PLTW Engineering
Civil Engineering and Architecture | Course Outline

Improving our world through thoughtful building design and development!

Students learn the fundamentals of building design, 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.

You can change the world, one project at a time.

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

The following is a summary of the units of study that are included in the course. Alignment with NGSS, Common Core, and other standards will be available through the PLTW Alignment web-based tool. Activities, projects, and problems are provided to the teacher in the form of student-ready handouts, teacher notes, lesson planning resources, and supplementary materials.

The course requires a rigorous pace, and it is likely to contain more material than a skilled teacher new to the course will be able to complete in the first iteration. Building enthusiasm for and a real understanding of role, impact, and practice of civil engineering and architecture as it relates to building design and development is a primary goal of the course.

CEA Unit Summary

Unit 1	Overview of Civil Engineering and Architecture
Unit 2	Residential Design
Unit 3	Commercial Applications
Unit 4	Commercial Building Systems

Unit 1: Overview of Civil Engineering and Architecture

Unit 1 provides an introduction and overview to the past accomplishments within the fields of civil engineering and architecture as well as a brief introduction to the wide variety of careers within the fields of civil engineering and architecture.

Overview of Civil Engineering and Architecture

Lesson 1.1 History of Civil Engineering and Architecture
Lesson 1.2 Careers in Civil Engineering and Architecture

Lesson 1.1 History of Civil Engineering and Architecture
The goal of this lesson is to introduce students to the vast history of accomplishments in civil engineering and architecture. The study and improvements on these accomplishments have paved the way for the structures that we use today. In this lesson students will begin to build a common vocabulary related to architectural styles and features, structural systems, and the elements and principles of design.

Lesson 1.2 Careers in Civil Engineering and Architecture
This lesson will provide foundation and perspective for students regarding careers in civil engineering and architecture as they venture through the remainder of the course. The primary duties and responsibilities of civil engineers (and related specialty disciplines) and architects are presented as well as the traditional educational and accreditation requirements that must be met in order to become a professional engineer and architect. Career connections and relationships between these two types of professionals and other stakeholders involved in building design and development are also introduced.

Unit 2: Residential Design

This unit of study introduces students to standard practice in the design of single family homes and provides an opportunity for students to develop a small single family home design that incorporates sustainable design practices as well as universal design features. Students will be introduced to building codes and their impact on design as well as common wood-framed residential construction techniques and practices. Students also will investigate the cost of construction and the significant impact of the choice of construction materials and practices on the ongoing cost of energy for heating and cooling. They will apply this knowledge to the design of a small, affordable home.

Residential Design Lesson Summary

Lesson 2.1 Building Design and Construction
Lesson 2.2 Cost and Efficiency Analysis
Lesson 2.3 Residential Design

Lesson 2.1 Building Design and Construction
In this lesson students will learn typical wood-framed residential construction techniques and practices. They will build a common vocabulary related to building components and materials and become familiar with a variety of residential framing methods and roof styles. In addition, students will be introduced to technical documentation of residential structures and will use 3D architectural modeling software to model and document the design of a small outdoor storage structure.

Lesson 2.2 Cost and Efficiency Analysis
In this lesson students investigate the cost of construction and the recurring energy costs associated with design decisions and construction techniques. Students will have the opportunity to perform quantity take-offs and cost estimates related to parts of small construction projects. In addition students will learn about and compare the energy efficiency of a variety of construction materials and calculate the rate of heat loss or gain through a building envelope which can be used to estimate energy demands for heating and cooling a building.

Lesson 2.3 Residential Design
In this lesson students apply elements of good residential building and site design to design a small affordable home for a client based on information gathered during a client interview and meetings. Students will perform code research and develop a design that meets applicable building codes and requirements as well as universal design principles. Students will also learn about sustainable building practices which they will apply to their home design in an effort to reduce the environmental impact of the building. Basic site design and orientation considerations are presented to guide students in appropriately locating the home on the building site to improve usability and reduce environmental impact. During the design process, students will also be introduced to a variety of residential foundation systems, basic residential electrical system components, plumbing systems and water supply calculations, and wastewater disposal and treatment systems. They will include consideration of these systems in their design development.

Unit 3: Commercial Applications

This unit will provide students with an opportunity to discover the diversity and complexity of commercial building design as they design a renovation to a commercial facility. The design of commercial facilities includes multiple building systems and involves a wide range of engineering and architectural considerations. In this unit students will learn about site considerations important to the function of the building. Students will learn about common built-up systems that provide the building envelope such as wall and roofs. They will learn about the utilities and services that supply power, water, and communication services to the building. In addition students will learn about common structural systems employed to support all of the building components. Applying the knowledge they gain from this unit of study, students will design a renovation to a commercial facility and document that design using 3D architectural software.

Commercial Applications Lesson Summary

Lesson 3.1 Commercial Building Systems
Lesson 3.2 Structures
Lesson 3.3 Services and Utilities

Lesson 3.4 Site Considerations

Lesson 3.1 Commercial Building Systems
In this lesson students will be exposed to the design and development of commercial facilities and the building codes and land development regulations that impact commercial construction. Students are presented with a commercial renovation design project on which they will work throughout this unit. They will research building codes and land development regulations and learn about a variety of commercial wall, roof, and floor framing systems as they further develop a common vocabulary related to building design and development. Students continue to build expertise in the use of a 3D architectural design software package as they model and document their commercial design project ideas.

Lesson 3.2 Structures
This lesson is designed to introduce students to the concepts and principles of structural engineering and structural efficiency. The activities related to this lesson are designed to aid students in learning about the variety of forces that impact the design and performance of a building and how to quantify those loads using building codes and the physical characteristics of the structure. Students are also introduced to the physical laws and mathematics involved in determining the internal resistive forces generated by the imposed loads as the loads are transferred through the structural elements of the building into the ground. A variety of structural systems and common commercial foundation systems are presented, and the lesson focuses on the analysis and design of beams and spread footings.

Lesson 3.3 Services and Utilities
This lesson will introduce students to the multiple modern utilities and services required in order for a building to function effectively and lawfully in today's society. These utilities and services include a reliable supply of energy and water, a system to dispose of wastes, and capacity for communication via multiple modes. Students will identify typical utilities and services for commercial buildings and common methods for distribution and measuring of those services. They will interpret and apply building code requirements and consider other physical constraints in the design and location of new utility service connections for their commercial project. In addition students will interpret and apply energy code requirements in the design of their commercial project building envelope and internal utility distribution systems in an effort to conserve natural resources, reduce operating costs, and protect the environment from the negative impact of development.

Lesson 3.4 Site Considerations
In this lesson students will learn about the important factors to be considered in commercial site design. They will perform a land survey, conduct a soil analysis, and conduct a physical investigation of the site in order to gather information relevant to their commercial project design. Students will use the information they have collected to design and document appropriate site improvements to provide adequate parking based on facility use and building code requirements and provide safe vehicular and pedestrian traffic access and flow. The site must also provide handicap access and provide access for emergency vehicles and the movement of goods and waste. Students will also become familiar with the requirements related to storm water runoff and management and learn the calculations necessary to comply with building codes. Based on the information they acquire during this lesson, students will design and document a site design for their commercial project. Their design will utilize low impact development techniques in order to incur minimal impact on people and the environment.

Unit 4: Commercial Building Design Problem

This unit will allow students to collaborate on the design and documentation of a small commercial facility within a project design team. They will identify a need within their community, investigate a potential site, develop a preliminary design, and document the design of the facility as a team. They will also present their design concept to a panel that will critique their design and offer feedback to the team related to their design and presentation.

Commercial Building Design Lesson Summary

Lesson 4.1 Commercial Building Design Problem
Lesson 4.2 Commercial Building Design Presentation

Lesson 4.1 Commercial Design Problem

In this lesson students will work within design teams to develop a preliminary design for a small commercial facility. As part of the design process, they will investigate a potential site for development of their commercial project; research codes, zoning ordinance, and regulations that impact the site; and determine the legal description of the property. Students will develop an architectural program to describe the desired outcome of the project and help guide development. They will become familiar with legal, physical, and financial conditions that should be considered in order to determine the viability of project development and help determine whether a project solution should be undertaken. As the team project progresses, students will apply the skills and knowledge they have gained throughout the course to the team commercial project. They will learn new skills related to team design work, including creating a project organization chart, developing and using a Gantt chart to plan and monitor project progress, and holding regular team meetings. Students will document their design according to accepted practice using 3D architectural modeling software.

Lesson 4.2 Commercial Design Presentation

In this lesson students will create and deliver a formal presentation (both oral and written) of their final team commercial design project to include a description of both the design process (and justifications of design decisions) as well as the resulting design. The project presentation will be reviewed and critiqued by a panel who will offer feedback to the team related to their design process, decision making, and the resulting design and documentation.