THE STEM ACADEMY AT GALENA HIGH SCHOOL

AT-A-GLANCE

The STEM Academy at Galena High School encompasses fields of study in **S**cience, **T**echnology,
Engineering, and **M**athematics. Students are enrolled in a 4-year course sequence that follows a nationally-recognized curriculum, *Project Lead The Way.* Students engage in open-ended problem
solving, learn and apply the engineering design process, and use the same industry-leading technology and software as are used in the world's top companies. Students investigate topics such as
aerodynamics/astronautics and biological engineering/sustainability which gives them an opportunity
to learn about different engineering disciplines before beginning post-secondary education or careers.

The sequence includes **two foundation courses**:

- **Introduction to Engineering Design (IED)**
  - Students dig deep into the engineering design process, applying math, science, and engineering standards to hands-on projects. They work both individually and in teams to design solutions to a variety of problems using 3D modeling software, and use an engineering notebook to document their work.
- **Principles of Engineering (POE)**
  - Through problems that engage and challenge, students explore a broad range of engineering topics, including mechanisms, the strength of structures and materials, and automation. Students develop skills in problem solving, research, and design while learning strategies for design process documentation, collaboration, and presentation.

These are followed by a **core specialization** course. Students will select one of the following specialization paths in their sequence:

or

- **Aerospace Engineering (AE)**
  - This course propels students' learning in the fundamentals of atmospheric and space flight. As they explore the physics of flight, students bring the concepts to life by designing an airfoil, propulsion system, and rockets. They learn basic orbital mechanics using industry-standard software. They also explore robot systems through projects such as remotely operated vehicles.
- **Environmental Sustainability (ES)**
  - In ES, students investigate and design solutions in response to real-world challenges related to clean and abundant drinking water, food supply issues, and renewable energy. Applying their knowledge through hands-on activities and simulations, students research and design potential solutions.

The sequence ends with a **capstone course** whereby students work in teams to design and develop an
original solution to a valid open-ended technical problem by applying the engineering design process.

- **Engineering Design and Development (EDD)**
  - The knowledge and skills students acquire throughout PLTW Engineering come together in EDD as they identify an issue and then research, design, and test a solution, ultimately presenting their solution to a panel of engineers. Students apply the professional skills they have developed to document a design process to standards, completing EDD ready to take on any post-secondary program or career.

CURRICULUM

Project Lead The Way (PLTW) is the leading provider of rigorous and innovative Science,

Technology, Engineering, and Mathematics (STEM) education curricular programs used in middle
and high schools across the U.S. STEM education is at the heart of today's high-tech, high-skill global economy. It will provide them with a foundation and proven path to post-secondary training
and career success in STEM-related fields. Because the STEM Academy's course of study closely
follows an Honors Diploma track, students who complete the program also have the opportunity to
earn accelerated admission for college programs. In addition, partnerships between the school and
industry will provide students with internships and other opportunities for experience.

CAREER AND COLLEGE READY

STEM Academy graduates have job specific, technical skills that lead to employment or acceptance
in post-secondary institutions. Along with internships and business partnerships, each program of study in the STEM Academy prepares students for good jobs for the future[1].

COURSE SEQUENCE

(Freshman)

Introduction to Engineering Design (IED)

(Sophomore)

Principles of Engineering (POE)

(Junior)

Aerospace Engineering (AE) | Environmental Sustainability (ES)

(Senior)

Engineering Design and Development (EDD)

"Science, technology, engineering and mathematics (STEM) workers drive our nation's innovation and competitiveness by generating new ideas, new companies and new industries. However, U.S. businesses frequently voice concerns over the supply and availability of STEM workers. Over the past 10 years, growth in STEM jobs was three times as fast as growth in non-STEM jobs. STEM workers are also less likely to experience joblessness than their non-STEM counterparts. Science, technology, engineering and mathematics workers play a key role in the sustained growth and stability of the U.S. economy, and are a critical component to helping the U.S. win the future."

~ STEM: Good Jobs Now and for the Future, U.S. Department of Commerce, July 2011

1 U.S. Department of Commerce, July 2011, STEM: Good Jobs Now and for the Future.

Aerospace Engineering (AE) Overview

AE is a Specialization Course within the PLTW Engineering Program.

Aerospace Engineering (AE) Course Information

This course propels students' learning in the fundamentals of atmospheric and space flight. As they explore the physics of flight, students bring the concepts to life by designing an airfoil, propulsion system, and rockets. They learn basic orbital mechanics using industry-standard software. They also explore robot systems through projects such as remotely operated vehicles.

Unit 1 – Introduction to Aerospace

1.1 – Evolution of Flight

Flight is rooted deep within cultures around the world from the time of ancient myth to the development of the international space station. The evolution of flight parallels the evolution of science, engineering, and industry. Exposing students to the engineering problems faced during the development of flight, will lay a foundation of appreciation of the challenges that engineers face when developing flying machines.

In this lesson, students will be introduced to the evolution of flight through the cause and effect relationship of flight advances.

1.2 – Physics of Flight

Flying inspires imagination in many people. In the first lesson students explored the rich history of leaving the Earth's surface. In this lesson students will see how science, engineering and imagination come together to make flying possible. Students will apply aerodynamic equations to solve aerospace engineering problems and apply that knowledge to design, build and test gliders.

1.3 – Flight Planning and Navigation

Effectively navigating to a destination is a skill that humankind has developed out of necessity. Very early in our history, humans needed to navigate to locate food and to return home. Sailors navigated across oceans, sometimes for the first time. Today your family can drive to your favorite vacation destination without getting lost. Pilots navigate their aircraft to airports in other cities, while astronauts navigate a space vehicle to another planet. Computer simulators provide opportunities for the development of navigation skills.

Computer simulators are highly integrated into aviation training programs. Difficult conditions which rarely occur in the real world can be realistically simulated. Crews learn to manage such conditions without endangering crew or equipment. These simulators are used for planning and then executing the flight to verify the plan's accuracy.

This lesson will introduce the students to the fundamentals of flight, navigation and the use of simulators.

Unit 2 – Aerospace Design

2.1 – Materials and Structures

The aerospace industry is diversified in task and craft, ranging from glider design to space re-entry vehicle design. Regardless of the diversity of the industry, aerospace design is centered on the understanding of materials and structures. Proper material selection and structural component configuration allow for craft safety and performance needs to be achieved and exceeded.

In this lesson students will design an aircraft structural component, create composite and test composite samples.

2.2 – Propulsion

Aircraft require a force to sustain flight. For example a glider uses upward rising air to increase its potential energy which it converts into lift by descending. Powered aircraft rely on internally generated thrust to sustain flight. Within the atmosphere an aircraft propulsion system uses air and fuel for the combustion process which then provides thrust. Beyond the atmosphere spacecraft produce thrust through a variety of methods since air is not available in the vacuum of space.

In the lesson students will explore various ways thrust is produced for aircraft and space craft. Students will also design, build and test their own model rockets.

2.3 – Flight Physiology

As we have discovered throughout this course, human flight has made significant technological advances since the Wright brothers. However, one critical system component has remained relatively unchanged: the human system. The study of flight Physiology or human factors is focused on the ability of the human body to adapt to the demands placed on it by flight. Through understanding the human element, aerospace engineers can design systems that minimize the risk to humans.

In this lesson students will gain an understanding of how the human body is affected by flight and its role within the aircraft design.

Unit 3 – Space

3.1 – Space Travel

Space is considered a resource for the benefit all of humankind. This resource is protected and its development is coordinated through a system of agreements between many nations and disputes are resolved through the application of Space Law.

After gaining the approval of the United Nations Office of Outer Space then a voyage into Space can begin. Space travel requires a complex system with many highly skilled people working together to lower the risk of mishap.

In this lesson students will gain a perspective of the immense scale of the universe. Students will also explore the growing space debris problem and design a mitigation system.

3.2 – Orbital Mechanics

Many years ago it was common knowledge that the sun revolved around the Earth. Through the work of scientists and scholars new theories were developed and proven through observations and scientific research. These advancements form the basis what is accepted as orbital mechanics today.

This lesson will provide students with an introduction to and basic understanding of laws governing and describing satellite orbits. Students will learn about the Keplerian Element Set and Kepler's Laws of Motion. They will understand why there are many different types of satellite orbits and how different orbits are well-suited for different satellite missions.

Unit 4 – Alternative Applications

4.1 – Alternative Applications

Designing shapes to direct air to perform a useful function is often thought of the sole domain of Aerospace Engineers. Mechanical, Civil and other Engineers apply the same aerodynamic principles to design windmills, automobiles, cooling systems and shapes of building to minimize wind load.

An aerospace engineer is typically part of a larger design team working on a larger project. A well-functioning team performs their work with consideration of the impact on other team member's work.

4.2 – Remote Systems

Remote systems are often highly sophisticated devices that perform tasks believed to be both monotonous and dangerous, including surveillance, intelligence, and combat engagement. Their use reduces the risk to human injury or death, which is a major motivation for development. Remote systems operate with or without direct operator input and can be operated for extended periods of time, ranging from days to months. They range in size from backpack-deployable devices, deep-water exploration vehicles, and planetary rovers.

Remote system design is distinguishable within the aerospace industry based upon the domain or environment in which the system operates and includes air, ground, maritime, and space. Today's remote system design advances are results of improvements in technology.

In this lesson students will develop a historical perspective of remote systems to place the development in context. Students will also develop robotic hardware and software skills to prepare for a simulated planetary exploration mission.

4.3 - Aerospace Careers

Aerospace and related industries provide career opportunities for students to apply the concepts learned in this course. One approach is to envision a future life and the steps necessary to achieve this status. In this lesson students will prepare an advertisement and interview to compete with peers for an opportunity to be profiled in a nationwide news broadcast.

Environmental Sustainability (ES) Overview

Environmental Sustainability (ES) Course Information

Environmental Sustainability (ES) is a high school-level specialization course in PLTW Engineering. In ES, students investigate and design solutions to solve real-world challenges related to clean drinking water, a stable food supply, and renewable energy. Students are introduced to environmental issues and use the engineering design process to research and design potential solutions. Utilizing the activity-, project-, problem-based (APB) teaching and learning pedagogy, students transition 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 scientific protocols such as project management, lab techniques, and peer review. Students develop skills in designing experiments, conducting research, executing technical skills, documenting design solutions according to accepted technical standards, and creating presentations to communicate solutions.

Unit 1: Environmental Sustainability for a Better Tomorrow

In this lesson, students examine current global problems and look specifically at world hunger, a lack of clean water, and the need for renewable energy sources. They complete a design challenge to build a device out of recycled materials. Students explore the diverse field of biological and environmental engineering, reflect on ways that engineers work to help solve environmental sustainability problems, and explore the ethical issues that influence the decisions engineers make.

Unit 2: Ensuring Safe and Abundant Water

This unit begins by establishing context around the extent of the global drinking water challenge. Students build models of natural water systems, investigate how these systems become contaminated, explore howcontamination can be prevented, and examine how polluted waters can be purified. Students practice laboratory methods for quantitatively measuring water quality. They investigate the role and effectiveness of biological organisms in cleaning up water polluted with crude oil. The physical, chemical, and biological technologies and processes utilized by waste water treatment plants are explored, with optional field trips to these facilities included. As a culmination project, students apply their knowledge of water issues, water treatment technologies, and the associated role of biological organisms, along with their engineering design experience, to the challenge of designing a small-scale water treatment system for rapid deployment within natural disaster zones.

Unit 3: Food Security

This unit focuses on the genetic modification of plants as a potential solution to food security issues around the globe. Students learn about the structure and function of DNA and the process of protein synthesis. They learn to determine whether familiar food items contain genetically modified organisms (GMOs). They investigate various molecular biology techniques while working through the steps necessary to create genetically modified plants. Through laboratory activities and simulations, students explore Polymerase Chain Reaction (PCR), DNA sequencing techniques, restriction enzyme action, ligation, gel electrophoresis, bacterial transformation, and plant transformation. They work through the beginning steps of the engineering design process and propose a genetic engineering solution to a global food security issue.

Unit 4: Renewable Fuels

This unit concentrates on the role of biological engineering and biomanufacturing of biofuels from algae and cellulosic plant materials in solving the challenges associated with producing biofuels in a sustainable and environmentally friendly manner. The unit begins by exploring current global energy consumption patterns and then examines futuristic energy consumption models that utilize types of energy other than fossil fuels. Students conduct a household energy audit to contextualize their energy consumption patterns.

They investigate the process of photosynthesis and its role in the formation of both fossil fuels and biofuels. Applying an engineering design process, students are challenged to design, build, and operate bench-top-scale algae bioreactors. Students design monitoring systems and apply standard laboratory processes in quantifying the efficiency of their systems at producing algae and purifying the end products.

Next, students dive into the production of ethanol from cellulosic plant sources. They investigate the role that enzymes play in this process. Students explore technologies used to produce ethanol and design an ethanol separation and purification system. In the last part of the unit, students are challenged to apply their knowledge of biofuels, engineering design, and biomanufacturing practices as they develop a proposal for a commercial-scale biofuels manufacturing plant.

Classroom pics:
Students hard
at work
... and having fun!

NOTE: You must earn an Honors
Diploma in order to participate
in the Academy

(Aerospace Engineering or Environmental Sustainability

Aerospace

Environmental
Sustainability (ES)

Engineering and Environmental Sustainability