justify viable decisions regarding the development of a project,

(I) investigate the legal, physical, and financial requirements of a project and consider the needs of the community to determine project viability,

(J) describe how zoning regulations are used to control land use and development,

(K) identify the types of requirements that pertain to site development and are typically included in Land Use Regulations,

(L) interpret how energy codes are designed to conserve natural resources, reduce operating costs, protect the environment, and create healthier living and working spaces, and

(M) describe the Leadership in Energy and Environmental Design (LEED) certification program and its purpose.

(3) Researching and Resources for Civil Engineering and Architecture. The student conducts field research related to a civil engineering and architecture problems or solutions. The student is expected to:

(A) research through site visits and information gathering pertinent information to analyze the viability of a project on the site,

(B) participate in a design charrette and justify its value for developing innovative solutions to support whole building design,

(C) analyze the relationships among the stakeholders involved in the design and construction of a building project.

(D) identify the needs and requirements of building and structure users,

(E) apply, critique, and review techniques to inform and provide suggestions for improvement,

(F) analyze a site soil sample to determine the United Soil Classification System designation, and

(G) classify soil according to its grain size and plasticity.

(4) Visualizing, Modeling, and Simulating. The student demonstrates the abilities to model and simulate civil engineering and architecture problems and solutions. The student is expected to:

(A) describe an architectural style or feature by creating a mock-up model using variety of materials,

(B) document the design of a home using 3D architectural design software and construction drawings, and

(C) develop fully rendered 3D models of residential and commercial buildings and sites.

(D) Structural Engineering. The student analyzes the forces and loads on structures to predict their performance. The student is expected to:

(E) identify and differentiate between the various design loads that may influence the structural design of a building including dead, live, snow, wind, earthquake, flood, and earth pressure loads,

(F) demonstrate how applied loads and forces are resisted in a structure and transferred to the Earth,

(G) explain why design loads are often dictated by building codes,

(H) apply building codes and other resources to calculate roof loading,

(I) analyze a simply supported beam subjected to a given loading condition to determine reaction forces,

(J) sketch shear and moment diagrams and determine the maximum moment resulting in the beam,

(K) apply building codes and other resources to determine the required floor loading,

(L) design a structural steel floor framing system (beams and girders) for a given building occupancy,

(M) determine the size of a spread footing for a given loading condition, and

(N) select appropriate roof components to safely carry the applied load.

(5) Buildings and Building Systems. The student examines the design and construction of buildings and related building systems including their architectural style, aesthetics, environmental impact, and accessibility. The student is expected to:

(A) describe how architectural style is an important key to understanding how a community or neighborhood has developed,

(B) explain how architectural styles provide an indication of changing needs of people, society, and uses for space,

(C) apply the visual design elements and principles to describe buildings and structures,

(D) determine how to maximize the potential of a property and minimize its impact on the environment using universal design concepts,

(E) identify sustainable building principles used in residential design,

(F) identify environmental, building code, infrastructure, and site considerations that should be taken into account when locating a residential building on a site, and

(G) apply sustainable building principles, energy conservation features, and universal design concepts on a residential design.

(6) Building Sites and Foundations. The student demonstrates the abilities to plan building sites and foundations. The student is expected to:

(A) identify and describe commercial and residential foundation types and their applications,

(B) recommend and defend an appropriate foundation for a residential application, and

(C) evaluate an appropriate building location on a site based on orientation and other site-specific information.

(7) Building Sites and Foundations. The student describes the purpose of land surveying during the design and construction of a project, including establishing the topography of a site, setting control points, and establishing the location of project features. The student is expected to:

(A) use appropriate tools and techniques to conduct a topographic survey,

(B) read and interpret topographic maps, and

(C) use differential leveling to complete a control survey to establish a point of known elevation for a project,

(8) Building Sites and Foundations. The student evaluates parking requirements, pedestrian access, ingress and egress, landscaping, storm water management, and site grading when creating a site design. The student is expected to:

(A) identify and explain the purpose of the use of Low Impact Development techniques in site development,

(B) design appropriate pedestrian access, vehicular access, and a parking lot for a commercial facility,

(C) estimate ingress and egress, parking, pedestrian, and handicapped access,

(D) apply codes to determine the type, sizing, and placement of site features including parking lots, entrance and exit roads, pedestrian and handicapped access, and storm water facilities,

(E) apply Low Impact Development techniques to a commercial site design to reduce the impact of development on storm water runoff quantity and quality,

(F) describe how the characteristics of soils present on a site will impact the design and construction of property improvements,

(G) identify storm water runoff situations and explain how they often increases when the site is developed,

(H) define and calculate the storm water runoff from a site before and after development, and

(I) explain how the surface conditions and topography of a site affect the quantity and quality of storm water runoff and the design of the storm water management system.

(9) Building Design. The student develops building designs that meet identified needs, codes, and constraints. The student is expected to:

(A) identify standard building practices using wood framing systems,

(B) design, modify, and plan structures using 3D architectural software,

(C) evaluate how green or sustainable design reduces the negative impact of a project on the environment and human health,

(D) examine how codes and building regulations define and constrain all aspects of building design and construction including the structure, site design, utilities, and building usage,

(E) apply the concepts of Universal Design to the design of products and environments that includes barrier free accessibility to projects required by federal regulations,

(F) describe the purpose and cite examples of Universal Design concepts in residential design,

(G) classify a building according to its use, occupancy, and construction type using the International Building Code,

(H) modify system designs to incorporate energy conservation techniques,

(I) estimate the type and location of new utility service connections for a commercial facility, and

(J) interpret drawings related to the design and construction of a building project including HVAC, electrical, and blueprints.

(10) Computation and Analyzing. The student demonstrates the abilities to apply computational and analytical knowledge and skills to civil engineering and architecture problems. The student is expect to:

(A) apply math, science, and discipline-specific skills to analyze and design problems and solutions,

(B) analyze the deflection of a simply supported beam subjected to a given loading condition,

(C) use structural analysis software to create shear and moment diagrams of simply supported beams subjected to a given loading condition,

(D) determine surface area and volume of building components,

(E) use beam formula to calculate end reactions and the maximum moments of a simply supported beam subjected to a given loading condition,

(F) propose and defend a cost estimate for a small construction project that includes a detailed cost break-down, and

(G) develop cost and material quantity estimates for a construction project.

(11) Communication and Collaboration. The student demonstrates the abilities to clearly and accurately record, elicit, convey, and verify information and knowledge related to civil engineering and architecture problems and solutions. The student is expected to:

(A) document and detail a building project on construction drawings,

(B) identify and describe the typical components of a given architectural view or drawing component including a schedule, site plan, floor plan, building section, or elevations,

(C) create appropriate documentation to communicate a commercial building design using 3D architectural design software,

(D) communicate ideas while developing a project using various drawing methods, sketches, graphics, or other media collected and documented,

(E) create an architectural program, a project organization chart and a Gantt chart and hold project progress meetings to help manage the team project,

(F) showcase a commercial project in an effective and professional manner, and

(G) present a proposal for the design and development of a commercial building project,

(H) work individually and in groups to produce a solution to a team project,

(I) collaborates with stakeholders in an organized meeting called a charrette, and

(J) demonstrate positive team behaviors, acts according to accepted norms, contributes to group goals, and uses appropriate conflict resolution strategies.

Recommended Resources and Materials:

The most current version of the PLTW curriculum must be used for instruction. Teacher and student resources are developed by PLTW and can only be accessed by trained teachers, authorized district personnel, and rostered students through the PLTW Learning Management System. Access to PLTW resources is through myPLTW.org after the appropriate training or authorization has been completed.

https://mypltw.org

In addition to the instructional equipment and materials required for the specific activities, projects and problems, each student in a class must have access to a computer that meets

PLTW's specifications and is furnished with the appropriate software for the course. These requirements are listed at:

https://www.pltw.org/get-involved/register-pltw/program-support/equipment-and-supplies

Recommended Course Activities:

CEA Students are involved in the following activities and projects.

Computational and Analytical Skills

- Analyze and/or design a simply supported beam
- Select a floor system to support applied loads
- Perform a closed loop (control) survey
- Perform sieve analysis and classify a soil sample
- Calculate heat loss/gain
- Calculate head loss and pressure in a pipe
- Estimate the simple cost of a small building system or project
- Calculate storm water runoff from a site
- Size a spread footing
- Create a project schedule for a small design project

Design Experience

- Design a small single family residential structure that reflects a set of basic building guidelines
- Create a site opportunities map and site plan for a small residential structure
- Create a simple residential electrical plan
- Document a residential design with construction drawings and a 3D computer model using 3D architectural software
- Collaborate effectively with peers to design a renovation to an existing commercial facility according to applicable building codes and regulations
- Collaborate effectively with peers to design a viable small commercial building that meets identified code and ordinance requirements
- Use Low Impact Development principals to design a site that support a commercial facility
- Document the design or renovation of a commercial facility with construction drawings and a 3D computer model, using 3D architectural software
- Design a sewer lateral
- Analyze a given building/site design and make recommendations to
- identify errors and/or omissions
- improve energy efficiency
- reduce the quantity and/or improve the quality of storm water runoff

Tools and Software

- Building Design Software
- Structural Analysis Tool
- Survey equipment
- Budgeting and Project Management

Professional Skills

- Team collaboration
- Project management
- Problem-solving
- Communication skills
- Presentation skills
- Technical writing

History

- Historical development of civil engineering and architecture
- Elements and principles of design

Careers

- Educational and professional requirements related to civil engineering
- Educational and professional requirements related to architecture
- Primary responsibilities of civil engineers and architects
- Specialty disciplines related to civil engineering
- Design Teams and Charrettes

Residential Design

- Residential framing methods and roof styles
- Cost of construction
- Heat loss/gain and energy efficiency
- Residential building code requirements
- Universal Design principles
- Green building and sustainable design
- Site design and orientation
- Residential building systems (plumbing, electrical, wastewater, and water supply)

Commercial Design

- Commercial building code requirements
- Building loads
- Zoning Ordinance
- Land development regulations

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- Energy code requirements
- Commercial wall, roof, and floor framing systems
- Commercial foundation systems
- Utilities and Services
- Land surveying

- Low Impact Development (LID)
- Parking lot and site design
- Project viability
- Project management
- Project report and presentation

Suggested methods for evaluating student outcomes:

PLTW Engineering assessments play an important role in providing meaningful feedback to students, teachers, administrators, and PLTW. Through assessments, students identify what they are doing well and what they need help with, and teachers are able to provide individualized direction and guidance to each student.

PLTW supports a balanced approach to assessment for all programs, integrating both formative and summative assessments. Through a balanced approach, assessment is an ongoing activity. Students demonstrate their knowledge throughout the course by completing activities, projects, and problems using a variety of assessment tools, such as performance rubrics and reflective questioning, to deepen and expand their knowledge and skills.

PLTW applies industry best practices and methods to design, test, and implement End of Course assessments for its schools. They receive valid and reliable scores on overall student performance within the course. The End of Course assessment gives students an objective evaluation of their achievement, and school administrators obtain data on program performance. Many colleges, universities, and other organizations use students' PLTW EoC scores for student recognition and recruitment opportunities.

Teacher qualifications:

An assignment for Civil Engineering and Architecture is allowed with one of the following certificates as well as successful completion of the Project Lead The Way's Core Training requirements for Civil Engineering and Architecture.

PLTW Core Training:

PLTW's Core Training requires approximately 90 hours of instruction led by PLTW approved Master Teachers. Course mastery is demonstrated by the submission and approval of a course portfolio that meet's PLTW's requirements. After successful completion of Core Training, teachers receive access to the National PLTW Engineering Professional Learning Community, course-specific student and classroom instructional resources, and Ongoing Training resources through the PLTW Content Management System.

- Mathematics/Physical Science/Engineering: Grades 6-12.
- Mathematics/Physical Science/Engineering: Grades 8-12.
- Secondary Industrial Arts (Grades 6-12).
- Secondary Industrial Technology (Grades 6-12).
- Technology Education: Grades 6-12.
- Trade and Industrial Education: Grades 6-12. This assignment requires appropriate work approval.

- Trade and Industrial Education: Grades 8-12. This assignment requires appropriate work approval.
- Vocational Trades and Industry. This assignment requires appropriate work approval.
- Vocational Trades and Industry (Grades 6-12). This assignment requires appropriate work approval.
- Vocational Trades and Industry Pre-Employment Laboratory (Grades 6-12). This assignment requires appropriate work approval.
- Vocational Trades and Industry Co-op (Grades 6-12). This assignment requires appropriate work approval.

Additional information:

Districts may use these courses only with the approval of Project Lead The Way. All requirements of Project Lead The Way must be met. Please contact Project Lead The Way directly for these requirements:

Project Lead The Way
Solution Center
Toll Free: 877.335.PLTW (7589)
solutioncenter@pltw.org