Project Lead The Way [PLTW] Aerospace Engineering

PEIMS Code: N1303745

Abbreviation: AERO

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:

In this course, students explore the fundamentals of flight in air and space as they bring the concepts to life by designing and testing components, such as an airfoil, propulsion system, and a rocket. They learn orbital mechanics concepts and apply these by creating models using industry-standard software. Students simulate a progression of operations to explore a planet, including creating a map of the terrain and using the map to execute a mission using an autonomous robot. Building enthusiasm while learning real-world skills related to the aerospace industry is a primary goal of the course.

This course prepares students for college, a career, or the military by deepening their knowledge of aerospace concepts, developing students problem-solving skills, transportable skills (such as communication and ethical reasoning), and exposing them to a variety of careers.

Essential Knowledge and Skills:

(a) General Requirements. This course is recommended for students in grades 9th – 12th. Recommended Prerequisites: At least one credit in a Level 2 or higher course in engineering. This course provides 1.0 unit of credit.

(b) Introduction.

(1) Aerospace Engineering (AE) ignites students' learning in the fundamentals of atmospheric and space flight. Aerospace Engineering is one of the specialization courses in the PLTW Engineering program. The course deepens the skills and knowledge of an engineering student within the context of atmospheric and space flight. Students explore the fundamentals of flight in air and space as they bring the concepts to life by designing and testing components related to flight such as an airfoil, propulsion system, and a rocket. They learn orbital mechanics concepts and apply these by creating models using industry-standard software. They also apply aerospace concepts to alternative applications, such as a wind turbine and a parachute. Students simulate

a progression of operations to explore a planet, including creating a map of the terrain with a model satellite and using the map to execute a mission using an autonomous robot.

(2) 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) Career and Readiness. The student describes and distinguishes among the different disciplines of engineering. The student is expected to explain how engineering disciplines continue to evolve and emerge as new interdisciplinary fields and sub-disciplines to better meet the needs of society such as aerospace engineering, biomedical engineering, environmental engineering, computer engineering, structural engineering, and water resource engineering.

(2) Career and Readiness. The student creates sustainable solutions to meet the needs of society without compromising the ability of future society to meet their needs. The student is expected to identify principles that help guide development of sustainable solutions, including people, planet, and profit.

(3) Communication. The student communicates effectively with an audience based on audience characteristics. The student is expected to:

(A) communicate using established conventions of written, oral, and electronic communications such as grammar, spelling, usage, and mechanics;

(B) apply acceptable formats for technical writing and professional presentations;

(C) cite references for all communication in an accepted format; and

(D) label tables and figures with units and explain the information presented in context.

(4) Collaboration. The student facilitates an effective team environment to promote successful goal attainment. The student is expected to:

(A) develop team roles and responsibilities to collaboratively obtain the project goal; and

(B) contribute individually to overall collaborative efforts.

(5) Critical and Creative Problem Solving. The student demonstrates independent thinking and self-direction in pursuit of accomplishing a goal. The student is expected to:

(A) develop a project management plan to accomplish a goal without direct oversight; and

(B) research additional knowledge to accomplish a goal.

(6) Critical and Creative Problem Solving. The student is expected to collect, analyze, and interpret information relevant to the problem or opportunity at hand to support engineering decisions. The student is expected to:

(A) identify relevant data in credible sources such as literature, databases, and policy documents;

(B) analyze and interpret information relevant to the problem; and

(C) cite data and information to support engineering decisions in your solution.

(7) Critical and Creative Problem-Solving. The student synthesizes an ill-formed problem into a meaningful, well-defined problem. The student is expected to:

(A) identify and define visual, functional, and structural design requirements with realistic constraints and evaluate them with alternative solutions; and

(B) identify potential constraints that may impact the success of a design solution such as economic (cost), environmental, social, political, ethical, health and safety, manufacturability, technical feasibility, and sustainability.

(8) Critical and Creative Problem-Solving. The student generates multiple potential solution concepts. The student is expected to:

(A) represent concepts using a variety of visual tools such as sketches, graphs, and charts, to communicate details of an idea; and

(B) apply the design process to derive a solution.

(9) Critical and Creative Problem-Solving. The student develops models to represent design alternatives and generate data to inform decision making, test alternatives, and demonstrate solutions. The student is expected to:

(A) develop a model to accurately represent the key aspects of an object, system or process; and

(B) develop a physical model using hand tools such as backsaw, file, wood shaper and simple construction techniques such as cutting, shaping, laminating materials.

(10)Critical and Creative Problem-Solving. The student selects a solution path from many options to successfully address a problem or opportunity. The student is expected to why there are often multiple viable solutions to a problem and recognize that tradeoffs should be considered and evaluated consistently throughout the engineering design process.

(11)Critical and Creative Problem-Solving. The student makes judgments and decisions based on evidence. The student is expected to evaluate evidence and arguments to identify deficiencies, limitations, biases and appropriate next steps in the pursuit of a better solution.

(12)Aerospace Industry Knowledge. The student analyzes the cause and effect of an aerospace engineering event. The student is expected to:

(A) identify the correct sequence and approximate dates of major events in aerospace engineering; and

(B) analyze the cause-and-effect relationship that led to aerospace developments.

(13)Aerospace Industry Knowledge. The student predicts future aerospace engineering developments. The student is expected to:

(A) analyze major development trends in aerospace engineering;

(B) predict future aerospace engineering needs; and

(C) analyze cause and effect relationships from past aerospace engineering to current events.

(14)Algorithms and Programming. The student designs an unmanned system. The student is expected to:

(A) research applications of an unmanned system;

(B) apply a control system in an unmanned system; and

(C) develop a mechanical design in an unmanned system.

(15) Algorithms and Programming. The student constructs a control program. The student is expected to:

(A) explain the purpose of pseudocode to develop a control program; and

(B) create pseudocode to perform a simple task.

(16) Engineering Tools and Technology. The student measures and reports quantities accurately and to a precision appropriate for the purpose. The student is expected to that all measurements are set within set tolerance of the true value of a measurement.

(17) Engineering Tools and Technology. The student uses a spreadsheet application to help identify and solve a problem. The student is expected to:

(A) collect and organize data in a spreadsheet application to be useful in accomplishing a specific goal; and

(B) use the functions and tools within a spreadsheet application to manipulate, analyze, and present data in a useful way.

(18) Engineering Tools and Technology. The student constructs physical objects using hand tools and shop tools. The student is expected to:

(A) identify basic hand tools and shop tools used in the field of aerospace engineering and describe their function;

(B) develop a plan to build a physical object based on a conceptual communication, such as a drawing or description; and

(C) create a physical object using hand tools and shop tools.

(19) Engineering Tools and Technology. The student applies computational thinking to generalize and solve a problem using a computer. The student is expected to:

(A) research project with content-specific models and simulation to support learning;

(B) use modeling and simulation to represent and understand natural phenomena related to aerospace engineering;

(C) design an algorithm (step-by-step process) for solving an aerospace problem;

(D) identify, test, and implement possible solutions to an aerospace engineering problem using a computer; and

(E) automate a solution using algorithmic thinking.

(20) Fundamentals of Flight. The student analyzes the interaction of the four major forces of atmospheric flight. The student is expected to:

(A) identify the three axes of an aircraft;

(B) compare the motion of an aircraft about the three axes; and

(C) explain the four forces of flight.

(21) Fundamentals of Flight. The student analyzes aircraft stability and control. The student is expected to:

(A) analyze major components of an aircraft and explore their functions;

(B) explain how the fixed and moveable components of an aircraft affect its stability and control; and

(C) analyze how pilot inputs control the movable components of an aircraft.

(22) Fundamentals of Flight. The student analyzes the effect of weight on an aircraft. The student is expected to:

(A) explain the importance of weight and balance of an aircraft;

(B) calculate the center of gravity of geometric shapes;

(C) calculate the center of gravity of an aircraft; and

(D) design the weight distribution plan of an aircraft for a safe flight condition.

(23) Fundamentals of Flight. The student designs an airfoil. The student is expected to:

(A) identify and label components of an airfoil;

(B) explain how lift and drag are generated by fluid flow around the airfoil;

(C) apply atmospheric calculations to airfoil design;

(D) apply the lift equation to an airfoil; and

(E) apply the drag equation to an airfoil.

(24) Fundamentals of Flight. The student designs an aircraft and spacecraft propulsion system using system characteristics and apply them to an aircraft design. The student is expected to:

(A) identify aircraft and spacecraft propulsion systems and their characteristics and apply them to an aircraft design;

(B) predict the effect of changing engine variables on the propulsion performance; and

(C) apply propulsion calculations to the design of a propulsion system.

(25) Fundamentals of Flight. The student designs a rocket for stable flight. The student is expected to:

(A) apply information from a rocket engine performance chart in the design of a rocket;

(B) describe how center of pressure and center of gravity affect rocket performance; and

(C) predict the stability of a rocket for stable flight.

(26) Fundamentals of Flight. The student applies aerospace concepts to non-aerospace systems. The student is expected to:

(A) explain how aerospace engineering concepts can be applied to non-aerospace systems; and

(B) identify and explain aerospace equations that can be applied to non-aerospace systems.

(27) Fundamentals of Flight. The student conducts research on aircraft and spacecraft designs for human systems. The student is expected to:

(A) analyze how human physiology is affected by flight;

(B) compare aircraft systems that adapt to human physiology;

(C) measure human reaction time and sensory acuity; and

(D) research how human factors affect aerospace system design.

(28) Flight Operations. The student interprets aircraft navigation systems. The student is expected to:

(A) describe the function and use of navigation systems; and

(B) interpret navigation system readings.

(29) Flight Operations. The student designs a solution to an aircraft traffic dilemma. The student is expected to:

(A) discuss the purpose and function of an air traffic control system;

(B) predict and explain how position information for aircraft is used in traffic control; and

(C) analyze an aircraft interaction scenario and design a solution to avoid collisions.

(30) Flight Operations. The student analyzes an aircraft accident to determine the probable cause. The student is expected to:

(A) research and analyze the typical factors that contribute to an aircraft accident; and

(B) explain how to examine information related to an aviation accident such as black box data, aircraft evidence, and environmental reports.

(31) Flight Operations. The student operates an aircraft in a virtual environment. The student is expected to:

(A) explain how the flight controls interact with the aircraft; and

(B) operate and maintain control of a simulated aircraft using standard operating procedures.

(32) Materials and Structures. The student analyzes the mechanical properties of materials. The student is expected to:

(A) explain the importance of mechanical properties of materials to the structure of an aircraft;

(B) describe the procedure for mechanically testing a material;

(C) apply equations that interrelate deflection, moment of inertia, and modulus of elasticity of a structure; and

(D) analyze and measure mechanical properties of a material.

(33) Materials and Structures. The student designs an aircraft structure. The student is expected to:

(A) compare common aerospace materials, properties, and applications;

(B) explain the impact of loading conditions on a structure; and

(C) design an aircraft structure and explain design reasoning of materials and load.

(34) Space Flight. The student analyzes an issue to which space law applies. The student is expected to:

(A) explain how global governance applies to space issues;

(B) evaluate the contributions commercial organizations have on space-related activities; and

(C) analyze the effect that space junk has on space-based activities.

(35) Space Flight. The student applies orbital mechanics equations to an orbiting body. The student is expected to:

(A) describe the six Keplerian elements;

(B) apply orbital mechanics equations to an orbiting body; and

(C) explain the energy forms within an orbital body.

(36) Space Flight. The student models an orbital system. The student is expected to:

(A) describe common satellite orbital patterns and applications; and

(B) design a satellite system using an orbital mechanics modeling software.

Recommended Resources and Materials:

National Aeronautics and Space Administration. 2010. “U.S. centennial of flight commission.” http://www.centennialofflight.gov/essay/Evolution_of_Technology/NACA/Tech1.html.

National Archives.2010. “Electronic code of federal regulations.” http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=3b1d9293eae33aeb0b3f9b278d7ed22b&rgn=div8&view=text&node=14:1.0.1.1.1.0.1.1&idno=14.

Garber, S. (2007). “Sputnik and The Dawn of the Space Age.” http://history.nasa.gov/sputnik/.

Project Lead The Way Teacher and Student Resources. 2022. https://my.pltw.org/login.

Project Lead The Way Software and Technology Requirements. 2022. https://pltw.org/pltw-software.

Recommended Course Activities:

1. Evolution of Flight: The goal of this lesson’s activities/projects is for students to develop a foundational understanding of aerospace accomplishments. Students develop their skills of working with a team and then within a larger group of the entire class while researching and discussing achievements in aerospace.

2. Physics of Flight: The goal of this lesson’s activities/projects is for students to build a foundational understanding of how flight within the Earth’s atmosphere is possible. Students learn about the parts of an aircraft, how aircraft are controlled, and how the four forces of flight interrelate. Students use a simulator to design an airfoil and analyze performance under changing conditions. An option is included for students to design, build, and test an airfoil in a wind tunnel if available. Students apply their knowledge and skills through a series of activities and projects to design, optimize, build, and test a competitive glider.

3. Flight Planning and Navigation: The goal of this lesson’s activities/projects is for students to fly an aircraft using simulation software and learn how aircraft are safely coordinated. Students are introduced to navigation systems such as the Global Positioning System (GPS). Students apply their knowledge of a navigational system to plan a route and exchange this plan with another group to evaluate the plan’s accuracy.

4. Materials and Structures: The goal of this lesson’s activities/projects, students will explore properties of some aerospace materials. Students will design an aircraft structural component in computer aided design (CAD) simulation software. Students will create and test composite samples which represent structural components used in aircraft construction.

5. Propulsion: The goal for this lesson’s activities/projects is for students to develop a deeper understanding of one of the four forces of atmospheric flight – thrust – while understanding the foundation of spacecraft propulsion. Students will learn about ways thrust is produced for

aircraft and spacecraft. Students learn how aircraft propulsion system parameters interrelate using simulation software. Students design, build, and test their own model rockets.

6. Orbital Mechanics: The goal of this lesson's activities/projects is for students to understand the need for various types of satellite orbits and how different orbits are well-suited for different satellite missions. This includes an introduction to, and basic understanding of, laws governing and describing satellite orbits. Students apply what they learned by creating a model of the International Space Station orbit using Systems Tool Kit (STK) software.

7. Remote Systems: The goal of this lesson's activities/ projects is for students to learn to integrate mechanical, electrical, and software systems in the context of accomplishing a sequence of objectives to explore a new planet. Students use the modeling system to design, build, program, and test an autonomous vehicle which simulates a rover sent to explore a remote location such as a planet or moon. An optional project is available for differentiated instruction in a classroom with a diverse level of student knowledge and skill. Students use the modeling system to create a physical simulation of an autopilot system. Students create a program to use an accelerometer input to control the output of an aircraft control surface.

Suggested methods for evaluating student outcomes:

PLTW supports a balanced approach to assessment for all programs. PLTW offers assessments that measure subject-matter knowledge as well as the in-demand, transportable skills that students need to succeed beyond high school. A sample of these assessment types are:

- Project Rubrics
- Written Records of Student Work
- Discussions and Observations
- Informative Assessments (by Unit)
- Live Presentations of Research and Design Ideas
- End of Course Assessment
- Conclusion Questions for Each Lesson
- Performance Checks (example: Successful flight in a flight simulator)

Teacher qualifications:

- Legacy Master Science Teacher.
- Mathematics/Physical Science/Engineering: Grades 6-12.
- Mathematics/Physical Science/Engineering: Grades 8-12.
- Physical Science: Grades 6-12.
- Physical Science: Grades 8-12.
- Physics/Mathematics: Grades 7-12.
- Physics/Mathematics: Grades 8-12.
- Science: Grades 7-12.
- Science: Grades 8-12.
- Science, Technology, Engineering, and Mathematics: Grades 6-12.
- Secondary Industrial Arts (Grades 6-12).
- Secondary Industrial Technology (Grades 6-12).
- Secondary Physics (Grades 6-12).
- Secondary Science (Grades 6-12).
- Secondary Science, Composite (Grades 6-12).

- Technology Education: Grades 6-12.
- Legacy Master Mathematics Teacher.
- Mathematics: Grades 7-12.
- Mathematics: Grades 8-12.
- Secondary Mathematics: Grades 6-12
- Secondary Physical Science (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.

Additional information:

Successful completion of the PLTW Core Training is required to offer the course.

PLTW's Core Training for Aerospace Engineering requires approximately 90 hours of instruction led by PLTW-approved Master Teachers (80 hours of class time plus 10 hours of prerequisite work). It is offered year-round with multiple options to allow teachers to select dates and pacing of their training sessions. Course mastery is demonstrated by the submission and approval of a course portfolio that meets 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.

Current details, such as pricing and listings for all PLTW professional development, can be found at https://www.pltw.org/our-programs/professional-development/core-training. At the time of this application submission, the course cost is *$2,400.

Note: Currently, PLTW offers a training guarantee to schools. The PLTW Training Guarantee protects a district's investment in PLTW programs by guaranteeing if a teacher leaves within four years of earning a PLTW credential, PLTW will provide a grant in the amount of the training fee for the district to train a teacher in the same course, replace the credential(s), and support continued student learning.

* PLTW Professional Development Fees are subject to change annually. Changes are communicated via email from PLTW Communications and on the PLTW website at least 90 days prior to the effective date for the upcoming school year. There are no changes for the 2023-24 school year.

Please contact Project Lead The Way directly for questions about these requirements:

Project Lead The Way

Solution Center

Toll Free: 877.335.PLTW (7589) solutioncenter@pltw.org